NDSU UPPER GREAT PLAINS TRANSPORTATION INSTITUTE

Infrastructure Needs: North Dakota's County, Township and Tribal Roads and Bridges: 2024-2043

Report to the North Dakota Legislative Assembly

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Executive Summary

This report is the response to the North Dakota Legislature's request for a study of the transportation infrastructure needs of all counties, townships and tribes in the state.

In 2019, the North Dakota Legislature advanced HB 1066 which had a provision for funding distributions to non-oil producing counties based on the most recent version of this study. HB 1066 also stated: "If the data compiled by the upper great plains transportation institute includes more than one twenty-year estimate for the total needs of each county, the state treasurer shall use an average of the twenty-year estimates for each County."

In this report, the Upper Great Plains Transportation Institute (UGPTI) estimated infrastructure needs using the most current production forecasts, traffic estimates, and roadway inventory and condition data available. Agricultural- and oil-related traffic are modeled in detail at the sub-county level. Oil-related traffic is predicted for individual spacing units, whereas agricultural production is estimated at the township level.

A significant data collection effort provides the most complete and current data on the condition of the state's county and township roadway system. In 2023, UGPTI acquired a portable road profiler to collect pavement condition data which replaced smartphone-based accelerometer condition assessment. Traffic counts were collected on the county and township road system across the entire state since 2021. The effort was a combination of additional counts requested of NDDOT along with vehicle classifications conducted by NDSU-UGPTI students and a consultant. The data was used to calibrate a statewide travel demand model, which was used to forecast future traffic levels. The GRIT (Geographic Roadway Inventory Tool) was used to gather and verify county roadway inventory information such as base thickness, pavement age, and pavement thickness, directly from local road authorities.

An enhanced county-level survey was developed to assess unpaved roadway component costs such as blading, gravel purchasing, hauling, and placement costs for each of the 53 counties in North Dakota. Training on how to accurately complete the survey was provided to counties via a live and recorded webinar. A secondary analysis of survey results was performed to identify significant variations from county to county by region within the state.

The bridge analysis underwent significant changes to accommodate the FHWA discontinuation of the bridge sufficiency rating (SR) in the previous study. In recent years, states have been developing a replacement index that fits their jurisdictions. The 2022 study advanced a new Bridge Needs Target (BNT) through use of a county expert panel. The analysis routine used the BNT for the first time in that study. Additionally, the North Dakota Department of Transportation (NDDOT) added consultant resources to the load rating of non-state bridges which resulted in more local bridges with a reduced load rating. In addition to major structures included in the National Bridge Inventory data, UGPTI estimated the needs for minor structures (less than 20 feet in span) which were not previously included due to data limitations.

For traffic forecasting, the UGPTI developed a travel demand model (TDM) for the entire state. The TDM network includes the origins of key inputs to the oil production process (e.g., fresh water, sand, scoria, gravel, and pipe), destinations for crude oil and saltwater shipments, and the capacities of each source or destination. The origins of movements on the highway network include railroad stations where sand, pipe, and other inputs are transferred from rail to truck. The destinations of crude oil shipments include refineries and railroad and pipeline transfer facilities. In the model, the estimated capacities of transfer sites are expressed in throughput volumes per day, while the capacities of material sources are expressed in quantities of supplies available during a given time period. Similarly, an agricultural sub model was developed to model truck movements of agricultural production across the state from farms to elevators and processors. The nine largest commodities by volume were modeled explicitly as part of TDM process.

Using the TDM, inputs and products are routed to and from wells to minimize time and/or cost, subject to available supplies and capacities. A comparable model is used to predict the trips of each crop produced in each township to elevators and/or processing plants, subject to the demands of these facilities. When all trips have been routed, the individual movements over each road segment are summed to yield the total truck trips per year. Using truck characteristics and typical weights, these trips are converted to equivalent single axle loads (ESALs) and trips per day. These two factors, in conjunction with the condition ratings and structural characteristics of roads, are used to estimate the improvements and maintenance expenditures needed for the expected traffic. While the focus is on agricultural- and oil-related activities, other movements (such as farm inputs and shipments of manufactured goods) are also included in the analysis.

Unpaved Road Needs

The following types of improvements to unpaved roads are analyzed in this study: increased graveling frequency, intermediate improvements, and asphalt surfacing. On heavily impacted gravel surface roads, the graveling interval decreases and the number of bladings per month increases as traffic volumes grow. For example, a non-impacted road has an expected graveling interval of five years and a blading interval of once per month, while an impacted section has an expected gravel interval of two to five years and a blading interval of twice per month. This doubles the gravel maintenance costs over the same period.

As shown in Table A, the predicted statewide unpaved infrastructure needs estimate is $6.97 billion over the next 20 years.

Table A: Summary of Unpaved Road Investment and Maintenance Needs for Counties, Townships and Tribal Areas in North Dakota (Millions of 2024 Dollars)

Period	Statewide
2024-2025	$707.88
2026-2027	$694.93
2028-2029	$714.99
2030-2031	$716.56
2032-2033	$693.38
2034-2043	$3,443.71
2024-2043	**$6,971.45**

Paved Road Needs

Table B shows that $3.5 billion in paved road investment and maintenance expenditures will be needed during the next 20 years. Almost 64% of these expenditures will be required in the first decade because of a shortfall of timely investments in previous years.

Table B: Summary of Paved Road Investment and Maintenance Needs for Counties, Townships and Tribal Areas in North Dakota (Millions of 2024 Dollars)

Period	Statewide
2024-2025	$433.82
2026-2027	$523.64
2028-2029	$436.78
2030-2031	$388.93
2032-2033	$368.57
2034-2043	$1,344.44
2024-2043	**$3,496.17**

Bridge Needs

Table C shows the estimated bridge investment and maintenance needs for county, township and tribal bridges for 2024-2043. Most of the improvement needs are determined by the study's improvement model to be backlog needs and occur during the first study biennium. Based on past discussions with NDDOT Bridge and Local Government Divisions, these needs have been distributed evenly over the first five biennia of the study period because it would not be possible to replace all the eligible bridges in one biennium with existing construction resources.

Table C: Summary of Bridge Investment and Maintenance Needs for Counties, Townships and Tribal Areas in North Dakota (Millions of 2024 Dollars)

Period	Statewide
2024-2025	$178.94
2026-2027	$178.94
2028-2029	$178.94
2030-2031	$178.94
2032-2033	$178.94
2034-2043	$192.45
2024-2043	**$1,087.16**

New for this report is the inclusion of county, township and tribal minor structures needs which are presented in Table D below. These are structures which are 20 feet or less in span. This study includes an analysis of these structures which range from 8 feet to 20 feet in span as directed by the UGPTI ND County Bridge Steering Committee. See the bridge section in this report for details and tables with separate and combined needs with the major structures which have a span of greater than 20 feet.

Table D: Summary of Minor Structures Investment and Maintenance Needs for Counties, Townships and Tribal Areas in North Dakota (Millions of 2024 Dollars)

Period	Statewide
2024-2025	$151.06
2026-2027	$151.06
2028-2029	$151.06
2030-2031	$151.06
2032-2033	$151.06
2034-2043	$49.72
2024-2043	**$805.00**

Total Statewide Needs

As shown in Tables E and F, the combined estimate of infrastructure needs for all county, township and tribal roads and bridges is $12.35 billion over the next 20 years. Unpaved road funding needs make up approximately 56% of the total. If averaged over the next 20 years, the annualized infrastructure need is equivalent to $618 million per year.

The values shown in Tables E and F do not include the infrastructure needs of Forest Service roads or city streets within municipal areas. The infrastructure needs of Indian Reservation roads are included for the paved roads and presented separately in the report.

Table E: Summary of All Road and Bridge Investment and Maintenance Needs for Counties, Townships and Tribal Areas in North Dakota (Millions of 2024 Dollars)

Period	Statewide
2024-2025	$1,471.70
2026-2027	$1,578.57
2028-2029	$1,481.77
2030-2031	$1,435.49
2032-2033	$1,391.95
2034-2043	$5,030.32
2024-2043	**$12,359.78**

Table F: Summary of All Road and Bridge Investment and Maintenance Needs for Counties, Townships and Tribal Areas in North Dakota (Millions of 2024 Dollars)

Period	Unpaved	Paved	Bridges	Minor Structures	Total
2024-2025	$707.88	$433.82	$178.94	$151.06	$1,471.70
2026-2027	$694.93	$523.64	$178.94	$151.06	$1,578.57
2028-2029	$714.99	$436.78	$178.94	$151.06	$1,481.77
2030-2031	$716.56	$388.93	$178.94	$151.06	$1,435.49
2032-2033	$693.38	$368.57	$178.94	$151.06	$1,391.95
2034-2043	$3,443.71	$1,344.44	$192.45	$49.72	$5,030.32
2024-2043	**$6,971.45**	**$3,496.17**	**$1,087.16**	**$805.00**	**$12,359.78**

General Comparison with Recent Studies

The 20-year cost estimate for unpaved/gravel roads increased by $425 million or 6.5% from the previous study. These increases are driven by increases in aggregate hauling cost and regional increases in aggregate unit prices. This increase is consistent with prior studies.

The 20-year cost estimate for paved roads increased by $248 million or 7.6% from the previous study. Much of the increase is because of inflation of construction and maintenance costs for pavements but also due to routine pavement deterioration since the last study. Figure B presents the percentage of paved miles statewide by condition from 2019 to 2024. Significant investments in paved road improvements occurred in the mid-2010s resulting in a larger proportion of miles in the good category. Because of routine pavement deterioration, the percentage of miles in the good category fell from

39% to 25% from 2019 to 2022 and to 23% in 2024. Over the same period, the percentage of miles in the fair category ranged from 50% to 60% while the percentage of miles in the poor category increased from 11% to 21%.

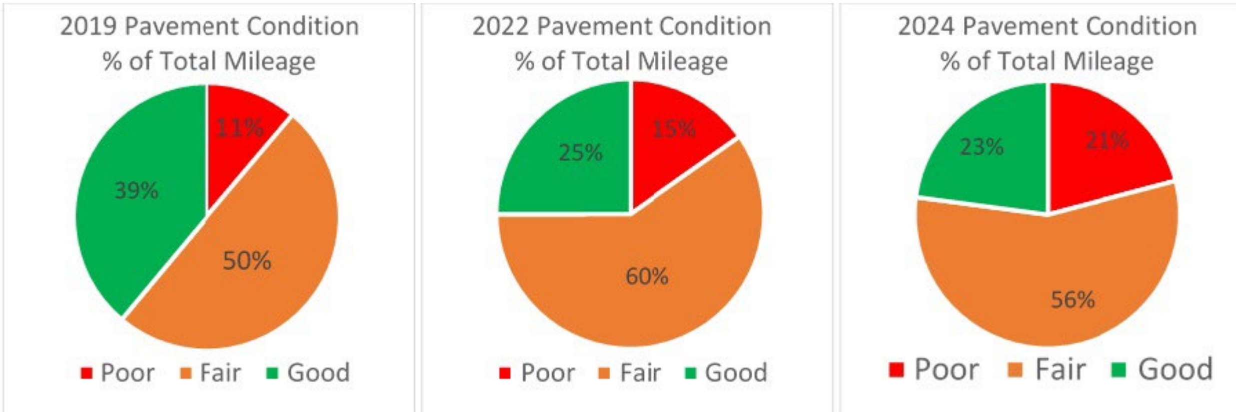

Figure B. Pavement Condition Change From 2019 to 2024

Estimates of bridge funding needs have increased by 51% for major bridge structures ($364 million) over the next 20 years. The primary factor behind this increase is an increase of the cost of construction from $370 to $530 per square foot of deck area since the previous study. Other factors include the rapid decline of bridge conditions. There were 206 additional bridges that deteriorated from the good to fair condition category since the previous study. For the first time ever, minor bridge structure needs have also been calculated with a grand total of $812 million in replacement needs for these structures which have spans of 8 feet to 20 feet. Major and minor bridge needs totals in this report result in a 20-year grand total of $1.89 billion.

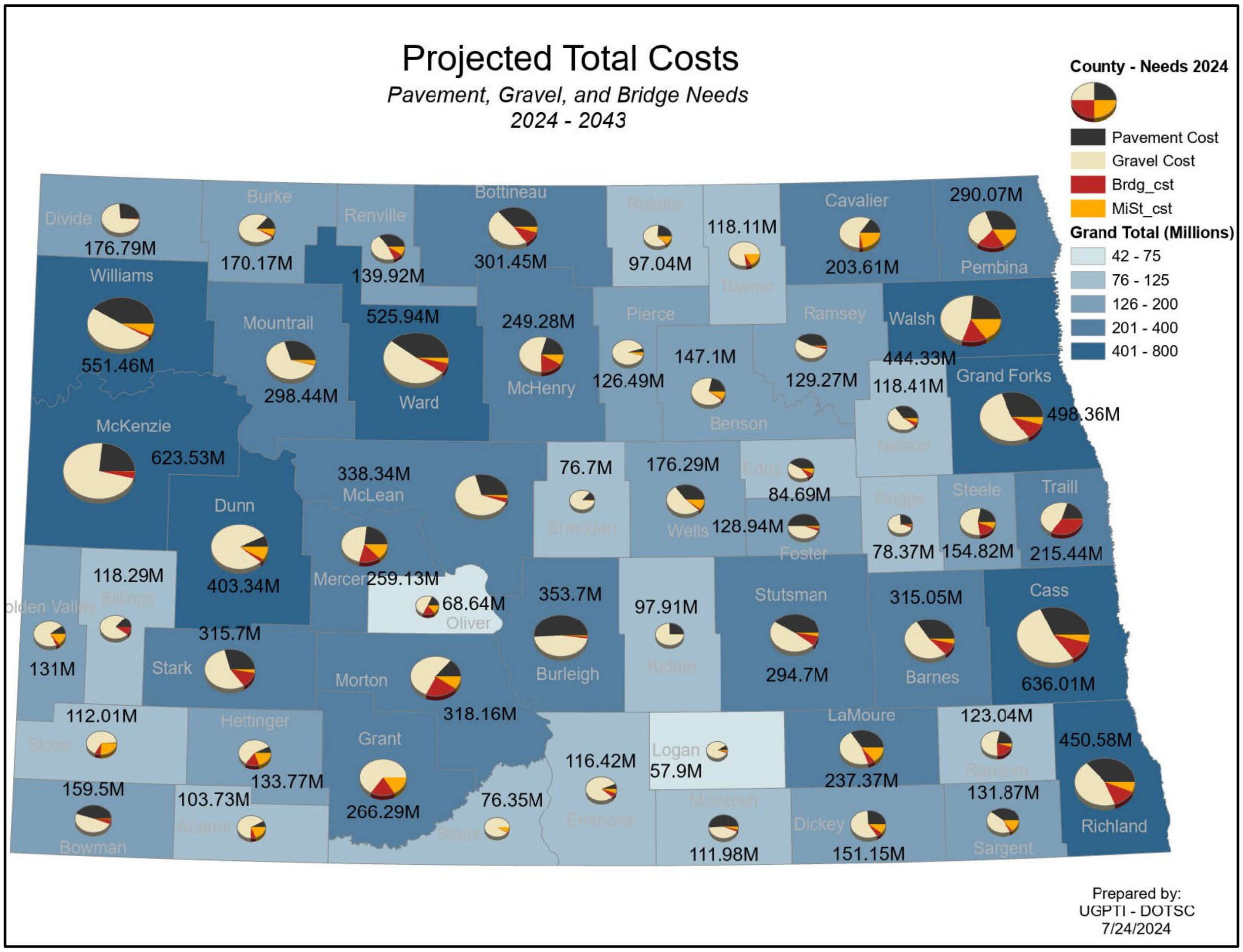

Figure C. Projected Total Costs for Pavement, Gravel and Bridges, 2024-2043

Contents

1. Introduction

In response to a request from the North Dakota Legislature, North Dakota State University's Upper Great Plains Transportation Institute (UGPTI) estimated county, township, and tribal road and bridge investment needs across the state. HB 1066 of the 2019 Legislative session, provided that distribution of funding to non-oil producing counties would be distributed based on the 2016 UGPTI study and if available, the average of the 2016 study and succeeding studies. This report is the seventh in a series of such studies.

In 2010, under the direction of the North Dakota Governor, UGPTI estimated the additional county and local road investment needs in western North Dakota as a result of rapid growth in oil production. The oil study was quickly followed by an analysis of the roadway investments needed to facilitate agricultural logistics. Results of both studies were presented to the Legislature in January 2011. Beginning in 2012 a statewide study was advanced to estimate road and bridge investments needed to maintain the current system including all traffic generators. Subsequent updates were completed in 2014, 2016, 2020, 2022 and in this current study.

Each study iteration includes updates to underlying assumptions of oil and agricultural volumes and reflects changes to the distribution networks and marketing channels and component costs and practices utilized across the state. In addition to these changes, updates to data collection sophistication, survey instruments, and gravel, paved and bridge methodology were implemented to improve the study process, ease of response by individual jurisdictions as well as to improve the accuracy of the data used in the study process.

In the current study update of statewide needs for county, township and tribal road and bridge needs, investment needs for minor structures was estimated in response to comments from counties, townships and legislators. Minor structures are defined as bridges with a span of less than 20 feet. Prior bridge analyses relied on data from the National Bridge Inventory System (NBIS) which includes bridges with a span of 20 feet or greater. There is not a corresponding database of bridge conditions for minor structures, so an extensive mapping and data collection effort was undertaken to estimate the needs to maintain these structures.

This report again focuses on county, township, and tribal roads and bridges for 2024 levels of agricultural and energy production using current road construction costs. State highway and city needs are not considered in this study. In this report, investment needs are estimated for three classes of road systems: county, township, and tribal – referred to collectively as local roads. In some cases, distinctions are made between county major collectors and county local roads. In these instances, "local" refers to a subclassification within a county.

The material presented in this report is organized under the following headings:

- Key economic and industry trends that affect the volume of traffic on local roads
- Key assumptions and methods related to agricultural and energy production and traffic forecasts
- The geographic information system and road network model used in this study
- The statewide traffic data collection and analysis plan
- The traffic prediction model used to forecast truck trips on individual road segments
- Methods of analyzing unpaved roads and forecasts of unpaved road funding needs
- Methods of analyzing paved roads and forecasts of paved road funding needs
- Methods of analyzing bridges and forecasts of bridge investment needs

2. Background Trends in Agriculture and Oil Development Impacting Traffic Levels on Local Roads

During the last decade, North Dakota's, local road systems have seen significant changes in traffic patterns, not only in volumes, but also in clustering because of changing land use and the consolidation of transload locations. This section describes major trends in agriculture and oil development that have had an impact on the number, type, and pattern of truck movements within the state during the past 10 years.

2.1. Agricultural Trends

2.1.1. Yield

Per acre yields for major crops in North Dakota increased or remained flat during the past 10 years because of increases in technology, genetically modified varieties, improved farming practices, and other factors. Dry weather conditions significantly impacted yields during the 2021 growing season. Figure 1 shows yield trends for the three major crops in North Dakota: corn, wheat and soybeans.

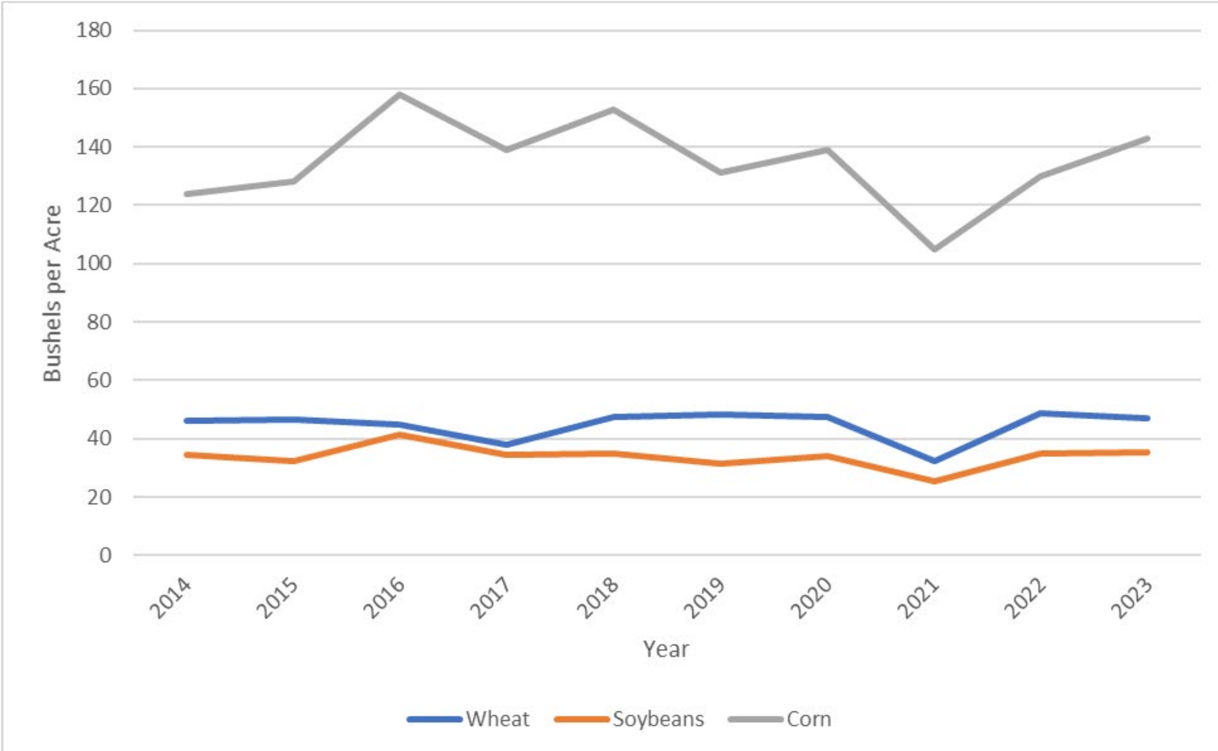

Figure 1. Average Yield for Corn, Soybeans and Wheat in North Dakota 2014-2023 (bushels per acre)

There are significant year-to-year yield variations, primarily due to changes in weather, but the overall trend is stable for wheat, corn, and soybeans. All crops demonstrated a notable decline in yield during the 2021 season due to drought conditions. In 2022, yields for all three of the major commodities increased to normal levels. Corn yields further increased from 130 bushels per acre in 2022 to 143 bushels per acre in 2023. Wheat and soybean yields remained relatively constant from 2022 to 2023.

If the acreage of each of these crops is held constant and outliers such as the 2021 growing season are removed, these yield increases will lead to a growth rate of slightly greater than 2% in the number of truck trips generated as a result of agricultural production in North Dakota. However, changes in the number of acres or to the crop mix during the last decade have also contributed to increased truck traffic.

2.1.2. Crop Mix

Crop mix refers to the percentage of land used to produce each commodity. As shown in Figure 1, the three major commodities have different yields. In 2023, the average statewide yield for wheat was roughly 47.1 bushels/acre. For soybeans, the average yield was 35.5 bushels/acre. Statewide average corn yield was 143 bushels/acre. Any shift in wheat acreage to corn would represent a 303% increase in yield on average. A shift in soybean acreage to corn would represent a 402% increase in yield on average. These increases directly correspond to increases in truck traffic. Moreover, the fertilizer requirements for corn production versus wheat production are nearly double, so an increase in inbound input movements is expected as well.

Again, using the largest three commodities by acreage for comparative purposes, Figure 2 shows the number of harvested acres by year of corn, soybeans and wheat in North Dakota from 2014 to 2023. This chart is a stacked line chart, so the difference between the top and the bottom of each of the commodity ranges is the number of acres. The sum of these ranges is the total number of acres that these three commodities comprise.

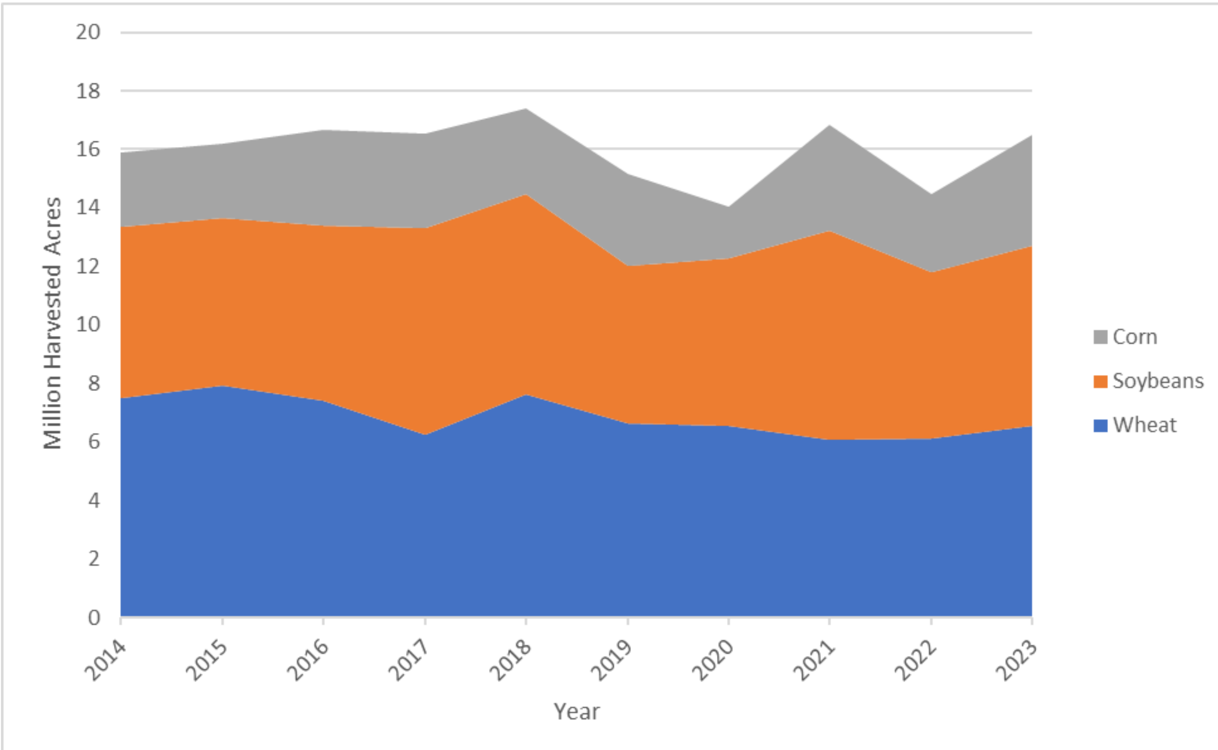

Figure 2. Planted Acres of Corn, Soybeans and Wheat in North Dakota (2014-2023)

Figure 3 breaks out the acreages by percentage. At the beginning of the period, acres of wheat harvested was 47% of the total harvested acres of corn, wheat and soybeans with soybeans comprising 37%, and corn 16% of these acres. In 2023, the harvested acres of wheat were 40%, soybeans 37% and corn 23%. For reference, in 2023, 16.5 million acres of corn, wheat, and soybeans were harvested in North Dakota, representing 70% of all harvested acres in North Dakota.

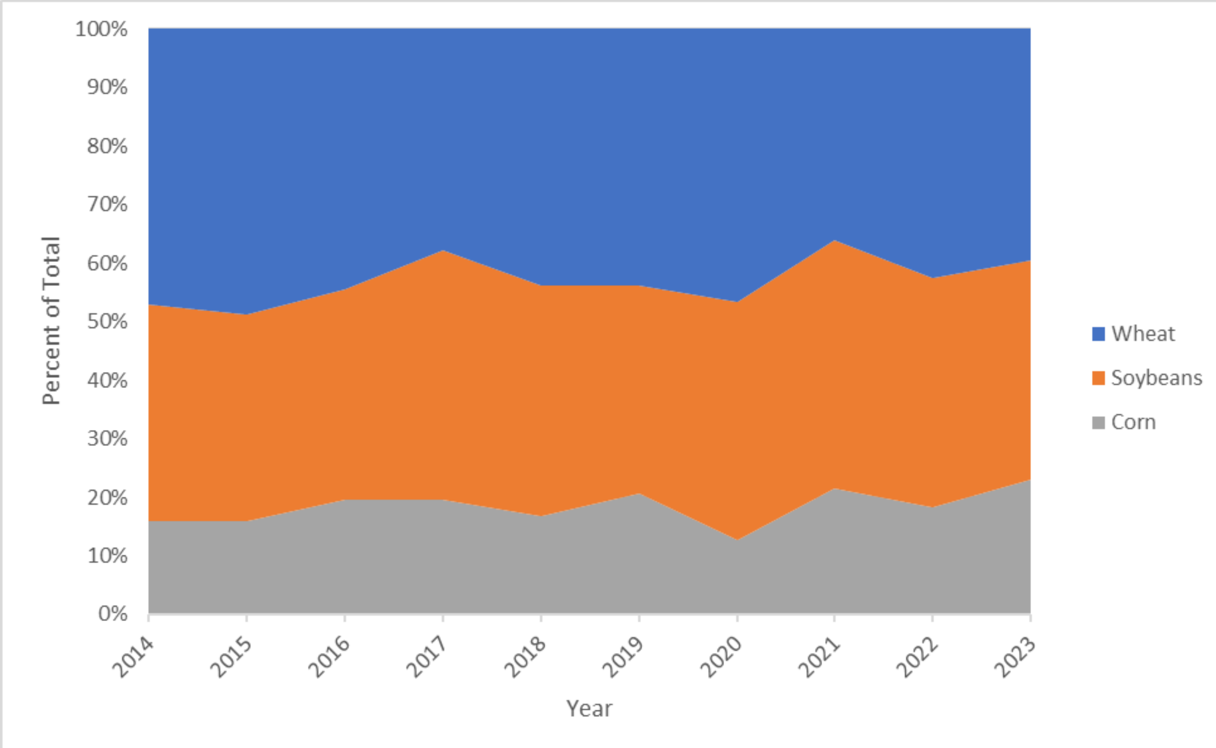

Figure 3. Percent Acres of Corn, Soybeans and Wheat in North Dakota (2014-2023)

2.1.3. Total Production

Because of the combination of increased yields and changing crop mix, total production has increased over the past decade. As shown in Figure 4, total production varied over the last decade, peaking in 2016 and 2018 with 1.098 and 1.051 billion bushels of corn, wheat and soybeans. In 2023, combined production of corn, wheat and soybeans totaled 1.07 billion bushels.

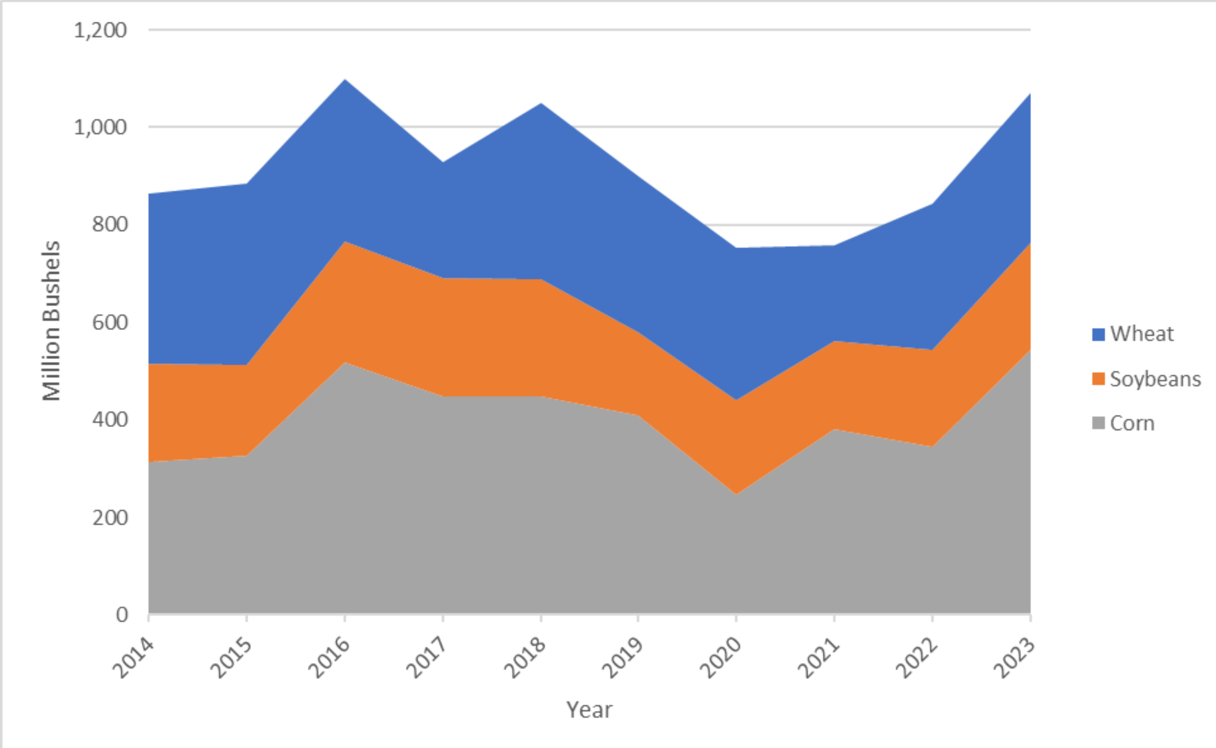

Figure 4. Total Production of Corn, Wheat and Soybeans in North Dakota, 2014-2023

2.1.4. Elevator Throughput

Since the mid-1990s there has been an increase in the number of grain elevators that can handle and load 100 or more rail cars. These shuttle elevators receive a discounted rail rate in exchange for guaranteed volumes and service times. Discounted transportation rates allow shuttle elevators to expand their draw areas through higher spot prices, thereby increasing the total volume of grain marketed at their facilities. In 2002, there were 15 shuttle elevators in North Dakota. By 2023, there were 58 shuttle elevators. A comparison of the numbers of elevators by shipment categories is shown in Table 1.

Table 1. Elevator Types in North Dakota, 2013 and 2023

Elevator Type	2013	2023	Change
No Rail (0 Car)	26	33	7
Single (1-25 Cars)	112	47	-65
Multi Car (25-52 Cars)	56	32	-24
Unit (52-100 Cars)	44	31	-13
Shuttle (100+ Cars)	53	68	15
All Types	291	211	-80

During the last decade there has been a decline in the numbers of all types of elevators, with the exception of shuttle elevators. Shuttle elevators experienced a 2.5-fold increase. The number of elevators by type tells only part of the story with regard to changes in agricultural marketing in North Dakota. The Annual Elevator Marketing Report compiled by UGPTI provides total throughput by elevators in each class. Figure 5 and Figure 6 show the total throughput by elevator class in 2013 and 2023 respectively and is taken directly from the Annual Elevator Marketing Report for the corresponding years.

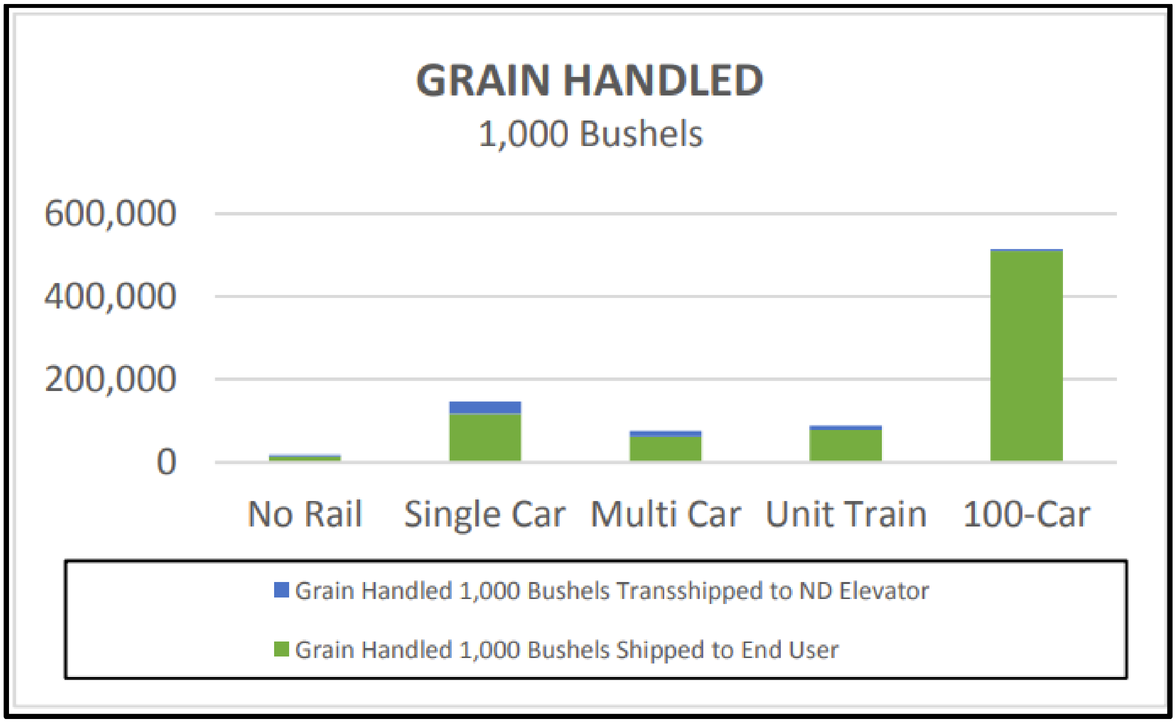

Figure 5. Elevator Throughput by Elevator Class: 2013

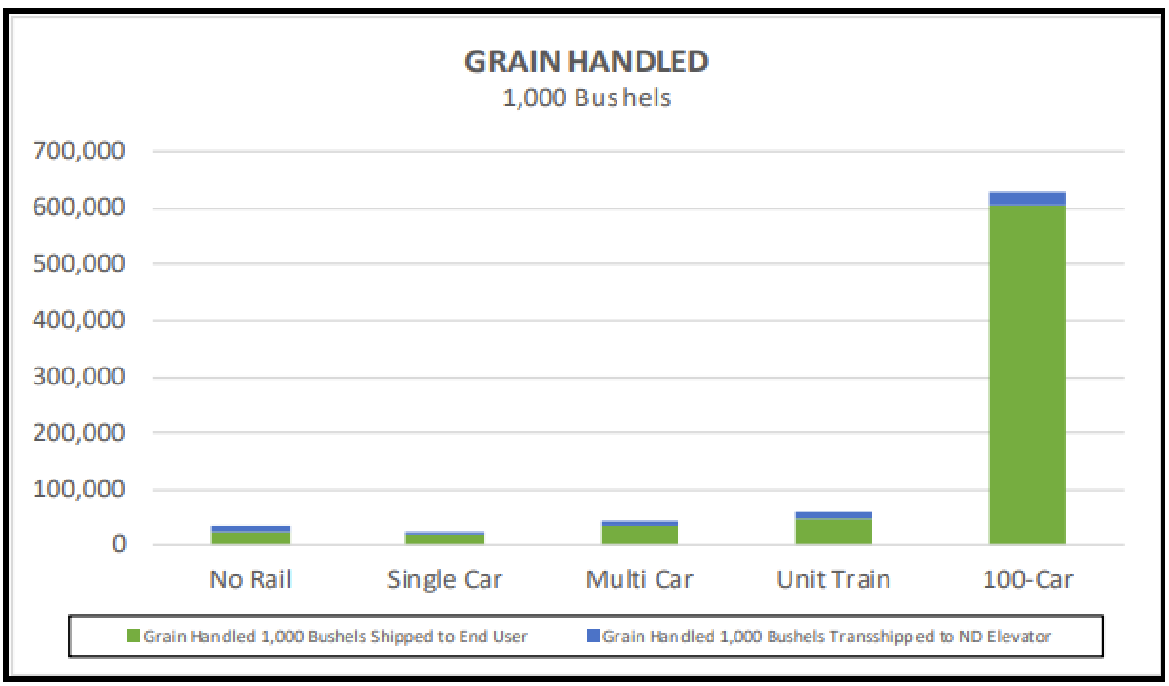

Figure 6. Elevator Throughput by Elevator Class: 2023

As these figures show, a larger percentage of grain was marketed through shuttle elevators in 2023 than in 2013. This change has an impact on the local road system throughout the state. For example, in 2013, unit and shuttle train elevators marketed roughly 550 million bushels of grain. At that time the combined number of facilities in those two classes was 97 elevators. In 2023, roughly 600 million bushels of grain were marketed through shuttle elevators which represent just 68 facilities statewide. The result of this change is consolidation of higher levels of truck traffic at fewer destination points. Often these shuttle elevators are located on or near state highways, but the county major collector (CMC) and other county routes where traffic is consolidated also may see increased truck traffic, depending on the location and network density near these facilities.

2.1.5. Combined Impact of Factors

As discussed in the previous sections, a variety of factors are changing in the agricultural industry within North Dakota, all of which may result in increased truck traffic related to agricultural production and marketing. Increased yield for nearly every crop produced in the state, a changing crop mix favoring the highest productivity, and higher consolidation of grain volumes at elevators and ethanol facilities each contribute to increased traffic. The combination of these factors, whether total acreage increases or not, trend toward higher traffic volumes, particularly on CMC routes and state highways.

2.2. Oil Production Trends

2.2.1. Technology

The current oil boom in North Dakota came about as a result of improved technology in oil exploration and extraction. Two primary technological advances have led to increased productivity within the Bakken/Three Forks formations: horizontal drilling and hydraulic fracturing.

Horizontal drilling consists of an initial vertical wellbore which, at a specified depth, is deviated at an angle that is adjusted until the final wellbore is a horizontal lateral wellbore. Because the shale formations being explored are relatively narrow, this allows for a much larger contact area between the wellbore and the formation, which is greatly enhanced through hydraulic fracturing. Hydraulic fracturing results in multiple longitudinal fractures along the horizontal lateral. Multiple fracturing stages ensure that fractures occur along the entire horizontal alignment thereby optimizing the oil recovery potential.

2.2.2. Well Productivity

As a result of the improved extraction technology, the average productivity of a North Dakota oil well has dramatically increased. From 2005-2020 average oil well production increased from 25 barrels of crude (BBL) oil/day to 79 BBL oil/day. From 2020 to 2023, the average well production is 66 BBL oil/day Figure 7 shows the daily average statewide oil production per well by year and daily oil production by year in North Dakota since the first well was drilled in 1951.

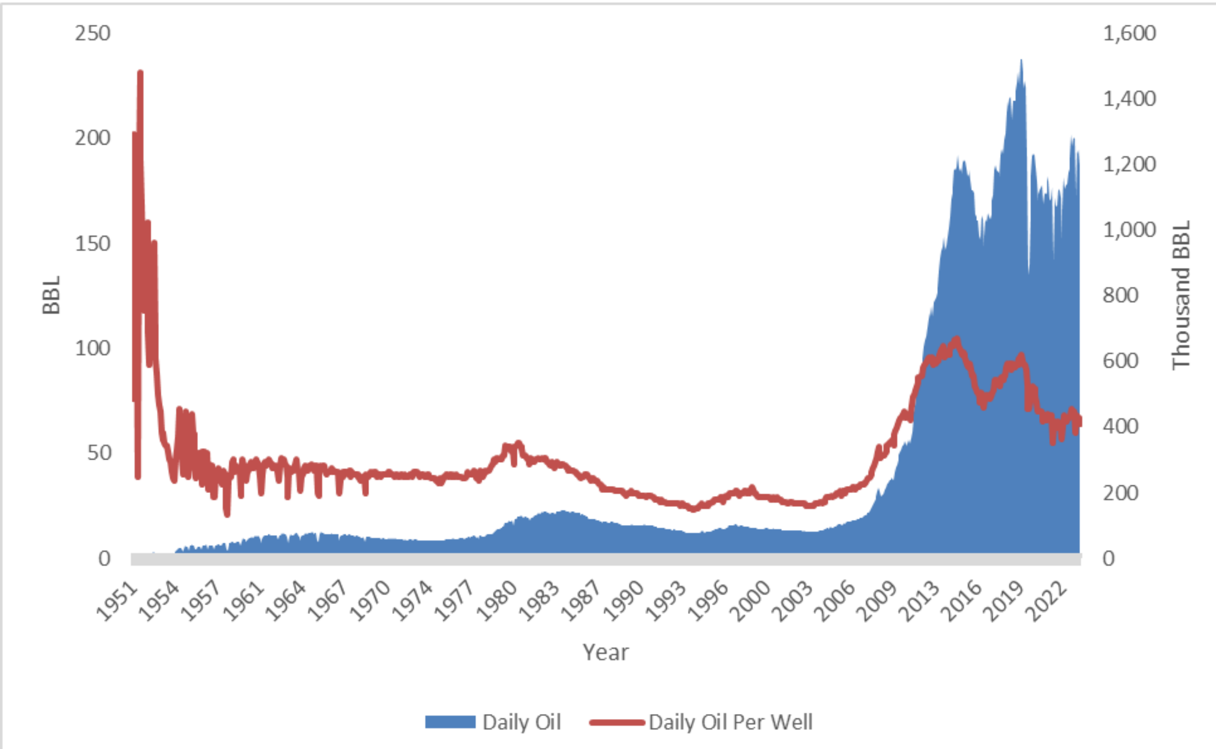

Figure 7. Daily Oil Produced in North Dakota, Total and Per Well: 1951-2023

2.2.3. Total Number of Wells

Improved extraction technology has not only increased the productivity of wells in North Dakota, but expanded the geographic area where oil can be profitably extracted. As a result, expanded drilling has occurred throughout the play, now encompassing 17 counties in western North Dakota, with the heaviest activity occurring in Dunn, McKenzie, Mountrail, and Williams counties. The total number of producing wells per year is shown in Figure 8. From the late 1970s until mid-2000s the number of producing wells remained relatively constant. With the technological advances in exploration and extraction, the number of producing wells has increased exponentially.

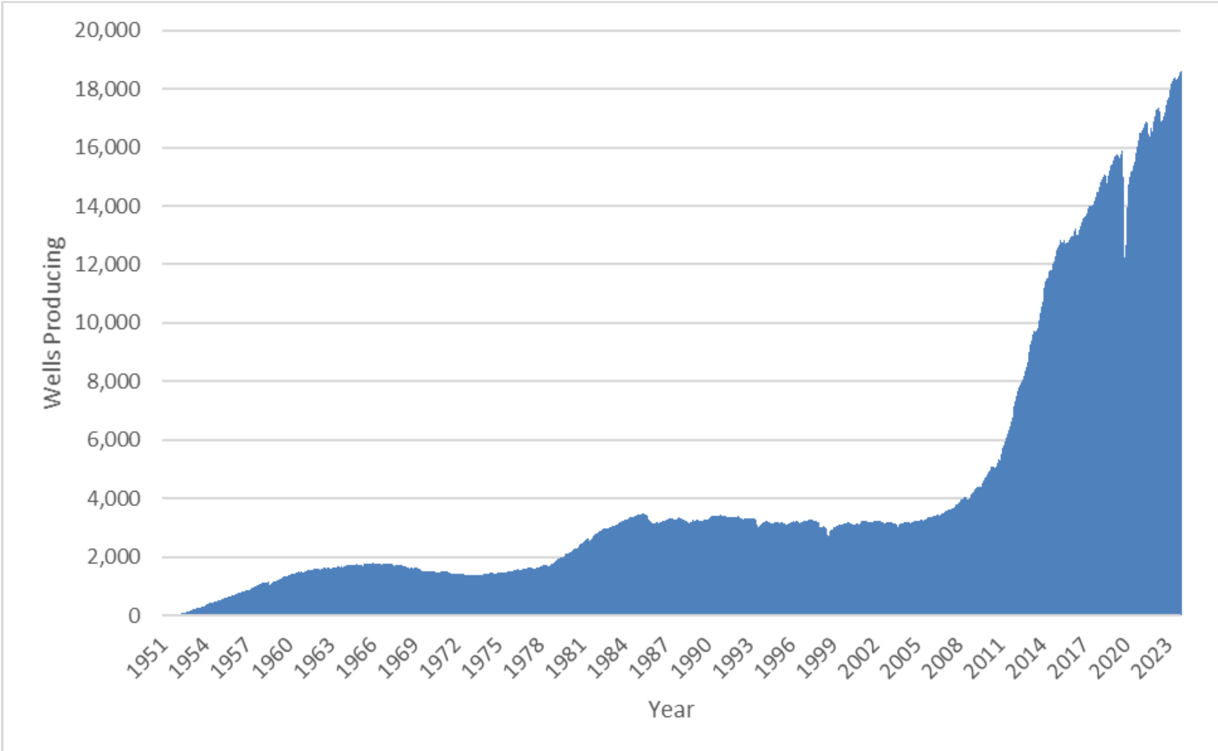

Figure 8. Total Producing Oil Wells in North Dakota: 1951-2023

2.2.4. Total Production

As outlined previously, productivity per well has increased while the total number of wells has increased as well. The combination of these two trends has resulted in a significant surge in the total statewide production of oil since 2007. Figure 9 shows the historical daily oil production from 1951 to 2023. From 2021 to 2023, average oil production was 1.14 million barrels per day.

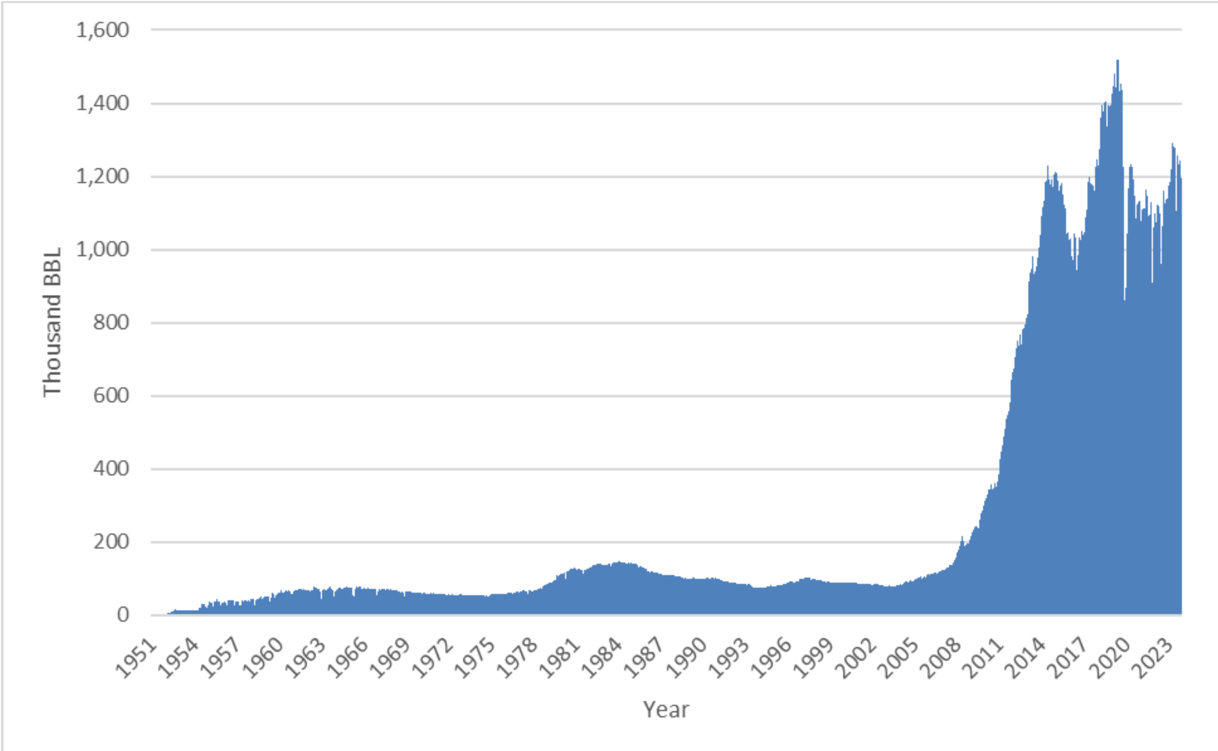

Figure 9. Historical Daily Oil Production in North Dakota: 1951-2023

2.2.5. Changes in Forecasted Development

Throughout the initial development of the Bakken and Three Forks formations, there was a degree of uncertainty about the extent and duration of the potential development of the play. In 2010, at the request of the North Dakota Department of Commerce and the North Dakota Oil and Gas Producing Counties Association, UGPTI conducted a study to estimate the additional road investment needs due to oil development impacts on county and township roads. At that time, the estimated scope and duration of the play was a total of 21,250 new wells over a 20-year timeframe.

At the time of UGPTI's statewide study of investment needs for county and township roads in 2011, the estimated number of new wells was 45,000. The current forecast for total new wells is 55,000. It is expected that as more is known about the development of the play, forecasts will become more consistent.

3. Model Methods and Assumptions

This section of the report describes the key assumptions related to agricultural and energy production and movement patterns, including: (1) primary sources of production and travel demand data, (2) the geographic basis for production forecasts, and (3) land use patterns (such as crop and well densities) that give rise to truck trips.

3.1. Agriculture

3.1.1. Transportation Analysis Zones

The base unit of production used in the agricultural model is the township, or county subdivision. Township shapefiles were obtained from the North Dakota Geographic Information System (GIS) Hub. However, organized townships do not exist in all North Dakota counties. Townships were selected for use as a geographic and not an organizational boundary. Where unorganized townships exist, a placeholder boundary was created to represent a geographic area similar in size to a township.

3.1.2. Modeled Commodities

The discussion of agricultural production in Section 2 of this report focused on the three largest commodities in North Dakota: corn, wheat and soybeans. In addition to these commodities, truck movements were estimated for barley, canola, sunflowers, dry edible beans, sugar beets, and potatoes. Because of the truck volumes required to deliver fertilizer to fields in the spring, fertilizer requirements for each acre produced of each commodity were estimated using NDSU Extension crop budgets. Truck movements from fertilizer locations to crop production areas were modeled in a similar, but reverse direction, as those for crop shipments. Finally, because of the structure of the elevator industry in North Dakota, transshipments between elevators (i.e. satellite elevator to shuttle elevator) were also included in the traffic forecasts.

3.1.3. Crop Mix and Production

Crop production data by county was obtained from the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) website. This data provides the number of acres planted and harvested, as well as yields and total production by county, crop, and production practice. The most current data available at the time of the analysis was from 2021. County-level data is not sufficient for use in a traffic model as it is too aggregated to accurately assign traffic to individual roadways, especially at the county level. To further disaggregate this data, the USDA's Crop Data Layer (CDL) was utilized.

The CDL is a satellite image of land use in North Dakota, with individual crop types represented by different colors. Each pixel of the image represents a 30-meter by 30-meter area. Used in conjunction with GIS software packages, the CDL provides data regarding the total number of acres of each crop produced in each county subdivision. In this study, acreage data was aggregated to the county level and compared against known NASS data for accuracy.

Analysis using the CDL is precise with respect to geographic area, but is only a snapshot of production in time and does not provide production data (e.g., bushels or pounds harvested).

In this study, NASS county-level data is used to approximate sub-county-level yield and production rates. For example, if a township is located within Barnes County, the Barnes County average wheat yield is used to approximate the actual township yield. The end result of these processes is the total production by crop for each township in the state. For use in traffic forecasting, township crop production estimates are converted to truck trips, based on each commodity's weight and density.

3.1.4. Total Acres

As presented in the previous section, annual acreage is relatively unchanged over the past 10 years despite 1.7 million additional acres being returned to production with the expiration of Conservation Reserve Program (CRP) contracts. With the estimated 1.16 million acres of CRP set to expire within the next 15 years, an increase in total acres is expected. However, spatial data is currently unavailable for the location of the acres set to expire by year. Consequently, the assumption made for the purpose of this study is that acres in production will remain at 2018 levels, which is the highest on record for the past 10 years.

3.1.5. Yield Trends

Following comparisons of NASS yield data trends for each of the eight crops specifically modeled in the rural road traffic model, there were variations from commodity to commodity in terms of yield growth. For the three major commodities, corn, soybeans, and wheat, there were 2%, 2%, and 4% growth rates respectively. Over the same time period, wheat acres decreased in favor of corn, so the effective level of wheat production is constant. For the purpose of forecasting increased tonnage and truck generation, a 2% yield growth rate was applied to all commodities for future year forecasting purposes. This is consistent with the historical yield growth rate for five of the eight modeled commodities.

3.1.6. Elevator and Processor Demands

Demand points for grain within the state include elevators, processors, and ethanol facilities. Elevator locations were obtained from a shapefile maintained by UGPTI, which was compared against the North Dakota Public Service Commission (NDPSC) licensed elevator report. Throughput information was obtained from the North Dakota Department of Agriculture Grain Movement Database, which provides the quantity of each commodity shipped through an elevator by mode and destination.

Ethanol facility demands were estimated by obtaining the output capacity of ethanol for each facility and dividing the capacity by the conversion rate of 2.78 gallons of ethanol per bushel of corn. For processing facilities, annual capacities were obtained through news releases, website publications, or phone surveys of the facilities. Individual elevator and plant demands are based upon actual data in the base year of 2023. Because there is forecasted growth in each commodity's yield over the 20-year analysis period, an equal increase in the plant and elevator demand for the commodities was implemented for future year analysis to balance the model.

3.2. Oil and Gas

3.2.1. Transportation Analysis Zones

The zone representing the geographic unit of production in this study is the spacing unit. The spacing unit defined in this study is a 1,280-acre (2-square mile) polygon that is the basis of oil development within the Bakken formation. The initial spacing unit shapefiles were obtained from the website of the North Dakota Department of Mineral Resources Oil and Gas Division. For areas within the study area that were not divided into spacing units, the fishnet procedure in ArcMap was used to construct new spacing units for the purpose of spatial forecasting of the future locations of new wells.

3.2.2. Wells per Rig per Year

Over the course of these studies, rig productivity has increased. At the outset of this study series, rig productivity was 10-12 new wells per year. Based on discussions with the Oil and Gas Division, the updated productivity rate is 20-24 new wells per year.

3.2.3. Well Forecasts

Because of uncertainty in present and future crude petroleum markets, three scenarios were estimated. Each of the scenarios forecasts the number of new wells drilled as a function of the number of active drilling rigs within the state. The baseline forecast scenario is equivalent to a 40-rig drilling level, representing 960 wells per year. As stated above, it is assumed that each rig can drill 20-24 new wells per year.

3.2.4. Spatial Forecasts

The annual forecasts and county-level forecasts provide the total number of wells expected within the oil patch and within each individual county. They do not, however, provide the locations of the wells within each county. To distribute the new wells within spacing units, a geospatial forecasting method called hot spot analysis was used. Hot Spot analysis identifies geographic clustering of activities within a specified region. Hot Spot analysis is also known as heat mapping, where the reference to heat refers to the concentration of the activity within any given area.

Figure 10 shows the clustering of existing wells in the base year which serves as the basis for locating future well drilling activities throughout the analysis period. Red areas represent significant clustering of existing wells, and blue areas represent a lack of clustering of oil development.

By identifying the degree of clustering of existing wells, one can forecast the location of future wells in areas where existing development has already occurred, subject to the constraint of 8-20 wells per spacing unit. Once that constraint has been reached, no additional wells may be added.

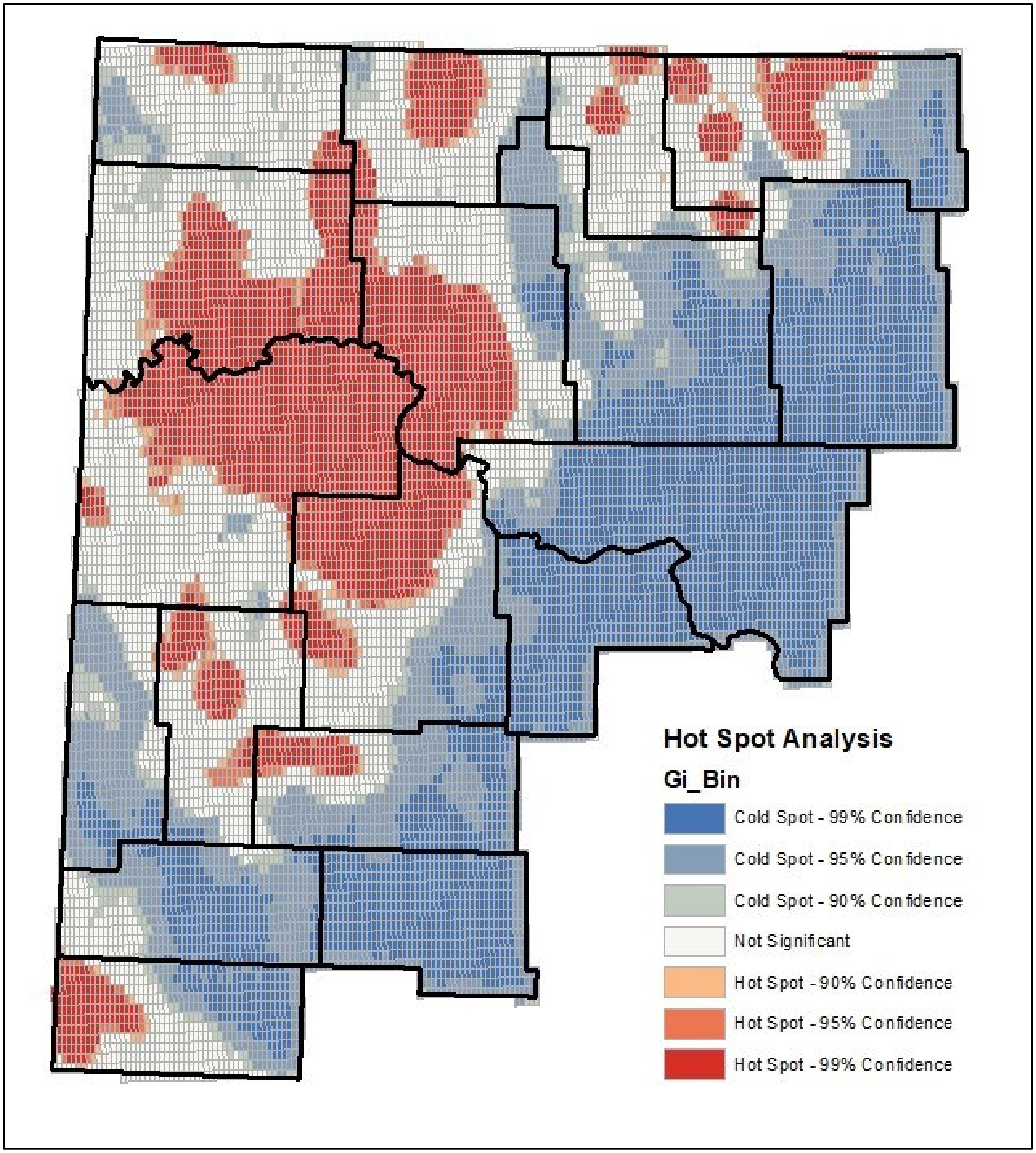

Figure 10. Hot Spot Map of Oilfield Spacing Units, 2023

All annual location forecasts are doubly constrained. That is, they are constrained by the statewide forecast of new wells and the county-level forecast of new wells per year provided by the Oil and Gas Division. These constraints ensure that, within the modeling framework, the forecasted truck trips generated cannot exceed the forecasted exploration and production limits.

3.2.5. Initial Production Rates

Once the wells have been drilled, an initial production rate must be applied to represent the starting point of production for an individual well. The Oil and Gas Division provided county average initial production rates for each oil-producing county. In addition, the Bakken well production curve is applied to this initial production rate to estimate future annual production levels. Because of the steep decline in production over the first three years of the life of a Bakken well, inclusion of this production curve is critical to avoid overestimating crude oil production and the number of truck trips generated by oil production in North Dakota.

3.2.6. Truck Volumes

Data on the number of trucks by type were compiled from input provided by the North Dakota Department of Transportation, and the Oil and Gas Division. As shown in Table 2, a total of 3,520 truck movements is estimated per well, with approximately half of them representing loaded trips.

Table 2. Drilling Related Truck Movements

Item	Number of Trucks	Inbound or Outbound
Sand	200	Inbound
Water (Fresh)	500-800*	Inbound
Water (Waste)	300	Outbound
Tanks and Equipment	460	Both
Total – Single Direction	1,760	
Total Truck Trips	3,020-3,520	

*Fresh water truck volumes decrease to nearly zero in areas with water pipeline availability

3.2.7. Mode Splits

Outbound crude is transported from well sites to either rail or pipeline transload locations via gathering pipeline or truck transportation. Over the recent past, significant expansion in the gathering pipeline network in areas with higher-density production has greatly reduced the proportion of outbound crude hauled via truck. In this study, from 2024 onward, an estimated 80% of outbound crude is assumed to be shipped via gathering pipeline with the remaining 20% shipped to transload locations via truck.

3.3. Road Network

The primary GIS network used for this study was obtained from the North Dakota Department of Transportation GIS and Mapping website at https://www.dot.nd.gov/construction-and-planning/planning-process/gis-and-mapping. Two individual shapefiles were utilized in the creation of the network: State and Federal Roads and County Roads. Both of these shapefiles are maintained by NDDOT.

3.4. Network Connectivity

Network connectivity is required to have a routable network for use in the travel demand modeling component of this study. Initially, both the state and federal and county and city roads presented multiple widespread connectivity errors which were repaired prior to conducting the routing analysis.

In addition, certain attributes were found to be in error, particularly in areas of significant growth. These errors will likely be corrected as the network is continually updated.

3.5. Jurisdiction

The County Roads shapefile contains an attribute named RTE_SIN which represents the jurisdiction of the roads. This attribute provides accurate data on the state and federal systems as well as the Federal-aid System. However, below the CMC (County Major Collector) system there is no distinction between county-owned non-CMC routes and township roads. To identify township roads apart from county non-CMCs, UGPTI and ND-LTAP conducted surveys of all 53 counties in North Dakota. The results were then attributed to the original network for identification purposes. In addition to non-CMC identification, UGPTI and ND-LTAP staff asked for information about other jurisdictional categories, but responses were not consistent on a statewide basis aside from the non-CMC designation.

Table 3 presents the total miles by initial "RTE_SIN" designation–the base designation on the GIS Hub shapefile. These numbers represent the data that was available prior to the survey of the counties by UGPTI and ND-LTAP. The area most in question is the second category "Township and County Non-CMC," primarily because this category combined two jurisdictions, county and township. Because two jurisdictions were combined within a single category, separating needs by jurisdiction proved difficult without additional information.

Table 3. Initial Jurisdiction Information Using Provided RTE_SIN Designation (Excludes Trails and Unimproved)

Jurisdiction	Miles
Forest Service/Reclamation	613
Township and County Non-CMC	59,275
CMC (Federal Aid)	11,736
Tribal	488
Total	72,113

Table 4 presents the updated jurisdictional information based upon the ND-LTAP/UGPTI survey of counties. There were minor reductions to the forest service roads because some in western North Dakota have been transferred to county jurisdictions. The largest change is in the township and county non-CMC categories. Within the township category, only organized townships are included. In the county non-CMC, county routes and unorganized townships are included. The instruction in the survey was to determine ownership of the road, not only who provides for maintenance on the road surfaces.

Table 4. Updated Jurisdiction Information Based Upon Survey Results (Excludes Trails and Unimproved)

Jurisdiction	Miles
Forest Service/Reclamation	613
Township	47,139
CMC (Federal Aid)	11,736
County Non-CMC	12,136
Tribal	488
Total	72,113

4. Traffic Data and Model

The primary objective of the traffic study was to collect traffic volume and classification data on county and township roads throughout the state. Traffic data was collected for two primary reasons: (1) to gain a better understanding of current traffic flows, and (2) enable the calibration of the traffic forecasting model used in the study.

The traffic collection plan provided for geographic coverage of the entire state, focusing on county major collector routes, higher-volume routes, and paved roads. Based on road mileage and other factors, it was determined that approximately 15 to 25 classification counts per county would provide adequate information to calibrate the traffic model.

At locations where traffic counts were taken, the raw information was turned into an estimate of the average number of vehicles traveling the road segment each day. At locations, where vehicles were classified, the raw information was used to estimate the daily trips of each type of vehicle, including single-unit, combination, and double-trailer trucks.

4.1. Traffic Data Collection

NDDOT collects traffic data on state and county major collectors on a 3-year cycle. In 2021, NDDOT counted the eastern part of the state and UGPTI requested that some additional county stations be added for NDDOT's part of the state. For the central 1/3 of the state, UGPTI used students from its Advanced Traffic Analysis Center (ATAC) to collect traffic data at approximately 100 county road locations. These sites were used in addition to the NDDOT county counts from previous years. For the western 1/2 of the state, UGPTI contracted with a traffic counting consultant to count at more than 300 county road locations. In counties with sparse classification count data, additional classification counts were conducted to establish more accurate estimates of truck percentages within those counties. Merging NDDOT counts with UGPTI and consultant counts, a total of 1,582 counts were used in the travel demand model development. Again, these counts were used in conjunction with, and to update, NDDOT county counts from previous years. Figure 11 depicts the locations of county and township traffic data collection.

All traffic counts were checked for quality control and processed using standard processes and procedures recommended by Federal Highway Administration. This detailed process entails the application of seasonal adjustment factors to the raw 48-hour counts to annualize them to an average annual daily traffic (AADT) volume. The seasonal adjustment factors used in the study were developed from annual traffic recorders (ATR's) located throughout the state on various road systems. For count locations involving volumes only, a seasonal axle factor was also applied to the raw counts.

All traffic data collected by UGPTI were verified and sent to NDDOT for final processing, using the same standard processes and procedures recommended by Federal Highway Administration. The joint processing of data by NDDOT and UGPTI assures consistency among the various traffic counts taken around the state.

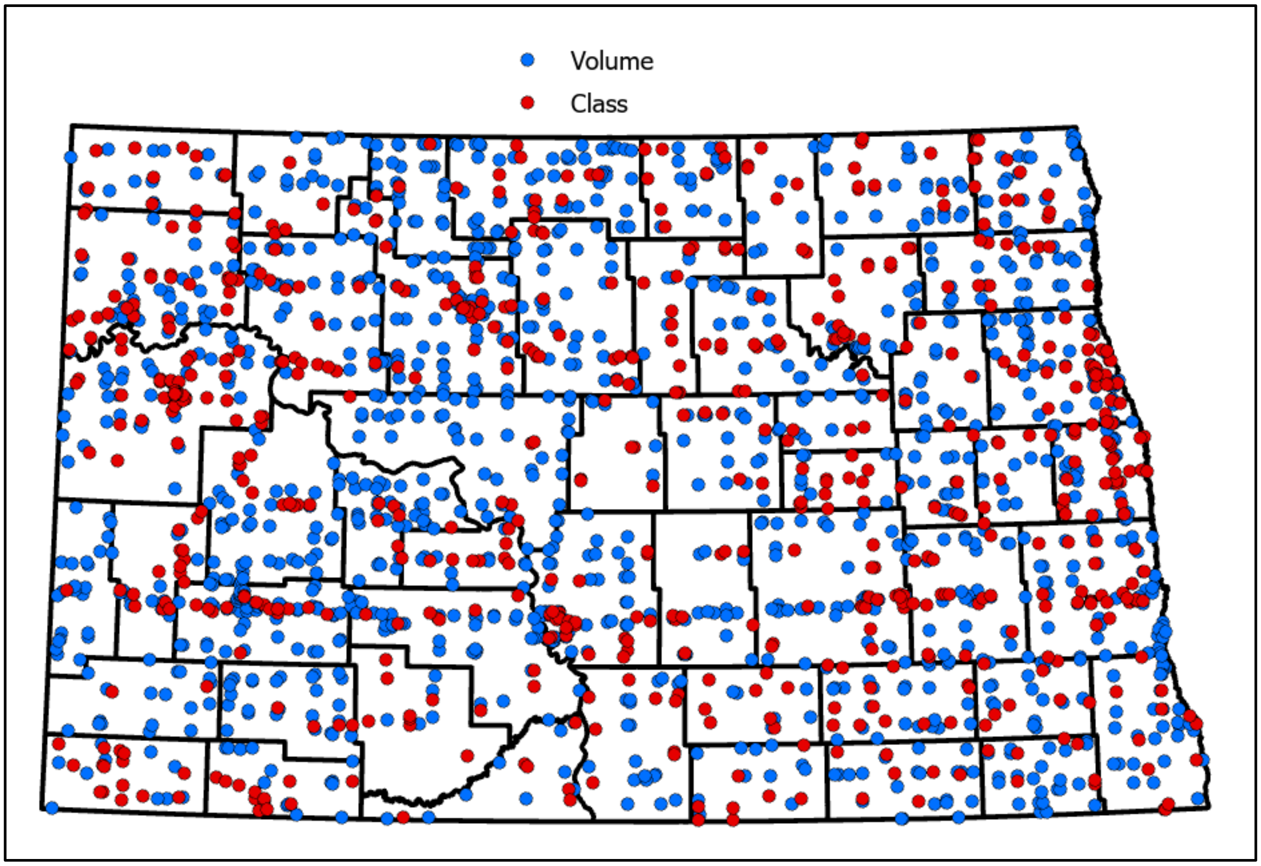

Figure 11. Traffic Data Collection Sites

4.2. Traffic Model Development

To forecast future traffic volumes on county and township roads, an effective base year traffic model must be constructed that accurately reflects existing truck traffic movements. The data collection described above provides direct observations against which the traffic model results can be compared. Only when the baseline traffic model has been shown to sufficiently model existing traffic can it be used to predict future traffic levels.

4.2.1. Movement Types

The travel demand model developed for this study consists of 18 individual sub models: 11 for agricultural movements and 7 for oil-related movements. Nine of the 11 agricultural sub models, represent individual commodities, with the remaining representing fertilizer and transshipment movements. Of the 7 oil-related sub models, five relate to inputs to the drilling process and the remaining 2 represent the movement of outbound crude oil and salt water.

4.2.2. Distribution Networks - Agriculture

For the two major sub model classes: (agriculture and oil), two different distribution networks are modeled. The traditional farm-to-market, and market-to-terminal destination network has changed significantly within the state over the past decade, primarily because of the increase in shuttle elevators, processors and ethanol facilities.

Figure 12 provides an overview of the movements from the farm to a variety of destinations. In this simplified diagram, the farm-to-elevator movement is shown, as well as farm-to-final destinations such as processors, ethanol facilities, or terminal destinations such as Minneapolis or Duluth. Each of these movements is effectively a truck movement because there is no rail access from individual farms.

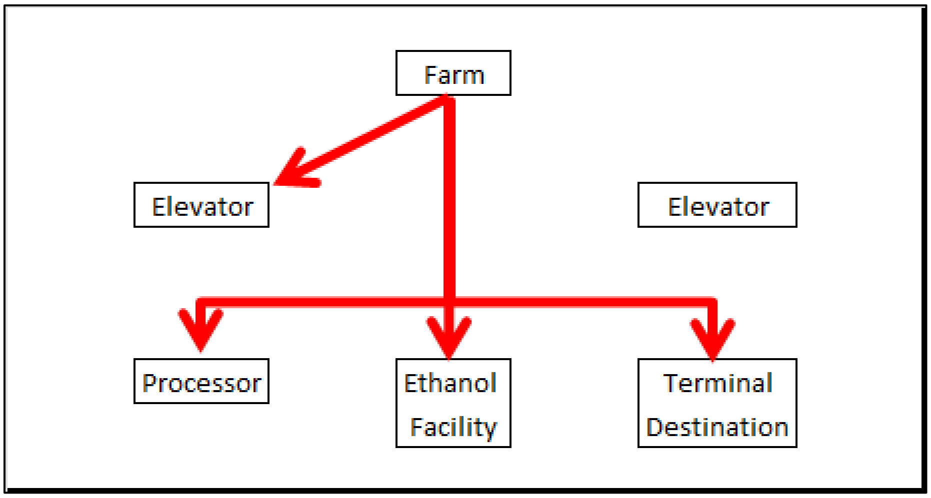

Figure 12. Agricultural Distribution Network without Transshipments

To take advantage of lower shipping rates at higher volumes, grain is commonly shipped between elevators for consolidation. Depending on the final destination of the grain from the elevator, the mode split between truck and rail varies. But as a general rule, as distance increases, truck transportation is less favored. However, almost all transshipment movements are performed via truck within the state, adding truck trips to the roadway networks.

Figure 13 shows potential movements from the elevator once the grain has been delivered from the farm. The elevator may transport grain to a processor, ethanol plant, terminal facility, or another elevator. The receiving elevator would then also have the same options as the prior elevator. As mentioned above, outbound movements from elevators have a mode choice option, as most grain elevators within the state have rail access. Numerous variables factor into mode choice at this point, but for the purposes of this study, sufficient data as to the actual mode split by elevator is available so actual observed data was used to model mode split for outbound movements.

4.2.3. Distribution Networks – Oil Related Movements

In contrast to the agricultural model where the base unit of production and related origin is the township, the oil model's base unit of production is the spacing unit, which functions as both an origin and destination as time progresses. Figure 14 provides a simplified diagram of the modeled oil-related movements. The blue arrows represent inbound drilling-related movements to the spacing unit, and the red arrows represent outbound produced oil and water from the spacing unit to transload or injection destinations.

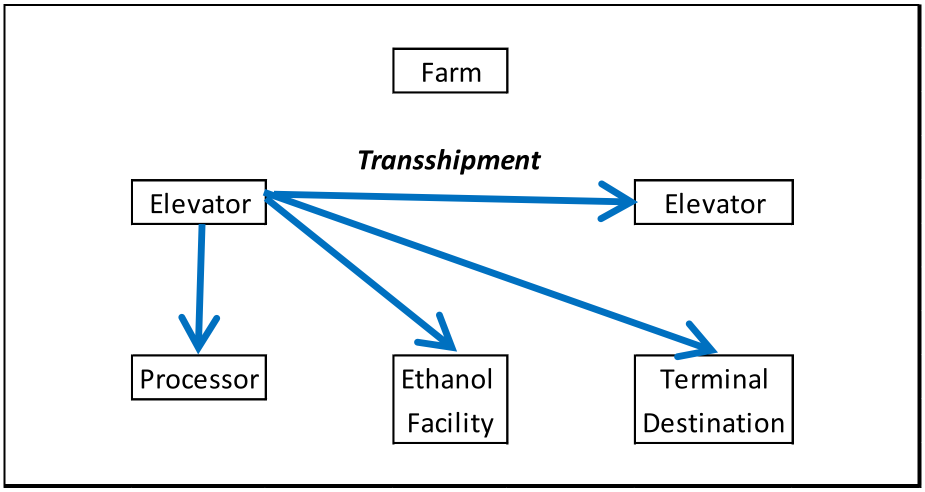

Figure 13. Transshipment Movements within an Agricultural Network

Within the model framework, both inbound and outbound movements were individually modeled. For example, frac sand, freshwater, gravel, supplies, equipment, and pipe movements were separately estimated and the results aggregated to the segment level. Similarly, both the movements from the well site to the oil collection sites and saltwater disposal locations were specifically modeled.

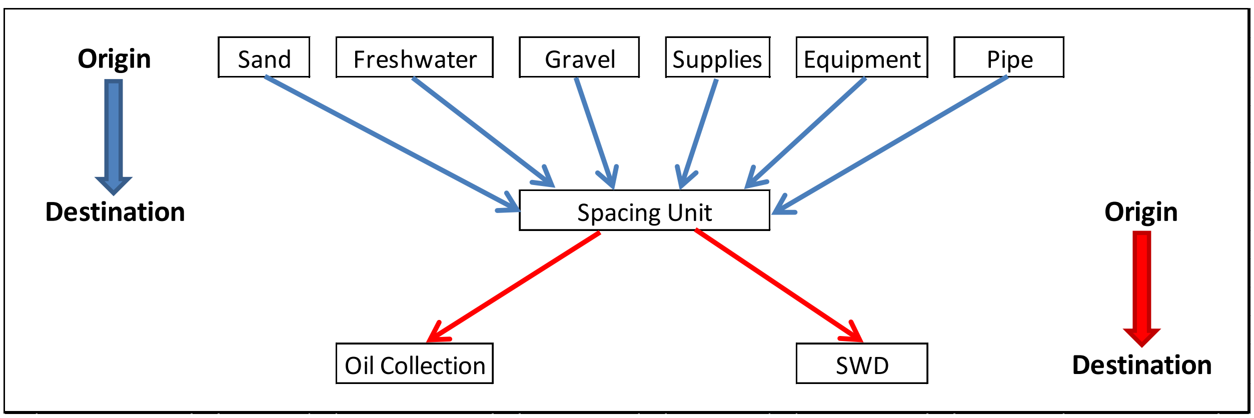

Figure 14. Oil Related Movement Network

4.2.4. Travel Demand Modeling Framework

Conventional transportation modeling utilizes the four step model (FSM). The components of the FSM are 1) trip generation, 2) trip distribution, 3) mode split, and 4) traffic assignment. The first step in the development of a transportation model is identification of the origins and destinations of the trips to be modeled. Trip generation forecasting identifies the type and scope of movements between traffic analysis zones (TAZ). As discussed above, the TAZ for the agricultural model is a township equivalent, and the TAZ for the oil model is the spacing unit.

Trip generation focuses on trips originating as a result of activities present within some zones, and trips attracted by activities present within other zones. Once the origins, potential destinations, and number of trips have been identified, movements between areas of production (origins), and attractions (destinations) are estimated. Distribution refers to the selection of flows between origins and destinations, and is generally made using a gravity model or linear programming model. Traffic assignment occurs once movements between origins and destinations have been selected, and the minimum-cost route between them is selected. The distinction between distribution and assignment is that distribution selects the origin and destination for individual trips generated, and assignment selects the method of connecting them. This is generally the final step in the FSM, but in the case of optimization models, traffic assignment for all possible destinations from origins is completed to generate arc cost data for the model.

Trip generation is the first of the four steps and, as the name indicates, generates trips and the origin and destination points. Using the agriculture model as an example, each township represents an area of production. Each grain elevator or processor represents an area of attraction. Based on known production at the township and known throughput at the elevator, trips generated at each can be estimated. For the oil sub models, a similar approach is used, but the focus is the spacing unit, rather than the township.

Trip distribution effectively pairs the origins and destination based upon production and attraction volumes and the effective cost between them. The gravity model for trip distribution contains three primary components: zones where trips originate, zones where trips terminate, and a measure of separation between the zones. The measure of separation between the zones is a key factor, as it represents the level of attraction between the zones or repulsion between zones. In many cases, a generalized cost of traveling between the zones, often a combination of travel time, distance traveled, and actual costs, is used (Evans S. P., 1972). "It is assumed that the number of trips per unit time between pairs of zones for a particular purpose is proportional to a decreasing cost function of the cost of traveling between them" (Evans E. , 1970). The use of the gravity model for trip distribution is widespread. The end result of this type of analysis is the number of trips between each origin and each destination (trip assignment).

Mode choice is the third step in the four-step model. This step was not directly included in the travel demand model for two reasons. First, the movements modeled were specifically truck-related movements. Second, the primary factor where mode split would have a significant impact on traffic volumes relates to gathering pipelines between well sites and oil transload facilities. Because assumptions were specified by the Oil and Gas Division and the North Dakota Pipeline Authority, they were implicitly utilized in the study.

Trip assignment is the final step in the four-step model. Trip generation estimated the total number of trips generated and attracted. Trip distribution organized them into origin-destination pairs. Trip assignment selects the optimal (least cost) route between the origin and destination for each of the individual O-D pairs. This is where the individual roadway segments are selected. The precise method for selecting the paths between origin and destination is minimization of cost using Djikstra's algorithm within the travel demand model. The cost selected for the purpose of routing is time. Each individual segment was assigned a travel speed based on posted speed or roadway class. Based on this speed, the individual travel time was calculated for each segment. The shortest path algorithm then selects the least-cost path between the origin and destination for each pair, aggregating the movements at the segment level.

4.2.5. Calibration Procedures

The traffic data collection effort described previously was a significant effort undertaken in conjunction with NDDOT to provide an accurate, objective and detailed estimate of traffic volumes for multiple classes of roadways throughout the state. For the purposes of the travel demand model, these counts are used for calibration purposes. As discussed previously, for a travel demand model to predict future traffic flows with confidence, it must sufficiently predict existing traffic flows. Comparing modeled traffic flows to observed counts determines whether the model sufficiently predicts existing traffic flows.

As part of the travel demand model development, a critical component of the four-step model is the trip distribution step. The gravity model described above uses friction factors between zones. These friction factors encourage or penalize movements within certain specified time thresholds. In the absence of trip length distribution data for individual commodity and input movements, scenario analysis was performed on the individual sub models for calibration of the traffic model.

The final step in the calibration process was to utilize matrix estimation. This process compares actual counts on segments to the predicted assigned traffic. Initially, the software provides detailed statistical measurements as to the quality of the fit. Then, utilizing the matrix estimation procedure, the software re-estimates the trip distribution matrix in an iterative fashion to improve the statistical comparisons. The resulting matrix was then compared to the initial unadjusted matrix to identify any significant variations. Where significant variations were identified, the trip generation volume estimates at the TAZ in question and related assumptions were reevaluated and altered if deemed appropriate.

5. Unpaved Road Analysis

The unpaved road analysis has two primary components: traffic volumes and maintenance practices. Traffic volumes are estimated using the travel demand modeling process described in Section 4 of this report. Maintenance practices and corresponding costs were obtained through a survey of county road maintenance officials and commissioners.

5.1. Costs and Practices Survey

Assessment of the funding needs to maintain and preserve unpaved county and local roads focuses on traffic levels and existing practices as reported by counties and townships in survey responses. Each county was analyzed separately, which allows the study to focus on county-level needs based upon existing practices and expectations. During the input process from the 2014 study, concern was expressed by policy-makers and county officials as to the homogeneity of costs and practices within regions, as well as the varied utilization of contractors for work within the counties. The survey was enhanced in 2016, 2019, and again during this study to collect additional information about graveling practices, aggregate type, use of contractors, and reported traffic levels by county. The survey enhancements were developed with the assistance of a panel of county engineers and road superintendents. Survey training webinars were hosted to provide additional insights to all county and township survey respondents. This provided additional information about the reason for regional discrepancies and allowed for consistency within regions where costs and practices are similar.

Because of variations in dedicated staff for roadway planning, separate surveys were designed for county and township officials. The county survey was mailed to all 53 counties in North Dakota and a 100% response rate was achieved. The township survey was mailed to all 1,333 organized townships (shown in Figure 15) with a 57% response rate. Unorganized township maintenance practices were derived from responses of organized townships within the same county or through county survey responses.

The survey was designed to obtain information on maintenance practices for unpaved roads as well as the costs are faced by each county and local entity. The full survey can be found in Appendix A of this report.

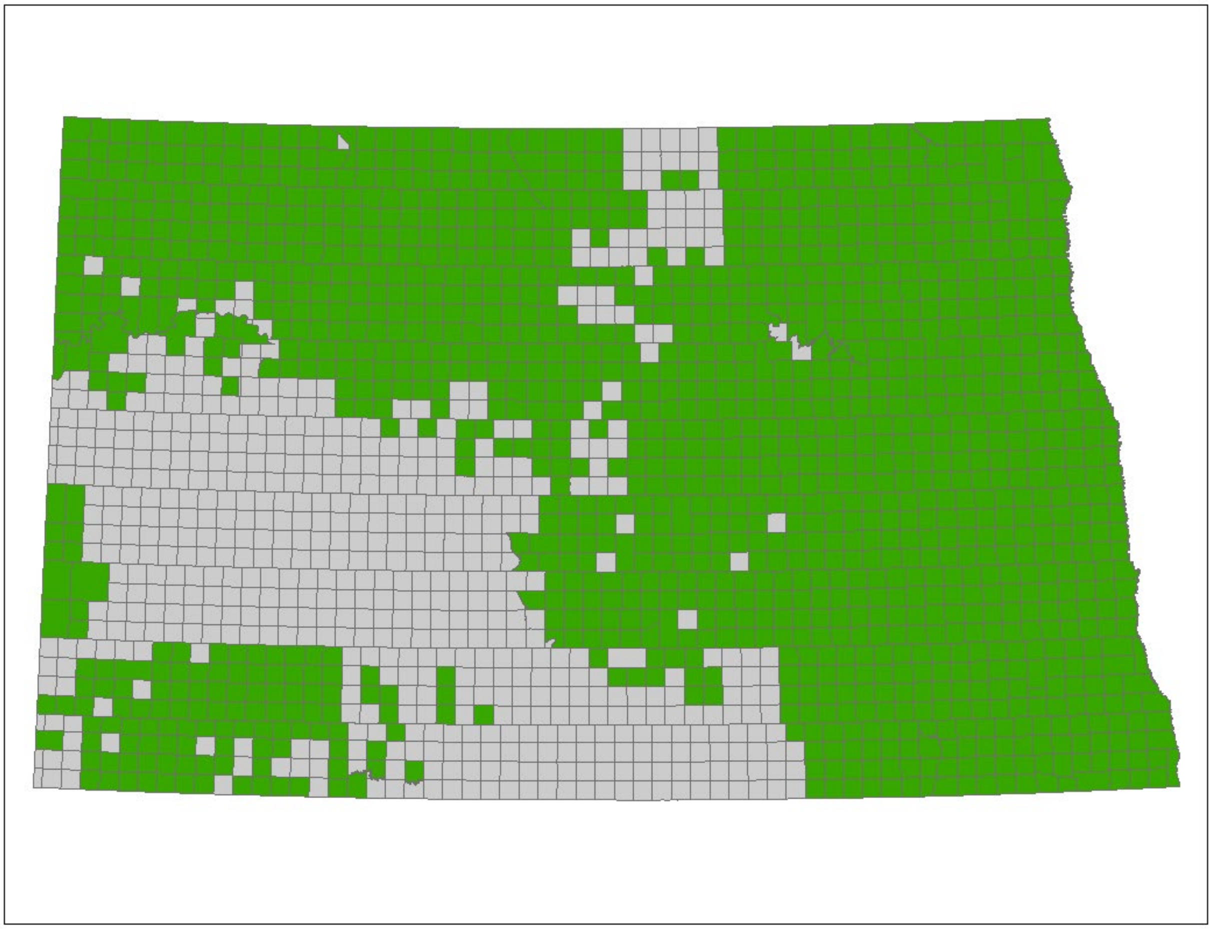

Figure 15. Organized Townships in North Dakota

Since the last study, there have been some changes in unpaved road maintenance practices that are intended to preserve the resources applied to the roads. These preservation techniques are evolving across the nation and North Dakota. The new techniques may slightly increase initial costs but will reduce costs over time through reduced blading and gravel overlay frequency. The goal of the new gravel techniques is to preserve the gravel on the roadway rather than let it be blown away as dust or have it roll into the adjacent ditches. At the time of this report, many counties were in the process of changing or had changed their gravel bidding and testing practices to ensure that higher quality and lower maintenance gravel was being purchased. The Federal Highway Administration (FHWA) and the Department of Defense (DOD) were also adding specification and testing requirements to missile road graveling projects administered by NDDOT.

5.1.1. Aggregate Description

The type and quality of aggregate used on unpaved roads has an impact on the cost and amount of maintenance required to maintain a road in acceptable condition. The survey utilized the following types of aggregate: gravel or scoria. In addition to aggregate type, respondents were asked whether their aggregate is pit run, screened, crushed material or if gravel purchases include specification and testing.

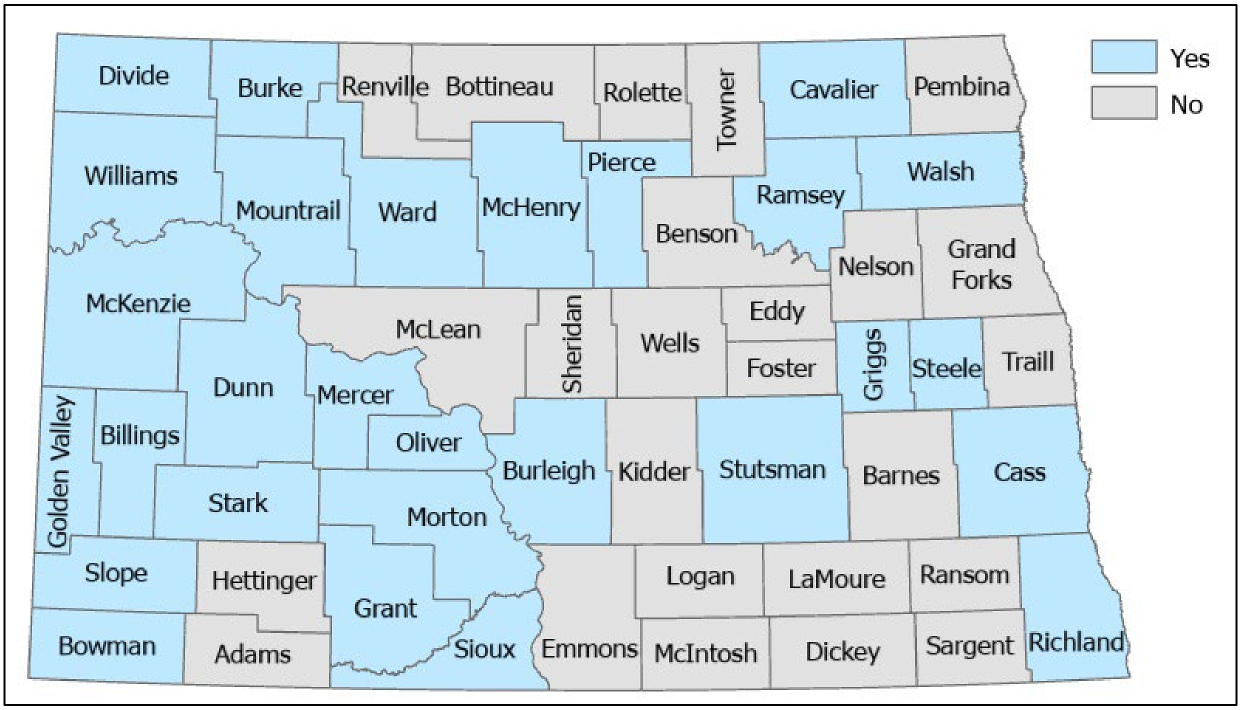

Figure 16. Survey Responses to Gravel Specifications

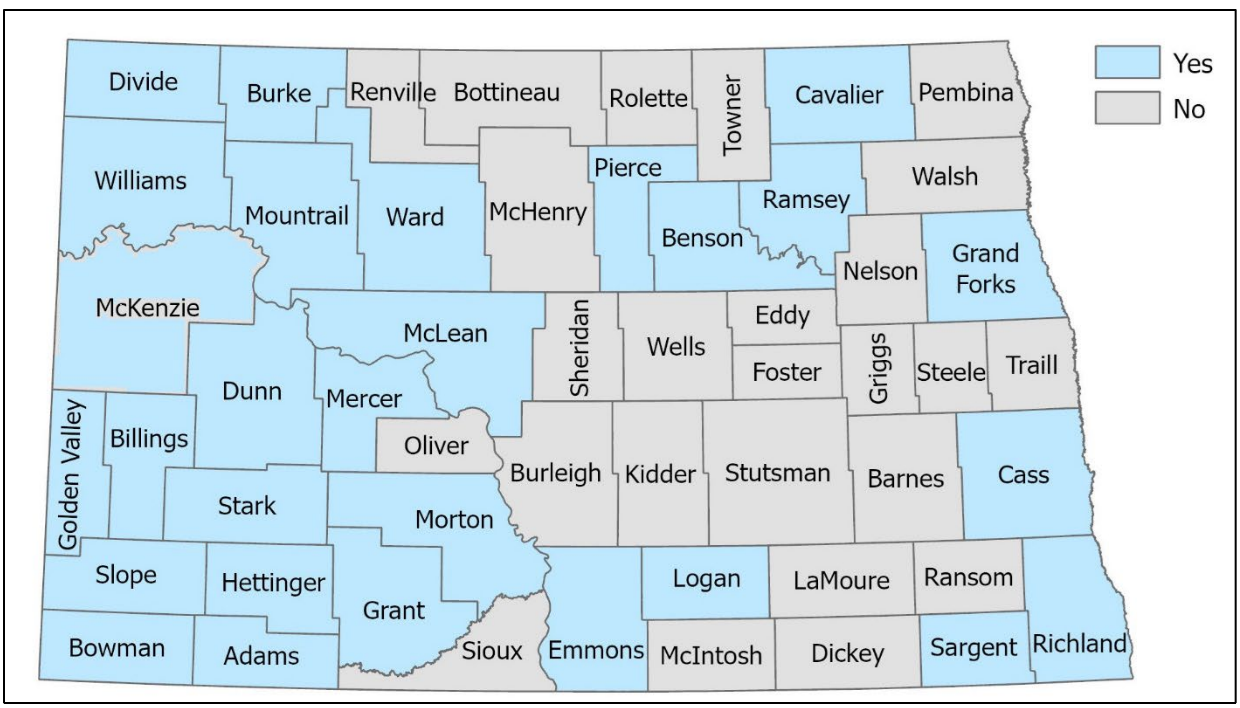

Figure 17. Survey Responses to Gravel Testing

5.1.2. Placement Practices

Common methods of applying a gravel overlay include truck drop and blading, windrowing and equalizing, watering rolling and compaction or a combination of any of the three. In addition, counties were asked for practices listed other than the most common placement techniques. Each of these techniques come at a different cost and the responses in this section of the survey help to reconcile reported placement costs in the cost section of the survey.

5.1.3. County vs. Contractor Work

In previous iterations of this study, significant variations in costs were observed and weren't readily explained by geographic aggregate and labor prices. Further conversations with county officials revealed that many of these cost differences could be explained by whether a county utilizes its own staff and equipment or contractors for gravel acquisition and maintenance activities. Consequently, county officials were asked whether county staff or contractors were utilized for crushing, hauling, placement, blading, dust control and base stabilization.

5.1.4. Costs

Depending on the region within the state, the survey indicated that there were significant variations in component costs. From region-to-region, aggregate availability and quality varies significantly and the resulting cost per yard and trucking cost from gravel pits to roads varies accordingly. County officials were asked for cost estimates for the following categories:

- cost per cubic yard
- trucking cost from gravel origin
- trucking distance
- truck payload
- placement costs
- blading cost
- dust suppressant cost
- base stabilization cost

To represent regional variations in aggregate price and availability, Figure 18 and Figure 19 show the unit price of aggregate per cubic yard and the average trucking distance for aggregate respectively. As Figure 18 shows, there are regional variations in aggregate prices with the highest per-yard costs in the western portion of the state and the lowest prices in the southeast and northeast part of the state. One outlier in eastern North Dakota is Traill County which reported the combined aggregate and hauling cost.

Figure 19 shows the average hauling distance from aggregate sources to improved roads. This map illustrates aggregate availability across the state. In counties having numerous sources of aggregate, the hauling distance is expected to be very short. In other counties with scarce aggregate resources, the hauling distance may be from one end of the county to the other, or even from outside of the county. The largest haul distances can be found in the Red River Valley because of low aggregate availability. As with Figure 21, Traill County is an outlier as it reported aggregate cost and hauling in one combined figure.

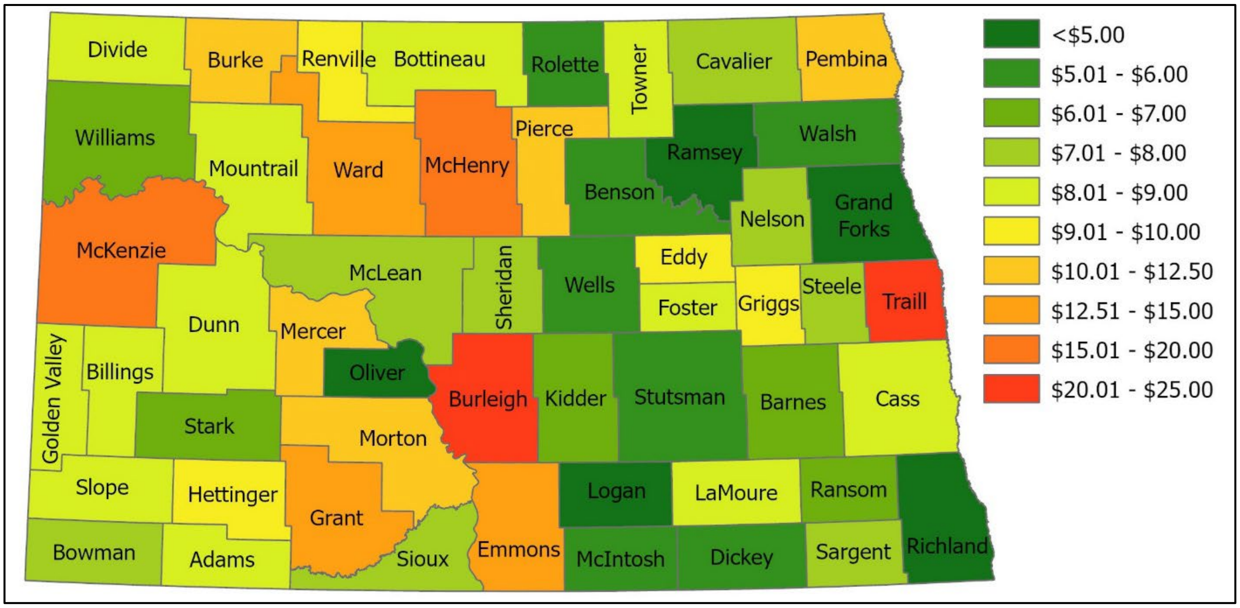

Figure 18. Aggregate Cost per Cubic Yard (2024 dollars)

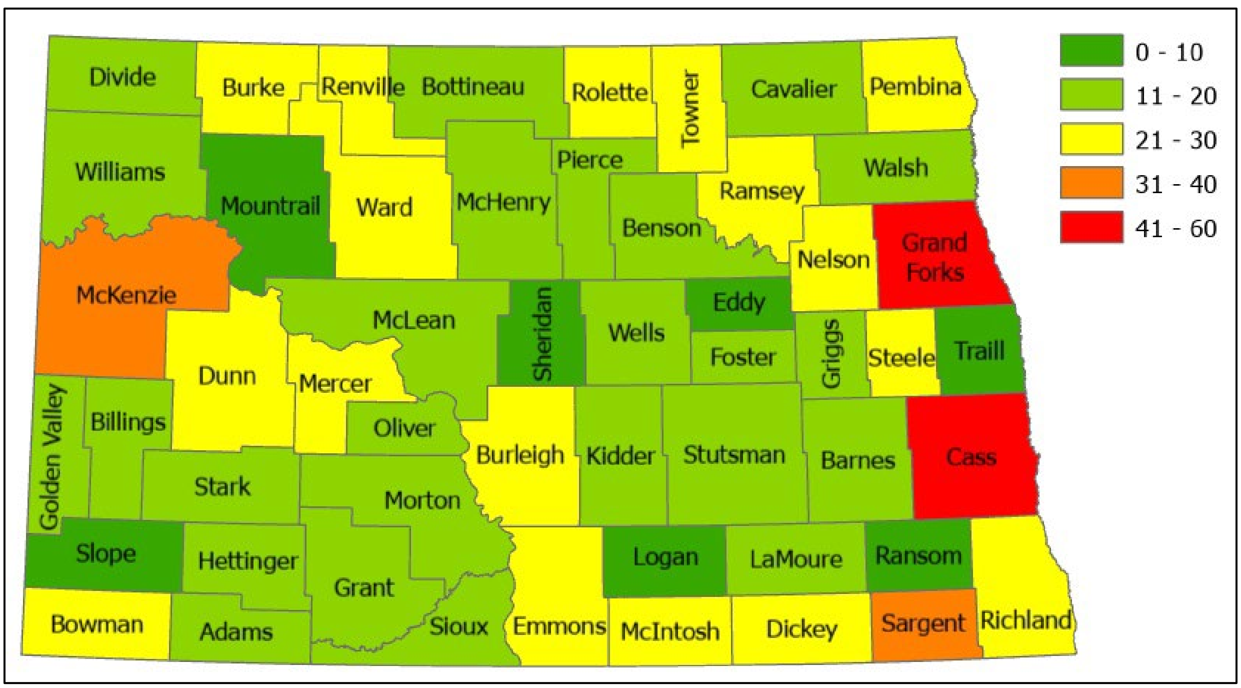

Figure 19. Aggregate Trucking One-Way Distance (Miles)

5.1.5. Practices by Traffic Level

Routine maintenance practices utilized by county and township officials for unpaved roads include blading and regraveling. The frequency and type of these practices vary based on the traffic levels on the road being maintained. For example, a high-volume gravel road requires more frequent blading and gravel overlays. Moreover, the gravel overlay would be thicker on a high-volume road than on a low-volume road. In addition to routine maintenance practices, many counties use dust suppressants or base stabilizations on high-volume roads to help preserve the road condition and mitigate impacts to citizens.

To assess how counties are maintaining their roads under different traffic categories, respondents were first asked to define what comprises a high-, medium- or low-volume road. There is also significant variation in traffic levels across the state; one county's high-volume road may be another county's low-volume road at the same traffic level. Following the question regarding the definition of traffic volumes, the county representatives were asked to provide blading and overlay frequencies at each traffic level. In addition, the overlay thickness and utilization of dust suppressant and base stabilization were established.

5.2. Analysis Procedures

5.2.1. Traffic Classification

Within each county, unpaved roads were classified by daily truck estimates. Classification ranges are shown in Table 5. Each category represents a differing traffic level leading to differing maintenance needs. Note that the 25-50 range represents the baseline traffic level. A 2007 survey conducted prior to significant oil development reported an average of 20 trucks per day on local roads and 22 on CMC routes. Traffic counts taken across the state for the purpose of this study indicate that these estimates have increased slightly statewide, and greatly in areas of oil development or in proximity to new shuttle train facilities. In the UGPTI conditions and practices questionnaire, counties were asked to provide information on maintenance practices on an average mile of gravel road classified by three traffic ranges (low, medium, high). Counties were asked to define their own range thresholds for these classifications. The surveys are presented in Appendix A.

Table 5. Unpaved Road Traffic Classification

Traffic Range (Truck ADT)	Category
0-25	Low
25-50	Baseline
50-100	Elevated
100-150	Moderate
150-200	High
200+	Very High

5.2.2. Improvement Types

Survey questions asked county and township officials to provide the improvement and maintenance cycles for gravel roads within their jurisdictions. The county surveys asked officials to provide these cycles separately for each of the three traffic volume categories. Improvement types included:

increased regraveling frequency, intermediate improvements, and asphalt surfacing. The first and the last improvement types are the most straight forward; as traffic increases, the application of gravel increases. Once traffic reaches a very high level, life cycle costs deem that an asphalt surface is the most cost-effective improvement type. The intermediate category of improvements includes base stabilization and armor coat treatments. There is no single intermediate improvement which can be applied to each county in North Dakota because of differing soil types, moisture levels, and skill and equipment availability. Types of intermediate improvements include the use of stabilizers such as Base 1 from Team Labs, Permazyme from Pacific Enzymes, and asphalt and cement stabilization. According to interviews with county road supervisors, stabilization has been used on a few county roads in North Dakota. Recent trials have yielded mixed results, with some positive cases resulting in reduced maintenance costs. However, the longevity of these types of treatments are unknown, particularly with regard to performance under North Dakota's freeze/thaw cycles.

Maintenance types by traffic category are shown in Table 6. The consensus from the survey responses was that on roads with higher traffic volumes, the graveling interval decreases and the number of bladings per month increases. For example, a road considered in the medium category has a graveling interval of three to five years and a blading interval of once per month. A high-traffic road has a graveling interval of one to three years and a blading interval of three-four times per month. The difference doubles the gravel maintenance costs over the same time period. The other important takeaway is that counties located in the oil patch tend to have shorter improvement cycles and higher standards for overlay thickness than the rest of the state. Most of these counties use advanced stabilization methods. The unit costs of gravel supply and transportation are generally higher in the western part of the state.

Table 6. Improvement Types for Unpaved Roads by Traffic Category

Traffic Category	Improvement
Low	Low Volume Average
Baseline	County Average
Elevated	County Reported
Moderate-High	County Reported and Indexed

It is entirely possible that at the very high and potentially high categories of traffic on gravel roads, counties may choose to convert the surfaces to an asphalt surface. This study does not explicitly model upgrading gravel pavements on a statewide basis, as it is expected that the decision to convert surface type is part of a county-level planning program. The estimates of maintenance costs in the very high and the potentially high categories may equal or exceed the annual equivalent improvement and maintenance costs for an asphalt surface, depending on an individual county's cost characteristics.

5.2.3. Projected Investment Needs

The projected costs by time period, region, and functional class are summarized in Table 7, Table 8, and Table 9. The total projected statewide need during the 20-year analysis period is $6.97 billion.

Table 7. Statewide Unpaved Road Investment and Maintenance Needs for Counties, Townships and Tribal Areas in North Dakota (Millions of 2024 Dollars)

Period	Statewide
2024-2025	$707.88
2026-2027	$694.93
2028-2029	$714.99
2030-2031	$716.56
2032-2033	$693.38
2034-2043	$3,443.71
2024-2043	**$6,971.45**

The estimated needs are shown by jurisdiction for the 2024-2025 biennium in Table 8. Similarly, the investment needs are shown by jurisdiction for the entire analysis period in Table 9.

Table 8. Unpaved Road Investment Needs, by Jurisdiction: 2024-2025

Jurisdiction and/or Maintenance Resp.	Needs (Millions)	Percent of Needs
County	$436.41	62%
Township	$252.06	36%
Tribal	$15.33	2%
Total	$707.88	100%

Table 9. Unpaved Road Investment Needs, by Jurisdiction: 2024-2043

Jurisdiction and/or Maintenance Resp.	Needs (Millions)	Percent of Needs
County	$4,348.78	62%
Township	$2,443.35	36%
Tribal	$137.87	2%
Total	$6,971.45	100%

Table 10 presents the unpaved road needs by county for the analysis period by biennium for each of the first 10 years, as well in total for as the last 10 years of the study period. Tribal roads not maintained by the counties are excluded from Table 10.

Table 10. Unpaved Road Needs by County (2024 Million)

County	2024-2025	2026-2027	2028-2029	2030-2031	2032-2033	2034-43
Adams	$6.94	$6.96	$6.96	$6.96	$6.97	$35.07
Barnes	$16.64	$16.64	$16.64	$16.64	$16.64	$83.24
Benson	$10.12	$10.12	$10.12	$10.12	$10.12	$50.58
Billings	$9.56	$8.82	$10.58	$9.91	$8.74	$43.49
Bottineau	$14.52	$14.47	$14.47	$14.54	$14.54	$72.68
Bowman	$7.82	$7.88	$7.90	$7.86	$7.81	$39.06
Burke	$13.45	$13.32	$13.30	$13.31	$13.35	$66.54
Burleigh	$16.74	$16.74	$16.74	$16.74	$16.74	$83.24
Cass	$33.76	$33.83	$34.02	$34.10	$34.33	$170.75

County	2024-2025	2026-2027	2028-2029	2030-2031	2032-2033	2034-43
Cavalier	$12.12	$12.12	$12.16	$12.17	$12.17	$60.74
Dickey	$8.93	$8.93	$8.93	$8.93	$8.93	$44.66
Divide	$12.91	$12.82	$12.88	$12.90	$12.85	$64.21
Dunn	$37.13	$33.84	$40.03	$42.15	$30.01	$151.34
Eddy	$3.70	$3.70	$3.70	$3.70	$3.70	$18.51
Emmons	$9.74	$9.74	$9.74	$9.74	$9.74	$48.70
Foster	$5.74	$5.74	$5.75	$5.75	$5.75	$28.72
Golden Valley	$9.68	$10.14	$9.80	$9.75	$9.61	$48.02
Grand Forks	$27.08	$27.17	$27.17	$27.17	$27.20	$135.78
Grant	$17.27	$17.27	$17.27	$17.27	$17.27	$86.35
Griggs	$5.35	$5.35	$5.35	$5.35	$5.38	$26.83
Hettinger	$7.70	$7.70	$7.70	$7.70	$7.71	$38.52
Kidder	$7.22	$7.22	$7.22	$7.22	$7.22	$36.48
LaMoure	$10.94	$10.94	$10.94	$10.94	$10.94	$54.72
Logan	$5.08	$5.08	$5.08	$5.08	$5.08	$25.42
McHenry	$13.69	$13.70	$13.70	$13.70	$13.73	$68.53
McIntosh	$4.84	$4.84	$4.84	$4.84	$4.84	$24.20
McKenzie	$50.70	$44.50	$51.31	$51.38	$46.24	$211.94
McLean	$22.08	$22.08	$22.08	$22.10	$22.11	$110.61
Mercer	$12.31	$12.31	$12.31	$12.25	$12.25	$61.25
Morton	$17.25	$17.25	$17.25	$17.25	$17.25	$86.24
Mountrail	$20.70	$18.81	$21.69	$21.77	$19.19	$94.51
Nelson	$6.53	$6.53	$6.53	$6.55	$6.55	$32.70
Oliver	$3.41	$3.38	$3.38	$3.38	$3.38	$16.60
Pembina	$9.31	$9.32	$9.32	$9.32	$9.32	$46.63
Pierce	$11.63	$11.63	$11.63	$11.63	$11.63	$58.15
Ramsey	$6.87	$6.88	$6.88	$6.88	$6.88	$34.38
Ransom	$6.67	$6.69	$6.69	$6.69	$6.69	$33.39
Renville	$6.60	$6.60	$6.60	$6.60	$6.60	$33.01
Richland	$20.16	$20.16	$20.16	$20.17	$20.18	$100.87
Rolette	$6.10	$6.10	$6.10	$6.10	$6.10	$30.51
Sargent	$5.76	$5.76	$5.76	$5.76	$5.76	$28.81
Sheridan	$6.58	$6.58	$6.58	$6.58	$6.58	$32.92
Sioux	$6.98	$6.98	$6.98	$6.98	$6.98	$34.91
Slope	$7.42	$7.42	$7.42	$7.32	$7.32	$36.61
Stark	$17.76	$17.73	$17.89	$17.69	$17.65	$88.69
Steele	$8.59	$8.59	$8.60	$8.60	$8.60	$42.97
Stutsman	$14.21	$14.21	$14.22	$14.23	$14.25	$71.15
Towner	$9.12	$9.12	$9.12	$9.12	$9.12	$45.62
Traill	$16.96	$16.99	$17.08	$17.11	$17.13	$85.24
Walsh	$20.39	$20.39	$20.53	$20.54	$20.54	$102.42
Ward	$26.77	$27.07	$27.25	$27.35	$27.20	$134.38
Wells	$9.38	$9.38	$9.38	$9.38	$9.38	$46.90

County	2024-2025	2026-2027	2028-2029	2030-2031	2032-2033	2034-43
Williams	$28.93	$27.36	$29.20	$29.25	$27.10	$135.92
Total	$707.88	$694.93	$714.99	$716.56	$693.38	$3,443.71

6. Paved Road Analysis

The paved road analysis follows a similar approach to the methods used in the 2019 study. For the most part, the same methods and models were used, but expanded data collection reduced uncertainty and improved the accuracy of this study's county and township paved roads needs forecasts.

A major part of the expanded data collection includes the use of the UGPTI/DOTSC-developed asset inventory tool, the Geographic Roadway Inventory Tool (GRIT). This online tool has allowed county roadway managers to input roadway data based on past improvement projects, providing a practical view of the roadway age and past construction practices of the counties. For the study, construction project data was taken from the inventory and input into the model to forecast future projects.

More than 5,500 miles of paved county and local roads (exclusive of city streets) are traveled by agricultural- and oil-related traffic and other highway users. Some of these roads are under the jurisdiction of governments or agencies other than counties, such as townships, municipal governments, the Bureau of Indian Affairs (BIA), and the Forest Service. City streets and Forest Service roads are excluded from the study.[1] BIA and tribal roads are included, but the results are presented separately from county and township roads.

In addition to miles of road and forecasted traffic levels, key factors that influence paved road investments are the number of trucks that travel the road, the types of trucks and axle configurations used to haul inputs and products, the structural characteristics of the road, the width of the road, and the current surface condition. The primary indicator of a truck's impact is its composite axle load – which, in turn, is a function of the number of axles, the type of axle (e.g. single, double, or triple), and the weight distribution to the axle units.

6.1. Truck Axle Weights

American Association of State Highway Transportation Officials (AASHTO) pavement design equations were used to analyze paved road impacts. These same equations are used by most state transportation departments. The equations are expressed in equivalent single axle loads (ESALs). In this form of measurement, the weights of various axle configurations (e.g., single, tandem, and tridem axles) are converted to a uniform measure of pavement impact. With this concept, the service life of a road can be expressed in ESALs instead of truck trips.

An ESAL factor for a specific axle represents the impact of that axle in comparison to an 18,000-pound single axle. The effects are nonlinear. For example, a 16,000-pound single axle followed by a 20,000-

[1] Investments in city streets primarily reflect access to commercial and residential properties and include the costs of parking and traffic control devices. This does not mean that city streets are unaffected by truck traffic. However, the specific focus of this study is county and township roads.

pound single axle generates a total of 2.19 ESALs, as compared to 2.0 ESALs for the passage of two 18,000-pound single axles.[2] An increase in a single-axle load from 18,000 to 22,000 pounds more than doubles the pavement impact, increasing the ESAL factor from 1.0 to 2.44. These nonlinear relationships result in exponential increases to ESALs & contribute to road damages. Even modestly illegal overloads (e.g. 22,000 pounds on a single axle) can significantly reduce pavement life.

6.2. Trucks Used to Haul Oil Products and Inputs

The forecasted trips for each type of load moving to and from well sites were shown in Table 2. The characteristics of these trips are depicted in Table 13. Specifically, the number of axles in the truck, the weight per axle group (in kilo pounds or kips), and the ESALs are shown.

For example, the truck used to transport a derrick has six axles positioned in three distinct groups, plus a single steering axle, for a total of seven axles. The first axle group (other than the steering axle) is a tandem set weighing 45,000 pounds. The second group is a three-axle set weighing 60,000 pounds. The third group is a tandem axle weighing 42,000 pounds. The ESAL factors for the three axle groups are 3.58, 2.48, and 2.49, respectively. The ESAL factor of the steering axle (which weighs 12,000 pounds) is 0.23. In total, the truck weighs 159,000 pounds with an ESAL factor of 8.78.

The heaviest weights and highest ESAL factors are generated by the indivisible loads listed in the first part of Table 11. These vehicles (which exceed the maximum vehicle weight limit) travel under special permits. In comparison, a truck used to transport sand while complying with Bridge Formula B weighs 76,000 pounds and generates an ESAL factor of 2.24. Nevertheless, based on enforcement data from the North Dakota Highway Patrol and results of special studies at truck weigh stations, it has been estimated that 25% of these trucks are overloaded. The typical overloaded vehicle weighs 90,000 pounds with an ESAL factor of 3.78 (instead of 2.24).

In the analysis, 75% of the trips for this type of truck are assumed to be legally loaded and 25% are assumed to be overloaded. A similar assumption is made for movements of fresh water. The estimated ESAL factor for movements of crude oil in 5-axle tanker trucks is 2.42. These tank trailers are designed for transporting oil at the 80,000-pound weight limit.

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[2] These calculations reflect a light pavement section with a structural number of 2.0 and a terminal serviceability (PSR) of 2.0.

Table 11. Axle and Vehicle Weights and Equivalent Single Axle Loads for Drilling-Related Truck Movements to and from Oil Wells

	Steering Axle			Axle Group 1			Axle Group 2			Axle Group 3			Axle Group 4			Vehicle Total	
Load Type	**Axles**	**Kips**	**ESALs**	**Axles**	**Kips**	**ESALs**	**Axles**	**Kips**	**ESALs**	**Axles**	**Kips**	**ESALs**	**Axles**	**Kips**	**ESALs**	**Kips**	**ESALs**
Generator House	1	12.7	0.40	3	54.7	1.90	4	59.4	6.08	2	33.4	1.11				160.2	9.49
Crown Section	1	15.0	0.65	2	45.0	3.58	2	45.0	3.58	2	35.0	1.38				140.0	9.19
Shaker Tank/Pit	1	14.1	0.65	3	51.6	1.44	4	54.0	4.00	2	23.0	0.32				142.7	6.40
Derrick	1	12.0	0.23	2	45.0	3.58	3	60.0	2.48	2	42.0	2.49				159.0	8.78
Suction Tank	1	11.8	0.23	3	42.1	0.78	3	49.6	1.24	1	17.1	1.00				120.6	3.25
VFD House	1	13.9	0.40	3	54.7	1.90	3	45.8	0.92	2	27.8	0.55	1	12.7	0.40	154.9	4.16
Mud Pump	1	12.9	0.40	3	54.3	1.90	3	56.5	2.17	2	37.2	1.69	1	5.0	0.02	165.9	6.18
Mud Boat	1	16.0	0.65	2	40.0	2.06	3	60.0	2.48	0	0.0					116.0	5.19
Shaker Skid	1	12.0	0.23	2	45.0	3.58	3	54.8	1.90	0	0.0					111.8	5.71
Substructure, Centerpiece, etc.	1	14.0	0.40	3	43.4	0.78	2	45.3	3.58	2	32.6	1.11	1	25.3	4.31	160.6	10.18
Draw Works	1	14.4	0.40	3	58.0	2.17	3	59.0	2.48	2	36.0	1.38				167.4	6.43
Hydraulic Unit	1	16.0	0.65	2	28.0	0.55	2	26.0	0.42	3	60.0	2.48				130.0	4.09
Choke Manifold	1	14.0	0.40	2	41.8	2.49	2	39.5	2.06	1	19.8	1.49	1	4.0	0.00	119.1	6.44
MCC House	1	18.0	1.00	3	58.5	2.48	3	58.5	2.48	2	39.0	2.06				174.0	8.02
Tool Room, Junk Box, etc.	1	12.0	0.23	2	45.0	3.58	3	60.0	2.48	0	0.0					117.0	6.29
Screen House	1	13.0	0.40	4	56.0	4.98	4	56.5	4.98	2	33.0	1.11				158.5	11.46
Light Plant	1	14.0	0.40	4	58.0	6.08	4	66.0	8.83	2	32.0	0.89				170.0	16.20
Mud Tank	1	13.0	0.40	3	47.5	1.07	4	58.8	6.08	1	19.5	1.49				138.8	9.04
Workover Rigs	2	45.0	3.58	3	60.0	2.48										105.0	6.06
Fresh Water Unpermitted Overloads[1]	1	14.0	0.40	3	38.0	0.46	2	19.0	0.16	2	19.0	0.16				90.0	1.18
Fresh Water Legal Loads [2]	1	10.0	0.12	3	33.0	0.31	2	16.5	0.11	2	16.5	0.11				76.0	0.64
Fresh Water Empty Return Loads	1	6.0	0.02	3	14.0	0.01	2	9.0	0.01	2	9.0	0.01				38.0	0.05
Sand Unpermitted Overloads[1]	1	14.0	0.40	2	38.0	1.69	2	38.0	1.69							90.0	3.78
Sand Legal Loads[2]	1	10.0	0.02	2	33.0	1.11	2	33.0	1.11							76.0	2.24
Sand Empty Return Loads	1	6.0	0.00	2	16.0	0.07	2	16.0	0.07							38.0	0.14

1. 25% of Loads @ 90 kips
2. 75% of Loads @ 76 kips

6.3. Trucks Used to Haul Grains and Farm Products

A previous survey of elevators revealed the types of trucks used to haul grains and oilseeds and the frequencies of use. As shown in Table 12, approximately 56% of the inbound volume is transported to elevators in five-axle tractor-semitrailer trucks. Another 4% arrives in double trailer trucks—e.g. Rocky Mountain doubles. Another 12% to 13% arrives in four-axle trucks equipped with triple or tridem rear axles.

Table 12. Types of Trucks Used to Transport Grain to Elevators in North Dakota

Truck Type	Percentage of Inbound Volume
Single unit three-axle truck (with tandem axle)	25.15%
Single unit four-axle truck (with tridem axle)	12.55%
Five-axle tractor-semitrailer	54.96%
Tractor-semitrailer with pup (7 axles)	3.62%
Other	3.72%

After considering entries in the “other” category, the following assumptions have been made. 62% of the grains and oilseeds delivered to elevators in North Dakota are expected to arrive in combination trucks, as typified by the five-axle tractor-semitrailer. The remaining 38% are expected to arrive in single-unit trucks, typified by the three-axle truck. The impact factor for grain movements in tractor-semitrailers is 2.7 ESAL per front-haul mile, which includes the loaded and empty trips. In comparison, the impact factor for a single-unit truck is 1.5 ESALs per mile. Nevertheless, the ESAL factors per ton-mile are roughly the same for both trucks, given the differences in payload.

6.4. Surface Conditions

In 2023, UGPTI acquired an IRISgo Portable profiler, which has since been utilized for collecting pavement condition data. This advanced laser-based profiler replaced the Roadbump Pro accelerometer-based smartphone system, which was used in 2022 for data collection in the northeastern region. This northeastern region data was calibrated and corrected with the data collected by the new profiler. (See Appendix H for details on Profiler)

The Roadway Image Capture (RIC) tool developed by DOTSC at UGPTI was also used to collect and upload images of the roads to the UGPTI server. These images have been used to rate (PSR_condition) the road sections subjectively. The integration of the RIC system further enhanced our data collection by providing visual confirmation and supplementary information about road surfaces.

Using the IRISgo Portable Profiler, our team collected pavement condition data from 6,105 miles of paved county roads. This comprehensive data set has significantly contributed to our understanding of the pavement condition and the necessary maintenance or repair actions.

All the international roughness index (IRI) values are expressed in inches per mile and converted into present serviceability index (PSR) ratings based on the Minnesota survey panel model. The model proposes two equations for bituminous and concrete pavements using subjective feedback from 32 citizens who drove on the 120 pre-selected test sections on the state’s highway system. Drivers reported their driving experience within the range of 0 (very poor) to 5 (very good), with poor, fair, and good grades between them. This value was then used with the AASTHO 93 pavement design equation. The following formulas were used for this conversion:

IRI to PSR is converted using the Minnesota survey panel equation (MnDOT, 2003):

$$PSR_{ride} = 5.697 - (0.264 * \sqrt{IRI})$$

Combined ride and condition values of PSR with the following equation:

$$PSR_{combined} = \sqrt{PSR_{ride} * PSR_{condition}}$$

The $PSR_{condition}$ used in the equation is the subjective 0 to 5 scale rating of cracking and surface deterioration of the road sections. Researchers rated approximately 4,000 miles of paved road sections for condition using the RIC images from GRIT. The images were also accessed to obtain any roadway information during the rating analysis. For the rest of the paved miles, data collected from 2021 is adjusted based on the assumptions of 0.1 yearly deterioration in PSR and any maintenance work done after 2021 data collection.

The results of the combined condition and ride PSR assessment are summarized in Table 13. About 23% of paved county and township road miles are in good condition. Another 56% of paved road miles are in fair condition and should be considered for improvements within the next ten years or so. The last 21% is in poor condition, which is likely in need of immediate improvement. Road condition ratings for each county are shown in Appendix C.

Table 13. Conditions of Paved County and Township Roads in North Dakota

Conditions	Miles - 2023	Percent- 2023	Percent- 2021	Percent- 2019
Good	1,360.014	23%	25%	39%
Fair	3,336.498	56%	60%	50%
Poor	1,242.148	21%	15%	11%
Total	5,938.66	100%	100%	100%

6.5. Structural Conditions

The capability of pavement to accommodate heavy truck traffic is reflected in its structural rating, which is measured through the structural number (SN). The structural number is a function of the thickness and material composition of the surface, base, and sub-base layers. The surface (top) layer is typically composed of asphalt, while the sub-base (bottom) layer is comprised of aggregate material. The base (intermediate) layers consist of aggregates of various classifications and/or reclaimed pavement and base material. County officials have access to update this layer thickness data in GRIT. For the analysis in this study, those updated layer thickness values are primarily selected from the GRIT inventory. If no data is available in GRIT, the gaps can be filled with the data collected via non-destructive testing (NDT) data collected in 2015. The analysis uses default values based on the region and pavement rating for any additional missing data. The same approach is adopted for calculating the resilient modulus where the subgrade strength information updated by county is initially used. If no data is entered, the elastic modulus provided by NDT or the default values were used for further calculation.

In this study, structural numbers are used to estimate the contributions of existing pavement and base layers at the time that a road is resurfaced and the overlay thickness required for a new structural number that will allow a 20-year service life. The existing pavement's structural number is calculated using the depth of different layers in the pavement with the respective structural coefficients. For example, when resurfaced, the average in-service structural number of a county road with a 6-inch aggregate sub-base and a 5-inch asphalt surface layer in fair condition is computed as $6 \times 0.08 + 5 \times 0.25 = 1.7$. In this equation, 0.08 and 0.25 are the structural coefficients of the sub-base and surface layers, respectively.

6.6. Types of Improvement

Five types of road improvements are analyzed in this study:

1) Resurfacing

If a pavement is not extensively deteriorated, normal resurfacing is a cost-effective method of restoring structural capacity and surface condition. In this type of improvement, a new asphalt layer is placed on top of the existing (or milled) pavement. The thickness of the layer may vary from two to seven inches depending on truck traffic and existing SN.

2) Reconstruction

This entails the replacement of a pavement in its entirety, i.e., the existing pavement is removed and replaced.

Reconstruction includes subgrade preparation, drainage work, shoulder improvements, and the widening of substandard lanes. A road may be reconstructed for several reasons:

- the pavement is too deteriorated to resurface,
- the road has a degraded base or subgrade that will provide little structural contribution to a resurfaced pavement, or the road is too narrow to accommodate thick overlays without widening. The graded width determines whether a thick asphalt layer can be placed on the existing pavement without compromising capacity.

3) Mine and Blend (Reclamation)

On low-volume roads, the high cost of full-depth pavement reconstruction may not justify the benefits in terms of pavement serviceability. In this case, the existing aggregate base and hot bituminous pavement can be salvaged as the base material for a new pavement in a "mine and blend" process. This treatment reduces the high-cost reconstruction of low-volume roads where subgrade strength is not a problem.

4) Sliver Widening with Resurfacing

As a road's surface is elevated by overlays, a cross-sectional in-slope must be maintained. As a result, the useable width may decline, or the in-slope may become steeper and not meet design standards. For narrower roads, this may result in reduced lane and shoulder widths and/or the elimination of shoulders. In such cases, resurfacing and widening within the existing right-of-way may be feasible if the road is not too badly deteriorated. This improvement does not necessarily result in wider lanes or shoulders. However, it prevents further reductions in lane and shoulder widths.

5) Concrete Break and Seat with Overlay

Several concrete pavements built during the oil embargo crisis of the 1970s remain on roads within North Dakota. These roadways cannot have a simple asphalt overlay to repair them. The existing concrete pavement must be cracked and re-seated and can then be overlaid. This option is to improve the ride quality and structure of the existing concrete pavement at a lower cost than a full reconstruction project.

Improvement Logic

The forecasting procedure used in this study considers the current serviceability of the road, condition of the subgrade, condition and thickness of the unbound base, lane and shoulder width deficiency, maximum daily truck traffic during the analysis period, and the overlay needed in light of forecasted traffic.[3] The PSR of each road segment is predicted year by year, starting from its current value and using the projected traffic load and characteristics of the pavement using the AASHTO 93 Pavement Design Model. When the PSR is projected to drop below the terminal serviceability level, an improvement is selected.

If a road segment shows evidence of subgrade failure through poor back-calculated modulus (less than 4000 psi), the segment is selected for reconstruction regardless of other criteria.

If the subgrade is adequate but the road segment has deteriorated to a condition where resurfacing is no longer feasible, the segment will be selected for major rehabilitation (e.g., reconstruction or mine and blend). Low-volume roads are selected for the less expensive mine and blend treatment. Otherwise, the road segment will be selected for full reconstruction.

If a pavement is still above the poor condition and has not yet dropped below the reconstruction PSR, it is slated for resurfacing and/or widening. This is considered the ideal time for a lower-cost surfacing improvement to avoid the much higher reconstruction costs. If the width is sufficient, the segment is resurfaced to the required thickness based on the following formula:

$$\mathrm{I} = \frac{\mathrm{SN}_{New} - \mathrm{SN}_{Old}}{0.40}$$

Where:

SN_{New} = Estimated structural number of the section corresponding to a 20-year design life, based on forecasted traffic

SN_{Old} = Estimated structural contribution of existing layers, based on the projected condition at the time of improvement

I = Inches of new asphalt surface layer required for the new structural number

[3] This improvement logic expands upon the logic used in previous UGPTI needs studies and is based upon general approaches that are widely followed in practice. However, individual counties may adopt different approaches based on local conditions and insights.

0.40 = Structural coefficient of asphalt surface layer

If the width is deficient and the projected overlay thickness is greater than 2 inches, treatment is determined based on the condition of the pavement's unbound base layer. If the base layer has inadequate strength or depth to support a thick overlay and high traffic loading, the segment is assigned major rehabilitation in the form of a mine and blend treatment. Otherwise, the road is resurfaced and widened within the existing right of way – a technique referred to as "sliver widening." However, if the width is deficient and the required overlay thickness is 2 inches or less, the road is assumed to be resurfaced (for perhaps the last time) without sliver widening. Note that sliver widening may not result in wider lanes or shoulders and added capacity. However, it prevents the further loss of lane or shoulder width and (for these reasons) is beneficial to capacity and safety.

Maximum sliver widening widths are defined regionally based on feedback from the NDDOT Local Government Division on current practices. The four major oil-producing counties (Dunn, McKenzie, Mountrail, and Williams) currently allow a maximum sliver widening of 2 feet per side. Other oil- and gas-producing counties may add up to 4 feet per side in a sliver widening treatment, while the rest of the state may extend paved width up to 5 feet per side.

6.7. Preservation Maintenance

Pavement preservation techniques include timely crack sealing, seal coats, and patching. These techniques, when combined with timely overlay projects, are intended to extend the life cycle and prevent the pavement from rarely, if ever, needing costly reconstruction, which can cost as much as six times the cost of an overlay. Although pavement preservation is generally accepted, it is not always practiced uniformly because of budgetary constraints. This study provides and includes the cost of timely pavement preservation techniques, even if the techniques are not uniformly applied across the jurisdictions included in this study. Preservation maintenance costs on paved roads include activities performed periodically (such as crack sealing and chip seals) as well as annual activities (such as patching). The cost relationships in Table 14 have been derived from a South Dakota Department of Transportation study and unpublished UGPTI research. Costs have been updated to 2024 levels and annualized based on the NDDOT price sheet and FHWA National Highway Construction Cost Index (NHCCI) changes from 2022. For example, the annualized seal coat cost would allow for at least two applications during a typical 20-year lifecycle for roads with a maximum daily truck volume greater than 500. Maintenance costs are derived separately for high-traffic segments in oil- and gas-producing counties because of the increased cost of micro-surfacing treatments in those counties.

Table 14. Routine Maintenance Cost for Paved Roads by Traffic Level (Million 2024 Dollars)

AADTT Truck Traffic	Region	Annualized Cost of Road Maintenance Activities				
		Chip Seal	Crack Sealing	Contract	Microsurfacing	Total
0-500	All	$6,993	$1,500	$3,997	-	$12,490
>500	All	$4,660	$2,000	$7,990	$15,980	$30,630

6.8. Forecasted Improvement Needs

6.8.1. Required Overlay Thickness

As noted earlier, the projected thickness of an overlay is a function of truck traffic and existing pavement structure and condition. Based on the estimated ESAL demand for the next 20 years, a new structural number is computed that considers the effective structural number of the existing layers at the time of resurfacing.

Overlay thicknesses may be classified as thin (≤ 2 inches), medium (between 2 and 4 inches), and thick (≥ 4 inches). As shown in Figure 20, 17% of the state's paved road miles are expected to need thick overlays or major rehabilitation. Another 22% will require medium overlays, and thin overlays will suffice for the remaining 61%.

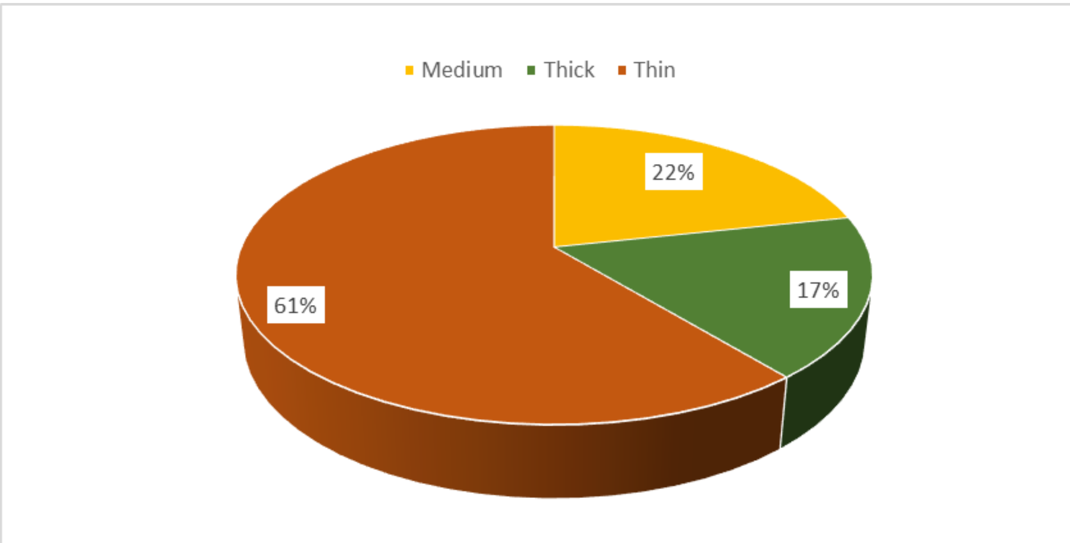

Figure 20. Statewide Projected Overlay Thickness

6.8.2. Miles Improved

As shown in Figure 21, approximately 4% of the paved roads miles in the state must receive major rehabilitation (reconstruction or mine and blend treatment) because of their poor condition and heavy traffic that will cause existing pavements to deteriorate very quickly.

This is 2% lower than the requirement from the last need study. About 2.3% of road miles must be widened when resurfacing, while 1.3% need a break and seat project.

Overall, the analysis shows that most of the miles in the state can be resurfaced without major rehabilitation or widening. However, many road segments that can be improved in the near term using thin overlays may need to be widened with future projects beyond the time frame of this study.

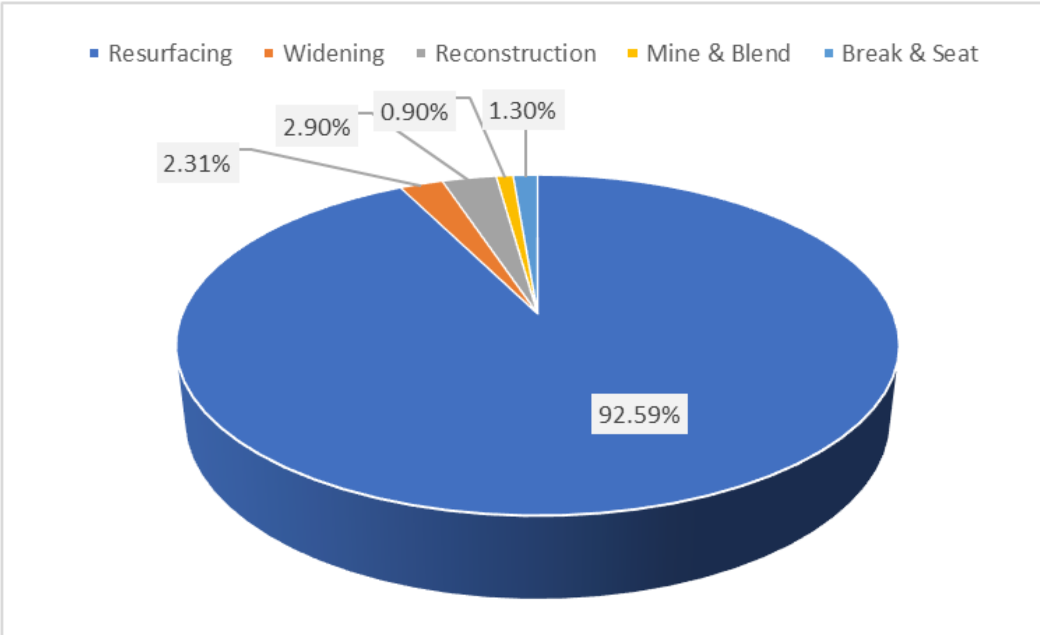

Figure 21. Percent of Paved Road Miles by Improvement Type

6.8.3. Improvement Costs per Mile

Construction costs continue to face upward pressure because of ongoing and emerging factors. The lingering effects of the COVID-19 pandemic on the global supply chain are diminishing. However, new challenges like increased inflation rates and rising interest rates have escalated the borrowing cost, eventually impacting the construction cost. Additionally, the transportation industry faces a skilled labor shortage due to an aging workforce nearing retirement, and there is a lack of strategic workforce development in the industry. Furthermore, geopolitical tensions, including ongoing conflicts and trade disputes, have contributed to fluctuating material costs and availability, making project budgeting increasingly unpredictable. These factors collectively contribute to the continued rise in construction costs in 2024.

In the previous study, the cost was reported for five categories of improvement types based on NDDOT bid information and plan documents. For this study report, a similar and very strong effort was made to collect and analyze the most recent construction and unit prices for local government projects that invited bids in 2023 and early 2024 construction, which shows an average increase of 6.16%. The FHWA suggested price index is also reviewed to track the changes in highway construction cost prices. Asphalt cost declined in late 2022, but experienced an average 2% increase over four quarters in 2023. However, prices appear to have remained steady for aggregate materials. According to the latest FHWA National Highway Construction Cost Index, there was an average increase of 16.26% per year from the fourth quarter of 2022 to the 4th quarter of 2023 (this is the most recent data from FHWA's NHCCI) for various types of construction projects. Considering the cost changes from both sources, a 10% increase in resurfacing cost was used for this study. With this information, the resurfacing cost of each project was determined to be $4,880 per inch foot width statewide. Therefore, a two-inch overlay costs roughly $234,240 per mile for a 24-foot roadway (Figure 22). A four-inch overlay costs roughly $468,480 per mile, while a six-inch overlay results in a cost of $702,720 per mile[4]. Break and seat costs for concrete roads were also increased by 10%.

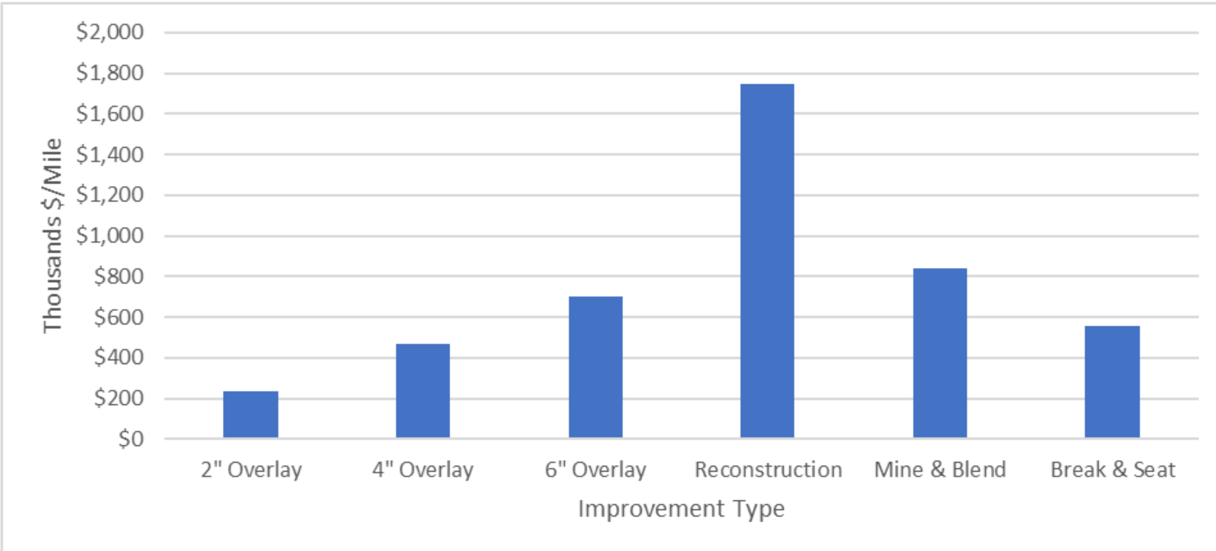

Figure 22. Average Cost per Mile for Different Improvement Types

Major rehabilitation costs are estimated using NDDOT unit cost data, which has also been normalized statewide. Reconstruction cost due to weak or failed subgrade is estimated at $1,747,970 per mile statewide. A mine and blend treatment is expected to cost roughly $839,025 per mile. Break and seat treatments are expected to cost approximately $559,350 per mile. Segments selected for sliver widening are assigned a widening cost of $108,375 per added foot width (in addition to overlay cost).

The results of the analysis are summarized in Table 15, Table 16, and Table 17. These tables show the projected improvements and costs (including maintenance costs) for each biennium during the next ten years, a projected subtotal for 2024-2033, and another subtotal for 2034-2043. Finally, Table 16 summarizes the total statewide costs for pavement preservation. Total paved road investment needs by county are presented in Appendix D.

As shown in Table 15, approximately 143 miles of paved county and township roads in North Dakota must be reconstructed or reclaimed because of poor conditions, high traffic loads, or deficient width. In comparison, 136.9 miles are candidates for widening. The remaining miles will need resurfacing during the next 20 years. On those roads, almost 77 miles of concrete roads must be considered for breaking and seating, while 43.5 miles need to go through a mine and blend treatment. Each mile of paved road is selected for only one type of improvement (e.g., reconstruction, mine and blend, resurfacing with sliver widening, or simple resurfacing). In addition, routine maintenance costs are estimated for each mile of road based on the traffic level.

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[4] As noted earlier, all of the improvement costs utilized in this study include allowances for preliminary and construction engineering costs.

The estimated cost for all county and township roads is approximately $3,496 million or $174.81 million annually. About 9% of the expected cost is due to major rehabilitation (Figure 23). Only 5% is attributable to each minor rehabilitation improvement like break and seat, mine and blend, and widening. Resurfacing accounts for 44% of the total expected cost. The remaining costs are linked to routine maintenance.

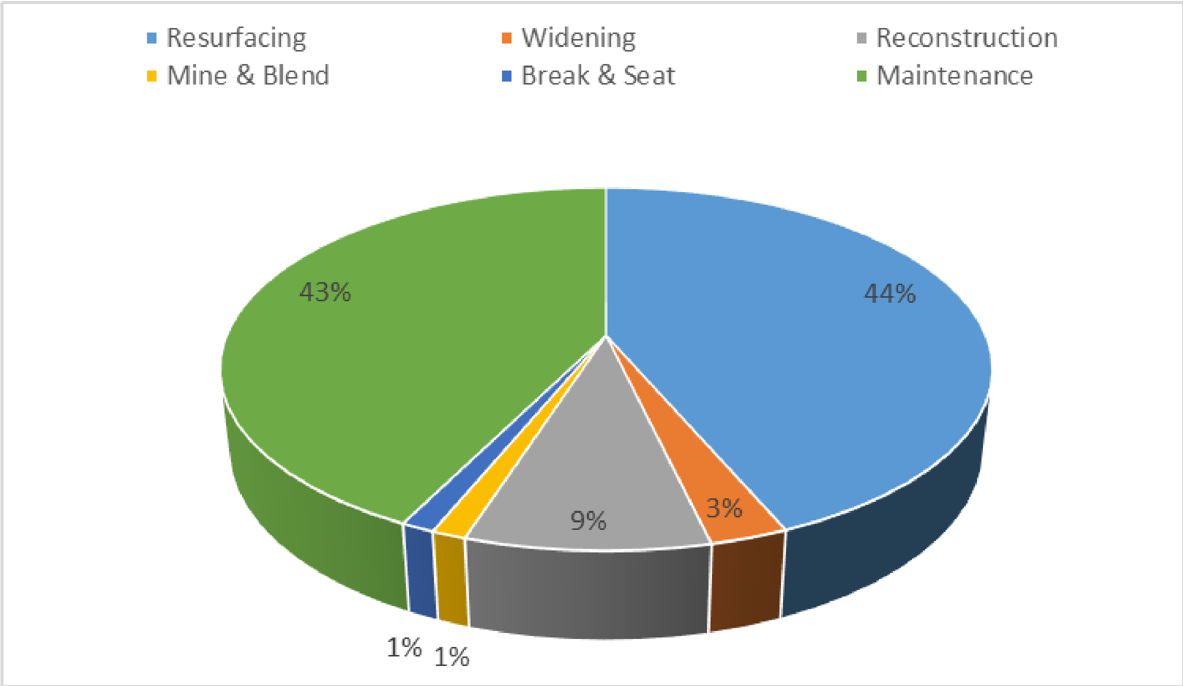

Figure 23. Percent of Cost for Different Improvement Types for All Statewide Roads

As shown in Table 15, the need for reconstruction is greater during the early years of the analysis period, with more than 83% of the reconstruction costs needed during the first decade.

The weighted average cost for the predicted resurfacing improvements is roughly $256,600 per mile. The average routine maintenance cost is approximately $12,550 per mile per year. The annualized cost per mile is approximately $13,540 per year for roads that do not require major rehabilitation or widening. Once deferred investment needs have been taken care of and regular preservation maintenance is practiced on all segments, annualized costs should stabilize near this level.

Table 15. Summary of Statewide Forecasted Improvements and Costs for Paved County and Township Roads (Million 2024 Dollars)

Period	Resurfacing		Widening		Reconstruction		Mine & Blend		Break & Seat		Mainte-nance Cost	Total Cost
	Miles	Cost	Miles	Cost	Miles	Cost	Miles	Cost	Miles	Cost		
2024-25	735.3	$248.2	47.4	$32.7	22.7	$39.6	30.7	$23.1	22.1	$12.4	$77.8	$433.8
2026-27	901.8	$278.2	56.6	$37.7	18.8	$32.9	0	$0.0	34.3	$19.0	$155.6	$523.6
2028-29	680.8	$201.3	22.8	$17.6	27.6	$48.3	9.7	$8.2	10.5	$5.9	$155.6	$436.8
2030-31	583.5	$146.6	2.5	$2.2	47.3	$82.7	1.9	$1.6	0	$0.0	$155.9	$388.9
2032-33	636	$163.0	0	$0.0	27.1	$47.4	1.2	$1.0	1.9	$1.1	$156.0	$368.6
2024-33	3,537.4	$1,037	129.3	$90.2	143.5	$250.9	43.5	$33.9	68.8	$38.6	$700.9	$2,151.7
2034-43	1,961.2	$486.6	7.5	$6.4	28.5	$49.8	10.03	$8.6	8.6	$3.1	$790.0	$1,344.4

Table 16. Statewide Pavement Investment Needs for County and Township Roads (Million 2024 Dollars)

Period	Statewide
2024-2025	$433.80
2026-2027	$523.60
2028-2029	$436.80
2030-2031	$388.90
2032-2033	$368.60
2034-2043	$1,344.40

6.8.4. Indian Reservation Roads

Some of the paved roads utilized by agricultural- and oil-related traffic are under the jurisdiction of the Bureau of Indian Affairs (BIA) and Native American tribal governments. These roads are included in the traffic model, data collection efforts, and GRIT; therefore, investment forecasts are also developed for them. These results are included in the total needs tables previously presented in this report and are also presented separately here. The same methods and assumptions used to analyze county and township roads are used to analyze tribal roads. The results of the paved road analysis are summarized in Table 17, which shows the forecasted improvements and costs for all tribal road segments that have been identified and entered into the GRIT program.

Table 17. Paved Indian Reservation Road Needs (Million 2024 Dollars)

County	2024-2025	2026-2027	2028-2029	2030-2031	2032-2033	2034-2043
Fort Berthold	$30.99	$3.09	$18.86	$5.52	$3.09	$18.42
Spirit Lake	$3.21	$4.28	$4.72	$1.83	$1.24	$8.71
Standing Rock	$11.13	$0.79	$2.72	$1.24	$0.79	$3.96
Turtle	$15.23	$14.84	$6.52	$2.99	$1.78	$8.89

7. Bridge Analysis

7.1. Major Structures

Ideally, bridges allow the highway network to meet the needs of the travelling public. However, bridge inadequacies can restrict the capacity of the transportation system in two ways. First, if the width of a bridge is insufficient to carry a modern truck fleet and serve current traffic demand, the bridge will restrict traffic flow and trucks may need to be rerouted. Second, if the strength of a bridge is unable to carry legal loads, then load limits must be posted and truck traffic again must be rerouted. These detours mean lost time and money for road users, including the agricultural- and energy-related traffic which are key drivers of the North Dakota economy. Therefore, a network of modern and structurally adequate bridges is critical to the state's transportation network. A total of 2,795 local government bridges were analyzed for this report. 750 county bridges are posted for load based on the ND DOT bridge dashboard. This is 31.8% of local government major bridges which results in transportation issues for the oil and agricultural industries in all of North Dakota. Bridges have the highest cost per linear foot of roadway compared to paved or gravel roads. Therefore, an adequate source of funding for their maintenance, repair, and replacement is important to maintain safety on public roads. Stutsman and Barnes Counties have city bridges under their jurisdiction, and these have been included in the data and analysis in this year's report. Two city bridges in each of these counties are showing the need for replacement.

This study expands upon the bridge needs forecasting methodology used in the previous UGPTI investment needs study. The forecast is based upon the goal of maintaining a bridge network that serves modern traffic demand.

7.1.1. Data Collection

Bridge inventory, condition, and appraisal data were collected from two resources: The National Bridge Inventory (NBI) database (comma delimited file) and the NDDOT's bridge inventory database (shapefile of county/urban bridges). These databases were combined and spatially merged with a shapefile of the county and local road centerlines which are the focus of this study. Each bridge was individually calibrated with regard to their spatial location and relationship to road segment.

The combined and spatially located data set includes a total of 2,795 (NBI 2024) rural non-culvert structures which are owned by counties, townships, parks or forest reserves, other local agencies, tribal governments, the Bureau of Indian Affairs, or the U.S. Forest Service and are currently open to traffic. There were 716 culvert bridges and minimum maintenance road bridges that were excluded from the SAS run analysis which included 2,079 bridge structures. Culvert bridges owned by counties were added as separate analysis. This dataset represents the basis for this study's needs analysis.

Bridges with total span length less than 20 feet and culverts are not included in the NBI database. However, this study includes a separate analysis of minor structure data which has been obtained from a 1985 ND DOT inventory that has been imported to GRIT. Counties were asked to review, update and approve these locations and at the time of this writing 75% of these structures had been approved. In addition, these locations were compared to the NBI to prevent overlaps and 632 of the original structures are now in the NBI so they are not included in the new minor structure analysis.

Major bridges which are culverts that have bridge numbers and are included in the NBI data have been added to the total bridge needs. These structures have spans of 20’ or greater and may consist of more than one main unit. If the structure material is steel or timber, the culverts that qualify have a culvert condition code of 5 or less. If the material is concrete, the qualifier is 4 or less. Only one timber culvert was found in the NBI data on a county road and this structure was in fair condition so it was not included. The decision tree flow chart is included in the Appendix F along with a table of the qualifying culvert bridge structures in Appendix G. Qualifying structures must have an ADT of at least 50. There are 14 major culvert bridges that qualify for replacement needs.

To support statistical significance, a complete NBI North Dakota bridge population dataset was used to develop the bridge condition forecasting models which will be explained in greater detail later.

7.1.2. Condition of County and Township Bridges

Table 18 summarizes the age distribution of county, township, and tribal-owned bridges in North Dakota based on the 2024 NBI, which was the most recent data available at the time of this report. Thirty-four percent of bridges in the data set are older than 50 years. Another 33% are between 30 and 50 years of age. A total of 405 bridges (19.48%) were built more than 75 years ago. Although 50 years was historically considered the design life of many bridges, service lives can be extended through diligent maintenance. However, many of the bridges are obsolete and beyond repair.

Table 18. Age Distribution of County, Township and Tribal Bridges in North Dakota

Age (Years)	Number of Bridges	Percent	Cumulative Frequency	Cumulative Percent
<= 20	103	4.95%	103	4.95%
> 20 and <= 30	151	7.26%	254	12.22%
> 30 and <= 40	295	14.19%	549	26.41%
> 40 and <= 50	408	19.62%	957	46.03%
> 50 and <= 75	717	34.49%	1,674	80.52%
> 75	405	19.48%	2,079	100.00%

The condition assessment scale used in the National Bridge Inventory is shown in Table 19. In this scale, a brand-new bridge component deteriorates from excellent condition to failure via eight interim steps or levels. Independent ratings are developed for each of the three major components which comprise a bridge structure – deck, superstructure and substructure. The latest recorded component ratings are shown in Table 20, and in an alternative format in Table 21.

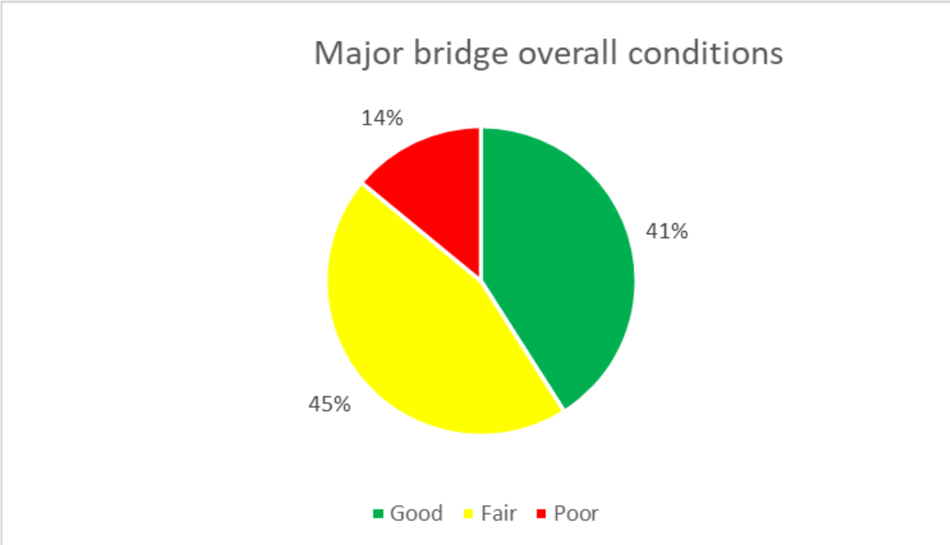

Figure 24. Major Bridge Overall Condition

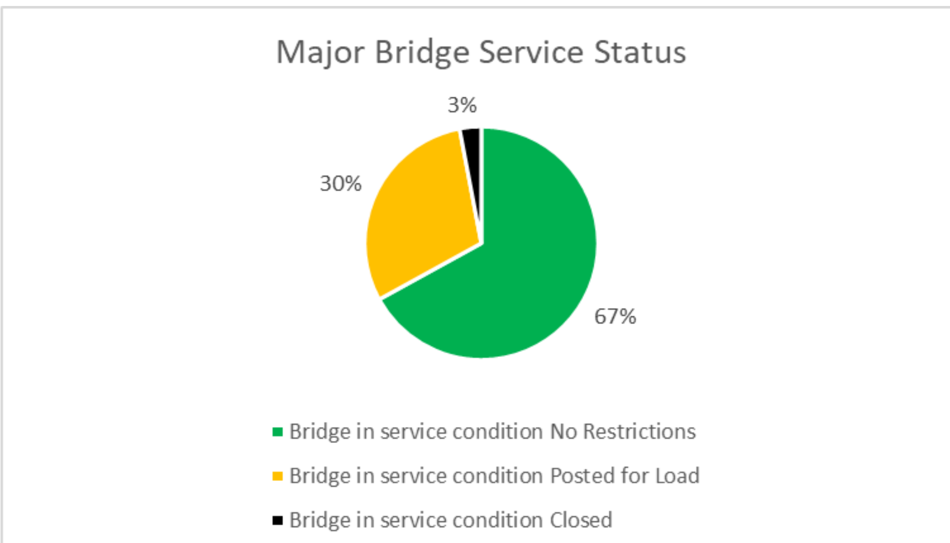

Figure 25. Major Bridge Service Status

Table 19. Component Rating Scales

Code	Meaning	Description
9	Excellent	
8	Very Good	No problems noted
7	Good	Some minor problems
6	Satisfactory	Structural elements show some minor deterioration
5	Fair	All primary structural elements are sound but may have minor section loss, cracking, spalling or scour
4	Poor	Advanced section loss, deterioration, spalling or scour
3	Serious	Loss of section, deterioration, spalling or scour has seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	Critical	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	Imminent Failure	Major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic; corrective action may put it back in light service.
0	Failed	Out of service – beyond corrective action.

Table 20. Deck, Superstructure and Substructure Component Condition Ratings

Component Rating	Deck		Superstructure		Substructure	
	Bridges	Percent	Bridges	Percent	Bridges	Percent
9	8	0.38%	17	0.82%	8	0.38%
8	238	11.45%	414	19.91%	251	12.07%
7	955	45.94%	631	30.35%	489	23.52%
6	638	30.69%	626	30.11%	588	28.28%
5	204	9.81%	285	13.71%	464	22.32%
4	32	1.54%	72	3.46%	196	9.43%
3	4	0.19%	34	1.64%	79	3.80%
2	0	0	0	0	4	0.19%
No component rating of 0 or 1 reported.						

Table 21. Compound Ratings, Alternative Format

Component Rating	Deck		Superstructure		Substructure	
	Bridges	Percent	Bridges	Percent	Bridges	Percent
Good (7-9)	1,201	57.77%	1,062	51.08%	748	35.98%
Fair (5-6)	842	40.50%	911	43.82%	1,052	50.60%
Poor (3-4)	36	1.73%	106	5.10%	275	13.23%
Critical (0-2)	0	0	0	0	4	0.19%

With the elimination of the Sufficiency Rating tracking by FHWA in its NBI data in 2015 which was used in the previous studies done by UGPTI, a new rating system was developed. This new calculator called Bridge Needs Target (BNT) was vetted through several meetings with UGPTI staff and county road superintendents and county engineers from across North Dakota during the summer of 2021. The 2022 study implemented this modified SR calculator which now includes special reduction factors for scour, fracture critical, timber and load ratings. These factors were implemented to provide a stronger focus on bridge elements and condition codes that generally result in bridge closures or failures. The new total bridge rating, referred to as the BNT, is solely used for the purpose of this needs study report. The previous internally developed SAS calculator was used as a basic framework for the BNT. This study continues using a trigger of 75 for the BNT in the decision flow charts. Trial runs of bridge inspection data resulted in an acceptable correlation with the old SR method and results and was approved by the ND County Bridge Steering Committee. Elements included in bridge needs target equation are shown in Table 22. The detailed BNT model components and calculations are shown in Appendix E.

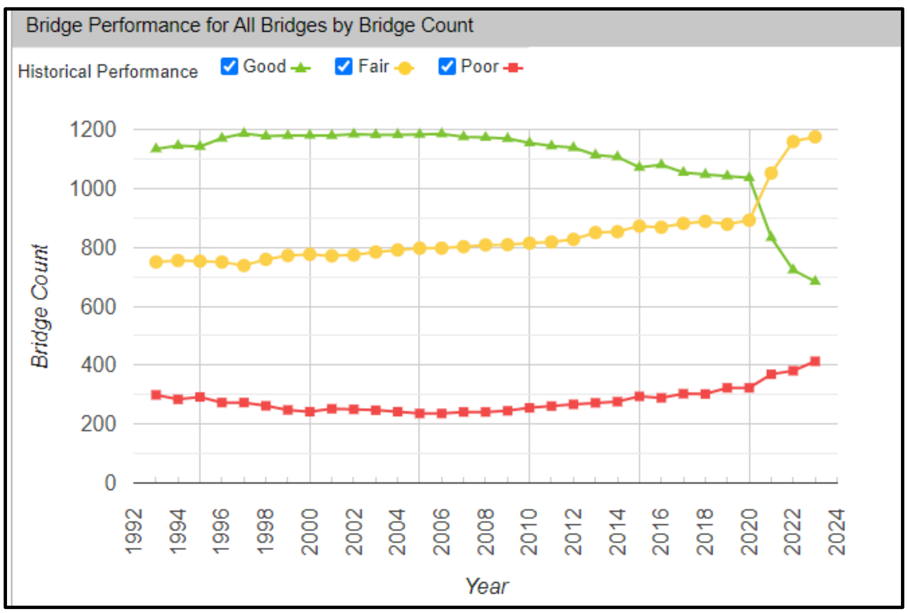

Figure 26. Historical Bridge Performance for Local Bridges (NBIS)

Table 22. NBIS Factors Used for Bridge Needs Target

NBI Item - Description
Deck NBI rating
Superstructure NBI rating
Substructure NBI rating
Culvert NBI rating
Fracture Critical NBI Y/N
Timber Structure Age starting > 30 years
Load Rating
Approach Road Alignment
Scour Code
Channel Protection Condition

Approximately 54%of bridges in North Dakota have a BNT of greater than 85%. About 20% of the bridges have a BNT rating of less than 60%.

7.1.3. Minimum Maintenance Bridges

Many of the state's county- and township-owned bridges exist on low- or minimum-maintenance roads. These bridges may be located on closed or unimproved roads and serve very low traffic demand. The user cost-benefit ratios of replacement typically do not justify the high investment cost. Based on discussion with NDDOT's Bridge and Local Government Divisions, this study assumes that structures on low-maintenance roads will not receive maintenance, rehabilitation, or replacement. The study's road network data did not include a designation for minimum maintenance roads, so an effort had to be made to identify these roads based on existing road data and recent satellite photography. This effort identified 182 bridges as existing on minimum maintenance roads.

7.1.4. Methodology – Major Structures

7.1.4.1. Deterioration Model

In prior studies, UGPTI developed a set of empirical models to forecast component (deck, superstructure, and substructure) deterioration rates for bridges nationwide. UGPTI also developed regional empirical regression models with a focus on North Dakota. In the prior studies, a sufficiency rating was predicted for each year of the 20-year study period. These past models were based heavily on the sufficiency rating and are of less value now that FHWA has dropped the sufficiency rating and the study team has moved to a BNT bridge condition concept.

7.1.4.2. Improvement Selection Model

The analysis considered three treatment types for each bridge: preventive maintenance, replacement, and no action. Bridge replacement is separated into three subcategories based on the type of structure which will replace the existing bridge:

1. New bridge with 32-foot width for CMC routes and 28' for non-CMC routes.
2. Single barrel reinforced concrete box culvert
3. Multiple barrels reinforced concrete box culvert

An improvement selection model was developed based on current practice and discussions with NDDOT personnel. The decision criteria include, but are not limited to, bridge status, BNT, operating rating, bridge geometry, and component condition ratings. The full improvement selection model is detailed in Appendix F.

The AASHTO and Federal Highway Administration (FHWA) have defined bridge preventive maintenance as "a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without substantially increasing structural capacity)" (FHWA 2011). This can include cyclical activities such as deck washing or condition-based activities such as scour mitigation or concrete patching. FHWA notes that effective bridge preventive maintenance activities can extend the useful life of bridges and reduce lifetime cost.

Preventive maintenance can encompass a wide variety of activities, but this study's improvement model was limited to the selection of a generalized annual "preventive maintenance" treatment category. It is assumed that each bridge owner will determine the maintenance treatments and intervals most appropriate for their bridges.

An additional forecasted preventive maintenance need was included for deck washing on maintenance-eligible bridges that exist on major collectors. This deck washing allocation recognizes the need for maintenance to combat chloride-induced corrosion of reinforcement (and resulting loss of service life) for concrete bridge decks.

Bridge replacement represents the final and most cost-intensive type of bridge treatment. It involves a complete replacement of the existing structure, either with a new bridge or another structure. This study assumes short span bridges will be replaced by reinforced concrete box culverts (RCBC), per current state of practice. Structures less than 40 feet in length will be replaced by a double-barrel RCBC, while structures between 40 and 50 feet in length will be replaced by multiple-barrel RCBC. Structures with total length greater than 50 feet are replaced by new bridges.

Typically, when older substandard bridges are replaced by modern ones, the lengths and widths of the structures increase. Based on recent North Dakota bridge replacement project data, a new structure is generally 70% longer than the original one. Replacement widths of 32 feet are used for bridges on the CMC system and 28 feet for non-CMC routes, respectively, to allow clearance for modern trucks and agricultural equipment.

Several criteria were used to qualify bridges for replacement. These are described in detail in Appendix F. In general, bridges qualified for replacement if they had low BNT (<75), or if they included a narrow deck (≤20 feet). Removal of load postings was a priority, so bridges on CMC routes with operating ratings of less than a standard HS-20 load were sent to replacement state regardless of other condition criteria. Special hauling vehicles can also result in the need for bridges to be posted for load maximums.

Functionally obsolete bridges are no longer tracked by the NBI. However, this classification referred to bridges that did not meet design standards for number of lanes, lane width, shoulder width and other safety factors for today's standards. Structurally deficient bridges are those with any parts of the deck, superstructure or substructure that have a condition rating of 4 out of 10 or less. For modeling purposes, functionally obsolete and structurally deficient ratings are still calculated based on the NBI data dictionary to produce a more detailed analysis of the bridge condition codes.

For the purpose of this study's 20-year analysis period, it is assumed that a bridge that receives a replacement will not be considered for another major improvement for the remainder of the study period and will instead be assigned preventive maintenance. Culvert structures require comparatively little preventive maintenance and are not considered eligible for preventive maintenance treatment in this study. If a bridge was replaced with a box culvert, no preventative maintenance costs would be modeled for the bridge.

For the first time, this study does include culvert bridges built from steel with a condition code of 5 or less and those built from concrete with a condition code of 4 or less. A total of 14 culvert bridges are included in the total bridge needs using these criteria. A table of the existing culverts and resulting improvements with a decision flow chart is shown in Appendix G.

7.1.4.3. Cost Model

This study includes the cost of timely bridge preservation techniques even if the techniques are not uniformly applied across the jurisdictions of this study. Preventive maintenance cost estimates used an annual unit cost of $0.35 per square foot of deck area for off-system bridges and $0.40 per square foot for on-system bridges. These costs were derived from input obtained at the December 2021 Midwestern & Western Bridge Preservation Conference with an added inflation factor from the NHCCI of 16%. These values represent a typical annualized cost of maintenance as derived from other state DOT preventive maintenance expenditures outlined in individual state needs studies and in NCHRP 20-68A Scan 07-05 Best Practices in Bridge Management Decision-Making (2009). A new length factor of 1.7 was used for this study to address the likelihood that a new bridge would be longer than the original bridge in order to accommodate current flood frequency requirements. The previous study used a factor of 1.8. This change was based on the average increase in length for new local bridge contracts awarded between February 2022 and March 2024.

Replacement costs were estimated by developing unit costs from recent (2023) NDDOT bid reports and plan documents for local government projects. Unit costs were adjusted for county projects based on NDLTAP and County input. The type of replacement structure was based on the criteria described in the Improvement Selection Model section of this chapter.

A deficient bridge less than 40 feet long is assumed to be replaced by a double box culvert structure at a cost of $635,000. A deficient bridge between 40 and 50 feet in length is assumed to be replaced by a multiple box culvert structure costing $1,134,000. Costs for bridges longer than 50 feet are calculated using the square footage of the deck and an average replacement unit cost. Unit replacement costs were $530 per square foot of deck area. All costs include approach grading, preliminary engineering and construction engineering costs. Preliminary engineering costs are assumed to add an additional 10% to the bid price, while construction engineering adds another 10% to the total price.

7.1.5. Results – Major Structures

Estimated statewide bridge improvement and preventive maintenance needs for the study period, 2024-2043 are $1.087 billion. Statewide bridge needs by biennium are shown in Table 23 with needs for individual counties presented in Table 24.

Table 23. Statewide Major Bridge Needs: 2024-2043

Period	Replacement		Maintenance Cost (million)	Total Cost (million)
	Number	Cost (million)		
2024-2025	141	$178.0	$0.943	$178.943
2026-2027	141	$178.0	$0.943	$178.943
2028-2029	141	$178.0	$0.943	$178.943
2030-2031	141	$178.0	$0.943	$178.943
2032-2033	141	$178.0	$0.943	$178.943
2034-2043	142	$178.3	$14.145	$192.445

Table 24. County and Township Major Bridge Needs by County: 2024-2043 ($2024)

County	Replacement Bridges	Replacement Cost	Preventive Maintenance Cost	Total Cost
Adams	7	$6,888,488	$281,726	$7,170,213
Barnes	8	$28,573,629	$726,365	$29,299,994
Benson	4	$2,148,908	$84,734	$2,233,642
Billings	7	$11,541,686	$175,752	$11,717,437
Bottineau	33	$32,632,751	$371,767	$33,004,518
Bowman	12	$7,657,782	$152,189	$7,809,971
Burke	6	$3,210,000	$41,537	$3,251,537
Burleigh	8	$4,447,150	$443,540	$4,890,689
Cass	43	$67,083,305	$2,611,942	$69,695,248
Cavalier	8	$6,581,618	$107,726	$6,689,344
Dickey	3	$8,340,325	$515,219	$8,855,544
Divide	2	$1,070,000	$78,929	$1,148,929
Dunn	6	$8,615,888	$356,721	$8,972,609
Eddy	3	$6,394,805	$246,622	$6,641,427
Emmons	8	$6,814,689	$317,254	$7,131,943
Foster	3	$4,378,343	$107,633	$4,485,975
Golden Valley	4	$4,864,477	$106,377	$4,970,854
Grand Forks	69	$50,994,703	$1,505,649	$52,500,352
Grant	24	$52,172,451	$198,248	$52,370,699
Griggs	1	$2,572,686	$178,237	$2,750,922

County	Replacement Bridges	Replacement Cost	Preventive Maintenance Cost	Total Cost
Hettinger	27	$21,271,138	$270,892	$21,542,031
Kidder	0	$0	$0	$0
LaMoure	11	$13,406,190	$292,155	$13,698,345
Logan	3	$1,070,000	$75,214	$1,145,214
McHenry	40	$41,817,900	$248,191	$42,066,090
McIntosh	2	$2,864,434	$0	$2,864,434
McKenzie	15	$20,948,780	$493,855	$21,442,636
McLean	7	$10,268,972	$331,983	$10,600,955
Mercer	21	$44,465,729	$306,424	$44,772,153
Morton	67	$74,452,252	$914,782	$75,367,034
Mountrail	1	$1,513,908	$216,550	$1,730,459
Nelson	3	$5,401,808	$262,719	$5,664,527
Oliver	7	$13,028,574	$102,033	$13,130,607
Pembina	62	$59,987,516	$525,743	$60,513,259
Pierce	1	$535,000	$0	$535,000
Ramsey	3	$3,282,255	$179,017	$3,461,273
Ransom	7	$25,100,829	$316,179	$25,417,007
Renville	6	$12,817,511	$128,672	$12,946,183
Richland	49	$56,553,486	$1,356,462	$57,909,948
Rolette	2	$1,070,000	$51,342	$1,121,342
Sargent	6	$3,210,000	$22,419	$3,232,419
Sheridan	0	$0	$0	$0
Sioux	1	$535,000	$154,888	$689,888
Slope	2	$8,291,283	$187,607	$8,478,890
Stark	23	$37,857,251	$546,073	$38,403,324
Steele	29	$24,276,691	$461,212	$24,737,903
Stutsman	11	$21,854,591	$397,453	$22,252,044
Towner	11	$7,682,000	$48,336	$7,730,336
Traill	61	$128,693,178	$607,596	$129,300,774
Walsh	68	$68,213,690	$913,930	$69,127,620
Ward	22	$29,362,926	$353,487	$29,716,413
Wells	4	$2,800,434	$316,106	$3,116,541
Williams	16	$8,688,000	$170,544	$8,858,544
Statewide	847	$1,068,305,012	$18,860,031	$1,087,165,04

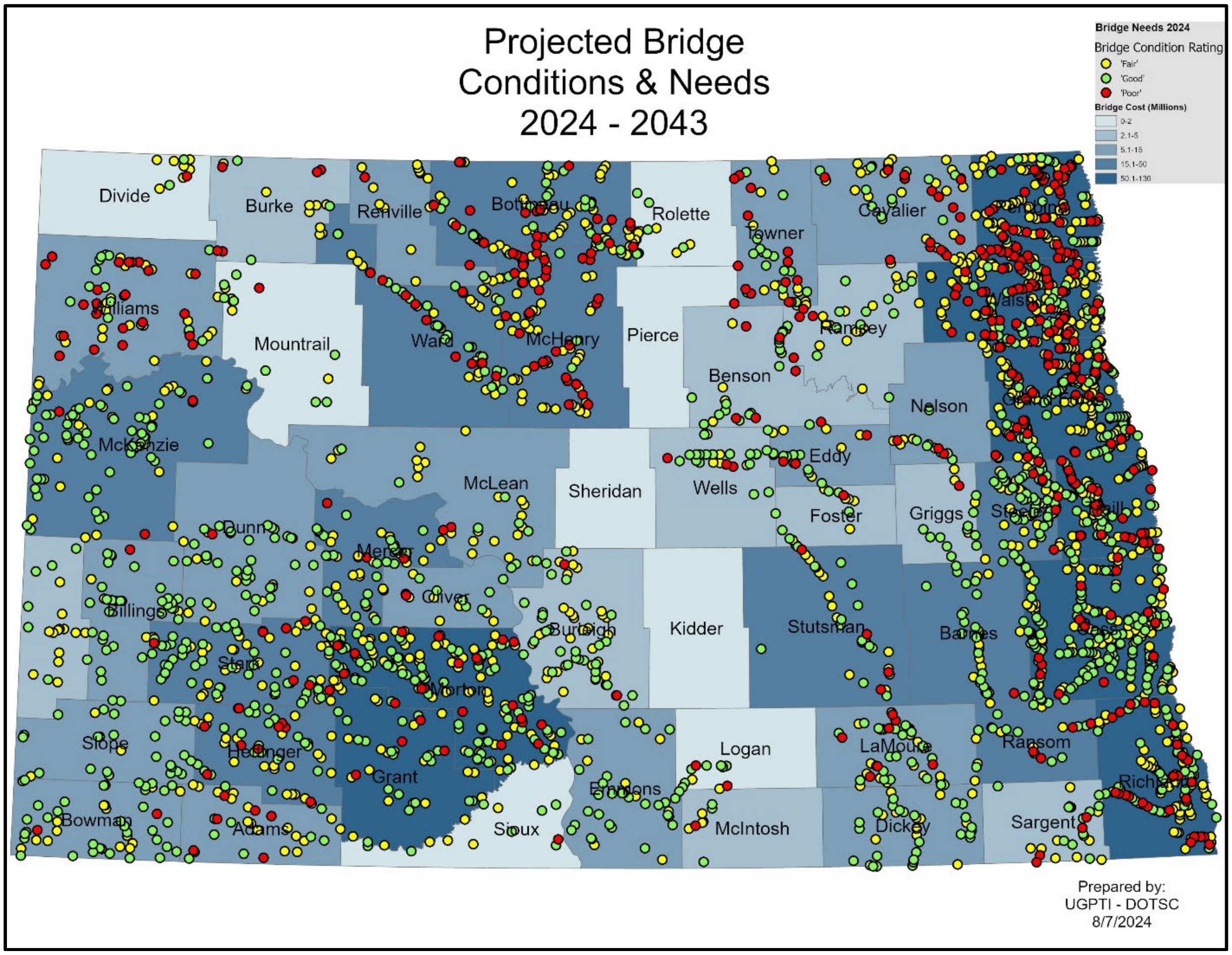

Figure 27. Projected Bridge Needs and Current Conditions

7.2. Minor Structures

Previous needs studies did not include bridge needs for smaller structures that are not included in the National Bridge Inventory which is only for bridges with spans of greater than 20 feet. However, there had been a lot of discussion about adding minor structures to this study for several years. The main issue was that no up-to-date inventory was available for each of the 53 counties in North Dakota. The UGPTI Geographic Road Inventory Tool has a minor structure layer but it was not being utilized by all of the counties. In the summer of 2023, a 1985 inventory of minor structures from the ND DOT was digitized and imported into the GRIT layer. After a meeting with the ND County Bridge Needs Steering Committee in July of 2023, support was overwhelming to move forward with a needs analysis for minor structures which had a span range of 8 to 20 feet. Discussions on the size range had actually begun in the fall of 2021 when the previous report's analysis began. The study team and the steering committee agree that the occurrence of these structures failing can cause severe injury or death to the traveling public. Failures of these structures can also impact the agricultural and oil economies on a local, regional and statewide basis by increasing detour lengths for deliveries of inputs and of the affiliated products produced here in North Dakota.

7.2.1. Data Collection

Counties were asked to go into their GRIT editor maps and review, edit and approve each minor structure that was imported from the 1985 inventory. UGPTI staff created a recorded webinar on how to review and approve the imported data for counties to use as an instructional guide. Culvert size and shape diagrams were also distributed to the counties as a helpful tool. A minor structure inventory/inspection form was created and distributed for counties to use as an in-the-field document. Some of these bridges were still in service, some had been replaced and some were closed.

The exported minor structures were compared with the NBI to avoid possible duplications. As a result, for the 3,324 exported structures with spans of 8 to 20 feet, 220 were eliminated to clean up the data. The resulting data was the basis for the minor structures analysis. There is no current traffic data for these structures. However, counties were asked to only approve structures that are in service and open to traffic.

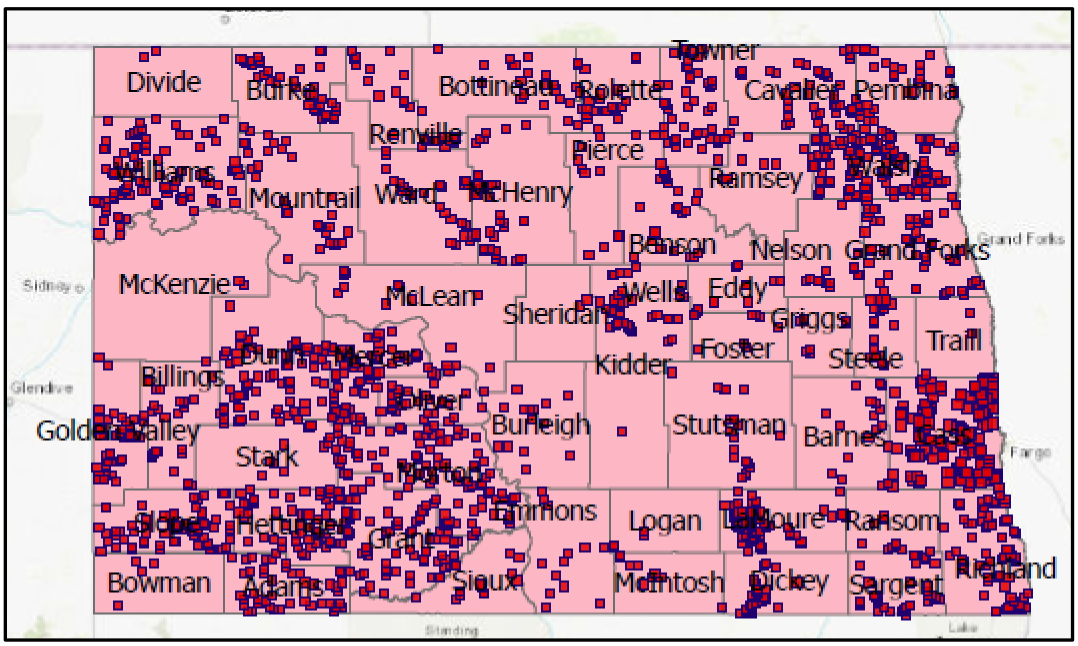

Figure 28. Locations of Minor Structures on County and Township Systems

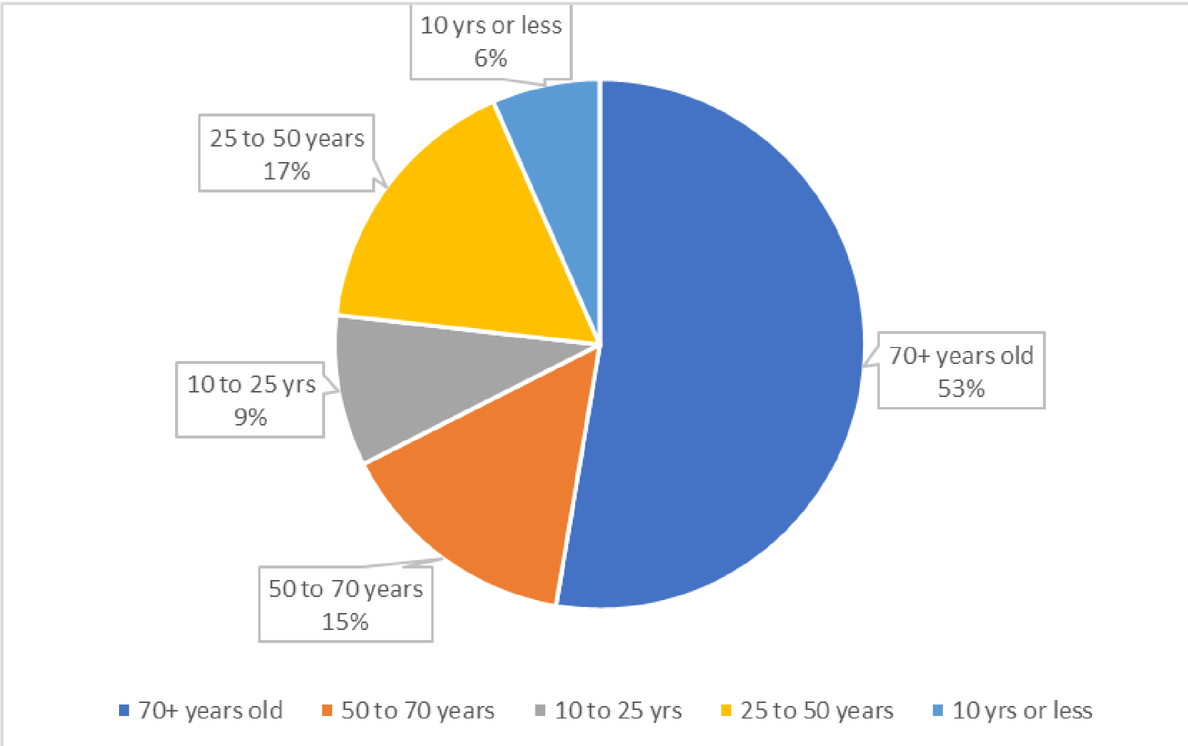

Figure 29. Age of Minor Structures in Service

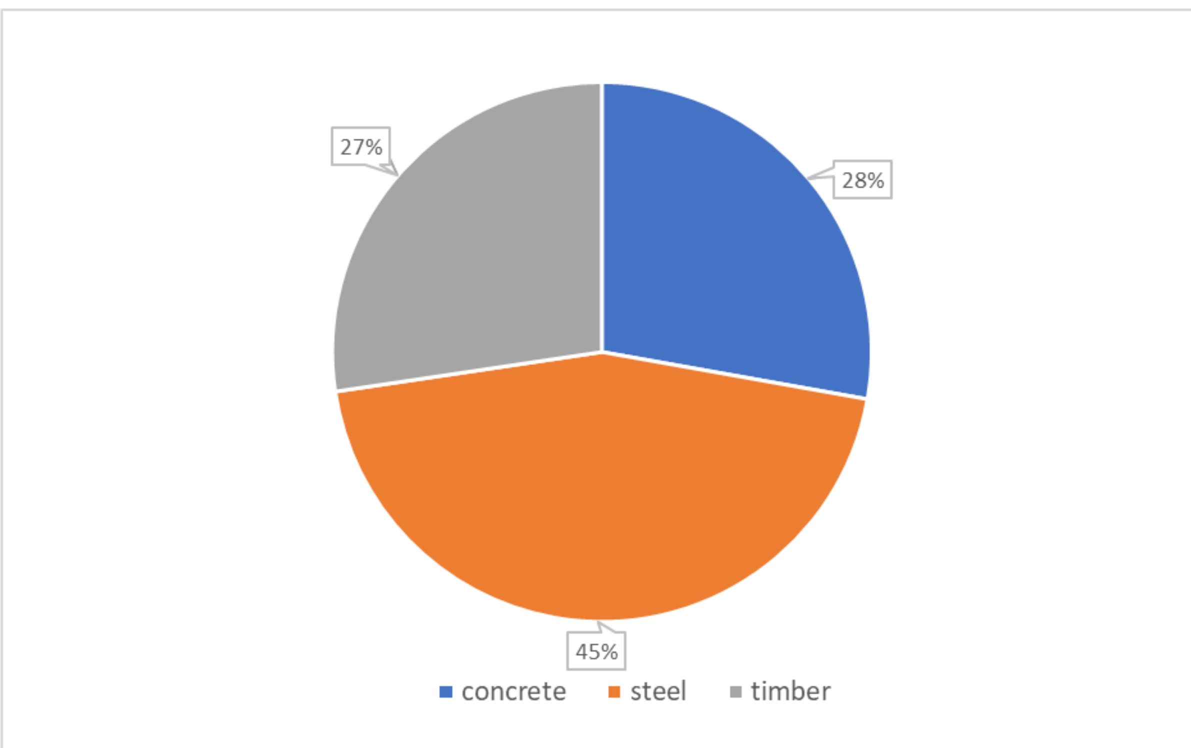

Figure 30. Percentage of Minor Structures by Material Type

7.2.2. Methodology – Minor Structures

The data file was exported from GRIT after counties had been given a period of time (July 2023 to Marcy 2024) to review the structures in their counties. This file included minor structures that ranged from 8 to 20 feet in span length as directed by the UGPTI ND County Bridge Steering group consisting of members from various counties around the state. The structures were then sorted into 3 groups of span lengths. These groups were structures with spans of 8 to 11 feet, 11.1 to 15 feet, and 15.1 to 20 feet. They were also sorted into three groups of materials including timber, steel and concrete. Structures that were rated in very poor, poor, and fair condition were designated as replacement needs. Structures that did not have a condition rating were evaluated based on age. The age of 40 years for timber, 50 years for steel and 70 years for concrete were used as the qualifier for replacement. For structures in good or excellent condition or that did not meet the age requirements were designated as maintenance needs. Table 25 shows the number of structures needing replacement or maintenance for each county. The decision flow chart for the analysis is shown in Appendix J. There is no deterioration model used in the analysis for minor structures. The output shows a current needs total vs a 20-year total. This total could be spread out over a 20-year delivery period for budgetary reasons.

7.2.3. Cost model

The cost model was created using the ND DOT Price Sheet List as the basis for construction items most commonly used for replacement of minor structures. Culverts with a minimum waterway opening of 50 square feet or greater were selected as recommended by the steering committee. Average prices for the construction items were adjusted to be more in line with typical county projects based on input from steering committee members and ND LTAP staff. For group A, with span ranges of 8 to 11 feet, a cost of $304,000 was used. For group B, with a span range of 11.1 to 15 feet, a cost of $455,000 was used and for group C, with a span range of 15.1 to 20 feet, a cost of $600,000 was used. These costs are also shown in the decision flow chart located in Appendix J.

For minor structures in the output data file which were in good to excellent condition it was decided to include a maintenance needs cost. This cost was assigned as an annual cost of $1000 for up to 2 years as this will be the period before the next needs study planned for 2026. At that time, some of the structures in good condition have deteriorated to the point where they will be rated in fair to poor condition which would then qualify them for replacement.

7.2.4. Results – Minor Structures

The total estimated replacement investment need for minor structures is $805.163 million. This amount is 72% of the amount needed for the major structures in this report. There are 1,734 minor structures that qualify for replacement beginning in 2024. There are 361 qualified minor structures that require maintenance at a cost of $361,000 per year or $722,000 for the 2 years until the 2024 study report is generated. See Table 25 for each county's minor structures investment needs. Counties not listed did not have any qualifying minor structures in the output data to be analyzed.

Table 25. County and Township Minor Structures Needs ($2024)

County	Replacement Bridges	Replacement Cost	Preventive Maintenance Cost	Total Cost
Adams	46	$19,384,000	$0	$19,384,000

County	Replacement Bridges	Replacement Cost	Preventive Maintenance Cost	Total Cost
Barnes	26	$10,743,000	$240,000	$10,983,000
Benson	24	$12,213,000	$0	$12,213,000
Billings	0	$0	$500,000	$500,000
Bottineau	22	$12,034,000	$260,000	$12,294,000
Bowman	2	$1,200,000	$0	$1,200,000
Burke	26	$11,039,000	$0	$11,039,000
Burleigh	7	$2,575,000	$0	$2,575,000
Cass	53	$24,907,000	$1,060,000	$25,967,000
Cavalier	107	$45,213,000	$560,000	$45,773,000
Dickey	34	$14,534,000	$0	$14,534,000
Divide	2	$759,000	$100,000	$859,000
Dunn	70	$32,739,000	$0	$32,739,000
Eddy	12	$5,593,000	$0	$5,593,000
Emmons	14	$5,609,000	$100,000	$5,709,000
Foster	7	$2,732,000	$0	$2,732,000
Golden	38	$16,922,000	$0	$16,922,000
Grand Forks	43	$20,659,000	$100,000	$20,759,000
Grant	81	$41,417,000	$60,000	$41,477,000
Griggs	4	$2,110,000	$0	$2,110,000
Hettinger	52	$26,240,000	$0	$26,240,000
Kidder	1	$455,000	$0	$455,000
LaMoure	67	$32,280,000	$0	$32,280,000
Logan	4	$1,669,000	$0	$1,669,000
McHenry	36	$19,709,000	$0	$19,709,000
McIntosh	8	$3,773,000	$0	$3,773,000
McKenzie	3	$1,504,000	$40,000	$1,544,000
McLean	14	$6,787,000	$0	$6,787,000
Mercer	70	$31,700,000	$0	$31,700,000
Morton	69	$29,330,000	$0	$29,330,000
Mountrail	24	$10,129,000	$0	$10,129,000
Nelson	14	$5,899,000	$0	$5,899,000
Oliver	26	$9,559,000	$0	$9,559,000
Pembina	101	$46,971,000	$1,580,000	$48,551,000
Pierce	11	$4,099,000	$0	$4,099,000
Ramsey	3	$1,655,000	$760,000	$2,415,000
Ransom	10	$4,683,000	$0	$4,683,000
Renville	23	$12,187,000	$0	$12,187,000
Richland	57	$26,256,000	$20,000	$26,276,000
Rolette	25	$11,780,000	$0	$11,780,000
Sargent	36	$18,259,000	$0	$18,259,000
Sheridan	2	$759,000	$0	$759,000
Sioux	12	$6,022,000	$0	$6,022,000

County	Replacement Bridges	Replacement Cost	Preventive Maintenance Cost	Total Cost
Slope	62	$29,588,000	$0	$29,588,000
Stark	16	$7,685,000	$280,000	$7,965,000
Steele	22	$10,717,000	$100,000	$10,817,000
Stutsman	17	$7,566,000	$0	$7,566,000
Towner	41	$19,193,000	$20,000	$19,213,000
Traill	3	$1,359,000	$840,000	$2,199,000
Walsh	137	$67,278,000	$580,000	$67,858,000
Ward	30	$15,221,000	$0	$15,221,000
Wells	35	$17,061,000	$0	$17,061,000
Williams	85	$35,408,000	$20,000	$35,428,000
Statewide	1,734	$805,163,000	$7,220,000	$812,383,000

8. Summary and Conclusions

This report outlines the study to estimate the needs for maintaining and improving North Dakota's network of county, township and tribal roads and bridges during the next 20 years. The needs estimates presented in this report have been developed at a network planning level. Project-specific costs may vary either above or below the estimated cost of a specific road segment for a number of reasons. Factors such as wetlands mitigation, geometric corrections, and high right-of-way acquisition costs, among others may influence the actual project-specific costs. In addition, because this is a network planning study, project-specific enhancements such as turning lanes and climbing lanes were not modeled. These enhancements are typically included in a project as a result of a project-specific analysis. The combined needs estimates by biennium are presented in Table 26.

Table 26. Combined Statewide Road and Bridge Needs, 2024-2043

Period	Unpaved	Paved	Bridges	Minor Structures	Total
2024-2025	$707.88	$433.82	$178.94	$151.06	$1,471.70
2026-2027	$694.93	$523.64	$178.94	$151.06	$1,578.57
2028-2029	$714.99	$436.78	$178.94	$151.06	$1,481.77
2030-2031	$716.56	$388.93	$178.94	$151.06	$1,435.49
2032-2033	$693.38	$368.57	$178.94	$151.06	$1,391.95
2034-2043	$3,443.71	$1,344.44	$192.45	$49.72	$5,030.32
2024-2043	**$6,971.45**	**$3,496.17**	**$1,087.16**	**$805.00**	**$12,359.78**

All estimates presented in this report are based upon the best available data at the time of the writing of the report, and assumptions used to arrive at these estimates are based upon the most recent forecasts of traffic within North Dakota. Any significant changes in costs, forecasts, practices or highway technology may require re-estimation of the needs for county, township, and tribal roads.

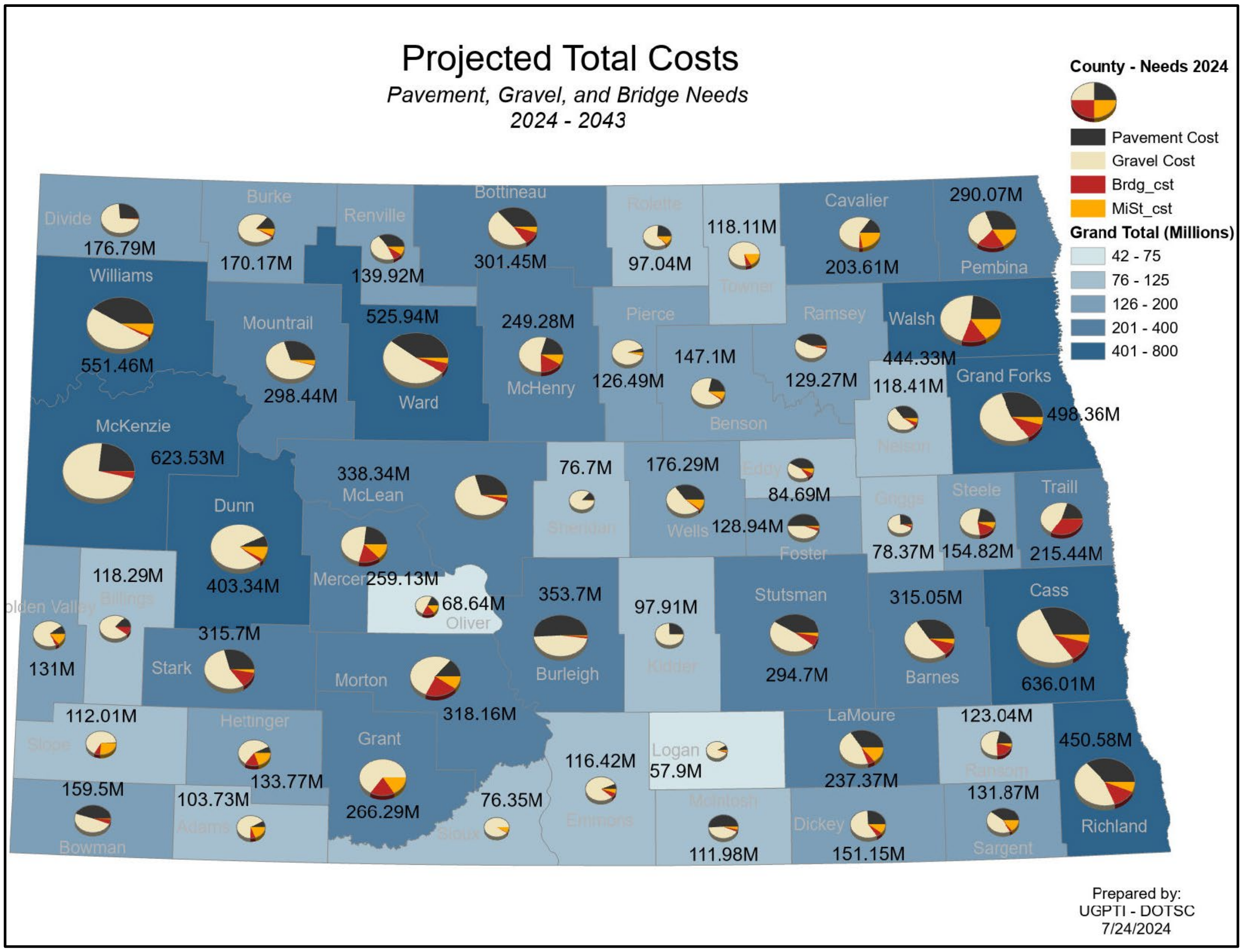

Figure 31. Projected Total Costs for Pavement, Gravel and Bridges, 2024-2043

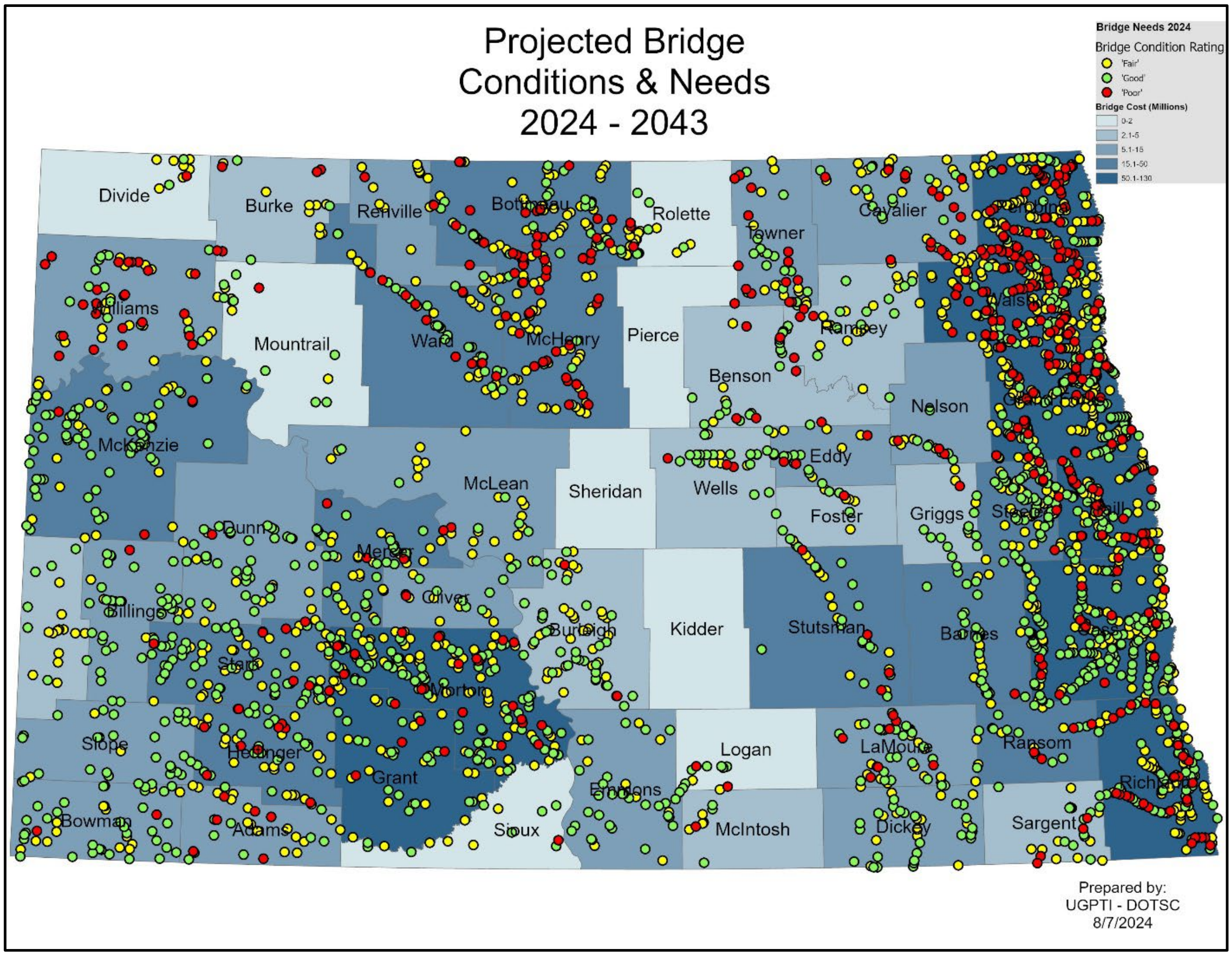

Figure 32. Projected Bridge Needs and Current Conditions, 2024-2043

Appendix A: Cost and Practices Surveys

NDSU UPPER GREAT PLAINS TRANSPORTATION INSTITUTE

2023 COUNTY ROAD NEEDS STUDY

County: ____

Contact: ____________________ ______________ ________________
Name Phone Email

Preparer: ____________________ Date Prepared: ____________________

Aggregate Description

To determine the type and quality of aggregate used in your county, please check all boxes that apply. For example, if your county uses crushed, specification base gravel – select gravel, crushed material and specifications.

- Gravel ❏
- Scoria ❏
- Pit Run ❏
- Screened ❏
- Crushed Material ❏
- Specifications ❏
  - Fractured Faces ❏
  - PI ❏
  - Other ______________ ❏
- Tested ❏
- Other________________ ❏

Placement Practices

When aggregate overlays are placed in your county, please select the all practices that are used to apply an aggregate overlay.

- Truck Drop and Blade ❏
- Windrow/Equalize ❏
- Water/Rolling/Compaction ❏
- Reshaping ❏
- Pulling in Shoulders ❏
- Soft Spot Repair ❏
- Other________________ ❏

Operational Tasks

In this section, please provide a percentage of tasks that are done using county resources versus the percentage of work done by a contractor. For example, if your county owns the pit and does all of the crushing using county labor, 100% would be entered into the first column, and 0% in the second column.

	Performed by:	
Task	**County**	**Contractor**
Crushing		
Hauling		
Placement		
Blading		
Dust Control		
Base Stabilization		

Gravel Road Costs

Please report costs for gravel for county roads in the table below. The table asks for unit costs for graveling, maintaining, and operating gravel roads. If you are quoting contractor prices, please circle "yes" in the right-hand column.

Gravel/Scoria Cost			
Average Gravel/Scoria Cost (crushing & royalties at the pit)		❑ Per cu. yard ❑ Per Ton	Is this Contractor Price? (yes/no)
Average Trucking Cost from Gravel Origin		❑ Per loaded mile ❑ Per cu. yard ❑ Per Ton	Is this Contractor Price? (yes/no)
Average trucking distance for aggregate		❑ Miles one-way ❑ Miles roundtrip	
Truck Payload		❑ Cu. Yards ❑ Tons	
Placement Costs		Per Mile	Is this Contractor Price? (yes/no)
Blading Cost		Annual cost per mile	Is this Contractor Price? (yes/no)
Dust Suppressant Costs		Per mile	Is this Contractor Price? (yes/no)
Base Stabilization Cost		Per mile	Is this Contractor Price? (yes/no)

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Gravel Road Practices

This section asks for information regarding gravel road practices based upon differing traffic levels. Under the "Daily Traffic" row, please enter what you would consider low, medium and high traffic levels on gravel roads within your county. In the example below, low is categorized as less than 50 vehicles, medium 50-150 vehicles and high 150-350. This is expected to vary significantly from county to county, so please use your own estimates of traffic levels. Following the traffic entry, please enter the regraveling thickness, blading frequency, regraveling frequency, and whether dust suppressant or base stabilization are used at each of these traffic categories.

EXAMPLE/ENTER ACTUAL BELOW	Traffic Levels		
	Low	Medium	High
Daily Traffic (Total AADT)	>50	50-150	150-350
Average Regraveling Thickness (specify)	1 1/2"	3"	6"
Blading Frequency (# per year)	8	12	16
Regraveling Frequency (years between regraveling)	7	5	3
Dust Suppressant (yes/no)	no	no	Yes
Base Stabilization (yes/no)	no	no	Yes

County Entry	Traffic Levels		
	Low	Medium	High
Daily Traffic (Total AADT)			
Average Regraveling Thickness (specify)			
Blading Frequency (# per year)			
Regraveling Frequency (years between regraveling)			
Dust Suppressant (yes/no)			
Base Stabilization (yes/no)			

If you answered yes for Dust Suppressant – which type do you use?

____

If you answered yes for Base Stabilization – which type do you use?

____

Are you using Recycled Asphalt Products?

____

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Gravel Road Condition

This section asks for information regarding gravel road conditions and is broken into two separate categories: Federal Aid, and Non-Federal Aid. Please provide a rough estimate of the percentage of unpaved roads by condition for these two categories.

Condition	% Federal Aid Roads (CMC)	% Non-Federal Aid Roads (non-CMC)
Very Good		
Good		
Fair		
Poor		
Total	100%	100%

Gravel Materials Specifications

If available, please attach a sample specification and sample gradation, or state materials specification number. If materials used on CMC routes differ from non-CMC routes, please provide sample specifications and gradation by system type, if available.

Comments or Suggestions (please attach additional sheets if needed):

Please return this survey in the enclosed envelope or email a copy to alan.dybing@ndsu.edu by November 20, 2023. Please direct any questions to Alan Dybing at 701.231.5988 or the email address above.

NDSU UPPER GREAT PLAINS TRANSPORTATION INSTITUTE

2023 TOWNSHIP ROAD NEEDS STUDY SURVEY

Please return this survey in the enclosed envelope by November 20, 2023. Please direct any questions to Alan Dybing at 701.231.5988 or alan.dybing@ndsu.edu.

Township:________________________________County:________________________________

Contact: ______________________ ______________________ ______________________

Name Phone Email

Preparer:________________________________Date Prepared: ______________________

Gravel Costs

Please report costs for gravel for township roads in either of the tables below. If information on cost breakouts is available, please use Table 1. If breakouts are not known, enter the information in the Table 2.

1. Cost Breakouts (If known)		
Average Gravel/Scoria Cost (crushing & royalties)		❑Per cu. yard ❑Per Ton
Average Transportation Cost from Gravel Origin		❑Per loaded mile ❑Per cu. yard
Average Placement Costs		Per mile
Blading Cost		Annual cost per mile
Dust Suppressant Costs (If applicable)		Per mile

2. Total Cost (if cost breakouts are not known)		
Total Cost	$	❑ Per cu. yard ❑ Per Ton ❑ Annual cost per mile
Number of Miles Maintained		

Average Gravel/Scoria OverlayThickness ______________________ ❑Cu. Yard/mile

❑Inches

❑Tons/mile

Survey Continued on the Reverse of this Page

Road Maintenance Practices

Who performs road maintenance in your township?

- ❑ County Maintained
- ❑ Township Contracted
- ❑ Township Staff

Please report blading and graveling frequency for gravel roads.

Blading Frequency

- ❑Every other month
- ❑1 per month
- ❑2 per month
- ❑1 per week
- ❑other (please explain) ____________________

Graveling Frequency

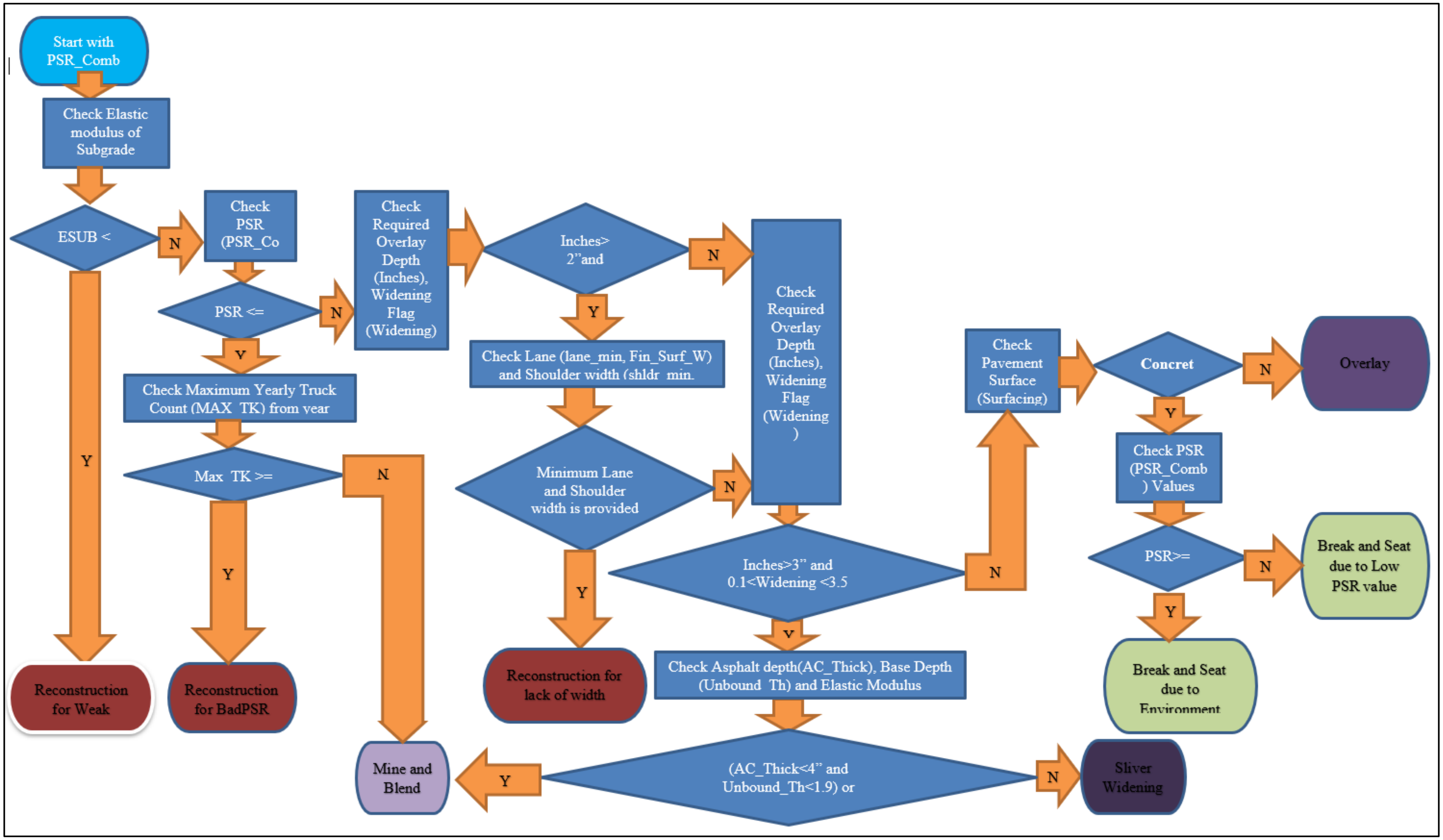
- ❑Every year
- ❑Every 2-3 years
- ❑Every 3-4 years
- ❑5 or more years
- ❑other (please explain) ____________________

Aside from routine maintenance and improvements, what other challenges are facing roadway maintenance in your township? (flooding, high traffic generators etc.).

Does your township have an emergency road fund account? ___ Yes ___ No

Comments or Suggestions:

Appendix B: Flowchart for Road Improvement



Appendix C: Paved Road Conditions by County, Surveyed in 2023

County	Condition	Miles	Percent
Adams	Fair	5.9	55%
	Poor	4.7	45%
Barnes	Fair	149.2	67%
	Poor	71.9	33%
Benson	Good	0.5	1%
	Fair	36.5	58%
	Poor	25.4	41%
Billings	Good	13.4	52%
	Fair	8.3	32%
	Poor	4.2	16%
Bottineau	Good	84.0	41%
	Fair	109.7	53%
	Poor	13.5	7%
Bowman	Good	23.8	17%
	Fair	87.3	63%
	Poor	27.4	20%
Burke	Good	37.3	78%
	Fair	9.9	21%
	Poor	0.6	1%
Burleigh	Good	90.1	32%
	Fair	76.3	27%
	Poor	113.3	41%
Cass	Good	110.5	32%
	Fair	222.4	64%
	Poor	13.6	4%
Cavalier	Good	0.9	1%
	Fair	54.5	84%
	Poor	9.1	14%
Dickey	Good	4.3	6%
	Fair	47.8	62%
	Poor	25.2	33%
Divide	Good	50.4	63%
	Fair	30.2	37%

County	Condition	Miles	Percent
Dunn	Good	12.1	22%
	Fair	43.5	78%
Eddy	Fair	41.6	68%
	Poor	19.2	32%
Emmons	Good	1.5	12%
	Fair	11.3	88%
Fort Berthold	Good	34.1	43%
	Fair	18.1	23%
	Poor	27.5	35%
Foster	Good	12.2	14%
	Fair	58.2	64%
	Poor	20.3	22%
Golden Valley	Fair	7.0	30%
	Poor	16.1	70%
Grand Forks	Good	32.5	12%
	Fair	184.1	66%
	Poor	64.1	23%
Griggs	Fair	33.1	87%
	Poor	5.0	13%
Hettinger	Good	0.7	4%
	Poor	16.1	96%
Kidder	Good	13.8	28%
	Fair	26.6	54%
	Poor	9.1	18%
LaMoure	Good	8.3	6%
	Fair	74.9	51%
	Poor	63.6	43%
Logan	Fair	1.7	21%
	Poor	6.7	79%
McHenry	Fair	61.7	68%
	Poor	29.4	32%
McIntosh	Good	4.1	5%
	Fair	44.8	53%
	Poor	36.1	42%

County	Condition	Miles	Percent
McKenzie	Good	106.4	43%
	Fair	123.7	50%
	Poor	16.7	7%
McLean	Good	40.3	28%
	Fair	49.8	34%
	Poor	56.1	38%
Mercer	Good	4.5	4%
	Fair	94.2	93%
	Poor	3.0	3%
Morton	Good	0.4	1%
	Fair	75.8	92%
	Poor	6.4	8%
Mountrail	Good	119.3	69%
	Fair	46.1	27%
	Poor	8.4	5%
Nelson	Good	16.5	20%
	Fair	40.5	49%
	Poor	25.2	31%
Oliver	Fair	5.6	23%
	Poor	18.4	77%
Pembina	Good	34.0	20%
	Fair	123.6	72%
	Poor	14.0	8%
Pierce	Good	5.2	43%
	Fair	6.9	57%
Ramsey	Good	65.6	56%
	Fair	52.0	44%
	Poor	0.1	0%
Ransom	Good	9.4	17%
	Fair	37.1	66%
	Poor	9.9	18%
Renville	Good	18.0	23%
	Fair	58.4	76%
	Poor	0.3	0%

County	Condition	Miles	Percent
Richland	Good	58.7	24%
	Fair	150.6	63%
	Poor	31.3	13%
Rolette	Good	21.9	48%
	Fair	23.4	52%
Sargent	Good	13.8	16%
	Fair	50.3	58%
	Poor	23.2	27%
Sheridan	Good	0.1	0%
	Fair	20.3	97%
	Poor	0.6	3%
Slope	Good	1.3	100%
Spirit Lake	Good	2.2	5%
	Fair	23.8	55%
	Poor	17.2	40%
Standing Rock	Fair	2.0	6%
	Poor	29.7	94%
Stark	Good	46.0	34%
	Fair	73.9	55%
	Poor	14.3	11%
Steele	Good	12.4	17%
	Fair	43.8	60%
	Poor	16.7	23%
Stutsman	Good	6.1	3%
	Fair	173.5	73%
	Poor	57.0	24%
Traill	Good	10.7	7%
	Fair	89.9	59%
	Poor	52.7	34%
Turtle Mountain	Fair	24.9	35%
	Poor	46.3	65%
Walsh	Good	10.6	6%
	Fair	130.6	76%
	Poor	31.7	18%

County	Condition	Miles	Percent
Ward	Good	113.3	35%
	Fair	188.8	58%
	Poor	22.0	7%
Wells	Good	4.0	4%
	Fair	49.1	47%
	Poor	50.8	49%
Williams	Good	104.9	34%
	Fair	133.9	44%
	Poor	68.3	22%

Appendix D: Detailed Results by County and Funding Period

Table D.1. County and Township Unpaved Road Investment Needs by County and Period (Million 2024 Dollars)

County	2024-25	2026-27	2028-29	2030-31	2032-33	2034-43	2024-43
Adams	$6.94	$6.96	$6.96	$6.96	$6.97	$35.07	$ 69.87
Barnes	$16.64	$16.64	$16.64	$16.64	$16.64	$83.24	$166.45
Benson	$10.12	$10.12	$10.12	$10.12	$10.12	$50.58	$101.18
Billings	$9.56	$8.82	$10.58	$9.91	$8.74	$43.49	$91.09
Bottineau	$14.52	$14.47	$14.47	$14.54	$14.54	$72.68	$145.24
Bowman	$7.82	$7.88	$7.90	$7.86	$7.81	$39.06	$78.33
Burke	$13.45	$13.32	$13.30	$13.31	$13.35	$66.54	$133.26
Burleigh	$16.74	$16.74	$16.74	$16.74	$16.74	$83.24	$166.91
Cass	$33.76	$33.83	$34.02	$34.10	$34.33	$170.75	$340.79
Cavalier	$12.12	$12.12	$12.16	$12.17	$12.17	$60.74	$121.50
Dickey	$8.93	$8.93	$8.93	$8.93	$8.93	$44.66	$89.32
Divide	$12.91	$12.82	$12.88	$12.90	$12.85	$64.21	$128.57
Dunn	$37.13	$33.84	$40.03	$42.15	$30.01	$151.34	$334.50
Eddy	$3.70	$3.70	$3.70	$3.70	$3.70	$18.51	$37.03
Emmons	$9.74	$9.74	$9.74	$9.74	$9.74	$48.70	$97.41
Foster	$5.74	$5.74	$5.75	$5.75	$5.75	$28.72	$57.45
Golden Valley	$9.68	$10.14	$9.80	$9.75	$9.61	$48.02	$97.01
Grand Forks	$27.08	$27.17	$27.17	$27.17	$27.20	$135.78	$271.57
Grant	$17.27	$17.27	$17.27	$17.27	$17.27	$86.35	$172.70
Griggs	$5.35	$5.35	$5.35	$5.35	$5.38	$26.83	$53.59
Hettinger	$7.70	$7.70	$7.70	$7.70	$7.71	$38.52	$77.04
Kidder	$7.22	$7.22	$7.22	$7.22	$7.22	$36.48	$72.59
LaMoure	$10.94	$10.94	$10.94	$10.94	$10.94	$54.72	$109.43
Logan	$5.08	$5.08	$5.08	$5.08	$5.08	$25.42	$50.84
McHenry	$13.69	$13.70	$13.70	$13.70	$13.73	$68.53	$137.06
McIntosh	$4.84	$4.84	$4.84	$4.84	$4.84	$24.20	$48.40
McKenzie	$50.70	$44.50	$51.31	$51.38	$46.24	$211.94	$456.08
McLean	$22.08	$22.08	$22.08	$22.10	$22.11	$110.61	$221.05
Mercer	$12.31	$12.31	$12.31	$12.25	$12.25	$61.25	$122.68
Morton	$17.25	$17.25	$17.25	$17.25	$17.25	$86.24	$172.47
Mountrail	$20.70	$18.81	$21.69	$21.77	$19.19	$94.51	$196.67
Nelson	$6.53	$6.53	$6.53	$6.55	$6.55	$32.70	$65.39
Oliver	$3.41	$3.38	$3.38	$3.38	$3.38	$16.60	$33.54
Pembina	$9.31	$9.32	$9.32	$9.32	$9.32	$46.63	$93.24
Pierce	$11.63	$11.63	$11.63	$11.63	$11.63	$58.15	$116.30
Ramsey	$6.87	$6.88	$6.88	$6.88	$6.88	$34.38	$68.77
Ransom	$6.67	$6.69	$6.69	$6.69	$6.69	$33.39	$66.81
Renville	$6.60	$6.60	$6.60	$6.60	$6.60	$33.01	$66.03
Richland	$20.16	$20.16	$20.16	$20.17	$20.18	$100.87	$201.69
Rolette	$6.10	$6.10	$6.10	$6.10	$6.10	$30.51	$61.03

County	2024-25	2026-27	2028-29	2030-31	2032-33	2034-43	2024-43
Sargent	$5.76	$5.76	$5.76	$5.76	$5.76	$28.81	$57.62
Sheridan	$6.58	$6.58	$6.58	$6.58	$6.58	$32.92	$65.84
Sioux	$6.98	$6.98	$6.98	$6.98	$6.98	$34.91	$69.79
Slope	$7.42	$7.42	$7.42	$7.32	$7.32	$36.61	$73.51
Stark	$17.76	$17.73	$17.89	$17.69	$17.65	$88.69	$177.42
Steele	$8.59	$8.59	$8.60	$8.60	$8.60	$42.97	$85.94
Stutsman	$14.21	$14.21	$14.22	$14.23	$14.25	$71.15	$142.28
Towner	$9.12	$9.12	$9.12	$9.12	$9.12	$45.62	$91.24
Traill	$16.96	$16.99	$17.08	$17.11	$17.13	$85.24	$170.50
Walsh	$20.39	$20.39	$20.53	$20.54	$20.54	$102.42	$204.80
Ward	$26.77	$27.07	$27.25	$27.35	$27.20	$134.38	$270.02
Wells	$9.38	$9.38	$9.38	$9.38	$9.38	$46.90	$93.81
Williams	$28.93	$27.36	$29.20	$29.25	$27.10	$135.92	$277.76
Total	$707.88	$694.93	$714.99	$716.56	$693.38	$3,443.71	$6,971.45

Table D.2. County and Township Paved Road Investment Needs by County and Improvement Type and Period (Million 2024 Dollars)

County	Miles Resurfaced	Miles Widened	Miles Reconstructed	Miles Mine & Blend	Miles Break & Seat	Total Miles Improved	Total Cost (Millions$)	Annual Cost per Mile
Adams	9	0	1.6	0	0	10.6	$7.60	$35,953.71
Barnes	221.1	0	0	0	0	221.1	$109.29	$24,712.22
Benson	61.7	0	0	0.7	0	62.4	$31.56	$25,289.55
Billings	23.5	0	2.3	0	0	25.8	$15.66	$30,300.16
Bottineau	207.2	0	0	0	0	207.2	$111.55	$26,915.09
Bowman	138.5	0	0	0	0	138.5	$72.31	$26,102.14
Burke	47.7	0	0	0	0	47.7	$22.66	$23,766.95
Burleigh	244.2	25.4	9.1	1	0	279.7	$179.76	$32,135.09
Cass	300	14.4	6.1	0	25.9	346.4	$203.22	$29,331.06
Cavalier	64.5	0	0	0	0	64.5	$30.32	$23,494.52
Dickey	77.3	0	0	0	0	77.3	$38.96	$25,192.11
Divide	76.2	0	4.3	0	0	80.6	$46.39	$28,785.85
Dunn	55.6	0	0	0	0	55.6	$27.48	$24,695.14
Eddy	57.5	0	0	3.3	0	60.8	$35.67	$29,334.50
Emmons	12.8	0	0	0	0	12.8	$6.59	$25,786.89
Fort Berthold	65.8	0	12.2	1.7	0	79.7	$79.97	$50,184.79
Foster	86.7	0	4	0	0	90.6	$64.38	$35,517.25
Golden Valley	21.2	0	0	1.9	0	23.1	$12.21	$26,444.99
Grand Forks	264.6	0	6.6	9.5	0	280.7	$155.14	$27,634.29

County	Miles Resurfaced	Miles Widened	Miles Reconstructed	Miles Mine & Blend	Miles Break & Seat	Total Miles Improved	Total Cost (Millions$)	Annual Cost per Mile
Griggs	38.1	0	0	0	0	38.1	$20.09	$26,382.69
Hettinger	16.9	0	0	0	0	16.9	$9.22	$27,337.41
Kidder	46.6	0	0	2.9	0	49.5	$24.85	$25,099.98
LaMoure	141.6	0	5.2	0	0	146.8	$82.25	$28,020.44
Logan	8.4	0	0	0	0	8.4	$4.31	$25,715.98
McHenry	85.2	5.9	0	0	0	91.1	$50.69	$27,825.62
McIntosh	82.9	0	0	2	0	84.9	$56.94	$33,518.65
McKenzie	239.3	0	7.5	0	0	246.8	$145.00	$29,378.73
McLean	131.7	0	14.2	0.3	0	146.2	$100.24	$34,288.30
Mercer	101.6	0	0	0	0	101.6	$60.28	$29,664.41
Morton	81.7	0.8	0	0	0	82.6	$41.90	$25,380.02
Mountrail	173.7	0	0	0	0	173.7	$90.13	$25,946.48
Nelson	76.9	0	0	5.2	0	82.1	$41.72	$25,403.03
Oliver	24	0	0	0	0	24	$12.50	$26,041.98
Pembina	171.6	0	0	0	0	171.6	$89.87	$26,191.62
Pierce	12.1	0	0	0	0	12.1	$5.55	$22,926.83
Ramsey	115.4	2.3	0	0	0	117.7	$55.55	$23,598.35
Ransom	56.4	0	0	0	0	56.4	$26.44	$23,454.99
Renville	67.1	3.5	6.1	0	0	76.7	$48.88	$31,881.77
Richland	194.7	32.2	13.6	0	0	240.5	$166.07	$34,519.34
Rolette	45.3	0	0	0	0	45.3	$23.16	$25,569.99
Sargent	81.4	0	6	0	0	87.4	$52.78	$30,200.08
Sheridan	20.9	0	0	0	0	20.9	$10.10	$24,169.38
Slope	1.3	0	0	0	0	1.3	$0.62	$22,926.83
Spirit Lake	42	0	0	1.2	0	43.1	$23.99	$27,819.34
Standing Rock	31.7	0	0	0	0	31.7	$20.64	$32,526.78
Stark	100.3	23.6	5.5	4.9	0	134.2	$92.73	$34,543.04
Steele	72.3	0	0	0.6	0	72.9	$33.89	$23,250.53
Stutsman	233	0	0	1.1	2.5	236.6	$123.00	$25,995.67
Traill	148.3	5	0	0	0	153.3	$74.20	$24,193.90
Turtle Mountain	19.8	0	0	9.2	42.1	71.2	$50.26	$35,313.29
Walsh	167.9	0	5	0	0	172.9	$104.04	$30,086.54
Ward	280.4	23.8	17.9	1.2	0.9	324.2	$211.33	$32,594.08
Wells	96.8	0	6	1	0	103.8	$62.62	$30,149.57
Williams	256.2	0	38.8	6	6.1	307.1	$229.60	$37,380.47

Table D.3. County and Township Paved Road Investment Needs by County and Period (Million 2024 Dollars)

County	2024-25	2026-27	2028-29	2030-31	2032-33	2034-43	2024-43
Adams	$1.16	$0.26	$0.26	$0.26	$0.26	$5.38	$7.60
Barnes	$12.80	$16.13	$8.74	$10.60	$11.71	$49.31	$109.29
Benson	$3.05	$6.46	$1.56	$2.91	$8.46	$9.12	$31.56
Billings	$1.43	$0.83	$4.72	$0.65	$1.05	$6.98	$15.66
Bottineau	$8.23	$7.53	$36.50	$12.32	$6.91	$40.07	$111.55
Bowman	$2.69	$3.46	$4.70	$9.84	$20.26	$31.35	$72.31
Burke	$0.71	$3.72	$1.19	$1.65	$1.19	$14.19	$22.66
Burleigh	$37.95	$41.76	$14.84	$11.83	$12.13	$61.25	$179.76
Cass	$14.48	$28.71	$29.04	$25.22	$23.75	$82.02	$203.22
Cavalier	$0.81	$5.25	$6.50	$2.94	$4.78	$10.04	$30.32
Dickey	$11.83	$1.93	$5.00	$4.36	$5.01	$10.83	$38.96
Divide	$1.01	$3.70	$2.76	$12.95	$2.68	$23.29	$46.39
Dunn	$0.70	$1.39	$2.66	$1.47	$3.79	$17.48	$27.48
Eddy	$12.46	$3.15	$6.04	$3.30	$3.13	$7.59	$35.67
Emmons	$0.16	$1.84	$1.64	$0.32	$0.32	$2.31	$6.59
Fort	$30.99	$3.09	$18.86	$5.52	$3.09	$18.42	$79.97
Foster	$21.44	$17.26	$4.35	$2.26	$4.91	$14.16	$64.38
Golden	$0.29	$1.10	$0.58	$4.80	$0.58	$4.86	$12.21
Grand Forks	$26.86	$13.51	$13.19	$15.97	$12.21	$73.39	$155.14
Griggs	$0.97	$3.66	$4.48	$4.36	$1.87	$4.76	$20.09
Hettinger	$0.46	$0.42	$0.42	$5.23	$0.42	$2.27	$9.22
Kidder	$4.00	$1.52	$4.01	$2.43	$1.86	$11.03	$24.85
LaMoure	$10.83	$22.08	$6.10	$6.14	$4.91	$32.20	$82.25
Logan	$0.10	$2.53	$0.21	$0.21	$0.21	$1.05	$4.31
McHenry	$14.84	$7.91	$3.53	$4.13	$7.39	$12.89	$50.69
McIntosh	$17.12	$14.12	$7.53	$2.12	$5.45	$10.61	$56.94
McKenzie	$5.93	$15.41	$27.07	$17.10	$13.16	$66.34	$145.00
McLean	$12.34	$18.20	$24.07	$9.15	$4.96	$31.53	$100.24
Mercer	$2.42	$14.49	$5.22	$6.36	$2.54	$29.26	$60.28
Morton	$3.00	$7.01	$3.13	$2.09	$13.36	$13.30	$41.90
Mountrail	$2.37	$5.19	$4.74	$8.06	$7.93	$61.84	$90.13
Nelson	$5.73	$6.89	$4.50	$2.05	$2.24	$20.31	$41.72
Oliver	$3.65	$0.60	$3.27	$1.39	$0.60	$3.00	$12.50
Pembina	$5.25	$14.73	$12.94	$11.39	$8.40	$37.16	$89.87
Pierce	$0.15	$0.30	$0.30	$0.54	$0.30	$3.95	$5.55
Ramsey	$1.47	$4.65	$8.01	$5.89	$3.52	$32.01	$55.55
Ransom	$1.64	$2.43	$3.22	$3.86	$1.69	$13.61	$26.44
Renville	$1.03	$4.39	$7.36	$19.53	$2.79	$13.77	$48.88
Richland	$22.67	$21.79	$37.22	$8.22	$12.83	$63.34	$166.07

County	2024-25	2026-27	2028-29	2030-31	2032-33	2034-43	2024-43
Rolette	$0.57	$1.13	$7.93	$4.13	$1.13	$8.28	$23.16
Sargent	$2.44	$21.54	$6.33	$3.74	$4.66	$14.08	$52.78
Sheridan	$0.39	$1.61	$0.52	$0.52	$1.85	$5.21	$10.10
Slope	$0.02	$0.03	$0.03	$0.03	$0.03	$0.47	$0.62
Spirit Lake	$3.21	$4.28	$4.72	$1.83	$1.24	$8.71	$23.99
Standing	$11.13	$0.79	$2.72	$1.24	$0.79	$3.96	$20.64
Stark	$1.73	$17.62	$13.46	$18.82	$9.33	$31.78	$92.73
Steele	$0.91	$5.39	$2.33	$7.56	$4.67	$13.02	$33.89
Stutsman	$16.06	$28.39	$9.75	$6.12	$11.36	$51.31	$123.00
Traill	$10.22	$11.93	$6.98	$7.24	$8.63	$29.20	$74.20
Turtle	$15.23	$14.84	$6.52	$2.99	$1.78	$8.89	$50.26
Walsh	$14.54	$17.14	$7.56	$8.11	$9.64	$47.06	$104.04
Ward	$11.43	$44.62	$16.10	$18.13	$47.35	$73.70	$211.33
Wells	$30.27	$2.59	$3.94	$3.52	$7.54	$14.74	$62.62
Williams	$10.66	$22.32	$17.42	$55.52	$35.91	$87.77	$229.60

Table D.4. Estimated Improvement Needs for Unpaved Indian Reservation Roads (Thousand 2024 Dollars)

Tribal Area	2024-25	2026-27	2028-29	2030-31	2032-33	2034-43	2024-43
Fort Berthold	$7,769.31	$5,226.27	$7,547.76	$6,636.51	$5,206.84	$29,860.92	$62,247.61
Spirit Lake	$263.54	$263.54	$263.54	$263.54	$263.54	$1,317.69	$2,635.39
Standing Rock	$6,534.27	$6,534.27	$6,534.27	$6,534.27	$6,534.27	$32,671.36	$65,342.72
Turtle Mountain	$655.96	$655.96	$655.96	$655.96	$655.96	$3,279.79	$6,559.57

Table D.5. Estimated Improvement Needs for Paved Indian Reservation Roads (Million 2024 Dollars)

Tribal Area	2024-25	2026-27	2028-29	2030-31	2032-33	2034-43	2024-43
Fort Berthold	$30.99	$3.09	$18.86	$5.52	$3.09	$18.42	$79.97
Spirit Lake	$3.21	$4.28	$4.72	$1.83	$1.24	$8.71	$23.99
Standing Rock	$11.13	$0.79	$2.72	$1.24	$0.79	$3.96	$20.64
Turtle	$15.23	$14.84	$6.52	$2.99	$1.78	$8.89	$50.26

Table D.6. County and Township Major Bridge Needs by County: 2024-2043 (Million 2024 Dollars)

County	Replacement Bridges	Replacement Cost	Preventive Maintenance Cost	Total Cost
Adams	7	$6.89	$0.28	$7.17
Barnes	8	$28.57	$0.73	$29.30
Benson	4	$2.15	$0.08	$2.23
Billings	7	$11.54	$0.18	$11.72
Bottineau	33	$32.63	$0.37	$33.00
Bowman	12	$7.66	$0.15	$7.81
Burke	6	$3.21	$0.04	$3.25
Burleigh	8	$4.45	$0.44	$4.89
Cass	43	$67.08	$2.61	$69.70
Cavalier	8	$6.58	$0.11	$6.69
Dickey	3	$8.34	$0.52	$8.86
Divide	2	$1.07	$0.08	$1.15
Dunn	6	$8.62	$0.36	$8.97
Eddy	3	$6.39	$0.25	$6.64
Emmons	8	$6.81	$0.32	$7.13
Foster	3	$4.38	$0.11	$4.49
Golden Valley	4	$4.86	$0.11	$4.97
Grand Forks	69	$50.99	$1.51	$52.50
Grant	24	$52.17	$0.20	$52.37
Griggs	1	$2.57	$0.18	$2.75
Hettinger	27	$21.27	$0.27	$21.54
Kidder	0	$0.00	$0.00	$0.00
LaMoure	11	$13.41	$0.29	$13.70
Logan	3	$1.07	$0.08	$1.15
McHenry	40	$41.82	$0.25	$42.07
McIntosh	2	$2.86	$0.00	$2.86
McKenzie	15	$20.95	$0.49	$21.44
McLean	7	$10.27	$0.33	$10.60
Mercer	21	$44.47	$0.31	$44.77
Morton	67	$74.45	$0.91	$75.37
Mountrail	1	$1.51	$0.22	$1.73
Nelson	3	$5.40	$0.26	$5.66
Oliver	7	$13.03	$0.10	$13.13
Pembina	62	$59.99	$0.53	$60.51
Pierce	1	$0.54	$0.00	$0.54
Ramsey	3	$3.28	$0.18	$3.46
Ransom	7	$25.10	$0.32	$25.42
Renville	6	$12.82	$0.13	$12.95
Richland	49	$56.55	$1.36	$57.91
Rolette	2	$1.07	$0.05	$1.12
Sargent	6	$3.21	$0.02	$3.23
Sheridan	0	$0.00	$0.00	$0.00

County	Replacement Bridges	Replacement Cost	Preventive Maintenance Cost	Total Cost
Sioux	1	$0.54	$0.15	$0.69
Slope	2	$8.29	$0.19	$8.48
Stark	23	$37.86	$0.55	$38.40
Steele	29	$24.28	$0.46	$24.74
Stutsman	11	$21.85	$0.40	$22.25
Towner	11	$7.68	$0.05	$7.73
Traill	61	$128.69	$0.61	$129.30
Walsh	68	$68.21	$0.91	$69.13
Ward	22	$29.36	$0.35	$29.72
Wells	4	$2.80	$0.32	$3.12
Williams	16	$8.69	$0.17	$8.86
Statewide	847	$1,068.31	$18.86	$1,087.17

Table D.7. County and Township Minor Structures Needs (Million 2024 Dollars)

County	Replacement Bridges	Replacement Cost	Preventive Maintenance Cost	Total Cost
Adams	46	$19.38	$0.00	$19.38
Barnes	26	$10.74	$0.24	$10.98
Benson	24	$12.21	$0.00	$12.21
Billings	0	$0.00	$0.50	$0.50
Bottineau	22	$12.03	$0.26	$12.29
Bowman	2	$1.20	$0.00	$1.20
Burke	26	$11.04	$0.00	$11.04
Burleigh	7	$2.58	$0.00	$2.58
Cass	53	$24.91	$1.06	$25.97
Cavalier	107	$45.21	$0.56	$45.77
Dickey	34	$14.53	$0.00	$14.53
Divide	2	$0.76	$0.10	$0.86
Dunn	70	$32.74	$0.00	$32.74
Eddy	12	$5.59	$0.00	$5.59
Emmons	14	$5.61	$0.10	$5.71
Foster	7	$2.73	$0.00	$2.73
Golden	38	$16.92	$0.00	$16.92
Grand Forks	43	$20.66	$0.10	$20.76
Grant	81	$41.42	$0.06	$41.48
Griggs	4	$2.11	$0.00	$2.11
Hettinger	52	$26.24	$0.00	$26.24
Kidder	1	$0.46	$0.00	$0.46
LaMoure	67	$32.28	$0.00	$32.28
Logan	4	$1.67	$0.00	$1.67
McHenry	36	$19.71	$0.00	$19.71
McIntosh	8	$3.77	$0.00	$3.77

County	Replacement Bridges	Replacement Cost	Preventive Maintenance Cost	Total Cost
McKenzie	3	$1.50	$0.04	$1.54
McLean	14	$6.79	$0.00	$6.79
Mercer	70	$31.70	$0.00	$31.70
Morton	69	$29.33	$0.00	$29.33
Mountrail	24	$10.13	$0.00	$10.13
Nelson	14	$5.90	$0.00	$5.90
Oliver	26	$9.56	$0.00	$9.56
Pembina	101	$46.97	$1.58	$48.55
Pierce	11	$4.10	$0.00	$4.10
Ramsey	3	$1.66	$0.76	$2.42
Ransom	10	$4.68	$0.00	$4.68
Renville	23	$12.19	$0.00	$12.19
Richland	57	$26.26	$0.02	$26.28
Rolette	25	$11.78	$0.00	$11.78
Sargent	36	$18.26	$0.00	$18.26
Sheridan	2	$0.76	$0.00	$0.76
Sioux	12	$6.02	$0.00	$6.02
Slope	62	$29.59	$0.00	$29.59
Stark	16	$7.69	$0.28	$7.97
Steele	22	$10.72	$0.10	$10.82
Stutsman	17	$7.57	$0.00	$7.57
Towner	41	$19.19	$0.02	$19.21
Traill	3	$1.36	$0.84	$2.20
Walsh	137	$67.28	$0.58	$67.86
Ward	30	$15.22	$0.00	$15.22
Wells	35	$17.06	$0.00	$17.06
Williams	85	$35.41	$0.02	$35.43
Statewide	1,734	$805.16	$7.22	$812.38

Table D.8. Total Road and Bridge Investment Needs, 2024-2043 (Million 2024 Dollars)

Period	Unpaved	Paved	Bridges	Minor Structures	Total
2024-2025	$707.88	$433.82	$178.94	$151.06	$1,471.70
2026-2027	$694.93	$523.64	$178.94	$151.06	$1,578.57
2028-2029	$714.99	$436.78	$178.94	$151.06	$1,481.77
2030-2031	$716.56	$388.93	$178.94	$151.06	$1,435.49
2032-2033	$693.38	$368.57	$178.94	$151.06	$1,391.95
2034-2043	$3,443.71	$1,344.44	$192.45	$49.72	$5,030.32
2024-2043	$6,971.45	$3,496.17	$1,087.16	$805.00	$12,359.78

Table D.9. Total Road and Bridge Investment Needs by County, 2024-2043 (Million 2024 Dollars)

County	Unpaved	Paved	Bridges	Minor Structures	Total Needs
Adams	$69.87	$7.60	$7.17	$19.38	$104.02
Barnes	$166.45	$109.29	$29.30	$10.98	$316.02
Benson	$101.18	$31.56	$2.23	$12.21	$147.18
Billings	$91.09	$15.66	$11.72	$0.50	$118.97
Bottineau	$145.24	$111.55	$33.00	$12.29	$302.08
Bowman	$78.33	$72.31	$7.81	$1.20	$159.65
Burke	$133.26	$22.66	$3.25	$11.04	$170.21
Burleigh	$166.91	$179.76	$4.89	$2.58	$354.14
Cass	$340.79	$203.22	$69.70	$25.97	$639.68
Cavalier	$121.50	$30.32	$6.69	$45.77	$204.28
Dickey	$89.32	$38.96	$8.86	$14.53	$151.67
Divide	$128.57	$46.39	$1.15	$0.86	$176.97
Dunn	$334.50	$27.48	$8.97	$32.74	$403.69
Eddy	$37.03	$35.67	$6.64	$5.59	$84.93
Emmons	$97.41	$6.59	$7.13	$5.71	$116.84
Foster	$57.45	$64.38	$4.49	$2.73	$129.05
Golden Valley	$97.01	$12.21	$4.97	$16.92	$131.11
Grand Forks	$271.57	$155.14	$52.50	$20.76	$499.97
Grant	$172.70	$0.00	$52.37	$41.48	$266.55
Griggs	$53.59	$20.09	$2.75	$2.11	$78.54
Hettinger	$77.04	$9.22	$21.54	$26.24	$134.04
Kidder	$72.59	$24.85	$0.00	$0.46	$97.90
LaMoure	$109.43	$82.25	$13.70	$32.28	$237.66
Logan	$50.84	$4.31	$1.15	$1.67	$57.97
McHenry	$137.06	$50.69	$42.07	$19.71	$249.53
McIntosh	$48.40	$56.94	$2.86	$3.77	$111.97
McKenzie	$456.08	$145.00	$21.44	$1.54	$624.06
McLean	$221.05	$100.24	$10.60	$6.79	$338.68
Mercer	$122.68	$60.28	$44.77	$31.70	$259.43
Morton	$172.47	$41.90	$75.37	$29.33	$319.07
Mountrail	$196.67	$90.13	$1.73	$10.13	$298.66
Nelson	$65.39	$41.72	$5.66	$5.90	$118.67
Oliver	$33.54	$12.50	$13.13	$9.56	$68.73
Pembina	$93.24	$89.87	$60.51	$48.55	$292.17
Pierce	$116.30	$5.55	$0.54	$4.10	$126.49
Ramsey	$68.77	$55.55	$3.46	$2.42	$130.20
Ransom	$66.81	$26.44	$25.42	$4.68	$123.35
Renville	$66.03	$48.88	$12.95	$12.19	$140.05
Richland	$201.69	$166.07	$57.91	$26.28	$451.95
Rolette	$61.03	$23.16	$1.12	$11.78	$97.09
Sargent	$57.62	$52.78	$3.23	$18.26	$131.89
Sheridan	$65.84	$10.10	$0.00	$0.76	$76.70
Sioux	$69.79	$0.00	$0.69	$6.02	$76.50

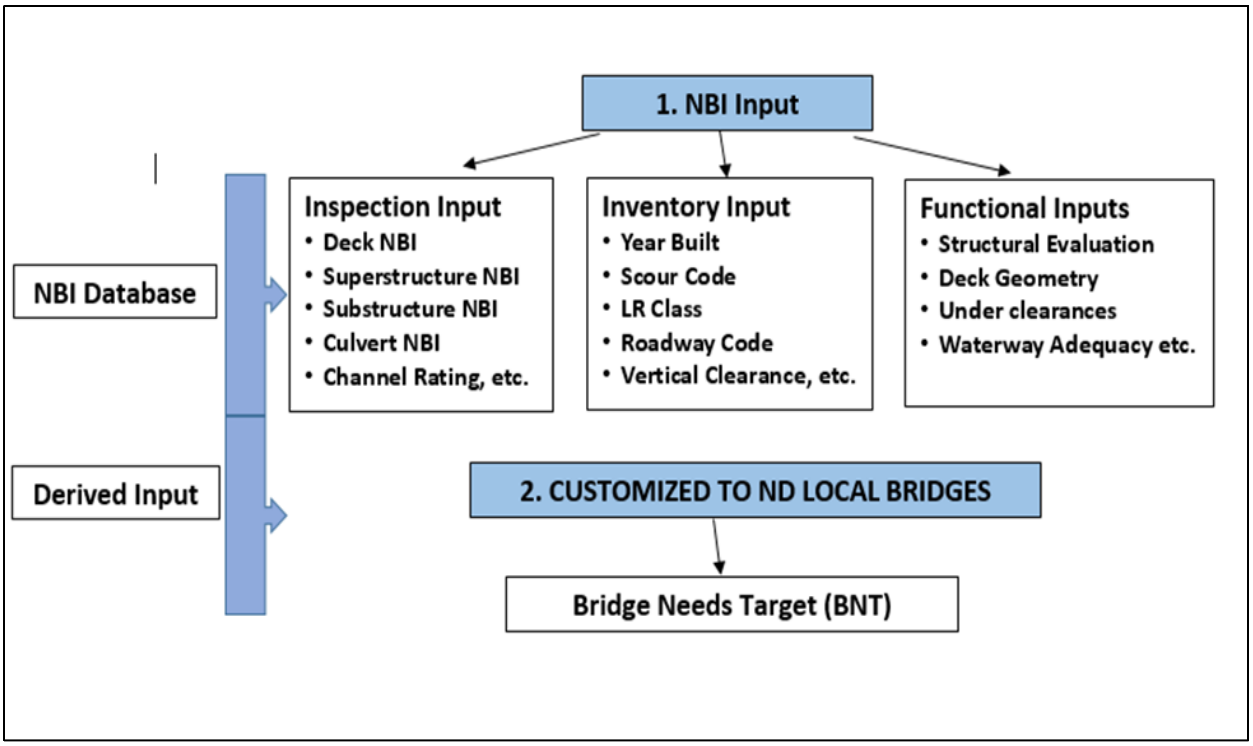
County	Unpaved	Paved	Bridges	Minor Structures	Total Needs
Slope	$73.51	$0.62	$8.48	$29.59	$112.20
Stark	$177.42	$92.73	$38.40	$7.97	$316.52
Steele	$85.94	$33.89	$24.74	$10.82	$155.39
Stutsman	$142.28	$123.00	$22.25	$7.57	$295.10
Towner	$91.24	$74.20	$7.73	$19.21	$192.38
Traill	$170.50	$50.26	$129.30	$2.20	$352.26
Walsh	$204.80	$104.04	$69.13	$67.86	$445.83
Ward	$270.02	$211.33	$29.72	$15.22	$526.29
Wells	$93.81	$62.62	$3.12	$17.06	$176.61
Williams	$277.76	$229.60	$8.86	$35.43	$551.65
Total	$6,971.45	$3,371.56	$1,087.17	$812.38	$12,242.56

Appendix E: Calculation of NBI Data to Bridge Needs Target (BNT)

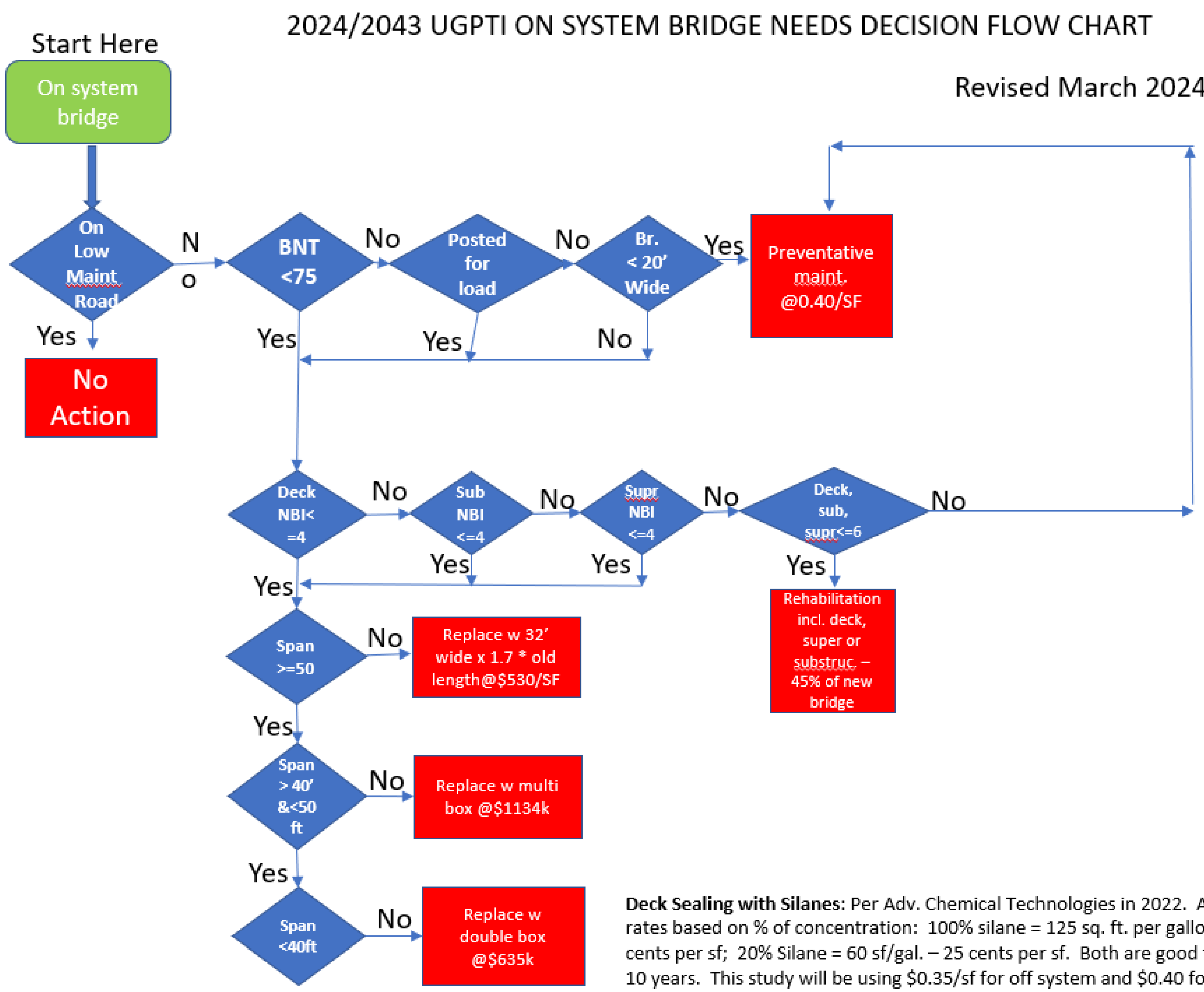
Introduction

The BNT includes special reduction factors for the following ratings in addition to those ratings already included in the obsolete sufficiency rating method. A scour reduction factor is determined by utilizing Channel Protection (61) and Scour Critical (113) condition codes from the NBI. The fracture critical reduction factor is based on code 92 A, B & C. The reduction factor for load capacity is based on Inventory Rating (66) and finally the reduction factor for timber materials in the main span which would be a maximum deduction of 5%.

Bridge Modeling Framework Chart



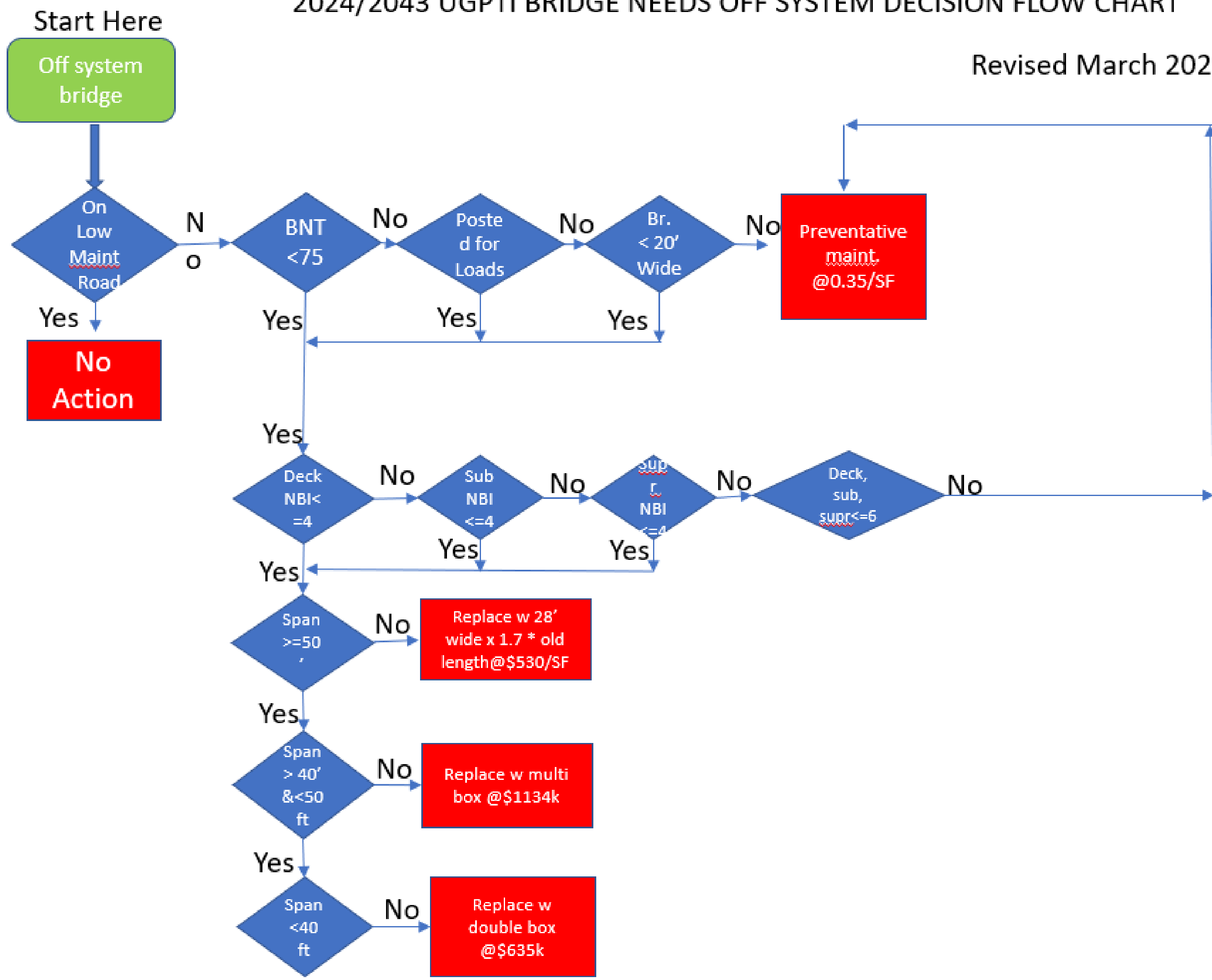
Appendix F: Bridge Improvement Flow Chart



Deck Sealing with Silanes: Per Adv. Chemical Technologies in 2022. Apply at rates based on % of concentration: 100% silane = 125 sq. ft. per gallon – 12 cents per sf; 20% Silane = 60 sf/gal. – 25 cents per sf. Both are good for 6 to 10 years. This study will be using $0.35/sf for off system and $0.40 for on system bridges.

2024/2043 UGPTI BRIDGE NEEDS OFF SYSTEM DECISION FLOW CHART

Revised March 2024



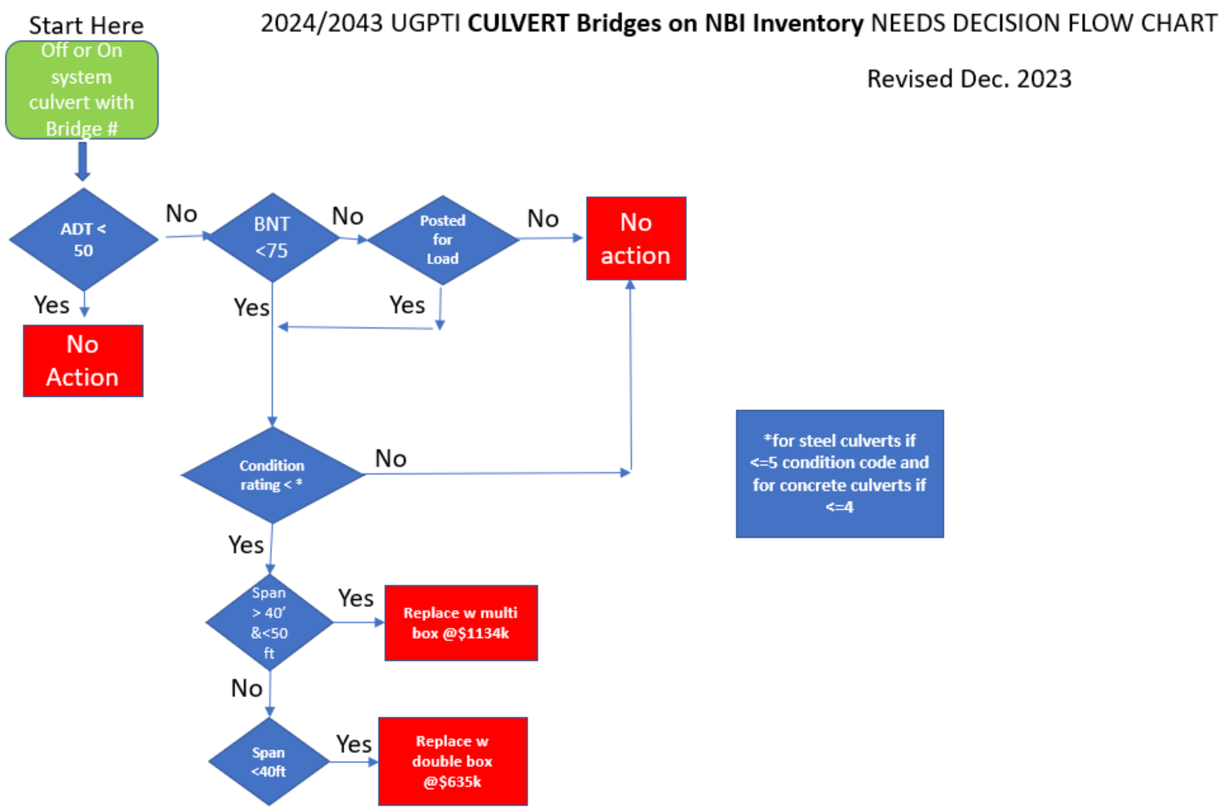
Appendix G: Culvert Flow Chart and Needs

Table G.1. Counties with Culverts 20-foot Span or Greater Drawing Replacement Needs

County	Number of Qualifying Culverts	Additional Needs
Benson	1	$635,000
Cavalier	1	$635,000
Grand Forks	2	$1,270,000
McLean	1	$1,134,000
Morton	1	$1,134,000
Pembina	1	$635,000
Richland	2	$1,270,000
Traill	4	$2,540,000
Walsh	1	$635,000
Totals	14	$9,888,000

(ADT >= 50)

Note: Qualifying culvert NBI Structures had condition codes of 5 or less for steel or timber and 4 or less for concrete.



Appendix H: Pavement Data Collection

IRISgo Portable Profiler

The portable profiler is equipped with several advanced features like an accelerometer that measures acceleration using the relative motion between a proof mass and a mounting substrate, a reflective target detection system for distance measurement, two spot lasers to measure the longitudinal profile in each wheel path, and a Garmin GPS to integrate the system with precise geolocation. The profiler can collect data at speeds as low as 25 mph. The laser readings on the longitudinal profile can be translated into International Roughness Index (IRI) values for every 500 feet of pavement, providing a detailed analysis of road smoothness.

Before data collection, various calibrations are performed to ensure accuracy: accelerometer, distance, block check, bounce test, etc. Accelerometer calibration needs to be done daily, which cancels out the effect of vehicle motion on sensor readings. Distance calibration and block check are other calibrations that need to be done each week. Distance calibration is used to calibrate the distance measurement instrument on a course with pre-measured distance. Block checks are conducted with different height blocks to ensure the elevation accuracy measured by each laser. Another calibration performed monthly is the bounce test, which is essentially a verification that the laser and processed initial reference height cancel out.

Figure H.1. UGPTI Utilized a Portable Profiler for Pavement Data Collection

Figure H.2. IRISgo Portable Profiler for Pavement Data Collection

Appendix I: Minor Structures Inventory Form

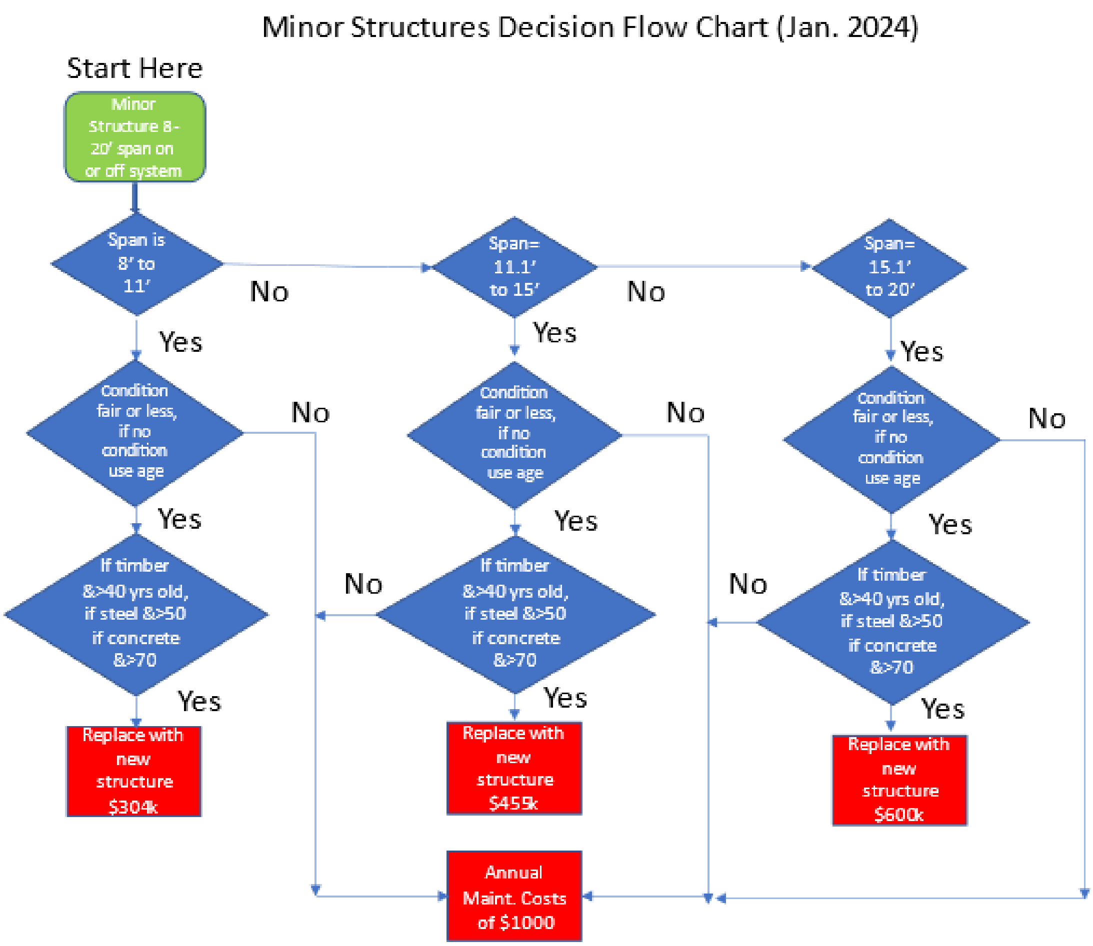
North Dakota Minor Structure Inventory Form **Bridge Inventory Form (Page 1 of 2)** **Revised 04/04/2023**

COMMON INVENTORY ITEMS			
Location			
Item 1	County Name		
Item 2	Town or Township Name		
Item 3	Road System	☐ Township ☐ County Secondary	☐ County ☐ Other
Item 4	Small Structure Local Identifier		
Item 5	Sequence Number		
Item 6	Inventoried By		
Item 7	Inventory Date	____/ ____/ 20____	
Item 8	Latitude	_____.________________ decimal degrees	
Item 9	Longitude	_____.________________ decimal degrees	
Item 10	Small Structure Number	____ - _________ - _________ (to be assigned later)	
Road Attributes			
Item 11	Road Name		
Item 12	Road Maintenance Level	☐ Full Maintenance ☐ Minimum Maintenance	☐ No Maintenance
Item 13	Road Surface	☐ Dirt ☐ Gravel ☐ Blotter	☐ Asphalt Mat ☐ Concrete ☐ Other
Item 14	Number Served	☐ Not a Dead End ☐ No homes, farms, ranches ☐ 1 home, farm, or ranch ☐ More than 1 home, farm, or ranch	
Item 15	Detour Length	______ miles	
(Items 16 – 49 are used only for Box and Pipe Culverts)			

SMALL BRIDGE INVENTORY ITEMS			
Bridge Attributes			
Item 50	Structure Design Type	☐ Slab ☐ Girder ☐ Box Beam ☐ Channel Beam ☐ Tee Beam ☐ Deck Truss	☐ Through Truss ☐ Deck Arch ☐ Through Arch ☐ Rigid Frame ☐ Combination ☐ Other
Item 51	Structure Material	☐ Concrete ☐ Steel ☐ Prestressed Concrete	☐ Wood ☐ Masonry ☐ Other
Bridge Dimensions			
Item 52	Overall Length	_____ feet	
Item 53	NBIS Length	_____ feet	
Item 54	Number of Spans	_____ spans	
Item 55	Traffic Lanes	_____ lanes	
Item 56	Deck Width	_____ feet	
Item 57	Roadway Width	_____ feet	
Item 58	Skew Angle	_____ degrees	
Bridge Condition			
Item 59	Deck Condition	☐ Good ☐ Fair	☐ Poor ☐ Critical
Item 60	Superstructure Condition	☐ Good ☐ Fair	☐ Poor ☐ Critical
Item 61	Substructure Condition	☐ Good ☐ Fair	☐ Poor ☐ Critical
Item 62	Channel Condition	☐ Good ☐ Fair	☐ Poor ☐ Critical
Item 63	Bridge Rail Condition	☐ Railing runs full bridge length in sound condition ☐ Railing is partially missing or needs repair ☐ No functional railing is present	
Item 64	Approach Rail	☐ Railing is present and in sound condition ☐ Railing is partially missing or needs repair ☐ No functional railing is present	

Instructions: Use this form with the Small Structure Inventory Handbook. Use a separate form for each Small Bridge inventoried. Information on this form must be entered into the GRIT Minor Structure Database.

Appendix J: Minor Structures Decision Flow Chart



Appendix K: List of Abbreviations

ATR- Annual Traffic Recorders
AADT- Average Annual Daily Traffic
BBL- Barrel of Oil
BIA- Bureau of Indian Affairs
CDL- Crop Data Layer
CMC- County Major Collector
CRP- Conservation Reserve Program
DOD- Department of Defense
DOTSC- Department of Transportation Support Center
ESAL- Equivalent Single Axle Loads
FHWA- Federal Highway Administration
FO- Functionally Obsolete
FSM- Four Step Model
FWD- Falling Weight Deflectometer
GIS- Geographic Information System
GPR- Ground Penetrating Radar
GRIT- Geographic Roadway Inventory Tool
HB- House Bill
IRI- International Roughness Index
KIPS- Kilopounds
NASS- National Agricultural Statistics Service
NBI- National Bridge Inventory
NDDOT- North Dakota Department of Transportation
NDPSC- North Dakota Public Service Commission
NDT- Non-Destructive Testing
PAVVET- Performance Analysis Via Vehicle Electronic Telemetry
PSR- Present Serviceability Index
R-Sq- Coefficient of Determination
RCBC- Reinforced Concrete Box Culverts
RIC- Roadway Image Capture
RIF- Road Impact Factor
RMS- Root Mean Square
SD- Standard Deviation/ Structurally Deficient
SN- Structural Number
SR- Sufficiency Rating
TAZ- Traffic Analysis Zones
TDM- Travel Demand Model
TWP- Township
UGPTI- Upper Great Plains Transportation Institute
USDA- United States Department of Agriculture