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GEOG 381 – Lab 103 – Assignment 1

Assignment 1: Serious Traffic Crimes in Waterloo Region in 2022

Introduction/Background

This report maps 2022 crime occurrence data from the Waterloo Regional Police Service (WRPS). To support better planning and response to serious traffic crimes in Waterloo Region, it will focus on 3 selected crimes (hit and runs, collisions involving fatalities/personal injuries, and impaired driving), analyzing their spatial distribution in relation to public transit and policing zones.

Study Site & Data

This analysis is being done in Waterloo Region, Ontario, Canada, which contains the major cities of Waterloo, Kitchener, and Cambridge, as well as several smaller townships.

The main data is sourced from the WRPS. This includes:

- **Crime occurrences in the region (2022)** – excel data from this site, by going to *Occurrence Data > Occurrence Data 2022*
- **WRPS policing zones within the region (2016)** – KML data from this site, by going to *WRPS Zone Maps > WRPS Zones*

The projection for both of these datasets is UTM NAD83 17N. In the first dataset, points are reported to the nearest street corner. The call type (in the *Final Call Type* field) for hit and runs, collisions involving fatalities/personal injuries, and impaired driving are 9520, 9530/9510, and 9570, respectively. Latitude and longitude data is stored in the *Geographic Location* field as a comma-delimited string, which needs to be separated. Additionally, this field contains null values that should be removed. Finally, there's a disproportionately large number of points at the WRPS Headquarters (200 Maple Grove Road), since all calls without a dispatch address were tied to this location.

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

- **Grand River Transit (GRT) routes (2023)** – shapefile data from this site

Methods/Process

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

The crime occurrences, WRPS policing zones, and GRT routes data all required preprocessing. The WRPS crime occurrences data was downloaded as an excel file. I removed unnecessary columns (all columns other than *Geographic Location* and *Final Call Type*) to slim down the size of the file and speed up processing times. To get rid of null data in the *Geographic Location* column (which were values of "0.00,0.00"), I filtered this column on this value and deleted the remaining rows. It was also necessary to split the coordinates into their own latitude and longitude columns. I did this by creating two new columns, X and Y. In column X, I used the equation `=VALUE(TEXTBEFORE(<cell with coords>, " "))` to get the longitude/X value. In column Y, I used `=VALUE(TEXTAFTER(<cell with coords>, ","))` to get the latitude/Y value. I then copied this equation for every row, and saved the sheet as a CSV. In ArcGIS Pro, I finally used the **XY Table to Point** tool to convert the CSV into a point polygon in my project geodatabase. The inputs were the CSV and fields X and Y, the coordinate system was UTM NAD83 17N to match the map, and the output was a point feature class called Total_Crime_Point.

The policing zones data was downloaded as a .KMZ file, so I used the **KML to Layer** tool to convert this file into a layer file in my GDB. The input was the data in .KMZ format and the output was a layer called WRPS_Zones.

To add the GRT Routes data to the geodatabase, I used the **Feature Class to Geodatabase** tool. The input was the GRT_Routes shapefile and the output was my project geodatabase.

To create new feature classes for each of the 3 specific types of crimes. I first opened the attribute table for Total_Crime_Point and used SQL to select entries equal to each FinalCallType field (9520 for hit and run, 9510 and 9530 and fatalities/personal injuries, and 9570 for impaired driving). I chose to combine occurrences for fatalities and personal injuries since there were not many fatalities and they're a similar concept but with different severity. Then, I used the **Copy Features** tool with the input being each of these three selections and the output being the point classes called Hit_and_Run_Point, Fatality_Personal_Injury_Point, and Impaired_Driver_Point.

To create the hexagon tessellation used in the choropleth maps, I used the **Generate Tessellation** tool. I chose the extent input to be equal to Total_Crime_Point data since this would cover only the necessary area. I chose a size of 0.5km^2 for each hexagon (which is roughly the area contained within Ring Road), since this struck a good balance between showing enough nuance between the numbers of occurrences in each hexagon while also not having too many hexagons. This gave each hexagon a diameter of ~850m, which I thought would cover a reasonable number of intersections in both the rural and urban areas present in the region. The output was a hexagon tessellation FC called Hexagon_Tessellation.

To join the occurrence data with the hexagon tessellation in order to apply symbology to it, I used the **Spatial Join** tool. The inputs were Hexagon_Tessellation as the target feature and each of the four point FCs as the join features. The join operation is One to Many since there are many points that can exist inside each hexagon. 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 crime points – this makes the base map visible in some locations which makes the map easier to interpret. The output was hexagon FCs for each crime grouping, called Total_Crime_Hex, Hit_and_Run_Hex, Fatality_Personal_Injury_Hex, and Impaired_Driver_Hex.

To analyze the number of crime occurrences in each policing zone, I used the **Spatial Join** tool. The inputs were WRPS_Zones as the target feature and each of the four point FCs as the join features. The join operation is One to Many since there are many points that can exist inside each zone. The match option is intersect since we want to join all points that intersect with each zone polygon. The output was hexagon FCs for each crime grouping, called Total_Crime_Within_Zones, Hit_and_Run_Within_Zones, Fatality_Personal_Injury_Within_Zones, and Impaired_Driver_Within_Zones.

To analyze the number of crime occurrences near a GRT route, I used the **Select Layer by Location** tool. I used each of the four point FCs as the input features and GRT_Routes as the selecting feature. For the relationship, I used within a distance of 10m, since the crime point polygon may not be directly on top of the GRT line polygon while still being on the same road. This ensured that I was still accurately joining relevant points, while not joining points on other roads (since a different intersection would likely be further than 10m away and thus would not be included). Since I was only interested in the raw number, I then opened the attribute table for each point FC and noted down the number of selected entries.

Results or Analyst Summary

There are three main police zones in Waterloo Region: North (Waterloo and northern townships), Central (Kitchener), and South (Cambridge and southern townships). The blue insets in my maps highlight Uptown Waterloo and Downtown Kitchener, while the green inset highlights Downtown Cambridge. The acronym "NOO" stands for "number of occurrences".

For total crime, **FIGURE 2** shows that 154 163 of 321 277 occurrences (48%) were on a GRT Route. **FIGURE 3** identifies the top five zones by NOO as S2 (13%), N6 (5%), C5 (4%), N5 (4%), and C4 (4%). In

the top ten zones by NOO, 4 are North, 4 are Central, and 2 are South.

For hit and runs, **FIGURE 4** shows that 1338 of 2143 occurrences (62%) were located on a GRT Route. **FIGURE 5** identifies the top five zones by NOO as S2 (7%), N6 (6%), C5 (6%), C6 (4%), and N5 (4%). In the top ten zones by NOO, 4 are North, 4 are Central, and 2 are South.

For fatalities and personal injuries, **FIGURE 6** shows that 1747 of 2617 occurrences (67%) were located on a GRT Route. **FIGURE 7** identifies the top five zones by NOO as S2 (7%), C5 (4%), C6 (4%), R2 (3%) and N6 (3%). In the top ten zones by NOO, 3 are North, 3 are Central, and 4 are South.

For impaired drivers, **FIGURE 8** shows that 594 of 856 occurrences (69%) were located on a GRT Route. **FIGURE 9** identifies the top five zones by NOO as C6 (6%), S2 (5%), N6 (4%), N4 (4%), and N2 (4%). In the top ten zones by NOO, 4 are North, 4 are Central, and 2 are South.

Discussion & Conclusion

Note that zone S2 is the one containing the WRPS Headquarters, which skews the data.

For hit and run, most occurrences were located in suburban zones. This is likely due to there being more chance for a collision than in rural areas, and less police presence or likelihood for a witness to the crime than in urban areas. There is also a hotspot around King Street near Laurier University, indicating that young adult students may be less likely to take responsibility for their actions than general citizens. Hit and runs are also very correlated around transit routes. This may be because an increased traffic and pedestrian volume as well as more complex driving environments can cause more collisions in general.

For collisions involving fatalities and personal injuries, most occurrences were located in zones around Highway 7 and 8. It is known that “speed kills” and these highways have many curves and complicated interchanges. There are also hotspots around Uptown Waterloo and Downtown Kitchener, where more students, pedestrians, and cyclists increase the likelihood of both a collision in general and a collision resulting in an injury or death. These occurrences are less correlated around transit than hit and runs, which may be due to lower speeds in general around GRT routes (required so that buses can stop safely and the ION can navigate the roads).

For impaired drivers, most occurrences were in zones with high student populations or urban areas, which is likely due to there being more bars and alcohol consumption here. There is a major hotspot near Laurier and Uptown Waterloo, where there are many university students. This demographic is typically able to drive and are known to consume large amounts of alcohol and other impairing drugs. These occurrences are also strongly correlated to transit routes. This is because large entertainment sectors and university campuses are often well-connected to the transit system.

In general, we see that compared to total crime, there is a much higher percentage of serious traffic crimes occurring near GRT routes. This is likely due to there being a higher population and traffic density in these areas as opposed to more rural areas not accessible by transit. WRPS should reconsider resource allocation for highly affected zones and hotspots. To combat hit and runs, the region could use better traffic control and law enforcement presence in areas with high public transit usage. For fatalities and injuries, the region could implement clearer traffic signals, improve lighting, and reduce speed on highways through the use of more speed cameras or speed traps. For impaired driving, public transit is already available in most places where impaired driving is occurring, so increased transit service during the late night/early morning or adding more patrols and DUI checkpoints in these areas could help. The WRPS can also create public awareness campaigns targeted at certain demographics, such as students, to help lower the number of serious traffic crimes.

Appendices

FIGURE 1 – Flowchart

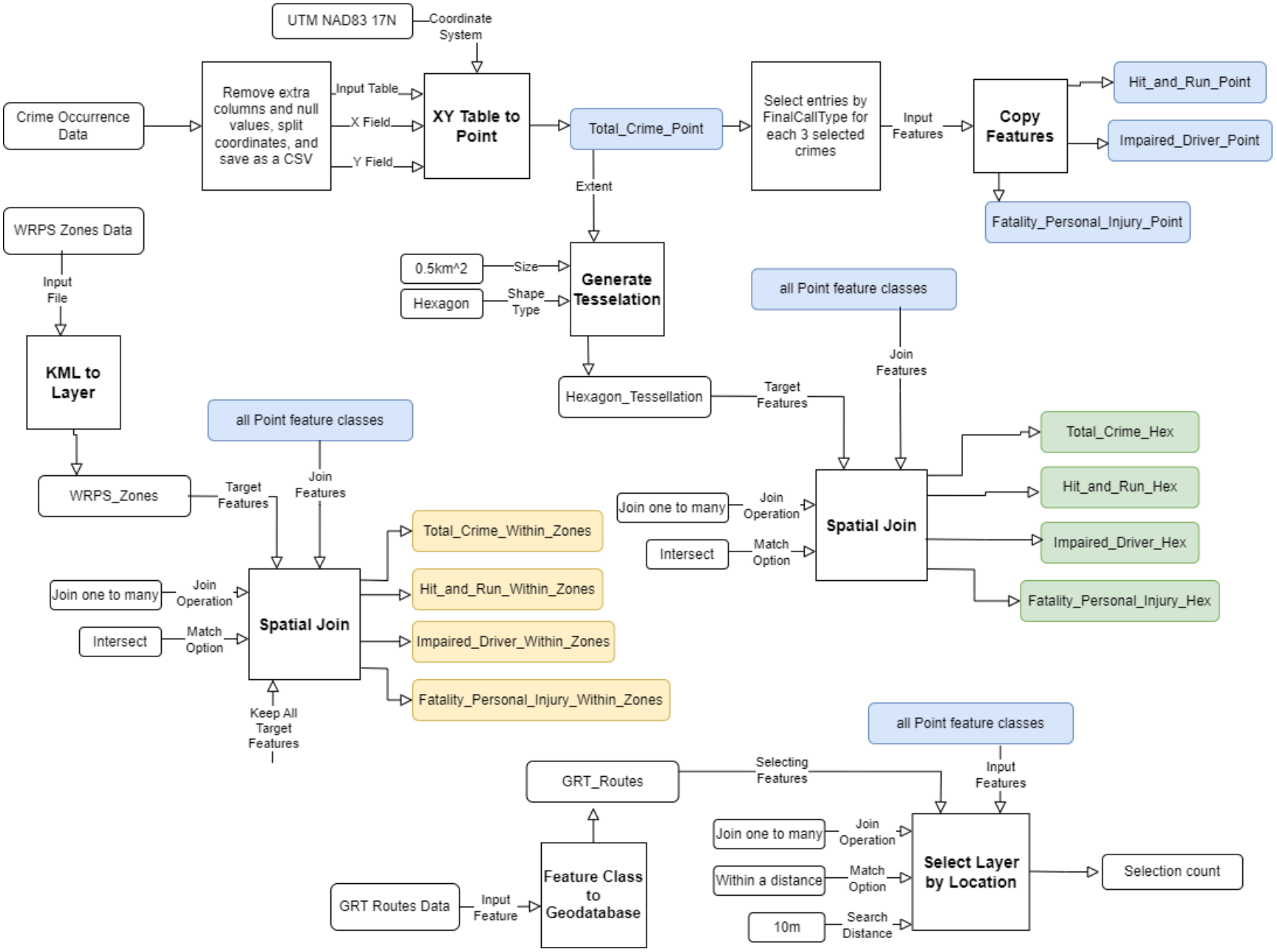

FIGURE 2 – Total Crime Choropleth

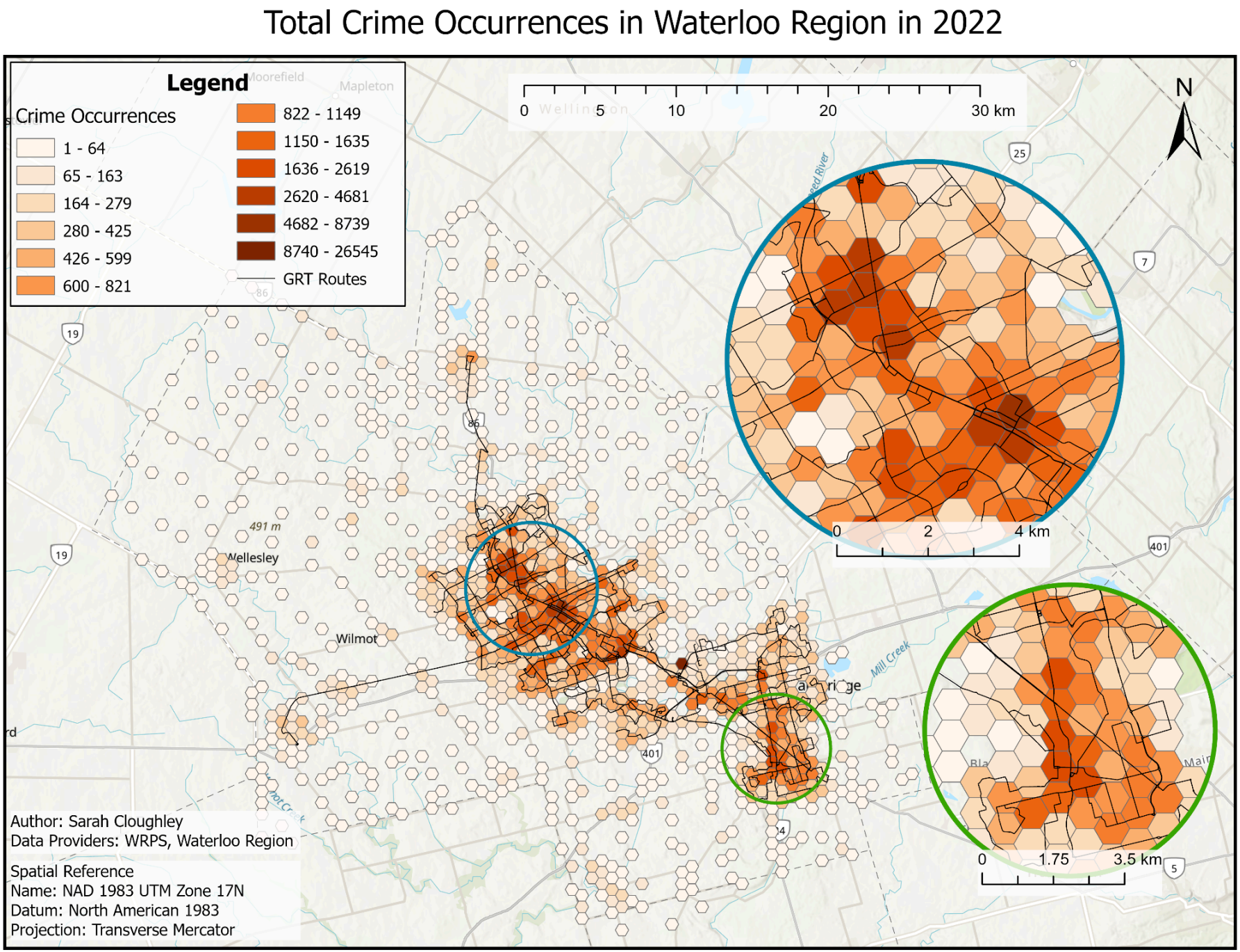

FIGURE 3 – Total Crime Graduated

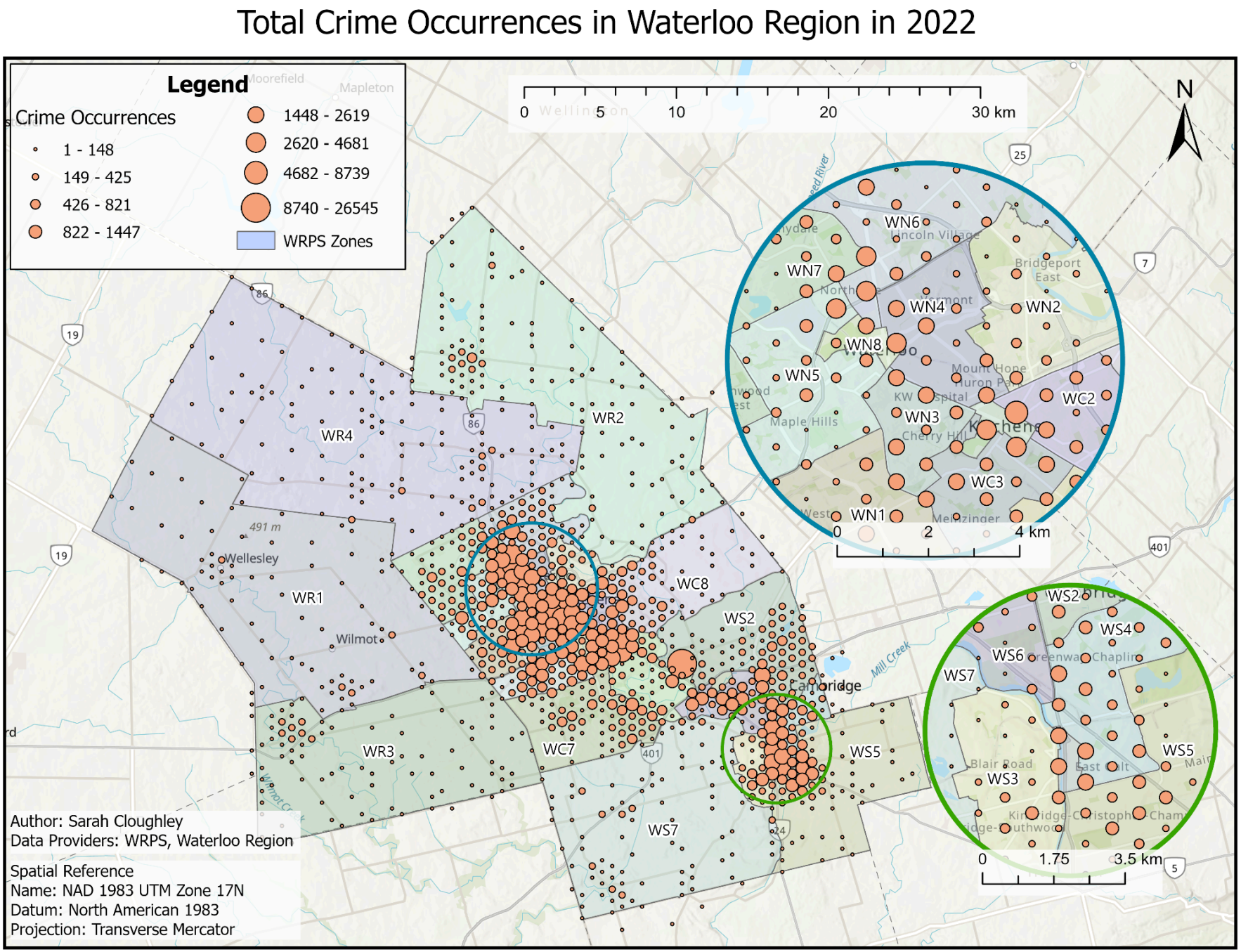

FIGURE 4 – Hit and Run Choropleth

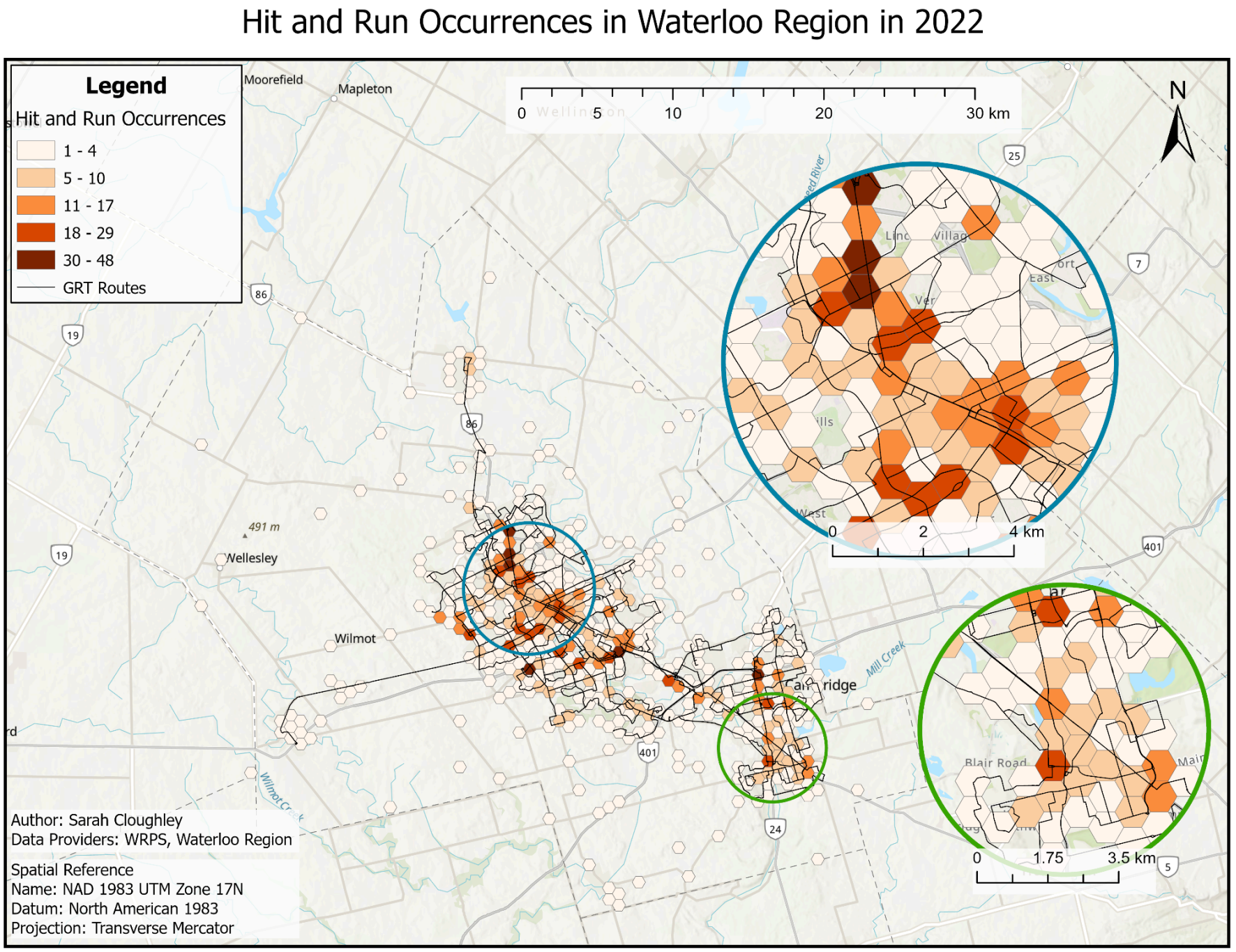

FIGURE 5 – Hit and Run Graduated

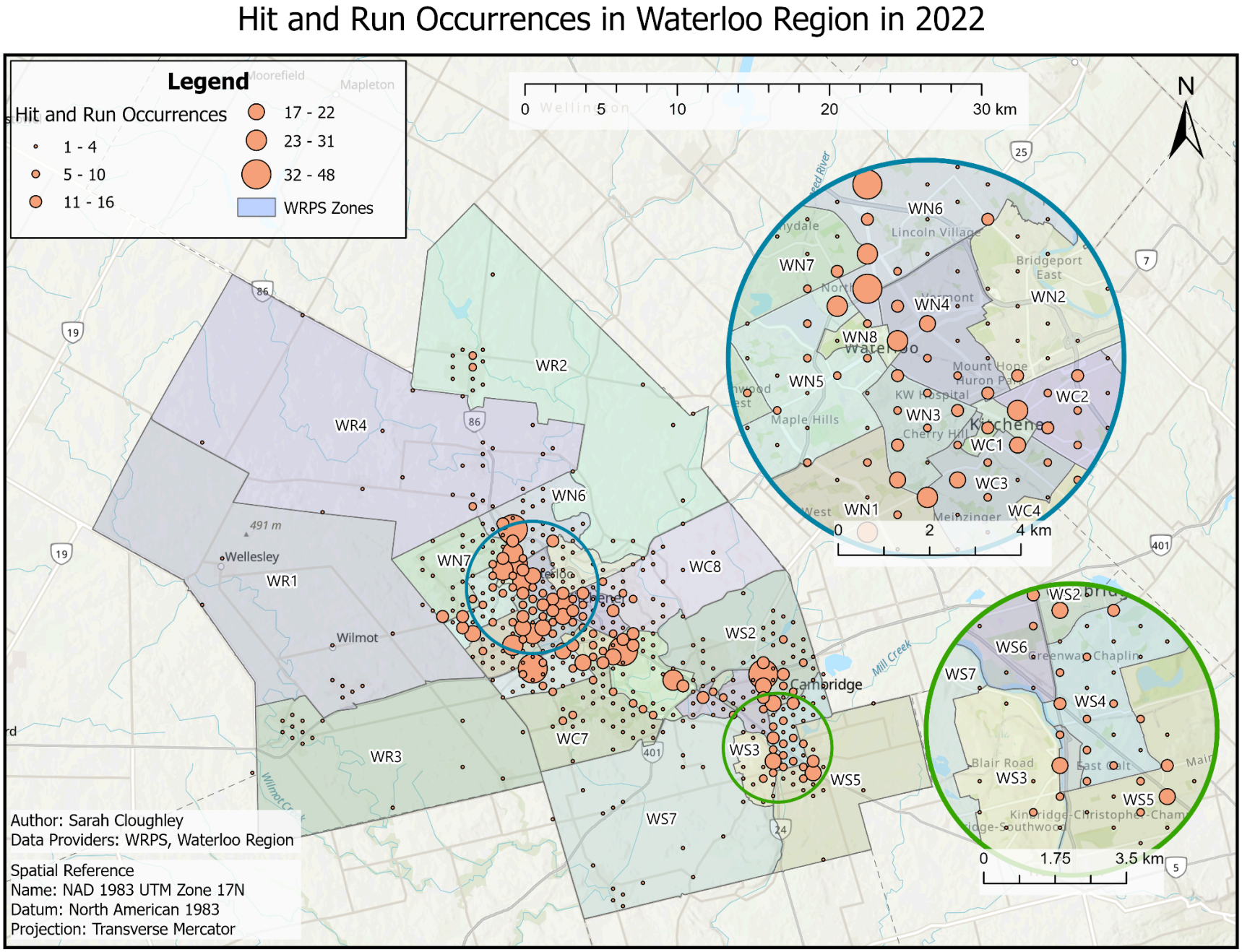

FIGURE 6 – Fatality and Personal Injury Collisions Choropleth

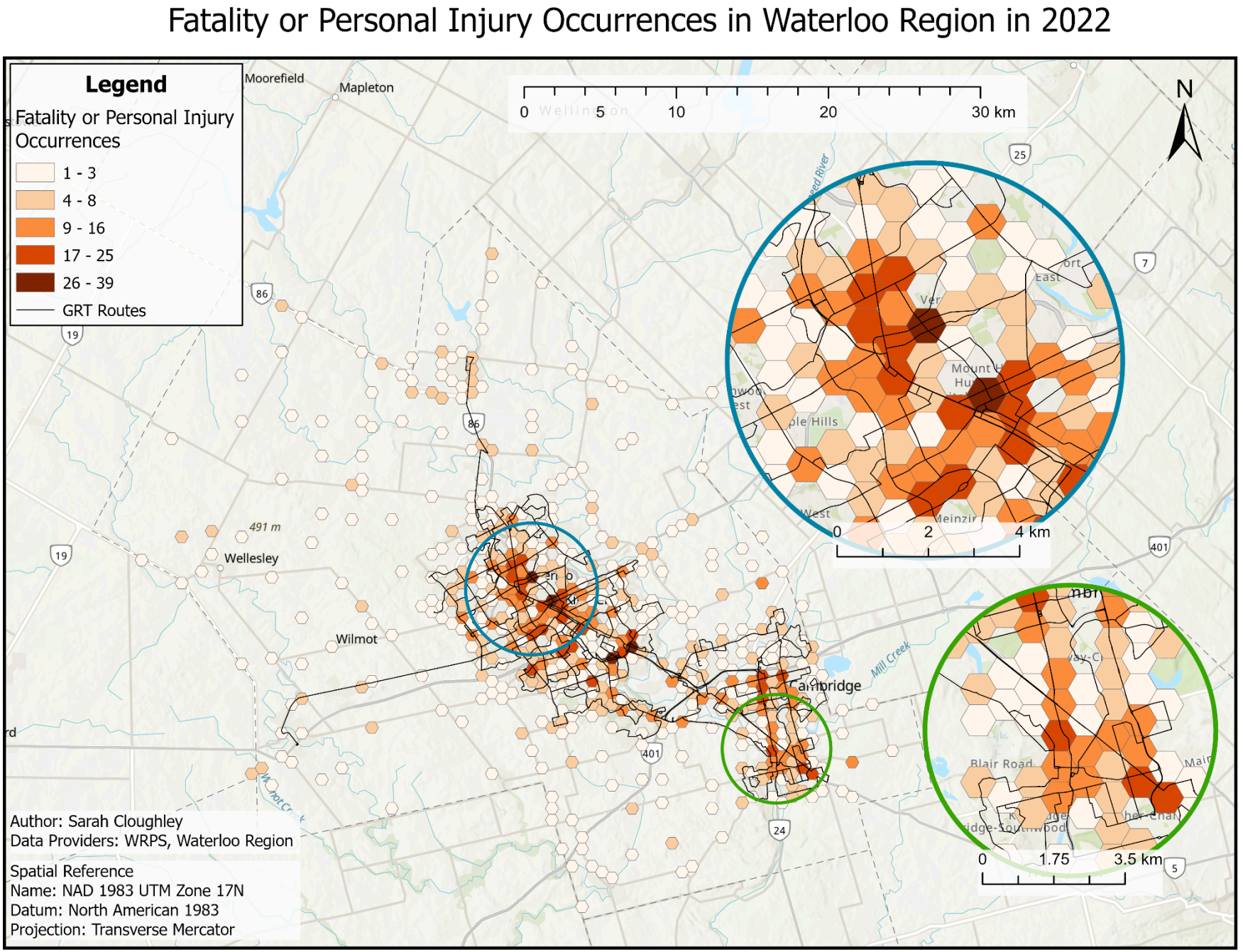

FIGURE 7 – Fatality and Personal Injury Collisions Graduated

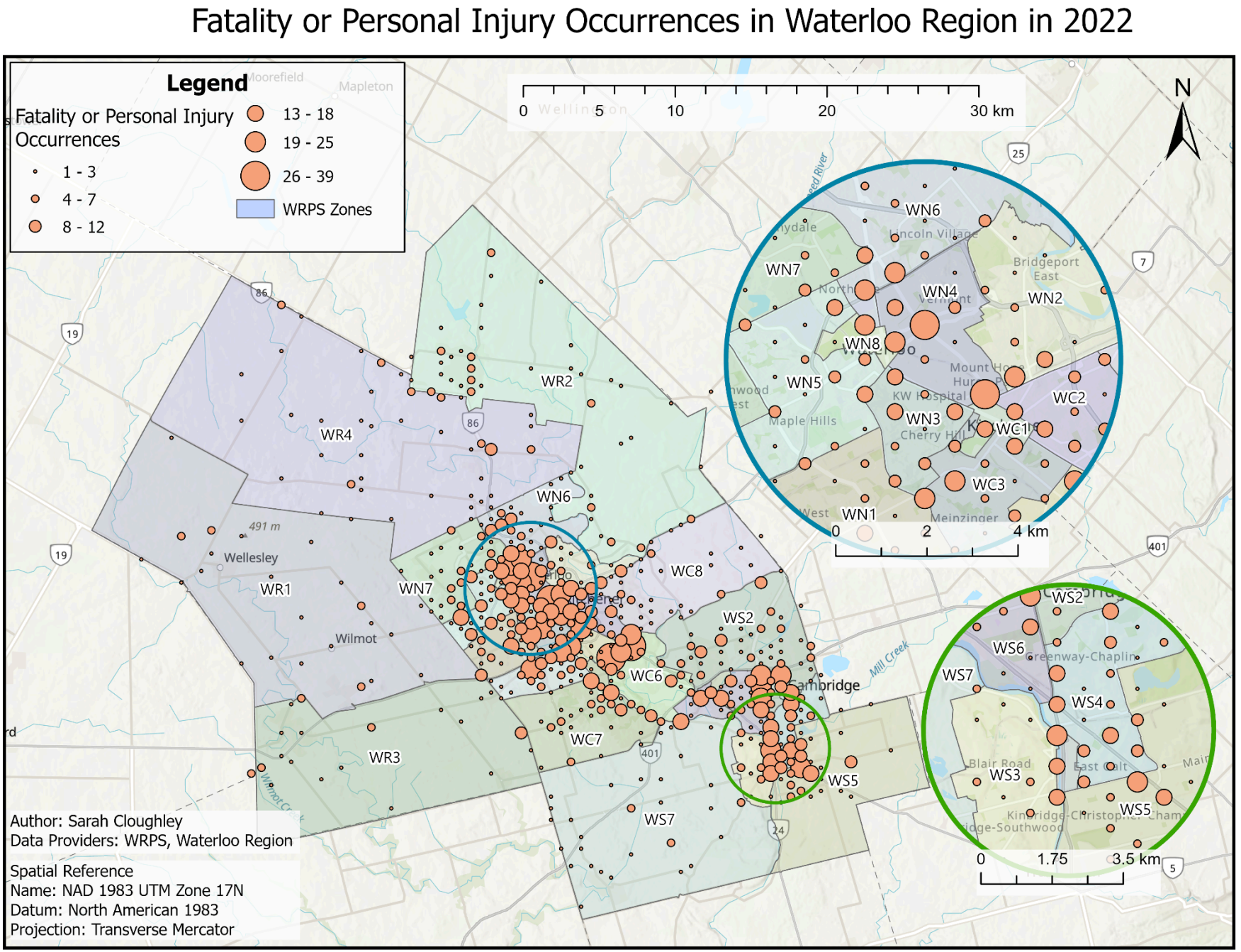

FIGURE 8 – Impaired Driver Choropleth

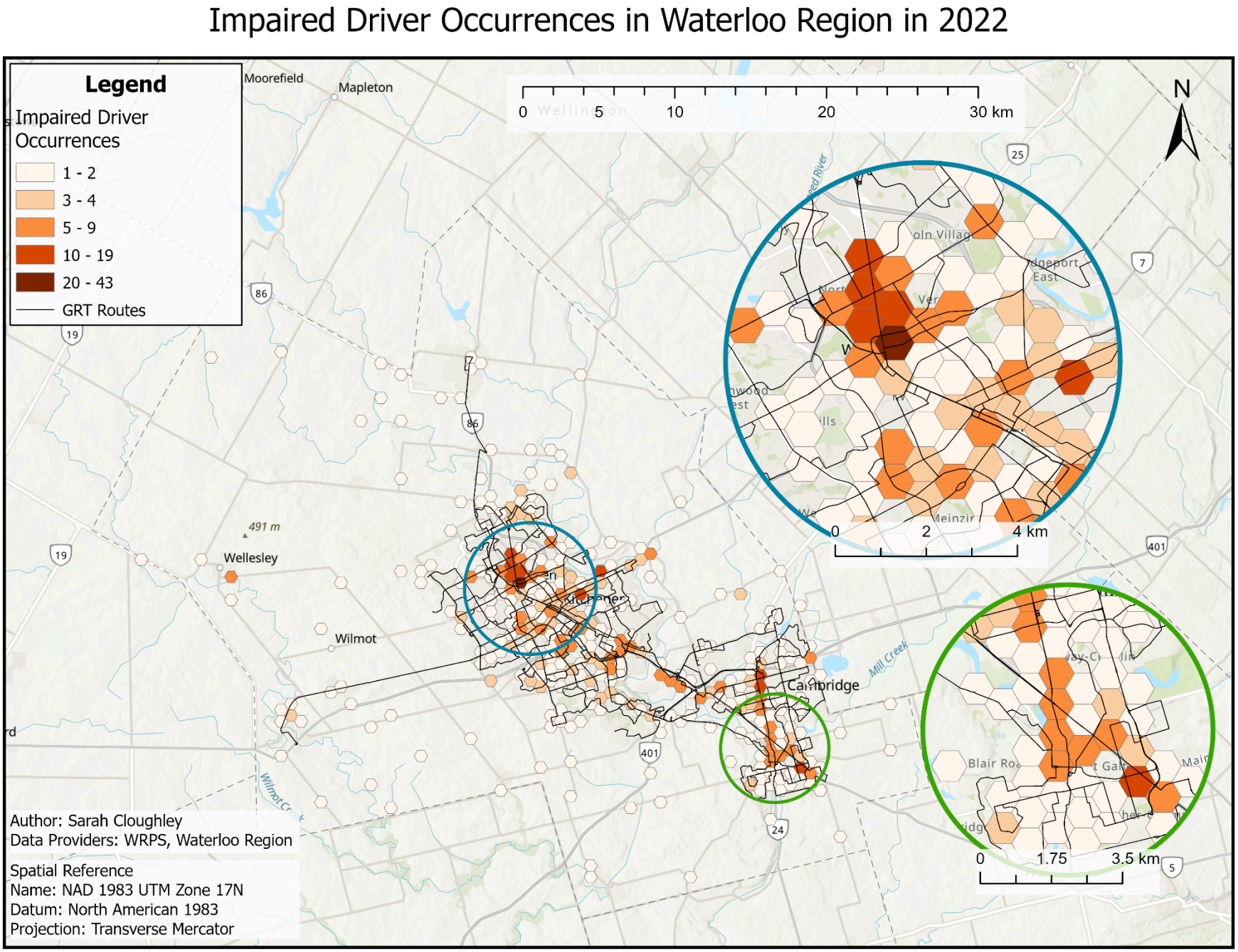

FIGURE 9 – Impaired Driver Graduated