Nationwide Recycled Aggregates Volunteer Registry | Scaling the Ontario Example

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1. ABSTRACT

Reclaimed Asphalt Pavement (RAP) and Recycled Concrete Aggregates (RCA) hold significant promise for advancing sustainable road construction practices through waste reduction and resource conservation. However, the lack of a standardized data collection method for assessing the quantities and geographic distribution of recycled aggregate resources has impeded the development of effective policies and informed decision-making in this domain.

In 2019, Ontario initiated a groundbreaking effort to address this challenge by utilizing satellite imagery to gather such information. This initiative gained traction and evolved into an unofficial voluntary stockpile registry in the province administered by Good Roads (previously Ontario Good Roads Association). Over several years, Good Roads conducted surveys across various sectors, yielding valuable insights into material quantities, local RAP management practices, adoption by transportation agencies, and location-specific data on annual usage.

Now, leveraging the success of Ontario's approach, Good Roads and the National Research Council of Canada are collaborating to extend this model to a national scale across Canada. The methodology involves identifying RAP and RCA stakeholders in Canadian provinces, surveying stakeholders to collect data on actual quantities of RAP and RCA, and utilizing satellite image analysis to supplement data collection in areas where information is lacking.

This paper will provide an overview of RAP trends and stockpiles in Ontario for the year 2024, along with preliminary findings from the ongoing 2024 Canada-wide study on RAP and RCA quantification. Through this collaborative effort, we aim to enhance understanding and support the sustainable utilization of recycled aggregates in road construction practices across Canada.

2. INTRODUCTION

Construction and rehabilitation activities within public works generate large quantities of removed materials with each construction season. The reusable portion of these removed materials can be broken down into Reclaimed Asphalt Pavements (RAP), Recycled Concrete Aggregates (RCA), and Excess Soils. However, this paper will only be focused on RAP and RCA. After processing to meet quality standards, RAP and RCA are often reused in the maintenance and construction of new pavements. Such use in road building includes:

- Incorporation of RAP in new asphalt mixes
- Use of RAP and/or RCA in the construction of road shoulders
- Use of RAP and/or RCA in granular base/subbase layers
- Use of RAP and/or RCA in the construction and maintenance of unpaved roads
- Use of RAP and/or RCA as fill materials and as embankments

In the past years there has been a growing awareness towards sustaining aggregate resources (EBA Engineering, 2013; Ministry of Natural Resources Ontario, 2010). According to The Ontario Aggregate Resource Corporation (2014), approximately 153 million tonnes of aggregates are produced each year in Ontario, out of which, 50% are used in the maintenance and construction of infrastructure in Ontario. This gives RAP and RCA the potential to be a significant contributor to aggregate sustainability. In addition to saving valuable diminishing aggregate resources, using RAP and RCA in infrastructure contributes to the following:

- Recovering non-renewable petrochemical resources
- Reducing road building costs
- Diverting large amount of solid waste from landfills
- Reducing greenhouse gases emissions
- Reducing road damage (ESALs) associated with long hauling of virgin materials.

There has been a noticeable increased adoption of the use of recycled material (RAP and RCA) in road construction in the past few years. However, the generated amounts of RAP and RCA due to rehabilitation activities far surpass the current allowable uptake. Managing this surplus of recycled materials is especially challenging since there is no data repository for the locations and amounts of available RAP and RCA across Canada. "*One of the main deficiencies identified for successful reporting on the level of aggregates reuse and recycling was a lack of a methodology or system to effectively track recycled materials use across the Province.*" (Ministry of Natural Resources Ontario, 2010). Having an ongoing monitoring and evaluation strategy including a voluntary registry of RAP and RCA is crucial to any advancement on the front of aggregate recycling.

This paper aims to document the framework used by Good Roads to initiate an ongoing voluntary registry for RAP materials in Ontario as well as the work underway to establish a RAP and RCA voluntary registry across Canada. In addition, this paper will also present a sample quantitative analysis of RAP inventory and RAP consumption in the past four years in Ontario. Such information may be used to facilitate decision making and strategic planning towards sustainability in infrastructure which falls within the government's mandate to manage natural resources and ensure their obtainability for the use of current and future generations.

3. METHODOLOGY / FRAMEWORK

3.1 Quantification Through Satellite Image Analysis
The study was initiated through quantification of unprocessed reclaimed asphalt pavement (RAP) in Ontario and established a baseline for overall RAP inventory using Google Earth Pro software in 2019 (Mneina & Smith, 2019). RAP stockpile locations were identified through an environmental scan utilizing publicly available lists and satellite imagery interpretation. Measurements of RAP stockpile volumes were estimated using the software's tools, with the base area measured and multiplied by average elevation height assuming a conical volume. Estimated values from this method were validated in the following years through actual values collected from different facilities. Limitations were noted due to the lack of density information for unprocessed RAP and the accuracy of elevation measurements restricted to the most recent satellite images.

3.2 Establishing Relationships with Stakeholders
Good Roads leveraged satellite image analysis for RAP inventory estimation to establish relationships with HMA producers and aggregate quarries. This innovative approach not only provided accurate insights into the availability of RAP stockpiles but also demonstrated Good Roads' commitment to adopting cutting-edge methodologies for industry advancement. By

employing this technology, Good Roads fostered trust among HMA producers, showcasing their dedication to promoting the utilization of RAP in asphalt production. The transparent and data-driven nature of the satellite image analysis instilled confidence within the industry, reinforcing Good Roads' position as a reliable partner in driving forward the adoption of sustainable practices. A true public/private sector partnership between Good Roads and Ontario Asphalt Pavement Council was established and became the seed for the voluntary RAP registry survey. This collaborative effort between Good Roads and industry stakeholders not only facilitated informed decision-making but also laid the groundwork for meaningful progress towards a more environmentally friendly and efficient asphalt production process.

3.3 Administering Survey to Collect Quantification Information

The survey comprising the voluntary RAP registry is administered annually through Good Roads and distributed in collaboration with the Ontario Asphalt Pavement Council. The survey objective is to collect information on quantities and locations of RAP. Simplicity of the survey is crucial in collecting such information especially when it is voluntary. To maintain simplicity and focus, the survey consisted only of one question about quantity and location of RAP which was repeated for as many facilities the respondent manages. Another crucial part of managing this voluntary survey is to recognize the trust instilled in it by respondents who are sharing information that is considered trade secrets. Therefore, it is a vital part of the survey to promise confidentiality for such specific information where only aggregated results be published into the report without mention of exact locations or facility attributes.

3.4 Data Analysis and Report Writing

In this study, Ontario was divided into four geographical zones (Northern, Southeast, Southwest, and Central) as presented in **Figure-1**. Collected data was aggregated to represent the four geographical zones. Heatmap data visualization techniques were used to provide a spatial representation of the RAP inventory as well as HMA production quantities without revealing the actual locations of each facility. The data from the RAP Survey was augmented with data from the annual Ontario Municipal Paving Survey (administered by Good Roads) to show estimated quantities of consumed RAP against available stockpiled RAP using Bubble Map data visualization techniques. Finally, the data from the RAP Survey was also used to validate the estimation model that was used to analyze satellite images in Mneina & Smith, 2019. The collected and analyzed data is published in the Ontario Paving Report annual series, (Mneina et al., 2024).
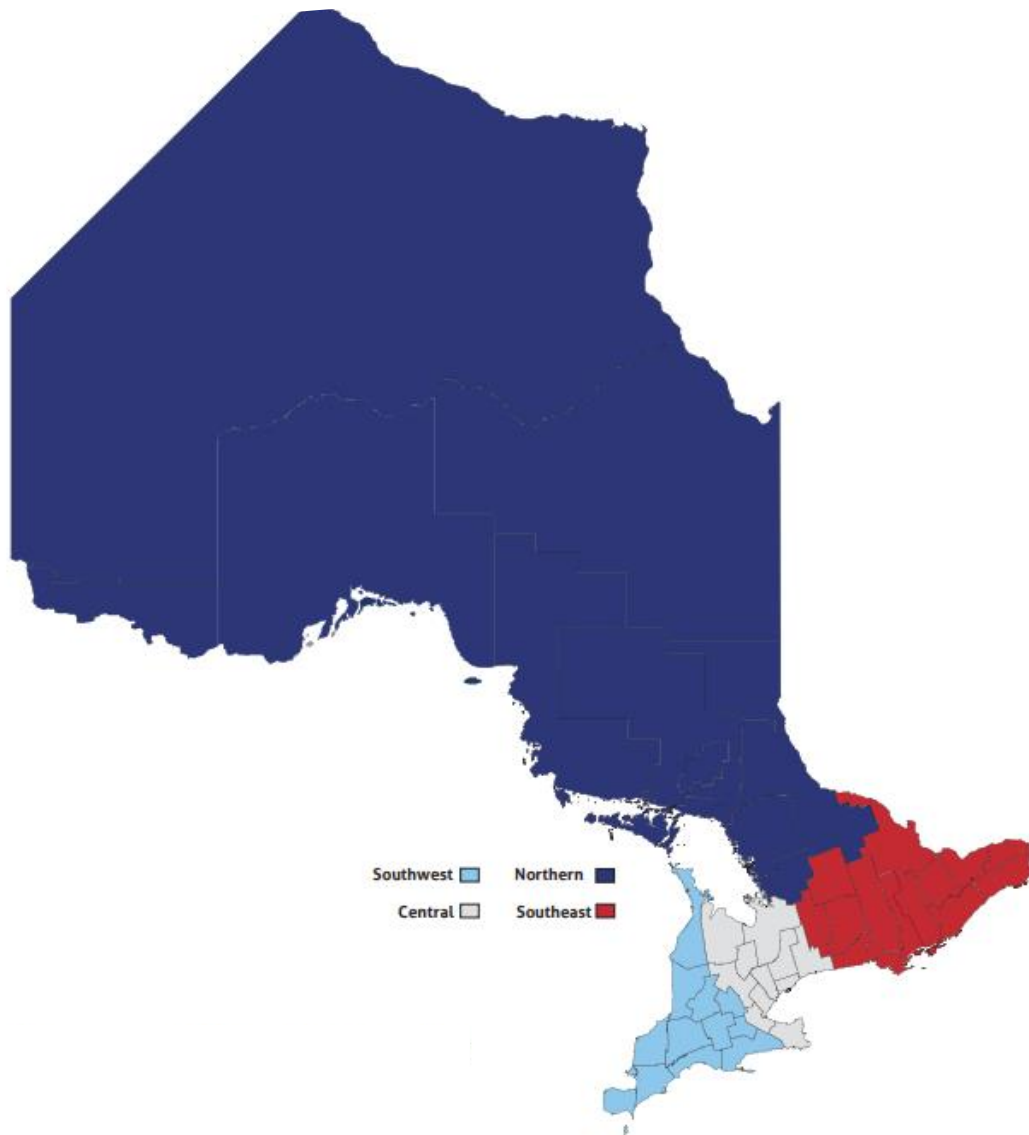
Figure 1- Province of Ontario Broken into Geographical Zones

4. RESULTS & DISCUSSION

4.1 Hot Mix Asphalt (HMA)

This section will discuss the trends on HMA production quantities, locations, and municipal paving consumption of HMA.

4.1.1 Total Produced HMA

Although municipal asphalt paving projects account for a large share of the total HMA produced in Ontario, it is still important to monitor the total HMA production trends and locations. **Table-1** presents a reported summary of the HMA production facilities locations and their annual production in the past years. **Figure-2** shows a spatial heatmap representation of the total HMA production data in Ontario.

Table 1- Total HMA Production Tonnage in Ontario, (Mneina et al., 2024)

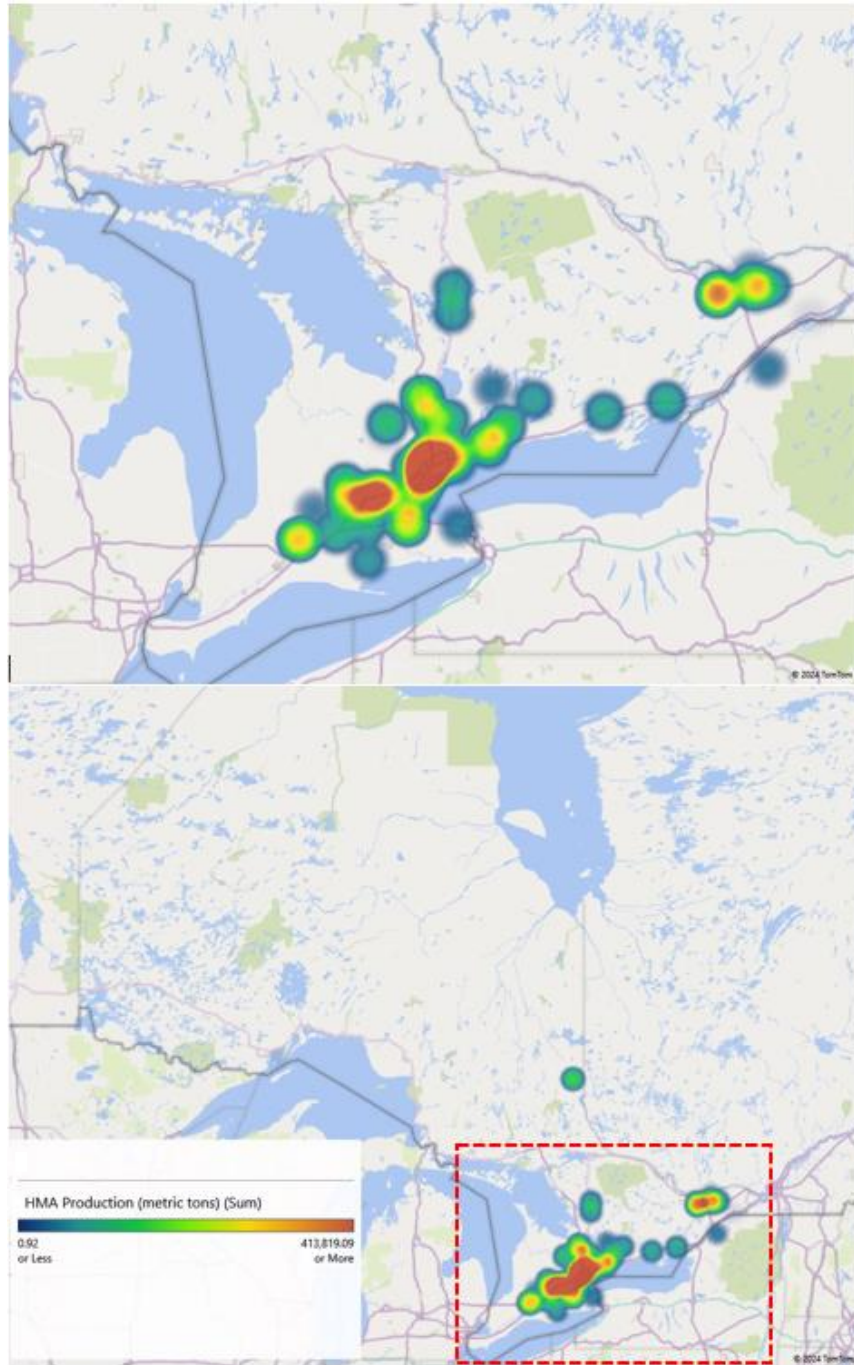| Year	Facilities	Total HMA Production (Tonnes)				
		North	Southwest	Central	Southeast	Total
2022	72	459,756 (8%)	1,100,611 (19%)	3,781,868 (66%)	648,700 (11%)	**5,690,935**
2023	94	171,000 (2%)	1,222,444 (17%)	4,840,826 (66%)	1,110,881 (15%)	**7,345,151**

Figure 2 - HMA Production Tonnage Distribution in Ontario

4.1.2 Consumed HMA in Municipal Paving

Based on survey responses, a total of 1.2M tonnes of HMA is estimated to be used in municipal paving projects for the 2024 construction season. A summary of the HMA paving quantities per year are presented in Error! Reference source not found. and **Figure-3**. The quantities a re summarized as per geographical zones. It is noted that the Central Zone had always accounted for most of the municipal paving tonnage with an average annual share of 46% from the total municipal HMA tonnage. It should be noted that the numbers for 2024 do not include the City of Toronto.

Through an extrapolation from the Municipal Paving Forecast data 2017-2021 it is estimated that in any given year, Ontario municipalities pave between 4.9M and 5.2M tonnes of HMA. These estimates counter the popular opinion which believes that MTO is the largest user of HMA at 2.5-3M tonnes/year. In the past eight years (2017-2024) the paving average represented the following percentages for each geo-zone: [N=4%, SW=22%, C=54%, SE=20%].

Table 2 - Municipal Hot-Mix Paving Quantities in Ontario, (Mneina et al., 2024)

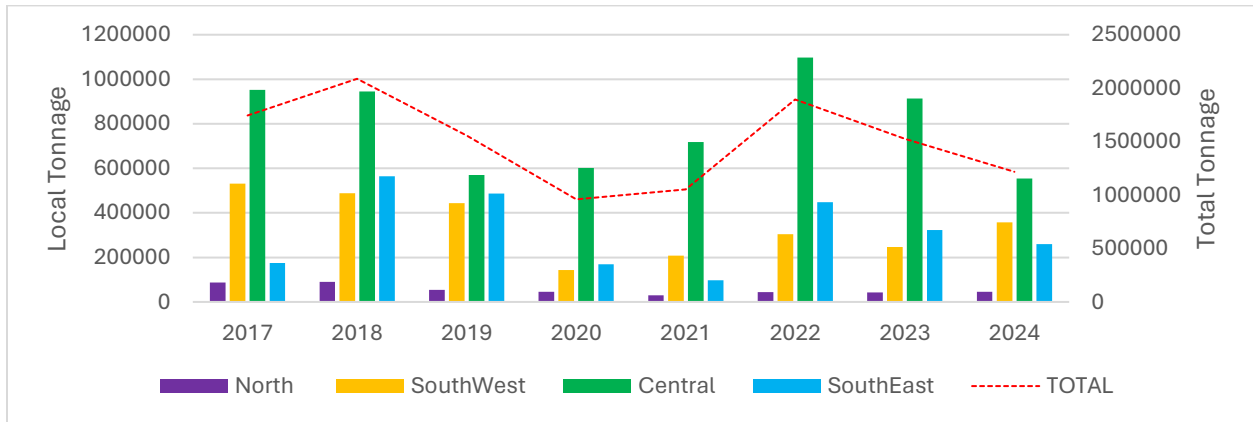| Year	Municipalities	Municipal HMA Paving (Tonnes)				
		North	**Southwest**	**Central**	**Southeast**	**TOTAL**
2017	54	87400 (5%)	531289 (30%)	952400 (55%)	174836 (10%)	**1,745,925**
2018	44	90300 (4%)	487810 (23%)	944905 (45%)	564807 (27%)	**2,087,822**
2019	58	54446 (4%)	443525 (29%)	569815 (37%)	486765 (31%)	**1,554,551**
2020	40	44925 (5%)	143680 (15%)	601915 (63%)	169341 (18%)	**959,861**
2021	43	30100 (3%)	207988 (20%)	718399 (68%)	97453 (9%)	**1,053,940**
2022	57	44150 (2%)	303530 (16%)	1097509 (58%)	448105 (24%)	**1,893,294**
2023	64	43,010 (3%)	246,377 (16%)	913,288 (60%)	323,486 (21%)	**1,526,161**
2024	54	45,307 (4%)	35,7245 (29%)	553,773 (46%)	26,0018 (20%)	**1,216,343**

Figure 3 - Annual Reported Municipal HMA Paving Tonnage, (Mneina et al., 2024)

4.2 Reclaimed Asphalt Pavement (RAP)
4.2.1 Total Available RAP

Table 3 presents a summary of facilities containing RAP in each geographical zone and their total reported unprocessed RAP inventory per year. The RAP quantities in the table do not include RAP that is stockpiled in municipal facilities as in 2020, it was found that RAP stockpiles

in municipal facilities represented only 5% of the total inventory. It is worth noting that (Mneina & Smith, 2019) observed a 91% increase in RAP in the Southwest zone over a ten-year period (2008-2018) by investigating historical satellite images.

Table 3 - RAP Inventory in Ontario as Reported in the Ontario RAP Survey, (Mneina et al., 2024)

		RAP Inventory in Ontario (Tonnes)				
Year	Facilities	North	Southwest	Central	Southeast	Total
2019	57	868,418	263,007	1,901,174	1,280,015	**4,312,614**
2020	39	299,000	287,296	1,434,510	260,000	**2,280,806**
2021	60	27,500	370,269	1,815,253	739,899	**2,952,920**
2022	72	229,993	413,435	1,839,396	791,342	**3,274,166**
2023	94	245,000	684,177	1,909,738	836,061	**3,606,461**

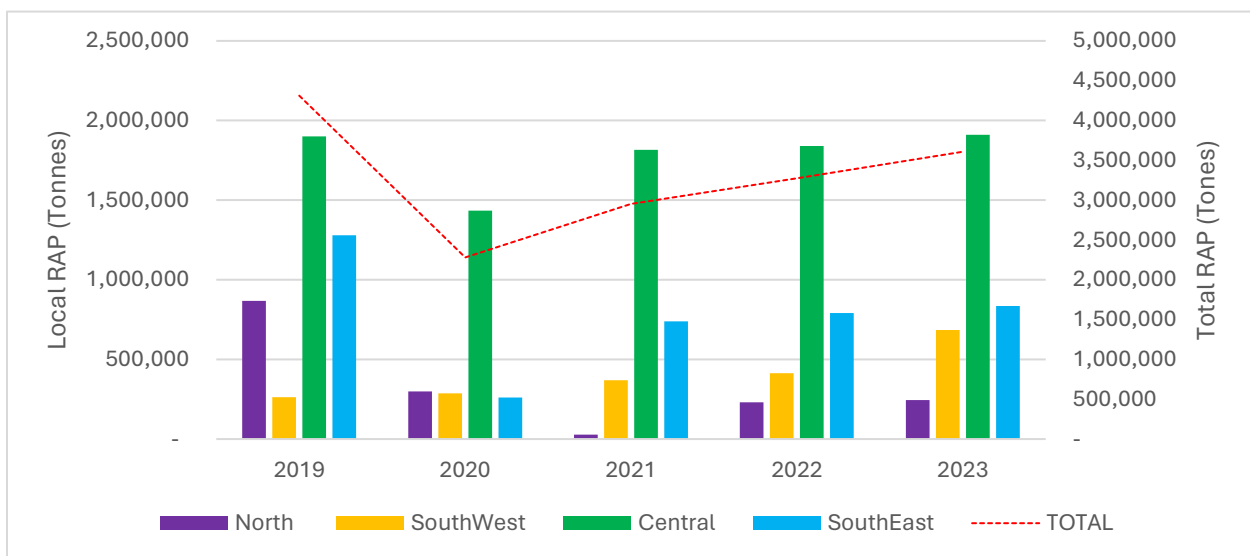

Figure 4 - Annual Reported RAP Quantities, (Mneina et al., 2024)

4.2.2 Consumed RAP in Municipal Paving

Availability of information on local quantities and practices of RAP in HMA paving is a key resource in the continuous improvement and growth of this industry's stakeholders. Estimating the municipal RAP consumption was made using the Municipal Paving survey results, assumptions, and simple calculations. Through the 2024 survey, information was collected on how much of municipal paving projects incorporated RAP in each municipality. Conservative assumptions were made that 15% RAP in HMA was used in projects that incorporated RAP. The estimated consumed RAP was then calculated based on the assumptions and the known paving tonnage of 54 municipalities. Although this estimate represents only 54 out of 444 municipalities, it is considered an accurate estimation as these 64 municipalities represent 47% of the total population of Ontario which strongly correlate to the road building activity and network distribution around the province. The bubble diagram in **Figure** presents the 2024 projected RAP consumption locations and quantities alongside the RAP inventory locations and quantities.
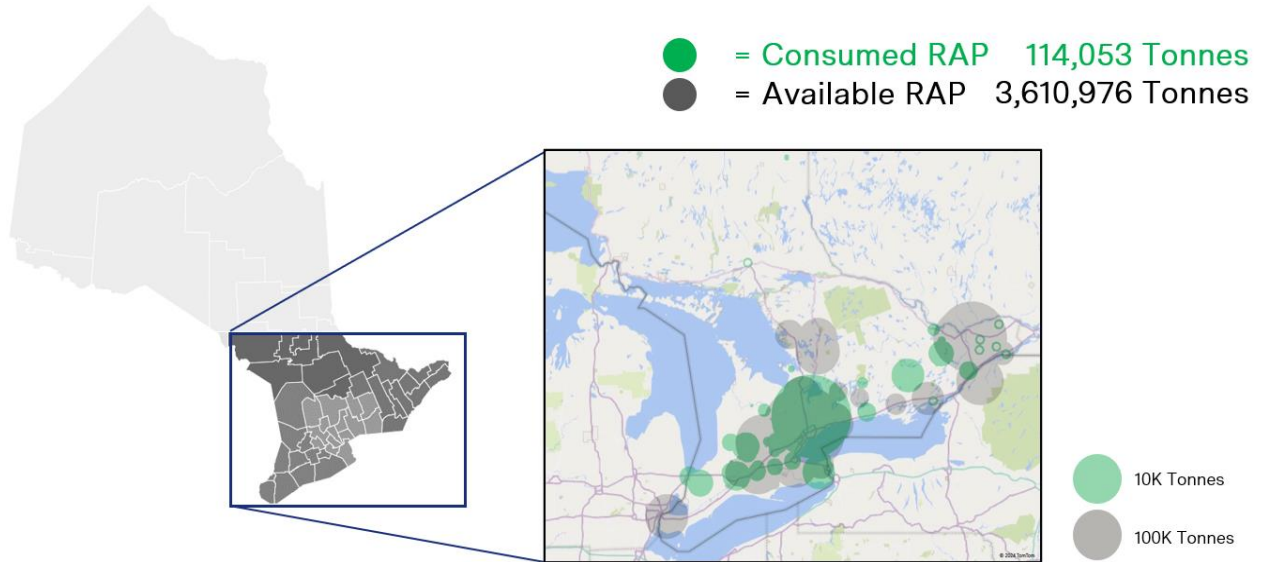
Figure 5 - Available and Consumed RAP in 2024 (not including MTO's consumption), (Mneina et al., 2024)

Table 4- Municipal Consumed RAP, (Mneina et al., 2024)

		Total Municipal RAP Consumption (Tonnes)				
Year	Muni.	North	Southwest	Central	Southeast	Total
2023	64	4,000	22,000	104,000	33,000	**163,360**
2024	54	3,468	28,961	65,231	15,504	**113,145**

4.3 Validation of the Satellite Image Estimation of RAP Quantities

A sample of 20 facilities from the 2021 Ontario RAP Survey data was used to validate the estimation method used by Mneina & Smith, 2019. Satellite images of the locations of the facilities were examined where the RAP stockpiles areas and heights were measured using the Google Earth Pro software. An estimate was made on the quantity of RAP in each stockpile using the collected information. The satellite image estimated quantities vs. actual quantities collected from the facilities are presented in **Figure-6.** Two outliers were observed as the topography in the satellite images were very poor in these locations. The overall R^2 value of 65% represents a fair correlation between the estimated and actual data. The validation also shows that the estimation method tends to overestimate the actual quantity of RAP in some locations. Looking back at **Table-3**, this can explain the some of the variation in RAP quantity between the year 2019 (which included all estimate values) and the following year of 2020 (which included all actual values).
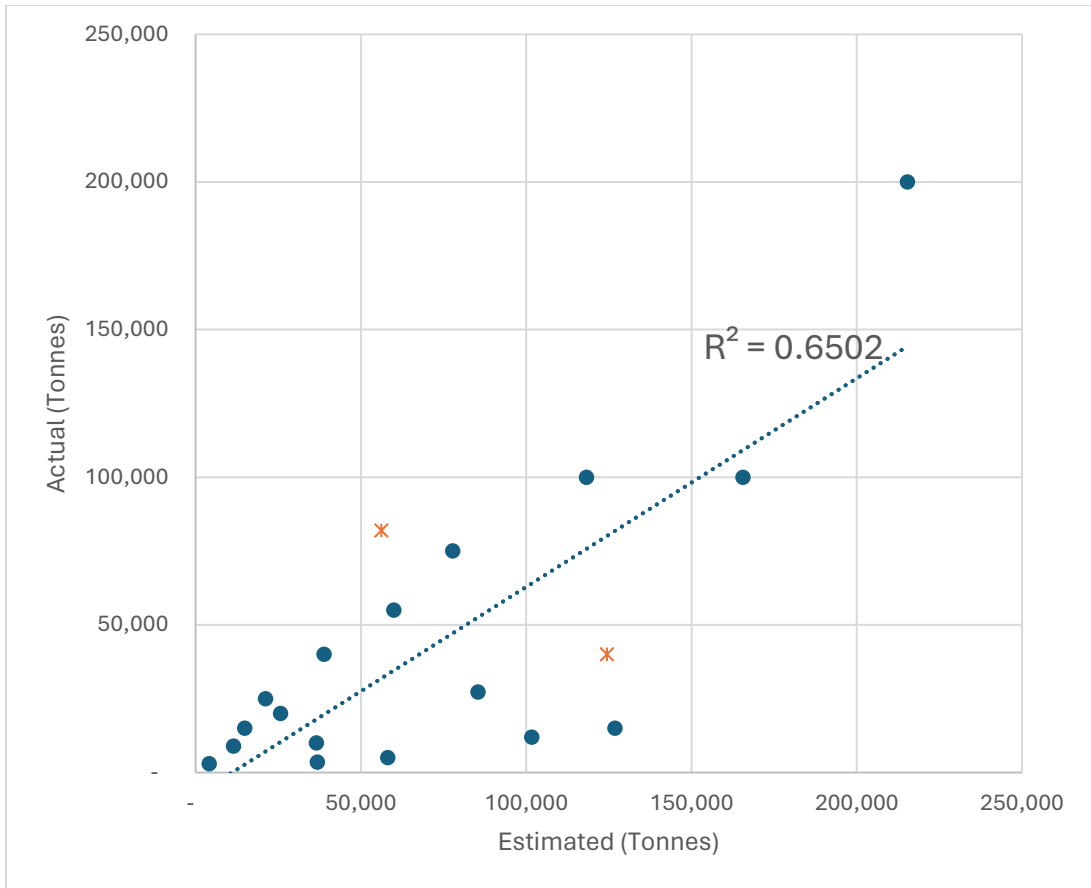
Figure 6 - Validation of the Estimation of RAP Stockpile Quantities using 2021 Data in Ontario

5. NEXT STEPS

In collaboration with the Low Carbon Built Environment Challenge Program (LCBE) of the National Research Council of Canada (NRC) and other industry partners, Good Roads is planning to scale the Ontario example of RAP inventory quantification into a Canada-wide initiative encompassing RAP and RCA. A stakeholder analysis is underway to identify candidates for the survey. Such candidates represent (but not limited to) the following:

- Ready-mix Concrete Producers
- HMA Producers
- Aggregate Quarries
- Municipal Governments
- Provincial Governments
- Landfill Facilities

Locations where quantity information may not be available will be analyzed using the established satellite image processing method. The project team will also work with NRC-LCA team to estimate potential GHG emissions reductions from the use of RAP and RCA due to reduced aggregate production and shorter transportation distances.

It is recommended for stakeholders to contact Good Roads and the authors of this paper to express interest in participating in this coming RAP/RCA survey.

6. REFERENCES

- Ministry of Natural Resources Ontario. (2010). *State of the Aggregate Resource in Ontario Study*
- Mneina & Smith, Promoting Sustainability in Infrastructure Through Quantifying Reclaimed Asphalt Pavement – An Ontario Municipal Case Study, Transportation Association of Canada, Halifax, NS, 2019.
- Mneina, Amin, Smith, J., & Ambaiowei, D. (2024). (rep.). 2024 Ontario Paving Report (pp. 1–17). Oakville, ON: Good Roads.