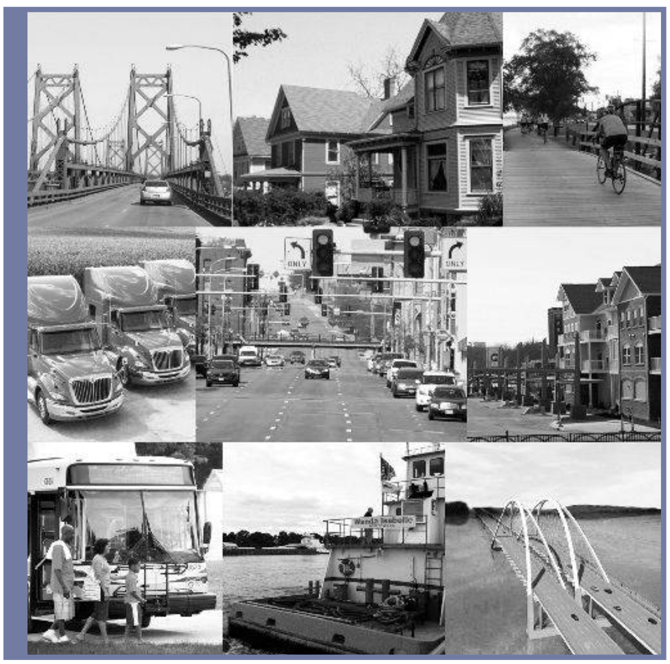
Transportation Model Documentation Technical Report

Addendum to the 2045 Quad Cities Long Range Transportation Plan

December 2016



Bi-State
Regional Commission

Transportation Model Documentation Technical Report

Addendum to the 2045 Quad Cities Long Range Transportation Plan

December 2016

Table of Contents

Transportation Model Documentation Technical Report

1.0 Introduction

A travel demand model is designed primarily for use in transportation planning at a regional scale, such as in the development of the long-range transportation plan or for regional air quality emissions analyses. The Bi-State Regional Commission (BSRC), the Metropolitan Planning Organization (MPO) for the Davenport, Iowa-Illinois Urbanized Area, utilizes a travel demand model as a decision-making tool to assist with transportation planning, prioritizing, and coordinating roadway projects within the metropolitan area.

The *2045 Quad Cities Long Range Transportation Plan* used a base year of 2010 and two horizon years of 2025 and 2045. The base year was selected to represent the most recently available Annual Average Daily Traffic (AADT) for the metropolitan area. The years 2025 and 2045 were selected as the short-term and long-term horizon periods for review and evaluation.

This model documentation technical report outlines the main steps and assumptions involved in developing the BSRC travel demand model for the metropolitan area as part of the *2045 Quad Cities Long Range Transportation Plan* update. The technical report assumes the audience has a general background in travel demand modeling and detailed knowledge for the Quad Cities metropolitan area.

1.1 Four-Step Travel Model

A travel demand model estimates existing and forecasted trips on the transportation system. Bi-State Regional Commission implemented the travel demand modeling process using TransCAD, a transportation modeling and GIS software package developed by Caliper Corporation. The geographic area covered by the travel demand process includes part of Scott, Rock Island, and Henry Counties that represent the Quad Cities Metropolitan Planning Area (MPA).

A travel demand model is used for decision-making. It is a tool to perform a comprehensive metropolitan transportation analysis and test specific land use and roadway changes or scenarios at different periods of time. It is also used to evaluate traffic effects resulting from changes in traveler behavior. Some of the most useful model outputs include:

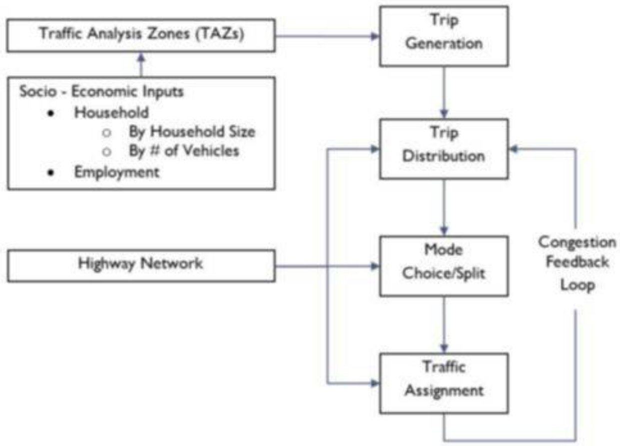
- Directional link vehicle volumes
- Intersection turning movement volumes
- Network Level-of-Service (LOS)

The travel demand model for the Quad Cities MPA is based on traditional four step trip based modeling process:

- Trip Generation
- Trip Distribution
- Modal Choice (Split)
- Trip Assignment

An overview of the basic modeling process is shown in Figure 1.1. At the start of a full model run, trip generation uses socio-economic data to calculate trip ends at the Traffic Analysis Zone (TAZ) level. These trip ends are then paired into trip tables in the distribution module, based on travel time “skimmed” from the highway network. The modal split step of the modeling process utilizes travel survey results to proportion total trips into vehicle, transit, non-motorized, and other trips. In the next step, vehicle trips are assigned to the highway network in the assignment module.

Figure 1.1 – Four Step Travel Demand Model



1.2 History of Model Development

The first generation of the BSRC travel demand model was built in TranPlan, which was a software package developed by the Urban Analysis Group. Since 2001, Bi-State Regional Commission shifted the TranPlan model platform to TransCAD in coordination with the Iowa DOT. The aim was to update the model software to be consistent with what the Iowa DOT and other MPOs in the state use.

Prior to this 2045 LRTP model, TransCAD was used to conduct the modeling process except for trip generation. The trip generation step was done in a spreadsheet program. It should be noted that the modal split step (person trips) used a different method for forecasting future travel demand.

In October 2008, the BSRC model went through a peer review as part of FHWA's Travel Model Improvement Program (TMIP). The following recommendations were made by the review panel. All of them have been achieved.

- Verify ES-202 employment data and be cautious about using labor force data in the development of demographic data inputs to the model.
- Look into a second source of employment data.
- Add trip rates for households without vehicle.
- Add special generators for the commercial aviation airport and major regional malls.
- Compare trip length frequency and average trip length against Census Transportation Planning Package (CTPP) data.
- Use person trips instead of vehicle trips.

A Certification Review of the transportation planning process for Quad Cities was performed by FHWA and FTA on April 16-18, 2012. The review was based on the 2040 LRTP model, and the review panel recommendations on model improvements are summarized below. All of these items have been addressed in the current 2045 LRTP model.

- Minimize using borrowed parameters.
- Enhance the model document to include a description of the input data and calibration parameters for each model component and validation statistics such as RMSE.
- Automate Trip Generation step in TransCAD.
- Include transit mode share.
- Build peak hour/time of day capabilities within the model structure.
- Document how the model is used to select and prioritize projects.

2.0 Model Data Requirements

A travel demand model forecasts the movements of people and goods within the study area in the present and future. Knowledge of local activities, socio-economic pattern, and growth trend is crucial to developing a reasonable model.

There are two primary categories of inputs essentially required to produce results for a travel demand model. These include:

- Traffic Analysis Zones (TAZs) with Socio-Economic Data
  - Population
  - Households
  - Employment
  - School enrollment
  - Vehicle ownership
- Roadway Network
  - TAZ centroids
  - External stations
  - Roadway nodes (endpoints of roadway links)
  - Roadway links (segment of roadway between two nodes)
  - Average daily traffic counts

2.1 Area Profile and Geographies

An area profile was prepared in Chapter 1 of the *2045 Quad Cities Long Range Transportation Plan* and is summarized here to provide an overview of the background socio-economic patterns and growth trends.

The Quad Cities Iowa/Illinois Metropolitan Planning Area (MPA) is located along the Mississippi River at the Eastern Iowa-Western Illinois border. It is defined as the Census-designated urbanized area, plus its expected growth boundary during 2045 planning horizon. The MPA covers approximately 391.12 square miles, including portions of Henry and Rock Island Counties, Illinois and Scott County, Iowa. These three counties altogether are also referred as the MPA region. According to U.S. Census data, the MPA has a population of 298,005 in 2010, which is 81.98% of the total population in MPA region (three-county area).

The Quad Cities Area Profile outlines the basic socio-economic elements of population, household, employment, education, and other elements for the MPA and MPA region (three-county area). This Profile is based on data from the U.S. Census, unless otherwise noted (Cross-reference Chapter 1 of the *2045 Quad Cities Long Range Transportation Plan*).

Area Population. The population of the Quad Cities MPA region (three-county area), was at its height in 1980 with a population of 383,958. As the decade closed, there was a drastic decline in population with the loss of thousands of jobs due to the devastating downturn of the farm implement industry. The 1990 Census population of the Quad Cities region was 350,855 and progressively rose to 359,062 in 2000 and 363,256 in 2010.

In 2010, the median age of the MPA was 38.4, which was higher on average than the U.S. (37.1), Illinois State (36.5), and Iowa State (38.0). The largest age group was 50-54, accounting for 7.5% of the total population in the MPA.

Area Households. As with many metropolitan areas, the number of households in Quad Cities Area is rising, while the household size is falling. In 2010, there were approximately 122,360 households, which was a 3.8% growth from 2000 household of 117,919. The 2010 average household size of the MPA was 2.44, which was a 2.2% reduction from 2000 household of 2.49. In comparison to the U.S., Illinois State, and Iowa State, the Quad Cities Area has a lower average household size.

Area Employment and Economy. The Quad Cities Area labor force has shown periods of decline and recovery since 1980. It peaked in 1980 at 175,044 workers. After a decline, the labor force showed signs of a rebound beginning in 2000 climbing to 160,226, and has remained steady since that time, slightly growing to 183,401 in 2010.

Between 1990 and 2010, the percent of Quad Cities Area workers employed in manufacturing increased from 17.1% to 17.7%, and the percent employed in retail trade dropped from 18.0% to 11.6%. The largest gain during the same period was in education, health, and social services, increasing from 11.8% in 1990 to 13.5% in 2010. In 2010, the largest sector employer by industry was education, health, and social services followed by manufacturing and retail trade.

Table 2.1 outlines major employers in the Quad Cities Area for the base year and used for comparative purposes with the model socio-economic data.

Table 2.1 – Top Employers in the Quad Cities Area (2010)

Rank	Company	Total Employee	Industry
1	Rock Island Arsenal	8,200	Manufacturing
2	Deere & Company	6,000	Manufacturing
3	Genesis Medical Center	3,850	Health Care
4	Trinity Medical Center	2,200	Health Care
5	Davenport Community School District	1,950	Education
6	ALCOA	1,900	Manufacturing
7	Kraft Foods (Oscar Mayer)	1,500	Manufacturing
8	Xpac (Export Packaging, Inc.)	1,200	Manufacturing
9	City of Davenport	980	Government
10	Isle of Capri Casino	925	Gaming

Source: Infogroup Reference USA Gov, 2010 and individual employers

Located on an island in the Mississippi River at the geographic center of the Quad Cities Area, the Rock Island Arsenal is the region's largest single location employer. With 8,200 employees in 2010, the Rock Island Arsenal serves the U.S. military as a manufacturing and logistics center. The vast majority of employees on the island are civilians working in highly skilled manufacturing jobs or logistics, procurement, planning, and scientific positions.

Deere & Company (brand name John Deere) is a worldwide leading manufacturer of agricultural, construction and forestry equipment. In 2010, it was listed as 107th in the Fortune Global 500 ranking with a revenue of $24 billion. Deere & Company has its world headquarter in Moline and had 6,000 employees in 2010.

2.2 Socio-Economic Data

A fundamental component of the travel demand forecasting process is determining where people live and where they work, both in the present and future. A base year of 2010 was used to calibrate the travel demand model for present conditions, while horizon years 2025 and 2045 data are used to project future traffic. Table 2.2 summarizes the demographic data used in the travel demand model.

Table 2.2 – Socio-Economic Data in Travel Demand Model

Planning Area Demographic Data	Base Year 2010 Total	Horizon Year 2025 Total	Horizon Year 2045 Total
Population	298,005	313,438	328,544
Households	122,360	130,901	136,863
School Enrollment (K-12)	47,072	53,808	59,064
College Enrollment	16,555	20,649	25,460
Employment (By Place of Work)	161,988	175,689	188,359

Source: Bi-State Regional Commission, 2016

TransCAD uses existing and forecasted socio-economic data to quantify the urban activity for the planning area. The data sources for the travel demand model include:

- 2010 U.S. Census data
- Census Transportation Planning Products 5-Year Summary (2006-2010)
- 2013/2014 Quad Cities Household Travel Survey
- 3rd Quarter 2010 Business data by Infogroup, Inc.
- 2011-2040 Employment Projection by Woods & Poole Economics, Inc.
- Traffic count data from Illinois and Iowa Departments of Transportation

- Enrollment data from local school districts
- Local officials, and planning and engineering staff

Base year 2010 data required for the travel demand forecasting model includes:

Population and Households. Population and total household data was pulled from the 2010 Census in the format of a CSV table. This data was joined to a Census block shape file with unique ID "GEO10" then spatially joined to Traffic Analysis Zone (TAZ) using ArcGIS software. Wherever Census blocks are intersected by multiple TAZs, parcel data and aerial imagery were used as a reference to proportion Census data among related TAZs.

Total household data was further disaggregated by household size and vehicle ownership. The proportion pattern was calculated based on Census Transportation Planning Product (CTPP) 5-year summary (2006-2010) Table A112211 "Household size by Vehicles available". Households with three or more people were grouped into one category, same as the households with three or more vehicles. Table 2.3 lists the 2010 total households by household size and vehicle ownership in the MPA.

Employment by Place of Work (Categories for "industrial," "retail," and "other"). Employment data was obtained directly from Infogroup for 3rd Quarter 2010 in the format of a point shape file. They were spatially joined to a TAZ shape file for zonal level aggregation. Employment data contains information such as employer name, address, number of employees, and business type. The business type information was classified by North American Industrial Classification System (NAICS) code, and was further stratified to represent the broad categories of retail, industrial, and other employment. Table 2.4 shows the relationship between NAICS code and the employment categories that are used in the BSRC model. Table 2.5 outlines the employment by place of work by year and category.

When reviewing the employment data, BSRC staff noticed that some large employers were missing or misplaced, which prompted a closer look at the data. Significant effort was then made to verify and correct employment data for better accuracy of spatial location, number of employees, and business type. BSRC staff verified employment data in two tiers. Employers with less than 50 employees were spatially verified with county parcel data and listed address. In addition to the spatial verification, employers with more than 50 employees were further checked for the number of employees through phone calls, website searches, and local knowledge.

For data records missing NAICS codes, business name and address were reviewed, and professional judgment was made to determine the business type. The 2010 Quarterly Census of Employment and Wages (QCEW), formerly known as ES202 data, was also used as a reference to verify the Infogroup data.

Persons per square mile and jobs per square mile maps are included in Chapter 3 of *2045 Quad Cities Long Range Transportation Plan*. Maps 3.11, 3.13, and 3.15 depict the persons per square mile by TAZ for Years 2010, 2025, and 2045. Maps 3.12, 3.14, and 3.16 show the jobs per square mile by TAZ for Years 2010, 2025, and 2045. Both population and employment are represented by ranges and illustrate the density of these socio-economic parameters.

School Enrollment. BSRC staff contacted each school district, private schools, colleges, and universities for fall 2010 enrollments and projected 2025 and 2045 enrollments. Projections for school enrollment were based on information provided by the respective school districts and identification of plans for any new facilities or closures through 2045. Building capacity was used as a reference to estimate horizon year enrollments for schools that did not have such projections. Table 2.6 lists the student enrollment for each college. It should be noted that Western Illinois University moved its Quad Cities campus in 2013 from TAZ1258 to TAZ1105.

Bi-State Regional Commission (BSRC) also requested college student address data for fall 2010. Anonymous student address data was received in the format of spreadsheets and geo-coded to points, then spatially joined with TAZs to get zonal level distribution. Such distribution patterns were then applied to 2010, 2025, and 2045 total enrollment to get zonal college enrollment.

Annual Average Daily Traffic (AADT). AADT is essential data required to validate model outputs. This data was obtained from Iowa and Illinois Departments of Transportation (DOT) for 2010, which was the most current, consistently available year, and coincided with the base year data. In the case that 2010 AADT was not available, most recent counts were used.

Illinois DOT publishes GIS polyline shape files of annual traffic volume at county level. A subset of the shape file was clipped for the Bi-State MPA. Many line features in the shape file span multiple model links, so engineering judgement was made to geo-code actual count locations as points, then spatially joined with BSRC model network.

Iowa DOT produced 2010 AADT traffic flow maps at county and city level. Maps are in PDF format. A consultant was hired to geo-code count locations to the BSRC model network, thus, AADT data in traffic maps can be utilized to compare with corresponding model links.

Map 2.1 symbolizes the locations of traffic counts and observed 2010 AADT that were used to calibrate the traffic assignment results.

Table 2.3 – 2010 Households by Household Size and Vehicle Ownership

2010	Number of Vehicle			
HH Size	0	1	2	3+
1	6,372	26,495	4,415	1,149
2	1,699	9,671	25,494	6,795
3+	1,140	6,466	18,704	13,960

Source: Bi-State Regional Commission, 2016

Table 2.4 – Employment Category

Employment Category	NAICS 2012	Description
Industrial	11	Agriculture, Forestry, Fishing, and Hunting
	21	Mining, Quarrying, and Oil and Gas Extraction
	22	Utilities
	23	Construction
	31-33	Manufacturing
	42	Wholesale Trade
	48-49	Transportation and Warehousing
	51	Information
Retail	44-45	Retail Trade
Other	51	Information
	52	Finance and Insurance
	53	Real Estate and Rental and Leasing
	54	Professional, Scientific, and Technical Services
	55	Management of Companies and Enterprises
	561	Administrative and Support Services
	61	Educational Services
	62	Health Care and Social Assistance
	71	Arts, Entertainment, and Recreation
	72	Accommodation and Food Services
	81	Other Services (except Public Administration)
	92	Public Administration

Source: Bi-State Regional Commission, 2016

Table 2.5 – Employment by Year and Category

Planning Area Demographic Data	Base Year 2010	Percent of Total Employment	Horizon Year 2025	Percent of Total Employment	Horizon Year 2045	Percent of Total Employment
Industrial	46,595	28.8%	50,375	28.7%	54,970	29.2%
Retail	23,651	14.6%	28,733	16.4%	31,863	16.9%
Other	90,154	55.7%	95,014	54.1%	99,494	52.8%
Casino	1,588	1.0%	1,567	0.9%	2,032	1.1%
Total Employment	161,988	100%	175,689	100%	188,359	100%

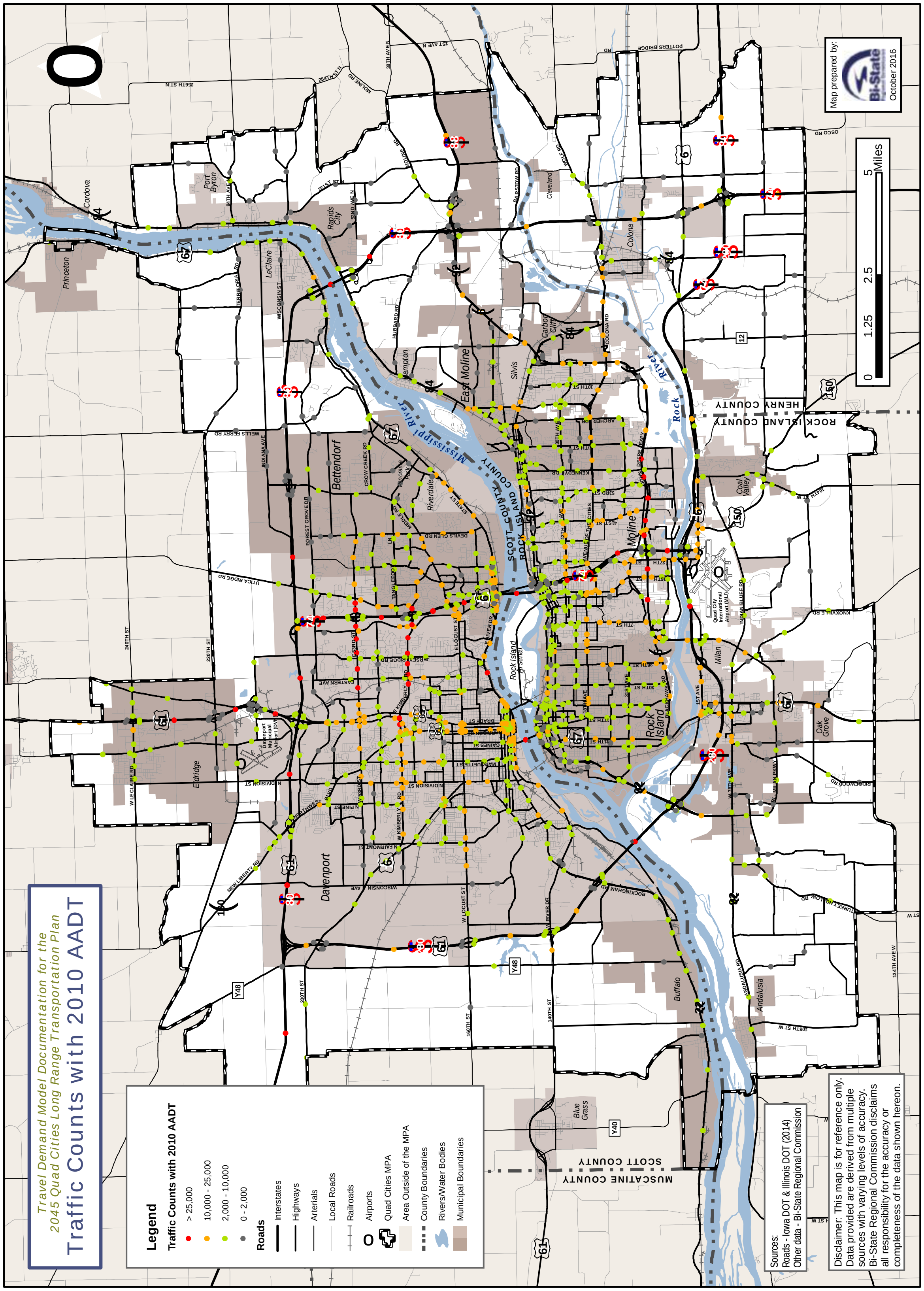
Source: Bi-State Regional Commission, 2016

Table 2.6 – College Enrollment

College	Address	TAZ	2010 Enrollment	2025 Enrollment	2045 Enrollment
Augustana College	639 38th St., Rock Island, IL 61201	1035	2,500	2,500	2,500
Black Hawk College	6600 34th Ave., Moline, IL 61265	1311	3,505	3,409	3,325
Palmer College	1000 Brady St., Davenport, IA 52803	1517	1,178	1,300	1,300
Scott Community College	500 Belmont Rd., Bettendorf, IA 52722	1810	2,941	4,049	6,363
St. Ambrose College	518 W. Locust St., Davenport, IA 52803	1584	3,308	4,100	5,000
Western Illinois University	3561 60th St., Moline, IL 61265	1258	1,100	0	0
Western Illinois University	3300 River Dr., Moline, IL 61265	1105	177	3,000	3,000
Black Hawk College Adult Learning Center	4610 Blackhawk Commons Dr., Rock Island, IL	1157	422	0	0
Eastern Iowa Community College	306 W River Dr., Davenport, IA 52801	1528	865	1,191	1,872
Kaplan University - Davenport	1801 E Kimberly Rd., #1, Davenport, IA 52807	1827	559	1,100	2,100

Source: Bi-State Regional Commission, 2016

Map 2.1 – Traffic Counts with 2010 AADT



Source: *Bi-State Regional Commission, 2016*

2.3 Projection Methodology for Population

Population data for horizon years 2025 and 2045 was derived from meetings with community and county officials based on their input and consistency with local comprehensive and development plans. The growth of population was developed from estimates of future dwelling unit growth by TAZ and density of persons. These estimates were cross-referenced and bounded by population projections produced by Bi-State Regional Commission.

Projection Methodology for Population. To develop population projections for each TAZ, meetings were held with representatives from the cities and counties in the MPA. Based on local knowledge, anticipated growth areas, and future plans for housing development, local officials provided estimated growth by households, and household size was applied to develop projected population growth by TAZ. Local officials reviewed the housing units growth from the last plan update and made estimates for the two horizon years 2025 and 2045.

Control Totals for Population Projections. To provide a range of population projections for the MPA as a whole in order to bound population growth input from the local jurisdictions within reasonable levels, fast-growth and slow-growth population scenarios were developed for the area within the MPA boundary. Both population projection scenarios are based on the starting base year 2010 population of 298,005. They were examined to determine a range of population projections and illustrate varying degrees of population growth in the Quad Cities Area. Following are explanations of these control total scenarios.

Slow Growth Population Scenario. The projected slow-growth or lower-limit projection is 298,527 persons by 2045. This scenario is based on the overall growth of the regional population within the past 40 years (1970-2010). During this period, decennial censuses show that the population in the MPA region grew from 362,638 to 363,256 with an annual average growth of 0.005%. This growth rate was used to project the population in each TAZ. The individual TAZ totals were added within each horizon year to provide the control total. The equation of population projections is described in Figure 2.1.

Figure 2.1 – Equation of Population Projection

$$\boldsymbol{F = B * (1 + G)^{T}}$$

Where: F – Future population

B – Base year population

G – Growth rate

T – Number of years

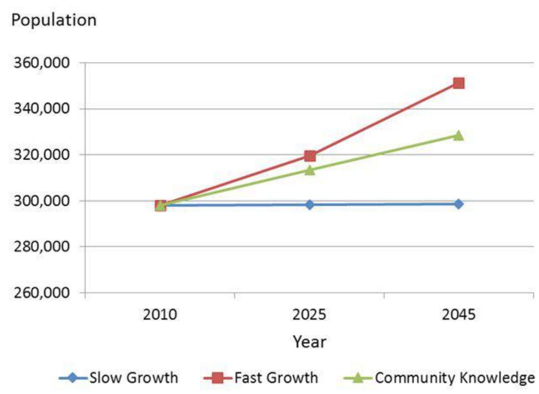
Fast Growth Population Scenario. The upper-limit or fast-growth projection for the MPA is 351,154 persons by 2045. This projection is based on the growth rate of population in Scott County, Iowa, which was the fastest growing county within the MPA from 1990 to 2010. According to Census data, the population in Scott County grew from 150,979 in 1990 to 165,224 in 2010, with an annual average growth rate of 9.4%. Table 2.7 and Figure 2.2 illustrate the upper and lower limit as well as the community approved population projection.

Table 2.7 – Projections of Population Growth

Population Scenario	2010	2025	2045
Slow Growth	298,005	298,229	298,527
Fast Growth	298,005	319,720	351,154
Local Land-Use Based Growth	298,005	313,438	328,544

Source: Bi-State Regional Commission, 2016

Figure 2.2 – Quad Cities MPA Population Projections



Source: Bi-State Regional Commission, 2016

2.4 Projection Methodology for Employment

Employment data for horizon years 2025 and 2045 was derived from the communities and counties based on their local comprehensive and development plans for industrial, retail, and other employment sectors. For the employment projections, growth was estimated by the type of commercial or industrial land use. It was represented by an estimated employees per business expected in that zone. These estimates were cross-referenced and bounded by employment projections produced by Bi-State Regional Commission.

Employment Projection Methodology for Travel Demand Model. To develop employment projections for each TAZ, meetings were held with representatives of the cities and counties in the MPA. Based on local knowledge, anticipated growth areas, and future plans for economic development, local officials provided estimated growth by TAZ and by employment category – industrial, retail, or other. Local officials reviewed the employment growth estimated from the last plan update and made estimates for the two horizon years 2025 and 2045.

Control Totals for Employment Projections. To provide a range of employment projections for the MPA as a whole, and in order to bound employment growth input from the local jurisdictions within reasonable levels, fast-growth and slow-growth employment scenarios were developed for the area within the MPA boundary. Following are explanations of these control total scenarios. In general, total employment is defined as total jobs at all places of employment within the MPA boundary.

The fast growth or upper limit projection. The fast-growth projection relies on economic-based employment projections from Woods & Poole Economics Inc. Woods and Poole uses a definition of jobs that is very broad, including sole proprietors and home-based workers. This definition is broader than that used by state agencies to produce Covered Employment and Wages data (commonly referred to as ES 202), which follows the federal Bureau of Labor Statistics definition of jobs. For the fast-growth scenario, a conscious decision was made to create a projection that reflected this broader definition of job types, due to their potential impact on the transportation system.

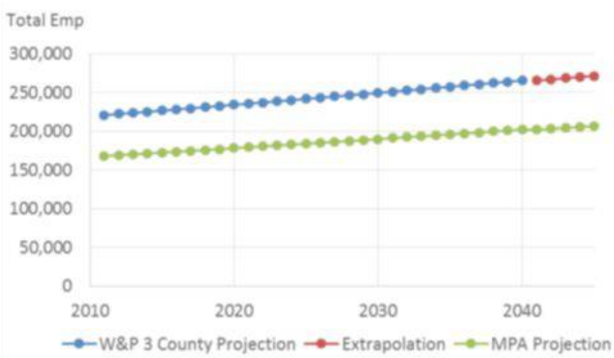
Woods & Poole produced employment projections from 1969 to 2040 in which a 2011-2040 projection was used and extrapolated to 2045 with a linear trend line. Woods and Poole provided data at the county level and larger geographies, but not at the sub-county level. To proportion this data specifically to the MPA, a ratio, or percentage, was applied. The applied percentage was derived from the observed percentage of jobs within the MPA in 2010 compared to all jobs in Henry, Rock Island, and Scott Counties. Infogroup data were used to identify this percentage. In 2010, about 76.10% of total employments in the three-county area were within the MPA. Thus, future year employment was projected at 76.10% of the Woods and Poole total.

For each employment category, with the horizon year projection calculated, individual TAZ employment was projected by applying the observed percentage of total employment in 2010. Thus, if a particular TAZ had 0.005% of the entire MPA retail employment in 2010, it was calculated to have the same percent of the projected MPA retail employment in future years. Figure 2.3 charts the fast-growth scenario based on Woods & Poole employment projection.

Slow Growth Employment Scenario. For consistency, the projected slow-growth or lower-limit employment projection is based on the slow population projection that has been documented in section 2.3. It assumes the MPA retains the same employment-to-population ratio from 2010 to 2045. According to Census and Inforgroup data, the Quad Cities MPA had a population of 298,005 and total employment of 183,401 in 2010. The employment-to-population ratio of 54.36% was then applied to the 2025 and 2045 projected population to determine the projected employment.

Table 2.8 and Figure 2.4 represent the upper and lower limit as well as the community based employment projection used in the travel demand model.

Figure 2.3 – Woods & Poole Employment Projection



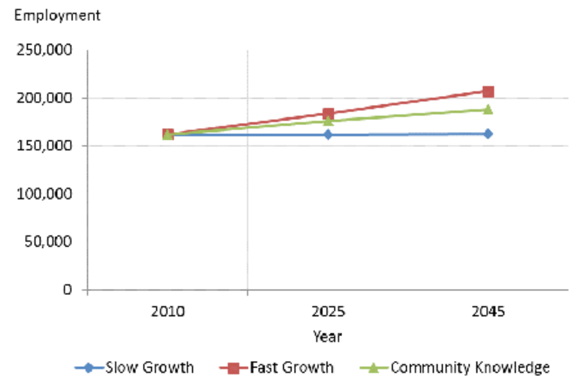
Source: Bi-State Regional Commission, 2016

Table 2.8 – Projections of Employment Growth

Employment Scenario	2010	2025	2045
Slow Growth	161,988	162,110	162,272
Fast Growth	161,988	184,166	206,947
Local Land-Use Based Growth	161,988	175,689	188,358

Source: Bi-State Regional Commission, 2016

Figure 2.4 – Quad Cities MPO Employment Projections



Source: Bi-State Regional Commission, 2016

2.5 Traffic Analysis Zones

Urban activities within the Quad Cities MPA are modeled and aggregated to the level of Traffic Analysis Zones (TAZs). A TAZ, in an ideal setting, is a portion of the planning or study area delineating homogeneous land use and travel purposes. TAZs are mutually exclusive (i.e. they do not overlap) and collectively exhaustive (they cover the entire model region). Socio-economic data was collected at this level of detail in order to better predict travel in the metropolitan area. TAZs vary in size by the density or nature of the urban land use that they encompass. TAZs in this report were created to analyze traffic flow on the major streets in the MPA.

Traffic Analysis Zones are the geographical units for the travel demand model. Major land uses are defined for each TAZ. It is assumed that all travel activities and characteristics are homogeneous within each TAZ. Following principals were followed when defined the TAZs:

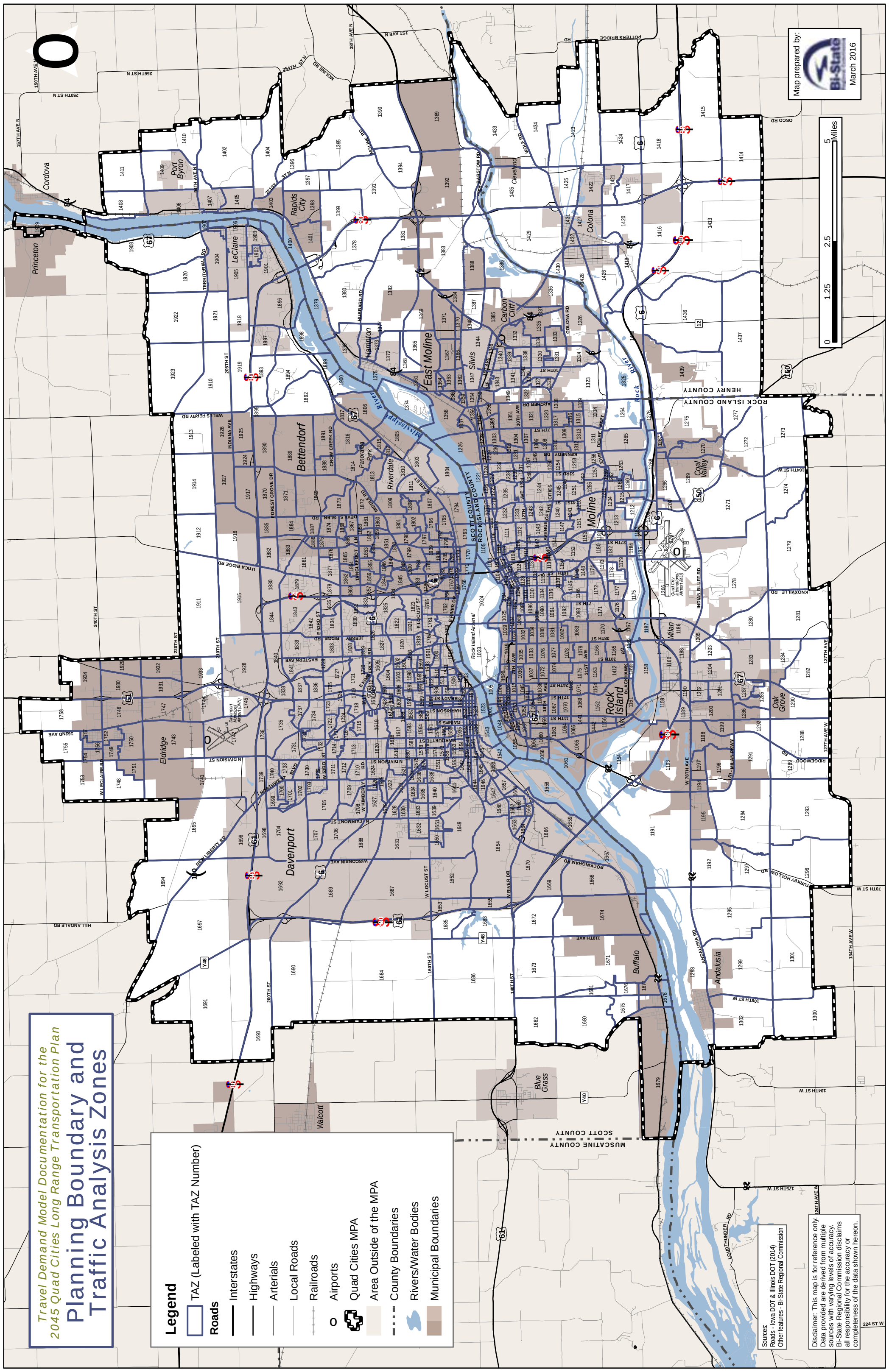
- Avoid irregular geometric shape of TAZ boundaries
- Follow Census, geographic, physical, and political boundaries
- Major roadways should not bisect a TAZ
- Natural barriers like lake and mountain should not bisect a TAZ
- Relatively similar land use in a zone

The Census 2010 Traffic Analysis Zones program was initiated in 2011, and TAZs were available from the Census Bureau in 2012. The TAZs designated under the Census criteria provided the basic geography for the travel demand model to geographically reference Census data by TAZ.

For modeling purposes, many of the TAZs were further split into smaller zones to provide higher resolution and more accurate details. In June 2012, the MPA boundary was revised by the Transportation Policy Committee to coincide with 2010 U.S. Census geography for the Davenport, IA-IL Urbanized Area. On July 5, 2012, it was conveyed to the states for concurrence. Map 2.2 illustrates the approved MPA boundary and TAZs geography for the BSRC model.

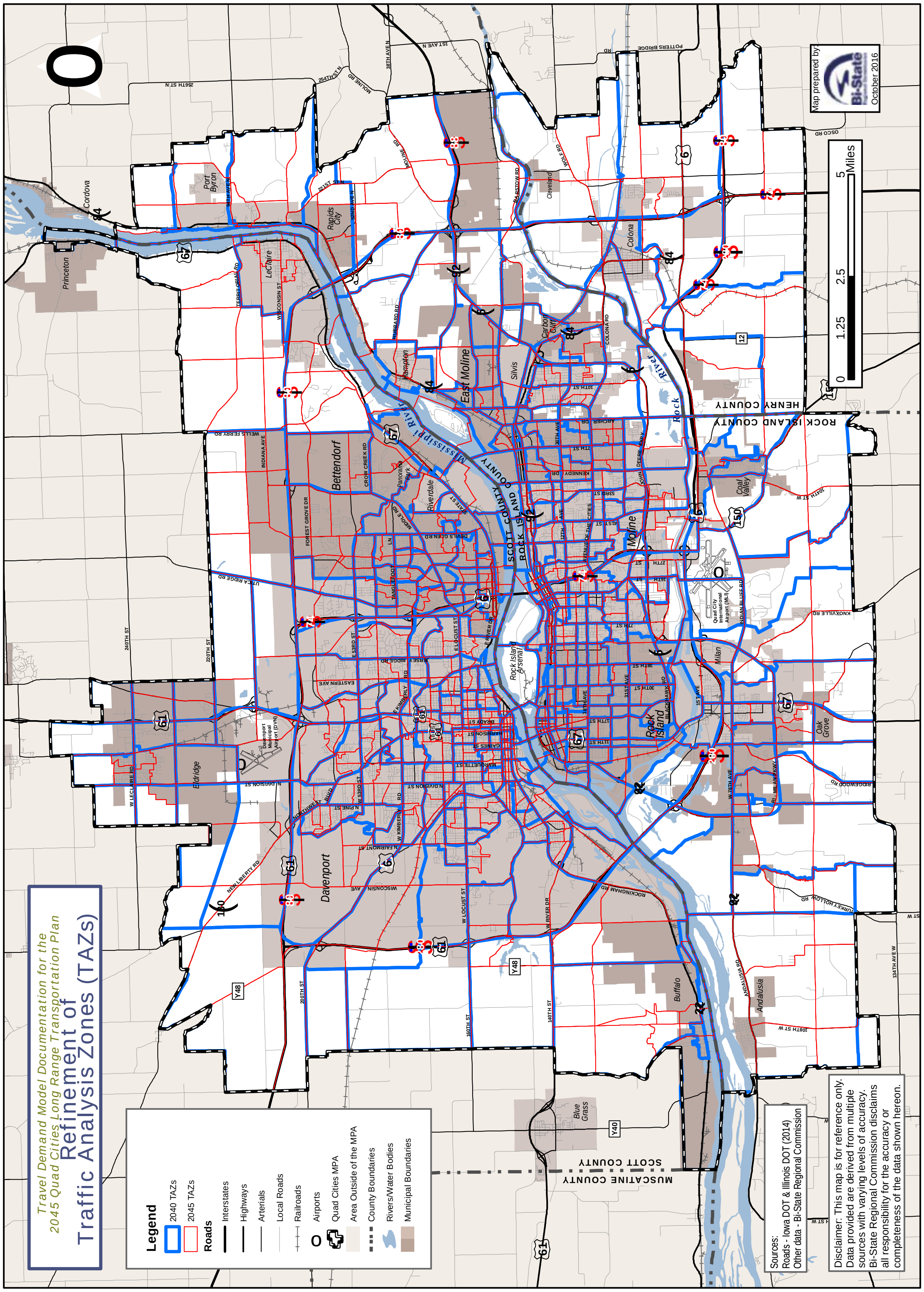
In previous version of the BSRC model, there were 453 internal TAZs. They were further refined into 881 internal TAZs in the MPA. TAZs 1001-1444 cover the model area in Illinois State, in which 27 zones (TAZ 1413-1439) cover the model area in Henry County. TAZs 1500-1939 cover model area in Iowa State. Map 2.3 shows the TAZ refinements by comparing current model TAZs and previous model TAZs, which were used for the 2040 LRTP.

Map 2.2 – Planning Boundary and Traffic Analysis Zones



Source: Bi-State Regional Commission, 2016

Map 2.3 – Refinement of Traffic Analysis Zones (TAZs)



Source: *Bi-State Regional Commission, 2016*

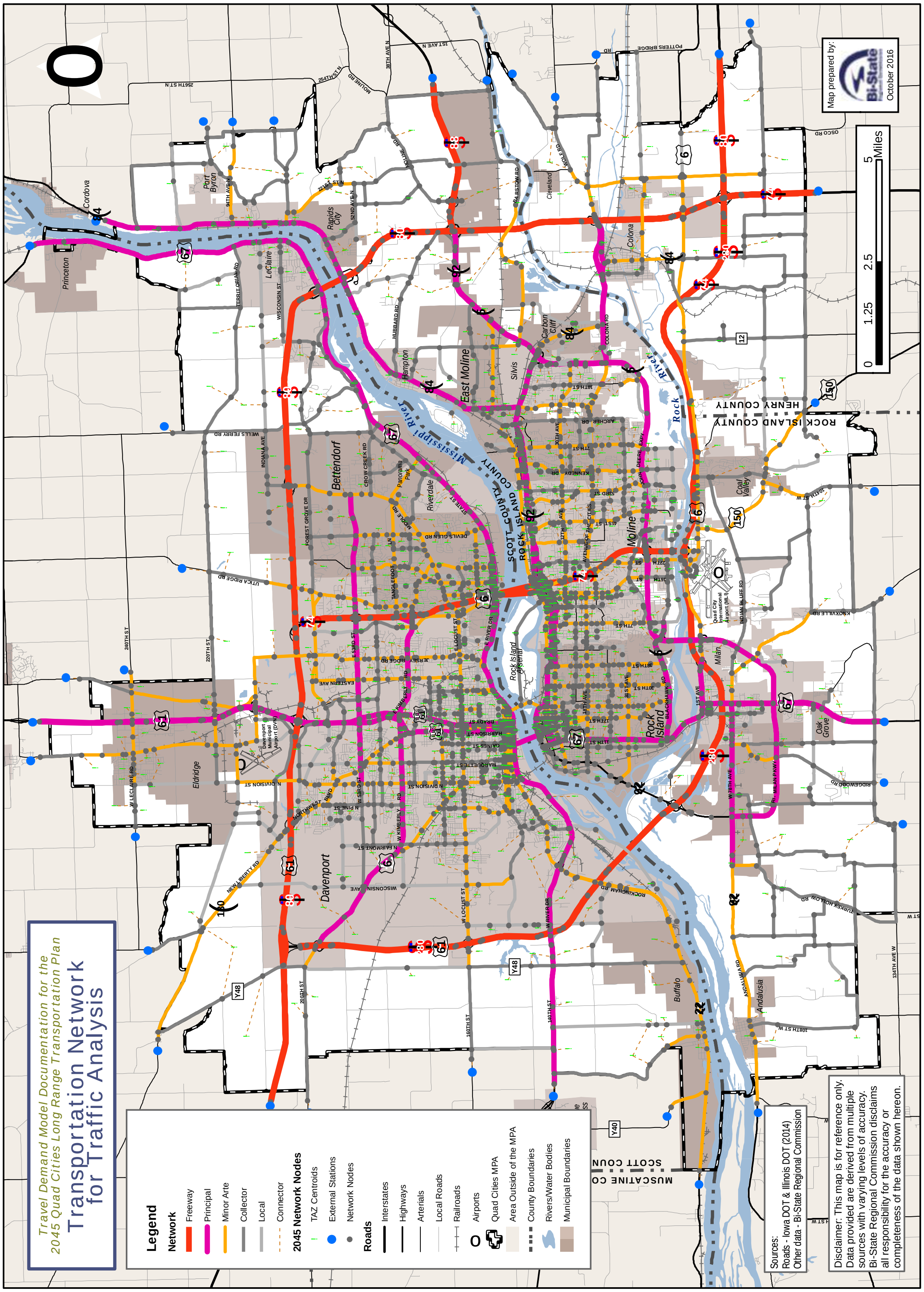
2.6 Roadway Network

Roadway network is the crucial input of a travel demand model. It provides geometric alignment and topological connectivity as well as important roadway characteristics such as number of lanes, functional classification, etc. Roadway network is made up of centroids, external stations, centroid connectors, highway nodes, and links.

Centroids are points representing the center of activity within a TAZ. Traffic generated or attracted by zonal socio-economic data are assumed to start and end at centroids. Accordingly, centroid connectors are links to load traffic from centroids to highway network and vice versa. Centroid connectors conceptually represent the local road system within each TAZ. Instead of representing internal TAZs, external stations are special centroids where external trips enter and leave the highway network. They are the bridges connecting the model area and the outside world. Highway links represent roadway segments, and highway nodes are the end points of links. Highway nodes typically represent intersections and access points.

Map 2.4 illustrates the structure of the model network, and symbolizes the links by functional classification and the nodes by node type.

Map 2.4 – Transportation Network for Traffic Analysis



Source: Bi-State Regional Commission, 2016

Highway networks were coded in a master network file that contains both existing facilities and planned improvements. Highway networks for each scenario are "generated" from the master network, which has a set of fields describing roadway characteristics when the road is first opened, another set of fields describing proposed roadway changes, and fields describing opening and project years. For more details of the master network, see section A.1 Master Network Preparation in the Appendix.

2.7 Estimation of Free Flow Speed

Highway travel time and highway capacity are the two main outputs of the highway network process. Attributes used to calculate travel time, included segment length (computed by TransCAD from highway alignments), posted speed, one/two-way operation, functional classification, and area type.

Free flow speed is used by travel demand model to calculate initial uncongested travel time (T_0), which is the "starting point" of the Bureau of Public Roads (BPR) Curves to determine the congested travel time.

The BSRC model estimates free flow speed based on posted speed limits with two levels of adjustments. The first level of adjustment is multiplier factors that were applied globally. They account for intersection delay in a generalized manner based on roadway functional classification and surrounding area type. Global Speed Factors are stored in a lookup table named "spdlut.bin."

During the model calibration, a second speed adjustment was introduced to approximately 10% of all links to bring model-estimated traffic volumes into better agreement with observed traffic counts. Some of these adjustments reflect driver preferences for certain routes, while others reflect delays that are not accounted for by the speed adjustment factors. For example, a speed reduction was necessary for the Government Bridge, which is a swing-span bridge that gives right-of-way to river traffic. Delays at this river crossing can be as long as 30 minutes for barges to lock through the navigation system. These Link Speed Adjustments were hand coded in the master network link attribute field "ADJSPEED."

Free flow speed was calculated by following equation.

Figure 2.5 – Free-Flow Speed Calculation

$$FFS = (PSP + LAS) * GAF$$

Where: FFS – Free flow speed

PSP – Post speed limit

LAS – Link speed adjustment

GAF – Global speed adjustment factor

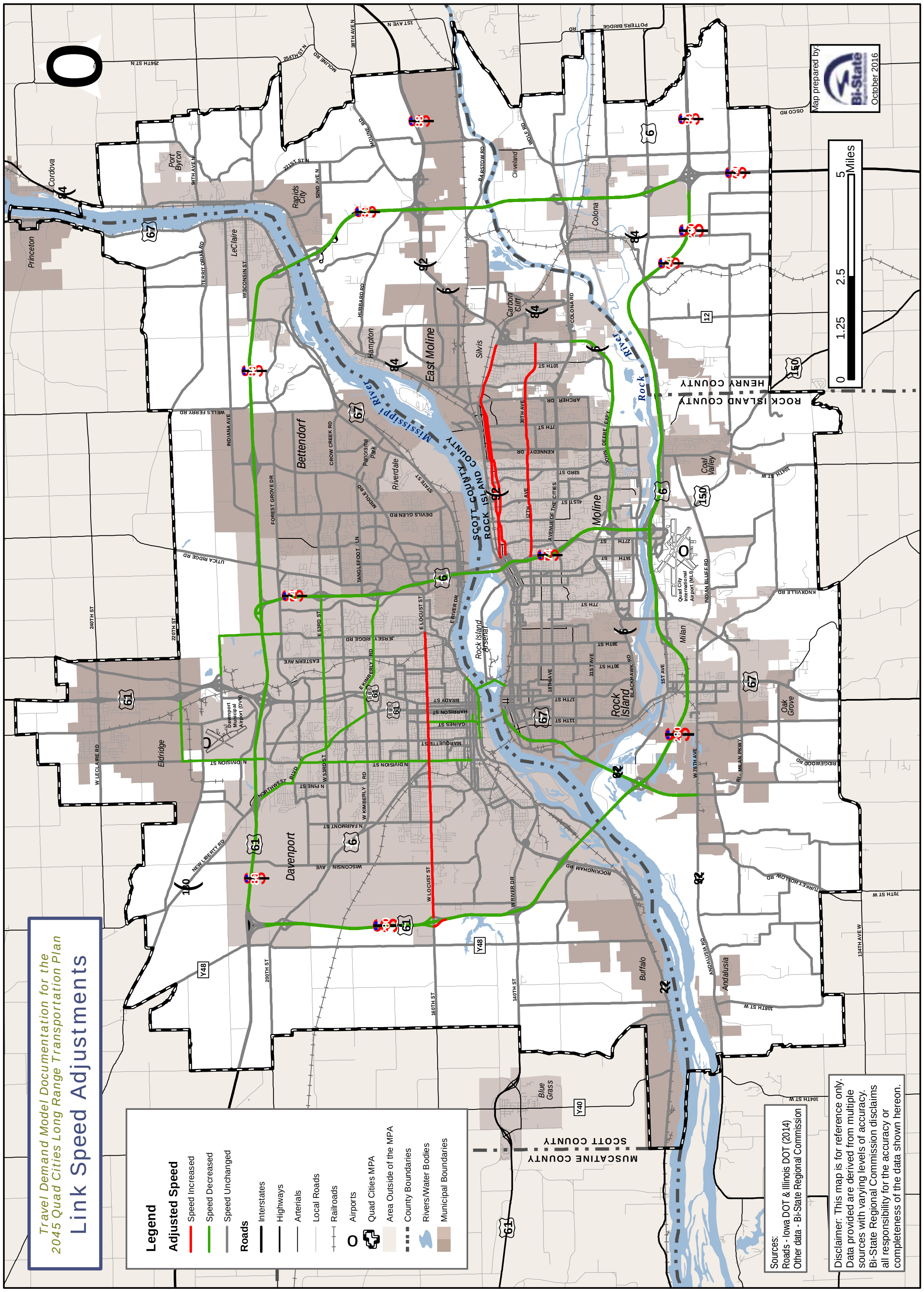
Table 2.9 lists Global Speed Factors applied to the network links by roadway functional classification and area type. Map 2.5 highlights the roadway segments with Link Speed Adjustment. (i.e. ADJSPEED does not equal zero)

Table 2.9 – Global Speed Adjustment Factors

Functional Classification	Area Type			
	CBD	Urban	Suburban	Rural
Freeway	1.00	1.00	1.00	1.00
Expressway	0.95	0.95	0.95	0.95
Principal Arterial	0.75	0.75	0.85	0.85
Minor Arterial	0.75	0.75	0.85	0.95
Collector	0.75	0.75	0.85	0.95
Local	0.75	0.75	0.85	0.95

Source: Bi-State Regional Commission, 2016

Map 2.5 – Link Speed Adjustments



Source: Bi-State Regional Commission, 2016

2.8 Estimation of Link Capacity

Capacity specifies the maximum amount of traffic that can be accommodated by a roadway segment before severe congestion occurs. Traffic and roadway condition affects the capacity of roadway. Lane width, road condition, shoulder width, and terrain of roadway are a few factors that can determine capacity. The travel demand model uses capacity as a denominator to calculate Volume over Capacity ratio, which is used in Bureau of Public Roads (BPR) Curves to determine congested travel time.

Based on methodologies documented in Highway Capacity Manual (HCM) 2010, the criteria for measurements of the highway capacity depends on determining Level-of-Service (LOS), which ranges from A to F. In previous model version, link capacity used to be set for LOS D. It is now based on LOS E, which is more consistent with common practice in travel demand modeling.

Table 2.10 lists the roadway capacity by number of directional lanes, functional classification, and area type.

Table 2.10 – Roadway Link Capacity

Functional Class	Lanes	CBD	Urban	Suburban	Rural
Freeway	2	3,500	3,500	3,500	3,500
	3	5,500	5,500	5,500	5,500
	4	7,500	7,500	7,500	7,500
Expressway	2	3,300	3,300	3,300	3,300
	3	5,100	5,100	5,100	5,100
	4	6,900	6,900	6,900	6,900
Principal Arterial	1	740	920	960	1,160
	2	1,480	1,840	1,920	2,320
	3	2,220	2,760	2,880	3,480
	4	2,960	3,680	3,830	4,640
Minor Arterial	1	650	760	790	950
	2	1,300	1,520	1,580	1,900
	3	1,950	2,280	2,370	2,850
	4	2,600	3,040	3,160	3,800
Collector	1	590	680	710	850
	2	1,180	1,360	1,420	1,700
	3	1,770	2,040	2,130	2,550
	4	2,360	2,720	2,840	3,400

Note: CBD = Central Business District

Source: 2010 Highway Capacity Manual

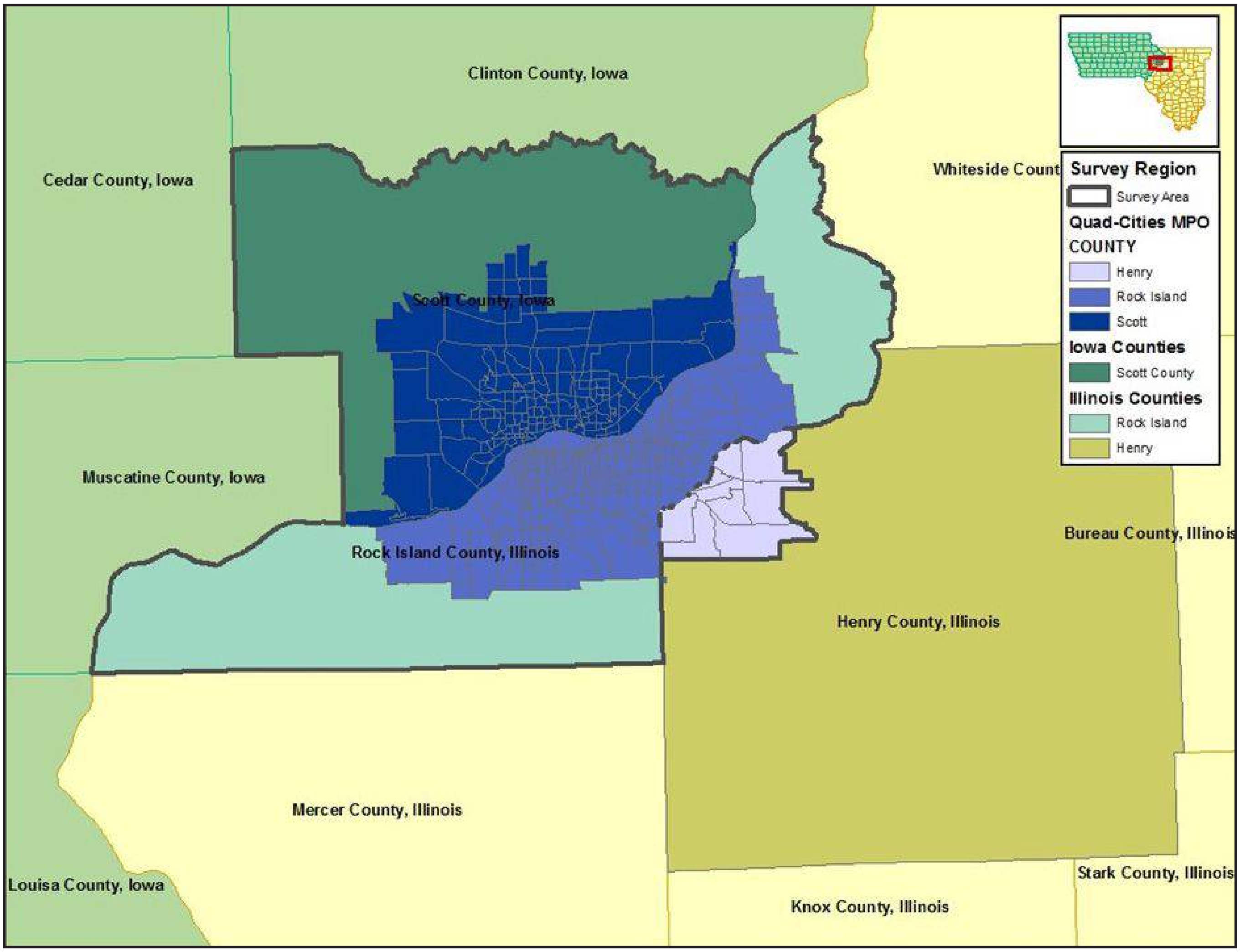
3.0 Household Travel Survey

From October 2013 to January 2014, Bi-State Regional Commission hired URS Corporation, ETC Institute, and Texas A&M Transportation Institute (TTI) to conduct the *Quad Cities Household Travel Survey (HHTS)*. This survey aimed to enhance data support for the BSRC modeling practice. It covered all of Rock Island and Scott Counties, and that portion of Henry County as captured in the MPA Boundary. By extending the study area from the MPA boundary to county borders in Rock Island and Scott Counties, the survey captured an additional 5% and 9% of populations, respectively. These populations were in the fringe city areas that exhibited strong connections to the Quad Cities MPA. Map 3.1 shows the study area within the dark boundary.

In the survey, 6,798 households were contacted, in which 1,793 households provided travel diary data. The overall response rate is 26%. It reflects a strong interest in transportation in the Quad Cities Area. Survey respondents provided a complete listing of activities made on a survey day with information such as start and end location, start and end time, trip purpose, and trip mode. Information was also collected about household, household member, and household vehicle characteristics. The survey data set contains data for all 1,793 households surveyed, 4,100 persons, 3,531 vehicles, and 13,790 trip locations.

Surveys from 168 households were determined to be unusable due to extreme weather and back in school session on survey days. It resulted in 1,625 survey households eventually used for model estimation. (See *Quad Cities Household Travel Survey* for more details. The document is available on the BSRC website at www.bistateonline.org.)

Map 3.1 – Study Area of 2013/2014 Quad Cities Household Travel Survey



Source: *2013/2014 Quad Cities Household Travel Survey*

4.0 Trip Generation

Travel demand forecasting is a tool used to quantify the amount of trips on the roadway network. Trip generation is the first step in travel demand forecasting. Zonal land use, population, and economic forecasts are multiplied with trip rates to calculate how many trips will be made to and from each TAZ.

Each trip has two ends, Origin and Destination. For modelling purposes, trip ends also can be categorized as Productions or Attractions. The concept of production is associated with a trip maker's home. For instance, in a Home Based Work (HBW) trip, home is always the production, regardless of if it is the trip origin when people travel from home to work or the destination when people come back from work to home. Accordingly, attraction is the non-home end of a trip.

Trip generation model includes the following essential steps:

- Calculating trip production
- Calculating trip attraction
- Adjusting productions and attractions for special generators
- Applying external trip ends
- Balancing production and attraction by trip purpose

4.1 Trip Rates

The trip generation model estimates average daily trips in the following seven purposes:

- **Home Based Work (HBW)**: Any trips with home at one end and work at the other end.
- **Home Based School (HBSCL)**: Any trips with home at one end and school activity at the other end (for both K-12 and college).
- **Home Based Shop (HBSH)**: Any trips with home at one end and shopping activity at the other end.
- **Home Based Social Recreation (HBSR)**: Any trips with home at one end and social visits or personal business activity at the other end.
- **Home Based Other (HBO)**: Any trips with home at one end and the other end at an activity not included in the above categories.
- **Non-Home Based (NHB)**: Trips that do not start or end at home.
- **Commercial Vehicle (CV)**: Any trips generated by trucks.

The six non-commercial trips were generated as person trips. Their trip rates were tabulated from the *Quad Cities Household Travel Survey (HHTS)*, stratified by household size and auto ownership. Person trips will be converted to vehicle trips by applying vehicle occupancy in the mode split step.

Commercial vehicle trips were generated as vehicle trips. For each TAZ, productions of commercial vehicle trips were set to be identical with attractions. The attractions of commercial vehicle trips were based on the number of employees in each category, school and college enrollment and total households.

Trip production rates shown in Table 4.1 were computed by following procedure:

- Assigned a trip purpose code to each HHTS activity record
- Aggregated total weighted activity records by household size, vehicle ownership, and trip purpose
- Aggregated total weighted household records by household size and vehicle ownership
- Divided number of trips by number of households within the cross classification table of household size, vehicle ownership, and trip purpose
- Smoothed trip rates in cells with low response rates
- Adjusted trip rates to correct for under reporting issues

Trip attraction rates shown in Table 4.2 were computed in a similar manner. HHTS respondents described the place name where each of their activities occurred. HHTS records were edited to attach socio-economic codes at the start and end of each activity. These codes include industrial employment, retail employment, other employment, K-12 school enrollment, college enrollment, and households. Weighted activity records were then tabulated by trip purpose and socio-economic category, and divided by the following 2010 socio-economic totals: 46,595 industrial employees, 90,154 other employees, 23,651 retail employees, 47,072 school enrollment (K-12), 16,555 college enrollment, and 122,360 households.

For each trip purpose, trip attraction rates were adjusted to match the total trip attraction with the total trip production. By doing this, it prevents significant scaling in the trip balancing step at the end of trip generation model.

Table 4.1 – Trip Generation Rates

Trip Purpose	House-hold Size	Number of Vehicles			
		0	1	2	3+
HBW	1	0.28	0.83	1.03	1.49
	2	0.28	1.02	2.01	2.75
	3+	0.28	1.10	3.18	5.10
HBSCL	1	0.00	0.00	0.00	0.00
	2	0.00	0.01	0.01	0.01
	3+	2.58	2.60	2.60	2.60
HBSH	1	0.55	1.08	1.04	1.10
	2	0.53	1.98	1.79	1.87
	3+	1.33	2.37	2.07	2.22
HBSR	1	0.39	0.87	0.96	0.92
	2	0.39	1.70	1.78	1.68
	3+	1.05	2.22	2.34	2.18
HBO	1	0.13	0.36	0.47	0.48
	2	0.14	0.74	0.90	0.91
	3+	1.11	2.45	2.70	2.71
NHB	1	1.40	1.40	1.54	1.86
	2	0.96	2.95	3.35	3.49
	3+	5.03	5.03	5.42	5.42

Source: 2013/2014 Quad Cities Household Travel Survey

Table 4.2 – Trip Attraction Rates

Purpose	Industrial	Other	Retail	Casino	K-12	College	HHs
HBW	1.28	1.37	0.91	1.32	0.49	1.02	0.07
HBSCL	0.00	0.00	0.00	0.00	2.24	0.00	0.00
HBSH	0.17	0.91	5.00	0.00	0.08	0.00	0.08
HBSR	0.06	1.34	0.24	9.24	0.25	0.18	0.36
HBO	0.11	0.41	0.24	0.00	1.48	1.30	0.16
NHB	0.65	1.80	4.92	3.90	1.17	0.42	0.47
CV	0.41	0.10	0.38	0.36	0.01	0.01	0.08

Source: 2013/2014 Quad Cities Household Travel Survey

4.2 Special Generators

Special generators have land use characteristics that create more trips than may be typical of other land uses. The most common types of special generators are universities, casinos, airports, shopping malls, etc.

Casino employment and college enrollment are used in the BSRC model to forecast casino and college trips respectively, within the stream of a standard trip generation procedure. The information regarding college enrollment is documented in Chapter 2.2, Table 2.6. The trip rates for casinos were borrowed from a study from Metropolitan Area Planning Agency (MAPA) MPO (Omaha-Council Bluffs Area). Table 4.3 lists the casinos in the Quad Cities MPA. It should be noted that Rhythm City Casino was relocated from TAZ1523 to TAZ1844 in 2016.

A mixed-use area adjacent to I-74 between East 53rd Street and East Kimberly Road has a number of high traffic generators including "big box" stores, medical facilities, and office buildings. Trips for the area were generated based on building area and hospital beds using unique equations that were estimated for each special generator zone. It should be noted that productions and attractions of these special generators were estimated independently and utilized to overwrite the productions and attractions estimated from household and employment data so that the model does not double count the trips within these special generator zones. Table 4.4 tabulates these special generators and their indicator variables for trip generation.

Table 4.3 – Casinos in the Quad Cities Area

Special Generator	TAZ	2010 Employees	2025 Employees	2045 Employees	Address
Jumer's Casino	1193	350	350	350	777 Jumer Drive, Rock Island, IL 61201
Rhythm City Casino	1523	650	0	0	212 N Brady St. Davenport, IA 52801
	1844	0	1000	1000	7077 Elmore Avenue, Davenport, IA 52807
Isle of Capri Casino	1770	588	588	588	1777 Isle Parkway Bettendorf, IA 52722

Source: Bi-State Regional Commission, 2016

Table 4.4 – Special Generators in the Quad Cities Area

Special Generator	TAZ	Address	Area (Sq.Ft.)	# of Beds	Flights per day
North Park Mall	1718	Kimberly Rd. and Welcome Way (Hwy. 61), Davenport, IA	1.58M	--	--
South Park Mall	1182	John Deere Road & 16th Street in Moline, Illinois	1.1M	--	--
The Mark Arena	1094	1201 River Dr. Moline, IL. 61265	52,500	--	--
Genesis West	1581	1401 W. Central Park Davenport IA 52803	--	261	--
Genesis East	1600	1227 E. Rusholme Davenport IA 52803	--	241	--
Trinity West	1071	2701 17th St. Rock Island IL 61201	--	354	--
Trinity Terrace Park	1878	4500 Utica Ridge Rd. Bettendorf, IA	--	150	--
Illini Hospital	1329	801 Hospital Rd. Silvis, IL	--	150	--
QC International Airport	1207	2200 69th Ave. Moline, IL 61265	--	--	48

Source: Bi-State Regional Commission, 2016

4.3 External Trips

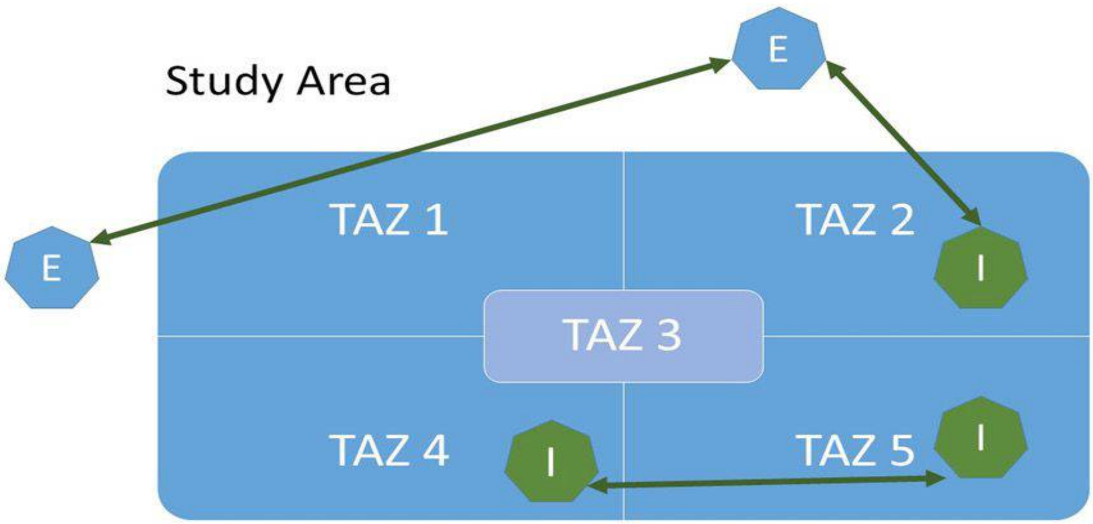
Trips having at least one end outside the planning area boundary are either called external-internal (E-I) trips (one end is outside the area) or external-external (E-E) trips (both ends are outside the area) (see Figure 4.1).

Traffic counts at the 35 external zones (TAZs that cross the planning area boundary) were used as base year control totals. Iowa DOT's Statewide Travel Demand Model (iTRAM) was used to obtain E-I trip totals by purpose at each external zone and E-E trips between zones. Outputs from the model were adjusted to match base year traffic counts at the external zones. Growth factors at each external station were calculated by comparing the 2010 and 2035 iTRAM model results. These growth factors were then applied to 2010 external trips to get projections in horizon year 2025 and 2045.

Table 4.5 summarizes base year and future traffic volumes resulting from this process at eight external zones with an Average Daily Traffic (ADT) of 5,000 or more. Map 4.1 highlights major external stations in green and other minor ones in blue.

It should be noted that E-I trips are further broken down by productions and attractions for the seven trip purposes: Home Based Work (HBW), Home Based School (HBSCL), Home Based Shop (HBSH), Home Based Social Recreation (HBSR), Home Based Other (HBO), Non-Home Based (NHB), and Commercial Vehicle (CV). The proportion was based on the percentage of each trip purpose in the 2001 *National Household Travel Survey* (NHTS).

Figure 4.1 – External Trip Types in Relation to the Study Area



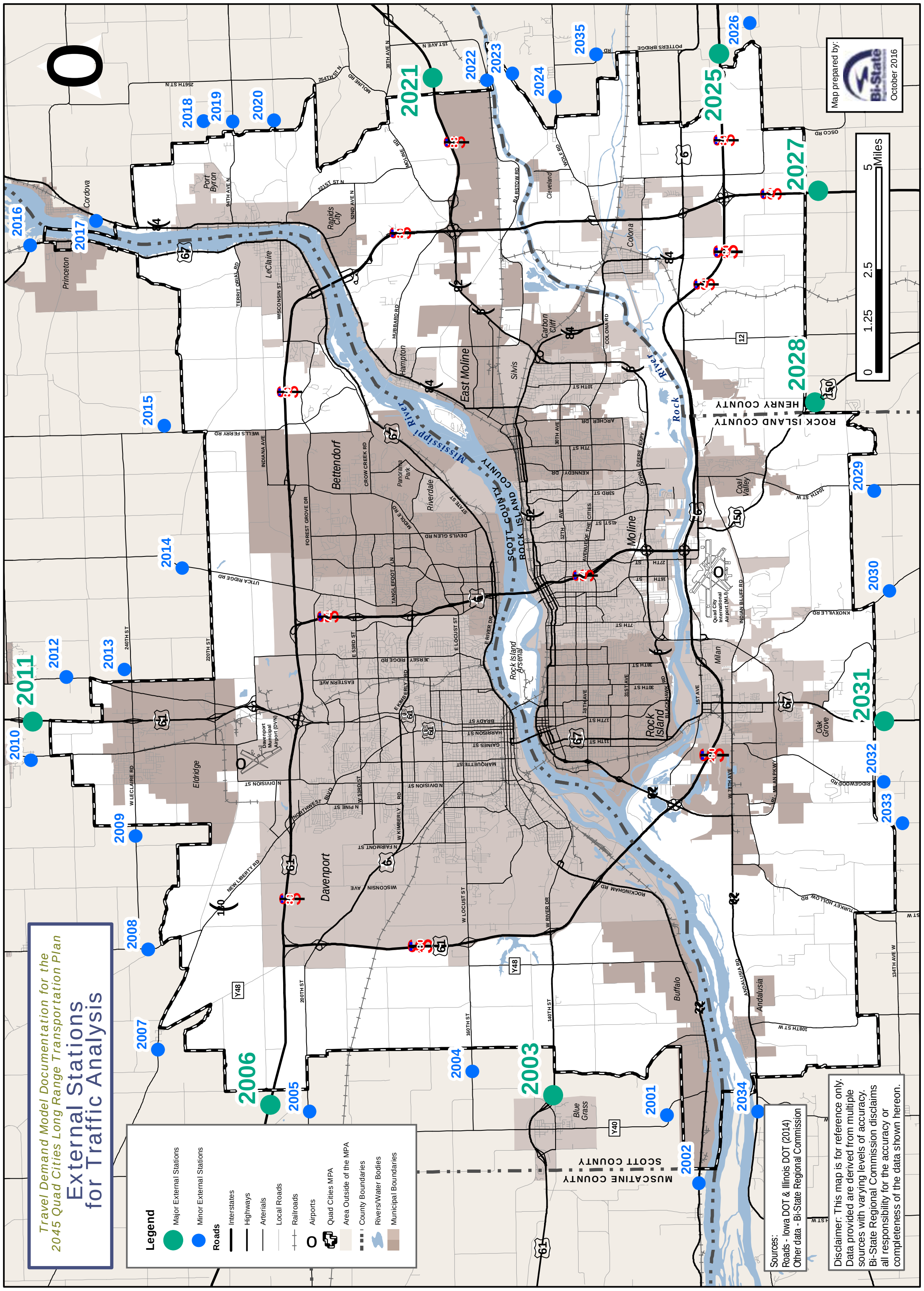
Legend	
E-I	External-Internal traffic
I-I	Internal-Internal traffic
E-E	External-External (through) traffic

Table 4.5 – Traffic at Major External Stations

TAZ	Location	Total ADT		E-E Trips		E-I Trips	
		2010	2045	2010	2045	2010	2045
2003	US 61 West	14,000	24,300	1,600	3,600	12,400	20,700
2006	I-80 West	33,300	64,600	16,200	39,500	17,100	25,100
2011	US 61 North	20,700	36,400	1,300	2,900	19,400	33,500
2021	I-88	14,900	26,100	8,200	19,300	6,700	6,800
2025	I-80 East	18,900	32,100	11,500	27,200	7,400	4,900
2027	I-74	13,900	23,900	6,000	13,700	7,900	10,200
2028	US 150	5,200	7,000	40	80	5,160	6,920
2031	US 67	6,600	9,800	600	1,200	6,000	8,600

Source: Iowa Department of Transportation, 2016

Map 4.1 – External Stations for Traffic Analysis



Source: *Bi-State Regional Commission, 2016*

4.4 Balancing Production and Attraction Trips

Trips are balanced to ensure that trip attractions and productions are equal for each trip purpose. Trip attractions are balanced to productions for all trip purposes, because there is a greater degree of confidence in household data than economic or employment data. More households in the study area will generate more trips, while more commercial places might simply grab customers from other places in the same system.

Comparing the "raw" trip production and attraction before trip balancing is a common practice to validate a trip generation model. The rule of thumb is that the production-to-attraction ratio before trip balancing should fall in the range of 0.90 to 1.10. Tables 4.6-4.8 tabulate the unbalanced productions and attractions by trip purpose for base year 2010 and horizon years 2025 and 2045. The comparison indicates that the trip generation model is well calibrated for base year 2010. In horizon year 2045, Home Based School (HBSCL) trips have the largest deviation between unbalanced productions and attractions, but are still within a reasonable range.

Table 4.9 illustrates productions and attractions by trip purpose after trip balancing. Table 4.10 outlines the model percentage of total trips by trip purpose versus the federal standards. It should be noted that the HBO trips in Table 4.10 actually represent Home Based Non-work trips, which are the combination of Home Based School (HBSCL), Home Based Shopping (HBSH), Home Based Social Recreation (HBSR), and Home Based Other (HBO) trips.

Table 4.6 – 2010 Unbalanced Trip Productions and Attractions

Purpose	Production	Attraction	P/A Ratio
HBW	258,387	261,401	0.99
HBSCL	104,336	105,633	0.99
HBSH	215,642	215,609	1.00
HBSR	206,677	207,258	1.00
HBO	162,157	161,856	1.00
NHB	424,091	422,018	1.00
CV	52,237	52,368	1.00

Source: Bi-State Regional Commission, 2016

Table 4.7 – 2025 Unbalanced Trip Productions and Attractions

Purpose	Production	Attraction	P/A Ratio
HBW	278,571	287,518	0.97
HBSCL	111,575	120,748	0.92
HBSH	232,377	246,198	0.94
HBSR	222,872	225,764	0.99
HBO	174,746	183,147	0.95
NHB	475,436	472,541	1.01
CV	58,010	58,144	1.00

Source: Bi-State Regional Commission, 2016

Table 4.8 – 2045 Unbalanced Trip Productions and Attractions

Purpose	Production	Attraction	P/A Ratio
HBW	296,779	313,057	0.95
HBSCL	117,525	132,543	0.90
HBSH	247,463	268,907	0.92
HBSR	237,535	240,380	0.99
HBO	186,006	202,992	0.92
NHB	516,647	512,739	1.01
CV	63,623	63,761	1.00

Source: Bi-State Regional Commission, 2016

Table 4.9 – Modeled Trips by Year and Purpose

Purpose	2010	2025	2045
HBW	258,000	279,000	297,000
HBSCL	104,000	112,000	118,000
HBSH	216,000	232,000	247,000
HBSR	207,000	223,000	238,000
HBO	162,000	175,000	186,000
NHB	455,000	489,000	517,000
CV	52,000	58,000	64,000
Total	1,454,000	1,568,000	1,667,000

Source: Bi-State Regional Commission, 2016

Table 4.10 – Percentage of Trips by Purpose

Trip Purpose	Model	TMIP
HBW	18%	18-27%
HBO*	47%	47-54%
NHB	31%	22-31%
CV	4%	--

Source: Bi-State Regional Commission, 2016;TMIP Model Validation and Reasonableness Checking manual, 2010

5.0 Trip Distribution

Following the trip generation process, the trip distribution model was developed to link productions with attractions. Trip distribution in the BSRC model is done using a gravity model. This step creates a matrix that allocates the number of trips going from each production to each attraction based on trip impedance, which is represented by travel time in the current BSRC model. Attraction zones with lower impedance from the production zone will exhibit a stronger attraction than those with higher impedance.

Figure 5.1 illustrates the equation of the gravity model. It is a doubly constrained model, which means that an iterative process is used to control both the productions and attractions for each zone. The process is complete when convergence criterion is met or maximum iteration is reached.

Figure 5.1 – Gravity Model

$$T_{ij} = P_i \times \left(\frac{A_j \times F_{ij} \times K_{ij}}{\sum_{j=1}^{n} A_j \times F_{ij} \times K_{ij}} \right)$$

Where: i – Production zone

j – Attraction zone

Tij – Trip produced in zone i and attracted to zone j

Pi – Trip productions in zone i

Aj – Trip attractions in zone j

Fij – Friction Factor, reflecting the travel time separation between zones i and j

Kij – An optional adjustment factor for interchanges between Zone i and Zone j

n – The number of zones in the model area

5.1 Network Skimming

The process of calculating trip impedance between each pair of zones is called network skimming. In the current BSRC model, the impedance used in trip distribution is solely based on travel time over the shortest path between origin and destination. For each trip purpose, travel impedances are computed separately for peak and off-peak hours. No travel time impedance is calculated for External-External trips, because E-E trips are static model inputs that were generated in the O-D format in the first place.

In the previous model version, bridge penalties on travel time were introduced at the Mississippi River crossings and the Government Bridge to simulate the extra delay. They were removed in the current model and replicated by travel speed adjustment and K factors.

5.2 Trip Friction Factors

The friction factors (F_{ij}) are empirically derived travel time factors that measure the average area-wide effect of spatial separation on trip interchange between zone "i" and zone "j." They determine the likelihood of a trip being made in each impedance increment and are used in the trip distribution model to reflect the difference of trip length among trip purpose. For example, shopping trips, which are much shorter than commute trips, have friction factors that diminish more rapidly than friction factors of work trips.

Friction factors are inversely proportional to travel time. As travel time increases, the friction factor decreases. There are many ways to estimate friction factors. Some of the methods include power functions, exponential functions, or gamma functions. The friction factors of the BSRC model were generated by a gamma function illustrated in Figure 5.2 and coefficients listed in Table 5.1.

Figure 5.2 – Gamma Function

$$F = A \times T^{-B} \times e^{-CT}$$

Where:

F = Friction factor

T = Travel time in minutes

A,B,C = Coefficients

e = Base of natural logarithms

Table 5.1 – Coefficients of Gamma Function

Coefficient	HBW	HBSCL	HBSH	HBSR	HBO	NHB	CV
A	5000	2500	2500	5000	1600	1700	2000
B	0.65	2.32	1.71	1.17	2.53	1.34	0.05
C	0.08	0.00	0.04	0.09	0.01	0.05	0.09

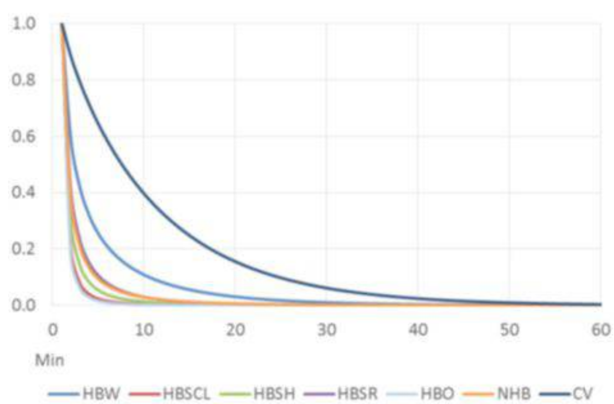
Source: Bi-State Regional Commission, 2016

Above gamma function coefficients were calibrated using the 2013/2014 *Quad Cities Household Travel Survey* data. Observed trip length distribution by trip purpose were tabulated from the survey. They were used to compare with the distribution of model trips and calibrated the friction factors in a trial-and-error process. Figure 5.3 shows the calibrated friction factor curves by trip purpose.

During the model calibration it was determined that K-factors were needed to better represent actual travel behavior in the following circumstances:

- Reducing the amount of travel between Illinois and Iowa
- Eliminating intra-zonal trips within single use zones, such as shopping centers
- Eliminating E-E trips between external zones that are accounted for exogenously by the iTRAM model

Figure 5.3 – Friction Factor Curves by Trip Purpose

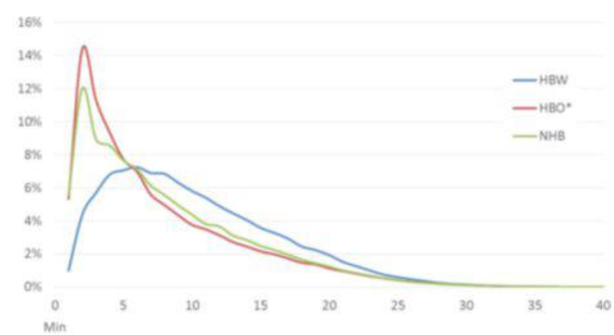


Source: Bi-State Regional Commission, 2016

5.3 Distribution Validation Statistics

Trip length distribution is an important summary of trip distribution model results. It aggregates trips for each increment of travel time in minutes or travel distance in miles. Figure 5.4 compares the trip length distributions in travel time (minutes) between trip purposes. Home Based Work trips have the longest travel length, followed by Non-Home Based trips, and Home Based Other trips have the shortest travel length. For purposes of this analysis, the four Home Based Non-Work purposes including HBSCH, HBSH, HBSR, and HBO were combined into a single HBO category.

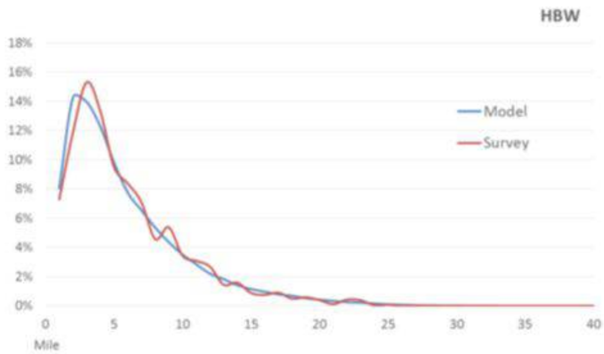
Figure 5.4 – Trip Length Distributions by Trip Purpose



Source: Bi-State Regional Commission, 2016

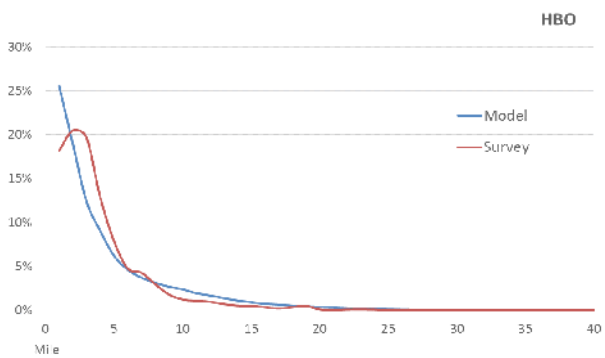
Figure 5.5, 5.6, and 5.7 compare model estimated trip length distribution in distance (miles) with observed distribution summarized from 2013/2014 Quad Cities Household Travel Survey. For each trip purpose, model results match well with observed patterns.

Figure 5.5 – Trip Length Distribution of Home Based Work Trips



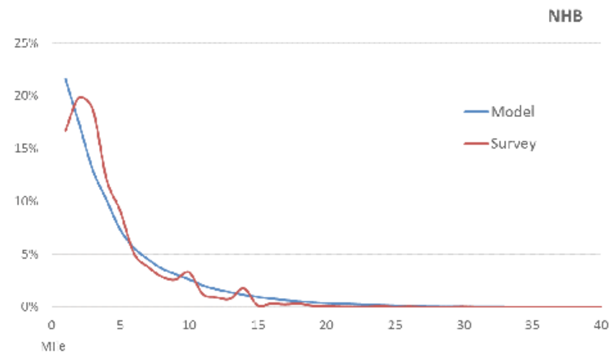
Source: Bi-State Regional Commission, 2016

Figure 5.6 – Trip Length Distribution of Home Based Other Trips



Source: Bi-State Regional Commission, 2016

Figure 5.7 – Trip Length Distribution of Non-Home Based Trips



Source: Bi-State Regional Commission, 2016

Average trip length was also summarized to evaluate the pattern of model trips. As shown in Table 5.2, model-estimated average trip lengths by distance (miles) and time (minutes) closely match survey results. In addition, FHWA published guidelines from other urban areas. Average trip lengths of BSRC model are shorter than national averages, probably because the Bi-State MPA is geographically smaller and has less traffic congestion than many other metropolitan areas. Another reason is that miscellaneous "terminal" time is often added to network time to represent out-vehicle walking time between parking lot and destination. Terminal time has not been included in current BSRC model.

Table 5.2 – Average Trip Length

Trip Purpose	Miles		Minutes		
	Model	HTTS	Model	HTTS	TMIP
HBW	5.9	6.0	10.3	10.8	11-15
HBO	4.6	4.0	7.7	7.5	9.5-13
NHB	4.9	4.3	8.2	7.9	9.5-12.5
Total	4.9	4.4	8.3	8.0	N/A

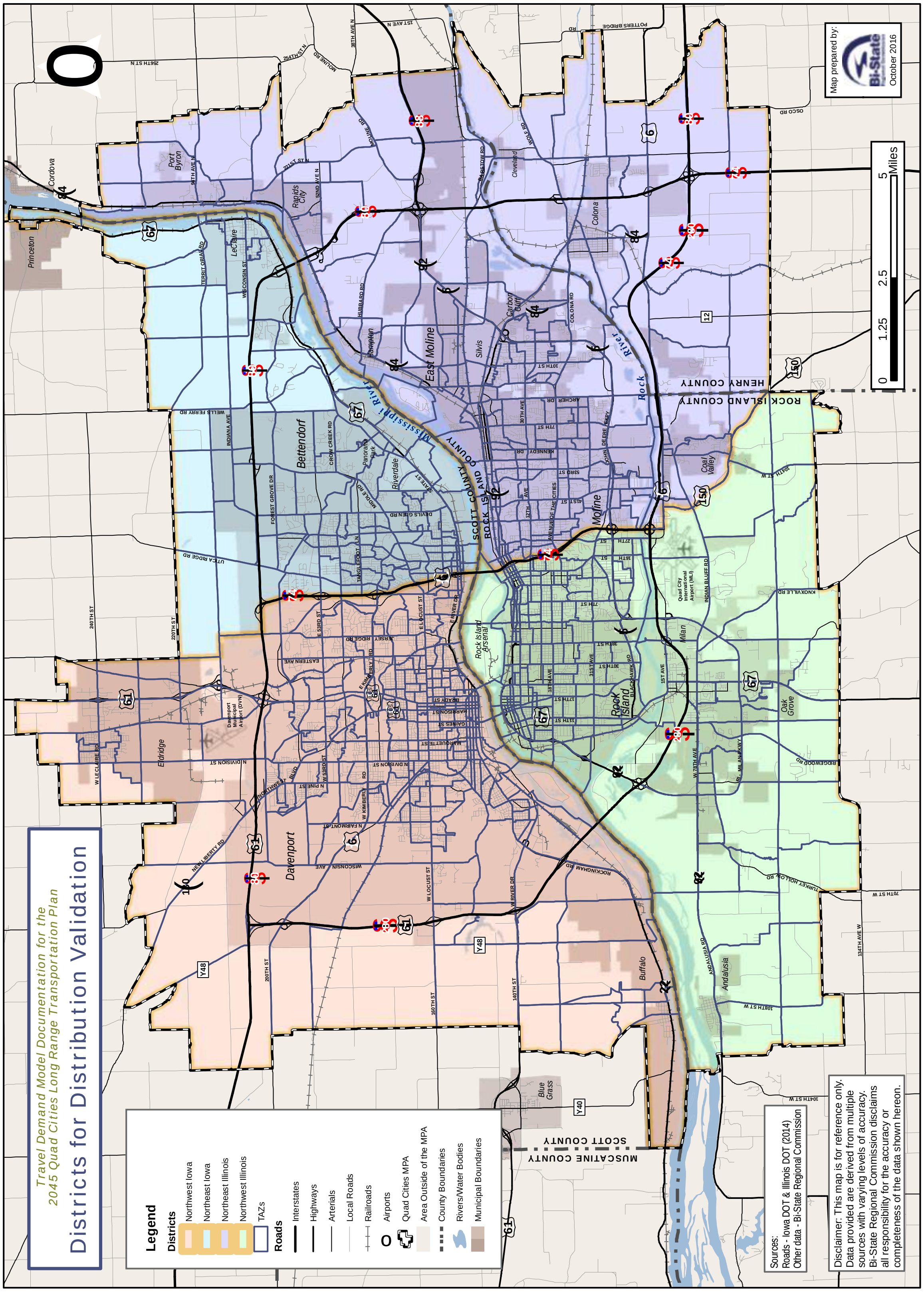
Source: Bi-State Regional Commission, 2016; 2013/2014 Quad Cities Household Travel Survey; and TMIP Model Validation and Reasonableness Checking Manual, 2010

Another measure of trip distribution model accuracy is to compare district flow patterns between the model and the survey. A district is a group of TAZs to summarize data on a broader geographic level. Bi-State MPA is naturally quartered by Mississippi River and I-74, thus following four districts were defined. Map 5.1 highlights the district boundaries.

- Northwest Iowa (IA/NW) - Iowa West of I-74
- Northeast Iowa (IA/NE) - Iowa East of I-74
- Northeast Illinois (IL/NE) - Illinois East of I-74
- Northwest Illinois (IL/NW) - Illinois West of I-74

Table 5.3 shows the percentage of total internal-internal (II) trips between districts. As indicated, there is close agreement between the model and the survey, which is important so that bridge crossings across the Mississippi River are accurately represented. The use of K-factors for TAZ interchanges between Iowa and Illinois were necessary to bring model-estimated trip flows into agreement with survey trip flows.

Map 5.1 – Districts for Distribution Validation



Source: Bi-State Regional Commission, 2016

Table 5.3 – District to District Flows

Production District	Data Type	Attraction District			
		IA/NW	IA/NE	IL/SE	IL/SW
IA/NW	Model	31.0%	3.7%	0.9%	2.3%
	HTTS	31.2%	3.6%	0.5%	1.9%
IA/NE	Model	4.6%	8.1%	0.6%	0.8%
	HTTS	4.0%	9.4%	0.6%	1.0%
IL/SE	Model	1.8%	1.2%	16.2%	4.8%
	HTTS	1.3%	0.8%	15.0%	5.9%
IL/SW	Model	2.4%	0.8%	3.1%	17.7%
	HTTS	2.9%	0.9%	5.7%	15.2%

Source: *2013/2014 Quad Cities Household Travel Survey*

5.4 Intra-zonal Trips

Intra-zonal trips are defined as trips that start and end in the same TAZ. Their impedances are estimated based on zone size and area type. The travel time within a TAZ is set equal to one-half of the average travel time to the nearest three adjacent TAZs.

Models have a tendency to overestimate intra-zonal trips, which can cause traffic volume on the roadway network to be underestimated. Adjustments to intra-zonal time estimates and the introduction of NHB K-factors for single use TAZs were necessary to bring model-estimated percentages into agreement with the survey. Table 5.4 summarizes intra-zonal trip percentages from the model and the survey.

Table 5.4 – Percentages of Intra-zonal Trips by Purpose

Purpose	Model	HHTS
HBW	1.2%	2.7%
HBO	5.1%	4.6%
NHB	3.7%	4.5%
Total	3.9%	4.4%

Source: *2013/2014 Quad Cities Household Travel Survey*

5.5 External-External Trip Distribution

Iowa DOT's Statewide Travel Demand Model (iTRAM) and traffic count data from Iowa DOT Geographic Information Management System (GIMS) and Illinois DOT are major resources used to estimate external trips for the Bi-State model area.

Subarea extraction analysis was done to iTRAM 2010 and 2035 model runs to get base year and horizon year E-E flows for each major external station. The gap between total flows and E-E flows were E-I Flows. E-I and E-E flows from iTRAM were then scaled to 2010 traffic count data, which was used as a control total for each external station.

The iTRAM does not have every external station that the BSRC model has in it. For minor external stations that were not included in the iTRAM, an assumption was made that no E-E flows passed these externals. In other words, 2010 GIMS Counts and Illinois DOT data represent the E-I flows for these minor external stations. Count data was then split into each trip purpose by multiplying the percentage of each trip purpose to the total. A similar proportion process was applied to iTRAM trips, which were modeled at a more aggregated level than BSRC model. Then, iTRAM trips were split into the

BSRC model purposes based on the proportion of trip purposes summarized from the *2013/2014 Quad Cities Household Travel Survey (HHTS)*.

The BSRC model utilizes the E-I flows in the format of PA tables. Therefore the E-I flows calculated above were tabulated for each external station. Trips entering the model area were in P's column, while trips leaving the model area were in A's column.

The BSRC model adopts the E-E flow pattern from the iTRAM model. Therefore, the trip distribution model avoids linking trip ends between externals by applying a K factor matrix to block the distribution of E-E trips. E-E flows from iTRAM were manually coded into a static matrix and directly added to the distribution results.

Single-Unit(SU) and Multi-Unit(MU) truck trips were forecasted by a similar process. However, additional tweaks were made to the iTRAM model in order to perform a subarea analysis with separate SU and MU truck trips as well as to redistribute "other" truck trips in the iTRAM model into SU and MU truck trips.

5.6 Feedback Loop and MSA

A trip distribution model is executed within a distribution-assignment feedback loop. In the first iteration, trip distribution is based on free flow time, which is calculated from free flow speed. Subsequent iterations use congested travel time, which is not a direct result of one single traffic assignment, but a weighted average of multiple feedback loop iterations.

It is called the Method of Successive Averages (MSA). "In the MSA method, output volumes from trip assignment from previous iterations are weighted together to produce the current iteration's link volumes. Adjusted congested times are then calculated based on the normal volume-delay relationship. This adjusted congested time is then fed back to the skimming procedures" (TransCAD6.0 User Manual, 2012). The MSA volume is calculated by following equation:

Figure 5.8 – Method of Successive Averages

$$MSAFlow_n = MSAFlow_{n-1} + \frac{1}{n} \times (Flow_n - MSAFLow_{n-1})$$

Where:

n – current MSA iteration number

$MSAFlow_n$ – calculated MSA flow at iteration n

$MSAFlow_{n-1}$ – calculated MSA flow at iteration n-1

$Flow_n$ – resulting flow directly from trip assignment

The distribution-assignment feedback loop ends when convergence criterion is met or the maximum iteration is reached. The number of max iteration is set to 10 by default. The measure of convergence is based on the Percent Root Mean Square Error (%RMSE) of shortest path impedance skims between current and last iterations. Its equation is shown in Figure 5.9, and the threshold was set to 0.001 to break the iteration.

$$\%\text{RMSE} = \frac{\sqrt{\sum_{i\in I}\left(T_i^n - T_i^{n-1}\right)^2/(I-1)} * 100}{\left(\sum_{i\in I} T_i^{n-1}/I\right)}$$

Figure 5.9 – Percent RMSE of Network Skims

Where:

n – current MSA iteration number

n-1 – last MSA iteration number

I – total number of O-D pairs

– Travel time of O-D pair i from last MSA iteration

– Travel time of O-D pair i from current MSA iteration

6.0 Mode Split

Trip distribution model produces daily person trips for the six non-commercial trip purposes. For each trip purpose, the BSRC model then applies different mode share factors to proportionate person trips into the following five travel modes:

- Drive alone (Driver only)
- Shared ride (Carpool)
- Transit
- School bus
- Bike/Walk

As shown in Table 6.1, these mode share factors were summarized from the *2013/2014 Quad Cities Household Travel Survey (HHTS)*

Table 6.1 – Mode Share Percentages by Trip Purpose

Mode	HBW	HBSCL	HBSH	HBSR	HBO	NHB	Total
Drive Alone	93.5%	16.4%	75.7%	62.5%	77.2%	73.6%	69.4%
Shared Ride	4.1%	52.1%	20.8%	32.2%	19.0%	22.6%	24.0%
Transit	0.6%	0.2%	1.1%	0.1%	0.8%	1.6%	0.9%
School Bus	0.0%	22.5%	0.0%	0.0%	0.1%	1.1%	2.7%
Bike/Walk	1.8%	8.9%	2.3%	5.2%	2.9%	1.1%	3.1%

Source: 2013/2014 Quad Cities Household Travel Survey

Only auto trips, which include drive alone and shared ride, were left for traffic assignment. Other non-auto trips were simply ignored because of their negligible market shares. Drive alone trips were converted directly to the same amount of vehicle trips. Shared ride trips were converted to vehicle trips by applying average vehicle occupancy rates summarized from the household travel survey. The commercial truck trips were generated as vehicle trips from the beginning, so they do not need any further conversion. Table 6.2 shows the average vehicle occupancy rates by trip purpose.

Table 6.2 – Vehicle Occupancy

Trip Purpose	Occupancy
HBW	2.87
HBSCL	2.14
HBSH	2.26
HBSR	2.44
HBO	2.58
NHB	2.46

Source: 2013/2014 Quad Cities Household Travel Survey

The level of congestion varies by traffic direction and time of day. In order to reflect these conditions in the model, daily vehicle trips were allocated to the following four time periods:

- AM Peak (AM): 6:30-9:00 a.m.
- Mid-day (MD): 9:00 a.m.-3:30 p.m.
- PM Peak (PM): 3:30-6:30 p.m.
- Night (NT): 6:30 p.m.-6:30 a.m.

For each trip purpose, *2013/2014 Quad Cities Household Travel Survey* data was tabulated to estimate the diurnal distribution factors shown in Table 6.3 and directional split factors shown in Table 6.4. These factors worked together to convert daily trips in the form of PA (Production & Attraction) to period directional trips in the form of OD (Origin & Destination), which eventually can be utilized by the traffic assignment model.

Table 6.3 – Diurnal Distribution Factors

Purpose	AM Peak	Mid-day	PM Peak	Night
HBW	29%	24%	29%	18%
HBSCL	46%	36%	15%	3%
HBSH	7%	62%	20%	11%
HBSR	9%	30%	31%	30%
HBO	29%	38%	20%	13%
NHB	12%	62%	18%	8%
CV	20%	46%	22%	12%

Source: 2013/2014 Quad Cities Household Travel Survey

Table 6.4 – Percentages of Trips from Production to Attraction

Purpose	AM Peak	Mid-day	PM Peak	Night
HBW	97%	50%	10%	56%
HBSCL	100%	11%	13%	33%
HBSH	71%	47%	30%	27%
HBSR	78%	50%	58%	27%
HBO	76%	53%	45%	31%
NHB	50%	50%	50%	50%
CV	50%	50%	50%	50%

Source: 2013/2014 Quad Cities Household Travel Survey

7.0 Traffic Assignment

Traffic assignment is the last step of the travel demand model process. The vehicle trips calculated in the mode choice model are assigned to the network based on minimum impedance paths available. As congestion builds over time, the highway assignment model shifts traffic to adjacent facilities having excess capacity. Similarly, corridors where new roads or roadway improvements are planned will see traffic diversions to the new facilities from parallel facilities having slower speeds or higher congestion. These shifts in traffic between facilities are a major component of what is perceived of as induced demand.

The BSRC model assigns traffic based on a "user equilibrium" algorithm, which is an iterative process. It uses the capacity constraints on links and calculates the updated minimum impedance path for each iteration until no travelers can reduce their travel cost (in time) by switching to another route. Unless convergence criteria is met, the iterative process of assignment ends when maximum iteration is reached. The maximum iteration is set to 25 by default.

7.1 Bureau of Public Roads (BPR) Curves

The Bureau of Public Roads (BPR) curves give the change in travel time with respect to change in the Volume over Capacity (V/C) ratios on a highway link. The BPR equation is given as follows:

Figure 7.1 – BPR Function

$$T = T_0\left[1 + a\left(\frac{v}{c}\right)^b\right]$$

Where:

T – Congested travel time

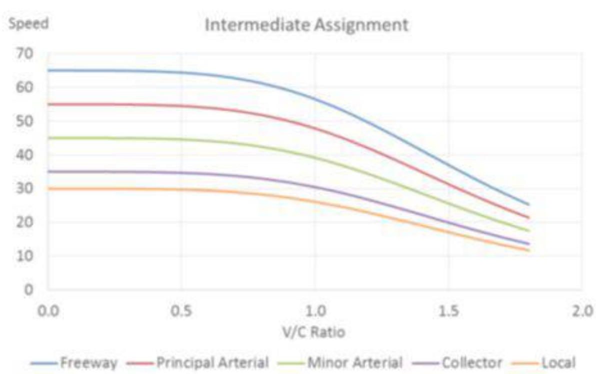
T_0 – Free flow travel time

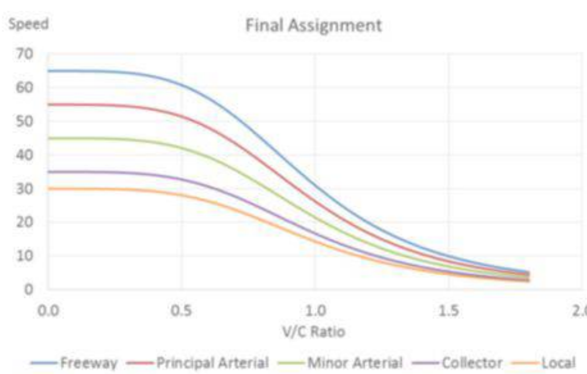
a and b – BPR coefficients

The highway links are grouped into different link classes based on facility type, area type, number of lanes, and free flow speed. Each link class is associated with a particular BPR curve. The default coefficients of BPR curves were borrowed from the *Travel Model Improvement Program (TMIP) Model Validation and Reasonableness Checking Manual* (2010).

Figure 7.2 illustrates the Volume-Delay Function (VDF) for facilities with different functional classification and free flow speed. These curves reflect how travel speed reduces on the facility as the loading traffic increases. The upper chart shows the VDF curves that are implemented in "intermediate" assignments done for the distribution-assignment feedback loop. The lower chart shows more rigorous VDF curves that are utilized in final assignment only.

Figure 7.2 – Volume Delay Curves





Source: Bi-State Regional Commission, 2016

7.2 Loading Multipliers

Congestion on roads varies with time of day and travel direction. Drivers may choose different paths to destinations during different time periods within one day. Congested facilities would tend to be avoided during peak periods, but not during off-peak hours. Therefore, the BSRC model assigns trips separately for a.m. peak, mid-day, p.m. peak, and night.

The following TransCAD "Loading Multipliers" were summarized from local traffic counts. They are the proportions of the highest one-hour volume within each time period. These multipliers were applied to a.m., mid-day, p.m., and night time trip tables respectively to convert period volume to a representative hourly volume within each period.

Table 7.1 – Loading Multipliers

Time Period	Multipliers
AM	0.39
MD	0.14
PM	0.39
NT	0.23

Source: Bi-State Regional Commission, 2016

7.3 Turn Prohibition and Turn Penalty

Both turn prohibition and turn penalty are scenario-specific data stored in a "linktp.bin" file in the output folder. The file has three data fields including "From LinkID," "To LinkID," and "Penalty". The combination of "From LinkID" and "To LinkID" defines the turn movement.

"Penalty" fields are labeled as 9999 for prohibited turn movements, such as U-turn on a freeway or an illegal turn entering the reverse direction of a one-way street. "Penalty" fields also carry turn penalties for certain turn movements at select intersections. These penalties are extra delay in minutes that are not well represented in the travel model. One example is the left turn movements at busy intersections where people have to wait longer to cross oncoming traffic.

7.4 Convergence

As mentioned above, traffic assignment is an iterative process to approach a "user equilibrium" condition. To avoid excessive running time, model users usually stop the iteration when

- Assignment results are within acceptable error tolerance. In BSRC model, assignment is considered "converged" if relative gap is less than 0.01.
- Assignment process has been running for sufficient amount of time. In BSRC model, the maximum iteration of assignment process is set to 25.

The measure of assignment convergence is the relative gap, which is a common criteria to compare the current assignment solution to the ideal shortest-route for all O-D pairs. Its equation is shown as follows:

Figure 7.3 – Relative Gap

$$RG = \frac{\sum_i \sum_k F_{ki} * T_{ki} - \sum_i D_i * U_i}{\sum_i D_i * U_i}$$

Where:

RG – Relative gap

F_{ki} – Volume flow on link k for O-D pair i

T_{ki} – Travel time on link k for O-D pair i

D_i – The total flow for O-D pair i

U_i – The shortest route travel time for O-D pair i

7.5 Post Processing

Once traffic assignments are done for all four time periods, additional processing is needed to produce reports, data files, and maps. The four period assignment results are combined into one summary file. In this process, the peak hour volume for each period is converted back to total period volume by applying the inverse of loading multipliers (2.56 for AM, 7.14 for MD, 2.56 for PM and 4.35 for NT). Volume from the four time periods are then added up to get Annual Average Daily Traffic (AADT).

Procedures from Highway Capacity Manual (HCM) 2010 are used to compute the Level-of-Service (LOS) for each highway segment based on a Volume over Capacity (V/C) ratio as shown in Table 7.2. V/C ratio varies by time period and direction. The highest V/C ratio on a link can be used to represent the worst case condition.

Table 7.2 – Level-of-Service Standards

Volume /Capacity	Level of Service
<= 0.29	A
0.30 - 0.49	B
0.50 - 0.69	C
0.70 - 0.84	D
0.85 - 0.99	E
>= 1.0	F

Source: Highway Capacity Manual 2010

8.0 Model Validation

A systematic and iterative procedure was used to calibrate each of the four steps in the Bi-State travel model to base year 2010 travel conditions. Over 50 calibration model runs were performed to achieve the following goals:

- Bring overall trips into agreement with overall counts
- Bring model estimates into agreement with household travel survey results
- Correct traffic volume at select locations with large errors

The calibration process consists of correcting model inputs as well as adjusting parameters. The following enhancements were made during the calibration process:

- Trip Generation Model
  - Verified and corrected zonal socio-economic data in individual TAZs
  - Corrected highway network coding errors
  - Adjusted trip generation rates and special generator trips
- Trip Distribution Model
  - Adjusted external travel estimates
  - Adjusted trip distribution parameters and added K-factors
- Modal Split Model
  - Adjusted modal split factors
- Traffic Assignment Model
  - Modified zone connector configurations
  - Adjusted highway capacity assumptions
  - Added link-specific speed corrections
  - Corrected turn penalty coding
  - Modified highway assignment parameters

The validation results of trip generation and distribution model have been documented in previous chapters. This chapter focuses on the final validation step that compared the 2010 model assigned volume with traffic count data from Iowa and Illinois Departments of Transportation (DOT). The validation step measures the Bi-State model's ability to replicate the actual travel characteristics on the streets. The primary goal of the validation is to ensure the model produces reasonable results and is ready for regional planning and corridor studies.

8.1 Assignment Validation Statistics

Table 8.1 summarizes regional level validation statistics after the model calibration process was finished. The "Total Traffic Volume" statistics measure how accurate the model was in replicating overall trips by functional classification.

Another model validation statistic is the Percent Root Mean Squared Error (%RMSE). The %RMSE aggregates the magnitudes of individual residuals at each count location into a single measure of model accuracy. It is calculated using the formula as follows:

Figure 8.1 – Percent RMSE of Count Validation

$$\%\text{RMSE} = \frac{\sqrt{\sum_{n\in N}(M_n - C_n)^2/(N-1)} * 100}{(\sum_{n\in N} C_n / N)}$$

Where:

– Model volume on link n

– Count volume on link n

– Total number of counts

Travel demand model is a closed system. It is not able to replicate the reality, which is an open world, with 100% accuracy. The *TMIP Model Validation and Reasonableness Checking Manual, 2010* suggested the following acceptable ranges of error for roadway facilities with different functional classification. Table 8.2 compares validation statistics from the BSRC model with the TMIP guidelines. In all cases, the Bi-State model is within the acceptable limits.

- Interstate Freeway ± 7%
- Major arterial ± 10%
- Minor arterial ± 15%
- Collector ± 25%

Figure 8.2 is a scatter plot comparing modeled and observed volume across all traffic counts. With a slope of 0.97 and high "R Squared" of 0.9, the scatters tend to concentrate in the vicinity of the identity line (y=x). It indicates that the BSRC model consistently replicates the base year 2010 count data, and margins of error are within a satisfying tolerance.

The ability of the BSRC model to accurately estimate Mississippi River bridge crossings is of particular interest in the Bi-State MPA. Table 8.3 shows that model errors are within 7% on all bridges. The total number of crossing trips over all bridges well matches the observed total.

Table 8.1 – Traffic Assignment Validation Statistics

Functional Classification	Number of Counts	Total Traffic Volumes		Percent Error	Model RMSE%
		Model	Observed		
Freeway	31	910,584	903,689	1%	10.3%
Expressway	6	59,199	60,700	-2%	21.4%
Principal Arterial	278	3,591,175	3,663,705	-2%	22.2%
Minor Arterial	462	3,268,355	3,418,630	-4%	35.0%
Collector	290	968,773	995,690	-3%	54.7%
Freeway Ramp	15	41,942	47,410	-12%	25.8%
On/Off Ramp	135	344,955	346,255	0%	43.2%
Total	1,217	9,184,983	9,436,079	-3%	30.9%

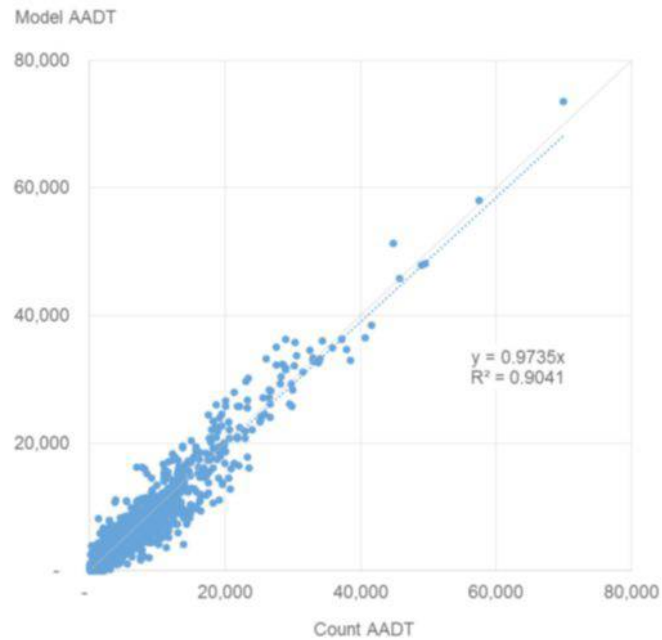
Source: *Bi-State Regional Commission, 2016; DOT traffic counts, 2010*

Table 8.2 – Comparison of Assignment Validation Statistics with Guidelines

Functional Class	Total Traffic Volume Error		%RMSE	
	Bi-State	TMIP	Bi-State	TMIP
Freeway	1%	± 7%	10.3%	10-26%
Expressway	-2%	± 7%	21.4%	10-26%
Principal Arterial	-2%	± 10%	22.2%	11-28%
Minor Arterial	-4%	± 15%	35.0%	18-36%
Collector	-3%	± 7%	54.7%	38-62%

Source: *TMIP Model Validation and Reasonableness Checking Manual, 2010*

Figure 8.2 – Traffic Count Comparison



Source: Bi-State Regional Commission, 2016; DOT traffic counts, 2010

Table 8.3 – Mississippi River Bridge Volumes

Bridge	Model	Observed	Error
I-280	23,622	25,300	-7%
Centennial	28,294	30,000	-6%
Arsenal	9,342	9,860	-5%
I-74	73,508	69,900	5%
I-80	32,855	33,000	0%
Total	167,621	168,060	0%

Source: Bi-State Regional Commission, 2016; DOT traffic counts, 2010

8.2 Screenline Validation

Screenlines are imaginary lines crossing natural or man-made physical dividers or corridor traffic flows. They are used as groups of traffic counts to indicate the traffic volume entering or leaving a certain area or passing a certain section.

Map 8.1 shows the 16 screenlines that were created for the 2045 LRTP travel demand model. Seven of them were oriented in the east-west direction, and the remaining nine were oriented in the north-south direction.

Screenline volumes were compared to the observed volumes using the percent deviation. The percent deviations were then compared with the maximum desirable deviations as given in the NCHRP 255 report. As the observed traffic across a screenline goes up, the acceptable percent of deviation goes down.

Table 8.4 illustrates percent of deviation for each screenline. The BSRC model well matches the overall total of the 16 screenlines. Model errors are also within the maximum desirable deviation for each screenline. It should be noted that during the calibration process, special attention was devoted to screenline #1, which is the Mississippi River screenline. It divides the region approximately in half, with five bridges as the sole linkage of the two parts.

The red guide line in Figure 8.3 is the maximum desirable deviation line recommended in NCHRP 255, which is widely referenced throughout the modeling literature. The BSRC model does a good job with this validation measure, with all screenline comparison within +/- 30% and the majority within +/-20%.

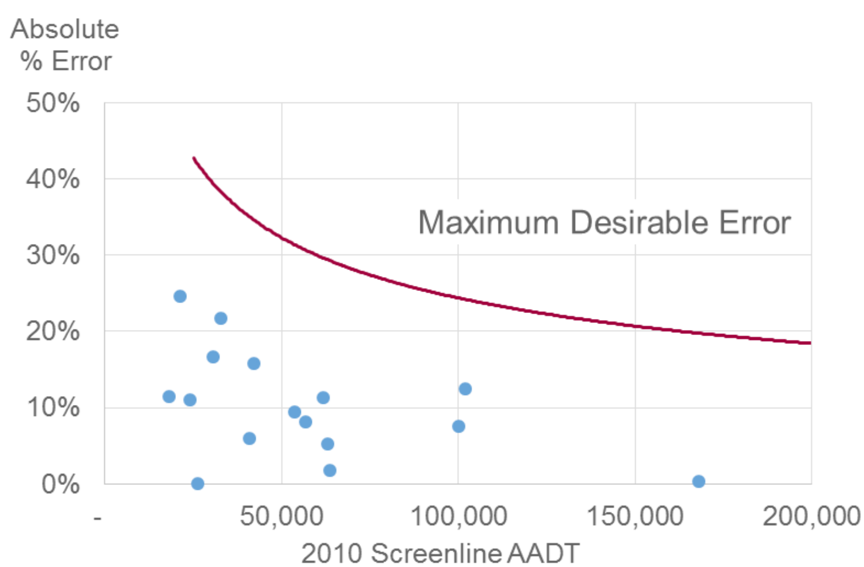
In conclusion, the comparison of model estimated trips and field traffic counts for the planning area, crossing the 16 screenlines, confirms that the Quad Cities MPA Travel Demand Model closely replicates the 2010 Base Year condition.

Table 8.4 – Screenline Volume Comparison

Screenline Number	AADT 2010	Model Volume	Percent Deviation	Maximum Desirable Deviation (NCHRP 255)
1	168,060	167,621	0%	20%
2	26,200	26,188	0%	30%
3	102,000	114,696	12%	28%
4	40,730	38,301	-6%	34%
5	18,070	16,012	-11%	39%
6	100,184	107,708	8%	22%
7	63,500	62,355	-2%	28%
8	61,700	68,723	11%	24%
9	32,700	39,786	22%	37%
10	21,200	15,994	-25%	35%
11	42,100	48,780	16%	32%
12	63,000	59,687	-5%	28%
13	53,600	48,573	-9%	30%
14	56,700	52,109	-8%	29%
15	30,500	25,414	-17%	28%
16	24,100	21,430	-11%	38%
Total	904,344	913,377	1%	N/A

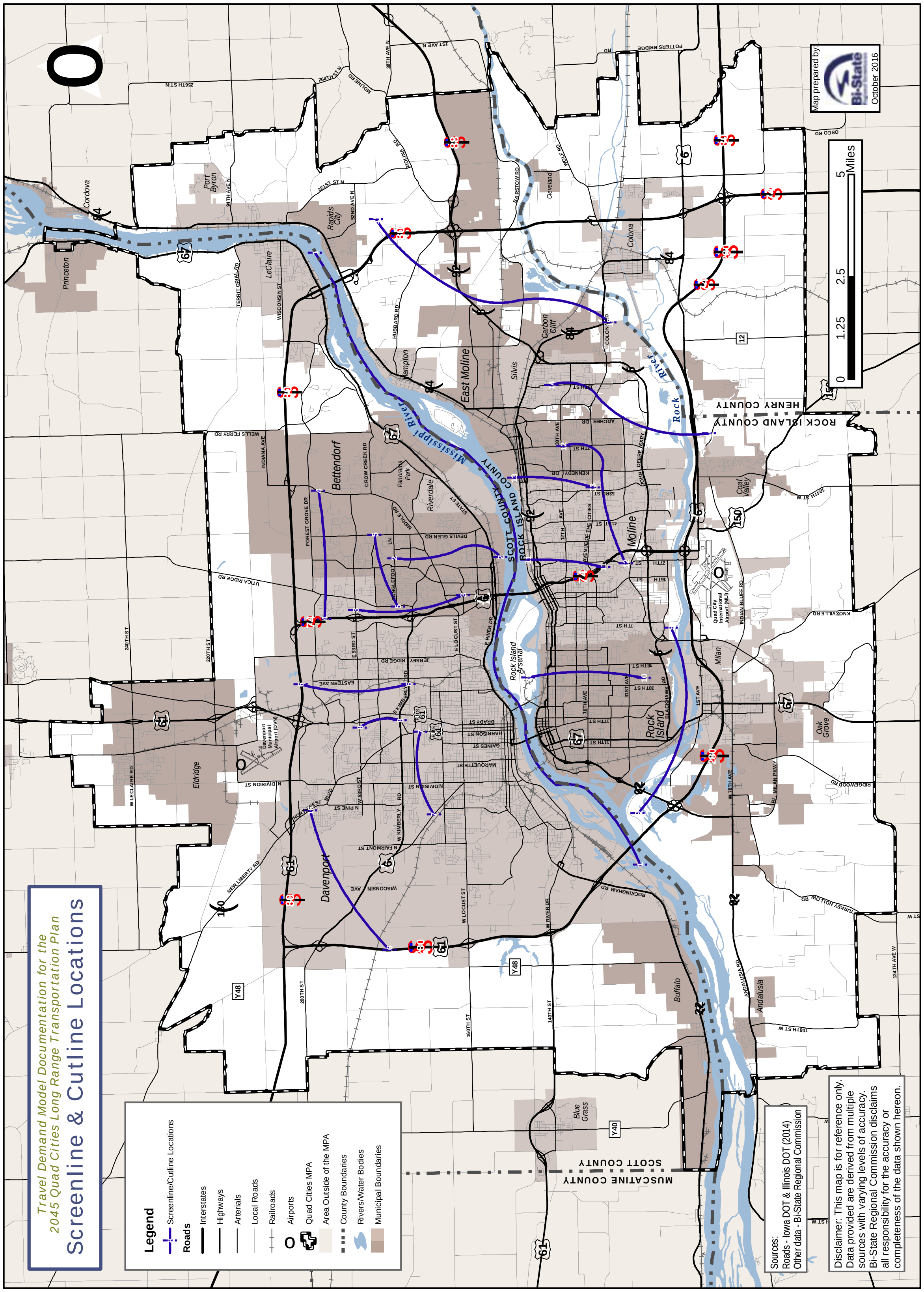
Source: Bi-State Regional Commission, 2016; DOT traffic counts, 2010

Figure 8.3 – Percent Deviation of Screenline Volume



Source: Bi-State Regional Commission 2016, DOT traffic counts, 2010

Map 8.1 – Screenline and Cutline Locations



Source: *Bi-State Regional Commission, 2016*

9.0 Alternatives Analyses for 2045 Roadway Network

Alternatives analyses for the roadway network were conducted. This analysis is one tool used by local and state jurisdictions to determine a future roadway network. In addition, pavement condition and crash history are other elements. Funding availability is another consideration. Alternatives analysis identifies existing and future congested roadway segments.

Projects are proposed and refined, based on these findings, to address the congested corridors within the roadway network. The calibrated model can demonstrate 24-hour traffic volumes, Vehicle Miles Traveled (VMT), and Vehicle Hours Traveled (VHT) for this analysis. Volume over Capacity (V/C) ratio illustrates the highest congestion levels during the day.

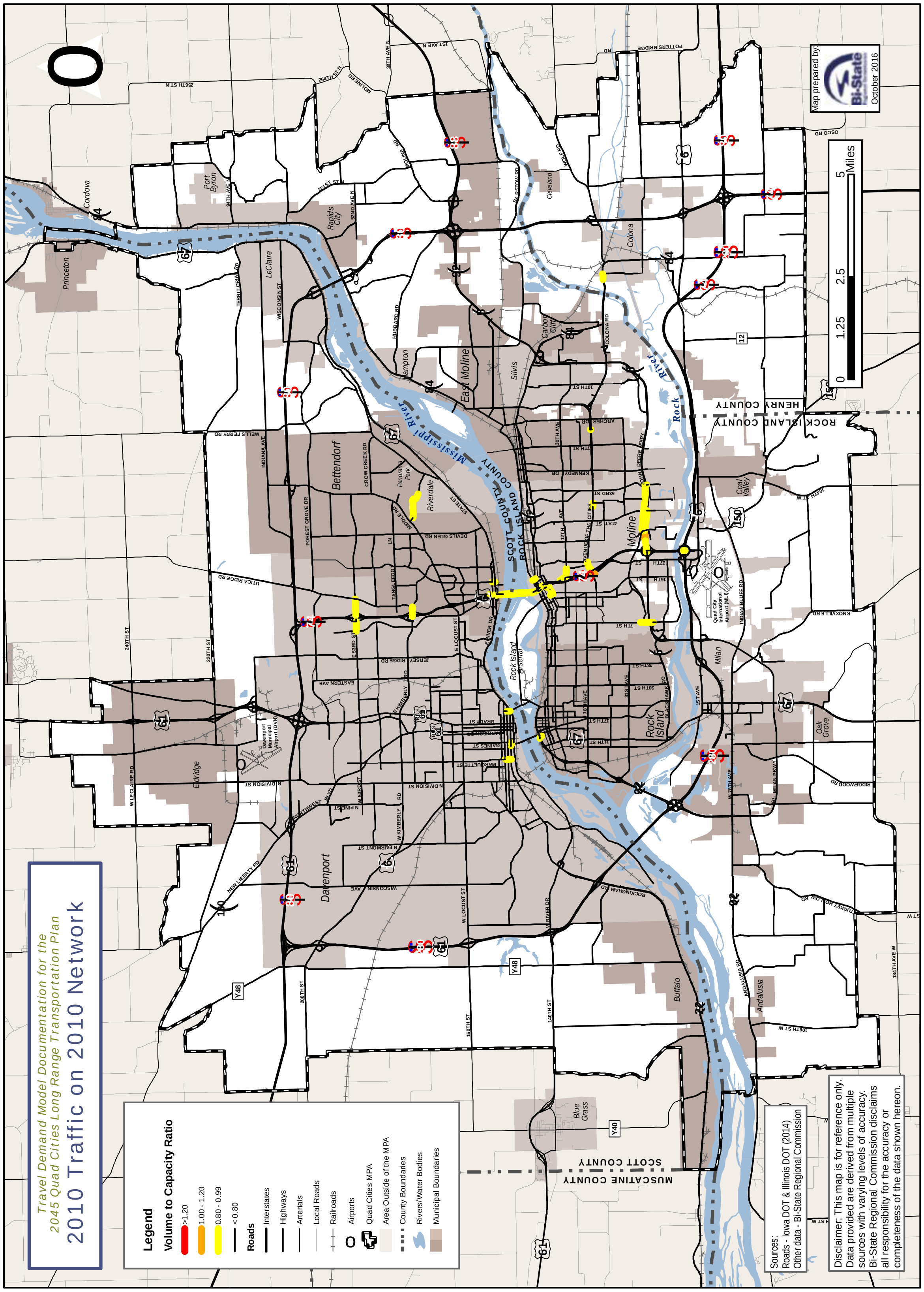
A detailed alternative analysis was included in the Chapter 3 of *2045 Quad Cities Long Range Transportation Plan (2045 LRTP)*. Some adjustments have been made to the BSRC model inputs and parameters since the 2045 LRTP was published. Therefore, V/C ratio maps in this model document would be slightly different from the ones in the 2045 LRTP.

Model results of the base year 2010 scenario are shown in Map 9.1. Red line segments demonstrate links where the modeled V/C ratio is greater than or equal to 1.20. This means that the modeled roadway segment has been overloaded with the level of traffic that the facility is failing to handle in the manner it was designed. Orange line segments indicate links where the V/C ratio is equal to or greater than 1.00 but less than 1.20. This means the traffic on the facility is over its capacity, and congestion has become a problem. Yellow lines indicate links where the modeled V/C ratio is equal to or greater than 0.80 but less than 1.00. It means the loaded traffic is approaching the roadway capacity. Grey lines illustrate links with V/C ratios less than 0.80. These segments did not demonstrate a capacity problem on average over a 24-hour period.

No-build scenarios that load 2025 and 2045 traffic onto the base year 2010 network are illustrated in Maps 9.2 and 9.3. Congested areas were identified from these no-build scenarios. Projects were evaluated, refined, and proposed to address the congested areas. A detailed list of projects and their descriptions are provided in Chapter 7, Tables 7.3 and 7.4 and Map 7.1 of 2045 LRTP. The results of adding these short-term (2011-2025) and long-term (2021-2045) projects to the network and their impact on the capacity of the roadway system are shown in Maps 9.4 and 9.5, respectively. They also represent the fiscally-constrained networks.

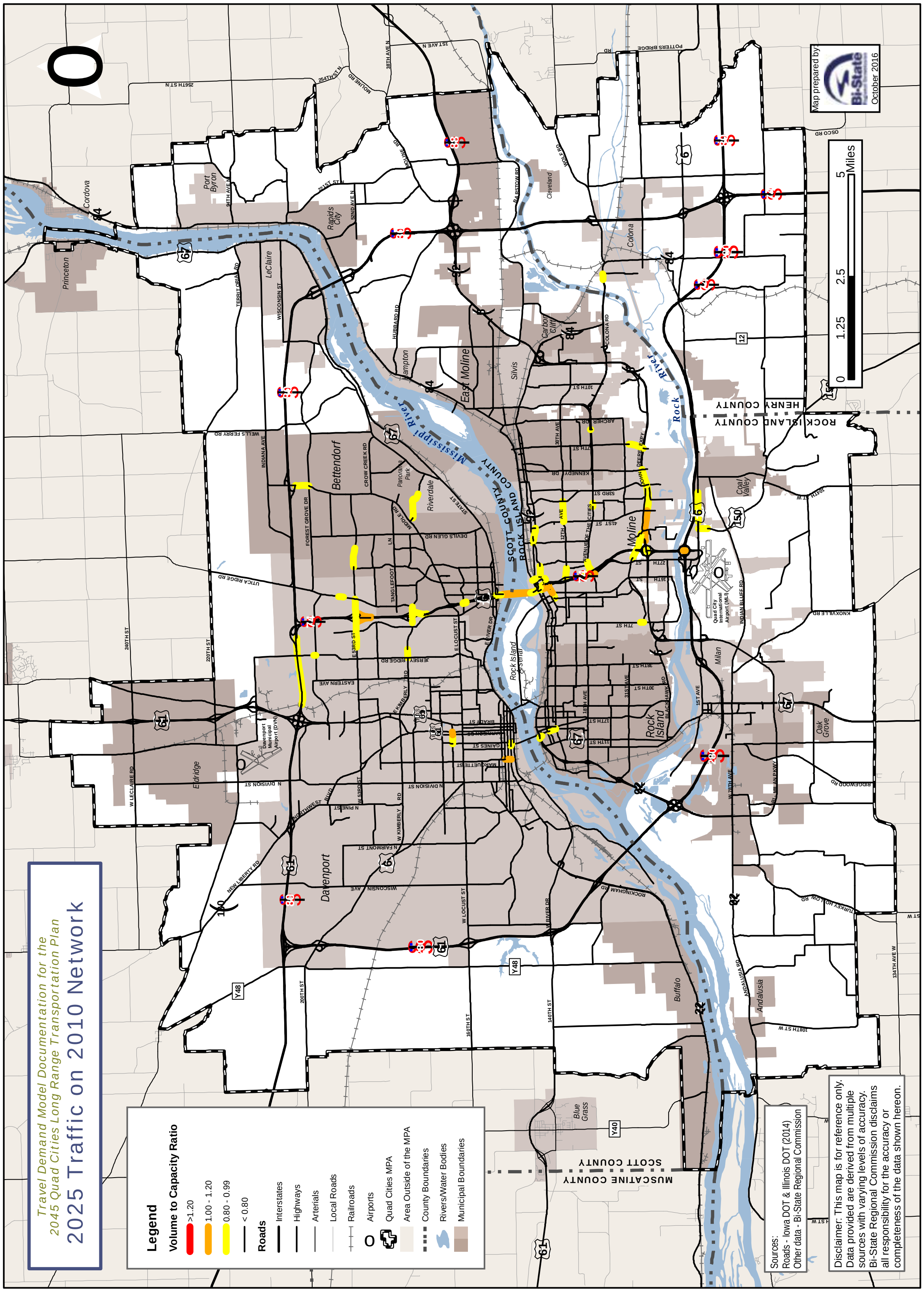
Some of the improvements are accomplished directly at the congested area, while others provide alternative routing via new roadways. In addition, not all congestion concerns could be addressed through roadway capacity expansion. Some may be addressed using alternatives in the Congestion Management Process (CMP). As a result of changing demographics, a few new congested locations are created and may need further study in the future. As the plan is reevaluated, amended, and/or updated in the future, these issues will be further studied.

Map 9.1 – Volume Over Capacity Ratio – 2010 Traffic on 2010 Network



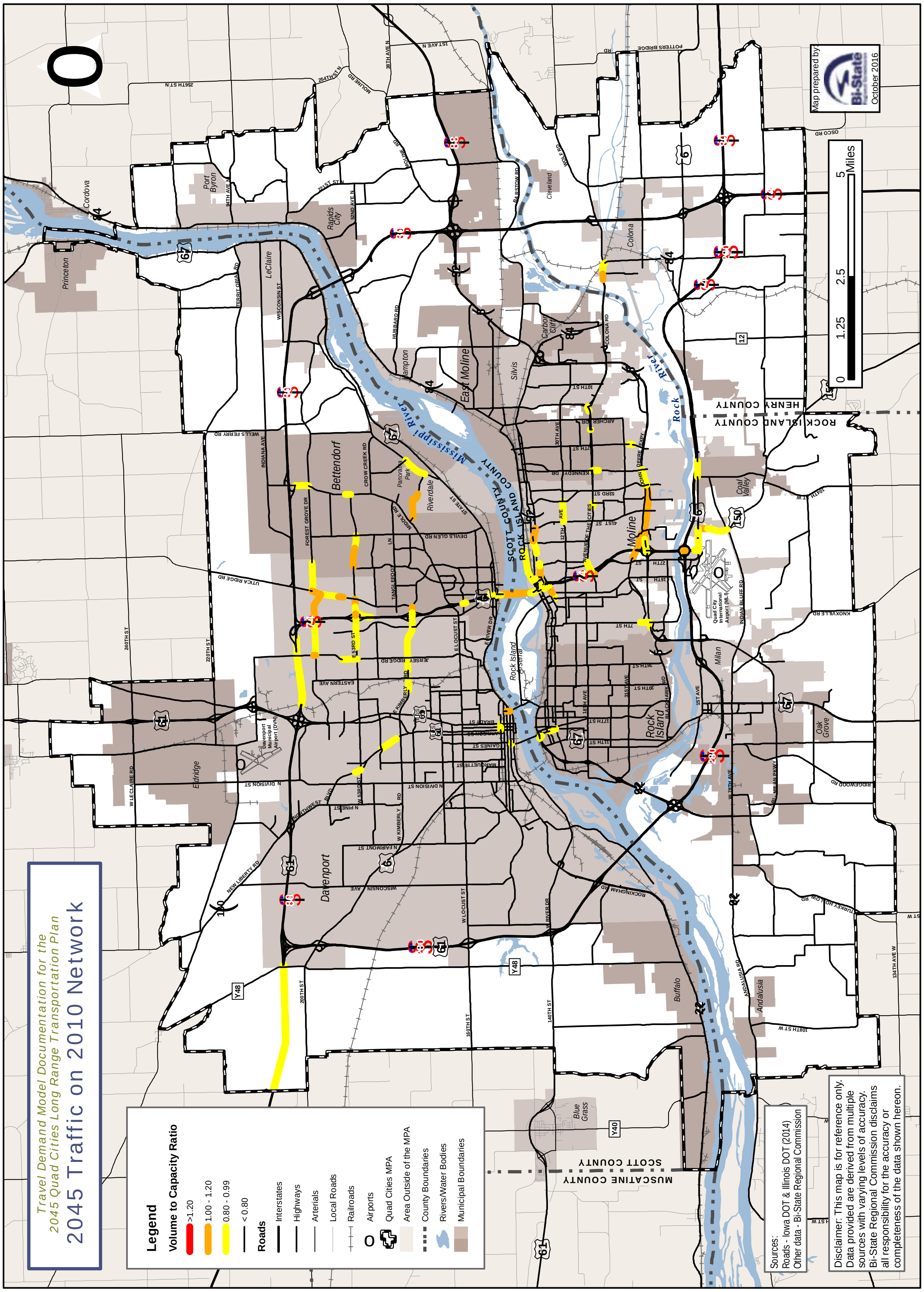
Source: *Bi-State Regional Commission, 2016*

Map 9.2 – Volume Over Capacity Ratio – 2025 Traffic on 2010 Network



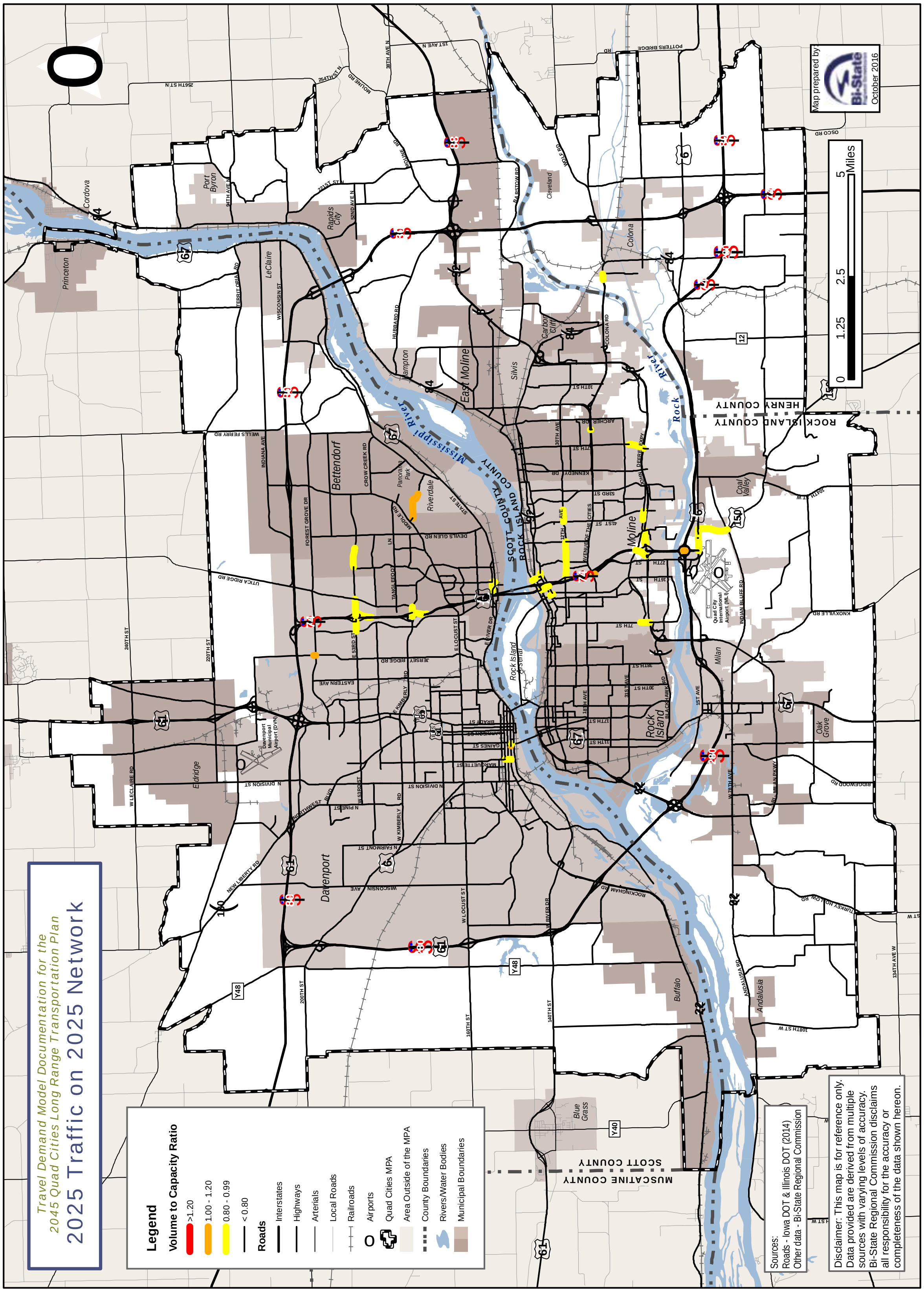
Source: Bi-State Regional Commission, 2016

Map 9.3 – Volume Over Capacity Ratio – 2045 Traffic on 2010 Network



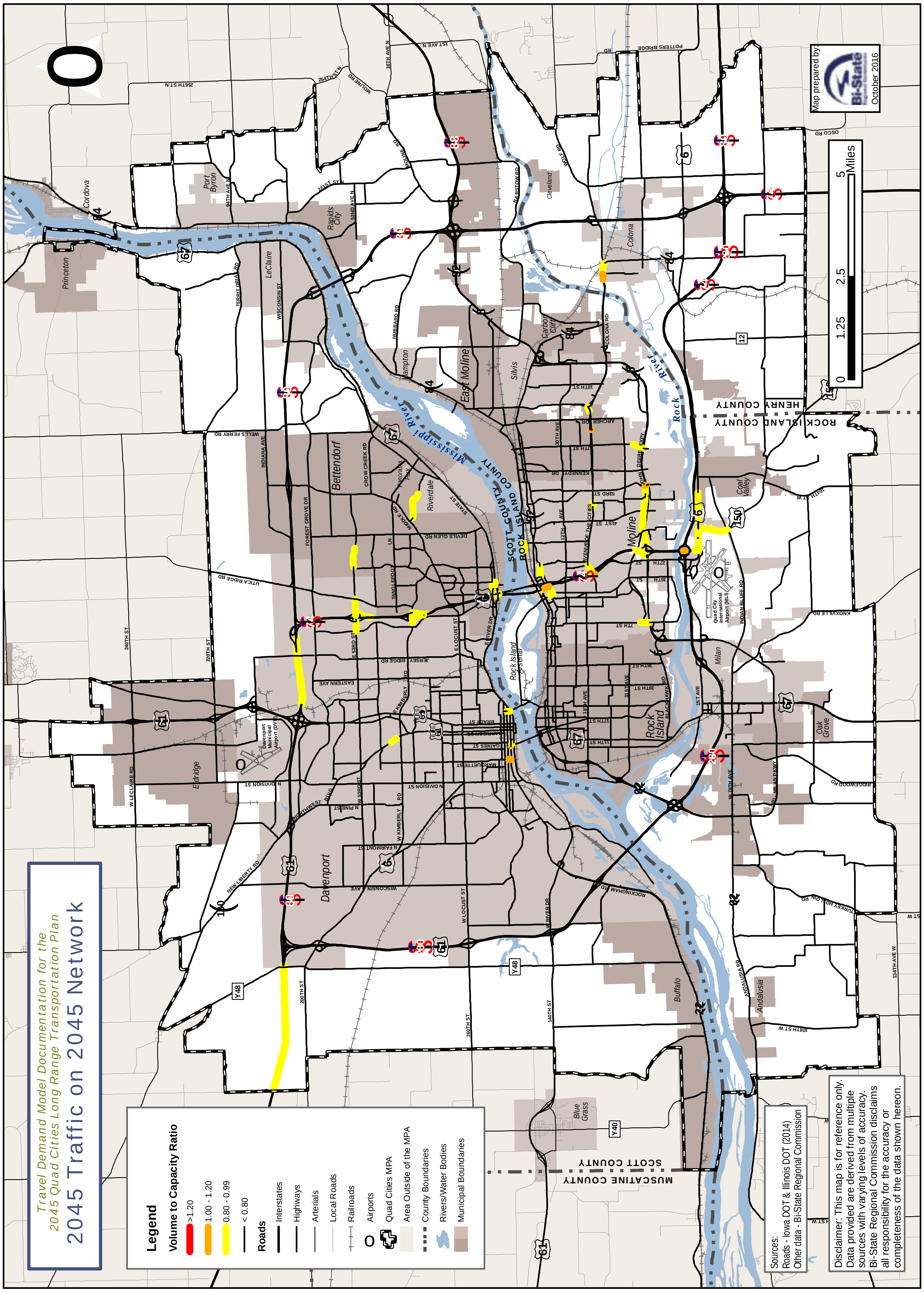
Source: Bi-State Regional Commission, 2016

Map 9.4 – Volume Over Capacity Ratio – 2025 Traffic on 2025 Network



Source: *Bi-State Regional Commission, 2016*

Map 9.5 – Volume Over Capacity Ratio – 2045 Traffic on 2045 Network



Source: *Bi-State Regional Commission, 2016*

10.0 Future improvements

A regional travel demand model requires long term, continuous efforts in maintenance and functional improvement to enhance its capability and reliability of traffic forecasting. A certification review of the transportation planning process for the Quad Cities MPA was performed by the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) on April 26-27, 2016, and the final report was released August 29, 2016. Through the process, the following model improvements were recommended by the review team:

- Concentration on employment data accuracy
- More details on trip generation procedures
- Better representation of travel time and capacity effects at signalized intersections
- Enhanced trip distribution procedures
- Improved mode share estimates
- Better highway assignment algorithms
- Improved reporting and mapping functionality

The current trip generation model utilizes the number of employees to forecast zonal attractions. Employment data classified by North American Industry Classification System (NAICS) code are clustered into three categories: retail, industrial, and other. The same attraction rates are applied to all types of employments in each category. This treatment ignores the different nature of jobs between business types. For instance, jobs in both Finance Insurance and Food Services are labeled as "Other" employment in current model. However, places with Food Services jobs typically attract more daily trips than places with same amount of Insurance jobs. Model capability of replicating the reality may be enhanced by introducing more detailed employment categories with differentiated attraction rates.

Auto trips and truck trips are mixed up in current traffic assignment process. However, truck trips cause more congestion on roadway facilities than the same amount of auto trips. Truck drivers also behave quite differently from auto drivers in many aspects such as operating speed, changing lane, and path choice. It is common practice to treat truck trips with special speed adjustment factors, route exclusion, and Passenger Car Equivalent (PCE) factors.

It is also recommended to enhance the traffic assignment process with tighter convergence criteria. A relative gap of 0.001 rather than 0.01 would help reduce the randomness of assignment results. Volume-Delay Functions (VDF) used in traffic assignment may also be further adjusted for roadway facilities with different functional classification.

Iowa DOT is working with consultants to develop Iowa Standardized Model Structure (ISMS). This project aims to "Provide a consistent comprehensive and standard framework of best practices and application of travel demand modeling and traffic forecasting tools" (Retrieved from http://www.mtmug.org/ISMS.htm). Bi-State Regional Commission is encouraged to work with the Iowa DOT and a consultant to update the travel demand model to new policy and procedure standards.

Appendix

A.1 Master Network Preparation

The first step toward completing the Base Year 2010 roadway network dataset was to review the *2040 Quad Cities Long Range Transportation Plan (LRTP)* Master Network for the entire MPA. Some roads were added to the road network to enhance connectivity, while other roads that no longer existed in 2010 were removed, such as the Blackhawk Road and Valley View Drive intersection in Moline, and the old Tanglefoot Lane and Middle Road intersection in Bettendorf.

The 2045 LRTP model used an updated version of the adopted 2040 plan model street network. Centerline files were the source of network editing. Bi-State Regional Commission created the Rock Island and Henry Counties' spatial line data. Scott County's spatial line data was provided by Iowa DOT. The attribute data used in the travel demand model were from each state's DOT. These attribute data sets included Annual Average Daily Traffic (AADT), Federal Functional Classification (FFC), number of lanes, and speed. Wherever possible for Rock Island and Henry Counties, data values for speed were provided directly by municipalities to reflect posted speed limits. The data created by Bi-State Regional Commission include roadway capacity, direction, travel time, and link distance.

Because Iowa and Illinois DOT have different methods of organizing their data, it was necessary to have each state's data prepared separately then merged. The data for Scott County was stored in multiple shapefiles and joined by using the field name "MSLINK," which was a unique identifier. Once all the data tables had been joined to a final shapefile, then they could be exported to represent Scott County with all the needed attribute data.

For roads in Rock Island and Henry Counties, Federal Functional Classification (FFC) and area type were manually entered based upon the previous 2040 travel demand model data, using an exported TransCAD file. The final step in preparing these two Illinois Quad Cities geographies was to remove unnecessary roads that would be anything with an FFC designation below collector. Prior to merging with the Iowa Quad Cities geography, the two shapefiles were merged, and the attribute table data was combined, so a single field would contain the data values of all three counties. The last step of preparing the preliminary road network was to clip the counties' road data to the MPA boundary and also keep a quarter mile buffer outside of the MPA boundary.

Centroids represent the origins and destinations of travel activities within each Traffic Analysis Zone (TAZ). They are not necessarily physically centered in the TAZ. There are 916 centroids in the model network. Of those 916, 881 represent internal zones, and the remaining 35 represent external stations, which are the points bordering the planning boundary that represent traffic entering, exiting, or passing through the study area.

For the geographic database, the setup of TAZ, TAZ centroids, and centroid connectors began with using an empty TAZ polygon file and assigning the proper TAZ numbers to the attribute table. Once the TAZs were given their ID number, they were overlaid on the 2010 base road network that allowed TAZ centroids to be placed. Centroids were placed in each TAZ by using 2010 aerial imagery and interpreting the single mostly likely source and destination of traffic based on ground structures and concentration. After that, the centroid connectors could be created.

Centroid connectors join centroids to the nearby road network. These connectors conceptually represent all local residential streets that are not included in the model highway network. The connectors were designated from each TAZ centroid to the most likely road that traffic would follow, typically the higher the FFC the greater the likelihood of being connected to the centroid.

Once the preliminary network data was created and combined, more in depth data manipulation could be done. This included the need to standardize FFC values from GIS files because Iowa and Illinois have slightly different ways of classifying their roads and illustrating them geographically. In addition to standardizing road classifications, highway entrance and exit ramps, and TAZ centroid connectors were also given values within the FFC data field.

Finally, once all the base network data was created in ArcMap, it could be exported for TransCAD. The first step of TransCAD preparation was to clean up the data for TransCAD to be able to be properly used. This meant making sure all intersections worked properly, dualizing divided, limited access highways, identifying one-way routes and their direction, and being sure all the network links were properly connected to allow the proper modeled flow of traffic. Network reviews were also performed when roadway capacities were generated, AADT values were entered, and number of lanes were verified.

Once the Base Year 2010 network was confirmed and verified, then roadway projects were coded into the network that are planned to be completed by 2045. The master network file has a set of fields describing roadway characteristics when the road is first opened, another set of fields describing proposed roadway changes, and fields describing opening and project years. For example, a road that exists in 2010 as a two-lane road and will be widened by 2020 to a four-lane road would have "2010" coded in the opening year field and "1" in the opening year directional number of lane fields. The project number will be coded into the project year field and "2" in the project year directional number of lane fields. The model will then read in the project database "projlut.bin" to lookup the change year based on the project number to decide whether the project has been complete or not in the scenario year.

After the master network was completed to encompass all road projects through 2045, the network was tested again for link connectivity and any other issues. Highway network files are created from the master network for each scenario based on a listing of projects to be included in the alternative.

A.2 Network Attributes

Table A.1 describes master network attributes used in the BSRC model. It should be noted that the master network includes additional fields that are either carried over from previous versions of the model or are computed variables based on the attributes listed below.

Table A.1 – TransCAD Master Network Attribute Table

Attribute Name	Description
ID	TransCAD assigned unique link identification number
Length	TransCAD computed link length in miles
DIR	Direction code where:
0 = Two-way operation	
1 = One-way operation in link flow direction	
-1 = One-way operation opposite link flow direction	
ROUTE_NAM	Street name
AADT_2010	Final edited Iowa traffic volume
COUNTLK	Illinois count link used to interface with count volume file
DUALIZED	Where:
0 = Not dualized	
1 = Dualized in SB/WB direction	
2 = Dualized in NB/EB direction	
LRTP_FFC	Functional classification:
1 = Freeways	
2 = Expressways	
3 = Principal arterials	
4 = Minor arterials	
5 = Collectors	
6 = Freeway-freeway ramps	
7 = On/off ramps	
8 = Local streets	
9 = Turn lanes	
10 = Zone connectors	
FCNAME	Functional class name
TYPE_AREA	Area type, where:
1 = Central Business District	
2 = Urban	
3 = Suburban	
4 = Rural	
ADJSPEED	Speed adjustment needed to calibrate the highway assignment model (added to posted speed)
YRPROJ1	Opening year (9999 = not included in any year), project codes entered for LRTP projects

Attribute Name	Description
PSPEED1	Posted speed limit in opening year
ABLANES1	Number of lanes in the AB direction in opening year (0 when DIR = -1)
BALANES1	Number of lanes in the BA direction in opening year (0 when DIR = 1)
YRPROJ2	Year link is changed, project codes entered for LRTP projects
PSPEED2	Posted speed limit in change year (0 if same as opening year speed)
ABLANES2	Number of lanes in the AB direction in change year (0 when DIR = -1 or same as opening year, -1 = links deleted in change year)
BALANES2	Number of lanes in the BA direction in change year (0 when DIR = 1 or same as opening year)
ABCAP	Hourly level-of-service "E" capacity in the A-B direction based on functional class, area type and number of directional lanes
BACAP	Hourly level-of-service "E" capacity in the B-A direction based on functional class, area type and number of directional lanes
FFSPEED	Free-flow speed which is the sum of the posted speed and the adjusted speed multiplied by a speed adjustment factor based on functional class and area type
FFTIME	Free-flow time (minutes) based on link length and free-flow speed

Source: Bi-State Regional Commission, 2016

A.3 Socio-Economic Data File

Table A.2 describes the data fields in socio-economic input files.

Table A.2 – Data Fields in Socio-Economic File

Field Name	Description
TAZ	ID number of Traffic Analysis Zone
HH1VEH0	Household with 1 person and 0 vehicle
HH1VEH1	Household with 1 person and 1 vehicle
HH1VEH2	Household with 1 person and 2 vehicles
HH1VEH3	Household with 1 person and 3 or more vehicles
HH2VEH0	Household with 2 persons and 0 vehicle
HH2VEH1	Household with 2 persons and 1 vehicle
HH2VEH2	Household with 2 persons and 2 vehicles
HH2VEH3	Household with 2 persons and 3 or more vehicles
HH3VEH0	Household with 3 or more persons and 0 vehicle
HH3VEH1	Household with 3 or more persons and 1 vehicle
HH3VEH2	Household with 3 or more persons and 2 vehicles
HH3VEH3	Household with 3 or more persons and 3 or more vehicles
IND	Industrial employment
OTH	Other employment
RET	Retail employment
CAS	Casino employment
ENROLL(K-12)	K-12 school enrollment
ENROLL(PSEC)	Post-secondary enrollment
TOT_HH	Total households
POP	Total population

Source: Bi-State Regional Commission, 2016