Executive Summary

Oxford County aims to achieve ubiquitous accessibility for electric vehicle (EV) charging within all communities via the County's Electric Vehicle Accessibility Plan (EVAP). To achieve this target, the County partnered with CUTRIC to conduct a study to map strategic locations for electric vehicle supply equipment (EVSEs) installation across the region.

First, the report provides a review of criteria that have determined EVSE infrastructure location selections in other jurisdictions. The report reviews the case studies of Tompkins County, San Joaquin Valley, and Uppsala to provide insight into the processes other jurisdictions have undertaken when determining EV charging station placement.

Secondly, the report uses original methodological insights to determine potentially optimal EVSE locations for Oxford County residents, commuters and through-traffic based on descriptive methods using Voronoi polygons, grid partitions, and household activity data, as well as predictive assessments based on a linear model of EV adoption rates assuming 1%, 5%, 10% and 25% adoption of EVs among car owners in and around the Oxford community.

Based on descriptive assessments using GIS-based models, the report concludes that Level 1 and Level 2 chargers should be placed in popular parking locations to serve Oxford residents best, including shopping malls, public parking lots, restaurants, service locations, and hospitals. These locations fill gaps currently demonstrated in the charging network within the Oxford County. The report also concludes Level 2 and Level 3 EV charging stations are best suited to transitory and through-way traffic commuters along highways in and around Oxford, and should be installed near busy highway exits that would be suitable for throughway traffic where demand is demonstrated by existing traffic flows.

Based on predictive assessments using linear models of adoption rates, the report concludes that a total of 163 Level 1, 54 Level 2 and 12 Level 3 chargers will need to be placed in suitable parking locations (i.e., employment workplace parking lots, public parking lots near workplaces, and long-stay public parking spots, such as shopping malls) to serve Oxford residents who adopt EVs in the future and who may or may not have access to home charging units throughout the evening and nighttime for recharging purposes.

In addition, the County intends to continue supporting its tourism industry within rural areas by ensuring adequate EV charging availability for travel to, from, and within the County. This report concludes that charging stations will need to be strategically placed nearby tourism destinations and/or outdoor recreation areas to allow for EV charging while tourists explore the area.

More detailed and granular data analysis on a community-by-community basis could be performed to support Oxford's electrification strategy; however, several data sources cannot be accessed today based on access restrictions imposed by Tesla Motors and the Ontario Ministry of Transportation (MTO) with relation to Tesla-funded and MTO-funded EVSEs and usage profiles in the community. Data utilized in this study have, therefore, been accessed via public sources or provided through the facilitated support of Oxford County directly.

Guiding variables utilized to support the predictive and descriptive assessment portion of this study are heavily based on prominent studies performed in the U.S. Department of Energy's two plug-in electric vehicle infrastructure studies and demonstrations: The EV Project and the ChargePoint America Project. Specifically, descriptive analysis here is influenced by three categories of variables, including optimal location variables, installation costs variables, and EV driver charging patterns needs. Three key variables have also shaped specific siting choices in this report, namely long-term parking opportunities (Level 1 & 2), special applications for Level 2, and highway intersectionality (Level 3).

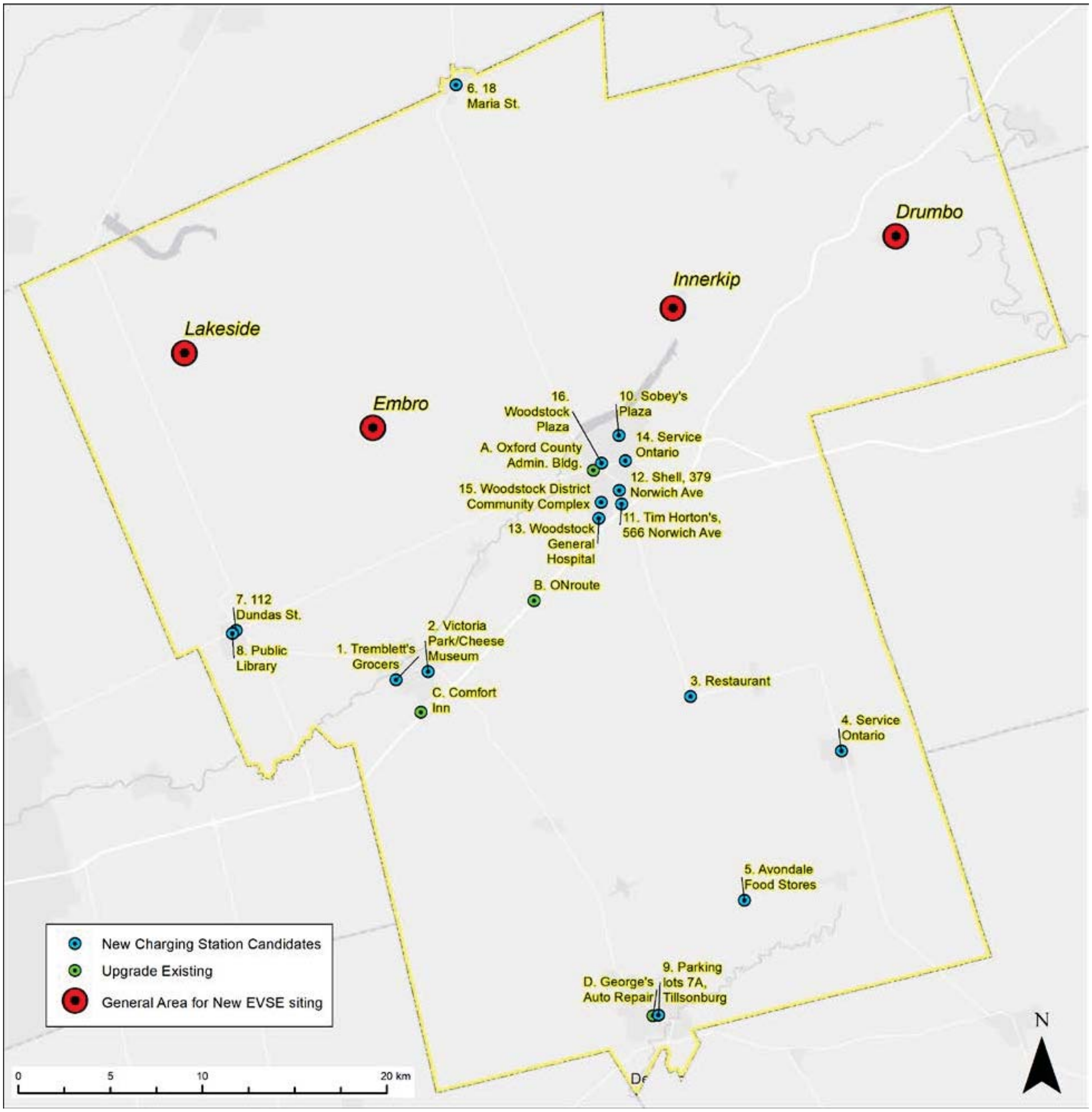
Guiding variables utilized to support the predictive assessment portion of this study include empirical outputs and performance (i.e., range capability) associated with two exemplar vehicle types: (1) Nissan Leaf 2017 and (2) Chevy Bolt 2017. These vehicle models were selected to guide the predictive assessments based on linear adoption rates of EVs in Oxford County due to their "affordability" as vehicles with a starting ticket price in the $30,000-$45,000 CAD, the availability of maximum Ontario government rebates for these model types which reduce their upfront costs to mid-$20,000-mid-$30,000 CAD in Ontario, and their significantly differing driving ranges as a comparative (experimental) variable that generates differing charging system needs within Oxford. In this section of the report, CUTRIC has adopted a "Best Case - Worst Case" scenario assessment, in which the total number of chargers required at a given location or within a given area to **fully satisfy charging needs** is based on the range capabilities of the vehicle, the drive cycle of the EV driver (as a commuter or otherwise), and the minimum required charger to "return to home base" for overnight charging. These assumptions generated a set of predictive "EV owner profiles" or typologies, labelled Types A to Type D, which demonstrate differing charging needs and therefore differing quantities of chargers within Oxford to satisfy all potential EV driver needs in the future.

The results of these predictive analyses demonstrate that Oxford County could address a large portion of commuter EVSE needs through the installation of workplace Level 1 chargers, which also constitutes the cheapest EVSE installation option for private and public sector workplace hosts, along with strategically placed Level 2 chargers in parking lots around the community which serve commuter parking purposes specifically. Meanwhile, out-of-town commuter traffic and tourist traffic will require a combination of Level 2 and Level 3 clusters of chargers.

In a final section of this report, ArcGIS software was used to **map the results from both the predictive and descriptive analyses** to determine optimal EVSE locations in both publicly- and privately-held parking locations. Because of the contrasting geographic controls on location of low-powered (Level 1) and high-powered (Level 2 and Level 3) EVSE, two distinct GIS approaches were adopted. Voronoi polygons were used to optimally locate high-powered EVSEs in relation to distribution of existing EVSEs. Also, a cluster of work places in close proximity with publicly-owned property were used to locate low-powered EVSEs.

Based on these analyses, CUTRIC has prioritized four charging station locations as "in need of upgrading" to address immediate EV charging needs in the community: (1) The Oxford County Administration Building, (2) The ONRoute charger at Ingersoll Travel Plaza, (3) The Ingersoll Comfort Inn, and (4) The charger at George's Auto Repair at 10 Bridge St., Tillsonburg. However, for the latter location, there is also the alternative option of installing new EVSEs at nearby municipal parking lots 6A and 7A in Tillsonburg.

In addition, CUTRIC has recommended specific and general locations for new EVSE installation locations to accommodate predicted EVSE demand growth based on 1%-25% adoption rate assumptions, as shown in the map below. The report concludes with a descriptive overview of potential EVSE locations as judged using key variables for optimal EVSE locations (derived from literature sources mentioned above).



Reproduction of Figure 4, see Table 9 for site descriptions.

Given that over 90 per cent of EV charging occurs at home for EV owners with home garages (The Economist, 2017), it is sensible to target future low-cost EVSE installations at workplaces so that residents can use workplaces in lieu of home charging if and when no garage option exists (e.g., condominium or apartment dwellers, or home basement renters) or use workplace charging to maximize the daily range of their vehicles when using a shorter-range vehicle (such as a Nissan Leaf 2017) to achieve multiple personal and family-life duties outside of the workplace and after work hours. Meanwhile, it is sensible to target future high-cost EVSE installations (i.e., Level 2 chargers) in densely populated urban areas where EV drivers may access charging systems for periods of 1 to 4 hours typically. Lastly, it is sensible to target high-usage highway intersections with the highest cost EVSE installations (i.e., Level 3 chargers) where drivers expect sub 20-minute stop overs.

Appendix I includes a techno-economic modeling conducted on the transit system in Woodstock, Ontario, with the aim of emphasizing the benefits of clean propulsion systems. Three different buses were used to model an interlined route 3/route 5 – a Nova Bus (76 kWh) and New Flyer Bus (200 kWh) with 450 kW chargers and a typical diesel bus. Light-, medium-, and heavy-duty cycles were simulated to determine edge cases of cost calculations and emissions. Routes were modelled based on topography and length, including exact locations of stops along a bi-directional route.

A typical diesel bus model based on road load calculations was developed to examine the fuel consumption and carbon dioxide emissions of the current diesel fleet using Advanced Vehicle Simulator (ADVISOR) 2002 and MATLAB. The electric buses were also modelled to determine energy consumption and regenerative breaking capacity using MATLAB and Python. Varying grid-to-battery efficiencies, electricity costs, and CO_2eq for electricity generation were then incorporated into the models where appropriate.

The modeling outcomes showed both environmental and economic benefits for electrifying route 3/route 5 within Woodstock's public transit system. The electric buses showed cost savings of between $57,613 to $88,945 and emissions reductions of between 191.12 CO_2eq to 372.28 CO_2eq. It is therefore recommended that Woodstock transit electrify their fleet due to impactful cost savings and environmental benefits.

Appendix II documents a short literature review describing possible variables determining installation of a hydrogen fuelling stations, reviewing the likelihood of H2 fuelling usage within a given community, and defining optimal locational variables to consider in such an installation.