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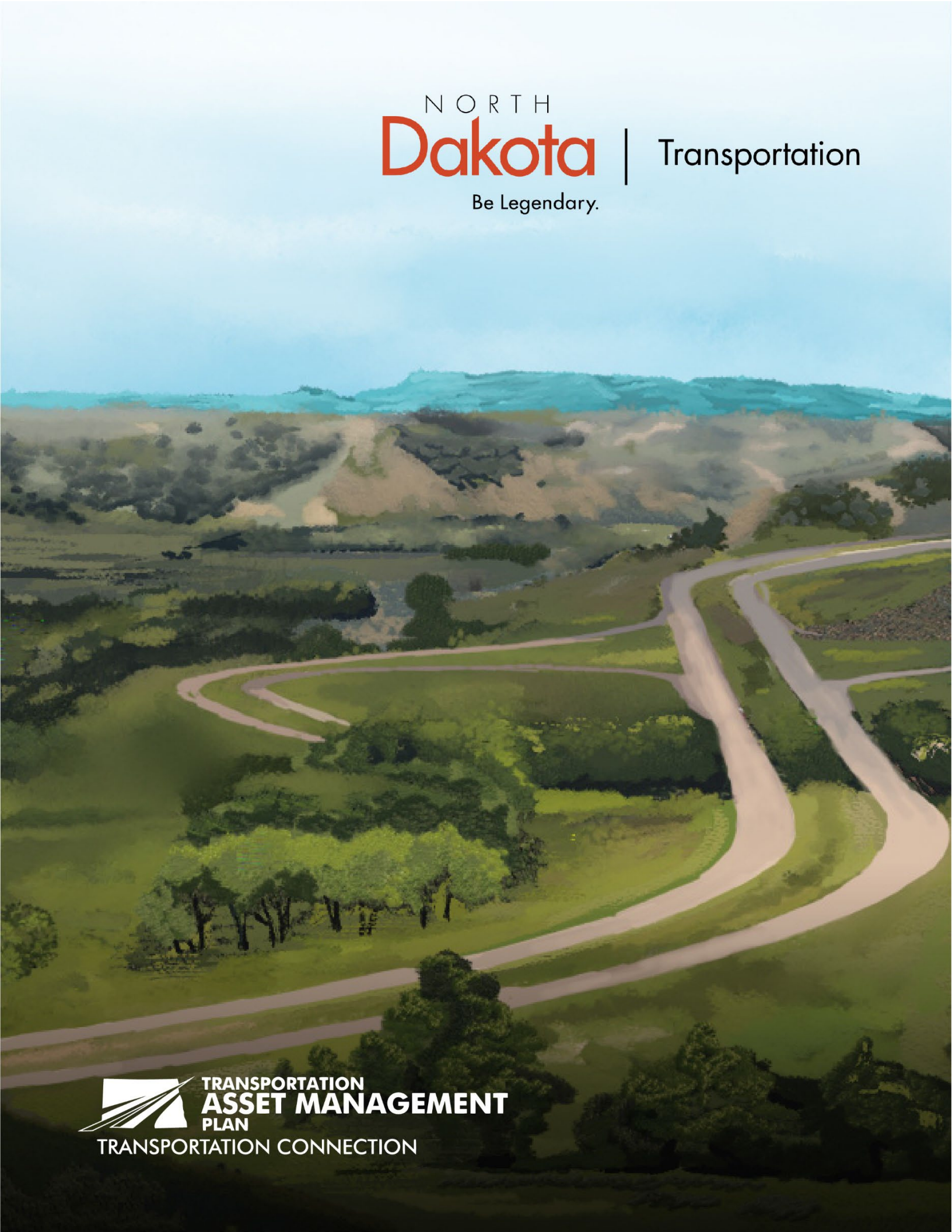

TRANSPORTATION ASSET MANAGEMENT PLAN

TRANSPORTATION CONNECTION

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November 15, 2022

Mr. Lee Potter
ND Division Administrator
Federal Highway Administration
4503 Coleman Street, Suite 205
Bismarck, ND 58503

BIL COMPLIANT TRANSPORTATION ASSET MANAGEMENT PLAN

Dear Mr. Potter:

Enclosed, for your approval, is the North Dakota Department of Transportation's (NDDOT) BIL Compliant Transportation Asset Management Plan (TAMP), as provided by the BIL and in compliance with the requirements of 23 CFR 515.11.

Upon FHWA approval, this document will be published on NDDOT's website.

Please contact Jack Smith at (701) 328-2016 or jasmith@nd.gov with any questions, concerns, or comments.

Sincerely,

Ronald J. Henke, PE
Director

17/js/ss
Enclosure

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Chapter 1: Introduction to the Asset Management Journey

TRANSPORTATION ASSET MANAGEMENT

Transportation asset management (TAM) is a performance-based, data-supported approach for managing the condition and performance of transportation infrastructure. It involves the collection and analysis of data regarding the costs and benefits of the initial construction, maintenance, preservation, rehabilitation, and reconstruction of physical highway assets to understand the likely outcomes of future investments. Through implementing TAM practices and analysis tools, system managers in the North Dakota Department of Transportation (NDDOT) establish long-term strategies for managing infrastructure to maximize asset service lives while minimizing life-cycle costs.

TAM analysis supports NDDOT management in making decisions that cost effectively progress asset conditions toward long-term goals and short-term targets. Implementing TAM involves the establishment of a continual improvement process, as shown in figure 1-1. Through this process, NDDOT works to continually refine its construction and maintenance program while also identifying opportunities to improve the data, systems, and practices used to make investment decisions.

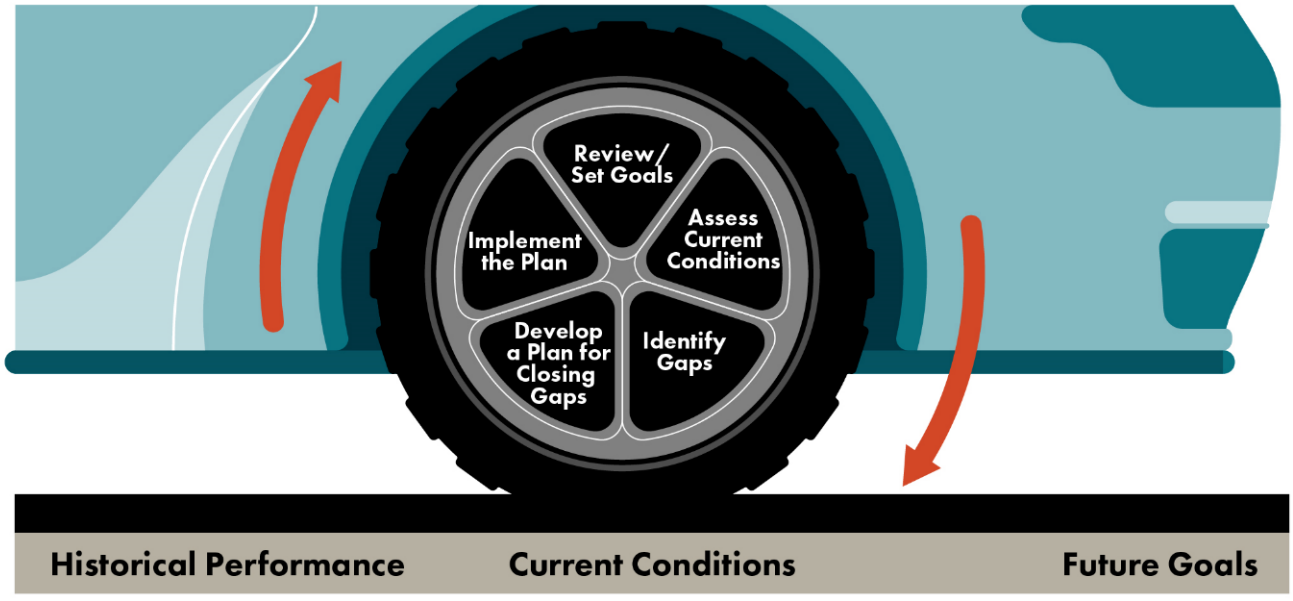


Figure 1-1. Asset management is a continual improvement process that supports achieving long-term goals.

TAM methods and philosophies can be applied to any asset class and even to non-physical asset investment classes, providing service to the end-system users (i.e., the customers). In addition to supporting internal decision-making processes, a mature TAM program provides information to the public so they may understand and verify how well investments in the infrastructure meet their needs.

NDDOT's TAM program is focused on the condition of pavements, bridges, and other physical assets on the State Highway System (SHS) and National Highway System (NHS) within the State of North Dakota.

TRANSPORTATION ASSET MANAGEMENT PLANS

This document is NDDOT's federally required Transportation Asset Management Plan (TAMP), developed under the requirements of 23 CFR 515. This TAMP addresses two asset classes, pavements and highway bridges, both in terms of their physical condition and the functional capacity these assets provide in support of freight movement in North Dakota. It further describes:

- The transportation system managed by the NDDOT.
- The method of managing transportation assets throughout their life cycles.
- The financial constraints in managing the system.
- The processes for managing risk related to the transportation system and services.

While federal regulations only require the TAMP to cover the National Highway System (NHS) pavements and bridges, NDDOT has chosen to manage all of its pavements and bridges using the asset management principles documented in this TAMP. The TAMP is developed and managed by NDDOT's Division of Planning and Asset Management. Per 23 CFR 515.13, NDDOT updates its TAMP every 4 years.

ASSET MANAGEMENT AND PERFORMANCE-BASED PLANNING AT NDDOT

TAM is an integral aspect of performance-based planning (PBP) and programming, which applies performance management principles to establish policy, practices, and investment decisions. PBP provides a strong link between long-range decisions on both priorities and policies and shorter-term investment decisions that are included in the development of programs such as the Statewide Transportation Improvement Program (STIP). NDDOT establishes its PBP vision though its long-range transportation plan, Transportation Connection. Figure 1-2 shows how Transportation Connection serves to guide NDDOT's family of performance-based plans, including this TAMP.

Figure 1-2. NDDOT's family of plans.

NDDOT's vision is that TAM fosters a culture of public dollar stewardship through both data-supported and goal-oriented decisions. The NDDOT TAM program has adopted the mission of strategically prioritizing the use of transportation resources to provide transportation infrastructure that safely moves people and goods at the lowest practical cost over the life of that infrastructure. As shown in figure 1-3, infrastructure condition is but one (albeit a very important and influential) source of information in the decision-making processes. NDDOT's TAM program is a collaborative and multi-disciplinary process that occurs through NDDOT's Investment Priorities Process, beginning with the establishment of long-range goals and culminating with the annual publication of the STIP. This process is described in more detail in Chapter 7.

Figure 1-3. National Goal Areas.

NDDOT's asset management program works in coordination with the other performance-based programs to support overall transportation performance management and shepherd NDDOT's continual progress in meeting its targets in each of the seven National Goal Areas shown in figure 1-3. The TAMP describes the investment strategies that will lead to accomplishing NDDOT's infrastructure condition targets, as established under 23 USC 150(b), for federal Transportation Performance Management (TPM).

OUR MAJOR HIGHWAY ASSETS

Pavement Inventory

To facilitate efficient management of NDDOT's transportation infrastructure assets, the concept of a state-system roadway classification framework was endorsed by the North Dakota legislature and the Governor in 2005 (N.D.C.C. §24-01-03.1). The framework, called the "Highway Performance Classification System" (HPCS), provides the overall framework to help guide NDDOT in establishing the desired state of good repair (DSOGR) for individual roadway corridors. Within HPCS, five roadway classifications are defined, as shown in figure 1-4. These classifications are based on reliability (e.g., will the roadway be available for travel as needed and expected), type of movement (e.g., long distance vs. local), typical travel speed, geometry (e.g., two-lane vs. four-lane), size and load restrictions, pavement condition (e. g., ride quality and distress), risk tolerance, and overall safety. The five classifications include:

- **Interstates**: Primarily used for long-distance travel; rural Interstates are multi-lane (typically four lane) facilities with fully controlled access.
- **Interregional Corridor**: Primarily used for long-distance travel; either two or multi-lane facilities; segments may have partially controlled access.
- **State Corridor**: Primarily used for medium-distance intrastate travel; provides connectivity between lower- and higher-level roadways; typically, two-lane facilities with segments or locations with partially controlled access.

- **District Corridor**: Primarily used for short- to medium-distance Intrastate traffic; typically, two-lanes.
- **District Collector**: Primarily used for short distance, local, farm to market traffic; provides connectivity to higher-level road systems; typically, two-lane facilities.

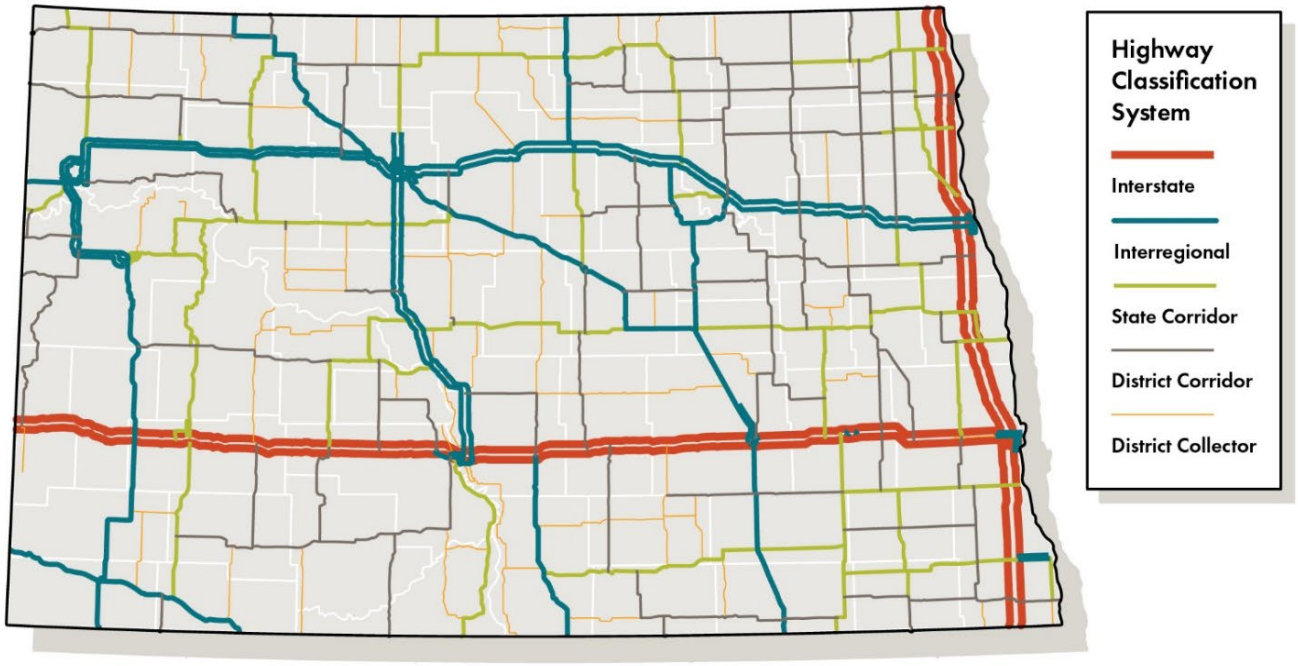


Figure 1-4. State highway performance classification system map.

NDDOT's network consists of almost 17,500 lane-miles of pavements, with 56 percent of the mileage on the NHS. Around 1 percent of the NHS is maintained by local agencies (cities and counties). The vast majority of the NHS pavements (around 85 percent) are contained in the top three corridors (Interstate, interregional, and state corridors). Figure 1-5 presents the distribution of NDDOT's pavement network inventory by system (NHS vs. Non-NHS, and NHS pavements on the HPCS). Additional details on the NHS pavement inventory are provided in Appendix A.

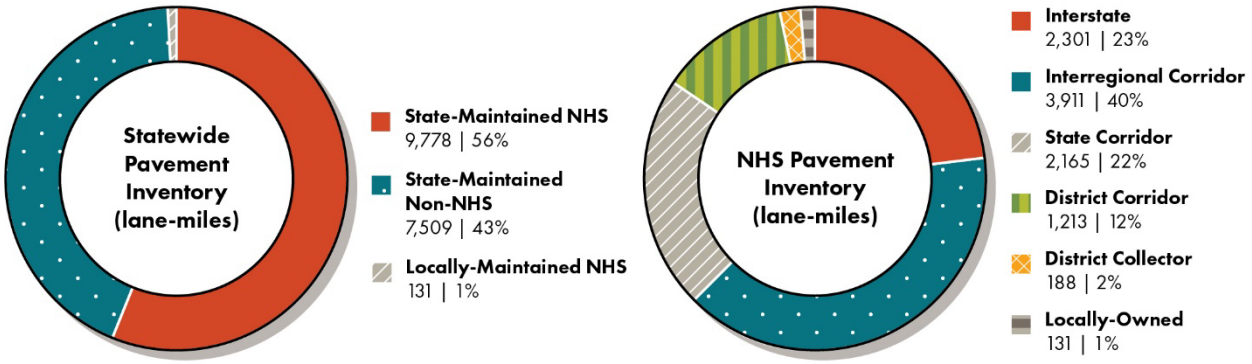


Figure 1-5. NDDOT pavement network inventory by system.

Figure 1-6 shows the distribution of pavement inventory by pavement type (asphalt, concrete, or composite). On the NHS, more than 80 percent of the inventory consists of asphalt-surfaced pavements, and the remaining are concrete pavements. On the other hand, the non-NHS system is almost entirely comprised of asphalt-surfaced pavements (around 99 percent).

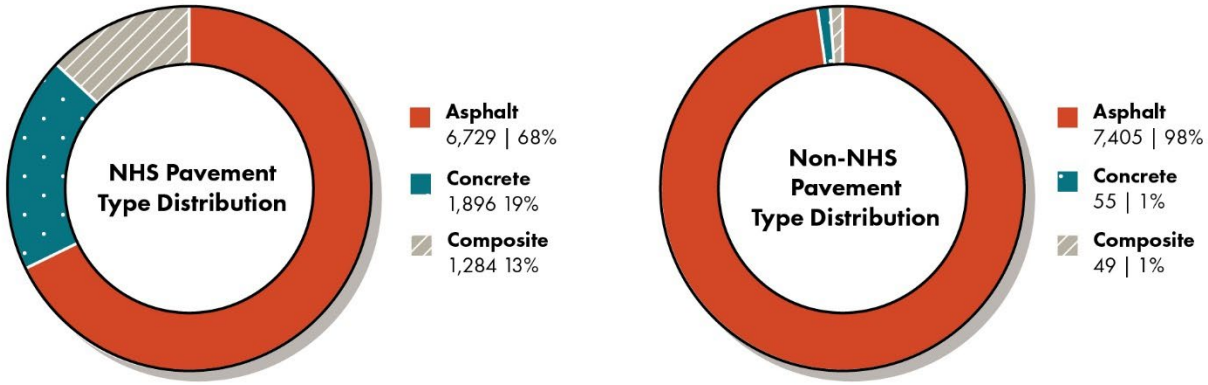


Figure 1-6. NDDOT pavement network inventory by pavement type.

Bridge Inventory

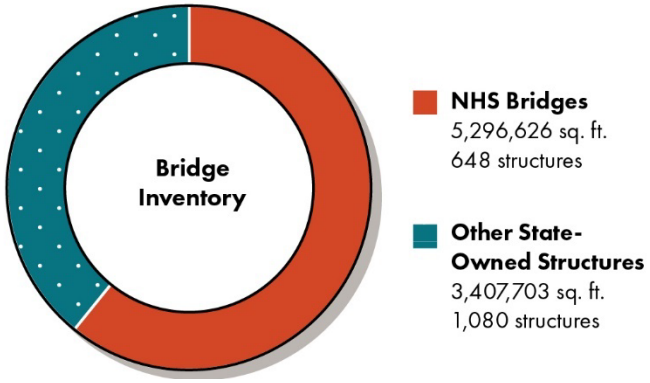


Figure 1-7. North Dakota's state-owned structure inventory.

The North Dakota Department of Transportation owns 1,728[1] highway bridges and large culverts with clear openings greater than 8 feet. Of these structures, 648 are part of the NHS and have a clear opening of at least 20 feet, which qualifies them as bridges in the National Bridge Inventory. As shown in figure 1-7, NHS bridges make up the majority of the state-owned bridge inventory, consisting of 61 percent of the total deck surface area. They also carry 63 percent of statewide traffic volume. All the state's NHS bridges are owned by NDDOT. Figure 1-8 shows the distribution of NDDOT bridge inventory by decade of construction. The average age of state-owned bridges is 51 years, and more than half of the State's bridges were built prior to 1980, when the typical design life for a bridge was 50 years.

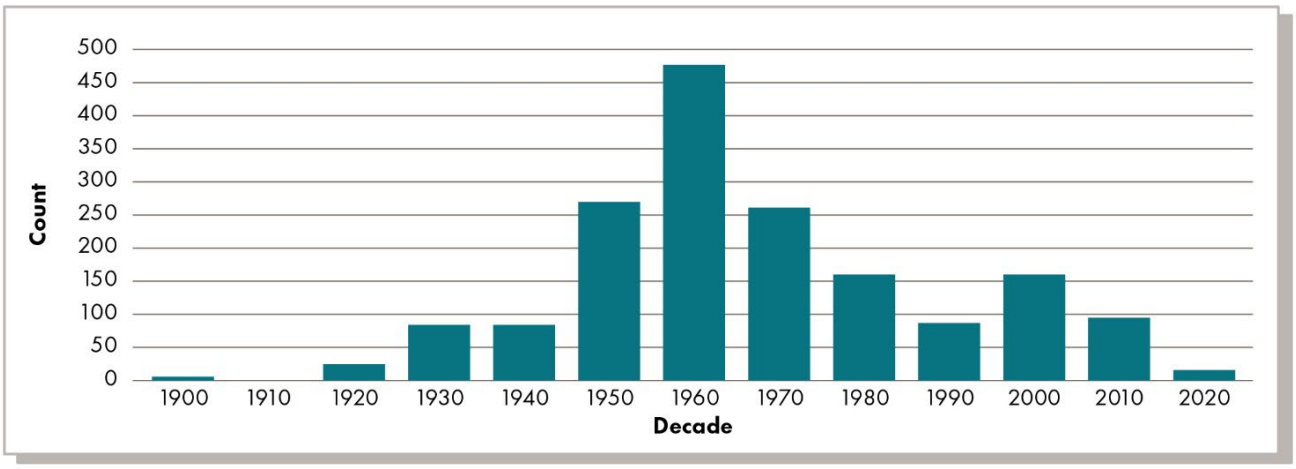


Figure 1-8. Construction year of state-owned structures.

[1] NDDOT Manages at total of 1,739 structures of which 11 are railroad bridges.

Chapter 2: Driving Success – Performance Objectives and Measures

INTRODUCTION

NDDOT uses a variety of measures to determine, document, and forecast the condition and performance of pavements and bridges. These measures provide the basis for establishing short term targets, long-term goals, and desired state of good repair (DSOGR) descriptions.

A DSOGR is a network-wide condition state that represents the highest level of condition or performance NDDOT seeks to achieve. Performance beyond the desired DSOGR is considered excessive. NDDOT establishes DSOGR for each asset class and the performance area of functional capacity. The DSOGR for functional capacity represents the removal of all known restrictions on capacity, beyond current design standards. The DSOGR for pavements and structures is a condition in which the assets, to an acceptable extent, are both:

- Functioning as designed.
- Sustained through cyclical and condition-based preventative maintenance, rehabilitation, and replacement activities.

Long-term performance goals serve to guide short- and mid-term decisions. NDDOT has established realistic long-term performance goals for pavements, bridges, and functional capacity based on 10-year forecasted conditions with expected resources.

Short-term targets represent the levels of condition or performance that NDDOT will attempt to reach in the short term (4 to 5 years) through its investments. These targets serve to push the Department toward its long-term goals, but ultimately are fiscally constrained. NDDOT defines short-term targets both in support of the STIP and federal TPM.

PAVEMENTS

Pavement Performance Measures

NDDOT collects pavement condition every year for the entire NHS network (except the locally owned NHS roads, which are collected every other year). For two-lane SHS highways, pavement condition data are collected for each lane every other year. On average, NDDOT monitors the condition of approximately 8,600 lane-miles of SHS network condition each year. Pavement data is collected at highway speeds with calibrated data collection equipment.

NDDOT utilizes ride quality, measured using the International Roughness Index (IRI), to track, report, and manage network performance. Pavement condition is reported based on the four condition categories defined in table 2-1.

NDDOT also utilizes the national performance management measures established under 23 CFR Part 490 (see figure 2-1) for reporting federal targets. NDDOT's pavement management system has been customized to enable the reporting of pavement conditions in accordance with the national performance measures.

Table 2-1. Pavement ride quality categories.

Category	IRI Range (inches per mile)
Excellent	< 60
Good	61 to 99
Fair	100 to 145
Poor	> 145

Condition Thresholds *Metric as defined in HPMS*	GOOD	FAIR	POOR
International Roughness Index (IRI) (in/mile)	<95	95–170	>170
Asphalt Concrete Cracking (%)	<5	5–20	>20
Jointed Plain Concrete (JPC) Cracking (% slabs)	<5	5–15	>15
Continously Reinforced Concrete (CRC) Pavement Cracking (%)	<5	5–15	>10
Rutting (in) (asphalt-surfaced pavements only)	<0.20	0.20–0.40	>0.40
Faulting (in) (concrete-surfaced pavements only)	<0.10	0.10–0.15	>0.15

Figure 2-1. Summary of condition thresholds and performance measures for pavements based on 23 CFR Part 490.

Pavement Goals

NDDOT has established a DSOGR to manage the pavement program on the SHS. Additional short-term targets for interstate and non-interstate NHS pavements have been established to support national TPM requirements (23 USC 150(d)). NDDOT's pavement goals are shown in table 2-2. Each measurable goal represents an average condition across respective the networks.

Table 2-2. Pavement goals.

Network	Measure	2-year target	4-year target	Desired SOGR
SHS	IRI	N/A	N/A	74.9
Interstates	IRI	N/A	N/A	74.9
	% Good	75.6%	75.6%	N/A
	% Poor	3%	3%	
Non-Interstate NHS	IRI	N/A	N/A	74.9
	% Good	58.3%	58.3%	N/A
	% Poor	3%	3%	

BRIDGES

Bridge Performance Measures

All NDDOT-owned bridges are routinely inspected by specially trained and certified personnel, typically on 24-month intervals. Bridge inventory and condition data is collected in accordance with National Bridge Inventory Standards. Inspectors carefully examine all components, elements, protective systems, and safety appurtenances for each bridge. They record significant defects and provide a detailed condition assessment for each element. Inspectors further group the structural elements of bridges into three components: deck, superstructure, and substructure. Figure 2-2 shows elements common to highway bridges. Culverts have just one component. NDDOT uses both element and component level condition data to manage its inventory of bridges.

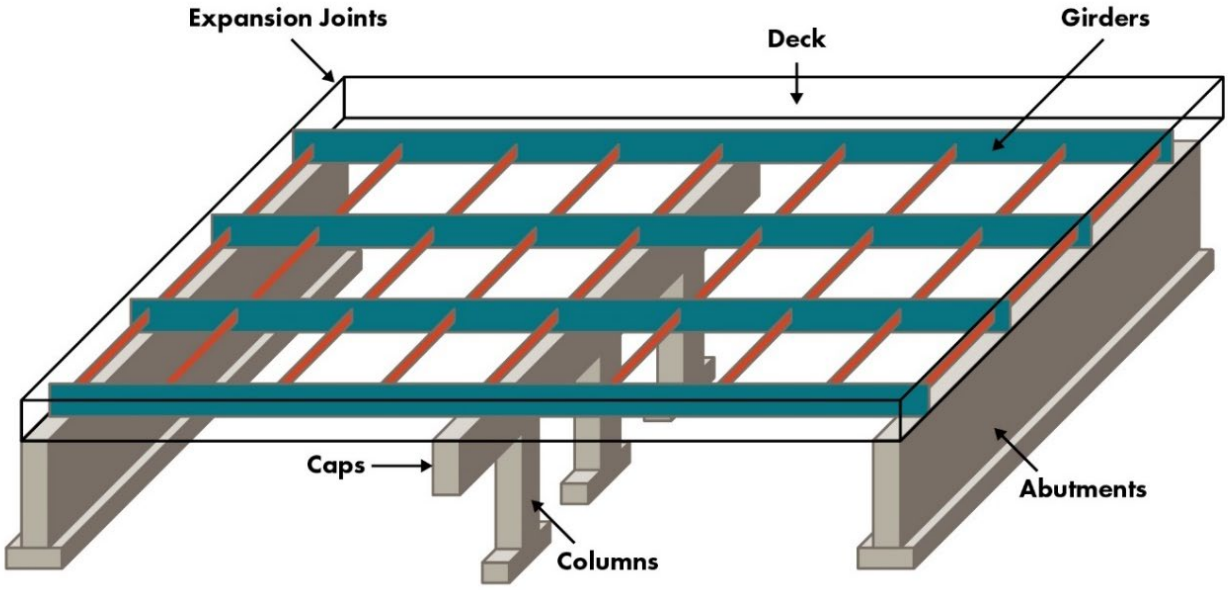


Figure 2-2. Typical bridge elements.

Element level inspection data is used to identify defects and to quantify the percentage of each element within each of four condition states. Depending on the condition state, some defects may signify safety or structural related deficiencies that warrant immediate follow-up action. Such defficiencies are identified as Critical Findings, which must be reported to Federal Highway Administration (FHWA) until resolved. Defects that warrant further attention, action, or monitoring but do not require immediate action or attention are defined as Significant Findings.

Bridge Element Condition States

Condition State 1 – Good

Condition State 2 – Fair

Condition State 3 – Poor

Condition State 4 - Severe

Component level condition assessments are used by the Department's engineers to plan corrective actions and prioritize investments that most effectively maintain NDDOT bridges in a DSOGR. Component and element ratings are used for asset management; however, component level ratings are used for reporting purposes, in accordance with FHWA requirements. Each component of a bridge is

classified using a number from 0 to 9, based on overall condition and performance, with an example rating shown in figure 2-3.

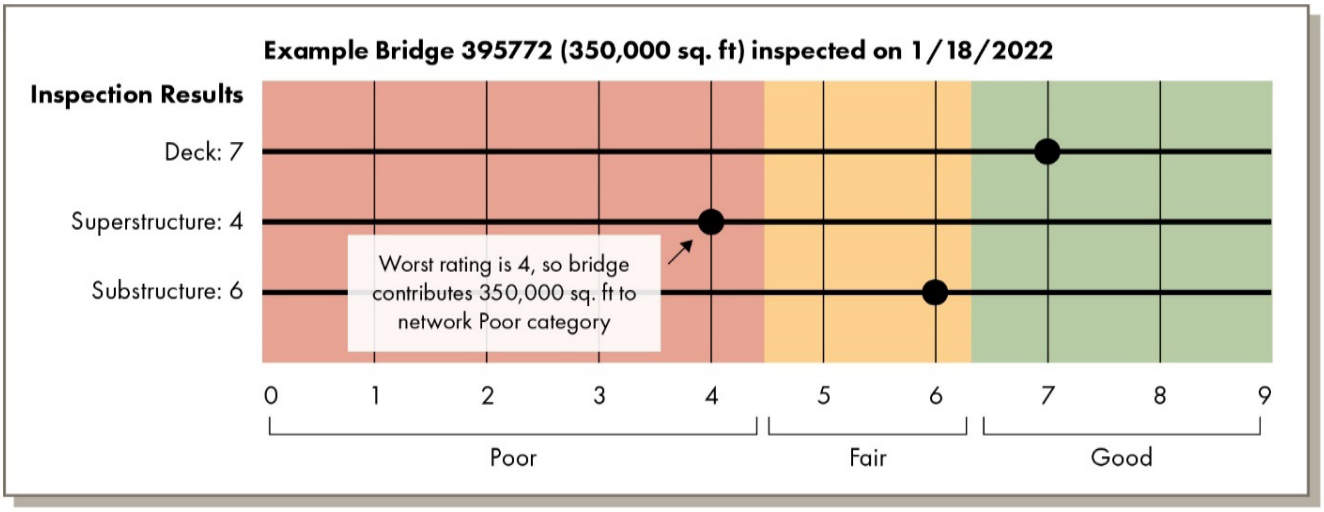


Figure 2-3. Example of a bridge performance rating.

In general, the ratings can be described as follows:

- **Good** (7, 8, and 9) – Good to excellent condition with minor problems at most.
- **Fair** (5 and 6) – Fair to satisfactory condition. Primary structural elements are sound, but minor problems are observed that may indicate the need for repairs or preservation work.
- **Poor** (0 through 4) – Poor to failed condition. Advanced deterioration that needs repair, rehabilitation, or reconstruction, with potential effects on the public such as a need to restrict or close the structure.

NDDOT and the FHWA monitor systemwide bridge performance by recognizing the lowest of the three component ratings on each bridge or culvert rating. From this information, two performance measures are tracked over time and form the basis of performance targets:

- **%Good** – Percent (as measured by total deck area) of structures with a lowest component rating of Good.
- **%Poor** – Percent (as measured by total deck area) of structures with a lowest component rating of Poor.

By these measures, larger bridges have a greater effect on network condition. They also tend to affect more road users and cost more to maintain and repair.

Bridge Goals

NDDOT inspects all NHS and state-owned bridges on a periodic basis, typically every 2 years. In the past 4 years the Department has significantly enhanced its inspection data quality, including full implementation of the American Association of State Highway and Transportation Officials (AASHTO) Manual for Bridge Element Inspection. This enhanced manual places particular emphasis on protective elements, such as deck wearing surfaces and paint systems, with the goal of protecting the more expensive underlying structural material.

NDDOT establishes a variety of criteria related to condition, safety, and mobility, which govern decisions about bridge maintenance, preservation, rehabilitation, functional improvement, and replacement. For condition, the Department's goals are expressed in the form of targets that are on three different time scales, as shown in table 2-3. The percent *Good* target is considered to be the minimum acceptable, while percent *Poor* target is the maximum acceptable. The long-term target is considered to be the DSOGR that the Department intends to maintain over a time frame of 10 years or longer.

Table 2-3. Bridge goals.

Network	2-year target	4-year target	DSOGR
SHS	N/A	N/A	50% Good 5% Poor
NHS	50% Good 10% Poor	50% Good 10% Poor	Included within SHS

FUNCTIONAL CAPACITY

Functional Capacity Measures

NDDOT manages the effectiveness of its highway system, independent of physical condition, by monitoring functional capacity of the system for providing freight and personal mobility. Functional capacity is determined based on physical and operational characteristics of both roadways and structures that hinder the efficient movement of people and goods (i.e., "deficiencies"). Examples of such deficiencies include load-carrying capacity, width and height clearances, and/or traffic saturation levels that do not meet expected limits. NDDOT uses a custom-developed Freight and Personal Mobility model to develop and publish the freight constraints map. A sample of this map is shown in figure 2-4.

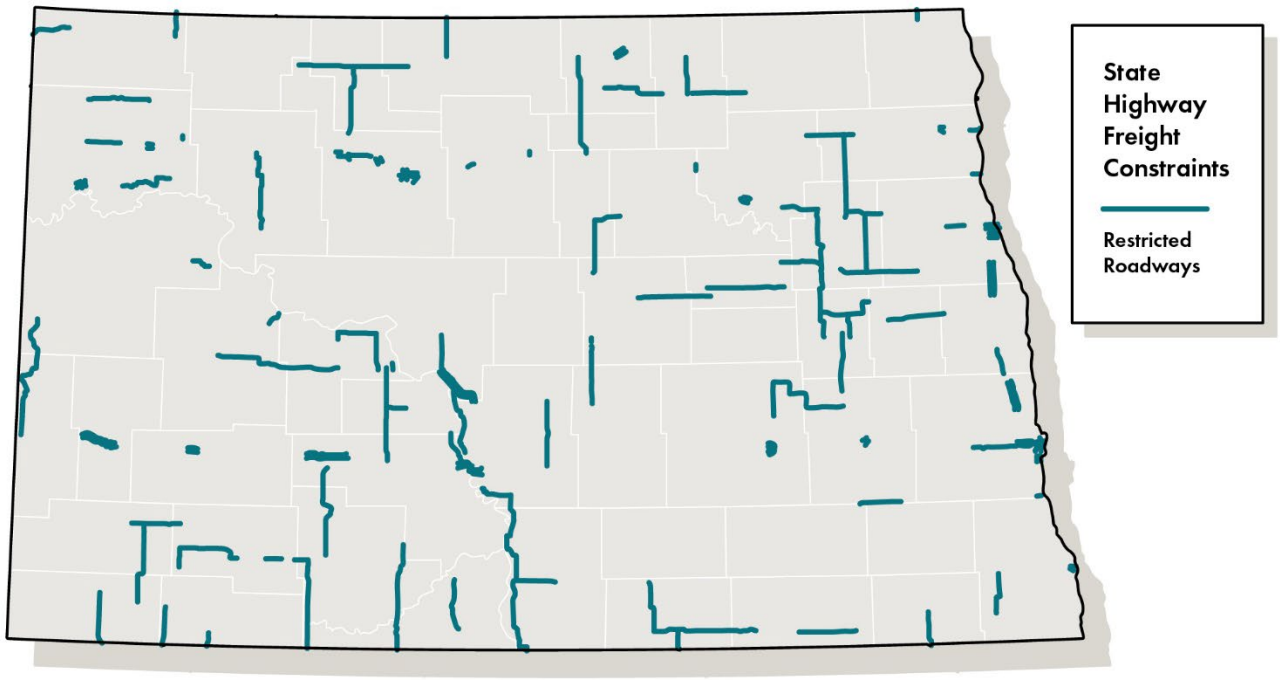


Figure 2-4. Sample freight constraint map.

Functional Capacity Goals

NDDOT has established a DSOGR for functional capacity of zero restrictions. While no short-term target has been established, NDDOT uses the Deighton Total Infrastructure Management System (dTIMS) to identify opportunities that address functional capacity. The Functional Capacity model is used to recommend prioritized freight projects and provide an understanding of the impact of increased or decreased funding to establish a balance between pavement conditions and functional capacity.

IDENTIFYING OPPORTUNITIES AND RISKS TO ACHIEVING OUR GOALS

Achieving NDDOT's long-term goals and DSOGR requires identifying investments that support sustainable improvements in asset conditions over the long term. Investment decisions are made with the best available information and forecasts of future performance. However, there are risks or uncertainties that could cause future performance to differ from predictions. Some risks could serve as opportunities to enhance NDDOT's efforts, while others could threaten NDDOT's ability to achieve its goals and objectives. These risks and uncertainties stem from the seven major risk categories shown in figure-2-5.

Figure-2-5. Major risk categories.

NDDOT has incorporated risk assessment into the TAMP to plan for any disruptions, anticipate opportunities, and mitigate any consequences more effectively. Through the process described in Appendix B, NDDOT has identified several risks within each risk category that can affect NDDOT's ability to fulfill its TAMP goals. Some of the risks or uncertainties, such as climate change, present a threat to NDDOT's goal of a well-maintained transportation infrastructure, while others, such as increased federal funding, present an opportunity to achieve goals faster. The process of identifying and addressing risk is shown in figure 2-6. A complete list of all risks identified, along with their mitigation strategies, are

presented in a risk register in Appendix B. Some of the individual risks and mitigation strategies are also referenced in the chapters of the TAMP that they impact.

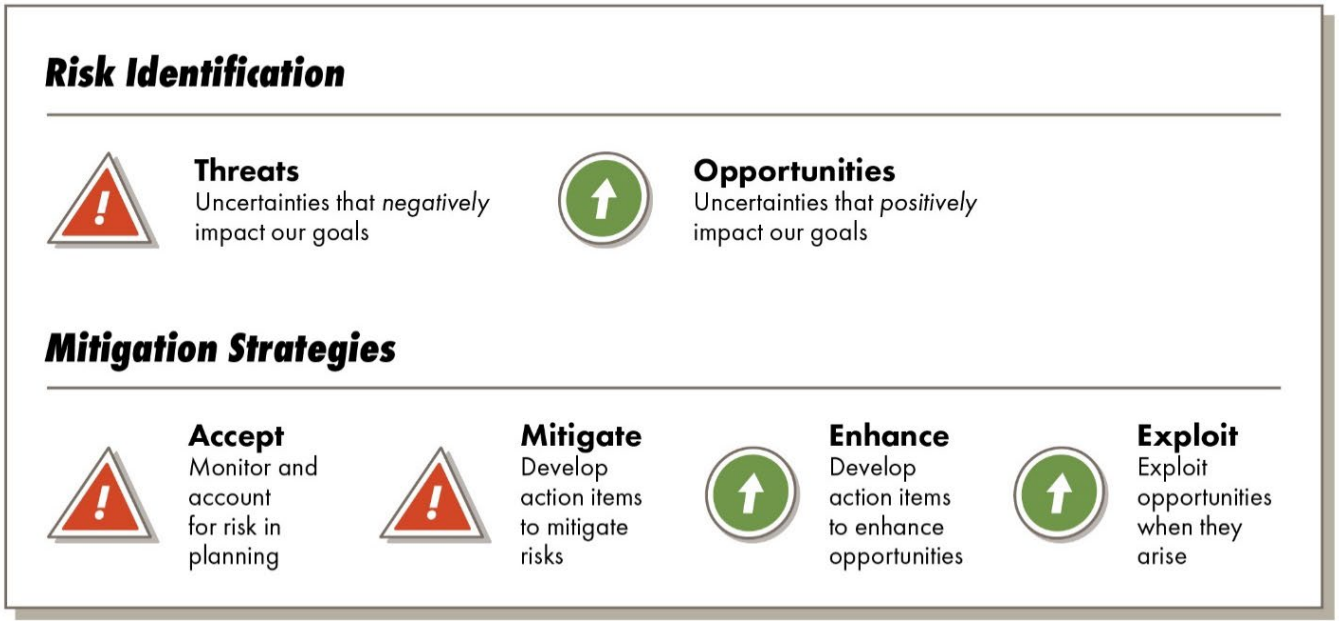


Figure 2-6. Process of identifying and addressing risks.

The risk assessment identified more threats than opportunities for NDDOT. The identified mitigation strategies should help minimize the impact of those threats. The main threats to the agency are:

- **Inadequate state funding resources –** these resources do not have a stable, permanent funding source.
- **Construction industry capacity and availability –** the lack of availability of contractors and skilled labor and their capacity and interest to take on preservation work may reduce the number of bidders, increase bid prices, and lower the quality of contractors.
- **Consultant availability and capabilities –** few consultants are qualified to design structures and deliver quality plans in a timely and cost-effective manner.
- **Agency's staffing and personnel management –** an adequate number of qualified staff may be unavailable to manage the program, or plan, design and deliver the projects.
- **Federal funding fluctuations and timing –** the TAMP relies on having federal funds to meet plan assumptions and asset management needs.
- **Information Technology (IT) capability limitations –** the TAMP relies on support from IT relative to data management, modeling, and cost estimating to make informed decisions to effectively manage our assets.
- **Severe Weather and Geotechnical Conditions –** NDDOT recognizes the increase in severe weather in the state as well as risks to geological landscape due to climate change, which

can impact critical assets, including pavement and bridges. This aligns with federal regulation, 23 CFR Part 667, which is further defined in Appendix C.

The primary opportunity identified in the risk assessment workshop is:

Communication with Customers and Leadership – the TAMP provides an opportunity to communicate with customers, stakeholders, decision-makers, advocacy groups, and representatives about the benefits of asset management, needs for funding the program, and the return on investment for use of available funds.

Chapter 3: Managing Our Assets for the Long Haul – Life Cycle Planning

Transportation infrastructure assets deteriorate over time due to many factors such as traffic loading, weather, and material and construction quality. Figure 3-1 illustrates the typical life cycle of an asset, where different treatments are applied at different times over the life of the asset. Life-cycle planning (LCP) is a process used to determine the cost of managing an asset network over its whole life at the lowest practical cost while preserving or improving asset conditions.

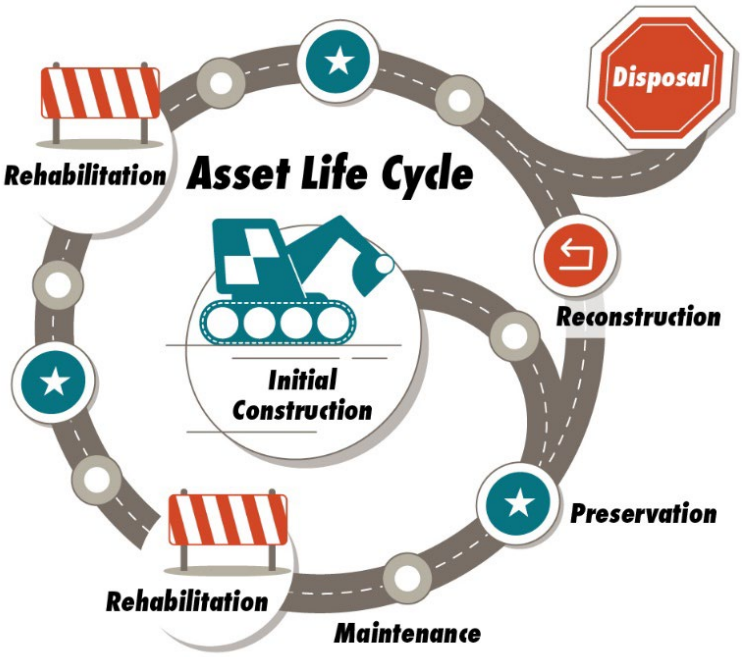


Figure 3-1. Asset life-cycle stages.

MANAGING PAVEMENTS

Deterioration, Treatments, and Costs

Pavement condition deteriorates over time because of exposure to factors such as traffic loadings; environmental impacts; construction quality; asphalt, concrete, and aggregate material properties; subgrade soil quality; maintenance magnitude and frequency; and human factors. NDDOT considers the impacts of these factors in pavement life-cycle planning and performance forecasting to determine the most cost-effective investment strategies to maximize pavement life.

Figure 3-2 presents a conceptual illustration of pavement deterioration and the impact of pavement preservation. When applied to pavement at the right time, preservation actions help extend asset life at a fraction of the cost of more expensive treatments.

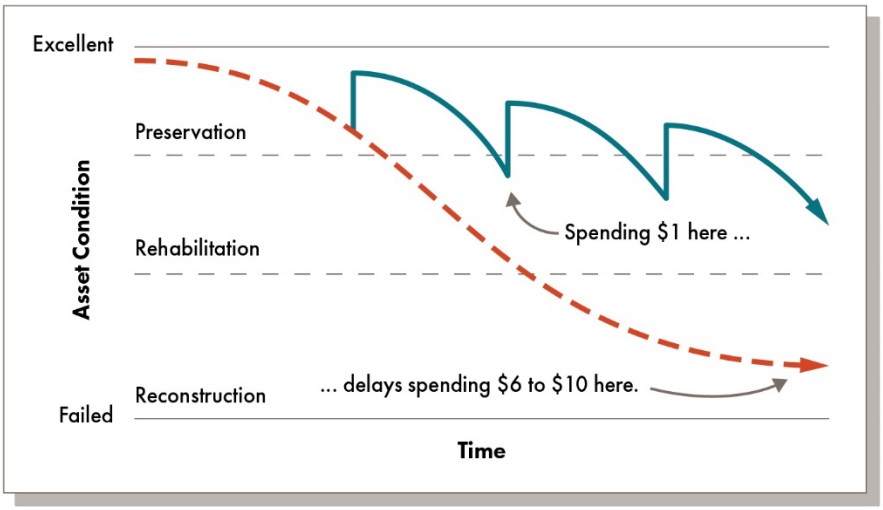


Figure 3-2. Example of pavement deterioration and treatment impacts.

NDDOT has developed pavement performance models to forecast pavement deterioration over time, to understand the impact of various treatment actions on pavement condition, and to determine the most cost-effective life-cycle strategies.

The performance models are routinely evaluated to determine if the deterioration rates need to be adjusted to better match ground truth. One example of such an event was the oil boom in 2015-2016, which led to a significant increase in truck traffic in the western part of the state that contributed to an accelerated rate of pavement deterioration. A summary of the performance models used in NDDOT's PMS is provided in Appendix D.

NDDOT currently does not have a maintenance management system (MMS), and thus, does not track routine pavement maintenance activities. However, historical funding levels for routine maintenance have been fairly consistent. Minor maintenance activities (such as crack sealing and pothole patching) are performed through in-house forces, and NDDOT typically hires contractors for major maintenance work (e.g., chip seals, slurry seals).

NDDOT classifies pavement treatment activities into six different categories, as shown in table 3-1. Unit costs for treatments used by NDDOT are presented in Appendix D. The unit costs are annually updated based on actual project costs, which include construction, engineering, material, and installation costs.

Table 3-1. Pavement treatment work types defined by NDDOT.

New Construction / New Alignment	Reconstruction	Major Rehabilitation	Structural Improvement	Minor Rehabilitation	Preventive Maintenance
▪ 2-lanes ▪ 4-lanes	▪ Portland cement concrete (PCC)	▪ Full depth reclamation ▪ Concrete overlay ▪ Asphalt overlay	▪ >3 inches ▪ Concrete overlay ▪ Mill and Asphalt overlay	▪ 2 to 3 inches ▪ Mill and Asphalt overlay	▪ <2 inches ▪ Thin overlay ▪ Asphalt overlay ▪ Chip seal ▪ Slurry seal

NDDOT's PMS uses treatment decision trees based on highway classification and pavement type. Some of the factors used in the decision trees to identify suitable treatments include traffic, fraction of design life utilized, roadway width, and pavement performance indicators, e.g., IRI, cracking, rutting, structural index (asphalt-surfaced pavements), and slab cracking index (concrete pavements).

Treatment application benefit is determined using the "area under the curve" method within the PMS. IRI is the primary performance indicator used in the benefit calculation model. The model estimates the difference in pavement condition between a "do nothing" strategy and the resultant pavement condition after applying a specific treatment strategy. The benefit calculation model also considers a traffic factor that has currently been set up to allow for higher benefits for treatments placed on higher traffic volume roadways. Additional information on the benefit calculation model is provided in Appendix D.

Life Cycle Strategies

NDDOT uses dTIMS for pavement management analyses. For a chosen analysis period, dTIMS generates all feasible treatment strategies (i.e., a sequence of treatments over a chosen analysis period) for each pavement segment in the PMS using the programmed performance models and decision trees. Once a budget level is applied, dTIMS then selects the most cost-effective treatment strategy based on a network-level benefit-cost analysis. Over the years, NDDOT has customized the decision trees and other analysis parameters used in dTIMS to generate practical and realistic treatment recommendations that support the implementation efforts. NDDOT periodically reviews these decision trees and other analysis parameters and updates them as needed. NDDOT's current strategy is a preservation-focused approach that prioritizes the application of preventive maintenance treatments on pavement in *Fair* or better condition. This approach has provided the greatest return on investment to NDDOT in terms of managing the pavement network in the best possible condition at the lowest practicable cost.

For this TAMP, NDDOT has considered a 20-year analysis period and evaluated the impact of three different budget scenarios on pavement life cycle strategy and resulting condition. With changes in budget, dTIMS determines the best mix of funding and life cycle strategy for each pavement segment, given the available funds. Figure 3-3 shows a comparison of the strategies determined by dTIMS for the three funding scenarios. Although NDDOT is facing a decline in pavement condition due to the age of much of its network, dTIMS still recommends a long-term emphasis on preservation, with at least 60 percent of the budget dedicated to preventive maintenance treatments in all three scenarios.

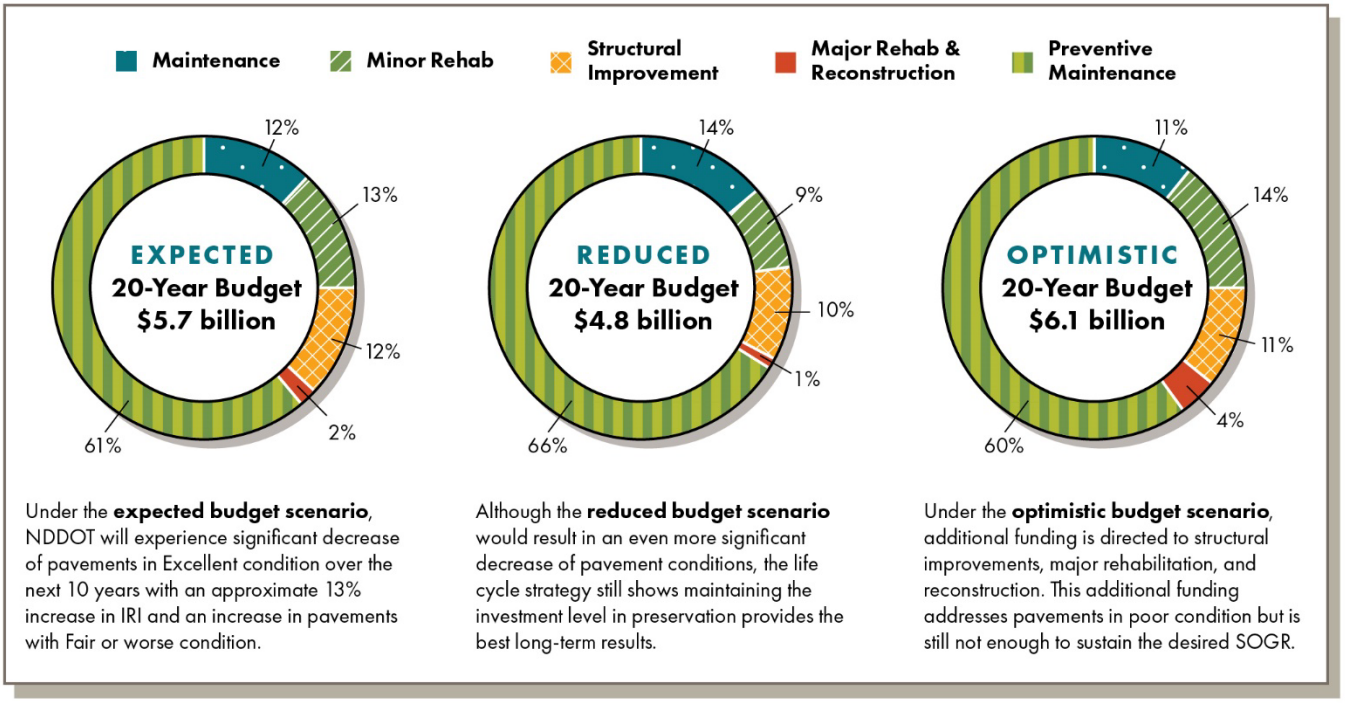


Figure 3-3. Comparison of budget scenarios by work types.

Figure 3-4 shows the 10- and 20-year forecasted conditions for each LCP scenario. The forecasted conditions from the expected scenario are very similar to the optimistic scenario. This suggests that a long-term commitment to preservation is a cost-effective means of addressing pavement conditions without an increase in pavement funding.

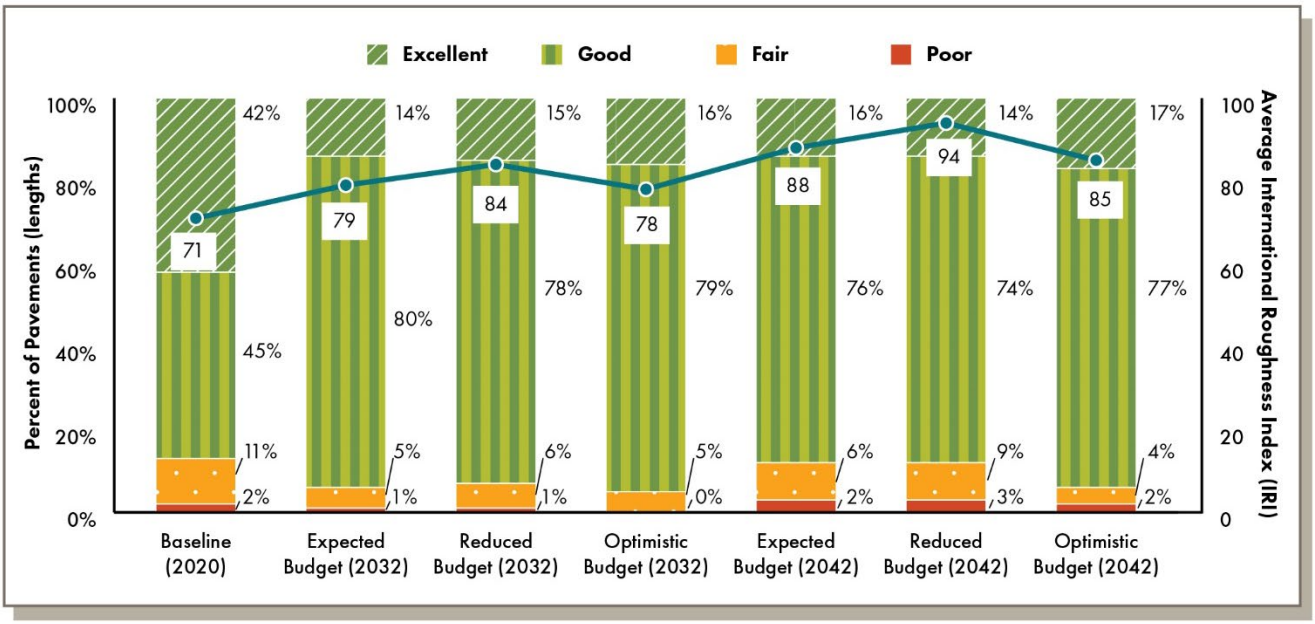


Figure 3-4. Forecasted pavement conditions for each life-cycle scenario.

MANAGING BRIDGES

Deterioration, Treatments, and Costs

The key to timely and cost-effective bridge preservation is the accurate forecasting of deterioration. All bridge elements gradually deteriorate under the influence of weather, traffic, and chemical attack. NDDOT, with its newly enhanced element level data, is cooperating with a consortium of twelve Midwest states to develop computer models of bridge element deterioration to significantly improve the accuracy of condition forecasts. The models quantify the annual probability of changes in condition in subsets of the bridge inventory, reflecting unique characteristics of the materials, location, and operating environment of each bridge. All common mechanisms of deterioration are considered, including concrete delamination and spalls, corrosion, cracking, collision damage, distortion, settlement, scour, and expansion joint damage. To prevent and respond to these deterioration processes, the Department has a variety of treatments at its disposal as shown in table 3-2.

Table 3-2. Bridge treatment work types defined by NDDOT.

Routine maintenance	Preservation	Rehabilitation	Reconstruction
▪ Cleaning and lubrication ▪ Sealing and filling ▪ Silane surface treatment	▪ Minor repair and local replacement ▪ Partial or complete repainting ▪ Cleaning, patching, and filling ▪ Repair of drainage system, joints and seals, erosion, and scour countermeasures ▪ Leveling of approach slabs and alignment of bearings	▪ Partial or complete replacement of decks and/or approach slabs ▪ Replacement of expansion joints, railings, and/or drainage systems ▪ Partial or complete replacement of primary structural elements and/or bearings ▪ Invert paving or slip lining of culverts ▪ Widening, strengthening, or raising to correct safety or mobility deficiencies ▪ Alterations to bridge or waterway to mitigate risk or improve resilience	▪ Complete replacement

In its financial and contract management systems, NDDOT gathers data on the costs of these various treatments that have been incurred by Department forces or contractors. By analysis of historical work orders and bid tabulations, in the past year, the Bridge Division has been able to significantly refine unit costs of treatments as they relate to bridge characteristics.

Figure 3-5 illustrates the life extension benefits of a preservation strategy on a typical bridge. In a replacement-only strategy, only the bridges in worst condition are replaced. A preservation strategy features ongoing routine maintenance and periodic preservation or rehabilitation work to interrupt the pattern of deterioration. The potential of a preservation strategy for extending the life of the bridge is significant, with this example representing the extension of the lifespan from 50 years to nearly 80.

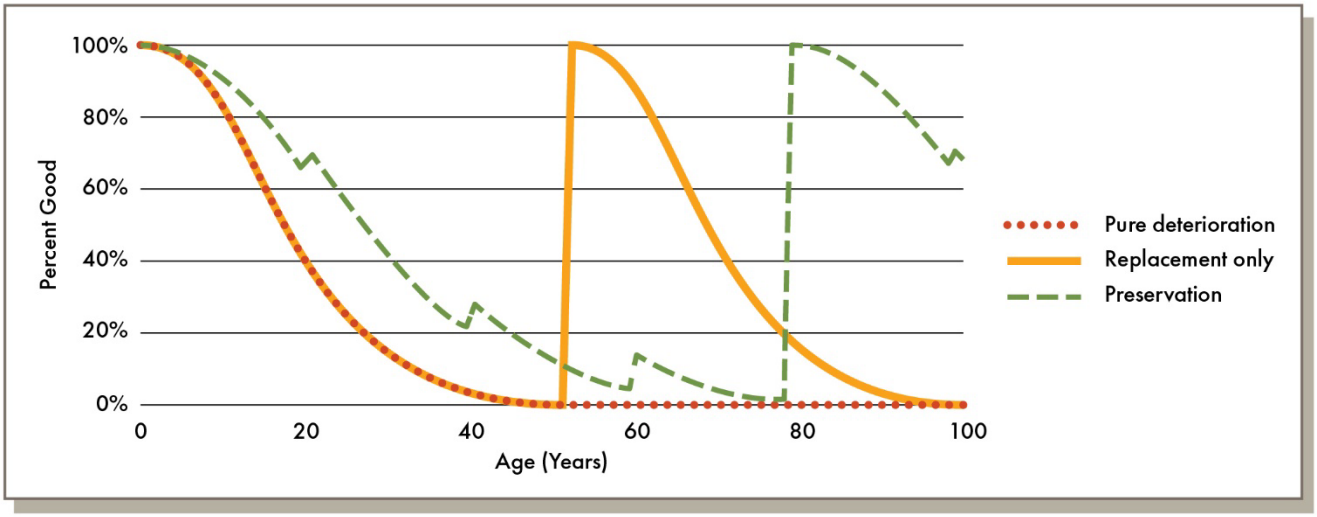


Figure 3-5. Life extension benefits of a preservation strategy.

Life Cycle Strategies

The Department manages its bridge inventory and condition data, deterioration models, and cost models in its AASHTOWare bridge management system (BrM). As an extension of BrM, NDDOT also uses StruPlan, an open-source spreadsheet program for long-range renewal planning for transportation structures. Using StruPlan to estimate the cost to maintain current conditions for the entire North Dakota inventory (all NHS and state-owned bridges), it was found that a sustained investment of $76 million per year is necessary to keep up with deterioration under an optimized preservation scenario. Approximately 47 percent of this cost is preservation work. To achieve the same results under a replacement-only, worst-first scenario would cost $110 million per year. The $34 million in annual cost savings implies a 96 percent return on the preservation investment.

A key tradeoff analyzed in the bridge management system is the benefit of timely low-cost preservation work as a means of reducing or delaying long-term costs of rehabilitation and replacement. StruPlan evaluates this tradeoff for each element of each bridge to generate an optimized 10-year program of projects, with network level expenditure plans and outcome forecasts.

Another key tradeoff is the ability of bridge risk mitigation actions to improve the resilience of the transportation network, protecting it from certain hazards such as scour, flooding, and damage from over-height or over-weight vehicles. The StruPlan models evaluate the likelihood and consequences of these risks, using the methodology in the AASHTO Red Book to quantify the road user benefits of risk mitigation. The treatments, costs, and benefits of cost-effective work are included in the scoping and prioritization of rehabilitation and reconstruction investments considered in StruPlan.

For the 2022 TAMP, NDDOT has considered a 10-year analysis period to forecast bridge condition and evaluate the impact of three different budget scenarios (see figure 3-6). With changes in budget, StruPlan determines the best mix of funding and life cycle strategy for NDDOT's bridge inventory. The analysis demonstrates the need to perform reconstruction of bridges in *Poor* condition to meet performance targets and support a safe and efficient highway network. As overall funding increases between the scenarios, StruPlan recommends increasing the percentage of funding directed toward rehabilitation, preservation, and maintenance.

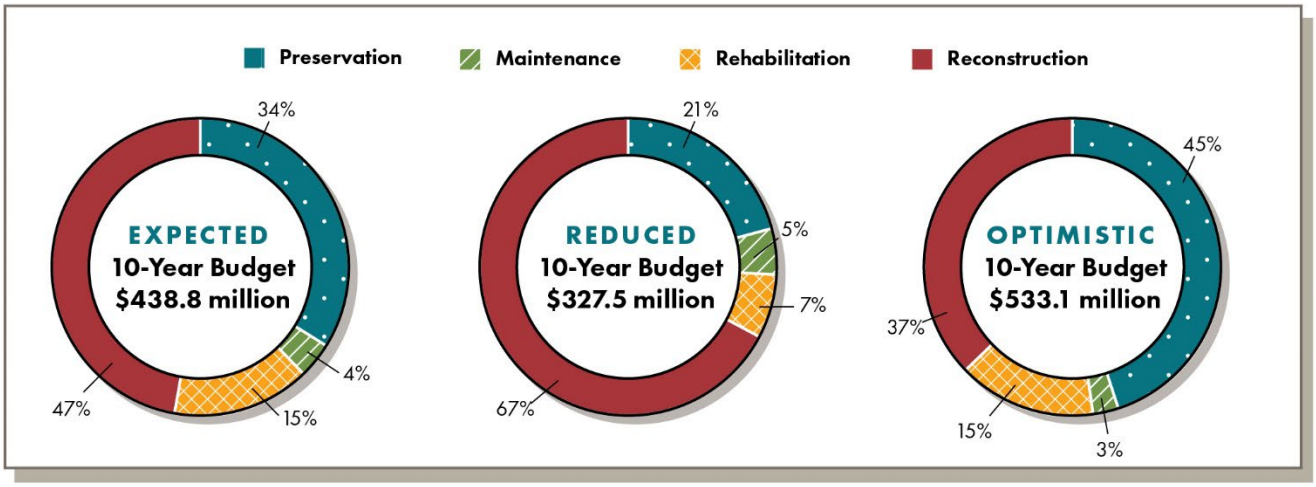


Figure 3-6. Comparison of budget scenarios by work type.

Figure 3-7 shows the initial condition of NDDOT's bridge network (in 2020) and the forecasted conditions for each LCP scenario investigated.

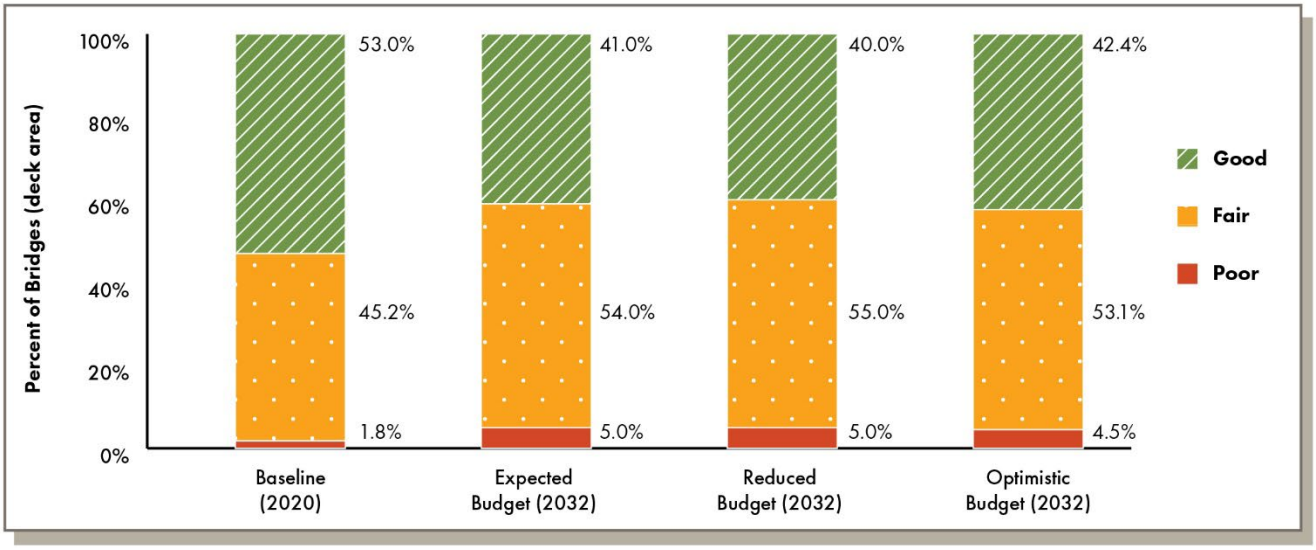


Figure 3-7. Comparison of all state-owned bridge scenarios in terms of 10-year forecast conditions.

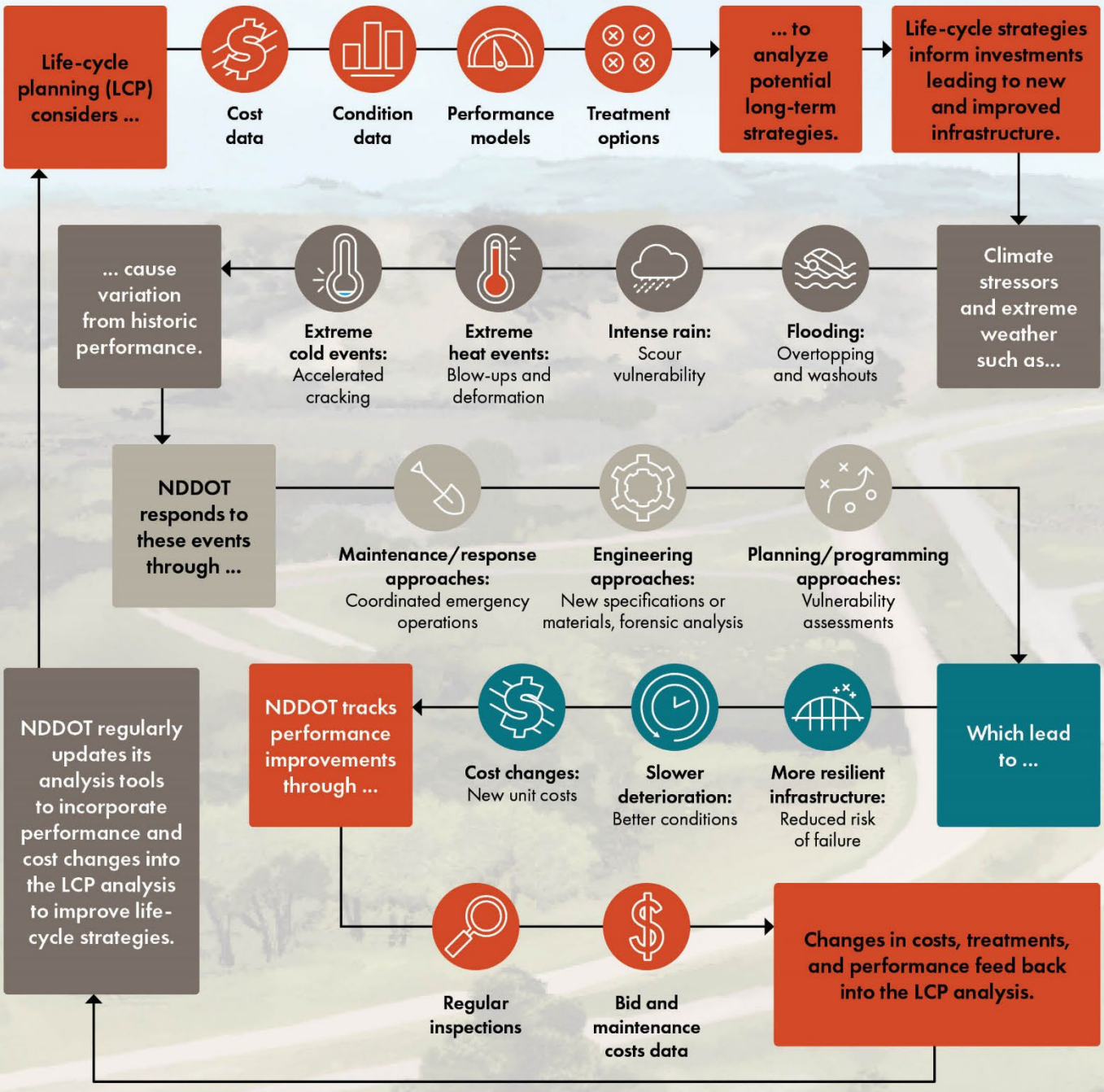
The key takeaways from Figure 3-7 are summarized below. The results are based on analysis of the full NDDOT inventory of bridges.

- Under the expected budget scenario, NDDOT will experience about a 12 percent decrease in the percentage of *Good* bridges over the next 10 years.
- Under the optimistic budget scenario, NDDOT will be able to maintain a steady-state condition by dedicating the additional funding to the reconstruction of bridges in *Poor* condition.
- The impact of reduced budget scenarios on bridge conditions do not appear significant in the short term because the overall investment in reconstruction remains steady. Budget reductions are applied to maintenance and preservation, which have less impact on short-term conditions.

CONSIDERING RESILIENCE IN LIFE CYCLE COST ANALYSIS

Both the pavement and bridge life cycle planning processes consider a number of factors that impact asset conditions and the agency's ability to address conditions through intervention activities. These factors include deterioration rates, traffic loading, environmental impacts, and costs. While the scenarios described above did not directly evaluate changes in these inputs, the inputs are tracked and adjusted over time to reflect future expectations based on historic records. The infographic on the next page describes how considerations for resilience to extreme weather and other environmental stressors are incorporated into the LCP analysis. This allows NDDOT to enhance the resilience of the highway system while directing investments to achieving long-term goals through effective use of life cycle cost analysis.

CONSIDERING RESILIENCE IN LIFE-CYCLE PLANNING



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Chapter 4: Paying Our Way – The Financial Plan

The TAMP financial plan outlines available funding sources and anticipated future funding to maintain pavement and bridges in North Dakota. As shown in table 4-1, to fully replace NDDOT's current system, as is, would cost nearly $12.6 billion on the NHS and nearly $21.7 billion on the entire SHS in 2022 dollars. Figures 4-2 and 4-3 show the funding expected to be available to address NDDOT's asset management needs. As described in Chapter 6, this level of funding is expected to be sufficient to sustain the condition of NDDOT's pavement and bridge assets above the agency's condition targets, thus sustaining the value of those assets, including the NHS.

Table 4-1. Pavement and bridge asset replacement value (in millions of 2022 dollars).

Asset	NHS	Non-NHS	Total SHS
Pavement	$10,963	$8,107	$19,070
Bridge	$1,589	$1,022	$2,611
Total	$12,552	$9,129	$21,681

NDDOT'S FUNDING SOURCES

As shown in figure 4-1, NDDOT receives funding from a variety of federal, state, and local sources. The amounts shown in the figure are based on NDDOT's 2021–2023 Biennium Revenue.

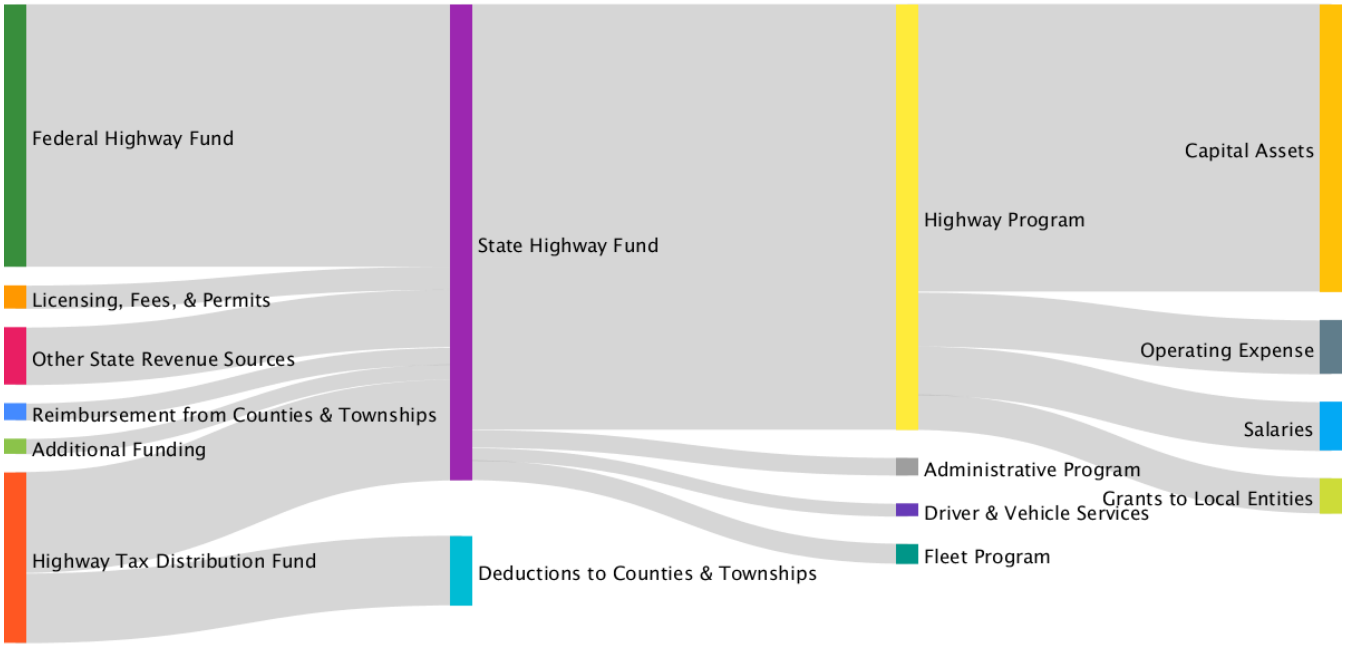


Figure 4-1. Typical sources and uses of North Dakota highway funding.

The largest sources of revenue are Federal highway funds and State taxes. These funds are used to support the asset management program as well as other programs and administrative costs. TAMP

investments are a portion of the capital asset investments. Although the diagram is based on what the legislature has authorized for the next 2 years, it is representative of typical funding sources and expenditures.

For the 2021–2023 biennium revenue budget, NDDOT received approximately $1.6 billion in total highway funding. Around 55 percent of NDDOT's total budgeted revenues comes from federal sources. The remaining 45 percent come from the highway tax distribution fund (motor vehicle fees and fuel taxes, of which more than 40 percent is distributed to counties and townships), licensing, fees and permits, other state revenue sources (e.g., fleet services and financial account interest), reimbursement from counties and townships, and additional funding to ensure NDDOT has adequate matches for federal funding. Although North Dakota lacks a dedicated funding source, the State is dedicated to matching federal funding on pavement and bridge assets.

Roughly two-thirds of the highway program is available for capital assets.

- In the 2021–2023 biennial budget, capital assets accounted for about $970 million. These capital assets include the NDDOT buildings and facilities, in addition to the SHS infrastructure.
- The remainder of the highway program is directed to operating expenses, salaries, and grants to local entities.

NDDOT's biennial budget is established through North Dakota's legislative session. While NDDOT proposes investments into various programs, including asset management, appropriation setting authority rests with the state legislature. Based on the 2023–2026 Distribution of Obligation Authority (OA) document, NDDOT can obligate approximately 64 percent of the total funding available for capital assets to asset management.

NDDOT's revenue for managing and improving assets, including bridges and pavements on the NHS and the SHS, to a state of good repair comes through a combination of federal and state funds. Nearly all revenues for the routine maintenance of the NHS and the SHS come from state sources.

ANTICIPATED FUTURE FUNDING

NDDOT has forecasted future funding available to TAMP investment strategies for fiscal years 2023 to 2032 (see figure 4-2). Approximately $310 million to $360 million are expected to be available annually to TAMP investments, which is about 61 percent of the $500 million to $590 million in total state and federal funding available annually. The rest goes to other investment priorities, including safety, operations, and capacity improvements.

Funding forecasts include federal funding that North Dakota anticipates receiving in fiscal years 2023 through 2026 under the Bipartisan Infrastructure Law (BIL), subject to NDDOT's obligation authority, and distributed to programs related to TAMP activities. They also include estimated annual redistributions based upon the amount North Dakota received in past years. NDDOT programs funds to fully take advantage of any federal redistributions received. Funding for future fiscal years (2027 to 2032) is assumed to be consistent with funding under BIL and grow by 2 percent per year. This funding growth is consistent with the BIL and historical growth in North Dakota transportation funding.

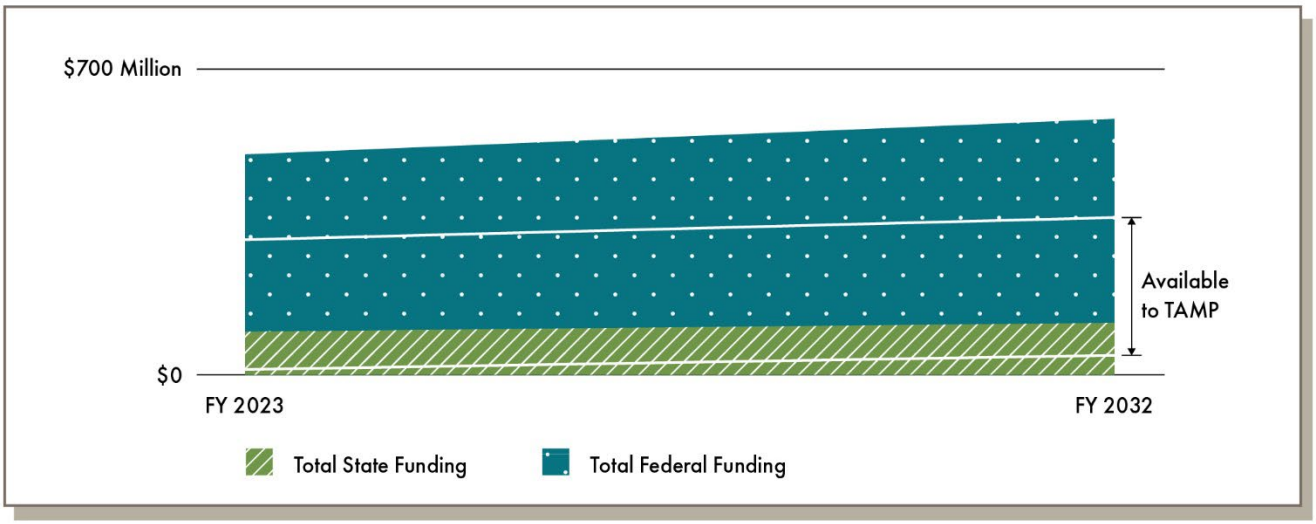


Figure 4-2. Forecast of federal and state funds for capital assets.

As identified in the risk register for the TAMP, there are several threats and opportunities that could influence the availability of future funding:

The passage of the BIL provides an opportunity for NDDOT to receive more federal funding for transportation projects. The BIL represents a 30 percent increase in federal funding, but this increase may not be available in future years.

Federal funding has fluctuated in recent years and the timing of federal funding is subject to Congressional authorization.

North Dakota lacks a dedicated funding source for transportation, and NDDOT may have inadequate state funding resources in the future, particularly to match increased federal funding under the BIL. For example, state revenues varied dramatically with the oil boom and bust. However, the Legislature has historically allocated funding to match federal funding and is expected to meet any funding gap.

NDDOT is committed to pursue all available federal grant opportunities to improve North Dakota's transportation infrastructure.

Future reduction in material availability and accompanying cost increases could reduce the purchasing power of available funding.

NDDOT estimates that the majority of TAMP funding will be dedicated to pavement work. Figure 4-3 shows the typical breakdown of TAMP funding by NDDOT investment class. This breakdown of funds is consistent with the investments identified for the expected scenario during life-cycle planning, excluding routine and cyclical maintenance. Maintenance expenditures, such as pavement surface sealing and bridge maintenance, performed by Districts (both cyclical and condition based) are excluded from the funding diagram because they are part of the maintenance budget, which is not included in the Tradeoff Hub analysis. Additional information on the Tradeoff Hub analysis process is included in Chapter 7. The PMS and BMS each assume that maintenance treatments are conducted appropriately. Expected maintenance costs are included in the investment strategies described in Chapter 5.

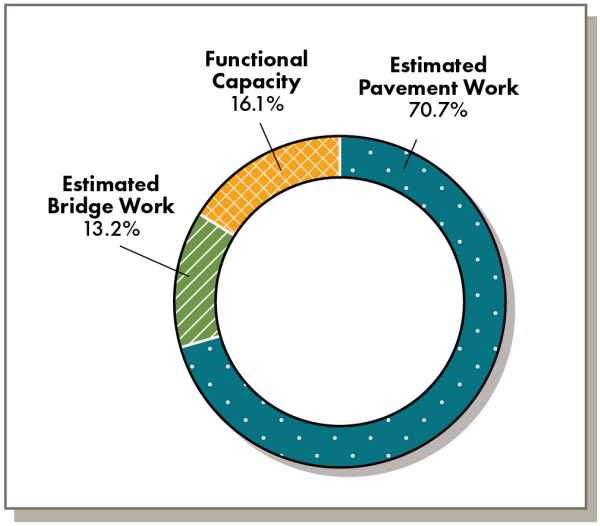


Figure 4-3. Typical breakdown of asset management funding by NDDOT investment class.

Table 4-2 provides a forecast of asset management funding for the next 10 years by NDDOT investment classes, included in the Tradeoff Hub analysis. This table excludes routine maintenance activities and seals, as these programs are funded before tradeoff decisions are made. Funding to improve facilities repeatedly requiring repair and reconstruction due to emergency events (US Code Part 667) is included within these totals, based on the assets involved.

Table 4-2. Forecasted asset management funding by NDDOT investment class (in $ million).

Year	Estimated Revenue	Estimated Pavement Work	Estimated Bridge Work	Functional Capacity
2023	$288.1	$203.7	$38.0	$46.4
2024	$294.2	$208.0	$38.8	$47.4
2025	$300.5	$212.4	$39.7	$48.4
2026	$306.9	$216.9	$40.5	$49.4
2027	$311.2	$220.0	$41.1	$50.1
2028	$316.4	$223.7	$41.8	$50.9
2029	$321.6	$227.4	$42.5	$51.8
2030	$327.0	$231.2	$43.2	$52.6
2031	$332.4	$235.0	$43.9	$53.5
2032	$338.0	$239.0	$44.6	$54.4

Chapter 5: Our Route to Success – Investment Strategies

Transportation Connection defines a five-part framework for meeting North Dakota's future transportation needs.

Keeping You Safe: *We are continually innovating and improving what we do to make sure you are safe and secure, whether driving, biking, or walking.*

Caring for What We Have: *We are maintaining our existing infrastructure in Good condition to save money down the road, and we are addressing risks to keep that system working for you.*

Connecting North Dakota: *We are leveraging transportation investments to enhance economic competitiveness and improve the quality of life in communities across the state.*

Helping You Get There: *We are helping make it more convenient for you to get where you want to go by improving data and information, travel choices and options, and operations and maintenance.*

Investing for the Future: *We are making smart investments in how we deliver services and are looking for responsible ways to fund our transportation system well into the future.*

The TAMP investment strategies directly support all these priorities by connecting the life-cycle strategies for pavements and bridges with NDDOT's planning and programming processes. This integrated planning and programming effort ensures that investments are focused on preserving the existing infrastructure and keeping NDDOT's highway system operating safely and efficiently.

PAVEMENTS & MOBILITY

Table 5-1 provides forecasted TAMP pavement funding by FHWA work type. This table includes maintenance funding, which consists of STIP investments as well as the planned maintenance allocations for the TAMP that come from state funding. The investment forecasts shown in table 5-1 represent the expected level of investment to deliver NDDOT's pavement lifecycle strategy and address functional capacity needs with the available funding. NDDOT uses the same software platform (dTIMS) with different models for both pavement management and functional capacity management. These models help identify opportunities for the rest of the prioritization process to consider.

The construction column includes both pavement and bridge construction activities. This is because construction of a corridor generally includes all asset classes. NDDOT includes capacity expansion of existing corridors as construction. The reconstruction work type is used to capture replacement of

pavement structure without significant capacity improvements. NDDOT is not planning any reconstruction beyond the current STIP, although individual projects may be scoped as such to address location-specific issues.

Table 5-1. Forecasted TAMP pavement funding by FHWA work type (in $ million).

Year	Maintenance	Preservation	Rehabilitation	Reconstruction	Construction*
2023	$45.8	$134.2	$69.5	$331.4	$43.1
2024	$46.3	$137.1	$70.9	$254.8	$31.3
2025	$46.9	$140.0	$72.4	$229.5	$25.0
2026	$47.4	$143.0	$74.0	$85.5	$33.1
2027	$48.3	$145.0	$75.0	$318.3	$33.8
2028	$49.3	$147.4	$76.3	$0.0	$34.5
2029	$50.3	$149.8	$77.5	$154.4	$35.2
2030	$51.3	$152.3	$78.8	$30.5	$35.9
2031	$52.3	$154.9	$80.1	$0.0	$36.6
2032	$53.4	$157.5	$81.5	$0.0	$37.3

** Includes new construction for both pavement and bridges.*

BRIDGES

Table 5-2 shows the expected future funding for all state-owned bridges by work type for each year of the TAMP. Year-to-year variations can occur in these work categories because of project readiness concerns, especially when dealing with the complexity of planning, design, environmental review, and market conditions. Since these variations are unpredictable on this time scale, the investment plan is expressed as an annual allocation with a regular annual increase for inflation. This table excludes bridge construction since that is included in table 5-1.

Maintaining a high level of *Good* condition in a bridge inventory requires a large allocation of resources to preservation activities, especially maintaining the integrity of coatings, wearing surfaces, and joint seals. The statewide plan calls for approximately 33 percent of the funding allocated to existing bridges to be spent on preservation.

Table 5-2. Forecasted TAMP bridge funding by FHWA work type (in $ million).

Year	Maintenance	Preservation	Rehabilitation	Reconstruction
2023	$3.0	$12.9	$5.7	$17.9
2024	$3.1	$13.2	$5.8	$18.3
2025	$3.1	$13.5	$5.9	$18.6
2026	$3.2	$13.8	$6.1	$19.0
2027	$3.3	$14.0	$6.2	$19.3
2028	$3.3	$14.2	$6.3	$19.6
2029	$3.4	$14.4	$6.4	$20.0
2030	$3.4	$14.7	$6.5	$20.3
2031	$3.5	$14.9	$6.6	$20.6
2032	$3.6	$15.2	$6.7	$21.0

MANAGING RISK

In order to preserve the existing infrastructure and keep NDDOT's highway system operating safely and efficiently, NDDOT must manage the risks to its transportation assets. As part of the TAMP risk assessment (as defined in Chapter 2), NDDOT identified the most critical risk threats to its assets and accompanying mitigation strategies to manage those risks.

Key mitigation strategies to manage NDDOT's high priority transportation risks include, but are not limited to:

- ***Increased Communication Internally and Externally*** – several risks are related to leadership and staff turnover, as well as transparency of asset operation and maintenance with the public. As such, NDDOT defined several mitigation steps to increase communication internally between staff and divisions, to better capture institutional knowledge, and to document key processes. Further, NDDOT will increase its communication in conveying the TAMP and corresponding planning assumptions during strategy reviews and budgeting processes.
- ***Improved Investment Prioritization and Decision Support Processes*** – the availability of funding to maintain appropriate asset condition and DSOGR was highlighted in several risks. As such, NDDOT plans to review and improve its current approaches to prioritizing investments for assets based on asset maintenance records, condition, and criticality, as well as ensuring the processes are well-defined and repeatable.
- ***Incorporate Extreme Weather Resiliency and Responses to Emergency Events*** – as a result of climate change impacts, NDDOT is exploring enhancements to its design standards to address weather-related impacts and will conduct geotechnical investigations to identify potential hazards to its transportation assets. This mitigation strategy specifically addresses federal regulation, 23 CFR Part 667, which is further defined in Appendix C**.**

A complete list of all risks and their mitigation strategies are presented in a risk register in Appendix B.

Chapter 6: The Road Ahead – Performance Gap Analysis

NDDOT is confident that its investment strategies represent the best use of available funding to support infrastructure conditions and performance over the long term. The performance gap analysis provides a comparison of the conditions expected to be achieved though implementation of the investment strategies with NDDOT's short and long-term objectives.

Recognizing that the future is always uncertain, the performance gap analysis also includes potential future conditions, should funding levels or system usage differ from what is expected. To evaluate different potential futures, NDDOT incorporated the potential alternative futures defined in the State's current Long-Range Transportation Plan (LRTP), *Transportation Connection*, summarized in figure 6-1. NDDOT identified the potential outcomes under each future scenario compared to performance targets and the expected investment scenario. This information will be used in future years to help understand how the agency can adjust its investments to best address changing trends.

Figure 6-1. NDDOT future scenarios.

CURRENT CONDITIONS AND TARGETS

Pavements

Table 6-1 compares current pavement conditions to NDDOT's short term targets for the Interstate and non-Interstate NHS pavements and long-term DSOGR for SHS pavements. It can be seen that North Dakota pavements currently meet these targets. The targets and DSDOGR are based on the respective measures described in Chapter 2.

Table 6-1. Pavement targets.

Network	Measure	Baseline (2020)	2-year target	4-year target	DSOGR[1]
SHS	IRI	71	N/A	N/A	74.9
Interstates	IRI	58	N/A	N/A	74.9
	% Good	80.9%	75.6%	75.6%	N/A
	% Poor	0.1%	3%	3%	
Non-Interstate NHS	IRI	68	N/A	N/A	74.9
	% Good	64.1%	58.3%	58.3%	N/A
	% Poor	0.2%	3%	3%	

[1]DSOGR is average IRI for whole network, not minimum IRI by pavement segment.

Bridges

Table 6-2 compares current bridge conditions to short-term targets for NHS bridges and the DSOGR for SHS bridges. It can be seen that North Dakota bridges currently do not meet these targets. The targets and DSOGR are based on the respective measures described in Chapter 2.

Table 6-2. Bridge targets.

Network	Measure	Baseline (2020)	2-year target	4-year target	Desired SOGR
SHS	% Good	53.0%	N/A	N/A	50%
	% Poor	1.8%	N/A	N/A	5%
NHS	% Good	52.0%	50%	50%	Included within SHS
	% Poor	1.1%	10%	10%	

POTENTIAL ROUTES TO OUR GOALS

The transportation ecosystem has evolved significantly in North Dakota over the last 20 years, and new technological innovations will continue to transform the surface transportation system. While the future can be difficult to predict, NDDOT has developed four alternate future scenarios in its LRTP (as compared to their expected investments) to be better prepared for how to maintain and manage its existing transportation infrastructure assets over the long term. These scenarios, which are summarized in figure 6-1, reflect several factors:

- Growing, aging, and more diverse populations.
- Shifting industries and workspaces.
- Emerging technology and transportation innovations.
- Change in travel patterns and expectations.
- Increasing e-commerce and movement of goods.

Each of these scenarios envision a future with different population and business locations, travel demand, and infrastructure impacts than anticipated under the expected investment scenario. The condition of NDDOT's assets were modeled for each scenario and compared to an expected investment strategy, based on the financial plan outlined in Chapter 5.

Figure 6-2 summarizes each scenario, expected funding, and the potential for funding to meet asset management needs in North Dakota. Each scenario is assessed based on varied funding levels to see how the condition of North Dakota's pavement and bridges change, as well as the associated impacts on the functional capacity goals. The four alternative future scenarios are compared to the expected investment scenario, which assumes expected growth in terms of revenue and expenses, in addition to historical asset deterioration rates. While changes in travel under the alternative scenarios may impact deterioration rates, much of the deterioration is dependent on time and weather factors that could not be captured in the asset management systems.

PERFORMANCE GAP ANALYSIS RESULTS

SCENARIO	BRIEF DESCRIPTION	EXPECTED ANNUAL FUNDING	IMPACTS TO THE SYSTEM	IMPACTS ON PRIORITIES	10-YEAR PAVEMENT CONDITIONS	10-YEAR BRIDGE CONDITIONS	10-YEAR FUNCTIONAL CAPACITY	PERFORMANCE AND FINANCIAL IMPLICATIONS
Desired State of Good Repair	NDDOT's long-term objectives	N/A	N/A	N/A	DSOGR: ≤74.9 IRI 50 — 100	DSOGR Good: 50% DSOGR Poor: 5%	DSOGR: 100% Unrestricted 50% — 100%	N/A
Expected Investment Scenario	Planned growth of both asset utilization and available funding, based on average historical growth rates	Pavement: $208.5M Bridge: $39M Capacity: $47.5M	• Travel occurs as modeled in the asset management system	• Funding is split among pavements, bridges, and functional capacity as described in the Life Cycle Planning section	Expected: 81.3 IRI 50 — 100	Expected Good: 40.7% Expected Poor: 4.6%	Expected: 89.0% Unrestricted 50% — 100%	• Performance as described in the Expected Investment Scenario, starting on page 34 with no expected funding gap
Rural Renaissance	Economic activity is similar to expected future, but growth is focused in rural areas	Pavement: $230.2M Bridge: $30M Capacity: $34.8M	• Increased travel occurs in rural areas • Slightly increased deterioration of pavements • Greater investments needed for pavements	• Priorities shift to rural access and last-mile issues • More funding to pavement compared to bridges and functional capacity projects	↑	↓	↓	• Pavement conditions improve while bridge and functional capacity needs grow with no expected funding gap
Centers and Cities	Economic activity is similar to expected future, but growth is focused in urban areas	Pavement: $188M Bridge: $50M Capacity: $57M	• Increased travel in rural areas • Greater needs for functional capacity projects and bridge management in urban areas	• Priorities shift away from personal car travel • Last-mile issues in urban areas are addressed • More funding to bridges and functional capacity compared to pavement	↓	↑	↑	• Bridge conditions improve and more functional capacity is met, while pavement conditions decline with no expected funding gap
Ghost Towns	Significant reduction in economic activity statewide	Pavement: $164M Bridge: $30M Capacity: $34.8M	• Decreased use of system • Slight reduction in deterioration • Less funding will be generated for investment in the system	• Funding will be limited due to reduced economic activity • Less funding available for pavements, bridges, and functional capacity projects	↓	↓	↓	• Asset conditions decline with less funding and a financial deficit results as funding cannot keep up with needs
Smart and Connected	Economy is strong, but personal travel decreases	Pavement: $234M Bridge: $50M Capacity: $34.8M	• Decreased use of system • Available funding increases with economic growth • Investments focus on innovation and mobility	• Priorities shift to connected infrastructure investments and improving pavements and bridges • No need for functional capacity improvements	↑	↑	↓	• Asset conditions improve under the increased funding and reduced system use

Does the scenario meet or exceed the 10-year goal?

Expected Investment Scenario

The expected investment scenario models North Dakota's expected growth and asset usage over the next 10 years. Based on the financial plan outlined in Chapter 4, funding needs are based on average historical expected revenue and expenses, as well as historical asset deterioration rates. Figure 6-3, Figure 6-4, and Figure 6-5 display North Dakota's expected 10-year conditions for pavement, bridges, and functional capacity compared to their respective DSOGRs.

Even in the expected investment scenario, pavement and bridge conditions, as well as functional capacity in 10 years, will fall short of the 4-year performance targets. Specifically, there will be an approximately 5-point IRI shortfall for pavement, a 9 percent shortfall for bridges in *Good* condition between the bridge performance target (50%) and the expected 10-year condition (41.3%), and a 10 percent shortfall for functional capacity.

The resulting investment strategy implements the life cycle strategies, described in Chapter 3, providing long term and efficient use of funding. The following figures demonstrate the anticipated performance in terms of pavement condition, bridge condition, and functional capacity over the next 10 years. As shown in figure 6-3, NDDOT is expecting an initial decline in pavement conditions followed by gradual improvement. This initial decline is largely due to the overall age of the highway network. NDDOT's pavement investment strategy will support long-term sustainability of pavement conditions.

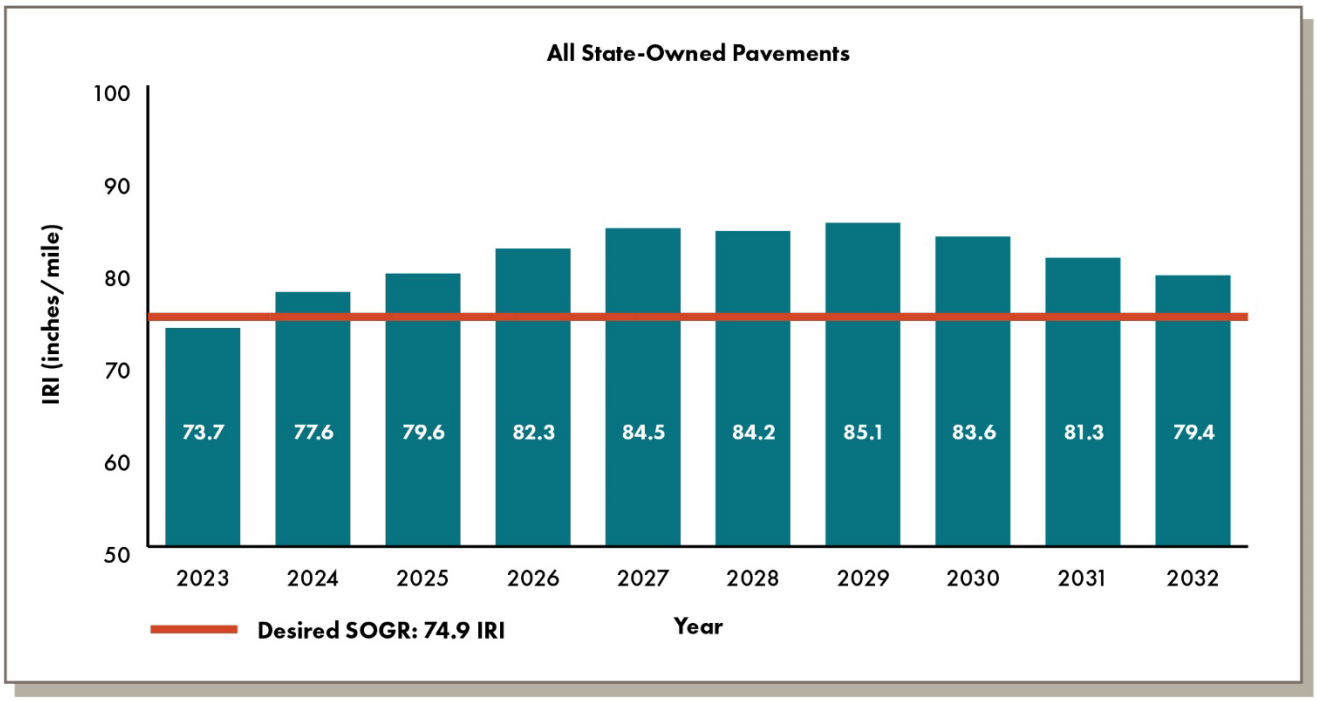


Figure 6-3. Pavement condition forecast.

Figure 6-4 shows details of bridge condition forecasts based on the expected investment scenario. Bridges are also expected to maintain a performance gap in terms of meeting the goal for the percentage of bridges in *Good* condition. While not meeting the DSOGR, this scenario represents the maximum level of bridge investment that NDDOT can deliver with available resources. The expected conditions will maintain relatively consistent overall system conditions and keep the system in a state

that can be improved for a reasonable future investment. However, this would require additional capacity to design and construct bridge projects.

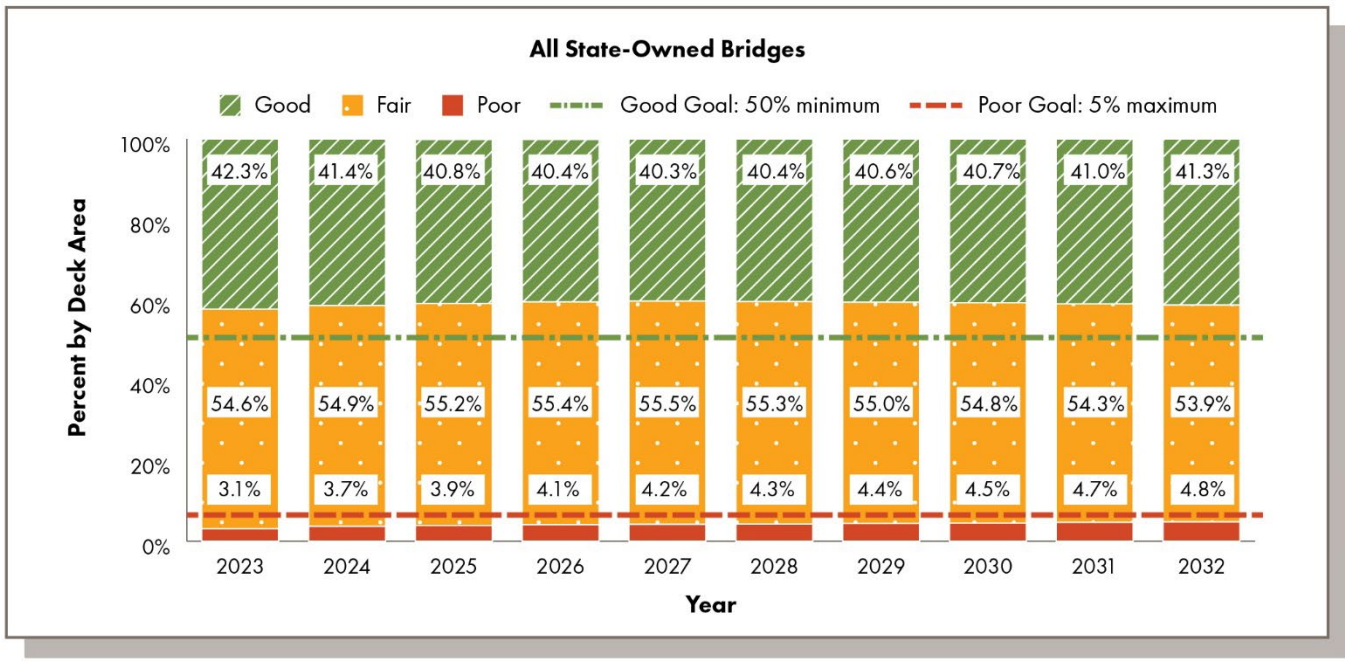


Figure 6-4. Bridge condition forecast.

Figure 6-5 provides details of expected levels of functional capacity based on anticipated investments over the next 10 years. NDDOT is expecting a gradual improvement of approximately 0.4 percent each year. While not meeting the DSOGR goal by 2032, NDDOT expects to be on track to achieve the goal in the future with reasonable investment allocations.

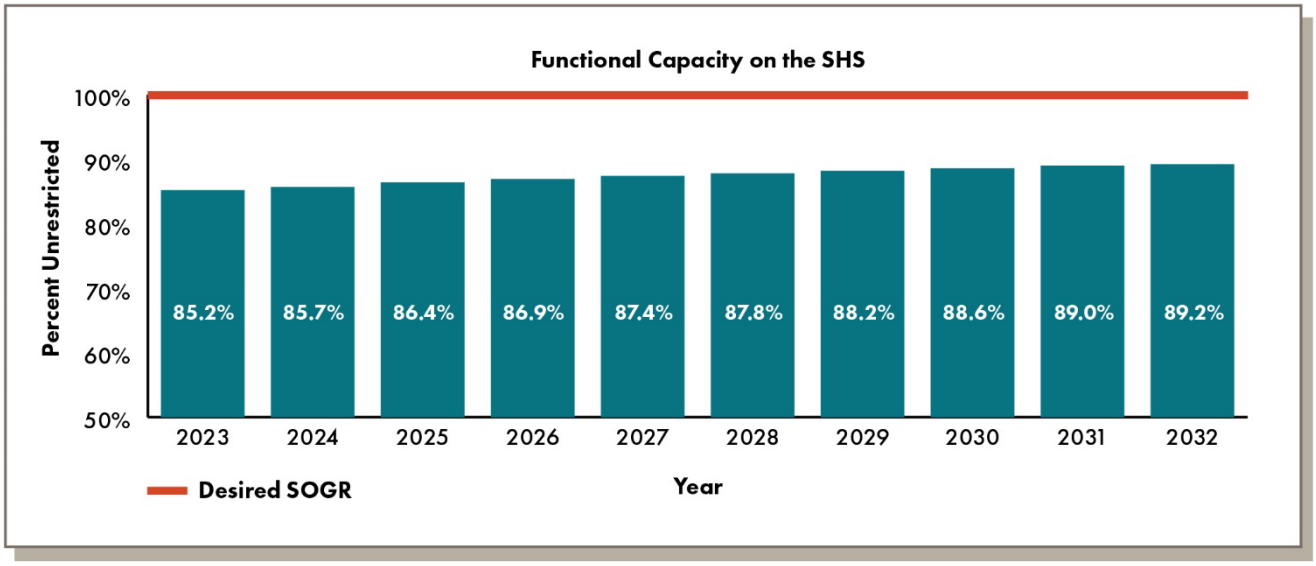
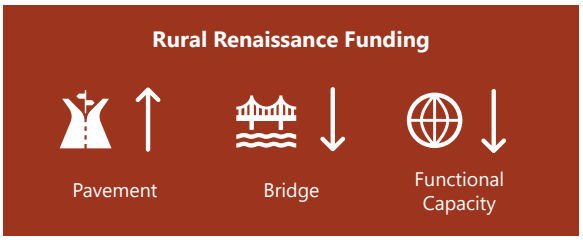


Figure 6-5. Functional capacity forecast.

Rural Renaissance

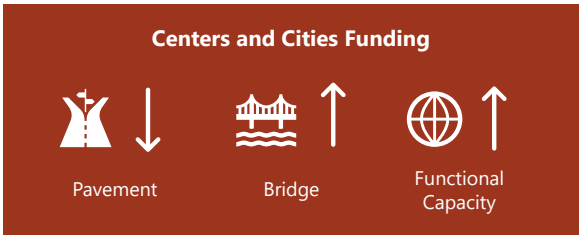
In this scenario, sustained economic growth and technological advances across the State provide opportunities for remote work and local and specialty agricultural production. North Dakota's small towns and rural areas become communities of choice, attracting new residents and building sustainable, vibrant local centers.



As such, investments in major State-owned roads and bridges are expected to decline steadily as priorities shift to maintenance of rural infrastructure. The available budget for asset management needs is expected to be the same as under the expected investment scenario, but funding is allocated from bridges and functional capacity to pavement. IRI condition score would decrease but still be short of the performance target for pavement. Bridge funding would be greatly decreased, with an additional 1 percent of bridges below *Good* condition as compared to the expected investment scenario.

Centers and Cities

In this alternative, accelerated innovation in all sectors, starting with agriculture and energy, leads to growth in tech centers around the state. Growth brings new opportunities and new industries to North Dakota. New residents and new job opportunities drives rapid population increases and creates diverse communities with new mobility needs.



As such, urban areas experience rapid growth and become centers of the state, which result in increased investment needs in managing roads and bridges in these urban settings. It is expected that the overall available budget for asset management needs remain the same, but more funding is allocated towards bridges compared to pavement. Further, there is an expected increase in functional capacity to support increased economic activity in major metropolitan areas.

Funding would be the same as under the expected investment scenario, but it would be re-allocated to bridges in the city and the functional capacity of the city transportation network. With an additional $10M dedicated to bridge asset management, the percent of bridges in *Good* condition would increase by roughly 1 percent as compared to the expected investment scenario. Since more funding is allocated to bridges, the pavement condition would worsen slightly compared to the expected scenario (approximately a 3-point IRI increase resulting in slightly rougher roadways on average).

Ghost Towns

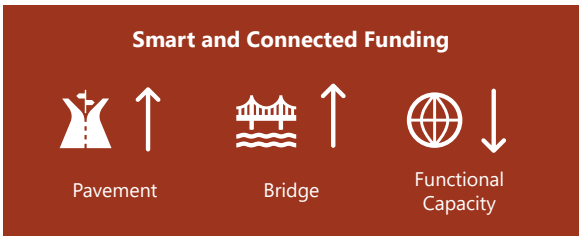
In this scenario, prolonged depression in energy and agricultural commodity markets leads to job losses and the collapse of local industries across the state. North Dakota ages more quickly as younger generations move away to look for work and communities are unable to

make quality-of-life investments. With limited business investment, North Dakota falls behind in adopting new industry, transportation, and communications technologies. Increasingly severe and frequent storm events decimate vulnerable communities and infrastructure.

As such, the economic downturn greatly reduces quality of life, and the NDDOT does not have adequate revenue to address growing asset management needs. In this case, the total expected annual budget for pavement, bridges, and functional capacity is expected to decrease across the board, as compared to the financial forecasts provided in Chapter 4.

When assuming standard asset deterioration as used in the expected investment scenario, the condition of bridges and pavements, along with functional capacity, would decrease compared to the expected investment scenario (as expected due to less funding). Annual funding would decrease by approximately $70M, causing a roughly 4-point change in IRI, a 1 percent decrease of bridges in *Good* condition, and only a slight drop in functional capacity (just over 1 percent).

Smart and Connected



In this alternative, accelerated innovation in all sectors, starting with agriculture and energy, leads to growth in tech centers around the state. Growth brings new opportunities and new industries to North Dakota. New residents and new job opportunities drives rapid population increases and creates diverse communities with new mobility needs. Rapid advances lead to entirely new uses of airspace and ground transport as drones and shuttles become commonplace.

As such, the accelerated pace of innovation requires investments in upgrading the state's infrastructure to support new technologies, like connected and automated vehicles and smart cities. The total expected annual budget for pavement, bridges, and functional capacity is expected to increase, as compared to the financial forecasts provided in Chapter 4, with additional funding being allocated to address both pavement and bridges. However, with the introduction of these new technologies, it is expected that not as much funding would be needed for functional capacity.

While asset usage is expected to increase, the condition of bridges and pavements would improve compared to the expected investment scenario, as shown in figure 6-2, if the standard asset deterioration under the expected investment scenario occurs in this scenario as well. Annual funding would only increase by approximately $20M, causing only a 1-point change in IRI and a 1 percent increase of bridges in *Good* condition. For this scenario, it is assumed that NDDOT would not need to focus as much on functional capacity, due to technological advances and use of intelligent transportation system assets.

Chapter 7: Delivering the Plan – TAM Implementation

DELIVERING THE INVESTMENT STRATEGY

NDDOT delivers its investment strategies through a combination of long- and short-term planning and programming activities that make up NDDOT Investment Priorities Process. Long-term planning is based on *Transportation Connection*, NDDOT's LRTP, which was updated in 2021. During the LRTP update, long-term policy goals were established that guide all the decision-making processes related to services provided. These goals are high-level, philosophical descriptions for how the public wants the overall transportation system and services to function in the state of North Dakota. The LRTP and associated goals are typically updated approximately every 5 years. The LRTP provides the connection among the agency's performance-based plans.

As shown in figure 7-1, the performance-based plans, including the TAMP, Freight and Rail Plan, and Strategic Highway Safety Plan are guided by the LRTP and impact each other through performance expectations, investment strategies, and needs. The LRTP policy goals are converted to measurable, long-term performance goals, based on the NDDOT's understanding of the public's desires. These are represented in the TAMP as the DSOGR for pavements, bridges, and functional capacity.

Figure 7-1. NDDOT's Family of Plans.

The short-term phase of the Investment Priorities Process begins with a detailed 5-year revenue forecast and culminates annually with the publication of a final STIP containing the actual list of planned projects to be constructed.

The STIP development process involves staff from each of NDDOT's program areas and is heavily reliant on forecasts from the pavement and bridge management systems, as described in Chapter 3.

The funding estimate is shared with Central Office and District staff, along with solicitations for projects based on the needs and investment strategies documented in the TAMP and other performance plans. NDDOT staff, along with municipal and county owners of federal-aid eligible highways, work together and through the Metropolitan Planning Organizations (MPOs) to develop an initial list of requested projects. Parallel to this process, NDDOT Planning staff use a multi-objective decision analysis (MODA) tool, *Tradeoff Hub*, to evaluate the impacts of different investment levels in different performance areas. Currently, the *Tradeoff Hub* includes pavements, bridges, and functional capacity. The inputs to the *Tradeoff Hub* analysis come from the pavement and bridge management systems.

Using results from *Tradeoff Hub*, and in coordination with staff and external partners, the NDDOT executives determine how the State program will be divided among the various infrastructure investment classes over the ensuing 5 years. The Programming Division conducts a prioritization process involving all key stakeholders to establish the STIP based on the funding allocations to investment classes and the projects submitted to the solicitations. Once the STIP is established, each performance area can use their respective management tools to forecast outcomes and compare them to long-term goals and short-term targets.

PLANNED IMPROVEMENTS

As part of developing this TAMP, NDDOT conducted a full review of the STIP-development process to document and determine opportunities for improvement. Opportunities were identified in the areas of organization, procedure, systems, and data and are summarized in table 7-1. NDDOT plans to implement these actions over the next 4 years.

Table 7-1. Planned asset management implementation improvements.

Improvement Area	Improvement Actions
Organization 	▪ Establish a Bridge Manager position as an Assistant Bridge Engineer. This position will oversee analysis of bridge data, life cycle strategy development, and treatment recommendations.
Procedures 	▪ Continue to use the TAMP investment strategies as an input to STIP development. ▪ Continue implementation of network level bridge analysis, implemented in support of this TAMP. StruPlan will continue to be used to establish long-term life cycle strategies. The use of StruPlan and BrM allow NDDOT to understand how long-term network-level needs can best be met through treatments that address the deficiencies of specific bridges. ▪ Continue to document and refine the STIP development process to support: ▸ Implementation of an "e-STIP" tool to automate STIP development and publication. ▸ Enhanced communications among NDDOT Divisions, Districts, and external stakeholders. ▸ Improved collaboration in STIP development. ▸ Identifying opportunities for efficiency.
Systems 	▪ Implement an e-STIP tool that: ▸ Brings automation to the STIP development and update processes. ▸ Integrates data with BrM, dTIMS, and other management systems to share project data. ▸ Allows Districts to see and edit data through an interactive map of project recommendations that can be filtered by attributes such as type, year, and District to support development of priorities. ▪ Implement StruPlan to allow both bottom-up (BrM) and top-down (StruPlan) analysis. ▪ Improve integration of Roadway Information Management System and ESRI Roads and Highways to allow single data entry and automated updating of events on the LRS.
Data 	▪ Continue to evaluate bridge health measures that better consider the benefits of preservation. Current measures are not improved by preservation activities. However, preservation has been proven to extend the service lives of bridges by slowing deterioration.

Appendix A: NHS Inventory by Owner

NHS pavement ownership is illustrated in Table C-1.

Table A-1. NHS inventory by owner.

Ownership	Owner	Length (miles)
State-owned	NDDOT	3674.2
County-owned	Burleigh	3.2
	Grand Forks	2.6
Municipality-owned	Bismarck	21.4
	Fargo	8.6
	Grand Forks	7.0
	Jamestown	2.9
	Mandan	1.6
	Unincorporated	0.1
Grand Total		3721.6

All NHS pavement inventory and condition data is collected by NDDOT, regardless of ownership, according to the procedures described in Chapter 3. All NHS bridges in North Dakota covered by this TAMP are owned by NDDOT.

Appendix B: NDDOT's Risk Management Process

In the context of asset management, FHWA defines risk as "the positive or negative effects of uncertainty or variability upon agency objectives" (23 CFR 515.5). Risk management is defined as "the processes and framework for managing potential risks." FHWA requires that states establish a risk management planning process for TAMPs.

Specific requirements for the process are listed below.

- Identification of risks that can affect the condition of NHS pavements and bridges and NHS performance, including risks associated with current and future environmental conditions.
- Assessment of the identified risks in terms of the likelihood of their occurrence and their impact and consequence if they do occur.
- Evaluation and prioritization of the identified risks.
- Mitigation plan for addressing the top priority risks.
- Approach for monitoring the top priority risks.
- Summary of the evaluations of facilities, including NHS pavements and bridges, repeatedly damaged by emergency events.

NDDOT has incorporated risk assessment into the TAMP to plan for any disruptions, anticipate opportunities, and mitigate any consequences more effectively. NDDOT is managing its asset management risks by implementing a process consisting of the following elements:

1. ***Risk Identification***: identify risks that can affect the condition and performance of NDDOT's pavement and bridges.
2. ***Risk Assessment and Prioritization***: assess each identified risk in terms of the likelihood of occurrence, impact, and consequence should the risk occur, then evaluate and prioritize the identified risk based on that likelihood and impact.
3. ***Mitigation Strategies***: develop a mitigation plan for addressing the top priority risks.
4. ***Risk Monitoring***: develop an approach to monitor the top priority risks.

RISK IDENTIFICATION

As part of the TAMP development, NDDOT initiated an effort to identify risks to maintaining asset conditions and performance long-term. Risk identification consisted of brainstorming and validating uncertainties and risks to NDDOT achieving its asset management goals. A workshop was conducted to identify, assess, and determine mitigation strategies to the risks identified. Participants at the workshop represented a variety of NDDOT divisions, including planning, programming, finance, engineering, maintenance, and district staff. The risk identification process included specific consideration of risks related to extreme weather and other weather-related events.

RISK ASSESSMENT AND PRIORITIZATION

Risks were then classified in terms of their likelihood and consequence, which was then used to determine a score to prioritize each risk. The matrix, as shown in Figure A-1, includes five categories for likelihood (listed in the left column of the figure) and five categories for consequence (listed in the bottom row). Risks were assessed based on qualitative data and severity profiles, which were calculated considering the combination of qualitative probability and impact ratings. Given that risks include both the positive and negative effects of uncertainty or variability, separate heat maps were developed. Figure A-1 shows NDDOT 2022 risk severity key.

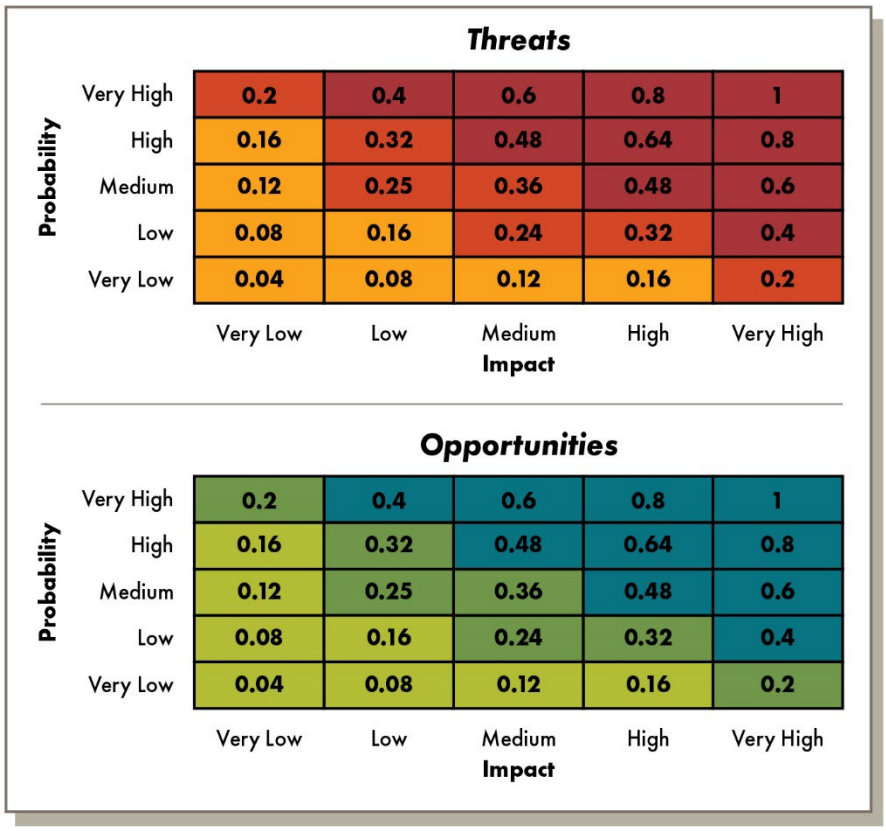


Figure B-1. Risk severity key.

MITIGATION STRATEGIES

NDDOT has developed response strategies for each of the risks identified during the previous phases. These strategies are intended to enhance resilience of NDDOT's infrastructure by reducing the likelihood a threat may occur, reducing the impact should a threat occur, or enhancing NDDOT's ability to respond during and after a threat's occurrence. Mitigation actions for risks include:

1. Accept – monitor and account for a risk in planning.
2. Mitigate – develop action items to mitigate risks.
3. Enhance – develop action items to enhance opportunities.

4. Exploit – exploit opportunities when they arise.

NDDOT developed risk action plans (i.e., statements of planned actions) for each risk. Each plan suggests a list of activities NDDOT will undertake to address the identified risks.

RISK MONITORING

NDDOT is taking the next steps to implement the risk action plans, monitor the identified risks over time, and periodically update the risk register. The risk monitoring activities include an annual review of all risks as well as a new risk workshop every 4 years. During the workshop, NDDOT will review and evaluate the efficacy of the risk action plans from the previous risk register. This includes updating the risk status as active, dormant, or retired, as well as updating the progression of each risk throughout the life cycle of the TAMP. The risk register will be updated and provided along with the updated TAMP. Careful consideration will also be taken for major catastrophic events, even if the likelihood of such an event is minimal.

RISK REGISTER

NDDOT 2022 TAMP risk register is presented in Table B-1.

Table B-1. 2022 Risk register.

Risk Event Name	SMART. Risk Description	Details	Mitigation Strategy Action Plan
Management / Leadership Turnover	Changes in high level leadership (Governor, NDDOT Senior Management, Key Legislators) may lead to abandonment/lack of support/reversal of existing strategic initiatives in which the state has invested considerable time and money. New administrations may change assumed priorities relative to plan goals for condition achievements, funding allocations, staffing, project-selections (mobility vs. preservation), and other infrastructure improvements. These changes normally occur in conjunction with state elections but can occur more frequently.	**Threat** **Risk priority**: 0.480 **Risk owner**: Planning asset management **Risk review date / frequency**: TAMP updates and leadership changes	Communicate priorities, assumptions, and business case for TAMP to new leadership and administrations. Work with industry partners and stakeholder groups so they can educate new leadership. TAMP response: Improve the readability of the TAMP across the public and leadership. Prepare a synopsis/summary of TAMP for quick reference. Develop a TAMP amendment process with FHWA.

Table B-1. 2022 Risk register (continued).

Risk Event Name	SMART. Risk Description	Details	Mitigation Strategy Action Plan
Inadequate State Funding Resources	The ability to predict funding can hamper NDDOT's ability to use funds on the most effective projects at the right time and increases the chances of being out of compliance with federal regulations and TAMP planning assumptions. State funded revenue sources are not from a stable, permanent source. Future state revenues are highly dependent on the actions of the Governor and Legislature and tax revenues, which may be inadequate to provide the required levels of state match for federal funds or a sufficient state funded program. Inadequacy of state funds may lead to not meeting federal funding match requirements and reduce flexibility of meeting state goals. This can make it extremely difficult to plan out a long-term transportation program with any degree of certainty.	**Threat** **Risk priority:** 0.640 **Risk owner:** Financial management **Risk review date / frequency:** Monthly	Develop strategies to provide options for projects based upon available funding. Consider innovative project financing options. Use the TAMP to communicate asset needs and funding. TAMP response: Evaluate modeling based upon state funding revenue projections and adjust accordingly.
Increased Bridge Deterioration Rates	As assets age, the bridge conditions deteriorate, resulting in potential load restrictions, increased time for inspecting, increased maintenance work and costs, more delays and disruptions to the traveling public, and increased cost of goods. Several factors affect the life of the bridges that were not anticipated at the time of design or construction such as increased heavy loads (oversize and overweight), increased use of deicing chemicals, and increase in traffic volumes. Deterioration curves in the TAMP may not reflect all the factors that lead to increased deterioration.	**Threat** **Risk priority:** 0.480 **Risk owner:** Bridge divisions **Risk review date / frequency:** Annual	NDDOT is currently conducting a research study to update deterioration rates in its bridge management system to reflect recent bridge inspection data from North Dakota and other nearby states. Sensitivity analysis in the bridge management system can be used to investigate the potential effects of unexpectedly higher future deterioration rates. These forecasting models will need to be updated periodically (e.g., every 10-15 years) to keep up to date with changing conditions. TAMP response: Shift funding from other asset classes to focus on the assets realizing increased deterioration. Analyze the deterioration assumptions against condition assessments.
Material Costs	Reduced availability and significant increases in costs for materials, particularly steel, concrete, or asphalt that could impact the ability to meet plan assumptions. This may be an issue in a short timeframe in a given year but may even out over the life of the TAMP.	**Threat** **Risk priority:** 0.480 **Risk owner:** Planning asset management **Risk review date / frequency:** Annual	Adjust investment and project type selections based upon spikes in material costs to shift the work to other classes. Identify options for alternative materials for construction based upon prices at the time of award. Develop a TAMP amendment process with FHWA. Develop bid alternates for projects to adjust to cost fluctuations. TAMP response: Evaluate cost assumptions in the TAMP relative to potential increase in construction costs. Apply appropriate cost modification factors to reflect expected costs. Update the base modeling to reflect updated cost information as it becomes available.

Table B-1. 2022 Risk register (continued).

Risk Event Name	SMART. Risk Description	Details	Mitigation Strategy Action Plan
Construction Industry Capacity / Availability	The availability of contractors and skilled labor and their capacity or interest to take on preservation work may impact the number of bidders, bid prices, and quality of contractors. Lack of competition among the construction industry may result in overall higher program costs. Rural projects and ND climate further reduce the attraction to qualified bidders. Larger projects may attract out-of-state contractors, but other states all have similar issues and similar projects. Increases in funding from large infrastructure spending will further reduce the industry capacity.	**Threat** **Risk priority:** 0.800 **Risk owner:** Construction division **Risk review date / frequency:** Ongoing	Review bid advertisement timing relative to contractor interest and availability timeframes. Advertise projects as early as possible and in advance. Develop and advertise an advance potential project list. Develop "shovel-ready" projects. Standardize designs of typical transportation elements. Extend completion dates of projects to increase contractor flexibility. Continue to communicate this concern to industry associations. TAMP response: Evaluate cost assumptions in the TAMP relative to potential increases in construction costs. Apply appropriate cost modification factors to reflect expected costs. Update the base modeling to reflect updated cost information as it becomes available.
Consultant Availability and Capabilities	There are a limited number of consultants qualified to design structures and deliver quality plans in a timely and cost-effective manner. NDDOT has historically designed bridges in-house. In-state consultants have limited capabilities for bridge design experience.	**Threat** **Risk priority:** 0.640 **Risk owner:** Project development **Risk review date / frequency:** Ongoing	Use on-call contracts for consultant services. Implement partnering and "over-the-shoulder" design development reviews. Develop and maintain manuals and standards guidelines. Develop standardized designs and templates. Develop design software guidelines. Outreach to education resources. Continue to communicate this concern to industry associations. TAMP response: Evaluate TAMP assumptions for the ability to deliver projects based upon design development capacity and capabilities.
Environmental Regulations	Changes in environmental regulations may result in additional time and costs for project development, construction, and maintenance. Examples include wildlife vehicle collision reduction measures, the Americans with Disabilities Act (ADA), and the National Environmental Policy Act (NEPA).	**Threat** **Risk priority:** 0.400 **Risk owner:** Planning asset management **Risk review date / frequency:** Ongoing	Communicate cost and schedule impacts of regulations with partner and regulatory agencies. Monitor plan execution (project estimates, project schedules) against potential regulatory requirement changes. Identify ways to be flexible with designs and construction plans. Limit project footprints where possible. TAMP response: Modify the TAMP during future updates per most recent guidelines.
Railroad Coordination	The TAMP assumes certain project delivery costs and schedules relative to delivery projects. These could be impacted by the coordination with railroads. Changing regulations and personnel in the railroad industry can result in unanticipated costs and increased time in developing and constructing projects as well as inspecting and maintaining structures.	**Threat** **Risk priority:** 0.320 **Risk owner:** Planning asset management **Risk review date / frequency:** Ongoing	Improve communications with railroad representatives. Use the TAMP to communicate project needs in advance. Provide adequate project delivery time where railroads are impacted. TAMP response: Evaluate project costs and schedule assumptions in the TAMP relative to railroad impacts.
Staffing and Personnel Management	NDDOT is challenged with the availability of qualified staff to manage the plan, design the projects, and deliver the projects. Salary reductions have severely limited the ability to fill positions with qualified personnel, further limiting the	**Threat** **Risk priority:** 0.800 **Risk owner:** Asset management division	Evaluate benefit and salary guidance/policies to retain resources. Develop junior staff into supervisory/senior roles with an improved legacy planning program. Perform cross-training of staff on asset management (AM) execution and decisions. Evaluate the NDDOT business

Table B-1. 2022 Risk register (continued).

Risk Event Name	SMART. Risk Description	Details	Mitigation Strategy Action Plan
	ability to produce quality work, deliver projects in a timely manner, and meet the department's mission and purpose. NDDOT is being asked to fill technical duties never before considered (e.g., land-use advisors, economic development advocates, and Unmanned Aircraft System (UAS) command and control), resulting in increased labor demands and costs with no corresponding increase in staff. Loss of staff that have a specialized role in executing the TAMP could disrupt the timeliness and accuracy of the decision making. Aging staff will be subject to retirement and younger staff may not stay as long as previous staff. Increased demand from the private industry may exacerbate the ability to retain good staff.	**Risk review date / frequency:** Annual	model relative to personnel dedicated to specific asset classes and consider shifting to meet identified needs. TAMP response: Increase information in the TAMP relative to documenting processes, procedures, and guidance. The TAMP could be used to inform the resourcing needs of the department based upon the project information and delivery needs.
Increase Federal Funding Grant Availability	Discretionary grant programs may provide more funding opportunities, but they require significant work to obtain, are unpredictable in success, and can impact their reliability as alternative funding sources. As the number of federal grant programs increases and NDDOT becomes more capable of obtaining grants, additional TAMP funding may become available to serve customers and meet TAMP planning assumptions.	**Opportunity** **Risk priority:** -0.360 **Risk owner:** Planning asset management **Risk review date / frequency:** Quarterly	Apply for all applicable grants. Work with federal partners to identify funding opportunities. Develop "shovel-ready" projects to award if additional funding is available. TAMP response: Evaluate plans and scenarios if potential additional funding is made available. Develop a plan to deliver additional projects if additional funding is made available.
Data Governance and Data Management	NDDOT relies on RIMS for the asset records. The system has data quality issues and has limited capabilities for data management. Current STIP priority software is outdated and unreliable, causing a lack of functionality in managing the program. The quality of the information ties directly into the asset management decisions and potentially the design of the treatments selected.	**Threat** **Risk priority:** 0.480 **Risk owner:** Planning asset management **Risk review date / frequency:** Quarterly	Adopt formal data governance and management. The replacement of RIMS is currently underway. Develop eSTIP capability. Develop a data management/governance committee. TAMP response: Evaluate scenarios and plan selection based upon better data integrity and reliability. Update the TAMP per data governance initiatives.
Increased Severe Weather	Severe summer and winter weather and flooding issues increase the rate of deterioration of bridges and roadways. Drought conditions contribute to higher temperatures, which contribute to pavement blow-outs/buckling. These tend to be more immediate impacts to the assets vs. long-term increased deterioration. Climate change may exacerbate these factors over time.	**Threat** **Risk priority:** 0.360 **Risk owner:** Bridge and pavement divisions **Risk review date / frequency:** Bi-annual	Implement strategies that deliver resiliency to the assets. Revise design requirements to address weather-related impacts. TAMP response: Analyze the deterioration assumptions against condition assessments from increased weather impacts to the assets. Add an investment category in the TAMP for system resilience projects.
Geologic / Geotechnical Conditions	Landslide-prone Western ND and soil-shifting Eastern ND imperil both roads and bridges. Climate change may exacerbate these factors over time.	**Threat** **Risk priority:** 0.160	Increase geotechnical investigations. Install monitoring and sensors to identify potential issues. Revise design requirements to address geotechnical/geological conditions.

Table B-1. 2022 Risk register (continued).

Risk Event Name	SMART. Risk Description	Details	Mitigation Strategy Action Plan
		Risk owner: Materials and research **Risk review date / frequency:** Bi-annual	TAMP response: Analyze the deterioration assumptions against condition assessments from worse geotechnical conditions.
dTIMS and BrM Model Limitations	The TAMP has made certain assumptions based on the asset management system model results. The decisions and priorities of the TAMP are all based upon these results. There are issues with the quality of the information being input into the models and issues with the data in the systems.	**Threat** **Risk priority:** 0.360 **Risk owner:** Bridge and planning asset management **Risk review date / frequency:** Annual	Dedicate sufficient staff to maintain and update the respective models. Review the efficacy and quality of the data being input into the models. Coordinate information between the two models (i.e. cost). TAMP response: Evaluate accuracy of the business rules, decision tree, deterioration rates, and model inputs to ensure they are accurate in the TAMP. Remodeling based upon actual project selections. Adjust project selection based on additional information in addition to the model results.
Changing Transportation Demands / Expectations	Transportation customers are demanding more flexibility in how they use the system (i.e., new modes or freight capacity), more continuously available system and performance information, and 24/7/365 operations, resulting in increased costs. An increase in freight traffic and over-sized vehicles could potentially cause an increase in deterioration of assets. This would cause an increase in costs for the TAMP and less life expectancy. The transportation system will potentially need to accommodate different transportation technologies (e.g., self-driving and electric vehicles).	**Threat** **Risk priority:** 0.360 **Risk owner:** Planning asset management **Risk review date / frequency:** TAMP updates	Increase public engagement on changing expectations of the transportation system. Use the TAMP to communicate costs of the system to meet expectations. Outreach to partner agencies regarding design requirements to support alternative transportation technologies. TAMP response: Improve readability of the TAMP and dissemination of the information. Ensure that the TAMP addresses the public as an audience. Develop performance measures in concert with public input to inform TAMP priorities.
Alignment with STIP Investments	There is potential of misalignment between the TAMP and the STIP where the projects and investments in the STIP do not provide the types of investments that are planned in the TAMP.	**Threat** **Risk priority:** 0.360 **Risk owner:** Planning asset management **Risk review date / frequency:** Annual	Review STIP investments and projects delivered based upon TAMP categories and adjust accordingly. Conduct consistency reviews to check the STIP against the TAMP, and provide the information back to Programming. TAMP response: Develop protocols in the TAMP relative to aligning with the STIP.
Increased Pavement Deterioration Rates	If NDDOT does not continue maintenance practices to be roughly consistent with historical levels, asset models will no longer properly predict outcomes and deterioration rates, resulting in degraded information being used in the project prioritization processes. As assets age, the pavement conditions deteriorate, resulting in potential load restrictions, increased time for inspecting, increased maintenance work and costs, more delays and disruptions to the traveling public, and increased cost of goods. Several	**Threat** **Risk priority:** 0.240 **Risk owner:** Pavement divisions **Risk review date / frequency:** Annual	NDDOT could implement rehab types that extend the useful life of pavements so that replacements can be spread out over a longer time, making them more fiscally manageable. NDDOT could also track maintenance activities through a formal maintenance management system. If a modern MMS is implemented within the life of the TAMP, NDDOT would see numerous maintenance efficiencies and have the opportunity to better consider maintenance costs in project prioritization. NDDOT could also increase levels of condition-based maintenance

Table B-1. 2022 Risk register (continued).

Risk Event Name	SMART. Risk Description	Details	Mitigation Strategy Action Plan
	factors affect the life of the pavement that were not anticipated at the time of design or construction, such as increased heavy loads (oversize and overweight), increased use of deicing chemicals, and increase in traffic volumes. Deterioration curves in the TAMP may not reflect all the factors that lead to increased deterioration.		projects to prolong asset life and seek alternative snow and ice control measures. TAMP response: Shift funding from other asset class to focus on the assets realizing increased deterioration. Analyze the deterioration assumptions against condition assessments.
Asset Treatment Performance	The TAMP has assumed certain life cycles for given treatments. The risk is that the assets do not have the life assumed due to the ineffectiveness of the treatment technology or that the treatment did not have the life that was assumed. This is reliant on quality and appropriateness of the design and quality control of construction activities.	**Opportunity** **Risk priority:** -0.120 **Risk owner:** Materials and research **Risk review date / frequency:** 4 years	Evaluate new material and treatment technologies, which may improve resiliency of the assets. TAMP response: Analyze the deterioration assumptions against improved treatment technologies and condition assessments over the life of the plan.
Pandemic Impacts	The TAMP may potentially be impacted due to future pandemic-related issues. Examples include reduced efficiency of staffing, supply chain issues with materials and equipment, and increased construction costs.	**Threat** **Risk priority:** 0.160 **Risk owner:** Planning asset management **Risk review date / frequency:** TAMP updates	Review project costs and schedules related to current and model future conditions. TAMP response: Evaluate TAMP models based upon past and future pandemic-related events.
Federal Funding Fluctuations and Timing	The TAMP relies on having federal funds to meet plan assumptions and asset management needs. There is potential that this funding is less than the estimated amounts over the life of the TAMP or that it will not be available at the time when needed to award projects. Fluctuations can be attributed to items such as continuing resolutions, the highway trust fund, and taxes.	**Threat** **Risk priority:** 0.640 **Risk owner:** Planning asset management **Risk review date / frequency:** Quarterly	Develop "shovel-ready" projects to adjust to federal funding fluctuations. Identify alternative financing options for projects. Work with federal representatives to maintain planned funding levels. Communicate with state representatives (Governor and Legislature) relative to the needs of state funding program. Use the TAMP to communicate asset management needs and appropriate use of federal funding. TAMP response: Evaluate models and scenarios based upon reduced federal fund availability. Incorporate revenue forecasts into TAMP models.
Communication with Customers and Leadership	The TAMP provides an opportunity and a means for communicating with customers, stakeholders, decision makers, advocacy groups, and representatives on the benefits of asset management, needs for funding the program, and the return on investment for use of available funding.	**Opportunity** **Risk priority:** -0.800 **Risk owner:** Planning asset management **Risk review date / frequency:** Annual, legislative sessions	Develop outreach protocols, presentations, and ways to highlight the effectiveness of the TAMP. Communicate TAMP planning assumptions during strategy reviews and budgeting processes. TAMP response: Improve readability of the TAMP and dissemination of the information. Ensure that the TAMP addresses the public as an audience, as well as representatives and other stakeholders.

Table B-1. 2022 Risk register (continued).

Risk Event Name	SMART. Risk Description	Details	Mitigation Strategy Action Plan
Increased Fuel Costs	Rising fuel prices can increase project costs and the ability to match federal funds from tax revenue.	**Threat** **Risk priority:** 0.480 **Risk owner:** Planning asset management **Risk review date / frequency:** Annual	Monitor fuel prices on plan objectives and modify the plan accordingly. Based on fuel prices, identify options for alternative materials for construction. Develop a TAMP amendment process with FHWA. Develop bid alternates for projects to adjust to cost fluctuations. Identify alternative funding streams other than fuel tax revenue. Include fuel cost adjustments in construction contracts. TAMP response: Evaluate cost assumptions in the TAMP relative to potential increases in construction costs. Apply appropriate cost modification factors to reflect expected costs. Update the base modeling to reflect revenue forecasting. Identify investment strategy for electric vehicles in the TAMP relative to revenue adjustments and electric vehicle (EV) registration fees.
Decreased Fuel Costs	If fuel prices decrease, there may be an increase in tax revenue available for funding. Project costs could be reduced if fuel prices decrease. Reduced fuel prices can lead to increased vehicle usage, which can lead to increased asset deterioration.	**Opportunity** **Risk priority:** -0.240 **Risk owner:** Planning asset management **Risk review date / frequency:** Annual	Monitor fuel prices on plan objectives and modify the plan accordingly. Include fuel cost adjustments in construction contracts. TAMP response: Evaluate cost assumptions in the TAMP relative to potential increases in construction costs. Update the base modeling to reflect revenue forecasting.
Transportation Technology Changes	Changes in transportation technologies, including electric vehicles and other vehicle propulsion technologies, may impact plan assumptions. These changes can impact design criteria, asset class priorities and ITS, and infrastructure needs.	**Threat** **Risk priority:** 0.480 **Risk owner:** Materials and research, Planning asset management **Risk review date / frequency:** Annual	Monitor technology developments and adjust plan assumptions accordingly. Review design standards relative to the needs of the technology. Evaluate the adjustments to higher use roadways vs. lower use to accommodate alternative technologies. TAMP response: Evaluate the plan based on how assets will be impacted by new technologies.
Transportation Technology Changes	Changes in transportation technologies, including electric vehicles and other vehicle propulsion technologies, may positively impact plan assumptions. This has potential to reduce staffing needs, reduce asset deterioration, improve efficiency of the transportation system, and reduce needs to expand the roadway system.	**Opportunity** **Risk priority:** -0.320 **Risk owner:** Materials and research, Planning asset management **Risk review date / frequency:** Annual	Monitor technology developments and adjust plan assumptions accordingly. Review design standards relative to the needs of technology. Evaluate the adjustments to higher use roadways vs. lower use to accommodate alternative technologies. TAMP response: Evaluate the plan based on how assets will be impacted by new technologies.
Alternative Project Selection Priorities	The TAMP has made certain assumptions based upon the needs of assets relative to investment selection and prioritization. These can be negatively impacted if outside forces, such as political pressure and statewide balancing, may influence project selection.	**Threat** **Risk priority:** 0.360 **Risk owner:** Planning asset management	Communicate priorities, assumptions, and the business case for TAMP investment priorities. TAMP response: Adjust TAMP investment strategies to account for external influences and pressures.

Table B-1. 2022 Risk register (continued).

Risk Event Name	SMART. Risk Description	Details	Mitigation Strategy Action Plan
		Risk review date / frequency: Annual	
Routine Maintenance Not Performed	The TAMP assumes certain historical activities will continue to occur relative to maintenance of the assets. This assumes consistency of funding levels to perform the routine maintenance, such as crack sealing, minor patching, and deck cleaning and flushing. If these activities are not performed, or if their funding is reduced, the assets will not meet the assumed projections for levels of deterioration.	**Threat** **Risk priority:** 0.480 **Risk owner:** District maintenance **Risk review date / frequency:** Annual	Document the routine maintenance activities that are expected to maintain TAMP assumptions. Monitor the routine maintenance program efficacy. Develop a maintenance management system to track and monitor the activities. TAMP response: Evaluate plan assumptions based upon increase in maintenance needs and reduction in asset conditions if not performed.
IT Capability Limitations	The TAMP relies on support from IT relative to data governance, modeling, cost estimating to make informed decisions, and effectively manage the asset management program. If the IT capabilities are limited or not kept up to date, the ability of the department to implement the plan is reduced.	**Threat** **Risk priority:** 0.640 **Risk owner:** Planning asset management **Risk review date / frequency:** TAMP update	Enhance IT capabilities with software development, staffing, data integration, and business intelligence. Develop a framework for data integration for TAMP-related elements. TAMP response: Develop connection between asset condition assessments with other data sets into a cohesive performance-based planning model.

Appendix C: Periodic Evaluation of Facilities Repeatedly Requiring Repair and Reconstruction due to Emergency Events

NDDOT provides support for responding to and recovering from emergency events that impact the operation and condition of the highway network. This work commonly involves repair or reconstruction of highways and bridges that are damaged during an event. NDDOT records information for each location where a repair or reconstruction is performed, including the specific location, the type of work performed, and the costs to deliver the work. The costs for these response and recovery activities are funded through a combination of state and federal funds, depending on the size and location of each emergency.

To comply with federal regulation, 23 CFR Part 667, *Periodic Evaluation of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Event*s, NDDOT periodically evaluates its emergency response data to identify any locations that have required repair or reconstruction on two or more occasions from emergency events since January 1, 1997, declared by the Governor or the President of the United States. This process is outlined in table B-1. Periodically on the NHS, and when an expenditure is planned for non-NHS facilities impacted by adverse events, NDDOT queries the location in GIS to verify if it was impacted in the past. During preparation of the TAMP, NDDOT reviewed the data in the GIS system that documents the outcomes of this process and determined that there have been no locations on the NHS that have required repair or replacement from two or more qualifying emergency events.

Table C-1. Business process to support 23 CFR Part 667 requirements.

Step	NHS Highways and Bridges	Non-NHS Highways and Bridges
Identification & Documentation	After a qualifying emergency event has been declared, the NDDOT Operations Division will assess the situation and evaluate the damage on roads, highways, and bridges on the NHS. Once the situation has been assessed, a DDIR will be completed and submitted to the FHWA. The DDIRs will be input into a GIS system for documenting the location, asset(s) damaged, and extent of damage.	
Evaluation	Following the qualifying event, NDDOT will perform a statewide evaluation of the NHS using the GIS database to identify recurring incidents of repair or reconstruction to particular locations. If recurring events (more than two events at a given location) are identified for a location on the NHS, NDDOT will develop an action plan for addressing the issue.	Prior to requesting federal aid for any highway or bridge project, NDDOT will compare all locations included in the project with its records of locations damaged by qualifying emergency events, using the GIS database.
Implementation	Asset managers will meet with subject matter experts to evaluate the most suitable repair and rehabilitation strategies. A funding request will be submitted to the appropriate authorities. The selected repair and rehabilitation strategy will be communicated to the responsible parties. The permanent repairs will be documented in the GIS database for future assessments.	NDDOT considers the outcomes of these evaluations during the development of transportation plans and programs, including TIPs and STIPs, and during the environmental review process, under 23 CFR Part 771.

Appendix D: Life-cycle Planning Analysis–Supplementary Information

PAVEMENTS

Performance Models

Table D-1 presents a summary of each pavement performance model used within the PMS. NDDOT uses different performance indicators to evaluate the pavement condition under varying budget scenarios. The PMS program utilizes pavement condition results and optimizes the benefits function, as shown in equation D-1. In LCP analysis, NDDOT chooses the pavement treatment strategies that maximizes the benefit function. Table D-1 describes how the PMS program calculates performance indicators.

Table D-1. Mathematical expressions of NDDOT pavement performance models.

Performance Indicator	Model Description
Rutting	Linear model; average rutting increases by 0.016 inches every year.
Load Limit	Linear model; load limit reduces by 0.05 tons every year.
International Roughness Index (IRI)	Linear model; function of initial IRI, changes in IRI, service life and effective age.
Slab Cracking Index (SCI)	Linear model; increase by 0.3 points per year.
Structural Index (SI)	Linear model; increase by 0.3 points per year.
Transverse Cracking	Linear model; increase by 0.25 points per year.

Unit Costs

Table D-2 presents a summary of unit costs for different pavement treatment work types. The PMS program runs a series of pavement treatment scenarios over the analysis period under a given budget and determines the most optimum LCP strategy. Pavement treatment work type unit costs are needed in the PMS program to calculate the benefit under each LCP strategy. Table D-2 provides the breakdown of NDDOT pavement treatment work types along with unit costs.

Table D-2. Unit costs for NDDOT pavement treatment work types.

Per Mile Costs	Statewide Construction and CE only Cost	Statewide Total Cost#
New Construction/New Alignment*	7,100,000	9,800,000
2-lanes	4,450,000	6,100,000
4-lanes	7,100,000	9,800,000
PCC Reconstruction	2,000,000	2,300,000
Major Rehabilitation	1,400,000	1,600,000
Full Depth Reclamation w/Widening	1,400,000	1,600,000
Full Depth Reclamation	900,000	1,000,000
Concrete Overlay/Widening	1,200,000	1,400,000
HBP Overlay w/Widening	1,050,000	1,200,000
Structural Improvement	1,100,000	1,300,000
Concrete Overlay	1,100,000	1,200,000
Mill and HBP Overlay > 3"	475,000	550,000
Crack/Seat or Break/Seat w/HBP Overlay	700,000	790,000
Minor Rehabilitation**	475,000	530,000
Sliver Grading w/HBP Overlay	475,000	530,000
Mill & HBP Overlay 2" > 3"	300,000	330,000
Preventive Maintenance	170,000	180,000
TLO ≤ 2" & Mill & HBP Overlay ≤ 2"	170,000	180,000
Microsurfacing	60,000	68,000
Slurry Seal	46,000	54,000
Chip Seal	36.5,000	44,000
Concrete Pavement Restoration/Grinding	150,000	160,000
Urban	-	-
Reconstruction***	7,650,000	9,000,000
Surfacing	1,200,000	1,400,000

All costs (except for 4-lane new construction/new alignment) are stated as 2-lane roadway costs. Multiply cost above by 2 to arrive at 4-lane for both roadway costs.
For some work types, no/few recent project data available. Costs a combination of actual project cost history and calculated costs based on recent average bid item costs.
Overall improvement category cost is based on highest cost within category.
*Does not include major structures.
**Cost may be higher for the roadways with wide shoulders.
#Total Cost includes Construction, CE, PE, ROW, Utilities, Wetlands, Cultural, Haul Roads.
***This is an average urban reconstruction cost.
Urban costs can vary widely dependent on the situation (e.g., section width, signals, storm sewer).

Benefits Calculation

The PMS program determines the present value benefits for each LCP strategy, as shown in Equation D-1. For a given average annual daily traffic (AADT), the benefits function evaluates each strategy in terms of IRI. Based on benefit calculation, PMS program recommends most cost-effective LCP strategy.

$$PV\ Benefit = AADT^{k} \times \frac{(IRI_{Strategy\ i} - IRI_{Do\ Nothing})}{(1+\frac{r}{100})^{i}} \quad \text{(D-1)}$$

Where:

i	The year in the analysis period (e.g., 1, 2,…n)
r	The discount rate (6.83 is currently used)
$PV\ Benefit$	Present value of benefit of the strategy from year i
$AADT$	AADT on the element in year i
k	AADT weighting factor (0.7)
$IRI_{Strategy\ i}$	IRI value for the strategy in year i
$IRI_{Do\ Nothing}$	IRI value for the do-nothing strategy in year i

BRIDGES

Table D-3 presents a summary of unit costs for different bridge treatment work types. The bridge management system (BMS) program runs a series of bridge treatment scenarios to determine the LCP strategy that provides better conditions for the lowest cost. To determine accumulated costs under each scenario, the BMS program utilizes the bridge treatment unit costs, as shown in Table D-3.

Table D-3. Unit costs for NDDOT bridge treatment work types.

Name	Units	Maintenance Cost ($)	Repair, Preservation, and Rehabilitation Cost ($)	Replacement Cost ($)
Reinforced Concrete Deck	sq.ft	1	25-100	100
Prestressed Concrete Top Flange	sq.ft	1-6	25-600	600
Reinforced Concrete Top Flange	sq.ft	1-6	25-600	600
Steel Deck with Concrete Filled Grid	sq.ft	1-2	61-186	186
Reinforced Concrete Slab	sq.ft	1	25-100	100
Steel Closed Web/Box Girder	ft	2-15	127-1,458	1,458
Prestressed Concrete Closed Web/Box Girder	ft	4-11	200-1,052	1,052
Reinforced Concrete Closed Web/Box Girder	ft	4-11	200-1,052	1,052

Table D 3. Unit costs for NDDOT bridge treatment work types (continued).

Name	Units	Maintenance Cost ($)	Repair, Preservation, and Rehabilitation Cost ($)	Replacement Cost ($)
Steel Open Girder/Beam	ft	3-15	127-1,458	1,458
Prestressed Concrete Open Girder/Beam	ft	3-15	127-1,458	1,458
Reinforced Concrete Open Girder/Beam	ft	2-6	100-600	600
Steel Stringer	ft	2-6	100-600	600
Prestressed Concrete Stringer	ft	2-4	75-400	400
Steel Truss	ft	241-370	12,025-37,000	37,000
Reinforced Concrete Arch	ft	11-12	602-1,052	1,052
Steel Floor Beam	ft	1-8	69-834	834
Reinforced Concrete Floor Beam	ft	4-11	200-1,052	1,052
Steel Pin and Pin & Hanger Assembly or both	each	120-185	6,013-18,500	18,500
Steel Gusset Plate	each	120-185	6,013-18,500	18,500
Steel Column	each	150-500	5,000-50,000	50,000
Prestressed Concrete Column	each	100-500	5,000-50,000	50,000
Reinforced Concrete Column	each	100-500	5,000-50,000	50,000
Timber Column	each	50-200	2,500-20,000	20,000
Reinforced Concrete Pier Wall	ft	50-100	2,500-10,000	10,000
Other Pier Wall	ft	50-100	2,500-10,000	10,000
Reinforced Concrete Abutment	ft	50-100	2,500-10,000	10,000
Timber Abutment	ft	25-100	1,500-10,000	10,000
Steel Abutment	ft	50-100	2,500-10,000	10,000
Reinforced Concrete Pile Cap/Footing	ft	8-20	400-2,000	2,000
Steel Pile	each	150-500	7,000-50,000	50,000
Reinforced Concrete Pile	each	100-500	7,000-50,000	50,000
Timber Pile	each	100-500	7,000-50,000	50,000
Steel Pier Cap	ft	40-80	2,000-8,000	8,000

Table D 3. Unit costs for NDDOT bridge treatment work types (continued).

Name	Units	Maintenance Cost ($)	Repair, Preservation, and Rehabilitation Cost ($)	Replacement Cost ($)
Reinforced Concrete Pier Cap	ft	20-40	1,000-4,000	4,000
Timber Pier Cap	ft	10-20	500-2,000	2,000
Steel Culvert	ft	30-50	1,500-5,000	5,000
Reinforced Concrete Culvert	ft	30-50	1,500-5,000	5,000
Other Culvert	ft	30-50	1,500-5,000	5,000
Prestressed Concrete Culvert	ft	30-50	1,500-5,000	5,000
Strip Seal Expansion Joint	ft	3	20-300	300
Pourable Joint Seal	ft	1	10-80	80
Compression Joint Seal	ft	1	15-100	100
Assembly Joint With Seal	ft	6-13	330-1,300	1,300
Open Expansion Joint	ft	6-13	330-1,300	1,300
Assembly Joint Without Seal	ft	6-13	330-1,300	1,300
Other Joint	ft	1	15-100	100
Elastomeric Bearing	each	30-60	1,300-6,000	6,000
Movable Bearing	each	30-60	1,850-6,000	6,000
Enclosed/Concealed Bearing	each	30-60	2,000-6,000	6,000
Fixed Bearing	each	30-60	1,400-6,000	6,000
Pot Bearing	each	50-100	2,000-10,000	10,000
Other Bearing	each	50-100	2,000-10,000	10,000
Prestress Concrete Approach Slab	sq.ft	1	20-60	60
Reinforced Concrete Approach Slab	sq.ft	1	20-60	60
Metal Bridge Railing	ft	3-7	136-682	682
Reinforced Concrete Bridge Railing	ft	2-4	75-376	376
Timber Bridge Railing	ft	2-4	89-444	444
Other Bridge Railing	ft	3-7	136-682	682
Wearing Surfaces	sq.ft	0	15-30	30
Steel Protective Coating	sq.ft	0	18-40	40
Concrete Protective Coating	sq.ft	0	18-40	40
Precast Reinforced Concrete Culvert	ft	30-50	1,500-5,000	5,000

Notes:
Source of unit costs: NDDOT BrM Action Report 10/12/2021, edited by NDDOT 3/7/2022.
Maintenance costs are $/year for the portions of each element in each indicated condition state.
Repair costs are the direct cost of corrective action applied to the quantities found in each condition state.

Table D 3. Unit costs for NDDOT bridge treatment work types (continued).

Name	Units	Maintenance Cost ($)	Repair, Preservation, and Rehabilitation Cost ($)	Replacement Cost ($)

Add thirty-five percent to account for indirect costs such as work zone traffic control and mobilization. Replacement cost is the cost per unit of replacing the entire element, regardless of condition.

Additional bridge-level unit costs, including direct and indirect costs:

$600 Cost per existing sq.ft to replace an entire bridge with one that meets current standards and does not add lanes.

$500 Cost per sq ft to widen a bridge to satisfy safety criteria, without adding lanes.

$300 Cost per sq. ft. to raise a bridge to increase vertical underclearance.

$300 Cost per sq ft to strengthen a bridge to meet current standards (if load-carrying capacity is deficient).

A two percent inflation rate was assumed for maintenance works. A 3% inflation rate and 2.2% discount rate was assumed for StruPlan analysis (I.e., preservation, rehabilitation, and reconstruction works).

Appendix E: FHWA Compliance Checklist

Table E-1. FHWA compliance checklist.

Required Elements	Indicators the TAMP Meets Element Requirements in 23 U.S.C. 119(e) and 23 CFR part 515	Location in the TAMP
TAMP approved by head of State DOT (23 CFR 515.9(k))	Does the TAMP bear the signature of the head of the State DOT?	
State DOT has developed its TAMP using certified processes (23 CFR 515.13(b))	Do the process descriptions align with the FHWA-certified processes for the State DOT? [If the process descriptions do not align with the FHWA-certified processes, the state DOT must request recertification of the new processes as amendments, unless the changes are minor technical corrections or revisions with no foreseeable material impact on the accuracy and validity of the processes, analyses, or investment strategies. State DOTs must request recertification of TAMP development processes at least 30 days prior to the deadline for the next FHWA TAMP consistency determination as provided in 23 CFR 515.13(c).]	(All chapters in ND 2022 TAMP)
	Do the TAMP analyses appear to have been prepared using the certified processes?	(All chapters in ND 2022 TAMP)
TAMP includes the required content as described in: 23 CFR 515.9(a)-(g) (23 CFR 515.13(b))	Does the TAMP include a summary listing of NHS pavement and bridge assets, regardless of ownership?	Chapter 1 and Appendix A Page 52.
	Does the TAMP include a discussion of state DOT asset management objectives that meets requirements?	Chapters 1 and 2 Pages 2, 3, 8, 10, and 11
	Does the TAMP include a discussion of state DOT measures and targets for asset condition, including those established pursuant to 23 U.S.C. 150, for NHS pavements and bridges, that meets requirements?	Chapter 2 Pages 7, 8 and 10
	Does the TAMP include a summary description of the condition of NHS pavements and bridges, regardless of ownership, that meets requirements?	Chapter 6 Pages 17, 20, and 30
	Does the TAMP identify and discuss performance gaps?	Chapter 6 Pages 29-36
	Does the TAMP include a discussion of the life-cycle planning that meets requirements, including results?	Chapter 3 Pages 14-21
	Does the TAMP include a discussion of the risk management analysis that meets requirements?	Chapter 2 and 5 and Appendix B Pages 11, 12, 28, and 40-49.
	Does the TAMP include the results of the evaluations of NHS pavements and bridges pursuant to 23 CFR part 667?	Appendix C Pages 50-51
	Does the TAMP include a discussion of a 10-year Financial Plan to fund improvements to NHS pavements and bridges?	Chapter 4 Pages 22-25

Required Elements	Indicators the TAMP Meets Element Requirements in 23 U.S.C. 119(e) and 23 CFR part 515	Location in the TAMP
	Does the TAMP identify and discuss investment strategies the state intends to use for their NHS pavements and bridges?	Chapter 5 Pages 26-29
	Does the TAMP include a discussion as to how the investment strategies make or support progress toward achieving and sustaining a desired state of good repair over the life cycle of the assets?	Chapter 6 Pages 29-26
	Does the TAMP include a discussion as to how the investment strategies make or support progress toward improving or preserving the condition of the assets and the performance of the NHS related to physical assets?	Chapter 6 Pages 29-36
	Does the TAMP include a discussion as to how the investment strategies make or support progress toward achieving the state's targets for asset condition and performance of the NHS in accordance with 23 USC 150(d)?	Chapter 6 Page 32
	Does the TAMP include a discussion as to how the investment strategies make or support progress toward achieving the national goals identified in 23 USC 150(b)?	Chapters 1 and 6 Pages 2-3 and 37-38
	Does the TAMP include a discussion as to how the TAMP's life-cycle planning, performance gap analysis, and risk analysis support the state DOT's TAMP investment strategies?	Chapters 2, 3, 5,& 6
LCP and risk analyses consider extreme weather and resilience 23 U.S.C. 119(e)(4)(D)	TAMP requirements were amended by the Bipartisan Infrastructure Law (BIL) (§ 11105) to require that states take into consideration extreme weather and resilience within their life-cycle cost and risk management analysis. These BIL amendments took effect on October 1, 2021 (§ 10003). As a result, state DOTs are required to consider extreme weather and resilience as part of the life-cycle cost and risk management analyses within a State TAMP (23 U.S.C. 119(e)(4)(D)).	Life Cycle Planning – Chapter 3, page 21. Chapters 2 and 5, and Appendix B. Pages 12, 13, 28, and 40-49