Arbutus Line

Feasibility Study of Transit along the Arbutus Corridor

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December 3, 2019

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Abstract

In 2016, the City of Vancouver and Canadian Pacific Railway (CPR) reached a deal for the city to purchase land surrounding the Arbutus corridor, including the inactive railway tracks. As part of the deal, the city committed to dedicate part of the corridor for light rail, in addition to expanding Vancouver's cycling path network. This project will serve as a transit corridor feasibility study using the route of the existing CPR tracks as a guide for the proposed alignment of an Arbutus rail line. Using a set of predetermined conditions and factors, we were able to determine the optimal location for 14 stations to be constructed along the line. With this information, we used an average walking distance to create a zone of activity radiating outwards from each station that included points of interest such as schools, libraries, and community centres. Additionally, by overlaying population data and density information for dissemination areas in the line's vicinity, we projected which stations could potentially see higher passenger volumes. The analysis of the resulting five maps thus allowed us to project the potential routing of an Arbutus transit line, the populations it can serve, and services and amenities that could be accessed.

Description of Project, Study Area, and Data

Congestion in Vancouver has continued to increase year after year, with solutions difficult to come by due to the city's unique geographical constraints and political considerations. The Arbutus Corridor was first considered as a potential route for transit development in the early 2000s during alignment research for the SkyTrain Canada Line. It was dismissed however due to its then-lack of attractive destinations for riders and a greater travel time from Downtown to the intended terminus at the airport. The corridor, still under the ownership of CPR, was intended to be broken up and sold to various developers, and a prolonged dispute between Canadian Pacific and the city ensued for over a decade as Vancouver fought to have the land retain its designation as a protected transportation line. In 2016, the city finally acquired the corridor from CPR for $55 million, and stated its intention to convert the area to greenspace and bike paths. As part of the agreement with CPR, provisions are in place to allow an upgrade to streetcar or light rail in the future.

For our transit feasibility study, the project focus area was the Arbutus land corridor in Vancouver and its surrounding neighbourhoods. The ultimate goal was to create a potential routing for an Arbutus transit line along with optimal locations for station and stop placement. From these locations, a buffer zone of 400m created radiating outwards from each station would include attractions and points of interest within a predetermined average walking distance.

Large portions of the land and population data was acquired from Statistics Canada through the Canadian Census Analyzer and Canadian census shapefiles on the Abacus Dataverse Network, while more specialized Vancouver information such as neighbourhood boundaries and city facility locations was acquired from the City of Vancouver's Open Data Catalogue. Additional data such as transit lines and bus routes was sourced from the UBC Geography Department's data servers.

Methodology of Analysis

To ensure a comprehensive overview of the corridor and relevant important information, we deemed it necessary to create five final maps to clearly show the final route alignment, the availability of public facilities and amenities within station walking distance, and the population density of areas in proximity to the proposed transit line.

Acquiring Data

All five maps share the same base land data, featuring the municipal boundaries of the City of Vancouver as outlined by the borders of Vancouver's dissemination areas (DA). The dissemination area information was taken from the Canada Census 2016 DA shapefile, which contained DAs for the entire country. From the Canadian Census Analyzer, we acquired a dBase database file that included population counts and areas (in square kilometers) for each DA in the country. This was then joined to the Census DA shapefile using a shared attribute (DAUID).

Each map also shared several common base layers, which were the proposed Arbutus line, the routes of the existing SkyTrain lines, and the road network. The SkyTrain lines and road networks data are from shapefiles in the UBC Geography Department database.

The proposed route of the Arbutus line was created by first taking a City of Vancouver shapefile containing historic railway data and overlaying onto each map.

Parsing and Filtering Data

The shapefile containing the DA information included data for all of Canada, far beyond what was needed for the project. This shapefile was queried by attribute to select only the DAs that matched to the Vancouver Census Subdivision name. This would serve as the base layer for each map.

The SkyTrain lines were each added to the maps and clipped to the boundaries of Vancouver's neighbourhoods. The alignment of the Arbutus corridor follows the tracks of the historic CPR railway that runs from north to south along Arbutus Street in Vancouver, before turning to the east near Marine Drive and continuing into Burnaby. Using the editor in ArcMap, we split this railway at the intersection of the line at Marine Drive and Cambie Street, to serve as the proposed southern terminus of the Arbutus line and facilitate hypothetical connections to the nearby Marine Drive SkyTrain station. The "Neighbourhoods_Selection" shapefile that was used as our project boundary for the proposed Arbutus line was taken from a select by location of the six neighbourhoods that intersected the Arbutus line stations buffer. By doing this we clipped many of our shapefiles to this boundary to condense the data to our focus zone.

The first two maps, "*Potential Arbutus Line Stations by Major Roads*" (Map 1) and "*Potential Arbutus Line Stations by Bus Routes*" (Map 2) showed the route's potential alignment and optimal station locations. We determined that detailed DA information was not necessary to be shown as neither population nor area data was being used, therefore, we dissolved the DAs using their Object ID numbers to create a solid single area region for Vancouver. The bus routes and road network were clipped to the Vancouver boundaries and added to the map. Roads were then further queried by attribute to select for only major roads, as we decided that minor roads and lanes were likely to be visually distracting.

The third map, "*Potential Arbutus Line Stations by Public Facilities of Interest*" (Map 3) was created to show access to public facilities and amenities in proximity to the Arbutus line, and was built upon the existing route and stations of the first map. New shapefiles from the City of Vancouver were added to the map and included data for the locations of community centres, parks, libraries, and schools. The parks polygon file needed to be clipped to the Vancouver boundaries after being added to the map.

The fourth map, "*Population Density of Neighbourhoods near Arbutus Line*" (Map 4), was designed to show population densities in relation to the overall route of the proposed Arbutus line. The DAs in this map were clipped to the boundaries of the neighbourhoods that surrounded the Arbutus line in order to remove unused data in other parts of the city, thus only showing population data for the neighbourhoods adjacent to the route.

The final map, "*Optimal Arbutus Line Stations*" (Map 5), took the data from three maps: Map 1, Map 2 and Map 3 to visualize the overall zones of potential interest within the reach of stations on our proposed Arbutus line project. No further data was filtered at this time.

Mining and Analyzing Data

From Map 1 and Map 2, a new shapefile layer was created. With this shapefile, we created points on the Arbutus line at intervals of 800m. This point shapefile, "*Arbutus_stations*", was used as a basis to create a buffer of 400m around each point. From here, we used the buffers to create two more shapefiles: one for buffers which intersected with bus routes, and one which intersected with major roads in Vancouver. These two shapefiles were then intersected to create a final station layer, and points were added to represent these stops. This was overlaid on top of our edited Arbutus line to create the final alignment of the route.

For Map 3, we reused the buffers previously featured on our last two maps, and placed them into a dataframe that consisted of points of interest within our neighbourhood boundary. With this, we used the buffers to select for location based on our points of interest. By using select for location to query for buffers that had any of these points within its borders, this resulted in a new shapefile based on this data.

In Map 4, the Vancouver dissemination areas were shown in their entirety, in addition to the overall route of the Arbutus line. Using the neighbourhoods previously selected in Map 3, each DA within these areas was symbolized by population count and then standardized by area (square kilometers).

Representing Data

All of our data layers were projected to the NAD 1983 UTM Zone 10 projection for uniformity. Colours were chosen to be associated with their represented items as much as possible (i.e., dark blue for SkyTrain Expo Line, green for park areas, etc.). For Map 1 and Map 5, the entire extent of Vancouver was used to show the Arbutus line in relation to citywide transit and traffic connections. For Maps 2, 3, 4, we narrowed our focus to the neighbourhoods in the vicinity of the Arbutus line, as the analysis here involved more detailed geographical information. Data from other areas of the city was not relevant to these maps and therefore removed or reduced in importance.

For Map 5, we compiled all the layers together to show the optimal station placements relative to our important conditions: bus routes, major roads, and facilities of interest. We did not use a basemap within our project as it was not relevant to the data analysis we conducted. Area was not our focus, rather it was where certain services and facilities of interest laid within our project boundary.

Discussion and Results

From the beginning, one of the most important foundation pieces for this study was the path that the proposed Arbutus transit line would follow. This was determined using the routing of the historic Canadian Pacific Railway tracks running parallel to Arbutus Street. As a base, we placed our northern terminus at the natural end of the rail track, just west of Granville Island under the Burrard Street Bridge. For the southern terminus, we selected the area where the tracks intersected Cambie Street in south Vancouver, just north of the Fraser River. This was chosen due to its close proximity (approximately 400m) to the Marine Drive Canada Line SkyTrain station and bus exchange, allowing for ease of transit connections.

To determine proposed locations for stations, we followed recommendations from both TransLink[1] and planning and transit consultant Jarrett Walker[2] which suggested that, service-dependent, the optimal spacing for stations is somewhere between 300m and 1500m, depending on the speed and frequency of the service. We settled on a distance of 800m for spacing between our stops, and have proposed locations for 14-15 total stations along the line. These points are reflected in Maps 1, 2, 3, and 5. This initial placement method is dependent on distance between stop locations, and does not consider any other variables such as population or nearby attractions and amenities. It is important to note that it is highly unlikely that the final routing for the Arbutus line would include every station that we have placed. To choose the most optimal stations, we must consider factors such as road and transit connection, accessibility to nearby services and amenities, and population densities in adjacent areas.

It is also important to take into consideration the technology type that will be serving the line when constructed. As indicated by TransLink, rapid transit-type service such as light rail and metro akin to Vancouver's SkyTrain is best served by stops with larger gaps ranging from 800-1500m. Conversely, express buses and trams (with smaller capacities and footprints) are better suited to shorter distances between stations, ranging from 300-800m[1]. We should also note that the pre-existing railway which runs through the Arbutus corridor has been bought by the City of Vancouver, although the actual physical track no longer exists in many areas along the route. Depending on the city's needs, the existing railway portions may be used, or the line may be taken underground in newly constructed segments. In this study, we assumed a 2-D visual concept of the Arbutus railway; it is up to the municipal government and TransLink to determine if they prefer to keep the line above ground, elevated, underground, or a combination of these methods.

The first factor considered for station placement was connections to major arterial roads, as shown in (Map 1 and 2). Each station is buffered by 400m radiating outwards to indicate the acceptable walking distance that an average commuter would be willing to walk to reach nearby attractions and services[3]. Using this buffer around each station, almost every stop has ample

[1] TransLink, 2018
[2] Walker, 2010
[3] Walker, 2015

connections to major roads, except again for the 10th potential station heading southwards (see Figure 1), which has no major roads within 400m. The idea behind selecting major roads as our first condition is to potentially alleviate congestion within this area. Getting more people to take public transit will help to decrease the number of cars on the road in the vicinity of the Arbutus corridor. Showing the general public a map of the route and the major intersections and roads intersecting the line may help to sway the public into considering the Arbutus line as a viable alternative to driving. Understanding where the major roads in the area intersect the Arbutus line also helps in uncovering areas where traffic flow may be an issue that would conflict with a non-separated rail system that interacts with road vehicles. Where necessary, traffic patterns may have to be modified to accommodate the introduction of a light rail or tram so as to not disrupt existing vehicle movement, something the Arbutus line would hopefully help to alleviate.

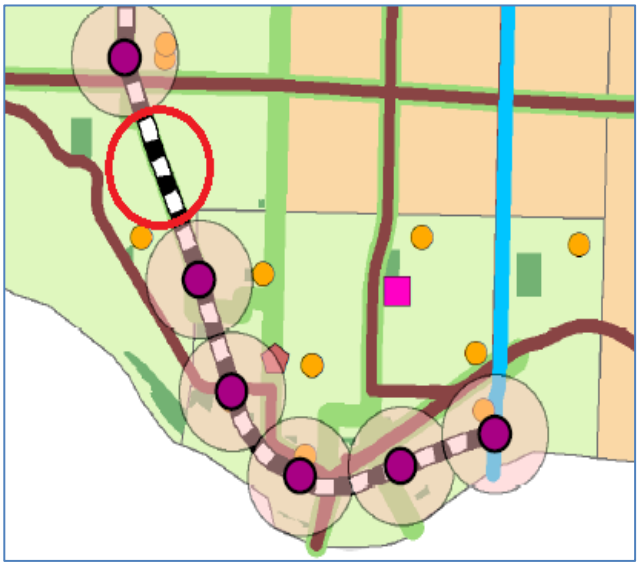

Figure 1 - Red outline of the potential 10th station at West Boulevard and 54th Street (retrieved and clipped from "Optimal Arbutus Line Stations")

Vancouver's bus network in relation to the Arbutus line and existing rapid transit lines is shown in Map 2. Using the same 400m buffer as in the first two maps, we can see that all stations along the Arbutus line would have easy access bus connections within a 400m radius. While this makes it easier for bus users to catch a ride on a potential Arbutus transit line, it has the potential to increase congestion in certain areas due to an increase in competing rail and auto traffic. This is why, as stated earlier, our points are only meant to serve as a guideline for optimal station placement once all other factors are considered. After existing rapid transit lines (Canada Line, Millennium Line, and Expo Line) were added onto this map, we noticed that the Canada Line took almost parallel route to the Arbutus line until it eventually connected with it at the southern terminus station. For users living in the area in between these two lines, this could result in some inefficiency and duplication of service as both services would be stopping at similar east-west crossroads.

The third factor to consider was the public facilities of interest within an easily reachable distance, including parks, schools, community centres, and libraries. We chose these areas as they are readily accessible and would likely have high levels of activity. This would allow us to better understand the area in which we are proposing to build the Arbutus line and let us see the potential user groups. Our results show an abundance of schools within the 400m buffer around the stations, with 10 schools directly inside our buffer and 46 schools in total within the selected neighbourhoods. Parks, community centres, and libraries were spread evenly throughout the line, and with a proposed rapid transit connection that would allow for easier access to these facilities, may see potential increased usage as well. These results are important for the City of Vancouver to consider as upgrades may be needed at facilities to accommodate the increased level of activity, and may even require planning for new facilities in the area if demand is great enough. When planning for future facilities, it would be helpful to consider the lack of community centres and libraries around the central part of the line. This could be due to the fact that the population spread is less dense within this area, which we discuss in the following section, but could be a key region to redevelop with more public facilities now that they would be more accessible through a potential Arbutus line.

The population densities of neighbourhoods surrounding the Arbutus line is the fourth variable to consider in station placement. During our analysis, we found that the Arbutus line would link two high density areas of population (see Figure 2). In Map 4 showing population density per dissemination area, we could see concentrated areas of both high and low-density population along the existing Arbutus Greenway. This allowed us to see the potential residential dwellings that could benefit from the creation of an Arbutus transit line. As this data was being prepared for both the City of Vancouver and TransLink, we would hope that in the event that the Arbutus line were to be fully developed and built out, that this population map may be used to help determine which areas would be in most urgent need of a station. This data could also be used to predict which stations would need to be designed to accommodate for a large flow of daily commuters. During our analysis of the area's population, we also noticed that there were many areas with noticeably low density. With the city beginning to more openly embrace the emerging trend of higher density housing replacing lower density, the proposed Arbutus line has the potential to help stimulate future transit-oriented developments within the area.

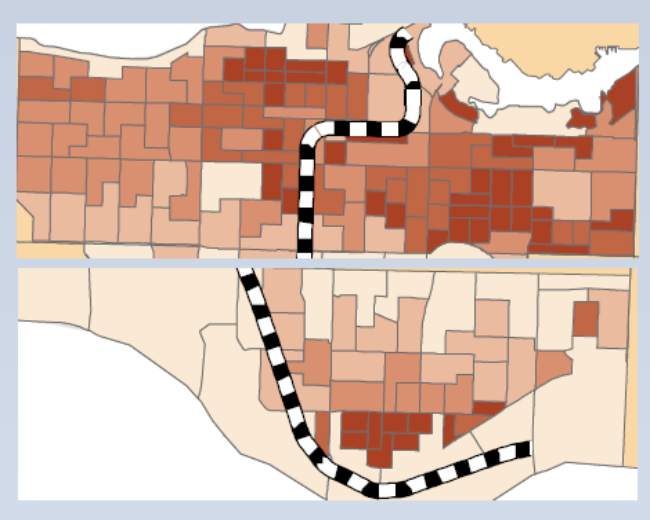

Figure 2 - Density of Broadway (top) and West 70th (bottom) (Retrieved and clipped from "Population Density of Neighbourhoods near Arbutus Line)

Our final map was created to consider the first three factors on a wider scale level. By overlaying the maps created by these factors, we could visualize the overall greater impact that the creation of the Arbutus line could result in. Previously we saw how the Arbutus line and its potential 15 stations separately connected to the major roads, bus routes, and areas of interest within its 400m walking distance. However, by overlaying all of the data onto one map, we could see how many of the points of interest outside of the buffer were also connected by either the bus routes or major roads also within the neighbourhoods around the Arbutus corridor. For areas to the west of the proposed Arbutus line, less distance would have to be travelled to travel to Marpole in South Vancouver, Downtown Vancouver, Richmond, and the airport via connection to the Canada Line. As commuters would now have to travel shorter distances to reach a faster rail transit system, users might have a greater inclination to visit and travel to these places.

Error and Uncertainty

There are a number of potential sources of error and uncertainty throughout this study. To begin with, due to a lack of readily available up-to-date data sources, the bus connections shapefile is from 2010. While there have been minor adjustments to the paths and names of some bus routes since then, in general these changes are not significant enough to introduce any kind of measurable uncertainty in our connections map. As for the road network of Vancouver, our selection of major arterial roads was based on the classification used in the data attribute table in our shapefile. However, it is possible that there may be some roads classified as minor-type that in fact serve as important and busy collector roads, and could offer just as much traffic connectivity as major roads. These would have been overlooked in our analysis as we have only chosen those major roads as designated by the City of Vancouver and CanMaps.

Another variable that was not factored into our study was elevation data of the areas along the Arbutus corridor. It is possible that an increase in slope elevation radiating outwards from the proposed stations would reduce the average walking distance that people would be willing to tolerate. On a related note, we also did not consider the demographics of potential riders of the Arbutus transit line, and whether certain population groups may be inclined to walk shorter or longer distances from stations to reach services and attractions.

There is also a level of uncertainty in the exact locations of our proposed stations and whether they are actually physically feasible at these points. Our station spacing has been determined using a distance based on recommended averages based on previous studies and research, and therefore does not take into consideration the surroundings and existing structures at each site. Locations labelled as potential station points could be physically unfeasible for construction, or already be occupied by other buildings. In the latter case, this would present additional challenges, such as securing land appropriation deals or negotiating right-of-way permissions from property owners.

As well, it is important to consider the zoning classifications of the areas where our proposed stations are located. During our study, we did not differentiate whether our stops were located in commercial or residential neighbourhoods. Residents and businesses may have different levels of tolerance for factors such as increased foot traffic and noise from a potential transit line running through their neighbourhoods. Noise levels from other transit lines have proven to be a particularly contentious issue in the past[4], and community concerns have the potential to force changes to the routing of the Arbutus line or the locations of its stations.

[4] Gold, 2019

Further Research and Recommendations

There are several avenues of opportunity for further research from the outcomes of this study. With the locations of potential stations now identified, this can be taken to further consideration with the maps presented. It must be noted, that what these maps are presenting are potential locations of stations, and by no means is the final area in which these stations should be implemented. Further research could be made in these variables:

1. Buildings and surrounding areas of the Arbutus line: An environmental assessment of the procedures for the Arbutus line's construction and implementation should be conducted to ensure any disruptions to the environment and biodiversity in the future are minimized.
2. Technology case study: As we never defined a specific kind of transportation method, it is important to investigate how different kinds of transportation technology could affect the performance and efficiency of the Arbutus line.
3. Line implementation and efficiency: Depending on technology, would it be faster to take the Arbutus line to get to a destination, or would it be faster to ride the bus to another connecting faster rapid transit system? This would be an interesting angle to study for transit planners.
4. Demographics of users and surrounding areas: By acquiring more data regarding businesses that surround the Arbutus line as well as the demographic of citizens who live in neighbourhoods around the Arbutus line, a further study on the inclination and incentives to use the Arbutus line could be viewed. This works into variable 2 as well.
5. Station location: Our study presented a map of potential stations, but due to the curvature of the Arbutus line, many of the buffers became overlapped. Future studies may take this into consideration and, by combining this with additional surrounding location data, may reduce the number of stations needed along an Arbutus transit line.

With this report, we are presenting to the City of Vancouver and TransLink our findings regarding the feasibility for the implementation of a potential transit line running along the Arbutus corridor using existing rail infrastructure. Our recommendation is for future planners and researchers to take into consideration the data presented and visualized here to help conceptualize the route and stations of an Arbutus transit line, if or when it is created.

Appendix I - Works Cited

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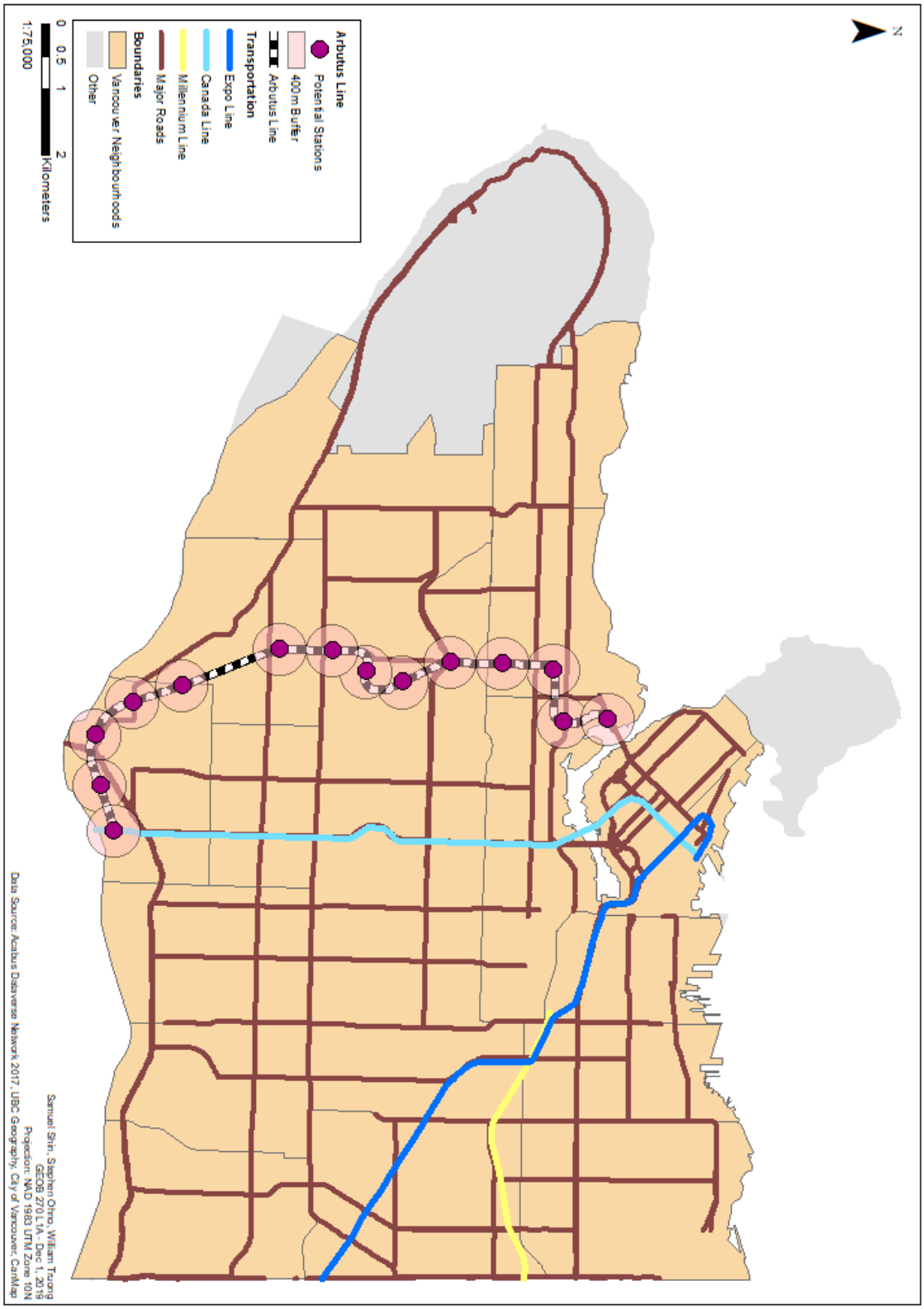
Appendix II – Maps, Figures, and Tables

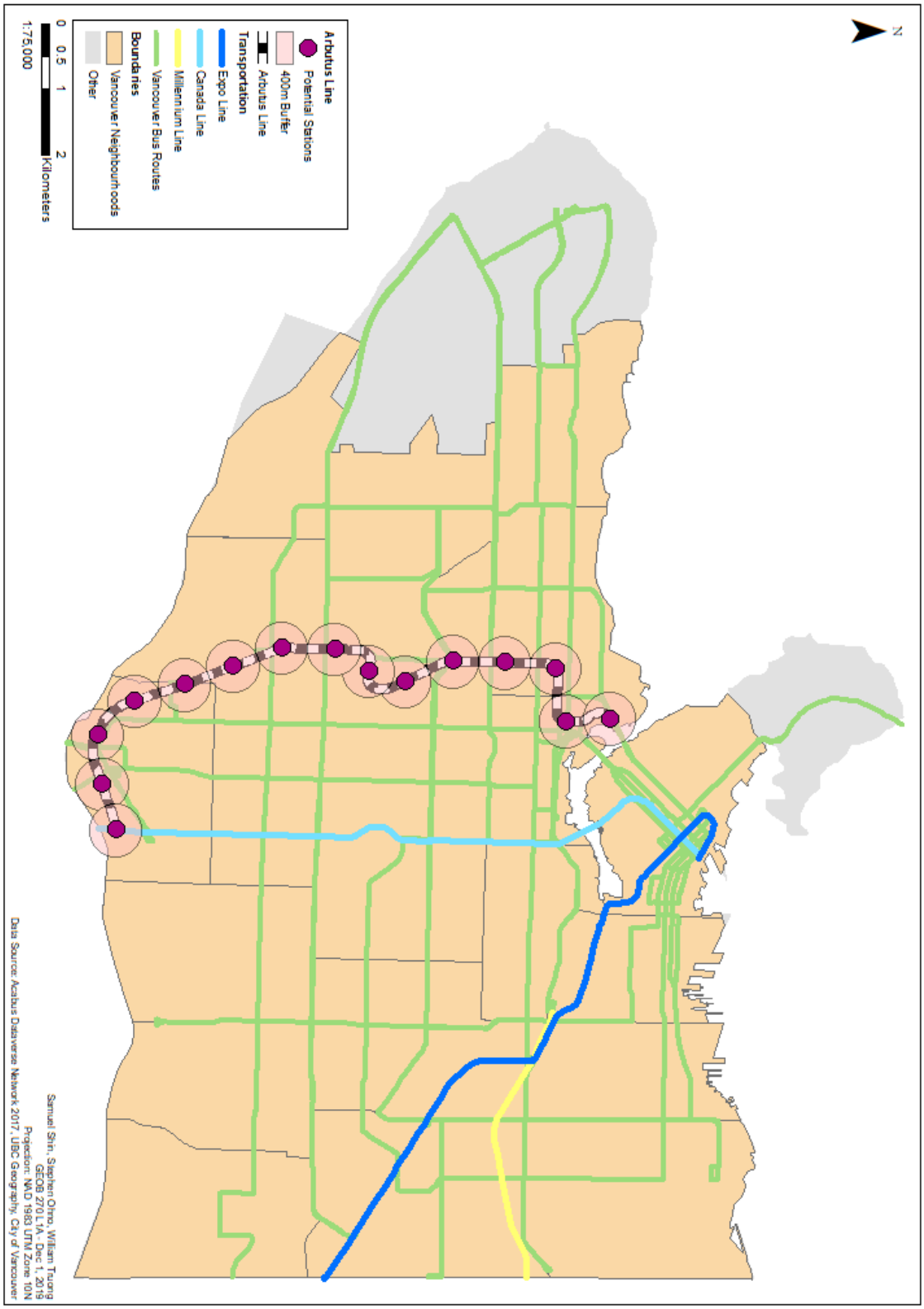
Appendix A – Original Dataset Table

Name	Source	Uses	Entity/data model	Attributes	Modifications
Railways/Arbutus_Line	City of Vancouver (Compiled - N/A ; Extracted - November 15, 2019)	Path/route of potential Arbutus LRT	Vector Polyline	FID, Shape, Name	Split line when it reached Canada Line
Community_centres/Community_clip	City of Vancouver (Compiled - N/A; Extracted - November 15, 2019)	Locations of community centres and recreation facilities	Vector (Points)	FID, Shape, Name, Address, urllink, geo_local	Clipped to Vancouver Neighbourhoods and Neighbourhoods near Arbutus Line
Schools/Schools_clip	City of Vancouver (Compiled - N/A; Extracted - November 15, 2019)	Locations of public and independent schools and preschools (StrongStart BC)	Vector (Points)	FID, Shape, Address, school_cat, school_nam, geo_local	Clipped to Vancouver Neighbourhoods and Neighbourhoods near Arbutus Line
Parks/Parks_clip	City of Vancouver (Compiled - N/A; Extracted - November 15, 2019)	Location of public parks and squares	Vector Polygon	FID, Shape, area_ha, park_id, park_name, park_url	Clipped to Vancouver Neighbourhoods and Neighbourhoods near Arbutus Line
Libraries/Libaries_clip	City of Vancouver (Compiled - N/A; Extracted - November 15, 2019)	Location of libraries	Vector (Points)	FID, Shape, Library Name, Latitude, Longitude, Address	Clipped to Vancouver Neighbourhoods and Neighbourhoods near Arbutus Line
BusRoutes_2010/Van_Bus_clip	UBC Geography G Drive (Compiled - 2010; Extracted - November 18, 2019)	Network of bus routes in Vancouver	Vector Polyline	FID, Shape, ObjectID, Length, Linecolor, Lineabbr, Status, Type, Shape Length	Selected and created new layer (bus routes), clipped to Vancouver Neighbourhoods
GVRD_DA/Vancouver_DA	Canadian Census Analyzer (Compiled - 2017; Extracted - November 18, 2019)	Population density per square km of census dissementation areas in Vancouver	Vector Polygon	ObjectID, Shape, DAUID, PRUID, CSDNAME, COL0, Population 2016, Land area in square kilometers	Joined with StatsCanDA, selected for arbutus line buffer and then created new layer
StatsCanDA/Vancouver_boundary	Acabus Dataverse Network (Compiled - 2017; Extracted - November 18, 2019)	Vancouver boundary	Vector Polygon	ObjectID, Shape, DAUID, PRUID, CSDNAME	Selected for Vancouver and created new layer
CanLine/CanLine_clip	UBC Geography G Drive (Compiled - N/A; Extracted - November 15, 2019)	Network of Canada line	Vector Polyline	FID, Shape, ObjectID, Municipality, Type, Shape Length	Clipped to Vancouver Neighbourhoods
CanLine_Stn/CanLine_Clip	UBC Geography G Drive (Compiled - N/A; Extracted - November 15, 2019)	Network of Canada line stations	Vector (Points)	FID, Shape, ObjectID, Station, Type	Clipped to Vancouver Neighbourhoods
SkyTLines/Millenium_clip/Expo_clip	UBC Geography G Drive (Compiled - N/A; Extracted - November 15, 2019)	Network of Skytrain lines in Vancouver	Vector Polyline	FID, Shape, ObjectID, Millennium, Expo, Municipality, Shape Length	Selected and created new layers (millennium/expo), clipped to Vancouver Neighbourhoods
GVRD_roads/Major_Roads_clip	UBC Geography G Drive/CanMap (Compiled - N/A; Extracted - November 15, 2019)	Road map of Metro Mancouver	Vector Polyline	Road_type	Selected and created new layer (major roads), clipped to Vancouver Neighbourhoods
Neighbourhoods/Neighbourhoods_clip	City of Vancouver (Compiled - N/A; Extracted - November 15, 2019)	Neighbourhoods in Vancouver	Vector Polygon	ObjectID, Shape, MapID, Name, Shape_Length, Shape_Area	Clipped to Vancouver DA

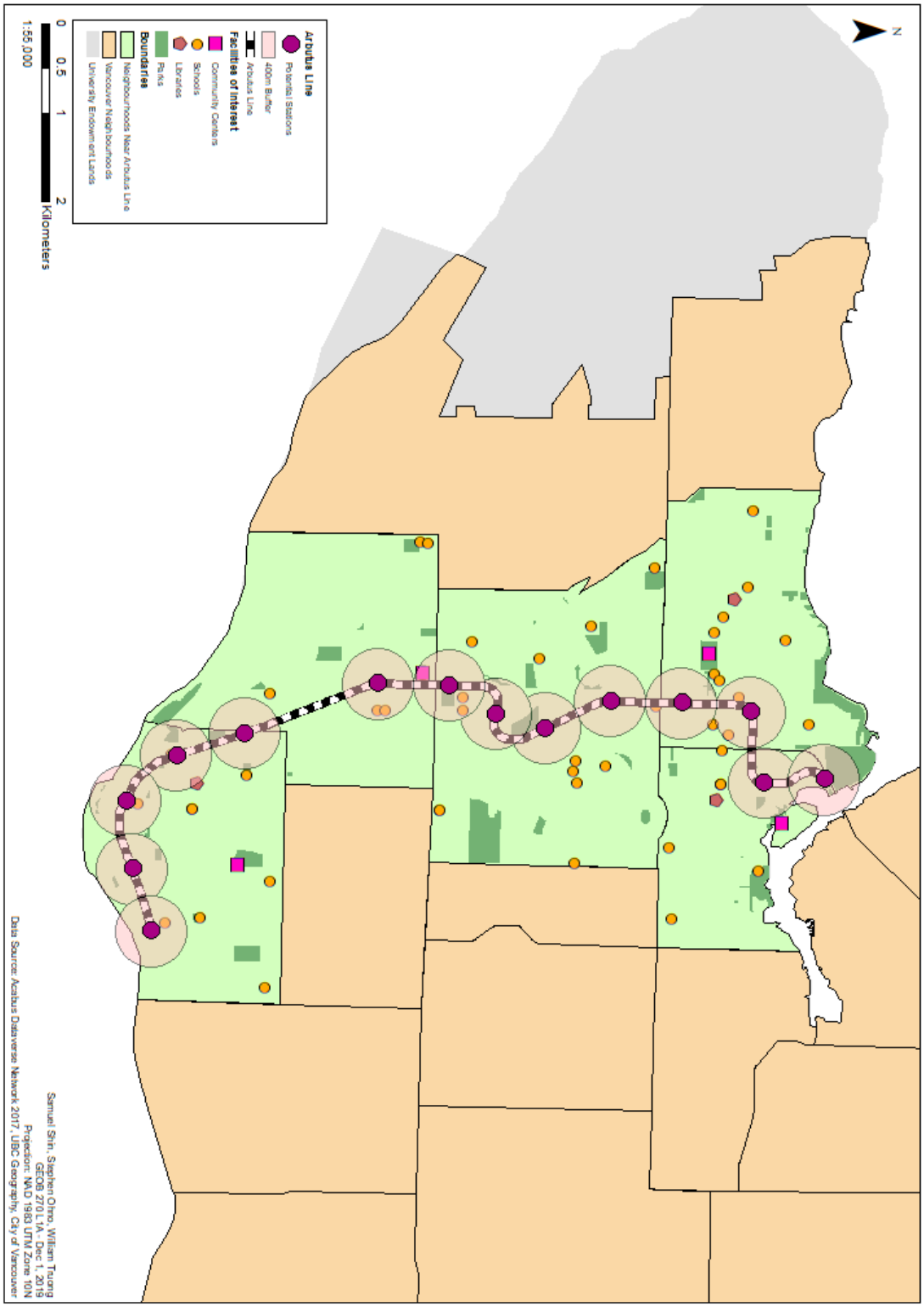
Appendix B – Map 1: ***Potential Arbutus Line Stations by Major Roads***



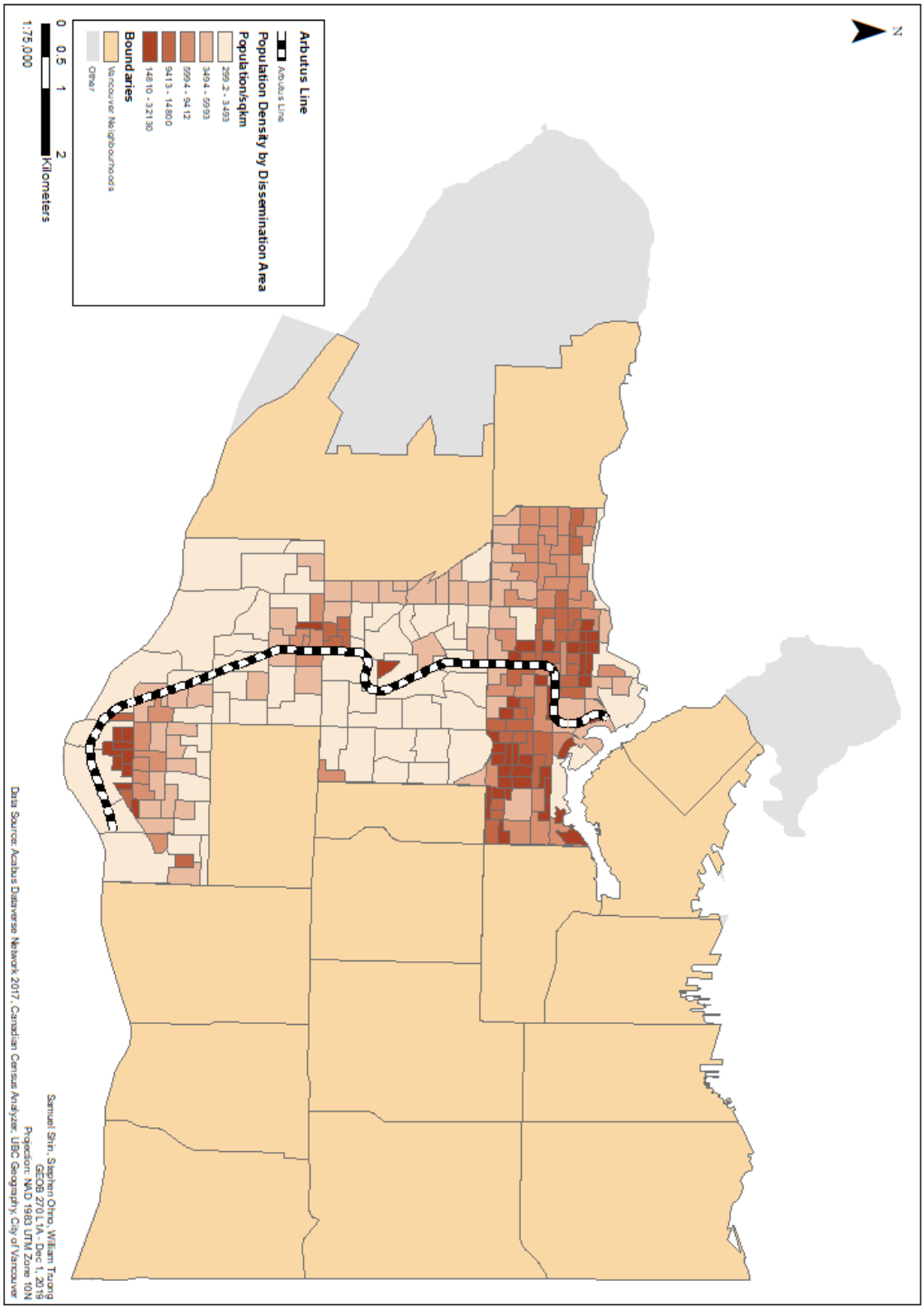
Appendix C – Map 2: *Potential Arbutus Line Stations by Bus Routes*



Appendix D – Map 3: ***Potential Arbutus Line Stations by Public Facilities of Interest***



Appendix E – Map 4: *Population Density of Neighbourhoods near Arbutus Line*



Appendix F – Map 5: *Optimal Arbutus Line Stations*