CONNECTING PLACES: A PRAGMATIC APPROACH TO RAPID TRANSIT FOR THE HALIFAX REGION

by

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Abstract

Connecting Places: A Pragmatic Approach to Rapid Transit for the Halifax Region explores the potential for the development of a simple, cost-effective rapid transit system for the Halifax Region, specifically for parts of the urban area that are not currently served by the MetroLink bus rapid transit system. The thesis examines previous proposals for rail-based transit along the Mainland North-Bedford Corridor as well as rapid transit systems that exist in other Canadian cities. Halifax Regional Municipality's long-term development goals were also examined in depth. Based on this research, a rapid transit system proposal has been generated, drawing inspiration from local proposals dating back to the 1970s as well as existing rapid transit systems elsewhere in Canada. This system is designed to help HRM achieve its development goals, particularly those related to land use, settlement patterns, and transportation, while also encouraging a more efficient, cost-effective public transit system. The proposal is not meant to be a "turn-key" system that could be implemented immediately, rather, it is intended to stimulate discussion and to provide the groundwork for further research and development.

Acknowledgements

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1.0 Introduction

This thesis will examine the potential for a simple, cost-effective rapid transit network for the urban core of the Halifax Regional Municipality. This proposal will build upon past and present efforts to establish commuter rail service along the existing CN rail line terminating at the Halifax Via station, using technology that has been identified as more cost-effective and better suited to potential demand than what is currently being proposed. It will expand upon this concept and include a different, but connected system linking major destinations on the Halifax Peninsula using in-street tracks.

1.1 Methodology

Research methods for this project have included a comprehensive examination of HRM's long-term planning objectives, past proposals for major expansions to the regional transit system, and rapid transit systems in other Canadian cities. The project was also informed by personal communications with Dan Fentiman, a representative of Ottawa's transit system, OC Transpo.

1.2 Background

In 2010, the Halifax Regional Municipality contracted private consulting firm Delphi-MRC to produce a comparative analysis of three potential transit services between Bedford and downtown Halifax; a high-speed ferry, a new express bus service, or commuter rail. The information used to project cost and ridership estimates for the commuter rail was largely based on previous studies that have been ongoing since 1975;

these studies are discussed below. The comparative analysis of the three options found that commuter rail would offer the fastest travel times when taking projected traffic increases into account. Its capital and operating costs would be comparable to those of the ferry alternative, which, until the report's publication, was the favoured option (Reashor 2011, p4). The report noted that previous estimates of travel time by ferry were overly optimistic and did not take into account factors such as frequent inclement weather and the operation of the service through an active shipping channel (Delphi-MRC 2011, p6).

Meanwhile, the municipality has also committed to intensifying new developments within areas that it has identified as growth centres in its Regional Municipal Planning Strategy, adopted in 2006. These growth centres are intended to facilitate the provision of public transit, as the municipality has also identified the need to increase the total modal share of public transit from 18% to 23% while decreasing dependence on single occupancy vehicles (Halifax Regional Municipality, 2006, p 63).

2.0 What is Rapid Transit?

A 2010 report entitled *Federal Support for Bus Rapid Transit and Light Rail Transit Systems in Canada* defines rapid transit as:

> *Transit service separated partially or completely from general vehicular traffic and therefore able to maintain higher levels of speed, reliability and vehicle productivity than can be achieved by transit vehicles operating in mixed traffic* (Ruffili, 2010, p. 1).

In *An Introduction to Sustainable Transportation*, transit system characteristics are broken down into three "right-of-way" categories:

> *RoW A: a full separation from all other modes and all cross-traffic. The most expensive solution, it also gives the best performance.*
>
> *RoW B: a lateral separation such that the mode runs in a fully separated lane, but there are still at-grade conflicts with other traffic at intersections. It is intermediate in cost and performance.*
>
> *RoW C: operating in mixed traffic, it requires little investment beyond the existing roadway and is thus the least expensive. It also guarantees that transit will be slower than private automobiles (Schiller et. al, 2010, p. 96).*

2.1 An Overview of Existing Canadian Rapid Transit Systems

A number of rapid transit systems have been employed in cities across Canada that may help to illustrate the differences between the characteristics of the different RoW scenarios mentioned above:

The Toronto Subway and Montreal Metro both fall into the RoW A category. These systems run mostly underground or along elevated rights-of-way with frequent service throughout the day and vehicles travel along tracks that do not interact directly with surface streets or other rail lines. Vehicles are self-propelled and are powered by electricity drawn from an active third rail. In 1985, the former City of Scarborough, Ontario built an extension to the Toronto subway system called the Scarborough RT, an experimental new transit system that used linear induction motors and semi-automated trains. Because of the special infrastructure required to support the linear induction motors, and to eliminate the possibility of collisions between the trains and pedestrians or vehicles, most of the tracks were built on concrete supports above street level, maintaining RoW A characteristics in this extension to the Toronto Subway (Canadian Urban Transit Association, 2006).

Vancouver's SkyTrain, which opened the following year, built upon that technology. The SkyTrain uses fully automated vehicles, which, for safety reasons, must be kept isolated from all other traffic. This system runs frequently throughout the day, largely on elevated rights-of-way, and can also be considered RoW A. Vehicles are electrically powered by use of a third rail; a "fourth rail" is used to propel the trains magnetically using linear induction motors (CUTA, 2006).

Ottawa's Transitway, established in the early 1980s, is Canada's most elaborate Bus Rapid Transit system, and consists of several kilometres of dedicated bus-only roadways, with dedicated bus lanes in the city centre. Service is frequent, and serves major, widely-spaced "stations" throughout the metro area rather than traditional bus stops, leading to service characteristics that more closely resemble those of a subway system than a conventional bus system. Service is frequent, though multiple routes share the same streets or busways near the city centre and then disperse to different peripheral areas, making the system slightly less intuitive for those unused to it. This can be classified mostly as RoW A, with a RoW B section in the city centre. The system has high operating costs because of the large number of staff required to operate it, and congestion of the system in the city centre is becoming an issue – due not to mixed vehicular traffic, but to the sheer number of buses using the Central Transitway. The City of Ottawa plans to convert part of the Transitway to a light rail line in the near future in order to improve the system's efficiency (City of Ottawa, 2012).

Edmonton's LRT system travels on surface-level tracks through most of the city, with a fully-separated tunnel section under the city centre. This can be classified mostly as RoW B, with a RoW A section in the city centre. Opened in 1978, the system was the first of its kind in North America. The Edmonton LRT built upon streetcar technology – light, medium capacity, self-propelled vehicles powered by overhead electrical wires – but tracks were kept separate from other vehicular traffic (CUTA, 2006).

Calgary's system, which began service three years later, uses the same technology as Edmonton's, but runs entirely at-grade, traveling through downtown Calgary via 7th Avenue, which is used as a transit-only corridor. The money saved by deciding not to tunnel beneath downtown Calgary was used to construct a more extensive system, which by 2006 had the highest ridership of any LRT system in North America (CUTA, 2006). This system can be classified as a pure RoW B type system.

Toronto's streetcar network provides service in the city centre and operates mostly in mixed traffic on city streets, with some lines operating in their own RoW on some streets. Service characteristics are comparable to those of a conventional bus network, and can be classified as primarily RoW C with some RoW B sections. Vehicles are self-propelled and draw power from overhead wires.

Toronto's GoTrain, Montreal ATM's Trains de Banlieue, and Vancouver's WestCoastExpress are examples of true commuter rail. While subway and LRT systems and their variants (such as the SkyTrain) evolved from streetcar technology, commuter rail evolved from mainline intercity rail transport, and generally uses heavy diesel or electric-powered locomotives to pull long trains of passenger coaches along existing railways. They may be considered a part of the RoW A category, but generally share track with other trains, which may include both passenger and freight trains. Due to the unlikely possibility of collision with other trains sharing their tracks, these vehicles are typically built much more sturdily (and are therefore heavier) than LRT or subway trains. Service is generally less frequent than LRT or subway systems, especially during the mid-day off-peak period, and stations are generally spaced much further apart.

Ottawa's O-train is a hybrid of LRT and commuter rail technologies, using self-propelled vehicles with on-board diesel engines, running on a surface rail line shared with freight traffic. The system was introduced in 2001 to supplement the Transitway network.

Because the O-train's vehicles are not built to the same crashworthiness standards as typical heavy commuter trains, freight traffic is scheduled so that the O-train and freight vehicles are never using the tracks at the same time. Service is at 15-minute intervals throughout the day, and the system can be considered mostly RoW A since there is only one street crossing. Though federal rail regulations normally require at least two personnel to operate each train on shared lines, OC Transpo is allowed to have a single operator per train because of the use of the Invero system, which provides automatic braking at stations (D. Fentiman, personal communication, Dec. 20, 2011).

2.2 An Overview of Proposals for Rail-Based Transit in the Halifax Region

Documents examined for this thesis include four independent consultants' reports on the feasibility of rail-based transit in the Halifax region, dating from 1975, 1990, 1996, and 2010, respectively. A fifth consultant's report from 2000 specifically examined station infrastructure requirements. Two municipal staff reports from 2011 are also included. Finally, two masters' theses on the subject, dating 1982 and 1997, respectively, were included.

For each report, the proposed route or series of stations was noted, along with the vehicle types that were considered in the report, whether the report recommended implementation of the system and how feasibility was determined. The results are displayed in table form in the following pages. The final column of the table notes significant changes in the Halifax region and elsewhere in Canada that may have affected future rail-based transit proposals.

It should be noted that, although the final independent consultants' report was completed in late 2010, the only publically available version of this report is attached to the related 2011 HRM staff report and for the purpose of analysis, the two reports are treated as a single document published in 2011.

It should also be noted that many station names changed from report to report while the actual locations of these stations remained more or less the same. For the purpose of analysis, proposed **Beaverbank** station is assumed to be coterminous with proposed Sackville station, **Windsor Junction** with Cobequid Rd, **Bedford Park** and

Rocky Lake with Duke St, **Mumford** with Armdale, **Rockingham** with Mount St. Vincent, and **Halifax VIA Station** with Halifax CN Station.

Year and type of publication	Route or stations proposed	Technology considered	Determination of feasibility	Significant developments since previous study
1975 independent consultant's report	Bedford – Cornwallis St.	BUDD self-propelled heavy rail diesel cars (RDCs or "rail liners")	Unfeasible based on low demand, distance of stations from trip origins and destinations	
1982 master's thesis	Beaverbank - Cornwallis St.	BUDD RDCs	Unfeasible due to high capital costs, unless a deal could be reached with VIA for use of their RDCs	Continued public interest, population growth; Establishment of electrified Light Rail Transit (LRT) systems in Edmonton (1978) and Calgary (1981).
1990 independent consultant's report	Bedford (exact location unknown) - Rockingham - Fairview - Mumford - Halifax VIA Station	Diesel Light Rail (DLRT) or bi-level coaches pulled by locomotives	Focused on benefits, which included reduced car traffic, reduced road maintenance costs, reduced dependence on imported oil, opportunity to redevelop parking lots, and relative ease of adding commuter traffic to the rail line compared to establishing bus lanes	Recent introduction of Diesel Light Rail technology in North America; Establishment of Transitway Bus Rapid Transit (BRT) corridors in Ottawa (1983); Establishment of Scarborough RT (1985) and Vancouver Skytrain automated electrified LRT (1986).
1996 independent consultant's report	Beaverbank – Windsor Junction – Bedford Park – Mill Cove – Rockingham – Mumford – Dalhousie* – Halifax VIA Station (*denotes optional/discretionary station)	BUDD RDCs, some consideration of DLRT as an economical alternative, noting that use of DLRT vehicles may add complexity to the project because of strict North American safety regulations.	Ambiguous; low revenue/cost ratio (0.30), but recognition of reductions in externalized costs such as road and bus investment, trauma and costs related to car accidents, emissions	Establishment of WestCoastExpress heavy commuter rail service in Vancouver (1995); Decline in use of RDCs by VIA in Atlantic Canada; Joint proposal from CN and VIA to establish commuter rail service for Halifax region using surplus RDCs

Table 1:Overview of past proposals, part 1

Year and type of publication	Route or stations proposed	Technology considered	Determination of feasibility	Significant developments since previous study
1997 master's thesis	Beaverbank – Windsor Junction – Bedford Park – Mill Cove – Rockingham – Mumford – Halifax VIA Station – Salter St. – Granville Mall (italicized stations require construction of additional tracks)	DLRT (Siemens RegioSprinter or similar vehicle)	Highly feasible; use of newer technology increases revenue/cost ratio to 0.82, extension of tracks beyond VIA station increases ratio to 0.90, well above threshold for acceptable cost recovery (0.40)	Amalgamation of HRM; Growing recognition of rail transit's tendency to encourage compact development near stations; Thesis recognizes potential of DLRT to extend through downtown core using in-street tracks; Thesis recognizes potential for public/private partnerships for station construction.
2000 independent consultant's report	Beaverbank – Windsor Junction – Bedford Park – Sunnyside – Central Bedford* – Mill Cove – Prince's Lodge* – Birch Cove* – Rockingham – Mumford – Dalhousie West – Saint Mary's* – VIA station (*denotes optional/discretionary station)	BUDD DRCs or DLRT	Study did not attempt to determine system feasibility, it simply provided a framework for the construction of stations and related infrastructure	Though previous studies asserted that a station near Dalhousie in the rail cut would be prohibitively expensive, this study argues that this is not necessarily true, depending on platform and station design; Introduced new station and platform styles that may reduce construction costs.
2011 HRM staff report	Windsor Junction – Bedford Park – Mill Cove – Rockingham – Mumford – Halifax VIA Station	BUDD RDCs	Not discussed in detail	Establishment of DLRT service in Ottawa on tracks shared with conventional trains (2001); Establishment of MetroLink basic BRT service in HRM (2005); Independent consultant recommends implementation of Bedford-Downtown ferry route in 2006; HRM publishes Regional Plan for next 25 years in 2006; Double tracks in Halifax rail cut reduced to single track in the 2000-2010 period; Significant rise in petroleum prices in 2000-2010 period.

Table 2: Overview of past proposals, part 2

Year and type of publication	Route or stations proposed	Technology considered	Determination of feasibility	Significant developments since previous study
2011 independent consultant's report + HRM staff report	Mill Cove – Rockingham – Mumford – Halifax VIA Station (Mill Cove designated as outer terminus to facilitate comparison with ferry and MetroLink services)	BUDD RDCs	Rail service found to be faster and more reliable than proposed ferry or MetroLink BRT service taking into account incremental increases in road traffic and inclement weather, capital costs less than ferry but greater than MetroLink, operating costs greater than ferry or MetroLink, assuming use of DRCs. MetroLink discouraged as a long-term solution	Bedford-Halifax ferry re-evaluated, a more conservative estimate of travel times and reliability deemed necessary when taking frequent low visibility situations into account.

Table 3: Overview of past proposals, part 3

3.0 Why rapid transit?

HRM has identified a goal of increasing the modal share of public transit over the course of its 25-year Regional Plan from 18% to 23%. To achieve this, it will be necessary for HRM to make its transit system more attractive to discretionary users – those who have the option of driving.

The popular MetroLink Bus Rapid Transit (BRT) system was introduced in 2005 and this remains the only rapid transit service in HRM. MetroLink is promoted as a "premium" service and offers faster travel times than standard bus routes by employing transit signal priority, a small number of bus-only lanes, and by limiting the number of stops along MetroLink routes. The introduction of the MetroLink service is credited as a major contributing factor to the 9% increase in overall transit ridership experienced in the first half of 2006 (HRM, 2007). Based on the criteria discussed in section 2.0, this system would be classified as RoW C. Currently, the MetroLink system does not serve Bedford, Mainland Halifax, or the Halifax Peninsula other than a single stop at Scotia Square used by two of the routes.

An HRM staff report from 2011 entitled *Five Big Moves for Transit* identified five important themes for improving public transit service in the region. These themes are:

- High Frequency Corridors
- Investing in service quality and reliability
- Focus on Cost Effective & High Ridership Service

- Urban Express
- Burnside/Dartmouth Crossing Realignment (Wilson & Redding, 2011).

While the last of the five themes falls outside of the scope of this project, experiences in other cities have shown that high-quality rapid transit is an effective means of accomplishing the other goals, by providing a high-capacity, high-frequency, comfortable and reliable transit service along important corridors. Notably, the Bedford Highway, Robie Street, and Barrington Street between North and South Streets are identified as potential high-frequency corridors, with the goal of providing at least one transit vehicle every 15 minutes throughout the day at stops along these routes. A public survey quoted in *Five Big Moves for Transit* indicated that improving schedule reliability would make public transit significantly more attractive to residents of the urban core and inner ring of suburbs, which include Bedford and Lower Sackville. Urban Express refers to routes where the stops or stations are placed further apart than on standard bus routes, which reduces the total travel time as stops are located near major trip generators. Designing a system to the RoW B standard discussed in section 2.0 would promote higher capacity, frequency and reliability, as transit vehicles would no longer be competing with other motor vehicles for road space.

3.1 Why focus on rail?

In the past, most transit discussions in the HRM have focused on improving bus and ferry service. Expansion of the ferry network may avoid the problem of road congestion but because of the point-to-point nature of ferry operations, fewer areas could be directly served by the ferry system, and none of these areas could be located inland. Upgrading the bus system to RoW B standards or higher would require the establishment of dedicated bus lanes, or bus-only streets. While this may be practical along certain corridors, in many cases, there simply is not enough space available to do so. A high-capacity, high-frequency system relying heavily on buses is also less cost effective than one that includes trains, because bus systems require more drivers and energy for the same number of passengers. Although the initial Regional Plan asserted that rail-based transit would not be a feasible or effective approach in the short term, Metro Transit's current 5-year operational plan asserts that Light Rail Transit will likely be *necessary* within the 2019-2024 time period in order to handle the projected increase in ridership levels (IBI Group, 2009, p. 8).

Rail-based transit is generally seen as a higher-quality service than bus-based transit, and is perceived as a faster, more reliable, cleaner, and more comfortable alternative. This means that rail-based transit systems are generally more successful than bus-based systems at attracting discretionary users who have the option of driving personal vehicles (Ruffili, 2010, p. 4). Rail vehicles also tend to have a longer lifespan than buses, with rail vehicles expected to last 35 years while buses used by Metro Transit are generally replaced every 20 years (Kelly, 1997; IBI, 2009).

3.2 An Overview of the Halifax Regional Municipal Planning Strategy

In 2006, Halifax Regional Council adopted the Halifax Regional Municipal Planning Strategy. This document, informally referred to as the Regional Plan, provides a framework for development initiatives intended to maintain economic growth and a high quality of life while accommodating a projected increase in population of up to 125,000 persons over a 25-year period (HRM, 2006, p. 7). In order to confirm that further investigation into rail-based transit services in HRM is a worthwhile venture, the Regional Municipal Planning Strategy was analysed to determine whether the provision of rail-based transit built around existing track infrastructure would be compatible with the municipality's long-term goals. Relevant articles were found in chapters 2 (Environment), 3 (Settlement and Housing), and 4 (Transportation), and excerpts are provided below. Though few of these articles focused on rail-based transit specifically, many focused on improving public transit and supportive land use:

Environment

Article 2.4.5 (Emissions Reduction) states that:

> *By adopting the settlement and transportation policies contained in this Plan, HRM should work towards improved air quality and reduced emissions by promoting compact development and active transportation, providing more public transit, using renewable energy sources, switching to lower-carbon fossil fuels (e.g. bio-diesel and natural gas), encouraging energy efficient buildings and preserving our urban and rural forests (HRM, 2006).*

Settlement and Housing

Article 3.0 (Introduction) states that:

> *The intention is not to discourage rural housing growth in favour of urban or suburban communities. Rather, the approach is to shape settlement in such a way that transit and other alternatives to commuting will become more viable. This offers not only lifestyle and environmental benefits, but also helps prepare for the possibility of rising oil prices (HRM, 2006).*

Article 3.1 (Urban Settlement Designation) states that:

> *This Plan supports the growth of a series of mixed-use transit-oriented centres in strategic locations throughout the designation... The designation is intended to provide for a diverse, vibrant and liveable urban environment which provides for the development of a series of mixed-use transit-oriented Centres within the*

general locations as shown on the Settlement and Transportation Map (Map 1) (HRM, 2006).

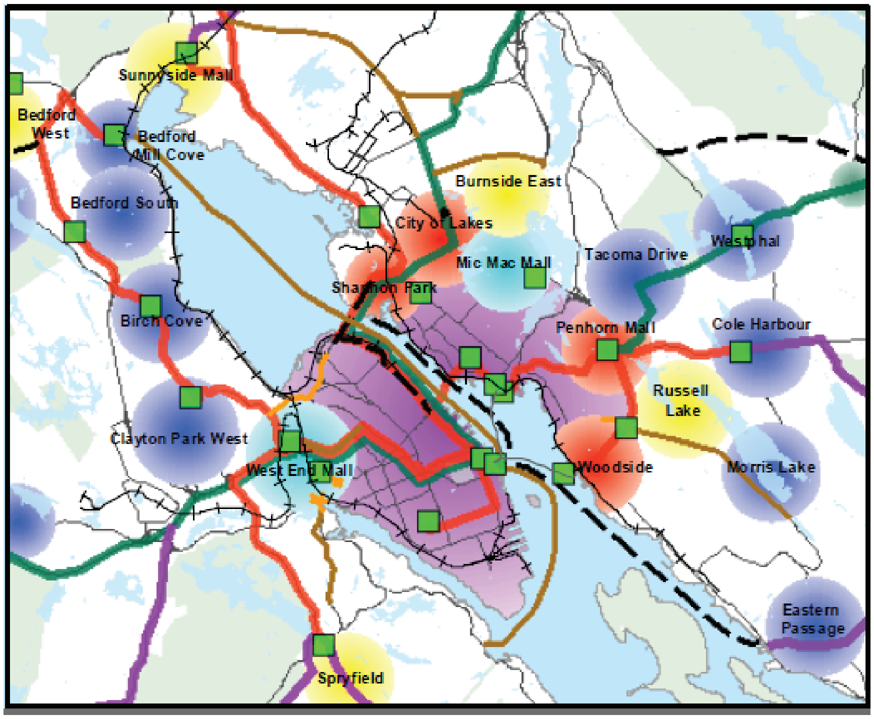

Figure 1: Settlement and Transportation Map inset (HRM, 2006, Map 1)

Transportation

Article 4.0 (Introduction) states that:

> *As the population grows, managing travel demand in HRM will be done through a variety of measures including: encouraging car and van pooling and greater use of transit... Improvements to Metro Transit's service levels and ridership through increased coverage, the Bus Rapid Transit (MetroLink) Service and express bus service... developing centres that are designed to encourage the use of alternative modes of transportation, especially transit (HRM, 2006).*

Article 4.3.2.4 (Rail Transit) states that:

> *The proposed fast ferry and MetroLink bus services offer the most cost effective opportunities for providing higher-order transit service for the foreseeable future. Compared to ferry or bus operations, rail transit involves greater complexity and higher costs. To justify the level of effort and investment required, there must be an adequate population base and a settlement pattern which focuses residential density, employment, campuses and commercial uses in pedestrian-oriented centres close to potential station sites.*

In the more distant future there may be potential to use rail lines in HRM for some form of transit service, either on rails or using busways built on abandoned track beds. Keeping options open for such eventualities would also ensure that federal funding opportunities for rail transit are not missed. With this in mind, it is important to consider long-term possibilities, including rail, when addressing proposals affecting railway infrastructure or corridors. It is also important to consider the potential for intermodal transfers when planning bus or ferry terminals close to rail lines (HRM, 2006).

3.3 Analysis of the Regional Municipal Planning Strategy

Chapter 2 of the Regional Municipal Planning Strategy does not include much discussion of public transit, it simply states that compact development and more public transit should be encouraged.

Chapter 3 acknowledges that different approaches to land use can make transit more or less viable, depending on the approach taken. The rising price of oil is also acknowledged. Perhaps of greatest interest is the section on Urban Settlement Designations, which states that designated centres should be developed as mixed-use, transit-oriented communities. Many of the centres identified in the Settlement and Transportation Map are analogous to potential rail stations discussed in the proposals. Sunnyside, Mill Cove, and Birch Cove are the most immediately obvious cases, since the urban centres have the same names as the analogous proposed stations. The proposed Prince's Lodge station falls within the Bedford South centre, Mumford station would be within the West End Mall centre, and any inner terminus on the Peninsula would fall within the Urban Core designation. Although Rockingham station does not fall directly within a centre, it is close to both Clayton Park West and Birch Cove, and immediately adjacent to Mount Saint Vincent University. It should be noted that many of the transit routes indicated on the Settlement and Transportation Map have not been established, including the Bedford-Downtown ferry and the MetroLink route running along the west side of the Bedford Basin. Additionally, while the map suggests that the MetroLink route running along the east side of the Bedford Basin would include a stop at Sunnyside Mall, the current route bypasses Bedford completely, stopping only in Lower Sackville, Burnside, and Downtown.

Chapter 4 asserts that "to justify the level of effort and investment required [for rail-based transit], there must be an adequate population base and a settlement pattern which focuses residential density, employment, campuses and commercial uses in pedestrian-oriented centres close to potential station sites" (HRM, 2006). It should be noted that the urban centres discussed in the previous chapter are precisely that. Although rail-based transit was considered less cost-effective than a ferry or bus equivalent at the time of the document's publication, the most recent staff and consultants' reports suggest that this is not the case – the rail option would provide the best travel times and reliability and would be comparable in price to the ferry option, if using self-propelling, heavy rail diesel cars. If modern Diesel LRT vehicles were used instead, as suggested by the reports from the 1990s, the rail-based option would be substantially less expensive to operate.

3.4 Ongoing Urban Planning Initiatives in the Halifax Region

As of April 2012, the 5-year review of the Regional Municipal Planning Strategy is underway, as is the development of the Centre Plan, which will create more specific urban development guidelines for the Halifax Peninsula and central Dartmouth. Of particular relevance is the identification of several sites within these boundaries that are expected to “[accommodate] new opportunities for well-designed densification” (HRM,, 2012). The implication is that most new growth on the Peninsula will be directed to specific areas, outlined in the map below. Notably, all of the “Areas of Proposed Change” fall along Robie Street, or in the neighbourhoods between Robie and Barrington Streets. The downtown core is excluded from this study, as it has already been the subject of a similar planning exercise, HRM by Design. The study area for HRM by Design is also indicated on the map.

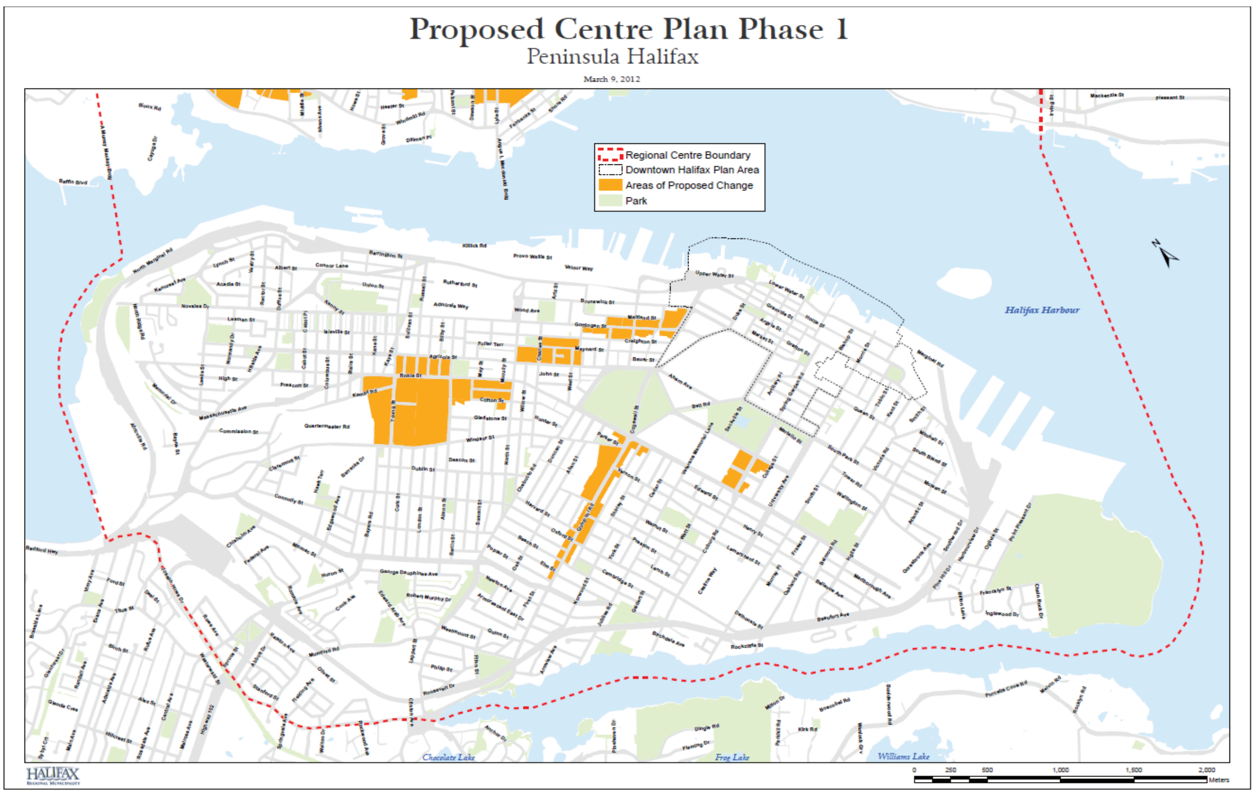

Figure 2: Proposed Centre Plan Phase 1, Peninsula Halifax (HRM, 2012)

4.0 Proposed System

In order to illustrate the potential service concepts made available through the use of rail-based concepts, a hypothetical system has been generated. The routes are based largely on qualitative research, and are centred on the principle of connecting important trip origins and destinations quickly and reliably. While previous proposals for expansions to the transit network have focused almost exclusively on commuters, the system proposed in this thesis accommodates not only the needs of commuters, but also students, consumers, hospital patients and visitors, tourists, business travellers, and citizens going about day-to-day activities. The goal is to provide citizens living along all three corridors with the viable option of choosing not to own a personal vehicle while also making many of the region’s important destinations more easily accessible to tourists and other visitors.

4.1 Methodology

Many factors were considered when planning routes. The route using the CN mainline was based on potential routes considered in proposals for commuter rail in the Halifax region dating as far back as 1975 and as recently as 2011. All of the stations discussed in this proposal that fall along this route were examined in Samostie’s 2000 review of infrastructure required for a public transit system using this route. Ken Kelly’s 1997 thesis was also a major foundation for much of this proposal. Stations along this corridor have been located in areas with a relatively high established or rapidly growing population density, since these areas are more likely to support collector bus routes or passengers walking to and from the stations, and also currently contribute heavily to traffic congestion on the Bedford Highway.

When planning the routes that would require new tracks, an effort was made to serve the largest number of people and destinations with the shortest amount of track, while complimenting the municipality's current transportation and land-use principles and goals. In addition to controlling overall capital costs, this also allows a higher service frequency with fewer vehicles. Efforts were made to avoid steep grades, to locate stations in areas where they could be built without major alterations to their surroundings, and where the required land is owned by the municipality, or where the use or acquisition of privately owned land could likely be negotiated without much difficulty. Efforts were also made to avoid restricting access to residential driveways or commercial loading bays.

For all three routes, stations were placed in locations that would minimize the need to construct new park-and-ride lots. Stations are generally placed closer together within the urban core and further apart in suburban areas. Data from the 2011 federal census was examined to determine the relative population density and population growth rates in areas around potential stations. Population densities were classified, based on categories used nationally by Statistics Canada, as Low (fewer than 500 persons per square kilometre), Medium-Low (between 500 and 2000 persons), Medium (between 2000 and 3000 persons), Medium-High (between 3000 and 5000 persons) and High (more than 5000 persons). Population growth rates were classified as Stagnant (no net population growth), Low (up to 5.9% growth rate), Medium (between 5.9% and 11.8%), High (between 11.8% and 17.7%), and Very High (more than 17.7%). It should be noted that some census tracts containing major parks or large tracts of wilderness may also contain built-up areas with higher population densities or growth rates than the tract's overall density or growth rate would suggest.

4.2 Overview of Routes and Stations

A stylized map has been included in order to better illustrate the layout of the proposed system. This map is not geographically accurate but distances between stations are noted. Each route is also presented in the form of a table highlighting the features of each station's surrounding area. The routes are then discussed in detail, followed by a discussion of each station.

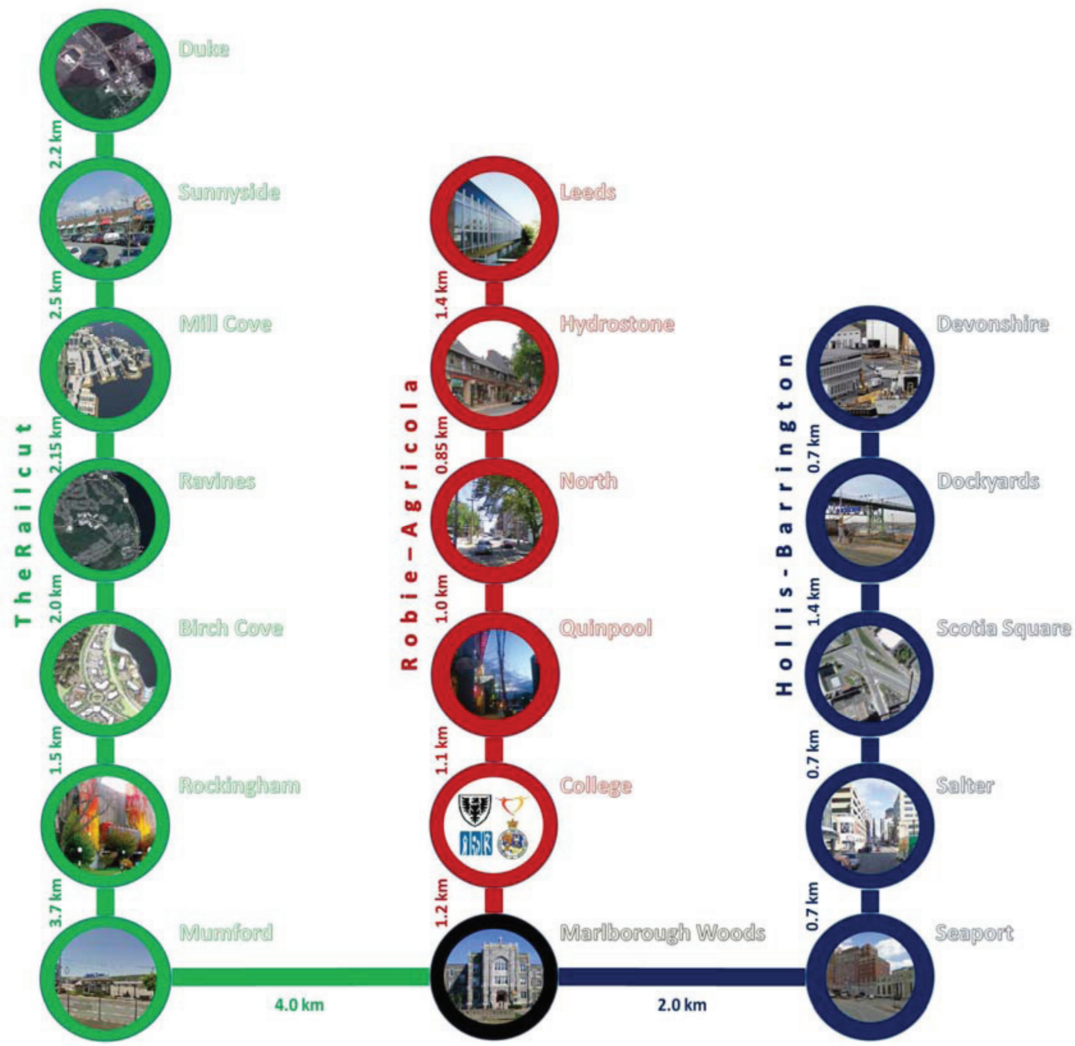

Figure 3: Stylized Map of Proposed System

4.2.0 The Mainland North-Bedford Corridor

Station	Major destinations	Potential connections	Local population density (2011)	Local population growth (2006-2011)	Approximate distance to next station
Duke	Bedford Commons	Duke/Glendale, Rocky Lake	Low; Low	Stagnant; Low	2.2 km
Sunnyside	Sunnyside Mall, Bedford Place Mall, other retail and office	Rocky Lake, Dartmouth Rd, Hwy 101/Bedford Hwy (BH)	Medium-low; Low	Medium; Stagnant	2.5 km
Mill Cove	Bedford Waterfront	Hammonds Plains Rd, Southgate, BH	Medium-low	Very high	2.15 km
Ravines	Hemlock Ravine	Larry Uteck, BH	Medium-low	Very high	2.0 km
Birch Cove	Hemlock Ravine	Kearney Lake Rd, BH	Medium-low; Medium	Very high; Low	1.5 km
Rockingham	MSVU	Flamingo, Bayview, BH	Medium	Low	3.7 km
Mumford	Mumford Terminal, Halifax Shopping Centre, other retail and office	Mumford Terminal	Medium	Stagnant	4.0 km
Marlborough Woods	SMU, AST, Point Pleasant Park	Robie-Agricola, Hollis-Barrington	Medium; Medium-low	Low; High	N/A

Table 4: Overview of Mainland North-Bedford Corridor

Route description

This line would use the existing CN tracks between the Bedford Commons and the VIA station at the southern fringe of downtown Halifax. The line would use diesel-powered vehicles, preferably similar to the Bombardier Talents used for Ottawa's O-Train system. At least one "passing track" would need to be constructed near the middle of the line to allow trains to pass one another. A park-and-ride based station could be constructed at **Duke** Street and Rocky Lake Drive - this would largely serve passengers traveling from eastern Lower Sackville via Glendale Avenue, so coordination with buses leaving from Cobequid Terminal would likely benefit overall ridership.

The next station, **Sunnyside**, has a larger local residential population and is adjacent to Sunnyside Mall and within easy walking distance of Bedford Place Mall, both of which already offer ample parking that could be used as park-and-ride.

Mill Cove, the following station, could connect with bus routes coming from Hammonds Plains Road and Southgate Drive. There is significant potential for attracting walk-up passengers and ample parking already exists in the immediate area.

The next station would be **Ravines**, at the foot of Larry Uteck Boulevard. This is one of the fastest-growing parts of the municipality, and new developments are generally mid-to-high density. There is little parking immediately available near Ravines Station, so it would be imperative to coordinate connecting buses traveling down Larry Uteck Boulevard in order to attract riders. However, many multi-unit residential buildings are located within easy walking distance of the proposed station.

The following station would be at **Birch Cove**. This area has a comprehensive redevelopment plan which anticipates the potential for rail service in the area. Connections with buses traveling on Kearney Lake Road would also increase the effectiveness of this station.

Rockingham, the next station, would be located across the Bedford Highway from Mount Saint Vincent University. Connections with buses traveling on Flamingo Drive and Bayview Road would enhance the effectiveness of this station.

The following station, **Mumford**, would serve one of the region's largest retail and service hubs, Halifax Shopping Centre and its annexes, along with local residents and other nearby commercial sites. The existing Mumford Terminal is already a major transfer point for bus passengers, and is slated to be redesigned and expanded within the next few years.

The line would terminate at **Marlborough Woods**, near Saint Mary's University. Riders could transfer to and from the system's other two lines here.

Station Descriptions

4.2.1 **Duke**

This station would be located at the eastern edge of Bedford Commons business park, at the intersection of Rocky Lake Drive and Duke Street. Unlike most of the proposed stations, Duke Station does not fall within any of the growth centres designated in the Regional Plan; this is a discretionary station that is unlikely to attract a significant number of walk-up passengers, but could attract passengers from Lower Sackville and surrounding communities if sufficient parking and bus connections are established. Additionally, the station may attract passengers from the Mainland North-Bedford corridor because of the growing retail presence around the station, though Sunnyside Station (see below) would likely be better suited to this purpose due to the physical nature of the development (auto-oriented power centre vs. two adjacent indoor shopping malls). Although Lower Sackville has a major bus terminal served by a MetroLink BRT route, this terminal is located near Sackville Drive and Beaverbank Road in the western half of Lower Sackville, while Duke Station would primarily serve the eastern part of the community. The establishment of a large park-and-ride lot (or shared parking with the business park) would likely be necessary in order to attract riders from lower-density areas such as Waverley and Windsor Junction. In his 2000 report, Samostie envisioned a dedicated park-and-ride lot at this station accommodating over 400 vehicles; he also noted that a spur rail line near the proposed station may require a shortened platform or significant alteration to the terrain in order to accommodate a full-length platform (Samostie, 2000, p.24).

4.2.2 **Sunnyside**

The station would be located adjacent to Sunnyside Mall, at the junction of Bedford Highway, Rocky Lake Drive, and Dartmouth Road. Sunnyside Mall is itself a part of a major retail and service area which also includes Bedford Place Mall and several strip malls, stand-alone storefronts, and office buildings along the Bedford Highway, forming a commercial hub recognised as a Suburban District Centre in the regional plan (HRM, 2006, Map 1). Residential density in the area to the west of the proposed station is relatively low, but experiencing moderate growth. Residential density in the area to the east of the proposed station is classified as low and stagnant based on 2011 census data, though it is important to note that the census tract contains a large, distinct area of undeveloped wilderness (over half of the land area), which lowers the overall population density significantly. Alan Samostie's 2000 study found that construction of a low-level or high-level platform at this site would be straightforward, and although space exists for the development of a dedicated park-and-ride lot, ample parking is already available in the immediate area (Samostie, 2000, pp. 25-26). Staircases and/or ramps would be required to connect the station to the adjacent Nova Scotia Power property (which includes an electrical substation) as well as Sunnyside Mall itself. If Duke Station is not constructed, this would be the line's northern terminus.

4.2.3 **Mill Cove**

The station would be located near the existing Mill Cove Plaza at the junction of Bedford Highway and Hammonds Plains Road. Land use around the potential station is mixed and includes a variety of commercial and residential uses. The area is designated as a Suburban Local Centre in the Regional Plan (HRM, 2006, Map 1). Adjacent to the potential station is a large area of infilled waterfront known as Bedford Waterfront Phase II, the development of which has recently begun and is governed by a comprehensive planning strategy, which includes provisions for a ferry terminal and commuter rail station to serve the existing community and the 2300 new residential units envisioned as part of the Bedford Waterfront Phase II development (Ekistics, 2011, p. 70). Based on the *Transit Alternatives for Bedford* report, it is unlikely that both the ferry and rail services will be established. However, since this development is being built around the availability of reliable, high-quality public transit, it is important that one of these services be established to avoid further congestion on the Bedford Highway and Highway 102. Samostie's 2000 report indicates that land is available for the straightforward construction of an at-grade platform, and land is available for the development of a dedicated park-and-ride lot, though ample parking is already available in the immediate area (Samostie, 2000, pp. 28-29).

4.2.4 **Ravines**

The station would be located adjacent to the intersection of Bedford Highway and Larry Uteck Boulevard. There are some nearby commercial uses along the Bedford Highway, though the primary land use in the area is residential. The area is designated as Bedford South Suburban Local Centre in the regional plan (HRM, 2006, Map 1). Though 2011 census data indicates the area has a medium-low residential density, the area surrounding the potential station includes several large apartment and condominium buildings, and is one of the fastest-growing census tracts in the Halifax region, having a growth rate of over 50% in the 2006-2011 period. Population growth is expected to continue steadily as the area between Hemlock Ravine and Bedford continues to be developed. As noted by Samostie, construction of a high-level platform would be straightforward, and construction of a low-level platform would require some alteration to the slope of the rock fill between the Bedford Highway and rail line. Construction of a park-and-ride lot would be difficult and would face significant spatial constraints (Samostie, 2000, p. 31). Therefore, an effort must be made to capitalise on walk-up service and connection of bus routes serving Larry Uteck Boulevard. The new residential developments along Larry Uteck Boulevard include two francophone public schools which may benefit from improved public transit since their student populations are drawn from the wider municipality. The station could also provide access to the nearby Hemlock Ravines park.

4.2.5 **Birch Cove**

This station would be located adjacent to the intersection of Bedford Highway and Kearney Lake Road. Current land-use in this location is predominantly medium-density residential, and includes some commercial properties; current growth rates are modest. The area is designated as a Suburban Local Centre in the regional plan (HRM, 2006, Map 1). Like Mill Cove, the Birch Cove area has developed a comprehensive planning strategy. Though the strategy envisions a more modest growth in population than that envisioned at Mill Cove – about 400-500 residential units in the immediate vicinity of the potential station, in addition to significant commercial developments – provisions exist in the plan for a commuter rail station (Ekistics, 2011, p. 29). As noted by Samostie, platform construction would be simple, and opportunities exist to provide parking at the station, though a significant number of passengers would likely transfer to and from buses traveling along the Kearney Lake Road corridor (Samostie, 2000, p. 32).

4.2.6 **Rockingham**

This station would be located near Mount Saint Vincent University. CN currently has facilities in this vicinity, and inter-urban trains used to stop here; as noted by Samostie, a station could be built around existing infrastructure, though this would require some upgrades and/or repairs (Samostie, 2000, p. 33). Current land use in the area is defined by Mount Saint Vincent University, and also includes some commercial uses as well as medium-density residential. The area has seen modest growth between 2006 and 2011, and significant residential developments are planned for this area within the next few years, anticipating new housing for approximately 4000 new residents (Zaccagna, 2011). The university is both a trip destination and origin, owing to the concentration of student residences on campus, as well as residential facilities owned by the Sisters of Charity, adjacent to the university itself. Samostie's report recommended the expansion of CN parking lots to accommodate transit users; existing low-level platforms could be upgraded, or high-level platforms could be constructed (Samoastie, 2000, p. 33).

4.2.7 **Mumford**

This station would be located near the existing Mumford Terminal. Land-use includes the adjacent Halifax Shopping Centre + Annex, Mumford Professional Centre, several office buildings accessed from Joseph Howe Drive, and medium-density residential, including several multi-unit buildings near the potential station. As one of the largest malls in Atlantic Canada, Halifax Shopping Centre and the former West End Mall form an important centre for retail, services, and employment, and the area is designated as an Urban District Centre in the regional plan (HRM, 2006, Map 1). Eastern College, a small private post-secondary institution, has recently relocated to the immediate area (Eastern College, 2012). Mumford Terminal is slated to be redeveloped and expanded by 2014 (IBI, 2009, pp. 94, 150); relocating the terminal closer to the rail line would allow for a multi-modal facility that would allow for easy transfers between buses and trains.

4.2.8 **Marlborough Woods**

This station would be located along the rail cut, near Saint Mary's University. This location falls within the Regional Centre, as defined in the regional plan (HRM, 2006, Map 1). Current land use is defined by Saint Mary's University and residential uses. The census classifies the population density to the west of the proposed station as medium-density, and population density to the east as medium-low, though it should be noted that the census tract to the east of the proposed station includes Point Pleasant Park and significant amounts of port-related infrastructure, which collectively take up about half the land area of the census tract. Residential density in the vicinity of the proposed station is boosted by the presence of significant amounts of on-campus housing at Saint Mary's. The university is envisioned as both a major trip destination, due to the number of students and staff using the university's facilities daily, and an origin, due to the amount of on-campus housing. In addition to serving students and staff, the station will also serve nearby residents and members of the public using the university's athletic and recreational facilities, as well as attending various public lectures and cultural events which occur regularly throughout the academic year. The nearby Atlantic School of Theology, though considerably smaller, would also likely attract passengers for similar reasons.

Within this proposal, Marlborough Woods Station will also serve as an important transfer point between the system's three lines, which ideally would all terminate at this station. The Robie-Agricola line will extend beyond the end of Robie Street, terminating adjacent to the rail cut; the station infrastructure proposed by Samostie would need to be modified to accommodate this, and this station would include lower and upper platform areas. Platform construction is envisioned as straightforward; the proposed pedestrian link to Robie Street will need to be widened somewhat to accommodate the extension of the Robie-Agricola line. It may be preferable to have a direct pedestrian connection between the lower and upper platform areas to facilitate transfers, rather than having a pedestrian link to Pine Hill Drive, as was suggested by Samostie (2006, pp. 39-40). Because of the physical challenges of linking the two different platform levels, and owing to its function as the only transfer station between the three lines, Marlborough Woods Station would likely be the most elaborate and expensive station within the system. Care should be taken to ensure that as much of Marlborough Woods itself as possible is preserved; this would have the added benefit of providing some noise mitigation. Other noise reduction initiatives may also be necessary, as this station would be located in what is traditionally thought of as one of the "quieter" areas of the Peninsula. It is envisioned that train schedules would be coordinated so that all three lines arrive at the station at the same time, dwell long enough to let passengers transfer, then leave at the same time.

4.3.0 Robie-Agricola Line

Station	Major destinations	Local population density (2011)	Local population growth (2006-2011)	Approximate distance to next station
Marlborough Woods				1.2 km
College	Dal-Studley, Dal-Carleton, King's, IWK, QE2 (VG), Spring Garden Road	Medium-low; Medium	Stagnant; Stagnant	1.1 km
Quinpool	QE2 (Infirmary), Quinpool Road, Commons, Citadel High, Atlantica Hotel	Medium-low; High	Stagnant; Low	1.0 km
North	MacDonald Bridge, Stadacona, local retail & entertainment	High; High; High; Medium-high	High; Low; Medium; Stagnant	0.85 km
Hydrostone	Hydrostone Market & other local retail, Oland Brewery, Halifax Forum, Windsor Park, Needham Memorial Park	Medium; Medium-high	Stagnant; Medium	1.4 km
Leeds	NSCC (NSIT), Devonshire Arena, Needham Pool	Medium-low	Stagnant	N/A

Table 5: Overview of Robie-Agricola Line

Route Description

This route would begin at street level at **Marlborough Woods** Station and travel along the eastern side of Robie Street. Transit priority signalling would be required and the width of the tracks would need to be reclaimed from the roadway. In most cases this could be done simply by eliminating on-street parking on the east side of the street. Trains would be powered by electricity, drawn either from overhead wires or an advanced third rail embedded in the ground. Trains would travel in either direction on a single set of track, with a double-tracked section located near the centre of the line allowing trains to pass one another.

The next station would be **College**, serving Dalhousie/King's, the hospitals, and the Coburg/Robie/Spring Garden area.

The following station, **Quinpool**, would be located on or adjacent to the Halifax Commons and would serve the Halifax Infirmary, Citadel High School, and the Quinpool Road area.

The next section of track may present a challenge since Robie Street narrows significantly at Cunard Street, and expansion would be difficult since many buildings along the street are built up to their property lines. Reserving a right-of-way for the LRT line may involve either:

- closing this section of Robie Street to other vehicular traffic;
- making this section of Robie Street a reversing one-way section, with reversal coinciding with rush hour in and out of downtown;

- elevating a small section of the LRT above Robie Street;

- unnelling a small section of the LRT beneath Robie Street.

While each successive option increases the total capital costs, it also presents less interference with current travel patterns. The aesthetic and environmental effects of elevating part of the LRT above Robie Street (wind, shadows, etc.) are not known at this time.

It is also important to note that the “passing track” for this line would likely be located in this area, since it is near the middle of the line. Ultimately the location of this passing track will be heavily influenced by the dwell times at each station, as the dwell time at Marlborough Woods Station is anticipated to be significantly longer than at other stations in order to allow passengers to transfer between trains. The longer the dwell time at Marlborough Woods, the more the “centre” of the line, and thus the passing track, will be skewed towards the south.

The next station, **North**, would serve the densely populated neighbourhood centred on Robie and North Streets, and would provide a transfer point for buses traveling to and from Dartmouth via the MacDonald Bridge.

The line would continue down Robie and turn right onto either Demone or Russell Street, with **Hydrostone** station located on the block between Robie and Agricola. This station would serve the local residential and commercial areas and provide access to the Hydrostone Market. By shifting the route to Agricola Street, the increasingly steep grade of Robie Street north of Young Street can be avoided. The northernmost section of Agricola is also wider than the corresponding section of Robie, and leads more directly to the NSCC campus on Leeds Street.

From Hydrostone Station, the line would turn left onto Agricola Street and continue along the right side of Agricola/Highland Avenue until reaching the terminus at **Leeds**, which would serve the NSCC and surrounding residential community.

Station descriptions

4.3.1 **College**

This station would be located on the east side of Robie Street, between University Avenue and College Street and adjacent to the Dalhousie Dentistry building. This would likely require an agreement to be negotiated with the university. The station would be within easy walking distance of Dalhousie's Studley and Carleton campuses, the University of King's College, the IWK Health Centre, the VG site of the QE2 Health Sciences Centre, and the surrounding residential neighbourhood. The station would also provide access to the commercial strip at the western end of Spring Garden Road.

The station itself would consist of a basic shelter with a system map and a ticket vending machine. The shelter should be designed in such a way that the mature trees growing between the street and the sidewalk do not need to be removed or disturbed in a significant way. The platform could simply consist of the existing curb and sidewalk, with some minor upgrades to create a flatter surface and to be flush with the floor of the LRT vehicle.

4.3.2 **Quinpool**

This station would be located on the east side of Robie Street, either just north or just south of the Robie & Quinpool intersection; immediately adjacent land belongs to the municipality in both cases. The station would be within easy walking distance of the Halifax Infirmary, Citadel High School, Citadel Hill, the Halifax Commons and related recreational infrastructure, the Museum of Natural History, the Atlantica Hotel, and the surrounding residential neighbourhood. The station would also provide access to the thriving commercial district centred on Quinpool Road.

Station design would be similar in principle to College. If located north of the intersection, the station would likely require alteration to a baseball diamond at the edge of Halifax Common. Like College, this station should be designed in a way that does not interfere with the mature trees growing on site. If located south of the intersection, the station would need to be located further from Quinpool Road and closer to the Infirmary, due to the moderate grade approaching the intersection.

4.3.3 **North**

This station would be located on the east side of Robie Street near its intersection with North Street. There is little available land on this side of the street near the intersection itself, but the area to the immediate north contains a corridor of parking lots, gas stations, and car dealerships and it is likely that a sufficient amount of land could be purchased from one of these owners, or potentially traded for property owned by the municipality elsewhere. The station would serve the surrounding high-density mixed-use neighbourhood and would also provide a transfer point for buses crossing the MacDonald

Bridge to Dartmouth. North Station would also be within easy walking distance of the west entrance to Stadacona.

Because the station would likely be built on land that has already been paved over, the design is more flexible than the previous two stations. Nevertheless, the general principle remains the same, and all that is needed is a shelter, a system map, and a ticket vending machine.

4.3.4 **Hydrostone**

This station would be located on Demone or Russell Street, where the line shifts from Robie Street to Agricola Street. Locating the station on one of these side streets maximises the efficiency of the system, since trains would decelerate as they approach the stations and accelerate as they leave. By locating the station between the only two turns in the track, additional instances of deceleration would be avoided. Like North Station, some land which is currently used for parking may need to be acquired by the municipality. The station would serve the surrounding mid-to-high density residential area, and would be within easy walking distance of the Hydrostone Market, the Halifax Forum, Windsor Park, and the mixed retail/office/light industrial area centring on Robie and Young Streets. Needham Memorial Park and surrounding recreational infrastructure are also nearby.

Station design would be similar to North Station. Alternatively, local traffic could be diverted from the street between Robie and Agricola and the street itself could be used as the station.

4.3.5 **Leeds**

This station would be located at Highland Avenue and Leeds Street, and would be the northern terminus on the Robie-Agricola line. The station would primarily serve the Nova Scotia Institute of Technology campus of the Nova Scotia Community College, as well as surrounding residential areas. Recreational facilities such as the Needham Pool and Devonshire Arena are a short walk away.

The station would be built on land between the college and St. Stephen's Elementary School. The land may need to be flattened, or station design could incorporate the smooth stone topography of the site. Like other stations on the line, little would be required beyond a shelter, system map, and ticket vending machine.

4.4.0 Hollis-Barrington Line

Station	Major destinations	Local population density (2011)	Local population growth (2006-2011)	Approximate distance to next station
Marlborough Woods				2.0 km
Seaport	Seaport district, South downtown businesses and entertainment, NSCAD-Port, hotels, VIA/Acadien, cruise ships	High	Low	0.70 km
Salter	Central downtown businesses and entertainment, Dal-Sexton, Spring Garden Road, hotels	High	Low	0.70 km
Scotia Square	North downtown businesses and entertainment, Scotia Square, Ferry Terminal, Historic Properties, City Hall, NSCAD-Granville, hotels	Medium-high	Medium	1.40 km
Dockyard	Naval Dockyard	High; Medium	Medium; Stagnant	0.70 km
Devonshire	Irving Shipyard	Medium	Stagnant	N/A

Table 6: Overview of Hollis-Barrington Line

Route Description

Like the Robie-Agricola Line, this route would use electrically-powered vehicles. Trains would depart **Marlborough Woods** and travel through the rail cut toward the VIA station. Trains would then cut in front of the VIA station, stopping at adjacent **Seaport** Station on new tracks that would then be extended northward on Hollis Street. Like the Robie-Agricola Line, trains would travel in either direction on the same set of tracks, and a set of passing tracks would need to be constructed near the mid-way point. Again, the location of this mid-way point would be influenced by dwell times at stations, particularly Marlborough Woods Station.

Tracks would run along the east side of Hollis street, and like the Robie-Agricola line, this would mostly involve simply removing on-street parking on this side of the street to reclaim the right-of-way. Trains would stop at **Salter** and continue northbound to **Scotia Square** Station, located at or near the current Cogswell Interchange.

North of the interchange, tracks would either continue in-street on the east side of Barrington Street, or parallel to Barrington Street in an abandoned rail right-of-way adjacent to Barrington. **Dockyard** Station would be located under the MacDonald Bridge, serving the navy base, and the line would terminate at **Devonshire** Station, near the Irving shipyard.

Station Descriptions

4.4.1 **Seaport**

This station would be either adjacent to, or integrated with, the existing VIA rail station at the southern edge of downtown Halifax. Surrounding land-use is multi-purpose and, in addition to being one of the most densely populated neighbourhoods in the region, includes a variety of important destinations, including:

- The VIA station and adjunct Acadien bus terminal, and cruise ship terminals
- Two major supermarkets in addition to the Seaport Farmers' Market
- The Canadian Museum of Immigration at Pier 21
- The Cunard Centre, a major events facility that regularly hosts conventions, trade shows, concerts, and other events of up to 4,000 people
- Several hotels, including the Westin Nova Scotian
- The Port of Halifax
- Office, retail, dining and entertainment presence in the southern fringe of downtown and in the Seaport district
- Southern terminus of the Halifax Harbourwalk

Samostie notes that the infrastructure in place for VIA trains could be shared with the commuter service, and that little additional infrastructure would be required. However, the low-floor LRT vehicles would require different platform heights than the intercity trains, so a preferred station design would involve routing a small section of track along the edge of the current Superstore parking lot with a purpose-built platform in front of the current VIA station, as discussed by Kelly (1997, pp. 48-51). The platform itself, like those of the Robie-Agricola line, would be relatively simple, and the degree of integration with the existing train station is flexible.

4.4.2 **Salter**

This station would be located on the north corner of the Hollis/Salter intersection. The existing extra-wide sidewalk would require very little modification for conversion to a platform, aside from providing a shelter, system map, and ticket vending machine. This station is near the heart of downtown and would be within easy walking distance of numerous major office buildings, hotels, and retail/food/entertainment venues. The eastern end of Spring Garden Road would also be highly accessible from this station.

4.4.3 **Scotia Square**

This station would be located near the present site of the Cogswell Interchange. Development of the line beyond this point will be contingent on the redevelopment of the interchange, and it is hoped that this redevelopment will incorporate a rail station. Designing or even placing a location based on the status quo is difficult because plans for the alignments of future streets have not yet been published. Care should be taken to locate the station between the current Scotia Square bus terminal and the George Street ferry terminal. This station would serve the northern end of downtown and would be within easy walking distance of Scotia Square, Purdy’s Wharf, and several other major office buildings, various hotels, city hall, Casino Nova Scotia, the northern terminus of the Harbourwalk, the Historic Properties and Granville Mall, which includes one of NSCAD's campuses, numerous retail/food/entertainment venues, and the southernmost entrance to HMCS Dockyard. Some high-density residential neighbourhoods are also within easy walking distance. Alternately, Scotia Square bus terminal itself could be integrated into the train station when the interchange is redeveloped. Though it would be possible to simply integrate the rail line into the existing Cogswell Interchange, this is not recommended unless the interchange can be redeveloped at a later date without disturbing the new rail line and station.

4.4.4 **Dockyard**

This station would be located near the base of the MacDonald Bridge, at the intersection of Barrington and North Streets. The station would primarily serve HMCS Dockyard, and would be within easy walking distance of the eastern entrances to Stadacona as well as surrounding higher density residential neighbourhoods.

Like most of the other urban stations, design could be quite simple and would require only some form of shelter, a system map, and a ticket vending machine. The concrete cable-base of the MacDonald Bridge could be integrated into the station design.

4.4.5 **Devonshire**

This station would be located at the intersection of Barrington Street and Devonshire Avenue, and would be the northern terminus of the Hollis-Barrington line. The station would primarily serve the Irving Shipyard, which is expected to become an increasingly important centre of employment following the federal government's recent announcement that it will build $25B worth of naval vessels at the shipyard in the next two decades. The station would also serve the local residential population, and would be within a relatively short walking distance of Needham Pool and Devonshire Arena.

5.0 Analysis of Proposed System

In order to compare the characteristics of this proposed system with established rapid transit systems across Canada, the approximate locations of stations were plotted on maps displaying population density, based on the Canadian Government's 2011 Census. The proposed system was compared to Edmonton's long-established LRT system and Calgary's C-Train (LRT) which is also well-established. Ottawa's O-Train (DLRT), established in 2001, was also used for comparative purposes, as was Ottawa's planned conversion of part of its BRT system to LRT. Though the new section of Ottawa's rail network is not yet operational, it is essentially a modified section of the Transitway system, which has been operational for several decades and has similar service characteristics with LRT. In the following maps, green dots represent rapid transit stations, while the shading of polygons represent the population density by census tract. Population density was chosen as an important indicator since it has a strong influence over the number of people who are able to walk to or use active transportation or buses to access the stations.

5.0.0 Map 1: Halifax

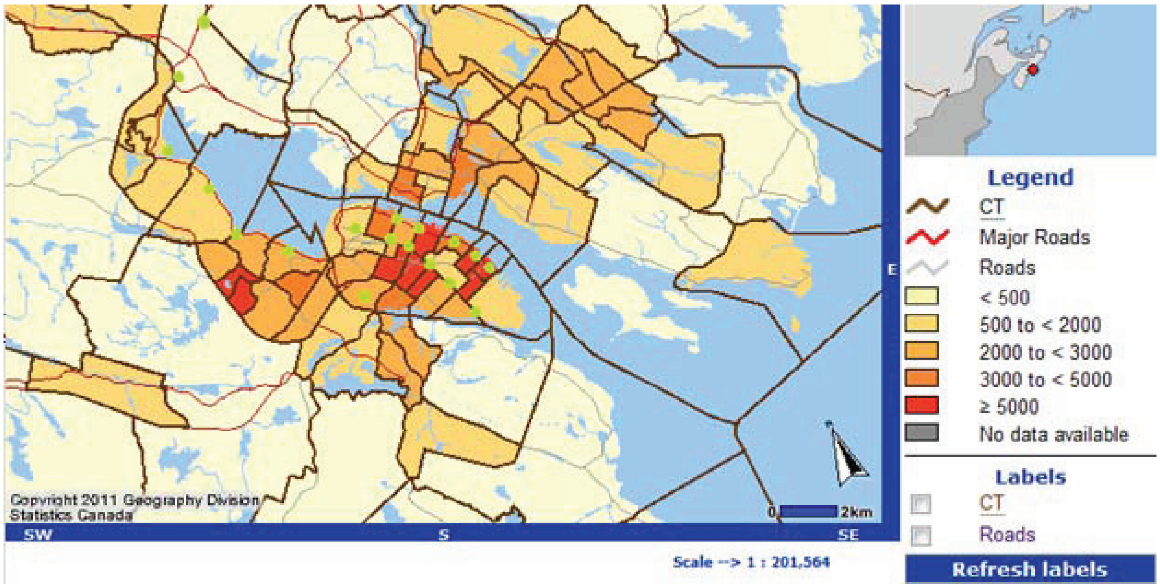

Figure 4: Halifax Population Densities by Census Tract with Proposed LRT Stations

5.0.1 Map 2: Edmonton

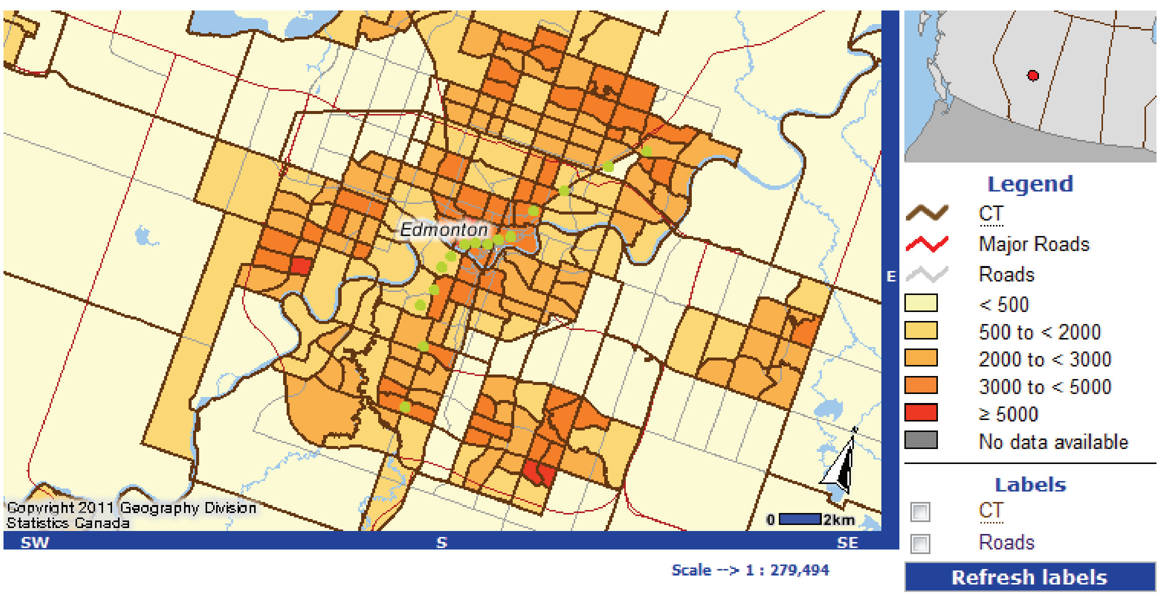

Figure 5: Edmonton Population Densities by Census Tract with LRT Stations

5.0.2 Map 3: Calgary

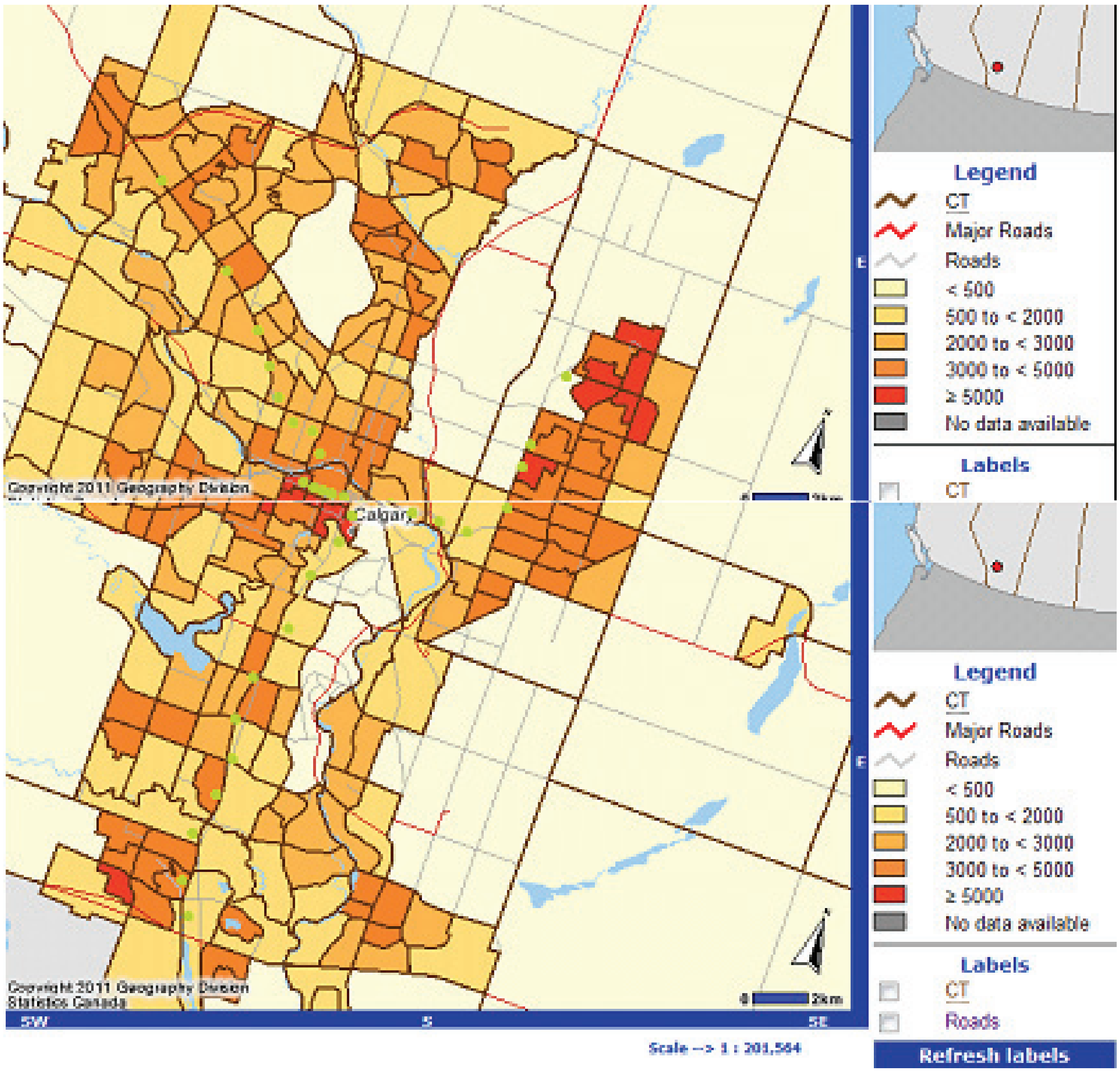

Figure 6: Calgary Population Densities by Census Tract with LRT Stations

5.0.3 Map 4: Ottawa

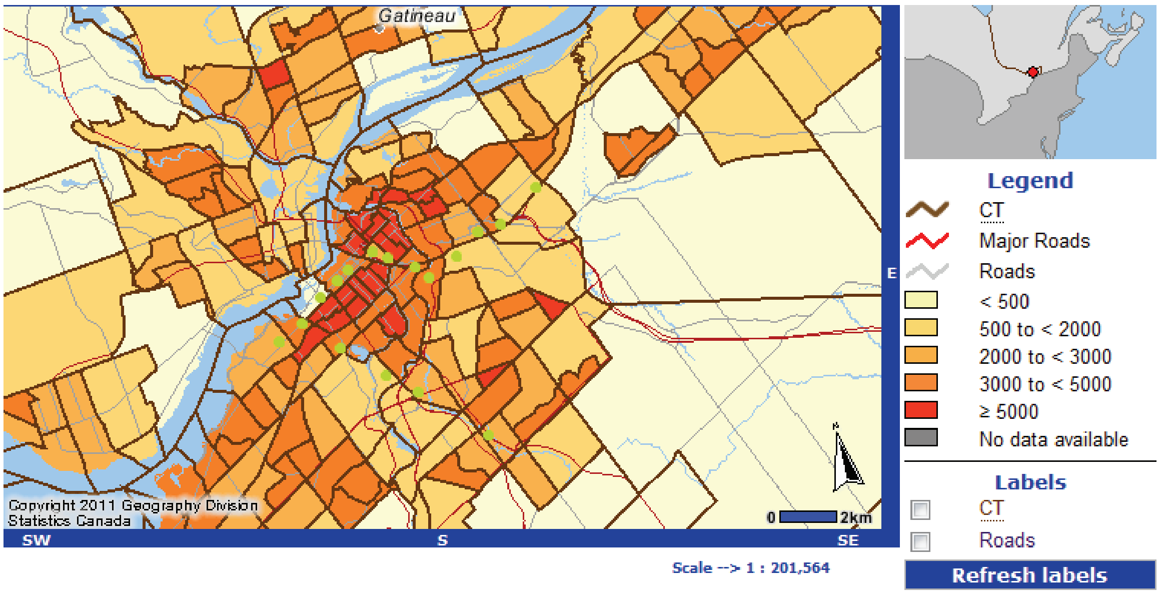

Figure 7: Ottawa Population Densities by Census Tract with Existing and Proposed LRT Stations

5.1 Discussion

Based on analysis of the Edmonton, Calgary, and Ottawa rapid transit systems, there is not necessarily a specific population density required to support a single rapid transit station. Nearly all of the stations observed in these three cities are located within census tracts with at least 500-2000 persons per square kilometre, and the number of stations falling within census tracts of this density is relatively low. Some are located within census tracts having more than 5000 persons per square kilometre, but the majority of stations fall within census tracts having population densities somewhere between these two categories. The same can be said of the proposed Halifax system, although Duke Station lies within a census tract having fewer than 500 persons per square kilometre, and population density between Duke and Birch Cove Stations is relatively low. However, this is one of the fastest-growing areas in the municipality, as illustrated by the following maps:

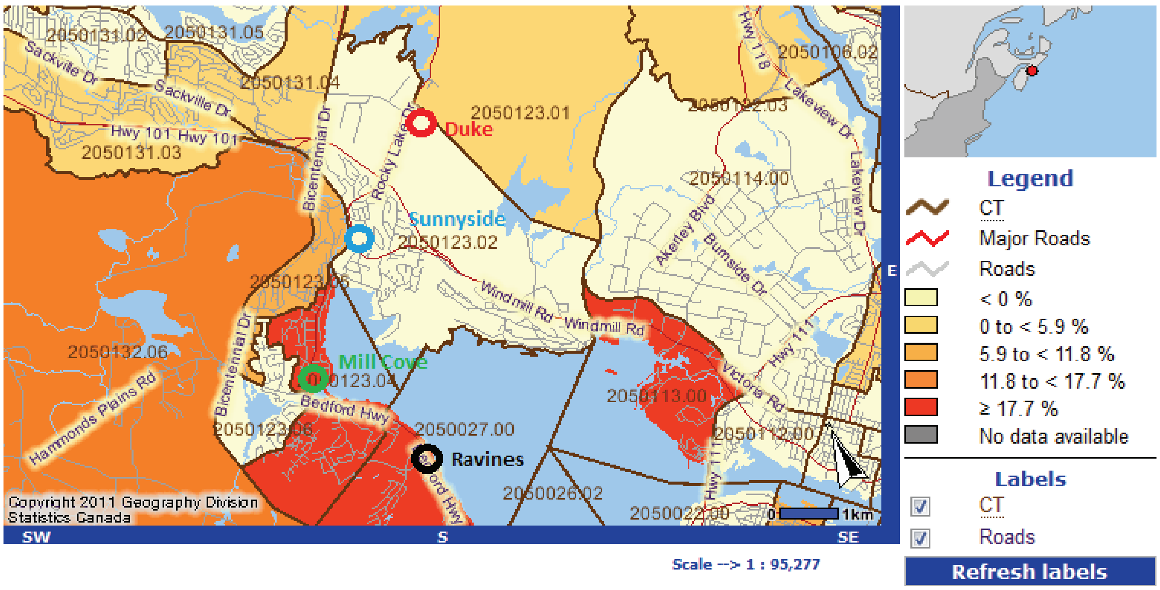

Figure 8: Bedford Population Growth Rates by Census Tract with Proposed Mainland North-Bedford Corridor Stations

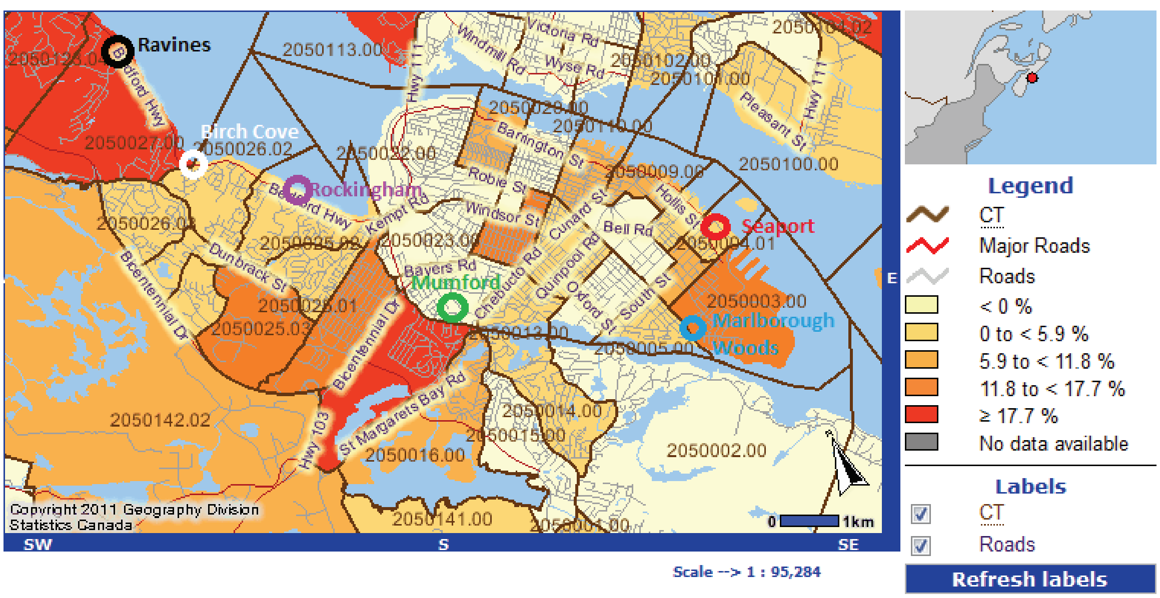

Figure 9: Halifax Population Growth Rates by Census Tract with Proposed Mainland North-Bedford Corridor Stations

This demonstrates that while the Mainland North-Bedford corridor may presently have a lower average population density than the rest of the area served by the proposed system, it is growing rapidly and can reasonably be expected to have a significantly larger population density within the near future.

It should be noted that most of the stations along the Mainland North-Bedford corridor fall within growth centres identified in the Regional Municipal Planning Strategy. The map displayed earlier as Figure # has been modified to show the approximate locations of stations along this route, shown as black circles. Duke Station, which does not fall within a growth centre, is not included, as it falls outside the boundaries of this map.

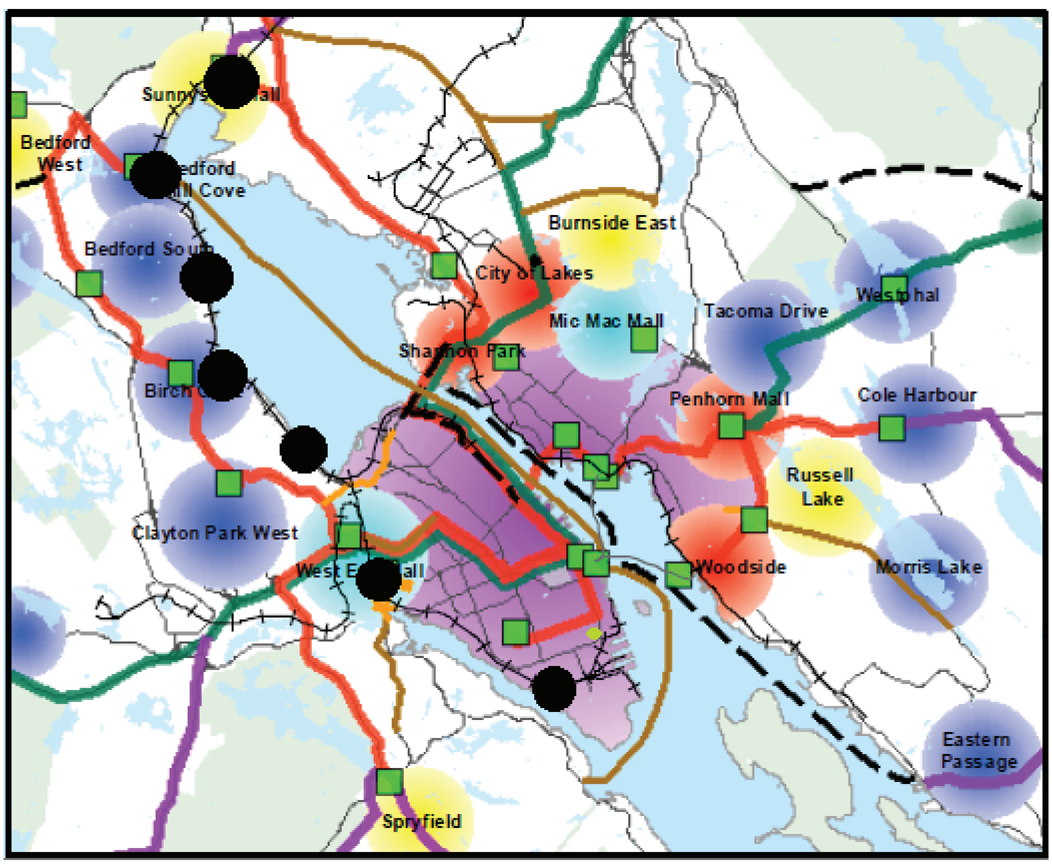

Figure 10: Settlement and Transportation Map with Proposed Mainland North-Bedford Corridor Stations

Additionally, several of the proposed stations along the other two lines fall within or immediately adjacent to the areas anticipated to accommodate increased densification in the regional centre. It should be noted that each of these areas would either be served directly by one of the proposed stations, or would be within easy walking distance of a station. The map displayed earlier as Figure # has been modified to show the approximate locations of stations within the urban core, shown as black circles.

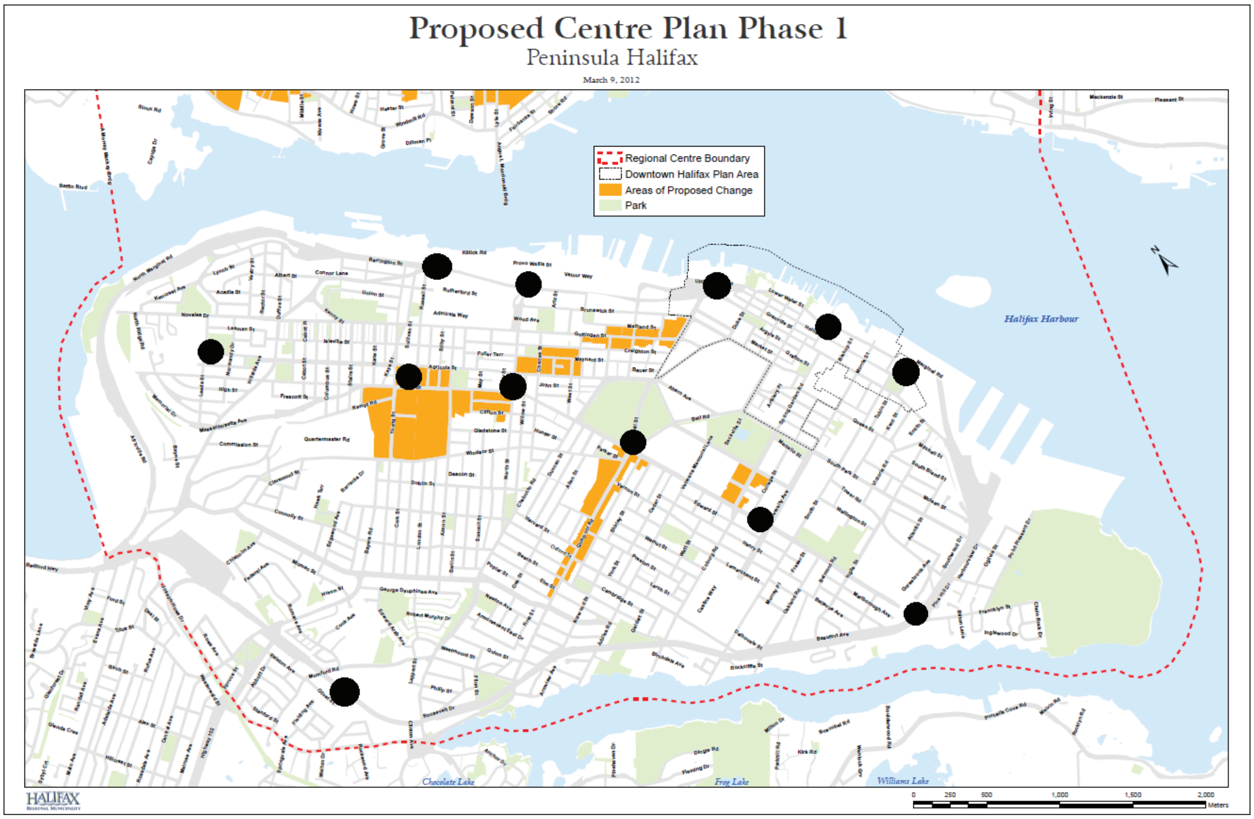

Figure 11: Proposed Centre Plan Phase 1 Map with Proposed LRT Stations

6.0 Levels of Service and Potential for Expansion

As mentioned in section 3.0, the establishment of high-capacity, high-frequency transit corridors is currently a priority for the municipality. Because vehicle performance varies in different contexts, and because technical data such as acceleration rates are not immediately available to the public, only a rough estimate of service frequency is possible at this time. Estimates have been based on the performance characteristics of the Bombardier Talent DLRT vehicle, used by Ottawa's O-Train system. According to Dan Fentiman, OC Transpo's current Superintendent of Light Rail, the 3-car Bombardier Talents used in Ottawa seat 135 and can accommodate an additional 150 standing passengers (D. Fentiman, personal communication, Mar. 27, 2012). Bombardier also produces a 35 metre, 2-car version of this vehicle which has a maximum capacity of 206 (Bombardier, 2012). For sake of comparison, the largest articulated buses currently used by Metro Transit have a maximum capacity of 112 (Nova Bus, 2011). The Talent requires about 30 seconds to reach its average operating speed of 60km/h (D. Fentiman, personal communications, Mar. 27, 2012). This means that for each station along the line, the train will be traveling at an average speed of 30km/h for approximately one minute, assuming a constant acceleration rate, and assuming that deceleration occurs at approximately the same rate. These are conservative estimates, since vehicles can normally decelerate more rapidly than they can accelerate. The remainder of travel along the line is assumed to be at 60km/h. These characteristics were used to estimate travel times along all three lines, though it should be noted that the in-street LRT sections of the Robie-Agricola and Hollis-Barrington Lines would likely be subject to the 50km/h speed limit imposed on standard motor vehicles. However, electrified LRT vehicles generally accelerate more rapidly than diesel-powered ones, so the reduced maximum speed is assumed to be offset by the quicker acceleration.

Based on this analysis, the travel time between Duke Station and Marlborough Woods Station, before station dwell times, is estimated at 20 minutes and 33 seconds;

travel time between Leeds and Marlborough Woods is estimated at 8 minutes and 3 seconds; travel time between Devonshire and Marlborough Woods is estimated at 8 minutes. Assuming an average dwell time of 20 seconds at each station other than Marlborough Woods, travel times may be estimated at 22 minutes and 55 seconds, 9 minutes and 43 seconds, and 9 minutes and 40 seconds, respectively. It is desirable to have a significantly longer dwell time at Marlborough Woods than at other stations, to allow passengers to transfer between trains.

At the same time, the above estimates show that if dwell times are reduced or average operating speed is increased slightly, 10-minute frequency might be achieved along the Robie-Agricola and Hollis-Barrington Lines using only two vehicles. 10-minute frequency could also be achieved by reducing the number of stations on each of these lines to five instead of six. Alternately, 12-minute frequency could be achieved using 20-second dwell times at stations while dwelling at Marlborough Woods for just over two minutes. This might initially make co-ordination with bus routes more difficult, but bus routes providing transfers with the rail network could be adjusted to run based on service frequency rather than fixed schedules. A single spare vehicle could be kept on standby for both routes, since they use the same type of vehicle. If the system is used heavily enough to require additional capacity, it may be necessary to construct a second track. This would require the use of another lane of roadway for each route, although if the system is stressed to the point that expansion is necessary, this likely means that it has diverted a significant number of people out of cars and buses, reducing the need for road space.

It may also be acceptable to initially run vehicles on the CN mainline at half the frequency of the other two lines, due to the lower population densities and lower incidence of major destinations along this line. If this approach is taken, this line would also only require two vehicles (plus a spare) in order to provide a service frequency of one train every 24 minutes, or half that of the other two lines. If Duke Station is not built initially, two vehicles could likely provide a service frequency of one train every 20 minutes. If demand requires an increase in service, two more vehicles could be added to this line. This would require the construction of additional passing track, but would reduce the time between trains to 10 minutes. If further expansion is necessary, the track could be twinned, as there is space for another set of tracks along the CN rail bed. This would require further negotiations with CN for use of this right-of-way.

Further lines could also be established in the future. The rail line running along the Dartmouth waterfront could be used to form the basis of a similar system in Dartmouth, as discussed in David Reage's thesis, *Connecting the dots: a study of the possibilities and challenges for passenger rail in Dartmouth* (Reage, 2004). A line running along Quinpool and Cogswell Streets, terminating at Scotia Square, could eventually be added to the system to serve the city's West End. The MetroLink network could also be expanded and integrated with the rail network in areas with ample road space.

6.1 Required Infrastructure

This thesis is meant to stimulate discussion and provide a starting point for the development of a rapid transit system in the urban core and along the Mainland North-Bedford corridor. As such, specifics such as the exact models of vehicles used, the exact properties that may need to be purchased by the municipality, the exact number of staff required, and the exact hours of operation have not been established, in order to allow for flexibility in the future. Additionally, CN was not asked specifics such as track rental fees and conditions of the municipality's use of its right-of-way, as it was felt that such conversations could have an impact on future negotiations. Nevertheless, an inventory of required infrastructure has been generated, and this can be used to determine capital and operating costs if details are finalized in the future. Federal funding for the development of rapid transit networks is available through several programs, outlined in the document *Federal Support for Bus Rapid Transit and Light Rail Transit in Canada*, which is publically available and was published in 2010.

6.1.0 Infrastructure Required by All Three Lines

Stations

Each station will require, at minimum, a shelter for passengers, a platform that is even with the floor of the vehicles traveling along the line, a system map, and a ticket vending machine. The physical layout of platforms will depend on whether the stations are located at street level or along the rail cut. While shelters may resemble modular aluminum-and-glass bus shelters, it may be desirable to modify the design of shelters to incorporate other materials such as wood or plastic, or to add features such as doors and lighting.

Using modular shelters where possible may reduce costs; if shelters are to be customized, one way to reduce costs may be to have post-secondary students design individual shelters as a major class project. This way, stations such as College that require sensitivity to their immediate environment can be custom-designed at a lower cost while also allowing local students to showcase their innovative design concepts. The Marlborough Woods station will require additional infrastructure including stairs and an elevator or ramp. It may be desirable to design this station to standards more closely resembling a major bus or ferry terminal.

Throughout this thesis, there has been a deliberate attempt not to name any of the stations after major local institutions. Many institutions, such as Dalhousie, Saint Mary's, or the NSIT may be willing to sponsor the construction of a station in their immediate area in exchange for naming rights.

There is also the opportunity to have other cities or transit agencies sponsor stations, which would then be themed after these cities or transit agencies in some way, including use of distinctive fonts, public art, or promotional or interpretive materials. This would be particularly appropriate since the proposed system draws its inspiration from various transit systems across the country. Sponsoring a station would likely improve the sponsor's public image and tourism potential.

Platforms will need to be long enough to provide access to all doors of whatever vehicle is chosen. If possible, platforms should be built longer than immediately necessary in order to accommodate future expansion. Samostie's inventory of required infrastructure examines in detail many different options for platform construction (Samostie, 2000). Wooden platforms are generally less expensive than those made of concrete, though they could potentially be made more attractive than concrete platforms by designing them to compliment the boardwalk aesthetic that has come to be associated with the Halifax waterfront.

Passing Tracks and Switching Mechanisms

Each line would initially use a single set of tracks for trains traveling in each direction with passing tracks installed at strategic points along the line. This will require the construction of additional track as well as switching mechanisms that will allow the trains to transfer between the main track and the passing track.

Vehicle Maintenance and Storage Facility

Because current transit maintenance facilities are not accessible by rail, a dedicated rail vehicle maintenance and storage facility will likely have to be built. All three lines must be able to connect to such a facility. VIA Rail has recently expressed interest in selling off surplus land around its South End station, and this would be an ideal location for such a facility because it is already connected to the existing rail network (Alberstat, 2011). If this land is no longer available, other properties in the immediate area should be considered as the area contains large amounts of underutilized surface parking and has good connections to the rail network. Because the Robie-Agricola line reaches Marlborough Woods at a different altitude from the other two lines, it will require extra tracks to allow vehicles to reach the maintenance facility. Alternately, tracks could be extended to one of Metro Transit's existing maintenance facilities if there is adequate capacity at one of these facilities.

6.1.1 Infrastructure required along the Mainland South-Bedford corridor

Park & Ride Lots

Many of the proposed stations would be located in areas that already have ample parking. Wherever possible, efforts should be made to facilitate the use of public transit or active transportation to reach stations. This has been shown in the Vancouver region to result in better urban design around the stations, as large dedicated park & ride lots create large "dead zones" for those who do not drive to the stations (Schiller et al., 2010). However, Duke Station in particular may require the establishment of a dedicated park & ride lot, as most of its potential users would not live within walking distance of the station. As mentioned before, an effort should be made to provide bus service between the stations and nearby residential communities.

Invero System

The Invero system is used in Ottawa to circumvent the requirement of having two personnel operating each train. Though relatively uncommon in North America, it is used widely in Europe. The system uses magnets to ensure that vehicles approaching stations are decelerating at the required rate. Though it is unknown how much this system costs to install, it would likely save money in the long run by reducing the line's staffing requirements.

Diesel-Powered Vehicles

As noted in section 6.0, service frequency approaching one train every 20 minutes along this corridor could be achieved using two vehicles, plus one spare. Consideration should be given to vehicles' acceleration performace. Low-floor vehicles are preferred as these increase the system's accessibility and decrease the time required for passengers to board and disembark at stations, and simplify platform design. Hybrid vehicles may also be considered. Ottawa's DLRT vehicles, with a capacity of 285 passengers each, cost approximately $6M each, bought new (D. Fentiman, personal communication, Dec. 20, 2011).

6.1.2 Infrastructure Required along the Robie-Agricola and Hollis-Barrington Lines

Electrically-Powered Vehicles

As noted in section 6.0, service frequency approaching one train every 10 minutes along these corridors could be achieved using two vehicles per line, with a single spare vehicle shared between the lines. Low-floor vehicles are preferred as these increase the system's accessibility and decrease the time required for passengers to board and disembark at stations. Preference should be given to vehicles that do not require raised platforms. Vehicle length is also an important consideration as vehicles cannot be longer than the shortest city block used as a station.

In-Street Tracks and Electrical System

Each corridor would require the installation of approximately 5.5km of track, not including passing tracks or tracks required to access the maintenance facility. Devonshire Avenue is a potential corridor that could be used to connect the two lines, allowing vehicles on the Robie-Agricola Line to access the maintenance facility. It is not known at this time whether the grade of Devonshire Avenue would be prohibitive for rail vehicles. An electrical system would also be required to power the vehicles. This would include either overhead wiring or an advanced electrified third rail embedded in the ground, as well as a system of supporting electrical infrastructure. Although "third rail" technology formerly required grade separation to eliminate the risk of injury to pedestrians or animals, recently developed technology allows for the construction of embedded third rails with isolated conducting segments that only activate when completely covered by a train (Alstom, 2008). This may be desirable to reduce the disruption of mature trees along the routes, as well as to reduce the potential for storms to damage the electrical system. Common construction costs for in-street LRT are reported at $5M per kilometre, although it is unclear whether this includes the electrical system, or whether this is for single- or double-tracked lines (Ruffili, 2010).

Transit Signal Priority

Transit signal priority should be installed at all signalled intersections along each route. This technology is already used by MetroLink buses. Additional traffic signals may also be necessary at intersections that currently use stop signs; whether this will be necessary is unknown at this time.

7.0 Conclusion

Though undoubtedly requiring a large capital expenditure, the proposed system would likely save money over the long run by reducing staffing requirements and fossil fuel dependency along heavily used corridors. Perhaps more importantly, the proposed system would complement HRM's goals of improving service frequency, capacity, reliability, and comfort along key corridors, increasing the modal share of public transit, and providing the groundwork for transit-oriented development in identified growth centres. Citizens and visitors alike would enjoy more convenient access to many of the region's key employment areas, retail centres, post-secondary institutions, hospitals, parks, and cultural and entertainment destinations. The three routes are also highly scenic, with the Mainland North-Bedford corridor offering unobstructed views of the Bedford Basin along much of its length, while the other two routes would showcase some of the region's most attractive streetscapes and architecture. Characteristics of the proposed system, regarding population density and land use around stations, are generally consistent with characteristics of well-established rapid transit systems elsewhere in Canada. While the exact capital costs of such a system are currently unknown, if they are generated in the future, they should be compared with the costs of road and highway expansion that will likely be necessary without a major investment in rapid transit.

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