2018 ANNUAL REPORT FOR THE MONTANA DEPARTMENT OF TRANSPORTATION RESEARCH PROGRAMS

FHWA/MT-19-004/8010

Final Report

prepared for
THE STATE OF MONTANA
DEPARTMENT OF TRANSPORTATION

in cooperation with
THE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

May 2019

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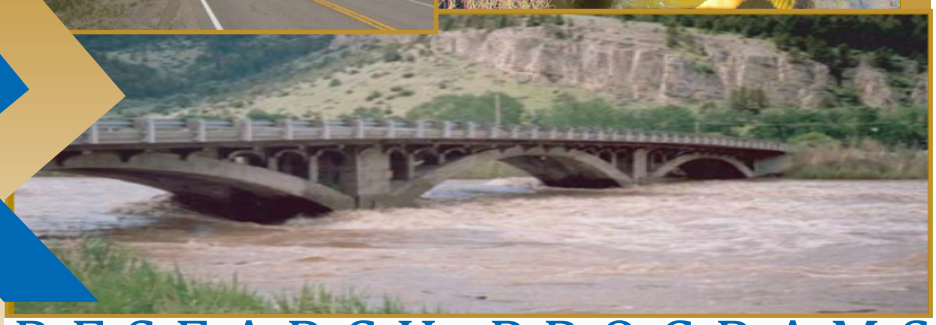

RESEARCH PROGRAMS

MDT

2018 ANNUAL REPORT
FOR THE MONTANA DEPARTMENT OF TRANSPORTATION
RESEARCH PROGRAMS

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16. Abstract

MDT's Research Programs are internally-driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are the goal. Implementation of research results also helps MDT in meeting its mission of providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality, and sensitivity to the environment. The purpose of this report is to give a comprehensive description of research, development, and technology transfer activities for federal fiscal year (FFY) 2018 within the Research Programs of the Montana Department of Transportation (MDT). Through these activities, the Research Programs enhance MDT's ability to meet its mission and to deliver efficient and effective transportation services. MDT's Research Programs impact each and every part of MDT's mission. Research projects completed in FFY 2018 yielded results that when fully implemented will improve:

- ★ Efficiency and effectiveness of MDT operations and technology transfer, and the quality of what we do and how we do it, including: improving cost estimating, decreasing overruns, and providing for improved construction portfolio of projects; improved bridge, culvert, and pavement design and processes; improved construction materials and methods; improved support for cities and counties; improved research processes; improved rockfall evaluation and mitigation; improved roadside revegetation; and improved air quality
- ★ Economic vitality
- ★ Sensitivity to the environment, including: improved roadside reclamation materials and methods; improved roadside revegetation; decreased erosion on construction and maintenance projects; improved environmental processes; decreased vehicle–wildlife collisions; improved habitat connectivity; and improved air quality
- ★ Safety, including: improved safety on low-volume roads and in rockfall areas and work zones; reduced vehicle–wildlife collisions; and improved safety culture both within MDT and among the travelling public

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The Montana Department of Transportation (MDT) Research Programs are internally driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are required.

The purpose of this report is to give an overall description of RD&T activities for federal fiscal year (FFY) 2018 within the MDT Research Programs. Through these activities, the Research Programs enhance MDT's ability to deliver efficient and effective transportation services.

Responsibilities of the MDT Research Programs include:

- Administer the research portion of the State Planning and Research Program (SPR).
- Lead and participate in cooperative research efforts with other states, universities, industry, and other partners through pooled fund and other cooperative RD&T efforts.
- Assist MDT staff in identifying and finding ways to meet research needs.
- Provide leadership for research, development, technology, and technology transfer initiatives within MDT.
- Conduct the Research and Experimental Projects Programs, and the Technology Transfer Program.
- Assist with the implementation of research results.
- Conduct project and program evaluation.

In taking a look back at where we have been, we are given a clearer view of where we are heading, continuously improving as we move forward.

The Roman god Janus symbolizes change and transition, such as the progression from past to future or from one vision to another.

2 ANNUAL PROGRAMS

2.1 ADMINISTRATIVE PROJECTS – ADMINISTRATION AND CONDUCT OF RESEARCH PROGRAMS

Project Number:	8010
Start Date:	10/1/17
Completion Date:	9/30/18
Total/FFY 2018 Cost:	$311,973
SPR Total/FFY 2018 (80%) Funds:	$249,578
State/FFY 2018 (20%) Total:	$62,395
FFY 2018 MDT Indirect Costs:	$30,529

Project Number:	8020
Start Date:	10/1/17
Completion Date:	9/30/18
Total/FFY 2018 Cost:	$47,705
SPR Total/FFY 2018 (80%) Funds:	$38,164
State/FFY 2018 (20%):	$9,541
FFY 2018 MDT Indirect Costs:	$4,603

Project Number:	8021
Start Date:	10/1/17
Completion Date:	9/30/18
Total/FFY 2018 Cost:	$65,880
SPR Total/FFY 2018 (80%) Funds:	$52,704
State/FFY 2018 (20%) Funds:	$13,176
FFY 2018 MDT Indirect Costs:	$6,469

Objective:

The purpose of these three annual projects is fourfold. The first is to plan and administer the Research Programs and related research activities of MDT to find solutions to existing highway and transportation challenges in Montana. The second objective is to manage, coordinate, and conduct a program to test and properly evaluate new highway materials, products, designs, and/or methods for the ultimate purpose of improving highway performance; decreasing various highway costs; or attempting to solve existing highway construction, maintenance, rehabilitation, or safety problems in Montana. The third objective is to provide federal funding for MDT staff when working on MDT research or experimental projects, where other federal funds are not appropriate or available. This can include, for example, fieldwork, such as traffic control and coring; and meeting time and travel associated with research or experimental

projects. The fourth and final objective is to plan and conduct a program of technology transfer and to develop and maintain knowledge and understanding of the latest highway research projects and programs.

Accomplishments – Research Projects:

For funding beginning FFY 2018, one solicitation cycle (February-April 2017) was completed with 20 submitted research topics, resulting in six topics being moved forward to technical panels. All of these projects were contracted in FFY 2018, except for the last project, which was cancelled.

- Alkali-Silica Reactivity in the State of Montana (9577-607)
- Concrete-Filled Steel Tube to Concrete Pile Cap Connections: Further Evaluation/Improvement of Analysis/Design Methodologies (9630-628)
- Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana – Phase 2: Field Application (9578-606)
- Large-Scale Laboratory Testing of Geosynthetics in Roadway Applications (9564-602)
- Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements (9596-617)
- Unmanned Aerial Vehicle (UAV) Applications for Montana Transportation Corridors (18-020)

The last project in the above list was since cancelled. It was felt that the information would be out-of-date before a final report was written. However, as a result of this research idea, MDT initiated a UAV forum with a listserv and a resources library.

During FFY 2018 for funding beginning FFY 2019, one solicitation cycle (February-April 2018) was completed, with 19 submitted research topics, resulting in seven topics being moved forward to technical panels:

- Bridge Deck Cracking Investigation (9696-700)
- Concrete-Filled Steel Tube to Concrete Pile Cap Connections: Specimen Testing (9630-628)
- Developing a Methodology for Safety Improvements on Low-Volume Roads in Montana (9679-699)
- Effectiveness of Highway Safety Public Education at Montana Motor Vehicle Registration Stations by Streaming a Variety of Safety Content (19-001)
- Evaluation of Thin Polymer Overlays for Bridge Decks (19-017)
- Monitoring Streamflow Using Video Cameras (19-011)
- Use of Fluorescent Orange Delineators in Temporary Traffic Control Work Zones (19-006)

Twenty-three projects were contracted and active in FFY 2018:

- Advanced Methodology to Determine Highway Construction Cost Index GIS Visualization Tool (8232-001)
- Alkali-Silica Reactivity in the State of Montana (9577-607)
- Concrete-Filled Steel Tube to Concrete Pile Cap Connections: Further Evaluation/Improvement of Analysis/Design Methodologies (9630-628)
- Consultant Research Project Managers (9529-589)
- Development of Non-Proprietary Ultra-High Performance Concrete – Phase 1 (8237-001)
- Effective Production Rate Estimation Using Construction Daily Work Report Data (9344-504)
- Evaluation of the Effectiveness and Cost-Benefits of Woolen Roadside Reclamation Products (8223-001)
- Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana – Phase 2: Field Application (9578-606)
- Guidelines for Chemically Stabilizing Problematic Soils (9389-522)
- Large-Scale Laboratory Testing of Geosynthetics in Roadway Applications (9564-602)
- FFY 2017 Local Technical Assistance Program (LTAP) (2443-035)
- FFY 2018 LTAP (2434-036)
- Investigation of Prefabricated Steel Truss/Bridge Deck Systems (8226-001)
- MDT Wildlife Accommodations Process (5896-423)
- Regional Regression Equations Based on Channel-Width Characteristics to Estimate Peak-Flow Frequencies at Ungauged Sites Using Data Through Water Year 2011 (9353-511)
- Research Peer Exchange: Implementation, Performance Measures, and the Value of Research (9510-566)
- Rockfall Hazard Process Assessment (8239-001)
- Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements (9596-617)
- Traffic Safety Culture Transportation Pooled Fund (TSC-TPF) (8882-309)
    - FFY 2018 Management Support Contract
    - Key Information for DUIC Policy
    - Traffic Safety Citizenship Communications Tools
    - Traffic Safety Culture and the Safe Systems Approach
    - Traffic Safety Culture Primer
    - Understanding Law Enforcement Attitudes and Beliefs about Traffic Safety

Of the 23 active research projects, seven were completed in FFY 2018:

- Advanced Methodology to Determine Highway Construction Cost Index GIS Visualization Tool (8232-001)
- Development of Non-Proprietary Ultra-High Performance Concrete – Phase 1 (8237-001)

- Evaluation of the Effectiveness and Cost-Benefits of Woolen Roadside Reclamation Products (8223-001)
- Investigation of Prefabricated Steel Truss/Bridge Deck Systems (8226-001)
- FFY 2017 Local Technical Assistance Program (LTAP) (2443-035)
- Research Peer Exchange: Implementation, Performance Measures, and the Value of Research (9510-566)
- Rockfall Hazard Process Assessment (8239-001)

A research project close-out questionnaire was sent to all technical panel members at the completion of each project. Results were compiled and disseminated with the ultimate goal of improving the conduct and management of research projects.

Finally, funds were contributed for 15 partnering projects:

- AASHTO Equipment Management Technical Services Program (EMTSP)
- AASHTO Innovation Initiative (AII) Technical Services Program
- AASHTO Load and Resistance Factor Design (LRFD) Bridges and Structures Specification Maintenance (LRFDSM) Technical Services Program
- AASHTO Materials Reference Library (AMRL) Technical Services Program
- AASHTO National Transportation Product Evaluation Program (NTPEP) Technical Services Program, includes AASHTO Product Evaluation List (APEL)
- AASHTO Technical Service Program to Develop AASHTO Materials Standards (DAMS)
- AASHTO Transportation System Preservation Technical Services Program (TSP2)
- Clear Roads – Phase 2 (TPF-5(353))
- Improving the Quality of Pavement Surface Distress and Transverse Profile Data Collection and Analysis (TPF-5(299))
- National Cooperative Highway Research Program (NCHRP) (TPF-5(418))
- Northwest Passage – Phase 4 (TPF-5(376))
- Technology Transfer Concrete Consortium (TPF-5(313))
- Traffic Control Device (TCD) Consortium (TPF-5(316))
- Transportation Research Board Core Services Support (TPF-5(378))
- Western Alliance for Quality Transportation Construction (WAQTC) (TPF-5(349))

Accomplishments – Experimental Projects:

During FFY 2018, 25 experimental projects were active:

- 3/8" Asphalt Cement Mix Placement with No Chip Seal Evaluation
- 3D Synthetic Geocomposite for Added Subsurface Drainage Layer in Asphalt Cement Pavement Structure Evaluation
- 3M Wet Reflective Ceramic Elements and Potters VISIMAX Plus New Bead Technology Evaluation
- Bituminous Concrete Pavement Surface Treatments Evaluation
- Break-Out Square Post Breakaway System Evaluation
- Centerline Contrast Striping and the Addition of High Visibility Striping Material Evaluation
- Centerline Rumble Strip Evaluation
- Contech A-2000 Polyvinyl Chloride Plastic Pipe Evaluation
- Conventional Chip Seal Under an Overlay to Mitigate Reflective Cracking Evaluation
- Crack Sealing Milled Pavement to Reduce Transverse Cracking Evaluation
- Fog Seal Chip Retention Evaluation
- Fog Seal Over Chip Seal Evaluation
- Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS) Evaluation
- High Friction Surface Treatments for Bridge Decks Evaluation
- Kwik Bond 1121 Polyester Polymer Concrete (PPV) Overlay Evaluation
- Profile Wall PVC Pipe Storm Drain Trunkline and Laterals in Mainline Evaluation
- Reinforcing Fibers in Plant Mix Asphalt Cement Evaluation
- Seal Coat Asphalt Emulsion (or Fog Seal Coating) Over Chip Seal for Improved Chip Retention Evaluation
- Sinusoidal Centerline Rumble Strip Evaluation
- Smart Cushion Innovations 100GM Crash Attenuator Evaluation
- Sprayroq Spraywall Polyurethane Applied Culvert Rehabilitation Evaluation
- T15 Base One Soil Stabilization Evaluation
- TAPCO Blinker Chevron Traffic Control Signage
- TenCate Mirafi H_2Ri – High-Strength Woven Geosynthetic with Wicking Capability to Mitigate Frost Heave Distress Evaluation
- TenCate Mirafi mPV400 Polypropylene Nonwoven Geotextile Evaluation

Of the 25 active projects, nine were completed in FFY 2018:

- 3M Wet Reflective Ceramic Elements and Potters VISIMAX Plus New Bead Technology Evaluation
- Break-Out Square Post Breakaway System Evaluation
- Contech A-2000 Polyvinyl Chloride Plastic Pipe Evaluation
- Conventional Chip Seal Under an Overlay to Mitigate Reflective Cracking Evaluation

- Crack Sealing Milled Pavement to Reduce Transverse Cracking Evaluation
- Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS) Evaluation
- Profile Wall PVC Pipe Storm Drain Trunkline and Laterals in Mainline Evaluation
- Smart Cushion Innovations 100GM Crash Attenuator Evaluation
- TAPCO Blinker Chevron Traffic Control Signage

During FFY 2018, seven projects were pending. Pending experimental projects are assigned to a construction, maintenance, or safety project and a plan-in-hand meeting has been held:

- Crafco Mastic One Joint Sealer Evaluation
- Electric Wildlife Deterrent Mat
- High Float vs. Polymer Modified Emulsion Seal and Cover With and Without a Fog Seal Evaluation
- Nomaflex Concrete Joint Filler Evaluation
- Reflective Cracking in Cement-Treated Bases Minimization by Micro-Cracking Evaluation
- Seal and Cover Emulsion Comparison
- Surfacing In-Slope Treatment Evaluation

During FFY 2018, seven projects were proposed. Proposed projects may or may not have been assigned to a construction or maintenance project, but a plan-in-hand meeting has not been held:

- Polystyrene Geofoam Blocks as Lightweight Fill Evaluation
- Portland Cement Concrete Pavement Over Existing Cement-Treated Base Evaluation
- Prefabricated Steel Truss Bridge Deck System Evaluation
- Roundabout Striping Durability Evaluation
- Texas Underseal with Scrub Seal Evaluation
- Weather Activated Detection System Evaluation
- Yellow-Dyed Concrete Curbing to Replace Epoxy Paint Evaluation

Accomplishments – Technology Transfer and Library Services:

Technology transfer and library-related accomplishments achieved in FFY2018 include the following:

- Published three research newsletters.
- Spoke at the Construction and Preconstruction conferences on research topics and library overview.
- Developed and deployed AASHTO standard materials lists, organized by specialty, to aid the use of materials by MDT employees.
- Created a new library brochure to market library materials and services to MDT employees.
- Updated and promoted OverDrive digital materials for MDT employee professional development.

- Collaborated with MDT training staff to incorporate library training into classes and training resources.
- Visited professional development trainings to provide on-the-spot instruction on how to access the materials used in their professional development programs.
- Provided library marketing through Interchange.
- Held Library and Research Customer Appreciation Day on April 11, 2018, for National Library Week.
- Provided database training for MDT employees.
- Provided catalog training for MDT employees.
- Provided 10 separate new employee orientation sessions in library and research topics.
- Provided brief reference (less than 5 minutes).
- Provided in-depth reference (requiring research).
- Added 733 new titles to the library collection.
- Updated and cleaned up library catalog.
- Registered 247 new patrons.
- Purged library patrons to remove former MDT employees from the library catalog.
- Circulated materials.
- Processed incoming and outgoing interlibrary loans, borrowing materials for patrons and lending materials to other libraries.
- Requested free materials offered through the transportation librarian network.
- Purchased new materials in response to patrons' requests.
- Accepted the Montana Shared Catalog role of Executive Board Representative for special libraries statewide.

Library Services Analysis:

The library services analysis totals as indicated in Table 2.1 include the following:

- **705 items circulated.** This count includes print and audiovisual materials that were both checked in and checked out of the library.
- **18 interlibrary loans borrowed.** This count refers to interlibrary loans that were requested for MDT Library patrons. It includes loans, which means physical items were mailed to the MDT Library for patrons, as well as copies, which means we received electronic copies of materials (usually journal articles) to pass on to MDT Library patrons.
- **4 interlibrary loans lent.** This means that, through interlibrary loan, 4 items were lent from the MDT collection to other libraries from around the country.
- **333 reference questions (brief).** This means 333 questions were answered that were short in nature and, generally, took 5 or less minutes to answer (for example, how do I check out a book, how long can I keep materials, where are you located, etc.).
- **733 titles cataloged.** This means 733 new publications were added to the MDT library.

- **234 in-depth reference.** This count includes literature searches, where literature was gathered on particular topics and presented to requestors in a report format; surveys to other state departments of transportation; and any in-depth reference, defined as answering customer questions that require more than 5 minutes to respond.

Table 2.1: FFY 2018 Library Services Analysis

	Oct. 2017	Nov. 2017	Dec. 2017	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Total
Items Circulated (Check-In/Out)	81	63	52	66	57	52	76	51	32	51	65	59	705
ILLs Borrowed		2	4	1	1	1	1	1		2	1	4	18
ILLs Lent		1				1				2			4
Renewals	29	12	15	21	23	37	21	23	12	14	15	20	234
Titles Cataloged	61	97	20	29	46	16	2	145	14	63	207	33	733

Library Collection Analysis:

The principal findings of the library collection analysis, as indicated in Table 2.2 and Figure 2.1, include the following:

- The MDT Library has a total of 26,637 copies held in the collection.
- The collection holds 17,255 titles. For some of these titles, there is more than one copy in the collection, which is why the total number of copies is greater than the number of titles.
- Of the 17,255 titles, 3,956 titles are held in electronic format only. These include electronic reports and web-only documents. This category is the second largest format type held in the library, after books.

Table 2.2: Library Collection Analysis by Item Type

Item Type	Number of Items
Book	21,067
Cassette	2
CD	385
Circ-Mag	63
Digital	3,956
DVD	250
Kit	75
Map	5
Media-Equip	10
Microform	2
Pamphlet	13
VHS	808
Total	26,637

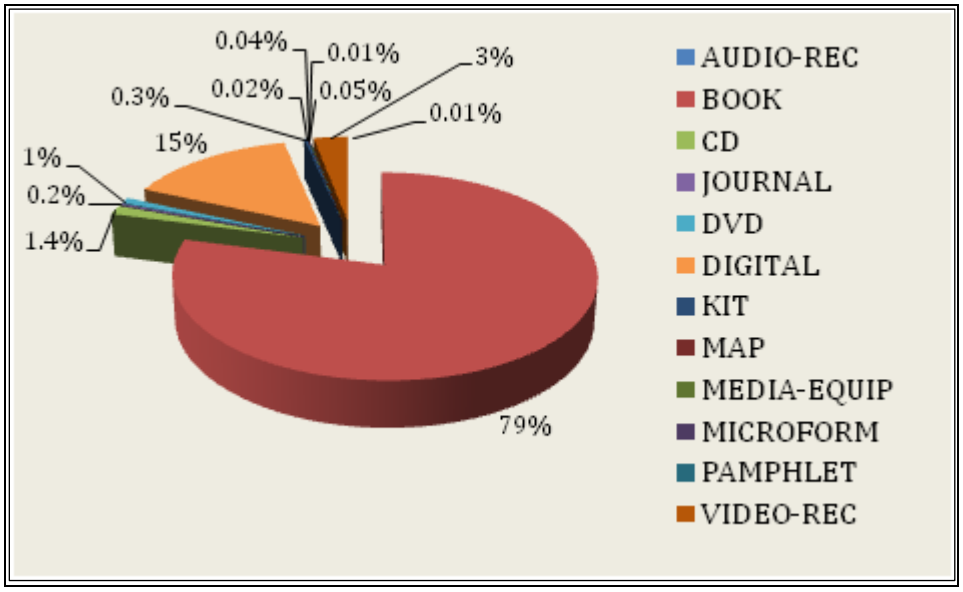

Figure 2.1: Library Collection Analysis by Item Type

Library Circulation Analysis:

The circulation analysis for FFY 2018, as indicated in Table 2.3 and Figure 2.2, include the following:

- ★ Books were the most heavily circulated items, closely followed by OverDrive resources.
- ★ There is no circulation information on e-resources that are not part of the OverDrive collection, as these titles are not circulated. They are instead accessed by patrons through the library catalog.

Table 2.3: Library Circulation by Item Type

Item Type	Total Circulation
Book	**275**
CD	**34**
DVD	**1**
Media-Equip	**2**
VHS	**1**
OverDrive E-Book	**97**
OverDrive Audiobook	**215**

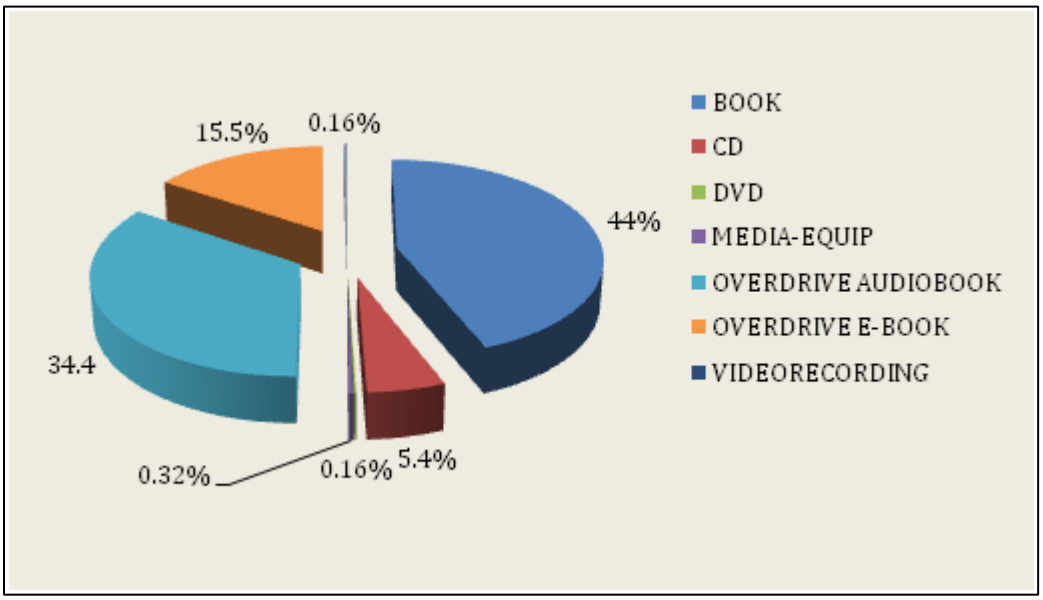

Figure 2.2: Library Circulation by Item Type

Research and Library Website Analysis:

The principal findings of the external research and library website analysis, as indicated in Figure 2.3, include the following:

- From October 1, 2017, to September 30, 2018, 16,129 visitors accessed the external MDT Research web page. 83.5% of these visitors were new to the site.
- The most commonly visited link on the MDT Research page was the Erosion and Sediment Control Best Management Practices landing page.
- Of the 18,064 total visits during FFY 2018 (note: This is the number of visits, not visitors), many were referred from Montana state government websites:
  - mdt.info.mt.gov referred 566.
  - montana.gov referred 308.
  - mdtinfo.mdthq.mt.ads referred 74.
  - app.mdt.mt.gov referred 65.
  - deq.mt.gov referred 62.
  - mdt.mt.gov referred 53.
- Of the 41,373 research page views, there were 1,045 (2.5%) library page views during FFY 2018.

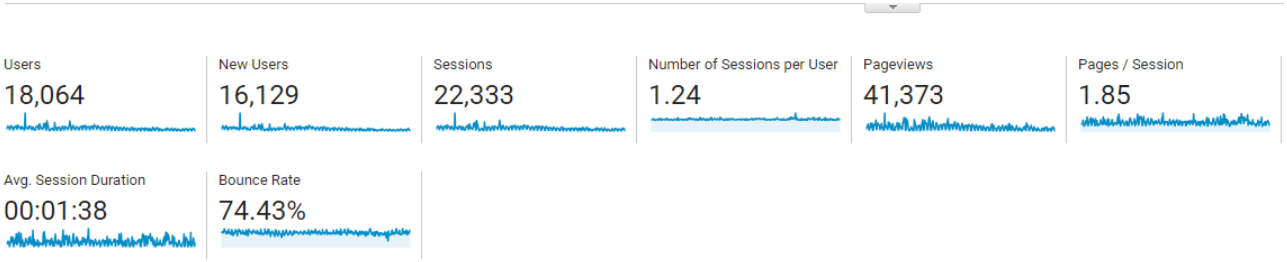

Figure 2.3: External Research Website Access

Source: Google Analytics

Table 2.4 shows the geographic locations where the visits originated.

Table 2.4: Visitor Geographic Origin

Source: Google Analytics

Country	Acquisition Users
	18,064 % of Total: 100.00% (18,064)
1. United States	11,393 (63.14%)
2. China	2,445 (13.55%)
3. India	844 (4.68%)
4. Canada	416 (2.31%)
5. United Kingdom	241 (1.34%)
6. Philippines	207 (1.15%)
7. Malaysia	194 (1.08%)
8. Nigeria	163 (0.90%)
9. Australia	128 (0.71%)
10. South Africa	106 (0.59%)

The internal library website analysis includes the following results as shown in Figure 2.4 and Tables 2.5 and 2.6.

Before visiting the library page:

- 75% of library users visit the link to Journals and Subscriptions. This is where they can gain access to AASHTO Publications, the ASTM, and OverDrive.
- 8% visit the Library and Collection Services page where they can visit the library catalog.
- 6.8% visit the Library Journals and Subscriptions page.
- 2% visited Library training where they can watch short tutorials about getting around in the catalog.
- 0.58% visit the research newsletter.
- 0.65% visit the link to our list of databases.

After visiting the library page:

- 57% of library users visit the link to Journals and Subscriptions. This is where they can gain access to AASHTO Publications, the ASTM, and OverDrive.
- 19% visit the Library and Collection Services page where they can visit the library catalog.

- 2.15% visited Library training where they can watch short tutorials about getting around in the catalog.
- 1.4% visit the research newsletter.
- 0.65% visit the link to our list of databases.
- 0.27% visit the page that explains how to perform a literature search.

Page	Pageviews	Unique Pageviews	Avg. Time on Page	Entrances	Bounce Rate	% Exit	Page Value
	2,221 % of Total: 0.06% (3,648,421)	1,362 % of Total: 0.06% (2,122,896)	00:00:28 Avg for View: 00:03:53 (-87.94%)	22 % of Total: 0.00% (1,204,276)	18.18% Avg for View: 48.15% (-62.24%)	2.93% Avg for View: 33.01% (-91.13%)	$0.00 % of Total: 0.00% ($0.00)
1. /mdt/library/default.shtml	**2,221**(100.00%)	1,362(100.00%)	00:00:28	22(100.00%)	18.18%	2.93%	$0.00 (0.00%)

Figure 2.4: External Library Website Access

Source: Google Analytics

Table 2.5: Page Visitors Accessed Just Prior to the Library Page

Previous Page Path	Pageviews	% Pageviews
/mdt/resources.shtml	1,415	74.63%
/mdt/library/services.shtml	155	8.18%
/mdt/library/journals.shtml	129	6.80%
/mdt/library/training.shtml	35	1.85%
/mdt/webapps_org.shtml	29	1.53%
/mdt/helpguides.shtml	14	0.74%
/mdt/library/	14	0.74%
/mdt/manuals.shtml	14	0.74%
/research/newsletter.shtml	11	0.58%
/mdt/other_links.shtml	10	0.53%

Table 2.6: Page Visitors Accessed Just After the Library Page

Next Page Path	Pageviews	% Pageviews
/mdt/library/journals.shtml	1,061	57.14%
/mdt/library/services.shtml	358	19.28%
/mdt/resources.shtml	176	9.48%
/mdt/library/training.shtml	40	2.15%
/	37	1.99%
/mdt/departments.shtml	35	1.88%
/research/newsletter.shtml	26	1.40%
/employees/	24	1.29%
/mdt/webapps_org.shtml	18	0.97%
/mdt/library/databases.shtml	12	0.65%

Reports/Training/Technology Transfer:

- Research and experimental project progress and final reports were published on the Research Programs website (https://www.mdt.mt.gov/research/projects/sub_listing.shtml)
- The RRC met five times throughout the year to discuss research and pooled-fund projects.
- The Research Program Manager attended the TRB Annual Meeting in January 2018.
- The Research Program Manager attended the AASHTO Research Advisory Committee (RAC) summer (in July 2018) and winter (at the TRB Annual Meeting) meetings.
- The Research Program Manager attended the NMDOT Research Peer Exchange in August 2018.
- The Research Program Manager attended periodic online meetings for the following AASHTO and TRB committees:
  - AASHTO Knowledge Management Committee
  - AASHTO RAC Coordination and Collaboration Task Force
  - AASHTO RAC Implementation Working Group
  - AASHTO RAC Program Management and Quality Task Force
  - AASHTO RAC Transportation Knowledge Network Working Group
  - AASHTO RAC Value of Research Task Force
  - AASHTO RAC Website Working Group
  - AASHTO Region 4 RAC
  - TRB Committee Research Coordinator's Council
  - TRB Conduct of Research Committee
  - TRB Research and Education Section
  - TRB Technology Transfer Committee
- The Librarian attended the July 2018 Annual Research Advisory Committee Meeting.
- The Librarian attended the Special Library Association's (SLA's) Annual Conference in June 2018.
- The Librarian attended the following periodic online meetings throughout the year.
  - Western Transportation Knowledge Network
  - Transportation Librarian Roundtables
  - Montana Shared Catalog member and Executive Board meetings

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2.2 MONTANA LOCAL TECHNICAL ASSISTANCE PROGRAM (LTAP)

Project Number:	2443-035[1]
Start Date[1]:	7/1/17
Completion Date:	6/30/18
Total Funds Obligated:	$380,000
Total Cost:	$379,992
SPR Funds (80%):	$63,994
Other Federal Funds:	$150,000
State Funds (20%):	$15,998
Other State Funds:	$150,000
Total MDT Indirect Costs[2]:	$0
Unexpended Funds:	$8
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/ltap/ltap.shtml

1 The LTAP program is run on a state fiscal year. Hence, it is run nine months behind the federal fiscal year. FFY 2018 LTAP is currently active, running from 7/1/18 to 6/30/19. Therefore, the FFY 2017/SFY 2018 LTAP Program is presented here.

2 MDT Indirect Costs have been waived for LTAP.

Objective:

The mission of the national Local Technical Assistance Program (LTAP) **i**s to foster a safe, efficient, and environmentally sound transportation system by improving skills and knowledge of local transportation providers through training, technical assistance, and technology transfer. LTAP centers enable counties, parishes, townships, cities, and towns to improve their roads and bridges by supplying them with a variety of training programs, an information clearinghouse, new and existing technology updates, personalized technical assistance, and newsletters. Through these core services, LTAP centers provide access to training and information that may not have otherwise been available. Centers are able to provide local road departments with work force development services; resources to enhance safety and security; solutions to environmental, congestion, capacity and other issues; technical publications; and training videos and materials.

Montana has more than 70,000 miles of roads in cities, counties, and highway districts. Montana LTAP has focused on assisting state and county road offices and city street departments in road and bridge maintenance and repair. By sharing technical information and improving the distribution of this information, the program promotes efficient use of local transportation agencies' scarce resources. Specific LTAP tasks in FFY 2017/SFY 2018 included: compile and maintain a mailing list, publish a quarterly newsletter, provide technology transfer materials, provide information and on-site technical assistance, conduct or arrange seminars/training sessions, and conduct program evaluation.

Progress:

Four quarterly newsletters were published and distributed electronically to a large listserv via e-mail. Technical assists and information were distributed and responded to through phone calls, faxes, and personal contact at workshops, conferences, and e-mail. The Road to Zero Coalition; Gravel Road Dust; Worker Safety; and city, county, MDT, and FHWA projects were highlighted in the LTAP newsletters.

LTAP worked with FHWA to promote the "Every Day Counts" initiatives, including the Local Road Safety Plans Development Process, which identify, analyze, and prioritize safety improvements and strategies for local roads.

A few examples of LTAP efforts include:

- At the request of the local agencies, a series of three-day hands-on Motor Grader Operation and Safety Training classes were presented throughout the state.
- LTAP renewed the forklift/skid steer certification program and has worked with two local agencies to renew their training certifications and internal training programs.
- LTAP worked in conjunction with the City of Sidney and Gerard Feist from North Dakota LTAP on an alley pavement improvement project in Sidney. The project helped prioritize surface condition repair options, run through equipment servicing requirements, and set up safe street work zones.

Since 2017, LTAP has experienced approximately a 40% increase in program content delivery, and the 2018 Program Assessment Report will show further growth including increased content in local trainings. Technical assists have also improved: Twelve technical assists of varying complexity and durations were conducted by Matthew Ulberg in FY 2018.

Reports:

Four quarterly progress reports were submitted, reviewed, and published on the project website at the above URL.

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2.3 TRANSPORTATION RESEARCH BOARD SUPPORT

Project Name:	TRB Core Services	**Project Name:**	NCHRP
Project Number:	TPF-5(378)	**Project Number:**	TPF-5(418)
Start Date:	10/1/17	**Start Date:**	10/1/17
Completion Date:	9/30/18	**Completion Date:**	9/30/18
Total Cost:	$104,345	**Total Cost:**	$470,810
SPR Funds (100%):	$104,345	**SPR Part A Funds (100%):**	$235,405
URL:		**SPR Part B Funds:**	$235,405
http://www.trb.org/Main/Home.aspx		**URL:** http://www.trb.org/NCHRP/NCHRP.aspx	

TRB Core Services Support

TRB was founded in 1919 to convene experts – from the public, private, and academic sectors, across transportation modes and disciplines – to advance the knowledge and practice of transportation in an open and non-partisan setting. These experts identify research needs, share the latest ideas and innovations, oversee cooperatively funded research, and provide independent advice on policy issues that entail significant and technical aspects.

The partnership of TRB and the state transportation research community has been in place since 1920, with states providing direct financial support beginning in the 1940s. This TRB/state partnership promotes the development and implementation of innovations that save countless lives, improve mobility and access, and vastly increase the cost-effectiveness of materials, designs, construction practices, and operations.

TRB provides an information infrastructure that is designed to serve the nation's highly decentralized transportation system in which no single organization dominates. Indeed, the cooperation that TRB encourages among transportation agencies at all levels is the envy of other sectors that are similarly decentralized but do not have a mechanism like TRB to facilitate interactions among practitioners and researchers in an independent setting.

MDT invests in TRB's Core Program, which provides a forum for state DOT employees to collaborate with transportation professionals from other organizations to share information on research and issues of interest.

MDT's investment leverages a considerable return. As part of the independent institution, The National Academy of Sciences, Engineering, and Medicine (NASEM), TRB has earned a national and international reputation for objective, high-quality products. In calendar year 2017, TRB's Core Program was funded at a level of $16.6 million, in part by the $7.4 million in contributions from state DOTs. The average state contribution in 2016 was approximately $145,000. Because of TRB's cooperative makeup, on average every $1 that a state invests in TRB Core Program

activities leverages approximately $114 in research-related activity ($7.4 million ÷ 50 states and DC = $145,000; $16.6 million ÷ $145,000 = $114).

TRB has made a concerted effort to diversify its revenue streams over the last seven years.

- State DOT dues for the TRB Core Program did not increase from 2006 through 2013, and they were reduced by 5% in 2014. Contributions are anticipated to increase modestly over the next few years consistent with the increase in SPR funding under the FAST Act, but in 2018 state contributions will still be slightly less than they were in 2005.
- The share of TRB Core Program income from state DOTs has remained less than 50% for more than 10 years.
- The share of TRB Core Program income from private sources has increased from 19% to 39% over the same time period.
- Core Program staffing has remained at essentially the same level for more than 15 years.

Over that same period:

- The number of Annual Meeting sessions and workshops has increased by 150%.
- The number of presentations at the Annual Meeting has increased by 146%.
- The number of papers undergoing peer review has increased by 168%.

A portion of MDT's federal State Planning and Research funds is invested in and is the primary source of funding for TRB's National Cooperative Highway Research Program (NCHRP), which conducts and delivers research in acute problem areas that affect state DOT highway planning, design, construction, operation, and maintenance nationwide. In addition to the financial contribution, Montana employees are involved in the following activities:

- Selecting and providing oversight to projects in TRB's National Cooperative Highway Research Program and second Strategic Highway Research Program (SHRP 2).
- Serving on panels for other TRB cooperative research programs in the areas of transit, airports, hazardous materials, and freight.
- Providing input to TRB's Technical Activities Division, which functions as a research clearinghouse and facilitates collaboration among the states, transportation organizations, academia, and individual researchers and practitioners.
- Serving on National Research Council-appointed committees that develop, refine, or offer direction on national transportation issues, often based on a request for advice from a public or private agency.

TRB's Core Program budget is approximately $16.6 million per year with approximately 43% funded by the state DOTs. The remainder comes from federal agencies, other transportation organizations, and TRB self-generated revenue. MDT's current contribution is $104,345 each year, which means MDT leverages approximately $159 in research-related activity for every $1 invested in TRB's Core Programs.

This investment in TRB and the pooled funding it represents is mission-critical, enabling MDT in the following ways:

- Have a voice in setting national research priorities and agendas.
- Continue to have access to the user-oriented research.
- Avoid duplication of research efforts.
- Demonstrate a return on investment of taxpayers' dollars.
- Support the uniform, practical, and common-sense application of transportation research results.
- Continue to develop a more enlightened and informed workforce.
- Improve our customers' experience by accelerating the development and implementation of solutions to problems that affect transportation planning, design, construction, operation, and maintenance.
- Retain employees by offering them stimulating and professionally rewarding opportunities to participate in efforts that will help improve the nation as a whole.

Tangible Benefits

MDT receives more than $60,708 worth of tangible benefits, which break down as follows:

- **Complimentary registration to the TRB Annual Meeting**. MDT sent five employees to the TRB Annual Meeting last year, saving Montana $ 5,625.
    - The face-to-face meetings and interactions that take place at the Annual Meeting generate ideas, products, and partnerships from which MDT benefits. The Annual Meeting provides an unparalleled opportunity for MDT staff to share knowledge and perspectives with 12,000 colleagues and to learn about the latest in transportation research, policy, and practice. This sense of community also offers a significant morale boost during tough economic times.
- To address budget restrictions within states, TRB offers activities that not only save states money, but push traditional conference type-information out to state employees who are not able to travel. Examples include the following:
    - **Complimentary access to Annual Meeting papers, extended abstracts, and speaker visual aids through the TRB Annual Meeting Online portal (AMOnline).** Speaker visual aids are from lectern and poster sessions, workshops, and peer-reviewed papers at committee meetings. Non-TRB sponsors are charged $20 per paper/presentation. Approximately 168 visitors from our state accessed the site, equating to a value of approximately $3,360 for MDT. (Note: This is an average based on site access over a three-year period.)
    - **Complimentary, unlimited participation in TRB webinars**. In 2016 TRB charged from $49 to $99 for each location that a non-sponsor organization registers to access any one of the approximately 72 webinars TRB produces per year. Last year, approximately 348 Montana employees "attended" a TRB webinar. If MDT

would have had to pay for these licenses on an individual basis it would have cost MDT $33,680. These webinars also provided continuing education credits for MDT employees, who attended webinars in 2017 where they could have potentially earned 522 Professional Development Hours for Professional Engineers, 174 Certification Maintenance Credits for Certified Planners, and 8 Continuing Legal Education Hours for attorneys. This provides MDT with a flexible and extremely economical way to ensure that our employees' professional licenses and certifications remain current.

- **Complimentary copies of TRB publications**. Last year we received approximately $8,718 worth of publications from TRB through our standing subscription requests. In addition, TRB fulfills all individual "over-the-counter" publication requests from state employees on a complimentary basis. (Note: Most states are now moving to all-electronic distribution. This number refers to printed publications.)
- **Complimentary, electronic access to the TRR Journal Online**, which includes more than 13,900 peer-reviewed papers that have been published as part of the *Transportation Research Record: Journal of the Transportation Research Board* (TRR Journal) series since 1996. Last year, state DOT employees downloaded 157 papers. TRB charges non-sponsor-affiliated individuals $25 per paper per download. Based on the $25 download rate, the value from the TRR Journal Online that we received last year was $3,925.
- **Reduced fees to TRB-sponsored specialty conferences**. This discount is about 25% below the general registration fee for the more than 25 specialty conferences TRB conducts each year. Last year no state DOT employees attended a TRB specialty conference, which resulted in a savings for the department of $0.
- **Reimbursement for State Representative Meeting Travel**. TRB reimburses the costs for lodging for TRB State Representatives to attend the State Representatives Annual Meeting, which is held in conjunction with the AASHTO Research Advisory Committee meeting. The reimbursement and reduction in travel cost savings associated with the dual scheduling of these events amounts to a value of approximately $1,800 per year.

Intangible Benefits – Avoiding Duplication

- **Access to research collaboration tools** such as the Research Needs Statements (RNS), Research in Progress (RiP), and Practice Ready Papers (PRP) databases, which were built and are maintained by TRB in part by the department's contribution to TRB.
- **Access to the Transport Research International Documentation (TRID) database.** TRID is an integrated database that combines the records from TRB's Transportation Research Information Services (TRIS) database and the Organisation for Economic Co-operation and Development's Joint Transport Research Centre's International Transport Research Documentation (ITRD) database. TRID provides access to more than one million records of transportation research worldwide. TRID is maintained by TRB in part by the department's contribution to TRB.

- **Weekly notices on TRB activities** via TRB e-newsletter. The weekly electronic service is designed to keep individuals up-to-date on TRB activities and to highlight selected transportation research-related activities taking place at the federal and state levels, and within the academic and international transportation communities. As of March 1, 2018, some 115 state employees receive the newsletter.
- **In-state, periodic access to TRB staff.** Not all of our staff can participate in TRB, so TRB comes to us. TRB's field visit program is designed to keep TRB aware of and responsive to our needs. TRB's last visit to Montana was in 2017**.**

National Cooperative Highway Research Program (NCHRP)

- State contributions to NCHRP in 2017 totaled almost $43 million. Our state's contribution to that total was $460,076, which means we leverage approximately $93 in research-related activity for every $1 we invest in TRB's NCHRP activities.
- MDT participates in NCHRP by
  - Submitting problem statements.
  - Rating problem statements.
  - Participating on and chairing NCHRP panels. TRB reimburses state employees for travel and lodging expenses related to participation in panel meetings.
- MDT benefits by implementing research results developed through NCHRP. In 2016, NCHRP produced some 44 publications that described the results of research.
- In addition to conducting research on specific problems identified by practitioners and selected by the AASHTO Standing Committee on Research, NCHRP through its 20-24 project series addresses issues selected by state CEOs in the areas of resource development, decision support, and financial management.
- NCHRP's Impact on Practice series, available at http://www.trb.org/NCHRP/NCHRPImpactsonPractice.aspx, highlights how transportation agencies have put NCHRP research results to use.

Other TRB Research Programs

In addition to TRB's NCHRP, TRB also manages a variety of other programs that are not directly supported by the states, but from which MDT benefits. These programs are authorized by Congress and funded through various administrations within the U.S. Department of Transportation. The programs include the following:

- The second Strategic Highway Research Program (SHRP 2) was established by Congress to investigate the underlying causes of highway crashes and congestion in a short-term program of focused research in the areas of safety, renewal, reliability, and capacity. The program was authorized in 2005 and funded at a level of $217 million. Many state DOT employees served on SHRP 2 committees and expert task groups. The research program is complete and results are being implemented in every state DOT.

- ★ The Transit Cooperative Research Program (TCRP) was funded at about $5 million per year by the Federal Transit Administration in 2017. TCRP is an applied, contract research program that develops near-term, practical solutions to problems facing transit agencies.
- ★ The Airport Cooperative Research Program (ACRP) was funded at about $15 million per year by the Federal Aviation Administration in 2017. ACRP is an industry-driven, applied research program that develops near-term, practical solutions to problems faced by airport operators.
- ★ The National Cooperative Freight Research Program (NCFRP) conducts research and disseminates timely findings that help inform investment and operations decisions affecting the performance of the freight transportation system. NCFRP was not reauthorized in Moving Ahead for Progress in the 21st Century Act (MAP-21). Work is currently underway to complete previously selected research projects.
- ★ The Hazardous Materials Cooperative Research Program (HMCRP) conducts research intended to advance current knowledge and practice relating to hazardous materials transportation. HMCRP was not reauthorized in MAP-21. Work is currently underway to complete previously selected research projects.
- ★ The National Cooperative Rail Research Program (NCRRP) was authorized in 2008 and addresses concerns in the areas of intercity passenger rail (including high-speed rail) and freight rail services. Continuation of the NCRRP is contingent upon reauthorization and subsequent appropriations. Work continues on previously-selected research projects.

Leadership within TRB

Montana's employees help provide direct leadership on TRB activities by participating in TRB committees and panels. Their direct involvement enables Montana to affect national transportation research agendas and activities, and provides direct information to Montana on the latest information from other states and countries.

Visit the following address to see a list of Montana's employees who help provide direct leadership on TRB activities: https://www.mytrb.org/CompanyDetails.aspx?CID=6744.

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3 RESEARCH PROJECTS

3.1 OVERVIEW

Once a year, the Research Program Manager solicits research ideas from as wide a variety of individuals as possible. This open solicitation enhances the possibility of receiving a diverse spectrum of research suggestions.

The solicitation process begins with the Stage 1: Research Idea form. This simple form is due each March 31 and contains four components: title, idea description, and submitter and champion information. A champion is any MDT staff member with a vested interest in the research who is willing to chair the technical panel if the research should move forward to that stage and make presentations to the Research Review Committee (RRC) at various stages in the life of the project. In doing this, the champion asserts there is a research need and this need is important to MDT. Champions are also involved in implementation of research results. The champion information is optional. If an idea is submitted by MDT staff, that person or their designee is the champion. If an idea is submitted by someone other than MDT staff and a champion is not included, Research staff will attempt to secure a champion. If one is not secured, the idea will not move forward.

For all ideas that have a champion, the MDT librarian conducts a literature search on the topic and shares this information with the champion, who determines, based on the results of this literature search, if the idea should move forward to the Stage 2: Research Topic Statement. The Stage 2 form is due each April 30 and contains the following fields: title; topic statement; related research summary; research proposed; research period; IT component; feasibility, probability of success, and risk; urgency, importance, and expected benefits/payoff; implementability, implementation plan, and responsibility; MDT priority focus areas; total cost estimate; funding source(s); funding match source and amount (if any); funding partners; potential technical panel members; and submitter; champion; and sponsor information. A sponsor is an MDT staff member at or above the District and Division Administrator level. Sponsors agree each topic is consistent with MDT needs and goals, should be considered by a technical panel, and ensures implementation, as applicable. A sponsor is required for each topic statement before it can be prioritized.

The champions for each topic statement present their topic to the RRC and District Administrators (DA) in May of each year. Between May and July, based on available funding, the RRC and District Administrators then select the topics that will move forward to the technical panel stage for funding beginning October 1st of each year. These topics are chosen because they address actual concerns of the Department.

Following the selection of these high-priority topics, Research Programs staff forms a technical panel for each topic. Technical panels are formed to follow research projects from inception through implementation and are typically composed of three to 10 people with knowledge or expertise and interest in the specific area of research. See Appendix A for Technical Panel Roles

and Responsibilities and for more information on the RRC. Panel members are drawn from MDT's Division and District offices, as well as from outside the Department. FHWA is invited to appoint staff to each technical panel. The technical panel's responsibility begins with a review of the literature to determine the need for research, if any, and continues with the development of a scope of work (SOW), which is developed on the SOW form (Appendix B) and includes the following fields:

- Project title
- Project background
- Benefits/business case/impact
- Objectives
- Tasks
- Acceptance criteria
- Cooperators, stakeholders, and partners
- Communications considerations
- Data requirements
- IT components
- Intellectual property considerations
- MDT involvement
- Deliverables, especially those that facilitate implementation
- Risks
- Implementation considerations, including barriers and any attempts to reduce or eliminate the barriers
- Performance measures considerations

The scope of work is used by consultants to prepare a proposal. The champion presents the proposal recommended by the technical panel to the RRC for funding approval.

During the research, the Research Programs representative on each technical panel serves as MDT's project manager and liaison between the technical panel and the consultant. The technical panel monitors research progress by reviewing monthly or quarterly, annual, task, final, project summary, implementation, and performance measures reports, and any other reports and deliverables produced.

When a contract is executed for each project, the Research Project Manager completes Part A of the Implementation Planning and Documentation form. The Research Project Manager completes Parts B-D when the research is concluded. Part D is the sign off by the project champion and sponsor. Also, at this time, the champion presents the research results and implementation plan to the RRC. The Implementation Planning and Documentation form provides a living implementation plan to track implementation activities until all are fully implemented or it is clear that no additional implementation will follow.

The research projects process as detailed above is shown in Figure 3.1. In addition to the solicitation process (as described above), there are a number of other methods to initiate research projects that require funding outside of the annual funding process; these include the following: Montana Partnership for the Advancement of Research in Transportation (MPART Small Projects), other partnership projects such as pooled funds and AASHTO Technical Services Programs (TSP), and Administration High Priority topics (Figure 1). In these cases, a champion presents the need and why it cannot wait until the next funding cycle to the RRC. Champions and sponsors are required for all projects; these roles may be filled by the same person if that person meets the requirements for a sponsor as described above.

MDT has contracts in place with the Montana University System for small projects (<$50,000 and 1 year) under the agency's MPART Small Projects agreement. If there is a need for a small project, such as a synthesis project, which includes a review of the literature and a survey of the state of the practice, similar to National Cooperative Highway Research Program (NCHRP) synthesis projects, the steps below are followed:

- ★ Champion notifies Research Programs of need.
- ★ Technical panel is formed.
- ★ Proposal is obtained.
- ★ Technical panel recommends proposal for funding to RRC through the champion
- ★ RRC approves or denies funding request.

For pooled fund projects and AASHTO TSPs, a technical panel is not required. The champion requests funding from the RRC via the Partnering Project Funding Request form (Appendix C), justifying the need for the expense and why it cannot wait until the next funding cycle. Each partnering project champion must prepare the Partnering Project Annual Evaluation form (Appendix D) and present it to the RRC in May of each year. When a partnering project is concluded, the Champion completes the Partnering Project Close-Out form (Appendix E) and presents to the RRC the results and implementation activities stemming from the project.

Finally, if MDT Administration identifies a research need that requires immediate attention, the Research Program Manager is informed, a technical panel is formed, and a proposal is obtained and approved either by the RRC or Administration.

More details on the research project identification, prioritization, and selection process can be found in Appendix F and more details on the implementation process can be found in Appendix G.

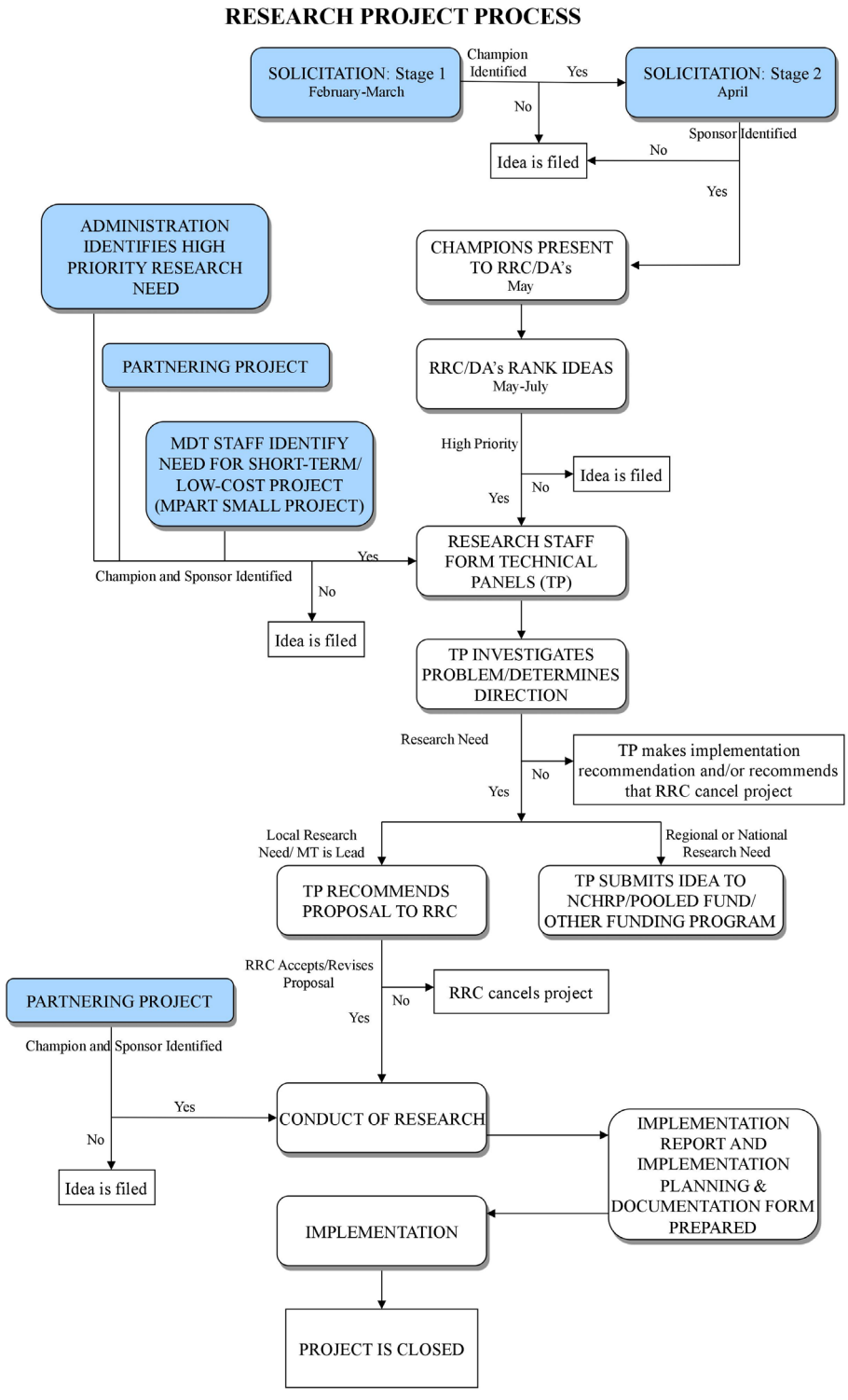

Figure 3.1: Research Project Process

3.2 BRIDGE AND HYDRAULICS RESEARCH PROJECTS

3.2.1 Active Projects

3.2.1.1 Concrete-Filled Steel Tube to Concrete Pile Cap Connections: Further Evaluation/Improvement of Analysis/Design Methodologies (Phase IV)

Project Number:	9630-628
Start Date:	7/10/18
Completion Date:	8/31/19
Total Cost:	$56,000
SPR Funds (80%):	$44,800
State Funds (20%)	$11,200
MDT Indirect Costs:	$5,892
Total MDT Expended To Date:	$6,889
Total MDT Indirect Cost Expended To Date:	$654
Total FFY 2018 Expended:	$6,889
FFY 2018 SPR Funds (80%) Expended:	$5,511
FFY 2018 State Funds (20%) Expended:	$1,378
FFY 2018 MDT Indirect Costs:	$654
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/structures/seismic.shtml

Objective:

MDT has found concrete-filled steel tube (CFST) piles connected at the top by a concrete pile cap to be a very cost-effective support system for short- and medium-span bridges. This type of system offers low initial cost, short construction time, low maintenance requirements, and a long service life. While the gravity load performance of these systems is well understood, their strength and ductility under extreme lateral loads (e.g., seismic events) is more difficult to reliably predict using

conventional design procedures. The proposed research aims to further develop newly established design and analysis methodologies, and to ultimately ensure the desired bridge performance.

The primary objective of this project is to further validate/improve MDT's CFST to concrete pile cap connection design/analysis methodologies, and to ensure the efficacy of these methodologies for a wide variety of potential design configurations.

This phase of the research project will be focused on identifying potential gaps in the existing design/modeling strategies and then designing future tests to help close these gaps.

Progress:

The project kick-off meeting was held in September 2018. Work began on the literature review (Task 1) and the identification of potential gaps in current design/analysis methodology (Task 2).

Reports:

Project information and reports can be viewed at the above URL.

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3.2.1.2 Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana – Phase 2: Field Application

Project Number:	9578-606
Start Date:	3/20/18
Completion Date:	6/30/20
Total Cost:	$162,000
SPR Funds (80%):	$124,965
State Funds (20%):	$31,241
Other State Funds:	$5,794
MDT Indirect Costs:	$16,332
Total MDT Expended To Date:	$41,599
Total MDT Indirect Cost Expended To Date:	$3,497
Total FFY 2018 Expended:	$41,599
FFY 2018 SPR Funds (80%) Expended:	$28,644
FFY 2018 State Funds (20%) Expended:	$7,161
FFY 2018 Other State Funds:	$5,794
FFY 2018 MDT Indirect Costs:	$3,497
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/mat/high_performance_concrete.shtml

Objective:

Ultra-high performance concrete (UHPC) has mechanical and durability properties that far exceed those of conventional concrete. However, using UHPC in conventional concrete applications has been cost-prohibitive, with commercially available/proprietary mixes costing approximately 30 times more than conventional concrete. Previous research conducted at Montana State University resulted in non-proprietary UHPC mixes made with materials readily available in Montana. These mixes are significantly less expensive than commercially available UHPC mixes, thus opening the door for their use in construction projects in the state. The MDT Bridge Bureau is interested in using UHPC in field-cast joints between precast concrete deck panels. The use of UHPC in this application will reduce development lengths, and subsequently reduce the requisite spacing between the decks and improve the overall performance of the bridge. The research will build on the non-proprietary UHPC research completed in Phase 1 of this project and focus on ensuring the successful application of this material in these field-cast joints. Specifically, this research will investigate several items related to the field batching of these mixes, and the potential variability in performance related to differences in constituent materials. Further, rebar bond strength and the subsequent effect this has on development length will be investigated.

Progress:

A fixed-drum rotating vane high-shear mortar mixer suitable for UHPC was purchased for the project and several UHPC batches were mixed to establish its suitability for field batching of UHPC. These mixes were successful and the effects of scaling up the mixes were documented. Most of the tests have been conducted to investigate the sensitivity of UHPC mixes to various materials and material parameters (e.g., sand source and type, fly ash source, steel fiber type, and aggregate moisture content). Data from these mixes was compiled and analyzed as results became available. Further testing may be conducted depending on the outcome of these initial mixes.

Reports:

Two progress reports were received. Project information and reports can be viewed on the project website at the above URL.

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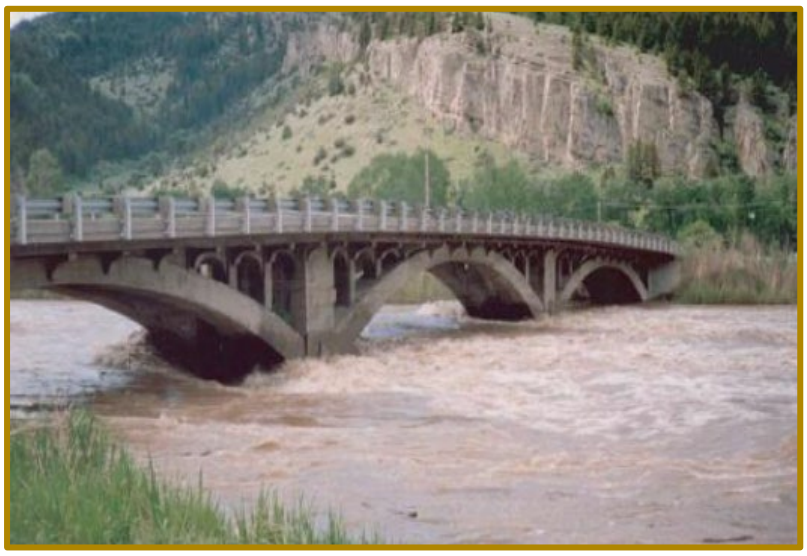
3.2.1.3 Regional Regression Equations Based on Channel-Width Characteristics to Estimate Peak-Flow Frequencies at Ungauged Sites Using Data Through Water Year 2011

Project Number:	9353-511
Start Date:	2/1/17
Completion Date:	9/30/19
Total Cost:	$240,000
SPR Funds (80%):	$120,000
Other Federal Funds:	$90,000
State Funds (20%)	$30,000
MDT Indirect Costs:	$15,000
Total MDT Expended To Date:	$121,463
Total MDT Indirect Costs Expended To Date:	$11,963
Total FFY 2018 Expended:	$67,518
FFY 2018 SPR Funds (80%) Expended:	$38,582
FFY 2018 Total Other Federal Funds Expended:	$19,921
FFY 2018 State Funds (20%) Expended:	$9,645
FFY 2018 MDT Indirect Costs:	$4,727
Consultant:	United States Geological Survey

URL: https://www.mdt.mt.gov/research/projects/hyd/peak_flow.shtml

Objective:

MDT uses peak-flow frequency data (i.e., 100-year flood) to design highway infrastructure, secure floodplain permits, and perform stream restoration activities. The United States Geological Survey, in cooperation with MDT, will develop regression equations which use channel width as a predictor to provide peak-flow frequency estimates to MDT. The research will develop channel width-based regression equations that could increase accuracy and reduce uncertainty when determining flood magnitudes and frequencies. Channel width



measurements are commonly obtained through on-site surveys. This project will evaluate the use of aerial photography and other remote measurement methods to quickly estimate channel widths to reduce the need for on-site surveys.

Progress:

Field measurements and channel width measurements from aerial photographs were completed and tabulated. Analyses of the channel width measurements from aerial photographs were being finalized. Regression equations were developed and results were being reviewed. Work was presented at the Association of Montana Floodplain Managers Conference in March and at the American Water Resources Association Specialty Conference in April 2018.

Reports:

Project information and reports can be viewed at the above URL.

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3.2.2 Completed Projects

3.2.2.1 Development of Non-Proprietary Ultra-High Performance Concrete – Phase 1

Project Number:	8237-001
Start Date:	4/1/15
Completion Date:	12/31/17
Total Cost:	$143,716
SPR Funds (80%):	$114,973
State Funds (20%):	$28,743
Total MDT Indirect Cost:	$13,856
Total FFY 2018 Expended:	$2,328
FFY 2018 SPR Funds (80%) Expended:	$1,862
FFY 2018 State Funds (20%) Expended:	$466
FFY 2018 MDT Indirect Costs:	$230
Unexpended Funds:	$76
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/mat/high_performance_concrete.shtml

Objective:

Ultra-high performance concrete (UHPC) has mechanical and durability properties that far exceed those of conventional concrete. Thus, elements made with UHPC are thinner/lighter than elements made with conventional concrete. The enhanced durability properties of UHPC also allow for longer service lives and decreased maintenance costs. However, using UHPC in conventional concrete applications has been cost prohibitive, with commercially available/proprietary mixes exceeding $2,000 per cubic yard, which is about 20 times the cost of conventional concrete.

The overall objectives of this project were to develop and characterize non-proprietary UHPC mix designs made with materials readily available in Montana. These mixes are anticipated to be significantly less expensive than commercially available UHPC mixes, thus allowing for the use of UHPC in construction projects in Montana. In particular, the Montana Department of Transportation Bridge Bureau (MDT) is interested in using UHPC as a field-cast jointing material between precast concrete deck panels and girders and between the flanges of adjacent girders.

Progress:

All research is complete and the final deliverables can be found at the above URL.

Reports:

All quarterly and task progress, and draft final deliverables were submitted approved by MDT, and posted to the above URL.

Implementation:

Prior to implementation, a follow-up study titled *Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana: Phase II Field Application* is being conducted. (See 3.2.1.2, page 30.)

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3.2.2.2 Investigation of Prefabricated Steel Truss/Bridge Deck Systems

Project Number:	8226-001
Start Date:	9/15/14
Completion Date:	12/31/17
Total Cost:	$47,481
SPR Funds (80%):	$37,985
State Funds (20%):	$9,496
MDT Indirect Costs:	$4,426
Total FFY 2018 Expended:	$0
FFY 2018 SPR Funds (80%) Expended:	$0
FFY 2018 State Funds (20%) Expended:	$0
FFY 2018 MDT Indirect Costs:	$0
Unexpended Funds:	$181
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/structures/prefab.shtml

Objective:

Steel truss bridges are an efficient and aesthetic option for highway crossings. Their relatively light weight compared with plate girder systems make them a desirable alternative for both material savings and constructability. A prototype of a welded steel truss constructed with an integral concrete deck was proposed as a potential alternative for accelerated bridge construction (ABC) projects in Montana. This system consists of a prefabricated welded steel truss topped with a concrete deck that can be cast at the fabrication facility (for ABC projects) or in the field after erection (for conventional projects). To investigate possible solutions to the fatigue limitations of certain welded member connections in these trusses, bolted connections between the diagonal tension members and the top and bottom chords of the truss were evaluated. In this research, both a conventional cast in place deck system and an accelerated bridge deck system (cast integral with the truss) were evaluated for the bolted/welded steel truss bridge.

Progress:

All research is complete and the final deliverables can be found at the above URL.

Reports:

All quarterly and task progress, and draft final deliverables were submitted approved by MDT, and posted to the above URL.

Implementation:

An implementation meeting was held with all stakeholders, including consultant designers, steel prefabricators, construction contractors, and MDT staff) in attendance.

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3.2.3 Proposed Projects

3.2.3.1 Bridge Deck Cracking Investigation

URL: https://www.mdt.mt.gov/research/projects/const/deckcracking.shtml

Topic Statement:

In the spring of 2016, MDT noted severe cracking on two bridge decks in the Missoula District which led to holes in these decks after small sections of concrete fell through. MDT hired Wiss, Janney, Elstner and Associates (WJE) to investigate the cause of these cracks and provide recommendations. The report by WJE was published in April 2017 and some, but not all, of the recommendations were implemented and proved successful in reducing early age cracking in new bridge decks. Although MDT had success with implementation, documentation of actual in-field procedures was not sufficient and there was not a clear understanding of which of the recommendations implemented were causing the success. It was determined a better way to document in-field procedures and specification enforcement is needed as well as a way to better determine which recommendations are the main cause of the success and which ones may not be proving beneficial.

Research Proposed:

Researchers propose to analyze data from the previous deck pours that used recommendations from the WJE report, document procedures for the new pours, monitor temperature and stress gradients with modified deck curing, and conduct modeling to demonstrate the benefit of modified curing on deck stresses and cracking risk. Project results from this investigation will be used to develop recommendations.

Urgency and Expected Benefits:

With bridge deck projects currently active and the need to gather existing information before it is lost, the urgency is great to complete this project. The faster we can get the project going the more information we will have to provide more comprehensive and accurate recommendations. This project will help meet MDT's mission by improving the quality and lifespan of bridge decks throughout the state.

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3.2.3.2 Concrete-Filled Steel Tube to Concrete Pile Cap Connections: Specimen Testing

URL: https://www.mdt.mt.gov/research/projects/structures/seismic.shtml

Topic Statement:

MDT has found concrete-filled steel tube (CFST) piles connected at the top by a concrete pile cap to be a very cost-effective support system for short- and medium-span bridges. This type of system offers low initial cost, short construction time, low maintenance requirements, and a long service life. While the gravity load performance of these systems is well understood, their strength and ductility under extreme lateral loads (e.g., seismic events) is more difficult to reliably predict using conventional design procedures. The proposed research aims to further develop newly established design and analysis methodologies, and to ultimately ensure the desired bridge performance.

Related Research:

MDT has sponsored previous research at Montana State University to investigate the performance of these systems under extreme lateral loads and to develop appropriate analysis/design procedures. As part of these investigations, MSU conducted physical tests on various half-size models of the CFST to pile cap connections under pseudo-static and cyclic loading. Although this research provided useful information regarding the behavior and design of CFST to concrete pile-cap connections, further research is required to more fully characterize this behavior and further develop the analysis/design methodologies. For example, several aspects of these methodologies rely on empirical assumptions that may not be valid for all possible cap configurations. That is, the tests carried out in this research did not vary cap dimensions, CFST diameter, or number of embedded piles in the test section, and therefore some of the empirical assumptions used in the proposed methodologies may not be valid for all conditions. Thus, further testing and/or further analytical modeling should be conducted to validate/modify these assumptions and to ultimately ensure the desired system performance.

Research Proposed:

The primary objective of this project is to further validate/improve MDT's CFST to concrete pile cap connection design/analysis methodologies, and to ensure the efficacy of these methodologies for a wide variety of potential design configurations. This research will include physical tests of scaled specimens, which may include specimens with variations in cap dimensions, CFST diameter, or number of embedded piles. Additionally, the use of battered piles or precast concrete pile caps in this system may be explored experimentally. This project will consist of two phases. The first phase of research will focus on identifying potential gaps in the existing design/modeling strategies, and then designing future tests to help close these gaps. This phase of research was proposed last year and is currently in the proposal stage. The second phase of research (proposed herein) will involve the testing of the specimens designed

in the first phase of research. The exact scope of this project will be further developed through collaboration with the technical panel at the next stage of the proposal.

Urgency and Expected Benefits:

Bridges have been found to be a particularly vulnerable element of critical infrastructure systems during earthquakes. While CFST pile to concrete pile cap bridge support systems designed following the current methodology offer significantly better performance in seismic events than those designed using older methodologies, this design procedure has not been fully validated by physical testing and analytical modeling. The results of this project will provide such validation, and the data necessary to revise this procedure so that the required connection performance during seismic events is realized under various conditions.

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3.2.3.3 Evaluation of Thin Polymer Overlays for Bridge Decks

URL: https://www.mdt.mt.gov/research/projects/const/evaluation.shtml

Topic Statement:

Thin composite polymer overlays are a cost-effective method for extending the service life and serviceability of concrete bridge decks by filling concrete cracks and increasing skid resistance. The overlays are a thin (1/4 to 1/2 inch) layer of polymer that seals existing cracks and is embedded with aggregate for wear and skid resistance. Based on a survey of all state transportation agencies, thin polymer overlays can provide a service life up to 25 years when constructed on a sound concrete deck (Fowler and Whitney 2011). The Montana Department of Transportation has recently observed varying performance of two different polymer overlay systems applied to three different bridge decks across the state. The two poorest performing bridge decks were located in Kalispell where below-standard skid resistance was measured after only two years.

Related Research:

Published field studies by state departments of transportation on the performance of thin polymer overlays have begun to identify specific products and contributing factors related to poor durability and skid resistance. The Oregon Department of Transportation (Soltesz 2009) evaluated eight different overlay systems and found three products wore through to the concrete surface after 1.3 million vehicles, and one product much sooner. For the five products that did not wear through, empirical equations predicted the skid resistance would match that of plain concrete after five months with an average daily traffic volume of 10,000 vehicles per day. The Wisconsin Department of Transportation completed a laboratory and field experimental program to compare the performance of nine different overlay systems (Tabatabai et al. 2016). From three types of aggregate considered, flint rock used with epoxy resin had the highest friction and best overall performance. The lowest friction values were obtained from calcined bauxite aggregate. In a synthesis of recently completed research, CTC and Associates (2012) reported six different states (MO, CA, IL, MI, UT, WY) have stopped using specific types of polymer overlay products where poor performance may have been influenced by traffic volumes, bridge type, and installation procedures. The Washington State Department of Transportation stopped using thin polymer overlays in certain locations after poor skid resistance was observed after only five years of heavy studded tire use.

CTC and Associates, L. (2012). "Ultra-Thin Concrete Polymer Concrete Overlays for Bridge Decks." 17.

Fowler, D. W., and Whitney, D. P. (2011). *Long-term performance of polymer concrete for bridge decks*, Transportation Research Board.

Soltesz, S. (2009). "Evaluation of thin overlays for bridge decks." Oregon Dept. of Transportation. Research Section.

Tabatabai, H., Sobolev, K., Ghorbanpoor, A., Nabizadeh, A., Lee, C.-W., and Lind, M. (2016). *Evaluation of Thin Polymer Overlays for Bridge Decks*, Wisconsin Highway Research Program.

Research Proposed:

The proposed research is divided into four tasks that will be used to assess the performance of thin polymer overlays on concrete bridge decks in Montana. Task 1 is a literature review investigating the performance of different overlay systems reported by other state departments of transportation. A review of the four polymer systems on MDT's qualified product list and recent skid resistance data for two of these materials will be included. Based on this information, Task 2 will implement an expanded and focused field investigation to measure skid resistance and durability of selected polymer systems. Bridge decks included in the field investigation will represent geographic locations, traffic volumes, and deck conditions that have been reported in the literature to be most closely related to the performance of polymer overlay systems.

The application of the polymer overlay systems selected for the field sites will be observed and documented to identify if construction factors are contributing to overlay performance. Task 3 will monitor the selected bridge sites for a minimum of two years through site observations, skid resistance and traffic volume data, and weather information (temperature, moisture/snow events). Task 4 will document the polymer overlay performance and contributing factors identified through the collected data for each bridge site during the two-year period. Results of the study will produce recommendations for polymer systems and locations appropriate for their use. Alternative concrete bridge deck maintenance procedures will be recommended for locations and traffic characteristics that are not well suited for thin polymer overlays.

Urgency and Expected Benefits:

This research meets MDT's mission by increasing the service life and quality of bridge decks through cost effective thin polymer overlay systems that require less maintenance and improved skid resistance for the travelling public.

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3.2.3.4 Monitoring Streamflow Using Video Cameras

URL: https://www.mdt.mt.gov/research/projects/hyd/streamflow.shtml

Topic Statement:

The United States Geological Survey (USGS) is exploring the use of large-scale particle image velocimetry (LSPIV) to obtain measurements of surface velocities in rivers. For LSPIV, a video camera records images of particles traveling along the stream surface; surface velocities are calculated from those images. LSPIV could be a valuable tool for measuring discharge when traditional measurement techniques are not possible, for verification of theoretical measurements, or as a "backup" to direct measurements of discharge. For example, this method might be especially suited to streams that experience very rapid changes in stage (and discharge), such as those that experience flash flooding. LSPIV may also be used to measure magnitudes and angles of surface velocities for bridge scour calculations, for model calibration, or for other hydraulic studies.

Related Research:

The USGS has installed and is testing LSPIV devices across the United States. The USGS WY-MT Water Science Center has installed one LSPIV on the Little Blackfoot River in Montana.

Research Proposed:

LSPIV equipment will be installed at approximately 10 sites (Crest-stage gage sites or other streamgage or bridge sites) in different stream settings in Montana.

Urgency and Expected Benefits:

LSPIV could greatly improve MDT/USGS Crest-stage gage (CSG) data collection efforts, by supplying velocity measurements during flash floods when personnel cannot reach the sites. Those measurements can be used to calculate stream discharges and be used to verify rating curves, thus improving discharge measurements for CSGs, and ultimately improving peak-flow frequency estimates.

LSPIV also can be used to measure velocity magnitude and angle of attack at bridge piers for various discharges, and can help improve pier scour estimates. Therefore, this project will help to meet MDT's emphases for safety, cost effectiveness, and sensitivity to the environment.

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3.3 CONSTRUCTION RESEARCH PROJECTS

3.3.1 Active Projects

3.3.1.1 Effective Production Rate Estimation Using Construction Daily Work Report Data

Project Number:	9344-504
Start Date:	1/1/17
Completion Date:	1/31/19
Total Cost:	$139,528
SPR Funds (80%):	$111,622
State Funds (20%):	$27,906
MDT Indirect Costs:	$13,729
Total MDT Expended To Date:	$133,767
Total MDT Indirect Costs Expended To Date:	$13,182
Total FFY 2018 Expended:	$83,878
FFY 2018 SPR Funds (80%) Expended:	$67,102
FFY 2018 State Funds (20%) Expended:	$16,776
FFY 2018 MDT Indirect Costs:	$8,254
Consultant:	Iowa State University

URL: https://www.mdt.mt.gov/research/projects/const/production_rates.shtml

Objective:

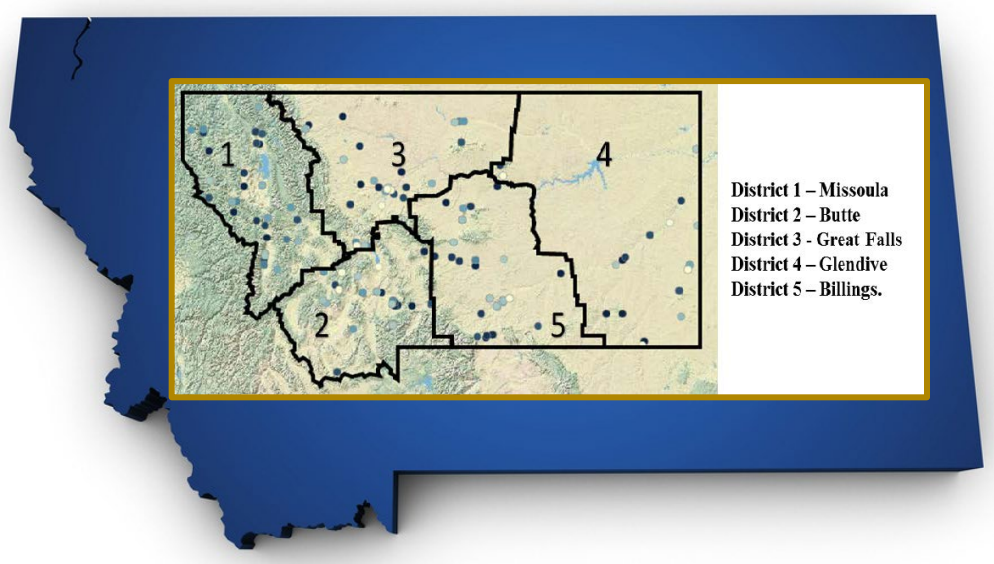
A production rate is a quantity of production accomplished over a specific period of time and realistic production rates are the key in determining reasonable contract times for construction projects. The production rates of major construction activities are important for planning resources and tracking project progress as these activities typically fall in the critical path of the project schedule. Therefore, the accuracy and reliability of the estimated production rates is an effective contract administration tool. The goal of this project is to enhance MDT's current contract time determination procedures by developing a historical data driven production rate estimation system using data available in construction daily work reports.

MDT plans to add a second phase to address activity sequence logics for different types of projects based on historical data. These new tools are expected to significantly improve the accuracy and reliability of MDT's contract time determination.

Progress:

All research is complete and the final deliverables are in review.

Reports:
All quarterly and task progress, and draft final deliverables were submitted and the final deliverables are in review.



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3.3.2 Completed Projects

3.3.2.1 Advanced Methodology to Determine Highway Construction Cost Index GIS Visualization Tool

Project Number:	8232-001
Start Date:	2/1/15
Completion Date:	1/31/18
Total Cost:	$199,673
SPR Funds (80%):	$159,738
State Funds (20%):	$39,935
MDT Indirect Costs:	$19,558
Total FFY 2018 Expended:	$25,106
FFY 2018 SPR Funds (80%) Expended:	$20,085
FFY 2018 State Funds (20%) Expended:	$5,021
FFY 2018 MDT Indirect Costs:	$2,480
Unexpended Funds:	$0
Consultant:	Iowa State University

URL: https://www.mdt.mt.gov/research/projects/const/const_cost_index.shtml

Objective:

Highway construction cost index (HCCI) is an indicator of cost fluctuation in current market condition and hence the purchasing power of a highway agency. It allows agencies to make early financial decisions based on the changing amount of financial resources and changing market conditions. It also helps determine the return on investment value of a new project. Higher budget and lower spending results in waste of remaining budget while lower budget and higher spending results in the cancellation or delay of projects. In addition, there is an inconsistency in the amount of federal funding available over years. Thus, quick and reliable conceptual cost estimation is very important for maximum utilization of available budget.

MDT used to use eight groups of bid items – earthwork, aggregate, plant mix, asphalt, reinforcing steel, structural steel, concrete, and structural concrete – to calculate the HCCI. The items were selected based on the availability of unit prices for a predetermined number of time periods. Items with same units within each group were then used to calculate the weighted average unit prices and were combined to generate HCCI. However, a single composite HCCI has serious limitations. Specifically, the effects of item quantities, project size, project type, and spatial distribution of the project are neglected, and it is in many cases difficult to estimate cost changes and differences for a wide range of construction projects. This can be specifically problematic when state DOTs shift their strategic focus from letting fewer larger projects to many smaller maintenance and rehabilitation projects. Thus, the high level of budget allocation

decisions driven by current indexes can be significantly misleading in the current environment because of those limitations and unreliable analysis techniques used. As a result, many state DOTs are looking forward to updating their HCCIs. There has been a strong need to develop an advanced methodology to determine realistic and practical HCCIs and tools that MDT can use.

This project developed a Montana-specific multidimensional highway construction cost index system using a newly developed concept of dynamic item basket. The new methodology and a computer software program developed in this study are expected to significantly improve the accuracy and reliability of HCCI for planning and budgeting for future fiscal years. The advanced HCCI system is expected to play a key role in maximizing the utilization of available budget.

This project was completed in FFY 2017; however, the contract was amended to add the development of a GIS tool for determining HCCI. This tool was developed in FFY 2018.

Progress:

All research is complete and the final deliverables can be found at the above URL.

Reports:

All quarterly and task progress, and draft final deliverables were submitted approved by MDT, and posted to the above URL.

Implementation:

The results of this research, including the GIS tool have been implemented.

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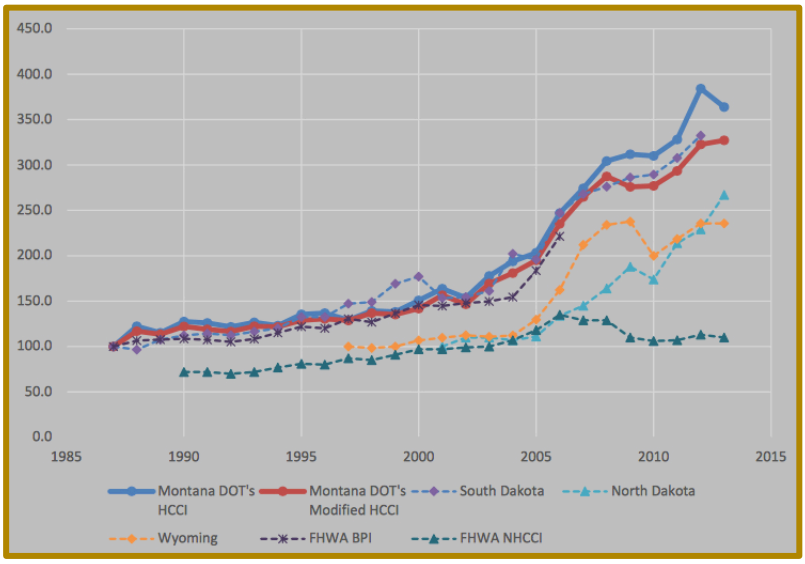

3.3.3 Proposed Projects

3.3.3.1 Use of Fluorescent Orange Delineators in Temporary Traffic Control Work Zones

URL: https://www.mdt.mt.gov/research/projects/safety/delineators.shtml

Topic Statement:

Road maintenance and reconstruction often present serious safety challenges to highway agencies due to the dynamic and variable work environment which may well be inconsistent with drivers' expectations. As such, proper delineation of travel path through work zones is critical for safe and efficient work zone operations. Currently the Manual on Uniform Traffic Control Devices (MUTCD) only allows white and yellow delineators within temporary traffic control work zones (Section 6F.80, MUTCD 2009). Field observations suggest that using the conventional white and yellow delineation may not be adequate to effectively delineate traffic through work zones. The proposed research aims to evaluate a new alternative fluorescent orange delineation device for its effectiveness in guiding traffic through work zones. MDT used the new proposed device (larger, 6" x 12" retroreflective fluorescent orange delineators) in lieu of the MUTCD-approved white delineators in two rural reconstruction projects during the summers of 2015 and 2016. Pictures and observations were taken and recorded for the original and proposed delineation device. MDT project inspectors report the new devices offer better visibility even when the delineators become dusty and dirty. Traffic control contractors also prefer the larger delineators as they offer an even bigger target value. The fluorescent orange delineators are much more visible during nighttime, adverse weather conditions, and construction activities. Further, road users are familiar with the fluorescent orange color within work zones, which may aid in identifying travelled ways that are not self-explaining. The MUTCD allows the use of devices not described in Chapter 6 of the Manual but this must be based on an engineering study, which is the main impetus for the proposed effectiveness evaluation project.

Related Research:

The literature search from Stage 1 showed that the proposed fluorescent orange delineators have not been used in practice nor evaluated in any previous study.

Research Proposed:

The proposed research project consists of six primary tasks: 1) State-of-the-art review of work zone delineation devices and the different approaches for assessing their effectiveness; 2) Selection of study sites to include a limited number of work zones with different work activity and site conditions; 3) Data collection. Traffic surveillance cameras and traffic recorders (on mobile trailers) will be used to collect data from study sites using regular and proposed delineation devices; 4) Data processing and compilation, which involves extraction of information from video records and traffic sensors in a format appropriate for analysis; 5) Data

analysis where major study variables (e.g., lateral clearance between vehicle and delineation devices, roadside encroachments, speeds, etc.) will be analyzed to examine the effectiveness of the proposed delineation devices; and 6) Final report to include a description of the investigations performed along with a summary of major findings and recommendations.

Urgency and Expected Benefits:

The MDT Work Zone Safety and Mobility Goals and Objectives report published in 2015 outlines Goal 1 as "reduce the number and severity of crashes, injuries and fatalities in construction zones." Effective channelizing devices including delineators are critical in guiding traffic safely through work zones, thus contributing to this important goal. The proposed study is required by MUTCD before application of the new delineation devices is allowed at maintenance and construction sites. Further, the proposed research is expected to have a very high pay-off for MDT given the extensive highway network and associated maintenance and reconstruction operations in the state.

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3.4 ENVIRONMENTAL RESEARCH PROJECTS

3.4.1 Active Projects

3.4.1.1 MDT Wildlife Accommodations Process

Project Number:	5896-423
Start Date:	3/1/16
Completion Date:	12/31/18
Total Cost:	$233,719
SPR-Part A Funds (80%):	$186,975
State Funds (20%):	$46,744
MDT Indirect Costs:	$22,905
Total MDT Expended To Date:	$233,719
Total MDT Indirect Costs Expended To Date:	$22,905
Total FFY 2018 Expended:	$92,301
FFY 2018 SPR Funds (80%) Expended:	$73,841
FFY 2018 State Funds (20%) Expended:	$18,460
FFY 2018 MDT Indirect Costs:	$10,096
Consultant:	KLJ

URL: https://www.mdt.mt.gov/research/projects/env/wap.shtml

Objective:

MDT has accommodated a variety of wildlife species in the last two decades in a number of different ways. However, the processes, justification, and criteria used for recommending and implementing accommodations have varied just as the technology and practices in the field have rapidly evolved. This project investigates how to establish a process to incorporate these features into construction projects by a documented justification process to determine the appropriateness of including wildlife accommodations in project development and design. The overall objective is to develop a wildlife accommodations process and guidelines specifically tailored to meet MDT's project development processes, Montana wildlife, and evaluate needs as well as feasibility.

Progress:

All research is complete and the final deliverables are in review.

Reports:

Four progress reports have been submitted, along with all draft final deliverables. This project was completed early in FFY 2019 and the final report, including a preliminary implementation plan, performance measures plan, and a plan for process review, and the desk guide can be viewed at the above URL.

Implementation:

A detailed implementation plan is being drafted, including performance measures and process review.

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3.4.1.2 Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements

Project Number:	9596-617
Start Date:	6/19/18
Completion Date:	9/30/19
Total Cost:	$245,456
SPR Funds (80%):	$49,600
State Funds (20%):	$12,400
Consultant/Other Cost Share:	$183,456
MDT Indirect Costs:	$7,000
Total MDT Expended To Date:	$0
Total MDT Indirect Costs Expended to Date:	$0
Total FFY 2018 Expended:	$0
FFY 2018 SPR Funds (80%) Expended:	$0
FFY 2018 State Funds (20%) Expended:	$0
FFY 2018 MDT Indirect Costs:	$0
Consultant:	University of Montana

URL: https://www.mdt.mt.gov/research/projects/env/wildlife_fence_mods.shtml

Objective:

Fences along roadways serve as safety measures to protect humans from vehicular collisions with wildlife and livestock by containing animals in appropriate pastures and keeping them off roadways. Fences can act as semi-permeable or complete barriers to wildlife movement. As a consequence, through landscape fragmentation, fences reduce landscape connectivity, impede resource selection, and are a direct cause of mortality in ungulates (e.g., pronghorn, elk, deer) and other species (e.g., greater sage-grouse). To combat these effects on wildlife, multiple fence modifications have been recommended by management agencies using the best available science to either facilitate or deter wildlife and/or livestock from crossing fences. This project evaluates the effectiveness of previously

recommended “wildlife-friendly” fence modifications to assess their effectiveness in allowing for continued wildlife movements while effectively controlling livestock. Researchers will use the outputs of a previously developed fence density map, together with the results of the final evaluation of the effectiveness of various “wildlife-friendly” fence modifications, to guide MDT District Biologists and right of way personnel in the application of effective “wildlife-friendly” fences and other effective habitat connectivity measures on the landscape. The project will demonstrate and present the importance of developing fence density maps for other important ecological areas, to create scientifically and economically defensible positions for MDT to use.

Progress:

The research team completed data processing with a completed database. The team completed an ANOVA analysis for all species and a logistic regression analysis for pronghorn only.

Reports:

One progress report was received. Project information and reports can be viewed at the above URL.

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3.4.2 Completed Projects

3.4.2.1 Evaluation of the Effectiveness and Cost-Benefits of Woolen Roadside Reclamation Products

Project Number:	8223-001
Start Date:	3/1/14
Completion Date:	12/31/17
Total Cost:	$249,960
SPR Funds (80%):	$128,837
Other Federal Funds:	$88,914
State Funds (20%):	$32,209
MDT Indirect Costs:	$14,651
Total FFY 2018 Expended:	$0
FFY 2018 SPR Funds (80%) Expended:	$0
FFY 2018 State Funds (20%) Expended:	$0
FFY 2018 MDT Indirect Costs:	$0
Unexpended Funds:	$0
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/env/wool_test.shtml

Objective:

The overall objective of the project was to evaluate wool products that can be used for roadside reclamation projects by MDT and other transportation agencies. The project seeks to develop and test potential wool products that can be easily produced as complementary or replacement products to existing standard best management practices (BMPs). The four specific objectives were to:

- Review existing woolen reclamation materials and products and develop new wool reclamation products for roadside purposes.
- Use geotextile and analytical laboratory tests to compare standard reclamation products to their woolen equivalents. The results will assure transportation agencies that woolen materials tested in this project are similar or comparable to existing reclamation products.
- Field test woolen reclamation products and standard erosion control blankets (ECBs) and compost products to determine if the woolen products provide equal or improved seeded species establishment and erosion control compared to the traditional commercial products being used by MDT.
- Conduct a cost-benefit analysis to evaluate the cost of producing woolen versus standard reclamation products.

A parallel project of the same title was conducted by the Center for Environmentally Sustainable Transportation in Cold Climates (CESTiCC) with $40,000 of MDT's project funds being used to match the CESTiCC project.

Progress:

All research is complete and the final deliverables can be found at the above URL.

Reports:

All quarterly and task progress, and draft final deliverables were submitted approved by MDT, and posted to the above URL.

Implementation:

The wool-straw erosion control blanket (ECB) is consistent with MDT policy; however, no ECB manufacturer produces a commercial line of wool-based ECBs that is available in the United States. When they become available, the MDT Reclamation Specialist will consider their deployment on roadside slopes steeper than 3 horizontal : 1 vertical, in harsh environments, and/or have challenging soils. More research is required as follows:

- The use of 100% wool as a component of 100% biodegradable silt fence.
- Determine the ideal mix of wool as an additive to compost.

Performance Measures:

The 50% wool/50% straw ECB cost $1.18/$m^2$, approximately twice the cost of standard ECB (70% straw/30% coconut). However, after two years, this product resulted in over five times more seeded grass canopy than the standard ECB. Also, the 50% wool/50% straw ECB cost $0.05/percent cover/$m^2$, while the 70% straw/30% coconut ECB cost $0.13/percent cover/ m^2. The wool ECB is nearly three times more cost effective if the goal is maximizing vegetative cover.

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3.5 GEOTECHNICAL RESEARCH PROJECTS

3.5.1 Active Projects

3.5.1.1 Guidelines for Chemically Stabilizing Problematic Soils

Project Number:	9389-522
Start Date:	4/21/17
Completion Date:	9/30/19
Total Cost:	$170,000
SPR Funds (80%):	$136,000
State Funds (20%)	$34,000
MDT Indirect Costs:	$17,300
Total MDT Expended To Date:	$81,500
Total MDT Expended Indirect Costs To Date:	$7,953
Total FFY 2018 Expended:	$44,708
FFY 2018 SPR Funds (80%) Expended:	$35,766
FFY 2018 State Funds (20%) Expended:	$8,942
FFY 2018 MDT Indirect Costs:	$4,514
Consultant:	Boise State University

URL: https://www.mdt.mt.gov/research/projects/geotech/chemical_stablize.shtml

Objective:

The main goal of this project is to establish protocols for conducting efficient chemical stabilization design for problematic soils with and without soluble sulfates within the state of Montana. MDT has very limited experience with chemical stabilization, and while there is a desire to potentially use chemical stabilization, a major concern with this approach is the presence of potential high sulfate concentrations and costs incurred in undertaking chemical stabilization projects. This project addresses these issues by conducting laboratory studies to determine effective chemical stabilizers for stabilizing Montana-specific problematic soils. A life cycle cost analysis will be conducted to compare and contrast existing approaches versus chemical stabilization alternatives in tackling these problematic soils.

Progress:

A combined report for Tasks 2, 3 and 4 was completed. Moisture conditioning and curing procedures (Task 5) were established for lime-treated soils. Freeze thaw durability, part of long-term durability studies (Task 6), was completed and wetting and drying durability was initiated.

Life cycle cost analysis (Task 7) was initiated, with the design of typical pavement section alternatives using untreated versus treated subgrade soil and data collection for cost analysis.

Reports:

Project information and reports can be viewed at the above URL.

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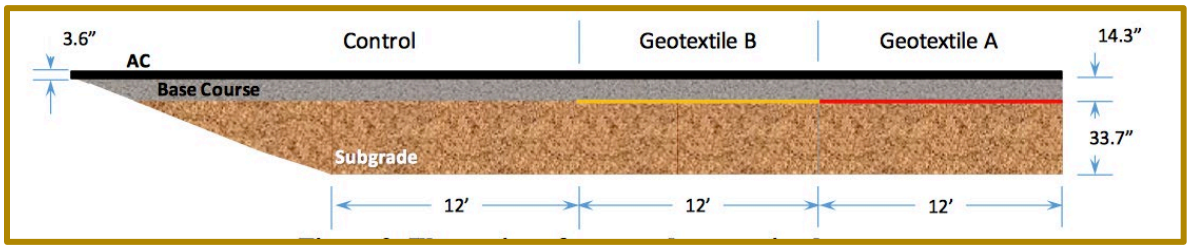
3.5.1.2 Large-Scale Laboratory Testing of Geosynthetics in Roadway Applications

Project Number:	9564-602
Start Date:	2/21/18
Completion Date:	2/28/20
Total Cost:	$422,001
SPR Funds (80%):	$337,601
State Funds (20%)	$84,400
MDT Indirect Costs:	$42,345
Total MDT Expended To Date:	$147,783
Total MDT Indirect Costs Expended To Date:	$14,488
Total FFY 2018 Expended:	$147,783
FFY 2018 SPR Funds (80%) Expended:	$118,226
FFY 2018 State Funds (20%) Expended:	$29,557
FFY 2018 MDT Indirect Costs:	$14,488
Consultant:	Montana State University

URL: http://www.mdt.mt.gov/research/projects/geotech/lab_testing.shtml



Objective:

The main objective of this project is to characterize the performance of geosynthetic-reinforced test sections when compared to an unreinforced case to assess benefit in terms of a reduction in the base course thickness, an extension of the life of the pavement, or the strengthening of the individual pavement layers. This objective will be achieved through the construction of a single test track containing three test sections, a detailed analysis and synthesis of the results, and the evaluation of an analytical design tool to be used by pavement engineers to design geosynthetic-reinforced pavements.

Progress:

The project kick-off meeting was held in March 2018. The literature review (Task 1) was completed. The following Task 2 items were completed:

- ★ Additional unsoaked CBR tests were performed on the subgrade soil at various moisture contents to define the moisture content producing a California Bearing Ratio (CBR) of 2.5.
- ★ MDT performed a R-Value test on the subgrade soil.
- ★ The following lab tests were performed on the aggregate: grain-size distribution, Atterburg limits, CBR, fractured face count, modified Proctor compaction, R-value, wear and Micro-Deval testing.
- ★ Coordination continued with the MDT Materials Bureau to identify and obtain samples of three HMA mixes typical of MDT pavement projects.
- ★ Work continued to identify three HMA mixes from the Greenville, South Carolina, area for testing to determine their suitability for use in constructed test sections.

Reports:

Project information and reports can be viewed at the above URL.

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3.5.2 Completed Projects

3.5.2.1 Rockfall Hazard Process Assessment

Project Number:	8239-001
Start Date:	6/1/15
Completion Date:	12/31/17
Total Cost:	$545,393
SPR Funds (80%):	$436,314
State Funds (20%):	$109,079
MDT Indirect Costs:	$52,688
Total FFY 2018 Expended:	$0
FFY 2018 SPR Funds (80%) Expended:	$0
FFY 2018 State Funds (20%) Expended:	$0
FFY 2018 MDT Indirect Costs:	$0
Unexpended Funds:	$1,245
Consultant:	Landslide Technology

URL: https://www.mdt.mt.gov/research/projects/geotech/rockfall.shtml

Objective:

The Montana Department of Transportation (MDT) implemented its Rockfall Hazard Rating System (RHRS) between 2003 and 2005, obtaining information on the state's rock slopes and their associated hazards. The RHRS data facilitated decision-making in an informal process over the next several years. MDT applied the RHRS ratings in an informal process, reviewing ratings and comparing them to event occurrences, maintenance needs, and rockfall mitigation project selection in the decade since completion. MDT found the RHRS to be a valuable tool providing relative rankings between sites. After nearly a decade of using RHRS, MDT decided to develop a more comprehensive and updated Rock Slope Asset Management Program (RAMP), due to a combination of changed sites, a need for additional tools to aid in project selection, and a desire to incorporate principles of Transportation Asset Management (TAM) in managing rock slopes. The goal of this research project was to assess changes in MDT's rock slope assets since 2003 and gather data that would allow MDT to develop an updated rock slope hazard assessment program with TAM-compatibility as an added benefit. The research project scope included identifying rock slope condition and risk factors, determining critical sites, incorporating benefit/cost analysis, and forecasting future asset condition based on various budget scenarios. The objectives of the program were to 1) update rock slope rating criteria; 2) determine critical sites based on condition, risk, and cost/benefits using new decision support tools; 3) develop/ cost benefit scenarios; and 4) evaluate compatibility of the RAMP process with MDT's Transportation Asset Management program.

Progress:

All research is complete and the final deliverables can be found at the above URL.

Reports:

All quarterly and task progress, and draft final deliverables were submitted, approved by MDT, and posted to the above URL.

Implementation:

The rockfall assessment tool is in use. The Condition State approach and percent retention is being used in the design process to develop rock slope design goals compatible with risk and budgetary constraints. MDT Geotechnical personnel are updating the RAMP data when changes to a rock slope occur, including known significant maintenance, mitigation, or construction of new slopes. MDT Maintenance staff are using rockfall-specific job codes in their Maintenance Management System (MMS). The rockfall event tracker and maintenance tracker tools are being used by Geotechnical personnel for larger rather routine maintenance events. Maintenance staff has been asked to use the maintenance tracker tool as often as practicable.

MDT is investigating the following:

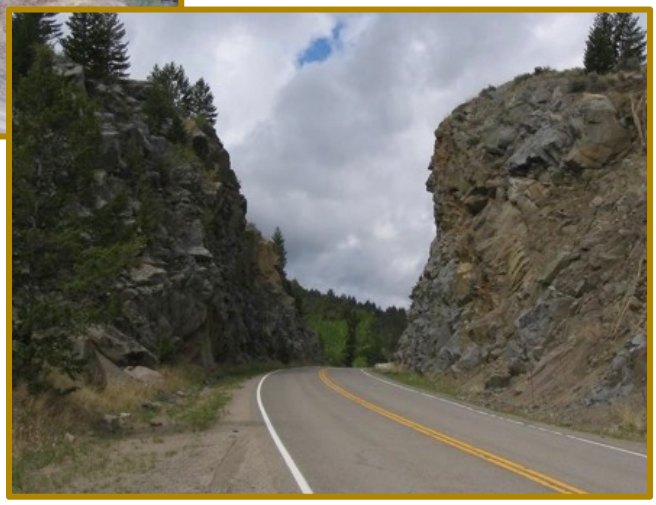
- Incorporating the RAMP Program as a part of the formal MDT TAM process
- Integrating the RAMP data into the planning workflow, addressing preservation and reconstruction measures for existing Fair and Poor condition rock slopes process early in the NEPA process
- Developing STIP and HSIP line items in state budgets for stand-alone rock slope mitigation projects that accomplish both corridor risk reduction and safety improvements

Performance Measures:

The following peformance measure data was calculated as a part of this research project.

- Replacement value of the assessed rock slope inventory = $4 B
- High hazard RAMP sites on the interstate = 997
- Average rock slope condition = 63%
- Number of significant rockfall events to occur annually = 27
- Estimated value lost to slope deterioration annually = $35 M
- Time for a “Good” slope to deteriorate to “Fair” without preservation = 36 years
- Estimated annual risk cost, including mobility and safety consequences for MDT and road users = $3.5 M
- Annual savings realized by preservation = $7 M
- Return on preservation investment = 114%

- Rock slope area (sf) on “Good” condition = 6.2 M
- Rock slope area (sf) in “Fair” condition = 31.4 M
- Rock slope area (sf) in “Poor” condition = 12.1 M



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3.6 MATERIALS/DATA COLLECTION & ANALYSIS

3.6.1 Active Projects

3.6.1.1 Alkali-Silica Reactivity in the State of Montana

Project Number:	9577-607
Start Date:	4/6/18
Completion Date:	7/30/20
Total Cost:	$74,000
SPR Funds (80%):	$59,200
State Funds (20%)	$14,800
MDT Indirect Costs:	$11,374
Total MDT Expended To Date:	$18,080
Total MDT Indirect Costs Expended To Date:	$1,770
Total FFY 2018 Expended:	$18,080
FFY 2018 SPR Funds (80%) Expended:	$14,464
FFY 2018 State Funds (20%) Expended:	$3,616
FFY 2018 MDT Indirect Costs:	$1,770
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/mat/alkali_silica.shtml

Objective:

Concrete can be susceptible to expansive reactions between alkalis in the Portland cement and reactive forms of silica in the aggregates, which can ultimately reduce the lifespan of the concrete resulting in costly repairs or even replacement. While alkali-silica reactivity (ASR) has been documented as an issue in many states, little work has been conducted to determine the presence/potential of ASR in Montana.

The primary objectives of the proposed research are to evaluate the potential for deleterious ASR in the state of Montana, and to develop a testing protocol for identifying potential reactive aggregates. This research will also identify/document existing ASR damage in the state, and investigate the potential underlying geological features that may contribute to the presence of reactive aggregates. Finally, this research will explore the efficacy of potential mitigation techniques employed to limit the effect of ASR.

Progress:

The project kick-off meeting was held in May 2018. Work began on the literature review (Task 1) and the testing protocol development, which is being guided by the literature review (Task 2).

Reports:

Project information and reports can be viewed at the above URL.

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3.6.2 Cancelled Projects

3.6.2.1 Unmanned Aerial Vehicle (UAV) Applications for Montana Transportation Corridors

Below is the Stage 2 Research Topic Statement for this project. This project was cancelled in FFY 2018 because it was felt that information gathered would be out-of-date by the time the final products were published. One outcome of this project is a UAV forum, led by MDT. It consists of a listserv and a resources guide.

Topic Statement:

This research will compile a comprehensive list of highway design, construction, and maintenance applications that have been successfully implemented in the US and overseas. It will then complete a critical analysis of each potential application within the Montana context, including the review of FAA and other regulations on this topic. The final deliverable will be a White Paper on the topic with recommendations for implementing high value applications within MDT.

Related Research:

In 2013, the State of Montana enacted legislation to restrict the use of information gained from UAVs as evidence in a court of law. At this point, the UAV was viewed as an unwarranted invasion of privacy, which required a search warrant to be legal. However, the industrial rather than military/law enforcement use of UAVs has increased substantially to the point where MDT's Aviation Bureau now maintains its own UAV. In 2016, FAA promulgated Rule Part 107 that provides a legal basis for the use of UAVs. UAVs have been found to be a very cost-effective means to gather technical information in remote or dangerous locations. A UAV bridge inspection pilot project by the Minnesota DOT concluded that this application not only increases safety for DOT bridge inspectors, but also reduces the time spent gathering bridge condition data. The TransCanada pipeline company is making extensive use of UAV-based imagery to document its progress and protect itself against frivolous law suits for environmental damage during and after construction. The Panama Canal Authority uses UAVs to document actual construction contractor progress as well as to calculate cut and fill volumes. The City of Oklahoma City is using UAVs to conduct topographic surveys in urban areas to avoid the need to install traffic control to protect surveyors and has found that UAV-based digital imagery can equal and sometimes better the accuracy of the Total Station. An OKC pilot project

completed the necessary data collection in less than one hour for an area that would have taken a typical survey party two days. Many power companies use drones to inspect transmission towers, eliminating the hazard to workers who used to have to climb the towers to complete each inspection. When combined with off-the-shelf commercial image analysis software, aerial imagery taken from UAVs can literally subtract before and after photographs to mathematically expose any changes. UAVs have been used to produce as-built surveys of completed construction projects and those surveys can be used to inform the agency's asset management database, as well as to contribute to 3D post-construction models for operations and maintenance planning. The list of current uses goes on and it suffices to say that this technology has an almost unlimited number of potential uses in transportation project delivery. Additionally, when combined with the fact that current computing power has reached a level where massive amounts of data can now be processed and converted into actionable technical information automatically with minimal need for human intervention, the power of these tools can be leveraged to the benefit of MDT's workforce constraints in a huge state with a very high percentage of low volume roads in remote, nearly inaccessible areas of Montana.

Research Proposed:

The proposed research will take place in two stages. Stage 1 will consist of a comprehensive synthesis domestic and international literature on the topic. It will be supplemented by a survey of US state and Canadian province transportation agencies to uncover those agencies that are currently using UAV technologies and identify potential case studies for each potential application in Montana. An internal survey of MDT personnel is also proposed to identify those areas where UAV technology can be used to cover functions where personnel constraints exist, where safety issues make data collection hazardous, and where accessibility constraints make it difficult or impossible to keep asset management databases current. The synthesis will include an assessment of available methodologies for assembling, cleaning and processing the data collected by the UAVs. Information on software, hardware, and personnel resources required for the data storage, analytics, and maintenance will be included in the data processing portion of the synthesis. Stage 1 will produce a synthesis report that benchmarks the state-of-the-practice in UAV applications in North America. If approved by MDT, Stage 2 will commence with an on-site demonstration of a typical UAV capabilities, conducted in two locations designated by MDT for individuals selected by MDT to furnish MDT decision-makers with a first-hand understanding of the technology's capabilities. After the demonstration, a short survey and structured interviews with demonstration observers will be conducted to further inform the research regarding MDT-specific needs. A critical analysis of the information gathered in the literature, surveys, case study and demonstration outcomes will be conducted within the MDT context, and from that, recommendations for high impact/low effort applications of UAV technology in the MDT program will be made. The critical analysis will include a top-down benefit-cost analysis for each of the recommended alternatives. The research deliverable will consist of a collection of 3 to 5 White Papers (4-6 pages) for the UAV alternatives that were found to have the greatest potential for immediate implementation in MDT. Each paper will make the business case for implementing a specific technology including up-to-date cost information, personnel resource requirements, hardware/software needs, necessary training,

and FAA constraints. The research plan will be structured in a manner where the above described effort can be considered Phase I with the ability to move directly into a Phase II pilot implementation project if MDT so desires.

Urgency and Expected Benefits:

The overarching benefit of implementing UAV technology is the significant savings possible in the number of human resources required by MDT to complete land surveying, asset management data collection, and construction engineering tasks. MDT is under pressure to reduce the size of its workforce and will probably not see the possibility of increasing the professional workforce for the foreseeable future. The condition of MDT transportation assets is such that the department will have to get more production out of its current personnel and monetary resources. UAVs are a workforce multiplier. For specific tasks, a UAVs can supplement MDT survey crews in the field, increasing the area of coverage while decreasing the time spent on site. The UAV can deploy to locations that are inherently unsafe to reach by a human being to conduct tasks like bridge inspections and can generally perform asset condition data collection tasks without the need to disrupt traffic or establish traffic control. The UAVs ability to access areas that are difficult to enter in the winter or because of natural obstacles like landslides or washed out culverts will provide MDT with the ability to reduce its emergency response time as well as the hazards to MDT maintenance personnel who do the responding. When coupled with state-of-the-art data acquisition and processing software, the result will be a significant increase in MDT's ability to perform data-driven tasks across a given project's life cycle from concept through maintenance and renewal.

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3.7 PLANNING AND SAFETY RESEARCH PROJECTS

3.7.1 Active Projects

3.7.1.1 Traffic Safety Culture Transportation Pooled Fund (TSC-TPF) Program

Project Number:	8882-309
Start Date:	10/1/14
Completion Date:	9/30/19
Total Cost:	$1,230,074
SPR Funds (100%):	$951,074
Other Federal Funds:	$109,000
Other State Funds:	$120,000
MDT Indirect Cost:	$120,699
Total MDT Expended To Date:	$616,232
Total MDT Indirect Costs Expended To Date:	$58,932
Total FFY 2018 Expended:	$116,211
FFY 2018 SPR Funds (100%) Expended:	$43,403
FFY 2018 State Funds (20%) Expended:	$10,851
FFY 2018 Other State Funds Expended:	$61,957
FFY 2018 MDT Indirect Costs:	$11,398
Consultant:	Montana State University

MDT URL: https://www.mdt.mt.gov/research/projects/trafficsafety.shtml
Current Pooled Fund URL: https://www.pooledfund.org/Details/Study/558
Follow-On Pooled Fund URL: https://www.pooledfund.org/Details/Solicitation/1482

Objective:

The Montana Department of Transportation initiated a multi-year pooled-fund program in partnership with the Center for Health and Safety Culture (CHSC) within the Western Transportation Institute (WTI) at Montana State University. This program is a cooperative effort of participating state DOTs and other organizations vested in traffic safety. The purpose of this effort is to accelerate the development and delivery of tools and services to transform traffic safety culture. The goal of this transformation is to support the Toward Zero Deaths (TZD) vision with sustainable traffic safety solutions.

The Toward Zero Deaths (TZD): National Strategy on Highway Safety is a cooperative and coordinated effort amongst state highway safety agencies and stakeholders. The transformation of the traffic safety culture is a primary element of the TZD strategy. Only through the growth of a positive safety culture can significant and sustainable reductions in

crash fatalities and serious injuries be achieved. Such transformation would not only support traffic safety goals by reducing risky behaviors and increasing protective behaviors, it would also increase public acceptance of other forms of effective safety programs.

Progress and Reports:

There are a total of 11 projects under the current five-year pooled fund program umbrella. It is anticipated a follow-on pooled fund program for an additional five years will be initiated.

Management Support:

This project provides project management assistance, including meeting support (web conference set-up, in-person meeting logistics and travel reimbursement, agenda input, post-meeting follow-up, and meeting notes), quarterly progress reporting, support for outreach and awareness activities, and support for work plan and project development.

This is an annual contract renewed each year of the pooled fund. For FFY 2018, all tasks were completed and four quarterly progress reports were received; they can be viewed at https://www.pooledfund.org/Details/Study/558.

Driving after Cannabis Use:
This project was completed prior to FFY 2018. The final deliverables can be viewed at https://www.mdt.mt.gov/research/projects/cannabis-use.shtml.

Exploring Traffic Safety Citizenship:
This project was completed prior to FFY 2018. The final deliverables can be viewed at https://www.mdt.mt.gov/research/projects/trafficsafety-citizenship.shtml.

Traffic Safety Cultures and the Safe Systems Approach:
This project brings together expertise in engineering (vehicle safety, road building, traffic system planning) as well as in the sciences of human action (psychology, sociology, anthropology) in order to develop a comprehensive framework of traffic safety culture that is useful for practical work in road safety as well as for academic research. Knowledge exchange will be a core element of the project, not only via the researchers that are seconded between partner organizations but also through a knowledge platform that will be created for the partners as well as for the public. The project will also include data from naturalistic driving studies that has not been used in the context of cultural analysis before. A major focus will be on factors that can be changed comparatively easy under given cultural conditions in order to contribute to road safety work in practice.

This project was completed in FFY 2018. More information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-ss-approach.shtml.

Understanding Law Enforcement Attitudes and Beliefs about Traffic Safety:
Law enforcement plays a critical role in traffic safety. However, traffic safety is one of many issues that law enforcement agencies must address. A variety of factors including budget limitations, political support, and agency culture can influence engagement in traffic safety. A decrease in law enforcement's engagement in traffic safety could make a reduction in fatalities and serious injuries less likely.

Recently, some traffic safety professionals have noted a change in the prioritization of traffic safety among law enforcement. It is difficult to determine whether this perception is accurate or not and the reasons and nature of this possible change. Therefore, understanding the attitudes and beliefs of law enforcement leaders and officers regarding traffic safety is critical to growing a positive traffic safety culture and ultimately achieving a goal of zero deaths on the nation's roadways.

The objectives of this case study are to understand:

- How law enforcement leaders and officers within the agencies selected prioritize traffic safety relative to other public safety issues;
- Self-reported attitudes, beliefs, and enforcement behaviors;
- Law enforcement's perceptions of how traffic safety enforcement behaviors have changed in recent years; and
- How prioritization of traffic safety; attitudes, beliefs, and enforcement; and perceptions of change vary between leaders and officers, agency types, and urban and rural settings.

Furthermore, the project would:

- Propose methods of increasing engagement in traffic safety efforts based on the beliefs identified in this study.

To support these objectives, this project will include the development and implementation of interviews and a survey to measure the beliefs and attitudes among law enforcement that influence traffic safety enforcement.

This project was active in FFY 2018 during which Task 1 and Task 2 reports were submitted, reviewed, and finalized. These reports and additional information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-attitudes.shtml.

Key Information for DUIC Policy:
There is growing concern about driving under the influence of cannabis (DUIC), especially as more states change laws around cannabis possession and use. This concern is often exacerbated by the inaccessibility of key information regarding the role of cannabis in crash risk. To rectify this situation, this synthesis project will capture the key information for the critical issues that affect policy decisions with DUIC. The synthesis will focus on the usability of information to garner stakeholder support and inform rational policy making.

This project will provide a set of tools to educate and engage stakeholders (e.g., enforcement agencies, traffic safety agencies, public health departments, etc.) to inform decision-making about effective DUIC policy and counter measures. These tools will include several products:

- **Concise information summary** that integrates current research on the key issues involved in the debate surrounding DUIC crash risk (e.g., methodological limitations of measuring DUIC crash risk, evidence of THC impairment on driver behavior, relationship of THC per se limits with crash risk, interactions with alcohol).
- **Compilation infographic** that summarizes the key points from the information summary. This will include a **revision of infographics** for the existing pooled fund DUIC project that captures the essence of this project within the theoretical framework upon which the study was designed.
- **Talking points** (based on the information summary and referencing the infographic) which can be used by practitioners to discuss DUIC with stakeholders to garner support for effective DUIC strategies.
- **Poster design and PowerPoint Presentation** will be created for traffic safety professionals to use to disseminate information in a traffic safety poster session.

This project was active in FFY 2018 during which the Task 1 report was submitted, reviewed, and finalized. This report and additional information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-duic.shtml.

Traffic Safety Citizenship Communication Tools:
Growing traffic safety citizenship is a novel approach that strategically shifts our focus to the engagement of the larger majority of safe road users to influence the behaviors of the smaller group engaging in risky behaviors. Previous research sponsored by the Traffic Safety Culture Pooled Fund to understand traffic safety citizenship revealed a variety of opportunities to bolster traffic safety citizenship behaviors to reduce traffic crashes and fatalities. However, in order for state highway safety agencies and stakeholders to embrace this strategic approach, information learned from research must be translated to practice. Communication tools that make traffic safety citizenship easier to understand and integrate into existing traffic safety efforts are needed.

The objective of this project is to create meaningful communication tools for state and local traffic safety professionals that can be implemented immediately to build the capacity of critical stakeholders about traffic safety citizenship as a strategy to improve traffic safety.

To support this objective, this project will develop four communication tools:

- **Traffic Safety Citizenship Primer** – This tool will introduce traffic safety professionals and stakeholders to the concept of traffic safety citizenship. Sections within the Traffic Safety Citizenship Primer will include a) what traffic safety citizenship is; b) the origin and background; c) the state of the science; d) examples of safety citizenship; e) talking points to introduce the concept to other professionals, stakeholders, and the

community; and f) examples of traffic safety citizenship activities that can be readily implemented.

- **Traffic Safety Citizenship PowerPoint Presentation** – This tool will be created for traffic safety professionals and stakeholders to introduce Traffic Safety Citizenship to other professionals, stakeholders, and the community.
- **Conversation Guide** – This tool will be created to support traffic safety professionals' efforts to engage their staff or coworkers about Traffic Safety Citizenship as a strategy to improve traffic safety. This will be a stand-alone document that can be printed and shared with others.
- **Poster** – This tool will be created for traffic safety professionals to use to disseminate information in a traffic safety poster session.

This project was active in FFY 2018 during which the Task 1 report was submitted, reviewed, and finalized. This report and additional information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-cc-tools.shtml.

Traffic Safety Culture Primer:
There is growing interest in "traffic safety culture" as a key factor to manage and sustain safe roadway transportation systems, especially as more jurisdictions adopt targets of zero traffic fatalities and serious injuries. However, the theory, terminology, and methods involved in addressing traffic safety culture come from human and social science disciplines that are not typically included in traditional traffic safety, engineering, or other behavioral change agencies (e.g., departments of transportation, driver's licensing, motor vehicles records, etc.). The lack of shared language and understanding about traffic safety culture limits the ability of agencies to explore this topic and engage new stakeholders. Additionally, the variation in the interpretation and implementation of strategies to improve traffic safety has resulted in no consensus about best practices. Communication tools that develop shared language and understanding about traffic safety culture and its relationship to vision zero goals are needed.

The objective of this project is to provide a multimedia primer about traffic safety culture and how a cultural perspective can support vision zero goals. The purpose of this primer is to foster shared language and understanding about traffic safety culture – thus "priming" stakeholders for new and constructive dialogue and thinking about this complex topic. The materials will include readily accessible definitions, insights, and examples of how traffic safety culture influences behaviors and questions to guide dialogue among stakeholders to make meaning of these ideas and expand their thinking.

To support this objective, this project will include:

- **A Traffic Safety Culture Primer** – A brief document will be created that can be readily printed by stakeholders. The primer will include sections addressing:
  - what is traffic safety culture;
  - how does traffic safety culture influence behavior;

- issues about measuring traffic safety culture; and
- how a cultural perspective expands approaches to improve traffic safety.

The format of the primer will be concise text intended for traffic safety practitioners and other stakeholders. The text will be augmented with infographics. The materials will be professionally laid out as an "electronic book" suitable for viewing and printing.

- **Series of PowerPoint Slides** – Each of the primer sections will have a set of accompanying PowerPoint slides with talking points that practitioners can use to communicate to other stakeholders. There will also be a brief overview suitable for a 20-minute presentation.
- **Animated Video** – A short (i.e., three to five minutes), animated video will be developed to introduce the key topics. The video can be easily shared and used to increase awareness and use of the primer.
- **Webinar** – A webinar will be created to introduce the primer to the traffic safety community. The webinar will highlight key features of the tools and promote their use.
- **Poster** – A high-resolution graphic will be created that is suitable for printing on a large poster for use in a conference poster session for traffic safety professionals to use to disseminate a summary of the primer and the tools.

This project was active in FFY 2018 during which the Task 1 report was submitted, reviewed, and finalized. This report and additional information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-primer.shtml.

Guidance for Evaluating Traffic Safety Culture Strategies:
In an effort to reduce the number of traffic crashes and resulting injuries and fatalities, traffic safety agencies are developing and implementing new intervention strategies aimed at changing road user culture. However, systematic evaluations of the implementation and impacts of these new programs are not advancing as rapidly as the programs themselves. At this point, there are neither well-developed summative/outcome evaluations nor formative/process evaluations of most existing programs. Compounding this lack of systematic evaluation is an underlying lack of consensus about or development of the sorts of evaluation designs capable of yielding results that researchers and program managers can be confident in to support future programming and resource allocation decisions.

To address the lack of generally accepted formative and summative evaluation designs and the resulting lack of available outcome and process data, this research will:

- Conduct a comprehensive systematic review of available evaluations of traffic safety culture initiatives in order to catalog and assess both their designs and findings. This will result in a better understanding of the state of the field with respect to what is known about the effectiveness of existing culture-focused interventions and countermeasures and will identify, catalog, and assess the evaluation designs including their associated impact indicators and measures.

- Conduct a parallel examination of what is known about formative and summative designs used to evaluate culture change initiatives in other fields including organization development, community development, and community health. An examination of these related fields will yield additional information about both the effectiveness and rigor of the evaluation designs as well as any knowledge generated about the effectiveness and operation of culture change programs in those fields.
- Provide guidance for practitioners on best practices to evaluate traffic culture strategies.

To support this objective, this project will create:

- **Summary Guidance on Best Practices to Evaluate Traffic Safety Culture Strategies** – A brief document will be created that can be readily used by traffic safety professionals and stakeholders.
- **Journal Article** – An academic journal article will be written and submitted for publication to a peer-reviewed journal in the traffic safety field. This article will help move the field of study forward and provide researchers with guidance on how to evaluate culturally-based strategies in the future.
- **Webinar** – A webinar will be created to summarize guidance for the traffic safety community. The webinar will highlight how program managers can use this guidance to select intervention strategies.
- **Poster** – A high-resolution graphic will be created that is suitable for printing on a large poster for use in a conference poster session for traffic safety professionals to use to disseminate a summary of guidance on the evaluation of traffic safety culture strategies. A handout with talking points will also be created.

This project will be initiated in FFY 2019.

Guidance on Messaging to Avoid Reactance and Moral Disengagement:
Not wearing a seat belt and speeding are two significant contributing factors to motor vehicle-related fatalities. Significant efforts, including messaging, have sought to increase seat belt use and decrease speeding. These efforts have been largely successful as the majority of adults wear a seat belt and do not speed. However, traditional messaging may not be as effective with the small minority of individuals still engaging in these risky behaviors because of two psychological phenomena: psychological reactance and moral disengagement. This project seeks to better understand if these two phenomena are more prevalent among individuals still engaging in these risky behaviors and how messaging might be adjusted to mitigate these phenomena.

The objectives of this research project are to:

- determine if the prevalence of psychological reactance and moral disengagement are higher among adult drivers who never or rarely wear their seat belts or who drive aggressively (i.e., speed, follow too closely, and pass excessively) compared to adults who do not engage in these risky behaviors; and

- identify potential messaging to minimize reactance and overcome moral disengagement regarding seat belt use and aggressive driving.

This project will be initiated in FFY 2019.

Guidance to Promote Workplace Policies and Family Rules to Reduce Cell Phone Use While Driving and Promote engaged Driving:
Distraction while driving is a significant cause of crashes resulting in fatalities and serious injuries. Distracted driving may be more prevalent among young drivers who are already at greater risk for crashes due to novice driving skills. One source of distraction is using a cell phone. Communication (both spoken and typed) is a primary function of cell phones, and such communication is distracting because it takes the driver's eyes off the road and pulls their attention from the driving task. Safe driving requires the driver to be engaged in the driving task. The family and workplace contexts offer two important opportunities to address cell phone use while driving and promote engaged driving. Families can establish rules about never using a cell phone while driving and never communicating using a phone with a family member who is driving. Workplaces can establish similar policies. Guidance to reach families and workplaces is needed for traffic safety practitioners to promote engaged driving – driving free of distractions like cell phones.

The objectives of this project are to identify strategies for families and workplaces that foster engaged driving (i.e., practices that promote engagement by the driver in the driving task). Specifically, the project will seek to answer the following questions:

- How do expectations within families and workplaces influence cell phone use while driving?
- What beliefs and attitudes need to shift to change these expectations and increase engaged driving?
- What are potentially effective strategies (and associated messages) to promote engaged driving within families and workplaces to reduce cell phone use?

This project will be initiated in FFY 2019.

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3.7.2 Proposed Projects

3.7.2.1 Developing a Methodology for Safety Improvements on Low-Volume Roads in Montana

URL: https://www.mdt.mt.gov/research/projects/planning/lvr-safety.shtml

Topic Statement:

Maintaining safety on the highway system has been a top priority for most highway agencies in the U.S. given the heavy toll in deaths and casualties associated with traffic crashes. The limited funds available to highway agencies for safety improvements require a careful consideration of sites that are more promising in improving safety at the network level. Therefore, highway agencies systemically screen the network to identify those sites that are expected to yield greater safety benefits, thus deserving more consideration for safety improvement funds. While this process has been successfully implemented by many agencies for urban and well-traveled major rural highways, it may prove difficult on rural low-volume roads including local county roads. The low traffic exposure on these roads and consequently the low number of crashes occurring may preclude the possibility of using crash data alone in identifying and ranking candidate sites for safety improvement projects. The proposed research attempts to address this issue by providing a much-needed guidance on how to systemically screen the network and rank sites on low-volume roads that are most deserving of safety improvements funds.

Related Research:

Two major aspects are critical to developing a systemic approach in implementing safety improvements on local roads: 1) A methodology for assessing risk which incorporates, besides crash history, other important factors contributing to the risk, and 2) A practical approach for network screening of high-risk locations using information that is readily available to the highway agency. The literature review done by MDT staff in Stage 1 research did not necessarily focus on the two aforementioned aspects. A fairly recent literature review done by the author on a different project revealed several proposed approaches which attempt to assess risks on low-volume roads using other factors besides crash history. However, the majority of those approaches have been exploratory in nature and have not moved into practice. In regards to the application of network-level screening for safety improvement on low-volume roads, the information published on these applications in the literature or on agency websites is limited at best.

Research Proposed:

The proposed research consists of the following tasks: 1) Review all published materials on the various approaches that have been proposed nationally or internationally in assessing risk and identifying sites for safety improvements on low-volume roads. This involves published

materials in scientific databases, online research reports and information available on agency websites; 2) Synthesize information gathered in Task 1 and develop a set of criteria that will be used in assessing the merits, or lack thereof, of any of the approaches currently used by highway agencies gathered in the following task; 3) Screen the different approaches for identifying sites for safety improvements on local roads that are currently adopted by different state DOTs in the U.S. and Canada. This task will be performed using agency survey and phone interviews to follow up with participants as needed; 4) Analyze and assess the merits and limitations of the different approaches used by highway agencies using the criteria developed in Task 2; and 5) Develop and recommend a methodology for use in the state of Montana which could incorporate certain elements of the various approaches analyzed in Task 4 or a totally novel approach that best suits MDT needs and the data structure used by the agency.

Urgency and Expected Benefits:

Maintaining safety on the highway system has been an utmost priority for MDT and critical for progress towards the Vision Zero initiative embraced by the agency. The proposed research is expected to help MDT move toward this goal on low-volume and local roads which constitute the majority of highways by length in Montana. The research will help the agency achieve a better use of the highway traffic safety grants program. The expected return on investment for this project is expected to be very high given that fact that findings will be used on a regular basis in the long term.

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3.7.2.2 Effectiveness of Highway Safety Public Education at Montana Motor Vehicle Registration Stations by Streaming a Variety of Safety Content

URL: https://www.mdt.mt.gov/research/projects/safety/safetyvideos.shtml

Topic Statement:

There is a need to educate Montanans about highway safety, the consequences of exhibiting risky behaviors while driving such as texting while driving, driving while impaired or distracted, driving unbuckled; and the benefits of proven innovative road safety countermeasures such as roundabouts and rumble strips installed by public transportation agencies. There is an opportunity to install video equipment at select Motor Vehicle Division licensing and vehicle registration stations around the state to continuously play highway safety video clips. At many of these locations, the public has waiting times of five minutes or longer. This is enough time for people to give their attention to a video screen playing safety messages.

Related Research:

TRID did not find results specific to safety videos related to showing them at Motor Vehicle Division or Vehicle Registration offices. However, there were two related research projects for using educational video to affect driver behavior and the better way to present educational videos:

- Impact of Education and Awareness Programs on the Usage and Attitude Towards Texting While Driving Among Young Drivers indicates that repeated consistent messaging about the danger of texting while driving may help in reducing texting while driving among young drivers.
- Employing Humor and Celebrities to Manipulate Passengers' Attention to Pre-Flight Safety Briefing Videos in Commercial Aviation. This research indicates the most effective way for people to retain information was through using humorous videos versus using celebrities or standard safety video.

Research Proposed:

This research would be the collection of data by giving short surveys to people as they conclude their business and prepare to leave. This data will be useful for identifying educational gaps, safety focus areas, educating legislators, etc. It would also provide important information about the safety culture, attitudes and beliefs of Montana drivers and provide insight into developing projects and programs to improve highway safety and reduce serious injuries and fatalities caused by vehicle crashes.

Urgency and Expected Benefits:

This research will clearly support MDT's Vision Zero goal of no fatalities or serious injuries on Montana's highways. The educational component is shown as a strategy within Montana's Comprehensive Highway Safety Plan. These educational videos will also support the Department's current effort to educate the traveling public on various topics such as proper use of roundabouts, flashing yellow arrows and rumble strips.

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3.8 RESEARCH (ABOUT RESEARCH) PROJECTS

3.8.1 Active Projects

3.8.1.1 Consultant Research Project Managers

Project Number:	9529-589
Start Date:	5/21/18
Completion Date:	5/21/19
Total Cost:	$133,846
SPR Funds (80%):	$107,077
State Funds (20%):	$26,769
MDT Indirect Costs:	$13,000
Total MDT Expended To Date:	$34,112
Total MDT Indirect Costs Expended To Date:	$3,268
Total FFY 2018 Expended:	$34,112
FFY 2018 SPR Funds (80%) Expended:	$27,290
FFY 2018 State Funds (20%) Expended:	$6,822
FFY 2018 MDT Indirect Costs:	$3,268
Consultant:	CTC & Associates LLC

Objective:

With the 2017 Montana legislative session, MDT lost nearly 70 positions. Guidance has been to contract-out more work. One of the positions lost and being contracted is a research project manager position. An RFP was issued in 2018 and CTC & Associates was hired to provide staff for this work. The consultant project managers serve as an extension of staff and manage projects just as internal staff would.

Progress:

The initial contract is for one year and is renewable up to a total of seven years, as per Montana State Law. The two consultant Research Project Managers oversee 14 active research projects, following a research project tasks checklist and guidance by the Research Program Manager. The two Research Project Managers are timely with their activities. Progress is accounted for in monthly progress reports associated with each billing. The research program manager oversaw 22 projects in FFY 2018, nine of which fall under a pooled fund program and remain active, three others of which remain active, four of which are annual projects, and six of which were completed in FFY 2018.

Reports:

Monthly progress reports are provided with each billing.

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3.8.2 Completed Projects

3.8.2.1 Research Peer Exchange: Implementation, Performance Measures, and the Value of Research

Project Number:	9510-566
Start Date:	8/1/17
Completion Date:	12/31/17
Total Cost:	$25,882
SPR Funds (100%):	$25,882
MDT Indirect Costs:	$2,556
Total FFY 2018 Expended:	$5,493
FFY 2018 SPR Funds (100%) Expended:	$5,493
FFY 2018 MDT Indirect Costs:	$543

URL: https://www.mdt.mt.gov/research/peer/overview.shtml

Objective:

State DOT research offices are required to host a peer exchange at least every five years to improve research program and project management. Specific topics are at the discretion of each research program manager. This peer exchange was held in September 2017. There were three focus topics: implementation of research results, research performance measures, and the value of research. Peer exchange team members included individuals from the following states and organizations: Applied Research Associates, CTC & Associates, MN DOT, NJ DOT, OH DOT, TRB, TX DOT, UT DOT, and VT Agency of Transportation. NJ DOT attended via videoconferencing. The team met for two and a half days.

Prior to the peer exchange, RAC peer exchange and survey reports were mined for related information, as was the Research Program and Project Management (RPPM) website. After review of this information, a survey was developed and sent to RAC.1 In order to achieve maximum benefit for all attendees, team members were asked to submit questions on these three topics. There was a total of 79 questions, which were organized by topic and subtopic. The peer exchange began with presentations from team members. This was followed by methodically discussing each question. The last component of the peer exchange was documentation of each participant's take-aways.

Progress:

All research is complete and the final report can be found at the above URL.

Reports:

The final report was drafted by CTC & Associates, reviewed by the team, with revisions made. It can be viewed at the above URL. A report out was given to MDT management via the Research Review Committee after the implementation plan was developed.

Implementation:

An implementation plan was developed early in FFY 2018 and implementation is in progress.

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4 EXPERIMENTAL PROJECTS

4.1 OVERVIEW

The experimental features program is a FHWA-sponsored program that allows incorporation of experimental features into a project (e.g., construction, maintenance, and safety projects) and provides a vital field evaluation of new materials and methods. This evaluation, if performed well and scientifically based, allows MDT to evaluate specifications and to determine the implementation value in terms of performance and cost effectiveness of these innovative practices.

FHWA defines an experimental feature as *a material, process, method, equipment item, or other feature that has not been sufficiently tested under actual service conditions or has been accepted but requires comparison with alternative acceptable features to determine their relative merits* (https://www.fhwa.dot.gov/programadmin/contracts/expermnt.cfm). This means that a material, process, method, equipment item, or other feature has not been sufficiently tested or requires comparison with alternative acceptable features in Montana.

Experimental features are identified by MDT staff (not Research staff) through the standard project process. The champion notifies the Experimental Projects Manager (ExPM) of the proposed experimental feature. The ExPM then attends all project meetings. Also, prior to developing a work plan, the ExPM may conduct a survey of other states and search TRB's TRID database to determine previous documented performance of an experimental feature, which may result in cancelling the proposed experimental feature.

4.1.1 Work Plan

Prior to construction, the ExPM writes a formal work plan. FHWA has delegated authority to MDT to proceed with experimental features without FHWA approval; however, every work plan is sent to FHWA for their information. This work plan includes the following information:

- Project location
- Project name
- Construction project number
- Experimental project number
- Project type/experimental feature
- Principal investigator
- Technical contact/champion
- Expected construction year
- Statement of objectives
- Experimental design
- Estimated quantities and costs

- Evaluation schedule
- Reporting requirements

This work plan is important as it yields two additional benefits:

- FHWA will participate in the original construction, as appropriate, and repair, if the project should fail prematurely, at the percent funded during construction.
- Proprietary features may be specified without a public interest finding as otherwise required by FHWA. Also, in terms of state procurement laws and regulations, proprietary features can be sole sourced.

The ExPM may visit the project site prior to construction to document site conditions and delineate test and control sections.

4.1.2 Construction Report

The ExPM will be present during construction of each experimental feature to observe construction practices, especially those that may have an effect on performance. Following the construction of an experimental feature, the ExPM prepares a construction report to document construction practices and baseline conditions. All reports are distributed to MDT statewide, via listserv, and posted on the experimental projects website (https://www.mdt.mt.gov/research/projects/exp_sub_listing.shtml). This report includes the following information:

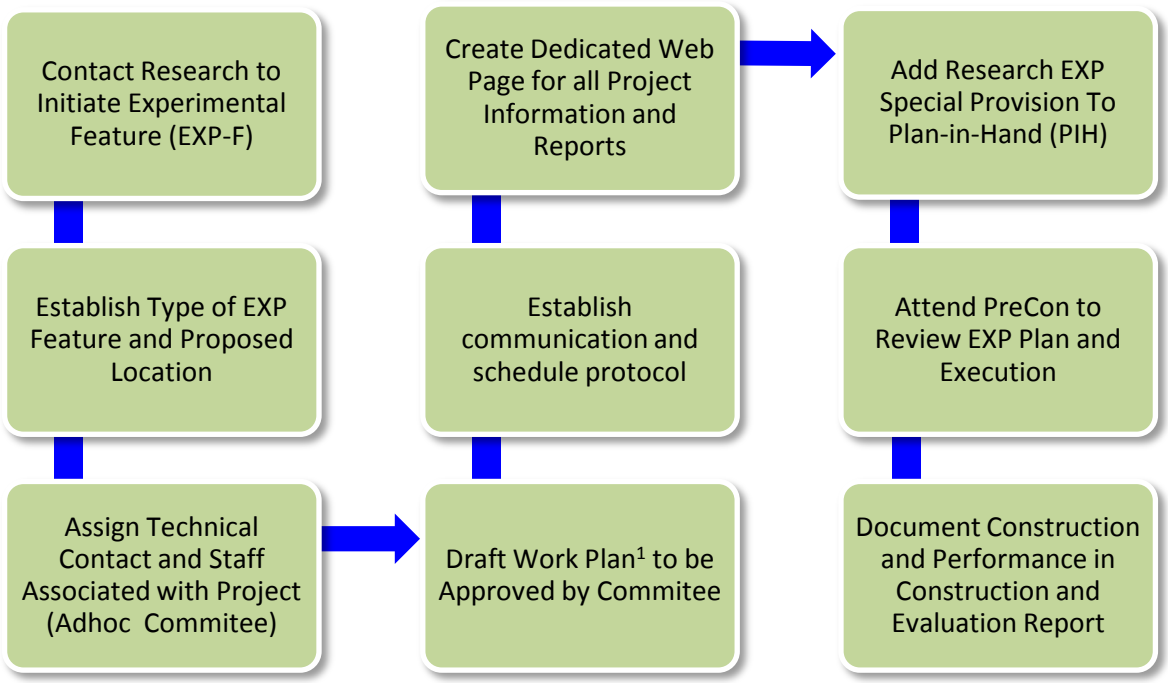
- Project location
- Project name
- Construction project number
- Experimental project number
- Project type/experimental feature
- Principal investigator
- Technical contact/champion
- Construction year
- Statement of objectives
- Experimental design
- Summary of materials and methods
- Quantity and cost of experimental feature
- Construction details
- Construction problems and a statement of how these problems might have been alleviated

4.1.3 Progress and Final Reports

Performance is evaluated as per the work plan, usually annually for a minimum of five years, unless otherwise indicated by the type of feature. Sometimes, evaluations continue beyond the initial five-year evaluation if needed to allow enough data to be collected to distinguish performance among the various test and control sections. Progress and final performance evaluations are documented and appended to the construction report. This process is documented in Figure 4.1. Annually, progress and final project results are presented to FHWA and MDT staff from Maintenance; Design; Construction; Materials; and District Offices, including the Field Research Coordinators and the District Construction Services Supervisors. This helps to ensure all parties are kept-in-the-loop with performance of the experimental features and creates a feedback loop from design to construction to maintenance and then back to design.

Finally, experimental projects are conducted in association with the Department's Product Acceptance Program. Two related AASHTO Technical Services Programs include:

- AASHTO Product Evaluation listing (APEL)
- National Transportation Product Evaluation Program (NTPEP)



1 The work plan (WP) contains project location, description and extent of experimental feature, how the EXP-F will be evaluated; schedule of installation, onsite evaluations, and reporting requirements. As a rule, all EXP projects should have a work plan.

Figure 4.1 Experimental Process Summary

Visit the MDT Research Programs website for additional information and current project reports at: http://www.mdt.mt.gov/research/

4.2 ACTIVE PROJECTS

4.2.1 3/8” Asphalt Cement Mix Placement with No Chip Seal Evaluation

Location:	Great Falls District , Cascade County, Interstate 15 (C000015), Approximate RP 282-283 (NB Lane Only)
Project Name:	Emerson Junction - Manchester
Project Number:	IM 15-5(124)282
Project Type:	Asphalt Concrete Pavement Evaluation
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2017
Inspection Dates:	Nov. 2017, May 2018, and Jan. 2019
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/asphalt-cement.shtml

Description:

This project is to determine how a 3/8" AC mix design performs without a chip seal compared to a 3/4" asphalt cement (AC) with conventional chip seal.

The two main measures of effectiveness of this project are to document: 1) visual distress of the pavement over time, and 2) the texture characteristics of the pavement. The Department’s Pavement Management section will conduct skid testing on both the 3/8" nonchipped and 3/4" chipped sections of the interstate for comparison annually. That data will be added to the report when available.

Analysis to Date:

No visual distress to report.

The Great Falls District has reported the results of Hamburg rut tests were peripheral with several of the samples marginally passing and several with signs of rutting.

Although test results did not initiate any rework on the project (possible pavement replacement), there may be potential for reduced service life of the AC pavement structure.

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4.2.2 3D Synthetic Geocomposite for Added Subsurface Drainage Layer in Asphalt Cement Pavement Structure Evaluation

Location:	Butte District, Gallatin County, State Highway 287 (P-87), R.P. 6.81-6.95
Project Name:	Jct. Raynolds Pass - Quake Lake
Project Number:	STPP 87-1(11)0
Experimental Project Number:	MT-15-02
Project Type:	Geocomposite Application
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2016
Inspection Dates:	Apr. and Aug. 2017, and Apr. and Oct. 2018
Project End Date:	2021

URL: https://www.mdt.mt.gov/research/projects/roadrain.shtml

Description:

This project is located on US 287 (P-87) in Gallatin County, from the junction with Montana Highway 87 (P-13) approximately 7.0 miles to southbound, toward West Yellowstone. Work to be performed includes cold milling, plant mix surfacing, seal and cover, guardrail installation, digouts, and signing and pavement marking.

As of four years ago prior to the new construction, the section of Highway 287 in question (R.P. 6.81-6.95) had deteriorated to the point a dig-out was performed and treated using usual methods of rehabilitation (geotextile, special borrow, CAC, PMS). The section has since failed, and the Department has installed a synthetic subsurface drainage layer (SSDL) under the assumption that water retention within the pavement layers deteriorated the structural base course, contributing to the premature failure of the pavement.

The Department elected to install Tensar RoaDrain 5 (TD-5) as an experimental feature in this project.

Analysis to Date:

No issues to report; no pavement distress apparent since installation of SSDL in October 2016.

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4.2.3 Bituminous Concrete Surface Treatments Evaluation

Location:	Great Falls District, Lewis & Clark, Teton, Pondera, and Glacier Counties, Highways US 89 and 287
Project Name:	Augustus North/SE of Dupuyer/US 89 N of Dupuyer
Project Number:	STPP-NHTSA 3-3(23)6/STPP 9-1(20)40/Maintenance Project
Project Type:	Pavement Surface Treatments
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Technical Contact:	Justun Juelfs, MDT Maintenance Reviewer
Construction Year:	2014
Inspection Dates:	Sep. 2014, Jun. 2015, Jun. 2016, Jun. 2017 and May 2018
Project End Date:	2019

URL: https://www.mdt.mt.gov/research/projects/seal_coat.shtml

Description:

The purpose of this project is to compare the following three types of surface applications under similar environmental and traffic conditions over time to determine the benefits of each treatment:

- Chip seal
- Fog seal over chip seal
- Microsurfacing

The Experimental Program will prepare long-term documentation on the installations in an attempt to establish performance with the surface applications and to ascertain applicable comparisons between the three projects and any other measurable outcomes.

Analysis to Date:

The spring 2018 site inspections mirror the same pavement condition as detailed in the 2017 inspection. All pavement treatments are performing well (other than the specific sites detailed in the MS section of the project). To date no specific trends of treatment performance is apparent; the next full project inspection will be in the spring of 2019.

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4.2.4 Centerline Contrast Striping and the Addition of High-Visibility Striping Material Evaluation

Location:	Missoula District, Missoula County, North Reserve St. Highway 93 (N 92) – Reference Point 0.0-5.4
Project Name:	Pavement Markings – Reserve St.
Project Number:	NH 92-1(12)0
Experimental Project Number:	MT-14-07
Project Type:	Enhanced Pavement Markings
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Technical Contact:	Gabe B. Priebe, P.E., Traffic Project Engineer
Construction Year:	2015
Inspection Dates:	Oct. 2015, Feb. 2016, Mar. 2016, *Oct. 2016, *May 2017, and *Apr. 2018
Project End Date:	2019

URL: https://www.mdt.mt.gov/research/projects/bead_technology.shtml

***** Informal Site Inspections

Description:

Human vision is tuned to detect edges of contrasting color or brightness. Concrete pavements are so light in color that during the day and at night (especially during wet conditions), white pavement markings appear to blend in with the pavement surface. To improve the visibility of pavement markings on light-colored pavements, markings are applied over the top of a compatible black marking material. The underlying black stripe is applied at a greater width than the actual marking so that it provides a contrasting border around the marking, basically to give the driver an increased preview distance.

For this project, a white-on-black centerline boxed contrast epoxy stripe was applied to Portland cement concrete pavement within a diamond grind (recessed) groove.

In addition, 3M Ceramic Elements and VISIMAX Plus striping beads were added to the conventional Type 2 glass bead in different test sections. The subject beads are claimed to provide increased retroreflectivity and radiance during wet, nighttime conditions.

Analysis to Date:

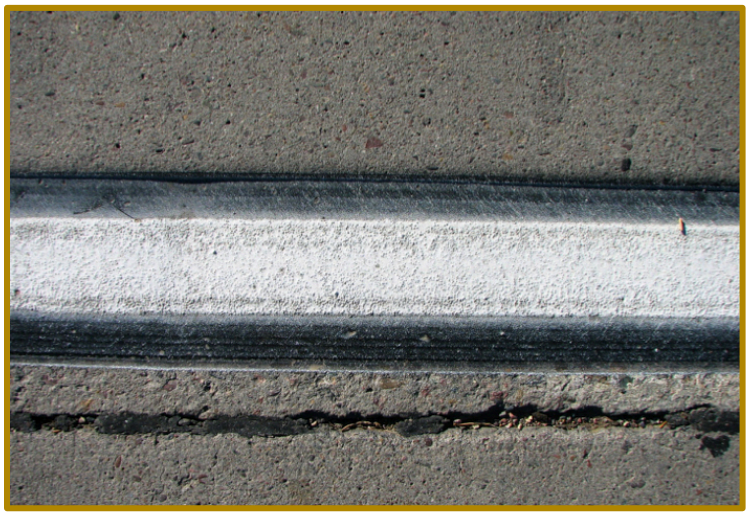
District staff reported that, soon after installation, delamination (or debonding) of the epoxy white stripe to the black underlying stripe was being observed. Research was informed of the stripe durability issue and conducted a site inspection in late February 2016; the inspection was then followed up with another inspection in late March 2016.

The main failure characteristic was a delamination (or debonding) of the white stripe from the black stripe. Field observations show the white epoxy stripe being removed in flakes or chunks by vehicle tire contact. Specifically, the areas with the most affected contrast stripes were intersections with a high level of traffic coupled with turning movements that offer the greatest contact with tire to stripe.

Since the initial debonding of the contrast stripe the District elected to replace those areas of failed stripe with 3M contrast pavement marking tape in the late fall of 2016. The 3M application is not part of the original intent of the project.

Research staff has informally inspected the site since the spring of 2017 to ascertain the level of performance of the tape and document the progression of delamination of the existing epoxy contrast marking.

Research will conduct a last inspection in the spring of 2019 to document the current project status and include those results in the current report as the final evaluation of the project.



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4.2.5 Centerline Rumble Strip Evaluation

Location: Missoula District, Lincoln County, US 2; RP 0.0-13.75
Project Name: 508 E/W
Project Number: N/A
Experimental Project Number: MT-17-04
Project Type: Centerline Rumble Strip
Principal Investigator: Craig Abernathy, Experimental Project Manager
Technical Contact: Justun Juelfs, Kalispell Maintenance Chief
Construction Year: 2017
Inspection Dates: April and September 2018
Project End Date: 2022
URL: https://www.mdt.mt.gov/research/projects/rumblestrip.shtml

Description:

This project is a centerline rumble strip (CLRS) longitudinal joint performance evaluation located in Lincoln County on US Highway 2 (C000001/N1), Missoula District, reference point 0.0 to 13.75. The 2016 average annual daily traffic through this corridor is 1539.

A centerline rumble strip is a longitudinal safety feature installed at or near the centerline of a paved roadway. On this project, the strip is a series of rectangular milled indents intended to alert distracted drivers (through vibration and sound) that their vehicles have left the travel lane.

Asphalt pavements are typically constructed with a longitudinal joint (or meet line) along the center of the road. Degradation over time may allow the entry of water, leading to early pavement deterioration. Rumble strips provide another potential reservoir to hold water and could accelerate this joint deterioration. Traffic and environmental characteristics may also affect joint performance.

This project has a test section of CLRS (TS1) adjacent to a control section on non-CLRS (CS2) to compare performance. TS1 begins at reference point (RP) 0.0 on the Idaho/Montana border

and runs east to the section transition CS2 at RP 8.2, which continues to RP 13.75 just east on the entrance to the township of Troy. TS1 pavement treatment was a mill and fill with CS2, a standard overlay.

Analysis to Date:

No issues at this time.

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4.2.6 Fog Seal Chip Retention Evaluation

Location:	Butte District, Gallatin County, Targhee Pass-West Yellowstone, State Highway 20 (N-12) – Reference Point 0.0-9.4
Project Name:	Targhee Pass-West Yellowstone
Project Number:	NH 12-1(20)0, UPN 8762000
Experimental Project Number:	MT-15-01
Project Type:	Fog Seal on Chip Seal
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2017
Inspection Dates:	April and October 2018
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/seal_coat.shtml

Description:

The project was nominated to compare whether the performance of a fog seal over the top of a chip seal (FSCS) will extend the service life (chip retention) of the pavement treatment compared to that of a conventional chip seal (seal and cover).

The area selected is a high mountain (average project elevation of 6800 ft.) section of state (secondary) highway with extreme weather conditions that maximize maintenance activities and has severely limited the effectiveness of past pavement preservation treatments.

The FSCS test section encompasses the westbound lane of the project length, with the eastbound lane serving as the conventional chip seal (CS) control section.

The level of objective relief (the visual appearance of the ratio of binder to the exposed vertical area of the aggregate) of the CS as compared to the level of an additional binder layer for an enhanced embedment of chip may show the FSCS creates a tighter bond with the aggregate. The level of texture is not an indicator of friction coefficient. The second objective is to ascertain the level of chip loss between the sections over time.

Analysis to Date:

The main measure of effectiveness is the average texture of embedded chip within the residual bitumen binder on the FSCS sections as compared to the conventional CS control.

Both lane treatments display good condition over the first winter season and subsequent 2018 fall inspection. During a complete drive through of the project, chip retention appears good with no visual indication of appreciable aggregate loss to date. Minimum voids were detected. There is some indication of minor flushing (or bleeding) in the fog sealed lane, more prevalent in the east portion of the project. The next site inspection will be in the spring of 2019.

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4.2.7 Fog Seal Over Chip Seal Evaluation

Location:	Missoula District, Mineral County, Interstate Highway 90 (C-000090), RP 5.7-23.3
Project Name:	Exit 5 – East – CN 8954000
Project Number:	IM 90-1(220)6
Experimental Project Number:	MT-18-02
Project Type:	Fog Seal on Chip Seal
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2017
Inspection Dates:	Oct. 2017, Apr. 2018 and Oct. 2018
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/seal_coat.shtml

Description:

This project was implemented to determine the performance of an applied fog seal to chip seal (FSCS), which may extend the service life of the pavement treatment (chip retention) compared to the conventional practice of a chip seal (seal and cover).

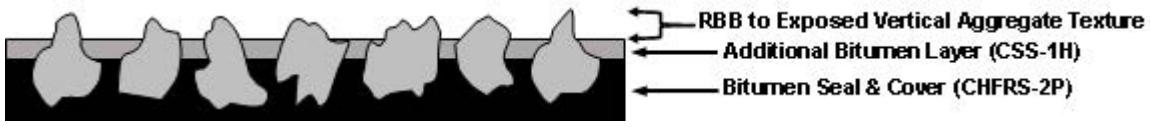
The area selected is a high mountain (average project elevation of 6800 ft.) section of state (secondary) highway with extreme weather conditions that maximize maintenance activities and has severely limited the effectiveness of past pavement preservation treatments.

The FSCS section encompasses both the westbound and eastbound lanes of the interstate.

The objective of the project is to determine if the selected emulsion (CSS-1H) will add additional reinforcement of the embedded type III chip (within the conventional seal using CHFRS-2P) to enhance the residual bitumen binder (RBB) on the FSCS section. The level of objective relief (the visual appearance of the ratio of binder to the exposed vertical area of the aggregate (as seen in the diagram below) may offer a tighter bond with the RBB (the level of texture is not an indicator of friction coefficient).

Analysis to Date:

The Exit 5 fog sealed section as of October 2018 exhibits good chip retention. The fog seal bitumen coating has flaked off the surface of the aggregate, which is normal. No maintenance issue to report. Next inspection will be the spring of 2019.



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4.2.8 High Friction Surface Treatments for Bridge Decks Evaluation

Location:	Missoula District, Kalispell-Flathead River: Highway 35
Project Name:	East of Kalispell (constructed 2014)
Project Number:	HSIP 52-2(38)49
Experimental Project Number:	MT-12-10
Project Type:	Poly-Carb Mark: 135 Safe-T-Seal/163 Flexogrid
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2014
Inspection Dates:	Mar. 2015
Project End Date:	2019
URL for all:	https://www.mdt.mt.gov/research/projects/polycarb.shtml

Location:	Glendive, Roundup-Musselshell River: Highway 87
Project Name:	South of Roundup (constructed 2014)
Project Number:	HSIP 16-2(14)47
Experimental Project Number:	13-01
Project Type:	Poly-Carb Mark: 135 Safe-T-Seal/163 Flexogrid
Construction Year:	2014
Inspection Dates:	Apr. to May 2016
Project End Date:	2019

Location:	Billings, Big Timber-Yellowstone River: Highway 191
Project Name:	Big Timber North (constructed 2014)
Project Number:	STPP 45-1(26)0
Experimental Project Number:	14-05
Project Type:	Dayton Superior: Unitex High Surface Friction
Construction Year:	2014
Inspection Dates:	May to Oct 2017
Project End Date:	2019

Location:	Missoula, Bigfork-Swan River Bridge: Highway 35
Project Name:	Safety Improvement Bigfork (constructed 2015)
Project Number:	HSIP 52-2(44)31
Project Type:	Dayton Superior: Unitex High Surface Friction
Construction Year:	2015
Inspection Dates:	Apr. 2018
Project End Date:	2020

Description:

High friction surface treatments (HFSTs) are pavement surfacing systems that provide skid-resistant and deck sealing properties not typically associated with conventional materials. The spot application of a thin layer of durable, high friction aggregates (Armorstone) as a topping on specially engineered resin or a polymer binder affords long-lasting traction (as stated by manufacturer information), while making the overlay much more resistant to wear and polishing.

MDT initiated this project to apply these treatments to the aforementioned selected decks in an effort to validate the added friction and durability claims.

Analysis to Date:

All deck surfaces reflect the same condition as noted in the 2017 documentation. There is pronounced polishing of the aggregates; however, epoxy bonding is intact with the exception on the MT35 Kalispell deck. This deck has areas of polymer delamination on the east span of the deck approach and increased loss of aggregate texture predominately in the wheel paths.

In September 2018, due to poor skid numbers and increased delamination of the polymer overlay, the District elected to repair the failed sections and apply another single layer lift to the deck.

The next project-level inspections will be conducted in the spring of 2019.

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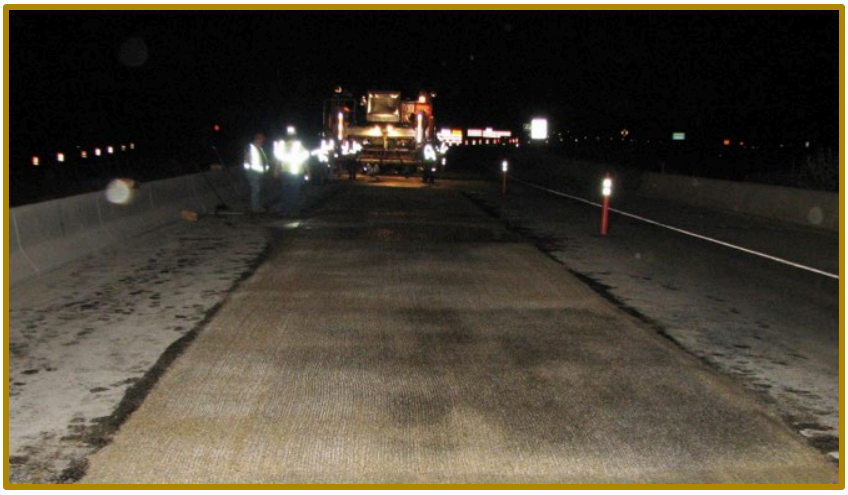
4.2.9 Kwik Bond 1121 Polyester Polymer Concrete Overlay Evaluation

Location:	Billings District, Stillwater County, Interstate 90, Three Decks: SEP County Road (I00090391+00402), Berry Creek (I00090400+03661), Berry Creek (I00090400+03662)
Project Name:	Br Deck Rehab/Repair 11
Project Number:	BH STWD (043) - CN 6837000
Experimental Project Number:	MT-13-05
Project Type:	Bridge Deck Rehabilitation
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Technical Contact:	Jeff Olsen, Bridge Bureau, Billings District
Construction Year:	2014
Inspection Dates:	Oct. 2014, Oct. 2015, Jun. 2016, Oct. 2017 and May 2018
Project End Date:	2019

URL: https://www.mdt.mt.gov/research/projects/kwikbond.shtml

Description:

This project is a bridge deck rehabilitation system using an engineered composite polyester polymer concrete (PPC) overlay system that (per manufacturer's information) can rehabilitate ride defects; seal out moisture, oxygen and chloride ions from permeating into the deck; and return traffic in two hours (based on thickness of overlay and environmental conditions) at temperatures down to 40°F**.**



The Kwik Bond 1121 PPC overlay was applied on three (3) designated bridge decks for the purpose of extending the life of the deck and restoring skid resistance. Overlay thickness was on average measured at 1.25" (3.2 cm). Deck surfaces were prepped by sand and shot blasting. A high molecular weight methacrylate sealer was applied to the deck surface prior to the overlay application.

Analysis to Date:

The Berry Creek and Sep County Road westbound structures are beginning to exhibit distress similar to punchouts down to the first mat of rebar, mainly in the travel lane at a proximity to the asphalt cement pavement and deck transverse joint. Some of the affected areas have previously been patched. In addition, visually, the wheel paths in the structure are exhibiting wear not seen in past inspections. The Department may want to perform skid testing to determine if skid resistance is within a reasonable range.

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4.2.10 Reinforcing Fibers in Plant Mix Asphalt Cement Evaluation

Location: Billings District, Yellowstone County-Billings, Division St. and 6th Ave N (27th to 32nd)
Project Name: Division St.-Billings and 6th Ave. N-27th to 32nd
Project Number: UPPIP 1017(2)7/UPPIP 1029(4)
Experimental Project Number: MT-18-03
Project Type: Sasobit-Aramid Fiber Reinforced Asphalt Cement
Principal Investigator: Craig Abernathy, Experimental Project Manager
Construction Year: 2018
Project End Date: 2023
URL: https://www.mdt.mt.gov/research/projects/fiber-rac.shtml

Description:

The Billings District incorporated synthetic fibers as an additive to improve asphalt cement (AC) properties. This is the first trial in the state that has used AC fiber reinforcement in a pavement preservation application. The intent of this chosen admixture is to improve resistance to cracking and rutting, a higher dynamic modulus, and increased service life.

Surface Tech is the chosen vendor to supply Ace Fiber (pretreated aramid fibers coated with Sasobit wax) used in the production of fiber reinforced asphalt cement (FRAC). Surface Tech was on site to monitor the inclusion of the Ace Fiber during AC production. Surface Tech also furnished the Ace Fiber Line-Vac delivery system, which is the device that introduces the fibers into the drum mixer. Over 18 million Aramid fibers are dispersed for each ton of mix to provide three-dimensional reinforcement.

Because untreated aramid fiber is a very lightweight material and difficult to work with, the fibers are soaked in a wax binder. This pretreatment adds weight to the fiber clips and prevents them from blowing away or clumping during the delivery and feeding process.

Analysis to Date:

No issues were reported in connection with the Ace Fiber addition at the AC production plant. The FRAC paving went well and to date no visible pavement distress is reported. The AC fiber production phase was conducted in July 2018.

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4.2.11 Seal Coat Asphalt Emulsion (or Fog Seal Coating) Over Chip Seal for Improved Chip Retention Evaluation

Location:	Mineral County, Interstate 90 (C000090)
Project Name:	Taft-West
Project Number:	IM 90-1(215)0
Project Type:	Work Type: 183 – Resurfacing – Seal and Cover
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2015
Inspection Dates:	June 2016 and *April 2017 and 2018
Project End Date:	2019

URL: https://www.mdt.mt.gov/research/projects/seal_coat.shtml

***Informal Site Inspections

Description:

The purpose of this project is to determine the effectiveness and added durability of applying a fog seal (SS1 asphalt emulsion) to a chip seal (CS). The goal is to reduce aggregate loss and maximize surface friction in an environment of extreme fluctuations in temperature and numerous snow removal activities.

The project will compare a conventional chip seal procedure to a fog seal over chip seal (FSCS) application on a section of Interstate 90 beginning at reference point 0.0 (Idaho border) east to approximate reference point 5.7 (Taft Area interchange). The project will use Type 2 cover material (1/2" chip). Traffic (2015 data) puts an average annual daily traffic at approximately 7600 with a 30 percent calculated commercial load.

Analysis to Date:

The main measure of effectiveness is the average texture of embedded chip within the residual bitumen binder on each of the test sections as compared to the control directly in an area which, historically, is difficult to maintain an effective chip seal. The project area will be reviewed semiannually with reporting once per year.

District staff reported a high rate of plow passes during the 2015/16 and 2016/17 winter seasons. Even with the additional application of emulsion to the chip seal aggregate loss was almost identical to the conventional CS sections. The FSCS portion of the project could be measured as having a slightly better performance than the CS, but that margin of performance may be minimized with the next cold weather period.

Conversely, there are intact sections of CS and FSCS on the project as well. Most of the distress observed is at the higher elevation portions of the project and where roadway curves are present. With almost 23 lanes miles on the project, it is difficult to ascertain the percentage of distress areas of pavement to those still intact.

Overall, the addition of the fog seal appeared to perform comparably to the control. The majority of the distress observed was located in the travel lane, which indicates traffic factors as an indicator of performance. That effect, combined with the severe environment and substantial snow plow miles this corridor receives, may result in the additional benefit of the FSCS being only marginal.

Research is still conducting informal site inspections since it is in the vicinity of other experimental projects. However, 2019 will be the last formal inspection with visual documentation of the site to close out the project.

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4.2.12 Sinusoidal Centerline Rumble Strip Evaluation

Location: Glendive District, Rosebud County, MT-39; RP 31-32.4
Project Name: Sinusoidal CLRS-Colstrip
Project Number: UPN 9370
Experimental Project Number: MT-18-02
Project Type: Centerline Sinusoidal Rumble Strip
Principal Investigator: Craig Abernathy, Experimental Project Manager
Construction Year: 2018
Project End Date: 2023
URL: https://www.mdt.mt.gov/research/projects/sclrs.shtml

Description:

The purpose of this project is to demonstrate the application of a sinusoidal centerline rumble strip (SCLRS) and evaluate performance. The 2017 average annual daily traffic through this corridor is 1235.

Centerline rumble strips are extremely effective in reducing severe roadway departure crashes at a low cost. Rumble strips use both noise and vibration to alert a driver that their vehicle is leaving the travel path. To be effective, the noise generated inside the vehicle must rouse a drowsy driver or grab the attention of a distracted driver. Since there is a wide range of "drowsiness" and "distraction" inside the vehicle compartment, more noise is typically better.

Conversely, the noise generated outside the vehicle can be disruptive to residents or businesses in the area, and the goal is to produce as little sound as possible broadcast outside the vehicle and still maintain the needed noise level for safety. The focus of this project is to document the method of installation and equipment used to apply this feature and to compare the current noise level of the conventional strips the Department now deploys to the sinusoidal rumble strips on this project.

The following indicates the SCLRS design parameters:

- Design S1: 14” longitudinal frequency, 12” wide, 1/8” to ½” depth frequency
- Design S2: 24” longitudinal frequency, 12” wide, 1/8” to ½” depth frequency
- Design S3: 14” longitudinal frequency, 14” wide tapered, 1/8” to ½” depth frequency
- Design S3A: 24” longitudinal frequency, 14” wide tapered, 1/8” to ½” depth frequency

Analysis to Date:

No issues with installation were reported. All design sections were fog sealed and restriped. No visual distress to the strips is noticeable. It is anticipated that decibel testing will be performed to determine adequate vehicle interior and roadside noise levels. If and when those tests take place, test results will be added to the online construction report.

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4.2.13 Sprayroq SprayWall Polyurethane Applied Culvert Rehabilitation Evaluation

Location:	Missoula District, Mineral County, Interstate 90, Reference Point (RP) 59, Nemote Creek Crossing
Project Name:	I-90 Nemote Creek Culvert
Project Number:	IM 90-1(205)59 – Work Type 312: Structure Safety
Experimental Project Number:	MT-13-14
Project Type:	Culvert Rehabilitation
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2017
Inspection Dates:	Apr. 2017 and 2018, and Jan. 2019
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/spraywall.shtml

Description:

The project is located at the crossing of Nemote Creek on Interstate 90, at RP 59.0 ±; approximately two miles west/north of the Tarkio Loop Road interchange, and 1.3 miles east/south of the Quartz Flats westbound rest area. The eight (8) gauge steel plate pipe culvert (SPPC) is 242 linear feet, and has an interior radius of 12 ft.

Bulging and sagging of the steel-plated panels located near the east end of the culvert were noted in 2006 and remedial action was recommended in May 2013. Maximum deflection within areas of deformation was roughly estimated to be 6 inches located in the upper plates of the pipe. The purpose of the rehabilitation effort is to improve the structural capacity of the pipe to reduce the chance of a culvert failure that would impact the I-90 roadway.

Due to site constraints and apparent minimal change in the areas of deformation over the past seven years, the Department used a cure-in-place-pipe (CIPP) process to provide structural enhancement and corrosion resistance.

The selected product is Sprayroq's catalyzed, two-component coatings, SprayWall. SprayWall is a procedure using self-priming, spray-applied structural polyurethane coating as the lining medium. The manufacturer states the lining allows return to active service within an hour of application.

The extent of the treatment will encompass the culvert inlet to approximately 30 ft. down flow into the culvert with a 360° SprayWall application. Areas of the apparent deformation will receive a thicker application of SprayWall.

Analysis to Date:

The SprayWall treatment appears to be intact with no visual evidence of separation or cracking.

During the April 2017 inspection, it was noted that areas of the steel plate seams and bolt connections received an additional (apparently hand-applied) application of SprayWall most likely applied soon after installation.

Information from District staff states the issue of moisture seepage (a condition evident in the culvert preparation phase) was observed after the initial SprayWall application was completed and required spot patching to eliminate the migration of moisture. Although the contractor attempted to check the leaks through the use of expanding sealants, 100 percent containment was not possible.

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4.2.14 T15 Base One Soil Stabilization Evaluation

Location:	Glendive District, Valley County-City of Nashua, Montana Route 117 (P-17)
Project Name:	Milk River – North
Project Number:	STPP 17-1(10)11
Experimental Project Number:	MT-18-05
Project Type:	Full-Reclamation Chemical Soil Stabilization
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2018
Project End Date:	2023

URL: https://www.mdt.mt.gov/research/projects/t5baseone.shtml

Description:

The project is located on Montana Route 117 (P-17) in Valley County from the north end of the Milk River bridge extending north approximately 1.91 miles to the new alignment and intersection of MT 117 and (NHS/NI) US2. Test sections will also include the old stretch of MT 117 through the town of Nashua (Front and Sargent streets).

The pavement sections located on this project were in variable condition with significant cracking, large partial and full-width patched sections and isolated repaired potholes. The pavement was generally considered to be in poor to fair condition. It was decided that full-depth reclamation was needed to restore the efficacy of the pavement and to employ a soil stabilizer to enforce the integrity of the pavement structure.

The chosen soil stabilizer (SS) is Team Labs T15 Base One, a proprietary blend of silicic acid and sodium salt. Six (6) test sections were installed on the project. A road reclaimer was used for pavement reclamation and for the homogeneous mixing/injection of the SS. The SS application rate was set at 0.005 (0.5 percent) gallons per square yard per inch of reclamation depth.

A Tetra Tech representative, one of the subcontractors on the project, was on hand to assist with and monitor the reclamation and application phases of the Base One soil stabilizer.

Analysis to Date:

Since construction in spring of 2018, no construction issues were reported during the Base One application phase. The paving phase went well, with no pavement distress to report.

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4.2.15 TenCate Mirafi H_2Ri – High-Strength Woven Geosynthetic with Wicking Capability to Mitigate Frost Heave Distress Evaluation

Location:	Glendive District, Valley County, Highway 117 (P-17), RP 7.17-7.36
Project Name:	FT Peck – NE
Project Number:	STPP 17-1(7)0
Experimental Project Number:	MT-13-13
Project Type:	Frost Heave Mitigation
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Technical Contact	Donald Berg, Glendive District Geotechnical Manager
Construction Year:	2016
Project End Date:	2021
Project URL:	https://www.mdt.mt.gov/research/projects/tencate.shtml

Description:

A significant section of pavement distress was observed on Highway 117, reference point 7.17 to 7.36, beginning near the G-C Road. Residents have reported worsening roadway conditions in the winter, suggesting that frost heave is the underlying cause of the distress. For frost heave to develop, the soil must be frost-susceptible, temperatures must be subfreezing, and there needs to be a source of water.

Based on the site investigation, it has been determined that all three of these conditions are met. The subgrade soils have been identified as Fat Clay, the northern climate is conducive for freezing temperatures, and adjacent wetlands and irrigated fields influence the soil moisture. Combined, these conditions indicate a high potential for frost heave.

The proposed grade is higher than the present traveled way, which will help mitigate the frost heave. However, a capillary break is recommended to eliminate future pavement distress. Usually, this is accomplished with open-graded gravel and separation geotextile. The Department is interested in a newly available, high-strength woven geosynthetic product.

The chosen geotextile (TenCate Mirafi H_2Ri) has wicking (or capillary) characteristics capable of breaking the vertical movement of moisture through the embankment (per manufacturer information). This is accomplished by integrated hydrophilic and hygroscopic fibers that provide wicking action through the plane of the geosynthetic.

Analysis to Date:

Due to the extensive instrumentation sensor arrays installed on the project to monitor moisture infiltration and migration, the Department's Geotechnical Section is tasked with the formal reporting of the performance of the Mirafi geotextile. Due to the amount of data to be analyzed to support a statistical trend, that report may not be available until 2020.

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4.2.16 TenCate Mirafi MPV400 Polypropylene Nonwoven Geotextile Evaluation

Location:	Great Falls District, Cascade County, U-5201; Smelter Ave. NW – 5th St. NW to 1st St. NW
Project Name:	Smelter-1st to 5th St NW
Project Number:	8978000 UPP 5201(24)
Experimental Project Number:	MT-17-03
Project Type:	Milled Overlay with Paving Fabric
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2017
Inspection Date:	Apr. 2018
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/tencate-mirifi-mpv400.shtml

Description:

The project is located in Cascade County within the township of Great Falls on route U-5201 (C005201), Smelter Ave. NW, beginning at RP 2.5, at 5th St NW and extending approximately 0.4 miles east ending at RP 3.0, 1st St NW. This is a pavement preservation project involving a cold mill, overlay and added paving fabric.

The purpose of adding the designated paving fabric on the prepared milled surface is to aid in extending the service life of the pavement. As claimed by the manufacturer, TenCate Mirafi MPV400 nonwoven asphalt overlay fabric forms a membrane that minimizes surface water from penetrating pavement systems and provides a stress relief interlayer that inhibits the growth of reflective cracks. Produced from polypropylene staple fibers, TenCate Mirafi is heat-set to provide a waterproofing barrier.

Analysis to Date:

No issues to report since installation. No visible pavement distress documented to date.

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4.3 COMPLETED PROJECTS

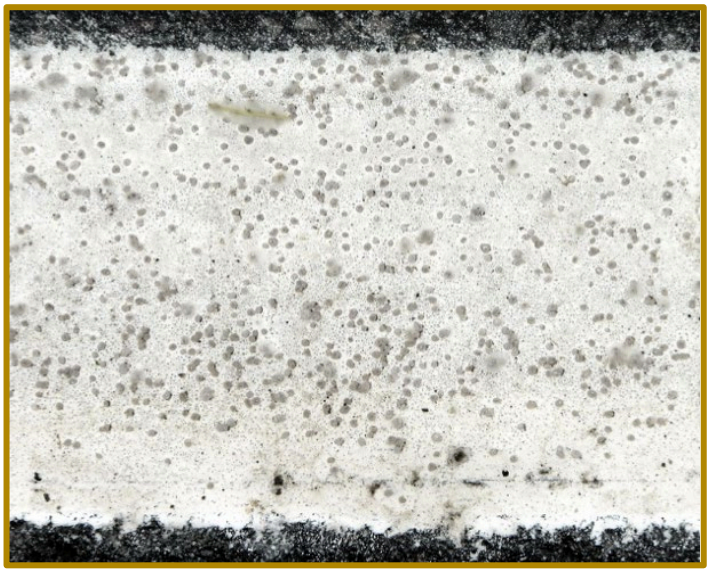
4.3.1 3M Wet Reflective Ceramic Elements and Potters VISIMAX Plus New Bead Technology Evaluation

Location:	Billings District, Carbon and Yellowstone Counties, US 310/US 212 (N4) Approximate Reference Point 43-53
Project Name:	Rockvale - Laurel
Project Number:	HSIP 4-1(63)43
Experimental Project Number:	MT-12-12
Project Type:	Pavement Markings Retroreflectivity
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2013
Inspection Dates:	Jul. 2018 (final annual evaluation)
Project End Date:	2018

URL: https://www.mdt.mt.gov/research/projects/bead_technology.shtml

Description:

The purpose of this project is to evaluate the effectiveness of 3M Ceramic Elements and Potters VISIMAX Plus when blended with conventional MDT Type 2 glass beads in highway pavement markings.



3M Ceramic Elements wet-reflective dual-optic beads (1.9 and 2.4 reflective-index bead blend) are microcrystalline ceramic beads embedded on a center core to provide added reflectivity for pavement markings under wet conditions. The 3M system combines standard glass beads with the ceramic elements blend to maintain optimal visibility, as described by the manufacturer.

Potters VISIMAX Plus incorporates beads three to four times the diameter of conventional beads with high-clarity glass to allow for maximum retroreflectivity in wet conditions. Thousands of high-index beads form the outer VISIMAX shell.

These elements are claimed to provide increased retroreflectivity during wet conditions, allowing states to recess a 20-mil-thick stripe in a 60-mil-deep grind resulting in an increased durability during plowing seasons. The increased retroreflectivity during wet conditions was also being evaluated to determine the effectiveness as safety treatment. These treatments will only be applied on the white striping (fog lines).

Final Analysis:

All project test and control section white lines placed in the 60-mil grooved recess are in appropriate shape with no appreciable visible distress due to environmental factors or from snow plow activities. The grooved pavement has allowed the white markings to remain in good visible condition.

As noted in the report, the 3M and VISIMAX sections have lost a proportion of bead elements from the binder, either from inadequate embedment, environmental factors, vehicle tire impact, or successive plow passes may be wearing the pavement surface to a point where top contact with the recessed stripe is now beginning to take place.

One of the main measures of effectiveness of the project was satisfactory retroreflectivity measurements. Unfortunately, the District was only able to take some of the scheduled retroreflectivity measurements, which are not enough to support statistical defensibility for the performance evaluation.

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4.3.2 Break-Out Square Post Breakaway System Evaluation

Location:	Billings District, Yellowstone County, Montana and Central Ave Jct.
Project Name:	Break-Out Square Post
Project Number:	N/A
Experimental Project Number:	MT-12-08
Project Type:	Sign Post Breakaway Trial
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2013
Project End Date:	2018

URL: https://www.mdt.mt.gov/research/projects/break_out.shtml

Description:

The purpose of this project is to determine the effectiveness of the break-out square (BOS) post coupler as a possible alternative to other breakaway devices. This product is designed to (upon impact) break flush with grade with no damage apparent to base or anchor which allows the new sign post quick insertion into the undamaged base and a quick turnaround to get the sign back in service.

Final Analysis:

The District notified Research in May of 2014 that the sign unit had taken a vehicle hit and was down. Upon a site visit it was found the breakaway unit had performed exactly as designed, snapping flush with the median surface with all sign components intact.

Based on initial performance of the BOS unit, the city of Billings elected to install additional breakaway posts at selected sites. Research was asked to replace and document the fix if any of these units were hit and required sign replacement. To date, the District has reported no incidents of the BOS units needing sign replacements.

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4.3.3 Contech A-2000 Polyvinyl Chloride Plastic Pipe Evaluation

Location:	Butte District, Meagher County, U. S. Highway 12/P-14 (C000014)
Project Name:	Checkerboard - Martinsdale (CN 4803000)
Project Number:	STPP 14-2(20)63
Experimental Project Number:	MT-12-02
Project Type:	Polyvinyl Chloride (PVC) Irrigation Pipeline Installation
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2012
Inspection Dates:	Apr. 2013, May 2014, Mar. 2015, Apr. 2016 and Sep.2017
Project End Date:	2018

URL: https://www.mdt.mt.gov/research/projects/a2000.shtml

Description:

The purpose of this project is to determine the effectiveness and long-term durability of the Contech A-2000 PVC pipe in an irrigation application. A-2000 is a corrugated PVC plastic pipe with a smooth interior wall that is designed for use in storm drain and sanitary sewer applications. Contech Construction Products Inc. manufactures the pipe. Two diameter sizes for three locations were used: 18" (45.7 cm) and 24" (61 cm).

Final Analysis:

Research documented the installation for best practice and any construction concerns germane to the performance of the product. Annual inspections reported on the pipe components' integrity and any other measurable outcomes. District Maintenance reported no issues with the A-2000.

This project is final with the A-2000 PVC exhibiting no performance issues during the time frame of the evaluation.

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4.3.4 Conventional Chip Seal Under an Overlay to Mitigate Reflective Cracking Evaluation

Location:	Billings District, Big Horn County, Secondary 313; C000313 – MP Reference approximately 27
Project Name:	St. Xavier N and S
Project Number:	SFCS 313-1(18)22
Project Type:	Conventional Chip Seal Under an Overlay (76mm-0.25') to Mitigate Reflective Cracking
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2008
Inspection Dates:	Jul. 2018 (final annual inspection)
Project End Date:	2018
Project URL:	https://www.mdt.mt.gov/research/projects/chipseal.shtml

Description:

This project consists of a conventional chip seal (CS) as an interlayer on an existing pavement prior to an overlay (0.25’ PMS thickness). The intent of the chip seal was to seal existing cracks and test the potential in retarding reflective cracking.

The project is located on Secondary 313, at the mile reference 27 (just south of St. Xavier). Two 305-meter (1000') sections encompass the experimental design.

Final Analysis:

Since installation in 2008, only two low-severity cracks in the control section were documented. No additional visual distress (transverse crack) has occurred since 2015.

Although no cracking has yet to be identified in the test section, with only two data points detected in the control section, any conclusion of the efficacy of the CS interlayer is difficult to quantify.

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4.3.5 Crack Sealing Milled Pavement to Reduce Transverse Cracking Evaluation

Location:	Great Falls District, Teton County, Interstate 15, Approximately Milepost 312; Northbound Lanes
Project Name:	Dutton N and S
Project Number:	IM 15-6(35)309
Project Type:	Crack Sealing of Milled Asphalt Concrete Pavement
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2005
Inspection Dates:	2018 (last annual inspection)
Project End Date:	2018

URL: https://www.mdt.mt.gov/research/projects/crack_sealing.shtml

Description:

This project sought to determine if crack sealing milled pavement prior to overlay will deter the migration of transverse (or reflective) cracking, or have an effect on pavement performance, when compared to an adjacent milled pavement section that received no crack sealing treatment.

Two 1000-foot sections were delineated during construction in the I-15 northbound lanes at approximately milepost 312. One section received the normal crack seal procedure and the second section received no treatment. A 100-foot transition zone separates the two sections. A crack map of the sections is included in the report to compare the progression of cracks to both sites.

Final Analysis:

Although data presented in the report is minimal even with a 13-year evaluation time frame, it may suggest that crack sealing milled pavement may not have mitigated reflective cracking as once believed.

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4.3.6 Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS) Evaluation

Location:	Great Falls District, Pondera County, Highway 89 (P-3/C000003), South Fork Dry Fork Marias River Crossing
Project Name:	S.E. of Dupuyer – S.E.
Project Number:	STPP NHTSA 3-3(23)65
Experimental Project Number:	MT-12-04
Project Type:	Geosynthetic Reinforced Soil-Integrated Bridge System Installation
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2013
Inspection Dates:	Jul. 2014, Jun. 2015, Apr. 2016, May 2017 and May 2018
Project End Date:	2018

URL: https://www.mdt.mt.gov/research/projects/grs_ibs.shtml

Description:

GRS-IBS is a system that uses a series of alternating layers of granular fill material and fabric sheets of geotextile to create a composite reinforcement that provides support for the bridge slab.

The combination of the compressive strength of the granular soil and the tensile strength of the geotextile results in a very strong internally supported structure that is able to handle a substantial load. Furthermore, this design provides a smooth transition from the roadway to the bridge since the construction is jointless and has no approach slab.

Construction time is reduced due to a number of factors, such as the use of very little concrete as compared to conventional abutment designs, which can take up a sizeable amount of project time. Also, significant cost savings are realized through the combination of reduced labor costs from shorter construction time due to simpler construction techniques.

Final Analysis:

The GRS-IBS Dupuyer structure was first checked for deck grade on 10/25/13 post bridge construction. It was then checked on 3/30/14. There was an average of 0.01 ft. (0.03 cm) of settlement on all four corners of the bridge deck from the original survey. The second check of settlement on 7/29/2014 registered at -0.08 (0.2 cm); the third check of settlement on 6/1/2015 was at -0.03 (0.08 cm). This fluctuation of settlement is considered normal with the GRS-IBS design.

Pavement approaches to slab transition are smooth. As noted in the 2014 inspection, several of the fascia concrete mason unit blocks were cracked. Several more have cracked since then; MDT staff has sprayed paint as a locator on the current visible cracks. To date, this block cracking is not seen as an indicator of performance. No visible structural anomalies are visually apparent.

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4.3.7 Profile Wall PVC Pipe Storm Drain Trunkline and Laterals in Mainline Evaluation

Location:	Glendive District, Miles City, Tatro St. and Milwaukee St. (U-8104)
Project Name:	Tatro Street-Miles City
Project Number:	STPU 8014(1), CN 7077000
Experimental Project Number:	MT-12-11
Project Type:	Polyvinyl Chloride (PVC) Storm Drain Lines
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Technical Contact:	Marc Wotring, P.E., Glendive District Hydraulics Engineer
Construction Year:	2014
Project End Date:	2018

URL: https://www.mdt.mt.gov/research/projects/pvc.shtml

Description:

This project entailed the installation of profile wall polyvinyl chloride (PVC) plastic pipe (18"/45.7cm and 12"/30.5cm), meeting ASTM F949, for use in an urban project comprised of a new trunkline and lateral connections. Profile wall PVC will also be used for connection into the existing storm drain laterals east of the Tongue River Slough. Based on specifications, the Contech A-2000 PVC pipe was selected for this project by the contractor.

Per information from District staff, installation went as planned with no construction issues reported that may affect future performance of the PVC.

The project's bedding specifications had stated the PVC pipe be installed per manufacturer's installation guidelines and bedded per the plan detail for flexible pipe, allowing bedding material to be left uncompacted under the pipe with the haunch and side and top fill placed in 8-inch lifts supplemented by vibratory compaction. However, due to the material properties and gradation of the supplied aggregate, it was determined that dropping the bedding by bucket achieved the necessary 85 to 90 percent compaction rate required for an adequate pipe embedment.

A deflection gauge (mandrel) was used to test the flexible pipe for out-of-roundness or deflection per ASTM specifications (distortions greater than 5 percent of the nominal pipe diameter); no issues were reported.

Final Analysis:

Due to the nature of the experimental project (i.e., limited access), annual site evaluations were not possible. A point of contact was established with the Miles City Public Utilities Office to be a direct liaison to the Glendive District office on any issue involving the PVC pipe post-construction.

Based on review of any issues, the District will determine if Research staff will be contacted for a site visit to document or address any problems until the end of the five-year evaluation time frame. Since construction, the District has had no issues of performance, and this project will be considered as final.

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4.3.8 Smart Cushion Innovations 100GM Crash Attenuator Evaluation

Location:	Missoula District, Mineral County, Interstate 90 (C000090), Approximate reference point 6-7
Project Name:	Taft-West
Project Number:	IM-90-1(84)0
Experimental Project Number:	MT-11-04
Project Type:	Crash Attenuator
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	2012
Inspection Dates:	Apr. 2013, Feb.2014, Mar. 2015, Apr. 2016, Jun. 2017 and Apr. 2018

URL: https://www.mdt.mt.gov/research/projects/sci.shtml

Description:

The purpose of this project is to determine the effectiveness of the SCI100GM in a mainline application. The SCI100GM is a fully redirective, speed-dependent, non-gating, bi-directional crash attenuator with a reverse-tapered design to eliminate side panel stress during a collapse. In addition, it has a low angle of exit on side impacts (<1°) to keep vehicles from rebounding back into traffic.

The hydraulic porting of the attenuator is designed so that the proper resistance is applied to stop the vehicle before it reaches the end of the cushion's usable length. Per the manufacture's information, this device, based on a frontal impact, may be reset and back in service under an hour with minimum cost.

Goals:

- ★ Document all processes pertaining to the installation procedures.
- ★ Install the device at strategic locations with high impact rates in an effort to determine:
  - ➢ Performance during an impact,
  - ➢ Repair procedures following impacts,

- Cost of repair and time required to fully repair product,
- Maintenance feedback following the repairs, and
- Any adverse effects of sanding and anti-icing agents on the cables, cylinder system, side guides, or front rollers.

Analysis to Date:

There have not been any collisions with these devices in the five-year evaluation period. All units (3) are in service. If any of the units are activated due to a collision, Research staff will document the process at that time and add that information to the existing report.

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4.3.9 TAPCO Blinker Chevron Traffic Control Signage

Location: Butte District, Madison County, MT Highway 41 (P-49) Reference Point 14.3
Project Name: Curve Near Beaverhead Rock
Project Number: HSIP 49-2(10)14
Experimental Project Number: MT-12-09
Project Type: Sequential Dynamic Curve Warning System
Principal Investigator: Craig Abernathy, Experimental Project Manager
Construction Year: 2013
Project End Date: 2018
URL: http://www.mdt.mt.gov/research/projects/tapco.shtml

Description:

The purpose of this project was to install a device to provide additional signage and delineation to better depict the curve to area motorists and to evaluate the performance of such a device. The TAPCO BlinkerBeam/BlinkSync dynamic LED curve warning system was the chosen device. This product is solar-charged with a nickel-metal hydride battery-powered wireless triggered device. The device is actuated by Doppler radar when a vehicle approaches to warn drivers and provide visual orientation through the curve.

The selected curve crash analysis reports on seventeen (17) crashes during the time frame of January 2001 through June 2012; four of those events involved fatalities. A realignment project is scheduled for 2019, which will correct the roadway geometrics attributed to the safety issue. In the interim, this automated chevron sign system was installed in an attempt to alleviate the current hazard and be in service for a sufficient duration to establish a trend and determine overall performance.

Final Analysis:

Since installation this project had numerous technical issues regarding faulty connections, inadequate solar power supply, durability of LED units and overall system performance (i.e., inconsistent operation of the individual TAPCO panel units).

However, the MDT Traffic and Safety Bureau has reported since the installation of the curve warning system in 2013, no accidents have occurred at the Beaverhead Rock curve. Also, the technical problems with this project caused TAPCO to retool their system to a more durable and reliable design that has been used in several other areas in the state.

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4.4 PENDING PROJECTS

4.4.1 Crafco Mastic One Joint Sealer Evaluation

Location:	Great Falls District, Pondera County, Interstate-15 and Secondary 218
Project Name:	Brady N and S (NB) and Conrad-East
Project Number:	IM 15-6(43)323 and STPS 218-1(11)0
Experimental Project Number:	MT-18-03
Project Type:	Crack Seal and Pavement Repair
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	Pending 2019
URL:	Pending

Objective:

Crafco Mastic One is a hot-applied, single component, pourable, aggregate-filled, polymer modified asphalt mastic used for maintenance, repair, and preservation of pavement and bridge surfaces.

Mastic One is used for sealing, filling and repairing many distresses in both asphalt concrete and Portland cement concrete pavements that are larger than those typically repaired by crack or joint sealing, but smaller than repairs requiring remove and replace patching procedures.

This application of the Mastic One will primarily be used for transverse cracks.

Status:

Project is slated for installation in the fall of 2019.

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4.4.2 Electric Wildlife Deterrent Mat

Location:	Butte District, Broadwater County, MT Route 287/12 (N-8)
	Missoula District, Sanders County, MT Route 200 (P-6)
Project Name:	Toston Structure
	East of Thompson River – East
Project Number:	NHIP-NHPBIP 8-4(66)86
	STPP 6-1(126)57
Experimental Project Number:	NHIP-NHPBIP 8-4(66)86
	MT-14-01
Project Type:	Wildlife Crossing Structure
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	Pending Fall 2019

URL: https://www.mdt.mt.gov/research/projects/electmat.shtml

Objective:

Generically known as electric mats, these structures are crossing deterrents to discourage animals from entering an area deemed necessary to be "animal free" to mitigate conflicts with travelling motorists. These mats incorporate a mild electric shock when a hooved animal attempts to enter the crossing.

The electric wildlife deterrent mat units are embedded directly in the pavement (concrete and metal fiber or rubberized composite material) in a full-width roadway application. Electric mats serve as an alternative to cattle guards and other non-electric crossing structures to manage ungulate movements.

The information gathered and analyzed from this project may result in a better understanding of how existing roadways may be utilized as wildlife barrier structures. In addition to gaining a better understanding of how "funnel" fencing can be used on existing and future projects, the goal is a roadway system that is safer for motorists and wildlife.

Status:

This project is slated for installation in the fall of 2019; however, right-of-way issues are still being negotiated.

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4.4.3 High Float vs. Polymer Modified Emulsion Seal and Cover With and Without a Fog Seal

Location: Hill County/US 2 (N-1)/Great Falls District
Project Name: Gilford-East
Project Number: NH 1-6(123)355
Experimental Project Number: MT-18-05
Project Type: Fog Seal/Chip Seal Emulsion Comparison
Principal Investigator: Craig Abernathy, Experimental Project Manager
Construction Year: Pending 2019
URL: https://www.mdt.mt.gov/research/projects/seal_coat.shtml

Objective:

The purpose of this project is to compare two emulsions with and without a fog seal, determining the short and long-term performance benefits of each application including cost effectiveness, long term durability, and/or potential chip retention benefits. The two emulsions are Cationic High Float Rapid-Set High Viscosity Polymer (CHFRS-2P) and Cationic Rapid Set High-Viscosity Polymer (CRS-2P). The former will be placed with a chip seal only. The latter will be placed with a chip seal only and with a Cationic Slow-set Low Viscosity Hard-base (CSS-1H/diluted 50 percent) fog seal treatment Maintenance is routinely using the CHRFS-2P chip seal oil. Benefits of fog seal on a new chip seal have been noted, but formal documentation of the benefits is lacking.

Status:

Project is slated for installation in the summer of 2019.

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4.4.4 Nomaflex Concrete Joint Filler Evaluation

Location:	Butte District, Gallatin County, Rouse Ave-Bozeman
Project Name:	Nomaflex Concrete Expansion Joint
Project Number:	STPP 86-1(27)0
Experimental Project Number:	MT-17-05
Project Type:	Concrete Expansion Joint
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	Pending 2019
URL:	Pending

Objective:

Nomaco Nomaflex is a closed-cell polypropylene foam used as a preformed expansion joint in concrete sidewalk applications. This product does not require the use of a bond breaker commonly used with other conventional expansion joints (i.e., asphalt saturated fiber). This product is also recyclable.

The manufacturer's information states that it extends the service life of concrete by reducing the amount of incompressible materials that may enter the joint over time and accelerate cracking or spalling.

Crews will install 3000 linear feet of Nomaflex from reference point (RP) 0.0 (Main Street) to RP 0.85 (Oak Street).

Status:

Project was slated for installation in the summer of 2018. Due to scheduling conflict this project is now pending for the summer of 2019.

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4.4.5 Reflective Cracking in Cement-Treated Bases Minimization by Microcracking Evaluation

Location:	Glendive District, Sheridan County, Westby
Project Name:	Westby West
Project Number:	UPN 7953
Experimental Project Number:	MT-18-07
Project Type:	Cement Treated Base
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	Pending 2019
URL:	Pending

Objective:

This project will focus on evaluating the effectiveness of the microcracking concept for reducing shrinkage cracking in cement-treated bases. Microcracking can be defined as the application of several vibratory roller passes to the cement-treated base at a short curing stage, typically after 1 to 3 days, to create a fine network of cracks to potentially minimize reflective cracking after paving course is applied.

Status:

Pending for the fall of 2019 but may be pushed back until the spring of 2020.

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4.4.6 Seal and Cover Emulsion Comparison

Location:	Missoula District, Sanders and Lake Counties, MT 200 and US 93
Project Name:	Dixon-West/Dixon -Ravalli
Project Number:	CNN 9238/9239
Experimental Project Number:	MT-18-02
Project Type:	Chip Seal Emulsion Comparison
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	Pending 2019
Project URL:	Pending

Objective:

Both test sites listed above were chosen to compare the performance of cationic high-float rapid set (CHFRS-2P) emulsified asphalt to cationic rapid set (CRS-2P) emulsified asphalt seal and cover (chip seal) for long-term durability of the pavement preservation application. In addition, for further comparison of chip seal performance; no fog seal will be applied to either project.

The Dixon-West project will utilize the CHRS-2P emulsion (full roadway width) and the Dixon-Ravalli project will employ the CRS-2P emulsion. Both sections will use type II chips and both projects will be constructed at the same time.

Status:

Project is slated for installation in the late summer/fall of 2019.

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4.4.7 Surfacing In-Slope Treatment Evaluation

Location:	Glendive District, Dawson County, I-94
Project Name:	Bad Route Interchange – NE
Project Number:	IM 94-6(59)193
Experimental Project Number:	MT-18-06
Project Type:	Top Soil Surfacing Comparison
Principal Investigator:	Craig Abernathy, Experimental Project Manager
Construction Year:	Pending 2019
URL:	Pending

Objective:

A section of Interstate 94 near the township of Glendive has deteriorated to the point a reconstruct is necessary. The primary cause of the subgrade failure exhibited on this project is heave action on the frost susceptible subgrade soils.

When drainage of the surfacing section is hindered, the susceptibility to freeze/thaw action increases significantly. By not top-soiling the new crushed aggregate course surfacing in-slope there may be a better chance of the surfacing section being able to drain during the fall, spring, and winter seasons when the presence of moisture, combined with freeze/thaw action is most prevalent. Two separate design changes to the roadway in-slope will be constructed to compare efficacy of the treatments as compared to the current practice of top soil placement.

Status:

Project is slated for installation in the fall of 2019.

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4.5 PROPOSED PROJECTS

Expanded Polystyrene Geofoam Blocks as Lightweight Fill
Swamp Creek East/NH 1-1(29) 45 F – Section 1304

Pre-Fabricated Steel Truss/Bridge Deck System
Conly Ave. Bridge-Deer Lodge/STPB 9039(43)

Portland Cement Concrete Pavement Over Existing Cement Treated Base
MT 200 – Fairview/STPP 20-2(31)62

Weather-Activated Detection System
Granite Powell Safety Project/HSIP-G STWD(538)

Roundabout Striping Durability Trails
Project Review in Billings and Poplar, Montana

Yellow-Dyed Concrete Curbing to Replace Epoxy Applied Curbing

Project Currently Under Consideration in Billings, Montana

Texas Underseal with Added Scrub Seal

Lewistown, Montana/UPP 7105(4)

5 PARTNERING PROJECTS AND POOLED FUND STUDIES

MDT contributed funds to the following partnering and pooled fund studies in FFY 2018 (Table 5.1). Click on the project links to view project information.

Table 5.1: FFY 2018 Partnering and Pooled Fund Contributions

Number	Name	Funding Level
N/A	AASHTO Equipment Management Technical Services Program (EMTSP)	$5,000
N/A	AASHTO Innovation Initiative (AII) Technical Services Program	$6,000
N/A	AASHTO Load and Resistance Factor Design (LRFD) Bridges and Structures Specification Maintenance (LRFDSM) Technical Services Program	$15,000
N/A	AASHTO Materials Reference Library (AMRL) Technical Services Program	$20,000
N/A	AASHTO National Transportation Product Evaluation Program (NTPEP) Technical Services Program, includes AASHTO Product Evaluation List (APEL)	$20,000
N/A	AASHTO Technical Service Program to Develop AASHTO Materials Standards (DAMS)	$10,000
N/A	AASHTO Transportation System Preservation Technical Services Program (TSP2)	$20,000
TPF-5(299)	Improving the Quality of Pavement Surface Distress and Transverse Profile Data Collection and Analysis	$15,000
TPF-5(313)	Technology Transfer Concrete Consortium	$12,000
TPF-5(316)	Traffic Control Device (TCD) Consortium	$10,000
TPF-5(349)	Western Alliance for Quality Transportation Construction (WAQTC)	$12,000
TPF-5(353)	Clear Roads – Phase II	$25,000
TPF-5(376)	Northwest Passage – Phase IV	$25,000
TPF-5(378)	Transportation Research Board Core Program Services Support	$104,345
TPF-5(418)	National Cooperative Highway Research Program (NCHRP)	$235,405
	TOTAL	$534,750

6 SUMMARY

6.1 GENERAL

MDT's mission is to serve the public by providing a transportation system and services that emphasize quality, safety, cost-effectiveness, economic vitality, and sensitivity to the environment. MDT's Research Programs impact each and every part of MDT's mission.

Research projects completed in FFY 2018 yielded results that when fully implemented will improve:

- Efficiency and effectiveness of MDT operations and technology transfer, including:
  - Improved cost estimating, decreasing overruns and providing for improved construction portfolio of projects
  - Improved bridge, culvert, and pavement design and processes
  - Improved construction materials and methods
  - Improved support for cities and counties
  - Improved research processes
  - Improved rockfall evaluation and mitigation
  - Improved roadside revegetation
- Economic vitality
- Sensitivity to the environment, including:
  - Improved roadside reclamation materials and methods
  - Improved roadside revegetation
  - Decreased erosion on construction and maintenance projects
  - Improved environmental processes
  - Decreased vehicle–wildlife collisions
  - Improved habitat connectivity
  - Improved air quality
- Safety, including:
  - Improved safety on low-volume roads
  - Improved safety in rockfall areas
  - Reduced vehicle–wildlife collisions
  - Improved safety culture both within MDT and among the travelling public
  - Improved safety in work zones
- Quality of what we do and how we do it, including:
  - Improved cost estimating, decreasing overruns and providing for improved construction portfolio of projects
  - Improved bridge, culvert, and pavement design and processes
  - Improved construction materials and methods

- Improved support for cities and counties
- Improved research processes
- Improved rockfall evaluation and mitigation
- Improved air quality

6.2 FISCAL

Research Programs expenditures occurred through research projects, AASHTO Technical Services Programs (TSP), LTAP, pooled fund studies, NCHRP and TRB Core Services support, and program administration (Figure 6.1). The program administration category not only includes MDT staff support, including travel, but also includes a contract for research project management services and a peer exchange that was conducted on implementation of research results, research performance measures, and the value of research. Figures 6.2 and 6.3 show these expenditures categorized by subject.

MDT, as of July 2007, is required to charge indirect costs. The indirect cost rates are revised each state fiscal year. From July 2017 to June 2018, the indirect cost rate charged to each expenditure was 10.96%, and from July 2018 to June 2019, the indirect cost rate charged to each expenditure is 10.49%. Figure 6.4 shows these indirect costs, as well as overhead costs, as compared to total project expenditures, including projects such as pooled fund studies that are not charged indirect costs by MDT. Figure 6.5 shows total funding for all active research projects by funding source. Figures 6.6 and 6.7 show funding for in-state and out-of-state researchers. Figures 6.8 and 6.9 show funding by public and private consultants. Figures 6.10 and 6.11 show funding by university and non-university researchers. Finally, for research projects completed in FFY 2018, $46,410 was unexpended.

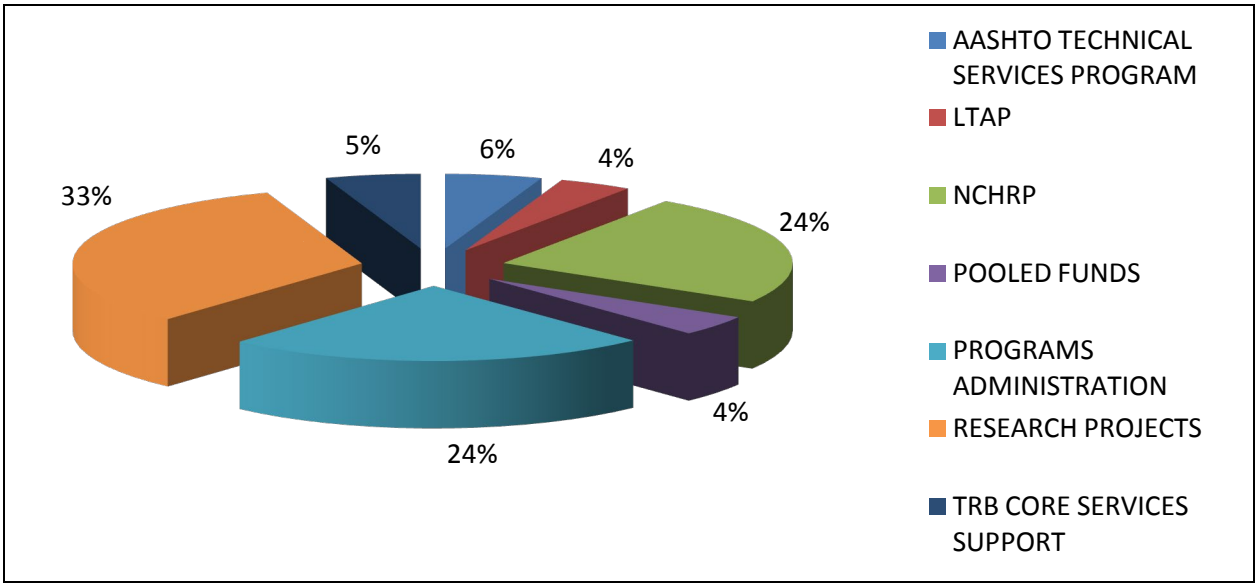

Figure 6.1: Research Program Expenditures by Project Type, FFY 2018

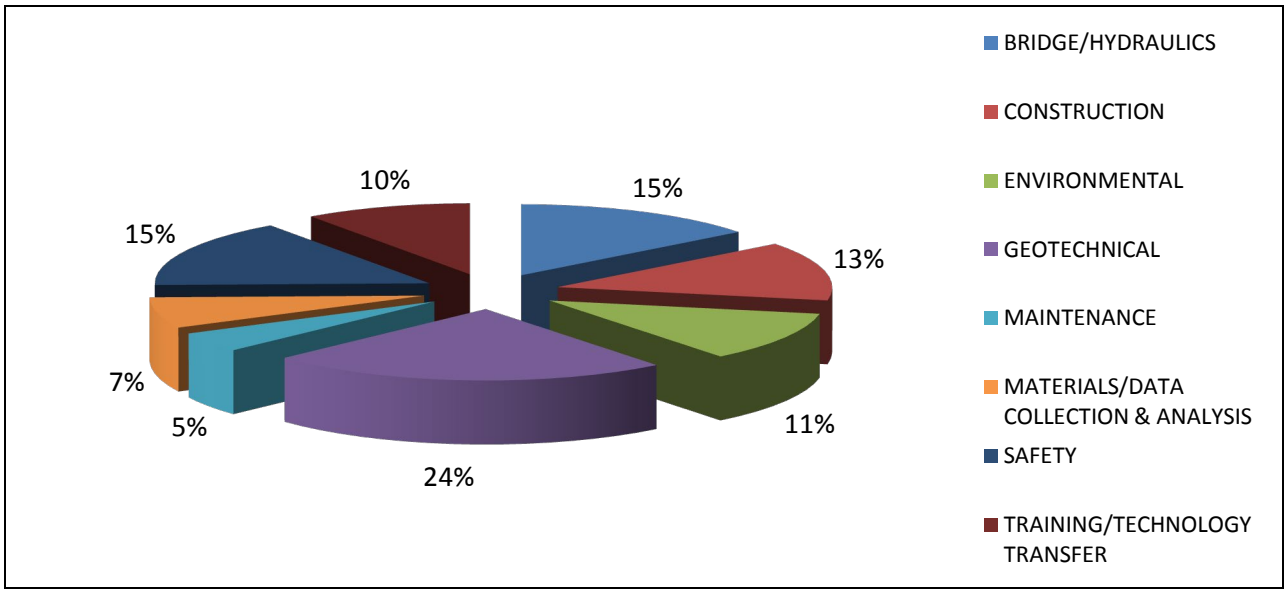

Figure 6.2: Research Program Expenditures by Subject, FFY 2018

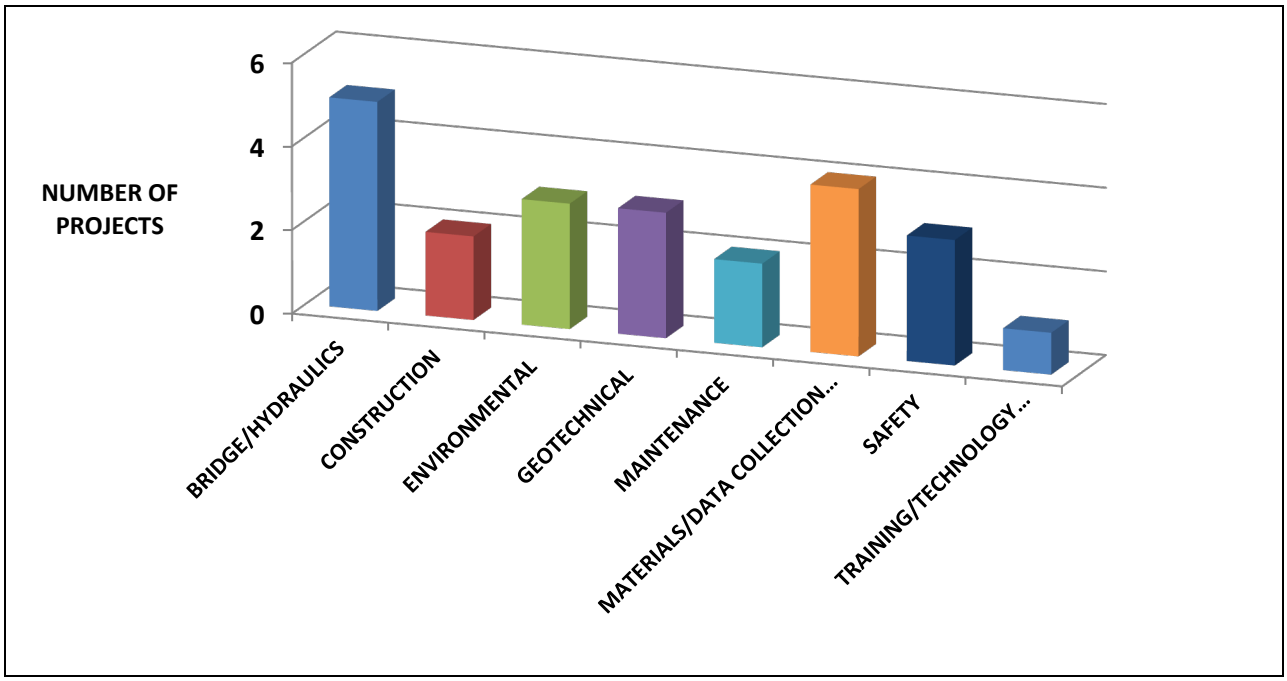

Figure 6.3: Number of Research Program Expenditures by Subject, FFY 2018

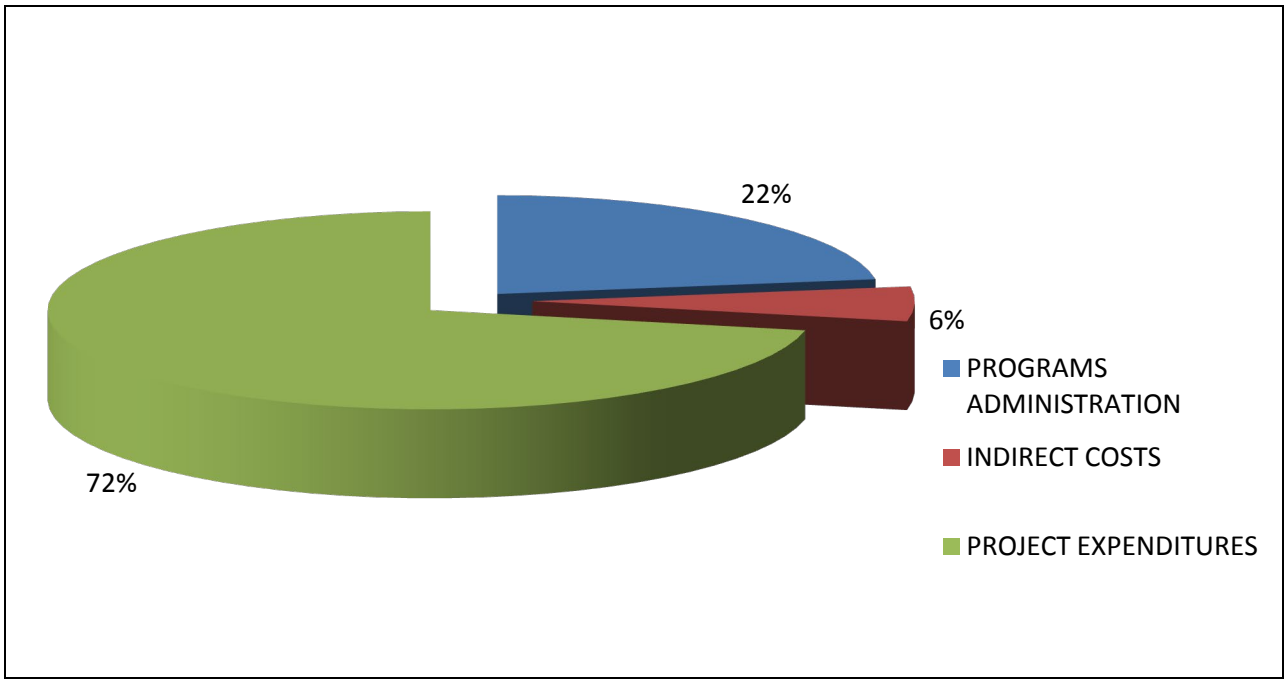

Figure 6.4: Research Programs Overhead and Indirect Expenditures as Compared to Other Expenditures, FFY 2018

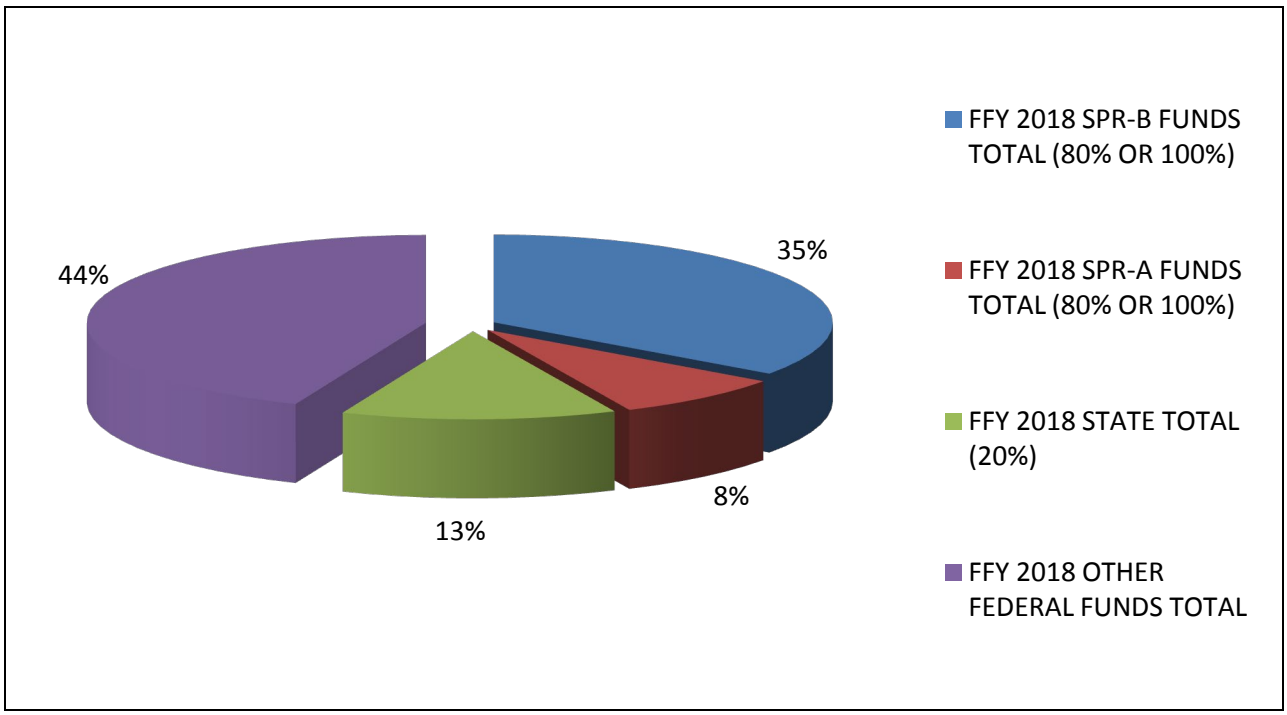

Figure 6.5: Research Program Expenditures by Funding Source

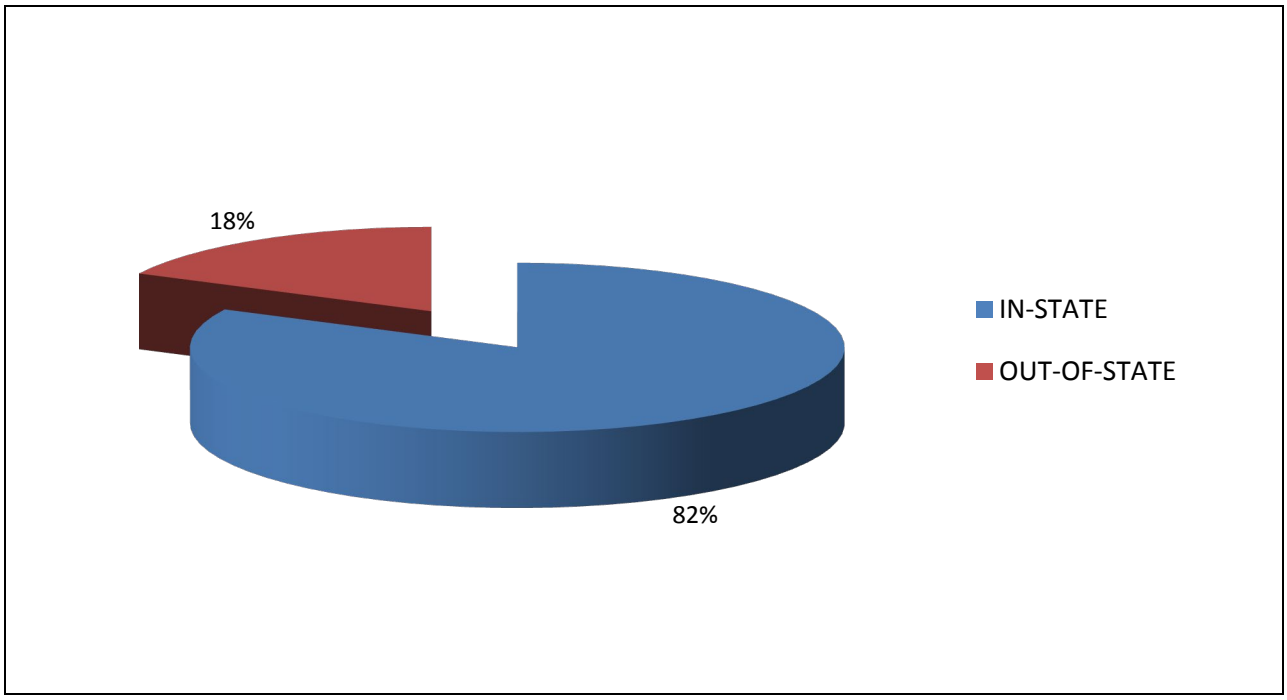

Figure 6.6: Research Program Expenditures by Researcher Location

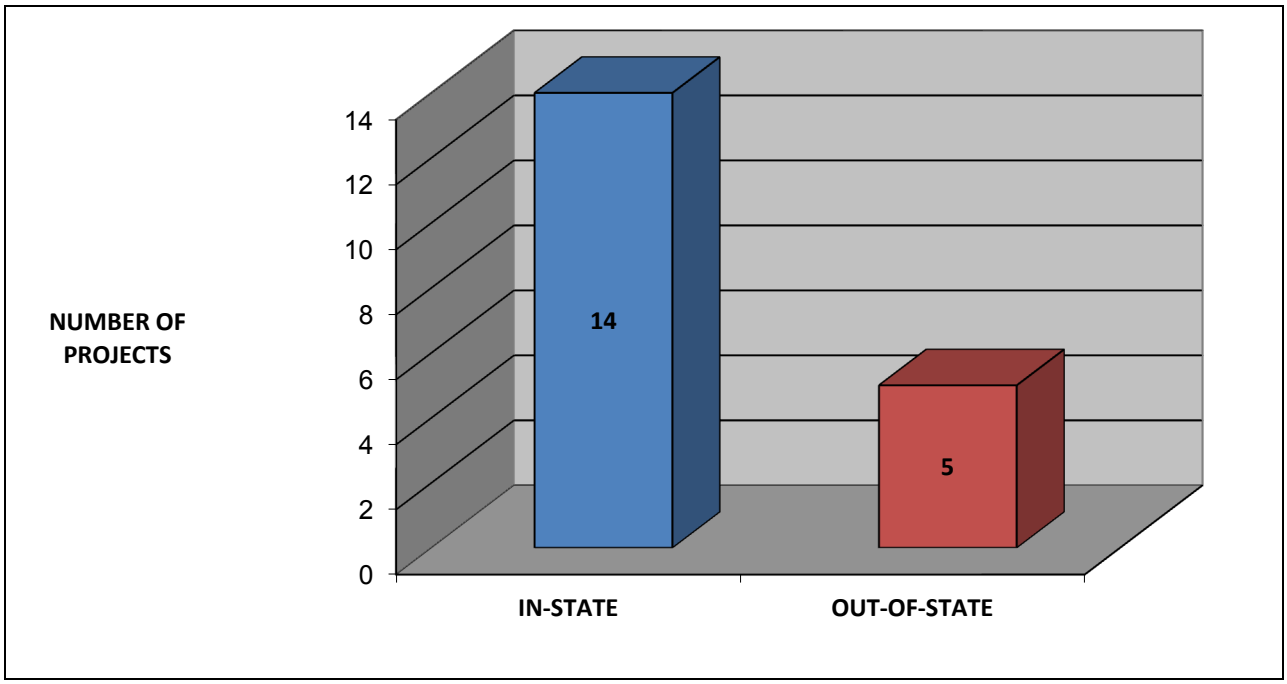

Figure 6.7: Number of Research Projects by Researcher Location

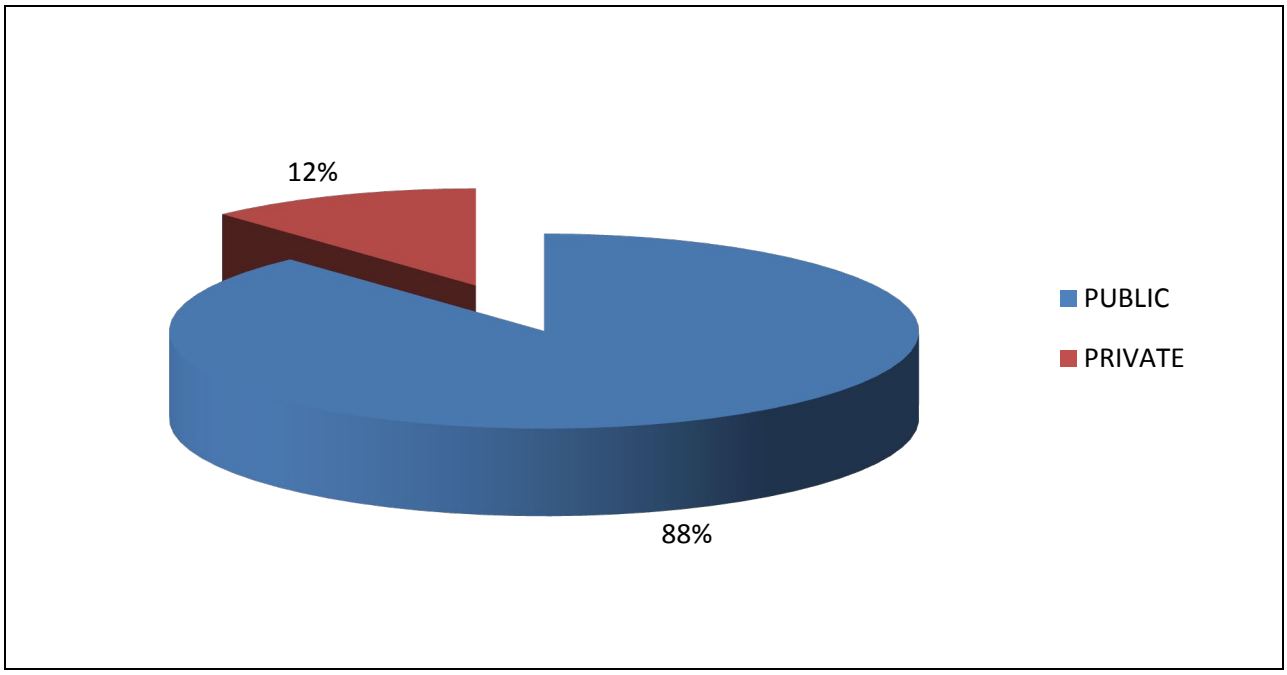

Figure 6.8: Research Program Expenditures by Sector

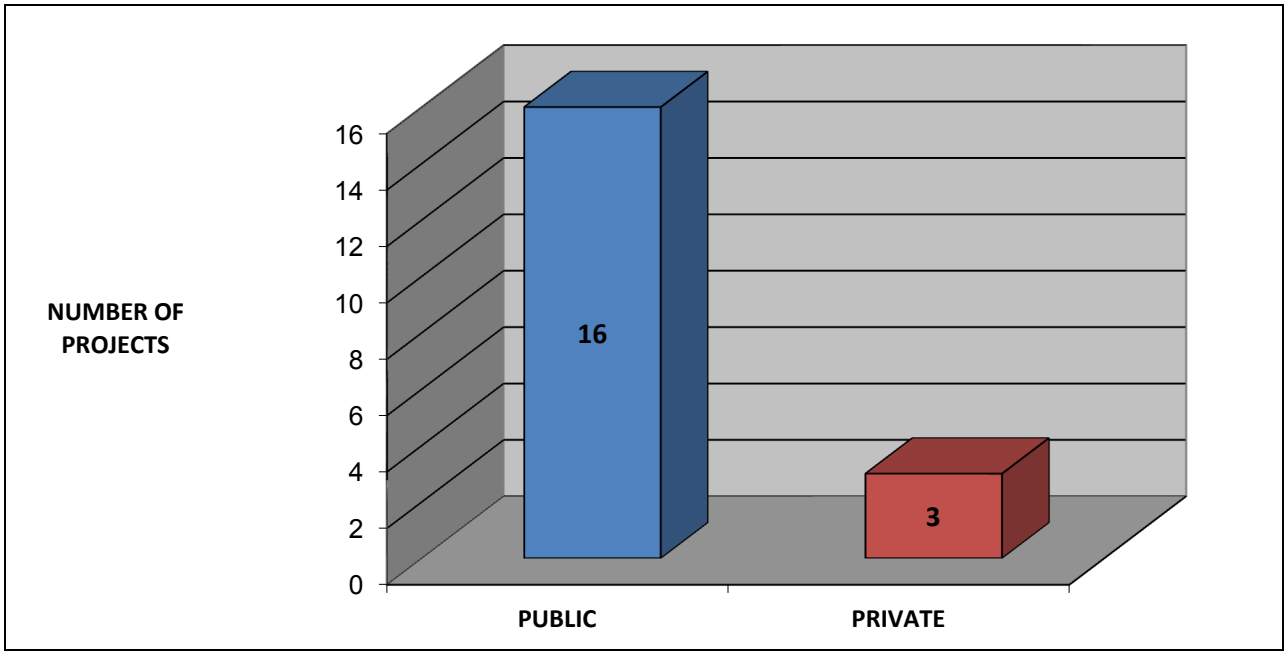

Figure 6.9: Number of Research Projects by Sector

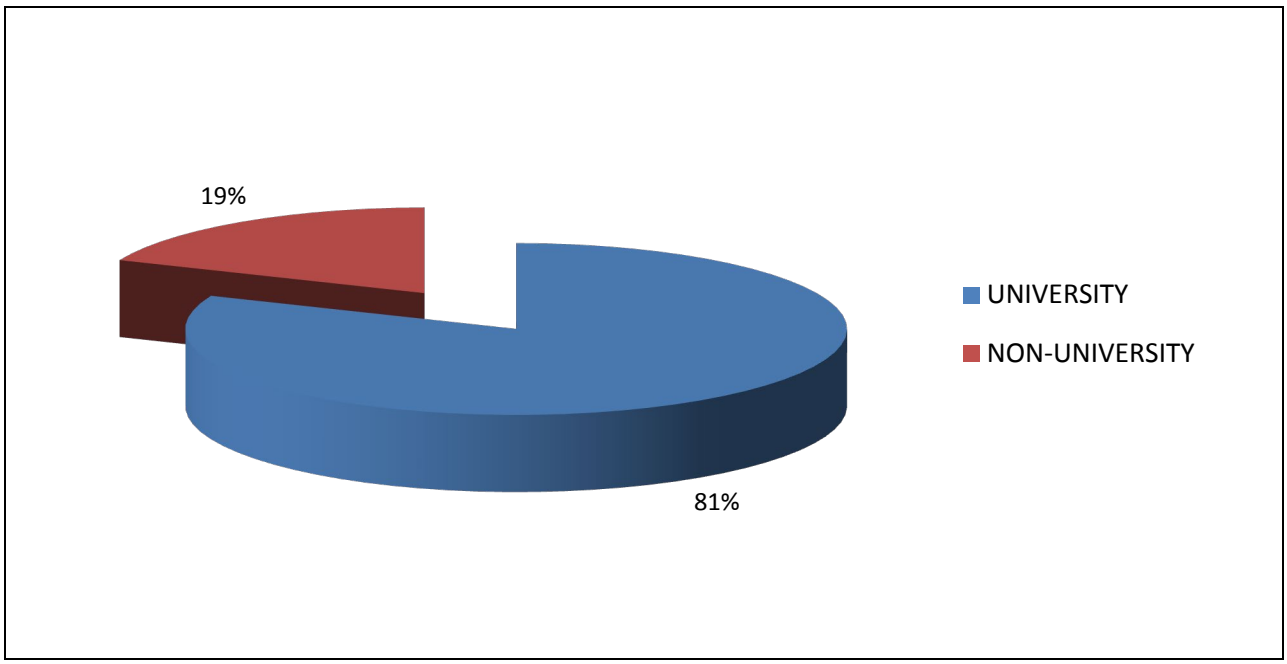

Figure 6.10: Research Program Expenditures by Researcher Type

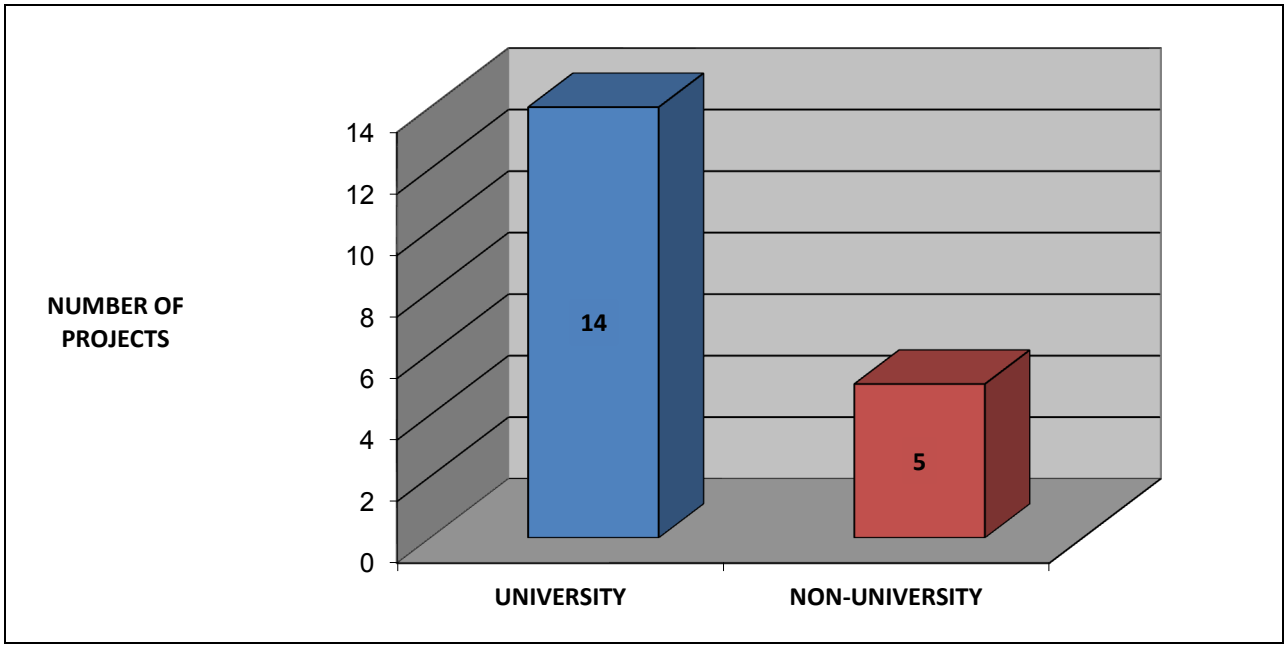

Figure 6.11: Number of Research Projects by Researcher Type

Appendix A

Research Project Technical Panel
Roles and Responsibilities

RESEARCH PROGRAMS

RESEARCH PROJECT TECHNICAL PANEL ROLES AND RESPONSIBILITIES

GENERAL

Research Review Committee

The Research Review Committee (RRC) oversees the Research Projects Program. This committee:

- Along with the District Administrators, determines which research topics submitted during the annual research solicitation move forward to the technical panel stage based on champion presentation, ranking (criteria listed below), and funding availability.
  - Priority research focus areas (e.g., TranPlanMT focus areas that lend themselves to research);
  - Scope, budget, and timeline are appropriate for available resources (limited funds need to be allocated to highest priorities) and timeliness/urgency of topic;
  - Importance (e.g., federal or state initiative or compliance);
  - Benefits and pay-off (including as they relate to MDT's mission and "strategic plan"; e.g., return on investment, cost/lives savings, etc.);
  - Implementability; and
  - Feasibility/probability of success/risk (What is success?)

- Identifies need for and approves administration high priority research topics, partnership projects, and small projects;
- Identifies additional technical panel members;
- Reviews technical panel recommendations (e.g., cancel, fund, implement) for each research project;
- Reviews and approves scopes of work for those research projects where an RFP is to be issued, the cost of the project has increased by the percentage shown in the below table or more, or if there was any contention within the RRC when the project was approved to move forward to the technical panel stage;

Project Cost	Percent Increase in Project Cost
$50,000 or less	N/A
$50,001 to $100,000	30%
$100,001 to $500,000	25%
Greater than $500,000	15%

- Approves funding for all MDT research projects based on the project proposal and technical panel recommendation;
- Approves funding for pooled-fund studies, based on the scope of work and staff recommendation;
- Reviews project progress, as desired; and
- Reviews and makes implementation recommendations.

The RRC consists of a FHWA and WTI representative, and the following MDT positions:

- Director,
- Deputy Director,
- Administrators (except HR), and
- Research Manager.

The RRC meets at most monthly (typically last Wednesday of the month from 9 am to 12 pm). Agenda items must be prepared and final approximately 2 weeks prior to each RRC meeting.

Technical Panels

Technical Panels (TP) oversee all MDT research projects. They are formed at the beginning of each project and members are chosen with careful consideration since the success of a project hinges on the Technical Panel and its oversight. **This is your project, not Research's; the project can only deliver the products the technical panel wants if there is appropriate technical panel oversight.** There is a different technical panel for each project, usually consisting of three to ten individuals from both inside and outside of MDT, with knowledge and a vested interest in the research topic, results, and implementation. FHWA and MDT Research Staff are on all technical panels. Individuals on panels should adequately represent the breadth of the issue at hand and be balanced with respect to viewpoint and representation. Each panel member is chosen to represent the needs of their respective division, department, organization, and/or constituencies.

Roles

1. Technical Panel Member
2. MDT Research Project Manager
3. Technical Panel Chair

Responsibilities

Note: All tasks must be performed in a timely manner.

1. Technical Panel Members, including Research staff (MDT Research Project Manager) and panel chair, who is usually the project champion
    a. Determine if others need to participate on the technical panel.

b. Oversee project from inception through implementation. Implementation (i.e., products necessary, identification of barriers, mitigation of barriers) should be considered from the very first panel meeting.
c. Determine if research need exists by a literature search and completing the research project statement form and, then, the best method to proceed (cancel project; implement available results; or secure funding from local/MDT, regional, or national research programs).
d. If it is determined a project is necessary and should be funded at the local/MDT level, develop a scope of work (SOW), based on the research project statement. Otherwise, work within the appropriate venue to submit research topic. It is critical that a clear, complete, and concise SOW is developed, as the proposal, which is a part of the project contract, is developed from this SOW.
    i. *Items e. through i. pertain to projects funded at by MDT*.
e. Determine if RFP should be issued or a governmental agency would be the best entity to conduct research. Review proposal(s) and recommend to the RRC a proposal for funding. Proposals are based on the SOW.
f. Meet with consultant in project kick-off meeting and other meetings, as determined by the project proposal and/or technical panel.
g. Carefully review all project products for completeness and accuracy. It is especially critical for technical panel members to review the Task Reports (TR). The TR will provide detailed information on each task, including what was done, how it was done, and the results. The TRs can be combined to form much of the final report.
h. Ensure the project stays on scope and delivers desired products by reviewing project deliverables (i.e., progress reports, task reports, other interim products, final report and other final products) and communicating issues with contractor through the MDT Research Project Manager. This is critical for project success.
i. Keep supervisor(s), organizations, and/or constituencies informed of all progress and products of the project.
j. Make implementation recommendations for MDT.

2. MDT Research Project Manager
    a. Identifies technical panel members and forms technical panels.
    b. The Research staff on each technical panel serves as the project manager.
    c. The project manager is the direct liaison between the technical panel and contractor, communicating panel decisions to the contractor.
    d. Serves as a conduit for all information flowing between the technical panel as a whole or individual technical panel members, and the contractor.
    e. Ensures project stays within scope and budget, and issues are addressed in a timely fashion.
    f. Takes meeting notes prior to contracting and for those meetings not attended by the contractor. Contractor takes meeting notes after contract is in place for those meetings contractor attends.
    g. Manages contractual compliance.
3. Technical Panel Chair
    a. Identifies technical panel members and makes sure they have the time and are willing and able to serve on the technical panel.
    b. Presents scope of work and business case information to RRC for approval-in-concept as described in the Research Review Committee Section on page 1.

c. Presents business case for project and proposal technical panel recommends for funding to RRC for funding approval.
d. Chairs, schedules, and moderates all technical panel meetings.
e. Encourages active participation by all panel members.
f. Helps the panel reach consensus.

Time Commitment

1. Scope and business case development – 2-8 hours.
2. Proposal review – 1-5 days if an RFP is issued; 2-4 hours if not.
3. Meetings and review of progress and interim products. – varies depending on length of project, about 1-2 hours per month.
4. Final Product Review – 1-2 days

Time commitment varies with each project.

Appendix B

On Developing a Research Project Scope of Work

RESEARCH PROGRAMS

On Developing a Research

Project Scope of Work

July 2018

Scope of Work Background and Description

MDT's Research Programs are internally-driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are the goal. Implementation of research results also helps MDT in meeting its mission of providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality, and sensitivity to the environment. As defined by MDT, implementation means the widespread use of research results and innovations.

A well-written scope of work (SOW) is critical for the success of a project and successful implementation of research results. Researchers use the scope of work to develop a proposal, which becomes a part of the contract and describes the details of performance, providing the yardstick to which performance is measured. A good SOW is clear, complete, concise, and logical enough to be understood by researchers, technical panels, and research project managers. A SOW describes the work to be performed or the services to be provided; the goal of the research and the application of the results; the benefits and impact, including who may be impacted by the use of research results. However, it does not describe every detail of the work to be conducted, rather it specifies the required elements. This leaves the methods and details of the research approach to the expertise of the researchers and provides a mechanism to select the best research approach.

Scope of Work Content

- **Title:** The title should briefly and immediately convey to the reader what the proposed study is about. It does not have to capture every element, nuance, and expected task of the research problem. It is like the title of a book—it should attract your attention, quickly convey the subject, draw you in, and make you want to read what's inside. A good title is like a good sound bite—people will remember it.

  Hint: Look at every word in your title and ask yourself if it's necessary.

- **Background:** This section sets the stage for the research. It describes the issue, and indicates why we care and why we are seeking to fund the research in the first place.

- **Benefits/Business Case/ Impact:** Address urgency, timeliness, and importance of the research. Identify if the research is required for any federal or state initiative or compliance. This section must include a description of how this research will help to meet MDT's mission (i.e., serve the public by providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality and/or sensitivity to the environment). It should also indicate the expected outcomes, such as cost savings, improvements in safety, user benefits, and process improvements.

- **Objectives:** Describe in very brief terms the expected product(s) of the research. The objective should be short, concise, and accurate. Don't put details in the objective related to how the study will be done unless some new or innovative research methodology is the key element of the research. The details will be in the research plan and reflected in the final product. If your objective is "to produce a new fuel-efficient vehicle," say so. Don't say that the objective is "to produce a new fuel-efficient vehicle, including the design, construction, testing, and installation of all necessary components including body, frame, power train, tires, wheels, seats, mirrors, and other appurtenances to be determined through a survey of user needs, performance measures, and financial constraints." If those things need to be done to accomplish the objective, put them in task statements.

  Hint: Go back and read the advice above on titling your research statement. A very reasonable objective statement is "…to develop (insert your title).

- **Tasks:** If you have identified specific tasks that absolutely have to be part of the project work plan, include them in the SOW. However, don't let your own biases determine the research plan. Focus your attention on providing a full and accurate description of the final product(s). To the extent possible, give the proposing research team the flexibility to describe a research plan that they feel will accomplish the project objectives.

  Hint: The more detail you include in the task statements, the less opportunity a researcher has to show initiative and innovation, and the more every proposal will come in looking the same. Don't be prescriptive.

- **Acceptance:** As appropriate and only as required, establish milestones or management control points in the sequence of events where actions for review, approval, acceptance, or rejection are required.

- **Collaborators, Partners, and Stakeholders:** Identify individuals and/or organizations that need to be brought into the fold to create buy-in and acceptance of the results; review results; and/or participate in communications, decisions, and/or deployment. Specify the relationship and roles.

- **Communications:** Identify any communication needs, including technology/knowledge transfer, marketing, and training. Consider such factors as the target audience, end users, communication methods, events, responsible person/area, required approvals, and efforts needed for full implementation. Timing for communications should also be considered.

- **Data Requirements:** Identify available data that may be helpful in conducting the research. Include the limits of the data, such as fields and date ranges. Identify the format, such as Excel spreadsheet or hardcopy documents. Indicate what MDT can provide to the consultant and how.

- **IT:** Identify if the project involves software, hardware, data management, or technology devices, including maintenance, that may require coordination with ISD and/or SITSD.

- **Intellectual Property:** Describe any potential intellectual property issues.

- **MDT Involvement:** As much as is known at this point, identify all MDT and consultant participation needed for the project, as well as the nature and extent of this participation. For example, MDT will provide gravel samples, traffic control, core samples to the consultant. The consultant may need to provide the time frame and required quantities. Another example may be that the consultant is required to visit MDT to review project hardcopy files or the consultant is required to provide specific equipment for use during the project.

- **Deliverables:** It is critical to identify deliverables needed to implement the results of the research. Final reports, while required, cannot typically be implemented. Determine the products that will facilitate implementation. To achieve a significant impact, products must be well specified, well matched to the needs of the users, implemented in a deliberate and adaptive manner, and supported by a hospitable environment and learning processes.

- **Risks:** Identify risks to budget, resources, schedule, and scope. Identify potential mitigation measures, forewarning indicators, and contingencies. Determine impact and probability. Rate risks as high, medium, and low. Develop a plan to mitigate risks.

- **Implementation:** As much as is possible at this point, describe how the results will be implemented, who will implement the results, and any barriers to implementation and how these barriers might be reduce or eliminated. Define/describe successful implementation and activities necessary for successful implementation. Describe the criteria for judging the progress and consequences of implementation.

- **Performance Measures:** The research to be conducted should include both qualitative and quantitative performance measures if at all possible. Performance measures include such improvements as cost and time savings; improved process, safety, environmental considerations, efficiency, quality, and service; and user benefits. As much as possible, these benefits need to be quantified. This is an indication of the value of the research. Consideration needs to be given to the data that will need to be collected to report performance measures. The proposal must describe how performance measures will be quantified.

- **Timeliness:** Add a timeliness statement to all SOWs, “Time is of the essence. The proposal must be submitted (original and revised), research conducted, and deliverables submitted as detailed in the proposal and the resulting contract.”

MONTANA MDT DEPARTMENT OF TRANSPORTATION

RESEARCH PROGRAMS

Scope of Work Development

INSTRUCTIONS

This form will help guide the development of a scope of work for each research project. It is absolutely critical that research requirements be included in the scope of work as it is the basis for the project proposal, which becomes a part of the contract and the standard to which researchers are held. Click in the field to enter data. See "On Developing a Research Project Scope of Work" for instructions on completing this form.

Date: Click to enter a date.	**Champion:** Click to enter name.	**Technical Panel Members:** Click to enter names & areas.
Solicitation Number: Click to enter # (e.g., 19-020)	**Sponsor:** Click to enter name.	
Project Number: Click to enter #.	**Research Project Manager:** Click to enter name.	
Project Title: Click to enter project title.		
Project URL: Click to enter project URL.		
Project Background: Click to enter text.		
Benefits/Business Case/Impact: Click to enter text.		
Objectives: Click to enter text.		
Tasks: Click to enter text.		
Acceptance: Click to enter text.		
Cooperators, Stakeholders, Partners: Click to enter name, org and role.		
Communications: Click to enter text.		
Data Requirements: Click to enter text.		
Acceptance: Click to enter text.		
IT: Click to enter text.		
Intellectual Property: Click to enter text.		
MDT Involvement: Click to enter text.		
Deliverables: Click to enter text.		
Risks: Click to enter text.		
Implementation: Click to enter text.		
Performance Measures: Click to enter text.		

Appendix C

Research Partnering Project Funding Request

MONTANA MDT DEPARTMENT OF TRANSPORTATION

RESEARCH PROGRAMS

Research Partnering Project Funding Request Form

INSTRUCTIONS

Complete this form to request funding for research projects and programs where MDT will not be the lead and will not contribute all funds for the project/program, such as AASHTO pooled fund programs/projects (TPF) and Technical Service Programs (TSP). Send completed form to the Research Programs Manager.

Part A: General Project/Program Information			
Date: Click to enter a date.	**Solicitation or Project Number:** Click to enter text as applicable. Poole funds will either have a 4-digit solicita number or a TPF number (e.g., TPF-5(	**Lead Entity:** Click to enter name.	
Title of Project or Program: Click to enter title.			
Project/Program URL: If applicable, click to enter URL.			
Project/Program Duration: Click to enter project duration in years. years, Click to enter p duration in months. months		**Project/Program Begin Date:** If known, click to enter a date.	
Total Cost: Click to enter total project co Enter N/A if a TSP or otherwis total cost is not applicable.	**Total Cost to MDT:** Click to enter total MDT cost.	**Annual Cost to MDT:** If an annual allotment is bein requested, click to enter annu cost to MDT.	**Total Years Funding Request** Click to enter total number o for which funding is requeste to three.

Part B: For Bureau Chief		
Click to enter name of MDT's technical representative for this project/program. will be the Technical Representative fo project/program.		
☐ **Yes**	☐ **No**	This employee will be encouraged to request travel approval to attend panel meetings in-person, as funded by the project/program.
☐ **Yes**	☐ **No**	If the employee is not granted travel approval, employee will be allowed to attend via conference call or web meeting, as provided through the project/program.
☐ **Yes**	☐ **No**	I will annually review MDT's participation in this project/program to determine value to MDT.
☐ **Yes**	☐ **No**	If this project/program is funded, but becomes no longer of significant value to MDT, I will alert the Research Programs Manager.

Part C: For Technical Representative		
☐ **Yes**	☐ **No**	I will attend project/program meetings, as funded by the project/program.
☐ **Yes**	☐ **No**	If I cannot attend in-person, I will attend via conference call or web meeting, as provided

☐ **Yes**	☐ **No**	I will review documents and deliverables, determining their value to MDT.
☐ **Yes**	☐ **No**	I will complete an annual evaluation form, for this project/program, and provide comprehensive feedback on its value to MDT.
☐ **Yes**	☐ **No**	If this project/program is no longer of value to MDT, I will alert my Bureau Chief and the Research Programs Manager.

Part D: MDT Benefits
Please explain the benefits MDT is expected to achieve through participation in this project/program. Click to enter text.

Part E: Approval (Technical Representative and Bureau Chief Sections are to be completed prior to submitting form)			
Click to enter name.	☐ Yes	☐ No	Click to enter a date.
Technical Representative Name	**Technical Representative Approval**		**Date**
Click to enter name.	☐ Yes	☐ No	Click to enter a date.
Bureau Chief Name	**Bureau Chief Approval**		**Date**
RRC Approval	☐ Yes	☐ No	**Date:** Click to enter a date.

Appendix D

Research Partnering Project Annual Evaluation

MONTANA MDT DEPARTMENT OF TRANSPORTATION

RESEARCH PROGRAMS

Research Partnering Project Annual Evaluation Form

INSTRUCTIONS

Complete this form to request funding for research projects and programs where MDT will not be the lead and will not contribute all funds for the project/program, such as AASHTO pooled fund programs/projects (TPF) and Technical Service Programs (TSP). Send completed form to the Research Programs Manager.

Part A: General Project/Program Information			
Date: Click or tap to enter a date.	**Solicitation or Project Number:** Click or tap here to enter text as applica Pooled funds will either have a 4-digit solicitation number or a TPF number (e TPF-5(309)).	**Lead Entity:** Click or tap to enter name.	
		Technical Representative: Click or tap to enter name.	
Title: Click or tap here to enter title.			
Project/Program URL: If applicable, click or tap here to enter URL.			
Project/Program Begin Date: Click or tap to enter date.		**Project/Program End Date:** Click or tap to enter date.	
Annual MDT Contribution: Click or tap here to enter ann MDT cost.	**Number of Years for Annual Contribution:** Click or tap here to enter nun years.	**Total Contributed:** Click or tap here to enter the amount that MDT has already contributed to this project/program.	**Total Yet to Contribute:** Click or tap here to enter the remaining amount that MDT agreed to contribute to this project/program.

Part B: Evaluation – Technical Representative		
Evaluation		
Is this project/program making progress toward stated goals?	☐ **Yes**	☐ **No**
If yes, please describe. Click or tap here to enter text.		
If no, please explain why. Click or tap here to enter text.		
What knowledge and/or deliverables has MDT received to date from participation in this project/program? Click or tap here to enter text.		
Do you anticipate that any results of this project/program will be implemented/used at MDT?	☐ **Yes**	☐ **No**
If yes, please describe. Click or tap here to enter text.		
If no, please explain why. Click or tap here to enter text.		

Communications		
How often are meetings held? Click or tap here to enter text.		
Are you able to attend?	☐ **Yes**	☐ **No**
Do you at least receive quarterly progress reports?	☐ **Yes**	☐ **No**
If no, please explain. Click or tap here to enter text.		
Should MDT continue to contribute?	☐ **Yes**	☐ **No**
If yes, please explain. Click or tap here to enter text.		
If no, please explain. Click or tap here to enter text.		

Part C: Evaluation – Bureau Chief		
What benefits has participation had on your bureau, staff, and/or on MDT? Click or tap here to enter text.		
Should MDT continue to contribute?	☐ **Yes**	☐ **No**
If yes, please explain. Click or tap here to enter text.		
If no, please explain. Click or tap here to enter text.		

Part D: Approval			
Click or tap here to enter name.	☐ Yes	☐ No	Click or tap to enter a date.
Technical Representative Name	**Technical Representative Approval**		**Date**
Click or tap here to enter name.	☐ Yes	☐ No	Click or tap to enter a date.
Bureau Chief Name	**Bureau Chief Approval**		**Date**

Appendix E

Research Partnering Project Close-Out Evaluation

MONTANA MDT DEPARTMENT OF TRANSPORTATION

RESEARCH PROGRAMS

Research Partnering Project Close-Out Evaluation Form

INSTRUCTIONS

Complete this form to request funding for research projects and programs where MDT will not be the lead and will not contribute all funds for the project/program, such as AASHTO pooled fund programs/projects (TPF) and Technical Service Programs (TSP). Send completed form to Research Programs Manager.

Part A: General Project/Program Information		
Date: Click or tap to enter a date.	**Solicitation or Project Number:** Click or tap here to enter text as applica Pooled funds will either have a 4-digit solicitation number or a TPF number (e TPF-5(309)).	**Lead Entity:** Click or tap to enter name.
		Technical Representative: Click or tap to enter name.
Title: Click or tap here to enter title.		
Project/Program Begin Date: Click or tap to enter date.	**Project/Program End Date:** Click or tap to enter date.	**Total Cost to MDT:** Click or tap here to enter total MDT cos

Part B: Close-Out Evaluation – Technical Representative		
What knowledge and/or deliverables did MDT receive from this project/program? Click or tap here to enter text.		
Do you anticipate that any results of this study will be implemented at MDT?	☐ **Yes**	☐ **No**
If yes, please describe implementation actitivites. Click or tap here to enter text.		
If no, please explain why. Click or tap here to enter text.		
What value did MDT receive from participation in this project/program? Click or tap here to enter text.		
What value did you receive from participating in this project//program? Click or tap here to enter text.		

Part C: Close-Out Evaluation – Bureau Chief
What benefits did participation have on your Bureau and/or MDT? Click or tap here to enter text.

Part D: Approval			
Click or tap here to enter name.	☐ Yes	☐ No	Click or tap to enter a date.
Technical Representative Name	**Technical Representative Approval**		**Date**
Click or tap here to enter name.	☐ Yes	☐ No	Click or tap to enter a date.
Bureau Chief Name	**Bureau Chief Approval**		**Date**

Appendix F

Research Project Identification, Prioritization, and Selection

The Research Review Committee (RRC) is the governing committee for all research conducted for MDT, regardless of funding source.

MDT's Research Programs are internally-driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are required.

Definitions of Research

- **Research** means a systematic study directed toward fuller scientific knowledge or understanding of the subject studied. It can be formally defined as a systematic controlled inquiry involving analytical and experimental activities that primarily seek to increase the understanding of underlying phenomena. Research can be basic or applied.
- **Applied Research** means the study of phenomena to gain knowledge or understanding necessary for determining the means by which a recognized need may be met. Applied research serves to answer questions or solve problems. This research tends to respond to specific problems, providing realistic solutions, with lower risk and a short-term focus. **Applied Research is a focus of MDT's Research Programs.**
- **Basic Research** means the study of phenomena, and of observable facts, without specific applications towards processes or products in mind. Basic research serves to increase knowledge and lays the foundation for advancements in knowledge that may lead to applied gains in the future. This research seeks comprehensive understanding and tends to be higher risk, with a long-term focus. In the transportation field, for the most part, basic research is conducted by the federal government, universities, and the private sector. **MDT does not conduct basic research; however, basic research can be a component of a research project if there are matching funds to conduct this research.**
- **Experimental Feature** is any material, method, and/or process that is deployed in the field through an MDT project (e.g., construction, maintenance, or safety) for the purpose of evaluating the material, method, and/or process. **Experimental Feature deployment is a focus of MDT's Research Programs.**
- **Development** means the systematic use of the knowledge or understanding gained from research, directed toward the production of useful materials, devices, systems or methods, including design and development of prototypes and processes. It includes the delivery, application, demonstration, or assessment of products, such as through the Experimental Features Program, that have the potential to be implemented by research customers. Development tends to turn research results

into useable materials, devices, systems, and methods. **Development is a focus of MDT's Research Programs.**

- **Technology or Knowledge Transfer** means the communication of knowledge with users and involves the dissemination, demonstration, training, and other activities that can lead to the adoption of a new technique or product by users and eventual implementation and innovation. It can occur at any time in the research cycle. **Technology Transfer is a focus of MDT's Research Programs.**
- **Implementation** means the widespread use of research results and innovations. Implementation activities can occur throughout the research process. While implementation itself is not an SPR-eligible activity, efforts to facilitate implementation are for the most part SPR-eligible. **Facilitating the implementation of research results is a focus on MDT's Research Programs, translating research results into practice and making MDT Research relevant to MDT staff.**

What Research is not: While research may involve some of the below activities, they are not the main component of research.

- Data collection
- Implementation of operational changes (e.g. computerizing existing processes)
- Routine testing
- Training
- IT development
- Routine and/or periodic updates of plans, data, surveys, etc.

Applicable federal regulation & law, and other resources:

- 23 CFR 420.203
- 23 USC 505
- NCHRP Synthesis Report 355: Transportation Technology Transfer: Successes, Challenges, and Needs (pages 7-8)
- NCHRP Synthesis Report 461: Accelerating Implementation of Transportation Research Results (pages 6-7)
- NCHRP Synthesis Report 768: Guide to Accelerating New Technology Adoption through Directed Technology Transfer (page 6)

Project Types

All projects, regardless of type, require a champion and sponsor; these roles may be filled by the same person if that person meets requirements for a sponsor as defined in the following text. The champion must be an MDT employee with a vested interest in the results and implementation of those results. This person typically chairs the project technical panel (TP), if one is formed (Note: Not all partnering projects will have a technical panel overseeing each project), and makes requests of and presentations to the MDT Research Review Committee (RRC). See MDT's Research Project Technical Panel Roles and Responsibilities document in Appendix A. The sponsor is a high-level MDT manager, division or district administrator, or higher. This person agrees the topic is consistent with Department needs and goals,

should be considered by a technical panel, if one is formed, and commits to ensuring implementation occurs, as appropriate. The project types are described below.

- **Administration High Priority:** Any project which the Administrative Staff deems necessary and funding is needed prior to the next annual research project funding cycle.
- **Partnering Projects/Pooled Fund Projects:** Any project where MDT will not be the sole contributor of funds, is not the lead for the project, and, for non-pooled fund projects, funding is needed prior to the next annual research project funding cycle. Pooled fund projects (TPF) and AASHTO Technical Services Programs (TSP) are examples of partnering projects.
- **Quick Response/Small Projects:** Any project low in cost and short in duration, as defined by the latest Montana Partnership for the Advancement of Research in Transportation (MPART) agreement, and funding is needed prior to the next annual research project funding cycle. Contracts with MSU-Bozeman, Montana Tech, and UM-Missoula are executed every seven years to facilitate rapid initiation of these projects. In addition to these contracted small projects, research staff conducts quick response activities, such as literature searches and surveys of other entities.
- **Standard Research Projects:** Any project that does not qualify as any of the above.

Research Topic Solicitation

Research ideas can be submitted by anyone at any time on any research topic, as defined above; however, they may only be considered annually, unless they fall outside of the standard research project as described in the previous section. Also, as previously mentioned, all research topics require an internal champion and sponsor.

The RRC may want to identify priority research focus areas annually or on some other basis. If so, these areas are advertised when research ideas are requested. Research ideas will still be accepted on any topic; however, those addressing a priority research focus area may be ranked higher.

Submittal of research ideas and topic statements is a two-stage process. Stage 1: Anyone submits a Research Idea form (Appendix B and http://www.mdt.mt.gov/research/unique/solicit.shtml) by March 31st of each year. A Champion is identified in the Research Idea Form or Research staff attempt to secure a Champion for the idea. The Champion works with the MDT librarian to conduct a literature search on the topic to identify related ongoing and completed research. If research is ongoing on the topic, the Champion may wish to wait until the research is complete to identify any additional related research topics or to initiate an implementation process and/or project (Stage 2). If research on the topic is complete, the Champion will evaluate the research to determine if it meets the specific need. If so, the Champion may want to initiate an implementation process and/or project (Stage 2). If completed research does not meet the specific need, the Champion can initiate Stage 2. Implementation of research results can be a research project in and of itself; in this case, the implementation project will move forward to Stage 2. Stage 2: A Research Topic Statement form (Appendix C and http://www.mdt.mt.gov/research/unique/solicit.shtml) will be submitted by April 30th of each year to be considered in June or July of that same year for funding in the next federal fiscal year. Champions present their research topics to the RRC in May of each year.

It must be realized that the cost and research period estimates are only that, as the final cost and research period will be based on the chosen research methods as described in the final proposal and

approved by the RRC. However, if the cost is higher than originally estimated, the project may be delayed.

MDT staff is encouraged to reach out to research staff, university staff, and others to discuss problems, rather than research needs. Once these problems are identified, potential for research solution(s) can be identified. Likewise, individuals interested in conducting research for MDT should make connections with MDT staff in their area of expertise to discuss MDT issues and the potential for research solution(s), matching researcher areas of expertise to MDT research needs. However, Research Topic Statements become the property of MDT and no entity is guaranteed to receive research contracts for their topic statements. Technical panels choose to contract directly with a public entity, issue an RFP, or to submit to another research program, such as the National Cooperative Highway Research Program (NCHRP). If a topic statement is submitted by a public entity, the panel will consider recommending the funding for the public entity first.

Topic statement champions will present their topic to the RRC and District Administrators annually at the May RRC meeting.

Research Topic Prioritization and Selection for Standard Research Projects

Who: RRC and District Administrators

When: Annually in June or July, after champions present at the May RRC meeting

How: The process is described below.

The RRC and District Administrators will rank the topic statements after the champion presentations in May, but by the deadline set for receipt of June or July RRC meeting agenda items. Items to be considered in the ranking include:

- Priority research focus areas (e.g., TranPlanMT focus areas that lend themselves to research);
- Scope, budget, and timeline are appropriate for available resources (limited funds need to be allocated to highest priorities) and timeliness/urgency of topic;
- Importance (e.g., federal or state initiative or compliance);
- Benefits and pay-off (including as they relate to MDT's mission and "strategic plan"; e.g., return on investment, cost/lives savings, etc.);
- Implementability; and
- Feasibility/probability of success/risk (What is success?)

Also, the RRC and District Administrators should identify additional technical panel members by naming individuals and/or stakeholder groups/entities. In addition, they should identify topic statements where they feel the requested funding is insufficient and identify an amount they feel is sufficient. Finally, rankers should identify any topic statements which they feel should not move forward.

Research staff will compile the rankings, projects identified for potentially not moving forward, proposed technical panel members, and funding level changes, along with changes to estimated ICAP. This information will be discussed at the June or July RRC meeting. The results of which will be a final ranking, identification of panel members, funding level, and identification of topic statements that will not be moved forward.

At the June or July RRC meeting, funding will be assigned to research topics based on their ranking, final estimated cost, and funding source(s), until all estimated available funds for research projects have been committed. Partial funding for projects will not be considered, unless, it makes sense to phase the project or it is a partnering project and the project is entirely funding by all of the partners. While funding is allocated to projects at this point, funding is not approved. Final funding approval occurs when each project proposal is presented to the RRC.

A 15%, of total available funds, contingency should be held back to cover potential project costs higher than the original estimate and other needs that arise, such as Administration High Priority Projects, as described below.

Research Topic Development and Proposal Solicitation for Standard Research Projects

Technical panels will be formed for the projects approved in June or July.

Technical panels will continue to fulfill their role, as identified in Appendix A, and as amended. Champions will review ongoing and completed research identified in Stage 1 with panel members. Technical panels will determine the specific research need (i.e., fine-tuning the Stage 2 Research Topic Statement into a scope of work (SOW)). Panels will determine the most appropriate venue for research (e.g., MDT funded research, pooled fund study, or NCHRP project). Panels may determine the need for research does not exist or the research should be submitted to another research program, in these cases, the panel will recommend the RRC cancel the project. If the technical panel recommends a project be cancelled and the RRC approves cancellation, the estimated cost is returned as available funds.

This will all be documented in the Research Project Statement form, which can be found at http://www.mdt.mt.gov/other/webdata/external/research/docs/project_statement_form.pdf.

Based on the completed research project statement form, the technical panel will develop a scope of work (SOW).

Sometimes, after discussion amongst technical panel members, the scope of the project changes from the original research topic statement. When the scope changes substantially (i.e., the SOW changes from the original intent; e.g., a different champion is required), the SOW will be presented to the RRC prior to requesting proposals. Also, if the estimated cost increases by the percentage shown in the below table or more (projects estimated to cost $50,000 or less do not need additional approval), or there was any contention when the research topic statement was moved forward to a technical panel, the SOW will be presented to the RRC. Finally, the SOW for which an RFP will be issued will be presented to the RRC. Technical panels have the authority to fine-tune the SOW without RRC approval if the original intent does not substantially change, the estimated cost does not increase by the percentage shown in the below table or more, and if an RFP will not be issued.

Project Cost	Percent Increase in Project Cost
$50,000 or less	N/A
$50,001 to $100,000	30%
$100,001 to $500,000	25%
Greater than $500,000	15%

The SOW will be used to solicit a proposal(s) in one of two ways: one or more public entities may be asked to submit a proposal, or an RFP will be issued. The time for proposal development can be quite varied depending on the topic, the method for obtaining each proposal, panel availability, and other factors.

Research Project Funding

Unless stated otherwise, funding is from federal appropriations or other sources and does not refer to state budget authority. State Planning and Research (SPR) funds are legislated as a 2% set aside of the apportionments MDT receives from the Interstate Maintenance, National Highway System, Surface Transportation, Highway Bridge, Congestion Mitigation and air Quality Improvement, and Equity Bonus programs. Legislation also mandates a minimum 25% of SPR funds be allocated to RD&T activities.

The champion will present the proposal selected by the technical panel to the RRC for funding approval. The RRC may approve or reject the proposal, request clarification, or cancel the project.

If the proposed funding for a project is not more than the percentage shown in the below table greater than identified in the Stage 2: Research Topic Statement (excluding ICAP) and the proposal is approved by the RRC, the project will be contracted.

Amount of Final Proposal	Percent Over Estimate
$50,000 or less	N/A
$50,001 to $100,000	30%
$100,001 to $500,000	25%
Greater than $500,000	15%

If the proposed funding for a project is more than that identified in the above table greater than identified in the Stage 2: Research Topic Statement (excluding ICAP) and the proposal is approved by the RRC, the RRC will evaluate the availability of funds and determine if the project can be contracted at the current time. Note: Contracting for projects resulting through an RFP must occur within a specified timeframe (currently, within 6 months of the original RFP posting date), or the RFP needs to be readvertised.

Projects that don't rank high enough to receive funding in the initial cut can be disposed of in a couple of ways, as determined by the RRC: 1) Any funding assigned to projects that are later cancelled can be reassigned to the next highest ranked project(s) and technical panels can be formed for these projects or 2) Champions can resubmit these Research Topic Statements to request funding in a future federal fiscal year.

The estimated ICAP will be updated as soon as the ICAP rate is known for each successive state fiscal year (SFY), during which each project is active. If the ICAP rate increases, it will result in less funds available for non-standard research projects and/or funds available for the next cycle.

Funds will be set aside for the following projects:

- Administration of research activities by Research staff (8010 and 8020);
- MDT staff participation in research activities (8021);

- LTAP SPR (2443) (Note: LTAP is exempt from ICAP);
- NCHRP (Note: This expense is treated as a pooled fund and is exempt from ICAP);
- TRB Core Services Support (Note: This expense is treated as a pooled fund and is exempt from ICAP);
- AASHTO Technical Services Programs (TSP);
- Activities mandated ad/or to support Research, such as peer exchanges.
- WAQTC Pooled Fund (Note: This expense is exempt from ICAP)

Non-Standard Research Projects

Administration High Priority Projects

These projects are deemed high priority by Administrative Staff and funding is needed prior to the next annual solicitation for research topics. These projects are assigned technical panel oversight. As soon as projects are identified, funds are diverted to these projects.

Partnering Projects/Pooled Fund Projects

These projects are any project where MDT will not be the sole contributor of funds, MDT is not the lead, and, for non-pooled fund projects, funding is needed prior to the next annual research project funding cycle. Pooled fund projects (TPF) and AASHTO Technical Services Programs (TSP) are examples of partnering projects. Most partnering projects are assigned only a champion, as opposed to a full technical panel. TPFs are typically approved by FHWA for use of 100% SPR funds and they are not charged ICAP. However, some pooled funds are more planning in nature and do not fit the definition of research as documented above. The RRC will discuss funding these as the situations arise. Many AASHTO TSPs are approved by FHWA for use of 100% SPR funds; however, they are charged ICAP.

Funding request, annual evaluation, and close-out forms for these projects are found in Appendices D-F.

For multi-year partnering projects, funding may be approved for a maximum of three years and funding commitments will be made. However, it will be noted, participation in future years for which commitments have been made is dependent on the results of the annual evaluation and presentation as described above. Champions will be required to present annual progress to confirm the next year's commitment, if applicable, at the May RRC meeting. Funding decisions will be made at the June or July RRC meeting.

Annual limits should be developed by the June or July RRC meeting to allow contribution for current commitments and to additional partnering projects as they arise. Funding for partnering projects, will be approved on a first come, first serve basis, until the funding set aside is exhausted.

Quick Response/Small Projects

Quick Response/Small projects are any project low in cost and short in duration, as defined by the latest Montana Partnership for the Advancement of Research in Transportation (MPART) agreement, and funding is needed prior to the next annual research project funding cycle. Contracts with MSU-Bozeman,

Montana Tech, and UM-Missoula are executed every seven years to facilitate rapid initiation of these projects. In addition to these contracted small projects, research staff conducts quick response activities, such as literature searches and surveys of other entities.

Annual limits should be developed by the June or July RRC meeting to allow contribution for current commitments and to additional quick response/small projects as they arise. Funding for quick response/small projects, will be approved on a first come, first serve basis, until the funding set aside is exhausted.

Work Plan Development

The Research portion of the SPR work plan will be developed and approved by FHWA annually in August and September for the FFY that begins in October. All RD&T activities planned for a particular year will be included in that annual work plan. If actual costs are unknown, estimates will be included.

Appendix G

Implementation of Research Results

MONTANA MDT DEPARTMENT OF TRANSPORTATION

RESEARCH PROGRAMS

Implementation of Research Results – Begin with the End in Mind

July 2018

Introduction

MDT's Research Programs are internally-driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are the goal. Implementation of research results also helps MDT in meeting its mission of providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality, and sensitivity to the environment. As defined by MDT, implementation means the widespread use of research results and innovations. While implementation itself is the responsibility of research customers and is not an SPR-B-eligible activity, Research provides support to facilitate implementation and tracks this implementation.

To enhance the chance of successful implementation, it should be considered as a driving force, an integral component of the research process serving as a constant reminder for the conduct of the research. It is a process, not an event, and must be considered from the beginning and throughout each research project, with consideration to the three key implementation drivers: competency, organization, and leadership. The competency to implement the results and sustain them must be present or developed. MDT, as an organization, must be ready for the required changes. There must be leadership buy-in and support to effect any change. A culture of implementation needs to be encouraged within the philosophy and processes of an organization.

Implementation Integration in the Research Process

Implementation is first considered in MDT's research process with the submittal of the Stage 2: Research Topic Statement form (Appendix A, https://www.mdt.mt.gov/research/unique/solicit.shtml), with the following directions.

- Describe how the project will address the need
- Address the implementability of the expected results from the proposed project.
- Identify products that will facilitate implementation and how these products may be used.
- Identify any known implementation barriers and how these barriers might be eliminated or reduced.
- Identify MDT office or entity outside of MDT responsible for implementation.
- Describe initial implementation plan, include timeframe for implementation.

The topic statement also requires a Champion, who is involved in the daily aspects of the research project, and a Sponsor, who is ultimately responsible for the implementation of research results. The 15 people who can sponsor research are the Division and District Administrators, the Deputy Director, and the Director. These individuals are also members of MDT's high-level Research Review Committee, which determines which Research Topic Statements will be moved forward to technical panels. Stakeholders, including potential implementers, are included on each technical panel. This helps to ensure that the process seamlessly flows from project idea through implementation, performance measurement, and determining the value of the research.

Implementation is next considered at the first technical panel meeting, through scope of work (see Appendix B: *On Developing a Research Project Scope of* Work and Appendix C: Scope of Work Development form) development and in Part A of the Implementation Planning and Documentation form (Appendix D), with the following considerations.

- Linking of objectives and tasks to deliverables
- Describing how the research will address the need
- Identifying key decision-makers
- Identifying the area(s) responsible for implementation
- Identifying other cooperators, stakeholders, and partners
- Identifying barriers to implementation and the actions necessary to reduce or eliminate these barriers
- Describing how the results will be implemented
- Defining successful implementation
- Identifying the benefits of implementation
- Identifying the products necessary for implementation (including any technology/knowledge transfer, marketing, and/or training activities).

  Technology/Knowledge Transfer means those activities that can lead to the adoption of a new technique or product by users and involves dissemination, demonstration, training, and other activities that may lead to eventual implementation.

  Marketing is directed towards a larger, general audience. Products can include such things as newspaper, radio, and TV outreach.

The scope of work is developed and the Implementation Planning and Documentation form is completed by the research project manager for each project. The latter begins as a planning document, with the assumption that the research will be successful and that results of the research will be implementable and is updated as new information is available. Early implementation efforts, those occurring prior to project completion, are documented as well.

It is critical that implementation requirements are included in the scope of work as it the basis for proposal development. The proposal becomes a part of the project contract and is the standard to

which consultants are held. Also, demonstrating the benefits of implementation will significantly increase the chances of successful deployment.

Implementation barriers, both internal and external, are considered early on so that the barriers can be eliminated or at least reduced. Considering these barriers early on in a project greatly increases the chances for a successful project and implementation. Also, providing the researchers with the knowledge of these obstacles may influence proposal development.

Typically, final reports are not implementable. Without engaged thought and a targeted deployment strategy, the research report will often die on the shelf or in the cyber world. Therefore, products necessary for implementation are identified so that these products can be added as deliverables in the project scope, proposal, and contract. If, as the research proceeds or as it is completed, there is a need for different or additional implementation products, the contract will be amended to include the appropriate and necessary deliverables, or a separate implementation assistance contract will be executed. To achieve a significant impact, products must be well specified, well matched to the needs of the users, implemented in a deliberate and adaptive manner, and supported by a hospitable environment and learning processes.

Implementation is next considered in the project proposal (https://www.mdt.mt.gov/other/webdata/external/research/docs/proposal.pdf), with directions to describe how research results can be applied, including the following, to the extent possible.

- Describe how the research will address the need.
- Describe the form in which the findings may be reported, such as a mathematical model, a laboratory test procedure, or a design technique. Describe these results in terms of the user (e.g., practicing engineer, administrator).
- Link the objectives and tasks to deliverables and successful implementation.
- Describe activities necessary for successful implementation.
- Identify who would logically be responsible for applying the research results, such as the American Association of State Highway and Transportation Officials (AASHTO), FHWA, MDT, or a particular office within MDT.
- Identify specific standards or practices that might be affected by the research findings, such as AASHTO or MDT specifications, MDT policies and procedures, legislation, or fiscal requirements.
- Submit an implementation plan tied to performance measures describing how to implement the results. If an IT component is part of the implementation submit a work plan for update and maintenance.
- Provide an estimate of the costs of implementation.
- Identify the long-term implementation activities and costs.
- Identify barriers of implementation and how these barriers might be reduced or eliminated.
- Describe the criteria for judging the progress and consequences of implementation.
- Describe the benefits of implementation

- If the findings of a study are not suitable for immediate application in practice, the proposal should specify additional steps needed before application can occur (e.g., additional research, field testing, changes in policy, etc.).

The proposal instructions continue with the following text: *It is understood the research may produce unanticipated findings, making changes in the implementation plan necessary. This is acceptable. The proposal selection, however, will be greatly influenced by the practicality and direction of the implementation plan presented in the proposal.*

As each research project progresses, from the project kick-off meeting through the conduct of research, the Implementation Planning and Documentation form (Appendix D) is updated. The following items are discussed at the project kick-off meeting.

- Research project process
- Key contractual requirements
- Research objectives, and link to tasks and deliverables
- Research approach to meet objectives
- Data requirements
- IT requirements
- Researcher needs of the technical panel
- Implementation barriers and actions to reduce or eliminate barriers
- Products, including those necessary for implementation
- Implementation process, including key players
- Benefits and impact of research (Both qualitative and quantitative performance measures will be captured and documented in the Performance Measures Report)
- Research performance measures
- Research timeline

Also, as research results are available, implementation can occur at any time in the research process and early implementation is enhanced with the requirement of project task reports. However, implementation recommendations and an implementation plan defining the procedure to introduce the results into practice are documented in final deliverables.

These recommendations are discussed at the project implementation meeting, along with MDT's response to each recommendation. This information is summarized in the implementation report, which requires a review and approval by the technical panel and the Sponsor. The final researcher presentation to the technical panel is also given at this meeting.

This triggers the completion of Part C in the Implementation Planning and Documentation form (Appendix D), which includes the following information for each implementation activity.

- Implementation Activity Description
- Required Resources, including an itemized cost for implementation, source of funds, tools, and any approvals needed

- Continuing Barriers, Planned Resolution, and Results
- Individual Responsible for Activity
- Begin Date
- Deadline
- Follow-up Schedule
- Updated Date
- Update Description
- Implementation Status
- Comments

Implementation Categories are listed below. These categories are not mutually exclusive and are updated with each update to the Implementation Planning and Documentation form (Appendix D).

- Change in practice (e.g., business practice, design, methods, plan, policies, procedures, process, regulation, rule, specification, standard)
- Current Practice Validation
- Data Collection and/or Processing
- Decision Support Tool, Simulation, Model, or Algorithm: New or Improved
- Demonstration
- Developmental: The research produces a new or modified material, method, device, system, or technology, including design and development of prototypes and processes.
- Equipment, Technology, or Tool: New or Improved
- Feasibility/Proof of Concept
- Field Guide, Guidelines, Handbook, or Manual: New or Improved
- Further Work Needed
- Information-Only/Knowledge Gained
- Information Dissemination/Training: New or Improved
- Product Evaluation

The implementation stages or statuses are listed below; these statuses are mutually exclusive and are updated with each update to the Implementation Planning and Documentation form (Appendix D).

- **Further Work Needed:** Further research, such as another phase or an Experimental Features project, and/or further preparation, such as an organizational change, are needed before implementation can begin.
- **Implementation Pending:** Implementation is planned but has not yet begun.
- **Implementation in Progress:** Implementation is actively proceeding.
- **Partially Implemented:** The implementation activity is not and will not be fully implemented.
- **Fully Implemented:** The implementation activity is complete as described or modified and is in wide use.
- **Not Implemented:** The implementation activity will not proceed to implementation.
- **Not Applicable for Implementation:** The project did not produce an implementable activity.

Research results indicating the current situation is the best alternative should be considered as implemented. Also, projects initiated to only provide information to staff are also considered implemented when the information is provided.

At this time, the champion presents the research, results, and planned implementation to MDT's high-level Research Review Committee.

Implementation for each research project is tracked as described in the Implementation Planning and Documentation form (Appendix D) until all implementation activities are complete or it is clear there will be no additional implementation. At this point this form is finalized, with a sign-off by the project champion and sponsor.

Beyond MDT Research: Implementing the Research Results and Innovations of Others

In addition to the implementation of MDT research results, MDT Research makes a deliberate and focused effort to identify the implementation of innovations from MDT staff and the innovations and research results from other organizations and programs, such as the AASHTO Innovation Initiative (AII), FHWA Accelerated Innovation Deployment (AID), FHWA Every Day Counts (EDC), FHWA Exploratory Advanced Research (EAR), TRB Innovations Deserving Exploratory Analysis (IDEA) programs and other research programs, that can either directly or with some additional work be implemented within MDT. There is no need to reinvent the wheel. In many cases, the research results from other entities can be directly implemented or implemented with little additional effort. MDT Research documents and quantifies the value of doing so as they result in a large cost savings to MDT, leveraging the funds from others. There are a number of key questions related to this implementation, including the following:

- Is the innovation implementation ready or does additional work need to be conducted to make it so? Is it feasible to deploy within MDT's environment?
- What are the qualitative and quantitative impacts of this implementation? Is data available or can it be generated to quantify the benefits?
- How does the innovation apply to MDT's mission, strategic goals, and performance measures?
- How is the innovation an improvement over the as is condition?
- What is the timeframe for implementation?
- What resources are required for implementation and to sustain the implementation of the innovation?
- How broadly does the innovation apply to MDT?
- What are the barriers to implementation and how can they be overcome?
- What are the risks?

There are a number of efforts to capture this information on research results and innovations that can be implemented by MDT.

- On a continuing basis, MDT Research identifies the implementation of innovations. For those innovations that can be quantified, data is collected to calculate value such as benefit/cost and return on investment. This ongoing effort is supplemented with an annual survey.

- When customers request literature searches from library staff, they are asked if they found that which they were seeking. If so and results will be implemented, implementation is documented, and performance measures identified, documented, and those quantitative performance measures are calculated.
- When MDT staff participate on panels for pooled fund and TRB Cooperative Research Programs, such as NCHRP, they are required to complete a Partnering Project Close-Out form (Appendix E) to identify MDT implementation efforts that will follow, from which performance measures are identified, documented, and those quantitative performance measures calculated. Also, staff are notified of the NCHRP Implementation Support Program, which provides funds to facilitate the implementation of the results of NCHRP projects.
- As external research reports are distributed to staff, staff are asked if they plan to implement any of the results. In addition to research final reports, many funding programs also publish implementation reports, successes, and other documents, such as TRB's Paths to Practice and Ready Results, which can facilitate implementing the results of research. If staff are planning to implement research results and innovations, implementation will be documented, and performance measures identified, documented, and those quantitative performance measures will be calculated. Also, staff are notified of the NCHRP Implementation Support Program, which provides funds to facilitate the implementation of the results of NCHRP projects.

A concerted effort is made to identify and document the implementation of research results and innovations, from both internal and external sources, to communicate and facilitate the practical use of these results and innovations, and to determine the value of this implementation value.

Implementation Funding

Implementation in itself is not an SPR-B-eligible activity. However, SPR-B funds can be used to facilitate implementation. SPR-B funds are the most common funds available for these activities. However, there are other sources of funds, such as the NCHRP Implementation Support Program, AASHTO Innovation Initiative (AII), FHWA Accelerated Innovation Deployment (AID), FHWA Every Day Counts (EDC), FHWA Exploratory Advanced Research (EAR), TRB Innovations Deserving Exploratory Analysis (IDEA) programs, and the State Transportation Innovation Councils (STIC).

Implementation Tracking

Implementation program-wide is also tracked and is an aggregation of project (both MDT Research and non-MDT Research) implementation. Implementation is tracked by project as detailed in the Implementation Planning and Documentation form for each project. It is aggregated annually in the MDT Research Annual Report.

Implementation Reporting

Implementation plans and results are reported in a number of documents, including: Project Summary, Implementation, Implementation Planning and Documentation, and Annual Research Reports.