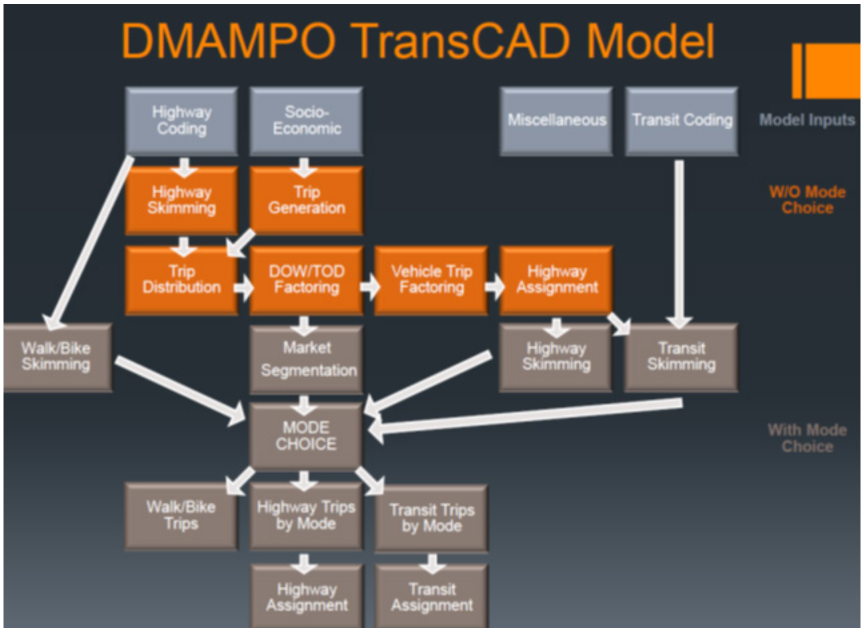
# APPENDIX J:

## TRAVEL DEMAND MODEL VALIDATION AND ANALYSIS

Travel demand models (TDM) simulate current travel conditions and forecast future travel patterns and conditions based on planned system improvements and socio-economic changes. The Des Moines Area MPO utilizes a TDM in assessing the performance of transportation system improvements and identifying impacts within the Metropolitan Planning Area (MPA) such as traffic volumes, traffic delay, transit ridership, and emissions.

FIGURE J1: TRAVEL DEMAND MODEL STRUCTURE




# Methodology

The Des Moines Area MPO's TDM utilizes TransCAD as the transportation planning computer software package that performs most of the computer processing involved with modeling the transportation system in Greater Des Moines. The Des Moines Area MPO staff ensures the TDM's development includes input and guidance from the Des Moines Area MPO Transportation Technical Committee (TTC), Engineering Subcommittee, and the Iowa Department of Transportation (DOT) modeling staff, as well as guiding documents from the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and the Transportation Research Board's (TRB) National Cooperative Highway Research Program (NCHRP).

The Des Moines Area MPO TDM is a four-step modeling process of trip generation, trip distribution, mode choice, and trip assignment. The Des Moines Area MPO TDM structure is shown in Figure H1.

## Survey Data & Socio-Economic Inputs

### Survey Data

The Des Moines Area MPO TDM utilizes survey data to establish relationships between input variables and model estimated results. The two surveys utilized in the TDM that provide the most calibration data are the 2017 National Household Travel Survey (NHTS) and the 2010 Des Moines Area Regional Transit (DART) Rider Survey. In addition to survey data, Iowa DOT traffic counts and DART passenger counts are used as validation data to verify model estimates with the observed data.

### Socio-Economic Data

The location and amount of population, housing units, employment, and school enrollment are some of the primary determinants of travel demand. The 2050 Growth Scenario, described in Appendix C, consists of three main steps: locating base year 2016 activity, forecasting future year growth at the regional level, and allocating growth to small areas within the region. Transit access procedures make use of the parcel level forecasts but other parts of the transportation modeling process are based on a traffic analysis zone (TAZ) system.

There are 2,310 internal zones, or TAZs, ranging in size from individual blocks in the Central Business District to several square miles in sparsely developed rural areas. The zone system also includes 120 external zones located where roads cross the planning area boundary. These external zones are used to represent travel passing through the Des Moines area and travel between the Des Moines area and other outside locations.

## Base Year Data

MPO staff collected data for population and employment that was current as of 2016, which serves as the base year. Population, housing unit, and household information were collected from the US Census Bureau's 2013-2017 American Communtiy Survey. Census population and housing unit counts at the block geographic level were aggregated to the TAZ level for use in the TDM. Census tract level housing unit rates for household size and vehicle availability were applied to TAZ housing units to estimate the distribution of households needed as inputs to the trip generation model. The socio-economic data was obtained as described below, and then visually inspected to confirm data assigned by TAZ.

Zone level employment data using Info USA and Iowa Workforce Development site level employer files were evaluated and found to have significant errors. As a result employment was determined using parcel-based building area to allocate Regional Economic Models, Inc. (REMI) regional level employment estimates. REMI forecasts were provided by the Iowa Department of Transportation.

MPO staff collected GIS information for commercial and industrial use parcels within Dallas, Madison, Polk, and Warren Counties. Information collected included the parcel size, detailed occupancy, building area, height, and age of the building. The detailed occupancy information was used to categorize each parcel into one of 26 land use categories. Building area was then aggregated to broader categories and a jobs per square foot ratio was applied to each building. Mixed use buildings were identified and employment estimates were developed based on the percentage of each building's area attributed to each use. Employment for each parcel was calculated by taking the building area multiplied by the number of floors multiplied by the jobs per square foot ratio.

Finally, the estimated employment was indexed to the REMI control total for each subarea. This was accomplished by summarizing the estimated employment for each parcel, determining the percentage of the total employment each parcel represents, and then applying that percentage for each parcel to the REMI control total for the parcel's respective subarea. This process changed employment on each parcel slightly yet results in the sum of all parcel employment equaling the REMI employment control total.

School enrollment for the base year by grade level and building was obtained from the Iowa Department of Education for K-12 schools. Enrollment was aggregated to zones by school type (elementary, junior high/middle school, and senior high school) for use in the trip generation model. Enrollment was also collected for the six major post-secondary school campuses: Drake University, the three Des Moines Area Community College campuses, Des Moines University, and Grand View University.

## Trip Generation

The purpose of trip generation is to estimate the number of average daily trips entering and leaving each zone for a forecast year. These trip end forecasts reflect new development, redevelopment, demographic, and economic changes that occur over time.

The model computes person trips, which account for trips by all forms of transportation including automobiles, trucks, taxicabs, motorcycles, public transit, bicycling, and walking. Trips serve five generic purposes: home-based work (HBW), home-based non-work (HBNW), non-home based (NHB), special purposes (university, hospital, airport, regional recreation, and hotel), and trucks (single-unit truck and combination truck). These trip purposes are designed to group together trips with similar travel patterns.

The model divides daily person trips into four time periods: AM (6:00 to 8:59), mid-day (9:00 to 14:59), PM (15:00 to 17:59), and off-peak (18:00 to 5:59). Each trip has two trip ends and the trip generation model calculates trip ends separately. One end is classified as a trip production and the other end as a trip attraction. Over a 24-hour period, roughly the same number of trips will originate in a zone as are destined there. However, residential zones will generate primarily trip productions while non-residential zones will generate primarily trip attractions. The production/attraction distinction is important for trip distribution.

## Trip Distribution

Trip distribution links together person trip productions and attractions from trip generation to determine trip movements between zones. The model produces trip tables that contain a row for each production zone and a column for each attraction zone zone based on a traditional gravity model.

The model is designed to modify trip patterns in response to new land use developments and transportation facility changes. For example, the opening of a new shopping center would shift trips from other nearby shopping areas to the new development. Another example would be the introduction of mixed-use development. In this case the model would yield shorter trip lengths by recognizing the increased opportunity for interaction between residential and commercial areas in the development.

## Mode Choice

Mode choice splits total weekday person trips from the trip distribution step into trips by individual forms of transportation called modes. Mode choice is designed to link mode use to demographic assumptions, highway network conditions, transit system configuration, land use alternatives, parking costs, transit fares, and auto operating costs. An update to the current TDM of note is the addition of separate local and express bus modes.

## Trip Assignment

Highway assignment is the process of loading vehicle trips between zones onto specific segments of roadway. Trips are apportioned to links based on the time and capacity associated with each link from the highway network. As congestion builds over time, the highway assignment model shifts traffic to adjacent facilities having excess capacity. Similarly, corridors where new roadways 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 transit assignment step determines route, link, and stop level ridership. These transit assignment results are important when evaluating model accuracy and the effectiveness of proposed transit improvements. TransCAD "Pathfinder Transit Assignment" function is used to assigns zone-to-zone transit trips to the transit network. Three separate transit assignments are produced for AM peak, PM peak and off-peak periods. These individual assignments are summed to obtain total transit ridership forecasts.

# Model Validation

Model calibration and validation takes place throughout the development of the TDM to ensure the model is representative of the transportation network within the region. Model calibration compares against the 2016 base year observed traffic volumes and traffic counts to determine the accuracy of the model. Differences between model estimated vehicle miles traveled (VMT) and observed VMT determines if the overall traffic for the region is modeled correctly. Additionally, estimated VMT by functional classification can indicate errors in speed assumptions for classifications.

To measure the accuracy of traffic assignment the root mean square error (RMSE) and percent RMSE (%RMSE) are used to estimate the average error between the observed and modeled traffic volumes on links with traffic counts. The following figures show the %RMSE by functional classifications in the MPO model and compare the %RMSE by volume groups against the Florida Standard Urban Transportation System (FSUTMS).

FIGURE J2: PERCENT ROOT MEAN SQUARE ERROR BY FACILITY TYPE

| FUNCTIONAL CLASSIFICA-TION | CENTRAL BUSINESS DISTRICT | UR-BAN/SUBURBAN | RURAL | TOTAL |
|---|---|---|---|---|
| Interstate | 7.1% | 10.8% | 12.5% | 11.0% |
| Principal Arteri-al | 40.3% | 24.3% | 23.5% | 24.8% |
| Minor Arteri-al | 44.4% | 30.5% | 39.5% | 32.2% |
| Major Collector | 75.3% | 58.7% | 64.7% | 63.0% |
| Minor Collector | 51.7% | 54.9% | 109.6% | 80.8% |
| Local | 147.7% | 85.0% | 156.7% | 118.1% |
| Ramp | 19.3% | 33.8% | 62.4% | 34.7% |
| Total | 38.4% | 25.8% | 38.1% | 28.2% |

FIGURE J3: PERCENT ROOT MEAN SQUARE ERROR BY VOLUME GROUP

| LOW | HIGH | MID-POINT | NUMBER OF COUNTS | % RMSE | FSUTMS - ACCEPTABLE | FSUTMS – PREFERABLE |
|---|---|---|---|---|---|---|
| 0 | 5,000 | 2,500 | 887 | 78.77% | 100% | 45% |
| 5,001 | 10,000 | 7,500 | 483 | 38.73% | 45% | 35% |
| 10,001 | 15,000 | 12,500 | 292 | 25.67% | 35% | 27% |
| 15,001 | 20,000 | 17,500 | 215 | 18.69% | 35% | 27% |
| 20,0001 | 30,000 | 25,000 | 223 | 19.01% | 35% | 27% |
| 30,0001 | 40,000 | 35,000 | 91 | 21.72% | 35% | 27% |
| 40,001 | 50,000 | 45,000 | 40 | 11.38% | 35% | 27% |
| 50,001 | 60,000 | 55,000 | 24 | 5.52% | 35% | 27% |
| 60,001 | 150,000 | 105,000 | 20 | 6.05% | 35% | 27% |

# Model Analysis

Analyses of the TDM outputs for fiscally constrained projects for the 2030, 2040, and 2050 timeframes were completed according to a no-build scenario, a build scenario, and a selective-build scenario for each timeframe. It was assumed that for each project timeframe the no-build scenario excludes all fiscally constrained projects from 2020 to the estimated build years prior to the first year of the project timeframe. For example, the no-build scenario for the 2050 timeframe was modeled without the fiscally constrained projects from 2020 to 2050 (for 2040, without projects from 2020 to 2040; for 2030, without projects from 2020 to 2030). The selective-build scenario for each project timeframe only includes all fiscally constrained projects with estimated build years a decade prior to the project timeframe. For example, the selective-build scenario for the 2050 timeframe was modelled with the fiscally constrained projects prior 2041 but not from 2041 and later (for 2040, projects prior 2031 but not from 2031 and later; for 2030, projects prior 2021 but not from 2021 and later).

For each of the project timeframes, the percent of roadway miles by level-of-service (LOS) and estimated VMT were compared to estimate the impact that fiscally constrained projects would have on future traffic in the MPO planning area.

## Model Year: 2016

Model Year 2016 is the base year for the MPO TDM. **Figure J4** shows the base year network by estimated LOS. **Figure J5** displays the estimated roadway miles by LOS and the estimate daily and annual VMT for the base year.

FIGURE J4: MODELED LEVEL OF SERVICE FOR MODEL YEAR 2016

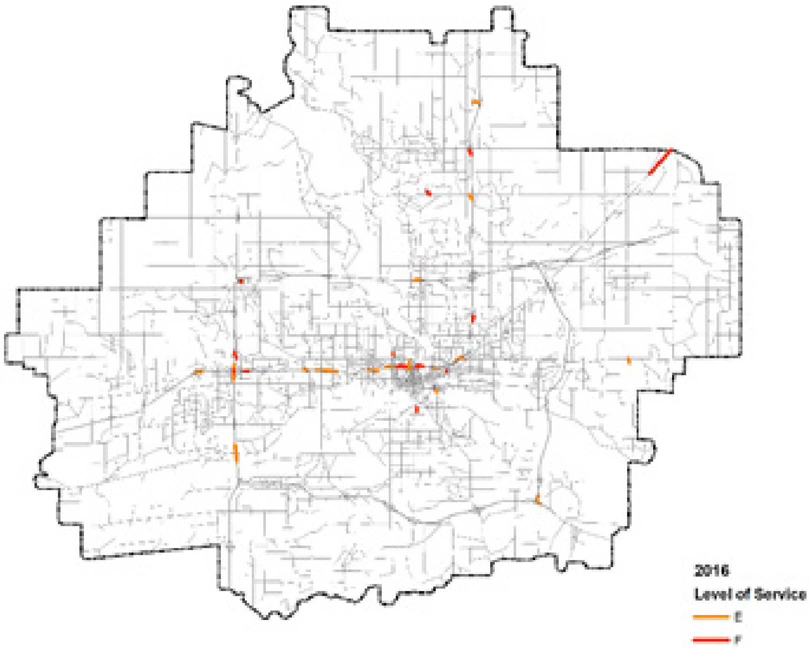



FIGURE J5: LEVEL OF SERVICE & VMT FOR MODEL YEAR 2016

| LEVEL OF SERVICE | MILES | PERCENT |
|---|---|---|
| A | 1,816.6 | 91.1% |
| B | 86.5 | 4.3% |
| C | 54.6 | 2.7% |
| D | 24.3 | 1.2% |
| E | 7.6 | 0.4% |
| F | 5.2 | 0.3% |
| Total | 1,994.8 | 100% |
| VMT/day | 4,942,096,621.7 | |
| Annual VMT | 13,539,990.7 | |
| Daily VMT/Capita | 24.93 | |

## Model Year: 2030

Model Year 2030 utilizes estimated socio-economic data from the year 2030 to estimate traffic on the three build scenarios shown in **Figures J6** and **J8**. The build scenario for the 2030 timeframe represents the change in LOS and VMT based on the completion of fiscally constrained projects identified for the timeframe ending at 2030. **Figure J9** displays the estimated roadway miles by LOS and the estimate daily and annual VMT for the years ending at 2030. Across the three scenarios, the percent of roadways with a LOS of E or F remains below the goal of 10 percent.

FIGURE J6: MODELED LEVEL OF SERVICE FOR MODEL YEAR 2030: NO-BUILD

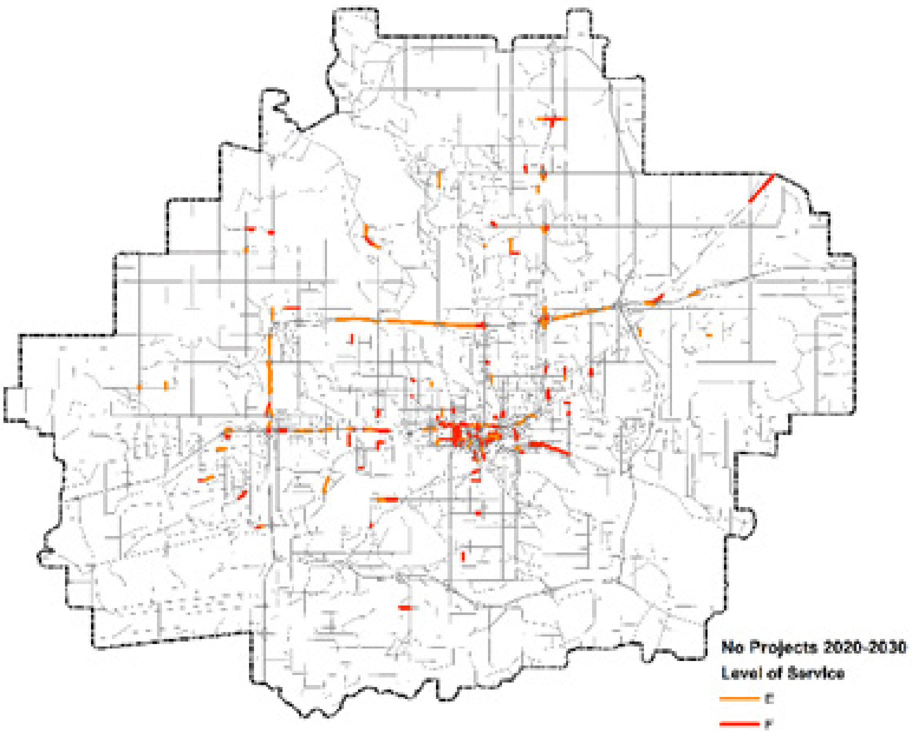



FIGURE J7:MODELED LEVEL OF SERVICE FOR MODEL YEAR 2030: BUILD

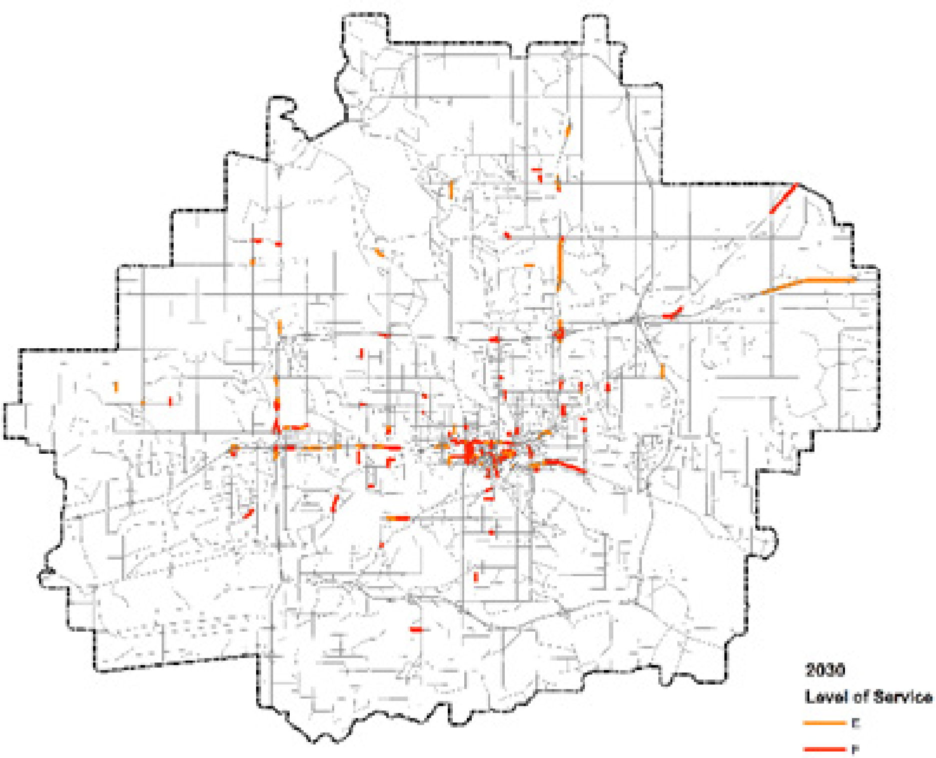


FIGURE J8:MODELED LEVEL OF SERVICE FOR MODEL YEAR 2030: SELECTIVE-BUILD

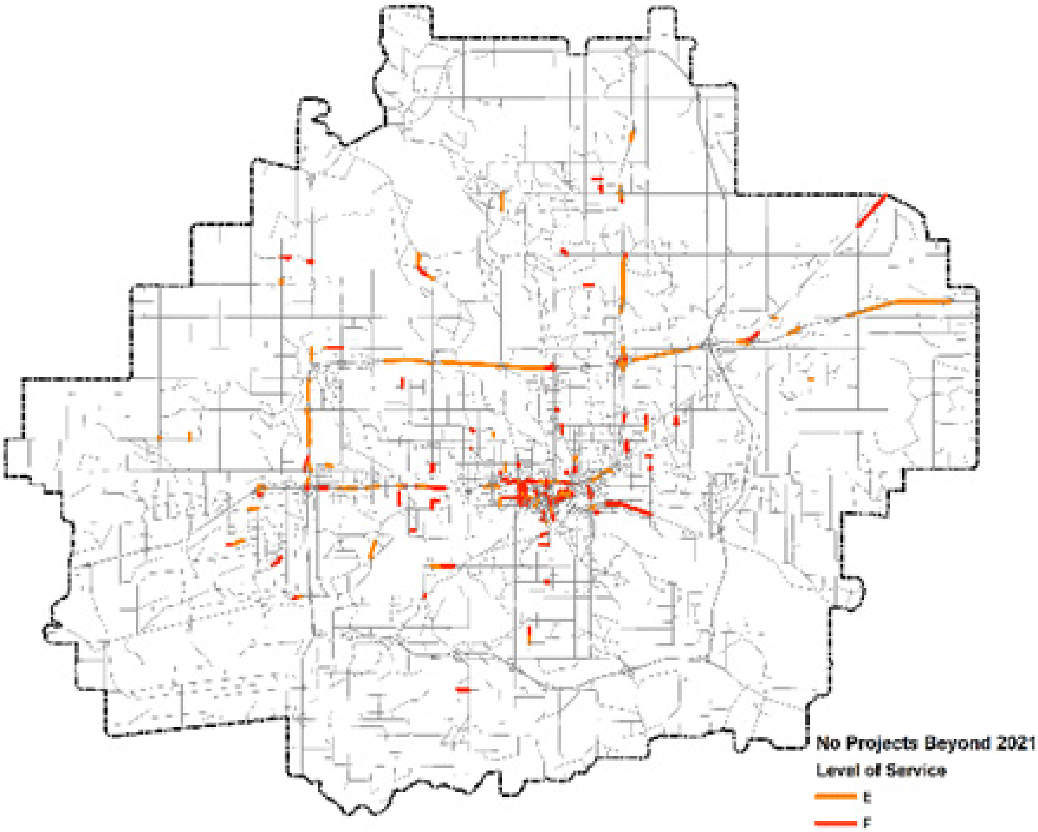



FIGURE J9: LEVEL OF SERVICE & VMT FOR MODEL YEAR 2030

| | NO-BUILD | | BUILD | | SELECTIVE BUILD | |
|---|---|---|---|---|---|---|
| LEVEL OF SERVICE | MILES | PERCENT | MILES | PERCENT | MILES | PERCENT |
| A | 1,713.1 | 85.9% | 1,760.5 | 87.5% | 1,721.5 | 86.1% |
| B | 89.9 | 4.5% | 87.1 | 4.3% | 89.2 | 4.5% |
| C | 75.7 | 3.8% | 75.7 | 3.8% | 74.3 | 3.7% |
| D | 64.3 | 3.2% | 44.5 | 2.2% | 58.9 | 2.9% |
| E | 26.9 | 1.3% | 18.4 | 0.9% | 32.5 | 1.6% |
| F | 25.0 | 1.3% | 25.8 | 1.3% | 23.9 | 1.2% |
| Total | 1,994.8 | 100% | 2,012.0 | 100% | 2,000.2 | 100% |
| Annual VMT | 5,747,658,542.7 | | 5,768,286,235.6 | | 5,753,150,744.8 | |
| VMT/day | 15,747,009.7 | | 15,803,523.9 | | 15,762,056.8 | |
| Daily VMT/Capita | 22.56 | | 22.64 | | 22.58 | |

## Model Year: 2040

Model Year 2040 utilizes estimated socio-economic data from the year 2040 to estimate traffic on the three build scenarios shown in **Figures H10** and **H12**. The build scenario for the 2040 timeframe represents the change in LOS and VMT based on the completion of fiscally constrained projects identified for the timeframe ending at 2040. **Figure H13** displays the estimate roadway miles by LOS and the estimate daily and annual VMT for the years ending at 2040. Across the three scenarios, the percent of roadways with a LOS of E or F remains below the goal of 10 percent.

FIGURE H10: MODELED LEVEL OF SERVICE FOR MODEL YEAR 2040: NO-BUILD

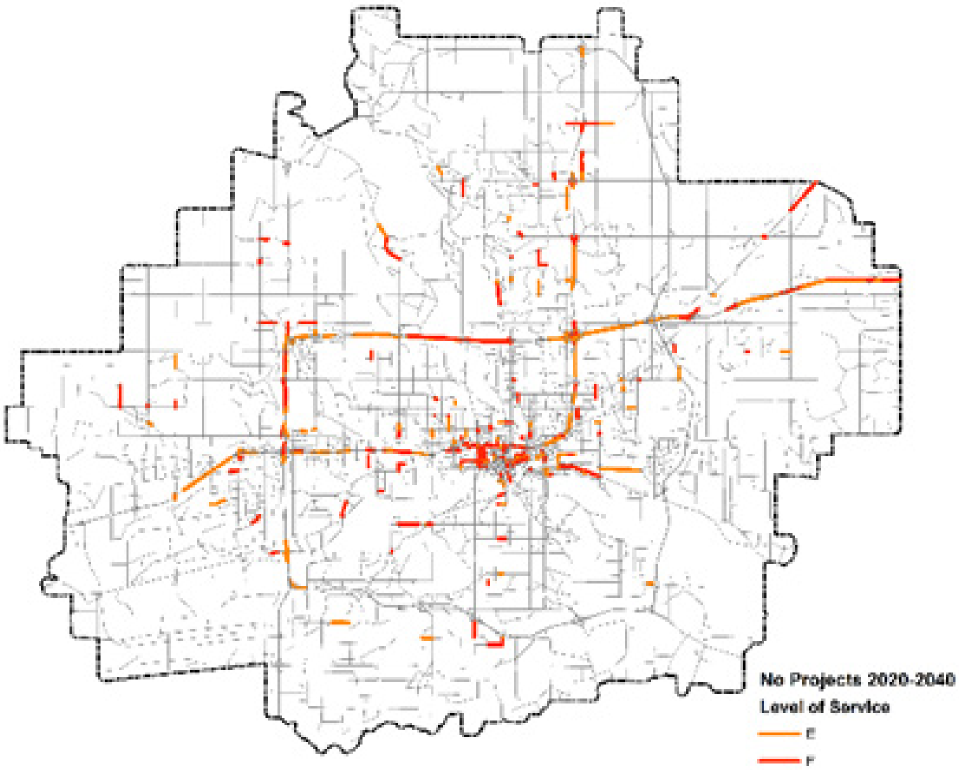



FIGURE H11:MODELED LEVEL OF SERVICE FOR MODEL YEAR 2040: BUILD

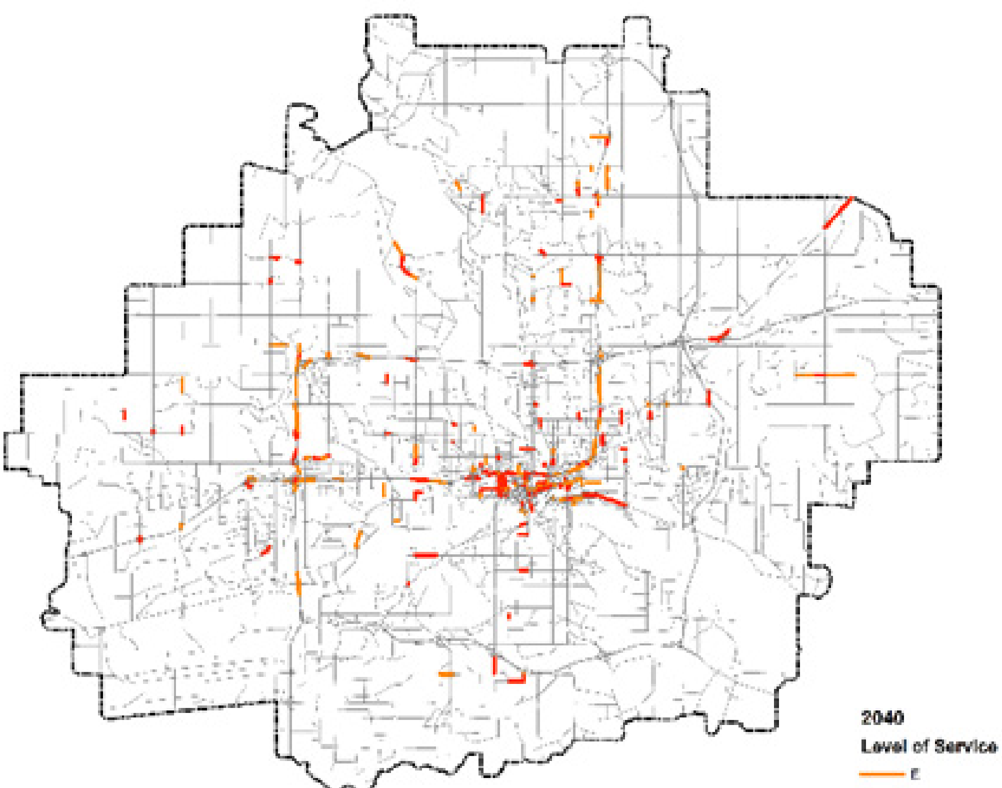


FIGURE H12:MODELED LEVEL OF SERVICE FOR MODEL YEAR 2030: SELECTIVE-BUILD

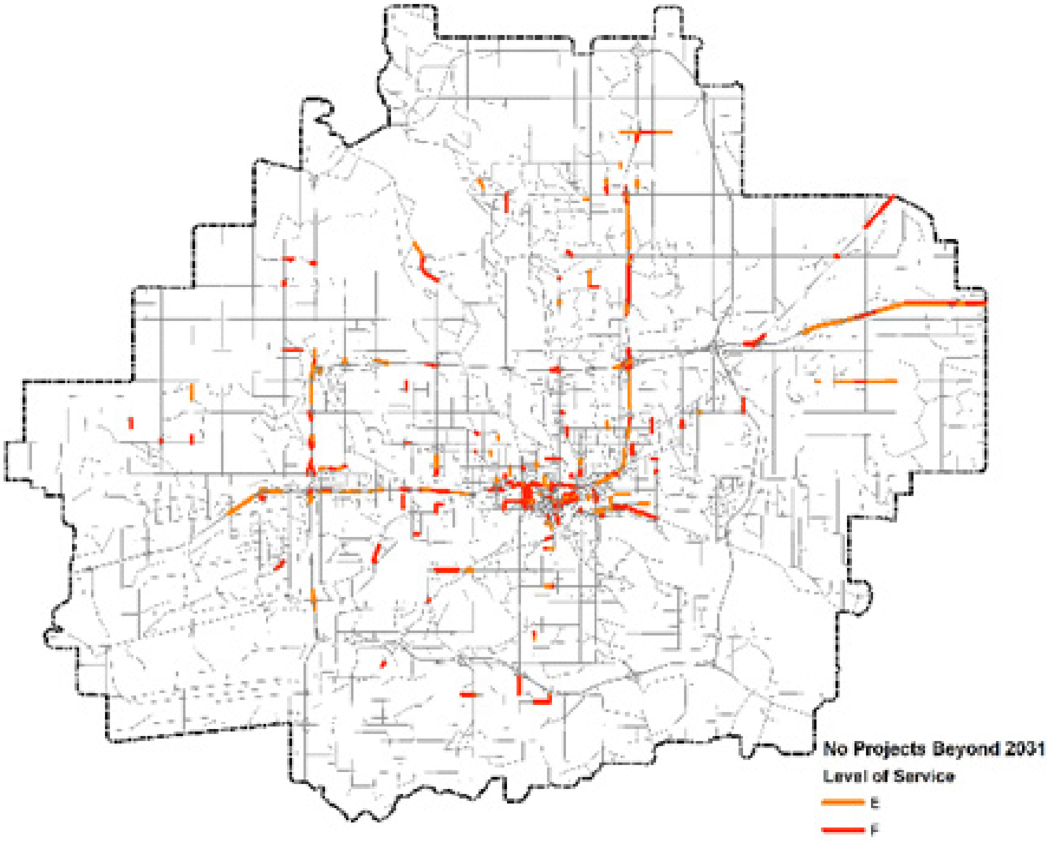



FIGURE H13: LEVEL OF SERVICE & VMT FOR MODEL YEAR 2040

| | NO-BUILD | | BUILD | | SELECTIVE BUILD | |
|---|---|---|---|---|---|---|
| LEVEL OF SERVICE | MILES | PERCENT | MILES | PERCENT | MILES | PERCENT |
| A | 1,587.9 | 79.6% | 1,704.1 | 83.8% | 1,643.3 | 81.7% |
| B | 142.5 | 7.1% | 118.8 | 5.8% | 126.1 | 6.3% |
| C | 88.5 | 4.4% | 92.8 | 4.6% | 89.2 | 4.4% |
| D | 68.2 | 3.4% | 57.9 | 2.8% | 73.6 | 3.7% |
| E | 57.8 | 2.9% | 30.2 | 1.5% | 38.5 | 1.9% |
| F | 49.9 | 2.5% | 29.4 | 1.4% | 41.2 | 2.0% |
| Total | 1,994.8 | 100% | 2,033.1 | 100% | 2,012.0 | 100% |
| Annual VMT | 6,624,740,341.4 | | 6,638,670,244.5 | | 6,648,682,991.52 | |
| VMT/day | 18,149,973.5 | | 18,188,137.7 | | 18,215,569.8 | |
| Daily VMT/Capita | 23.39 | | 23.44 | | 23.48 | |

## Model Year: 2050

Model Year 2050 utilizes estimated socio-economic data from the year 2050 to estimate traffic across the three build scenarios shown in **Figures J14** and **J16**. The build scenario for the 2050 timeframe represents the change in LOS and VMT based on the completion of fiscally constrained projects identified for the timeframe ending at 2050. **Figure J17** displays the estimate roadway miles by LOS and the estimate daily and annual VMT for the years ending at 2050. In both the no-build and build scenarios, the percent of roadways with a LOS of E or F remains below the goal of 10 percent. The selective-build scenario for Model Year 2050 was not modeled as there were no fiscally constrained projects with a completion time beyond 2037.

FIGURE J14: MODELED LEVEL OF SERVICE FOR MODEL YEAR 2050: NO-BUILD

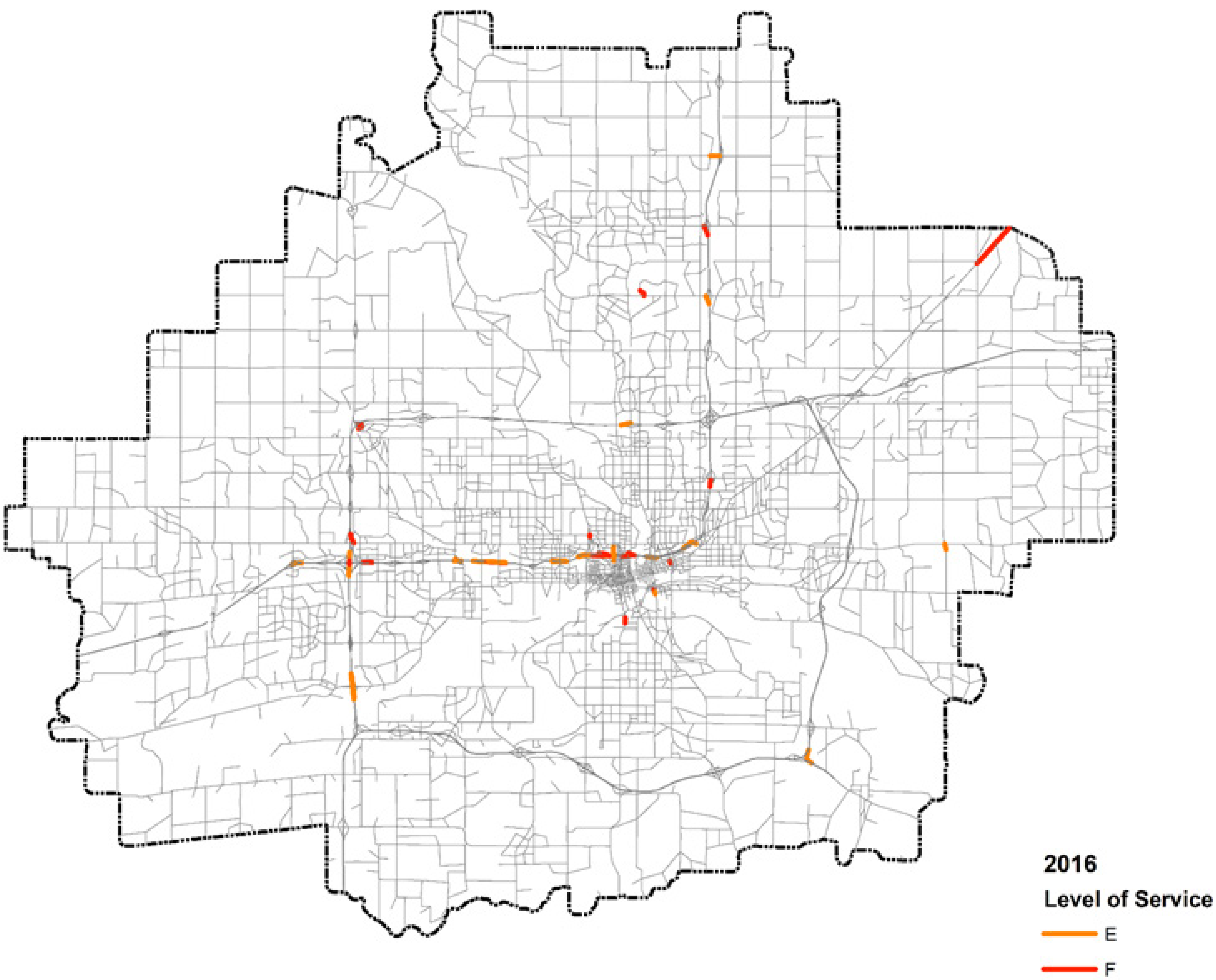


FIGURE J15:MODELED LEVEL OF SERVICE FOR MODEL YEAR 2050: BUILD

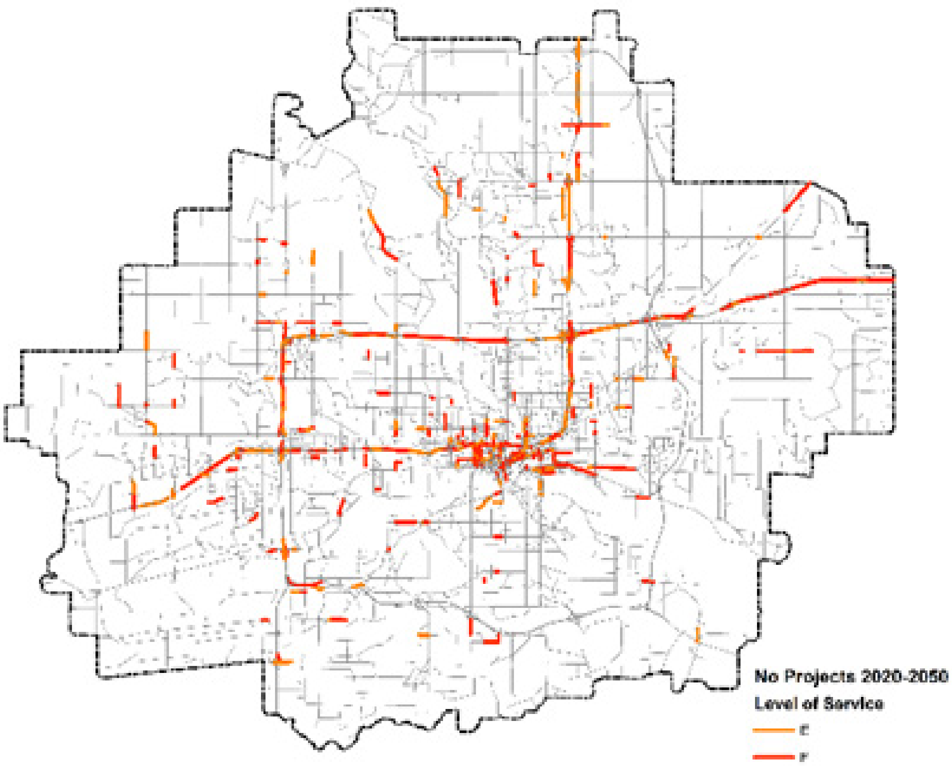



FIGURE J16:MODELED LEVEL OF SERVICE FOR MODEL YEAR 2050: SELECTIVE-BUILD

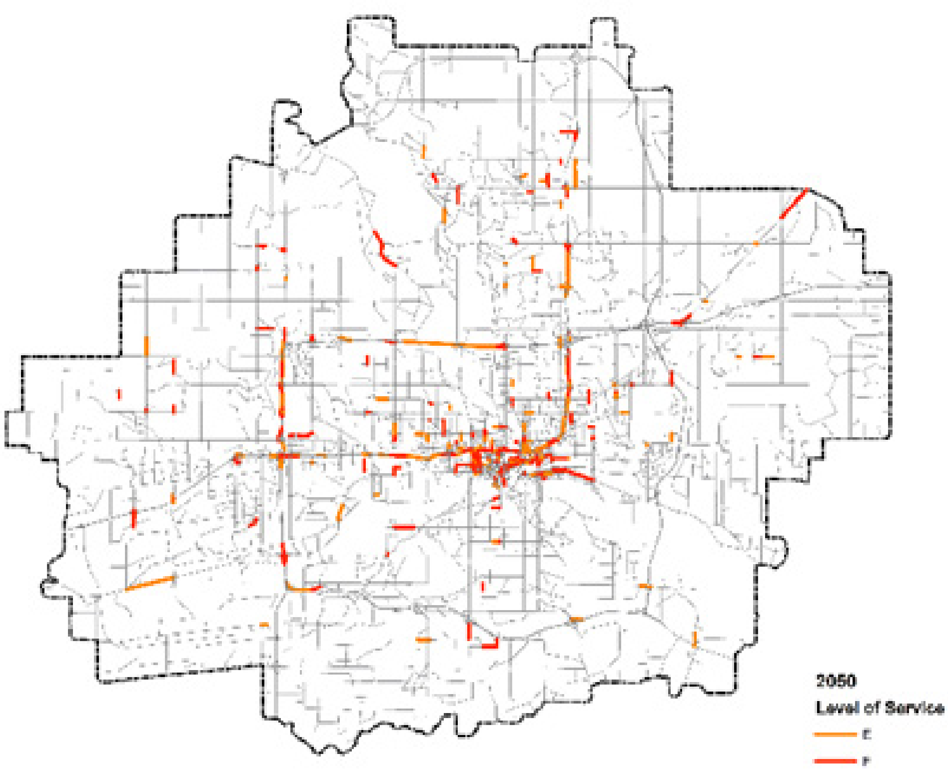


FIGURE J17: LEVEL OF SERVICE & VMT FOR MODEL YEAR 2050

| | NO-BUILD | | BUILD | | SELECTIVE BUILD | |
|---|---|---|---|---|---|---|
| LEVEL OF SERVICE | MILES | PERCENT | MILES | PERCENT | MILES | PERCENT |
| A | 1,472.1 | 73.8% | 1,616.5 | 79.5% | 1,643.3 | 81.7% |
| B | 180.4 | 9.0% | 152.1 | 7.5% | 126.1 | 6.3% |
| C | 109.3 | 5.5% | 93.6 | 4.6% | 89.2 | 4.4% |
| D | 85.1 | 4.3% | 84.5 | 4.2% | 73.6 | 3.7% |
| E | 56.7 | 2.8% | 42.8 | 2.1% | 38.5 | 1.9% |
| F | 91.3 | 4.6% | 43.6 | 2.1% | 41.2 | 2.0% |
| Total | 1,994.8 | 100% | 2,033.1 | 100% | 2,012.0 | 100% |
| Annual VMT | 7,186,304,841.0 | | 7,207,136,729.1 | | 6,648,682,991.52 | |
| VMT/day | 19,688,506.4 | | 19,745,580.1 | | 18,215,569.8 | |
| Daily VMT/Capita | 23.92 | | 23.99 | | 23.48 | |