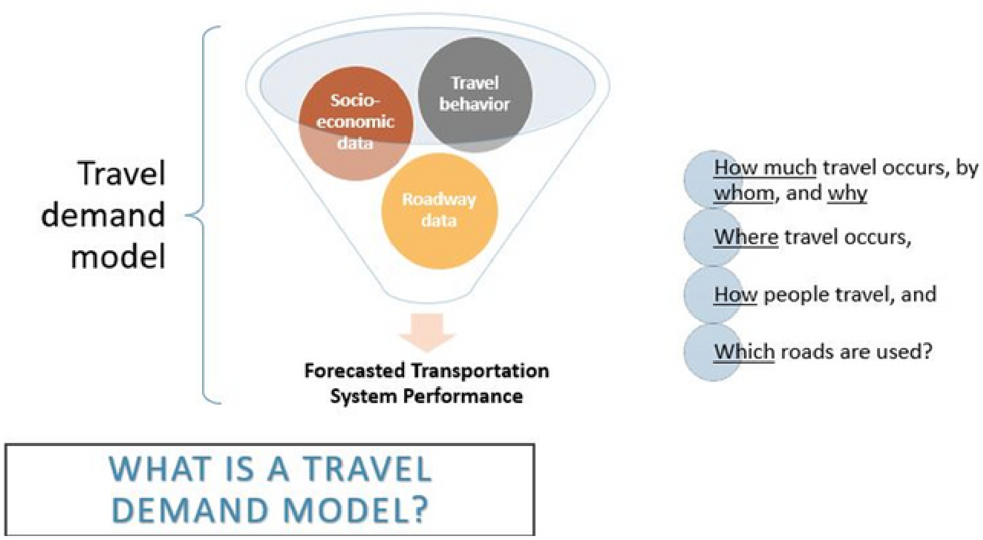
CHAPTER EIGHT

Travel Demand Model

MACC LRTP TRAVEL DEMAND MODEL

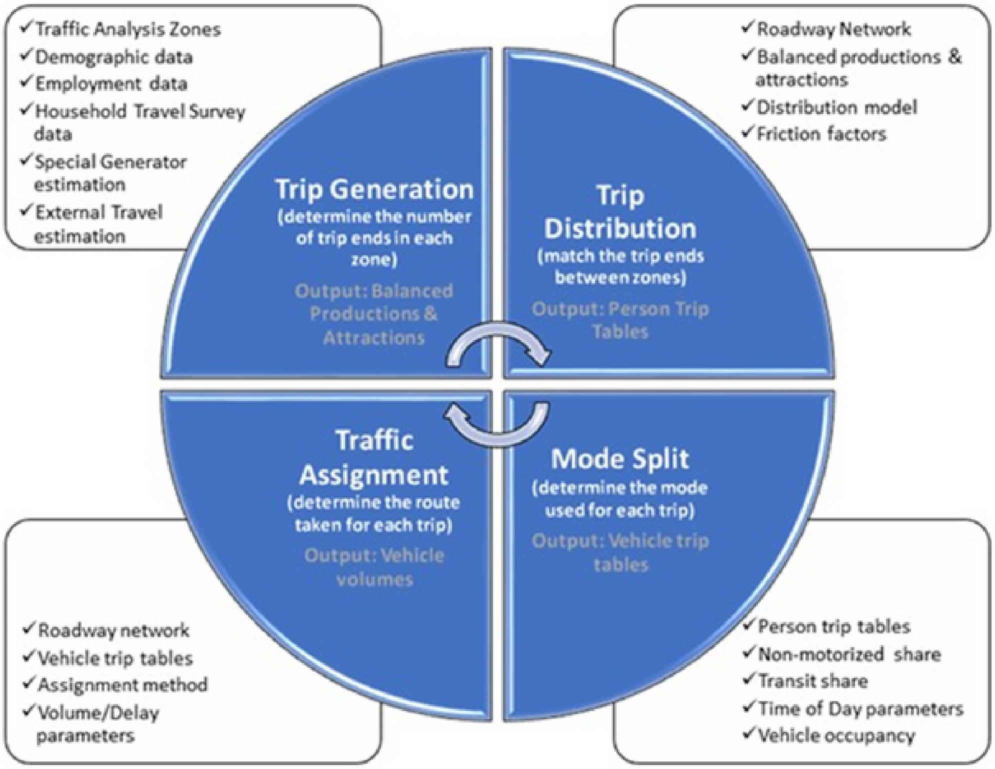
Travel demand forecasting models (TDMs) are a major analysis tool for the development of long-range transportation plans. These mathematical models attempt to estimate the number of trips, connect their origins and destinations, forecast the mode of travel, and identify the roadways or transit routes most likely to be used in completing a trip. Models are used to try to determine where future transportation problems are likely to occur, as indicated by modeled roadway congestion. Once identified, the model can test the ability of roadway to address those problems. The travel demand model provides an important decision-making tool for the MPO Metropolitan Transportation Plan development as well as any transportation related studies that might follow. The modeling process is a systems-level effort. Although individual links of a highway network can be analyzed, the results are intended for determination of system-wide impacts. At the systems level, impacts are assessed on a broader scale than the project level. The model is a computer estimation of current and future traffic conditions and is built and ran through TransCAD software.



MACC LRTP TRAVEL DEMAND MODEL

- The model generates a synthetic population of households based on the aggregate characteristics of the population encoded in the traffic analysis zones (TAZ).
- The level of vehicle ownership is applied to the household.
- The number of trips of various purposes (work, school, other, etc.) are predicted for each household.
- The dominant mode of travel (private automobile, bus, walking/biking) is modeled for the household’s trip of each purpose.
- Probable destinations of each trip type are chosen.
- Finally, the trips are assigned to the roadway network and routes are chosen such that travelers minimize their travel time and costs.

COMPONENTS OF THE MODEL



TRAFFIC ANALYSIS ZONE (TAZ)

The Traffic Analysis Zone (TAZ) is the primary geographical unit of analysis of the travel demand model and it represents the origins and destinations of the travel activity within the model area. TAZ's are determined based on several criteria including similarity of land use, compatibility with jurisdictional boundaries, presence of physical boundaries, and compatibility with the road system. Streets and natural features such as rivers are generally utilized as zone boundary edges. TAZ's vary in size depending on population, employment, and road network density. Each TAZ includes population and employment data (aggregated from census blocks) which is fed into the Travel Demand Model.

ROAD NETWORK

Using the TransCAD software, a traffic network is built to represent the existing road system. The Model network includes most roads within the study area classified as a minor collector or higher by the national functional classification system. Other roads are added to provide continuity and/or allow interchange between these facilities.

Transportation system information or network attributes required for each link include facility type, area type, lane width, number of through lanes, parking availability, national functional classification and traffic counts (based on availability).

Link capacities and free flow speeds are determined based on network attributes such as national functional classification, facility type, and area type. These features of the road network are used in the traffic assignment process and in determining traffic conditions.

SOCIO-ECONOMIC (SE) DATA & POPULATION SYNTHESIS

Travel demand models are driven, in part, by the relationship of land use activities and characteristics of the transportation network. Inputs to the modeling process include the number of households, population-in households, vehicles, and employment located in each TAZ. These characteristics are generally referred to as socioeconomic data (SE-Data). The collection and verification of the SE-Data was a collaborative effort between the MPO and MDOT. Household, population, and employment data were derived from several sources including the U.S. Census, the American Community Survey, and the Nielson employment database. For the future years of the model, multiple sources were utilized including the Regional Economic Models Incorporated (REMI) TranSight Model, the MDOT Statewide Travel Demand Model, and input from the MPO & local agencies.

The travel demand model generates a synthetic population of households based on the demographic information associated with the traffic analysis zones. For each zone, individual households are created. Each household has a total number of persons, workers, and students. Each household also has an income variable that indicates whether the household belongs to the lower, middle, or upper-income category. The number of vehicles available to each household is modeled separately, after the population synthesis, based on these variables and other variables describing the zone in which the household is located.

TRIP GENERATION

The trip generation process calculates the number of person-trips produced from or attracted to a zone, based on the socio-economic characteristics of that zone. The relationship between person-trip making and land activity is expressed in equations for use in the modeling process. The formulas were derived from MI Travel Counts Michigan travel survey data and other research throughout the United States. Productions were generated with a cross-classification look-up process based on household demographics. Attractions were generated with a regression approach based on employment and household demographics. To develop a trip table, productions and attractions must be balanced. Walk/bike trips are calculated using a factor for each trip purpose derived from the MI Travel Counts travel survey data. The walk/bike trips are removed from the production/attraction table before trip distribution is performed.

Trips that begin or end beyond the study area boundary are called "External trips." These trips are made up of two components: external to internal (EI) or internal to external (IE) trips and through-trips (EE).EI trips are those trips which start outside the study area and end in the study area. IE trips start inside the study area and end outside the study area. EE trips are those trips that pass through the study area without stopping; this matrix is referred to as the through-trip table.

TRIP DISTRIBUTION

Trip distribution involves the use of a mathematical formula which determines how many of the trips produced in a TAZ will be attracted to each of the other TAZs. It connects the ends of trips produced in one zone to the ends of trips attracted to other TAZs. The equations are based on travel time between TAZs and the relative level of activity in each zone. Trip purpose is an important factor in the development of these relationships. The trip relationship formula developed in this process is based on principals and algorithms commonly referred to as the Gravity Model.

The process that connects productions to attractions is called trip distribution. The most widely used and documented technique is the "gravity model" which was originally derived from Newton's Law of Gravity. Newton's Law states that the attractive force between any two bodies is directly related to the masses of the bodies and inversely related to the distance between them. Analogously, in the trip distribution model, the number of trips between two areas is directly related to the level of activity in an area (represented by its trip generation) and inversely related to the distance between the areas (represented as a function of travel time).

Research has determined that the pure gravity model equation does not adequately predict the distribution of trips between zones. The value of time for each purpose is modified by an exponentially determined "travel time factor" or "F factor" also known as a "Friction Factor." "F factors" represent the average area-wide effect that various levels of travel time have on travel between zones. The "F factors" used were developed using an exponential function described in the Travel Estimation Techniques for Urban Planning, NCHRP 716, and calibrated to observed trip lengths by trip purpose derived from the MI Travel Counts travel survey data. The F factor matrix is generated in TransCAD during the gravity model process.

The primary inputs to the gravity model are the normalized productions (P’s) and attractions (A's) by trip purpose developed in the trip generation phase. The second data input is a measure of the temporal separation between TAZs. This measure is an estimate of travel time over the transportation network from TAZ to TAZ, referred to as "skims." In order to more closely approximate actual times between TAZs and to account for the travel time for intra-zonal trips, the skims were updated to include terminal and intra-zonal times. Terminal times account for the non-driving portion of each end of the trip and were generated from a look-up table based on area type.

They represent that portion of the total travel time used for parking and walking to the actual destination. Intra-zonal travel time is the time of trips that begin and end within the same zone. Intra-zonal travel times were calculated utilizing a nearest-neighbor routine.

The Gravity Model utilizes the P’s & A's by trip purpose, the "F factors", and the travel times, including terminal and intra-zonal to create a TAZ-to-TAZ matrix of trips for each trip purpose for the model.

MODE CHOICE

The number of person trips and their trip starting and ending points have been determined in the trip generation and trip distribution steps.The mode choice step determines how each person's trip will travel. The travel demand model uses a simplified mode choice to predict mode choice. The process uses a qualitative measure of transit network service at the zonal level to estimate transit mode shares. The transit trips are accounted for but not assigned to a specific route. The split between single occupancy vehicles (SOV) and shared ride trips (SR2 & SR3+) is based on the average auto occupancy for the applicable trip purpose. The output to this step is a vehicle trip matrix by trip purpose. The external trips and the truck trips, which are originally developed as vehicle trips which eliminates the need of the mode choice step for these trip purposes, are added to the vehicle trip matrix.

ASSIGNMENT

Traffic assignment is the final step in the traditional four step TDM process. In this step, trips are assigned to a “route” (or path) on the roadway network between each trip origin and destination. The basic premise of trip assignment is that trip makers will choose the “best” path between each origin and destination. The determination of the “best” path is based upon selecting the route with the least “impedance”. Impedance, in this application, is based upon travel time – calculated as a function of link distance and speed (and later as a function of link volume and capacity). Essentially, trip makers on the roadway network will choose the route, between each trip origin and destination, which minimizes travel time.

The “User Equilibrium” algorithm (a commonly used algorithm) is employed in the traffic assignment component. User equilibrium is based on the principle that while selecting the “best” route, trip makers will use “all” possible paths between an origin and destination that have equal travel time – so that altering paths will not save travel time. This algorithm attempts to optimize the travel time between all possible paths, reflecting the effects of system congestion.

Thus, the product of the traffic assignment component is a series of vehicle-trip (volume) tables, by mode, for each link in the model roadway network. These “assigned” link volumes are then compared to “observed” traffic data as part of the model calibration, validation, and reasonability-checking phase of the overall modeling process.

APPLICATIONS OF THE VALIDATED TRAVEL DEMAND MODEL

Generally, three distinct alternative scenarios are developed for a LRTP:

1. Simulated Base Year (2019) volumes assigned to the Base Year (2019) Roadway Network; this scenario includes the assignment of 2019 model volumes, generated using 2019 SE data, onto the roadway network representing 2019 conditions. This is referred to as the "validated", existing network scenario, or "base-year" alternative, and is a prerequisite for the other two scenarios.

*As a result of the COVID-19 pandemic, 2020 presented a unique shift in terms of travel patterns and the collection efforts of traffic counts. Since the model is a long-term forecast model, the 2019 traffic counts provide a more reliable source for representing the base-year travel characteristics of the region.

2. Simulated Forecast Year (e.g. 2050) volumes assigned to a Modified Base Year Roadway Network; this scenario includes the assignment of 2050 volumes, generated using 2050 SE data, onto an amended roadway network representing 2019 conditions, and including any improvements completed since 2019 and future (near term) improvements for which funds have been "committed". This alternative characterizes future capacity and congestion problems if no further improvements to the transportation system are made. This "congestion analysis" on the "existing plus committed" (E+C) network is also called the "do nothing", or "no-build" alternative, and includes only the E+C roadway system.

3. Simulated Forecast Year (e.g. 2050) volumes on a proposed Forecast Year (e.g. 2050) Roadway Network; this scenario includes the assignment of 2050 volumes, generated using 2050 SE data, onto the roadway network as it is proposed to exist in the forecast year of 2050. This scenario is the long-range transportation plan "build" alternative. It includes the E+C roadway network, plus proposed capacity improvement and expansion projects.

SYSTEM ANALYSIS

Once the base and future trips have been estimated, a number of transportation system analyses can be conducted:

- Roadway network alternatives to relieve congestion can be tested as part of the LRTP. Future traffic can be assigned to an amended, existing roadway network (i.e. “No Build” Network) to represent the future impacts to the transportation system if no improvements were made. From this, improvements and/or expansions can be planned that could help alleviate demonstrated capacity issues.
- The impact of planned roadway improvements or expansions can be assessed.
- Individual links can be analyzed to determine which TAZs are contributing to the travel on that link (i.e. the link's service area). This can be shown as a percentage breakdown of total link volume.
- The impacts of land use changes on the roadway network can be evaluated(e.g. what would be the impact of a new major retail establishment).
- Road closure/detour evaluation studies can be conducted to determine the effects of closing a roadway and detouring traffic during construction activities. This type of study is very useful for construction management.

ANALYSIS

With the completion of the travel demand model, areas of potential congestion in the roadway network were identified based on the modeled volume to modeled road capacity ratios of the links, generally referred to as V/C. This means that the higher the V/C ratio, the higher the chances are that the roadway could experience congestion. In the examples below, the following can V/C ranges (potential congestion) of the model can be interpreted as follows:

V/C >.81: Traffic fills capacity of the roadway, vehicles are closely spaced, incidents can cause serious breakdown.
V/C = .61-.8: Movements more restricted, travel speeds begin to decline.
V/C = .41-.6: Stable condition, movements somewhat restricted due to higher volumes, but not objectionable for motorists.
V/C = .21-.4: Minimum delay, stable traffic flow.
V/C = 0-.2: Free flow, low traffic density.

The regional travel demand model identifies areas where traffic congestion is expected and highlights roadway segments that are congested or are close to capacity (in the years 2023 and 2050). It is important to understand that the modeling process is most effective for system-level analysis. Although detailed volumes for individual intersections and "links" of a highway are an output of the model, additional analysis and modification of the model output may be required for project-level analysis. The accuracy of the model is heavily dependent on the accuracy of the socio-economic data and network data provided by the local participating agencies, and the skill of the users in interpreting the reasonableness of the results.

2023

The Base Year scenario shows the existing conditions of the area-wide transportation system as it was in 2023. There is little traffic congestion in the majority of the MACC road network.

According to the model, the following corridors were identified as likely to experience congestion: See Figure 8.1

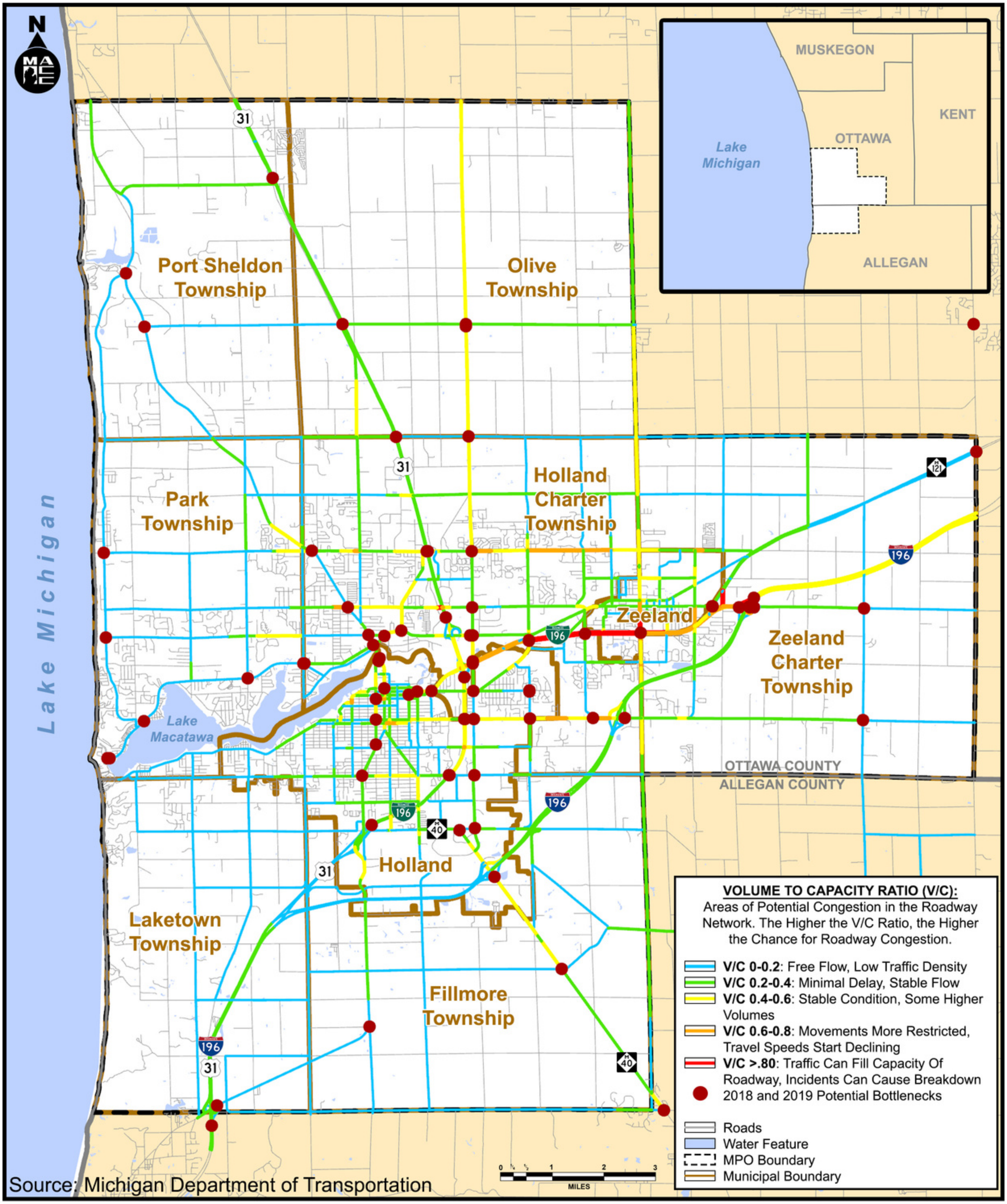
- I-196 BL Eastbound/Westbound (I-196 to US-31)
- James St. & Butternut Dr.
- 32nd St. (Michigan Ave. to State St.)
- 16th St. (River Ave. to I-196)
- River Ave. (Michigan Ave./State St. to Lakewood Blvd.)
- US-31 (Chicago Dr. to Lincoln Ave.)
- Riley St. (120th Ave. to 96th Ave.)

2050

The 2050 scenario shows forecasted conditions of the area-wide transportation system including both committed projects and proposed capacity improvements and expansion projects. In general, congestion increased slightly along the same corridors highlighted from the 2019 model results with additional sections of Pine Avenue, 8th Street, and 120th Avenue

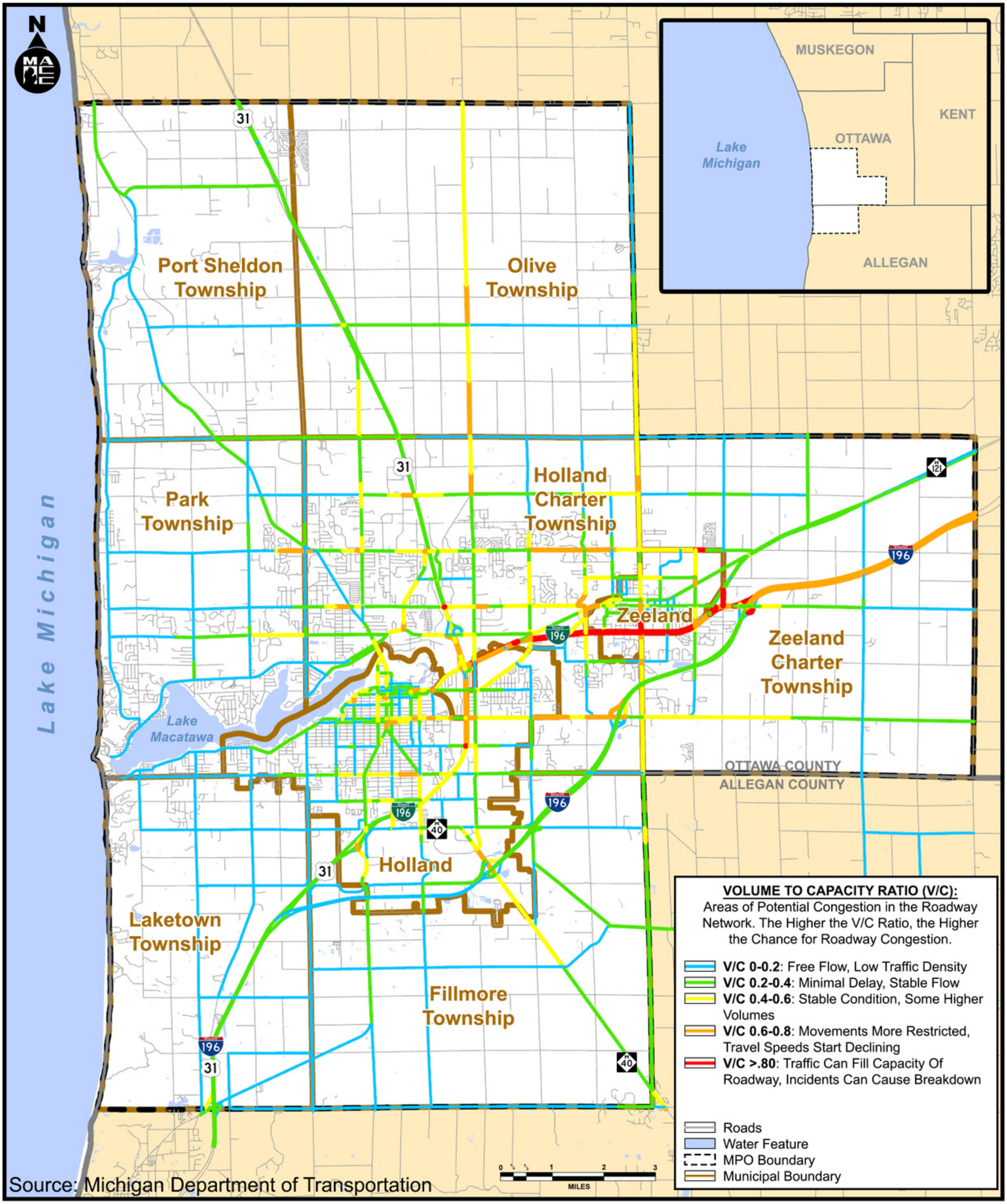
The 2050 model predicts the following corridors will likely experience congestion in the future: See Figure 8.2

- I-196 BL Eastbound/Westbound (I-196 to US-31)
- James St. (144th Ave. to Butternut Dr.)
- 32nd St. (Ottawa Ave. to Lincoln Ave.)
- 16th St. (River Ave. to I-196)
- River Ave. (Michigan Ave./State St. to Lakewood Blvd.)
- US-31 (Chicago Dr. to Lincoln Ave.)
- Riley St. (120th Ave. to 96th Ave.)
- Pine Ave. (9th St. to River Ave.)
- Waverly/120th Ave. (Lakewood Blvd. to Ottogan St.)



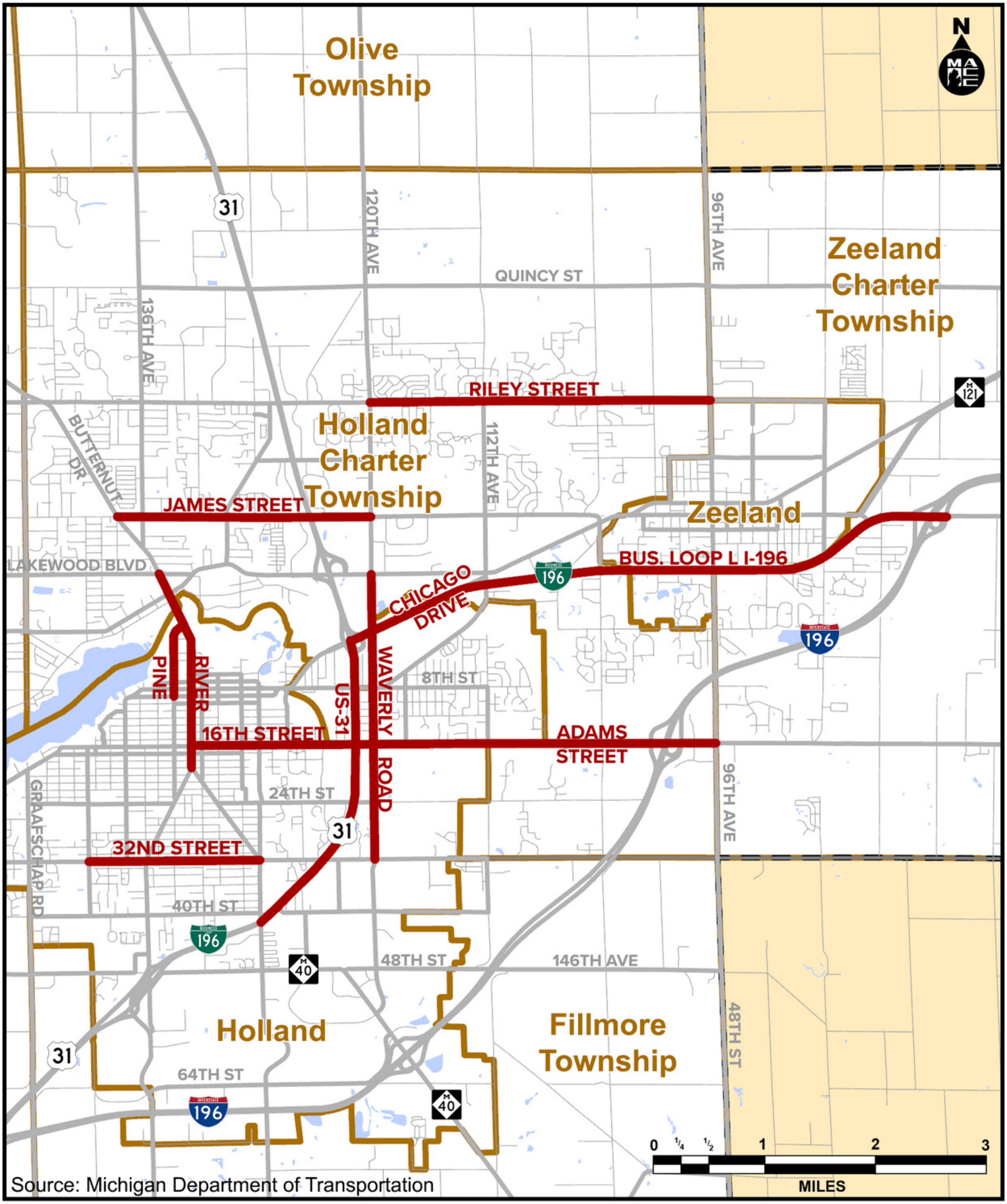
Base Year Congestion (2023)

Figure 8.1



Model Year Congestion (2050)

Figure 8.2



Likely Corridor Congestion (2050)

Figure 8.3