



ARRIVE 2050

FORECASTS

Arrive 2050 Forecasts: Travel Demand Model Socio-Economic Update

Final Report



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Glossary

Age Cohorts: Groupings of people of the same age.

Average Daily Traffic (ADT): A traffic volume that represents an average, 24-hour period.

Bismarck-Mandan: Used to describe the entire MPO area, including Bismarck, Mandan, Lincoln and the metropolitan portions of Burleigh and Morton County.

Bismarck-Mandan Metropolitan Planning Organization (BMMPO): The Metropolitan Planning Organization (MPO) for the Bismarck-Mandan region.

Centroid: A point that represents the center of an area. In travel modeling, the centroid represents where all traffic generated by a transportation analysis zone (TAZ) is loaded onto the travel model's network via centroid connectors or pseudo links.

Centroid Connectors: An abstract link that connects the centroid to the TDM roadway network. Typically, centroid connectors are intended to represent one or more local street or driveways where development-generated traffic connects to the functionally-classified street network. Also known as Pseudo Links.

Feedback Loop: A process where the output from a step in a model sequence is used as a revised input for a prior step, and the model sequence is executed again. In the Bismarck-Mandan TDM, the congested travel time results of the traffic assignment step are "fed back" as inputs for the trip distribution step.

Freight Analysis Framework (FAF): FAF is typically produced every 5 years by the Bureau of Transportation Statistics (BTS) and Federal Highway Administration (FHWA). It is a data source that

provides current year and forecasted future year freight movement among states and major metropolitan areas.

Friction Factors: Parameters used in the Gravity Model to represent the relative impact various travel costs have on trip length choice.

Functional Classification: A system used to classify streets and roadways according to the function they provide. Example classifications for the Bismarck-Mandan area include Interstate, arterial, collector, and local streets. All collectors, arterials, and Interstates in the Bismarck-Mandan region are included in the TDM.

Geographical Information System (GIS): A software package that integrates spatial mapping and databases, providing spatial analysis and mapping capabilities.

Gravity Model: A trip distribution approach that estimates trip levels exchanged between two zones based on the pair's trip productions, trip attractions, and cost of traveling between the zones.

Goodness of Fit: A statistical measure that describes how well a set of model-estimated data fit with observed (or real) data.

Gross Metropolitan Product (GMP): The measure of the market value of all final goods and services produced in a metropolitan area.

Infogroup: A company that provides a range of data products. The Infogroup data referred to in this report are estimates of existing employment levels by location and industry used by the MPO for model data development.

K-Factors: A parameter used in the Gravity Model to adjust trip distribution levels between zones. K-Factors are asserted values, sometimes referred to as a "socio-economic" adjustments, that are inserted to account for trip-making factors not otherwise explained by zonal productions, attractions, or travel costs.

Metropolitan Transportation Plan (MTP): A Federally-required planning document all MPOs complete every 5-years that should establish regional transportation goals and evaluate system performance, culminating in a fiscally-constrained list of projects and strategies over the next 20 plus years.

Mode Choice: In a traditional four-step model, mode choice is the third step following the trip distribution and prior to traffic assignment. Mode choice evaluates reasonable travel modes between TAZs, and assigns a mode of travel to each trip. Mode choice is not currently included in the Bismarck-Mandan TDM.

Pseudo Links: An abstract link that connects the centroid to the TDM roadway network. Typically, centroid connectors are intended to represent one or more local street or driveways where development-generated traffic connects to the functionally-classified street network. Also known as Centroid Connectors.

Quarterly Census of Employment Wages (QCEW): A Bureau of Labor Statistics program that publishes a quarterly count of employment and wages reported by employers

Root Mean Square Error: A statistical test that measures the difference between predicted and observed values; in the case of the TDM comparing model predicted traffic volumes at a location to observed traffic volumes at that location.

Sensitivity Test: A model run that evaluates model response to controlled changes to a model input variable.

Socio-Economic Data: A community's population characteristics like household status, vehicles available, employment type, and educational status. Socio-economic data is the independent variable which the Bismarck-Mandan TDM uses to generate trips.

Time-of-Day Factors: Parameters that convert the daily trip tables by trip purpose to peak period trip tables according to the estimated percentage of daily traffic that occurs during peak periods.

Traffic Assignment: The final step in the Bismarck-Mandan model, traffic assignment is the module that assigns or routes each trip to network links between its origin and destination.

Transportation Analysis Zone (TAZ): Also called traffic analysis zones, the TAZ is the basic unit of geography for the travel model. The MPO defines the TAZ boundaries for the model.

Travel Demand Model (TDM): A computerized application that combines an area's transportation system data, land use data, and tailored region-specific travel parameters to forecast regional or statewide travel. A TDM can evaluate how land development and the transportation system interact, and how transportation investments and land use development decisions can impact travelers and system performance.

Trip Attraction: Trips generated have both a production and an attraction. The number of trip attractions in a zone is defined by the amount of trip-attracting socio-economic data in that zone. Employment, measured in jobs, is the primary unit for trip attractions in the Bismarck-Mandan model.

Trip Distribution: The process of matching generated productions and attractions, thereby estimating the number of trips exchanged between all TAZs. The Bismarck-Mandan TDM uses the gravity model for trip distribution

Trip Generation: The first step in the model process that estimates the number of trips occurring for all TAZs, based on the input socio-economic data. Trips generated have both a production and an attraction.

Trip Production: Trips generated have both a production and an attraction. The number of trip productions in a zone is defined by the amount of trip-producing socio-economic data in that zone. Households are the primary unit for trip productions in the Bismarck-Mandan model.

Validation: The process by which a model, after development, is tested to see how accurately it predicts observed travel patterns.

Woods and Poole: A firm that specializes in long-term economic and demographic projections.

Overview & Introduction

The Bismarck-Mandan Metropolitan Planning Organization (BMMPO) has prepared herein: the *Arrive 2050: Travel Demand Model Socio-Economic Update* (hereafter referred to as the ‘TDMSE update’) to develop demographic forecasts for the Bismarck-Mandan metropolitan area. The TDMSE update occurs every five years in advance of the long-range Metropolitan Transportation Plan (MTP) update process. The forecast projections of the TDMSE update are vital to local area jurisdictions and other entities and help to support different planning efforts throughout the region.

Population, households, and employment are the primary socio-economic factors used to explain travel trends and predict future travel patterns. Demographic forecasts developed by the BMMPO are used to revise and update the region’s Travel Demand Model (TDM), the primary tool for assessing future conditions of the regional surface transportation system, particularly the roadway system, as well as freight and transit planning needs. The model estimates travel demand by evaluating the location and amount of housing and employment, the number of people in each household, and the types of jobs in different employment categories.

To better anticipate future transportation needs, the TDMSE update seeks to understand what strategies, techniques, variables, and methodologies have been used in prior demographic forecasts, and how past projections have compared with actual data from the U.S. Census Bureau. This includes a close examination of socio-economic factors from previous forecasts including the 2018 TDMSE update, the most recently completed study for the Bismarck-Mandan metropolitan area. This study then sets out a framework for three unique growth scenarios based primarily on trend variables (cohort age structures, industry labor distribution), dynamic variables (birth rates, death rates, migration), and constants (housing to demographic

relationships, labor force participation rates, gender ratio). Socio-economic factors from these scenarios are forecast in five-year increments, from 2025 through 2050.

Travel Demand Model (TDM) Background

The BMMPO and its member organizations (City of Bismarck, City of Mandan, City of Lincoln, Burleigh County, and Morton County) have continually invested in the region’s TDM. The regional TDM is a computerized application that forecasts travel across the transportation system. Regional travel forecasts are developed by combining data on the Bismarck-Mandan area’s transportation system, regional land use and development patterns, and the travel characteristics of area residents. The TDM is used by the BMMPO and its partners to evaluate how land development and the transportation system interact, and how transportation investments and land use development decisions impact travelers and the performance of the regional transportation system. The BMMPO and its partners recognize the utility and importance of the TDM, as it provides data-driven, thoughtful, and reasonable results at a level of detail required for the analyses of regional scenarios.

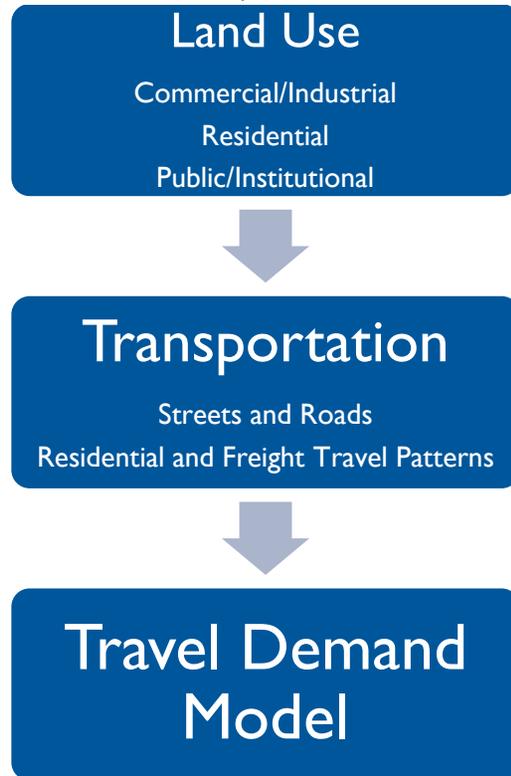
The Bismarck-Mandan TDM is developed and maintained by the Advanced Traffic Analysis Center (ATAC) at North Dakota State University. ATAC provided the model files and validation statistics for this study.

Study Purpose

There are two primary purposes of the TDMSE update. The first is to update the future socio-economic scenario to the year 2050, to be consistent with the planning horizon with the ongoing MTP update. The second is to provide an independent technical review of the TDM. This study comes at a critical juncture for the Bismarck-Mandan area, as the region moves passed the 2020 COVID-19 Pandemic and a previous decade of intense growth in development

and traffic associated with the oil boom in Western North Dakota. Previous TDMSE updates reflected the oil boom, which led to a significant increase in the Bismarck-Mandan region's rate of growth through [peak oil/development and production in 2014](#). This study reflects a decrease in oil development, stabilized oil production market, and socio-economic impacts caused by the pandemic. This TDMSE update provides an opportunity to reevaluate a post-pandemic way of life, a more stable oil market in the region, and what future growth trajectories the region may experience as a result. The remainder of this document summarizes these elements of the study.

Figure 1. Travel Demand Model Process/Inputs



Study Area

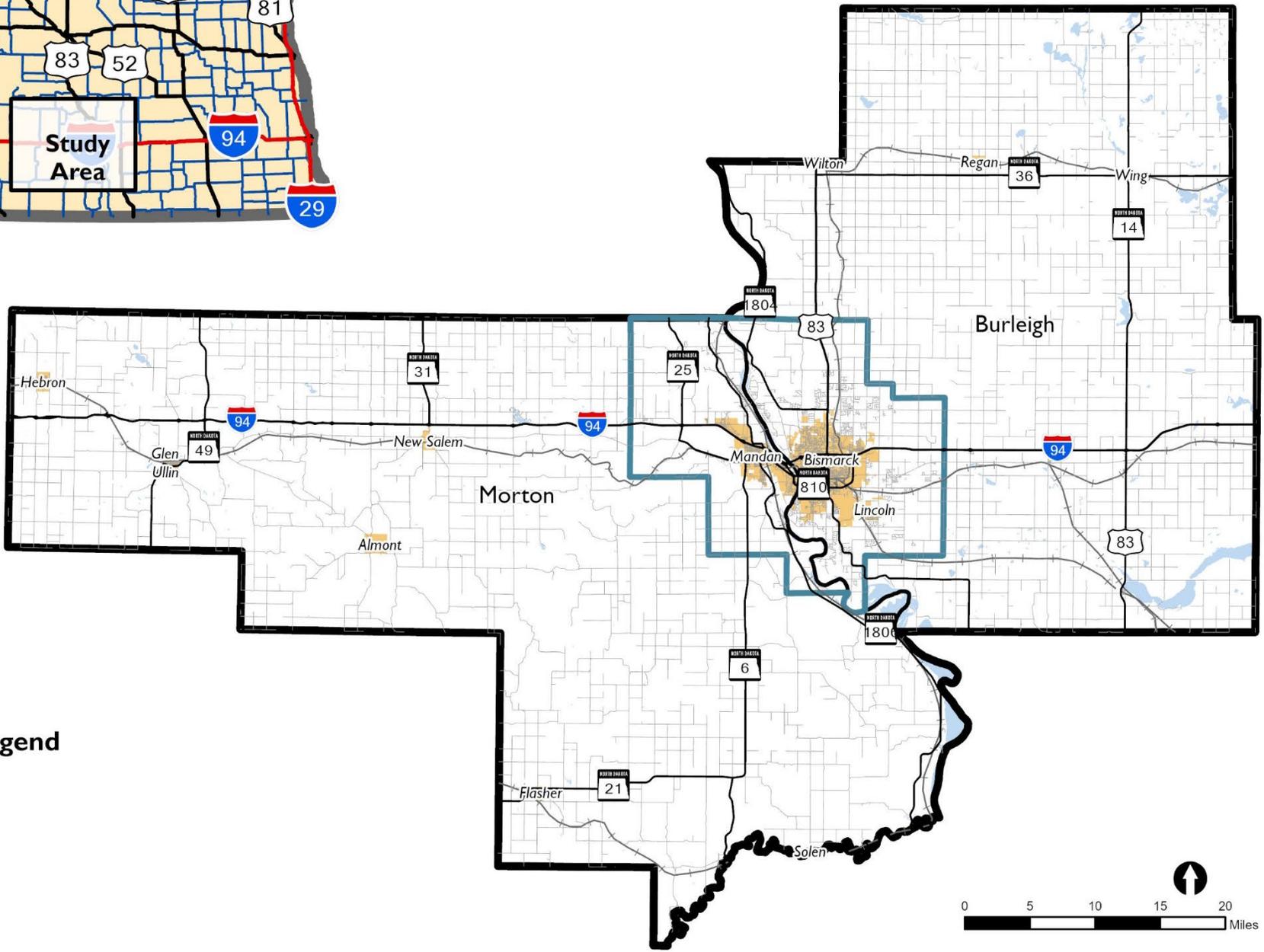
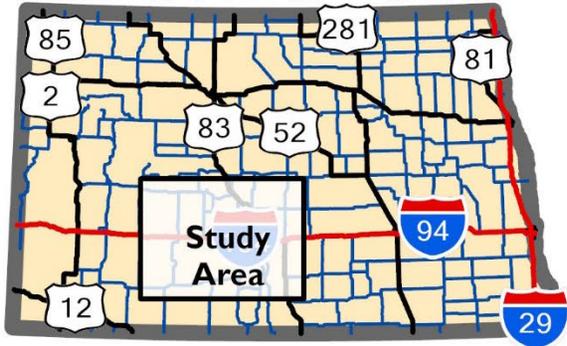
The BMMPO has been designated by the governor of North Dakota to function as the Metropolitan Planning Organization (MPO) for the Bismarck-Mandan metropolitan area. Urban areas in the United States with a population of 50,000 or more have a designated Metropolitan Planning Organization (MPO) to assist in making fair and impartial transportation decisions and to help administer federal transportation funds the [Metropolitan Transportation Planning process](#).

Throughout the TDMSE update, references are made to both the Bismarck-Mandan Metropolitan Statistical Area (MSA) and the Bismarck-Mandan Metropolitan Planning Area (MPA), and each denotes different geographic areas. An MSA is defined as a region consisting of one or more counties that contain at least one combined urban area with a population of at least 50,000. These are used by the U.S. Census Bureau and other federal government agencies for statistical purposes. The Bismarck-Mandan MSA includes Burleigh and Morton Counties.

The MPA is the boundary by which an MPO's transportation planning process is carried out. It accounts for both urbanized areas as well as contiguous exurban areas with vital county, state, and federal roadways that can be expected to urbanize over a 25-year period. The BMMPO's MPA covers three cities, eight townships in Burleigh County, one township in Morton County, and 15 unorganized townships in Burleigh or Morton Counties.

Figure 2. TDMSE Update Study Area

State of North Dakota



Legend

- MPA
- MSA
- Cities

Community Snapshot

As part of the data-driven update process, the BMMPO's TDMSE update utilizes robust quantitative socio-economic data sets. This study supplements the quantitative analysis by gathering robust qualitative data, obtained through public engagement and conversations with key local stakeholders about the future of the Bismarck-Mandan region. This qualitative information is used to cross-reference the quantitative socio-economic data being used to forecast population, households, and employment to the planning horizon year of 2050.

Ultimately, the feedback provided through the focus group and Steering Committee engagement process has guided the update of the BMMPO's TDM and will continue through the MTP update. The qualitative feedback received ensures both updates estimate the most practical and realistic assumptions. Sections of this report include the focus group engagement process, steering committee engagement process, and major themes that guide the TDMSE update.

Steering Committee

The Steering Committee (SC) provided overall guidance for the TDMSE update. Meetings with the SC occurred at critical milestones as described below:

Steering Committee Meeting #1

Meeting held in November 2022 to kick-off the TDMSE Update with the steering committee. Key takeaways:

- Provide a defensible rate of growth.
- Compare to historical projections or forecasts.
- Focus on the region's unique opportunities and challenges to growth.

Steering Committee Meeting #2

Meeting held in February 2023 to review socio-economic forecasts from previous planning efforts, review draft forecast methodology, and review draft forecast scenarios which included:

- Low growth scenario.
- Medium growth scenario.
- High growth scenario.

Allocation Workshops

East River Allocation Workshop

Workshop held in April 2023 with City of Bismarck, City of Lincoln, and Burleigh County steering committee members. Workshop centered around allocating socio-economic data in the BMMPO's metropolitan area east of the Missouri River. Roll plots were used to draw specific growth areas with real-time tracking of targets in ArcGIS.

West River Allocation Workshop

Workshop held in April 2023 with City of Mandan and Morton County steering committee members. Workshop centered around allocating socio-economic data in the BMMPO's metropolitan area west of the Missouri River. Roll plots were used to draw specific growth areas with real-time tracking of targets in ArcGIS.

Steering Committee Meeting #3

Meeting held October 2023 to review refinements and socio-economic shifts resulting from allocation workshops.

Focus Group Engagement Process

The engagement process used focus group meetings to gather qualitative data about the future of the Bismarck-Mandan region. Focus groups were organized around perspectives related directly to the future growth of the region and driving forces of community growth. The focus groups included engaging technical professionals in the following fields or areas:

- Economic Development
- Housing Agencies
- Social Service Agencies
- School Districts and Private K-12 Institutions
- Higher Education
- Real Estate Development

Informal conversations/interviews were held with individuals and small groups to assess the perception of growth or decline in BMMPO's metropolitan area.

Key Questions

The conversations revolved around key high-level questions. The questions were intended to examine socio-economic growth and decline in the Bismarck-Mandan region and helped interviewees think critically about the future of their communities. Questions were tailored to the group being interviewed but generally were similar overall to ensure consistent feedback. The specific questions may be found in Appendix B.

Focus Group Discussion Timeline

Focus group meetings were held between mid-November, 2022 to early-January, 2023.

Major Themes

Overall, the major themes from the focus group meetings include:

Expectations for the Region

There was consensus that the Bismarck-Mandan region will likely grow into the future. People were optimistic about the direction and expect stable, steady growth through 2050. Focus groups mentioned the need to grow smart and responsibly moving forward. Focus groups also speculated more regional competitiveness for Bismarck-Mandan which will help attract people from small towns in North Dakota, other communities across the upper Midwest (big and small), and beyond.

Drivers of Growth

The region's economy feels stable to people. Healthcare, State Government, and Education were mentioned most often as the biggest reasons for stability. The energy and financial sectors were also mentioned as being critical to the regional economy.

Parks and recreation, natural resources, the Missouri River, and the attractive landscape were mentioned as a growth driver in nearly every focus group meeting. The region is very connected to the natural beauty of the area, and people expressed pride in the regional landscape.

Interviewees mentioned the family-friendliness, cleanliness, sense of community, diversity, and safety of Bismarck-Mandan as important social factors that will help continue to drive growth for the region in the future.

People are noticing the rural exodus happening across the state/upper Midwest, with people moving to regional hubs like Bismarck-Mandan for better access to education, healthcare, business opportunities, social services, and other amenities not found in rural areas.

Other trends were brought up, which have been seen nationally in the post-covid era included:

- workforce shortage,
- immigration,
- e-commerce,
- telecommuting,
- cost of living (inflation),
- and the mental health crisis.

These factors could have a positive or negative impact to growth moving forward and although it may be too early to speculate how they'll specifically impact regional growth in the future, considerations of these factors shed light on the TDMSE update.

Challenges to Growth

There was a lot of speculation that housing availability (options) and affordability will continue to be a challenge and change is likely needed. Incentives, infill development, and increased density are a few of the examples mentioned to address housing challenges in the region.

The workforce crisis is a national trend, but was mentioned as the biggest barrier to growth moving forward across the board, with nearly every focus group interviewee mentioning it as an challenge for their representative business, organization, or institution.

Infrastructure and the timing of development was also a concern for most real estate developers. The expense and financing of infrastructure in and of itself was seen as barrier, but also the time spent getting infrastructure in the ground, ready for homes and businesses has delayed projects and added to the overall cost of real estate in the region. It was mentioned that the City of Bismarck is in the process of pursuing funding for a city-wide sewer system upgrade.

Another concern is migration (out of the region), specifically the migration of young people looking to establish themselves in the community. People thought the region could do a better job of marketing to and retaining young people who may be looking to settle down and start building their lives after receiving an education or starting a career.

Opportunity Areas

Focus group interviewees mentioned the following specific opportunity areas for the region to address growth:

- Poor mobility north and south across the region.
- Lack of public transit and taxi services to meet the needs of social services and other people who utilize transit or taxi service.
- Implement 66th Street interchange with I-94, on the eastern edge of Bismarck as a short-term priority.
- Public Private Partnerships - Silver Ranch property owner interested in helping with local match for Transportation Alternatives (TA) grant to construct a grade separated path or trail for cyclists and pedestrians to cross 43rd Avenue.
- Need for the planned interchange on the western edge of Mandan.
- Intersection safety concerns with ND 1804 (United Tribes Technical College).
- Safety and operational issues at the intersection of N 19th Street and Shiloh Drive (Shiloh Christian School).
- Explore bike and pedestrian trail feasibility along BNSF railroad through downtown.

Please see Appendix B for further detail.

Socio-Economic Update

Socio-Economic Forecast Methodology

The primary purpose of the socio-economic data update is to provide updated land use growth information to support the BMMPO's future transportation planning efforts. The BMMPO staff used several sources of data such as Data Axle employment data, the 2020 Decennial Census, local jurisdiction building permits, and aerial photography to compile a 2021 base year socio-economic dataset. The socio-economic data were updated to the year 2050, consistent with the minimum 20- year planning horizon of the ongoing MTP update. For the purposes of use by the TDM, socio-economic data were developed in the following categories:

Population

To forecast the Bismarck-Mandan regional population as accurately as possible, a cohort survival model was used to forecast future population, in 5-year intervals: 2021, 2025, 2030, 2035, 2040, 2045, and 2050. The cohort model estimated critical rates to 'naturally' project the population into the future:

- Births
- Deaths
- Migration

These rate estimates are applied to the current population, and the future (new) population is formed. A new set of birth, death, and migration rates are then estimated for the new model which is used to create another iterative future population. This is applied iteratively over several periods of time into the future. The existing cohorts are also 'aged' through the process, meaning the 2020 population of 55-year-olds are the same model units as the 2025 population of 60-year-olds, after deaths and migration are calculated. Age cohorts continuously move forward through the cohort survival

model. This process is repeated at 5-year intervals through the analysis period of 2050.

The qualitative analysis described in the community snapshot section above, has the most impact on model results. For example, regional opportunities and challenges can vary birth, death, and migration rates; the natural drivers of growth into the future.

Households

Housing forecasts include aggregate measures of housing as well as more detailed socio-economic breakdowns of current and future housing in the Bismarck-Mandan region. Baseline housing characteristics were derived from the 2020 Decennial Census, 2021 ACS data, and inventory of aerial imagery (in newer developments/fringe areas). This data established household size and makeup.

Current demographic information was used to perform a regression analysis between the number of households and each age cohort's population. The estimated coefficients from the regression analysis can be applied to the forecast age cohort populations to estimate the complete housing stock in any given forecast year. Other demographic elements like number of college students or percentage renter occupied housing will also be regressed on past cohort data in order to use the forecast cohort information to estimate future values.

Table 1. Select Household (HH) Statistics

AREA	HHs	PERSONS PER HH
City of Mandan	9,832	2.24
City of Bismark	32,393	2.20
Morton County	13,502	2.26
Burleigh County	39,805	2.32

Table 1 shows recent data on households in the region. The table shows the number of households and the persons per household. A simple way to estimate future households is to estimate future population and then divide by the baseline persons per household. That

Source: American Community Survey (2016-2020)

approach can be used in this project as one validation check against the linear model that will predict future housing and households.

Employment

Since the 2018 TDMSE update, employment evolved in the Bismarck-Mandan region, and across the United States. Where people work, how, and how often changed with the advent of widespread remote work in response to the COVID-19 pandemic. While the level of remote work has decreased since March 2020 in North Dakota, remote work continues to be a large part of the economy moving forward. Automation and other recent technological advancements, particularly in the field of robotics, will undoubtedly continue to reshape the economy. Employment forecasts took elements like this into account as they were created. As part of the scenario estimations, adjustments were made to inputs to reflect the different factors impacting work and the workplaces of the region into the future.

The employment forecast is based on the gross domestic product (GDP) of Burleigh and Morton Counties. The aggregate GDP is broken down into broad sectors based on the North American Industry Classification System, 2 Digit (NAICS2) Codes.

Table 2 displays the sector codes used to classify jobs. The regression analysis considered the NAICS2 codes directly to provide greater detail but then aggregated those codes according to Table 2.

Table 2. NAICS2 Industry Classification

INDUSTRY	NAICS2 CODE
Agriculture	11
Educational Services	61
Manufacturing	31-33
Construction and Mining	21,23
Retail Trade	44-45
Services	51-53,55-56,62,71,81,92,99
Utilities, Wholesale Trade, and Transportation	22,42,48,49

Tables 3 and 4 reflect data from Woods & Poole and the Bureau of Economic Analysis (BEA).

See Appendix C for further detail on socio-economic forecast modeling.

Figure 4. Burleigh County Employment/GDP

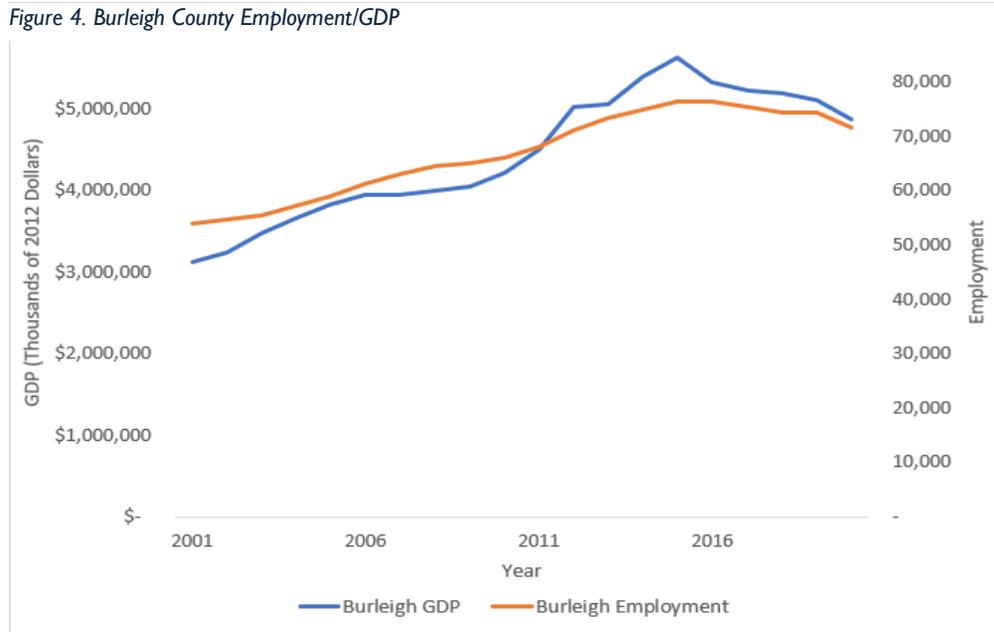
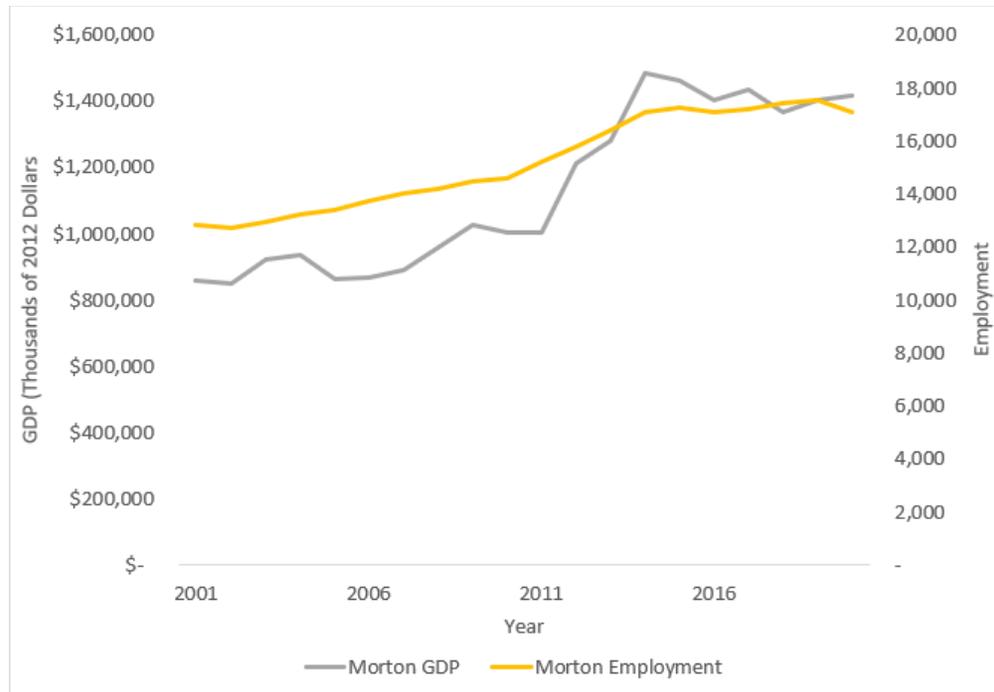


Figure 3. Morton County Employment/GDP



Growth Scenario Development

Several steps went into the update of the socio-economic data and subsequent growth scenario development:

- Reviewing long-term and recent regional growth trends
- Reviewing other economic data for growth projections
- Identifying three potential development scenarios
- Selecting a preferred future development scenario
- Allocating future regional growth to traffic analysis zone (TAZ) geographies

The general process followed for the development of regional growth scenarios included:

1. Reviewed the current growth context for Bismarck-Mandan, including an assessment of recent population growth and trends.
2. Established feasible growth rates based on historical trends and previous planning efforts.
3. Refined the cohort survival model and subsequent socio-economic data update to evaluate and develop regional control-total projections of future population, households, and employment through year 2050.
4. Estimated the BMMPO's MPA portion of the MSA population, households, and jobs. As shown in Figure 1, the BMMPO's study area or MPA, is in portions of northeast Morton County and southwest Burleigh County.

Grounding Scenarios in Context

Several perspectives were considered when evaluating current trends and potential growth trajectories through 2050 for the Bismarck-

Mandan metropolitan area. These perspectives included the review of the following key inputs.

Population

Key quantitative inputs were used to develop grounded forecasts:

- Decennial Census: current and historical demographics
- American Community Survey (ACS): Current
- Center for Disease Control and Prevention (CDC): birth and death rates

Employment

The quantitative inputs used for employment forecasts was updated since the 2018 TDMSE update, and include the following:

- Quarterly Census of Employment Wages (QCEW): current industry level calculation
- Gross Domestic Product (GDP) Data: current and historical GDP trends
- Woods & Poole Economics, Inc.: labor productivity and gross domestic product (GDP) forecast

The reviews identified likely trends for Bismarck-Mandan's growth moving forward, and grounded scenarios in realistic context.

Calibrating Scenarios

Additional information was used to help calibrate growth scenarios to both national and local conditions.

- National Historical Growth Trends
- Regional Historical Growth Trends
- Local Considerations
- Woods and Poole Data

National Demographic and Growth Trends

When reviewing historical population trends in Bismarck-Mandan, it is important to consider the context of national demographic trends. Figure 4 shows that while the number of US live births is at levels consistent with the 1950s, the birth rate has declined significantly over the past several decades.

As shown in Figure 3, population growth rates in the United States have trended down since the 1950s, due in large part to declining birth rates.

Due in part to a nationally declining birth rate, the median age in the MSA has increased steadily from 24.9 years in 1970 to 37.9 (estimated) in 2021. Projections from Woods and Poole, shown in Figure 5, estimate median age in the MSA will increase to 47.2 years of age by 2050.

Figure 5. U.S. Historic Population Growth Rate 1950-2024

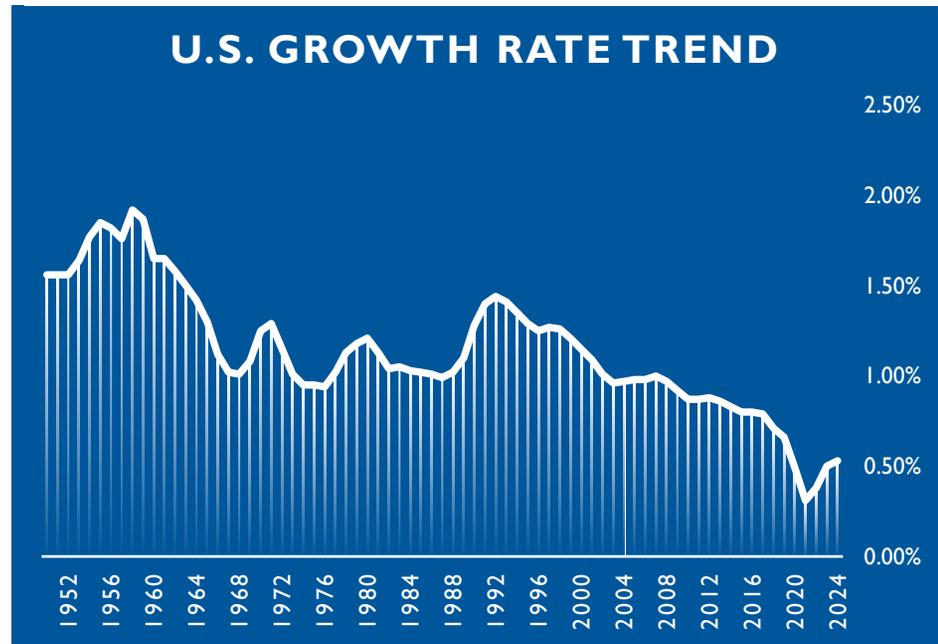
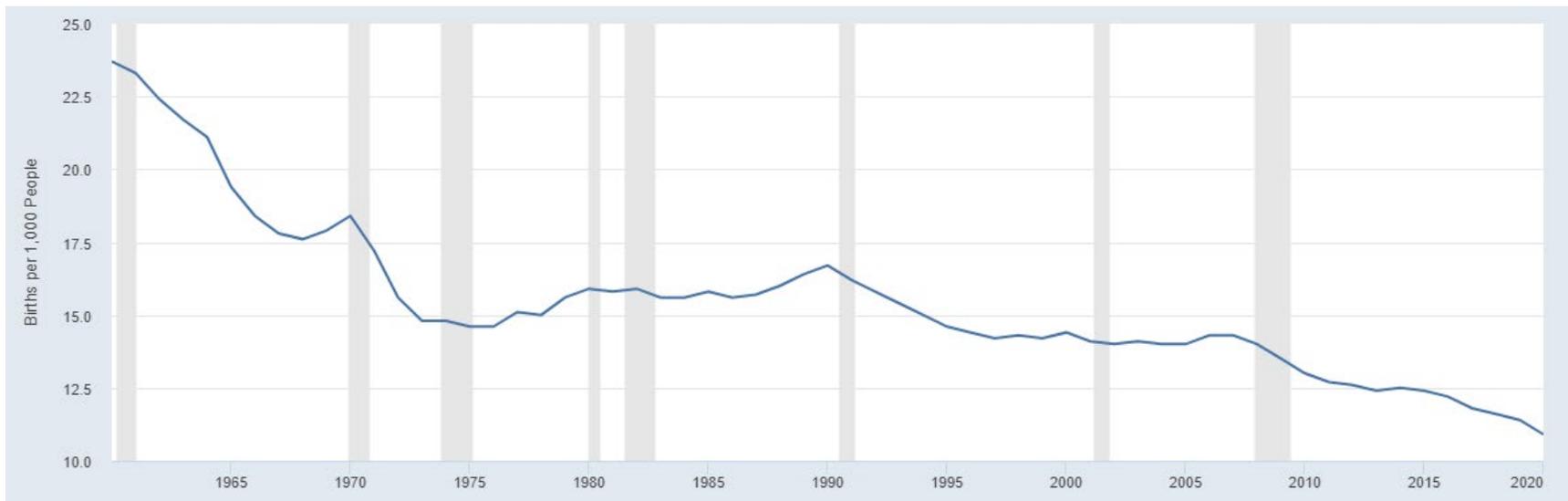


Figure 6. US Birth Rate Trends (FRED, Federal Reserve Bank of St. Louis)



The key takeaway from Figures 5, 6, and 7 is that trends indicate that declining birth rates and an aging population will have some downward impact on future growth rates for the nation and Bismarck-Mandan.

Woods & Poole Demographic Projections and Trends

Woods & Poole Economics, Inc. (Woods & Poole) is an economics firm specializing in national and regional models for long-term county economic and demographic data projections. The Woods & Poole data calibrates the BMMPO's growth forecasts to national trends because Woods & Poole forecasts socio-economic data for every county in the nation simultaneously. The national simultaneous forecasting done by Woods & Poole provides a reasonable forecast based on the flow of socio-economic activity at the national level. The data provided critical insight into employment trends within industry sectors and population changes within age cohorts.

- Household sizes are projected to stabilize in the future, after declining over the last several decades. As shown in Figure 8, those trends recently stabilized between 2015-2017 however, Woods and Poole project minor decreases in household size between 2021 and 2050.
- Woods & Poole projects employment growth at 1.45% per year for the two-county area between 2021 and 2050. Employment by industry sector for both counties is shown in Figure 9¹. The three fastest growing sectors are projected to be:
 - Real Estate (+2.8% / year)
 - Education (+2.7% / year)
 - Mining (+2.6% / year)

¹ Note that the Woods and Poole data were used as a basis for forecasting relative growth rates by job sector, not for developing an absolute number of forecasted jobs.

Figure 7. MSA Median Age Trend 1970-2060

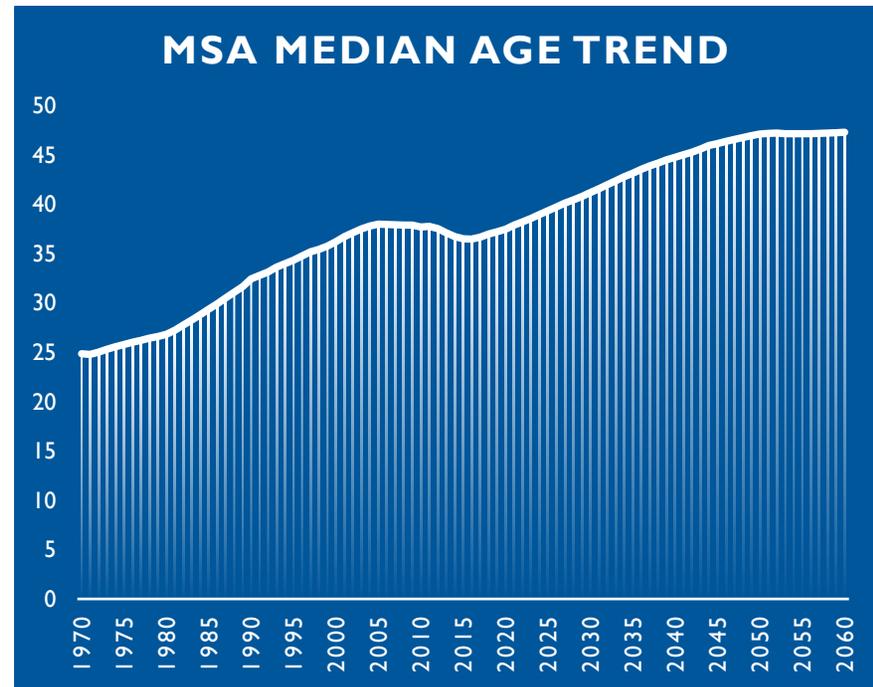


Figure 8. Woods & Poole Population Projections 2021-2060

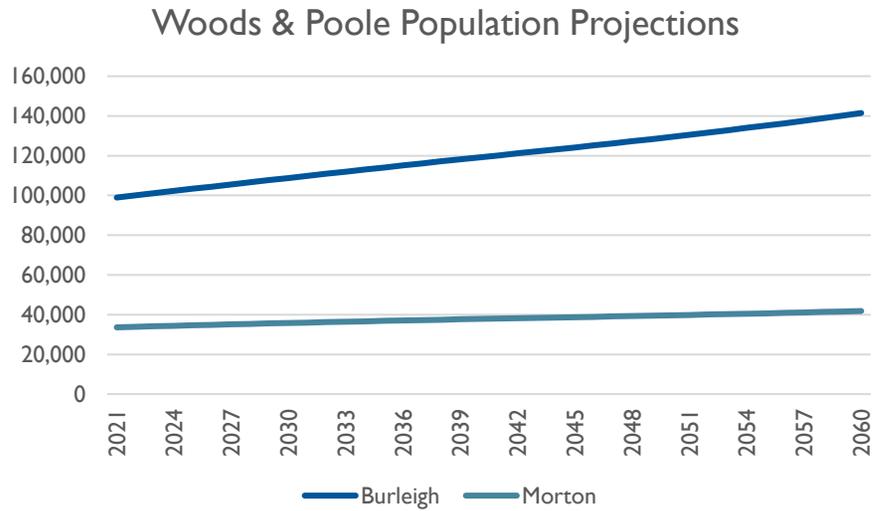
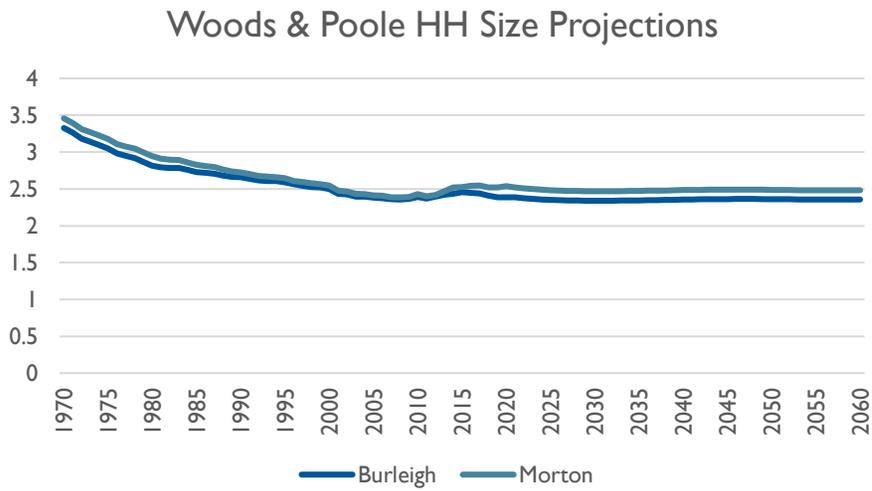


Figure 9. Woods & Poole Household Size Projections 1970-2060



- The ratio of regional employment to population is projected to increase in the future. This ratio increased rapidly over the last several decades however, in 2021 during the pandemic, jobs per 100 people actually decreased. The ratio is projected to increase moving forward however, the rate of increase is projected to decline in the future. By year, the employment-to-population ratios are:
 - 1970 – 46 jobs / 100 people
 - 1980 – 55 jobs / 100 people
 - 1990 – 62 jobs / 100 people
 - 2000 – 70 jobs / 100 people
 - 2010 – 74 jobs / 100 people
 - 2021 – 67 jobs / 100 people (estimated)
 - 2035 – 75 jobs / 100 people (projected)
 - 2050 – 78 jobs / 100 people (projected)

One item to note when considering employment trends shown in the bullet points above is that Woods and Poole includes secondary jobs other data sources do not. These include part time, private household employees, miscellaneous workers, and proprietors. Thus, absolute levels of base year employment were taken from the Infogroup data used by the Bismarck-Mandan MPO to estimate current year employment levels in the TDM. The critical insights offered by the Woods and Poole data are the growth trends by industry sector that can be applied to the current year data.

² Based upon City of Bismarck staff's monitoring of employment projections and accuracy as compared to local conditions, QCEW was referenced in Steering Committee Meeting #2 as being the most accurate.

Quarterly Census of Employment Wages (QCEW) Data

Employment trends are one of the stickiest data points in the TDMSE Update meaning, the data and subsequent forecasts can vary wildly depending upon the data sources used. In previous TDMSE updates, Woods and Poole data were relied upon to estimate jobs. However, Woods and Poole include secondary jobs which other data sources do not. These include part time, private household employees, miscellaneous workers, and proprietors.

Table 3. Comparison of Employment Estimates

Data Source	BEA	Woods & Poole	QCEW	Data Axle
2021 Burleigh County Employment Estimate	75,145	75,098	56,290	56,493

Given the significant changes seen in the workforce and labor market during and after the COVID-19 pandemic, the BMMPO pursued a simpler, more realistic² data-source to base employment projections from QCEW data.

Base year employment data was taken from the Data Axle data used by the BMMPO to estimate current year, or 2021 employment levels

in the TDM. The Data Axle data matched closely to the QCEW data, as shown in Table 3 using Burleigh County as an example. The critical insights gleaned from the Woods and Poole data are the growth trends by industry sector and GDP which were then applied to the current year data.

Comparing QCEW based data with that of previous TDMSE updates, there is a stark difference however, QCEW was used for the baseline of the 2022 TDMSE Update for several reasons:

- Excludes most home-based employment and those receiving unemployment benefits (trips associated with each are factored into how ATAC models household trips).
- Known in the TDM industry as being the top federal resource for estimating at-work employment³.
- Matches Data Axle baseline data purchased by the BMPPO in 2021.
- Incorporates Woods & Poole data to set growth trends and reasonableness of growth.

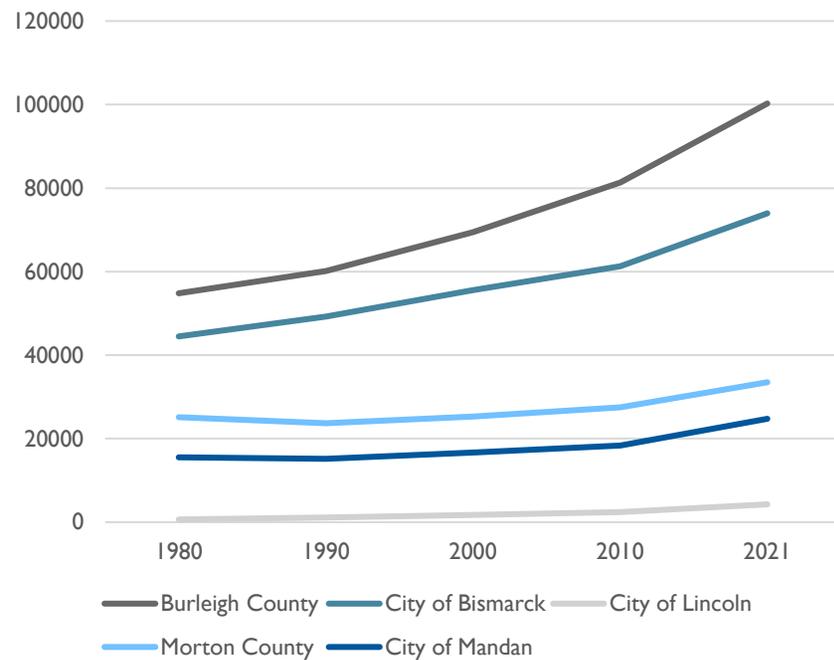
Previous TDMSE updates leaned on BEA and/or Woods and Poole data which is locally known to overestimate jobs for the region.

Regional Growth Trends

The Bismarck-Mandan area has experienced consistent growth over the past several decades, with some periods of rapid growth. In the period 1980-2021, the region has grown approximately 1.6% per year, on average, with the decade between 1980-1990 being the slowest (0.5% per year) and 2010-2021 being the fastest (2.3% per year). Figure 9 shows the population growth in Burleigh and Morton counties since 1980.

³ TRB. National Cooperative Highway Research Program (NCHRP). (2016). Report 716. Chapter 3. Pg. 16. Virginia Department of Transportation, Transportation and Mobility Division. (2020) Travel Demand Modeling and Procedures.

Figure 10. MSA Historic Population Growth Trends



Previous Studies

Development scenarios considered past completed planning efforts with socio-economic forecasts from the region. The following plans were reviewed and are listed below:

- *Together 2045: Bismarck's Comprehensive Plan (2022)*
 - Population growth through 2045: 1.2%
 - Household growth through 2045: 1.1%-1.6%
 - Employment growth through 2045: N/A
- *Arrive 2045 Metropolitan Transportation Plan (2020)*
 - Population growth through 2045: 1.2%
 - Household growth through 2045: 1.2%
 - Employment growth through 2045: 1.7%
- *Envision 2040: 2015-2040 Bismarck-Mandan MPO Long Range Transportation Plan (2015)*
 - Household growth through 2040: 1.9%
 - Employment growth through 2040: 2.2%
- *Bismarck-Mandan MPO 2010-2035 Long Range Transportation Plan*
 - Household growth through 2035: 1.3%
 - Employment growth through 2035: 1.2%

The previous studies averaged the following growth rates:

- Population: 1.2%
- Households: 1.4%
- Employment: 1.7%

Higher rates of growth forecasts were assumed during western North Dakota's oil boom, which peaked in 2014 and is reflected in the BMMPO's 2015 LRTP/MTP. Please see Appendix D for further detail.

Potential Growth Scenarios Considered

Based on the data, trends reviewed, and previous studies, the TDMSE Update steering committee convened and identified three preliminary scenarios for further consideration. These three scenarios were developed from a population growth perspective only, with an understanding that employment and household details would be developed based on the selected population scenario. These three potential scenarios were based upon a stable and steady development pace anticipated by the region moving forward:

High Growth Scenario: "High Growth without an Oil Boom"

Steady pace of growth in between historic averages and previous forecasts. Guided by identified heightened opportunities, challenges, and national trends.

- This scenario yields an average 1.4% annual growth rate.
- Total scenario 2050 MPA Population of 202,780.

Medium Growth: "Realistic Growth"

Steady pace of realistic growth with expectations guided by identified opportunities, challenges, and national trends.

- This scenario yields an average 1.1% annual growth rate.
- Total scenario 2050 MPA Population of 186,610.

Low Scenario: "Conservative Growth"

Steady pace of conservative growth with expectations guided by identified opportunities, heightened challenges, and national trends.

- This scenario yields a 0.9% annual growth rate.
- Total scenario 2050 MPA Population of 173,180.

The three scenarios were presented to the MPO's TAC and Policy Board in March 2023. Based on the recommendation of the Steering Committee, the TAC and Policy Board decided to advance these three development scenarios for further consideration, and inclusion of all three in the scenario planning efforts of the Metropolitan Transportation Plan (MTP) update:

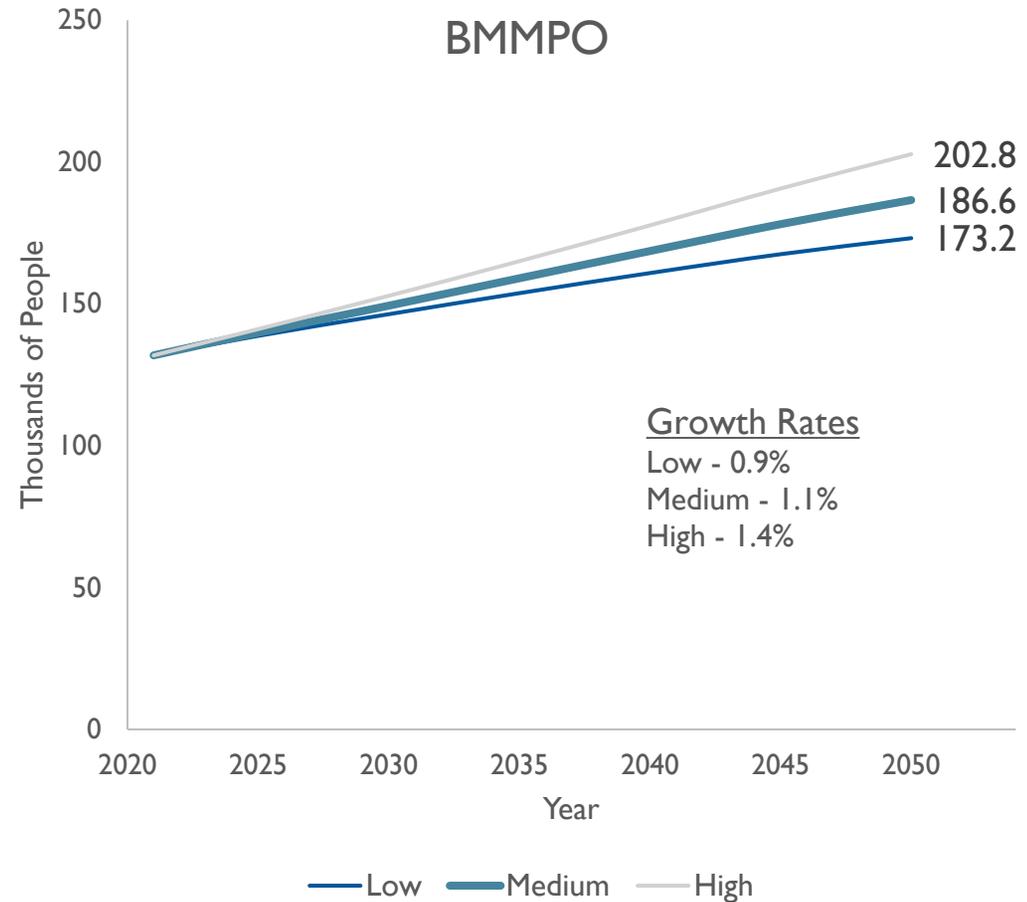
- High: "High Growth without an Oil Boom"
- Medium: "Realistic Growth"
- Low: "Conservative Growth"

The MPA population growth associated with these three scenarios is illustrated in Figure 10. The TAC and Policy board also identified a preferred growth scenario, as highlighted below.

Future levels of households and employment totals were projected based on the trends from Woods and Poole for the three development scenarios established by the TAC and Policy Board. Household growth forecasts were derived by applying the household size factors derived from Census and Woods and Poole data, and are identified in Table 4. The resulting MPA household totals for the preferred growth scenario are also shown in Table 4.

Employment growth forecasts were developed by industry sectors, based on projected trends from QCEW, GDP, and Woods and Poole data as described in the sections above. The resulting MPA employment totals for the preferred scenario are illustrated in Table 5.

Figure 11. MPA Population Forecasts



A summary of the growth scenarios is provided in Appendix E.

Table 4. Preferred (Medium) Growth Household Projections

Households Characteristics							
Year	2021	2025	2030	2035	2040	2045	2050
Households	56,130	63,100	68,830	72,870	76,490	78,560	82,720
PPHH	2.3	2.2	2.1	2.2	2.2	2.2	2.2
HH with Children	17,644	18,325	19,581	20,006	20,818	21,952	22,793
3+ Veh	21,072	22,625	23,682	24,433	25,008	25,368	26,076
2 Veh	24,019	27,619	30,706	32,879	34,883	36,011	38,286
1 Veh	10,209	11,916	13,410	14,462	15,444	15,992	17,102
0 Veh	830	940	1,032	1,097	1,156	1,189	1,256
Renter Households	17,955	20,590	22,796	24,343	25,746	26,540	28,137

Household Structure Type							
Year	2021	2025	2030	2035	2040	2045	2050
HH in 1-unit structure	33,990	36,268	37,740	38,787	39,548	40,039	40,999
HH in 2 or more unit structure	16,896	20,925	24,634	27,240	29,751	31,131	33,933
HH in Mobile or Other	5,243	5,907	6,456	6,843	7,191	7,389	7,788

Household Income Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
Less than \$10,000	5.7%	6.1%	6.5%	6.7%	6.9%	7.0%	7.2%
\$10,000 to \$14,999	4.3%	4.4%	4.5%	4.6%	4.6%	4.6%	4.7%
\$15,000 to \$24,999	9.2%	9.5%	9.8%	9.9%	10.1%	10.2%	10.3%
\$25,000 to \$34,999	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%
\$35,000 to \$49,999	12.6%	12.2%	11.9%	11.7%	11.6%	11.5%	11.3%
\$50,000 to \$74,999	18.0%	17.0%	16.2%	15.7%	15.2%	14.9%	14.5%
\$75,000 to \$99,999	14.4%	14.1%	13.9%	13.8%	13.6%	13.6%	13.4%
\$100,000 to \$149,999	16.6%	17.0%	17.3%	17.5%	17.7%	17.8%	18.0%
\$150,000 to \$199,999	5.2%	5.2%	5.1%	5.1%	5.1%	5.1%	5.1%
\$200,000 or more	4.9%	5.3%	5.7%	5.9%	6.1%	6.2%	6.4%

Household Size Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
1 Person	32.4%	34.1%	35.7%	36.6%	37.5%	38.0%	38.8%
2 Person	37.8%	38.4%	39.0%	39.4%	39.7%	39.9%	40.2%
3 Person	13.8%	13.2%	12.6%	12.3%	12.0%	11.8%	11.5%
4 Person	10.1%	9.1%	8.2%	7.6%	7.1%	6.8%	6.3%
5 Person	4.5%	3.9%	3.4%	3.1%	2.8%	2.6%	2.3%
6 Person	1.1%	0.9%	0.8%	0.7%	0.7%	0.6%	0.6%
7+ person	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%

Table 5. Preferred (Medium) Growth Employment Projections

BMMPO Medium Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	1.4%	250	250	250	350	250	400	350
21	Mining, quarrying, and oil and gas extraction	0.7%	250	250	300	250	300	300	300
22	Utilities	1.5%	350	350	350	400	400	450	500
23	Construction	1.2%	3,750	4,800	3,850	4,800	4,450	4,700	5,050
31-33	Manufacturing	0.7%	2,700	3,050	3,050	3,050	3,150	3,200	3,250
42	Wholesale Trade	1.5%	3,400	3,900	3,700	3,900	4,200	4,500	4,900
44-45	Retail Trade	1.0%	7,350	7,450	7,500	8,000	8,650	8,750	9,550
48-49	Transportation and Warehousing	1.7%	2,350	2,450	2,650	2,850	3,100	3,200	3,500
51	Information	-1.1%	750	700	600	600	600	500	500
52	Finance and Insurance	0.3%	2,550	2,900	2,550	2,850	2,750	2,900	2,800
53	Real estate and rental and leasing	4.0%	600	800	800	950	1,000	1,200	1,300
54	Professional, scientific, and technical services	2.8%	3,450	3,800	3,950	4,550	5,150	5,600	6,250
55	Management of companies and enterprises	2.8%	1,400	1,550	1,600	1,900	2,100	2,300	2,550
56	Administrative and support and waste management and remediation services	1.1%	2,550	2,700	2,600	2,900	3,100	3,200	3,400
61	Education services	2.3%	1,800	1,900	1,950	2,150	2,450	2,650	3,000
62	Health care and social assistance	1.7%	11,150	12,150	12,500	13,350	14,550	15,200	16,500
71	Arts, entertainment, and recreation	3.0%	1,150	1,300	1,550	1,650	1,850	2,000	2,150
72	Accommodation and food service	0.1%	5,850	6,000	6,050	5,950	6,100	6,050	6,050
81	Other services (except government and government enterprises)	0.3%	2,300	2,450	2,300	2,450	2,400	2,550	2,500
92	Government and government enterprises	1.3%	6,050	6,300	6,650	7,050	7,450	7,900	8,300
TOTAL		1.3%	60,000	65,100	64,800	70,000	74,000	77,600	82,700

Preferred Growth Scenario

For the BMMPO's planning purposes, it was necessary to select an official future development scenario. This official development scenario would be the baseline planning scenario for 2035 and 2050 planning horizons, including the basis for developing the "fiscally-constrained" elements of the MPO's MTP.

The process for adopting the official development scenario included discussions and decisions from three different groups.

Steering Committee

A presentation and discussion of the three final development scenarios was held with the steering committee on February 13, 2023. The purpose of this meeting was the selection of a recommended official MPA development scenario for the TDMSE Update and subsequent MTP update. The steering committee discussed the past and future economic and demographic trends, within the MPA, the wider state, and the nation. The steering committee decided that the Medium / "Realistic Growth" scenario was the most reasonable scenario to use. The reasons communicated by steering committee members for this recommendation were:

- The medium or "Realistic Growth" scenario reflects 30 years of booms and busts in Bismarck-Mandan, including the late 1980s (bust), early 2010s (boom), and post COVID-19 era (uncertainty). With oil development stable, less-exaggerated highs and lows the region might experience in the future are reflected by this development scenario.
- Housing and employment trends across the nation, including the Bis-Man market, have created uncertainty in how people will live and work in the future.
- It is understood that the oil extraction industry and technology has matured, and even if a significant prolonged increase in oil prices occurs during the planning horizon it would likely require

less of a worker influx than the recent oil boom, as most of the infrastructure to increase production is in place.

Technical Advisory Committee

The MPO's TAC met on March 20, 2023, with an action item to provide a recommendation for selecting a development scenario. After a brief presentation and some discussion of all scenarios, the TAC forwarded the recommendation for approval of the Medium / "Realistic Growth" scenario as the official BMMPO development scenario.

Policy Board

The MPO's Policy Board met on March 21, 2023, with an action item to approve a final BMMPO development scenario. After a brief presentation and some discussion, the Policy Board voted to adopt the Medium / "Realistic Growth" scenario as the official MPO development scenario.

Growth Allocation

The purpose of development allocation was to identify the location and timing of the new jobs and housing associated with the three future development scenarios. For the purposes of use in the TDM, growth needed to be allocated to the transportation analysis zone (TAZ) geographies of the model for both the 2035 interim planning horizon and the 2050 planning horizon.

The allocation of future land development was guided primarily by:

- An understanding of current development densities (jobs per acre, housing units per acre).
- Local planning and development expertise on the land development market.
- Geographic Information System (GIS) mapping of recent building permits, future land use plans, and land suitability elements such as flood zones, elevations, and wetlands.

The development allocation was structured in sequential development tiers. The development tiers were a combination of year (either 2035 or 2050) and development scenario (low, medium, or high). Six tiers were identified so that each growth area was assigned to a tier according to its assumed sequence of timing:

- Tier 1: Low / Conservative Growth Scenario for 2035
- Tier 2: Medium / Realistic Growth Scenario for 2035
- Tier 3: High / High Growth without an Oil Boom Scenario for 2035
- Tier 4: Low / Conservative Growth Scenario for 2050
- Tier 5: Medium / Realistic Growth Scenario for 2050
- Tier 6: High / High Growth without an Oil Boom Scenario for 2050

The tiers were compounding so that Tier 3 High / High Growth without an Oil Boom level of job and household growth for 2035 included all of the development associated with Tiers 1 and Tier 2.

Current Development Densities

Typical development densities were identified through a review of current development patterns based on a combination of geographic information system (GIS) aerial photos, parcel data, and Data Axle employment data from the BMMPO. The review indicated the following typical development densities:

- **Multi-Family Residential:** 16 units / acre
- **Urban Single-Family Residential:** 2.6 units / acre
- **Rural Single-Family Residential:** 0.6 units / acre
- **Commercial:** 18 jobs / acre
- **Industrial:** 6 jobs / acre

Commercial developments looked at office developments and shopping developments separately, looking at the breakdown of service industry, retail industry, and “other” industry jobs for each. It was noted that more recent suburban commercial developments in Bis-Man had seen higher job densities. For instance, the area northeast of State Street and Century Avenue in Bismarck, which is a mix of retail, service, and office uses, has over 23 jobs per acre. Through discussions with the steering committee and understanding of the tight labor market, 18 jobs per acre for commercial is utilized for future development density assumptions.

Like commercial, industrial developments looked at the breakdown of industrial industry, manufacturing industry, and “other” industry jobs for each. Many industrial developments in the region are relatively low-density. The city staff on the steering committee suggested more typical developments would trend towards a density of 6 jobs per acre for future developments.

Development Allocation Workshop and Revisions

Once the expected future development densities were established, the allocation effort transitioned into working with the steering committee, particularly members involved in planning and development within their jurisdiction, to identify the likely location and sequential timing of developments. This process involved first holding a workshop on April 14, 2023, which established the major growth areas and projected development timing by tier for the study area. The workshop was an opportunity to identify the locations of future growth by type and timing. The major elements of the workshop involved:

- **Verifying 2022-2023 Development Areas:** The model is a 2021 baseline, so the future year data needed to incorporate any development that had occurred since January 2022. Much of this work was completed prior to the workshop, including reviewing updated building permit data in GIS, reviewing recent aerial photography to verify, and discussing reasonable jobs and housing assumptions for each recent development.
- **Reviewing On-going and Near-Term Developments:** The workshop participants identified ongoing and recently-platted commercial and residential developments. These developments were associated with Tier 1 and Tier 2, as they were the most likely to occur next.
- **Reviewing GIS data and recently completed future land use plans to identify Mid-Term and Long-Term Developments:** The workshop participants discussed next parcels and groups of parcels for development, with an understanding of the likely development environment and constraints. These locations were primarily associated with Tiers 3 through 4.

- **Discussing Infill Opportunities:** Planning staff identified opportunities for infill development in the downtown areas and fringe areas located in proximity or with accessibility to city centers. In Bismarck, staff identified areas for potential commercial and residential development, based on an assessment of underutilized serviceable parcels. In Mandan, staff recommendation guided by the Mandan Downtown Subarea Study was used to identify locations and development assumptions. Infill development was assumed in all growth tiers and across each scenario.
- **Discussing Development Details:** As the workshop went through individual parcels and groups of parcels for developments, comments were recorded on development timing, unique features on development density or type. These discussions informed how many jobs and how many housing units could fit within the identified development areas, and which Tier each area should fall into.

Following the allocation workshop a first draft of the resulting development types and development timing was developed in GIS, with additional time spent refining development areas and jobs and housing calculations by area. This first draft was distributed to the steering committee for review and comment in May 2023.

Several iterations of follow-up small-group and individual conversations about refinement of the draft development allocations occurred from May 2023 to October 2023. The revised development allocations were incorporated into the TAZ geographies and submitted to the steering committee for final review on October 19, 2023. Based on final comments received, the development allocation was finalized. The final development allocation was presented to the TAC and Policy Boards at the April 2024 meetings. Figure 13 shows the resulting allocation of households by TAZ. Figure 14 shows the allocation of jobs by TAZ.

Figure 12. Preferred (Medium) Employment Growth Scenario

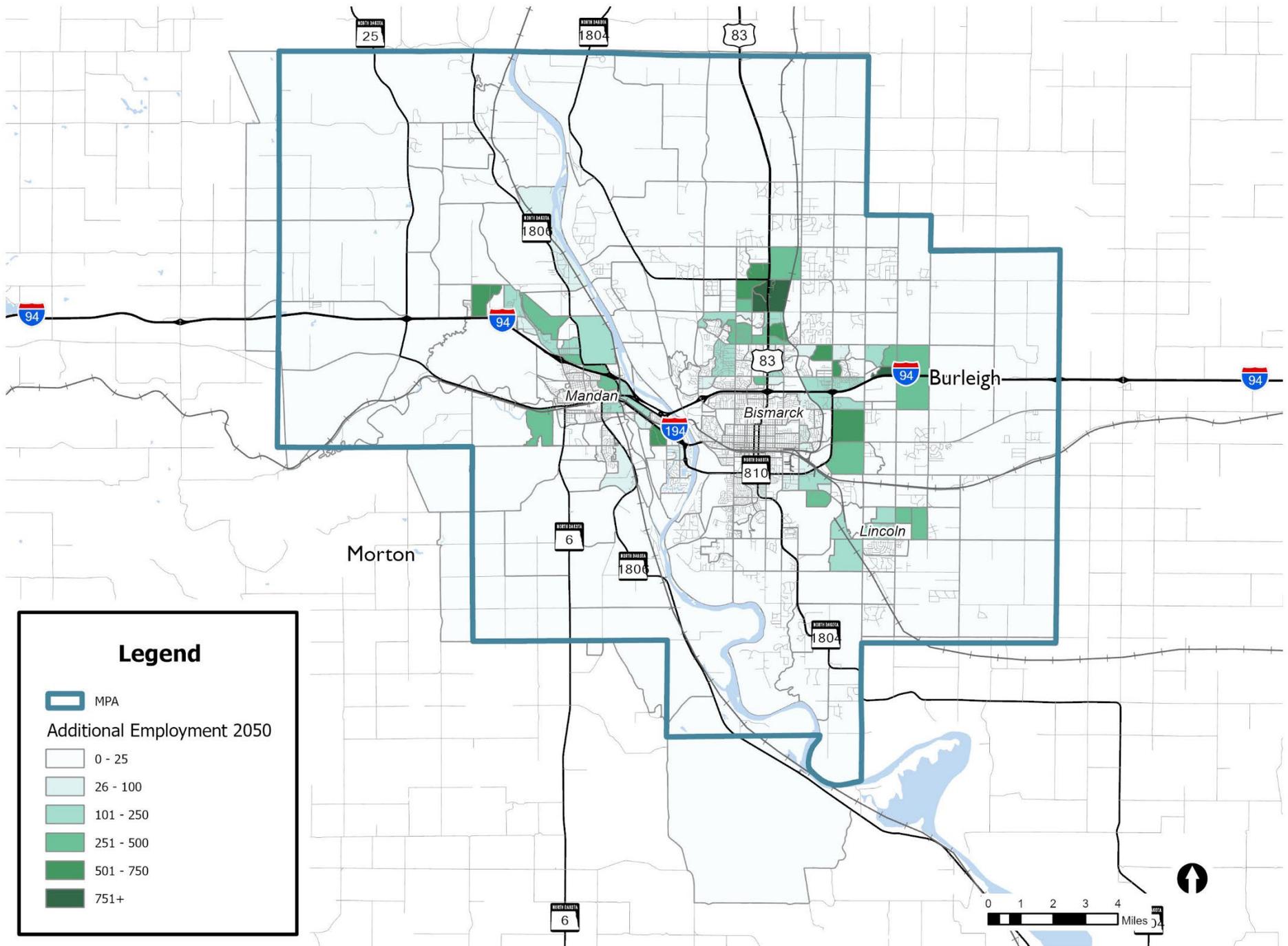
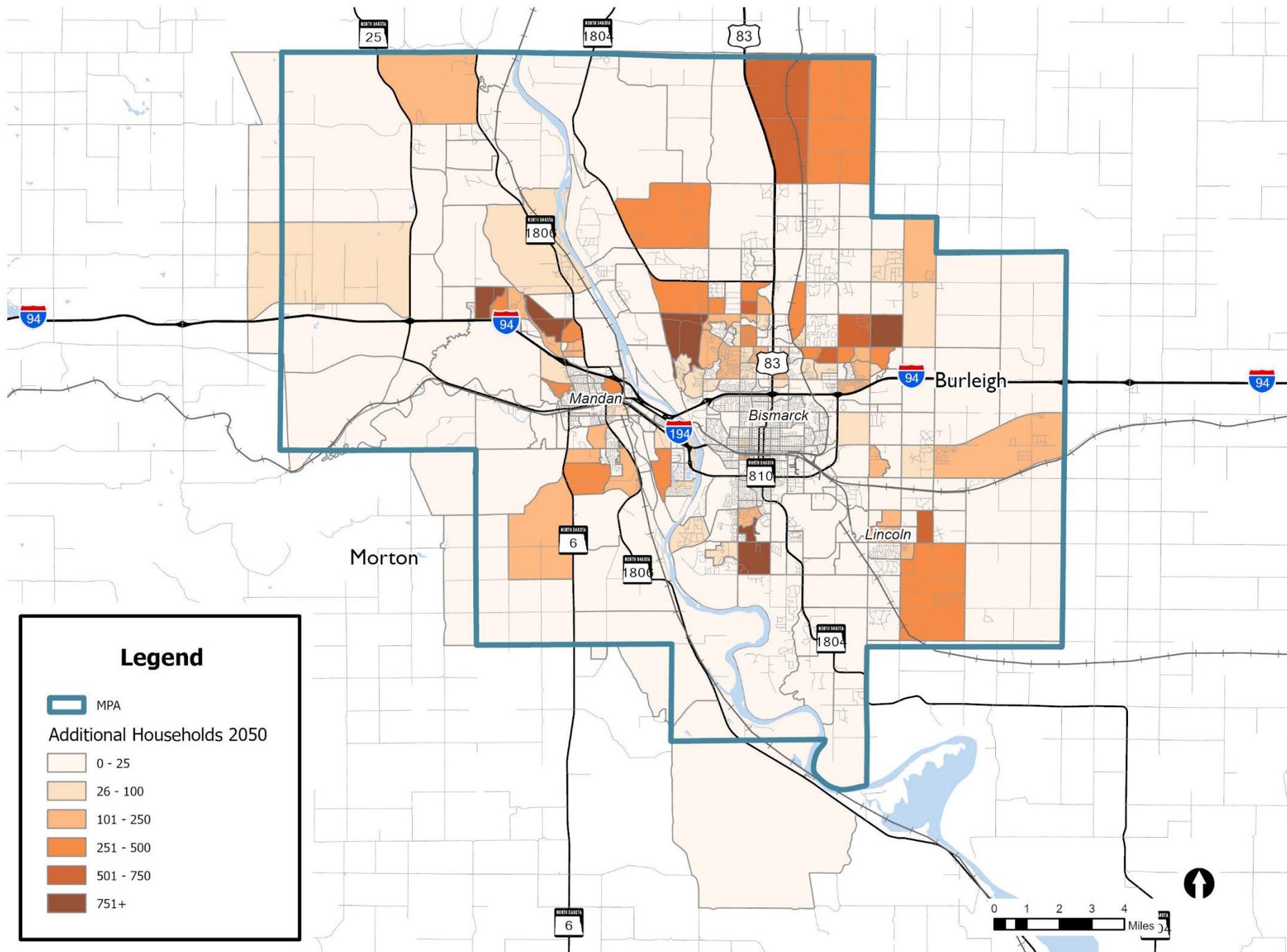


Figure 13. Preferred (Medium) Household Growth Scenario



Travel Model Review

The overall goals of the travel model review were to review the travel model for reasonable assumptions and to get steering committee input on model construction.

Model Technical Review

As with the 2045 version of the TDM, the review of the model focused on developing a useful tool for transportation planning applications. The goals of the model review were to work with ATAC to provide a model that provided:

1. A good representation of existing travel patterns, and
2. Flexibility to respond to transportation network and socio-economic inputs.

This second point is an important consideration because some models have several parameter constraints that provide a model that accurately replicates observed travel patterns but can constrain the model too much so that it cannot be a useful scenario tool that responds to desired tests of network and socioeconomic changes.

The model review team structured the model technical review to focus on the elements summarized in this section.

Model Network Review

The model team and the TDMSE steering committee reviewed several elements of the model network, including:

- **Transportation Analysis Zone (TAZ) construction:** the original TAZ structure was developed by MPO staff based on Census geography. During review of the TAZs, it was determined that one TAZ should be subdivided. The area east of State Street, north of 43rd Avenue, south of 57th Avenue, and west of Hay Creek contains several significant

large retail, service, and residential trip generating uses and was originally all a single TAZ. It was decided that this TAZ should be split into three (3) TAZs with Skyline Boulevard and La Salle Drive acting as the dividing line for this subdivision.

- **Centroid Connectors:** In several locations, centroid connector locations were adjusted to best reflect how development in the TAZs could actually access the arterial and collector network. There were extensive edits made to the original version of the network based on this centroid connector review.
- **Local Street Network:** In several locations, it was recommended that that local streets get added to the network to do a better job of reflecting how TAZ traffic would actually load onto the network. These local streets were added into the network.
- **TAZ data miscoding:** During the model review, it was noted that some TAZs had data but did not assign any trips to the network. This was due to a difference in TAZ name and centroid identification numbers, and this was fixed during review.

Base Year 2021 Model Socio-Economic Data

The model review team noted some TAZs that had significant development in reality had unreasonably low socio-economic data. These discrepancies were addressed by the model development team at ATAC.

Script Review

During review of the model script, several items were identified which were addressed.

Distributed Trips

Initially, trips were lost during the model trip distribution procedure. Table 6 shows the old (before trip distribution) and distributed trips (after trip distribution). Initially, 6.4% of trips were lost during the processing steps. ATAC updated the script which resulted in about the same number of distributed trips as balanced trips (with some rounding error). Table 7 shows the new balanced trips.

Table 6. Original (Pre-Review) Model Trip Distribution Loss

	Original Balanced Trips (From Trip Generation)	Original Distributed Trips (Into Trip Distribution)	Percent Difference
Total	541,207.9	506,406.97	-6.4%

Table 7. Revised (Post-Review) Model Trip Distribution Loss

	Updated Balanced Trips (From Trip Generation)	Updated Distributed Trips (Into Trip Distribution)	Percent Difference
Total	540,941.3	541,525.10	0.1%

IE & EI Freight Trip Program Input File Location

One program in the script initially searched for a file location that differed from the other programs for the same file. As a result, anyone running a scenario would receive an error message unless the user copied an additional file into a new scenario file location. Instead, it was recommended to have the IE & EI Freight Trip Program file use the same input file location for the *Socioeconomic_2020.dbf* file as the

other programs in the script so that running scenarios does not require additional file management outside of the script.

Speed Adjustments

ATAC used travel probe data to make adjustments to posted speeds by facility type for multiple subareas across the model area. Several of the adjustments were rather severe adjustments to posted speeds, with adjustments 10 to 15 miles per hour lower or higher to posted speeds. The concern was that these adjustments to base year speeds would carry unreasonably restrictive link coding into the future year. The model review team pointed out these speed adjustments to the ATAC staff and suggested these speed adjustments be within five (5) miles per hour of the posted speeds. These reduced speed adjustments were made to the final version of the model.

Post-processing

Post-processing is a forecasting refinement that adjusts the traffic volume output of a scenario model run according to the level of deviation seen for that link in the base year model. The future year model outputs originally did not include the correct base year absolute and relative difference values that were calculated in the base year, leading to missing calculations. The model review team moved those values to the E+C road network, so that adjusted volumes could be calculated.

Trip Generation

Separate production and attraction modules are used for trip generation. The model includes some standard trip purposes that the model review team reviewed against other sources to look at consistency. Those standard trip purposes were:

- Home-Based Work (HBW)
- Home-Based Shopping (HBSH)
- Home-Based Other (HBO)
- Non-Home Based (NHB)

The trip attraction rates used by the travel demand model for these standard purposes are shown in Table 8 below. The trip attraction rates are relatively consistent with the national trip rates documented in National Cooperative Highway Research Program (NCHRP) Report 716.

Table 8. Trip Attraction Rates

Purpose	Household	Other Jobs	Retail Jobs	Service Jobs
HBW	0	1.284	1.284	1.284f
HBSH	0	1.08	5	0.91
HBO	1.2	0.2	1.1	1.5
NHB	0.6	0.5	2.1	1.4

The trip production rates approach uses household size for trip rates for each trip purpose and shown in Table 9 below.

Table 9. Trip Production Rates

Trip Purpose	1-Person Households (HH)	2-Person HHs	3-Person HHs	4-Person HHs
HBW	1.049	1.665	2.624	2.457
HBSH	1.127	2.092	3.424	3.242
HBO	1.322	2.465	2.390	4.665
NHB	2.006	2.421	2.961	3.329

The other trip purposes in the model include:

- Grade School
- Middle School
- High School
- Freight

University trips are generated in terms of HBW, HBO, NHB, and HBSH for Bismarck State College, University of Mary, and United Tribes Technical College.

Additionally, special generators are used for hospitals, shopping malls and supercenters, and the Airport. The special generator number of productions and attractions are determined using the initially calculated productions and attractions based on employment data and trip rates, and then scaled up or down.

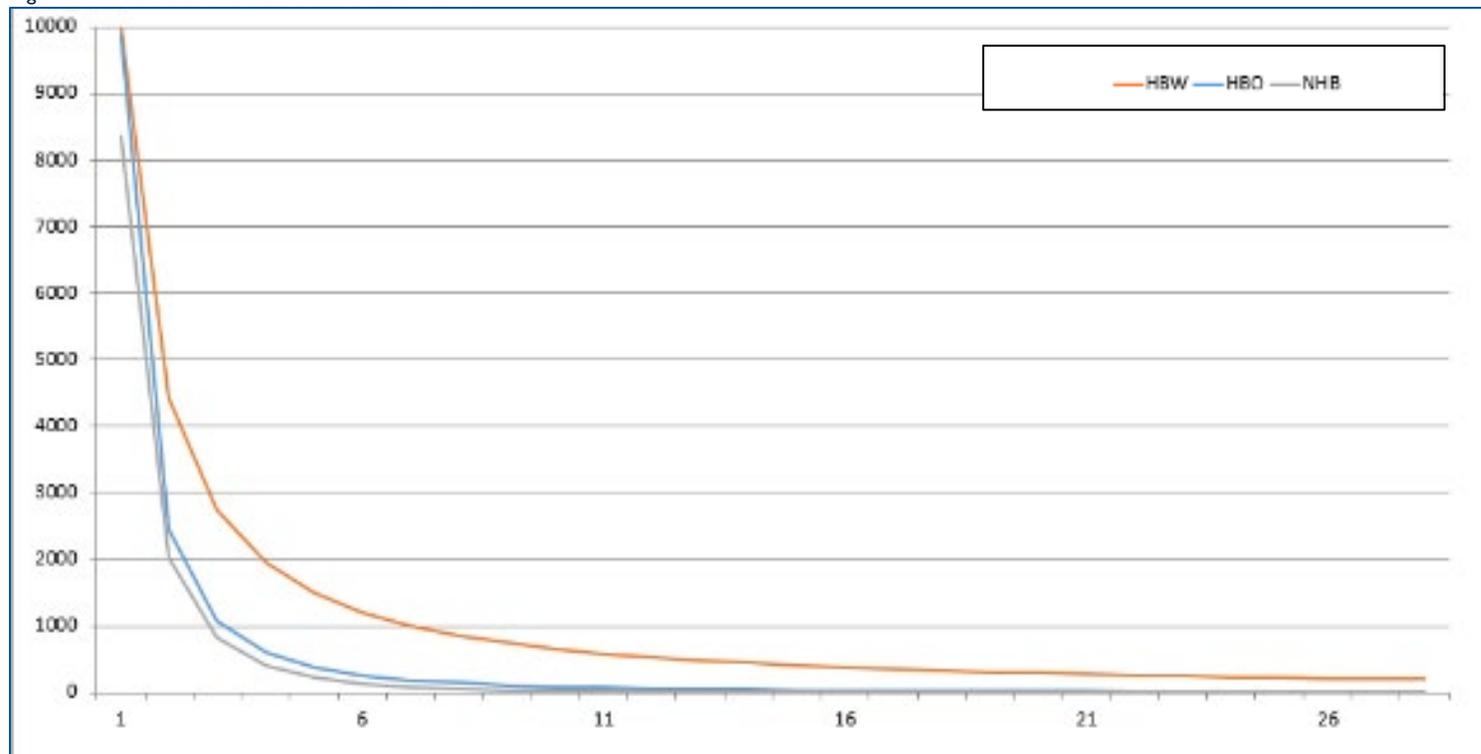
Trip productions and productions do not go through a balancing step, instead the input trip rates result in balanced trips.

Trip Distribution

Trip distribution is completed through use of a gravity model, a standard approach to trip distribution that predicts the trip interaction between two TAZs based on two factors: the amount of activity in a zone (measured in jobs and households) and the cost of traveling between the zones (measured in time). Additional factors are used to specify the gravity model to fit observed conditions in the Bismarck-Mandan area.

Friction Factors specify how much time is a disincentive to travel in the gravity model. The friction factor curves are shown in Figure 16. These curves are relatively standard applications and deemed appropriate by the model review team.

Figure 146. Bismarck-Mandan Friction Factor Curves



K-Factors are special “socio-economic” factors that adjust trip-making behavior to account for forces not explained by other elements of the gravity model. They are recommended to be used sparingly and only for special circumstances. Two different k-factors are used in the Bismarck-Mandan model:

- Trips crossing the river have a 0.8 k-factor placed on them. All else being equal, this factor places a slight penalty on a trip crossing the Missouri River from the east side to the west side.
- Trips with both trip ends east of the river have a k-factor of 1.2 placed on them. All else being equal, this factor slightly increases the propensity of trips to stay east of the river.

In both cases, there is likely a case that residents on each of the river are slightly more likely to choose a trip destination on their own side of the river. Thus, these k-factors are somewhat minor and for the most part are considered reasonable.

Time of Day Element

The Bismarck-Mandan model includes three time periods for the AM peak, the PM peak period, and all other periods (off-peak). This approach provides some enhanced benefits to the model for period-only capacity assessments, and no exceptional items were noted during review of this element.

External Traffic

While traffic with internal trip ends are generated and distributed according to socio-economic data, external traffic is estimated through asserting trip levels and patterns, rather than model generated elements. The original version of the model had major discrepancies ADTs at external stations (shown in Table 10). Given the complexity of modeling external process, this was pointed out to ATAC staff and some revisions were made to get this deviation lower particularly for the higher volume stations. The revised external station deviations are shown in Table 11.

Table 10. Original Model External Station Volume Deviation

Zone	Name	Counted ADT	Modeled ADT	Deviation
447	Highway 25 N	1,400	1,478	5.6%
448	I-94 W	10,880	9,982	-8.3%
449	Hwy 139	1,345	1,245	-7.4%
450	Hwy 6 S	2,385	2,224	-6.8%
451	US 83 N	7,245	6,838	-5.6%
452	Hwy 1806 S	1,440	1,769	22.8%
453	Hwy 1804 S	595	481	-19.2%
454	Apple Creek	835	781	-6.5%
455	Co Rd 10	4,895	4,591	-6.2%
456	Hwy 1806 N	485	495	2.1%
457	I-94E	9,520	8,692	-8.7%
458	71 st Ave	5,620	5,518	-1.8%
459	Hwy 1804 N	480	472	-1.7%

Table 11. Revised Model External Station Volume Deviation

Zone	Name	Counted ADT	Modeled ADT	Deviation
447	Highway 25 N	1,400	1,567	11.9%
448	I-94 W	10,880	10,682	-1.8%
449	Hwy 139	1,345	1,332	-1.0%
450	Hwy 6 S	2,385	2,380	-0.2%
451	US 83 N	7,245	7,315	1.0%
452	Hwy 1806 S	1,440	1,893	31.5%
453	Hwy 1804 S	595	622	4.5%
454	Apple Creek	835	835	0%
455	Co Rd 10	4,895	4,912	0.3%
456	Hwy 1806 N	485	532	9.7%
457	I-94E	9,520	9,303	-2.3%
458	71 st Ave	5,620	5,903	5.0%
459	Hwy 1804 N	480	504	5.0%

Traffic Assignment

The traffic assignment step occurs after all trip origins and destinations have been identified and the travel route is selected. The Bismarck-Mandan travel model uses a rather standard approach to traffic assignment with a User Equilibrium methodology supported by a Bureau of Public Roads (BPR) formulation look up. The model uses daily capacities that are a factor of 10 times higher than hourly capacity (a standard assumption for the industry, reflecting a typical peak hour percentage of daily traffic.)

Traffic Assignment Validation Results

Model validation is a process by which the base year model is compared to existing travel data to determine model performance. The validation statistics from the model indicate that the model does a relatively good job of reflecting observed conditions in the MPO area.

A standard measure of model validation is root mean square error (RMSE). RMSE is a measure that summarizes the standard deviation of the residuals, in this case the amount of error between predicted values and observed values in locations where there was a traffic count. Percentage RMSE (%RMSE) is the standardized way we have evaluated the goodness of fit for the traffic assignment. Table 12 shows the draft validation results by facility type. Table 13 shows the draft validation results by volume range. Generally, this level of %RMSE indicates a good fit between modeled and observed conditions.

Table 12. Validation Results by Facility Type

Facility Type	Number of Counts	% RMSE	Validation Target
Freeways	13	25.65%	30%
Principal Arterials / Expressways	208	26.03%	30%
Minor Arterials	242	43.00%	40%
Collectors	160	59.15%	50%
Total	623	35.40%	N/A

Table 13. Validation Results by Volume Range

ADT Range	Volume	Number of Observations	% RMSE
1 -5,000		272	80.48%
5,001 -10,000		179	31.88%
10,001 - 15,000		111	30.11%
15,001 - 20,000		37	20.12%
20,001 - 30,000		18	14.39%
30,001 or higher		5	8.02%

A summary of the model construction and performance from ATAC is provided in Appendix A.

Appendix A



Bismarck Mandan 2021 TRAVEL DEMAND MODEL
UPDATE
REPORT

To the Bismarck Mandan MPO

APRIL 2024

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1. INTRODUCTION

The Bismarck Mandan Metropolitan Planning Organization (B-M MPO) Travel Demand Model (TDM) undergoes a comprehensive update every five years to incorporate the latest ground truths/data and advancements in transportation modeling techniques. The latest update incorporates data from the base year 2021 and partially from 2022, necessitated by the unique traffic patterns resulting from the COVID-19 pandemic, which rendered the 2020 data unreliable for traffic forecasting. The model adheres to a four-step TDM framework, comprising trip generation, trip distribution, modal split, and trip assignment. The update procedure includes meticulous calibration of the model's input parameters and validation against actual data. This calibration is iterative, as depicted in Figure 1.

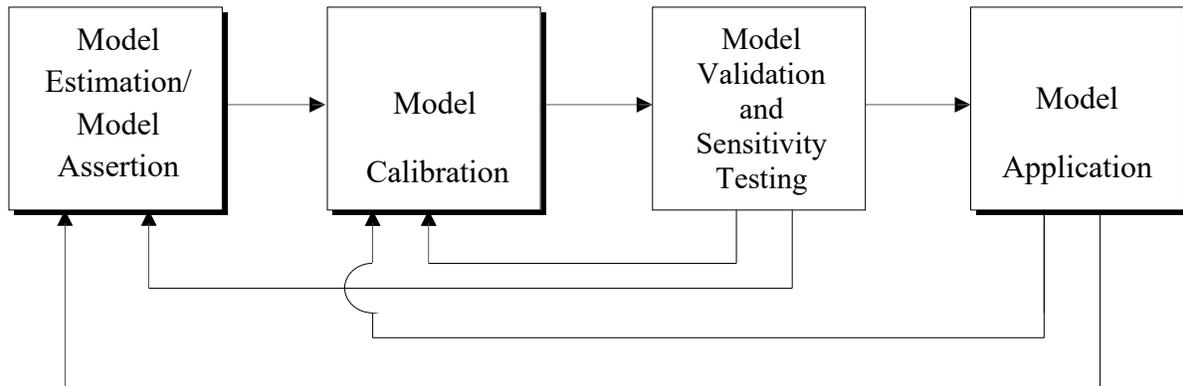


Figure 1 B-M TDM Calibration Flow Chart

The rest of this document describes the model update process including the data, methods, and models that were used to update the model. Chapter 2 discusses the improvements made to the 2021 TDM; Chapter 3 discusses the capacity calculation methodology; Chapter 4 discusses the input data used in the model; Chapter 5 summarizes the trip generation models and methods; Chapter 6 discusses the trip distribution step; Chapter 7 discusses the trip assignment step; Chapter 8 discusses the model calibration, validation, and output.

2. IMPROVEMENTS TO THE 2021 TDM

The 2021 base year model received numerous updates to incorporate the latest data and methodologies, along with enhancements in modeling software and the integration of long-haul freight movements. The updates for the 2021 model leveraged several new data sources:

1. Origin Destination Data obtained from Streetlight, which offers detailed insights into travel patterns.
2. Traffic analysis tool data, providing comprehensive traffic flow and usage statistics.
3. Traffic Analysis Zone (TAZ) and socioeconomic data supplied by the MPO, are crucial for understanding demographic and geographic influences on travel demand.
4. Traffic count data is sourced from the NDDOT website's interactive map, offering real-time and historical traffic volume information.

These updates ensure that the model remains cutting-edge, reflecting the latest trends and data in transportation modeling.

2.1. Origin Destination Data Obtained from Streetlight

Origin-destination (OD) data, is a critical component for TDMs, and this data was obtained from Streetlight Data. Streetlight uses anonymized cellular data from millions of individuals nationwide to craft comprehensive mobility patterns for road users. Their online platform offers a suite of analytical tools, enabling users to generate estimates on Annual Average Daily Traffic (AADT), Vehicle Miles Traveled (VMT), turning movement counts, OD data, trip speed, demographic insights, travel modes, trip attributes (such as travel time and length), and the proportion of trip purposes (Home-Based Work [HBW], Non-Home-Based [NHB], and Home-Based Other [HBO]) for varying time frames from 15 minutes up to a year. Several Datasets were obtained from Streetlight's platform and used to calibrate the model including:

1. Three matrices each for weekdays, weekends, and all days were estimated showing OD trips separately for HBW, HBO, and NHB purposes.
2. Hourly OD trips were estimated for each of the HBW, HBO, and NHB purposes, which were further divided into 15-minute time spans to identify the peak hour.
3. Daily trips were divided into four time periods to differentiate between peak-hour trips and off-peak-hours trips. 7 AM to 8 AM was selected as AM peak hours, 3 PM to 6 PM was selected as PM peak hours, a time span between 9 AM and 3 PM was selected as AM off-peak hours and the time between 6 PM and 7 AM is selected as PM off-peak hours.
4. Trips were estimated for the months of March 2022 and April 2022, this is because all the traffic data used for calibration and comparison of TDM was also from 2022.
5. The data was estimated separately for private vehicles and trucks. Further, long-distance OD trips were also estimated to reflect internal-external, external-internal, and external-external trips. These trips were processed separately for HBW, HBO, and NHB in the case of private vehicles, and in case of freight traffic, trips were analyzed as NHB trips.

2.1.1. Internal-Internal OD Trip Summary

Table 1 shows the distribution of trip purposes by time of day within the Bismarck Mandan Metropolitan Planning Organization (B-M MPO) Traffic Analysis Zones (TAZs) as obtained from Streetlight. It details Home-Based Work (HBW), Home-Based Other (HBO), and Non-Home-Based (NHB) trips during different time segments: AM Peak, AM Off-Peak, PM Peak, and Night.

For HBW trips, the distribution is as follows: 19.57% in the AM Peak, 27.15% during the AM Off-Peak, 29.39% in the PM Peak, and 23.88% during Night. HBO trips show a significant skew towards Night trips (38.35%), with descending proportions in PM Peak (28.76%), AM Off-Peak (28.39%), and AM Peak (4.49%). This pattern aligns with typical non-work-related travel behaviors, where fewer trips originate in the morning peak. NHB trips are predominantly during the AM Off-Peak (45.75%), with subsequent frequencies in the PM Peak (30.36%), Night (20.52%), and AM Peak (3.36%). The "% of Overall" column indicates the percentage of trips within the B-M MPO area, segmented by purpose: 25% for HBW, 38% for HBO, and 37% for NHB, reflecting their share of total internal-internal trips.

Table 1 Summary of Internal-Internal OD Data from Streetlight Analysis

Bismarck-Mandan MPO TAZ OD Trips						
Purpose	7-8 AM	8 AM-3 PM	3-6 PM	Night	Total	% of Overall
HBW	29,631	41,096	44,493	36,166	151,386	24.76%
HBO	10,558	66,617	67,511	89,989	234,675	38.39%
NHB	7,569	103,018	68,371	46,206	225,164	36.83%
Total	47,758	210,731	180,375	172,361	611,225	100%
Proportions by Trip Purpose and Time of Day, B-M MPO TAZ Only						
Purpose	7-8 AM	8 AM-3 PM	3-6 PM	Night	Total	% of Overall
HBW	19.57%	27.15%	29.39%	23.88%	100%	25%
HBO	4.49%	28.39%	28.76%	38.35%	100%	38%
NHB	3.36%	45.75%	30.36%	20.52%	100%	37%
NCHRP 718 Time-of-day Distributions by Purpose						
Purpose	7-8 AM	8 AM-3 PM	3-6 PM	Night	Total	
HBW	14.4%	25%	28%	32.6%	100%	
HBO	5.5%	36.2%	24.5%	28.8%	100%	
NHB	4.9%	53.9%	25.00%	16.2%	100%	

2.1.2. Internal-External/External-Internal Origin-Destination Data

Table 2 shows details of the External-Internal (EI) and Internal-External (IE) trip data for the Bismarck-Mandan MPO area, highlighting the proportions of these trips concerning the total trips for each purpose (HBW, HBO, NHB) and time period. These figures offer insight into the through-trip travel patterns within the study area.

2.1.2.1. Analysis of EI Trips:

- **HBW Trips:** EI trips account for 17.9% of total HBW trips, with the highest proportion (5.5%) during the 7-8 AM time slot, which aligns with typical morning commute hours.
- **HBO Trips:** EI trips represent a significant 35.9% of HBO trips, peaking during the 8 AM to 3 PM period (14.5%), possibly reflecting errands or other non-work-related activities.
- **NHB Trips:** For NHB trips, EI trips are the most prevalent, comprising 46.2% of total NHB trips, with the highest proportion (24.3%) from 8 AM to 3 PM, indicating substantial midday travel.

The overall data show that EI trips are most common in the midday hours (8 AM to 3 PM), suggesting a significant amount of travel into the MPO area during these hours, likely for various purposes including work, errands, and other activities.

2.1.2.2. Analysis of IE Trips:

- **HBW Trips:** IE trips make up 13.2% of HBW trips, with the largest share (4.3%) in the 3-6 PM window, aligning with typical evening commuting times.
- **HBO Trips:** HBO trips see the largest IE proportion at 40.1%, with the highest percentage (15.8%) during nighttime, which might indicate returning home after various personal activities.
- **NHB Trips:** Similar to EI, NHB trips have a high IE trip proportion (46.7%), with a significant amount during the 7 AM to 3 PM period (12.6%), suggesting outward travel from the MPO area for various non-home-based activities.

The data indicates that IE trips are more evenly distributed throughout the day, with a notable number of trips occurring in the morning and early afternoon hours.

2.1.2.3. Conclusions on IE-EI Trips

- The high percentage of NHB trips in both EI and IE categories suggests a dynamic interplay of travel purposes that extend beyond typical work commutes, likely influenced by the area's economic, social, and geographical characteristics.
- The substantial percentage of HBO and NHB trips in EI and IE categories during non-peak hours reflects the diversity of travel reasons, including leisure, errands, and other non-work-related activities.

Analysis of IE Trips:

Table 2 EI and IE Trips from OD Data for the B-M MPO Area

EI Trips Total					
Purpose	7-8 AM	8 AM-3 PM	3-6 PM	Night	Total
HBW	1,254	720	1,030	1,083	4,087
HBO	391	3,322	2,192	2,290	8,195
NHB	367	5,551	2,899	1,751	10,568
Total	2,012	9,593	6,121	5,124	22,850
Percentage of EI Trips to Total Trips for B-M Area					
Purpose	7-8 AM	8 AM-3 PM	3-6 PM	Night	Total
HBW	5.5%	3.2%	4.5%	4.7%	17.9%
HBO	1.7%	14.5%	9.6%	10.1%	35.9%
NHB	1.6%	24.3%	12.7%	7.6%	46.2%
Total	8.8%	42%	26.8%	22.4%	100%

IE Trips Total					
Purpose	6-7 AM	7 AM-3 PM	3-6 PM	Night	Total
HBW	397	668	891	792	2,748
HBO	280	2,628	2,142	3,285	8,335
NHB	381	4,889	2,338	2,093	9,701
Total	1,058	8,185	5,371	6,170	20,784
Percentage of IE Trips to Total Trips for BM Area					
Purpose	6-7 AM	7 AM-3 PM	3-6 PM	Night	Total
HBW	1.9%	3.2%	4.3%	3.8%	13.2%
HBO	1.3%	12.6%	10.3%	15.8%	40.1%
NHB	1.8%	23.6%	11.3%	10.0%	46.7%
Total	5.0%	39.4%	25.9%	29.6%	100%

2.1.3. External-External OD Data

Table 3 shows presents the External-External (EE) Origin-Destination (OD) data derived from Streetlight, highlighting the through trips that traverse the B-M MPO area without any stops. This data was sourced from Streetlight, a robust web platform designed for extensive data analysis in transportation planning. The approach to estimating EE OD pairs traversing the B-M MPO area involved a methodical process, which included:

1. Identifying and selecting all OD pairs that are external to the B-M MPO's internal OD Traffic Analysis Zones (TAZs), focusing on the remaining 13 external OD TAZs.
2. Uploading these external zones into the Streetlight platform for further analysis.

3. Conducting a comprehensive Origin-Destination Analysis, utilizing the external zones as the starting and ending points. The analysis covered all vehicle types and was conducted over a recent time frame from March 1, 2022, to April 30, 2022. The analysis was restricted to weekdays (Monday to Thursday) and segmented into hourly intervals to capture detailed travel patterns. Additional parameters, including Trip and Traveler Attributes, were factored into the analysis, yielding a dataset that includes vehicle trip volumes and the distribution of trips across different purposes (HBW, HBO, and NHB).

The findings from Table 3 reveal that EE trips account for approximately 0.03% of the total combined EE and EI/IE trips within the B-M MPO area, a figure considerably lower than the usual 10-12% typically observed in through-trip analyses. The distribution of EE trips varies by time of day and purpose:

- During the Night period, EE trips peak at 0.03% of the total, likely due to the inclusive early morning and late evening hours, suggesting that travelers passing through the area prefer these less congested times.
- HBW trips predominantly occur at night (0.005%), with minimal activity during the AM Peak and Off-Peak periods, indicating that work-related through trips are more frequent during early and late hours.
- HBO trips follow a similar pattern to HBW, with the highest occurrence at night (0.0039%) and the lowest in the AM Peak and Off-Peak periods.
- NHB trips exhibit the most substantial variation, with the highest night-time activity (0.008%) and significant movement during the PM Peak period (0.007%).

Table 3 EE Trips from Streetlight OD Data

EE Trips Passing through BM MPO					
Purpose	9-11 AM	11 AM-1 PM	1-5 PM	Night	Total
HBW	1	1	14	20	36
HBO	25	16	42	105	188
NHB	151	138	318	364	971
Total	177	155	374	489	1195
Percentage of EE Trips Passing through BM MPO					
Purpose	9-11 AM	11 AM-1 PM	1-5 PM	Night	Total
HBW	2.8%	2.8%	38.9%	55.5%	100%
HBO	13.3%	8.5%	22.3%	55.9%	100%
NHB	15.6%	14.2%	32.7%	37.5%	100%
Total	14.8%	13.0%	31.3%	40.9%	100%

Percentage of EE Trips to Total EE/EI Trips					
Purpose	9-11 AM	11 AM-1 PM	1-5 PM	Night	Total
HBW	0%	0%	0.0003%	0.0005%	0.0008%
HBO	0.0006%	0.0004%	0.0009%	0.002%	0.0039%
NHB	0.003%	0.003%	0.007%	0.008%	0.021%
Total	0.004%	0.004%	0.008%	0.01%	0.03%

2.2. Summary of OD Data

The Origin-Destination (OD) data presented, sourced from Streetlight, offers a detailed examination of travel patterns within the Bismarck-Mandan MPO area, enhancing the calibration and validation of the Travel Demand Model (TDM). This data provides insights into various trip types and purposes, including External-Internal (EI), Internal-External (IE), and External-External (EE) trips, across different time periods and for distinct trip purposes (HBW, HBO, NHB). By leveraging anonymized cellular data, Streetlight enables the estimation of crucial metrics such as AADT, VMT, and trip attributes, facilitating a more nuanced understanding of mobility patterns. This comprehensive dataset is instrumental in refining the TDM, ensuring it accurately reflects current and evolving transportation dynamics in the Bismarck-Mandan area, ultimately aiding in more informed transportation planning and policy decision-making.

3. CAPACITY CALCULATIONS

Capacities are pivotal in the operation of Travel Demand Models (TDM), serving as key indicators for measuring the Level of Service (LOS) and playing a crucial role in the traffic assignment phase. Traffic assignment in TDMs is influenced by the saturation levels (Volume to Capacity ratio) on each link, guiding the redistribution of traffic as saturation increases. The Transportation Research Board (2010) defines capacity as the maximum sustainable hourly flow rate at which persons or vehicles can traverse a specific point or section under prevailing conditions. However, the notion of capacity in traffic engineering, as outlined by NCHRP 716, differs slightly, often aligning with the volume at LOS E, whereas traditional travel models used capacity to denote the volume at LOS C.

Link capacities are generally determined by the number of lanes, but the actual capacity per lane can vary based on several factors such as lane and shoulder widths, peak-hour factors, transit stops, truck percentages, median treatments, access control, intersection control types, provision of turning lanes, and signal timing at intersections. Some methodologies integrate link and node capacities to offer a more nuanced view of each link, considering the attributes of the approaching intersection.

To refine the model's capacity calculations, a comprehensive literature review was conducted, examining capacity calculation methodologies across various MPOs, including those in Lincoln-NE, Des Moines Area-IA, and larger regions like Atlanta-GA and Dallas-Fort Worth-TX. This review aimed to gather insights and assumptions from these models, guided by population thresholds as suggested by NCHRP 716. Table 4 summarizes the literature review used in different MPO planning models for capacity calculations. It showcases the diverse approaches to capacity calculations in TDMs across different MPOs, providing a foundation for updating the capacity analysis in the B-M MPO's TDM.

Table 4 Summary of Capacity Calculations for MPO Planning Models

Lincoln MPO-NE, 2006	<p>For the Lincoln MPO model, capacity at Level of Service (LOS) C was used as the threshold capacity. Highway Capacity Manual (HCM) 2000 procedures were used for estimating the capacity for each combination of functional class and area type. First, peak hour lane capacity was calculated after the effects of percent green time and peak hour factor. Second, the 24-hour lane capacity was calculated using peak hour lane capacity and percent of traffic in the peak hour. Finally, the threshold capacity at LOS C was assumed to be 75% of the 24-hour lane capacity.</p> <p>Reference: LIMA & Associates, 2006 http://www.princeton.edu/~alaink/Orf467F12/LincolnTravelDemandModel.pdf</p>
VDOT, 2014	<p>For all model regions, it is an acceptable practice and recommended practice to use the most recent version Highway Capacity Manual (HCM) as the basis for roadway capacities. It is not acceptable to use older versions of the HCM or arbitrary figures for roadway capacities.</p> <p>Based on functional class and land use/area type Tabulation process Reference: http://www.virginiadot.org/projects/resources/vtm/vtm_policy_manual.pdf</p>
ODOT, 1995	<p>The procedure used to estimate free flow speed and capacity is a detailed methodology that utilizes the</p>

	<p>maximum amount of information from the network and "connects" this data with information from the Highway Capacity Manual. http://www.oregon.gov/ODOT/TD/TP/docs/reports/guidex.pdf</p>
Memphis MPO-TN	<p>Hourly capacities were developed for the Memphis model in order to use collected street data. This provides the most accurate representation of actual capacity (levels of service A through E) on an individual link. These capacities — detailed in the Technical Memorandum #8(b) – Capacity Development — are implemented using an equation which takes into account functional classification, speed limit, lanes, signal density, median treatment, area type, average lane width, and average shoulder width. The capacity equations are built into the model process as a TransCAD lookup table, so modifications to network attributes automatically update the capacity in subsequent runs. Since the model is based on four multi-hour time periods, a conversion factor must be used to create a time period capacity for each of the four time periods. The capacity factors below are based on hourly traffic count data and the Memphis household travel survey http://www.memphismpo.org/sites/default/files/public/documents/lrtp/appendix-g-travel-demand-model.pdf</p>
GDOT, 2013	<p>Facility type and area type are used in combination to determine free-flow speeds and capacities. Link capacities for the model network are obtained from a lookup table of per-lane hourly capacities based on facility type and area type. The final link capacity is calculated by multiplying the hourly capacity per lane by the number of lanes, which is automatically added to the links during the model application. http://www.dot.ga.gov/BuildSmart/Programs/Documents/TravelDemandModel/GDOT%20Model%20Users%20Gude_050813.pdf</p>
MassDOT, 2013	<p>The coding of the EMME/2 highway network basically follows the hierarchy of the functional classification system. Expressways, other than those passing through denser urban areas, are generally coded for 60 mph speeds and hourly capacity per lane of 1,950. Higher-level arterials are coded for speeds ranging from 45 to 50 mph and corresponding capacities of 1,050 to 1,100. Lower-level arterials and major collectors range from 35 mph to 40 mph, with capacities of 950 to 1,000. Minor collectors and local streets that are not in urban centers range from 23 mph to 30 mph, with capacity generally at 800. Streets in urban centers can have substantially lower speeds and capacities. https://www.massdot.state.ma.us/theurbanring/downloads/CTPS_Travel_Demand_Modeling_Methodology.pdf</p>
Syracuse Metropolitan Transportation Council, NY, 2012	<p>The speed and capacity values are stored in lookup tables and automatically imported to the network each time the model runs. The main benefits of importing these data from a lookup table, as opposed to maintaining an explicit speed and capacity for every link within the highway network, are that the user has less data to manage and can easily quote values. However, there are some links in the SMTC network that warrant special attention because their actual speed or capacity is substantially different from what the lookup tables say. Therefore, the SMTC model also supports the ability to code a speed or capacity for each link by entering a value into the "TOTAL_HCAP_FIXED" or "SPEED_FIXED" fields on the network http://www.thei81challenge.org/cm/ResourceFiles/resources/SMTC%20Model%20Version%203.023%20Documentation.pdf</p>
Atlanta Regional Commission (ARC), GA, 2011	<p>By area type and facility type Tabulation method 20 facility type and 7 area type Total link capacity (1Hr- LOS E) http://www.atlantaregional.com/transportation/travel-demand-model</p>
Capital Area MPO (CAMPO)-MO, 2013	<p>The model computes link capacities at run time. Capacities are initially based on functional class and number of lanes, adjusted based on directionality, median type, and roadway slope. Capacity is expressed in terms of vehicles per day for each link by direction. http://www.jeffersoncitymo.gov/11Jan2013CAMPOTDMDocumentation.pdf</p>
Champaign-Urbana Urbanized Area Transportation Study (CUUATS), IL	<p>The daily capacity for each link in the Champaign County model network was calculated based on its facility type and area type. If a Two-Way Left Turn Lane (TWLTL) was present, the link capacity was increased by 30%. The lookup table was included in the model script to uniformly assign the</p>

	capacity on the model network. The centroid connectors have high capacity and very low speed (15mph).
Chattanooga-Hamilton County Regional Planning Agency, TN, 2013	Using the collected street data, the proposed capacity calculation for the Chattanooga model will be implemented using an equation that takes into account data such as functional classification, speed limit, lanes, median treatment, area type, average lane width, and average shoulder width. Traffic signal delays and the impact of steep grades may also be considered. The equations were originally developed using the Highway Capacity Manual (HCM) and analysis performed by the Indiana Department of Transportation in 1997 for the Indiana State Highway Congestion Analysis Plan. KHA successfully applied this method in other urban area models, in conjunction with analysis performed using North Carolina DOT's Level of Service (LOS) software. http://www.chcrpa.org/2040RTP/2040RTP_Draft_Plan/Volume_III_Travel_Demand_Model.pdf
Dallas-Fort Worth (DF): North Central Texas COG, TX, 2009	Hourly Capacity Per Lane (Divided or One-Way Roads) – The hourly capacity per lane for divided roads is given by area type and functional class. AMFactor, PMFactor, OPFactor – These factors are used in the conversion of capacity from hourly to time period. Factors are defined by functional class 1-8 http://www.nctcog.org/trans/modeling/documentation/DFWRTMModelDescription.pdf
San Diego Association of Governments, CA, 2011	Two capacities are calculated for each direction of a highway link: 1. Intersection and mid-link Hourly basis Time category Factored Future ramp metering improved the capacity growth by 10 percent. See the equations http://www.sandag.org/uploads/publicationid/publicationid_1624_13779.pdf
Chicago Metropolitan Agency for Planning, IL, 2014	Zonal capacity system Capacity represented within the link travel time function is approximately the service volume at the level of service C. It is calculated as 75 percent of the level of service E time link capacity. Note that link capacity is calculated by multiplying the hourly lane capacity by the number of lanes and the number of hours in the assignment time period
Omaha-Council Bluffs Metropolitan Area Planning Agency (MAPA), NE, 2010	The daily capacity is based on the hourly ultimate capacity, that is the point at which the Level of Service (LOS) changes from an “E” to an “F” as defined by the Highway Capacity Manual. To support the daily model, the hourly capacity is multiplied by a factor of 10, which represents a typical ratio of peak hour to daily traffic. Capacity varies by functional class, presence of turn lanes, the number of lanes, and whether the road is divided or undivided. The capacities are based on those used in Des Moines, Iowa. The capacities vary by side friction to take into account differences in driveway density. MAPA is currently comparing the capacities with other sources such as the capacity tables developed by the Florida DOT. The model does not include intersection delay separately from link delay. MAPA has attempted to represent intersection delay using downward adjustments to free-flow speeds https://www.fhwa.dot.gov/planning/tmip/resources/peer_review_program/mapa/mapa_report.pdf
Des Moines Area MPO, IA, 2006	Daily directional capacity of a link Divided or undivided Number of lanes Access condition Facility coding http://www.ctre.iastate.edu/educweb/ce451/LABS/Lab%2012/DSM_Documentation.pdf
KYOVA Interstate Planning Commission, WV, 2013	Capacity based on area and functional class Tabulation and look-up method http://www.kyovaijpc.org/2040MTP/documents/KYOVA2040_ModelDocumentation_121213_withFigures.pdf
Knoxville Regional Transportation Planning Organization, TN, 2010	Peak hour capacities of the roadway network were estimated using Highway Capacity Manual 2000 procedures, which results in much more precise estimates of capacity verses traditional methods used in models that entail using a lookup table based on functional class and area type. http://www.knoxtrans.org/plans/mobilityplan/cndetern.pdf

<p>Tulare County Association of Governments, CA, 2021</p>	<p>Link capacity is defined as the number of vehicles that can pass a point on a roadway at free-flow speed in an hour. One important reason for using link capacity as a model input is for congestion impact; which can be estimated as the additional vehicle -hours of delay based on the 2000 Highway Capacity Manual (2000 HCM). The capacity assumption used in the TCAG model of each road segment in the network is based on the terrain, facility type, and area type, which is consistent with the methodology suggested in the 2000 HCM http://www.arb.ca.gov/cc/sb375/tcag_scs_staff_report_final.pdf</p>
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Figure 3 shows the comparison of the capacity calculations from the 2021 base year planning model of the Bismarck Mandan MPO against those from various other MPOs. Notably, freeway capacities align closely with those from the 2021 Bismarck Mandan base model. However, ramp capacities in other MPO areas tend to be lower than those in the 2021 Bismarck Mandan model. When examining major arterials, minor arterials, collectors, and local roadways, it is evident that the capacity calculations are generally higher in the compared MPOs. This is primarily attributed to these MPOs utilizing Level of Service E for their capacity calculations, which typically yields higher capacity values. The comparison provides a perspective on how different MPOs approach capacity calculations within their traffic models, which is essential for traffic management and planning.

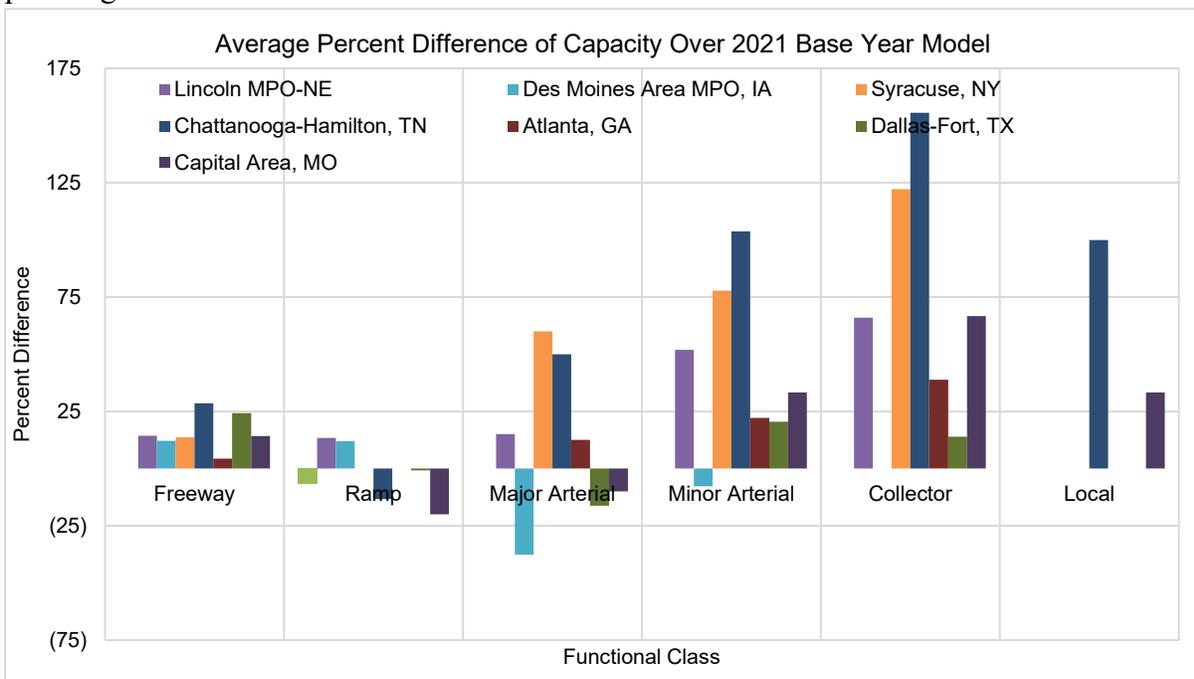


Figure 2 Capacity Comparisons to Bismarck Mandan MPO 2021 Base Year Model

For the 2021 base year model, network-wide capacities were updated to reflect the most recent and updated Highway Capacity Manual HCM 6th Edition and capacities estimated in other recent literature. The calculation of capacities took into account several variables including the functional classification, the number of through links, the number of turn lanes, the location of the intersection (rural, urban, CBD, suburban), the intersection control, and effective green

ratios, heavy vehicle adjustment factors and the speeds. The next subsections discuss the capacity calculations for different types of intersections.

3.1. Capacity Calculations for Signalized intersections

For signalized intersections, a step-by-step procedure was used to estimate the capacities.

3.1.1. Step 1: Develop Lane Groups for each Link

The first step defined the lane groups for each link. For the 2021 network, lane groups are defined by the Attribute Linkgrp1. Table 5 shows the codes for each link group. The lane group describes the geometry at the B-node of each link including the number of through lanes, the number of right turn lanes, and the number of left turn lanes. The first Number in the linkgroup1 category shows the number of through lanes while the second number represents the number of turn lanes for either right or left turns as shown in Table 5. For example, if Linkgroup1 for a link was 20, it meant that the link had two through lanes with no turn lanes. Similarly, if the Linkgroup1 code was 35, it means the link had three through lanes, with two right-turn lanes.

Table 5 Lane Group Classification (Linkgroup 1)

Code	Lane Group Description
N0	N through lanes and no turn lane
N1	N through lanes and single exclusive left turn lane
N2	N through lanes and two exclusive left turn lanes
N3	N through lanes and continuous exclusive left turn lane from intersection to intersection
N4	N through lanes and single exclusive right turn lane
N5	N through lanes and two exclusive right turn lanes
N6	N through lanes and continuous exclusive right turn lane from intersection to intersection
N7	N through lanes, single exclusive left turn lane, and single exclusive right turn lane
N8	N through lanes, two exclusive left turn lanes, and a single exclusive right turn lane
N9	N through lanes, two exclusive right turn lanes, and a single exclusive left turn lane

3.1.2. Step 2: Determining saturation flow rate (S_i) for each lane group:

Step 2 included determining the saturation flow rate (S_i) for each Lanegroup using Equation 1. It is important to note that not all the parameters in Equation 1 were used for the model. Some of the parameters like the lane width and approach grades are not used in calculating the saturation flow rate. If the data is however available, say for a subarea study, these parameters can potentially be used to estimate capacities. The parameters were developed from different sources including Highway Performance Monitoring System (HPMS) and HCM6.

Equation 1

$$S_i = S_0 \times N \times f_w \times f_{HV} \times f_g \times f_p \times f_{bb} \times f_a \times f_{LU} \times f_{LT} \times f_{RT} \times f_{Lpb} \times f_{Rpb} \times PHF$$

Where:

S_i	=	Saturation flow rate for subject lanegroup, expressed as a total for all lanes in lane group (vph)
S_o	=	Base saturation flow rate per lane (pcphpln)
N	=	Number of lanes in lane group
f_w	=	Adjustment factor for lane width
f_{HV}	=	Adjustment factor for heavy vehicles in the traffic stream
f_g	=	Adjustment factor for approach grade
f_p	=	Adjustment factor for the existence of a parking lane and parking activity adjacent to lane group
f_{bb}	=	Adjustment factor for blocking effect of local buses that stop within the intersection area
f_a	=	Adjustment factor for area type
f_{LU}	=	Adjustment factor for lane utilization
f_{LT}	=	Adjustment factor for left turns in lane group
f_{RT}	=	Adjustment factor for right turns in lane group
f_{Lpb}	=	Pedestrian-bicycle adjustment factor for left turn movements
f_{Rpb}	=	Pedestrian-bicycle adjustment factor for right turn movements
PHF	=	Peak Hour Factor

The formulas for calculating the parameters in Equation 1 from the HPBS are shown next:

1. Base Saturation Flow Rate, S_o

Following the HPMS procedure, the base saturation flow rate was set at 1,900 passenger cars per hour per lane (pcphpl).

2. Adjustment Factor for Lane Width, f_w

Using HPMS lane adjustment factors directly, Equation 2 was used to calculate the adjustment for lane widths,

Equation 2

$$f_w = 1 + \frac{(W-12)}{30}$$

Where:

W = Lane width, minimum of 8ft and maximum of 16ft.

3. Heavy Vehicle Adjustment Factor, f_{HV}

Equation 3 was used to calculate the heavy vehicle adjustment factor.

Equation 3

$$f_{HV} = \frac{100}{100 + HV(E_T - 1)}$$

Where:

HV = percent heavy vehicles

E_T = 2.0 passenger car equivalents

4. Adjustment for Grade, f_g

Due to a lack of grade information on urban minor arterials and collectors, HPMS uses f_g as 1.0.

5. Adjustment for Parking, f_p

For parking adjustment, Equation 4 is used to calculate the capacity adjustment.

Equation 4

$$f_p = \frac{N - 0.1 - \frac{18N_m}{3,600}}{N}$$

Where:

f_p = Parking adjustment factor

N = Number of lanes in a group

N_m = Number of parking maneuvers per hour (6 for two-way streets with parking on one side, 12 for two-way streets with parking on both sides or one-way streets with parking on one side, 24 for one-way streets with parking on both sides)

If no parking space or parking data is available, then f_p is set equal to 1.0.

6. Adjustment for Bus Blockage, f_{bb}

Due to the non-availability of bus route data, f_{bb} is set to 1.0. Also, the default values of f_{bb} used in HCM 2000 for bus routes are close to one.

7. Type of Area Adjustment, f_a

According to HCM 6, f_a is set to 0.9 for CBDs and 1 elsewhere.

8. Lane Utilization Adjustment, f_{LU}

A lane utilization adjustment factor of 1.0 was used for the model.

9. Adjustment for Left Turns, f_{LT}

An adjustment factor of 0.95 is used for left turn movements to estimate the capacities in this study.

10. Adjustment for Right Turns, f_{RT}

For right-turn movements, the adjustment factor of 0.85 was used for the model.

11. Adjustment for Pedestrian-Bicycle Blockage on Left Turns, f_{Lpb}

The adjustment factor for pedestrian-bicycle blockage is set to 1.0 in the HPMS procedure due to the non-availability of extensive inputs.

12. Adjustment for Pedestrian-Bicycle Blockage on Right-Turns, f_{Rpb}

Similarly, the adjustment factor for pedestrian-bicycle blockage for right turns is also set to 1.

13. Peak Hour Factor (PHF)

The default values of 0.92 and 0.88 are set for urban and rural sections respectively.

14. Effective Green Ratios (g_i/C) for Lane Groups

A g_i/C value of 0.45 is used for principal and minor arterials while 0.40 is used for collectors. These values were default values suggested in HPMS. The values were evaluated based on signal timing data provided by the MPO and were found to be reasonable.

3.1.3. Step 3: Approach Capacity Calculation

After estimating the saturation flow rate for each lane group, the approach capacity for each link at the B end node of the link is calculated. This calculation is done by incorporating adjustment factors using the effective green ratio as shown in Equation 5.

Equation 5

$$C_{SI} = \sum_i S_i \times \frac{g_i}{C}$$

Where C_{SI} is signalized intersection approach capacity,

S_i represents the saturation flow rate for lane group i and

$\frac{g_i}{C}$ represents effective green ratio for lane group i .

3.2. Capacities for Stop Control Intersections

The calculation for capacities for links that have stop controls at the B-node end also follows a series of steps as described next.

3.2.1. Step 1: Calculate the Potential Capacity for each Turning Movement

The potential capacity for each turning movement uses the conflicting flow rate, the critical gap, the number of lanes, the follow-up time for each movement, and percent heavy vehicles as input parameters. Equation 6 is used to calculate the potential capacity for stop-controlled intersections for movements that are not shared.

Equation 6

$$C_{p,x} = CV_{c,x} \times \frac{e^{-V_{c,x} \times t_{c,x} / 3600}}{1 - e^{-V_{c,x} \times t_{f,x} / 3600}}$$

Where:

$C_{p,x}$	=	Potential Capacity of movement x (vph)
$CV_{c,x}$	=	Conflicting flow rate for each movement x (vph)
$t_{c,x}$	=	Critical gap (seconds) for each movement x = $t_{c,base} + (P_{HV} * t_{c,HV})$
$t_{c,base}$	=	Default values from Table 6
$t_{c,HV}$	=	1.0 for one or two-through-lane roads 2.0 otherwise
P_{HV}	=	Percent of heavy vehicles in traffic stream, peak period, expressed as decimal
$t_{f,x}$	=	Follow-up time (seconds) for each movement x = $t_{f,base} + (P_{HV} * t_{f,HV})$
$t_{f,HV}$	=	0.9 for one or two through-lane roads 1.0 otherwise

Tables 6 and 7 show the default values that were used for calculating the potential capacities for stop-controlled intersections in the model.

Table 6 Default values for calculating potential capacities ($C_{p,x}$) of stop sign-controlled highways

Vehicle Movement (x)	Base Critical Gap, $t_{c,base}$	Follow-up Time, $t_{f,base}$
Right Turns	6.2	3.3
Through	6.5	4.0
Left Turns	7.1	3.5

Table 7 Default Values for Conflicting Flow Rates

Functional Class	Conflicting Flow Rate, $CV_{c,x}$
Rural Principal Arterials	100
Rural Minor Arterials	150
Other Rural	200
Urban Principal Arterials	250
Urban Minor Arterials	500
Other Urban	750

3.2.2. Step 2: Determine Potential Approach Capacity for Shared Lanes

For stop-controlled intersections with shared turning lanes, Equation 7 was used to determine each approach's capacity. If turn lanes are not shared, step 2 is skipped.

Equation 7

$$C_{p,SH} = \frac{\sum_x V_x}{\sum_x \left(\frac{V_x}{C_{p,x}} \right)}$$

Where,

$C_{p,SH}$	=	Potential capacity of the shared lane (vph)
V_x	=	Flow rate of the x movement in the shared lane (vph)
$C_{p,x}$	=	Potential capacity of x movement in the shared lane (vph)

3.2.3. Step 3: Calculate Approach Capacity for each Lane Group Type

Table 8 shows the different equations that are used to calculate the approach capacity for each lane group as described previously for stop-controlled intersections.

Table 8. Stop Sign Control Intersection Capacity Equations for Different Lane Groups

1	All Movements from Shared Lane	$C_A = N_T \times C_{p,SH}$
2	Shared LT + T lane; exclusive RT lane	$C_A = N_T \times C_{p,SH(LT+T)} + N_{RT} + C_{p,RT}$
3	Shared RT + T lane; exclusive LT lane	$C_A = N_T \times C_{p,SH(RT+T)} + N_{LT} + C_{p,LT}$
4	Exclusive lanes for all movements	$C_A = N_{LT} \times C_{p,LT} + N_T \times C_{p,T} + N_{RT} \times C_{p,RT}$
5	Consider only through volumes	$C_A = N_T \times C_{p,T}$

Where:

N_T	=	Number of peak through lanes; 1 for rural highways with two through lanes, 2 for rural highways with three through lanes
N_{LT}	=	Number of left turn lanes
N_{RT}	=	Number of right turn lanes
$C_{p,SH}$	=	Potential capacity of shared lane (vph)
$C_{p,T}$	=	Potential capacity for through movement (vph)
$C_{p,RT}$	=	Potential capacity for right turn movement (vph)
$C_{p,LT}$	=	Potential capacity for left turn movement (vph)

3.3. Freeway Capacity

For freeways, the following steps detail the equations and procedures used to calculate their capacities.

3.3.1. Step 1: Calculate Free Flow Speed

Equation 8 is used to calculate free-flow speeds. The equation utilizes the base free flow speed which is calculated using an algorithm that incorporates real-time travel time data, lane width, right shoulder, number of lanes, and interchange density adjustments.

Equation 8

$$FFS = BFFS - f_{LW} - f_{LC} - f_N - f_{ID}$$

Where:

BFFS	=	Base free flow speed
f_{LW}	=	Adjustment factor for lane width
f_{LC}	=	Adjustment factor for right shoulder lateral clearance
f_N	=	Adjustment factor for number of lanes
f_{ID}	=	Adjustment factor for interchange density

Table 9 shows the adjustment factors for lane width. This value is zero for 12ft wide lanes. However, if different widths exist, the values should be adjusted accordingly.

Table 9 Adjustment Factors Lane Width

Lane Width	Reduction in FFS (mph, f_{LW})
12 Ft	0.0
11 Ft	1.9
<= 10 ft	6.6

Table 10 shows the adjustment factors for right shoulder clearance. The model assumed a right shoulder clearance of greater than 6 ft. Adjustments should be made accordingly if these are different. For studies used to evaluate the construction/reconstruction impacts on freeways, this parameter will be critical in determining the reduced capacity if shoulders are closed or reduced.

Table 10 Right Shoulder Clearance Adjustment Factor

Right Shoulder Width (Ft)	Reduction in FFS (mph, f_{LC})			
	Lanes in one direction			
	2	3	4	>=5
>=6	0.0	0.0	0.0	0.0
5	0.6	0.4	0.2	0.1
4	1.2	0.8	0.4	0.2
3	1.8	1.2	0.6	0.3
2	2.4	1.6	0.8	0.4
1	3.0	2.0	1.0	0.5
0	3.6	2.4	1.2	0.6

Table 11 shows the adjustments used for interchange densities. The distance between two nodes connecting the interchanges is used to calculate the interchange density. The values for small urban areas are used in the model. For the model, all interchange densities were greater than 1 mile. This parameter becomes important when new interchanges that increase interchange densities are being considered as they will potentially reduce freeway capacities.

Table 11 Adjustments for Interchange Density

Area Size	Interchange Density	Interchange Adj. Factor, (f_{ID})
Small Urban	0.70	1.0
Small Urbanized	0.76	1.3
Large Urbanized	0.83	1.7
Small Urban	0.83	1.7
Small Urbanized	0.88	1.9
Large Urbanized	0.91	2.1

Table 12 details the adjustment factors used for adjusting freeway capacities based on the number of lanes.

Table 12 Adjustments for Number of Lanes

No of Lanes (One direction; Urban only)	Reduction in FFS (mph, f_N)
≥ 5	0.0
4	1.5
3	3.0
2	4.5

3.3.2. Step 2: Calculate Base Freeway Capacity

The base freeway capacity is calculated using Equation 9 for freeways with speeds less than 70mph and freeways with speeds greater than 70mph.

Equation 9

$$BaseCap = 1,700 + 10FFS; \text{ for } FFS \leq 70 \text{ mph}$$

$$BaseCap = 2,400 \quad ; \text{ for } FFS > 70 \text{ mph}$$

3.4. Ramp Capacity Calculations

The following steps were used to calculate ramp capacities:

3.4.1. Step 1: Calculate Free Flow Speed

Using Equation 10, the free flow speed for ramps was calculated as follows

Equation 10: Ramp Capacity Equation

$$S_{fo} = 25.6 + 0.47 * S_{pl}$$

Where S_{fo} = base free-flow speed (BFSS); and

S_{pl} = posted speed limit

3.4.2. Step 2: Calculate Maximum Saturation Flow Capacity

The Chattanooga-Hamilton model was used to develop Equation 11 to calculate ramp capacities as follows:

Equation 11: Maximum Saturation Flow Capacity

$$SF = C * N * (v/c)_I * PHF$$

Where SBMaximum service flow rate;

C ideal capacity based on S_{fo} ;

N represents number of lanes;

(v/c) is rate of service flow for levels of service D or E. $v/c=0.88$ at LOS D, 1 at LOS E; and

PHF represents the peak hour factor.

Table 26 and Table 27 Appendix 1 shows sample Capacity calculations that are used in the model for signalized intersections.

4. MODEL INPUT DATA

The main data inputs for the travel demand model consist of transportation network details and socioeconomic datasets. These are developed in a concerted effort by the MPO staff and the Advanced Transportation Analysis Center (ATAC). The ensuing discussion elaborates on these datasets.

4.1. Transportation Network Data

The transportation network forms a vital abstract model of the actual transportation infrastructure, encapsulating crucial supply-side data. Maintained within a GIS geodatabase, it encompasses four primary feature classes: links, which depict the roadways; nodes, representing the intersections; centroids, denoting trip origins/destinations within the Transportation Analysis Zones (TAZs); and external centroids, marking the external trip entry points.

This network has been jointly updated by ATAC and the MPO to mirror the conditions of the base year 2021, ensuring an accurate representation of the transportation system's current state. Critical attributes of the network utilized in the modeling process include the geometric configurations of the network (such as the number of lanes, including turn lanes), posted and optimal free-flow speeds, functional classifications, the length of links, Average Daily Traffic (ADT) for both passenger and freight traffic, the type of area in which a link is located, and the nature of intersection controls. These attributes are integral to the model as they directly influence the simulation of traffic flow and behavior. Distribution of Modeled Network by Functional Classifications. Table 13 shows the percentage of centerline miles by functional class.

Table 13 Centerline Miles Distribution by Functional Classification

Functional Class	Centerline Miles	Percentage
Interstate	35.32261	9.6%
Major	76.7199	21.0%
Minors	131.20811	35.8%
Collectors	121.0004	33.1%
Locals	1.80722	0.5%

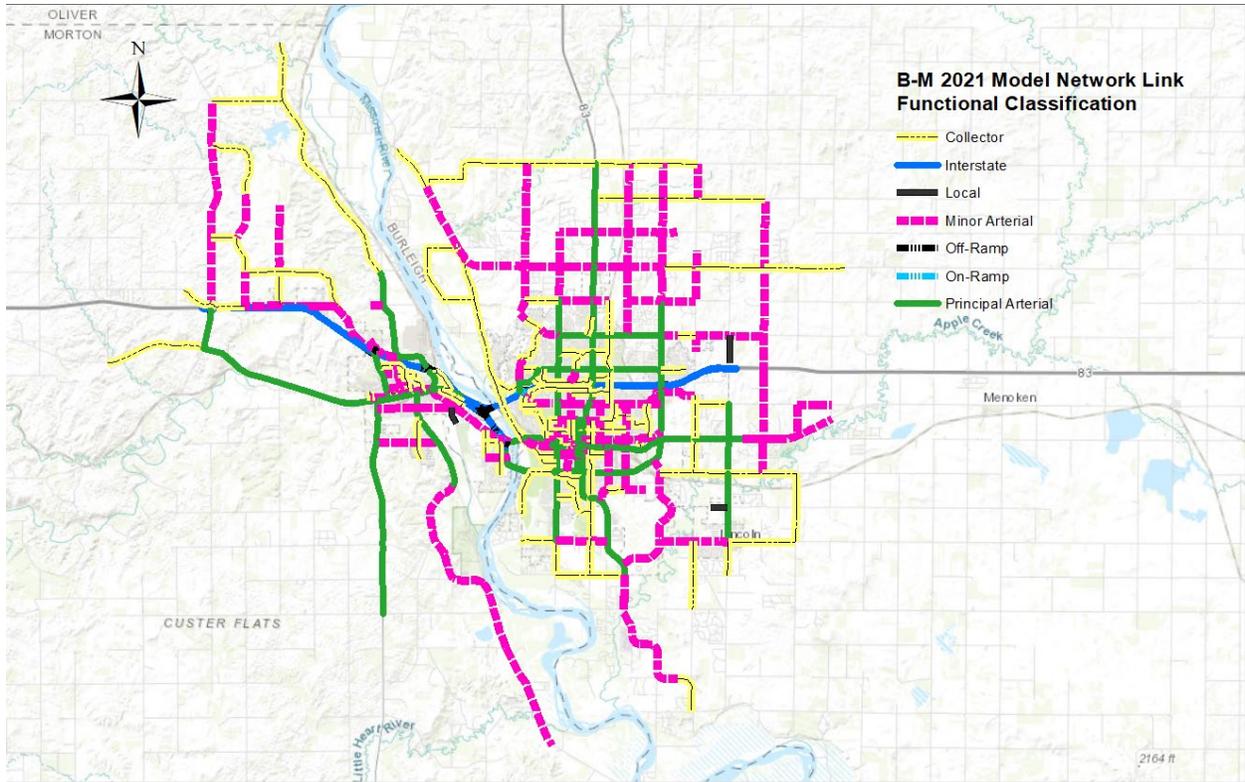


Figure 3 2021 Model Network

Figure 4 shows the modeled network distribution by functional class. The network does not show the centroid connectors.

4.2. Socioeconomic Data

Socioeconomic data are used to generate the total number of trips produced and attracted by each TAZ in the TDM. The TAZ geographies and the socioeconomic data included within each TAZ were developed by a collaborative effort between MPO staff and the ATAC. The socioeconomic data that was used in the model is described next.

4.2.1. TAZ Geography files:

A total of 408 internal TAZs were used for the 2021 model. Only one TAZ (TAZ 44) was modified (split or merged). TAZ 44 was a TAZ that was East of State Street from 43rd Ave NE to 57th Ave NE and included both Walmart and Costco. This TAZ was split into three TAZs (444,407 and 408).

4.2.2. Socioeconomic Data TAZ Attributes

The socioeconomic data within the TAZ contained the following fields

4.2.2.1. *Number of Persons per household in each TAZ according to the following categories (attributes)*

1. # of one person households
2. # of two person households
3. # of three person households
4. # of four person households
5. # of five person households
6. > # five person households
7. Total number of households

1. # of Grade school age children
2. # of Middle age school children
3. # of High school age children
4. # of College age (18-23)

4.2.2.3. *Employment data (# for each TAZ)*

For the employment data, the categories listed below were grouped into retail, service, and other jobs for trip generation. The data was provided by SRF and was vetted by HDR Inc. The data underwent several iterations to get it into the final dataset that was used for the model.

1. Commercial Jobs
2. Industrial Jobs
3. Commercial Office Jobs
4. Comm. Shopping Jobs
5. Other Jobs

4.2.2.4. *Enplanements*

8. Yearly enplanements for the Bismarck Airport for 2021 (259,734)

4.2.2.5. *Special generators*

9. Special generator TAZS (wholesale distributors (Walmart and Super Target, large retail stores, and Malls).

4.2.2.6. *ADT at external locations*

Used as estimates of trips that have at least one trip end outside of the MPO area.

5. TRIP GENERATION

Trip generation is the initial phase of the Travel Demand Model (TDM), which assesses the volume of trips both originating and destined for each Transportation Analysis Zone (TAZ). Utilizing the socioeconomic data detailed in Chapter 4 alongside established regression parameters, the model estimates trips generated and attracted per TAZ. Typically, trips produced are associated with household attributes within a TAZ, while trips attracted correlate with the employment factors of that TAZ. A notable enhancement in this iteration of the model is the incorporation of long-haul freight movements, which adds depth to the trip generation analysis. The next sections describe in detail, the different trip generation procedures that were used and their results.

5.1. Internal-Internal Passenger Vehicle Trip Productions and Attractions

The internal-internal passenger vehicle trip generations (II Trips) encapsulate those passenger vehicle trips that both start and finish within the MPO's purview. These trips are categorized into six principal purposes: Home-Based Work (HBW), Home-Based Shop (HB-Shop), Home-Based Other (HBO), Home-Based School K-12 (HBSchool K-12), Home-Based University (HBU), and Non-Home Based (NHB).

5.1.1. Trip Productions

Table 14 shows the trip generation equations that were used to develop the II trip production tables. The numbers in bold show the actual regression parameters used while the number underneath each one shows the p-value for each of the regression equations. The model parameters were developed from a household travel survey that was done in the Fargo-Moorhead area. These parameters are the starting equations that were used, the final equations were adjusted during the calibration process to reflect different area types and to match the observed traffic counts in the trip assignment step.

Table 14 Internal-Internal Passenger Trip Generation Equations

Purpose	Persons per Household				Overall
	1	2	3	4+	
HBW	1.049	1.665	2.624	2.457	2.21
	<i>14.9</i>	<i>19.82</i>	<i>13.61</i>	<i>17.15</i>	<i>30.45</i>
HBSH	1.127	2.092	3.424	3.424	2.86
	<i>5.03</i>	<i>11.52</i>	<i>5.70</i>	<i>6.65</i>	<i>14.23</i>
HBO	1.322	2.465	2.390	4.665	3.08
	<i>11.9</i>	<i>21.04</i>	<i>9.64</i>	<i>9.74</i>	<i>20.81</i>
NHB	2.006	2.421	2.961	3.329	3.04
	<i>11.44</i>	<i>17.78</i>	<i>7.39</i>	<i>10.1</i>	<i>22.49</i>

5.1.2. Trip Attractions

Trip attractions represent the number of trips attracted to each zone typically based on employment and the size of the school for school trips. Table 15 shows the trip attraction rates derived from NCHRP 718 employed in developing the trip attraction tables. While the socioeconomic data indicated diverse employment categories, for modeling simplicity, these were consolidated into broader groups as depicted in Table 15.

Table 15 Trip Attraction Rates

Purpose	Retail	Service	Other
HBW	1.284	1.284	1.284
HBO	1.1	1.5	0.2
NHB	2.1	1.4	0.5

Table 16 shows the school trip attraction rates that were used for the model. These trip rates were obtained from the ITE Trip Generation Manual.

Table 16 School Trip Attraction Rates

School	Rate
Elementary	1.85
Middle	1.85
High	1.96

6. TRIP DISTRIBUTION

The trip distribution step is an essential component in the progression of the Travel Demand Model (TDM), where it allocates the trip productions and attractions, identified during the trip generation phase, between various Origin-Destination (OD) pairs. Utilizing the gravity model, this step disperses trips according to the volume of trip productions and attractions, a friction factor (F), and a scaling factor (K).

The friction factor is critical to the gravity model as it represents the travel impedance, or resistance, between zonal pairs and is inversely related to measures such as distance, time, or cost. This factor plays a pivotal role in modeling as it influences the likelihood of travel between zones based on the "cost" of travel, whether in terms of actual monetary cost, travel time, or distance.

The K factor acts as an adjustment tool within the model calibration process. It is applied to modify the volume of traffic traversing the network's segments, effectively scaling the distributed trips to match observed traffic counts. By fine-tuning the K factor, the model can more accurately reflect real-world traffic patterns, ensuring the distribution of trips within the model aligns with the empirical data. This process of calibration and validation is crucial to ensure the model's outputs are reliable and can be used to inform transportation planning and policy decisions. Equation 12 shows the gravity model formulation used in the model.

Equation 12 Gravity Model Used for Trip Distribution

$$T_{ij} = P_i \frac{K_{ij} A_j F_{ij}}{\sum K_{ij} A_j F_{ij}}$$

T_{ij} = Number of trips assigned between Zones i and j;

P_i = Number of Productions in Zone i;

A_j = Number of Attractions in Zone

j; F_{ij} = Friction Factor; and

K_{ij} = Scaling factor used in calibration to influence specific ij pairs

The trip distribution phase in Travel Demand Models (TDM) typically produces an Origin-Destination (OD) matrix that outlines the starting point and endpoint for each trip within the study area. This process employs the outputs from the trip generation step—namely the number of trips produced and attracted by purpose in each zone. It also uses a measure of travel impedance (often travel time) between zonal pairs, in conjunction with a set of socio-economic and area characteristic variables, often referred to as the "K-factor."

The K-factor is an adjustment variable used to account for the influence of factors beyond the standard travel impedance within the gravity model. This includes socio-economic variables and other area-specific characteristics that might affect trip distribution patterns. OD data serves as a foundational element for deriving K-factor matrices which are then integrated into the gravity model, particularly for the distribution of External-Internal (EI) and Internal-External (IE) trips.

To refine the K-factors, external trips were consolidated into four principal external "super zones" based on their geographic origination relative to the MPO area. For instance, all trips originating north of the MPO were grouped into a single "super TAZ." The trip proportions from each internal 2021 OD TAZ to this "super TAZ" were calculated and applied as the K-factor in the trip distribution process. This approach enhances the model's efficiency in distributing trips across the network.

For the distribution of External-External (EE) trips, the OD data were leveraged to develop K-factors in a method akin to that of EI/IE trips, facilitating their inclusion in the EE trip distribution segment of the TDM.

Regarding the distribution of K-12 school trips, specific school zones were designated for public schools in Bismarck Mandan, with the gravity model being utilized to distribute trips to private schools. This dual approach ensures that the model accurately reflects the unique travel patterns associated with school trips within the region.

7. 1. TRIP ASSIGNMENT

The trip assignment is the final computational step in the four-step travel demand modeling process. This phase involves determining the specific routes that trips will take across the transportation network from origin to destination. For the purposes of the model, trip assignments are differentiated across three temporal matrices: the morning peak (AM peak), evening peak (PM peak), and off-peak periods.

The model employs the user equilibrium method for traffic assignment. This method posits that each traveler chooses their route based on the least cost to themselves, which is often synonymous with the least travel time. However, this individual optimization does not account for the overall efficiency of the network; users operate independently without consideration for the collective travel time.

In contrast, a system-equilibrium approach would entail travelers selecting routes in a cooperative manner that benefits the entire system, thereby minimizing the average travel time or cost for all users. Such a method assumes a level of coordination among users to achieve an optimized network.

8. VALIDATION AND CALIBRATION

Model calibration and validation are integral to the efficacy and accuracy of a Travel Demand Model (TDM). Calibration is the process of fine-tuning the model's input parameters to ensure that the model's outputs closely match observed data from the real world. This is often done for a specific base year and encompasses adjustments to trip generation rates, node delays, free flow speeds, K factors, friction factors, and other relevant parameters. The goal of calibration is to tailor the model so that it not only replicates known traffic patterns but also provides a reliable framework for predicting future conditions.

Validation, on the other hand, follows calibration and is a process to confirm that the calibrated model can accurately forecast travel behavior and traffic flows under different conditions. It typically involves comparing the model's outputs to an independent set of traffic data not previously used in calibration. Successful validation indicates that the model can be a reliable tool for predicting traffic responses to changes in the network, such as new infrastructure, policy changes, or fluctuations in demand.

Figure 6 illustrates the calibration and validation flow chart, which outlines the iterative nature of these processes. This iterative process is critical as it allows for continuous refinement of the model parameters. The aim is to reach a level of confidence where the model's simulated outputs have an acceptable level of agreement with observed traffic data, which is often quantified through statistical measures such as the root mean square error (RMSE), the coefficient of determination (R^2), or other goodness-of-fit indicators.

Calibration and validation are not one-time processes but rather ongoing requirements as new data become available, the transportation network changes or the model is applied to forecast future scenarios. This ensures that the model remains accurate over time and can adapt to the evolving patterns of travel behavior and network usage.

The next sections describe the different model parameters that were used for model calibration and validation.

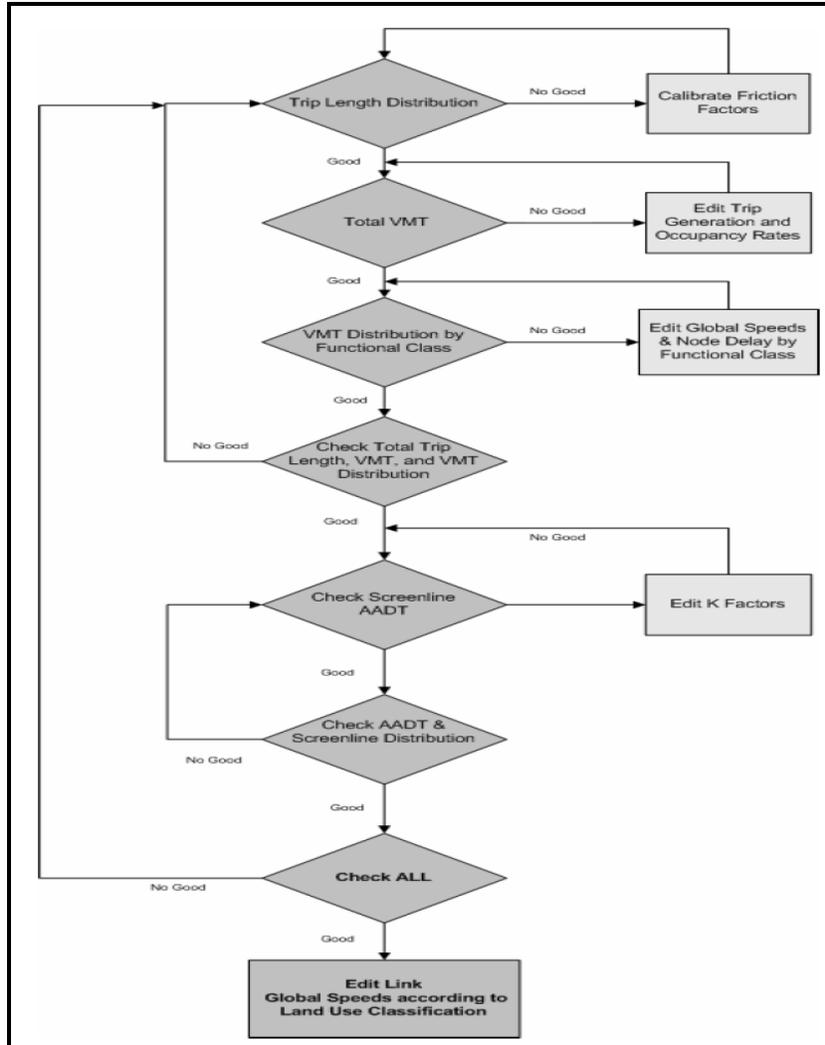


Figure 4 Calibration Flow Chart

8.1. Trip Length Frequency Calibration and Validation

Trip length frequency distributions are fundamental in understanding the behavioral aspects of travel demand, as they reflect the tendency of travelers to undertake trips of various distances. These distributions are often visualized as curves, with the steepness indicating how sensitive travelers are to travel time for a particular trip purpose. For instance, steep curves signify a high sensitivity, implying that travelers are less likely to engage in longer trips, or will do so only if travel times are relatively short.

Calibrating friction factors is a crucial step in tailoring the trip length frequency to align with observed data. Friction factors, pivotal in the gravity model, essentially weigh the attractiveness of a destination against the cost of getting there, with the cost usually being measured in terms of travel time

or distance. When the observed trip lengths are matched, it suggests that the model can accurately reflect how real-world factors such as distance and time influence trip-making behavior.

The gamma function is a flexible tool for shaping friction factors because it can be adjusted to produce a variety of curve forms to match the observed trip length frequencies. By manipulating the parameters of the gamma function, modelers can fine-tune the sensitivity of the gravity model to distance or travel time, ensuring that the modeled trip distribution realistically reflects the observed patterns of travel within the region. This level of detail in the modeling process ensures that the resulting TDM can reliably forecast travel behaviors and inform transportation planning and infrastructure investment decisions.

The gamma function was used to develop the friction factor for this model and are shown in Figure 7.

Equation 13 Friction Factor Equation

$$F_{ij}^p = a * t_{ij}^b * \exp(c * t_{ij})$$

Where,

F_{ij}^p = Friction factor for purpose p (HBW, HBO, NHB)

t_{ij}^b = travel impedance between zone i and j,

a, b and c are gamma function scaling factors.

The friction factors were calibrated by adjusting the b and c parameters until the desirable trip length frequency distribution for Home Based Work Travel times were reached. Observed trip length frequency data for the home-based work trips were obtained from Streetlight. Only trips up to 40 minutes were considered with the assumption that 40 minutes was the highest possible travel time between any two points within the metro area. However, Streetlight data shows that about 45% of the trips fall within 2 minutes which is not feasible. Therefore, the trips that fall within the trip length 1-4 minutes are deleted. After those trips were deleted, the average trips were closer to the model trip length frequency. Deletion of trips less than 5 minutes is justified because the American Community Survey (ACS) report about travel time to work in the United States (2019) calculates the travel time to work at a 4 minutes interval. Also, most of the trips percentages fall within probably 10-14 minutes in the census block data. The average trip length for the observed data was calculated as 9.93 compared to the average trip length of 10.498 produced by the model for HBW trips. The desired average trip lengths for HBO and NHB trips

were 100% and 104% of the average trip length for HBW trips. The average trip length for the models HBO and NHB trips were 10.0 and 10.05 minutes respectively.

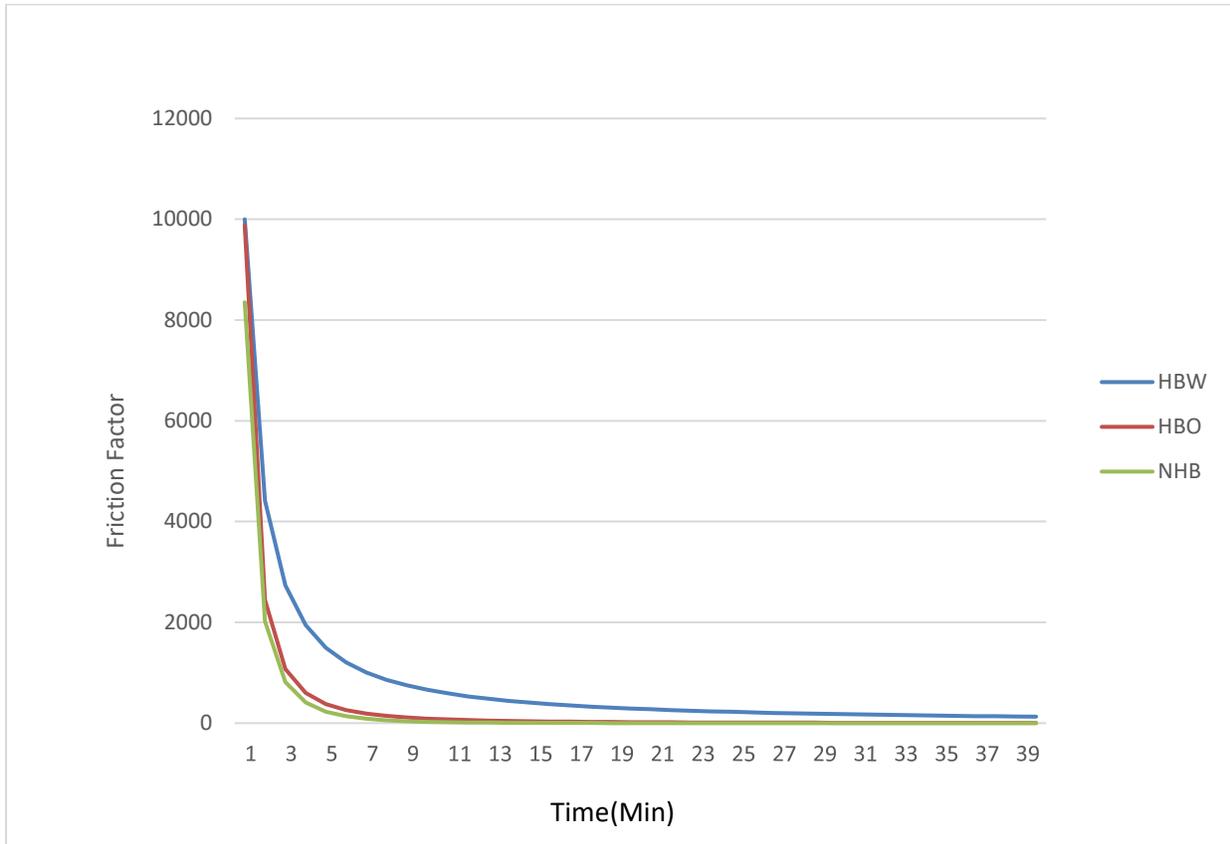


Figure 5 Friction Factors

Figure 8 shows the comparison between observed and modeled trip length frequencies across total Home-Based Work (HBW), Home-Based Other (HBO), and Non-Home Based (NHB) trips. The close alignment between the observed and modeled data suggests that the model has been calibrated effectively.

The two curves in the graph present a similar shape and follow the same trend across the range of trip lengths, which indicates that the model accurately captures the real-world distribution of trip lengths. The peak of both curves occurs at the shorter trip lengths, with a rapid decline as trip length increases. This is typical of trip length frequency distributions, as shorter trips are usually more common.

A small difference at the beginning of the trip lengths suggests some variation in trip initiation or recording, but the overall correspondence between the two curves in the majority of the trip length bands underscores a well-calibrated model. Such congruence demonstrates that the model can reliably replicate actual travel patterns, which is essential for predicting future

travel behaviors under various scenarios and for assessing the impacts of transportation planning decisions.

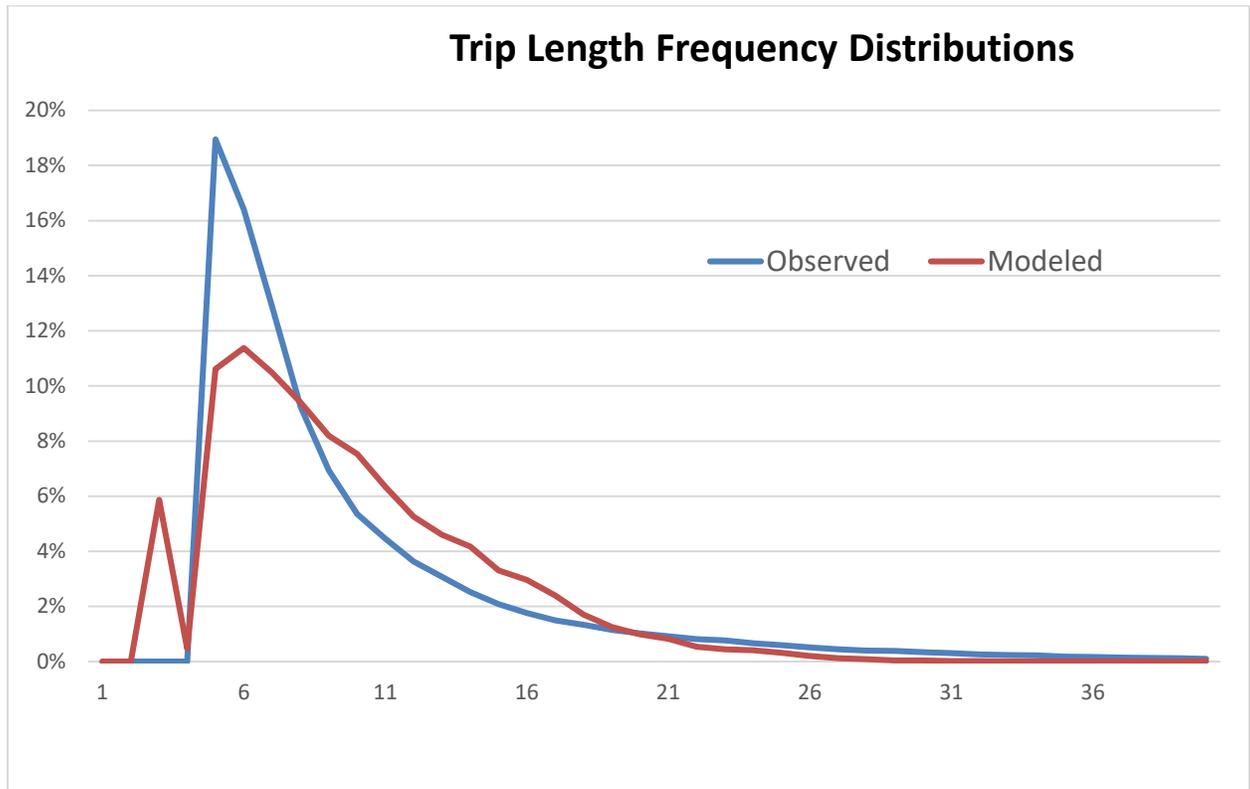


Figure 6 Comparison of Observed to Model Trip Length Frequency

8.2. Vehicle Miles Traveled (VMT) Calibration and Validation

The modeled VMT is calculated based on the number of trips generated by the model and their respective trip lengths. An accurate VMT estimate is essential, as it provides a measure of the travel demand's reasonableness and can have significant implications for planning and policy decisions related to transportation. To calibrate VMT, the total modeled VMT for the entire model area is initially adjusted. This is done by comparing it against observed VMTs, which are calculated by multiplying the Average Daily Traffic (ADT) counts by the lengths of the links. Discrepancies between the modeled and observed VMTs prompt adjustments in trip generation rates and vehicle occupancy figures until the two values converge. Adjusting the trip generation and occupancy rates changes the total number of trips that are generated within the transportation model. This in turn increases or decreases the total number of vehicle miles traveled.

Once the total VMT was reasonable, ATAC checked the VMT distribution across various functional classes of roadways is examined. This distribution offers insights into the model's assignment accuracy and can reveal whether the model is effectively replicating real-world speed, capacity, and assignment behaviors. If the VMT distribution by functional class diverges

from expected patterns, modifications to the model, such as adjusting global speeds by facility type, may be necessary.

Table 17 shows the comparison between the observed and modeled VMTs, showcasing how they align by functional class as a percentage of the total VMT. A well-calibrated model is indicated by minor VMT differences—such as the less than 5.1% variance observed for interstates—and a distribution that mirrors the observed data. An overall deviation of 0.3% suggests the model is robust in mimicking VMT by functional class.

Table 17 Modeled VMTs compared to Observed VMTs by Volume Range

Functional Class	Observed VMT	Modeled VMT	% Diff
Interstate	340,737	350,320	3%
Major	544,264	585,191	7%
Minors	239,948	221,695	-8%
Collectors	131,353	134,397	2%
Total	1,256,302	1,291,603	3%

8.3. Modeled ADT Comparison to Observed ADT

Comparing the modeled ADTs to the Observed ADTs is the ultimate test of how well the model can replicate ground truths. The MPO provided traffic counts for several links that were compared to the Model ADTs. Two comparisons are made, one for the different functionally classifications and one by volume ranges.

Table 18 shows the comparison of the modeled and observed ADTs by functional classification. Overall, the model performs reasonably replicating over 73% of observed counts.

Table 18 Comparison of Modeled and Observed ADTs by Functional Classification

Functional Classification	Below Criteria	Within Criteria	Above Criteria	Total	%age Within	RMSE %
Interstates	1	11	1	12	84.62%	22.50%
Major Arterials	33	147	28	208	70.67%	41.16%
Minor Arterial	29	160	53	242	66.12%	141.18%
Collectors	21	114	24	159	71.70%	100%
Locals	0	1	0	0	100%	0%
Total	84	433	106	621		
Percent	13.53%	69.73%	17.07%			

Table 19 shows the comparison of modeled and Observed ADTs by volume range. The FHWA criterion sets limits to the deviations between observed and modeled ADTs. Overall the model meets all deviation criterion for all the volume ranges and replicates 70% of the observed traffic.

Table 19 Comparison of Modeled and Observed ADT by Volume Range

ADT Range	#Above	#Within	#Below	%Within	RMSE
ADT >25,000	2	10	1	76.92%	0.1283
25,000 TO 10,000	16	115	28	0.7233	0.2396
10,000 TO 5,000	30	116	33	0.6480	0.3469
5,000 TO 2,500	38	84	22	0.5833	0.6326
2,500 TO 1,000	13	81	0	0.8617	1.0439
ADT<1000	7	27	0	0.7941	28.2414
Total	106	433	84	70%	

8.4.Scatter Plots, R Squares of Model and Observed Traffic

Scatter plots of the modeled traffic volumes against the observed traffic volumes are a good indicator of the model's fit. Figure 9 shows the scatter plot of modeled traffic volumes versus observed counts. The scatter plot suggests that the amount of error in the modeled volumes is proportional to the observed traffic count which is an indication of a good fit between the model and the observed traffic counts.

The R-square (coefficient of determination) is the proportion of the variance in a dependent variable that is attributable to the variance of the independent variable. They typically measure the strength of the relationships between the assigned volumes and the traffic counts. It measures the amount of variation in traffic counts explained by the model. The modeled R-square of 0.85 shows a strong linear relationship between modeled and observed traffic counts.

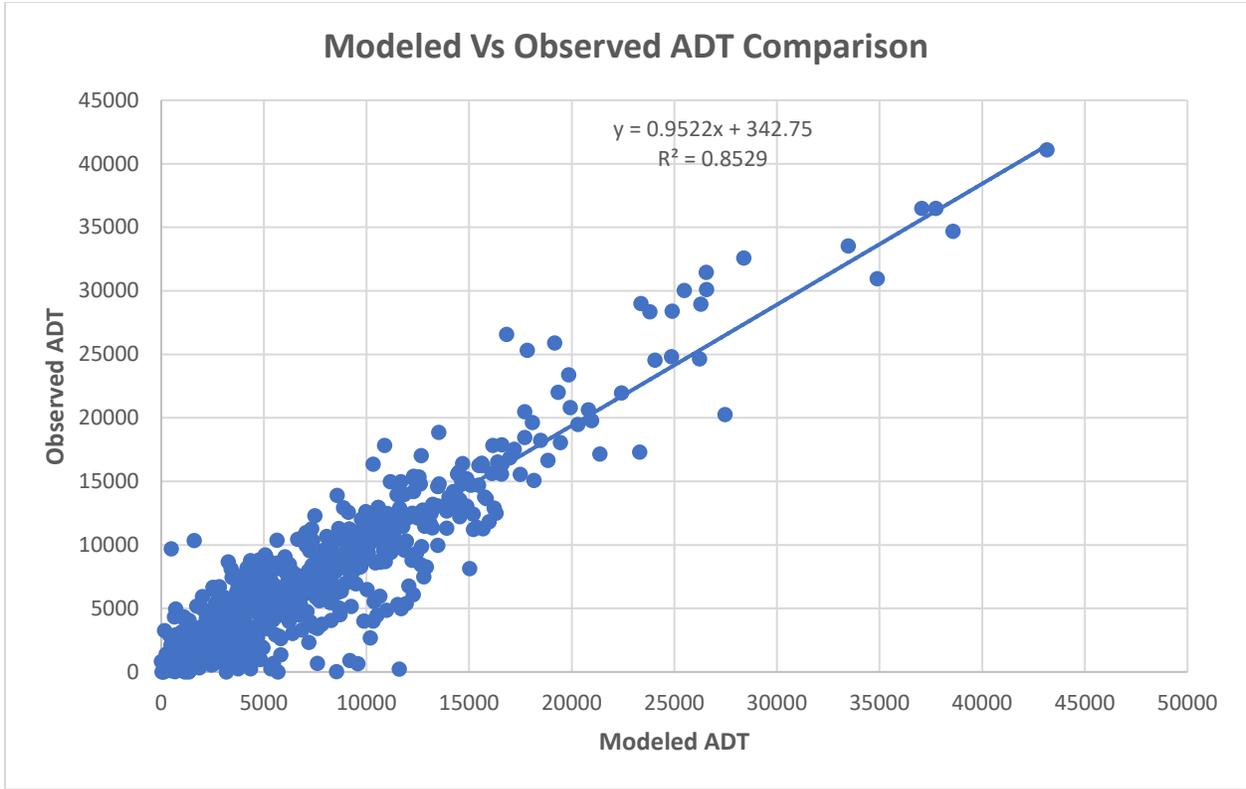


Figure 7 Scatter Plot of Modeled and Observed ADTS

9. CONCLUSIONS

In conclusion, the travel demand modeling process for the Bismarck Mandan Metropolitan Planning Organization (B-M MPO) has been conducted with a meticulous approach, adhering to the current state-of-the-art methodologies within the field. This comprehensive process encompassed the essential steps of trip generation, trip distribution, modal split, and trip assignment, each carefully executed to build a model that reflects the intricate dynamics of the region's transportation system.

The trip generation phase accurately estimated the number of trips starting and ending in each TAZ, employing advanced regression techniques and the inclusion of long-haul freight movements—a notable enhancement. The trip distribution step, underpinned by the gravity model, effectively assigned these trips between OD pairs, with friction factors finely tuned to match observed trip length frequencies.

During the trip assignment phase, the user equilibrium method was adeptly applied to simulate realistic routing choices based on individual travel times, thus providing a robust estimate of traffic flows for different periods of the day. The model's performance was particularly exemplified by its close replication of observed VMT distributions and trip length frequencies, indicating a high degree of accuracy in capturing travel patterns.

Throughout the calibration and validation processes, a series of iterative adjustments ensured that the model's output aligned with real-world data, reflecting the true state of travel in the B-M MPO area. The calibration honed in on key parameters such as trip generation rates and VMT, while validation processes confirmed the model's predictive reliability across various traffic scenarios.

The culmination of this rigorous modeling effort is a robust tool, now finely tuned and validated, that stands as a testament to the application of contemporary best practices in travel demand forecasting. This model is poised to inform strategic decision-making, support sustainable transportation initiatives, and guide the development of infrastructure that meets the current and future needs of the Bismarck Mandan Regional MPO area.

10.APPENDIX

Table 20 Calculated Capacities for Signalized Intersections for Different Functional Classifications

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity
N0	1	0	0	1	Principal	Urban	0.9	1900	0.90	1416	1416	0.55	779	7,787
	1	0	0			Rural	1	1900	0.90	1505	1505	0.55	828	8,276
	1	0	0		Minor	Urban	0.9	1900	0.90	1416	1416	0.45	637	6,371
	1	0	0			Rural	1	1900	0.90	1505	1505	0.45	677	6,772
	1	0	0		Collector	Urban	0.9	1900	0.99	1308	1308	0.4	523	5,233
	1	0	0			Rural	1	1900	0.99	1390	1390	0.4	556	5,562
	2	0	0	2	Principal	Urban	0.9	1900	0.90	2832	2832	0.55	1557	15,575
	2	0	0			Rural	1	1900	0.90	3010	3010	0.55	1655	16,553
	2	0	0		Minor	Urban	0.9	1900	0.90	2832	2832	0.45	1274	12,743
	2	0	0			Rural	1	1900	0.90	3010	3010	0.45	1354	13,543
	2	0	0		Collector	Urban	0.9	1900	0.99	2866	2866	0.4	1146	11,463
	2	0	0			Rural	1	1900	0.99	3046	3046	0.4	1218	12,183
	3	0	0	3	Principal	Urban	0.9	1900	0.90	4248	4248	0.55	2336	23,362
	3	0	0			Rural	1	1900	0.90	4514	4514	0.55	2483	24,829
	3	0	0		Minor	Urban	0.9	1900	0.90	4248	4248	0.45	1911	19,114
	3	0	0			Rural	1	1900	0.90	4514	4514	0.45	2031	20,315

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity	
	3	0	0		Collector	Urban	0.9	1900	0.99	4439	4439	0.4	1776	17,755	
	3	0	0			Rural	1	1900	0.99	4718	4718	0.4	1887	18,870	
	1	1	0			Principal	Urban	0.9	1900	0.90	1416	1841	0.55	1012	10,124
N1	1	1	0	2	Principal	Rural	1	1900	0.90	1505	1956	0.55	1076	10,759	
	1	1	0			Minor	Urban	0.9	1900	0.90	1416	1841	0.45	828	8,283
	1	1	0		Collector	Urban	0.9	1900	0.99	1433	1863	0.4	745	7,451	
	1	1	0			Rural	1	1900	0.99	1523	1980	0.4	792	7,919	
	2	1	0		3	Principal	Urban	0.9	1900	0.90	2832	3257	0.55	1791	17,911
	2	1	0				Rural	1	1900	0.90	3010	3461	0.55	1904	19,036
	2	1	0	Minor		Urban	0.9	1900	0.90	2832	3257	0.45	1465	14,654	
	2	1	0			Rural	1	1900	0.90	3010	3461	0.45	1557	15,575	
	2	1	0	Collector		Urban	0.9	1900	0.99	2959	3403	0.4	1361	13,612	
	2	1	0			Rural	1	1900	0.99	3145	3617	0.4	1447	14,467	
	3	1	0	4	Principal	Urban	0.9	1900	0.90	4248	4672	0.55	2570	25,698	
	3	1	0			Rural	1	1900	0.90	4514	4966	0.55	2731	27,312	
3	1	0	Minor		Urban	0.9	1900	0.90	4248	4672	0.45	2103	21,026		
3	1	0			Rural	1	1900	0.90	4514	4966	0.45	2235	22,346		
3	1	0	Collector		Urban	0.9	1900	0.99	4486	4934	0.4	1974	19,736		
3	1	0			Rural	1	1900	0.99	4767	5244	0.4	2098	20,976		

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity	
N2	1	2	0	3	Principal	Urban	0.9	1900	0.90	1416	2265	0.55	1246	12,460	
	1	2	0			Rural	1	1900	0.90	1505	2408	0.55	1324	13,242	
	1	2	0		Minor	Urban	0.9	1900	0.90	1416	2265	0.45	1019	10,194	
	1	2	0			Rural	1	1900	0.90	1505	2408	0.45	1083	10,835	
	1	2	0		Collector	Urban	0.9	1900	0.99	1480	2367	0.4	947	9,469	
	1	2	0			Rural	1	1900	0.99	1573	2516	0.4	1006	10,064	
	2	2	0	4	Principal	Urban	0.9	1900	0.90	2832	3681	0.55	2025	20,247	
	2	2	0			Rural	1	1900	0.90	3010	3912	0.55	2152	21,519	
	2	2	0		Minor	Urban	0.9	1900	0.90	2832	3681	0.45	1657	16,566	
	2	2	0			Rural	1	1900	0.90	3010	3912	0.45	1761	17,606	
	2	2	0		Collector	Urban	0.9	1900	0.99	2990	3887	0.4	1555	15,550	
	2	2	0			Rural	1	1900	0.99	3178	4132	0.4	1653	16,526	
	N3	3	2	0	5	Principal	Urban	0.9	1900	0.90	4248	5097	0.55	2803	28,034
		3	2	0			Rural	1	1900	0.90	4514	5417	0.55	2980	29,795
		3	2	0		Minor	Urban	0.9	1900	0.90	4248	5097	0.45	2294	22,937
		3	2	0			Rural	1	1900	0.90	4514	5417	0.45	2438	24,378
		3	2	0		Collector	Urban	0.9	1900	0.99	4532	5439	0.4	2175	21,755
		3	2	0			Rural	1	1900	0.99	4817	5780	0.4	2312	23,121
N3	1	1	0	2	Principal	Urban	0.9	1900	0.90	1416	1841	0.55	1012	10,124	
	1	1	0			Rural	1	1900	0.90	1505	1956	0.55	1076	10,759	

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity
	1	1	0		Minor	Urban	0.9	1900	0.90	1416	1841	0.45	828	8,283
	1	1	0			Rural	1	1900	0.90	1505	1956	0.45	880	8,803
	1	1	0		Collector	Urban	0.9	1900	0.99	1433	1863	0.4	745	7,451
	1	1	0			Rural	1	1900	0.99	1523	1980	0.4	792	7,919
	2	1	0	3	Principal	Urban	0.9	1900	0.90	2832	3257	0.55	1791	17,911
	2	1	0			Rural	1	1900	0.90	3010	3461	0.55	1904	19,036
	2	1	0		Minor	Urban	0.9	1900	0.90	2832	3257	0.45	1465	14,654
	2	1	0			Rural	1	1900	0.90	3010	3461	0.45	1557	15,575
	2	1	0		Collector	Urban	0.9	1900	0.99	2959	3403	0.4	1361	13,612
	2	1	0			Rural	1	1900	0.99	3145	3617	0.4	1447	14,467
	3	1	0	4	Principal	Urban	0.9	1900	0.90	4248	4672	0.55	2570	25,698
	3	1	0			Rural	1	1900	0.90	4514	4966	0.55	2731	27,312
3	1	0	Minor		Urban	0.9	1900	0.90	4248	4672	0.45	2103	21,026	
3	1	0			Rural	1	1900	0.90	4514	4966	0.45	2235	22,346	
3	1	0	Collector		Urban	0.9	1900	0.99	4486	4934	0.4	1974	19,736	
3	1	0			Rural	1	1900	0.99	4767	5244	0.4	2098	20,976	
N4	1	0	1	2	Principal	Urban	0.9	1900	0.90	1416	1557	0.55	857	8,566
	1	0	1			Rural	1	1900	0.90	1505	1655	0.55	910	9,104
	1	0	1		Minor	Urban	0.9	1900	0.90	1416	1557	0.45	701	7,009
	1	0	1			Rural	1	1900	0.90	1505	1655	0.45	745	7,449

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity	
	1	0	1		Collector	Urban	0.9	1900	0.99	1433	1576	0.4	630	6,305	
	1	0	1			Rural	1	1900	0.99	1523	1675	0.4	670	6,701	
	2	0	1	3	Principal	Urban	0.9	1900	0.90	2832	2973	0.55	1635	16,353	
	2	0	1			Rural	1	1900	0.90	3010	3160	0.55	1738	17,380	
	2	0	1		Minor	Urban	0.9	1900	0.90	2832	2973	0.45	1338	13,380	
	2	0	1			Rural	1	1900	0.90	3010	3160	0.45	1422	14,220	
	2	0	1		Collector	Urban	0.9	1900	0.99	2959	3107	0.4	1243	12,429	
	2	0	1			Rural	1	1900	0.99	3145	3302	0.4	1321	13,209	
	3	0	1		4	Principal	Urban	0.9	1900	0.90	4248	4389	0.55	2414	24,141
	3	0	1				Rural	1	1900	0.90	4514	4665	0.55	2566	25,657
	3	0	1	Minor		Urban	0.9	1900	0.90	4248	4389	0.45	1975	19,752	
	3	0	1			Rural	1	1900	0.90	4514	4665	0.45	2099	20,992	
	3	0	1	Collector		Urban	0.9	1900	0.99	4486	4635	0.4	1854	18,540	
	3	0	1			Rural	1	1900	0.99	4767	4926	0.4	1970	19,704	
N5	1	0	2	3	Principal	Urban	0.9	1900	0.90	1416	1699	0.55	934	9,345	
	1	0	2			Rural	1	1900	0.90	1505	1806	0.55	993	9,932	
	1	0	2		Minor	Urban	0.9	1900	0.90	1416	1699	0.45	765	7,646	
	1	0	2			Rural	1	1900	0.90	1505	1806	0.45	813	8,126	
	1	0	2		Collector	Urban	0.9	1900	0.99	1480	1776	0.4	710	7,102	
	1	0	2			Rural	1	1900	0.99	1573	1887	0.4	755	7,548	

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity	
	2	0	2	4	Principal	Urban	0.9	1900	0.90	2832	3115	0.55	1713	17,132	
	2	0	2			Rural	1	1900	0.90	3010	3311	0.55	1821	18,208	
	2	0	2		Minor	Urban	0.9	1900	0.90	2832	3115	0.45	1402	14,017	
	2	0	2			Rural	1	1900	0.90	3010	3311	0.45	1490	14,898	
	2	0	2		Collector	Urban	0.9	1900	0.99	2990	3289	0.4	1316	13,157	
	2	0	2			Rural	1	1900	0.99	3178	3496	0.4	1398	13,984	
		3	0	2	5	Principal	Urban	0.9	1900	0.90	4248	4531	0.55	2492	24,919
		3	0	2			Rural	1	1900	0.90	4514	4815	0.55	2648	26,484
		3	0	2		Minor	Urban	0.9	1900	0.90	4248	4531	0.45	2039	20,389
		3	0	2			Rural	1	1900	0.90	4514	4815	0.45	2167	21,669
		3	0	2		Collector	Urban	0.9	1900	0.99	4532	4834	0.4	1934	19,338
		3	0	2			Rural	1	1900	0.99	4817	5138	0.4	2055	20,552
N6	1	0	1	2	Principal	Urban	0.9	1900	0.90	1416	1557	0.55	857	8,566	
	1	0	1			Rural	1	1900	0.90	1505	1655	0.55	910	9,104	
	1	0	1		Minor	Urban	0.9	1900	0.90	1416	1557	0.45	701	7,009	
	1	0	1			Rural	1	1900	0.90	1505	1655	0.45	745	7,449	
	1	0	1		Collector	Urban	0.9	1900	0.99	1433	1576	0.4	630	6,305	
	1	0	1			Rural	1	1900	0.99	1523	1675	0.4	670	6,701	
	2	0	1	3	Principal	Urban	0.9	1900	0.90	2832	2973	0.55	1635	16,353	
	2	0	1			Rural	1	1900	0.90	3010	3160	0.55	1738	17,380	

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity		
	2	0	1		Minor	Urban	0.9	1900	0.90	2832	2973	0.45	1338	13,380		
	2	0	1			Rural	1	1900	0.90	3010	3160	0.45	1422	14,220		
	2	0	1		Collector	Urban	0.9	1900	0.99	2959	3107	0.4	1243	12,429		
	2	0	1			Rural	1	1900	0.99	3145	3302	0.4	1321	13,209		
	3	0	1	4	Principal	Urban	0.9	1900	0.90	4248	4389	0.55	2414	24,141		
	3	0	1			Rural	1	1900	0.90	4514	4665	0.55	2566	25,657		
	3	0	1		Minor	Urban	0.9	1900	0.90	4248	4389	0.45	1975	19,752		
	3	0	1			Rural	1	1900	0.90	4514	4665	0.45	2099	20,992		
	3	0	1		Collector	Urban	0.9	1900	0.99	4486	4635	0.4	1854	18,540		
	3	0	1			Rural	1	1900	0.99	4767	4926	0.4	1970	19,704		
	N7	1	1		1	3	Principal	Urban	0.9	1900	0.90	1416	1982	0.55	1090	10,902
		1	1		1			Rural	1	1900	0.90	1505	2107	0.55	1159	11,587
1		1	1	Minor	Urban		0.9	1900	0.90	1416	1982	0.45	892	8,920		
1		1	1		Rural		1	1900	0.90	1505	2107	0.45	948	9,480		
1		1	1	Collector	Urban		0.9	1900	0.99	1480	2071	0.4	829	8,286		
1		1	1		Rural		1	1900	0.99	1573	2202	0.4	881	8,806		
2		1	1	4	Principal	Urban	0.9	1900	0.90	2832	3398	0.55	1869	18,690		
2		1	1			Rural	1	1900	0.90	3010	3612	0.55	1986	19,863		
2		1	1		Minor	Urban	0.9	1900	0.90	2832	3398	0.45	1529	15,292		
2		1	1			Rural	1	1900	0.90	3010	3612	0.45	1625	16,252		

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity
	2	1	1	5	Collector	Urban	0.9	1900	0.99	2990	3588	0.4	1435	14,354
	2	1	1			Rural	1	1900	0.99	3178	3814	0.4	1526	15,255
	3	1	1		Principal	Urban	0.9	1900	0.90	4248	4814	0.55	2648	26,477
	3	1	1			Rural	1	1900	0.90	4514	5116	0.55	2814	28,140
	3	1	1		Minor	Urban	0.9	1900	0.90	4248	4814	0.45	2166	21,663
	3	1	1			Rural	1	1900	0.90	4514	5116	0.45	2302	23,023
	3	1	1		Collector	Urban	0.9	1900	0.99	4532	5137	0.4	2055	20,546
	3	1	1			Rural	1	1900	0.99	4817	5459	0.4	2184	21,836
N8	1	2	1	4	Principal	Urban	0.9	1900	0.90	1416	2407	0.55	1324	13,238
	1	2	1			Rural	1	1900	0.90	1505	2558	0.55	1407	14,070
	1	2	1		Minor	Urban	0.9	1900	0.90	1416	2407	0.45	1083	10,831
	1	2	1			Rural	1	1900	0.90	1505	2558	0.45	1151	11,512
	1	2	1		Collector	Urban	0.9	1900	0.99	1495	2542	0.4	1017	10,167
	1	2	1			Rural	1	1900	0.99	1589	2701	0.4	1081	10,806
	2	2	1	5	Principal	Urban	0.9	1900	0.90	2832	3823	0.55	2103	21,026
	2	2	1			Rural	1	1900	0.90	3010	4063	0.55	2235	22,346
	2	2	1		Minor	Urban	0.9	1900	0.90	2832	3823	0.45	1720	17,203
	2	2	1			Rural	1	1900	0.90	3010	4063	0.45	1828	18,283
	2	2	1		Collector	Urban	0.9	1900	0.99	3021	4079	0.4	1632	16,316
	2	2	1			Rural	1	1900	0.99	3211	4335	0.4	1734	17,341

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity
	3	2	1	6	Principal	Urban	0.9	1900	0.90	4248	5239	0.55	2881	28,813
	3	2	1			Rural	1	1900	0.90	4514	5568	0.55	3062	30,623
	3	2	1		Minor	Urban	0.9	1900	0.90	4248	5239	0.45	2357	23,574
	3	2	1			Rural	1	1900	0.90	4514	5568	0.45	2505	25,055
	3	2	1		Collector	Urban	0.9	1900	0.99	4532	5590	0.4	2236	22,359
	3	2	1			Rural	1	1900	0.99	4817	5941	0.4	2376	23,763
N9	1	1	2	4	Principal	Urban	0.9	1900	0.90	1416	2124	0.55	1168	11,681
	1	1	2			Rural	1	1900	0.90	1505	2257	0.55	1241	12,415
	1	1	2		Minor	Urban	0.9	1900	0.90	1416	2124	0.45	956	9,557
	1	1	2			Rural	1	1900	0.90	1505	2257	0.45	1016	10,157
	1	1	2		Collector	Urban	0.9	1900	0.99	1495	2243	0.4	897	8,971
	1	1	2			Rural	1	1900	0.99	1589	2384	0.4	953	9,534
	2	1	2	5	Principal	Urban	0.9	1900	0.90	2832	3540	0.55	1947	19,468
	2	1	2			Rural	1	1900	0.90	3010	3762	0.55	2069	20,691
	2	1	2		Minor	Urban	0.9	1900	0.90	2832	3540	0.45	1593	15,929
	2	1	2			Rural	1	1900	0.90	3010	3762	0.45	1693	16,929
	2	1	2		Collector	Urban	0.9	1900	0.99	3021	3777	0.4	1511	15,107
	2	1	2			Rural	1	1900	0.99	3211	4014	0.4	1606	16,056
	3	1	2	6	Principal	Urban	0.9	1900	0.90	4248	4956	0.55	2726	27,256
	3	1	2			Rural	1	1900	0.90	4514	5267	0.55	2897	28,967

Lane Group	Number of Through Lanes (N)	Number of Left Turn Lanes	Number of Right Turn Lanes	Total Number of Through Lanes	Type of Arterial	Area Type	Area Type Adjustment Factor (f _a)	Base Saturation Flow Rate (S ₀)	Heavy Vehicle Adjustment Factor (f _{HV})	Saturation Flow Rate for Through Lanes (S)	Total Saturation Flow Rate	Effective Green Ratio (g/C)	Intersection Approach Hourly Capacity (C _A)	Intersection Daily Approach Capacity
	3	1	2		Minor	Urban	0.9	1900	0.90	4248	4956	0.45	2230	22,300
	3	1	2			Rural	1	1900	0.90	4514	5267	0.45	2370	23,701
	3	1	2		Collector	Urban	0.9	1900	0.99	4532	5288	0.4	2115	21,150
	3	1	2			Rural	1	1900	0.99	4817	5620	0.4	2248	22,479

Table 21 Calculated Capacities for Ramps

	Speed	Ideal Capacity (Ex 13-10)	Speed Adjustment	V/C	PHF	Capacity	Daily Capacity
Urban	>50	2,100	1.00	0.9	0.800	1,512	15,120
	>40-50	2,100	0.95	0.9	0.800	1,443	14,433
	>30-40	2,100	0.91	0.9	0.800	1,375	13,745
	>=20-30	2,100	0.86	0.9	0.800	1,306	13,058
	<20	2,100	0.82	0.9	0.800	1,237	12,371
Rural	>50	2,200	1.00	0.9	0.868	1,719	17,186
	>40-50	2,200	0.95	0.9	0.868	1,641	16,405
	>30-40	2,200	0.91	0.9	0.868	1,562	15,622
	>=20-30	2,200	0.86	0.9	0.868	1,484	14,843
	<20	2,200	0.82	0.9	0.868	1,406	14,062

Appendix B

ARRIVE 2050

FORECASTS



Focus Group Summary MEMORANDUM





To: Rachel Lukaszewski, Executive Director
Bismarck-Mandan MPO

From: SRF Consulting Group, Inc.

Date: January 16, 2023

Subject: Arrive 2050 Forecasts – Focus Group Summary Memorandum

INTRODUCTION

As part of the Bismarck-Mandan Metropolitan Planning Organization's (BMMPO) updates to its Travel Demand Model, this memorandum documents the qualitative data obtained through public engagement and conversations with key stakeholders about the future of the Bismarck-Mandan region. This qualitative information will be used to cross-reference the quantitative socio-economic data being used to project population, households, and employment to a horizon year of 2050 (see the Socio-Economic Methodology Memorandum). Ultimately, the feedback provided through the focus group engagement process will help guide the update of the BMMPO's travel demand model and Metropolitan Transportation Plan (MTP) with the most practical and realistic assumptions. Sections of this memorandum include the focus group engagement process, major themes, and individual focus group summaries.

FOCUS GROUP ENGAGEMENT PROCESS

The engagement process used focus group meetings to gather qualitative data about the future of the Bismarck-Mandan Metro region. Focus groups were organized around perspectives related directly to the future growth of the region and driving forces of community growth. The focus groups included engaging stakeholders in the following fields:

- Economic Development
- Housing Agencies
- Social Service Agencies
- School Districts and Private K-12 Institutions
- Higher Education
- Real Estate Development

Brief, informal conversations/interviews were had with individuals to assess the climate and potential for growth or decline.

Key Questions

The conversations revolved around key high-level questions. The questions were intended to examine socio-economic growth and decline in the Bismarck-Mandan region and helped interviewees think critically about the future of their communities. Questions were tailored to the group being interviewed but generally were similar overall to ensure consistent feedback. The questions are listed below:



Table 1. Focus Group Discussion Questions

FOCUS GROUP	QUESTIONS
<p>Economic Development</p>	<ol style="list-style-type: none"> 1. What is the most impactful trend or issue impacting the future of the region? 2. What do you see in the future for the region? Will it continue to grow? 3. How do you see the Bismarck-Mandan area economy evolving in the future? Which industries will drive opportunity? 4. What are the region’s competitive advantages and assets that are driving growth? 5. What are the major hurdles to growth? Are there parts of town that have infrastructure and/or utility limitations? 6. Describe changes you see with respect to immigration. What about migration?
<p>Housing</p>	<ol style="list-style-type: none"> 1. How is your agency involved with regional growth? 2. How do you feel about the future of the region? 3. What is the most impactful trend or issue impacting the future of the region? 4. Are you seeing any trends or shifts to your programs/services? 5. What are the region’s competitive advantages and assets that are driving growth?
<p>Social Services</p>	<ol style="list-style-type: none"> 1. How is your agency involved with regional growth? 2. How do you feel about the future of the region? 3. What is the most impactful trend or issue impacting the future of the region? 4. What are the most critical factors impacting the people you serve? 5. Provide your perspective on immigration and it’s impact on the region. What about migration?
<p>School Districts/Private Institutions (k-12)</p>	<ol style="list-style-type: none"> 1. Has your district developed future enrollment projections? If so, would you be willing to share? 2. What are the most significant factors influencing growth or decline in school enrollment in your district? 3. What are the most important community factors impacting families in your district? 4. Do you feel that your community is growing or declining? What do you believe are the key drivers of this trend? 5. What do you see as the most impactful constraints on future growth in your community?



	<p>6. Are you optimistic about the future of your community? Why or why not?</p>
Higher Education	<p>1. Does your institution develop future enrollment projections? If so, would you be willing to share?</p> <p>2. Does your institution have any data on where students come from, and where they go after receiving their degree? If so, would you be willing to share?</p> <p>3. What are the most significant factors influencing growth or decline in enrollment at your institution?</p> <p>4. What are the most important community factors impacting employees and students at your institution?</p> <p>5. Do you believe your community is growing or declining? What do you believe are the key drivers of this trend?</p> <p>6. What do you see as the most impactful constraints on future growth in your community?</p> <p>7. Are you optimistic about the future of your community? Why or why not?</p>
Real Estate Development	<p>1. What is the most impactful trend or issue impacting the future of development in the Bismarck-Mandan Region?</p> <p>2. Could you provide some insight into current commercial/industrial/housing trends?</p> <p>3. Do you feel that your community is growing or declining? What do you believe are the key drivers of this trend?</p> <p>4. What do you see as the most impactful constraints on future growth in your community?</p> <p>5. Are there parts of town that have infrastructure and/or utility limitations?</p>

Focus Group Discussion Timeline

The following table shows the specific meeting dates, interviewee, and represented organization. Overall, focus group meetings were held between mid-November, 2022 to early-January, 2023.

Table 2. Focus Group Meetings Schedule

FOCUS GROUP	DATE	PERSON	REPRESENTING
Economic Development	11/23/2022	Nathan Schneider	Bismarck Mandan Chamber EDC
Housing	11/17/2022	Dwight Barden	Burleigh County Housing Authority
	11/17/2022	Rick Horn	Morton County Housing Authority
Social Services	12/8/2022	Dennis Meier	Three Rivers Human Service Zone



School Districts/Private Institutions (k-12)	12/28/2022	Chelsea Flory	Burleigh County Human Service Zone (Social Services Department)
	11/17/2022	Doreen Oucharek	Dakota Adventist Academy
	11/18/2022	Darin Scherr	Bismarck Public Schools
	11/18/2022	Daniel Neff	Light of Christ Catholic Schools
	11/18/2022	Todd Benson	Shiloh Christian School
	11/28/2022	Ryan Lagasse	Mandan Public Schools
Higher Education	12/01/2022	Brenda Nagel	University of Mary
	12/01/2022	Brent Kleinjan and Leander (Russ) McDonald	United Tribes Technical College
	01/05/2023	Karen Erickson	Bismarck State College
Real Estate Development	12/13/2022	Donna Fricke, Karen Silbernagel, and Nadeane Silbernagel	Silver Ranch/Silbernagel Family
	12/14/2022	Kelsi Hach and James Hach	Hach Family
	12/14/2022	Robert Martin	Ward Family
	12/16/2022	Chad Wachter and Jamie Schmidt	Investcore and Wachter Development
	12/19/2022	Chad Moldenhauer	K&L Homes
	12/19/2022	David Witham and Jake Axtman	Denizen Partners
	12/21/2022	Cam Knutson	Kuntson Realty

MAJOR THEMES

Overall, the major themes from the focus group meetings include:

Growth Expectations

There is consensus about growth moving forward for the Bismarck-Mandan region. People are optimistic about the direction and expect stable, steady growth through 2050. Focus groups mentioned the need to grow smart and responsibly moving forward. Focus groups also speculated more regional competitiveness for Bismarck-Mandan which will help attract people from small towns in North Dakota, other communities across the upper Midwest (big and small), and beyond.

Growth Drivers

The region's economy feels stable to people. Healthcare, State Government, and education were mentioned most often as the biggest reasons for stability. The energy and financial sectors were also mentioned as being critical to the regional economy.

Parks and recreation, natural resources, the Missouri River, and the attractive landscape were mentioned as a growth driver in nearly every meeting. The region is very connected to the natural beauty of the area, and it's attracting people.



Interviewees mentioned the family-friendliness, cleanliness, sense of community, diversity, and safety of Bismarck-Mandan as important social factors that will help continue to drive growth for the region in the future.

People are noticing the rural exodus happening across the state/upper Midwest, with people moving to regional hubs like Bismarck-Mandan for better access to education, healthcare, business opportunities, social services, and other amenities not found in rural areas.

Other trends brought up, which are seen nationally include workforce shortage, immigration, e-commerce, telecommuting, cost of living (inflation), and the mental health crisis. These factors could have a positive or negative impact to growth and it may be too early to speculate how they'll specifically impact regional growth in the future.

Negative Factors

There is a lot of speculation that housing availability (options) and affordability will continue to be an issue and something different needs to happen to make ground on these issues. Incentives, infill development, and increased density are a few of the creative examples mentioned.

The workforce crisis is a national trend, but it was mentioned as a big barrier to growth moving forward across the board, with nearly every focus group interviewee mentioning it as an issue for their business/organization/institution.

Infrastructure and the timing of development is a concern for most real estate developers. The expense and financing of infrastructure in and of itself is a barrier, but also the time it takes to get infrastructure in the ground ready for homes and businesses can delay projects and add to the overall cost of real estate. It was mentioned that the City of Bismarck is in the process of pursuing funding for a city-wide sewer system upgrade.

Another concern is migration, specifically the migration of young people looking to establish themselves in a community. People think the region could do a better job of marketing to and retaining young people looking to settle down and start building their lives after receiving their education.

Specific Locations/Issues Related to Transportation

- Poor mobility north and south across the region.
- Lacking public transit and taxi services to meet the needs of social services and other people who utilize transit or taxi service.
- People see the planned 66th Street interchange with I-94, on the eastern edge of Bismarck as a short-term priority.
- Silver Ranch property owner interested in helping with local match for TA grant to construct a grade separated path or trail for bicyclists and pedestrians to cross 43rd Avenue.
- Need for the planned interchange on the western edge of Mandan also mentioned.
- UTTC intersection safety issues with ND 1804.
- Shiloh Christian School safety and operational issues at the intersection of N 19th Street and Shiloh Drive.
- Explore bike and pedestrian trail feasibility along BNSF railroad through downtown.



INDIVIDUAL FOCUS GROUP SUMMARIES

Focus Group summaries are a compilation of the key takeaways from individual meetings. Please see Attachment A for individual meeting responses.

Economic Development

Opportunities

- Half-cent sales tax for major roadways sunsets in 2028. Has been a positive for Bismarck.
- New interchanges should be studied east of Bismarck and west of Mandan. Will need to explore resources to get those built.
- Been improvement in future planning for k-12 education, investment in smart expansion.
- Attractive to people leaving rural communities.
- Will have to get more competitive regionally. Foster creative development and programs.
- Stable economy – diverse economy. Healthcare, education, energy sector, and state government.
- Some of the lowest utility rates in the state/country.
- Interstate access, service from two class I railroads.
- Compared to neighboring states, a lot of business incentives. Bank of ND could be tapped into even more, marketed to attract business development.

Constraints

- Infrastructure to accommodate growth, funding infrastructure, timing for development.
- Chamber EDC wants to attract a larger manufacturing base.
- Retail and service sector growth – workforce shortage and finding employees is difficult.
- Climate, construction season is shorter, leads to other issues.
- Addressing housing is a big priority for the Chamber EDC. Looking to do a housing assessment and start a housing task force in the region.

Other Feedback – Economic Development

The Bismarck Mandan Chamber EDC's most recent strategic plan is projecting 10% growth over 10-years. Bismarck-Mandan could benefit from more telework, allowing people from bigger cities to move to a place with higher quality of life, lower cost of living, shorter commute times, etc. The Chamber EDC does a lot of targeted marketing in other states/metros like Seattle, Portland, Denver, Kansas City, Chicago, Minneapolis, State of Illinois, and the State of Michigan. They try to keep it to areas with similar climate, also trying to attract and recruit people back who have left the state. Typically, people move back to the region because they have some sort of tie to the area.

Sanford hiring 200 international nurses and Cloverdale hires a lot of workforce from American Territories. May be more opportunities for Ukrainian immigration because there is already an established Ukrainian population/heritage in the region.



Housing

Opportunities

- Tremendous growth, quite a few sites for single-family and multi-family housing development
- School growth and enrollment, projecting future growth
- Healthcare, education, and state government.
- Very active social services and non-profits. Housing agency tenants have more support and access to support than other parts of the state.
- Parks and recreation, other amenities are attracting people to the area. Communities making conscious effort to provide extra draw for people to live here.
- Second biggest region in the state, but still feels small
- A lot of jobs in the region

Constraints

- Workforce impacts to the economy, could stifle growth
- Continuous growth
- Cost of housing is not affordable, makes jobs harder to fill
- Starting to see more “big city” problems.
- Housing for ex-convicts/sex offenders is really tough but a necessary service. Really challenging to get those people in units as they are excluded from some federal programs and most landlords don’t accept vouchers knowing the tenant’s history.
- Mental illness and addiction services are a growing need in the area. Need more tie between housing and those types of services and will grow in importance.

Other Feedback – Housing

Housing agency tenants are made up of 1/3 seniors and 1/3 families. There is a lack of affordability in the region (and across the state). Affordable housing projects need to keep pace with other types of development.

Morton County only offers a voucher program and voucher numbers/applications have been dropping which is the opposite of what they expected. More people signed up for ND Rent Help (funded through the state by COVID-19 relief packages). People can be on both programs but ND Rent Help has fewer barriers. There is a two to four month lead time for Morton County Housing vouchers and one month lead time for ND Rent Help. ND Rent Help also pays higher dollar amounts without income limits. The ND Rent Help program was funded with \$150 million COVID-19 stimulus. Funds will dry up eventually.

Burleigh County Housing uses six to eight different programs/grants to put one affordable housing project together. They do about four to five projects per year. Their largest project to date was a 40-unit permanent supportive housing project in 2019.



Social Services

Opportunities

- Lots of jobs, could get a job anywhere.
- Clean community, welcoming, a lot of activities.
- Family oriented
- Outdoor recreation.
- Need more transit and transportation services for the people they serve.
- Lots of collaboration across the region in the social services sphere.
- Fostering and supporting growth of the healthcare system in the region.

Constraints

- Labor shortage
- Need more elderly supportive services.
- Housing affordability
- Poverty, transportation for impoverished. Coordinate a lot of transportation for families in need.
- Working poor, people not making enough to meet the cost of living.
- Addiction issues, people still need services.
- Taxi service in the region is unreliable.
- Workforce retention is really hard for social services.
- Inflationary pressure for basic needs.
- Medical transportation.
- Need more robust transit service.
- Emergent mental health or addiction services, need timelier services.

Other Feedback – Social Services

Not directly involved in future growth of the region but has more of a reactionary impact. Agencies respond as needed to help impacted folks. Elderly services to keep people aging at home is a growing service area. Have seen more families moving to rural parts of Morton County without even having a connection to the community because that is where they found affordable housing. Not a huge trend of people moving to smaller towns and rural areas of Morton but it's noticeable by their department. Poverty is the most prevalent issue they see. 3 Rivers Human Service Zone doesn't see a huge impact from immigration. They have lost staff to higher paying jobs outside of the community.

Burleigh County services continue to grow. Some immigrants are eligible for Temporary Assistance for Needy Families (TANF), may see more Ukrainian refugees. Haven't seen any immigration impact to services.



School Districts/Private Institutions (k-12)

Opportunities

- Great healthcare, great schools including higher education, natural resources, and state government.
- Financial service industry.
- Blue-collar jobs.
- Family values.
- Good size city with attractive amenities. Size of city is attractive to people who want big city amenities but Fargo feels too big, more approachable size.
- Lots of diversity.
- Healthy competition between education institutions.
- Hunting and fishing, Missouri River.
- Economy of scale, easier to make a life for yourself in Bismarck-Mandan, and the American dream is still alive. Accessibility to amenities and opportunities.
- School choice.
- Mandan being more and more progressive, investing in parks and recreation, other amenities. Tax dollars being put to good use.

Constraints

- Affordable housing, may be worse in Bismarck than in Mandan. Housing options needed.
- Workforce shortage.
- Childcare.
- Cost of living, inflation.
- Safety—starting to see more big city safety issues.
- 19th Street N intersection (Shiloh Christian School entrance) is hazardous and functions terribly during school drop off and pick up.
- Growth.
- Finances.
- Infrastructure extensions are cost prohibitive.

Other Feedback – School Districts/Private Institutions (k-12)

Bismarck School District is focused on social-emotional learning and has a systems integration framework for example, they partner with Sanford to provide children's doctor appointments at school during the school day. Strong English learning curriculum and provide education for workforce and families. Well-balanced priorities in fine arts and athletics, not hyper-focused on just one thing.



Dakota Adventist Academy does not project much enrollment growth long-term. Recent enrollment has varied from 34-50 students. There are also 17 staff and 3 families that live on campus. In the 1980s enrollment was as high as 180 students and have seen long-term decline in student population.

Light of Christ believes Bismarck-Mandan has a great education ecosystem, especially with strong Catholic Schools and the University of Mary (Catholic University).

Shiloh Christian Schools is going to be at capacity with 720 students in three short years. Not 100% certain how or if they will expand beyond that number. The pandemic was a boon for Shiloh, as they allowed in-person classes and were able to add another section of kindergarten. Provide flexible hybrid high school curriculum that allows students to take college credits, internships, etc. to help better prepare to enter the workforce or to transition to higher education.

Mandan’s housing is closer to Mandan’s city center/commercial district and hasn’t yet sprawled like Bismarck is experiencing. New Mandan High School north of I-94 opens in the Fall of ’24. Excited about the direction of the Mandan community, amenities, new schools, young families, and heading in the right direction. Speculates higher growth rates in Mandan than Bismarck because there is more land closer to the core of the community.

Table 3. School Enrollment (k-12) Projections

SCHOOL	2022/2023	2023/2024	2024/2025	2025/2026	2026/2027
Bismarck School District	13,656	13,912	14,081	14,217	14,331
Light of Christ	1,434	1,475	1,509	1,546	1,573
Shiloh Christian School	650	No projection available	No projection Available	No projection Available	720 (max.)
Mandan School District	4,267	4,412	4,511	4,620	4,794

Higher Education

Opportunities

- Changing, growing community.
- Mandan Downtown district, has a lot going on.
- State government, good jobs, school system is great (public and private), investing even more in education, supporting kids, starting to pump out a lot of good workforce.
- Lots of business successes in the community.
- Parks and recreation.
- Regional businesses providing resources across the western part of the state.



- Diversity. Bismarck-Mandan has a higher % of Native American/Indigenous people than other parts of the state.
- Education, services, shopping, and healthcare.
- Oil and energy administration in the region.
- Strong job market. Regional competition.

Constraints

- Community open-mindedness.
- Infrastructure needed to support businesses.
- Washington St. between 3:00pm and 5:00pm is an absolute nightmare.
- Workforce and retention.
- Housing for students. Especially those working to pay for school. Need more affordable options.
- Cost of living.
- Job market for employers (current).
- Small-town agriculture.
- Child care.

Other Feedback – Higher Education

University of Mary is projecting 5,000 students by 2030 with 2,500 undergrad and 2,500 online. They recruit 510 Freshman students each fall and 140 transfer students. Good percentage of students live on campus. Freshman residence halls are 100% full. Currently have 3,800 students. Bulk of growth moving forward will be online students. Their best estimate is that 35% to 40% of undergraduates stay in the region. Very good nursing program, business administration, and behavioral sciences. Just added an engineering school/program – trying to help with the regional workforce problems everyone is experiencing.

United Tribes Technical College (UTTC) is on 230 acres that was the former Fort Lincoln internment site. UTTC receives federal funding, USDA funding, Bureau of Indian Education (BIE) funding, and some Indian Health Services (HIS) funding. Enrollment has to be majority native/indigenous, or funding could be lost. UTTC’s focus is tribal affiliated students. UTTC doesn’t do enrollment projections but shared that they project historic growth long-term based off historic enrollment. There was a fatality (or two) at UTTC’s back entrance and intersection with ND 1804.

Table 4. UTTC Historic Enrollment

STUDENTS	2018	2019	2020	2021	2022
Full Time	369	388	316	423	473
Part Time	59	46	10	51	33
Total	428	434	326	474	506



Bismarck State College (BSC) does not project enrollment rather, credit hour production. Their goal is to hit 90,000 credit hours by 2027. Current enrollment is around 4,000 and they have housing on campus for 400. Their average students are less than full time, which is less than 12 credit hours (per semester). BSC recently transitioned to a polytechnic institution. Strong energy related education and training, BSC is home to the Department of Energy's National Energy Center of Excellence.

Real Estate Development

Opportunities

- Internal growth and retention.
- Market is strong.
- Housing growth potential in rural communities of Burleigh and Morton Counties (affordability).
- Parks and recreation, outdoor recreation, clean air.
- State government jobs, associated federal satellite offices and jobs.
- Aesthetically nice community.
- Amenities, outdoor activities, bike facilities, and Missouri River.
- Infill, and different housing types (patio homes/missing middle)
- Attracting older population with good healthcare.
- Pursue more state funding.
- High quality of life, and relatively low cost of living.
- Bank of ND and business development.
- Stable, consistent growth.
- Smaller community businesses moving to Bismarck-Mandan.
- Coal industry transition.
- Immigration, people from other countries.

Constraints

- Housing affordability.
- Developments/Developers waiting for infrastructure—infrastructure timing.
- Workforce.
- North-south arterial roadway, north-south mobility.
- Local jurisdictions not always prepared for development.
- Cost of living for families. Lack of winter amenities/activities.
- Internal circulation problems run rampant.



- Transit.
- Financing costs.
- Carbon sequestration pipeline (easement north/northwest of region).
- Utilities—sewer utility biggest concern. Seem to be limitations everywhere.
- Supply chain.
- Climate of the region is just hard to sell.
- Floodplain.
- More industry in town.
- Mobility to and from Downtown Bismarck medical facilities.

Other Feedback – Real Estate Development

North-south mobility in the region was brought up as a complaint from numerous developers. North part of region anticipating where most growth is going to occur.

Smaller developers or areas with different land owners struggle to develop because a lot of land is needed to make the financials work, in part due to infrastructure costs.

Planned 66th Street interchange was brought up as important to development in the northeast area of Bismarck but also for City of Lincoln mobility.

Housing trends seem to be more north, not a lot of opportunities to south. Mandan housing may be cheaper than Bismarck.

Commercial trends towards shop condos. Even some discussion about live/work type shop condos in the region.

City/developer cooperation and coordination so things can line up and move forward on schedule. Processes are improving but not where they need to be.

Appendix C

ARRIVE 2050

FORECASTS



Forecast Methodology MEMORANDUM





To: Rachel Lukaszewski, Executive Director
Bismarck-Mandan MPO

From: SRF Consulting Group, Inc.

Date: December 21, 2022

Subject: Arrive 2050 Forecasts – Forecast Methodology Memorandum

INTRODUCTION

As part of the Bismarck-Mandan Metropolitan Planning Organization’s (BMMPO) updates to its Travel Demand Model, the socio-economic data used for the travel demand model will be updated and extended to a horizon year of 2050. The socio-economic data includes information about population, households, and employment. Forecast approaches for each of these variables are outlined in this document.

This memorandum documents the data, methods, assumptions, and results of the demographic forecasts prepared for BMMPO’s update of its travel demand model and Metropolitan Transportation Plan (MTP). Sections of this memorandum include the population model process, the household model, and employment forecasts.

POPULATION MODEL METHODOLOGY

This project will use a cohort-survival model to forecast the Bismarck-Mandan population from 2021 to 2050. The population will be forecast by five-year age cohorts and sex. All model elements will be estimated for the years 2021, 2025, 2030, 2035, 2040, 2045, and 2050. Detailed cohort data will be available at each five-year interval.

There are a total of 36 categories modeled within the age-sex cohorts at each 5-year interval. This produces valuable information for planning projects among others. Cohort model total population forecasts will be enhanced using estimates of population growth rates calculated outside the cohort model. Population totals will be forecast at the county and city level from 2021 to 2050 using linear time-series analysis and compared to the cohort model result. These totals will then be used to balance and calibrate the cohort model.

Comparing the cohort survival model totals with trend analysis results will meet the demographic forecast data needs of the BMMPO. The cohort survival model will be informed by the cohort models estimated as part of the “North Dakota Population Projections: 2005 to 2020” (Source: NDSU) and the “New York City Population Projections by Age/Sex & Borough 2000-2030” (Source: City of New York). The New York City study provides information regarding migration estimation over time. The model used in that study isolates migration changes at the cohort level. Their approach will be the basis of modeling migration at the more granular level. Both data sources offer a wide breadth of approaches that will help augment SRF’s existing cohort model in the estimation of the BMMPO model.



Cohort Model Description

Broadly speaking there are two types of demographic models, component models and summary models. Summary models analyze a ‘top-level’ variable that ‘summarizes’ information, like the total population of the BMMPO. It is a data point summation or grouping of all people in the BMMPO into one statistic: total population. A linear model can predict this top-level variable effectively and efficiently with relatively little time or effort. However, linear models do not take cohort interaction effects into account.

The component model takes the opposite approach. Instead of working from the total and forecasting, component models look at the ‘components’ of a population, the things that separately impact population change. In demographic cohort models, migration, birth, and death are the three components changing a population over time.

The cohort model estimates births, death, and migration for a current population into the future. These estimates are applied, and the new population is formed. A new set of births, deaths, and migration is estimated for the new model which is used to create a new future population. This is applied iteratively over several periods. The existing cohorts are also ‘aged’ through the process, meaning the 2020 population of 55-year-olds are the same model units as the 2025 population of 60-year-olds, after death and migration are calculated. This process is repeated at 5-year intervals throughout the analysis period. How the inputs are found and agreed upon has the most impact on model results.

There are a group of models like the one used in this analysis that have similar names like, “age-period-cohort analysis” and “cohort component analysis”. These models might follow identical approaches or very different approaches depending on who named them. “Cohort-survival model” is the term used in the 2002 North Dakota population projections from the North Dakota State Data Center, which is part of the foundation for this study. For this report, “cohort-survival analysis” or simply “cohort analysis” will be used to describe the model method. However, if further research into this subject is desired, an internet search of the term “cohort component analysis” will yield results most pertinent to this project.

Cohort Model Review

To review the previous population studies in this area and cohort models in general, the North Dakota 2005-2020 forecasts are compared to observed populations in 2010 and 2020.

Table 1. 2010 Forecast Comparisons

AREA	2010 FORECAST	2010 DECENNIAL CENSUS	PERCENTAGE DEVIATION
North Dakota	645,325	672,591	-4%
Burleigh County	72,531	81,708	-11%
Morton County	27,481	27,570	-0%



Table 2. 2020 Forecast Comparisons

AREA	2020 FORECAST	2020 DECENNIAL CENSUS	PERCENTAGE DEVIATION
North Dakota	651,291	779,094	-16%
Burleigh County	74,727	98,458	-24%
Morton County	29,521	31,503	-6%

Table 3. Cohort Forecast Comparisons

COHORT AGE	2010 ACS	2010 ND FORECAST	PERCENTAGE DEVIATION	2020 ACS	2020 ND FORECAST	PERCENTAGE DEVIATION
Under 5 years	44,561	37,359	-16%	53,408	36,579	-32%
5 to 9 years	42,536	38,739	-9%	50,371	38,301	-24%
10 to 14 years	37,810	39,968	6%	47,837	37,679	-21%
15 to 19 years	47,262	45,877	-3%	47,973	41,547	-13%
20 to 24 years	59,415	49,614	-16%	63,280	44,295	-30%
25 to 29 years	49,288	40,487	-18%	60,455	34,771	-42%
30 to 34 years	39,160	36,576	-7%	55,001	36,153	-34%
35 to 39 years	37,810	36,988	-2%	48,616	38,503	-21%
40 to 44 years	38,485	37,925	-1%	41,968	35,237	-16%
45 to 49 years	46,587	45,837	-2%	39,175	35,876	-8%
50 to 54 years	50,638	49,481	-2%	41,668	37,101	-11%
55 to 59 years	46,587	42,337	-9%	48,052	41,247	-14%
60 to 64 years	36,459	33,908	-7%	46,184	44,436	-4%
65 to 69 years	26,332	26,433	0%	38,071	42,015	10%
70 to 74 years	20,255	22,942	13%	26,029	34,293	32%
75 to 79 years	18,905	21,380	13%	19,609	26,493	35%
80 to 84 years	15,529	20,647	33%	14,913	22,507	51%
85 years and over	16,879	18,827	12%	17,784	24,258	36%

Tables 1, 2 and 3 show the differences between predicted populations and actual populations in 2010 and 2020 in the state of North Dakota. These predictions were published in 2002, so these are 8- and 18-year forecasts. Table 1 shows the statewide and county level differences for 2010. At this point the forecasts are fairly accurate, with Morton County at 0% deviation and Burleigh being off the by 11%. Contrast this with Table 2 where the Burleigh difference increases to 24% lower than the forecast. The Morton County 18-year forecast us very accurate. The forecast population was only 6% less than the true 2020 population.

Table 3 displays the cohort data compared at the statewide level. The 2010 results show the forecast data to be fairly accurate for ages 30 to 70, but that many of the ages on the edges were less accurate.



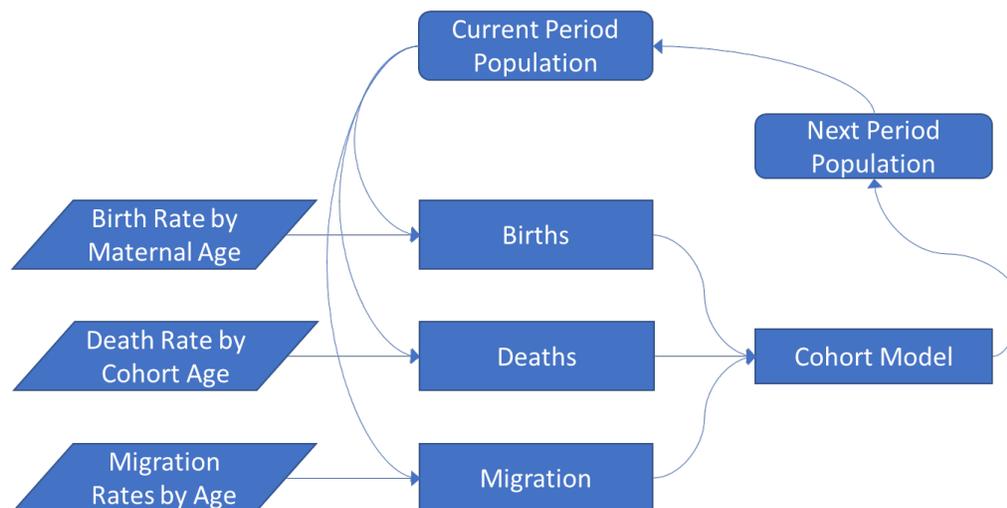
The 2020 results show a similar trend, although all the cohorts have high differences except 45-49 and 60-64. The starting ages of those cohorts in the 2005 model year were 30-34 and 45-49.

These tables show that this cohort model has a reasonable level of error and can make good predictions. The shale oil boom and its myriad impacts on the state present a situation that would have been hard to foresee. This contributes greatly to the areas where the cohort model is incorrect in general. The 2002 North Dakota study shows the importance of accounting for as much as possible and the inevitability of error in forecasts. The forecast also shows that cohort models are good predictors on shorter time frames, which is often true of the forecast method. This isn't necessarily a problem, rather a reason to continue to update forecasts about once every 5 years.

Cohort Model Application

The application of the cohort model is an iterative process that can be performed with any preferred mathematical analysis/modeling software. At a high level, the estimation process is the same across all cohort models.

Figure 1. Cohort Model Process Flowchart



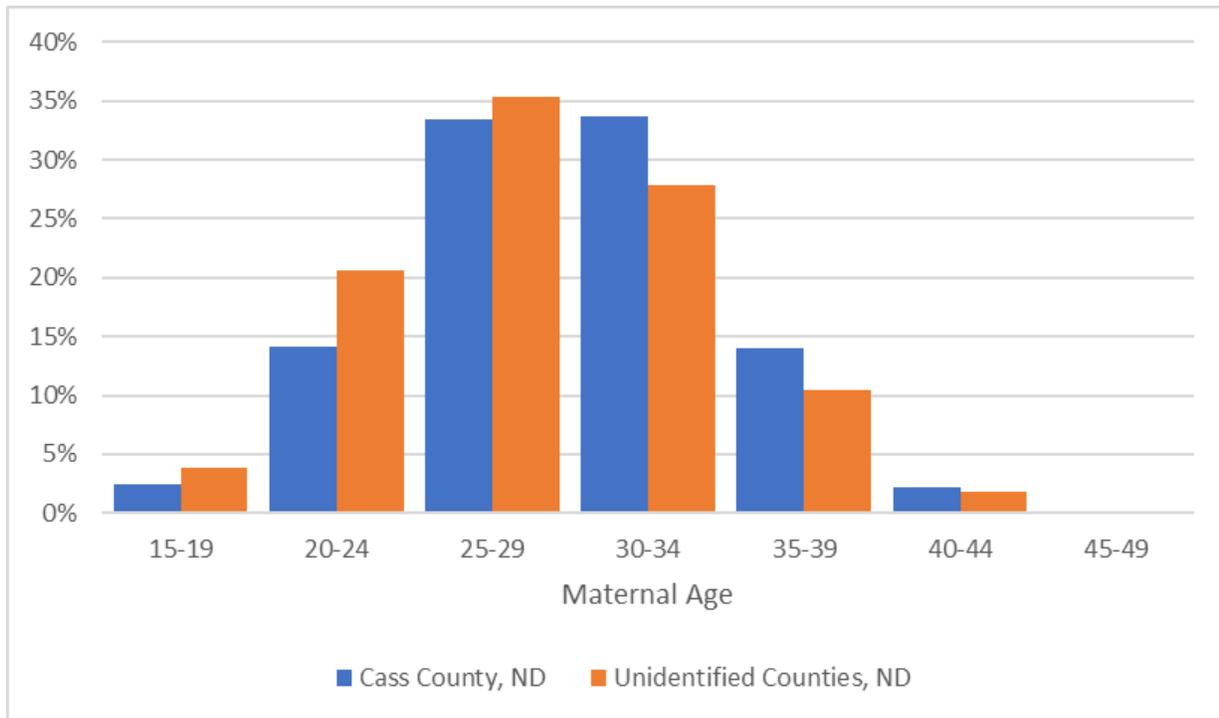
The flowchart in Figure 1 shows how the input statistics, birth, death, and migration rates are combined with information about that period's population to calculate the estimated births, deaths, and migration. Once this data is run through the mathematical model, a new population is estimated. The new population is put into the model again and the population is forecast another 5 years into the future. This process is repeated until the desired length of forecast is complete.

Birth Rates

Birth rates are available online from the CDC using the webapp, CDC WONDER. However, the detailed CDC birth rate data only covers Cass County and the so called 'Unidentified Counties' in North Dakota.



Figure 2. North Dakota Birth Rates



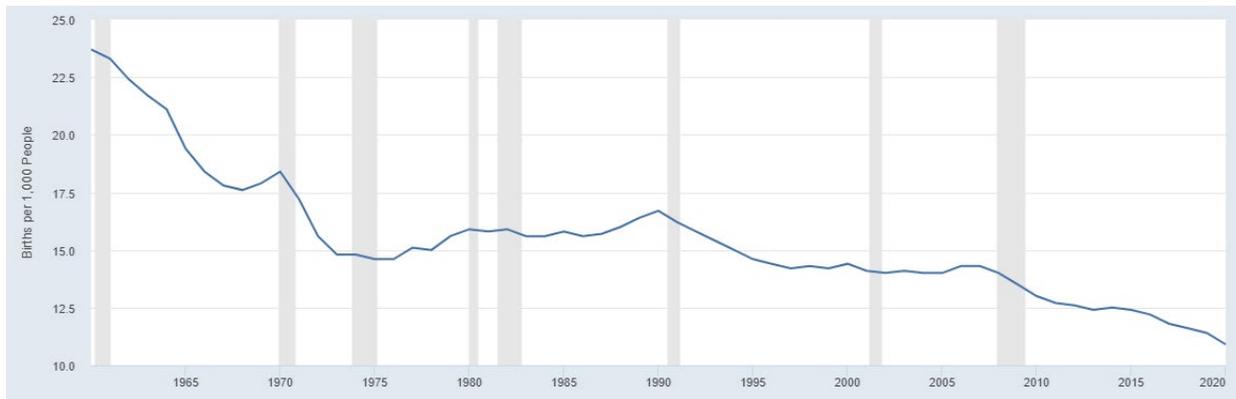
Source: CDC WONDER, <https://wonder.cdc.gov>

Figure 2 shows birth rates for Cass County as well as the unidentified counties, which includes BMMPO. The distribution trends older in Cass County and younger elsewhere. Cass County has relatively more births with maternal ages between 30 and 39 while the other counties have relatively more births with maternal ages between 20 and 29. The 2005-2050 North Dakota cohort model, described above, estimates birth rates using a 3-year average, 1998 – 2000, and applies a county specific rate for the birth estimates. The document does not describe a data source for these rates.

This analysis will use maternal age-specific birth-rates from all North Dakota counties, other than Cass. Birth rates have changed a lot in recent decades. Older motherhood has become more common and has caused slight increases in maternal birth age. The overall birthrate has dropped in many places. The continued decline of pregnancy in women’s teens and early twenties which began in the 1990’s has decreased the birth rate overall.



Figure 3. US Birth Rate Trends



Source: World Bank, Crude Birth Rate for the United States [SPDYNCBRTINUSA], retrieved from FRED, Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/SPDYNCBRTINUSA>, October 23, 2022.

Figure 3 shows the long-term trend of birth rates in the United States. It is easy to assume these changes apply everywhere around the country. However, Table 4 shows North Dakota birth rates have followed a different pattern. In 2005 the fertility rate in North Dakota was 64.8 births per 1,000 women of childbearing age and increased to 67.4 in 2020. The rate was as high as 76.4 in 2015. This is different from the country-wide slow decline from 66.7 to 56.0 between 2005 to 2020.

Table 4. Fertility Rate Comparison – Births per 1,000 Women Aged 15-55

YEAR	NORTH DAKOTA	UNITED STATES
2005	64.8	66.7
2015	76.4	62.5
2018	72.2	59.0
2020	67.4	56.0

Source: https://www.cdc.gov/nchs/pressroom/sosmap/fertility_rate/fertility_rates.htm.

The birth rates, by maternal age, will be held constant throughout the analysis period. The empirical data shows the North Dakota birth rate to be stable, if not increasing. Keeping the birth rate constant would be an accurate reflection of the recent history in North Dakota, with respect to a long-term forecast into the future. It is also a better approach from a modeling perspective. The more model inputs that are modeled themselves, the less accurate the model becomes. Trying to model too many inputs results in over-specification and an overly sensitive model. Such a model would likely be overreactive and often overestimate the impacts of various exogenous shocks to the system. However, scenarios can be analyzed where birth rates are higher, or increase or decrease throughout the analysis period.



Table 5. North Dakota County* Births 2016-2020

MATERNAL AGE	NUMBER OF BIRTHS	MATERNAL AGE DISTRIBUTION
<15	16	0.0%
15-19	1,581	3.9%
20-24	8,403	20.6%
25-29	14,429	35.3%
30-34	11,387	27.9%
35-39	4,259	10.4%
40-44	724	1.8%
45-49	44	0.1%
50+	-	-

Source: CDC Wonder Natality, 2016-2020 Expanded,
*Does not include Cass County

Table 5 shows the distribution of births across different maternal ages in North Dakota from 2016 through 2020. The aggregate birth rate in this model will be 70.6 births per 1,000 women between 15 and 55. This is consistent with recent observed trends in North Dakota and the Together 2045 Comprehensive Plan that reports the North Dakota aggregate birthrate to be 70.6. Births will be calculated with age-specific rates in Table 5, and then checked, calibrated, and adjusted with 70.6 as a reference point.

Death Rates

Death rates do not stay the same over time. At what point in time a person is born is highly correlated with their life expectancy. Someone born in 2010 has an overall longer life expectancy than someone born in 1910. Cohort models track a group of individuals over time and the starting age of each cohort impacts its longevity. Death rates will be calculated using CDC WONDER data, at the county or city level where possible.

As the model progresses through time. The life expectancy of the cohorts will increase slightly. The magnitude of these increases will be determined by the birth year of each cohort. For this model, at the 2021 starting point, the 85+ cohort was born in 1936 and before. The 5 to 9 age cohort will have a birth year range of 2012 – 2016. The life expectancy of the 5 to 9 cohort will increase over the course of the model along with the other younger age cohorts. Older cohorts, like the 85+ will experience smaller increases. These adjustments can also help create the three different scenarios for this project. Increasing or decreasing the overall changes to life expectancy will increase or decrease the overall populations as part of creating the scenarios.

Migration Rates

Migration plays a large role in population change in any community. The level to which migration impacts a community varies based on economic, geographic, or political elements. Migration can be studied to a very detailed level by itself. Cohort modeling is not specifically focused on studying migration in an area. The goal is to have an input to the larger model that is reflective of observed reality while also functioning correctly within the cohort model.



Aggregate migration rates and totals will be calculated using available county-to-county migration data. These rates are not broken down by age or sex. To find these age and sex specific migration rates to use in the cohort model past cohort data is analyzed. Consecutive ACS data combined with recorded death rates are used to estimate cohort specific migration rates. The age specific rates are compared to the aggregate totals, and this should yield cohort migration rates for the model. Migration trends can also be adjusted, like life expectancy, to help create different scenarios to analyze.

HOUSING AND DEMOGRAPHICS FORECAST

Housing forecasts will include aggregate measures of housing as well as more detailed socio-economic breakdowns of current and future housing in the Bismarck-Mandan Area. Baseline housing characteristics will be taken from the 2020 Decennial Census as well as 2021 ACS data. This data will establish household size and makeup.

Current demographic information will be used to create a regression analysis between the number of households and each age cohort’s population. The estimated coefficients can be applied to the forecast age cohort populations to estimate the complete housing stock in any given forecast year. Other demographic elements like number of college students or percentage renter occupied housing will also be regressed on past cohort data in order to use the forecast cohort information to estimate future values.

Table 6. Select Housing Statistics

AREA	HOUSEHOLDS	PERSONS PER HOUSEHOLD
City of Mandan	9,832	2.24
City of Bismarck	32,393	2.20
Morton County	13,502	2.26
Burleigh County	39,805	2.32

Source: American Community Survey (2016 – 2020)

Table 6 shows recent data on households in Burleigh and Morton Counties. The table shows the number of households and the persons per household. A simple way to estimate future households is to estimate future population and then divide by the baseline persons per household. That approach can be used in this project as one validation check against the linear model that will predict future housing.

EMPLOYMENT FORECAST

Employment is quickly evolving. Where people work from, how, and how often has changed with the advent of widespread remote work in response to COVID-19. While the level of remote work has decreased since March 2020 it is likely remote work will continue to be a large part of the economy moving forward. Automation and other recent technological advancements, particularly in the field of robotics, will undoubtedly continue to reshape the economy. Employment forecasts will take elements



like this into account as they are created. As part of the scenario estimations, adjustments can be made to inputs to reflect the different things impacting work and the workplace into the future.

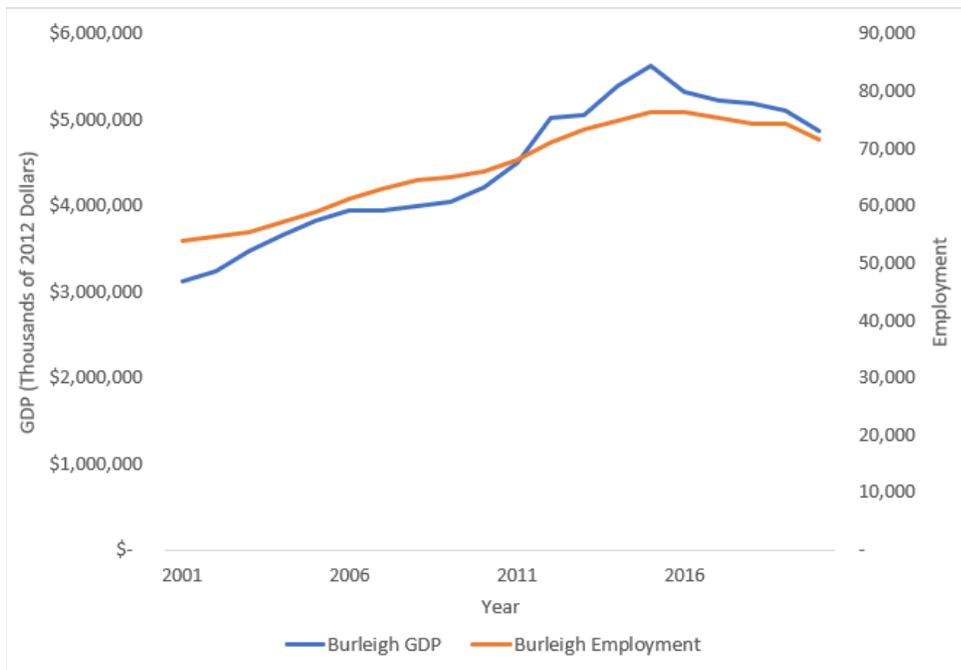
The employment forecast will be based on the gross domestic product (GDP) of Burleigh and Morton Counties. Using machine learning based time-series analysis the GDPs will be projected into the future. The aggregate GDP will be broken down into broad sectors based on the North American Industry Classification System, 2 Digit (NAICS2) Codes.

Table 7. NAICS2 Industry Classification

INDUSTRY	NAICS2 CODE
Agriculture	11
Educational Services	61
Manufacturing	31-33
Construction and Mining	21,23
Retail Trade	44-45
Services	51-53,55-56,62,71,81,92,99
Utilities, Wholesale Trade, and Transportation	22,42,48,49

Table 7 displays the sector classifications that will be used. The regression analysis will consider the NAICS2 codes directly to provide greater detail but will then aggregate those codes according to Table 7. Alternatively, if individual NAICS2 code time-series have significant variance issues, projections would be performed at the aggregate level to stifle the ‘noise’ in the data.

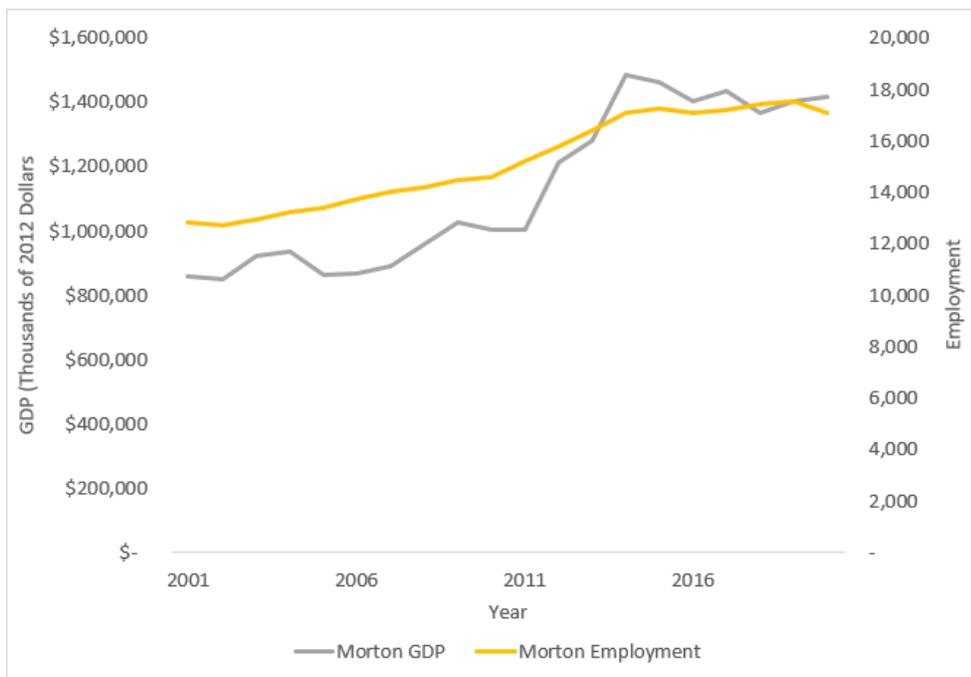
Figure 4. Burleigh County Employment/GDP



Source: Woods & Poole, CAGDP9 Table Bureau of Economic Analysis



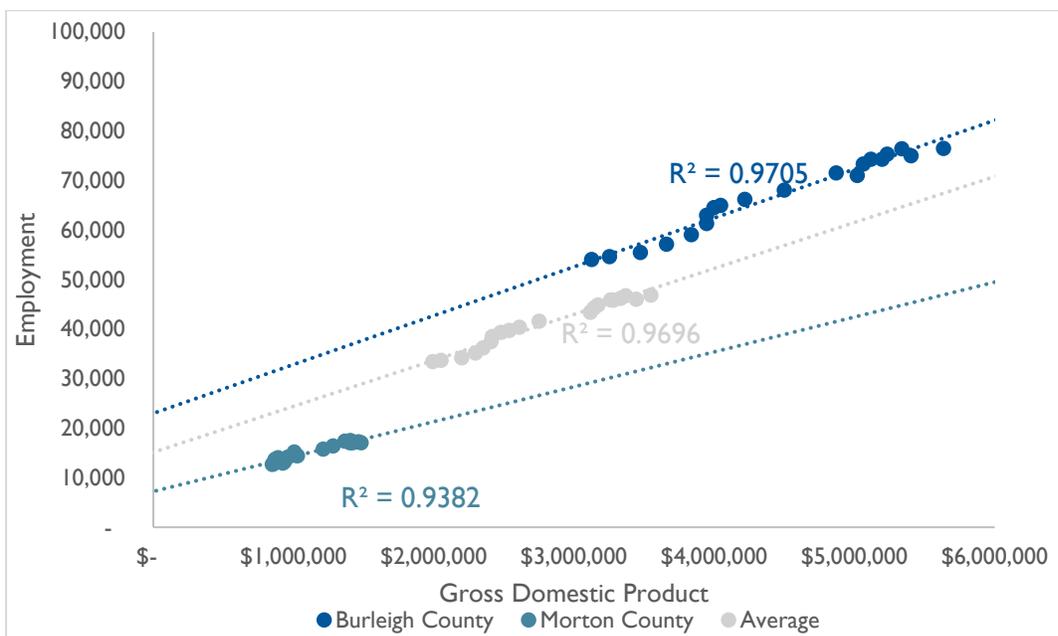
Figure 5. Morton County Employment/GDP



Source: Woods & Poole, CAGDP9 Table Bureau of Economic Analysis

Employment is going to be forecast from the time-series projections of GDP. Figures 4 and 5 show employment and GDP times-series for Burleigh County and Morton County. Both sets of lines follow very similar paths over time, which is to be expected given what the data represents. The relationship between employment and GDP is also estimated using regression analysis.

Figure 6. GDP Employment Regression Relationship



Source: Woods & Poole, CAGDP9 Table Bureau of Economic Analysis



Figure 6 shows that Burleigh and Morton Counties display high correlation between employment and GDP. GDP is more accurately measured than employment because it's based on consumption. In any given year it is much easier to calculate the total amount of money that was spent on construction compared to the actual number of employees who worked in construction.

Equation 1. GDP Machine Learning Model

$$k_{GDP_t} = KNN(GDP_{t-1}, GDP_{t-2}, \dots, GDP_{t-n})$$

$$GDP_t = \overline{GDP_k}$$

Equation 2. Linear Employment Projection

$$\ln(\text{Employment}_t) = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 \text{Year}_t + \beta X + \varepsilon_t$$

Equation 1 shows the model for GDP. The model is known as K-Nearest Neighbors (KNN) regression, a machine learning approach. This approach has been found to outperform both linear models and traditional time series approaches in forecasting GDP.¹ This is likely because the approach captures multiple trends within GDP simultaneously in ways other methods cannot.

The KNN algorithm clusters data with similar data points. Existing GDP data is clustered into groups based on GDP in previous periods. Then to estimate future values, the future time-period is linked to the cluster it is most associated with based on that time-period's past GDP values. Then the GDP prediction is the average value of the GDP data points in the cluster it is assigned to. This is expressed in the equations. GDP_t is assigned to cluster k based on a function of its past values using KNN, $KNN(GDP_{t-1}, GDP_{t-2}, \dots, GDP_{t-n})$ which results in the estimate of GDP_t in time t $GDP_t = \overline{GDP_k}$ as equal to the mean value of observed GDP data points in its cluster k .

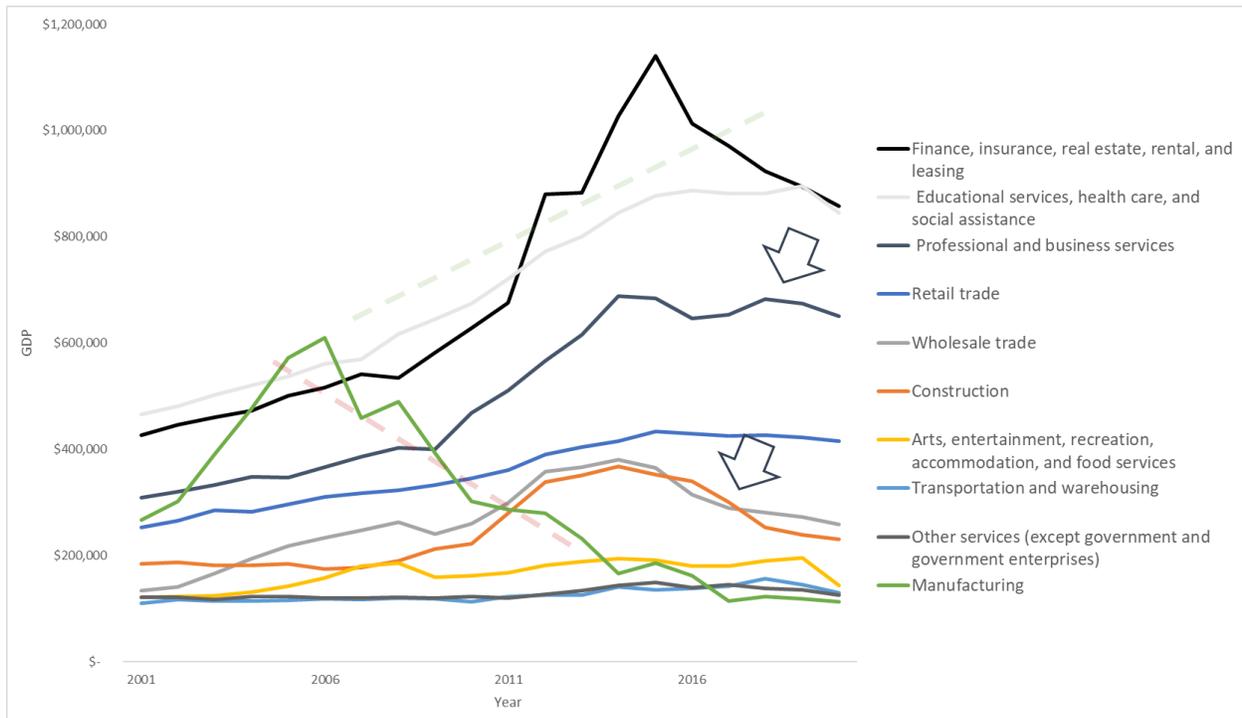
Equation 2 shows the log-linear prediction model for employment. The model uses a natural log transformation of employment and estimates a quadratic function of its relationship with GDP over time. Both measures improve the accuracy of the model and are commonplace in statistics.

The real power potential of this method is in Equation 2. While this project will estimate a model based on only GDP and Year. The βX represents all the variables that can be added to this model in the future, demographic variables or other work force or population determinants of employment. Many of these variables will be estimated into the future as part of the cohort analysis. This will allow future employment analysis to expand and enrich this model even further. Any future detailed employment analysis or projection will benefit greatly from this model configuration.

¹ Maccarrone G, Morelli G, Spadaccini S. GDP Forecasting: Machine Learning, Linear or Autoregression? Front Artif Intell. 2021 Oct 15;4:757864. doi: 10.3389/frai.2021.757864. PMID: 34723174; PMCID: PMC8554645. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8554645/>

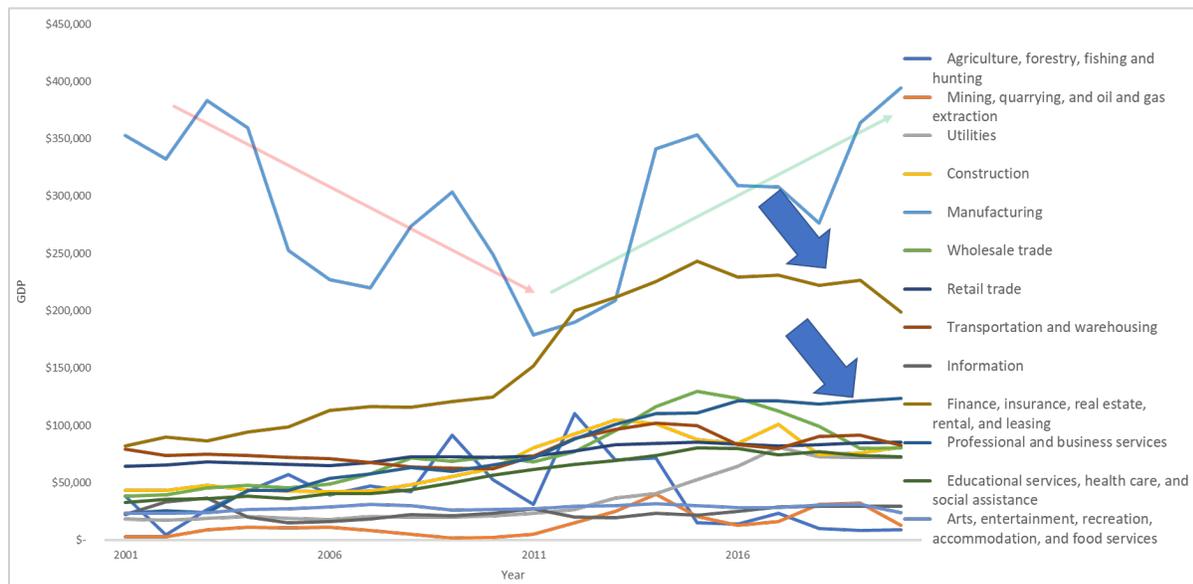


Figure 7. Burleigh County GDP Industries



Source: CAGDP9 Table Bureau of Economic Analysis

Figure 8. Morton County GDP Industries



Source: CAGDP9 Table Bureau of Economic Analysis

The economy in the Bismark-Mandan study area is strong and dynamic. For example, Figure 7 shows the large changes that have occurred in Burleigh County in the Manufacturing and Finance, Insurance, Real Estate, and Leasing industries. The Manufacturing industry has contributed less and less to the overall



GDP since 2006, this trend is represented by the red dashed line in Figure 7. The Finance, Insurance, Real Estate, and Leasing industry reached a peak in 2016 and has been decreasing since.

Special attention will be paid to emerging trends. Arrows in Figure 7 indicate the Professional and Business Services, Construction, and Wholesale Trade as industries where the future trend is not necessarily clear based on the recent GDP data. Industries like this will be analyzed using s-curve and/or life-cycle analysis to help determine the future behavior of those markets.

Manufacturing is an important part of the Morton County economy. This is displayed by Figure 8 the manufacturing line is the highest and has been for many years. Red and green arrows intend to represent a decline in the manufacturing GDP between 2001 and 2011. The green arrow highlights an upward trend in manufacturing production from 2011 to the present. The brown line, representing Finance, Real estate, Rental, and Leasing, shows fast growth between 2011 and 2016, but that growth appears to have tapered off. Industries like Construction and Professional and Business Services will be closely studied to determine where on the growth of they are. This information will be used to validate employment forecasts.

Appendix D

ARRIVE 2050

FORECASTS



Previous Study Review

MEMORANDUM





To: Rachel Lukaszewski, Executive Director
Bismarck-Mandan MPO

From: SRF Consulting Group, Inc.

Date: December 21, 2022

Subject: Arrive 2050 Forecasts – Previous Study Review Memorandum

INTRODUCTION

The Bismarck Mandan Metropolitan Planning Organization (BMMPO) is updating its travel demand model. Part of the update process is updating socioeconomic model inputs. This document reviews past population studies covering the Bismarck-Mandan area. The current BMMPO socioeconomic data updates use these plans as a foundation.

PAST BISMARCK-MANDAN STUDIES

Together 2045: Bismarck’s Comprehensive Plan (Draft, October 2021)

The City of Bismarck’s Together 2045 is the most recent plan. It includes population projections focused on the Bismarck-Mandan area. The plan contains an up-to-date outlook on recent growth in the City of Bismarck planning area. Together 2045 acknowledges recent forecasts that over-estimate growth because of the “oil boom.” The plan uses the growth rate from the 2020 Arrive 2045 Metropolitan Transportation Plan (MTP). Table 1 outlines the results of the study.

Table 1. 2045 Bismarck Comprehensive Plan – October 29th, 2021

YEAR	POPULATION	HOUSEHOLDS	EMPLOYMENT
2020	80,000*	34,049	57,500*
2045	99,647	44,971 - 50,938	N/A
Change	19,647	10,922 – 16,889	N/A
Average Growth Rate	N/A	N/A	N/A
Compound Growth Rate	1.2%	1.1% - 1.6%	N/A

Source: Together 2045: Bismarck’s Comprehensive Plan, *Imputed

Housing and Population

The Bismarck fertility rate is reported as 70.6 births per 1,000 women of child-bearing age. This is after increases in fertility in recent years in North Dakota. Which can be attributed to community growth and relative economic prosperity.

Every year, about 12% of the Bismarck population “turns over.” Bismarck’s in-out migration balance is around equilibrium after becoming very positive during the “oil-boom.” This was after a previously net negative migration rate. IRS reported in 2018 that 788 people left Burleigh County the year before. The overall population did not decrease due to other sources of population increase.

There are potential disruptors to a forecast of Bismarck’s population at the 25-year time span.



- A major shift in the North Dakota/National energy markets that impact these variables
- Remote work
- Climate Change
- Changes in costs to residential rural development brought on by exogenous forces
- Major natural hazard. 2011 flood of the Missouri River did not notably effect population

An **overall growth rate of 1.2%** was chosen for the population in Bismarck.

- Reasonably aligns with long-term trends.
- Fits the exponential shape of the empirical population curve
- A fixed annual rate of growth is simple to use and apply to any future year
- This is the growth rate from the 2020 Arrive 2045 Metropolitan Transportation Plan and associated model

Housing projections are assumed proportional to the population projection, **growing at 1.2%**. This is logical because it means household size is being held constant throughout the modeling period. People living in group quarters (colleges, nursing homes, prisons) represented 3.8% of the population in Bismarck in 2020. In 2000 this population represented 3.1% of the population. This shows stability. The proportion of individuals living in group quarters is held constant. The 2020 housing vacancy in Bismarck was 6.8%. This is below the 13% state average and 9.7% national average. It is lower than both Grand Forks and Fargo. The 2010 rate was 4.8% and 2015 rate was 1.9%. Household size has increased in Bismarck since 2010, 2.18 to 2.36. It had previously been declining like the rest of the United States.

Arrive 2045 Metropolitan Transportation Plan (March 2020)

Arrive 2045 is a metropolitan transportation plan for the BMMPO. The plan is meant to study future transportation needs in the Bismarck-Mandan Metro area. Table 2 outlines the results of the study.

Table 2. Arrive 2045 Metropolitan Transportation Plan

Year	Population	Households	Employment
2015	114,300	46,300	71,800
2045	164,500	65,400	121,000
Change	50,200	19,100	49,200
Growth Rate	1.2%	1.2%	1.7%

Overview

The plan outlines “Arrive Goals,” which follow the federally established Performance Target Areas. These include safety, infrastructure resilience, congestion reduction, system reliability for freight/economic vitality, encourage non-auto modes, environmental sustainability, reduced project delivery, etc.



Growth and Demographics

Arrive 2045 shows Bismarck-Mandan metro area population has grown at a rate of **1.2%**. Recent years, 2010 – 2015, have seen unusually high growth, 2.4%, but that can be explained by the concurrent economic boom. Another sign of growth, the study predicts an increase in enplanement or airplane boarding, from about 275,000 passengers in 2017 to 425,000 passengers in 2055. An increase in air cargo is predicted too, from 8 million pounds in 2015 to 8.8 million pounds in 2035. The plan contains household and growth maps showing the 2045 forecast.

Envision 2040: 2015 – 2040 Bismarck–Mandan MPO Long Range Transportation Plan (March 2015)

This study mentions the 2012-2013 oil boom in the opening paragraph. This long range transportation plan (LRTP) was prepared in a high growth environment. The land use totals were established based on historical growth rates that were then adjusted to create other growth scenarios. Table 3 outlines the results of the study.

Table 3. 2040 LRTP

YEAR	HOUSEHOLDS	EMPLOYMENT
2010	41,756	64,100
2040	73,088	124,200
Change	31,332	60,100
Average Growth Rate	2.50%	3.13%
Compound Growth Rate	1.88%	2.23%

Bismarck-Mandan MPO 2010-2035 Long Range Transportation Plan (March 2010)

Controls totals were created using data analysis and local input. An ArcGIS model was developed to determine the likelihood/suitability of growth in each TAZ. This model was used to find draft results that were then workshopped with stakeholders to meet approval. Table 4 outlines the results of the study.

Table 4. 2035 LRTP Control Totals

YEAR	HOUSEHOLDS	EMPLOYMENT
2007	37,300	52,100
2035	52,900	73,300
Change	15,600	21,200
Average Growth Rate	1.49%	1.45%
Compound Growth Rate	1.26%	1.23%

Appendix E

ARRIVE 2050

FORECASTS



Draft Demographic Forecast Scenarios

MEMORANDUM





To: Rachel Lukaszewski, Executive Director
Bismarck-Mandan MPO

From: SRF Consulting Group, Inc.

Date: April 03, 2023

Subject: 2050 Forecasts – Updated Draft Demographic Forecast Scenarios

INTRODUCTION

As part of the Bismarck-Mandan Metropolitan Planning Organization’s (BMMPO) updates to its Travel Demand Model, this memorandum documents population forecasts developed based on quantitative data inputs and calibrated using nationally sourced forecasts and locally sourced qualitative data. Methodology used to develop the forecasts contained herein is detailed in the previous *Demographic Forecast Methodology Memorandum*. After review and verification of the population forecast scenarios provided herein, the corresponding household and employment scenarios will also be provided.

FORECAST INPUTS

Population

Key quantitative inputs were used to develop the forecasts. Common quantitative sources used for the basis of these forecasts, and a reference to their applicability, include the following:

- Decennial Census: current and historical demographics
- American Community Survey (ACS): current and historical demographics
- Center for Disease and Control and Prevention (CDC): birth and death rates

Employment

Common quantitative sources used for the basis of the employment forecasts, and reference to their applicability, include the following:

- Bureau of Labor Statistics: current industry level calculations and labor productivity
- Gross Domestic Product (GDP) Data: current and historical GDP trends

FORECAST CALIBRATION

Additional information was used to help calibrate the forecasts to both national and local conditions.

National Economic Considerations

Woods & Poole Economics, Inc. (Woods & Poole) forecasts for Burleigh and Morton Counties was purchased to help calibrate the initial forecasts. Woods & Poole provides forecasts down to the county level. Their forecasts are performed for each county in the United States and are “done simultaneously



that changes in one county will affect growth or decline in other counties”—in other words, their forecasts provide a reasonable forecast based on the flow of economic activity at the national level¹.

Local Considerations

Local conditions impacting regional growth were understood through information gathering and discussions with local focus groups. A summary of this discovery process is documented in the *Focus Group Summary Memorandum*. Various local organizations were consulted who specialize in various areas related to demographic growth, such as economic development, education, and real estate development.

SCENARIO DEVELOPMENT

Low, medium, and high forecast scenarios were developed. These three scenarios were developed to understand the likely range of growth (or decline) expected over the forecast period. The population forecasts were also developed to provide stakeholders with different growth scenarios to consider and ultimately adopt one as the preferred scenario from which to base Metropolitan Transportation Plan (MTP) expectations.

Population Process

A baseline forecast² model was first developed to project existing growth trends forward based on the available inputs noted earlier. The initial model output resulted in the medium forecast scenario. To generate the low and high forecast scenarios, migration trends were factored up or down. This method is used because changes in migration rates, relative to birth and death rates, are more likely to change over time and have a broader impact on the population when they do change. These migration trends were understood through many of the national and local considerations noted above.

Employment Process

Baseline employment was derived from available inputs and local considerations noted above. Initial model output resulted in the medium forecast scenario. To generate the low and high forecast scenarios, employment forecasts mirrored population forecasts and were factored up or down. This method is used to reflect changes in GDP and labor productivity based upon population and workforce population and subsequent correlation between low and high population scenarios.

FORECAST SCENARIOS

Figures 1 – 6 and Tables 1 – 6 show population forecasts developed for the Bismarck-Mandan Metropolitan Area, and each city and county in the region. Each figure and table indicates low, medium, and high forecasts for each geography. Migration rates were altered to understand possible low and high scenarios. Tables 7-15 show employment forecasts indicating low, medium, and high scenarios.

¹ Woods & Poole Economics, Inc. (2022) *Summary Technical Description of the Woods & Poole Economics, Inc. 2022 Regional Projections and Database*. Retrieved from <https://www.woodsandpoole.com/wp-content/uploads/2022/06/TECH22-summary.pdf>.

² Baseline forecast is derived from 2020 Decennial Census population estimates. 2021 baseline population was estimated by utilizing 2009 to 2021 ACS 5-year estimates to establish a trendline to 2020 Decennial Census population and ultimately arrive at the 2021 Baseline estimates.



Basis for Scenarios

High Forecast

The key factor influencing the high forecast scenario is growth in the manufacturing sector, which would drive increased migration to the region. In addition, currently strong sectors, such as healthcare and education, would grow at more aggressive rates than current trends (current trends are factored into the medium forecast scenario). Note that growth in the education sector is partly influenced by the migration of families and young adults. Current projections from K-12 and higher education are positive and support the medium forecast scenario. The high forecast scenario would expect that at least some of the current growth challenges (e.g. housing affordability, workforce attraction, infrastructure development/expansion) would significantly soften.

Low Forecast

The low forecast scenario reflects continued economic trends, but with fewer people staying in the BMMPO area and more migrating to other places. The area would continue to be strong in the government, education, healthcare, and energy sectors, but growth would be less than the current pace. Growth in currently smaller sectors, such as manufacturing, would not occur in this scenario. These economic factors would cause individuals from around the country to choose somewhere other than the BMMPO area to relocate or to come back to. Several issues discussed with local stakeholders could influence the low forecast scenario, such as continued and growing challenges related to housing affordability, workforce attraction, and infrastructure development/expansion.

Adjustments Between Geographies

Discussion with local stakeholders provided valuable insight as to the variations in growth potential for different geographies or jurisdictions in the region. Recent plans and studies pertaining to future growth and related projections were also helpful. These insights were also verified against recent population trends.

Looking to 2050, at the county level, Morton County is expected to grow at a faster rate than Burleigh County in all the scenarios. This is consistent with current housing opportunities understood from local stakeholders—Mandan has been noted as being the more affordable option when compared with Bismarck, and Mandan provides more opportunities for new housing in closer proximity to city amenities and the community core. Morton County's smaller size also makes it easier to achieve a higher growth rate. When removing years impacted by the last energy boom, Morton County has a noticeable difference in the annual percentage increase in population. Between 2015 and 2021, Morton County's population grew 1.87% annually on average, compared with Burleigh County at 1.01% annually³.

At the city level, the largest growth rate is expected in the City of Lincoln across all scenarios. Lincoln's much smaller size in comparison to the other cities makes a higher growth rate more easily achievable. An additional factor is Lincoln's location with room to expand, with fewer physical barriers to growth in the present compared to the other cities. Note that the City of Lincoln's forecasted population growth does not necessarily have to be confined to current Lincoln City limits—it could occur in unincorporated Burleigh County depending on the type of development that occurs and the City's approach to annexation.

³ Data retrieved from <https://datacommons.org/place/geoid/38015?category=Demographics>



PREFERRED GROWTH SCENARIO

Through thoughtful consideration of growth scenarios, focus group & stakeholder feedback, and Transportation Advisory Committee (TAC) & Policy Board review, a preferred growth scenario was selected. The preferred growth scenario is to be used moving forward to:

- Refine socio-economic data in 5-year increments
- Focus Travel Demand Model (TDM) runs and subsequent analysis & recommendations of the Metropolitan Transportation Plan
- Set realistic expectations for growth and growth priorities based on best-available quantitative and qualitative data

In March 2023, the BMMPO TAC recommended, and Policy Board approved the Medium Growth Scenario as the preferred population growth scenario. The preferred growth scenario is selected for the BMMPO's Metropolitan Planning Area (MPA) as a whole and applies only to population. Population forecasts, employment forecasts, and associated preferred growth scenario socio-economic data is shown below in Figures 1-6 and Tables 1-21.

See the following pages for population forecasts, employment forecasts, and preferred growth scenario socio-economic characteristics.



Figure 1: BMMPO Population Forecasts

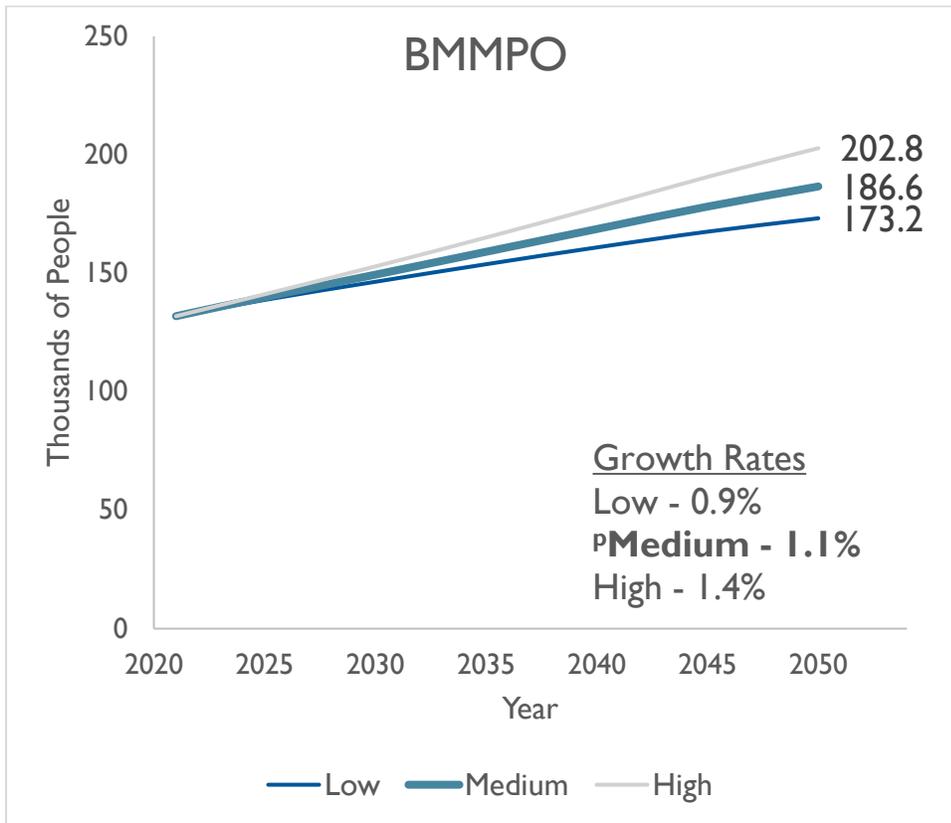


Table 1: BMMPO Population Forecasts by Scenario

BMMPO			
Year	Low	^P Medium	High
2021 ⁴	133,760	133,760	133,760
2025	138,740	139,860	141,130
2030	146,380	149,380	152,860
2035	153,790	159,040	165,070
2040	160,880	168,640	177,700
2045	167,530	178,120	190,660
2050	173,180	186,610	202,780
Growth Rate	0.9%	1.1%	1.4%

^P Preferred Scenario

⁴ Source: 2021 Baseline population estimate as described on page 2



Figure 2: Burleigh County Population Forecasts

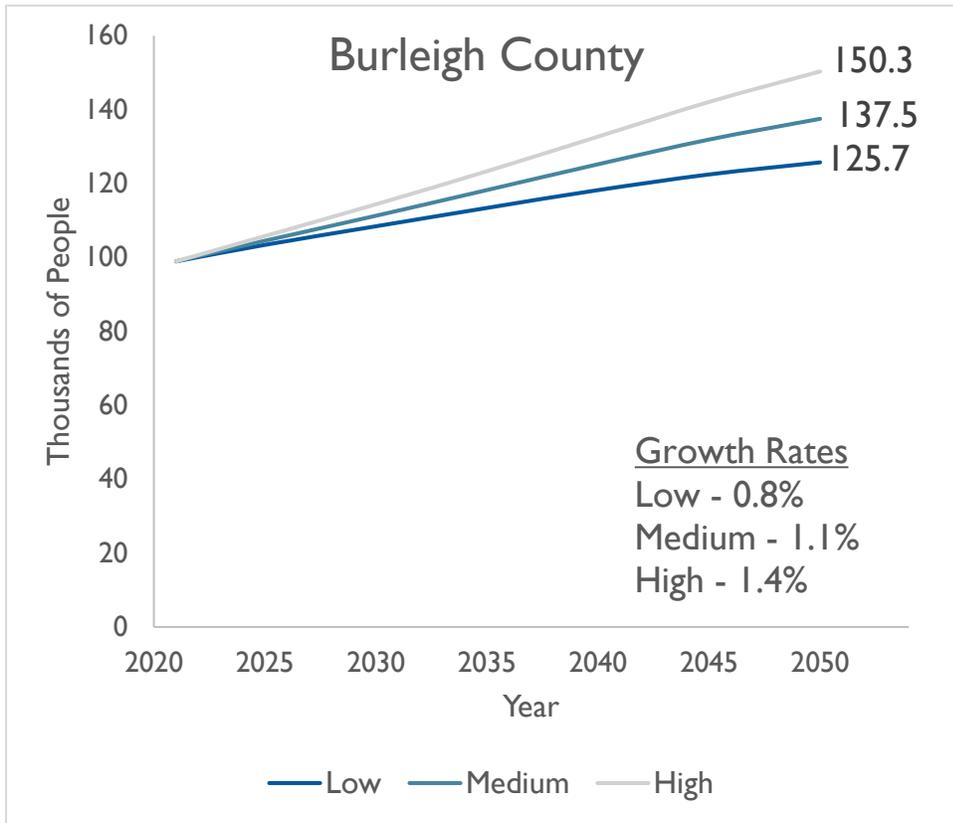


Table 2: Burleigh County Population Forecasts by Scenario

Burleigh County			
Year	Low	Medium	High
2021 ⁵	100,250	100,250	100,250
2025	103,410	104,530	105,800
2030	108,440	111,290	114,390
2035	113,410	118,250	123,350
2040	118,230	125,230	132,710
2045	122,470	131,920	142,100
2050	125,740	137,530	150,340
Growth Rate	0.8%	1.1%	1.4%

⁵ Source: 2021 Baseline population estimate as described on page 2



Figure 3: Morton County Population Forecasts

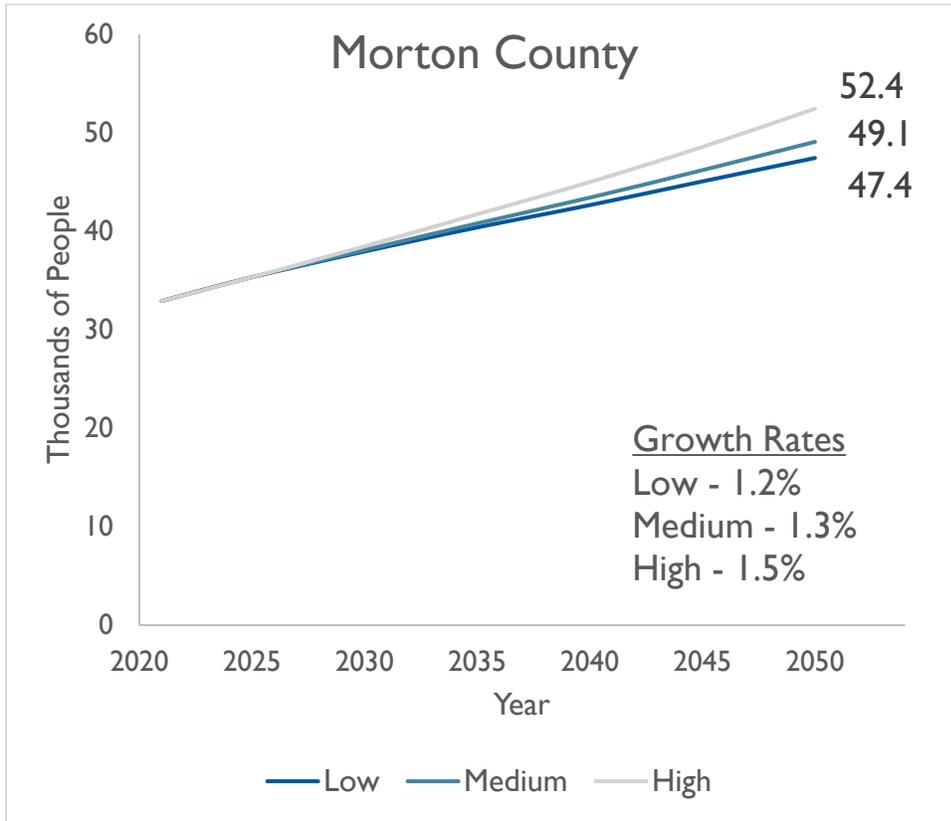


Table 3: Morton County Population Forecasts by Scenario

Morton County			
Year	Low	Medium	High
2021 ⁶	33,510	33,510	33,510
2025	35,330	35,330	35,330
2030	37,940	38,090	38,470
2035	40,380	40,790	41,720
2040	42,650	43,410	44,990
2045	45,060	46,200	48,560
2050	47,440	49,080	52,440
Growth Rate	1.2%	1.3%	1.5%

⁶ Source: 2021 Baseline population estimate as described on page 2



Figure 4: City of Bismarck Population Forecasts

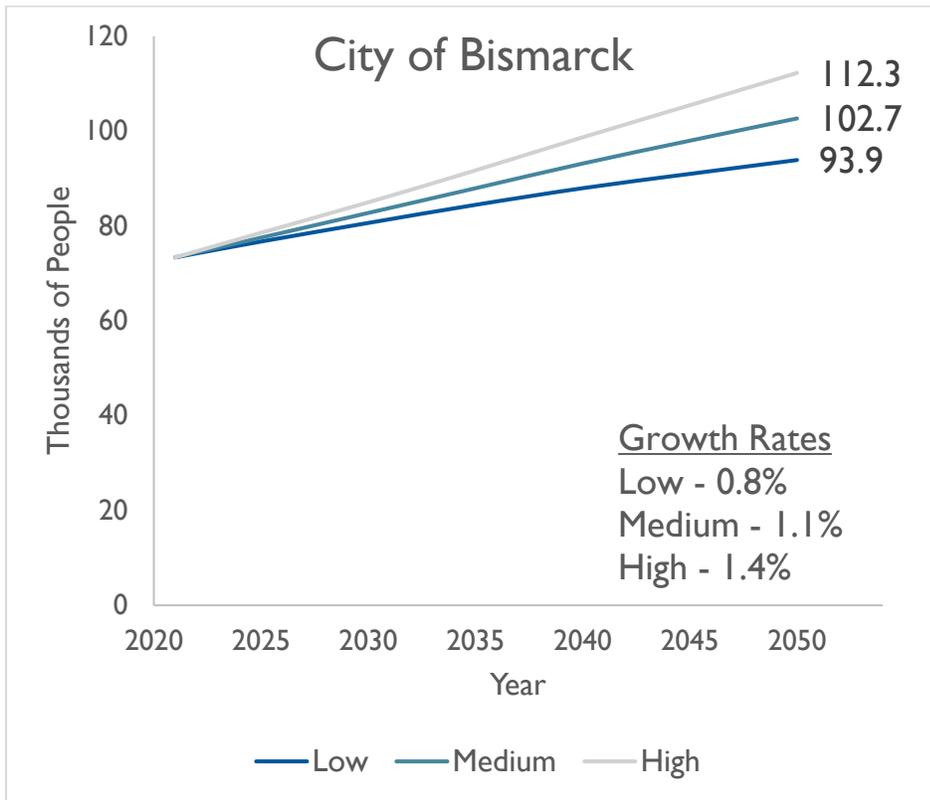


Table 4: City of Bismarck Population Forecasts by Scenario

Bismarck			
Year	Low	Medium	High
2021 ⁷	73,960	73,960	73,960
2025	76,710	77,530	78,560
2030	80,630	82,740	84,980
2035	84,450	87,950	91,720
2040	87,960	93,160	98,690
2045	90,980	97,980	105,460
2050	93,900	102,670	112,260
Growth Rate	0.8%	1.1%	1.4%

⁷ Source: 2021 Baseline population estimate as described on page 2



Figure 5: City of Mandan Population Forecasts

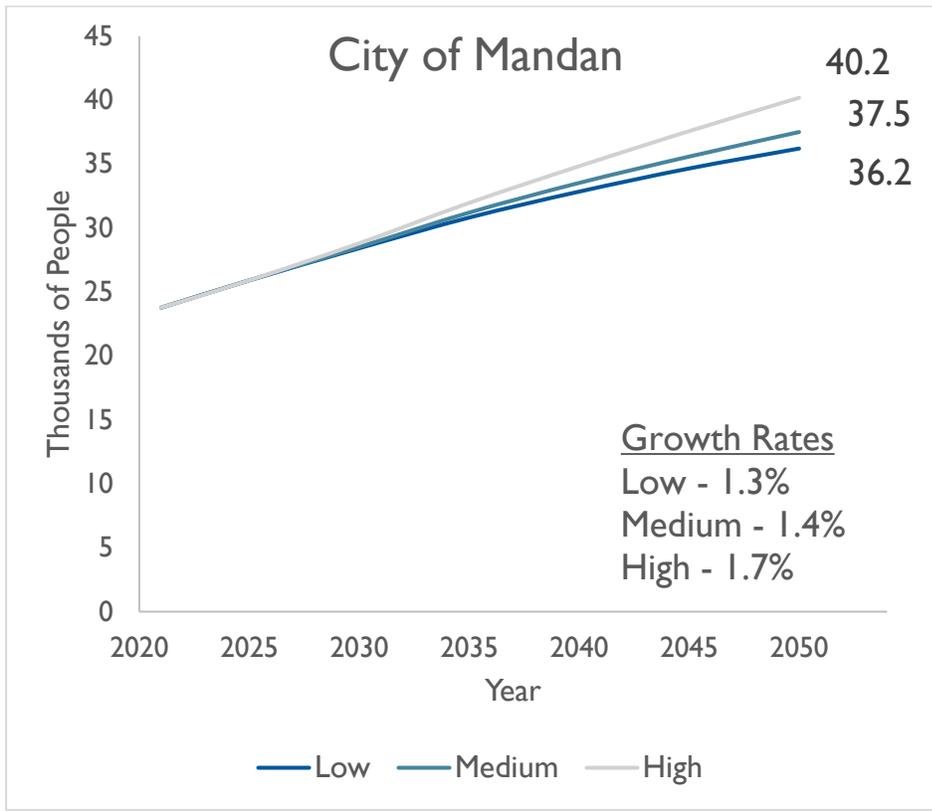


Table 5: City of Mandan Population Forecasts by Scenario

Mandan			
Year	Low	Medium	High
2021 ⁸	24,760	24,760	24,760
2025	25,910	25,910	25,910
2030	28,420	28,520	28,810
2035	30,820	31,210	31,970
2040	32,850	33,530	34,840
2045	34,660	35,590	37,580
2050	36,220	37,510	40,190
Growth Rate	1.3%	1.4%	1.7%

⁸ Source: 2021 Baseline population estimate as described on page 2



Figure 6: City of Lincoln Population Forecasts

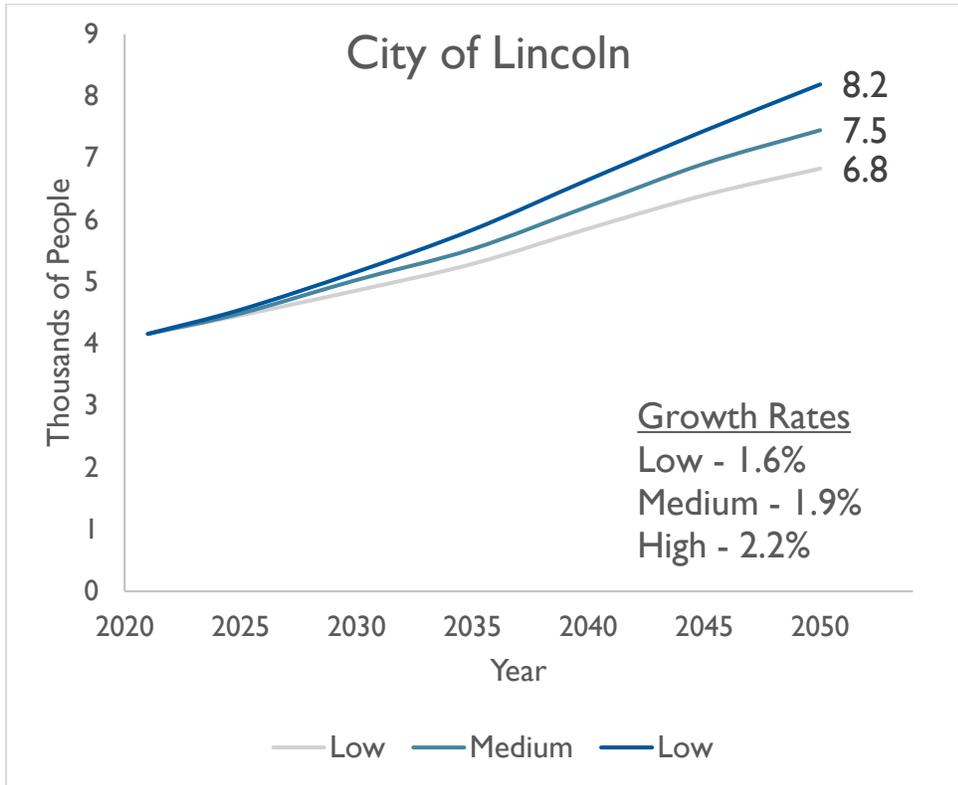


Table 6: City of Lincoln Population Forecasts by Scenario

Lincoln			
Year	Low	Medium	High
2021 ⁹	4,280	4,280	4,280
2025	4,460	4,490	4,550
2030	4,860	5,030	5,160
2035	5,290	5,530	5,840
2040	5,860	6,220	6,650
2045	6,400	6,910	7,440
2050	6,830	7,450	8,190
Growth Rate	1.6%	1.9%	2.2%

⁹ Source: 2021 Baseline population estimate as described on page 2



Table 7. BMMPO Employment Forecast Low Scenario

BMMPO Low Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	1.7%	200	300	300	300	200	400	300
21	Mining, quarrying, and oil and gas extraction	0.0%	300	300	300	300	300	300	300
22	Utilities	2.3%	300	300	400	400	400	400	500
23	Construction	0.9%	3,800	4,700	3,800	4,700	4,300	4,500	4,800
31-33	Manufacturing	0.6%	2,700	3,000	3,000	3,000	3,000	3,100	3,200
42	Wholesale Trade	1.3%	3,400	3,900	3,600	3,800	4,100	4,300	4,700
44-45	Retail Trade	0.9%	7,300	7,400	7,400	7,800	8,400	8,400	9,200
48-49	Transportation and Warehousing	1.3%	2,400	2,400	2,600	2,800	3,000	3,100	3,300
51	Information	-1.0%	700	700	600	600	600	500	500
52	Finance and Insurance	0.1%	2,600	2,900	2,500	2,800	2,600	2,800	2,700
53	Real estate and rental and leasing	3.4%	600	800	800	1,000	1,000	1,200	1,200
54	Professional, scientific, and technical services	2.5%	3,500	3,800	3,900	4,500	5,000	5,400	6,000
55	Management of companies and enterprises	2.7%	1,400	1,500	1,600	1,800	2,100	2,200	2,500
56	Administrative and support and waste management and remediation services	1.0%	2,500	2,700	2,600	2,800	3,000	3,100	3,200
61	Education services	1.9%	1,800	1,900	1,900	2,100	2,300	2,600	2,800
62	Health care and social assistance	1.5%	11,100	12,100	12,300	13,100	14,200	14,700	15,800
71	Arts, entertainment, and recreation	3.1%	1,100	1,300	1,500	1,600	1,800	1,900	2,100
72	Accommodation and food service	-0.1%	5,900	6,000	6,000	5,800	5,900	5,800	5,800
81	Other services (except government and government enterprises)	0.1%	2,300	2,400	2,300	2,400	2,300	2,400	2,400
92	Government and government enterprises	1.0%	6,100	6,300	6,600	6,900	7,300	7,600	7,900
TOTAL		1.1%	60,000	64,700	64,000	68,500	71,800	74,700	79,200



Table 8. Burleigh County Employment Forecast Low Scenario

Burleigh Low Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	0.0%	150	125	125	100	100	125	150
21	Mining, quarrying, and oil and gas extraction	1.0%	175	175	200	175	200	200	225
22	Utilities	1.1%	225	225	250	250	275	275	300
23	Construction	0.7%	2,875	3,650	2,825	3,500	3,175	3,225	3,475
31-33	Manufacturing	0.1%	1,700	1,900	1,850	1,825	1,800	1,775	1,750
42	Wholesale Trade	1.3%	2,050	2,450	2,075	2,225	2,375	2,475	2,800
44-45	Retail Trade	0.8%	7,000	7,050	7,025	7,425	7,975	7,975	8,675
48-49	Transportation and Warehousing	1.7%	1,650	1,750	1,875	2,100	2,175	2,350	2,450
51	Information	-1.4%	625	600	500	475	450	400	375
52	Finance and Insurance	0.0%	2,100	2,350	2,050	2,225	2,100	2,175	2,075
53	Real estate and rental and leasing	3.6%	500	650	625	800	850	975	1,025
54	Professional, scientific, and technical services	2.8%	2,600	2,875	2,925	3,450	3,875	4,200	4,675
55	Management of companies and enterprises	2.6%	1,325	1,450	1,475	1,725	1,950	2,100	2,325
56	Administrative and support and waste management and remediation services	0.4%	1,975	2,050	1,925	2,075	2,150	2,150	2,200
61	Education services	1.3%	850	925	925	975	1,050	1,100	1,175
62	Health care and social assistance	1.5%	11,075	12,025	12,275	13,025	14,100	14,625	15,775
71	Arts, entertainment, and recreation	3.0%	800	950	1,075	1,175	1,325	1,425	1,500
72	Accommodation and food service	-0.1%	4,925	5,050	50,00	4,875	4,950	4,875	4,825
81	Other services (except government and government enterprises)	0.0%	1,925	2,025	1,900	2,025	1,925	2,000	1,950
92	Government and government enterprises	1.1%	5,500	5,700	5,975	6,300	6,625	6,925	7,250
TOTAL		1.0%	50,025	53,975	52,875	56,725	59,425	61,350	64,975



Table 9. Morton County Employment Forecast Low Scenario

Morton Low Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	4.6%	75	125	125	225	125	225	175
21	Mining, quarrying, and oil and gas extraction	0.0%	75	75	75	75	100	75	75
22	Utilities	1.7%	100	100	100	125	125	150	150
23	Construction	1.9%	875	1,075	925	1,175	1,125	1,275	1,350
31-33	Manufacturing	1.4%	1,000	1,100	1,150	1,175	1,225	1,300	1,400
42	Wholesale Trade	1.3%	1,350	1,450	1,550	1,575	1,675	1,825	1,875
44-45	Retail Trade	1.6%	325	350	375	400	425	450	475
48-49	Transportation and Warehousing	0.9%	700	675	700	700	800	750	875
51	Information	0.0%	100	100	100	100	100	100	100
52	Finance and Insurance	1.1%	450	525	475	550	525	600	600
53	Real estate and rental and leasing	2.6%	100	125	125	150	150	175	175
54	Professional, scientific, and technical services	1.9%	850	925	925	1,025	1,150	1,175	1,325
55	Management of companies and enterprises	2.3%	75	75	75	100	100	100	125
56	Administrative and support and waste management and remediation services	3.0%	550	625	650	750	850	900	1,025
61	Education services	2.7%	925	950	975	1,125	1,275	1,450	1,650
62	Health care and social assistance	0.0%	50	50	50	50	50	50	50
71	Arts, entertainment, and recreation	2.4%	325	350	400	425	475	500	550
72	Accommodation and food service	0.1%	925	925	950	925	950	925	950
81	Other services (except government and government enterprises)	1.0%	350	375	375	400	400	425	450
92	Government and government enterprises	0.8%	550	575	600	600	625	650	675
TOTAL		1.5%	9,750	10,550	10,700	11,650	12,250	13,100	14,050



Table 10. BMMPO Employment Forecast Medium Scenario

BMMPO Medium Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	1.4%	250	250	250	350	250	400	350
21	Mining, quarrying, and oil and gas extraction	0.7%	250	250	300	250	300	300	300
22	Utilities	1.5%	350	350	350	400	400	450	500
23	Construction	1.2%	3,750	4,800	3,850	4,800	4,450	4,700	5,050
31-33	Manufacturing	0.7%	2,700	3,050	3,050	3,050	3,150	3,200	3,250
42	Wholesale Trade	1.5%	3,400	3,900	3,700	3,900	4,200	4,500	4,900
44-45	Retail Trade	1.0%	7,350	7,450	7,500	8,000	8,650	8,750	9,550
48-49	Transportation and Warehousing	1.7%	2,350	2,450	2,650	2,850	3,100	3,200	3,500
51	Information	-1.1%	750	700	600	600	600	500	500
52	Finance and Insurance	0.3%	2,550	2,900	2,550	2,850	2,750	2,900	2,800
53	Real estate and rental and leasing	4.0%	600	800	800	950	1,000	1,200	1,300
54	Professional, scientific, and technical services	2.8%	3,450	3,800	3,950	4,550	5,150	5,600	6,250
55	Management of companies and enterprises	2.8%	1,400	1,550	1,600	1,900	2,100	2,300	2,550
56	Administrative and support and waste management and remediation services	1.1%	2,550	2,700	2,600	2,900	3,100	3,200	3,400
61	Education services	2.3%	1,800	1,900	1,950	2,150	2,450	2,650	3,000
62	Health care and social assistance	1.7%	11,150	12,150	12,500	13,350	14,550	15,200	16,500
71	Arts, entertainment, and recreation	3.0%	1,150	1,300	1,550	1,650	1,850	2,000	2,150
72	Accommodation and food service	0.1%	5,850	6,000	6,050	5,950	6,100	6,050	6,050
81	Other services (except government and government enterprises)	0.3%	2,300	2,450	2,300	2,450	2,400	2,550	2,500
92	Government and government enterprises	1.3%	6,050	6,300	6,650	7,050	7,450	7,900	8,300
TOTAL		1.3%	60,000	65,100	64,800	70,000	74,000	77,600	82,700



Table 11. Burleigh County Employment Forecast Medium Scenario

Burleigh Medium Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	0.0%	150	125	125	100	100	150	150
21	Mining, quarrying, and oil and gas extraction	1.0%	175	175	200	175	200	200	225
22	Utilities	1.5%	225	225	250	250	275	300	325
23	Construction	0.9%	2,875	3,675	2,875	3,575	3,250	3,350	3,625
31-33	Manufacturing	0.2%	1,700	1,925	1,875	1,850	1,850	1,825	1,800
42	Wholesale Trade	1.5%	2,050	2,450	2,125	2,275	2,450	2,575	2,925
44-45	Retail Trade	1.0%	7,000	7,075	7,100	7,575	8,200	8,275	9,050
48-49	Transportation and Warehousing	1.9%	1,650	1,750	1,900	2,125	2,225	2,425	2,550
51	Information	-1.2%	625	600	500	475	475	400	400
52	Finance and Insurance	0.1%	2,100	2,375	2,075	2,275	2,175	2,250	2,150
53	Real estate and rental and leasing	4.0%	500	650	650	800	850	1,000	1,075
54	Professional, scientific, and technical services	3.0%	2,600	2,875	2,975	3,500	3,975	4,350	4,875
55	Management of companies and enterprises	2.9%	1,325	1,475	1,500	1,775	2,000	2,175	2,425
56	Administrative and support and waste management and remediation services	0.6%	1,975	2,050	1,950	2,125	2,225	2,225	2,300
61	Education services	1.5%	850	925	950	1,000	1,100	1,125	1,225
62	Health care and social assistance	1.7%	11,075	12,100	12,425	13,300	14,500	15,150	16,450
71	Arts, entertainment, and recreation	3.3%	800	950	1,100	1,200	1,350	1,475	1,575
72	Accommodation and food service	0.1%	4,925	5,075	5,075	4,975	5,100	5,050	5,025
81	Other services (except government and government enterprises)	0.2%	1,925	2,050	1,925	2,050	1,975	2,075	2,025
92	Government and government enterprises	1.3%	5,500	5,725	6,050	6,425	6,800	7,175	7,550
TOTAL		1.2%	50,025	54,250	53,625	57,825	61,075	63,550	67,725



Table 12. Morton County Employment Forecast Medium Scenario

Morton Medium Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	4.6%	75	125	125	225	125	250	175
21	Mining, quarrying, and oil and gas extraction	0.0%	75	75	75	75	100	75	75
22	Utilities	1.7%	100	100	100	125	125	150	150
23	Construction	2.1%	875	1,100	950	1,200	1,175	1,325	1,400
31-33	Manufacturing	1.6%	1,000	1,100	1,175	1,200	1,275	1,375	1,450
42	Wholesale Trade	1.5%	1,350	1,450	1,575	1,600	1,750	1,900	1,950
44-45	Retail Trade	1.9%	325	350	400	400	425	475	500
48-49	Transportation and Warehousing	1.1%	700	675	725	700	850	775	925
51	Information	0.0%	100	100	100	100	100	100	100
52	Finance and Insurance	1.3%	450	525	475	575	550	625	625
53	Real estate and rental and leasing	3.4%	100	125	125	150	150	175	200
54	Professional, scientific, and technical services	2.1%	850	925	950	1,050	1,175	1,225	1,375
55	Management of companies and enterprises	2.3%	75	75	75	100	100	125	125
56	Administrative and support and waste management and remediation services	3.4%	550	625	650	775	875	950	1,100
61	Education services	3.1%	925	950	1,000	1,150	1,325	1,525	1,750
62	Health care and social assistance	0.0%	50	50	50	50	50	50	50
71	Arts, entertainment, and recreation	2.7%	325	350	425	450	500	525	575
72	Accommodation and food service	0.3%	925	925	950	950	1,000	975	1,000
81	Other services (except government and government enterprises)	1.0%	350	375	375	400	425	450	450
92	Government and government enterprises	1.1%	550	575	600	625	650	700	725
TOTAL		1.8%	9,750	10,575	10,900	11,900	12,725	13,750	14,700



Table 13. BMMPO Employment Forecast High Scenario

BMMPO High Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	1.5%	250	250	275	300	325	300	325
21	Mining, quarrying, and oil and gas extraction	1.0%	250	250	275	300	325	300	325
22	Utilities	1.9%	325	325	350	400	425	450	500
23	Construction	1.5%	3,750	4,800	3,900	4,925	4,600	4,925	5,350
31-33	Manufacturing	1.0%	2,700	3,050	3,100	3,150	3,225	3,350	3,500
42	Wholesale Trade	1.8%	3,400	3,950	3,775	4,025	4,375	4,725	5,175
44-45	Retail Trade	1.3%	7,325	7,500	7,625	8,225	8,950	9,150	1,0075
48-49	Transportation and Warehousing	1.9%	2,350	2,475	2,650	2,925	3,175	3,375	3,675
51	Information	-1.0%	725	700	625	600	575	525	525
52	Finance and Insurance	0.5%	2,550	2,900	26,00	2,925	2,825	3,050	2,950
53	Real estate and rental and leasing	4.3%	600	775	775	975	1,050	1,250	1,350
54	Professional, scientific, and technical services	3.2%	3,450	3,850	4,000	4,700	5,375	5,850	6,625
55	Management of companies and enterprises	3.3%	1,400	1,550	1,600	1,925	2,200	2,400	2,725
56	Administrative and support and waste management and remediation services	1.5%	2,525	2,700	2,650	2,975	3,225	3,325	3,600
61	Education services	2.7%	1,775	1,875	1,975	2,200	2,525	2,800	3,175
62	Health care and social assistance	2.0%	11,125	12,250	12,700	13,725	15,100	15,900	17,425
71	Arts, entertainment, and recreation	3.6%	1,125	1,325	1,525	1,700	1,925	2,100	2,300
72	Accommodation and food service	0.3%	5,850	6,075	6,125	6,100	6,325	6,325	6,375
81	Other services (except government and government enterprises)	0.5%	2,275	2,425	2,375	2,550	2,500	2,650	2,625
92	Government and government enterprises	1.5%	6,050	6,350	6,775	7,250	7,750	8,250	8,750
TOTAL		1.6%	59,775	65,400	65,650	71,900	76,700	81,100	87,350



Table 14. Burleigh County Employment Forecast High Scenario

Burleigh High Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	0.0%	150	125	125	100	125	150	150
21	Mining, quarrying, and oil and gas extraction	1.0%	175	175	200	200	225	200	225
22	Utilities	1.5%	225	225	250	275	300	300	325
23	Construction	1.1%	2,875	3,700	2,925	3,675	3,375	3,500	3,825
31-33	Manufacturing	0.5%	1,700	1,925	1,900	1,900	1,900	1,900	1,925
42	Wholesale Trade	1.7%	2,050	2,475	2,150	2,350	2,550	2,700	3,075
44-45	Retail Trade	1.3%	7,000	7,125	7,225	7,800	8,500	8,650	9,550
48-49	Transportation and Warehousing	2.2%	1,650	1,775	1,925	2,200	2,300	2,550	2,700
51	Information	-1.1%	625	600	525	500	475	425	425
52	Finance and Insurance	0.3%	2,100	2,375	2,100	2,350	2,250	2,375	2,275
53	Real estate and rental and leasing	4.5%	500	650	650	825	900	1,050	1,150
54	Professional, scientific, and technical services	3.4%	2,600	2,900	3,025	3,600	4,125	4,550	5,150
55	Management of companies and enterprises	3.3%	1,325	1,475	1,525	1,825	2,075	2,275	2,575
56	Administrative and support and waste management and remediation services	0.8%	1,975	2,075	1,975	2,175	2,300	2,325	2,425
61	Education services	1.8%	850	925	950	1,025	1,125	1,175	1,300
62	Health care and social assistance	2.0%	11,075	12,200	12,650	13,675	15,050	15,850	17,375
71	Arts, entertainment, and recreation	3.8%	800	950	1,100	1,250	1,400	1,550	1,675
72	Accommodation and food service	0.3%	4,925	5,125	5,150	5,125	5,275	5,300	5,300
81	Other services (except government and government enterprises)	0.4%	1,925	2,050	1,975	2,125	2,050	2,175	2,125
92	Government and government enterprises	1.6%	5,500	5,775	6,150	6,600	7,050	7,525	7,975
TOTAL		1.5%	50,025	54,625	54,475	59,575	63,350	66,525	71,525



Table 15. Morton County Employment Forecast High Scenario

Morton High Employment Scenario									
NAICS 2-Digit Code & Employment Sector		% Linear Growth	2021	2025	2030	2035	2040	2045	2050
11	Agriculture, forestry, fishing and hunting	4.6%	75	150	125	225	125	250	175
21	Mining, quarrying, and oil and gas extraction	1.1%	75	75	75	100	100	100	100
22	Utilities	2.6%	100	100	100	125	125	150	175
23	Construction	2.6%	875	1,100	975	1,250	1,225	1,425	1,525
31-33	Manufacturing	2.0%	1,000	1,125	1,200	1,250	1,325	1,450	1,575
42	Wholesale Trade	1.9%	1,350	1,475	1,625	1,675	1,825	2,025	2,100
44-45	Retail Trade	2.1%	325	375	400	425	450	500	525
48-49	Transportation and Warehousing	1.4%	700	700	725	725	875	825	975
51	Information	0.0%	100	100	100	100	100	100	100
52	Finance and Insurance	1.7%	450	525	500	575	575	675	675
53	Real estate and rental and leasing	3.4%	100	125	125	150	150	200	200
54	Professional, scientific, and technical services	2.5%	850	950	975	1,100	1,250	1,300	1,475
55	Management of companies and enterprises	3.4%	75	75	75	100	125	125	150
56	Administrative and support and waste management and remediation services	3.9%	550	625	675	800	925	1,000	1,175
61	Education services	3.5%	925	950	1,025	1,175	1,400	1,625	1,875
62	Health care and social assistance	0.0%	50	50	50	50	50	50	50
71	Arts, entertainment, and recreation	3.2%	325	375	425	450	525	550	625
72	Accommodation and food service	0.6%	925	950	975	975	1,050	1,025	1,075
81	Other services (except government and government enterprises)	1.5%	350	375	400	425	450	475	500
92	Government and government enterprises	1.4%	550	575	625	650	700	725	775
TOTAL		2.1%	9,750	10,775	11,175	12,325	13,350	14,575	15,825



Table 16. Preferred Scenario BMMPO Socio-Economic Characteristics

Total Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	8,010	6,950	8,770	9,330	10,100	10,140	9,760
5 to 9 years	7,870	7,980	6,900	8,710	9,250	10,010	10,030
10 to 14 years	9,500	8,320	8,570	7,430	9,360	9,960	10,800
15 to 19 years	8,150	9,520	8,390	8,660	7,480	9,450	10,050
20 to 24 years	8,040	8,830	10,420	9,030	9,350	8,050	10,140
25 to 29 years	8,920	8,420	9,380	11,110	9,590	9,930	8,550
30 to 34 years	9,700	9,580	9,300	10,250	12,010	10,670	11,030
35 to 39 years	9,410	10,230	10,290	10,000	11,030	12,950	11,520
40 to 44 years	8,090	9,740	10,750	10,890	10,590	11,630	13,620
45 to 49 years	7,960	8,280	10,110	11,150	11,330	11,010	12,140
50 to 54 years	7,060	8,070	8,430	10,270	11,350	11,490	11,190
55 to 59 years	7,800	7,120	8,180	8,550	10,430	11,530	11,700
60 to 64 years	9,250	7,820	7,170	8,260	8,610	10,610	11,680
65 to 69 years	6,990	8,970	7,430	6,820	7,890	8,260	10,060
70 to 74 years	5,960	6,700	8,520	7,050	6,480	7,540	7,880
75 to 79 years	3,490	5,690	6,250	8,030	6,590	6,080	7,140
80 to 84 years	3,060	3,080	4,920	5,360	7,010	5,770	5,350
85 years and over	2,610	4,040	4,200	5,800	6,910	8,820	8,600
	131,870	139,340	147,980	156,700	165,360	173,900	181,240

Male Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	4,260	3,480	4,400	4,680	5,060	5,080	4,890
5 to 9 years	4,390	4,240	3,450	4,360	4,630	5,010	5,010
10 to 14 years	4,310	4,650	4,580	3,750	4,720	5,020	5,430
15 to 19 years	4,360	4,380	4,680	4,640	3,760	4,750	5,060
20 to 24 years	4,290	4,680	4,810	5,150	5,110	4,150	5,250
25 to 29 years	4,400	4,500	4,970	5,120	5,480	5,430	4,420
30 to 34 years	5,310	4,820	5,070	5,640	5,770	6,260	6,190
35 to 39 years	4,540	5,570	5,140	5,410	6,030	6,180	6,730
40 to 44 years	4,700	4,780	5,950	5,530	5,820	6,500	6,660
45 to 49 years	4,040	4,750	4,900	6,090	5,690	5,980	6,720
50 to 54 years	3,760	4,110	4,860	5,020	6,260	5,840	6,150
55 to 59 years	4,060	3,810	4,200	4,960	5,150	6,410	6,030
60 to 64 years	4,350	4,000	3,760	4,140	4,890	5,150	6,390
65 to 69 years	3,370	4,230	3,740	3,520	3,920	4,670	4,740
70 to 74 years	2,930	3,180	3,950	3,510	3,310	3,690	4,400
75 to 79 years	1,790	2,750	2,860	3,620	3,200	3,030	3,390
80 to 84 years	1,100	1,550	2,350	2,390	3,130	2,740	2,610
85 years and over	830	1,250	1,580	2,310	2,640	3,360	3,400
	66,790	70,730	75,250	79,840	84,570	89,250	93,470

Female Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	3,750	3,470	4,370	4,650	5,040	5,060	4,870
5 to 9 years	3,480	3,740	3,450	4,350	4,620	5,000	5,020
10 to 14 years	5,190	3,670	3,990	3,680	4,640	4,940	5,370
15 to 19 years	3,790	5,140	3,710	4,020	3,720	4,700	4,990
20 to 24 years	3,750	4,150	5,610	3,880	4,240	3,900	4,890
25 to 29 years	4,520	3,920	4,410	5,990	4,110	4,500	4,130
30 to 34 years	4,390	4,760	4,230	4,610	6,240	4,410	4,840
35 to 39 years	4,870	4,660	5,150	4,590	5,000	6,770	4,790
40 to 44 years	3,390	4,960	4,800	5,360	4,770	5,130	6,960
45 to 49 years	3,920	3,530	5,210	5,060	5,640	5,030	5,420
50 to 54 years	3,300	3,960	3,570	5,250	5,090	5,650	5,040
55 to 59 years	3,740	3,310	3,980	3,590	5,280	5,120	5,670
60 to 64 years	4,900	3,820	3,410	4,120	3,720	5,460	5,290
65 to 69 years	3,620	4,740	3,690	3,300	3,970	3,590	5,320
70 to 74 years	3,030	3,520	4,570	3,540	3,170	3,850	3,480
75 to 79 years	1,700	2,940	3,390	4,410	3,390	3,050	3,750
80 to 84 years	1,960	1,530	2,570	2,970	3,880	3,030	2,740
85 years and over	1,780	2,790	2,620	3,490	4,270	5,460	5,200
	65,080	68,610	72,730	76,860	80,790	84,650	87,770

Group	Growth Rate
Total	1.1%
Male	1.2%
Female	1.1%

BMMPO

PREFERRED OR MEDIUM SCENARIO

Summary and Demographic Estimates							
Year	2021	2025	2030	2035	2040	2045	2050
Males	66,790	70,730	75,250	79,840	84,570	89,250	93,470
Females	65,080	68,610	72,730	76,860	80,790	84,650	87,770
Under 20	33,530	32,770	32,630	34,130	36,190	39,560	40,640
20 to 64	76,230	78,090	84,030	89,510	94,290	97,870	101,570
65+	22,110	28,480	31,320	33,060	34,880	36,470	39,030
K-12 Students	20,442	22,612	24,393	25,651	26,777	27,421	28,712
College Students	7,074	8,740	9,655	8,031	6,015	6,087	9,282

Households Characteristics							
Year	2021	2025	2030	2035	2040	2045	2050
Households	56,130	63,100	68,830	72,870	76,490	78,560	82,720
PPHH	2.3	2.2	2.1	2.2	2.2	2.2	2.2
HH with Children	17,644	18,325	19,581	20,006	20,818	21,952	22,793
3+ Veh	21,072	22,625	23,682	24,433	25,008	25,368	26,076
2 Veh	24,019	27,619	30,706	32,879	34,883	36,011	38,286
1 Veh	10,209	11,916	13,410	14,462	15,444	15,992	17,102
0 Veh	830	940	1,032	1,097	1,156	1,189	1,256
Renter Households	17,955	20,590	22,796	24,343	25,746	26,540	28,137

Household Structure Type							
Year	2021	2025	2030	2035	2040	2045	2050
HH in 1-unit structure	33,990	36,268	37,740	38,787	39,548	40,039	40,999
HH in 2 or more unit structure	16,896	20,925	24,634	27,240	29,751	31,131	33,933
HH in Mobile or Other	5,243	5,907	6,456	6,843	7,191	7,389	7,788

Household Income Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
Less than \$10,000	5.7%	6.1%	6.5%	6.7%	6.9%	7.0%	7.2%
\$10,000 to \$14,999	4.3%	4.4%	4.5%	4.6%	4.6%	4.6%	4.7%
\$15,000 to \$24,999	9.2%	9.5%	9.8%	9.9%	10.1%	10.2%	10.3%
\$25,000 to \$34,999	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%
\$35,000 to \$49,999	12.6%	12.2%	11.9%	11.7%	11.6%	11.5%	11.3%
\$50,000 to \$74,999	18.0%	17.0%	16.2%	15.7%	15.2%	14.9%	14.5%
\$75,000 to \$99,999	14.4%	14.1%	13.9%	13.8%	13.6%	13.6%	13.4%
\$100,000 to \$149,999	16.6%	17.0%	17.3%	17.5%	17.7%	17.8%	18.0%
\$150,000 to \$199,999	5.2%	5.2%	5.1%	5.1%	5.1%	5.1%	5.1%
\$200,000 or more	4.9%	5.3%	5.7%	5.9%	6.1%	6.2%	6.4%

Household Size Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
1 Person	32.4%	34.1%	35.7%	36.6%	37.5%	38.0%	38.8%
2 Person	37.8%	38.4%	39.0%	39.4%	39.7%	39.9%	40.2%
3 Person	13.8%	13.2%	12.6%	12.3%	12.0%	11.8%	11.5%
4 Person	10.1%	9.1%	8.2%	7.6%	7.1%	6.8%	6.3%
5 Person	4.5%	3.9%	3.4%	3.1%	2.8%	2.6%	2.3%
6 Person	1.1%	0.9%	0.8%	0.7%	0.7%	0.6%	0.6%
7+ person	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%



Table 17. Preferred Scenario Burleigh County Socio-Economic Characteristics

Total Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	5,970	5,000	6,350	7,070	8,000	7,990	7,530
5 to 9 years	5,500	5,940	4,950	6,290	6,990	7,910	7,880
10 to 14 years	7,520	5,870	6,430	5,370	6,810	7,570	8,570
15 to 19 years	6,290	7,480	5,880	6,430	5,350	6,800	7,550
20 to 24 years	6,050	7,030	8,590	6,710	7,340	6,130	7,780
25 to 29 years	6,430	6,420	7,550	9,250	7,210	7,890	6,580
30 to 34 years	7,270	6,630	6,700	7,840	9,550	7,530	8,230
35 to 39 years	6,840	7,700	7,120	7,180	8,420	10,270	8,080
40 to 44 years	6,410	7,000	7,950	7,340	7,430	8,690	10,560
45 to 49 years	6,180	6,540	7,210	8,160	7,550	7,630	8,940
50 to 54 years	5,150	6,320	6,730	7,420	8,410	7,790	7,870
55 to 59 years	5,500	5,180	6,370	6,780	7,480	8,490	7,860
60 to 64 years	7,150	5,480	5,170	6,370	6,750	7,520	8,470
65 to 69 years	5,150	7,030	5,380	5,080	6,260	6,680	7,400
70 to 74 years	4,660	4,990	6,760	5,180	4,890	6,050	6,430
75 to 79 years	2,590	4,550	4,850	6,580	5,040	4,770	5,920
80 to 84 years	2,300	2,290	3,930	4,200	5,730	4,430	4,210
85 years and over	1,990	3,160	3,320	4,750	5,670	7,410	7,060
	98,950	104,610	111,240	118,000	124,880	131,550	136,920

Male Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	3,250	2,500	3,180	3,540	4,000	4,000	3,770
5 to 9 years	3,040	3,230	2,470	3,140	3,490	3,950	3,930
10 to 14 years	3,410	3,220	3,470	2,660	3,370	3,750	4,240
15 to 19 years	3,290	3,520	3,350	3,610	2,760	3,510	3,900
20 to 24 years	3,320	3,560	3,880	3,700	3,980	3,050	3,870
25 to 29 years	3,240	3,500	3,800	4,140	3,950	4,250	3,250
30 to 34 years	4,120	3,500	3,850	4,170	4,550	4,340	4,670
35 to 39 years	3,230	4,330	3,720	4,090	4,440	4,850	4,620
40 to 44 years	3,740	3,390	4,580	3,940	4,340	4,710	5,140
45 to 49 years	3,080	3,740	3,390	4,590	3,950	4,350	4,720
50 to 54 years	2,750	3,160	3,860	3,500	4,750	4,090	4,500
55 to 59 years	2,860	2,760	3,180	3,880	3,520	4,780	4,120
60 to 64 years	3,350	2,760	2,650	3,050	3,730	3,390	4,610
65 to 69 years	2,350	3,390	2,800	2,690	3,100	3,800	3,460
70 to 74 years	2,380	2,220	3,160	2,620	2,520	2,910	3,570
75 to 79 years	1,410	2,280	2,100	3,000	2,490	2,400	2,780
80 to 84 years	860	1,270	2,030	1,880	2,700	2,260	2,190
85 years and over	540	940	1,280	1,980	2,150	2,870	2,850
	50,220	53,270	56,750	60,180	63,790	67,260	70,190

Female Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	2,720	2,500	3,170	3,530	4,000	3,990	3,760
5 to 9 years	2,460	2,710	2,480	3,150	3,500	3,960	3,950
10 to 14 years	4,110	2,650	2,960	2,710	3,440	3,820	4,330
15 to 19 years	3,000	3,960	2,530	2,820	2,590	3,290	3,650
20 to 24 years	2,730	3,470	4,710	3,010	3,360	3,080	3,910
25 to 29 years	3,190	2,920	3,750	5,110	3,260	3,640	3,330
30 to 34 years	3,150	3,130	2,850	3,670	5,000	3,190	3,560
35 to 39 years	3,610	3,370	3,400	3,090	3,980	5,420	3,460
40 to 44 years	2,670	3,610	3,370	3,400	3,090	3,980	5,420
45 to 49 years	3,100	2,800	3,820	3,570	3,600	3,280	4,220
50 to 54 years	2,400	3,160	2,870	3,920	3,660	3,700	3,370
55 to 59 years	2,640	2,420	3,190	2,900	3,960	3,710	3,740
60 to 64 years	3,800	2,720	2,520	3,320	3,020	4,130	3,860
65 to 69 years	2,800	3,640	2,580	2,390	3,160	2,880	3,940
70 to 74 years	2,280	2,770	3,600	2,560	2,370	3,140	2,860
75 to 79 years	1,180	2,270	2,750	3,580	2,550	2,370	3,140
80 to 84 years	1,440	1,020	1,900	2,320	3,030	2,170	2,020
85 years and over	1,450	2,220	2,040	2,770	3,520	4,540	4,210
	48,730	51,340	54,490	57,820	61,090	64,290	66,730

Group	Growth Rate
Total	1.1%
Male	1.2%
Female	1.1%

BURLEIGH

PREFERRED OR MEDIUM SCENARIO

Summary and Demographic Estimates							
Year	2021	2025	2030	2035	2040	2045	2050
Males	50,220	53,270	56,750	60,180	63,790	67,260	70,190
Females	48,730	51,340	54,490	57,820	61,090	64,290	66,730
Under 20	25,280	24,290	23,610	25,160	27,150	30,270	31,530
20 to 64	56,980	58,300	63,390	67,050	70,140	71,940	74,370
65+	16,690	22,020	24,240	25,790	27,590	29,340	31,020
K-12 Students	14,561	16,369	17,905	18,862	19,762	20,213	21,082
College Students	5,402	7,510	8,270	6,449	5,011	5,160	7,764

Households Characteristics							
Year	2021	2025	2030	2035	2040	2045	2050
Households	42,020	47,830	52,770	55,850	58,740	60,190	62,990
PPHH	2.4	2.2	2.1	2.1	2.1	2.2	2.2
HH with Children	13,030	13,565	14,478	15,196	16,343	17,927	18,586
3+ Veh	14,771	15,866	16,617	17,001	17,302	17,431	17,642
2 Veh	18,564	21,680	24,435	26,201	27,893	28,754	30,439
1 Veh	8,057	9,563	10,917	11,797	12,646	13,081	13,937
0 Veh	628	721	801	852	900	924	971
Renter Households	14,022	16,273	18,215	19,438	20,593	21,175	22,304

Household Structure Type							
Year	2021	2025	2030	2035	2040	2045	2050
HH in 1-unit structure	23,612	25,146	26,121	26,576	26,894	27,014	27,176
HH in 2 or more unit structure	14,471	18,191	21,680	24,008	26,300	27,489	29,856
HH in Mobile or Other	3,938	4,494	4,969	5,266	5,546	5,686	5,958

Household Income Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
Less than \$10,000	6.3%	6.7%	7.1%	7.4%	7.6%	7.8%	8.0%
\$10,000 to \$14,999	4.4%	4.6%	4.7%	4.7%	4.8%	4.8%	4.9%
\$15,000 to \$24,999	9.6%	10.0%	10.3%	10.5%	10.7%	10.8%	10.9%
\$25,000 to \$34,999	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%
\$35,000 to \$49,999	12.1%	11.7%	11.3%	11.1%	10.9%	10.8%	10.6%
\$50,000 to \$74,999	16.6%	15.5%	14.5%	13.9%	13.3%	13.0%	12.5%
\$75,000 to \$99,999	14.0%	13.7%	13.5%	13.3%	13.1%	13.0%	12.9%
\$100,000 to \$149,999	17.1%	17.6%	18.0%	18.2%	18.5%	18.6%	18.8%
\$150,000 to \$199,999	5.1%	5.1%	5.1%	5.0%	5.0%	5.0%	5.0%
\$200,000 or more	5.5%	5.9%	6.3%	6.6%	6.8%	7.0%	7.2%

Household Size Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
1 Person	34.8%	36.9%	38.7%	39.8%	40.9%	41.4%	42.5%
2 Person	38.7%	39.5%	40.1%	40.6%	41.0%	41.2%	41.6%
3 Person	12.9%	12.2%	11.6%	11.2%	10.8%	10.6%	10.3%
4 Person	8.7%	7.4%	6.4%	5.7%	5.1%	4.7%	4.1%
5 Person	3.7%	3.0%	2.4%	2.0%	1.6%	1.4%	1.1%
6 Person	0.9%	0.7%	0.6%	0.5%	0.4%	0.4%	0.3%
7+ person	0.4%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%



Table 18. Preferred Scenario Morton County Socio-Economic Characteristics

Total Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	2,040	1,950	2,420	2,260	2,100	2,150	2,230
5 to 9 years	2,370	2,040	1,950	2,420	2,260	2,100	2,150
10 to 14 years	1,980	2,450	2,140	2,060	2,550	2,390	2,230
15 to 19 years	1,860	2,040	2,510	2,230	2,130	2,650	2,500
20 to 24 years	1,990	1,800	1,830	2,320	2,010	1,920	2,360
25 to 29 years	2,490	2,000	1,830	1,860	2,380	2,040	1,970
30 to 34 years	2,430	2,950	2,600	2,410	2,460	3,140	2,800
35 to 39 years	2,570	2,530	3,170	2,820	2,610	2,680	3,440
40 to 44 years	1,680	2,740	2,800	3,550	3,160	2,940	3,060
45 to 49 years	1,780	1,740	2,900	2,990	3,780	3,380	3,200
50 to 54 years	1,910	1,750	1,700	2,850	2,940	3,700	3,320
55 to 59 years	2,300	1,940	1,810	1,770	2,950	3,040	3,840
60 to 64 years	2,100	2,340	2,000	1,890	1,860	3,090	3,210
65 to 69 years	1,840	1,940	2,050	1,740	1,630	1,580	2,660
70 to 74 years	1,300	1,710	1,760	1,870	1,590	1,490	1,450
75 to 79 years	900	1,140	1,400	1,450	1,550	1,310	1,220
80 to 84 years	760	790	990	1,160	1,280	1,340	1,140
85 years and over	620	880	880	1,050	1,240	1,410	1,540
	32,920	34,730	36,740	38,700	40,480	42,350	44,320

Male Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	1,010	980	1,220	1,140	1,060	1,080	1,120
5 to 9 years	1,350	1,010	980	1,220	1,140	1,060	1,080
10 to 14 years	900	1,430	1,110	1,090	1,350	1,270	1,190
15 to 19 years	1,070	860	1,330	1,030	1,000	1,240	1,160
20 to 24 years	970	1,120	930	1,450	1,130	1,100	1,380
25 to 29 years	1,160	1,000	1,170	980	1,530	1,180	1,170
30 to 34 years	1,190	1,320	1,220	1,470	1,220	1,920	1,520
35 to 39 years	1,310	1,240	1,420	1,320	1,590	1,330	2,110
40 to 44 years	960	1,390	1,370	1,590	1,480	1,790	1,520
45 to 49 years	960	1,010	1,510	1,500	1,740	1,630	2,000
50 to 54 years	1,010	950	1,000	1,520	1,510	1,750	1,650
55 to 59 years	1,200	1,050	1,020	1,080	1,630	1,630	1,910
60 to 64 years	1,000	1,240	1,110	1,090	1,160	1,760	1,780
65 to 69 years	1,020	840	940	830	820	870	1,280
70 to 74 years	550	960	790	890	790	780	830
75 to 79 years	380	470	760	620	710	630	610
80 to 84 years	240	280	320	510	430	480	420
85 years and over	290	310	300	330	490	490	550
	16,570	17,460	18,500	19,660	20,780	21,990	23,280

Female Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	1,030	970	1,200	1,120	1,040	1,070	1,110
5 to 9 years	1,020	1,030	970	1,200	1,120	1,040	1,070
10 to 14 years	1,080	1,020	1,030	970	1,200	1,120	1,040
15 to 19 years	790	1,180	1,180	1,200	1,130	1,410	1,340
20 to 24 years	1,020	680	900	870	880	820	980
25 to 29 years	1,330	1,000	660	880	850	860	800
30 to 34 years	1,240	1,630	1,380	940	1,240	1,220	1,280
35 to 39 years	1,260	1,290	1,750	1,500	1,020	1,350	1,330
40 to 44 years	720	1,350	1,430	1,960	1,680	1,150	1,540
45 to 49 years	820	730	1,390	1,490	2,040	1,750	1,200
50 to 54 years	900	800	700	1,330	1,430	1,950	1,670
55 to 59 years	1,100	890	790	690	1,320	1,410	1,930
60 to 64 years	1,100	1,100	890	800	700	1,330	1,430
65 to 69 years	820	1,100	1,110	910	810	710	1,380
70 to 74 years	750	750	970	980	800	710	620
75 to 79 years	520	670	640	830	840	680	610
80 to 84 years	520	510	670	650	850	860	720
85 years and over	330	570	580	720	750	920	990
	16,350	17,270	18,240	19,040	19,700	20,360	21,040

Group	Growth Rate
Total	1.0%
Male	1.2%
Female	0.9%

MORTON

PREFERRED OR MEDIUM SCENARIO

Summary and Demographic Estimates							
Year	2021	2025	2030	2035	2040	2045	2050
Males	16,570	17,460	18,500	19,660	20,780	21,990	23,280
Females	16,350	17,270	18,240	19,040	19,700	20,360	21,040
Under 20	8,250	8,480	9,020	8,970	9,040	9,290	9,110
20 to 64	19,250	19,790	20,640	22,460	24,150	25,930	27,200
65+	5,420	6,460	7,080	7,270	7,290	7,130	8,010
K-12 Students	5,882	6,242	6,488	6,788	7,015	7,208	7,629
College Students	1,672	1,230	1,384	1,581	1,003	927	1,518

Households Characteristics							
Year	2021	2025	2030	2035	2040	2045	2050
Households	14,110	15,270	16,060	17,020	17,750	18,370	19,730
PPHH	2.3	2.3	2.3	2.3	2.3	2.3	2.2
HH with Children	4,614	4,760	5,103	4,810	4,475	4,025	4,206
3+ Veh	6,301	6,759	7,065	7,432	7,707	7,937	8,433
2 Veh	5,455	5,939	6,271	6,678	6,990	7,257	7,847
1 Veh	2,151	2,353	2,493	2,665	2,798	2,911	3,164
0 Veh	202	219	231	245	256	265	285
Renter Households	3,933	4,317	4,581	4,905	5,153	5,365	5,833

Household Structure Type							
Year	2021	2025	2030	2035	2040	2045	2050
HH in 1-unit structure	10,379	11,122	11,618	12,211	12,654	13,025	13,823
HH in 2 or more unit structure	2,425	2,734	2,954	3,232	3,451	3,642	4,077
HH in Mobile or Other	1,306	1,414	1,487	1,577	1,645	1,703	1,830

Household Income Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
Less than \$10,000	4.1%	4.2%	4.2%	4.3%	4.4%	4.4%	4.5%
\$10,000 to \$14,999	3.8%	3.9%	3.9%	3.9%	3.9%	3.9%	4.0%
\$15,000 to \$24,999	7.9%	8.0%	8.0%	8.1%	8.1%	8.2%	8.3%
\$25,000 to \$34,999	9.1%	9.1%	9.1%	9.1%	9.1%	9.1%	9.1%
\$35,000 to \$49,999	14.0%	13.9%	13.8%	13.8%	13.7%	13.7%	13.6%
\$50,000 to \$74,999	21.9%	21.7%	21.6%	21.4%	21.2%	21.1%	20.8%
\$75,000 to \$99,999	15.5%	15.5%	15.4%	15.4%	15.3%	15.3%	15.2%
\$100,000 to \$149,999	15.0%	15.1%	15.2%	15.3%	15.3%	15.4%	15.5%
\$150,000 to \$199,999	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%
\$200,000 or more	3.3%	3.3%	3.4%	3.5%	3.6%	3.6%	3.7%

Household Size Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
1 Person	25.1%	25.5%	25.8%	26.2%	26.4%	26.7%	27.2%
2 Person	35.0%	35.2%	35.3%	35.4%	35.5%	35.6%	35.8%
3 Person	16.3%	16.1%	16.0%	15.9%	15.8%	15.7%	15.6%
4 Person	14.5%	14.2%	14.0%	13.8%	13.7%	13.5%	13.2%
5 Person	7.0%	6.9%	6.8%	6.6%	6.6%	6.5%	6.3%
6 Person	1.6%	1.6%	1.6%	1.5%	1.5%	1.5%	1.5%
7+ person	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%



Table 19. Preferred Scenario City of Bismarck Socio-Economic Characteristics

Total Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	4,690	3,930	5,120	5,380	5,620	5,760	5,830
5 to 9 years	4,570	4,650	3,900	5,080	5,330	5,550	5,690
10 to 14 years	4,550	4,870	5,050	4,220	5,500	5,770	6,010
15 to 19 years	4,490	4,530	4,880	5,040	4,200	5,480	5,750
20 to 24 years	4,750	5,020	5,190	5,560	5,760	4,820	6,280
25 to 29 years	5,660	5,040	5,400	5,580	5,980	6,200	5,180
30 to 34 years	5,030	5,840	5,240	5,590	5,780	6,230	6,450
35 to 39 years	5,200	5,330	6,260	5,610	6,000	6,210	6,690
40 to 44 years	4,590	5,340	5,500	6,460	5,800	6,190	6,400
45 to 49 years	3,920	4,700	5,480	5,640	6,640	5,960	6,380
50 to 54 years	4,020	4,020	4,840	5,650	5,820	6,850	6,150
55 to 59 years	4,350	4,040	4,050	4,870	5,700	5,870	6,920
60 to 64 years	4,930	4,340	4,030	4,050	4,880	5,690	5,860
65 to 69 years	3,740	4,850	4,250	3,960	3,990	4,810	5,620
70 to 74 years	3,060	3,620	4,650	4,090	3,810	3,850	4,650
75 to 79 years	2,040	2,990	3,530	4,530	3,990	3,730	3,770
80 to 84 years	1,810	1,810	2,570	3,050	3,950	3,500	3,290
85 years and over	1,970	2,720	2,740	3,400	4,130	5,200	5,300
	73,370	77,640	82,680	87,760	92,880	97,670	102,220

Male Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	2,470	1,970	2,560	2,690	2,810	2,880	2,920
5 to 9 years	2,430	2,450	1,950	2,540	2,660	2,770	2,840
10 to 14 years	2,210	2,570	2,640	2,090	2,720	2,860	2,970
15 to 19 years	2,200	2,280	2,680	2,740	2,170	2,830	2,970
20 to 24 years	2,410	2,380	2,510	2,950	3,020	2,400	3,120
25 to 29 years	2,830	2,550	2,540	2,680	3,150	3,230	2,560
30 to 34 years	2,800	3,060	2,800	2,790	2,940	3,460	3,550
35 to 39 years	2,840	2,950	3,250	2,970	2,970	3,130	3,690
40 to 44 years	2,320	2,980	3,120	3,450	3,150	3,150	3,320
45 to 49 years	1,860	2,320	2,980	3,120	3,450	3,160	3,160
50 to 54 years	2,030	1,910	2,390	3,080	3,230	3,570	3,270
55 to 59 years	2,160	2,030	1,920	2,400	3,100	3,250	3,600
60 to 64 years	2,430	2,080	1,950	1,840	2,310	2,980	3,130
65 to 69 years	1,670	2,460	2,110	1,980	1,880	2,360	3,040
70 to 74 years	1,340	1,570	2,290	1,970	1,850	1,760	2,210
75 to 79 years	1,000	1,290	1,490	2,180	1,880	1,770	1,680
80 to 84 years	560	910	1,140	1,330	1,960	1,700	1,610
85 years and over	640	750	940	1,190	1,450	2,040	2,100
	36,200	38,510	41,260	43,990	46,700	49,300	51,740

Female Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	2,220	1,960	2,560	2,690	2,810	2,880	2,910
5 to 9 years	2,140	2,200	1,950	2,540	2,670	2,780	2,850
10 to 14 years	2,340	2,300	2,410	2,130	2,780	2,910	3,040
15 to 19 years	2,290	2,250	2,200	2,300	2,030	2,650	2,780
20 to 24 years	2,340	2,640	2,680	2,610	2,740	2,420	3,160
25 to 29 years	2,830	2,490	2,860	2,900	2,830	2,970	2,620
30 to 34 years	2,230	2,780	2,440	2,800	2,840	2,770	2,900
35 to 39 years	2,360	2,380	3,010	2,640	3,030	3,080	3,000
40 to 44 years	2,270	2,360	2,380	3,010	2,650	3,040	3,080
45 to 49 years	2,060	2,380	2,500	2,520	3,190	2,800	3,220
50 to 54 years	1,990	2,110	2,450	2,570	2,590	3,280	2,880
55 to 59 years	2,190	2,010	2,130	2,470	2,600	2,620	3,320
60 to 64 years	2,500	2,260	2,080	2,210	2,570	2,710	2,730
65 to 69 years	2,070	2,390	2,140	1,980	2,110	2,450	2,580
70 to 74 years	1,720	2,050	2,360	2,120	1,960	2,090	2,440
75 to 79 years	1,040	1,700	2,040	2,350	2,110	1,960	2,090
80 to 84 years	1,250	900	1,430	1,720	1,990	1,800	1,680
85 years and over	1,330	1,970	1,800	2,210	2,680	3,160	3,200
	37,170	39,130	41,420	43,770	46,180	48,370	50,480

Group	Growth Rate
Total	1.1%
Male	1.2%
Female	1.1%

BISMARCK

PREFERRED OR MEDIUM SCENARIO

Summary and Demographic Estimates							
Year	2021	2025	2030	2035	2040	2045	2050
Males	36,200	38,510	41,260	43,990	46,700	49,300	51,740
Females	37,170	39,130	41,420	43,770	46,180	48,370	50,480
Under 20	18,300	17,980	18,950	19,720	20,650	22,560	23,280
20 to 64	42,450	43,670	45,990	49,010	52,360	54,020	56,310
65+	12,620	15,990	17,740	19,030	19,870	21,090	22,630
K-12 Students	11,361	12,567	13,352	14,171	14,873	15,372	16,158
College Students	4,300	4,500	5,322	5,532	4,570	4,137	6,107

Households Characteristics							
Year	2021	2025	2030	2035	2040	2045	2050
Households	31,730	35,600	38,130	40,760	43,020	44,620	47,150
PPHH	2.3	2.2	2.2	2.2	2.2	2.2	2.2
HH with Children	9,751	10,403	11,326	11,842	12,329	13,050	13,486
3+ Veh	12,266	13,292	13,908	14,502	14,975	15,288	15,749
2 Veh	13,372	15,276	16,552	17,906	19,091	19,942	21,309
1 Veh	5,625	6,505	7,103	7,744	8,310	8,720	9,382
0 Veh	467	527	567	608	644	669	710
Renter Households	10,140	11,583	12,538	13,540	14,407	15,025	16,008

Household Structure Type							
Year	2021	2025	2030	2035	2040	2045	2050
HH in 1-unit structure	19,861	21,425	22,348	23,222	23,905	24,349	24,988
HH in 2 or more unit structure	8,910	10,849	12,215	13,721	15,082	16,085	17,734
HH in Mobile or Other	2,960	3,326	3,567	3,817	4,033	4,186	4,428

Household Income Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
Less than \$10,000	5.5%	5.8%	6.0%	6.2%	6.4%	6.5%	6.7%
\$10,000 to \$14,999	4.2%	4.3%	4.4%	4.4%	4.5%	4.5%	4.6%
\$15,000 to \$24,999	9.0%	9.2%	9.4%	9.5%	9.7%	9.8%	10.0%
\$25,000 to \$34,999	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%
\$35,000 to \$49,999	12.8%	12.5%	12.3%	12.2%	12.0%	11.9%	11.7%
\$50,000 to \$74,999	18.6%	17.8%	17.3%	16.8%	16.4%	16.0%	15.5%
\$75,000 to \$99,999	14.6%	14.4%	14.2%	14.1%	14.0%	13.9%	13.7%
\$100,000 to \$149,999	16.4%	16.7%	16.9%	17.1%	17.3%	17.4%	17.6%
\$150,000 to \$199,999	5.2%	5.2%	5.2%	5.2%	5.1%	5.1%	5.1%
\$200,000 or more	4.7%	5.0%	5.2%	5.4%	5.6%	5.7%	5.9%

Household Size Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
1 Person	31.2%	32.6%	33.5%	34.5%	35.3%	35.9%	36.9%
2 Person	37.3%	37.8%	38.2%	38.6%	38.9%	39.1%	39.5%
3 Person	14.2%	13.7%	13.4%	13.0%	12.7%	12.5%	12.2%
4 Person	10.8%	10.0%	9.4%	8.9%	8.4%	8.0%	7.5%
5 Person	4.9%	4.4%	4.1%	3.8%	3.5%	3.3%	3.0%
6 Person	1.1%	1.0%	1.0%	0.9%	0.8%	0.8%	0.7%
7+ person	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%



Table 20. Preferred Scenario City of Mandan Socio-Economic Characteristics

Total Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	1,400	1,540	2,030	1,850	1,580	1,510	1,510
5 to 9 years	1,500	1,400	1,550	2,030	1,850	1,570	1,510
10 to 14 years	1,600	1,560	1,470	1,630	2,140	1,960	1,670
15 to 19 years	1,450	1,630	1,570	1,530	1,680	2,220	2,040
20 to 24 years	1,750	1,420	1,470	1,490	1,360	1,520	1,980
25 to 29 years	2,200	1,760	1,450	1,490	1,530	1,390	1,550
30 to 34 years	1,680	2,620	2,300	1,900	1,980	2,000	1,910
35 to 39 years	1,850	1,760	2,810	2,490	2,050	2,160	2,200
40 to 44 years	1,150	1,970	1,950	3,150	2,790	2,310	2,460
45 to 49 years	1,360	1,190	2,100	2,080	3,350	2,990	2,520
50 to 54 years	1,530	1,330	1,160	2,070	2,040	3,290	2,930
55 to 59 years	1,460	1,550	1,380	1,200	2,150	2,120	3,400
60 to 64 years	1,330	1,480	1,600	1,440	1,260	2,270	2,240
65 to 69 years	1,420	1,230	1,320	1,390	1,230	1,090	1,900
70 to 74 years	860	1,330	1,110	1,190	1,270	1,140	1,000
75 to 79 years	370	750	1,080	920	990	1,050	930
80 to 84 years	480	330	670	900	810	880	910
85 years and over	390	550	420	650	910	940	1,020
	23,780	25,400	27,440	29,400	30,970	32,410	33,680

Male Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	640	770	1,020	930	800	760	760
5 to 9 years	950	640	780	1,020	930	790	760
10 to 14 years	740	1,010	710	860	1,130	1,040	890
15 to 19 years	900	700	940	650	790	1,040	950
20 to 24 years	870	950	760	1,030	710	870	1,160
25 to 29 years	990	890	990	800	1,080	750	920
30 to 34 years	830	1,130	1,100	1,240	1,000	1,350	970
35 to 39 years	1,050	870	1,210	1,190	1,340	1,090	1,490
40 to 44 years	580	1,120	960	1,360	1,330	1,510	1,240
45 to 49 years	750	610	1,220	1,060	1,490	1,470	1,680
50 to 54 years	820	740	600	1,220	1,060	1,500	1,480
55 to 59 years	690	850	790	650	1,310	1,150	1,630
60 to 64 years	600	710	900	850	700	1,420	1,250
65 to 69 years	790	500	540	670	630	520	1,030
70 to 74 years	320	750	470	510	640	610	500
75 to 79 years	170	270	590	370	410	510	480
80 to 84 years	140	130	180	400	250	280	340
85 years and over	200	190	150	180	360	310	330
	12,030	12,830	13,910	14,990	15,960	16,970	17,860

Female Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	760	770	1,010	920	780	750	750
5 to 9 years	550	760	770	1,010	920	780	750
10 to 14 years	860	550	760	770	1,010	920	780
15 to 19 years	550	930	630	880	890	1,180	1,090
20 to 24 years	880	470	710	460	650	650	820
25 to 29 years	1,210	870	460	690	450	640	630
30 to 34 years	850	1,490	1,200	660	980	650	940
35 to 39 years	800	890	1,600	1,300	710	1,070	710
40 to 44 years	570	850	990	1,790	1,460	800	1,220
45 to 49 years	610	580	880	1,020	1,860	1,520	840
50 to 54 years	710	590	560	850	980	1,790	1,450
55 to 59 years	770	700	590	550	840	970	1,770
60 to 64 years	730	770	700	590	560	850	990
65 to 69 years	630	730	780	720	600	570	870
70 to 74 years	540	580	640	680	630	530	500
75 to 79 years	200	480	490	550	580	540	450
80 to 84 years	340	200	490	500	560	600	570
85 years and over	190	360	270	470	550	630	690
	11,750	12,570	13,530	14,410	15,010	15,440	15,820

Group	Growth Rate
Total	1.2%
Male	1.4%
Female	1.0%

MANDAN

PREFERRED OR MEDIUM SCENARIO

Summary and Demographic Estimates							
Year	2021	2025	2030	2035	2040	2045	2050
Males	12,030	12,830	13,910	14,990	15,960	16,970	17,860
Females	11,750	12,570	13,530	14,410	15,010	15,440	15,820
Under 20	5,950	6,130	6,620	7,040	7,250	7,260	6,730
20 to 64	14,310	15,080	16,220	17,310	18,510	20,050	21,190
65+	3,520	4,190	4,600	5,050	5,210	5,100	5,760
K-12 Students	4,661	4,964	5,172	5,396	5,587	5,733	6,130
College Students	1,574	763	534	529	458	1,000	1,463

Households Characteristics							
Year	2021	2025	2030	2035	2040	2045	2050
Households	10,180	11,150	11,820	12,540	13,160	13,630	14,900
PPHH	2.3	2.3	2.3	2.3	2.4	2.4	2.3
HH with Children	3,276	3,216	3,717	3,625	3,352	2,799	2,830
3+ Veh	4,682	5,092	5,371	5,667	5,920	6,109	6,614
2 Veh	3,857	4,246	4,516	4,809	5,063	5,257	5,784
1 Veh	1,496	1,654	1,764	1,885	1,989	2,069	2,289
0 Veh	145	159	169	179	188	195	214
Renter Households	2,670	2,976	3,190	3,421	3,622	3,775	4,194

Household Structure Type							
Year	2021	2025	2030	2035	2040	2045	2050
HH in 1-unit structure	7,737	8,406	8,862	9,346	9,758	10,066	10,886
HH in 2 or more unit structure	1,503	1,713	1,865	2,035	2,185	2,303	2,635
HH in Mobile or Other	940	1,030	1,093	1,160	1,217	1,261	1,379

Household Income Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
Less than \$10,000	3.8%	3.9%	3.9%	4.0%	4.0%	4.1%	4.2%
\$10,000 to \$14,999	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.9%
\$15,000 to \$24,999	7.7%	7.7%	7.8%	7.8%	7.9%	7.9%	8.0%
\$25,000 to \$34,999	9.1%	9.1%	9.1%	9.1%	9.1%	9.1%	9.1%
\$35,000 to \$49,999	14.2%	14.2%	14.1%	14.1%	14.0%	14.0%	13.9%
\$50,000 to \$74,999	22.7%	22.5%	22.4%	22.2%	22.1%	22.0%	21.8%
\$75,000 to \$99,999	15.7%	15.7%	15.7%	15.6%	15.6%	15.5%	15.5%
\$100,000 to \$149,999	14.7%	14.8%	14.9%	14.9%	15.0%	15.0%	15.1%
\$150,000 to \$199,999	5.4%	5.4%	5.4%	5.4%	5.4%	5.3%	5.3%
\$200,000 or more	2.9%	3.0%	3.1%	3.1%	3.2%	3.2%	3.3%

Household Size Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
1 Person	23.7%	24.1%	24.3%	24.6%	24.8%	25.0%	25.5%
2 Person	34.5%	34.6%	34.7%	34.8%	34.9%	35.0%	35.1%
3 Person	16.8%	16.6%	16.6%	16.5%	16.4%	16.3%	16.2%
4 Person	15.3%	15.1%	14.9%	14.8%	14.6%	14.5%	14.3%
5 Person	7.5%	7.4%	7.3%	7.2%	7.1%	7.0%	6.9%
6 Person	1.7%	1.7%	1.7%	1.6%	1.6%	1.6%	1.6%
7+ person	0.6%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%



Table 21. Preferred Scenario City of Lincoln Socio-Economic Characteristics

Total Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	340	240	300	400	560	520	440
5 to 9 years	430	340	240	300	400	550	520
10 to 14 years	680	460	370	260	320	440	600
15 to 19 years	230	670	470	370	270	310	430
20 to 24 years	230	260	770	520	420	300	360
25 to 29 years	200	230	280	830	560	450	330
30 to 34 years	680	210	250	290	860	600	470
35 to 39 years	230	720	230	260	310	920	640
40 to 44 years	240	240	750	230	280	310	950
45 to 49 years	290	240	240	760	230	290	330
50 to 54 years	140	300	240	250	790	250	290
55 to 59 years	220	140	310	240	250	800	250
60 to 64 years	40	210	140	300	240	250	790
65 to 69 years	110	40	210	130	290	240	250
70 to 74 years	90	100	40	200	120	280	230
75 to 79 years	0	90	100	40	190	120	280
80 to 84 years	10	-	80	90	20	170	110
85 years and over	-	10	10	60	100	70	170
	4,160	4,500	5,030	5,530	6,210	6,870	7,440

Male Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	150	120	150	200	280	260	220
5 to 9 years	360	150	120	150	200	270	260
10 to 14 years	290	390	160	130	160	220	300
15 to 19 years	20	300	400	170	140	160	220
20 to 24 years	170	20	330	440	190	150	180
25 to 29 years	90	170	20	350	470	200	160
30 to 34 years	400	100	190	30	390	520	220
35 to 39 years	120	420	110	200	30	410	550
40 to 44 years	150	130	450	110	220	30	440
45 to 49 years	150	150	130	450	110	220	30
50 to 54 years	50	160	150	130	470	120	220
55 to 59 years	120	50	160	150	130	470	120
60 to 64 years	20	110	50	150	140	130	450
65 to 69 years	50	20	120	50	150	150	130
70 to 74 years	80	40	20	110	40	140	140
75 to 79 years	0	80	40	20	100	40	140
80 to 84 years	0	-	70	40	10	90	40
85 years and over	-	-	-	50	50	30	80
	2,220	2,410	2,670	2,930	3,280	3,610	3,900

Female Population							
Year	2021	2025	2030	2035	2040	2045	2050
Under 5 years	190	120	150	200	280	260	220
5 to 9 years	70	190	120	150	200	280	260
10 to 14 years	390	70	210	130	160	220	300
15 to 19 years	210	370	70	200	130	150	210
20 to 24 years	60	240	440	80	230	150	180
25 to 29 years	110	60	260	480	90	250	170
30 to 34 years	280	110	60	260	470	80	250
35 to 39 years	110	300	120	60	280	510	90
40 to 44 years	90	110	300	120	60	280	510
45 to 49 years	140	90	110	310	120	70	300
50 to 54 years	90	140	90	120	320	130	70
55 to 59 years	100	90	150	90	120	330	130
60 to 64 years	20	100	90	150	100	120	340
65 to 69 years	60	20	90	80	140	90	120
70 to 74 years	10	60	20	90	80	140	90
75 to 79 years	0	10	60	20	90	80	140
80 to 84 years	10	-	10	50	10	80	70
85 years and over	-	10	10	10	50	40	90
	1,940	2,090	2,360	2,600	2,930	3,260	3,540

Group	Growth Rate
Total	2.0%
Male	1.9%
Female	2.1%

LINCOLN

PREFERRED OR MEDIUM SCENARIO

Summary and Demographic Estimates							
Year	2021	2025	2030	2035	2040	2045	2050
Males	2,220	2,410	2,670	2,930	3,280	3,610	3,900
Females	1,940	2,090	2,360	2,600	2,930	3,260	3,540
Under 20	1,680	1,710	1,380	1,330	1,550	1,820	1,990
20 to 64	2,270	2,550	3,210	3,680	3,940	4,170	4,410
65+	210	240	440	520	720	880	1,040
K-12 Students	1,911	1,922	2,117	2,231	2,344	2,367	2,421
College Students	0	456	941	420	0	0	87

Households Characteristics							
Year	2021	2025	2030	2035	2040	2045	2050
Households	1,340	1,370	2,000	2,370	2,730	2,800	2,980
PPHH	3.1	3.3	2.5	2.3	2.3	2.5	2.5
HH with Children	653	618	680	460	599	744	657
3+ Veh	657	671	976	1,153	1,325	1,358	1,444
2 Veh	484	495	725	861	994	1,020	1,087
1 Veh	180	184	271	322	373	382	408
0 Veh	19	19	28	33	38	39	42
Renter Households	215	221	361	447	535	553	597

Household Structure Type							
Year	2021	2025	2030	2035	2040	2045	2050
HH in 1-unit structure	1,092	1,116	1,622	1,916	2,201	2,256	2,398
HH in 2 or more unit structure	125	128	194	235	277	286	307
HH in Mobile or Other	123	126	184	218	251	258	274

Household Income Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
Less than \$10,000	3.1%	3.1%	3.1%	3.2%	3.2%	3.2%	3.2%
\$10,000 to \$14,999	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%
\$15,000 to \$24,999	7.1%	7.1%	7.2%	7.2%	7.2%	7.2%	7.2%
\$25,000 to \$34,999	9.1%	9.1%	9.1%	9.1%	9.1%	9.1%	9.1%
\$35,000 to \$49,999	14.8%	14.8%	14.8%	14.8%	14.7%	14.7%	14.7%
\$50,000 to \$74,999	24.4%	24.4%	24.2%	24.2%	24.1%	24.1%	24.1%
\$75,000 to \$99,999	16.2%	16.2%	16.2%	16.2%	16.1%	16.1%	16.1%
\$100,000 to \$149,999	14.1%	14.1%	14.1%	14.1%	14.2%	14.2%	14.2%
\$150,000 to \$199,999	5.4%	5.4%	5.4%	5.4%	5.4%	5.4%	5.4%
\$200,000 or more	2.2%	2.2%	2.3%	2.3%	2.3%	2.4%	2.4%

Household Size Distribution							
Year	2021	2025	2030	2035	2040	2045	2050
1 Person	20.6%	20.7%	20.9%	21.0%	21.1%	21.2%	21.2%
2 Person	33.3%	33.3%	33.4%	33.5%	33.5%	33.5%	33.5%
3 Person	17.8%	17.8%	17.7%	17.7%	17.7%	17.6%	17.6%
4 Person	17.1%	17.1%	17.0%	16.9%	16.8%	16.8%	16.8%
5 Person	8.5%	8.5%	8.4%	8.4%	8.4%	8.3%	8.3%
6 Person	2.0%	2.0%	1.9%	1.9%	1.9%	1.9%	1.9%
7+ person	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%