NEVADA DEPARTMENT OF TRANSPORTATION

BIL-COMPLIANT

Transportation Asset Management Plan

MAY 2022

NEVADA DOT

Contents

Chapter 1. Introduction

Overview

Nevada's Statewide Transportation Plan establishes the critical role that the state's transportation infrastructure system plays in supporting a growing economy and a high quality of life for its residents. The Nevada Department of Transportation (NDOT) is responsible for designing, constructing, maintaining, and operating this transportation system, which includes 13,584 lane miles of rural and urban highways, 1,239 bridges, and many other assets required to keep the transportation system operating smoothly, safely, and efficiently. Although the road network maintained by NDOT represents only 16 percent of all the roads in the State of Nevada, this network carries 58 percent of all automobile traffic and 83 percent of all truck traffic[1].

NDOT takes pride in maintaining of the nation's highest levels of pavement and bridge condition. According to the Reason Institute's *26th Annual Highway Report on the Performance of State Highway Systems*[2], NDOT boasts some of the best pavement and bridge conditions in the country. As shown in the call-out box, NDOT's commitment to preserving the condition of its pavements and bridges has led to a 7-spot improvement (from 27th to 20th) in the state's ranking for overall performance and cost-effectiveness. Nevada also ranks number one in the country in terms of bridge conditions.

While these achievements are notable, NDOT recognizes the importance of maintaining its commitment to preserve its investment in these valuable assets as the infrastructure ages and demand on the system increases. For instance, most bridges are designed for a 75-year lifespan. NDOT recognizes that 21 percent of its existing bridge deck area has exceeded that lifespan. NDOT's current goal has been to replace one structurally deficient bridge per year but would need to replace 27 bridges per year over the long term to keep up with bridges built prior to 1970. Pavement conditions have improved over the past several years, largely due to the Department's investment in pavement preservation.

NEVADA RANKING ACCORDING TO THE 26TH ANNUAL HIGHWAY REPORT ON THE PERFORMANCE OF STATE HIGHWAY SYSTEMS

20th in Overall Highway Performance (up 7 spots)

11th in Urban Interstate Pavement Condition

13th in Rural Interstate Pavement Condition

9th in Urban Arterial Pavement Condition

2nd in Rural Arterial Pavement Condition

1st in Bridge Conditions (up 1 spot)

To a large degree, the improvements in pavement and bridge conditions can be tied to the processes outlined in NDOT's 2019 Transportation Asset Management Plan (TAMP). These processes have led to a more sustainable allocation of funding for Nevada's transportation infrastructure that are reflected in this updated TAMP. Over the next 10 years, pavement and bridge conditions are projected to maintain targeted conditions under the expected funding levels.

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1 https://www.dot.nv.gov/home/showpublisheddocument/2573/636184361436770000#:~:text=Nevada's%20Statewide%20Long%2DRange%20Transportation,of%20many%20individuals%20and%20organizations.

2 https://reason.org/policy-study/26th-annual-highway-report/

Even though targets are expected to be achieved, NDOT desires to improve the condition of its transportation system even further. To do this, NDOT is continuing its commitment to asset management principles that provide a framework for making cost-effective decisions that reflect agency priorities and demonstrate fiscally responsible investment choices. This updated TAMP documents the asset management framework, describes advancements that have taken place since the 2019 TAMP was published, and outlines NDOT's plans for preserving its existing transportation system over the next 10 years. The TAMP contents have been developed through the efforts of an Asset Management Oversight Committee that represents a broad cross section of the Department and operates under the direction of the NDOT Director and the Transportation Board.

Purpose and Requirements

Federal highway legislation passed in 2012 established a performance-based federal highway program with funding focused on national transportation goals and increased accountability and transparency. One of the requirements of the legislation was the development of a risk-based asset management plan for pavement and bridge assets on the National Highway System (NHS). States were encouraged to expand their TAMP to include all state-maintained pavements and bridges, and to include other infrastructure assets within the highway right-of-way. The TAMP is expected to include a 10-year investment strategy that enables states to make progress towards state performance targets and national goals. Subsequent legislation passed since 2012 retained the requirements for a TAMP, but in October 2021, TAMP requirements were amended by the Bipartisan Infrastructure Law (BIL). The amendments require that states take into consideration extreme weather and resilience within their life cycle and risk management analyses. This TAMP satisfies the new requirement by including the consideration of extreme weather and resilience in both life cycle planning and risk management.

NDOT continues to embrace asset management as the basis for its performance management process to ensure that system preservation investments are aligned with agency priorities. Its asset management framework considers factors such as current and projected conditions, costs over the life of an asset, available funding, and risks in evaluating investment options. These asset management practices have proven to reduce preservation costs while maximizing performance across the transportation network. Asset management and system preservation continue as priorities at NDOT, largely due to the features and benefits identified in Table 1-1.

Table 1–1. Transportation asset management program features and benefits.

Asset Management Program Features	Asset Management Benefits
• Track system condition and performance • Consider public expectations and desires when setting strategic objectives • Align agency investment decisions to achieve strategic goals • Optimize the use of available funding • Use an objective process to manage assets that considers needs, performance, funding, risks, operational constraints, and maintenance costs	• Optimize and improve transportation system performance • Improve customer satisfaction • Minimize life cycle costs • Match level of service provided to public expectations • Make more informed, cost-effective program decisions and better utilize existing assets • Develop an objective method for balancing tradeoffs between competing objectives

Since NDOT had begun the implementation of asset management principles prior to the federal legislation in 2012, the Department was in a good position to expand the scope of the TAMP beyond the

minimum requirements outlined in the law. NDOT evaluated the availability and maturity of its asset data and decided to include all state-maintained roads and bridges in the TAMP. In addition, NDOT elected to include certain Intelligent Transportation System (ITS) assets since an objective assessment concluded that data on ITS assets was available and they were a high priority to the Department in managing traffic operations. There were other high priority items such as hydraulic infrastructure, sign structures, slopes, and guard rails; however, NDOT decided to reconsider their inclusion in future TAMPs when the inventory and condition information for these assets matures. Guardrail, barriers, slopes, and culverts are among the highest-priority assets for possible inclusion in future TAMPs.

TAMP Content

In addition to satisfying a federal requirement, this TAMP serves as an important communication and accountability tool that will guide NDOT's investments in pavement, bridge, and ITS preservation over the next 10 years. The TAMP content has been developed using processes certified by the Federal Highway Administration (FHWA) on May 30, 2018. TAMPs are required to be updated for re-certification when processes change or within 4 years of certification. Although NDOT updated its TAMP in 2019, the 4-year re-certification requirement is based on the original certification date from 2018.

As in the previous two TAMPs, this document summarizes the pavement, bridge, and ITS assets that NDOT maintains, providing information about the asset inventory and condition. In addition, the document describes the performance metrics that are used to monitor the performance of these assets. Using life cycle planning, the TAMP illustrates the cost-effectiveness of timely preservation activities and the costly consequences if these activities are deferred.

In addition to costs, the TAMP considers the potential risks that NDOT faces while managing assets that continue to age and deteriorate in an unpredictable environment. This TAMP expands the focus on risks to include system resilience and extreme weather events in response to new federal requirements. The formal risk analysis used to consider uncertainties enables NDOT to analyze and prioritize problem areas before unexpected events occur, rather than wait and react to the resulting damage. As a result, future improvements can be planned and prioritized within the highway construction program to address high-risk or vulnerable areas.

The TAMP also includes a 10-year financial plan based on projected revenue and forecasted conditions. Planned investment strategies place a high priority on continuing NDOT's efforts to preserve the performance of the state's high-volume facilities because of the substantial cost associated with re-building these facilities should conditions deteriorate. The planned investment strategies included in the TAMP continue NDOT's use of low-cost preservation treatments, which has led to improved conditions over the last several years. Targeted conditions for pavements and bridges are expected to be maintained over the 10-year period with expected levels of funding. NDOT will continue to base future system preservation expenditures on improving conditions, especially on the lower-volume facilities, using its systematic process that is aligned with agency goals and priorities.

The TAMP also includes a chapter on planned enhancements that NDOT will make to improve the implementation of asset management within the Department. These activities will enhance NDOT's current analysis capabilities and refine existing asset management processes.

The TAMP content is organized into the chapters and appendices listed below.

THE NDOT TRANSPORTATION ASSET MANAGEMENT PLAN

Summarizes the number and condition of pavement, bridge, and ITS assets NDOT maintains.

Illustrates the cost-effectiveness of the preservation strategies NDOT is currently using.

Identifies, evaluates, and prioritizes risks that may impact NDOT's ability to achieve its goals and build a resilient transportation system.

Describes expected funding levels and recommends 10- year investment strategies for pavements, bridges, and ITS assets.

Documents future enhancements that NDOT will undertake to improve its practices.

- **Chapter 1: Introduction**—Introduces the TAMP and its content.
- **Chapter 2: Asset Management Objectives**—Introduces NDOT's asset management program and the business processes that support these efforts, including current performance measures and targets.
- **Chapter 3: Asset Inventory and Performance**—Summarizes information about the pavement, bridge, and ITS assets included in the TAMP, including the size of the inventory, the condition of the assets, and their replacement value.
- **Chapter 4: Life Cycle Planning Considerations**—Describes the life cycle planning that was conducted to evaluate the cost-effectiveness of NDOT's current treatment strategies and demonstrates the long-term financial benefits to NDOT's preservation strategy.
- **Chapter 5: Risk and Resilience**—Identifies the risks that may hinder NDOT's ability to achieve its performance targets and establishes priorities for managing them to build a more resilient transportation system.
- **Chapter 6: Financial Plan and Investment Strategies**— Uses forecasting and trend analysis to develop revenue projections and describes how available funds will be invested in pavements, bridges, and ITS assets over the 10-year planning horizon.
- **Chapter 7: Asset Management Process Enhancements**—Summarizes roles and responsibilities for asset management governance and describes enhancements that are expected to be made to further develop NDOT's asset management capabilities.
- **Appendix A: TAMP Compliance Checklist**—Summarizes TAMP requirements and the sections of the TAMP that address those requirements.
- **Appendix B: Nevada NHS Roadway Listing**—Provides a summary listing of the NHS routes in Nevada.
- **Appendix C: Assumptions Used in Life-Cycle Planning Analysis for ITS Assets—**Documents key assumptions used in modeling the life cycle performance and investment needs for the ITS assets addressed in this TAMP.

Chapter 2. Asset Management Objectives

Overview

To manage the state's highway system effectively, NDOT has established a strategic performance management process. This process uses measurable performance indicators for monitoring progress toward strategic targets. The targets, which are guided by input from the traveling public, the State Legislature, the Transportation Board, NDOT leadership, and NDOT Division offices, drive investment decisions and the allocation of resources. The results of this effort are monitored regularly and published in the annual Performance Management Report. The process is illustrated in Figure 2-1.

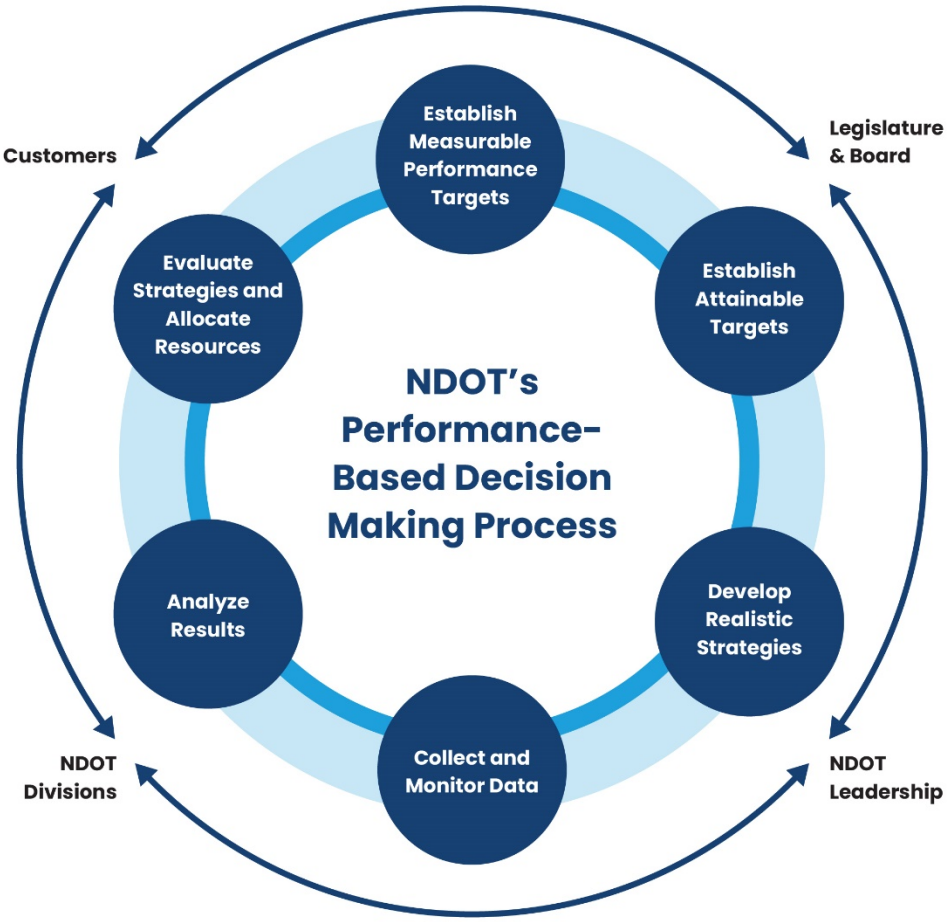


Figure 2-1. NDOT's strategic performance management process.

Given the scarcity of adequate financial resources, NDOT has focused on developing better methods to prolong the service lives of its assets and maintain their performance as cost-effectively as possible. Asset management has been a key to achieving this with its emphasis on life cycle planning strategies that keep assets in good condition through the timely use of low-cost preventive maintenance treatments that defer the need more costly reconstruction activities.

Asset management starts with identifying and measuring NDOT's objectives for level of service and carefully evaluating each proposed investment for its ability to improve system performance. Every time NDOT builds new infrastructure, it commits to a stream of future costs to keep the assets in service and performing as intended. Investment decisions are based on solutions that keep costs low in the long run and maximize asset service lives. This strategic approach to performance and costs is supported in state law. For example, Nevada Revised Statutes (NRS) 408.133 calls on the Department to measure and report on system performance and NRS 408.3195 requires an analysis of expected costs and benefits for proposed highway projects.

Goals and Objectives

The NDOT *Statewide Transportation Plan – Moving Nevada Through 2028* establishes a list of key performance objectives, or Guiding Principles, which guide the Department's construction and maintenance decisions. These include:

- Safety—Improve safety for all modes of our transportation system.
- Customer Service—Improve internal and external customer service and satisfaction.
- Fiscal Responsibility—Secure the highest amount of funding possible for our state and ensure that it is invested responsibly and properly.
- Asset Management—Protect the public's investment in our transportation system.
- Mobility/Accessibility—Provide a statewide, multimodal, interconnected, efficient transportation system that enhances Nevada's economic competitiveness.
- Freight Movement—Improve the safety and mobility of freight movers.
- Environmental Stewardship—Ensure the human and natural environments are considered when developing the transportation system.

NDOT One Nevada Transportation Plan provides strategic direction and essential actions to meet Nevada's current and future transportation needs. The plan is being built on a foundation of six critical goal areas that encompass an array of transportation issues and opportunities that reflect Nevada's public and transportation partner priorities. The critical goal areas include:

- Enhance safety.
- Preserve infrastructure.
- Optimize mobility.
- Transform economies.
- Foster sustainability.
- Connect communities.

Both documents place a priority on protecting and preserving the investment in the transportation infrastructure through sound asset management principles.

Linking the TAMP to Existing Business Practices

NDOT's asset management process is presented in Figure 2-2. It reflects activities that ensure that the Department is continuously measuring its performance and programming investments that are most cost effective to improve performance. It is based on the principle that what gets measured gets done. Key features include:

- A clear relationship between investment decisions and agency objectives using performance measures designed to indicate how well each asset and project satisfies agency goals and policies.
- Maintenance of an asset inventory for pavements, bridges, and other significant asset classes.
- Periodic asset inspections to update the inventory and monitor performance. This information serves as the basis for identifying candidate projects and treatments. Forecasting models estimate future changes in performance and future needs, providing an opportunity for NDOT to anticipate and avoid or delay future costs.
- Consideration of project alternatives to account for uncertainty in funding, costs, conditions, and hazards.
- Development of short- and long-range plans, programs, and targets culminating in updates to this TAMP and projects in the State Transportation Improvement Plan (STIP).

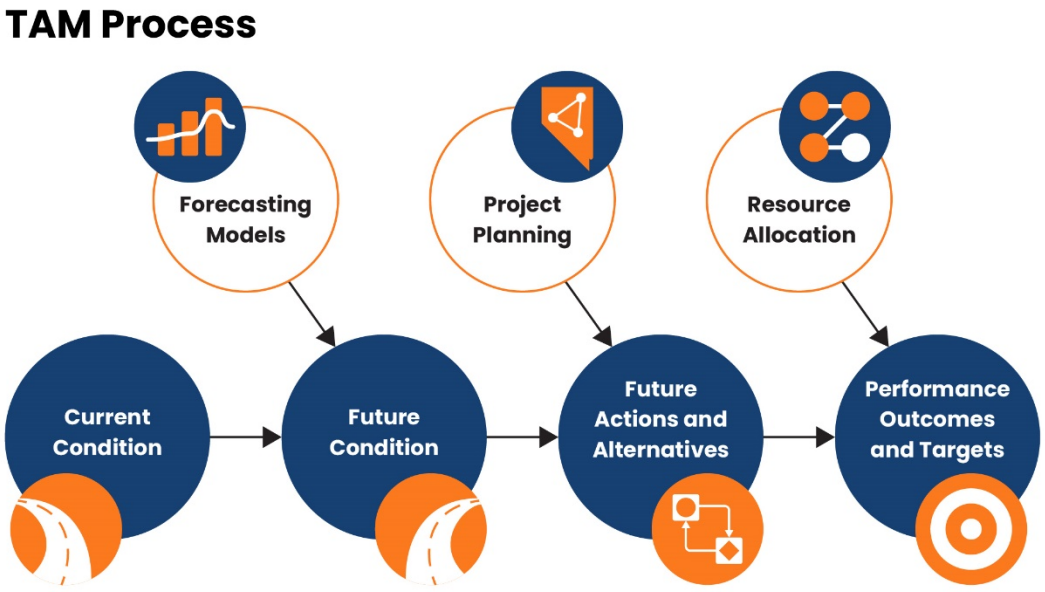


Figure 2-2. NDOT's TAM process.

As optimized investments in system preservation are delivered, their effectiveness is measured to monitor progress towards NDOT's objectives and targets. Throughout the process, adjustments are made to further improve NDOT's forecasting and delivery capabilities. In this way, NDOT engages in a process of continuous improvement, using its ability to measure performance to identify ways of

improving. All the ingredients in the process work together to help NDOT keep its long-term costs lower and manage risk at acceptable levels.

For many years NDOT has had in place a set of procedures and systems for monitoring the condition of its infrastructure, focused on pavements and bridges. These systems include an up-to-date inventory and a variety of data items related to physical deterioration, traffic, safety, mobility, risk, and costs. These processes comply with federal requirements and are subject to uniform national quality assurance processes. NDOT has also developed a Data Quality Management Plan for pavement condition assessments that is in accordance with the FHWA requirements and the new Enterprise Asset Management System (EAMS) that is being implemented is in accordance with the requirements specified under 23 CFR 515.17.

For pavements, NDOT is in the process of upgrading its analysis capabilities in EAMS. The new features provided in EAMS enable NDOT to improve its forecasting and analysis capabilities so the Department can better develop, compare, and optimize program alternatives based on future cost savings and performance. The enhanced capabilities are currently being tested and refined prior to their full implementation. NDOT is also implementing new analysis methods for bridges in EAMS. These new tools promise considerable potential for long-term cost savings from taking a more developed approach to bridge preservation when making decisions.

The TAMP reflects NDOT's commitment to asset management and the Department's efforts to integrate asset management into planning and programming activities. As shown in Figure 2-3, the TAMP links high-level, long-term transportation plans (such as the Statewide Transportation Plan and the One Nevada Plan) with both capital and maintenance improvement programs.

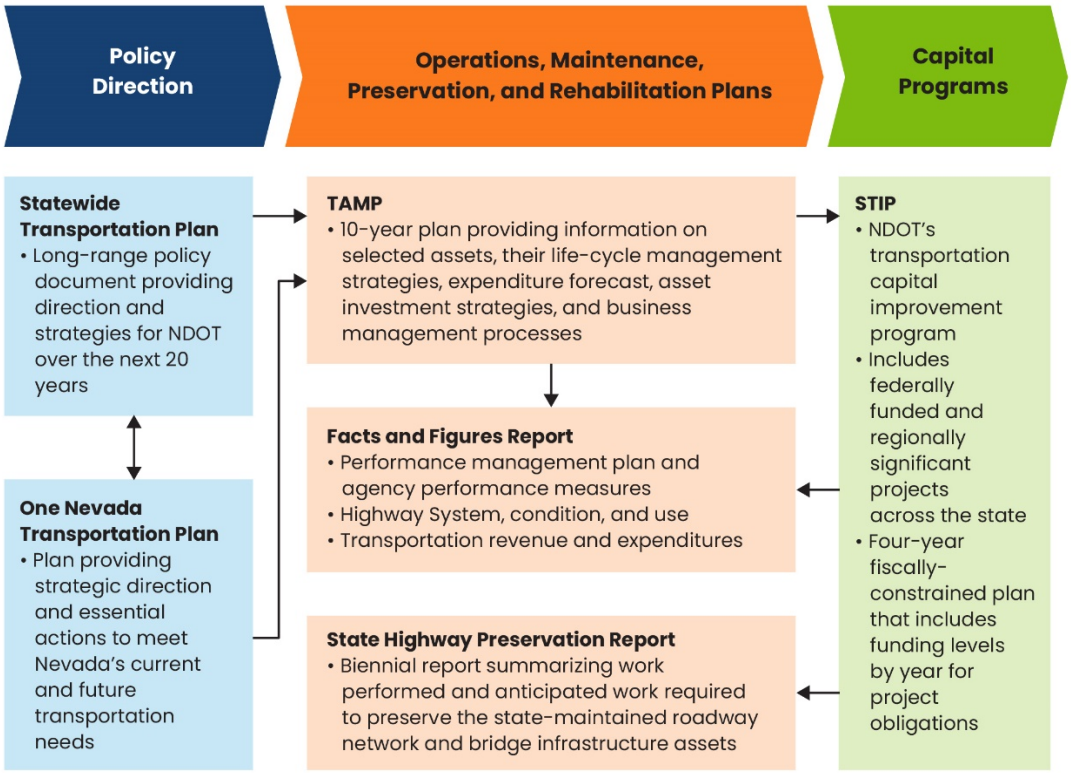


Figure 2-3. The TAMP's link to NDOT policies, plans, and programs.

Additional information about asset management within NDOT can be found in the documents shown in Figure 2-4. These include the *Statewide Transportation Plan*, the *One Nevada Plan*, the *State Highway Preservation Report*, and the *Facts and Figures Report*.

Figure 2-4. Guiding documents for TAMP development.

Chapter 3. Asset Inventory and Performance

Overview

Nevada's state highway system includes 13,584 lane-miles of roadways, 1,239 bridges and 2,187 ITS assets. Collectively, the replacement value of these assets is approximately $23 billion. In addition to roadways and bridges, numerous other transportation assets are maintained by NDOT, as shown in Table 3-1.

Table 3-1. Examples of assets managed by NDOT.

Asset Category	Asset Type
Pavements	Mainline Pavements
	Shoulders
Bridges	Bridges and Bridge Culverts
Hydraulic Infrastructure	Drainage Culverts
	Pipes
	Other Drainage Structures [drop inlets, manholes, basins, and channels (ditches and irrigation)]
Other Roadside Assets	Pavement Striping and Marking
	Curb and Gutter
	Guard Rails, Barriers, and Impact Attenuators
	Slopes and Embankments
	Retaining Walls
	Noise Barrier Walls
	Rest Areas, Salt-Sand Storage Areas, Weigh Stations
	Maintenance Depots, Pump Houses, Communication Buildings
	Lighting Structures
	Landscape Features
Traffic Assets	Intelligent Transportation Systems (ITS)
	Signs and Support Structures
	Traffic Signals
Multimodal Assets	Americans with Disabilities Act (ADA) Features
	Bike Paths
	Sidewalks

NDOT routinely collects asset performance data on its highway system to evaluate the effectiveness of its investments and determine future maintenance needs. Maintaining transportation assets in *Good* condition by preserving their condition is key to reducing life cycle costs and providing a safe transportation system for Nevada's citizens. NDOT uses a standardized approach, which has continuously been improved over the years, to evaluate, maintain, and manage asset performance data.

Asset Inventory

Pavements

NDOT's road network is divided into five road prioritization categories (as shown in Figure 3-1) determined by heavy truck traffic loads [based on Equivalent Single Axle Loads (ESALs) and average daily traffic (ADT)]. Local roads maintained by cities and counties, and roads on federal lands, are not included in the state-maintained road network. Brief descriptions of the five road prioritization categories are provided below:

- **Category 1: Controlled Access Roads.** These roads include NHS routes like Interstates, freeways, and expressways with limited access and high traffic speeds. Examples include Interstate 15 (Clark County), Interstate 580 (Washoe County), and Interstate 80 (Elko County).
- **Category 2: ESALs > 540 or ADT > 10,000.** These roads have high traffic volumes and heavy truck loads but are not considered controlled-access roads. They include mostly Non-Interstate NHS routes and some non-NHS routes. Examples include SR146, St. Rose Parkway (Clark County), US 050, Lincoln Highway (Carson City), SR227, and Fifth Street (Elko County).
- **Category 3: 540 ≥ ESALs > 405 or 1,600 < ADT ≤ 10,000**. These roads have relatively high traffic and truck loads and includes mostly NHS routes and some non-NHS routes. These are generally considered to be state routes (SR) such as SR157, Kyle Canyon Road (Clark County), SR028, Lake Tahoe Area (Douglas County), and SR225, and West Urban Limits of Elko (Elko County).
- **Category 4: 405 ≥ ESALs > 270 or 400 < ADT ≤ 1,600.** These roads include the lower volume state routes that include mostly non-NHS routes although there are some NHS routes. Examples include SR158, Deer Creek Road (Clark County), SR206, Foothill Road/Genoa Lane (Douglas County), SR228, and Jiggs Road (Elko County).
- **Category 5: ADT ≤ 400.** These roads are non-NHS routes with the lowest traffic volumes in the state. Examples include SR 156, Lee Canyon Road (Clark County), SR229, and Secret Pass Road (Elko County).

NHS routes include the Interstate Highway System and additional roads that serve major airports, ports, and other strategic transport facilities. Although most of the NHS routes are managed by NDOT, there are approximately 815 lane-miles that make up approximately 6 percent of the total pavement mileage that are managed by local agencies in the state. A summary listing of all the NHS routes in Nevada, including those managed by local agencies is available in Appendix B.

NDOT collects cracking, roughness, rutting, and faulting data on all NHS routes as part of its pavement management practices in compliance with the Highway Performance Monitoring System (HPMS) reporting requirements. The performance targets established for the state-maintained NHS pavements also apply to the NHS pavements maintained by local agencies (discussed in Chapter 6).

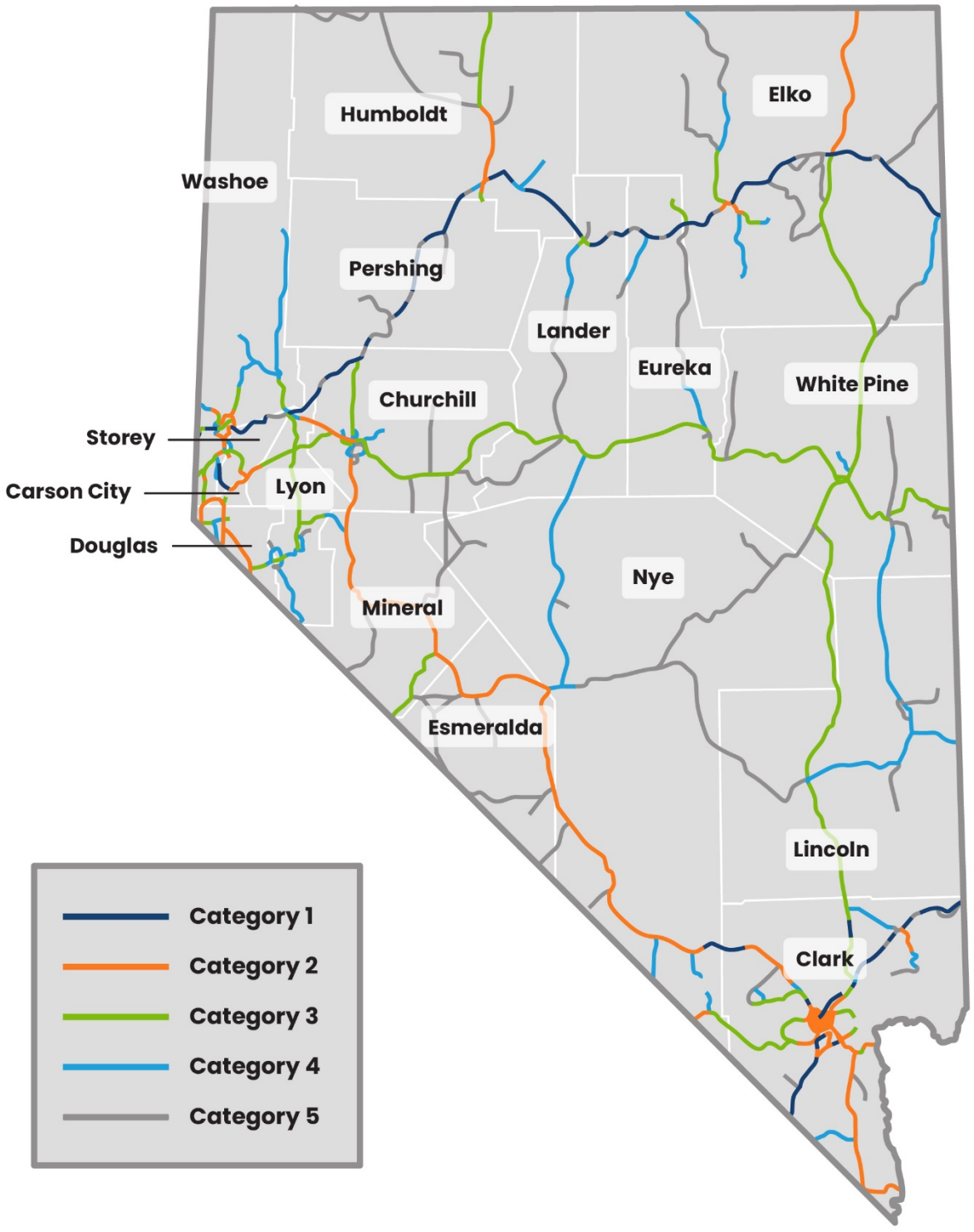


Figure 3-1. Nevada's state-maintained roadway network by prioritization categories.

Figure 3-2 shows the distribution of the pavement inventory by system (NHS vs. non-NHS), pavement type (the type of road surface, such as asphalt surfaced or concrete surfaced), and prioritization category.

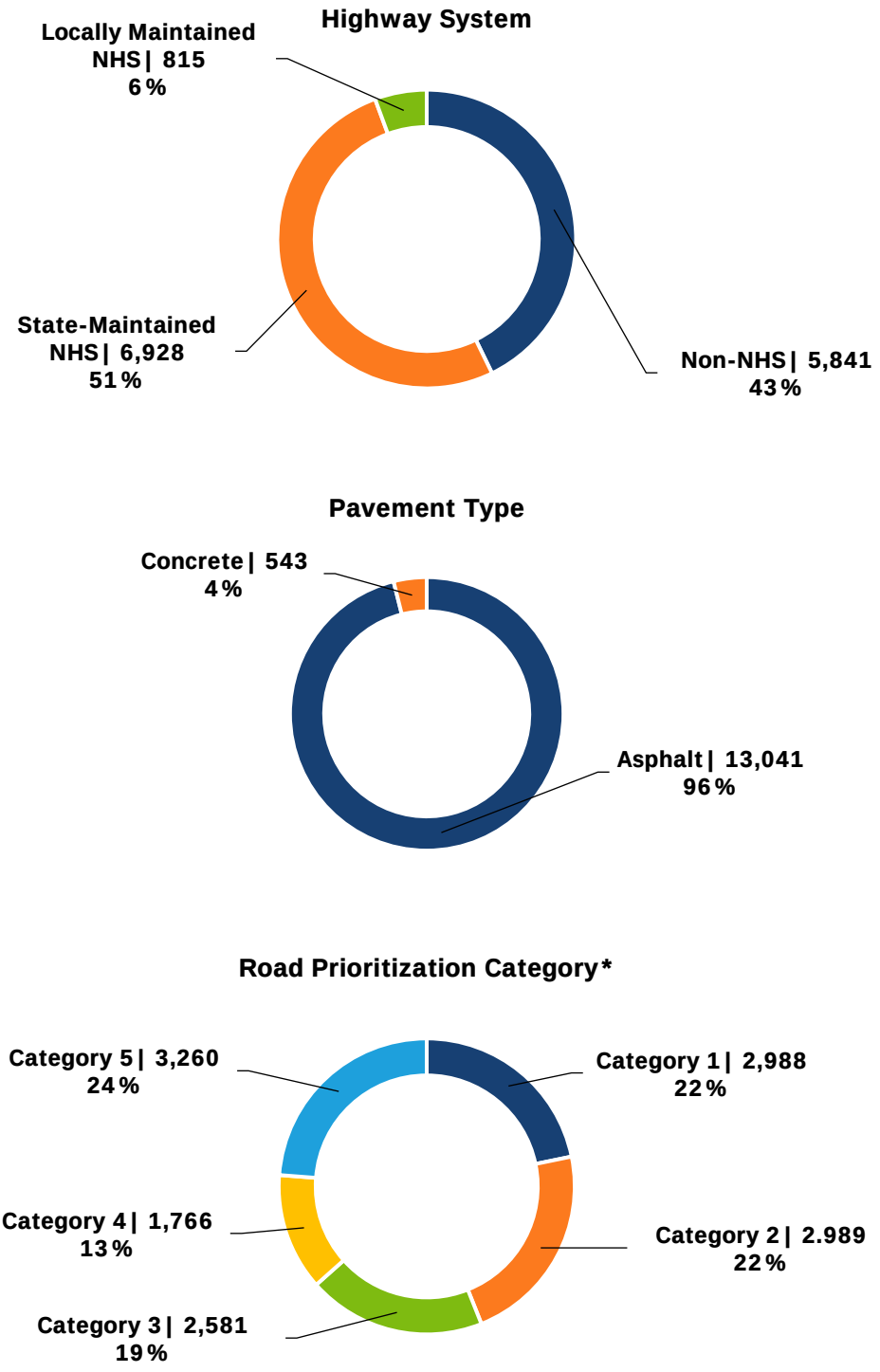


Figure 3-2. Distribution of NDOT's state-maintained road network inventory in lane-miles. (Based on NDOT's pavement management data)

Bridges

NDOT owns 1,239 bridges across the state. In addition to the state-maintained bridges, there are 114 bridges on the NHS that are owned by local agencies. This TAMP addresses a total of 1,353 bridges.

NHS bridges are structures that carry passenger vehicles and truck traffic on NHS routes with a clear span of more than 20 feet along the roadway centerline. The Non-NHS category includes all state-owned structures in the NDOT bridge inventory that do not qualify as NHS, either because they do not carry an NHS route, do not carry vehicular traffic, or carry railroad traffic. Figure 3-3 shows the distribution of NDOT's state- and locally maintained bridge inventory by count and deck area.

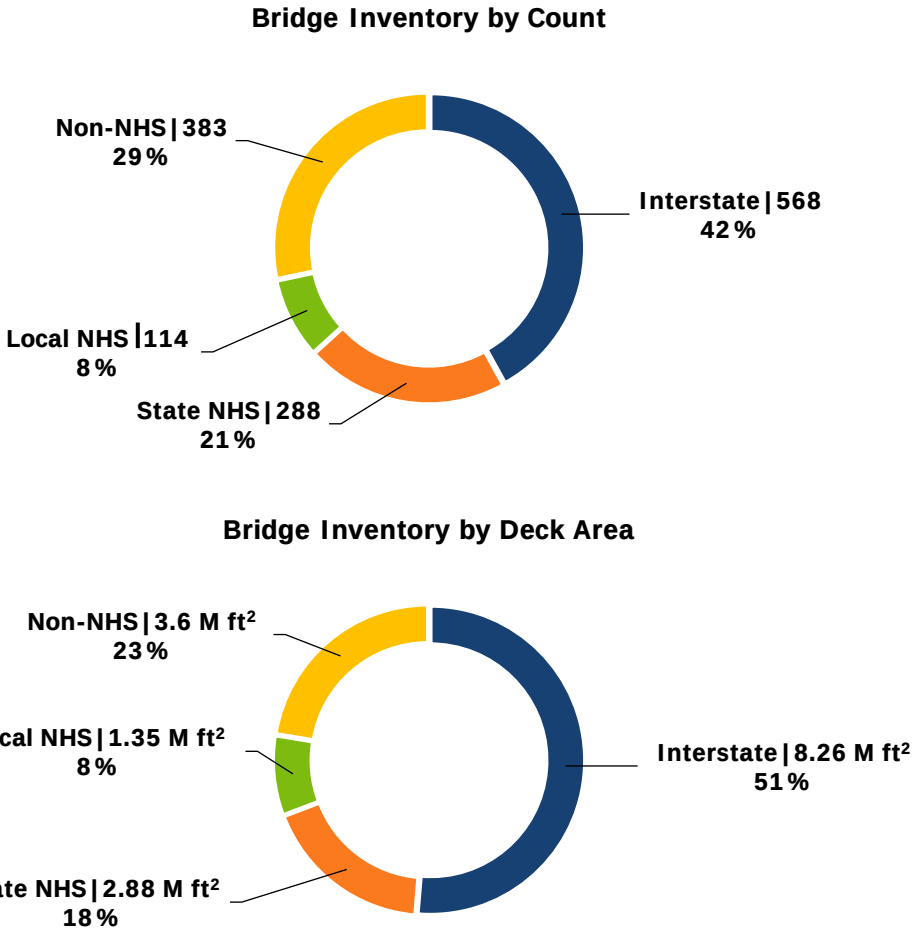


Figure 3-3. NDOT's bridge inventory.

Intelligent Transportation System (ITS) Assets

NDOT's Traffic Operations Division maintains and manages several types of ITS assets to address highway safety and mobility needs. The following ITS assets are addressed in this TAMP: Closed Circuit Television Camera (CCTV) devices, Dynamic Message Signs (DMS), Flow Detectors (FD), Highway Activity Radios (HAR), Ramp Meters, Road Weather Information Systems (RWIS), Active Traffic Management System (ATM DMS), Wrong Way Driver (WWD) detection, and High-Occupancy Vehicle (HOV) detection devices. The ITS asset maintenance and management strategies discussed in this TAMP

cover only the devices and not the supporting structures and other secondary devices that make up the equipment. Figure 3-4 shows a summary of the ITS asset inventories included in this TAMP.

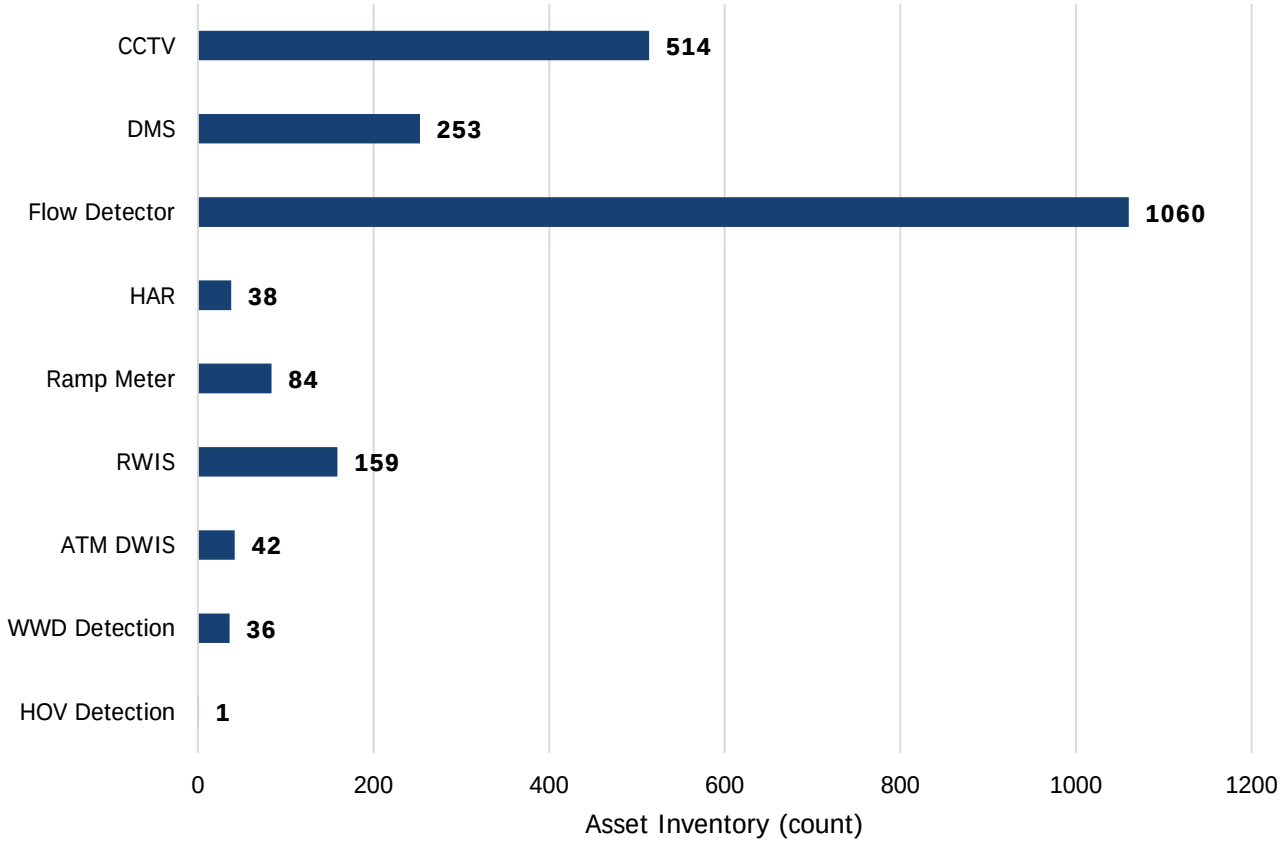


Figure 3-4. ITS asset inventories.

Factors Influencing Asset Condition and Performance

Asset age is one of the key factors influencing performance. As assets age, they require more maintenance and rehabilitation to provide an acceptable level of service. Figures 3-5 and 3-6 show the age profile of NDOT's pavements and bridges, respectively. One-third of the state-maintained pavements have a surface that is less than 10 years old, which means that less than 40 percent of its design life has passed. These represent either newly constructed pavements or, more typically, pavements that have recently been resurfaced. They require maintenance and preservation treatments to maintain or improve their conditions, extend their service life, and delay the need for major rehabilitation or reconstruction.

Approximately 59 percent of the state-maintained bridges are between 11 and 40 years old. As with pavements, routine maintenance and preservation are key to ensuring good bridge performance although older bridges may need more substantial repairs. A more detailed discussion on life cycle planning strategies is presented in Chapter 4.

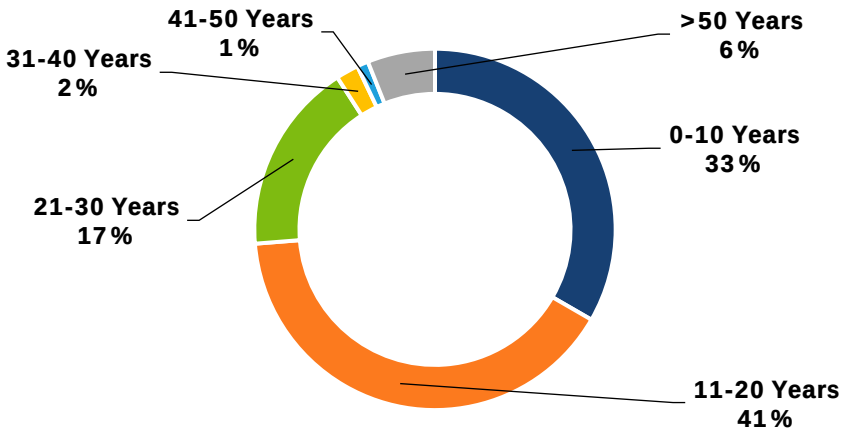


Figure 3-5. Age profile of state-maintained pavements (based on lane-miles).

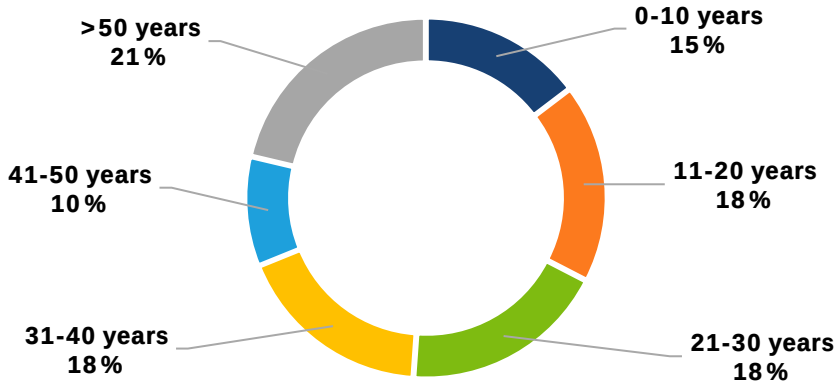


Figure 3-6. Age profile of NHS and state-owned NBIS bridges (based on deck area).[3]

In addition to age, asset conditions are also influenced by other factors such as construction type and quality, climatic and operating conditions, traffic loading, and human factors. Some of the main factors influencing the condition and performance of the assets included in the TAMP are highlighted in Table 3-2.

[3] Based on historical data sets in the National Bridge Inventory, excluding bridges of less than 20-foot span, and bridges that do not carry vehicular traffic.

Table 3-2: Significant factors influencing asset conditions.

Pavements	Bridges	ITS Assets
Pavement type	Bridge type	Fabrication quality
Traffic volumes	Usage of deicing chemicals	Installation quality
Traffic weight	Presence of water	Traffic hits
Environmental factors	Traffic volumes	Strong winds
Material properties	Traffic weight	Firmware issues
Type of underlying material	Environmental factors	Obsolescence
Maintenance frequency	Material properties	
Construction quality	Maintenance frequency	
	Construction quality	

Performance Measures

NDOT Performance Measures for Pavements

NDOT collects international roughness index (IRI), faulting, and rutting data using a high-speed laser profiler annually for NHS routes and biennially for non-NHS routes. Friction data is collected using a one-sided locked wheel friction tester biennially on concrete pavements. Pavement distress and cracking data is manually collected (following the NDOT Flexible Pavement Distress Identification Manual) biennially on the entire flexible pavement network. Distress data for flexible pavements are collected over a 1,000 sq.ft. section (based on a 100 ft. x 10 ft. sample) that is averaged to represent a one-mile segment. NDOT currently does not collect distress data on concrete pavements. Network level pavement data is collected only in the rightmost through lane. Pavement data for other locations (e.g., ramps, shoulders, medians, and turn lanes) are collected only for project specific needs.

For internal uses, NDOT assesses pavement conditions using the Present Serviceability Index (PSI), which measures pavement condition attributes that are important to the traveling public. The PSI is computed using pavement condition measurements (such as smoothness) and distresses such as cracking, rutting, and patching. The raw distress data is combined to determine the PSI on a 5-point scale with 5 representing a new pavement and 0 representing a pavement in failed condition. Table 3-3 summarizes the relationship between PSI ratings and pavement condition categories that include *Very Good*, *Good*, *Fair*, *Mediocre*, *Poor*, and *Very Poor* or *Failed*. NDOT considers pavement in *Fair* or better condition, which is indicated by a PSI ≥3.0 to be in a State of Good Repair (SOGR). Pavements in a SOGR have little structural deterioration present and can be preserved very cost-effectively.

NDOT's recently retired its in-house Oracle-based pavement management system (PMS) developed originally in 1980. However, the system was used to conduct all the data analyses for this TAMP since the new PMS was still in testing stages as the TAMP was being developed. NDOT has implemented a new Enterprise Asset Management System (EAMS) to replace the legacy systems. The EAMS includes the following components: maintenance management system (MMS), PMS, bridge management system (BMS), and a stormwater management system (SWS). This single, integrated EAMS is expected to provide seamless data exchange between pavement, bridge, maintenance, and stormwater management functions thereby reducing risk, enhancing system usability, and increasing staff efficiency through data integration.

Table 3-3. PSI rating scale categories.

PSI Range & Condition Category	Example Photo	Description	SOGR
Very Good 5.00 to 4.00		• Very smooth ride quality with very little to no pavement distress. • Pavement is in like-new condition.	✓
Good 3.99 to 3.50		• Very smooth ride quality with minor distresses that are typically environmental rather than load related. • Distresses include minor non-wheel path longitudinal and transverse cracks as well as minor surface raveling. • Candidate for preventive maintenance such as crack sealing and surface treatments such as chip, slurry, and scrub seals. • Surface treatments reduce pavement deterioration and protect the pavement structure from water infiltration and weathering.	✓
Fair 3.49 to 3.00		• Good ride quality except noticeable environmental distress such as longitudinal and transverse cracks, light surface oxidation and weathering. • Structural distress in the form of ruts and fatigue cracks begin to occur. • Candidate for a surface treatment such as microsurfacing or double chip seal, and possibly a two-inch overlay.	✓
Mediocre 2.99 to 2.50		• Barely acceptable ride quality and significant environmental and structural distresses have accumulated. • Pavement has non-wheel path longitudinal cracking and transverse cracks so closely spaced that block cracks develop. Ruts and fatigue cracks are present. • Pavement structural deterioration is evident. • Candidate for three inch or thicker overlays and may require patching before the new overlay is placed.	
Poor 2.49 to 2.00		• Poor ride quality and large amounts of environmental and structural related distresses have accumulated. • Non-wheel path longitudinal and transverse cracks are severe. The surface is weathered, rutted, and fatigue cracks are widespread. • Lower volume roads are candidates for thick overlays or cold in-place recycling (CIR) and overlay repair. Higher • volume roads will require reconstruction such as a full depth recycling and overlay repair.	
Very Poor or Failed < 2.00		• Very poor ride quality and significant environmental and structural distresses have accumulated. • The surface is pitted and there are wide non-wheel path longitudinal and transverse cracks. Networked, spalled fatigue cracks, deep ruts, and potholes are prevalent. • Requires constant maintenance activity such as patching and filling potholes. • Requires full-depth reconstruction and recycling the road may not be an option.	

The recently implemented PMS includes pavement prediction models for each road prioritization category established based on historical information, regression analysis, application of the family model prediction method, and institutional knowledge from NDOT's pavement management experts. The PMS provides information that enables NDOT to make informed decisions on how to maintain and improve the condition of the roadway network while maximizing pavement performance through the practical use of available funds. The PMS improves the efficiency of decision making, provides assessment on the consequences of decisions through comparative analysis, and ensures consistency of network and project level activities and results. NDOT's new PMS satisfies all the 23 CFR 515.17 requirements.

NDOT is also in the process of replacing the existing data collection process and equipment with a modern 3D laser-based system. This new equipment is expected to greatly improve the quality of pavement performance data. In parallel with the implementation of new data collection equipment, NDOT will also be working on updating the PSI calculation procedures (which is partially based on manually collected distress data). The updated procedures are expected to be in place prior to the full network data collection effort for 2023.

NDOT Performance Measures for Bridges

NDOT manages the inspections and collects all the data for all state- and locally owned bridges in Nevada and provides the data to the bridge owners. The data in the NDOT bridge inventory is collected in accordance with the National Bridge Inspection Standards (NBIS) and is reported to the National Bridge Inventory.

The NDOT BMS is part of the new EAMS that is currently being implemented. The BMS uses bridge inventory and condition data to assess current bridge conditions and forecast future bridge conditions. Once fully implemented, EAMS will satisfy all the 23 CFR 515.17 requirements for a BMS.

Bridge inspectors rate condition on the NBI component scale of 0 to 9 as shown in Table 3-4. The deck, superstructure, and substructure of each bridge are rated separately. For the purposes of this TAMP, and for developing performance targets, the three bridge ratings are combined by selecting the worst of the assessed ratings. Then, the 0-9 scale is collapsed into just three classes with ratings of 7 or better representing bridges in *Good* condition, ratings of 5 or 6 representing bridges in *Fair* condition, and ratings of 4 or lower represent bridges in *Poor* condition (shown later in Table 3-9).

When any of the NBI condition ratings fall to 4 or below, the bridge is considered structurally deficient (SD). For NHS bridges, federal law specifies a penalty for states that have more than 10 percent of their deck area on structurally deficient bridges. Nevada currently has only 0.9 percent in this category and is not at risk of failing the federal criterion in the next 10 years.

NDOT considers a bridge to be in a State of Good Repair when the primary NBI Condition Ratings (Items 58, 59, 60, and 62) are 5 or higher. Therefore, bridges that are in *Good* or *Fair* condition are in a State of Good Repair. The percentage of bridges in a State of Good Repair has experienced a minor amount of fluctuation but has consistently been greater than 98% in the past ten years.

Table 3-4. Bridge condition rating scale.

	NBI Rating	Condition	Condition Description	SOGR
Good	9	*Excellent*	Like new condition	✓
	8	*Very Good*	No problems noted	✓
	7	*Good*	Some minor problems	✓
Fair	6	*Satisfactory*	Structural elements show minor deterioration	✓
	5	*Fair*	All primary structural elements are sound but may have minor section loss, cracking, spalling or scour	✓
Poor	4	*Poor*	Advanced section loss, deterioration, spalling or scour	
	3	*Serious*	Loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present	
	2	*Critical*	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken	
	1	*Imminent Failure*	Major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic, but corrective action may put back in light service	
	0	*Failed*	Out of service—beyond corrective action	
	N		Not Applicable	

ITS Assets

Unlike pavements and bridges, ITS assets do not have a formally established performance metric for condition. Additionally, there are no federally required performance measures that must be reported. For the purposes of the TAMP, a simplified subjective performance metric based on the manufacturers-recommended service life for each device was established as shown in Table 3-5.

Table 3-5. ITS condition rating scale.

Condition Category	Condition Description
Good	Age of the device is less than 80 percent of the manufacturers' recommended service life.
Low Risk	Age of the device is between 80 and 100 percent of the manufacturers' recommended service life.
Medium Risk	Age of the device is between 100 and 125 percent of the manufacturers' recommended service life.
High Risk	Age of the device is greater than 125 percent of the manufacturers' recommended service life.

Currently, NDOT does not track ITS device age. However, NDOT is taking the necessary steps to establish a more structured data management system for ITS assets. The ITS asset age information used for LCP analysis (discussed in Chapter 4) was estimated based on input from NDOT's ITS experts.

Asset Performance

Performance Trends

Historical pavement performance trends are illustrated in Figure 3-7. Since 2012, statewide pavement conditions have remained stable. Category 1 pavements (which includes all the Interstate pavements) have remained in *Very Good* condition over the last decade, which is testament to the fact that NDOT places high importance on maintaining Interstate pavements at a very high level of service. Over the years, the condition of Category 5 pavements has been lower than desired because historic funding levels were inadequate to maintain lower-priority pavements (further discussed in Chapter 4). The current funding level is significantly higher than the historical average, and it is expected to be adequate to maintain pavement condition (across all categories) over the next 10 years (discussed in Chapter 6).

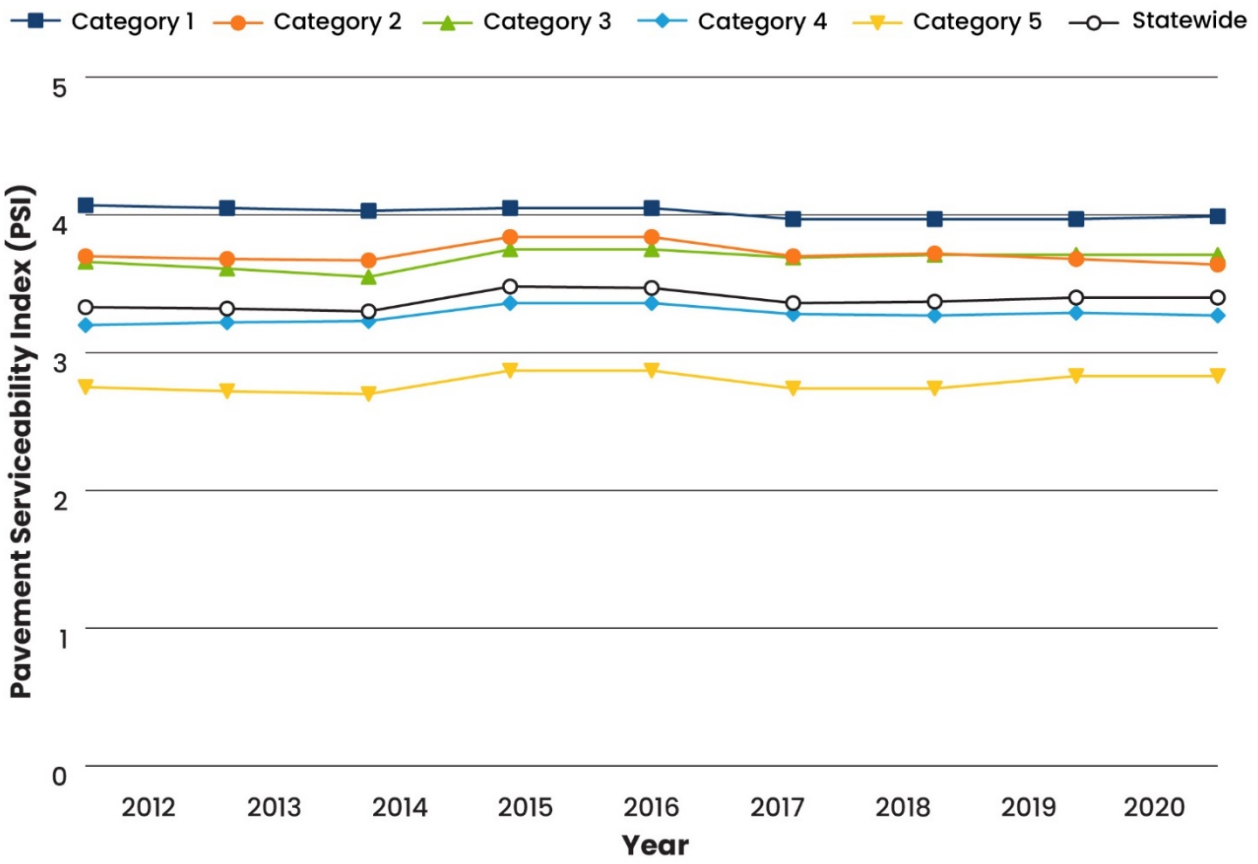


Figure 3-7. Pavement performance trends.

Figure 3-8 illustrates historical bridge condition trends. The percent of bridges in Good condition dropped significantly beginning in 2016. However, bridge conditions have stabilized, and improved slightly, in recent years due to the implementation of the previous TAMP investments. The investment plan discussed in Chapter 6 seeks to gradually increase the percent in *Good* condition while keeping the percent *Poor* at its relatively low level.

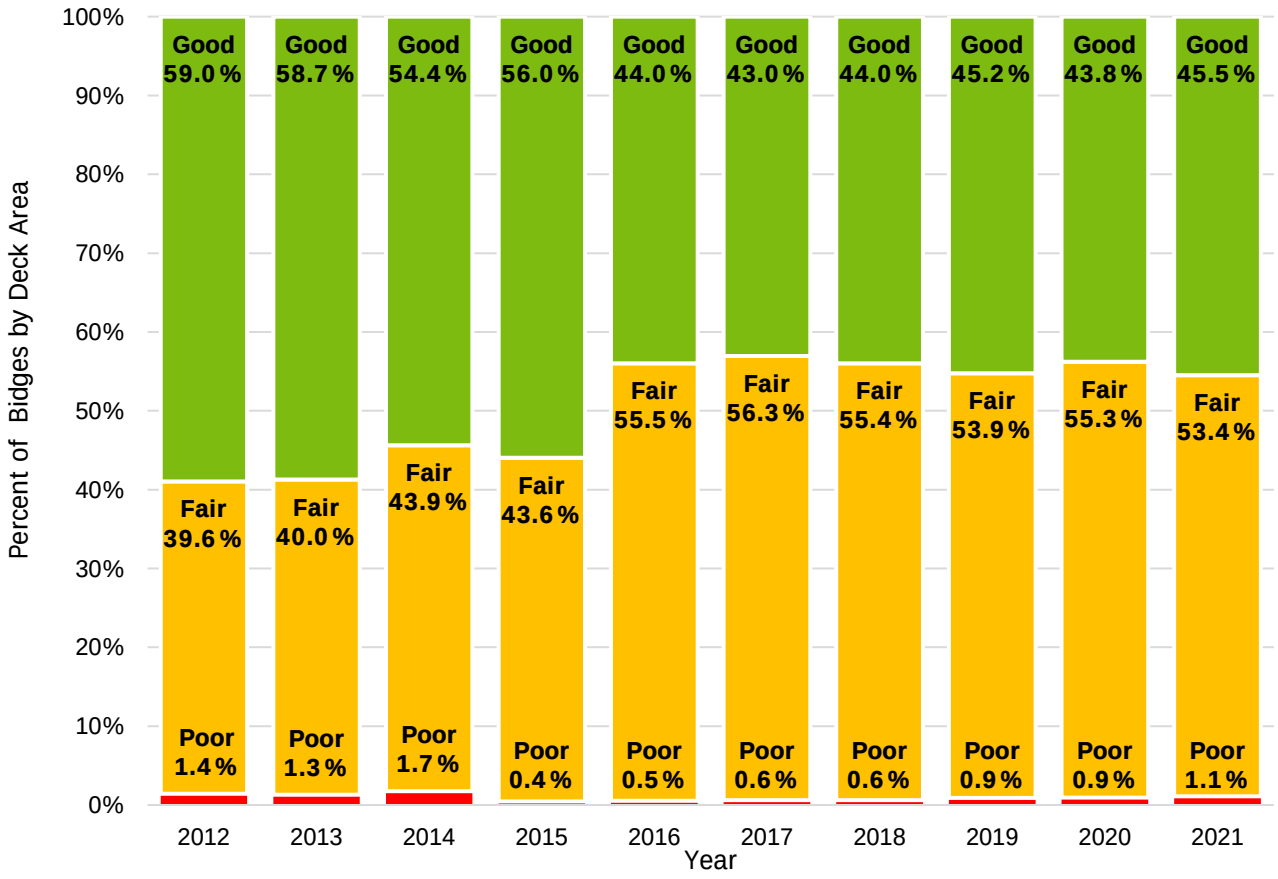


Figure 3-8. Bridge performance trends for NHS and state-owned NBIS bridges.[4]

Current Conditions

Table 3-6 summarizes the current conditions of pavements, bridges, and ITS assets.

The ITS conditions in Table 3-6 were estimated based on input from NDOT subject matter experts. NDOT has not formally adopted the ITS performance measures reported in the TAMP; however, NDOT is looking to adopt a performance-based approach for ITS assets and is actively working on implementing its EAMS to monitor the inventory, performance, and investments in ITS assets.

[4] Based on historical data sets in the National Bridge Inventory, excluding bridges of less than 20-foot span, and bridges that do not carry vehicular traffic.

Table 3–6. Current asset conditions.

Pavements (2020 Pavement Condition)		
NDOT Performance Measures		
Prioritization Category	**% Fair or Better**	
1	96.2%	
2	87.0%	
3	93.0%	
4	72.0%	
5	44.4%	
National Performance Measures		
System	**% Good**	**% Poor**
Interstate	81.40%	0.20%
Non-Interstate NHS	72.10%	0.10%
Bridges NDOT Performance Measures (2021 Bridge Condition)		
System	% Good	% Poor
NHS (NBI-qualified, including local)	44.9%	0.9%
Non-NHS (all other state-owned)	49.1%	2.5%

ITS Assets (2021 Asset Condition)				
Asset Type	**Estimated Condition (Based on % of total asset count)**			
	Good	**Low Risk**	**Medium Risk**	**High Risk**
CCTV	20%	30%	30%	20%
DMS	40%	10%	20%	30%
Flow Detectors	20%	20%	30%	30%
HAR	0%	0%	18%	82%
Ramp Meters	20%	30%	30%	20%
RWIS	40%	19%	10%	30%
ATM DMS	100%	0%	0%	0%
WWD Detection	0%	100%	0%	0%
HOV Detection	100%	0%	0%	0%

Federal Performance Measures, Targets, and Performance Gaps

Federal Performance Measures for Pavements and Bridges

In addition to the processes NDOT uses to assess asset conditions, the FHWA requires State DOTs to assess the condition of pavements and bridges on the NHS using the thresholds and performance measures summarized in Tables 3-7 through 3-9.

Table 3-7. Summary of federal condition thresholds for pavements.

Federal Pavement Condition Thresholds			
Metric as defined in HPMS	Good	Fair	Poor
IRI (in/mile)	<95	95–170	>170
Asphalt ConcreteCracking (%)	<5	5–20	>20
Jointed Plain Concrete (JPC)Cracking (% slabs)	<5	5–15	>15
Continuously Reinforced Concrete (CRC) PavementCracking (%)	<5	5–10	>10
Rutting (in) [asphalt-surfacedpavements only]	<0.20	0.20–0.40	>0.40
Faulting (in) [concrete-surfacedpavements only]	<0.10	0.10–0.15	>0.15

Table 3-8. Summary of federal performance measures for pavements.[5]

Federal Pavement Performance Measures[1]	
Good	**Poor**
Asphalt Pavements: Pavement section is rated as "*Good*" if all three metrics (IRI, Asphalt Cracking, and Rutting) are rated as "*Good*"	Asphalt Pavements: Pavement section is rated as "*Poor*" if two or more of the three condition metrics (IRI, Asphalt Cracking, and Rutting) are rated as "*Poor*"
JPC Pavements: Pavement section is rated as "*Good*" if all three metrics (IRI, JPC Cracking, and Faulting) are rated as "*Good*"	JPC Pavements: Pavement section is rated as "*Poor*" if two or more of the three condition metrics (IRI, Jointed Plain Cracking, and Faulting) are rated as "*Poor*".
CRC Pavements: Pavement section is rated as "*Good*" if both metrics (IRI and CRC Pavement Cracking) are rated as "*Good*"	CRC Pavements: Pavement section is rated as "*Poor*" if both condition metrics (IRI and CRC Pavement Cracking) are rated as "*Poor*"
State DOTs report individual metrics and the following pavement measures calculated as part of their HPMS submittal: • Percentage of pavements on the Interstate System in *Good* condition. • Percentage of pavements on the Interstate System in *Poor* condition. • Percentage of pavements on the NHS (excluding the Interstate System) in *Good* condition. • Percentage of pavements on the NHS (excluding the Interstate System) in *Poor* condition.	
To meet federal minimum condition requirements, no more than 5% of the Interstate pavement may be in *Poor* condition.	

NDOT has adjusted its pavement management system reporting capabilities to enable the reporting of pavement conditions in accordance with the national performance measures.

[5] 23 CFR Part 490 National Performance Management Measures – Provides guidance on assessing pavement and bridge conditions, including national performance measures to assess the performance of the NHS.

Table 3-9. Federal condition thresholds and performance measures for bridges.

Federal Bridge Condition Thresholds and Performance Measures		
Item	**Good**	**Poor**
Bridges—Lowest of: • Deck (NBI item 58) • Superstructure (NBI item 59) • Substructure (NBI item 60)	7–9	0–4
Culverts (NBI item 62)	7–9	0–4
Performance measures for bridges and culverts are based on the NBI component rating. NHS bridge conditions are reported in terms of: • Percentage of NHS bridges classified in *Good* condition. • Percentage of NHS bridges classified in *Poor* condition.		

For bridges, NDOT is already using the required national performance measures in accordance with 23 CFR 490.

Federal Performance Targets

State DOTs are also required to submit 2- and 4-year performance targets to FHWA in accordance with a schedule outlined in the Transportation Performance Management (TPM) rules and regulations[6]. The targets set by NDOT are shown in table 3-10. In addition to satisfying the federal requirements, NDOT also used these targets to drive the investments outlined in Chapter 6. A comparison of the current and targeted pavement and bridge conditions was conducted to determine whether a performance gap exists between targeted and actual conditions. The analysis found that no performance gaps currently exists and, since NDOT expects to maintain or improve pavement and bridge conditions, no performance gaps are anticipated over the 10-year period covered in the TAMP. NDOT also expects to satisfy the minimum condition requirements for pavements and bridges over the next 10 years.

State DOTs are not required to set 2- and 4-year targets for additional assets included in its TAMP so no performance targets have been reported to FHWA for ITS assets.

As shown in Table 3-10, in addition to meeting federally mandated performance requirements for pavements and bridges on the NHS, NDOT also meets the performance goals set internally by the Department. The expected levels of funding and investment strategies that will enable NDOT to achieve its goals are discussed in Chapter 6.

Over time, NDOT will continue refining processes and monitoring conditions to meet its objectives to preserve pavement and bridge conditions cost-effectively.

[6] https://www.federalregister.gov/documents/2017/01/18/2017-00550/national-performance-management-measures-assessing-pavement-condition-for-the-national-highway

Table 3-10. Federal NHS pavement and bridge targets and performance gap assessment.

Pavements			
Federal Performance Targets		**Current Condition (2020 Pavement Condition)**	**Performance Gap**
NDOT Federal Performance Targets	Interstate Pavements: ≥74.70% in *Good* Condition ≤1.40% in *Poor* Condition Non-Interstate NHS Pavements: ≥55.80% in *Good* Condition ≤6.5% in *Poor* Condition	Interstate Pavements: 81.4% in *Good* Condition 0.20% in *Poor* Condition Non-Interstate NHS Pavements: 72.1% in *Good* Condition 0.10% in *Poor* Condition	No Gap
Federally Mandated Performance Requirement	≤5% of Interstate Pavements in *Poor* Condition		No Gap
Bridges			
Federal Performance Targets		**Current Condition**	**Performance Gap**
NDOT Federal Performance Targets	NHS Bridges by Deck Area: ≥35% in *Good* Condition <7% in *Poor* Condition	NHS Bridges by Deck Area: 44.9% in *Good* Condition 0.9% in *Poor* Condition	No Gap
Federally Mandated Performance Requirement	NHS Bridges by Deck Area: ≤10% Structurally Deficient	NHS Bridges by Deck Area: 0.9% Structurally Deficient	No Gap

Asset Value

It would cost more than $23 billion to replace its pavements, bridges, and ITS assets. This represents a significant investment in Nevada's transportation assets, which are crucial to the economic vitality of the state. Therefore, NDOT is committed to preserving the value of these assets through a whole-life strategy that extends asset service life as cost-effectively as possible. A summary of the current replacement cost of the three assets included in the TAMP is provided in Table 3-11.

Table 3-11. Summary of current asset replacement value.

Asset	Current Approximate Replacement Value
Pavement[1]	$16.6 Billion
State-Maintained Bridges[2]	$6.4 Billion
ITS Assets[3]	$82.7 Million
Total	**$23.08 Billion**

[1]Pavement replacement costs: Categories 1 and 2: $1.8 Million/lane-mile, Categories 3 and 4: $1 Million/lane-mile and Category 5: $0.5 Million/lane-mile.
[2]Bridge replacement cost: $400 per square foot.
[3]ITS replacement costs are provided in Appendix B.

Chapter 4. Life Cycle Planning Considerations

Overview

NDOT's transportation infrastructure is constantly deteriorating due to many factors, including both physical and chemical impacts; the damaging consequence of floods, earthquakes and other hazards; and the normal wear and tear caused by traffic. Infrastructure assets are managed using a whole-life approach that includes planned maintenance and rehabilitation activities to sustain performance levels, to keep the system operating, and to lower life-cycle costs.

Managing The Infrastructure Life Cycle

Asset management practices help to preserve asset value and minimize the total costs attributable to NDOT's transportation assets by planning effective treatment strategies for each stage of an asset's life cycle (illustrated in Figure 4-1).

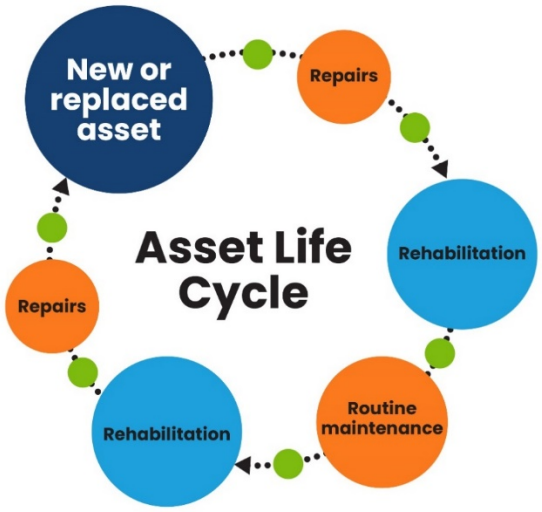


Figure 4–1: Typical asset life cycle stages.

As shown in the figure, each new or replaced asset requires planned activities at different phases of its life cycle. It is very expensive to replace assets, so transportation agencies use a series of preservation treatments to extend the life cycle as much as possible. These preservation activities prevent or slow the rate of deterioration and defer the need for replacements. Preservation treatments are an effective way to lower costs and keep the transportation system operating at an acceptable level.

This chapter documents the results of the network-level life cycle planning (LCP) analysis performed for pavements, bridges, and ITS assets. NDOT's existing approach for managing pavements, bridges, and ITS assets has been effective in the past and it is forecasted to continue providing a smooth, safe, and efficient transportation system.

NDOT'S APPROACH TO MANAGING TRANSPORTATION INFRASTRUCTURE ASSETS

Designing and constructing durable, long-life assets by applying smart decisions during the planning and design phases.

Adopting sound maintenance and preservation practices and deploying well-trained maintenance staff to apply the necessary maintenance actions at the right places at the right times.

Monitoring asset conditions using a performance-based approach to determine preservation needs.

Taking advantage of proactive preservation opportunities when they arise.

Minimizing the impact of work zones on the traveling public.

Life Cycle Planning Analysis

The analysis of different treatment strategies was conducted using a LCP analysis, which considers the costs incurred over the service life of an asset. For a comparable basis, the LCP analysis considers the costs associated with construction, inspection, maintenance, rehabilitation, and replacement (or reconstruction) once the asset's service life has ended. This type of analysis is important because each time NDOT invests in constructing a new road or bridge, or installing a new ITS device, the Department not only commits to the initial construction costs, but also to the future costs of maintaining and operating that asset over its service life. The future maintenance and operational expenditures can often be much greater than the initial investment made in the asset, therefore it is important to consider current and future costs when planning investment strategies.

To manage its transportation system, NDOT uses cost-effective preservation treatments. However, these treatments have to be applied before extensive deterioration is present to be cost-effective. When preservation is delayed, the asset continues deteriorating to the point that safety and serviceability are impacted and repair costs skyrocket. Examples of highly effective activities that prolong asset service life include:

- Painting a steel bridge before any significant material is lost to corrosion.
- Applying a chip seal treatment to a pavement in *Fair* to *Good* condition.

Delaying the bridge painting and chip seal application activities at some point will result in: (a) too much of the steel rusting, thereby rendering the painting activity ineffective, and (b) the pavement will eventually develop structural distresses and will no longer be suitable for a preservation treatment. Eventually, a more expensive treatment, such as major rehabilitation or replacement, will be required.

A key goal of an LCP analysis is to manage assets at the lowest practical life-cycle cost. Conceptually, this "happy medium" point (illustrated in Figure 4-2) exists where maintenance expenditures are neither too frequent nor delayed too long. Typically, a properly maintained pavement or bridge, when maintained at a level that minimizes costs in the long term, is continuously kept in relatively *Good* condition. Over the life of these assets, preservation activities that are optimally timed are estimated to cut long-term life cycle costs roughly in half, compared to a policy where no preservation activities are performed at all.

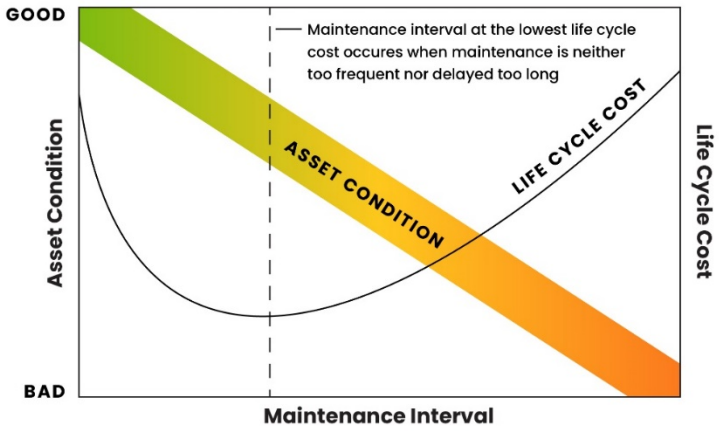


Figure 4-2. Illustration of the life cycle cost analysis concept.

Forecasting Deterioration

Transportation infrastructure assets deteriorate over time. For example, pavements are damaged by traffic, heavy trucks, freeze and thaw cycles, extreme heat, and moisture in the underlying layers. Pavement materials can crack or shrink as they age, thus weakening their structural strength and providing a pathway for water damage. Similarly, bridges are also degraded by corrosion, chemical activity, collisions, metal fatigue, increasing traffic loading, and earthquakes.

The causes of deterioration can vary drastically from one site to another and from year to year. To quantify and predict deterioration, engineers use mathematical models. In Nevada, it takes about 25 years for half of any set of bridges to deteriorate from *Good* condition to *Fair* condition under normal maintenance. Generally, each year approximately 2.85 percent of bridges transition from *Good* to *Fair* condition. Pavements typically transition from *Good* to *Fair* condition in approximately 10 to 20 years, depending on the road prioritization category[7].

Figure 4-3 shows a conceptual illustration of how preservation actions help extend asset life at a fraction of the cost of more extensive treatments by keeping assets in *Good* condition.

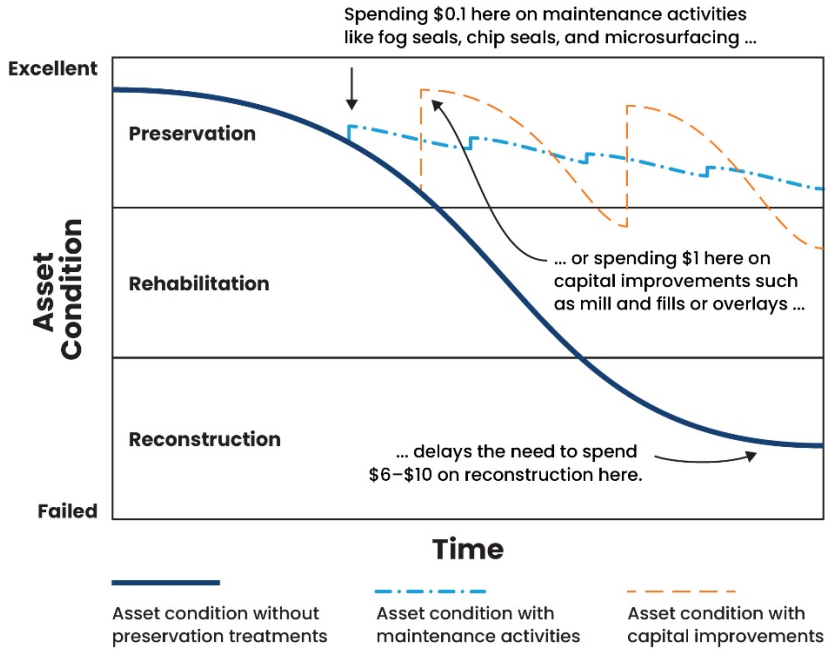
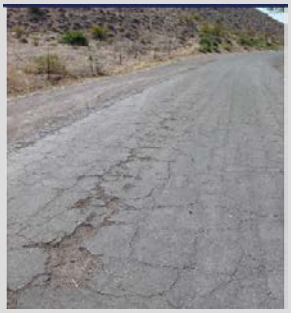


Figure 4-3. Conceptual model of asset deterioration and treatment strategies.

ASSET DETERIORATION



Deteriorated asphalt pavement.

Corroded steel on a bridge girder.

NDOT has been improving its ability to forecast asset deterioration rates and developing processes to determine the effectiveness of its maintenance and rehabilitation activities to improve its ability to manage assets from a whole-life perspective. Pavement deterioration models have been developed by analyzing historical pavement conditions for each road prioritization category. The pavement condition

[7] Definitions of *Good*, *Fair*, *Poor conditions for pavements and bridges are provided in Chapter 3.*

forecasting models used by NDOT's PMS for asphalt and concrete pavements are shown in Figures 4-4 and 4-5, respectively. These models have been developed using historical pavement condition data stored in the PMS. NDOT periodically reviews and updates its performance models to improve the accuracy of the pavement condition forecasts.

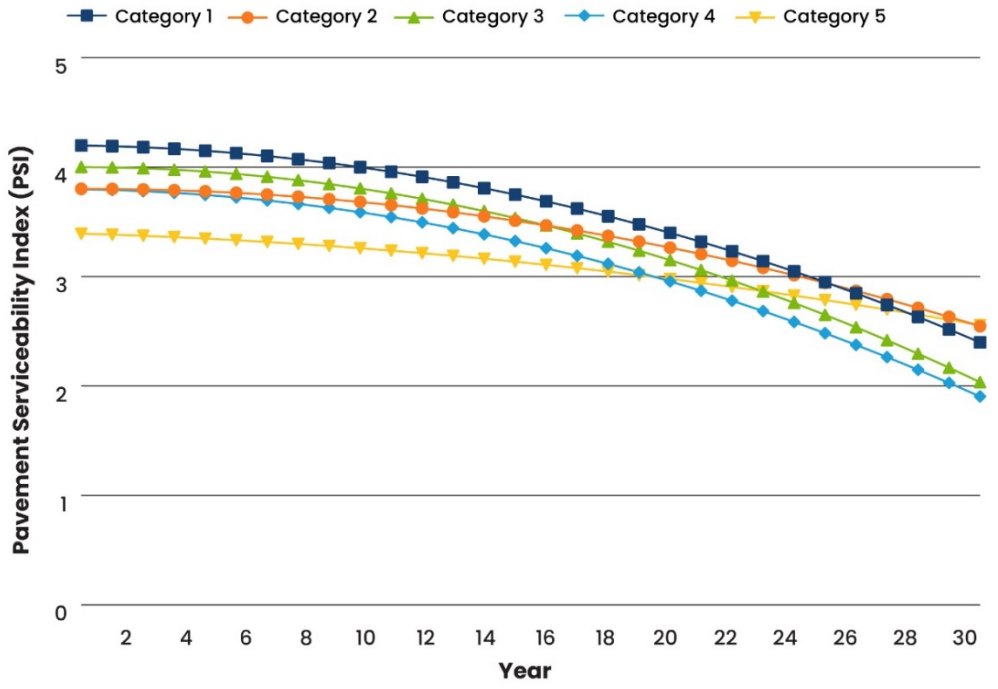


Figure 4-4. Asphalt pavement condition deterioration models used by NDOT.

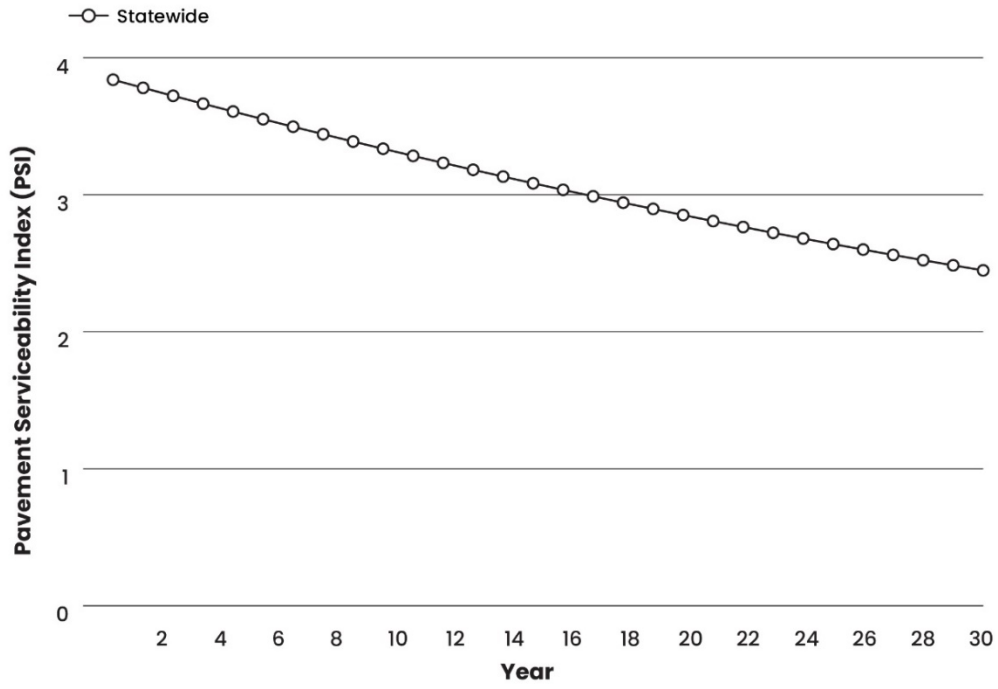


Figure 4-5. Concrete pavement condition deterioration model used by NDOT.

NDOT is also interested in developing deterioration models for its bridges. In the absence of an operational BMS, probabilistic deterioration models were developed for use in a spreadsheet tool for analyzing the long-term impacts of different investment options. These models were derived from the National Bridge Investment Analysis System (NBIAS), a planning tool used by the FHWA for bridge needs analysis. Cost models were developed by NDOT's bridge technical experts, based on their experience and judgment, for each class of bridge elements. In the future, more sophisticated models will be developed for bridges under NDOT's current contract with Agile Assets to implement new EAMS software for managing bridge assets. The ability to forecast bridge deterioration is one of the requirements of this new system.

Pavement Life Cycle Management

Pavement performance is a function of several parameters, as discussed in Chapter 3. As pavement ages, the ride quality gradually deteriorates, and the pavement structure exhibits distresses that need to be repaired to restore the structural and functional capacity. Different types of pavement distresses require different types of repairs. For instance, some distresses don't change significantly over time and can be addressed through relatively minor repair strategies. Pavements with more significant distresses that show signs of structural damage, indicate the need for more substantial rehabilitation actions due to increased traffic volumes, heavy trucks, or inadequate thickness.

NDOT uses different types of treatments to address pavement performance issues and the various distresses. These treatments fall under the general FHWA descriptions of Maintenance, Preservation, Rehabilitation, and Reconstruction, as summarized below:

- **Maintenance:** Maintenance describes work that is performed to maintain the condition of the transportation system or to respond to specific conditions or events that restore the highway system to a functional state of operation. Maintenance is a critical component of an agency's asset management plan and is comprised of both routine and preventive maintenance. Preventive maintenance is a cost-effective means of extending the useful life of the Federal-aid highway system.
- **Preservation:** Preservation consists of work that is planned and performed to improve or sustain the condition of the transportation facility in a state of good repair. Preservation activities generally do not add capacity or structural value but restore the overall condition of the transportation facility.
- **Rehabilitation:** Rehabilitation includes more substantial repairs that are applied when the pavement in is *Fair* or *Poor* condition to repair a structurally- or functionally-deficient section and provide a new surface that improves the pavement's ability to carry traffic loads.
- **Reconstruction:** Reconstruction includes any pavement repair that requires the removal and replacement of the entire pavement structure.

PAVEMENT PRESERVATION IS COST-EFFECTIVE

NDOT uses maintenance and preservation strategies to extend a pavement's service life to defer the need for rehabilitation.

This cost-effective strategy reduces the overall cost of maintaining the road network and demonstrates the Department's efforts to use taxpayer money wisely.

Table 4-1 summarizes the types of treatments used on various road categories along with their costs.

Table 4-1. Treatments used by NDOT.

Treatment	Mapping to FHWA Work Type	Road Category	Cost ($ per centerline-mile)
Crack Seal	Maintenance	3, 4, 5	$10,000 to $30,000
Scrub Seal	Preservation	3, 4, 5	$50,000 to $70,000
Chip Seal	Preservation	2, 3, 4, 5	$50,000 to $70,000
Microsurfacing	Preservation	2, 3, 4, 5	$50,000 to $80,000
Thin Asphalt Mill and Overlay (1 to 2 inches)	Preservation	1	$1.5 to $2.0 million
		2	$900,000 to $1.2 million
		3	$500,000 to $700,000
		4	$300,000 to $400,000
		5	$200,000 to $300,000
Structural Asphalt Mill an Overlay (3 to 5 inches)	Rehabilitation	1	$1.8 to $2.5 million
		2	$1.3 to $1.5 million
		3	$700,000 to $1.0 million
		4	$500,000 to $700,000
		5	$300,000 to $500,000
Crumb Rubber Overlay - Concrete Pavement	Rehabilitation	1	$1.8 to $2.5 million
Complete Reconstruction – Asphalt Pavement	Reconstruction	1	$2.5 to $3.0 million
		2	$2.0 to $2.5 million
		3	$1.0 to $1.5 million
		4	$1.0 to $1.5 million
		5	$1.0 to $1.5 million
Rubblization – Concrete Pavement	Reconstruction	1	$2.5-3 million

Figure 4-6 summarizes the typical treatment cycles for each roadway category. The treatments shown in the figure are intended only for illustrating typical practices. While the average treatment timing is expected to be the same as indicated in the figure, the treatment types may vary based on pavement type and traffic, and other site-specific conditions.

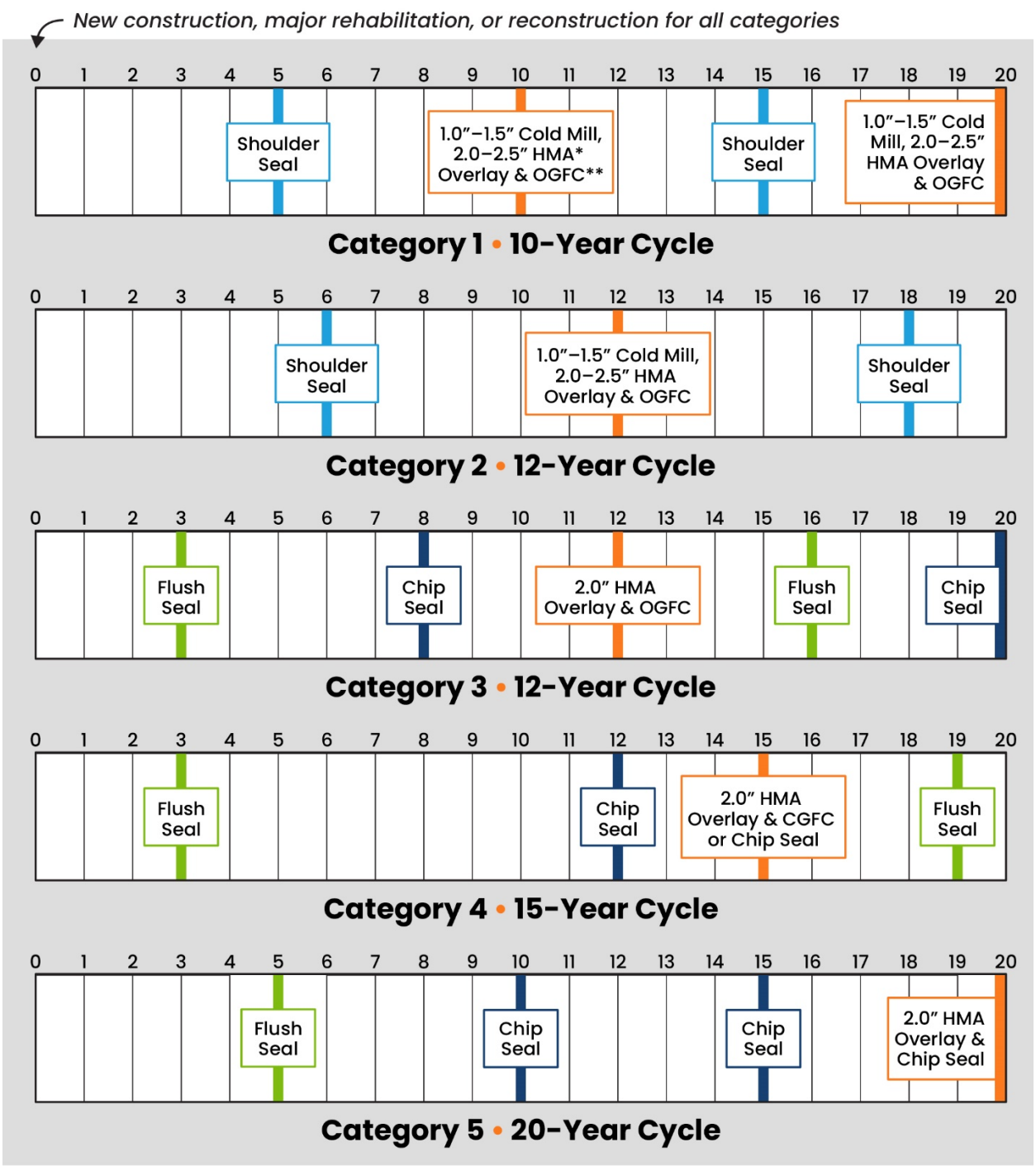


Figure 4–6. Illustration of treatment scenarios over a 20-year period for each road category.

Pavement maintenance and rehabilitation treatment needs are determined based on the distresses observed and the overall pavement condition (based on of PSI). Pavements with a PSI rating of 3.5 or higher (on a 5-point scale) are typically suited for maintenance and preservation activities. Pavements with a PSI rating of less than 3.5 are candidates for structural overlays or other rehabilitation activities (illustrated in Figure 4-7).

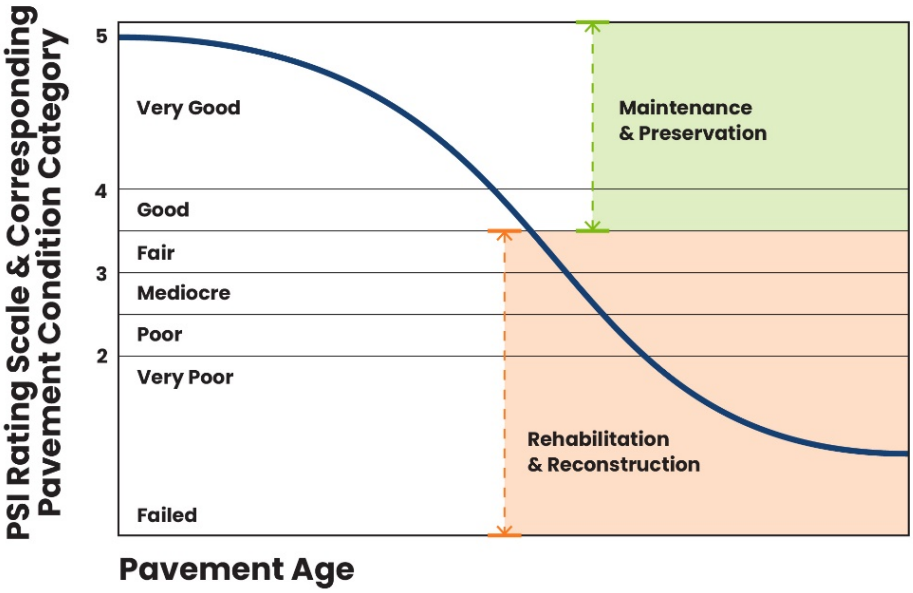


Figure 4-7. Illustration of a typical pavement deterioration curve and suitable repair strategies based on the PSI rating.

NDOT evaluated the impact of two LCP strategies using its PMS:

- **Current Strategy**: The repair strategy illustrated in Figure 4-7 was applied. This strategy includes maintenance and preservation activities for pavements in *Good* or better condition and rehabilitation activities for pavements in *Fair* or worse condition. To determine the amount of work conducted each year, the average annual maintenance or repair work typically performed by NDOT was applied to current and projected conditions within each road category (using the performance models shown earlier in Figure 4-6). The projections were provided by the PMS. Three budget scenarios were evaluated using the current strategy, as illustrated in Table 4-2.
- **Worst-First**: NDOT also evaluated the impacts of a "worst-first" strategy in which pavements are not repaired until they reach a *Poor* condition. In this scenario, current and projected pavement conditions were used to determine when rehabilitation activities would be needed.

For the LCP analysis, a 20-year analysis period was used, and no inflation or discount rate was applied. Table 4-2 summarizes the LCP strategies and budget scenarios evaluated.

Table 4-2. LCP Strategies and budget scenarios evaluated.

LCP Strategy	Budget Scenarios
Current Strategy	Scenario 1 (Average Annual funding: $237.5 million) Years 1-5: $244 million annually Years 6-10: $231 million annually
	Scenario 2: $309 million annually
	Scenario 3: $142 million annually
Worst-First	Scenario 1 (Average Annual funding: $237.5 million) Years 1-5: $244 million annually Years 6-10: $231 million annually

Figure 4-8 illustrates the distribution of funding across various treatment types for each LCP analysis run conducted. As seen in the figure, NDOT's current strategy prioritizes preservation and rehabilitation treatments over reconstruction. Approximately 63 percent of the budget is allocated to preservation treatments under the current strategy at the current budget level. Under the worst-first strategy, no budget is allocated to maintenance and preservation activities.

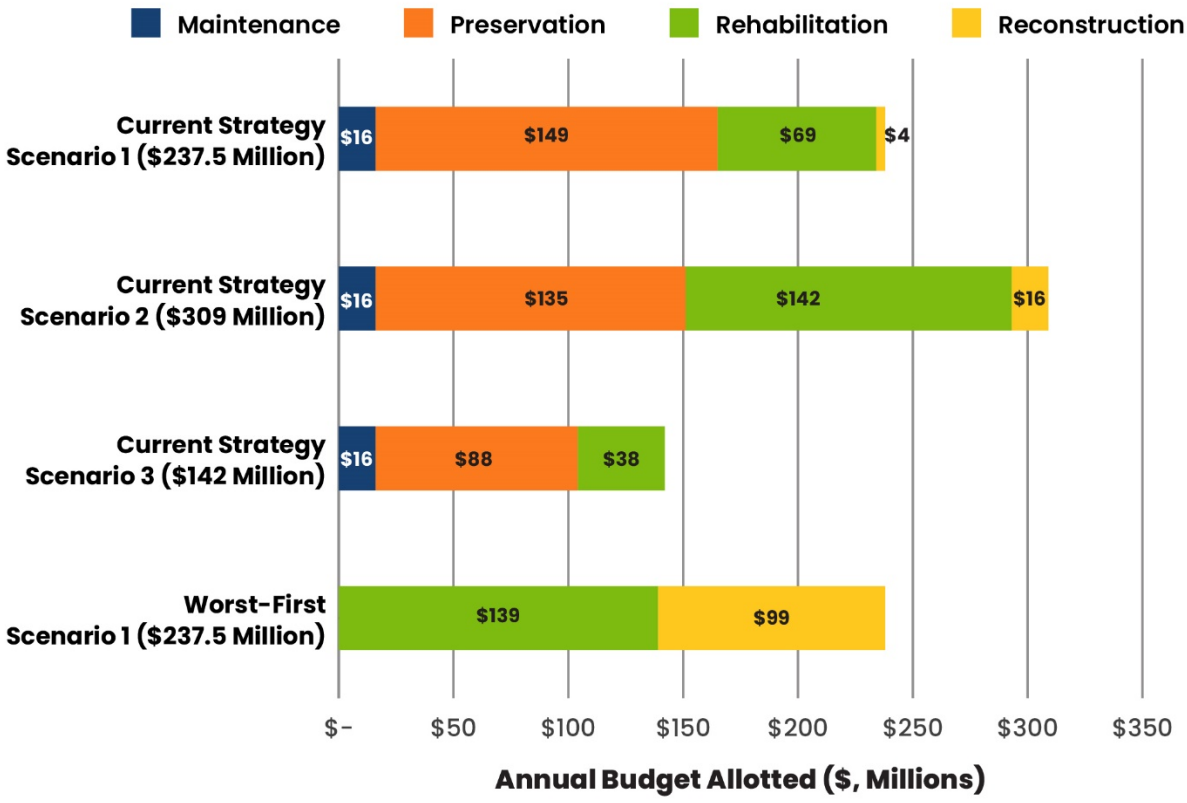


Figure 4-8. Percent funding allocations by treatment type for the four LCP strategies.

Figure 4-9 shows the base year (2021) condition of NDOT's pavement network and the projected pavement condition at the end of the analysis period (2041) for each LCP analysis run.

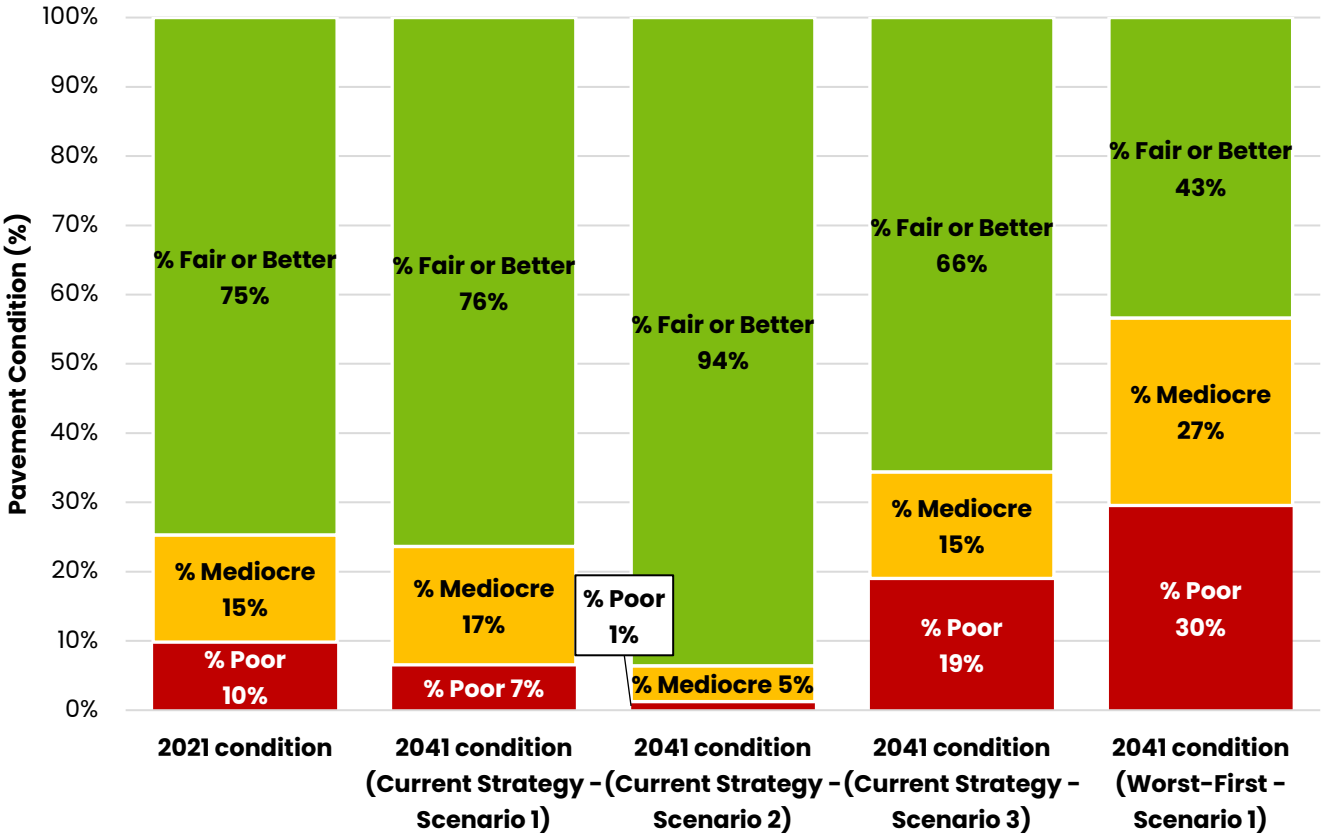


Figure 4-9. Initial and projected statewide pavement condition for each LCP analysis run.

Key takeaways from figure 4-9 are summarized below:

- The preservation-centric strategies result in significantly better performance outcomes in comparison to the worst-first strategy. As expected, increasing the budget results in better conditions.
- When the preservation strategy is employed, the current budget level is sufficient to achieve steady state conditions over the 20-year analysis period.
- The worst-first strategy results in constantly declining pavement conditions over the analysis period. The fraction of pavement in *Poor* condition triples over 30 years and the fraction of pavements in *Fair* or better condition decreases by approximately 30 percent.

Figure 4-10 shows the projected pavement performance trends (in terms of percent *Poor*) based on the anticipated investment level for each roadway category. The key takeaways from figure 4-10 are summarized below:

- NDOT prioritizes investments on pavements in Category 1 and hence these pavements are in significantly better condition (less than 0.3 percent *Poor* pavements) in comparison to the rest of the network.
- Currently, over 25 percent of the pavements in Category 5 are in *Poor* condition and over time, NDOT's preservation strategy will help in reducing the fraction of pavements in *Poor* condition. Even so, by 2041, almost 20 percent of the pavements in Category 5 are still expected to be in *Poor* condition.

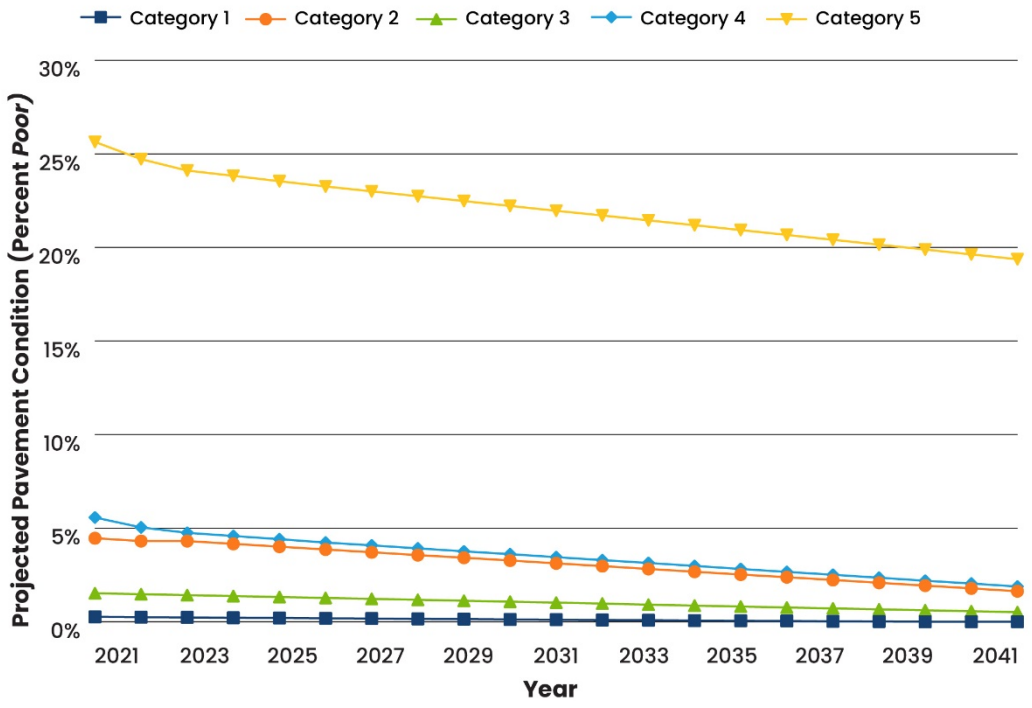


Figure 4-10. Projected pavement conditions (percent *Poor*) for each roadway category at the anticipated investment level.

Overall, the fraction of pavements in *Poor* condition is projected to drop across all roadway categories. This clearly demonstrates the effectiveness of NDOT's existing pavement preservation approach. Based on the results of this analysis, NDOT will continue with its current pavement management approach that optimizes the use of low-cost preservation treatments. Under this strategy the proactive application of preservation treatments is used to delay the progression of deterioration and the need for major rehabilitation and reconstruction actions.

The projected pavement conditions and targets based on the investment strategy adopted by NDOT are documented in Chapter 6.

Improving Pavement System Resilience

NDOT has taken a holistic approach to build a more resilient pavement network for its citizens. The main environmental risks that impact the resilience of NDOT's pavement assets include:

- Temperature extremes (high and low)
- Higher average precipitation levels
- More extreme rainfall events
- Wetter winters and drier summers
- Low summer humidity
- Droughts resulting in decreased subgrade moisture
- Increased large forest fire incidences
- Increasing numbers of flooding events

For the key risks identified, some of the main pavement vulnerabilities include the following:

- Increased rate of asphalt binder aging
- Increased curling and warping stresses in concrete pavements that can result in more blow-ups during the summer months
- Reduced pavement structural capacity of unbound base layers and subgrade due to increased precipitation and flooding
- Reduced surface friction due to more extreme rainfall events

For the key risks and vulnerabilities identified for pavements, NDOT considers a range of adaption strategies that can be implemented at various stages of the pavement life cycle. These strategies, which are shown in Figure 4-11, include adaptions to:

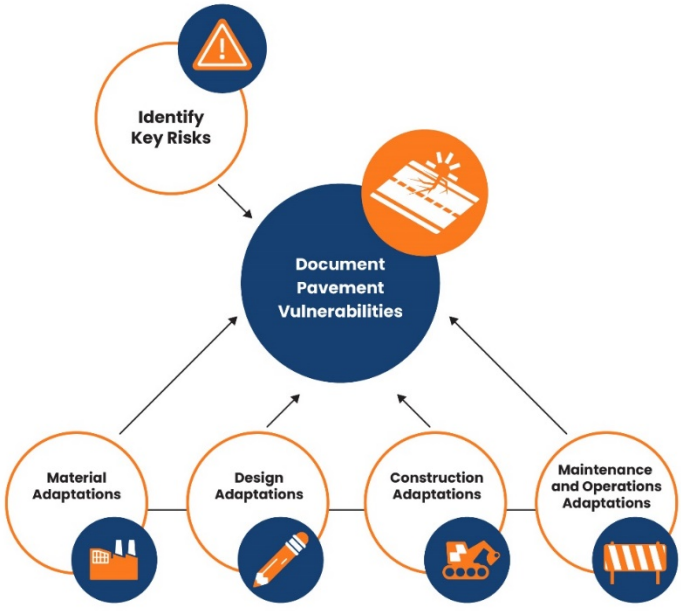


Figure 4-11. Framework for considering pavement resilience.

- **Material selection**. Use of pavement materials that are less susceptible to extreme temperature and moisture variations.
- **Design approaches**. Employment of design standards that result in improved structural support and drainage.
- **Construction procedures**. Adjustment of construction season to reduce construction during hotter months, flexibility in construction schedule to accommodate precipitation events that may impact overall project schedule, and improvement of finishing and curing practices.
- **Maintenance and operation activities**. Increased efforts to seal cracks and joints in existing pavements, adjustment of spring thaw load restrictions, use of asphalt pavement preservation techniques that reduce surface course binder aging (e.g., chip seals, fog seals, microsurfacing etc.), maintenance of high friction pavement surfaces, and employment of nondestructive methods to determine pavement structural adequacy in inundated/flood condition to determine structural loading restrictions after inundation events.

Extreme weather events can potentially influence pavement treatment strategies over the long-term and NDOT considers these risks and adaption approaches while developing its LCP strategies. NDOT considers a balanced priority between preservation and major rehabilitation actions that not only ensures that *Good* pavements continue to provide a good level-of-service for the road users, but pavement sections that are more vulnerable to extreme weather events receive a fair allocation of funding to address imminent risks. Based on routine vulnerability assessments, if a certain portion of NDOT's pavement network is found to be more vulnerable to extreme weather events, the pavement deterioration models and treatment strategies will be recalibrated to help improve the overall resiliency of the pavement network.

Bridge Life Cycle Management

Bridges are subject to corrosion, cracking, and other damage caused by weather, traffic, and age, so they require regular corrective action to keep them in a state of good repair. Bridge repair needs are identified by inspectors in the field and documented as a part of each bridge's biennial inspection report. Each district compiles its program of capital projects from the inspection results. By means of its district forces and contractors, NDOT has a variety of bridge preservation capabilities at its disposal:

- Patching of concrete.
- Repair of corroded steel.
- Spray liners and paving of culverts.
- Replacement of bridge decks.
- Installation or replacement of deck waterproofing systems.
- Replacement or patching of deck wearing surfaces.
- Spot painting or total repainting.
- Sealing and repair of expansion joints.
- Repair or replacement of bridge bearings.
- Placement of rip rap or other slope and stream bank protection.

Bridge costs can vary widely depending on the severity and extent of deterioration. Table 4-3 summarizes some typical unit costs in the LCP analysis results.

Table 4-3. Typical bridge unit costs (typical range in parentheses).

Treatment category	Typical unit cost (range)
Routine maintenance	$0.03 per deck square foot per year
Preservation	$40 ($10 to $100) per deck square foot per project
Rehabilitation	$96 ($50 to $300) per deck square foot per project
Replacement	$400 ($200 to $1000) per square foot of existing bridge to be replaced

The LCP analysis for bridges was conducted using StruPlan, an open-source spreadsheet model for long-range renewal planning for transportation structures. The model forecasts scenarios of preservation, rehabilitation, and replacement for each element of each bridge, projecting costs year-by-year over a 75-year period, followed by a perpetuity model to estimate residual costs beyond that period. Within the first 10 years, the model optimizes project selection based on minimization of long-term costs, and forecasts 10-year ending conditions for any given set of policies and funding levels.

Across the Nevada bridge inventory, and if no maintenance is performed, NDOT's analysis has found that the median time from new to *Poor* condition is about 51 years. NDOT currently experiences a median lifespan of 62 years for bridges as currently constructed and maintained. Under an expanded preservation program, a median life of 70 years or more may be possible. Figure 4-12 compares these scenarios. Each bridge receives preservation work on average once each 20 years, and this causes a significant improvement in condition, especially to protective systems such as expansion joint seals, deck wearing surfaces, and coatings. These help the structural components of the bridge to last longer.

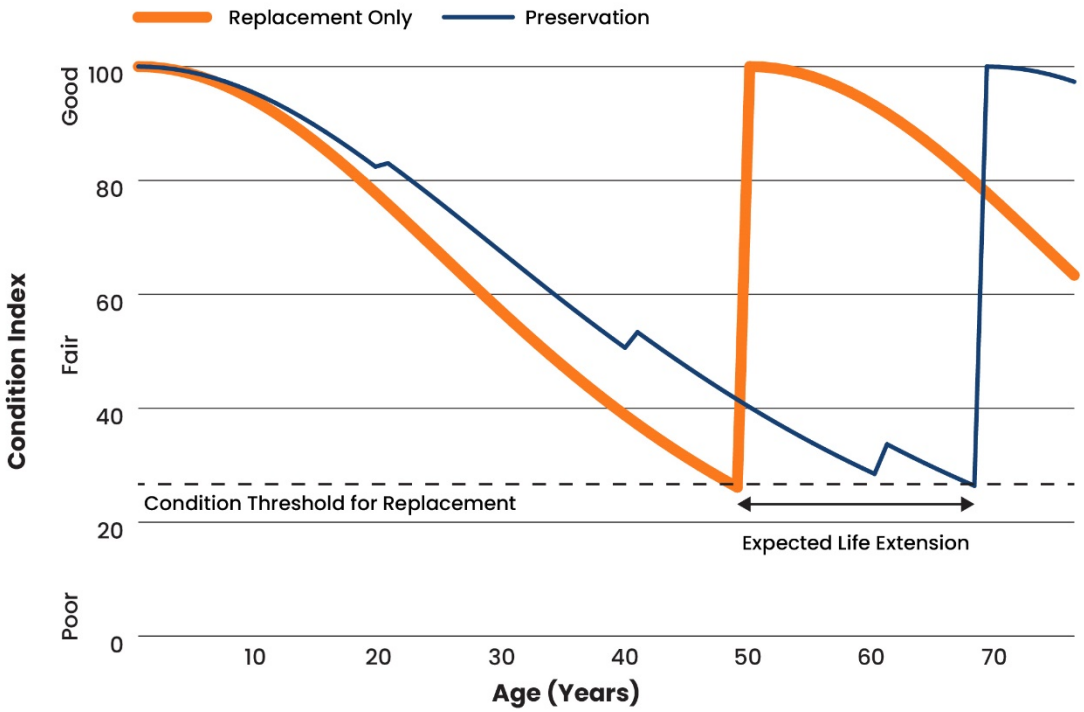


Figure 4-12. Bridge life extension achievable with increased emphasis on preservation.

Figure 4-13 illustrates the budget distribution across the treatment work types under each LCP strategy investigated and resulting conditions after 10 years. Using the element-level life cycle cost analysis in its StruPlan model, an optimized preservation program devotes 46 percent of its budget to preservation activities, 31 percent to rehabilitation, and 23 percent to reconstruction. It results in maintaining steady conditions of 50 percent *Good* and 1.3 percent *Poor*, under the anticipated funding level of $433 million over 10 years (excluding new construction). For comparison, the worst-first strategy (prioritizing only by condition and spending only 27.4 percent on preservation) would cost $661 million for the same condition outcome. Chapter 6 provides detail on the Department's financial forecasts and the effect of fiscal uncertainty on condition outcomes.

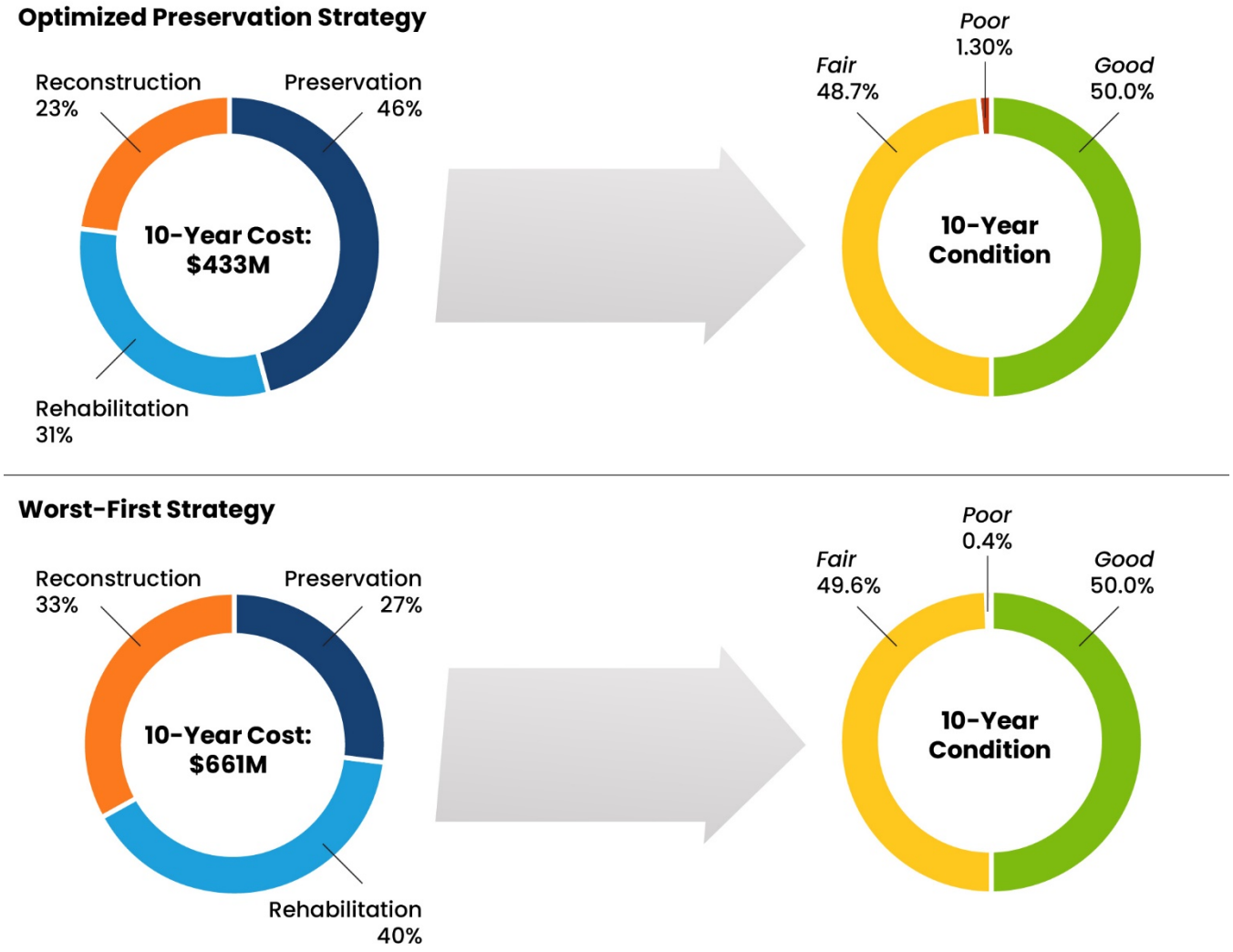


Figure 4-13. Budget distribution and resulting conditions under the optimized preservation program and worst-first strategy.

NDOT Structures has adopted the EAMS –BMS for bridge asset management and preservation planning. NDOT's intent is to utilize the BMS to replace legacy systems and processes that are currently utilized to satisfy the minimum standards identified in CFR 515.17 (Minimum standards for developing and operating bridge and pavement management systems). Initial adoption revealed limitations with the BMS' capability to satisfy many of the specific requirements listed in CFR 515.17. A significant time and resource commitment will be needed to close the large gap between the aspirations of CFR 515.17 and

the capabilities of the BMS. To advance that effort, Structures has requested a position upgrade that, if approved, will add capacity to its existing staff that can be devoted to further development of BMS. This would be the first step in what will be a lengthy process to collect and process the requisite data to develop accurate deterioration modeling, which would in turn feed the benefit-cost life cycle analysis that is at the core of CFR 515.17.

Improving Bridge System Resilience

In addition to its efforts to extend the economic life of its bridges, NDOT also invests to improve safety and mobility by managing bridge resilience, the ability of bridges to maintain service in the face of extreme events such as severe storms, heavy vehicle collisions, and overloads. In its StruPlan model, each bridge is evaluated against a set of level-of-service standards for lane widths, clearances, load capacity, and (for bridges over water) assessment of scour and waterway adequacy. When a bridge is found to be deficient, an estimate of excess user cost is prepared, using the methodology of the AASHTO Red Book, to represent the inconvenience to road users that might be avoided if the bridge is improved or replaced. This estimate is included in life cycle cost estimates used in calculating the benefits of rehabilitation and reconstruction of bridges.

Life Cycle Management of ITS Assets

As described in Chapter 3, ITS assets do not have performance measures that have been formally adopted by NDOT. For the purposes of the TAMP, ITS asset conditions were based on the device manufacturer's recommended service life as described below:

- *Good*: Device age is less than 80 percent of the manufacturers' recommended service life.
- *Low Risk*: Device age is between 80 to 100 percent of the manufacturers' recommended service life.
- *Medium Risk*: Device age is between 100 to 125 percent of the manufacturers' recommended service life.
- *High Risk*: Device age is greater than 125 percent of the manufacturers' recommended service life.

A simple condition transition probability matrix was developed for each ITS device included in the TAMP (discussed in Appendix C). These transition matrices were used to model the deterioration of ITS assets based on expert opinion provided by NDOT staff. The matrices describe the time required for the device to deteriorate from one condition state to another (e.g., *Good* to *Low Risk*), with an inherent assumption that there is a 50 percent probability that devices would deteriorate to the lower condition categories after the time period established in the transition matrix.

Similarly, a simple annual inspection and treatment matrix was developed for each ITS device included in the TAMP (presented in Appendix C). These matrices are used to determine the fraction of the network that will be inspected or will receive a particular type of treatment annually. Three separate annual treatment distribution matrices were developed that reflect three strategies for managing ITS assets:

- **Current Strategy:** This approach uses the expected level of funding to determine the mix of fixes that can be performed to maintain the best possible conditions under the budget constraints imposed.
- **Maintain Minimum Level-of-Service (M-LOS)**: Under this approach, the ITS assets are managed at the minimum acceptable level-of-service (at least 15 percent of more assets in *Medium*

Risk or better condition) with additional consideration given to treatments that will improve ITS asset reliability.

- **Maintain Desired Level-of-Service (D-LOS)**: Under this approach, no more than 5 percent of the ITS assets are allowed to be in the *High Risk* category by 2031.

Brief descriptions of the inspection and treatment actions performed on ITS devices are provided below:

- **Inspection**: Involves routine maintenance of the device or asset by NDOT typically performed annually or biannually based on type of device.
- **Minor Repairs**: Typically performed on site and these include activities such as adjusting loose cables, battery replacement, firmware upgrades.
- **Major Repairs**: Typically requires the device to be sent back to the maintenance shop or factory for repairs and involves the replacement of one or more key parts to ensure satisfactory device functioning.
- **Replacement**: Involves complete removal and replacement of the device.

Detailed descriptions specific to each ITS device along with the unit costs for different treatment actions for each ITS asset is included in Appendix C.

The impact of the type of maintenance activity on the existing condition states are shown in Table 4-4. For instance, an ITS asset in *Good* condition requires only periodic inspection. If the results of the inspection indicate that the asset is a *Low Risk*, minor repairs could be applied to bring that asset back up to *Good* condition. Similarly, if an ITS asset is a *Medium Risk*, major repairs could improve the status to *Low Risk*. Finally, an asset that is *High Risk* can either be converted to a *Medium Risk* with major repairs or could be returned to *Good* condition if replaced.

Table 4-4. ITS maintenance activity impact matrix.

Current Condition	Resulting Condition After			
	Inspection	Minor Repair	Major Repair	Replacement
Good	*Good*			
Low Risk	*Low Risk*	*Good*		
Medium Risk	*Medium Risk*	*Medium Risk*	*Low Risk*	
High Risk	*High Risk*	*High Risk*	*Medium Risk*	*Good*

Figure 4-14 shows the distribution of conditions over the 10-year performance for each ITS asset for the three LCP strategies evaluated.

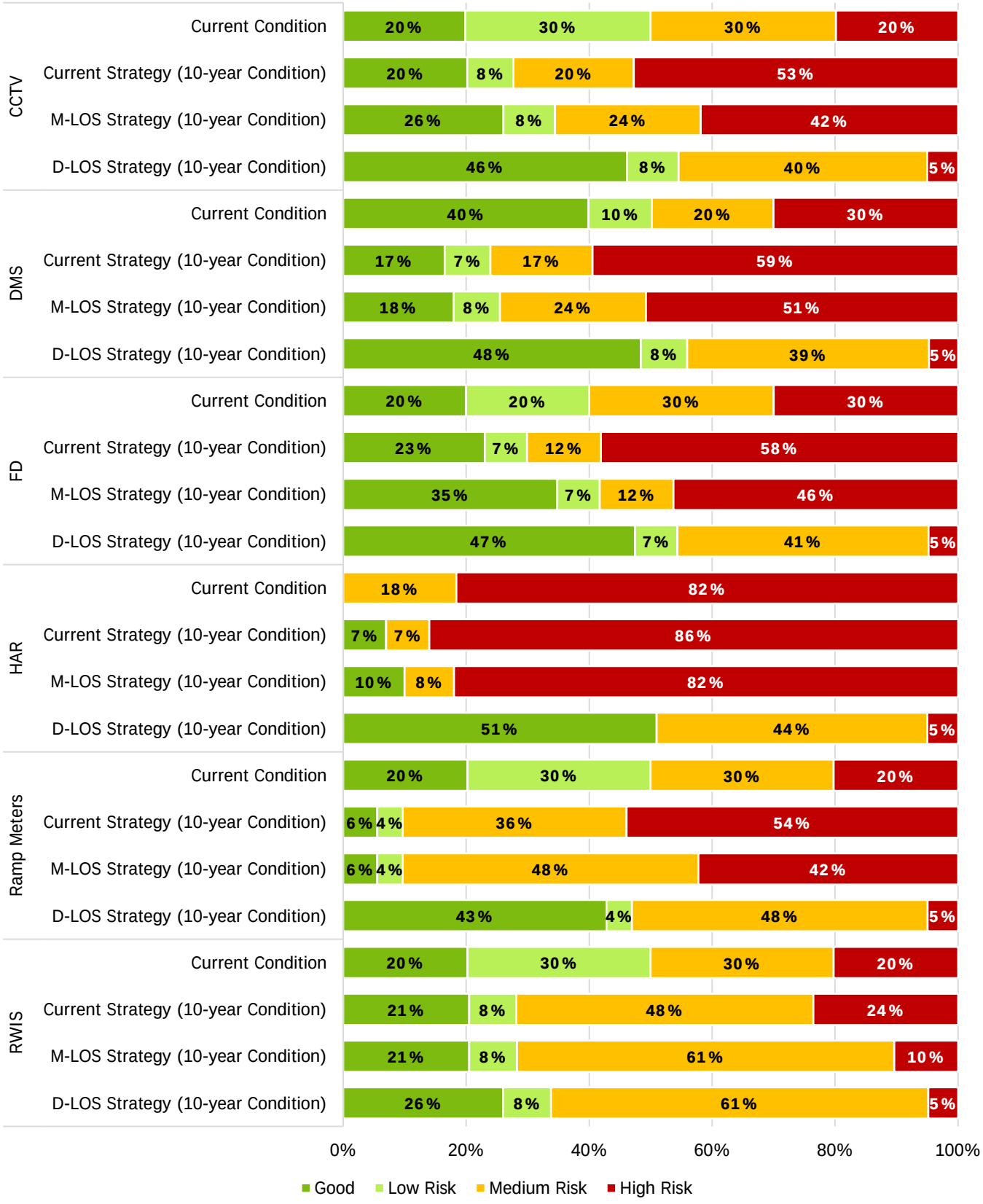


Figure 4-14. Comparison of current and projected 10-year ITS asset conditions.

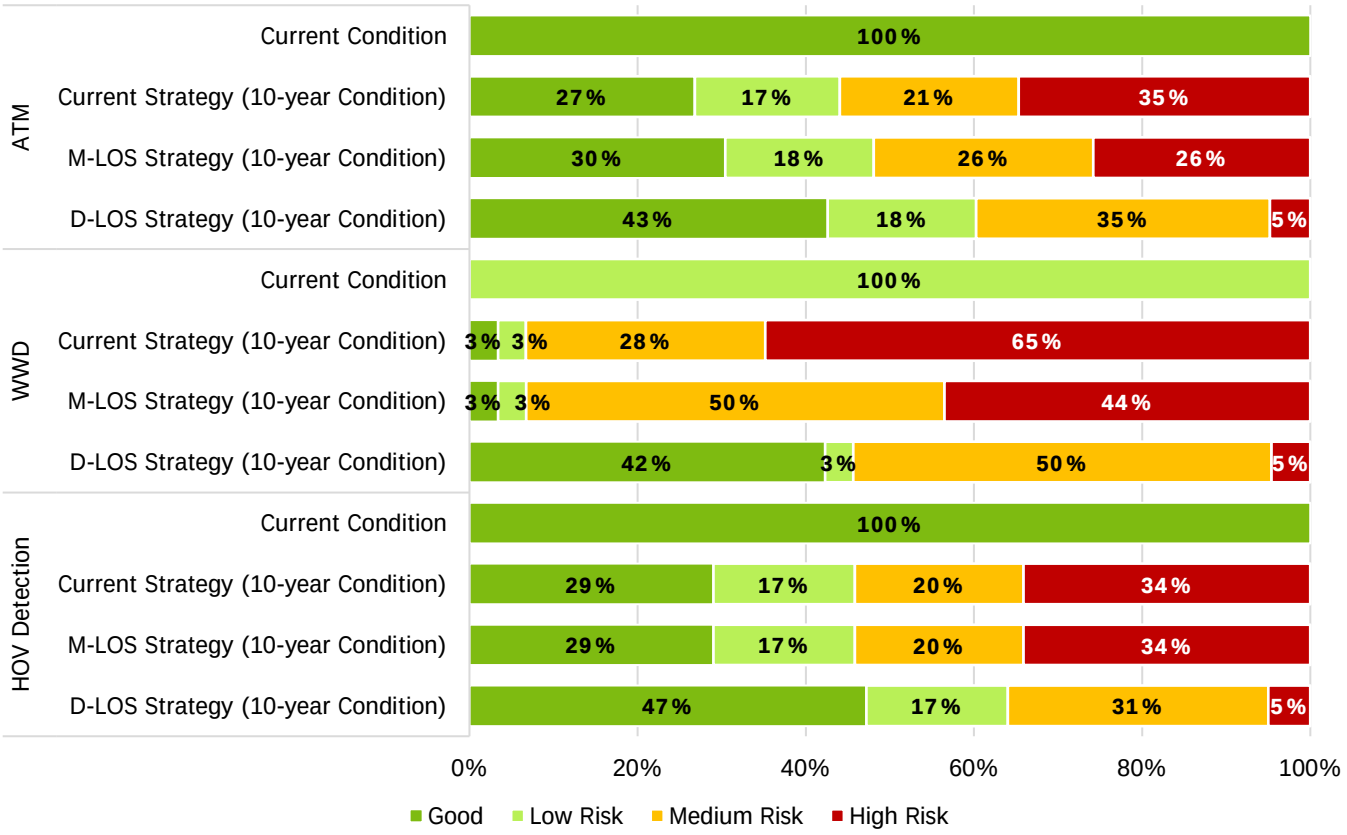


Figure 4-14. Comparison of current and projected 10-year ITS asset conditions (continued).

As seen in Figure 4-14, a vast majority of the ITS assets are expected to deteriorate to a *High Risk* category under the current strategy. This clearly indicates that the expected level of funding is not adequate to sustain current conditions over the 10-year period. The ITS asset network is also growing at a rapid pace, and it is estimated that NDOT will be maintaining approximately 3,500 more devices (across all ITS asset types) by 2031. The additional responsibility of maintaining the newly added devices is also expected to result in an increased funding need over time.

Table 4-5 summarizes the 10-year treatment costs for each ITS asset under each LCP strategy investigated. A total budget increase of approximately 25 percent is needed to maintain the minimum level-of-service. In order to achieve the aspirational goal of having no more 5 percent of the ITS asset network in *High Risk* condition, NDOT would need to double its 10-year budget.

In comparison, if NDOT adopted a worst-first approach to achieve the desired level-of-service, the 10-year costs are expected to be 4 times higher than the preservation-based strategy (D-LOS Strategy). This clearly demonstrates the benefits associated with NDOT's preservation-focused approach for managing ITS assets.

Table 4-5. Summary of 10-year treatment costs for each LCP strategy.

ITS Asset	10-Year Treatment Costs ($, Millions)		
	Current Strategy	M-LOS Strategy	D-LOS Strategy
CCTV	8.5	10.6	17.6
DMS	10.2	12.7	26.1
Flow Detectors	12.4	15.5	26.4
HAR	0.4	0.5	2.2
Ramp Meters	3.7	4.7	7.7
RWIS	9.4	11.8	12.8
ATM DMS	2.5	3.2	3.7
WWD Detection	3.5	4.3	5.9
HOV Detection	0.4	0.5	0.6
Total	**51.1**	**63.9**	**103.0**

Summary

The overarching purpose of conducting a network-level LCP analysis is to explore the most cost-effective, long-term investment strategies to keep the infrastructure in serviceable condition. As shown in the analysis presented in this chapter, the planned use of preservation treatments on assets that are in relatively good condition is significantly more cost effective than other strategies that defer treatment until significant amounts of deterioration are present. NDOT has employed a preservation strategy for maintaining its pavement assets for years and is proposing to continue this approach to managing pavement and bridge assets. The management approach for ITS assets continues to evolve and NDOT is working on improving the consistency in ITS maintenance across each District. Since the preservation-focused approaches provide the best return on investment in the long-term, NDOT will continue with its proactive preservation strategies for the 10-year period addressed in this TAMP.

Chapter 5. Managing Risk and Resilience

Overview

NDOT strives to provide a safe and functional transportation system that delivers the highest possible level of service within funding constraints. However, unexpected or unplanned events, such as disruptions to revenue, unexpected inflation, or extreme natural hazards (such as floods and earthquakes), can threaten NDOT from meeting its goals. Other factors for some assets, such as the lack of reliable performance data or workforce reductions, will impact an agency's ability to anticipate and plan for risks.

The International Organization for Standardization (ISO) defines risk as the "effect of uncertainty on objectives" (ISO 31000). Risks are more than just threats to the effective functioning of an organization and can have positive or negative effects on agency objectives. Risk Management is the identification, assessment, and prioritization of risks followed by the coordinated and economical application of resources to monitor risk indicators, minimize the consequences of threats, and prepare for potential opportunities. Acknowledging, understanding, and managing risks associated with Nevada's transportation assets helps NDOT plan for potential system disruptions, be ready for opportunities, and improve the resilience of the overall system.

Understanding risks to the organization and the services it provides is critical to NDOT's ability to fulfill its mission, as articulated in the NDOT mission statement.

NEVADA DOT'S MISSION STATEMENT

Provide, operate, and preserve a transportation system that enhances safety, quality of life and economic development through innovation, environmental stewardship, and a dedicated workforce. (source: www.dot.nv.gov)

Incorporating this understanding of risk into the TAMP involves an assessment of key risks that could impact the Department's ability to achieve the 10-year performance outcomes, as defined in Chapter 6. The primary objectives of the risk management analysis conducted by NDOT were to:

- Articulate the story behind what does, or what could, potentially impede NDOT's asset management objectives.
- Illustrate uncertainties that NDOT must address to achieve its long-term goals.
- Identify decisions that could potentially damage the public's perception of NDOT.
- Prioritize investments to mitigate risks.

Risk Management Process

NDOT recognizes the importance of evaluating and managing uncertainties that could impact its ability to execute its mission. To ensure that risks are considered consistently throughout the agency, and to ensure that risks are monitored regularly, NDOT has implemented a formal Enterprise Risk Management (ERM) program that is based on a process developed by ISO. This process is summarized in Table 5-1. The first five steps shown in Table 5-1 are performed every 4 years in preparation of the updated TAMP. The final two steps, *Communicate and Consult* and *Monitor and Review*, are regularly addressed through quarterly meetings of the asset owners, per the ERM.

Table 5-1. NDOT risk management process.

Activities	Tasks Performed
Establish the Context Identify goals, objectives, targets, environmental, political, economic context	TAMP goals, targets as well as environmental, political, and economic contexts are established and the primary risks to Nevada's transportation assets are identified.
Risk Identification Identify risks to condition, performance of assets Part 667 assets repeatedly damaged	
Risk Analysis Assess likelihood, impact, and consequence	NDOT personnel assign likelihood and impact ratings to each risk identified during a workshop based on their professional judgement and working experiences. For this TAMP update, the scoring was conducted using a web-based survey. A risk heat map (shown in Table 5-4) is used to assign an overall risk rating based on the likelihood of that event occurring and the magnitude of its impact. The risk owners establish final risk ratings through a consensus process.
Risk Evaluation Prioritize identified risks	
Manage Risks Mitigation plan for top priority risks Approach for monitoring top risks Summary of Part 667 evaluations	One or more risk management and mitigation strategies are developed for each risk to help reduce NDOT's potential exposure.
Communicate and Consult	The risk owners meet regularly to monitor risks. Mitigation strategies are reviewed and updated as needed to support NDOT's asset management program.
Monitor and Review	

Risk Owners

The TAMP risk management process is supported by a group of risk owners representing all major organizational units at NDOT. A summary of risk owners at the Division and Delivery Program levels are shown in Figure 5-1. The risk owners are responsible for all steps of the risk management process.

The risk management process results in the development of the risk register, presented in table 5.5. The TAMP risk register documents the key threats and opportunities that could impact the achievement of NDOT's asset management goals. For each risk, the register describes the strategies employed to mitigate the risk, and the NDOT staff responsible for delivering those strategies. Per the ERM, the risk register is reviewed quarterly so changes in risks can be monitored. Risk owners are responsible for reporting upward to senior management and laterally to peers if risks to his or her area could affect

other objectives, programs, projects, or activities. Communication is expected to be both continuous and effective.

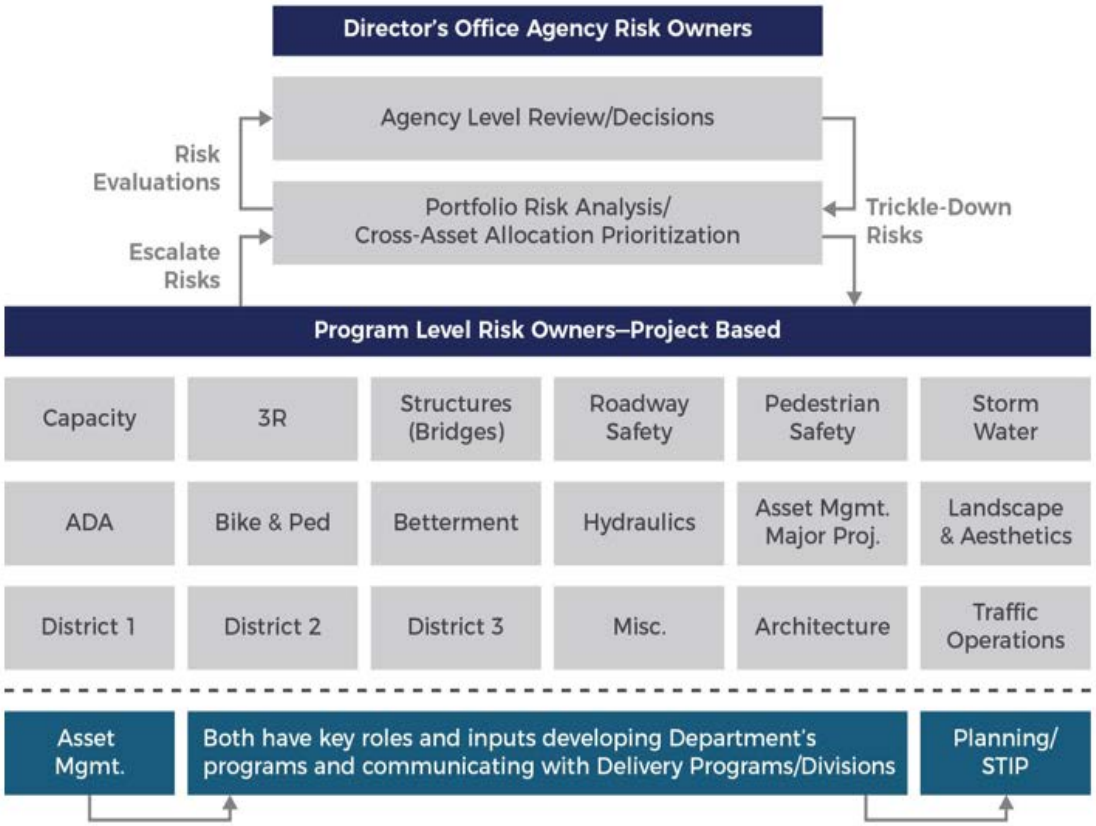


Figure 5-1: Summary of risk owners at the division and delivery program levels.

Risk Context and Identification

NDOT's ERM program addresses a broad array of strategic, program, project, and activity risks, as shown in Figure 5.2. Through the ERM program, NDOT engages in risk management at each of these levels as appropriate. The analysis conducted as a part of the TAMP development efforts focused on agency and program risks that could impact NDOT's ability to achieve and sustain its asset management goals.

Figure 5-2: Risk levels.

Risk owners work together to identify and describe a comprehensive set of program- and agency-level risks and their consequences. Common risk categories and consequences to transportation assets are illustrated in Figure 5-3.

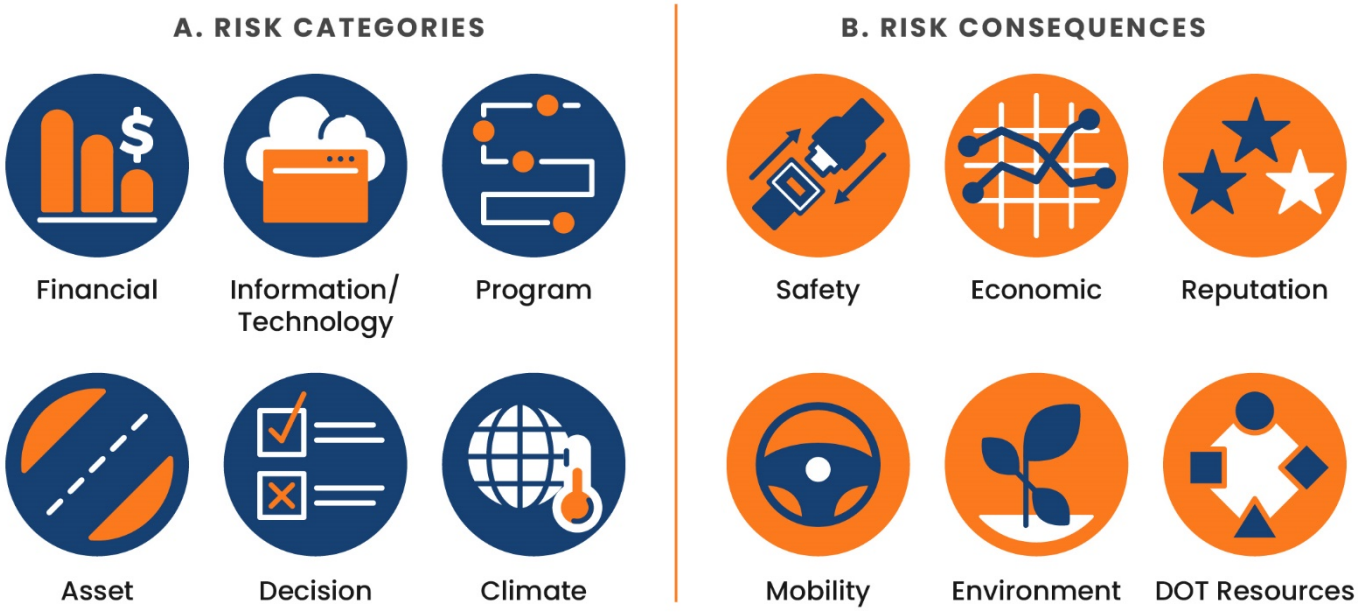


Figure 5-3: Common transportation asset risk categories and consequences.

Risk Analysis and Evaluation

Each identified risk is rated by the risk owners to provide an assessment of likelihood and impact. NDOT's rating system for likelihood and impact are shown in Tables 5-2 and 5-3, respectively. Using these ratings, risk owners establish the relative consequence of each risk using the risk heat map shown in Table 5-4. After rating each risk, the risk owners review the findings to develop consensus agreement on each rating. During this process risk consequence ratings may be adjusted based on expert opinion or additional data presented by one or more risk owners.

Table 5-2: Risk likelihood ratings.

Ranking	Likelihood	Frequency	Score
Almost Certain	Near Certainty (90-100%)	Likely to occur within the year	5
Likely	Highly Likely (70-90%)	Likely to occur within two years	4
Moderate	Likely (30-70%)	Likely to occur within 3 to 5 years	3
Unlikely	Unlikely (10–30%)	Likely to occur within 6—10 years	2
Rare	Remote (<10%)	Not likely to occur for 10 or more years	1

Table 5-3: Risk impact ratings.

Impact	Score
Catastrophic Impact on System Performance	5
Major Impact on System Performance	4
Moderate Impact on System Performance	3
Minor Impact on System Performance	2
Insignificant Impact on System Performance	1

Table 5-4: Risk heat map.

Likelihood Ratings and Risk Levels					
Impact Ratings	**Rare (1)**	**Unlikely (2)**	**Moderate (3)**	**Likely (5)**	**Almost Certain (5)**
Catastrophic (5)	Low	Medium	High	Extreme	Extreme
Major (4)	Low	Medium	High	High	Extreme
Moderate (3)	Low	Low	Medium	High	High
Minor (2)	Very Low	Low	Low	Medium	Medium
Insignificant (1)	Very Low	Very Low	Low	Low	Low

Risk Mitigation

NDOT takes several different approaches to address risk that vary in terms of cost and the amount of residual risk that remains. In general, risk mitigation strategies can be classified into the following categories:

- **Terminate**: Eliminate threat posed by the risk.
- **Transfer**: Shift risk to third party.
- **Treat**: Take steps to reduce probability and/or impact of risk.
- **Tolerate**: Deal with the risk and monitor it for changes.
- **Take Advantage**: Use it as an opportunity to seek external funding or partnership.

The NDOT risk owners establish specific strategies and approaches for monitoring each risk, which are documented in the risk register.

BUILDING RESILIENCE TO CLIMATE CHANGE AND EXTREME WEATHER EVENTS

Climate and extreme-weather events pose recognized risks to NDOT's transportation infrastructure. Unexpected events and long-term changes caused by these risks can have broad social, economic, and environmental consequences. While it is not realistic to be able to completely prevent the impacts related to climate risks, NDOT is working toward implementing adaptation strategies that will help its infrastructure become more resilient to such events. The first steps towards building a more resilient transportation infrastructure system are to identify the most significant risks and assess system vulnerability to these risks. The vulnerability assessment involves a critical assessment of assets in terms of robustness and redundance. The results suggest the following approaches will improve system resilience:

- Prioritize the maintenance and management of routes that do not have redundancies.
- Maintain and update emergency response plans frequently.
- Update the asset vulnerability assessment periodically to address changes that occur.
- Monitor asset deterioration rates to determine appropriate asset life-cycle treatment strategies that consider unexpected events.

Risk Register

The results of the risk management analysis for the 2022 TAMP are presented in the risk register shown in Table 5-5. These risks will be monitored on a regular basis, per the ERM program, and the risk register will be updated periodically to help ensure that the significant risks are mitigated or managed.

Table 5-5: NDOT's asset management risk register.

Risk Category What Is The Risk?	Likelihood	Impact	Risk Rating	What Are Likely Causes And Consequences?	How Will NDOT Deal With It?	Who Is The Responsible Party?
 **Program** Inability to recruit and retain a sufficient workforce with needed skills reduces the efficiency of operations and maintenance programs.	**4**	**4**	**High**	**Causes:** • Lack of qualified candidates. • Uncompetitive wages. • Staff retirements. • Staff moving to new positions within the Department. • Issues with hiring and/or training staff. **Consequences:** • Impacts planning, design, and program delivery • Inability to perform needed maintenance. • Inability to respond adequately to emergency events. • Lack of expertise to operate required management systems with confidence • Increasing project delivery costs.	• Conduct succession planning. • Identify and conduct training for current NDOT staff. • Develop and maintain documents describing procedures and practices. • Modify the internship program to allow high-performing entry-level staff to work part time. • Hire more contractors to perform work to account for lack of in-house workforce.	• Exec Leader Team (ELT) • Senior Leader Team SLT • Training Dept. • Human Resources (HR) • Districts
 **Financial** Fluctuation in construction costs will impact NDOT's ability to meet performance targets.	**4**	**3**	**High**	**Causes:** • Material & labor shortages. • General inflation. • Increases in commodity prices. • Production disruptions for asphalt and cement. **Consequences:** • Less work can be delivered with existing funds. • Asset conditions decline. • Cost of future work to recover system condition increases. • Unable to meet performance targets.	• Identify additional sources of funding. • Include escalation language in contracts for materials.	• Financial Mgt. • Planning • Construction
 **Program** Due to absence of reliable equipment and other resources, NDOT might not deliver maintenance works in a timely manner.	**4**	**3**	**High**	**Causes:** • Aging equipment not replaced on desired cycle. • Insufficient budget for maintenance materials. • Inability to recruit and retain workers. **Consequences:** • Unable to deliver needed maintenance in a timely manner. • Unable to adequately respond to emergency events. • Accelerated deterioration of pavements and bridges.	• Increase funding for maintenance equipment purchase or rental, as appropriate. • Review fleet patterns to identify opportunities to reallocate purchases to more critical equipment. • Deliver maintenance by contract for services that field crews are not equipped to deliver.	• ELT • Equipment • Districts

Risk Category What Is The Risk?	Likelihood	Impact	Risk Rating	What Are Likely Causes And Consequences?	How Will NDOT Deal With It?	Who Is The Responsible Party?
 **Decision** Existing project prioritization rankings may not adequately account for condition-based project needs and would cause investment imbalance across assets and work types	**3**	**4**	**High**	**Causes:** • Rapid expansion in some parts of the state. **Consequences:** • Inadequate investment in pavement and bridge preservation. • Over prioritization of rehabilitation and reconstruction in heavily populated areas.	• Convey the importance of achieving asset condition objectives.	• Planning • One Nevada
 **Program** Changes in leadership & organizational structure, & restructuring with NDOT might shift the programming priorities	**3**	**3**	**Medium**	**Causes:** • Normal political cycle. • Changes in the perception of NDOT's mission. • Forced responses to reduced staff and resources. **Consequences:** • Changes in programming priorities. • Loss of productivity as staff assignments change.	• Improve documentation and transparency in programming. • Take steps to further integrate asset management into existing processes.	• Planning • Multimodal
 **Financial** Inadequate funding to achieve asset management objectives will cause the asset conditions to deteriorate at a faster rate	**3**	**3**	**Medium**	**Causes:** • Revenue shortfalls due to pandemic and aftermath. **Consequences:** • Fewer projects funded. • Less work accomplished. • Decreasing asset conditions. • Increased risk of failure. • Increased future costs to address declining conditions.	• Identify additional sources of funding. • Re-evaluate road resurfacing strategies for more cost-effective alternatives. • Develop/build direct relationships between the Department and NV Congressional delegation to provide input on legislation.	• Financial Mgt. • Materials • Maintenance • ELT

Risk Category What Is The Risk?	Likelihood	Impact	Risk Rating	What Are Likely Causes And Consequences?	How Will NDOT Deal With It?	Who Is The Responsible Party?
 **Climate** More frequent and more intense extreme weather events might cause substantial damage to assets.	**3**	**3**	**Medium**	**Causes:** • Changes in weather and climate patterns. **Consequences:** • Asset damage and mobility issues. • More frequent asset repairs or replacement needs. • Reduction in funding available for other planned activities. • Reduction in staff available to perform other daily activities due to utilization of resources in emergency responses. • Data sharing and connectivity issues.	• Monitor events using established processes to prioritize mitigation strategies. • Maintain emergency response plans and ability to reprioritize quickly. • Pre-plan, train, pre-deploy, assets and staff to ensure adequate response. • Set standards for resilient designs and preventive strategies based on existing localized historic data.	• Subject Mater experts (SME) • Maintenance • Emergency Mgt. • SLT
 **Information/ Technology** As a result of lack of accuracy in Asset management forecasts (needs & outcomes), NDOT will be unable to balance investment funding across asset classes and work types.	**3**	**3**	**Medium**	**Causes:** • Asset management systems still under development. **Consequences:** • Under- or over-funding of preservation. • Inefficient use of funds. • Accelerated system deterioration.	• Build adequate analytical capabilities (systems and staff) to continually improve forecasting capabilities. • Establish routines to regularly update asset management plan to better match project planning priorities.	• Pavement SME • Structural SME • AM Core Team
 **Asset** Advancement in technological changes might cause the ITS assets & other equipment to become obsolete.	**3**	**3**	**Medium**	**Causes:** • Normal technology advancement. • Increased use of connected/autonomous vehicles. • Increased use of integrated, internet-based equipment. **Consequences:** • Deployed assets are unable to communicate with newer technology. • Multiple technologies must be managed, which increases costs and labor requirements.	• Develop a plan for equipment maintenance and replacement that considers changing technology. • Evaluate opportunities to procure data as a service.	• ITS SME

Risk Category What Is The Risk?	Likelihood	Impact	Risk Rating	What Are Likely Causes And Consequences?	How Will NDOT Deal With It?	Who Is The Responsible Party?
Asset As a result of slow replacement of damaged ITS assets, transportation safety, mobility and overall system performance will reduce.	**3**	**3**	**Medium**	**Causes:** • Material shortages or shipping constraints. • Inadequate funding. • Accelerated obsolescence. • Inadequate staffing. **Consequences:** • Reduced level of service provided to highway users. • Increased congestion. • Increased incident and emergency response times.	• Stockpile critical components needed for maintenance and normal operation. (Structural components not included) • Evaluate opportunities to procure data as a service.	• Local Gov. Agencies SME
Asset Insufficient investment in preventive maintenance would result in costly and substantial repair works in future	**2**	**3**	**Low**	**Causes:** • Lack of funds. • Inaccurate forecasts and needs estimates. • Lack of urgency to perform preventive maintenance. • Inadequate understanding of benefits. • Inadequate staff. **Consequences:** • Pavements and bridges deteriorate and require more expensive preservation treatments. • Unable to meet performance targets. • Increased future costs to recover deteriorated conditions with more substantial treatments.	• Regularly review road resurfacing strategies for more cost-effective alternatives.	• Pavement SME • Structures SME
Program Possible shut down(s) in the federal aid program due to short-term highway bills and congressional inaction might result in disruptions in project and program delivery.	**2**	**2**	**Low**	**Causes:** • Political stalemates in the U.S. Congress. **Consequences:** • Temporary disruptions in project and program delivery. • Conservative programming (fewer projects). • Reduced work delivered. • Declining asset conditions. • Increased risk of asset failure.	• Identify additional sources of funding • Identify cashflow strategies that avoid potential shutdowns of construction activities.	• Financial Mgt. • Planning.

Special Requirements For Periodic Evaluation of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events

NDOT 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. NDOT records information for each location where repairs 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, NDOT regularly evaluates its emergency response data to identify any locations have that have required repair or reconstruction on two or more occasions from emergency events declared by the Governor or the President of the United States, since January 1, 1997. This process is outlined in Table 5-6. To date, there have been no locations on the NHS that have required repair or replacement from two or more qualifying emergency events.

Table 5-6: Business process to support 23 CFR Part 667 requirements.

Step	NHS Highways and Bridges	Non-NHS Highways and Bridges
Documentation	After a qualifying emergency event has been declared, the NDOT Operations Division will assess the situation and evaluate the damage on roads, highways, and bridges on the National Highway System. Once the situation has been assessed, a Detailed Damage Inspection Report (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 NDOT will perform a statewide evaluation of the NHS, using the GIS database, to identify recurring incidents of repair or reconstruction particular locations. If recurring events (more than two events at a given location) are identified for a location on the NHS, NDOT will develop an action plan for addressing the issue.	Prior to requesting federal aid for any highway or bridge project, NDOT 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.	NDOT 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.

Risks Considered in NDOT's Planning Documents

NDOT's planning documents inform the risk management strategies that are considered as part of NDOT's delivery programs. Alongside the TAMP, these documents include Transportation System Projects (TSP), STIP, the One Nevada Transportation Plan and the Nevada State Freight Plan. These connections between plans are illustrated in Figure 5-3.

One Nevada Transportation Plan: NDOT and its regional and local partners emphasize safety initiatives aimed at reducing fatalities, serious injuries, and crashes; minimizing risk; and improving responsiveness to emergencies and natural hazards. NDOT takes a broad view of public safety, recognizing the importance of identifying, mitigating, preparing for, and responding to a growing number of security risks and potential emergencies involving Nevada's transportation system. NDOT designs infrastructure to manage stormwater, allow for safe wildlife crossings, avoid historic or culturally sensitive areas, and manage risks from extreme weather events and natural hazards. Before construction begins on major projects, NDOT evaluates potential impacts and considers strategies to address those impacts and enhance environmental sustainability and stewardship.

Nevada State Freight Plan: Nevada's Freight Transportation System presents a preliminary natural disaster risk management assessment. Furthermore, NDOT is in the process of enhancing the freight plan to mitigate the impacts of unplanned emergency effects (such as Covid-19) on freight operations. The impacts of Covid-19 highlighted the external factors that can have a dramatic impact on both the demand for freight services and the usage of freight infrastructure. The sources, locations, and quantities of both inputs and final demand were altered dramatically for many commodities and the supply chains continue to adapt to these demand changes. The corresponding rise in e-commerce has increased demand for urban distribution centers, changing land use and truck travel patterns in local communities across Nevada. NDOT is in the process of developing a statewide Freight Resiliency Plan as part of the next Freight Plan update that incorporates freight emergency preparedness techniques to ensure that supply chains can adjust to disruptions that occur in the external environment.

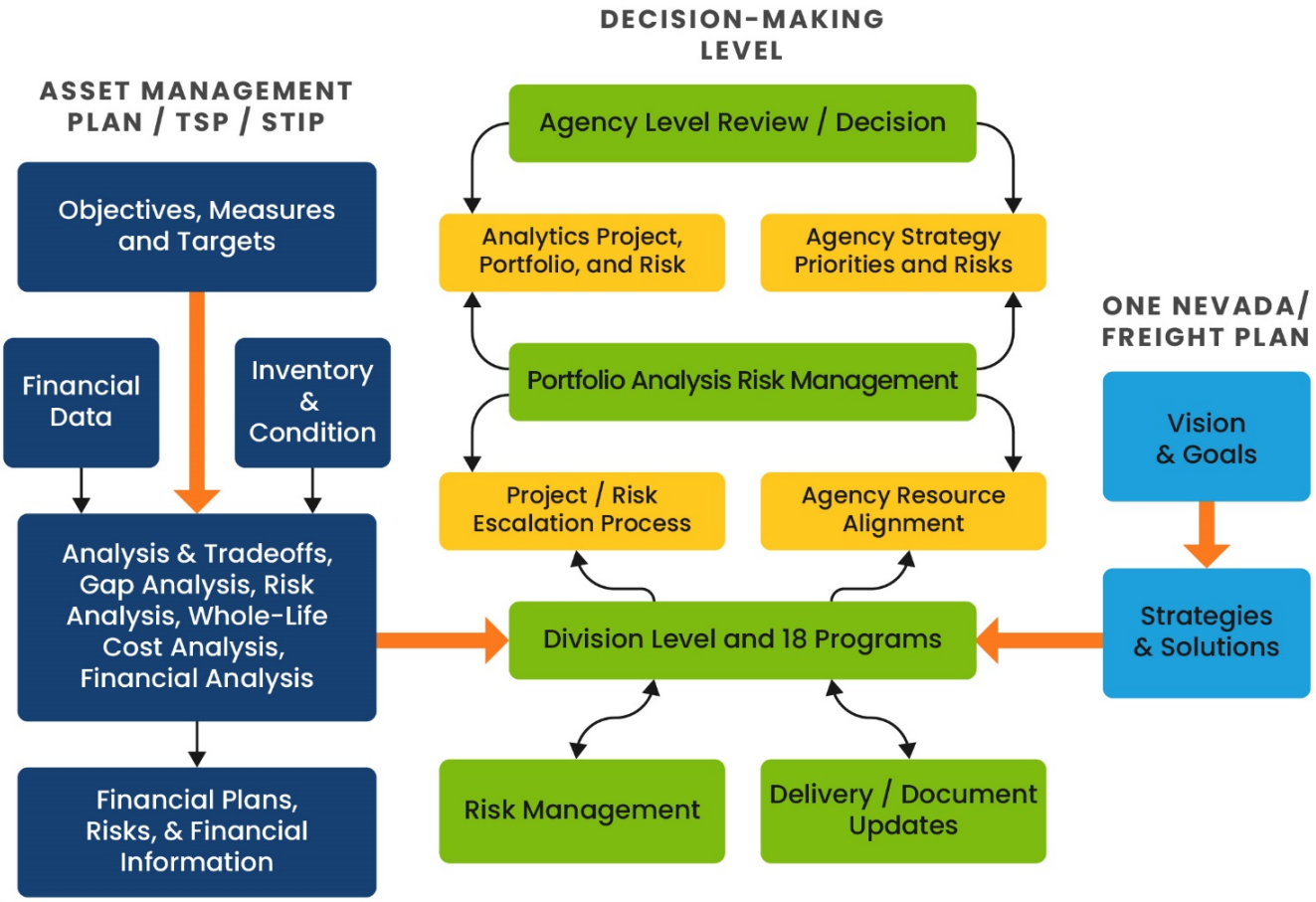


Figure 5-3: Risk management strategies as part of NDOT's delivery programs.

Chapter 6. Financial Plan and Investment Strategies

Overview

Financial planning involves assessing available funding to determine the extent to which it supports NDOT in achieving its goals and objectives. The TAMP financial plan provides an estimate of the sources and amount of revenue expected to be available for maintaining and improving the bridge, pavement, and ITS asset conditions. The TAM investment strategies describe how NDOT expects to invest the available revenue over the next 10 years to implement the life cycle strategies described in chapter 4, manage the risks described in chapter 5, and support overall performance of the NHS and state-maintained networks.

Highway Fund Sources

NDOT uses funding from both state and federal revenue sources to support its Maintenance, Operations, Asset Management, and New Construction programs.

Nevada State Highway Fund

NDOT's principal source of funding for highway construction, maintenance, and repair is the State Highway Fund, which is a dedicated source of funding established by the Nevada State Constitution expressly for this purpose and appropriated by the legislature. State Highway Fund revenue (excluding NDOT and Las Vegas Convention and Visitors Authority [LVCVA] bond proceeds) totaled approximately $8.4 billion and averaged approximately $1.1 billion per year in fiscal years 2014 through 2021. The majority of this revenue is provided by Federal Aid and state resources, such as the state gasoline and special fuel taxes, vehicle registration fees, commercial carrier fees, and driver's license fees. This revenue is sometimes bolstered with the sale of bonds to finance construction projects. For example, NDOT and LVCVA bonds sold during the fiscal years of 2014 through 2021 totaled $785 million. In addition to NDOT, the Department of Motor Vehicles (DMV) and the Department of Public Safety receive a significant amount of state user fee funding from the State Highway Fund. The various funding sources that contribute to the State Highway Fund are shown in Figure 6-1.

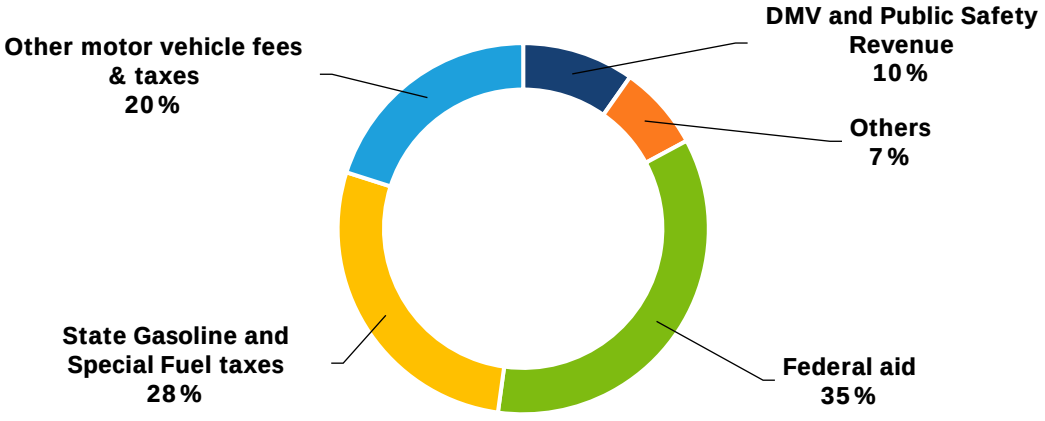


Figure 6-1. Funding sources for the Nevada State Highway Fund (2014 to 2021).

Figure 6-2 shows the total State Highway Fund revenue between fiscal years 2014 and 2021 by source. A summary of the key financial information for this 8-year period is summarized below.

- NDOT's Average Annual Share of Total State Highway Fund Expenditures (including bond repayment): $631 million
- Average Annual State Gas and Motor Vehicle Taxes: $502 million
- Average Annual Federal Aid Revenue: $368 million
- Average Annual Bond and Other Revenue: $98 million

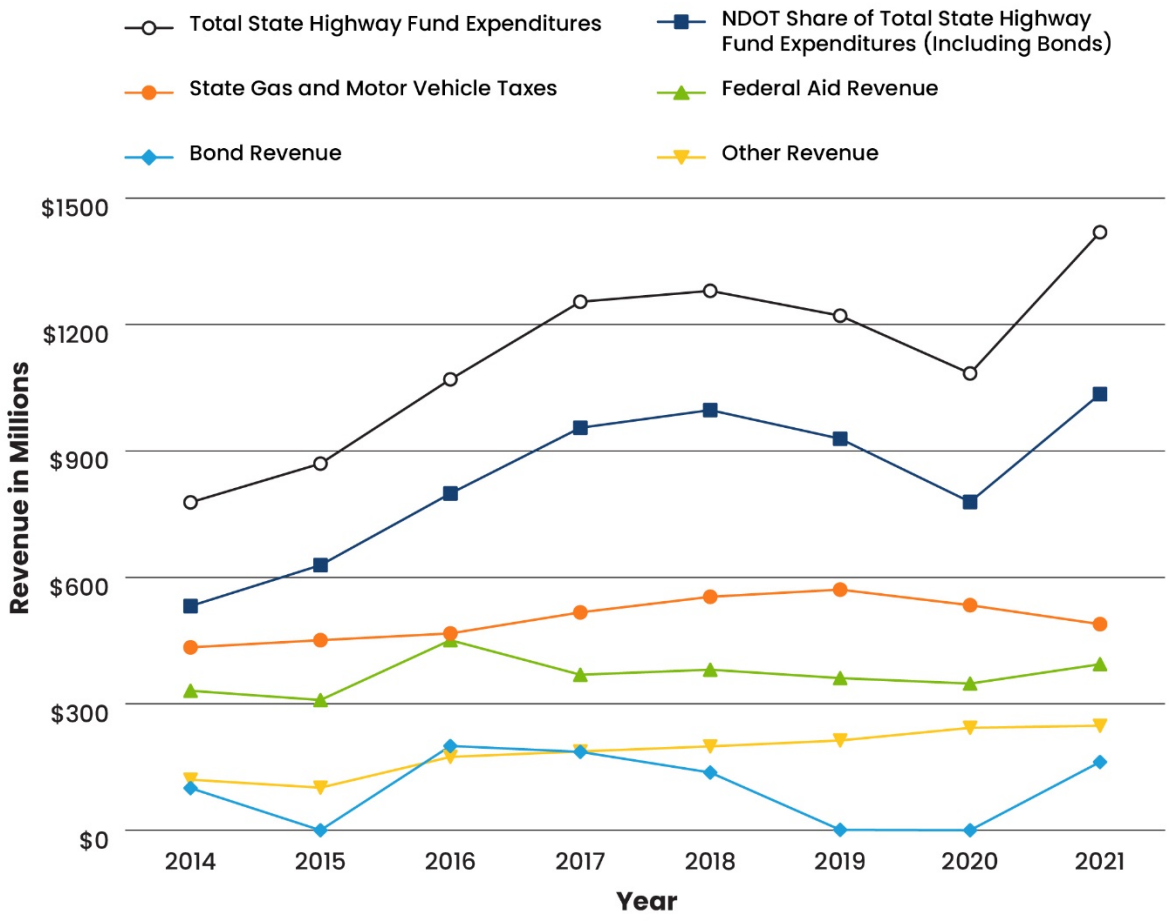


Figure 6-2. Historical State Highway Fund revenue (2014 to 2021).

Additional State Fund Sources

The Nevada State Legislature has provided some additional revenue sources in recent years to bolster funding available to NDOT.

Assembly Bill 595 (2007)

This legislation requires counties with a population of 100,000 or more (Clark and Washoe Counties) to allocate a portion of ad valorem tax for capital projects into the State Highway Fund. These funds are to be used for the construction and maintenance of public highways, with property taxes raised in Clark and Washoe counties to be spent only in the county where the taxes were collected. This revenue

source contributed $183 million to the State Highway Fund between FY 2014 and FY 2021, averaging $23 million per fiscal year.

Senate Bill 5 (2009 – 26th Special Session)

This legislation requires any amount of the Fund for Cleaning Up Discharges of Petroleum which exceeds $7,500,000 at the end of any fiscal year to be allocated to a special account in the Highway Fund. The money distributed from the account must only be used for construction, reconstruction, improvement, and maintenance of public roads. It is allocated as follows: 70 percent to projects in Clark County, 20 percent to projects in Washoe County, and 10 percent to projects in other counties. This revenue source contributed $38.2 million to the State Highway Fund between FY 2014 and FY 2021, averaging approximately $4.8 million per fiscal year.

Senate Bill 483 (2015)

This legislation modified the distribution of the basic governmental services tax authorized by Senate Bill 429, 2009. The bill allocated this revenue solely to the General Fund in FY 2016, but changed to 50 percent to the General Fund and 50 percent to the State Highway Fund in FY 2017. State Highway Fund revenue received as a result of this legislation was $38.6 million in the State FY 2017.

Senate Bills 486 (2015), SB 541(2017), SB 3 (2020)

- SB 486 (2015): Modifies the distribution of the basic governmental services tax authorized by SB 429 (2009). The legislation allocates this revenue 25 percent to the State General Fund and 75 percent to the State Highway Fund in fiscal years 2018 and 2019.
- SB 541 (2017): Removes the expiration date of the divided distribution, thus continuing to require the Department to direct 25 percent of the proceeds to be transferred to the State General Fund and 75 percent to the State Highway Fund.
- SB 3 (2020): Temporarily required the Department to direct the entire amount of these proceeds to be transferred to the State General Fund. This legislation began on July 1, 2020 and expired on June 30, 2021.

Federal Aid Programs

On November 15, 2021, President Biden signed into law the Infrastructure Investment and Jobs Act (IIJA). It will provide approximately $550 billion over the next five federal fiscal years to support transportation infrastructure, nationwide. Table 6.1 lists Nevada's highest funded categories with the estimated funding levels through 2025. The numbers are estimated per the information available at this time. Each year Congress must pass budget authority, which regulates the amount of federal funds Nevada will be able to obligate. Out of the funding types listed below, five of the funding categories are used mainly on maintenance, construction and/or bridge. These are listed in the top portion of Table 6.1.

Table 6.1 – Expected federal funds from the IIJA ($ millions).

Program	2022	2023	2024	2025
National Highway Performance (exempt)	$5.40	$5.40	$5.40	$5.40
Highway Bridge	$45.00	$45.00	$45.00	$45.00
Off-System Bridge	$3.00	$3.54	$4.18	$4.93
Surface Transportation Block Grants	$108.00	$118.80	$120.94	$123.12
National Highway Performance	$232.00	$236.18	$240.43	$244.75
Subtotal for Pavement and Bridge	**$393.40**	**$408.92**	**$415.94**	**$423.20**
Highway Safety Improvement	$27.00	$27.49	$27.54	$27.59
Carbon Reduction	$11.00	$12.98	$15.32	$18.07
Congestion Mitigation	$35.00	$35.00	$35.00	$35.00
Rail-Highway Crossing Hazard Elimination	$1.30	$1.30	$1.30	$1.30
Transportation Alternatives	$9.20	$10.86	$12.81	$15.12
National Highway Freight	$12.00	$12.00	$12.00	$12.00
PROTECT	$12.00	$12.22	$12.44	$12.66
Subtotal of other highest programs	**$107.50**	**$111.83**	**$116.39**	**$121.73**

Revenue Projections

NDOT receives funding from both state and federal sources. State revenue is dependent on various factors such as the amount of fuel purchased during the year or the authorization of bonding by the State legislature. NDOT is allocated state revenues on an annual basis through the Nevada State budgeting process. Federal revenue is authorized through acts of the United States Congress. The current levels of funding were authorized through the IIJA, which was passed in 2021 and provides funding through federal fiscal year 2026. Revenue projections in the TAMP provide an estimate of the expected levels of funding for the entire 10-year period. To develop these estimates, NDOT reviewed historic data and evaluated current economic and legislative trends.

State Revenue Projections

Recent trends in State Highway Fund revenue show that the overall State Highway Fund revenue has varied between a high of $1,293 million in fiscal year 2021 and a low of $861 million in fiscal year 2015. Over the next decade, the average annual State Highway Fund revenue is projected to show modest growth. The State Highway Fund increased in part due to the addition of Government Services Tax

(GST) revenue, in the amount of about $63 million a year beginning in state fiscal year 2017. This additional revenue is partially offset by increases in the Department of Motor Vehicles (DMV) system enhancement budget. Excluding possible bond sales, State Highway Fund revenue is projected at approximately $1.06 billion while NDOT's portion of that revenue (excluding bond revenue and bond debt repayment) is expected to be approximately $770 million annually. NDOT expects to spend approximately $631 million annually (about 82 percent of the net revenue to NDOT) on new construction and non-maintenance activities such as operations, payroll, administrative support, and services. The remaining $140 million (about 18 percent of the net revenue to NDOT) is expected to be allocated for maintenance and asset management activities. Maintenance and asset management activities include maintenance, preservation, rehabilitation, and reconstruction.

Federal Aid Projections

As shown in Table 6.1, federal funding is expected to increase at approximately 1.7 percent per year in 2024 and 2025. Based on historic funding levels, it is expected this rate of increase will continue through 2031.

Funding Available for Maintenance and Asset Management

Table 6-2 shows the funding expected for investments in new construction and asset management activities over the next 10 years. Of the $631 million spent on non-maintenance activities annually, $400 million is expected to be spent on planning, design and operations, district offices, and other administrative and support services. Of the remaining $230 million, approximately $170 million is expected to be budgeted for new pavement construction and $17 million for new bridge construction activities. The remaining $43 million will be budgeted for addressing emergency needs and other work activities. The annual expenditures for pavement, bridge, and ITS asset management activities (i.e., Maintenance, Preservation, Rehabilitation, and Reconstruction) are explained in the remainder of the chapter.

Over the next 10 years, the annual investments in pavements, bridges, and ITS assets are expected to remain consistent. However, the costs to address needs are expected to increase each year due to inflation. Therefore, a 4.5 percent inflation rate (based on Utah DOT Inflation Projection statistics) has been applied to the future maintenance and preservation costs. The resulting decrease in purchasing power is directly reflected in the asset conditions that are achievable at the end of the 10-year period, reported later in this chapter. NDOT uses the funding described above to support all of its programs, initiatives, and priorities.

Table 6-2. Expected annual asset management budget ($ millions).

Asset Type	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Federal	$393	$409	$416	$423	$430	$445	$452	$460	$468	$476	$4,373
State	$631	$634	$637	$641	$644	$647	$650	$653	$580	$660	$7,117
Total	$1,024	$1,043	$1,053	$1,064	$1,074	$1,092	$1,102	$1,113	$1,125	$1,136	$10,827

In addition to the expected future funding estimates, NDOT also expects to pursue several discretionary federal funding opportunities. Any discretionary funding that NDOT is successful in obtaining will be in addition to what has been used in developing the TAMP.

Risks to Future Revenue

The financial risks that could impact future asset management revenue can potentially be attributed to the factors described below.

- **Improvements in Vehicle Fuel Efficiency and Other Automobile Technologies**: Increased fuel efficiency (see Figure 6-3) has been required by the federal government through the Corporate Average Fuel Economy (CAFE) program. While lowered emissions have a positive impact on the environment, the increased efficiency results in fewer dollars spent fueling the more efficient vehicles. This, in turn, results in less funding available because the gas tax is one of the major sources of both federal and state revenue. Additionally, electric and hybrid vehicles are gaining in popularity and becoming more affordable, leading to more conversions from gasoline-based automobiles to alternatives that offer a more economical and environmentally-sustainable solution.
- **Reduction in Vehicle Sales and Registration/Renewal Revenue:** Consumers are keeping their vehicles longer, thereby decreasing the revenue generated from the number of vehicles sold and the associated initial vehicle registration fees and taxes. Additionally, vehicle registration renewal fees in Nevada decline with each subsequent year of ownership over the life of the vehicle. It is anticipated that this trend of consumers keeping their vehicles longer will result in declining revenues from vehicle registration renewals.
- **Uncertainty of Future Federal Aid:** Federal highway funding is authorized through acts of the U.S. Congress which cover specific periods of time. Once a highway funding act expires, Congress must take action to allocate new funding. The current highway funding act is the IIJA, which provides funding through September of 2026. NDOT's ability to forecast Federal Aid levels beyond this point is limited. However, in the past Congress has consistently extended funding or passed new highway bills that either maintained or increased federal highway funding levels from year to year.

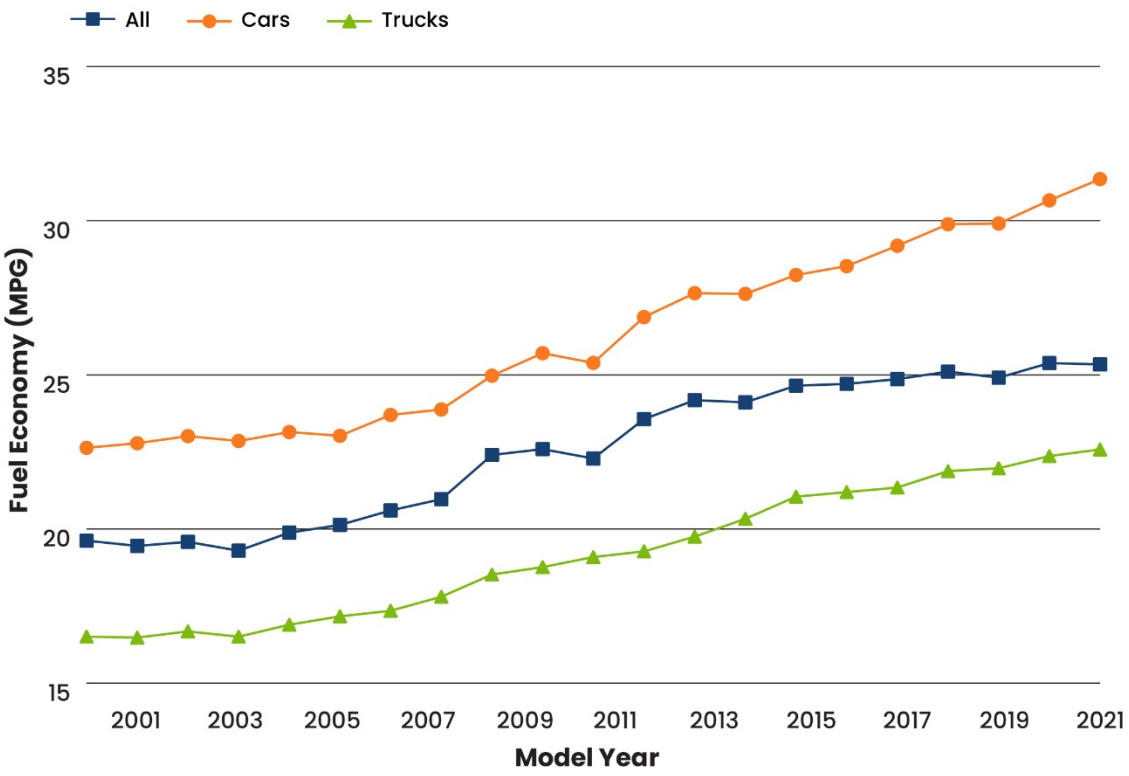


Figure 6–3. Average fuel economy (miles per gallon) by model year, 2001-2021 (Source: EPA Website).

Investment History

From 2019 through 2021, NDOT has spent approximately $114 million per year on maintenance (including corrective and preventive actions) and rehabilitation (including replacement) to partially offset deterioration. As the state's infrastructure ages, the need for reinvestment increases. NDOT has been working to increase its use of preventive maintenance and repair strategies for extending the life of its assets. During fiscal years 2019 through 2021, NDOT spent approximately 60 percent of its pavement investments and 35 percent of its bridge investments on low-cost preventive and repair actions. As illustrated in Figure 6-4, trends in spending on preventive and corrective maintenance actions include the following:

- In general, funding for pavement and bridge maintenance has been increasing.
- Annual expenditures on pavement and bridge maintenance fluctuate regularly.
- Pavements receive more funding than bridges.

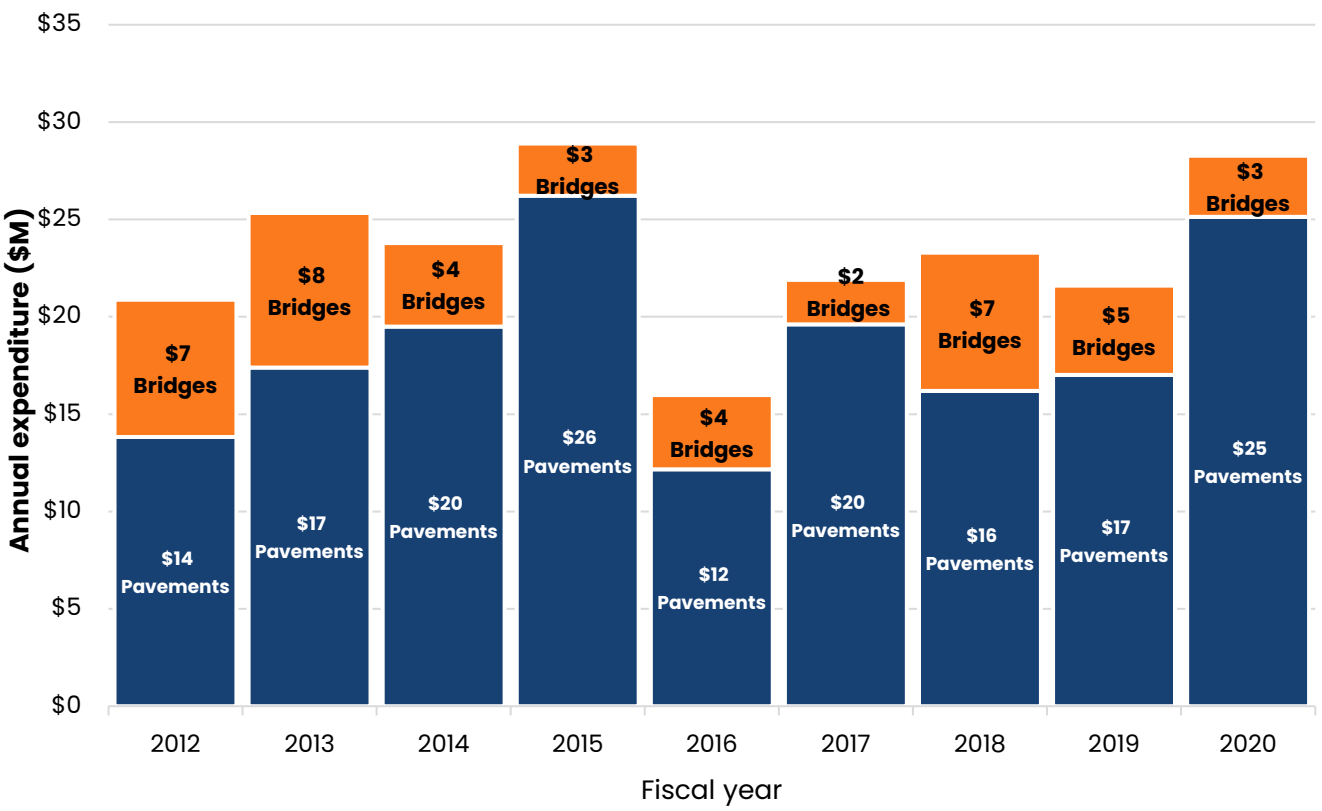


Figure 6-4. NDOT expenditures for preventive and corrective actions (2012 to 2020).

Investment Strategies

Pavement Investment Strategies

NDOT uses a financial consequence-based project prioritization process for its pavement management practices. Roadways with the most important financial consequence, such as Interstates and non-Interstate principal arterials, are kept at a higher level-of-service than low-volume roads. Projects are prioritized based on the proactive strategy of maintaining pavements in *Fair* or better condition rather than waiting until pavements deteriorate to *Poor* conditions when rehabilitation costs can be up to six times higher. The following priorities have been implemented as the NDOT long-term action plan for project selection:

- Maintaining the Interstate highways and Non-Interstate principal arterial roads (Category 1) at a high level of service by constructing proactive, thin asphalt overlays at the right time, as funding allows.
- Managing the Non-Interstate NHS (Categories 1 and 2) routes at a higher priority than other roadways in need of rehabilitation. This is due to higher standards and expectations for the NHS.
- Preserving major collectors and other roads with moderate traffic (Categories 3 and 4) at a *Good* level of service by constructing proactive, thin plant-mix overlays at the right time, as funding allows.
- Managing the low volume roads (Category 5) at an acceptable level of service through the limited use of state Force Maintenance and District contract funds.

Predicting the optimal timing for programming rehabilitation projects for different road prioritization categories can be challenging. Projects can be deferred or canceled if the total project cost is too high in relation to the size of the overall program budget. When funding amounts are limited, some projects are not funded. Frequently, the Category 5 projects are deferred or canceled first because these projects have the smallest financial consequence to the agency if rehabilitation is not performed. If further funding reductions are required, then Category 4 projects are deferred or canceled, and so forth. Occasionally, the available revenue allows for rehabilitation on Category 1 roadways only.

As discussed in Chapter 4, NDOT utilizes a proactive pavement preservation strategy that includes the application of treatments like fog seals, crack sealing, and chip seals to maintain and preserve the condition of pavements that are in *Good* or better condition (PSI > 3.5). Pavements that have a PSI rating of less than 3.5 are better suited for structural overlays or other rehabilitation activities. NDOT's pavement investment strategy is summarized in Figure 6-5.

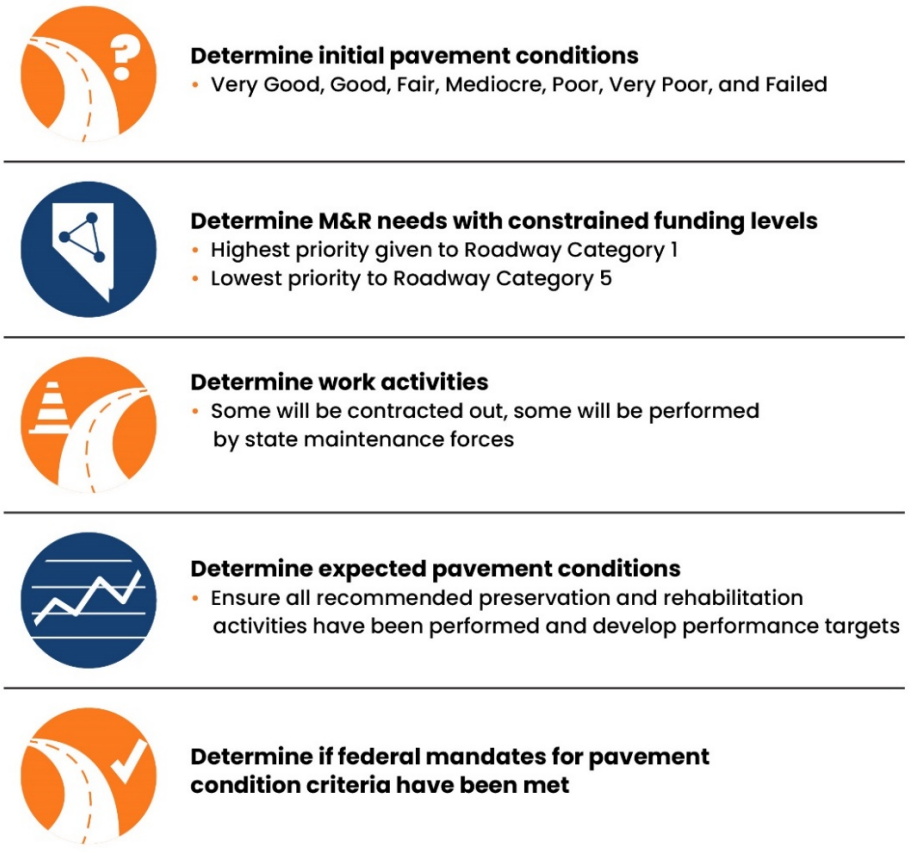


Figure 6-5. NDOT's pavement investment strategy.

Tables 6-3 and 6-4 show the anticipated level of investment on pavements under NDOT's pavement preservation strategy[8]. The plan documented here envisions a 10-year investment of $2.518 billion in maintenance, preservation, rehabilitation, and reconstruction of existing pavements of which 65 percent

[8] The split between NHS and Non-NHS investments is based on the average funding from the last several years of the program delivery.

is preservation. The high level of preservation is appropriate to sustain and even improve the condition of Nevada pavements.

Table 6-3. Anticipated level of investment in NHS pavements ($ millions).

Work type	2022	2023	2024	2025	2026	2027	2028	2039	2030	2031	Total
Maintenance	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$80.0
Preservation	$131.4	$131.4	$131.4	$131.4	81.4	81.4	81.4	81.4	81.4	81.4	1,014.0
Rehabilitation	60.8	38.8	38.8	$38.8	38.8	36.1	36.1	36.1	36.1	36.1	$396.5
Reconstruction	$7.2	$4.4	$4.4	$4.4	$4.4	$-	$-	$-	$-	$-	$24.8
New Capacity	$5.5	$142.4	$350.0	$880.0	$410.0	$186.0	$186.0	$186.0	$186.0	$186.0	$2,717.9
Total	$212.9	$325.0	$532.6	$1,062.6	$542.6	$311.5	$311.5	$311.5	$311.5	$311.54	$4,233.24

Table 6-4. Anticipated level of investment in non-NHS pavements ($ millions).

Work type	2022	2023	2024	2025	2026	2027	2028	2039	2030	2031	Total
Maintenance	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$80.0
Preservation	$14.6	$67.6	$67.6	$67.6	$67.6	$67.6	$67.6	$67.6	$67.6	$67.6	$622.6
Rehabilitation	$6.8	$32.2	$32.2	$32.2	$32.2	$29.9	$29.9	$29.9	$29.9	$29.9	$285.2
Reconstruction	$0.8	$3.6	$3.6	$3.6	$3.6	$0.0	$0.0	$0.0	$0.0	$0.0	$15.31
New Capacity	$77.9	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$77.9
Total	$108.1	$111.38	$111.38	$111.38	$111.38	$105.48	$105.48	$105.48	$105.48	$105.48	$1,081

Bridge Investment Strategies

In its 2019 TAMP, NDOT noted that the historical level of reinvestment in its bridge inventory was just a small fraction of what would be needed to sustain a state of good repair over the long term. The TAMP investigated higher funding levels and since then has been ramping up its resource commitment to life extension of its transportation structures. Tables 6-5 and 6-6 show the anticipated level of investment in NDOT NHS and Non-NHS bridges. The plan documented here envisions a 10-year investment of $438.4 million in maintenance, preservation, rehabilitation, and reconstruction of existing bridges, of which 46 percent is preservation. The high level of preservation, which includes bridge deck overlays, painting, and expansion joint repairs on heavily trafficked roads, is appropriate to sustain and even improve the excellent condition of Nevada bridges.

At the same time, Nevada's population continues to increase, spurring the development of new roads to serve the state's brisk economic growth. The state is channeling this growth to already-developed urban areas to manage the necessary infrastructure development. About $25 million per year is anticipated in new bridge construction to serve this need.

Table 6-5. Anticipated level of investment in NHS bridges ($ millions).

Work type	2022	2023	2024	2025	2026	2027	2028	2039	2030	2031	Total
Maintenance	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.5	$0.5	$4.3
Preservation	$8.4	$10.9	$12.7	$14.4	$16.2	$18.0	$18.0	$18.0	$18.0	$18.1	$152.7
Rehabilitation	$6.4	$8.3	$9.7	$11.0	$12.4	$13.7	$13.7	$13.7	$13.7	$13.8	$116.4
Reconstruction	$3.8	$4.9	$5.7	$6.5	$7.3	$8.1	$8.1	$8.1	$8.1	$8.1	$68.8
New Capacity	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0	$200.0
Total	$39.0	$44.5	$48.4	$52.4	$56.3	$60.2	$60.3	$60.3	$60.3	$60.4	$542.2

Table 6-6. Anticipated level of investment in non-NHS bridges ($ millions).

Work type	2022	2023	2024	2025	2026	2027	2028	2039	2030	2031	Total
Maintenance	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$1.2
Preservation	$2.6	$3.4	$3.9	$4.5	$5.0	$5.6	$5.6	$5.6	$5.6	$5.6	$47.4
Rehabilitation	$1.0	$1.2	$1.4	$1.7	$1.9	$2.1	$2.1	$2.1	$2.1	$2.1	$17.5
Reconstruction	$1.7	$2.1	$2.5	$2.8	$3.2	$3.5	$3.5	$3.5	$3.6	$3.6	$30.1
New Capacity	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$50.0
Total	$10.3	$11.9	$13.0	$14.1	$15.2	$16.3	$16.3	$16.3	$16.3	$16.4	$146.1

ITS Assets Investment Strategies

As described in Chapter 3, ITS assets do not have performance measures that have been formally adopted by NDOT. For the purposes of the TAMP, the condition of the ITS assets were based on the device manufacturer's recommended service life.

The ITS asset investment strategies developed as a part of the TAMP address the following devices: CCTV, DMS, Flow Detectors, HAR, Ramp Meters, RWIS, ATM DMS, WWD Detection, and HOV Detection. However, the budget allocated for ITS assets in the financial plan includes other ITS devices being maintained and managed by NDOT.

The investment strategy used by NDOT was obtained during meetings with the ITS asset work group to understand general steps for identification and response to aging equipment and devices. A simple MS-Excel-based spreadsheet tool was developed by NDOT to forecast deterioration of the devices and determine the 10-year investment needs (using the approach illustrated in Figure 6-6) to maintain current levels of service. As NDOT expands its TAMP to include other ITS assets in future years, a similar process for developing investment strategies could be adopted. Tables 6-7 and 6-8 show the anticipated level of investment on the ITS assets.

To help ensure the operation and maintenance of its ITS assets, NDOT has entered into an Interlocal Agreement with the Regional Transportation Commission of Southern Nevada (RTC) to provide funding to the RTC for the operations and maintenance of ITS devices for the controlled access freeways located in southern Nevada. This agreement has helped to ensure that ITS devices are maintained in working condition as outlined in this investment plan.

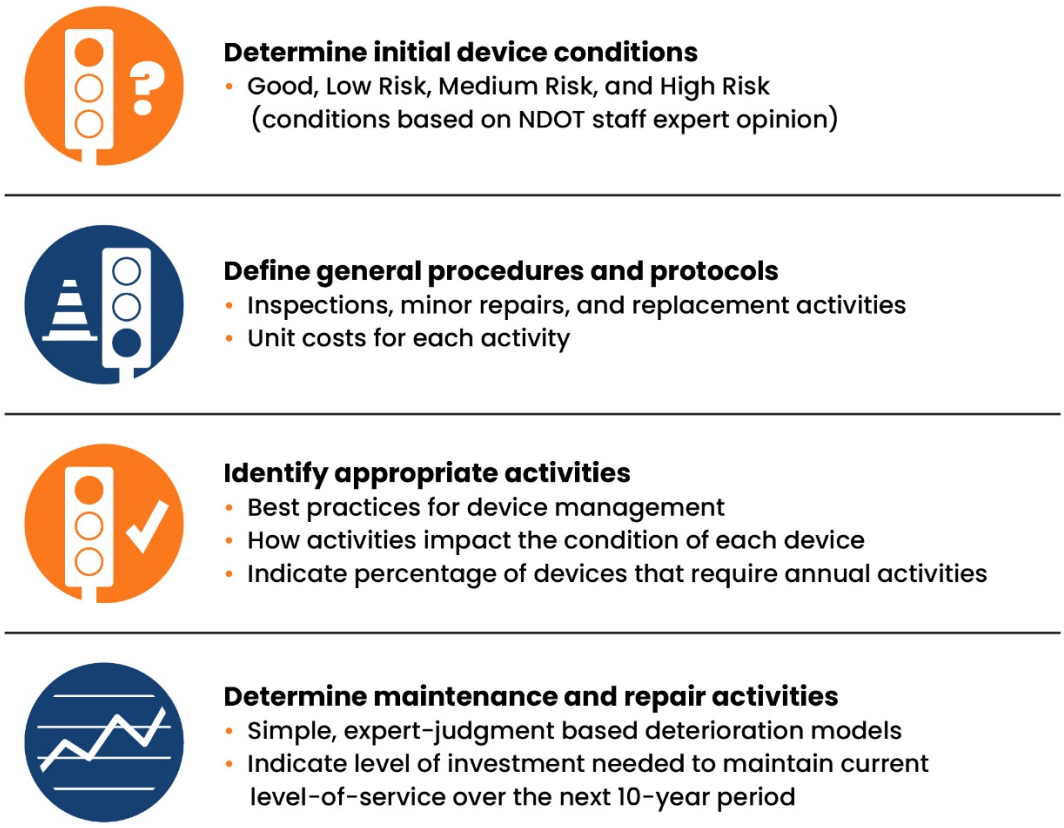


Figure 6-6. ITS asset investment strategy.

Table 6-7. Anticipated level of investment on NDOT NHS ITS assets ($ millions).

Work type	2022	2023	2024	2025	2026	2027	2028	2039	2030	2031	Total
Inspection	$1.1	$1.2	$1.3	$1.4	$1.5	$1.5	$1.6	$1.7	$1.8	$1.8	$14.9
Minor Repair	$0.3	$0.4	$0.4	$0.4	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$4.4
Major Repair	$1.2	$1.4	$1.5	$1.6	$1.7	$1.9	$2.0	$2.1	$2.2	$2.2	$17.8
Replacement	$0.5	$0.7	$0.8	$0.9	$0.9	$1.0	$1.1	$1.1	$1.2	$1.2	$9.5
New Capacity[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	$3.1	$3.6	$3.9	$4.3	$4.6	$4.9	$5.2	$5.5	$5.7	$5.7	$46.6

[1]The ITS new construction costs come from the *Capital Improvement/New Construction* budgets.

Table 6-8. Anticipated level of investment on NDOT Non-NHS ITS assets ($ millions).

Work type	2022	2023	2024	2025	2026	2027	2028	2039	2030	2031	Total
Inspection	$0.12	$0.13	$0.14	$0.15	$0.16	$0.17	$0.18	$0.19	$0.20	$0.20	$1.60
Minor Repair	$0.03	$0.04	$0.04	$0.04	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.47
Major Repair	$0.13	$0.15	$0.16	$0.18	$0.19	$0.21	$0.21	$0.22	$0.23	$0.23	$1.90
Replacement	$0.06	$0.08	$0.09	$0.10	$0.10	$0.11	$0.12	$0.12	$0.13	$0.13	$1.02
New Capacity[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	$0.33	$0.39	$0.42	$0.46	$0.49	$0.53	$0.56	$0.59	$0.62	$0.62	$4.99

[1]The ITS new construction costs come from the *Capital Improvement/New Construction* budgets.

Performance Gap Analysis

Pavement Performance

Figure 6-7 shows the forecasted pavement condition at the anticipated investment level. The current pavement preservation strategy envisions a gradual improvement in conditions to 77 percent *Fair* or better and 8 percent *Poor*. A general improvement in condition is seen over the 10-year TAMP period.

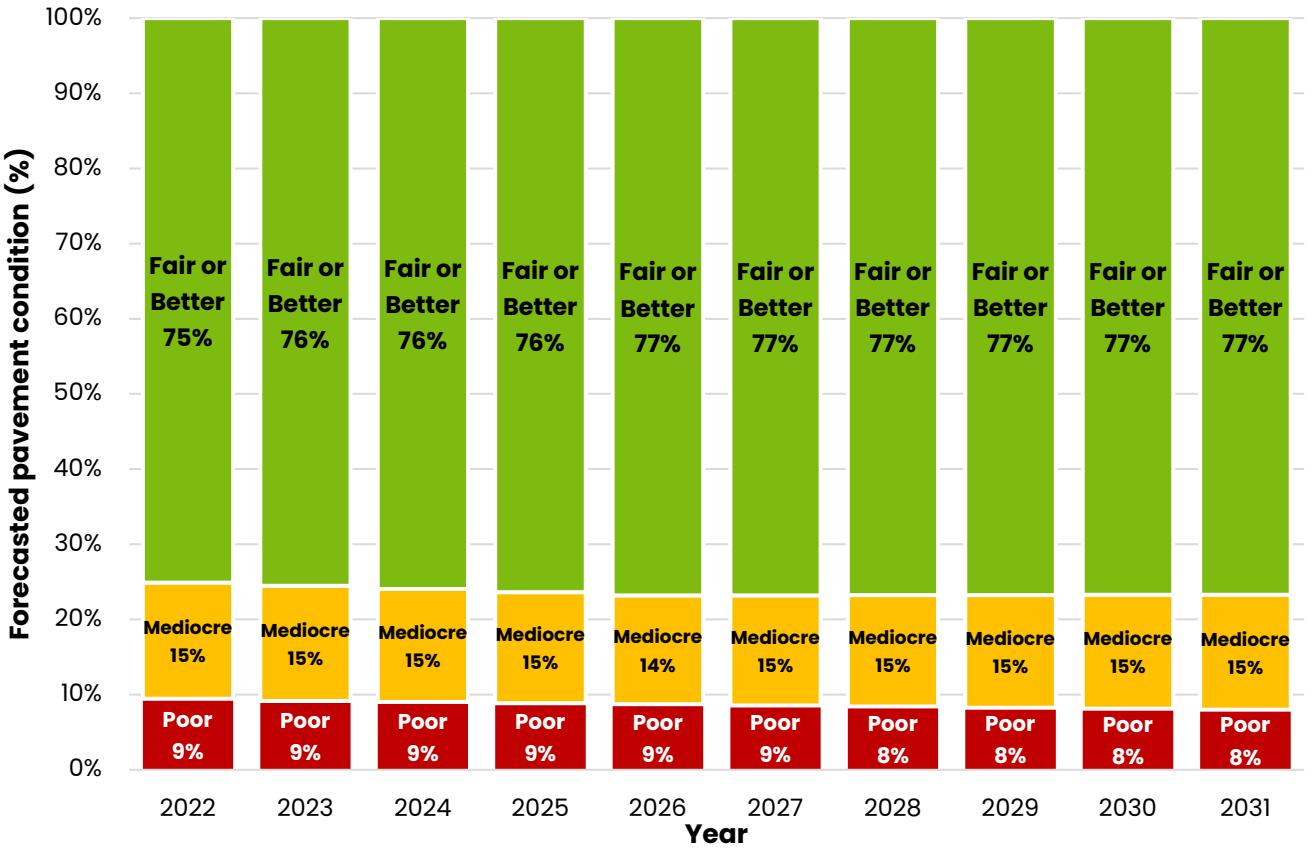


Figure 6-7. Forecasted pavement conditions at the anticipated investment level.

Pavement Targets

Pavement performance targets have been established to measure the effectiveness of the maintenance and rehabilitation work performed on the state-maintained roadway system. Careful consideration was given to balance the cost of rehabilitation at varying pavement condition levels with the availability of funds. Other criteria used in the process included pavement deterioration rates, the effectiveness of maintenance repair work, traffic volume, the number of heavy trucks, and the cost to repair or replace roads in each Roadway Prioritization Category.

Because a portion of the pavement network (approximately 815 lane-miles, around 6 percent of the total network) is maintained by the Local Public Agencies (LPAs) rather than state-maintained, NDOT has been working with its regional planning partners to establish common goals for the entire NHS within the state. To facilitate this activity, a Performance Management Working Group was established under the Planning Executive Group at NDOT. This group meets regularly to discuss the pavement condition data reporting requirements for HPMS and national performance management (23 CFR 490). Based on the discussions during the Performance Management Working Group meetings, the LPAs decided to adopt the state targets established by NDOT and are currently working on common statewide targets. The group meets monthly and is actively working towards establishing common performance targets that can be used to manage pavements and bridges on the NHS and fulfill FHWA reporting requirements.

If adequate funding levels were available, the pavement performance target, referred to as an "aspirational" or "desirable" goal, would be to maintain the entire network to a minimum of 95 percent of the roads in *Fair* or better condition. Since adequate funding is not anticipated, NDOT set a more realistic target for its pavement conditions, which is referred to as a "constrained" or "realistic" target for managing the pavement network. NDOT's constrained 10-year targets are presented in Table 6-9, along with the pavement conditions that are expected to be achieved at the end of the 10-year period. The results illustrate that the expected funding level of $238 million per year between 2022 and 2031 is adequate to achieve both the state and federal performance targets across all pavements categories.

Table 6-9. Predicted pavement conditions and performance targets.

Category / Network	Current Condition	2031 Predicted Conditions	Performance Target
NDOT Pavement Performance Measures			
Category 1	96% Fair or Better	98% Fair or Better	≥95% Fair or Better
Category 2	88% Fair or Better	90% Fair or Better	≥90% Fair or Better
Category 3	93% Fair or Better	90% Fair or Better	≥85% Fair or Better
Category 4	72% Fair or Better	75% Fair or Better	≥75% Fair or Better
Category 5	45% Fair or Better	50% Fair or Better	≥50% Fair or Better
Network Total	75% Fair or Better	77% Fair or Better	
Federal Pavement Performance Measures		**2023 Targets**	**2025 Targets**
Interstate	81.4% Good 0.2% Poor	≥80% Good ≤1% Poor	≥80% Good ≤1% Poor
Non-Interstate NHS*	72.1% Good 0.10% Poor	≥66% Good ≤1% Poor	≥66% Good ≤1% Poor

*Includes both state and locally maintained NHS
* Federal performance targets are preliminary targets which will be updated based on 2021 data

Additional Pavement Investment Scenarios Investigated

Using the LCP strategy discussed in chapter 4, NDOT investigated the impact of three investment scenarios on future pavement conditions:

- $142 million per year (baseline scenario, lowest funding expected to be available for maintenance, and preservation).
- $252 million per year (expected current average annual investment).
- $309 million per year (funding needed to achieve the aspirational state of good repair of 95 percent of the pavements in all roadway categories in Fair or better condition).

Figure 6-8 shows the impact of the various investment scenarios investigated.

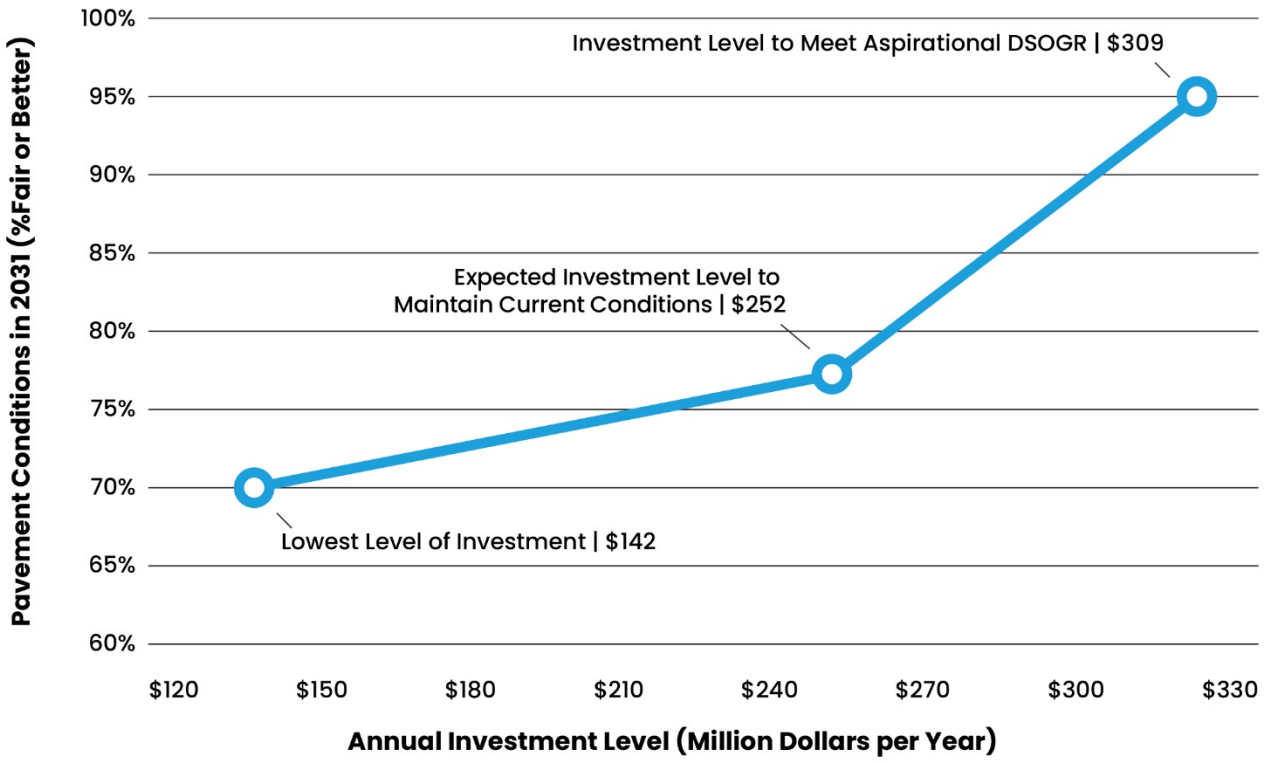


Figure 6-8. Condition comparisons for pavement investment scenarios.

Figure 6-8 shows that the projected annual average level of investment of $252 million per year over the next 10 years will result in a slight improvement in pavement conditions from the current level of 75 percent of the network in *Fair* or better condition to approximately 77 percent of the network in *Fair* or better condition. However, to meet the aspirational state of good repair of 95 percent *Fair* or better, an annual investment of $309 million each year is required between 2021 and 2031.

Bridge Performance

As noted earlier, the implementation of the 2019 TAMP succeeded in stabilizing the observed decline in bridge conditions in earlier years. Figures 6-9 and 6-10 show the forecasted bridge conditions at the anticipated investment level for state-owned bridges. This new plan envisions a gradual improvement in

conditions to 50 percent *Good* and 1.3 precent *Poor* on NHS and Non-NHS state-owned bridges, as seen in the two figures. The Department continues to believe that the pre-existing goals of 35 percent *Good* and 7 percent *Poor* are sufficient for a state of good repair but believes the higher condition levels will optimize the state's investment in its bridges in the long-term and best serve the needs of the state's economy and its road users.

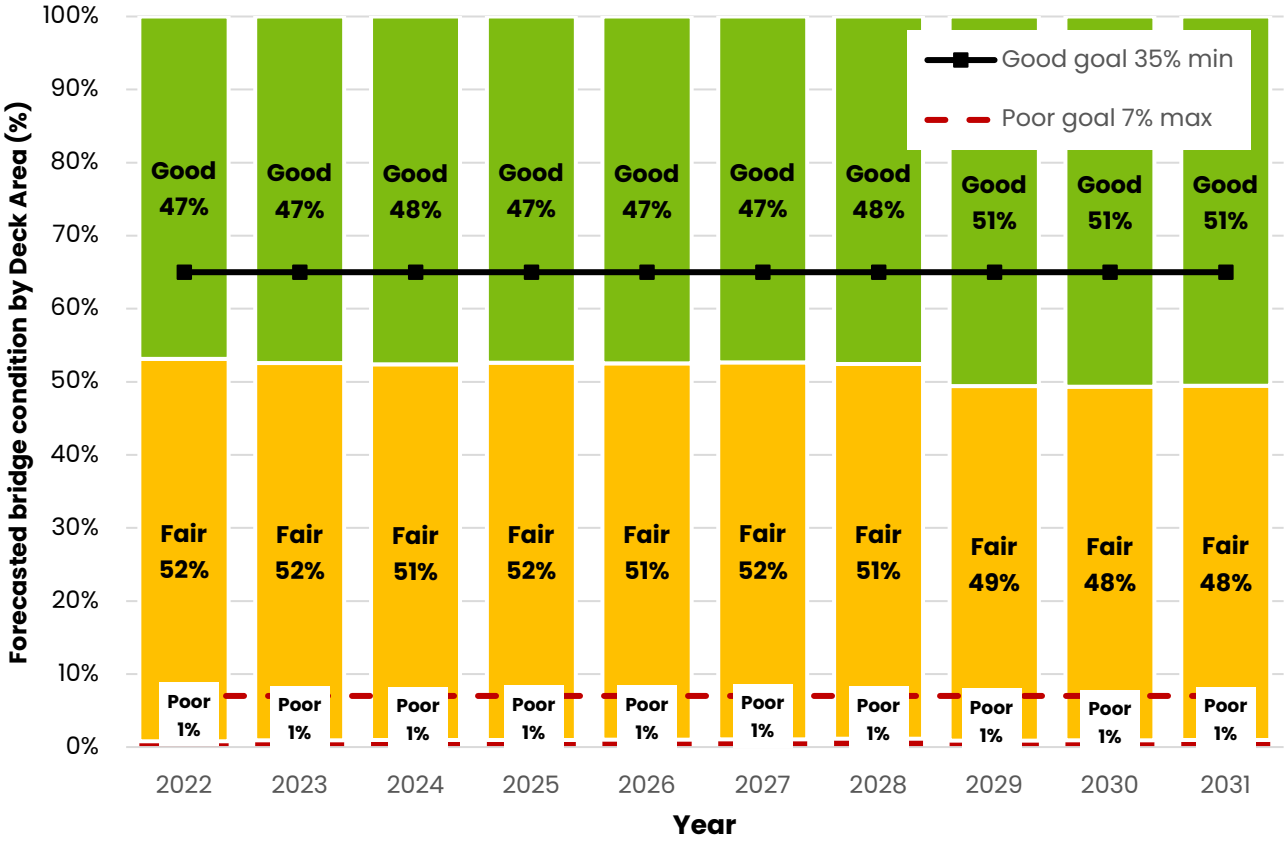


Figure 6-9. Forecasted conditions at the anticipated investment level on NHS bridges.

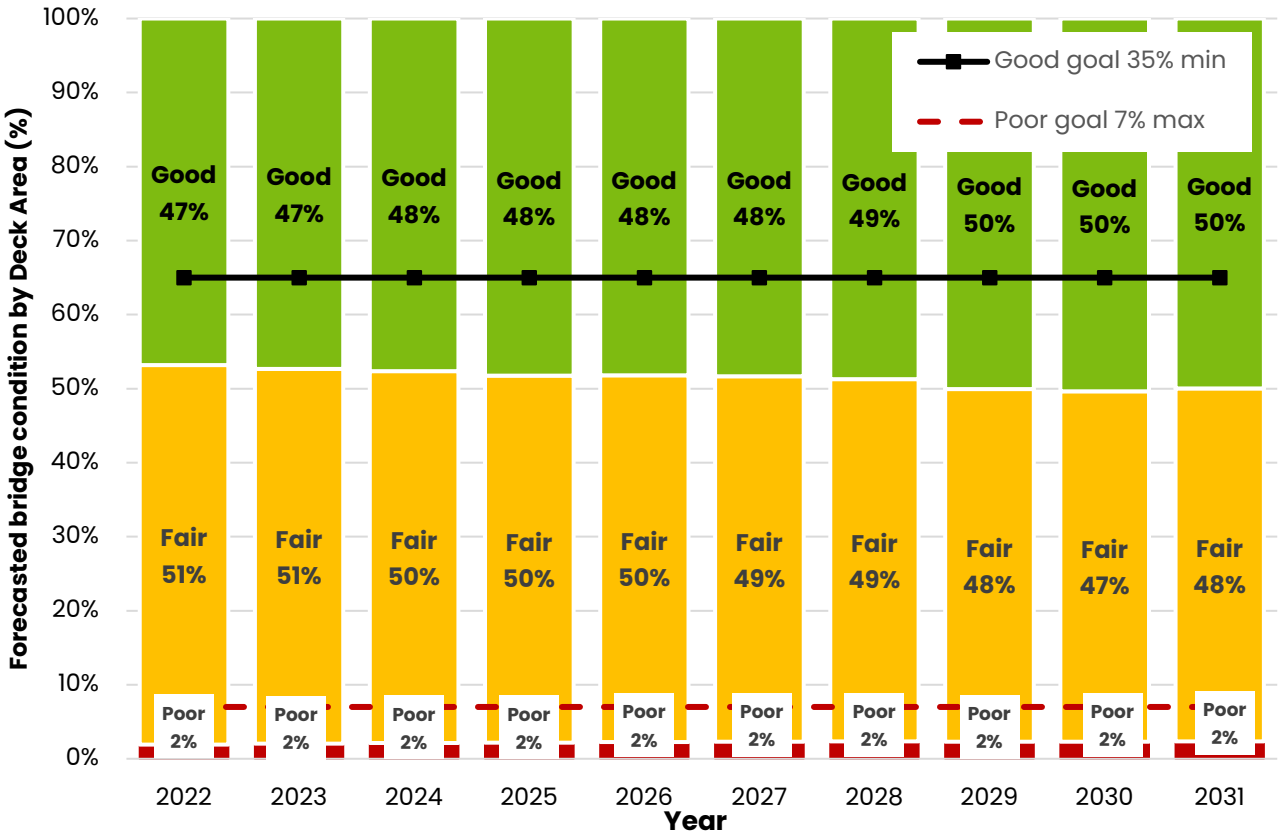


Figure 6-10. Forecasted conditions at the anticipated investment level on non-NHS bridges.

Bridge Targets

NDOT has established financially-constrained performance targets, acknowledged as the constrained SOGR for bridges, to:

- Improve bridge conditions and maintain at least 35 percent of deck area on NHS and state-maintained bridges in *Good* condition and,
- Minimize the fraction of bridges in *Poor* condition by allowing no more than 7 percent of deck area on NHS and state-maintained bridges to fall below this threshold.

As with pavements, 2- and 4-year targets were reported to the FHWA for NHS bridges. The targets were established using federal definitions for *Good*, *Fair*, and *Poor*. NDOT's bridge targets are presented in Table 6-10. As indicated in the table, the planned investment strategies will result in achieving NDOT's bridge condition targets and desired SOGR.

Table 6-10. Federal bridge targets.

System	Current Condition	2031 Predicted Condition	2- and 4-Year Targets
NHS bridges	47% *Good* 1% *Poor*	51% *Good* 1% *Poor*	≥ 35% Good < 7% Poor
Non-NHS bridges	47% *Good* 2% *Poor*	50% *Good* 2% *Poor*	

Additional Bridge Investment Scenarios Investigated

Recent state and federal investments in infrastructure have clarified the fiscal picture for Nevada bridges considerably, but there remains modest uncertainty in revenues and costs. As a result, optimistic and pessimistic funding levels were identified as 10 percent above or below the anticipated level. Figure 6-11 compares these levels and finds that the condition forecast is relatively robust within this range of uncertainty for NHS and non-NHS state-owned bridges. No performance gap is expected.

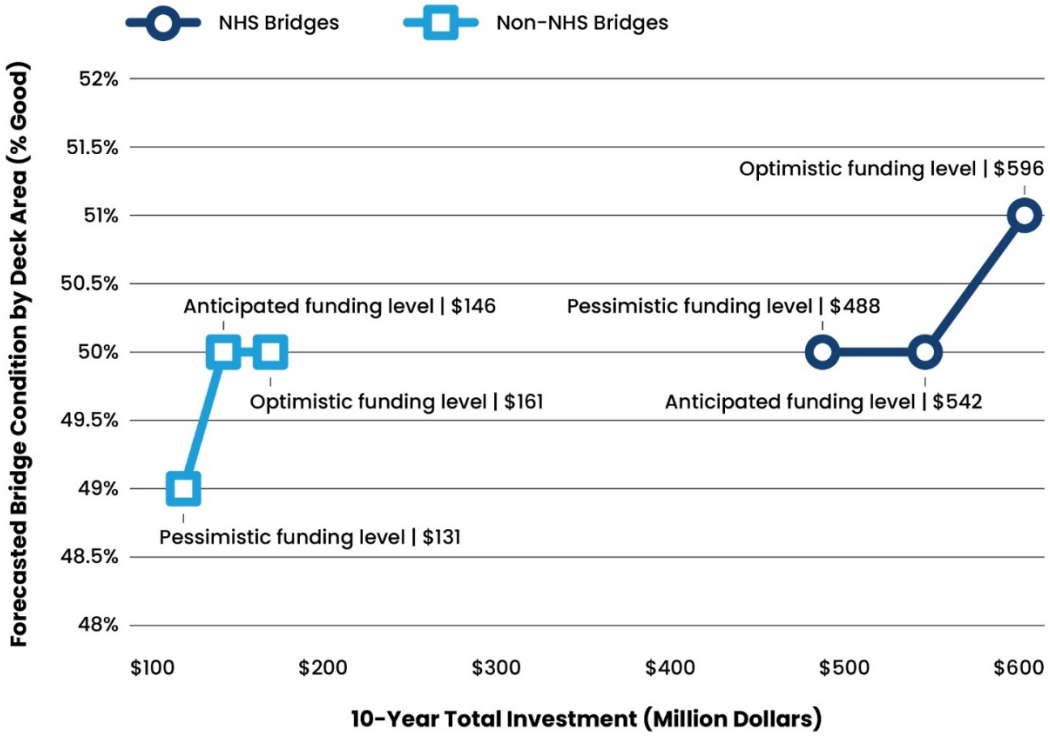


Figure 6-11. Effect of fiscal uncertainty on forecast condition outcomes for NHS and non-NHS state-owned bridges.

ITS Performance

Table 6-11 shows the current condition and the 10-year projected condition of ITS assets at the anticipated investment level. The 10-year projected conditions show that none of the ITS assets meet the target of at least 5 percent assets in *High Risk* condition at the end of 10 years.

To ensure that the ITS assets meet the condition target of 5 percent *High Risk*, NDOT needs to invest two times more than their current anticipated investment. A 10-year total investment of approximately $51 million is required to maintain the current level-of-service and approximately $103 million is required to maintain a desired level-of-service for the ITS assets. A detailed budget split among the ITS assets is provided in Chapter 4 in table 4-5, where the anticipated investment is represented by the “Current Strategy” and investment need is represented by the “D-LOS Strategy”.

Table 6-11. Current and 10-year projected ITS asset conditions at the anticipated investment level.

ITS Asset	Current condition		10-year condition			
	Low Risk or Better	High Risk	Low Risk or Better	High Risk	10-year target	Performance Gap
CCTV	50%	20%	28%	53%	≤ 5% High Risk	48%
DMS	50%	30%	24%	59%	≤ 5% High Risk	54%
Flow Detectors	40%	30%	30%	58%	≤ 5% High Risk	53%
HAR	0%	82%	7%	86%	≤ 5% High Risk	81%
Ramp Meters	50%	20%	10%	54%	≤ 5% High Risk	49%
RWIS	60%	30%	28%	24%	≤ 5% High Risk	19%
ATM	100%	0%	44%	35%	≤ 5% High Risk	30%
WWD Detection	100%	0%	7%	65%	≤ 5% High Risk	60%
HOV Detection	100%	0%	46%	34%	≤ 5% High Risk	29%

Addressing System Performance

The management of NDOT's transportation system requires the agency to balance asset condition needs with other system priorities, such as ensuring safe travel, providing an efficient system that addresses mobility goals, and addressing demands for system expansion. To help achieve this balance, NDOT has incorporated asset management objectives into its Statewide Transportation Plan, which guides the Department's construction and maintenance decisions. This emphasis on system performance drives strategic investments at all levels of the organization. For instance, NDOT's emphasis on reducing congestion on state highways was influential in the Department's decision to include ITS assets in its TAMP. This decision was made because ITS devices have a significant role in relieving congestion in urbanized areas and enabling users to make better informed and safer use of the state-maintained highways.

In addition, NDOT is implementing a statewide Transportation System Management and Operations (TSMO) program that optimizes system performance of existing infrastructure through integrated, multimodal, and cross-jurisdictional projects that maintain capacity while improving security, safety, and reliability. TSMO is being implemented because NDOT is facing inadequate funding to address the dramatic increases in population and traffic volumes. TSMO is aimed at helping NDOT find ways to make the existing transportation system work better.

The TSMO program objectives address several of NDOT's strategic goals, including enhancing safety, optimizing mobility, fostering sustainability, enhancing reliability, optimizing customer service, and enhancing collaboration. Preserving the existing infrastructure is another goal that has been established, including the maintenance of TSMO assets (such as ITS) and preserving the transportation system (including pavements and bridges). The TSMO implementation includes the development of an Investment Prioritization Tool (IPT) that allows the Department to prioritize asset needs efficiently, allocate resources, and ensure alignment between planned investments and NDOT's strategic goals. The

IPT considers factors such as goals, project drivers, strategic value, return on investment, available research, business risks, and value to establish project priorities.

As shown in Figure 6-12, TSMO links all aspects of performance and investment to help NDOT realize the greatest possible value from each planned investment, enabling the Department to stretch its limited funding as much as possible using integrated solutions.

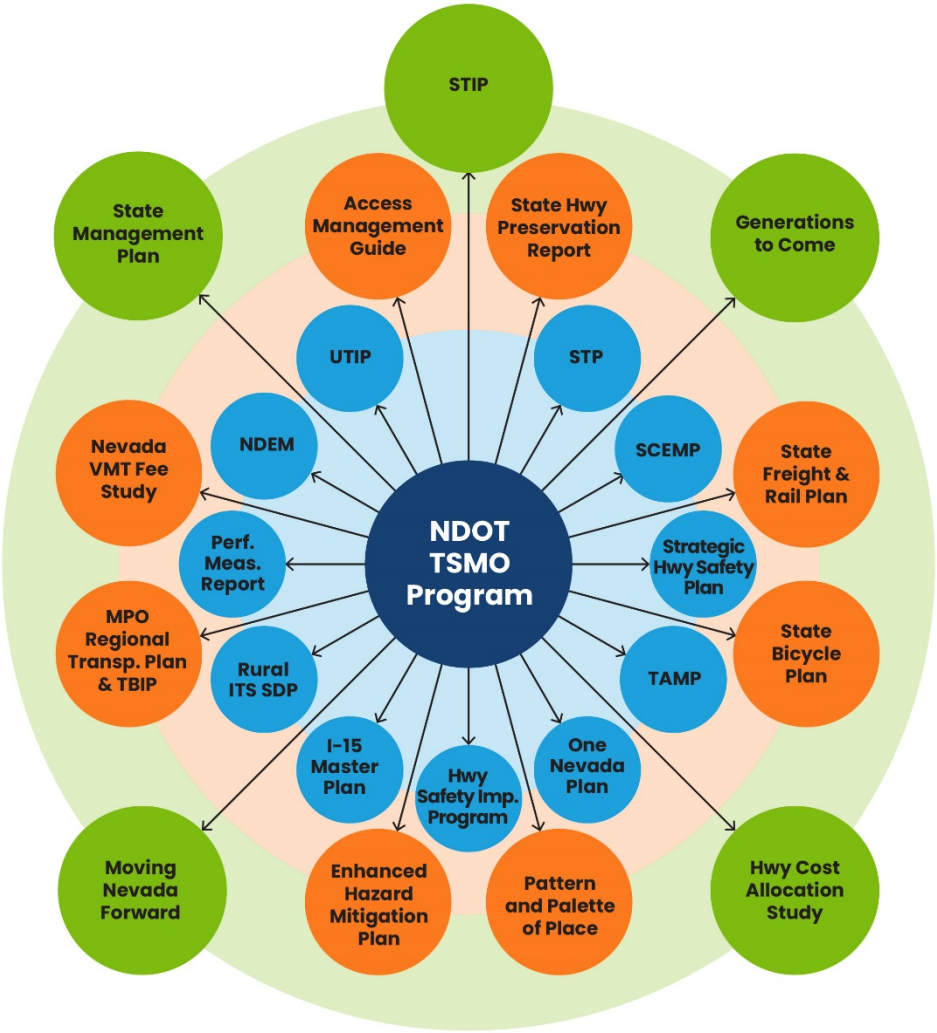


Figure 6-12. Links between TSMO and existing NDOT plans and programs.

Chapter 7. Asset Management Governance and Enhancements

Overview

An effective TAMP is a dynamic document that is updated periodically to reflect the changing environment in which asset investment decisions are made. At a minimum, NDOT updates its TAMP on a 4-year cycle as required in federal legislation. NDOT's commitment to asset management extends beyond what is required in the legislation. This commitment is reflected in NDOT's efforts to achieve its strategic objectives and the investment that has been made to improve its data and analysis capabilities.

NDOT has plans to continue its on-going investment in asset management and has identified several enhancements that are planned to improve existing practices. This chapter outlines NDOT's plans for administering and updating the TAMP as well as the enhancements that will be made to improve the Department's future asset management practices.

Asset Management at NDOT

This document represents NDOT's third TAMP. The first TAMP, which documented NDOT's TAM processes and provided planned 10-year investments, was certified by the FHWA on May 30, 2018. In 2019, the 2018 TAMP was updated to reflect more recent information using the processes certified by FHWA. Federal requirements demand that TAMPs are updated and recertified at least every four years. This document updates the TAMP content to reflect more current processes and analysis results based on changes that have taken place since 2019. The TAMP will again be submitted to FHWA for recertification in accordance with the federal requirements.

The Maintenance and Asset Management division is responsible for leading and administering NDOT's asset management implementation efforts and the development of the TAMP. An Asset Management Oversight Committee (AMOC) provides guidance and direction during the development of the TAMP. As shown in Figure 7-1, the AMOC includes representatives from across different divisions with the expertise needed to ensure that asset management addresses issues from a cross-cutting perspective.

The AMOC meets on a regular basis to:

- Monitor the TAMP's implementation efforts to reflect key changes and improvements within NDOT or changes in federal requirements.
- Update the TAMP when process changes occur and/or at least every four years.
- Assess NDOT's readiness to add additional asset classes in future TAMPs.
- Monitor progress towards the performance targets established and recommend adjustments (if needed).
- Conduct dialogue between various asset groups and program areas within NDOT to establish a process for allocating funds and resources effectively.
- Inform NDOT Executive Leadership on asset management activities within the Department and promote asset management policies that strengthen its implementation.
- Promote the implementation of data and analysis tools that support asset management.

- Monitor the annual use of available funds for system preservation as outlined in the TAMP and submit required consistency documentation to FHWA.
- Support and promote the implementation of sound asset management principles at all levels within NDOT.

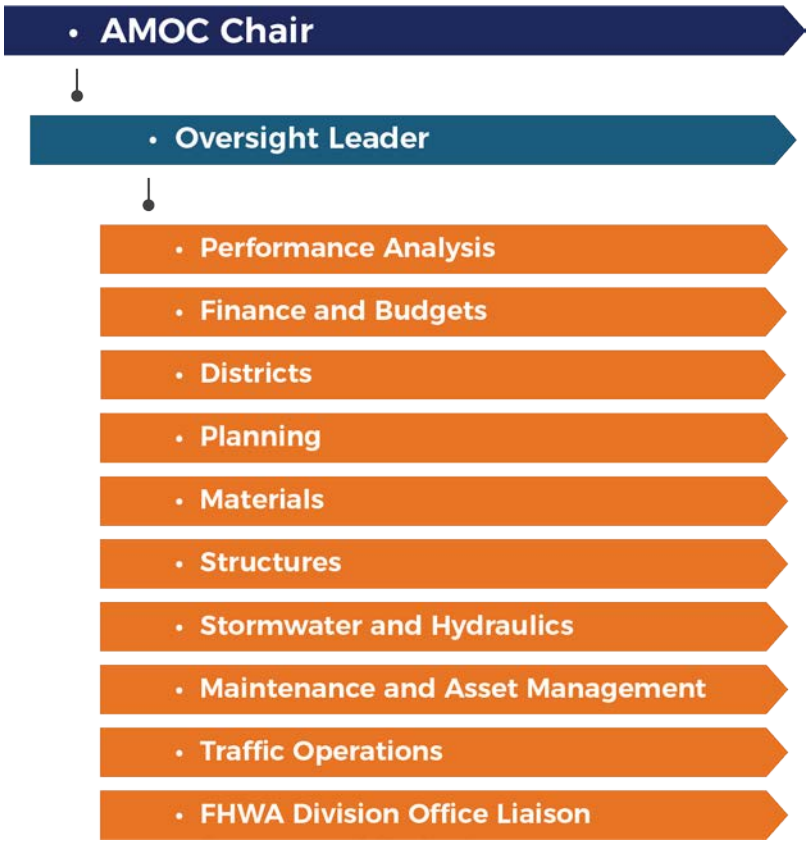


Figure 7–1. Composition of the Asset Management Oversight Committee (AMOC).

Planned Asset Management Enhancements

Table 7-1 summarizes NDOT's planned asset management initiatives that will be implemented during the next four years. The table also included expected outcomes and the expected implementation schedule.

Table 7-1. Planned asset management initiatives.

Motivation/ Driver	ImprovementInitiative	Expected Outcomes	Time-frame
Assets were being managed in silos. Software was acquired to link data from various programs to improve decision-making.	NDOT is continuing the implementation of its Enterprise Asset Management System (EAMS) that will manage many of the assets that NDOT is responsible for maintaining.	Asset inventory and performance data will be housed in a single system. Cross-asset trade-off decisions will be easier to make.	See schedules below for each module
The new pavement management software is still under development and is not yet being used to model deterioration or analyze life cycle strategies.	The Pavement Management module within EAMS will be able to support deterioration modeling and life cycle planning activities.	The ability to estimate long-term consequences of different investment strategies will be enhanced. Life cycle planning will be improved. NHS and Non-NHS improvements can be reported separately.	Early 2024
The bridge management system is not capable of modeling deterioration and analyzing life cycle strategies.	The Bridge Management System implemented as a part of the EAMS will be able to support deterioration modeling and life cycle planning activities.	Bridge investment decisions can be made using a data-driven approach. Analysis of life-cycle performance data will help NDOT improve bridge maintenance and preservation strategies.	Early 2025
The current pavement data collection processes do not use a modern, 3D laser-based system.	Initiate a project to explore the necessary changes to the current manual distress-based condition assessments driven by a shift to automated data collection equipment.	The quality of IRI, rutting, and faulting data will improve with the use of laser-based data collection equipment.	Changes to distress and PSI by late 2022 Use of automated equipment used for full network collection during 2023
The TAMP is not fully aligned with other NDOT plans.	Coordinate efforts with Planning to ensure alignment between the TAMP and One Nevada (a mid-year plan).	Alignment between plans to ensure that the mid-year plans in One Nevada are aligned with planned 10-year investments in the TAMP.	Late 2024

The asset management improvement initiatives summarized in Table 7-1 are described in more detail below.

- **Continue the EAMS implementation.** NDOT's asset information was historically stored in separate databases that were not accessible department-wide. Additionally, asset inventories for some assets are not complete. To address these and other issues, NDOT's Information Technology (IT) Division has been implementing the Agile Assets infrastructure asset management software. Maintenance activities have been added to EAMS for tracking time, material, and equipment usage. Pavements, bridges, and hydraulic structures are being added to EAMS to improve NDOT's analysis capabilities. Other assets will be added once the initial assets are up and running.

- **Improve pavement management tools**. The Pavement Management module within EAMS has been adopted for managing the pavement network. The intent is to replace the existing legacy system and processes with the EAMS-PMS tool; however initial outputs from the system have not been reliable so on-going efforts are being made to improve the performance modeling and treatment rules used in the analysis. A significant effort is required to update and test these models, so NDOT is planning to run its legacy system and the EAMS-PMS concurrently for several analysis periods until they have a sufficient level of confidence in the EAMS-PMS results.
- **Improve bridge management tools.** NDOT Structures has adopted the Enterprise Asset Management System – Bridge Management (EAMS-BMS) for bridge asset management and preservation planning. The intent of the Department is to utilize EAMS-BMS to replace legacy systems and processes that are currently utilized to satisfy the minimum standards identified in CFR 515.17 (Minimum standards for developing and operating bridge and pavement management systems). Initial adoption revealed limitations with the EAMS-BMS capability to satisfy many of the specific requirements listed in CFR 515.17. A significant time and resource commitment will be needed to close the large gap between the aspirations of CFR 515.17 and the capabilities of the EAMS-BMS. To advance that effort, Structures has requested a position upgrade that, if approved, will add capacity to its existing staff that can be devoted to further development of EAMS-BMS. This would be the first step in what will be a lengthy process to collect and process the requisite data to develop accurate deterioration modeling, which would in turn feed the benefit-cost life cycle analysis that is at the core of CFR 515.17.
- **Collect pavement condition data using automated equipment.** Current pavement condition assessments rely on a manual process for distress identification. Automated equipment is available that will improve the quality of IRI, rutting, and faulting data. However, the shift to the automated equipment will require changes to distress data and the way PSI is currently calculated. NDOT intends to address the changes needed in time so that automated equipment can be used for the full network collection effort in 2023.
- **Develop a process to synchronize the TAMP with other NDOT plans.** To continue to be effective, it is important that the TAMP aligns with other NDOT planning and programming documents. This synchronization will be one of the responsibilities of the Asset Management Oversight Committee discussed earlier in this chapter. During the TAMPs update, the team met with Planning representatives to begin aligning the TAMP with One Nevada, which is being established to improve the prioritization of projects in the mid-year period between the STIP and the Long-Range Plan.

Future TAMP Enhancements

In addition to the software and business process enhancements described previously, NDOT has identified several additional enhancements that will be considered in future versions of the TAMP. These enhancements are described below.

- **Expand the TAMP to include additional assets.** The first action item for NDOT is to determine the list of assets (in addition to those included in this TAMP) to be considered for the next TAMP. Hydraulic infrastructure assets have already been looked at as one of the high priority assets that could potentially be included in the next TAMP. Decisions on the additional assets to be included will be based on the recommendations provided by the AMOC.
- **Improve and embrace decision-making based on long-term life-cycle cost considerations.** The TAMP has demonstrated the value of life-cycle costing to help formulate a suitable investment strategy for pavements, bridges, and ITS assets. NDOT will embrace the results

of this analysis and continue to identify strategies that reduce the overall life cycle cost of asset preservation. For instance, the bridge investment strategies reflect an increased investment in bridge preservation over the next 10 years to extend bridge service life.

- **Develop communication materials.** Communication materials that convey the significance of the efforts undertaken during the TAMP development effort will help to ensure that asset management practices are embraced at all levels within the Department. Therefore, communication materials will be developed to promote the TAMP and explain its role in supporting asset investment decisions both internally and externally.

Appendix A. TAMP Certification Requirement Checklist

This checklist is provided to assist FHWA with its review of the required content to certify NDOT's TAMP.

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
Asset Inventory, Performance Measures, and Condition				
1	23 CFR 515.9 (b)	An asset management plan shall include, at a minimum, a summary listing of all NHS pavement and bridge assets, regardless of ownership	The inventory and condition information for all NHS pavements and bridges has been included in Chapter 3. Nevada's NHS roadway listing is provided in Appendix B.	13, 14, 23 to 27, 101 to 108
2	23 CFR 515.9 (d) U.S.C 150(c)(3)(A)(ii)	The Plan must include measures and associated targets the State DOT can use in assessing the condition of the assets and performance of the highway system as it relates to those assets.	Measures and targets used by NDOT are documented in Chapter 3.	17 to 27
3	23 CFR 515.9 (d) U.S.C 150(c)(3)(A)(ii)	The measures and targets must be consistent with the State DOT's asset management objectives	NDOT's asset management objectives are summarized in Chapter 2. The measures and targets summarized in Chapter 3 show how they are related to NDOT's overall asset management objectives.	6, 17 to 27
4	23 CFR 515.9 (d) U.S.C 150(c)(3)(A)(ii)	Bridge Performance Measures determined according to 23 CFR 490.409: • Percentage of NHS bridges in *Good* condition • Percentage of NHS bridges in *Poor* condition	Bridge performance measures have been determined according to 23 CFR 490.409 and the data is summarized in Chapter 3.	19, 20, 26, 27

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
5	23 CFR 515.9 (d) U.S.C 150(c)(3)(A)(ii)	Pavement Performance Measures determined according to 23 CFR 490.313: • Percentage on Interstate pavements in *Good* condition • Percentage of Interstate pavements in *Poor* Condition • Percentage of non-Interstate NHS in *Good* condition • Percentage of non-Interstate NHS in *Poor* condition	Pavement performance measures have been determined according to 23 CFR 490.313 and the data is summarized in Chapter 3.	24, 25, 27
6	23 CFR 490.315	Minimum condition level for pavements: • Percentage of lane-miles of interstate pavement shall not exceed 5% *Poor* condition as computed per 23 CFR 490.313(e)(3) except as noted below	NDOT will meet the meet minimum condition level for pavements. 2020 conditions for interstate pavements: 81.4% *Good*, 18.4% *Fair*, 0.2% *Poor* NDOT does not project 10-year pavement condition on NHS routes. Based on historical performance trends, interstate pavements are expected to meet the minimum condition levels over the next 10-years.	27
7	23 CFR 490.411	Minimum Condition level for bridges: • Percentage of deck area of Structurally Deficient bridges does not exceed 10 percent • Includes bridges carrying NHS, including on- and off-ramps connected to NHS within a state and bridges carrying NHS that cross a state border	NDOT will meet the meet minimum condition level for bridges. 2020 conditions for NHS bridges: 44.9% *Good*, 54.2% *Fair,* 0.9% *Poor* 2031 predicted conditions for NHS bridges: 51% *Good*, 48% *Fair*, 1% *Poor*	27

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
8	23 CFR 515.9 (d)	Document performance measures used by state for NHS pavements and bridges that were established through pre-existing management efforts and/or additional performance measures developed to supplement pavement and bridge measures required under 23 U.S.C. 150	For bridges, NDOT has been using performance measures that are consistent with the 23 CFR 490.409 requirements. For pavements, NDOT uses a PSI rating scale, and this is discussed in Chapter 3. For all the NHS routes, NDOT reports pavement conditions that are consistent with the 23 CFR 490.313 requirements.	17 to 24
Asset Management Objectives				
1	23 CFR 515.9	Align asset management objectives with agency's mission	NDOT's asset management objectives and the relationship between the TAMP and existing business processes are documented in Chapter 2.	5 to 9
2	23 CFR 515.9	Objectives consistent with purpose of asset management, which is to achieve and sustain the desired state of good repair over the life cycle of the assets at a minimum practicable cost		
3	23 CFR 490 Subpart C, D	State DOT targets for NHS pavements and bridge asset conditions based on National Performance Management Measures for Pavements and Bridges	State DOT targets for NHS pavements and bridges are documented in Chapter 3.	24 to 27
Performance Gap Analysis				
1	23 CFR 515.7(a) 23 U.S.C. 150(d)	Establish a process for conducting a performance gap analysis	The gap analysis process is described in Chapter 6.	73 to 79
2	23 CFR 515.7(a) 23 U.S.C. 150(d)	Long-term vision (performance goals and targets) of a state of good repair (SOGR)	The performance goals for NHS pavements and bridges are summarized in Chapters 3 and 6.	17 to 19 73 to 79
3	23 CFR 515.7(a) 23 U.S.C. 150(d)	Identify deficiencies hindering progress towards achieving and sustaining desired SOGR as defined by the state DOT	NDOT does not have any performance gaps. In addition to meeting federally mandated performance requirements for pavements and bridges on the NHS, NDOT	24 to 27 73 to 79

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
4	23 CFR 515.7(a) 23 U.S.C. 150(d)	Comparison between current condition and short-term performance targets	also meets the performance goals set internally by the Department. The expected levels of funding and investment strategies will enable NDOT to achieve its goals.	
5	23 CFR 515.7(a) 23 U.S.C. 150(d)	Gaps in the performance of NHS that affect NHS pavements and bridges regardless of their physical condition in their ability to provide safe and efficient movement of people and goods		
6	23 CFR 515.7(a) 23 U.S.C. 150(d)	Strategies to close or address the gaps identified		
Life-Cycle Planning (LCP)				
1	23 CFR 515.7 (b) 23 USC 119(e)(4) (D)	Process for conducting a life-cycle planning (LCP) analysis for an asset class or asset sub-group at network level	Chapter 4 documents the process and results of the network-level life-cycle planning analysis performed for pavements, bridges, and ITS assets. Two strategies were compared for pavements and bridges: (a) NDOT's existing strategy for maintaining and managing its assets and (b) a worst-first strategy where assets would be replaced as they deteriorate to a Poor condition. For ITS assets, three strategies were compared: (a) NDOT's existing strategy, (b) Strategy that maintains a minimum acceptable level-of-service and (c) Strategy that achieves the desired level-of-service.	28 to 47
2	23 CFR 515.7 (b) 23 USC 119(e)(4) (D)	Factors that could impact whole life cost of assets (e.g., changes in demand, environmental condition, climate change, seismic activity etc.)	Factors influencing asset condition and performance are documented in Chapter 3 and the impact of different treatment strategies on life-cycle cost is presented in Chapter 4.	15 to 17, 32 to 47

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
3	23 CFR 515.7 (b) 23 USC 119(e)(4) (D)	State DOT targets for asset condition for each asset class or asset sub-group	NDOT's road network is divided into five road prioritization categories based on heavy truck traffic loads (in terms of Equivalent Single Axle Loads or ESALs) and average daily traffic (ADT). In addition to establishing performance targets for NHS pavements, performance targets have also been established for each of these five categories. Performance targets have been established for both NHS and non-NHS bridges.	27, 74, 77
4	23 CFR 515.7 (b) 23 USC 119(e)(4) (D)	Deterioration models for each asset class or asset subgroup	Pavement deterioration models have been developed by analyzing historical pavement conditions with pavement age for each road prioritization category. NDOT bridge deterioration models were derived from the National Bridge Investment Analysis System (NBIAS), a planning tool used by the Federal Highway Administration for bridge needs analysis. These were used within NDOT's StruPlan model to forecast element conditions over 75 years, and to develop long-term estimates of life cycle costs and investment benefits. ITS asset deterioration models are documented in Appendix C.	30 to 41, 109
5	23 CFR 515.7 (b) 23 USC 119(e)(4) (D)	Potential work types for the whole life of each asset class or asset subgroup and their relative unit costs	Treatments used on pavements and bridges are summarized in Chapter 4. ITS asset work types are documented in Appendix C.	33, 40, 41, 110 to 113

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
6	23 CFR 515.7 (b) 23 USC 119(e)(4)(D)	Strategies to manage asset class/subgroup by minimizing life-cycle cost while achieving State DOT targets for condition of NHS pavements and bridges	NDOT's current pavement preservation strategy enables the agency to keep its roads in the best condition possible at the lowest practical life-cycle cost. Over a 20-year analysis period, the NDOT's preservation strategy is estimated to reduce the percent *Poor* pavements by 23 percent over the "worst-first" strategy at the same level of funding. At the current level of funding, NDOT is expected to be able to achieve the established performance targets for each roadway category. Starting with current bridge inventory conditions, the bridge analysis model is able to forecast future conditions and evaluate the cost and benefit of each work type across the whole life of the bridge population, to quantify the amount of preservation and replacement work required at each condition level. This approach leads then to a management strategy whose near-term costs and outcomes during the next 10 years can be estimated. The life cycle cost and investment model allows NDOT to forecast bridge conditions ten years in the future under fiscal constraints, and to design a preservation program that can meet ten-year targets. NDOT's expected level of funding for ITS assets is not adequate to even sustain current conditions over a 10-year analysis period. A 20 percent budget increase is needed to maintain the minimum level of service and the budget would need to double to be able to achieve the desired level of service.	32 to 47

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
7	23 CFR 515.7 (b) 23 USC 119(e)(4)(D)	Consider extreme weather and resilience as part of the lifecycle cost and risk management analysis	The general framework adopted by NDOT for considering risk and resilience within LCP is documented in Chapter 5. While developing the risk register, NDOT identifies climate-related risks (extreme weather events). NDOT has also established a process for identifying locations needing repair due to repeated emergency events as required under 23 CFR Part 667. In addition to its efforts to extend the economic life of its bridges, NDOT also invests to improve safety and mobility by managing bridge resilience, the ability of bridges to maintain service in the face of extreme events such as severe storms, heavy vehicle collisions, and overloads. In its StruPlan model, each bridge is evaluated against a set of level of service standards for lane widths, clearances, load capacity, and (for bridges over water) assessment of scour and waterway adequacy. When a bridge is found to be deficient, an estimate of excess user cost is prepared, using the methodology of the AASHTO Red Book, to represent the inconvenience to road users that might be avoided if the bridge is improved or replaced. This estimate is included in life cycle cost estimates used in calculating the benefits of rehabilitation and reconstruction of bridges.	39, 40, 43, 53, 58

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
Risk Management Plan				
1	23 CFR 515.7 (c)	Process for developing a risk management plan: Risk identification process People involved in the process	The analysis conducted as a part of the TAMP development efforts focused on agency and program risks because NDOT handles project-level risks separately. During the risk analysis process, NDOT representatives were asked to identify the various types of risks that could impact their program. For each risk, potential areas of concern were identified, and mitigation strategies were developed.	48 to 60
2	23 CFR 515.7 (c)	Identify risks that can affect condition of NHS pavements and bridges such as: Risks associated with current and future environmental conditions, such as extreme weather events, climate change, and seismic activity Financial risks Operational risks such as asset failure Strategic risks such as environmental compliance	The risks identified during the risk management analysis effort have been summarized in a risk register.	54 to 57
3	23 CFR 515.7 (c)	Assess risks in terms of likelihood of their occurrence and their impact and consequence of they do occur.	NDOT developed likelihood and impact ratings to rate and prioritize each risk identified.	54 to 57
4	23 CFR 515.7 (c)	Describe process for evaluation and prioritization of identified risks	A risk heat map was used to assign an overall risk rating based on the likelihood of that event occurring and the magnitude of its impact. One or more risk management/ mitigation strategies were developed for each risk to help reduce NDOT's potential exposure.	48 to 53
5	23 CFR 515.7 (c)	Identify top priority risks, develop, and document a mitigation plan for addressing top priority risks including steps for implementation (scope, duration, funding)	The causes, consequences, and mitigation/adaptation strategies have been documented in the risk register.	54 to 57

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
6	23 CFR 515.7 (c)	Process for monitoring risks and personnel responsibilities	The process for monitoring risks identified has been documented in the risk register.	54 to 57
7	23 CFR 667	Describe process for periodic evaluation of facilities (on the NHS at a minimum) requiring repair and rehabilitation due to emergency events	NDOT has completed an evaluation of the repair and reconstruction events that have been undertaken as a result of emergency events that have occurred since January 1, 1997. NDOT has been determined that, to the best of their knowledge, no road, highway, or bridge on the NHS has required repair or reconstruction on two or more occasions due to emergency events.	58
8	23 CFR 667	Determine if there are roads, highways, or bridges (on the NHS at a minimum) that have required repair and reconstruction due to emergency events on two or more occasions		
9	23 CFR 667	Conduct statewide evaluation to determine if there are reasonable alternatives to roads, highways, and bridges that have required repair and reconstruction on two or more occasions due to emergency events		
10	23 CFR 667	Describe how the DOT considers the results when developing projects.	NDOT has developed a process to support the 23 CFR Part 667 requirements.	58
Financial Plan				
1	23 CFR 515.7 (d)	Process for developing a 10-year financial plan Consider strategies from gap analysis, LCP, and risk management analysis in developing financial plan Process for determining funding sources and expected funding levels for NHS pavement and bridges	The process for developing a financial plan including revenue sources, revenue projections, revenue trends, and financial risks are documented in Chapter 6.	61 to 66
2	23 CFR 515.7 (d)	Funding sources and amount of funding available from each source for the 10-year financial plan		63 to 65

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
3	23 CFR 515.7 (d)	Forecasted available funding levels for NHS pavements and bridges by fiscal year	Expected annual investments in new construction and asset management activities over the next 10 years is summarized in Chapter 6.	63 to 65
4	23 CFR 515.7 (d)	Elaboration of financial risks influencing success of financial plan	NDOT considered three financial risks that could potentially impact the asset management revenue: (a) improvements in vehicle fuel Efficiency and other automobile technologies, and (b) reduction in vehicle sales and registration/renewal revenue, and (c) uncertainty of future federal aid	66, 67
5	23 CFR 515.7 (d)	Trade-off analysis in prioritizing funding strategies using result of performance gap analysis, LCP, and risk management analysis	For pavements, available funding is adequate to address the needs of all five categories, given the constrained fiscal targets. However, the available funding is only adequate to address the "aspirational" needs of Category 1 pavements. NDOT continues to prioritize high volume roads to maintain them in better conditions and use the maintenance dollars to keep the roads in other categories in safe operable conditions. To maintain relatively good bridge conditions at modest investment levels, NDOT recognizes there is a need to extend the average lifespan of each bridge well beyond the intended 50-years by including preservation activities, as well as to gradually increase the level of reinvestment. NDOT is expected to expand its use of inexpensive preventive maintenance and corrective actions to extend bridge service life and implement a bridge management system to find the most attractive strategic investments. NDOT's current expected level of funding for ITS assets is not adequate to even sustain current conditions over a 10-year analysis period.	67 to 78

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
6	23 CFR 515.7 (d)	Asset valuation for NHS pavements and bridges including annual investment needs to maintain asset value	NDOT invests in preserving the value of its transportation assets through a whole-life management strategy that extends the service life of these assets. A summary of the current replacement values of the assets included in Chapter 3. Annual investment needs are documented in Chapter 6.	27
Investment Strategies				
1	23 CFR 515.7 (e) 515.9 (f)	How investment strategies were influenced by financial plan, performance gap analysis, LCP, and risk management analysis	Investment strategies were primarily driven by the fiscal constraints. The LCP analysis clearly showed great benefits of increase preservation actions on both pavements and bridges. The risk analysis showed the importance of prioritizing investments to achieve agency goals. NDOT's StruPlan analysis prioritizes annual bridge investments to fit fiscal constraints, giving appropriate priority to preservation and risk mitigation work based on long-term agency and user cost. The analysis readily generates and updates its forecasts with new information and scenarios as the fiscal environment and bridge conditions change over time.	67 to 79

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
2	23 CFR 515.7 (e) 515.9 (f)	Methodology for developing investment strategies that support progress toward: Achieving and sustaining desired SOGR over life cycle of asset Improving or preserving condition of NHS pavements and bridges Achieving state DOT targets for NHS pavements and bridges Achieving national goals identified in 23 USC 150(b): (safety, infrastructure condition, congestion reduction, system reliability, freight movement and economic vitality, environmental sustainability, reduced project delivery delays)	The investment strategies developed have placed an emphasis on preserving the condition of Interstate and other NHS pavements and bridges. Safety and infrastructure condition have been utmost importance during the development of the plan. The expected level of funding between 2022 and 2031 is adequate to address the needs of all five categories, given the constrained fiscal targets. A general improvement in pavement condition is seen across all categories. The implementation of the 2019 TAMP succeeded in stabilizing the observed decline in bridge conditions in earlier years. This new plan envisions a gradual improvement in conditions to 50% Good and 1.3% Poor. The plan also makes progress toward state and national goals of safety, reliability, mobility, and sustainability by correcting functional deficiencies on certain bridges to reduce the risk of scour, over-height truck collisions, overloads, and vehicular crashes.	67 to 79
Obtaining Data from Other NHS Owners				
1	23 CFR 515.7(f)	Methodology for obtaining necessary data from other NHS owners in a collaborative and coordinated effort	Because a portion of the pavement network (approximately 815 lane-miles) is maintained by the Local Public Agencies (LPAs) NDOT has been working with its regional planning partners to establish common goals for the entire NHS within the state. Nevada's NHS roadway listing is provided in Appendix B.	11, 101 to 108

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
Ensuring Use of Best Available Data and Use of Pavement and Bridge Management Systems				
1	23 CFR 515.7(g)	Ensure use of best available data for development of TAMP	NDOT has had in place a set of procedures and systems for monitoring the condition of its infrastructure, focused on pavements and bridges. These systems include an up-to-date inventory and a variety of data items related to physical deterioration, traffic, safety, mobility, risk, and costs. These processes comply with federal requirements and are subject to uniform national quality assurance processes. NDOT has also developed a data quality management plan that is in accordance with the FHWA requirements and the new Enterprise Asset Management System (EAMS) being implemented is in accordance with the requirements specified under 23 CFR 515.17	8
2	23 CFR 515.7(g)	Develop TAMP using PMS and BMS that meet 23 CFR 515.17 requirements	NDOT is in the process of implementing the EAMS system for pavements and bridges which will meet all requirements under 23 CFR 515.17.	8
3	23 CFR 515.7(g)	If state DOT does not have PMS and BMS that meet 23 CFR 515.17 requirements for first certification, document the process used for analysis and steps that DOT is taking to meet all the requirements Plans and timeframe to improve efficiency and functionality of PMS and BMS	Initial adoption revealed limitations with the EAMS-BMS capability to satisfy many of the specific requirements listed in CFR 515.17. A significant time and resource commitment will be needed to close the large gap between the aspirations of CFR 515.17 and the capabilities of the EAMS-BMS. To advance that effort, Structures has requested a position upgrade that, if approved, will add capacity to our existing staff that can be devoted to further development of EAMS-BMS. This would be the first step in what will be a lengthy process to collect and process the requisite data to develop accurate deterioration modeling, which would in turn feed the benefit-cost life cycle analysis that is at the core of CFR 515.17	28 to 47, 82 to 84

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
4	23 CFR 515.7(g)	Ensure process for using information from Statewide Transportation Improvement Program (STIP) in the TAMP is consistent with TAMP process and data requirements	The results from the PMS and BMS analysis are used to determine the projects for the. The projects already included in the STIP have been accounted for during the development of the investment strategies for this TAMP.	7, 8
5	23 CFR 515.7(g)	Ensure accuracy and consistency in data and data collection methodology amongst NHS owners	Although most of the NHS routes are managed by NDOT, there are approximately 815 lane-miles of pavements that are managed by local agencies in the state. NDOT collects roughness, rutting, and faulting data on all NHS routes as part of its pavement management practices. NDOT is responsible for all NHS bridge inspections in the state and provides the data to appropriate local agencies. The data quality requirements documented in NDOT's DQMP also apply to the local NHS routes.	8, 11
6	23 CFR 515.7(g)	Document assumptions made to complete analyses in the absence of PMS and/or BMS	Chapter 4 documents the sources and assumptions used in the analysis conducted for pavements, bridges, and ITS assets.	28 to 47
7	23 CFR 515.7(g)	Detailed action plan including timeframes to address issues related to data unavailability	The major asset management improvement initiatives that are being advanced by NDOT along with the expected outcome and the timeframe for implementation have been documented in Chapter 7.	81 to 84
Minimum Standards for PMS and BMS				
1	23 CFR 515.17	Documented procedures for collecting, processing, storing, and updating inventory and condition data for NHS pavements and bridges	Chapter 3 documents NDOT procedures for collecting, processing, storing, and updating inventory and condition data for NHS pavements and bridges. NDOT has recently adopted a new EAMS system for pavements and is currently in	N / A
2	23 CFR 515.17	Forecasting deterioration for NHS pavements and bridges		N / A

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
3	23 CFR 515.17	Determine benefit-cost over life cycle to evaluate alternative actions (including no action) for managing NHS pavement and bridge condition	the process of testing and validating the system. Once fully implemented, the new system will meet all the minimum standards for PMS. Currently NDOT uses StruPlan to compute bridge benefits and costs, identify budget needs, determine strategies to maximize program benefits within financial constraints, and to develop programs and schedules of bridge work. Ultimately NDOT intends to use its new EAMS system for all of this functionality, and is working with the EAMS contractor and expanded internal staffing to bring that model up to full accuracy.	N / A
4	23 CFR 515.17	Identify short- and long-term budget needs for managing NHS pavements and bridges		N / A
5	23 CFR 515.17	Determine strategies identifying NHS pavement and bridge projects that will maximize overall program benefits within financial constraints		N / A
6	23 CFR 515.17	Recommend programs and implementation schedules to manage NHS pavement and bridge condition within policy and budget constraints		N / A

Appendix B. Nevada National Highway System (NHS) Roadway Listing

The data provided tables B-1 and B-2 are up to date as of December 2021. The tables reflect the roadways on the NHS by owner. Table B-1 presents the state-owned NHS roadways and Table B-2 lists the locally-owned NHS roadways. Table B-3 summarizes the quantities in Tables B-1 and B-2.

Table B-1. State-owned NHS roadway listing (in centerline miles).

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
IR11	11383	CL	-	9.157	8.269	5.419	22.845
IR15	1	CL	CA state line to AZ state line	80.348	35.605	7.812	123.765
IR215	2	CL	IR515 to IR15	-	11.173	-	11.173
IR515	3	CL	US93/US95 @ Wagonwheel Intg to IR15	-	14.444	-	14.444
IR580	4	CC	From US50/US395 JCT to the CC/WA county line	0.261	9.03	-	9.291
	4	WA	CC/WA county line to IR80	9.828	15.931	-	25.759
IR80	5	WA	CA stateline to WA/ST county line	22.479	22.589	-	45.068
	5	LY	ST/LY county line to LY/CH county line	8.711	-	7.197	15.908
	5	CH	LY/CH county line to CH/PE county line	27.71	-	-	27.71
	5	PE	CH/PE county line to PE/HY county line	75.07	-	-	75.07
	5	HU	PE/HU county line HU/LA county line	52.777	-	8.581	61.358
	5	LA	HU/LA county line to LA/EU county line	26.855	-	-	26.855
	5	EU	LA/EU county line to EU/EL county line	25.815	-	-	25.815
	5	EL	EU/EL county line to UT state line	117.622	-	15.012	132.634
US6	9	MI	CA state line to Mina/Basalt (SR360) cutoff	11.952	-	-	11.952
	9	ES	JCT W/US95 Coaldale to ES/NY county line	38.904	-	-	38.904
	9	NY	ES/NY county line to the JCT of SR376 E of Tonopah	7.187	-	-	7.187
	9	WP	Sunnyside RD SR318 to UT state line	86.686	-	-	86.686
US50	7	DO	CA state line to DO/CC county line	13.155	-	1.433	14.588
	7	CC	DO/CC county line to JCT of IR580/US395	6.608	0.968	-	7.576

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
	7	CC	Williams St/US50 Intg IR580 to CC/LY county line		4.129	-	4.129
	7	LY	CC/LY county line to LY/CH county line	24.323	1.219	9.846	35.388
	7	CH	LY/CH county line to CH/LA county line	98.104	-	8.859	106.963
	7	LA	CH/LA county line to LA/EU county line	56.738	-	-	56.738
	7	EU	LA/EU county line to EU/WP county line	47.338	-	-	47.338
	7	WP	EU/WP county line to the JCT of US6 in Ely	68.29	-	-	68.29
US50ALT	8	LY	US95A at roundabout to LY/CH county line	0.943	-	6.873	7.816
	8	CH	LY/CH county line to US50	9.096	-	-	9.096
US93	10	CL	FRCL08 on the south side of Garnet Interchange to CL/LN county line	33.112	-	-	33.112
	10	LN	CL/LN county line to Sunnyside Rd SR318	50.601	-	-	50.601
	10	WP	JCT W/US50 in Ely to WP/EL county line	63.27	-	-	63.27
	10	EL	WP/EL county line to ID state line	141.759	-	-	141.759
US93 BUSINESS	11433	CL	IR11 to SR172	4.162	0.431	4.836	9.429
US95	12	CL	CA state line to JCT with US93 @ Railroad Pass & from IR15 @ downtown Expwy Intg to the CL/NY county line	90.269	21.332	-	111.601
	12	NY	CL/NY county line to NY/ES county line & ES/NY county line to the JCT W/US6 in Tonopah	108.454	-	-	108.454
	12	ES	NY/ES county line to ES/NY county line and from the JCT with US6 @ Coaldale to the ES/MI county line	57.829	-	-	57.829
	12	MI	ES/MI county line to MI/LY county line	92.168	-	-	92.168
	12	LY	MI/LY county line to LY/CH county line	2.822	-	-	2.822
	12	CH	LY/CH county line to the JCT W/US50 in Fallon and from US50 to IR80	52.832	-	6.095	58.927
	12	HU	IR80 Winnemucca West downtown exit to NV/OR state line	69.743	-	5.62	75.363
US95ALT	13	LY	JCT with US50A @ Fernley Roundabout to IR80 @ E. Fernley Intg	-	-	0.927	0.927
US395	6	DO	CA state line to DO/CC county line	20.052	2.962	10.942	33.956

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
	6	CC	DO/CC county line to JCT with IR580/US/50	-	0.531	-	0.531
	6	WA	IR80 to NV/CA state line	-	15.896	-	15.896
US395 ALT	11257	WA	Mt Rose Hwy to Patriot Blvd	-	3.808	-	3.808
Woodfords Rd (SR88)	195	DO	CA state line to US395	1.367	-	6.503	7.87
St Rose Pkwy (SR146)	23	CL	IR15 Southern Highlands Pkwy Intg Ramps 3 & 4 to IR215 Pecos Intg Ramps 1 & 2	-	6.606	-	6.606
E Lake Mead Blvd (SR147)	24	CL	Losee Rd to Civic Center Dr/Eastern Ave	-	1.482	-	1.482
Charleston Blvd (SR159)	28	CL	S. Martin L King Blvd to S. Commerce St	-	0.409	-	0.409
Blue Diamond/ Pahrump RD (SR160)	29	CL	Las Vegas Blvd to CL/NY county line	32.314	10.971	-	43.285
	29	NY	CL/NY county line to Boothill Dr in Pahrump	-	-	11.086	11.086
Laughlin Hwy (SR163)	31	CL	Casino Dr to AZ state line	-	-	0.108	0.108
McCarran Inter. Airport Connector (SR171)	37	CL	McCarran Inter. Airport to IR215	-	0.685	-	0.685
SR173	11410	CL	US95 to US93 Business	1.075	-	-	1.075
Mountain City Hwy (SR225)	43	EL	IR80 W Elko Intg Ramps 3 & 4 to SR535 Idaho St	-	-	0.982	0.982
E Winnemucca Blvd (SR289)	58	HU	US95 at Melarkey St to IR80 Ramps 3 & 4	-	-	0.749	0.749
Sunnyside Rd (SR318)	67	LN	US93 to LN/NY county line	49.113	-	-	49.113
	67	NY	LN/NY county line to NY/WP county line	38.912	-	-	38.912
	67	WP	NY/WP county line to US6	22.712	-	-	22.712
Mina/Basalt Cutoff (SR360)	78	MI	US6 to US95	23.229	-	-	23.229
Tonopah/Austin Hwy (SR376)	85	NY	US6 E of Tonopah to NY/LA county line	81.68	-	-	81.68
	85	LA	NY/LA county line to US50	18.048	-	-	18.048
N Virginia St (SR430)	98	WA	N McCarran Blvd to US395	-	3.158	-	3.158

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
USA Parkway (SR439)	11048	LY	US50 @ Opal Ave to LY/ST county line	8.554	-	-	8.554
USA Parkway (SR439)	11048	ST	LY county line to WA county line	10.434	-	-	10.434
USA Parkway (SR439)	11048	WA	WA/ST county line to IR80, Ramps 3 & 4	0.116	-	-	0.116
Pyramid Wy (SR445)	101	WA	Nugget Ave to Descanso Ln	-	12.711	-	12.711
Idaho St (SR535)	117	EL	W Elko Intg to the W city limits and SR225 to SR 227	-	-	3.191	3.191
Lake Mead Pkwy (SR564)	119	CL	IR515 to Lake Las Vegas Pkwy	-	6.602	-	6.602
Craig Rd (SR573)	120	CL	US95 to Decatur Blvd and Frehner Rd to Las Vegas Blvd	-	5.278	-	5.278
Boulder Hwy (SR582)	124	CL	IR515 Wagonwheel Intg Ramps 3 & 4 to Shahra Ave	-	14.16	-	14.16
Sahara Ave (SR589)	125	CL	S Rancho Dr to Sammy Davis Jr Dr	-	0.465	-	0.465
Tropicana Ave (SR593)	128	CL	Maryland Pkwy to SR582 Boulder Hwy	-	5.39	-	5.39
Rainbow Blvd (SR595)	130	CL	Tropicana Ave (SR593) to Ramp 2 @ US95	-	5.366	-	5.366
Rancho Rd (SR599)	132	CL	Redondo Ave to 0.28 miles N of N Rainbow Blvd	-	6.947	-	6.947
Nellis Blvd (SR612)	138	CL	Tropicana Ave to Las Vegas Blvd	-	9.4	-	9.4
Summerlin Pkwy (SR613)	11448	CL	CC215 SB Ramp to Antelope Way	-	5.626	-	5.626
Prater Way (SR647)	140	WA	Galetti Wy to E ROW of IR80 near View St	-	0.182	-	0.182
Glendale Ave (SR648)	141	WA	Kietzke Ln to McCarran Blvd (SR659)	-	2.651	-	2.651
Plumb Ln (SR653)	144	WA	Kietzke Ln to Terminal Wy	-	0.588	-	0.588
McCarran Blvd (SR659)	11119	WA	McCarran, from IR580, clockwise W, N, E, S, back to IR580	-	23.031	-	23.031
Kietzke Ln (SR667)	149	WA	S Virginia St to Kuenzli St	-	3.314	-	3.314
Stead Blvd (SR673)	152	WA	Ramps 3 & 4 to 0.230 N	-	0.23	-	0.23
Union Ln (SR720)	157	CH	US95 to Pasture Rd	-	-	3.258	3.258

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
Williams St (FRCC11)	11189	CC	From Russell Wy to IR580	-	0.123	-	0.123
Eastern Ave/Civic Center (FRCL53)	11152	CL	Ramps 1 & 2 to Ramps 3 & 4 IR515	-	0.17	-	0.17
Lake Mead Blvd (FRCL57)	10192	CL	US95 Ramp 3 to Rainbow Blvd	-	0.181	-	0.181
E Jennings Wy (FREL17)	1510	EL	Idaho St to IR80 E. Elko Intg Ramps 3 & 4	-	-	0.197	0.197
Vista Blvd (FRWA08)	294	WA	IR80 to 0.030 miles N of Ramps 3 & 4	-	0.124	-	0.124
Neil Rd (FRWA44)	376	WA	W IR580 ROW to the E IR580 ROW	-	0.185	-	0.185
Damonte Ranch Pkwy (FRWA49)	10384	WA	W ROW of IR580 to the E ROW of IR580	-	0.162	-	0.162
FRWA51	10394	WA	Plumb Ln to Villanova Dr	-	0.243	-	0.243
Sparks Blvd (FRWA53)	10432	WA	0.037 miles S of Ramps 1 & 2 Sparks Intg to N ROW fence	-	0.249	-	0.249
Wells Ave (FRWA54)	10410	WA	S of IR80 Ramps 1 & 2 to N of IR80 Ramps 3 & 4	-	0.125	-	0.125
Keystone Ave (FRWA55)	10413	WA	Stardust St. To EB IR80 SB Off Ramp	-	0.048	-	0.048
Oddie Blvd (FRWA58)	1520	WA	W of US395 Ramp 4 to E of US395 Ramp 1	-	0.165	-	0.165
4th St (FRWA62)	11200	WA	0.028 W of IR580 to 0.030 E of IR580	-	0.058	-	0.058
FRWA66	11268	WA	SR659 to Neil Rd	-	0.459	-	0.459
FRWA67	11269	WA	Neil Rd to SR659	-	0.468	-	0.468
Moana Ln (SO10392)	10392	WA	Ramps 3 & 4 to Ramps 1 & 2 of IR580	-	0.078	-	0.078
Damonte Ranch Pkwy (SO11039)	11039	WA	N Virginia St to W ROW of IR580	-	0.311	-	0.311
S Virginia St (SO11049)	11049	WA	0.064 S. of IR580 to 0.087 N. of IR580	-	0.151	-	0.151
N Virginia St (SO11050)	11050	WA	FRWA24 to FRWA25	-	0.055	-	0.055
CC215 (SO1509)	1509	CL	CC215 to Ramps 1 and 2 IR15	-	0.086	-	0.086
N Las Vegas Blvd (SO1693)	1693	CL	IR515 Interchange	-	0.089	-	0.089
			Totals	**2000.58**	**297.09**	**125.53**	**2423.21**

Table B-2. Locally-owned NHS roadway listing (in centerline miles).

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
W 2nd St	100170	WA	S Virginia St to Keitzke Ln	-	0.685	-	0.685
5th St	100257	CL	SR147 Lake Mead Blvd to CC215	-	6.603	-	6.603
McCarran Inter. Airport Connector 5	100594	CL	SR171 to Paradise Rd	-	1.283	-	1.283
Baring Blvd	102730	WA	McCarran Blvd to Vista Blvd	-	1.646	-	1.646
S Casino Drive	106625	CL	JCT of Thomas Edison Dr to SR163 Laughlin Hwy	-	-	1.876	1.876
E Charleston Blvd	107203	CL	S Las Vegas Blvd to N Eastern Ave	-	1.73	-	1.73
Civic Center Drive	107766	CL	E Owens Ave to E Lake Mead Blvd	-	0.506	-	0.506
CC215	107810	CL	IR15 South to IR15 North	-	38.875	-	38.875
W Craig Rd	109265	CL	N Decatur Blvd to Goldfield St	-	3.831	-	3.831
Damonte Ranch Pkwy	109904	WA	E ROW of IR580 to Double R Blvd	-	0.104	-	0.104
Double R Blvd	111188	WA	Damonte Ranch Pkwy to Longley Ln	-	3.456	-	3.456
N Eastern Ave	111773	CL	Fremont St to E Owens Ave	-	1.882	-	1.882
W Idaho St	117680	EL	W. City Limits of Elko to SR225	-	-	0.57	0.57
E Idaho St	117681	EL	SR227 to E Jennings Wy	-	-	1.569	1.569
Keystone Ave	119208	WA	W 2nd St to IR80 Intchg	-	0.392	-	0.392
Kietzke Ln	119228	WA	Neil Rd to S Virginia St	-	1.067	-	1.067
Kitty Hawk Way	119440	CL	Paradise Rd to JCT of Wayne Newton Blvd and Swenson St	-	0.152	-	0.152
Keunzli St	119569	WA	E 2nd St to Kietzke Ln	-	1.047	-	1.047
W Lake Mead Blvd	119856	CI	N Rainbow Blvd to N Commerce St	-	5.723	-	5.723
Lake St	119886	WA	Amtrak Station to 4th St	-	0.122	-	0.122
Longley Ln	121178	WA	S Virginia St to S Rock Blvd	-	3.352	-	3.352
Los Altos Pkwy	121256	WA	Sparks Blvd to Vista Blvd	-	0.549	-	0.549
Neil Rd	124629	WA	Kietzke Ln to FRWA44	-	0.06	-	0.06

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
Neil Rd	124629	WA	E IR580 ROW to S Virginia St	-	0.107	-	0.107
Paradise Rd	126845	CL	Sahara Ave to SR171 Airport Connector - I Wy Southbound only from E Harmon Ave to Airport Connector	-	4.427	-	4.427
W Prater Way	128585	WA	I80 Intchg to Stanford Way	-	1.888	-	1.888
McCarran Airport Connector NB	129347	CL	E Russel Rd to Wayne Newton Blvd	-	0.236	-	0.236
Rancho Dr	129569	CL	Sahara Ave to Redondo Ave	-	1.856	-	1.856
W Sahara Ave	131772	CL	Rainbow Blvd to S Las Vegas Blvd	-	4.322	-	4.322
Stead Blvd	135171	WA	0.230 N of Ramps 3 & 4 to Lear Blvd	-	1.446	-	1.446
Stewart Ave	135271	CL	N Main St to N Las Vegas Blvd	-	0.36	-	0.36
Swenson St	136195	CL	Wayne Newton Blvd to Thomas and Mack Dr	-	0.522	-	0.522
Tropicana Ave	137611	CL	Rainbow Blvd to Dean Martin Dr	-	3.363	-	3.363
S Virginia St	138887	WA	Patriot Blvd to SO11049	-	1.856	-	1.856
S Virginia St	138887	WA	SO11049 to Truckee River Bridge	-	3.358	-	3.358
Vista Blvd	138907	WA	0.030 miles N of Ramps 3 & 4 to Los Altos Pkwy	-	4.615	-	4.615
Wayne Newton Blvd	139447	CL	Paradise Rd to Swenson St	-	0.175	-	0.175
Sparks Blvd	155556	WA	E Greg St to IR80 Intchg	-	0.424	-	0.424
Sparks Blvd	155556	WA	IR80 Intchg to Pyramid Hwy	-	5.446	-	5.446
W 4th St	178854	WA	McCarran Blvd to N Virginia St	-	2.772	-	2.772
N Main St	189177	CL	Fremont St to Stewart Ave	-	0.182	-	0.182
N Las Vegas Blvd	189603	CL	Fremont St to IR515 Intchg	-	0.1	-	0.1
Oddie Blvd	190000	WA	Sutro St to FRWA58 and from FRWA58 to Pyramid Hwy SR445	-	2.327	-	2.327
S Eastern Ave	200299	CL	St Rose Pkwy to E Charleston Blvd	-	10.62	-	10.62
E Craig Rd	206354	CL	Goldfield St to Frehner Rd	-	1.655	-	1.655
E Sahara Ave	206465	CL	S Las Vegas Blvd to Boulder Hwy	-	3.166	-	3.166
E Tropicana Ave	206477	CL	S Las Vegas Blvd to S Maryland Pkwy	-	2.019	-	2.019
N Nellis Blvd	207008	CL	N Las Vegas Blvd to Craig Rd	-	0.302	-	0.302

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
Rainbow Blvd	207016	CL	SR160 Blue Diamond to Tropicana Ave	-	5.335	-	5.335
E Moana Ln	207124	WA	Virginia St to E Ramps 3 & 4 of IR580	-	0.604	-	0.604
W Plumb Ln	207125	WA	S Virgina St to Kietzke Ln	-	0.758	-	0.758
E 2nd St	207148	WA	N Virgina St to Kietzke Ln	-	1.304	-	1.304
E 4th St	207150	WA	N Virgina St To Gailetti Way	-	1.775	-	1.775
E Prater Way	207219	WA	S Stanford Way to Westview Blvd	-	2.112	-	2.112
N Virginia St	207296	WA	Truckee River Bridge to N McCarran Blvd	-	1.846	-	1.846
N Wells Ave	207297	WA	2nd St to FRWA54	-	0.596	-	0.596
S Main St	207344	CL	E Charleston Blvd to Fremont St	-	0.98	-	0.98
W Charleston Blvd	215544	CL	SR595 To Martin L King Blvd, S Commerce St to S Las Vegas Blvd	-	4.975	-	4.975
			Totals		**150.89**	**4.02**	**154.91**

Table B-3. Total Nevada NHS roadway listing (in centerline miles).

NHS	Rural	Urban	Small Urban	Total
State-owned NHS	2000.58	297.09	125.53	2423.21
Locally owned NHS	-	150.89	4.02	154.91
Total	**2000.58**	**447.98**	**129.55**	**2578.12**

Appendix C. LCP Analysis Assumptions for ITS Assets

This appendix documents the key assumptions used in modeling the life cycle performance of the ITS assets addressed in this TAMP.

Deterioration Model

NDOT developed simple condition transition probability matrices for each ITS asset. These matrices were used to develop Markov models to describe asset deterioration using the expert judgement provided by NDOT staff. The matrices describe the time required for the device to deteriorate from one condition state to another (e.g., *Good* to *Low Risk*), with an inherent assumption that there is a 50 percent probability that devices would deteriorate to the lower condition categories after the time period established in the transition matrix. Table C-1 shows the time in years required for each ITS device to transition between condition states.

Table C-1. Time required to transition between condition states for each ITS asset (Years).

Device	Time to Transition Between Condition States (Years)		
	Good to Low Risk	Low Risk to Medium Risk	Medium Risk to High Risk
CCTV	4	3	1
DMS	5	2	2
Flow Detectors	5	3	1
HAR	3	2	1
Ramp Meters	3	2	1
RWIS	6	2	2
ATM	5	2	2
WWD Detection	3	2	1
HOV Detection	5	2	1

ITS Asset Treatment Descriptions

Detailed descriptions of the inspection and maintenance activities by ITS asset type are summarized inTable C-2.

Table C-2. Descriptions of inspection and maintenance activities by ITS device type.

Device	Inspection	Minor Repairs	Major Repairs	Replacement
CCTV	• Performed once a year. • Standard factory recommended preventive maintenance (PM) performed on all devices. • PM activities include: cleaning cabinet and device, changing filters, checking connections, ensuring proper functionality, run manufacturer recommended tests. • One to two person crew required for inspection which takes about 2 hours per device.	• Repairs typically performed on site, takes 4 to 8 hours. • Typical repairs include: adjusting loose camera and cables, repairing camera lowering device, encoder programming, and configuring devices.	• Repairs typically require device to be sent back to shop or factory for major repairs. Typical repairs include: zoom repair, camera features repair, gyro and motor repair, CCTV and lowering device cable repairs. • Repairs can take anywhere from 1 day to 1 week.	• Replacement is typically required when the device/parts are no longer serviceable or become obsolete. • Typical parts needing replacement include: camera, encoding device, cabinet. • Replacement can take anywhere between 3 to 6 weeks.
DMS	• Performed once a year. • Standard factory recommended PM performed on all devices. • PM Activities include: replacing filters and lamps, checking interior lighting, checking visible damage to sign structures and electrical connections, checking functionality of cooling fan, backup UPS, and lubricating engines in cabinet. • Inspection takes 2 hours per device, one person crew.	• Repairs typically performed on site, takes 4 to 8 hours. • Typical repairs include: replacement of power supply box, changing batteries.	• Repairs typically require device to be sent back to shop or factory for major repairs. • Typical repairs include: changing LED boards (for new signs), controller replacement Signs will be down when repairs are being performed. • Repairs can take anywhere from 1 day to 1 week.	• Replacement is typically required when the device/parts are no longer serviceable or become obsolete. • Replacement is usually required when the sign/cabinet is damaged after accidents. • Replacement can take anywhere between 3 to 6 weeks
Flow Detectors	• Performed once a year. • Standard factory recommended PM performed on all devices. • PM Activities include: fine-tuning configurations, calibration, checking connections, verifying device functionality. • Inspection takes 2 hours per device, one person crew.	• Repairs typically performed on site, takes 4 to 8 hours. • Typical repairs include: wire repairs, re-aiming, unit reconfiguration, surge protection.	• Repairs typically require device to be sent back to shop or factory for major repairs. • When unit goes down, some parts will need to be replaced as required. • Repairs can take anywhere from 1 day to 1 week.	• Replacement is typically required when the device/parts are no longer serviceable or become obsolete. • Typically involves replacement of accompanying devices (as needed). • Replacement can take anywhere between 3 to 6 weeks

Device	Inspection	Minor Repairs	Major Repairs	Replacement
HAR	• Performed once a year. • Standard factory recommended PM performed on all devices. • PM Activities include: device cleaning and testing connections. • Inspection takes 2 hours per device, one person crew	• Repairs typically performed on site, takes 4 to 8 hours. • Typical repairs include: replacing card and motors, firmware upgrades.	• Repairs typically require device to be sent back to shop or factory for major repairs. • When unit goes down, the entire system needs to be taken out for repair. • Repairs can take anywhere from 1 day to 1 week.	• Replacement is typically required when the device/parts are no longer serviceable or become obsolete. • Typically involves replacement of accompanying devices (as needed). • Replacement can take anywhere between 3 to 6 weeks.
Ramp Meters	• Performed once a year. • Standard factory recommended PM performed on all devices. • Inspection takes 2 hours per device, one person crew.	• Repairs typically performed on site, takes 4 to 8 hours. • Typical repairs include: controller replacement, load bay replacement, lamp replacement.	• Repairs typically require device to be sent back to shop or factory for major repairs. • Typical repairs include: cabinet replacement, pole repair, detection system repair. • Repairs can take anywhere from 1 day to 1 week.	• Replacement is typically required when the device/parts are no longer serviceable or become obsolete. • Replacement is usually required when intersection designs are updated (freeway widening, ramp reconfiguration etc.,). • Replacement can take anywhere between 3 to 6 weeks.
RWIS	• Performed once a year. • Standard factory recommended PM performed on all devices. • PM Activities include: device cleaning and testing connections. • Inspection takes 2 hours per device, one person crew.	• Repairs typically performed on site, takes 4 to 8 hours. • Typical repairs include: replacing card and motors, firmware upgrades	• Repairs typically require device to be sent back to shop or factory for major repairs. • When unit goes down, the entire system needs to be taken out for repair. • Repairs can take anywhere from 1 day to 1 week.	• Replacement is typically required when the device/parts are no longer serviceable or become obsolete. • Typically involves replacement of accompanying devices (as needed). • Replacement can take anywhere between 3 to 6 weeks.

Device	Inspection	Minor Repairs	Major Repairs	Replacement
ATM	• Performed once a year. • Standard factory recommended PM performed on all devices. • PM Activities include: replacing filters and lamps, checking interior lighting, checking visible damage to sign structures and electrical connections, checking functionality of cooling fan, backup UPS, and lubricating engines in cabinet. • Inspection takes 2 hours per device, one person crew.	• Repairs typically performed on site, takes 4 to 8 hours. • Typical repairs include: replacement of power supply box, changing batteries.	• Repairs typically require device to be sent back to shop or factory for major repairs. • Typical repairs include: changing LED boards (for new signs), controller replacement. • Signs will be down when repairs are being performed. • Repairs can take anywhere from 1 day to 1 week.	• Replacement is typically required when the device/parts are no longer serviceable or become obsolete. • Replacement is usually required when the sign/cabinet is damaged after accidents. • Replacement can take anywhere between 3 to 6 weeks.
WWD Detection	• Performed once a year. • Standard factory recommended PM performed on all devices. • Inspection takes 2 hours per device, one person crew.	• Repairs typically performed on site, takes 4 to 8 hours. • Typical repairs include: controller replacement, load bay replacement, lamp replacement.	• Repairs typically require device to be sent back to shop or factory for major repairs. • Typical repairs include: cabinet replacement, pole repair, detection system repair. • Repairs can take anywhere from 1 day to 1 week.	• Replacement is typically required when the device/parts are no longer serviceable or become obsolete. • Replacement is usually required when intersection designs are updated (freeway widening, ramp reconfiguration etc.,). • Replacement can take anywhere between 3 to 6 weeks.
HOV Detection	• Performed twice a year. • Standard factory recommended preventive maintenance (PM) performed on all devices. • PM activities include: cleaning cabinet and device, changing filters, checking connections, ensuring proper functionality, run manufacturer recommended tests. • One-to-two-person crew required for inspection which takes about 2 hours per device.	• Repairs typically performed on site, takes 4 to 8 hours. • Typical repairs include: adjusting loose camera and cables, repairing camera lowering device, encoder programming, and configuring devices	• Repairs typically require device to be sent back to shop or factory for major repairs. • Typical repairs include: zoom repair, camera features repair, gyro and motor repair, CCTV and lowering device cable repairs. • Repairs can take anywhere from 1 day to 1 week.	• Replacement is typically required when the device/parts are no longer serviceable or become obsolete. • Typical parts needing replacement include: camera, encoding device, cabinet. • Replacement can take anywhere between 3 to 6 weeks.

The average inspection and treatment costs for each ITS asset are shown in Table C-3.

Table C-3. Average treatment cost by ITS device type.

Average Maintenance Cost/Unit				
Device	**Inspection**	**Minor**	**Major**	**Replacement**
CCTV	$300	$1,100	$4,000	$12,000
DMS	$1,500	$3,800	$15,000	$115,000
Flow Detectors	$350	$1,500	$3,000	$12,500
HAR	$200	$1,000	$6,000	$32,000
Ramp Meters	$300	$1,600	$12,500	$85,000
RWIS	$300	$2,000	$15,000	$65,000
ATM	$2,500	$7,000	$18,000	$300,000
WWD Detection	$1,200	$4,000	$18,000	$80,000
HOV Detection	$2,000	$5,000	$10,000	$55,000

Annual inspection and treatment fractions are used to determine the number of assets inspected and receiving a particular type of treatment action over each year of the analysis period. Separate annual inspection and treatment fractions were developed for each of the three LCP strategies documented in Chapter 4: Current Strategy, M-LOS and D-LOS (presented in Tables C-4 through C-6).

Table C-4. Average annual inspection and treatment fractions for the current strategy.

Device	Maintenance Type	Good	Low Risk	Medium Risk	High Risk
CCTV	Inspection	100%	100%	100%	100%
	Minor Repair	0%	20%	20%	10%
	Major repair	0%	0%	21%	19%
	Replacement	0%	0%	0%	18%
DMS	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	20%	10%
	Major repair	0%	0%	9%	10%
	Replacement	0%	0%	0%	8%
FD	Inspection	100%	100%	100%	100%
	Minor Repair	0%	5%	5%	5%
	Major repair	0%	0%	4%	10%
	Replacement	0%	0%	0%	21%
HAR	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	10%	3%
	Major repair	0%	0%	3%	7%
	Replacement	0%	0%	0%	7%
Ramp Meters	Inspection	100%	100%	100%	100%
	Minor Repair	0%	20%	30%	20%
	Major repair	0%	0%	20%	37%
	Replacement	0%	0%	0%	3%
RWIS	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	50%	10%
	Major repair	0%	0%	9%	56%
	Replacement	0%	0%	0%	10%
ATM	Inspection	100%	100%	100%	100%
	Minor Repair	0%	4%	4%	4%
	Major repair	0%	0%	3%	3%
	Replacement	0%	0%	0%	3%
WWD Detection	Inspection	100%	100%	100%	100%
	Minor Repair	0%	20%	30%	20%
	Major repair	0%	0%	19%	27%
	Replacement	0%	0%	0%	3%
HOV Detection	Inspection	76%	76%	77%	77%
	Minor Repair	0%	10%	15%	10%
	Major repair	0%	0%	10%	20%
	Replacement	0%	0%	0%	5%

Table C-5. Average annual inspection and treatment fractions for the M-LOS strategy.

Device	Maintenance Type	Good	Low Risk	Medium Risk	High Risk
CCTV	Inspection	100%	100%	100%	100%
	Minor Repair	0%	20%	20%	10%
	Major repair	0%	0%	40%	25%
	Replacement	0%	0%	0%	25%
DMS	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	20%	10%
	Major repair	0%	0%	10%	20%
	Replacement	0%	0%	0%	10%
FD	Inspection	100%	100%	100%	100%
	Minor Repair	0%	5%	5%	5%
	Major repair	0%	0%	5%	10%
	Replacement	0%	0%	0%	35%
HAR	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	20%	5%
	Major repair	0%	0%	5%	8%
	Replacement	0%	0%	0%	10%
Ramp Meters	Inspection	100%	100%	100%	100%
	Minor Repair	0%	20%	30%	20%
	Major repair	0%	0%	20%	50%
	Replacement	0%	0%	0%	3%
RWIS	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	50%	10%
	Major repair	0%	0%	10%	75%
	Replacement	0%	0%	0%	10%
ATM	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	20%	10%
	Major repair	0%	0%	10%	20%
	Replacement	0%	0%	0%	10%
WWD Detection	Inspection	100%	100%	100%	100%
	Minor Repair	0%	20%	30%	20%
	Major repair	0%	0%	20%	50%
	Replacement	0%	0%	0%	3%
HOV Detection	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	15%	10%
	Major repair	0%	0%	10%	20%
	Replacement	0%	0%	0%	5%

Table C-6. Average annual inspection and treatment fractions for the D-LOS strategy.

Device	Maintenance Type	Good	Low Risk	Medium Risk	High Risk
CCTV	Inspection	100%	100%	100%	100%
	Minor Repair	0%	20%	20%	30%
	Major repair	0%	0%	40%	45%
	Replacement	0%	0%	0%	49%
DMS	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	20%	10%
	Major repair	0%	0%	10%	42%
	Replacement	0%	0%	0%	52%
FD	Inspection	100%	100%	100%	100%
	Minor Repair	0%	5%	5%	5%
	Major repair	0%	0%	5%	44%
	Replacement	0%	0%	0%	50%
HAR	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	20%	5%
	Major repair	0%	0%	5%	44%
	Replacement	0%	0%	0%	51%
Ramp Meters	Inspection	100%	100%	100%	100%
	Minor Repair	0%	20%	30%	20%
	Major repair	0%	0%	20%	50%
	Replacement	0%	0%	0%	45%
RWIS	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	50%	10%
	Major repair	0%	0%	10%	75%
	Replacement	0%	0%	0%	18%
ATM	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	20%	10%
	Major repair	0%	0%	10%	44%
	Replacement	0%	0%	0%	43%
WWD Detection	Inspection	100%	100%	100%	100%
	Minor Repair	0%	20%	30%	20%
	Major repair	0%	0%	20%	50%
	Replacement	0%	0%	0%	45%
HOV Detection	Inspection	100%	100%	100%	100%
	Minor Repair	0%	10%	15%	10%
	Major repair	0%	0%	10%	44%
	Replacement	0%	0%	0%	45%