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GEOG 381 – Lab 103 – Assignment 2

Assignment 2: Urban Sprawl in Kitchener From 1999-2022

Introduction/Background

This report maps building permits for New Constructions in the City of Kitchener between the years 1999 and 2022. In investigating and analyzing the spatial and temporal relationships of issued permits, the city can better understand urban sprawl and development trends in order to make more informed planning decisions in the future.

Study Site & Data

This analysis is being done in the City of Kitchener, Ontario, Canada.

The main data is sourced from the Region of Waterloo Open Data portal. This includes:

- **Kitchener Building Permits** – CSV data from the assignment
- **Kitchener Addresses (2024)** – CSV data from this site

In the addresses dataset, the X_COORD and Y_COORD fields contain the coordinates in easting/northing format, with a projection of UTM NAD83 17N. Note that these coordinates are also measured to the geometric centroid of the feature location.

Ancillary data is sourced from the Kitchener GeoHub. This includes:

- **Kitchener Municipal Boundary (2024)** – shapefile data from this site

Methods/Process

My flowchart can be found as **FIGURE 1** in the appendices.

The addresses dataset required preprocessing – I used the **XY Table to Point** tool to convert the CSV into a point polygon in my project geodatabase. This was necessary for creating a locator in the next step, since the Primary Table can't be a CSV. The inputs were the addresses CSV and fields X_COORD and Y_COORD, the coordinate system was UTM NAD83 17N, and the output was a point feature class called Addresses.

The next step involved using the **Create Locator** tool to create a locator based on the Addresses dataset. This locator will be used in the next step to geocode building permit data. The main input was the Addresses FC as the Primary Table with a role of Point Address. I chose this role since it facilitated addresses containing a street name and number. For the Field Mapping, I mapped Feature ID to OBJECTID, House Number to CIVIC_NO, Street Name to STREET, Full Street Name to STREET, Unit to UNIT, Unit Type to UNIT_TYPE, and Community/Municipal District to WARD. These were the fields from the Addresses data that matched with the pre-defined fields – I matched as many as possible to get a more accurate locator. I chose Canada as the Country or Region and English as the Language Code, since the data is in English and is located in Canada. The output was a locator called Kitchener_Locator.

Next, I geocoded the building permits dataset using the **Geocode Addresses** tool. This was necessary to match the addresses in this dataset to a position, which is done using the position data from the Addresses dataset via the locator. The Input Table was the building permits CSV and the Input Address Locator was the Kitchener_Locator that was just created. The input Address Field was Single Field and the Single Line Input was Foldername, since the Foldername field alone stored the addresses in the building permits data. The Preferred Location Type was Address location since this returns a centroid, which matches how our address dataset was defined. The output was a Building_Permits point feature class.

See **FIGURE 2** for a table illustrating the geocoding success rate. There was a 96.95% success rate, which is quite successful since a rate over 90% indicates an accurate geocoding. Thus, I don't have worries about the quality of my locator, and believe that my building permits have been largely successfully geocoded. To remediate the 4 ties, I right clicked on the FC and went to Data > Rematch Addresses, then went to the Tied tab and selected the correct ones. All of the ties were discerning between the streets Upper Canada Drive vs. Upper Canada Place.

Then, I used the **Select by Attributes** tool to select only the "New Construction" permits from the larger dataset. The Input Rows was the Building_Permits FC, and the selection statement was `WHERE Work Type is equal New Construction`. Then, with this selection active, I used the **Export Features** tool to create a new FC with only these select points. The Input Features was Building_Permits with the "use selected records" toggle active, and the output was a New_Construction feature class.

To get a chart displaying the total number of permits per year, I right clicked on the New_Constructions FC, then clicked on Create Chart > Bar Chart. In Chart Properties, I used Issue Year for Category or Data and Count for Aggregation.

To create a choropleth representation of the data, I first used the **Generate Tessellation** tool. I chose the extent input to be equal to New_Construction data since this would cover only the necessary area. I chose a size of $0.2km^2$ for each hexagon since this would cover roughly one suburban block worth of houses. The output was a hexagon tessellation FC called Hexagon_Tessellation. I then used the **Spatial Join** tool to join the tessellation with the New_Constructions points. The inputs were Hexagon_Tessellation as the target feature and New_Constructions as the join feature. The join operation is One to Many since we needed to retain the Issue Year data for each hexagon in order to enable temporal properties properly. The match option is intersect since we want to join all points that intersect with each hexagon polygon. I deselected "Keep All Target Features" since I didn't want to show hexagons where there are 0 permits – this makes the base map visible in some locations which makes the map easier to interpret. The output was the hexagon FC New_Construction_Tesselation. Next, I used the **Summary Statistics** tool to count how many points there are in each hexagon. The Input Table was New_Construction_Tesselation, the Field was TARGET_FID, and the Statistic Type was Count. The output was a table called New_Construction_Statistics. Finally, I used the **Add Join** tool to join the count table to the original table. The Input Table was New_Construction_Tesselation, the Input Field and Join Field were TARGET_FID, and the Join Table was New_Construction_Statistics. The output was a modified tessellation FC that included a COUNT_TARGET_FID field that I then used to apply graduated symbology to.

To enable time properties, I set the Layer Properties of the permits FC to have a single time field for each feature, with the Time Field being Issue Year in format YYYY, and a Time Extent from 1/1/1999 12:00:00 AM to 12/31/2022 11:59:59 PM. In the Time tab, I then set steps to span 3 years. I chose to group years together instead of showing every year to ensure the animation wasn't too long but still showed a noticeable spatial change. Additionally, there are a total of 24 years, and 3 divides 24 evenly, so there was no bias in the animation. Finally, I created an animation by directly importing Time Slider Steps and adding an overlay to each keyframe with the years.

Results or Analyst Summary

Based on the spatial data from **FIGURE 4**, most of the points are clustered around the edges of the Kitchener boundary, with fewer in the central/downtown areas. Based on the choropleth data in **FIGURE 5**, the distributions become clearer. Most hexes in central/downtown Kitchener have between 1 and 15 new constructions over the time period and there are many empty hexes, while some areas have numerous hexes of 100-250 constructions clustered together. These clusters appear to be mostly focused in relatively new suburban developments in the following neighbourhoods/areas:

- Huron South, Rosenburg, and Williamsburg (southwest) – Represented by large, densely packed clusters with several 190-250 hexes grouped next to each other.
- Highland West (east) – Similar to the previous neighbourhoods, but is restricted to the east by the Grand River and is distributed more to the west as a result.
- Doon South and Pioneer Tower West (south) – Represented by larger but less dense clusters than the previous neighbourhoods, with fewer 190-250 hexes but more hexes overall.
- Grand River South (west) – Represented by smaller and less dense clusters than the previous neighbourhood, with a maximum of only 148-189.
- Bridgeport North (north) – Similar to the previous neighbourhood, but is restricted to the north and east by the Grand River and is thus less expansive.

In terms of temporal data gathered from **FIGURE 3**, we see that the number of permits issued in 1999 and 2022 is coincidently roughly the same, hovering around 800. However, there is significant fluctuation in this number over time. Permits increase from 1999-2005, where there's a max of 1625. Then there's a steady decrease from 2006-2013 with a min of 644. Next, there is a sharp increase to a high of 1368 in 2016, followed by an even sharper decrease in 2017 to 511, which is a ~63% decrease in just one year. Finally, the data is steady at around 800 permits for the last few years.

Discussion & Conclusion

As a whole, it is clear that new constructions in Kitchener over the last 24 years have been dominated by residential urban sprawl through the development of suburbs at the edge of the city. The lower density of developments in the middle of the city indicates that only small cases of infill development were constructed in the already moderately dense downtown. We also see that there were the most new constructions in the early 2000s. This may be due to the relatively large influx of new residents to the region in the late 1990s. There is also a large spike in 2016, which was "prior to the amending by-law for Transit and Waste Management coming into force for January 1, 2017" (Waheed, 2018). This indicates that developments can be largely driven by politics, and the city should be careful to consider these effects when implementing new by-laws.

In terms of trends over time, the data from **FIGURE 3** along with the corresponding animation allows us to see that there has been significantly less development in the suburban hotspots in recent years. The number of permits has been consistently low for the past 5 years, which could be due to the construction of denser residential buildings requiring only one permit for many units instead of one permit per single family home. Furthermore, the most intense development is near the center of each cluster, and not near the edges where the most recent development would be. Also, these trends have occurred despite the population of the region increasing by 50% during this time period, so demand for housing has not decreased.

Overall, this indicates that recent plans for the City of Kitchener are focused on reducing urban sprawl and instead implementing more sustainable, high-density housing. This kind of growth is essential for more efficient infrastructure and services planning, reducing negative environmental impacts of human settlements, and protecting the far future of residents in the region. By continuing on the same trend, Kitchener can ensure that these needs are being met. Furthermore, the city should also begin to think about other factors that become more crucial with a denser city, such as an improved public transit network, affordable housing options, and developing green spaces and public areas.

Appendices

FIGURE 1 – Flowchart

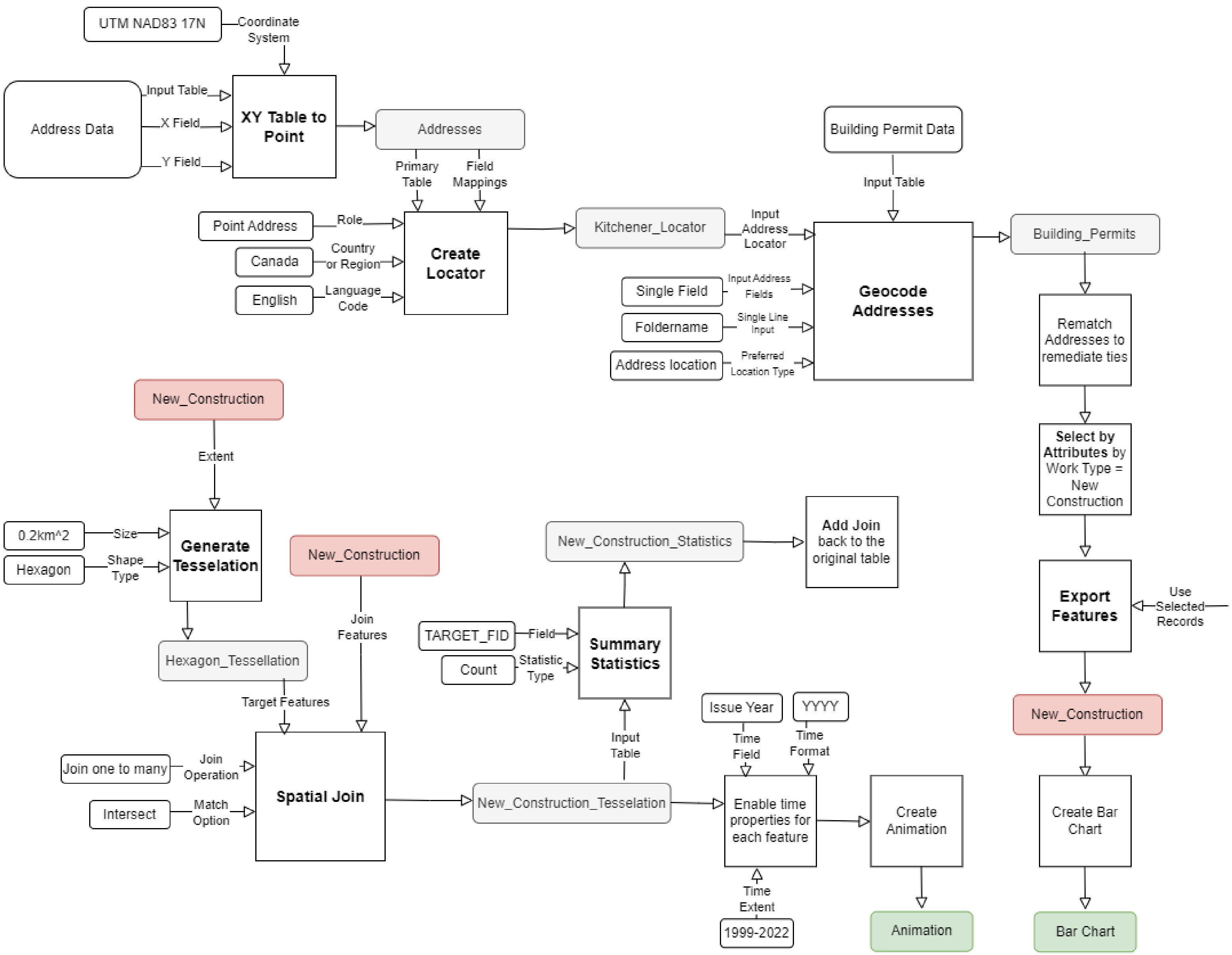


FIGURE 2 – Geocoding Success Table

Matched	Unmatched	Tied
65 694 (96.95%)	2063 (3.04%)	4 (0.01%)

FIGURE 3 – New Constructions by Year Bar Chart

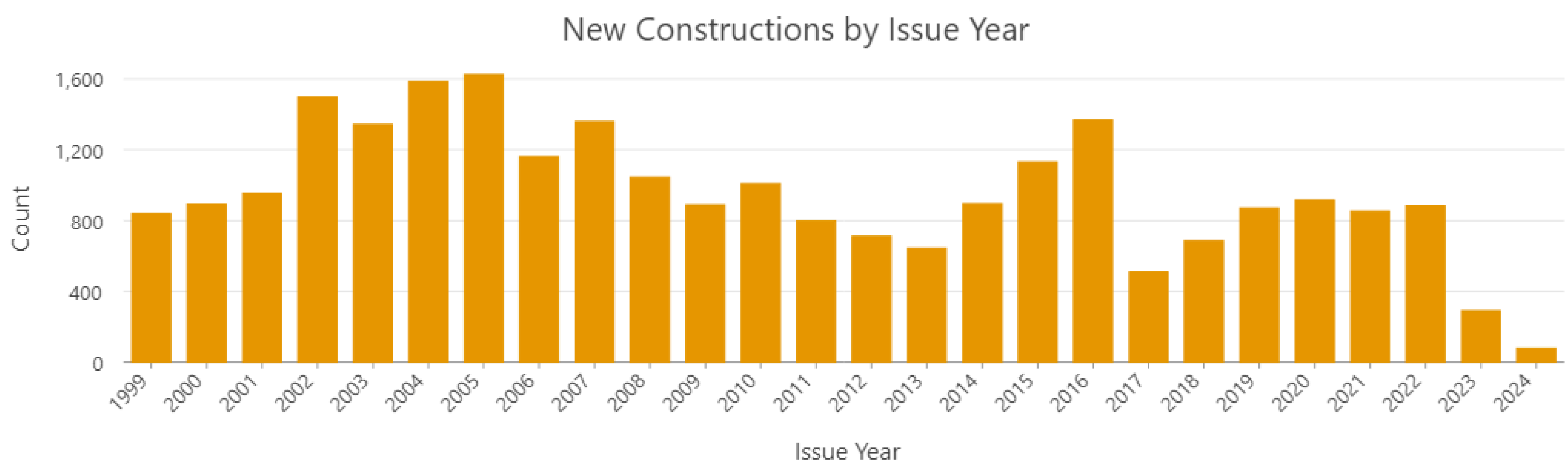


FIGURE 4 – Building Permits Point Map

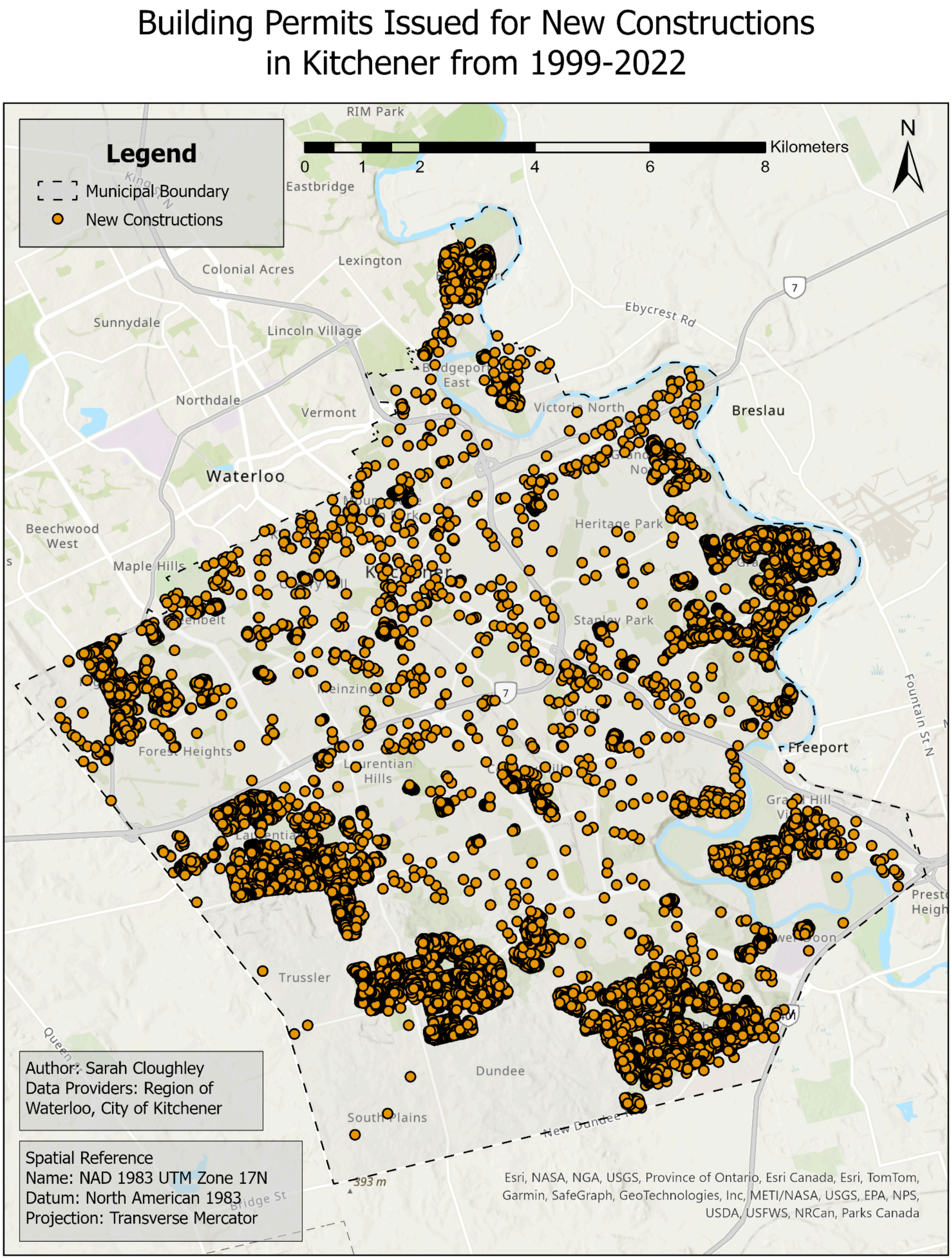
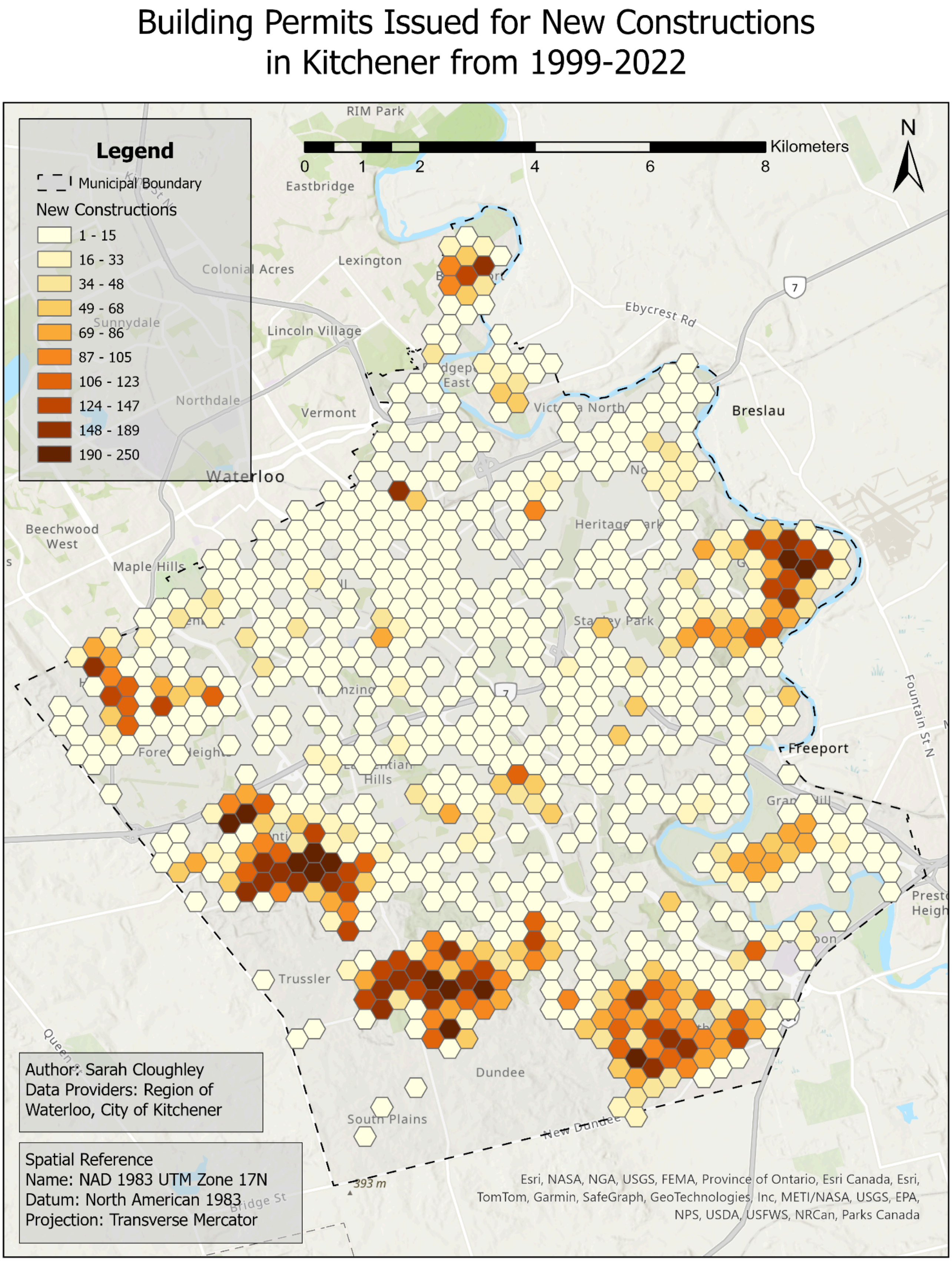


FIGURE 5 – Building Permits Choropleth Map



Reference

Waheed, R. (2018). *2017 Building Permit Activity and Growth Monitoring*. Region of Waterloo. https://www.regionofwaterloo.ca/en/resources/2017_Building_Permit_Activity_and_Growth_Monitoring.pdf