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mndot.gov/research

# **RESEARCH** AT-A-GLANCE

Informing, Improving and Innovating Transportation in Minnesota

MnDOT is exploring best practices for involving individuals with visual impairment in assessing transportation needs. > TRS 1808



A comprehensive guide helps hydraulic engineers promote safe passage of fish and other aquatic organisms through culverts while ensuring statewide stream connectivity. Report 2019-02



The Twin Cities' bus rapid transit A Line is a successa popular alternative to local bus service without significant impacts to local traffic. X Report 2018-35



# OUR MISSION

*MnDOT's Office of Research & Innovation supports Minnesota's transportation community by meeting the innovation and information needs of practitioners.* 

In addition to running the state transportation library, our office manages research funded by the MnDOT State Research Program (SRP) and Federal Highway Administration (FWHA) State Planning and Research (SP&R) Program (Part II). We also administer the Local Road Research Board (LRRB) program, which facilitates transportation research and information-sharing among city and county engineers.



#### **MnDOT Library**

Our librarians are experts at tracking down hard-to-find information and can keep you up to date in your field. Request a literature search, interlibrary loan, periodical or special publication at 651-366-3791, library.dot@state.mn.us or mndot.gov/library.



#### **Research Implementation**

We provide seed funding throughout the year to get research results and transportation innovation into practice. Funding is available for small-scale deployment or the development of training materials. Contact us at 651-366-3780 or **research.dot@state.mn.us** about your implementation needs.



#### New Office, New Director

In 2019, MnDOT implemented part of its research strategic plan by elevating the former Research Services & Library Section to the Office of Research & Innovation and appointing a new director, Katie Walker. The agency also conducted its first Research Implementation and Outcomes Survey to determine the impact of research completed from 2013 to 2018 based on changes in practices or policies. More at **mndot.gov/research/strategic.html.** 



#### **Research Funding**

If you need research assistance, we can help you develop your idea and apply for funding. Submit research ideas at **mndot-Irrb.ideascale.com**.

#### **RESEARCH FUNDING CYCLE**



NOTES: Dates subject to change. Check mndot.gov/research for current schedule. Out-of-cycle funding requests are accepted in some circumstances.

of recently completed research has already impacted how MnDOT serves Minnesotans!

#### 2013-2018 RESEARCH PROJECT OUTCOMES SURVEY

) Efficiency

50% informed a process or an operation

Safety 28% resulted in new or improved tools and software

Skilled Training 21% resulted in training or knowledge-sharing tools

Effectiveness 21% informed a technical memo or construction specifications

Guidance 11% resulted in a new or improved MnDOT policy

Accurate Timely Response 6% resulted in legislation or response to a legislative inquiry

#### **REQUEST A TRS**

A Transportation Research Synthesis (TRS) is a shortturnaround research report that helps answer your research questions without the time or expense of a full research project. These reports may summarize completed and in-progress research, or describe the state of practice among your peers in Minnesota and other states. For more information or to request a TRS, visit mndot.gov/research/TRS.html.



**TRS 1809** examined the benefits and drawbacks of the Continuous Green T-Intersection, which can reduce crashes if it is carefully designed and sited.

# OUR STRATEGIC PRIORITIES

Nearly 200 MnDOT professionals and leaders participated in the Research Strategic Direction Visioning workshops. Their input provided the framework for MnDOT's Research Strategic Priorities: safety, advancing equity, asset management, climate change and the environment, and innovation and future needs. On pages 4-6, we've highlighted examples of our research that supports these priorities.

The Research Strategic Priorities do not explicitly direct the topics of research; instead, they show ways that research at MnDOT garner progress toward MnDOT's strategic operating goals and mission (PDF) Safety is a key part of MnDOT's mission. This priority aims to ensure that all road users have access to a safe roadway system, work zones are safe for the public and workers, and MnDOT employees have the tools and skills to work in the safest way possible.



#### **Cloud-Based Dynamic Warning System**

Over a quarter of fatal highway crashes occur at horizontal curves. In Minnesota, these curves are a contributing secondary factor in 49 percent of fatal crashes. If drivers are warned of upcoming curves, they reduce speed, but automatic systems are very expensive. Researchers focused dramatic cost savings over warning signs placed at every curve. County road agencies can also easily update their databases to include work zone activities, controlled intersections, and bumps and cracks in the pavement caused by seasonal changes. **Report 2019-19** 

on developing a proofof-concept smartphone app that would warn drivers of upcoming curves and speed reduction requirements. They also created a database for county road agency managers to input curve locations within their jurisdictions, speed limits and sign facing direction for use with the smartphone app. Researchers layered the



Learn more about the dynamic curve warning system at LRRB's YouTube channel.

related, in-progress project, **Development** and Demonstration of an In-Vehicle Lane Departure Warning System Using DSRC Based on V2V Communication, are seeking to develop and demonstrate a lane departure and advance curve warning system using

Investigators for a

database into their geographic roadway inventory tool, which draws on GPS and mapping data, and combined data from the sources into a cloud-based curve database.

The system's performance is comparable to expensive dynamic sign warning systems, but using a single cloudbased system for the entire roadway inventory offers a dedicated short-range communication (DSRC) based on vehicle-to-vehicle (V2V) communications. The proposed system will obtain the trajectory of the moving vehicle using GPS and compare it to the direction of travel of a neighboring vehicle via DSRC-based V2V communication to detect lane departure and inform the driver.

Work zone speed notification systems use variable message signs to warn drivers of traffic slowdowns.

Urban construction work zones can cause unpredictable traffic slowdowns and queues, with many drivers braking suddenly and risking rear-end collisions. Researchers evaluated MnDOT's newly developed Smart Work Zone Speed Notification system over two construction seasons along a 4.4-mile section of a complicated, multilane highway project. The system monitors traffic speed and flow, and uses an algorithm to generate messages on variable message signs that warn drivers of slowed and stopped traffic. With this real-time information, drivers can slow down before a congestion hazard, avoiding sudden braking and collision risks. MnDOT is now using the system on two construction sites with more planned. **Report 2019-21** 

#### Smart Work Zone Speed Notification System



Advancing equity aims to recognize the role research plays in the assurance of equitable access to safe and efficient transportation systems. While research may not necessarily focus only on equity, MnDOT prioritizes research projects that advance equitable access to safe and efficient transportation systems.

# Involving People With Visual Impairment in Facility Decision-Making

People with visual impairment have unique perspectives



MnDOT works to make transportation facilities safe and accessible to people with visual impairment.

on crosswalks, transit stations, traffic intersections and related facilities. MnDOT's Office of Transportation System Management researched best practices for communicating facility designs to this community. Researchers determined that tactile maps, scale models, large print presentation materials and braille documents are effective aids, while face-to-face meetings are critical when planning transportation facilities. **TRS 1808** 

#### **Mitigating Construction Impacts on Local Businesses**

MnDOT's Office of Public Engagement & Constituent Services is evaluating ways to mitigate the impacts of construction projects on local businesses. Communication strategies, construction techniques that mitigate noise and project duration, and outreach to minority business owners or those with limited proficiency in English are particular areas of focus. This study examined the practices and experience of selected state transportation agencies and Minnesota municipal transportation agencies in reducing the impacts of construction projects. **TRS 1901** 



Businesses are frequently affected by highway construction.



Asset management research may include projects that focus on asset-related data collection processes and data management, measurement of asset life cycle and life-cycle costs. Such projects inform preservation of assets and are critical measurements of return on investment.



*Improved remaining service life measures will allow better estimates of bridge and pavement maintenance needs.* 

#### **Remaining Service Life Asset Measure—Phase I**

Pavement engineers often explain the maintenance and construction needs of Minnesota's 14,000-mile highway system in terms of remaining service life (RSL), an estimate of years of service after which a road will require replacement or rehabilitation. MnDOT's Bridge Office uses different ways to describe the needs of its 20,000 bridges. Two methods make judging and funding the needs of both highway and bridge systems challenging. Researchers developed a revised version of RSL that fits both pavements and bridges to help managers plan and budget for the long-term health of the entire system. **Report 2018-23**  Climate change and environment research may manifest as projects specific to endangered and threatened species, wetland protections, salt use and incursion, congestion impacts on air quality, and the impacts of MnDOT work on the environment.

# o<sub>00</sub> climate change & environment

# Using Small Animal Exclusion Fencing to Reduce Vehicle–Animal Collisions

MnDOT and the Minnesota Zoo are collaborating on a new research project that will protect wildlife and enhance driver safety by keeping small animals away from highways. Investigators are installing small animal exclusion fencing along roads to redirect turtles and other small animals to culverts and bridges where they can cross the road safely. Researchers will be monitoring the effects of these fences on target species and will evaluate costs and design specifications. Watch a video about this project on MnDOT's YouTube channel. Active Project



KSTP reported on the partnership between MnDOT and the Minnesota Zoo to protect wildlife. Watch the story on KSTP.

#### Investigating Wastewater Reuse at MnDOT Truck Stations



A researcher collects wastewater samples from a Shakopee facility holding tank.

Despite Minnesota's abundance of water resources, 75 percent of the state's water comes from underground aquifers. Increasing demand for water in densely populated areas is depleting aquifers at unsustainable rates. Since every MnDOT building uses water, the potential for substantial water reuse exists among the agency's 137 truck stations and storage facilities and over 50 rest areas. Researchers investigated the potential for wastewater reuse, including all barriers to implementation. They recommended that MnDOT begin with a membrane bioreactor at the Granite Falls facility. The technology has been installed at the facility, and implementation at additional sites is being considered. **Report 2019-22** 

To better understand and meet the transportation needs of the future, MnDOT must continue to invest in forward-looking research.





A ditch washout on U.S. Highway 169 in Belle Plaine.

#### New GIS Model for Assessing Slope Failure Vulnerability

Increasing heavy rainfalls and annual precipitation combined with frost action can create geological instability in slopes near state roadways. Slope failures and rockfalls may result in millions of dollars in damage and cleanup costs. MnDOT set out to identify, map and rank slopes for failure vulnerability along state highways and then develop a method to quantify the risk of failure. In the first phase of this project, researchers integrated software with MnDOT's own geological information system (GIS) platform and mapped county slopes. They visited actual slope failures to validate the findings from their GIS models and mapped the entire trunk highway system of 12 counties in three districts. In Phase II, researchers will map and evaluate slopes in 32 counties covering five districts. **Report 2019-28** 

# LEVERAGING OUR RESEARCH DOLLARS

# For every \$1 ( invested in a pooled fund study with other states, MnDOT leverages \$10 5 worth of research.

The Transportation Pooled Fund (TPF) Program allows federal, state and local agencies and other organizations to combine resources to support research into shared transportation priorities.

Minnesota leads nine pooled funds and participates in another 36. Find a summary of all pooled fund activity at mndot.gov/research/pooled.html. Some of our notable studies:

CLEAR ROADS

Clear Roads. The Clear Roads research program brings research for winter highway maintenance together transportation

professionals and researchers from around the country to drive innovation in winter maintenance. By evaluating materials, equipment and methods in real-world conditions, the program identifies the most effective techniques and technologies to save agencies money, improve safety and mobility, and increase efficiency. clearroads.org



National Road Research Alliance. The National Road Research Alliance (NRRA) was created by MnDOT to help fund and direct research at the

MnROAD cold-weather pavement test track. NRRA finds ways to build roads faster, make them last longer, perform better, cost less to build and maintain, and have less impact on the environment. mndot.gov/mnroad/nrra



**Clear Roads** Project 14-03 determined the most effective practices used by agencies nationwide to

plow snow from complex interchanges. Investigators developed a set of resources to assist agencies in efficiently and effectively removing snow from these configurations. This image from the training video and manual shows an animated sequence of a plow path for clearing the Double Roundabout Interchange.



North/West Passage. Minnesota initiated this pooled fund to investigate intelligent

transportation systems solutions to traffic management, traveler information and commercial vehicle operations on Interstates 90 and 94 between Washington and Minnesota. nwpassage.info

#### How to Participate in National **Research Projects**

Pooled Funds — If your research idea addresses an issue that affects multiple states, we can help establish a TPF project to leverage resources and collaborate with other state DOTs to solve a problem. Find guidance at mndot.gov/research/pooled.html.

#### **Track National Trends**

Get the latest research news in your subject area from across the country by searching the national database (trid.trb.org), watching webinars (webinar.mytrb.org) or getting regular alerts via a trb.org RSS feed.



**NCHRP Research** — If you are trying to solve a problem of regional or national significance, we can help you develop a problem statement through the National Cooperative Highway Research Program (NCHRP). Contact us at research.dot@state.mn.us.

# FY2019 RESEARCH ACTIVITIES

### FINANCIAL OVERVIEW

MnDOT research is funded through the MnDOT SRP and FWHA SP&R (Part II). MnDOT's Office of Research & Innovation also manages research for the LRRB.

2%

#### **FY2019 Funding Sources**

State Research Program*	\$ 4,952,892
FHWA State Planning and	
Research (Part II)**	\$ 3,607,486
Local Road Research Board***	\$ 6,810,099
Other****	\$ 283,007
Total	\$ 15,653,484

\* Includes \$326,351 carried forward from FY2018 \*\* Includes \$142,794 in prior years' funds released

- from closed projects \*\*\* Includes \$2,789,143 carried forward
- from FY2018 \*\*\* Includes contributions from other MnDOT funds, partnerships with other agencies and other federal sources

#### Subset: FY2019 SP&R (Part II) Funding Distribution\*

FHWA SP&R (Part II) funds are allocated to MnDOT for eligible state-specific needs and to participate in multi-state initiatives as shown below:

Multi-State Pooled Funds a: Participation in Pooled	\$	1,410,495
Funds Led by Other States b: MnDOT-Led Pooled Funds	\$ \$	775,720 634,775
Single-State SP&R Projects	\$	1,297,114
Federal Program Support a: National Cooperative	\$	899,876
Highway Research	~	762 222
Program b: Transportation	Ş	762,232
Research Board	\$	137,644
Total	\$	3,607,485

\*This excludes 2019 commitments that were paid in advance with 2018 funds and includes 2020 commitments paid in advance with 2019 funds.





# FY2019 RESEARCH CONTRACTS

# Each research topic area on the following pages includes two tables:

- Research reports completed in fiscal year 2019 (FY2019), followed by other research contracts active during FY2019, sorted by contract end date.
- Multi-state pooled funds and American Association of State Highway and Transportation Officials (AASHTO) projects, with MnDOT-led pooled funds listed first.

# Prefixes in project titles indicate funding for projects not supported entirely by the MnDOT SRP:

- INV Partial or full LRRB funded
- MPR/MP 80% federally funded/20% state funded
- TPF MnDOT-administered pooled fund (100% federal funds)

For more information about projects, including two-page Technical Summaries for completed reports, search by the title on the "Projects" tab at **mndot.gov/research**. For more information about pooled funds, search at **pooledfund.org**.

#### **BRIDGES & STRUCTURES**

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost		
2018-24	A Rational Method of Surface Treatment Selections for Concrete Decks	Mary Vancura, Beton Consulting	Paul Pilarski, Nathan Schutte	8/31/18	\$94,523		
2018-26	MP-16(008): Improving the Quality of Bridge Inspections Using Unmanned Aircraft Systems (UAS)	Barritt Lovelace, Collins Engineers, Inc.	Jennifer Wells	9/30/18	\$99,980		
2018-27	Retightening the Large Anchor Bolts of Support Structures for Signs and Luminaires	An Chen, Iowa State University	Jihshya Lin	8/31/18	\$145,238		
2019-05	Displacement Monitoring of I-35W St. Anthony Falls Bridge With Current Vibration-Based System	Lauren Linderman, University of Minnesota	Benjamin Jilk	2/28/19	\$141,114		
2019-07	INV 1035: Anchorage of Epoxy-Coated Rebar Using Chemical Adhesives	Ben Dymond, University of Minnesota Duluth	Joseph Black	4/30/19	\$42,210		
2019-09	INV 1035: Deterioration of Mixed Rebar and Fiber-Reinforced Concrete Bridge Decks	Ben Dymond, University of Minnesota Duluth	Nickolas Haltvick	4/30/19	\$34,400		
2019-30	INV 1035: Debonded Strands in Prestressed Concrete Bridge Girders	Cathy French, University of Minnesota	Brian Homan	7/31/19	\$35,000		
2019-37	Maintenance Painting for Steel Bridges: Evaluation of Coating Systems Over Minimally Prepared Surfaces to Delay Rehabilitation	Daniel Zienty, Short Elliott Hendrickson, Inc.	Sarah Sondag	8/31/19	\$94,738		
	Bridge Construction Time and Costs	Ross Jentink, WSB & Associates, Inc.	Paul Johns	5/31/19	\$95,141		
	Bridge Construction Time Estimation Guidebook	Mike Rief, WSB & Associates, Inc.	Paul Pilarski	6/30/19	\$31,354		
	MP-17(004): Understanding and Mitigating the Dynamic Behavior of RICWS and DMS Under Wind Loading	Lauren Linderman, University of Minnesota	Jihshya Lin	12/31/19	\$182,034		
	INV 976: Development and Integration of Advanced Timber Bridge Inspection Techniques for NBIS: Purchase Equipment and Train Users	Victor Krause, University of Minnesota Duluth	David Conkel, Peter Wilson	1/20/20	\$42,794		
	10-Year Review of Monitoring System on I-35W St. Anthony Falls Bridge	Lauren Linderman, University of Minnesota	Benjamin Jilk	1/31/20	\$70,355		
	Evaluation of Electrochemical Chloride Extraction (ECE) and Fiber Reinforced Polymer (FRP) and Sealers for Corrosion Mitigation in Reinforced Concrete Bridges	Mark Chauvin, Wiss, Janney, Elstner Associates, Inc.	Paul Pilarski	1/31/20	\$34,998		
	INV 1009: Field Investigation of Bridge Deck Reinforced With Glass Fiber Reinforced Polymer (GFRP) Rebar	Behrouz Shafei, Iowa State University	Paul Rowekamp	2/29/20	\$88,000		

### BRIDGES & STRUCTURES [cont.]

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost
	MP-18(005): Review and Assessment of Past MnDOT Bridge Barrier Types	William Williams, Texas A&M Transportation Institute	Paul Rowekamp	3/31/20	\$175,304
	Implementation of New Guidelines in Tightening Large Anchor Bolts of Supports for Signs and Luminaires	An Chen, Iowa State University	Jihshya Lin	6/20/20	\$125,500
	INV 983: Cost-Competitive Timber Bridge Designs for Long-Term Performance	Don Fosnacht, University of Minnesota Duluth	David Conkel	8/31/20	\$212,883
	Unmanned Aircraft Systems (UAS): Metro District Bridge Inspection Implementation	Barritt Lovelace, Collins Engineers, Inc.	Jennifer Wells	8/31/20	\$99,897
	MP-18(008): Detecting Pile Length of Sign Structures and High Mast Poles	Bojan Guzina, University of Minnesota	Derrick Dasenbrock	2/28/21	\$198,000
	MP-18(004): Assessment of Bridge Decks With Glass Fiber Reinforced Polymer (GFRP) Reinforcement	Behrouz Shafei, Iowa State University	Paul Kettleson	5/31/21	\$100,104
	Retightening the Large Anchor Rods of Support Structures for Signs and Luminaires—Phase II	An Chen, Iowa State University	Jihshya Lin	9/30/21	\$175,000

FUNDED FOR FY2021: Load Rating Assessment of Three Slab-Span Bridges Over Shingle Creek

### **Bridges & Structures Pooled Fund Studies**

Study Number	Title	Lead State or Agency	Number of Participating Agencies	Total Cost	MN 2019 Contribution	Total MN Contribution	Current MN Contribution End Date
TPF-5(328)	Strain-Based Fatigue Crack Monitoring of Steel Bridges Using Wireless Elastomeric Skin Sensors	KS	6	\$490,000	\$0	\$75,000	2018
TPF-5(356)	Structural Design Methodology for Spray-Applied Pipe Liners in Gravity Stormwater Conveyance Conduits	ОН	8	\$529,547	\$29,221	\$79,221	2019
TPF-5(381)	Evaluation of Lateral Pile Resistance Near MSE Walls at a Dedicated Wall Site—Phase II	UT	7	\$240,000	\$20,000	\$40,000	2019
TPF-5(387)	Development of an Integrated Unmanned Aerial Systems (UAS) Validation Center	IN	9	\$650,000	\$0	\$75,000	2018
TPF-5(392)	Construction of Low-Cracking High-Performance Bridge Decks Incorporating New Technology	KS	2	\$270,000	\$45,000	\$135,000	2021
TPF-5(432)	Bridge Element Deterioration for Midwest States	WI	12	\$440,000	\$20,000	\$40,000	2020
TPF-5(436)	Development of Criteria to Assess the Effects of Pack- Out Corrosion in Built-Up Steel Members	IN	6	\$760,000	\$40,000	\$120,000	2021

### ENVIRONMENTAL

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost			
2019-01	INV 1006: Regional Optimization of Roadside Turfgrass Seed Mixtures	Eric Watkins, University of Minnesota	Dwayne Stenlund	1/31/19	\$142,346			
2019-02	INV 1007, MP-16(005): Minnesota Guide for Stream Connectivity and Aquatic Organism Passage Through Culverts	Matt Hernick, University of Minnesota	Nicole Bartelt	2/28/19	\$164,353			
2019-06	Concrete Grinding Residue: Its Effect on Roadside Vegetation and Soil Properties	Halil Ceylan, Iowa State University	David Hanson	4/30/19	\$154,996			

### ENVIRONMENTAL [cont.]

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost
2019-22	Investigating Wastewater Reuse at MnDOT Truck Stations	Sara Heger, University of Minnesota	Neile Reider	8/31/19	\$150,301
2019-23	Sediment Control Log Performance, Design and Decision Matrix for Field Applications	Bruce Wilson, University of Minnesota	Dwayne Stenlund	6/30/19	\$101,814
2019-25	Monitoring and Habitat Assessment of Declining Bumble Bees in Roadsides in the Twin Cities Metro Area of Minnesota	Daniel Cariveau, University of Minnesota	Christopher Smith	8/31/19	\$111,264
2019-27	INV 1017: Iron-Enhanced Swale Ditch Checks for Phosphorus Retention	John Gulliver, University of Minnesota	Beth Neuendorf	8/31/19	\$200,036
2019-31	MP-17(005): Development and Regionalization of In Situ Bioslopes and Bioswales	David Saftner, University of Minnesota Duluth	Dwayne Stenlund	10/31/19	\$195,955
2019-38	TPF-5(346): Regional Roadside Turfgrass Testing Program	Eric Watkins, University of Minnesota	Dwayne Stenlund	10/31/19	\$200,000
2019-40	MP-17(008): MnDOT Best Management Practices (BMPs) for Potentially Acid-Generating (PAG) Rock	Ward Swanson, Barr Engineering Company; Dean Peterson, University of Minnesota Duluth	Jason Richter	10/31/19	\$148,949
TRS 1801	Infiltration Basins: Standards and Procedures to Ensure Performance	Patrick Casey, CTC & Associates, LLC	Dwayne Stenlund	7/31/18	\$9,994
	TPF-5(362): Improvements to the Infrastructure Carbon Estimator (ICE)	Jeffery Ang-Olson, ICF Incorporated, LLC	Timothy Sexton	1/31/20	\$309,998
	INV 984: Expanding the Success of Salt-Tolerant Roadside Turfgrasses Through Innovation and Education	Eric Watkins, University of Minnesota	Dwayne Stenlund	2/29/20	\$168,974
	Assessment of Field Infiltration Performance of Swales in Comparison to Minnesota Swales Calculator Estimates	Joel Toso, Wenck Associates, Inc.	Nicklas Tiedeken	3/31/20	\$99,897
	Use of Innovative Technology to Deter Bat Bridge Use Prior To and During Construction	Basak Aldemir Bektas, Iowa State University	Christopher Smith	5/31/20	\$143,290
	INV 1016: Permeable Pavement for Road Salt Reduction	John Gulliver, University of Minnesota	Richard McCoy	8/31/20	\$197,835
	MPR-5(006): Monitoring Iron-Enhanced Stormwater Infiltration Basin in the Real World	Omid Mohseni, Barr Engineering Company	Barbara Loida	8/31/20	\$65,001
	INV 1027: Characterization of Runoff Quality from Paved Low- Volume Roads and Optimization of Treatment Methods	John Gulliver, University of Minnesota	John Welle	11/30/20	\$192,527
	Highway Renewable Energy: Harnessing the Sun's Energy Through Noise Barriers and Structural Snow Fencing	Mijia Yang, North Dakota State University	Daniel Gullickson	6/30/21	\$149,060
	INV 1041: Assessing Culverts in Minnesota: Fish Passage and Storm Vulnerability	Jessica Kozarek, University of Minnesota	Nicole Bartelt	7/31/21	\$158,374
	INV 1060: Reuse of Regional Waste in Sustainably Designed Soils	Marsha Patelke, University of Minnesota Duluth	Dwayne Stenlund	7/31/21	\$197,406
	INV 1039: Design and Construction of Infiltration Facilities	John Gulliver, University of Minnesota	Dwayne Stenlund	8/31/21	\$238,572
	INV 1059: Wet Pond Maintenance for Phosphorus Retention	John Gulliver	Leslie Stovring	6/30/22	\$222,467
	INV 1038: Regional Optimization of Roadside Turfgrass Seed Mixtures—Phase II: Regional Field Trials and Economic Analysis	Eric Watkins, University of Minnesota	Dwayne Stenlund	8/31/22	\$467,139

FUNDED FOR FY2021: Climate Change Adaptation of Urban Stormwater Infrastructure; Cost-Effective Roadside Revegetation Methods to Support Insect Pollinators; Evaluate Effectiveness of Storm Ponds and Wetlands for Water Quality; Have Minnesota's Warmer Winters Increased the Number of Freeze-Thaw Cycles?

### **Environmental Pooled Fund Studies**

Study Number	Title	Lead State or Agency	Number of Participating Agencies	Total Cost	MN 2019 Contribution	Total MN Contribution	Current MN Commitment End Date
TPF-5(362)	Improvements to the Infrastructure Carbon Estimator (ICE)	MN	6	\$380,000	\$10,000	\$30,000	2019
TPF-5(352)	Recycled Materials Resource Center-4th Generation	WI	9	\$1,335,000	\$40,000	\$200,000	2020
TPF-5(358)	Wildlife Collision Reduction and Habitat Connectivity	NV	13	\$1,135,000	\$20,000	\$100,000	2021

### MAINTENANCE OPERATIONS

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost			
2019-10	Optimizing Truck Station Locations for Maintenance Operations	William Holik, Texas A&M Transportation Institute	Christopher Moates	4/30/19	\$163,413			
2019-26, 2019-26A	INV 1029: Appendices to Cost–Benefit Analysis of the Effectiveness of Crack Sealing Techniques	Manik Barman, University of Minnesota Duluth	Daniel Knapek	6/30/19	\$108,504			
2019-44	MP-18(007): Expanding Landowner Adoption of Snow Control Measures Through a Better Understanding of Landowner Knowledge, Attitudes and Practices	Dean Current, University of Minnesota	Daniel Gullickson	1/31/20	\$104,974			
2019RIC09, 2019RIC09H	Best Practices for Boulevard Turf Design Maintenance	Michael Marti, SRF Consulting Group, Inc.	Paul Oehme	12/31/19	\$42,978			
2019RIC10	Best Practices: Corridor Management/Maintenance of Paved Recreational Trails	Michael Marti, SRF Consulting Group, Inc.	Steven Bot	12/31/19	\$46,959			
2019RIC11	New Pavement Preservation Techniques: Micro, Thinlay, Etc.	Michael Marti, SRF Consulting Group, Inc.	Joel Ulring	12/31/19	\$40,940			
	TPF-5(218): Clear Roads Administration and Information Services	Patrick Casey, CTC & Associates, LLC	Thomas Peters	7/7/18	\$746,283			
	TPF-5(218): Clear Roads Utilization of AVL/GPS Technology: Case Studies	Ming Shiun Lee, AECOM Technical Services, Inc.	Thomas Peters	9/30/18	\$113,698			
	TPF-5(218): Clear Roads: Develop a Training Video and Manual for Best Practices and Techniques in Clearing Different Interchange Configurations and Other Geometric Layouts RFP	Yan Qi, Southern Illinois University Edwardsville	Thomas Peters	10/31/18	\$113,619			
	INV 645: Personal Protection Equipment Poster and Website	Mindy Carlson, University of Minnesota Center for Transportation Studies	John Brunkhorst	12/31/18	\$21,000			
	TPF-5(353), 1028425: Clear Roads: AWSSI Enhancements in Support of Winter Road Maintenance—Phase II	Micheal Timlin, Midwestern Regional Climate Center, University of Illinois	Thomas Peters	2/28/19	\$39,915			
	TPF-5(218): Clear Roads: Standards and Guidance for Using Mobile Sensor Technology to Assess Winter Road Conditions	Erik Minge, SRF Consulting Group, Inc.	Thomas Peters	4/30/19	\$152,379			
	TPF-5(218): Clear Roads: Synthesis of Material Application Methodologies for Winter Operations RFP	Xianming Shi, Washington State University	Thomas Peters	4/30/19	\$117,658			
	TPF-5(218), TPF5(218), 1001484: Developing Test Bed Software to Qualify Plug-and-Play Technology	Parsons Transportation Group, Inc.	Thomas Peters, Clark Moe	6/30/19	\$108,161			

#### MAINTENANCE OPERATIONS [cont.]

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost
	District 1: Alternative De-Icing Chemical–Potassium Acetate	Patrick Casey, CTC & Associates, LLC	Perry Collins	9/30/19	\$89,233
	TPF-5(353): Clear Roads: Standard Specifications for Plow Blades With Carbide Inserts—Phase II	Erik Minge, SRF Consulting Group, Inc.	Thomas Peters	10/31/19	\$53,787
	INV 1015: Optimized Taconite-Based Pavement Repair Compound and Deployment System	Lawrence Zanko, University of Minnesota Duluth	Perry Collins	12/31/19	\$100,000
	TPF-5(218): Clear Roads Weather Event Reconstruction and Analysis Tool	Chris Albrecht, The Narwhal Group	Thomas Peters	12/31/19	\$93,223
	TPF-5(353), 1028425, 1026447, 1027913: Clear Roads: Alternative Methods for De-Icing—Phase II	Laura Fay, Montana State University	Thomas Peters	1/31/20	\$77,529
	INV 1047: Techno-Economic Analysis of Implementing Hybrid Electric Utility Vehicles in Municipal Fleets	Will Northrop, University of Minnesota	Kevin Schlangen	2/29/20	\$100,767
	TPF-5(353), 1027913, 1028425, 1026447: Clear Roads: Clear Roads Administration, Research Support and Information Services—Phase II	Patrick Casey, CTC & Associates, LLC	Thomas Peters	6/30/20	\$365,487
	TPF-5(353): Clear Roads: Integrating Advanced Technologies Into Winter Operations Decisions—Phase II	Erik Minge, SRF Consulting Group, Inc.	Thomas Peters	6/30/20	\$90,311
	TPF-5(353): Clear Roads: Aftermarket Cameras in Winter Maintenance Vehicles—Phase II	Erik Minge, SRF Consulting Group, Inc.	Thomas Peters	6/30/20	\$88,977
	INV 1034: Adaptive Management to Improve De-Icing Operations	Larry Baker, University of Minnesota	Ross Bintner	7/31/20	\$204,000
	TPF-5(353), 1027913, 1026447, 1028425: Clear Roads: High- Performance Blade Evaluation—Phase II	Bill Schneider, University of Akron	Thomas Peters	7/31/20	\$99,674
	TPF-5(353), 1028425, 1026447, 1027913: Clear Roads: Defensive Driving for Snowplow Operators—Phase II	Matthew Camden, Virginia Polytechnic Institute and State University	Thomas Peters	8/31/20	\$70,000
	TPF-5(353), 1028425, 1027913, 1026447: Clear Roads: Review and Summary of Prewet Methods and Procedures— Phase II	Xianming Shi, Washington State University	Thomas Peters	9/30/20	\$74,721
	INV 645: RIC: Best Practices to Manage Effects of Settlement and Heave at Catch Basins and Manholes	Derek Tompkins, American Engineering Testing, Inc.	Steven Bot	10/31/20	\$59,676
	INV 998: Operational Research Program for Local Transportation Groups (OPERA) (FY2019-2020)	Mindy Carlson, University of Minnesota Center for Transportation Studies	Kristine Elwood	10/31/20	\$160,000
	TPF-5(353), 1028425, 1026447, 1027913: Clear Roads: Evaluation of SSI and WSI Variables—Phase II	Chris Albrecht, The Narwhal Group	Thomas Peters	10/31/20	\$74,940
	MP-18(010): Reducing Winter Maintenance Equipment Fuel Consumption Using Advanced Vehicle Data Analytics	Will Northrop, University of Minnesota	Joseph Huneke	1/31/21	\$212,919
	MP-19(002): Hot Shots for Cold Climes—Evaluating Treatment of the Hardest Icy Spots	Stephen Druschel, Minnesota State University, Mankato	Thomas Peters	1/31/21	\$170,315
	INV 1065: Implementation of Lane Boundary Guidance System for Snowplow Operations	Max Donath, University of Minnesota	Daniel Rowe	10/31/21	\$283,622

FUNDED FOR FY2021: Benefit-Cost of Applying a Higher Asphalt Film Thickness (AFT) Versus Doing a Chip Seal at One Year; Effectiveness of Fog Seal on Chip Sealed Low-Volume Roads; Evaluation of Fatigue on Snowplow Drivers and of Aids to Assist Drivers in Recognizing and Dealing With Fatigue; Mitigating Frost Dips Over Newly Installed Centerline Culverts

# **Maintenance Operations Pooled Fund Studies**

Study Number	Title	Lead State or Agency	Number of Participating Agencies	Total Cost	MN 2019 Contribution	Total MN Contribution	Current MN Commitment End Date
TPF-5(353)	Clear Roads II	MN	36	\$3,475,000	\$25,000	\$125,000	2021
TPF-5(290)	Aurora Program	IA	19	\$2,250,000	\$25,000	\$150,000	2019
TPF-5(347)	Development of Maintenance Decision Support System	SD	14	\$1,400,149	\$30,000	\$105,000	2019

### **MATERIALS & CONSTRUCTION**

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost				
2018-17	MnPAVE-Rigid 2.0	Derek Tompkins, American Engineering Testing, Inc.	Timothy Andersen	7/31/18	\$23,626				
2018-23	MP-17(002): Remaining Service Life Asset Measure—Phase I	Mihai Marasteanu, University of Minnesota	Glenn Engstrom	8/31/18	\$61,379				
2018-29	INV 1013, MP-16(007): Comparison of Performances of Structural Fibers and Development of a Specification for Using Them in Thin Concrete Overlays	Manik Barman, University of Minnesota Duluth	Maria Masten	8/31/18	\$153,792				
2018-30	Performance Specification for Geogrid Reinforced Aggregate Base	John Siekmeier, MnDOT Office of Materials and Road Research	Bruce Tanquist	9/30/18	\$40,000				
2018-32	Cone Penetration Test Design Guide for State Geotechnical Engineers	David Saftner, University of Minnesota Duluth	Derrick Dasenbrock	12/31/18	\$100,000				
2018-33	INV 981: Field Investigation of Stabilized Full-Depth Reclamation (SFDR)	Charles Jahren, Iowa State University	Guy Kohlnhofer	1/31/19	\$126,991				
2019-03	Investigation of Cracking Resistance of Asphalt Mixtures and Binders	Mihai Marasteanu, University of Minnesota	David Van Deusen	2/28/19	\$149,762				
2019-11	INV 971: Optimal RAP Content for Minnesota Gravel Roads	Charles Jahren, Iowa State University	Joel Ulring	2/28/19	\$92,538				
2019-24	Disk-Shaped Compact Tension (DCT) Specifications Development for Asphalt Pavement	Andrea Schokker, University of Minnesota Duluth	Shongtao Dai	7/7/19	\$172,728				
2019-36	INV 1045: Life-Cycle Civil Integrated Management (CIM) Advancements in Preliminary Design BIM for Infrastructure	Chris Trboyevich, SRF Consulting Group, Inc.	Lyndon Robjent	10/31/19	\$99,955				
2019-39	MnDOT EPD Pilot Project: Development of a Sustainable Procurement Roadmap	Amlan Mukherjee, Michigan Technological University	Curt Turgeon	6/30/19	\$75,001				
2019-41	INV 1023: Experimental and Computational Investigations of High-Density Asphalt Mixtures	Mihai Marasteanu, University of Minnesota	Eddie Johnson	9/30/19	\$150,935				
2019-43	INV 1057: Evaluating Effective Asphalt Content (AC) in Cold In- Place Recycling Mixtures	Daniel Wegman, Braun Intertec Corporation	Wayne Stevens	3/31/20	\$34,998				
2019RIC03	Gravel Road Management Tools	Michael Marti, SRF Consulting Group, Inc.	Michael Flaagan	12/31/19	\$18,021				
2019RIC04	Current Practices for Lightly Surfaced Roadway: Workshop and Materials	Michael Marti, SRF Consulting Group, Inc.	John Brunkhorst	12/31/19	\$16,216				
TRS 1804	Ultra-Thin Bonded Wearing Course (UTBWC) Snow, Ice and Wind Effects	Daniel Wegman, Braun Intertec Corporation	Cody Brand	7/31/18	\$55,212				
TRS 1901	Mitigating Construction Impacts on Local Businesses	Patrick Casey, CTC & Associates, LLC	Jeanne Aamodt	8/31/19	\$9,972				

### MATERIALS & CONSTRUCTION [cont.]

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cos
	TPF-5(341), 10003283: R1.5/R2.5: PCC Sampling/Testing	Derek Tompkins, American Engineering Testing, Inc.	Benjamin Worel	7/18/18	\$61,51
	INV 1028: Is Seal Coating Counterproductive or Not?	Brian Arman, American Engineering Testing, Inc.	Steven Bot	2/28/19	\$14,92
	Pavement Thickness Evaluation Using 3D Ground Penetrating Radar	Lev Khazanovich, University of Pittsburgh	Shongtao Dai	8/31/19	\$113,85
	Smooth Ride Solution and e-Ticketing	RDO Equip Co.	Rebecca Embacher	10/31/19	\$20,11
	TPF-5(341), 10003283: T1.5.1: NRRA Short-Term Research Projects	Andrea Blanchette, WSB & Associates, Inc.	Benjamin Worel	10/31/19	\$92,30
	TPF-5(269): Development of an Improved Design Procedure for Unbonded Concrete Overlays	Lev Khazanovich, University of Pittsburgh	Thomas Burnham	11/30/19	\$118,3
	TPF-5(341), 10003283: T1.3.1: Short-Term Research	Renae Kuehl, SRF Consulting Group, Inc.	Benjamin Worel	1/31/20	\$95,62
	MP-18(006): Quantifying Benefits of Improved Compaction	Christopher Williams, Iowa State University	Kyle Hoegh	2/28/20	\$125,5
	Ultra-Thin Bonded Wearing Course (UTBWC) Snow and Ice and Wind Effects—Phase II	Mohammad Sabouri, Braun Intertec Corporation	Cody Brand	3/31/20	\$44,76
	INV 1040: Development of Pavement Condition Forecasting for Web-Based Asset Management for County Governments	Bradley Wentz, North Dakota State University	Bruce Hasbargen	4/30/20	\$92,83
	INV 645: RIC: Construction Inspection and Documentation Training Course	Stephanie Malinoff, University of Minnesota Center for Transportation Studies	Rollin Larson	5/31/20	\$137,3
	TPF-5(341), 10003283: NRRA: R1.18: Maintaining Poor Pavements	Renae Kuehl, SRF Consulting Group, Inc.	Gerard Geib	5/31/20	\$77,96
	INV 986: Performance Monitoring of Olmsted CR 117/104 and Aggregate Base Material Update.	Kyle Hoegh, MnDOT Office of Materials and Road Research	Kaye Bieniek	6/30/20	\$44,00
	INV 1046: Innovative Materials and Advanced Technologies for a Sustainable Pavement Infrastructure	Jia-Liang Le, University of Minnesota	Juan Pinero	8/31/20	\$151,5
	Modulus and Dynamic Cone Penetrometer Data Collection for Full-Depth Reclamation Projects	Derek Tompkins, American Engineering Testing, Inc.	Bruce Tanquist	8/31/20	\$99,99
	MP-18(011): Test Methods for Verification of Low-Temperature Cracking Resistance of Asphalt Binders and Mixtures	Dave Newcomb, Texas A&M Transportation Institute	David Van Deusen	8/31/20	\$203,6
	TPF-5(341), 10003283: NRRA: R1.11: Cold Central Plant Recycling (CCPR)	Dave Rettner, American Engineering Testing, Inc.	David Van Deusen	8/31/20	\$99,99
	Use of J Band to Improve the Performance of the HMA Longitudinal Joint	Christopher Williams, Iowa State University	Eddie Johnson	8/31/20	\$125,8
	MP-17(009): Implementation of Recycled Unbound Base Material Properties for MnPAVE	Derek Tompkins, American Engineering Testing, Inc.	David Van Deusen	10/31/20	\$74,99
	TPF-5(341), 10003283: R1.17: Determining Pavement Design Criteria for Recycled Aggregate Base and Large Stone Subbase	Bora Cetin, University of Iowa	John Siekmeier	10/31/20	\$225,0
	INV 1028: Is Seal Coating Counterproductive or Not? Evaluation of Stripping Under Chip Seals—Phase II	Zhanping You, Michigan Technological University	Steven Bot	12/31/20	\$140,5
	TPF-5(341), 10003283: R1.12: Performance Benefits of Fiber- Reinforced Thin Concrete Pavement and Overlays	Manik Barman, University of Minnesota Duluth	Thomas Burnham	12/31/20	\$149,9
	TPF-5(334): Enhancement to the Intelligent Construction Data Management System (Veta) and Implementation—Phase I	George Chang, The Transtec Group, Inc.	Rebecca Embacher	1/31/21	\$775,1

### MATERIALS & CONSTRUCTION [cont.]

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost
	TPF-5(341), 10003283: R1.14: Evaluation of Long-Term Impacts of Early Opening of Concrete Pavements	Lev Khazanovich, University of Pittsburgh	Bernard Izevbekhai	1/31/21	\$149,999
	TPF-5(341), 10003283: R1.15: Reduced Cementitious Material in Optimized Concrete Mixtures	Peter Taylor, Iowa State University	Bernard Izevbekhai	2/28/21	\$147,627
	TPF-5(341), 10003283: NRRA: R1.10: Developing Best Practices for Rehabilitation of Concrete With Hot-Mix Asphalt (HMA) Overlays Related to Density and Reflective Cracking	Eshan Dave, University of New Hampshire	Shongtao Dai	4/30/21	\$169,970
	TPF-5(341), 10003283: R1.19: Effective Long-Lasting Partial Depth Joint Repairs for Challenging ConditionsDevelopment of Superpave 5 Asphalt Mix Designs for Minnesota Pavements	Justin Lashley, Braun Intertec Corporation	Gerard Geib	4/30/21	\$74,978
		Mihai Marasteanu, University of Minnesota	Chelsea Bennett	7/31/21	\$121,564
	Establishing Fresh Properties of Fiber-Reinforced Concrete for Performance Engineered Mixture (PEM)	Manik Barman, University of Minnesota Duluth	Robert Golish	7/31/21	\$147,070
	INV 1067: Construction Incentives: Are They Working?	Mohamed Diab, Minnesota State University, Mankato	Fausto Cabral Neto	7/31/21	\$88,620
	INV 1069: Optimizing Asphalt Mixture Designs for Low-Volume Roads of Minnesota	Manik Barman, University of Minnesota Duluth	Joel Ulring	7/31/21	\$161,333
	Cold In-Place Recycling (CIR) for Bituminous Over Concrete (BOC)	Dave Rettner, American Engineering Testing, Inc.	Terrence Beaudry	8/31/21	\$39,995
	TPF-5(341), 1003283: R.1.23: Evaluation of Levels 3-4 Intelligent Compaction Measurement Values (ICMV) for Soils Subgrade and Aggregate Subbase Compaction	George Chang, The Transtec Group, Inc.	Benjamin Worel	9/30/21	\$162,024
	TPF-5(375): MnROAD/NCAT Joint Study: National Partnership to Determine the Life-Extending Benefit Curves of Pavement Preservation	Adriana Vargas-Nordcbeck, Auburn University	Gerard Geib	6/30/22	\$1,750,000

FUNDED FOR FY2021: Performance of Overlays: Mill and Overlay—Best Management Practices; Full Depth Reclamation (FDR) for Urban and Suburban Street Application

### **Materials & Construction Pooled Fund Studies**

Study Number	Title	Lead State or Agency	Number of Participating Agencies	Total Cost	MN 2019 Contribution	Total MN Contribution	Current MN Contribution End Date
TPF-5(334)	Enhancement to the Intelligent Construction Data Management System (Veta) and Implementation	MN	16	\$1,151,500	\$0	\$150,000	2018
TPF-5(341)	National Road Research Alliance (NRRA)	MN	8	\$4,025,000	\$150,000	\$750,000	2020
TPF-5(375)	National Partnership to Determine the Life- Extending Benefit Curves of Pavement Preservation Techniques (MnROAD/NCAT Joint Study—Phase II)	MN	23	\$3,350,000	\$50,000	\$250,000	2022
TPF-5(297)	Improving Specifications to Resist Frost Damage in Modern Concrete Mixtures	ОК	19	\$1,237,500	\$17,500	\$105,000	2019
TPF-5(313)	Technology Transfer Concrete Consortium (TTCC)	IA	36	\$1,736,000	\$12,000	\$60,000	2019
TPF-5(374)	Accelerated Performance Testing on the 2018 NCAT Pavement Test Track With MnROAD Research Partnership	AL	19	\$12,074,807	\$100,000	\$300,000	2020
TPF-5(368)	Performance-Engineered Concrete Paving Mixtures	IA	19	\$2,125,000	\$15,000	\$75,000	2021

### MULTIMODAL

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost			
2018-15	Measure of Truck Delay and Reliability at the Corridor Level	Chen-Fu Liao, University of Minnesota	Andrew Andrusko	8/31/18	\$87,760			
2018-35	After Study of the Bus Rapid Transit A Line Impacts	Alireza Khani, University of Minnesota	Carl Jensen	2/28/19	\$105,687			
2019-17	Accessibility and Behavior Impacts of Bus–Highway System Interactions	Andrew Owen, University of Minnesota	Jim Henricksen	6/30/19	\$152,458			
2019-29	MP-17(003): Evaluation of Sustained Enforcement, Education and Engineering Measures on Pedestrian Crossings	Nichole Morris, University of Minnesota	Melissa Barnes	8/31/19	\$177,226			
	TPF-5(315): National Accessibility Lab Pool Fund Project	Andrew Owen, University of Minnesota	Deanna Belden	1/31/19	\$1,198,500			
	INV 645: FY2018 ADA Workshops for Local Agencies	Mindy Carlson, University of Minnesota Center for Transportation Studies	Kristine Elwood	8/31/19	\$125,000			
	INV 645: RIC: Pedestrian Crosswalk Policy Development Guidelines	Anita Benson, Stonebrooke Engineering, Inc.	Marc Culver	2/29/20	\$58,901			
	INV 645: RIC: Guidance for Bicycle Facility Selection and Design	Michael Marti, SRF Consulting Group, Inc.	Chad Millner	4/30/20	\$62,994			
	Measuring the Economic Benefits of Rural and Small Urban Transit Service in Greater Minnesota	Jeremy Mattson, North Dakota State University	Sara Dunlap	6/30/20	\$120,534			
	Understanding Pedestrian Travel Behavior and Safety in Rural Settings	Greg Lindsey, University of Minnesota	Hannah Pritchard	7/31/20	\$150,000			
	INV 1044: Quantifying the Impacts of Complete Streets: The Case of Richfield	Zhirong Jerry Zhao, University of Minnesota	Jack Broz	10/31/20	\$103,834			
	INV 1049: Guidance for Separated/Buffered Bike Lanes With Delineators	John Hourdos, University of Minnesota	Paul Oehme	12/31/20	\$90,578			
	Impact of Transitways on Travel on Parallel and Adjacent Roads	Alireza Khani, University of Minnesota	Jim Henricksen	1/31/21	\$109,952			
	TPF-5(315), Division Funds: National Accessibility Evaluation Years 4-5	Andrew Owen, University of Minnesota	Deanna Belden	1/31/21	\$752,500			
	Understanding Pedestrian Travel Behavior and Safety in Rural Settings	Greg Lindsey, University of Minnesota	Hannah Pritchard	6/30/23	\$311,434			

FUNDED FOR FY2021: Economic Benefits of Truck Weight and Safety Enforcement Improvements; Guidelines for Safer Pedestrian Crossings: Understanding the Factors That Positively Influence Vehicle Yielding to Pedestrians at Unsignalized Intersections; Pedestrian Engineering and Enforcement at Signalized Intersections

### **Multimodal Pooled Fund Study**

Study Number	Title	Lead State or Agency	Number of Participating Agencies	Total Cost	MN 2019 Contribution	Total MN Contribution	Current MN Commitment End Date
TPF-5(315)	National Accessibility Evaluation	MN	15	\$1,994,000	\$40,000	\$225,000	2019

#### **POLICY & PLANNING**

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost		
2018-31	INV 1031: Investigating Inductive Loop Signature Technology for Statewide Vehicle Classification Counts	Chen-Fu Liao, University of Minnesota	Gene Hicks	2/28/19	\$92,820		
2019-12	MnDOT Slope Vulnerability Assessments	Peter Muehlbach, WSB & Associates, Inc.	Andrew Shinnefield	2/28/19	\$148,309		
2019-28	OTSM Budget: MnDOT Slope Vulnerability Assessments— Phase II	Peter Muehlbach, WSB & Associates, Inc.	Andrew Shinnefield	6/30/19	\$99,540		
2019-33	INV 1020: LRRB Strategic Plan 2019-2024	Vivek Sakhrani, CPCS Transcom, Inc.	Lyndon Robjent	7/31/19	\$88,821		
2019-42	INV 1050: A Guide to Successfully Convert Severely Distressed Paved Roads to Unpaved Roads	Laura Fay, Montana State University, Western Transportation Institute	Tim Stahl	12/31/19	\$100,047		
2019RIC06	INV 645: Consolidated Asset Management Guide for Local Agencies	Michael Marti, SRF Consulting Group, Inc.	Lyndon Robjent	12/31/19	\$27,002		
TRS 1805	Content Management Systems and Website Practices	Patrick Casey, CTC & Associates, LLC	Micheal Foley	10/31/18	\$8,569		
TRS 1806	INV 1058: Local Agency Permit Fee Policies for Oversize/ Overweight Vehicles	Patrick Casey, CTC & Associates, LLC	Rich Sanders	1/31/19	\$9,896		
TRS 1808	Involving Individuals With Visual Impairment in Project Decision-Making: A Survey of Practice	Patrick Casey, CTC & Associates, LLC	Benjamin Timerson	3/31/19	\$13,005		
TRS 1903	360-Degree Point Cloud Technology for Building Management	Barritt Lovelace, Collins Engineers, Inc.	Christopher Bjork	8/31/19	\$23,303		
	INV 645: RIC: Managing Utility Congestion Within the Right of Way	Bryan Nemeth, Bolton & Menk, Inc., Consulting Engineers & Surveyors	Julie Long	12/31/19	\$59,824		
	INV 645: RIC: GIS Tools and Apps—Integration With Asset Management	Annette Theroux, Pro-West & Associates, Inc.	John Brunkhorst	2/29/20	\$59,021		
	INV 1037: Workforce Planning and Human Resource Development Strategies for Minnesota's Public Transportation Agencies	Kenneth Bartlett, University of Minnesota	Lyndon Robjent	5/31/20	\$137,281		
	INV 1043: Evaluating the Impact of Local Expenditures on State and Regional Transportation Facilities	Zhirong Jerry Zhao, University of Minnesota	Russ Matthys	8/31/20	\$121,668		
	Extreme Flood Vulnerability Analysis	Chris Dorney, WSP/Parsons Brinckerhoff, Inc.	Siri Simons	1/31/21	\$81,357		

FUNDED FOR FY2021: Outcome Evaluation Metrics Related to Equity That Include Both Quantitative and Qualitative Measures; Impact of Deferred Maintenance in Minnesota; System Preservation Guide—A Planning Process for Local Government Management of Transportation Networks

#### **Policy & Planning Pooled Fund Studies**

Study Number	Title	Lead State or Agency	Number of Participating Agencies	Total Cost	MN 2019 Contribution	Total MN Contribution	Current MN Contribution End Date
TPF-5(198)	Urban Mobility Study—2009 Continuation	тх	16	\$3,050,000	\$30,000	\$460,000	2019
TPF-5(293)	Mid-America Freight Coalition	WI	10	\$1,200,000	\$0	\$125,000	2018
TPF-5(326)	Develop and Support Transportation Performance Management (TPM) Capacity Development Needs for State DOTs	RI	37	\$3,749,500	\$10,000	\$195,000	2019
TPF-5(335)	Biennial Asset Management Conference and Training on Implementation Strategies (2016-2020)	IA	22	\$714,000	\$0	\$36,000	2018
TPF-5(384)	Exploring Nontraditional Methods to Obtain Vehicle Volume and Class Data	FHWA	18	\$1,385,000	\$25,000	\$75,000	2019

### **TRAFFIC & SAFETY**

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost			
2018-28	Development of a Travel-Time Reliability Measurement System	Eil Kwon, University of Minnesota Duluth	Brian Kary	11/30/18	\$176,000			
2018-34	INV 1004: Development and Demonstration of a Cost-Effective In-Vehicle Lane Departure and Advanced Curve Speed Warning System	Imran Hayee, University of Minnesota Duluth	Victor Lund	2/28/19	\$124,704			
2019-08	INV 1032: Personal Warning Sensor for Road Construction Workers	Gerald Ullman, Texas A&M Transportation Institute	Milford Ulven	2/28/19	\$17,490			
2019-14, 2019- 14A	MP-17(010): Evaluation of a Central Traffic Signal System and Best Practices for Implementation	John Hourdos, University of Minnesota	Kevin Schwartz	4/30/19	\$57,486			
2019-18	INV 1026: Preparing Local Agencies for the Future of Connected and Autonomous Vehicles	Shauna Hallmark, Iowa State University	Douglas Fischer	5/31/19	\$51,503			
2019-19	INV 1033: Cloud-Based Dynamic Warning System	Bradley Wentz, North Dakota State University	Richard West	8/31/19	\$79,629			
2019-21	MPR-5(013): Evaluation of the Smart Work Zone Speed Notification System	John Hourdos, University of Minnesota	Brian Kary	6/30/19	\$229,576			
2019-32	INV 1042: Design Standards for Unobstructed Sight Lines at Left Turn Lanes	David Noyce, University of Wisconsin–Madison	Kristi Sebastian	8/31/19	\$50,008			
2019-34	INV 1030: Examining Optimal Sight Distances at Rural Intersections	Nichole Morris, University of Minnesota	Tracey Von Bargen	9/30/19	\$170,549			
2019-35	INV 1025: How Locals Need to Prepare for the Future of V2V/V2I Connected Vehicles	John Hourdos, University of Minnesota	Deb Heiser	11/30/19	\$79,260			
TRS 1802, TRS 1802S	INV 1036: High Friction Surface Treatments Supplement	Patrick Casey, CTC & Associates, LLC	Tracey Von Bargen	8/31/18	\$9,988			
TRS 1809	Use of Continuous Green T-Intersections	Patrick Casey, CTC & Associates, LLC	Douglas Carter	3/31/19	\$11,373			
	INV 924: Ineffective Specialty Signs Video for Local Agencies	Bryan Nemeth, Bolton & Menk, Inc., Consulting Engineers & Surveyors	Gary Reihl	8/31/18	\$28,569			
	TPF-5(190): Program Support Services and Technical Writing for the North/ West Passage Pooled Fund Research Program—Work Plan 12	Dean Deeter, Athey Creek Consultants, LLC	Cory Johnson	9/30/18	\$99,701			
	TPF-5(190), TPF-5(190) 00712, TPF-5(190) 98689, T: North/West Passage Project 12.2 Freight Task Force—Year 3	Donald Ludlow, CPCS Transcom, Inc.	Cory Johnson	2/28/19	\$49,908			
	Traffic, Security and Real-Time Integration of Arrow Board Messages Into Traveler Information Systems	Linda Preisen, Athey Creek Consultants, LLC	Daniel Rowe	3/31/19	\$44,996			
	RTMC Funds: Road Weather Messaging on Dynamic Message Signs (DMS)	Market Cube	Brian Kary	6/30/19	\$1,600			
	Traffic, Security and Real-Time Integration of Arrow Board Messages Into Traveler Information Systems	Castle Rock Consultants, Inc.	Daniel Rowe	6/30/19	\$130,000			
	INV 1064: RCI Video Project	James Douglas, Nighthawk Marketing	Scott Thompson	8/31/19	\$20,000			
	Road Weather Messaging on Dynamic Message Signs (DMS)	Patrick Casey, CTC & Associates, LLC	Brian Kary	10/31/19	\$55,182			
	INV 1022, MP-17(001): Pavement Markings— Wet Retroreflectivity Standards	Adam Pike, Texas A&M Transportation Institute	Kenneth Johnson	11/30/19	\$175,062			
	Assessing the Impact of Pedestrian-Activated Crossing System	John Hourdos, University of Minnesota	Melissa Barnes	11/30/19	\$153,962			
	TPF-5(190), TPF-5(190) 1000639, TPF-5(190) 93139: North/West Passage Pooled Fund Study Website Maintenance	Bradley Wentz, North Dakota State University	Cory Johnson	1/31/20	\$10,570			
	TPF-5(190), TPF-5(190) 98044, 1000639, TPF-5(190): Program Support Services and Technical Writing for the North/West Passage Pooled Fund Research Program	Dean Deeter, Athey Creek Consultants, LLC	Cory Johnson	1/31/20	\$88,008			

#### TRAFFIC & SAFETY [cont.]

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost
	INV 1024: Evaluation of the Effectiveness of Stop Lines in Increasing the Safety of Stop-Controlled Intersections	John Hourdos, University of Minnesota	Nick Bauler	2/29/20	\$150,330
	INV 1052: Effectiveness of Teenage Driver Support System (TDSS) on Reducing Traffic Violation Behaviors for Teenage Drivers at the Early Time of Licensure	Nichole Morris, University of Minnesota	Joe Gustafson	2/29/20	\$93 <i>,</i> 928
	Improve Traffic Volume Estimates from Regional Transportation Management Center (RTMC)	Taek Kwon, University of Minnesota Duluth	Gene Hicks	4/30/20	\$97,484
	Traffic Sign Life-Cycle Evaluation	Gene Hawkins, Texas A&M Transportation Institute	Josephine Tayse	6/30/20	\$65,482
	MP-18(009): Deploy and Test a Smartphone-Based Accessible Traffic Information System for the Visually Impaired	Chen-Fu Liao, University of Minnesota	Michael Fairbanks	8/31/20	\$165,780
	Generating Traffic Information From Connected Vehicle V2V Basic Safety Messages	Michael Levin, University of Minnesota	Ray Starr	11/30/20	\$249,994
	INV 1048: Criteria and Guidelines for Three-Lane Road Design and Operation	Gary Davis, University of Minnesota	Jack Broz	11/30/20	\$155,559
	Evaluation of Metro Freeway System for Reliability and Resilience	Eil Kwon, University of Minnesota Duluth	Brian Kary	2/28/21	\$118,000
	INV 1064: Establishing a Repeatable Method for Presenting Nontraditional Traffic Treatments to Maximize Stakeholder Support	Nichole Morris, University of Minnesota	Scott Thompson	5/31/21	\$237,611
	Evaluation and Refinement of Minnesota Queue Warning Systems	John Hourdos, University of Minnesota	Garrett Schreiner	6/30/21	\$254,187
	INV 1051: Development and Demonstration of an In-Vehicle Lane Departure Warning System Using DSRC-Based V2V Communication	Imran Hayee, University of Minnesota Duluth	Victor Lund	6/30/21	\$133,656

FUNDED FOR FY2021: Assessing Pavement Markings for Automated Vehicle Readiness; Cost–Benefit Analysis of Fuel-Efficient Speed Control Using Signal Phasing and Timing (SPaT) Data: Evaluation for Future Connected Corridor Deployment; Development of a Smartphone App to Warn the Driver of Advance Curve and Unintentional Lane Departure Using GPS Technology; Driver Comprehension of Flashing Yellow Arrows; Evaluation of Road Weather Messages on Dynamic Message Signs (DMS) Based on Roadside Pavement Sensors; Impact of Speed Limit Changes on Urban Streets; Pedestrian User Experience at Roundabouts; Refining Inductive Loop Signature Technology for Statewide Vehicle Classification Counts; Taconite as a Lower Cost Alternative High Friction Surface Treatment to Calcined Bauxite for Low-Volume Roads in Minnesota; Transverse Rumble Strips at Rural Intersections; Signing for Effective Roundabout Approach Speed Reduction

#### **Traffic & Safety Pooled Fund Studies**

Study Number	Title	Lead State or Agency	Number of Participating Agencies	Total Cost	MN 2019 Contribution	Total MN Contribution	Current MN Contribution End Date
TPF-5(376)	North/West Passage—Phase IV	MN	6	\$550,000	\$25,000	\$125,000	2022
TPF-5(193)	Midwest States Pooled Fund Crash Test Program	NE	23	\$15,153,491	\$66,000	\$719,500	2019
TPF-5(316)	Traffic Control Devices Consortium	FHWA	28	\$1,710,725	\$0	\$45,000	2018
TPF-5(319)	Transportation Management Center Pooled Fund Study	FHWA	21	\$2,435,569	\$25,000	\$100,000	2019
TPF-5(322)	High Occupancy Vehicle (HOV)/Managed Use Lane (MUL)	FHWA	11	\$330,000	\$25,000	\$75,000	2019
TPF-5(340)	Axle and Length Classification Factor Analysis and Effects on Annual Average Daily Traffic	WI	13	\$262,500	\$0	\$25,000	2018
TPF-5(343)	Roadside Safety Research for MASH Implementation	WA	29	\$3,565,000	\$50,000	\$200,000	2019
TPF-5(359)	ITS Pooled Fund Program (ENTERPRISE)	MI	8	\$1,062,967	\$30,000	\$90,000	2019
TPF-5(377)	Enhanced Traffic Signal Performance Measures	FHWA	10	\$870,000	\$30,000	\$90,000	2020
TPF-5(380)	Autonomous Maintenance Technology (AMT)	СО	13	\$875,000	\$25,000	\$75,000	2020

### ADMINISTRATIVE

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost
	INV 916: LRRB Technology Transfer Material Development (2017)	Patrick Casey, CTC & Associates, LLC	Shannon Fiecke	7/31/18	\$98,942
	INV 936: Research Need Statement Development for Minnesota Local Road Research Board	Renae Kuehl, SRF Consulting Group, Inc.	Mitchell Rasmussen	7/31/18	\$51,459
	MPR-16(012): Technical Transfer Material Development: Technical Summaries and Project Evaluation Forms (2017-2018)	Patrick Casey, CTC & Associates, LLC	Shannon Fiecke	7/31/18	\$99,816
	Research Project Management and Implementation Support	Patrick Casey, CTC & Associates, LLC	Hafiz Munir	7/31/18	\$99,023
	INV 645B: LRRB Outreach and Marketing Support (2017-2018)	Renae Kuehl, SRF Consulting Group, Inc.	Shannon Fiecke	8/31/18	\$83,812
	MnDOT Research Services Drupal Website Development	Andrea Douglas, Nighthawk Marketing	Shannon Fiecke	12/31/18	\$24,750
	MP-16(002): Technology Transfer Material Development (2017-2019)	Patrick Casey, CTC & Associates, LLC	Shannon Fiecke	5/31/19	\$99,904
	INV999: Research Services & Library Report Publication Services (FY2018-2019)	Arlene Mathison, University of Minnesota Center for Transportation Studies	Shannon Fiecke	6/30/19	\$91,812
	MP-16(002): Technology Transfer Material Development (RS AAG and Newsletter) (2018-2019)	Patrick Casey, CTC & Associates, LLC	Shannon Fiecke	7/31/19	\$99,773
	Implementation Project Support	Patrick Casey, CTC & Associates, LLC	Katie Fleming	8/31/19	\$11,008
	INV 645B: LRRB Outreach and Marketing Support (2018 -2019)	Renae Kuehl. SRF Consulting Group, Inc.	Shannon Fiecke	8/31/19	\$99,886
	Research Project Management and Implementation Support	Patrick Casey, CTC & Associates, LLC	Hafiz Munir	8/31/19	\$46,991
	Research Management Training	Patrick Casey, CTC & Associates, LLC	Hafiz Munir	11/30/19	\$42,806
	INV 645: Research Implementation Committee - RIC Implementation of Research Findings (Fiscal Year 2017-2019)	Michael Marti, SRF Consulting Group, Inc.	Michael Flaagan	12/31/19	\$523,209
	INV 916: LRRB Technology Transfer Materials Development (FY2018)	Patrick Casey, CTC & Associates, LLC	Shannon Fiecke	2/29/20	\$99,824
	MP-16(002): Technology Transfer Material Development	Patrick Casey, CTC & Associates, LLC	Shannon Fiecke	5/31/20	\$99,984
	INV 916: LRRB Technical Summaries and Project Evaluation Forms (LRRB Technical Transfer Materials Development) (FY2019)	Patrick Casey, CTC & Associates, LLC	Shannon Fiecke	6/30/20	\$80,555
	INV 645B: LRRB Outreach and Marketing Support (2019-2020)	Renae Kuehl, SRF Consulting Group, Inc.	Shannon Fiecke	7/31/20	\$99,965
	MP-16(001): ARTS Technical Support and Maintenance Services (FY2019)	Ryan Anderson, ArchWing Innovations, LLC	Katie Fleming	7/31/20	\$152,190
	TPF-5(376), 1031010: Program Support Services and Technical Writing for the North/West Passage Pooled Fund Research Program—Work Plan 14	Dean Deeter, Athey Creek Consultants, LLC	Cory Johnson	8/31/20	\$99,774

ADMINISTRATIVE [cont.]							
Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost		
	MP-16(002): Technology Transfer (T2) Material Development: R&I At-A-Glance, Accelerator Newsletter, Other T2 Materials (FY2020)	Patrick Casey, CTC & Associates, LLC	Shannon Fiecke	1/31/21	\$99,947		
	INV 927: LRRB Website Development and Hosting	Patrick Casey, CTC & Associates, LLC	Shannon Fiecke	7/31/21	\$39,462		

### **Federal Program Support**

Study Number	Title	MN 2019 Contribution
TPF-5(397)	Transportation Research Board (TRB)	
TPF-5(419)	National Cooperative Highway Research Program (NCHRP)	\$762,232

#### **DEDICATED PROGRAMS**

Report Number	Title	Investigator	Technical Liaison	End Date	Total Cost
Number	INV 668: Local Technical Assistance Program (LTAP) (FY2018)	Stephanie Malinoff	Mitchell Rasmussen	8/31/18	\$450,500
	INV 998: Operational Research Program for Local Transportation Groups (OPERA) (FY2017-2018)	Mindy Carlson, University of Minnesota Center for Transportation Studies	Mitchell Rasmussen	9/30/18	\$160,000
	CTS Operations (FY2018-2019)	Laurie McGinnis, University of Minnesota Center for Transportation Studies	Deborah Sinclair	6/30/19	\$3,878,742
	INV 668, 0001(219): Local Technical Assistance Program (LTAP) (FY2019)	Stephanie Malinoff, University of Minnesota Center for Transportation Studies	Mitchell Rasmussen	9/30/19	\$450,500
	MnDOT Research Librarian Services (2019-2020)	Arlene Mathison, University of Minnesota Center for Transportation Studies	Sheila Hatchell	6/30/20	\$77,274



# JOIN A TECHNICAL ADVISORY PANEL

You can help shape research and innovation projects in your subject area by serving on a Technical Advisory Panel (TAP). Involvement may include a few meetings and assistance developing work plans and reviewing final deliverables.

# **RESEARCH ACROSS MnDOT**



MnDOT is working with Plus.ai to perform winter driving tests on selfdriving trucks that could play a key role in the future of transporting Minnesota freight.

In addition to the more than 170 local, state and federal transportation research projects administered annually through the MnDOT Office of Research & Innovation, the following MnDOT programs have in-house teams that conduct or sponsor specialized research:

- Maintenance Operations Research
- MnROAD (Office of Materials & Road Research)
- Connected and Automated Vehicles
- Traffic Engineering

Learn more at mndot.gov/research.html.



# LOCAL ROAD RESEARCH BOARD

Administered by the MnDOT Office of Research & Innovation, the LRRB has been bringing innovations to local Minnesota engineers since 1959. LRRB research ideas come from local Minnesota transportation professionals, either through the IdeaScale button at Irrb.org or at LRRB sessions during October State Aid prescreening meetings held around the state. MnDOT Office of Research & Innovation helps to identify existing solutions and formulate need statements to elicit project proposals. In December, the LRRB evaluates all proposals and makes funding selections.

#### **New LRRB Resources**







Fleet Management Tools for Local Agencies

# KEEP UP WITH MnDOT RESEARCH



Email Updates and Accelerator Newsletter: Subscribe at mndot.gov/research/subscribe.html.



**Crossroads Blog:** Check out our recent stories on Minnesota transportation research at **mntransportationresearch.org**.



**Presentations:** Schedule a visit to learn how the research program or library can help your office or district.



**Social Media:** Connect with us at @MnDOTResearch using your favorite social media channels.

# **BY THE NUMBERS**



reference questions answered by the MnDOT Library (2018)





delivered to library customers (2018)



Produced by CTC & Associates LLC for:

Minnesota Department of Transportation Office of Research and Innovation MS 330, First Floor 395 John Ireland Blvd., St. Paul, MN 55155-1800 651-366-3780 Website: mndot.gov/research Minnesota Department of Transportation: mndot.gov MnDOT Library: mndot.gov/library Minnesota Local Road Research Board: Irrb.org

#### Videos



BRIDGE BEAM END RECONSTRUCTION Minnesota Department of Transportation Bridge Office

#### MnDOT WINS 2019 INNOVATION AWARD FOR BRIDGE REPAIR

MnDOT's Bridge Office received a 2019 State Government Innovation Award for its research and application of the "shotcrete" repair method for bridge beams. The \$69,000 research project has saved taxpayers an estimated \$1.3 million and months of road closures to date. Watch this video and others at youtube.com/mndotresearch.