

MINISTRY OF TRANSPORTATION ONTARIO (MTO)

# Highway Infrastructure Innovation Funding Program

*Guidelines & Application Forms for  
Ontario Universities and Colleges*

**2017**

**ONTARIO MINISTRY OF TRANSPORTATION  
HIGHWAY INFRASTRUCTURE INNOVATION  
FUNDING PROGRAM  
for Ontario Universities and Colleges  
Guidelines 2017**

**Table of Contents**

**1.0 INTRODUCTION .....4**

**2.0 PURPOSE OF THE PROGRAM.....4**

**3.0 SCOPE OF THE HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM.....5**

    3.1 Eligible Institutions .....5

    3.2 Eligible Research Topics .....5

    3.3 Ministry Assistance in Conducting Funded Research .....7

    3.4 Available Funds and Eligible Expenditures .....7

    3.5 Fieldwork on Ministry Highways .....8

    3.6 Information and Data Confidentiality .....8

**4.0 APPLICATION PROCEDURE, DEADLINES.....8**

    4.1 Application Components.....8

    4.2 Detailed Research Proposal Requirements .....9

    4.3 Deadlines & Address for Applications.....9

**5.0 BUDGET ..... 10**

    5.1 General .....10

    5.2 Budget Summary .....10

**6.0 SELECTION CRITERIA..... 11**

**7.0 NOTIFICATION OF AWARD..... 12**

**8.0 FINANCIAL ARRANGEMENTS & REPORTING REQUIREMENTS..... 12**

**9.0 AMENDMENTS TO A RESEARCH PROPOSAL..... 13**

**10.0 ANTICIPATED OUTCOME / DELIVERABLES ..... 13**

    10.1 Disclaimer .....14

**11.0 RESEARCH OUTCOMES..... 14**

**12.0 EXTERNAL PUBLISHING AND COMMUNICATION OF RESEARCH OUTCOMES ..... 14**

**13.0 OCCUPATIONAL HEALTH AND SAFETY..... 15**

**ATTACHMENT A – DETAILED DESCRIPTIONS OF SPECIFIC TOPICS..... 16**

**ATTACHMENT B – APPLICATION FORM..... 50**

**ATTACHMENT C – RESEARCH PROPOSAL SUMMARY.....51**  
**ATTACHMENT D – BUDGET SUMMARY.....52**  
**ATTACHMENT E – PROGRESS REPORT TEMPLATE .....53**

**ONTARIO MINISTRY OF TRANSPORTATION**

**HIGHWAY INFRASTRUCTURE INNOVATION  
FUNDING PROGRAM**  
*for Ontario Universities and Colleges*  
**Guidelines 2017**

**Deadline for Applications is  
Friday, March 17, 2017 at 2:30PM**

**1.0 INTRODUCTION**

The Ontario Government seeks to invest in the future of Ontario's Transportation Infrastructure through its Highway Infrastructure Innovation Funding Program.

HIIFP provides a challenge to Ontario's academic community to contribute to solutions in a number of areas including engineering materials, traffic operations, intelligent transportation systems, highway design, investment planning, environmental, bridges, geomatics, construction and maintenance. Some of these challenges involve detailed technical issues and others are open invitations for new ideas in a focus area. Your Institution is invited to submit one or more applications on how you can help us meet these challenges.

A glossary of terminology and acronyms used in these Guidelines are provided for your ease of reference:

- Institutions: Ontario universities (and their affiliated colleges, research centres, and institutes) and Ontario colleges of applied arts and technology
- Ministry: Ministry of Transportation Ontario (MTO)
- HIIFP: Highway Infrastructure Innovation Funding Program

**2.0 PURPOSE OF THE PROGRAM**

The purpose of this program is to fund research at Ontario colleges and universities to encourage applied research in transportation infrastructure in Ontario. This program is intended to solicit innovative solutions to assist the Ministry in meeting its strategic plan and to encourage undergraduate and graduate research in transportation and infrastructure engineering by providing funding to aid in such research. The present funding program is designed to supplement the research expertise at the Ministry with that available from Ontario's academic community. The following areas of transportation and infrastructure engineering are included in this program:

- Traffic Operations
- Intelligent Transportation Systems
- Engineering Materials
- Highway Design
- Investment Planning
- Environmental

- Geomatics
- Bridges
- Construction
- Maintenance

Research needs statements have been developed that outline the background of the research need, the challenge or problem to be addressed and anticipated research deliverables. Most of the challenge statements involve specific problems that will require innovation to solve. Typically, the anticipated research deliverable includes a technical report (that follows the Technical Style Manual – attached) and a presentation to a Ministry technical committee.

HIIFP is intended to support and encourage research into highway infrastructure. The Ministry has identified a number of specific topics that offer an opportunity for learning, innovation, and results. The Ministry will further support researchers with the opportunity for direct contact with Ministry specialists.

**3.0 SCOPE OF THE HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM**

3.1 Eligible Institutions

All Ontario’s 22 public universities and 24 colleges are eligible for funding under the HIIFP. The principal researcher must be a member of the faculty (full or part-time) at the sponsoring Institution.

3.2 Eligible Research Topics

A diverse range of research topics in the area of transportation and infrastructure engineering are included in this program.

**To be eligible for funding, HIIFP applications must cover one (or several) of the topics from the following categories:**

- **Specific Research Topics**
- **Open Research Topics**

3.2.1 Specific Research Topics

Each Specific Research Topic is defined as follows:

|                           |  |
|---------------------------|--|
| Subject Area:             | General Subject Area   |
| Title:                    | Title that identifies subject area   |
| Background:               | Discussion of the subject area, work done to date, thoughts on how to solve the challenge, reference information.  |
| Challenge:                | A statement or question that outlines the challenge.   |
| Anticipated Deliverables: | Typical deliverable is a technical report that demonstrates how the challenge was addressed and/or met and shows how improvements may be made. A presentation to a technical committee is also expected. Sometimes the anticipated deliverable provides more information on how to meet the challenge. |

The following topics have been identified as priority research areas for this year and detailed descriptions of each topic are provided in [Attachment A](#).

|    | Title   |
|----|---|
| 1  | <a href="#">Experimental analysis of road salt and winter sand application practices for highway maintenance</a>            |
| 2  | <a href="#">Evaluation of Innovative Performance Measures for Winter Highway Maintenance</a>                                |
| 3  | <a href="#">Developing Climate Severity Factors Affecting Equipment Complement of Area Maintenance Contracts</a>            |
| 4  | <a href="#">Source Water Protection from road salt.</a>   |
| 5  | <a href="#">New technology demonstration and evaluation for maintenance on snow packed highways.</a>                        |
| 6  | <a href="#">Predicting Level of Service for Alternative Winter Class Standards on Provincial Highways</a>                   |
| 7  | <a href="#">Estimation of the Stripping by Static Immersion using digital image processing</a>                              |
| 8  | <a href="#">Barn Swallow Nesting Deterrents</a>   |
| 9  | <a href="#">Barn Swallow GPS tracking on MTO infrastructure sites containing high nesting colonies</a>                      |
| 10 | <a href="#">Aerial Emissions Monitoring of Highways</a>   |
| 11 | <a href="#">Wildlife Detection Systems Comparison and Analysis</a>  |
| 12 | <a href="#">Resistance of Native Seed Assemblages to Phragmites</a>   |
| 13 | <a href="#">Training Dogs to Detect Turtle Eggs in Highway Shoulders</a>  |
| 14 | <a href="#">The Effect of Soil Plugging on the Geotechnical Resistance of Driven Piles</a>                                  |
| 15 | <a href="#">Integral Abutment - Backfill</a>  |
| 16 | <a href="#">Sustainability Assessment for Geotechnical Projects</a>   |
| 17 | <a href="#">Settlement / Instability of Highway Embankments due to Seismic Loading and Liquefaction</a>                     |
| 18 | <a href="#">Impact of Additives on the Performance of In-place Recycled Pavements</a>                                       |
| 19 | <a href="#">Load and Resistance Factor Design for Laterally Loaded Piles</a>  |
| 20 | <a href="#">Assessment of the Economic Benefit of Open Graded Drainage Layer (OGDL) in Pavement Design and Construction</a> |
| 21 | <a href="#">Estimating Pavement Damage associated with Heavy Vehicle Loading using In-road Sensor Technology</a>            |
| 22 | <a href="#">Seismic Forces on Abutment/Retaining Walls</a>  |
| 23 | <a href="#">Solar Roadway – Demonstration Project</a>   |

|    |   |
|----|---|
| 24 | <a href="#">Re-Use of Existing Piles</a>  |
| 25 | <a href="#">Non-Destruction Testing of Laminated Elastomeric Bearings</a>             |
| 26 | <a href="#">Financial Management System for High Occupancy Toll (HOT) lanes</a>       |
| 27 | <a href="#">Electronic Toll Collection System for High Occupancy Toll (HOT) lanes</a> |
| 28 | <a href="#">Enforcement Technology for High Occupancy Toll (HOT) lanes</a>            |
| 29 | <a href="#">Relating End Result Pay Factors to Pavement Performance</a>               |

### 3.2.2 Open Research Topic(s)

MTO will also accept and evaluate HIIFP proposals on topics not specified in the Guidelines that the principal researcher considers relevant to highway infrastructure innovation and the Ministry's business needs.

If you choose to submit an HIIFP application on another research topic, please carefully outline to the Ministry a clear need for the research topic(s) including how its application will enhance MTO practices and business needs.

For more information and to determine suitability of the proposed topic, contact:

Jessica Grimes  
 Provincial Highways Management Division  
 Ministry of Transportation  
[Jessica.Grimes@ontario.ca](mailto:Jessica.Grimes@ontario.ca)

### 3.3 Ministry Assistance in Conducting Funded Research

For each application that is approved, a Ministry technical specialist in the relevant subject area will be assigned to liaise with the principal researcher.

Timing of periodic meetings or telephone conference calls and brief progress reports will be negotiated at commencement of the project. Brief written progress reports will be required a minimum of every 6 months; see [Attachment E](#) for sample template.

For most funded applications, a technical presentation of the study results will be required. The presentation will typically be held at a location agreed to and acceptable to both parties.

### 3.4 Available Funds and Eligible Expenditures

Please be advised that the award value is subject to budget approval and the Ministry may have to delay any awards until the budget has been approved.

The total value of the awards is expected to be about \$1,000,000 beginning April 2017. It is expected that approximately twenty-eight projects will be funded. The Ministry reserves the right not to provide any funds in its sole discretion and without any reasons.

The Ministry will consider applications that are multi-year, where funding is required in each year. In such cases the Ministry will endeavour to provide funding beyond next fiscal year (ending March 31, 2018), however, cannot guarantee funding in future years and reserves the right to not provide the funding and terminate the research on written notice to the Institution.

For approved multi-year applications, Institutions will be required to provide brief progress reports to the Ministry indicating progress made on the project by the Institution; see [Attachment E](#) for sample template. Failure to provide such progress report(s) that describes substantial completion of tasks set out may result in the Institution being denied funding in subsequent fiscal years.

The salary of the principal researcher is not eligible for funding under the HIIFP, and nor is the principal researcher to charge any fee in this respect.

### 3.5 Fieldwork on Ministry Highways

The Ministry must approve proposed fieldwork on Ministry highways, and any proposed fieldwork on Ministry highways must be communicated by the principal researcher to the Ministry prior to submitting an HIIFP application. Approval to proceed will be given by:

Jessica Grimes  
Provincial Highways Management Division  
Ministry of Transportation  
[Jessica.Grimes@ontario.ca](mailto:Jessica.Grimes@ontario.ca)

### 3.6 Information and Data Confidentiality

The principal researcher and the Institution agree that all information and data that the Ministry may provide in respect of the research project shall be kept confidential and that the Institution shall only use the information and data for the purposes related to the submission of a final report to the Ministry for the research project. The Institution shall ensure that reasonable methods are taken to secure the confidential information and data of the Ministry. Failing to comply with this provision may result in the termination of the project, where upon the Institution shall return all information and data, return all monies paid by the Ministry and may result in the Institution being precluded from the award of future HIIFP awards.

## 4.0 APPLICATION PROCEDURE, DEADLINES

### 4.1 Application Components

The application shall consist of the following components:

1. **MTO HIIFP Application Form** ([Attachment B](#))
2. **Summary** of Research Proposal (300 words maximum, in plain language suitable for communicating with the public ([Attachment C](#)). Portions of this summary may be used in a media release, so the language should be non-technical and free of acronyms or jargon.
3. **Budget Summary** ([Attachment D](#))
4. Detailed **Research Proposal** (maximum 12 pages in 12-point font). Note, requirements are described in [Section 4.2](#)

5. **Budget** Details (see section [5.0 BUDGET](#)).
6. **Curriculum vitae** of Principal Researcher and other principal research staff named in the Application Form (component 1, above).  
**Only ONE COPY of the curriculum vitae for each principal staff member need accompany the application. Submission of an NSERC Form 100 personal data form is acceptable.**
7. Appendices. Only **ONE SET** of the complete appendices containing papers, reports, and other relevant information need accompany each application.
8. **For Principal Researchers who received funding for research projects as part of the 2016 HIIFP, a brief Progress Report is required** for each respective research project that the Principal Researcher received HIIFP funding for in 2015. The principal researcher can provide a progress report as per sample template in [Attachment E](#) or copy(s) of written progress reports complete to date if within the previous 3 months.
9. If applicable, description of and reason for request for use of MTO Facilities and or work on MTO highways.

Section [6.0 SELECTION CRITERIA](#) outlines the criteria used to assess the applications for HIIFP funding.

The Ministry reviewers will treat information contained in the submitted applications as confidential.

#### 4.2 Detailed Research Proposal Requirements

The detailed research proposal must include a description of:

- Understanding of the need for this research and the objective
- Methodology and details of the proposed analysis
- Proposed innovation in approaches, methodologies and potential outcomes
- Schedule of the activities to be undertaken during the project, identifying key milestone and associated dates
- Qualifications of the principal researcher in the planned area
- Related work performed by the applicant and others on the team.

#### 4.3 Deadlines & Address for Applications

Deadline for the receipt of applications is **Friday, March 17, 2017, 2:30PM EST**. Completed applications and all supporting documentation must be received by this deadline. They must be submitted to:

Jessica Grimes  
Executive Office, Highway Standards Branch  
Ministry of Transportation  
301 St. Paul Street, 2<sup>nd</sup> Floor  
St. Catharines, ON L2R 7R4

#### **Please submit:**

- 1 electronic digital copy on CD or USB.

- 1 hard copy of the innovation funding application form with original signatures (application components as describe in [4.1 Application Components](#)). Only one copy of the appendices need be supplied.

## 5.0 BUDGET

### 5.1 General

The detailed budget must include a full account of purchases and activities to be financed by the HIIFP funding. The level of budget breakdown and supporting information provided should be sufficient to justify the items relative to the Research Proposal description.

As stated in [Section 3.4](#), multi-year funding applications will be considered and provided on condition that sufficient information is provided.

The Ministry selection committee reserves the right to disallow expenditures in the budget that are not adequately justified. The committee may recommend partial support of a Proposal.

### 5.2 Budget Summary

Institutions must submit a budget summary as stated in [4.0 Applications Procedures, Guidelines](#), and having regard to the provision of [Available Funds and Eligible Expenditures](#).

Furthermore, the following types of expenditures are eligible for funding:

#### 5.2.1 Estimated Salaries and Benefits

Salaries, stipends, and related federal, provincial and institutional non-discretionary benefits for research work performed by research personnel (i.e., students, research associates, and technicians). The Ministry will not fund the salary of the principal researcher.

#### 5.2.2 Estimated Equipment or Facility

Equipment or facility costs directly attributed to the research proposal may be funded. The researcher may propose to use Ministry materials and structural laboratory facilities as part of their application, where facilities are not available in their Institution. The Ministry will not normally fund the purchase of major equipment, or the rental of existing equipment. However, in exceptional cases that satisfy the Ministry, major equipment purchases, rental of large shared equipment or purchase of computer time will be considered on a case-by-case basis.

#### 5.2.3 Materials and Supplies

Materials and Supplies include materials directly attributable to the research proposal such as the purchase of engineering materials. Where the Ministry is supplying materials, this has been indicated in [Section 3.2.1 Defined Research Topics](#) and [Attachment A](#).

Supplies include expendable materials, printing, photocopying, and other similar office supplies.

#### 5.2.4 Travel

A presentation to a Ministry technical committee will normally be required and the location will typically be agreed to by both institutions. Travel and accommodation costs should be in accordance with the Institution's internal guidelines.

#### 5.2.5 Dissemination Costs

Dissemination costs include costs associated with the preparation of the final report. The Ministry will require the technical report to be submitted in accordance with the **Style Manual for Technical Publications** as shown in Attachment F Word document template. This Style Manual will enable researchers to submit in a consistent and cost effective format.

#### 5.2.6 Overhead

Overhead may be included in the cost of your application. The Budget Summary form provided in [Attachment D](#) requires that you identify the rate of overhead for your Institution. **Please note that funds provided under this Program are considered a Research Grant and overhead rates should be calculated and presented accordingly, but must not exceed 25%.**

### 6.0 SELECTION CRITERIA

Staff of the Ministry of Transportation will review applications for funds from the HIIFP. To assist Institutions/applicants in completing the forms, the selection criteria for applications are as follows:

- Experience and qualifications of the researcher(s) in the subject area(s) – maximum of 20 points
- Demonstrated understanding of the need for the research and the objective – maximum 20 points
- Innovativeness of proposed research approach, methodologies and potential outcomes – maximum 20 points
- Adequacy and appropriateness of proposed research methodology and analysis – maximum 20 points
- Feasibility of accomplishing the research within estimated timelines and budgets using proposed methodology – maximum 20 points
- Other Considerations Not Awarded a Numerical Score:
  - Value-for-money (overall costs to the Ministry including Overhead Rate)
  - Importance of research proposal to MTO strategic plan
  - Demonstrates the utilization of sustainable materials and processes
  - If requested by principal researcher, availability of Ministry facilities for research and/or approval of proposed fieldwork on Ministry highways

- For principal researchers who received funding for project(s) from the 2013 HIIFP, satisfactory work in progress of their respective 2013 HIIFP research project(s). The evaluation of this criterion will be based on the brief progress reports requirement as described in Section [4.0 Application Procedures, Deadlines](#)
- Level of funding secured or provided in-kind from other sources.

The Ministry selection committee may request clarification of points contained in the proposal of any applicant, by letter or personal interview.

## 7.0 NOTIFICATION OF AWARD

A letter announcing an award will be sent from the Ministry to the principal researcher at the beginning of the award period, and a copy is sent to the financial official of the Institution designated in the application. The letter provides authority to incur project expenses for items and amounts specified in the **approved**, detailed budget. Expenses incurred in excess of the approved budget are not the responsibility of the Ministry.

The holders of research awards and their associates are not considered employees of the Ministry of Transportation Ontario or the Government of Ontario. The Ministry reserves the right to terminate an award without cause at any time by providing written notice of termination.

Any public announcements about the award of funding for the HIIFP shall be made by the Ministry, unless the Institution obtains the prior written approval of the Ministry.

## 8.0 FINANCIAL ARRANGEMENTS & REPORTING REQUIREMENTS

Awards will be paid to the Institution in one instalment of each year of the award in May.

Recipients of funds under this program are requested to maintain periodic contact with MTO staff assigned to monitor the progress on the research. A **financial report** must be submitted to the Ministry by the designated official of the Institution upon completion of the research project. This report will include a full account of purchases and activities financed by the HIIFP. It will also include an itemized list of equipment that was purchased in whole or part with the funds. The following headings will be included in the financial report:

- Salaries and Benefits;
- Equipment or Facility;
- Materials and Supplies;
- Travel;
- Dissemination Costs;
- Other Costs

The Ministry reserves the right to audit any project. The Institution is required to keep for five years any records that may be required for a financial audit.

For approved multi-year applications, in order for an institution to be funded in subsequent years on a multi-year basis, Institutions will be required to provide brief progress reports to the Ministry indicating progress made on the project by the Institution; see Attachment E for sample template. Failure to provide such progress

report(s) that describes substantial completion of tasks set out may result in the Institution being denied funding in subsequent fiscal years.

Any surplus or funds not spent must be returned to the Ministry by the Institution. If the research is not started or terminated part way through a project, any unused portion of the research funding must be returned to the Ministry within 30 calendar days.

## 9.0 AMENDMENTS TO A RESEARCH PROPOSAL

The Ministry must be notified either in writing or verbally in advance of any intention to:

- Alter the direction or intent of the research;
- Terminate the research;
- Reassign research responsibilities to other researchers, than those named in the original HIIFP application;
- Alter the work schedule.

The principal researcher must consult with the Ministry and obtain approval from:

Jessica Grimes  
Provincial Highways Management Division  
Ministry of Transportation  
[Jessica.Grimes@ontario.ca](mailto:Jessica.Grimes@ontario.ca)

Written approval from the Ministry must be obtained before any alterations in the project are implemented. If the Institution is uncertain as to what constitutes a major alteration in the project, he/she should contact the above noted contact to discuss this matter. If the principal researcher is unable to provide a significant level of participation as originally set out in the application, then alternative arrangements for responsible supervision of the project must be submitted for Ministry approval prior to the start of the absence.

## 10.0 ANTICIPATED OUTCOME / DELIVERABLES

The Institution shall submit a final report (typically about ten to fifteen pages in length) in both hard copy and electronic format no later than **three months after** the end of the funding period or after termination of funding by the Ministry. Some or all of the members of the Ministry application review committee that recommended support of the research will review the final report.

The final report shall be submitted in PDF format and should include:

- Conclusions and discussion of applications of the new findings to the challenge statement
- Plans for publication and for dissemination of results

The Ministry will retain the final report and usually make it widely available to others through the [MTO Online Research Library](#).

**Note:** A copy of a student thesis or dissertation is **NOT** a substitute for a final report according to the above format

Reprints of publications or manuscripts submitted to journals and copies of papers presented at scientific meetings should be included with the final report. (Manuscripts and articles *in press* will remain confidential.)

The Institution or the principal researcher shall also provide the Ministry a copy of any follow-up publications which the researcher prepares following the project and which incorporates any portion of the research outcomes.

#### 10.1 Disclaimer

Any publication resulting from research funded under this program shall acknowledge the source of funds and include a disclaimer, indicating that the views of the authors may not necessarily reflect the views and policies of the Ministry.

**Sample of Disclaimer to be used:**

“This research was supported [or in part] by a grant from the Ministry. Opinions expressed in this report are those of the authors and may not necessarily reflect the views and policies of the Ministry.”

Should the Institution want to make specific reference to the Ministry and/or name Ministry staff in the publication, permission of the Ministry must be obtained prior to publication. Permission requests should be sent to the contact mentioned in Section 9.0.

#### 11.0 RESEARCH OUTCOMES

The Ministry may use the research outcomes from the HIIFP applications that are funded by the Ministry. In this regard, and as a condition of funding the research project, the Ministry shall be granted a non-exclusive, royalty-free license without charge to use the outcomes and/or conclusions in the research outcomes for the Ministry’s own non-commercial internal purposes including use on Ministry highway contracts and work conducted on behalf of the Ministry.

In the event the Institution is able to obtain patent protection for any of the outcomes and/or conclusions in the research outcomes, the Ministry shall be granted a royalty-free non-exclusive license without charge to use the outcomes and/or conclusions in the research outcomes with no right to sub-license to third parties. The Institution shall arrange for the execution of the appropriate documents to give such licenses to the Ministry.

Should the research outcomes be further interpreted and/or refuted by the Ministry, then the Ministry’s findings and/or conclusions shall become the responsibility of the Ministry. Should the Ministry’s findings and/or conclusions differ from the findings and/or conclusions in the research outcomes, the names of the principal researchers, original authors, and Institution shall not be associated with the Ministry’s findings and/or conclusions.

#### 12.0 EXTERNAL PUBLISHING AND COMMUNICATION OF RESEARCH OUTCOMES

Researchers are encouraged to publish and present their research findings independently, but must notify the Ministry of the research findings and/or conclusions, and/or research outcomes being published or communicated must follow the procedure

set out below, and must ensure the disclaimer described in [Section 10.1](#) is attached there to:

- 12.1 In determining when the research findings and/or conclusions in the research outcomes, or the research outcomes should be disclosed, both the Ministry and Institution shall be sensitive to the need for timely approval of graduate student theses and essays.
- 12.2 The Institution, using best efforts, shall provide to the Ministry, at least sixty (60) calendar days in advance of any proposed publication or presentation, an outline and associated abstract of any research findings and/or outcomes, and/or research outcomes (or any other matter related to these Guidelines) which it intends to publish or present.
- 12.3 For the purpose of section 12.2 the terms "disclosure", "publication" and "presentation" include articles, seminars and any other oral or written presentations as deemed appropriate by the Institution to the public, but does not include student theses or other communications submitted for the purpose of evaluating student performance.
- 12.4 The Institution retains the right to have graduate student theses reviewed and defended for the sole purpose of academic evaluation in accordance with the Institution's established procedures.
- 12.5 All media inquiries regarding HIIFP awarded research should be referred to the Ministry. Researchers should not speak to the media directly regarding research outcomes. If Researchers are contacted by the media please communicate that: "Highway Infrastructure Innovation Funding Program policy is to refer all media inquiries to MTO corporate communications." Once the request is received by MTO, staff will work with researchers on a suggested response.

### **13.0 OCCUPATIONAL HEALTH AND SAFETY**

The Institution will be responsible for meeting all of the obligations under the Occupational Health and Safety Act (OHSA) and shall ensure that the research is carried out in accordance with the OHSA and all applicable regulations. This includes but is not limited to, the duties to: provide a safe workplace; provide information and educate the workers on workplace hazards; appoint a competent supervisor; prepare and provide a health and safety policy; implement a comprehensive health and safety program to support the policy; and take every reasonable precaution to protect the health and safety of workers.

Researchers intending to carryout fieldwork on Ministry right of way and researchers proposing to make use of Ministry laboratories must contact the Ministry for additional information on operational constraints and occupational health and safety requirements.

**ATTACHMENT A – DETAILED DESCRIPTIONS OF SPECIFIC TOPICS**

|                             |  |
|-----------------------------|--|
| <b>Subject Area:</b>        | Highway Winter Maintenance   |
| Title:                      | 1. Experimental analysis of road salt and winter sand application practices for highway maintenance  |
| <b>Background:</b>          | <p>MTO best practices for winter materials were last updated 10 years ago. Alternative practices have been adopted by other agencies during that period such as; lower application rates, increased ratio of liquid to granular material, finer granulation of rock salt, and use of liquids at lower temperatures. Virtually no formal analysis has been undertaken to define the conditions where alternate practices are safe or beneficial. The Ministry has undertaken a program of field comparison that includes precise monitoring of plowing, material spreading and road surface conditions through multiple winter test events at three different locations. The challenge is to integrate the comparative data and use it to calibrate models to assess the relative performance of the alternative practices and materials with a view to estimating equivalent application rates from the perspective of road surface conditions and cost effectiveness.</p> |
| <b>Challenge:</b>           | <p>The challenge is to develop and apply analyses that compare the alternate practices with conventional application of road salt under the variety of winter conditions experienced on Ontario highways. The analyses should consider effectiveness in restoring bare pavement conditions, road safety during storms, direct and indirect costs, and make recommendations on suitable alternative practices. Successful approaches may be added to Ministry Best Practices or Contact Standards.</p>  |
| <b>Anticipated Outcome:</b> | <p>Results are to be presented in a written report, a seminar sponsored by the Ministry, and at least one paper at a recognized technical conference.</p>  |

|                             |  |
|-----------------------------|--|
| <b>Subject Area:</b>        | Maintenance  |
| <b>Title:</b>               | 2. Evaluation of Innovative Performance Measures for Winter Highway Maintenance  |
| <b>Background:</b>          | <p>Performance measures are used by many public agencies to ensure that services are provided on an equitable and consistent basis, and to demonstrate accountability. Performance measures can take many forms and are commonly categorized as input, output, outcome and impact. Performance measures for winter maintenance are particularly difficult to establish because of the strong influence of external factors such as winter weather and traffic (<a href="https://www.nap.edu/catalog/23059/performance-measures-for-snow-and-ice-control-operations-supplemental-material">https://www.nap.edu/catalog/23059/performance-measures-for-snow-and-ice-control-operations-supplemental-material</a>).</p> <p>MTO’s performance-based contracts for winter maintenance focus on input measures of response time and circuit time, and the output measure of bare pavement regain time after a storm. (<a href="http://www.auditor.on.ca/en/content/specialreports/specialreports/winterhighway_en.pdf">http://www.auditor.on.ca/en/content/specialreports/specialreports/winterhighway_en.pdf</a> )</p> <p>While these measures provide a consistent approach, Ontario’s Auditor General recently identified a need for performance monitoring tools specific to winter maintenance, and recent research suggests that within-storm conditions that are not accounted by current measures can have an important impact on road safety (<a href="https://trid.trb.org/view.aspx?id=11389230">https://trid.trb.org/view.aspx?id=11389230</a>) (<a href="http://www.westernstatesforum.org/Documents/2013/presentations/Idaho_Jensen_FINAL_WinterMaintenancePerformanceMeasures.pdf">http://www.westernstatesforum.org/Documents/2013/presentations/Idaho_Jensen_FINAL_WinterMaintenancePerformanceMeasures.pdf</a>)</p> <p>Concurrent developments in road monitoring technology hold out the possibility for future automation of monitoring and reporting winter maintenance program performance. (<a href="http://itsslabs.com/itss-at-the-2016-trb-annual-meeting-jan-10-14-2016/">http://itsslabs.com/itss-at-the-2016-trb-annual-meeting-jan-10-14-2016/</a>).</p> <p>Such approaches may have advantages in objectivity, timeliness and normalization to weather factors.</p> <p>Archival data are available from past season operations and from dedicated research projects at MTO that can be adapted to demonstrate, calibrate and validate key alternative measures.</p> |
| <b>Challenge:</b>           | <p>The challenge is to provide guidance on shortcomings of current winter maintenance performance measures, to recommend new measures and their monitoring technologies, and demonstrate the benefits of the recommended measures using case studies and network-scale analyses. Demonstrations should include characterisation of the range of values, suitable measuring technologies and costs of implementation, and calibration of new performance measures to current measures.</p>  |
| <b>Anticipated Outcome:</b> | <p>Results are to be presented in a written report, a seminar sponsored by the Ministry, and at least one paper at a recognized technical conference.</p>  |

|                             |   |
|-----------------------------|---|
| <b>Subject Area:</b>        | Maintenance   |
| <b>Title:</b>               | 3. Developing Climate Severity Factors Affecting Equipment Complement of Area Maintenance Contracts   |
| <b>Background:</b>          | <p>Resources applied to winter maintenance on Provincial Highways are determined primarily by Level of Service Class (1-5). Resources determine the maximum circuit time for patrolling, plowing and material spreading as determined by plow complement. Optimal circuit time, equipment complement and other maintenance inputs are based on a standards snowfall rate of 1.1 inches per hour; similar values are used in neighbouring jurisdictions but the source of the design storm is not clear. . The resource allocation does not vary nominally by the severity of climate, for example typical snowfall rates. The same equipment complement is available for a Class 1 highway in areas of the province experiencing light snow as in areas that frequently experience heavy snow or freezing rain or colder temperatures. This results in inefficiencies where snowfall rates are typically light and risk of significant accumulation where snowfall rates are heavier or conversely, providing excess resources where service levels are easier to meet. Application of knowledge on the spatial patterns of weather and climate can be applied to balance resources such as equipment complement, to historical weather conditions. For example a Winter Severity Index was recently implemented to account for year to year variance in weather by Contract Area (<a href="http://www.mto.gov.on.ca/english/ontario-511/how-we-measure-performance.shtml">http://www.mto.gov.on.ca/english/ontario-511/how-we-measure-performance.shtml</a>), and other analyses characterize long-term trends in weather parameters that impact on winter maintenance resources (GWKMoore, HIIFP 2016).</p> <p>A climate-based index based on long-term trends would reduce the risk associated with this external factor in pricing and management of contracts for winter maintenance, and allow for optimizing equipment complements and operations.</p> |
| <b>Challenge:</b>           | The challenge is to model relationships between climate parameters and winter maintenance demand, and apply the model to estimate Regional or Contract Area adjustment factors for winter maintenance resources, specifically equipment complement and winter material quantities.  |
| <b>Anticipated Outcome:</b> | Results are to be presented in a written report, a seminar sponsored by the Ministry, and at least one paper at a recognized technical conference. The report shall explain the data and models used in the study and shall provide a table or map of Winter Climate Adjustment factors by Contract Area.   |

|                             |   |
|-----------------------------|---|
| <b>Subject Area:</b>        | Maintenance, Environment  |
| <b>Title:</b>               | 4. Source Water Protection from road salt.  |
| <b>Background:</b>          | <p>Road salt is widely used on provincial highways to help provide safe driving conditions during winter. Snow and ice melt drains from the road surface into roadside ditches and to natural watercourses. Salt concentration in runoff water is influenced by handling and application practices, local geology and drainage conditions. These variables influence local conditions that may pose a risk to source water (e.g. poor drainage conditions may result in higher salt concentrations near sources of drinking water). Attempts have been made to capture and divert salt from areas of high concentration, to remove road salt and other highway contaminants from runoff using phyco-remediation and ion exchange, and to either discharge it or re-use the concentrate for winter maintenance. Decontamination of salty runoff has had very limited success at the scale required for highway operations due to practical limitations of conventional ion exchange technology and bio-remediation.</p> <p>The challenge is to overcome the limitations of conventional bioremediation and ion exchange technologies and to investigate and demonstrate scalability to highway maintenance practice.</p> |
| <b>Challenge:</b>           | Demonstration and measure of effectiveness of a laboratory scale bioremediation and ion exchange system for road salt runoff, analysis of its scalability to highway maintenance practice, and a plan for full-scale demonstration at a highway site.   |
| <b>Anticipated Outcome:</b> | Results are to be presented in a written report, a seminar sponsored by the Ministry, and at least one paper at a recognized technical conference.  |

|                             |   |
|-----------------------------|---|
| <b>Subject Area:</b>        | Highway Winter Maintenance  |
| <b>Title:</b>               | 5. New technology demonstration and evaluation for maintenance on snow packed highways.   |
| <b>Background:</b>          | <p>Delayed clearing of packed snow and ice under extreme cold weather impacts road safety and mobility. Newly available mechanical icebreakers and low temperature de-icers provide potential solutions to clearing snow under these conditions if they are shown to be effective and affordable. Field evaluation and comparison of three or four innovative technologies, including objective measures of performance and logistics, is planned for the three winter seasons beginning in 2016-2017. The methodology and measures will be generally similar to those used in past years such as reported at Transportation Association of Canada Annual Meeting (Salek et al, 2016; Perchanok et al, 2010). They will provide before and after measures of road surface conditions, snow properties, weather, traffic, maintenance actions applied, pavement surface and marking condition.</p> |
| <b>Challenge:</b>           | <p>The challenge is to analyse the data and develop or apply models and performance measures to estimate the overall benefit of the alternative technologies in providing a safe driving surface under very cold, snow-packed conditions. Key aspects to be assessed and analysed are: road surface condition, pavement and pavement marking condition, logistics of deployment from patrol yards in a Contract Area, direct and indirect costs, direct and indirect benefits.</p>  |
| <b>Anticipated Outcome:</b> | <p>Quantitative analyses and narrative will lead to recommended technologies and deployment options for unconventional winter maintenance practices under very cold, snow-packed conditions. Results are to be presented in written reports, annual seminars sponsored by the Ministry, and at least one paper at a recognized technical conference.</p>  |

|                             |  |
|-----------------------------|--|
| <b>Subject Area:</b>        | Highway Winter Maintenance   |
| <b>Title:</b>               | 6. Predicting Level of Service for Alternative Winter Class Standards on Provincial Highways   |
| <b>Background:</b>          | <p>Winter Class Standards provide for similar winter road conditions anywhere in the Province on a given class of highway. Realignment of Winter Class Standards is under consideration to adjust for changing traffic levels.<br/> <a href="http://www.auditor.on.ca/en/content/specialreports/specialreports/winterhighway_en.pdf">http://www.auditor.on.ca/en/content/specialreports/specialreports/winterhighway_en.pdf</a></p> <p>The realignment could involve adjustments to traffic thresholds, circuit time, material application rates or other factors. The multiple factors involved make it difficult to predict the impact of the alternative classes on maintenance outputs such as regain time, and on outcomes such as road safety and mobility. Models have been developed to relate inputs, outputs and outcomes of winter maintenance in Ontario and elsewhere (<a href="http://conf.tac-atc.ca/english/annualconference/tac2012/docs/session7/usman.pdf">http://conf.tac-atc.ca/english/annualconference/tac2012/docs/session7/usman.pdf</a>;) , but have not been calibrated nor applied to the proposed new winter class standards.</p> |
| <b>Challenge:</b>           | The challenge is to develop calibrated models to assess the impact of different Winter Class Standards to direct and indirect costs of highway maintenance across the Provincial highway network. Indirect costs include changes in road safety and mobility.  |
| <b>Anticipated Outcome:</b> | Results are to be presented in a written report, a seminar sponsored by the Ministry, and at least one paper at a recognized technical conference. Deliverables will include a computer application that allows the Ministry to undertake its own case studies and network analyses.   |

|                             |  |
|-----------------------------|--|
| <p><b>Subject Area:</b></p> | <p>Engineering Materials (Asphalt)</p>   |
| <p><b>Title:</b></p>        | <p>7. Estimation of the Stripping by Static Immersion using digital image processing</p>   |
| <p><b>Background:</b></p>   | <p>MTO uses an Ontario Ministry of Transportation Laboratory Standard method (LS-285, Stripping by Static Immersion) to evaluate the ability of an aggregate to remain coated with asphalt cement (AC) with or without the aid of specific anti-strip treatment(s). Retained coating of the AC on the aggregates is a parameter provided by the test and is regularly used to evaluate anti-strip treatments and to assist in investigating pavement durability issues such as ravelling.</p> <p>Retaining coating is an estimate of the percentage of aggregate surface that retains the AC coating. The estimate is determined, solely based on a visual assessment of the percent of total visible area of aggregate.</p> <p>The visual assessment is performed by trained and experienced technicians. While it has proven to be a valuable tool, the subjectivity of the observation can produce variable results by unexperienced evaluators, especially when aggregates are stained with bitumen rather than coated, insufficient lighting is used or the aggregates are naturally darker in colour.</p> <p>An automated method based on digital image processing for quantifying the percent of retained coated surface could make it an objective test.</p> |
| <p><b>Challenge:</b></p>    | <p>The goal of this research is to provide MTO with guidance in terms of refining the existing test method by developing a digital image processing methodology for directly quantifying the percent coating of the aggregate (not stained). To achieve the above goal, the following challenges are identified for this work:</p> <ul style="list-style-type: none"> <li>• Identify all of the significant image parameters that impact the estimating the percent of total visible area of aggregate that remains coated.</li> <li>• The observation parameters should include, at least, aggregates that are stained with AC rather than coated, and aggregates that are darker in colour for further comparison with the end percent of total visible area of aggregate that remains coated.</li> </ul>  |

|                                    |   |
|------------------------------------|---|
|                                    |   |
| <p><b>Anticipated Outcome:</b></p> | <ul style="list-style-type: none"> <li>• Technical report and presentation to a functional MTO Committee summarizing the findings of this research.</li> <li>• Conduct a correlation between the relevant image parameters and the estimation of the percent of total visible area of aggregate that remains coated in an accurate manner.</li> <li>• Automated retained coating calculation model: develop and provide a software package to execute the retained coating estimation using digital images of the aggregate that remains coated samples.</li> <li>• An automated retained coating calculation model guide.</li> </ul> |

|                             |  |
|-----------------------------|--|
| <b>Subject Area:</b>        | Environmental  |
| <b>Title:</b>               | 8. Barn Swallow Nesting Deterrents   |
| <b>Background:</b>          | <p>Barn Swallows were up-listed to ‘threatened’ under the Endangered Species Act (ESA) in 2012. Current legislative requirements do not allow the ministry to undertake any construction on structures that have evidence of Barn Swallow nests, unless mitigation measures are in place to prevent access to nest sites. These mitigation measures typically include covering a structure with an impermeable material. MTO is also required to erect alternative nesting sites (kiosks), if no other suitable nesting habitat is nearby. This mitigation can be costly, is time sensitive and requires intensive monitoring. Often these mitigation measures are not successful. For example, birds may penetrate the material, or do not utilize kiosks, and/or monitoring is not consistently undertaken. This may result in significant construction delays, increased costs (delay claims, monitoring requirements, etc.), and potential impacts to the species.</p> <p>Research is being conducted by others on alternate “avian nesting deterrents”. Deterrents include, but are not limited to, non-toxic chemicals, plastic/slippery surface treatments, spike belts, sprinkler systems, and lighting.</p> <p>The MTO would like to build upon this research by exploring alternative nest prevention methods, specific to Ontario that are low cost, low maintenance and will significantly reduce monitoring costs, especially in northern regions where distances to project sites can be large due to extensive geographical areas. Short-term (during construction) and long-term (structures requiring regular maintenance) methods will be investigated for effectiveness, maintenance requirements and costs.</p> <p>Deterrents will be piloted at various test sites in Northwest and/or Northeast Region where occurrences are common.</p> |
| <b>Challenge:</b>           | How can we deter Barn Swallows from nesting on MTO structures, in a consistent and cost effective manner?  |
| <b>Anticipated Outcome:</b> | Technical or Scientific report, to be submitted for a scientific journal if warranted, and/or made available for public review. Presentation to technical committee.   |

|                             |  |
|-----------------------------|--|
| <p><b>Subject Area:</b></p> | <p>Environmental</p>   |
| <p><b>Title:</b></p>        | <p>9. Barn Swallow GPS tracking on MTO infrastructure sites containing high nesting colonies</p>   |
| <p><b>Background:</b></p>   | <p>Since the uplisting of the Barn Swallow to ‘threatened’ under the <i>Endangered Species Act</i> in January, 2012, the MTO has been creating habitat for the Barn Swallow by replacing a nest that was removed, damaged or destroyed on MTO infrastructure with artificial nest cups (at a 1:1 ratio). Although the nest cups (often contained within kiosks) built as part of the compensation strategy exhibit some success, the success rate is significantly less than the compensate rate.</p> <p>The purpose of this research need is to study where the swallows relocate to under conditions where the existing colonized area is under construction and inaccessible for nesting (e.g., a bridge site). For example, in 2014, MTO Central Region boarded up the underside of the South Canal Bridge along Highway 400, which contained 89 Barn Swallow nests, 68 of which were active during the 2014 breeding bird season. Two (2) large 45 foot long kiosks were constructed within 200 m of foraging habitat, and within 1 km of the site.</p> <p>During the 2015 breeding bird season, approximately 15 new nests were constructed under the existing bridge; in new areas (e.g., concrete pier vertical faces) not previously nested on. Where did the other 53 breeding pairs nest? There are notable colonized sites within 5 km of the South Canal Bridge; were additional breeding pairs found on these sites? Did they not migrate back to the province?</p> <p>The research will involve placing GPS trackers (i.e., geolocators, satellite transmitters, or similar) on the swallows specific to high colonized areas. The activities shall include at least three (3) project sites with over 20 breeding pairs (e.g., the North Canal Bridge/Highway 400). The birds are to be captured and equipped with tracking devices in year 1 of nesting (before any exclusion measures are placed on the site) preferably in April. Prior to the second year of nesting, exclude the test site (boarding/tarping) and provide a kiosk at a 1:1 ratio, and track where the birds are relocating to. If the birds relocate to other suitable sites adjacent to the area of study, this will provide information on the suitability of kiosks, including the extent of compensation required.</p> <p>Bird banding is a feasible alternative but will involve recapturing. In addition, bird banding will only provide us</p> |

|                          |   |
|--------------------------|---|
|                          | <p>with information on whether the bird returns to the same site, it will not reveal where else the bird is going unless recapturing is done at other sites.</p> <p>Research to date undertaken at the MTO has not focused on the birds themselves. Rather, it has focused on monitoring the success of the kiosks as well as researching new kiosk designs to attract barn swallows. Moreover, the MTO Central Region has already been exploring new design in consultation with other agencies including Bird Studies Canada (BSC) and Bird Ecology and Conservation Ontario (BECO) without much success. To date, innovative features have included placing actual nests in the nest cups (social cue), cross beams, privacy walls, dowels, artificial swallows made of wood and perched on the kiosks, as well as playback calls.</p> <p>Of the kiosks built across the province, the highest probability of success may be in part to the lack of adjacent suitable nesting sites. For example, in NWR, success rates are as high as 50% (e.g., 4 occupied nests in year 1 out of 8 nest cups in 2 kiosks). However in CR, where adjacent habitat is prominent, the success rate of kiosks along Highway 407, Highway 9, and within patrol yards is not as high (10-20% success at best) perhaps due to the abundance of adjacent suitable habitat (e.g., other bridge sites, culverts, salt domes, etc.). If we can ascertain where the birds are going, we can propose more suitable compensation strategies.</p> <p>MTO CR has established good working relationships with various agencies across the province from the Barn Swallow recovery strategy meetings. As part of this proposal, the researchers shall consult and obtain input from MNRF Policy, Environment Canada CWS, BSC, and BECO. Contact personnel information will be provided.</p> |
| <p><b>Challenge:</b></p> | <p>For high colonized areas where exclusion measures are implemented on MTO infrastructure (e.g., tarping, boarding) and kiosks are installed, the success rate is much lower than on the bridge. Where are the birds going during construction?</p> <p>Challenges with the research:</p> <ul style="list-style-type: none"> <li>• The work will include harassment of the birds and may require a permit under the Act.</li> <li>• Capturing the birds at the sites will be challenging and mist nets will likely need to be installed</li> <li>• The battery life of the geolocators/transmitters may only reveal data for 1 year, which means the birds will need to be recaptured after the first year to ascertain multi-year data.</li> </ul>   |

|                             |   |
|-----------------------------|---|
| <b>Anticipated Outcome:</b> | Technical report and data sheets. Presentation to technical committee as well as regulatory agencies involved in the study. |
|-----------------------------|---|

|                             |   |
|-----------------------------|---|
| <b>Subject Area:</b>        | Environmental and Intelligent Transportation Systems  |
| <b>Title:</b>               | 10. Aerial Emissions Monitoring of Highways   |
| <b>Background:</b>          | <p>MOECC latest directive on air quality, greenhouse gasses and climate change is requiring MTO to address these issues in Environmental Assessments and Class Environmental Assessments. An Environmental Assessment approval or clearance is required prior to tendering MTO construction contracts, and an effective way to address greenhouse gasses and emissions emanating from highways is becoming increasingly important.</p> <p>This research project would consider the use of emissions sensors (i.e. emissions radar sensors that can detect the amount of absorption of CO2 &amp; nitrogen in the sampled air particles) with either roadside fixed sensors or unmanned aerial vehicles and would monitor actual emissions in the vicinity of MTO highways.</p> <p>The research objective is to find and apply an emissions monitoring methodology that would provide an accurate picture of current roadway conditions rather than relying on assumption-based modeling based on traffic estimations. This research will provide MTO with a way to monitor air quality in environmental assessments and provide baseline data for future evaluations of the impacts of changes to the transportation network (such as Connected Automated Vehicles or other congestion reduction measures), which could result in dramatically less greenhouse gasses.</p> |
| <b>Challenge:</b>           | Finding and apply an emissions monitoring methodology that will provide an accurate picture of current roadway conditions rather than relying on assumption-based modeling based on traffic estimations through use of innovative and state of the art technology.  |
| <b>Anticipated Outcome:</b> | <p>Technical report</p> <p>Presentation to technical committee</p>  |

|                             |  |
|-----------------------------|--|
| <p><b>Subject Area:</b></p> | <p>Environmental and Intelligent Transportation Systems</p>  |
| <p><b>Title:</b></p>        | <p>11. Wildlife Detection Systems Comparison and Analysis</p>  |
| <p><b>Background:</b></p>   | <p>There is an increasing public focus on wildlife and transportation interactions both from the safety aspect as well as the impact of roadways on habitat fragmentation, migration corridors and wildlife movement. MTO is increasingly incorporating wildlife mitigation measures into projects. The technologies for wildlife monitoring and detection is an emerging field and it is important for MTO to have a better understanding of which technologies work best to determine how wildlife moves in our right-of-way and to detect wildlife on MTO highways in order to provide accurate warning to motorists and to improve our wildlife mitigation measures.</p> <p>The Environmental Commissioner ( ECO) has just recently publicly highlighted the need for MTO to do more on this issue in her annual report and also stating in subsequent newspaper articles that “The Ministry of Transportation has done far too little to tackle wildlife road kills despite practical and proven solutions such as fencing and wildlife passages in the right spots”. In the report, the ECO recommends that MTO finalize and publicly consult on its draft wildlife mitigation strategy for Ontario.</p> <p>MTO has issued a statement that agrees with this recommendation and will ensure timely consultation on new components of its wildlife mitigation strategy as they are developed. This project would be a key component of that strategy by developing how MTO can reduce wildlife vehicle interactions on our highways and can be added to our wildlife mitigation strategy.</p> <p>This research project would consolidate and compare the results and dig into the effectiveness of various technologies within MTO regions where wildlife detection systems have been implemented, as well as other applicable jurisdictions. This project would include a literature search and jurisdictional outreach to identify other applicable wildlife applications, conduct surveys and review data in order to narrow down and evaluate the most promising wildlife detection technologies, and finally recommended the type of systems/technologies that should be used on MTO highways to accurately detect wildlife on the ROW and warn motorists.</p> |

|                             |  |
|-----------------------------|--|
|                             | MTO could provide video footage and test results of wildlife monitoring pilots using video analytics and different types of radar technology at up to 4 locations across Ontario. This will provide data to evaluate effectiveness of existing systems employed in various MTO regions.  |
| <b>Challenge:</b>           | The technologies for wildlife monitoring and detection is an emerging field and it is important for MTO to have a better understanding of which technologies work best to determine how wildlife moves in our right-of-way and to detect wildlife on MTO highways in order to provide accurate warning to motorists and to improve our wildlife mitigation measures. Installing detection systems without confirmation of effectiveness leaves the motorist with a false sense of safety the opportunity to develop or modify effective wildlife passage and mitigation is lost. |
| <b>Anticipated Outcome:</b> | Technical report<br>Presentation to technical committee<br>Identification of effective wildlife detection systems/technologies for use on MTO highways.  |

|                      |  |
|----------------------|--|
| <b>Subject Area:</b> | Environmental  |
| <b>Title:</b>        | 12. Resistance of Native Seed Assemblages to Phragmites  |
| <b>Background:</b>   | <p><i>Why is controlling the spread of Phragmites of concern to MTO?</i></p> <p>Several studies have shown that transportation corridors are a major vector for the spread of Phragmites. Without careful management, roadway construction and maintenance activities can also contribute to the spread of Phragmites. Phragmites can impact transportation corridors and MTO-mandated activities in a number of ways:</p> <ol style="list-style-type: none"> <li>1) Phragmites can impede drainage in highway ditches which can lead to improper drainage of roadbed material and ultimately damage to road surfaces.</li> <li>2) Phragmites can impede sight lines, in highway corridors including at entrances and in medians.</li> <li>3) Phragmites poses a fire hazard, particularly during the dormant season. While the risk of ignition along the highway corridor is low, the potential impact could have</li> </ol> |

|  |   |
|--|---|
|  | <p>significant health and safety concerns.</p> <p>4) The spread of Phragmites can negatively impact environmental assets including ecological restoration areas, created wetlands and fish habitat compensation areas required by Environmental Legislation, including the Federal Fisheries Act and the <i>Endangered Species Act (ESA)</i>, 2007 permits.</p> <p>MTO is listed as a supporting Ministry for a number of the activities in the State of Ontario’s Biodiversity report, 2015, and the Ontario Biodiversity Strategy, 2011 including: Activity 12 - Reduce the threat posed to biodiversity by invasive species by working to implement the Ontario Invasive Species Strategic Plan, 2012.</p> <p>This research needs statement responds directly to the <i>Ontario Invasive Species Strategic Plan, 2012</i>:</p> <ul style="list-style-type: none"> <li>• Action 19 - Improve research on methods to eradicate and inhibit the spread of invasive species.</li> <li>• Action 20 - Conduct research to better understand and predict the impacts of invasive species on Ontario’s society, economy and biodiversity.</li> <li>• Action 23 - Manage key pathways to prevent the introduction and spread of invasive species.</li> </ul> <p>Ontario’s draft Pollinator Health Action Plan includes the establishment of plants that support pollinators. In support of this initiative, MTO has committed to exploring opportunities within our corridors to increase pollinator habitat. To be effective, this will include exploring opportunities to control Phragmites, which displaces native vegetation that supports pollinators.</p> <p>Ontario’s Invasive Species Act is now in force and Phragmites is now regulated as a restricted species. This reflects the increasing public attention on its negative environmental, economic and social impacts. Best Management Practices are being developed that can assist the ministry in managing their corridors to prevent the spread of invasive Phragmites.</p> <p>There is an urgent need for greater focus on preventing Phragmites from establishing in roadside soils that have been disturbed as a result of construction or maintenance. Researching whether assemblages of native seeds can offer some resistance to invasion by Phragmites seeds in a controlled growing environment will provide valuable information to MTO and other road authorities for future re-seeding of disturbed soils following construction and maintenance.</p> <p>Two HIFP research projects are underway in respect to</p> |
|--|---|

|                             |  |
|-----------------------------|--|
|                             | management of Phragmites on our Rights of Way and a third is testing native seed mixes. This research proposal seeks to integrate these two research areas by determining if through the use of native seed mixes, Phragmites spread can be resisted and the costs of controlling Phragmites (e.g. application of herbicide) can be reduced.   |
| <b>Challenge:</b>           | <p>The challenge will be to conduct greenhouse or garden controlled growing of Phragmites seeds and assemblages of native seed mixes as well as control plots using MTO's standard roadside mixes, to determine if native seed assemblages can offer some resistance to invasion by Phragmites. Opportunities would also be available to establish plots within the ROW.</p> <p>This research is not intended for application to areas that have an established population of Phragmites, as it is recognized that native plants would not be able to compete.</p> |
| <b>Anticipated Outcome:</b> | <p>Technical or Scientific report, to be submitted for a scientific journal if warranted, and/or made available for public review.</p> <p>Presentation to technical committee.</p>   |

|                      |  |
|----------------------|--|
| <b>Subject Area:</b> | Environmental  |
| <b>Title:</b>        | 13. Training Dogs to Detect Turtle Eggs in Highway Shoulders   |
| <b>Background:</b>   | <p>MTO conducted an initial study in 2016 partnership with Working Dogs for Conservation (wd4c.org), Scales Nature Park, and McIntosh Perry to train dogs to identify the location of Blanding's Turtles eggs within the shoulder of a highway. The intention of the training was to use the dogs as a species at risk (SAR) turtle mitigation tool to determine the presence of Blanding's Turtles eggs in the shoulder of the road. If found, the eggs could then be exhumed, incubated, hatched and released to nearby suitable habitat. In this way, impacts to the eggs as a result of shoulder work are avoided.</p> <p>Four dogs were trained to identify recovered Blanding's Turtles eggs that were buried in progressively more challenging training scenarios.</p> <p>The training culminated in the dogs detecting two known wild Blanding's Turtle nests with some success in a roadway shoulder setting. Due to the low number of known wild</p> |

|                             |   |
|-----------------------------|---|
|                             | <p>Blanding’s Turtle nests available for training the study was not conclusive.</p> <p>The next phase of training would essentially be a continuation of the first phase. Consideration should be given to detection of all expected species of turtle eggs and not just Blanding’s Turtle eggs (i.e. protected under the ESA).</p>   |
| <b>Challenge:</b>           | <p>Can trained dogs detect Blanding’s Turtle eggs that have been buried in the shoulder of the highway in an efficient manner to benefit MTO’s major capital program and also provide overall benefit to the species?</p>   |
| <b>Anticipated Outcome:</b> | <p>A continuation of the training that was started in 2016 to further the research to determine whether trained dogs are able to identify turtle eggs within highway shoulders within a practical period of time and of a sufficient areal extent so that use of these trained dogs could be a feasible SAR turtle impact mitigation tool for MTO. If the use of trained dogs is found to be feasible, pre-construction shoulder clearing could be used instead of installation of temporary turtle exclusion fencing along highways, at considerable overall savings to MTO.</p> <p>Peer reviewed technical or scientific report with the study results.</p> |

|                      |   |
|----------------------|---|
| <b>Subject Area:</b> | Bridges / Foundations   |
| <b>Title:</b>        | 14. The Effect of Soil Plugging on the Geotechnical Resistance of Driven Piles  |
| <b>Background:</b>   | <p>A large number of bridges in Ontario are supported on pile foundations. In many cases, the depth to bedrock is very deep (&gt; 30 m) and piles must be designed for shaft resistance/friction within the overburden versus end-bearing on bedrock. These foundations are subject to the possible formation of soil plugs as the pile is driven into the overburden. In some cases, a void or gap may develop, resulting in loss of strength or even loss of contact between the pile and surrounding soil and subsequent loss of shaft resistance. Design of these piles is crucial for serviceability of bridges. The current practice for calculation of axial</p> |

|                                    |   |
|------------------------------------|---|
|                                    | <p>capacity of piles for MTO projects is based on methods described in the CHBDC and CFEM, but these methods may overestimate the actual field resistance. A more accurate method for calculation of axial capacity for friction piles is required for economical and safe pile design considering the effect of soil plugging.</p> <p>On a recent MTO project in West Region the Designer (DB) concluded that soil plugging occurred while pile driving operations were suspended for pile splicing. When pile driving resumed, the soil plug created a gap/void/zone of reduced strength along the pile above the plug. Measured resistance was much less than calculated design resistance.</p> <p>The phenomenon of soil plugging occurs when driving steel H-piles or steel tube piles (open-end) in cohesive soils. Design of friction piles in cohesive soils poses some challenges, particularly due to uncertainties in the calculation of shaft resistance in clays of medium-to-high shear strength and the potential for reduced resistance along the shaft above a soil plug.</p> <p>The research in this assignment would include review of available literature into the development of soil plugs and could include PDA testing on an MTO project(s) to determine geotechnical resistance of piles.</p> |
| <p><b>Challenge:</b></p>           | <p>Suitable methods for axial capacity calculations available in the CHBDC and CFEM are used for design, but not without proper verification regarding its applicability for friction piles in firm to stiff cohesive soils Ontario. Thus, the challenge is to develop the most appropriate method for determining axial capacity of friction piles in Ontario where soil plugging may occur.</p>   |
| <p><b>Anticipated Outcome:</b></p> | <p>Technical Report<br/>                 Design Guideline<br/>                 Presentation to Technical Committee</p>  |

|                             |   |
|-----------------------------|---|
| <p><b>Subject Area:</b></p> | <p>Bridges/Foundations</p>  |
| <p><b>Title:</b></p>        | <p>15. Integral Abutment - Backfill</p>   |
| <p><b>Background:</b></p>   | <p>Integral Abutment Bridges have become very popular at the MTO due to the economic, functional and durability advantages of these structures</p> <p>Integral Abutment Bridges are single or multiple span structures with a continuous concrete deck and approach slabs. They differ from conventional bridges in the method of disposition of stresses due to temperature change, prestressing, shrinkage and creep and the restraints provided by abutment foundation and backfill. The effect of the longitudinal forces is minimized by making the abutment foundations flexible and less resistant to longitudinal movements</p> <p>The force or restraint due to backfill is dependent on the type of backfill and the movement of the abutment. The current guideline considers that the force or restraint in the backfill ranges from full passive pressure to the at-rest earth pressure. Abutment movement of 60 mm to 80 mm is required to mobilize full passive pressure. Full passive pressure, however, creates a very large design force that, in all likelihood would be a conservative estimate. The current guideline suggests that the backfill force should be based on a coefficient of earth pressure (<math>K_p</math>) calculated in accordance with the design procedure in Appendix 1 of the current MTO guideline (Bridge Office Report S0-96-01).</p> <p>The objective of the research study is :</p> <ol style="list-style-type: none"> <li>1. to review existing design methodologies to determine what pressure should be used in the design (<math>K_o</math>, <math>K_p</math>, <math>K_o &lt; x &lt; K_p</math>) and,</li> <li>2. to investigate other materials or combination of materials that may be used as backfill to the abutment wall to reduce the magnitude of pressure and hence create a more cost effective design.</li> </ol> |
| <p><b>Challenge:</b></p>    | <p>Requires experience with and knowledge of integral abutment design and associated lateral earth pressures.<br/>Requires incorporating all backfill scenarios and their properties into the study analysis.</p>   |

|                             |  |
|-----------------------------|--|
| <b>Anticipated Outcome:</b> | Technical report<br>Technical Report<br>Design Guideline<br>Presentation to Technical Committee  |
| <b>Subject Area:</b>        | Construction   |
| <b>Title:</b>               | 16. Sustainability Assessment for Geotechnical Projects  |
| <b>Background:</b>          | <p>Sustainable development requires that a proper balance between economical, environmental, and societal needs is maintained in any form of developmental efforts. This approach is different from traditional engineering practice in which economical goals are given the highest priorities.</p> <p>Geotechnical engineering projects within MTO use a significant amount of natural resources and create environmental pollution. Therefore, it is necessary to incorporate sustainable practices in the geotechnical constructions of MTO projects. A balanced approach can be obtained by performing life cycle assessment (LCA) and integrating the results of LCA in the traditional design. Life cycle assessment can be used to assess the environmental impacts of geotechnical constructions. The input and output inventory and the environmental impacts can be calculated using LCA.</p> <p>The objective of this research is to develop a framework for assessing sustainability of MTO construction activities related to geotechnical / foundation engineering.</p> |
| <b>Challenge:</b>           | Challenge lies in identifying input values appropriate for Ontario and in integrating geotechnical design and LCA as a unified tool to provide an optimized solution that satisfies the sustainability requirements.   |
| <b>Anticipated Outcome:</b> | Technical Report<br>Design Guideline<br>Presentation to Technical Committee  |

|                             |  |
|-----------------------------|--|
| <p><b>Subject Area:</b></p> | <p>Bridges / Foundations</p>   |
| <p><b>Title:</b></p>        | <p>17. Settlement / Instability of Highway Embankments due to Seismic Loading and Liquefaction</p>   |
| <p><b>Background:</b></p>   | <p>For seismic loading conditions, the CHBDC Clause 6.7.3 requires evaluation of liquefaction potential of the ground and impact of liquefaction on the foundation and supported structure. Further, CHBDC Clause 6.17.3.1 specifies that integral abutments shall not be used where the soil is susceptible to liquefaction because liquefaction can result in unbalanced earth pressures at both ends of the integral abutment bridge causing increased lateral loads on the abutment and a single row of piles for which they might not have been designed.</p> <p>Where investigation for foundation design under seismic loading is required, there are several different field exploration methods to identify soils that are susceptible to liquefaction, including SPT, CPT, BPT and SWVT.</p> <p>More accurate methods for estimation of liquefaction potential and embankment design for bridge approaches under seismic loading are required for economical and safe highway design.</p> <p>Design of highway embankments to address settlement / instability due to seismic loading and liquefaction poses some challenges. There are several methods available to assess liquefaction potential and settlement of highway embankments due to seismic loading but they involve a degree of uncertainty in terms of estimated results versus actual results and degree of conservatism in design.</p> <p>There is need for further research and assessment of modelling techniques and applicability to Ontario – MTO Projects. The research in this assignment would include review of available literature, including the CHBDC, CFEM and codes / guidelines / research papers from other jurisdictions. The challenge is to develop the most appropriate method(s) for most applicable and useful for Ontario conditions.</p> <p>The objective of the research study is to:</p> <ol style="list-style-type: none"> <li>1. Develop foundation investigation criteria for screening level assessment of liquefaction susceptibility of fine-grained soils subjected to seismic loads based on</li> </ol> |

|                             |  |
|-----------------------------|--|
|                             | <p>seismic loading conditions, index properties and grain size distribution data should be obtained.</p> <ol style="list-style-type: none"> <li>2. Establish the cyclic resistance and deformation characteristics of fine-grained soils susceptible to liquefaction based on results from cyclic simple shear or cyclic tri-axial testing. .</li> </ol> |
| <b>Challenge:</b>           | <p>Only a limited number of academic and consulting organizations are currently conducting these specialized tests and special care is required when retrieving undisturbed soil samples and establishing the testing protocols</p>  |
| <b>Anticipated Outcome:</b> | <p>Technical Report<br/>Design Guideline<br/>Presentation to Technical Committee</p>   |

|                      |  |
|----------------------|--|
| <b>Subject Area:</b> | Pavements - Engineering Materials  |
| <b>Title:</b>        | 18. Impact of Additives on the Performance of In-place Recycled Pavements  |
| <b>Background:</b>   | <p>In-place recycling of existing asphalt pavement is a rehabilitation strategy that the ministry adopted decades ago. Emulsion and expanded asphalt are the two most common types of bitumen stabilising agent incorporated into recycled mixtures in Ontario. Active fillers such as Portland cement, hydrated lime and fly ash may be added (&lt;1%) to the recycled mixtures to improve dispersion of the bitumen in the mixtures and to increase the stiffness of the mixtures and rate of strength gain. The short-term benefit is to increase the initial strength and to shorten the curing period of the mixtures. However, long-term benefits or impacts are unknown. In particular, there is concern that excess amounts of Portland cement in the mixture causes premature cracking and construction joint opening in the surface course.</p> <p>The objective of this research is to:</p> <ol style="list-style-type: none"> <li>1. investigate the long-term impact of adding Portland cement to recycled asphalt mixtures on pavement performance, and</li> <li>2. determine the optimum Portland cement content to the recycled mixtures without compromising</li> </ol> |

|                             |  |
|-----------------------------|--|
|                             | <p>the stiffness of the flexible pavement.</p> <p>The objective of this study can be achieved by setting up an engineering model to investigate the shrinkage, thermal and structural properties of the cement added mixtures, accompanied by field investigation and laboratory testing of cores obtained from the field.</p> |
| <b>Challenge:</b>           | <p>Identification of representative sites and performing investigation and testing will require coordination with MTO's regional offices.</p>  |
| <b>Anticipated Outcome:</b> | <p>Technical report of findings and recommended strategy<br/>Presentation to technical committee</p>   |

|                      |   |
|----------------------|---|
| <b>Subject Area:</b> | <p>Construction</p>   |
| <b>Title:</b>        | <p>19. Load and Resistance Factor Design for Laterally Loaded Piles</p>   |
| <b>Background:</b>   | <p>A large number of bridges in Ontario are supported on pile foundations and these piles are subjected to lateral loads and moments from various sources including traffic, wind, and seismic activities. Current design methods focus on approaches like the subgrade reaction method or the p-y method but do not consider the uncertainties associated with them. In the current paradigm, it is important that the Load and Resistance Factor Design (LRFD) approach adopted for foundation design be consistent with the structural design. Design of these piles against lateral loads is crucial for serviceability of bridges. LRFD has not been developed in geotechnical engineering practice for serviceability-based designs such as that of the laterally loaded piles.</p> <p>The ultimate objective of this research assignment is to develop resistance factors for Ontario conditions by:</p> <ol style="list-style-type: none"> <li>1. Identifying the uncertainties in current design methodology and in Ontario site characteristics, and</li> <li>2. Incorporating uncertainties in a probabilistic analysis to develop LRFD for laterally loaded piles.</li> </ol> |
| <b>Challenge:</b>    | <p>Experience with LFRD and lateral loading of piles is required to conduct this research.</p>  |

|                             |  |
|-----------------------------|--|
| <b>Anticipated Outcome:</b> | Technical Report<br>Design Guideline<br>Presentation to Technical Committee  |
| <b>Subject Area:</b>        | Pavements - Engineering Materials  |
| <b>Title:</b>               | 20. Assessment of the Economic Benefit of Open Graded Drainage Layer (OGDL) in Pavement Design and Construction  |
| <b>Background:</b>          | <p>Open Graded Drainage Layer (OGDL) is used to ensure rapid and effective drainage of pavement structures thereby improving pavement performance and has been part of MTO freeway pavement design since the mid-1980s. A MTO research report, published in 1991, documented the field performance of OGDL. The findings reaffirmed MTO pavement design practice to include OGDL as part of the pavement subsurface drainage structure.</p> <p>More recently, there have been suggestions by industry that OGDL represents a weakened layer within the pavement structure when compared to a dense-graded base layer because of its lower modulus value and its higher void content. The weakening effect is intensified if the drainage layer fails to maintain an effective drainage outflow and traps water. A drainage system that is not properly maintained can be more detrimental to the strength of the pavement than having no drainage system at all.</p> <p>Literature review of a Virginia Department Of Transportation (VDOT) report indicates that OGDL is a positive influence on in-situ structural number and should continue to be specified for high priority routes.</p> <p>The objective of this study is to assess the economic benefits of using OGDL in Ontario and its impact on the life cycle of the pavement. The scope of the assignment should include the following:</p> <ul style="list-style-type: none"> <li>• Literature review of other jurisdictions on their experience of using OGDL</li> <li>• Identification of representative pavement structure sites, both flexible and rigid pavement, with and without OGDL</li> <li>• Conduct a modelled study of the engineering properties of OGDL such as permeability, thermal regime, structural capacity, etc.</li> <li>• Carry out field testing and/or investigation, including FWD</li> </ul> |

|                             |  |
|-----------------------------|--|
|                             | <p>testing and analysis, to estimate in-situ pavement life and to determine pavement life cycle.</p> <ul style="list-style-type: none"> <li>• AASHTOWare Pavement M-E design should be used as one of the life prediction tools for the analysis.</li> <li>• Determine the life cycle cost of pavements with and without the use of OGDL</li> <li>• Cost and benefit assessment of including OGDL in pavement design.</li> </ul> |
| <b>Challenge:</b>           | Identification of representative sites and performing FWD testing will require coordination with several MTO offices.  |
| <b>Anticipated Outcome:</b> | <p>Technical report</p> <p>Presentation to technical committee</p>   |

|                             |   |
|-----------------------------|---|
| <b>Subject Area:</b>        | Engineering Materials   |
| <b>Title:</b>               | 21. Estimating Pavement Damage associated with Heavy Vehicle Loading using In-road Sensor Technology  |
| <b>Background:</b>          | <p>MTO pavements are designed to carry commercial vehicle loads based on traffic data and axle configurations and loading limits as defined in the Highway Traffic Act. Pavement serviceability is impacted by increasingly heavier vehicle loading. Pavement damage costs associated with heavier axle loading are generally determined based on an estimated loss in service life. The objective of this assignment is to obtain real time data to determine actual stresses and strains occurring in different pavement types under heavy loading. The assignment includes:</p> <ol style="list-style-type: none"> <li>1. Identification of representative pavement structure sites in the vicinity of truck inspection stations</li> <li>2. Installation of pressure-in-motion sensor technology together with stress/strain instrumentation within the pavement layers</li> <li>3. Monitoring long term stresses/strains within the pavement structure</li> <li>4. Determine/predict pavement damage associated with heavy traffic loading.</li> </ol> |
| <b>Challenge:</b>           | Identification of sites for pressure/weight in motion instrumentation will require coordination with several MTO offices.   |
| <b>Anticipated Outcome:</b> | <p>Technical report</p> <p>Presentation to technical committee</p>  |

|                             |   |
|-----------------------------|---|
| <p><b>Subject Area:</b></p> | <p>Bridges</p>  |
| <p><b>Title:</b></p>        | <p>22. Seismic Forces on Abutment/Retaining Walls</p>   |
| <p><b>Background:</b></p>   | <p>Section C4.6.5 of the Commentary of the Canadian Highway Bridge Design Code states that seismically induced lateral soil pressures may be calculated using the Mononobe-Okabe Method where:</p> <p><math>K_h = \frac{1}{2} F (pga) * PGA</math> for structures that allow lateral yielding and<br/> <math>K_h = F (pga) * PGA</math> for non-yielding walls</p> <p>Section 4.6.4 of the Code states that the soil-foundation-structure system maybe represented using simplified models and the response assessed using the pseudo-static method.</p> <p>The Mononobe-Okabe Method is a modification of the Coulomb classic earth pressure theory which takes into account the inertia forces on a potential sliding wedge caused by seismic earth pressures. One of the basic requirements of the Mononobe-Okabe Method is that the wall moves sufficiently to create a limit equilibrium state in the backfill. This condition is not satisfied in rigid walls.</p> <p>A more accurate model is needed to predict seismic lateral pressures on abutment and retaining walls. As part of this research study, prediction of seismic lateral pressures shall be determined using models including experimental, analytical (elastic, limit state) and Finite Element Model. These models shall be compared with the Mononobe-Okabe Method and the results provided to determine the validity and accuracy of the model.</p> <p>A physical centrifuge model shall be undertaken to calibrate the predictive analytical and Finite Element Model.</p> <p>Recommendations for a detailed instrumentation monitoring program for full scale structures shall be provided</p> |
| <p><b>Challenge:</b></p>    | <p>Good grasp of modelling and analysis needed for this assignment.</p>   |

|                                    |   |
|------------------------------------|---|
| <p><b>Anticipated Outcome:</b></p> | <p>Technical report<br/>Design Guideline<br/>Presentation to Technical Committee</p>  |
| <p><b>Subject Area:</b></p>        | <p>Pavements</p>  |
| <p><b>Title:</b></p>               | <p>23. Solar Roadway – Demonstration Project</p>  |
| <p><b>Background:</b></p>          | <p>Ontario’s transportation network is a key driver of the province’s economic success. In support of provincial initiatives to protect Ontario’s natural environment and reduce greenhouse gas emissions, MTO is exploring emerging green technologies. One such new technology is the application of a thin film of photovoltaic panels onto an existing pavement to harness solar energy for generation of electricity. The electricity could be used to power surrounding roadway infrastructure or feed into the existing grid.</p> <p>A previous HIIFP research study completed in 2015 assessed the solar energy potential of Ontario roadways and provided an overview of developments in solar panel technologies for roadways. The main challenge was the structural capacity of the solar panels to support vehicle/tire loads.</p> <p>Advances in the manufacture of photovoltaic cells have resulted in the development of ultra-thin solar panels. The application of thin solar panels to a roadway surface has been demonstrated and monitored in several European countries and the product has recently been introduced in North America.</p> <p>A trial site for this product has been identified in a Central Region commuter parking lot at Highway 404 and Major Mackenzie Rd.</p> <p>The objective of this research assignment is to develop an instrumentation and monitoring program for the installation and to document and monitor product performance over a period of 2 or 3 years.</p> |
| <p><b>Challenge:</b></p>           | <ul style="list-style-type: none"> <li>○ Research team requires sound knowledge and understanding of state-of-the-art solar technology,</li> </ul>  |

|                                    |   |
|------------------------------------|---|
|                                    | <p>mechanical/electrical engineering and experience in materials and impact of traffic loads on pavement</p> <ul style="list-style-type: none"> <li>○ The impact of this technology is significant in its potential to not only supplement existing sources of electricity but to provide a source of electricity in isolated areas of the province.</li> <li>○ The success of this project depends on the collaborative effort of Provincial Office and Regional staff (from design and construction to maintenance) to support the demonstration over the long term.</li> </ul> |
| <p><b>Anticipated Outcome:</b></p> | <p>Demonstration of the technology at an MTO commuter parking lot</p> <p>Technical report that includes:</p> <ul style="list-style-type: none"> <li>○ Documentation of the design and installation</li> <li>○ Instrumentation and monitoring program</li> <li>○ Analysis of Performance, Cost/ Benefit</li> </ul> <p>Presentation to technical committee</p>  |

|                             |   |
|-----------------------------|---|
| <p><b>Subject Area:</b></p> | <p>Bridges / Foundations</p>  |
| <p><b>Title:</b></p>        | <p>24. Re-Use of Existing Piles</p>   |
| <p><b>Background:</b></p>   | <p>Many of our existing bridges are founded on driven piles or drilled shafts. The MTO has been and continues to assess its existing infrastructure. This process includes comparing the option of bridge replacement vs bridge rehabilitation. Typically, for bridge rehabilitation the existing foundations remain in place. However for bridge replacements, consideration could be given to re-using the existing deep foundations.</p> <p>As part of this research study, non-destructive testing methods for existing piles such as PDA, Impulse Response Test and Seismic Parallel and new technologies such as Embedded Data Collectors(EDC'S) as a proactive wireless monitoring system for new piles shall be reviewed and discussed. Indirect measurements such as borehole investigation shall also be considered along with direct observational methods through test pits or similar.</p> |

|                             |  |
|-----------------------------|--|
| <b>Challenge:</b>           | The challenge is determining methods or a combination of methods to verify the integrity, capacity and durability of the existing piles and project if the existing deep foundation units can provide the required service life. |
| <b>Anticipated Outcome:</b> | Technical Report<br>Design Guideline<br>Presentation to Technical Committee  |

|                      |   |
|----------------------|---|
| <b>Subject Area:</b> | Bridges, Engineering Materials, Construction  |
| <b>Title:</b>        | 25. Non-Destruction Testing of Laminated Elastomeric Bearings   |
| <b>Background:</b>   | <p>Laminated elastomeric bearings consist of steel shims embedded within rubber. The relative spacing of the steel shims determines one of the main physical properties of the bearing and determines how the bearing will respond to applied load. Additionally, the rubber surrounds and protects the steel shims.</p> <p>The MTO uses quality assurance as the basis for acceptance of laminated elastomeric bearings. All properties of the bearing, as specified to the manufacturer, are tested in order to ensure the bearing complied with the design requirements, and the specification. While the compression loading test is non-destructive, all other tests involve destructively cutting the bearing in order to take measurements, and extract samples of rubber and steel for individual physical tests.</p>   |
| <b>Challenge:</b>    | <p>The MTO is interested in developing non-destructive testing for elastomeric bearings. The testing could consist of industrial CT scanning, thermal imaging, magnetic resonance, ultrasonic, or physical means (such as pressing on the bearing from the perimeter or loading both vertically and in shear). The goal of the testing is to effectively measure all geometric aspects of the bearing non-destructively, including the overall dimensions of the bearing, the rubber cover to internal steel shim plates, the spacing of shim plates, and the thickness of shim plates, and the thickness of the internal layers of rubber.</p> <p>Additionally, the MTO is interested in the possibility of routinely analysing laminated elastomeric bearings with non-linear finite element methods typically used for modeling the behaviour of rubber bearings, with the information collected by non-destructive means. The MTO envisions a point cloud</p> |

|                             |  |
|-----------------------------|--|
|                             | of the bearing’s outer and internal components being produced by the aforementioned non-destructive means, being fed into a finite element analysis program and typical loading scenarios (shear, compression, rotation, and a combination thereof) applied to assess the performance of the as-constructed geometry of the bearing. |
| <b>Anticipated Outcome:</b> | Technical report<br>Yearly presentation to the Expansion Joints and Bearings Working Group   |

|                             |  |
|-----------------------------|--|
| <b>Subject Area:</b>        | Intelligent Transportation Systems   |
| <b>Title:</b>               | 26. Financial Management System for High Occupancy Toll (HOT) lanes  |
| <b>Background:</b>          | <p>Since 2013, MTO has made commitments to assess the feasibility of building new and/or converting existing High Occupancy Vehicle (HOV) lanes to HOT lanes. Most recently, in 2016, the commitment was to open electronically tolled HOT lane(s) on Highway 427 by 2021.</p> <p>MTO is currently investigating various financial management systems for Highway 427 opening day. The system must be modular and field tolling technology agnostic.</p> <p>MTO is looking for innovative financial management systems that would be suitable for deployment in the next 3-5 years.</p> <p>The objective of this research study is to develop a financial management system that:</p> <ul style="list-style-type: none"> <li>• Processes field transactions and applies variable toll rates to formulate trips</li> <li>• Validates trip information and reviews violations</li> <li>• Produces bills and/or notices based on formulated trips and violations</li> <li>• Supports a range of payment methods and different account management services (eg, online, mobile app, walk-in centers, phone, etc.)</li> </ul> |
| <b>Challenge:</b>           | Develop a financial management system.   |
| <b>Anticipated Outcome:</b> | <p>A prototype of a financial management system that can generate bills and notices using sample input data from Google Maps.</p> <p>Technical report that includes:</p>   |

|  |   |
|--|---|
|  | <ul style="list-style-type: none"> <li>• Specifics of the proposed financial management system, along with sample account and billing information.</li> <li>• A summary of the benefits and limitations of the system.</li> <li>• Preliminary capital, maintenance and operational costs associated with the system.</li> </ul> <p>Presentation to technical committee.</p> |
|--|---|

|                      |  |
|----------------------|--|
| <b>Subject Area:</b> | 27. Intelligent Transportation Systems   |
| <b>Title:</b>        | Electronic Toll Collection System for High Occupancy Toll (HOT) lanes  |
| <b>Background:</b>   | <p>Since 2013, MTO has made commitments to assess the feasibility of building new and/or converting existing High Occupancy Vehicle (HOV) lanes to HOT lanes. Most recently, in 2016, the commitment was to open electronically tolled HOT lane(s) on Highway 427 by 2021.</p> <p>MTO is currently investigating various field tolling technologies for Highway 427 opening day. The field tolling technology must adhere to the HOT technology requirements shown in Table 1.</p> <p>While there is proven technology that could be deployed for HOT lanes in Ontario and would meet the requirements of an Electrical Toll Collection (ETC) system, MTO is looking for innovative, new and upcoming technologies that would be suitable for deployment in the next 5-10 years.</p> <p>The current proven ETC tolling technology includes:</p> <ul style="list-style-type: none"> <li>• In-vehicle tolling device with occupancy declaration – Radio Frequency Identification (RFID) passive 3-state switchable transponders</li> <li>• Validation of HOT lane use – Gantry mounted multi-protocol transponder reader</li> </ul> <p>The objective of this research study is to develop an alternative ETC system that allows for Open Road Tolling (ORT). The users of the HOT lanes should be able to pay a toll automatically at freeway speeds without the need to slow down. The study should focus on technologies that can minimize the need for field infrastructure, such as poles and toll gantries.</p> |

|                             |  |
|-----------------------------|--|
| <b>Challenge:</b>           | Develop an accurate Electronic Toll Collection (ETC) system that can minimize field infrastructure.  |
| <b>Anticipated Outcome:</b> | <p>Technical report that includes:</p> <ul style="list-style-type: none"> <li>• Specifics of the proposed ETC system, along with how each unique user and vehicle occupancy will be identified.</li> <li>• A summary of the benefits and limitations of the ETC system.</li> <li>• Preliminary capital, maintenance and operational costs associated with the ETC system.</li> </ul> <p>Presentation to technical committee.</p> |

|                      |  |
|----------------------|--|
| <b>Subject Area:</b> | Intelligent Transportation Systems   |
| <b>Title:</b>        | 28. Enforcement Technology for High Occupancy Toll (HOT) lanes   |
| <b>Background:</b>   | <p>Since 2013, MTO has made commitments to assess the feasibility of building new and/or converting existing High Occupancy Vehicle (HOV) lanes to HOT lanes. Most recently, in 2016, the commitment was to open electronically tolled HOT lane(s) on Highway 427 by 2021.</p> <p>MTO is currently investigating various field tolling technologies for Highway 427 opening day. The field tolling technology must adhere to the HOT technology requirements shown in Table 1.</p> <p>While there are methods for enforcement of HOT lanes in Ontario, MTO is looking for innovative, new and upcoming technologies that could provide automatic enforcement and would be suitable for deployment in the next 5-10 years.</p> <p>The current method of enforcement includes:</p> <ul style="list-style-type: none"> <li>• Enforcement of tolling device requirement – Gantry mounted transponder reader and Automatic License Plate Recognition (ALPR)</li> <li>• Enforcement of occupancy – Visual and transponder reader enforcement by Ontario Provincial Police (OPP)</li> <li>• Enforcement of buffer violations – Gantry mounted transponder reader strategically placed in advance of congested areas and locations where weaving typically occurs.</li> </ul> <p>The objective of this research study is to develop a means of enforcing the HOT lanes to ensure compliance. Enforcement</p> |

|                             |   |
|-----------------------------|---|
|                             | is required in order to optimize traffic, minimize safety concerns and provide a reliable and sustainable system. The study should focus on enforcement technologies that can minimize the need for field infrastructure, such as poles and toll gantries.  |
| <b>Challenge:</b>           | Develop an accurate enforcement system that can minimize field infrastructure.  |
| <b>Anticipated Outcome:</b> | <p>Technical report that includes:</p> <ul style="list-style-type: none"> <li>• Specifics of the proposed enforcement system.</li> <li>• A summary of the benefits and limitations of the system.</li> <li>• Preliminary capital, maintenance and operational costs associated with the system.</li> </ul> <p>Presentation to technical committee</p> |

|                      |  |
|----------------------|--|
| <b>Subject Area:</b> | Engineering Materials (Asphalt)  |
| <b>Title:</b>        | 29. Relating End Result Pay Factors to Pavement Performance  |
| <b>Background:</b>   | <p>MTO’s End-Result Specifications (ERS) are statistically-based specifications which base acceptance on sampling and testing throughout production and placement of a product to determine measured quality level for key Quality Characteristics. A price adjustment is then based upon the degree of compliance with the specification criteria in relation to the impact an attribute has on the life and performance of the product produced.</p> <p>End-Result Specifications stress sampling and testing as the main measure of Agency Acceptance. The specification either accepts or rejects the final product, or applies a payment adjustment (penalty/bonus) system that accounts for the degree of compliance. In developing this type of specification, it is important to determine reasonable levels of acceptance and relationships between the materials properties and final product performance. Acceptance criteria is based on an engineering analysis of historical data to establish practical target values and to identify inherent variability.</p> |

|                                    |   |
|------------------------------------|---|
| <p><b>Challenge:</b></p>           | <p>While MTO’s hot mix asphalt ERS system was established in the 1990’s and is due for a review. Asphalt cement and the physical properties of the aggregate in a mix are accepted separately from the current hot mix asphalt ERS system. Asphalt cement has recently been found to have a significant impact on a pavement’s performance.</p> <p>The goal of this research is to examine MTO’s End Result Specification for Asphalt to determine whether the pay factors are still appropriate or could be better optimized with regard to long term performance of the asphalt pavement, testing and materials used today. The research would also revisit the payment of positive payment adjustments (bonuses) for work that meets agency requirements; cumulating positive payment adjustments (bonuses), averaging negative payment adjustment; and how asphalt cement quality is incorporated in other Agency acceptance systems. A jurisdictional scan of other transportation agency pay adjustment practices would be a requirement.</p> |
| <p><b>Anticipated Outcome:</b></p> | <ul style="list-style-type: none"> <li>• Technical report and presentation to a functional MTO Committee summarizing the findings of this research.</li> <li>• Conduct a jurisdiction scan of North American transportation agencies to determine their pay adjustment practices for transportation products and practices.</li> <li>• Relate pay adjustment factors for Key Characteristics to long term pavement performance to determine if they can be better optimized.</li> </ul>   |

HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM 2017  
**ATTACHMENT B – APPLICATION FORM**

| For Ministry use only   |                                    |   |                            |
|---|------------------------------------|---|----------------------------|
|   |                                    | Application Number:   |                            |
| Principal Researcher (Name & Business Address):   |                                    | Location of Research (address):   |                            |
|   |                                    |   |                            |
| Institution:  |                                    | Applicant's Business Telephone No.  |                            |
|   |                                    |   |                            |
|   |                                    | Applicant's Email Address   |                            |
|   |                                    |   |                            |
| Co-Applicants (name, institutional affiliation, city):  |                                    |   |                            |
| 1   |                                    |   |                            |
| 2   |                                    |   |                            |
| 3   |                                    |   |                            |
| Title of Research including Ministry Topic Number:  |                                    |   |                            |
| Brief Purpose of Research   |                                    |   |                            |
|   |                                    |   |                            |
| FINANCIAL SUMMARY:  |                                    |   |                            |
| Funds Requested From MTO  | Funds Requested from Other Sources | Starting Date:  | Estimated Completion Date: |
|   |                                    |   |                            |
| Total Budget (MTO and other sources):   |                                    |   |                            |
| Have you applied to any other funding agencies for support of part of this Research?  |                                    |   |                            |
| <b>YES</b> <input type="checkbox"/> <b>NO</b> <input type="checkbox"/> If YES, please provide details below:  |                                    |   |                            |
|   |                                    |   |                            |
| <b>Signatures:</b> It is understood that the provisions of the Ontario Ministry of Transportation HIIFP as outlined in the 2017 HIIFP Guidelines are hereby accepted and agreed to. |                                    |   |                            |
| Principal Researcher  | Head of Department                 | Dean/Director of Research or Authorized Signing Officer of Sponsoring Institution |                            |
|   |                                    |   |                            |
| Name and Title:   | Name and Title:                    | Name and Title:   |                            |
|   |                                    |   |                            |

**HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM 2017  
ATTACHMENT C – RESEARCH PROPOSAL SUMMARY**

|  |  |
|--|--|
| Short Title of Research including Ministry Topic Number:                           |  |
| Principal Researcher   |  |
| <b>SUMMARY OF RESEARCH PROPOSAL</b><br>(Non-technical language; 300 words maximum) |  |
|  |  |

**HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM 2017  
ATTACHMENT D – BUDGET SUMMARY**

**Note:**

For multi-year applications, complete one form for each Ministry Fiscal Year ending March 31.

FISCAL YEAR ENDING: March 31, \_\_\_\_\_(INSERT YEAR)

| Principal Researcher:                                    |                          |   |                              |                           |
|--|--------------------------|---|------------------------------|---------------------------|
| Short Title of Research including Ministry Topic Number: |                          |   |                              |                           |
| RESEARCH ITEMS   | Direct Costs of Research | Percent Overhead (%)<br>(not to exceed 25%) | Net Funds Requested from MTO | Amount from other sources |
| <b>SALARIES AND BENEFITS</b>                             |                          |   |                              |                           |
| a) Students  |                          |   |                              |                           |
| b) Postdoctoral fellows                                  |                          |   |                              |                           |
| c) Technical/professional assistants                     |                          |   |                              |                           |
| d)   |                          |   |                              |                           |
| <b>SUBTOTAL:</b>   |                          |   |                              |                           |
| <b>EQUIPMENT OR FACILITY</b>                             |                          |   |                              |                           |
| a) Purchase or rental                                    |                          |   |                              |                           |
| b) Operation and maintenance costs                       |                          |   |                              |                           |
| c) User fees   |                          |   |                              |                           |
| d)   |                          |   |                              |                           |
| <b>SUBTOTAL:</b>   |                          |   |                              |                           |
| <b>MATERIALS AND SUPPLIES</b>                            |                          |   |                              |                           |
| a)   |                          |   |                              |                           |
| b)   |                          |   |                              |                           |
| c)   |                          |   |                              |                           |
| d)   |                          |   |                              |                           |
| <b>SUBTOTAL:</b>   |                          |   |                              |                           |
| <b>TRAVEL</b>  |                          |   |                              |                           |
| a) Technical presentation                                |                          |   |                              |                           |
| b) Field work  |                          |   |                              |                           |
| c)   |                          |   |                              |                           |
| <b>SUBTOTAL:</b>   |                          |   |                              |                           |
| <b>DISSEMINATION COSTS</b>                               |                          |   |                              |                           |
| a) Publication costs                                     |                          |   |                              |                           |
| b)   |                          |   |                              |                           |
| <b>SUBTOTAL:</b>   |                          |   |                              |                           |
| <b>OTHER (specify)</b>                                   |                          |   |                              |                           |
| a)   |                          |   |                              |                           |
| b)   |                          |   |                              |                           |
| c)   |                          |   |                              |                           |
| <b>SUBTOTAL:</b>   |                          |   |                              |                           |
|  | Direct Costs of Research | Net Overhead                                | Net Funds Requested from MTO | Amount from other sources |
| <b>COLUMN TOTAL:</b>                                     |                          |   |                              |                           |
| <b>TOTAL:</b>  |                          |   |                              |                           |

**HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM 2017  
ATTACHMENT E – PROGRESS REPORT TEMPLATE**

**PAGE 1 OF 2**

|  |  |                    |                              |   |  |
|--|--|--------------------|------------------------------|---|--|
|  |  |                    | <b>For Ministry use only</b> |   |  |
|  |  |                    | Application Number:          |   |  |
| HIIIFP Funding Year:   |  |                    | Date:                        |   |  |
|  |  |                    |                              |   |  |
| Principal Researcher (Name & Business Address):  |  |                    | Business Telephone No.       |   |  |
|  |  |                    |                              |   |  |
| Institution:   |  |                    | Email Address:               |   |  |
|  |  |                    |                              |   |  |
| Title of Research including Ministry Topic Number:   |  |                    |                              |   |  |
| Start Date of Research:  |  |                    |                              |   |  |
| Estimated Completion Date of Research:   |  |                    |                              |   |  |
| Brief Description of Progress completed to date including 1) status of major tasks, 2) status of outcomes/report, and if applicable, 3) changes and or issues: |  |                    |                              |   |  |
|  |  |                    |                              |   |  |
| Continue on page 2   |  |                    |                              |   |  |
| <b>Signatures:</b>   |  |                    |                              |   |  |
| Principal Researcher   |  | Head of Department |                              | Dean/Director of Research or Authorized Signing Officer of Sponsoring Institution |  |
|  |  |                    |                              |   |  |
| Name and Title:  |  | Name and Title:    |                              | Name and Title:   |  |
|  |  |                    |                              |   |  |

**HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM 2017  
ATTACHMENT E – PROGRESS REPORT TEMPLATE**

**PAGE 2 OF 2**

|  |  |       |
|--|--|-------|
| Principal Researcher (Name & Business Address):  |  | Date: |
|  |  |       |
| Institution:   |  |       |
| Title of Research including Ministry Topic Number:   |  |       |
| Brief Description of Progress completed to date including 1) status of major tasks, 2) status of outcomes/report, and if applicable, 3) changes and or issues: |  |       |
| Continued from page 1  |  |       |