Rapid Transit Initiative

Phase 2 Summary Report – Environmental Assessment Study

September 24, 2009
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<tr>
<td>Preparation</td>
<td>Doug Willoughby</td>
<td>AECOM Project Manager</td>
<td>September 24, 2009</td>
</tr>
<tr>
<td></td>
<td>Katie Harvey</td>
<td>AECOM Designer - Transportation</td>
<td></td>
</tr>
<tr>
<td>Revision</td>
<td>Darshpreet Singh Bhatti</td>
<td>Region of Waterloo Senior Project Manager</td>
<td>July 14, 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rapid Transit Initiative</td>
<td></td>
</tr>
<tr>
<td></td>
<td>David Durant</td>
<td>Region of Waterloo Senior Project Manager</td>
<td></td>
</tr>
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<td>Rapid Transit Initiative</td>
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| ACRONYMS USED IN THIS REPORT | | |
|-------------------------------|------------------|
| aBRT                          | Adapted Bus Rapid Transit |
| BAU                           | Business as Usual  |
| BRT                           | Bus Rapid Transit   |
| CA                            | Conservation Authority |
| CEA                           | Canadian Environmental Assessment |
| CEAAP                         | Canadian Environmental Assessment Act |
| CTC                           | Central Transit Corridor |
| DFO                           | Department of Fisheries and Oceans |
| DMU                           | Diesel Multiple Unit |
| EA                            | Environmental Assessment |
| ESPA                          | Environmentally Sensitive Policy Area |
| FEAC                          | Federal Environmental Assessment Coordinator |
| GHG                           | greenhouse gas      |
| Hwy                           | Highway             |
| iEA                           | Individual Environmental Assessment |
| Leq                           | equivalent sound    |
| LRT                           | Light Rail Transit  |
| MAE                           | Multiple Accounts Evaluation |
| Maglev                        | Magnetic Levitation |
| MOE                           | Ministry of the Environment (Ontario) |
| PCC                           | Public Consultation Centre |
| PLUM                          | Population and Land Use Model |
| PPHPD                         | Passengers per Hour in Peak Direction |
| PRT                           | Personal Rapid Transit |
| PSW                           | Provincially Significant Wetland |
| RA                            | Responsible Authority |
| Region                        | Regional Municipality of Waterloo |
| RGMS                          | Regional Growth Management Strategy |
| ROP                           | Regional Official Plan (new) |
| ROPP                          | Regional Official Policies Plan |
| RoW                           | Right of Way        |
| RT                            | Rapid Transit       |
| RTMP                          | Regional Transportation Master Plan |
| SAR                           | Species at Risk     |
| ToR                           | Terms of Reference  |
| UW                            | University of Waterloo |
| WLU                           | Wilfrid Laurier University |
1.0 INTRODUCTION

As a key component of its Regional Growth Management Strategy\(^1\), the Regional Municipality of Waterloo (Region) is proposing a new rapid transit system to link the major urban centres of the City of Cambridge, City of Kitchener and City of Waterloo.

This Phase 2 Summary Report documents the Environmental Assessment (EA) process undertaken to the end of Phase 2 of the Individual Environmental Assessment (IEA) by the Region for the new Rapid Transit system in accordance with the Terms of Reference (ToR) approved in July, 2005 by the Minister of the Environment (Ontario).

1.1. ONTARIO ENVIRONMENTAL ASSESSMENT PROCESS FOLLOWED

The Region of Waterloo initiated an Individual EA under the Ontario Environmental Assessment Act (EA Act) in 2005. This included preparation of a Terms of Reference (ToR) that was approved by the Minister of the Environment (Minister) on July 21, 2005. Following approval of the Waterloo Rapid Transit Initiative ToR, the Region proceeded to prepare the EA.

In June 2008, Ontario Regulation 231/08 Transit Projects and Greater Toronto Transportation Authority Undertakings (Regulation) was approved under the EA Act. This provided the Region with the opportunity to expedite the EA in the interest of initiating rapid transit within the Region of Waterloo as quickly as possible. The Regulation sets out a new assessment process for transit projects in Ontario based on a six month regulated timeline from project notice of commencement to statement of completion. An overview of the transit project assessment process under the Regulation is shown in Figure 1-1\(^2\).

As a result, for projects subject to the Regulation, proponents are no longer required to follow the Class EA or IEA processes. In the spirit of streamlining the approval process for transit infrastructure improvements in Ontario, new transit initiatives can be constructed faster and the benefits to communities, the environment and the economy can be recognized sooner.

In a letter (July, 2009) to the MOE, the Region advised the Minister of its intent to transition from the IEA process to the new O.Reg. 231/08 assessment process.

This Phase 2 Summary report is intended to summarize Phase 2 of the IEA and to serve as background document for the new transit project assessment process.

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1.2. FEDERAL ENVIRONMENTAL ASSESSMENT PROCESS FOLLOWED

The Canadian Environmental Assessment Act (CEAA) is triggered when a federal authority exercises a power, duty or function in relation to a proposed undertaking (e.g., through federal funding, granting a permit, licence or authorization, etc.). For the Waterloo Rapid Transit project, because federal funding is being secured through the Build Canada fund program (administered by Infrastructure Canada) this will trigger the CEAA. As a result, CEAA approval will be sought concurrently with the Provincial EA Act approval under the Provincial / Federal Harmonization process.

In order to formally initiate the CEAA process and confirm the scope of the assessment, a Project Description will be prepared based on the preferred rapid transit system and submitted to the CEA Agency, who will act as the Federal Environmental Assessment Coordinator (FEAC). As the FEAC, the CEA Agency will coordinate distribution of the Project Description with other Federal Authorities (FAs) to determine if there are any Responsible Authorities (RAs) in addition to Infrastructure Canada or interested FAs who wish to participate in the EA based on their review of the Project Description. The RA is the federal authority that is required pursuant to subsection 11(1) of the CEA Act to ensure that an EA of the project is conducted prior to exercising a power, duty or function in relation to the undertaking.

Under a Ministry of the Environment (MOE) approval lead, MOE would be responsible for communicating appropriate information to the CEA Agency, who would be responsible for communicating to potential RAs, in accordance with the Federal / Provincial Harmonization Process.

The Project Description for the CEAA process will be prepared concurrently with the transit project assessment under the Regulation.

1.3. DESCRIPTION OF THE UNDERTAKING

Rapid transit is defined in the approved IEA ToR:

“… as a public transportation system operating for its entire length primarily on an exclusive RoW. The definition includes systems operating at-grade, and systems operating on elevated or underground facilities.”

In the IEA ToR, the “Undertaking” is defined as:

- one or more proposed rapid transit technologies,
- one or more proposed rapid transit routes,
- several proposed rapid transit stations,
• Enhancing our Natural Environment
• Building Vibrant Urban Places
• Providing Greater Transportation Choice
• Protecting Our Countryside
• Fostering a Strong Economy
• Ensuring Overall Coordination and Cooperation

To achieve these goals, the Region will be adopting new approaches to re-urbanization and intensification in the main urban area formed by the Cities of Cambridge, Kitchener and Waterloo. Reshaping this urban environment will require the Region to consider its changing demographics towards a maturing population, increased ethnic mix, increasing density forms and an increased number of people who do not or cannot travel by private automobile. Some of the benefits to this reshaped urban environment will be reduced air pollution, improved public health, reduced dependence on fossil fuels, and the long-term protection of ecological systems and precious rural lands and agricultural resources.

The Region considers the establishment of a rapid transit system in the Region’s primary re-urbanization area to be an essential catalyst to achieving the goals set out in the RGMS. The primary re-urbanization area and symbolic potential central transit corridor are shown in Figure 1-2.

The 38 kilometre long Central Transit Corridor extends from North Waterloo, south to Uptown Waterloo and through the Kitchener downtown to the Galt City Centre in downtown Cambridge. A system planning approach seeks to integrate rapid transit in the corridor with other public transit services such as GRT buses, intercity bus services, VIA Rail service, future GO Transit and Park and Ride facilities. The system approach also calls for integration of rapid transit with other transportation modes such as pedestrian travel and cycling. The Region anticipates that, over time, its pursuit of new approaches to re-urbanization and intensification will support increased use of the proposed rapid transit system and conventional transit services.

Figure 1-2 – Regional Growth Management Strategy Central Transit Corridor

1.4.3. REGIONAL TRANSPORTATION MASTER PLAN

A new Regional Transportation Master Plan (RTMP) is currently being developed by the Region of Waterloo. The new RTMP provides a comprehensive, forward-looking strategy focused on sustainable forms of transportation and building on other Regional policies, such as the Region’s Pedestrian Charter, Regional Cycling Plan, and the RGMS. The new RTMP will also plan for the implementation of the rapid transit system in the Central Transit Corridor as part of its “transit first” approach, integrating GRT bus service with rapid transit service and developing cross corridors with frequent bus service to build up transit ridership.

1.4.4. OTHER REGIONAL INITIATIVES SUPPORTIVE OF THE RAPID TRANSIT INITIATIVE

In addition to policies previously mentioned, the Region of Waterloo has set in place a number of other policies, programs, and publications that have been developed to support the proposed rapid transit system. Some of these programs are listed below:
1.4.5. PROJECT SPECIFIC STUDIES

Technical Studies for a contemplated rapid transit project were prepared in 2004-2005, prior to the commencement of the IEA. The studies included a detailed cost-benefit analysis that was submitted to the Provincial and Federal Governments in November 2005. The Technical Studies concluded that rapid transit was a feasible transportation alternative and a strategic financial investment that would support the Region’s economy, competitiveness and prosperity over the next 30 years, while meeting Provincial and Regional planning goals.

The Region subsequently entered into the IEA process in 2006. At the time, the IEA Terms of Reference bound the proponent to completing a three phase process. The phases were outlined in the ToR as follows:

- Phase 1: Assessment of the Undertaking and Alternatives to the Undertaking
- Phase 2: Assessment of Alternative Methods of Carrying out the Undertaking
- Phase 3: Assessment of the Preliminary Design of the Undertaking

Phase 1 was completed in July 2006. Phase 2 was completed in mid-2009. The ToR Phase 3 has not been initiated. The following outlines the work which was prepared as a part of the IEA process in Phases 1 and 2 prior to transitioning to O. Reg. 231/08.

**Phase 1: Alternative transportation strategies**

Phase 1 required that the proponent compare the Rapid Transit Undertaking to alternative transportation strategies (i.e. alternatives to the undertaking) that may also address the long-term transportation needs of the Region. Using the six identified RGMS Goals and 15 measures as the basis of comparison, rapid transit was compared to the following alternatives:

- Baseline
- Road Improvement and Expansion
- Improve Conventional Transit

It was concluded that rapid transit is the preferred strategy for the Region because it best meets the goals of the RGMS. It was recommended that a package of planning initiatives, including new land use policies should be developed within the Central Transit Corridor to support rapid transit. Phase 1 was approved by Regional Council on July 12, 2006.

**Phase 2: Alternative Methods**

The purpose of Phase 2 was to assess the alternative methods of carrying out the undertaking, with the undertaking being rapid transit. To allow for a logical, traceable approach to the identification and evaluation of alternative methods, Phase 2 was divided into three Steps.

In Phase 2 Step 1, alternative technologies (i.e., Bus Rapid Transit and Light Rail Transit) and route designs (i.e., on and off-road) were assessed in order to screen out from further consideration those rapid transit alternatives that did not meet the Region’s objectives. On February 28, 2007, Regional Council approved Bus Rapid Transit (BRT) and Light Rail Transit (LRT) operating at grade in dedicated on-road and off-road conditions as the best technologies and route designs for further consideration. Each of these technology and route design options were found to be potentially capable of accommodating the projected passenger demands and fulfilling other project objectives.

In Phase 2 Step 2, potential rapid transit routes and station locations were identified. Between five and eight route alternatives were developed within each of seven segments of the Central Transit Corridor. Each route alternative was evaluated for both LRT and BRT technologies using a series of 21 criteria, identified in the IEA Terms of Reference. The evaluation produced a set of rankings of rapid transit technologies and route alternatives for each segment. This evaluation provided the basis to identify top-ranked route segments for assembling a set of 3-5 rapid transit system alternatives.

In Phase 2 Step 3, combinations of route and technology alternatives from the top ranked route segments were assembled to create a long list of reasonable system alternatives. The long list was narrowed to reasonable route and technology alternatives through a series of transportation planning and engineering feasibility studies. A Multiple Accounts Evaluation (MAE) was applied to evaluate the alternative rapid transit systems. The MAE results were used to select a preferred rapid transit system that would serve the long-term needs of the cities of Cambridge, Kitchener and Waterloo. Phase 2 of the IEA was then concluded.

The following reports were prepared as a part of the IEA process in Phase 2.
2.0 PURPOSE OF THE RAPID TRANSIT PROJECT

A new rapid transit system is intended to address the Region’s forecasted future growth, from 520,000 people today to 729,000 over the next 20 years. Planning studies conducted during the development of the RGMS concluded that road expansions alone would not provide a sustainable solution for Waterloo Region.

Consequently, the purpose of the rapid transit project is to add transportation system capacity in the most heavily used transit corridor, to stimulate re-urbanization particularly in the Central Transit Corridor, while providing greater transportation choice to the Region’s residents, businesses and institutions moving within and among the Region’s major urban areas.

Primarily, the project is intended to foster intensification and redevelopment within the Region’s primary re-urbanization area. Intensification and redevelopment are expected to shape urban form in a more efficient manner and thereby avoid, delay or minimize the expansion of urban areas into the Region’s valuable agricultural, environmental and rural areas. As a result, the Region is also encouraging aggressive land use and transportation policies that would promote use of public transit and stimulate re-urbanization.

3.0 THE PREFERRED TRANSPORTATION SOLUTION FOR WATERLOO REGION

Phase 1 of the IEA established that the rapid transit undertaking is the Preferred Transportation Solution for Waterloo Region for the following reasons:

- Best achieves the goals of the Regional Growth Management Strategy
- Is consistent with the Provincial Policy Statement and conforms with the Provincial Places to Grow Plan for the Greater Golden Horseshoe
- Supports re-urbanization objectives, downtown revitalization and innovative urban design
- Increases transportation choice and transit ridership
- Is the least expensive form of motorized transportation in the long term when considering personal transportation costs
- Contributes to the Region’s countryside protection goal by facilitating re-urbanization and reducing the pressure to expand urban boundaries
- Provides a safe mode of transportation and promotes an active and healthier lifestyle
- Utilizes the least amount of land and minimizes the impact on air quality and greenhouse gas emissions

Background documentation related to Phase 1 of the IEA is available in the Phase 1 Summary document under separate cover.

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4.0 DESCRIPTION OF THE ENVIRONMENT POTENTIALLY AFFECTED

4.1. DESCRIPTION OF THE STUDY AREA

The Study Area for the IEA is focused on the central urban core areas within the Region’s three Cities: Cambridge, Kitchener, and Waterloo, also referred to as the Central Transit Corridor. An area designated in the Regional Official Policies Plan (ROPP) for industrial/commercial development located immediately north of the Waterloo urban boundary (i.e. the Mercedes Industrial/Commercial Area) is also part of the Study Area. The boundaries of the Study Area extend from immediately north of Waterloo, through the Kitchener core area and south to the Galt City Centre in downtown Cambridge, as illustrated in Figure 4-1. The Study Area was divided into the following seven unique segments from north to south.

Segment 1 – Uptown Waterloo North
Segment 2 – Uptown Waterloo to Downtown Kitchener
Segment 3 – Downtown Kitchener to South Kitchener (Fairview Park Mall)
Segment 4 – South Kitchener to Cambridge (Preston)
Segment 5 – Preston Towne Centre to “The Delta”
Segment 6 – Hespeler Road Section
Segment 7 – The Delta to South Cambridge

4.2. EXISTING ENVIRONMENTAL CONDITIONS

For the purposes of this study, the existing environment includes the existing built environment and the existing natural environment.

4.2.1. EXISTING BUILT ENVIRONMENT

This description of the existing built environment within the study area highlights major cultural, social and economic features and facilities contributing to the Region’s high quality of life for residents. It also describes the existing transit system and road network.

Existing Cultural Features and Facilities

St. Jacob’s Farmers Market is located at the north end of Segment 1. This market serves local residents and is a popular tourist attraction. Waterloo Park is located south of the University of Waterloo on the Waterloo Spurline railroad owned by the Region. This park covers approximately 110 acres and includes many recreational facilities. It serves as the venue for many summer events. Uptown Waterloo, including Waterloo Town Square, is an important commercial and cultural feature in the City of Waterloo.

Downtown Kitchener is included in Segment 2. Downtown amenities include numerous restaurants and nearby Victoria Park. The northeast projection of the downtown is the Civic Centre District with a number of major civic uses such as the Centre in the Square theatre, an art gallery, and the main branch of the Kitchener Library. The south end of the downtown is the Market District with the new Farmers Market – an area of significant redevelopment potential.

Included in Segment 4 is the Grand River which is a federally designated Heritage Waterway. The river has features of natural and cultural heritage, as well as significant recreational and scenic value.

In Segment 5 includes Linear Park and Riverside Park along the Speed River, the Preston Memorial Auditorium and Preston Library.

In Segment 7, features within the downtown include the year-round farmer’s market, a linear park along the picturesque Grand River, the Cambridge Centre for the Arts and David Durward Centre, and many historical churches and buildings.

Existing Social Features and Facilities

Segment 1 includes large areas of residential land use. Many residential units near King Street and University Avenue are rented to university students. The University of Waterloo is located at University Avenue and the Waterloo Spurline crossing. Wilfrid Laurier University is located at University Avenue and King Street. The universities have a combined student population of nearly 40,000.

In Segment 2, significant multi-residential development has taken place in Kitchener’s downtown neighbourhoods. The City has designated Mixed Use Corridors along arterial roads surrounding the downtown to allow for intensification of arterial corridors while providing stability to the interior residential neighbourhoods. Mixed Use Corridor designations with redevelopment potential are situated along Queen Street, Margaret Avenue, Weber Street and Victoria Street. Grand River Hospital completed major renovation and expansion to now include a state-of-the-art regional cancer centre, new emergency department and other new health care facilities. The outpatient caseload at the Hospital is forecast to double from 62,300/year in 2002, to almost 120,000/year by 2010. The northeast section...
of the downtown area is the Civic Centre District with a number of major civic uses such as the Provincial and County
courthouse buildings, Registry office and Region of Waterloo headquarters.

Both sides of King Street in Segment 3 are designated as a Mixed Use Corridor, providing for intensification
opportunities in the form of office, commercial and residential uses. Cameron Heights Secondary School is located
on Charles Street, and Eastwood Collegiate Secondary School on Weber Street. There is potential for an intensified
node at the King Street and Ottawa Street intersection given Ottawa Street functions as an east-west arterial. Other
uses in the vicinity of Fairview Park Mall include a significant area of high density residential to the north and the
Hidden Valley Residential Community Plan for further estate residential development on the south side of Fairway
Road.

The Regional Police headquarters and Regional Operations Centre are located in Segment 4 on Maple Grove Road
east of Highway 8.

The Preston Towne Centre, in Segment 5, fronts onto King Street and is designated as a Community Core Area in the
ROPP. The Towne Centre is a linear concentration of low-rise mixed-use retail, commercial and residential buildings.
Eagle Street, provides a road connection from the Preston Towne Centre to the Bridgecam Power Centre at Hespeler
Road and Pinebush Road, with a new 12 storey condominium built near the Eagle Street / King Street intersection.

Generally, the neighbourhood surrounding the Preston Towne Centre is stable, with the potential for some
intensification along Eagle Street on the northerly edge of the core. To the southeast along Coronation Boulevard is a
mix of stable fronting residential lots that transition into institutional, recreational, open space and commercial uses
including the Cambridge Memorial Hospital, the Galt Country Club and the Dumfries Conservation Area. The Hospital
medical centre also contains a grouping of medical clinics and professional offices, as well as service commercial uses.
The Riverbend Residential Care Facility directly south of the hospital functions both as a retirement home and
long term care centre.

Uses within Segment 6 include the Regional Police headquarters at Hespeler Road and Munch Avenue, Conestoga
College Academic Upgrading Campus and the Greyhound Bus Terminal on Langs Drive. Large parcels of undeveloped
land to the east and south of the Cambridge Centre offer opportunities for intensification. Potential
infilling and intensification opportunities exist within numerous parts of this corridor section.

In Segment 7, the Delta area contains a number of single detached dwellings. Further south on Water Street is Galt
College Institute Secondary School. The Galt City Centre of Cambridge extends south from Samuelson Street
approximately two kilometres, situated on both sides of the Grand River. It is designated as a Community Core Area
in the Regional Plan, with a mix of retail / office commercial, industrial, community and civic uses. The Galt City
Centre is the location of the City of Cambridge municipal offices and Council chambers. The University of Waterloo’s
School of Architecture is located just off Main Street, on Melville Street South.

Existing Economic Features and Facilities

Segment 1 includes the Weber Street Business Park area and the North Campus Research and Technology Park.
Conestoga Mall, a Regional shopping centre, the University of Waterloo, and Wilfrid Laurier University. Many small
businesses near King Street and University Avenue cater to university students and provide a large number of jobs.

Segment 2 includes two major regional employers at Grand River Hospital and the Sun Life / Clarica headquarters on
King Street west between Union Street and Pine Street. The downtown core of the City of Kitchener is designated as
a Community Core Area in the ROPP, and includes approximately one million square feet of retail space and two
million square feet of office space. The northwest area of the downtown, described as the Warehouse District, is
characterized by warehouse buildings slated for office conversion.

Both sides of King Street in Segment 3 are designated as a Mixed Use Corridor, providing for intensification
opportunities in the form of office, commercial and residential uses. On Fairway Road, Fairview Park Mall is
designated as a Regional Shopping Centre, and has recently undergone extensive renovations. The Mall includes a
transit centre, functioning as a transfer and destination point. Other uses in the vicinity of the Mall include varying
forms of retail and service commercial uses along Fairway Road and an approved Hidden Valley Industrial Secondary
Plan for business park development. A number of hotels and large restaurants are also located at the King Street /
Fairway Road intersection in the Arterial Commercial District.

The former Sportsworld Park is located in Segment 4. The City of Kitchener Official Plan designates the urban area
surrounding the former Sportsworld Park as a Planned Commercial Campus. This designation accommodates large
retail uses consisting of buildings or plazas in a power centre format. An office park complex and retail units are
currently being developed on the former Sportsworth site. Existing uses in south Kitchener include large format retail
stores such as the Brick, Costco, Future Shop, Sears Furniture & Appliances, Home Depot, and numerous service
commercial uses on a regional and inter-regional scale. Major entertainment venues such as Famous Players Silver
City Cinemas, Chapters Bookstore, hotels, and restaurants offer variety and diversity to this commercial node. Sites
such as the formerly empty Lulu’s Plaza have already undergone redevelopment. This section is also located
immediately west of the Cambridge Business Park centred on Maple Grove Road in the City of Cambridge, with major
employers including Toyota Motor Manufacturing Canada Inc. (3,000 employees) and Automated Tooling Systems.

Preston Towne Centre, in Segment 5, is a traditional downtown; which has a Business Improvement Area program in
place that encourages infilling and redevelopment. To the southeast along Coronation Boulevard is a mix of stable
residential lots that transition into institutional, recreational, open space and commercial uses.

Segment 6 consists mainly of a 3.5 kilometre Hespeler Road segment, which is located between Highway 401 to the
north and “The Delta” (Hespeler Road / Dundas Street intersection) to the south. Central to this “strip” is the 725,000
square foot Cambridge Centre, a Regional shopping centre. To the west and east of the Hespeler Road commercial
strip are the Eagle Industrial Park and the L.G. Lovell Industrial Park. Both are major employment areas that could
benefit from further business intensification. At the north end of this section, the Bridgecam Power Centre is situated
at Hespeler Road and Pinebush Road. The Power Centre includes large format freestanding retail (Rona, Canadian
Tire and Wal-Mart) and retail outlets in plaza formats (i.e. Roots, Old Navy, Staples, Bouclair, and Michael’s). A large Home Depot outlet is located on the south side of Pinebush Road. On Eagle Street, west of Hespeler Road, existing uses that include gas stations, auto dealerships, etc. have potential to be intensified. Industrial lands adjacent to the Power Centre have redevelopment opportunities that could provide future employment.

In Segment 7, the Delta area is the roadway junction between Galt City Centre, Preston Towne Centre and the Hespeler Road commercial corridor. The Delta corner is designated a Neighbourhood Shopping Centre in Special Policy No. 24 of the Official Plan, and has recently developed in part to provide service commercial uses to service the traveling public. Existing warehouse buildings provide opportunities for redevelopment to office, retail and residential uses. Successful redevelopment projects in the core already include the Southworks outlet mall on Grand Avenue west of the Grand River, which is a major tourist attraction. The Galt City Centre of Cambridge extends south from Samuelson Street approximately two kilometres, situated on both sides of the Grand River. It is designated as a Community Core Area in the Regional Plan, with a mix of retail / office, commercial, industrial, community and civic uses.

The following figures show maps of the existing built environment for each segment. The built environment is divided into the following categories; multiple residential, mixed-use, commercial core, commercial, institutional, industrial / business park, and park / recreation.

Existing Transit and Road Network

Grand River Transit (GRT) currently provides all of the Region of Waterloo’s public transportation services in the tri-cities, with extended limited services to the outlying townships. Local bus service and an iXpress service currently operate in the Region. The iXpress route operates in a north-south corridor and includes 13 stations between Conestoga Mall and the Ainslie Terminal. Grand River Transit operations utilize standard 40 ft. buses and mobility plus buses for the disabled. Some buses are “hybrid” powered. Many main arterial roadways throughout the Region feature cycling lanes or nearby cycling trails and the vast majority of municipal and regional roads are lined with sidewalks and other pedestrian amenities.

While alternative transportation options are, for the majority, readily available throughout the Region, most trips made in the Region of Waterloo are made by private automobile. The existing transportation network in the Region of Waterloo has evolved with, and to suit, the automobile. Although infrastructure improvements have been made to accommodate other modes of travel, the road network favours the automobile. Major highways in the CTC include Highway 7, Highway 8, Highway 401, and Highway 85. Expansion of the highway network is now underway. Supporting arterial roads include King Street, Northfield Drive, Columbia Street, University Avenue, Erb Street, Victoria Street, Ottawa Street, Fairway Road, and Hespeler Road.

Figure 4-2 – Uptown Waterloo North Section
Figure 4-3 – Uptown Waterloo to Downtown Kitchener Section

Figure 4-4 – Downtown Kitchener to South Kitchener
Figure 4-5 – South Kitchener to Cambridge (Preston)

Figure 4-6 – Preston Towne Centre to “The Delta” & Hespeler Road
4.2.2. EXISTING NATURAL ENVIRONMENT

Since the study area for this undertaking involves a designated and largely built-up urban environment, the natural environment features or systems that are affected by the undertaking are modest. In particular, the Region anticipates no displacement of the whole or any part of a provincially significant environmental feature or regional environmentally sensitive policy area. The only new intrusions upon the natural environment anticipated by the Region are future watercourse crossings. Further details are provided below.

Provincially Designed Environmental Features

The IEA study area includes one provincially designated environmental feature, namely a provincially significant wetland (PSW) located along the Speed River in the vicinity of Highway 401 as shown on the south part of Figure 4-8. Six other PSWs are located in proximity to the study area, associated with the following Environmentally Sensitive Policy Areas (ESPA), and the Region intends to avoid or minimize impact on these wetland features:

- In ESPA 27 – Hidden Valley on the west side of Highway 8 adjacent to the South Kitchener portion of the study area
- In north Waterloo associated with ESPA 18 – Laurel Creek west of the study area
- Associated with ESPA 26 – Idlewwood Park in central Kitchener east of the study area
- Associated with ESPA 36 – Speed and Grand Confluence just south of Highway 401 and west of the study area
- Associated with ESPA 38 – Cruickston Park west of the study area
- Associated with ESPA 59 – Devil’s Creek Swamp & Forest in Cambridge, west of study area

Regionally Designated Natural Habitat Network

Figure 4-8 also shows that the IEA study area includes no designated ESPAs, although two ESPAs are located in the following nearby locations, and are designated as such in the ROPP:

- ESPA 27 – the Hidden Valley area south of Fairway Road and west of Highway 8 in the South Kitchener to Preston section
- ESPA 73 – Grandview Woods on the south side of the Grand River, south of ESPA 27 and immediately west of Highway 8

Five other ESPAs are located in proximity to the study area as shown on Figure 4-8 and will also be considered in the evaluation of potential impacts and mitigation measures. The Region intends to avoid or minimize any impact on any provincially or regionally significant natural features and areas. There are also records of a number of Species at Risk (SAR) within and adjacent to the study area. They will be considered not only within designated features, but also undesignated features such as natural corridors.
Figure 4-8 – Major Designated Natural Environment Features

Watercourse Crossings

The Region anticipates that, regardless of alignment, the future rapid transit system will need to cross two major watercourses:

- The Grand River in the Freeport area of South Kitchener where King Street and the CPR rail line currently cross on existing, adjacent structures. The Grand River is a significant natural heritage feature and designated a Heritage River, navigable waterway and fish habitat. The river corridor is also used by wintering Bald Eagles. Potential impacts on this important natural heritage feature and Bald Eagle use in this area will be addressed in the transit project assessment if this route is selected.

- The Speed River through the Preston area is managed as an urban fishery, with a diverse warmwater fish community dominated by top predators (e.g. smallmouth bass and pike).

For routes that cross watercourses, the Region intends to consider alternative designs to determine what is feasible and reasonable to avoid or minimize adverse environmental impacts on these watercourses.

5.0 PHASE 2: ALTERNATIVE DESIGN METHODS CONSIDERED

This section highlights the alternative design methods that were considered, their evaluation, and the identification of the recommended rapid transit project.

Identifying the recommended transit project involved three steps:

Step 1: Identification and Evaluation of Alternative Transit Technologies and Route Designs: This first step was to evaluate transit technologies and route designs, and recommend the ones best suited for the Region of Waterloo (Section 5.1).

Step 2: Identification and Evaluation of Technology and Route Section Alternatives: This second step was to evaluate and rank various route alternatives and technologies within each of the seven corridor segments (Section 5.2).

Step 3: Identification and Evaluation of Rapid Transit System Alternatives: Finally, using the top ranked combinations of technology and route alternatives for each segment, reasonable rapid transit route system alternatives were developed and evaluated (Section 5.3).

Sections 5.1, 5.2 and 5.3 provide a chronological summary of the process followed and conclusions reached in order to arrive at the preferred technology and functional design of the recommended rapid transit system. The detailed analysis, evaluation and consultation undertaken with respect to these alternatives, including the identification of the preferred alternatives, can be found in the Phase 2 Reports from the IEA. A summary of the information is provided below.

5.1. PHASE 2 STEP 1: IDENTIFICATION AND EVALUATION OF ALTERNATIVE TRANSIT TECHNOLOGIES AND ROUTE DESIGNS

In accordance with the IEA Terms of Reference, in Phase 2 Step 1, a variety of rapid transit technologies and several route designs were examined. These technologies and route designs were screened with the intention of keeping only those that best met the needs and goals of the Region's Rapid Transit Initiative.

5.1.1. IDENTIFICATION OF ALTERNATIVE TECHNOLOGIES

The Region’s Project Team evaluated a wide range of rapid transit technologies for the purposes of the IEA. Rapid transit technologies that were considered are as follows:

- Aerobus – vehicle suspended from cables
- Automated Guideway Transit (AGT) – uses fully automated driverless trains with fully grade separated operations typically on an elevated guideway
- Bus Rapid Transit (BRT) – buses operating in some form of exclusive bus lanes or RoW
- Commuter Rail – typically involves locomotives hauling a train of passenger cars in a rail RoW, sometimes sharing track with freight trains
• Light Rail Transit (LRT) – steel wheeled vehicles operate in an exclusive rail RoW, exclusive on-road route or mixed rail-road route using overhead electric propulsion
• Magnetic Levitation (Maglev) – where the vehicle is magnetically lifted, guided and propelled by a wave of magnetic energy on an elevated guideway
• Monorail – fixed guideway transit mode using a series of electrically powered vehicles that straddle atop, or are suspended from a single elevated guideway beam, rail or tube
• Personal Rapid Transit System (PRT) – electrified driverless pod system usually designed to move people over short distances
• Diesel Multiple Units (DMU) – self-propelled cars providing a lower cost and lower capacity form of commuter rail
• Subway or Metro (heavy rail) – typically grade separated high capacity passenger rail cars operating in trains of two or more cars on fixed rails in exclusive rights-of-way

5.1.2 IDENTIFICATION OF ROUTE DESIGNS

Four (4) different route designs for rapid transit service within the Region’s primary re-urbanization area were identified. These four route design options are set out below in Table 5.1.

<table>
<thead>
<tr>
<th>Alternative Route Designs</th>
<th>Basic Route Characteristics</th>
<th>Potential Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dedicated On-Road Route</td>
<td>Rapid Transit operating at-grade within the road RoW in a dedicated lane or lanes along the route length.</td>
<td>Bus Rapid Transit (BRT) Light Rail Transit (LRT – Electric) Light Rail Transit (LRT – Diesel)</td>
</tr>
<tr>
<td>2. Dedicated Off-Road Route</td>
<td>Rapid Transit operating within an exclusive at-grade RoW along the route length.</td>
<td>Bus Rapid Transit (BRT) Commuter Rail Light Rail Transit (LRT – Electric) Light Rail Transit (LRT – Diesel) Diesel Multiple Units (DMU)</td>
</tr>
<tr>
<td>3. Mix of On/Off Road Route</td>
<td>Rapid Transit that is compatible operating at-grade in dedicated on-road conditions, and dedicated off-road conditions along the route length.</td>
<td>Bus Rapid Transit (BRT) Light Rail Transit (LRT – Electric) Light Rail Transit (LRT – Diesel)</td>
</tr>
</tbody>
</table>

5.1.3 CRITERIA FOR SCREENING OF TRANSIT TECHNOLOGIES AND ROUTE DESIGNS

As set out in the IEA Terms of Reference, a screening process determined which alternative technologies and route designs would meet the Region’s rapid transit system objectives, and merit detailed consideration by the Region. The broad screening criteria are listed in Table 5.2 below.

<table>
<thead>
<tr>
<th>Screening Criteria</th>
<th>Pass / Fail Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGMS Re-urbanization</td>
<td>Is the route design consistent with municipal urban design, intensification and re-urbanization objectives?</td>
</tr>
<tr>
<td>Service Quality</td>
<td>Are there proven applications of the method in comparable settings?</td>
</tr>
<tr>
<td>Threshold Capacity</td>
<td>Is the capacity of the method appropriate for the expected demand?</td>
</tr>
</tbody>
</table>

Measures were developed to help define how well each particular technology and route design satisfied the above-noted criteria. A brief overview of the measures and ways of describing them is provided below:

RGMS Re-urbanization

• System Flexibility – Is the route design and technology adaptable to the physical landscape and environmental characteristics that would be encountered within Waterloo Region? Can it easily accommodate future expansion of the system to meet demand? Can it be integrated with other urban transit systems? This was assessed qualitatively based on the characteristics of each technology.
• Environmental Impacts – Is the route design and technology detrimental to the natural and socio-economic environments? Issues such as air quality, noise and vibration and visual intrusion are to be considered. This was assessed qualitatively based on the characteristics of each technology and vehicle propulsion method.
• Land Use Compatibility – Is the route design and technology compatible with established residential neighborhoods, commercial districts and existing sensitive land use (i.e. built heritage and cultural landscape features)? Can the route design and technology influence intensification and compliment planned mixed-use development areas within the urban cores? This was assessed qualitatively based on the degree to which each technology and route design concept can be integrated with existing land uses and encourage intensification.
• Operating Constraints – Can the technology be scaled to physically fit within the urban environment and areas designated for intensification? This was a quantitative and qualitative assessment based on the design characteristics of each technology / route design alternative. Considerations were station size, height (if elevated) and width of running way.

Table 5.2 – Criteria for Screening Alternative Methods

<table>
<thead>
<tr>
<th>Alternative Route Designs</th>
<th>Basic Route Characteristics</th>
<th>Potential Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Grade-Separated Route</td>
<td>Rapid Transit that operates above or below street level other than bridges or tunnels for crossing purposes.</td>
<td>Aerobus Automated Guideway Transit (AGT) Magnetic Levitation (Maglev) Monorail Personal Rapid Transit System (PRT) Subway</td>
</tr>
</tbody>
</table>
• Urban Design – Is the route design and technology consistent with the municipal urban design objectives for the communities served? This was assessed qualitatively based on the design characteristics of stations (elevated or not) and their ability to integrate into the urban streetscape and foster street-level activities.

Service Quality

• System Compatibility – Can the route design and technology be easily integrated with other public transport systems and provide ease of transfer between alternative urban modes? This was assessed qualitatively based on the operating characteristics of each technology and route design concept and how well transferring can be made with other modes.

• System Accessibility – Is the route design and technology easily accessible for all passengers including the disabled in terms of proximity to stations, station configuration (barrier free access) and spacing of stations? This was assessed qualitatively based on the proximities of stations (for walking a short distance) and whether typically accessed either on foot, feeder bus and park and ride modes.

• Service Frequency – Is the route design and technology adaptable to accommodate fluctuations in demands to ensure fast, reliable service? This was assessed qualitatively / quantitatively based on the operating characteristics of each technology considering the vehicle fleet (capacity) and its expansion capability, and service frequency.

• User Comfort – Will the route design and technology provide a positive experience for patrons in terms of ride quality, ease of access (distance) to stations and ability to provide premium service? This was assessed qualitatively based on the design characteristics of each technology (ride quality) and stations (amenities).

• Safety and Security – Are safety and security risks to transit patrons and other modes (including automobile traffic and pedestrians) acceptable? This was assessed qualitatively based on the relative risk to transit patrons and other modes including auto traffic and pedestrians.

Threshold Capacity

• Ridership / Capacity – Is the route design and technology capacity appropriate relative to near and longer term projected ridership demands? This was assessed quantitatively in terms of the typical capacity (in passengers per hour per direction – pphp) of each technology and how this meets the Region’s anticipated ridership demands in the near and longer terms.

• Operating Speeds – Do vehicle headways and acceleration / operating speeds between stations support ridership forecast and station spacing? This was quantitatively assessed in terms of typical vehicle operating speeds of each technology / route design alternative that reflects the frequency of service and the close station spacing in the downtowns.

• Cost – Are the capital, operating and maintenance costs reasonable as relative to industry benchmarks? This was assessed quantitatively in terms of the range of capital costs per km for each technology and route design concept, as well as average vehicle costs and operating and maintenance costs per hour of service.

Each route design and technology alternative was evaluated against the three evaluation criteria and the 13 measures developed to help with the assessment of each criterion. For the assessment of each technology, inherently linked to a specific route design(s), failure in one measure meant that the technology could not fully meet the criterion and therefore failed that criterion. Failure in one criterion resulted in a “FAIL” for the technology and eliminated it from further consideration. Route designs were assessed using a “preferred” rating based on how well they responded to each measure.

5.1.4 EVALUATION OF TRANSIT TECHNOLOGIES

Highlights of the screening process for each of the transit technologies are as follows:

Bus Rapid Transit (BRT) is feasible due to the flexibility of the technology in a variety of operating environments. BRT can be expanded as ridership grows and is easily integrated with existing and planned local bus systems. Modern bus technologies can be powered by alternative fuels (natural gas, propane gas and dual mode diesel-electric) which may address concerns regarding environmental impacts on air quality and noise. Other new developments such as mechanically or optically guided buses with 100% low floor accessibility also address some accessibility concerns. The technology is proven in Canadian environments (e.g. the Ottawa BRT system has been operating for 25 years) and a variety of systems are available from many vendors. BRT capital and operating costs are low to moderate making it economically viable to accommodate demands at an affordable cost. High quality vehicle and station design can provide an attractive, reliable system, adaptable to a variety of operating environments and passenger capacities. Operating speeds of up to 80 km/h may suit suburban services, while lower average speed of 25 km/h would be most common in downtown areas, in transit malls or on arterial roads with commercial activity. Station spacing can be close (450 m) enough to provide convenient pedestrian access and a system compatible with existing land uses. BRT is recognized as fostering compact multi-use development around stations but not as widely so as LRT. It is a street-level system that can be integrated with street level development and pedestrian systems.

Light Rail Transit (LRT) is feasible and offers flexibility in operating environments such as a “streetcar” operating on existing roads, or LRT in rail corridors or exclusive rights-of-way. LRT is predominantly a street-level rapid transit system that makes it easily accessible for patrons and integration with alternative modes (e.g. feeder bus systems, park and ride, pedestrian walkways). Permanent track alignment and LRT stations can provide the catalyst for urban redevelopment with opportunities to integrate stations with new higher density development. LRT vehicles can be operated as single vehicles or in trains to accommodate fluctuating passenger demands. The technology is proven in Canadian environments and a variety of systems are available from vendors. Capital and operating costs are moderate making LRT economically viable. LRT with modern electrically powered vehicles is clean and has low noise levels. High quality vehicle and station design can provide an attractive, reliable system, adaptable to a variety of operating environments and passenger capacities. Operating speeds of up to 80 km/h may suit suburban services, while speeds of 25 km/h would be applicable for application in downtown areas, in transit malls or on arterial roads with commercial activity. Station spacing can be close (500 m) enough to provide convenient pedestrian access and a system compatible with existing land uses and positively influencing intensification.
Commuter Rail operates in heavy railway rights-of-way only and cannot operate on a roadway due to vehicle size, safety and geometric constraints. It’s ability to influence urban growth patterns is limited to suburban areas where low density development catering to automobile travel is dominant. The service is generally suited to peak hour operations with less frequent off-peak trains and would not be suitable for an intra-urban public transportation system serving the downtown cores of Waterloo, Kitchener and Cambridge.

Diesel Multiple Units (DMU) or light rail transit (LRT – Diesel) are lighter versions of commuter trains and are best suited to operate in railway rights-of-way and not on urban roadways. Note: there are a few examples of such technology using mixed rail rights-of-way and urban roadways, but none are in Canada. DMUs provide a suburban-downtown rail service and have no track record for influencing re-urbanization and compact development form. Lack of operating flexibility, longer station spacing (4 kilometre minimum), relatively poor acceleration, less desirable noise and emission characteristics make DMUs an unsuitable alternative for rapid transit service in the Central Transit Corridor and particularly within the cores.

Aerobus is an elevated system that is most commonly used for recreational and special activity application and is not considered to be fully adaptable to an urban environment. The less frequent service, longer station spacing (2 kilometres) and limited passenger access to street level are inconsistent with the type of rapid transit service envisaged for the Central Transit Corridor.

Automated Guideway Transit (AGT) represents a family of “automated people mover technologies” that are typically applied on short systems at airports, institutions and amusement parks and not for intra-urban public transportation systems.

Maglev is a technology best suited to long distance, high speed inter-urban travel and not suitable for rapid transit services in an urban environment and particularly in the downtown core (e.g. longer station spacing of 4 kilometres).

Monorail is a fully elevated system that requires substantial investment in fixed guideway and stations and accordingly has a high infrastructure cost. The monorail is disconnected from the street environment, requiring stairs and elevators to access elevated stations. Monorail can be located within road and rail RoWs but cannot operate at ground level. There are few urban applications in North America and these have mainly been demonstration projects in the downtown (Seattle) or high activity areas (Las Vegas). Monorail is considered unsuitable for the longer distance service required through the Central Transit Corridor and for reason of its disconnect with street level activity within the urban cores.
Personal Rapid Transit (PRT) is an automated people mover system that provides a point-to-point service through an extensive guideway network. PRT technology has only limited experimental application and is unproven for an urban transportation rapid transit system.

Subway / Heavy Rail Transit is a high capacity rapid transit system, normally constructed above or below grade in large urban centres such as Vancouver, Toronto and Montreal. Heavy Rail provides high carrying capacity and frequent service as well as encourages land use intensification; however, it requires a dedicated RoW that is not accessible to the public (except at stations). In the context of Waterloo Region, the heavy rail capacity and cost are too high for the anticipated ridership demand in the Central Transit Corridor.

Table 5.3 – Evaluation Summary – Rapid Transit Technologies and Route Designs

<table>
<thead>
<tr>
<th>Technology Options</th>
<th>Evaluation Measures</th>
<th>Grade Separated (either above or below ground)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRT – Conceptual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subway / Heavy Rail Transit – Yonge Line, Toronto</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following table shows the evaluation of each technology and route design considered and the “pass / fail” grades associate with each measure.

The technology screening shows that bus rapid transit and light rail transit are the only technologies that can achieve the necessary “Pass” grades for all of the thirteen measures that were adopted to express the three screening criteria of Compatibility for Re-urbanization, Service Quality and Threshold Capacity (see Table 5.3). All other technologies have fewer “Pass” grades ranging from one/two (out of thirteen) with Personal Rapid Transit and Commuter Rail to ten passing grades in the case of Automated Guideway Transit and Monorail. These latter technologies fail to meet the grade of system flexibility, environmental impacts, operating constraints, urban design, and cost-effectiveness largely because they are elevated systems that cannot (or not fully) achieve the key re-urbanization objectives and have a high infrastructure cost.
5.1.5. EVALUATION OF ROUTE DESIGNS

The four route design alternatives were evaluated based on the applicable measures identified in Section 5.1.3. The screening criteria considered RGMS re-urbanization, service quality and threshold capacity as noted in the IEA Terms of Reference. The advantages and disadvantages of the alternative route designs are summarized as follows:

1) Dedicated On-Road Route (BRT, LRT) – NOT PREFERRED

**Advantages**
- Supports redevelopment and intensification objectives
- Low to moderate capital cost
- Quick to implement
- Compatible with existing and planned built neighbourhoods

**Disadvantages**
- Insufficient capacity of central corridor road network may lead to road reconstruction
- Rapid transit service may deteriorate as traffic and congestion increase in some parts of the Study Area

2) Dedicated Off-Road Route (BRT, Commuter Rail, LRT, DMU) – NOT PREFERRED

**Advantages**
- Low cost but only on existing off-road corridors
- Safety and security to patrons and other transportation modes is enhanced by physical separation of rapid transit

**Disadvantages**
- Separated corridors may not be located in areas that support re-urbanization and intensification
- Separated corridors will not allow for integration with existing on street / at grade urban environment or destinations
- May be incompatible with existing and planned neighbourhoods and urban design objectives
- High cost for developing new corridors that may limit expansion opportunities

3) Mix of On/Off Road Route (BRT, LRT) – PREFERRED

**Advantages**
- Supports redevelopment and intensification objectives where routes are in proximity to areas planned for re-urbanization
- Optimizes use of existing off-road routes and on-road routes to serve destinations
- Compatible with existing and planned built neighbourhoods
- Provides opportunity to reduce rapid transit infrastructure cost by using existing corridors

4) Grade-Separated Route (Aerobus, AGT, Maglev, Monorail, PRT, Subway) – NOT PREFERRED

**Advantages**
- Supports redevelopment and intensification objectives where routes are in proximity to areas planned for re-urbanization
- Rapid transit service is removed from road traffic
- Visible as a superior service

**Disadvantages**
- Would be incompatible with existing and planned neighbourhoods and street level urban design objectives
- Promotes higher density development associated with large downtown cores (e.g. Toronto, Vancouver) which may be incompatible with areas designated for intensification
- System expansion is relatively difficult and expensive
- High infrastructure cost

The mix of on/off road route design is preferred for the following reasons:
- Supports redevelopment and intensification objectives
- Optimizes use of existing off-road routes and on-road routes to serve destinations
- Compatible with existing and planned built neighbourhoods
- Provides the opportunity to reduce rapid transit infrastructure cost by using existing corridors

5.1.6. SUMMARY OF TECHNOLOGY AND ROUTE DESIGN SCREENING

Both technologies that have been selected (LRT and BRT), along with the preferred route design (mix of on-road and off-road routing), are intrinsically compatible and linked to best achieve the objectives for a rapid transit system in Waterloo Region. This mix of technologies and route designs represent state-of-the art systems that have been developed and have flourished in other cities across North America and Europe. They will encourage a more compact urban form and urban design that fosters greater use of alternative modes, a healthy lifestyle, street-level development around stations, barrier-free access, reduced corridor congestion and a long list of other positive benefits.

BRT and LRT combined with a mix of on-road and off-road route design offer a wide variety of options in the development of an integrated transit system that will attract new riders, improve mobility, provide regional connectivity and encourage core intensification and transit-oriented development. BRT and LRT in a mix of on-and off-road routes were carried forward as the preferred technologies / route design in the assessment of alternative corridors and routes.
5.2. PHASE 2 STEP 2: IDENTIFICATION AND EVALUATION OF ROUTE SEGMENT ALTERNATIVES AND THE APPROPRIATE RAPID TRANSIT TECHNOLOGY

As a result of choosing BRT and LRT as the preferred technologies using a mix of on-road and off-road route designs, the next step was to identify the potential routes from point to point, and determine which technology was best suited for a particular route. Therefore, Phase 2 Step 2 of the IEA focused on developing the best routes within seven separate segments, including the potential RT station locations within each segment. The outcome of Phase 2 Step 2 was the ranking of route and technology alternatives in each of the seven segments to be carried through to Phase 2 Step 3 (Section 5.3) to create reasonable rapid transit system alternatives.

5.2.1. THE ROUTE SEGMENTS AND STATION LOCATIONS

Potential RT routes and station locations were identified within seven segments of the 38 km long study area. The Corridor Screening Report documented the process followed for establishing potential station locations and short listed RT route alternatives for evaluation. Routes were chosen for each of the seven segments and five to eight reasonable route alternatives were identified in each segment. The routes were then evaluated for both BRT and LRT technologies, except in a few cases where LRT was deemed unfeasible due to constructability constraints, narrow RoW, and cost.

The Corridor Screening Report summarized the basis for providing recommendations for the route and station alternatives that would be carried forward through the evaluation of route options for each Segment.

The following principles were adopted for identifying routes / corridors:

- Corridors should connect potential stations and transit destinations in a direct manner.
- Corridors should minimize disruption through environmentally sensitive areas and mature stable residential neighbourhoods.
- Corridors should have a reasonable right of way (RoW) width for either BRT or LRT (minimum 26 m).
- Corridors should take into consideration potential redevelopment and intensification of lands within 600 m of a station.

Reasonable route alternatives were selected based on the following method:

- The Project Team conducted workshops with staff of the cities Cambridge, Kitchener and Waterloo to identify areas of potential re-urbanization along the corridors and areas of natural and man-made constraints.
- Land use mapping, aerial photography and social and environmental conditions were examined.
- An assessment of re-urbanization potential was undertaken at alternative potential station locations.
- A public workshop was held in September, 2006 to identify potential stations, major transit destinations and corridor linkages.
- Based on the above, a preliminary set of alternative route linkages was assembled for each segment and further refined with city staff.
- Public workshops were held in March, 2007 to review the proposed station locations and route alternatives.

An evaluation of the preliminary route alternatives was undertaken that could differentiate between the alternatives at a strategic level focusing on transit performance, overall feasibility of implementation, and appropriateness of the corridor. A short list of station locations and route alternatives was defined.

The public provided input on the preliminary list of station locations and route alternatives during three workshops held in the cities of Cambridge, Kitchener and Waterloo on March 20 – 22, 2007. New route options and station locations proposed by the public were reviewed by Regional staff and the consultant team for their suitability to meet the principal evaluation criteria established for reasonable routes. As a result of this input and review, a final short list of station locations and reasonable route alternatives was prepared for further analysis and evaluation in Step 2.

The recommended route alternatives for Phase 2 Step 2 evaluation are summarized in Figure 5-1 to Figure 5-4. These alternatives for each segment are shown and described in more detail in Appendix A1.

For a summary of the public input and the resulting changes to the initial short list, refer to Section 10.3.1 of this report.
5.2.2. EVALUATION OF THE ALTERNATIVE ROUTES AND TECHNOLOGIES

Once the alternative routes had been identified, each route within each segment was assessed along with the available technology for that route (BRT or LRT) using the evaluation criteria and indicators established in the ToR. The ToR identified four major criteria groups:

- Transportation
- Social / Cultural Environment
- Natural Environment
- Economic Impact

The criteria groups contained a total of 21 criteria, and each of these criteria contained indicators and measures. These are presented in Table 5.4. In addition, for each measure, the ranking criteria outlined whether a high data value or a low data value was considered desirable.

Section 5.2.3 outlines the process followed for assessing and comparatively evaluating the alternative routes and BRT or LRT technologies in order to arrive at their ranking. The assessment was based on the following principles:

- A semi-exclusive rapid transit corridor would be provided with a route design consisting of on-road and off-road sections. The rapid transit corridor would cross intersections at grade.
- The rapid transit corridor would generally be located in the centre of existing roads, displacing two traffic lanes for roads with four or more lanes. For rapid transit routes on two lane roads, two additional traffic lanes would be constructed.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Indicator</th>
<th>Measurement</th>
<th>Units of Measurement</th>
<th>Ranking Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transportation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridership Potential</td>
<td>Ridership forecast and % share of total transportation trips</td>
<td>2031 daily ridership compiled from station boardings and lightings within the segment. Percent (2031- AM peak hour) transit modal share of all trips made within the segment.</td>
<td>For each rapid transit route and technology in a segment: 2031 horizon - Passengers / day (total number for all stations) % of AM peak hour trips using transit compared to all future trips made within each segment</td>
<td>Highest ridership number and % transit share ranks highest</td>
</tr>
<tr>
<td>System Reliability / Speed</td>
<td></td>
<td>Number of signalized intersections along the route and percent of route (on-road portion) operating in the future (2031) with a V/C ratio greater than 0.9 (near and at capacity).</td>
<td>For each rapid transit route and technology in a segment: Number of signalized intersections along route segment % of route length that use on-road segments having a V/C ratio of 0.90 or greater by 2031 horizon</td>
<td>Fewest number of signalized intersections ranks highest Least % of on-road route length having a V/C ratio of 0.90 or greater ranks highest</td>
</tr>
<tr>
<td>System Performance</td>
<td>Rapid Transit speed, average travel time and auto vehicle-km of travel within the study area.</td>
<td>Estimated speed and trip time along the route alignment within the segment. Annual auto vehicle-km traveled per segment population plus employment (2031) for the area contained within the segment boundary.</td>
<td>For each rapid transit route and technology in a segment: Average route speed (km/h) based on length of route in segment for 2031 horizon Estimated trip time along each route (minutes) for 2031 horizon Estimated travel time and lowest auto vehicle-km ranks highest</td>
<td>Highest average speed ranks highest Lowest average travel time and lowest automobile vehicle-km ranks highest</td>
</tr>
<tr>
<td>Property Requirement</td>
<td>Hectares of land needing to be purchased and associated cost for rapid transit.</td>
<td>Land requirement for widening rail ROW and road ROW to accommodate rapid transit alignment. Note: The required ROW for an on-road route was assumed to be 26 m. For rail corridors, the required ROW was assumed to be 28 m to accommodate the existing heavy rail line and the new rapid transit system.</td>
<td>For each rapid transit route and technology in a segment: Area of land (hectares) required for route ROW Estimated value of the land to be purchased ($2006)</td>
<td>Smallest property requirement and lowest cost for rapid transit ROW ranks highest</td>
</tr>
<tr>
<td>Travel Time Competitiveness with Auto</td>
<td>Estimate future travel times and trip length for auto vs. transit.</td>
<td>For trips destined to the Am peak hour, the 2031 average travel time difference between auto and transit was estimated for the area contained within the segment boundary. The average trip length did not vary significantly between auto and transit and was therefore not included.</td>
<td>For each rapid transit route and technology in a segment: Difference between auto and transit average travel times (min) for trips (2031 horizon) made within a segment</td>
<td>Lowest difference in travel time ranks highest</td>
</tr>
<tr>
<td>Roadway Network Demand</td>
<td>Forecast change in roadway volumes on rapid transit route and adjacent roadways.</td>
<td>2031 AM peak hour auto screenline volumes and V/C ratios for key roads in a segment. Screenline crosses rapid transit route and roads run in same direction as the rapid transit route.</td>
<td>For each rapid transit route and technology in a segment: AM peak hour screenline volume and V/C ratio (2031 horizon) in the heaviest volume direction of all roads along the route</td>
<td>Lowest AM peak hour volume and lowest V/C ratio rank highest</td>
</tr>
<tr>
<td><strong>Social / Cultural Environment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to serve residential uses</td>
<td>Number of existing and potential housing units and affordable housing units within 600 m of all proposed stations along the route.</td>
<td>Existing (2005) and future (2031) housing units within 600 m circle of potential stations along a particular rapid transit route within the segment. Number of existing (2005) and future (2031) affordable housing units within 600 m of stations. Note: future BRT housing units were assumed to be the existing units plus 70% of the LRT growth factor (LRT future units minus existing units).</td>
<td>For each rapid transit route and technology in a segment: Number of existing residents living within 600 metres of proposed stations along a route Estimated number of future residents (2031 horizon) living within 600 m of proposed stations along a route Number of existing plus any planned affordable housing units located within 600 m of proposed stations</td>
<td>Maximum number of existing and future residents ranks highest Maximum number of existing and future affordable housing units ranks highest</td>
</tr>
<tr>
<td>Ability to serve institutional uses</td>
<td>Number of existing and potential institutional land uses and users within 600 m of potential station locations. Institutional uses include secondary / post-secondary schools, hospitals, and major government buildings.</td>
<td>Existing and future (2031) institutional employment and users were used to distinguish the size of institutions. Number of existing and future institutional employment and users were measured within 600 m of the potential station locations. This includes student populations, hospital patients and visitors. Government buildings are relatively few in number within the potential station areas and data on their usage is not available - these users were excluded.</td>
<td>For each rapid transit route and technology in a segment: Number of existing institutional employees and users located within 600 m of proposed stations on a route</td>
<td>Highest employment and user numbers rank highest</td>
</tr>
<tr>
<td>Vibration</td>
<td>Number of existing and potential buildings within 50 m of the route centerline.</td>
<td>Plots of building data were prepared along the potential routes using the GIS data base. Numbers of existing buildings were identified within 50 m of the alternative routes within a segment. No data available for future buildings.</td>
<td>For each rapid transit route and technology in a segment: Number of existing buildings within 50 m of route alignment</td>
<td>Lowest number of existing buildings ranks highest</td>
</tr>
</tbody>
</table>
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#### Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Indicator</th>
<th>Measurement</th>
<th>Units of Measurement</th>
<th>Ranking Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>Linear extent (km) of route adjacent to noise sensitive land uses where</td>
<td>Noise levels were forecast based on 2031 traffic volumes and bus / truck volumes on a route in a segment. LRT vehicles do not contribute significantly to road noise levels. 5 dBa noise increase is a Regional standard to determine possible mitigation such as noise walls.</td>
<td>For each rapid transit route and technology in a segment: Identification and location of noise-sensitive land uses on rapid transit route (meters) where noise levels are forecast to increase by 5 dBa or greater</td>
<td>Shortest length of noise-sensitive frontage length ranks highest</td>
</tr>
<tr>
<td>Contribution to cultural environment</td>
<td>Number of existing and potential cultural attractions within 600 m of all proposed stations along the route. Cultural uses include museums, libraries, music venues, heritage districts and built heritage structures, arts / community centres.</td>
<td>Region supplied GIS maps of heritage / cultural districts and built cultural attractions within the study area. These were plotted around the potential stations. Future cultural uses are uncertain and were assumed to be the same as the existing uses.</td>
<td>For each rapid transit route and technology in a segment: Number of existing cultural attractions and properties</td>
<td>Highest number of existing and proposed attractions ranks highest</td>
</tr>
<tr>
<td>Contribution to recreational environment</td>
<td>Number of existing and potential recreational uses within 600 m of all proposed stations along the route. Recreational uses include parkland, natural areas, sports arenas, ball fields, sports facilities (e.g. YMCA).</td>
<td>Recreational uses (both municipal and private sector responsibility) were identified around the rapid transit stations from Air Photo mapping. Future planned facilities are uncertain, and were therefore assumed to be the same as existing.</td>
<td>For each rapid transit route and technology in a segment: Number of existing recreational uses</td>
<td>Highest number of existing and proposed recreational uses ranks highest</td>
</tr>
<tr>
<td>Contribution to public health</td>
<td>Average percentage of total transit trips taken by cycling or walking to transit stations. Number of auto trips converted to transit trips.</td>
<td>For each route and station, access mode percentages were determined at stations. For each route, determine the total number of transit trips (destinations in Segment) during the AM Peak Hour. The total number of transit trips is used as an indicator of auto trips saved.</td>
<td>For each rapid transit route and technology in a segment: Percent of total transit trips taken by cycling or walking to access proposed stations on a route for 2031 horizon</td>
<td>Highest percent of cycling or walking trips ranks highest</td>
</tr>
<tr>
<td>Contribution to built heritage</td>
<td>Number of designated heritage properties and buildings within 600 m of the proposed stations along the route.</td>
<td>The total number of existing properties and buildings was determined.</td>
<td>For each rapid transit route and technology in a segment: Number of existing designated heritage properties and buildings</td>
<td>Highest number of heritage properties and buildings ranks highest</td>
</tr>
<tr>
<td>Natural Environment</td>
<td></td>
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</tr>
<tr>
<td>Ecological impact</td>
<td>Displacement plus disruption of any important natural features adjacent to system which will receive increased daily noise, light, vibration in consideration of the quality of the features being impacted.</td>
<td>Total direct or indirect displacement (ha) of any important natural features, as well as the total disruption of important heritage features (length of feature – km) adjacent to rapid transit system. Natural features would include PSW, Wetland, EIS, ANSI, Flood Plain, and Prime Agricultural Land.</td>
<td>For each rapid transit route and technology in a segment: Identification and location of defined important natural features – i.e. PSW, Wetland, EIS, ANSI, Flood Plain, and Prime Agricultural Land.</td>
<td>Smallest area with impacts ranks highest</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Length (km) of surfaces to require salting or similar de-icing.</td>
<td>Rail transit does not typically require salt or de-icing solution on the tracks; however it may be required on station platforms. BRT (on or off-road) will require de-icing compounds. The length of paved surface for each BRT route in a segment was measured to obtain the length needed for de-icing. For LRT, the length of the station platforms was measured.</td>
<td>For each rapid transit route and technology in a segment: Length (km) of route or station requiring salting or similar de-icing compounds</td>
<td>Shortest length requiring salting or de-icing ranks highest</td>
</tr>
<tr>
<td>Air Quality</td>
<td>Linear extent (km) of locations adjacent to sensitive land uses receiving new emissions from inhalable / respirable particulate matter and total GHGs saved. Sensitive land uses include hospitals, nursing / retirement homes, schools, and day-care centres.</td>
<td>Estimate linear extent of sensitive uses receiving new emissions for off-road and on-road sections. GHGs emissions for future development levels (2031) were determined from total GHGs estimated for a segment and factored by population to estimate the impact within a route and segment.</td>
<td>For each rapid transit route and technology in a segment: Identification and location of emissions-sensitive land uses adjacent to routes. Identification and location of emissions-sensitive land uses adjacent to new roads attributed to rapid transit route Length (metres) of frontage of emissions-sensitive land uses on rapid transit rapid transit route</td>
<td>Shortest length of sensitive adjacent land uses ranks highest</td>
</tr>
<tr>
<td>Mineral Aggregate Resources</td>
<td>Total displacement of any mineral aggregate resources. These aggregate resources include pits, quarries, etc.</td>
<td>Fill material is gathered from pits and quarries to construct an off-road and on-road rapid transit line. Air Photos were used to determine location of existing pits and area falling within proposed rapid transit ROW. Volume of fill material required for constructing alternative routes in each segment. Note: It was assumed BRT would not require reconstruction of road base / pavement for on-road sections.</td>
<td>For each rapid transit route and technology in a segment: Estimated volume (m³) of fill from pits and quarries required to construct each route as determined from the typical cross section of a route / technology x length of route in segment Area of aggregate pits, and quarries within route ROW (hectares)</td>
<td>Lowest usage of aggregate resource ranks highest</td>
</tr>
</tbody>
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*Note: The above table is a partial representation of the document and may require further context or clarification for full comprehension.*
### Economic Impact

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Indicator</th>
<th>Measurement</th>
<th>Units of Measurement</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Ability to serve concentrations of employment</td>
<td>Number of existing and potential employment opportunities within 600 m of all proposed stations along the route.</td>
<td>Employment data (existing and 2031) were available from station area analysis of existing and new employment opportunities (by type) within 600 m of the potential stations. Note: future BRT employment was assumed to be the existing employment plus 70% of the LRT growth factor (LRT future employment minus existing employment) to reflect lower intensification levels around potential stations.</td>
<td>For each rapid transit route and technology in a segment: Existing employment number within 600 m of all stations of the proposed route Estimated future (2031 horizon) employment number within 600 m of all stations of the proposed route</td>
<td>Largest existing and future potential employment ranks highest</td>
</tr>
<tr>
<td>Ability to serve retailers</td>
<td>Square footage of existing and potential retail space and existing and projected customers within 600 m of all proposed stations along the route.</td>
<td>Retail space data (existing and 2031) were available from station area analysis identifying retail opportunities within 600 m of the potential stations. The associated customer base was estimated from the additional retail floor area within the stations areas. Note: future BRT retail space was assumed to be the existing retail space plus 70% of the LRT growth factor (LRT future retail space minus existing retail space) Note: future BRT retail customers were assumed to be the existing retail customers plus 70% of the LRT growth factor (LRT future retail customers minus existing retail customers)</td>
<td>For each rapid transit route and technology in a segment: Available existing retail space (m²) within 600 m of all stations on a route Potential retail space (m²) for 2031 horizon within 600 m of all stations on a route Number of existing retail customers for the above-noted space Projected number of future customers (2031) for the projected retail space</td>
<td>Highest potential for retail space area and projected number of customers ranks highest</td>
</tr>
<tr>
<td>Cost</td>
<td>Estimated capital cost and annual O&amp;M cost associated with the route / technology.</td>
<td>Initial capital cost (construction) was estimated for the route / technology alternative and divided into segments based on the route length in the segment. Annual operating and maintenance (O&amp;M) cost was estimated (2031 horizon) for each route / technology option and assigned to a segment based on the length of the route in the segment. Annual O&amp;M cost was divided by the annual ridership generated by a route in a segment to estimate the annual O&amp;M cost per ride.</td>
<td>For each rapid transit route and technology in a segment: Estimated initial capital cost of route in segment Estimated annual O&amp;M cost by 2031 ($2007) and factored for future ridership in segment</td>
<td>Lowest initial capital cost ranks highest Lowest 2031 O&amp;M cost per ride ranks highest</td>
</tr>
</tbody>
</table>
5.2.3. COMPARATIVE EVALUATION OF STATION LOCATIONS, ALTERNATIVE TECHNOLOGIES AND ROUTES

The process of assessing, comparing and evaluating alternate technologies (BRT vs. LRT) and routes in each of the seven segments is described as follows:

- For each evaluation criterion and indicator identified in the ToR, measures, units of measurement and ranking criteria were identified and confirmed.
- Studies were undertaken to determine the value of each indicator and measure.
- The values generated were normalized to facilitate comparison of data.
- Normalized data were entered into spreadsheets to determine ranking of route and technology alternatives.
- Studies and evaluation results were documented for peer and public review. Each study is documented in a separate report. Each report is documented under separate cover and can be obtained from the Region upon request.

Data for Phase 2 Step 2 Evaluation and Ranking

Data used to evaluate each of the above-noted criteria and measures were generated and documented through a variety of supporting data analyses. The following sections summarize the findings of various reports and memoranda that populated the data set. Appendix A2 provides a summary of the data collected for each measure for each route and technology alternative.

5.2.3.1. TRANSPORTATION

To evaluate each of the transportation related measures, a transportation planning model was developed – the Regional Travel Forecasting Model. The following measures were identified through transportation modeling for each route and technology alternative.

- Ridership Potential
- System Reliability / Speed
- System Performance
- Travel Time Competitiveness with Auto
- Roadway Network Demand

The Phase 2 Step 2 Transportation Modeling Technical Memos, by Halcrow, detail the results of the transportation modeling.

Land use scenarios used as input into the Regional Travel Forecasting Model were identified using the Region’s Planning and Land Use Model (PLUM). Figure 5-5 provides a general overview of the structure of PLUM.

Property Requirements

For Phase 2 Step 2, the property requirement measures were based on the following assumptions.

- Where a route follows an existing road, the RoW must be at least 26 m wide. If the existing RoW is less than 26 m, then adjacent lands would need to be purchased to obtain a 26 m RoW.
- Where a route follows an existing rail corridor, the RoW must be at least 28 m wide to accommodate the existing heavy rail line as well as the new rapid transit system. If the existing RoW is less than 28 m, then adjacent lands would need to be purchased to obtain a 28 m RoW.
- Where the rail corridor is owned by the Region of Waterloo, only the land outside of the existing RoW (if needed to meet the 28 m RoW requirement) would be purchased by the Region to accommodate the new rapid transit system.
- Where the rail corridor is owned by CP Rail or CN Rail, all land required for the new rapid transit system would need to be purchased. If the existing RoW is less than 28 m wide, the Region would need to purchase land from the rail company as well as additional land from the adjacent land owners.
- Along Highway 401 and Highway 8, land would not need to be purchased to construct bus-bypass shoulders.
- The assumed cost associated with purchasing land, whether owned by CN Rail, CP Rail, or a private property owner, was assumed to be $2 million per hectare.

In general, routes which made use of the CP or CN Rail corridor resulted in the greatest property acquisition requirements. Routes which made use of Highway 401 and Highway 8 resulted in the least property acquisition requirements. On-road routes generally resulted in moderate to low property acquisition requirements.
5.2.3.2 SOCIAL / CULTURAL

Re-urbanization Potential – Rapid Transit Station Areas

The Re-urbanization Potential, Rapid Transit Station Areas report investigated the re-urbanization potential within each of the station areas to determine which routes and technologies would provide the greatest benefit to the community according to the re-urbanization goals of the RGMS. Other work was considered for this report, including the Region’s Visualizing Density Study, the City of Waterloo’s Height and Density Study, the City of Kitchener’s Built Form Review, and the City of Cambridge’s OP Review and Intensification Study.

The report investigated the re-urbanization potential of potential station locations within a 600 m radius of the station. Beyond this distance, it has been found that the influence of rapid transit on development intensification substantially wanes. Existing land uses were identified in the station area, as were the total population and employment. The potential increase of population and employment was then estimated according to forecast mature state land uses, as shown in Table 5.5.

Stations experiencing the highest growth of new residents and jobs include Conestoga Mall, Northfield / Waterloo Spurline, Research and Technology Park (Waterloo Spur), King and University, Weber and King, all three stations in downtown Kitchener, Charles and Ottawa, Sportsworld, Bridgecam, Hespeler Road and Can Amera Pkwy. The high growth stations are located on: Waterloo Spurline route, King Street North route, Charles Street route through Kitchener and the Hespeler Road route in Cambridge. Therefore, these routes were identified as being the best alternatives for re-urbanization potential.

Transit technology affects land value through its physical characteristics. Buses can be loud and emit exhaust fumes, while LRT is quiet and electric powered (no emissions). Studies in Portland, Baltimore, Dallas, St. Louis and San Diego have shown positive property uplift benefits from LRT. The evidence for property uplift benefits from BRT technologies is more limited. In general, BRT with similar operational characteristics as LRT (running in a dedicated RoW, fast, stopping at permanent stations, and with high grade pedestrian access) showed stronger land use benefits than buses operating in mixed traffic with more stops. This fits with the rational that the faster the service, the stronger the benefits.

A small number of studies including Ottawa, Brisbane and Pittsburg identified land use benefits (of BRT) that were equivalent to LRT. However, the evidence is generally anecdotal or based on a single station. Permanence of the route and stations is often cited as critical to enticing development investment around stations and LRT is seen as a fixed in place transit system.

<table>
<thead>
<tr>
<th>Table 5.5 – Station Area Projections (Population plus Employment)</th>
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<tbody>
<tr>
<td><strong>Station Area Projections – Total People + Jobs</strong></td>
</tr>
<tr>
<td>Potential Station Location</td>
</tr>
<tr>
<td>Conestoga Mall</td>
</tr>
<tr>
<td>Northfield / Waterloo Spurline</td>
</tr>
<tr>
<td>R&amp;T Park</td>
</tr>
<tr>
<td>University of Waterloo</td>
</tr>
<tr>
<td>King / University</td>
</tr>
<tr>
<td>Uptown Waterloo</td>
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<tr>
<td>Grand River Hospital</td>
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<td>Weber / King</td>
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<tr>
<td>Weber / Bridgeport</td>
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<tr>
<td>Victoria</td>
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<td>Ottawa / Charles</td>
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<td>Courtland / Ottawa</td>
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<tr>
<td>Courtland / Blockline</td>
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<tr>
<td>King East / Montgomery</td>
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<tr>
<td>Fairview Mall</td>
</tr>
<tr>
<td>Sportsworld</td>
</tr>
<tr>
<td>Preston Core</td>
</tr>
<tr>
<td>King / Montrose</td>
</tr>
<tr>
<td>Bridgecam</td>
</tr>
<tr>
<td>Hespeler / Bishop</td>
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<tr>
<td>Hespeler / CanAmera</td>
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<tr>
<td>Dundas / Samuelson</td>
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<tr>
<td>Galt Core</td>
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</tbody>
</table>

LRT is a better catalyst for growth and virtually all comparative evaluations point to BRT as not having the same degree of development impact as LRT. It is acknowledged that the research is largely qualitative due to the difficulty in isolating the effects of accessibility from all other factors that determine land value uplift. The re-urbanization report concludes that there is substantial potential to support higher density development in the Region’s Central Transit Corridor and LRT is the best technology choice.

Transit Oriented Development (TOD) was also examined in the report entitled, Land Use Benefits of Intermediate Capacity Rapid Transit – LRT vs BRT. TOD is based on the idea that rapid transit can attract new development (and higher land values) around stations because of the increased accessibility (faster travel time, convenience and
comfort) afforded by the transit technology. To be successful, the technology must be more accessible (as viewed by the potential transit users) than its competitors (e.g., auto).

Assessment of Ability to Serve Residential / Institutional Uses

The Assessment of Ability to Serve Residential and Institutional Uses Report, in conjunction with the Re-urbanization Potential Report examined the following evaluation criteria laid out in the Terms of Reference for the rapid transit IEA:

- Number of Existing (2006) and Future (2031) Residential units / residents within 600 m of Stations
- Number of Existing (2006) and Future (2031) Affordable Housing Units within 600 m of Stations
- Number of Existing (2006) and Future (2031) Institutional Land Uses within 600 m of Stations
- Number of Existing (2006) and Future (2031) Institutional Employees within 600 m of Stations
- Number of Existing (2006) and Future (2031) Institutional Users within 600 m of Stations

A detailed land use assessment was prepared as part of the Re-urbanization Potential Report. Forecasting mature state development potential within 600 m of a proposed station was established. Development potential addressed eleven different land use categories, including six separate residential unit types. However, for the purpose of this evaluation, only the total number of dwelling units and total number of residents were chosen. Future dwelling units and population were forecast up to the year 2041. The methodology for preparing the forecasts is documented in the Re-urbanization Potential report. The estimates were scaled back to 2031 to provide figures for a forecast year consistent with the Provincial Places to Grow Plan's population targets. Data on the current (year end 2005) population in station areas were drawn from a land use database maintained by the Region of Waterloo. The number of current institutional uses was drawn from the same source. Data on the existing number of affordable housing units was provided by the Region of Waterloo. Data on existing institutional users was drawn from two sources. Enrolment figures for secondary schools and post-secondary institutions were provided by the Region of Waterloo, and the number of hospital users was determined using data contained in the annual reports of the hospital organizations.

For each segment and route alternative, the current and future number of residents, institutional employment and users, affordable housing units combining all stations in a Segment were tallied and the routes were ranked on the basis of each land used category. The top ranked route alternatives were then established as a combined ranking of the data. In some cases there were no distinguishable differences between route alternatives. The top ranked route alternatives for each segment are listed below.

- Segment 1: King Street, King-University-Waterloo Spur, Northfield-Waterloo Spur
- Segment 2: King-Charles, King-Duke-Downdale
- Segment 3: Charles-King-Dixon-Shelley-Hydro, Charles-Bordon-Courtland-Fairway, Charles-Ottawa-Railway
- Segment 4: Hwy 8-Sportsworld-Railway, King-Sportsworld-Railway
- Segment 5: Railway, Railway-Coronation, King-Coronation
- Segment 6 and 7: No difference

Vibration Impact Assessment

The Vibration Impact Assessment Report, prepared by MMM, looked at both short-listed rapid transit technologies operating along a 35 km stretch from North Waterloo to the Galt Core of Cambridge through the core of Kitchener. In general, the study found that BRT typically produces lower ground-borne vibration than LRT, but neither technology is expected to have significant ground-borne vibration impact. The assessment of the alternative routes segment-by-segment indicated that the corridors with the least amount of urban development typically had the fewest number of buildings that would potentially be impacted.

Based on operational vibration measurements of BRT and LRT technologies in the Greater Toronto Area, significant impacts were not expected beyond 10 m of the route centerline. For this project, 11 buildings were identified within 10 m of the track centreline for the route segments. Ten of these buildings were located in Cambridge.

As for construction, LRT was likely to generate a larger vibration impact than BRT; however, at the station locations, the differences would be less pronounced. These effects are expected to be manageable through site-specific mitigation related to the required construction activities.

Overall, construction vibration issues and operating vibration issues were concluded to have a minor impact on the route selection.

Noise Impact Assessment

The Noise Impact Assessment Report, prepared by MMM, addressed the potential noise impacts due to the implementation of the rapid transit system in the study area on any noise-sensitive receptors adjacent to the new transit system network. The report detailed potential noise sources for both LRT and BRT technologies, which included bells and whistles, station parking lot noise, yard activities, rail maintenance and the wheel squeal of LRT vehicles.

Noise sensitive receptors were determined in accordance with Ministry of the Environment (MOE) and Health Canada guidelines based on sound level criteria established by the Ministry of Transportation, Canadian Mortgage and Housing Corporation, MOE, Canadian National Railways, and Canadian Pacific Railways. Municipal noise by-laws were also considered.

The measurement for noise was the linear extent of the route (km) adjacent to noise sensitive receptors, where the noise was expected to increase from the current levels by more than 5 dBA.

The present and future noise and construction noise generated for each technology were considered, along with the number of sensitive noise receptors adjacent to each route. The preliminary assessment that was carried out determined that ambient noise levels were not expected to increase by 5 dBA (point at which noise mitigation would be required) or more along any of the proposed route configurations in each segment.
Since the analysis showed no areas where the increase in noise would be greater than 5 dBA, the resulting measurements for ‘linear extent of the route (km) adjacent to noise sensitive receptors, where the noise was expected to increase from the current levels by more than 5 dBA’ were zero for all route alternatives in all segments.

Cultural Heritage Resources

The need to identify, evaluate, manage, and conserve Ontario’s heritage was acknowledged as an essential component of EA and municipal planning in Ontario, which led to the development of the Cultural Heritage Built Heritage & Cultural Heritage Landscapes report, prepared by Unterman McPhail. This report analyzed cultural heritage resources within the study area to address those above-ground, person-made heritage resources over 40 years old.

Regional mapping was used to determine the heritage and cultural resources located within the study area. In general, the development of a rapid transit system within the Central Transit Corridor is expected to contribute to the cultural and built heritage environment by enhancing accessibility to these resources. Route alternatives in each of the seven segments were evaluated according to a single criterion of the total number of cultural heritage resources located along the length of the route in a particular segment. Cultural heritage resources include cultural attractions, designated heritage properties, and designated heritage buildings.

The top ranked route alternatives for proximity to cultural-heritage buildings and properties are noted as follows:

- Segment 1: All except for Weber Street corridor
- Segment 2: King-Charles, King-Duke-Queens-Courtland
- Segment 3: All
- Segment 4: Railway, Hwy 8-Sportsworld-Railway, King-Sportsworld-Railway
- Segment 5: All except for Speedsville and Eagle
- Segment 6 and 7: No difference

Recreational Environment

The Recreational Environment Evaluation Report investigated the ability of a route / technology to serve recreational land uses. The report examined the number of recreational land uses within each station area to determine the ability for rapid transit to serve recreational users. Recreational uses include parkland, natural areas, sports arenas, ball fields, theatres, museums, libraries, community centres and various municipal and private sports facilities (e.g. YMCA). For the purpose of this assessment, sports fields at schools were considered to be recreational facilities, since they are often used to host non-school related leagues (i.e. softball, baseball, soccer, football). The Region of Waterloo’s GIS database of recreation facilities was supplemented with data from Map Art to identify those facilities near routes and stations. The Region obtained information on potential future facilities through discussion with the local municipalities. The above information sources were supplemented by field reviews of existing facilities.

The introduction of rapid transit will enhance accessibility to a large number of recreational facilities within the Central Transit Corridor by offering an alternate mode choice and improving trip time. In North Waterloo, there are a number of recreational facilities along the rail corridor including the sports and recreational complexes at McCormick Arena, the University of Waterloo, Wilfred Laurier University and Waterloo Park. The King Street and Weber Street corridors through this segment have significantly fewer facilities. There are a number of recreational facilities in the Preston Core area, including Riverside Park that would benefit from routes that include a Preston Core Station.

The top ranked route alternatives for proximity to recreational facilities in the CTC are:

- Segment 1: King Street, Northfield-Waterloo Spurline, King-University-Waterloo Spur
- Segment 2: King-Charles, King-Duke-Queen-Courtland, Railway-Weber-Frederick-Courtland, Weber-Queen-Charles
- Segment 3: Charles-King-Dixon-Kingsway-Hwy 8, Charles-King-Dixon-Shelley-Hydro
- Segment 4: Railway, Hwy 8-Sportsworld-Railway, King-Sportsworld-Railway
- Segment 5: All except for Speedsville and Eagle
- Segment 6 and 7: No difference

Public Health Benefits

The Public Health Benefits Assessment Report investigated the social health benefits of rapid transit route alternatives by using the following indicators to represent their potential contributions to public health:

- Average percentage of total transit user trips taken by cycling or walking to transit stations
- Number of auto trips converted to transit trips

The benefits of rapid transit with respect to improved air quality within the Region of Waterloo were noted as well.

The Regional Travel Forecasting Model forecasts the mode of travel used by transit riders to access the system. This model was developed based on observed transit travel patterns in the Region, the access mode of transit patrons, and ridership counts on key transit routes within the Central Transit Corridor.

The report revealed that stations that feature significant population and employment uses within the station area tend to generate a higher share of walk-on trips than stations at major transit terminals or bus transfer locations. It was also noted that the iXpress route, a higher order transit service already in place in the Region, generates a higher share of walking trips than the conventional bus system. The report recommended improvements to the pedestrian and cycling environment in order to facilitate the usage of these alternative modes.

The top ranked route alternatives for achieving health benefits of rapid transit are:

- Segment 1: King Street, King-University-Waterloo Spur
- Segment 2: King-Charles, King-Duke-Queen-Courtland, King-Charles-Benton-Courtland
- Segment 3: Charles-King-Dixon-Kingsway-Hwy 8, Charles-King-Dixon-Shelley-Hydro, Charles-King-Weber-Fairway Road
- Segment 4: Hwy 8-Sportsworld-Railway, King-Sportsworld-Railway
- Segment 5: Railway, Railway-Coronation, Railway-Bishop-Hespeler Road
• Segment 6: Hwy 401-Hespeler (BRT), Eagle-Hespeler

• Segment 7: All

5.2.3.3. NATURAL ENVIRONMENT

Ecological Impact Assessment

The Ecological Impact Assessment Report utilized background information along with field investigations to determine what impact the proposed rapid transit system would have on the Region’s natural heritage resources. The study considered both the physical and topographic features of the study area, including physiography, topography and soils, aquatic features, such as the Grand River and Speed River, and terrestrial features, including Environmentally Sensitive Landscapes, Environmentally Sensitive Policy Areas, wetlands, woodlots greater than four hectares, and significant wildlife habitats. Constraints were then identified for the rapid transit system with respect to these natural features.

For each rapid transit route and technology, calculations were made to determine the total area (in hectares) of significant natural features potentially displaced and the total length (in kilometres) of significant natural features potentially disturbed, based on an assumed 30 m wide RoW. Overall, potential displacement of natural features was found to be minimal, with 0-5% of the total area of natural features within each segment might be displaced. This was due to most routes using existing road / rail transit ways through built up areas, which would not significantly impact existing natural environmental features within the study area. The study determined that LRT had slightly fewer negative impacts on the natural environment, however, both LRT and BRT impacts could be mitigated.

The top ranked route alternatives for minimizing the displacement of natural features or impact on noise, light or vibration are:

• Segment 1: King Street, Weber Street and King-University-Waterloo Spur

• Segment 2: All

• Segment 3: Charles-King-Dixon-Kingsway-Hwy 8, Charles-Borden-Courtland-Fairway

• Segment 4: King-Maple Grove-Cherry Blossom-Royal Oak, Speedsville-Eagle

• Segment 5: Railway-Bishop, King-Bishop, Eagle

• Segment 6 and 7: No significant difference

Assessment of Hydraulic and Stormwater Impacts

The Assessment of Hydraulic and Stormwater Impacts report, prepared by MMM, addressed the potential impact on the quantity and quality of stormwater runoff resulting from the implementation of the rapid transit system in the study area. The assessment looked at the use of road salt, paving requirements, watercourse crossings and other stormwater management issues to determine the impact of rapid transit on stormwater. The measure that was used was ‘linear km of surfaces likely to require salting or similar de-icing compounds’. LRT alternative routes would not require salting or de-icing in the on-road or off-road sections; only at station locations. Based on a review of the BRT route alternatives and their on-road sections, the length of paved surface needing snow and ice removal or salting was determined to satisfy the measure.

It follows that the de-icing effects for LRT were negligible when compared to BRT. When comparing BRT route alternatives within a given segment, de-icing effects increased with the length of the route alternative.

Two watercourse crossings were examined: Grand River rail bridge at Freeport and Speed River bridge in the Preston Core. These are both LRT routes. Both existing bridges could not accommodate two LRT tracks as well as the existing single freight line. At Phase 2 Step 2 it was concluded that if LRT was chosen as the recommended technology at the Grand River and Speed River Crossings, there would be a need to further investigate new bridge structures at these locations. It would follow that impacts to the watercourses would need to be further examined for these two new structures. If BRT was the chosen technology, the system would be aligned on the existing Hwy 8 and 401 bridges.

Air Quality Assessment

As indicated in the EA ToR, the measures for estimating air quality impacts are: 1) the linear extent (km) of locations adjacent to sensitive land uses receiving new emissions of inhalable / respirable particulate matter; and 2) total kilograms of greenhouse gas (GHG) emissions saved. The Air Quality Assessment report provided the background assessment to support the evaluation of each of the rapid transit route and technology alternatives in terms of these criteria.

The measure of ‘linear extent of route (km) adjacent to sensitive land uses receiving emissions of inhalable / respirable particulate matter’ was determined using GIS mapping provided by the Region of Waterloo. Sensitive land uses were defined for this application as schools, daycare centers, hospitals, and senior’s homes.

Annual greenhouse gas emissions for the year 2031 were modeled for each route and technology and are reported in the Transportation Modeling Technical Memos. The emissions estimates were developed using Halcrow’s GHG emissions sub-model. The sub-model is based on the United States Environmental Protection Agency (USEPA) MOBILE6.2C air emission model. It calculates the direct GHG emissions associated with the operation of gasoline automobiles, light trucks and urban transit vehicles (diesel buses). The main input into the GHG sub-model is vehicle–kilometres traveled (VKT) data by vehicle type and speed that were obtained from the Regional travel model. Emissions from electrical generation required for LRT was assumed to be zero, however the model considered emissions resulting from intensification of transportation vehicles as well as emissions from the rapid transit system itself. Therefore additional emissions were measured for both the LRT and BRT systems on a basis of emissions per capita.

The top ranked route alternatives based on the lowest greenhouse gas emissions per capita were:

• Segment 1: King Street (LRT), Rail-Weber-King (LRT) and King-University-Waterloo Spur (LRT)

• Segment 2: No significant difference (LRT)

• Segment 3: Charles-King-Borden-Courtland-Fairway (LRT), Charles-King-Dixon-Shelley-Hydro-Hwy 8 (LRT), and Charles-King-Dixon-Kingsway-Hwy 8 (LRT)

• Segment 4: No significant difference (LRT)
• Segment 5: King-Bishop (LRT) and King-Coronation (LRT)
• Segment 6 and 7: No significant difference

Mineral Aggregate Resources

The two measures used to evaluate the impact on mineral aggregate resources were:

• Estimated volume ($m^3$) of fill from pits and quarries required for construction
• Area of aggregate pits, and quarries within route RoW (hectares)

An investigation of the study area showed that there were no aggregate pits or quarries within the RoW along any of the alternate routes.

The estimated volume of fill from pits and quarries required for construction of the rapid transit system was estimated by multiplying the estimated amount of fill for a typical cross section of a route / technology by the route length. In general, the LRT technology generated greater quantities of required fill when compared to the BRT technology over the same route.

The top ranked routes, based on the lowest amount of fill from pits and quarries required for construction, are listed below:

• Segment 1: Weber Street Corridor BRT
• Segment 2: King-Duke-Queen-Courtland BRT
• Segment 3: Charles-King-Dixon-Kingsway-Hwy 8 BRT
• Segment 4: Hwy 8-Sportsworld-Cherry Blossom-Royal Oak-Speedsville BRT
• Segment 5: Speedsville-Eagle BRT and Eagle BRT
• Segment 6: Bishop-Hespeler BRT
• Segment 7: Hespeler-Water-Ainslie-Bruce-Water BRT

5.2.3.4 ECONOMIC IMPACT

Assessment of Economic Benefits

The Economic Impact Report, in conjunction with the Re-urbanization Potential Report noted the following evaluation criteria as per the ToR for the rapid transit EA:

• Estimated existing and future (2031) employment within 600 m of stations
• Estimated existing and future (2031) retail space (square feet) within 600 m of stations
• Estimated existing and future (2031) retail customers

The forecast land use generated as part of the Re-urbanization Potential Report provided key input to this assessment. As part of the Re-urbanization Potential Report, an extensive and detailed land use assessment was prepared with future development potential forecast for each station area – i.e. within 600 m of a proposed station.

All employment-generating land uses were included for each station area in order to project gross floor area and employment estimates. The methodology for preparing these forecasts was documented in the report for Re-urbanization Potential. Data on current conditions were drawn from a land use database maintained by the Region of Waterloo.

Based on two of the above-noted categories, (i.e. future employment and future retail customers using the 2031 estimates), the top ranked route alternatives for maximizing economic growth in the various segments included:

• Segment 1: King Street, King-Northfield-Waterloo Spur, King-University-Waterloo Spur. The King-Northfield-Waterloo Spurline route has potential for 40,800 jobs and 222,000 retail customers to draw on around the rapid transit stations while the King Street-University Avenue-Spurline route has 34,800 jobs and 280,000 retail customers.
• Segment 2: King-Charles, King-Duke-Queen-Courtland, Railway-Weber-Frederick-Courtland. The King-Duke-Queen-Courtland route has the highest employment potential (38,000 jobs) and 181,000 potential retail customers. King-Charles routing has 32,900 jobs and 146,800 customers to draw on at the stations.
• Segment 3: Charles-King-Dixon-Kingsway-Hwy 8-Sportsworld-CPR line. The Charles-King-Dixon-Kingsway route has 9,100 employment and 152,000 retail customers vs Charles-Ottawa-Railway route with 12,700 jobs and 142,000 retail customers.
• Segment 4: Hwy 8-Sportsworld-CPR line, King-Sportsworld-CPR line. These two routes have identical job numbers (15,700) and retail customers (59,000) to draw on at their stations and are the top performers.
• Segment 5: Railway, Railway-Coronation-King-Coronation. Both routes are top performers with potential jobs of 6,300 and 27,000 retail customers within 600 m of their stations.
• Segment 6: All except Bishop-Hespeler. Most route options have 19,000 future jobs and 330,000 retail customers allocated around the stations.
• Segment 7: No difference. This segment has the lowest number of jobs (6,300) and retail customers (43,000).

Capital and Operating Costs Summary

Preliminary order-of-magnitude capital and operating costs were estimated to meet ToR requirements. The preliminary capital cost estimates for each route and technology alternative were based on line diagrams of the route alternatives and typical on and off-road cross-sections. The following elements of construction costs were estimated:
LRT Alternatives

- Track and roadbed
- Vehicles
- Yard
- Stations
- Traction power
- Hydro supply
- Yard electrical
- Substation electrical
- Line electrical
- Signals
- Communications and SCADA

BRT Alternatives

- Property Acquisition
- Structures
- Civil modifications
- Street beautification
- Utility relocations
- Transit way civil works
- Vehicles
- Yard
- Stations
- Signals
- Communications and SCADA

Operating cost estimates were based on projected ridership, route system length and vehicle headway and then broken into the segments based on the individual route lengths. The total annual vehicle hours were first calculated and then, by applying an estimated operating cost per vehicle hour (BRT vs LRT), the annual operating costs were derived.

The routes with the lowest Phase 2 Step 2 capital and operating costs are listed below for each technology. Operating costs were ranked based on the cost per annual rider.

- Segment 1: LRT (Capital): Weber Street, King Street, and Railway-Caroline-King
  LRT (Operating): King-Kraus-Northfield-Railway, Weber Street, Railway-Caroline-King
  BRT (Capital): Weber Street, King Street, and Rail-Weber-King
  BRT (Operating): King-University-Railway, Weber Street, King Street

  LRT (Operating): Railway-Weber-Frederick-Courtland, Weber-Queen-Charles, and King-Charles
  BRT (Operating): King-Charles, King-Duke-Queen-Courtland, and King-Charles-Benton-Courtland

- Segment 3: LRT (Capital): Charles-King-Dixon-Kingsway, Railway-Mill-Courtland-Fairway, and Railway
  LRT (Operating): Railway-Mill-Courtland-Fairway, Courtland-Fairway, and Railway
  BRT (Capital): Charles-King-Dixon-Kingsway, Charles-King-Weber-Fairway, Railway-Mill-Courtland-Fairway
  BRT (Operating): Charles-King-Dixon-Kingsway, Charles-King-Weber-Fairway, Railway-Mill-Courtland-Fairway

- Segment 4: LRT (Capital): Railway, Hwy 8-Sportsworld-Railway, Hwy 8-Sportsworld-Cherry Blossom-Royal Oak-Speedsville
  LRT (Operating): King-Sportsworld-Railway, Hwy 8-Sportsworld-Railway, and King-Maple Grove-Cherry Blossom-Royal Oak-Speedsville
  BRT (Capital): River Road Extension-Hwy 8 / 401, Hwy 8-Sportsworld-CherryBlossom-Royal Oak-Speedsville and Hwy 8-401
  BRT (Operating): Hwy 8-Sportsworld-Railway, King-Sportsworld-Railway, and Hwy 8-401

- Segment 5: LRT (Capital): Speedsville-Eagle, Eagle, King-Bishop, and Railway-Bishop
  LRT (Operating): King-Coronation, King-Bishop, and Railway
  BRT (Capital): Eagle, Speedsville-Eagle, and King-Bishop
  BRT (Operating): Railway-Bishop, King-Bishop, and King-Coronation

  BRT (Operating): Eagle-Hespeler, Hwy 401-Hespeler, and Eagle-Waterway-Dunbar-Hespeler

- Segment 7: LRT (Capital): Hespeler-Water-Ainslie, Hespeler-Water-Bruce, and Coronation-Dundas-Beverly-Main
  LRT (Operating): Railway-Beverly-Wellington, Hespeler-Water-Bruce, and Coronation-Dundas-Railway-Main-Ainslie
  BRT (Capital): Hespeler-Water-Ainslie, Hespeler-Water-Bruce, and Coronation-Dundas-Beverly-Main
  BRT (Operating): Hespeler-Water-Ainslie, Railway-Beverly-Wellington, and Coronation-Dundas-Beverly-Main

5.2.3.5. OTHER PHASE 2 STEP 2 REPORTS

Phase 2 Step 2 Conceptual Design

A conceptual design for rapid transit route alternatives, including rapid transit centerline placement and preliminary station locations, was prepared as a part of Phase 2 Step 2. For the set of drawings, see Appendix A3. Conceptual designs were developed to facilitate a high-level assessment of infrastructure needs, property requirements, potential benefits / impacts and to facilitate the development of order of magnitude cost estimates. The design criteria adopted for both LRT and BRT technologies were documented in a Phase 2 Step 2 Functional Design Criteria report.

Transit and Traffic Operations

The Transit and Traffic Operations report, prepared by MMM, documented the operational analyses conducted for the rapid transit corridor alternatives. For each corridor and technology, key segments and intersections were assessed to verify operational effectiveness on roadways within the Central Transit Corridor (CTC).
This report examined current traffic volumes, road capacities, and estimated delay for road users in the corridor. It also established existing bus volumes, ridership, delays and other measures of existing transit service in the corridor. The analysis identified changes to existing and future year (2031) traffic and transit operations that might result from implementing the rapid transit corridor and technology alternatives.

The intersection operations assessment considered:

- 2011 and 2031 roadway operation at screenlines and key intersection
- Route system reliability and speed

In terms of system reliability and speed, signalized intersections represent potential points of delay along the rapid transit route. Transit service slowed by road congestion is counterproductive, and rapid transit alternatives that are freed from congestion are operationally more effective. A number of measures were considered as described below:

**Number of signalized intersections crossed**

Off-road routes provide some benefit over on-road sections in terms of the lower total number of signalized crossings that the rapid transit line must cross. On-road route alignments will encounter some interference at signalized intersections that will affect rapid transit line speed even though transit signal priority will minimize the delay to rapid transit. More signalized intersections reflect slower rapid transit operation, which was the first criterion that was considered for the corridor and technology review. The following provides the ranking of segments based on this criterion:

- **Segment 1**: Route alternatives along the Waterloo Spurline (i.e. King-Northfield-Spurline, Spurline-Weber-King) have minimal delay as they cross only 10 percent or less of the total intersections within the segment.
- **Segment 2**: Route alternatives Railway-Weber-Frederick-Courtland which partially uses the Waterloo Spurline has the highest speed and least delay as it is less affected by signalized intersections than the King Street West routes.
- **Segment 3**: The CNR railway route is the only option that does not encounter delay at signalized intersections. However, route alternatives Charles-Ottawa-CN Huron Spur railway and CNR railway route-Mill-Courtland-Fairway Road perform well, crossing only 10 percent of the total intersections within this segment.
- **Segment 4**: The CPR rail route option performs best as it does not cross any intersections through Segment 4. However, the combined on and off-road routes of Highway 8 / 401, Highway 8-Sportsworld Drive-CPR rail line, King Street-Sportsworld Drive-CPR line also perform well as each crosses less than 15 percent of the total number of intersections in Segment 4.
- **Segment 5**: Route alternatives CPR line-Bishop Street, Speedsville-Eagle, and Eagle Street are the best routes as they cross the least number of signalized intersections in Segment 5.
- **Segment 6**: The Eagle Street and waterway routes are most desirable since they cross the fewest signalized intersections – only 11 percent of the total intersections in this segment.
- **Segment 7**: The CPR line and Beverly Street route minimize the delay associated with traffic signals along the rapid transit corridor in this segment.

**Congested Road Links**

The second criterion addresses which routes encounter road congestion on the on-road sections measured by the percent of the on-road route at 90% of the road link capacity. Congestion will affect the operation of private and commercial traffic and not necessarily the rapid transit line as it would operate in its own RoW with a separate signal system. However, there could also be some effect on rapid transit operation where the road sections are congested.

The following provides the ranking based on road congestion:

- **Segment 1**: The Weber Street route (BRT), and Waterloo Spurline routes (LRT) have the lowest percentage (about 35%) of their on-road sections near or at road capacity.
- **Segment 2**: Route alternatives King-Charles, King-Charles-Queen-Railway, King-Duke-Queen-Courtland, and King-Charles-Benton-Courtland have the lowest percentage (less than 30%) of their route on congested roads.
- **Segment 3**: Route alternative Charles-King-Dixon-Kingsway (LRT) has the lowest percentage (23%) of its route near or at the on-road section capacity.
- **Segment 4**: All routes have similar congestion levels by 2031 with the Hwy 8-Sportsworld Drive-CPR Line route (LRT) having the lowest percentage (33%) of congested roads.
- **Segment 5**: BRT routes Speedsville-Eagle and Eagle Street have the lowest percentage (22%) of on-road congestion. This percentage is significantly lower than the other route alternatives.
- **Segment 6**: Route alternative Bishop-Hespeler (LRT) has the lowest percentage (28%) of its route on congested roads.
- **Segment 7**: Route alternatives Coronation-Dundas-Beverly Street (BRT and LRT) and Coronation-Dundas-CPR rail line (LRT) have the lowest percentage (37%) of their on-road sections near or at road capacity.

Most of best performing routes in the 7 segments have their on-road sections operating with approximately 25-35% of the route length congested by 2031. This is acceptable operation for an urban rapid transit corridor.

**Intersection Operations**

The intersection operational review considered planned road improvements within the Central Transit Corridor and accounted for reduced lanes on streets with rapid transit operating in a dedicated centre median.

Most intersections in Segment 1 are expected to operate at an acceptable level of service for all routes, by 2031. The intersection of Northfield Drive and King Street is expected to operate at its capacity limit by 2031 for route alternatives King-Northfield-Waterloo Spurline and King-University-Waterloo Spurline. The intersection of King Street and University Avenue is expected to operate under congested conditions in 2031 that will affect the LRT Route Alternative on King Street and King-University Avenue-Waterloo Spurline alternative. The Erb-King Street intersection will also be congested for the King Street LRT/BRT routing.

The 2031 analysis indicates that the King and Victoria Street intersection will be at capacity by 2031, affecting all routes following the King Street West routing into downtown Kitchener. This is caused by reduced road capacity with lanes being removed for rapid transit purposes.
In Segment 3, the majority of intersections are expected to operate under congested conditions for most route options. The intersection of Charles Street and Ottawa Street shows significant increases in delay with lanes being removed for rapid transit purposes. Courtland Avenue and Ottawa Street will be at capacity for certain movements affecting those Ottawa Street route alternatives. The Highway 8 ramp at Fairway Road will be congested, affecting the BRT route options (to Cambridge) that use Fairway Road to access the highway.

In Segment 6, the Pinebush Road / Hespeler Road intersection will operate under poor conditions by 2031 for BRT Route Alternatives Hwy 401-Hespeler and Eagle-Hespeler.

In Segment 7, Hespeler Road and Coronation Boulevard and Water Street at Park Hill Road were analyzed for future conditions. Both intersections are expected to operate at an acceptable level of service for most route alternatives except Hespeler-Water-Ainslie (LRT).

Archaeological Assessment

A Stage 1 Archaeological Assessment for the proposed rapid transit study area was prepared by Archeoworks for the purpose of determining what archaeological impacts might occur through the implementation of the new rapid transit line. There are 26 registered sites within a 600 m radius of the proposed rail corridors, 51 within 600 m of the on-road corridors, and 23 within 600 m of the connector routes. Because of the Grand River, the Speed River, and numerous creeks bisect the study area, there is significant potential for locating and recovering Aboriginal archaeological resources within undisturbed portions of the study area. Also, the study area comprises the historic Townships of Woolwich, Waterloo and North Dumfries, in the County of Waterloo and the historic towns of Waterloo, Berlin, Freeport, Preston and Galt. This could lead to archaeological discoveries within undisturbed portions of the study area.

For the majority of the built-up area, there were no archaeological concerns, with the exception of Shelley Drive where it connects to First Avenue along Wilson Park and any undisturbed park lands, grass frontages and cemeteries that may be disturbed by construction. Routes that followed principally already developed areas would be unaffected.

The Stage 1 field review of the study area revealed that the study area is predominantly urban in nature, comprising commercial, industrial, institutional and residential lands, with some park lands and agricultural areas. Disturbances include paved roads, driveways, sidewalks, parking lots, residences, commercial / industrial buildings, utilities and railway tracks where it is unlikely to uncover historic remains. To facilitate the assessment, three categories of routes were examined: (1) rail corridors; (2) on-road corridors; and (3) corridor connectors. Specific stations were considered within each of these categories. The following summarizes the Stage 1 report findings for each segment.

Segment 1:

The area is primarily urban and impacted by industrial, commercial, residential and institutional development. It is dotted with a small collection of park and agricultural lands.

The rail corridor route in this segment follows an existing railway corridor that extends mostly through industrial / commercial and institutional areas and has been significantly disturbed by maintenance activity over the years. Despite its current disturbed condition, should the corridor need to be widened, further Stage 2 archaeological testing will be necessary to confirm the degree of disturbance, especially where it bisects Waterloo Park.

The on-road corridors include the King Street North and Weber Street routes. These are heavily disturbed, existing roadways that will not require further testing, unless to be disturbed beyond the existing RoW. Any undisturbed residential frontages and agricultural fields (at the north end of the King Street route) will require further Stage 2 testing to ensure no archaeological remains will be impacted by construction. Specifically, the Martin Mennonite pioneer cemetery grounds on King Street at Bridge Street will require Stage 2/3 archaeological testing within the existing RoW to ensure there will be no impacts to human remains that may be unmarked. This involves a Stage 2 test-pit survey adjacent to the cemetery grounds followed by the systematic removal of topsoil (Stage 3) to expose any unidentified grave shafts that may exist within the current RoW limits.

Connector routes in this segment include the Northfield Drive / Kraus Drive corridors, a Hydro corridor, the University Avenue West route and the Caroline Street route. Most connector roadways in this segment have sufficient RoW width to accommodate rapid transit without further widening. The Northfield Drive / Kraus Drive route follows an existing road alignment in an industrial area that has been significantly disturbed. The Hydro corridor, while it extends through an industrial area, is partially undisturbed where it bisects an open field. This open field will require further Stage 2 archaeological testing to confirm any disturbances. The University Avenue West route is located in a commercial / residential area that has been significantly disturbed. The Caroline Street route is located in a residential area that is also significantly disturbed by road construction and, thus, with the exception of the open field within the Hydro corridor, there are no further archaeological concerns for these connector routes.

Segments 2 and 3:

These segments do not contain any major watercourses; however, they are bisected by various creeks. Land use is primarily urban, with industrial, commercial and residential sections dotted with a small collection of park lands.

The rail corridor route (i.e. Waterloo Spurline) extends through industrial and commercial areas that are significantly disturbed through its maintenance. Should this corridor need to be widened for rapid transit construction purposes, then further Stage 2 archaeological testing will be necessary.

The on-road corridors consist of Courtland Avenue, Charles-King-Hwy 8, and Weber Street routes. These routes follow existing road alignments that will not require further testing unless widening beyond the existing RoW is necessary. In this case, any undisturbed residential frontages, grass margins and park lands (including the Rockway Golf Course) will require further Stage 2 testing to ensure no archaeological remains will be impacted by construction. Additionally, if St. Peters Lutheran cemetery frontage is impacted on the Weber Street route, further Stage 2/3 archaeological testing will be required within the existing road RoW to ensure there will be no impacts to human remains. This would involve a Stage 2 test pit investigation adjacent to the cemetery grounds followed by the topsoil removal (Stage 3) to expose any unidentified grave shafts that may exist within the road RoW.
Connector routes in the area are more extensive including the Benton / Queen / Duke Street routes, Kingsway Drive / Shelley Drive / Dixon Street / Eckert Street routes as well as the Ottawa Street / Borden Avenue / Mill Street routes. For the most part, these routes follow existing roads which are largely disturbed and warrant no further archaeological investigation. However, of particular concern is where Shelley Drive is to connect with First Avenue and Dixon Street. This connection will bisect Wilson Park in close proximity to an existing creek, and is, thus, high in archaeological potential. Further Stage 2 testing will be necessary in Wilson Park next to the RoW.

Segments 4 to 6:
This portion of the study area is bisected by the Grand and Speed Rivers and contains both urban sections at the north and southwest ends and extensive rural lands located centrally within the study area.

The rail corridor route follows an existing railway corridor that extends largely through industrial areas that are significantly disturbed. However, should this corridor need to be widened, then further Stage 2 archaeological testing will be necessary to confirm the degree of disturbance, especially where it crosses the Grand River and the Speed River.

The on-road corridors in this segment consist of the King Street East, Highway 8 and Cherry Blossom route. As these corridors follow existing road alignments, they are significantly disturbed. However, if roads need to be widened beyond the existing RoW, which is likely, those portions that border undisturbed residential frontages, park lands (Riverside Park) or rural agricultural fields (along the Cherry Blossom Route) will require further Stage 2 archaeological testing to ensure no archaeological remains will be impacted by construction.

Two possible connector routes exist near the Sportsworld complex. The first route follows Maple Grove Road while the second follows King Street East. As these routes follow existing road alignments through commercial areas, they can be classified as disturbed and do not warrant further archaeological concern unless road widening is required beyond the RoW boundaries.

Segments 5 to 7:
This portion of the study area is bisected by the Grand and Speed Rivers; however, only the Speed River is traversed by the proposed routes. There are rural uses at the north and east ends and includes the Dufries Conservation Area, while the remainder has been impacted by industrial, commercial and residential development.

The rail corridor route follows existing railway tracks which partially follow the Great Western Railway tracks illustrated in historic mapping and is thus, disturbed. However, should this corridor need to be widened for rapid transit purposes, then further Stage 2 archaeological testing will be necessary to confirm the degree of disturbance.

The on-road corridors include the Beverly-Main route, King-Coronation, Hespeler Road / 401, and the Eagle Street rapid transit routes. At the southern end of the study area, the on-road corridors pass through the historic downtown of Cambridge, where many heritage buildings still exist. However, it is expected that rapid transit will run within the road RoWs and, therefore, this area is considered free from archaeological concern. Further Stage 2 testing will, however, be required adjacent to the Dufries Conservation Area, adjacent to the Hespeler Road route, and at any undisturbed residential frontage and grass margin locations that exist beyond the RoW limits. Additionally, if any impacts are to occur along the St. Clements cemetery frontage, i.e. east side of Speedsville Road, further Stage 2/3 archaeological testing will be required within the existing RoW to ensure there will be no impacts to human remains. This involves a Stage 2 test-pit investigation adjacent to the cemetery grounds, followed by removing topsoil (Stage 3) to expose any unidentified grave shafts that may exist within the RoW limits.

There are three connector routes in this part of the study area – i.e. along Bishop Street, the internal waterway / Dunbar Street and Eagle Street. The Bishop Street route is largely commercial and industrial, with a small residential pocket. The waterway / Dunbar route is all industrial / commercial and the Eagle Street route is mainly residential and industrial. Because these routes follow existing road alignments through commercial, industrial and residential areas, they can be classified as disturbed and do not warrant further archaeological concern unless they need to be widened (which is likely) for rapid transit construction purposes.

5.2.3.6. DATA ANALYSIS AND ROUTE / TECHNOLOGY RANKING
As mentioned, the Phase 2 Step 2 evaluation was performed considering four criteria groups – Transportation, Social / Cultural Environment, Natural Environment, and Economic Impact. Each of these criteria groups were divided into sub-criteria, and each of the sub-criteria were represented by measures.

An evaluation tool referred as “The Bands Method” grouped the ‘measures’ data into five bands. Each data point was assigned to a band based on its relation to the mean of its corresponding data set. The data set was defined as the data for one measure for an entire segment.

The bands were numbered 1 through 5, with 5 being the most desirable. Depending on the criterion, a high or low data value may be desirable. For example, it is better to have high ridership and speed while it is better to have low per capita greenhouse gas emissions. See the chart below for a description of how the measures data were grouped into the five bands.

<table>
<thead>
<tr>
<th>Band</th>
<th>Low Data is Most Desirable</th>
<th>High Data is Most Desirable</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Less than 30% lower than the mean</td>
<td>Greater than or equal to 30% higher than the mean</td>
</tr>
<tr>
<td>4</td>
<td>30% lower than the mean to 10% lower than the mean (but not including values which are exactly equal to 10% lower than the mean)</td>
<td>10% higher than the mean to 30% higher than the mean (but not including values which are exactly 30% higher than the mean)</td>
</tr>
</tbody>
</table>

Table 5.6 – Bands Method
The Bands Method was used for all measures except one. It was determined that this method was not suitable for the "% of AM Peak Hour Trips" measure. A different calculation was required because a difference of 1% for this measure represents a significant variance. In this case, the maximum value within a segment was assigned the band of 5, and the others would receive band values of 4 through 1 based on a 1% difference from the maximum. For example, if the data set for a segment contained the values 10%, 9%, and 8%, the band values assigned were 5, 4, and 3 respectively. Appendix A4 contains the tables which show each data point for each measure converted into a band value 1 through 5.

Sub-criteria bands were then calculated using the band values from the measures. The bands from each of the measures under the applicable sub-criterion were averaged and then rounded up to the nearest whole number. To generate the bands for the criteria, the bands of the corresponding sub-criteria were averaged. Within each of the four criteria, the routes were ranked based on the associated band. To provide a total score of all criteria for each route / technology, the rankings from each of the four criteria were added. These scores were then ranked based on the lowest score corresponding to the top ranking. If two or more routes were tied, they were given the same ranking. For example, if two routes tied for 3rd, they were both given a 3. The next lowest scoring route was given a 5. Appendix A5 contains the tables which show the band values for each sub-criterion. The ranking for each route within each segment is shown in the bottom line of these tables.

5.2.4. RANKING OF THE ROUTE AND TECHNOLOGY ALTERNATIVES

Based on the above-noted ranking method, the resulting rankings for each route segment are shown in the following table. Refer to Appendix A1 for detailed route alternative maps and descriptions.
The top five ranked routes and their rankings were then carried forward to Phase 2 Step 3 in order to identify reasonable alternative rapid transit systems to serve the entire study area – from Cambridge through Kitchener to Waterloo.

5.2.5. REASONED ARGUMENT

A reasoned argument was prepared to support the numerical results of the route and technology rankings. The reasoned argument describes in words how the evaluation data for each route and technology compared to the evaluation data for other routes and technologies within its respective segment. The reasoned argument focused on the main advantages and disadvantages (positive and negative attributes) of each alternative in order to make comparisons. Table 5.7 to Table 5.13 provides a summary of the reasoned argument for the top ranked routes and technologies. See Appendix A6 for the reasoned arguments prepared for each of the routes and technologies studied.

5.2.6. RECOMMENDATIONS

Based on the rankings identified along with the reasoned argument approach that was undertaken, the top-ranked route, station and technology alternatives were identified as follows:

**Segment 1**
- Route 1-4 LRT King-Kraus-Northfield-Railway
- Route 1-6 LRT King-University-Railway
- Route 1-1 LRT King Street
- Route 1-4 BRT King-Kraus-Northfield-Railway
- Route 1-6 BRT King-University-Railway

**Segment 2**
- Route 2-2 LRT King-Charles
- Route 2-2 BRT King-Charles
- Route 2-6 LRT Weber-Queen-Charles
- Route 2-1 LRT King-Charles-Queen-Railway
- Route 2-3 LRT King-Duke-Queen-Courtland

**Segment 3**
- Route 3-2 LRT Charles-Dixon-Shelley-Hydro-Hwy 8
- Route 3-3 LRT Charles-King-Borden-Courtland-Fairway-King
- Route 3-2 BRT Charles-Dixon-Shelley-Hydro-Hwy 8
- Route 3-4 LRT Charles-King-Ottawa-Railway
- Route 3-1 LRT Charles-Dixon-Kingsway-Hwy 8

**Segment 4**
- Route 4-4 BRT Hwy 8-Sportsworld-Railway
- Route 4-6 BRT Hwy 8-Sportsworld-Cherry Blossom-Royal Oak-Speedsville
- Route 4-4 LRT Hwy 8-Sportsworld-Railway
- Route 4-6 LRT Hwy 8-Sportsworld-Cherry Blossom-Royal Oak-Speedsville
- Route 4-3 LRT Railway

**Segment 5**
- Route 5-1 LRT Railway
- Route 5-2 LRT Railway-Coronation
- Route 5-5 LRT King-Coronation
- Route 5-4 LRT King-Bishop

**Segment 6**
- Route 6-4 LRT Eagle-Waterway-Dunbar-Hespeler
- Route 6-5 LRT Eagle-Waterway-Bishop-Hespeler
- Route 6-1 BRT Hwy 401-Hespeler
- Route 6-4 BRT Eagle-Waterway-Dunbar-Hespeler
- Route 6-3 LRT Bishop-Hespeler
- Route 6-5 BRT Eagle-Waterway-Bishop-Hespeler

**Segment 7**
- Route 7-7 LRT Railway-Beverly-Wellington
- Route 7-4 LRT Railway
- Route 7-7 BRT Railway-Beverly-Wellington
- Route 7-3 LRT Hespeler-Water-Bruce
- Route 7-2 BRT Hespeler-Water-Ainslie
### Table 5.8 – Segment 1 Reasoned Argument

<table>
<thead>
<tr>
<th>Rank</th>
<th>Route 1-4 LRT</th>
<th>Route 1-6 LRT</th>
<th>Route 1-1 LRT</th>
<th>Route 1-4 BRT</th>
<th>Route 1-6 BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>King – Kraus – Northfield – Railway</td>
<td>King – University – Railway</td>
<td>King Street</td>
<td>King – University – Railway</td>
<td>King – University – Railway</td>
</tr>
</tbody>
</table>

#### Transportation
- Highest ridership potential of all Segment 1 options.
- Second-highest average speed due to minimal impact of road traffic, resulting in the shortest estimated trip time.
- Land purchase needs are relatively high.
- Using the rail corridor reduces the impact on nearby road traffic in Segment 1.

#### Social / Cultural Environment
- Low number of residents and affordable housing units within the station area.
- High number of institutional users and institutional employment by serving the University of Waterloo.
- Because the number of buildings next to the route is low, there is low impact from LRT vibrations.

#### Natural Environment
- No significant environmental impacts result from this route alternative.
- High quality benefits compared to other alternatives in this segment.
- High construction material (mineral aggregate) needs.

#### Economic Impact
- Serves high concentrations of employment, such as at the R&T Park and University of Waterloo.
- Moderate ability to serve retailers and customers by providing service to St. Jacobs Market, Conestoga Mall and Uptown Waterloo.
- Length of route results in the highest capital cost of all Segment 1 options.
- Moderate operating and maintenance costs per trip.

- Serves high concentrations of employment, including King Street, two universities, and Conestoga Mall.
- High potential to serve retail customers, servicing both King Street stations and Conestoga Mall.
- High capital cost and the highest operating and maintenance costs per trip, because this route is less direct.

- Serves moderate concentrations of employment within station areas along King Street.
- Best ability to serve retail space and customers from St. Jacobs Market, Conestoga Mall, Uptown Waterloo and King Street.
- High capital cost, although moderate compared to other LRT routes in this segment, and high operating and maintenance costs per trip.

- High ability to serve concentrations of employment, such as R&T Park and University of Waterloo.
- Moderate potential to serve retailers and customers by providing service to retail such as St. Jacobs Market, Conestoga Mall and Uptown Waterloo.
- Route design results in highest capital cost of all BRT routes, although below LRT.
- Route design results in highest capital cost of all BRT routes, although lower overall when compared to other options. Operating and maintenance costs per trip are moderate.

- Lower ridership potential than Route 1-6 using LRT, because BRT has less influence on land development and attracts fewer transit users. This less direct route has the lowest average speed and highest estimated trip time of all options in Segment 1.
- Land purchase costs are low in relation to the other options.
- Use of the rail corridor lessens impacts on auto traffic for a portion of the route.
<table>
<thead>
<tr>
<th>RANK: 1</th>
<th>Route 2-2 LRT</th>
<th>King – Charles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transportation</td>
<td>Highest ridership potential. Moderate average speed due to moderate traffic congestion along this route and a high number of intersections with traffic signals. This results in moderate trip time. Tied for the lowest land purchase costs.</td>
</tr>
<tr>
<td></td>
<td>Social/Cultural Environment</td>
<td>Tied for the highest number of residential and affordable housing units close to stations. Highest number of institutional users and institutional employment because of the station at Grand River Hospital. Low potential for impacts associated with LRT vibration because it has the lowest number of buildings close to the route.</td>
</tr>
<tr>
<td></td>
<td>Natural Environment</td>
<td>Moderate air quality benefits compared to other alternatives in this segment. Low impact on water quality. Deicing required at station platforms only. Moderate construction material (mineral aggregate) needs.</td>
</tr>
<tr>
<td></td>
<td>Economic Impact</td>
<td>Serves moderate concentrations of employment. This route provides service to downtown Kitchener and Grand River Hospital. Moderate number of retail customers serviced by this option which includes a station at Your Kitchener Market. High capital costs, but low operating and maintenance costs per trip.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RANK: 2</th>
<th>Route 2-2 BRT</th>
<th>King – Charles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transportation</td>
<td>High ridership potential. BRT on this route has the lowest speed of all route options and the highest trip time in this segment. Tied for the lowest land purchase costs.</td>
</tr>
<tr>
<td></td>
<td>Social/Cultural Environment</td>
<td>Tied for the highest existing residential and affordable housing units close to stations, but has lower future growth than LRT near stations on this route. Highest existing institutional users and institutional employment because of a station at Grand River Hospital. Low potential for impacts associated with LRT vibration because it has the lowest number of buildings close to the route.</td>
</tr>
<tr>
<td></td>
<td>Natural Environment</td>
<td>Moderate air quality benefits, but results in higher greenhouse gas emissions per capita than LRT on the same route. Low construction material (mineral aggregate) needs.</td>
</tr>
<tr>
<td></td>
<td>Economic Impact</td>
<td>Serves moderate concentrations of employment although future employment and retail somewhat less than LRT on same route. This route services downtown Kitchener and Grand River Hospital. Low capital cost. Lowest operating and maintenance costs per trip in this segment.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RANK: 3</th>
<th>Route 2-6 LRT</th>
<th>Weber – Queen – Charles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transportation</td>
<td>Moderate ridership potential. The ridership potential for this route is the lowest of the LRT options in Segment 2. High average speed, which results in the fastest estimated trip time. Moderate land purchase costs.</td>
</tr>
<tr>
<td></td>
<td>Social/Cultural Environment</td>
<td>Lowest number of existing residential and affordable housing units. Future residential and affordable housing units are among the lowest near stations on this route. Low number of institutional users and lowest institutional employment because Grand River Hospital is not serviced. Lowest number of designated heritage sites serviced.</td>
</tr>
<tr>
<td></td>
<td>Natural Environment</td>
<td>Highest air quality benefits as a result of limited sensitive land uses along the route. Moderate construction material (mineral aggregate) needs.</td>
</tr>
<tr>
<td></td>
<td>Economic Impact</td>
<td>Lowest ability to serve concentrations of employment. This route does not serve downtown Kitchener or Grand River Hospital. High number of retail customers serviced. Kitchener Market station is included in this route. In comparison to all routes, capital cost is high, but it has the lowest capital cost of LRT routes in this segment. This route has the lowest operating and maintenance costs per trip.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RANK: 4</th>
<th>Route 2-1 LRT</th>
<th>King – Charles – Queen – Railway</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transportation</td>
<td>High ridership potential. Moderate average speed due to less traffic congestion impacts and a lower than average number of intersections with traffic signals on the route. This results in a moderate trip time. Low land purchase costs.</td>
</tr>
<tr>
<td></td>
<td>Social/Cultural Environment</td>
<td>Moderate number of residential units, but lowest number of affordable housing units. Moderate number of institutional users and institutional employment. Low potential for impacts associated with LRT vibration.</td>
</tr>
<tr>
<td></td>
<td>Natural Environment</td>
<td>Low air quality benefits when compared to other alternatives in this segment. Low impact on water quality. Deicing required at station platforms only. High construction material (mineral aggregate) needs.</td>
</tr>
<tr>
<td></td>
<td>Economic Impact</td>
<td>Serves highest concentrations of employment. This route services downtown Kitchener and Grand River Hospital. High number of retail customers serviced. Tied for highest capital costs and has highest operating and maintenance costs per trip.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RANK: 4</th>
<th>Route 2-3 LRT</th>
<th>King – Duke – Queen – Courtland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transportation</td>
<td>High ridership potential. Moderate average speed due to moderate traffic congestion. This results in a moderate trip time. High land purchase costs.</td>
</tr>
<tr>
<td></td>
<td>Social/Cultural Environment</td>
<td>High number of residential and affordable housing units, with highest potential for future residential and affordable housing units close to stations. High number of institutional users and institutional employment. High potential for impacts associated with LRT vibration due to quantity of residential and affordable housing units close to route.</td>
</tr>
<tr>
<td></td>
<td>Natural Environment</td>
<td>As with all LRT options in this segment, this route option has a very low potential to impact water quality. High construction materials (mineral aggregate) needs.</td>
</tr>
<tr>
<td></td>
<td>Economic Impact</td>
<td>Serves highest concentrations of employment. This route services downtown Kitchener and Grand River Hospital. High number of retail customers serviced. Tied for highest capital costs and has highest operating and maintenance costs per trip.</td>
</tr>
<tr>
<td>RANK: 1</td>
<td>Route 3-2 LRT Charles – King – Dixon – Shelley – Hydro – Hwy 8</td>
<td></td>
</tr>
</tbody>
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Table 5.11 – Segment 4 Reasoned Argument

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<th>RANK: 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Route 4-4 BRT</strong>&lt;br&gt;Hwy 8 – Sportsworld – Railway</td>
<td><strong>Route 4-6 BRT</strong>&lt;br&gt;Hwy 8 – Sportsworld – Cherry Blossom – Royal Oak</td>
<td><strong>Route 4-6 LRT</strong>&lt;br&gt;Hwy 8 – Sportsworld – Railway</td>
<td><strong>Route 4-6 LRT</strong>&lt;br&gt;Hwy 8 – Sportsworld – Cherry Blossom – Royal Oak</td>
<td><strong>Route 4-3 LRT</strong>&lt;br&gt;Railway</td>
</tr>
</tbody>
</table>

**Transportation**
- Highest ridership potential of all route options in this segment.
- Moderate average speed and longer estimated trip time compared to other route options.
- Using the rail corridor reduces the impact on other road traffic.
- High land purchase needs.
- High overall ridership potential compared to the other routes despite most use occurring during morning rush hour.
- Moderate average speed, resulting in a moderate trip time.
- Less land purchase needs than most other options.
- High ridership potential, moderate average speed, and therefore longest estimated trip time.
- High land purchase needs for this option.
- High ridership potential. Moderate average speed, resulting in a moderate route trip time.
- Less land purchase needs than most other options.
- High ridership potential. Second highest speed of all routes after 4-2 BRT (Highways 8 and 401 route) resulting in a short trip time for the segment.
- Highest land purchase needs and associated costs.

**Social / Cultural / Environment**
- Second-highest number of residential units served of all route options. BRT has less influence on land use and does not attract as much development around stations.
- Highest number of institutional uses, the same as routes 4-3 LRT and 4-4 LRT.
- High number of cultural buildings, recreational uses, and designated heritage properties/buildings served.
- Low vibration impact due to few buildings situated near this route.
- Serves very low number of future residential units, due to less influence on reurbanization than LRT.
- No institutional uses within the stations served by this route.
- Low potential for impacts associated with vibration from BRT.
- Highest number of residents and institutional users served by this route.
- High number of cultural buildings, recreational uses, and designated heritage properties/buildings served.
- Low potential impact associated with vibration as few buildings are located near this route.
- Low number of residential units served.
- No institutional uses within the station areas served by this route option.
- This route does not serve any heritage properties or recreational areas.
- High number of residential units served.
- Highest number of institutional uses, tied with Route option 4-4 LRT.
- High number of cultural buildings, recreational uses, and designated heritage properties/buildings served.
- Low contribution to public health as a percentage of walking or cycling trips to transit stations is low.

**Natural Environment**
- Moderate environmental impact when compared to other options due to significant length of natural features affected (e.g. light, noise, vibration) by route option.
- Moderate amount of construction materials (mineral aggregate) required.
- Lower environmental impacts than most other route options.
- Lower amount of construction materials (mineral aggregate) required.
- Moderate environmental impact when compared to other options due to significant length of natural features impacted by route.
- High amount of construction materials (mineral aggregate) required.
- Lower environmental impacts than most other route options.
- Low amount of construction materials (mineral aggregate) required.
- Highest environmental impact given significant length of natural features impacted by route (e.g. noise, light, vibration).
- Highest amount of construction material required.

**Economic Impact**
- Serves high concentration of employment, but slightly less than 4-4 LRT. This route serves Toyota, which has a high concentration of employment. Also, it includes downtown Preston adding some employment.
- Serves high retail space and customer base with inclusion of Sportsworld station and downtown Preston along this route.
- Capital cost is high. This option has the lowest per trip operating and maintenance costs.
- Serves moderate concentrations of employment, but lower than 4-4 LRT. This route serves Toyota, which has a high concentration of employment.
- High quantity of retail space and retail customers served as a result of the inclusion of Sportsworld station in this route.
- Low capital and operating and maintenance costs per trip.
- Serves highest concentration of employment. This route services Sportsworld, Toyota, and downtown Preston.
- High quantity of retail space and retail customers served as a result of the inclusion of Sportsworld station and downtown Preston along this route.
- Capital cost is high overall, but low when compared to other LRT alternatives in this segment. This option has moderate operating and maintenance costs per trip.
- Serves high concentrations of employment including Toyota.
- High quantity of retail space and retail customers served as a result of the inclusion of Sportsworld station and downtown Preston along this route.
- High capital and operating and maintenance costs per trip.
- This route serves moderate concentrations of employment when compared to other route options in this segment. It does not serve the Sportsworld station.
- Low retail space and retail customers served, as downtown Preston is the only contributing station to retail uses.
- Capital cost is high overall, but low when compared to other LRT alternatives in this segment. This option has the highest operating and maintenance costs per trip.
### Table 5.12 – Segment 5 Reasoned Argument

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<tbody>
<tr>
<td><strong>Route 5-1 LRT Railway</strong></td>
<td><strong>Route 5-2 LRT Railway - Coronation</strong></td>
<td><strong>Route 5-3 LRT King - Coronation</strong></td>
<td><strong>Route 5-4 LRT King - Bishop</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rank 1</th>
<th>Rank 2</th>
<th>Rank 3</th>
<th>Rank 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transportation</strong></td>
<td>Highest ridership potential of the options in this segment – tied with 5-2 LRT</td>
<td>Moderate average speed and estimated trip time</td>
<td>Using the rail corridor reduces the impact on other road traffic in Segment 5</td>
<td>Using the rail corridor reduces the impact on road traffic, although not as much as in option 5-1</td>
</tr>
<tr>
<td></td>
<td>Highest land purchase needs and costs for this option</td>
<td>High ridership potential</td>
<td>Low average speed and therefore relatively longer estimated trip time than most other options</td>
<td>Low land purchase needs and associated costs</td>
</tr>
<tr>
<td><strong>Social/Cultural Environment</strong></td>
<td>Highest number of institutional users and institutional employment in the segment due to inclusion of Cambridge Memorial Hospital Station</td>
<td>Highest number of institutional users and institutional employment due to Cambridge Memorial Hospital Station</td>
<td>Highest potential for vibration impacts due to the higher number of buildings on Coronation Boulevard as compared with the other routes</td>
<td>Serves low number of institutional users and institutional employment when compared to other options because this route does not serve Cambridge Memorial Hospital</td>
</tr>
<tr>
<td></td>
<td>High ability to serve residential uses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Natural Environment</strong></td>
<td>Highest ecological impact with one of the longest lengths of natural features next to the route</td>
<td>Moderate ecological benefits</td>
<td>Moderate ecological benefits</td>
<td>Very low ecological impacts and water quality impacts</td>
</tr>
<tr>
<td></td>
<td>High air quality benefits</td>
<td>Less construction material (mineral aggregate) needed than 5-1 LRT, but still more than the other route options; overall ranking is low</td>
<td>Less construction material (mineral aggregate) needed than 5-1 LRT and 5-2 LRT, but more than the other route options; overall ranking is low</td>
<td></td>
</tr>
<tr>
<td><strong>Economic Impact</strong></td>
<td>Serves high concentrations of employment because of Cambridge Memorial Hospital station</td>
<td>Serves high concentrations of employment with a station serving Cambridge Memorial Hospital</td>
<td>Serves high concentrations of employment due to station at Cambridge Memorial Hospital</td>
<td>Serves low concentrations of employment because this route does not serve Cambridge Memorial Hospital</td>
</tr>
<tr>
<td></td>
<td>Serves more retail space and customers along this route due to a station in Preston city centre</td>
<td>Serves more retail space and customers along this route due to a station in Preston city centre</td>
<td>Serves more retail space and customers due to a station in Preston city centre</td>
<td>Moderate ability to serve retail space and customers compared to other options</td>
</tr>
<tr>
<td></td>
<td>Second-highest capital costs after 5-2 LRT and low operating and maintenance costs per trip compared to other route options</td>
<td>High capital costs; however, operating and maintenance costs per trip are low</td>
<td></td>
<td></td>
</tr>
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</table>
### Table 5.13 – Segment 6 Reasoned Argument

<table>
<thead>
<tr>
<th>Rank</th>
<th>Route 6-4 LRT</th>
<th>Route 6-5 LRT</th>
<th>Route 6-1 BRT</th>
<th>Route 6-4 BRT</th>
<th>Route 6-3 LRT</th>
<th>Route 6-6 BRT</th>
</tr>
</thead>
</table>

#### Evaluation Criteria

**Transportation**
- High ridership potential compared to other route options in this segment.
- Moderate average speed on route, which results in a moderate estimated trip time.
- Tied for the lowest land acquisition requirement and cost since it mainly uses wide road rights-of-way.
- Highest ridership potential of all route options in this segment.
- Best system reliability due to fewer intersections with traffic signals on this route (waterway and short stretch of Hespeler Road).
- Moderate average speed on route and moderate trip time.
- Low land purchase needs and cost since route uses the wide right-of-way on Hespeler Road.
- High ridership potential compared to the other route options in this segment.
- Moderate average speed with lowest estimated trip time as this route is short and has only two stations, which results in a lower trip time.
- Low land acquisition cost.
- High ridership potential compared to the other route options in this segment.

**Social / Cultural Environment**
- High number of residential uses.
- Moderate vibration impacts due to proximity of buildings along route.
- High contribution to public health with small number of people walking or cycling to transit stations.
- High number of residential uses within the station areas.
- Lowest impact due to vibration (low number of buildings along the route).
- High contribution to public health with high percentage of people walking or cycling to transit stations.
- Serves moderate number of residential uses - less than top ranked LRT options.
- Moderate vibration impacts due to moderate number of residences along this route.
- Lowest contribution to public health with low number of transit trips and the lowest percentage of people walking or cycling to access stations.
- Serves moderate number of residential uses - less than top ranked LRT options.
- Moderate vibration impacts due to moderate number of residences along this route.
- Lowest contribution to public health with lowest percentage of people walking or cycling to transit stations.

**Natural Environment**
- Moderate environmental impact with no displaced natural features, but some length of route possibly impacting designated features (e.g. noise, light, vibration).
- Low water quality impacts.
- High air quality benefits.
- High construction material (mineral aggregate) needs.
- Moderate environmental impact with no displaced natural features, but some length of route possibly impacting designated features (e.g. noise, light, vibration).
- Low water quality impacts.
- High air quality benefits.
- High construction material (mineral aggregate) needs.
- Moderate environmental impact with no displaced natural features, but some length of route possibly impacting designated features (e.g. noise, light, vibration).
- Low water quality impacts.
- High air quality benefits.
- High construction material (mineral aggregate) needs.
- Moderate environmental impact with no displaced natural features, but some length of route possibly impacting designated features (e.g. noise, light, vibration).
- Low water quality impacts.
- High air quality benefits.
- High construction material (mineral aggregate) needs.

**Economic Impact**
- Serves high number of existing and future jobs close to stations.
- High capital cost but low operating and maintenance costs per trip.
- Serves high number of existing and future jobs close to stations and same potential as most other top ranked routes to serve retailers.
- High capital cost but lowest operating and maintenance costs per trip.
- Serves high concentration of jobs near stations with same ability as most other top ranked routes in serving retailers.
- Low capital cost and highest operating and maintenance costs per trip.
- Serves high concentration of jobs (existing and future) near stations (because of fewer stations along this route) and less retail space than other options.
- High capital cost and highest operating and maintenance costs per trip.
- Serves high concentration of jobs (existing and future) near stations with same potential as most other top ranked routes in serving retailers.
- Low capital cost but high operating and maintenance costs per trip.
## Table 5.14 – Segment 7 Reasoned Argument

<table>
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<tr>
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<th>RANK: 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Route 7-7 LRT Railway – Beverly – Wellington</strong></td>
<td><strong>Route 7-4 LRT Railway</strong></td>
<td><strong>Route 7-7 LRT Railway – Beverly – Wellington</strong></td>
<td><strong>Route 7-3 LRT Hespeler – Water – Bruce</strong></td>
<td><strong>Route 7-2 BRT Coronation – Dundas – Railway – Main – Ainslie</strong></td>
</tr>
</tbody>
</table>

### Transportation
- **Tied for highest ridership potential with LRT route 7-4.**
- **Very limited impact on nearby road traffic since this route uses the rail corridor.**
- Combined with low number of intersections with traffic signals in the area, rapid transit service would be very reliable.
- **Tied for lowest land purchase needs and costs.**

**Lowest ridership potential with LRT route 7-4.**

- **Very limited impact on nearby road traffic since this route uses the rail corridor.**
- Combined with low number of intersections with traffic signals to cross, rapid transit service would be very reliable.
- **Moderate average speed on route and moderate trip time.**
- **Low land purchase needs resulting in low land purchase costs.**

**Moderate ridership potential.**
- **Moderate average speed on this route and a moderate trip time due to the directness of the route.**
- **High congestion and traffic on nearby roads compared with other route options will slow the rapid transit system.**
- **Low land purchase needs and cost.**

**Moderate ridership potential although best of all BRT route options for this segment.**
- **High average speed, resulting in a low trip time.**
- **Moderate land purchase needs and cost.**

### Social / Cultural Environment
- **Tied with all other LRT options in this segment for ability to serve residential uses.**
- **All route options serve the same number of cultural attractions in this segment.**
- **Moderate ability to serve existing and future recreational sites.**
- **Lowest potential impact from vibration because of the lowest number of buildings close to this route.**
- **Tied for highest contribution to public health with the highest percentage of cycling or walking trips taken to transit stations.**

**Similar to other route options in this segment, this route serves a moderate number of residential and institutional facilities such as schools and government buildings.**

- **High contribution to public health with most trips taken by cycling or walking to transit stations when compared to other route options.**

**This route serves a moderate number of residential and institutional facilities such as schools and government buildings.**

- **Similar with other route options, this route has a moderate noise impact on nearby properties.**

**Provides service to the same number of cultural attractions as other route options in this segment.**

- **This route has the lowest percentage of transit users travelling to transit stations by cycling or walking in this segment.**

### Natural Environment
- **Much like all other LRT route options, this route has a very low impact on water quality, requiring de-lang only on station platforms.**
- **Low impact on existing natural features resulting from increased light, noise and vibration.**
- **High construction material needs.**

**As with other route options in this segment, this route does not displace any natural features.**
- **High construction material needs.**

- **Along with other BRT routes, the need for de-lang of the entire BRT route in water results in the highest impact on water quality when compared to other route options.**
- **High construction material needs.**

**Tied for the highest amount of natural features along its length that could be impacted by increased light, noise and vibration.**

- **Moderate air quality benefit compared to other route options in this segment.**
- **Low construction material needs.**

### Economic Impact
- **Serves moderate employment concentrations along route – similar to other LRT route options.**
- **Although this route option has a high capital cost, it is the least expensive per trip (tied with BRT route 7-2) to operate and maintain.**

**This route serves similar existing and future retail shops in Galt City Centre as other route options in this segment.**

- **This route has a high capital cost and moderate operations and maintenance cost per trip when compared to other route options in the segment.**

**Serves moderate employment concentrations along route – slightly lower than LRT route options.**

- **This route option is tied for the lowest capital cost and has low operation and maintenance costs per trip.**

**Tied for highest capital cost, however, low operation and maintenance costs per trip.**

- **Serves moderate employment concentrations along route – slightly lower than LRT route options.**

- **This route option has both the lowest capital cost and lowest operating and maintenance costs per trip of all the route options in this segment.**
5.3. PHASE 2 STEP 3: IDENTIFICATION AND EVALUATION OF RAPID TRANSIT SYSTEM ALTERNATIVES

Following completion of Phase 2 Step 2, the highest ranked routes and technology alternatives within each segment were combined across all segments in order to identify reasonable rapid transit system alternatives for consideration and assessment in Step 3.

As a starting point, the highest ranked routes from Step 2 (see Section 5.2.6) were combined to develop a "long list" of 52 complete routes for the entire 38 km length (the system alternatives). From the 'long list', additional studies were undertaken to identify two short-listed route system alternatives that would be examined in greater detail.

The two basic routes that were short-listed included one BRT route and one LRT route. Each route included a number of "decision sections" where two or more possible routes exist between two common stations along short sections of the 38 km route. These decision sections were subjected to a high level evaluation using 13 key measures developed in Step 2 as described in the report "Phase 2 Step 3 Evaluation of Rapid Transit System Alternatives – Assessment of Decision Sections on Route Alternatives" (October, 2008). The report contained views of the public on the decision sections and which ones they felt could be removed from further consideration.

The remaining BRT and LRT route system alternatives were then further evaluated using a detailed Multiple Accounts Evaluation (MAE) that included development of route functional design plans. The functional design plans enabled more detailed cost estimates to be prepared including preliminary estimates of project capital and operating / maintenance costs. The results of the MAE analysis, used in combination with public input on the MAE and functional plans have led to the identification of a preferred route system alternative.

The following summarizes the identification of route systems and the two-tiered evaluation process ("long list" to "short list") for Phase 2 Step 3 of the IEA.

5.3.1. IDENTIFICATION OF ALTERNATIVE RAPID TRANSIT SYSTEMS

The Study Team used the Phase 2 Step 2 rankings of routes in the seven segment areas as well as public input gained from the January 2008 Public Consultation Centres to develop a "long-list" of 52 possible route system alternatives. These route systems are shown in Figure 5-6.

The 52 route alternatives were then examined and some routes were resolved for several decision sections as documented in the report "Phase 2 Step 3 Evaluation of Rapid Transit System Alternatives – Assessment of Decision Sections on Route alternatives". Decision sections occur where two or more route options exist between two common stations. Maps of the decision sections and their routes are illustrated in Figure 5-7 (LRT) and Figure 5-8 (BRT).

The decision sections for both LRT and BRT systems were compared against 13 key criteria and measures that were developed in the Step 2 evaluation. The key criteria and measures that were selected were:

- Transportation: daily ridership, system reliability and speed, system performance, property requirements, route length, number of stations.
- Social / Cultural: ability to serve residential and institutional uses. Includes the number of residential and affordable housing units within 600 m of a rapid transit station (between 2005 and 2031). Estimated numbers of institutional employment and users (between 2005 and 2031).
- Economic Impact: ability to serve concentrations of employment and retailers. Growth (between 2005 and 2031) in employment and retail customers within 600 m of a rapid transit station. Estimated capital cost (in 2007 $).

Routes in the decision sections were compared using the following approach:

1. Targets (thresholds) were set for each measure and these were used to score the alternatives. Those route alternatives that scored below the targets were dropped from further consideration. It is important to note that this approach is a relative comparison for routes of the same technology. For example, route alternatives using BRT were compared to other BRT routes, while routes using LRT were compared only to other LRT routes.

2. Second, a field review was conducted along each route to identify engineering considerations that could pose obstacles to construction or implementation of the final system. The purpose of this review was to look for engineering challenges that could impact the feasibility of the rapid transit route alternatives. The main considerations were:

   - Major utilities (e.g. gas, water, hydro) that may need to be relocated to accommodate construction
   - Rail and road bridges with limited RoW width crossing rivers and streams, highways, and railway lines
   - Steep hills or sharp curves in the road and railway lines that could impact the operations of a rapid transit vehicle
   - Narrow rail rights-of-way that would need widening where freight rail operation could co-exist with the dedicated lanes needed for rapid transit
   - Narrow road rights-of-way that would need widening or removal of traffic / parking lanes to accommodate dedicated rapid transit lanes
   - Property access on the on-road sections of rapid transit routes
   - Local site conditions or other factors that could significantly increase construction costs

3. Several additional measures were also considered:

   - Land use fronting a route option: Adjacent land use was determined by type from available GIS data. Sensitive land uses (i.e. schools, nursing homes, hospitals, daycare centres, and seniors homes) were identified along each route.
   - Public and Private accesses: number of access points were counted along a route option. Driveways and intersections were categorized.
Figure 5-6 – All Systems and Variants Resulting from Phase 2 Step 2 Evaluation
4. Capital Cost Estimates: Preliminary capital cost estimates were updated from the Step 2 estimates including revised segment lengths and using typical LRT and BRT on and off-road cross-sections, updated property requirements and land cost, updated road and rail corridor construction requirements, order-of-magnitude structure costs, preliminary assessment of utility relocation cost, allowance for rapid transit stations, allowance for traction power, power supply, substations, signals and communications. No engineering design had been undertaken at this point in the EA – thus, cost estimates were based on line drawings of the route.

The decision sections and route options are illustrated in Figure 5-7 (LRT) and Figure 5-8 (BRT) and described below:

- **Decision Section A:** LRT and BRT routes are identical in this section. Three routings are shown. A1 – Conestoga Road to Kraus Drive to Northfield Drive to Waterloo Spur to Uptown Waterloo. A2 – King Street North to University Avenue to Waterloo Spur to Uptown Waterloo. A3 – Conestoga Road to Kraus Drive to Northfield Drive to Waterloo Spur to University Avenue to King Street North to Uptown Waterloo.

- **Decision Section B:** Both LRT and BRT follow these routings in Uptown Waterloo. B1 uses Caroline Street from the Erb Street rail crossing to Allen Street to King Street. B2 is two-way on King Street between Waterloo Town Square rail crossing to Allen Street. Another route option was considered that combined B1 and B2 to form a one-way loop with the northbound leg on King Street from Allen Street to Erb Street and then westbound on Erb Street to the rail line. The southbound leg follows Caroline Street from the rail line at Erb Street to Allen Street.

- **Decision Section C:** Both LRT and BRT follow these routings in Downtown Kitchener. C1 – King Street to Francis Street to Duke Street to Frederick Street to Benton Street to Charles Street. C2 – King Street to Francis Street to Charles Street to Benton Street. Another route option was considered that formed a one-way loop with the northbound leg running on Duke Street and the southbound leg on Charles Street, between Francis Street and Frederick Street.

- **Decision Section D:** LRT Only routings include D1+D1-1: Ottawa Street South to CN Huron Park Spur to CPR Waterloo S/D to Fairview Park Mall D1-D1-2: Ottawa Street South to CN Huron Park Spur to Hayward Avenue to Courtland Avenue East to the Hydro Corridor to Kingsway Drive to Fairview Park Mall. BRT Only routings include D1+D1-1: Ottawa Street South to CN Huron Park Spur to Hayward Avenue to Courtland Avenue to Fairway Road to Fairview Park Mall and D1+D1-2: Ottawa Street South to CN Huron Park Spur to Hayward Avenue to Courtland Avenue East to the Hydro Corridor to Kingsway Drive to Fairview Park Mall. Both LRT and BRT follow D2: Charles Street East to King Street East to Dixon Street to Eckert Street to 1st Avenue to Kingsway Drive to Fairview Park Mall.

- **Decision Section E:** Only LRT has two optional routes in this decision section. E1-F1: CPR Waterloo S/D to Eagle Street to Hespeler Road to Water Street to GRT Ainslie Street Bus Terminal. E2-F2: CPR Waterloo S/D to Coronation Boulevard to Beverly Street to Wellington Street to GRT Ainslie Street Bus Terminal.

The evaluation of these decision sections is presented in the following section.
Figure 5-7 – Phase 2 Step 3 LRT Short-listed Route Alternatives
Figure 5-8 – Phase 2 Step 3 BRT Short-listed Route Alternatives
5.3.2. RENDERINGS

Figure 5-9, Figure 5-10 and Figure 5-11 renderings that were prepared by BMI as part of the Phase 2 Step 3 Public Consultation materials. The renderings show what dedicated rapid transit lanes would look like in three locations along the proposed route.
Artistic Rendering of Duke Street looking south towards Ontario Street

Existing Conditions

Figure 5-9 – Rendering of Rapid Transit Lanes and Station at Duke Street and Ontario Street
Figure 5-10 – Rendering of Rapid Transit Lanes and Station at Hespeler Road and Can-Amera Parkway
Figure 5-11 – Rendering of Rapid Transit Lanes and Station at University Avenue and King Street
5.3.3. EVALUATION OF ALTERNATIVE RAPID TRANSIT SYSTEMS

While the report “Phase 2 Step 3A Evaluation of Rapid Transit System Alternatives – Assessment of Decision Sections on Route Alternatives” includes tables that summarize the evaluation of the various decision sections, the following provides an overview of the content of those tables.

In consideration of the 13 key measures, the evaluation results for the decision sections are provided below:

Decision Section A – LRT: Route A1 (Waterloo Spur) achieved the highest ridership and was faster than the others due to its dedicated rail corridor. Station areas showed strong employment growth, surpassing all other route options. Capital cost was in the mid-range of LRT routes. A1 included the fewest sensitive properties and lowest number of driveways along the route. It was recommended that A1 to go forward into next phase of evaluation. Route A2 (King Street) had the lowest ridership of three routes and its trip time was longer than A1. Employment growth was half that of A1. However, residential growth was greater, especially on King Street for student housing. This route had the lowest capital cost and the highest impact on adjacent property (driveway access and sensitive properties). It was recommended that A2 go forward for further examination. Route A3 (Xpress routing) had high ridership potential, but was the longest and slowest route of three routes. It had one more station than the other routes. A3 had similar residential growth potential as A2, but with the highest capital cost. It also had the largest number of affected properties (access and sensitive uses). It was recommended that A3 be removed from further consideration.

Decision Section B – BRT: Route A1 achieved the highest BRT ridership and was the fastest, compared to the other routes because it was on the rail corridor. There was strong employment growth around stations, but less than LRT. Capital cost was significantly higher than A2 and the same as A3. It has the least number of sensitive properties and driveway access to contend with. It was recommended that A1 be carried forward for consideration. A2 had the lowest ridership potential and was slower (two minutes) than A1 in that its route is almost entirely on road. Employment growth was lower than A1 (50% less) but it had strong residential growth potential. It had the lowest capital cost, but impacted the largest number of driveway accesses. It was recommended that A2 be carried forward for further evaluation. Route A3 had the same ridership as A1, but it was significantly longer and slower (by 4 minutes) than A1. It had similar residential growth as A2 and slightly less employment than A1. The costs were the same as A1, and it had the largest property impact of all three route options. It was recommended that A3 be removed from further consideration.

Decision Sections B and C for both LRT and BRT systems were comprised of short route segments in the two downtown areas. Minimal differences in the measures between the route pairs were observed. In addition, the loop options proved to be more flexible in terms of access to property and parking lots / garages, retaining the current two-way traffic system in the downtowns, and minimizing property requirements and utility relocation costs. Accordingly, further examination and functional design was undertaken for various route options in these decision sections as well as gaining additional input and insight from the public, City staff and Committees of City Council.

Decision Section D – LRT: Route D1 Ottawa / Courtland had two variants. Both had substantially higher ridership than D2 because of potential intensification and bus connections at the Courtland / Block Line Road station. Trip time was slightly longer (1 minute) for D1 because of the less direct routing than Kingsway – rail / hydro corridors lessen the time. D1-2 capital cost was the lowest, while D1-1 was the highest of all three options. Route D1-2 had the highest number of affected sensitive properties. It was recommended that D1-1 and D1-2 be carried forward for further consideration. Route D2 (Charles-King-Kingsway) had significantly lower ridership than D1 options and was much shorter (1.5 km), however trip time savings were not high because of being on-road. Montgomery / King Station had little development potential as it is surrounded by park land and stable neighbourhoods. Capital cost was in the mid-range of other two routes. Kingsway Drive is too narrow for two-way LRT – therefore substantial property acquisition or a tunnel (0.6 km) would have been required. It was recommended that D2 be removed from further evaluation.

Decision Section E-F – LRT: Route E1-F1 had 30% more ridership than E2-F2 because of potential intensification and better bus connections on Hespeler Road. It was a longer route (1.4 km) and had more stations, which added to trip time. Residential growth (Hespeler Road route) was three times that of the Coronation route and it had double the employment potential. Capital cost was slightly higher than E2-F2. More driveways were impacted on Hespeler Road, however there were fewer sensitive properties included. It was recommended that E1-F1 be brought forward for further evaluation. The ridership for Route E2-F2 was substantially lower than that of E1-F1. The line was shorter, making for travel time savings (2 ½ minutes). E2-F2 had considerably less development potential along the rail corridor and Coronation. The capital cost was slightly lower than E1-F1. It was recommended that E2-F2 be removed from further consideration.

Public Comments on Decision Sections

The public was consulted in a series of public open houses held in June, 2008. Based on comment sheets handed out to participants of the public open houses, preferences for the route alternatives of the three decision sections were established. The results of the public input on the decision sections follows:

Decision Section A: The Public was split between the two routes in North Waterloo (Waterloo Spur and King-University). Comments about this decision section included:

- Keep rapid transit away from traffic routes
- The system should serve both universities
• A stop is needed in Waterloo Park
• The system should serve the R&T park
• Use the existing rail corridor and have stations near redevelopment opportunities

Decision Section D: The public preferred the Courtland route over Kingsway by a small margin. Comments included:

• Kingsway is most direct
• Courtland has better neighbourhood connections
• Use the rail RoW
• Choose route with most redevelopment opportunities (Courtland)
• Don’t use Fairway Road – too busy

Decision Section E/F: Most people preferred the Hespeler Road route. Comments given were:

• Provide a stop at Cambridge Memorial hospital
• CP / Coronation routing is most direct
• Rapid transit on Hespeler Road will lessen congestion and has most development opportunities
• Negative impact on Preston core, Coronation is most visually appealing

Generally, the public preferred those rapid transit routes that are separated from traffic, provide the most direct routing, and offer redevelopment opportunities. There was a split decision on the North Waterloo routes, but the Ottawa / Courtland route was preferred, and a clear majority was given to the Eagle-Hespeler Road route.

5.3.4. RIDERSHIP FORECASTING

Ridership forecasts were developed as part of the IEA for Phase 2 Step 2 and updated in Step 3. The forecasts were based on the Region’s Central Transit Corridor (CTC) Ridership Forecasting Model that was developed in 2005 by TSi Consultants (Vancouver) and updated more recently by Halcrow Consulting Inc. (Toronto). The earlier ridership model was developed as part of the 2004-05 Rapid Transit Initiative Technical Studies funded under the Canada Strategic Infrastructure Program of the Federal Government. The model was peer reviewed by Eric Miller of the University of Toronto and deemed to be a sound forecasting tool. Refer to the reports for more detail: “Growth Management Strategy and Transit Initiative – Travel Surveys, Model Development and Ridership Forecasting, TSI Consultants, July 2005”, “Peer Review on Waterloo Growth Management Strategy and Transit Initiative, Deloitte, Feb 2006”, and “Waterloo Rapid Transit – Individual EA Study Phase 2 Step 3 Rapid Transit Ridership Forecasts, Halcrow Consulting Inc., March 2009”.

5.3.4.1. 2004 MODEL DEVELOPMENT

The CTC Ridership Forecasting Model was developed based on a variety of information sources including CTC Auto and Transit OD and Stated Preference surveys conducted in 2004-05, the 1996 Transportation Tomorrow Survey (TTS), latest traffic and transit count information within the study area. In addition to the 2004 base year, transportation network scenarios were developed for 2011, 2021, and 2041. Model inputs and parameters were established specifically for Waterloo Region based on travel and physical surveys as well as experience elsewhere for rapid transit projects. The traffic zone system, population and employment data, auto and transit user costs, road and transit networks, and model ridership forecasts are briefly described below:

Traffic Zones: The 2004 traffic zone system developed for this study contained 567 internal zones and 21 connectors to areas external to the Region (mainly highway routes). The zone system was conceived as an amalgamation of two zone systems used by the Region: (i) the Planning Land Use Model (PLUM) zone system; and (ii) the traffic zone system from the 2001 Waterloo Travel Demand Model. The PLUM zone system covers the entire Region of Waterloo from Woolwich to North Dumfries, and divides the region into 1,605 planning zones. The 2001 traffic zone system contained 519 internal zones along with 21 external zones. For transit corridor modelling, it was important to refine the traffic zone system and connectors within the study area to ensure a more realistic representation of the network and proper depiction of walk distances to stations. The map below shows the traffic zone system used for ridership forecasting purposes.

Population and Employment Data: Key inputs to the CTC ridership forecasting model were current and future year demographics by traffic zone. These inputs include population by age category, employment, secondary and post secondary student enrolment and housing location data. Regional staff provided base year and future year estimates of total population and employment by PLUM zone, 2001 census age category data, future age profile estimates and information on post secondary student housing locations. This information was used to develop the traffic zone level inputs for the base year and future horizons. In 2004, Regional population was 470,000 with 244,000 employees. By 2041, this was expected to rise to 700,000 residents and 390,000 employment. More significant is the growth anticipated in the CTC (i.e. Kitchener and Waterloo) which is needed to support rapid transit as illustrated below:
Two growth assumptions were made when developing the land use forecasts: 1) full intensification (LRT) that would reflect development occurring around rapid transit stations, and 2) a lower level of intensification (BAU) in the CTC that would not include rapid transit; more in line with expanding the conventional bus service including iXpress.

Secondary and post secondary student enrolment data was obtained from Regional data and institutions. This includes the two universities (UW and WLU) as well as Conestoga College. In 2004, there were 39,000 full time students enrolled in programs at these three institutions located mainly in the Kitchener-Waterloo area. Of that, 9,000 students lived on campus. By 2041, post secondary enrolment was estimated at 47,000, with 12,000 students living in on-campus housing. Future estimates and assumptions were developed in consultation with Regional planning staff.

Auto and Transit User Cost: The combination of out of pocket travel costs and time are commonly referred to as the generalized cost of travel. Generalized cost is an important aspect of the modern transportation planning model as it influences the destination choice as well as by what mode. Travel costs used in the CTC model include auto-operating costs, parking charges and transit fares. These “out of pocket” costs are converted to time (based on a perceived value of time by the user) and added to the travel time derived from the travel model’s road and transit networks. Auto operating costs (e.g., fuel and oil, maintenance and tires) were derived from CAA publications and an average value of 12.2 cents / kilometre was used. Fixed or sunk costs (e.g., insurance, license and registration fees, taxes, financing costs and depreciation) are typically not used in the generalized cost formulations. 2004 daily parking charge data were gathered for various pay parking lots in the downtown areas and universities. At that time they ranged from $2.50 to $5.50 a day in the downtowns with only 90 cents in Cambridge. For future conditions, parking charges were not increased in the travel model which is a conservative approach to ridership forecasting. Transit fares for Grand River Transit (GRT) system varied between $1.00 and $2.25 in 2004, depending on the payment method (e.g., cash, tickets, passes) and any discounts (e.g., students, seniors). Based on fare audit and revenue information provided by the Region, the average fare was estimated at $1.50 per trip. A fundamental aspect of choosing to make a trip is how an individual values his or her time. Most transportation agencies have adopted around 40 to 60 percent of the average hourly wage rate as representative of the value of time (VOT). Stated preference (SP) surveys were conducted in the CTC in order to better estimate mode choice for market segments (i.e. work versus social trip making). A by-product of the estimated models is the VOT and weights placed on various time elements (e.g. waiting at a bus stop). A recommended VOT of $10.30 per hour (half of the local wage rate) for all trip types was adopted.

Road and Transit Networks: The AM base road network consists of freeways, arterial and collector roads of various size (e.g. number of lanes and capacity) and connections to the traffic zones. The road network was developed in the Region’s TransCAD model – a GIS based transportation planning platform that is used by many municipalities in Canada and world wide. Traffic flows were simulated on the road network between traffic zones and these are restricted by the effects of congestion also simulated in the model. An AM peak transit network was developed in 2004 was based on the fall transit schedule. This involved coding all bus routes operated by GRT serving the Region of Waterloo as shown in tabular form above. Note that bus routes with different headways inbound and outbound or different start locations were split into multiple itineraries.

Ridership Forecasts: Based on the new CTC model, ridership forecasts were developed for several scenarios in three time horizons, 2011, 2021, 2041. These scenarios were defined by HLB Decision Economics to support a TransDEC evaluation of the different CTC transit technologies (i.e., Express Bus, Bus Rapid Transit or BRT, Light Rail Transit or LRT). A summary of the scenarios used for the original cost-benefit analysis are shown on the next page; these scenarios were represented by different land use, technology and road networks.

Figure 5-12 – Population and Employment (2004 Model)

Table: Ridership Forecasts Scenarios

<table>
<thead>
<tr>
<th>Scenario Description</th>
<th>Ridership Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario A</td>
<td>2011</td>
</tr>
<tr>
<td>Scenario B</td>
<td>2021</td>
</tr>
<tr>
<td>Scenario C</td>
<td>2041</td>
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Table 5.15 – Ridership Projections (2004 Model) – Boardings and Maximum Load

<table>
<thead>
<tr>
<th>Scenario Number</th>
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<th>HLB #3A</th>
<th>HLB #4A</th>
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<td>12000</td>
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<td>32000</td>
<td>14000</td>
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<td>25000</td>
<td>36000</td>
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<table>
<thead>
<tr>
<th>Description</th>
<th>HLB #2A</th>
<th>HLB #3A</th>
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<tr>
<td>BAU (w/CCTCpr)</td>
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<td></td>
<td></td>
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<tr>
<td>LRT Targeted Road</td>
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<tr>
<td>BRT Min Road</td>
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<tr>
<td>Horizon Year</td>
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<td>2021</td>
<td>2041</td>
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<td>2021</td>
<td>2041</td>
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<tr>
<td>2021</td>
<td>2041</td>
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| Bus Fleet (Approx.)| 180     | 240     | 410     |
|                   | 180     | 230     | 410     |
|                   | 190     | 250     | 420     |

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<th>BAU</th>
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Table 5.16 – Ridership Projections (2004 Model) – AM Peak Hour, Daily, and Annual

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<tr>
<td>Sc33010</td>
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</table>

As indicated in the above table, land use development was represented by three scenarios:

- **Business and Usual (BAU)**
- **Bus Rapid Transit (BRT)** – more concentration in CTC area than BAU
- **Light Rail Transit (LRT)** – highest concentration in the CTC area

Targeted Road Network included road projects as per the 2004 Regional Road capital expansion program plus targeted road improvements focusing on the CTC corridor. Improvements were coded into their respective future year road networks. Table 5.2 in the Technical Studies report “Growth Management Strategy and Transit Initiative – Travel Surveys, Model Development and Ridership Forecasting, TSi Consultants, July 2005, pp 55-56” shows the road widenings and new links that were assumed for the economic analysis.

Transit route headway assumptions that were developed for the BAU and BRT/LRT scenarios are shown in Table 5.3b (Final HLB Scenarios) in the above noted Technical Studies report. Note that for the BAU scenario, a CTC Express Bus route was introduced between downtown Cambridge and Conestoga Mall with a line time of approximately 70 minutes in 2004 (this increases over time with congestion). For the BRT and LRT scenarios, the Cambridge Express is short-turned at Fairview Mall, and integrated with the BRT/LRT line. Both BRT and LRT follow the same general alignment and same station locations, travel times and frequencies. The rapid transit headway was established as 7.5 minutes. For this analysis the BRT/LRT extends from Fairview Mall in the south to Northfield Drive at the railway line (west of Conestoga Mall) in the north.

AM ridership forecasts were developed for the three transit scenarios. Transit mode share for the BAU increased from 4.4% in the base year to 4.7% by 2011 and 6.5% by 2041 resulting from increased conventional bus services. Transit mode share is higher for the BRT and LRT scenarios (7.1-7.6% by 2031) due to the greater land use concentration in the CTC. LRT had the highest mode share. AM peak hour boarding and maximum load statistics are show below as totaled for the 11 rapid transit stations in Kitchener-Waterloo. Under BAU, the CTC Express boardings are 940 by 2011 increasing to 1,100 by 2041 with buses running every 7.5 minutes. Note: by 2041, bus route frequency across the system is improved resulting in low growth on the CTC Express due to diversion to other routes. Under the BRT and LRT scenarios, the CTC Express boardings are lower since the line only runs between Cambridge and Fairview Mall. LRT boardings (AM peak) are higher by 25% than BRT (2090 vs 2300) by 2041.

Daily and annual ridership factors were derived from hourly transit data and 2003 GRT operating statistics showing annual and average weekday ridership for all GRT routes. Evidence from other cities indicates that higher-order transit services (e.g., BRT and LRT) are better utilized throughout the day and hence may warrant higher ridership levels. However, in line with current GRT statistics, an AM to daily expansion factor of 10 and a daily to annual factor of 300 was assumed for BRT and LRT.

The table above provides a summary of the AM, daily and annual boarding estimates for the BRT and LRT scenarios. In 2011, BRT daily boardings are estimated at 10,600 increasing to 23,000 by 2041. For LRT, 2011 daily boardings are estimated at 11,800 increasing to 30,900 by 2041.

As a point of comparison, the Edmonton LRT system (track length 12.5 km and 10 stations and service population of 0.66 m) similar to what is proposed in Waterloo (track length of approximately 15 km and 11 stations) reported 36,000 daily boardings. By 2041, the Waterloo transit system and service population assumptions would be similar to Edmonton. Portland, Oregon, a much larger city (1.25 m service population) and LRT system (60 km and 55 stations)
can be used to compare daily boards per station and daily boards per track kilometre. The Portland LRT system reports 80,000 daily boardings or 1,300 boards per km and 1,500 boards per station. For the Waterloo LRT line, boards per km are estimated at between 800 and 2,100 (2011 to 2041), while boards per station are estimated at between 1,100 and 2,800 (2011 to 2041).

As a final note on the 2004 ridership forecasting, increased parking charges and implementation of a UPASS (for university students) would have a positive impact on transit ridership. If parking charges were doubled at downtown locations and in large business parks (e.g. University and R&T Park), transit ridership could increase by approximately 5%. Introducing parking charges within the vicinity of all rapid transit stations as well as doubling charges at existing locations could result in approximately a 10% increase in ridership. Furthermore, based on evidence from other cities, UPASS programs have generated up to a 50% increase in transit usage by university students. UPASS could increase overall transit ridership by 5%. Therefore, the combination of a parking management strategy and UPASS could increase transit ridership by 10-15% throughout the CTC.

5.3.4.2. 2006-2008 MODEL DEVELOPMENT

The environmental assessment (EA) study for rapid transit service in Waterloo Region commenced in 2006. As a part of the Phase 2 evaluation of Route and Technology Alternatives, an AM peak hour ridership model was developed by Halcrow Consulting Inc. using TransCAD model software. While the original CTC model provides reasonable traffic and transit ridership forecasts at the regional and screenline level, updates and further refinements were required to support the more detailed forecasting requirements of the EA study. The exercise involved updating previously applied model parameters and data sets, testing the new model for integrity and accuracy, preparing model inputs for the BAU and rapid transit scenarios, modifying the feeder bus networks, adding park and ride lot interface to encourage transferring to rapid transit, and summarizing the ridership forecasts and relevant model outputs for input to the proposed economic analysis (using the Multiple Accounts Evaluation framework). More detail on this work can be found in the report “Waterloo Rapid Transit – Individual EA Study Phase 2 Step 3 Rapid Transit Ridership Forecasts, Halcrow Consulting Inc., March 2009”.

The traffic zone system, population and employment data, auto and transit user costs, road and transit networks, and ridership forecasts are briefly described below:

Traffic Zones: The 2004 traffic zone system (567 internal zones and 21 connectors) was expanded slightly to add 9 new zones in the CTC (for a total of 576) that would better refine the ridership forecasting. The 21 external boundary connections remained intact. The study area for the EA was somewhat larger than the previous CTC area and was subdivided into 7 “segments” for purpose of the Phase 2 Step 2 evaluation. The segment areas are illustrated in the map (below):

<table>
<thead>
<tr>
<th>Segment Area</th>
<th>Population Data (2006-2008 Model) – Intensified Land Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment 1</td>
<td>33,430, 37,264, 49,274, 1.4%, 1.7%</td>
</tr>
<tr>
<td>Segment 2</td>
<td>24,972, 29,536, 39,952, 2.1%, 1.8%</td>
</tr>
<tr>
<td>Segment 3</td>
<td>23,876, 25,627, 31,122, 0.9%, 1.1%</td>
</tr>
<tr>
<td>Segment 4</td>
<td>9,383, 10,628, 12,521, 1.6%, 1.0%</td>
</tr>
<tr>
<td>Segment 5</td>
<td>14,794, 15,647, 16,718, 0.7%, 0.4%</td>
</tr>
<tr>
<td>Segment 6</td>
<td>6,389, 7,918, 12,425, 2.7%, 2.7%</td>
</tr>
<tr>
<td>Segment 7</td>
<td>14,863, 15,986, 17,625, 0.9%, 0.6%</td>
</tr>
<tr>
<td>All Seg. Areas</td>
<td>127,708, 142,605, 179,637, 1.4%, 1.4%</td>
</tr>
</tbody>
</table>

Connections between the traffic zones and the road / transit network (i.e. centroid connectors) were improved in the Segment areas to ensure that there are reasonable walking distances to the rapid transit stations. This would encourage more walk trips for zones close to the stations and thereby increase the ridership potential in these areas.

Population and Employment Data: Key inputs to the EA ridership forecasting exercise are current and future year demographics by traffic zone. These inputs include population by age category, employment by type, secondary and post secondary enrolment and housing location data. This information was used to develop the traffic zone level inputs for the base year and future horizons. The Province’s Places to Grow Growth Plan for the Greater Golden Horseshoe Area has identified three urban growth centres in Waterloo Region with potential for future intensification. Targets were established for Waterloo Region of 729,000 population by 2031 which would generate approximately 365,000 jobs associated with this population level. Note: in 2006, Regional population was 509,000 with 260,000 employees. Segment population levels are shown in Table 7.17 confirming the growth in all seven Segment areas – about 52,000 new residents between 2006 and 2031. This accounts for 23% of the population growth in this period for the entire Region.
Table 5.18 – Employment Data (2006-2008 Model) – Intensified Land Use

<table>
<thead>
<tr>
<th>Segment Area</th>
<th>Employment</th>
<th>Annual Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2006</td>
<td>2006-2014</td>
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<tr>
<td></td>
<td>Intensified</td>
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<tr>
<td>Total</td>
<td>48,903</td>
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<tr>
<td></td>
<td>1.3%</td>
<td>0.9%</td>
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<tr>
<td></td>
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<td>3.5%</td>
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<tr>
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<td>6,575</td>
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<td></td>
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<td>1.3%</td>
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<td></td>
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<td>3.5%</td>
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<tr>
<td>All Seg. Areas</td>
<td>136,968</td>
<td>152,400</td>
</tr>
<tr>
<td></td>
<td>1.3%</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

Rapid transit would be the catalyst to ensure growth occurs in the CTC especially around rapid transit stations.

MGI Consultants developed population and employment forecasts within 600 m of stations (Table 5.19). Two growth scenarios were identified: 1) full intensification (LRT) with development occurring around the rapid transit stations, and 2) a lower level of intensification (BAU) that would not include rapid transit; more in line with expanding the conventional bus service including IrExpress.

Table 5.19 – Employment Data by Station Area (2006-2008 Model): Intensified Land Use vs. BAU Land Use

<table>
<thead>
<tr>
<th>Segment Area</th>
<th>Employment Data (2006-2008 Model): Intensified Land Use vs. BAU Land Use</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

Population is shown to increase (2006-2031) around rapid transit stations by 32,000 residents for the intensified land use scenario and 10,000 residents for the BAU. The BAU reflects a lower market share due to limiting new transit infrastructure. Employment is forecast to rise by 35,000 employees between 2006 and 2031 for the intensified land use, while the BAU would only gain 18,000 new jobs. By 2031, station area development will accommodate 1/3 of the employment growth (intensified land use) across the Region.
The two LRT and two BRT routes had different operating speeds based on analysis conducted by Halcrow (see March, 2009 report – Tables 8-11 on pp13-16). Summary operating statistics for the uni-directional line are provided below:

- **LRT 1A (Waterloo Spurline)**: route length – 36.6 km; total running time - 78.1 minutes, average speed – 28 km/h
- **LRT 1C (King Street)**: route length – 35.6 km; total running time - 80.6 minutes, average speed – 27 km/h
- **BRT 2A (Waterloo Spurline)**: route length – 35.7 km; total running time – 78.9 minutes, average speed – 27 km/h
- **BRT 2C (King Street)**: route length – 34.7 km; total running time – 80.8 minutes, average speed – 26 km/h

The operating speeds do not vary by time horizon since the dedicated RoW would protect rapid transit from most congestion effects.

The iXpress is a limited stop express bus service that has been operational in the CTC since September, 2005. It runs from Conestoga Mall in the North to Ainslie bus terminal in downtown Cambridge in the South as seen in the map below.

It serves major centres such as McCormick arena, UoFW, WLU, Grand River Hospital and all three downtowns. Travel time assumptions for iXpress were developed by Halcrow Consulting to reflect auto congestion in mixed traffic in future years. This service is integral to the BAU scenario. It was recognized that total vehicle-hours traveled on the road network would increase in the future with more intensified development in the CTC and rising road congestion. Congestion delays on road links where the iXpress runs were estimated using the Regional travel model for years 2014 and 2031. The iXpress running time and average speed for the uni-directional route with 14 stations are summarized below:

- **iXpress (2014):** northbound route length – 39.3 km; total running time - 95.9 minutes, average speed – 25 km/h
- **southbound route length – 36.3 km; running time – 91.8 minutes; average speed – 24 km/h**
- **iXpress (2031):** northbound route length – 39.3 km; total running time - 104.9 minutes, average speed – 22 km/h
- **southbound route length – 36.3 km; running time – 100.3 minutes; average speed – 22 km/h**

In addition to the planned rapid transit line, there will be changes to the conventional bus routings across the transit network called feeder bus routes (see map below).

Routes and bus stop locations vary by scenario depending on where there is a rapid transit station to serve. Generally speaking, feeder bus routes are shorter enabling the buses to provide more direct and frequent service to the outlying communities. Some existing bus routes were altered to better connect with rapid transit stations while some were eliminated due to service duplication with the planned rapid transit alignment. The eliminated routes include routes 7 and iXpress. Note: one route remains on King Street to serve local bus stops. Feeder bus headway ranges from 12 minute service for all routes in 2014 and 10 minutes in 2031.

Park and Ride facilities: a new addition to the 2006 travel model, i.e. park and ride (P&R) trips were estimated for all route / technology alternatives but not the BAU. With the exception of the Northfield Drive P&R, all rapid transit scenarios had identical park and ride facilities. Five locations were selected for analyzing P&R demand as illustrated in the map below:

- Northfield Drive / Weber Street North area, Waterloo
- Conestoga Mall, North Waterloo
- Fairview Park Mall, Kitchener
- Sportsworld, South Kitchener
- Bridgecam Power Centre, Cambridge
- Downtown (Galt core), Cambridge
The P&R facility at Northfield Drive was not assumed for either King Street routings (LRT or BRT). All P&R lots were assumed to have 200 stalls although demand may not warrant this capacity.

Staging Options were developed as part of the Multiple Accounts Evaluation. The Staging Options are combinations of LRT and BRT technologies with LRT operating from St. Jacobs Farmers Market to Fairview Park Mall and connecting with BRT for the remaining trip to Cambridge. Two forms of BRT were identified for Cambridge – BRT: using bus bypass shoulders on Highway 8 and Highway 401 and dedicated BRT RoW along Hespeler Road / Water Street, and Adapted BRT (aBRT): bus bypass shoulders on Highway 8 and Highway 401 and a mix of queue jump lanes and bus priority using regular traffic lanes on Hespeler Road / Water Street. In the first case, BRT running in a dedicated RoW would not be affected by road congestion. For the second case, traffic congestion would influence the bus running speed in Cambridge.

- Staging Option 1: LRT (Waterloo Spurline): route length – 18.5 km; total running time - 43.1 minutes, average speed – 28 km/h ; BRT (south of Fairview Mall): route length – 17.25 km; total running time – 33.3 minutes, average speed – 32 km/h; Total running time (LRT and BRT) – 76.4 minutes.
- Staging Option 2: LRT (Waterloo Spurline): route length – 18.5 km; total running time - 43.1 minutes, average speed – 28 km/h ; Adapted BRT (south of Fairview Mall): route length – 17.25 km; total running time – 33.3 to 47 minutes, average speed – 22 to 32 km/h; Total running time (LRT and BRT) – 76.4 to 90.1 minutes.

For the Staging Options, the rapid transit headway would be 7.5 minutes (2014) and 5 minutes by 2031.

Ridership Forecasts: Based on the above-noted assumptions and parameter values used in the Regional travel model, ridership forecasts were developed for the six route / technology systems and two time scenarios, 2014 and 2031. The scenarios were defined by MKI Consultants to support the Multiple Accounts Evaluation requirements. The following data were taken from the travel model for use in the MAE. They are described below:

--

### Table 5.20 – 2014 Ridership Projections (2006-2008 Model)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>BAU</th>
<th>LRT Spur</th>
<th>LRT Ring</th>
<th>BRT Spur</th>
<th>BRT Ring</th>
<th>Staging Option 1</th>
<th>Staging Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Level</td>
<td>LRT6A</td>
<td>LRT6A</td>
<td>LRT6A</td>
<td>LRT6A</td>
<td>LRT6A</td>
<td>LRT6A</td>
<td>LRT6A</td>
</tr>
<tr>
<td>Rapid Transit Method</td>
<td>Express</td>
<td>LRT</td>
<td>LRT</td>
<td>BRT</td>
<td>BRT</td>
<td>BRT</td>
<td>BRT</td>
</tr>
<tr>
<td>AM Peak Hour Boardings</td>
<td>1,520</td>
<td>3,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>BRT Headway (min)</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Daily Ridership</td>
<td>11,200</td>
<td>21,000</td>
<td>21,000</td>
<td>21,000</td>
<td>21,000</td>
<td>21,000</td>
<td>21,000</td>
</tr>
<tr>
<td>AM Peak</td>
<td>3.4</td>
<td>5.3</td>
<td>8.0</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

---

1. **Rapid transit ridership:** System ridership on a daily basis for each route / technology system alternative.
2. **Vehicle-kilometres travelled:** Total auto trips on the regional road network multiplied by the average trip length.
3. **Criteria Pollutants and GHG emissions:** Broken down into the various noxious gases emitted from automobiles and transit vehicles. Calculated from Regional AM model based on number of auto trips and vehicle kilometres travelled. Bus trips and kilometres travelled were determined from the travel model.
4. **Travel time savings:** Single occupant vehicles and transit vehicles were treated separately. For autos, vehicle-hours travelled between an origin – destination pair (i.e. # trips x travel time) is calculated and compared between the route-technology scenario and BAU. Fewer auto trips or lower trip time translates into travel time savings for the auto mode. For transit, (trip and time) by transit between each origin and destination are calculated for the rapid transit scenario and BAU and then translated into travel time savings.

Model runs were prepared for the various route / technology systems identified above. The results (2014 and 2031) are shown below for AM peak system ridership and the maximum load point volume as well as the assumed headway. Daily and annual ridership numbers were calculated by using an expansion factor of 10 (for daily) and converting to annual ridership by an expansion factor of 300. It should be noted that the intensified land use (LRT1A) was used throughout the evaluation.

---

### Ridership Option 1

- **AM Peak Boardings:** 1,520
- **BRT Headway:** 2.5 minutes
- **Daily Ridership:** 11,200
- **AM Peak:** 3.4

### Ridership Option 2

- **AM Peak Boardings:** 1,520
- **BRT Headway:** 2.5 minutes
- **Daily Ridership:** 11,200
- **AM Peak:** 3.4

---

### Figure 5.18 – Ridership System Ridership Projections

- **MAE Indicators:**
  - Total AM peak boardings (per hour)
  - Vehicle-kilometres travelled (VKT): Auto / Only
  - Criteria pollutants (annual)
  - CO
  - VOC
  - NOx
  - SOx
  - PM10

- **CO2e (tonne):**
- **Greenhouse Gas Emissions (tonne):**
- **Value of Time:** $1.5/Min
Table 5.21 – 2031 Ridership Projections (2006-2008 Model)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>CMP</th>
<th>LRT</th>
<th>LRT</th>
<th>BRT</th>
<th>LRT</th>
<th>BRT</th>
<th>LRT</th>
<th>BRT</th>
<th>LRT</th>
<th>BRT</th>
<th>LRT</th>
<th>BRT</th>
<th>LRT</th>
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<tbody>
<tr>
<td>Horizon Year</td>
<td>2021</td>
<td>2025</td>
<td>2031</td>
<td>2021</td>
<td>2025</td>
<td>2031</td>
<td>2021</td>
<td>2025</td>
<td>2031</td>
<td>2021</td>
<td>2025</td>
<td>2031</td>
<td>2021</td>
<td>2025</td>
</tr>
<tr>
<td>Rapid Transit Method</td>
<td>LRT</td>
<td>LRT</td>
<td>LRT</td>
<td>LRT</td>
<td>LRT</td>
<td>LRT</td>
<td>LRT</td>
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<td>LRT</td>
<td>LRT</td>
<td>LRT</td>
<td>LRT</td>
<td>LRT</td>
<td>LRT</td>
</tr>
<tr>
<td>AM PM Peak Boardings</td>
<td>1,200</td>
<td>2,600</td>
<td>2,900</td>
<td>5,000</td>
<td>5,900</td>
<td>7,100</td>
<td>1,120</td>
<td>2,600</td>
<td>2,900</td>
<td>4,800</td>
<td>5,900</td>
<td>7,100</td>
<td>1,200</td>
<td>2,600</td>
</tr>
<tr>
<td>Network Line Load</td>
<td>0.6</td>
<td>0.8</td>
<td>1.1</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td>RT Mode Share (%)</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
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<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Daily Ridership</td>
<td>19,000</td>
<td>63,800</td>
<td>59,000</td>
<td>93,800</td>
<td>92,600</td>
<td>127,200</td>
<td>16,600</td>
<td>63,800</td>
<td>59,000</td>
<td>93,800</td>
<td>92,600</td>
<td>127,200</td>
<td>16,600</td>
<td>63,800</td>
</tr>
<tr>
<td>Annual (M)</td>
<td>5.8</td>
<td>18.2</td>
<td>18.0</td>
<td>16.7</td>
<td>16.8</td>
<td>5.2</td>
<td>14.9</td>
<td>17.6</td>
<td>4.5</td>
<td>14.4</td>
<td>16.8</td>
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<td></td>
</tr>
</tbody>
</table>

The results of the ridership analyses were:

- LRT (King Street or Waterloo Spur) ridership is 15% higher than BRT due to shorter trip time, increased accessibility and modal preference towards LRT technology as determined by the Stated Preference Survey conducted in 2005.
- LRT ridership rises from 31,000 to 64,000 between 2014-2031. This is mainly due to increased intensification around stations and lower rapid transit and feeder bus headway in the latter period. Another factor is the parking increases that were introduced into the model for the 2031 horizon.
- The Staging Options gain substantial ridership in the 2014-2031 period; higher than that reported for BRT. This is due to the higher intensification levels associated with LRT in the north part of the CTC.

Peak hour rapid transit line volumes (passengers per hour per direction) are shown in the map above for the 2031 horizon year – i.e. assuming LRT is used throughout the entire 38 km corridor. These are the highest line volumes of all the scenarios tested. As shown, the area of maximum ridership is between Victoria and Grand River Hospital stations in Kitchener where the line volume exceeds 2600 passengers. This would require 18 LRVs to accommodate the peak demand loads by 2031. With a five minute headway and two car trains, the LRT line capacity is ample enough to accommodate the forecast demand. However, for a BRT system, the maximum load of 2200 passengers per direction by 2031 would require 25-30 buses with a much lower headway of about 2-2.5 minutes. This reduced headway raises questions about BRT capacity and whether there is sufficient reserve for future ridership growth in the north part of the corridor when using a BRT based system. Note: in Cambridge, the maximum loads are much lower (about 800 pphpd in the Preston area) and LRT capacity would be underutilized. For example, a single LRV running at 10 minute frequency would only be needed to satisfy the Cambridge ridership forecast. Loads in Cambridge are strong in both directions which attest to the benefits of the rapid transit route serving all three urban centres.

Stations boardings / lightings (AM peak hour – 2031) are shown below for the LRT Waterloo Spurline route between North Waterloo and downtown Cambridge.

Table 5.22 – Station Boards / Alights for the 2031 AM Peak hour (2006-2008 Model)

<table>
<thead>
<tr>
<th>Station Activity</th>
<th>Boards</th>
<th>Alights</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ainslie GRT Terminal</td>
<td>519</td>
<td>264</td>
</tr>
<tr>
<td>2. Waterloo / Hespeler Road</td>
<td>41</td>
<td>45</td>
</tr>
<tr>
<td>3. Conestoga Mall</td>
<td>130</td>
<td>87</td>
</tr>
<tr>
<td>4. Conestoga Mall</td>
<td>130</td>
<td>87</td>
</tr>
<tr>
<td>5. Conestoga Mall</td>
<td>130</td>
<td>87</td>
</tr>
<tr>
<td>6. CPR Line / Preston Corridor</td>
<td>232</td>
<td>244</td>
</tr>
<tr>
<td>7. CPR Line / Preston Corridor</td>
<td>232</td>
<td>244</td>
</tr>
<tr>
<td>8. CPR Line / Preston Corridor</td>
<td>232</td>
<td>244</td>
</tr>
<tr>
<td>9. Fairview Park Mall</td>
<td>253</td>
<td>316</td>
</tr>
<tr>
<td>10. Courtland / Hespeler Road</td>
<td>1,219</td>
<td>1,219</td>
</tr>
<tr>
<td>11. Ottawa / Charles Street</td>
<td>393</td>
<td>130</td>
</tr>
<tr>
<td>12. Kitchener West</td>
<td>345</td>
<td>305</td>
</tr>
<tr>
<td>13. Downtown Kitchener</td>
<td>454</td>
<td>365</td>
</tr>
<tr>
<td>14. Victoria Village</td>
<td>392</td>
<td>257</td>
</tr>
<tr>
<td>15. Grand River Hospital</td>
<td>216</td>
<td>514</td>
</tr>
<tr>
<td>16. Hespeler Road</td>
<td>267</td>
<td>965</td>
</tr>
<tr>
<td>17. M Line / Waterloo</td>
<td>216</td>
<td>116</td>
</tr>
<tr>
<td>18. CPR Line</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>19. Kitchener West</td>
<td>248</td>
<td>291</td>
</tr>
<tr>
<td>20. Conestoga Mall</td>
<td>126</td>
<td>215</td>
</tr>
<tr>
<td>21. Conestoga Mall</td>
<td>126</td>
<td>215</td>
</tr>
<tr>
<td>Total</td>
<td>3,356</td>
<td>3,356</td>
</tr>
</tbody>
</table>

Stations with the strongest ridership potential for this horizon year are Ainslie GRT Terminal, Bridgemark (Pinebush / Hespeler Road), Fairview Park Mall, Courtland / Block Line Road, Ottawa / Charles Street, Kitchener Market, Downtown Kitchener, Grand River Hospital, Uptown Waterloo, U of W, R&T Park. Station demand in all three downtowns display heavy ridership demand pointing to the effectiveness of linking the three urban cores with rapid transit. Major retailing areas with high ridership include Bridgemark, Fairview Mall, Kitchener Market. Although Conestoga Mall comes in with lower ridership, this is largely due to the AM peak ridership model which does not forecast shopping trips. The lowest ridership activity occurs at Water / Samuelson (Galt Collegiate), CPR line / Fountain Street, St. Jacob's Farmer's Market.

The Multiple Account Evaluation (MAE) that was adopted for the Phase 2 Step 3 economic analysis of rapid transit system alternatives considers a variety of quantitative and qualitative measures. Some of the data used in the “Transportation” account of the MAE is generated from the Regional ridership forecasting model as illustrated in the...
tables on the next page. The travel data include rapid transit daily ridership and line running time, auto and transit vehicle-kilometres, auto vehicle-hours and average speed, average auto and transit trip length and time. Emission data for the “Environmental” account include critical gas pollutants and various greenhouse gases. Travel time savings used in the “Economic” account include time saved (in minutes) by using transit rather than automobile and the annual monetary benefits (in $ million) gained from time savings. The calculation of travel time savings follows the “Consumer Surplus” approach in which every trip origin and destination is accounted for in time saved by implementing rapid transit within the CTC as opposed to “Business As Usual” or the BAU scenario. With less congestion on the road network, the rapid transit scenario will save time for both auto and transit users.
### Table 5.23 – Regional Ridership Forecasting Model (Transportation and Environmental) Measures (2007 – 2008 Model)

<table>
<thead>
<tr>
<th>BAU_2</th>
<th>LRT 1A</th>
<th>LRT 1C</th>
<th>BRT 2A</th>
<th>BRT 2C</th>
<th>Staged w/BRT</th>
<th>BAU_2</th>
<th>LRT 1A</th>
<th>LRT 1C</th>
<th>BRT 2A</th>
<th>BRT 2C</th>
<th>Staged w/BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total RT daily boardings</td>
<td>11,200</td>
<td>31,000</td>
<td>30,000</td>
<td>26,200</td>
<td>26,300</td>
<td>21,900</td>
<td>19,800</td>
<td>63,900</td>
<td>59,900</td>
<td>55,600</td>
<td>52,600</td>
</tr>
<tr>
<td>Total RT travel time (min)</td>
<td>93.8</td>
<td>78.1</td>
<td>80.6</td>
<td>78.9</td>
<td>80.8</td>
<td>75.4</td>
<td>102.6</td>
<td>78.1</td>
<td>80.6</td>
<td>78.9</td>
<td>80.8</td>
</tr>
<tr>
<td>Total RT trip length (min)</td>
<td>37.8</td>
<td>36.6</td>
<td>35.6</td>
<td>35.7</td>
<td>34.8</td>
<td>35.7</td>
<td>37.8</td>
<td>36.6</td>
<td>35.6</td>
<td>35.7</td>
<td>34.8</td>
</tr>
<tr>
<td>Average RT travel speed (kph)</td>
<td>24.2</td>
<td>28.1</td>
<td>26.5</td>
<td>27.2</td>
<td>25.8</td>
<td>28.4</td>
<td>22.1</td>
<td>28.1</td>
<td>26.5</td>
<td>27.2</td>
<td>25.8</td>
</tr>
<tr>
<td>Number of auto trips converted to transit/bike/walk**</td>
<td>NA</td>
<td>770</td>
<td>580</td>
<td>560</td>
<td>420</td>
<td>540</td>
<td>NA</td>
<td>1690</td>
<td>1350</td>
<td>1320</td>
<td>1060</td>
</tr>
<tr>
<td>Vehicle kilometer travelled - Auto Only</td>
<td>1,210,670</td>
<td>1,210,240</td>
<td>1,521,230</td>
<td>1,508,230</td>
<td>1,510,640</td>
<td>1,510,520</td>
<td>1,512,130</td>
<td>1,510,440</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle kilometer travelled - Transit Only</td>
<td>5,430</td>
<td>4,790</td>
<td>4,720</td>
<td>5,390</td>
<td>5,350</td>
<td>5,240</td>
<td>5,780</td>
<td>5,240</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average transit in-veh travel time - All Trips (min)</td>
<td>18.0</td>
<td>19.1</td>
<td>19.2</td>
<td>19.0</td>
<td>19.3</td>
<td>19.2</td>
<td>18.3</td>
<td>19.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average transit trip length - All trips (km)</td>
<td>6.4</td>
<td>7.0</td>
<td>6.9</td>
<td>6.9</td>
<td>7.1</td>
<td>6.9</td>
<td>6.8</td>
<td>7.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average transit in-veh speed - All Trips (kph)</td>
<td>21.3</td>
<td>22.0</td>
<td>21.5</td>
<td>21.8</td>
<td>22.0</td>
<td>21.5</td>
<td>22.0</td>
<td>21.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average transit weighted travel cost - All Trips (min)</td>
<td>56.4</td>
<td>56.9</td>
<td>57.0</td>
<td>57.0</td>
<td>57.2</td>
<td>57.0</td>
<td>56.5</td>
<td>57.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Auto Travel Time - All trips (min)</td>
<td>11.2</td>
<td>11.2</td>
<td>11.2</td>
<td>11.2</td>
<td>11.2</td>
<td>11.2</td>
<td>11.2</td>
<td>11.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Auto Trip Length - All trips (km)</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
<td>7.9</td>
<td>7.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Auto Speed - All Trips (kph)</td>
<td>42.0</td>
<td>41.9</td>
<td>41.8</td>
<td>41.8</td>
<td>41.8</td>
<td>41.8</td>
<td>41.7</td>
<td>41.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 5.24 – Consumer Surplus Method of Travel Time Savings (2007-2008 Model)

<table>
<thead>
<tr>
<th>Test Scenario</th>
<th>LRT1A</th>
<th>LRT1C</th>
<th>BRT2A</th>
<th>BRT2C</th>
<th>Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM Benefits (min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOV</td>
<td>-3,688</td>
<td>-10,057</td>
<td>-11,651</td>
<td>-16,510</td>
<td>-11,182</td>
</tr>
<tr>
<td>HOV</td>
<td>-666</td>
<td>-1,812</td>
<td>-2,100</td>
<td>-2,975</td>
<td>-2,015</td>
</tr>
<tr>
<td>Transit</td>
<td>46,587</td>
<td>33,407</td>
<td>35,855</td>
<td>26,040</td>
<td>36,130</td>
</tr>
<tr>
<td>Total</td>
<td>42,234</td>
<td>21,537</td>
<td>22,104</td>
<td>6,555</td>
<td>22,933</td>
</tr>
</tbody>
</table>

### Table 5.25 – Consumer Surplus Method of Travel Time Savings (2007-2008 Model)

<table>
<thead>
<tr>
<th>Test Scenario</th>
<th>LRT1A</th>
<th>LRT1C</th>
<th>LRT1A</th>
<th>LRT1C</th>
<th>Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM Benefits (min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOV</td>
<td>-51.8</td>
<td>-5.2</td>
<td>-5.0</td>
<td>-8.5</td>
<td>-5.8</td>
</tr>
<tr>
<td>HOV</td>
<td>-0.4</td>
<td>-0.1</td>
<td>-1.1</td>
<td>-1.6</td>
<td>-1.1</td>
</tr>
<tr>
<td>Transit</td>
<td>24.0</td>
<td>11.3</td>
<td>18.5</td>
<td>13.4</td>
<td>18.6</td>
</tr>
<tr>
<td>Total</td>
<td>21.7</td>
<td>11.3</td>
<td>3.3</td>
<td>11.8</td>
<td></td>
</tr>
</tbody>
</table>
5.3.5 FUNCTIONAL DESIGN

As part of Phase 2 Step 3 of the IEA process, functional design plans, select profiles and typical cross-sections were prepared for the short-listed BRT and LRT system alternatives. These system alternatives are shown in Figure 5-7 and Figure 5-8.

Functional design plans identified the general impact of proposed route alternatives on adjacent properties and detailed the integration of the rapid transit system into the existing railway corridor and road network. Refer to Appendix B1 for the Phase 2 Step 3 functional design plans and typical cross sections.

Design Criteria

The basic design criteria adopted for the planning and design of the facilities for both LRT and BRT technologies are outlined below. The design aimed to provide alignments which reduce sags, crests and directional changes to a minimum, consistent with sound design principles, including consideration of:

**Safety**
- Sight distance and visibility (for train operators, other vehicle drivers, cyclists and pedestrians)
- Passenger comfort
- Impact on at-grade crossings
- Adjacent roadways and railways
- Vehicle performance
- Impact on adjacent property
- Intended operating and service plan
- Underground and overhead utilities
- Horizontal and vertical clearances
- Cost-effectiveness

**Technology**

Light Rail Transit: LRT is a flexible, rail-based transit mode that can operate in a variety of urban RoW settings. This technology is electrically propelled, commonly obtaining power from overhead catenary wires and can provide a broad range of passenger capacities due to its ability to use coupled vehicles.

The overhead power supply feature allows LRT systems to interface safely with other at-grade transportation modes and with pedestrians. Vehicles are generally bidirectional, low-floor and articulated with multiple doors on both sides. LRT has the ability to be placed into built-up urban areas and is designed to integrate with vehicular and pedestrian traffic. Passengers access the service as they would to a BRT service by walking or cycling to the stations, transferring from feeder buses and by using park and ride facilities where provided. In addition, some trips could be made without a transfer. Table 5.25 provides a summary of the LRT geometric design criteria used for the functional design.

<table>
<thead>
<tr>
<th>Item</th>
<th>Preferred Criteria</th>
<th>Restricting Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design Speed</td>
<td>90 km/h (55 mph) on dedicated RoW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 km/h (30 mph) within city streets</td>
</tr>
<tr>
<td>2</td>
<td>Design Train Consist</td>
<td>A 2 car married pair, 20 metres long, 2.8 metres wide and 5.0 metres high</td>
</tr>
<tr>
<td>3</td>
<td>Traffic Control Method</td>
<td>TBD (Minimum signals required for Safety)</td>
</tr>
<tr>
<td>4</td>
<td>Maximum Permissible Axle Load</td>
<td>TBD</td>
</tr>
<tr>
<td>5</td>
<td>Track Gradient</td>
<td>Maximum grade of 6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum compensated gradient of 3.5%</td>
</tr>
<tr>
<td>6</td>
<td>Grade Compensation</td>
<td>0.04% per Degree of Curve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Per AREMA Chapter 5 Section 3.7</td>
</tr>
<tr>
<td>7</td>
<td>Gauge</td>
<td>V= 1.435 metres (4'-8 ½&quot;)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gauge widening where required in accordance with AREMA Chapter 5</td>
</tr>
<tr>
<td>8</td>
<td>Superelevation (Cant)</td>
<td>Ea= 0.0116*V^2/R where:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ea= actual superelevation applied</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V is in km/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R is in metres</td>
</tr>
<tr>
<td>9</td>
<td>Maximum Superelevation (Cant)</td>
<td>124 mm (4.5&quot;) Design</td>
</tr>
<tr>
<td>10</td>
<td>Maximum Unbalance (Cant Deficiency)</td>
<td>Eu = 75 mm Passenger</td>
</tr>
<tr>
<td>11</td>
<td>Track Horizontal Curvature</td>
<td>250 metre or larger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-metre minimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-metre desirable minimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15-metre absolute minimum</td>
</tr>
<tr>
<td>12</td>
<td>Track Vertical Curvature</td>
<td>L = (D/V*K)/A where:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L = length of Vertical Curve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D = Absolute change in grade</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V = Speed of Trains in km/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>K = Conversion factor for L in metres = 0.0772</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A = Vertical acceleration (metres per second)^2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Set A equal to 0.03046 per AREMA Chapter 5 Section 3.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LVC = 30.0 m (100') Min.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimum distance between vertical curves shall be 30.0 metre (100')</td>
</tr>
<tr>
<td>13</td>
<td>Vertical Clearance</td>
<td>TBD</td>
</tr>
</tbody>
</table>
Table 5.26 – BRT Design Criteria

<table>
<thead>
<tr>
<th>Location</th>
<th>Design Speed</th>
<th>Horizontal Curve Min. Radius</th>
<th>Vertical Alignment</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km/hr</td>
<td>metre</td>
<td>Crest K Min.</td>
<td>Sag K Max.</td>
</tr>
<tr>
<td>Mainline Busway</td>
<td>90</td>
<td>340</td>
<td>65</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 % rural</td>
<td>3 %</td>
</tr>
<tr>
<td>Busway in Node Areas (1)</td>
<td>60</td>
<td>130</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.5 % urban</td>
<td>3 %</td>
</tr>
<tr>
<td>Busway in Station Areas</td>
<td>60</td>
<td>130</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.35 % urban</td>
<td>0.5 %</td>
</tr>
<tr>
<td>Arterial ramps and Access Roads</td>
<td>40</td>
<td>55</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 %</td>
<td>10 %</td>
</tr>
</tbody>
</table>

(1) Busway with pedestrian sidewalks or in arterial median.
(2) This may be reduced to as low as 90 metres where constraints dictate.

**Bus Rapid Transit:** Can operate in a variety of right-of-way settings and has the flexibility to enter and exit a rapid transit RoW and therefore offer the opportunity to link certain feeder and other express bus services to reduce the need for passengers to transfer. In the early stages of the rapid transit system development, BRT services are recommended from Fairview Park Mall to Downtown Cambridge operating in mixed traffic together with geometric and operational improvements to avoid congested areas.

The typical BRT operating configuration consists of a high frequency service running the full length of the corridor and stopping at each station. It provides a service not unlike that of LRT except the vehicle used is rubber tired (can be articulated for greater capacity). Table 5.26 summarizes the BRT design criteria used for the functional design. These criteria have been developed with possible future conversion to LRT in mind.
Beyond the barrier curb is an inner boulevard a sidewalk and an outer boulevard. The width of these elements is dependent on the width of the RoW.

The 4-lane and 6-lane variants of the preferred section include the same rapid transit corridor in the center of the roadway and the same outer boulevard / sidewalk elements bordering the outer portions of the roadway. Differences are in the lane configurations.

The preferred lane width used throughout the functional design drawings is 3.65 m where the lane is adjacent to another lane. 3.5 m has been used where space is limited and dedicated turn lanes are proposed at 3.0 m.
Figure 5-13 – Two Lane Typical Section
Figure 5-14 – Four Lane Typical Section
Figure 5-15 – Six Lane Typical Section
Curb side Rapid Transit:
The curbside configuration is proposed for loop scenarios in Uptown Waterloo and Downtown Kitchener. The corresponding rapid transit corridor is narrower than that of the center running configuration. Typically, the curbside rapid transit corridor is 4.0 m wide and is level with the adjacent roadway surface to enable crossing of the corridor and access to driveways along the same side of the street.

It is proposed that some means of visual delineation between the rapid transit corridor and adjacent lanes be used. This can be accomplished in a number of ways such as simply as painted lines to as robust as textured, coloured concrete separating the corridors.

Horizontal and Vertical Alignment
The proposed rapid transit corridor comprises of relatively straight roads. For rapid transit design, the horizontal alignment conforms to minimum LRT and BRT standards as much as the situation permits. The final roadway design is to conform to the existing posted speeds ranging from 50 km/h to 80 km/h and is to be in accordance with the Geometric Design Manual for Ontario Highways. At specific locations, new tangents and horizontal curves are also incorporated to shift the existing alignment to minimize the impacts on properties.

Vertical alignment generally follows the profile of the existing roadways. In order to obtain good ride quality and the required service speeds for rapid transit, a best-fit vertical profile will be considered during preliminary design to achieve a smooth profile for the rapid transit lanes.

Pavement Widening
Wherever possible, RoW widening or impact on private properties including parking has been minimized. However, additional pavement width is required in certain locations to incorporate the rapid transit lanes. The additional pavement will require widening of the curb lines and some local RoW widening. It is anticipated that complete reconstruction of the cross-section may also be required (to be confirmed during preliminary design) at some locations.

Intersections
During preliminary design, specific signalized intersections will be improved to allow U-turns with signal protection. However, it is anticipated that most heavy vehicles would adopt an alternative routing to reach destinations to avoid making U-turns. Unsignalized intersections have been designed to maintain existing turning radii with these intersections becoming right-in / right-out with the introduction of the median rapid transit lanes. Property may be acquired as part of the rapid transit improvements to provide for adequate day-lighting triangles for all intersections.

Structures
A number of road, rail and water crossing structures along the rapid transit route alternatives have been identified for widening and/or replacement to accommodate the proposed rapid transit lanes. Cost estimates for these improvements have been developed at a functional level. Comprehensive structural analyses and design work will be addressed during the preliminary and detail design phases.

Stations
Stations will be normally unattended and their design will stress passenger safety, convenience, comfort, low maintenance and accessibility. Station locations and layouts will facilitate convenient transfer between the rapid transit service and local GRT services as well as to any park and ride facility, where provided. Stations will be configured to allow convenient access by pedestrians, cyclists and persons with disabilities. Pedestrians traveling by foot, cycle or bus will access the station platforms at signalized intersections where most stations are conveniently located. Space for bike lockers will be identified adjacent to sidewalks near most stations.

Stations are normally spaced such that the majority of walk-in passengers walk less than 5 to 6 minutes to and from the station; however, some passengers can be expected to walk upwards of 8 to 9 minutes. This provision results in station spacing between 1 and 1.5 km.

Typical station geometry includes a station platform that measures 3.5 m wide and 60 m long. This allows for double berthing of LRT vehicles (Light Rail Vehicles – LRVs) and adequate loading / unloading area for multiple BRT vehicles. Possible station configurations include:

- Side-loading platform - adjacent
- Side-loading platform - staggered (e.g. far sides of an intersection)
- Centre-loading island platform
- Terminus Stations (i.e. Fairview Park Mall, Conestoga Mall)

Fare collection equipment, signage and system maps and information will be presented at each station. This predictability of information and placement will enhance the passenger’s experience.

Integration with Other Transit
The rapid transit corridor is part of a complex network facilitating the movement of people through the Region. The linkages that connect private vehicles, passenger pick-up and drop-off, park and ride, bicycles, local transit buses, GO Transit buses, etc., to the future rapid transit system will be further refined during preliminary design to make the transitioning to transit services efficient.

Park and Ride Facilities
The Region’s rapid transit plan includes provision of parking facilities, where practical and cost effective to facilitate access to the system by private vehicles. A number of park and ride facilities are proposed at strategic locations along the corridor to provide convenient access to the rapid transit system for commuters. During preliminary design, options to share commercial parking lots and/or joint development in the vicinity of key rapid transit stations will be considered.
Park and ride facilities are proposed at the following locations:
- Northfield Drive / Weber Street North area, Waterloo – near interchange with Conestoga Pkwy
- Conestoga Mall, Waterloo – near interchange of King Street North and Conestoga Pkwy
- Fairview Park Mall, Kitchener – near interchange of Fairway Road and Highway 8
- Sportswork – near interchange with Highway 8
- Bridgemark Power Centre – near interchange of Hespeler Road and Highway 401
- Downtown Galt, Cambridge – near Ainslie Street Terminal

Maintenance Facility

A review of potential locations for a maintenance facility will be undertaken during the next phase of the EA. The planning criteria adopted for site selection, development of the conceptual layout of the facility and the components are listed below:
- Suitability of site size and configuration (producing efficient circulation of rapid transit vehicles on site)
- Site ownership and acquisition timeline and cost
- Site topography, specifically grading and drainage requirements
- Compatibility with surrounding neighborhood (zoning, land uses and security)
- Site vehicular access and surrounding traffic conditions
- Site servicing and utility relocation requirements
- Flexibility for expansion
- Environmental conditions and constraints

A primary factor in developing the layout for the facility is the site’s ability to accommodate a rail vehicle storage yard and shop complex incorporating convenient double end track access to a storage area with sufficient storage track length and possibly a loop track. The latter avoids the need for reverse moves between storage, wash and shop tracks. The main entry and exit location must also be selected to minimize impact on external traffic flow along with generous sight distances for transit vehicles entering and exiting the site.

BRT vs LRT Operation and Passenger Capacity

A report was prepared to review the operational and capacity characteristics of BRT within the Waterloo rapid transit corridor. The portion of the study area in question is between Conestoga Mall and Fairview Park Mall where the maximum ridership potential of the line is expected. The purpose of the report was to confirm whether a 2-2.5 minute BRT headway (as required to accommodate the system demand volumes by 2031) would be operationally feasible. Assumptions used for the analysis include:
- Waterloo Spur routing in North Waterloo to South Kitchener is 18.5 km in length
- 12 stations are proposed in Kitchener-Waterloo
- On-road route has a 2-lane median for rapid transit with at-grade intersections
- Side-loading stations with 20-30 second dwell time
- Peak hour ridership (2031) BRT – 2220 passengers per peak hour direction and LRT – 2660 passengers per peak hour per direction
- Maximum station load – 845/hour (Courtland / Shelley)

Based on the above, the peak hour headways are calculated as 2-2.4 minutes for BRT (assuming articulated buses) and 6 minutes for LRT (with 2 car trains).

Interviews were arranged with several transit professionals in cities across the US and Canada where BRT is used in some form. Their views on the operational feasibility of BRT with a 2 minute headway are summarized below:
- Toronto TTC: TTC has no experience with BRT although this technology was considered for the Transit City LRT Program. TTC has used exclusive bus lanes in the past. TTC’s rule of thumb is that bus service under 3 minute headway require by-pass capability (i.e. where buses can pass one another at a station or on the busway using a separate bypass lane). Articulated buses could be used to increase capacity and increase the headway. Articulated (60’) buses (see top left) can accommodate about 90 passengers. Bi-articulated buses (see bottom left) are even larger (120 passenger capacity) and are used in Europe; however, TTC has no experience with them.
- In Sheppard Avenue corridor, LRT was only considered because the frequent station spacing (i.e. less than 450 m apart) would negatively affect BRT operation. However, at greater station spacing, BRT can have the capability to accommodate passenger demand of 3000 pphpd. Other factors needed to ensure BRT operational feasibility are: proof-of-payment fare collection to allow multiple door boarding, traffic signal priority to move buses through congested intersections, enhanced terminal operation including grade-separating access and egress.
- York Region Viva BRT: The most important factor considered in York Region to ensure BRT operational feasibility is the station spacing and the number and spacing of signalized intersections.
- Chicago Transit Authority: Often BRT express or semi-express services are overlaid on top of local services. Ridership levels of up to 3000 pphpd could be accommodated with BRT assuming exclusive lane operation, proof-of-payment / pre-paid fare collection, and traffic signal priority.
- Vancouver, BC: Three BRT services are in operation in Vancouver – one a precursor to the Canada LRT Line. On Broadway Avenue, which is a highly urbanized corridor, buses operate in exclusive curb lanes in the peak periods with approximately 2 minute headway and 3 minutes in the off-peak. Broadway is 3 lanes in each direction and on-street parking is allowed in the off-peaks. Articulated buses with design capacity of 80 passengers are used and peak hour ridership reaches 3000 passengers pphpd at some locations. All door boarding is allowed. Buses can leapfrog others to meet the schedule.

Based on experience elsewhere, BRT is considered operationally feasible with headways of 2 minutes and 3000 passengers (pphp) can be accommodated by certain conditions: fares are not collected on the buses, larger (60 ft.) articulated buses are used, roads are wide enough to accommodate leapfrogging (bypass lanes), and traffic signal priority can be used to avoid congestion.
In Waterloo’s rapid transit corridor, several potential problems were identified with BRT operating conditions.

- At this time, the Region cannot ensure that a full fleet of articulated buses would be available to meet the peak hour demand. The existing fleet of 40 ft. regular buses would likely be deployed, in part, on an exclusive rapid transit RoW, both on-road and off-road. Thus, the passenger capacity could not be entirely met with the larger buses. Assuming a 50/50 mix of regular and larger buses and 2 minute headway, the line capacity is estimated as 2200 pphpd - equal to the forecast demand by 2031.

- In downtown areas, there may be no room in narrow road RoWs to accommodate bypass lanes. Without bypass lanes, buses would need to wait for other buses that are delayed at stations or at congested intersections. Further study is needed to determine the need for and the feasibility of bypass lanes.

- BRT operations at short headways could be negatively impacted at congested intersections where pedestrians in the cross-walks or traffic on the cross-street may slow down buses to safely pass through the intersection.

- In the downtown areas, the BRT route would follow the curb lane around tight corners and past numerous driveways. Tight corners along the route (e.g. at Francis Street and King Street) will slow down regular and larger buses. Similarly, vehicle turning into and out of driveways along the curb lane would reduce bus speed through the downtown. Automobiles are more likely to use a curb-side bus lane than might occur with LRT and its tracks. As a consequence, maintaining the 2 minute headway through the downtown will be difficult with buses bunching up in the curb lane. With no bypass lane for buses to pass others, transit operations may be hindered.

In view of these potential problems associated with BRT operation in the Central Transit Corridor including bunching of buses and auto / commercial vehicle use of the exclusive curb lanes through the downtowns, the Region concludes that BRT could not conclusively achieve the required 2 minute headway to meet demand levels by 2031. Thus, the capacity of the BRT system in the Central Transit Corridor could be much less than the 3000 pphpd estimated for other cities. The inability to leap-frog buses at stations and elsewhere, as well as delays expected at congested intersections would jeopardize BRT operation if implemented within the entire CTC corridor (Conestoga Mall to Fairview Park Mall). Poor bus operation will negatively affect ridership growth – one of the principal objectives of Waterloo’s rapid transit initiative. Accordingly, the Region does not view BRT as the appropriate technology for the rapid transit corridor in Kitchener and Waterloo.

5.3.6. MULTIPLE ACCOUNTS EVALUATION

A Multiple Accounts Evaluation (MAE) provides a broad-based assessment of a potential project or projects, to understand their costs and benefits. Unlike traditional cost-benefit analysis, MAE is a more flexible framework capable of considering non-monetized and/or qualitative measures of benefits. This approach produces several advantages over traditional cost-benefit analysis. Besides considering less tangible factors that would not be considered in a traditional analysis; the structuring of a series of separate accounts allows for a comparison of project alternatives on different aspects of the economy, environment and society. In this way, the MAE framework provides decision-makers with a broader representation of a project’s benefits. MAE has been used to evaluate recent rapid transit projects in British Columbia and is the method of assessment used by Metrolinx for rapid transit projects in various route / technology options (e.g., by taking transit, users achieve savings from reduced travel time, lower vehicle operating cost, and reduced parking cost).

MAE was used to provide an assessment of the economic costs and benefits of up to six rapid transit route systems and technologies as noted in the IEA ToR. The rapid transit route system / technology alternatives considered were:

- Light Rail Transit Scenario 1 (Spurline) – LRT on the rail spur in Waterloo, then via King Street, Charles Street, Ottawa Street, Courtland Avenue, Fairway Road, the CPR rail line to Cambridge, Eagle Street, Hespeler Road / Water Street
- Light Rail Transit Scenario 2 (King Street) – LRT on King Street North in north Waterloo, west on University Avenue to the University of Waterloo, then via the rail spur, King Street, Charles Street, Ottawa Street, Courtland Avenue, Fairway Road, the CPR rail line to Cambridge, Eagle Street, Hespeler Road / Water Street
- Bus Rapid Transit Scenario 1 (Spurline) – BRT on the rail spur in Waterloo, then via King Street, Charles Street, Ottawa Street, Courtland Avenue, Fairway Road, Highway 8, Highway 401, and Hespeler Road / Water Street
- Bus Rapid Transit Scenario 2 (King Street) – BRT on King Street in north Waterloo, west on University Avenue to the University of Waterloo, then via the rail spur, King Street, Charles Street, Ottawa Street, Courtland Avenue, Fairway Road, Highway 8, Highway 401, and Hespeler Road / Water Street

All route system and technology scenarios were evaluated against a baseline scenario, called the “Business As Usual” or BAU case. BAU presumes the gradual expansion of the existing iXpress service over time, through increased service frequency in the Central Transit Corridor. Costs and benefits associated with this scenario were established as a point of comparison for each of the alternative rapid transit systems. Therefore, all results shown in the forthcoming accounts and their descriptions are the level of cost or benefit in excess of the BAU – or better than future transit service without rapid transit.

5.3.6.1. ACCOUNTS

The purpose of the MAE is to prepare an assessment of a transit project (and its alternatives) using a series of categories (called “accounts”) that include all aspects of transportation-related benefits. The five accounts are outlined as follows:

- Direct Project and Transportation Account – capital and operating costs directly related to the rapid transit project and the related infrastructure needs.
- Direct Transportation User Benefits Account – reviews the transportation benefits expected from the various route / technology options (e.g., by taking transit, users achieve savings from reduced travel time, lower vehicle operating cost, and reduced parking cost).
- Environmental Account – assesses the environmental benefits of the rapid transit project in terms of reduced greenhouse gases (GHGs) and criteria air contaminant (CAC) emissions.
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• Land Use Economic Development Account — reviews the benefits in terms of intensification, transit-oriented development, and employment impact that may be generated from the rapid transit project.

• Social and Community Benefits Account — takes into account the benefits in terms of improved public health and community liveability that directly relate to the rapid transit project.

Table 5.27 shows a series of metrics measuring the costs and benefits of the project options within each account. Note that the metrics are presented as a mix of monetary and non-monetary quantitative metrics, and qualitative metrics.

Table 5.27 – Multiple Accounts Evaluation Framework

<table>
<thead>
<tr>
<th>Account</th>
<th>Metric</th>
<th>Unit</th>
<th>RGMS Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs</td>
<td>$ (Total, NPV)</td>
<td></td>
<td>Foster a Strong Economy</td>
</tr>
<tr>
<td>Operating/Maintenance Costs</td>
<td>$ (Annual, NPV)</td>
<td></td>
<td>Foster a Strong Economy</td>
</tr>
<tr>
<td>Summary Metric:</td>
<td></td>
<td></td>
<td>Foster a Strong Economy</td>
</tr>
<tr>
<td>Direct Transportation User Benefits Account</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel Time Savings</td>
<td>Minutes</td>
<td></td>
<td>Foster a Strong Economy</td>
</tr>
<tr>
<td>Vehicle Operating Cost Savings</td>
<td>$ (Annual, NPV)</td>
<td></td>
<td>Foster a Strong Economy</td>
</tr>
<tr>
<td>Summary Metric:</td>
<td></td>
<td></td>
<td>Foster a Strong Economy</td>
</tr>
<tr>
<td>Environmental Account</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Footprint</td>
<td>Tonnes</td>
<td></td>
<td>Enhance our Environment</td>
</tr>
<tr>
<td>Summary Metric:</td>
<td></td>
<td></td>
<td>Enhance our Environment</td>
</tr>
<tr>
<td>Land Use/Economic Development Account</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential Development</td>
<td>Units within 600m</td>
<td></td>
<td>Protect Countryside/Build Vibrant Urban Places/Enhance Environment</td>
</tr>
<tr>
<td>Non-Residential Development</td>
<td>SF within 600m</td>
<td></td>
<td>Protect Countryside/Build Vibrant Urban Places/Enhance Environment</td>
</tr>
<tr>
<td>Summary Metric:</td>
<td></td>
<td></td>
<td>Protect Countryside/Build Vibrant Urban Places/Enhance Environment</td>
</tr>
<tr>
<td>Social and Community Benefits Account</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Health Benefits - Public Transportation</td>
<td></td>
<td></td>
<td>Foster a Strong Economy</td>
</tr>
<tr>
<td>Summary Metric:</td>
<td></td>
<td></td>
<td>Foster a Strong Economy</td>
</tr>
</tbody>
</table>

The following Table 5.28 relates each of the RGMS goals to the metrics in the framework.

Table 5.28 – Multiple Accounts Evaluation Metrics Related to RGMS Goals

<table>
<thead>
<tr>
<th>RGMS Goal</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs</td>
<td>GHG Emissions</td>
</tr>
<tr>
<td>Operating Costs</td>
<td>Critical Air Contaminants (CAC) Emissions</td>
</tr>
<tr>
<td>Operating Revenues (Fares, Parking)</td>
<td>Public Health Benefits - Air Quality</td>
</tr>
<tr>
<td>Travel Time Savings</td>
<td>Public Health Benefits - Active Transportation</td>
</tr>
<tr>
<td>Vehicle Operating Cost Savings</td>
<td>Residential Development</td>
</tr>
<tr>
<td>Accident Avoidance Emissions</td>
<td>Non-Residential Development</td>
</tr>
<tr>
<td>Parking Cost Savings</td>
<td>Support to Regional Land Use Objectives</td>
</tr>
<tr>
<td>Employment Generated</td>
<td></td>
</tr>
<tr>
<td>Taxes Generated</td>
<td></td>
</tr>
<tr>
<td>Construction Disruption</td>
<td></td>
</tr>
</tbody>
</table>

5.3.6.2. DATA INPUT

The MAE draws upon data inputs from a wide range of sources to develop the various different metrics.

Land use modeling was conducted by the Region of Waterloo, with inputs from MKI, to establish the distribution of population and employment within the Region. MKI supplied estimates of intensification potential for possible station areas in Cambridge, and reviewed and updated forecasts for station included in the previous (2004-05) Rapid Transit Initiative Technical Studies for Kitchener and Waterloo. Land use forecasting was performed using the Region’s Population and Land Use Model (PLUM) for two scenarios (the BAU, and Full Intensification scenario). The Full Intensification scenario, which assumes the presence of rapid transit in the station areas, was adopted for transportation modeling of all the route / technology system alternatives. PLUM model output (population and employment forecasts for various horizon years) was used for several of the land use metrics in the MAE, as well as the land use inputs for the travel forecasting model.

A travel forecasting exercise was conducted using the Region’s Ridership Forecasting Model. Hatch Consulting Inc. performed the ridership and traffic forecasting, which is described in their report “Waterloo Rapid Transit IEA Phase 2 Step 3 Transit Ridership Forecasts Final Report, March, 2009” which appears in Appendix B2 of this report. It is important to emphasize that ridership forecasts were based on a single land use scenario (Full Intensification) for each of route / technology system alternative as well as the BAU Scenario. However, the pace of intensification in the Transit Corridor may vary depending on the transit technology implemented, it is recognized therefore that the potential exists for the ridership associated with the bus-based transit scenarios to be overstated, since the land use scenario assumed transit-oriented development commensurate with the implementation of a fixed, higher-order rapid transit system. However, in the interests of providing a consistent baseline for scenario evaluation, and in line with accepted best practice, the land use inputs have been held constant across all scenarios.
Capital and operating cost estimates for each route / technology scenario were prepared by Hatch Mott MacDonald (HMM) Inc. These estimates are included as Appendix B3 of this report. BAU costs were determined separately through consultation with GRT, and are included in Appendix B4.

5.3.6.3. METHODOLOGY

This section provides a description of each of the metrics within the MAE, and the approach taken to developing inputs, for each of the five accounts in the MAE. For each account metric, the performance measures of each route / technology alternative were compared, relative to the BAU. Specific assumptions and data underlying the BAU case, and those of the route / technology system alternatives are outlined in the Appendices.

The analysis period for this project is 30 years. The discount rate applied was 6%, consistent with the Region of Waterloo’s long-term borrowing costs in 2009.

Direct Project and Transportation Account

This account includes the capital and operating costs directly related to the BAU and rapid transit system alternatives and the related transportation infrastructure. It is intended to capture the full costs of the project over the thirty-year analysis period. The metrics in this account are as follows.

- Capital Costs – capital costs including public works, vehicle purchases, property, and soft costs such as project management. Capital costs are reported both as a total cost (escalated) and as a Net Present Value (NPV), at the discount rate established for the analysis.
- Operating Costs – an estimate of the rapid transit operating costs. Operating costs for the opening year (2014), and for the 2031 horizon were calculated and a cash flow stream was interpolated in between and extrapolated linearly over 30-year period.
- Summary Metric: NPV of Cash Flows – this metric is the NPV of the sum of the two cost streams (capital costs and operating costs) discounted for the full costs of the project.
- Operating Revenues (from fares) – Estimate of fare revenue based on boardings for a route / technology alternative and assuming $0.96 per boarding in 2009, based on GRT system data. Fares are assumed to increase by $0.25 every five years. This metric is reported as an annual figure in a typical year and the net present value for the 30-year cash flow stream.
- Net Operating Costs – reported as dollars per ride for a sample year. This is the balance of the operating costs less the estimated fare revenues in a given year.

Direct Transportation User Benefits Account

This account includes the benefits expected from the various rapid transit system alternatives.

- Travel Time Savings – The time saved per trip (minutes) as calculated from the ridership forecasting model and then converted to monetary values based on the consumer surplus method. This metric is reported in two ways: annual minutes saved in a typical year, and the NPV of the monetary value over the 30-year period. Travel time savings are for trips by all modes of travel – i.e. auto travel times (driver and passenger trips), transit travel times, and walk / bike travel times. The measure captures the impact of travel time savings across the regional transportation network.
- Vehicle Operating Cost Savings – This metric establishes the operating costs avoided for car owners who travel instead by transit, or partly by transit. The calculation is the product of vehicle kilometres travelled (VKT) determined by the travel forecasting model for all auto trips, and the costs per kilometre of operating a standard four-door sedan in Ontario including gas, oil, tire wear, maintenance, insurance, and depreciation. The metric is reported as the NPV of the monetary value of these savings over the 30-year period.
- Accident Avoidance Savings – this metric represents the savings to society resulting from the road accidents avoided through the shift of trips to public transit, which has much lower rates of accidents. The calculation is performed using incident factors for accidents per vehicle kilometre, typical costs of fatal, injury, and property accidents, and the reduction in vehicle kilometres between the base case and the rapid transit route scenario. The metric is reported as the NPV of the monetary value of these savings for the 30-year period.
- Summary Metric: The summary metric totals the NPV of these categories of user benefits.

Environmental Account

This account includes the environmental benefits of rapid transit in terms of savings of greenhouse gases (GHGs) and criteria air contaminant (CAC) emissions.

- GHG Emissions Savings – Greenhouse gas (GHG) emissions are reduced by shifting travel from cars to rapid transit. Emission reductions are calculated by the travel forecasting model. The volume of GHG emission savings is reported in tonnes per year for a typical year. The monetary value of the GHG emission savings are calculated using a per tonne value of $37 per tonne, as reported in the publication “Estimating the Costs of Greenhouse Gas Emissions from Transportation (Transport Canada, 2007)”.
- Criteria Air Contaminants (CAC) Emissions Savings – CACs are noxious gases released into the atmosphere through auto exhaust and are monetized using a per tonne unit cost. CAC emissions are carbon monoxide (CO), volatile organic compounds (VOC), nitrous oxides (NOx), sulphur oxides (SOx), and particulate matter (PM). The CAC emission unit dollar values were taken from the publication ‘Evaluating the Total Cost of Air Pollution due to Transportation in Canada (Transport Canada, 2007)’, using the value for Ontario.

Summary Metric: The summary metric totals the NPV of the two monetary categories of environmental benefits.

Land Use Economic Development Account

This account includes the benefits associated with intensification surrounding transit stations, as well as economic impacts such as employment and land value uplift that may be generated from the rapid transit route / technology alternative, as compared with the Base Case scenario. The metrics are:

- Residential Development – measured by the incremental number of residents (population) within 600 m of proposed station locations, between 2006 and 2031, taken from the PLUM model. The figure reported is the number of additional population within 600 m of proposed stations, compared to the Base Case scenario.
- Non-Residential Development - measured by the incremental number of jobs (employment) with 600 m of proposed station locations, between 2006 and 2031. The figure reported is the number of additional employment within 600 m of proposed stations, compared to the Base Case scenario.
- Land Value Uplift – land value uplift has been calculated for each scenario, using a range of potential value uplift factors. Lands around stations (600 m) were given an approximate value per hectare dependent on the existing land use. A percentage uplift factor (differing by land use type) was applied to calculate its uplift potential. This represents a coarse assessment of the value of land value increases with rapid transit. It should be noted that land value uplift values are not independent of travel time savings, and therefore should not be added together.
- Support to Regional Land Use Objectives – this is a qualitative metric identifying the degree to which the route / technology alternative reflects the land use objectives of the Regional Plan, including focusing development within the Central Transit Corridor, and linking major land uses with rapid transit. A simple three-score system is used for these qualitative metrics.
To establish the “score” for each route / technology system alternative, the consultant team examined one or more criteria related to each policy objective and exercised professional judgment as to how well the alternative supported the policies.

- Employment Generated – this metric represents the number of jobs created by the capital expenditure to build the project. Calculated using the Provincial Government’s TREIM (Transportation Related Expenditure Investment Model) model, the metric is the total number of direct, indirect, and induced jobs generated by the capital expenditure.
- Taxes Generated – also calculated using the TREIM model, the metric reports the total federal, provincial, and municipal taxes that would be paid as a result of the capital expenditure. This metric is useful in providing some perspective of the revenues returned to the various levels of government as a result of the investment.

Social and Community Benefits Account

The final account includes benefits in terms of public health and community liveability that would result from the rapid transit initiative.

- Public Health – Air Quality – two measures are used: the number of Hospital Admissions Avoided, and Economic Damage. Using factors generated by Waterloo Public Health to quantify the health costs of poor air quality, air quality impacts were calculated by mode for each route / technology system alternative. Number of hospital admissions avoided was calculated using data from the Waterloo Public Health Unit across the Region. This was converted into an estimate of economic damage by the identified change in emissions resulting from each system alternative.
- Public Health – Active Transportation / Community Liveability / Construction Disruption – these three metrics are qualitative in nature and are evaluated on the basis of the three-score system (see above).

5.3.6.4. KEY FINDINGS

The first four route / technology alternatives (i.e. full LRT and BRT throughout the 38 km route) were evaluated through each of the five MAE accounts. Herein, the results are presented for the metrics identified in each account. It is important to note that all results reported here are incremental to the base case – that is, the value given is the difference between the specific route / technology alternative and the Base Case (Business As Usual).

1) Direct Transportation Cost Account

<table>
<thead>
<tr>
<th>Metric</th>
<th>Unit</th>
<th>LRT (Spurline)</th>
<th>LRT (King St.)</th>
<th>BRT (Spurline)</th>
<th>BRT (King St.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs (incremental)</td>
<td>$ (NPV)</td>
<td>$1,213</td>
<td>$1,189</td>
<td>$526</td>
<td>$502</td>
</tr>
<tr>
<td>Operating Costs (incremental)</td>
<td>$ (NPV)</td>
<td>$230</td>
<td>$212</td>
<td>$129</td>
<td>$115</td>
</tr>
<tr>
<td>Summary Metric: NPV of Total Project Costs</td>
<td>$ (NPV)</td>
<td>$1,443</td>
<td>$1,401</td>
<td>$656</td>
<td>$617</td>
</tr>
<tr>
<td>Additional Metric - Net Operating Costs (incremental)</td>
<td>$ per ride (2031)</td>
<td>$7.55</td>
<td>$7.56</td>
<td>$1.92</td>
<td>$1.92</td>
</tr>
<tr>
<td>Additional Metric - Operating Revenues (Fares)</td>
<td>$ (annual, 2031)</td>
<td>$21</td>
<td>$19</td>
<td>$17</td>
<td>$16</td>
</tr>
<tr>
<td>Additional Metric - Operating Revenues (Fares)</td>
<td>$ (NPV)</td>
<td>$100</td>
<td>$119</td>
<td>$103</td>
<td>$97</td>
</tr>
</tbody>
</table>

The incremental capital and operating costs associated with each of the route / technology alternatives, as well as the anticipated fare revenues and the net operating costs, are shown in the table above. The costs are incremental to the Business As Usual case and have been converted to a net present value using the discount rate of 6%.

Capital and operating costs reflect the transit technologies involved. LRT technology is considerably more expensive (2X) than BRT from both a capital and operating cost perspective. Fare projections are based on the ridership forecasts. The NPV of the incremental operating revenue compared to the base case over 30 years indicates that although the BRT route options will not attract as many riders, they perform proportionately better than the LRT options. The subsidy required per ride is $1.56 less in the LRT options than in the base case (BAU) option, and $1.92 less in the BRT options, than in the BAU scenario. This suggests that all route options will be fiscally positive compared to the BAU option, with better fare recovery per trip than continuing on with the current service.

2) Direct Transport User Benefits Account

The transportation user benefits calculated within each metric are outlined in the table below.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Unit</th>
<th>LRT (Spurline)</th>
<th>LRT (King St.)</th>
<th>BRT (Spurline)</th>
<th>BRT (King St.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time Savings</td>
<td>Minutes, All Periods (2031)</td>
<td>40.234</td>
<td>21.537</td>
<td>25.704</td>
<td>6.050</td>
</tr>
<tr>
<td>Travel Time Savings</td>
<td>$ (NPV)</td>
<td>$203</td>
<td>$99</td>
<td>$110</td>
<td>$16</td>
</tr>
<tr>
<td>Vehicle Operating Cost Savings</td>
<td>$ (NPV)</td>
<td>$232</td>
<td>$187</td>
<td>$167</td>
<td>$169</td>
</tr>
<tr>
<td>Accident Avoidance Savings</td>
<td>$ (NPV)</td>
<td>$88</td>
<td>$70</td>
<td>$71</td>
<td>$50</td>
</tr>
<tr>
<td>Summary Metric: NPV of Annual Benefits</td>
<td>$ (NPV)</td>
<td>$523</td>
<td>$396</td>
<td>$360</td>
<td>$233</td>
</tr>
</tbody>
</table>

Travel time savings (measured in minutes and $NPV) are clearly strongest for the LRT Spurline option. This is a result of the considerable time savings experienced by transit users in using the rail routing. The LRT King Street option does not perform as well due to its longer route and on-road congestion. BRT Spurline performs better than the other route alternative, BRT on King Street. All rapid transit route / technology alternatives perform better than the BAU, which will experience severe congestion effects as a result of more intensification in the CTC.
Vehicle operating cost (VOC) savings are strongest in the LRT Spurline route option, and there is a marginal difference among LRT King Street and the BRT route options. VOC savings are a function of the number of new riders on transit, which in turn affects the number of vehicle kilometres travelled (VKT) on the Regional road network. VKT is forecast by the travel forecasting model.

Accident avoidance savings are a direct result of reduced vehicle kilometres travelled (VKT) due to trips being taken by transit instead. These savings show a similar pattern to the VOC, with LRT Spurline having the largest benefit, followed by similar benefits for LRT King Street and BRT Spurline.

Considering all three benefit streams, the total transportation user benefits are clearly highest for LRT Spurline option. In terms of relative "value for money", the best performing route option would be BRT Spurline. It should be noted, however, that BRT Spurline may experience restricted ridership near the end of the forecast period (2031), as a BRT system in the north will encounter operational problems before 2031 brought on by limited transit vehicle capacity, buses blocking one another with the more frequent service, and reduced speed due to increasing road congestion in the Central Transit Corridor.

3) Environmental Account

The environmental benefits of the various route / technology options are outlined in the table below.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Unit</th>
<th>LRT Spurline</th>
<th>LRT King St.</th>
<th>BRT Spurline</th>
<th>BRT King St.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG Emissions Savings</td>
<td>Tonne/Year, 2031</td>
<td>$22,296</td>
<td>$17,700</td>
<td>$12,240</td>
<td>$11,250</td>
</tr>
<tr>
<td>Value of GHG Emissions Savings</td>
<td>$ (NPV)</td>
<td>$12.4</td>
<td>$10.2</td>
<td>$9.9</td>
<td>$9.3</td>
</tr>
<tr>
<td>Criteria Air Contaminants (CAC) Emissions Savings</td>
<td>Tonne/Year</td>
<td>$90</td>
<td>$46</td>
<td>$55</td>
<td>$200</td>
</tr>
<tr>
<td>Criteria Air Contaminants (CAC) Emissions Savings</td>
<td>$ (NPV)</td>
<td>$7.0</td>
<td>$6.1</td>
<td>$4.1</td>
<td>$4.0</td>
</tr>
<tr>
<td>Summary Metric: NPV of Annual Benefits</td>
<td>$ (NPV)</td>
<td>$19.4</td>
<td>$16.3</td>
<td>$12.9</td>
<td>$12.4</td>
</tr>
</tbody>
</table>

Greenhouse gas (GHG) emission savings are highest in the LRT Spurline option, followed by the LRT King Street option, then the two BRT options. Given the nature of the transit technology, (electric LRT versus diesel or hybrid-fuel buses), the savings in part reflect the means of propulsion of the transit technologies themselves. The bulk of GHG savings, however, are associated with the vehicle kilometres travelled and number of trips made by private car.

Criteria Air Contaminants (CAC’s) are pollutants with a variety of impacts on the natural environmental and human health. They are associated with vehicle emissions and, as such, are also a function of vehicle kilometres travelled. Results indicate that CAC emission reductions are highest for the LRT Spurline option, followed by LRT King Street, and the BRT route options.

The dollar values of emissions savings are low due to the relatively low prices currently placed on emissions. Most cost-benefit analyses of transit projects produce low dollar values for environmental benefits for this reason. Regardless of the dollar value assigned to emissions, arguments are commonly made that environmental benefits such as emission reductions have much broader benefits to society.

4) Land Use Economic Development Account

Land use and economic development benefits associated with the route / technology alternatives are shown in the table below.

Table 5.32 – MAE Results – Land Use / Economic Development Account

This account contains a variety of metrics designed to reflect the relative benefit of the rapid transit project in terms of achieving the Region’s land use objectives and economic development benefits.

The number of people living and working within 600 m of transit stations is a measure of the degree to which each route / technology alternative is likely to encourage intensification. The results indicate that both LRT Spurline and LRT King Street options have the highest overall potential to encourage intensification in the CTC.

Although rapid transit is likely to produce considerable intensification in the CTC, there is evidence of extensive intensification with the BAU case as well. This is largely due to a large number of projects proceeding in the CTC.
over the past 5 years without rapid transit in place. Also, large tracts of vacant land available (e.g. R&T Park) along the Spurline route are earmarked for large employment concentrations. This area was planned far before the rapid transit EA commenced. Table 5.33 lists the total population and employment forecast within 600 m of proposed stations for both the BAU and the rapid transit route / technology alternatives. Both Regional and Provincial planning policies place considerable emphasis on the intensification of the CTC, particularly the three Urban Growth Centres defined in the Province’s Growth Plan for the Greater Golden Horseshoe. The effect of rapid transit, therefore, is to catalyze a higher degree of intensification, sooner, than would occur in its absence.

Similarly, the calculation of land value uplift around rapid transit stations reflects the much greater impact of LRT on land value, in comparison to BRT. The land value uplift calculation also reflects the different pattern of land uses in the corridors, with the LRT King Street route serving King Street commercial and institutional uses. This results in a slightly higher estimated land value uplift for the King Street route compared to the Spurline.

The last two metrics refer to the economic development benefits associated with the rapid transit initiative. These metrics are functions of the capital spending on the project. The first indicates the number of jobs created through the construction project in terms of the total direct, indirect, and imputed benefits – this captures all employment from workers employed on the construction site, factories building the vehicles, and those working for companies providing professional services on the project, and so forth. With the highest cost, LRT Spurline has the highest number of jobs generated, followed closely by the LRT King Street. Taxes generated follow similar pattern of results.

5) Social and Community Benefits Account

This account is the most qualitative of the five accounts. It attempts to capture benefits that are difficult to monetize or report quantitatively. The results are outlined in the table below.

The two air quality metrics – calculation of hospital visits avoided and the estimated economic impact associated with poor air quality – are a product of the emission of criteria air contaminants by mode for each route / technology alternative. The LRT Spurline scenario performs the strongest, followed by the LRT King Street scenario, and then the BRT routes.

Public Health – Active Transportation metric refers to the number of walk, bike, and transit trips taken for each route / technology alternative and their ability to support active transportation through intensifying land use and creating pedestrian (and transit) oriented environments. LRT Spurline performs most strongly, as it generates the largest number of walk / bike / transit trips, and will offer strong support for transit-oriented development. LRT King Street and BRT King Street do not produce as many additional trips by active transportation modes. BRT options have the fewest additional trips by active transportation modes and have weaker land use impacts.

Community Liveability reflects the intangible, "quality of life" benefits associated with the route / technology options, including issues such as noise generated by the transit system, fumes generated, and aesthetic considerations. While certainly subjective, LRT options have fewer fumes and noise associated with them than BRT, leading to reduced impacts.

Construction Disruption is a qualitative measure of the likely disruption to existing residents and businesses in the corridor associated with the construction of the rapid transit project. LRT construction will require closing lanes on some City roads for short periods of time to install tracks and catenaries; while it is surmised BRT route options would require a shorter period of construction time on roads.

Variation of the metrics under the Social / Community Benefits Account makes it difficult to provide a summary measure. However, for most metrics, the LRT Spurline comes out the strongest performer and BRT King Street the weakest.

Summary of Results

MAE provides different measures indicating the strength of each route / technology alternative in different accounts that reflect the goals of the RGMS. A comparison of the relative costs and benefits of the four route / technology alternatives is summarised in the chart below. An indexing approach was used, by proportioning the metric values within each account to determine whether a particular route option performs better or worse than the others. Five bars for each route / technology option are shown; the height of a bar representing how much the benefits and costs exceed those of the BAU, and whether it performs below or above the average for that account. Route options that show above average performance in many or all accounts are the strongest candidates; options that show stronger results in accounts relative to the project costs (the red bar) are showing stronger return on investment.

Note that all bars are higher than “0” which is the relative benchmark of the BAU metrics for each account. Note also that for two accounts, the bar represents score on only the quantitative metrics. For the Land Use account, the bar
shows intensification (jobs / population in station areas). Similarly, for the Social / Community Benefit account, the metric displayed is the number of hospital visits avoided per year.

The results indicate that:

- The LRT route options have highest capital and operating costs. They also have the highest monetary and non-monetary benefits. LRT Spurline performs better overall than LRT King Street.
- BRT has the lowest capital cost and higher return per dollar spent in terms of the transportation user benefits. BRT Spurline performs better overall than BRT King Street.
- LRT Spurline has the highest overall benefits, but the highest overall cost.
- BRT Spurline provides less overall benefits than LRT options, and BRT King Street provides the lowest benefits of all rapid transit options.

Based on this evaluation, LRT Spurline best accomplishes the objectives of the RGMS, and presents the highest overall benefit. Although BRT Spurline may have the best return on its benefits compared to costs, it does not perform as well as the LRT options in terms of overall benefit, and performs quite poorly in terms of land use and social / community benefits. As a result, LRT is the preferred technology for the Region’s rapid transit system.

Staging Options
Following the first-cut MAE assessment on the full LRT and BRT route alternatives, it was determined that LRT is the preferred technology for the entire system. However, in terms of capital costs, the LRT route options are more than twice as costly as the BRT options, and roughly 30% more expensive in terms of annual operating costs. Significantly, roughly three-quarters of the forecast ridership occurs in the north portion of the corridor (north of Fairview Mall), and roughly three-quarters of the identified intensification potential also occurs in the north portion of the corridor. In order to identify variations that could produce a more effective deployment of capital spending, two Staging options were developed as a hybrid of LRT and BRT technologies. This analysis looked at two Staging options for implementing rapid transit, with a view to:

- maximizing benefits to the community
- providing rapid transit technology that best meets the level of demand
- developing a cost effective approach

The following two Staging options were evaluated:

**Staging Option A** – A mixture of LRT and BRT options – LRT from Conestoga Mall to Fairview Park Mall, BRT from Fairview Mall to downtown Cambridge using Highway 8/401 bus bypass shoulders and a dedicated RoW on Hespeler Road.

**Staging Option B** – A mixture of LRT and Adapted BRT (aBRT) – This scenario considered BRT operating through transit priority measures rather than on an entirely segregated corridor, i.e. on Hespeler Road in the south portion of the corridor. Adapted BRT could include queue jump lanes at intersections, signal priority, additional stations, enhanced shelters, automated ticketing, real-time passenger information systems.

Preliminary cost estimates for the two Staging options were prepared and, in order to evaluate their performance against the four route / technology alternatives, the MAE analysis was completed for both Staging options. The following two Staging options were evaluated:

**Staging Option A**
- LRT from Conestoga Mall to Fairview Park Mall
- BRT from Fairview Mall to downtown Cambridge using Highway 8/401 bus bypass shoulders and a dedicated RoW on Hespeler Road.

**Staging Option B**
- A mixture of LRT and Adapted BRT (aBRT)
- BRT operating through transit priority measures rather than on an entirely segregated corridor, i.e. on Hespeler Road in the south portion of the corridor.

Adapted BRT could include queue jump lanes at intersections, signal priority, additional stations, enhanced shelters, automated ticketing, real-time passenger information systems.

Preliminary cost estimates for the two Staging options were prepared and, in order to evaluate their performance against the four route / technology alternatives, the MAE analysis was completed for both Staging options.

1) **Project Costs**
Capital cost estimates were developed for both Staging options as shown below.

**Table 5.35 – MAE Results – Direct Project and Transportation Account (Including Staging Options)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Unit</th>
<th>LRT Spurline</th>
<th>LRT King St.</th>
<th>BRT Spurline</th>
<th>BRT King St.</th>
<th>Capital Spurline</th>
<th>Capital King St.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs (Incremental)</td>
<td>$M (NPV)</td>
<td>$2.13</td>
<td>$1.69</td>
<td>$2.60</td>
<td>$1.52</td>
<td>$7.30</td>
<td>$7.95</td>
</tr>
<tr>
<td>Operating Costs (Incremental)</td>
<td>$M (NPV)</td>
<td>$2.39</td>
<td>$2.12</td>
<td>$2.69</td>
<td>$1.71</td>
<td>$10.50</td>
<td>$11.14</td>
</tr>
<tr>
<td>Summary Results: NPV of Total Project Costs</td>
<td>$0 (NPV)</td>
<td>$1,643</td>
<td>$1,491</td>
<td>$3,043</td>
<td>$1,077</td>
<td>$16,750</td>
<td>$17,250</td>
</tr>
<tr>
<td>Additional Benefits: Operating Revenues (Fares)</td>
<td>$M (NPV)</td>
<td>$1.86</td>
<td>$1.90</td>
<td>$1.95</td>
<td>$1.82</td>
<td>$3.93</td>
<td>$2.23</td>
</tr>
<tr>
<td>Additional Benefits: Operating Revenues (Fares)</td>
<td>$M (NPV)</td>
<td>$0.91</td>
<td>$0.78</td>
<td>$0.85</td>
<td>$0.70</td>
<td>$1.80</td>
<td>$1.06</td>
</tr>
</tbody>
</table>
| Capital costs of the Staging options are 30-42% lower than LRT Spurline, i.e. between $792M to $701M, with Staging Option B some 11% lower than for Staging Option A. Operating costs associated with Staging Option B are about ¼ of those of LRT Spurline and 30% lower than the full Staging Option A. Relative to BRT, Staging Option B has about the same operating costs.
Both Staging options provide significant capital and operating cost savings over the LRT route options. Fiscal performance measured in terms of NPV operating cost per ride is the strongest for Staging Option B. The subsidy required with Option B is $2.23 less per ride than the base case (BAU), significantly outperforming both LRT and BRT. The graph on left shows how well the Staging options perform relative to the LRT and BRT route alternatives.

2) Direct Transport User Benefits

Direct transportation user benefits are presented in the table and graph below.

Table 5.36 – MAE Results – Direct Transportation User Benefits Account (Including Staging Options)

<table>
<thead>
<tr>
<th>Metric</th>
<th>BAU</th>
<th>LRT</th>
<th>BRT</th>
<th>Staging Option A</th>
<th>Staging Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time Savings</td>
<td>$1,610</td>
<td>$1,495</td>
<td>$1,382</td>
<td>$1,310</td>
<td>$1,250</td>
</tr>
<tr>
<td>Travel Cost Savings</td>
<td>$102</td>
<td>$98</td>
<td>$94</td>
<td>$92</td>
<td>$90</td>
</tr>
<tr>
<td>Vehicle Operating Cost Savings</td>
<td>$103</td>
<td>$98</td>
<td>$94</td>
<td>$92</td>
<td>$90</td>
</tr>
<tr>
<td>Summary: NPV of Annual Benefits</td>
<td>$2,713</td>
<td>$2,575</td>
<td>$2,439</td>
<td>$2,355</td>
<td>$2,290</td>
</tr>
</tbody>
</table>

For travel time savings, Staging Option A outperforms Option B because it is removed from the traffic on Hespeler Road / Water Street. LRT Spurline shows the largest savings (double the others) for this metric. Staging Options A and B fall in the mid-range of route options for vehicle operating cost savings. The same results hold for accident avoidance savings.

3) Environmental Benefits

The environmental benefits of the route / technology alternatives that include the Staging Options are outlined in the table below.

Table 5.37 – MAE Results – Environmental Account (Including Staging Options)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Total</th>
<th>LRT</th>
<th>BRT</th>
<th>Staging Option A</th>
<th>Staging Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse Gas Emissions Savings</td>
<td>12.20%</td>
<td>11.70%</td>
<td>12.10%</td>
<td>11.90%</td>
<td>12.00%</td>
</tr>
<tr>
<td>Value of Greenhouse Gas Emissions Savings</td>
<td>$12.0</td>
<td>$11.7</td>
<td>$12.1</td>
<td>$11.9</td>
<td>$12.0</td>
</tr>
<tr>
<td>Criteria A (Air Quality) Criteria B (Water Quality)</td>
<td>$7.3</td>
<td>$6.1</td>
<td>$4.1</td>
<td>$4.0</td>
<td>$4.8</td>
</tr>
<tr>
<td>Summary: NPV of Annual Benefits</td>
<td>$10.3</td>
<td>$10.3</td>
<td>$10.2</td>
<td>$10.2</td>
<td>$10.2</td>
</tr>
</tbody>
</table>

LRT technology in the Staging Options leads to lower emissions as compared to the BRT scenarios. Both the Staging Options perform better than BRT on emission reductions, but much less than the full LRT options as shown in the graph on the left. Relative to cost, the Staging options show stronger environmental benefits per dollar spent than the BRT route options.

4) Land Use / Economic Development Account

Land use benefits remain strong with both Staging Options as a result of strong intensification in the north end of the corridor associated with LRT.

Table 5.38 – MAE Results – Land Use / Economic Development Account (Including Staging Options)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Total</th>
<th>LRT</th>
<th>BRT</th>
<th>Staging Option A</th>
<th>Staging Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Development (Incremental)</td>
<td>10,512</td>
<td>10,524</td>
<td>10,556</td>
<td>10,560</td>
<td>10,560</td>
</tr>
<tr>
<td>Non-Residential Development (Incremental)</td>
<td>21,418</td>
<td>21,418</td>
<td>21,418</td>
<td>21,418</td>
<td>21,418</td>
</tr>
<tr>
<td>Land Value uplift (incremental)</td>
<td>$305.0</td>
<td>$305.0</td>
<td>$305.0</td>
<td>$305.0</td>
<td>$305.0</td>
</tr>
<tr>
<td>Summary: Strongly / Moderately / Weakly supportive</td>
<td>Strongly supportive</td>
<td>Strongly supportive</td>
<td>Strongly supportive</td>
<td>Strongly supportive</td>
<td>Strongly supportive</td>
</tr>
</tbody>
</table>

For travel time savings, Staging Option A outperforms Option B because it is removed from the traffic on Hespeler Road / Water Street. LRT Spurline shows the largest savings (double the others) for this metric. Staging Options A and B fall in the mid-range of route options for vehicle operating cost savings. The same results hold for accident avoidance savings.
All LRT and Staging Options outperform the BRT routes for residential and non-residential growth around stations. Even with BRT technology in the south end of the corridor resulting in less intensification in these station areas, the Staging Options are estimated to support 80% to 90% more intensification than the full BRT options. Land value uplift is much higher than BRT Options and less than LRT routes, again due to the Staging Options implementing LRT technology, which has the highest intensification potential. Jobs and taxes generated through capital spending are also higher for both Staging Options than the BRT Options. Overall, the Staging Options perform quite well with this set of metrics.

5) Social and Community Benefit Account

In terms of Public Health and air quality, both Staging Options perform slightly better than BRT, but their performance is lower than the LRT route options. This is expected since the Staging options have bus transit proposed for half of their route length. Construction of Staging Option B is likely to be less disruptive than full LRT and Staging Option A. Overall, Staging Option B comes in a strong third place after the full LRT route options as seen in the chart below:

Table 5.39 – MAE Results – Social and Community Benefit Account (Including Staging Options)

<table>
<thead>
<tr>
<th>Social and Community Benefit Account</th>
<th>LRT Spurline</th>
<th>LRT King St</th>
<th>BRT Spurline</th>
<th>BRT King St</th>
<th>Staging Option A</th>
<th>Staging Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Health – Air Quality</td>
<td>Moderately</td>
<td>Strongly</td>
<td>Moderately</td>
<td>Strongly</td>
<td>Strongly</td>
<td>Strongly</td>
</tr>
<tr>
<td>Public Health – Air Quality, economic impact</td>
<td>$15.0 M</td>
<td>$15.5 M</td>
<td>$15.7 M</td>
<td>$16.0 M</td>
<td>$15.0 M</td>
<td>$15.5 M</td>
</tr>
<tr>
<td>Public Health – Active Transportation</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
</tr>
<tr>
<td>Community Liveability</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
</tr>
<tr>
<td>Construction Disruption</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
<td>Qualitative</td>
</tr>
</tbody>
</table>

Comparison of Benefits and Costs

A comparison of the relative costs and benefits of all six route/technology alternatives is summarized in the chart below. An indexing approach was used, by proportioning the metric values within each account to determine whether a particular route option performs better or worse than the others. Five bars for each route/technology option are shown; the height of a bar representing how much the benefits and costs exceed those of the BAU, and whether it performs below or above the average for that account. Route options that show above average performance in many or all accounts are the strongest candidates; options that show stronger results in accounts relative to the project costs (the red bar) are showing stronger return on investment.

Figure 5-17 – Summary of MAE Results (Including Staging Options)

The LRT options have the highest capital and operating costs. But, they also have the highest monetary and non-monetary benefits as seen by all bars exceeding the average. LRT Spurline performs better overall than LRT King Street except under the land use account.

The BRT Options have the lowest capital cost, but below average user benefits. BRT Spurline performs better in the benefit categories than BRT King Street. When comparing only those monetary benefits against costs, BRT Spurline performs best of all the route/technology options. Still, BRT’s benefits fall short of the average in most accounts.

Staging Options perform closer to the average mark of benefits than the BRT options but at a higher capital cost. However, in terms of land use benefits, Staging Options perform much better than average and closer to the full LRT options. This is because Staging Options allow for introduction of the transit technology with the strongest potential for intensifying land use in the north while phasing in rapid transit in the lower ridership, less intensified southern portion.

Since most successful LRT projects (e.g. Calgary and Portland) were staged in rather than building the entire line all at once, the proposed Staging Options allow for more flexibility in terms of outlaying infrastructure dollars at the outset, and are more economically efficient by providing capacity where transportation demand requires it.

MAE Conclusions

The MAE clearly shows that the “Spurline” route options are superior to the “King Street” route options. Although there are a few metrics where the King Street routes perform as well or slightly better than the Spurline routes, the Spurline routes outperform other alternatives in most accounts.
Overall, in terms of transportation benefits per dollar spent, BRT Spurline is the best value for money if considering monetary benefits only. However this option underperforms in promoting the intensification objectives of the Region.

When considering only costs and other monetized benefits in the various accounts, Staging Option B represents good value for money spent. Staging Option B provides above average benefits in most accounts but these are still below the full LRT (Spurline) route scenario, which has a much higher cost.

Non-monetary accounts and metrics of the Staging Options are generally above average. The land use impacts of the Staging Options are considerably higher than full BRT, as LRT technology in the north corridor has greater potential for intensification. The higher ridership associated with the Staging Options is forecast to produce higher environmental and community benefits than full BRT. Finally, the Staging Options have considerable flexibility in terms of supplying the right level of transit service required to meet demand at this time. Full LRT to Cambridge in the early years would not be economically efficient.

In summary, the primary reasons for Staging Option B to be the preferred implementation option for rapid transit in Waterloo Region are that:

- The bulk of the ridership occurs north of Fairview Mall.
- The up front cost to build LRT to the south end of the corridor is extremely high.
- A BRT system in the north would encounter operational constraints before 2031 that would inhibit ridership growth.
- A Staging approach is cost-effective and provides best value when considering all project benefits and the RGMS goals.

The goals of the RGMS provide the framework for the MAE analysis. The MAE results indicate that a Staging approach achieves the objectives of the RGMS nearly as well as LRT Spurline, at much lower project cost. Further, it leaves the door open for a future LRT system throughout the CTC.

6.0 DESCRIPTION OF THE PREFERRED RAPID TRANSIT SYSTEM

6.1. PREFERRED RAPID TRANSIT SYSTEM - OVERVIEW

The outcome of Phase 2 of the Rapid Transit Initiative IEA was the identification of a preferred Rapid Transit system, including the preferred technology / technologies and route design(s), linking the urban areas of Waterloo, Kitchener and Cambridge. The preferred first stage route / technology choice is described in this section:

- North – LRT
  - In Waterloo (LRT) – Starting on King Street North, at Conestoga Mall, the rapid transit line runs west along Northfield Drive, south along the rail corridor, north on King Street and south on Caroline Street (the loop), and east to King Street via Allen Street.
  - In Kitchener (LRT) – South on King Street to Victoria Street, west on Victoria Street – south on Charles Street and east on Frederick Street – north on Duke Street (the loop), south on Charles Street to Ottawa Street, west on Ottawa Street to the CNR Huron S/D rail line, along this rail corridor to Hayward Avenue, east on Hayward Avenue to Courtland Avenue, along Courtland Avenue to Fairway Road and along Fairway Road to the most southerly station at Fairview Park Mall.

- South – Adapted BRT (aBRT)
  - In Cambridge (BRT – upgraded iXpress) – From the transfer station at Fairview Park Mall, BRT follows along bus bypass shoulders on Highway 8 to Highway 401 and along Highway 401 bus bypass shoulders to the Hespeler Road interchange. The route runs south on Hespeler Road in mixed traffic to Dundas / Coronation Boulevard, then south on Water Street to Bruce Avenue, east on Bruce Avenue to Ainslie Street and up to Ainslie Station at the GRT bus terminal.

The proposed stations are as follows:

- **Waterloo**
  - Conestoga Mall, on King Street North across from the GRT bus terminal at the Mall
  - Northfield / Parks lane Station, on the Waterloo Spurline at Northfield Drive
  - R&T Park, at the rail corridor, across from Wes Graham Way
  - University of Waterloo, on the rail corridor north of University Avenue
  - Waterloo Park – on the Spurline at Seagram Drive
  - Uptown Waterloo, split stations on King and Caroline Streets near Willis Way (the loop)

- **Kitchener**
  - Grand River Hospital, at King Street and Pine Street
  - King / Victoria, split stations on King Street and Victoria Street
  - Downtown Kitchener, split stations on Charles Street and Duke Street at Ontario Street (the loop)
  - Kitchener Market, at Charles Street and Cedar Street
  - Charles / Ottawa, at Charles Street and Ottawa Street
  - Courtland / Block Line, at Courtland Avenue and the future Block Line Road
  - Fairview Park Mall, either on the Hydro corridor at Fairview Park Mall or on south boulevard of Fairway Road at the signalized Mall entrance

- **Cambridge**
  - Sportsworld, at Sportsworld Drive west of Highway 8
- Hespeler / Pinebush, at Hespeler Road and Pinebush Road
- Cambridge Centre, at Hespeler Road mid-way between Bishop Street and Dunbar Road
- Hespeler / CanAmera, Hespeler Road at Can-Amera Parkway
- Galt Collegiate at Water Street North and Dando Avenue
- Ainslie Street Terminal, at the Ainslie Street Terminal

The LRT system is to operate in an exclusive RoW on city roads and rail corridors. The Adapted BRT system is to operate in mixed traffic on roads. Bus-bypass shoulders are proposed for Highway 8 and Highway 401 for use when the traffic speed drops below 60 km/hr.

The following map shows the proposed system. It is important to note that in North Waterloo, the map shows two routes. These routes include the Railway Corridor (Spurline) and the King Street Routes. Both routes were presented at PCC #5 for comments from the public. Following the PCC, the Railway Corridor Route was endorsed by Regional Council and chosen as the preferred route for North Waterloo.
Figure 6-1 – Preferred Rapid Transit System
6.2. THE LRT SYSTEM

The recommended LRT route is further described below. Any remaining choices or alternatives would be further examined and recommendations made during the preliminary design phase.

6.2.1. NORTHFIELD DRIVE TO UNIVERSITY AVENUE

- Northfield Drive, from King Street North to the Waterloo Spur, has a 30 metre wide RoW that allows widening the road cross-section through this section to accommodate a two-way rapid transit alignment while maintaining the existing road cross-section.
- The most northerly station is proposed at the intersection of Northfield Drive and the rail corridor, the adjacent side platforms could be located on Northfield Drive with access to the centre median provided by a new signalized cross-walk; or, the platforms could be located right in the rail corridor just south of Northfield Drive.
- In order to accommodate two-way rapid transit within the railway corridor, the rail RoW would need to be widened from 20 metres to 22 metres and the existing heavy rail track moved further east to allow the rapid transit alignment to fit in on the west side and maintain heavy rail operations. Stations are best situated on the west side of the rail corridor.
- Another station is proposed within the R & T Park at a location mid-way on the railway corridor between Columbia Street and Bearinger Road (near the end of Frank Tompa Drive).
- The third station on this route is proposed within the University of Waterloo lands either near the Davis Centre entrance (location of the Xpress stop) or adjacent to University Avenue. This latter location allows proximity to the at-grade pedestrian crossing or grade-separated bridge over University Avenue into the campus.

6.2.2. UNIVERSITY AVENUE TO ERB STREET (UPTOWN WATERLOO)

South of University Avenue, the LRT route alignment continues southward on the west side of the rail spur line through Waterloo Park to connect with Erb Street in Uptown Waterloo. A station would be located at the Park entrance near Seagram Drive serving both the WLU campus (a nine minute walk) and Park activities. This alignment minimizes the impacts on the multi-use trail located on the east side of the railway corridor and the pedestrian bridge (over Laurel Creek) at the south end of the park. However, it requires that a new railway structure be built to cross over Laurel Creek at Silver Lake.

The route emerges from the Waterloo Spur rail corridor as a two-way LRT route which splits into a one-way loop through the Uptown area between Caroline and King Streets. The LRT loop system travels:

- Southbound on Caroline Street (in the west curb / parking lane) from Erb Street to William Street. At this intersection, the one-way southbound route shifts from the west curb lane to the east curb lane of Caroline Street as far as the intersection of Allen Street.
- Westbound on the north side of Allen Street (in the grass boulevard along the Adult Recreation Centre) to connect with the two-way LRT route on King Street.
- Northbound on King Street (in the east curb / parking lane) between Allen Street and Erb Street.
- Westbound on Erb Street (in the north curb lane / boulevard) from King Street to Caroline Street where the northbound LRT alignment joins with the southbound route on Caroline Street into the two-way route on the rail corridor. Note: an alternative to Erb Street is for the northbound leg to follow the freight track through Waterloo Square between King and Caroline Streets.

- LRT station platforms are proposed on King Street (northbound) and Caroline Street (southbound) at the signalized intersections of Willis Way. Willis Way provides a natural pedestrian corridor in Uptown Waterloo.

The loop option is preferred in Uptown Waterloo for the following reasons:

- Reduced physical footprint on the roadway by maintaining the rapid transit corridor in a single curb / parking lane. This allows the station platforms to be incorporated into the sidewalk / boulevard area of the street.
- Expanding station access to a larger area by providing two separate platforms within walking distance to each other on King Street and Caroline Street.
- The station at Willis Way is centrally located to serve all of the Uptown district.
- Lesser impacts on Uptown traffic circulation and on-street parking by preserving as much of the existing road cross-section as possible.
- More flexibility for utility relocations as only one side of the road is impacted.

6.2.3. ALLEN STREET TO VICTORIA STREET (DOWNTOWN KITCHENER)

South of Allen Street, the LRT alignment continues as two-way operation in a centre raised median on King Street as far as Victoria Street in downtown Kitchener.

- King Street (Allen Street to the Victoria Street) has a narrow 25 – 27 metre RoW. King Street would be narrowed to a single 4.8 metre wide lane in each direction with a curb / swale on the LRT median and outside curb / sidewalk to accommodate traffic, cyclists and Fire / EMS services. Few properties would be impacted in order to accommodate any required road widening through this section.
- A station with staggered side platforms (on each side of the signalized intersection) is proposed at Pine Street / Grand River Hospital emergency access driveway. The station would require widening the existing road RoW, where there is room along the west side grass boulevard and partly into the Hospital emergency parking area.
- King Street RoW widening would be required at Agnes Street where some property would also be required.
- The section of LRT alignment between Wellington Street and Victoria Street may require a subway section for LRT to avoid an at-grade crossing of the CNR mainline crossing. Here the falling grade of King Street across the railway tracks would maintain a reasonable grade for the LRT line. The LRT portal (subway entry) must be located just north of Victoria Street to avoid impacting significant underground utilities in Victoria Street.
- Given the possibility of locating a multi-modal transit terminal (LRT, future GO rail service and VIA Rail) near Victoria and King Street, the best location for an LRT station would be directly adjacent to the CN Rail line. An underground LRT station could be considered near the CN Rail crossing; however, an at-grade station platform would not be possible on King Street, at this location, due to the proximity of the LRT portal and Victoria Street.

The route would split as a bi-directional route north of Victoria Street to a one-way loop arrangement through downtown Kitchener. The loop system operates as:

- Westbound on Victoria Street and southbound on Charles Street (curb lanes) where station platforms would be located in front of the School of Pharmacy building on Victoria Street and adjacent to the Grand River Bus Terminal on Charles Street. The one-way alignment continues as far south as Benton Street where it joins as a bi-directional route on Charles Street.
6.2.4. CHARLES STREET (BENTON STREET TO OTTAWA STREET)

South of downtown Kitchener, the LRT alignment continues as a two-way route in the centre of Charles Street on a raised center median. A staggered platform station is proposed at the intersection of Cedar Street and Charles Street close to the Kitchener Market (King and Cedar Street) and another near the intersection of Ottawa Street.

- Charles Street East, from Benton Street to Ottawa Street South, has a narrow 20 – 26 metre RoW. Therefore, Charles Street would need to be narrowed to a single 4.8 metre wide lane in each direction with a curb / swale on the rapid transit median and the outside curb / sidewalk to accommodate traffic, cyclists and Fire / EMS services.
- In order to accommodate the LRT station at Cedar Street, road widening is required. Property acquisition for Cedar Street station would occur primarily on the northeast side of the intersection to avoid the large retaining wall structure on the southwest side.
- Some property may be required at the Sterling Avenue and Charles Street intersection where there is a jog in the Charles Street alignment.
- Another station (staggered platforms) is proposed on Charles Street East between Borden Avenue and Ottawa Street South. This is a narrow section of Charles Street with industrial buildings located close to the sidewalk. Some property acquisition would be required in this block, most likely on the east side of Charles Street. An option would be to construct a single platform on the south side of Ottawa Street between Charles Street and Maurice Street, a residential street. Its raised platform would restrict left turn movements to and from Maurice Street.

6.2.5. OTTAWA STREET (CHARLES STREET EAST TO MILL STREET)

The LRT route heads westward on Ottawa Street South towards Courtland Avenue as a two-way route in a centre raised median and continues further west to Mill Street and the connection with CN Rail's Huron Park Subdivision corridor. Besides Ottawa and Charles Street, there is no other station in this section.

- Ottawa Street South currently has 2 traffic lanes on a 20 metre wide road RoW. Note: the Regional Official Plan designates this road section with a 26 metre wide RoW. Abutting properties and buildings adjacent to the 2-lane street are mainly single family residential and commercial uses between Charles Street and Courtland Avenue while it is predominantly single family residential between Courtland Avenue and Mill Street. In order to accommodate the LRT tracks, Ottawa Street would need to be widened on both sides beyond the existing 20 metre wide RoW. Single 4.8 metre wide traffic lanes are proposed in each direction with a curb / swale on rapid transit median and outside curb / sidewalk to accommodate traffic, cyclists and Fire / EMS services.

Improvements are proposed to the existing horizontal alignment of Ottawa Street west of Courtland Avenue from Lilac Street to Acacia Street. In this section where residential buildings are located close to the road, 6-8 properties would be required on the east side of the Ottawa Street RoW.

6.2.6. CNR HURON PARK SUBDIVISION (OTTAWA STREET SOUTH TO HAYWARD AVENUE)

From Ottawa Street, near Mill Street, the LRT alignment follows along the CN Huron Park rail corridor on the Rockway Golf course side. It runs beneath the Highway 7/8 embankment and across the existing Schneider Creek rail bridge towards Hayward Avenue. The rail RoW will need to be widened (by about 2 metres) to accommodate two new tracks – existing land uses are predominantly industrial and open space. The existing structures at Highway 7/8 and Schneider Creek will need to be replaced. At the railway crossing with Hayward Avenue, the LRT alignment runs along the southeast grass boulevard of Hayward Avenue to minimize its impact on accesses and then connects with Courtland Avenue. There are no stations planned in this section.

6.2.7. COURTLAND AVENUE

The two-way LRT route continues south on Courtland Avenue in the west boulevard as:

- The grass boulevard on the west side of Courtland Avenue is for the most part wide enough to accommodate Fire / EMS services.
- A station on Courtland Avenue is proposed at the future Block Line Road intersection (just north of Shelley Drive) where future bus service could be provided to serve areas of West Kitchener.

6.2.8. HYDRO CORRIDOR – FAIRWAY ROAD ROUTE OPTIONS

Near the existing Hydro One corridor, which crosses Courtland Avenue, two route alternatives were considered:

- The Hydro One corridor could be utilized to access Fairview Park Mall. A station could be located in the Hydro One corridor at Wilson Avenue or alternatively within the Fairview Park Mall property near the existing GRT bus terminal (west entrance to The Bay store).
- The Fairway Road route has the LRT tracks continuing along the boulevard of Courtland Avenue as far as Manotick Drive and then entering into the south boulevard of Fairway Road to Fairview Park Mall.
  - The grass boulevard along the south side of Fairway Road could accommodate LRT with some property required near the intersections with Manotick Drive, Wilson Avenue, and the signalized access driveway into the Canadian Tire Mall and Best Buy retail outlet.
  - A station could be located on Fairway Road at the Record / Best Buy signalized access road across from Fairview Park Mall. This intersection would facilitate pedestrians crossing Fairway Road.

6.3. THE ADAPTED BRT SYSTEM

The Adapted BRT system would run from Fairview Park Mall in South Kitchener to downtown Cambridge (Galt) in bus by-pass shoulders on Highways 8 and 401, and along Hespeler Road / Water Street in mixed traffic (general purpose lane). It could also include the following features:
Operational improvements:
- Queue jump or HOV lanes on Hespeler Road and Water Street
- Traffic signal priority
- More stations with enhanced shelters and automated ticketing, real-time passenger information systems
- Larger branded buses with higher frequency service

Urban design improvements at stations:
- Streetscape, bicycle and pedestrian amenities
- Connections to intercity transit
- Park and ride lots

Transitional Planning for future LRT implementation:
- Corridor protection
- Land acquisition

The recommended Adapted BRT route is described below.

6.3.1. HIGHWAY 8 AND HIGHWAY 401

The Adapted BRT (aBRT) route connects with Highway 8 at Fairway Road or the proposed River Road extension (a new interchange at Highway 8 is planned) and continues south to Highway 401. It continues along Highway 401 eastward to gain access to Hespeler Road in Cambridge. The aBRT route would use Bus Bypass Shoulders along both highways to by-pass any congested sections. At the Hespeler Road / Highway 401 interchange, the route alignment would merge into mixed traffic lanes and travel south towards downtown Cambridge. Features of this route are:

- No new river crossing structures would be required to accommodate the aBRT route on bus bypass shoulders. These wider shoulders would be accommodated as part of the planned Highway 8 widening project over the Grand River.
- A station would be developed on the former Sportsworld site, where the Greyhound bus terminal is located, at the northwest corner of Sportsworld Drive and Highway 8. A park and ride lot would be located nearby. Buses would leave or enter the highway by the existing interchange ramps. Note: MTO has proposed to reconfigure the interchange but this will not affect access to the proposed station site.
- Hespeler Road, from Highway 401 ramps to Pinebush Road / Eagle Street, has an existing six-lane road cross-section that would accommodate a BRT operating in mixed traffic.
- Queue jump lanes could be provided in the northbound and southbound traffic lanes at the intersection of Hespeler Road with Pinebush Road / Eagle Street.

6.3.2. HESPELER ROAD TO WATER STREET

South of Pinebush Road / Eagle Street, the aBRT alignment travels as a two-way route in mixed traffic on Hespeler Road as far as the Dundas Street / Coronation Boulevard “Delta” intersection. Several station locations are proposed in this section.

- A station is proposed on the south side of the Pinebush Road / Eagle Street and Hespeler Road intersection as there is insufficient room for a station platform on the north side. The outside right turn traffic lanes may be converted to bus queue jump lanes as far as 50 m on both sides.
- Hespeler Road from Eagle Street to Dunbar Road has a six-lane cross-section with a wide 40 m RoW with a wide grass boulevard on both sides of the road.
- Another station is proposed at the signalized entrance to the Cambridge Centre mall, mid-way between Bishop Street and Dunbar Road.
- A third station is proposed at the signalized intersection of Hespeler Road and Can Amera Parkway.
- Hespeler Road, from Dunbar Road to the Delta intersection (Dundas Street / Coronation Boulevard at Hespeler Road), is currently a four-lane cross-section and is planned to be widened to six-lanes together with constructing the new CP rail structure in 2011. The heavy northbound and southbound left turn movements (dual turn lanes) at the Delta intersection are maintained. The outside right turn traffic lanes on Hespeler Road and Water Street could be converted to bus queue jump lanes as far as 50 m on both sides of this intersection.

6.3.3. WATER STREET (DOWNTOWN CAMBRIDGE – GALT)

The BRT route continues south on Water Street past Galt Collegiate to run as a bi-directional route in mixed traffic as far as the Ainslie Street junction. From here, the bi-directional route follows Water Street in mixed traffic to Park Hill Road. South of Park Hill Road, the route follows Water Street as far as Bruce Street where it crosses over to Ainslie Street. From here, it is a short run to the downtown GRT Bus Terminal. There are two stations proposed en route: one on Water Street at Dando Avenue (signalized intersection) near Galt Collegiate and the other just south of the GRT Bus Terminal on Ainslie Street (single platform on east side of road next to the bowling alley). Part of the route on Water Street could use queue jump lanes at signalized intersections or an HOV lane where there is a four lane section.

6.4. PARK AND RIDE

Six Park and Ride locations were identified in the transportation modeling report which is included in Appendix B2. All park and ride capacities were assumed to be 200 spaces for the modeling. The locations identified are as follows:

- Northfield Drive / Weber Street North area, Waterloo – near interchange with Conestoga Pkwy
- Conestoga Mall, Waterloo – near interchange of King Street North and Conestoga Pkwy
- Fairview Park Mall, Kitchener – near interchange of Fairway Road and Highway 8
- Sportsworld – near interchange with Highway 8
- Bridgescam Power Centre – near interchange of Hespeler Road and Highway 401
- Downtown Galt, Cambridge – near Ainslie Street Terminal
Of the six locations, Northfield, Fairview Park Mall, and Sportsworld were chosen for having the best potential for park and ride facilities for the first phase implementation.

6.5. STRUCTURES

There are a number of existing structures along the proposed route. The following table identifies each of the structures and summarizes the proposed work associated with each structure.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Proposed Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian crossing over King Street at Conestoga Mall</td>
<td>New structure for pedestrians</td>
</tr>
<tr>
<td>Northfield Drive West bridge over the Conestoga Parkway</td>
<td>Structural analysis and deck / superstructure modifications to accommodate LRT</td>
</tr>
<tr>
<td>Northfield Drive West level crossing @ Waterloo Spur</td>
<td>No structural work required</td>
</tr>
<tr>
<td>Waterloo Spur under Weber Street North</td>
<td>Move freight track to East span, Install crash walls along piers, Possible utility relocation</td>
</tr>
<tr>
<td>Waterloo Spur over Silver Lake / Laurel Creek</td>
<td>Existing structure to be removed, New structure for all three tracks, Pedestrian bridge to remain</td>
</tr>
<tr>
<td>King Street West grade separation @ CN Guelph S/D (Victoria Street North)</td>
<td>New semi-grade separated crossing with rapid transit under CN Guelph S/D and general purpose lanes at level crossing</td>
</tr>
<tr>
<td>CN Huron Park Spur under the Conestoga Parkway</td>
<td>Complete structure replacement with new single span bridge for three tracks</td>
</tr>
<tr>
<td>CN Huron Park Spur over Schneider Creek</td>
<td>New bridge of same or similar construction adjacent to existing bridge</td>
</tr>
<tr>
<td>Pedestrian crossing over Fairway Road</td>
<td>New structure for pedestrians</td>
</tr>
</tbody>
</table>

### 7.0 IMPACT ASSESSMENT AND MITIGATION MEASURES FOR THE PREFERRED RAPID TRANSIT SYSTEM

The IEA ToR identified specific “high level” impact criteria and indicators for use in the Phase 2 assessment. The ToR contemplated that a full range of environmental issues affecting the design of the rapid transit system would be undertaken as part of Phase 3 of the IEA. Accordingly, the impact assessment, identification of mitigation measures and net effects will be part of the next phase of the EA. However, the Phase 2 preliminary impact assessment is summarized in the following sections.
7.1. TRANSPORTATION

7.1.1. PROPERTY

To this point in the EA, little engineering work has been undertaken to establish actual property requirements. However, the plan elements in the Phase 2 Step 3 Functional Design define the general impact that the proposed systems would have on adjacent properties. The Region’s March 2008 GIS file was used as the basis to establish existing property lines.

Where the functional design showed a route extending beyond the existing RoW, this indicated that additional property would be required.

Mitigation Measures and Net Effects

During functional design, the horizontal alignment, location within the corridor, and cross section features were evaluated to reduce the impact that the rapid transit corridor would have on adjacent properties. The generation of profiles and cross sections during preliminary design will further refine the property requirements. The design can also be further optimized throughout the design process to limit property takings in the Region.

7.1.2. TRANSIT AND TRAFFIC OPERATIONS

The Transit and Traffic Operations Report documents some of the operational constraints associated with the rapid transit system. These are as follows:

- Each corridor has a number of streets which intersect the rapid transit corridor at unsignalized intersections. Operational policies will have to be developed to control how vehicles are permitted to use and/or cross the reserved transit lane. The issue becomes even more complicated in downtown areas where on-street parking is permitted adjacent to the reserved rapid transit lane. Vehicles entering and exiting from on-street parking may impede rapid transit service. Vehicles may also use the lane in advance of right turn movements. This is an issue for any rapid transit alternative operating in an exclusive curbside lane.

- A number of the key intersections are physically constrained with respect to intersection widenings. There are two basic types of physical constraints. The first relates to existing buildings or developments located adjacent to an intersection. The second is based on the fact that an existing intersection cross-section may already be so large that a further increase would have negative pedestrian impacts. This is an issue for rapid transit alternatives which require addition of a lane in order to provide an exclusive transit lane. 

- Intersection geometry requirements – intersections which include extremely acute angles (substantially less than 90 degrees) would be of concern in terms of the potential operation of either LRT or BRT service. There are no intersections which are acute to the point of restricting rapid transit operations in the Study Area. The cross-section of intersecting streets may also be of concern. LRT or BRT operating on a two-lane road cross section may encounter problems at intersecting streets with two-lane or four-lane cross-sections as vehicles turning may cross over into the rapid transit lanes.

- Impacts for access from unsignalized minor street intersections – this is an issue for on-road alternatives throughout the Study Area. LRT or BRT operating in a dedicated right-of-way (i.e. the centre lanes) can be expected to restrict left turns from unsignalized intersections in order to maintain exclusivity of the transit RoW. Right turns would be permitted in this case. In the case of LRT or BRT operating in exclusive (curb) transit lanes, it can be expected that neither left nor right turns across the transit lanes (to or from the minor street) would be permitted. Such turns would likely only be permitted at signalized intersections.

- Impacts on parking – if LRT or BRT is introduced in a dedicated transit RoW, without widening on a street where parking is permitted, then it is possible that parking may need to be eliminated or relocated. This would be a question of a trade-off between traffic capacity and parking needs. This could be an issue in Uptown Waterloo along King Street from north of Bridgeport Road to south of William Street, in Kitchener along sections of King Street and Charles Street south of the downtown, and also throughout the Galt core.

There is also a number of opportunities associated with the rapid transit system. Key opportunities are as follows:

- Ability to improve transit operations and improve travel times for other transit vehicles within the Study Area if transit priority or reserved lanes constructed for rapid transit could be used by regular bus services.

- Ability to increase transit ridership resulting from new vehicles, faster, more reliable and increased frequency of service. This increase may spill over to regular bus services which provide connections to the new rapid transit service.

- Opportunity to realize an increase in transit ridership for all service by ensuring good connectivity to rapid transit. This includes connectivity between different lines and connectivity to rail, inter-city bus, and local and provincial (GO Transit) services.

- Ability to promote transit supportive development along the rapid transit corridor. Transit supportive development will help promote improved transit ridership by providing opportunities for higher density redevelopment and mixed-use development, along the rapid transit corridor.

- Opportunity to improve traffic operations at some intersections through adjusted signal timing, signal coordination and reduced vehicular traffic volumes where lanes are given over to rapid transit. Given the traffic operations analyses summarized in this report for the key intersections, any traffic operations improvements would likely only be realized at minor signalized intersections. It should also be noted that any unused capacity created by converting vehicle trips to transit trips would likely only be a short-term opportunity. Over the longer term, this capacity would be utilized as traffic grows.

In terms of system reliability and speed, signalized intersections represent potential points of delay along the rapid transit route. Delay is considered one of the most important measures of effectiveness used to design, optimize and evaluate the operation of signalized intersections. Transit service slowed by congestion is counterproductive, and rapid transit alternatives that are freed from congestion and on schedule provide for an efficient mode of transportation.

Mitigation Measures and Net Effects

In the next phase of the EA, the major sources of traffic operational problems and road network deficiencies should be identified – either for travel along the preferred route, or for other traffic crossing the preferred route. Once identified, the operational and network issues can be categorized into those that can be minimized through the use of transit priority measures such as signal priority or minor geometric improvements, and those that positively reinforce the rapid transit system. The intersection and screenline analyses will be useful in designing the preferred transit alternative and road network.
7.2. SOCIAL / CULTURAL ENVIRONMENT

7.2.1. RAPID TRANSIT NOISE

Potential noise effects were evaluated in Phase 2 of the IEA process. Potential sources of noise from an LRT system include engine bells and whistles, station parking lot noise, pedestrian crossing warning bells, LRT yard activities, rail maintenance (rail grinding), and rail wheel squeal.

Warning bells are only to be used in case of an emergency. Chimes may also be used when the LRT vehicle is entering or leaving a station to indicate that vehicle doors are closing. The sound levels associated with the chimes on the LRT vehicles are not expected to be high enough to impact noise sensitive receptors.

During Phase 2 it was not possible to determine the effects of station parking lot noise, pedestrian crossing warning bells, or yard activities. It was suggested that these types of noise be reassessed once the final route was chosen.

Regular rail maintenance typically includes grinding of the top surface of rails in order to remove surface wear and tear. The frequency of rail grinding is not known at this stage, and generally rail grinding usually occurs on an annual basis.

It should be noted that noise from rail grinding may be audible and louder than the ambient. Rail grinding is expected to be conducted in accordance with the restrictions outlined in the applicable Noise By-Laws and is expected to use industry standard methods.

It is expected that as LRT vehicles travel around sections of track which are curved, wheel squeal noise may be generated as the wheels laterally slip across and along the LRT track as the train executes the turn. The proposed LRT track is expected to incorporate design features in order to control wheel squeal noise. Wherever possible, the proposed railway design avoids tight turning radii. Wheel squeal is generally most pronounced for turning radii less than 27 m (90 feet). In addition, the proposed train design is expected to incorporate ‘bochum’ type wheels, complete with rubber block isolation of the wheel rim. These types of wheels are recommended, as they reduce the wheel squeal by 10 to 20 dBA in comparison to normal rail wheels.

Other methods used to control railroad wheel squeal, which have been proven to be an economical and effective means of reducing rail wheel squeal, include:

- Vibration Dampening
- Trackside and Waytrack Top of Rail Friction Modifiers and Application Systems;
- On-board Top of Rail Friction Control Systems
- Solid Stick Top of Rail Friction Modifiers

It is anticipated that with the inclusion of these design features, wheel squeal is expected to be minimized. If future wheel squeal issues are identified, treatment measures such as petroleum lubrication, rail inlays, water spray lubrication, or the addition of an on-board friction modifier / lubrication system could be implemented. With the incorporation of these mitigation measures, wheel squeal is not expected and therefore has not been considered in the noise assessment.

The only identified source of noise associated with BRT is the noise produced by the vehicle pass-bys themselves. No other noise sources are expected.

The preliminary assessment indicated that ambient noise levels were not expected to increase by 5 dBA along any of the proposed route configurations for both LRT and BRT technologies. As a result, the analysis showed that the linear extent of route adjacent to noise sensitive land use that is impacted by noise from the proposed rapid transit line is zero km.

Mitigation Measures and Net Effects

The results of the analysis for LRT technology shows outputs calculated at approximately 56 dBA and at an approximate distance of 20 m from the track centreline. Based on the anticipated ambient sound levels, the analyses indicate that future sound levels resulting from the LRT line are expected to remain under 5 dBA attenuation at all noise sensitive areas within all segments of the study corridor. This is within acceptable limits as identified in the “Protocol for Dealing with Noise Concerns During Preparation, Review and Evaluation of Provincial Highway's Environmental Assessments”. Therefore, noise mitigation is not warranted at this stage.

The result of the analysis shows that sound level contribution for BRT service is estimated at 52 dBA. Given the industry standard methods, results of this analysis, it has been determined that future sound levels for BRT technology are not expected to exceed 5 dBA attenuation and are considered to be considerably lower than that of LRT. Therefore, noise mitigation is not warranted at this stage.

No significant sources of stationary noise have been identified at the present time. However, it is expected that potential sources will include areas close proximity to maintenance yards that are situated away from the rapid transit main line. Maintenance yard switching and vehicle marshalling activities are expected to be the dominant sources and contributors of noise for nearby sensitive receptors. Rail yards would typically be classified as a stationary source due to the noise of moving vehicles and trains within the maintenance yard.

Other potential sources for stationary noise include transit stations with parking lots. Noise resulting from the movement of vehicles within the parking lots could be classified as potential sources of stationary noise. However, the hourly sound levels produced by vehicular movement are usually below applicable criteria and not generally considered.

Based on the Phase 2 analysis, mitigation measures are not required for sound attenuation for either BRT or LRT technologies, as the ambient noise levels for each technology are not expected to increase by 5 dBA at any location along the study corridors. Potential noise effects should be re-evaluated as part of preliminary design.
7.2.2. CONSTRUCTION NOISE

Construction noise impacts were evaluated in Phase 2 Step 2 of the IEA process. At this stage of the noise assessment, the exact nature of construction activity cannot be specified.

It is expected that noise will be generated from construction activities for station construction (including parking lot construction) as well as noise generated from the laying of new track (for LRT). Construction activities for the stations on greenfield sites are expected to include site preparation and leveling, paving, concrete pouring for the foundation, and construction of any station shelters. Station construction along the rapid transit corridor would typically include removal of existing pavement, construction of station foundations, construction of station shelters, and re-paving of disturbed sections.

Mitigation Measures and Net Effects

In many cases, impacts resulting from construction noise are relatively temporary in nature, and are largely unavoidable. It is for this reason that applicable MOE guidelines stipulate limits on individual pieces of equipment as opposed to a site specific or receptor-based limit. With adequate controls, it is expected that direct impacts can be mitigated. However, it should be noted that for some periods of time and depending on the type of work, construction noise is expected to be noticeable, and impacts will be significant. If noise complaints become persistent, it is recommended that the equipment used meets the construction equipment noise emission standards specified in MOE Publication NPC-155 “Construction Equipment”. The applicable standards are shown in Table 7.1 below.

Vibration was studied in the Phase 2 Step 2 Vibration Impact Assessment Report. Sources of vibration include LRT vehicles, BRT vehicles, and LRT/BRT yard activities. It is expected that the proposed project will require the use of a dedicated LRT/BRT yard for vehicle storage and maintenance. Potential sites to house the LRT/BRT yard have not yet been confirmed and the project is not sufficiently advanced to allow a preferred site to have been selected at this time. Vibration sources within the storage yards are expected to include switching and taxiing LRT vehicle movements and vibration associated with scheduled maintenance activities.

It is expected that existing and future land uses along the proposed LRT/BRT corridor will have various levels of vibration sensitivity. In general, vibration sensitivity can be ranked using the following criteria, in keeping with the criteria outlined in international standard ISO 2631-1 [2].

- Residential Spaces: Includes permanent and seasonal residences, hotels, motels, hospitals, nursing homes, and student residences.
- Commercial / Office: Includes commercial offices, warehouses, school lecture halls and auditoriums.
- Industrial and Workshop: Includes general industrial land uses.
- Critical Spaces: Includes hospitals, medical operating theatres and precision labs which house optical microscopes, electron microscopes, Magnetic Resonance Imaging machines (MRIs), photolithography machines and other high performance lab equipment.

The vibration impacts associated with the Region’s proposed rapid transit line were assessed using a prediction model to quantify LRT vibration, which is based on the U.S Federal Transportation Authority (FTA) algorithms. When undertaking the vibration model analysis, the following factors were taken into consideration:

- Horizontal and vertical rail line-receiver geometry (which includes distances from the track, as well as portions of the track that are laid out at the bottom of an in-cut trench)
- LRT train type

Table 7.1 – NPC-115 Maximum Noise Emission Levels for Typical Construction Equipment

<table>
<thead>
<tr>
<th>Type of Unit</th>
<th>Maximum Sound Level¹ (dBA)</th>
<th>Distance (m)</th>
<th>Power Rating (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation Equipment²</td>
<td>83</td>
<td>15</td>
<td>Less than 75 kW</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>15</td>
<td>75 kW or Greater</td>
</tr>
<tr>
<td>Pneumatic Equipment³</td>
<td>85</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Portable Compressors</td>
<td>76</td>
<td>7</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes:
1. Maximum permissible sound levels presented here are for equipment manufactured after Jan 1, 1981.
2. Excavation equipment includes bulldozers, back hoe, front end loaders, graders, excavators, steam rollers and other equipment capable of being used for similar applications.
3. Pneumatic equipment includes pavement breakers.

With respect to noise impacts during construction of the rapid transit line, the following should be specified during the preparation of detailed design drawings and adhered to during construction:

- Noise sensitive areas are to be identified.
- The Contractor to be required to comply with the appropriate municipal or regional bylaws regarding noise emission standards for construction equipment that may be in place at the time of construction.
- General noise control measures (not sound level criteria) to be referred to, or placed into the contract documents.
- Any initial complaint from the public to require verification by the Ministry of Transportation to determine if the general noise control measures agreed to, are in effect. The Ministry of Transportation will investigate any noise concerns, warn the Contractor of any problems and enforce its contract.
- A persistent complaint to require the Contractor to comply with the Ministry of the Environment’s sound level criteria for construction equipment contained in the MOE Model Municipal Noise Control By-law. Subject to the results of the field investigation, alternative noise control measures to be required, where these are reasonably available.
- In selecting the appropriate construction noise control mitigation measures, consideration to be given to the technical, administrative and economic feasibility of the various alternatives.

7.2.3. VIBRATION

Vibration was studied in the Phase 2 Step 2 Vibration Impact Assessment Report.

Vibration impacts were assessed using a prediction model to quantify LRT vibration, which is based on the U.S Federal Transportation Authority (FTA) algorithms. When undertaking the vibration model analysis, the following factors were taken into consideration:

- Horizontal and vertical rail line-receiver geometry (which includes distances from the track, as well as portions of the track that are laid out at the bottom of an in-cut trench)
- LRT train type

• Speed
• Type of wheel and suspension
• Type of track
• Transit structures
• Any geological conditions that may affect transmission of vibration

The assessment of the alternative routes segment-by-segment indicates that the corridors with the least amount of urban development (e.g. rail or highway corridors) typically have the fewest number of buildings with the potential to be impacted.

In order to evaluate the potential vibration impacts of each of the alternative rapid transit routes, all buildings within 50 metres of the route centreline were identified within the seven separate segments, as per the ToR. Each route alternative is comprised of a series of rapid transit corridor segments (i.e. either on-road segments, rail corridor segments, or other off-road segments) and a series of stations. However, the use of a 50-metre setback as the criterion for vibration impacts does not provide a comprehensive basis for any definite conclusions regarding the preferred route since many buildings on all segments are located within this setback distance.

Based on vibration measurements of LRT technologies in the Greater Toronto Area, significant impacts are not expected beyond ten metres of the route centreline. Eleven buildings were identified within 10 metres of the track centreline for the route segments. This can be considered minimal and confirms that ground-borne vibration impacts will be negligible, and more importantly, vibration is expected to have a minor impact on the route selection.

Mitigation Measures and Net Effects

The conclusion was that in general, BRT typically produces lower ground-borne vibration than does LRT, but for comparison purposes, neither technology is expected to have a significant ground-borne vibration impact.

Site-specific mitigation may be needed, and issues should be addressed in the next phase of the EA.

7.2.4. CONSTRUCTION VIBRATION

At this stage of the vibration assessment, the exact nature of construction activities cannot be specified. This may be completed when more detail is available regarding the preferred alternative route and technology, as well as the phasing of design and construction and method of construction.

Specific activities that are required for maintenance yard construction include grading, drainage, electric installation, track construction and roadwork. It is expected that the majority of these facilities will require the use of bulldozers, excavators, tree excavators, compactors, rollers, ditchers, graders, pavers, loaders dump trucks, cranes, as well as pneumatic or hydraulic tools and compressors.

Construction vibration is typically quantified in terms of peak particle velocity (PPV). The PPV level is a peak level of vibration which occurs at any given time. It is often used in assessing human vibration impacts. Vibration, at high levels, can often lead to community concerns in fear of structural damage to local buildings and heritage sites. Table 7.2 outlines estimated PPV level limits for building damage by building class and measured in in/s.

### Table 7.2 – Estimated Vibration Levels Associated with Building / Structural Damage

<table>
<thead>
<tr>
<th>Class</th>
<th>Building / Structure Class</th>
<th>PPV mm/s (in/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Steady State</td>
</tr>
<tr>
<td>I</td>
<td>Buildings constructed in steel or with reinforced concrete, including factories, retaining walls, bridges, steel towers, open channels, underground chambers, and tunnels with or without concrete alignment</td>
<td>12.7 (0.5)</td>
</tr>
<tr>
<td>II</td>
<td>Buildings constructed with foundation walls and floors in concrete, walls in masonry, stone retaining walls, underground chambers and tunnels with masonry alignments, conduits in loose material including multi-storey towers.</td>
<td>7.6 (0.3)</td>
</tr>
<tr>
<td>III</td>
<td>Buildings constructed with wooden walls including that of single family residences</td>
<td>5.0 (0.2)</td>
</tr>
<tr>
<td>IV</td>
<td>Construction which is very sensitive to vibration impacts including historic sites, heritage buildings and archaeological sites.</td>
<td>3.0 (0.12)</td>
</tr>
</tbody>
</table>

Notes: Adopted from Swiss Association for Standardization (International Organization for Standardization). Effects of Vibration on Construction. Seefeldstrasse CH 8008, Zurich Switzerland.

Generally, Class III PPV limits should be maintained in proximity to residential areas. Class II PPV limits should be maintained in downtown core urban areas. A survey of surrounding buildings / structures should be conducted to indicate if any sensitive structures require more stringent limits. In addition, water, sewer and underground cabling should be included as part of the assessment.

Typical vibration limits based on human perceptibility are illustrated in Table 7.3. An increase in the human perception of construction activity often results in the potential for complaints, even if damaging thresholds are not exceeded.

### Table 7.3 – Human Perception of Vibration

<table>
<thead>
<tr>
<th>Human Perception of Vibration</th>
<th>PPV mm/s (in/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steady State</td>
</tr>
<tr>
<td>Imperceptible</td>
<td>&lt; 0.25 (0.01)</td>
</tr>
<tr>
<td>Slightly Perceptible</td>
<td>0.25 (0.01) to 0.7 (0.03)</td>
</tr>
<tr>
<td>Distinctly Perceptible</td>
<td>0.7 (0.03) to 2.5 (0.1)</td>
</tr>
<tr>
<td>Strongly Perceptible</td>
<td>&gt; 2.5 (0.1)</td>
</tr>
</tbody>
</table>

Based on a review of the data presented in the tables above, vibration levels that are below those that may cause damage to buildings under Class III may experience vibration levels that are strongly perceptible.

Blasting noise and vibration impacts have specific limits that have been specified by the Ministry of Environment. These limits are outlined in the Publication NPC-119, and have been derived to protect structures from concussion and home-borne vibration. Cautionary limits are shown applicable to unmonitored blasts. Blasts should be designed such that they meet the limits criteria shown in Table 7.4. It is expected that the peak limit may be used where routine monitoring of blasts are conducted.

<table>
<thead>
<tr>
<th>Vibration Source</th>
<th>Cautionary¹</th>
<th>Peak²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concussion (air overpressure)</td>
<td>120 dB</td>
<td>128 dB</td>
</tr>
<tr>
<td>Ground-borne Vibration</td>
<td>10 mm/s (0.4 in/s)</td>
<td>12.5 mm/s (0.5 in/s)</td>
</tr>
</tbody>
</table>

Notes:
1. The cautionary limit applies for unmonitored blasts.
2. The peak limit may be used in scenarios where routine monitoring blasts are undertaken.

Mitigation Measures and Net Effects

Construction-related vibration effects for LRT would likely be greater than for BRT. At the stations, the differences would be less pronounced (depending on design). However, these effects are not expected to require widespread mitigation. Site-specific mitigation may be needed, and should be addressed in the next phase.

7.3. NATURAL ENVIRONMENT

7.3.1. STORMWATER

The Phase 2 Step 2 assessment of alternatives included an impact assessment for the quantity and quality of stormwater runoff.

Quantity Control

None of the alternative routes being considered for the proposed rapid transit system will result in a significant increase in pavement area. Both the Grand River and the Speed River have large drainage areas and high flow rates in the vicinity of the proposed crossings. As a result, the small additional volume and rate of runoff from the proposed rapid transit system will have negligible flooding and erosion impacts. In Phase 2, it has been concluded that no stormwater quantity control will be required for rapid transit lanes.

Quality Control

The Terms of Reference indicated that the alternative routes were to be assessed as follows:

Water quality  Criterion
"Linear km of surfaces likely to require salting or similar de-icing compounds"

It was assumed that the LRT alternative routes would not require salting or de-icing, in the on-road or off-road sections, therefore water quality would not be affected as a direct result of constructing LRT.

However, both the Grand River and Speed River are warmwater streams that have been identified as being highly sensitive due to the presence of rare species. As a result, it is expected that an enhanced level of treatment will be required for runoff from any additional pavement associated with the proposed rapid transit system.

The proposed rapid transit system routes are largely located within existing developed areas where opportunities for implementation of stormwater management practices may be limited.

Mitigation Measures and Net Effects

During the next phase of the EA, the analysis should investigate enhanced levels of treatment for runoff from the additional pavement associated with the proposed rapid transit system including park and ride facilities. Effective and feasible treatment options should be investigated. Opportunities for treatment of existing pavement areas in lieu of the additional pavement due to the proposed rapid transit system which is not feasible to control should be considered.

7.3.2. ECOLOGICAL

The Phase 2 Step 2 Ecological Impact Assessment Report provides the detailed methodology and the list of identified environmentally sensitive landscapes.

The primary issue of importance for the study area, with regard to the natural heritage features, is the protection of the features and functions of the existing Environmentally Sensitive Landscapes (ESL’s), Environmental Sensitive Policy Areas, wetlands, woodlands and watercourses.

There are two key stages in the development of a rapid transit system during which potential environmental effects may occur: 1) construction stage and, 2) post-construction stage. The majority of short-term impacts will be related to the construction stage of the transit system. Generally, these will be temporary in nature and are preventable through proper construction practices and site inspection. Long-term impacts, however, are considered as those related to the operation of the rapid transit system where an increase in human use and presence, noise pollution, light pollution, vibration and fragmentation are anticipated. Noise, vibration and air pollution studies are addressed separately. These can also be prevented and mitigated through transit design, buffer implementation and environmentally sound management practices.
Potential Short-term Construction-related Effects

The potential short-term environmental effects associated with the proposed transit system relate primarily to construction activities. Relevant potential construction related impacts include:

1) Use of heavy machinery causing soil compaction and potential vegetation damage – The use of heavy machinery within proximity to the natural features may potentially cause soil compaction, soil contamination and damage to vegetation.
   - Soil Compaction is the act of compacting the soil where pore spaces between soil particles are decreased. The reduced pore space makes it more difficult for water to infiltrate the soil causing increased surface runoff which assists erosion processes to occur at a more rapid pace and roots to dehydrate / suffocate leading to vegetation mortality.
   - Soil Contamination could occur where oils / fuels / greases are accidentally emitted from heavy machinery entering natural features and drainage courses.
   - Damage to Vegetation could occur where machines enter natural areas or brush against vegetation causing wounded trunks or limbs / roots to break, increasing the possibility of disease. Roots generally grow within a few inches of soil, so that there is a potential for damage if heavy machinery is used within a certain distance of a natural feature where tree roots are present. If vegetation is trampled, this could result in:
     - Increased erosion
     - Sedimentation and turbidity
     - Loss of wildlife habitat and/or habitat productivity
     - Reduced input of organic matter (leaves, twigs, insects)
     - Loss of shade, resulting in increased soil and water temperatures
     - Introduction of non-native invasive species

2) Noise and vibration disturbance to wildlife – The use of heavy construction equipment and trucks can generate significant noise and vibration that have the potential to disturb breeding and other woodland wildlife. Such impacts have greater potential for disturbance during the breeding season and in the early hours of the day. Considering that the natural features already experience high volumes of noise, it is likely that resident wildlife populations have already adapted to current noise levels, or have migrated out of the area.

3) Grading and soil disturbance – The grading and disturbance of soils within the transit corridor create the potential for erosion and sedimentation within wetland and terrestrial communities.

Potential Long-term Related Effects

The potential long-term environmental effects associated with the proposed transit system relate to: 1) direct displacement of natural communities as a result of transit construction and 2) indirect impacts such as increased noise, light and vibration, which permanently alter habitat conditions. Noise, vibration and air pollution studies are also being completed and will be addressed separately.

1) Direct Displacement of Natural Features – Potentially the edge of some wetland / terrestrial communities may be lost due to the construction of part of the rapid transit system. This will increase edge effects, encroachment of invasive species, and degrade wildlife habitat.

2) Indirect displacement of Natural Features – Even though a proposed transit corridor may not result in the physical loss of natural features, it may indirectly affect habitat quality within a natural feature through the increase of noise, light and vibration.
   - Noise Disturbances have the potential to disturb breeding birds and other wildlife. These impacts have greater potential for disturbance during the breeding season and in the early hours of the day (i.e. morning rush hour). Noise disturbances would be related to rapid transit operations and would be on a more frequent or daily basis.
   - Light Disturbances could result in a significant intrusion into the natural environment (i.e. many animal species are only active at night and can be adversely affected by, or discouraged from, lit areas). Artificial lighting can also affect the physiology and behavior of other flora and fauna.
   - Vibration Disturbances could result in increased erosion within vegetation communities, depending on site-specific grading. It could also disrupt lifecycle processes of resident wildlife.

Mitigation Measures and Net Effects

The following conclusions can be made with regards to the Regional Municipality of Waterloo – rapid transit Ecological Impact Assessment:

- All proposed corridor routes use existing road / rail transit ways or utility corridors and, therefore, do not significantly affect the existing natural environment within the study area.
- Potential displacement of natural features is minimal where 0-5% of the total area of natural features within each segment may potentially be displaced.
- The preferred rapid transit technology is Light Rail Transit, due to it having slightly fewer negative impacts on the natural environment. However, both BRT and LRT are comparable and if proper mitigation measures are implemented, both technologies will have minimal impact toward the natural environment.

Potential ecological impacts should be re-evaluated as part of preliminary design.

7.3.3. AIR QUALITY

Annual greenhouse gas emissions for the year 2031 were modeled for each route and technology by Halcroft Consulting Inc. and were submitted in a series of memos from August 31, 2007 to November 12, 2007. The estimates were developed using Halcroft's GHG emissions sub-model. The sub-model is based on the United States Environmental Protection Agency (USEPA) MOBILE6.2C air emission model and is designed to use output data from Emme/2. MOBILE6.2C is a computer program that estimates hydrocarbon, carbon monoxide, oxides of nitrogen, particulate matter (exhaust, tire wear and brake wear), sulphur dioxide, ammonia, and carbon dioxide emission factors for gasoline-fueled and diesel highway motor vehicles. It calculates the direct GHG emissions associated with the operation of gasoline automobiles, light trucks, and urban transit vehicles (all diesel buses). The primary input into the model is vehicle kilometre traveled (VKT) data by vehicle type and speed bin, which were obtained from The Region’s transportation model.
Mitigation Measures and Net Effects

LRT is powered by electricity, and does not emit air pollutants adjacent to the sensitive land uses. However, it was assumed that rapid transit would generate urban intensification including both population and employment; therefore air quality would be impacted by the additional vehicular traffic resulting from the intensification.

Air quality estimates should be updated during the next phase of the EA.

7.3.4. MINERAL AGGREGATE RESOURCES

Fill material is gathered from pits and quarries to construct an off-road and on-road rapid transit line. In Phase 2 Step 2, the estimated volume (m$^3$) of fill from pits and quarries required to construct each route as determined from the typical cross section of a route / technology multiplied by the length of route in a segment.

Mitigation Measures and Net Effects

During preliminary and detailed design, the amount of fill required will be minimized as much as possible to reduce impacts to mineral aggregate resources and to lower costs.

8.0 MONITORING AND FUTURE COMMITMENTS

To ensure that the Region considers the full range of environmental issues affecting design of the undertaking in the ToR, the Region committed to carrying out specific assessments on the following topics during the preliminary design phase:

- Accessibility for persons with disabilities
- Archaeological resources
- Air quality
- Alignment design
- Built heritage
- Construction
- Cultural heritage landscapes
- Cyclist access
- Development standards
- Economic costs and benefits
- Existing and planned land use
- Natural heritage feature impacts
- Noise
- Parking impacts
- Pedestrian access
- Transit system operations
- Station design
- Maintenance and storage facility design
- Traffic impacts
- Transit integration
- Vibration
- Water Resources

9.0 OTHER APPROVALS REQUIRED

In addition to requiring EA Act approval, there are a number of municipal, provincial and federal approvals required in order to implement the Preferred Undertaking.

The potential approvals identified for the preferred alternatives are as follows.

9.1. MUNICIPAL APPROVALS

It is anticipated that a number of municipal approvals will be required from the Cities of Cambridge, Kitchener and Waterloo, and utility authorities for such items as road closures, entrance permits, road detours and temporary traffic management, utility relocation, tree cutting, topsoil stripping, building permits, noise by-law exemptions, property agreements, temporary power and water supply for construction. The specific approvals required will be confirmed in the preliminary design stage of the project.

9.2. PROVINCIAL APPROVALS

A number of provincial approvals from the following agencies may be required for the Preferred Undertaking:

- MOE (e.g., Permits to Take Water (PTTW), issued under Section 34 of the Ontario Water Resources Act (OWRA) for temporary water takings that exceed the trigger threshold of 50,000 L/day (or 7.5 Igpm))
- Ministry of Culture (e.g., a Letter of Concurrence will be required from the Minister of Culture (MOC) if any Stage 2 Archaeological Assessments are required).
- Grand River Conservation Authority (e.g., CA approval may be required for watercourse crossings depending on the nature of the crossing and the potential for impacts to the watercourses; CA may also be involved in co-ordination and assistance to DFO for review and assessment of any work that may impact fisheries and/or fish habitat and require authorization under the federal Fisheries Act).
- Utilities (e.g., approval for relocations, changes to access, etc.)

Based on the proposed improvements to Hespeler Road and Water Street to accommodate the aBRT, the potential exists that the Municipal Class EA (Schedule A+) would be required to fulfill the EA Act requirements. Similarly, the potential for reconstruction and widening of the shoulders along Highway 8 and Highway 401 to accommodate the aBRT may require fulfillment of the MTO Class EA (Group C). In both cases, discussion with the MOE is required.
when initiating the Transit Regulation to confirm whether or not the aBRT components can be included under the Transit Regulation or the Class EA processes must be followed.

The specific approvals required will be confirmed in the preliminary design stage of the project.

9.3. FEDERAL APPROVALS

The Canadian Environmental Assessment Act (CEAA) is triggered when a federal authority exercises a power, duty or function in relation to a proposed undertaking (e.g., through federal funding, granting a permit, license or authorization, etc.). For the Waterloo rapid transit project, because federal funding is being secured through the Build Canada fund program, this will trigger the CEAA. Additional triggers for this project may include approval from DFO under the Federal Fisheries Act and approval from Transport Canada under the Navigable Waters Protection Act. As a result, CEAA approval should be sought concurrently with the Provincial EA Act approval under the Provincial / Federal Harmonization process.

In order to formally initiate the CEAA process and confirm the scope of the assessment, a Project Description must be prepared based on the preferred rapid transit System and submitted to the CEA Agency, who will act as the Federal Environmental Assessment Coordinator (FEAC). As the FEAC, the CEA Agency will coordinate distribution of the Project Description to the Responsible Authorities (RAs) and any other relevant Federal Authorities (FAs) to determine if there are any interested FAs who wish to participate in the EA based on their review of the Project Description. The RA is the federal authority that is required pursuant to subsection 11(1) of the CEA Act to ensure that an EA of the project is conducted prior to exercising a power, duty or function in relation to the undertaking.

Under a Ministry of the Environment (MOE) approval lead, MOE would be responsible for communicating appropriate information to the CEA Agency, who would be responsible for communicating to potential RAs, in accordance with the Federal / Provincial Harmonization Process.

10.0 CONSULTATION UNDERTAKEN DURING PHASE 2 OF THE EA

Consultation is a required aspect of the EA process, and the Region has been proactive in its approach to soliciting the opinions of the Region’s citizens and project stakeholders. This section provides a general overview of the consultation performed throughout the EA process as well as summaries of public comments received. Detailed public comments and feedback were tracked by the Region and are contained in a report under separate cover.

10.1. ENVIRONMENTAL ASSESSMENT CONSULTATION FRAMEWORK

The Region’s EA consultation process was based on the following five consultation principles, as outlined in the ToR:

1. To make all reasonable efforts to provide potentially affected or interested parties with the opportunity to participate in the Environmental Assessment process. This will include any potentially interested aboriginal communities, including the Six Nations of the Grand River.

2. To ensure that each of the Phases of the environmental assessment process will include structured opportunities for public information and input from stakeholders (i.e. ratepayer groups, special interest groups, companies) and the general public.

3. To seek to address all input received during the consultation process constructively and objectively.

4. To make every reasonable effort to resolve concerns and issues brought forward through the consultation process.

5. To receive new ideas on improving the undertaking openly throughout the EA process, particularly measures that may enhance its benefits and/or avoid or mitigate its adverse effects.

10.1.1. PHASE 2 PUBLIC CONSULTATION

During the course of Phase 2 of the EA process, the Region conducted numerous consultation events in several formats. In addition to the formal consultation efforts outlined below, the Region also set up displays at public gathering places, such as local festivities and Regional Malls during important stages of Phase 2. The Region also published regular Newsletters to keep the public informed of the project details, and maintained a website specifically focused on the rapid transit EA. Formal meetings and consultation events throughout Phase 2 the EA process included:

1. September 21, 2006 – Public Information Session and Workshop #1 on Phase 2 Step 1: Phase 2 Step 1 of the EA involved the screening of rapid transit technologies and route designs. The public workshop provided a forum wherein members of the public were given maps of the study area and asked for their opinion on what areas were important for inclusion in the rapid transit system. Stakeholders were also asked to discuss the route options available to different technologies and record their discussions on the maps that were provided. Comment sheets were also given to the participants, collected and reviewed during further evaluation of the route and technology options in Phase 2 Step 1.

2. January 9, 10, 11, 2007 – Public Consultation Centre #2 on Phase 2 Step 1: The public was presented with information on the evaluation measures and results for the selection of preferred rapid transit technologies and routing options. Public input from the Workshop in September of 2006 was used to help shape the evaluation criteria used. The mixed on/off road route option was selected based on the evaluation criteria, and bus rapid transit (BRT) and light rail transit (LRT) were narrowed down as the preferred technology alternatives. The public was asked to comment on the evaluation and the selection of the preferred routing and technology alternatives.

3. March 20, 21, 22, 2007 – Public Workshop #2 on Phase 2 Step 2: This public workshop asked participants to discuss the Preliminary Route and Station alternatives presented by Regional staff. Participants were asked to comment on the presented options and suggest other alternatives if they were in disagreement. These comments were then incorporated into the refinement of the preliminary route and station alternatives.

4. January 10, 15, 17, 2008 – Public Consultation Centre #3 on Phase 2 Step 2: In consultation with the Local Municipalities and the public, the Region finalized the list of routes and station locations in each of the seven segments of the study area and began an in-depth evaluation of route, station and technology alternatives based
on 21 different criteria. The criteria were grouped in four different categories: transportation, social and cultural environment, natural environment, and economic impact. The evaluation methodology and results of the route, station and technology alternatives were presented to the public and feedback was requested.

5. June 17, 19, 24, 2008 – Public Consultation Centre #4 on Phase 2 Step 3: Using the top ranked routes / technology alternatives in Step 2, public input and other technical considerations, a variety of rapid transit route alternatives were developed. The Region then evaluated these alternatives and short-listed two routes – a BRT route and an LRT route. The short-listed rapid transit route alternatives were presented to the public to better understand the public’s preferences regarding the remaining “decision sections” (variants) in the system design. Public opinion was used in the development of the preferred rapid transit system (including route, station locations and technology).

6. September 2008 – Focus Group Meetings on Phase 2 Step 3: The public was once again asked to comment on the short-listed route alternatives, and the associated variances, developed for both BRT and LRT technologies. The focus groups looked at photo montages at some key station locations and provided feedback on the remaining route options.

7. May 19, 21, and 26, 2009 – Public Consultation Centre #5 on Preferred rapid transit System: The results of Phase 2 Step 3, including the MAE and the preferred rapid transit system was presented to the public for review and comment.

8. Storefront Displays: The Region rented commercial / retail buildings in Uptown Waterloo, Downtown Kitchener and Downtown Cambridge (Galt) to present displays on the preferred rapid transit system and to obtain public input and comments. Street front displays were held on June 3, 5, 20, 12, 17, 19, 24, 26 and July 8 and 15, 2009.

The Region of Waterloo exceeded the public consultation commitments outlined in the Terms of Reference. Namely, the Region of Waterloo:

- Provided notices of Study Commencement and Study Public Consultation Centres during each phase of the Assessment Process, and Study Completion / Minister Submission in the local Waterloo Region media
- Identified direct phone, fax, and e-mail contacts with key project team staff, including Region staff and consulting team members
- Continued and maintained direct notification mailing and e-mail lists of all interested members of the public, stakeholders and agencies throughout the EA process
- Established and maintained a project website at www.region.waterloo.on.ca/transitEA offering information updates on the EA preparation, and opportunities to submit comments to the project team
- Convened PCCs in each phase of the EA process to allow the public to see study results to date, exchange information and ask questions directly to members of the project team. The PCCs were also used as a means for project team members to gather opinions from the public to assist in guiding the decision-making process
- Arranged individual meetings and presentations with organized stakeholder groups to allow for informal discussions of any serious issues identified through the EA preparation or to provide information updates
- Continued to present rapid transit EA updates to the Public Advisory Committee
- Presented updates to the Region of Waterloo, Cities of Cambridge, Kitchener, and Waterloo councils and other committees on an “as-requested” basis or as deemed necessary by Waterloo Region in consultation with the involved municipal staff.

All public consultation efforts, including the notice of submission of the EA, provided opportunity for public comment.

10.2. CONSULTATION ON PHASE 2, STEP 1

A Public Information Session and Workshop and a Public Consultation Centre (PCCs) were held for Phase 2 Step 1.

The public was notified of the meetings through:

- The Rapid Transit Newsletter, Connecting to the Future, which was delivered to every household in Waterloo Region
- Newspaper advertisements in advance of the meetings in three local newspapers having general circulation in the area
  - Waterloo Chronicle
  - Cambridge Times
  - The Record
- Television advertisements on the local CTV affiliate during key news programming
- Notices posted on the Region’s Rapid Transit website at www.region.waterloo.ca / transitEA
- Mail-outs to interested public and agencies who asked to be added to the Region’s contact list through previous involvement in the Region’s consultation process for the RGMS and Rapid Transit Initiative
- Staffed information displays at three area shopping centres and two community events
  - Cambridge Centre
  - Fairview Park Mall
  - Conestoga Mall
  - Victoria Park Car Free Week Event
  - University of Waterloo Car Free Week Event
- Two road signs placed on busy arterial roads in the vicinity of the public meeting locations in advance of the meeting

10.2.1. PUBLIC INFORMATION SESSION AND WORKSHOP 1

At the beginning of Phase 2, a Public Information Session and Workshop was held on September 21, 2006 to discuss the rapid transit technology and possible route designs that were being considered by Regional staff and the consultant team. The aim was to gather feedback on what the public felt would be the most appropriate solution for Waterloo Region. The aim of the information session and workshop was to:

- Explain the process for Phase 2 of the EA
- Provide an opportunity for the public to meet with Project Team members from the Region and Local Municipalities to discuss issues regarding the Rapid Transit EA
- Seek public input on rapid transit technologies, route designs, station locations and routes
The information session and workshop featured an open house from 6:00 pm to 6:30 pm, which included information displays on the rapid transit technologies that were being considered, followed by a presentation from 6:30 to 7 pm and the workshop from 7:00 pm to 8:30 pm. The 140 workshop participants were divided into small facilitated groups of 10 and discussed the following four questions:

1. What major destinations in the Study Area should rapid transit serve?
2. Considering current and future nodes of activity in the Region, where should rapid transit stations be located in the Study Area? (maps were provided)
3. Considering the characteristics of rapid transit technologies, which routes would you use to connect the stations? (maps provided on which to draw the routes)
4. In your opinion, what are the most important characteristics for a rapid transit system in Waterloo Region?

During the group discussions, several common themes emerged from the various groups:

- Major destinations in the Study Area that should be served by rapid transit:
  - Downtown cores
  - Transportation centres (Grand River Transit terminals as well as intercity bus terminals, train stations and park and ride facilities to connect destinations outside the Region)
  - Commercial centres in and adjacent to the Study Area
  - Employment centres in and adjacent to the Study Area
  - Industrial areas
  - Schools, post-secondary educational institutions, hospitals
  - Recreation and tourist centres
  - Residential areas in and adjacent to the Study Area

- Locations for rapid transit stations:
  - Shopping areas such as the St. Jacob's Farmers Market, Conestoga Mall, Waterloo Town Square, Kitchener Market, Fairview Park Mall, Gateway Drive and Bridgecam Power Centre and Cambridge Centre
  - Key educational nodes such as the University of Waterloo and Wilfrid Laurier University main campus, Conestoga College, and the future University of Waterloo School Health Sciences campus in downtown Kitchener
  - Key health care centres such as Grand River Hospital and Cambridge Memorial Hospital
  - Key employment areas such as UW Research and Technology Park, Manulife, Sunlife, North Waterloo Industrial Area, Cambridge Industrial Park at Maplegrove Road
  - Major transportation hubs (areas for future GO connection, train stations, Waterloo Region International Airport, Highway 401 to connect to London and Toronto, Highway 7 to connect to Guelph)

- Routes to connect rapid transit stations:
  - Existing road and rail RoWs and infrastructure
  - King Street corridor
  - Hespeler Road
  - Feeder routes that connect Preston and Hespeler to downtown
  - Feeder routes that connect areas outside of the Study Area to rapid transit

- Most important characteristics of rapid transit:
  - Accessibility
  - Speed
  - Frequency
  - Flexibility
  - Connectivity
  - Affordable
  - Environmentally sustainable
  - Limited stops
  - Takes people where they need to go

10.2.2. PUBLIC CONSULTATION CENTRE 2

The Phase 2 Step 1 PCC presented the evaluation results for the technology and route design alternatives. PCCs were held in Cambridge, Kitchener and Waterloo on January 9, 10, 11, 2007. The PCCs provided members of the public to see how their comments from the September 2006 workshop guided the evaluation process at the Region and also to see the results of the Phase 2 Step 1 evaluation.

Public information handout and feedback forms were distributed at the PCCs to provide background and reference information to participants and to solicit comments on the evaluation results.

Question one on the feedback form asked whether the individual being surveyed was in agreement with the Rapid Transit Project Team’s proposal to short list BRT and LRT operating at road level using a mix of off-road and on-road dedicated RoWs. Overall, survey participants were supportive of the decision, citing the benefits of feasibility, integration with “human-scale” development, cost effectiveness, environmental responsibility and reporting that BRT and LRT were the best overall options. Some respondents continued to be supportive of other technology options, namely monorail and aerobus.

PCC participants also provided general feedback on route and station locations, technology considerations, and Regional considerations. Some concern was expressed with respect to the ability of existing roadways to accommodate rapid transit technologies and using existing railways was encouraged. Some respondents suggested a combination of technologies might be the best solution, including an LRT spine and BRT feeder system. Due diligence was encouraged concerning the cost of the undertaking and in the protection of the environment. Although no details on the issue were available, participants discussed possible tax impacts, and some were supportive of the system despite possible increases.
10.3. CONSULTATION ON PHASE 2, STEP 2

Public consultation during Phase 2 Step 2 consisted of a Public Workshop and PCC, along with several smaller displays held throughout the tri-cities. The public workshop was held in March of 2007 and members of the public provided their comments and preferences on the proposed preliminary rapid transit route options. The PCC was held in January 2008 and served to present the final route and technology alternatives to the public. Further details on public consultation efforts are provided below.

10.3.1. PUBLIC WORKSHOP 2

Public workshops were held on March 20-22, 2007 in each of the three cities of Cambridge, Kitchener and Waterloo. These public workshops presented members of the public with the preliminary route and station alternatives for the rapid transit system. The initial route and station alternatives were largely based on public consultation during Phase 2 Step 1, and also on the detailed Corridor Screening Report (Section 6.2.2).

In general, the majority of people who answered the question asked at the workshops “Do you agree with the proposed route and station locations to be evaluated?” stated that they agreed (approximately 60%) with the preliminary list. Several people offered suggestions of additional stations and routes to be added, removed or relocated. Specific comments for each segment included:

- **Segment 1:**
  - The workshop revealed that there was general consensus from public preferring either the Waterloo Spur rail corridor or King Street North for King Street at least as far north as Waterloo Town Square.
  - The public noted that a connection between the two universities was important either by following University Avenue (between King and the rail line) or a more centrally-located station on the rail line (near Seagram Drive).
  - Little support was given to WaterStreet and the Park Street routes with mixed opinions for the Iron Horse Trail.
  - The public suggested adding a route to the Farmer’s Market area, the University Avenue cross-corridor (King Street to the Waterloo Spur) and to eliminate the Park Street on-road route.
  - It was noted that impacts on Waterloo Park (trailways) should be addressed with some thought given to other alternative alignments that would reduce the potential pedestrian interaction with the dedicated RoW.

- **Segment 2:**
  - The public generally agreed with the proposed routes in North Kitchener and downtown Kitchener with the addition of a route along King Street through the downtown core.
  - The Park Street route was eliminated due to its narrow road RoW (60-66 feet) in many parts and low density residential frontage along sections of this roadway.
  - It was noted that the Iron Horse Trail is narrow in places and backs on to low density residential (i.e. Victoria Park) areas.
  - The final routing options, in consideration of the comments raised by the public for this segment, changed the preliminary list as follows:
    - Add King Street through Kitchener’s core (Victoria Street to Benton Street)

- **Segment 3:**
  - The public considered the King Street / Kingsway route the most direct to Fairview Park Mall and less so for Courtland Avenue. Several functional design issues were noted along King Street in the area of the Highway 7/8 underpass.
  - The Weber Street route was viewed by many as least desirable in this segment as it contained mostly residential frontage, mature residential areas on the east side and, compared to King Street, has limited redevelopment potential.
  - A route was suggested through Stanley Park; however, it is far too circuitous from Fairview Mall and, as well, falls outside of the study area.
  - Specific route options added / removed from the final list:
    - Remove the Weber Street route from Benton Street in downtown Kitchener to Montgomery Road
    - Remove the Highway 8 route in this segment due to the complex traffic movements at the Highway 7/8 interchange and restricted width under the Highway 7/8 bridge
    - Will not consider a “Stanley Park” routing that would follow River Road to Ottawa Street

- **Segment 4:**
  - The public preferred Highway 8 and the CP Rail corridor while King Street East was viewed as less desirable especially the section south of Highway 401 and Shantz Hill.
  - Fountain Street was not considered viable since access from Fairway Road is circuitous and outside of the study area. Also, a route on Fountain Street crossing Highway 401 and down the steep hill into Preston was not a reasonable alternative (given the steep grade and a new bridge structure would be needed for the highway crossing).
  - Specific route options added / removed from the final list:
    - Remove the King Street East routing between Highway 401 and Shantz Hill
    - Investigate an off-road route along King Street East immediately south of Highway 401

- **Segment 5:**
  - Specific route options added / removed from the final list based on public feedback:
    - Remove Industrial Road as a possible cross-corridor. As compared with Hespeler Road, there would be limited intensification opportunities suitable for rapid transit albeit that the adjacent land use is industrial uses. This local street is some distance away from the Hespeler Road commercial strip and, a route here, would add to the trip time of the rapid transit system.
    - Add a possible cross-corridor along a north-south drainage channel between Hespeler Road and Industrial Road. This north-south route would be closer to the Hespeler Road commercial area and avoid the congestion and limited road RoW at the Eagle Street and Hespeler Road intersection. It runs between Eagle Street and Dunbar Road.

- **Segments 6 & 7:**
  - In these segments, the final routing options would remain the same as the preliminary route alternatives.
10.3.2. PUBLIC CONSULTATION CENTRE 3

PCCs were held on January 10, 15, and 17, 2008 in Cambridge, Kitchener and Waterloo. At the PCCs, the public was presented with the final ranking of route alternatives, based on the evaluation and ranking criteria. At this stage, none of the route alternatives had been eliminated. It was noted that the ranking helped to determine the options with the greatest benefits and lowest potential impacts, segment by segment; however, all route options would still be considered in overall preliminary system design in Phase 2 Step 3.

Public information displays were also held in conjunction with the PCCs at local malls and community markets. The information distributed at the PCCs was also available at the displays and Regional staff were on hand to answer any questions concerning the project.

The following summary of public input is intended to provide an overview of the responses and other comments provided by the public in relation to the Phase 2, Step 2 Public Consultation Centre as they were relayed in response to the questions posed. Responses have been organized in order to provide a sense of the major themes common in the feedback.

**Question 1** Overall, do you support the results of the Phase 2, Step 2 ranking?
- Of the 113 comment forms received, 81 of those who answered: 70% supported, 19% did not support, and 11% were undecided.

**Question 2** Segment Rankings: Please let us know what you think about the route alternatives identified for each segment in the Study Area.

**Segment 1 – Uptown to North Waterloo** Do you agree with the Top Ranked Alternatives?
- 77 responded:
  - Yes 53%
  - No 31%
  - Undecided 16%

The top ranked routes for Segment 1 were 1-4 LRT (King Street) and 1-6 LRT (King University-Railway):
- LRT preferred for speed, low noise impact and low emissions
- Important to have stations at the Grand River Hospital, University of Waterloo, and Wilfrid Laurier University
- System needs to link to King Street in Uptown Waterloo for positive impacts on business / retail
- High ridership potential – serves residential, commercial, and institutional

Concerns for Segment 1:
- Expect low ridership demand for Northfield / Parkside
- Noise, vibration and safety through the Mary-Allen neighborhood

**Segment 2 – Uptown Waterloo to Downtown Kitchener** Do you agree with the Top Ranked Alternatives?
- 72 responded:
  - Yes 71%
  - No 7%
  - Undecided 22%

The top ranked route for Segment 2 was 2-2 LRT (King-Charles):
- LRT preferred for speed, low noise impact and low emissions
- LRT on King Street would have great benefits for businesses along the corridor
- Important for stations to be located at Grand River Hospital, Kitchener Market, and King / Victoria (with consideration of moving VIA station for future connectivity)

Concerns for Segment 2:
- Ensure stations are located at the Grand River Hospital and Kitchener Market

**Segment 3 – Downtown Kitchener to South Kitchener** Do you agree with the Top Ranked Alternatives?
- 70 responded:
  - Yes 44%
  - No 29%
  - Undecided 27%

The top ranked routes for Segment 3 were 3-2 LRT (Charles-King-Dixon-Shelley-Hydro Hwy 8), 3-3 LRT (Charles-King-Borden-Courtland-Fairway-King) and 3-1 LRT (Charles King-Dixon-Kingsway-Hwy 8):
- LRT preferred for speed and low environmental impacts
- Many felt it was important to keep the route near King Street
- Important to stop at Fairview Mall
- Good for shopping and potential business development

Concerns for Segment 3:
- Routes seem indirect – negative impact on travel times
- Consider link to Conestoga College (i.e. express bus)

**Segment 4 – South Kitchener to Cambridge (Preston)** Do you agree with the Top Ranked Alternatives?
- 63 responded:
  - Yes 29%
• No 33%
• Undecided 38%

The top ranked route for Segment 4 was 4-4 LRT (Hwy 8-Sportsworld-Railway):
• LRT produces less emissions and is worth the higher capital costs
• Good station connections with Sportsworld, Toyota, and Preston Core
• Good connection to Highway 401 for commuters
• Serves high employment area

Concerns for Segment 4:
• Sportsworld Station unnecessary unless area intensifies
• Costs of constructing bridge over Grand River
• BRT uses more gasoline and oil; creates more pollution

Segment 5 – Preston Towne Centre to the Delta Do you agree with the Top Ranked Alternatives?
62 responded:
• Yes 45%
• No 18%
• Undecided 37%

The top ranked route for Segment 5 was 5-1 LRT (Railway):
• Existing railway corridor appealing for its low environmental impacts
• Cambridge Memorial Hospital is an important station location
• Fast, direct route
• Good separation from traffic
• Least negative impact on Preston Core

Concerns for Segment 5:
• Capital costs

*NOTE: Several comments for Segment 5 indicated the respondent was too unfamiliar with the area to comment*

Segment 6 – Hespeler Road Area Do you agree with the Top Ranked Alternatives?
60 responded:
• Yes 52%
• No 12%
• Undecided 37%

The top ranked route for Segment 6 was 6-4 LRT (Eagle-Waterway-Dunbar-Hespeler):
• Most direct route
• Will alleviate traffic congestion on Hespeler Road and get people out of their cars
• Serves major points in Cambridge
• LRT offers high reliability and lower operating costs
• Lowest land purchases

Concerns for Segment 6:
• Hespeler Road not dense enough for LRT stations

*NOTE: Several comments for Segment 6 indicated the respondent was too unfamiliar with the area to comment*

Segment 7 - The Delta to South Cambridge Do you agree with the Top Ranked Alternatives?
55 responded:
• Yes 56%
• No 7%
• Undecided 36%

The top ranked route for Segment 7 was 7-7 LRT (Railway-Beverly-Wellington):
• Highest ridership potential
• Most efficient route
• Logical transition into downtown Galt
• LRT offers high reliability and lower operating costs
• Lowest land purchase costs

Concerns for Segment 7:
• Not enough ridership potential

*NOTE: Several comments for Segment 7 indicated the respondent was too unfamiliar with the area to comment*

Question 3 Was the format and content of the information presented at this Public Consultation Centre informative and useful to you? Please feel free to provide feedback.

General Comments:
• Staff very friendly, helpful and informative
• Interesting to talk to representatives from the Region, the consulting firms and GRT
• Having detailed study area information available in-advance online would be beneficial
• Well organized and presented information
• Video was informative and entertaining
• Maps showing the sections were clearly exhibited
• Station area location maps were useful for determining distance from my house

General Concerns:
• Difficult to decipher routes displayed on panels
• There was a lot of information, it was slightly overwhelming
• Larger venues with guided tours / presentations would be helpful. Space felt congested around displays
• Display material awkward to read in crowd, written material very helpful
• A lecture format with questions would be helpful
• Extremely complex for an informal, drop-in session
• Difficult to determine which stations corresponded with the different route alternatives
• Confused about the combination of the Rapid Transit Evaluation and the GRT Business Plan Update

Question 4 How would you like to be kept informed about the progress of the Rapid Transit Environmental Assessment?

Respondents indicated the would most prefer to be updated on the Rapid Transit Environmental Assessment by personal email, the website and the Rapid Transit Newsletter.

Question 5 How did you hear about this Public Consultation Centre?

Respondents indicated they heard about the various PCC meetings via personal email, new stories and the Rapid Transit Newsletter.

Question 6 Other Comments:

General Comments:
• The Region needs to work closely with GRT to ensure frequent East-West feeder buses to connect outlying areas to the central transit corridor
• Configure the rapid transit system and stations in a manner that will allow for future expansion and linkages to inter-provincial transit to other metropolitan areas (i.e. Guelph, London, Brantford, Hamilton, the GTA)
• The VIA Rail station be relocated to the intersection of King Street and Victoria Street to allow connection to the Region's possible rapid transit location. Also, for possible future GO Train services
• Emphasis must be placed on connecting suburbs to transit
• Core areas would be greatly stimulated with rapid transit

Comments on LRT Technology
• More beneficial and worthwhile investment
• Quiet and fast technology

Comments on BRT Technology
• Less invasive and more adaptable to future changes
• Lower capital and operating costs
• Minimal impact on existing roads
• More flexible if plans need to change
• BRT could use King Street without shutting it down
• Bus based system preferred- too early for light rail
• Ineffective technology to get people out of their cars
• Difficult to justify investing millions of dollars to replace the current bus-based system with essentially another bus-based system
• Based in Ottawa experience, generally does not work well
• Insufficient to drive change in land use
• Less likely to attract private development investment
• Produce greenhouse gas emissions
• BRT more suitable for the size of Waterloo Region
• Necessity of road de-icing (salt) has negative environmental impacts

General Concerns:
• Important that the new rapid transit system not interfere with existing biking and walking trails
• Phasing, timing and construction impacts
• Investment needs to be well spent
• Reasonable service times between trains / buses (i.e. 15-30 minutes)
• Negative cultural and environmental impacts
• Rapid transit system will suffer same fate as current transit and be under-utilized
• Must be affordable for riders
• Long-term construction will negatively affect core areas
• Accessibility for those with disabilities
• Bridge construction over the Grand River
• Not enough evaluation given to cost factors (i.e. maintenance and facilities)
• Will rapid transit actually be faster then driving?

10.4. CONSULTATION ON PHASE 2, STEP 3
Interactive public consultation opportunities continued into Phase 2 Step 3 of the Rapid Transit IEA process. In Step 3, three opportunities to formally submit comments and speak to rapid transit project staff were provided. These events included two PCCs and a series of Focus Group Meetings each held in all three cities. Other smaller promotional events were also held in and around the times of the aforementioned functions, which are also detailed in the following sub-sections.

10.4.1. PUBLIC CONSULTATION CENTRE 4
The fourth PCC for the rapid transit initiative was held on June 17th, 19th, and 24th, 2008. 112 comment sheets were received from the public. Members of the Project Team also attended the Multicultural Festival held June 21st and 22nd in Kitchener, the Mill Race in Cambridge on August 2nd and 3rd, and the Busker Festival in Waterloo on August 22nd and 23rd, 2008. The feedback received from members of the public on the submitted comment sheets included:

Question 1 What are your comments on the rapid transit route alternatives?
• Public is concerned with the safety and community impacts of a rapid transit system operating in Waterloo Park.
• In general, the public prefers LRT as they see it as more permanent and more able to encourage investment, while BRT is preferred where there are perceived dangers associated with street tracks.

Question 2 Which routing options (A,B,C, etc.) do you prefer and why?
• In North Waterloo, the public was evenly split between the King Street / University Avenue and Kraus Drive / Northfield Drive options. The public was concerned with impacts on traffic and felt that the rapid transit system should serve both UW and WLU.
• In Uptown Waterloo, the King Street route was slightly preferred; however, there was ongoing confusion with respect to how the system would look and the impact on traffic flow through the area.
• In Downtown Kitchener, Charles Street was preferred over Duke Street, due to the desire for integration with local bus and intermodal transit services.

10.4.2. FOCUS GROUP MEETINGS
A series of Focus Group Meetings were held in September 2008 to gather feedback from the individuals living, working and owning property along the proposed rapid transit route alternatives. Approximately 9,500 addressed invitations were sent out. Only 72 people attended the meetings; however, some participants provided their feedback on the direction of the project. Their concerns included:

• Maintaining driveway access
• Loss of parking, both in lots and on-street
• Noise and vibration caused by LRT vehicles
• Increased congestion resulting from the exclusive use of lanes for rapid transit

These concerns were noted and considered during the development of the preliminary functional designs.

10.4.3. PUBLIC CONSULTATION CENTRE 5 AND STOREFRONT DISPLAYS
The fifth PCC was held on May 19, 21, and 26, 2009. Also, the Region rented commercial / retail buildings in Uptown Waterloo, Downtown Kitchener and Downtown Cambridge (Galt) to present displays on the preferred rapid transit system and to obtain public input and comments. Street front displays were held on June 3, 5, 20, 12, 17, 19, 24, 26 and July 8 and 15, 2009.

The following summarized each of the questions proposed to the public as well as the comments received by the public, up until June 16, 2009.

Question 1 Do you agree with the preferred rapid transit system alternative?

274 responded:
• Yes – 60%
• Questioned part of the preferred system – 15%
• No – 20%
• Undecided – 4%

Some common reasons cited by those who agreed with the preferred rapid transit system:
• Best meets future transportation / growth management needs
• Helps reduce traffic congestion
• Protects the environment
• Attracts jobs and redevelopment in our urban cores
• Provides transportation choice / encourages transit use
• Effective route with well connected stations
• Curbs urban sprawl
• Great alternative for people who do not own cars
• LRT is most cost effective
• Easier to take this opportunity now when it is financially / structurally feasible

Some common reasons cited by those who questioned part of the preferred rapid transit system:

• Want to see LRT extended to Cambridge; aBRT is not an adequate system for Cambridge
• Better to build full system now when costs are less
• Rural areas should be serviced too
• Route alignment (i.e. one-way systems in downtowns, cuts through Waterloo Park)
• Should first build a better bus system, then transition to LRT
• Stops too frequently (or not frequently enough)
• Competes too much with traffic, loss of traffic lanes
• Should extend rail to Sportsworld in first phase instead of stopping at Fairview
• Property tax increases for home owners near route
• Concerns it will fragment street space and make it dangerous for cyclists and pedestrians
• WLU should be included
• LRT should follow a more direct route than what is being proposed
• Concerns about timeliness and convenience of system
• Too many controlled intersections involved.
• Not enough focus on surrounding suburbs
• Need a system that connects region to Toronto
• Overhead wires unattractive
• Rather see east to west transit first
• Noise concerns
• Might interfere with social or cultural uses (e.g. Busker Fest)

Some common reasons cited by those who said they did not agree with the preferred rapid transit system:

• Region lacks population size to sustain system
• The iXpress service is adequate
• Loss of business on King Street
• Limited access points
• LRT not appropriate at this time of high unemployment, job loss, and present debt
• Ridership will not materialize as projected
• Will be seen as a ‘white elephant’
• An expanded bus system would achieve immediate results.
• Eliminates parking
• Winter maintenance
• Lack of development potential
• System is too inflexible in event of emergencies
• Prefers comfort and convenience of driving a car

**Question 2** Which northern Waterloo route option do you prefer and think will best serve the community between the University of Waterloo and Conestoga Mall?

208 responded:

• University Avenue and King Street – 46%
• Spurline – 50%
• Undecided – 4%

Those who chose the University / King option most commonly cited these reasons:

• Better serves university students, who are significant users of transit
• Better re-urbanization and intensification potential
• People who work at R+T Park are less likely to take transit
• Goes through areas of higher residential densities
• More potential riders
• Better to develop now, as future possibilities may diminish over time
• Spurline can be adapted later more easily

Those who chose the Spurline option most commonly cited these reasons:

• Serves large employment area and technology sector
• Faster travel time and less congested
• Easier to build
• Avoids interference with roads
• Provides public transit access to the R+T Park
• University students are seasonal riders

**Question 3** What are potential benefits and impacts of rapid transit to you specifically?

**Potential benefits included:**

- Reduced automobile dependency
- Improved air quality
- Faster commute times between school, home, work
- Reduced ‘carbon footprint’
- Monetary savings
- Creates more vibrant urban spaces for pedestrians
- Cycling becomes more pleasant and safe with fewer cars on road
- Employment opportunities
- Curbs urban sprawl
- Potential multi-modal transportation hub linking VIA Rail, Greyhound, GO
- Less noise impact
- Environmental protection and preservation
- Improves overall quality of life
- Sense of pride in community

**Potential impacts included:**

- Greater traffic congestion
- Interference with downtown festivals
- Increased taxes
- Loss of parking spaces
- Dispersal of traffic onto quiet neighbourhood streets

Those who stated there were no benefits and impacts most commonly cited these reasons:

- Route is not near house
- Walk and bike already
- System will not be built before I graduate

**Question 4** Was the format and content of the information presented at this PCC informative and useful to you?

149 responded:

- Yes – 84%
- No – 16%

The majority of respondents agree that the format and content of the information presented at the PCC were informative and useful. The comments below reflect feedback from all who answered the question, including those who did not specifically answer yes or no to the question.

**Comments that it was informative and useful:**

- Staff were helpful, courteous, friendly and informative
- Level of detail in the large route maps was appreciated
- Information was clearly presented
- More information was provided than at previous PCCs
- Great to have the “take-home” package
- The posters were ordered in an easy to understand method
- The maps were clear
- Questions were answered in full
- People who were not happy with rapid transit were dealt with in a respectful way

**Comments that it was not informative and useful:**

- Information seems slanted to the preferred rapid transit system
- Examples of LRT should be of comparable cities to Waterloo Region
- Found it hard to talk to someone
- Functional diagrams should be more spread out, not overlapping, or printed on a longer page to follow the order better
- Information is already provided on website
- Want more information on technology (e.g. how trains will look)
- A bit text heavy
- Hard to follow the various options
- Too much background noise to listen to video
- Need more information on the rationale
- Seemed that decision was already made and public input was for show
- Regional Councillors were not present

**Question 5** How would you like to be kept informed about the progress of the Rapid Transit Environmental Assessment?

459* responded:

- Information Session – 35%
- Stakeholder meeting discussions – 15%
• Online chat, Blog, or Forum – 16%
• E-mail – 28%
• Other – 6%
* Multiple methods indicated

Over half of respondents indicated they would like to participate in future planning activities for the new rapid transit system through information sessions and e-mail.

**Question 6** How did you hear about this Public Consultation Centre? Please check all that apply.

445* responded:

- E-mail – 16%
- Rapid Transit Newsletter – 19%
- Sidewalk Sign – 13%
- Website – 10%
- News Story – 19%
- Road Sign – 9%
- Other – 14%
* Multiple methods indicated

Respondents indicated they most often heard about the PCC through the Rapid Transit Newsletter and News Story.

**Additional Comments**

The Region received additional comments through comment sheets, e-mails and letters providing comment on the preferred rapid transit option.

**Positive Comments:**

- Curbs sprawl
- Controls gridlock
- Reinvigorate cores
- Reduces congestion
- Beneficial to the environment
- Allows for less car dependency
- Greater speed, comfort and convenience
- Allows for better quality of life
- Support for the Spurline option because neighbouring high tech companies have been anticipating the arrival of rapid transit

**Additional Concerns:**

- Snow removal (weather concerns)
- Additional parking near LRT stations
- Too costly
- Station placements at malls not attached directly to the mall
- Pedestrian safety
- Effects LRT will have on Waterloo Park
- Distance between stations too large
- One way loops

**General Comments:**

- Need to ensure connections with intercity transit
- LRT must accommodate for the elderly and handicapped persons
- Improve bus service instead of building light rail
- Could build tunnels for the LRT to minimize interference and congestion
- Consider expanding the route to Sportsworld to reduce vehicular traffic on Highway 8 and facilitate transfers
- Add a stop at Speedsville and Eagle for residential area to the south of Speedsville Road
- Suggestion for alternate route using existing railway corridors to provide LRT for all three cities
- Suggestion for two proposed LRT route segments in the south part of the Region
- Not all people work in the downtown
- Need to serve outlying towns.
- Is population density sufficient for LRT?
- Details have not been addressed fully in media
- It would have been helpful for the open houses to be publicized more
- Lack of detailed current information on website