Fire Hazards in Montreal: Evaluating the Risks and Preparedness

# Method

# Risks

# Preparedness

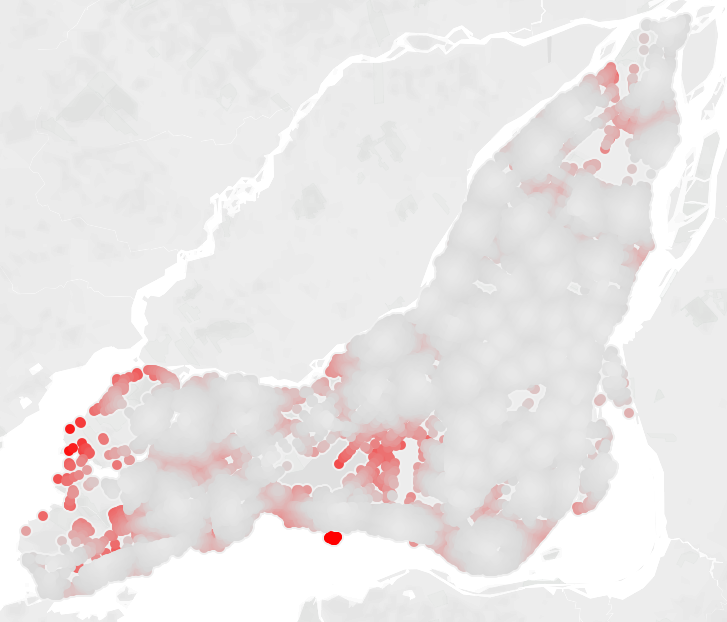
In the previous section it was detailed how the risk of fire incident can vary from area to area. In the following section the preparedness for a given area to respond to a given fire event will be evaluated in order to determine if there are areas that not only are at a high risk of fire incident, but also lack the ability to respond to such events.

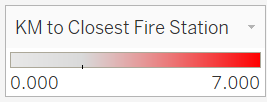
To evaluate the preparedness of the city of Montreal to respond to fire-related events the average response time to dispatch incidents must be evaluated. Given that the response time data is not released by the city of Montreal there is no golden source for this data. To overcome this issue graph theory was implemented.

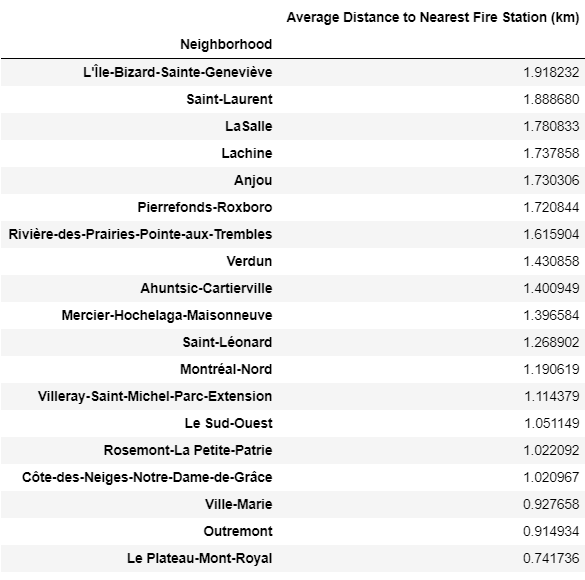
Graph theory is the study of graphs: mathematical structures used to model relationships between nodes via edges between successive nodes. The most common analogy graphs have to our everyday lives happens to be the application we are pursuing: modelling the distance between points on a map via roads. Given the city of Montreal has released their geobase dataset (a geospatial dataset linking all roadways in the city) we have what is necessary to begin our work.

### Approach #1: Minimum Distance to Fire Stations

Our initial (naïve) approach was simple: given we have graph data for every intersection in Montreal, we can calculate the minimum distance a fire truck would need to travel from the closest fire station to that point. To prepare the data the first task was to identify which nodes in the geobase dataset represented the points closest to the fire stations. Taking the Euclidean distance between each node and the fire stations from the fire stations dataset we effectively “snapped” these fire stations to our dataset. With this step complete we now needed to calculate, for every intersection (of which there are roughly 25 thousand), the minimum distance via road to the nearest fire station. This requires iteration through all 25 thousand nodes nested with looping through all 68 fire stations in Montreal. To calculate the shortest distance the data was cleaned into graph form and Dijkstra's algorithm for shortest paths was implemented to find the streetwise distance between the points. The weights of the edges between nodes considered was simply the distance in kilometres between the nodes (hence the naive approach).







As shown in the previous figure there is a range of travel distances from 1.92km average travel distance from Ile-Bizard to 0.74km in the Plateau. Anecdotally the close travel distance being smallest makes sense in the Plateau as this area has the largest population density in all of Canada. In this particular case the fire stations plotting have been planned well.

### Approach #2: Minimum Travel Time to Fire Stations

While the Naïve approach gives a good geographic estimate on fire response preparedness it does not take into account how traffic can affect the time it takes first responders to get to the scene. The metric that should really be minimized is the response time.

Starting from the naïve approach we have the travel distance between each node and which nodes are fire stations. To enrich this data we amassed free-flow traffic data from TomTom. TomTom Automotive supports a developer pack which allows you to call their API with a given coordinate pair and it will return the average free-flow traffic speed close to that point. With this information we can take the edge data from our graphs and divide the distance between each node with the average free-flow travel speed at that point – giving us the free-flow travel times between these two nodes. Obviously this approach doesn’t mimic the travel time taken by fire fighters exactly, but its certainly a decent proxy. With our data assembled we can run the iterative approach described in the naïve solution substituting minimizing travel distance with travel time.