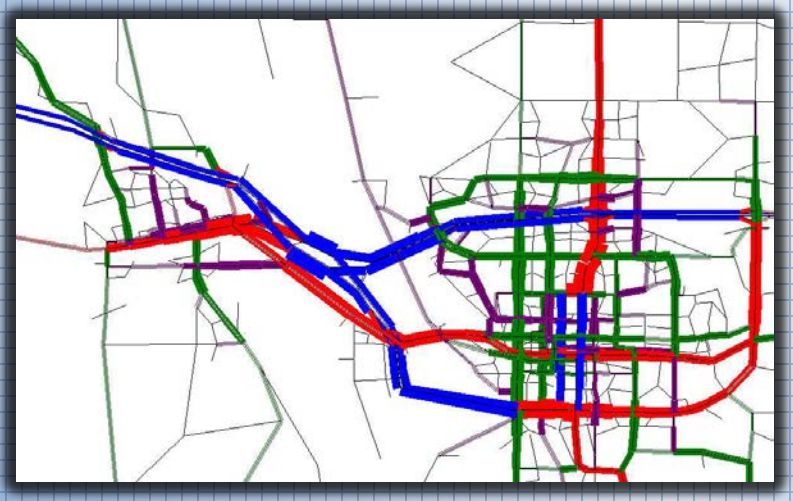
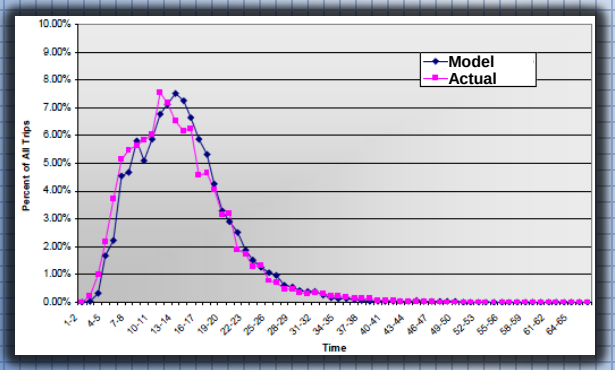
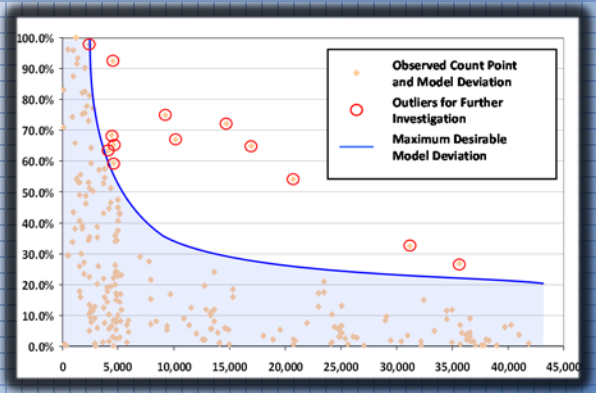
Bismarck-Mandan
Metropolitan Planning Organization

Bismarck-Mandan MPO Travel Demand Model Study







URS

BISMARCK-MANDAN TRAVEL DEMAND MODEL REVIEW STUDY

Report

Completed for:
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URS February 2012

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GLOSSARY

Average Daily Traffic (ADT): The total amount of traffic observed, counted or estimated in both directions during a 24-hour period.

Advanced Traffic Analysis Center (ATAC): A research group that is part of North Dakota State University Upper Great Plains Transportation Institute (UGPTI). ATAC develops and maintains the Bismarck-Mandan travel model.

Capacity: The maximum volume of travel that a transportation facility can accommodate.

Centroid: A point that represents a TAZ, that loads traffic onto the model network via centroid connectors. Centroids are typically placed so that they represent the approximate "center of mass" for trips generated by the TAZ.

Cordon Line: An imaginary line that surrounds a unique subarea or the study area. Traffic counts along the cordon line are reviewed and compared to those estimated in the travel model. For the Bismarck-Mandan model, cordon lines are drawn around the entire model study area and downtown Bismarck and downtown Mandan.

Equilibrium Assignment: a method of traffic assignment where trips select the shortest path while considering the estimation of congestion effects on travel time.

Friction Factors: Parameters used in the Trip Distribution step of the model which are used in the gravity model to represent the effects of travel impedance.

Geographic Information Systems (GIS): Computer software and databases that allow for the storage, retrieval and analysis of spatial information.

High-Occupancy Vehicle (HOV): Vehicles with a driver and one or more passengers. Policies are in place in some localities that provide dedicated arterial and freeway lanes that are reserved for vehicles with at least two occupants (driver and one or more passengers).

High-Occupancy / Toll (HOT): Policies that provide designated lanes on arterials and freeways that gives motorists in single-occupant vehicles access to high-occupancy vehicle lanes (or "HOV lanes").

K-Factors: A parameter used in trip distribution to adjust trip making interchanges between two subareas of the region, often thought of as a "socioeconomic" adjustment that cannot otherwise be represented in the model.

Level of Service (LOS): A qualitative measure of intersection or road segment operating condition. A grading scale of A through F is used to characterize traffic operating conditions. The scale is based on the ability of an intersection or street segment to accommodate the amount of traffic using it, and can be used for both existing and projected conditions. The scale ranges from "A" which indicates little, if any, vehicle delay, to "F" which indicates significant vehicle delay and traffic congestion.

Macroscopic Model (Regional Travel Demand Model): A computer-based application that forecasts traffic volumes / travel demands across a region or metropolitan area by evaluating the interaction between transportation supply (roadway networks, transit routes, etc.) and the sources of travel demand (such as locations of housing, shopping, employment, etc). Traditional regional travel demand models incorporate a four-step travel demand forecasting process that includes trip generation, trip distribution, mode choice, and traffic assignment.

Microsimulation / Microsimulation Modeling: Microsimulation is the detailed modeling of individual vehicles across a corridor or transportation system.

Mesoscopic Modeling: A travel modeling approach that bridges the gap between a microscopic modeling and the typical regional travel demand models. It includes more detailed trip making details, detailed network modeling and smaller / refined time packets than traditional regional travel demand models.

Mode Choice: A model step following the trip distribution step that evaluates the available travel options from one TAZ to another and allocates trips into various modes of travel. This is typically the third step in the "four-step" model process. The Bismarck-Mandan travel model does not currently include a mode choice step.

National Cooperative Highway Research Program (NCHRP): A US transportation research program. NCHRP research reports, specifically NCHRP Report 365, are cited in this study.

Origin-Destination (O-D): A description of where a trip begins and ends.

Post-Processing: The practice of adjusting travel model output for the forecast year based on known errors in the base year / current year model. In its simplest form, post-processing acknowledges that there are locations of error and deviations between a base year travel model and base year observed traffic conditions, and applies these observed deviations to adjust the forecast year model.

Regional Travel Demand Model: See "Macroscopic Model".

Screenline: An imaginary line, usually along a physical barrier such as river, roadway or railroad tracks, that divides the study area into parts. Traffic counts along the screenline are reviewed and compared to those estimated in the travel model.

Terminal Times: The additional out-of-vehicle time that occurs at the beginning and end of each trips, accounting for time spent parking a vehicle or walking between the vehicle and ultimate trip end.

Time of Day (TOD) Model: A model sub-step that converts daily trips into multiple time period-specific trips.

Traffic Analysis Zone (TAZ): The smallest geographic area used in travel demand modeling. In the Bismarck – Mandan model, traffic is predicted to / from each TAZ in the model.

Traffic Assignment: The model step that determines the travel route / path that all of the trips across the travel model will take. This is typically the fourth and final step in the "four-step" model process.

Transportation Improvement Program (TIP): This is primarily a spending plan for Federal funding expected to flow to the region from all sources for transportation projects of all types.

Travel Demand Model: A computer application that simulates an area's land development patterns (often, where houses and jobs are located) and its transportation system, and looks at the interaction between the two. It is a tool used to evaluate transportation and land use scenarios, such as how travel is affected when changes are made to the transportation system, or how travel patterns change as land development patterns change in the metropolitan area.

Travel Model Improvement Program (TMIP): A partnership of the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), Office of the Secretary of Transportation (OST) and the Environmental Protection Agency (EPA) to cooperatively fund and support travel model research.

Travel Skims: A summary of all of the travel times of the shortest path between all TAZs in the travel model.

Trip Distribution: The model step that summarizes where generated trip productions are linked to generated trip attractions on a zone-to-zone basis. This is typically the second step in the "four-step" model process.

Trip Generation: The model step that summarizes a TAZ's socioeconomic inputs (such as homes, employees by type, and schools) and generates an estimate of trip / traffic levels for each. Trips are generated as either **productions** (typically generated at the traveler's home) or **attractions** (typically tied to the non-home end of trip, whether for work, shopping, social or school purposes). Trip generation is typically the first step in the "four-step" model process.

Vehicle Hours Traveled (VHT): A measure of the cumulative vehicle travel time (in hours) on a transportation system measured for a given period of time, typically a day or over a year.

Vehicle Miles Traveled (VMT): A measure of cumulative of vehicle travel mileage on a transportation system, measured for a given period of time, typically a day or over a year.

CHAPTER 1: INTRODUCTION

The goal of the Bismarck-Mandan Travel Model review was to assess the current modeling package and identify revisions and enhancements that would meet the local modeling objectives. The MPO desired to have a study that included the following:

- Review the 2007 transportation model and practices to ensure best practices were being used.
- Determine the capabilities of the 2007 transportation model to evaluate various scenarios such as but not limited to, mixed-use development patterns, transit oriented development, and other development alternatives of varying residential densities. Provide recommendations regarding updates and changes needed for the transportation model to effectively evaluate the aforementioned scenarios if necessary.
- Review and provide recommendations of the 2007 model Transportation Analysis Zone (TAZ) structure.
- Review the 2007 transportation model network for accuracy relative to the actual roadway system.
- Review pseudo link / centroid connector locations and how they connect to the 2007 transportation model network.

The proposed product of the study was to provide the MPO opinions, recommendations and an action plan for those items warranting an update.

The study approach included:

- Establishing a model vision, by conducting user interviews and determining how the current model functions meet the users' needs.
- Conducting a best practices review, finding relevant areas where model enhancements might be made to meet local modeling goals.
- Evaluate the 2007 travel model from a technical perspective, including an assessment of baseline travel model performance and consistency with good travel modeling practice.
- Model enhancement action plan, identifying which model changes are feasible and effective in meeting model user expectations, and providing a blueprint for implementing those model enhancements.

An important element of the Model Review Study was involving a study Working Group. The Model Review Working Group included representation from:

- MPO staff
- Technical staff from local City and County jurisdictions
- NDDOT staff

The Working Group members represented the travel model's technical stakeholders, who use, maintain and rely on the results of the model. The Working Group provided direction to the model review team by giving feedback on how the model is used and proving input on their needs and expectations regarding model performance.

TRAVEL MODEL BACKGROUND INFORMATION

To understand the model review process and model recommendations that come out of this study, it is important to first understand the current model context. When the study was initiated, the Bismarck-Mandan Travel Demand Model was validated for year 2007 using Citilabs CUBE / TP+ modeling platform. The 2007 model was updated in support of the MPO's *2010-2035 Long Range Transportation Plan* (LRTP). All input data used in the model was either provided by the Bismarck-Mandan Metropolitan Planning Organization (MPO) or generated by the Advanced Traffic Analysis Center (ATAC). The model is developed and maintained by ATAC.

The model uses a streamlined four step planning model approach, utilizing the trip generation, trip distribution, and trip assignment steps, skipping the travel mode split step as all modeled trips are auto trips. The travel model provides forecasts of vehicle trip generation, trip distribution and traffic for 24-hour travel. Trips are generated using household and employment data at the traffic analysis zone (TAZ) level. The Bismarck-Mandan travel model represents the roadway network with a link-node system; links representing street segments and nodes representing the intersections. The 2007 model included roadways classified as Collector, Arterial or Freeway. The MPO area was divided into 239 TAZs for the 2007 model.

CHAPTER 2: MODEL VISION AND EXPECTATIONS

This phase of the study was essentially the data / issues collection element of the study, where the study team gained an understanding of the wants and needs of the model stakeholders. URS staff initiated the Travel Model Review Study by conducting several in-person and telephone discussions with members of the Working Group. For this phase of the study, input from the Working Group was supplemented with input from consultants with recent experience using the travel model.

MODEL USER INTERVIEWS

The purpose of the meetings and interviews was to identify the experiences, issues, problems and positive aspects that local users of the Bismarck-Mandan Travel Model have identified in regards to its use. Through this initial involvement effort, users also raised model questions and model options for the study to investigate and address. A travel model working group meeting was held on April 19, 2011. Individual discussions with users were conducted to supplement the kick-off meeting, as many members were unable to attend. While the model is developed, maintained and run solely by ATAC staff, local "users" were those that have some experience using model output to support their local transportation projects. Those users that either attended the kick off meeting and / or were interviewed include:

- Kim Adair, NDDOT Transit
- Dave Bechtel, Mandan Engineering
- Mark Berg, Bismarck Engineering
- Ben Ehreth, Bismarck-Mandan MPO
- Steve Grabil, Ulteig Engineering
- Marcus Hall, Burleigh County Engineering
- Stacey Hanson, NDDOT Local Government
- Steve Saunders, Bismarck-Mandan MPO
- Bob Shannon, Kadrmas, Lee and Jackson
- Robin Werre, Bis-Man Transit

The discussions focused on understanding how local planners / engineers used the model, specifically their experiences with the model and datasets, including any issues, both good and bad. The purpose of these discussions was to help the study team identify:

- What changes could be made to the current model structure to improve its operation.
- What additional model functions, if any, might be needed / desired in the future.
- What technical areas of the model might merit added attention.

TRAVEL MODEL USES

The discussion on model uses found that the model is predominantly used to develop project-level traffic data (daily and peak hour forecasts / growth rates) at specific intersections, along corridors and in subareas of the metropolitan area. The model data output has been on projects in the following ways:

- Users reviewed the modeled traffic assignments straight from the model to develop a base year-to-future year traffic growth rate.
- Model growth rates were compared to historical trends for reasonableness and goodness of fit. In some cases, the user would combine both the model data and the historical trend to develop a traffic forecast.
- Traffic assignment growth in the project corridors were, compared to the growth rates in adjacent parallel corridors and make adjustments to the studied corridor accordingly to smooth out the growth amongst adjacent corridors.
- Use the future traffic assignments straight from the model as a planning level screening of daily traffic forecasts. This exercise helped determine the general types of improvements that a corridor might require in the future, answering questions such as: "Is a 4-lane widening going to be required? Will turn lanes be needed?"
- Some users rely on consultants to interpret the model output for them on projects and studies.

Project Data Support: Many projects used model data straight from the already-established model network scenarios that were run for the 2035 LRTP: the 2007 base year, 2035 existing-plus-committed network, and 2035 LRTP Recommended Network. Some larger-scale projects that included significant roadway

network alternatives / adjustments involved developing a new network scenario for ATAC to run. In some cases, scenario-specific job and housing allocations were included in the future year model runs to reflect their project-specific assumptions. All of these project-specific travel model scenario runs were set up and run by ATAC.

Developer Requests: One public sector user noted that there has been an increase in the number of requests from developers to get traffic information to support development proposals. The user who receives these calls, believes that the general public and development community has become more aware of the model over the past few years.

Employment and Household Data Source: One user noted that they had used the socioeconomic inputs to the model as a basis for some utilities planning.

Transit Usage Potential: Transit trips are not modeled, and there have been limited uses of the model to support transit planning. The 2010-2035 LRTP update did use the model vehicle trip table as a screening tool for identifying potential candidate growth corridors / subareas for locating future bus routes, in addition to looking at socioeconomic projections and accessibility levels. Transit staff does not use the model, but indicated that if a transit component were added they would be interested in using it. Transit trips represented 0.3 percent of all modes of commuting trips in the Bismarck-Mandan region according to the 2010 American Community Survey. The ongoing Bis-Man Transit Development Plan study has not used any travel model datasets. The overall input received during the April – May 2011 discussion of model issues indicated that users thought a transit component would be a nice feature, but it was not viewed as essential to any of the respondents' planning functions.

Freight Usage Potential: The 2007 model does not include a freight component, and through interviews with users it was not believed that the model had been used to support freight planning. There was some interest in adding a freight component amongst the model users, noting that many state roads projects would benefit from truck forecasts. It was also noted that Bismarck sits on the edge of the oil fields and truck traffic might continue increasing in the future as a result.

Bicycle and Pedestrian Usage Potential: Non-motorized trips are also not currently modeled, and through discussions with the users it was not believed that the model has been used to support walk / bike planning in the region. While there would be some value to adding a non-motorized component to the model, based on a comparison of the time / effort required to implement and maintain a robust non-motorized model element, it was not viewed as one of the highest model priorities by the interviewed users.

Special Assessments: The City of Bismarck currently does special assessments for road improvement projects. The possibility of using the model to evaluate roadway assessments was brought up by one user, wondering if it was it a good way to use the traffic model. Travel models are often used as a means of assessing impact fees or user fees, and Bismarck and Mandan might consider using the model as a means of street assessments in the future.

Travel Model Issues and Experiences

In addition to understanding how the model is used locally, the study team wanted to get feedback from the users on their experiences using the model, specifically how it met their needs and how it might be improved. Through discussions with the various users of the model, many of the issues that were identified were brought up by multiple users. Thus, the issues that arose are organized into topics in the remainder of this section.

NDDOT staff indicated that they have used the travel models from all three MPOs across the state for their state projects, and have had instances in at least one other MPO where their in-house (NDDOT) forecasts differed significantly from the MPO model forecasts. The NDDOT representative did not recall having any major recent discrepancies like this in Bismarck-Mandan on state routes.

Network Accuracy: Several users believed that the accuracy of the 2007 model network attribute coding could be improved. In most cases, the concerns were not with widespread errors, just minor coding issues that combined might be a more significant issue. Specific network accuracy issues that users cited included:

- Users identified some concerns with the representation of the number and configuration

of lanes (both through lanes and turn lanes). In the models, the lane coding affects roadway capacities. In some corridors, incorrect network geometries have been observed by users.

- The locations at which centroid connectors load TAZ trips onto the network. In many instances, it was felt that there could be improved representation of how local streets actually feed the collector and arterial network.
- Users felt that many of the current model TAZs could be subdivided into smaller TAZs – particularly in cases where commercial and residential were together in one zone, the zones could be split to create more land use-homogenous zones.
- It was also felt that in some places the physical location / alignment of roads was not entirely correct. No specific locations were mentioned.
- Interstate highway link speeds in the model are significantly lower than actual speeds. This is not the case along other roadways.

Socioeconomic Data Update Frequency: The future socioeconomic projections used in the model provide anticipated locations of future job and household growth. The socioeconomic projections are typically produced during the LRTP update on a five-year cycle. Several users noted instances where the model's future socioeconomic data allocation did not fit with more recently-observed job and housing growth. These included instances where recent land development in a certain TAZ was of a different type and/or intensity than the model's 2035 projections, and more "general" large-scale trends, such as more observed short-term growth in North Bismarck, less growth in South Bismarck than reflected in the model. It was discussed that perhaps more frequent reviews and updates (perhaps every year or two) to the model's future year socioeconomic projections might be beneficial.

Peak Period Conditions Not Reflected: Some users did not think that the model was accurately reflecting capacity restraint. Specifically, there were concerns that the 2007 model doesn't reflect the level of traffic diversion from congested corridors that is observed in the AM and PM peak hours. It was also noted that the AM and PM characteristics of some corridors (in terms of the intensity and directionality of traffic) are likely not well-represented by the simplified assumptions necessary in a daily model. After more discussion, it was mentioned that perhaps a model that considered peak hour traffic patterns and peak hour capacity might be a more accurate and effective means of modeling trips in Bismarck-Mandan.

Trip Distribution Enhancements: A few trip distribution issues were discussed:

- One user indicated that on a recent project, they noticed that a nearby school TAZ was attracting trips from locations outside of the schools' attendance areas. As the model is constructed, there is no special school trip purpose or unique trip distribution patterns to specific schools. Thus, at least one user indicated an interest in enhancing model detail by incorporating a school trip purpose, and validating those school trips with available student address data by school. Often there are privacy concerns in providing any of this data, even if it will be used in the model in an anonymous manner. An alternative approach that would require less work and have less privacy implications would be to limit trip productions for each school to its general school attendance area.
- There was also some concern about the length and orientation of trips across major barriers like I-94 and the Missouri River. The 2007 Bismarck-Mandan model has several K-Factors to limit the amount of trip-making across some "screenlines" in the metro area, including both I-94 and the Missouri River. The issues associated with K-Factors will discussed in more detail in Chapter 3.
- Another user believed that the overall basis for trip origins and destinations in the Bismarck-Mandan model was outdated, since no travel survey had been conducted in decades. The user thought that an origin-destination study for the region would enhance the travel model. In our discussions with ATAC, they agreed with this point of view and would like for the MPO to conduct a user survey in the near future.

Land Use – Transportation Sensitivity in the Model: There were two different perspectives offered on this issue:

- One user thought the land development scenarios that drive trip-making in the model should be sensitive to transportation system improvements and overall network

accessibility. This is often called a land use – transportation "feedback loop" in modeling. The user believed this could be either an automated model procedure or a more manual process, but thought that some jobs / housing data changes might be warranted when regionally-significant transportation system improvements or overall regional accessibility levels are changed in the model.

- Another user was concerned with the model's ability to address the trip making effects of mixed-use developments. When development proposals that mix retail, office, entertainment and / or residential uses are analyzed in the model, it should be able to account for those trips which are internally captured. There are limited local instances of true "mixed-use" developments to validate this model capability against, but there are national resources that provide a basis for identifying trip reduction factors based on the unique characteristics of a development.

More Model Details Should be Published: One user thought that the Long Range Transportation Plan and Model Validation Reports should include more detailed data. The desired data included items such as:

- More reported 2035 traffic forecast locations.
- More documentation of base year and future raw travel model traffic output and how it was corrected.
- Detailed explanation and summary of the land development growth assumptions that are included in the model, including the overall level of regional job / housing growth assumed. This discussion should also describe how growth was allocated to the jurisdictions within the MPO, the relative breakdown of infill development and suburban fringe development and how that breakdown was chosen.

Present Model Results with Care: Some studies have presented model traffic numbers associated with full "build out" development scenarios that are intended to be beyond the traditional 20-25 year planning horizon. A user expressed concern that the results of these relatively extreme scenarios, while likely a reasonable representation of the input model assumptions, need to be fully explained, and presented in relation to a more "status quo" 20-25 year traffic forecast. Otherwise, the build out forecasts can seem unreasonably high, potentially making some in the public doubt the reasonableness of model results on other projects based on a misunderstanding of the scenario being presented.

Another user discussed potentially incorporating more extensive sensitivity testing of scenarios to present a range of potential outcomes, specifically reviewing different development and network assumptions to test the performance of a study corridor.

Additional Model Topics to be Addressed

Users had several topics and questions that they hoped would be addressed by the study. These topics are outlined and the answers were considered for incorporation into the study recommendations. Many of the questions relate to the more technical aspects of travel modeling, and some discussion has been added to provide some context.

Consider New Modeling Approaches for Bismarck-Mandan: In addition to discussing the desire to consider a time-of-day / peak regional travel demand model, one user asked if there was a point at which mesoscopic and/or microscopic models would be needed or appropriate for Bismarck-Mandan. As a follow up, they asked about the implications in terms of data collection and maintenance of the model if the region moved to one of these models.

New Model Approaches Discussion: Microscopic simulation models are typically developed for a corridor or sub-area level for traffic operations analysis or as a design-level decision tool, and typically are not used as a regional planning tool. Microscopic (also known as "microsimulation") models are a fairly common tool to analyze corridor traffic operations alternatives, and Bismarck-Mandan likely has had / will have corridor studies and roadway projects where their use would be appropriate and beneficial. Although linkages between the two are possible, there is typically limited direct operational overlap between the corridor-based Microscopic models and the regional travel model. *Mesoscopic* models bridge the gap between a microscopic model and the typical regional travel demand (also known as "Macroscopic") models. Mesoscopic models are being implemented in some larger metropolitan regions or sub-areas with significant levels of congestion, or with complex travel management conditions such as road pricing or areas

that use high-occupancy vehicle (HOV) or high-occupancy toll (HOT) lanes. The current model would need to undergo several model enhancements before it could be updated to run a Mesoscopic traffic assignment. Data collection needs include detailed volume information by time of day and extensive speed data by time of day. Current Mesoscopic applications are quite computing-intensive and metro-wide applications would likely require significant computing upgrades. It is assumed that over time, computing power will become less of a limitation for implementing mesoscopic travel models.

Consider Implementing a New Assignment Methodology if it is Needed or Appropriate: Dynamic Traffic Assignment (DTA) was mentioned as something that should be examined to determine if it was worth considering for inclusion in the Bismarck-Mandan model at some point. A follow up question was regarding how much more accurate DTA is than traditional traffic assignment techniques.

Assignment Methodology Discussion: DTA is a network route assignment approach that is typically based on the mesoscopic model platform discussed above. DTA is essentially a more realistic approach where drivers' route selections are time-dependent and can change from period to period (i.e., "dynamic"). Unlike traditional assignment approaches, DTA evaluates travel time conditions during short periods of time, and for each small time slice selects a route based on a fairly extensive modeling of network details, including signal timing and coordination. This approach allows for route choice and travel delays to be calculated for more accurate and realistic conditions, including a time-sensitive simulation of queuing and spill-back between adjacent intersections. As with the discussion of Mesoscopic modeling above, the Bismarck-Mandan model would require some significant updates in the data inputs and model functionality before DTA could be considered.

Identify the Data Collection Needs for an Effective Travel Model: The study was tasked with identifying an effective approach to continuously maintaining and improving the travel model to meet the planning needs of Bismarck-Mandan. Related to this task, there were several data items users wanted the study to address, including:

- Determine a desirable frequency for conducting Origin-Destination (O-D) studies to support model development.
- Determine a desirable frequency for conducting travel time studies.
- Determine the model data needs beyond those currently collected, such as socioeconomic data estimates and projections, travel time data and average daily traffic volumes.
- Identify data maintenance roles.

Determine How the Model Can Support Environmental Documentation and NDDOT's new Noise Analysis Policy: A user wanted the study to determine how the model could be used to support implementation of NDDOT's new noise analysis policy in Bismarck-Mandan, and how else the model could be used to support Environmental Documentation requirements.

Model Support for Environmental Documentation Discussion: All states including North Dakota were required to update their highway traffic noise policies by July 2011. The new noise policy will require traffic noise analyses to be completed on all federally-funded projects that increase roadway capacity or substantially move the roadway alignment. The noise analysis will determine project noise levels, and evaluate the reasonableness and feasibility of implementing noise abatement measures. The traffic forecasts provided by the model are essential in noise studies, as the noise studies are required to predict traffic noise impacts 20+ years beyond roadway construction.

Get Opinions on the Model from ATAC Staff: One user thought that this study should get ATAC's perspective on the model, and what more they might need from the MPO and / or jurisdictions in terms of data or coordination to improve the model. An outcome of this effort will include a list of tasks for the MPO to complete when requesting model updates from ATAC. Several users thought there may be a benefit to clearly defining the roles and outlining tasks for the MPO and ATAC when it comes to the model. ATAC was included in discussions on model capabilities and model needs throughout study development.

MODEL VISION GUIDING PRINCIPLES

The best model for Bismarck-Mandan is one that is tailored to meet the analysis needs of local planning and engineering professionals. Thus, this phase of the study focused on understanding how the model is used and what the collective model "vision" was before evaluating the model itself. The study team needed to first understand how it is used and based on how well it performs on those tasks before any technical evaluations or any model improvement alternatives could be undertaken.

Based on the feedback received during this exploratory phase of the study, it was apparent that:

- The model has traditionally been, and for the foreseeable future will continue to be, a tool predominantly used for **roadway analysis**. These roadway analyses include understanding current demands on the roadway system and forecasting future demands under different roadway improvement scenarios.
- There was some interest in expanding the role of the forecasting tool so that it was capable of evaluating other modes of travel. The model users understand the significant investment in model update and maintenance efforts that would result from adding these modes to the model structure. Given the **current** limited role other modes play in the region it was believed that there would be a limited return on this sizeable investment.
- Users' most significant issues focused on identifying and resolving any problems with current model accuracy and reviewing if the current modeling approach is sufficient and represents the state-of-the-practice.
- Users were interested in further examining whether some existing model functions might need to be enhanced or new model components should be added.

These principles set the context for the remainder of the study, as the study team moved into the technical evaluation and looking at different potential approaches to how the model might be improved.

CHAPTER 3: TECHNICAL REVIEW OF THE 2007 MODEL AND RECOMMENDATIONS

The technical model review portion of the study looked at how the 2007 model functioned from a technical and methodological perspective. This review evaluated whether or not each of the model inputs / steps were achieving their intended goals and if the model was constructed in a manner consistent with best practices.

This review included an evaluation of the model documentation, input files and script files. The first purpose of the review was to gain a full understanding of how the 2007 model addressed trip generation, trip distribution, mode split and traffic assignment. Once the model processes were understood, the model review moved to an evaluation of:

- The accuracy and consistency of the model application procedures and parameters.
- How the procedures and parameters fit with standard forecasting practice.

As documented in this report, following the study team's review of the 2007 model it was recommended that the model be updated to address some of the issues identified in this chapter. Those recommendations are currently being implemented and the model is in the process of being updated to a 2010 base year and addresses nearly all of the technical issues identified with the 2007 model.

This chapter is organized so that there are separate discussions for each step of the model review. For each subsection, some background discussion of each of the travel model elements is provided for context.

MODEL FILES REVIEW

The review of the 2007 model files was completed in a sequential order that followed the model job stream. Thus, the observations are presented in a step-wise order consistent with model execution. The issues are presented below by subsection. Each of the model review topics includes study team analysis and opinions and summary of the discussions between consultant, ATAC and MPO staff during the model review.

Network Travel Times

In the 2007 Bismarck-Mandan model, network travel times were estimated for all of the possible trip origins and destinations across the Bismarck-Mandan region. Travel times were the main "impedance" value in the model, meaning that the higher the travel time is between two traffic analysis zones (TAZ), the higher the cost of the trip and the lower the desire / likelihood of making the trip. Speeds were coded onto each link in a corridor, and these speeds were the starting point for determining the travel time between TAZs. Initial speeds reflected uncongested / "free flow" conditions and the model adds time based on estimated congestion.

An additional modeling factor that typically goes into calculating model travel time is **terminal time**. Terminal time is the extra out-of-vehicle time that occurs at the beginning and end of trips, such as time spent parking the vehicle and time spent walking between the ultimate trip end (home, office building, store, school, etc.) and the vehicle. The 2007 Bismarck-Mandan model included terminal time estimates.

Issue Discussion:

Input model speeds for the 2007 model were based on a speed study completed by ATAC in 2000. The 2007 model documentation indicated that global speed adjustments were made to these observed speeds during the validation process to complete network-wide adjustments to travel time, which effected the model's trip distribution and traffic assignment volumes.

During the review of speeds and capacities used in the street and roadway network, the most significant issue observed was speeds on Interstate highways. Interstate speeds were coded in the 2007 model network significantly lower than the posted speeds on these facilities, with model input speeds on I-94 ranging from 42 miles per hour (mph) to 47 mph for both the rural and urban portions of the MPO area. I-194 / Hwy 810 freeway segments on the Mandan side of the river had model input speeds that ranged from 35 to 37 mph. Through our experience on the interstate in the region, operating speeds are much closer to the posted speeds of 55 to 75 mph. None of the other facility types had this large of a discrepancy from actual field travel speeds.

In addition to freeway speeds, a few issues were discovered in regards to the terminal times used in the model.

- Terminal times are typically applied based on area type (rural, suburban, urban, central business district) and that was the intent in the 2007 Bismarck-Mandan model. The review found locations in the 2007 model where the terminal times used did not fit an area type pattern. Additionally, several TAZs did not have terminal time applied (terminal times were missing for TAZs 188 through 200 and TAZs 240 through 248 were assigned terminal times of 0).
- Some of the TAZs had an extra 30 seconds of terminal time added on the destination end of the trip, to represent the time spent parking the vehicle. ATAC staff based this approach on data they had from Fargo. The concept of more destination terminal time is logical, but the practice was not uniformly applied across the 2007 model network.

Origin and destination terminal times by TAZ for the 2007 model are illustrated in Figures 1 and 2.

Technical Recommendations for Travel Time:

- Input speeds on the Interstate system should be significantly closer to posted / observed speeds.
- Terminal times should be applied consistently and logically based on a defined area type.
- Future model updates should document and standardize application of 30 second extra terminal time on the destination side of the trips. If no basis exists for its application to a TAZ, eliminate the extra 30 seconds.
- Review how terminal times affect trip length distribution by area type. In the central parts of Bismarck and Mandan, the relatively high terminal times in the 2007 model forced some relatively short distance zone-to-zone trips to have high travel times, potentially making them less likely to occur than may be reasonable.

Trip Generation

The trip generation step of the model determines how many and what type of person or vehicle trips are being made for each TAZ. Trip generation is directly tied to a TAZ's land use type and land use intensity. In the 2007 Bismarck-Mandan model, there were three trip purposes:

- Home-based Work (HBW)
- Home-based Other (HBO)
- Non-home based (NHB)

Trip generation models consist of two elements: trip productions and trip attractions. Trip productions are typically tied to the traveler's home, while trip attractions are tied to the traveler's non-home end of the trip (school, shopping, work, leisure, etc.).

Trip production rates in the 2007 Bismarck-Mandan model were based on national default data available from National Cooperative Highway Research Program (NCHRP) Report 365, *Travel Estimation Techniques for Urban Planning*. This document is widely used in the travel modeling community as a starting point for developing travel models in urban areas without travel survey data, such as Bismarck-Mandan. The 2007 model trip attraction rates were also based on data available in NCHRP 365.

Issue Discussion:

Table 1 is taken directly from ATAC's 2007 *Model Construction and Calibration* report, and illustrates that the trip production model is set up to use parameters that vary trip production rates by household size. Single-person households generate 3.7 daily trips. Households with 5 or more people in them generate 16.6 daily trips[1]. The intent of the trip production data cited in NCHRP 365 is that the unique household size characteristics of each TAZ will allow for different trip production rates across the metropolitan area. TAZs that have a higher proportion of large household sizes will have greater average trip production rates than TAZs that have a lower proportion of large household sizes.

1 The trip production rates that are cited in Table 1 are the weighted average **person trip** rates for metropolitan areas with populations between 50,000 and 199,999. Table 5 in NCHRP 365 also provides differing trip production rates by household income levels, which were not used in the Bismarck-Mandan model.

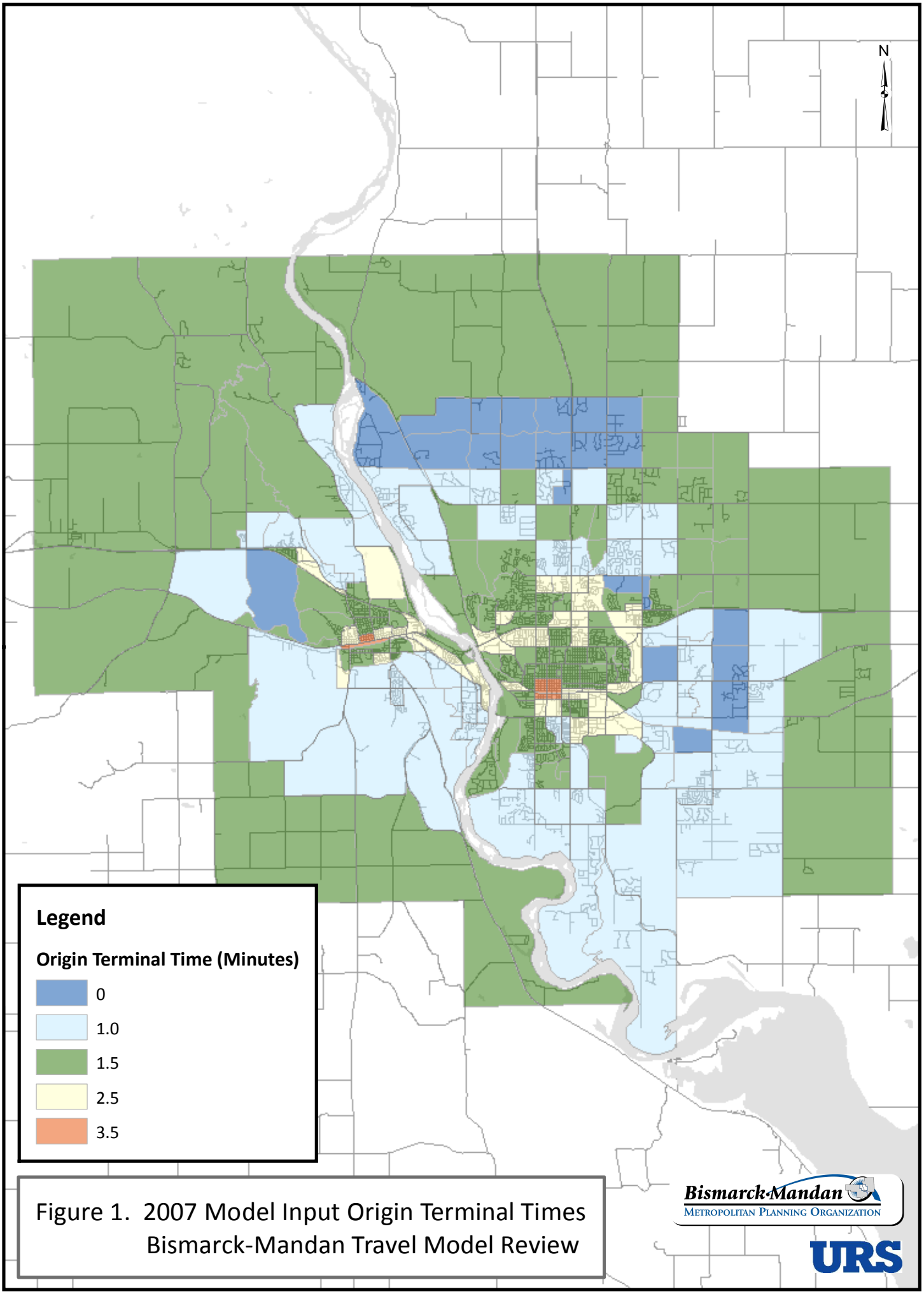


Figure 1. 2007 Model Input Origin Terminal Times
Bismarck-Mandan Travel Model Review

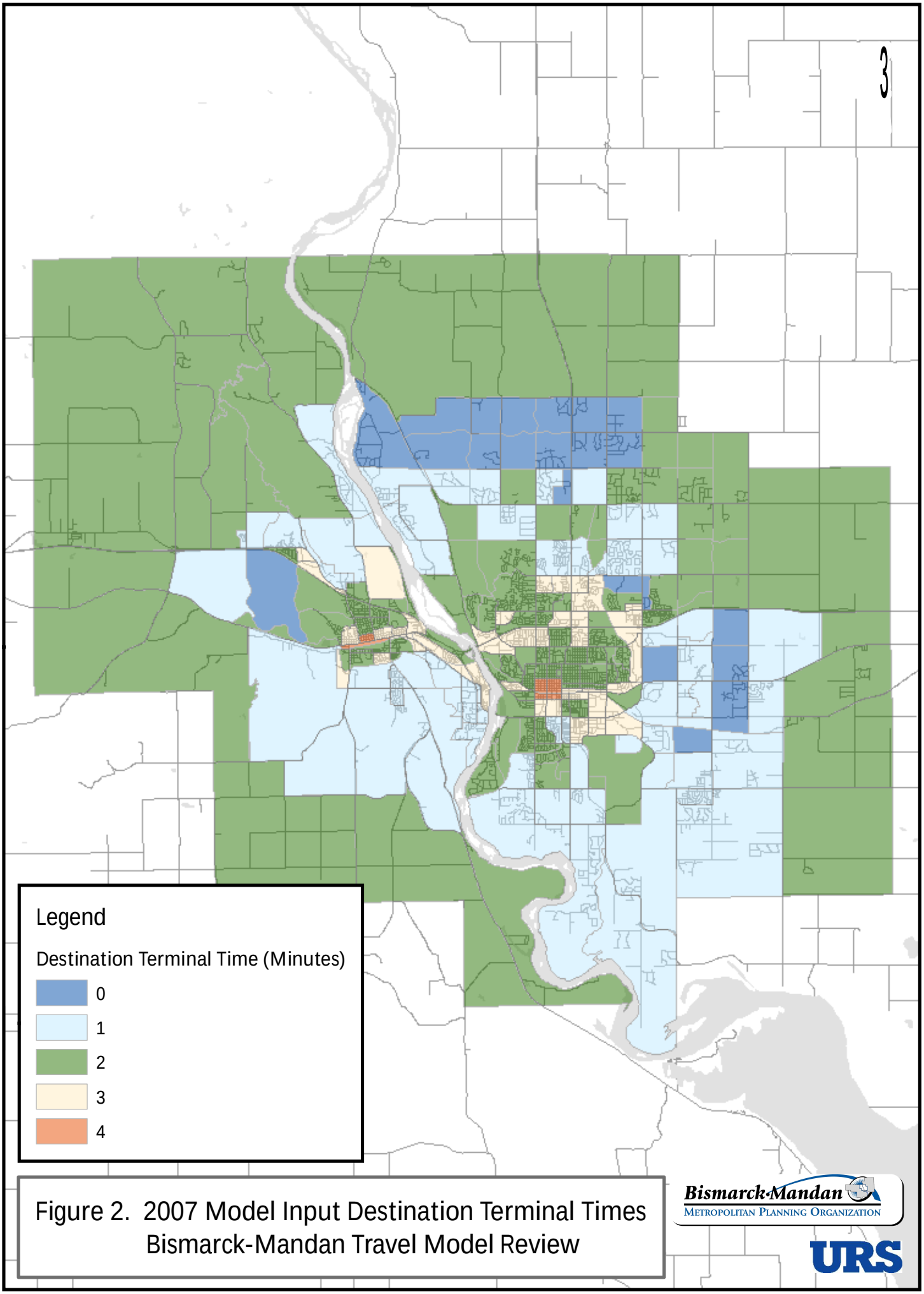


Figure 2. 2007 Model Input Destination Terminal Times
Bismarck-Mandan Travel Model Review

Table 1. 2007 Bismarck-Mandan Model Trip Production Rates

Household (HH) Size	HH in Each HH Category	Average Daily Person Trips Per HH	Average Daily Person Trips By Purpose		
			HBW	HBO	NHB
1	28.0%	3.7	20%	54%	26%
2	34.5%	7.6	22%	54%	24%
3	15.6%	10.6	19%	56%	25%
4	14.0%	13.1	19%	58%	23%
5+	7.9%	16.6	17%	62%	21%

Source: NCHRP 365, Report 365, Table 5 (3).

The first trip generation issue identified in the 2007 Bismarck-Mandan model was that the sliding scale trip production rates by household size were not applied. The way the 2007 model was set up, every TAZ was producing approximately 8.4 trips per household, regardless of how many 1-, 2-, 3-, 4- or 5+-person households were actually located in that particular TAZ. As constructed in the 2007 model, this likely led to too many trips being generated in areas with lower household sizes, and not enough trips being generated in areas with larger household sizes.

Trip generation is the foundation of this and any travel model, as all of the subsequent steps rely on trip generation estimates. Errors that occur during the trip generation module carry over into the later steps, and potentially force modelers to make unwarranted adjustments to "correct" for the earlier trip generation error.

A separate issue identified with the 2007 model trip generation rates was the lack of clear distinction between person trips and vehicle trips. Travel models are either person-trip based or vehicle-trip based:

- Person-trip based model: Trips are generated and distributed for individual travelers, and then these trips are split into the various modes of travel (auto, bus, bike, walk), or auto occupancy rates are applied to the person trip data to estimate vehicle trips. A typical auto occupancy rate for all trip purposes combined would be approximately 1.50.[2]
- Vehicle-trip based model: Vehicle trip-based models use trip generation rates set up for vehicle trips, and auto occupancy rates are already accounted for in the trip generation rates. Thus, if we assume an average auto occupancy rate of 1.50 persons / vehicle, a household that produces 9 person trips per day would produce 6 vehicle trips per day (6 vehicle trips x 1.5 persons per vehicle = 9 person trips).

NCHRP 365 trip rates in Table 1 are intended to estimate *person trips*. In the Bismarck-Mandan model, the person trip rates were applied without a subsequent mode split / vehicle occupancy adjustment that would convert them to *vehicle trips*. The 2007 model construction and calibration report discussed the modeling of **person** trips, consistent with how NCHRP 365 presents the trip generation rates it provides. The 2007 model documentation incorrectly reported trip generation in terms of person trips, and based on interviews with ATAC staff the intent was to generate **vehicle** trips. Through ATAC's 2007 model validation process, they determined that the NCRHP 365 person trip rates more closely matched vehicle trip rates in Bismarck-Mandan. Thus, ATAC applied the rates as vehicle trip rates rather than person trip rates in the 2007 model. This means that households in 2007 Bismarck-Mandan model were generating approximately 50 percent more vehicle trips than the national averages provided in NCHRP 365. This was a rather large discrepancy considering there was not any data or documentation provided to support applying such high trip generation rates.

Technical Recommendations for Trip Generation:

- The most critical element in the 2007 model was lack of consistency in its treatment of trip generation rates as either person trips or vehicle trips. Models that use the NCHRP 365 person trip rates should treat them as person trips, and should add an auto occupancy factor that converts auto person trips to vehicle trips. It was recommended that the model update develop auto occupancy factors from Census, American Community Survey (ACS) and National Household Transportation Survey (NHTS) sources, and potentially from similar metropolitan areas' travel survey results.
- The next model update needs to apply 2010 Census / ACS household data at the TAZ level to provide area-specific values for household size. This allows the model to have significantly improved, more accurate trip generation rate detail.
- Future model updates should consider applying a second "cross-classification" variable, such as an income or auto ownership variable to provide enhanced trip production rate sensitivity. These approaches are also documented and available in NCHRP 365, and Bismarck-Mandan specific data for cross-classification will also be available from Census / ACS data sources.
- Future travel model updates look for local data sources regarding special generators

2 NCHRP 365, Table 37.

(Bismarck State, University of Mary and the airport). All three of these special generators (particularly U of M and the airport) have unique driveway access in and out and counting vehicular traffic into / out of each should be relatively straight-forward.

- The MPO should consider administering a travel survey in the future to get local information on trip production and attraction rates, and getting information on origins and destinations in the metropolitan area.

External Travel

Not all trips within Bismarck-Mandan are made by residents. Some trips have one trip end inside the region, one trip end outside of the region – these are internal-to-external (I-E) or external-to-internal (E-I) trips. Other trips travel through the region but do not start or stop in the region - these are external-to-external (E-E) trips. The model treated each of these as a separate trip purpose and balances I-E/E-I trips separately from the HBW, HBO and NHB trip purposes.

Issue Discussion:

The 2007 Bismarck-Mandan model assumed that 10% of trips at the model cordon for I-94 and US 83 were through (E-E) trips. The remaining trips were all I-E/E-I trips, 80% of which were assumed to be external trip productions (home outside of Bismarck-Mandan with work, shopping or school destinations within Bismarck-Mandan) and 20% of which were assumed to be external trip attractions (Bismarck-Mandan residents working / shopping / school trips outside the region). I-E/E-I travel was then considered as a separate trip purpose during trip balancing, where attractions and productions were made equal prior to trip distribution.

Technical Recommendation for External Travel:

In the trip balancing process (where trip productions and attractions are normalized to one another by purpose), it is recommended that the updated model to allocate the internal-to-external (I-E) trips to the standard three trip purposes (HBW, HBO and NHB). This would entail adding a step where I-E/E-I trips are assigned to a trip purpose, adding those I-E/E-I trips to the I-I trips by purpose and then scaling all HBW and HBO attractions to productions and NHB productions to attractions. Thus, both I-I and I-E/E-I trip productions and attraction totals combined will be part of the production/attraction balancing factors. This is consistent with the trip balancing methodology described in NCHRP 365 on page 33.

Trip Distribution

The trip distribution step of travel modeling estimates the starting and ending points for trips by linking the trip productions and attractions established in the trip generation step. The product of trip distribution is a set of trip interchanges between each TAZ pair. Consistent with most regional travel demand models, trip distribution was accomplished in the 2007 Bismarck-Mandan model through application of the Gravity Model. The Gravel Model estimates the number of trips between two TAZs to be directly proportional to the *attractiveness* of each TAZ and inversely proportional to the *distance or time* (also referred to as "friction") separating the two TAZs.

In the 2007 Bismarck-Mandan trip distribution module:

- Attractiveness was measured by the number of productions and attractions in each TAZ. Productions and attractions were broken up into the three trip purposes previously described, so that a HBO trip will link a HBO production to a HBO attraction.
- Friction was measured by how much time it takes to travel between the two TAZs. Friction factors are a set of impedance variables that models use to quantify the effects of travel time. Thus, friction factors should have an inverse relationship with time; as travel time increases the desirability of the trip decreases. This represents the assumption that all else being equal, travelers will chose a shorter trip over a longer trip.
- K-factors were used extensively in the 2007 Bismarck-Mandan model to modify the trip distribution outside of the framework of the attractiveness and friction considerations. K-factors are typically thought of as social factors that influence individuals' travel decisions beyond the model's quantifiable time and attractiveness variables. State lines and major river crossings are typical applications for K-factors.

Issue Discussion:

There were two primary issues that we observed in the trip distribution element of the 2007 travel model as it was applied. The first issue is with the **friction factors** that were used in the Bismarck-Mandan model. ATAC staff developed the dataset through an iterative process of adjusting friction factor values until the model output trip length distribution matched local data. Adjusting friction factor values so that the gravity model provides trip lengths that match local trip length data is common practice. However, the means by which the 2007 friction factors were adjusted was not typical and does not fit with expected driver behavior. The 2007 Bismarck-Mandan model friction factors are illustrated in Figure 3. As illustrated in Figure 3, the 2007 friction factors were somewhat "choppy" at some locations along the curve between 3 minutes and 30 minutes.

While it is typically accepted practice to adjust the shape of the downward sloping friction factor curve (through adjustment of the parameters in the gamma function) for validation purposes, dips and peaks over the course of the curve are not thought to be reasonable representations of driver behavior. Based on the 2007 model factors, commuters would prefer to make a 12 minute work trip rather than a 5 minute work trip. Without an area-specific survey to support this assertion, this situation is not standard practice.

The second trip distribution issue was with the use of **K-factors** in the 2007 model. In the gravity model, K-factors were applied for four (4) different geographic areas in the model. Figures 4 through 7 illustrate how the K-factors were applied[3]. The 2007 model K-factors used were:

- Interstate 94: illustrated in Figure 4. The K-factor used for trips crossing I-94 was 1.4. K-factors greater than 1.0 increase trip attractiveness.
- Missouri River: illustrated in Figure 5. The K-factor used for trips crossing the Missouri River was 0.24. K-factors of less than 1.0 decrease trip attractiveness.
- Urban Bismarck ("Downtown") Cordon: ATAC has established a cordon line that represents most of urban Bismarck, illustrated in Figure 6. The K-factor used for trips into / out of the cordon was 1.5, which increased the trip attractiveness to cross the cordon.
- BNSF Railroad Tracks: illustrated in Figure 7. The K-factor used for the railroad tracks was 1.0, and has no effect on trip attractiveness.

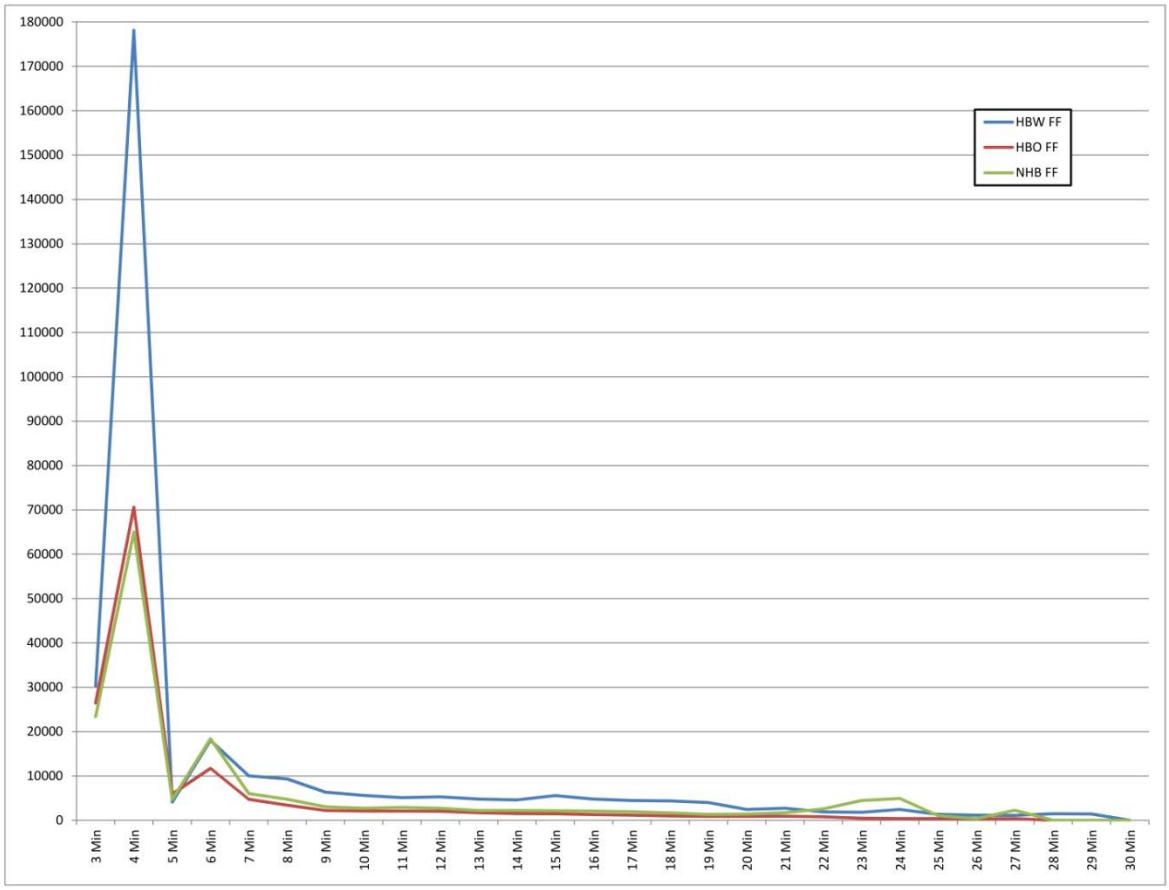
Typically, K-factors are intended to be a special case adjustment factor that is used to account for social barriers to travel that cannot otherwise be accounted for in the Gravity Model. The 2007 Bismarck-Mandan model employed K-factors extensively. They are typically viewed as a tool of "last resort" after all other possible causes for error and validation measures have been assessed[4]. If no other validation measures (trip generation rates, travel speeds, volume-delay curve relationships, etc.) reasonably explain the travel pattern across a major geographic or political barrier such as the Missouri River, many travel modeling practitioners believe it is valid to apply a K-factor. The other K-factors that were used in the 2007 Bismarck-Mandan model (I-94, downtown, railroad) did not reflect these major barriers and were likely adjustments for items that would have more effectively been corrected in the earlier modeling steps (such as trip generation). In addition to the 2007 model's K-factor over-use, specific issues that the study team believed needed to be addressed in a model update included:

- K-Factors were applied in an overlapping manner for all screenlines, such that crossing I-94, the river and the "downtown" cordon was the product of all three sets of K-factors. This compounded the issue of the K-factors' overuse.
- The 2007 K-Factor at I-94 screenline was only applied for one direction. In a daily model, the K-factors should be balanced by direction as every trip that crosses a K-factor cordon one direction, crosses the cordon in the other direction by the end of the day.
- There were some minor errors in assigning the K-factor geographic flags for the Missouri River Crossing and I-94, as shown in Figures 5 and 6.

3 The TAZs with differing geographic "flags" have the K-factors applied, and those with the same K-factor flag do not have K-factors applied.

4 *Travel Model Validation and Reasonableness Checking Manual*, 2nd Edition, Travel Model Improvement Program, 2010.

Figure 3. 2007 Model Friction Factors by Trip Purpose



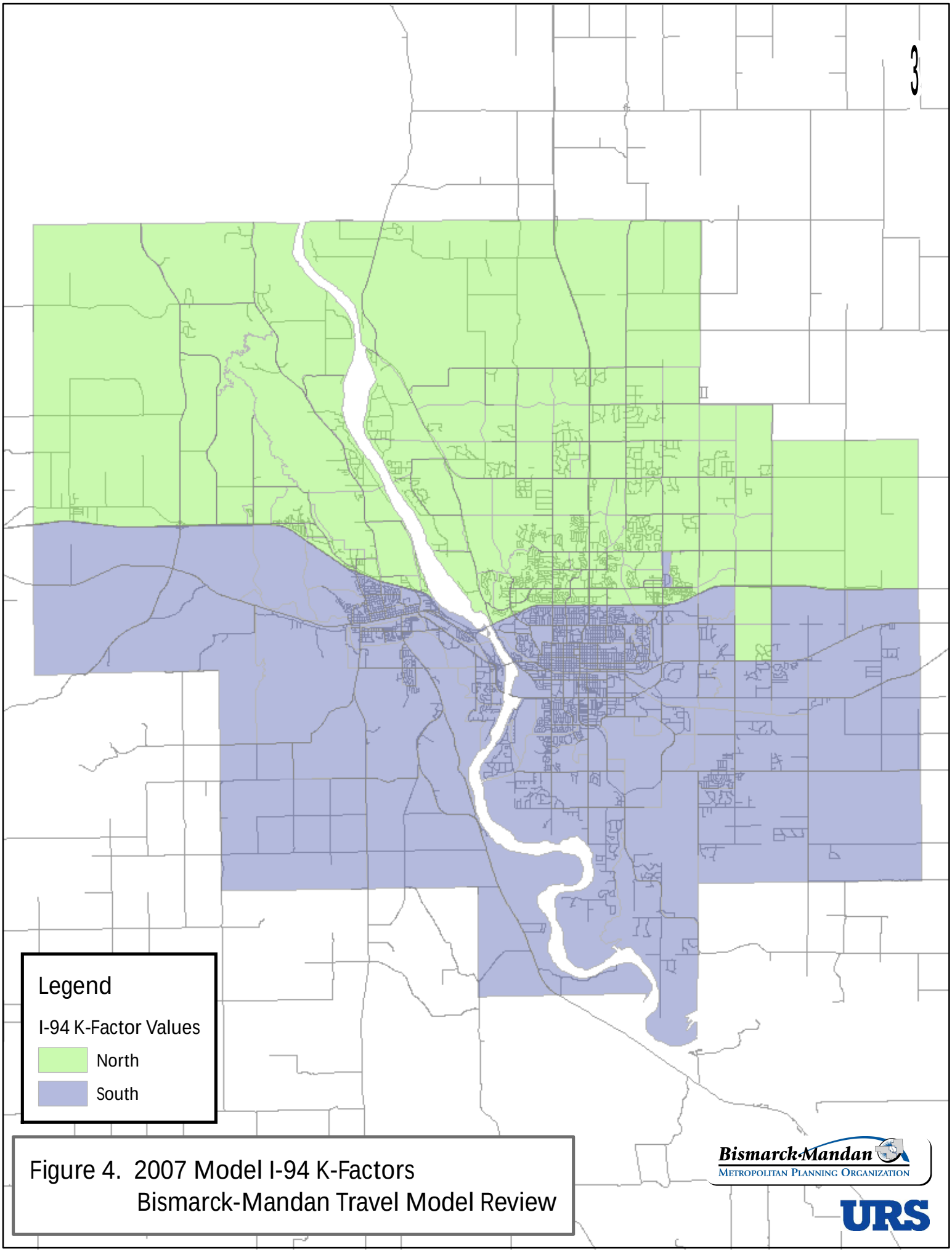


Figure 4. 2007 Model I-94 K-Factors
Bismarck-Mandan Travel Model Review

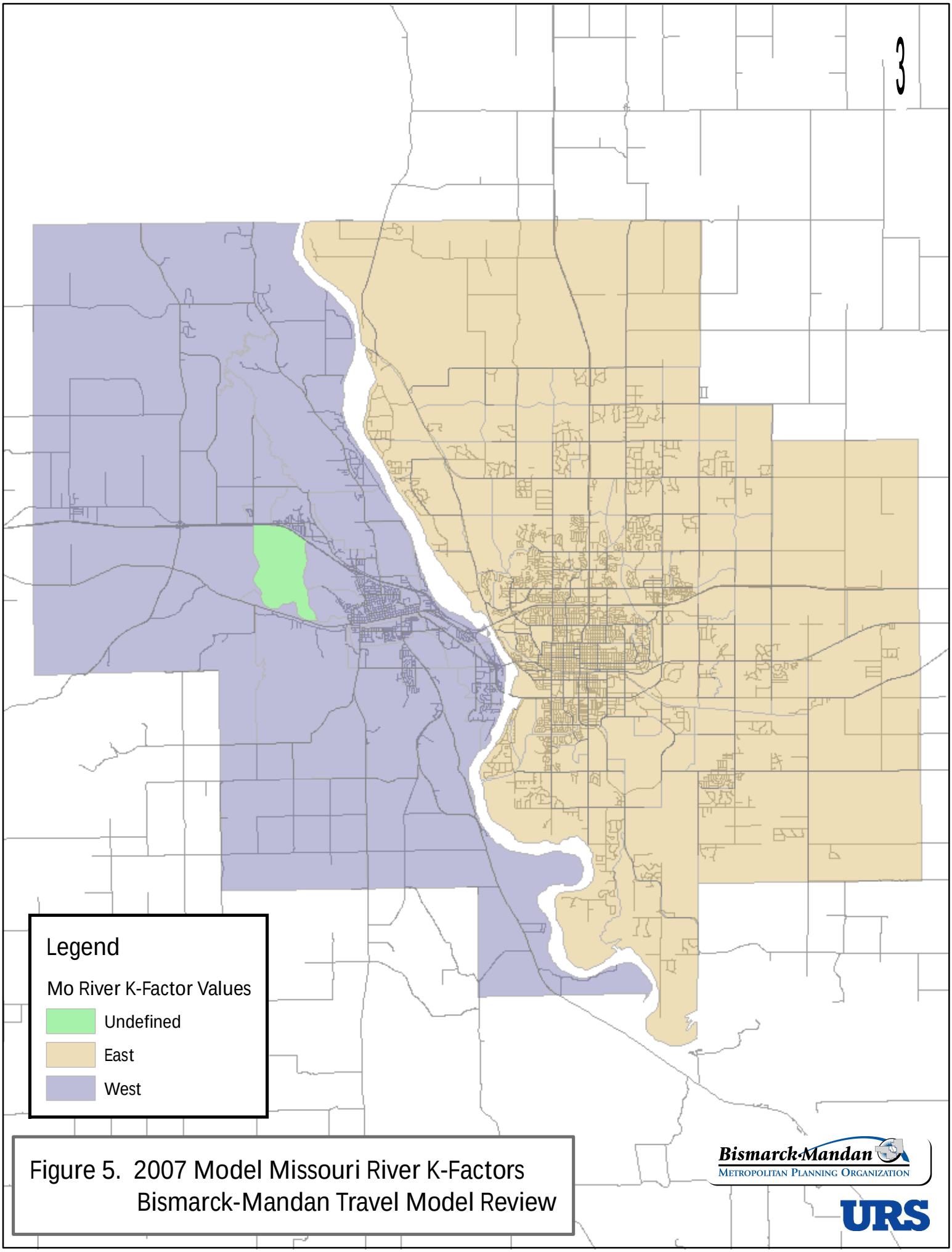


Figure 5. 2007 Model Missouri River K-Factors
Bismarck-Mandan Travel Model Review

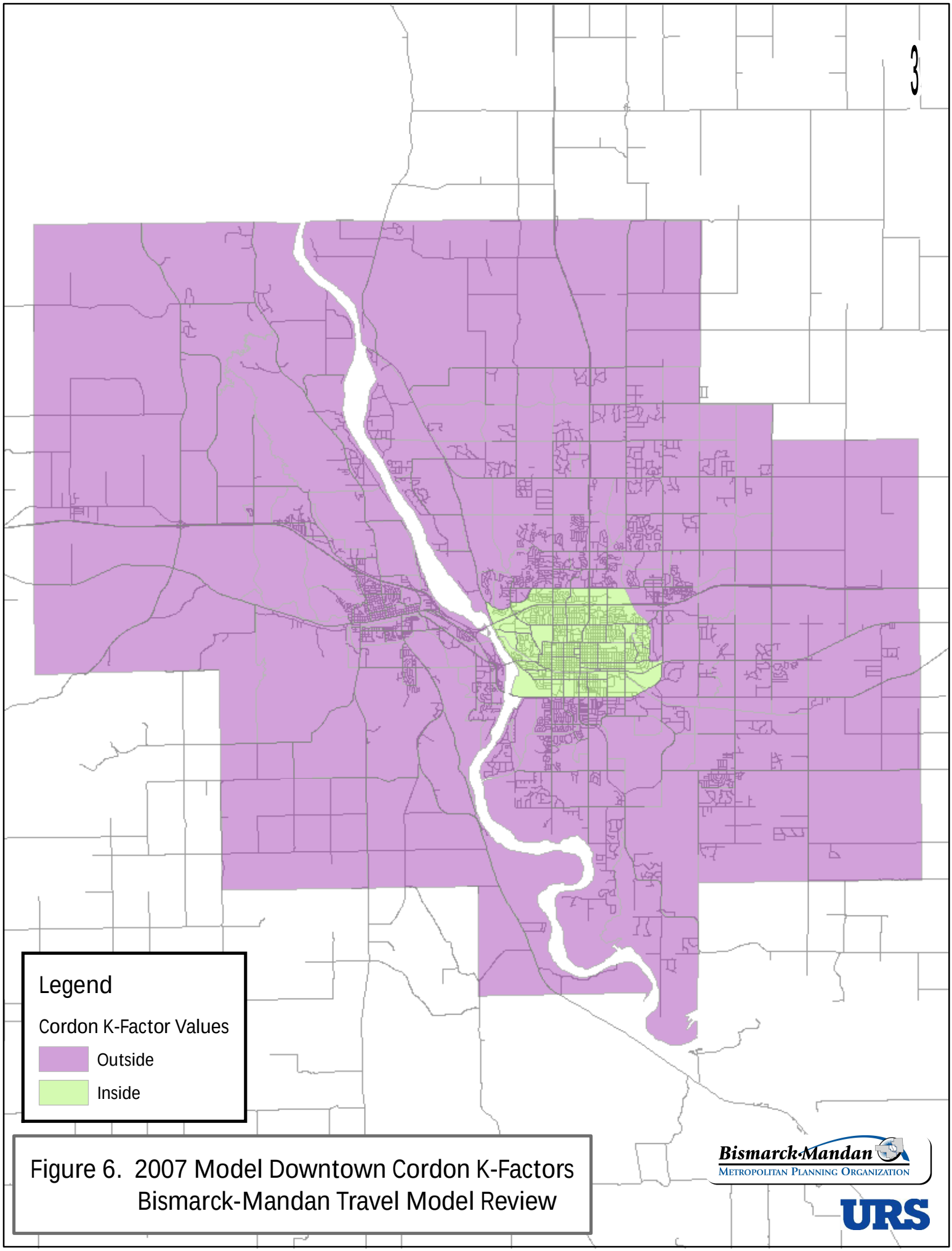


Figure 6. 2007 Model Downtown Cordon K-Factors
Bismarck-Mandan Travel Model Review

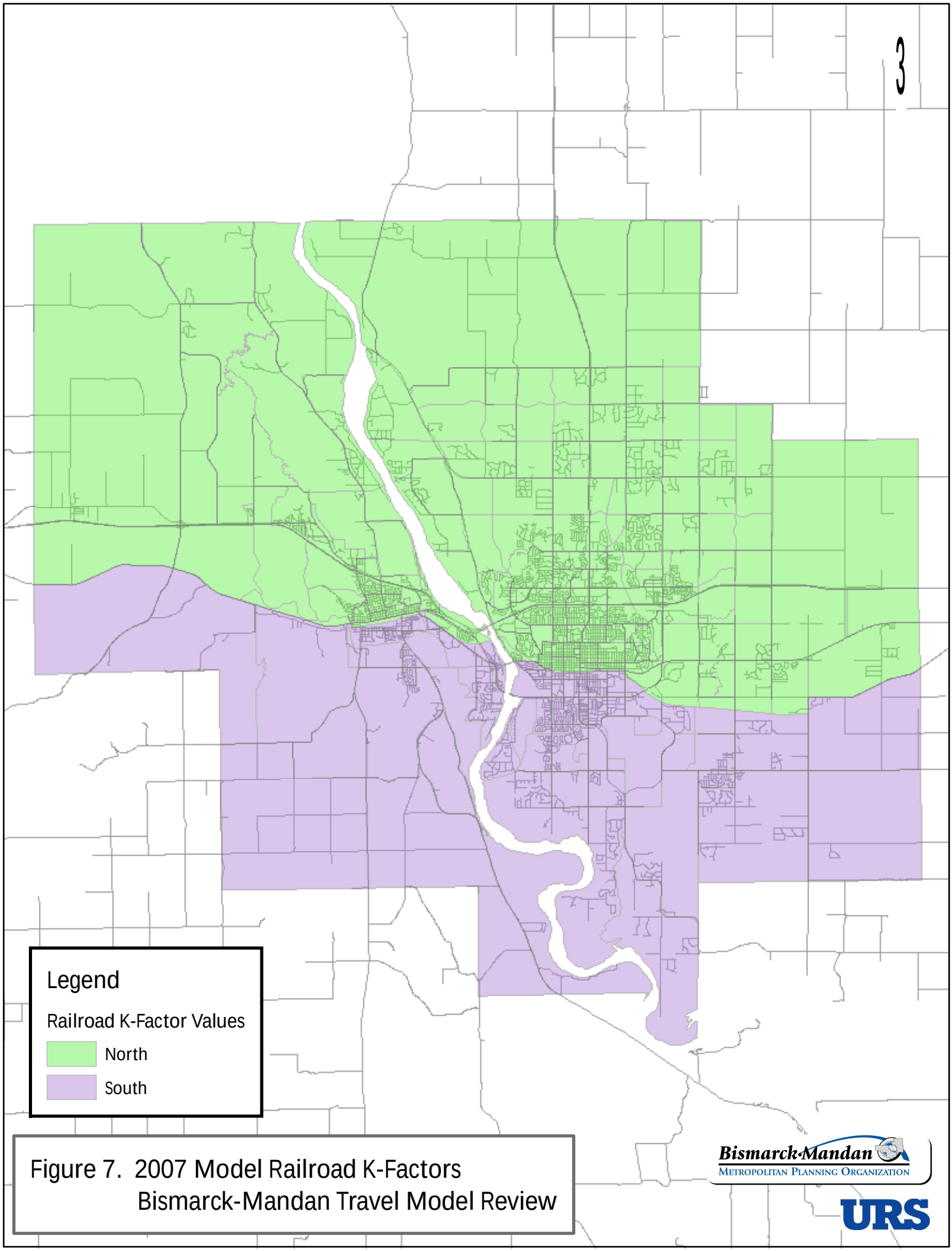


Figure 7. 2007 Model Railroad K-Factors
Bismarck-Mandan Travel Model Review

Technical Recommendations for Trip Distribution:

- For the model update, friction factors need to be developed based on a set of values that peak at 5-minutes or less and then consistently decrease in value as travel time increases. The gamma function is a widely accepted method for developing friction factors that resemble realistic driver behavior, with *b* and *c* parameters that can be calibrated to more closely match local trip length distribution patterns.
- For the model update, K-factors should be used as a model validation "last resort" after all other reasonable validation measures have been completed. These other reasonable validation measures include adjusting trip production and attraction rates, friction factor function is calibrated to observed trip patterns, volume-delay curves adjusted to reflect local observed travel conditions, etc. When overused, K-factors degrade the model's ability as a forecasting tool by diluting the basic spatial and trip making relationships planners intend to model. It is also emphasized that K-factors should also only be applied only where it makes sense that there is a logical "social factor" that influences travel that cannot be otherwise represented with model parameters. In our experience in the Bismarck-Mandan region, the one location where an updated travel model might consider a K-factor is the Missouri River crossing between Burleigh and Morton counties. The 2010 model update will consider a K-Factor at the Missouri River between Burleigh and Morton Counties if other validation measures cannot capture the observed travel across the river.
- A local travel survey, in addition to providing trip generation information, would provide valuable trip distribution information such as origins and destinations and trip lengths by trip purpose.

Traffic Assignment

Traffic assignment is the model step that determines the routes that all of the trips across the model will take. The traffic assignment methodology employed in the 2007 Bismarck-Mandan travel model used an equilibrium assignment methodology with a single feedback loop. The equilibrium assignment approach is a standard methodology employed by similarly-sized MPOs across the country, and takes into account estimated congested travel times based on traffic volumes. Equilibrium assignments go through multiple iterations of assignments and recalculate travel times for each iteration based on the congestion observed. The equilibrium assignment process iterates until it reaches "convergence", whereby no trips can have a shorter travel time by changing routes. After the equilibrium assignment was completed in the 2007 model's "initial loop", the congested times (also known as "skims") from the assignment module were fed back into the trip distribution step module and the distribution of trips is modified. This "feedback" process attempts to reflect that travelers make their trip destination decision based on congested travel times.

Issue Discussion:

The feedback loop was incorporated into the 2007 Bismarck-Mandan model to ensure that trip distribution considered congested travel times when trip destinations were estimated. The simple feedback loop utilized in the 2007 model provided single-iteration congested travel times for the second (final) iteration. ATAC did not document the sensitivity of the 2007 model between the first and second iterations in terms of the changes in model traffic assignments or in model travel times.

Many travel models utilize a more complex assignment approach that incorporates multiple feedback iterations of the trip distribution (and sometimes trip generation and mode choice) model step(s) in the model input speeds and travel times. The method of successive averages (MSA) assignment is a common way of achieving this. Congested speeds and travel times from each iteration serve as inputs to the next iteration, and often times assigned traffic volumes are averaged from one iteration to the next. Each successive loop is a feedback from the preceding model. The process continues until some convergence criteria are met; typically these criteria are met and the feedback loop stops when volumes and / or travel times do not change significantly from one iteration to the next.

Technical Recommendations for Traffic Assignment:

A feedback loop in the model may not be necessary, as the 2007 model was a daily model that estimated

little congestion across the network. On the other hand, the 2007 model's simple, single-loop feedback approach might be perfectly acceptable, due to both the limited amount of congestion observed in the Bismarck-Mandan travel model, and the model's use of daily volumes and capacities. There was not an investigation of how much the 2007 model results changed between the first (uncongested skim) assignment iteration and the second (congested skim) assignment iteration, so the was no way to gauge if this approach was sufficient or not.

It was recommended that if a feedback loop were maintained in the 2010 model update, ATAC would document summary statistics of the link-by-link changes in travel times and traffic assignments between the first and second iterations. If there were a significant level of change between iterations (for instance, if 5% or more of the links have travel times or volumes that change by 5% or more), it would possibly be worth considering additional iterations and averaging the results of each.

In addition to Technical Recommendations for the 2007 model, recommendations were made **regarding File Organization** and **Model Technical Documentation**. Those recommendations were outlined in a technical memorandum to MPO staff and the model review working group on July 7, 2011.

Summary

Based on the study team's technical review of the 2007 Bismarck-Mandan model, there were several items that needed be addressed and corrected immediately so that the regional travel model would be a more reliable product. The highest priority issues identified by the study team that needed to be addressed in the immediate model update were:

- **Trip Generation:** First, NCHRP 365 rates should be used as person trip rates, as they are intended, and adjust them to vehicle trips by applying locally-applicable vehicle occupancy rates. Second, the Bismarck-Mandan trip production function should be applied as it was intended and vary trip production rates by household size. TAZ-specific values have to be developed and applied for household size in the Bismarck-Mandan model update.
- **Friction Factors**: Friction factors typically represent the assumption that, with all else being equal, travelers will choose a shorter trip over a longer trip. This was not the case at several time slots in the 2007 Bismarck-Mandan model friction factor curves, reflecting a preference in some instances to travel a longer time.
- **K-factors**: In the 2007 gravity model, K-factors were applied extensively across the model, which is generally not a common practice. It was recommended that all K-factors except the Missouri River screenline be eliminated in the model update. If possible, the Missouri River K-factor should be eliminated as well. Furthermore, any K-factors that are applied need to have the same value for both directions of travel.
- **Auto Occupancy Factoring**: Consistent with treating the NCHRP 365 trip production and attraction rates as *person trips* not *vehicle trips*, as they are intended, it is recommended that auto occupancy factoring be incorporated into the Bismarck-Mandan travel model update, following the trip distribution step. Sources of data that provide relevant local data for the occupancy factors are available from the US Census and from the National Household Transportation Survey.

The number of issues, inconsistencies and errors that were observed with 2007 model was to a level that it was recommended an immediate model update and revalidation take place.

TECHNICAL REVIEW ACTION

Based on the findings of the technical model review and recommendations, the Bismarck-Mandan MPO and ATAC, along with URS Corporation, initiated a model update and revalidation starting in September 2011. The model update started with a 2010 base year using updated Decennial Census data and employment data from InfoGroup. The previous problematic model input parameters and approaches documented in this chapter were eliminated, and new sets of inputs were used, using local and national sources of data as a starting point, including:

- 2009 National Household Transportation Survey data.
- NCHRP 365 Travel Estimation Techniques for Urban Planning.
- TMIP Model Validation Reasonableness Checking Manual, 2nd Edition.
- 2010 US Census Data.

A model validation process was established that examined model parameter performance at each modeling step. Adjustments were made to the parameters within a reasonable range. A full documentation of the validation for the 2010 model update process will be provided by ATAC in a Model Validation Report.

CHAPTER 4: MODEL ENHANCEMENT ALTERNATIVES

In the initial portion of the Model Review Study, the study team met with and discussed the Model Review Working Group and other model users' experiences with the model, including issues, problems, things that were missing or could be improved and positive impressions. The results of these meetings and interviews were documented in Chapter 2. The study team then identified potential model enhancement alternatives that could address these issues, and provided some evaluation of each option. The discussion of alternative enhancement options was conducted with the ultimate goal of:

- To first provide local model users an evaluation of the various model enhancement options.
- Then to work with the study group to determine the feasibility and priority for implementing some of the enhancement options.

The enhancement alternatives were reviewed with the local users to get an assessment of how each might get used, and to get an idea of what priority the users would place on each. The alternatives enhancement step discussed in this chapter provides a summary of the model enhancement options, based on interviews of model user needs and issues. This chapter also provides an evaluation of some of the decision considerations, and data sources for the model enhancement alternatives.

ALTERNATIVES CONSIDERED

The following alternatives were considered for enhancements to the existing, vehicle-based daily traffic model for the Bismarck-Mandan area:

- Time of Day Modeling: Time of day models consider travel time and flows during peak periods relative to off-peak period. The model currently completes a daily traffic assignment only.
- Freight Component: A freight component would allow the forecasting of freight system demand, which is not currently included in the Bismarck-Mandan model.
- Enhanced Economic / Land Use Forecasting Model: This enhancement would quantitatively asses several development variables such as transportation accessibility, proximity to infrastructure to develop land use forecasts. These forecasts can also test development sensitivity transportation investments.
- Mixed-Use Development Trip Sensitivity: Enhances model sensitivity to the trip rate reductions associated with mixed-use developments.
- Transit Component: Also known as "mode choice" component, this would allow the model to allocate person trips between automobiles and transit.
- Non-Motorized Travel Component: Allows the model to estimate walk and bicycle travel.
- Trip Distribution Enhancements for Special Generators: This model enhancement would provide unique distribution parameters for special generators, such as constraining origins and destinations according to survey data or an attendance area for schools.
- Policy Sensitive Model Components: Models with an expanded set of input parameters can have the capability to evaluate travel effects of policies like tolls, parking costs, economic development impacts, demographic changes, gasoline prices and HOV lanes.
- Traffic Assignment Enhancements: Advanced models can implement more detailed traffic assignment approaches that look at small slices of time, evaluate the effects of queuing on downstream intersections and more accurately model individual drivers' choices.

Table 2 provides a summary of model enhancement options that were discussed with the Model Working Group. For each potential model enhancement there is discussion included on:

- A description of the model enhancement option.
- Additional discussion of the option, pros / cons, etc.
- An initial assessment of the data sources available for developing the enhancement option. This column also provides a general assessment of the potential sources of data from peer communities that could be borrowed, and how much local data collection would be required.

Table 2. Summary of Model Enhancement Options Considered

Model Enhancement Alternative	Enhancement Overview	Decision Considerations	Data Sources Available
Time of Day Modeling	The Bismarck-Mandan Travel model currently completes a daily traffic assignment. Daily traffic capacity is assumed to be 7.5 times greater than hourly capacity. This approach limits the models' sensitivity to hourly traffic flow patterns and the differences in a given corridor's peak and off-peak congestion / capacity. Peak period / off-peak period modeling allows consideration of travel time and flows during peak periods relative to off-peak periods, when congestion is typically minimal.	Peak period models require more validation effort than current daily model, as peak hour / period model performance needs to be verified against peak hour traffic conditions, such as peak hour traffic volumes and peak hour travel speeds. There are 2 separate validation processes with peak hour modeling, one for time period, one for daily, so it is twice the work for traffic assignment validation. But, this enhancement would provide greater utility for end users.	**Peer Data Transferability:** High. **Local Data Collection Effort:** Moderate. Local traffic counts and peak / off peak travel speed data collection. National and regional datasets, including ITE trip generation. Might require an expanded local traffic counting program from Cities / Counties.
Freight Component	Currently, the Bismarck-Mandan model does not estimate trucks or freight. A freight model component would allow the estimation and forecasting of demands on the freight system. Modeling freight movement allows the region to look at the implications of land use decisions, safety, infrastructure maintenance, economic development and freight-related congestion.	Some past projects might have benefitted from an understanding of freight flows and potential future freight / heavy truck demands. However, truck freight impacts are limited to mainly arterials, so benefits would not be for all facilities. NDDOT and the MPO indicated there may be some benefit to having a freight model. Sources of local truck generation / travel pattern data are limited.	**Peer Data Transferability:** Moderate. **Local Data Collection Effort:** Moderate to High. National resources available for trip generation, and aggregate (state level) commodity flow information. Local data limited, would require some survey or borrowed parameters. ATAC has implemented a freight model in Fargo.
Enhanced Economic / Land Use Forecasting Model	Projections of population, households, and employment (how much regional growth, and where that growth is allocated) are a foundation of travel forecasting. These socioeconomic projections are typically developed without input / feedback to planned changes in the transportation system. An enhanced economic / land use forecasting model would quantitatively evaluate several development variables (transportation accessibility, proximity to infrastructure, development suitability) to develop land use forecasts. The land use development forecasts could then also be "fed back" to see what impact transportation investments have on development levels across the metro area.	Bismarck-Mandan currently uses a land use / socioeconomic forecasting approach within a GIS that reviews several variables (topography, accessibility to infrastructure) to establish land development suitability by subarea. MPO staff then work with planning staffs from the local jurisdictions to manually allocate the regional socioeconomic development increment. Given the smaller, more manageable size of Bismarck-Mandan, the current approach, if well documented, is likely a sufficient general approach for the metropolitan area. Many of the more advanced models are developed for large metropolitan areas with hundreds of development areas that are difficult to manually track, unlike Bismarck-Mandan. An enhanced economic / land use forecasting model might be beneficial for LRTP updates, large sub-area studies and City / County land use planning. The ability to generate scenario-specific land use projections for major transportation facilities may be beneficial (e.g., two different development scenarios at a proposed beltway / I-94 interchange - one with the interchange in place, one where it is not in place.)	**Peer Data Transferability:** Low to Moderate. **Local Data Collection Effort:** Moderate. "Off the Shelf" land use forecasting models are available, like UrbanSim. Current GIS-based development suitability approach provides a good foundation to build an enhanced model. Local data requirements might include an inventory of parcel or TAZ level: jobs by sector, residential types, development densities, building square footage, historical development projects by location, transportation accessibility measures, etc. Much of this information likely exists, just needs to be assembled into the right format.
Mixed-Use Development Trip Sensitivity	Developments that mix land uses (such as office, retail and residential) will have many linked trips that do not leave the development, or are "internally captured". Traditional travel models do not always effectively reflect the internal capture effect of large mixed-use development, depending on the sensitivity of its trip distribution module.	With this component, additional model detail is required that identify and define the characteristics of existing / future / proposed mixed-use developments. While national data are available, local mixed-use developments to validate against are limited.	**Peer Data Transferability:** Moderate. **Local Data Collection Effort:** Moderate. Limited local data to collect. National resources are available for estimating mixed-use trip rates / internal capture rates. Institute of Transportation Engineers (ITE) Trip Generation rates are not helpful - do not consider specific to development characteristics like land use mix and density. A mixed-use model (MXD model) that uses data and parameters from larger metro areas is available. Relevance to Bismarck might be limited?

Table 2. Summary of Model Enhancement Options Considered (Continued)

Model Enhancement Alternative	Enhancement Overview	Decision Considerations	Data Sources Available
Transit Component	The Bismarck-Mandan travel model currently generates vehicle trips, and does not consider trips made by transit. Mode choice would allocate person trips between automobiles and transit. Varying transit module complexities are available. Simple "diversion curve" approach estimates the number of transit trips by TAZ according to independent variables such as development density, autos available, age of population, etc. More complex disaggregate choice models that look at each bus route as a part of the network and look at bus service levels, and determine probabilities that each traveler will choose various modes and technologies.	More effort and data required to construct and validate compared to current auto-only model. Limited current bus ridership (<1% mode share) in Bismarck-Mandan might make this less of a priority. A simple transit element might be beneficial to "screening" potential bus service extensions.	**Peer Data Transferability:** Moderate to High. **Local Data Collection Effort:** Moderate to High. Surveys currently being conducted for TDP update would likely provide some of the information; parameters from other models in medium-sized MPOs could be borrowed. More local surveying would likely be required for a more complex mode choice model.
Non-Motorized Travel Component	Similar to adding a transit component, a non-motorized module would estimate / forecast pedestrian and bike activity. Some approaches will simply estimate a TAZ's percentage of walk / bike trips; more detailed approaches will generate bike / pedestrian trips, distribute them across the network based on a modeled sidewalk and trail network.	More effort and data required to construct and validate compared to current auto-only model, including bike / pedestrian counts or surveys. More detailed bike / pedestrian module likely unnecessary in terms of a benefit-cost perspective. As with transit component, simple bike / pedestrian element might be beneficial to "screening" potential trail / bike lane extensions.	**Peer Data Transferability:** Low. **Local Data Collection Effort:** High. Limited current data available. Significant local data collection required to get useful information on walking / biking.
Trip Distribution Enhancements for Special Generators	Similar to most small-medium metro areas, trip distribution is accomplished in Bismarck-Mandan through application of the Gravity Model. The Gravel Model **estimates** the number of trips between two TAZs to be directly proportional to complementary activities in each pair and inversely proportional to the distance or time separating the two TAZs. Presently, all uses employ the same attractiveness parameters and assumptions. Trip distribution can be refined for special generators (such as schools and the airport) to reflect **actual / surveyed** trip origins and destinations.	The gravity model estimates where trips go from / to based on the number of compatible trip productions (home-based trip end) and attractions (destination-based like shopping, work, school, recreational trip end) and the time it takes to travel between the two. It does not use any local "knowledge" of what the actual travel patterns are between two locations. Employing known / surveyed origin-destination data for some uses will improve overall model trip accuracy.	**Peer Data Transferability:** Low. **Local Data Collection Effort:** Moderate to High. Much of the data is confidential. Schools can provide information on attendance areas and trip distribution can be adjusted accordingly for those uses. Colleges / Universities can provide information on where students live and commute from. An airport user survey could provide a snapshot of where airport trips are coming from.
Policy Sensitive Model Components	More complex travel models can model the travel effects of various policies, such as roadway tolls, parking cost or restrictions, economic development impacts, demographic changes, gasoline prices and HOV lanes. MPOs can "pick and choose" the types of policies they want the model to be sensitive to when building the model.	Policy-sensitive models need to be constructed so that they respond to the various variables that they are intend to measure. For instance, a model that evaluates the effects of parking price on destination choice needs to consider parking cost when distributing trips. The current Bismarck-Mandan model only considers the effect of travel time in its trip distribution function; travel cost is not considered. However, Bismarck-Mandan have limited sets of choices (in terms of travel modes, destinations, etc.) so many policy components would have marginal benefits here. Some policy-analysis capabilities would require a complete model make-over as an "Activity Based" model; a computationally- and survey-intensive approach to travel modeling currently used in much larger metro areas.	**Peer Data Transferability:** Low to Moderate. **Local Data Collection Effort:** Moderate to High. Parameters can be borrowed from other areas, and then adjusted based on local conditions / data (if applicable). Some policy variables will be more readily measured by local conditions than others.

Table 2. Summary of Model Enhancement Options Considered (Continued)

Model Enhancement Alternative	Enhancement Overview	Decision Considerations	Data Sources Available
Traffic Assignment Enhancements	Dynamic Traffic Assignment (DTA) and mesoscopic models were brought up as something the group should discuss. Mesoscopic models bridge the gap between a microscopic model (which looks at individual driver behavior through a detailed transportation network) and the typical regional travel demand (also known as "Macroscopic") models. DTA is a network route assignment approach that is typically based on the mesoscopic model approach, and is essentially a more realistic approach where drivers' route selections are time-dependent and can change from period to period (i.e., "dynamic") and model extensive network details like signal time, corridor delays, queuing and signal coordination.	These advanced traffic assignment approaches are being implemented in some larger metropolitan regions or sub-areas with significant levels of congestion, or with complex travel management conditions such as road pricing or areas that use high-occupancy vehicle (HOV) or high-occupancy toll (HOT) lanes. These do not exist in Bismarck-Mandan. Data collection and model construction efforts are substantial and would only benefit peak hour traffic conditions, reflecting approximately 20% of daily traffic assignment that occurs during the peak periods.	**Peer Data Transferability:** Low . **Local Data Collection Effort:** High. Several layers of Bismarck-Mandan model enhancements would be required prior to implementing advanced traffic assignment methodologies including a peak hour model, intersection control modeling and conducting extensive local travel surveys. Detailed traffic signal data and coding is required, and time of day speed data is necessary for validation. Currently requires significant computing capacity to complete for an entire metro area. This is likely not a component that Bismarck-Mandan will require, or be capable of implementing, for several years.

- Anticipated level of effort to implement and maintain, again in relative low to high terms.

ENHANCEMENTS DISCUSSION

The range of model enhancement options was discussed those members of the Model Review Working group that were in attendance at an August 25, 2011 workshop. The primary purpose of this meeting was to review each of the alternatives with the group, providing details of the pros and cons of each, to elicit a range of input from various user perspectives. The outcome of the workshop was to work with the group to provide a group action recommendation for each alternative.

The group discussion is summarized in the "Enhancement Options Discussion" section. Each option that was discussed also includes the group recommendation for how each of the identified enhancements should be addressed. Based on the discussion and group consensus, each of the alternatives were placed into one of the following action categories:

- **Category #1 - Near Term Implementation:** Implementation of this enhancement should be pursued following completion of the on-going revalidation.
- **Category #2 - Mid Term Implementation:** Implementation of this enhancement should be considered prior to initiation of the public and agency involvement portions of the next LRTP update (anticipated for 2014).
- **Category #3 - No Implementation for Foreseeable Future:** When comparing the level of investment compared to the anticipated benefits / returns, the enhancement does not provide a substantial level of utility for users and/or requires more development effort than the increment of utility it provides. These ideas should be aside from further discussion at this time.

Enhancement Options Discussion

This part of the chapter provides a summary of each enhancement alternative, including the discussion and recommendations that came of out the model enhancement workshop with the Model Working Group. The remainder of this section provides a summary of the discussion for each enhancement component.

Time of Day Modeling

Time of Day Modeling Background:

- Many time of day / peak period models are validated against ONLY daily traffic data. Local data or borrowed data that reflect the percentage of daily trips that occur during peak period by individual trip purpose are often the only peak period data that are applied.
- Any additional peak hour traffic data that can be used to validate and adjust the time of day factors helps increase the validity of the peak hour traffic assignments.
- Presently, there are between 550 and 600 stations for DAILY count collection. The NDDOT provides average daily traffic (ADT) counts for their facilities and the city borrows the NDDOT equipment to supplement key city routes.
- Most of the equipment used by the NDDOT does not have the capability to accumulate to hourly periods. Only those locations where vehicle classification counts are provided have the capability to summarize traffic counts in hourly intervals. These classification counts are collected at approximately 75 stations, mostly along state facilities such as I-94, US 83, Bismarck Expressway and Highway 1804. Thus, hourly volume data is somewhat limited.
- Additional potential sources of hourly data to support time of day model development include:
    - ATAC has discussed studying whether accurate counts can be obtained using existing video detection equipment already in place at traffic signals. The traffic signal video detection equipment deployed in limited portions of Bismarck (specifically State Street / US 83 corridor) is already capable of providing video-detected hourly counts if reconfigured. ATAC is in the process of bringing on staff with expertise in Traffic Operations and once in place, will investigate the feasibility of collecting data with existing signal detection equipment and the accuracy of such data.

If accurate counts can be obtained using video detection equipment, information for the most problematic locations could be collected in a relatively cost-effective manner.

- URS has discussed with NDDOT the feasibility of them providing expanded hourly count data with their current classification counting equipment. This equipment is the traditional "tube count" equipment that has been widely used for years, and is the source of the approximately 75 NDDOT classification count stations in Bismarck-Mandan. The proportion of the NDDOT equipment that is capable of collecting hourly data is limited, as most of the tube count equipment just collect axle hits over the course of a day and do not keep track of hourly data.

  There are limited opportunities for expanding the locations of these hourly tube counts for at least two reasons:
  - The classification tube counters that collect hourly data are not well suited for data collection in urban corridors with slower travel speeds, congestion, vehicle queuing and dense driveway / access point spacing.
  - The NDDOT does not change the locations of the classification counts significantly over time, so there is limited opportunity to rotate count stations from daily counts to hourly counts.

  There may be some limited capacity to expand the locations where classification / hourly counts are collected in Bismarck-Mandan, but due to limited resources it is not expected that this would lead to a significant number of new hourly count stations. The data collectors are relatively expensive and are often in use, but there is some circumstances where borrowing the equipment for a few extra hourly counts might be possible.

- An additional data collection source that NDDOT has started using is Miovision. Miovision is a company that sells video data collection equipment and data collection services. Once their video detection equipment is set up in the corridor by their client (in this case City, MPO and/or DOT staff) the data are uploaded and Miovision collects and processes the captured video counts. The Miovision equipment are capable of providing turning movement counts at intersections, which are more detailed than tube counters can typically provide, although turning movement counts are not typically required for time of day model validation.

  The City of Bismarck has used some of the DOT counts collected by this method with success. An added benefit of Miovision counts compared to tube counts is that urban conditions such as low speeds, queuing and cars turning in the corridor should have a much less negative impact on count collection performance. It is possible that additional counts could be collected with the DOT's Miovision equipment and the Cities / MPO could collaborate to purchase some of the "credits" required for providing count data with the Miovision equipment – depending on the volume of counts that is purchased, the cost can range from $10 to $28 per hour for the traffic counts collected. If additional equipment were needed, the cost to purchase the equipment itself can range from $5,000 to $8,000 per unit with a one-time setup fee of $950; NDDOT has several of these Miovision data collection devices. As with the tube counters, resources are limited and there are demands for this equipment across the state. In some key corridors, it would likely be a good investment to collect some hourly data to supplement the data already available.

Conclusions:

- There are no widely established model validation guidelines for peak period traffic count coverage requirements. In many cases, models that employ time-of-day components are only validated against summarized daily traffic benchmarks. However, it is advised that hourly data be collected and compared against

the peak period model output for a variety of facility types and areas types to ensure that the peak period output of the model is representative of Bismarck-Mandan conditions. It is recommended that as many peak period counts as practicable be collected to support validation of the time of day elements of the model.

- Prior to implementing a time of day model component, it is recommended that hourly directional counts be expanded through a combination of approaches (manual, tubes and video). It is anticipated that expanding the counts in a limited, but targeted manner would improve the effectiveness of the proposed time-of-day / hourly model. The targeted hourly directional counts should include a mix of:
    - Area types (rural, suburban, urban, central business district).
    - Facility Types (major arterial, minor arterial, collector).
    - Metropolitan Area Subregions (North Mandan, South Mandan, North Bismarck, South Bismarck, Lincoln, etc.)
- Any future travel surveys should collect sufficient data to estimate the departure time-of-day for the various trip purposes used by the model. This will allow the modeled time-of-day factors to be tailored to local conditions.
- **Recommended action Category: #2 (**Mid Term Implementation prior to 2014 LRTP update).

Freight Component Modeling

Freight Modeling Background:

- Analysis of truck volumes is very limited in the region.
- Higher truck generation can generally be tied to the routes providing access to heavy and light industrial areas. As these areas are relatively concentrated in the east and southeast parts of Bismarck and on the fringes of Mandan, the extent to which trucks impact the entire system is limited.
- Observations from local staff are that truck volumes through Bismarck-Mandan have increased in the last year or two due to activity in the western North Dakota oil fields. Very little of this traffic has an origin or destination in Bismarck-Mandan, but does pass through on the Interstate and US 83.

Conclusions:

- Based on the input received, truck traffic does not play a large enough role in the system to warrant a unique trip table application.
- **Recommended action Category #3** (set aside from further discussion).

Enhanced Economic and Land Use Forecasting Model

*Enhanced Economic / Land Use Forecasting Background***:**

- There are no local land use policies in place that connect development actions specifically to travel demand. Thus, there is not really an end use for this enhancement at this time.

Conclusion:

- **Recommended action Category #3.**

Mixed-Use Development Trip Sensitivity

Mixed-Use Development Background:

- For modeling purposes, a mixed-use development would be a contiguous development that contains complementary activities. Examples of mixed-use development are first floor retail and second (upper) floor residential or office, or a planned development with residential that is of an appropriate value and type with commercial (non-retail) or even industrial.
- There is not a substantial level of mixed-use in the region, however, the concept is growing as a discussion item. The model should be ready to incorporate the concept if it takes off.
- A definition of a mixed-use development is needed, as there is a relatively broad interpretation locally.

Conclusions:

- The MPO and planning should develop a definition of mixed-use development so there is a consistent application.
- Additional trip generation rates should be developed to reflect the defined mixtures.
- **Recommended action Category #2**.

Transit Component

Transit Model Background:

- A transit component for the model would provide estimates of transit travel demand across the metropolitan area. Some model users indicated that this capability would be nice to have, but that its practical applications are currently limited and will be for the foreseeable future.
- Transit is currently and will likely remain a relatively small part of overall travel.
- Transit does not likely impact traffic on any route to the extent that future recommendations for improvements would be affected.

Conclusions:

- **Recommended action Category #3**.

Non-motorized Travel Component

Non-Motorized Model Background:

- There is very little applicability or identified need for this component on a wide spread basis in Bismarck-Mandan.
- Most of the identified non-motorized issues are with the continuity and level of completeness of the trail and sidewalk system. Assessment of needs is more to do with continuity, ADA and Title VI issues than with demands on the system. These priority non-motorized issues are not items that are analyzed by travel demand models.

Conclusion:

- **Recommended action Category #3**.

Trip Distribution Enhancement for Special Generators

Special Generator Trip Distribution Background:

- There are few, if any, special generators in the area that are of a significant enough trip generation scale that their trip generation influences roadway improvement decisions beyond how access is provided. Thus, completing studies to quantify how their directional distribution may differ from other uses is not likely one of the higher model enhancement priorities.

Conclusion:

- **Recommended action Category #3**.

Policy Sensitive Model Components

Policy Sensitive Model Background:

- Few, if any, of the features/conditions that could be incorporated into this enhancement are present or play a measurable role in the Bismarck-Mandan decisions. There are no toll roads/facilities. Trips are short enough that fuel price does not substantially influence trip making (at least to the extent that a causal relationship can be determined).
- This enhancement is not warranted in a region the size of Bismarck-Mandan and in a region with the limited congestion relatively good connectivity present.

Conclusion:

- **Recommended action Category #3**.

Traffic Assignment Enhancements

Traffic Assignment Enhancements Background:

- Conditions that warrant this type of an application are not present and will not likely be present in the foreseeable future (substantial peak hour congestion in many corridors).
- ATAC staff have discussed that for the next model update, they are considering adding junction modeling (providing details of intersection control) as a model improvement. This would move the model a step closer to having the capability for enhanced assignment approaches. In the long term, ATAC has stated

that they would like to move some / all of the models in the state towards activity-based models with advanced assignment algorithms.

- Not likely warranted at this time.

Conclusion:

- **Recommended action Category #3.**

CHAPTER 5: IMPLEMENTATION PLAN

In discussions with those that rely on the model and the data it provides in Bismarck-Mandan, it became apparent that the travel model supports mainly two planning activities in the region:

- Provide traffic forecasts for corridor and subarea studies / design projects.
- Development of the Long Range Transportation Plan.

The alternatives reviewed and the recommendations for the model **functions** provided in this document were framed with these two model roles in mind. In developing the implementation plan **schedule**, there are several upcoming activities that will guide the prioritization of when certain model updates and enhancements can and should happen. The model must be fully functioning and validated prior to its use for these activities, so implementing new components needs to be phased so that it falls in line with upcoming planning activities.

SHORT TERM IMPLEMENTATION

Two corridor studies are anticipated to begin in early 2012: the 43rd Avenue Corridor Study in Bismarck and the North Mandan Subarea Study. These activities will be relying on model output in 2012, so all recommendations slated for the short-term need to be completed by mid-2012. As a result of the short-time frame for these upcoming corridor studies, only the most critical update was recommended for the short term: a *2010 model update and revalidation*.

Model Update and Revalidation

The 2010 model update is currently ongoing, and was initiated in August 2011 based on the findings of this study. The MPO, ATAC and URS staff are working together to assemble the required data, review and test potential model parameters and document model performance. The model has been updated to a 2010 base year with the recently released 2010 Census data, 2011 InfoGroup employment data, 2005-2009 American Community Survey (ACS) data and 2009 National Household Transportation Survey (NHTS) travel data. The update is also adjusting model parameters to fit within a reasonable range to provide fixes for the technical issues documented in Chapter 3.

The updates to the model included review and suggested revisions by consultant and MPO staff of the following model components:

- Model Network inputs, including appropriate recoding of corridor functional classification, reviewing and fixing input travel speeds, reviewing and revising the TAZ construction, revising centroid connector loading locations and correcting existing corridor lane geometries (number and type of lanes).
- Travel speed information, including terminal time standardization (with area type reclassifications) and elimination of the speed penalty on the interstate system.
- Trip generation inputs, including reviewing various data sources for trip generation rates, appropriately differentiating between person trip rates and vehicle trip rates, and utilizing TAZ-specific data on household size to vary trip rates according to area-specific household characteristics.
- Trip distribution inputs, including utilizing the gamma function for a smooth set of friction factor curves, and elimination of all K-factors with the exception of allowing a limited K-factor for Missouri River crossings.
- Traffic assignment inputs, including reviewing alternative travel impedance functions that include both travel time and travel distance and testing the model with and without a feedback loop.

Following completion of the 2010 Model Update and Revalidation, ATAC will provide a model development and validation document.

In addition to a model update and revalidation, a second short term recommendation is to standardize the "Practices for Applying Model Output" in Bismarck-Mandan.

Practices for Applying Model Output

Travel models are not perfect representations of land use conditions and the roadway network on which traffic travels. Certain aspects of the "real world" need to be aggregated in the modeling environment, and that perspective needs to be understood when users start evaluating modeling results. Local streets and driveways are not modeled, their access to the larger

collector / arterial / freeway network is approximated on a larger scale by modeling elements called "centroid connectors". Individual houses and business are not modeled, but larger geographies known as "traffic analysis zones (TAZ)" represent them in the modeling environment. Thus, model users know that there are some simplifications and areas of error in all travel models, and need to keep this in mind when evaluating the data that comes out of the model. The travel model is a useful tool in identifying travel patterns and traffic growth levels in subareas and corridors. However, model output should not be used directly from the model without understanding and applying some context.

In our discussions with the model users, most seemed to have a reasonable approach to using the model output. Most understood that the model should reflect reasonable travel patterns and traffic growth levels, but that model output needed some level of interpretation to produce traffic forecasts. We often refer to this as "**post-processing**" travel model traffic assignments. The basis of the post-processing is the assumption that the model reflects, but there is typically some level of deviation seen in the base year model (2010) between model-estimated traffic and observed traffic. This deviation should be corrected for in the future year model (2035 or 2040). This approach has its basis in NCHRP 255, "Highway Traffic Data for Urbanized Area Project Planning and Design".

Before applying travel model output on regional, subarea and corridor studies and projects, post-processing should generally be completed through the following steps:

1. *Comparison of 2010 Assignments and Counts*: On a link-by-link basis, compare the 2010 model-assigned daily traffic volumes ("assignment") to the observed 2010 daily traffic volumes ("count") where available. This comparison includes developing two different correction factors: an **absolute correction factor** and a **relative correction factor**.
2. *Calculate Correction Factors*: The absolute correction factor is calculated by subtracting the traffic model assignment from the observed traffic count (2010 COUNT – 2010 ASSIGNMENT). The relative correction factor calculated by taking the observed count and dividing by the traffic assignment (2010 COUNT / 2010 ASSIGNMENT).
3. *Determine Which Correction Factor(s) to Apply*: For each link, determine whether the 2010 model traffic assignment is relatively close to the observed count. For instance, 15 percent might be considered "close" for post-processing purposes.
   - In this case, if the 2010 model assignment within 15 percent of the 2010 observed count, where the relative correction factor is between 0.85 and 1.15, both correction factors should be applied to the 2040 assignment and the results averaged.
   - If more than 15 percent deviation, where the relative correction factor is less than 0.85 or greater than 1.15, apply only the absolute correction factor to the 2035 assignment.

Two example situations are provided below to illustrate.

Example #1:

Link #1:
2010 Observed Count = 5,000
2010 Model Assignment = 4,000
2040 Model Assignment = 9,000

Correction factors:
Absolute = 5,000 – 4,000 = 1,000
Relative = 5,000 / 4,000 = 1.2
Decision - **Apply Absolute Only (more than 15% deviation)**

Forecasted / Post-Processed Volume on Link #1:
2040 Assignment + Absolute Correction Factor = 2040 Forecasted Volume
9,000 + 1,000 = 10,000

Link #1 2040 Forecast = 10,000 vehicles

Example #2:

Link #2:
2010 Observed Count = 10,000
2010 Model Assignment = 10,500
2040 Model Assignment = 18,000

Correction Factors:
Absolute = 10,000 – 10,500 = -500
Relative = 10,000 / 10,500 = 0.95

Decision – **Apply Absolute and Relative and Average Results (within 15%)**

Forecasted / Post-Processed Volume on Link #2:
Absolute Approach: 18,000 – 500 = 17,500
Relative Approach: 18,000 * 0.95 = 17,100
Averaged Results: (17,500 + 17,100) / 2 = 17,300

Link #2 2040 Forecast = 17,300 vehicles

Much of these correction factors can be computed automatically as a part of the travel model process and / or in GIS output files. However, it is important for those using the model output to review the inputs and outputs of these correction factors for reasonableness. In corridors with significant levels of trip growth over the planning horizon, it is recommended that users review the segment-by-segment forecasts and make sure they exhibit relatively even growth levels. For instance, in a corridor such as north Washington Street we would expect that traffic volumes would increase as we move from 71st Ave / Highway 1804 to the south near I-94 and the "built out" portions of the city. This is the case currently in the corridor, as traffic "accumulates" and increases between the north part of the corridor and the south part of the corridor. It can sometimes be the case that the resulting post-processed volumes are somewhat choppy and volumes go up and down across the corridor – this is typically a result of low existing condition volumes and high future condition volume growth in a corridor. In these higher-growth corridors, it is sometimes necessary to "smooth" volumes through the corridor to avoid unreasonable variability in adjacent forecasts.

It is also important to **compare forecasted growth rates** in the corridor of interest and its immediately adjacent corridors that serve the same general "travel shed". The growth in parallel / competing corridors should be compared to each other and *generally* have similar growth rates between the base year and forecast year. If some corridors serve more local traffic (such as a neighborhood collector) and others serve longer trips serving growth areas (such as arterials), significantly differing growth rates in parallel corridors might be justified. Other items to evaluate include:

- Reserve capacity in corridors: If the competing parallel corridors have different levels of reserve capacity, they might grow at different rates. A corridor that is currently congested will experience increasing travel delays as traffic levels increase, and as a result will become less "attractive" if an adjacent uncongested corridor is available.
- Differing operating speeds: For similar travel time reasons, corridors with different average operating speeds will be more / less attractive for routing traffic with a similar travel shed.
- Selected Link Analysis: It is recommended that a selected link analysis be completed for the corridors, to verify the reasonableness of the traffic using the corridor(s)[5]. If unexpected results are revealed by the selected link analysis, some adjustment to corridor volumes may be warranted.

To some extent, this is where forecasting incorporates "art" rather than pure science.

MPO Database of Transportation Improvement Projects

To streamline the model update process, and assist with future LRTP updates, the MPO should establish and annually update a database of historical transportation projects. The annual Transportation Improvement Program (TIP) is a good source of data for developing this database. Not only would the database aid in future LRTP updates, but would provide a snapshot of the network improvements that have occurred in between the typical 5-year cycles of significant model updates. Specific to the needs of the model updates, the project database should include:

- Construction Year(s)
- Project Improvement Type Description (such as number of lanes added)
- Project Location and Limits

Additional cost information on constructed TIP projects would provide some benefit to future LRTP updates.

MID-TERM IMPLEMENTATION

As the MPO looks ahead to its next LRTP update scheduled for 2014, there are opportunities to implement some additional model enhancements and have time to test / validate them prior to use on the LRTP.

5 Selected link analyses provide a summary of the trip origins and destinations using the selected link.

Socioeconomic Data Monitoring and Allocation Updates

Background/Purpose

The travel model is a tool that that integrates land use planning and transportation planning by translating development actions and assumptions into roadway and transit requirements and demands (and vice versa). Historically, updating the locally approved travel demand model has been tied to the five-year cycle of updating the Long Range Transportation Plan. Corridor or subarea studies completed in periods between LRTP updates have included revisions to the socioeconomic data forecasts, but typically the revised development assumptions are not adopted into the approved regional model until the next LRTP update. Some Bismarck-Mandan model users raised concerns that the interval at which the Long Range socioeconomic data are updated is a rather long time frame, and can lead to a future land use development scenario that does not reflect emerging development patterns / intensity in some Bismarck-Mandan corridors and subareas

Local programs and activities that will be required to implement the socioeconomic data monitoring program being recommended are:

- A system for tracking actual versus projected development levels including:
  - The regional increment relative to projections.
  - The geographical distribution of households and employment across the region relative to projections.
  - The proportion of household growth relative to employment growth (is there balanced or unbalanced regional growth in residential relative to commercial/industrial growth?).
- A methodology for linking changes in development (focusing on deviation from the projected) to determining the need to update the travel demand model datasets in the interim period between LRTP updates.

The MPO intends to implement a building permit tracking tool that will be capable of addressing the first bulleted item. The purpose of this section of the report is to address the second bulleted item. Implementation of the model updating program will rely on bringing on-line and maintaining the development tracking program. Without consistent and accurate development proposals/ plans tracking relative to projections, it is not possible to accurately determine whether a travel demand model socioeconomic database update is warranted.

Monitoring and Trigger Process

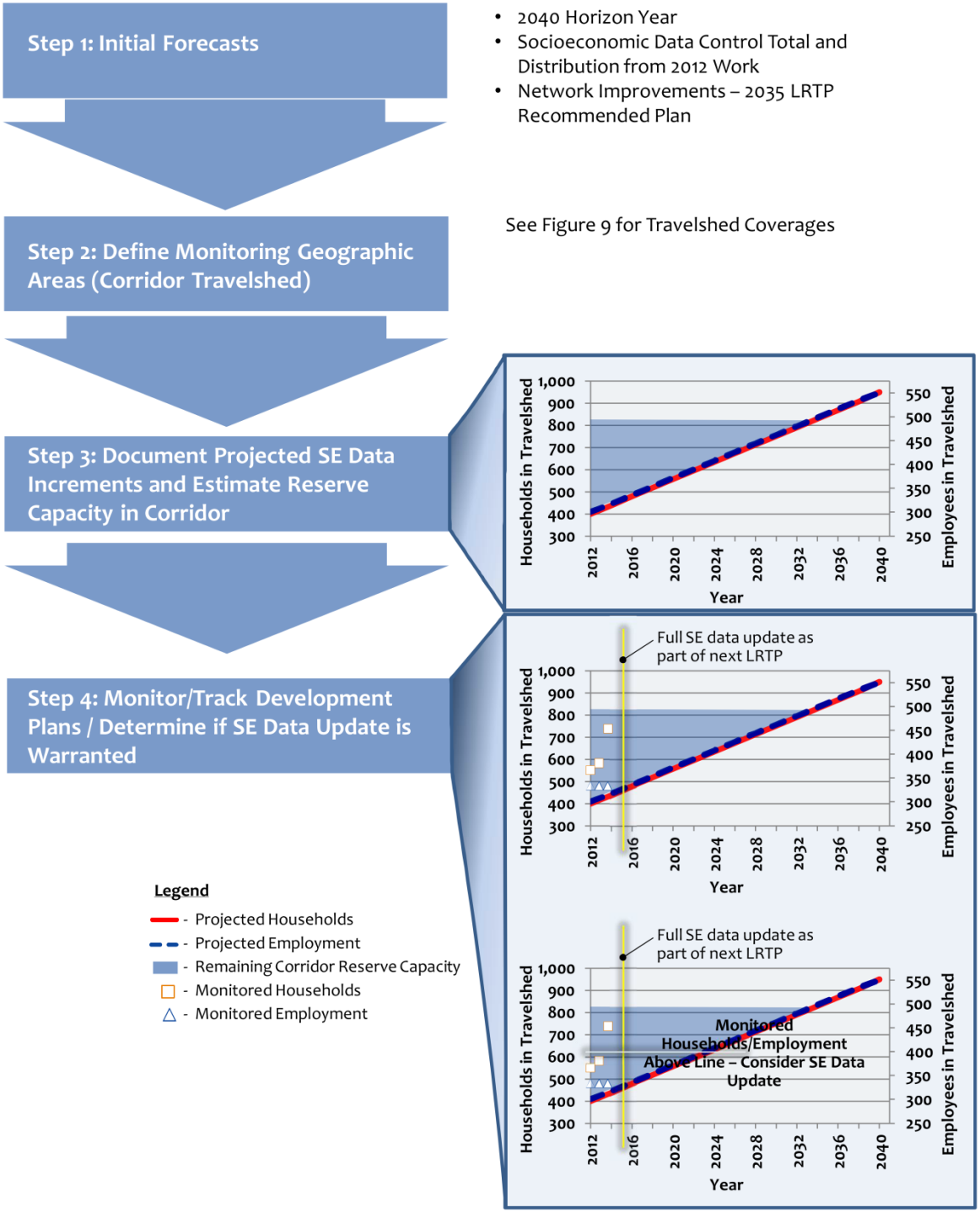
Figure 8 displays the approach proposed for integrating the review of the travel demand model dataset with the development monitoring program. Each of the key steps is highlighted below.

Step #1: Initial 2040 Allocation and Travel Forecasts: The purpose of the monitoring program is to identify when the actual increment of development in the region has deviated from the projected/ estimated increment enough to warrant updating the MPO's travel demand model households and employment data. Thus, the critical first step is identifying a locally approved concept for the regional households and employment control totals as well as an approved geographic distribution of the base year to horizon year increment.

Step #2: Consider Regional and Subarea/Corridor Sensitivity to Changes in Development Assumptions: Initially, the study team considered model update triggers that were global thresholds based on deviation from the projected new regional development and/or a geographic distribution deviation. For example, a global threshold could be the number of projected households or employment deviating from projected values for a TAZ (say 100 households or employees). While the global threshold application simplifies when to address a model data update, it is not sensitive to the unique land development and transportation supply characteristics of various subareas and corridors.

The proposed action trigger should be connected directly to a transportation facility's capacity available to accommodate development-driven travel. If there is a substantial amount of reserve roadway capacity in a developing area, there may not be as immediate of a need to update the model datasets when/if development deviates from the assumed projection. Conversely, there will be areas of the metro where straying from the development projections warrant closer observation and tracking. These areas are most likely those that currently have less roadway infrastructure

Figure 8. Socioeconomic Data Monitoring Approach



(lane capacity) to accommodate or serve growth (i.e. areas currently on the edge of the urban area served by rural section roads), but are ripe for urban density development. This kind of approach would allow users the capability to consider how changes in land development trends might affect the need to alter planned transportation system investments.

Step #3: Estimate Travelshed Corridor Reserve Capacity: To address the wide differences in various metro corridors' and subareas' ability to accommodate land development without requiring roadway network improvements, the proposed "update triggers" incorporate assessing the reserve capacity along various routes. Reserve capacity is defined as the increment of vehicle traffic beyond the current level that could be accommodated on a route before an unacceptable level-of-service is reached. The proposed geographical unit used to estimate travel in a corridor is the travelshed. Development activity monitoring and tracking would happen at the travelshed level, and structured this way the program would provide a dynamic measure that is sensitive to:

- The amount of roadway infrastructure (reserve capacity) present to accommodate development traffic.
- Differences in the development types proposed versus projected.
- The deviation, in units of households and/or employment, that actual development follows relative to the originally projected plan.

Determining the corridors (roadways) used to establish travelsheds took into account the regional forecasting purpose of the model. Consistent with the regional forecasting purpose, arterial roadways (minor and principal) were used as the basis for defining travelsheds. Figure 9 displays the corridors and their estimated travelshed boundaries. The boundaries follow traffic analysis zone (TAZ) borders to allow more convenient record keeping. **It is recommended that the reserve capacity for each travelshed be estimated during each LRTP update.** Some travelsheds, such as the US 83 North travelshed, may need to have and additional arterial corridor or two considered in the reserve capacity evaluation (such as 71st Avenue / Highway 1804). This will need to be determined at the time of LRTP update.

Step #4: On-going Development Monitoring: The end product of development monitoring and tracking program is a determination as to whether model socioeconomic datasets, and subsequently the traffic forecasts, need to be updated in an interim period to the LRTP cycle. Land development proposals and permit requests will be tracked, not traffic counts, to determine whether the model should be updated. Key elements of tracking/monitoring are outlined below:

- Geocode residential, commercial and industrial development proposals so that they can be assigned to a regional model corridor travelshed. Information to record with the data points includes:
  - Type of development.
  - Number of units (dwellings, 1000s of square feet of commercial or industrial).
  - Number of employees associated with commercial and industrial development.
- Determine whether observed development patterns or levels deviate from the projected trend enough to warrant an update to the traffic model's socioeconomic data. The purpose of setting up the development monitoring program is to better coordinate arterial improvement timing and scope of proposed improvements with development that is occurring in the region. The reserve capacity threshold will reflect level-of-service (LOS) D operations in the arterial corridor, which represents the lowest acceptable operations. As the monitoring program is intended to be a pro-active approach to land use-transportation coordination, the trigger for updating the model should reflect a development increment below the reserve capacity limit. There is not a hard rule that states if and when development in the travelshed exceeds some level of the development increment assumed that the model socioeconomic data should be updated. In addition, the trigger is intended to set in motion an update of the travel demand model, not a re-ordering of corridor improvement project priorities or approval / denial of a development proposal. Thus, the MPO can take a fairly conservative approach to defining the trigger. It is recommended that a development threshold of 50 percent of the reserve capacity limit be used as the trigger. Setting this conservative level will likely provide adequate notice that action in a corridor should be considered, while not being so conservative that unwarranted actions are suggested.

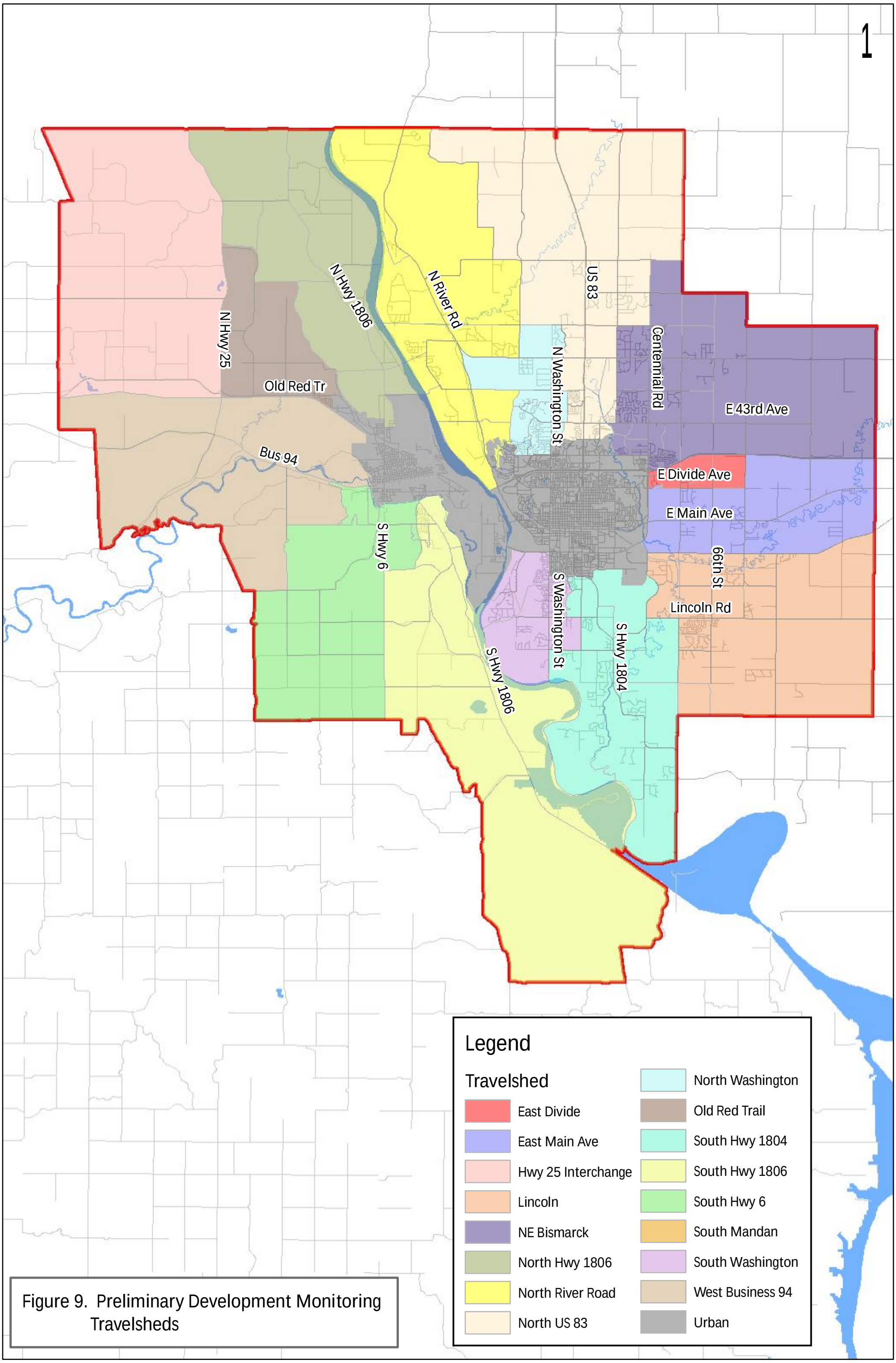


Figure 9. Preliminary Development Monitoring Travelsheds

If the development monitoring trigger indicates a potential need to update the socioeconomic dataset, some additional questions that should be asked include:

- **How much remaining developable land is there in the travelshed?** While it is possible that the pace of development in a corridor has outpaced the anticipated long-term development trend in recent years, and that travelshed has reached 50 percent or more of reserve corridor capacity, it does not necessarily mean that the travelshed is at risk of overshooting its reserve capacity. If there is limited developable land remaining in the travelshed, there is likely little potential for significant additional travel in the arterial corridor(s) of focus. A quick review of the potential number of jobs / houses that are anticipated to "fit" in the remaining travelshed development area will allow the MPO to determine if travelshed reserve capacity is in jeopardy of being exceeded.
- **What transportation improvements are planned for the travelshed?** If the main arterial corridor in the travelshed is planned to be improved during the planning horizon, the analyst should determine the planned improvement's impact on reserve travelshed capacity. If the project would add significant capacity to the corridor, the 50 percent trigger might not be representative of the long-term travelshed capacity. A related question is: **When are those transportation improvements planned to be implemented?** The timing of LRTP project(s) for a travelshed corridor might need to be re-evaluated based on the data being tracked in the development monitoring system. In such as case, a socioeconomic data update might not be required, but it might be warranted to change the LRTP's implementation timeframe for the improvement.

Example Monitoring Program Display

Figure 10 displays a potential example format for the development monitoring program reporting. The intent is to provide an informative and readily understandable product for each of the travelsheds. The proposed display provides:

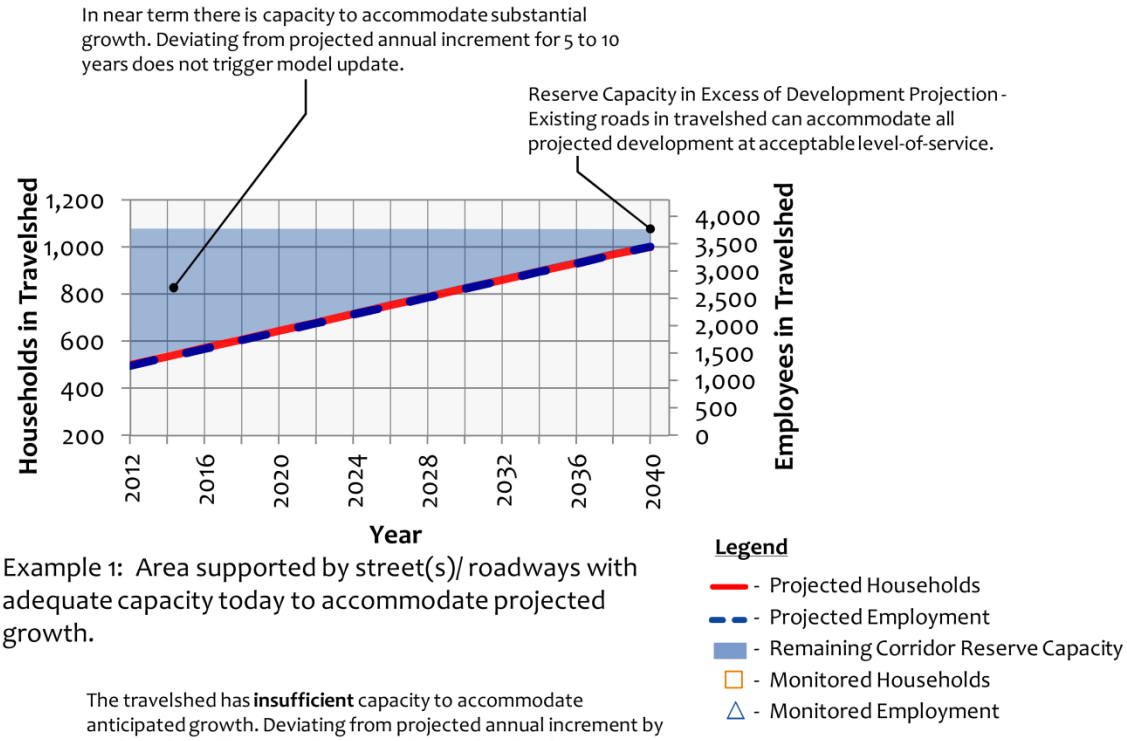
- Baseline data levels (households and/or employment in the TAZ), current assumptions on the horizon year level of household and employment and a straight line annual trend.
- Measure of the level of reserve capacity in the corridor in the period from today to the horizon year assuming relatively consistent year-to-year growth.
- A snapshot (pie charts) of the current and horizon level of land development within the travelshed relative to the available land for development.

This information will be helpful in assessing the significance of a deviation from the projected increment. If the current or future level of development encompasses the vast majority of the area of a travelshed, the reviewer will have another piece of information to determine the significance of a deviation from the projections. Conversely, if the increment of development monitored over a period deviates from the assumed trend and there is a substantial amount of developable property in the travelshed, a closer look at the area may be warranted. Summaries of the approach are provided in Figure 11.

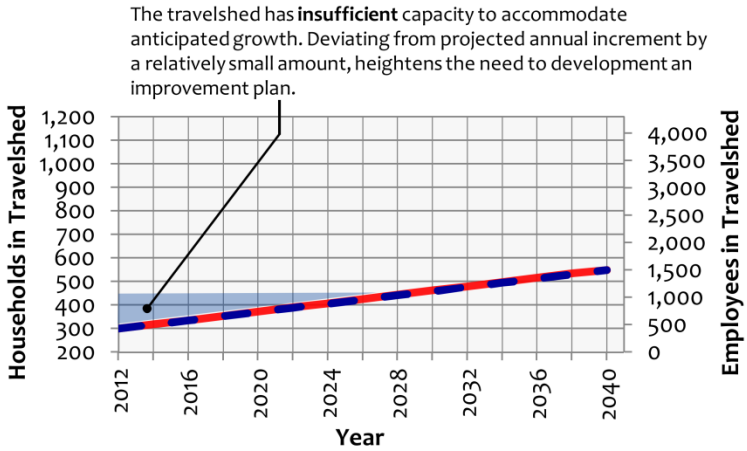
Bismarck-Mandan Travel Survey

A statistically valid survey of local Bismarck-Mandan area residents' travel would provide detailed local travel characteristics, such as the number of trips, length of trip, trip origin and destination. This information would be available by trip type (work trip, school trip, shopping trip, etc.) and would benefit the model by providing a local snapshot of travel in Bismarck-Mandan and provide added validity to the travel forecasting efforts in the region. This local information is currently not available. The travel model currently relies on national data sources for estimating these travel characteristics in Bismarck-Mandan, and these travel parameters are adjusted to match limited local observations and estimates. ATAC staff have advocated for administration of a local travel survey, and the MPO recognizes the value one would provide.

Figure 10. Examples of Development Monitoring Program

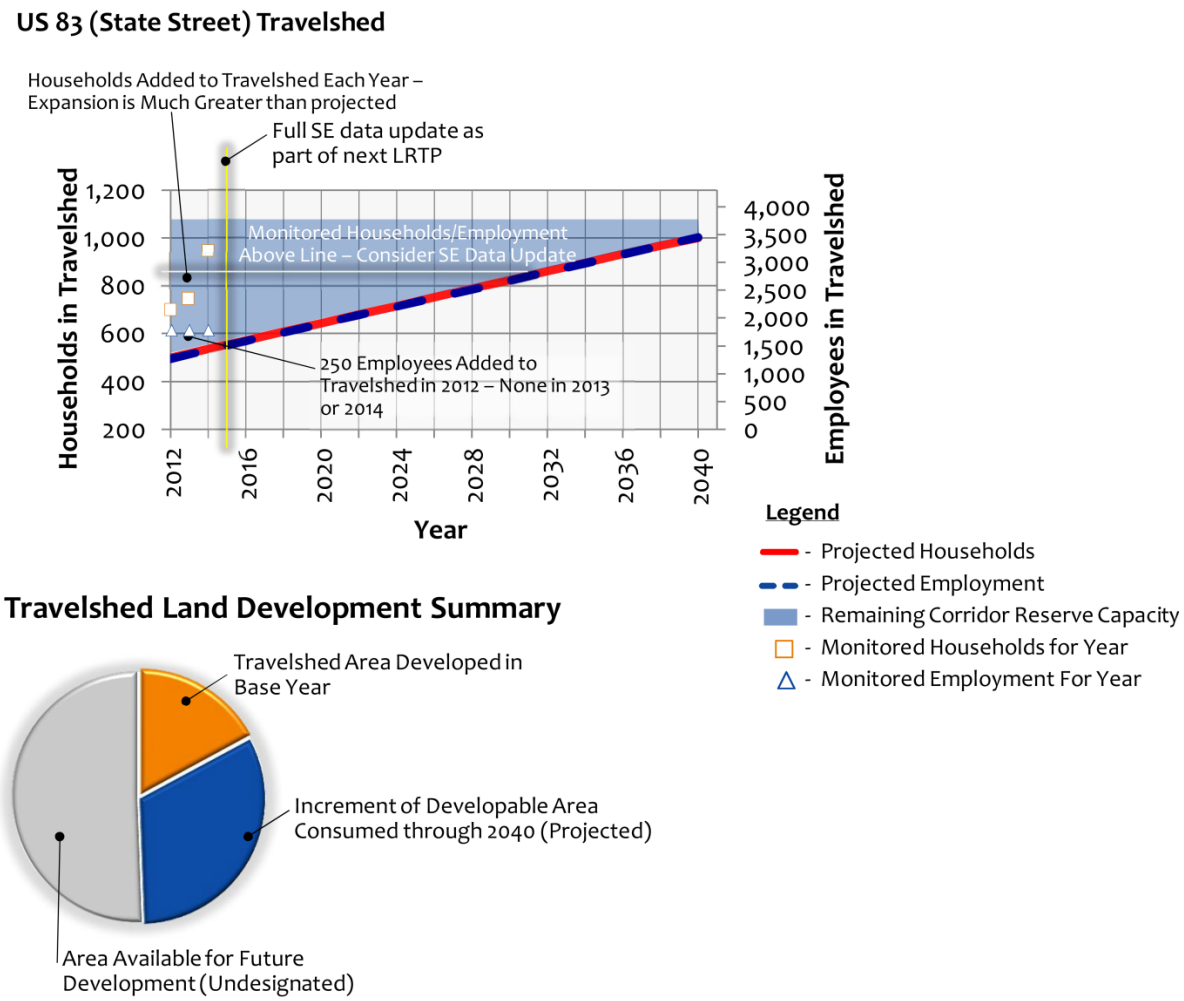


Example 1: Area supported by street(s)/ roadways with adequate capacity today to accommodate projected growth.



Example 2: Area supported by street(s)/ roadways with limited reserve capacity to accommodate projected growth.

Figure 11. Summary of Development Monitoring Program



There are two general options for the MPO to consider for implementing a survey:

- Contract with a Firm to Conduct a Local Travel Survey: This option would go through the MPO's consultant selection process to contract with a firm that would complete a local travel survey. There are several firms that specialize in conducting travel surveys, and Bismarck-Mandan could choose to select a firm to conduct a travel survey that would provide the key, local information required for a rigorous model update. Through this approach, the Fargo-Moorhead COG completed a travel survey in the Fall 2011 (not yet documented). This provides a valuable opportunity for Bismarck-Mandan MPO staff to learn from the experiences in that area.
- Participate in the NHTS Add-On Survey: The US Department of Transportation sponsors the NHTS to collect data on travel in America, including trip-related data such as mode of transportation, duration, distance and trip purpose. Metropolitan areas like Bismarck-Mandan can sign up for an "add on" survey as part of the NHTS. The add-on survey increases the sampling coverage in the metropolitan area to get a statistically valid sample of travel. The costs of the add on are generally similar to contracting out a travel survey and provide similar results. Several metropolitan areas in the Midwest have used NHTS add-on surveys in recent years including Cedar Rapids (IA), Sioux Falls (SD), Des Moines (IA) and Omaha-Council Bluffs (NE and IA). If the MPO choses to go this route, there are several peer organizations that can provide advice.

There are pros and cons associated with each approach. Both approaches should provide the MPO with:

- Data on all aspects of travel (trip purpose, time of day, number of trips, length of trip, origin and destination).
- Weighted data, essentially smoothing out the survey data so that over-represented and under-represented populations in the survey are normalized, and the responses reflect the entire Bismarck-Mandan population.
- Data for trip origins and destinations by trip purpose and mode of travel

The benefits of contracting with a survey firm to conduct a local travel survey would essentially be schedule flexibility. The MPO could conduct the travel survey at any time the funding became available to hire a survey firm and staff availability allowed a survey to be administered. There are potentially also some added survey structure flexibility by going with a private survey firm, although MPOs that go with an NHTS add-on are allowed to adjust how their NHTS surveys are administered.

The benefits of doing an NHTS add-on include:

- Limited need to provide survey oversight locally, as it's centrally administered as part of the NHTS and one national survey firm is working with USDOT staff to complete the surveys nationwide.
- Potentially more flexible funding sources. NHTS staff note that State planning and research (SPR) funds and metropolitan planning (PL) funds can be used to pay for the add-on survey.
- Consistency of the locally collected data with the National NHTS data. There are some benefits here when wishing to complete an "apples-to-apples" comparison between Bismarck-Mandan and other parts of the US.

The difference in cost between the two approaches is anticipated to be minimal. The MPO has set aside $75,000 for surveying efforts in 2012. A full travel survey will likely cost more than that. The travel survey in Fargo, which would likely be a similar effort to a Bismarck-Mandan survey, was budgeted to cost approximately $150,000. Our discussions with MPOs that have completed the NHTS add-on indicate that its costs are in a similar range.

Which implementation option the MPO pursues might come down to timing. The next NHTS is likely to be administered in 2014 (or potentially later) and typically the data from the survey are not available until the following year. Thus, while the NHTS add-on option might be a desirable approach, it will likely not provide travel survey data in time for the 2014 LRTP update.

Regardless of the travel survey approach used, it needs to be structured so that it provides the necessary data for the model. When talking with the surveyor about designing the survey, the following questions need to be kept in mind:

- **What are the goals of the model?** The survey needs to ask questions relevant to the model's capabilities. As the model moves towards a time-of-day component, the survey needs to be structured so that it asks questions about not only trip purpose, but also trip time.
- **What size and what type of a sample are needed?** This depends on the model goals being supported by the survey. At a minimum, a statistically valid sample of the overall metropolitan area population is desired. A related question is whether there are any subgroups for which you need a valid sample. For instance, the survey might be trying to get an understanding of the travel of transit dependent populations, or the commuting details of a certain subarea of resident / employee.
- **For what day(s) of the week is information required?** The Bismarck – Mandan model is an "average weekday" model, so survey responses collected on the weekend will be of limited benefit for the model. The NHTS is set up to ask questions every day of the week, but the add-on sample can be set up to get a valid selection of "average weekday" responses.

Based on schedule reasons alone, if funding is available it is *preliminarily* recommended that the MPO hire a firm to complete a travel survey by 2013 if funding is available. Bismarck-Mandan MPO staff are encouraged to discuss the ongoing travel survey in Fargo-Moorhead with Metro COG staff. Their staff can share valuable lessons based on their experiences overseeing the travel survey. If MPO staff feel that a travel survey can wait until after the LRTP update, talking with MPO staffs that have used the NHTS add-on survey and hearing their lessons learned would also be beneficial, and there may be some benefits in choosing the NHTS add on format.

Travel Time and Speed Study

An accurate picture of travel speeds and the amount of time it takes for a typical vehicle to travel through a corridor is an important travel model input. As discussed in *Chapter 3, Technical Model Review and Recommendations*, travel times are the main "impedance" value in the 2007 model (the 2010 model update is considering including both travel time and travel distance in its impedance estimates).

ATAC conducted a travel time study in 2000 to support development of the model. The 2000 travel time study completed a loop in Bismarck that surveyed travel times over several runs across different facility types (interstate, arterial, collector). Travel time studies have been completed over the past few years in limited corridors to support various corridor studies in the Bismarck-Mandan area, including the Bismarck Expressway and State Street. This data is currently used in support of the model. However this travel time and speed data is a patchwork of older travel time data and more recent data from a limited set of select corridors, so a mid-term recommendation is to complete an updated Travel Time and Speed Study to update and standardize the travel time dataset.

It is recommended that ATAC conduct an updated and somewhat expanded travel time / travel speed study for Bismarck-Mandan. Various methods of data collection through a cross-section of corridors can be used, including:

- GPS collection of travel times "average vehicle method", where the data collection vehicle travels at speeds similar to surrounding vehicles.
- Spot speed checks with radar guns or other stationary data collection mechanisms.

The study should sample from a range of corridor types, including a representation of various:

- Area types (CBD, urban, suburban, rural)
- Corridor types (interstate, principal arterial, minor arterial, collector).
- Collect on both sides of the river. That data collection effort should include collecting information on Mandan, which was not done in the 2000 study, to ensure that the speeds are not significantly different.

Peak and off-peak periods should be collected for the above cross-section of corridors, to help in validating the time-of-day capacities used in the model, which affect peak period congested travel times.

Time of Day Modeling

It is recommended that the MPO implement a time-of-day (TOD) model prior to the 2014 LRTP update. There are several approaches to how the time of day model can be incorporated. For the purposes of the

Bismarck-Mandan travel model, one of two approaches would be the most practical to implement in the mid-term:

- TOD Application after Daily Trip Assignment: This approach assigns daily link volumes and then multiplies each link by a time-of-day factors to produce hourly / time of day traffic assignments. This is the simplest approach to TOD modeling and provides a rough approximation of traffic peaking on a given link. This approach does not allow the traffic assignment to respond to peak period congestion, as it estimates time of day volumes after traffic assignment has been completed.
- TOD Application between Mode Choice (Auto Occupancy Factoring) and Trip Assignment: This approach factors the purpose-specific daily trip tables by mode (which in Bismarck-Mandan is just a vehicle trip table) prior to traffic assignment. Purpose-specific factors are developed for each direction, based on available local survey or NHTS data, that reflect the time-of-day or "diurnal" travel characteristics. These trip tables are then used as inputs to period-specific trip assignments, which can be for a single peak hour (e.g., 7:00 to 8:00 AM) or for a multiple-hour "period" (e.g., 6:00 AM to 9:00 AM) . Daily traffic volumes are produced by adding up the results of all of the morning, afternoon, and off-peak period traffic assignments.

The TOD split before assignment approach allows for some traffic assignment sensitivity to peak period congestion, because peak period trip tables are assigned to a roadway network with appropriate estimates of peak period capacity, allowing for approximations of peak period congestion. The TOD split after assignment approach provides no such congestion sensitivity, as it is merely factoring a daily assignment by observed peak hour percentage factors. This is more realistic, because peak travel route choices are made based on congested period networks, while off-peak travel route choices are made in uncongested periods.

While the TOD split before assignment approach is preferred to the TOD after assignment approach, it does complete trip distribution step (which estimates trip origins and destinations) without accounting for peak period congested times. However, for the purposes of the Bismarck-Mandan model with limited periods of congestion, this approach should suffice and be an improvement over the current daily model structure.

Thus, it is recommended that a Time-of-Day model be implemented with the TOD split before assignment approach. Specifically:

- Time of day factors by trip purpose (HBW, HBO, NHB, HBSch) and by direction (whether production or attraction) will need to be developed from either the local travel survey, if administered, or with available NHTS data.
- ATAC and the MPO should work together to identify the peak periods to be modeled, whether just peak hours (i.e., 7:00 to 8:00 AM, 5:00 to 6:00 PM) or whether multi-hour peak periods should be assigned. In either case, in addition to the two or three peak hours / periods modeled, an off-peak period will need to be implemented to account for the remainder of the daily traffic.
- Validate the time-of-day periods with both traffic volume and travel time data collection efforts. In addition to peak period traffic data, the period-specific travel time / travel speed data collected (see Travel Time and Speed Study recommendation) should be compared to period-specific model output to verify that the peak periods of the model are reasonably replicating the travel speeds observed in the field.

Mixed-Use Trip Generation Modeling

In the mid-term, it is recommended that the MPO and ATAC research development of a mixed-use trip generation component. Mixed-use developments can have lower trip generation rates compared to more traditional single-use developments because many trips can be internally captured due to the diverse set of uses located on a single site.

This model component will require some additional investigation from MPO and ATAC staff, as mixed-use development of any significant scale is limited in Bismarck-Mandan. There are several mixed-use development trip generation tools available to planners, but they are typically limited to identifying trip rates for sites that have:

- A diverse range of on-site uses such as residential and varied commercial businesses often referred to as "live, work, play" areas.
- Site orientation that encourages multi-modal options including active pedestrian areas, sidewalk and trail connections within the development to connect uses and high levels of transit service.

Mixed-use models incorporate many different types of variables to estimate reduced trip rates, including:

- Site size
- Employment / Housing Density by Type / Mix
- Area Transit Mode Share
- Area socioeconomic variables such as auto ownership, household size, age distribution.

Before any model adjustments are made to account for reduced trip generation rates at mixed-use developments, it is recommended that the MPO work with its constituent model users to identify answers to the following questions:

- What constitutes mixed-use development in Bismarck-Mandan?
- How should any mixed-use developments be identified and incorporated into the model environment?
- Are there any significant mixed-use development areas that should be included in the future land development concept?

FUTURE MODEL UPDATE ROLES

One of the outcomes of working through this travel model review and update is that the study team identified the need to clearly define and establish model maintenance and update roles for both the MPO and ATAC staff. The modeling process will be more efficient in future updates if both entities know their roles throughout the model's lifecycle. In addition to laying out recommendations and an implementation schedule for future model activities, this document is identifying a preliminary set of roles for both the MPO and ATAC staff. The roles provided in this section are considered preliminary as the model will be undergoing some upgrades over the next few years. As new features are added to the model, ATAC and the MPO should agree upon roles for data development, model review and implementation.

Table 3 provides a description of the details associated with each of the preliminary tasks and the roles for the MPO and for ATAC. Figures 12 and 13 break the tasks into two separate phases: model update and revalidation and model application. Figures 12 and 13 illustrate each of the preliminary tasks and roles by assigning a primary action for each, whether that role is to develop data, review, or implement the model step.

The Bismarck-Mandan Model Update and Maintenance Responsibilities are broken into several steps. Steps 1 through 5 relate to model updates and validation, while step 6 and 7 relate to model application and model review:

- Step 1. Develop / update model inputs
- Step 2. Update / validate trip generation
- Step 3. Update / validate trip distribution
- Step 4. Update / validate mode choice / auto occupancy
- Step 5. Update / validate traffic assignment
- Step 6. Model application for planning studies
- Step 7. Periodic model review

Table 3. Preliminary Model Role and Responsibilities by Task[6]

MODEL STEP	MPO ROLE / RESPONSIBILITIES	ATAC ROLE / RESPONSIBILITIES
Step 1. Develop / Update Model Inputs		
1. **Land Use Information:** Review areas of new land development since last model update and make necessary model updates.	A. MPO Staff to review and provide recommendations as necessary on: • TAZ Geography – does detail need to be improved anywhere? • Centroid Connectors – are the current locations appropriate? Have local roads been added or changed roles which should be reflected in model connector placement? • Area Types - has new development changed how we should classify any TAZ area types? Every 10 years as Decennial Census geography and data become available: • Update TAZ boundaries to reflect changes in Census geography. • Update base year housing / population / enrollment data in model.	B. Determine if MPO-desired TAZ / network changes can be implemented and advise how they might affect model performance. C. Come to agreement with MPO on how changes will be implemented. D. Make changes to model network and scripts.
2. **Network Changes:** Review Transportation Improvement Program (TIPs) and determine how roadway network characteristics have changed.	A. MPO staff review network and determine if and where recent capacity projects (new turn lanes / through lanes) have been added. Note any changes in posted speeds on system. Provide all network changes to ATAC in agreed-upon format (hardcopy notes on map, shapefile, etc.). C. Review ATAC model network after changes have been implemented.	B. Implement MPO-identified changes into CUBE network. Provide MPO staff with CUBE network in shapefile format to verify all network changes have been implemented.
3. **Socioeconomic Dataset**: Estimate base year and project future year levels of housing and employment	B. MPO staff to develop socioeconomic data inputs through the following steps: • Allocate base year socioeconomic data to Traffic Analysis Zones (TAZs) for each category specified by ATAC for model application. • Develop regional control total socioeconomic projections for future year(s). • Allocate regional control totals for future year(s) projections to TAZs.	A. Determine what household and employment independent variables are required. Current model uses: • School enrollment • Households by household size • Retail, service and other sector employment. C. Review MPO control totals for reasonableness by looking at: • Jobs / Housing balance • Average HH Size • Job sector balances (split of Retail, Service and Other) For all of these comparisons, review the consistency between today and future? If the ratio is not consistent, why not? Is it consistent with historic trends or 3rd party demographic projections?
4. **Traffic Data**: Input appropriate traffic dataset(s) for validation.	A. Provide ATAC with all available traffic data sources, including NDDOT counts, City counts and any project / corridor-specific data. Current model requires average daily traffic counts only; future upgrade to a time of day (TOD) model would require some peak period traffic count data. Traffic data collected within 1-2 years of the defined model base year is recommended. Older data may be appropriate in low growth subareas. C. Review model network for count coding accuracy once ATAC has added observed counts.	B. Input traffic data required for validation by direction into network. If model moves to a TOD model, input period volumes by direction in separate field from ADT.

6 The study intends to include specific references to the appropriate model validation data sources for review of future model update / validation output. The best source of this data will be NCHRP Report 716 (an update to NCHRP Report 365), which was expected to be published in late 2011. The publishing date has been pushed back to June 2012, after the Model Review Study has been completed. An addendum to Table 3 will be provided to MPO staff, likely in the second half of 2012, that will include citations to where to find the appropriate model review data and reference tables in the NCHRP 716 report.

Table 3. Preliminary Model Role and Responsibilities by Task (Continued)

Step 2. Update / Validate Trip Generation		

5. **Trip Generation Rates**: Apply the trip generation module and determine how model trip rates fit with observations.	B. Review:
	• Trip rates by purpose for consistency with previously validated models and latest regional / national NHTS rates.
	  ○ Trips / HH
	  ○ Trips / Job
	• Amount of "balancing" required by trip purpose. Ideally, balancing adjusts trips by 10% or less by purpose. In some situations, adjusting by more (25% - 50%) through the balancing process might be acceptable.
	• External station volumes for reasonable growth from previous years and consistent internal / external splits.
	• Establish and review cordons around focused / homogenous areas such as:
	  ○ Suburban residential neighborhoods
	  ○ CBDs
	  ○ Commercial areas
	Compare observed counts with model-assigned traffic volumes at Cordon line.
		A. Update trip generation module with latest available information and apply trip generation rates to updated socioeconomic data.
		
		C. Provide MPO these model results:
		• Unbalanced Productions and Attractions by Trip Purpose
		• Balanced Productions and Attractions by Trip Purpose
		• Assumptions for external station volumes and I-E / E-E splits.
		• Preliminary traffic model assignment results for cordon count-assignment comparisons.
		
		Correct trip rates within acceptable parameters to align trip generation results with expected values.

Step 3. Update / Validate Trip Distribution		
6. **Trip Distribution Patterns:** Establish and review trip distribution parameters.	C. Review preliminary trip distribution results. Average Trip Length by purpose compared to: • Past Bismarck-Mandan model results • Most recent NHTS data Compare trip length distribution results to most recent ACS data for Bismarck-Mandan (HBW). If Bismarck-Mandan participates in next NHTS add-on survey, compare model trip length distribution and NHTS add-on results for non-work purposes. Compare model-derived Traffic Analysis District (TAD) to TAD HBW trips matrix to Census/ACS-estimated TAD workflows.	A. Begin with previous model's friction factors and apply gravity model to derive preliminary trip distribution. B. Provide MPO summary of: • Trip Length Distribution by Purpose • Average Trip Lengths by purpose • District-to-district HBW trip matrix that at a geography equivalent to Census TADs. Document any K-Factors used and reasoning for implementation. D. Revise the friction factor gamma function parameters as needed so model output better fit Census / NHTS data. Friction factors should have decreasing values as time increases.
Step 4. Update / Validate Mode Choice / Auto Occupancy		
7. **Mode Choice:** Allocate person trips to modes of travel OR convert person trips to vehicle trips based on available data.	Review auto occupancy rates for reasonableness / consistency with documented local / national data sources.	Within current automobile-only model context, develop auto occupancy rates based on ACS / Census data for HBW and for non-work purposes with NHTS data.
Step 5. Update / Validate Traffic Assignment		
8. **Traffic Assignment**: Apply assignment module to route traffic onto roadway network and review / adjust results.	A. Provide a set of screenlines to ATAC to use in validating the model. Screenlines might include downtown Bismarck cordon, I-94, Missouri River, Main Avenue (Bismarck), Main Street (Mandan), Bismarck Expressway. C. Look for geographic locations with more deviations than others. If these locations are discovered, work with ATAC to identify source (Area type trip rates? Error in network coding? Bad SE data? Bad counts?) D. Design a land use scenario as a sensitivity test for draft travel model – do the land use inputs provide the expected amount of incremental traffic?	B. After validation changes have been incorporated for previous steps, run model and provide the following assignment checks / data to MPO: • Loaded Network, with fields for model traffic assignment and base year ADT count. • Scatterplot of individual count – assignment data points with expected / allowable deviation. • Summary of observed counts and model assignments across all cordon and screenlines. • Summary of VMT by facility type compared to HPMS VMT. • Summary of Counts and Model Assignments by Facility Type. • Correlation coefficient of count-assignment goodness of fit. • RMSE by facility type. • Documentation of assignment outliers – what is the story? A. For all of the above assignment validation tests, ATAC should document model results and corresponding model performance targets. Targets should be established from *TMIP Model Validation and Reasonableness Checking Manual*, 2nd Ed and *NCHRP 8-61*.

Table 3. Preliminary Model Role and Responsibilities by Task (Continued)

Step 6. Model Application for Planning Studies		
9. **Minor Corridor Studies:** Corridor studies with little change to the major inputs to corridor travel demand and supply, such as number of lanes, speeds and adjacent socioeconomic assumptions.	B. MPO to work with ATAC and project staff to post-process traffic volumes and / or provide project staff / consultant with sufficient information to produce traffic forecasts in the corridor. This information includes: • Base year observed traffic count • Base year model traffic assignment • Future year model traffic assignment	A. Provide MPO with relevant model datasets (Base Year Loaded Network, Future Year E+C and / or LRTP Loaded Network) for request.
10. **Major Corridor or Subarea Planning Studies:** Studies where changes to the major inputs to corridor or travel demand and supply, such as number of lanes, speeds and adjacent socioeconomic assumptions need to be evaluated.	A. MPO to identify and provide to ATAC all necessary changes in network and socioeconomic assumptions for the planning scenarios. Determine best format of model adjustment request (shapefile, hardcopy, etc.). C. MPO to work with study staff / consultant to review ATAC model run results for reasonableness. Things that might be reviewed include: • Comparison of before and after traffic assignments - in general, did traffic volumes change as anticipated? • Selected links in focus corridor – do the before and after origin and destination patterns through corridor make sense? • Comparison of summary travel statistics (VMT, VHT) before and after – are they as expected? E. MPO to work with ATAC and project staff to post-process traffic volumes and / or provide project staff / consultant with sufficient information to produce traffic forecasts in the corridor. This information includes: • Base year observed traffic count • Base year model traffic assignment • Future year model traffic assignment	B. ATAC update future year model assumptions based on input from MPO. Prior to turning over draft travel model scenario results, conduct an internal review of model output for reasonableness. Once ATAC staff believe model scenario output is reasonable, provide necessary files to MPO and study staff / consultant for their review. D. ATAC to investigate any questions or issues that MPO and / or study staff / consultant have with draft traffic model results. This includes documentation of input assumptions. After investigation, agree what model changes should be made and rerun model, providing output files to MPO and study staff / consultant for their review and acceptance.
Step 7. Periodic Model Review / Functionality Assessment		
11. MPO – ATAC Discuss Model Functionality	A. MPO should periodically assess if the model provides all of the outputs users need. Since the last model review, determine: • Are there demands for new model uses? • Do model users have confidence in the model outputs?	B. Provide requested model performance statistics. C. Work with MPO to identify opportunities and challenges to potential model updates. D. Provide guidance to MPO staff and recommendations regarding modeling trends and current best practices for enhancements to consider for the Bismarck-Mandan model.

Figure 12. Bismarck-Mandan Regional Travel Demand Model Re-validation/Calibration Update Responsibilities

Legend of Responsibilities

- D — Develop Data
- R — Review
- I — Implementation

	Bismarck-Mandan Metropolitan Planning Organization	ATAC
Primary Responsibility		
STEP 1. Model Inputs		
Land Use Information – Identify areas of new development and/or substantial redevelopment influencing TAZ and network structure	D, R	I
Network modifications since last re-validation/calibration	D, R	I
Socioeconomic datasets to reflect land use changes (new development and redevelopment)	D, I	R
Traffic count dataset to current validation/calibration year/period.	R	D, I
STEP 2. Update / Validate Trip Generation		
Identify if new source datasets for trip generation rates have been prepared/ available for testing.	R	D, I
Trip generation validation	R	D, I
STEP 3. Update/Validate Trip Distribution		
Determine whether trip length changed (overall or by trip purpose) since last update?	D, R	I
Determine/document need to update parameters (Friction Factors, K-Factors)	R	D, I
Trip distribution validation	R	D, I
STEP 4. Update/Validate Mode Choice/Auto Occupancy		
Determine whether the local vehicle occupancy has changed?	D, R	I
Mode split / auto occupancy validation	R	D, I
STEP 5. Update / Validate Traffic Assignment		
Revisions to datasets (links making up cordon or screenlines, links with counts, etc.)	D, R	D, I
Assignment validation/calibration	R	D, I

Figure 13. Bismarck-Mandan Regional Travel Demand Model Application/Assignment Preparation Responsibilities

Legend of Responsibilities

- D — Develop Data
- R — Review
- I — Implementation

	Bismarck-Mandan Metropolitan Planning Organization	ATAC
	Primary Responsibility	
STEP 6. Model Application for Planning Studies		
Minor Corridor Studies: Characterized by little change to the major model inputs, such as number of lanes, speeds and adjacent socio-economic assumptions.		
Identify appropriate network scenarios to analyze (Future E+C, Future LRTP)	I	
Provide project staff with model datasets for traffic forecasts	I	
Subarea Studies: Characterized by studies/projects that include changes to the approved land use plan for the coverage area, addition of new collector or arterial roadways, upgrade of an existing facility that would include centroid connector/ access changes		
Land use update/socioeconomic data update	D R	I
Description of corridor improvements (Facility Type/Lanes/Speed Limit/Intersection Geometry/Access Locations)	D R	I
Network update	D R	I
Trip generation/distribution update	R	I
Assignment update	R	I
Major Corridor Studies: Characterized by substantial change in corridor capacity (i.e. widening from 2 to 4-lane divided, or 4 to 6-lane divided, or to Expressway). Change in land use not expected with network change.		
Description of corridor improvements (Facility Type/Lanes/Speed Limit/Intersection Geometry/Access Locations)	D	
Network update	D R	I
Trip generation/distribution update	R	I
Assignment update	R	I
STEP 7. Preliminary Model Review / Updates		
Periodic Review of Model: Recalibration is likely warranted on a 5-year cycle. Interim assessments		
Assess model performance	R	D I
Assess model features	R	D I