MINISTRY OF TRANSPORTATION ONTARIO (MTO)

Highway Infrastructure Innovations Fund Program Guide

Guidelines & Application Forms for
Ontario Universities and Colleges

2018

ONTARIO MINISTRY OF TRANSPORTATION
HIGHWAY INFRASTRUCTURE INNOVATION
FUNDING PROGRAM
for Ontario Universities and Colleges
Guidelines 2018

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ONTARIO MINISTRY OF TRANSPORTATION

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Deadline for Applications is
Friday, March 16, 2018 at 2:30PM

1.0 INTRODUCTION AND PURPOSE

Ontario's transportation infrastructure is critically important to the Province's economy, to business and to everyday life of residents and visitors. The province is committing approximately $2.5 billion annually to repair and expand provincially owned highways and bridges across Ontario. This investment helps to ensure that the infrastructure meets the demand for transportation now and in the future, and is supported by ongoing maintenance, renewal and expansion supervised by Provincial Highways Management Division.

The Highway Infrastructure Innovation Funding Program (HIIFP) was introduced to promote the use of innovative solutions to challenges in highway management with the assistance of Ontario colleges and universities. In doing so the program also helps to develop the next generation of transportation professionals for Ontario by providing an understanding of current transportation issues through direct contact with government and industry.

The program operates by funding graduate and undergraduate research under the supervision of professors who are experts in various aspects of transportation science, technology and engineering, employing a combination of Ministry-driven and university-driven topics. Ministry-driven topics are defined by MTO staff or other stakeholders, as a specific challenge or objective to which Researchers respond with their own innovative solutions. University-driven topics are proposals in which the Researcher defines both the challenge and the proposed solution approach. The output from the research includes both a technical solution and a technology transfer or implementation component.

HIIFP is focussed on highway infrastructure but its scope includes broader interactions of infrastructure with road safety, policy and planning, investment decisions, and environmental sustainability.

3.0 SCOPE OF THE HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM

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

- Award Letter: The letter of agreement signed by a person with designated financial authority at the institution such as the Director of Research, and at the Ministry such as the Executive Director, that binds both parties to the terms of the proposal.
- Funding Program: A contractual agreement in which funding is provided in return for a specific deliverable such as a report or seminar.
- HIIFP: Highway Infrastructure Innovation Funding Program
- Institutions: Ontario universities (and their affiliated colleges, research centres, and institutes) and Ontario colleges of applied arts and technology
- Invited Topic: A research challenge defined by the Ministry
- Ministry: Ministry of Transportation Ontario (MTO)
- Open Topic: A research challenge proposed by a university or college Researcher
- Principle Researcher: The project lead as identified in the proposal.

3.1 Eligible Institutions

All public universities and colleges in Ontario 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

Topics that are eligible for consideration address challenges to the development and management of Ontario's highway transportation infrastructure.

Invited Topics vary from year to year and may involve specific technical issues or broader themes crossing multiple aspects of highway management. Example issues include, but are not limited to:

- investment planning,
- asset management engineering materials,
- highway design,
- construction
- geomatics,

- pavements and foundations,
- bridges,
- traffic operations, intelligent transportation systems
- environmental impacts, climate change and sustainability,
- highway maintenance
- Cycling and active transportation.
- Climate change
- Autonomous and connected vehicles
- Rapid bridge rehab
- UAV's
- Variable speed limits
- GHG savings in concrete and materials
- Curing of concrete
- Asphalt testing (mix test)
- Queue end warning technology
- Cable guiderail

The current list of Invited Topics is provided in Table 3.1 and described fully in Appendix A by subject area(s), title, background, challenge and anticipated deliverables. Each proposal may address one or multiple topics.

Open Topics are Researcher-identified challenges falling outside the scope of the Invited Topics. Institutions are invited to contact the HIIFP Co-ordinator or other Ministry staff to discuss the suitability of proposed Open Topics. Invited and Open Topics use the same application forms and process.

Table 3.1 Ministry-proposed challenges, 2018-19.

	Ministry-proposed challenges, 2018-19
1	Quantifying Greenhouse Gas Mitigation Measures during Provincial Highway Design, Construction, and Maintenance Activities
2	Greenhouse Gas Mitigation in Highway Design, Construction and Maintenance - Jurisdictional Scan
3	Asphalt cement modifiers and their impact on mixture low temperature and fatigue cracking.
4	Refinement of Double Edge Notch Tension Test
5	Evaluation of Testing Variability of Semi-Circular Bend (SCB) and Disc-Shaped Compact Tension (DCT) Fracture Tests.
6	Development of a Test Method to Evaluate the Performance of Concrete Pavement Joints in a Freeze-Thaw Environment
7	Evaluation of Non-Invasive Methods for Assessing Concrete Pavement Joint Deterioration, and Development of a Protocol for use in Field Investigations
8	Effect of Climate Change on Embankment Stability
9	Re-Use of Existing Piles
10	Rockfill Settlement Prediction
11	Prediction of Scour – Foundation Engineering Input
12	Soil Structure Behaviour of Three Sided Culverts
13	Using Artificial Intelligence Method to Perform QA&QC in Processing Image Data of Pavement Conditions and Rating
14	Developing Effective Measures to Mitigate Reptile Road Mortality on Ontario Highways
15	Developing plantings and assessing their effectiveness to attract deer and keep them on the non-highway side of deer fence.
16	UAVs for Highway Mapping and Asset Inspections
17	Development of mobile terrestrial photogrammetry systems and, data collection and processing methodologies for use in ministry rockfall hazard management processes.
18	Fusion of sensors for incident monitoring
19	Improving the consistency of cost estimation during early project development.
20	Innovative Winter Maintenance Materials, Equipment, and Procedures Evaluations
21	Environmental protection from road salt
22	Winter Driving Conditions assessment for optimal public understanding
23	Safety Impacts of a Variable Speed Limit System
24	Sustainability of Bridges in Ontario

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

Coordinator for Innovation and Sustainability
Executive Director's Office
Provincial Highways Management Division
Ministry of Transportation
HIIFP@ontario.ca
(905) 704-3998

3.3 Ministry Assistance in Conducting Funded Research

A Ministry technical specialist in the relevant subject area will be assigned to each approved project to liaise with the principal researcher.

Proposals may request the use of specific data or facilities or other resources owned by the Ministry. The feasibility of providing the requested resources will be considered in the proposal evaluation and Researchers are strongly recommended to discuss the expected resource need with a Ministry contact prior to submitting a Proposal.

It is recommended that proposals include scheduled meetings with Ministry staff to ensure an ongoing understanding of study objectives and progress and discussion of interim results. The timing and location of such meetings will be negotiated at the commencement of the project.

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 HIIFP budget has been approved.

The total value of awards is expected to be about $1,500,000, including approximately thirty new projects in addition to ongoing projects.

The Ministry will consider multi-year applications. In such cases the Ministry will endeavour to provide funding in each year, however, funding is not guaranteed in future years and the Ministry reserves the right to not provide the funding and terminate the research on written notice to the Institution.

For approved multi-year applications, Institutions are required to provide written progress reports to the Ministry by February 15 of each year; see Attachment E for report template. Failure to provide such progress reports indicating substantial completion of scheduled tasks to that date 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.

Proposals may include funding from other sources and these must be clearly identified in the application (see below and Attachment D).

3.5 Fieldwork on Ministry Highways

The Ministry must approve any proposed fieldwork on Ministry highways, and any proposed fieldwork on Ministry highways must be clearly identified in the HIIFP application. Respondents are advised to contact the Ministry about field work requests before submitting a proposal. Work within the highway right-of-way normally requires formal training in Ontario Traffic Manual's Book 7 (Temporary Conditions), for of all personnel working in the highway right-of-way. The University must pay for this training for their students or personnel if required by the project. Training is offered commercially, typically as a one day course. Information on the cost and scheduling of training courses is readily available on the internet. For projects that require training, proof of training must be provided to the MTO contact prior to field work commencing. Traffic control may be required for some projects with field work within the right-of-way. Traffic control will be arranged and paid for by the Ministry, but must be identified in the proposal, including the specific location and the estimated dates and duration (hours).

3.6 Ministry Data

Researchers may request the use of non-confidential Ministry data. Requests must be specific regarding the data type, location, date-ranges, sample interval or other characteristics. Where available the data will be provided to the project at no charge. The Ministry may decline to provide data due to concerns of privacy, confidentiality or commercial interest.

The use of Ministry data shall be limited to the funded project unless otherwise agreed by the Ministry in writing (see Section 3.7 below).

3.7 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 use the information and data only for the purposes related to the proposed HIIFP 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).** The application form must include all signatures.
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).** A separate page shall be used for each requested year of funding.

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 (item 1, above). Curriculum vitae should focus on information relevant to the submission and must not exceed five pages per individual.
   Submission of the NSERC Form 100 personal data form is acceptable.
7. **Appendices**. Up to three relevant research papers, reports, or other documents demonstrating the experience or capabilities of the Researchers in the subject area may be included as appendices.
8. **For Principal Researchers who received funding for research projects in the previous year HIIFP, a Progress Report is required** for each of the ongoing research projects using the template in Attachment E, or other written interim deliverables completed to date if within the previous 3 months.
9. If applicable, the Detailed Research Proposal shall include a description of and reason for requesting the use of **MTO Facilities, data or work on MTO highways**.

Section 6.0 SELECTION CRITERIA outlines the criteria used to assess the applications for HIIFP funding.

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

4.2 Detailed Research Proposal Requirements

The detailed research proposal must clearly describe:

- Understanding of the context and the specific objectives of this research, including both technical aspects and broader impact to the public
- Methodology and details of the proposed data, analysis and modelling
- Nature of the innovation in approaches, methodologies or expected outcomes
- Schedule of the activities to be undertaken during the project, identifying key milestones and associated dates including work tasks, meetings or presentations, and preparation of the draft and final report using the Technical Style Manual template (Attachment F).
- Qualifications of the Principal Researcher in the topic area, especially any qualifications, skills, experience or facilities that are unique
- Related work performed by the applicant and others on the team
- Budget requested of MTO and from other sources.
- The detailed proposal heading must reference either the Challenge # and title (see Table 3.1) , or Open Topic and the proposed title.

4.3 Deadlines & Address for Applications

Deadline for the receipt of applications is **Friday, March 16, 2018, 2:30PM EST.**

Completed applications with a cover letter and all supporting documentation must be submitted as attachments to one or more emails sent to the HIIFP email box: HIIFP@ontario.ca. Email is the only allowed form of submission.

The cover letter should be addressed to:

Coordinator for Innovation and Sustainability
Executive Director's Office
Provincial Highways Management Division
Ministry of Transportation
301 St. Paul Street, 4th Floor
St. Catharines, ON L2R 7R4
HIIFP@ontario.ca

Submission Details:

- Submissions must be provided as MSWord or MSExcel documents, as applicable. The maximum allowable size of an incoming file is 20 Mb so multiple emails may be required. The submission emails must use the following Subject Line convention: Institution Name, HIIFP number [year-topic# or Open Topic], Principal Researcher Last Name, email number if applicable. [Example: Carleton, HIIFP 2018-03, Smith, 1 of 1]. The attached files should use a similar naming convention. [Example: Carleton, HIIFP 2018-03, Smith, Appendix D].
- The submission must include a scanned copy of the innovation funding application form with original signatures (see 4.1 Application Components).
- Send a one-line notification email (with no attachments) immediately after the full submission email(s), using the same Subject Line, and stating in the message body, Proposal submitted for HIIFP 2018 and the number of emails used to submit the application.
- The sender will be notified by email if a notification email was received by the deadline, and the number of application emails received. If a reply is not received it should be assumed that the submission was not received. It is the sender's responsibility to ensure that electronic submissions are received by the deadline.

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.

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 normally not fund the purchase of major equipment, or the rental of existing equipment. However, in exceptional cases that satisfy the Ministry and are agreed in advance, 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 must be indicated.

Supplies may 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 at a location agreed to by both parties. Travel and accommodation costs should be included in the budget and 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** MSWord document template. This Style Manual will enable researchers to submit in a consistent and cost effective format. Submission is required in English only.

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 Research Support and overhead rates should be calculated and presented accordingly, but must not exceed 25% of the funding provided by MTO.** Funds from sources other than MTO must not be included in the overhead calculation.

5.2.7 Leverage or co-funding
Proposals that include funding in cash or in-kind contribution from other government, industry or academia sources are encouraged where appropriate and eligible. All

sources of co-funding must be shown in Appendix D. Note: in-kind resources provided by the sponsoring college or university are not to be included in the calculation of leverage or co-funding.

5.2.8 Taxes
No tax calculations shall be included in the Appendix D budget submission. Applicable taxes, if any, will be added upon payment.

6.0 EVALUATION and SELECTION CRITERIA
Each application is evaluated by Ministry technical experts using a standard scoring template and criteria. All submissions addressed to a given Research Need are scored by the same Ministry experts who represent the interests and expertise of a Ministry function.

The primary criteria for project selection are the numerical scores assigned by the evaluation team. However, and especially where scores do not clearly distinguish a difference between proposals, non-numerical criteria may be considered. Scoring criteria and weights, and other criteria are listed below. All scored criteria normally have equal weights. Where weights are adjusted, the same adjustments will be used for all submissions on a given topic.

- Understanding of the Problem and its Context – maximum 25 points

- Methodology – maximum 25 points
    - A logical sequence, schedule, detail of tasks and practical deliverables proposed to address the Research Need

- Experience and qualifications of the researcher(s) in the subject area(s) – maximum of 25 points

- Schedule and budget– maximum 25 points

- Other Considerations That Are Not Awarded a Numerical Score:

    - Relevance of research proposal to MTO Sustainability Strategy, such as including sustainable materials and processes

    (refer to: www.mto.gov.on.ca/english/sustainability/strategy/MTO_sustainabilityreport-en.pdf)

    - For principal researchers who received funding for project(s) from previous years, satisfactory work in progress and deliverables of ongoing projects, completion and deliverables of past projects.

    - Relative value of funding or in-kind services secured from other sources

    - The cost and availability of Ministry providing requested internal resources such as access to labs, right-of-way, patrol yards, traffic control or other services on highways

    - Indirect benefits and status of co-funding identified in the proposal.

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

7.0 NOTIFICATION OF AWARD

A letter announcing awards for all new and ongoing, multi-year projects will be sent from the Ministry to the Principal Researcher and the financial official of the Institution designated in the application, at the beginning of the award period. The letter identifies the Ministry technical contact for each project and 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.

A letter of non-award will be sent for submitted proposals that did not receive funding.

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 upon receipt of an invoice, normally in May of each year of the award.

Recipients of funds under this program are required to maintain periodic contact with MTO staff assigned to monitor the progress on the research as indicated in the Award Letter. 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 progress reports to the Ministry by February 15 of each year 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 scheduled tasks 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 OR EXTENSIONS 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 technical contact who will then obtain approval from the Coordinator for Innovation and Sustainability.

Written approval must be obtained from the Ministry 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.

Requests to amend the cost of a proposal, for example to extend the work with financial support for an additional year, must be made by January 1. The request should be made in writing to the technical contact who will forward it to the Coordinator for Innovation and Sustainability. The request must include an amended proposal, budget and schedule, explaining the reason for the request and clearly showing the changes from the original. The request will normally be considered as part of the proposal evaluation process.

10.0 ANTICIPATED OUTCOME / DELIVERABLES

The Institution shall submit a draft final report (typically about twenty to eighty pages in length) in MS Word format using the Ministry style template (**Attachment F**), no later than **three months after** the end of the funding period or after termination of funding by the Ministry. The final report shall include sufficient detail or reference to other publicly available documents with detail, to transfer new learning to Ministry staff and to support the technical approach, data, analysis and conclusions of the project if challenged by stakeholders.

Ministry staff that recommended support of the research will review the draft final report and provide comments to the Principal Researcher within three weeks of receipt. Comments may relate to technical clarifications or avoidance of value statements on policies or actions of stakeholders. Any contentious issues will be addressed and agreed through discussion with the Ministry, and a final copy in .pdf format will be provided by the Institution within three weeks after receipt of Ministry comments.

The final report shall include:

- Conclusions and discussion of applications of the new findings to the challenge statement
- A letter attachment outlining plans for publication or other means of disseminating 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. The final report may reference a student thesis for pertinent details so long as the thesis is available to the public.

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 do 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 or electronic 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 The institution shall obtain written approval from the Ministry prior to communicating the outcomes of HIIFP research to the media. All media inquiries regarding HIIFP awarded research should be referred to the Ministry unless otherwise approved in writing. 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

HIIFP 2018-01

Subject Area:	Climate Change
Idea Title:	Quantifying Greenhouse Gas Mitigation Measures during Provincial Highway Design, Construction, and Maintenance Activities
Background:	The effects of climate change and extreme weather pose a serious threat to infrastructure, health, standard of living, and can result in significant financial consequences unless immediate action is taken. Mitigation of greenhouse gas emissions is required to avoid the worst impacts of climate change. The Ontario government has committed to reducing greenhouse gas emissions to 80% below 1990 levels by 2050, and build a prosperous low-carbon economy. According to *Ontario's Five Year Climate Change Action Plan*, the Transportation sector currently accounts for 35% of all greenhouse gases in Ontario. Accurate and transparent monitoring and reporting of Canada's greenhouse gas (GHG) emissions and removals is a requirement of the United Nations Framework Convention on Climate Change (UNFCCC). This is also key to demonstrating progress in reducing greenhouse gases and combating climate change. There is a need for the identification of greenhouse gas sources and sinks associated with highway management activities. Identification of all major sources and quantification of mitigation activities will influence future policy development and further evolve efforts against climate change.
Challenge:	There is currently no standardized greenhouse gas tracking and mitigation measurement method developed that can be applied to highway design, construction, and rehabilitation in Ontario. The biggest challenges associated with quantification of current greenhouse gas emissions and mitigation efforts are capturing the diversity of all activities in design, construction, and maintenance. Each measure has different requirements

	and contains unique nuances associated with tracking. Any process for tracking methodologies must be robust to capture new and emerging practices as policies and innovations evolve. A further challenge is creating a process that can be applied using minimal internal resources. Any process developed cannot be labor-intensive, require specialized training, and must be intuitive to account for high staff turnover rates.
Anticipated Outcome:	• Technical Report • Presentation to Technical Committee • Tracking Template

HIIFP 2018-02

Subject Area:	Climate Change
Idea Title:	Greenhouse Gas Mitigation in Highway Design, Construction and Maintenance - Jurisdictional Scan
Background:	The effects of climate change and extreme weather pose a serious threat to infrastructure, health, standard of living, and can result in significant financial consequences unless immediate action is taken. Mitigation of greenhouse gas emissions is required to avoid the worst impacts of climate change. The Ontario government has committed to reducing greenhouse gas emissions to 80% below 1990 levels by 2050, and build a prosperous low-carbon economy. According to *Ontario's Five Year Climate Change Action Plan*, the Transportation sector currently accounts for 35% of all greenhouse gases in Ontario. The Climate Change Action Plan contains references adjusting traditional procurement to account for low carbon emission opportunities. The MTO Provincial Highway Management Division recently began developing a list of greenhouse gas mitigation measures for road design, construction, rehabilitation and maintenance activities. In order for the MTO to further evolve its efforts against climate change, it is crucial to compare and evaluate practices from other jurisdictions for future policy development.
Challenge:	To date there has not been a fulsome jurisdictional scan of greenhouse gas mitigation measures that considers design, construction, rehabilitation and maintenance associated with highway management. The biggest challenges associated with implementation of new innovations include potential cost increases of adopting measures, the industry's capacity to respond to new requirements, availability of internal resources to develop new specifications and contract requirements, and social resistance to adopt changes.

	A concise summary is required that can be shared with policy and decision makers, service providers and contractors.
Anticipated Outcome:	• Technical Report • Presentation to Technical Committee

HIIFP 2018-03

Subject Area:	Engineering Materials (Asphalt)
Idea Title:	Asphalt cement modifiers and their impact on mixture low temperature and fatigue cracking.
Background:	Asphalt cements (AC) can be made using different processes (visbroken, oxidation, etc) and are typically modified using various additives (polymers, waxes, oils, recycled oils, natural bitumen etc). The asphalts are tested both neat and aged. Lab aging from Rolling Thin Film Oven (RTFO) and Pressure Aging Vessel (PAV) can be for 20 or 40 hours. AC recovered from loose mix, cores and lab generated mix are aged differently and the properties of in-place AC may be influenced by the properties of recycled asphalt content. The viscoelastic behavior of the original and aged AC is determined using a Dynamic Shear Rheometer (DSR) at various temperatures and quantified through Complex modulus (G*) and phase angle (δ). Studies suggest that the limiting temperature determined based on δ may correlate well with Extended Bending Beam Rheometer (EBBR) and both could predict asphalt pavement performance to a high degree of accuracy. Using δ will require less material and time compared to the EBBR. Aged AC is being tested at low temperatures (-18^{o}C, -24^{o}C etc.) to predict an asphalt mixture's susceptibility to low temperature cracking and fatigue through BBR and EBBR. At low temperatures, Critical Temperatures (T_c) are calculated based on AC stiffness (T_{cS}) or on the m-value (T_{cm}). Some modifiers lead to a rheological behaviour that is controlled to a certain extent by stiffness, while others are controlled by m-value (creep). Critical Temperature Difference ($\Delta T_c = T_{cS} - T_{cm}$) may also characterize AC behaviour related to pavement low temperature cracking and fatigue.
Challenge:	Examine unmodified AC and AC modified with a variety of commercial processes and additives (air blowing, polymer modification, modification with warm mix additives, bio oils, pitches etc.). The study should also include AC recovered

	from asphalt mixtures manufactured with these ACs, integrating also an Extended High Temperature Oven Aging (EHTOA) protocol of asphalt mixture to simulate pavement in-service aging in an attempt to compare with the RTFO and PAV aging methods. Monitor AC aging using Infra-Red (IR) spectroscopy to examine changes in asphalt binder functional groups (carbonyl, sulfoxide, carboxylic acid, ketone) and polymer functional groups (butadiene and styrene). Use the EHTOA protocol to age asphalt mixtures and prepare specimens to determine thermal failure using: i) Illinois Flexibility Index Test (I-FIT); ii) Texas A&M Transportation Institute's Indirect Tensile Asphalt Cracking Test (IDEAL-CT); and iii) the Notched Restrained Cooling Test (NRCT) which is a variation of the Thermal Stress Restrained Specimen Test (TSRST). Determine: i) phase angle (δ); ii) critical temperatures based on δ and ΔT_c values for un-modified and modified binders available in Ontario; and iii) their relationship to binder aging and rheological response. It is expected that the findings will lead to a better understanding of the asphalt supply to predict the pavements behaviour and life expectancy. Compare the different processes and propose acceptance criteria for PGAC's based on performance expectations.
Anticipated Outcome:	Test data, findings and recommendations for limits on phase angle and ΔT_c based on testing and analyses conducted. Technical Report on findings and presentation to MTO Technical Committee.

HIIFP 2018-04

Subject Area:	Engineering materials(Asphalt)
Idea Title:	Refinement of Double Edge Notch Tension Test
Background:	The double edge notched tension (DENT) test is used by MTO and other transportation agencies for acceptance of asphalt cement. The test evaluates an asphalt cement's ability to resist ductile failure. Samples with notches are stretched until ductile failure is achieved. The test is conducted after thermal conditioning to determine the critical crack tip opening displacement (CTOD) at a specific temperature and rate of loading. MTO has been using the DENT test for acceptance of asphalt cement since 2012. The test and criteria were developed by Dr. S. Hesp, Queen's University and MTO. AASHTO published the method as provisional method TP-113. Ontario changed to brass molds having smooth wall end pieces from the forced ductility test to provide consistent sample thickness and shape. The method used in MTO contracts is published as LS-299. MTO has designed a modified brass mold to address stiff asphalt that occasionally pull off the mold end pieces. The newly designed mold has fins that prevent the asphalt from detaching from the end pieces. It would be valuable to use the new molds in an experimental matrix, studying different conditioning and test temperatures to determine corresponding CTOD values for PGAC used in Ontario. In addition, researchers in the United States of America have also looked at alternative tests. They include: • A vertical version of the DENT test using DSR (Dynamic Shear Rheometer) at different conditioning and testing temperatures by Gerald Reinke. • A single notch specimen by Don Christensen. • Poker Chip Failure Testing at Intermediate Temperatures (PCFTIT), a newly introduced test performed on DSR.

Challenge:	Compare results obtained for each of the ductile failure testing variation discussed under background to the method currently in MTO LS-299 with: • PG XX-40 tested at 4°C and 15°C, • PG XX-34 and PG XX-28 tested at 15°C. Evaluate the impact of mold configurations and test temperature with the separation that can occur of material at end pieces and determine impact on test results for different asphalt cements.
Anticipated Outcome:	Recommendations for refinements to the DENT test procedure established based on testing and analyses conducted. Findings to include comparison of methods evaluated and recommended acceptance criteria for PGAC's used in Ontario for the alternatives evaluated. Technical Report provided covering findings and recommendations.

HIIFP 2018-05

Subject Area:	Engineering Materials
Idea Title:	Evaluation of Testing Variability of Semi-Circular Bend (SCB) and Disc-Shaped Compact Tension (DCT) Fracture Tests.
Background:	Fatigue and low temperature cracking are the two most common modes of cracking in cold climates in asphalt concrete pavements. Recently, fracture mechanics performance based tests have been developed to evaluate fatigue and low temperature cracking resistance of asphalt concrete mixtures. Two promising tests are: • Semi-circular bend (SCB) test, using two different test methods, AASHTO TP124 and ASTM D8044 to evaluate fatigue crack resistance of asphalt concrete mixtures. • Disc-shaped Compact Tension (DCT) according to ASTM D7313 and SCB test according AASHTO TP105 to evaluate low temperature cracking resistance of asphaltic concrete mixtures. These two tests are drawing attention in North America due to their simplicity and reasonable correlation with field pavement performance. Transportation agencies are interested in using these tests for asphalt mix acceptance during mix design or production. It is important to evaluate these test methods using procedures that are practical and doable by many laboratories during design and paving.
Challenge:	Investigate through laboratory testing and statistical analysis the testing parameters that have the most effect on results obtained by SCB and DCT tests using testing jigs and the following equipment typically available in Quality Control and Quality Assurance laboratories throughout Ontario: • loading frames, • freezers, and • conditioning baths. Evaluate testing variability of these two fracture tests in order to assess their potential use for acceptance of construction contracts.

Anticipated Outcome:	Technical report including test results, data analysis including repeatability and reproducibility, findings, and procedure recommendations for practical use by Quality Control and Quality Assurance laboratories for SCB and DCT testing.

HIIFP 2018-06

Subject Area:	Pavements, Engineering Materials
Idea Title:	Development of a Test Method to Evaluate the Performance of Concrete Pavement Joints in a Freeze-Thaw Environment
Background:	Ministry of Transportation of Ontario (MTO) observed a problem with premature joint deterioration of concrete. The deterioration mechanism was determined to be freeze-thaw damage of critically saturated joints. MTO wants to be able to evaluate, using accelerated testing methods, potential means of improving resistance to joint deterioration for new pavements. Current MTO joint design includes use of a reservoir cut to allow for proper placement of joint sealant and backer rod. However this design leaves an area below the backer rod, where water can pool, leading to saturated joints, and subsequent freeze-thaw damage. A review of the literature and of practices by other agencies determined that there are a number of ways to potentially reduce the amount of water that is trapped in the joint. These can include eliminating the reservoir cut, not using a backer rod and instead completely filling the joint with joint sealant, or leaving joints unsealed. These alternative approaches attempt to reduce the amount of water that ponds in the joint. The use of penetrating concrete sealers on the inside faces of the joints has also been proposed by researches, as a means of reducing the degree of saturation of the concrete in the joints. Currently there are no standardized tests that specifically assess concrete pavement joint performance in a saturated freeze-thaw environment. Development of a standardized test method to examine concrete pavement joint performance would allow MTO to assess the impact of changes to concrete material properties in improving joint performance and also to evaluate the effectiveness of various joint designs as well as the use of penetrating concrete sealers.
Challenge:	Develop a test method to assess the performance of concrete pavement joints in a freeze-thaw environment. Once developed, carry out an experimental program using the new test method to evaluate several concrete mix designs, several joint designs and several types of penetrating concrete sealers.

Anticipated Outcome:	Technical Report detailing the test procedure for assessing joint performance and outlining the findings of the experimental programme and recommended changes, if any, to current MTO specifications. Presentation to technical committee.

HIIFP 2018-07

Subject Area:	**Engineering Materials/Geotechnical Committee (Concrete Pavements)**
Idea Title:	Evaluation of Non-Invasive Methods for Assessing Concrete Pavement Joint Deterioration, and Development of a Protocol for use in Field Investigations
Background:	Ontario's concrete pavement joints are experiencing premature concrete deterioration, which may progress significantly within the joint area before it is visible on the pavement surface. The current approach used for joint condition assessment relies on visual surveys with removal of core samples to confirm subsurface conditions. Existing non-destructive assessment methods could potentially be used to quickly survey large sections of concrete pavement and reliably identify subsurface deterioration at an earlier stage. This would provide better information on which the ministry could base repair/replacement decisions, and provide for application of preventative maintenance strategies. It is also expected this could be less costly and disruptive to traffic, and ensure that all areas of damage are identified. Under the proposed project, techniques should be studied and then demonstrated in a real-world situation to determine which is/are most effective in identifying early joint deterioration. Significant study of investigation methods has already taken place in the U.S. Potential techniques to be investigated and considered for application by MTO in Ontario include x-ray, radar, ultrasound and MIRA (ultrasonic array technology) which has shown promise in recent U.S. research (1, 2). Once a technique is identified which can reliably identify the presence and severity of subsurface joint deterioration, a protocol for investigation of pavements based on the method should be developed, applicable to Ontario pavements. The protocol should describe how the method is to be used to assess condition of concrete pavement joints, on a large scale basis. It protocol should also include correlation between data from condition assessment (i.e. degree of deterioration) with recommended joint treatment.

	References: 1) Detection of Subsurface Joint Deterioration, Transportation Research Record Journal of the Transportation Research Board, 2367(2367):3-12 · December 2013 2) 2) https://www.fhwa.dot.gov/pavement/concrete/ultrasonic.cfm
Challenge:	A protocol for assessing the condition of concrete pavement joints is to be developed based on the most effective non-destructive test method(s) for this application, identified through literature review and proven through field demonstration. The protocol should minimize interruption to traffic and require a minimum of invasive or destructive testing to verify the results of non-destructive testing.
Anticipated Outcome:	Technical report summarizing the research carried out and including a comprehensive literature review, to support the recommended technology. Protocol suitable for use by MTO in assessing concrete pavement condition. Presentation to committee.

HIIFP 2018-08

Subject Area:	Environmental
Idea Title:	Effect of Climate Change on Embankment Stability
Background:	The effect of climate is slowly becoming apparent with more frequent natural disasters like hurricanes, floods, intense drought, etc. Such extreme events with changing characteristics over time have a detrimental effect on the transportation infrastructure. For example, intense heat and drought followed by sudden heavy rainfall and even flooding make natural and man-made slopes vulnerable. Several Ontario highways are supported on embankments with sloping grounds. Failure of these slopes can be dangerous, disruptive and expensive. Traditional designs of slopes and embankments cannot take into account the climate change effects. However, it is necessary to incorporate these effects to ensure safety and serviceability of highway infrastructure.
Challenge:	A previous study was conducted using a climate model in Toronto. To understand how climate change will impact embankment stability at other locations across the province of Ontario, the study has to be extended to provide analyses for each of the five MTO Regions Based on the findings, a risk register shall be developed that will enable MTO to categorize the risk as High, Medium and Low based on a number of criteria including climate data, soil-atmospheric modelling, slope stability analyses, importance factor and consequence factors. An Embankment Stability Climate Change Information Management System (ESCCIMS) with GIS and relational databases shall be developed. This database shall identify fill materials including coarse grained sands, fine grained silts and clays and project specific climate data with an assessment of the risk of failure and consequences. The analyses shall be undertaken using extreme precipitation events. The analyses shall consider the geometry herefore, a parametric study on the embankment design parameters such as the height, slope, geology, and material properties would provide additional understanding on transportation embankments behavior under changing climate

Anticipated Outcome:	Technical Report Design Guideline Presentation to Technical Committee

HIIFP 2018-09

Subject Area:	Bridges/Foundations
Idea Title:	Re-Use of Existing Piles
Background:	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. However for bridge replacements, consideration should be given to re-using the existing deep foundations. If the new span configuration is such that the previous deep foundations can be used, the MTO can save time and money.
Challenge:	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. 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 as well as direct observational methods through test pits or similar..
Anticipated Outcome:	Technical Report Design Guideline Presentation to Technical Committee

HIIFP 2018-10

Subject Area:	Construction
Idea Title:	Rockfill Settlement Prediction
Background:	The settlement of a rock fill mass when subjected to a load, occurs as a result of: • Elastic deformation of the particles; • Slippage and sliding of particles; and, • Crushing of particles. Currently, for highway design in Ontario, the estimation of magnitude of settlement for rock fill embankments is based on an MTO guideline titled, "*Rock Fill Settlement and Rock Fill Quality Estimates*", dated September 14, 2010. The guideline presents methods for estimating the short-term and long-term settlements of rock fill embankments as functions of the rock fill thickness and method of placement (compacted versus dumped).
Challenge:	The challenge is to examine the limitations of the current methodology and to develop a model that accurately predicts the short term and long term settlement. Different models of prediction including but not limited to simplified empirical/analytical and refined analyses such as numerical methods shall be investigated and a preferred method developed. To calibrate the preferred predictive model, projects that have actual settlement monitoring shall be used. One such project is the current rock fill embankment settlement monitoring program that is being carried out within a section of the new highway between Parry Sound and Sudbury, near the French River in Ojibway Canyon. Guidelines for instrumentation monitoring program and settlement predictions shall be produced to upgrade the existing guidelines.

Anticipated Outcome:	Technical Report Design Guideline Presentation to Technical Committee

HIIFP 2018-11

Subject Area:	Bridges/Foundations
Idea Title:	Prediction of Scour – Foundation Engineering Input
Background:	The prediction of scour for bridges and culverts requires a scour analysis. The scour analysis is typically undertaken by the Hydraulic Engineer using a Hydraulic model. At the MTO, the Drainage Manual provides guidelines for the scour analysis. The FHWA has published guidelines Hydraulic Engineering Circular No. **18** (**HEC**-**18**) (evaluating scour at bridges) and HEC-23 (bridge scour and stream instability countermeasures) that presents the state of knowledge and practice for the design, evaluation and inspection of bridges for scour. Scour design is a multi-disciplinary exercise that involves the structural and hydrology designer as well as the foundation/geotechnical designer working as a team. Observational methods have demonstrated that the predictions of scour have been conservative. In order to produce cost effective scour countermeasures, a better understanding of the process and specifically the foundation engineering involvement is needed.
Challenge:	The role of the Foundation Engineer in the scour analysis at the MTO requires clarity. There is a need to upgrade the input from the Foundation Engineer. The appropriate physical, mechanical and erodibility properties of the soil/rock need to be determined and included in the Foundation Investigation and Design Reports (FIDR) for use in the scour analysis. Conceptual scour countermeasures can be provided in the FIDR with the disclaimer that the Hydraulic Engineer is responsible for generating the analysis and selecting a preferred countermeasure in collaboration with the Bridge Engineer. The Foundation Engineer needs to be kept in the loop and be

	given the opportunity to review and endorse the resulting scour design as meeting the minimum scour protection from a foundation perspective. Specific guidelines are needed to ensure that the appropriate factual information and recommendations are included in the FIDR and that a process of scour analysis is implemented that ensures collaboration between the Foundation Engineer, the Bridge Engineer and the Hydraulic Engineer.
Anticipated Outcome:	Technical Report Design Guideline Presentation to Technical Committee

HIIFP 2018-12

Subject Area:	Bridges/Foundations
Idea Title:	Soil Structure Behaviour of Three Sided Culverts
Background:	The lack of understanding of the behaviour of a buried three sided culvert can lead to uncertainty of the performance of the culvert under static and dynamic loadings. The prediction of displacements, shear forces and bending moments is a function of a number of factors including the structure stiffness, the backfill and cover, embedment, founding soil and foundation type, arching factors, time effects including downdrag forces and soil consolidation. The MTO needs to have a better understanding of the behaviour of buried three sided culverts in order to produce designs that are more accurate and cost effective.
Challenge:	The challenge is to examine the limitations of current methodology and develop a model that accurately predicts the behaviour. Different models of prediction including but not limited to simplified empirical/analytical and refined analyses such as numerical methods shall be investigated and a preferred method developed. Guidelines for instrumentation monitoring shall be developed in order to gather short term(during construction) and long term (following construction) data to calibrate the preferred predictive model
Anticipated Outcome:	• Technical Report • Design Guideline • Presentation to Technical Committee

HIIFP 2018-13

Subject Area:	Materials Engineering and Research Office and MTO Geotechnical Engineering Committee
Idea Title:	Using Artificial Intelligence Method to Perform QA&QC in Processing Image Data of Pavement Conditions and Rating
Background:	In practicing pavement management system, it has been a very challenging technology and computerized system to have the capability of detecting, classifying and rating pavement distresses from the existing road surface image data collected by high-speed vehicles equipped with 2D and/or 3D cameras and laser measurements, which can be detailed as following areas: • To develop a fully-automated computer program that can be used to identify, classify and quantify individual pavement distress based on its density and severity calculated from standard pavement image data. • To develop an artificial intelligence computer system that is able to perform tasks that normally require human intelligence, such as visual perception, pattern recognition and classification decision-making and condition rating. • To provide an automated process that has the ability of comparing and verifying all individual classified pavement distresses based on artificial intelligence The results of pavement condition evaluation and ratings, including detection, classification and evaluation rating, are used in the process of determining multi-year maintenance and rehabilitation program for the whole road network. Hence, the quality of pavement condition data collection and evaluation has significant impacts on investment in pavement maintenance management. The Ministry currently uses fully equipped vehicles to collect pavement condition data for the purpose of analyzing pavement functional and structural conditions. The primary pavement condition indices, International Roughness Index (IRI), integrated Surface Distress Index (SDI) or Distress Manifestation Index (DMI), Rutting Depth Index (RDI) and individual distresses such as longitudinal and transverse cracks and alligator cracks. Each of the indices is averaged statistically over a pavement section divided along a highway

	in the network. These indices and some individual distresses are the key factors that are currently considered in the assessment of pavement condition ratings and the decision-making process of pavement maintenance and rehabilitation treatments. The current approach is deficient in terms of not being able to classifying and quantifying all identified individual pavement surface distresses, including evaluation rating methods and ineffective process of image data.
Challenge:	The challenge is to develop and implement a computer application that uses Artificial Intelligence to process image data to perform QA&QC of Pavement Conditions and Rating The Ministry will provide a standard video image library for researchers to conduct any analyses and activities relating to the HIIFP. The pavement image library contains view of all King's highway (provincial freeways and arterial highways) pavement surface images taken by MTO ARAN 9000 and saved in every 10 meters along each of the highways. In addition, MTO will provides testing road sections that can be used to calibrate data collection equipment, compare and verify pavement condition evaluation quality and other analysis purposes such artificial surface cutting patterns and classification of individual distress severity levels.
Anticipated Outcome:	A written technical report A computer application that can use MTO ARAN LCMS image data, process and provide outputs of classified pavement distress types and rating via AI algorithms Provide technology transfer materials to Ministry staff

HIIFP 2018-14

Subject Area:	Environmental
Idea Title:	Developing Effective Measures to Mitigate Reptile Road Mortality on Ontario Highways
Background:	Most turtle species and many snake species found in Ontario are at risk and protected under the Endangered Species Act. Road mortality is a major threat to their existence and contributes to their decline, particularly those for which road shoulders and slopes meet preferred conditions for nesting or basking. MTO has been implementing temporary and permanent mitigation measures to protect species at risk and their habitat during and after construction and during routine maintenance of provincial highways for more than a decade, with encouragement from the Ministry of Natural Resources and Forestry (MNRF) and environmental NGOs. Silt fence geotextile has been adopted as a preferred temporary measure for excluding turtles from nesting in construction areas. However it has limitations with respect to installation and maintenance, discourages consideration of possible non-fencing options, and ignores the turtles' need for alternative nesting locations during the exclusion period. MTO has also been searching on a project by project basis for optimal and cost effective permanent mitigation measures using several types of metal fence fabrics to exclude turtles and snakes from highways on an operational basis, along with various wildlife escape measures and crossing structures to provide passage under roads. The options for mitigation may be constrained by highway design and construction standards, requiring different approaches in different settings. A goal is to apply the most effective measures at high priority mortality locations across the province, and to use what is learned to assist development of and improvements to contract specifications. Significant research and monitoring has also been conducted by MTO and others to determine where to implement mitigation, including a road ecology study comprising analysis and provincial mapping of mortality hotspots of target species at risk (Blanding's turtles and Foxsnake and Massassauga Rattlesnake), using a habitat model that predicts where road

	mortality is likely to occur, based on historical observations as well as the land-use and habitat surrounding the roads. Validation and prioritization of very high predicted reptile mortality hotspots in one of MTO's regions (Western, Eastern, Northeastern or Central) will provide a methodology that can be applied to other parts of the province. Ultimately the mitigation measures used must be effective, affordable, robust and must stand up to snow load as well as winter and summer maintenance. They must also be adaptive to each of the target species' life-cycle behaviours (e.g. strong nesting site affiliation, climbing ability, etc.). Reptile mitigation measures that have, will or may be installed on MTO highways in very high road mortality hotspots provide good opportunity for case studies to identify the most effective measures. Following are locations that shall be included: • Study of temporary measures within 100 km of North Bay in MTO's Northeastern Region on active construction sites that can be arranged by MTO, or within known, unmitigated turtle mortality hotspots with approval of MNRF. • Comparison of two mesh sizes for permanent reptile fence installations on Highway 401 east of the Highway 137 interchange in MTO's Eastern Region within the Thousand Islands Frontenac Arch Biosphere Reserve, identified as highest priority for key SAR species including Blanding's Turtle and Gray Ratsnake, where a finer mesh fence installed in 2017 failed during early winter maintenance, and where MTO intends to install 1 km of thicker gauge fencing with a ¼" mesh on one side of the highway and a 3/8" mesh on the other side. • Monitoring for effectiveness of a suite of mitigation measures and their individual and collective ability to reduce road mortality on a segment of Highway 12 in MTO's Central Region located on land with Lake Simcoe to the south, and a wetland and Lake Couchiching to the north, identified as special concern Snapping turtle and threatened Blandings turtle habitat, where permanent exclusion fencing with six turtle escape ramps, alternate nesting materials, and the extension of a culvert to provide habitat connectivity and safe passage under Highway 12 were constructed in 2017.
Challenge:	To develop a comprehensive approach to mitigating reptile road mortality associated with highway construction and operation in Ontario with consideration for species life-cycle and behavioural factors, regulatory requirements for protection of species, geographical and landscape challenges (earth vs. rock), climate

	and climate change, ease of installation/implementation, cost and availability of materials/measures, compatibility with highway safety standards, and feasibility and durability within the highway environment. A multi-faceted research study for a minimum of two years using multiple case studies is required to achieve these objectives. Proposals are invited for individual components of the work or for all components together. All work must be carried out in the specified locations unless otherwise stated. Available reports pertaining to the research and monitoring that has been undertaken in relation to the above case studies are provided for information purposes. Completion of a Notification of Field Work Operations form for submission to the MTO Regional Traffic Operations Centre will be required prior to any field work being conducted. Because this research pertains to species at risk, MNRF should be included as a partner where field work is necessary and/or registration may be required under the Endangered Species Act.
Anticipated Outcome:	Draft progress reports every 6 months and a final technical report that documents the following: • Results and methodologies for testing, evaluation and/or comparison of all existing and proposed temporary and permanent mitigation measures at all locations studied, including as applicable exclusion fences, reptile escapes, passages and alternative nesting habitat for protecting reptiles and reducing mortality; • Recommendations for the adoption of the most effective mitigation measures or for improvements to increase effectiveness; • ArcMap shapefiles of all validated very high mortality hotspots found within the chosen region on a highest to lowest priority basis and the validation and prioritization methodologies used • If more than one or all components of the work are awarded to the same research team, a technical report that contains the results of all applicable case studies separated into individual sections that would allow them to stand alone shall be provided.

HIIFP 2018-15

Subject Area:	Environmental
Idea Title:	Developing plantings and assessing their effectiveness to attract deer and keep them on the non-highway side of deer fence.
Background:	The area bordering Highway 26 New, between Wasaga Beach and Collingwood has a historically high population of deer. To provide habitat connectivity, two wildlife crossings under Highway 26New were constructed and deer fencing was installed to increase safety for motorists and to guide deer to the crossings. In addition, 18 deer escape ramps, or jump outs were also constructed. Wildlife monitoring of this highway has been provided through the use of motion activated cameras by the Central Region University Student Co-op wildlife monitoring program. Some video recording of wildlife movement was also done. Monitoring reports are available. While mitigation measures have been installed, deer are able to find their way onto the right-of-way (ROW) as 26New has roundabouts at crossing roads, where deer fencing extends only a short distance on these side roads. Monitoring data shows frequent deer usage of the ROW for grazing during all seasons. Development of a planting scheme of native plants that is self-sustaining and an attractive food source for deer that can be planted on the non-right-of way side of deer fence or near mitigation measures to guide deer into safe crossings or locations and to keep them off the ROW would provide a cost effective, easy to institute, tool for deer mitigation Plantings, if successful, will complement the current constructed mitigation measures, enhancing both deer habitat and motorist safety.
Challenge:	Plant species selection is to be based a literature review of suitable plantings and their effectiveness to attract deer as well as a field assessment of Hwy 26 New, and MTO owned land available for planting, to determine suitable locations. A plan for monitoring the effectiveness of these plantings is to be provided through all seasons, following planting. The planting scheme will include options and a recommendation and also consider costs, including which plant species will

	require minimal maintenance following installation. Using data from supplied past wildlife monitoring periods, the most populated/heavily used sections of the highway should be prioritised. The selected vegetation cannot be invasive to the local ecosystem and ideally, assists in ecological functions.
Anticipated Outcome:	The requirements are: • Preliminary report detailing the research on species selection, recommended planting scheme. Location selection to be approved by MTO • Installation of appropriate vegetation along Hwy 26 New. • Monitoring of the success of the measures. • A monthly update report including monitoring photos • A final presentation at Central Region on the research. If the recommendations are successful, deer occupying habitat along Hwy 26 New will be drawn to the new plantings and less likely to approach the highway side of the fencing in search of sources of food and may be drawn to food sources along their current side of the highway, increasing motorist safety. This planting scheme could become a standard for use in areas of high deer population.

HIIFP 2018-16

Subject Area:	Geomatics
Title:	UAVs for Highway Mapping and Asset Inspections
Background:	1. UAVs for Highway Mapping UAVs (Unmanned Aerial Vehicles or "drones") with high quality cameras and even LiDAR sensors are increasingly used for the creation of products such as orthomosaics (scaled photographic maps) and CAD plan products (Vector drawings and point clouds) that can be used for preliminary engineering design. They are inexpensive and can be mobilized quickly. With suitable equipment, procedures, and weather, some of these products may approach or meet MTO standard accuracies for detailed engineering design needs. UAV operations, however, are constrained by Transport Canada regulations and policies as set out in a Special Flight Operations Certificate that MTO currently flies under. Minimum distances to built-up areas and travelled roads are set out, but lessened restrictions might be negotiated as experience is gained and safety near civil infrastructure is assured. With a flight being as brief as 20-minutes over the site of a proposed new interchange, for example, the use of short traffic closures may be feasible. MTO Geomatics has already successfully created a number of orthoimages, digital terrain models and dense 3D point cloud models with two relatively inexpensive UAV units, but accuracy testing has been limited, and only over low-risk areas such as aggregate pits, a farm, and a former landfill park. 2. UAVs for Asset Inspections UAVs with cameras and other sensors (eg, thermal) are increasingly used by public sector and other owners to assess the condition of their civil infrastructure as hardware and software improvements are introduced, prices decline, and usability is simplified. UAVs now have collision avoidance sensors and protective cages capable

	of working safely under bridges and in confined spaces such as chemical refining chambers and penstock tunnels. MTO has many assets such as bridges, high-mast lighting, COMPASS camera poles, overhead signs etc. that might benefit from cheaper and more frequent visual inspections by safe, remote UAV means. UAV operations, however, are constrained by Transport Canada regulations and policies as set out in a Special Flight Operations Certificate that MTO currently flies under. MTO Geomatics has already performed some initial testing of bridge imagery acquisition in NWR with a DJI Inspire Pro 2 UAV, and has discussed similar future work with HSB Bridge Office.
Challenge:	1. Provide a report on the practicality and advantages of expanding the use of UAV hardware, sensor, and software technologies to perform mapping projects for typical highway design, planning or as-built needs, while meeting current MTO accuracies and standards for photogrammetric or engineering (topographic) surveys. Provide recommendations on minimum hardware and software requirements and best practices to conduct UAV mapping, while respecting federal aviation and MTO technical and safety requirements. 2. Provide a report on the practicality and advantages of applying existing UAV hardware, sensor, and software technologies for performing inspections as needed to meet current MTO standards and specifications for bridge, sign and other infrastructure. Consider where current standards and specifications might be raised by introducing the new technologies to gain productivity or safety enhancements in operations across the province. Provide recommendations on minimum hardware and software requirements to conduct regular asset inspections, while respecting federal aviation and MTO legal and policy requirements.
Anticipated Outcome:	• Technical Report • Presentation to technical committee.

HIIFP 2018-17

Subject Area:	Geotechnical – Rockfall Hazard Risk Management
Idea Title:	Development of mobile terrestrial photogrammetry systems and, data collection and processing methodologies for use in ministry rockfall hazard management processes.
Background:	The Ministry of Transportation of Ontario (MTO) manages over 16,500 km of provincial highways, much of which has been blasted through the Precambrian rocks of the Canadian shield. Due to blasting method, weathering and erosion, rockfalls occur seasonally. Most of the broken rock fragments have been captured by roadside ditches however, occasionally some reached the highway which, posed a risk to the motorists. With limited resources, it was recognized some form of prioritization was needed to ensure that the funds that are available are allocated in a systematic and cost-effective manner. With this in mind, MTO developed and implemented the Rockfall Hazard Rating System for Ontario (RHRON) which follows the basic principles established by the Oregon Rockfall Hazard Rating System (RHRS), created as part of a US Federal Highways Administration national pooled-fund research project on managing rock slopes along transportation corridors The RHRON system has been in use by MTO for many years in the selection of appropriate mitigation strategies to reduce or eliminate rockfall hazards. Details regarding application of the RHRON are included in the report published by the Materials Engineering and Research Office (MERO-043 RHRON: Ontario Rockfall Hazard Rating System – Field Procedures Manual). Most recently the ministry application rock hazard management practices was set out under HSBM #2016-12. Currently, data collection for preliminary screening, detailed screening as well as condition monitoring is being done manually on or along the side of the highway. While it has been a well-established method, it poses certain amount of safety risks to the field staff. Also, there are thousands of rock sites along the province's highway corridor which, makes manual data collection time consuming and labour intensive. Depending on the location of the sites, lane closures may be

	required, with associated costs and impacts to traffic. The ministry has been exploring technologies to enhance our rock hazard management processes. One emerging technology that has particular promise is mobile photogrammetry. Through interaction with academia and experts in the field we are aware of two technologies that we feel hold particular promise. The first technology of interest is referred to as change detection. This involves building 3D digital models of a rock face typically using either photogrammetry of LiDAR separated by some time interval. Processing software can highlight areas that have moved from one survey to the next. This has obvious applied uses in prioritizing remedial works. The second technology of interest is the building of digital rock face models using mobile collection of photos. To date this has been through aerial surveys. More recently the ministry has been looking to collect photogrammetry of rock faces from a moving terrestrial vehicle. MTO has two Automated Road Analyzer (ARAN) vehicles that already travel the ministry highway network each year capturing high definition imagery including roadside images. What has been proposed is to retrofit at least one of these vehicles to capture images of rock faces. The ministry will require expert assistance in configuring equipment; in developing data collection and processing methodologies; and, ultimately to incorporate automated data into our rock hazard management processes. It is our understanding that this would be a first, that no other agency or service provider has collected photogrammetry of rock faces from a moving land-based vehicle. Accordingly we believe it is appropriate to look to the academic community in this endeavor.
Challenge:	Enable automated photogrammetry data collection for rockhazard screening and monitoring at from highway speed. Incorporate photogrammetry data collection equipment with the existing ARAN vehicle(s). Develop data collection and processing methodologies. Incorporate automated data collection into rock hazard management processes.
Anticipated Outcome:	Technical report. Equipment installation, data collection and processing guidelines to incorporate terrestrial based mobile photogrammetry and into rock hazard management processes. Presentation to technical committee.

HIIFP 2018-18

Subject Area:	Operations – Video Analytics
Title:	Fusion of sensors for incident monitoring
Background:	Early incident detection results in reduced congestion by dispatching emergency services sooner as such we feel a solution will benefit the public by reducing congestion, emissions, and travel times on our roadways.
Challenge:	It is difficult to detect incidents by monitoring over 300 CCTV cameras. Cameras are not always pointed in the right direction as such the investigation of the use of video analytics paired with other technologies, thus a fusion of different sensors, would assist in determining abnormal situations on the highway. The proposed solution should reduce the amount of cameras that need to be reviewed by COMPASS operators, thus only the relevant camera streams are shared to the Traffic Operation Centre.
Anticipated Outcome:	Must include a written report, and demonstration of proof of concept demonstrating the benefits of pairing multiple technologies for incident monitoring.

HIIFP 2018-19

Subject Area:	Project Management
Idea Title:	Improving the consistency of cost estimation during early project development.
Background:	This project is about estimating the construction value of a project during early project development (prior to detail design). During preliminary design of a highway infrastructure project, after a technically preferred alternative is selected, a budget submission is required prior to proceeding to detail design and construction. Estimates at a later stage of project development (detail design), based on a bottom up analysis of plans, quantities, and specifications, are more reliable indicators of project cost than early stage estimates. Estimates at these two stages may differ widely. Estimating the value of construction project during the early stages of project development is challenging. As noted in NCHRP Report 574, transportation agencies face a major challenge in controlling project budgets over the time span between project initiation and the completion of construction. Project cost increases, as reflected by budget overruns during the course of project development, are caused by factors that have been identified through a large number of studies and research projects. These factors, the root causes behind estimation problems, differ with project development phase and project complexity. There is considerable variation in the approach taken to estimating the preliminary design alternative used in the budget submission. Typically the cost of the major items are estimated parametrically, but there is an inconsistent approach to estimating the percentage allowance for minor items, an inconsistent application of contingencies, and or an inconsistent approach to quantifying risk. Preliminary design cost estimates are not consistently reliable predictors of the actual construction value. The Parametric Estimating Guide (2016) provides some guidance in Appendix B of typical contract cost percentages by work type but standardized work processes to incorporate this guidance into project estimates are not available. There

	is no specific guidance for using analogous or similar projects in developing an estimate during preliminary design. Some transportation agencies use a probabilistic approach to estimating project value during preliminary design. In a probabilistic approach, a baseline estimate is established for the project if everything goes as expected. The baseline estimate usually includes a quantification of the major items, and a percentage allowance for minor items to establish the baseline estimate. The pessimistic, expected and optimistic values for major items are established and other major risks such as the cost and schedule risk in obtaining permits, unknown ground conditions etc. are established. A Monte Carlo Analysis is used to develop a probabilistic distribution of cost and schedule risks. Refer to Washington State Department of Transportation CVEP for more information or refer to Risk Management for Design and Construction, ISBN 9781118984017 for specific guidance in risk based cost and scheduling estimating for transportation projects. In the UK, the Green book provides guidance in estimating major projects, http://www.hm-treasury.gov.uk/greenbook, and more specifically in dealing with optimism bias, Procedures for Dealing with Optimism Bias in Transport Planning. Uplift factors have been developed for different types of transport project including confidence intervals in establish project budgets. In NCHRP 826, Estimating Highway Preconstruction Services Costs, chapter 4, Top-Down Cost Estimating there is some discussion of predictive model for costing design services. This research project is focused on construction cost predictions. As noted above a number of different approaches can be used to improving estimating. The applicability of these techniques and resource impacts on MTO and our service providers are not known.
Challenge:	The challenge is to identify and evaluate project estimating methods that more reliably predict the construction value of a project during early project development (preliminary design). MTO will provide access to source information such as preliminary design budget submissions, additional estimates during detail design and project values at contract award and final values at contract completion.

Anticipated Outcome	A report that explains the research findings, and; presentations to MTO staff on the findings, implications and recommendations on improvement to project cost estimation at MTO.

NCHRP Report 574, Guidance for Cost Estimation and Management for Highway Projects during Planning, Programming and Pre-Construction

HIIFP 2018-20

Subject Area:	Maintenance (RMET)
Idea Title:	Innovative Winter Maintenance Materials, Equipment, and Procedures Evaluations
Background:	MTO is a leader in winter maintenance across North America and continues to strive to undertake maintenance practises in the most efficient, economical and environmentally responsible way possible. As such, MTO undertakes annual trials comparing different materials, equipment and procedures seeking innovative ways to better service Ontario. Completed studies on winter materials are available from the MTO on-line library: https://www.library.mto.gov.on.ca/SydneyPLUS/Sydney/Portal/default.aspx. Current activities for the winter 2017/18 include the evaluation of pre-wet sand, variable liquid rates for pre-wet salt and ice breaker technologies. Road Weather Information Stations (RWIS), Mobile RWIS (MARWIS and Teconer), friction measuring devices and cameras are typically used to collect data to evaluate the new innovation against current practices. Participation in spring and fall meetings (typically in Huntsville) with MTO and maintenance contractor staff are required to understand issues, conditions and fine tune the field trials and evaluations as well as present findings. Weekly teleconferences throughout the winter season are used to confirm that relevant and quality data is received, equipment is working properly and problems are resolved quickly. Site visits may also be required at various locations in Ontario. Innovative initiatives requiring evaluation for the winter 2018/19 will be identified by various MTO working groups in the spring / summer of 2018 and require the following actions. • Testing and evaluation plans for each new innovation including locations, equipment, materials, data. • Track progress throughout the winter solving problems and keeping project on track.

	• Undertake sophisticated analysis enabling statistically significant assessments and recommendations
Challenge:	The challenge is to plan and coordinate the collection of data from mobile and roadside instrumentation along with field observations and experience, and analyze the data to characterize the relative performance of alternative materials and equipment in winter maintenance. Progress and results are also to be presented in person to assist a Ministry Working Group to develop future maintenance practices and specifications. Field work will be undertaken at various locations in the province over the winters 2018-19 and 2019-20.
Anticipated Outcome:	Results are to be presented in a written report, presentations to the MTO working group, and at least one paper and presentation at a recognized technical conference.

HIIFP 2018-21

Subject Area:	Maintenance, Environmental, Landscape Architecture
Idea Title:	Environmental protection from road salt
Background:	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. 1. In 2017 MTO initiated an HIIFP assignment utilizing continuous ion exchange technologies to demonstrate chloride removal from highway runoff water and scalability to highway maintenance practice. MTO would like to build on this concept seeking opportunities to demonstrate removal of salt from the Sundridge Patrol Yard waste water collection system to reduce disposal costs and return the water to the natural environment locally. 2. MTO would also like to explore opportunities to mitigate salt contamination along the highway environment by various means which may include non-invasive plantings or other methods. This work will also contribute to MTO's efforts under the Ontario Source Water Protection Program, including a commitment to consider new practices and mitigative technologies to minimize the impact of winter maintenance on the environment.
Challenge:	Demonstration and measure of effectiveness of road salt mitigation opportunities.
Anticipated Outcome:	Jurisdictional Scan Demonstration and evaluation of salt removal technologies. Prepare a written report and presentation for MTO. Prepare a presentation appropriate for technology transfer to audiences including other road authorities, TAC, TRB etc.

HIIFP 2018-22

Subject Area:	RMET, Ontario511
Idea Title:	Winter Driving Conditions assessment for optimal public understanding
Background:	In fall 2017 PHM implemented a pilot program on the Ontario511 website providing winter driving conditions forecasts for the public to consider when proactively planning trips. The website allows users to click on the forecasted timeframe of 0-3, 3-6, 6-9 or 9-12 hours to see the driving conditions forecast based on atmospheric weather such as snow, rain, freezing rain, wind, icing potential etc. Once a forecast time is identified, the roads on the interactive map are highlighted in green, yellow, orange or red depicting the driving conditions expected. The Ontario511 system also provides a road condition layer populated by patroller reported conditions. The road conditions are updated 5 times per day and as conditions change. The road conditions currently use the TAC standards highlighting roads on the interactive map in black, yellow and white. There are concerns that the TAC colours are difficult to see when the roads are snow covered against the back drop of the map and that the black and white colours are neutral colours. The road conditions and driving conditions forecast are currently mutually exclusive layers with the former being recent pavement conditions and the latter being future atmospheric forecasts. While the new pilot is very helpful, there is confusion regarding what the road conditions represent versus the driving conditions forecast. It is critical to accurately convey the message to the public regarding the reported road conditions and the forecasted driving conditions to ensure trips are planned appropriately. Failure to easily understand the information can lead to travel during conditions that may be unsafe for some users. Human factors assessments and testing is expected for this evaluation to ensure optimal public understanding of the new terminology / colours and thresholds for each criteria.

	Accessibility for Ontarians with Disabilities Act(AODA) standards must be met on the Ontario511 website.
Challenge:	Review the Ontario511 layers for road conditions and winter driving conditions forecast and develop new terminology / colour standards / threshold including human factors analysis to effectively convey public understanding.
Anticipated Outcome:	Jurisdictional scan of road conditions and forecasted driving conditions. Develop new terminology / colour standards for Ontario511 winter driving condition forecast including the layer(s) title, pop up boxes descriptions and the detailed information / explanation on the link. English and French final versions will be required. Prepare a report detailing the study including the current challenge, evaluation, new standard terminology and any additional recommendations. Prepare a presentation for MTO review / approvals. Prepare a presentation appropriate for technology transfer to audiences including other road authorities, TAC, TRB etc.

HIIFP 2018-23

Subject Area:	HSB Traffic Office, Safety and Information Management Section
Idea Title:	Safety Impacts of a Variable Speed Limit System
Background:	Other agencies have implemented trials of Variable Speed Limit Systems (VSLS) as a possible method to achieve safety improvements on highway sections that experience regularly occurring extreme weather conditions involving poor driving traction and/or poor visibility. Where implemented, data that have been collected on the number and severity of traffic collisions, and on other safety measures such as enhanced police enforcement, education campaigns, roadside safety improvements, signs, etc. can be analysed to provide guidance on the success and contribution of each factor to the overall success of VSLS. An additional factor of consideration is the potential shift in responsibility for safe operating speed from the driver to the road agency.
Challenge:	The challenge is to analyze data and experience from other jurisdictions that have implemented either a regulatory or an advisory VSLS, to inform the Ministry of the benefits and issues involved.
Anticipated Outcome:	Must include a written report, presentation of the results to Ministry staff is encouraged as well. Final report is to include the results of the analysis of several jurisdictions and their experience on changes to the number, types and severity of collisions in and near sections of highways with a VSLS. In addition, the study should also document the rate of acceptance by motorists (change in driving speeds during activation of the VSLS). Report should highlight the expected benefits and challenges associated with VSLS and, if possible, include any resulting liability issues encountered after the implementation of a VSLS. All results shall be documented in a final report including, but not limited to: a summary, recommendations, analysis of options, jurisdictional scan, and detailed review of metrics used to determine the success of existing VSLS trials/projects.

HIIFP 2018-24

Subject Area:	Bridges
Idea Title:	Sustainability of Bridges in Ontario
Background:	Sustainability in bridge design is about meeting the current needs without taking away from future generations. Bridges are costly to construct and maintain. The construction and operation of our infrastructure has a negative impact on our natural resources and ecological systems. A bridge constitutes a large investment of natural, material, financial, and human capital. Bridges we build today have design lives in excess of 75 years and thus establish the materials, energy, and maintenance for future generations. They are a significant part of the built landscape, and will be viewed by millions of motorists through their life. For bridges, the basic goal of sustainability is to establish net gains, ideally through actions that benefit the social, economic and environmental pillars of sustainability. Supporting this objective, the Transportation Association of Canada (TAC) released the Sustainability Considerations for Bridges Guide (SCBG) [5]. Within the guide, sustainability objectives provide direction for improving the sustainability of infrastructure projects and the rationale for undertaking specific actions. • Reduce virgin material use • Reduced energy • Engage community values and sense of place • Increase lifecycle efficiency • Reduce emissions to air • Improve local economy • Promote innovation • Maintain or Improve Hydrologic Characteristics • Improve Access and Mobility • Optimize Waste Stream • Maintain Biodiversity • Improve Safety

Challenge:	Compare bridges in Ontario in terms of the ability to meet the sustainability objectives established in the TAC SCBG. This could include a direct comparison of a few similar sized bridges at the system level, or could focus on a comparison at the component level (i.e. comparing a concrete slab reinforced with GFRP, black steel, stainless steel, post-tensioned, fibre-reinforced, or another system). The comparison should include some quantification of overall GHGs and energy of materials and equipment used both in the final structure and/or during construction. A traditional comparison would be between a steel girder bridge, a concrete girder bridge, and post-tensioned bridge. Propose some improvements or refinements to standard practices that would contribute positively to sustainability. MTO has vast amounts of data on material quantities in structures and condition information and which can be made available to the researcher.
Anticipated Outcome:	Technical report Yearly presentation to the Bridge Office

HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM 2018

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?

YES ☐ **NO** ☐ If YES, please provide details below:

Signatures: It is understood that the provisions of the Ontario Ministry of Transportation HIIFP as outlined in the 2018 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 2018
ATTACHMENT C – RESEARCH PROPOSAL SUMMARY

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

HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM 2018
ATTACHMENT D – BUDGET SUMMARY

Institution:
Researcher:

Note:

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

FISCAL YEAR ENDING: March 31, _____ (year) Ministry Topic Number:						
Principal Researcher:						
Short Title of Research:						
RESEARCH ITEMS	**Funding from MTO**			Other funding or in-kind, if any (specify source, not to include submitting institution)		All sources
	direct costs	% Overhead (max 25%)	Net MTO			Total
SALARIES AND BENEFITS						
a) Students						
b) Postdoctoral fellows						
c) Technical/professional assistants						
d)						
SUBTOTAL:						
EQUIPMENT OR FACILITY						
a) Purchase or rental						
b) Operation and maintenance costs						
c) User fees						
d)						
SUBTOTAL:						
MATERIALS AND SUPPLIES						
a)						
b)						
c)						
d)						
SUBTOTAL:						

RESEARCH ITEMS	**Funding from MTO**			Other funding or in-kind, if any (specify source, not to include submitting institution)		All sources
	direct costs	% Overhead (max 25%)	Net MTO			Total
TRAVEL						
a) Technical presentation						
b) Field work						
c)						
SUBTOTAL:						
DISSEMINATION COSTS						
a) Publication costs						
b)						
SUBTOTAL:						
OTHER (specify)						
a)						
b)						
c)						
SUBTOTAL:						
	direct MTO	overhead	net MTO	Other	other	Total
COLUMN TOTAL:						

HIGHWAY INFRASTRUCTURE INNOVATION FUNDING PROGRAM 2018
ATTACHMENT E – INTERIM PROGRESS REPORT TEMPLATE

PAGE 1 OF 2

	For Ministry use only	
	Application Number:	

HIIFP Funding Year:	Date:
Principal Researcher (Name & Business Address):	Business Telephone No.
Institution:	Email Address:
Title of Research including Ministry Topic #	
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	

Signatures:		
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 2018
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

Attachment F:

Ontario

Ministry of Transportation
Provincial Highways Management Division Report
Highway Infrastructure Innovation Funding Program

TITLE: Style Manual for Technical Publications

Final Report

[date]

HIIFP-000

Technical Report Documentation Page

Publication Title	# Style Manual for Technical Publications of the Provincial Highways Management Division
Author(s)	University authors
Originating Office	Highway Standards Branch, Ontario Ministry of Transportation
Report Number	HIIFP-000; ISBN 0-7794-2199-X [to be provided by MTO]
Publication Date	November, 2001
Ministry Contact	Provincial Highways Management Division Executive Office, Ontario Ministry of Transportation 301 St. Paul Street, St. Catharines, Ontario, Canada L2R 7R3 Tel: (905) 704-3998; HIIFP@ontario.ca
Abstract	The intent of this manual is to support the transfer of technical information. It is meant to aid authors in creating reports that are well written, functional, professional, and conform to ministry standards. This manual may be found useful as a reference in the preparation of reports and papers. The manual gives some general writing hints, discusses format of reports, and reviews grammatical and punctuation rules. The guidelines offered in this manual are not intended to infringe upon the technical contents of the paper to be published or the writing style of the author. Its purpose is to aid authors in giving attention to the details that make a good report, and to give authors some understanding of the editing and publishing requirements necessary to achieve the best possible product.
Key Words	To be provided by authors
Distribution	Unrestricted technical audience.

Ontario

Ministry of Transportation
Highway Standards Branch Report

HIIFP-000

Style Manual for Technical Publications of the Highway Standards Branch

November 2001

Prepared by
Highway Standard Branch Executive Office
Ontario Ministry of Transportation

301 St. Paul Street,
St. Catharines, Ontario, Canada L2R 7R3
Tel: (905) 704-2638; Fax (905) 704-2626

Table of Contents

Executive Summary

The intent of this manual is to support the transfer of technical information. It is meant to aid authors in creating reports that are well written, functional, professional, and conform to ministry standards. A written report remains one of the most significant means of relaying our research and technical findings to others. However, report writing is an infrequent activity and a well-written report may appear more difficult to create than it actually is. This manual is here to help, and has been specifically prepared to guide authors in writing technical reports for the Highway Standards Branch. It documents current ministry standards for technical report style and format. Tips on punctuation and grammar are also included.

Steps and processes involved in writing and publishing a report are covered in the first chapter. In the following chapters there are descriptions of what report elements should be considered, what each should consist of and their proper sequencing. Report elements fall into one of three categories: preliminaries, text, including figures and tables, and references. Preliminaries cover all report components that appear before the body of the report. Text topics are defined to give some direction on how content may be shaped. Vital information on the specifications and presentation of graphical materials is included in the text section. Standards for referencing are also provided in the manual.

In addition, multiple appendices are included as useful reference tools. Two sections provide specific information on format requirements and layout specifications. Writing tips are covered in appendices on frequently misused terms, form, and usage. Some authors may also find the page on proofreader's symbols useful.

It should also be noted that this manual is available electronically. Authors are expressly invited to work directly in the existing format. Should authors find any sections unclear, burdensome, or feel that topics are missing, any suggestions for improvement would be most gratefully accepted.

Introduction

In 1974, the Ministry of Transportation published *The Style Manual for Publications of the Research and Development Division*[1] to set report standards and to encourage good report writing. The same need exists today. The general purpose of a report is to record and preserve information so that corporate memory is not lost. Moreover, it ensures that the information is easily available to others. Writing an effective report remains a process of logically presenting a body of knowledge in a manner suitable for the intended audience. Through the writing, editing, and publishing stages, there are some basic ground rules of preparation that will assure the best possible results. This manual offers the author's suggestions for each section of the report so the final result will be valuable to the reader.

The current manual has been adapted from the original publication and has been significantly modernized. This report sets required electronic format and typographic styles for reports published by the Highway Standards Branch (HSB).

The subject matter suitable for publication as reports falls into the following categories:

1. Reports on research carried out within the ministry. This work may include work on development of laboratory or field testing procedures, results of correlation programs on variability of test procedures, and work on the behaviour of materials.

2. Reports on the long-term performance of innovative techniques, designs, or materials incorporated into actual structures or pavements.

3. Reports on the development and success of new or innovative specifications or standards for control of construction activities.

4. Reports on research carried out by others under contract to the ministry.

The cost of preparing and publishing reports is a small part of the value of the information obtained. As a consequence, and in view of the limited audience, reports published by HSB should be made available at no cost to the reader. The cost of publication and distribution (if any) of the report should be borne by the originating office. By publishing in a recognized report series, with each publication having a designated number, material will be preserved and can be easily referenced for retrieval.

1 The Research and Development Division no longer exists at the Ontario Ministry of Transportation, although transportation research is still conducted by various offices of the ministry.

Report-Writing Process

Report-writing activities include the following processes:

PREPARING AN OUTLINE

In deciding how long a report should be, there is a conflict between reader resistance to long, heavy reports and the author's desire to cover the subject completely. One solution is to write and prepare the report with a detailed outline. A conceptual plan with rough outlines should be created first. Check each section as you write it to ensure that the report is growing according to the plan.

Use headings and subheadings effectively to organize the text into legible and flowing units. A reader should be able to grasp the structure of the sections from reading the subheadings. One or two grades of headings within a chapter are usually enough.

Write a first draft with a preliminary layout that conforms to the required format. For typographic and page layout requirements, see Appendix D. Authors are expressly invited to work directly in the electronic format of this manual.

DRAFT REPORTS AND PROOFING

Draft reports should be printed on one side only, and on white bond paper. The draft report should be as letter perfect as possible. Spell-check the final version before sending for review or approval. Pay particular attention to equations, formulas, tables, captions, spelling of proper names and numbering of illustrations and references.

Drafts and proofs should be checked and returned promptly.

PEER REVIEW

The Project Manager or author should give consideration to whether a peer review is required, and if so, who the appropriate reviewers should be. Persons selected for peer review should be knowledgeable about the topic. Normally, at least two persons should conduct a peer review. Where an external party is conducting research as part of a project, the need for a peer review should be considered for inclusion as one of the deliverables of the project.

The persons selected to conduct the review would normally work for MTO, but in cases where there are no suitable internal reviewers, external reviewers may be sought. Of course, such persons must be independent, impartial, and have no potential conflicts of interest. The identity of reviewers should not be revealed to the author.

APPROVAL PROCESS

Ministry authors or managers are responsible for obtaining approval from the appropriate Director(s) to publish reports. After approval, the report may be published. Note that changes following Director approval may require re-approval and delay publication.

REPORT NUMBERING

Report numbers are to be assigned by the individual offices. Reports will be assigned a three-digit code in sequence, starting with 001. Report numbers are prefixed by office codes as outlined below.

- BRO – (Bridge Office)
- HSB – (Highway Standards Branch)
- GEO – (Geomatics Office)
- DCSO – (Design and Contract Standards Office)
- MERO – (Materials Engineering and Research Office)
- TRO – (Traffic Office)

For example, this report is designated as: HSB-001.

REPORT AUTHORING

Generally, the primary author should be the person who wrote the report. Contributors who may have suggested extensive revisions, written parts of the report, or participated in a significant way in the reported work, will normally have their names following the primary authors. When reports are authored externally, the MTO contact would normally be acknowledged on the technical document page.

ELECTRONIC FILE FORMATS

- Reports must be in a version of MS Word meeting current ministry practice. Figures, if possible, should be imported as documents within the file.
- A single PDF file compatible with Adobe Acrobat Reader must be created.
- See "**Main Body – Illustrations"** guidelines regarding print quality.

METRIC STANDARD

Canada adheres to the International System of Units (SI) in the application of metric measurements to scientific and engineering endeavours. Reports prepared for the Ontario Ministry of Transportation must conform to the SI standard when describing units of measurement. Imperial units are not permitted unless quoting another source that used imperial measurements. In this case, put SI units in parentheses.

REPORT FILING AND RETENTION

The original, and copies of illustrations, must accompany the sample copy of the report, which is retained by the originating office. Filing requirements are:

- The originating office will retain the original report for a minimum of 25 years.
- Two copies of the report must be filed with the Ministry of Transportation Library.
- Three copies of the report must be filed with the Ontario Legislative Library.

INTENT TO PUBLISH AND ISBN NUMBER

All publications must either meet, or be exempt from, the requirements of the Government Publications Directive. HSB reports meeting the requirements of this publication, HSB-001, will normally be exempt from the directive with respect to translation requirements and Cabinet Office approval processes. The directive can be reviewed on-line at the Corporate Policy Branch's intranet site under Corporate Directives/Information & IT Management/Government Publications Directives: http://intra.cpb.gov.on.ca.

All government reports that are published must be filed with Management Board Secretariat through a "Notice of Intent to Publish and Distribute". An on-line form can be accessed and filed through the Corporate Policy Branch's intranet site under Corporate Directives/Information & IT Management/Government Publications Directives/Government Publications/"Notice of Intent to Publish and Distribute": http://intra.cpb.gov.on.ca.

- Each format of the same report must have its own ISBN (number). For instance, a printed report and a report published on the Internet would have a different ISBN, as would a second edition of a publication.
- Contact the Information Resources Branch of the Ontario Legislative Library for the "Assigning ISBN Quiz" form and an "ISBN/ISSN Printing Instructions FAQ" sheet. An ISBN number will be assigned once the Library has received both completed forms, "Notice of Intent to Publish and Distribute" and "Assigning ISBN Quiz".

- The “ISBN/ISSN Printing Instructions FAQ” sheet includes instructions on layout location for the numbers.

PRINTING AND DISTRIBUTION

The originating office is responsible for printing and arranging distribution of paper copies of the report. The number of copies printed and distributed will depend on the intended audience.

Report Elements

Canadian English is the standard for ministry reports. Technical reports are exempt from Ontario government requirements for French translation.

Logos or identifiers, other than that of the government of Ontario, are not permitted. Consultant company names and addresses may be shown on the title page. For guidelines on how to list authors, please refer to **"Report Authoring"** in the previous chapter.

See Appendix D for layout specifications. The material included in a report is grouped into three divisions and arranged in the following order regardless of omissions:

A. PRELIMINARIES

- Cover
- Technical Report Documentation Page
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A. PRELIMINARIES

Preliminary pages are numbered with small Roman numerals. The cover, the technical report documentation page, and the title page are not numbered.

1. COVER

Use the cover page in this report as the format. A light green cover stock will be used to identify HSB reports. Confidential reports will have a red cover stock with no report number and will be marked "Confidential" on the cover.

2. TECHNICAL REPORT DOCUMENTATION PAGE

An abstract, text only, of approximately 200 words, should be included on the documentation page. An abstract should summarize essential report findings. This page should always appear as the front inside cover of the report; use the one in this report as the format.

3. TITLE PAGE

Use the title page in this report as a guide. It is important to include the disclaimer, "Published without prejudice as to the application of the findings. Crown copyright reserved".

4. TABLE OF CONTENTS

The table of contents lists all main headings and subheadings with their corresponding page numbers. It does not include the cover, technical report documentation, or title pages. Use the table of contents in this report as the format.

5. EXECUTIVE SUMMARY

All reports should contain an executive summary, which is an expanded abstract of one to two pages in length. A well-crafted executive summary will convey to the reader a good understanding of the contents of the report. The following topics will generally bring out the relations, processes, findings, and applications that are contained in the report, and should be described in an informative abstract or summary.

- Problem statement
- Alternatives considered
- Findings
- Recommendations
- Potential impacts

B. MAIN BODY

1. INTRODUCTION

The introduction explains the general scope and content of the report. It should discuss purpose and methodology, provide any background material the reader may require, and the approach used by the author. A good introduction will normally fit the reasons for the work reported on into an appropriate context. This is usually done by a literature review of previous work in the topic area. If a literature review is extensive, it may warrant a separate heading following the introduction. Arabic numerals are used for page numbers beginning with the introduction through to the appendices.

2. TEXT

Major divisions of the text are referred to as chapters, though the word *chapter* does not appear in the heading. If chapters are numbered, use Roman numerals in front of each chapter title. Each chapter (or main heading) begins on a new page. Examples of what would constitute a chapter are *Introduction* or *Background*. In long reports, related chapters may be grouped into 'parts'. Whenever possible, avoid dividing a word at the end of a line and a paragraph at the foot of the page. If a title head will have three or less lines of text below, move the head to the next page.

Numerous authoritative texts on rhetoric, style, and grammar are listed in the bibliography. The author should strive for conciseness and clarity. Words and expressions should be chosen carefully to convey the correct meaning.

All illustrations, including tables and figures, are to be included within the body of the text. They should be referred to clearly within the text. Illustrations should be placed as close to the related text as possible. Text should also tell the reader what the illustrations show and what to look for when viewing them.

3. ILLUSTRATIONS

Whether they are photographs, drawings, tables, or graphs, illustrations should be included only when they substantially increase understanding of the text.

a) Illustrations must be accurate, clear, simple, and well proportioned. Lines and wording should be reduced to a minimum. Consistency should be maintained in all artwork prepared for a single report.
b) The required resolution for a continuous tone image is 300 dpi at 100% reproduction size. A jpeg is the preferred graphic file format for supplied digital images. For line art, supply digitally at a minimum of 800 dpi at 100% reproduction size or higher if the image contains fine detail. Images are expected to be high quality.

c) Greyscale, i.e. black and white only, illustrations are preferred. Colour should be used only when necessary to illustrate some critical feature not otherwise identifiable. For best quality images, illustrations should exhibit good contrast and a full tonal range.
d) Drawings and graphs may be created in appropriate graphic software and imported into the current ministry word processing application used to produce the report. Avoid showing more than three or four curves on one illustration. Avoid interlaced or unrelated curves. It is preferable to label each line rather than using a key. Colour is not permitted.
e) Format and style for mathematical expressions are assumed to follow mathematical conventions.
f) All illustrations should be numbered in sequence, with Arabic numerals, in order of appearance. Number as Figure 1, Figure 2, etc. (not Figure 1.1, 1.2, etc.) and avoid using terms such as "Chart" or "Plate".
g) Every figure must have a caption that includes the figure number and a brief, informative title. If more information is needed on the figure, use complete sentences and standard punctuation. If possible, the caption should provide enough detail to make the figure self-explanatory.

Table 1 – Standard Type and Line Sizes to be used in Drafting Illustrations.

Minimum Height for Lettering	Thickness of Ruled Lines
10 pt. preferred, 8 pt. minimum for lower case lettering, numerals, capital letters, symbols within drawings 12 pt. for titles and captions of figures and tables	Light: 0.5 pt., for graph grids, arrows Medium: 1.0 pt., for graph borders or reference lines Heavy: 2.0 – 3.0 pt., for graph curves or emphasis lines

h) Figure captions should appear below the illustration. Table titles are placed above the tables.
i) Whenever feasible, illustrations should be contained within letter or legal-sized sheets. Reproduced illustrations should fit within the margins of the report page format.
j) To improve the visual appearance of line graphs, the following is suggested:
A ruled open-grid may be used if quantitative reference to the figure is to be made. Tick marks may be employed if only semi-quantitative presentation is desired.

- The grid scale for each axis should be chosen with the proportion, number, and type of rulings that will help the reader to best interpret the data and the curve.
- Show all scale numbers and titles outside the grid border.
- The axis must be labelled clearly with both the quantity measured and the units in which it is measured. Each caption should be parallel to its axis.
- All lettering and numbers should read from left to right, if possible, or from bottom to top, if necessary.
- For plot-points, use template data symbols. The following symbols are recommended in order of preference**:** ●, ○, ▲, △, ■, □, ∇, ▼, ✕
- Each curve should preferably be labelled rather than using a key.
- If legends or keys to symbols are needed, they should appear in the figure itself.

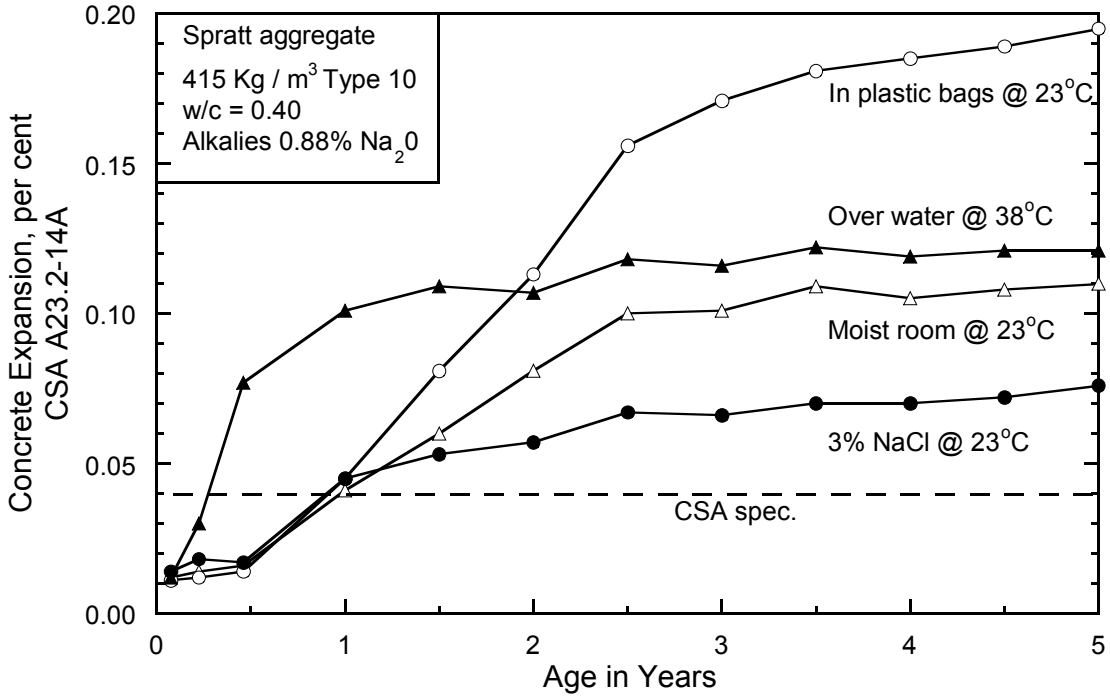

Figure 1 – Graph Meeting Style Manual Requirements

4. RESULTS AND/OR DISCUSSION

For most reports, the presentation of results and discussion of their significance may be separated into two distinct sections. Occasionally, however, a chronological approach may be preferable. In either event, the following points should be noted:

a) Only relevant data should be included. Equations, figures, and tables should be introduced where necessary for *clarity and conciseness.* In general, the same data should not be reported in both figures and tables. Other data may be included in appendices.
b) In the discussion of the significance of the results, an objective explanation should include features and limitations of the work, and results should be interpreted, compared, and contrasted.
c) A summary may add to the value of the presentation of the results. It should be interpretive and not repetitious. The problem may not have been completely solved; if so, further study may be suggested.

5. CONCLUSIONS

The essential points and conclusions of the report should be summarized for the reader in this section.

6. RECOMMENDATIONS

Recommendations should only be presented after some thought is given to their implications. This will normally require discussion and agreement with the report sponsor.

7. ACKNOWLEDGEMENTS

The inclusion of acknowledgements is left to the discretion of the author. Below is one example.

> *The authors wish to acknowledge the assistance and dedicated work of the staff of the Materials Engineering and Research Office in testing aggregates, measuring frictional properties of pavements, and assisting in the work described herein. In particular, the efforts of Everton Arnold, Tom Gillanders, David Howard, Hernan Maldonado, Frank Marciello, Judy Pretty, Ray Ramasray, Dale Smith, Brian Schubert, Danny Tari, and David Williams are gratefully acknowledged. The laboratory testing was carried out in the Soils and Aggregates Laboratories of the Ministry of Transportation. The assistance of aggregate suppliers throughout Ontario, who have provided samples and access to their properties, is also gratefully acknowledged.*

C. REFERENCE MATTER

1. FOOTNOTES

The use of content footnotes is discouraged. If it is worth saying, include it in the body of the text. If necessary, footnotes[2] should appear at the bottom of' the same page as the text referred to. They should be numbered in sequence of appearance.

Notes to tables are handled independently of, and should never be numbered in sequence with, other footnotes. Table footnotes are placed directly under the table. They are indicated by underlined lowercase letters as superscripts and are listed consecutively as part of each table.

2. REFERENCES

Author references within text should appear as author(s) name(s) and year of publication in brackets, e.g. [Smith and Kwok, 1998], immediately after being referred to. When there are more than two authors, use "*et al*", but in the reference list, provide all authors' names. If the same authors have more than one paper published in a year referenced, use a, b, etc.

Complete references are listed under the heading "**REFERENCES**". Follow the order of items below when referencing.

a) For a **book** reference:
   - Author's name as it appears on the title page, with last name first;
   - Title of book;
   - Edition, if other than the first;
   - Name of publisher;
   - City of publication;
   - Date of publication; and
   - Chapter or page of book referred to.

b) For a **periodical** reference (including magazines, conference proceedings):
   - Author's name, if any, as for a book;
   - Title of article;
   - Title of periodical (in full, unless periodical is a legal or technical journal);
   - Volume number, if any;
   - Number of issue, if any;
   - Date of publication; and
   - Page numbers.

2 A content footnote that is very long may be more appropriately placed in an appendix.

REFERENCE FORMATS

Usage	Examples
Book: One author	Bonner, David M., *Heredity*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1961, pp. 32-34.
Book: Two or more authors	Fisher, Robert C., and Ziebur, Allen D., *Calculus and Analytic Geometry*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1961, p. 575.
Book: No author given	*A Manual of Style*, The University of Chicago Press, Chicago, 1949, pp. 46f.
Book: Edited or revised other than by the original author	Ivey, Paul W., and Horvath, Walter, *Successful Salesmanship*, rev. by Wayland A. Tonning, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1961, p. 102.
Book: Translation	Mann, Thomas, *Joseph in Egypt*, trans. H.T. Lowe-Porter, Alfred A. Knopf, Inc., New York, 1944, p. ix. Shaw, T.E., trans., *The Odyssey of Homer*, Oxford, University Press, New York, 1940, p. 25.
Book: In a series	Vroom, Victor H., *Some Personality Determinants of the Effects of Participation*, The Ford Foundation Doctoral Dissertation Series, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1960, p. 23.
Periodical: Author	Bozozuk, M., "Downdrag Measurements on a 160-ft Floating Test Pipe Pile in Marine Clay", Canadian Geotechnical Journal, Vol. 9, No. 2, 1972, pp. 127-136.
Periodical: No author	"*Training Probation and Parole Personnel*", Focus, March, 1948, pp. 44-48.
Unpublished Work	Bayne, M.M., "*Sir Thomas Browne and the Metaphysicals*", Masters thesis, Harvard University, 1945, p. 30. Colvin, Sidney, to R.L.S., April 26, 1880, Stevenson Papers, Yale University.
Encyclopaedia Article	"*Descriptive Geometry*", Encyclopaedia Britannica, 1953, VII, 254-257.
Legal journal article	39 Harv. L. Rev. 725, 1926.

c) For **unpublished** and **multi-volume** references:
   - Put chapter and article titles and titles of unpublished works in quotes.
   - Italicize book and journal titles and titles of separate volumes in a multi-volume work.

Follow these rules for all types of references:

a) Use abbreviations, "Vol.", "Part", "Chap.", "Sec.", "No.", "p." or "pp.". Do not use "Vol." and "p." when both are given, unless required for clarity. Use "n.p." when the place of publication cannot be found.
b) Use capital Roman numerals for volume and part numbers, lowercase Roman numerals for chapter numbers and front-matter pages, and Arabic figures for section, page, and periodical numbers.
c) In citing consecutive page numbers (or dates), omit hundreds from the second number unless the first number ends in two zeros; in that case, repeat the full form. If the next to the last figure in the first number is a zero, do not repeat it in the second number:
   - *pp. 11-12, pp. 111-12, pp. 200-204* (*not 200-4*), *pp. 204-5* (*not 204-05*)
   - *1811-12*, *1800-1804* (*not 1800-04*), *1898-1904*, *1904-5* (*not 1904-05*)
d) Write (or provide) the publisher's name exactly as the publisher's imprint reads, using "Co." or "Company", "Inc.", or "Incorporated", "Ltd.", or "Limited", "K" or "and". Use "n.d." when the date of publication cannot be found.

3. BIBLIOGRAPHY

A bibliography is a list of sources of information on a given subject. If deemed necessary, a bibliography should be a carefully selected list of sources, brief notes on content, or level of treatment. Bibliographic lists should be alphabetical by author's name, or by title, if no author is given in the reference source. Long bibliographies can be grouped according to subject and then alphabetized. Use the same order of items in a bibliographical reference as a reference footnote, but with modified punctuation.

4. APPENDIX

Material not absolutely necessary to the text, but too long for a content footnote, is placed in an appendix. When there are several kinds of materials to be included, more than one appendix should be used, each having a main title and being prefixed with a capital letter. When there are large numbers of tables or illustrations, which may distract or interrupt the flow of the text, these may be placed in appendices. Each appendix starts on a new page.

5. GLOSSARY

The intended audience may not be familiar with the technical language used for a particular subject. When necessary to ensure the reader's understanding of the language used, authors are encouraged to define each new term in the text or list the definitions alphabetically in a glossary following the appendices. The glossary should also include acronyms where applicable. Common engineering and scientific terms, unless the report is written for a non-technical audience, do not require definition.

Conclusions

This manual offers some suggestions and guidelines for authors to follow in the preparation of their reports. The appendices also provide information on form and usage, with some specific examples for technical writers.

In addition, as all concerned gain experience in using this manual, it is hoped that useful additions and revisions may result.

Recommendations

It is recommended that offices within the Engineering Standards Branch use the format and guidelines contained in this document for publishing reports.

References

1. *The Style Manual for Publications of the Research and Development Division*, Ontario Ministry of Transportation and Communications, Toronto, Ontario, Canada, 1974.

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Amato, C., J., *The World's Easiest Guide to Using the MLA*, Stargazer Publishing Company, Westminster, CA, USA, 1999.

Fowler, H.W., *A Dictionary of Modern English Usage,* Oxford University Press, London, England, 1983.

Hacker, D., *A Canadian Writer's Reference*, Nelson Canada, Scarborough, Ontario, 1990.

McFarlane, J. A.*, Globe & Mail Style Book,* Penguin Books Canada Ltd., Toronto, Canada, 1996.

Sabin, W. A., Millar, W. K., Sine, S., L., Strashok G., W.*, The Gregg Reference Manual,* McGraw-Hall Ryerson Limited, Canada, 1999.

Chambers Science and Technology Dictionary, General Editor Peter M. B. Walker, Cambridge University Press, New York, N. Y., USA, 1988.

Appendix A: Frequently Misused Terms

Accuracy, precision - *Accuracy* refers to the discrepancy between the true value and the result obtained by measurement. *Precision* refers to the agreement among repeated measurements of the same quantity.

Adjust, calibrate - *Adjust* is now and then confused with *calibrate*. Adjustments or changes - usually slight ones - may be made without even hinting at calibration. *Calibration* suggests the determination of exact gradations, as of a measuring device.

Affect, effect - *Affect* is the verb; *effect,* the noun - in most usages. *Affect* means to change or modify; *effect* is the result of something. *Effect* may be used as a verb to mean *put into effect.* Correct: "This change will not affect system operation. The effect will be nil."

Alternate, alternative - Alternate means reciprocal, occurring, or succeeding by turns; an *alternative* offers two things, one of which must be chosen.

Apparent, obvious, evident - That which is *apparent* is open to view; that which is *obvious* is unavoidably clear, so clear as to need no explaining; that which is *evident* is demonstrable by facts or evidence.

Assure, insure, ensure - *To assure* is to confirm or to make (one) certain; to *insure* is to assure against a loss by a contingent event, on certain stipulated conditions or at a given rate, i.e., to underwrite; to *ensure* is to make sure, certain, safe, to guarantee.

Compare, contrast - In most usage, *compare* means to point out similarities and differences, but *contrast* should be reserved for the latter meaning. A few writers restrict the meaning of *compare* to pointing out likenesses-alone.

Compose, comprise, consist - These words are not synonymous and may not always be used interchangeably. Consult your dictionary. For example:

A solution *is composed of* solute ions and solvent.
A solution *comprises* solute ions and solvent.
A sodium chloride solution *consists of* sodium ions, chloride ions, and solvent.

Continual, continuous - The former means over and over again at short intervals; the latter means occurring without ceasing.

Distinguish, differentiate - The former means to recognize (and point out) those aspects of something that mark its separate identity; the latter means to point out the difference between two things.

Enable, permit - To *enable* is to provide power or competency to be or do something; to *permit* is to allow or authorize.

Fewer, less - Fewer applies to individual units; *less* to quantity. It is not best usage, therefore, to speak of less people being in attendance than formerly.

Flammable, inflammable - Both words have the same meaning. However, *flammable* is preferred.

Imply, infer - *To imply* means to express an opinion or to present a fact indirectly without being blunt or outspoken; to *infer* means to draw a tentative conclusion and to suggest it as a hypothesis.

Partially, partly - The antonyms suggest the distinction to be made in these words; partially -completely; partly - wholly. Although, for many uses, the two may be synonymous, *partly* is preferred.

Portion, proportion, part - *A portion* is a part of a whole; a *proportion* is the relation of one portion to another, or to the whole, or of one thing to another, as respects magnitude, quantity, or degree. *Proportion* is often misused for *part;* it should be reserved to express a comparative relation between things or magnitudes.

Principal, principle - These two words are frequently confused even though the distinction in meaning is commonly understood; the trouble is basically one of spelling forms. *Principal* means (in technical usage) *main, chief, most important; principle* means a physical truth or an accepted code of conduct. *Principle* is always a noun; *Principal* is an adjective in technical writing.

Utilize, use - As a verb, *use* has the same meaning as utilize, since nothing is gained in precision of meaning by using the longer word, the shorter words *use, used, using* should be used in place of *utilize, utilized, utilizing.*

Various, varying - Various is an adjective meaning different, changeable, inconstant; *varying,* from the verb *to vary,* means modifying, altering in form, appearance, substance, position.

Appendix B: Form and Usage

Although not an exhaustive review of grammar and punctuation, the rules given below cover problem areas encountered most frequently in writing,

I. PUNCTUATION

Usage	Rules	Examples
Apostrophe: Possessive case of nouns.	a) Add *'s* to all singular nouns, unless they already end in *s*.	*John's* *Charles'*
	b) When the plural is formed by adding *s*, add *'* only.	*employees'* or *programmers'*
	c) When the singular noun ends in *s* and the plural is formed by adding *es*, add *'* only.	*Holmeses' car*
	d) When the plural is formed by a word change which does not end in *s*, add *'s*.	*women's*
	e) When forming the plural of letters, figures, or words used as exhibits, add *'s*.	*I could not tell his m's from his n's. The 7's look like 9's.*
	f) When indicating possession of nouns that do not refer to living things, use a prepositional phrase.	*the residents' petition* *the city's parks* *the condition of the highway*
	g) Some expressions of time are exceptions to (f).	*a week's vacation* *today's schedule*
Apostrophe: Possessive case of indefinite pronouns.	As rules given for nouns.	*one's* or *everybody's*

Usage	Rules	Examples
Apostrophe: Common possession of two or more persons.	Apostrophe used with the last name only	*Mary and Sue's office is on this street.* (one office) *Mary's and Sue's trucks are being repaired.* (two trucks)
Apostrophe: Contractions	Used where letters are omitted	*It's* is the contraction for *it is; its* is the possessive form of the pronoun it.
Brackets	To interpolate material into a quoted passage for the reader's benefit.	*"The population of the study area for that year [1974] was about one million."* *"It was the general feeling that they [the committee members] had not studied the report carefully."*
Colon	a) To introduce a formal statement or quotation.	*Surely Thoreau envisioned today's urban expressway when he said: "The swiftest traveller is he that goes afoot."*
	b) Before a listing.	*At the end of each day, the clerk should do the following:* *a) put away all papers;* *b) fill printer trays; and,* *c) turn off computers.*
	c) When the list is short and follow *are, were, such as, and include,* no colon is used.	*The topics include land use forecasting, economic impact of new transportation facilities, and traffic control.*
	d) A period may precede a listing when a complete sentence introduces the list and when each item in the list is a complete sentence.	*Here are some of the reasons why we do not communicate with each other.* *a) We assume everybody understands our viewpoint.* *b) We mean to say one thing but say something different.* *c) We "talk past each other" rather than have a meeting of minds.* *d) We do not consider that words mean different things to different people and the way we say them may cause misunderstanding.*

Usage	Rules	Examples
Comma: To separate parenthetical expressions.	a) For year following month and day.	*The project started January 1, 1974 and ended March 10, 1974.*
	b) For abbreviations – note that viz. (*namely*), e.g. (for example), and i.e. (that is) are preceded by a comma. A comma is used after *e.g.* but not necessary after *viz.* Also, i.e. should not be followed by a comma, unless the sense requires one. Avoid using etc. in formal writing.	*John W Smith, Jr., is the new employee.* *The forms, envelopes, reports, etc., should be stored until needed.*
	c) For conjunctive adverbs such as *however, moreover, nevertheless, consequently, therefore, thus, then, so, yet,* and *otherwise.* Note: When a conjunctive adverb joins two independent clauses, it is preceded by a semicolon and followed by a comma.	*The meeting, therefore, was postponed.* *The meeting has been postponed; therefore, I will not see you on Thursday.*
	d) For province or country following the name of a city.	*Two early studies were conducted in Toronto, Ontario, and Halifax, Nova Scotia.*
	e) For words used in apposition. Note: Names used in apposition after words such as *brother and friend* and restrictive appositives are not set off by commas.	*Jane Williams, representing M.M. Dillion and Co., will be here on Monday.* *You may want to interview my friend John Smith.* *The expression in this day and age is trite and should not be used.*
Comma: Before and after a direct quotation.	When the sentence continues and no other punctuation is required.	*He said, "I'll get my book," and left the room.*

Usage	Rules	Examples
Comma: To the left of every three digits.	Common NA practice uses commas between groups of three digits, which diverges from the SI standard of using a single space. Either practice is acceptable.	*1,928,499* or *1 928 499* *2,348* or *2 348* *732*
Comma: To set off non-restrictive clauses and phrases.	A non-restrictive clause or phrase adds information about the word it modifies, but is not essential to the meaning of the sentence. If it were omitted from the sentence, the meaning would still be clear.	*The staff members, who attended the orientation sessions, have completed the forms.* The clause, "*who attended the orientation sessions*", does not limit or restrict the meaning to specific ones. To limit the meaning to only those staff members who attended the sessions, omit the commas and make the clause restrictive, as in: *The staff members who attended the orientation sessions have completed the forms.*
Comma: To separate the clauses in a compound sentence.	Note: A semicolon is used to separate two clauses in a compound sentence, when: a) the co-ordinating conjunction is omitted; b) clauses are connected by an adverbial conjunction such as *moreover, however,* and *nonetheless;* and, c) one or both of the clauses are long and contain commas.	*The survey was completed in June, but the data have not been processed.* *Gregory did the work; Eric got the praise.* *At-grade crossings cause traffic accidents and delays; therefore, proposed rail or highway construction plans should not include plans for at-grade crossings.* *The parcel can be recognized on assessment maps, planimetric maps, and Sanborn atlases; and, as an aerial unit, it can also be recognized on the ground.*

Usage	Rules	Examples
Comma: To separate introductory phrases and clauses.	Note: A gerund or infinitive phrase used as the subject of the sentence should not be confused with an introductory clause or phrase in an inverted sentence.	*Although you requested three copies of the report, I can send you only one.* *Ignoring the confidential nature of the project, he discussed the salient points with almost everyone at the meeting.* *Extending the model to include estimates of other social and economic characteristics of the population requires only a minor revision.* (The long noun clause introduced by the gerund *extending* is the subject of the sentence.)
Comma: To separate words or groups of words in a series.	a) Usually, a comma before *and* is not functional. b) Sometimes, a comma before *and* is necessary to avoid ambiguity. Note: If members of a series are long and contain commas, semicolons should be used between the members instead of commas.	*French, German, Spanish and English were taught.* *The report is based on current inventories, analyses and forecasts, and budgets.*
Comma: To separate two or more adjectives.	When the adjectives co-ordinately modify the noun. Note: Additional rules governing multiple modifiers are noted in the section on hyphens. (See note on page 34.)	*Long, narrow roads lay ahead of us. These roads are long and narrow.* (The two adjectives are co-ordinate and a comma is needed.) *Unpaved country roads lay ahead of us. These roads are country roads, which are unpaved.* (The two adjectives are not co-ordinate, and no comma is needed.)

Usage	Rules	Examples
Dash: To indicate an abrupt break or indicate a series of words.	a) Abrupt break in thought.	*His actions at the meeting are hard to understand -- but that is not your problem now.*
	b) Abrupt break in parenthetical words or phrases.	*They were less hostile -- almost friendly -- during the meeting today.*
	c) A series of words used in apposition.	*Officials of all the cities concerned -- Toronto, London, St. Catharines and Windsor -- are invited.*
Ellipsis: To show that something has been left out of a quoted passage.	If the omitted portion comes within a sentence, the mark consists of three spaced periods. If it comes at the end of the sentence, the mark consists of four spaced periods, the last period to indicate the end of the sentence. Omission of an entire paragraph is indicated by a full line of spaced periods.	*"After 1122 B.C, the Chou dynasty of Chinese rulers founded … first organization to operate and repair roads …".*
Hyphen: To divide a word at the end of a line.	a) Divide at the syllable.	*pro-tect* (not *prot-ect*) *know-ledge* (not *knowl-edge*)
	b) Divide between double letters.	*intel-ligent* *plan-ning* (the second n is not part of the root word) *tell-ing* (both l's are part of the root word)
	c) Divide after a vowel.	*digi-tal* (not *dig-ital*) *analy-sis* (not *anal-ysis*) *popu-lation* (not *pop-ulation)*
	d) Divide compound words only at the hyphen.	*president-elect* (not: *presi-dent-elect*)
	e) Do not divide single-syllable words.	*wrapped* (not *wrap-ped*) *charged* (not *charg-ed*)
	f) Do not divide before or after only one or two letters.	*eco-nomic* (not *econom-ic*) *econo-mic* (not *e-conomic*)

Usage	Rules	Examples
Hyphen: Compound noun, unless dropped by common usage.	When in doubt, consult the dictionary.	*airport* *person-hour* *courthouse*
Hyphen: After prefixes.	a) When three identical letters occur in succession. b) When the last letter of the prefix is the same as the first letter of the word to which it is attached. c) When the prefix comes before a proper noun or adjective.	*wall-like* (not *walllike*) *anti-intellectual* (not *antiintellectual*) *co-ordinate* (not *coordinate*) *co-operate* (not *cooperate*) *ex-President* *post-Reformation*
Hyphen: With compound modifiers to convey the intended meaning of the sentence.	a) If the first word modifies the second, a hyphen should connect the two modifiers. b) If the first modifier is an *ly* form of an adverb, no hyphen is used. c) If the first modifier is in the form of a comparative or superlative, no hyphen is used. d) When two or more modifiers are hyphenated to one noun, use a suspended program. e) Between the numerator and the denominator of fractions and have compound numerals from 21 to 99.	*Interim plan report* (means an interim report of a plan) *Interim-plan report* (means report of an interim plan) *six-foot length* *five-page report* *rough-edge paper* *roughly edged paper* *a fast-moving* car *the fastest moving car* *single- and multiple-mode transportation* *three-fourths* *twenty-one to ninety-nine*

Usage	Rules	Examples
Parentheses: To enclose parenthetical and other elements.	a) Note that standard punctuation is used; the comma is placed after the parenthesis. b) References or direction. c) A definition or an example given to explain a word in a sentence.	*Before our next meeting* (*Is it at the* regular *time?*), *I should like to* review *your proposal for the project.* *In this example, one time period is used for five age groups.* (*See Figure 1*) *Findings of the field staff* (*see Chapter 111*) *help to explain the patterns shown here.* *Indefinite pronouns* (*that, which, and who*) *are frequently used as subjects of clauses.*
Period: After standard abbreviations.	a) No space is left after periods within the abbreviation, though a space is left following each period after an initial of a person's name. b) Periods are not used in acronyms or abbreviations of the names of many countries and government organizations.	*Mr. R.S. Brown* *Ph.D.* *a.m.* and *p.m.* *AASHTO, ASTM, CSA, MTO, TRB, UK, USA, etc.*
Quotation Marks: At the beginning and end of all direct quotations.	Note: If the quoted material is longer than two or three lines, it should be placed in a separate, single-spaced paragraph with the quotation marks omitted. The paragraph should be indented eight spaces on both right and, left sides.	In his essay "Of Boldness", Bacon gives this account of Mahomet and the hill: Mahomet called the hill to come to him, again and again: and when the hill stood still he was never a whit abashed, but said, "If the hill will not come to Mahomet, Mahomet will go to the hill."

Usage	Rules	Examples
Quotation Marks: Alternate double (") and single (') quotation marks.	When there is quoted material within quoted material.	*He said, "Wasn't it George who said, 'Let's have a party'?"*
Quotation Marks: Usage with other punctuation.	Generally, periods and commas go within quotation marks; semicolons and colons remain outside. Question marks and exclamation points may be placed inside or outside, depending on the structure and punctuation of the sentence.	*Did you say "Am I my brother's keeper"?*
Quotation Marks: Around titles of incomplete works.	Use for articles in magazines, chapters of books, or reports. Do not use for titles of complete works such as books, magazines, reports and newspapers or the names of trains, planes, and ships.	
Quotation Marks: Around words or phrases for meaning.	a) When it is desired to convey a meaning not generally associated with the word. b) Do not use for foreign words and words, letters, and numbers used as exhibit. c) Do not use for technical terms, slang or colloquialisms.	*This "original" research was discussed in a scientific journal in 1920.*
Semicolon: To separate two independent clauses.	a) When the co-ordinating conjunction is omitted. b) When a conjunctive adverb is used. c) When a co-ordinating conjunction is used, but the clauses are long and contain commas.	See examples under "Comma" for sentences illustrating these rules.
Semicolon: To separate members of a series.	When one or all members are long and contain commas.	See example Colon (b) to an example of this rule.

II. GRAMMAR

Usage	Rules	Examples
Agreement in Number and Case: Agreement of Noun and Verb.	a) Phrases introduced by *in addition to, as well as, with, or including* placed between the subject and verb does not change the number of the verb.	*The final plan, as well as some alternate plans, is included in the report.* *The program, including diagrams, cards, and printouts, is available.*
	b) Predicate nouns do not affect the number of the subject and verb.	*The first thing we saw were the papers scattered across the table.*
	c) Collective nouns and fractions take a singular verb unless members of the group are considered individually.	*The staff is having its picnic tomorrow. The staff have returned to their offices.* *Two-thirds of the committee is in favour of the resolution. Two-thirds of the committee are wearing black suits.*
	d) When some plural nouns describe a quantity or unit, they take a singular verb.	*Thirty miles is the average length of all trips originating at places of residences.*
	e) Compound subjects joined by and require a plural verb unless the two nouns refer to a single thought or are preceded by *every.*	*My supervisor and friend supports me in this action.* *Every residence and business establishment was listed.*
	f) Compound subjects joined by *or, either ... or, and neither ... nor* take a singular or plural verb depending on the number of the noun nearest the verb.	*Either the employees or the supervisor is responsible for this error. Neither the mayor nor the transit commissioners know what the problem is.*
	g) The plurals of foreign nouns require plural verbs.	*These are the data you requested. Are these the only criteria you considered? Is that the only criterion you considered?*

Usage	Rules	Examples
Agreement in Number and Case: Agreement of Pronoun and Antecedent.	a) A pronoun must have a noun for an antecedent, and the pronoun must agree with the noun in gender, number, and person.	*Because cars are double-parked on the streets, it is difficult to drive through the town.* (*It* lists no noun antecedent. Corrected: Because cars are double-parked on the streets, driving through the town is difficult.)
	b) A relative pronoun (*that, which,* and *who*) must be placed next to its antecedent. The relative pronoun must agree in number with both its antecedent and its verb. Note: *Who* refers to persons; *which* refers to things or groups of persons; and *that* refers to persons or things.	*This letter informs the household that they have been selected.* (*Household is* singular and requires a singular pronoun. Corrected: *This letter informs the household that it has been selected.*) *He removed the overlays from the charts and sent them out to be reproduced.* (Antecedent of *them* is not clear: *charts or overlays?* Corrected: *He removed the overlays, and sent the charts out to be reproduced.*) *He took one of the charts to the meeting which was not yet completed.* (The relative pronoun *which* is separated from its antecedent *charts* by a prepositional phrase. The antecedent of the pronoun is plural while the verb is singular. The sentence should read: *He took one of the charts, which were not yet completed, to the meeting.*)

Usage	Rules	Examples
Agreement in Number and Case: Form of Pronouns.	a) Nominative forms (I, you, he, she, it, we, you, they, and who) are used as subjects of sentences or of clauses or after any form of the verb *to be.*	*Could it have been he who wrote this report?* (*He* follows form of verb *to be; who* is subject of clause.) *The director, the executive director, and I will attend the meeting.* *He speaks better than I* (*I* is subject of clause in which the verb *speak* is omitted.) *The presentation will depend on who is present. (Who* is the subject of the clause.) *Who did you say she is?* (Rearranged: *She is who? Who* follows form of verb *to be.*) *The report may be sent to whoever requests it.* (*Whoever* is the subject of the clause; the entire clause is object of the preposition to.)
	b) Objective forms of pronouns (me, you, him, her, it, us, them, and whom) are used as objects of prepositions, verbs, infinitives, and other verbals.	*The project has been assigned to Jane and me.* (*Me* is object of preposition to.) *Not: Between Jane and 1 ...* *Between Jane and myself …* *She will take you to the meeting rather than me.* (*Me* is object of verb *take* which is omitted.) *The new director is someone whom everyone will respect.* (*Whom* is object of verb respect.) *For the first time, he let George and me prepare the requisitions.* *Whom are you going to vote for?* (*Whom* is object of preposition *for*.)
	c) A possessive pronoun is used before a gerund (an *ing* form of verb used as a noun).	*We are all in favour of her getting the promotion.* (*Getting* is a gerund.) *We saw him driving down the street.* (*Driving* is a participle.)

Usage	Rules	Examples
Handling of Words	a) Avoid introducing sentences by "it was found that" or "it was demonstrated that".	
	b) Where directness is desired, use the active voice. Avoid passive constructions such as "is depended upon"; "depends upon" is preferred.	
	c) Avoid unnecessary words and duplication.	Not: *estimated at about 10 per cent* *they are both alike* *bright red in colour* *oval in shape* *throughout the entire experiment* *fewer in number* *two equal halves*
	d) Wordy expressions may often be substituted by a single word.	*owing to the fact that - because* *by means of – by* *subsequent to - after* *it appears that – apparently* *in the near future – soon* *at the present time - now* *a very limited number of – few*
Sentence Structure: Dangling Phrases or Words.	These words usually are placed at the beginning of the sentence and refer illogically to the subject of the sentence.	*After completing the interview, the form should be checked by the interviewer.* (Corrected: *After completing the interview, the interviewer should check the form.*) *To meet that schedule, coffee breaks must be discontinued.* (Corrected: *To meet that schedule, employees must discontinue coffee breaks.*) *Narrow and unpaved, the traffic on the street is heavy.* (Corrected: *Narrow and unpaved, the street carried heavy traffic.*)

Usage	Rules	Examples
Sentence Structure: Modifiers	a) Modifying words and clauses should be placed as close as possible to the words they modify	*The data only include the number of trips originating within the study area.* (Corrected: *The data include only the number of trips originating within the study area.*) *The report did not make the relationship between income and travel mode clear.* (Corrected: *The report did not make clear the relationship between income and travel mode.*)
	b) Avoid allowing modifiers to accumulate in front of a noun until it becomes difficult to know where hyphens and commas should be placed.	*The poorly-planned congested expressway* . (Corrected: *The poorly planned expressway is already congested.*) *The universally-used blue lined pink pads* (Corrected: *The pink pads with blue lines are universally used.*) *A computerized traffic simulation program* (Corrected: *A computer program for traffic simulation.*)
Sentence Structure: Parallel Construction	When parallel ideas are expressed in a sentence, they must be expressed in parallel form. If the first is expressed as a noun, the second must be expressed as a noun. Parallel ideas may be connected by *and, but, for, either … or, neither . nor, not only … but also, and whether … or.*	*The decision will either be made this morning or it will be made next Thursday.* (Corrected: *The decision will be made either this morning or next Thursday.*) *That building always has and always will be on that corner.* (Corrected: *That building always has been and always will be on that corner.*) *At the meeting, we discussed the travel surveys, the network selection, and how the maps would be prepared.* (Corrected: *At the meeting, we discussed the travel surveys, the network selection, and map preparation.*)

III. STYLE

Usage	Rules	Examples
Abbreviations	a) In formal writing, do not use abbreviations at all except for ones such as *Mr., Ms., Messrs., Dr.,* and abbreviations for academic degrees.	
	b) Do not abbreviate names of persons and titles of positions.	Not: *Dr. Wm. T. Hardin, Pres.* But: *Dr. William T. Hardin, President* or *Dr. W.T. Hardin, President*
	c) Do not abbreviate the names of streets, cities, and provinces or the words, *street, avenue,* and *boulevard.*	*Beech Street, Toronto, Ontario* *111 N. 17th Street*
	d) Do not use symbols for *and* (*&*), *number* (*#*), or *at or per (@).* The symbol for *degrees* (°), however, is permissible as is that for *per cent* (%), *cents* (*¢*) and *dollars* (*$*), though money amounts or per cents less than ten should be written out. Note that *per cent* is two words and *percentage* is one word.	*truck and taxi* (Not: *truck & taxi*) *number of people* (Not: *No. of people*) *item number 121* (Not: *item 121*) *119 km. at 30 cents a km.* (Not: *119 km. @30/km.*) *five per cent* (Not: *5%*) or *25%*
	e) Note: Abbreviations and symbols are permitted in column heads of tabular material, forms, and other materials where space limits the number of characters, which may be used. If abbreviations are unclear, explanations should be given in footnotes.	

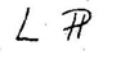
Usage	Rules	Examples
Capitalization	a) The first word and all-important words in headings, and in titles of books, articles, speeches and reports.	
	b) The first word in each item in a listing and each item in a topical or sentence outline.	
	c) The first word of a complete sentence following a colon.	*The citizens made their position clear: They do not want an expressway.*
	d) Titles accompanying the names of persons, but not titles used alone.	*Jane Smith, Director, is the speaker. The director is in her office.*
	e) Points of the compass when they refer to parts of the country but not when they refer to direction.	*We travelled through the Maritimes. The northern part of the province does not have a large population.*
	f) Names of languages, nationalities, constellations, planets (but not earth), political parties, religious groups, and historical events, persons, and documents.	*French* *Mars* *Unitarian* *Second World War*
	g) Do not capitalize seasons of the year, names of classes and subjects, a.m. and p.m., or words such as *federal, nation, government, city, county, and province* unless used with a proper noun.	*economics* *The cities, countries, and province have agreed to undertake co-operative transportation planning.* *He represents the City of Hamilton.*

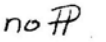
Usage	Rules	Examples
Italics	a) When words are used separately, only those words that require it should be italicized.	too many *if's, and's* and *but's* (Not: too many *if's, and's and but's*)
	b) Italicize all headings except first-degree headings that are typed in capital letters.	
	c) Italicize the titles of complete works such as books, newspapers, magazines, and plays.	I read that in *The Toronto Star*. The feature article in this month's *MacLean's Magazine* is "Canadians and Leisure Time".
	d) Italicize the titles of bound and printed reports; titles of articles, short papers, and speeches should be in quotation marks.	Our report, *Staggered Hours in the Central Business District,* contains the data you requested. Can you give a fifteen-minute talk on *"The Role of the Construction Engineer in the Ministry"?*
	e) Italicize foreign words and phrases when usage has not made them a part of the English language.	The *raison d'etre* for the project is to prepare a transportation plan for the province.
	f) Italicize words, letters, or numbers when used as exhibits.	Interviewers should be instructed to form their *7's* and *9's* correctly. There are six *the's* in that sentence.

Usage	Rules	Examples
Numbers	a) Numbers are written as numerals, except for one digit numbers.	*The average lot size is 11,000 square meters. There are 1,550 square kilometers in the study area.*
	b) Numbers are written as words when they come at the beginning of the sentence.	*Forty to fifty thousand rail cars pass through the study area each week.*
	c) Numbers are written as numerals when the sentence contains a series of numbers and any one number would require more than two words.	*The 1,550 square kilometres in the study area is divided into 40 districts, 541 zones, 8 rings, and 7 sectors.*
	d) Both words and figures may be used for large round numbers.	*25 million* or *twenty-five million* *$1.5 million* or *1.5 million dollars*
	e) Amounts of money are written as figures accompanied by the dollar or cent sign.	*$1, 792* *$75* *$75.00*, *$63.57,* and *$9.40* *$6* or *six dollars* *6¢* or *six cents* but not *$0.06*
	f) Figures are used to express dates when the month is used.	*I have your letter of May* 7. (Or *May seventh*, or *the seventh of May* -- but not *May 7th* or the *7th of May*.) *We will see you on the twenty-second.* (Not *22nd*)
	g) Figures or words are used to express time.	7*:00 a.m.* *7:00 in the morning* *seven in the* morning *seven o'clock* in the morning
	h) If the numerator or denominator is more than one digit or word, and no other number is attached, fractions may be written out. Otherwise, figures are used to express decimals and fractions.	*17.2* *14 3/4* (*not 14 - 3/4*) *9/10* *0.134* *one-tenth*

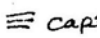
Usage	Rules	Examples
Spelling	For consistency of style, use the most recent edition of the Oxford Dictionary or the current edition of the Canadian Oxford Dictionary. When multiple spellings are acceptable for a word, choose one spelling and use it throughout the report.	

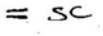
Appendix C: Proofreader's Symbols


Paragraph


No paragraph


Close up


Set in caps


Set in small caps


Superior characters: small characters above alignment


Inferior characters


Straighten type matter


Set in italics


Set in lower case


Change to Roman type


Query author to verify copy encircled


Set in bold face


Asterisk


Use ligatures, as fi, fl, ffi, ffl


Take out


Let it stand. Used in margin when copy has been inadvertently crossed out


Hyphen


Semicolon


Colon


Interrogation mark

Exclamation mark


Period


Comma


Apostrophe


Push down space that is printing


Insert space


Equalize spacing in a line


Insert copy written in margin


(flush left) Move to left


(flush right) Move to right

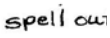

Move up


Move down


Turn over (letter, line, etc.)


Transpose (letters, lines, or matter)


Broken letter or bad type; reset


Figures should be spelled out


Wrong font


Parentheses


Ampersand ("and" sign)


Letter space

Appendix D: Layout Specifications

Element	Font	Size	Attributes	Justification	Line Spacing
Body Text	Times Roman	12		Full	1 line space between paragraphs
Chapter Head	Arial Narrow	28	Bold	Left	0.5 pt. line, start body text 3 x 12 pt. lines below
2nd Level	Times Roman	14	Bold Caps	Left	2 x 12 pt. lines below text 1 x 12 pt. line above text
3rd Level	Times Roman	12	Bold Caps	Left	1 line space below text
4th Level	Times Roman	12	Bold	Left	1 line space below text
5th Level	Times Roman	12	Underlined	Left	1 line space below text
Title (Table or Illustration)	Arial	12	Bold	Centred	2 line spaces below text
Caption (Table or Illustration)	Arial	10		Centred	1 line space above table or below the illustration
Head/Label (Table or Illustration)	Arial Narrow	12/10	Bold		Within table or illustration
Page Number	Times Roman	10		Centred	Page top
Footnote	Times Roman	9		Left	
Footer	Arial Narrow	9		Centred	Page bottom

COVER PAGE:

Element	Font	Size	Attributes	Justification	Line Spacing
Report Identification (top 2 lines)	Arial Narrow	16	Bold	Right	
Report Title	Arial Narrow	28	Bold	Right	Start 3 lines below report number
Report Number	Arial Narrow	16	Bold White	Centre	

TECHNICAL DOCUMENTATION PAGE:

Element	Font	Size	Attributes	Justification	Line Spacing
Page Subhead (top line)	Times Roman	10	Bold, White text in black background	Left, 6.25 cm (2.5") from left edge of page	
Page Heading	Arial Narrow	18	Bold	Left, 6.25 cm (2.5") from left edge of page	
Documentation Table Headings	Arial Narrow	10	Bold	Left	
Documentation Table Text	Times Roman	10		Ragged left, 3.125 cm (1.25") from left edge of table	0.5 pt. line between table heading sections

TITLE PAGE:

Element	Font	Size	Attributes	Justification	Line Spacing
Report Identification and Number (top 3 lines)	Arial Narrow	14	Bold	Right	1 line space before report number
Report Title	Arial Narrow	24	Bold	Right	Start 3 lines below report number
Date	Arial Narrow	12	Bold	Right	Start 3 lines below report title
Author/ Originating Office	Arial Narrow	12		Right	1 line space below date
Contact Information	Arial Narrow	12		Right	1 line space below author/ originating office
Copyright Label	Arial Narrow	10	Bold (1st sentence only)	Right	2 line spaces below contact information

Table of Contents:

Element	Font	Size	Attributes	Justification	Line Spacing
Title	Arial Narrow	28	Bold	Left	0.5 pt. line under title
Chapter Heading and Dot Leader	Arial Narrow	12	Bold	Left	6 pt. Before paragraph format
Subchapter Heading and Dot Leader	Arial Narrow	12		Left	indent 1.25 cm (0.5") from the margin

GENERAL LAYOUT

PAGE MARGINS:
- Top: 2.5 cm (1”)
- Bottom: 1.25 cm (0.5”)
- Sides: 3.125 cm (1.25”)

LINES:
- From margin to margin
- Header line: 0.75 pt., black
- Footer line: 0.5 pt., 50% black
- Chapter heading line: 0.5 pt., black, left justified and ending with text

INDENTS:
At 0.625 cm (0.25”) or 1.25 cm (0.5”) intervals.