Enhanced Road Weather Information System Services for the Ontario Ministry of Transportation and Municipalities

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1.0 Enhanced Road Weather Information Systems (RWIS) for the Ontario Ministry of Transportation, Municipalities and Other Road Authorities

Winter road maintenance operations to fight snow and ice throughout Canadian winters is critical for road user safety and economic viability. Winter maintenance operations in Canada use over 5 million tonnes of road salt annually. The effectiveness of salt is very sensitive to the pavement temperature. As the temperature decreases, salt becomes less effective and, as a result, salt application rates are typically increased at colder temperatures to compensate for the reduced effectiveness and ensure safe driving conditions. Traditional weather forecasts provide atmospheric temperatures well above the earth's surface and don't accurately reflect the pavement temperature which is key to the operational effectiveness of salt. Salt applied at the incorrect application rate results in significant waste, reduced road safety and is a negative impact on the environment.

Road Weather Information System (RWIS) stations (Figure 1) provide valuable weather and pavement data used to produce pavement forecasts. Pavement forecasts provide the actual pavement temperature and condition enabling maintenance service providers to identify the right product to be applied at the right application rate, the right time and in the right location. This optimizes winter maintenance operations, reduces the quantity of salt applied, enhances public safety and mobility and minimizes the environmental impact.

While RWIS stations provide valuable information, they are expensive to build (~$100,000 / station), forecast, operate and maintain (~$10,000/year/station). New smaller stations have recently come on the market to supplement full RWIS stations adding value at a reduced capital price (~$20,000). These mini RWIS stations have similar forecasting and operating costs with slightly less maintenance costs in comparison with the RWIS.

Wood has designed a set of algorithms to produce Virtual RWIS observations and an RWIS forecast showing pavement temperatures and conditions. This innovative method utilizes the RWIS network and regional information while eliminating the capital and maintenance costs. This enables RWIS information to be more readily available to all road authorities across Canada at significantly reduced costs.

The Virtual RWIS enables road authorities to densify their existing RWIS network and gain critical information in micro-climate areas or in areas with sparse RWIS stations. Virtual RWIS also enables other road authorities, who may not have an RWIS network, to acquire RWIS observations and forecasts to optimize their operations, public safety and environmental stewardship, at a significantly reduced cost.

The Virtual RWIS stations significantly enhance winter road maintenance operations for road authorities. This in turn increases road user safety, reduces congestion, reduces crashes, health care costs, associated lost work time and quality of life, reduces salt released into the environment and reduces greenhouse gases.

1.1 Benefits of Enhanced Road Weather Information Systems

The Virtual RWIS provides road authorities with a detailed pavement forecast to plan their winter maintenance operations effectively. This enables them to optimize their road maintenance operations and apply the suitable materials (salt, sand, liquids), in the optimal quantity, at the right location and time. This results in safer roads while yielding cost savings and environmental benefits.

Environmental Impact Benefits

Environment and Climate Change Canada (ECCC) identified road salt as a toxic substance and released the Code of Practice for the Environmental Management of Road Salts (Code). The objective of the Code is to ensure environmental protection while maintaining roadway safety.

The Transportation Association of Canada (TAC) created a Syntheses of Best Practices to help road authorities manage road salt and comply with the Code. RWIS is a key factor in the best practices as an understanding of pavement temperature forecasts and trends can improve the accuracy of winter maintenance decision-making. This optimizes winter maintenance operations ensuring the right material is applied in the right quantity, at the right time and the right location, thereby reducing salt applied to roads and released into the environment.

The Virtual RWIS will enable the maintenance crew to treat a road based on an observation and forecast for the location and not several tens of kilometers away. This will result in applying the correct road treatment for that specific area.

Reduced RWIS Station Costs

RWIS stations typically cost approximately $100,000 to install depending on components, power and communication opportunities. RWIS also cost approximately $10,000 annually to operate and maintain. The Virtual RWIS eliminates costs of capital construction, maintenance, power, and cell communication. Only the initial setup and forecasting fees are required for the Virtual RWIS, resulting in approximate savings of 99% in capital costs and more than 82% in annual operation costs per Virtual RWIS station.

Salt Reduction Benefits

Winter road maintenance is critical for safety, mobility and economic viability in Canada where snow and ice conditions are a regular experience throughout the winter months. Winter road maintenance is expensive to ensure public safety, approximately costing 66% of the maintenance budget.

Annually, Canada uses 5 million tonnes of road salt (de-icers) on average, as stated by ECCC. At approximately $100 per tonne, the cost to road authorities is $500 million annually. Utilizing Virtual RWIS to optimize winter maintenance operations and ensure only the right amount of salt is placed at the right location and time will significantly reduce salt applications and the associated budgetary and environmentally impact.

Accident and Mobility Reductions Resulting from Effective Winter Maintenance Operations

Winter road conditions in Canada are a serious risk to public health and safety resulting in an estimated 30% of all crashes. In 2018, Canada had 1,922 fatal, 9,494 serious injury and 108,371 injury crashes according to Transport Canada's Canadian Motor Vehicle Traffic Collison Statistics. It is difficult to calculate the total cost of accidents including traffic delays, out-of-pocket expenses, hospital/health care,

tow trucks, and police, fire and ambulance services. The 2007 report prepared by Transport Canada and the Ontario Ministry of Transportation on the Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario, Final Report August 2007 N0779, indicates an annual cost of $18 billion and $63 billion for Ontario and Canada respectively. Research has demonstrated the relationship between road surface condition and road safety (Usman et al., 2010).

1.2 Degree of innovation

Wood has developed an innovative scientific cost-effective method to create Virtual RWIS stations. This system uses the RWIS observations from nearby RWIS stations and specialized algorithms to produce a set of virtual observations that is being displayed to road authorities and updated at the same rate of the nearby RWIS stations (e.g. every 10 min). The virtual observations are then used alongside weather forecast data at that location obtained from the Wood Forecast Engine (WFE) to produce and RWIS pavement forecast. The Virtual RWIS system was verified against existing RWIS stations showing less than 2°C Mean Bias Error (MBE) for all the suite of virtual observations.

Wood has successfully demonstrated the value and reliability of Virtual RWIS to further densify the RWIS network providing additional pavement forecasts at key locations. Through experience, maintenance staff can identify their critical locations that are prone to drifting snow, lake effect, or cold spots due to their geographical location, surrounding topography and ecosystems. However, even given this insight, it is difficult to quantify the forecast variation at such locations on a daily basis. The Virtual RWIS can encompass all such factors and produce a specific forecast at such locations.

The Ontario Ministry of Transportation (MTO) experiences significant winter conditions along Highway 401 between Kington and Brockville due to channeling winds off Lake Ontario at the throat of the St. Lawrence River, the proximity to the lake, river, rock cuts, overpasses etc. Wood, in collaboration with MTO, utilized a mobile RWIS (MARWIS) collecting detailed atmospheric and pavement data during the winter season. Wood analyzed the MARWIS data and provided a thermal pavement temperature for that stretch of the highway. The analysis identified locations with colder bias due to a variety of reasons (e.g. geographical, topographical, structural). This result was used to further enhance the five Virtual RWIS sites on Ontario's Highway 401 between Kingston and Brockville (Figure 2 and 3). It is worth noting that thermal mapping by MARWIS is not required to establish Virtual RWIS, but it is useful in highlighting colder spots along the highway.

Figures 4 and 5 show a case study of a Virtual RWIS within 6 km from an RWIS station where the Virtual RWIS pavement forecast predicted freezing and icing conditions that are not predicted at the RWIS station. Identifying these micro-climate locations and generating specific pavement forecast ensures safer roads and a greener environment through applying the appropriate treatment.

Virtual RWIS forecasts can be created in various locations across Ontario and Canada where sensitive micro-climates create unique winter maintenance challenges and safety concerns. Other municipalities in Ontario are already using Wood's Virtual RWIS, some to initiate their experience with RWIS and others to densify their existing RWIS network with detailed forecasts in micro-climate locations. Interest beyond Ontario is growing with opportunities from coast to coast.

1.3 Transferability to other Canadian communities and organizations

Virtual RWIS observations and pavement forecasts provide an opportunity for all road authorities, including smaller municipalities across Canada, to benefit from existing RWIS technology by leveraging data from the existing RWIS stations in the surrounding areas and providing cost effective observations and pavement forecasts. The MTO along with a number of municipalities are now using Virtual RWIS pavement forecasts to economically enhance their winter maintenance operations effectiveness. The detailed pavement forecasts enable winter maintenance service providers to monitor pavement forecasts and plan specific winter maintenance operations to optimize road safety. Virtual RWIS is an innovative technology that will significantly help economically expand the RWIS network and move Canada toward Vision Zero and become the safest roads in the world.

1.4 Photos

Figure 1: Road Weather Information Station (RWIS) collects atmospheric and pavement temperature data along the highway

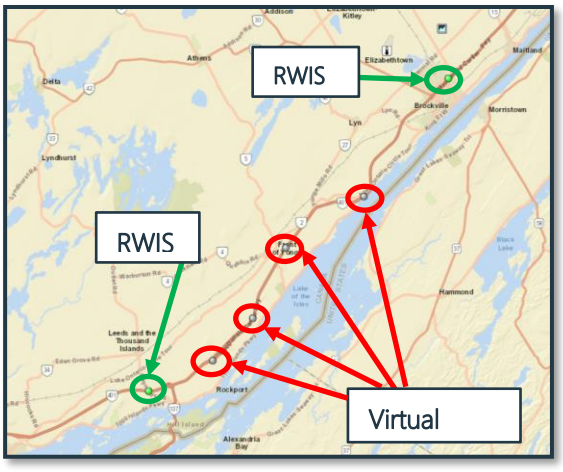

Figure 2: Virtual RWIS station extrapolated from RWIS

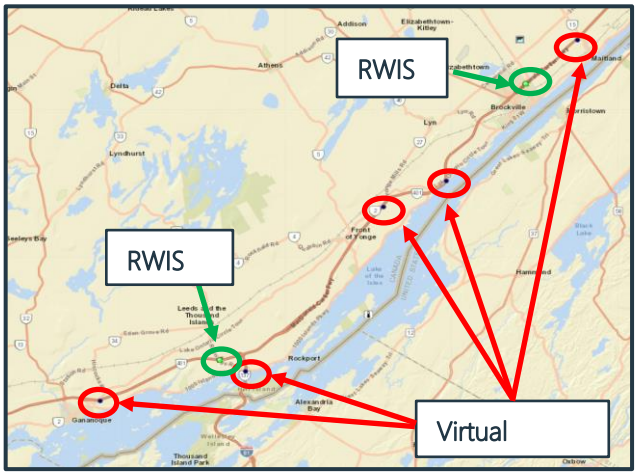

Figure 3: Virtual RWIS stations with pavement profiles and advanced algorithms

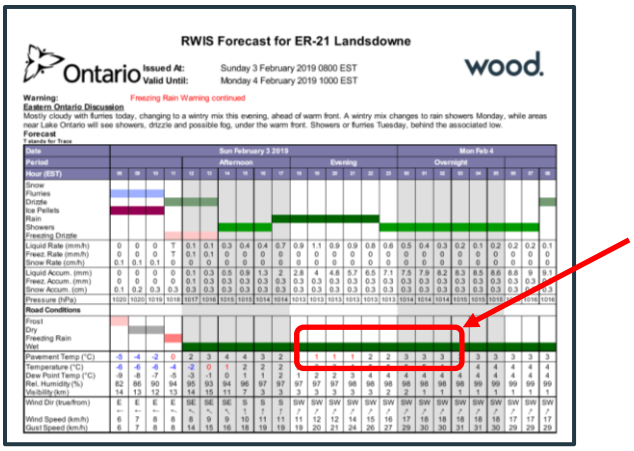

Figure 4: RWIS forecast showing atmospheric and pavement fForecasts

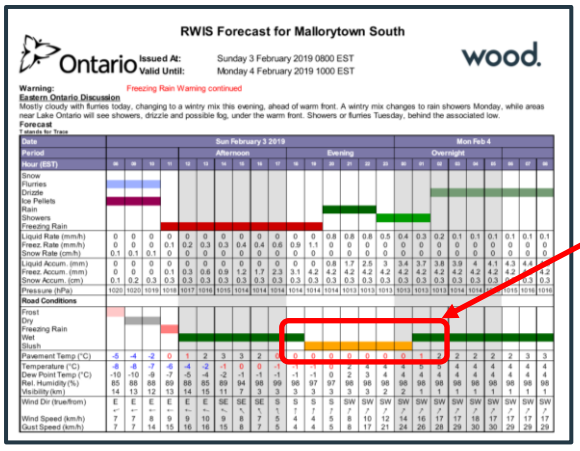

Figure 5: Virtual RWIS forecast showing freezing conditions requiring winter maintenance

2.0 References

Usman,T., Fu, L., Miranda-Moreno, LF. 2010 Quantifying Safety Benefit of Winter Road Maintenance: Accident Frequency Modelling. Accident Analysis and Prevention 40 (2010), 1878-1887