A Salty Situation

An Environmental and Economic Analysis of Ice-Management on Dalhousie University, Halifax Campuses

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Executive Summary

Road Salt is a common ice-management strategy, however it can be extremely damaging to the environment. In Halifax, Nova Scotia, Dalhousie University's only form of de-icing is currently road salt. However, due to its close location and steep elevation into a nearby harbour, Dalhousie is threatening the local wildlife and ecosystems. The following report is based off of a study performed by a sustainability class at Dalhousie University who wanted to consider other ice-management alternatives that would be sustainable both economically and environmentally. Through this study, it was concluded that an alternative called Beet 55, which is a liquid form of beet juice, from sugar beets, is the most economically and environmentally sustainable option. Beet 55 is not only less expensive, in comparison to salt, but it is also non corrosive, non toxic to marine and terrestrial environments and works efficiently in extremely low temperatures. After careful analysis, it is recommended to Dalhousie University to shift away from harmful road salt and become more economically and environmentally sustainable with the ice-management product, Beet 55.

Introduction

Project Definition

This study aimed to determine, during the school year of 2015/2016, the economic and environmental sustainability of ice removal methods used on Dalhousie University Halifax campuses and explored potential alternatives using a cost-benefit analysis. De-icing and snow removal are an important part of keeping campuses safe and accessible in winter conditions. Safety and accessibility are vital parts of maintaining social sustainability throughout the university community. However, snow removal and salt application can become a large expense during a harsh winter. Salt (NaCl) is the most commonly used form of snow and ice removal and is used across the city of Halifax and Dalhousie campuses (Trenouth, 2015). However, with the extensive use of salt applied to city and campus streets and sidewalks, serious environmental effects can arise (Corsi et al., 2010). In order to assess the economic and environmental sustainability of Dalhousie's salt application, all three of Dalhousie's Halifax Campuses were considered in this study.

Key Concepts

Economic sustainability can in this instance, be described as the de-icing method that outweighs the costs of alternative methods in a formula that will encompass the future value of present costs of all methods.

Environmental sustainability can be described in terms of de-icing methods as a substance that does not change or alter the habitat in a way that makes it uninhabitable to various species that depend on that ecosystem.

Cost-Benefit Analysis is the actual practice of weighing specific methods using present value, future value and coding for qualitative answers.

Rationale

De-icing and salting in northern climates are extremely important during the winter months. Salt can lower water's natural freezing point and, as a result, can de-ice sidewalks and roads, allowing for safe and accessible transportation (Trenouth, 2015). However, salt can also have serious environmental impacts on the surrounding ecosystems and waterways where it is applied. Runoff is the main contributor for road salt pollution, and has been documented to negatively affect marine ecosystems and vegetation (Corsi et al, 2010). Dalhousie's Studley campus is located on a hill, which leads directly into the Northwest Arm passage (see Appendix D). As a result of its location and elevation, Dalhousie and its surrounding streets could have a direct impact on the marine ecosystem of the Northwest Arm. The salt application at Dalhousie has also lead to issues with corrosion of walkways, buildings and damage to the campuses flowerbeds (personal communication, Michael Wilkinson, 2016). Defining an environmentally sustainable amount of road salt is extremely difficult, and is dependant on multiple variables (Transportation Association of Canada, 2013). Environment and Climate Change Canada along with Transportation Association of Canada have identified the need to reduce road salt application but they do not define a sustainable quantity. Environment and Climate Change Canada state that application is dependant based upon area, sensitivity of the environment and the application should be applied based upon the judgment of a "maintenance supervisor with many years of experience and training" (Transportation Association of Canada, 2013). As a result of the insufficient data of an 'environmentally sustainable' quantity of salt, the research within this project will be focused on comparing the economic sustainability of road salt and measuring the extent of how environmentally friendly the de-icing alternatives are. The scope of our research will be limited to Dalhousie's Campuses in Halifax, Nova Scotia. All three campuses in Halifax will be considered because the data we received only pertained to all three campuses. The main objective of this study is to explore and compare the economic and environmental sustainability of de-icing alternatives versus road salt on Dalhousie's Halifax campuses.

Background

Road salt is a substance commonly used to melt snow and ice on all the Dalhousie Halifax Campuses as well as throughout the Halifax Regional Municipality (Morrisey et al., 2009). Road salt can be applied both in a physical form as well as made into a liquid form and sprayed onto the roadways and sidewalks (Halifax.ca, n.d.). The Halifax Regional Municipality (HRM) is responsible for the clearing of roadways and public sidewalks, while private businesses are responsible for their own snow clearing and de-icing. This means that Dalhousie University is legally responsible for clearing their sidewalks and roadways, and this is enforced through Bylaw Number S-300 (Halifax Regional Municipality, 1997).

When applied to roadways, parking lots and sidewalks, road salt lowers the melting point of snow/ice, which allows the snow/ice to easily run off road and sidewalk surfaces such as concrete and asphalt (Trenouth, 2015). This salt comes mostly in the form of $NaCl$ and approximately 5 million tons is used across Canada within a given year. This type of salt is generally low in cost and is easily accessible and produced, making it one of the best options financially for municipalities and cities across Canada. Though the use of salt on roadways and sidewalks is effective, there are adverse environmental impacts associated with it (Corsi et al., 2010). It has been widely accepted by various studies that when applied in large quantities, road salt can have several negative impacts on terrestrial and aquatic ecosystems within proximity to the application area (Corsi et al., 2010). These impacts can negatively affect water quality, terrestrial and aquatic species habitat, human health and more (Corsi et al., 2010). This is most likely due to the use of salt as well as the runoff of salt from roadways, sidewalks and parkways (Li et al., 2014).

Observing the usage of road salt on the three Dalhousie Campuses could have great importance in terms of financial gains and environmental protection. With new technologies and inventions every year, critically examining road salt usage and application at Dalhousie can produce positive influences. By determining aspects of salt usage on campus and comparing these methods to sustainable alternatives, Dalhousie could potentially benefit financially. One reason Dalhousie could save money is through the use of various alternatives that could be cheaper and more affordable to use as a form of de-icing on Dalhousie Campuses. Dalhousie University could also benefit from using alternatives because it would provide a safer, more environmentally friendly campus when trying to melt snow and ice. One positive impact from using alternatives is it could have a better impact on the surrounding area in terms of runoff into waterways from melting and storm water runoff (Li et al., 2014). Alternative methods could also have a positive impact on campus in terms of keeping students safe from slipping on ice and snow because the alternatives could possibly melt snow and ice more quickly and in more extreme temperatures. For the purpose of this project, we looked into three potential alternatives: pickled salt (used in Calgary, Alberta, Canada), Calcium Magnesium Acetate (CMA) and beet juice (specifically Beet 55). These alternatives were chosen based on their usage in other areas for melting salt and because each has been studied extensively in scholarly papers and articles, as well as in salt management plans.

There was a previous project that focused on de-icing and road salt at Dalhousie University which was conducted and completed in 2009 (Morrisey et al., 2009). Different educational institutions and municipalities/cities across Canada use various techniques and road management plans to effectively remove snow and ice. In 1995, the University of Michigan (U-M) created the Salt Use Improvement Team and the Best Management Practices (BMPs) in order remove snow and ice by using salt and sand efficiently on campus roadways, parkways, and sidewalks (OSEH, 2010). U-M has used substances like calcium magnesium acetate (CMA) in granular form, magnesium chloride in granular and liquid form, and a potassium acetate carbohydrate based solution (corn or beet by products) as de-icers and anti-icers (OSEH, 2010).

The University of Michigan did piloting projects in the winters of 1995-1996, and found that the four previously listed materials are less corrosive, more effective, and less harmful to the environment than other products such as rock salt (sodium chloride) and calcium chloride (OSEH, 2010). Simon Fraser University in Burnaby, British Columbia also developed a salt management plan, where they outlined specific goals and actions to keep roadways and walkways clear of snow while also protecting the surrounding environment (Simon Fraser University, 2009). Specific details such as the total area of road salt application, training requirements for distributing salt, and type of salt used for removing ice and snow on campus are outlined within this developed salt management plan (Simon Fraser University, 2009). Other institutions like the University of Nebraska-Lincoln were able to create a conductive concrete that heats up by electricity and melts snow and ice on concrete (Schrage, 2016). According to the University of Nebraska- Lincoln report, the conductive concrete has a zero net effect on the environment; nevertheless, it has lower operating and maintenance costs (Schrage, 2016).

In terms of bigger areas such as cities and municipalities, the City of Calgary also developed a salt management plan for de-icing within city limits, while minimizing environmental damage and keeping monetary costs low (Calgary.ca, n.d.). This management plan specifically outlines when salt (CaCl) will be applied (between 0^{O}C and -10^{O}C) and when a mixture of salt and gravel (defined as pickled salt) will be applied when temperatures reach below -5^{O}C (Calgary.ca, n.d.). This plan allows for the most effective method to de-ice roads and sidewalks, while causing a minimal impact on the environment (Calgary.ca, n.d.). Depending on the city/municipality and educational institution, some places may have a salt management strategy in place, while some may not have a specific plan detailed or outlined (Stone et al., 2010). Many smaller municipalities do not have a salt management plan in place due to financial constraints, with finances and tax money going towards other projects such as fixing roads and public services (Stone et al., 2010).

The following project is important to Dalhousie University, students, staff and faculty at Dalhousie, and the Dalhousie Facilities Management. Using the data collected and analyzed, this project has the potential to lessen environmental damage from salt runoff while also increasing Dalhousie's profit margin due to buying less road salt and/or using a cheaper, more effective alternative. This in turn could allow Dalhousie to fund other important projects on campus because there are less expenses going towards the purchasing and distribution of road salt.

Research Methods

The purpose of this research was to gather information regarding the economic and environmental sustainability of ice removal methods used on Dalhousie University Halifax campuses during the 2015/2016 year and potential alternatives were explored using a cost-benefit analysis.

For this project we used mixed research methods, which involved the collection of both qualitative and quantitative data, in response to the research question (Creswell, 2014). An in person interview was conducted with Michael Wilkinson, the Environmental Services Manager at Dalhousie. A second interview was conducted on the phone with Steve Leeds, an advocate for Beet 55 within the Smith Fertilizer and Grain Company in Knoxville, Iowa, USA. The interviews were conducted using qualitative methods, whereas the Geographic Information System (GIS) analysis and cost-benefit analysis used quantitative methods.

In order to answer the research question, we conducted a face-to-face and phone interview using purposive non-probabilistic sampling. We strategically chose our study population because they had a good understanding of the topic and therefore, we intentionally sought those individuals out (Creswell, 2014). Our first sample population was the Environmental Services Manager at Dalhousie University, Michael Wilkinson, because he is in charge of salt usage on Dalhousie campus. Secondly, we called the customer service line at Smith Fertilizer and Grain, Iowa, and were transferred to Steve Leeds, a sales representative who is one of the experts on Beet 55.

Michael Wilkinson was contacted by email to confirm that he was willing to participate in this study (Appendix C). He agreed to be a participant and we then sent a list of interview questions over email before meeting in person so that he could have the answers prepared. The interview questions can be found in Appendix C, and include some of the following:

• **Amounts of salt applied during 2015/2016**	• **Cost of salt applied during 2015/2016**
• **Who supplied the salt during 2015/2016**	• Where the salt was applied during 2015/2016
• **If any problems have ever been associated with the application of the salt**	• **If any alternative de-icing methods have ever been executed**

The results from the email interview were analyzed using a grounded *a posteriori* content sensitive method. This was done as a group in order to minimize the potential for individual bias. Our aim was to determine how much road salt was used and how much it cost and the data was then used in the Cost-Benefit Analysis.

A Geographic Information System (GIS) analysis of all three Dalhousie Halifax campus pathways, parking lots and roadways was used in order to understand where the salt is applied to.

GIS mapping allowed us to determine which areas were under the jurisdiction of Dalhousie Facilities Management and which areas were applied road salt by the Halifax Regional Management. Two of our group members who are familiar with the use of GIS analyzed this data, which was collected from the GIS Centre in Dalhousie University Killam Library. Once acquiring the necessary geo-database for the HRM, we then used ArcGIS to create a map for all of the roads and walkways at Dalhousie campuses that are maintained by Dalhousie Facilities Management for snow and ice removal (Appendix C). We accomplished this by selecting specific layers such as Road Polygons, Building Polygons, and Sidewalk Lines to develop a map of each campus. Using Microsoft Word, we were then able to add in a red line to outline the areas that were under the jurisdiction of Dalhousie Facilities Management (and which were not). In building the various maps, a comprehensive scale bar was implemented along with a north arrow and legend to outline the specific attributes (roads, sidewalks, parking lots, etc). Through the GIS software ArcGIS, we also developed a map to show the environmental impacts of road salt due to the elevation and runoff (Appendix D). This can be seen with a red arrow pointing downwards to the Northwest Arm and through the contour intervals added to show the elevation change.

A cost-benefit analysis was conducted for this study, which included a comparison of de-icing salt to three alternatives, which included beet 55 (beet juice), calcium magnesium acetate (CMA) and pickled sand. A cost-benefit analysis is defined as a tool that is used with decision-making (Fuster et. al, 2004). Using this tool, an individual can compare the total monetary costs of a potential project with the total monetary benefits and conclude whether the project’s benefits outweigh the costs and determine if the project should be implemented. With the information collected from our cost-benefit analysis, we were able to determine whether the costs of salt and its alternatives outweighed the benefits, and if the sustainable alternatives were more environmentally friendly at an attainable cost.

Information including the cost of each substance per ton, the lowest effective temperature, erosion damage, future value and how toxic it is to plants, soil and marine life was gathered in order to carry out the cost-benefit analysis. The data for this information was obtained through the interview with Michael Wilkinson and secondary research. Secondary research entailed looking into salt company's guidelines through their introductory package, and various other sources. The same information pertaining to alternative sustainable methods was collected for the cost-benefit analysis. Once all of the data was collected for the benefits and costs, a chart was created to organize all data and clearly separate the benefits and costs pertaining to salt application and alternatives. Two charts were created to compare salt with the three potential alternatives, see Appendix A. The first chart, Figure 1 in Appendix A, was created with the actual values for each factor we were looking which included, price per ton and the lowest effective temperature. The other factors considered were corrosiveness, toxicity to plants and soil and toxicity to marine life, these indicators were assigned a “yes” or “no” based on information gathered through secondary research. For the final analysis (Figure 2, Appendix A), we used a non-monetary cost-benefit analysis. The second chart was made to compare each substance through a number assigned based on the positive and negative aspects of each substance. The numbering system was used because it was difficult to assign a monetary figure to erosion and toxicity and we wanted each variable to be on the same scoreboard. As shown in Figure 2, we rated the costs from least (1) to most (4) expensive and the lowest effective temperature (1) to highest effective temperature (4). When analyzed findings were shown to be corrosive or toxic, they then were given a value of 2, whereas if they were not, they were given a value of 1. After completing the cost-benefit analysis, it could be concluded that beet juice is the best overall option, followed by CMA, pickled sand and then road salt.

Limitations and Delimitations

Limitations associated with the project include:

- Potentially not receiving a response from our participants (Environmental Services Manager, Michael Wilkinson, and an Expert on Beet 55), or not receiving a response in a timely manner
- The GIS data might have been unobtainable and/or ineffective in terms of selecting for the correct attributes
- Monetary costs of benefits for salt applications were difficult to locate and calculate
- Monetary costs for sidewalk degradation were difficult to locate and calculate and thus unusable

De-limitations associated with the project include:

- We collected GIS data from Dalhousie University to measure ground coverage instead of analyzing the ground coverage ourselves
- We analyzed just three de-icing alternatives instead of all the possibilities
- We used Beet 55 as an alternative, when it is only effective when mixed with a salt brine (recommended mixture is 40% Beet 55 and 60% salt brine mixture)

Results

After analyzing each substance through the cost-benefit analysis, our team determined the best alternative method for de-icing purposes is Beet 55. Beet 55 is not harmful to the environment because it is a natural product made with less chlorides and metals than the opposing alternatives (Lugr Enterprises, 2016). As displayed in Figure 1 (Appendix A), the lowest effective temperature of Beet 55 is -32 degrees Celsius, and the cost is $48.00 per ton, making it the most efficient in cold temperatures and tied with pickled sand for the most cost effective de-icing alternative.

Next to Beet 55, Calcium Magnesium Acetate (CMA) is the next best environmentally sustainable alternative to salt. As shown in Figure 1 (Appendix A), it is not toxic to the environment or marine life, and it has a comparatively low effective-temperature of -27.5 degrees Celsius. However, CMA costs $650 per ton, about 14 times more expensive than Beet 55, and about 9 times more expensive than rock salt. The cost of CMA makes it less economically attainable than other alternatives and therefore is not a realistic option when considering de-icing alternatives for Dalhousie University.

As displayed in Figure 1 (Appendix A), pickled sand is comparably cheap with a price of $48 per ton and is non-corrosive. However, the relatively high effective-temperature of just -7 degrees Celsius is not favourable. Pickled sand is also toxic to the environment and therefore is not a viable option.

After analyzing the results, it is clear that rock salt is neither economically sustainable nor safe for the environment. Figure 1 (Appendix A) demonstrates that rock salt is more expensive than Beet 55 and pickled sand, and the lowest effective temperature for salt is -9 degrees Celsius. Rock salt is currently favoured for de-icing methods due to the price and accessibility; however, our results from this study have demonstrated that there are other economically sustainable alternatives that are also environmentally friendly.

Discussion

When comparing the economic and environmental sustainability for de-icing methods on Dalhousie's Halifax Campuses using a cost-benefit analysis, our team considered multiple sustainable options. Ice management is a necessary part of public safety and social sustainability during winter. However, we were curious if we could provide ice-management without compromising the environment and the budget. Through the cost-benefit analysis, salt and the three alternatives; beet juice, pickled sand and calcium magnesium acetate were compared based upon cost, toxicity to the soil and marine ecosystems and their effectiveness. A second analysis ranked each method based upon price and the various other indicators. Within our findings we concluded that Beet 55 had the lowest score indicating it was both economically feasible and also had a low impact on the environment. Beet 55's low score suggests it should be considered by Dalhousie's Facilities Management Team as a new form of ice-management based upon the economic and environmental sustainability it provides.

The Salt Use Improvement Team in the University of Michigan developed the Best Management Practices (BMPs) to remove snow and ice by using salt efficiently (OSEH, 2010). According to their tests, studies and practices, the salt and carbohydrate based solution (corn or beet by-products) along with other 3 alternatives such as CMA, are considered to be the best de-icing methods, due to their environmental friendly and cost effective characteristics (OSEH, 2010). It was a result of the Salt Use Improvement Team at the University of Michigan that Beet juice was considered as a sustainable alternative. Beet 55 has also been implemented as a new form of ice-management in many cities across Canada (Brennan, 2012). Beet 55 is used in Toronto, ON and Williams Lake, BC (Hume, 2014). Both cities rave about its affordability, effectiveness and low impact on infrastructure and the environment (Brennan, 2012) (Hume, 2014).

While we suggest the new implementation of Beet 55, we do realize there are other aspects to consider in the introduction of a new de-icing method and further research is necessary. Further research should include analyzing the transportation costs of salt or the alternatives, which was not done in our CBA. However, when our team spoke with Steve Leeds, a salesperson for Beet 55, he explained that shipment does add an extra cost (Appendix B). Another limitation of Beet 55, which Dalhousie would have to monitor, is a result of the liquid form Beet 55 takes. According to the research by Minnesota Department of Transportation, and the research by Blackburn et al., liquid anti-icing operations can be inhibited when wind speed is above 24 km/h (2009; 2004). This limitation could affect the effectiveness of Beet 55 application, especially when large winter storms hit the east coast.

Beet 55 is a mixture of beet juice with salt brine; it is this combination that allows it be effective. Beet 55 is North America's primary beet juice supplier, and they sell the product to be used as a de-icing method. However, it is up to the purchaser to create a salt-brine mixture to be mixed with the beet juice in order for it to actually lower the freezing temperature of ice and snow. The reason beet juice is used is because it drops the freezing temperature significantly more than a salt brine on its own, and creates a less corrosive environment (SFG, 2013). This salt brine creation may prose more costs and difficulties to Dalhousie Facilities Management, and should be seriously considered before making a final decision.

Conclusion

Based on the cost benefit analysis and through the use of secondary research, it was concluded that beet juice (specifically Beet 55) was not only the least expensive in bulk, but is also the most environmentally friendly alternatives we compared. This concluded alternative is different than what Dalhousie currently uses. Dalhousie University currently used road salt (NaCl) as the method for melting snow and ice from parking lots, roads and sidewalks. Through a cost-benefit analysis, it was determined that road salt - the current Dalhousie road management method - was the third highest in bulk price, and also contributed to negatively impacting the environment through corrosion to marine life, soil and plants. By comparing the alternatives, it was concluded that road salt is not the most effective technique to melting snow and ice and the other alternatives are more suitable options in terms of environmental and economically sustainability.

To ensure that Dalhousie University can effectively remove snow and ice while being environmentally and financially conscious, it is recommended that Dalhousie University conducts a further analysis to determine whether it is possible that alternatives like Beet 55 and CMA would be effective in an area like Nova Scotia. This would be to ensure that these alternatives could still be effective in the varying climate present in Nova Scotia while still being fiscally and environmentally conscious. Furthermore, if Dalhousie University was to start implementing Beet 55 as its new de-icing road management method, there should be an in-depth analysis into transportation of Beet 55 to the university. Beet 55 is produced in Iowa, so an analysis into which transportation method (boat, train, truck, plane, etc) is not only economically feasible, but is also environmentally conscious in terms of greenhouse gas emissions, possible spillage and runoff, and contamination. The creation of salt brine for Beet 55's effectiveness should be analyzed as well. Through this in-depth analysis, Dalhousie Facilities Management can make an educated decision and determine which substance is the most appropriate in terms of finances, environmental impact and also the effectiveness of melting snow and ice to keep our campuses safe during the fall and winter seasons.

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Appendix

Appendix A
Cost Benefit Analyses:

Cost Benefit Analysis of Salt and Alternative De-Icing methods					
	Cost Per Ton	Lowest Effective Temp (Degrees Celcius)	Corrosive/Explosion	Toxicity to plants & soil	Toxicity to marine life
Salt	$73	-27.5	Yes	Yes	Yes
CMA	$650	-27.5	No	No	No
Beet Juice	$48.00	-32	No	No	No
Pickled Sand	$48	-7	No	Yes	Yes
**Original findings and values above					

Figure 1 Qualitative and quantitative comparisons between road salt and the three potential de-icing alternatives

	Cost Per Ton	Lowest Effective Temp	Corrosive/Explosion	Toxicity to plants & soil	Toxicity to marine life	Total
						12
Salt	3	3	2	2	2	9
CMA	4	2	1	1	1	5
Beet Juice	1	1	1	1	1	10
Pickled Sand	1	4	1	2	2	
				***yes = 2	*** no = 1	

Figure 2 Coding used to conduct the final cost benefit analysis where answers were given a 2 if they were a "yes" and answers were given a 1 if they were a "no"

Appendix B

Interview with Steve Leeds:

Hillary: "Hi there, I'm doing a research paper on de-icing methods for my University and was wondering if I could ask a question about your product, Beet 55?"
Steve: "Absolutely."
Hillary: "I was wondering if you could tell me how much it typically costs per whichever measurement you use?"
Steve: "Well, if you're buying in bulk [which is 4500 gallons], it will cost $1.18 US per gallon. Then if it's being delivered by truck like ours it will cost an extra $4.25 per gallon. There may be other modes of transport used to get it to Canada, but that's the fees that are usually paid to get to a large purchaser of ours in Missouri."

Appendix C

Initial email sent to Dalhousie maintenance department staff and interview with Michael Wilkinson:

Good morning!

I am a student at Dal in the Environmental Science program and we are required to do a research project on a sustainability issue on Studley Campus. My group's project is surrounding salt usage for de-icing purposes.

We would like to conduct an interview with someone who is knowledgeable surrounding amounts of salt used, cost etc. Are you able to put me in contact with someone who would know this type of information?

Thanks so much,

Caitlin Tonner

Data Collected from Michael Wilkinson's interview:

1. What is the amount of salt that has been applied to Dalhousie's Studley campus during the 2015/2016 year thus far?

Michael: 259 tons was bought (for all 3 campuses) 59 tons still in storage. Do not have an exact amount for only Studley campus

2. How much money has been spent on salt during the 2015/2016 year?

Michael: $19 000

3. What is the cost of the salt per ton?

Michael: $73 per ton

4. Who is the supplier for salt during the 2015/2016 year?

Michael: Windsor Salt K&S

5. What areas of campus is salt applied?

Michael: Walkways, stairs, building entrances, roadways, parking lots

6. Are there any recorded problems associated with salt?

Michael: Yes

a. If so, what are they?

Michael: It's corrosive, and causing problems in garden beds

7. Are any alternative methods used for de-icing roadways/walkways?

a. If yes, what are they?

Michael: Potentially implement stale air exhaust, more covered entrances, there is a heated road on Carlton campus

8. Has the salt supplier changed over the past 10 years?

Michael: No

Appendix D

Maps of Carleton, Sexton, and Studley Campus, Dalhousie University:

Figure 3 Map shows the jurisdiction of Salt Management for Dalhousie University Carleton Campus, using the HRM geo-database data supplied by the GIS Centre, Killam Library, Dalhousie University

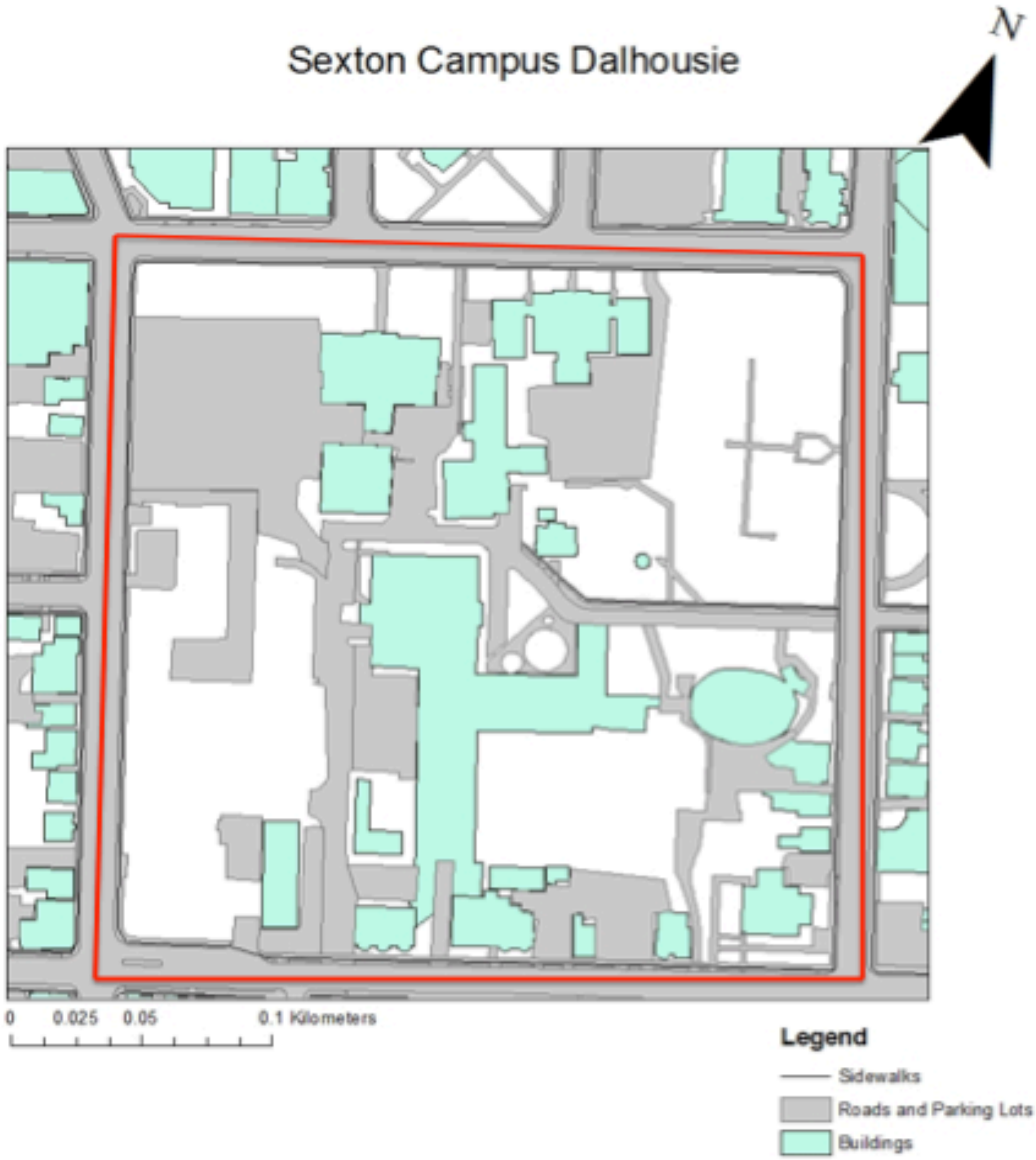

Figure 4 Map shows the jurisdiction of Salt Management for Dalhousie University Sexton Campus, using the HRM geo-database data supplied by the GIS Centre, Killam Library, Dalhousie University

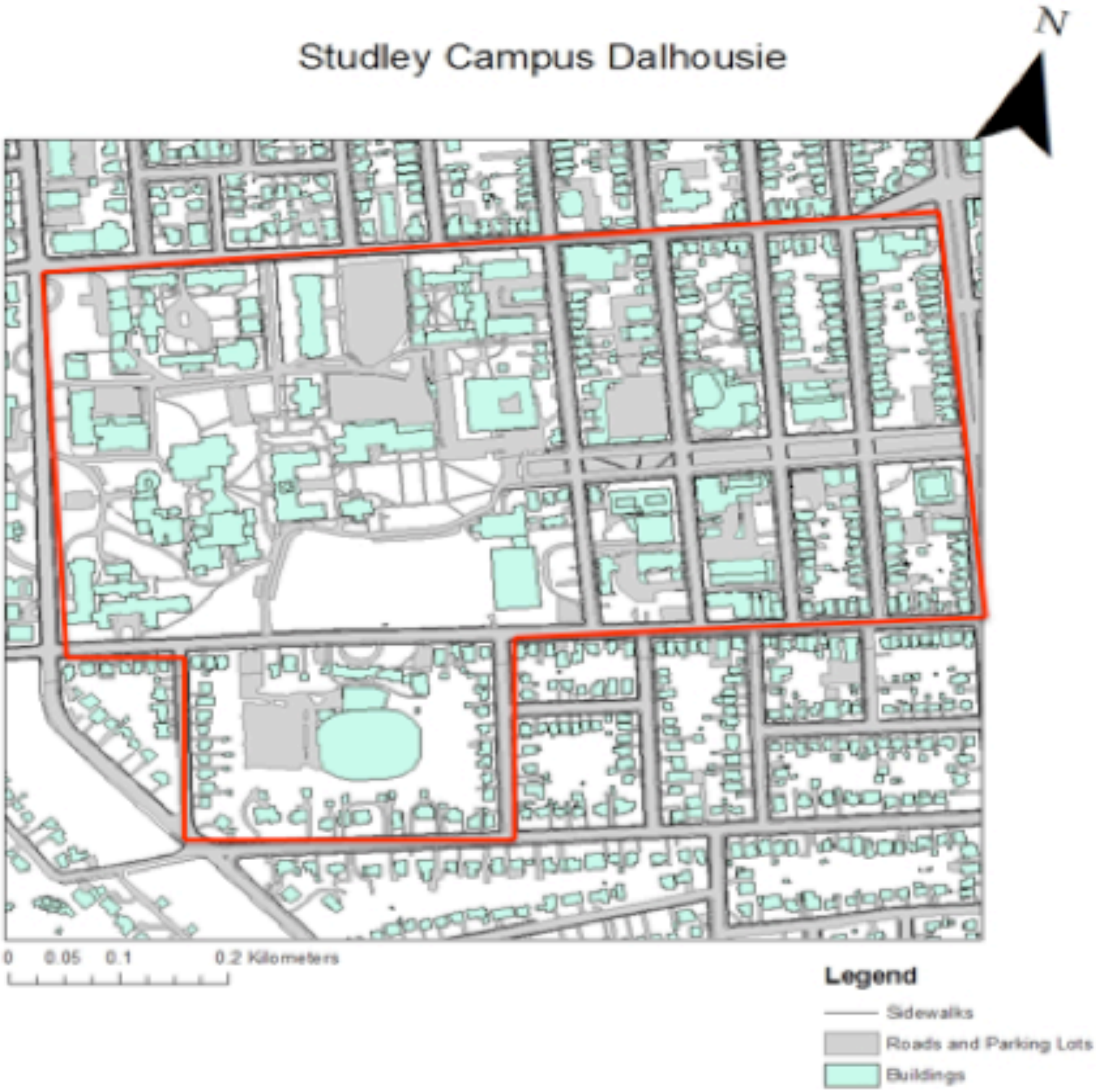

Figure 5 Map generated to show the jurisdiction for salt management at Dalhousie for Studley Campus, Dalhousie University Halifax using the HRM geo-database supplied by the GIS Centre, located in the Killam Library, Dalhousie University

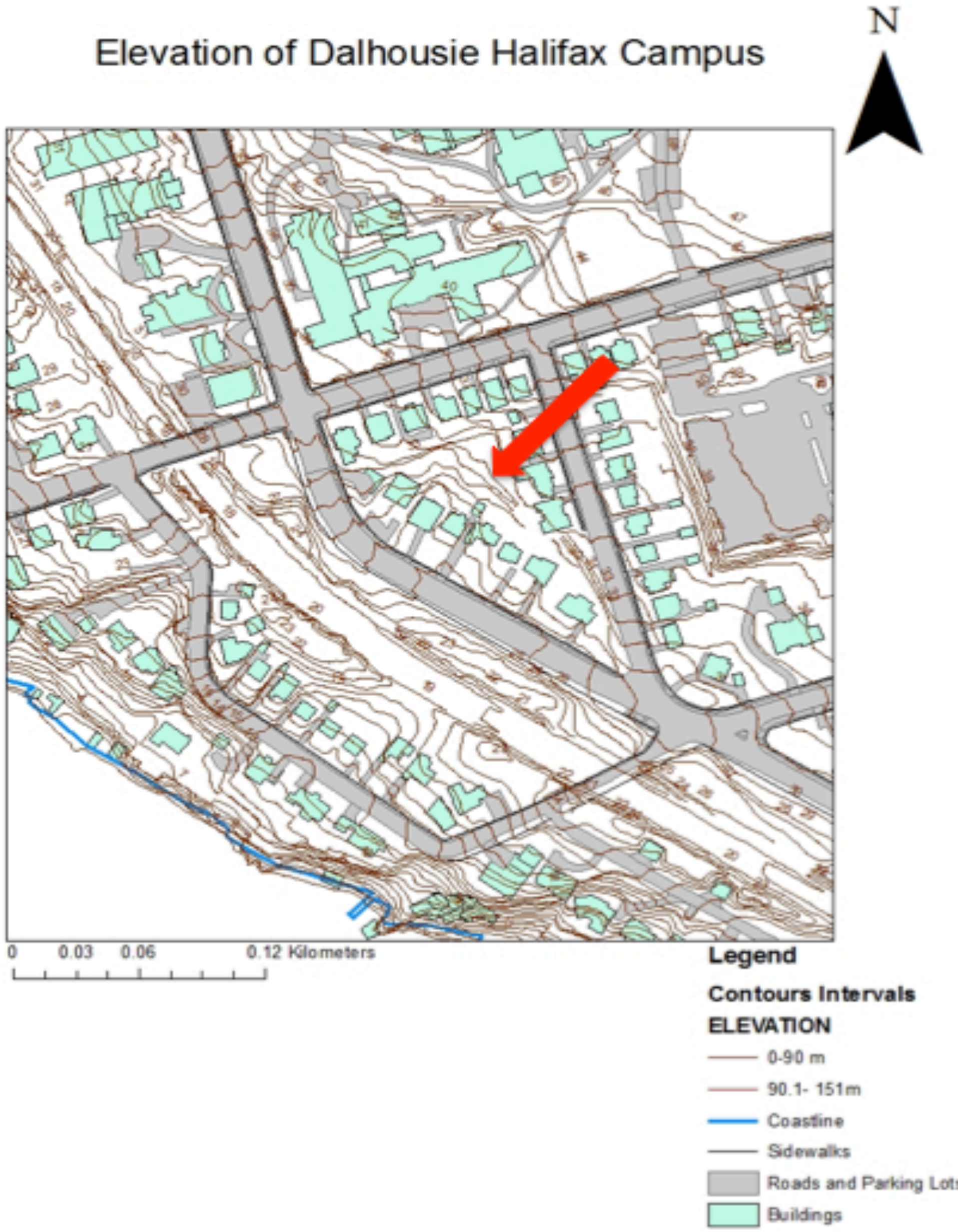

Figure 6 Elevation map of Studley Campus, Dalhousie University with an arrow showing the downward slope of Studley Campus towards the Northwest Arm, with the data being the HRM geo-database, supplied by the GIS Centre, Killam Library, Dalhousie University