Partnership of

Transport Canada Transports Canada

MDOT

Ontario

**Canada-United States-Ontario-Michigan Border Transportation Partnership Planning/Need and Feasibility Study**

# Travel Demand Analysis Process

## Working Paper

January 2004

**Prepared by IBI Group for URS Canada**

# S. Executive Summary

## S.1. Introduction

The travel demand analyses to be carried out for the Ontario-Michigan Border Planning / Need and Feasibility Study and subsequent environmental studies involve the development of a comprehensive travel demand analysis process to estimate future demand at existing and potential new crossings, evaluate potential diversions due to potential new crossings, and to assess the impacts on the connecting road and highway system if a new crossing is built.

This Working Paper provides a review and assessment of available data and modelling/forecasting methods and techniques, and describes the development of a highway/road/rail travel demand analysis process and the Regional Travel Demand Forecasting Model (Regional Model). This process includes the development of a traffic zone system, trip origin-destination tables for cross-border and local background travel, and a road network. The Working Paper also describes the validation of the Regional Model to base year (2000) conditions.

The coverage area for the travel demand analysis process corresponds with a Broad Geographic Area, which comprises Southwestern Ontario and Southeastern Michigan. This includes Windsor-Detroit and Sarnia-Port Huron crossings as well as key points on the road system where decisions to use one crossing instead of another are made.

## S.2. Model Process

Where possible, the process builds on extensive work already carried out various agencies. There are four existing transportation models that have been calibrated and are available for use in this study:

- SEMCOG Model – Tranplan-based model covering Southeastern Michigan;
- MDOT Model – TransCAD based model covering the State of Michigan;
- City of Windsor Model – System II based model covering Greater Windsor Area; and
- MTO Truck Model – Emme/2 based model focused on Ontario, but covering North America.

None of the above models were developed to examine cross-border movements. The four models have different base years and horizon years and with very limited overlap or common elements. It is necessary to build on the existing models to develop a single model that captures travel within the entire study area, with corresponding trip tables for the designated study horizon years.

Two recent major data collection efforts provide the foundation for the development of cross-border vehicular demand forecasts and associated analyses in this study:

- The **Ontario-Michigan Border Crossing Traffic Study** (August 2000). The completed dataset consists of trip characteristics obtained from 22,310 roadside surveys of passenger-vehicles crossing the Ambassador, Blue Water and International (Sault Ste. Marie) Bridges as well as the Detroit-Windsor Tunnel, coded and expanded to represent the total auto volumes at each crossing.
- The **Ontario Commercial Vehicle Survey/National Roadside Study** (summer and fall of 1999). Commercial vehicle data were collected by roadside survey at 238 sites across Canada. The completed dataset consists of about 65,000 observations. The MTO has supplemented this with a further 3,000 observations from an additional collection effort in 2000, and expanded all records to represent the estimated number of trucks operating on a given stretch of highway with the same characteristics.

Data for rail and cross-border goods movement are much more limited. Available data from Statistics Canada and the United States Bureau of Transportation Statistics are highly aggregated with annual statistics provided by border crossing region.

The travel demand forecasting requirements are unique and wide-ranging: the model must be able to respond to broad strategic considerations, yet must also be very detailed, allowing the assessment of conditions on local streets and access roads. An integrated modelling framework has therefore been developed, involving several inter-related processes. In this framework, four streams combine to provide total vehicular traffic and rail freight movements:

- **Regional Model** – This is the primary demand analysis tool, which provides network assignment capabilities for cross-border traffic between Ontario and Michigan for the Broad Geographic Area. The model will provide two levels of network detail, with a more refined level of network detail for Focused Analysis Areas. It must also consider the impacts of tolling at a strategic and local level. Trip tables combining peak hour local travel and cross-border passenger car and commercial vehicle travel will be assigned to the road network within the Regional Model.
- **Cross-Border Passenger Forecasting Process** – A process estimating the total demand for person trips crossing the Detroit and St. Clair Rivers is required. Passenger car demands will be estimated by trip purpose and imported into the Regional Model to be assigned to the transportation network.
- **Cross-Border Goods Movement Forecasting Process** – A process is required to estimate rail and truck flows across the border. Truck results will be imported into the Regional Model and assigned to the transportation network.
- **Micro-Simulation Corridor Model** – After analysis of the Regional Model results, detailed traffic simulations will be undertaken for the travel corridors leading to and from border crossings in the Focused Analysis Area. This will provide an assessment of traffic operations on approach roads and local streets in the vicinity of the crossings, including queuing delay and impacts at each border crossing, and operational and performance measures of traffic. Traffic demand inputs for the micro-simulation analysis will be derived from the Regional Model and calibrated with traffic

and turning movement counts. An important requirement of the micro-simulation analysis will be the modelling of customs/immigration facilities and toll booths.

Various modelling platforms have been evaluated taking into account the modelling requirements and wide-ranging types of analyses needed, resulting in the following recommendations:

- **Regional Model:** The TransCAD package was selected as the platform for the model, due largely to its superior graphic/GIS capabilities and simplified conversion of existing models to TransCAD. TransCAD provides full network assignment and statistical analysis capabilities, which will be used to summarize the assignment results.
- **Micro-Simulation Corridor Model:** CORSIM is a highly flexible and proven tool and is widely recognized in the industry. It provides reasonable graphics and is capable of illustrating various alternatives, and was selected as the micro-simulation platform for this study.

The passenger cross-border and goods movement forecasting sub-models are highly specific and cannot be modelled with off-the-self commercial packages; a spreadsheet-based approach is proposed for these model components. Trend/causal factor analysis and various statistical analysis and estimation techniques, including multivariate regression analysis, will be used to help establish relationships to predict future cross-border traffic by mode/market.

## S.3. Selection of Time Periods for Analysis

The selection of time periods for analysis is one of the most important considerations in the modelling process. For modelling purposes, it is necessary to simulate the peak hour(s) that dictate transportation infrastructure requirements for the crossings and access roads and highways to the crossings.

Historic cross-border passenger and commercial vehicle data from 1995 to 2001 indicate that for combined passenger and truck traffic, August has consistently been the peak month for border crossing traffic.

The peak hours for demand modelling selected for this study include the following:

- A weekday morning peak hour, representative of conditions on a Friday morning between 7:00 AM and 8:00 AM;
- A weekday afternoon peak hour representative of conditions on a Thursday afternoon between 5:00 PM and 6:00 PM.

The above reflect the peak hours in terms of total vehicle demands (cars and commercial vehicles, in passenger-car equivalents).

## S.4. Traffic Zone System

The traffic zone system developed for the Regional model provides a basis for the development of trip tables and road networks. Traffic zone systems from the four existing models were used toward developing the zone system for the Regional model.

In total, the zone system contains 1,489 zones, of which 520 are in Canada and 969 are in the US. All trip origins, trip destinations, population, employment and trip tables within the travel demand model system are based upon this traffic zone system.

## S.5. Development of Trip Tables

Passenger car and commercial vehicle trip tables have been developed for both cross-border and local background traffic. The resulting trip tables have been synthesized to correspond with the two time periods being modeled, and with the study zone system.

The basis for the cross-border *passenger* vehicle trip matrices was the database of survey responses from the **Ontario-Michigan Border Crossing Traffic Study**.

For the Broad Geographic Area and external zone system, trip ends in the survey data were recoded from the approximately 50-zone Super Analysis Zone (SAZ) system to the study's zone system, using various methods depending on how well the SAZ zone corresponded to the study zone system.

For the Windsor/Detroit areas, more detailed coding was required. More refined but incomplete geocoding had also been carried out for locations within the SEMCOG and WALTS areas based on the WALTS and SEMCOG traffic zone systems (88% of SEMCOG/WALTS locations for weekday responses). Previously ungeocoded local trip records were coded to the traffic zone system based on address information of trip origins and destinations where possible, or ascribed to appropriate traffic zones based on geocoded data of similar trips. This additional work increased the usable sample of local trips by 12%.

Expansion factors were developed for the revised passenger vehicle database for each crossing and direction for each of five time periods. To develop peak hour matrices, all peak period records were multiplied by a peak-hour-to-peak-period factor.

The primary source of data for developing the cross-border *commercial* vehicle trip matrices was the Commercial Vehicle Survey database provided by the MTO. This data set is based on the **1999 National Roadside Survey** (NRS), combined with results from the **2000/2001 MTO Commercial Vehicle Survey**.

The geographic information in the NRS/MTO data set was coded to the nearest city or town. This level of detail is suitable for assigning trip origins and destinations to many of the regional and external traffic zones, and for strategic modelling purposes. However, a more refined level of geographic detail for the many origins and destinations in the Detroit or Windsor areas was needed to allow for the required trip assignment precision for trips with at least one end in these areas. In consultation with the Partnership, a methodology was developed and carried out to provide an enhanced level of traffic zone level detail for commercial vehicle travel in the Windsor/Detroit area. The process maintained the NRS/MTO data control totals for each origin-destination pair and the general breakdown by commodity (auto-related and other) and involved combining information and data from the following sources:

- MDOT/SEMCOG external commercial vehicle survey, including survey stations at Ambassador Bridge (1996) and Blue Water Bridge (1994); before using these data, original geocoding to the traffic zone level of detail was carried out;
- home addresses of the carriers associated with the NRS/MTO trip records, where these represented possible legitimate trip origins or destinations;
- trip ends from SEMCOG's internal commercial vehicle trip table, provided for a 2005 forecast year;
- identification of locations of auto plants, parts manufacturers and other major truck generators, and the review of land use and truck route designations in the Windsor/Detroit area;
- discussions with truck and auto industry representatives.

To the extent possible, actual origin-destination survey data were used to provide the additional traffic zone level detail.

The auto industry is a significant contributor to commercial vehicle flows in the study area. The major truck trip origins and destinations of the "Big Three" auto makers are generally dispersed in a wide corridor extending from the Greater Toronto Area, through Southeast Michigan and including nodes in Ohio, Illinois, Missouri, and Kentucky, among others. Daimler-Chrysler is the heaviest generator of local Windsor/Detroit trips.

Among smaller operators and those that use the crossings less frequently than the auto industry, there is a general preference for the Ambassador Bridge crossing. In discussions with the Ontario Trucking Association, it is felt that the reasons for this include greater familiarity with routing and customs brokers at the Ambassador Bridge, not being aware of the recently increased capacity at the Blue Water Bridge, administrative departments of operators preferring to deal with one bridge (typically the Ambassador Bridge) for simplicity, better access to I-75 south of Detroit via Windsor; and a perception of a shorter distance via the Ambassador Bridge for more of the total trips between Ontario and Michigan.

Review of initial commercial vehicle origin-destination travel matrices resulted in the identification of a bias in the expansion of the NRS/MTO data as provided by MTO, with the expanded NRS/MTO database significantly under-representing local trips. To correct for this, the proportions of long-distance and local trips for each crossing derived by using all expanded records were adjusted to reflect proportions derived by using those records representing surveys undertaken at the respective border crossings only.

Peak-hour trip data from the SEMCOG Model and the WALTS Model are used to develop trip tables for background vehicular traffic. Both the SEMCOG and WALTS Models include border crossing trips, but with insufficient trip detail on the other side of the border. These trips are therefore extracted from the respective trip matrices. PM peak hour matrices were developed from each model, with the resulting matrices adjusted using a Fratar balancing process to reflect a year 2000 trip matrix. Since the SEMCOG and WALTS Models do not simulate the AM peak hour, PM peak hour travel was transposed to reflect AM peak hour travel, and factored to match the observed AM to PM peak hour traffic ratios across screenlines. The SEMCOG matrices provided for this study were reflective of combined passenger car and truck trips. To reflect the impacts of trucks in the WALTS matrices, the passenger car matrix (excluding cross-border movements) was increased by 5%.

For the two Windsor-Detroit Crossings (approximately 40 million in 2001), Windsor Transit bus passengers represent about 0.6% of the total passenger market and will not be modelled in detail. The approximate mode share for the intercity bus component of cross-border passengers is estimated to be 2.9%. Given its relative significance, intercity bus ridership will need to be given consideration in the development of future traffic forecasts.

Passenger rail accounts for approximately 0.2% of the total number of border-crossing person trips. The passenger rail mode is assumed, at least for the base case, to remain constant in terms of its relative mode share. Rail freight is not modelled within the Regional Model transportation network.

The amount of people crossing the Ontario-Michigan Border as pedestrians or cyclists is extremely small and therefore not considered further in this study.

The Detroit-Windsor truck ferry handles about 40 trucks per day on average (less than 0.3% of truck traffic at Detroit-Windsor crossings). Given the unique nature of ferry services, it is not considered possible or appropriate to apply traditional demand forecasting and assignment techniques for this service.

## S.6. Transportation Networks

Network development was based on the road networks from the four available models previously described. Networks developed in other platforms besides TransCAD were converted to TransCAD, and the networks were merged to provide a single comprehensive and coherent network for the year 2000. The composite network was developed as follows:

- Windsor Area – based on networks from the WALTS Model;
- Rest of Southwestern Ontario – based on road and highway links from the MTO model;
- SEMCOG Area – SEMCOG network was simply adopted for the entire SEMCOG area, rather than “mixing-and-matching” the SEMCOG and MDOT networks;
- External to SEMCOG Area – based on MDOT networks, connected only to SEMCOG network at the SEMCOG county borders.

Considerable effort was required to ensure that the networks for the different areas were consistent and compatible. A unified road link type classification system was developed based on the existing WALTS and SEMCOG models and consisting of nine road classifications. Two additional classes of links representing cross-border exit customs and entry customs were also defined. The SEMCOG Model's volume-delay functions were adopted for all network links in the composite network. Link speed and capacity values have generally been adopted from the source networks except where changes were required for additional calibration or to make the links consistent with a year 2000 peak hour model.

Roadbed capacities of border-crossing facilities are based on level-of-service E. For model calibration, the following two-way hourly capacity values were used: Ambassador Bridge – 7,000 passenger car equivalents (PCEs), Blue Water Bridge – 11,000 PCEs, Detroit-Windsor Tunnel – 3,050 PCEs.

## S.7. Model Validation

Validation of the base-year model involves assigning the total base-year demand trip table to the existing road network within TransCAD, and then comparing observed volumes at border crossings, on highways and other major road links with the model-predicted values. Where significant discrepancies exist, changes are made to the model to better capture travel interactions and dynamics in the study area.

Before calibrating the model, it is important to understand the basic factors that could influence the route choice of travellers. These include the following:

- border crossing fees – these could influence choice of crossing for commercial vehicles more than for passenger vehicles;
- driving distances – a routing through Sarnia-Port Huron can result in shorter driving distances for several major origin-destination pairs, although it may be perceived that a Detroit-Windsor routing is more direct;
- border-crossing times – delays for passenger vehicles are generally much shorter than for commercial vehicles;
- congestion – choice of crossing is relatively sensitive to congestion levels on access routes; congestion delay diverts trips from the Detroit-Windsor Tunnel to the Ambassador Bridge, and from the Detroit-Windsor crossings to the Blue Water Bridge during peak periods; and
- physical constraints – e.g. the Detroit-Windsor Tunnel cannot accommodate large trucks due to height and length constraints.

To calibrate the model at a strategic level, a factor was applied to capture preferences in crossing at Windsor-Detroit, all other factors being equal. A 14-minute adjustment factor for the Sarnia/Port-Huron routes, applied on Highway 402 outside Sarnia so as not to distort local Sarnia/Port Huron trips, was found to provide good model calibration during the peak periods. At a local level, a 2-minute penalty applied at the Detroit-Windsor

Tunnel was sufficient to best replicate the existing distribution between the bridge and tunnel.

A considerable level of care was taken to develop the best possible model while minimizing the number of correction factors and adjustments needed to achieve reasonable traffic assignments. In general, the assignments appear reasonable based on current observations and data, including the allocation of trips between the crossings and the access/egress facilities used to reach these crossings.

## S.8. Next Steps

The process and tasks described in this report have resulted in a calibrated transportation model that will be used to assign future trip matrices and evaluate border-crossing needs. The findings will be summarized in the **Existing and Future Travel Demand Working Paper**. The travel demand forecasts and findings will be a major input into the Analysis Area Working Paper, which will provide the rationale for the boundaries of the Focused Analysis Area.

The validated model will be used to produce Base Case runs for 10, 20 and 30 years in the future, which will provide auto and truck volumes, rail and transit passenger volumes, and truck and rail goods movement volumes from the Regional Model: The forecasts will be developed on the “most probable” set of future assumptions, as determined by the Study Team in consultation with the partnership agencies.

Two or three alternative demand scenarios will be developed for sensitivity testing purposes. These runs will involve changes in some of the key input parameters such as population and employment levels and their distribution, future economic conditions, as well as different assumptions regarding future trip-making behaviour (e.g. trip rates, modal split, etc.). The specific definition of the sensitivity runs will be undertaken in consultation with the Project Team during the study.

# Travel Demand Analysis Process Working Paper

**List Of Appendices**

## List of Exhibits

# Preface

The Canadian, U.S., Ontario and Michigan governments are conducting a Needs and Feasibility Planning Study to provide a long-term strategy that will ensure the safe and efficient movement of people, goods and services between Southeast Michigan and Southwest Ontario. The study will assess the existing transportation network, including border crossings and will identify medium- and long-term transportation needs, alternatives and potential new crossings in the region of Southeast Michigan and Southwest Ontario.

The context under which this study was carried out, the justification for the project and the issues and opportunities to be addressed by the study is documented in the **Transportation Problems and Opportunities Report.** This Report incorporates the findings of four technical Working Papers:

- Strategic and Geographic Area Working Paper;
  - Will set the context of the study in terms of identifying jurisdictions involved and their respective legislation and policies which provide the framework for this study.
- Travel Demand Analysis Process Working Paper;
  - Determines the appropriate methodology to be used for travel demand forecasting.
- Existing and Future Travel Demand Working Paper;
  - The description, analysis and assessment of existing and future scenarios for road and rail to develop a quantitative and qualitative understanding of travel demand.
- Environmental Overview;
  - Inventory existing conditions to assist in the generation and evaluation of alternatives.

The Transportation Problems and Opportunities Report provided the basis for the identification, development and assessment of transportation alternatives.

# 1. Introduction

The travel demand analyses to be carried out for the Ontario-Michigan Border Planning / Need and Feasibility Study and subsequent environmental studies involve the development of a comprehensive travel demand process to estimate future demand at existing and potential new crossings, evaluate potential diversions due to potential new crossings and to assess the impacts on the connecting road and highway system if a new crossing is built.

The modelling techniques will analyze auto, truck, rail and inter-city bus modes to estimate future growth in traffic over a 30-year horizon at Ontario-Michigan border crossing and related access facilities. It will provide the following:

- 10, 20 and 30 year traffic volume estimates at international crossings;
- projections of auto and truck traffic volumes on provincial, state and national highways;
- projections of auto and truck traffic volumes on major regional and municipal arterial roads that are connected to the international crossings;
- projections of passenger and freight carried on rail lines at international crossings.

A range of infrastructure and socio-economic scenarios will be examined, with the resulting travel demand analyses providing key inputs into the analysis of alternatives to address mid-term and long-term cross-border needs.

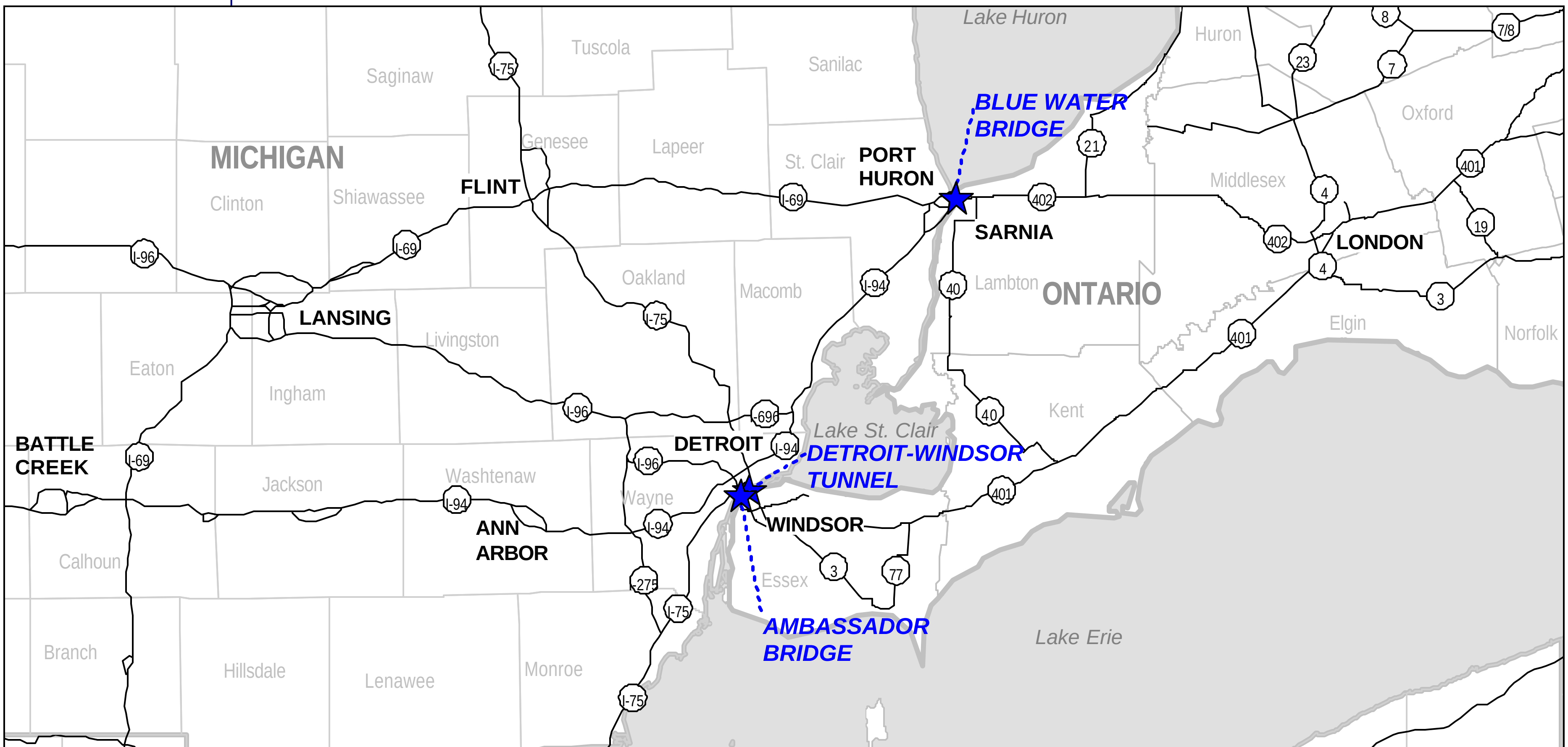
## 1.1. Analysis Area

The coverage for the travel demand analysis process corresponds with the Broad Geographic Area, which includes Windsor-Detroit and Sarnia-Port Huron crossings to allow an assessment of the relative traffic flows by mode and diversions between the two crossing locations and their associated needs and deficiencies. The Broad Geographic Area, as defined for this study, is shown in Exhibit 1.1 and comprises Southwestern Ontario and Southeastern Michigan. This geographic coverage is sufficiently large to capture key decision points on the road system where motorists must determine which crossing location they intend to use (e.g. Windsor/Detroit or Sarnia/Port Huron).

## 1.2. Purpose

The purpose of this Working Paper is to document the development and validation of the travel demand analysis process to be used in this study and subsequent environmental studies, including methodology, model structure, components/modules, model platform and validation results. It includes:

### EXHIBIT 1.1: BROAD GEOGRAPHIC AREA



- a review and assessment of available data and modelling/forecasting methods and techniques; and
- the development of a highway/road/rail travel demand analysis process and the Regional Travel Demand Forecasting Model (Regional Model), including:
  - the development of the traffic zone system;
  - the development of trip tables, describing cross-border passenger car and commercial vehicle travel and local background (intra-Windsor Area and intra-Detroit Area) travel;
  - the development of the road network;
  - the validation of the Regional Model to base year (2000) conditions.

As part of the base year model validation process, this report also presents selected information on existing travel data and travel patterns where appropriate to provide context for the development of trip tables and general modelling assumptions. The subject of existing and future travel demand will be covered in detail in the **Existing and Future Travel Demand Working Paper**.

## 1.3. Report Organization

This Working Paper is organized in seven chapters. Following this introduction, Chapter 2 provides an overview of the model process and approach. Chapter 3 describes the analyses undertaken to select the peak hour time periods for modelling and infrastructure design purposes. Chapter 4 provides an overview of the development of the traffic zone system. Chapter 5 documents the development of trip tables corresponding to the traffic zone system. Chapter 6 discusses the development of road networks and the associated modelling parameters. Chapter 7 summarizes the validation and the results of this process. Finally, Chapter 8 discusses the next steps.

# 2. Model Process

This chapter provides an overview of the travel demand model process and provides the rationale for its development based on an assessment of forecasting requirements, available data sources and available transportation models and techniques.

## 2.1. Existing Transportation Models and Data Sources

A guiding principle of the travel demand analysis process is to develop an integrated and consistent forecasting approach that builds on extensive work that has already been undertaken by various agencies (EBTC, SEMCOG, MDOT, MTO, USDOT, Transport Canada and City of Windsor) through previous traffic studies, developing transportation models and collecting and analyzing data.

***Existing Transportation Models***

There are four existing transportation models that have been calibrated and are available for use in this study:

- SEMCOG Model[1] – Tranplan based model covering Southeastern Michigan;
- MDOT Model – TransCAD based model covering the State of Michigan;
- City of Windsor Model – System II based model covering Greater Windsor Area; and
- MTO Truck Model – Emme/2 based model focused on Ontario, but covering North America.

There is no existing traffic model for the Sarnia Area. The main attributes of the four models are summarized in Exhibit 2.1, with more detailed descriptions of each model provided in Appendix A. The four models cover four different study areas, with the network detail emphasizing one area with limited treatment of the other. None of the above models were developed to examine cross-border movements. The four models involve four different modelling platforms, with different base years and horizon years and with very limited overlap or common elements. From a technical standpoint, it is necessary to build on the existing models to develop a single model that captures travel within the entire study area, with corresponding trip origin-destination tables for the designated study horizon years.

[1] SEMCOG is in the process of converting their regional model to TransCAD. It will incorporate new data, with the 2030 Regional Development Forecast available in about two years.

### EXHIBIT 2.1: CHARACTERISTICS OF EXISTING TRANSPORTATION MODELS

| Model/ Study | MTO Truck Model | Michigan Statewide Travel Demand Model | SEMCOG Model | City of Windsor |
|---|---|---|---|---|
| **Model Platform** | EMME/2 | TransCAD | TRANPLAN | SYSTEM II |
| **Model Area** | Ontario | Michigan + North America | SEMCOG Counties | Windsor + area |
| **No. of Zones** | 49 in Ontario | 2392 | 1505 | 507 |
| **Time Period** | 24hr | 24hr | 24 & PM Peak hour | PM Peak hour |
| **Base Year** | 1995 | 1991 household survey | 1994 household survey | 1996 |
| **Future Horizons** | 2021 | 2000, 2005, 2010, 2015, 2020, 2025 | 2000, 2005, 2025 | 2016 |
| **International Traffic** | Modelled | Trucks modelled; Auto demand exogenous | Exogenous | Explicit growth rates on observed base |
| **Strengths** | Cross-border trips validate well; Good broad area detail | Good broad area detail, Many horizon years | Detailed Network in focus area; Comprehensive survey | Good external trip basis from 1997 surveys; Detailed network in focused area |
| **Weaknesses** | Data used do not capture trips terminating near border | Old trip patterns; Less detailed in focused area than SEMCOG | Must develop horizon year matrices | No modelling of external trip growth; Early future horizon |

The four models cover four different study areas, with the network detail emphasizing one area with limited treatment of the other. None of the above models were developed to examine cross-border movements. The four models involve four different modelling platforms, with different base years and horizon years and with very limited overlap or common elements. From a technical standpoint, it is necessary to build on the above to develop a single model that captures travel within the entire study area, with corresponding trip origin-destination tables for the designated study horizon years.

### *Existing Data Sources*

A major recommendation of the *1997 Eastern Border Transportation Coalition (EBTC) Trade And Traffic Across the Eastern U.S.-Canada Border* study was to undertake major data collection efforts to provide quality cross-border traffic data, describing trip characteristics with trip origins and destinations for all modes, but particularly for private automobiles and commercial vehicles. This and other related initiatives have resulted in two major data collection efforts, which provide the foundation for the development of cross-border demand forecasts and associated analyses in this study.

The **Ontario-Michigan Border Crossing Traffic Study** was conducted in August of 2000 under the lead of both the Ontario Ministry of Transportation and the Michigan Department of Transportation. It consisted of a minimum 5% sample of passenger vehicles crossing the Ambassador, Blue Water and International (Sault Ste. Marie) Bridges as well as the Detroit-Windsor Tunnel. The main objectives were to collect trip origin and destination information as well as trip purpose, frequency and duration data from vehicles crossing in both directions. This was accomplished by means of roadside surveys conducted for 24-hour periods at all crossings for several weekdays and one Saturday. Traffic counts by vehicle classification were also collected at all crossings. The completed survey consists of 22,310 observations (representing 7.9% of all non-commercial vehicles), which were subsequently coded and expanded to represent the total auto volumes at each crossing.

The **Ontario Commercial Vehicle Survey/National Roadside Study** was conducted in the summer and fall of 1999 through a joint effort among the Canadian Council of Motor Transport Administrators and federal, provincial and territorial transportation authorities. It was partially funded by the Eastern Border Transportation Coalition. Data were collected at 238 sites across Canada only, each for a one-week period, and targeted cargo and heavy trucks (i.e. with gross vehicle weights greater than 4,500 kilograms). The survey elicited 241 characteristics of the truck, cargo, trip, driver and carrier. As such, the resulting data set can be used to quantify truck traffic in several ways, including the number of trips, the weight of cargo, the weight of trucks making the trips and the distance travelled and an inputted value of cargo. The completed survey consists of about 65,000 observations, which were expanded to meet the estimated number of trucks operating on a given stretch of highway with the same characteristics. The MTO has supplemented this Commercial Vehicle Survey with an additional data collection effort in 2000, which provided travel data for a further 3,000 cross-border commercial vehicle trips. In total, this corresponded to an approximate 9% sample rate of trucks during the survey.

While the above provide a rich database as a basis for forecasting vehicular travel, available data for rail and cross-border goods movement are much more limited. Data on rail and cross-border goods movement available through Statistics Canada and the United States Bureau of Transportation Statistics are quite limited. However, the available data are highly aggregated with annual statistics provided by border crossing region. The competitive environment of the private sector means that access to more detailed data is often restricted or limited.

A summary of the available data sources is provided in Appendix B.

## 2.2. Model Framework

The travel demand forecasting requirements are unique and wide-ranging, reflecting the many complexities of the study. At one level, the model must be able to respond to broad strategic considerations, such as the potential for the Blue Water Bridge to help address delays at Windsor-Detroit crossings or the impact of shifts in goods movement between rail and truck modes. At another level, it must be very detailed, allowing the assessment and testing of roadway designs to ensure that local streets and access roads to international crossings will perform at a reasonable level-of-service. The process must therefore provide a comprehensive demand picture, covering many technical areas, as described in Exhibit 2.2. These forecasting needs are quite diverse and will require several models and techniques, which are described in the following sections.

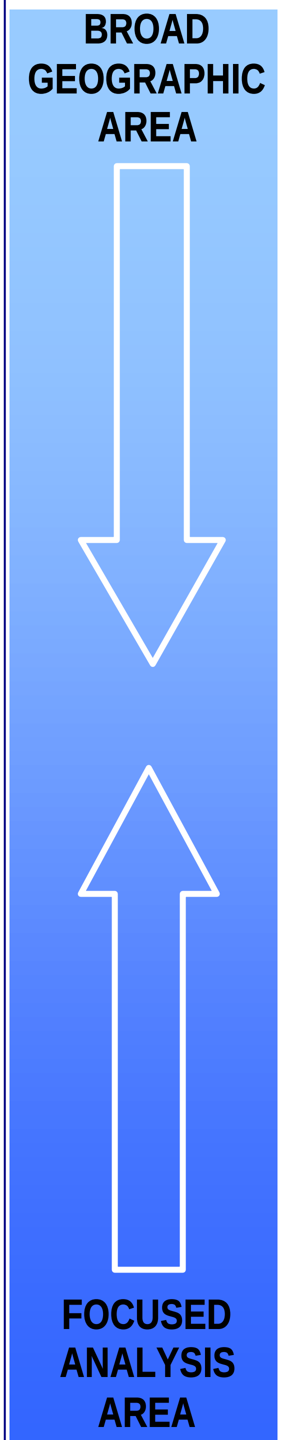
An integrated modelling framework has therefore been developed, involving several inter-related processes. Exhibit 2.3 provides an overview of this model process and the stages leading to the development of traffic forecasts, including the key model inputs and forecasting processes.

Four streams are defined in the process, which combine to provide total vehicular traffic and rail freight movements:

- **Regional Model** – This is the primary demand analysis tool, which will provide network assignment capabilities for cross-border traffic between Ontario and Michigan for a geographic area corresponding to the Broad Geographic Area.
- **Cross-Border Passenger Forecasting Process** – A process is required to estimate the total demand for persons crossing the Detroit and St. Clair Rivers. Passenger car demands will be estimated by trip purpose and imported into the regional model to be assigned to the transportation network. The process will also project passenger rail and bus person volumes and possible interactions/diversions with passenger car traffic.
- **Cross-Border Goods Movement Forecasting Process** – A process is required to estimate rail and truck flows across the border. Truck results will be imported into the main regional model and assigned to the transportation network. This process will also consider cross-border movements by ferry, which is used to transport dangerous goods.
- **Micro-Simulation Corridor Model** – After analysis of the Regional Model results, detailed traffic simulations will be undertaken in the next stage, which will analyze the alignments leading to and from border crossings in the Focused Analysis Area. This will provide an assessment of traffic operations on approach roads and local streets in the vicinity of the crossings, including queuing delay and impacts at each border crossing and operational and performance measures of traffic. Traffic demand inputs for the micro-simulation analysis will be derived from the Regional Model and calibrated with traffic and turning movement counts.

A description of the proposed modelling platforms is provided in the following section, with Section 2.5 providing details on the methodology for each model/sub-model.

### EXHIBIT 2.2: REQUIRED LEVELS OF ANALYSIS




**Multi-modal demand forecasting** – The approach must be capable of forecasting truck and rail movements including the interaction and diversions between truck and rail goods movement.

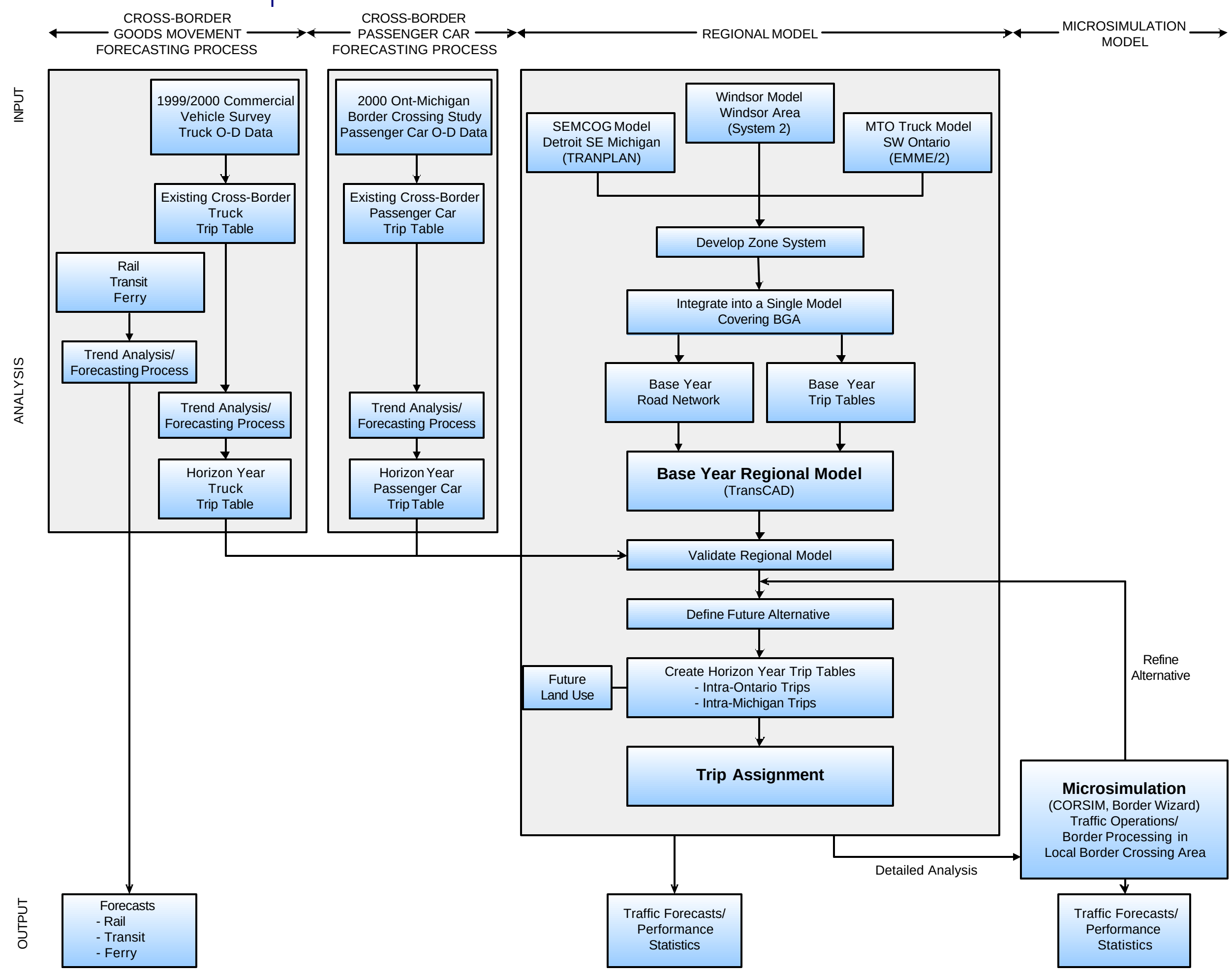
**Strategic level demand forecasting** – A strategic approach is required to examine demand flows between United States and Canada and to forecast people, vehicle and goods movement flows across the Michigan-Ontario border. The process must also be capable of determining relative flows between Sarnia-Port Huron and Windsor-Detroit crossings and identifying areas of future needs and deficiencies to undergo more focused analysis.

**Toll traffic and review estimates** – Future cross-border traffic will be affected by future toll levels, which in turn affects toll revenues. As well, there is the potential to toll new highway facilities constructed to feed directly to a new or existing border crossing. Modelling procedures must reflect the relationship between toll rates and traffic levels for different vehicle classes for bridge crossings and value-of-time and potential travel time savings if potential toll highways are to be examined.

**Sub-area demand forecasting** – The strategic level analysis will identify subarea(s) with existing or future needs and deficiencies, which will be subject to more detailed analysis. Within the modelling process, the sub-area or focused area will include all roads in the vicinity of border crossings where major needs have been identified, with the ability to examine demand and diversion/demand levels between crossings within the focused area. This will capture typical cross border traffic flows, comprising commuter, business and recreational/non-work traffic, overlaid on local traffic to address the impacts and implications on the road system leading to border crossings.

**Micro-simulation analysis** – A regional modelling approach is not capable of accurately simulating traffic at a local corridor level, as it cannot capture traffic signal operations, turning movements at intersections, traffic signals, border processing delays, and queuing impacts that are vital part of the assessment of cross-border alternatives. A micro-simulation approach tracks individual vehicles within the local area, which can provide a more theoretically sound basis to examine the diversion and routing of traffic, traffic operations, network performance levels and queuing impacts, while explicitly considering different assumptions in border processing rates and its associated variability.

## EXHIBIT 2.3: CONCEPTUAL MODELLING FRAMEWORK



## 2.3. Selection of Model Platforms

Various modelling platforms have been evaluated and recommended based on the modelling requirements and taking into account the wide-ranging types of analyses that are required. The selected modelling packages are summarized in Exhibit 2.4. As discussed later in Section 2.5, the passenger cross-border and goods movement forecasting sub-models are highly specific and cannot be modelled with off-the-shelf commercial packages; a spreadsheet-based approach is proposed for these model components.

### EXHIBIT 2.4: ANALYSIS TOOLS

| Level of Analysis | Tool | Purpose |
|---|---|---|
| Broad Area | TransCAD regional model | ***Strategic Assignment***<br>– Assessment of regional demand, problems and opportunities<br>– Interaction between Port Huron/ Sarnia and Detroit/Windsor crossings,<br>– Interaction between rail and road modes<br>– Impact of strategic network changes<br>– Demand for focused area |
| Focused Area | TransCAD regional model | ***Local assignment***<br>– Interaction between existing and potential new crossing(s)<br>– Interaction of international traffic within local traffic conditions<br>– Modelling of peak and off-peak conditions<br>– Impact of local infrastructure changes<br>– Corridor demand for micro-simulation model |
| Corridor | CORSIM micro-simulation model | – Local operations<br>– Congestion related to crossing facilities<br>– Turning movements and queuing at local intersections<br>– Impact of changes to facility design and operations |
| | Border Wizard micro-simulation model | – Local operations<br>– Movement at the border crossing<br>– Congestion related to crossing facilities<br>– Optimizing plaza layouts |

**Regional Model**: Based on a review of the models, as well as discussions with agency staff responsible for the operations of each of the models, the TransCAD package was selected to be the modelling platform for this study, with existing models to be converted to this modelling platform. TransCAD is currently used by MTO [2], SEMCOG [3] and MDOT.

[2] MTO's Data Management and Analysis Office uses TransCAD to assist in the coding of travel data. Transcad is not presently being used by MTO for travel demand forecasting purposes.

The decision to use TransCAD was based to a large extent on its superior graphics/Geographic Information System (GIS) capabilities as well as the fact that converting existing networks from the SEMCOG and Windsor models can be simplified through the use of existing network conversion utilities within TransCAD. As well, MDOT, SEMCOG and MTO each have in-house TransCAD capabilities and expertise, providing support and transferability benefits. Emme/2 was also a strong contender, given that it meets the modelling needs of the study, its open architecture benefits, and the high level of expertise among the Consultant Team members. However, Emme/2 would not provide as much transferability and is not as convenient for converting existing models.

**Micro-Simulation Corridor Model:** In recent years, a number of micro-simulation models have become commercially available. These micro-simulation models are capable of simulating "car following" and "lane change" behaviour of drivers on a second-by-second basis. The attraction of micro-simulation models is that they can capture a high level of detail in specific corridors including lane geometry, signal timing/phasing and other factors that affect capacity. Two of the most recognized micro-simulation models that would meet the requirements for this study are CORSIM and Paramics. The Synchro/Simtraffic package was also considered but ruled out due to the fact that Simtraffic is not a true micro-simulation model (i.e. vehicle movements are not tracked throughout the network but instead are estimated at each intersection based on turning movements) and therefore does not provide the level of sophistication that is anticipated for this study. Another modelling package called WATSIM, which is an enhancement of CORSIM, was also considered. WATSIM is well suited to simulating border crossings and toll booths, but requires specialized programming to be carried out by the model developer in order to be fully operated to its potential. It was determined that CORSIM meets all of the requirements for this study and will be the micro-simulation model for this study.

CORSIM is a software system developed by the Federal Highway Administration (FHWA) that consists of several modules that can be used to analyze traffic operations in an urban area or corridor. The two main components of CORSIM are FREESIM and NETSIM, the former dealing with freeways and the latter dealing with urban street traffic. NETSIM is based on a car following technique whereby each vehicle is a distinct object and moves through the network in discrete time intervals. Vehicles respond to traffic control and other network demands, including parked cars, stopped buses and congestion. CORSIM is a highly flexible and proven tool and is widely recognized in the industry. The graphics provided by CORSIM are reasonably good and is capable of illustrating various alternatives.

Border Wizard is a highly specialized micro-simulation model, developed for the US Customs Agency and recently acquired by Canadian Customs and Revenue Agency (CCRA). The model is capable of assessing the impacts/benefits of various plaza configurations and border processing requirements, given defined cross-border demand and supply characteristics. This tool may be available to the Study Team and, if available, will be used where appropriate.

[3] SEMCOG is in the process of converting their Regional Model to TransCAD.

## 2.4. Regional Model

The Regional Model provides network assignment capabilities that will be used to estimate flows and routings for automobiles and trucks. It will provide two levels of transportation network detail for a geographic coverage area corresponding to the Broad Geographic Area.

The minimum level of network detail will reflect a strategic transportation network of provincial/state highways and major regional/county roads leading to the Detroit-Windsor and Port Huron-Sarnia border crossings.

A refined level of network detail is required to perform sub-area level analyses, which will be undertaken in this study for areas identified as Focused Analysis Areas based on existing and future needs/deficiencies and other considerations later in this study. The level of detail in a Focused Analysis Area will correspond to the level of accuracy typically provided in comprehensive urban transportation models, which includes all collector and arterial roads and highways and a detailed traffic zone system. This level of detail will allow analyses of traffic flows and conditions on all roads/highways in the vicinity of the border crossings in the Focused Analysis Area(s), as well as the impact of diversions from existing to proposed cross-border facilities. Subsequent work will be required to review the zone system for the identified Focused Analysis Area(s).

***Toll Traffic and Revenue Forecasting Capabilities***

The impacts of tolling on traffic levels may be required at two levels. At a strategic level, different toll levels and toll policies will have an impact on overall demand levels. At a local level, different tolls for individual facilities or routes would have an impact on routing choice.

The above traffic modelling process will provide cross-border traffic at bridges and tunnels assuming no real increase in toll rates by vehicle type. However, an increase in tolls will normally result in a decrease in vehicular traffic thereby affecting total traffic volumes and revenues collected. To assess these changes, an elasticity-based model (executed within a spreadsheet) will be developed to assess changes in truck and passenger car traffic levels at different toll rates. The degree of elasticity is dependent upon the trip purpose and the type of vehicle, where elasticity is defined as the ratio of the percentage change in traffic to the percentage change in tolls. For example, longer distance passenger trips are fairly inelastic to different toll levels as the toll represents a small portion of the overall trip cost. Conversely, shorter distance trips tend to be highly elastic, with tolls levels being a key factor in travel choices. Toll elasticities will be determined based on historic data for Ontario-Michigan crossings and industry data and applied to each vehicle type. The future stream of traffic and revenues will feed into the Revenue Generation Report.

In addition to border crossings, it is also possible that new road/highway infrastructure to border crossings could be tolled if it were to provide significant travel time benefits to existing conditions. In this event, a toll diversion algorithm (logit model), applied by the

Consultant Team on previous toll traffic and revenue forecasting studies for the MTO could be applied. This algorithm is used to predict the proportion of auto drivers and trucks that will use the toll facility based the utility of toll and non-toll route paths calculated from travel time, vehicle operating cost and toll rate for the origin-destination of the trip and the user's value of time. Revenue streams from this source, if examined, will also feed into the Revenue Generation Report.

## 2.5. Cross-Border Passenger Forecasting Process

***Passenger Sub Model***

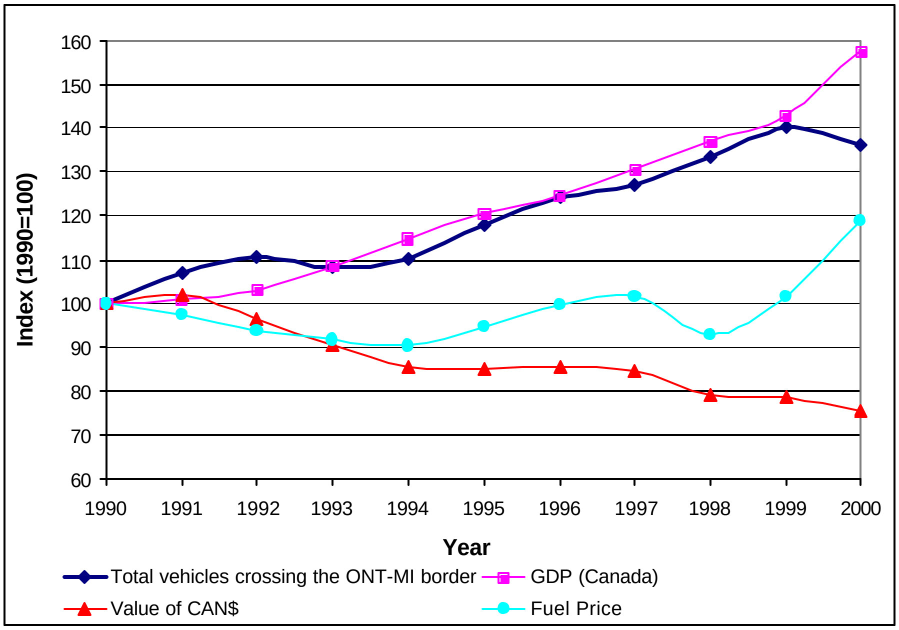
The passenger sub-model will provide estimates of future cross-border person-trips by the following modes:

- passenger car;
- bus;
- passenger rail.

The use of complex mathematical models to estimate cross-border traffic has proven to be extremely difficult in the past, with no single model being capable of capturing all of the relationships and interactions between the different modes and markets/sub-markets describing cross-border travel. This finding is also supported by a review of forecasting techniques employed in previous cross-border studies, as provided in Appendix C. A major reason for this difficulty is the lack of highly disaggregate cross-border data on which to establish firm causal relationships to quantify trip-making attributes. However, the large influence and uncertainty associated with many key factors, including international trade (e.g. NAFTA, Auto Pact), policies (e.g. tariffs, tobacco taxes), US/Canada economies (e.g. exchange rate, imports/exports, GDP growth) and others (e.g. casinos, border processing times), have overwhelmed the predictive ability of any mathematical model. As such, any forecasting approach to estimate future cross-border demand, while supported by solid technical analysis, must reflect the complex dynamics and on-going structural changes in the Canadian/United States economies that so dramatically influence cross-border traffic and trade and which cannot be captured within a mathematical model.

Recognizing future uncertainties, a forecasting approach that is based on expert opinion, consensus on key assumptions, sensitivity testing and a solid fundamental understanding of the factors and rationale behind key assumptions will be applied. The approach focuses on establishing an understanding of past trends and causal relationships influencing Ontario-Michigan cross-border traffic in qualitative terms, with quantitative techniques used where appropriate to supplement this knowledge and executed within a spreadsheet. Trend/causal factor analysis and various statistical analysis and estimation techniques, including multi-variate regression analysis, will be used to help establish relationships to predict future cross-border traffic by mode/market. As an example, Exhibit 2.5 shows a plot of past trends in annual border passenger volumes versus various economic and socio-economic factors to help identify causal relationships. A multi-variate regression analysis will be built on cross-border regression analysis previously undertaken by MDOT, as well as findings from EBTC analyses. The regression analyses will include diagnostic analyses of multi-colinearity in selected independent variables.

### EXHIBIT 2.5: ILLUSTRATIVE EXAMPLE OF RELATIONSHIP BETWEEN PASSENGER BORDER CROSSINGS AND SOCIO-ECONOMIC FACTORS




Source: Annual vehicle Crossings – SEMCOG; GDP – Canadian Economic Observer; Value of Canadian Dollar – T-facts (1990-99), Bank of Canada (1995 – 2000); Fuel Price – Transport Canada T. Facts.

This general methodology will be applied to each of the passenger car, passenger rail and bus modes to the extent possible with available data. Given the large uncertainty in predicting key input variables (e.g. value of Canadian dollar), sensitivity analyses will be undertaken on these key variables to examine the possible range in the forecasts.

The result of the trend analysis/forecasting process will be growth rates by trip purpose (e.g. commute, vacation/recreation) for passenger car trips by decade, with a qualitative rationale and justification for the selection of the given growth rates. For the passenger rail and bus modes, overall growth rates by decade will be developed because of the lack of availability of detailed market data for these modes. In some instances, a range will be provided, recognizing that a high level of future uncertainty exists and the impact of different but equally realistic future assumptions. The resulting growth rates will be applied to the trip table describing existing cross-border travel flows (i.e. travel data from the Ontario-Michigan Border Study Traffic Survey) to represent the horizon year cross-border traffic levels. The future distribution of productions and attractions will be adjusted in a

"Fratar" like manner to reflect relative increases in population and employment in various areas and expected growth areas in vacation/recreation traffic. The resulting horizon year cross-border trip tables for passenger cars will be input into the Regional Model and will be assigned to the road network with other local and intra-state/provincial traffic and cross-border truck traffic as described below. The process will also examine the possibility of diversion of passenger car traffic to the passenger rail and bus modes. At present, these modes carry a very small proportion of the cross-border passenger traffic. As such, the determination of potential diversion will be undertaken through an expert opinion approach, based on the understanding of trends, future directions and anticipated transportation improvements by the various modes, as developed in this task. The projected levels of diversion, if any, will be supported by technical analysis to the extent possible and based on the study team's opinion of the "most probable" future scenarios for the rail and bus modes.

## 2.6. Cross-Border Goods Movement Forecasting Process

Following a similar approach and rationale to that described above for the Cross-Border Passenger Forecasting Process, the goods movement forecasting process will involve a trend/causal factor analysis supplemented by other available information sources (e.g. employment by sector, economic forecasts, international trade data/reports/forecasts, etc.) executed within a spreadsheet. This approach reflects the large uncertainties and difficulties in predicting goods movement flows and cross-border traffic, with emphasis on developing a strong qualitative understanding of cross-border movements. Historic trend data and other data will be used to develop relationships and factors, supplemented with discussions with Agency staff who are knowledgeable in the goods movement area. Multi-variate regression analysis will also be used to provide insight into the relative contributions of the various factors influencing demand. In addition, a significant amount of research has been undertaken in the areas of US- Canada trade, impacts of Free Trade and future directions for cross-border trade and travel, which will be exploited.

Also, the impacts of new technologies will be examined when considering future characteristics of truck and rail systems. This will require insights with respect to the impacts on the economy (e.g. new spatial patterns of the auto industry) and their related transportation impacts (just-in-time delivery and e-commerce impacts) and the impacts of new technology on border crossing and management (e.g. pre-clearance). Combining planning judgement, the study team's understanding of the factors influencing past trends and how those factors will change in the future, and other available information, a procedure will be developed that is traceable with identified markets, factors and relationships used to determine growth.

A key challenge in goods movement forecasting will be in establishing the relative distribution of goods carried by rail versus truck. Again, the development of a detailed statistical model to determine rail/truck shares is not considered appropriate since it is dependent upon policy, economic competitiveness issues, industry trends, and major infrastructure decisions, among others, which are highly unknown and which are beyond the ability to model credibly. The approach for this study will be to develop a "most probable" future scenario of the future characteristics of the truck and rail systems and ,combined with trend data, to make reasonable judgements using expert opinion, supported by analysis, where possible. The process will involve the following:

- A review of literature describing current truck, rail and intermodal goods movement trends and projections;
- Discussions with representatives of government, the carriers and other stakeholders;
- Identification of major issues and discussion of the policy environment; and
- Review of costs and constraints/opportunities influencing modal shares and volumes.

The process and results to be documented in the Existing and Future Travel Demand Working Paper will provide the rationale and justification for the resulting rail/truck goods movement breakdown. Sensitivity analysis/discussion of the possible future ranges will be provided to attempt to bracket the range of future uncertainty.

## 2.7. Regional Model Assignment Process

The product of the above steps is a base-year TransCAD model that will be used to simulate peak hour traffic conditions for auto and truck traffic for the study area. The trip tables will combine local travel (as provided from the SEMCOG and Windsor Models) and cross-border passenger car and commercial vehicle travel, which will be simultaneously assigned to the road network within the Regional Model. TransCAD provides full network assignment and statistical analysis capabilities, which will be used to summarize the assignment results. Additional selective analyses such as select link analyses will be undertaken, as appropriate. Rail and ferry travel are not included in the regional model assignment process.

## 2.8. Micro-Simulation Model

As discussed previously, a deficiency of regional transportation models, such as TransCAD or Emme/2, is their inability to adequately simulate intersections, signal delays, queues and other traffic operational details, as they are designed for estimating traffic flows over large areas. Given the current traffic operational issues on roads approaching bridge/tunnel crossings, there is a need to undertake a micro-simulation approach once specific alignments have been defined for the crossing alternatives. For instance, Huron Church Road features frequent signalized intersections, several unsignalized intersections and numerous commercial and private entrances, which dramatically impact level-of-service and require a micro-simulation approach to model suitably. As well, border processing and resulting queues are presently a major problem, imposing large delays with queues interfering with local traffic operations. We propose to use the CORSIM model for this task. The CORSIM network performance statistics will be supplemented with Highway Capacity Manual (HCM) analyses for key highway segments.

Once the study has reached the point where the alternatives have been screened to the final set of alternatives, it will be necessary to examine the operational and local road impacts through a detailed corridor analysis. Based on the detailed corridors identified through the study process, the CORSIM model will be developed to capture the travel corridor encompassing the bridge/river crossing and will provide level-of-service information, detailed statistical outputs, visual graphics and animation. The demand matrix to input into CORSIM will be extracted from the Regional Model using TransCAD's sub-area matrix capabilities, with the matrix reassigned in the CORSIM model to a more detailed network (e.g. lane geometry, traffic signal timings) with more sophisticated capabilities. The process also ensures that compatibility is maintained through all modelling levels: Broad, Focused and Corridor. The URS Team have applied this process previously and have standard routines/procedures for translating results from the Regional Model to CORSIM.

***Simulation of Customs and Immigration***

An important requirement of the micro-simulation analysis will be the modelling of customs/immigration facilities and toll booths within CORSIM.

At the customs and immigration plaza, the CORSIM model will capture the following cross border groups/markets for the auto/truck modes:

- Regular Passenger Cars – reflecting different processing rate during peak weekdays (commuter) and peak weekend day (tourist/recreational) travellers;
- Pre-Cleared Passenger Cars – travellers who have qualified and registered in programs, such as NEXUS, who are provided with a transponder that allows the use of a priority lane/booth at the plaza and automated entry into the destination country without interrogation of a customs inspector;
- Pre-Cleared Commercial Vehicles – vehicles that have proper documentation and are able to proceed across the border with reduced inspection delay;
- Non-Pre-Cleared Commercial Vehicles – vehicles that require more thorough inspection;
- Passenger Cars and Commercial Vehicles Requiring Secondary Inspection – passenger cars and commercial vehicles identified at primary inspection for further inspection.

Each of the above groups/markets will have different processing rates. The border processing rates, the variability/distribution of the rates and the composition of the traffic by these groups/markets will be determined based on existing data to the extent it can be provided by the respective customs and immigration agencies.

The intent of the micro-simulation is to capture the traffic operations and queuing at the border crossings so that general space requirements for plaza facilities can be determined at a conceptual level and so that the impacts on access roads leading to the plaza can be assessed. Specifically, the output from the CORSIM model will provide a general representation of the anticipated border crossing processing times, delays and queuing and traffic flows and therefore provide the basis for determining the footprint necessary to protect land for additional border crossing infrastructure needs associated with the projected growth.

To model a border crossing, the micro-simulation model will need to capture border processing time and its associated variability. In CORSIM, the standard practice to model delays due to toll booths or other queuing facilities is to set up an individual link for each toll booth lane. A pre-timed controller is then used to represent the delay associated with passing through the toll booth. Different cycle lengths can be used as a surrogate to represent lanes with different clearance times, such as priority lanes (e.g. Nexus Lanes). To model the scenario of a customs plaza, where the delay or processing time is available to each vehicle and depends on the type/characteristics of the vehicle (e.g. truck, passenger car), a different approach is required.

CORSIM allows the user to specify a lane blockage that would cause traffic to back up due to a stopped vehicle on a given link. This feature allows introduction of a random event with a specified mean duration up to 60 seconds, and a specified mean frequency of events per hour. The distribution of the delay duration can be altered to calibrate the delay to field observations. This approach could be use to simulate the random additional delay to vehicles due to interrogation of drivers at primary and secondary inspection areas.

A mean blockage duration of up to 60 seconds should be sufficient for most vehicle types, with the capability of incorporating a longer average delay in the model possible within CORSIM using back to back lane blockages or adding a fixed delay on a link. Values to capture border processing delays will be investigated further based on discussions with customs and immigration officials to capture the appropriate processing time and distribution at inspection facilities.

In addition to the above, vehicle entry headways can be approximated by a normal distribution, an Erlang distribution or by a uniform headway.

To calibrate the model, information from customs operations including the average time taken by a vehicle to pass through the customs booth would be required, as well as the estimated frequency and duration of any random inspections that may occur in the lane and block traffic. These inputs can be varied easily in CORSIM, and used to calibrate the model against observed queues.

The above procedure has been tested using CORSIM for a dummy network of toll booth and customs booth lanes.

***Compatibility with the "Border Wizard" Model***

The United States Customs Service, through Regal Consultants, have developed a micro-simulation model of border stations, referred to as Border Wizard, to assist border regions in evaluating the impacts of proposed improvements and infrastructure planning. The model details each specific process at border stations using inputs such as auto, bus, truck and pedestrian arrival rates, processing rates by category, bus, booth operating schedules, physical geometry of the station and other inputs. The model includes animation, which displays the movement of individual vehicles through the system, including queues. It also generates a wide range of delay and other performance statistics. The model can be customized to any border station and, at present, it includes a library of ten U.S. border crossing locations. The Canadian Customs and Revenue Agency (CCRA) has expressed strong interest in this model and a prototype of Canadian operations has been developed for the Ambassador Bridge. At present, Border Wizard cannot model both U.S. and Canadian operations at a border station and this software cannot yet be integrated with a traffic modelling package such as CORSIM.

Based on the information on the Border Wizard model obtained through a meeting with Regal Consulting and follow-up telephone conversations, it was determined that there were potential synergies between the two models. It is also recognized that compatibility with Border Wizard is needed to ensure that the results of the modelling process are consistent with customs operations and characteristics, as well as potential plans of the customs agencies that will affec t future border processing rates and vehicle throughput and capacity.

At a minimum, compatibility between Border Wizard and the CORSIM micro-simulation package will be achieved by using compatible processing rates by vehicle type for primary and secondary inspection processes. This approach does not require the Study Team to obtain the Border Wizard Model. As described in the above section, border processing times are variable with mean, standard deviation following a skewed-normal distribution (Erlang Distribution) determined using the same base processing rate data that was collected to calibrate the Border Wizard Model for the Ambassador Bridge and Windsor-Detroit Tunnel crossings. Following this approach, the resulting footprint to describe the space requirements for future customs infrastructure should be generally compatible with the overall footprint derived using Border Wizard.

Possible new initiatives, including those considered under the Smart Border initiative, will change existing processing rates, which will need to be reflected in the CORSIM model developed for this study. In these cases, it is hoped that Border Wizard runs performed by customs agency staff could be undertaken to determine the change in the mean and standard deviation in border processing rates, which would be incorporated into the CORSIM model. If Border Wizard results are not available for a scenario being tested, the expertise of the Consultant Team will be used to determine the change in border processing rates, in consultation with customs staff from the U.S. and Canada.

If the Border Wizard is made available to the Partnership, more extensive modelling of cross-border operations will be possible, and will be undertaken where possible, in close coordination with customs agency staff.

# 3. Selection of Time Periods for Analysis

The selection of time periods for analysis is one of the most important considerations in the modelling process, particularly given the varying types of users/trip purposes of the border crossings (e.g. commute, vacation, goods movement, etc.) and the different peaking characteristics of each. For modelling purposes, it is necessary to simulate the peak hour(s) that dictate transportation infrastructure requirements for the crossings and access roads and highways to the crossings. Other time periods that influence border processing requirements will be examined subsequently using queuing analysis/micro-simulation techniques, as a Regional Model is not capable of simulating queues. This chapter provides a discussion of how the time periods for the regional modelling were selected.

## 3.1. Monthly Trends

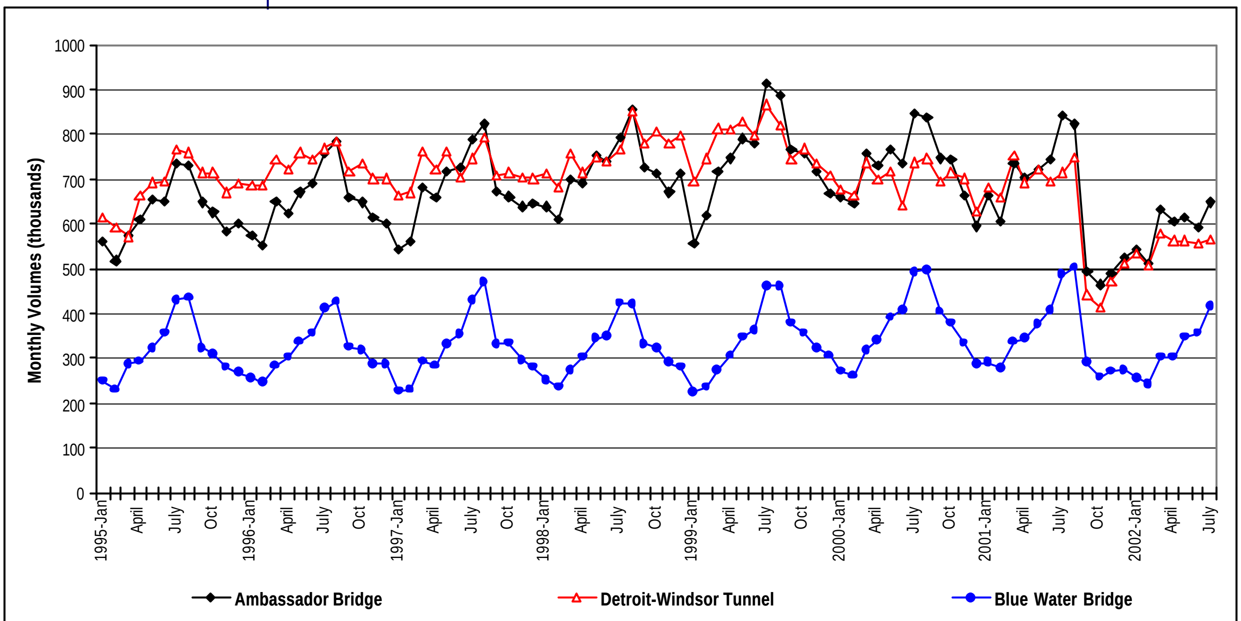
Data from the Bridge and Tunnel Operators Association were examined to determine seasonal trends for border crossing vehicles, as shown in Exhibits 3.1 and 3.2 from 1995 to 2001 for passenger cars and trucks, respectively. July has been the peak month for passenger car activity, followed closely by August. For truck traffic, the peak month varies: March in 1999 and 2000, and May in 2001. July is traditionally low because of vacations and plant shutdowns in the auto industry. Examining total demands by combining passenger and truck traffic, August has consistently been the peak month for border crossing traffic.

Exhibit 3.3 shows the monthly volumes for the year 2000, which corresponds with the study's base year. Since August is the peak month and the main source of border crossing traffic that will be used in this study (i.e. the Ontario-Michigan Border Crossing Traffic Study, August 2001) is based on a survey conducted in August 2000, no seasonal adjustments are required.

For background traffic, detailed information by month is not available for a single location; however, in most urban areas, seasonal trends are relatively constant for weekday traffic, varying by less than 10-15%. Typically commuter and school related traffic drops off in the summer but this is offset by higher tourist traffic.

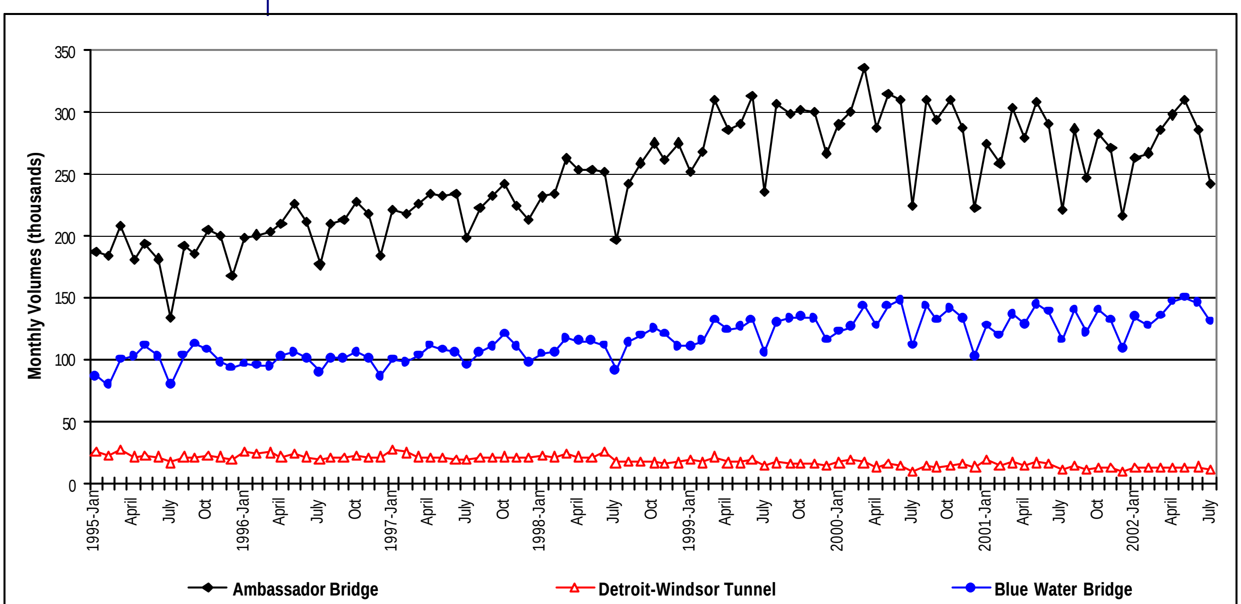
Background traffic volumes are simulated using the Regional Model, with existing travel demand matrices available from SEMCOG and the City of Windsor updated to 2000 counts to correspond with the cross-border survey. No adjustments were made for seasonal variation, as most of the traffic on the links leading to the border crossings is dominated by cross-border traffic, for which the data reflect the peak month.

### EXHIBIT 3.1: MONTHLY PASSENGER CAR VOLUMES JAN 1995 – JUNE 2001



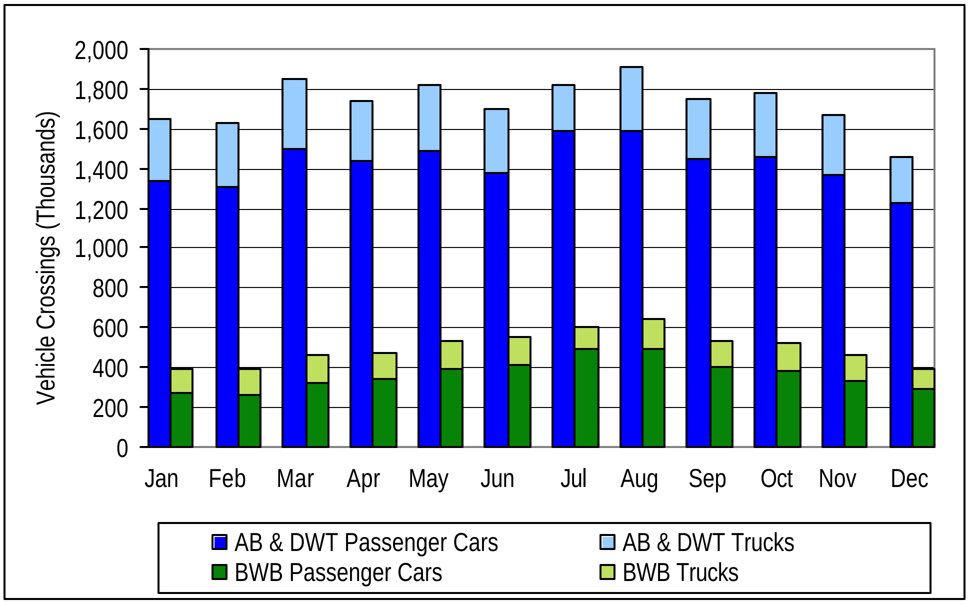

Data Source: Bridge and Tunnel Operators Association as provided by MTO Data Management and Analysis Office.

### EXHIBIT 3.2: MONTHLY TRUCK VOLUMES – JAN 1995 TO JUNE 2001




Data Source: Bridge and Tunnel Operators Association, as provided by MTO Data Management and Analysis Office.

**EXHIBIT 3.3 MONTHLY TRAFFIC – YEAR 2000**
**AMBASSADOR BRIDGE, DETROIT-WINDSOR TUNNEL AND BLUE WATER BRIDGE**




Note: Trends are available for the year 2001; however, due to significant declines as a result of September 11th, 2001, trends for 2000 are considered to be more representative than 2001. Trends are for the Ambassador Bridge, Tunnel and Blue Water Bridge.

Source: Bridge and Tunnel Operators Association as provided by MTO Data Management and Analysis Office.

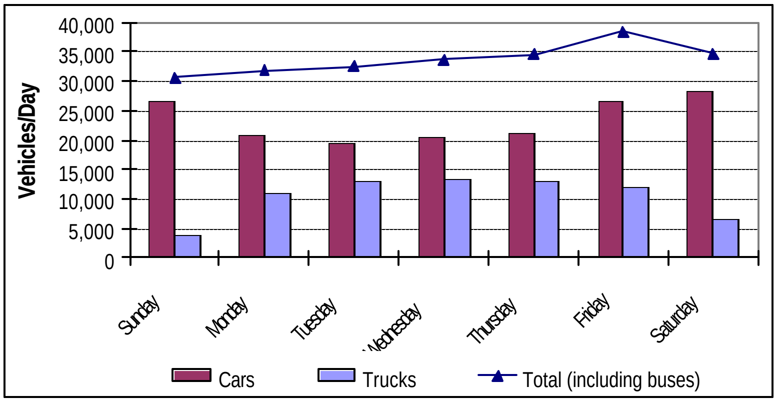
## 3.2. Daily Trends

The 1999/2000 Commercial Vehicle Survey dataset provided by MTO was used to assess traffic trends by day of week for the Ontario-Michigan Border Crossings. Traffic by day of week for the three crossings is shown on Exhibit 3.4. These counts were conducted in August and September of 1999. Data by day of week are also available from the Ontario-Michigan Border Crossing Traffic Study conducted in August 2000; however, this survey covered the period between Wednesday afternoon and Saturday evening only. Trends from the August 2001 survey are discussed in the next section.

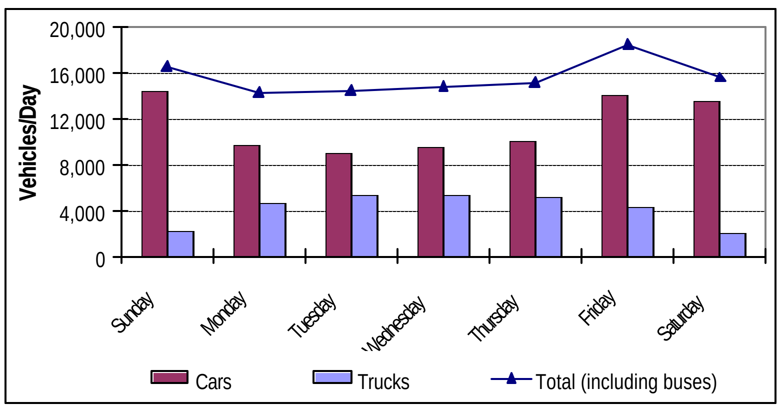
For the Ambassador Bridge, the weekly profile shows marked differences between cars and trucks. The number of cars is greatest on the weekend, when the majority may be on leisure trips, whereas trucks are highest during the week. The combination of these two profiles gives a fairly flat weekly profile, with Saturday being the busiest day of the week.

## EXHIBIT 3.4: DAILY TRAFFIC LEVELS AT ONTARIO-MICHIGAN CROSSINGS (1999) AMBASSADOR BRIDGE, BLUE WATER BRIDGE AND DETROIT-WINDSOR TUNNEL

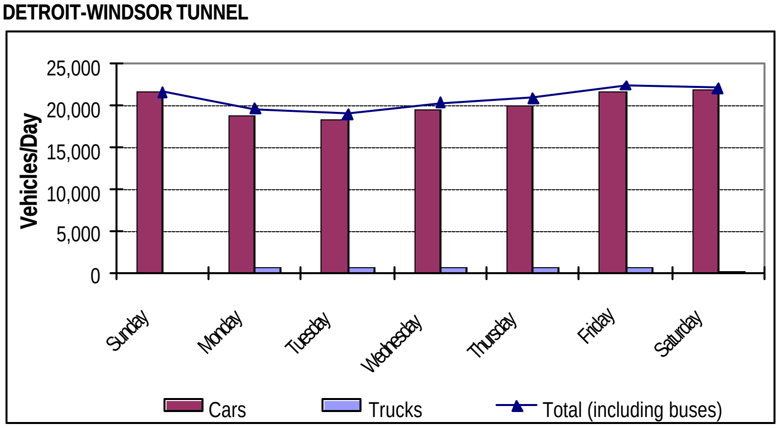
**AMBASSADOR BRIDGE**




**BLUE WATER BRIDGE**




**DETROIT-WINDSOR TUNNEL**




Note: Figures are for Daily (24-hr) Two-way Traffic
Source: 1999/2000 Commercial vehicle survey, Ministry of Transportation, Ontario

In the Windsor-Detroit Tunnel, truck traffic is relatively low (less than 5% of vehicles) resulting in a weekly profile is closely linked to the profile of cars. The highest car traffic occurs on weekend days, but the difference in car traffic between weekend days and weekdays is much less pronounced than for the Ambassador Bridge, suggesting that the high truck levels on the Ambassador Bridge tends to divert car traffic to the tunnel during the week. Also, the tunnel provides convenient access between the Windsor and Detroit downtowns and therefore accommodates a significant volume of discretionary travel to restaurants, casinos and entertainment venues in addition to weekday business/commute travel.

## 3.3. Hourly Trends by Trip Purpose

Trends by time of day are available from the Ontario-Michigan Border Crossing Traffic Study and are illustrated in Exhibits 3.5 and 3.6 for the Thursday to Sunday time period. These trends reflect traffic crossing all three Ontario-Michigan Border Crossing facilities. Detailed trends by facility are presented in Appendix D. In terms of the individual crossings, the same general profiles by time of day are similar for the same trip purpose, although the magnitudes are different.

Exhibit 3.5 shows the hourly traffic profiles by trip purpose for the three crossings combined. Trip purpose is a consideration in the selection of design hour since certain types of trips have a higher tolerance for waiting times. For example, people travelling for recreation or shopping can vary their travel time more than people travelling to work or for business. As shown in the exhibit, the highest peaks occur for work related trips, at 7:00-8:00 AM for people travelling to work and 5:00-6:00 PM for people travelling from work to home. The more detailed plots in Appendix D reveal that work trip peaks are highly directional; that is, the morning peak corresponds to trips going to the US and the afternoon peak corresponds to trips returning to Canada.

Other major peaks are observed for recreation/entertainment/casino/shopping trips. On Fridays and Saturdays, these categories experience higher peaks than afternoon peak period work trips. For trucks, border crossings are distributed more evenly throughout the day with the peak occurring around 11:00 AM on Thursday. (Note: as shown previously in Exhibit 3.1, the peak day for trucks is Wednesday; however, the August 2001 survey did not cover Wednesday morning.)

Exhibit 3.6 shows the hourly profiles, combining the individual trip purposes. For passenger traffic, peak hours are approximately the same for Thursday and Friday. Peak passenger traffic on Thursday occurs at 5:00 PM in the afternoon while peak traffic on Friday occurs at approximately the same time but is slightly more dispersed. On Friday afternoons, vacation and other non-commercial traffic constitute a slightly higher proportion of the peak traffic than Thursday. On Saturday, the peak for passenger traffic occurs at around 3:00 PM, but is spread over several hours. The Saturday traffic peak is dominated by non-work travel.

### EXHIBIT 3.5: TRENDS BY TIME OF DAY AND TRIP PURPOSE (AMBASSADOR BRIDGE, WINDSOR-DETROIT TUNNEL AND BLUE WATER BRIDGE)

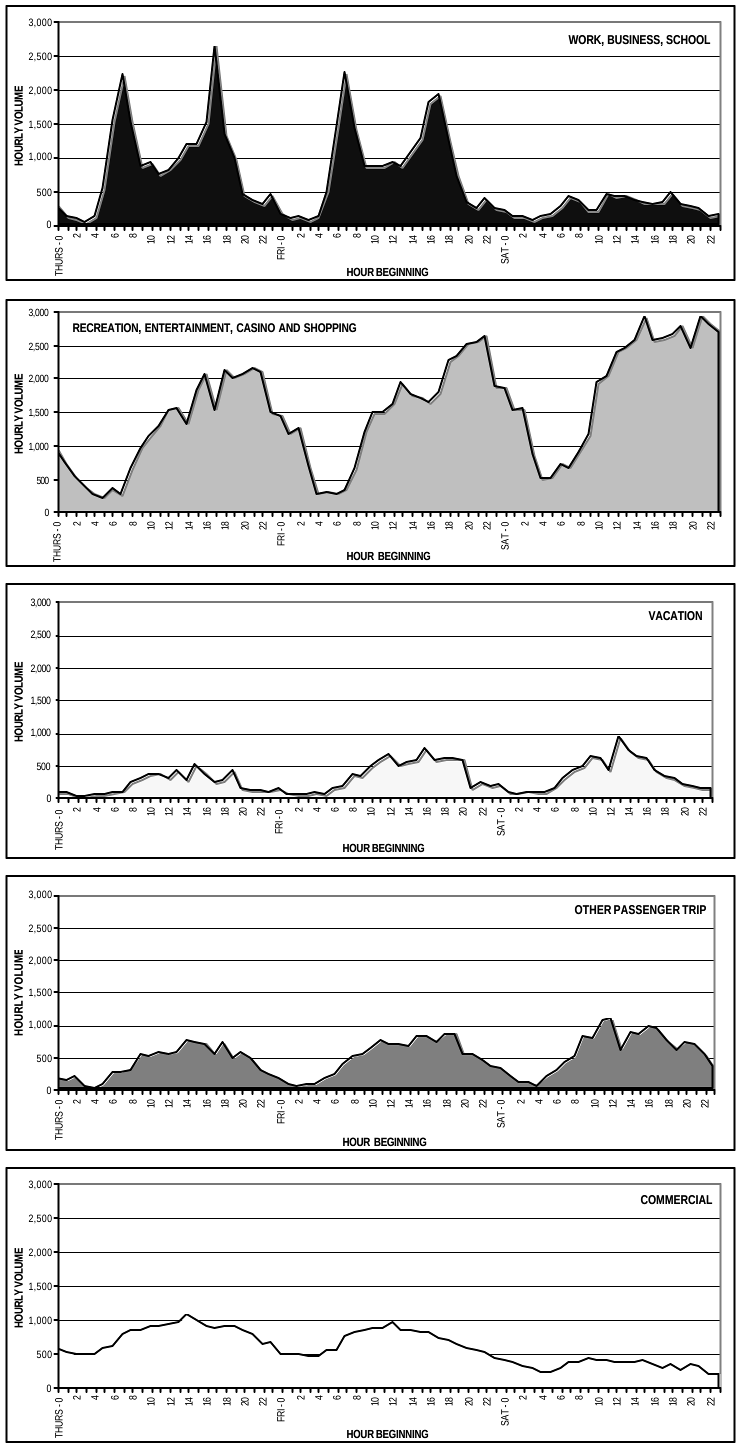
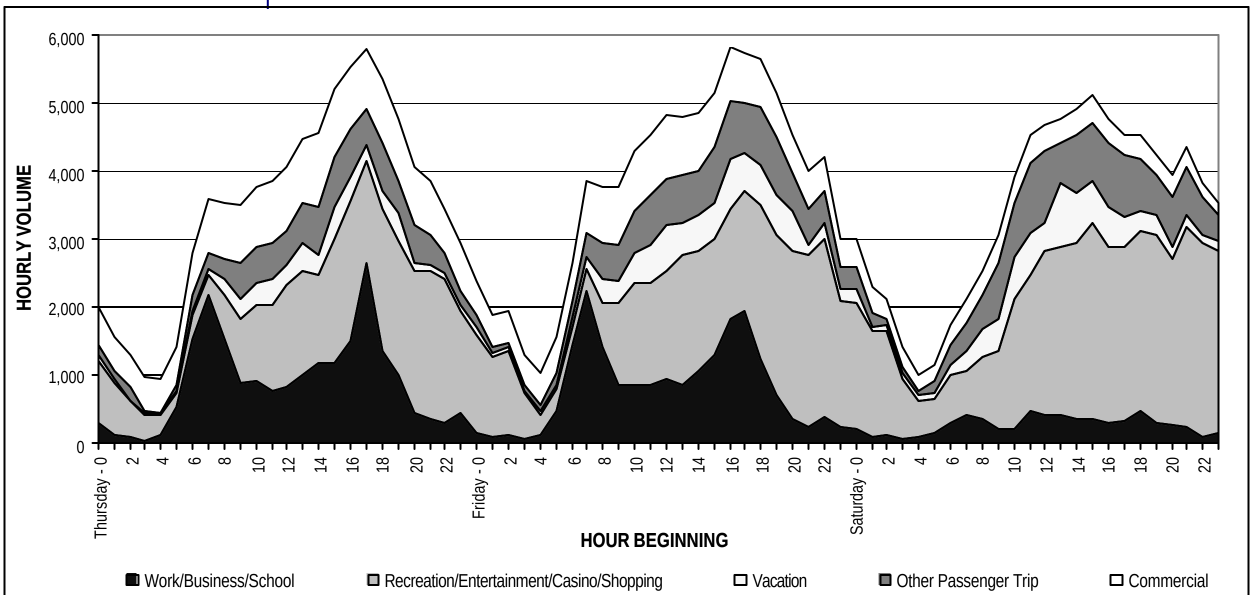


**EXHIBIT 3.6: CUMULATIVE TRENDS BY TIME OF DAY AND TRIP PURPOSE (AMBASSADOR BRIDGE, WINDSOR-DETROIT TUNNEL AND BLUE WATER BRIDGE)**




When trucks are added to the peak period, the peaks by time of day do not change significantly nor does the relative difference between Thursday and Friday.

## 3.4. Selection of Peak Hour Traffic

The Regional Traffic Model developed for this study is a peak hour model, meaning that road capacities are coded in terms of vehicles per hour. This is appropriate when analysing the performance and capacity of existing facilities and determining the need for new facilities. The selection of the peak periods for analysis involved several decisions as discussed below.

***Consistency with Background Traffic Peaks***

In selecting the peak hours for border crossings, background traffic must also be considered, since this local-oriented travel shares the use of many of the same road and highway facilities as the international traffic. Background traffic is reflected in the Regional Model using trip matrices extracted from the Windsor and SEMCOG models. The Windsor Area Long Range Transportation Study indicates that peak hours for traffic in the City are between 8:30 and 9:30 in the morning, and 3:30 to 4:30 in the afternoon. Traffic count data indicate that the patterns are similar in the Detroit area. Therefore, weekday peaks for background traffic are generally consistent with weekday peaks for border crossing traffic, although in the morning, border crossing traffic peaks earlier in the morning, between 7:00 AM and 8:00 AM, and later in the afternoon, 5:00 PM to 6:00 PM. On weekends, background traffic is less of an issue; however, in most urban areas peak traffic on Saturday occurs in the early afternoon.

***Weekday vs. Weekend Traffic***

As shown previously in Exhibit 3.4, the peak days for border crossing traffic are Friday, Saturday and Sunday for passenger cars and Wednesday for commercial. When commercial vehicles and cars are combined, Friday and Saturday are generally similar, with Saturday travel more uniform throughout the day. Also, background traffic on Saturday is generally less than on weekdays. Considering all of these factors, it was determined that a weekday peak period would be representative of peak border crossing conditions. No modelling of weekend traffic is being considered at this time.

***Peak Times by Crossing***

Consideration was given as to the need to have different peaks for the Sarnia-Port Huron crossing than for the Detroit-Windsor crossings. At a broad strategic level, there is considerable benefit in modelling the same peak hours for all crossings. Fortunately, peak hours are generally similar for all crossings, although hourly variations for the Blue Water Bridge are somewhat flatter, due to a lower percentage of commuter traffic in the traffic stream.

***Morning and Afternoon Peak Hours***

As discussed above, for the Detroit-Windsor crossings in particular, peak hours are not the same by direction. The peak for traffic entering the US occurs in the morning while the peak for traffic entering Canada occurs in the afternoon. This is a direct result of commuting patterns.

Due to the different peak times by direction, it was concluded that both the AM and PM peak hours would need to be modelled. This will be particularly important for the micro-simulation exercise, which will focus on the operations of the border crossing access links.

***Peak Hours by Mode***

As shown in the graphs presented previously, autos and trucks have different peak hours. For autos, the peaks occur in the traditional morning and afternoon periods. For trucks, the peak occurs in the late morning. In order to determine how this would impact the overall peak period, border-crossing trips were compared by hour and by mode for the Ambassador Bridge and Detroit Tunnel. The results are summarized in Exhibit 3.7a.

### EXHIBIT 3.7A: BORDER-CROSSING VOLUMES BY TIME OF DAY (AMBASSADOR BRIDGE AND DETROIT-WINDSOR TUNNEL)

| | | ENTERING CANADA | | | | ENTERING USA | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hour Beginning | Trucks | Auto | Total Vehicles | Total PCEs (1) | Trucks | Auto | Total Vehicles | Total PCEs (1) |
| **Wednesday** | | | | | | | | | |
| AM Peak Period | 6:00 | | | | | 265 | 1603 | 1868 | 2398 |
| | 7:00 | | | | | 304 | 678 | 982 | 1590 |
| | 8:00 | | | | | 363 | 678 | 1041 | 1767 |
| Mid-Day Peak Period | 12:00 | 204 | 1012 | 1216 | 1624 | 345 | 1045 | 1390 | 2080 |
| | 13:00 | 450 | 1265 | 1715 | 2615 | **367** | 1084 | 1451 | 2185 |
| | 14:00 | 416 | 1150 | 1566 | 2427 | 274 | 1285 | 1559 | 2107 |
| PM Peak Period | 15:00 | 394 | 1709 | 2103 | 2942 | 335 | 1204 | 1539 | 2209 |
| | 16:00 | **461** | 2070 | 2531 | 3498 | 286 | 1187 | 1473 | 2045 |
| | 17:00 | 389 | 2219 | 2608 | 3399 | 281 | 1039 | 1320 | 1882 |
| | 18:00 | 333 | 2052 | 2385 | 3051 | 317 | 1061 | 1378 | 2012 |
| **Thursday** | | | | | | | | | |
| AM Peak Period | 6:00 | 155 | 426 | 581 | 891 | 251 | 1478 | 1729 | 2231 |
| | 7:00 | 245 | 578 | 823 | 1274 | 347 | 1903 | 2250 | 2944 |
| | 8:00 | 271 | 740 | 1011 | 1566 | 281 | 1490 | 1771 | 2333 |
| Mid-Day Peak Period | 10:00 | 399 | 1221 | 1620 | 2429 | 271 | 954 | 1225 | 1767 |
| | 11:00 | 398 | 1201 | 1599 | 2420 | 279 | 953 | 1232 | 1790 |
| | 12:00 | 321 | 1247 | 1568 | 2210 | 341 | 1097 | 1438 | 2120 |
| | 13:00 | 362 | 1391 | 1753 | 2501 | 343 | 1246 | 1589 | 2275 |
| PM Peak Period | 15:00 | 357 | 1747 | 2104 | 2858 | 290 | 1279 | 1569 | 2149 |
| | 16:00 | 315 | 2225 | 2540 | 3219 | 285 | 1315 | 1600 | 2170 |
| | 17:00 | 320 | **2792** | **3112** | **3752** | 282 | 1246 | 1528 | 2092 |
| | 18:00 | 314 | 2308 | 2622 | 3281 | 310 | 1207 | 1517 | 2137 |
| **Friday** | | | | | | | | | |
| AM Peak Period | 6:00 | 170 | 444 | 614 | 954 | 234 | 1471 | 1705 | 2173 |
| | 7:00 | 279 | 572 | 851 | 1409 | 263 | **2162** | **2425** | **2951** |
| | 8:00 | 293 | 775 | 1068 | 1654 | 298 | 1611 | 1909 | 2505 |
| Mid-Day Peak Period | 10:00 | 350 | 1361 | 1711 | 2426 | 282 | 1113 | 1395 | 1959 |
| | 11:00 | 348 | 1467 | 1815 | 2534 | 274 | 1121 | 1395 | 1943 |
| | 12:00 | 397 | 1494 | 1891 | 2697 | 274 | 1254 | 1528 | 2076 |
| | 13:00 | 335 | 1497 | 1832 | 2515 | 238 | 1310 | 1548 | 2024 |
| PM Peak Period | 15:00 | 320 | 1822 | 2142 | 2815 | 243 | 1432 | 1675 | 2161 |
| | 16:00 | 337 | 2585 | 2922 | 3605 | 215 | 1373 | 1588 | 2018 |
| | 17:00 | 325 | 2581 | 2906 | 3566 | 219 | 1371 | 1590 | 2028 |
| | 18:00 | 285 | 2346 | 2631 | 3201 | 184 | 1444 | 1628 | 1996 |
| Maximum by Time Period | | 461 | 2792 | 3112 | 3752 | 367 | 2162 | 2425 | 2951 |
| **SCENARIOS AND CONTROL TOTALS** | | | | | | | | | |
| 1. Weekday AM Peak Hour (to capture vehicles entering USA) | | **279** | **572** | **851** | | **263** | **2162** | **2425** | |
| 2. Weekday PM Peak Hour (to capture vehicles entering Canada) | | **320** | **2792** | **3112** | | **282** | **1246** | **1528** | |

(1) Assumes an average truck is equivalent to 3.0 passenger car equivalents.

## EXHIBIT 3.7B: BORDER-CROSSING VOLUMES BY TIME OF DAY (BLUE WATER BRIDGE)

| | Hour Beginning | ENTERING CANADA Trucks | Auto | Total Vehicles | Total PCEs [1] | ENTERING USA Trucks | Auto | Total Vehicles | Total PCEs [1] |
|---|---|---|---|---|---|---|---|---|---|
| **Thursday** | | | | | | | | | |
| AM Peak Period | 6:00 | 70 | 83 | 153 | 293 | 139 | 182 | 321 | 599 |
| | 7:00 | 60 | 182 | 242 | 362 | 120 | 231 | 351 | 591 |
| | 8:00 | 112 | 227 | 339 | 563 | 180 | 325 | 505 | 865 |
| Mid-Day Peak Period | 12:00 | 149 | 428 | 577 | 875 | 124 | 437 | 561 | 809 |
| | 13:00 | 137 | 496 | 633 | 907 | 127 | 420 | 547 | 801 |
| | 14:00 | **224** | 508 | 732 | 1180 | **189** | 482 | 671 | 1049 |
| PM Peak Period | 15:00 | 178 | 629 | 807 | 1163 | 163 | **607** | **770** | **1096** |
| | 16:00 | 186 | **708** | **894** | **1266** | 126 | 402 | 528 | 780 |
| | 17:00 | 129 | 522 | 651 | 909 | 136 | 456 | 592 | 864 |
| | 18:00 | 126 | 503 | 629 | 881 | 165 | 463 | 628 | 958 |
| **Friday** | | | | | | | | | |
| AM Peak Period | 6:00 | 47 | 78 | 125 | 219 | 108 | 126 | 234 | 450 |
| | 7:00 | 88 | 167 | 255 | 431 | 122 | 263 | 385 | 629 |
| | 8:00 | 100 | 276 | 376 | 576 | 135 | 257 | 392 | 662 |
| Mid-Day Peak Period | 10:00 | 118 | 553 | 671 | 907 | 117 | 353 | 470 | 704 |
| | 11:00 | 149 | 670 | 819 | 1117 | 114 | 435 | 549 | 777 |
| | 12:00 | 174 | 634 | 808 | 1156 | 106 | 489 | 595 | 807 |
| | 13:00 | 165 | 581 | 746 | 1076 | 96 | 567 | 663 | 855 |
| PM Peak Period | 15:00 | 149 | 541 | 690 | 988 | 103 | 527 | 630 | 836 |
| | 16:00 | 118 | 574 | 692 | 928 | 144 | 528 | 672 | 960 |
| | 17:00 | 102 | 611 | 713 | 917 | 73 | 471 | 544 | 690 |
| | 18:00 | 148 | 701 | 849 | 1145 | 88 | 542 | 630 | 806 |
| **Saturday** | | | | | | | | | |
| AM Peak Period | 6:00 | 38 | 76 | 114 | 190 | 40 | 109 | 149 | 229 |
| | 7:00 | 48 | 194 | 242 | 338 | 39 | 97 | 136 | 214 |
| | 8:00 | 53 | 304 | 357 | 463 | 53 | 160 | 213 | 319 |
| Mid-Day Peak Period | 10:00 | 59 | 571 | 630 | 748 | 54 | 372 | 426 | 534 |
| | 11:00 | 66 | 542 | 608 | 740 | 59 | 514 | 573 | 691 |
| | 12:00 | 48 | 599 | 647 | 743 | 56 | 535 | 591 | 703 |
| | 13:00 | 54 | 521 | 575 | 683 | 51 | 562 | 613 | 715 |
| PM Peak Period | 15:00 | 87 | 603 | 690 | 864 | 55 | 580 | 635 | 745 |
| | 16:00 | 73 | 517 | 590 | 736 | 46 | 544 | 590 | 682 |
| | 17:00 | 47 | 540 | 587 | 681 | 44 | 461 | 505 | 593 |
| | 18:00 | 36 | 602 | 638 | 710 | 54 | 492 | 546 | 654 |
| Maximum by Time Period | | 224 | 708 | 894 | 1266 | 189 | 607 | 770 | 1096 |
| **SCENARIOS AND CONTROL TOTALS** | | | | | | | | | |
| 1. Weekday AM Peak Hour (to capture vehicles entering USA) | | **112** | **227** | **339** | | **180** | **325** | **505** | |
| 2. Weekday PM Peak Hour (to capture vehicles entering Canada) | | **178** | **629** | **807** | | **163** | **607** | **770** | |

[1] Assumes an average truck is equivalent to 3.0 passenger car equivalents.

In determining a combined peak hour, it is important to recognize that trucks require more capacity than cars; typically trucks are considered equivalent to approximately 2.0 to 2.5 passenger cars, depending on the proportion of trucks and the grade based Highway Capacity Manual methods. A 3.0 passenger car equivalent was considered appropriate for this study given the truck characteristics at the crossings, with approximately 90% of the trucks being multi-unit vehicles. The relatively steep gradient on the bridges and tunnel also support a relatively high passenger car equivalent.

As shown in Exhibit 3.7b, the peak hours in terms of passenger car equivalents clearly occur during the AM and PM peak periods. This is also demonstrated in Exhibit 3.8, which plots the hourly traffic in terms of passenger car equivalents. The maximum traffic flow (in passenger car equivalents) entering Canada occurs on Thursday afternoon at 5:00 PM. The maximum flow for traffic entering the US occurs Friday morning. (Note: there are actually 30 more vehicles Wednesday morning; however, this represents the very beginning of the survey and there are no equivalent data for traffic entering Canada.)

***Summary and Peak Hours for Analysis***

The peak hours for demand modelling in this study include the following:

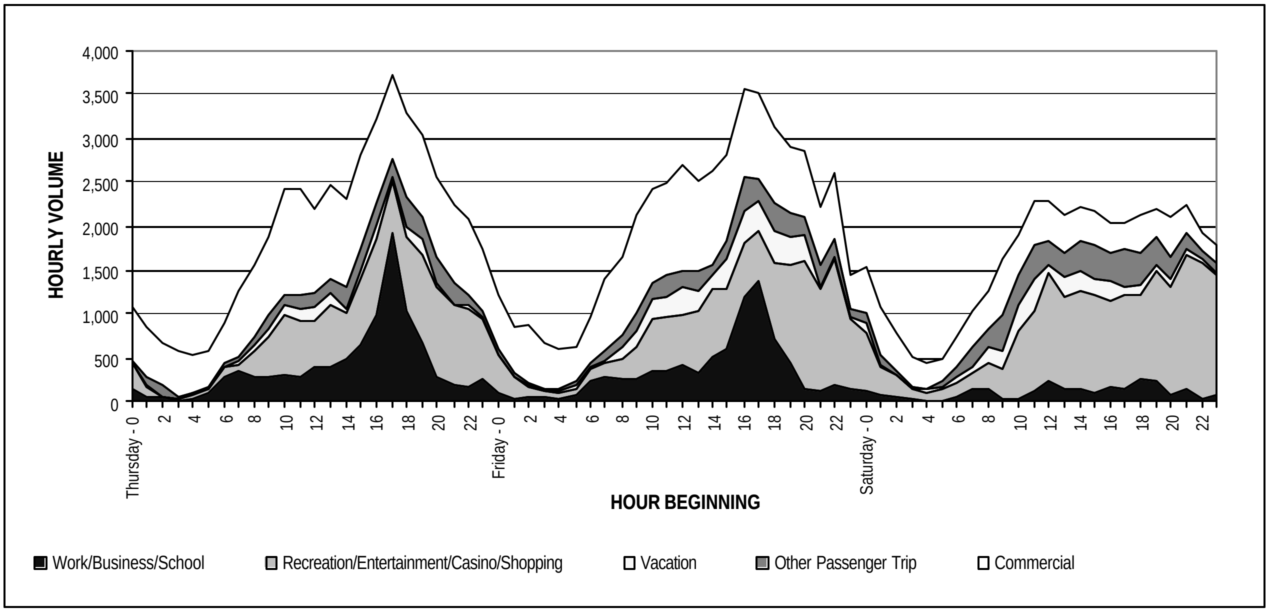
- A weekday morning peak hour, representative of conditions on a Friday morning between 7:00 AM and 8:00 AM. This represents the peak hour for cross-border traffic in terms of passenger car equivalents leaving Canada and entering the United States;
- A weekday afternoon peak hour representative of conditions on a Thursday afternoon between 5:00 PM and 6:00 PM. This represents the peak hour for cross-border traffic in passenger car equivalents leaving the United States and entering Canada.

The above reflects the peak hours in terms of total vehicle demands (cars and commercial vehicles) and therefore will dictate infrastructure requirements for the road, highway and bridge/tunnel infrastructure. The peak hour for commercial vehicles occurs during the mid-day period and operations during this period will be examined separately as part of a micro-simulation border processing analysis that will consider delays and queuing at the customs plazas during various time periods (e.g. AM peak hour, PM peak hour, truck peak hour, weekend day peak hour).

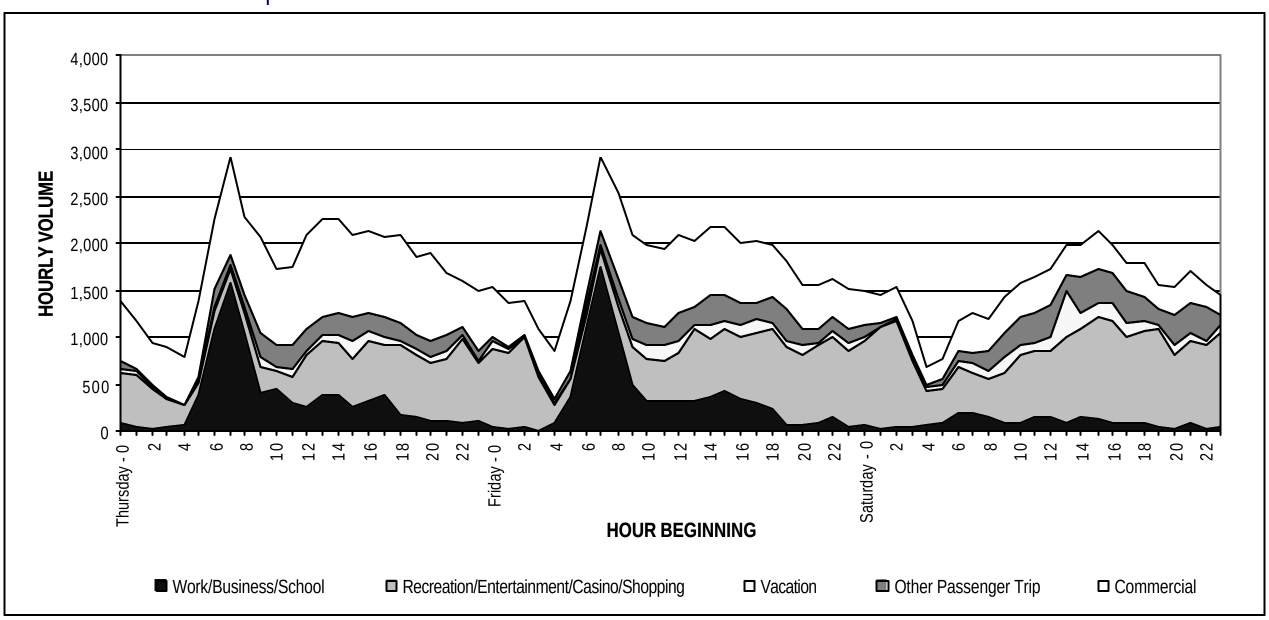
Chapter 5 discusses the process used to develop the peak hour trip matrices from available data sources. In general, the process involves the selection of trips from peak periods for all weekdays in the survey to maximize use of the survey sample. These matrices are then controlled to the crossing volumes for the representative peak hour. The same general process is used for both trucks and cars.

**EXHIBIT 3.8A: HOURLY DISTRIBUTION OF BORDER-CROSSING VOLUMES IN PASSENGER CAR EQUIVALENTS (AMBASSADOR BRIDGE AND DETROIT-WINDSOR TUNNEL)**

## A. INTO CANADA



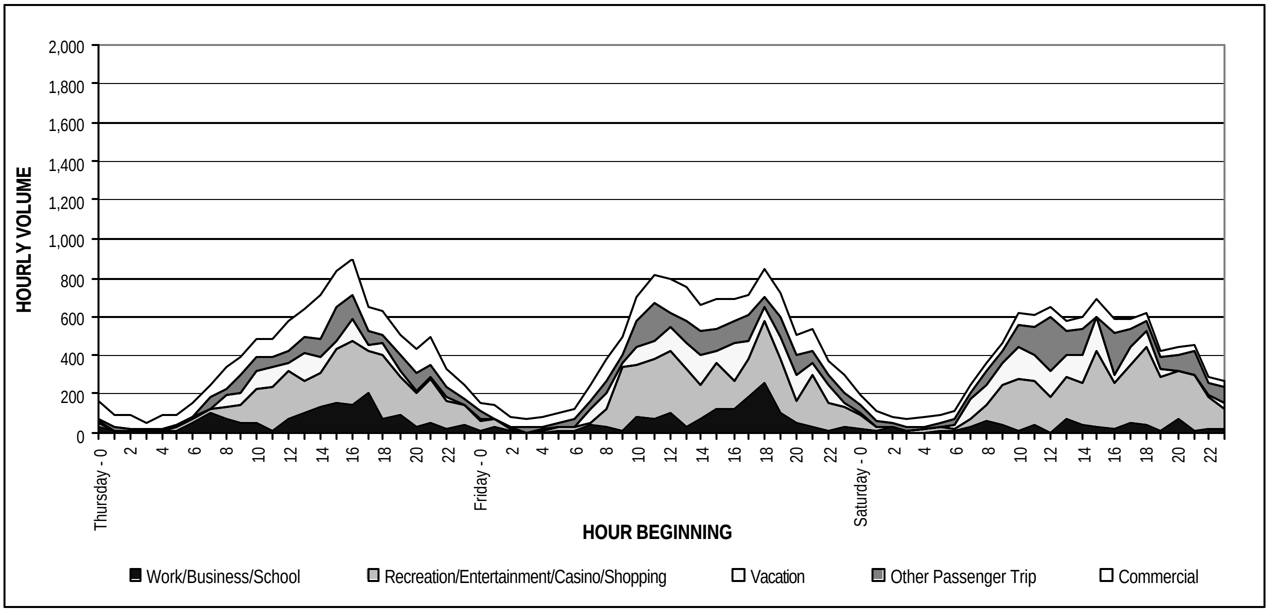

## B. INTO USA



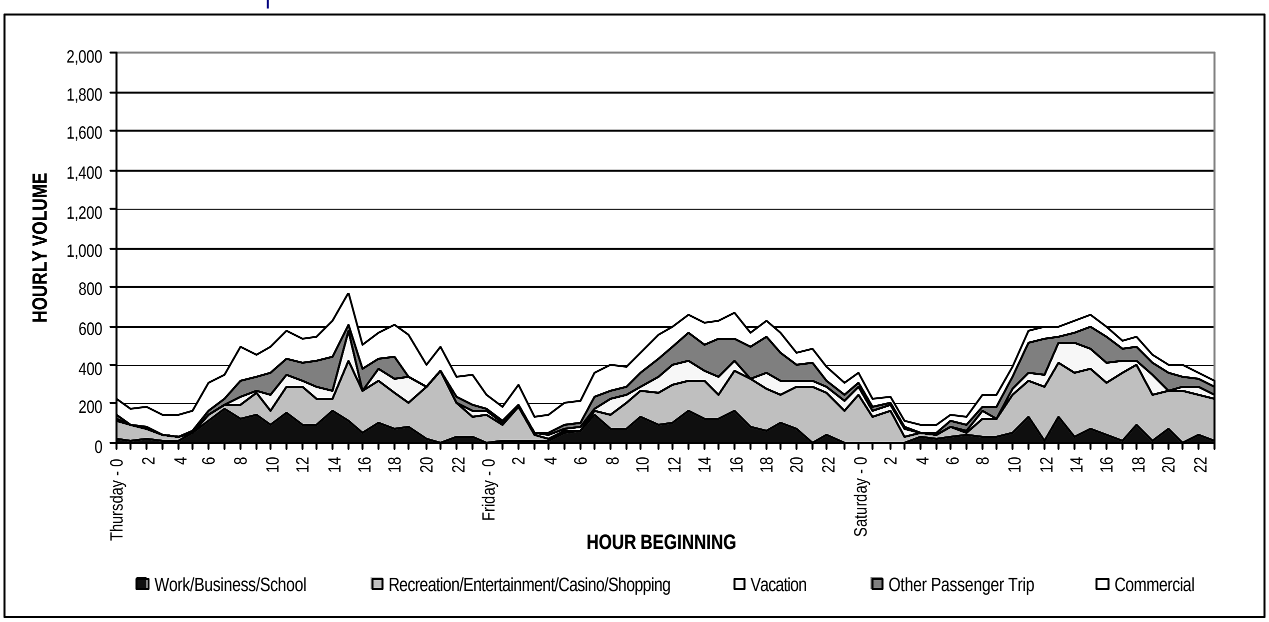

Note: the passenger car equivalent (PCE) equivalent of a truck is 3.0.

**EXHIBIT 3.8B: HOURLY DISTRIBUTION OF BORDER-CROSSING VOLUMES IN PASSENGER CAR EQUIVALENTS (BLUE WATER BRIDGE)**

## A. INTO CANADA




## B. INTO USA




Note: the passenger car equivalent (PCE) equivalent of a truck is 3.0.

# 4. Traffic Zone System

The purpose of this section is to describe the development of the traffic zone system for the Regional Model. The traffic zone system is designed to provide the overall geographic coverage corresponding to the Broad Geographic Area with a high level of zone refinement to enable more detailed analysis of travel demand. The traffic zone system provides a basis for the development of trip tables and road networks, as discussed in Chapters 5 and 6, respectively.

## 4.1. Overview of Existing Zone Systems

There are four existing transportation models available to the study with zone systems that could be used toward developing the Regional Model:

- *Michigan Statewide Model (Michigan Department Of Transportation):* The Michigan Model represents the state with 2307 zones. It includes 85 external zones that cover other states, Canada and Mexico. The Michigan Model is detailed within Wayne County.
- *Southeastern Michigan Council of Governments (SEMCOG) Model:* The SEMCOG Model, covering the seven SEMCOG counties, is represented by 1442 zones. External trips from the rest of the US and Canada are assigned to the network using 63 external zones at boundary locations. External demand is estimated from volumes crossing the cordons at the external boundaries.
- *Ministry of Transportation of Ontario (MTO) Truck Model:* The MTO truck model includes 49 zones for Ontario, with zones for the rest of North America being relatively coarse.
- *Windsor Area Long Term Study (WALTS) Model:* The Windsor Model covers the City of Windsor and its immediate environs. The zone system includes 464 internal zones with a further 156 zones used for the rest of Canada and the US. Like the external zones in the SEMCOG Model, the Canadian externals in the Windsor model represent purely cordon demand and have no definite origin area. However, geographic zones represent the SEMCOG area, Michigan counties, and other states.

## 4.2. Zone System for Regional Model

The Regional Model will be used to provide estimates of traffic flows at international border crossings and on the major road networks to and from existing and potential future border crossings. The traffic zone system has been developed to provide the level of traffic assignment detail needed for analysis purposes in this study.

***Regional Model Zone System***

The zone system for the Regional Model (and road network) must be sufficiently detailed to provide the level of refinement necessary to examine crossing alternatives in terms of their impact on the local and state/provincial road and highway networks and generally conform with the coverage of the Broad Geographic Area. The detail must also be sufficient to provide output in the form of a sub-area matrix for use in the micro-simulation process.

On the US side of the border, the SEMCOG model zone system provides very detailed zone systems in the area of the border crossings, as well as the rest of Wayne County. In the vicinity of the Detroit-Windsor crossings, the SEMCOG zone system within Wayne County is more than sufficient to cover the geographic area around the border crossings and was adopted (without aggregation) for the Regional Model. At this level, Wayne County comprises 626 traffic analysis zones. In the Port Huron area, the MDOT zone system was adopted, as it provided the greatest level of zonal detail available.

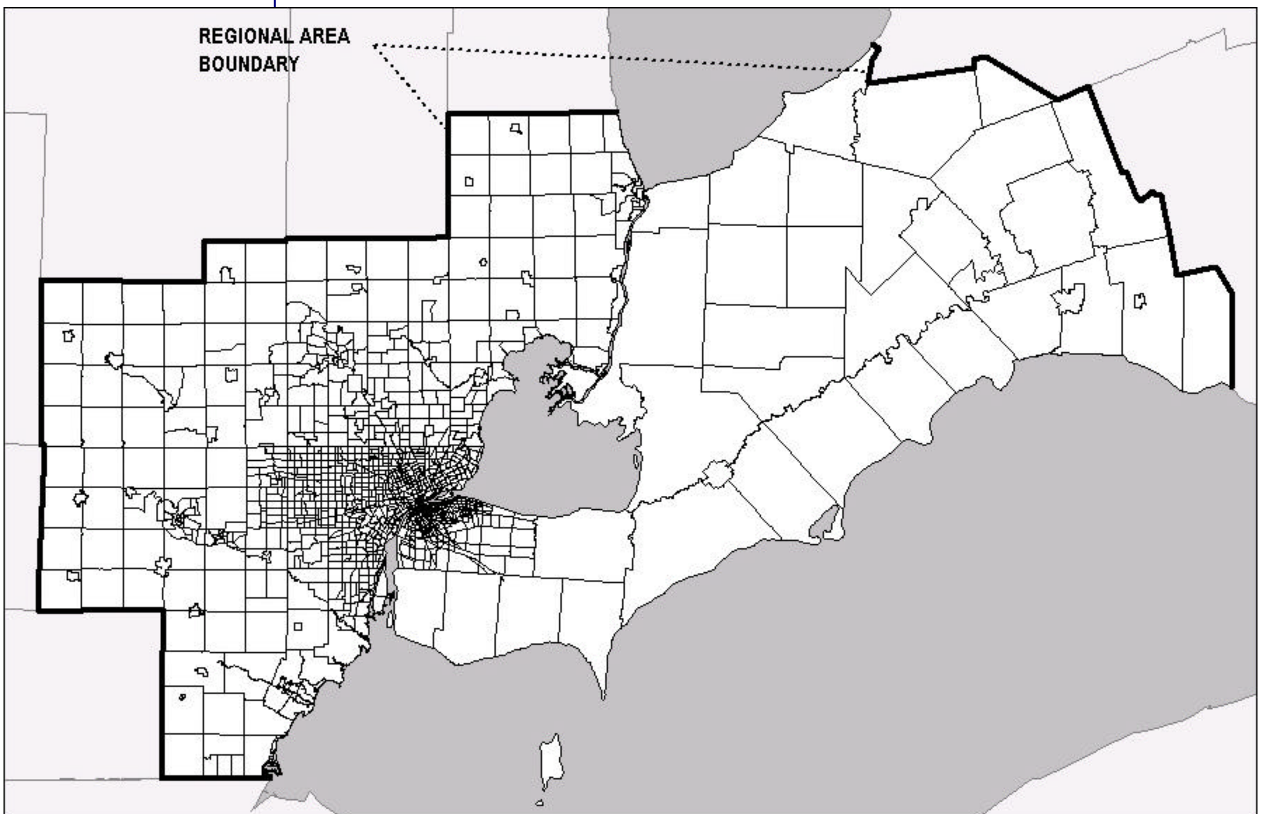
Within the remaining six counties in the SEMCOG area outside of Wayne County, the SEMCOG level of detail is not required. To avoid an over-complex and unwieldy model these zones have been aggregated to the MDOT model traffic zone system. All (non-cross-border) travel demand data for the SEMCOG area have been derived from the SEMCOG model. At this level of detail, 327 zones represent the 6 counties of SEMCOG, excluding Wayne County, with zones based on the larger MDOT zones.

On the Canadian side of the border, the 464 internal WALTS model zones cover an area encompassing the Windsor border crossings and are sufficiently detailed to carry out the required analysis. The WALTS Model includes zones only within the City of Windsor and immediate environs (i.e. LaSalle, Tecumseh, and the former Maidstone area of Lakeshore).

Outside of the WALTS area, traffic zones are based on Census subdivisions (municipalities) for the five counties representing the rest of Broad Geographic Area in Ontario – Essex, Kent, Lambton, Middlesex and Elgin. At this level of detail, 36 zones represent this immediate area of SW Ontario.

The traffic zone system for the regional area is illustrated in Exhibit 4.1.

**EXHIBIT 4.1: REGIONAL ZONE SYSTEM**




### *External Level Zone System*

The external area comprises the area outside of the regional area and is required only to allow the assignment of long-distance and international trips to major highway corridors and subsequently to the regional-level network. A cordon type approach was considered for external trips; however, since the passenger car survey and truck survey include actual origins and destinations of international traffic, it is preferable to define an external zone system.

In Canada, seven external zones are defined. These include the Greater Toronto Area and four other Ontario zones, one zone for Eastern Canada, and one zone for Western Canada. The West Central Ontario zone has access to Sarnia via Highway 21. The remaining Ontario external zones and Eastern Canada connect into the Broad Geographic Area via Highway 401. The Western Canada zone captures trips originating from and destined to Canada that use a US travel routing through Michigan and other states to reduce driving distances.

In the US, and within Michigan, 6 external zones are defined, based on the market areas for major highway corridors. Counties were used as the building blocks for these zones, although highway alignments required that the zones follow township boundaries in some cases. Outside of Michigan, 10 zones are defined. These include three states with relatively high volumes of traffic using the Ontario-Michigan crossings: Ohio, Indiana and Illinois. Niagara and Erie Counties in New York State are identified as a zone to capture the many through-Canada trips made by US-based vehicles that use a shorter distance southern Ontario routing to travel between New York and Michigan. The remaining US zones represent larger regions: one representing the southeast states and areas with a propensity to use Interstate 75 and an external zone the southwest and northwest US with a propensity to use Interstate 94 and Interstate 69.

The SEMCOG model loads external trips onto the network using 63 cordon zones, but at this distance from the focused area it was not considered necessary to retain this level of disaggregation. These zones have therefore been aggregated into 10 cordon zones for the purpose of assigning background traffic. Cross-border traffic from these cordon zones has been eliminated to avoid double counting with data from the cross-border passenger and truck surveys.

The external zone system is shown in Exhibit 4.2 on the following page.

### *Summary of Zone System*

Exhibit 4.3 provides a summary of the traffic zone system. In total, the zone system contains 1,489 zones, of which 520 are in Canada and 969 are in the US. All trip origins, trip destinations, population, employment and trip tables within the travel demand model system are based upon this traffic zone system. The development of trip matrices from the passenger car and commercial vehicle databases to correspond with this zone system is discussed in the next chapter.

**EXHIBIT 4.3: SUMMARY OF ZONE SYSTEM FOR REGIONAL MODEL**

| Area | Base for Zone System | ON-MI Zone Numbers | Number of Zones |
|---|---|---|---|
| Detroit and Windsor Area | WALTS Model | 1001-1464 | 464 |
| | SEMCOG Model (Wayne County) | 2001-2626 | 626 |
| Regional Area | Census Subdivisions within Essex, Kent, Lambton, Middlesex and Elgin | 3001-3036 | 36 |
| | Rest of SEMCOG Model Area, Aggregated to MDOT Zones* | 4001-4327 | 327 |
| External Area | External WALTS zones (for background loading only) | 5001-5013 | 13 |
| | Major regions for the rest of Michigan | 6001-6006 | 6 |
| | Major regions for the rest of Canada | 7001-7007 | 7 |
| | Major regions for the rest of the USA and Mexico | 8001-8010 | 10 |
| **Total Model Area** | | | **1,489** |

* Trip data from the SEMCOG Model are aggregated to MDOT zones.

## EXHIBIT 4.2: EXTERNAL ZONE SYSTEM

# 5. Development of Trip Tables

This chapter describes the development of passenger car and commercial vehicle trip tables, which includes both cross-border and local background traffic. Cross-border trip tables have been developed from recent international crossing surveys undertaken for passenger cars and commercial vehicles in 2000. The Ontario-Michigan Border Crossing Traffic Study (passenger car data) and the National Roadside Survey/MTO Commercial Vehicle Surveys, provides an extremely rich and comprehensive dataset of international vehicular traffic and a solid basis for transportation modelling.

The resulting trip tables from the international surveys have been synthesized to correspond with the two time periods being modelled (i.e. Weekday AM Peak Hour, Weekday PM Peak Hour), as described in Chapter 2, and the study zone system, as described in Chapter 3. The local background traffic is based on trip tables provided by the City of Windsor and SEMCOG, as represented in their respective transportation models. Combined, these data sources provide the most up-to-date and accurate portrayal of traffic possible based on existing data sources.

## 5.1. Cross-Border Passenger Car Trips

The basis for passenger-car cross-border trip matrices was the database of survey responses from the ***Ontario-Michigan Border Crossing Traffic Study***, carried out by Paradigm and Stantec for the MTO, MDOT, Transport Canada and the US DOT. This was a passenger-vehicle intercept survey undertaken over 3 to 4 days in August 2000 at each of the Ambassador Bridge, the Detroit-Windsor Tunnel, Blue Water Bridge, and International Bridge border crossings. The survey collected travel origin-destination and travel characteristic data for over 22,300 passenger car vehicles crossing the Ambassador Bridge, Detroit-Windsor Tunnel, Blue Water Bridge and International Bridge. This represents a sample rate of 5% of passenger car trips over the 4 day survey. This provides an extremely rich dataset for travel demand forecasting and a level of data quality and unprecedented cross-border traffic data in terms of data quality and detail. A complete description of the survey process and results are provided in the report[4].

Survey origin and destination results were coded to an approximately 50-zone Super Analysis Zones (SAZ) system in the Ontario-Michigan survey. More refined but incomplete geocoding was also carried out for locations within the SEMCOG and WALTS areas: 17,380 (88%) of the 19,660 locations (weekday responses) were also given x and y coordinates and allocated to a Transportation Analysis Zone (TAZ), using the WALTS and SEMCOG traffic zone systems. All survey records that could be coded to the SAZ level

[4] Ontario-Michigan Border Crossing Traffic Study, prepared for MTO, MDOT, Transport Canada and US DOT, prepared by Paridigm Transportation Solutions and Stantec, August 2001

were included in the survey expansion. Expansion factors were developed for each crossing, direction, day and hour of the survey, resulting in a large range of factors.

For use in this study, the passenger car survey data were converted to study's 1,489 traffic zone system, described in Chapter 4. This required recoding trip records from the SAZ system to the zones defined for the Broad Geographic Area and external zone system. Within the Windsor/Detroit area, more precise location detail was nec essary, given a much more refined zone system used in this study for this area. This required geocoding the trip records to the traffic zone system based on address information of trip origins and destinations provided in the passenger car database and then ascribing the appropriate traffic zones.

The 13,172 weekday records (26,344 origins and destinations) for the three crossings of interest were examined and updates made to obtain suitable input into the traffic modeling process. The passenger survey also recorded two types of origins and two types of destinations, which in most cases were the same; the development of the passenger-car cross-border trip tables used only the "just from" and "now to" locations.

***Allocation to Model Traffic Zones and Geocoding***

For the Broad Geographic Area, in the few cases where the SAZ definitions were entirely within a model zone, all records in that SAZ could be updated to the model zone number. For remaining zones, lists of place names (states, provinces and cities) and model zones were created using GIS–based process; these were used as quick-reference look-up lists to allocate model zones to records. In many cases, for smaller towns and monuments, an atlas or Internet search was needed to pinpoint these locations. In addition, locations that were originally coded as "Unknown" and not given a SAZ designation were reviewed and 46 (37%) of these were located and allocated to a model zone.

For records that had been geocoded in detail in the SEMCOG and WALTS areas, traffic zone numbers were replaced using a traffic zone equivalency file. (Because of overlap in the traffic zone numbering systems in the SEMCOG and WALTS areas as used in the original survey database, SEMCOG and WALTS area zones were replaced in separate steps.)

Where possible, records that had only been coded to the SAZ level in the SEMCOG and WALTS areas were also assigned to a model zone. For this purpose, Michigan and Ontario streets layers were overlaid with the model zone system in a GIS plot, using queries to pinpoint streets and their corresponding model zone on the plot. Results of address searches on MapQuest's Internet site were also used. In many cases, the address could be found directly from the address information included in the database. In other cases, a change in the spelling of a street, the address of a location coded only as a monument (e.g. restaurant, hospital, manufacturer) could be located in a directory and subsequently coded. Street information was considered to be more accurate than city information, where these were reasonably close not to be considered contradictory (e.g. an intersection in LaSalle reported with the city of "Windsor" would be coded to the LaSalle intersection). In cases where there was contradictory information (e.g. both a postal code and town name a significant distance from the postal code were reported), location detail could not be found within the reported location parameters (e.g. a street address that could not be found in a given town, implying that one or the other could have been misreported), or given information could not be found (e.g. a postal code that could not be located) the record was coded as "Unknown" and its results not included in the survey expansion.

A total of 656 locations had insufficient location information to code the records precisely (e.g. location information was only "Windsor" or "Detroit", or the name of a long street with no street number or intersection specified). These records were "ascribed" detailed locations: model zones were randomly selected from other records in the broadly specified area (e.g. "Detroit"), and, where possible, from the same crossing and with the same trip purpose. This ascription process was necessary so that the sample would not be biased toward longer-distance trips, as the records with insufficient location information were local oriented with a Windsor/Detroit trip start and/or end.

This geocoding process and logic checks (e.g. direction, crossing location given O-D) resulted in several updates to the trip records. For instance, in several cases, the original SAZ designations would change following additional detailed geocoding or ascription. (For example, locations coded as "WALTS – not Central Core" would become "Central Core" or "Essex County – not WALTS".)

Exhibit 5.1 summarizes the additional geocoding carried out on the records with locations within the SEMCOG and WALTS area zones.

### EXHIBIT 5.1: GEOCODING REVISIONS TO CROSS-BORDER PASSENGER CAR DATABASE FOR SEMCOG AND WINDSOR AREAS

| | Windsor and Area (WALTS)[1] | Wayne County | Rest of SEMCOG Area | TOTAL |
|---|---|---|---|---|
| | (number of records) | | | |
| Original Detailed Coding | 7,564 | 4,952 | 4,859 | 17,375 |
| Additional Direct Coding | 786 | 310 | 296 | 1,392 |
| Ascribed Records | 383 | 219 | 54 | 656 |
| TOTAL CODED | 8,733 | 5,481 | 5,209 | 19,423 |
| *Designated Unknown* | *146* | *72* | *14* | *232* |
| Increase in Sample Size | 15% | 11% | 7% | 12% |

Note
[1] These include records that were later assigned to a zone outside of the WALTS area with the additional geocoding work.

### *Data Expansion*

Data for the ***Ontario-Michigan Border Crossing Traffic Study*** were collected over 3 to 4 days: from Wednesday or Thursday, depending on the crossing, to Saturday. To use the largest and therefore most representative sample size possible for the weekday model, records from all weekdays were included. Expansion factors were developed for each crossing and direction for each of five time periods: AM Peak (6-9 AM), Mid-Day (9 AM – 3 PM), PM Peak (3-7 PM), Evening (7-11 PM), and Night (11 pm - 6 PM), with volumes during the week's peak period used as the control volumes. Resulting expansion factors range from 2.94 to 11.48. This greatly reduces the variability in expansion factors seen in the factors developed based on hourly volumes (1.3 to 118).

To develop peak hour matrices, all peak period records were multiplied by a peak-hour-to-peak-period factor, as it is not expected that variation in origin-destination travel patterns within the peak period is significant. The average expansion factor applied to each trip record to produce the trip tables was approximately 1.5, reflecting a very high sample rate for a travel survey and thus an extremely high level of confidence in the reflecting travel origin-destination patterns.

### *Data Summary*

Exhibit 5.2 summarizes cross-border passenger-car trips for each crossing, for a weekday 24-hour period and for the AM and PM peak hour, as used in the modelling process. (Data used for the traffic model are at the traffic zone level.)

## EXHIBIT 5.2: SUMMARY OF CROSS-BORDER PASSENGER CAR TRAVEL ORIGINS AND DESTINATIONS

### A. 24-HOUR

**AMBASSADOR BRIDGE**

| ORIGIN | DESTINATION 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** Detroit + NE Wayne | | | 5 | | | 19 | 1,959 | 605 | 5 | 353 | 2945 |
| **2** Rest of Wayne County | 9 | | | 5 | | 28 | 3,107 | 851 | 9 | 595 | 4605 |
| **3** Port Huron/St. Clair County | | | | | | | 18 | 13 | | | 31 |
| **4** Rest of SEMCOG | | | | | | 49 | 2,149 | 887 | | 652 | 3737 |
| **5** Rest of MI | | | | | | 19 | 307 | 78 | | 138 | 542 |
| **6** Other USA/Mexico | 10 | 49 | | 69 | 93 | 30 | 862 | 154 | 5 | 1,105 | 2377 |
| **7** Windsor | 1,685 | 2,610 | 50 | 1,789 | 305 | 578 | 10 | 9 | 12 | 11 | 7058 |
| **8** Rest of Essex County | 581 | 713 | 6 | 750 | 119 | 128 | | | 12 | 13 | 2322 |
| **9** Sarnia/Lambton County | | | | | 4 | 4 | 40 | 5 | | | 53 |
| **10** Other Ontario/Canada | 204 | 419 | 4 | 382 | 438 | 1,158 | 25 | 8 | 4 | 42 | 2683 |
| **TOTAL** | 2489 | 3791 | 65 | 2995 | 958 | 2013 | 8477 | 2609 | 47 | 2909 | **26352** |

**DETROIT-WINDSOR TUNNEL**

| ORIGIN | DESTINATION 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** Detroit + NE Wayne | 4 | | | | | 12 | 3,730 | 588 | | 311 | 4646 |
| **2** Rest of Wayne County | | | | | | | 1,041 | 78 | | 98 | 1217 |
| **3** Port Huron/St. Clair County | | | | | | | 127 | 19 | | | 145 |
| **4** Rest of SEMCOG | | | | 12 | | 24 | 4,967 | 519 | 6 | 332 | 5860 |
| **5** Rest of MI | | | | | | | 422 | 53 | | 55 | 531 |
| **6** Other USA/Mexico | 24 | 5 | | 18 | | 6 | 162 | 49 | | 115 | 379 |
| **7** Windsor | 3,206 | 1,214 | 89 | 5,154 | 499 | 317 | 9 | | 28 | 28 | 10544 |
| **8** Rest of Essex County | 416 | 69 | 5 | 588 | 35 | 25 | | | 5 | 14 | 1157 |
| **9** Sarnia/Lambton County | | | | | | | 25 | | 4 | | 29 |
| **10** Other Ontario/Canada | 198 | 84 | | 270 | 72 | 68 | 11 | 6 | | 21 | 730 |
| **TOTAL** | 3849 | 1371 | 94 | 6043 | 607 | 452 | 10495 | 1312 | 42 | 974 | **25239** |

**BLUE WATER BRIDGE**

| ORIGIN | DESTINATION 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** Detroit + NE Wayne | | | | | | 22 | | | 68 | 123 | 212 |
| **2** Rest of Wayne County | | | | | | 12 | | | 94 | 124 | 230 |
| **3** Port Huron/St. Clair County | | | | | | 10 | | 5 | 2,288 | 383 | 2686 |
| **4** Rest of SEMCOG | | | | | | 155 | 6 | | 639 | 943 | 1743 |
| **5** Rest of MI | | | | | | 242 | 6 | | 543 | 800 | 1590 |
| **6** Other USA/Mexico | 20 | | 3 | 143 | 190 | 54 | | | 101 | 264 | 775 |
| **7** Windsor | | | | | 9 | | | | 50 | 15 | 74 |
| **8** Rest of Essex County | | | 5 | | | | | | 19 | 6 | 30 |
| **9** Sarnia/Lambton County | 67 | 89 | 2,474 | 655 | 506 | 82 | 52 | 44 | 3 | 14 | 3987 |
| **10** Other Ontario/Canada | 122 | 63 | 481 | 660 | 739 | 368 | 11 | | 31 | 292 | 2768 |
| **TOTAL** | 210 | 153 | 2963 | 1458 | 1445 | 945 | 75 | 49 | 3835 | 2964 | **14097** |

## EXHIBIT 5.2 (CONTINUED): SUMMARY OF CROSS-BORDER PASSENGER CAR TRAVEL ORIGINS AND DESTINATIONS

### B. PEAK HOURS

**AM PEAK HOUR**

**AMBASSADOR BRIDGE**

| | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ORIGIN** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **TOTAL** |
| **1** Detroit + NE Wayne | | | | | | | 50 | 9 | | 16 | 76 |
| **2** Rest of Wayne County | | | | | | | 100 | 14 | | 38 | 153 |
| **3** Port Huron/St. Clair County | | | | | | | 4 | 2 | | | 5 |
| **4** Rest of SEMCOG | | | | | | 2 | 54 | 10 | | 22 | 88 |
| **5** Rest of MI | | | | | | | 5 | | | 5 | 10 |
| **6** Other USA/Mexico | | 3 | | 3 | 5 | | 21 | | | 20 | 52 |
| **7** Windsor | 172 | 197 | 4 | 198 | 14 | 37 | | | | | 622 |
| **8** Rest of Essex County | 106 | 106 | | 129 | 10 | 14 | | | | 3 | 368 |
| **9** Sarnia/Lambton County | | | | | | | 2 | | | | 2 |
| **10** Other Ontario/Canada | 22 | 16 | | 16 | 17 | 52 | | | | | 123 |
| **TOTAL** | 300 | 322 | 4 | 346 | 46 | 104 | 236 | 36 | 0 | 105 | **1499** |

**DETROIT-WINDSOR TUNNEL**

| | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ORIGIN** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **TOTAL** |
| **1** Detroit + NE Wayne | | | | | | 3 | 73 | 32 | | 19 | 127 |
| **2** Rest of Wayne County | | | | | | | 24 | 3 | | 14 | 41 |
| **3** Port Huron/St. Clair County | | | | | | | | | | | 0 |
| **4** Rest of SEMCOG | | | | | | 3 | 141 | | | 16 | 160 |
| **5** Rest of MI | | | | | | | 11 | | | 3 | 14 |
| **6** Other USA/Mexico | 5 | | | 2 | | | | 3 | | 3 | 12 |
| **7** Windsor | 294 | 66 | 2 | 312 | 14 | 5 | | | 2 | 2 | 697 |
| **8** Rest of Essex County | 68 | 5 | | 79 | | 5 | | | | 2 | 158 |
| **9** Sarnia/Lambton County | | | | | | | | | | | 0 |
| **10** Other Ontario/Canada | 16 | 2 | | 7 | 2 | | | | | | 27 |
| **TOTAL** | 382 | 72 | 2 | 400 | 16 | 14 | 249 | 38 | 2 | 59 | **1235** |

**BLUE WATER BRIDGE**

| | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ORIGIN** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **TOTAL** |
| **1** Detroit + NE Wayne | | | | | | 6 | | | 2 | 4 | 11 |
| **2** Rest of Wayne County | | | | | | | | | | 4 | 4 |
| **3** Port Huron/St. Clair County | | | | | | | | 2 | 30 | 11 | 43 |
| **4** Rest of SEMCOG | | | | | | 13 | | | 6 | 47 | 66 |
| **5** Rest of MI | | | | | | 19 | | | 6 | 19 | 43 |
| **6** Other USA/Mexico | | | | | 4 | 2 | | | | 9 | 15 |
| **7** Windsor | | | | | | | | | | | 0 |
| **8** Rest of Essex County | | | 2 | | | | | | | | 2 |
| **9** Sarnia/Lambton County | 6 | 2 | 109 | 30 | 19 | 8 | 2 | 2 | | 2 | 179 |
| **10** Other Ontario/Canada | 6 | | 15 | 17 | 11 | 17 | | | | 17 | 83 |
| **TOTAL** | 11 | 2 | 126 | 47 | 34 | 64 | 2 | 4 | 43 | 112 | **445** |

**PM PEAK HOUR**

| | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ORIGIN** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **TOTAL** |
| **1** Detroit + NE Wayne | | | | | | 3 | 199 | 93 | | 48 | 342 |
| **2** Rest of Wayne County | 3 | | | | | | 283 | 111 | 3 | 53 | 453 |
| **3** Port Huron/St. Clair County | | | | | | | | 1 | | | 1 |
| **4** Rest of SEMCOG | | | | | | 8 | 245 | 122 | | 61 | 436 |
| **5** Rest of MI | | | | | | 3 | 32 | 8 | | 3 | 45 |
| **6** Other USA/Mexico | 1 | 3 | | 9 | 5 | 1 | 61 | 15 | | 88 | 184 |
| **7** Windsor | 71 | 158 | 2 | 125 | 19 | 38 | | 3 | 1 | 1 | 417 |
| **8** Rest of Essex County | 21 | 35 | | 36 | 7 | 7 | | | 1 | | 107 |
| **9** Sarnia/Lambton County | | | | | | | 3 | | | | 3 |
| **10** Other Ontario/Canada | 15 | 33 | | 44 | 24 | 92 | 6 | | 1 | 4 | 218 |
| **TOTAL** | 110 | 229 | 2 | 214 | 54 | 151 | 830 | 352 | 6 | 258 | **2206** |

| | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ORIGIN** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **TOTAL** |
| **1** Detroit + NE Wayne | 1 | | | | | | 349 | 68 | | 21 | 439 |
| **2** Rest of Wayne County | | | | | | | 89 | 7 | | 3 | 99 |
| **3** Port Huron/St. Clair County | | | | | | | 7 | 3 | | | 10 |
| **4** Rest of SEMCOG | | | | | | 2 | 410 | 63 | | 27 | 502 |
| **5** Rest of MI | | | | | | | 44 | 3 | | 9 | 56 |
| **6** Other USA/Mexico | | | | | | | 17 | 7 | | 9 | 32 |
| **7** Windsor | 160 | 69 | 6 | 276 | 34 | 21 | 1 | | 4 | 3 | 574 |
| **8** Rest of Essex County | 19 | 3 | | 35 | 4 | 1 | | | | | 61 |
| **9** Sarnia/Lambton County | | | | | | | 2 | | 1 | | 3 |
| **10** Other Ontario/Canada | 11 | 8 | | 16 | 11 | 6 | | | | 2 | 54 |
| **TOTAL** | 191 | 79 | 6 | 328 | 49 | 30 | 919 | 152 | 5 | 73 | **1832** |

| | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ORIGIN** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **TOTAL** |
| **1** Detroit + NE Wayne | | | | | | | | | 2 | 12 | 14 |
| **2** Rest of Wayne County | | | | | | | | | 9 | 9 | 19 |
| **3** Port Huron/St. Clair County | | | | | | | | | 215 | 47 | 262 |
| **4** Rest of SEMCOG | | | | | | 5 | | | 61 | 54 | 119 |
| **5** Rest of MI | | | | | | 16 | | | 58 | 58 | 133 |
| **6** Other USA/Mexico | 3 | | | 14 | 14 | 6 | | | 9 | 19 | 66 |
| **7** Windsor | | | | | | | | | 5 | 2 | 7 |
| **8** Rest of Essex County | | | | | | | | | 5 | | 5 |
| **9** Sarnia/Lambton County | 6 | 12 | 151 | 49 | 26 | | | | | | 243 |
| **10** Other Ontario/Canada | 14 | | 43 | 49 | 64 | 20 | 3 | | 5 | 16 | 215 |
| **TOTAL** | 23 | 12 | 194 | 113 | 104 | 47 | 3 | 0 | 369 | 217 | **1082** |

## 5.2. Cross-Border Commercial Vehicle Trips

***NRS/MTO Commercial Vehicle Survey***

The primary source of data for developing cross-border commercial vehicle trip matrices was the Commercial Vehicle Survey database provided by the MTO. This data set is based on the 1999 National Roadside Survey (NRS), combined with results from the 2000/2001 MTO Commercial Vehicle Survey. This combined NRS/MTO database provides a more comprehensive commercial vehicle travel data for this study, which provides more than 13,500 actual records collected for truck trips crossing between Ontario and Michigan. This represents an extremely rich sample of travel data that is unprecedented in terms of size of the sample and comprehensive in describing cross border commercial vehicle traffic. Details on the design and conduct of these surveys, including validation and sample statistics, may be examined in relevant the reports documenting these surveys[5][6].

The 1999 NRS is the third commercial vehicle intercept survey of its type in Canada (1991 and 1995 being the previous years surveyed). This major survey effort was a joint effort by federal, provincial and territorial transportation departments. The 1999 NRS survey is also the first NRS survey that included the participation of US transportation authorities, led by the Eastern Border Transportation Coalition (EBTC) to obtain a profile of truck traffic using the major Canada-US border crossings. As such this survey provides an unprecedented detailed look at cross-border truck traffic movements. The survey involved traffic counts and driver intercept surveys over a seven-day period at each of a total of 238 sites. The survey stations for the Ambassador Bridge, Detroit-Windsor Tunnel and Blue Water Bridge were located at the Canadian Primary Inspection, with surveying on the Detroit-Windsor Ferry occurring in-transit on the ferry.

Commercial vehicle drivers were asked questions about the vehicle profile, carrier, travel origins and destinations, and commodity for their trip. These records were expanded to the universe of truck travelers for each day of the week, with adjustments made for multiple counting where the same commercial vehicle trip would pass more than one survey point. The 2000/2001 MTO CVS was built into this dataset to include more detailed Ontario geographic information from a survey of 37 one-directional sites in Ontario. The MTO synthesized these datasets and developed expansion factors for each record. The resulting data set included 10,242 records of truck trips passing through the border crossings of interest to this study, 2,619 of these representing trips during weekday AM or PM peak periods. This reflects a sample rate of approximately 9% of trucks crossing the border at the three locations during the survey.

---

[5] 1999 National Roadside Study Project Report, prepared by Canadiain Council of Motor Transport Administrators,October 30, 2001.

[6] 2000 Commercial Vehicle Survey – Study Design, prepared for Ministry of Transportation of Ontario, Data Management & Analysis Office, prepared by Earth Tech (Canada) Inc., September 1, 2000

Commercial vehicle trip tables were generated from the NRS/MTO dataset to represent the weekday AM peak 3-hour period and PM peak 4-hour period using the 1,489 traffic zone system developed for this study. Since a typical weekday was being represented, trip records for all weekdays in the survey dataset were used to generate the trip tables, making greater use of the available data.

AM peak hour and PM peak hour trip tables were then developed using peak period to peak hour conversion factors, calculated from traffic count data. As part of this process, additional geocoding was required on the dataset and is described in the section below.

Given the large sample size and using data from all weekdays to reflect a typical weekday, the average expansion factor applied to the trip records to generate the peak hour trip tables is less than 1, meaning that each trip in each of the AM and PM peak hour trip tables is based on an actual observed commercial vehicle trip. Hence, an effective weekday sample rate of 45% was achieved.

***Additional Local Geographic Detail***

The geographic information in the NRS/MTO data set was coded to the nearest city or town, including Windsor, Detroit and nearby townships such as Dearborn as single zones. This level of detail is suitable for assigning trip origins and destinations to many of the regional and external traffic zones, and for strategic modelling purposes, such as determining the flow of travel between the Windsor-Detroit and Sarnia-Port Huron gateways. However, a more refined level of geographic detail for the many origins and destinations in the Detroit or Windsor areas was required to allow for the required trip assignment precision for trips with at least one end in these areas. As described further below, NRS/MTO volume totals were maintained for each origin-destination pair in this database (i.e. maintained the same control totals for trips to/from Windsor and to/from Detroit and all other zones), while refining the geographic detail within the Detroit/Windsor areas.

As an additional source, MDOT and SEMCOG had carried out a survey of commercial vehicles at six locations for external travel: Ambassador Bridge (1996), Blue Water Bridge (1994) and four weigh stations (1994). (Windsor-Detroit Tunnel commercial vehicles were not included as part of this survey.) These data provided address information for the trip origin and trip destination as part of the dataset. Expansion factors for this data set were developed for each crossing only to reflect daily totals; these did not reflect variations in sampling rates by time of day. For the stations surveyed in 1994, MDOT traffic zones had been assigned to the origins and destinations. However, these were again coded to the city or township level, so that all locations in Detroit were coded to a single zone in the Detroit downtown. Before using these data, original geocoding to the traffic zone level of detail was carried out similar to the process used to provide additional locational detail for the passenger car survey.

Other commercial vehicle data sources that were drawn on for developing an enhanced level of detail for local commercial vehicle origins and destinations are as follows:

- home addresses of the carriers associated with the NRS/MTO trip records, where these represented possible legitimate trip origins or destinations for the trips;
- trip ends from SEMCOG's internal commercial vehicle trip table, provided for a 2005 forecast year;
- identification of loc ations of auto plants, parts manufacturers and other major truck generators and the review of land use and truck route designations in Windsor/Detroit;
- discussions with truck and auto industry representatives and to gain insights on truck origin-destination patterns, volumes and crossing issues and needs, as they relate to this study; emphasis was placed on obtaining information to capture the traffic flows associated with the auto industry and the "Big Three" auto makers.

In consultation with the Partnership, a methodology was developed to provide an enhanced level of traffic zone level detail for commercial vehicle travel in Windsor/Detroit. The process maintained the NRS/MTO data control totals and the general breakdown by commodity (auto-related and other) and involved combining information and data from the sources listed above, as described in the following section for each crossing. To the extent possible, actual origin-destination survey data were used to provide the additional traffic zone level detail.

***Integration of Geographic Detail***

The use of the MDOT/SEMCOG external commercial vehicle database and other data/information sources involved various approaches to obtain the local geographic detail necessary for each crossing and then combining the additional detail into the NRS/MTO commercial vehicle dataset.

For the **Ambassador Bridge**, this process required original geocoding of the MDOT/SEMCOG data to the traffic zone level. The geocoding process used was similar to that developed to update the passenger-car survey, as described in Section 5.1. Records in the NRS/MTO commercial vehicle database reflecting trips between the Windsor area and the Detroit area were replaced by successfully geocoded records from the SEMCOG data set, matching auto industry-related commodity information with auto-industry locations where possible, then expanding the new trips to reflect the NRS/MTO commercial vehicle totals for the origin-destination pair. Records from the same peak period were used in the replacement where available, supplemented by records from other time periods if necessary. For records reflecting trips between the local areas and other areas, the local trip end was ascribed, that is replaced with a random selection of origins or destinations in the area in the MDOT/SEMCOG external commercial vehicle database. Because there was a smaller proportion of local-to-longer-distance trips in the MDOT/SEMCOG database than in the NRS/MTO database, the selection of local locations for replacements was expanded to include known industrial locations and locations observed for the local-to-local trips. Auto-industry-related trips were also assigned to the most likely auto industry locations in Detroit and Windsor for these trips.

There was no additional source of data specifically describing origins and destinations of commercial vehicles using the **Detroit-Windsor Tunnel**. Because the Detroit-Windsor Tunnel serves a different commercial vehicle market than the Ambassador Bridge, it was not feasible to use the detailed geographic information from the Ambassador Bridge. As a first step, information in the NRS/MTO database describing the carrier or commodity for trips using the Detroit-Windsor Tunnel was examined to determine how much detailed location information could be inferred. Detailed locations could be inferred for approximately 10% of local origins and destinations, mostly on the Windsor side. As a second step, for the Detroit side, a 2005 truck matrix for trips internal to the SEMCOG area was made available by SEMCOG; this was based on the 1999 CVS expanded sample. Plotting the trip origins showed which zones were major generators of truck trips. A selection of such zones in the general area of the origins and destinations that were inferred from the first step were randomly ascribed as trip ends for the remaining Detroit trips. On the Windsor side, the origins and destinations that were inferred in the first step, along with a selection of known industrial zones in the same general area, were randomly ascribed as trip ends for the remaining Windsor trips.

For the **Blue Water Bridge**, because of the smaller number and proportion of trips to the Detroit area, and the longer distance traveled to the area, the distribution of trips in the Detroit area was not as crucial. For these trips, auto-industry-related trips were randomly ascribed to auto-industry traffic zones in the Detroit area.

Exhibit 5.3 provides a summary of the process for enhancing local geographic detail for each crossing, in terms of the number of affected unexpanded records in the NRS/MTO database.

***Interviews with Trucking and Auto Industry Representatives***

To assist in refining the commercial vehicle trip table, interviews were conducted with trucking and auto industry representatives to obtain information on truck volumes crossing the border and origin-destination patterns. Other qualitative insights were also gathered, such as on factors influencing the choice of border crossing (e.g. processing times, congestion, toll rates, travel times/distances). This is important, as the difference between the perception and the reality of the magnitudes of these factors helps to explain any differences between the model results and reality. Insights into any intentions to switch current truck operations to intermodal were also obtained, as these would have obvious implications for future year results and will affect the commercial vehicle forecasting methodology.

### EXHIBIT 5.3 SUMMARY OF REFINEMENT OF GEOGRAPHIC DETAIL FOR DETROIT/WINDSOR AREA COMMERCIAL VEHICLE TRIP RECORDS – PEAK PERIODS ONLY

| | NUMBER OF NRS/MTO COMMERCIAL VEHICLE DATABASE RECORDS | | | | |
|---|---|---|---|---|---|
| **CROSSING** | **Local to Local Trips** | **Long Distance Trips – One Detroit Area End** | **Long Distance Trips – One Windsor End** | **Total Refined Records** | **Total Records** |
| AMBASSADOR BRIDGE | **20** records (40 trip ends), replaced with equivalent, detailed records from MDOT/SEMCOG external truck survey for Ambassador Bridge | **176** records<br>Local trip ends randomly replaced with local trip end from equivalent MDOT/SEMCOG external truck survey trip end, or known industrial location, matching auto-industry related vs. other trip types | **30** records | 226 | 1313 |
| DETROIT-WINDSOR TUNNEL | **36** records (72 trip ends)<br>approx. 10% of trip ends inferred from carrier or commodity information (mostly Windsor), remainder randomly ascribed to these locations, to known industrial locations, or to traffic zones with high levels of truck trip generation (SEMCOG internal truck trip matrix), generally matching auto-industry related vs. other trip types | **14** records | **18** records | 68 | 105 |
| BLUE WATER BRIDGE | N/A | **23** auto-industry related trip ends randomly replaced with auto-industry trip end in Detroit | N/A | 23 | 1201 |

Representatives from the trucking and auto industry interviewed included the following:

- Auto Manufacturers – Daimler Chrysler, Ford, General Motors;
- Logistics – Ryder;
- Carriers – JB Hunt, SLH Transport, Sysco Food Services;
- Associations – Auto Parts Manufacturers Association, Canadian Trucking Alliance, Ontario Trucking Association, Canadian Vehicle Manufacturers Association;
- Government/Municipal – SEMCOG, City of Windsor.

Where possible, quantitative origin-destination or volume information was obtained, with much of the information based on experienced observation and insights of those in the industry. The qualitative information served to provide a check of the overall reasonableness of the trip table and greater understanding of the characteristics of commercial vehicle movements.

Commercial vehicle movements at the Ambassador Bridge and Blue Water crossings (and thus the entire gateway in general) are highly dominated by the auto industry. This industry was therefore the focus of the interview process in terms of the quantitative information gathered. Exhibit 5.4 summarizes the industry's truck flows across the border for the "Big Three" manufacturers, in terms of the number of vehicles per day, the crossings used and the major nodes that define travel corridors. The travel patterns performed by these manufacturers are complex with numerous origin and destination pairings. As indicated in the table, the vast majority of the "Big Three" related truck trips between Ontario and the US use the Windsor-Detroit crossings, followed by Sarnia-Port Huron and the Queenston-Lewiston crossings.

### EXHIBIT 5.4 CURRENT AUTO INDUSTRY CROSS-BORDER TRUCK MOVEMENTS

| Company | Truck Crossings/Day | Crossings Used | | Major Nodes | |
|---|---|---|---|---|---|
| | | US to Canada | Canada to US | US | Canada |
| DAIMLER CHRYSLER | 1500 | 98% Windsor-Detroit<br>2% Sarnia-Port Huron | 76% Windsor-Detroit<br>12% Sarnia-Port Huron<br>12% Buffalo-Fort Erie | Detroit, MI (3)<br>St. Louis, MO (2)<br>Toledo, OH (2)<br>Belvedere, IL<br>Newark, NJ | Windsor, ON (2)<br>Brampton, ON |
| GENERAL MOTORS | 1200 | 64% Windsor-Detroit<br>19% Queenston-Lewiston<br>13% Sarnia-Port Huron<br>4% Gananoque | | Buick City, MI<br>Flint, MI<br>Warren, MI<br>Texas<br>Tennessee<br>Kentucky<br>Mexico | Windsor, ON<br>Oshawa, ON |
| FORD | 1080 | 80% Windsor-Detroit<br>7% Sarnia-Port Huron<br>3% Buffalo-Fort Erie<br>10% Other | 62% Windsor-Detroit<br>9% Sarnia-Port Huron<br>9% Buffalo-Fort Erie<br>20% Other | Wayne, MI<br>Kansas City, MO<br>Dearborn, MI<br>Chicago, IL<br>Atlanta, GA<br>Wixom, MI<br>St. Louis, MO<br>Mexico | Windsor, ON<br>Oakville, ON |

Notes: () indicate number of nodes in city if more than one.

The major nodes represent the truck trip origins and destinations of the "Big Three" (i.e. manufacturing plants, suppliers, etc.) and are generally dispersed in a wide corridor extending from the Greater Toronto Area, through Southeast Michigan and including nodes in Ohio, Illinois, Missouri, and Kentucky, among others. The locations are indicative of the large interactions between assembly plants/parts manufacturers situated in this "automotive" corridor that is focused in the Detroit area, with high auto related traffic to or from Windsor and Detroit, as well as flows travelling in the corridor and travelling through Windsor-Detroit.

With respect to local truck traffic between Windsor and Detroit, Daimler-Chrysler is the heaviest generator of local trips, with 5 major nodes within a short distance of the border. Daimler-Chrysler has indicated that approximately 200 trucks per day use the Detroit-Windsor Tunnel (with special "low boy" trailers), which are predominantly local Windsor-Detroit trips.

In choosing between which crossing to use, the logistics groups of the auto industry are well informed of the factors that affect what is truly the shortest route. Distances, congestion and processing times are carefully considered when determining routes and crossings. However, smaller operators and those that use the crossings less frequently are less aware of these factors. The preference towards the Ambassador Bridge crossing is a fact that is recognized by the Ontario Trucking Association and others. In discussions with these associations, it is felt that the reasons for this include the following:

- operators are more familiar with the routing and comfortable with customs brokers at the Ambassador Bridge, resulting in the formation of travel habits;
- the Blue Water Bridge has only had increased capacity for a relatively short period of time, not long enough for the increased attractiveness of this crossing to have broken these habits;
- it is easier (or habitual) for the administrative departments of operators to deal with one bridge (typically the Ambassador Bridge) for matters such as pre-clearance papers, so there is no choice available to the driver;
- there is better access to I-75 south of Detroit via Windsor, as traveling down I-94 via Sarnia-Port Huron requires going through the core of Detroit; and
- there is a perception of a shorter distance via the Ambassador Bridge for more of the total trips between Ontario and Michigan.

The switch to intermodal is being considered by the auto industry in general but has not, as yet, become a major focus due to its continued lack of competitiveness with trucks. Recent initiatives by CN and CP to expand their intermodal operations have, however, supported a recent trend towards an increased share of goods transported by intermodal in general. As the auto industry has indicated a willingness to switch to intermodal given improved reliability and speed, continued improvements will likely result in the continuation of this trend into the near future. This is particularly true for longer distance trips and for transporting of finished products where the time of delivery is not as critical.

***Data Summary***

Exhibit 5.5 summarizes cross-border commercial vehicle trips for each crossing for a weekday 24-hour period and the AM and PM peak hour that was used in the modelling process. (Note: data used for the traffic model are at the traffic zone level).

## EXHIBIT 5.5: SUMMARY OF CROSS-BORDER COMMERCIAL VEHICLE TRAVEL ORIGINS AND DESTINATIONS

### A. 24-HOUR

**AMBASSADOR BRIDGE**

| ORIGIN | DESTINATION 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Detroit + NE Wayne | | | | | | 23 | 279 | 15 | | 310 | 627 |
| 2 Rest of Wayne County | | | | | | 65 | 613 | 46 | | 355 | 1079 |
| 3 Port Huron/St. Clair County | | | | | | 2 | 31 | | | | 33 |
| 4 Rest of SEMCOG | | | | | | 8 | 156 | 89 | | 149 | 402 |
| 5 Rest of MI | | | | | | 10 | 129 | 35 | | 172 | 346 |
| 6 Other USA/Mexico | 59 | 56 | 2 | 33 | 26 | 56 | 499 | 28 | 6 | 2,879 | 3642 |
| 7 Windsor | 531 | 296 | | 344 | 145 | 538 | | | | 84 | 1937 |
| 8 Rest of Essex County | 26 | 30 | | 26 | 29 | 221 | | | | 17 | 350 |
| 9 Sarnia/Lambton County | | 0 | | | 6 | 2 | | | | | 9 |
| 10 Other Ontario/Canada | 297 | 420 | | 177 | 147 | 2,501 | 56 | 8 | | 14 | 3621 |
| TOTAL | 912 | 803 | 2 | 580 | 353 | 3426 | 1763 | 221 | 6 | 3981 | **12046** |

**DETROIT-WINDSOR TUNNEL**

| ORIGIN | DESTINATION 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Detroit + NE Wayne | | | | | | 3 | 86 | 22 | | 17 | 129 |
| 2 Rest of Wayne County | | | | | | 5 | 62 | 20 | | 12 | 99 |
| 3 Port Huron/St. Clair County | | | | | | | | | | | 0 |
| 4 Rest of SEMCOG | | | | | | 3 | 68 | 12 | | 10 | 93 |
| 5 Rest of MI | | | | | | | 16 | 15 | | 5 | 36 |
| 6 Other USA/Mexico | 2 | | | 6 | | 1 | 4 | | | 12 | 24 |
| 7 Windsor | 104 | 41 | 1 | 41 | 33 | 11 | | | | | 231 |
| 8 Rest of Essex County | 13 | 6 | | 12 | 4 | | | | | | 35 |
| 9 Sarnia/Lambton County | | | | | | 0 | | | | | 0 |
| 10 Other Ontario/Canada | 12 | 15 | 4 | 30 | 1 | 16 | | | | | 78 |
| TOTAL | 130 | 61 | 5 | 89 | 37 | 39 | 237 | 69 | 0 | 57 | **725** |

**BLUE WATER BRIDGE**

| ORIGIN | DESTINATION 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Detroit + NE Wayne | | | | | | 28 | | | 6 | 82 | 117 |
| 2 Rest of Wayne County | | | | | | 8 | | | 5 | 58 | 70 |
| 3 Port Huron/St. Clair County | | | | | | 39 | | | 9 | 88 | 136 |
| 4 Rest of SEMCOG | | | | 2 | | 83 | | | 7 | 286 | 378 |
| 5 Rest of MI | | | | | | 176 | 4 | 1 | 25 | 605 | 811 |
| 6 Other USA/Mexico | 41 | 27 | 41 | 139 | 183 | 67 | 2 | 2 | 66 | 969 | 1537 |
| 7 Windsor | | | 8 | 1 | | 1 | | | | | 11 |
| 8 Rest of Essex County | | | | | | | | | | | 0 |
| 9 Sarnia/Lambton County | 10 | 5 | 13 | 19 | 29 | 58 | | | | | 134 |
| 10 Other Ontario/Canada | 92 | 52 | 101 | 446 | 663 | 1,149 | | | 2 | 41 | 2547 |
| TOTAL | 143 | 84 | 164 | 607 | 876 | 1610 | 6 | 3 | 120 | 2129 | **5742** |

## EXHIBIT 5.5 (CONTINUED): SUMMARY OF CROSS-BORDER COMMERCIAL VEHICLE TRAVEL ORIGINS AND DESTINATIONS

### B. PEAK HOURS

**AM PEAK HOUR**

**AMBASSADOR BRIDGE**

| ORIGIN | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
| 1 Detroit + NE Wayne | | | | | | | 50 | | | 9 | 59 |
| 2 Rest of Wayne County | | | | | | 7 | 13 | | | 6 | 26 |
| 3 Port Huron/St. Clair County | | | | | | | | | | | 0 |
| 4 Rest of SEMCOG | | | | | | | 5 | 13 | | 8 | 26 |
| 5 Rest of MI | | | | | | 1 | 4 | | | 7 | 13 |
| 6 Other USA/Mexico | 8 | 7 | | 2 | 5 | 6 | 14 | 2 | | 84 | 129 |
| 7 Windsor | | | | | 20 | | | | | 10 | 30 |
| 8 Rest of Essex County | | 19 | | | | 24 | | | | | 43 |
| 9 Sarnia/Lambton County | | | | | | | | | | | 0 |
| 10 Other Ontario/Canada | 19 | 21 | | 11 | 13 | 117 | | | | 3 | 183 |
| TOTAL | 27 | 47 | 0 | 13 | 39 | 155 | 86 | 15 | 0 | 127 | 508 |

**DETROIT-WINDSOR TUNNEL**

| ORIGIN | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
| 1 Detroit + NE Wayne | | | | | | | 7 | 4 | | 1 | 12 |
| 2 Rest of Wayne County | | | | | | | 6 | 5 | | | 11 |
| 3 Port Huron/St. Clair County | | | | | | | | | | | 0 |
| 4 Rest of SEMCOG | | | | | | | 7 | | | | 7 |
| 5 Rest of MI | | | | | | | 1 | 3 | | | 4 |
| 6 Other USA/Mexico | | | | | | | | | | | 0 |
| 7 Windsor | 14 | 5 | | 3 | 1 | 2 | | | | | 25 |
| 8 Rest of Essex County | 7 | | | 3 | | | | | | | 10 |
| 9 Sarnia/Lambton County | | | | | | | | | | | 0 |
| 10 Other Ontario/Canada | 2 | 6 | 2 | 3 | | 2 | | | | | 15 |
| TOTAL | 23 | 11 | 2 | 9 | 1 | 4 | 20 | 13 | 0 | 1 | 84 |

**BLUE WATER BRIDGE**

| ORIGIN | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
| 1 Detroit + NE Wayne | | | | | | 1 | | | | 2 | 3 |
| 2 Rest of Wayne County | | | | | | 0 | | | 0 | 1 | 2 |
| 3 Port Huron/St. Clair County | | | | | | 2 | | | 1 | 3 | 6 |
| 4 Rest of SEMCOG | | | | | | 3 | | | | 6 | 9 |
| 5 Rest of MI | | | | | | 9 | | | 1 | 11 | 21 |
| 6 Other USA/Mexico | 3 | 0 | 1 | 7 | 12 | 4 | | | 3 | 28 | 58 |
| 7 Windsor | | | | | | | | | | | 0 |
| 8 Rest of Essex County | | | | | | | | | | | 0 |
| 9 Sarnia/Lambton County | | 1 | | 2 | 1 | 1 | | | | | 6 |
| 10 Other Ontario/Canada | 2 | 2 | 5 | 16 | 24 | 24 | | | | 2 | 76 |
| TOTAL | 6 | 4 | 6 | 25 | 37 | 44 | 0 | 0 | 5 | 53 | 180 |

**PM PEAK HOUR**

**AMBASSADOR BRIDGE**

| ORIGIN | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
| 1 Detroit + NE Wayne | | | | | | 0 | 6 | | | 14 | 20 |
| 2 Rest of Wayne County | | | | | | 2 | 17 | | | 18 | 38 |
| 3 Port Huron/St. Clair County | | | | | | | | | | | 0 |
| 4 Rest of SEMCOG | | | | | | | 6 | 6 | | 5 | 18 |
| 5 Rest of MI | | | | | | | 11 | 3 | | 9 | 23 |
| 6 Other USA/Mexico | 1 | 4 | 0 | 2 | | 0 | 21 | | 1 | 162 | 191 |
| 7 Windsor | 17 | 7 | | 14 | 4 | 21 | | | | 3 | 67 |
| 8 Rest of Essex County | | | | | | 10 | | | | 2 | 12 |
| 9 Sarnia/Lambton County | | | | | | 1 | | | | | 1 |
| 10 Other Ontario/Canada | 14 | 14 | | 3 | 5 | 165 | 3 | | | 0 | 203 |
| TOTAL | 32 | 25 | 0 | 19 | 9 | 199 | 65 | 9 | 1 | 215 | 573 |

**DETROIT-WINDSOR TUNNEL**

| ORIGIN | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
| 1 Detroit + NE Wayne | | | | | | | 4 | 0 | | 0 | 5 |
| 2 Rest of Wayne County | | | | | | | 4 | | | | 4 |
| 3 Port Huron/St. Clair County | | | | | | | | | | | 0 |
| 4 Rest of SEMCOG | | | | | | | 3 | | | 1 | 4 |
| 5 Rest of MI | | | | | | | | | | 1 | 1 |
| 6 Other USA/Mexico | 0 | | | | | 1 | 1 | | | | 2 |
| 7 Windsor | 2 | 1 | | 2 | 1 | 0 | | | | | 7 |
| 8 Rest of Essex County | | 0 | | 1 | | | | | | | 1 |
| 9 Sarnia/Lambton County | | | | | | | | | | | 0 |
| 10 Other Ontario/Canada | 0 | | | 3 | | 1 | | | | | 5 |
| TOTAL | 3 | 2 | 0 | 6 | 1 | 2 | 13 | 0 | 0 | 2 | 29 |

**BLUE WATER BRIDGE**

| ORIGIN | DESTINATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL |
| 1 Detroit + NE Wayne | | | | | | 1 | | | 0 | 4 | 5 |
| 2 Rest of Wayne County | | | | | | 1 | | | | 3 | 4 |
| 3 Port Huron/St. Clair County | | | | | | 3 | | | | 6 | 9 |
| 4 Rest of SEMCOG | | | | | | 4 | | | | 14 | 17 |
| 5 Rest of MI | | | | | | 7 | 0 | 0 | 1 | 40 | 49 |
| 6 Other USA/Mexico | 1 | 1 | 2 | 3 | 4 | 1 | | | 3 | 39 | 54 |
| 7 Windsor | | | | | | 0 | | | | | 0 |
| 8 Rest of Essex County | | | | | | | | | | | 0 |
| 9 Sarnia/Lambton County | 0 | | 0 | | 2 | 3 | | | | | 5 |
| 10 Other Ontario/Canada | 4 | 1 | 3 | 21 | 30 | 61 | | | | 1 | 121 |
| TOTAL | 5 | 2 | 6 | 24 | 35 | 81 | 0 | 0 | 5 | 106 | 265 |

## 5.3. Background Vehicular Traffic

Background vehicular traffic is required in the model to ensure that delays on routes to and from border crossings and interactions with non-border-crossing traffic are adequately reflected. Peak-hour trip data from the SEMCOG Model and the WALTS Model are used to estimate background traffic volumes. Both the SEMCOG and WALTS Models include border crossing trips, but without detailed origin or destination information on the other side of the border. These trips are therefore extracted from the respective trip matrices and replaced with the cross-border trip data discussed above.

***PM Peak Hour Trip Tables***

Trips from the SEMCOG Model are based on information collected in the 1994 SEMCOG Trip Survey. For base-year calibration, SEMCOG provided 24-hour trip tables by trip purpose that were then converted into a PM peak hour matrix using peak hour factors by trip purpose, as available from SEMCOG[7]. Temporal adjustment factors for each trip purpose are applied, reflecting the the percent of daily travel that occurs within the analysis period and the percent of the trips that move from the production end of the trip to the attraction end of the trip and vice versa.

The resulting PM peak hour trip matrix was then adjusted using a Fratar balancing process to reflect a year 2000 trip matrix, taking into account changes in population and employment between 1994 and 2000. As discussed above, the Ontario-Michigan Model utilizes the SEMCOG trip tables, but aggregates trips outside of Wayne County to the MDOT Zones. The model also utilizes the external trip matrix (excluding cross-border trips) from the SEMCOG Model for the purpose of loading background traffic onto the network. For background traffic (i.e. non-cross-border), it is not important to know the external origin or destination of trips, only the point where they enter the system.

The WALTS Model is calibrated to a base year of 1996 based on a household survey conducted in the spring of 1997. Forecasts are available for one year, 2016. Since the WALTS Study was completed, no major updates to the trip matrices have been made. Therefore, in order to develop background traffic estimates for 2000, adjustments to the 1996 matrices were required. At the time of this report, information on 2001 population was available from the 2001 Census only at the census subdivision (CSD) level (i.e. Windsor, Tecumseh, etc.). The procedure used to adjust the 1996 matrix involved creating new (year 2000) production and attraction totals by traffic zone and using a Fratar balancing procedure to update the 1996 matrix. The procedure for creating new attraction totals (which are based on population in a PM model) was to interpolate year 2000 productions from the 1996 and 2016 matrices and adjust the totals by CSD such that

---

7 Structure and Implementation of the Regional Travel Forecasting Model for Southeast Michigan, Final Report, prepared for Southeast Michigan Council of Governments by Parsons Brinckerhoff Michigan, May 1, 2000.

average annual growth rates between 1996 and 2000 were equivalent to those from the Census between 1996 and 2001. This process retains the relative growth rates by traffic zone that were envisioned in the WALTS exercise. These trip tables were subsequently factored using TransCAD's matrix estimation process to match observed traffic counts at screenlines.

***AM Peak Hour Trip Tables***

Since the SEMCOG and WALTS Models do not simulate the AM peak hour, a process was developed to create AM peak hour matrices, as origin-destination data from travel surveys are not available for the AM peak hour in Windsor or Detroit. The process assumed that travel patterns in the AM peak hour were a mirror image of PM peak hour travel, allowing the PM peak hour trip tables for work and non-work trips to be transposed to reflect AM peak hour travel.

Based on traffic counts and consistent with travel in other urban areas, AM peak hour traffic was found to be slightly lower than the PM peak hour. This required the AM peak hour trip table generated by transposing the PM peak hour work and non-work trip tables to be factored to match the observed AM to PM peak hour traffic ratios across screenlines using a similar process as the PM peak hour.

***Commercial Vehicle Trips***

Neither the WALTS Model nor the SEMCOG Model estimate truck traffic flows explicitly. The SEMCOG Model includes a process to increase the passenger trip matrix to account for truck traffic. The matrices provided for this study were reflective of combined passenger car and truck trips. Matrices provided from the WALTS study included only passenger vehicles. In order to reflect the impacts of trucks, the passenger car matrix (excluding cross-border movements) was increased by 5%. This increase is based on an estimated 2.0% commercial vehicle composition multiplied by a passenger car equivalent factor of 2.5. The figure of 2% truck volumes is reasonable since most truck traffic on the border crossing routes is already accounted for in the model in the cross-border truck matrix.

***Summary of Background Trips***

The final background trip matrices developed for this study represent total vehicle (auto and truck) trips in the AM and PM peak hours. The totals for each matrix are as follows:

Windsor Area Trips:

AM Peak Hour – 75,500

PM Peak Hour – 89,800

SEMCOG Area trips:

AM Peak Hour – 889,000

PM Peak Hour – 1,123,700

## 5.4. Local and Intercity Bus

***Local Bus Transit***

Windsor Transit operates a bus service between downtown Windsor and downtown Detroit via the Detroit-Windsor Tunnel. The service operates seven days per week at regular headways (generally 20 minutes in peak periods and 30 minutes off-peak). The last bus leaves Windsor at 12:00 midnight and Detroit at 12:30 AM. The cost of the service is $2.60 CDN. Detroit DOT, Sarnia Transit and Blue Water Area Transit (Port Huron) do not offer cross-border services.

Annual ridership for the Windsor Tunnel bus service was obtained from the City of Windsor. In the year 2001, ridership was 257,000 passengers. The majority of bus users (82%) pay a cash fare rather than using a pass, suggesting that most of the bus users are discretionary users, as opposed to commuters. On average, ridership for the first six months in 2002 was down about 15% compared to the same months in 2001, largely attributable to the events of September 11, 2001.

For the two Windsor-Detroit Crossings (approximately 40 million in 2001[8]), the total number of tunnel bus passengers represents about 0.6% of the total passenger market.

Given its relatively low mode share, the local bus mode will not be modelled in detail but rather assumed, at least for the base case, to remain constant in terms of its relative mode share.

***Intercity Transit***

Data on intercity bus ridership are not readily available, as these services are operated by private for-profit carriers. However, both the US BTS and the BTOA maintain records of total (i.e. local plus intercity) bus activity. In the year 2000, there were 860,000 passengers entering the US by bus through Detroit and 155,100 passengers entering through Port Huron. This includes scheduled and chartered buses. This represents a 3.5% modal share of the total local and intercity passenger trips entering the US in the year 2000 based on 28.6 million people entering the US at the Detroit and Port Huron crossings. Assuming this includes the passengers using the Windsor Tunnel bus, the approximate mode share for the intercity bus component of bus passengers would be 2.9%.

Given its relative significance, intercity bus ridership will need to be given consideration in the development of future traffic forecasts.

[8] This is based on an average auto occupancy of 2.6 people per vehicle derived from U.S. BTS data (entering US only) multiplied by the total number of passengers reported by the BTOA.

## 5.5. Passenger Rail

As discussed in the Strategic and Geographic Area Overview Report, there is one cross-border passenger train service operating between Toronto and Chicago, which utilizes a Sarnia-Port Huron crossing. The service is a joint VIA/Amtrak routing. Presently there is no through passenger rail service between Windsor and Detroit, although VIA passengers can travel from Toronto to Windsor and transfer to Amtrak services in Detroit using another mode.

Data on rail passenger traffic were obtained from a special run produced by the US Bureau of Transportation Statistics for passengers entering the US. In the year 2000, there were 53,700 annual passengers entering the US by train across the Ontario Michigan Border. Of these, 40,630 entered at Port Huron, 11,800 at Detroit, and 1,300 at Sault Ste. Marie, MI. As the only through train service is via Sarnia-Port Huron, it is uncertain how rail passengers at the other crossings were defined. [9]

Assuming the data are reasonably correct, rail passenger travel can be put in context with other border crossing data. In the year 2000, there were approximately 28.6 million people entering the US at the Detroit and Port Huron crossings. This suggests that for people entering the US, passenger rail accounts for approximately 0.2% of the total.

Given its relatively low mode share, the passenger rail mode will not be modelled in detail but rather assumed, at least for the base case, to remain constant in terms of its relative mode share.

## 5.6. Rail Freight

Rail freight is not modelled within the Regional Traffic Network. The role of rail freight in goods movement and the outlooks for its demand is discussed in detail in the Existing and Future Demand Working Paper.

## 5.7. Walk and Cycle Cross-Border Trips

Walking and cycling through the Detroit-Windsor Tunnel are not possible and generally not considered practical for the Ambassador Bridge and Blue Water Bridge. Statistics from the BTS indicate that about 15,000 people entered the US as pedestrians at Port Huron. Statistics are not available for Windsor-Detroit. The amount of people crossing the Ontario-Michigan Border as pedestrians or cyclists is extremely small and therefore not considered further in this study.

[9] BTS has been contacted to seek clarification.

## 5.8. Ferry Services

There are currently three ferry services operating in the study area. These consist of the Walpole Island Ferry, Marine City Ferry and Detroit-Windsor Truck Ferry. Each provides a relatively limited service (in terms of total vehicle capacity), however the last does service a specialized market in the Detroit-Windsor area that is not catered by either of the crossings there.

The Walpole Island Ferry provides transport between Algonac, Michigan and Wallaceburg, Ontario at the northern end of Lake St. Clair using two boats. Each is capable of servicing 20 passenger cars and/or small commercial vehicles. There is a 20-minute headway and a 6-minute travel time at a cost of $4 US.

The Marine City Ferry operates between Marine City, Michigan and Sombra, Ontario, also using two boats when busy. The ferries can transport 12 passenger vehicles each, but will also take large trucks. The service runs every 20 to 30 minutes and charges $5 US per car. Travel time is 7 minutes.

The Detroit-Windsor Truck Ferry was started in 1990 for the purpose of handling trucks carrying dangerous goods (Class 1,3,7 and 8), which are banned from the Ambassador Bridge and Detroit-Windsor Tunnel crossings in accordance with Michigan State law. The ferry also handles over-sized loads, which cannot use the bridge or tunnel. Ordinary trucks may also use this service.

The ferry operates with one-hour headways for 10-hour days and handles about 40 trucks per day on average. The cost of a one-way crossing is $100.

The ferry provides a significant distance saving by allowing trucks to cross at Windsor-Detroit as opposed to the nearest alternative routes via the Blue Water Bridge for hazardous goods and via Fort Frances for oversized goods. It is estimated that more than 50% of the ferry crossing trips are from within west of London, with a similar market range on the Detroit side.

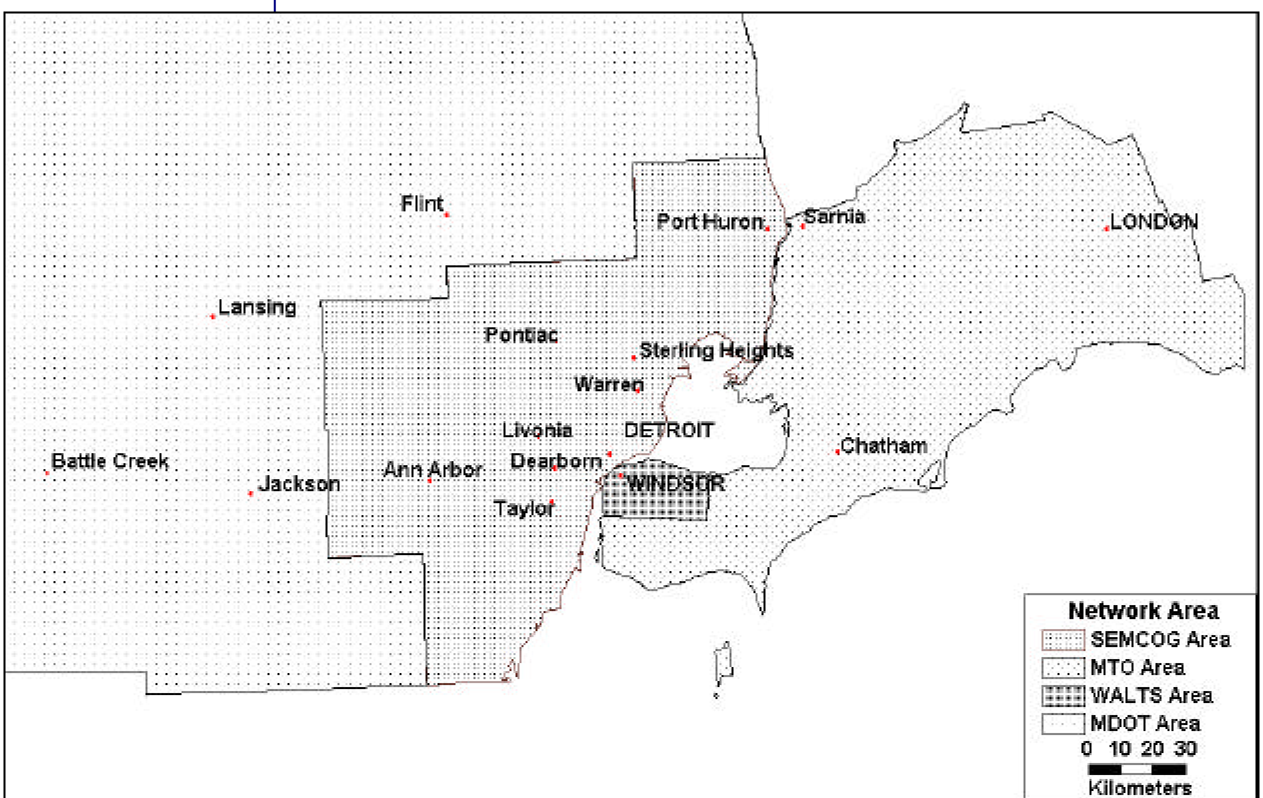
Given the unique nature of ferry services, it is not possible or appropriate to apply traditional demand forecasting and assignment techniques to dangerous goods vehicles or a low capacity truck ferry service that carries less than 0.3% of truck traffic at Windsor/Detroit crossings. The process used to estimate demand for the ferry service will be discussed in the Existing and Future Demand Report, as well as other proposals to provide truck ferry services connecting Windsor and Detroit for peak period and emergencies.

# 6. Transportation Networks

## 6.1. Road Network Requirements

The road network for the Regional Model must be able to assign trips from the O-D matrices described in the previous chapter such that trips are accurately and reasonably distributed between the Ontario-Michigan border crossing locations. To achieve this, networks have been developed approximately from London, Ontario (including the Highway 401/Highway 402 interchange) to Battle Creek, Michigan (including the Interstate-69/Interstate-94 interchange), as shown in Exhibit 6.1. The limits of this area are sufficiently distant to capture common points and decision points in the road network. For example, the decision point for Sarnia vs. Windsor (i.e. where Highway 401 and Highway 402 separate) is west of London.

**EXHIBIT 6.1: NETWORK COVERAGE AREA**



## 6.2. Description of Source Road Networks

Network development for this study was carried out using the TransCAD package. All networks developed in other platforms were converted to TransCAD. A common coordinate system based on UTM NAD 83 is used to describe the Regional Model network.

Road networks are available from the following sources:

- *Windsor Area Long Term Study (WALTS)* – The WALTS network was developed in System II and covers the City of Windsor and environs (see Exhibit 6.1); networks are available for 1996 and 2016. The WALTS network includes all local, arterial and higher level roads.
- Ministry of Transportation of Ontario Highway Networks – the road/highway network developed by MTO for southwestern Ontario as described by the MTO's Truck Model provides coverage for the rest of SW Ontario (see Exhibit 6.1). This basic network is available in TransCAD and has been developed for the current year. The MTO network includes highways and major roads.
- SEMCOG Model: The SEMCOG networks were developed in TRANPLAN[10] and covers the South East Michigan Area (see Exhibit 6.1). Networks are available for 2000 and 2025. Committed road improvements are available from SEMCOG's Transportation Improvement Program (TIP) such that intermediate year networks and can be developed. The SEMCOG network is highly detailed and generally covers all local, arterial and higher level roads.
- MDOT Model: The MDOT Model covers the State of Michigan and includes all major roads and highways. The MDOT model was created in TransCAD and includes networks for 2000. Future years are also available.

The above road networks are applied with each agency's travel forecasting model. The networks are constantly being reviewed and updated and provide a solid basis for network development in this study.

## 6.3. Network Development

Networks for the Ontario-Michigan study were developed for the base year of 2000, which corresponds to the MDOT and SEMCOG models. Networks from the above sources were merged to provide a single comprehensive and coherent network within TransCAD. The composite network was developed as follows:

**Windsor Area**: Networks fom the WALTS Model were converted to TransCAD from System II. Modifications to the link structure were made to make the network compatible with the base TransCAD networks (see section below).

[10] At the time of this report, SEMCOG was in the process of converting its model to TransCAD.

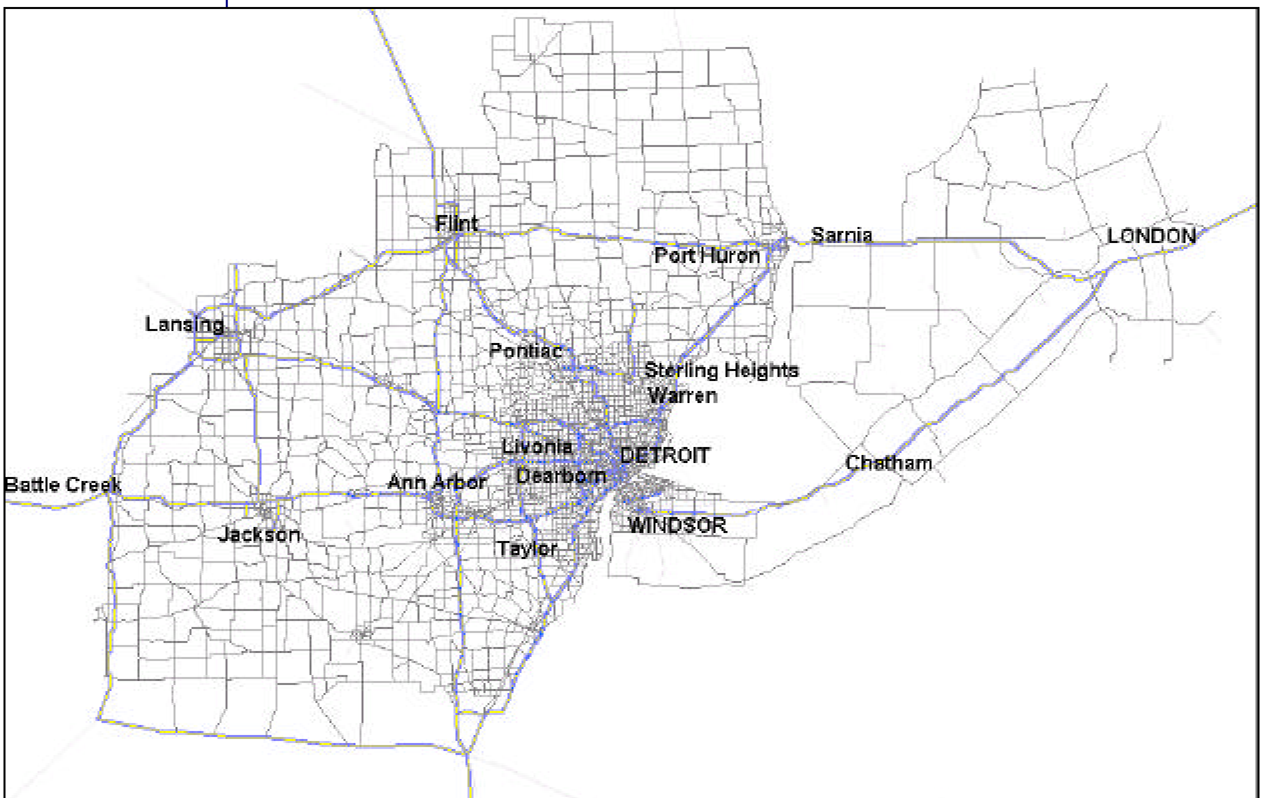
**Rest of Southwestern Ontario**: The road and highway links from the MTO model were used to develop the required network coverage for this area. These links provide coverage to the Blue Water Bridge as well as to Eastern Canada and Northeastern USA.

**SEMCOG Area:** In the initial iteration of the network development, the SEMCOG networks were used for Wayne County while the MDOT networks were used to provide coverage for the rest of the SEMCOG area. The rationale for using the MDOT networks was that less detail was required outside of Wayne County. This was also consistent with the trip table development where the SEMCOG trip matrices were aggregated to MDOT zones outside of Wayne County. In the initial assignments of trips, it was found that because the MDOT network is relatively sparse outside of Wayne County, many of the links were well over capacity, particularly in Oakland County and Macomb County. Attempts to rectify this problem by adding centroid connectors did not prove successful. As a result, the SEMCOG network was simply adopted for the entire SEMCOG area, rather than "mixing-and-matching" the SEMCOG and MDOT networks.

**External to SEMCOG Area:** The MDOT networks were used to provide the basic level of coverage required to distribute external trips to the network. The network extends north of Flint, West of Lansing and south of the Michigan state line as a schematic network to include the rest of the USA (except NE USA) and Western Canada. The network is connected only to SEMCOG network at the SEMCOG county borders.

Exhibit 6.2 provides an illustration of the final composite network developed from the above sources.

**EXHIBIT 6.2: STUDY AREA ROAD NETWORK**




# 6.4. Link Attributes

Due to the fact that a number of different networks from different sources were used to develop the composite network, considerable effort was required to ensure that the networks for the different areas were consistent and compatible. The following is a discussion of the decisions made as to the various link attributes.

***Link Type Definitions***

Links are defined by type for the purpose of assigning capacities, speeds and volume-delay functions. A unified link type classification system was developed based on the existing WALTS and SEMCOG models and consists of nine road classifications:

1 Freeway
2 Major Arterial/Arterial highway
3 Minor arterial
4 Collector
5 Local through road

6 Other local road (WALTS area only)
7 Freeway-freeway ramps (SEMCOG only)
8 Other freeway ramps
9 Centroid connectors

Two of these (6 – other local roads and 7 – freeway-freeway ramps) are specific to the WALTS and SEMCOG networks; however, it was considered preferable to keep this distinction to retain the integrity of the original networks.

In addition to the above link type definitions, two classes of links have been defined for border crossing links reflecting the unique nature of these links:

Cross-border link: Exit Customs

Cross-border link: Entry Customs

These additional link types provide additional opportunities for calibrating the model results.

Due to the wide variety of roadway types in the SEMCOG Area, the definition of area types provides greater flexibility in defining link attributes. Area types were adopted without modification from the SEMCOG Model. The five area types are:

Area 1: Urban District

Area 2: Urban residential

Area 3: Sub-urban residential

Area 4: Small urban residential

Area 5: Rural residential

Area types are not used in the WALTS Model, nor was an attempt made to adopt area types for the WALTS area in the current model. Where greater flexibility was required in the WALTS area, individual link speeds and capacities were adjusted as necessary.

***Volume-Delay Functions***

Volume delay functions are used within the TransCad model to define the relationships between link travel time and volume to capacity ratios. Generally, travel times increase as links become more congested.

The widely used BPR volume-delay function developed by the Bureau of Public Roads was adopted for the composite model. The BPR function is used in both the SEMCOG and MDOT networks.

The original WALTS networks developed in System II used a completely different volume-delay function based on speed limits. As the functions from the System II model are not compatible with the BPR function, new functions had to be defined for the WALTS area network.

In the BPR function, link travel times are defined according to the following equation:

$$T_n = T_o \left[ 1 + a \left( \frac{V}{C} \right)^b \right]$$

where

$T_0$ is free-flow travel time

V is volume, and

C is link capacity.

a and b are calibrated.

For the SEMCOG model, different parameters are specified depending on whether the link is a freeway link or a non-freeway link. The SEMCOG Model uses the following parameters:

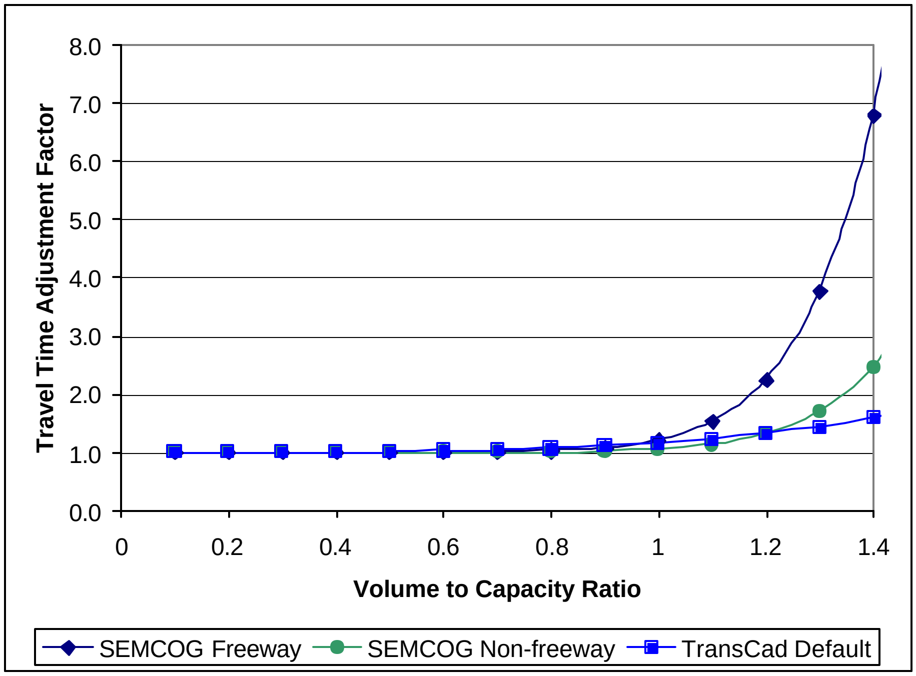
| | a | b |
|---|---|---|
| Freeways | 0.2 | 10 |
| Non-freeways | 0.05 | 10 |

For the MDOT Model, the default parameters of $\alpha$= 0.15 and $\beta$= 4.0, as defined in TransCAD, are used.

Exhibit 6.3 illustrates the two BPR functions from SEMCOG and the BPR function for the MDOT network. Generally, these functions are the same except for the freeway function, which tends to increase beyond V/C ratios of about 1.2.

For the composite network, the SEMCOG functions were adopted for all networks links, including those in the WALTS area.

### EXHIBIT 6.3: BPR FUNCTIONS




### *Speed and Capacity Attributes*

Link speed and capacity values have generally been adopted from the source networks except where changes were required for additional calibration. For the links obtained from the MDOT network, capacities were redefined to reflect peak hour conditions rather than all-day conditions, as the MDOT model is based on an all-or-nothing assignment of all-day trips. Similarly, capacities for the links covered by the MTO networks were developed based on road type and classification, as these were not provided in the original source data.

Exhibit 6.4 summarizes the link attributes by link type for the road network.

## EXHIBIT 6.4: LINK ATTRIBUTES BY LINK TYPE

| Unified Class No. | Description | WALTS | | Ext. SEMCOG (MDOT) | | SEMCOG Area | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | All Areas | | All Areas | | Area Type 1 (Urban Business) | | Area Type 2 (Urban Residential) | | Area Type 3 (Suburban Residential) | | Area Type 4 (Small Urban Residential) | | Area Type 5 (Rural Residential) | |
| | | Cap. | Speed | Cap*. | Speed | Cap. | Speed | Cap. | Speed | Cap. | Speed | Cap. | Speed | Cap. | Speed |
| 1 | Freeway | 1850 | 100 | 1900 | 89-113 | 1850 | 88.5 | 1850 | 96.6 | 1850 | 104.6 | 1900 | 104.6 | 1900 | 104.6 |
| 2 | Arterial hwy/ Major Arterial | 1100/ 900 | 50-100 | 950 | 40-105 | 850 | 48.3 | 900 | 56.3 | 950 | 72.4 | 950 | 72.4 | 950 | 88.5 |
| 3 | Minor arterial | 800 | 35-80 | 850 | 40-105 | 650 | 40.2 | 700 | 48.3 | 750 | 64.4 | 750 | 64.4 | 850 | 80.5 |
| 4 | Collector | 650 | 35-60 | 700 | 34-105 | 550 | 40.2 | 600 | 48.3 | 650 | 56.3 | 650 | 56.3 | 700 | 64.4 |
| 5 | Local street | 500 | 30-50 | - | - | 500 | 32.2 | 550 | 40.2 | 550 | 40.2 | 550 | 40.2 | 575 | 56.3 |
| 6 | Freeway ramp | 1300 | 50-100 | - | - | 1200 | 48.3 | 1250 | 48.3 | 1250 | 56.3 | 1250 | 56.3 | 1300 | 64.4 |
| 7 | Freeway-freeway ramp | | | - | - | 1600 | 64.4 | 1600 | 72.4 | 1600 | 72.4 | 1600 | 72.4 | 1600 | 80.5 |
| 8 | Local non-through | 350 | 35-50 | - | - | | | | | | | | | | |
| 9 | Centroid connector | N/a | 50-80 | - | 40 | N/a | 16.1 | N/a | 24.1 | N/a | 24.1 | N/a | 24.1 | N/a | 32.2 |

Capacities are shown in vehicles per hour per lane.

* Taken from SEMCOG network

Speeds are shown in km/h.

## 6.5. Capacity of Border Crossing Facilities

The basic capacities of the border crossing facilities are a required input for the Regional Model. The basic capacity, or roadbed capacity, is distinguished from border processing times. Border processing times and their input into the Regional Model are discussed in the following chapter.

Given the unique physical, traffic use and vehicle mix characteristics of international bridge and tunnel crossings, standardized traffic engineering techniques do not exist for these types of facilities. An accurate figure for the roadbed capacity of an international bridge is also complicated since customs and/or access road capacity is often the bottleneck thereby restricting the true roadbed capacity of the bridge to be realized.

***Roadbed Capacity Estimate***

In previous studies, highway capacity methods have been adopted to estimate roadbed capacity for an international bridge, most notably in the a 1990 report by the MTO, MDOT and Transport Canada[11], which provided roadbed capacity estimates for the Ambassador Bridge, Detroit-Windsor Tunnel and Blue Water Bridge.

For this report, roadbed capacity estimates for the three crossings have been updated using HCM 2000 procedures, reflecting changes in car/truck composition and the recent widening of the Blue Water Bridge. The capacities of each border crossing facility are summarized in Exhibit 6.5. These capacities are based on level-of-service E and are shown in passenger car equivalents (PCE's). The capacities reflect existing lane configurations (e.g. width, lateral clearance). The capacities do not account for the impact of operating rules that restrict vehicles from queuing on the Ambassador Bridge or in the Detroit-Windsor Tunnel. Detailed capacity calculations are provided in Appendix E.

**EXHIBIT 6.5: HOURLY CAPACITY OF EXISTING BORDER CROSSING FACILITIES**

| Facility | No of Lanes One-Way | Capacity Per Lane (PCE's) | Total One-Way (PCE's) |
|---|---|---|---|
| Ambassador Bridge | 2 | 1,750 | 3,500 |
| Blue Water Bridge | 3 | 1,900 | 5,700 |
| Detroit-Windsor Tunnel | 1 | 1,500 | 1,500 |

A passenger car equivalent factor of 3 was assumed for trucks based on review of different approaches. Using HCM methods, the recommended PCE for a truck based on the physical characteristics of the Ambassador Bridge (e.g. 4.5% grade) is 2. The Canadian Capacity Guide for Signalized Intersections suggests a PCE factor of 2.5 for

[11] ***St. Clair and Detroit Rivers International Crossings Study***, Ontario Ministry of Transportation, Michigan Department of Transportation and Transport Canada, Final Report, prepared by A.T. Kearny, June 1990.

multi-unit trucks and 3.5 for heavily loaded multi-unit trucks. Based on discussions with the study's Model Working Group, a PCE factor of 3 was adopted to reflect the predominance of multi-unit vehicles using the Ambassador and Blue Water Bridges and to provide a degree of conservatism into the capacity calculations.

***Verification of Roadbed Capacity***

To verify the roadbed capacities derived using the above HCM 2000 procedures, field observations were performed at the Ambassador Bridge to observe truck flow rates on the bridge and the average headway or time separation between trucks. Observations were made at three locations on the bridge with the average headway between trucks ranging from 5.2 to 6.1 seconds. This reflects an hourly capacity of 593 trucks (1,779 PCE's) to 698 trucks (2,094 PCE's) and compares to 585 trucks (1,750 PCE's) using HCM 2000 methods. This was felt adequate to validate the use of the HCM 2000 capacity values for this study.

# 7. Model Validation

Validation of the base-year model involves assigning the total base-year demand trip table (local, intra-state/provincial and cross-border demands) to the existing road network within TransCAD, then comparing observed volumes at border crossings, on highways and other major road links with the model-predicted values. Where significant discrepancies exist, changes are made to the model to better capture travel interactions and dynamics in the study area.  These changes involve a combination of matrix adjustment techniques, road network adjustments and travel time delay adjustments. The following is examined in the validation process:

- Comparisons of screenline traffic volumes obtained in the Regional Model against those obtained in the SEMCOG/WALTS models;
- Comparison of observed and model-assigned traffic volumes at key locations and across various screenlines, as well as at the bridge crossings – Traffic count data have been obtained for this purpose;
- The relative distribution of car and truck traffic between the bridge/tunnel crossings – The available data provide a breakdown of the particular bridge crossing and the associated trip origin and destination, which will be compared to the model assigned results; It is important to reasonably reflect the distribution of traffic between the crossing locations by the various markets (e.g. local cross-border, long distance cross-border, commute trips, entertainment trips, recreational/vacation trips, etc.);
- Travel routings for select origins and destination pairs to determine that the actual routing within the model is consistent with current understanding;
- Logic and range checks on the road and highway networks to ensure the coded links and link attributes are within reasonable range; analysis of route paths for reasonableness against known driving paths.

## 7.1. Travel Choice Context

Before calibrating the traffic model, it is important to understand the basic factors that could influence the route choice of travellers. Drivers will generally chose the route that provides the shortest time and lowest cost, although route familiarity and other factors can influence the route choice for cross-border trips. This section provides a discussion of factors that could influence travel choices to provide context when examining the reasonableness of the traffic assignments in the Regional Model.

***Border Crossing Fees***

Basic toll rates ($CAN) for passenger cars are as follows:

| | |
|---|---|
| Ambassador Bridge | $3.50 (increased to $4.00 July 2002)<br>($2.75 US) |
| Detroit-Windsor Tunnel | $3.50 (increased to $4.00 September 2002)<br>($2.50 US) |
| Blue Water Bridge | $2.50<br>($1.75 US) |

Toll rates ($CAN) for commercial vehicles vary based on weight and number of axles as follows for the three facilities:

| | |
|---|---|
| Ambassador Bridge | $0.0335 per 100 lbs gross weight 2-7 axles<br>($0.0230 US)<br>$0.03698 for 8 axles or more<br>($0.0255 US)<br>Minimum toll ranges from $4.25 for 2 axles to $26.50 for 12 axles.<br>($3.00 to $18.25 US) |
| Detroit-Windsor Tunnel | $2.75 plus $0.037 per 100 lbs gross weight<br>($2.25 plus $0.025 US)<br>(discounts for frequent users) |
| Blue Water Bridge | $2.75 per axle<br>($2.00 US) |

There are no tolls on existing routes leading to and from the border crossings.

In relative terms, particularly for longer-distance trips, the differences in toll rates for many passenger car trips are likely not sufficient to influence travel decisions. For example, assuming a value of time of $15/hr, a 50-cent difference in toll rates would equate to about 2 minutes. For very short trips, where the bridge and tunnel offer similar travel times, differences in tolls could play a small role in travel choices.

For commercial vehicle travel, there can be significant differences in the toll rate between the Ambassador Bridge and Blue Water Bridge. For example, consider two different vehicles, the first a 5-axle truck weighing 40,000 gross pounds and the second an 8-axle truck weighing 100,000 gross pounds. The first truck would be charged a toll of $13.40 ($9.20 US) at the Ambassador Bridge and $13.75 ($10.00 US) at the Blue Water Bridge, a difference not likely to affect choice of crossing. The second truck, on the other hand, would be charged $36.98 ($25.50 US) at the Ambassador Bridge and $22.00 ($16.00 US) at the Blue Water Bridge. The difference of $15 ($9.50 US) would likely have some impact on drivers of heavier commercial vehicles to choose the Blue Water Bridge crossing.

For very short trips, where the bridge or tunnel offers essentially the same travel time, differences in tolls could play a small role in travel choices. For this reason, tolls were added to the transportation model. A value of time of $15 per hour, consistent with current research, was assumed for all passenger car trips for simplicity, recognizing that most of the toll sensitive trips would be short work or recreation trips as opposed to higher value business trips. A value of $75 per hour was assumed for commercial vehicle trips.

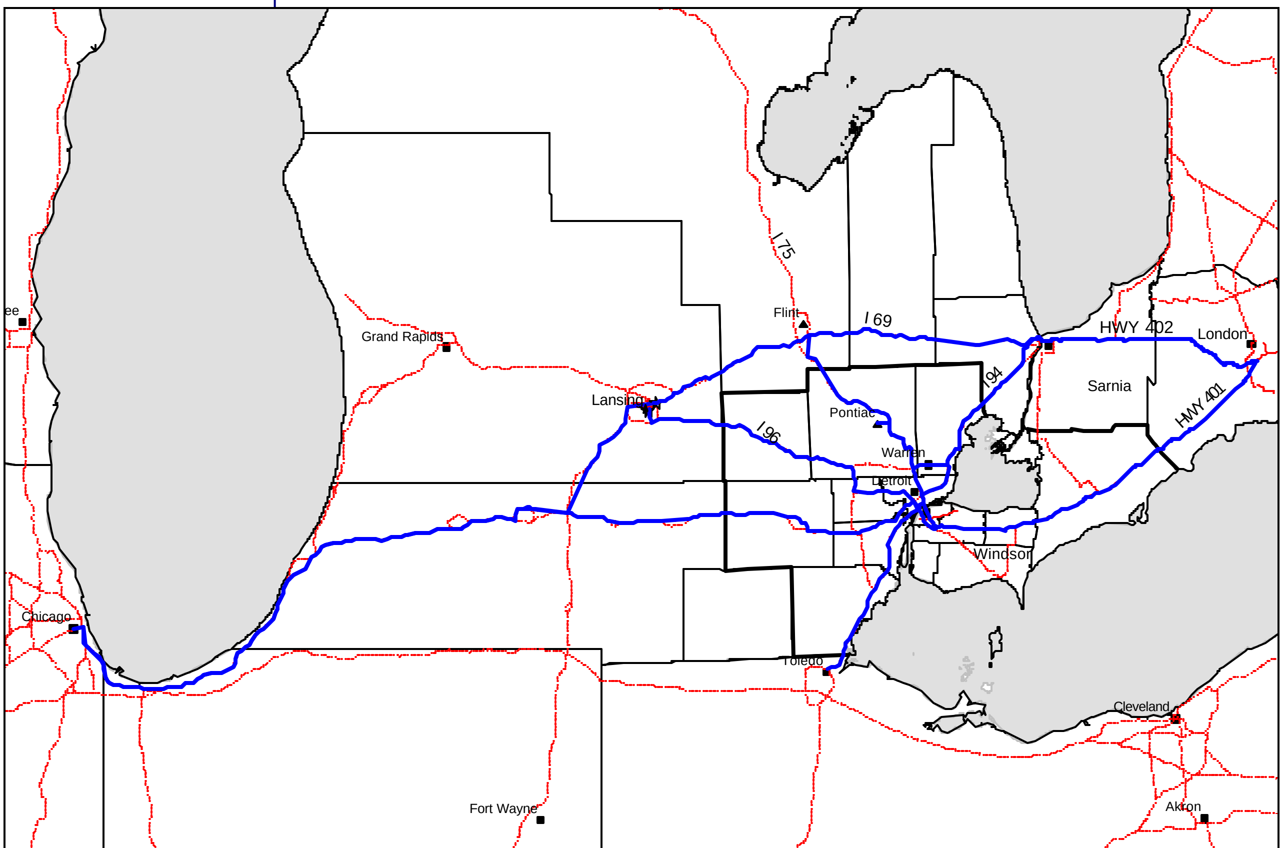
***Driving Distances***

For several major trip origin-destination pairs between Ontario and Michigan, trip distances via a Highway 402 routing through Sarnia/Port Huron are similar to those via a Highway 401 routing through Windsor/Detroit. To illustrate the differences, trip distances have been calculated for several representative origin-destination pairs. All trips are compared using London, Ontario as the starting point as this is where the decision point between a Highway402/Sarnia and Highway 401/Windsor route choice is made when travelling to the United States. The major highway routings are shown in Exhibit 7.1 with the travel distances shown on Exhibit 7.2.

A trip from London, Ontario to Detroit would only be 21 km (13 miles) shorter via Windsor than via Sarnia. For trips to Lansing and Flint, the Sarnia/Port Huron crossing provides a significant distance savings. For trips to Chicago, there is approximately only a 3-km (2-mile) difference between the two routes.

The results of the travel distance comparison indicate that the Sarnia/Port Huron crossing provides competitive travel times for many of the longer distance border crossing trips between Ontario and Michigan. As discussed later in this chapter, there is an inherent preference towards the Detroit-Windsor crossings among travellers, as the calculated travel distance would suggest greater use of the Sarnia-Port Huron crossing in comparison to observed travel. A possible reason is that a Highway 401 – Interstate 94 routing appears to be flatter and shorter in distance on a map. Also, the greater familiarity with Windsor-Detroit and Highway 401 and increased roadside services (e.g. gas stations, restaurants, attractions in Windsor/Detroit) may also result in a preference for Windsor/Detroit crossings. For commercial vehicles, there are lower toll rates at the Ambassador Bridge for lighter vehicles compared to the Blue Water Bridge, while heavier vehicles tend to favour the Blue Water Bridge where rates are lower for these types of vehicles.

## EXHIBIT 7.1: ROUTING CHOICES FOR SELECTED TRIPS




## EXHIBIT 7.2: COMPARISON OF DRIVING DISTANCES FOR SELECTED TRIPS

| Trip Interchange | Via Windsor-Detroit (Hwy 401) | Via Sarnia - Port Huron (Hwy 402) | Difference (SA-PH Relative to WI-DET) |
|---|---|---|---|
| London / Detroit | 190 km (119 mi) | 203 km (127 mi) | +13 km (+8 mi) |
| London / Pontiac | 229 km (142 mi) | 222 km (138 mi) | -6 km (-4 mi) |
| London / Flint | 296 km (184 mi) | 210 km (131mi) | -86 km (-53 mi) |
| London / Lansing | 328 km (204 mi) | 285 km (177 mi) | -43 km (-27 mi) |
| London / Toledo | 269 km (167 mi) | 290 km (180 mi) | 21 km (13 mi) |
| London / Chicago | 629 km (391 mi) | 632 km (393 mi) | 3 km (2 mi) |

### *Border Crossing Times*

Border crossing times can influence decisions on the use of a particular crossing. Information on border crossing times for trucks is available from a recent FWHA study[12] and shown on Exhibit 7.3. These crossing times are based on the time from the initial queue point in the exporting country to the point of exit from the first inspection station in the importing country. This point varies in location depending on the queue length.

The FWHA data, which were collected prior to the events of September 11th, indicate that the crossing time for trucks using the Blue Water Bridge for trips entering the US is higher than at the Ambassador Bridge. There is also significantly more variability in the crossing times.

No data on crossing times for automobiles were included in the FHWA study. The delays for cars are generally much shorter.

**EXHIBIT 7.3: BORDER CROSSING TIMES (TRUCKS, MINUTES)**

| | Baseline Time (shortest time) | Average Time | 95th Percentile Time | Delay Time (Average – Baseline) |
|---|---|---|---|---|
| Ambassador Bridge – to Canada | 5.7 | 8.8 | 13.7 | 3.1 |
| Ambassador Bridge – to US | 12.9 | 20.4 | 33.9 | 7.5 |
| Blue Water Bridge – to Canada | 5.0 | 6.2 | 9.1 | 1.2 |
| Blue Water Bridge – to US | 11.1 | 34.2 | 80.3 | 23.1 |

Notes: Times are in minutes. Data reflect year 2001 (pre-9-11) conditions.

Source: Measurement of Commercial Motor Vehicle Travel Time and Delay at U.S. International Border Stations, FWHA, 2001.

A second source of truck crossing time data was provided from a Transport Canada commercial vehicle travel time study[13], which analyzed tractor logs for a sample of commercial vehicles crossing international borders in Southern Ontario. This small, homogeneous sample is not representative of all truck types, but indicative of delays. The study found the average time to cross the border at the Ambassador Bridge to be higher than at the Blue Water Bridge based on post September 11 conditions:

- Ambassador Bridge – 25 minutes to US / 18 minutes to Canada;
- Blue Water Bridge – 20 minutes to US / 12 minutes to Canada.

12 Measurement of Commercial Motor Vehicle Travel Time and Delay at U.S. International Border Stations, FWHA, 2001.

13 Using GPS-Encoded Tractor Logs to Estimate Travel Times at Borders in Southern Ontario, Transport Canada, June 2002.

The variability of crossing times, as noted above, indicates the difficulty in using a time/delay penalty within the Regional Model to describe current conditions. As discussed further in Section 6.2, a single calibration factor is used to capture external factors such as crossing delay and preferences toward one facility over another to improve the assignment of trips between the Windsor/Detroit and Sarnia/Port Huron crossings.

***Impact of Congestion***

As with border crossing delays, congestion on access routes may also have an impact on routing choice. The impacts of congestion are reflected in the TransCAD model, which estimates link travel times according to volume to capacity ratios (see Section 5.4 for a discussion of volume delay functions). The impacts of congestion can be quantified by comparing the results of an “all-or-nothing” traffic assignment to the “capacity-constrained assignment.” The differences between these two assignments are attributable to the impacts of congestion.

As shown in Exhibit 7.4, congestion has a fairly significant impact on travel routing choices. Under free flow conditions without congestion delay, 701 vehicles are assigned in the model to the Tunnel to US in the PM peak. With congestion delays included (capacity restrained), approximately 14% of the trips divert to another crossing to avoid the congestion delay..

Exhibit 7.5 and 7.6 show the congestion levels in the immediate vicinity of the two Detroit-Windsor crossings. This peak period congestion has the impact of shifting trips to the Blue Water Bridge. At the local level, congestion in the downtown cores has the impact of shifting trips from the Tunnel to the Bridge in the PM peak, and shifting trips to the Tunnel in the AM peak.. Given that there are very small travel time differences between Sarnia/Port Huron and Windsor/Detroit routes for many trip linkages, the results can be relatively sensitive to local traffic congestion levels.

***Physical Constraints***

In addition to travel time and cost, other factors influence routing choices. For example, the Detroit-Windsor Tunnel cannot accommodate many large trucks due to physical constraints (height and length). Similarly, the Detroit-Windsor Tunnel and the Ambassador Bridge do not accommodate trucks with dangerous goods.

### EXHIBIT 7.4: IMPACTS OF CONGESTION (TOTAL VEHICLE)

| Crossing / Direction | AM Peak | | |
|---|---|---|---|
| | Free-Flow | Capacity Constrained | % Change |
| Ambassador Bridge – to US | 1,379 | 1,310 | -5% |
| Ambassador Bridge – to Canada | 571 | 534 | -6% |
| DW Tunnel – to US | 905 | 963 | 6% |
| DW Tunnel – Canada | 285 | 283 | -1% |
| Blue Water Bridge – to US | 315 | 325 | 3% |
| Blue Water Bridge – Canada | 213 | 252 | 18% |

| Crossing / Direction | PM Peak | | |
|---|---|---|---|
| | Free-Flow | Capacity Constrained | % Change |
| Ambassador Bridge – to US | 933 | 939 | 1% |
| Ambassador Bridge – to Canada | 1,795 | 1,792 | 0% |
| DW Tunnel – to US | 701 | 600 | -14% |
| DW Tunnel – Canada | 1,359 | 1,312 | -3% |
| Blue Water Bridge – to US | 482 | 576 | 19% |
| Blue Water Bridge – Canada | 597 | 645 | 8% |

Note: Totals include automobiles and trucks

### EXHIBIT 7.5: VOLUME TO CAPACITY RATIOS (AM PEAK HOUR)

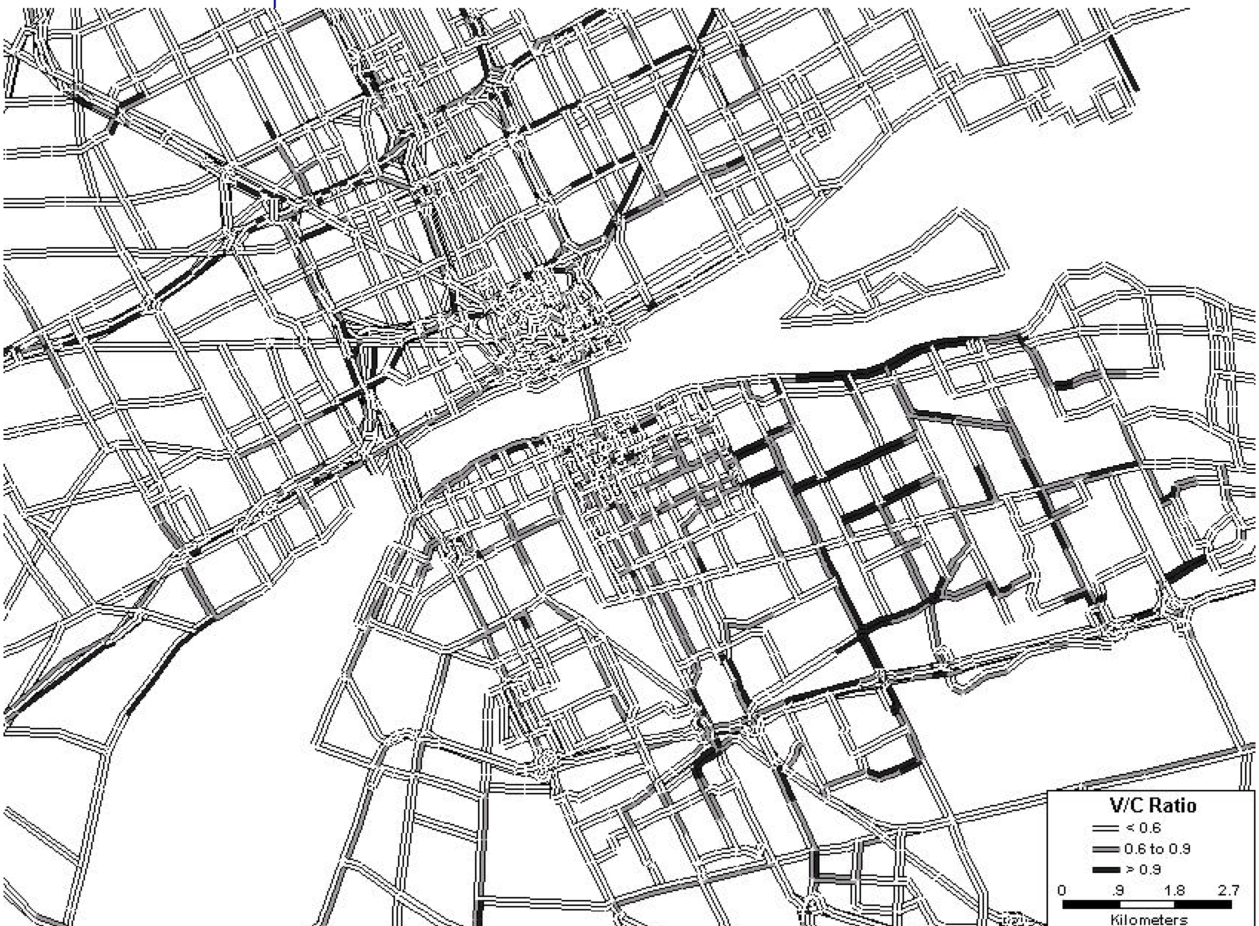


**EXHIBIT 7.6: VOLUME TO CAPACITY RATIOS (PM PEAK HOUR)**

## 7.2. Strategic Level Model Calibration

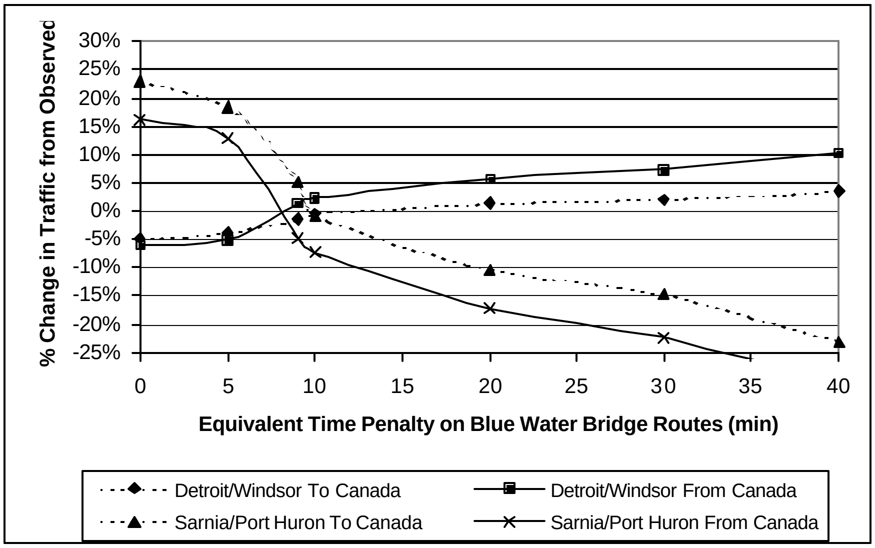
Model calibration was carried out in an iterative manner to ensure the best fit possible between observed travel characteristics and assigned model volumes. At the strategic level, calibration focused on properly assigning cross-border trips between the Windsor-Detroit and Sarnia-Port Huron crossings.

Based on the traffic assignments and the coded speeds and distances in the road network, the Regional Model was found to to over-predict trips at the Sarnia/Port Huron crossing and under-predict trips at the Windsor-Detroit crossings. In the PM peak, the model was over-predicting Sarnia/Port Huron trips by 16% and 19% for the US bound and Canada-bound directions respectively. Similar results were observed for the AM peak. The origins and destinations of the trips that were being under-predicted were analyzed by conducting select-link analysis (i.e. Ambassador Bridge and Detroit-Windsor Tunnel trips assigned to the Blue Water bridge were plotted) and it was determined that the model was behaving rationally. Most of the “over-assigned” trips to the Blue Water Bridge were trips where the travel times were very similar to the Detroit-Windsor routing.

To address this bias, a factor was applied at border crossings to capture preferences in crossing at Windsor-Detroit, all other factors being equal, and differences in crossing delay and toll rate to improve the trip assignment distribution between Sarnia/Port Huron and Windsor/Detroit. As noted previously, this preference could be due to several external factors such as the perception that a Windsor-Detroit routing is significantly shorter than a Sarnia/Port Huron crossing, as well as the greater familiarity with this crossing. Another factor could be that there are more amenities in Windsor and Detroit. The adjustment factor was calibrated and applied to the long distance Sarnia/Port Huron routes. This factor, expressed in minutes of delay, represents the ‘equivalent time value’ of the external factors. The *adjustment factor* is intended strictly as a calibration factor and does not reflect actual time penalties at the border crossing.

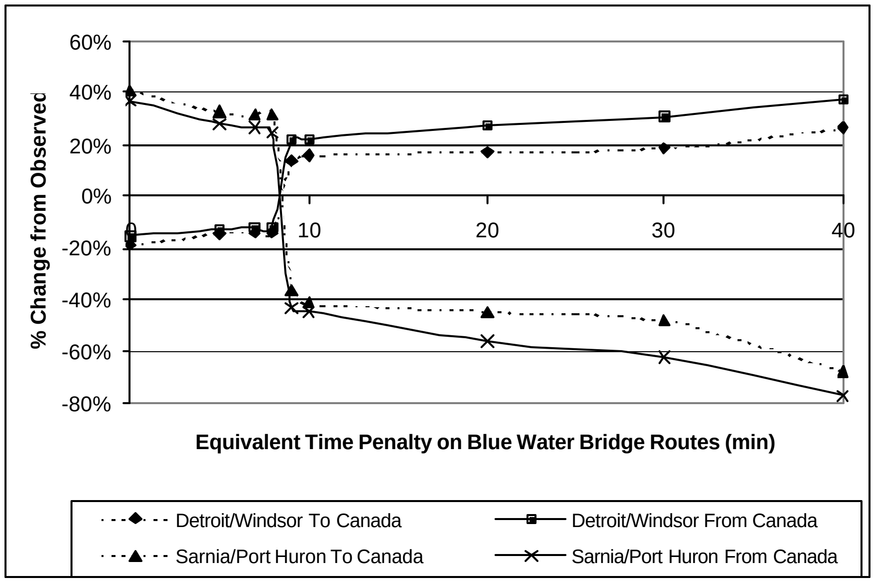
Exhibit 7.7 illustrates the impact of adding an adjustment factor to the Sarnia/Port Huron crossing on free flow auto volumes for the PM peak period, while Exhibit 7.8 shows the effect on truck volumes. As shown, with no adjustment factor, the model over-predicts Sarnia/Port Huron crossings by 15 to 25% and under-predicts the Detroit/Windsor crossings by about 5% (the values are not the same, as the latter handles more traffic). At a 5-minute adjustment factor, traffic begins to divert to the Detroit-Windsor crossings., and the optimum factor is around 9 minutes. With a capacity constrained PM peak assignment congestion in Windsor and Detroit requires Sarnia/Port Huron adjustment factors are increased to 10 minutes eastbound and 11 minutes Westbound to ensure that the model provided the best fit between the two major gateway locations. A 10-minute factor for both directions provided good calibration for the AM peak hour.

**EXHIBIT 7.7: IMPACT OF EQUIVALENT ADJUSTMENT FACTOR TIME PENALTY AT SARNIA/PORT HURON CROSSING ON AUTO ASSIGNMENT (PM PEAK PERIOD AUTOS)**




The same analysis was carried out for passenger cars, with the results of this analysis shown in Exhibit 7.8. As shown, the optimal calibration factor for trucks is about 7.5 minutes under free flow conditions. When assigning with capacity constraints congestion in the Detroit-Windsor area, it was required that this factor be increased to around 10 minutes eastbound and 12 minutes westbound

**EXHIBIT 7.8: IMPACT OF EQUIVALENT ADJUSTMENT FACTOR TIME PENALTY AT SARNIA/PORT HURON CROSSING ON AUTO ASSIGNMENT (PM PEAK PERIOD TRUCKS)**




## 7.3. Local Level Model Calibration

In the absence of adjustment factors, the model was found to under-assign trips using the Ambassador Bridge by about 10% and over predict trips for the tunnel. Several of the observed trips were found to use the bridge despite the fact that the tunnel provides a short and more direct route. Reasons for this include the possibility that the bridge provides easier access, drivers want to avoid real or perceived congestion in the downtown core of Detroit or Windsor and a possible preference for a bridge crossing compared to a tunnel. It was also found that the model is fairly sensitive to minor changes in travel times in allocating trips between the bridge and tunnel because the two facilities provide similar times for many trips. This indicates the difficult modeling issues involved and it is recognized that the model cannot adequately capture these inherent preferences.

Based on the assignment runs, it was found that adding a penalty to the Detroit-Windsor Tunnel of 1 minute for cars and 2 minutes for trucks was sufficient to get the model to best replicate the existing distribution between the bridge and tunnel. This is in addition to the 10 or 11-minute penalty for cars and 10 or 12 minute penalty for trucks that are added to the Blue Water Bridge, as discussed above.

## 7.4. Validation by Major Origin-Destination

An important aspect of the model validation was to ensure that the model properly assigns both long and shorter distance trips, as they represent distinct markets, with the propensity to use different border crossings.

***Passenger Cars***

Exhibit 7.9 summarizes the passenger car assignments by major trip interchange. These model runs were compared to Regional Model runs where the model assignment algorithm determined the use of the crossings. These runs therefore attempt to replicate actual volume to capacity conditions in the network.

As shown in Exhibit 7.9, the model does a good job of predicting trips by major trip interchange. On a strategic level, assignments between Detroit-Windsor and Sarnia-Port Huron are generally within 10%. On a local level (the choice between Ambassador Bridge and the Tunnel), the differences are greater in percentage terms. As discussed above, the fact that there is a strong preference to use of the Ambassador Bridge over the Blue Water Bridge for many trips that could use either crossing, and that the bridge and tunnel provide similar routings for many trips, it is difficult to achieve an exact calibration between these facilities. The fact that the under-prediction on one facility is offset by an equivalent over-prediction on the competing facility is an indication that there are no problems with the trip matrices.

***Trucks***

Calibration of the Regional Model for commercial vehicle trips was more difficult than for passenger cars due to the lower number of trips and greater dispersion of trip patterns. The results of model validation for truck trips by major origin-destination pair are shown on Exhibit 7.10. Generally, the model is performing reasonably well in terms of the assignment of truck trips to the crossings.

## EXHIBIT 7.9: VALIDATION OF MODEL RESULTS BY MAJOR ORIGIN-DESTINATION TYPE (AUTOS)

**AM PEAK HOUR AUTO TRIPS**

| | AMBASSADOR BRIDGE | | | | DW TUNNEL | | | | BLUE WATER BRIDGE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Origin Destination Pair | Obs. | Model | Abs. Diff. | % Diff. | Obs. | Model | Abs. Diff. | % Diff. | Obs. | Model | Abs. Diff. | % Diff. |
| **LOCAL-LOCAL TRIPS** | | | | | | | | | | | | |
| WALTS to City of Detroit +H.P/H.T) | 212 | 181 | -31 | -15% | 319 | 350 | 31 | 10% | 0 | 0 | 0 | - |
| WALTS to rest of Wayne County | 240 | 230 | -10 | -4% | 65 | 75 | 10 | 15% | 0 | 0 | 0 | - |
| WALTS to rest Oakland/Macomb | 215 | 200 | -15 | -7% | 345 | 360 | 15 | 4% | 0 | 0 | 0 | - |
| City of Detroit + to WALTS | 46 | 36 | -10 | - | 74 | 84 | 10 | 14% | 0 | 0 | 0 | - |
| Rest of Wayne to WALTS | 87 | 75 | -12 | -14% | 19 | 31 | 12 | - | 0 | 0 | 0 | - |
| Oakland/Macomb to WALTS | 35 | 24 | -11 | | 106 | 117 | 11 | 10% | 0 | 0 | 0 | - |
| Sarnia - Port Huron | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 94 | 94 | 0 | 0% |
| Port Huron – Sarnia | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 31 | 31 | 0 | - |
| **LONG DISTANCE – LOCAL** | | | | | | | | | | | | |
| CAN excl. WALTS/Sarnia - Wayne | 131 | 131 | 0 | 0% | 50 | 51 | 1 | 2% | 5 | 4 | -1 | - |
| US excl. Wayne/P.H. – WALTS | 38 | 38 | 0 | - | 15 | 15 | 0 | - | 0 | 0 | 0 | - |
| **LOCAL TO LONG DISTANCE** | | | | | | | | | | | | |
| WALTS to US excl. Wayne/P.H. | 90 | 91 | 1 | 1% | 30 | 29 | -1 | - | 0 | 0 | 0 | - |
| Wayne to CAN excl. WALTS/Sarnia | 63 | 84 | 21 | 33% | 28 | 13 | -15 | - | 14 | 8 | -6 | - |
| **LONG DISTANCE TO LONG DISTANCE** | | | | | | | | | | | | |
| CAN excl. WALTS/Sarnia to US excl. Wayne/P.H. | 162 | 187 | 25 | 15% | 34 | 21 | -13 | - | 57 | 45 | -12 | -21% |
| US excl. Wayne/P.H. to CAN excl. WALTS/Sarnia | 41 | 48 | 7 | 17% | 19 | 3 | -16 | - | 111 | 120 | 9 | 8% |
| Other Trips | 2 | 6 | 4 | - | 15 | 15 | 0 | - | 101 | 98 | -3 | -3% |
| **TOTAL** | 1362 | 1331 | -31 | -2% | 1119 | 1164 | 45 | 4% | 413 | 400 | -13 | -3% |

Note: Percentage differences are not calculated for linkages with less than 50 trips
Obs - Observed,
Abs. Diff.- Absolute Difference.
H.P. = Highland Park, H.T. = Hamtramck

## EXHIBIT 7.9 (CONTINUED): VALIDATION OF MODEL RESULTS BY MAJOR ORIGIN-DESTINATION TYPE (AUTOS)

**PM PEAK HOUR AUTO TRIPS**

| | AMBASSADOR BRIDGE | | | | DW TUNNEL | | | | BLUE WATER BRIDGE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Origin Destination Pair | Obs. | Model | Abs. Diff. | % Diff. | Obs. | Model | Abs. Diff. | % Diff. | Obs. | Model | Abs. Diff. | % Diff. |
| **LOCAL-LOCAL TRIPS** | | | | | | | | | | | | |
| WALTS to City of Detroit +H.P/H.T) | 69 | 72 | 3 | 4% | 155 | 153 | -2 | -1% | 0 | 0 | 0 | |
| WALTS to rest of Wayne County | 145 | 157 | 12 | 8% | 65 | 52 | -13 | -20% | 0 | 0 | 0 | |
| WALTS to rest Oakland/Macomb | 94 | 80 | -14 | -15% | 267 | 281 | 14 | 5% | 0 | 0 | 0 | |
| City of Detroit + to WALTS | 265 | 221 | -44 | -17% | 415 | 459 | 44 | 11% | 0 | 0 | 0 | |
| Rest of Wayne to WALTS | 376 | 342 | -34 | -9% | 97 | 132 | 35 | 36% | 0 | 0 | 0 | |
| Oakland/Macomb to WALTS | 321 | 259 | -62 | -19% | 446 | 508 | 62 | 14% | 0 | 0 | 0 | |
| Sarnia - Port Huron | 0 | 0 | 0 | - | 0 | 0 | 0 | | 141 | 141 | 0 | 0% |
| Port Huron - Sarnia | 0 | 0 | 0 | - | 0 | 0 | 0 | | 188 | 188 | 0 | 0% |
| **LONG DISTANCE – LOCAL** | | | | | | | | | | | | |
| CAN excl. WALTS/Sarnia - Wayne | 64 | 71 | 7 | 11% | 25 | 26 | 1 | - | 16 | 9 | -7 | - |
| US excl. Wayne/P.H. – WALTS | 167 | 160 | -7 | -4% | 96 | 103 | 7 | 7% | 0 | 0 | 0 | - |
| **LOCAL TO LONG DISTANCE** | | | | | | | | | | | | |
| WALTS to US excl. Wayne/P.H. | 81 | 95 | 14 | 17% | 60 | 46 | -14 | - | 0 | 0 | 0 | 0% |
| Wayne to CAN excl. WALTS/Sarnia | 222 | 234 | 12 | 5% | 54 | 51 | -3 | -6% | 18 | 10 | -8 | - |
| **LONG DISTANCE TO LONG DISTANCE** | | | | | | | | | | | | |
| CAN excl. WALTS/Sarnia to US excl. Wayne/P.H. | 163 | 207 | 44 | 27% | 43 | 14 | -29 | - | 168 | 153 | -15 | -9% |
| US excl. Wayne/P.H. to CAN excl. WALTS/Sarnia | 225 | 272 | 47 | 21% | 85 | 36 | -49 | -58% | 137 | 140 | 3 | 2% |
| Other Trips | 14 | 5 | -9 | - | 24 | 15 | -9 | - | 310 | 304 | -6 | -2% |
| **TOTAL** | 2206 | 2175 | -31 | -1% | 1832 | 1876 | 44 | 2% | 978 | 945 | -33 | -3% |

Note: Percentage differences are not calculated for linkages with less than 50 trips.
Obs - Observed,
Abs. Diff.- Absolute Difference.
H.P. = Highland Park, H.T. = Hamtramck

## EXHIBIT 7.10: VALIDATION OF MODEL RESULTS BY MAJOR ORIGIN-DESTINATION TYPE (TRUCKS)

**AM PEAK HOUR TRUCK TRIPS**

| | AMBASSADOR BRIDGE | | | | DW TUNNEL | | | | BLUE WATER BRIDGE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Origin Destination Pair | Obs. | Model | Abs. Diff. | % Diff. | Obs. | Model | Abs. Diff. | % Diff. | Obs. | Model | Abs. Diff. | % Diff. |
| **LOCAL-LOCAL TRIPS** | 0 | 2 | 2 | - | 30 | 28 | -2 | - | 0 | 0 | 0 | - |
| WALTS to City of Detroit +H.P/H.T) | 0 | 4 | 4 | - | 7 | 3 | -5 | - | 0 | 0 | 0 | - |
| WALTS to rest of Wayne County | 0 | 0 | 0 | - | 8 | 8 | 0 | - | 0 | 0 | 0 | - |
| WALTS to rest Oak land/Macomb | 40 | 40 | 1 | - | 4 | 3 | -1 | - | 0 | 0 | 0 | - |
| City of Detroit + to WALTS | 10 | 17 | 7 | - | 7 | 0 | -7 | - | 0 | 0 | 0 | - |
| Rest of Wayne to WALTS | 4 | 2 | -2 | - | 4 | 6 | 2 | - | 0 | 0 | 0 | - |
| Oakland/Macomb to WALTS | 0 | 2 | 2 | - | 30 | 28 | -2 | - | 0 | 0 | 0 | - |
| Sarnia - Port Huron | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 | 0 | 0 | - |
| Port Huron - Sarnia | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 1 | 1 | 0 | - |
| **LONG DISTANCE – LOCAL** | | | | | | | | | | | | |
| CAN excl. WALTS/Sarnia - Wayne | 60 | 54 | -6 | -10% | 7 | 22 | 15 | - | 9 | 1 | -8 | - |
| US excl. Wayne/P.H. – WALTS | 24 | 21 | -3 | - | 2 | 5 | 2 | - | 0 | 0 | 0 | - |
| **LOCAL TO LONG DISTANCE** | | | | | | | | | | | | |
| WALTS to US excl. Wayne/P.H. | 58 | 61 | 3 | 5% | 4 | 1 | -3 | - | 0 | 0 | 0 | - |
| Wayne to CAN excl. WALTS/Sarnia | 20 | 24 | 4 | - | 3 | 0 | -3 | - | 4 | 2 | -2 | - |
| **LONG DIATANCE TO LONG DISTANCE** | | | | | | | | | | | | |
| CAN excl. WALTS/Sarnia to US excl. Wayne/P.H. | 167 | 168 | 1 | 1% | 5 | 5 | 0 | - | 97 | 96 | -1 | -1% |
| US excl. Wayne/P.H. to CAN excl. WALTS/Sarnia | 127 | 119 | -8 | -6% | 0 | 0 | 0 | - | 48 | 56 | 8 | - |
| Other Trips | 0 | 1 | 1 | - | 2 | 0 | -2 | - | 21 | 21 | 0 | 0% |
| **TOTAL** | 508 | 513 | 5 | 1% | 84 | 81 | -3 | -4% | 180 | 177 | -3 | -2% |

Note: Percentage differences are not calculated for linkages with less than 50 trips.
H.P. = Highland Park, H.T. = Hamtramck

### EXHIBIT 7.10 (CONTINUED): VALIDATION OF MODEL RESULTS BY MAJOR ORIGIN-DESTINATION TYPE (TRUCKS)

**PM PEAK HOUR TRUCK TRIPS**

| | AMBASSADOR BRIDGE | | | | DW TUNNEL | | | | BLUE WATER BRIDGE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Origin Destination Pair | Obs. | Model | Abs. Diff. | % Diff. | Obs. | Model | Abs. Diff. | % Diff. | Obs. | Model | Abs. Diff. | % Diff. |
| **LOCAL-LOCAL TRIPS** | | | | | | | | | | | | |
| WALTS to City of Detroit +H.P/H.T) | 69 | 72 | 3 | 4% | 155 | 153 | -2 | -1% | 0 | 0 | 0 | - |
| WALTS to rest of Wayne County | 145 | 157 | 12 | 8% | 65 | 52 | -13 | -20% | 0 | 0 | 0 | - |
| WALTS to rest Oakland/Macomb | 94 | 80 | -14 | -15% | 267 | 281 | 14 | 5% | 0 | 0 | 0 | - |
| City of Detroit + to WALTS | 265 | 221 | -44 | -17% | 415 | 459 | 44 | 11% | 0 | 0 | 0 | - |
| Rest of Wayne to WALTS | 376 | 342 | -34 | -9% | 97 | 132 | 35 | 36% | 0 | 0 | 0 | - |
| Oakland/Macomb to WALTS | 321 | 259 | -62 | -19% | 446 | 508 | 62 | 14% | 0 | 0 | 0 | - |
| Sarnia - Port Huron | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 141 | 141 | 0 | 0% |
| Port Huron – Sarnia | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 188 | 188 | 0 | 0% |
| **LONG DISTANCE – LOCAL** | | | | | | | | | | | | |
| CAN excl. WALTS/Sarnia – Wayne | 64 | 71 | 7 | 11% | 25 | 26 | 1 | - | 16 | 9 | -7 | - |
| US excl. Wayne/P.H. – WALTS | 167 | 160 | -7 | -4% | 96 | 103 | 7 | 7% | 0 | 0 | 0 | - |
| **LOCAL TO LONG DISTANCE** | | | | | | | | | | | | |
| WALTS to US excl. Wayne/P.H. | 81 | 95 | 14 | 17% | 60 | 46 | -14 | -23% | 0 | 0 | 0 | - |
| Wayne to CAN excl. WALTS/Sarnia | 222 | 234 | 12 | 5% | 54 | 51 | -3 | -6% | 18 | 10 | -8 | - |
| **LONG DISTANCE TO LONG DISTANCE** | | | | | | | | | | | | |
| CAN excl. WALTS/Sarnia to US excl. Wayne/P.H. | 163 | 207 | 44 | 27% | 43 | 14 | -29 | - | 168 | 153 | -15 | -9% |
| US excl. Wayne/P.H. to CAN excl. WALTS/Sarnia | 225 | 272 | 47 | 21% | 85 | 36 | -49 | -58% | 137 | 140 | 3 | 2% |
| Other Trips | 14 | 5 | -9 | - | 24 | 15 | -9 | - | 310 | 304 | -6 | -2% |
| **TOTAL** | 573 | 556 | -17 | -3% | 29 | 36 | 7 | - | 265 | 276 | 11 | 4% |

Note: Percentage differences are not calculated for linkages with less than 50 trips.
H.P. = Highland Park, H.T. = Hamtramck

## 7.5. Screenline Comparisons

***Border Crossings***

The border crossings represent the primary screenlines used to calibrate the model. The results of the final calibrated model are shown on Exhibit 7.11. In terms of the assignments by major crossing location (i.e. Windsor/Detroit vs. Sarnia/Port Huron), all of the assignments are within 9% of the observed values.

For the two Windsor/Detroit crossings, the differences are greater. However, as discussed previously, this reflects the best possible calibration given the number of unexplained factors that dictate driver's choice of crossing and the similar role these two facilities provide. At the crossing level, it can be concluded that the model is performing adequately.

### EXHIBIT 7.11: COMPARISON OF OBSERVED AND MODELLED TRIPS BY BORDER CROSSING

#### AM PEAK HOUR

| | Observed | Modelled | Abs. Diff | % Diff |
|---|---|---|---|---|
| Ambassador Bridge – to Canada | | | | |
| Cars | 306 | 310 | 4 | 1% |
| Trucks | 224 | 224 | 0 | 0% |
| Total PCE | 978 | 983 | 5 | 1% |
| Ambassador Br. – to United States | | | | |
| Cars | 1,056 | 1021 | -35 | 4% |
| Trucks | 284 | 289 | 5 | -6% |
| Total PCE | 1,908 | 1888 | -20 | -1% |
| DW Tunnel – to Canada | | | | |
| Cars | 272 | 268 | -4 | -1% |
| Trucks | 21 | 15 | -6 | 28% |
| Total PCE | 335 | 312 | -23 | -7% |
| DW Tunnel – to United States | | | | |
| Cars | 847 | 896 | 49 | 6% |
| Trucks | 63 | 67 | 4 | 6% |
| Total PCE | 1,036 | 1096 | 60 | 6% |
| Blue Water Bridge – to Canada | | | | |
| Cars | 182 | 186 | 4 | 2% |
| Trucks | 60 | 66 | 6 | 9% |
| Total PCE | 362 | 383 | 21 | 4% |
| Blue Water Br. – to United States | | | | |
| Cars | 231 | 214 | -17 | -7% |
| Trucks | 120 | 111 | 9 | -7% |
| Total PCE | 591 | 548 | -43 | -7% |

## EXHIBIT 7.11 (CONTINUED): COMPARISON OF OBSERVED AND MODELLED TRIPS BY BORDER CROSSING

### PM PEAK HOUR

| | Observed | Modelled | Abs. Diff | % Diff |
|---|---|---|---|---|
| Ambassador Bridge – to Canada | | | | |
| Cars | 1,586 | 1493 | -93 | -6% |
| Trucks | 309 | 299 | -10 | -3% |
| Total PCE | 2,513 | 2389 | -124 | -5% |
| Ambassador Br. – to United States | | | | |
| Cars | 620 | 682 | 62 | 10% |
| Trucks | 264 | 257 | -7 | -3% |
| Total PCE | 1412 | 1452 | 40 | 3% |
| DW Tunnel – to Canada | | | | |
| Cars | 1,206 | 1296 | 90 | 7% |
| Trucks | 11 | 16 | 5 | 45% |
| Total PCE | 1,239 | 1345 | 106 | 9% |
| DW Tunnel – to United States | | | | |
| Cars | 626 | 580 | -46 | -7% |
| Trucks | 18 | 20 | 2 | 11% |
| Total PCE | 680 | 639 | -41 | -6% |
| Blue Water Bridge – to Canada | | | | |
| Cars | 522 | 511 | -11 | -2% |
| Trucks | 129 | 134 | 5 | 4% |
| Total PCE | 909 | 913 | 4 | 0% |
| Blue Water Br. – to United States | | | | |
| Cars | 456 | 434 | -22 | 2% |
| Trucks | 136 | 142 | 6 | 4% |
| Total PCE | 864 | 859 | -5 | -1% |

Note: PCE – passenger car equivalents with 1 truck assumed to be equivalent to 3.0 PCEs.

### *Other Selected Screenlines*

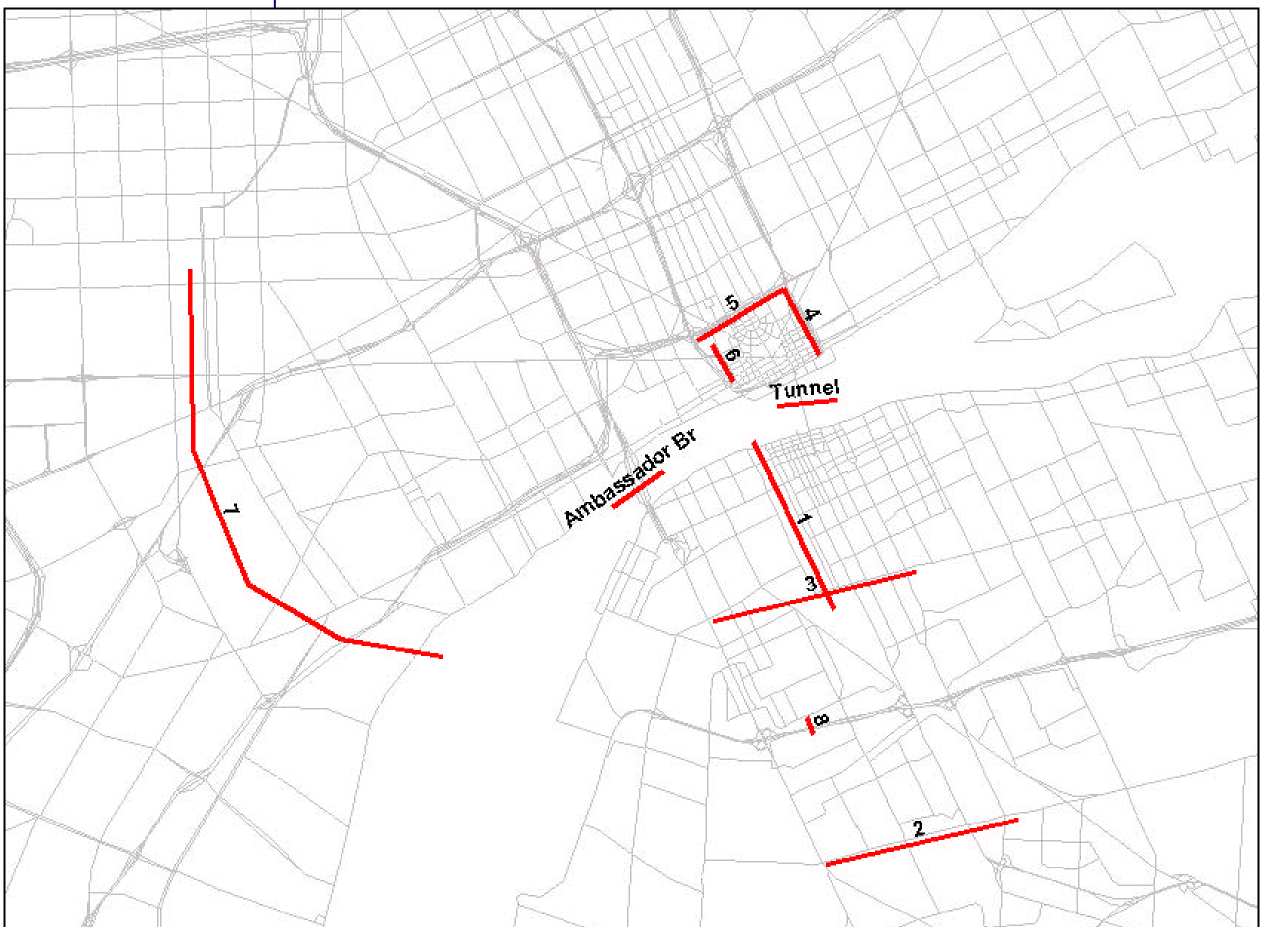
Model results were compared to observed traffic counts across representative screenlines to ensure that background traffic was adequately reflected in the model. Traffic counts were obtained from the City of Windsor and SEMCOG.

Exhibit 7.12 shows the performance of the model by screenline (see Exhibit 7.13 for screenline locations). In general, the results are within 20% of the observed traffic volumes. Given that the origin-destination matrices are based on a relatively small sample of trips from surveys undertaken in 1994/96 and updated to 2000 conditions and that traffic volumes tend to vary by day and time of year, the results were felt to be acceptable.

**EXHIBIT 7.12: SCREENLINE VALIDATION**

| | | AM | | | PM | | |
|---|---|---|---|---|---|---|---|
| Screenline | # | Observed | Modelled | % Diff. | Observed | Modelled | % Diff. |
| Windsor Area Screenlines | | | | | | | |
| Crawford Avenue | 1 | 4,580 | 5,039 | 10% | 6,186 | 6,523 | 5% |
| Cabana Road | 2 | 3,597 | 3,800 | 6% | 4,507 | 4,853 | 8% |
| Tecumseh Road | 3 | 7,065 | 7,332 | 4% | 9,790 | 9,880 | 1% |
| Detroit Area Screenlines | | | | | | | |
| I-375 | 4 | 8,899 | 8,810 | -1% | 8,998 | 10,053 | 12% |
| I-75 | 5 | 4,392 | 4,211 | -4% | 4,577 | 4,266 | -7% |
| US-10 | 6 | 2,500 | 2,474 | -1% | 3,380 | 3,633 | 7% |
| Schaefer Highway | 7 | 6,647 | 7,035 | 6% | 9,128 | 10,447 | 14% |
| Spot Location | | | | | | | |
| EC Row/East of Huron Church | 8 | 3,455 | 3,437 | -1% | 6,254 | 5,783 | -8% |

**EXHIBIT 7.13: SCREENLINE LOCATIONS**




# 7.6. Final Model Results

The final calibrated model results are shown on Exhibits 7.14A-7.14L. These exhibits show the assignment of auto and truck trips to the road network, which can be compared to the observed trips in Appendix F.

A considerable level of care was taken to develop the best possible model while minimizing the number of correction factors and adjustments that need to be made to achieve reasonable traffic assignments. The result is a model that will be capable of assigning future travel matrices and assessing the impact of possible new crossing facilities. However, it is very important to examine the sensitivity of the routing assignments to the various crossings when examining future runs, as small changes in delay at one crossing can result in significant shifts in traffic to another crossing. This high sensitivity reflects the very similar travel times that exist between the crossings for several major trip interchanges. For instance, London to Chicago travel time is very similar between the Sarnia/Port Huron and Windsor/Detroit crossings. Similarly, there are small travel time differences between the Ambassador Bridge and the Detroit-Windsor for many local Detroit/Windsor cross border trips.

A final table, Exhibit 7.15 identifies the highways used to access or egress each crossing facility. The table shows that I-75 from the south is the most significant highway for access to the Detroit-Windsor crossings with I-94 from the west the next most significant access highway. The majority of tuck trips are long distance trips travelling beyond the local Windsor-Detroit area, with the I-75 corridor being used for over 40% of truck trips crossing the Ambassador Bridge and over 15% of trucks at the Detroit-Windsor Tunnel based on the assignments. Passenger car trip are more local in nature and therefore show much lower utilization of the highway system.

Based on the assignments, truck trips accessing Blue Water Bridge are primarily focused on the I-69 corridor, with 70%-80% of trucks using this facility, many extending as far as Chicago and beyond. A smaller proportion (16%-23%) is oriented to the I-94 corridor and the Greater Detroit area. Few trips terminate within Port Huron or use other routes. Car trips, show a greater orientation to the I-94 corridor.

In general, the assignments appear reasonable based on current observations and data, including the allocation of trips between the crossings and the access/egress facilities used to reach these crossings.

## EXHIBIT 7.14A: MODELLED ASSIGNMENTS – AM PEAK HOUR AUTOS

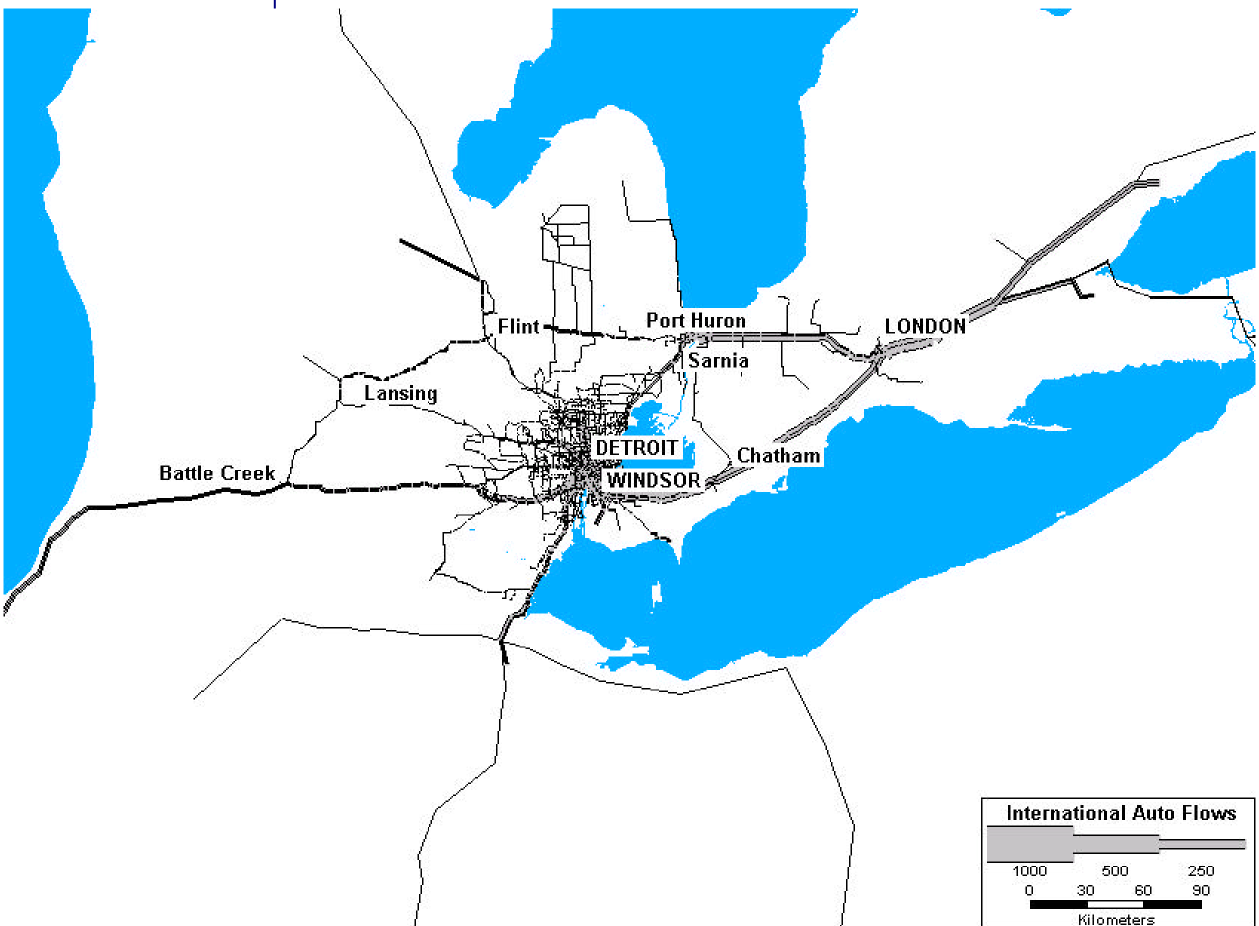


**EXHIBIT 7.14B: MODELLED ASSIGNMENTS – AM PEAK HOUR AUTOS**

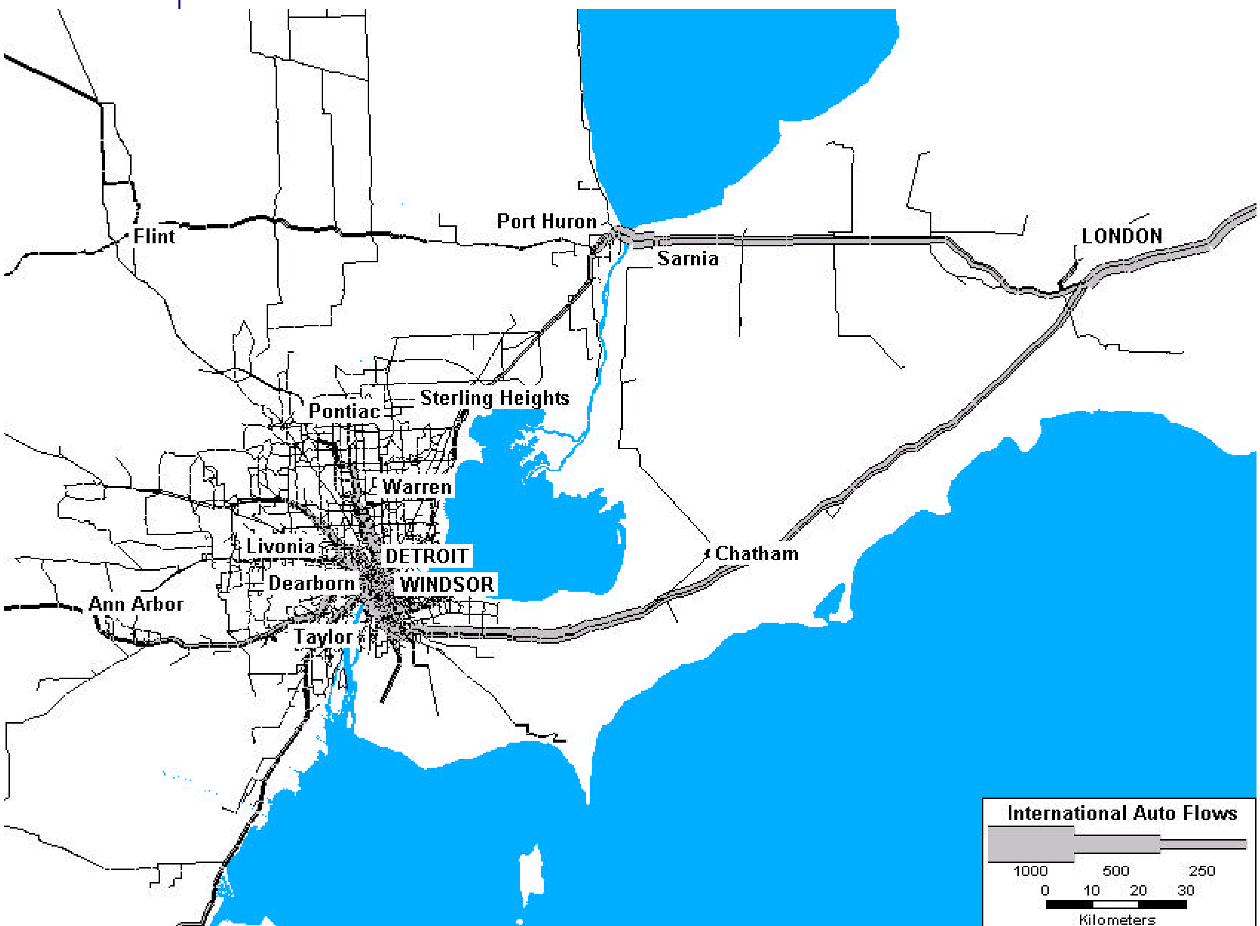


**EXHIBIT 7.14C: MODELLED ASSIGNMENTS – AM PEAK HOUR AUTOS**

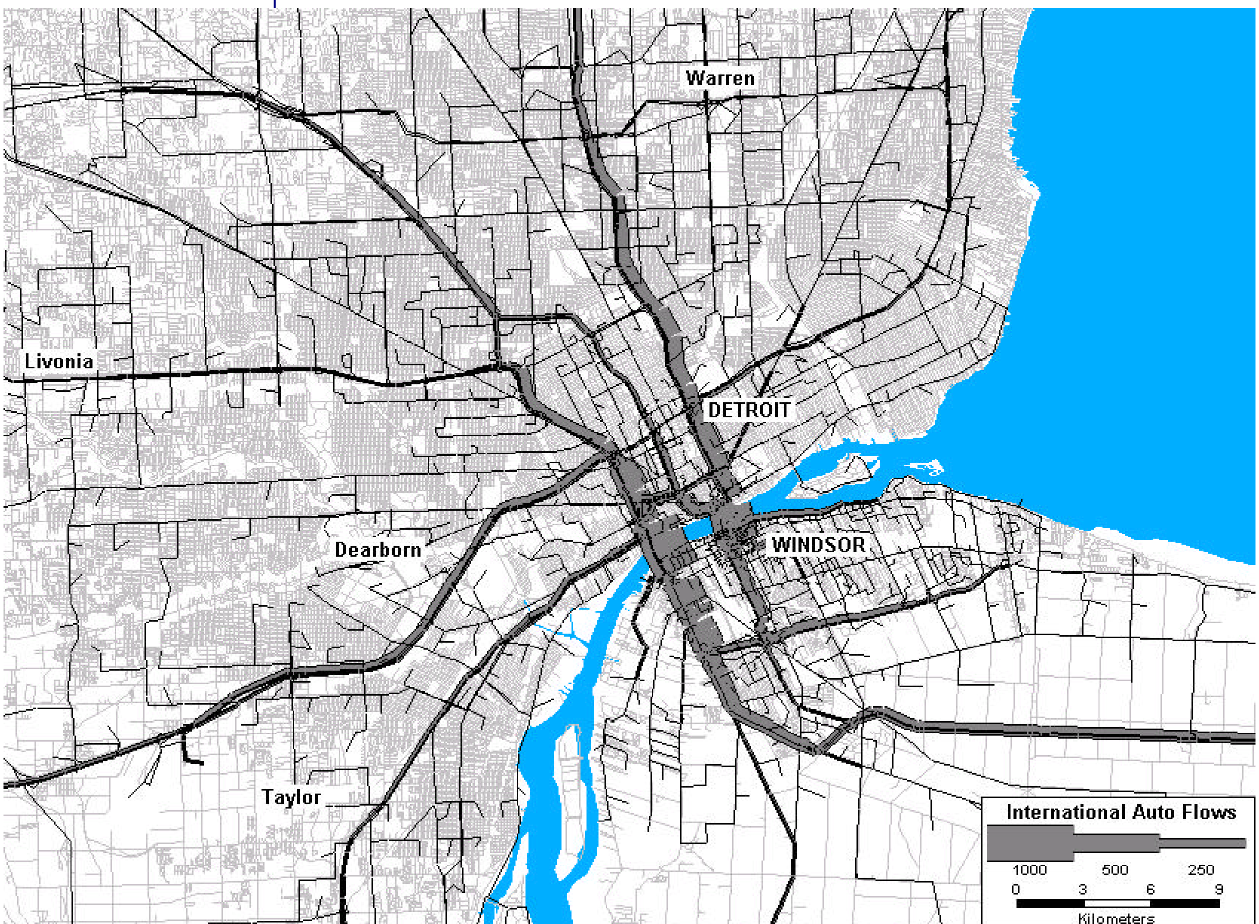


**EXHIBIT 7.14D: MODELLED ASSIGNMENTS – AM PEAK HOUR TRUCKS**

## EXHIBIT 7.14E: MODELLED ASSIGNMENTS – AM PEAK HOUR TRUCKS

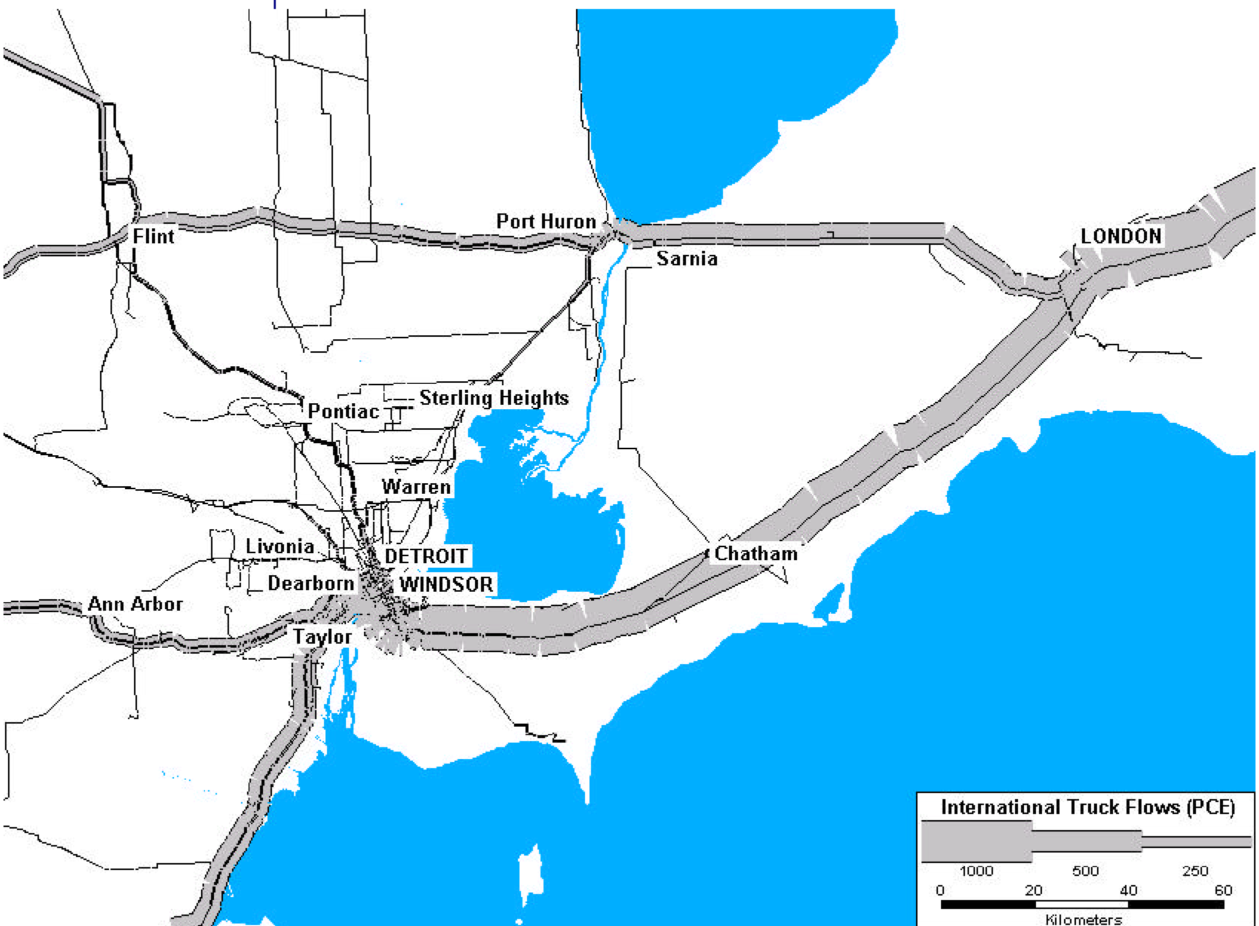
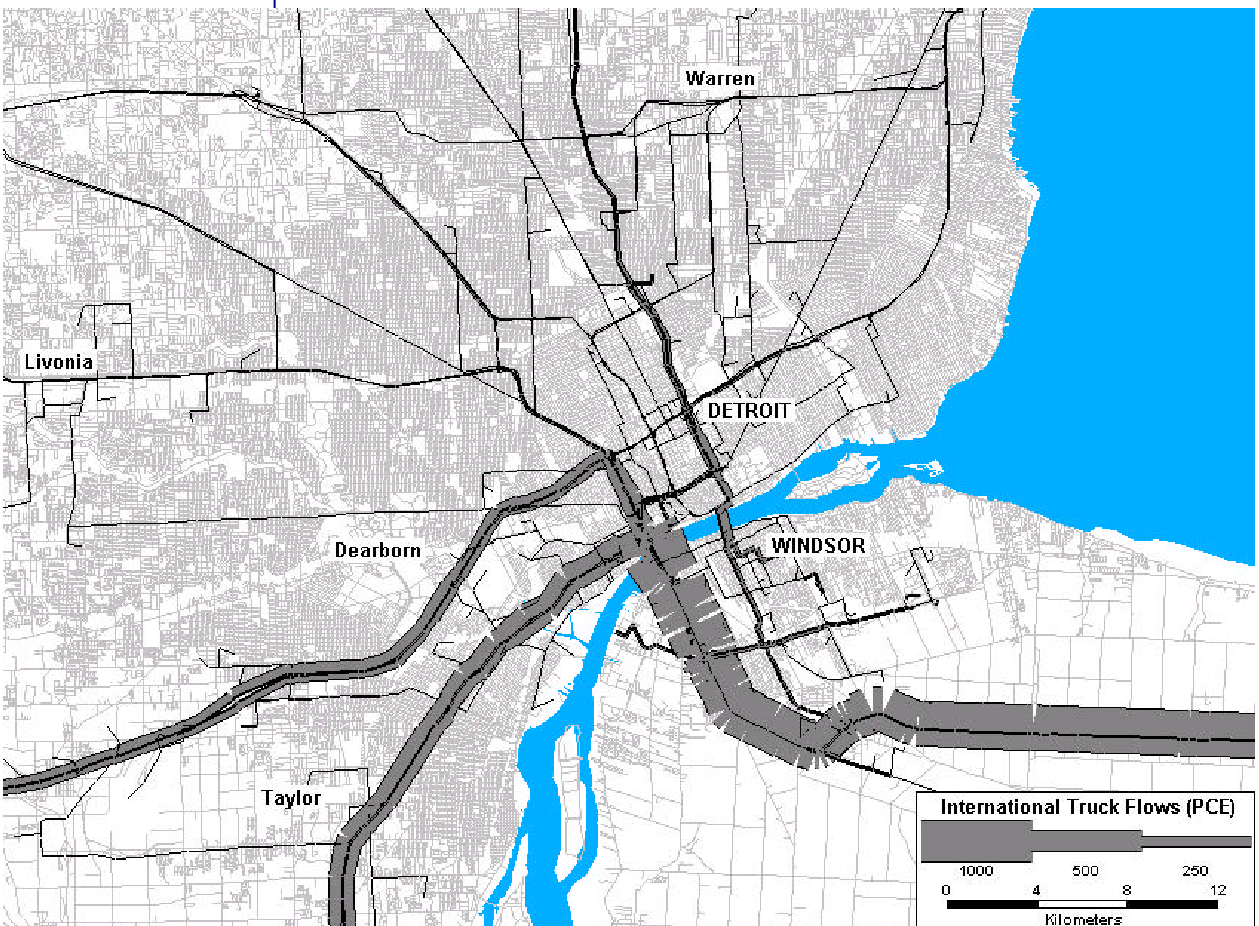


**EXHIBIT 7.14F: MODELLED ASSIGNMENTS – AM PEAK HOUR TRUCKS**



## EXHIBIT 7.14G: MODELLED ASSIGNMENTS – PM PEAK HOUR AUTOS

## EXHIBIT 7.14H: MODELLED ASSIGNMENTS – PM PEAK HOUR AUTOS

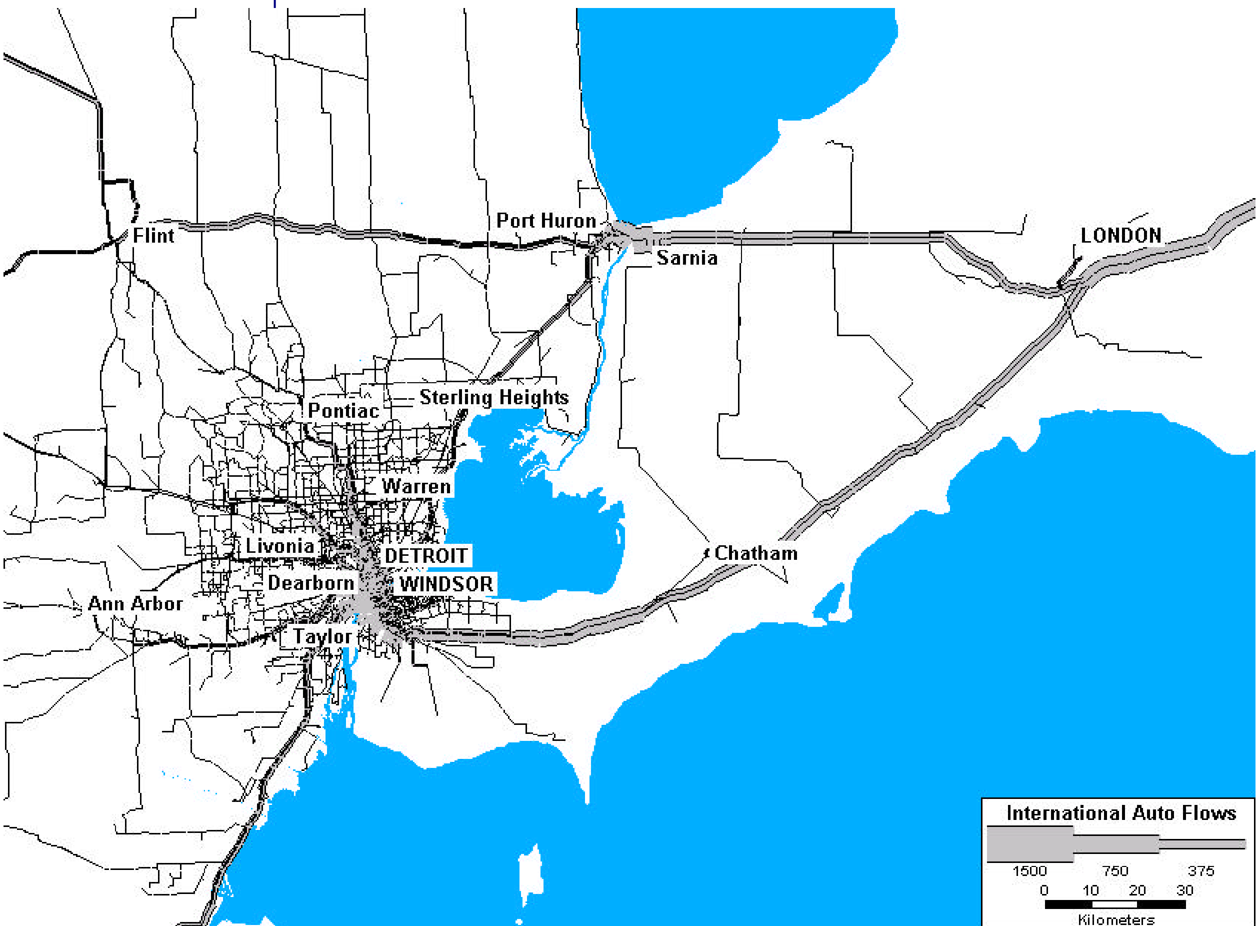
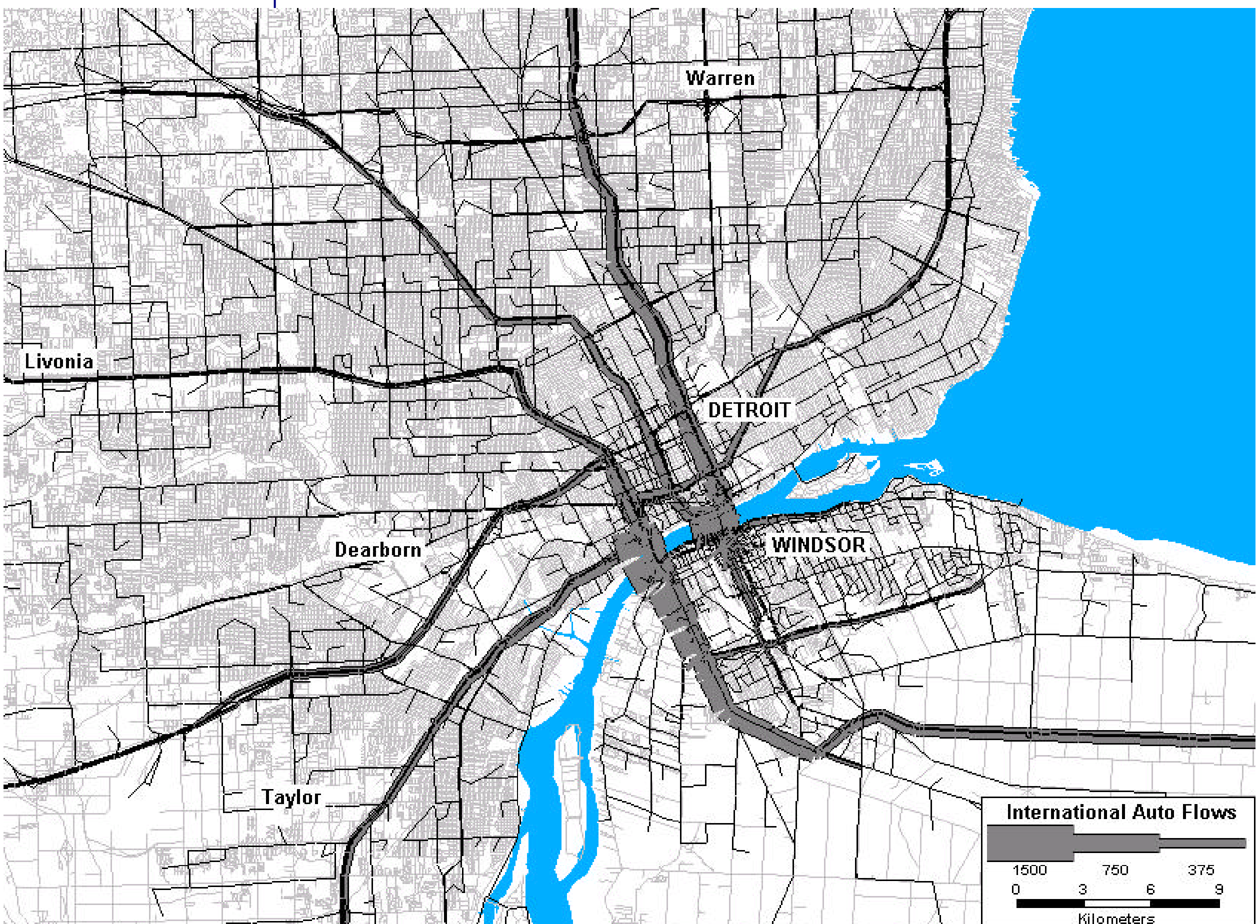
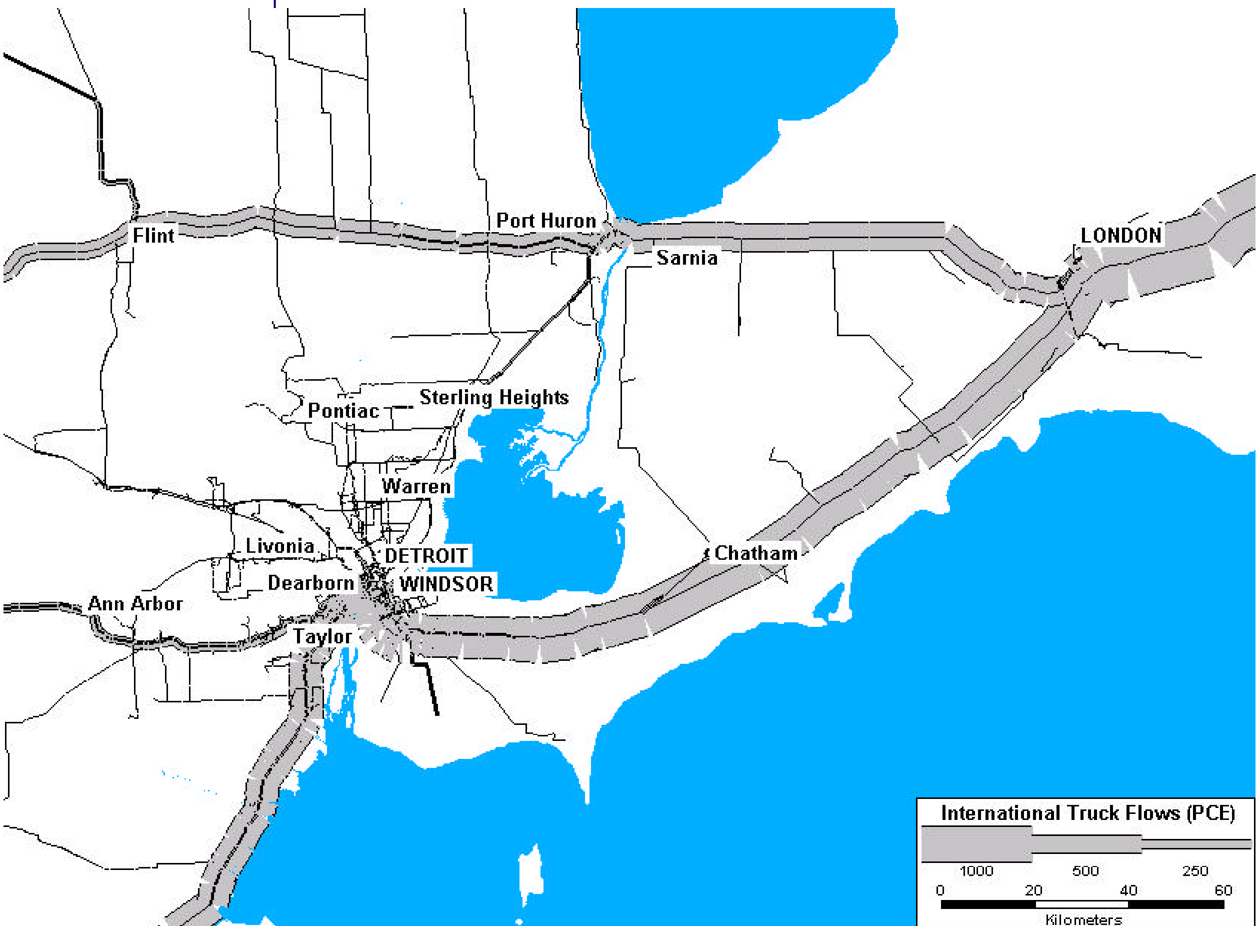


**EXHIBIT 7.14I: MODELLED ASSIGNMENTS – PM PEAK HOUR AUTOS**

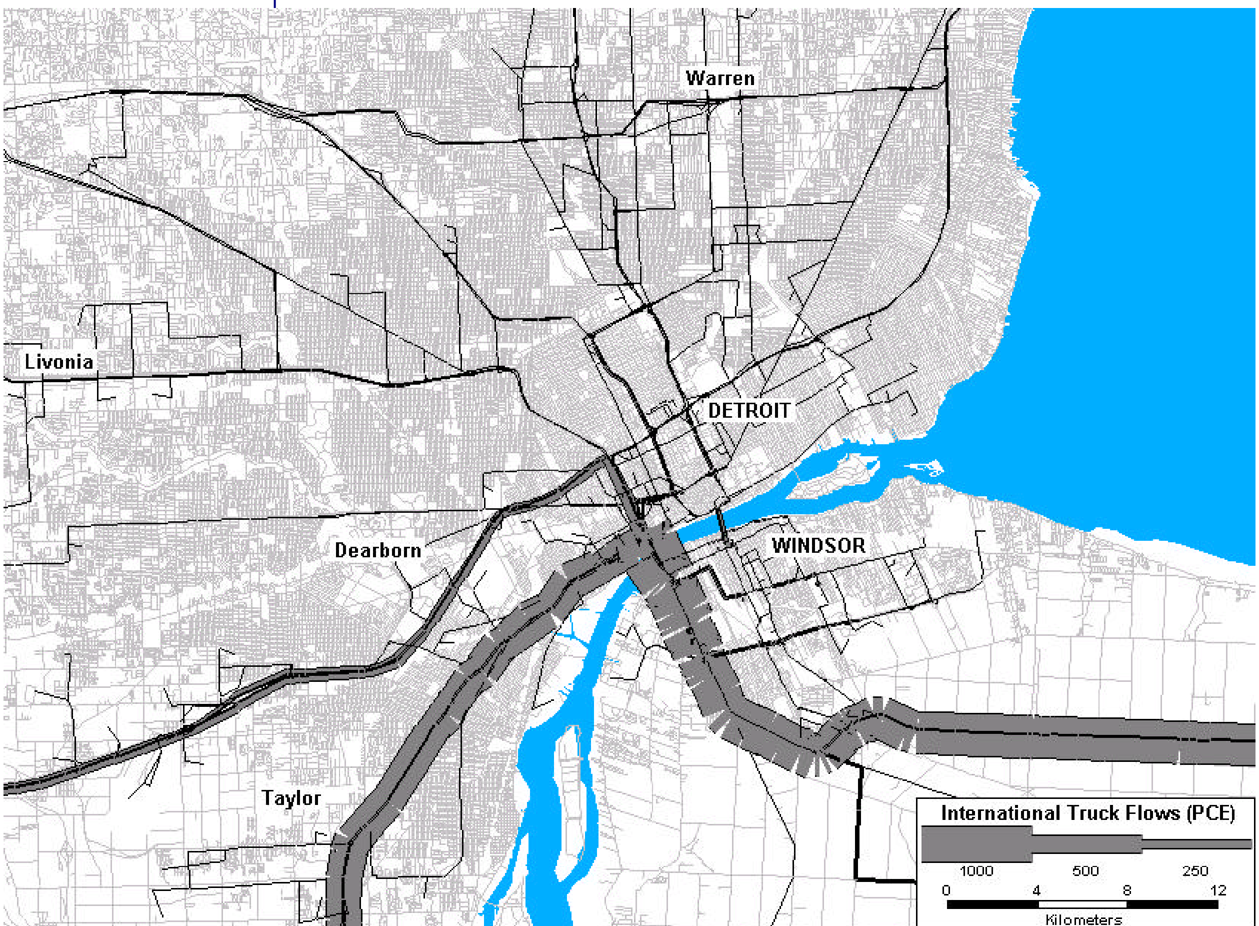


## EXHIBIT 7.14J: MODELLED ASSIGNMENTS – PM PEAK HOUR TRUCKS

## EXHIBIT 7.14K: MODELLED ASSIGNMENTS – PM PEAK HOUR TRUCKS



### EXHIBIT 7.14L: MODELLED ASSIGNMENTS – PM PEAK HOUR TRUCKS



### EXHIBIT 7.15: ACCESS/EGRESS HIGHWAYS TO INTERNATIONAL CROSSINGS

| **AM Peak** | | | | | | |
|---|---|---|---|---|---|---|
| Access/Egress Highway | Ambassador Bridge | | Detroit-Windsor Tunnel | | Bluewater Bridge | |
| | Cars | Trucks | Cars | Trucks | Cars | Trucks |
| I-75 North | 7% | 4% | 18% | 15% | - | - |
| I-75 South | 10% | 41% | 1% | 0% | - | - |
| I-96 West | 3% | 1% | 1% | 0% | - | - |
| I-94 West | 10% | 27% | 1% | 0% | - | - |
| I-94 North | 1% | 0% | 3% | 0% | - | - |
| | | | | | | |
| I-94 West | - | - | - | - | 46% | 23% |
| I-69 North | - | - | - | - | 27% | 70% |
| Other/Local | 68% | 28% | 75% | 85% | 27% | 7% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% |
| **PM Peak** | | | | | | |
| Access/Egress Highway | Ambassador Bridge | | Detroit-Windsor Tunnel | | Blue Water Bridge | |
| | Cars | Trucks | Cars | Trucks | Cars | Trucks |
| I-75 North | 7% | 1% | 19% | 23% | - | - |
| I-75 South | 15% | 57% | 1% | 6% | - | - |
| I-96 West | 2% | 4% | 2% | 1% | - | - |
| I-94 West | 11% | 15% | 1% | 3% | - | - |
| I-94 North | 2% | 0% | 4% | 1% | - | - |
| | | | | | | |
| I-94 South | - | - | - | - | 36% | 16% |
| I-69 West | - | - | - | | 31% | 79% |
| Other/Local | 63% | 23% | 72% | 66% | 33% | 4% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% |

Note: Trips on I-75, I-96, I-94 or I-69 are based on international traffic measured at city or municipal boundary.

# 8. Next Steps

This report has described the process and tasks undertaken to develop the traffic analysis zone system, trip tables and road networks for the Regional Model. The result of this effort is a calibrated transportation model that will be used to assign future trip matrices and evaluate border-crossing needs.

The validated Regional Model and Cross-Border Passenger Car and Goods Movement Modelling Processes will then be applied to produce forecasts for the 2010, 2020 and 2030 horizon years. Combined with an analysis of existing conditions, the forecasts will be used to assess current and future travel demand characteristics and needs related to cross-border traffic in the Broad Geographic Area. The findings will be summarized in the **Existing and Future Travel Demand Working Paper**, scheduled for completion in October 2002. This Working Paper will be presented to the Public and Private Sector Advisory Groups.

Travel demand analysis tasks will provide key inputs to major study deliverables over the course of the study:

- Transportation Problems and Opportunities Report – will include discussions on travel demand analysis, existing and future travel demand, anticipated transportation problems and rationale for Focused Analysis Area.
- Feasible Transportation Alternatives Working Paper – will include traffic volumes and impacts for a long list of potential alternatives to identify feasible alternatives;
- Transportation Alternatives Working Paper – demand analysis input into the assessment of the feasible alternatives, including the micro-simulation analysis.
- Economic Benefits Report – passenger and goods movement travel and associated delay and travel costs from the modelling process to provide input into the determination of economic benefits for the selected alternatives.
- Revenue Generation Report – modelling process to provide the annual stream of toll revenues collected for the use of border crossing facilities.

## 8.1. Future Year Model Runs

The validated model will be used to produce Base Case runs for 10, 20 and 30 years in the future, which will present the following information from the Regional Model:

- **Auto and Truck Volumes** – peak hour and DHV for highways, major regional roads and for international crossings; trip pattern analysis; capacity analysis and system performance indicators (e.g. system delay, average travel times, etc.);
- **Rail and Transit Passenger Volumes** – weekday and annual passenger volumes; trip pattern analysis;

- **Truck and Rail Goods Movement Volumes** – annual tonnage; trip analysis.

The forecasts will be developed on the "most probable" set of future assumptions, as determined by the Study Team in consultation with the partnership agencies. These forecasts will be presented in the Existing and Future Travel Demand Working Paper to be completed in Fall 2002.

Further along in the study, the model will be used to provide traffic forecasts for up to three alternatives that will emerge from the feasible transportation alternatives tasks.

## 8.2. Sensitivity Analysis

Two or three alternative demand scenarios will be developed for sensitivity testing purposes. These runs will involve changes in some of the key input parameters such as population and employment levels and their distribution, future economic conditions, as well as different assumptions regarding future trip-making behaviour (e.g. trip rates, modal split, etc.).

Three different sensitivity cases could involve scenarios such as the following:

- High – a combination of a set of input assumptions that reflect a more optimistic scenario for future cross-border traffic, as compared to the base case assumptions;
- Low – a less optimistic scenario for future cross-border traffic;
- Major Policy/Technology Change – it is possible that major changes to trade/cross-border policies (e.g. open border) or technology could cause a restructuring in travel patterns and behaviour, which would greatly affect cross-border needs.

Transportation Demand Management (TDM), HOV lanes, road pricing/tolls and other such initiatives may also be considered in combination or separately, as part of the sensitivity analyses.

The specific definition of the sensitivity runs will be undertaken in consultation with the Project Team during the study.

Partnership of

# APPENDIX A:

# Characteristics of Existing Transportation Models

Prepared by IBI Group for URS Canada

## EXHIBIT A.1: CHARACTERISTICS OF EXISTING DEMAND MODELS

| Model/Study | EBTC: Low | EBTC: High | MTO Truck Model | Michigan's Statewide Travel Demand Model | SEMCOG Model | City of Windsor | SW Ontario Frontier International Gateway |
|---|---|---|---|---|---|---|---|
| **Model Type** | Median Regression & time series | Time series | Assignment | 4-stage | 4-stage | 4-stage | Time series |
| **Model Platform** | - | - | EMME/2 | TransCAD | TRANPLAN | SYSTEM II | - |
| **Model Area** | Eastern North America border crossings | Eastern N America border crossings | Ontario | Michigan + North America | SEMCOG Counties | Windsor + area | SW Ontario |
| **Network Coordinates** | - | - | latitude/longitude | latitude/longitude | UTM/NAD 83 | UTM NAD 83 | - |
| **No. of Zones** | 4 regions | 4 regions | 49 in Ontario | 2392 (2307 in MI) | 1505 | 507 (464 internal; 30 US) | Roads by link |
| **No. of Links** | - | - | 5000 | 13000 | 18000 | 3300 | 200 |
| **Segmentation** | - | By commodity group | By commodity group | 5 trip purposes + truck (11 commodities) | 6 trip purposes | 3 trip purposes | Passenger vehicles, local and international trucks |
| **Demand variables** | Canadian GDP, time series | Growth by commodity, Canadian GDP | Industrial output | Household size, Income/hhld, Employment | Household size, Cars/hhld, Children/hhld, Workers/hhld, Employment (by type) | Population, Employment | Tourism, Canadian import/exports and population forecasts (based on historic) |
| **Trip Generation** | - | - | - | Cross classification | HB production: Cross classification; HB attraction & NHB: regression | Trip rates | - |
| **Trip Distribution** | - | - | - | Gravity model: National Personal travel survey | Gravity model: hhld surveys | Gravity model: hhld surveys | - |

## EXHIBIT A.1: CHARACTERISTICS OF EXISTING DEMAND MODELS (CONT.)

| Model/Study | EBTC: Low | EBTC: High | MTO Truck Model | Michigan's Statewide Travel Demand Model | SEMCOG Model | City of Windsor | SW Ontario Frontier International Gateway |
|---|---|---|---|---|---|---|---|
| **Modal Split** | - | - | - | Cross classification and network cost model | County level observations and network cost model | Household survey | - |
| **Time Period** | - | - | 24hr | 24hr | 24 & PM Peak hour | PM Peak hour | - |
| **Assignment** | - | - | User equilibrium | All or nothing | Modified User Equilibrium | User equilibrium | - |
| **Base Year** | 1995 | 1995 | 1999 | 1991 household survey | 1994 household survey | 1996 | 1997 |
| **Future Horizons** | Continuous | Continuous | 2021 | 2000, 2005, 2010, 2015, 2020, 2025 | 2025 | 2016 | Continuous |
| **International Traffic** | Modelled | Modelled | Modelled | Trucks modeled; auto demand exogenous | Exogenous | Explicit growth rates on observed base | From imports/exports EBTC |

Partnership of

# APPENDIX B:

# Available Data Sources

Prepared by IBI Group for URS Canada

## EXHIBIT B.1: SUMMARY OF AVAILABLE DATA FOR ONTARIO-MICHIGAN STUDY

| Source | Data and Vehicle Types | Location/ Crossings | By Direction | Time Frame | Years | Geographic Detail | Usefulness | Other Notes |
|---|---|---|---|---|---|---|---|---|
| BTOA -Bridge and Tunnel Operators Association | Vehicle crossings: Passenger cars, Trucks, Buses & misc. | Blue Water Bridge, Ambassador Bridge, Detroit-Windsor Tunnel | No | Annual<br><br>Monthly | 1990-2001<br><br>1995-1997; Nov. 1998-April 2002 | By crossing | Historic annual volumes from 2000;<br>Historical monthly variation from 1995, with some gaps | |
| IBTTA | Total passenger and commercial crossings | International Bridge, Blue Water Bridge; Detroit-Windsor Tunnel | No | Annual | 1992-1999 | By crossing | Less complete than BTOA+MTO; should note whether numbers are similar | |
| Transport Canada T-facts | Total Autos, Trucks, Person-Trips | Total national crossings | No | Annual | 1990-1999 | Total national crossings | Compare with total national border crossing activity | Source: Statistics Canada, International Travel, Internal Files |
| Ontario-Michigan Border Crossing Traffic Study | Border crossings by 8 vehicle types | Blue Water Bridge, Ambassador Bridge, Detroit-Windsor Tunnel | Yes | Hourly over 3-4 August days (Wed. or Thurs., to Sat) | 2000 | Detailed passenger-car O-D data by crossing | Most recent hourly variation; trip volume by trip purpose can be inferred using survey data | Prepared by Paradigm and Stantec; includes O-D data to incorporate into model<br>Includes NB/SB breakdown at Huron Church in Windsor |
| MTO 1999/2000 Commercial Vehicle Survey Summary | Vehicle crossings: Cars, Buses, Straight trucks, Semi-trucks, Train trucks | Blue Water Bridge, Ambassador Bridge, Detroit-Windsor Tunnel, Windsor Ferry | Yes | Hourly totals over one week | 1999 | Detailed truck O-D data by crossing | Provides complete week of hourly traffic data, also Windsor Ferry data | Advance Release of Data for study use only.<br>Ambassador Bridge: September;<br>Detroit-Windsor Tunnel: August;<br>Windsor Ferry: September and November;<br>Blue Water: September |
| 1999 CCMTA National Roadside Study | Commercial vehicles by vehicle type | Locations include crossings, Hwy 401 outside Windsor, and Hwy 402 outside Sarnia | Yes | Daily, Annual or Weekly | 1999 | O-D available at CD level; by crossing | O-D data for trucks | Same data source as MTO CVS;<br>Program to extract data is cumbersome and excludes all records for zero result;<br>New release of data expected |
| MDOT/SEMCOG | 1994/1996 External Commercial Vehicle Survey | Blue Water Bridge, Ambassador Bridge, four weigh stations; does not include Detroit-Windsor Tunnel | Yes | Daily | Ambassador Bridge - 1996, Blue Water Bridge - 1994; weigh stations - 1995 | Detailed O-D data for trucks by crossing | Needs to be geocoded before use | |

## EXHIBIT B.1: SUMMARY OF AVAILABLE DATA FOR ONTARIO-MICHIGAN STUDY (CONT.)

| Source | Data and Vehicle Types | Location/ Crossings | By Direction | Time Frame | Years | Geographic Detail | Usefulness | Other Notes |
|---|---|---|---|---|---|---|---|---|
| MTO | Passenger cars, Trucks | Blue Water Bridge, Ambassador Bridge, Detroit-Windsor Tunnel | Yes | Daily | Sept. 1-10, 2001; Oct. 3-13, 2001 | By crossing | Note impact of Sept. 11 attacks on US | Prepared by Data Management Office (MTO) with input from US and Canadian Bridge and Tunnel Operators |
| US DOT, BTS | Passenger Vehicles Trucks, Truck Containers (loaded, unloaded), Bus Passengers, Pedestrians | Detroit, Port Huron, Sault Ste Marie | To USA | Annual | PV's: 1992-1999; Truck Containers: 1996-2000; Bus and Pedestrians: 1994-2000; Port Huron: Trucks – 1994-1997 | Detroit only – not broken down by crossings | Limited, as not broken down by crossing; Provides an indication of bus and pedestrian activity | Based on data from US Customs Service, Mission Support Services, Office of Field Operations, Operations Management Database. |
| Transport Canada T-facts | Total Autos, Trucks, Person-Trips | All Crossings | No | Annual | 1990-1999 | Total crossings | Ranking compared to other crossings | Source: Statistics Canada, International Travel, Internal Files |
| Bureau of Transportation Statistics | Database of freight crossings by mode (Rail, Truck, Pipeline, Mail): Value of US imports and exports, Weight of US imports only; (no volume data) | Most data available by port; commodity detail available by port or geography (not both) | Yes | Monthly and annual totals | 1994-2001 | State or province of origin/ destination; by crossing | May provide understanding of freight traffic trends and commodities | Some data available on J;\ drive; other data can be downloaded from www.bts.gov.transborder |
| SEMCOG | 1999 Internal Commercial Vehicle Survey | No cross-border data | N/A | | 1999 | SEMCOG area | Internal commercial vehicle trip tables; identify truck traffic productions | |
| City of Windsor | Cross-Border Survey | Ambassador Bridge and Detroit/Windsor Tunnel | Yes | 3 – 6 PM on a weekday | September 1997 | Car and truck O-D data and other trip character-istics | Compare O-D information with other updated and more extensive surveys | |
| MDOT | AADT and Commercial vehicle ADT | Links throughout Michigan | No | Annual | Not stated (web site updated 2002) | Highway links in Michigan | Model calibration | http://www.michigan.gov/ mdot/1,1607,7-151-9622_11033_11149---,00.html |

## EXHIBIT B.1: SUMMARY OF AVAILABLE DATA FOR ONTARIO-MICHIGAN STUDY (CONT.)

| Source | Data and Vehicle Types | Location/ Crossings | By Direction | Time Frame | Years | Geographic Detail | Usefulness | Other Notes |
|---|---|---|---|---|---|---|---|---|
| MDOT | Blue Water Bridge historical data: Cars and Trucks | Blue Water Bridge | Yes | Annual totals | 1938-1998 | Blue Water Bridge only | | http://www.michigan.gov/documents/cartruckdetail_16532_7.pdf |
| MDOT | Blue Water Bridge traffic projection: Cars and Trucks | Blue Water Bridge | No | Annual totals | 1999-2021 | Blue Water Bridge only | | http://www.michigan.gov/documents/projections_16534_7.pdf<br>This has car traffic increasing by 2.0% annually and truck traffic, 6.0-9.0% annually, so that car and truck volumes are about equal in 2021 |

Partnership of

# APPENDIX C:

# Literature Review of Existing Models and Forecasts

Prepared by IBI Group for URS Canada

# Appendix C: Literature Review of Existing Models and Forecasts

Following is a review of the relevant literature on cross-border travel from both a macro-level (i.e. regional travel demand models) and micro-level perspective (i.e. crossing simulations and studies). This includes discussions of the studies and travel demand models that have focused in and around the Ontario-Michigan border as well as other relevant investigations of cross–border activities from within North America.

***Forecasts for the Ontario-Michigan Border Crossings***

The EBTC's *Trade And Traffic Across The Eastern U.S.-Canada Border* (1997) studied flows across the eastern U.S.-Canada border in general. The objectives of the study were to:

- Provide a descriptive analysis of past and present trade and traffic flows across eastern border;
- Project future demand;
- Consider the roles of Federal inspection agencies as they affect border crossings;
- Identify short- and long-term infrastructure needs;
- Evaluate alternative criteria for defining international trade and transportation corridors; and
- Identify deficiencies in the data and recommend ways to resolve them.

Low and high trade and traffic forecasts were made for four regions to year 2015 using two autoregressive time-series techniques. The first was a mixed time series-regression model that linked trade growth to forecasted changes in Canadian GDP with robust autoregression, also known as median regression. It included a logarithmic trend model to explain the residual element from the regression. This technique is derived from the autoregressive-integrated-moving average (ARIMA) family of models, typically used by economists to forecast time series data. It provides a conservative estimate of trade growth, as it is relatively insensitive to the effects of outliers, which, in this case, represent periods of high and low trade growth.

The second model forecasted growth rates by commodity group, region and flow direction using moving average autoregression. Thus, each region grew at a rate determined by the composition of its commodities. These growth rates were then constrained to ensure overall growth did not exceed 4%, which is the highest growth forecast for Canadian GDP. This model resulted in optimistic overall growth and was considered to represent the upper limit of forecasts.

Both sets of forecasts assumed that (i) the direction, not the rate, of trends would continue as in the past decade; (ii) the amount of trade between the two countries would be dictated by the Canadian economy; (iii) there would be no major economic shocks; and (iv) the mixture of commodity flows would remain unchanged.

Annual trade flow growth for the Ontario-Michigan region ranged from a low of 3.7% from the U.S. to Canada to a high of 8.7% from Canada to the U.S, with transport equipment, machinery and electronics the principal commodity. Growth forecasts for passenger and truck traffic were not determined explicitly by the models, but rather indirectly as increasing at the same rate as the overall trends observed in the trade forecasts. They ranged by region from 2.0% to 2.5% for passenger vehicles and 4.1% to 7.5% for commercial trucks.

Due to limitations with the data this methodology was not extended to the individual crossing level. Furthermore, the addition of an assignment component to analyse competing crossings was considered beyond the scope of the data available. Instead, historical trends for each crossing were extrapolated, within the constraints of the regional forecasts. This mostly resulted in the continuation of current trends, sometimes to unrealistic levels where recent growth has been high.

The lack of an assignment element to the model leaves it insensitive to policy actions and inactions, particularly regarding infrastructure improvements. The model is also unable to incorporate new trends in the transportation industry, such as the increasing market for inter-modal rail. The study recognizes that the inclusion of these uncertainties would require a high number of alternative model scenarios.

It was concluded that congestion was not an immediate problem due to a recent decrease in auto volumes as well as infrastructure and inspection procedure improvements. However, projected growth would affect cross-border activities in the near future, requiring improved crossing procedures. A series of investment proposals were also defined for immediate, short- and long-term implementation. Specific proposals suggested for the Ontario-Michigan border crossings included:

- Highway crossing projects for both sides, consisting of re-decking the Blue Water Bridge and adding a second span, as well as improving access to the Ambassador Bridge;
- Highway corridor projects for both sides, consisting of physical improvements to I-69, I-75, I-94, 401, 403, 407 and QEW as well as implementation of ITS technologies;
- Rail crossing projects for both sides, consisting of a double-stack tunnel between Detroit and Windsor;
- Rail corridor projects for the Michigan side, consisting of a Detroit freight inter-modal terminal, Detroit-Chicago high speed rail, CN/CP corridor improvements; and
- Marine projects for the Michigan side, consisting of a new lock.

Total costs of implementing these recommendations are estimated at over US$5 billion over the horizon period.

The MTO's *Southwestern Ontario Frontier International Gateway Study* (1998) encompassed the surrounding freeway system and the three main crossings at Sarnia-Port Huron and Windsor-Detroit. The objectives of this study were to:

- Identify the importance of trade and tourism;
- Examine the existing traffic characteristics of the freeways and border crossings in terms of volume and level-of-service;
- Forecast future traffic demand;
- Identify current and future problem areas; and
- Identify possible mitigation/improvement alternatives to satisfy future demand.

A 1997 base year was developed initially from 1993 traffic counts, which were factored up by road section to 1997 levels. Using the findings of the EBTC and other sources, growth forecasts were then developed separately for passenger and commercial vehicles, with commercial vehicles further split into local and international trips. Commercial and passenger vehicles were forecast separately with horizon years 2011 and 2021. Passenger vehicle traffic growth was linked to an increase in tourism, forecast to increase at 2% per annum. Local and inter-provincial commercial vehicles were assumed to grow in line with Canadian and Ontario GDP as well as South-western Ontario population, also at 2% per annum. International commercial traffic, however, was linked to more rapidly growing Canadian exports and imports. Growth for these trips was forecast at a robust 5% per annum.

The 1995 Commercial Vehicle Survey provided respective proportions of trucks in each trip type (i.e. intra- and inter-provincial, international), enabling an average truck growth rate to be developed for each highway. Truck growth on Highway 402 was estimated at 4.25% per annum, and on Highway 401 forecast at 3.65% per annum.

Specific freeway and crossing problem areas were identified in terms of standard level-of-service indicators. These indicated that the Windsor-Detroit gateway, which combines the Ambassador Bridge and Windsor-Detroit Tunnel, would reach capacity around year 2012 and that the Blue Water bridge has adequate capacity to beyond year 2021 following capacity improvements already completed. Short- and long-term recommendations are proposed comprising implementation of ITS technologies and infrastructure improvements consisting mainly of corridor widening. Rail transport is discussed in a historical perspective only.

Concurrently in 1998, the MTO undertook another study of trade issues of both the South-western Ontario and Niagara Gateways. This study incorporated the findings of the EBTC to forecast traffic and commodity flows at each gateway to year 2015. The biggest issue raised concerned accessibility to the Ambassador Bridge, for which there was very little infrastructure on the Michigan side. Thus, the report called for a direct access ramp from I-75 to the Bridge as well as improvements to the I-75 and I-94 corridors close by.

Both of the MTO studies rely heavily on the findings and methodology of the EBTC report. As such, they suffer from the same deficiencies and shortcomings of the data (as identified by the EBTC) as well as the methodology, which is not sensitive to the physical infrastructure supporting the gateway. Furthermore, as aggregate forecasts should only be applied at the aggregate level, it is dangerous to make crossing-specific forecasts and recommendations with such data.

To further the work done in 1997, the EBTC in 2002 acquired new data that allowed for forecasts of truck flows at specific crossings. Rather than using trade forecasts, the method forecasted truck volumes directly at major crossings. This was accomplished by fitting linear regressions to the time series moving average. The models fit the data well, in most cases meeting or exceeding the original time series analysis of trade by commodity. Findings show that although growth will be greatest in the Pacific Northwest in terms of rate, in will be highest in terms of absolute truck volumes in the Niagara and South-western Gateways. The study also notes that the forecasts are still more accurate at the state/provincial level than by crossing, as the method still neglects to capture all of the factors unique to each crossing that will affect their future truck volumes.

### *Forecasts for Other Eastern U.S.-Canada Border Crossings*

The NYSDOT's *Northern New York Border Crossing Study* (1998) investigated current and future performance at several New York State-Ontario/Quebec border crossings. The objectives consisted of:

- Determining travel patterns and growth around the crossings;
- Determining the causes and degree of congestion and delays;
- Forecasting the short- and long-term effects of growth;
- Quantifying the economic importance to the State and the nation; and
- Identifying short- and long-term mitigation measures and strategies to accommodate the growth.

High and low demand forecasts of passenger and commercial vehicles for each crossing were made to year 2021 using time series techniques. These forecasts were used to assess the capacity needs for each corridor, also considering vehicle processing times. From these needs a series of recommendations were made. One of the key recommendations was that customs and immigration could be improved with pre-clearance technology and the sharing of border facilities. It was also believed processing times could be reduced, considering the large variation in processing time currently between crossings. Where toll collection is a constraint, transponder technology could ease congestion.

The study also indicated that existing capacity could be used more efficiently. The diversion of truck to rail would achieve this, although its contribution was not considered significant due to the low proportion of long trips. However, a more equitable distribution of traffic among the four crossings and bridge geometric improvements were believed to be more effective.

*The Economic Importance of the Peace Bridge* (O'Dell 2000) considered truck volumes on the bridge in terms of current and future capacity. The economic growth in trade was the driver, defined as increases in Ontario's exports as a percent share of Ontario's GDP to year 2021. The forecasts assume that:

- The bridge's share of imports/exports remains unchanged;
- The bridge's capacity is that of the current volume;

- Auto growth will be absorbed by increases in capacity and processing technologies; and
- There will be no effects from other crossings.

Three scenarios were developed, assuming a one-third, two-thirds and equal growth relative to that occurring from 1981 to 1998, resulting in annual traffic growth rates of 3.6%, 4.4% and 5.0%, respectively. Findings indicated that the bridge is already over capacity and that level-of-service is expected to deteriorate until a proposed twin bridge is completed.

The International Bridge Authority of Michigan in their *International Bridge at Sault Ste. Marie: Traffic and Revenue Forecasts* (1994) undertook a study of the Sault Ste. Marie crossing to determine traffic and revenue forecasts to year 2014. Traffic volume was forecasted for six vehicle types based on relationships with the growth of factors including population and employment, gas prices, the exchange rate and Ontario GDP. Rail and shipping's contribution was also included. Given an increasingly unified North American economy and a more balanced pricing of goods, overall annual growth to year 2014 was projected to grow more slowly than in the recent past at rates of 0.44% for passenger vehicles and 3.0% for commercial vehicles.

***Travel Demand Models of Areas Adjacent to the Ontario-Michigan Border***

The MTO's *Value of Goods Transported by Truck in Ontario* (1997) used their 1995 Commercial Vehicle Survey to assign truck travel in Ontario. The survey contains information about the vehicle, driver, carrier and commodity characteristics as well as detailed trip data. As the surveys were mostly carried out between urban nodes, rather than at the customs staging areas, trips terminating at locations near to the border were not captured. Canada customs and bridge authority counts were used to recalibrate these trips.

Flows were developed for the 5,000 links of the provincial highway system using standard route assignment techniques and background passenger volumes. Following the assignment, the economic importance of each link and corridor was then determined by assigning a value to the commodity being transported by each truck. The importance of border crossings was also identified in the same manner. The model was then used to forecast year 2021 commodity flows using industrial sector output projections.

*Michigan's Statewide Travel Demand Model* (MDOT, 1998) incorporates urban area models into their four-stage model. It is comprised of 2,307 internal and 85 external zones (representing other states, Canada and Mexico) and simulates the highway system using over 13,000 links.

Trip generation is developed using a cross-classification model with 5 trip purposes. The number of trips is dependent on household size and income. The gravity model used for distribution is calibrated from the National Personal Travel Survey. Mode share is incorporated as a cross-classification model, although a network-based mode share model incorporating comparative costs of modes is under development.

Truck flows are determined separately from customs data, surveys, U.S. input-output accounting and the 1993 National Commodity Survey. This model develops international and domestic data and outputs the flow of commodities in terms of tons, dollars and trucks.

Passenger and commercial vehicle flows are then combined for the network assignment. This uses an all-or-nothing assignment method, as congestion is not considered significant in route choice in rural areas.

The City of Windsor's *Windsor Area Long Range Transportation Study* (1999) prepared a transportation model that included the effects of cross-border traffic. The model was calibrated using 1997 household survey data with forecasts made to year 2016.

The household survey data was augmented by two further surveys, a cordon survey and a border crossing survey. These allowed through traffic to be accurately described, and provide good linkage with nearby models such as that of SEMCOG.

The model predicts PM peak-hour traffic volumes through a traditional four-stage process that utilizes 464 internal and 43 external zones, including 30 U.S. zones. Three trip purpose trip rates were developed for internal zones, based on population and employment. While trip rates were developed for external areas, several explicit vehicle growth scenarios were developed to determine the performance of the road network. Problem links were identified under the heavier scenarios, involving the supporting roads and the border crossings themselves.

The study produced a transportation master plan developed through public consultation and the model's forecasts. Improvements are focused on the local area, but they also recognize the importance of the City as a throughway for truck traffic. Thus, additional attention is given to improving connections from the crossings to the highway infrastructure.

The SEMCOG's *Structure And Implementation Of The Regional Travel Forecasting Model For Southeast Michigan* (2000) developed a model for southeast Michigan and the Detroit metropolitan area using their 1994 Household-Based Person Trip Survey.

This is also a four-stage complete model, although external trips are added exogenously. Trips are generated for 6 trip purposes using cross-classification, and distributed according to friction factors from the 1994 survey. Modal split factors are partly derived from the survey, but also include transit observations. Although the model was calibrated using 24-hour observations, a PM peak-hour model has also been developed using factors derived from the 1994 survey.

The focus is on passenger travel, although a simple cross-classification truck model is included. Unlike Michigan's statewide and Windsor's municipal model, however, there is no consideration of international cross-border travel effects.

***Other Relevant Studies of Cross-Border Activities***

In the wake of free trade, the development of international cross-border trade and travel demand forecasting methods has become more important. As a result, several other studies have looked at various topics and techniques in an attempt to capture the unique aspects of border crossings. Below is discussion of a wide range of studies relevant to this study's objective.

Paselk and Mannering (1993) used hazard-duration models to estimate traffic delays at four U.S.-Canada crossings. This approach was utilised to account for stated inadequacies of standard queuing analysis techniques, which do not capture the "duration dependence" of waiting in a queue. Wait time was chosen as the dependent variable, as opposed to the total delay from wait and service times. Independent variables consisted of various crossing attributes such as the number of open lanes and average service time. These were chosen so as to be measurable by standard vehicle detection technology. A range of model formulations was tested with results varying by model formulation and the input variables used.

Fang *et al.* (1996) developed an aggregate logit model of simultaneous mode and destination choice for truck and rail shipments of machinery, electronics and automobiles from the U.S. to Mexico. Models incorporating both discrete and pooled origins (i.e. representative cities and the country as a whole) were tested. Explanatory variables included measures of distance and value of the shipment by mode as well as destination characteristics of population, employment and the number of firms. Results showed that the discrete origin models predicted better, with rho-square values of around 0.5.

Christie (2000) modelled regional and international flows of combined passenger and truck traffic based on origin/destination count data from 1979. He used a gravity model with population as an attractor and travel time as an impedance. Although the model predicted well for base year data, forecasts to year 1997 revealed some shortcomings. Plans to improve model performance include incorporating more socio-demographic factors, disaggregating the zone system and separating the two traffic types.

Figliozzi *et al.* (2001) estimated truck flows across the Texas-Mexico border resulting from international trade. The authors took two different approaches. The first modified actual truck counts based on correction factors that accounted for empty and local trucks as well as inter-modal travel to determine volumes using a standardized value called the Equivalent Trade Truck (ETT). The second approach calculated the same as a direct result of trade commodity densities and volumes, rather than extrapolating past truck flow rates as is commonly practiced. That is, the physical characteristics of each commodity type as well as standard truck capacities (i.e. of maximum volume and weight) were used to calculate the number of trucks required for transport. In this way, it was shown that trade forecasts can be used directly for the estimation of truck traffic.

Ashur *et al.* (2001) developed a microsimulation model of a crossing from El Paso, Texas into Mexico. Their objectives were to: estimate queue lengths and crossing times; analyse the efficiency of operations; identify bottlenecks; quantify traffic impacts on adjacent infrastructure; and make recommendations for more efficient operations. The main inputs to the model consisted of inter-arrival and service times in addition to traffic counts and the percentage of trucks. The times were fitted to exponential distributions for use in the simulator. Once validated, the model was used to test scenarios that varied in vehicle processing characteristics and traffic volume. Some of these revealed possible future facility deficiencies in terms of an estimated maximum queue length capacity.

Finally, Lin and Lin (2001) modelled traffic delays at three New York border crossings. The model was developed using a microsimulation of the crossings as a guide. The dependent variable is average approach delay, which is equal to the actual travel time through the crossing minus the free flow travel time to a point just after the plaza booth. The acceleration of the vehicle after the booth is determined separately and can be combined with the approach delay to evaluate the total delay. Independent variables include the vehicle processing rate, analysis time period, volume to capacity ratio, number of available gates and calibration factors. Estimated values from the model were compared to those of the simulator and were usually within 10 percent.

***Summary***

In reviewing the preceding studies, a common theme is apparent. All conclude that although the physical infrastructure in place at crossings throughout the eastern U.S.-Canada border (and, indeed, all of North America) is currently sufficient, it will not be within the 20-year planning horizons typically investigated in each. In fact, many predict capacity problems to arise within much shorter time periods. This is generally the consequence of forecasted annual average growth rates of 1 to 3 percent for passenger traffic and 2 to 5 percent for truck traffic, which themselves are the result of forecasted increases to population, employment, trade and tourism on both sides of the border. The problem is compounded when considering that traffic from commercial trucks, which places a much greater burden on crossing infrastructure and processing procedures than passenger vehicles, has and will be increasing its share of the total volume at crossings as indicated by the recent trends and growth forecasts. By and large, all recommendations call for improvements to the capacity of these crossings through the construction or rehabilitation of the physical infrastructure as well as through the implementation of faster processing procedures and technology. The latter has gained an increased importance given recent events.

The techniques employed by these studies have tended to focus on a single or limited number of transport modes as well as on only one side of the border. All models treat the other side of the border as ‘external’; thus, there is no comprehensive cross-border travel model for the south-western gateway that considers the physical infrastructure of both sides in addition to that of the connecting crossings to determine the auto, bus, commercial truck and rail (freight and passenger) traffic flows. The historical trend and extrapolation analyses consider multiple modes while failing to capture large-scale infrastructure effects, apart, perhaps, from those of the specific crossings. Even then, consideration of crossing infrastructure effects are crude and appear to be handled much better by the microsimulations. Also, while these methods are probably appropriate for short-range forecasting, in which the observed trend being used can be expected to hold barring major disruptions, they are likely inappropriate for long-range forecasting. Here, forecasts should be made incorporating the direct determinants of growth. For passenger travel, population and employment growth is the commonly accepted determinant. Likewise, commercial traffic should be forecast as a direct function of forecasted economic and trade growth, rather than indirectly from assumed rates based on these analyses, as appears to be the common approach. On the other hand, the travel demand models forecast down to the transportation link level, but only on one side of the border and only for passenger vehicle and commercial truck modes of transport. It must be acknowledged, however, that data on commercial truck travel are sparse and that for rail practically non-existent. This recognition leads many to also recommend investment in data gathering for these modes.

Thus, there exists the requirement for a comprehensive model that captures socio-economic and physical infrastructure effects on both sides of the border. The 1997 EBTC report proposes that such a model would incorporate:

- Sensitivity to changes in investment in infrastructure serving travel between the countries, as well as changes to government policies and technological advancements;
- The ability to model both person and commercial travel across the border over a 20-year horizon;
- The ability to express freight movement in dollar, weight and truckload values;
- The ability to express person movements in person and vehicle equivalents;
- The ability to model changes in mode share; and
- The ability to model person and commercial travel by port of entry and, if possible, individual crossing.

The preceding studies have each considered at least one of these components with varying success, but none have managed all. The opportunity exists to merge some of the newer concepts into a combined micro- and macro-level model so as to capture as many of these factors as possible.

***References***

Ashur, S., J. Weissmann, S. Perez and A. Weissmann (2001). *Traffic Simulation at International Ports of Entry*. Transportation Research Record (1763), pp. 48-56.

Christie, J. (2000). *Regional and Extra-Regional Highway Traffic in Atlantic Canada: A Review and Preliminary Model*. In CTRF 2000 Proceedings, Vol. 2, Proceedings of the 35th Annual CTRF Conference, Charlottetown, PEI, June 4-7, 2000.

City of Windsor (1999). *Windsor Area Long Range Transportation Study: Final Report*. Prepared by Stantec Consulting Limited.

EBTC (1997). *Trade and Traffic Across the Eastern US-Canada Border*. Prepared by Parsons Brinckerhoff Quade & Douglas Incorporated.

EBTC (2002). *Forecasts of Truck Flows by Major Crossings*, Chapter 6 in Truck Freight Crossing the Canada-U.S. Border. Prepared by Parsons Brinckerhoff Quade & Douglas Incorporated.

Fang, Y., R. Harrison and H. Mahmassani (1996). *Forecasting Freight Traffic Between the U.S. and Mexico*. Research Report CTR 1319-2, Federal Highway Administration.

Figliozzi, M., R. Harrison and J.P. McCray (2001). *Estimating Texas-Mexico North American Free Trade Agreement Truck Volumes*. Transportation Research Record (1763), pp. 42-47.

International Bridge Authority of Michigan (1994). *International Bridge at Sault Ste. Marie: Traffic and Revenue Forecasts*. Prepared by URS Consultants Incorporated.

Lin and Lin (2001). *Modelling Traffic Delays at Northern New York Border Crossings*. Journal of Transportation Engineering, Vol. 127(6), pp. 540-545.

MDOT (1998). *Michigan's Statewide Travel Demand Model*.

MTO (1998a). *Southwestern Ontario Frontier Gateway Study*. Prepared by McCormick Rankin Corporation.

MTO (1998b). *Trade Issues at Ontario's International Gateways*. Prepared by Parsons Brinckerhoff Quade & Douglas Incorporated.

MTO (1997). *Value of Goods Transported by Truck in Ontario*.

NYSDOT (1998). *Northern New York Border Crossing Study*. Prepared by The Sear-Brown Group Incorporated.

Paselk, T. and F. Mannering (1993). *Use of Duration Models for Predicting Vehicular Delay at U.S./Canadian Border Crossings*. Paper presented at the 72nd Annual Meeting of the Transportation Research Board, Washington, D.C., January 10-14, 1993.

Robert O'Dell Management and Strategic Projections Incorporated (2000). *The Economic Importance of the Peace Bridge*.

SEMCOG (2000). Structure and Implementation of the Regional Travel Forecasting Model for Southeast Michigan. Prepared by Parsons Brinckerhoff Quade & Douglas Incorporated.

Partnership of

U.S. Department of Transportation

Transport Canada Transports Canada

MDOT

Ontario

# APPENDIX D:

# Hourly Traffic Trends from Ontario-Michigan Border Crossing Study

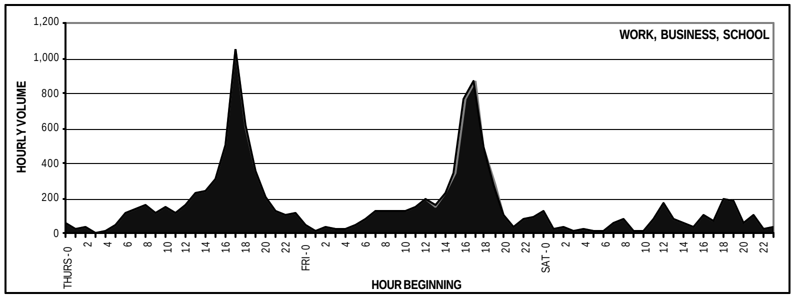
**Prepared by IBI Group for URS Canada**

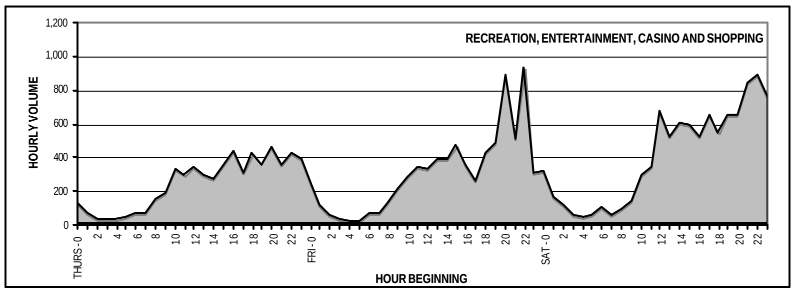
IBI GROUP

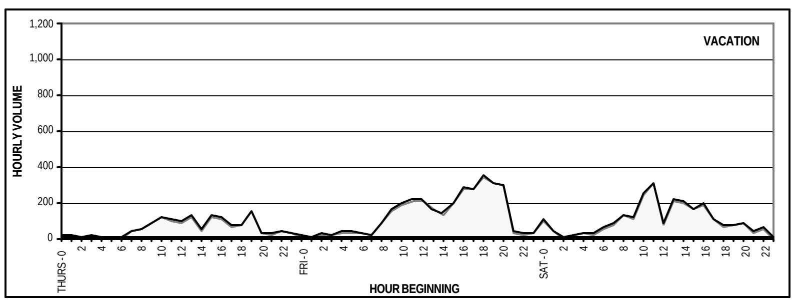
# Appendix D: Hourly Traffic Trends from Ontario-Michigan Border Crossing Study

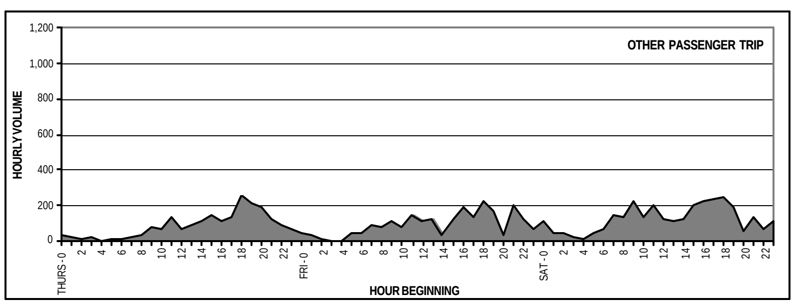
Exhibits D.1 to D.6 show hourly traffic variation by direction for each crossing by trip purpose. Exhibits D.7 to D.12 show the hourly profiles, combining the individual tip purposes. These exhibits are based on the hourly vehicle classifications and trip purpose information from the ***Ontario-Michigan Border Crossing Traffic Study***.

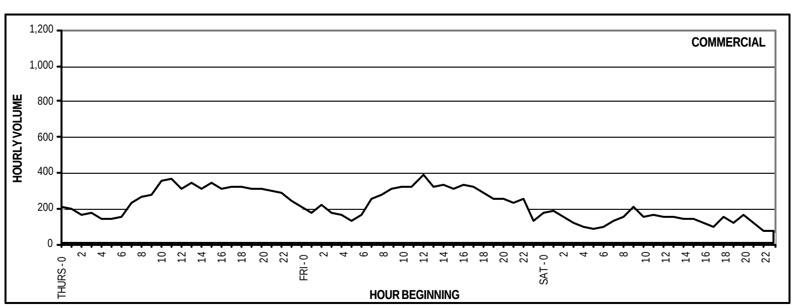
## EXHIBIT D.1: AMBASSADOR BRIDGE: HOURLY VOLUMES TO CANADA BY TRIP PURPOSE



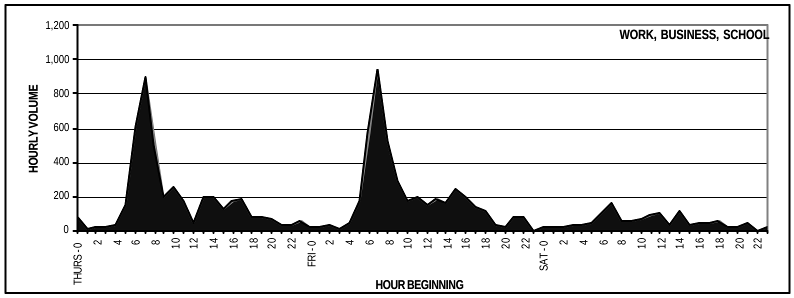



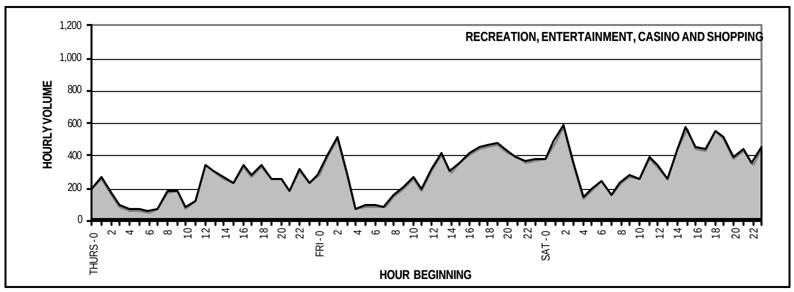



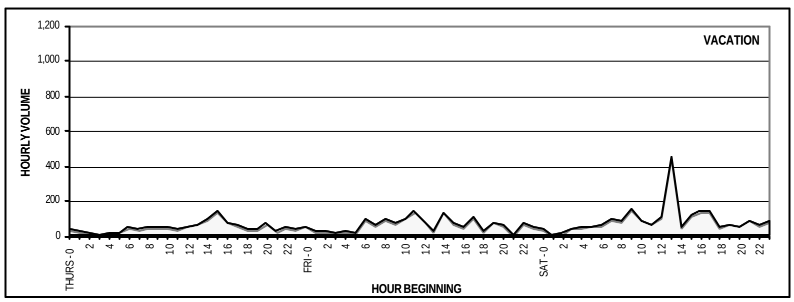



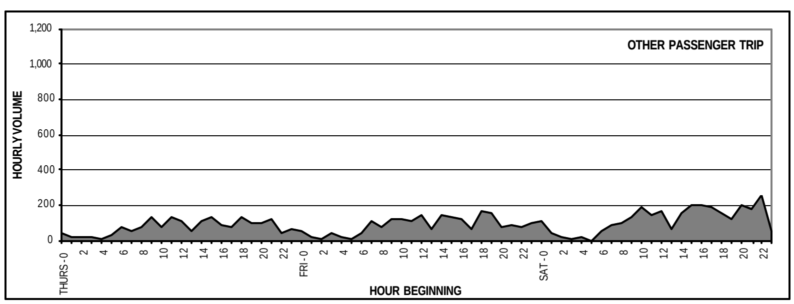



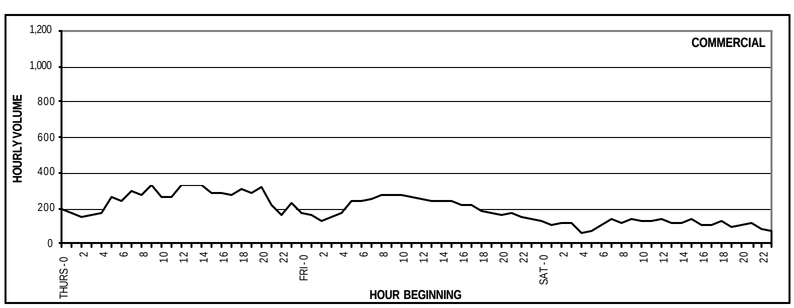
## EXHIBIT D.2: AMBASSADOR BRIDGE: HOURLY VOLUMES TO USA BY TRIP PURPOSE



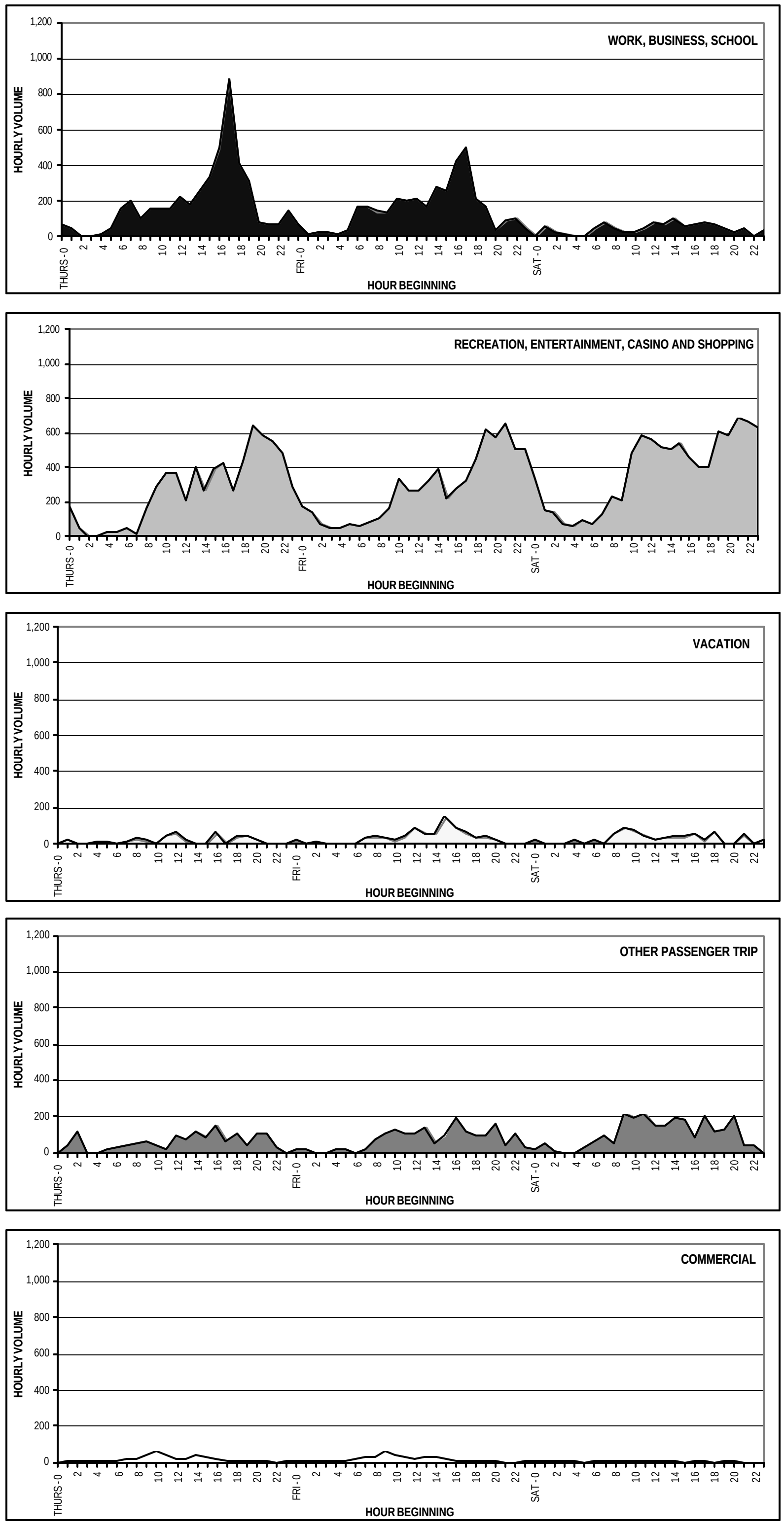



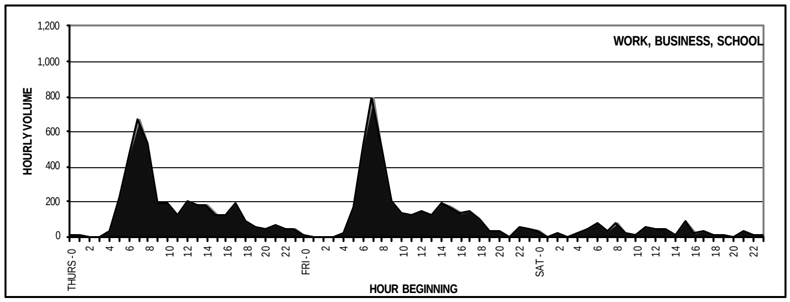



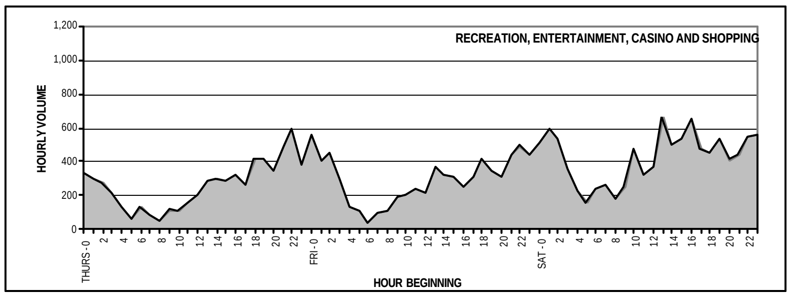



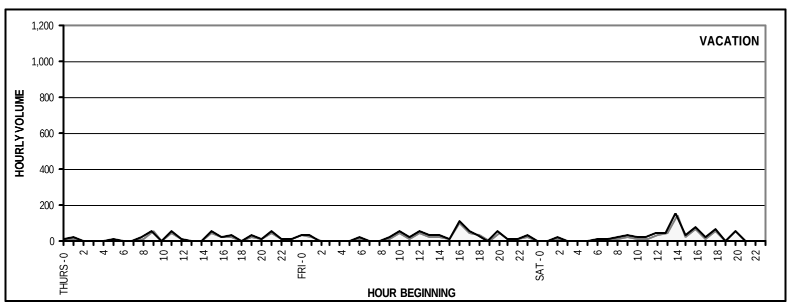
## EXHIBIT D.3: WINDSOR-DETROIT TUNNEL: HOURLY VOLUMES TO CANADA BY TRIP PURPOSE

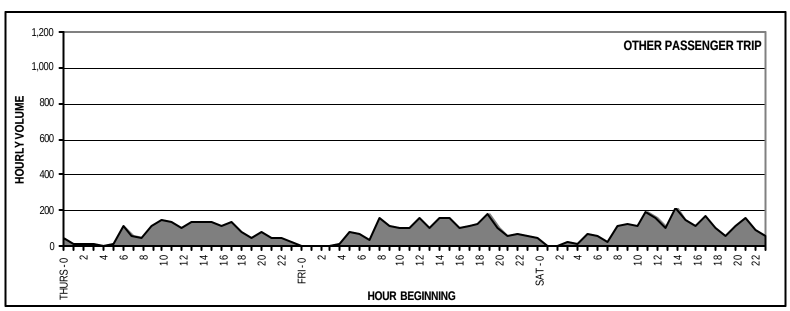


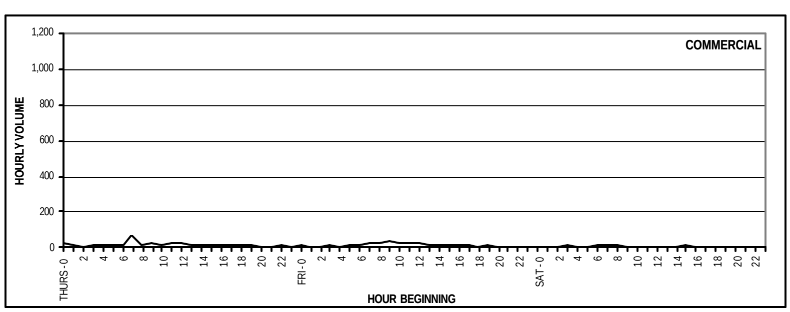
## EXHIBIT D.4: WINDSOR-DETROIT TUNNEL: HOURLY VOLUMES TO USA BY TRIP PURPOSE



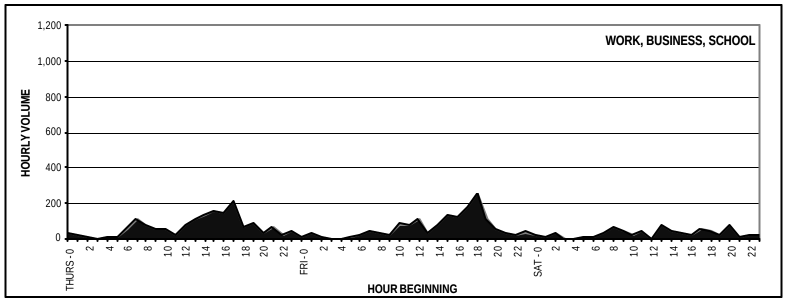



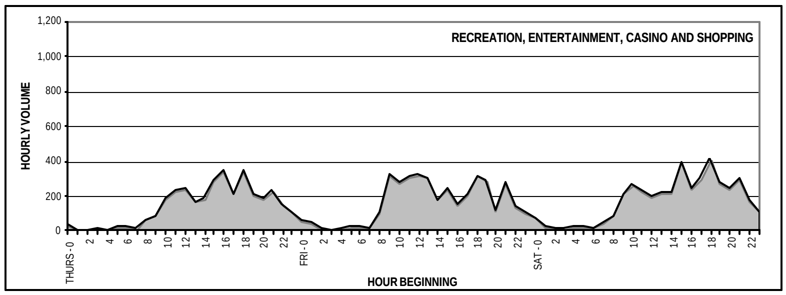



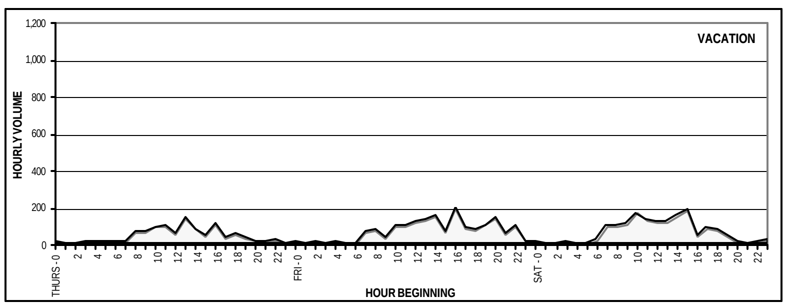



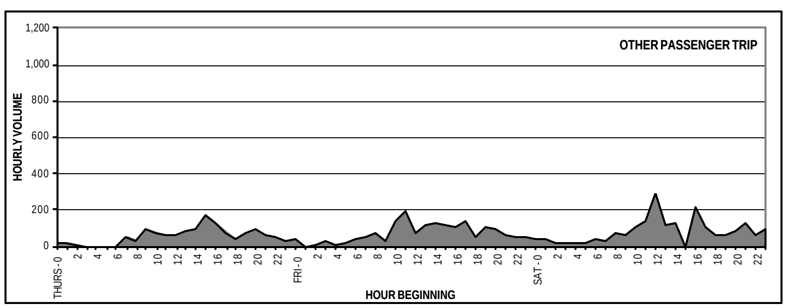



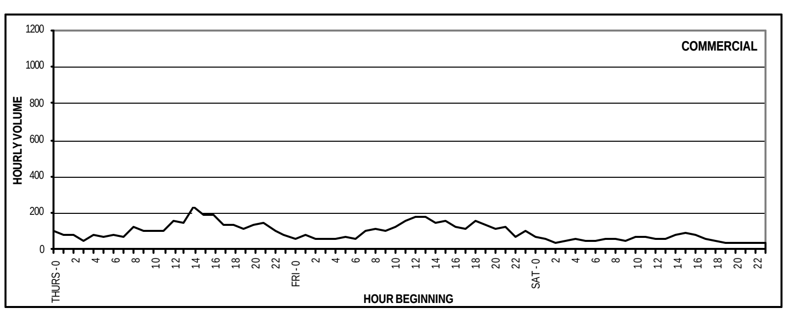
## EXHIBIT D.5: BLUE WATER BRIDGE: HOURLY VOLUMES TO CANADA BY TRIP PURPOSE



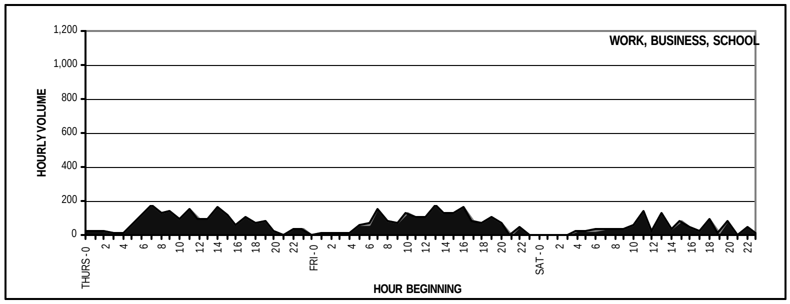



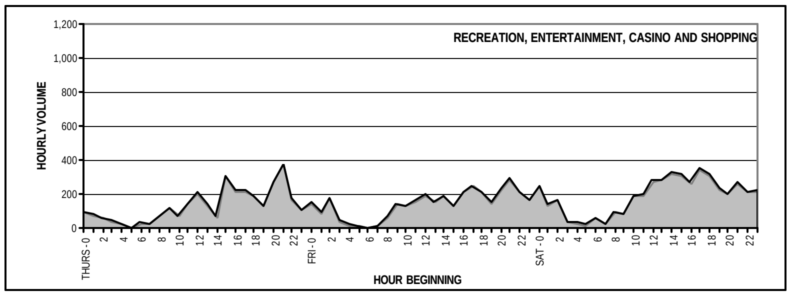



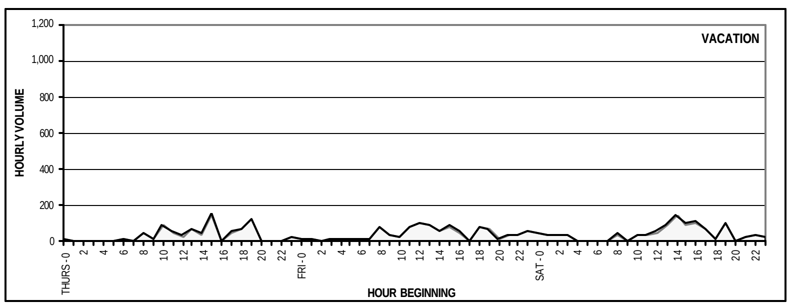



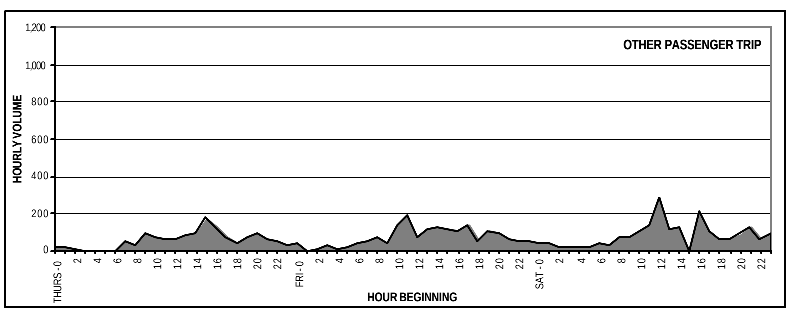



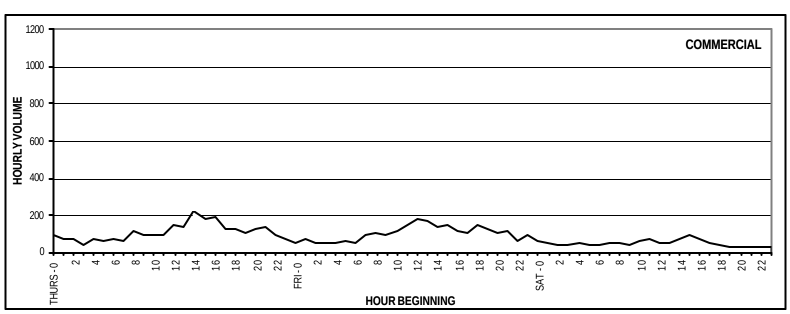
## EXHIBIT D.6: BLUE WATER BRIDGE: HOURLY VOLUMES TO USA BY TRIP PURPOSE



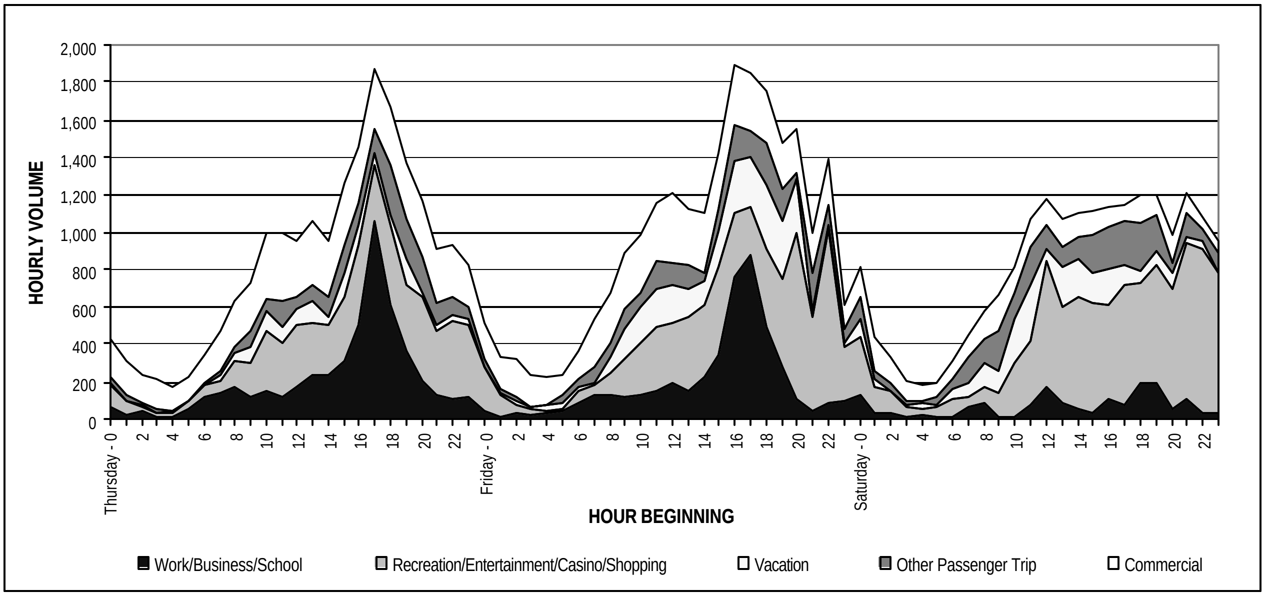



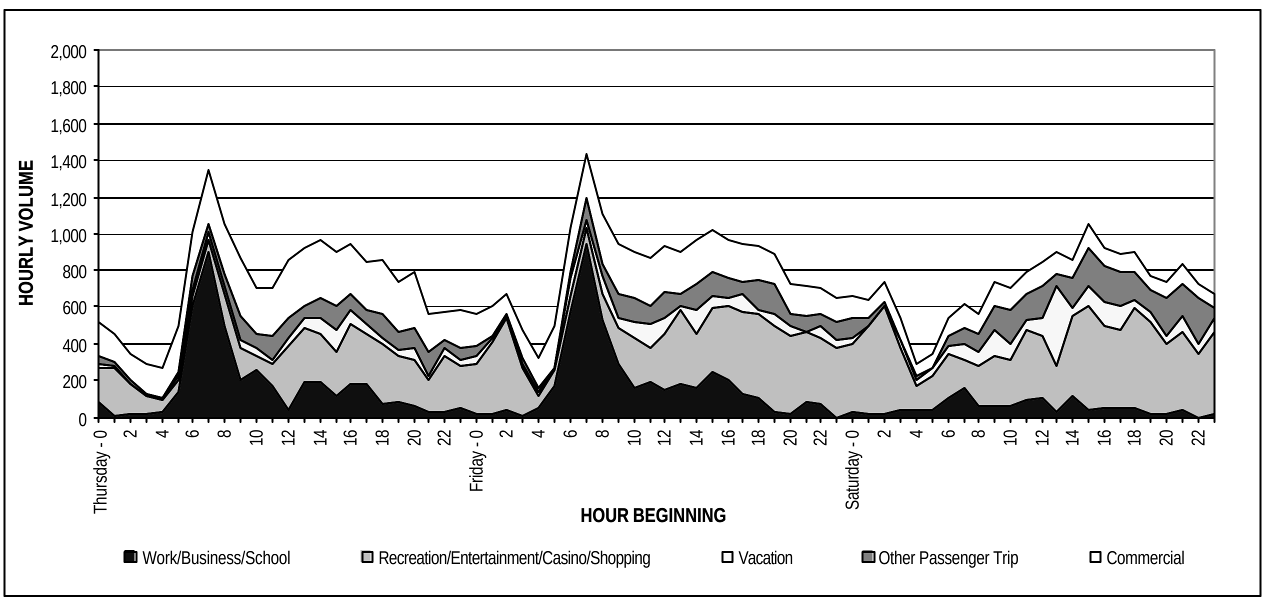



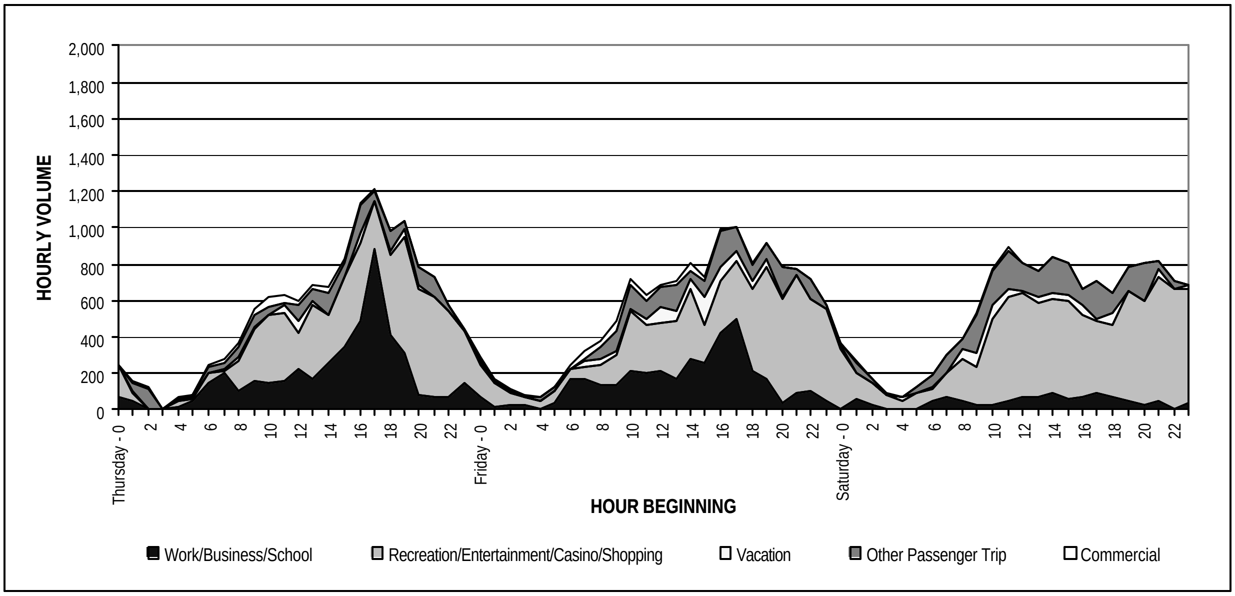
## EXHIBIT D.7: AMBASSADOR BRIDGE: CUMULATIVE HOURLY VOLUMES INTO CANADA BY TRIP PURPOSE




## EXHIBIT D.8: AMBASSADOR BRIDGE: CUMULATIVE HOURLY VOLUMES INTO USA BY TRIP PURPOSE



## EXHIBIT D.9: WINDSOR DETROIT TUNNEL: CUMULATIVE HOURLY VOLUMES INTO CANADA BY TRIP PURPOSE




## EXHIBIT D.10: WINDSOR DETROIT TUNNEL: CUMULATIVE HOURLY VOLUMES INTO USA BY TRIP PURPOSE

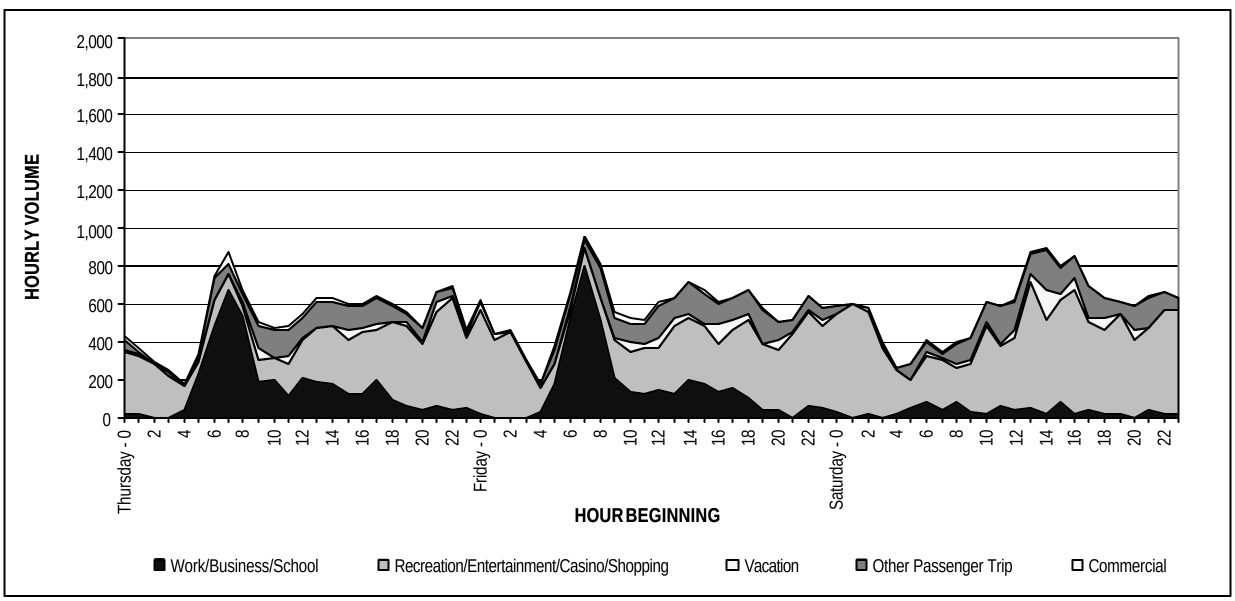


**EXHIBIT D.11: BLUE WATER BRIDGE: CUMULATIVE HOURLY VOLUMES INTO CANADA BY TRIP PURPOSE**

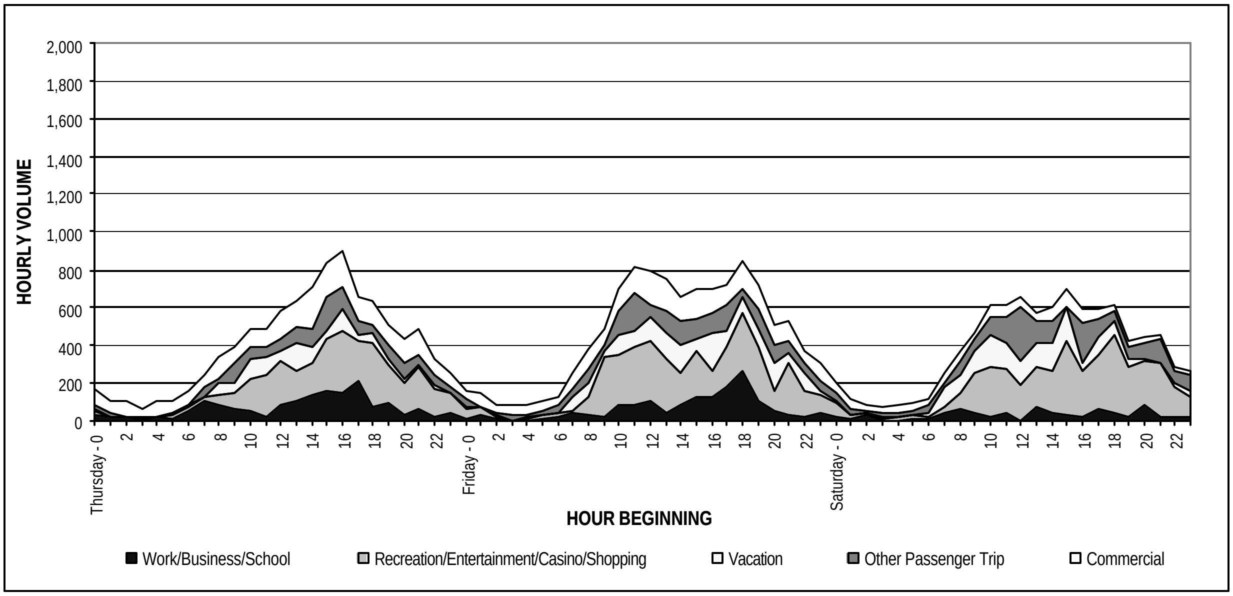
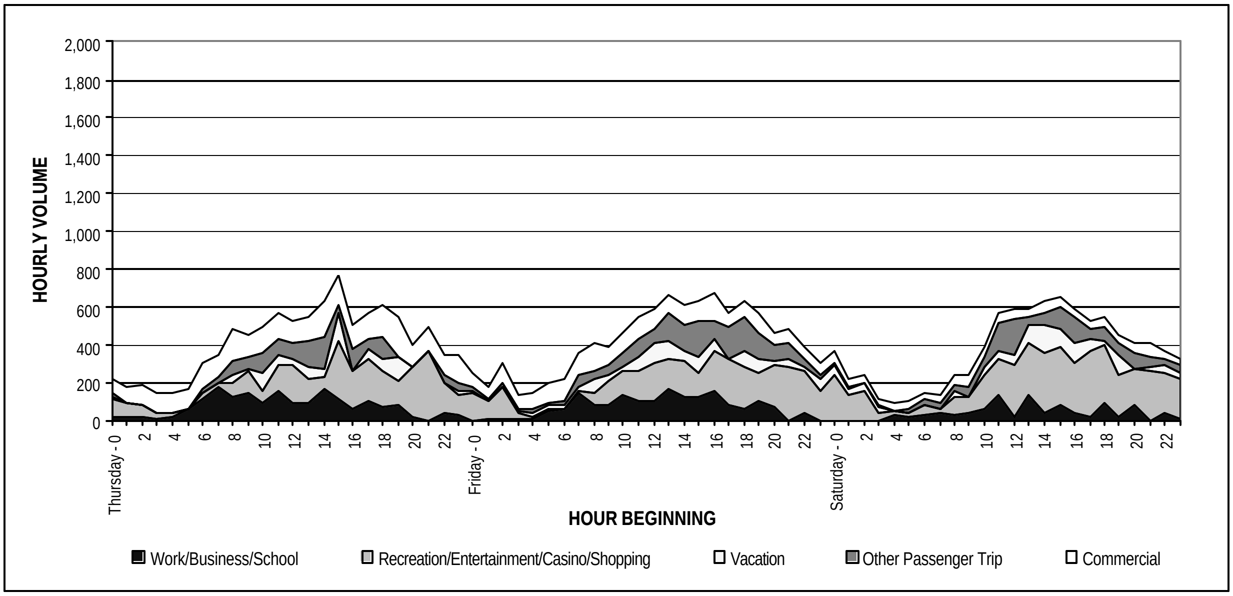



**EXHIBIT D.12: BLUE WATER BRIDGE: CUMULATIVE HOURLY VOLUMES INTO USA BY TRIP PURPOSE**



**Partnership of**

# APPENDIX E:

# Capacity Analysis for Border Crossings

**Prepared by IBI Group for URS Canada**

# Appendix E: Capacity Analysis for Border Crossings

Exhibits E.1 to E.3 are copies of the detailed output from Highway Capacity Software (HCS 2000) Version 4.1b for each crossing.

### EXHIBIT E.1: AMBASSADOR BRIDGE PEAK HOUR FLOWS ANALYSIS 2002 – CARS ONLY

| LEVEL OF SERVICE | | |
|---|---|---|
| **Direction** | **1** | **2** |
| Desired LOS | E | E |
| **FREE-FLOW SPEED** | | |
| **Direction** | **1** | **2** |
| Lane Width | 3.5 m | 3.5 m |
| Lateral Clearance: | | |
| Right Edge | 0.0 m | 0.0 m |
| Left Edge | 0.0 m | 0.0 m |
| Total Lateral Clearance | 1.8 m | 1.8 m |
| Access points per km | 0 | 0 |
| Median Type | Undivided | Undivided |
| Free-Flow Speed: | Base | Base |
| FFS or BFFS | 80.0 km/h | 80.0 km/h |
| Lane width adjustment, FLW | 1.0 km/h | 1.0 km/h |
| Lateral Clearance Adjustment, FLC | 5.8 * km/h | 5.8 * km/h |
| Access Points Adjustment, FA | 0.0 km/h | 0.0 km/h |
| Median Type Adjustment, FM | 2.6 km/h | 2.6 km/h |
| Free-Flow Speed | 70.6 km/h | 70.6 km/h |
| **VOLUME** | | |
| **Direction** | **1** | **2** |
| Volume, V | 1750 vph | 1750 vph |
| Peak-Hour Factor, PHF | 0.95 | 0.95 |
| Peak 15-Minute Volume, v15 | 461 | 461 |
| Trucks & Buses | 0 % | 0 % |
| Recreational Vehicles | 0 % | 0 % |
| Terrain Type: | Grade | Grade |
| Grade | 4.50 % | 3.25 % |
| Segment Length | 0.80 km | 1.04 km |
| Trucks & Buses PCE, ET | 3.0 * | 3.0 * |
| Recreational Vehicles PCE, ER | 3.0 * | 3.0 |
| Heavy Vehicle Adjustment, fHV | 1.000 | 1.000 |
| Driver Population Adjustment, fP | 1.00 | 1.00 |
| Flow Rate, vp | 1842 pcph | 1842 pcph |
| **RESULTS** | | |
| **Direction** | **1** | **2** |
| Desired LOS | E | E |
| Flow Rate, vp | 1842 pcph | 1842 pcph |
| Free-Flow Speed, FFS | 70.6 km/h | 70.6 km/h |
| Allowable Maximum Service Flow Rate for Desired LOS, MSF | 1852 pcphpl | 1852 pcphpl |
| Number of Lanes Required, N | 1.0 | 1.0 |

### EXHIBIT E.2: BLUE WATER BRIDGE PEAK HOUR FLOWS ANALYSIS 2002 – CARS ONLY

| | | |
|---|---|---|
| **LEVEL OF SERVICE** | | |
| **Direction** | **1** | **2** |
| Desired LOS | E | E |
| **FREE-FLOW SPEED** | | |
| **Direction** | **1** | **2** |
| Lane Width | 3.6 m | 3.6 m |
| Lateral Clearance: | | |
| Right Edge | 1.0 m | 1.0 m |
| Left Edge | 0.0 m | 0.0 m |
| Total Lateral Clearance | 1.0 m | 1.0 m |
| Access points per km | 0 | 0 |
| Median Type | Divided | Divided |
| Free-Flow Speed: | Base | Base |
| FFS or BFFS | 80.0 km/h | 80.0 km/h |
| Lane width adjustment, FLW | 0.0 km/h | 0.0 km/h |
| Lateral Clearance Adjustment, FLC | 3.9 km/h | 3.9 km/h |
| Access Points Adjustment, FA | 0.0 km/h | 0.0 km/h |
| Median Type Adjustment, FM | 0.0 km/h | 0.0 km/h |
| Free-Flow Speed | 76.1 km/h | 76.1 km/h |
| **VOLUME** | | |
| **Direction** | **1** | **2** |
| Volume, V | 1840 vph | 1840 vph |
| Peak-Hour Factor, PHF | 0.95 | 0.95 |
| Peak 15-Minute Volume, v15 | 484 | 484 |
| Trucks & Buses | 0 % | 0 % |
| Recreational Vehicles | 0 % | 0 % |
| Terrain Type: | Grade | Grade |
| Grade | 4.50 % | 3.25 % |
| Segment Length | 0.80 km | 1.04 km |
| Trucks & Buses PCE, ET | 3.0 * | 3.0 * |
| Recreational Vehicles PCE, ER | 3.0 * | 3.0 |
| Heavy Vehicle Adjustment, fHV | 1.000 | 1.000 |
| Driver Population Adjustment, fP | 1.00 | 1.00 |
| Flow Rate, vp | 1936 pcph | 1936 pcph |
| **RESULTS** | | |
| **Direction** | **1** | **2** |
| Desired LOS | E | E |
| Flow Rate, vp | 1936 pcph | 1936 pcph |
| Free-Flow Speed, FFS | 76.1 km/h | 76.1 km/h |
| Allowable Maximum Service Flow Rate for Desired LOS, MSF | 1938 pcphpl | 1938 pcphpl |
| Number of Lanes Required, N | 1.0 | 1.0 |

### EXHIBIT E.3: DETROIT-WINDSOR TUNNEL EXISTING PEAK HOUR CAPACITY ANALYSIS, 2002

| INPUT DATA | | |
|---|---|---|
| Highway Class | Class 1 | |
| Shoulder Width | 0.0 | m |
| Lane Width | 3.5 | m |
| Segment Length | 1.6 | km |
| Terrain Type | Rolling | |
| Grade: | | |
| Length | | km |
| Up/Down | | % |
| Peak-Hour Factor, PHF | 0.95 | |
| % Trucks & Buses | 4 | % |
| % Recreational Vehicles | 0 | % |
| % No-Passing Zones | 100 | % |
| Access Points/km | 0 | /km |
| Two-Way Hourly Volume, v | 2800 | veh/h |
| Directional Split | 50 | / 50% |
| **AVERAGE TRAVEL SPEED** | | |
| Grade Adjustment Factor, fG | 0.99 | |
| PCE for truckks, ET | 3.0 | * |
| PCE for RVs, ER | 1.1 | |
| Heavy Vehicle Adjustment Factor | 0.926 | |
| Two-Way Flow Rate, (Note-1) vp | 3215 | pc/h |
| Highest Directional Split Proportion (note-2) | 1609 | pc/h |
| Free-Flow Speed from Field Measurement: | | |
| Field Measured Speed, SFM | - | km/h |
| Observed Volume, Vf | - | veh/h |
| Estimated Free-Flow Speed: | | |
| Base Free-Flow Speed, BFFS | 80.0 | km/h |
| Adj. For Lane & Shoulder With, fLS | 7.5 | km/h |
| Adj. For Access Points, fA | 0.0 | km/h |
| Free-Flow Speed, FFS | 72.5 | km/h |
| Adjustment for No-Passing Zones, fnp | | km/h |
| Average Travel Speed, ATS | | km/h |
| **PERCENT TIME-SPENT-FOLLOWING** | | |
| Grade Adjustment Factor, fG | 1.00 | |
| PCE for Trucks, ET | 3.0 | * |
| PCE for RVs, ER | 1.1 | * |
| Heavy Vehicle Adjustment Factor | 0.926 | |
| Two-Way Flow Rate (note-w) vp | 3183 | pc/h |
| Highest Direction Split Proportion (note-2) | 1592 | pc/h |
| Base Percent Time-Spent-Following, BPTSF | 93.9 | % |
| Adj. For Directional Distribution and No-Passing Zones, fd/np | 1.4 | |
| Percent Time-Spent-Following, PTSF | 95.3 | % |
| **LEVEL OF SERVICE AND OTHER PERFORMANCE MEASURES** | | |
| Level of Service, LOS | | |
| Volume ot Capacity Ration, v/c | 1.00 | |
| Peak 15-Min Vehicle-Kilometres of Travel, VkmT15 | 1179 | veh-km |
| Peak-Hour Vehicle-Kilometres of Travel, VkmT60 | 4480 | veh-km |
| Peak 15-Min Total Travel Time, TT15 | | veh-h |

Notes:

1. If vp>=3200 pc/h, terminate analysis - the LOS is F.
2. If highest directional split vp>+1700 pc/h, terminate analysis - the LOS is F.

Partnership of

Transport Canada Transports Canada

# APPENDIX F:

# Observed Border Crossing Volumes

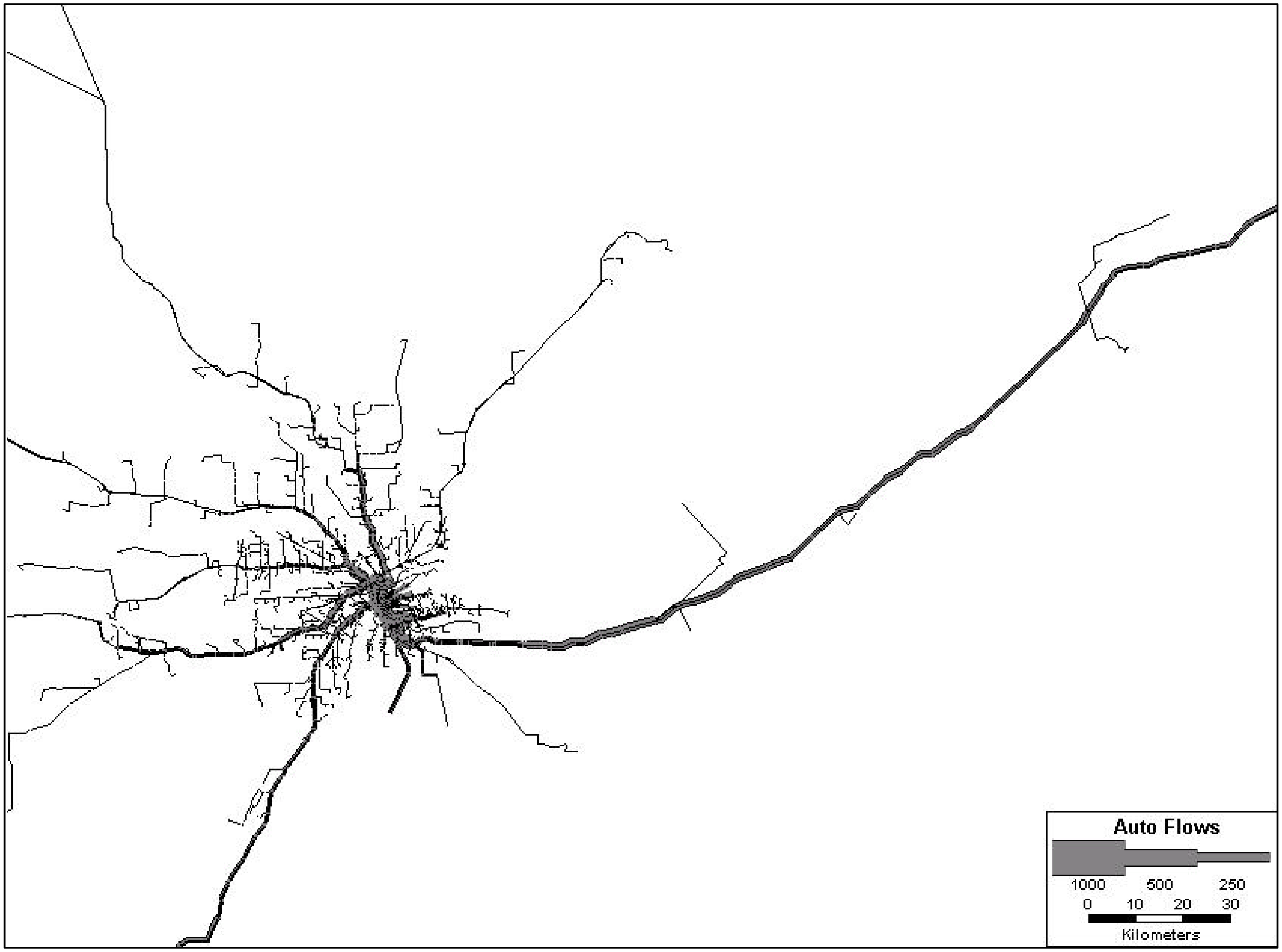
Prepared by IBI Group for URS Canada

# Appendix F: Observed Border Crossing Volumes

Exhibits F.1 to F.12 show the observed traffic volumes as assigned by the Regional Model. The assignments were carried out by assigning trip tables for each crossing facility and restricting traffic flow across other facilities.

Note that not all exhibits are shown at the same scale.

## EXHIBIT F.1: AMBASSADOR BRIDGE: AM PEAK HOUR AUTO TRAFFIC



### EXHIBIT F.2: WINDSOR-DETROIT TUNNEL: AM PEAK HOUR AUTO TRAFFIC

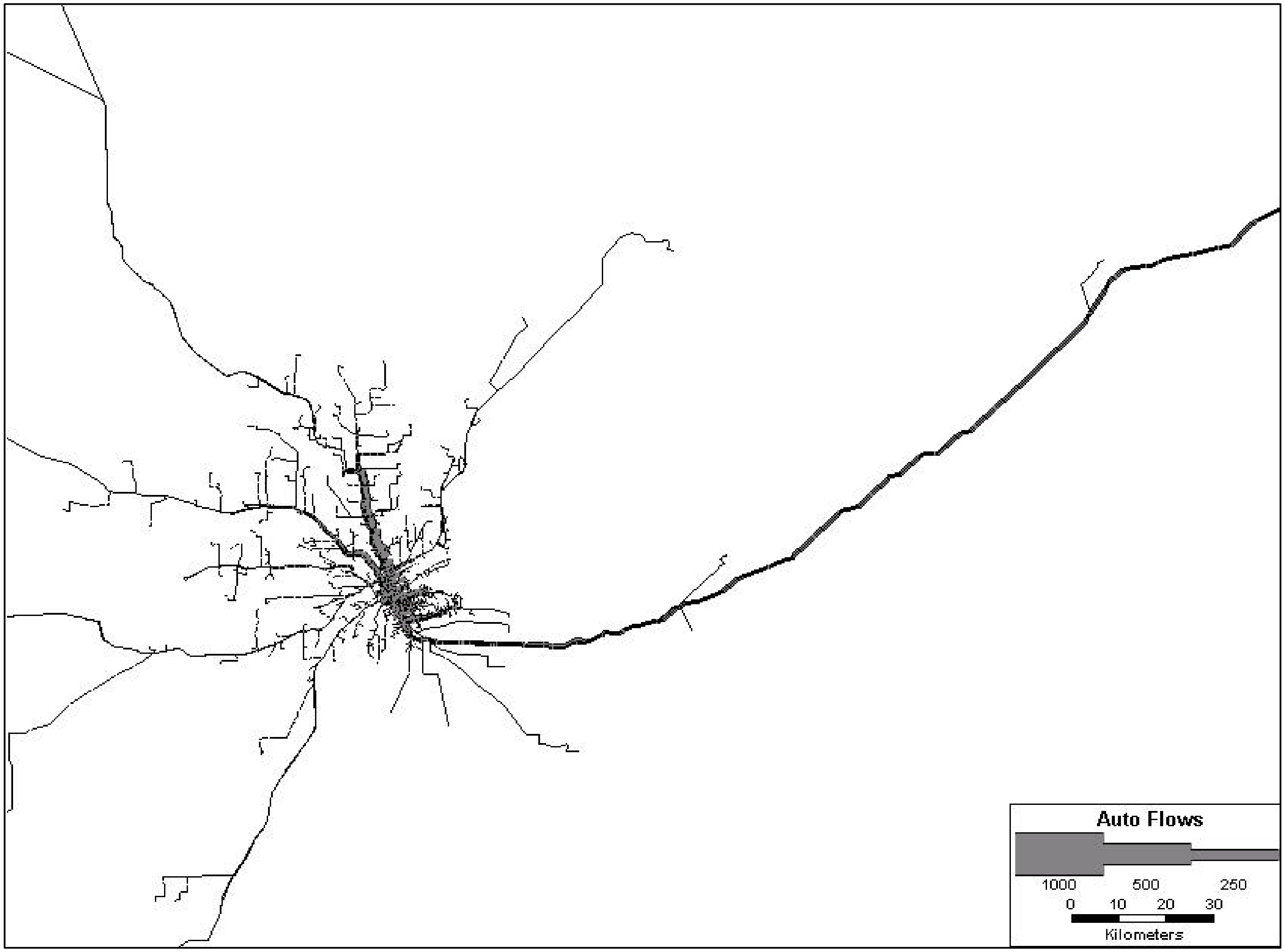
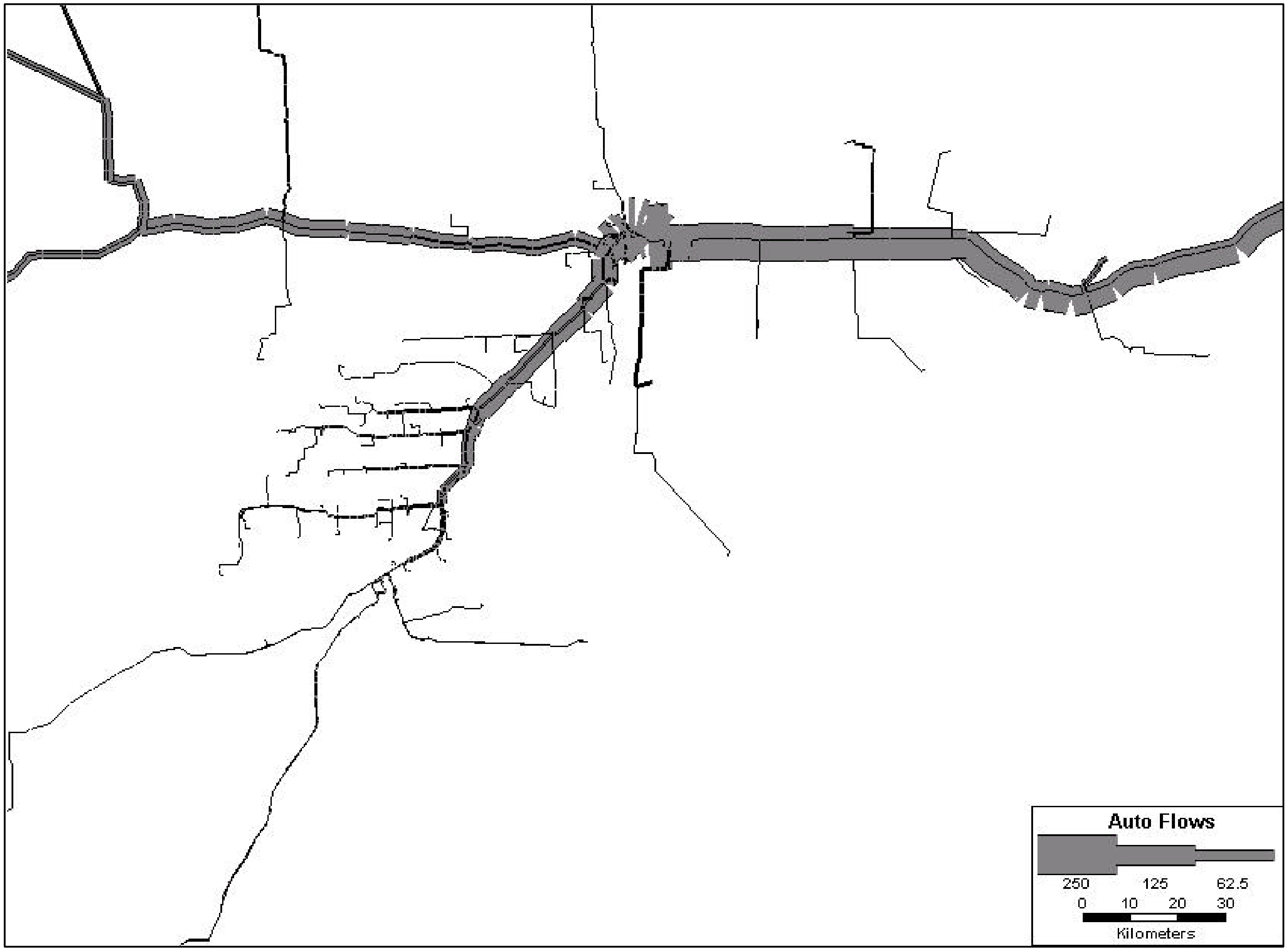
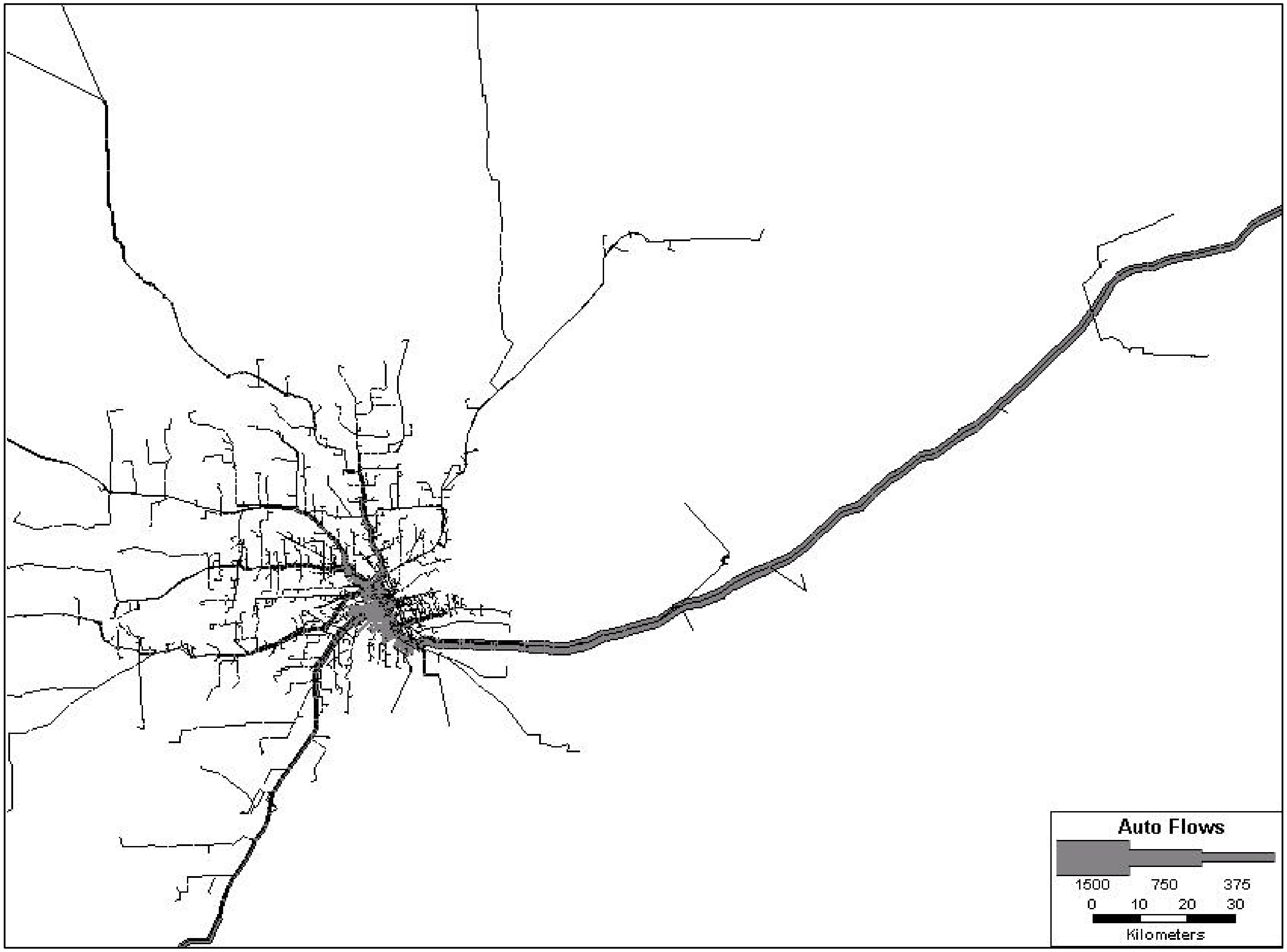


**EXHIBIT F.3: BLUE WATER BRIDGE: AM PEAK HOUR AUTO TRAFFIC**



## EXHIBIT F.4: AMBASSADOR BRIDGE: PM PEAK HOUR AUTO TRAFFIC



### EXHIBIT F.5: WINDSOR-DETROIT TUNNEL: PM PEAK HOUR AUTO TRAFFIC

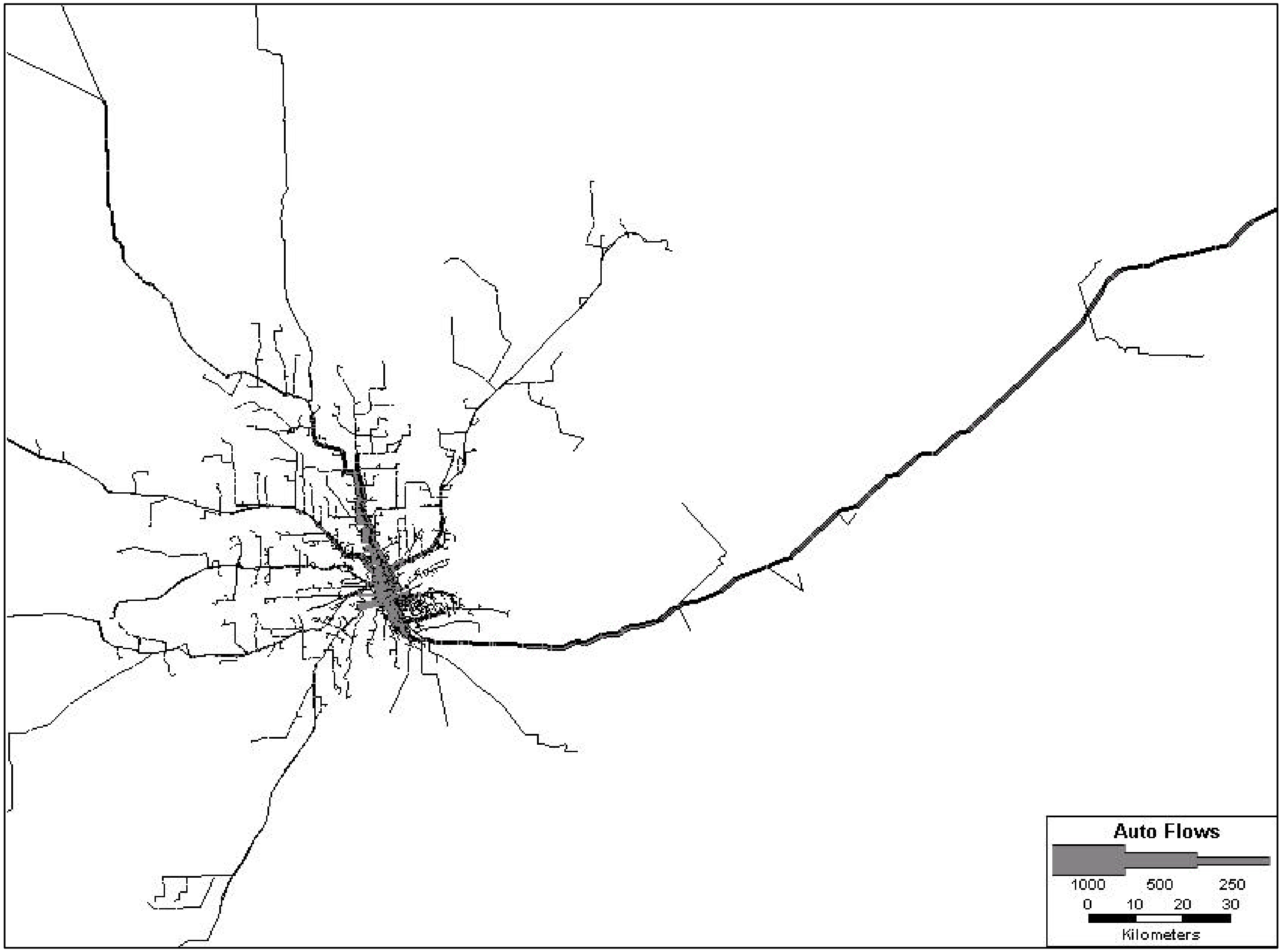
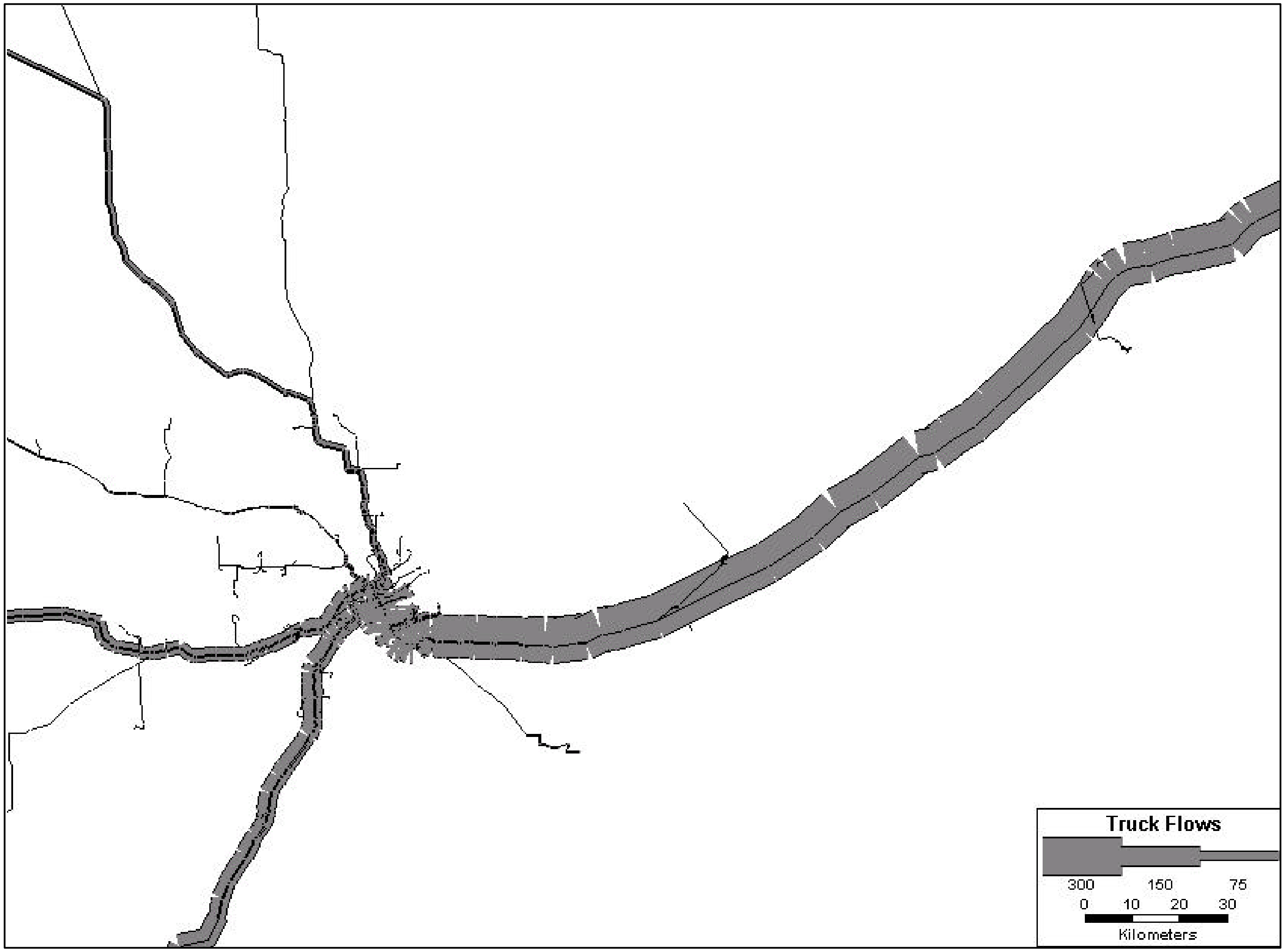
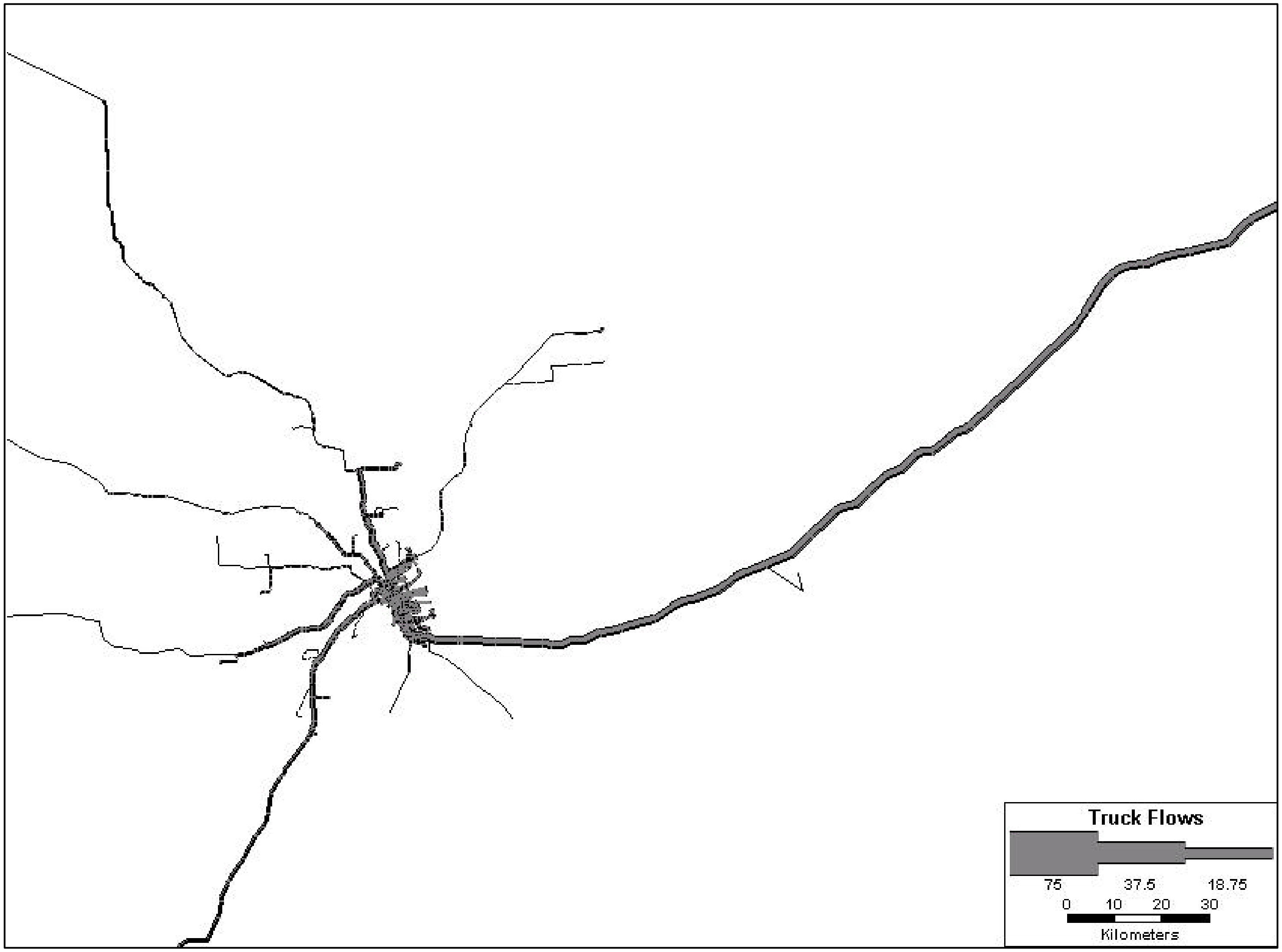


**EXHIBIT F.6: BLUE WATER BRIDGE: PM PEAK HOUR AUTO TRAFFIC**

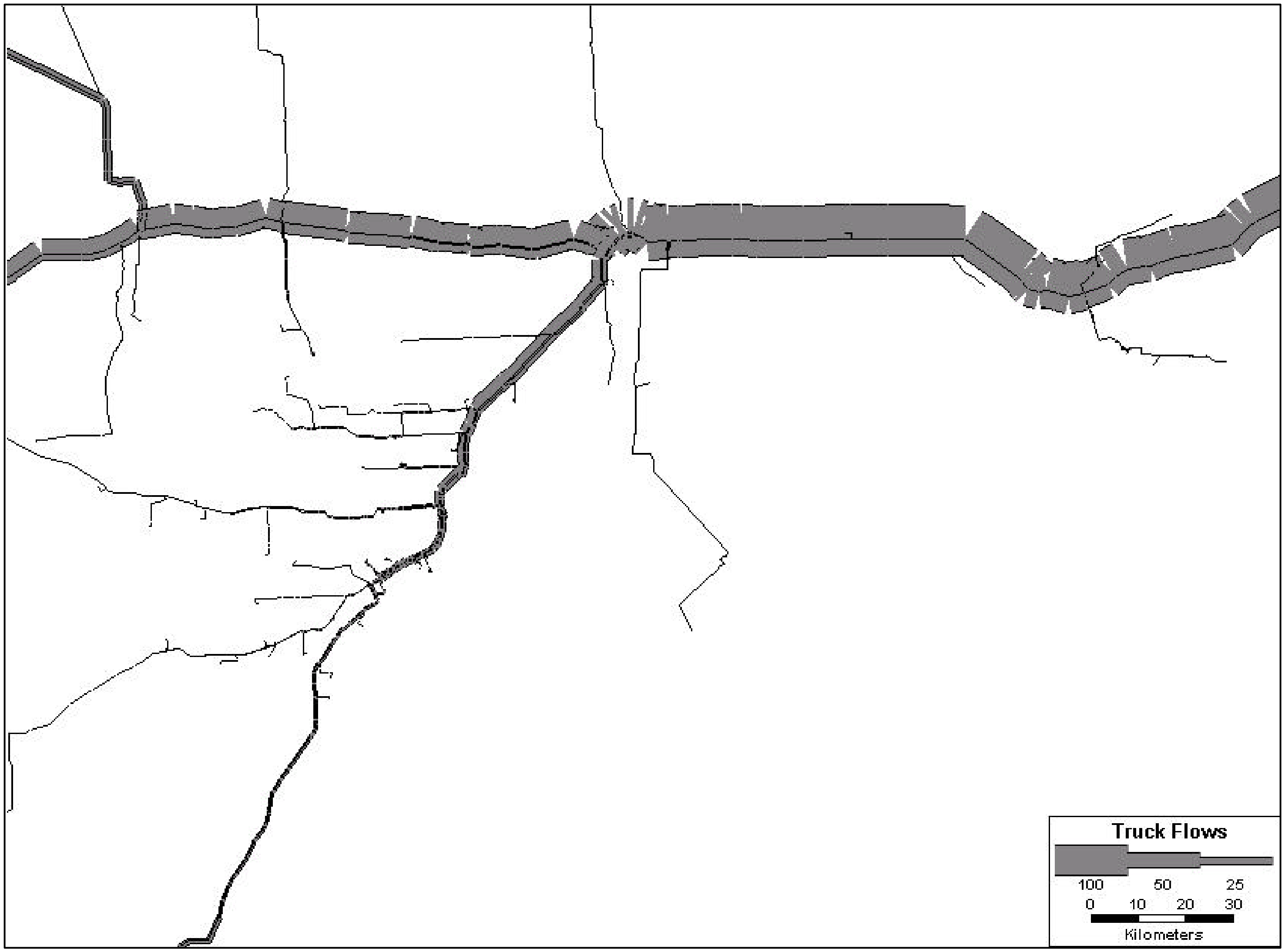
### EXHIBIT F.7: AMBASSADOR BRIDGE: AM PEAK HOUR TRUCK TRAFFIC



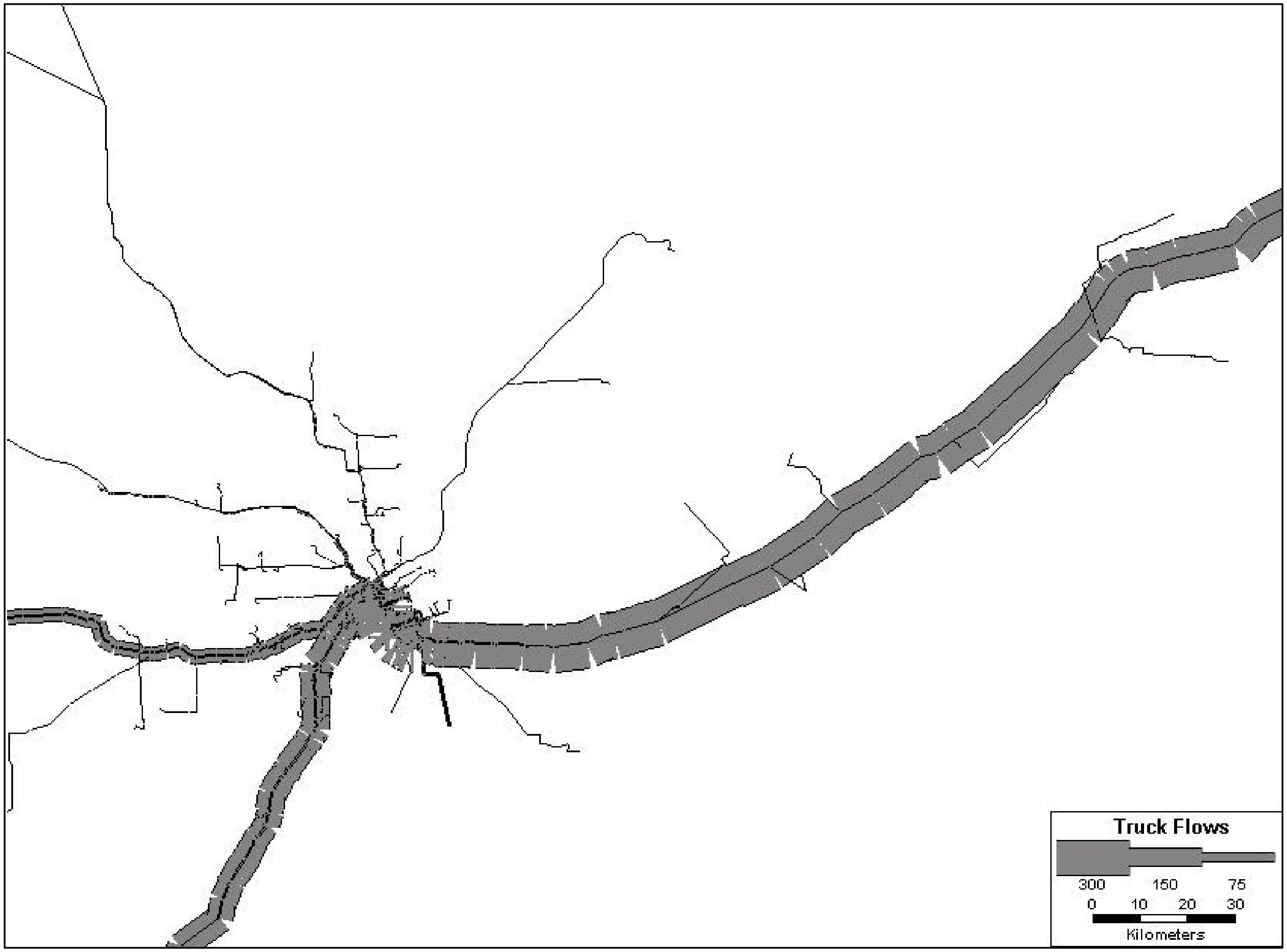
## EXHIBIT F.8: WINDSOR-DETROIT TUNNEL: AM PEAK HOUR TRUCK TRAFFIC



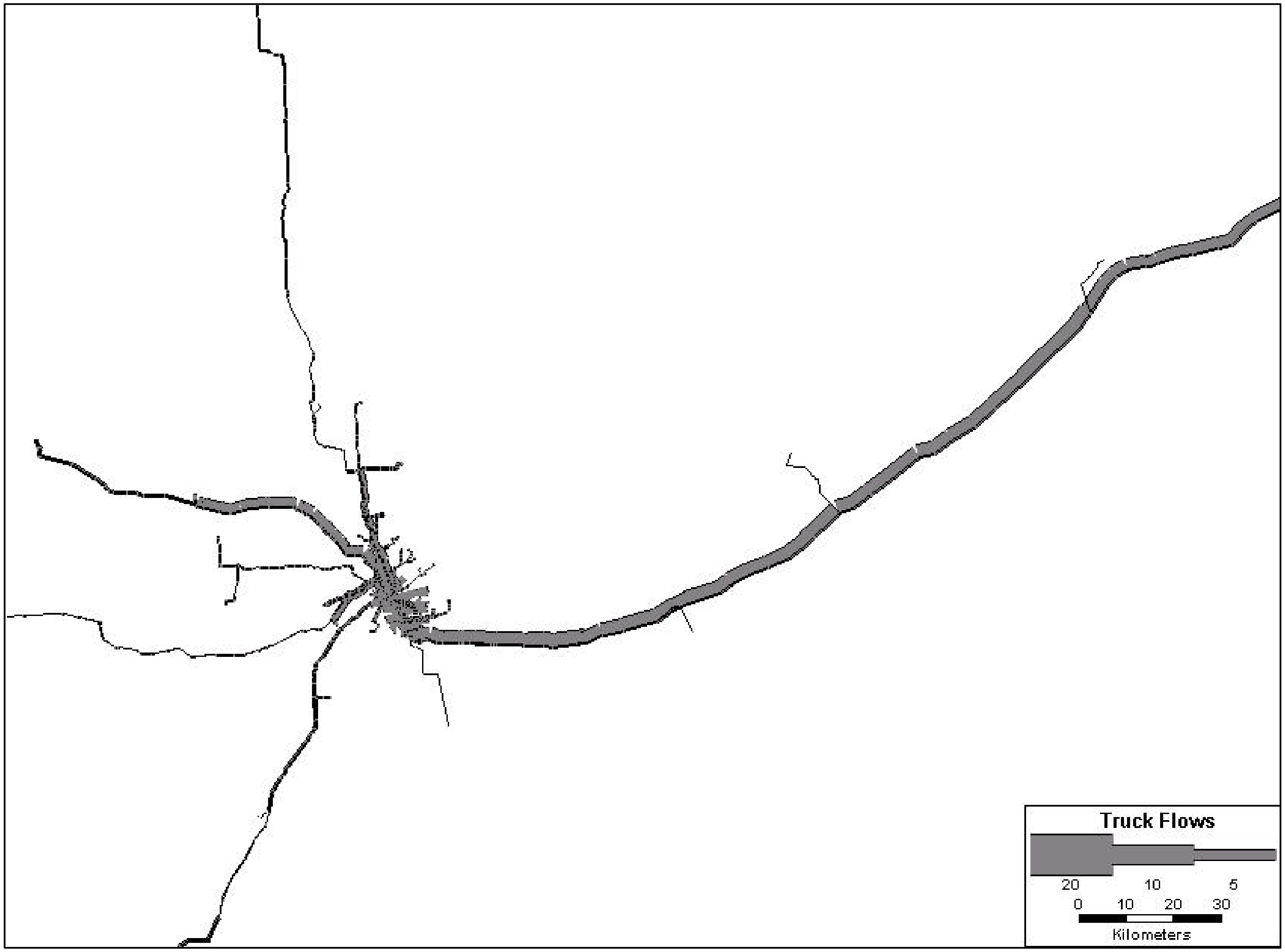
## EXHIBIT F.9: BLUE WATER BRIDGE: AM PEAK HOUR TRUCK TRAFFIC



### EXHIBIT F.10: AMBASSADOR BRIDGE: PM PEAK HOUR TRUCK TRAFFIC



### EXHIBIT F.11: WINDSOR-DETROIT TUNNEL: PM PEAK HOUR TRUCK TRAFFIC



## EXHIBIT F.12: BLUE WATER BRIDGE: PM PEAK HOUR TRUCK TRAFFIC