Asset Management Plan

for

Pavements & Bridges on the
National Highway System

June 21, 2019
(Version 2)

New Hampshire DOT
Department of Transportation

Asset Management Plan
for Pavements & Bridges on the National Highway System

New Hampshire Department of Transportation
7 Hazen Drive
Concord NH 03301

This Asset Management Plan for Pavements and Bridges on the National Highway System has been prepared by the New Hampshire Department of Transportation. The plan, developed in accordance with 23 USC Parts 119 and 150 as well as 23 CFR Parts 515 and 667, fulfills the requirements of an Asset Management Plan. The Plan will continue to be reviewed on a biennial basis, to ensure consistency with planning the process, and will be updated at least every 4 years.

Victoria F Sheehan, Commissioner

8/16/19
Date

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List of Acronyms

A/B	New Hampshire State funding reserved for municipalities under two programs: Apportionment A and Apportionment B
AIP	Airport Improvement Program
AM	Asset Management
AMPS	Asset Management, Performance, and Strategies Office within NHDOT
ARR	Asset Renewal Ratio
BLS	United States Bureau of Labor Statistics
BME	Bridge Management Elements
BMS	Bridge Management System
BOPR	Bridge Overweight Permit Review
CCI	Construction Cost Index
CFR	Code of Federal Regulations
CMAQ	Congestion Management and Air Quality Program (federal program)
CoRe	Commonly Recognized
CPI	Consumer Price Index
CPI-U	Consumer Price Index-All Urban Consumers
DMV	New Hampshire Department of Motor Vehicles
DOS	New Hampshire Department of Safety
DOT	United States Department of Transportation
DRC	Depreciated Replacement Cost
ERB	Estimate Review Board
FAST	Fixing America's Surface Transportation Act (federal law)
FHWA	Federal Highway Administration
FY	Fiscal Year
GACIT	Governor's Advisory Commission on Intermodal Transportation
GO	General Obligation
GRC	Gross Replacement Cost
GSP	Gross State Product
HIB	High Investment Bridges
HPMS	Highway Performance Monitoring System
HSIP	Highway Safety Improvement Program (federal program)
ICAP	Indirect Cost Allocation Plan
IRI	International Roughness Index

MAP-21	Moving Ahead for Progress in the 21st Century (federal law)
MPOs	Metropolitan Planning Organizations
NBE	National Bridge Elements
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NHDOT	New Hampshire Department of Transportation
NHPP	National Highway Performance Program (federal program)
NHS	National Highway System
PM 2	Federal rule defining metrics to assess pavement and bridge conditions
PMS	Pavement Management System
RPC	Regional Planning Commission
RSA	Revised Statutes Annotated, the codified law of the State of New Hampshire
SD	Structurally Deficient
SOA	Statement of Appropriations
STIP	Statewide Transportation Improvement Program
STBG	Surface Transportation Block Grant (federal program)
AM	Asset Management
AMP	Asset Management Plan
TIFIA	Transportation Infrastructure Finance and Innovation Act (federal law)
TIGER	Transportation Investment Generating Economic Recovery (federal funding program)
TIP	Transportation Improvement Program
TSMO	Transportation Systems Management and Operations
TYP	New Hampshire Ten Year Transportation Improvement Plan
USC	United States Code
VMT	Vehicle-Miles Travelled
WR	Weight Restricted

Executive Summary

ES-1 Overview

The purpose of Asset Management (AM) is to help decision makers use good data to prioritize strategies that minimize the lifecycle cost of assets while managing performance and potential risks toward the achievement of a State of Good Repair (SOGR). The NHDOT AM process is guided by this risk-based Asset Management Plan (AMP), which documents business, engineering, and data-driven processes supporting resource allocation, performance, and risk management decisions. The AMP has been developed in accordance with the requirements of the Moving Ahead for Progress in the 21st Century (MAP-21) and Fixing America's Surface Transportation (FAST) Acts, in collaboration with the 4 metropolitan planning organizations (MPOs) in NH. This AMP serves as a tactical document outlining a 10-year roadmap to guide the strategic management of the pavement and bridge assets on the National Highway System (NHS). Requirements for the NHS AMP are outlined in 23 CFR parts 515 and 667.

ES-2 NHDOT's Strategic Approach

NHDOT's strategic approach to business decision-making is supported by the Department's mission, vision, and strategic goals and objectives. NHDOT integrates AM into these strategic goal areas to improve decision-making and to facilitate the achievement of the Department's mission and goals. AM is considered an enabler to NHDOT's strategic approach providing a wide range of strategies to guide the allocation of available resources and aid the achievement of desired performance outcomes.

Table ES-1 shows the strategic relationship among four strategic goals and the 12 strategic objectives.

ES-3 Asset Management Governance Structure

The AM governance structure consists of cross-functional membership throughout the Department. The Commissioners are the final decision-making authority on all AM matters. The overall AM coordination responsibilities reside in the Asset Management, Performance, and Strategies (AMPS) office of the Commissioner's Office at NHDOT. The AM Coordinator for the Department is the AMPS Administrator and this position serves as a focal point for technical and day-to-day advancement of AM within the Department. AMPS is also responsible for management and update of the AMP. Table ES-1 illustrates the NHDOT's AM governance structure.

Table ES-1 NHDOT Strategic Objectives

Customer Satisfaction	Increase Customer Satisfaction
Performance	Improve Asset Conditions
	Increase Mobility
	Improve System Safety & Security
	Improve Department Efficiency
	Identify, Communicate, & Collaborate with Partners
Effective Resource Management	Effectively Manage Financial Resources
	Implement Strategic Workforce Planning
	Protect and Enhance the Environment
Employee Development	Increase Bench Strength
	Optimize Employee Health & Safety
	Align Employees Around the Department's Mission

Source: https://www.nh.gov/dot/org/commissioner/balanced-scorecard/goals.htm

Figure ES-1 AM Governance Structure

Source: NHDOT Policy EX-2

ES-4 State of the System

ES-4.1 Pavement

Table ES-2 presents a summary of New Hampshire's NHS pavement distribution by management responsibility. The categories include the centerline miles of Interstate and non-Interstate NHS pavements.

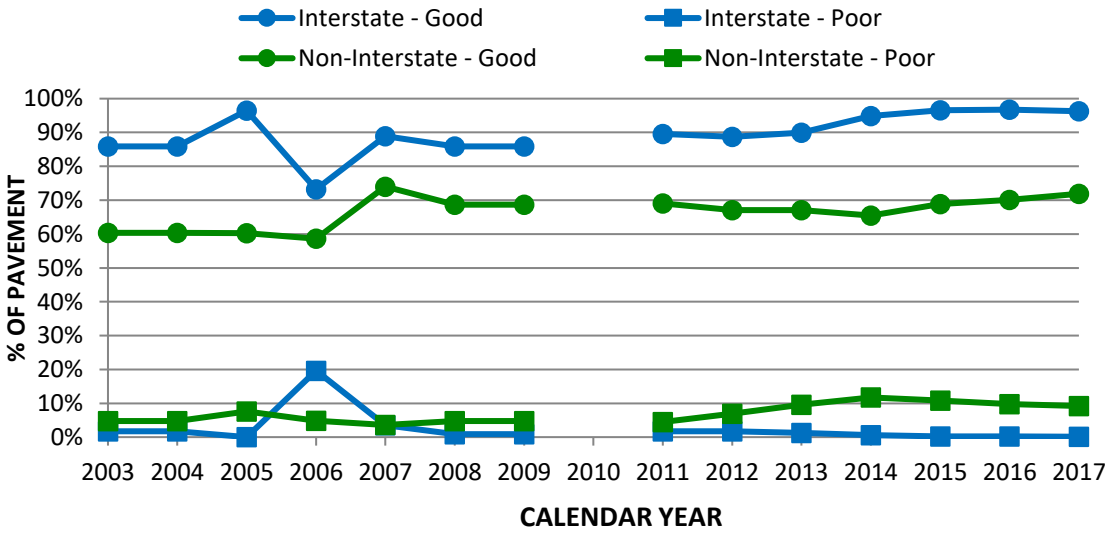
Table ES-2 Asset Register – NHS Pavement Inventory by Jurisdiction

Category	State Maintained		Turnpike Maintained		Municipal Maintained		Total Miles
	Miles	%	Miles	%	Miles	%	
Interstate	484	83	102	17	0	0	586
Non-Interstate NHS	666	74	151	17	80	9	897
Total NHS	1149	78	253	17	80	5	1,483

Source: GISOWNER.ASSET_2019_ROADS, NHDOT

Figure ES-2 illustrates a historical trend for the condition of New Hampshire's NHS pavements. The figure uses the PM2 Rule reporting criteria of "Good" and "Poor" condition on the Interstate and non-Interstate systems, with pavement roughness (IRI) as the underlying measure. Intermittent problems with the data collection vehicle in 2005 manifested as problems with the 2006 data submission to HPMS. Engineers determined that erroneously high roughness values overinflated the number of roads in poor condition and underestimated the number of roads in good condition.

Figure ES-2 NHS Pavements Classified "Good" and "Poor" by IRI



Source: HPMS, Table HM-47.

ES-4.2 Pavement Gap Analyses

Performance Gap Analyses for NHS pavements compare current conditions to targets and national-level minimum condition requirements as well as to the Department's long-term SOGR. Performance gaps occur when current conditions are not aligned with targets. Targets are developed through the process described in section 3.3.5. Current conditions and trends outperform all targets.

The Department also monitors gaps between estimated funding needs to achieve the SOGR (7.1.3) and anticipated funding levels (described in Table 6-1). For NHS pavements no such gap currently exists.

Table ES-3 Pavement Performance Gap Analyses

Measure	Baseline Condition	2 yr. Target	4 yr. Target	SOGR Target	Gap
Interstate Good	96.7%	Not Applicable	95.0%	95.0%	Outperform
Interstate Poor	0.2%	Not Applicable	0.8%	0.8%	Outperform
Non-Interstate NHS Good	73.1%	65.0%	65.0%	65.0%	Outperform
Non-Interstate NHS Poor	9.1%	12.0%	12.0%	12.0%	Outperform

According to a nationally established minimum condition threshold for pavements, a state may not have 5% or more poor condition pavements on the interstate. In this area, a gap would occur if poor conditions exceeded this amount and would be measured by how much it exceeds. As shown in Table ES-4, poor conditions in NH are significantly lower than the threshold.

Table ES-4 Pavement Minimum Condition Gap Analysis

Measure	Baseline Condition	Threshold	Gap
Interstate Poor	0.1%	5.0%	Outperform

ES-4.3 Bridges

Table ES-5 illustrates the distribution by count of NHS bridges in New Hampshire by owner of the facility. The entire interstate and most of the non-interstate NHS is managed by either DOT Districts or the Bureau of Turnpikes. A small portion of the non-interstate NHS is managed by municipalities.

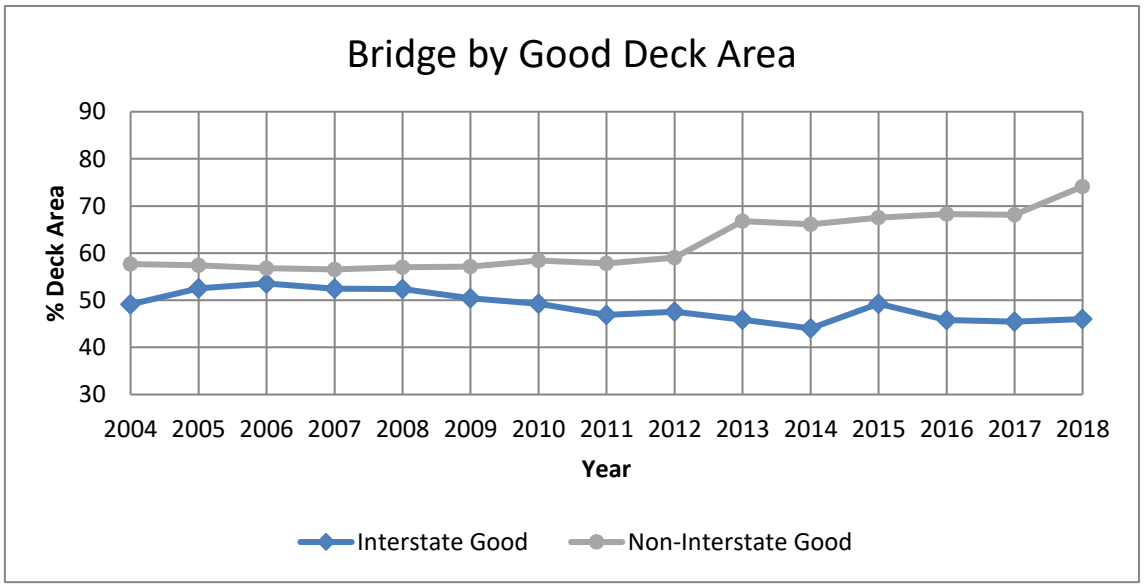
Table ES-5 Asset Register - Bridge Count and Percent by Owner of the Facility

Owner	Area	Percentage
State	4,677,004	64%
Turnpikes	2,055,306	28%
Municipal	549,928	8%
Total	**7,282,238**	**100%**

Source: NBI Submission (2018)

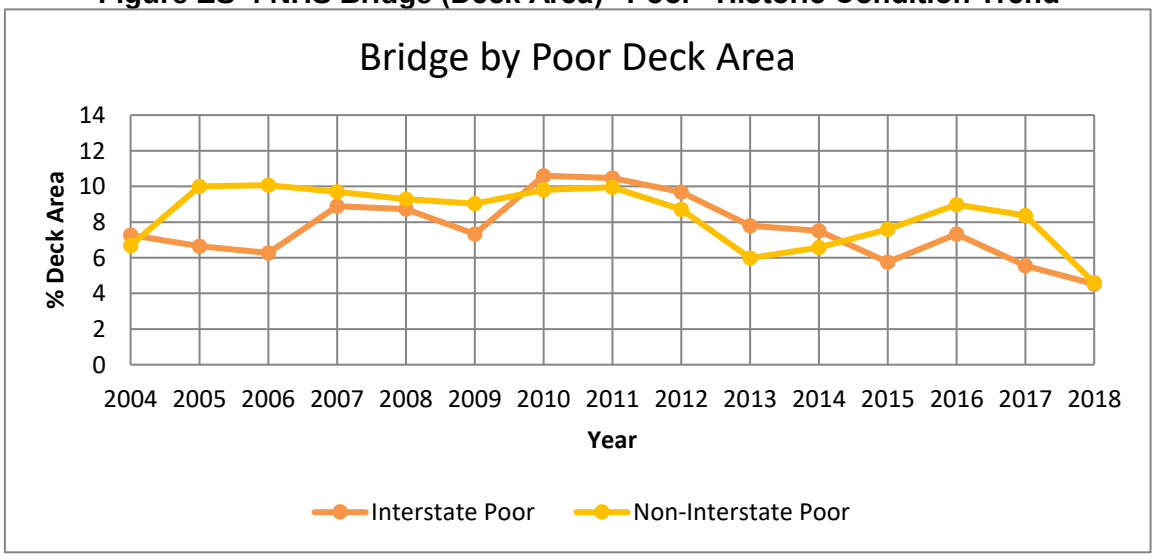
Figure ES-5 and ES-4 show the historic condition trend, presented as the percentage of deck area in Good and Poor conditions, respectively.

Figure ES-3 NHS Bridge (Deck Area) "Good" Historic Condition Trend



Source: NBI data

Figure ES-4 NHS Bridge (Deck Area) "Poor" Historic Condition Trend



Source: NBI data

ES-4.4 Bridge Gap Analyses

Performance Gap Analyses for NHS bridges compare current conditions to targets and national-level minimum condition requirements as well as to the Department's long-term SOGR. Performance gaps occur when current conditions are not aligned with targets. Targets are developed through the process described in section 3.4.5. As shown in Table ES-6, there are no performance gaps for NHS bridges because current baseline conditions are aligned with targets. Trends (see Figures ES-3 and ES-4) are moving toward outperforming the targets.

The Department also monitors gaps between estimated funding needs to achieve the SOGR (7.1.5) and planned funding levels (described in Table 6-2). A gap between funding needs and levels exists for maintenance and preservation on Tier 1 & 2 bridges which could lead to a long-term performance gap. The Department recognizes the gap and will continue to advocate for the importance of bridge preservation while monitoring conditions.

Table ES-6 Bridge Performance Gap Analyses

Measure	Baseline Conditions	2 yr. Target	4 yr. Target	SOGR Target	Gap
NHS Good	57.0%	57.0%	57.0%	57.0%	None
NHS Poor	7.0%	7.0%	7.0%	7.0%	None

According to nationally established minimum condition thresholds for bridges, a state may not have 10% or more structurally deficient bridge area. In this area, a gap would occur if structurally deficient conditions exceeded this amount and would be measured by how much it exceeds. As shown in Table ES-7, structurally deficient conditions are lower than the threshold.

Table ES-7 Bridge Minimum Condition Gap Analysis

Measure	Baseline Condition	Threshold	Gap
NHS Structurally Deficient	7.0%	10.0%	Outperform

ES-5 Lifecycle Planning

Transportation assets go through different phases over their whole life including planning, designing, construction, operation (i.e., maintenance, preservation, and rehabilitation or reconstruction), and disposal. Lifecycle planning considerations, or whole life management of assets, recognizes that assets have varying needs at every phase of their lifespan.

Assets require different treatment due to age, remaining service life, purpose, or criticality. Over the years, the transportation system in New Hampshire has developed organically, through new additions, modifications, and expansions. The evolution has

contributed to a complicated system that requires NHDOT to employ various management standards and methods to minimize cost, maximize system performance, and manage risks. NHDOT applies five work types to pavement and bridge assets. They include initial construction, maintenance, preservation, rehabilitation, and reconstruction. After assets are constructed investments keep them operational at the appropriate level of service for as long as possible. Preservation activities keep good and fair condition assets in a state of good repair. Maintenance activities reduce deterioration and may address specific deficiencies. Rehabilitation activities restore poor assets to conditions that can be preserved.

ES-6 Risk Assessment

The Federal Highway Administration (FHWA) defines risk as "the positive or negative effects of uncertainty or variability upon agency objectives."[1] Accounting for this uncertainty is essential to Whole Life Asset management. Planning for risk will not only allow the NHDOT to engage in educated preparation for future conditions, but will also allow the Department to communicate sources of uncertainty to stakeholders and the public.

A Risk Register was developed and refined through discussions within NHDOT's asset management team. The Department also collected input from subject matter experts during a risk workshop attended by personnel from maintenance, finance, pavement, bridge, traffic and safety, and other groups that have some specific asset-related expertise. During the workshop, participants quantitatively assessed the likelihood of each risk as well as five elements of its consequence: Public Safety, Asset Condition, Geographic Scope, Mobility, and Finance. The risk analysis considered different types of risks - Asset, Program, and Department wide.

The analysis also reviewed positive risks. The resultant risk analysis along with the ratings for each risk is contained in Chapter 5. A mitigation strategy was also incorporated for each risk.

A requirement of 23 CFR Part 667 is to identify portions of the NHS that have been damaged by more than one declared disaster. Chapter 5 includes a description of the methodology utilized by NHDOT as well as the one location that was identified on NH 9 in Roxbury.

ES-7 Financial Plan

NHDOT's overall financial portfolio as stated in this document comes from the Statement of Appropriations for the State of New Hampshire and follows the State fiscal year. This portfolio is subdivided into four individual pools of funds. These funds do not conform to modes, types of assets, or to tier system. Rather, they reflect the way financial resources flow throughout the Department. They include:

- **General Fund:** The General Fund is reserved for non-highway functions of NHDOT (aeronautics, rail, and transit). Its revenues are primarily restricted grants from several Federal modal agencies;
- **Highway Fund:** A portion of the Highway Fund flows to NHDOT and supports construction, maintenance, and operations of NHDOT's highways, including pavement and bridges. Its primary sources of revenue are the State Road Tolls (gas tax), driver fees, such as vehicle registration, and Federal-Aid programs. The Highway Fund also covers expenses that are mandated by the Legislature

[1] *Risk-Based Transportation Asset Management – Report 1*, June 2012

for NHDOT, primarily municipal aid, debt service and labor costs (e.g., salaries, salary increases, healthcare coverage, benefits, and overtime);

- **Turnpike Fund:** The Turnpike Fund exclusively supports capital, operations, maintenance and debt service spending on the New Hampshire Turnpike System. Its primary source of revenue is tolls from Turnpike users, collected and managed by NHDOT's Bureau of Turnpikes; and
- **Capital Fund:** The Capital Fund represents State of New Hampshire General Obligation bonds that support a limited number of non-Highway NHDOT construction and other projects.

In Fiscal Year (FY) 2018, NHDOT received approximately $732 million in revenue. Of that total, approximately $704 million accumulated in the Highway Fund and the Turnpike Fund; those dedicated to highways, pavements, and bridges.

ES-8 Asset Valuation

Asset valuation remains a critical component in AM because it enables a transparent approach to reporting the financial value of NHDOT's transportation infrastructure. NHDOT has adopted a cost valuation approach that recognizes existing conditions and the expected future condition of the NHS assets. Table ES-8 shows the current and estimated future value of NHS pavements and bridges in NH (in 2018 dollars). The future value is based on an analysis of the 2019 TYP.

Table ES-8 NHS Pavement and Bridge Valuation

Asset Category	Current Value	Future Value (2029)
NHS Pavements	$8.68B	$8.69B
NHS Bridges	$6.66B	$6.64B

ES-9 External Engagement & Coordination

The NHDOT, MPOs, non-MPO RPCs, municipalities, and elected officials are partners in the continuous and coordinated planning process in NH. The planning process includes routine attendance at joint meetings between the MPOs, non-MPO RPCs, and NHDOT, including policy and technical meetings, executive director meetings, interagency consultation, SHRP2 and Partnering for Performance in NH, and the Transportation Planners Collaborative. Through those meetings many components of this AMP have been discussed and reviewed. In addition, the planning process includes the development of the 10-Year Transportation Improvement Plan (TYP) which encompasses many of the investment strategies outlined in this AMP. The Initial AMP was reviewed over several months with the MPOs and finally with FHWA. This version of the AMP includes revisions in specific areas and was reviewed for 30 days with the MPOs and public.

1 Introduction

1.1 Overview

The Moving Ahead for Progress in the 21st Century (MAP-21) Act became effective in June 2012. The requirements of MAP-21 were reinforced with the passing of the Fixing America's Surface Transportation (FAST) Act in December 2015. Under section 23 U.S.C 119(e) of MAP-21, State Departments of Transportation are required to develop a risk-based transportation asset management plan (AMP). The AMP documents the processes and procedures the New Hampshire Department of Transportation (NHDOT) uses to guide National Highway System (NHS) spending and manage performance of NHS assets. NHDOT's AMP describes the strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the lifecycle of assets at minimum practicable cost. This is the AMP for New Hampshire as described in the asset management final rule.

The development of the AMP considers and builds on existing strategic and business goals in the Department. This chapter documents the following as it relates to the AMP:

- **NHDOT's Strategic Approach:** this section describes how the AMP aligns with the Department's approach to strategic planning including the Department's vision, mission, and strategic goals and objectives.
- **Purpose and AM/AMP Process:** this section describes the purpose of the AMP and the planning process of asset management (AM) in conjunction with other strategic plans guiding business decisions at NHDOT.
- **The Benefits of AM:** this section summarizes how formal AM practice and this AMP benefit the citizens of New Hampshire.
- **Scope and Structure of the AMP:** this section describes the assets and systems covered under this version of the AMP. The remainder of the section will preview the contents of each chapter in the AMP.

1.2 Strategic Approach

NHDOT's strategic approach to business decision-making is supported by the Department's mission, vision, and strategic goals and objectives. NHDOT integrates AM into these strategic goal areas to improve decision-making and to facilitate the achievement of the Department's mission and goals. AM is considered an enabler to NHDOT's strategic approach providing a wide range of strategies to guide the allocation of available resources and aid the achievement of desired performance outcomes.

1.2.1 Mission

Transportation excellence enhancing the quality of life in New Hampshire.

1.2.2 Vision

Transportation in New Hampshire is provided by an accessible, multimodal system connecting rural and urban communities. Expanded transit and rail services, a well-maintained highway network and airport system provide mobility that promotes smart growth and sustainable economic development, while reducing transportation impacts on New Hampshire's environmental, cultural, and social resources. Safe bikeways, sidewalks, and trails link neighborhoods, parks, schools, and downtowns. Creative and stable revenue streams fund an organization that uses its diverse human and financial resources efficiently and effectively.

1.2.3 Strategic Goals

NHDOT has four strategic goals supported by 12 strategic objectives to help accomplish the Department's mission. The four strategic goals are:

- Increase **Customer Satisfaction** providing transparent communication and being responsive to the citizens of New Hampshire and users of the systems.
- Improve **Performance** in all business operations including asset conditions, mobility, system safety and security, department efficiency, and stakeholder engagement.
- Improve **Resource Management** by effectively managing financial resources, protecting and enhancing the environment, and implementing strategic workforce planning.
- Implement **Employee Development** strategies that increase bench strength, optimize employee health and safety, and align employees around the department's mission.

NHDOT has developed 12 strategic objectives to monitor performance towards the achievement of the goals. Many of the strategic objectives form the foundation of AM practice and the use of the AMP. In particular, the strategic objectives identified as, customer satisfaction, improve asset condition, improve department efficiency, and effectively manage financial resource are among the central components of AM. Table 1-1 shows the strategic relationship among NHDOT's mission, the four strategic goals, and the 12 strategic objectives[2].

[2] https://www.nh.gov/dot/org/commissioner/balanced-scorecard/goals.htm#ed

Table 1-1 NHDOT Strategic Objectives

Customer Satisfaction	Increase Customer Satisfaction
Performance	Improve Asset Conditions
	Increase Mobility
	Improve System Safety & Security
	Improve Department Efficiency
	Identify, Communicate, & Collaborate with Partners
Effective Resource Management	Effectively Manage Financial Resources
	Implement Strategic Workforce Planning
	Protect and Enhance the Environment
Employee Development	Increase Bench Strength
	Optimize Employee Health & Safety
	Align Employees Around the Department's Mission

Source: https://www.nh.gov/dot/org/commissioner/balanced-scorecard/goals.htm#ed

1.3 Purpose and AM/AMP Process

1.3.1 Purpose of AM/AMP

The purpose of AM is to help decision makers use good data, economic inputs, expert knowledge, and systematic approaches to make investment choices that achieve desired performance outcomes at minimal practicable cost. The NHDOT AM process overall is guided by a Strategic Plan for Asset Management. This risk-based AMP, which documents business, engineering, and analytics supporting the allocation of resources, system performance, and risk-based management decisions, is focused on the NHS and strongly tied to the Strategic Plan (see Chapter 2 for more detail). As previously stated, the AMP serves to outline a 10-year roadmap to guide the management of the NHS assets. Specifically, the AMP is expected to enable NHDOT to accomplish the Department's mission by:

- Tracking inventory and condition of assets,
- Identifying existing opportunities and risks,
- Providing transparent and consistent information to the citizens and customers as stewards of a heritage system, and
- Identifying and applying efficient resource management strategies to minimize cost while achieving a state of good repair.

1.3.2 AM/AMP Process

NHDOT initiated a formal AM practice by undertaking AM self-assessment and gap analysis through a pilot effort with FHWA. This action provided a means for NHDOT to understand the current practice of AM in many different areas including inventory and condition, lifecycle planning, availability and sharing of data that support better decision making, the state of AM systems that support analytical analysis, the management of risk, etc. The outcome of the effort was a strategic analysis that outlined initiatives to improve the practice of AM at NHDOT. One of the priorities was to develop an AMP that fulfills the Federal mandate.

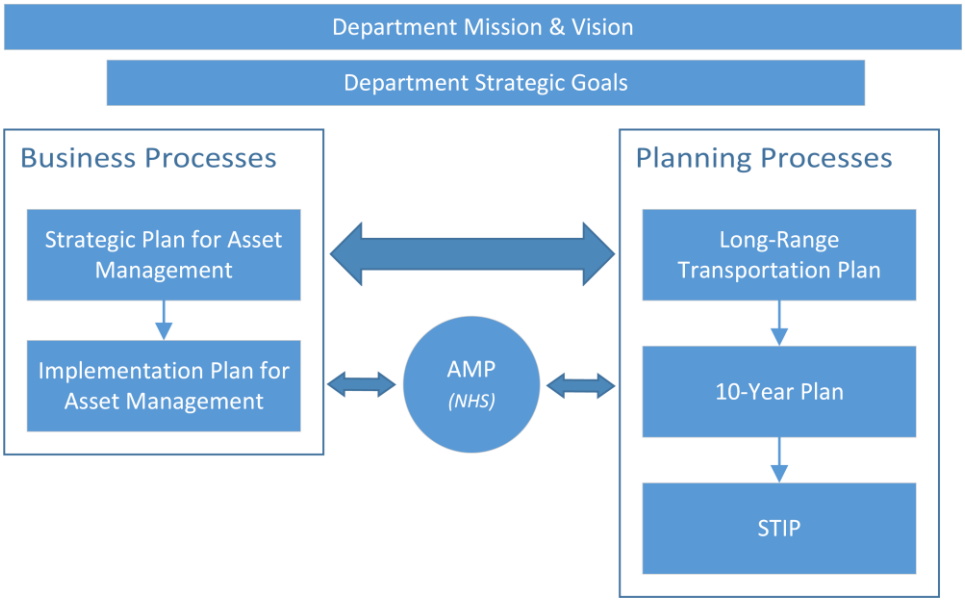
1.3.3 AMP Development Process

The AMP development process is a structured, coordinated, and collaborative process led by the Asset Management, Performance, and Strategies (AMPS) Office. This process draws from technical analysis, expert knowledge, stakeholder engagement, and workshop discussions and consensus building to generate meaningful information in support of the developed strategies to improve asset performance. The AMP is expected to transcend all divisions within the Department and key external agencies. The process involved individuals from policy and executive level, finance office, pavement and bridge divisions, maintenance division, and external stakeholders. NHDOT will continue to refine and update the AMP according to the federal timelines, which has been documented in various sections of the AMP.

1.3.4 Integrating the AMP

The planning, construction, operation, and disposal of transportation assets at NHDOT are guided by different processes such as the Department's Long-range Transportation Plan (LRTP), the TYP, the Statewide Transportation Improvement Program (STIP), and annual work plans. In concert with those planning activities, the Department has initiated business processes to enhance and formalize the integration of asset management practices on a day to day basis. The AMP is not expected to function in isolation, but to benefit from and inform these two areas.

Figure 1-1 NHDOT AMP Integration



1.4 Benefits of Asset Management

Developing and enhancing programs and processes using the asset management philosophy will produce many benefits for the Department, partnering stakeholders, and the citizens, businesses, and visitors to New Hampshire:

- Transparency and repeatability – the decision-making processes will be clear and well documented enabling consistent and straightforward communication about how an investment decision was arrived at.
- Long-term thinking – an asset management-based approach will ensure that the Department is always considering the entire life-cycle of the assets, including the long-term needs, costs, and implications of investment decisions, helping to ensure that we make the best investments possible.
- Minimal practicable cost – through consideration of the entire lifecycle, use of quality data, and a throrough systematic approach, the Department will identify the most cost effective approach that provides the greatest benefits for the available budget.
- Performance based – the asset management approach at NHDOT includes the integration of performance management within the business and planning processes to ensure that the Department continues to move in the appropriate direction.

National goals for Federal Highway Programs are supported by enhancing asset management. The goals are listed below. Asset management directly impacts goals dealing with the planning and construction of the transportation network; such as Infrastructure Condition and Reduced Project Delivery Delays. The remaining goals are supported indirectly maximizing resources.

- Safety - To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.
- Infrastructure Condition - To maintain the highway infrastructure asset system in a state of good repair
- Congestion Reduction - To achieve a significant reduction in congestion on the National Highway System
- System Reliability - To improve the efficiency of the surface transportation system
- Freight Movement and Economic Vitality - To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development.
- Environmental Sustainability - To enhance the performance of the transportation system while protecting and enhancing the natural environment.
- Reduced Project Delivery Delays - To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices

1.5 Scope and Structure of the AMP

The contents of this AMP were developed in accordance with the requirements of MAP-21. This plan covers pavement and bridge assets on the NHS in New Hampshire. The remainder of the AMP contains system profiles, processes, and projections over a ten-year period to support transparent, data-driven investment decisions. Specifically, the following sections were developed and presented:

- **Chapter 2** lays the foundation for the remainder of the AMP by describing how AM is governed within the Department, how decisions are made, and laying out the general principles upon which the NHDOT AM program is founded.
- **Chapter 3** summarizes the state of the system of pavement and bridge assets in the State of New Hampshire including system demand, asset inventory and condition, existing performance metrics used to track asset performance, and a timeline to implement the National Highway Performance Program (NHPP) metrics.
- **Chapter 4** reviews the principles of lifecycle planning of assets at NHDOT. The chapter describes the current state of the practice within the Department as well as deterioration models for NHS pavements and bridges.
- **Chapter 5** discusses risks that directly cause asset damage and service interruption (e.g., extreme events, asset failures, bridge scour, etc.), as well as risks associated with delivering asset management programs and projects (e.g., loss of funding, uncertainty of quality of materials, project costs, unknown bridge depths, risky bid types, etc.).
- **Chapter 6** summarizes the flow of financial resources and funding mechanisms for NHDOT with regard to asset management including revenue acquisition and distribution, forecasted projections, and valuations for NHS pavements and bridges in NH.
- **Chapter 7** outlines the Department's investment approach to minimize the lifecycle cost of assets while managing performance and risk.
- **Chapter 8** describes enhancements and additions that will be necessary to continue to mature asset management at NHDOT.

2 Asset Management

2.1 Introduction

This chapter describes the AM business structure, overarching business processes, and goals of the AM way of doing business. There are several components to this chapter including:

- The vision for AM;
- A discussion of the AM Governance structure and roles and responsibilities of each workgroup;
- External engagement; and
- A discussion on continuous process improvement and its role in AM.

This chapter lays the foundation for the remainder of the AMP by describing how AM is governed within the Department, how decisions are made and laying out the general principles upon which the NHDOT AM program is founded.

2.2 Asset Management Vision

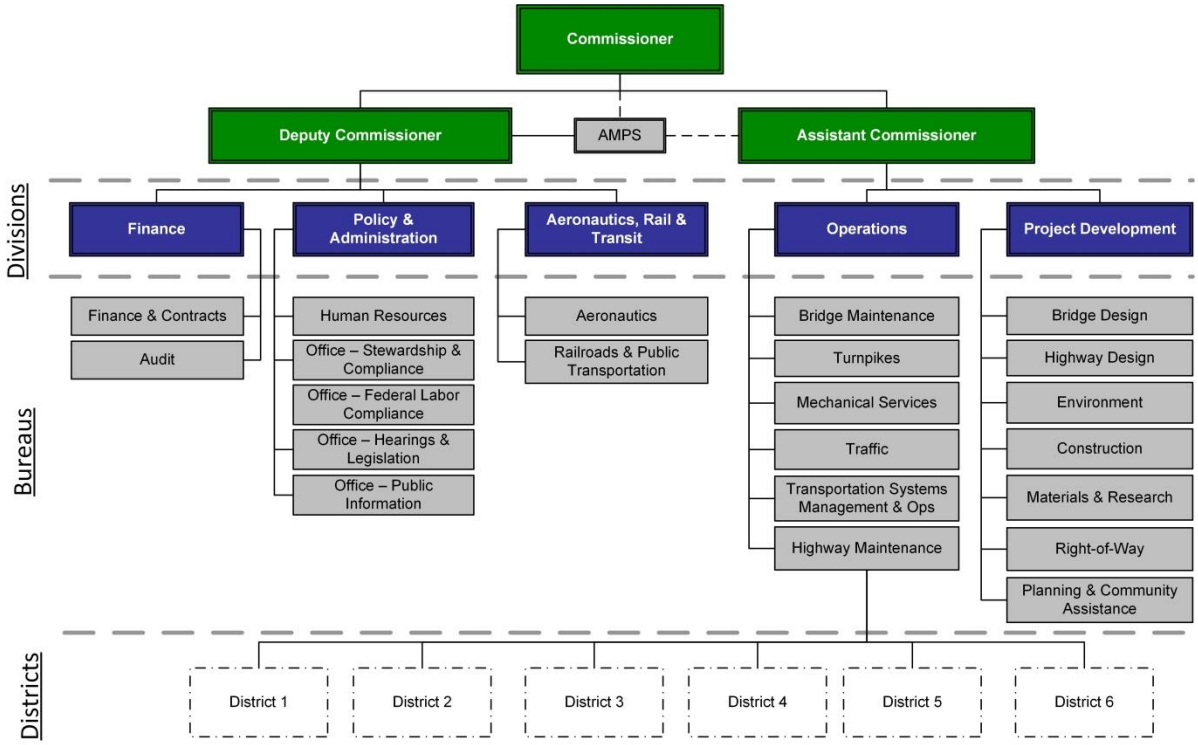
The AM Vision Statement for the NHDOT builds on the Department's Mission of transportation excellence and aligns with the federal definition of asset management.

> *Transportation assets are known and well understood by NHDOT personnel. Knowledge of assets is used in a strategic and systematic process for maintaining, preserving, and improving the transportation assets based on economic analysis, engineering, age/use of asset, and customer focused feedback considerations. The Department forecasts what will happen when we make investments in assets and what the future needs are of those assets to meet established performance goals. NHDOT is able to compare and quantify the trade-offs made when investing in one asset over another. Personnel are able to communicate relevant asset information across the Department, to other stakeholders in transportation, to the legislature, and to the public. Decisions are based on high quality data, integrated systems, and accessible information.*

2.3 Asset Management Governance Structure

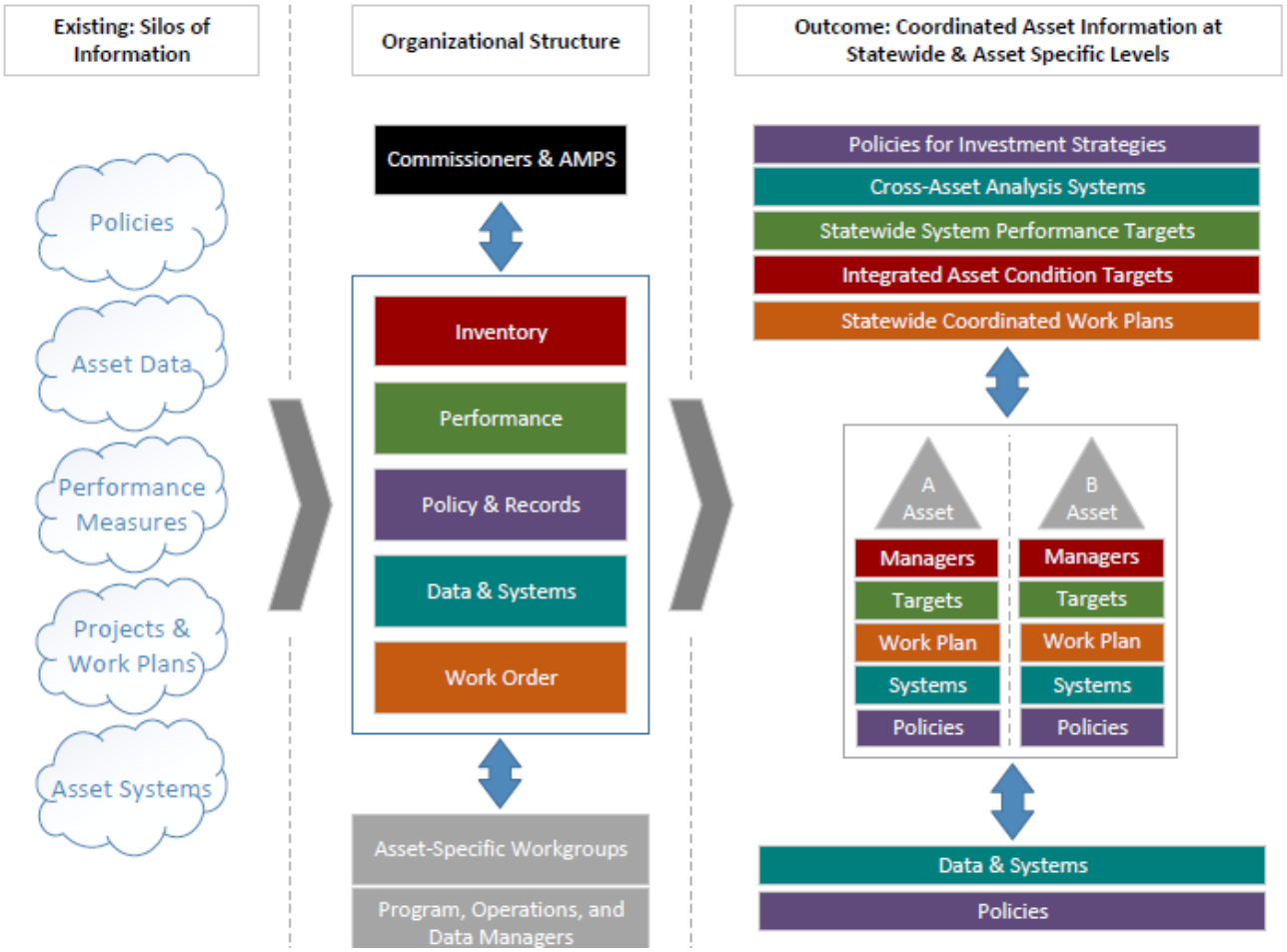
NHDOT is led by the Commissioner of Transportation. The Commissioner of NHDOT oversees a $700 million transportation Department of over 1,600 employees with the daily mission of "Transportation Excellence Enhancing the Quality of Life in New Hampshire." The overall organizational structure of NHDOT is shown in Figure 2-1.

Figure 2-1 NHDOT Organizational Structure



Within this organization structure, overall AM coordination responsibilities reside in the AMPS Office which reports to the Deputy Commissioner. The AM Coordinator for the Department is the AMPS Administrator and this position serves as a focal point for technical and day-to-day advancement of AM within the Department. The AMPS Office is also responsible for management and update of the AMP. Establishing coordination and management "ownership" through the AMPS Office provides clear accountability for asset management stewardship and ensures that efforts throughout NHDOT are coordinated and performed in a logical sequence. This organizational approach enables the Department to move from an existing silo approach of management to a more coordinated and integrated format as illustrated in Figure 2-2.

Figure 2-2 NHDOT TAMP Organizational Approach



NHDOT Strategic Plan, 2017

The AM governance structure consists of cross-functional membership throughout the Department. The Commissioners are the final decision-making authority on all AM matters. The structure has the following components:

1. Commissioners and AMPS Administrator
2. AM Focus Area Workgroups
3. Divisions, Bureaus, and Districts
4. Committees and Taskforces

NHDOT's internal asset management governance structure is illustrated in Figure 2-3.

Figure 2-3 Asset Management Governance Structure

Source: NHDOT Strategic Plan, 2017

This approach enables personnel throughout the Department to use a systematic process that considers various inputs, evaluates potential outcomes, recommends efficient investment strategies, and monitors both implementation and outcomes for the entire lifecycle for each asset class. This approach also builds a common foundation between assets, data, and systems that will enable the Department to perform cross-asset analyses in the future as well as provide consistent and accurate information to stakeholders.

2.3.1 Commissioners

The Commissioners of NHDOT have final decision-making authority for department-wide policy level decisions. This includes asset management policies and standards that impact external stakeholders. The Commissioners and other executive-level personnel are directly involved with all 5 of the focus area workgroups and meet regularly to make coordinated strategic decisions.

2.3.2 The Role of AMPS

The AMPS Office is responsible for the coordination of asset management and performance management at NHDOT. Those responsibilities include ensuring alignment across the workgroup structure and that the Department approach remains consistent and transparent. The Administrator of AMPS is engaged with decision-making amongst the Commissioners. The AMPS Office is responsible for ownership and update of the AMP.

2.3.3 Divisions, Bureaus, and Districts

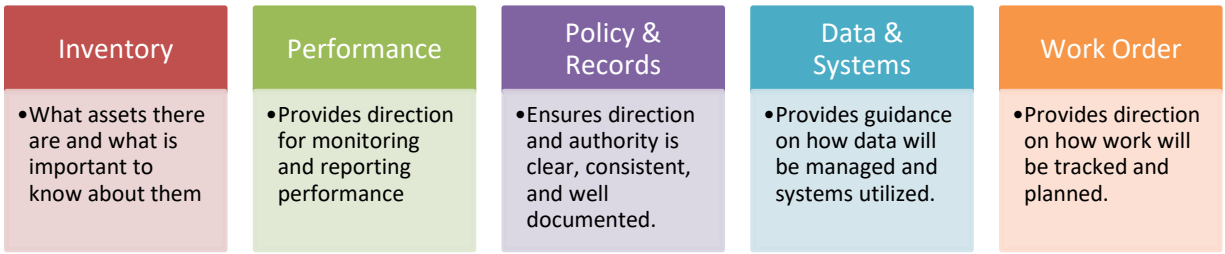
The divisions, bureaus, and districts form the standard organizational units of the Department. These entities are responsible for implementing the day-to-day activities of

the Department. They will incorporate AM principles and activities into the regular work responsibilities, follow policies and procedures, and provide feedback.

2.3.4 Workgroups – AM Focus Areas

The AM Focus Area workgroups are made up of multidisciplinary experts within the Department and chaired by Commissioners or Directors. The overarching roles for these workgroups are to craft policies and provide direction to the entire Department, ensuring the implementation of AM across NHDOT. Representatives from the AMPS Office are involved with all five workgroups and responsible for coordination. The five focus areas and the specific roles are listed in Figure 2-4.

Figure 2-4 AM Focus Areas and Responsibilities



Source: NHDOT Strategic Plan, 2017

2.3.5 Committees and Taskforces

The committees and taskforces are made up of multidisciplinary experts responsible for the management and implementation of AM principles among asset classes (e.g., pavements, bridges, etc.) and related activities (e.g. system development, goal setting, etc.). These groups assist with AM implementation by identifying asset needs, recommending policies and procedures, monitoring the implementation process, and through many other ways.

2.4 External Engagement and Collaboration

The National Highway System crisscrosses the State of New Hampshire and while NHDOT has ownership and management responsibility for most of the system, other jurisdictions also have responsibility, primarily:

- Municipalities
- Metropolitan Planning Organizations (MPOs); and
- Regional Planning Commissions (RPCs)

Through the continuous and collaborative planning process in New Hampshire, including the development of the TYP and the STIP, the Department already has very good communication with the MPOs and the RPCs. Through those processes, along with the day-to-day role that NHDOT plays in the state, there exist very good communication channels with municipalities. NHDOT will continue to leverage those existing communication channels, relationships, and processes to further asset management across the State.

2.4.1 Municipalities

In NH, state law delegates management responsibility of state highways in certain areas (urban compacts) to the municipality in which they are located. This includes non-interstate portions of the NHS and some bridges. Through various programs, NHDOT provides funding opportunities, both state and federal, for the preservation and improvement of these facilities. These programs are part of the planning process and involve the MPOs and RPCs. In addition, NHDOT includes the portion of the NHS that is managed by municipalities in the data collection process for both pavement and bridges. NHDOT relied on the MPOs for outreach to municipalities through the normal processes at the regional level.

2.4.2 Metropolitan Planning Organizations (MPOs) and Regional Planning Commissions (RPCs)

MPOs and RPCs play an integral role in the continuous, cooperative, and comprehensive approach to planning in NH. As part of the development of Metropolitan Transportation Plans (MTP) and rural transportation plans the needs of the transportation system are identified, including those of the NHS. The biennial process to update the TYP begins at the MPO/RPC level where information from the MTPs, citizens, transit providers, and elected officials are gathered.

Many of the components included in this AMP were developed as part of routine engagement between NHDOT and the regional organizations. The NHDOT meets regularly with the regional organizations for technical and policy committees, interagency consultation, transportation planners collaborative, executive directors group, and partnering for performance in NH. Over the past 3.5 years, throughout the development of this AMP, NHDOT leveraged those opportunities to discuss the state of the system, target setting, risk, financial sustainability & constraint, lifecycle planning, and investment strategies. Feedback and themes from those discussions have shaped the content of this AMP and the overall planning process. NHDOT meets with the regional organizations to review drafts of the AMP. The RPCs and MPOs worked through staff and committees to provide comments to the draft during that period.

There are 4 areas designated as MPOs in NH which are organized as:

- Nashua Regional Planning Commission
- Rockingham Planning Commission
- Southern NH Planning Commission
- Strafford Regional Planning Commission

There are 5 non-MPO regional planning commissions in NH:

- Central NH Regional Planning Commission
- Lakes Region Planning Commission
- North Country Council
- Southwest Region Planning Commission
- Upper Valley Lake Sunapee Regional Planning Commission

2.5 Continual Process Improvement

NHDOT is continually improving the efficiency and effectiveness of its asset management business practices and tools. The Department recognizes that many changes will take years to mature and has already established the appropriate organizational changes for the long-term.

Targeted business improvements are generated from many sources. The primary sources are:

- Guidance provided by the Strategic Plan for Asset Management and through the development of annual implementation plans.
- Internal assessments, reviews, and audits that are performed by program areas as part of the normal business practice of continual improvement.
- External policies including legislative actions, federal Department rules, judicial findings, etc.
- External reviews and audits by regulatory agencies such as the FHWA.

The AMP will be subject to a series of continuous improvements as asset information and systems mature and in accordance with federal phase-in periods. Chapter 8 of the AMP identifies areas where additional development is necessary to continue to mature the AMP.

On a biennial basis, the AMP will be reviewed by the NHDOT. The review will be initiated by the AMPS Office and will be collaborative in nature. Internally, the review will include the focus area workgroups described earlier as well as other subject matter experts. The review will also include the MPOs, RPCs, FHWA, and other external stakeholders. Through a 30-day comment period participants and the public will be invited to provide feedback.

3 State of the System

The State of the System provides a snapshot as to the status of the transportation system and while the chapter provides information for the entire system for context, the focus is on the NHS. This chapter summarizes pavement and bridge assets in the State of New Hampshire using metrics described in the rule dealing with National Performance Management Measures; Assessing Pavement Condition for the National Highway Performance Program and Bridge Condition for the National Highway Performance Program (PM2 Rule). Changes to transportation system demand and asset inventory are included as well as a timeline to implement the remaining National Performance Management components

3.1 System Overview

The practice of developing an inventory and assessing condition of assets is a fundamental element of asset management business practice. The inventory of roads and bridges collected by the department cater to several layers of definition and management and it is important to isolate the assets described in 23 CFR 490 for reporting or target setting. Five levels are described for the purposes of this AMP:

1. Total NHDOT Inventory
2. State Managed
3. Federal Interest
4. NHS
5. NHS Assessment

The inventory of roads documented by the department contains 16,619 miles of public roads as defined by state law RSA 229:5, and the inventory of bridges contains 3,850 structures. The inventory of structures includes highway bridges as defined by state law 234:2 as well as other bridges spanning watercourse or other openings greater than or equal to 10 feet. The state manages only a portion of the assets documented in each inventory. NHDOT manages 4,606 miles of roads and 2,162 bridges.

Assets that are of a particular federal interest may be grouped within each inventory. These are not subsets of the state managed portions, instead they are subsets of the larger inventory because in both cases municipalities may own or manage assets that are of federal interest. Out of the 4,160 miles of road that are eligible for federal aid, the state owns 3,462 miles of those roads. Approximately 2,426 bridges in the state meet the federal definition, which requires spanning greater than 20 feet.

The National Highway System (NHS) is the level of inventory this document focuses on. The NHS is a subset of the assets that are of federal interest and makes up of 1,483 miles of roads and 881 bridges. Of those totals, most are managed by the NHDOT; 1,402 miles of roads and 844 bridges. Municipalities manage the remaining assets, therefore planning and reporting for those assets requires collaborative processes.

It is important to understand the system as required by federal regulations for assessing the condition of assets on the NHS when considering target setting and minimum conditions. The NHS assessment level does not adhere to the strict definition of the NHS. Only pavement conditions collected in the inventory direction of dual carriageway routes are reported through the Highway Performance Monitoring System (HPMS). Therefore, the assessment level of roads represents a portion of the NHS. In contrast

for bridges, the network is expanded and includes bridges that support the NHS. There are 1,248 miles of pavement and 844 bridges are included in the NHS Assessment level.

The National Highway Performance Program analyses the NHS Assessment level through two categories:

1. Interstates NHS
2. Non-Interstate

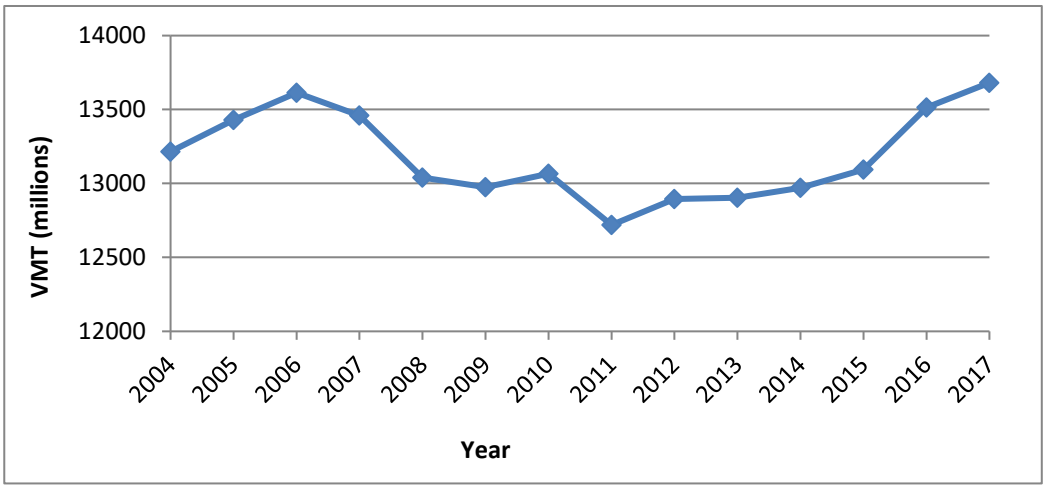
} NHPP

3.2 Demand

Demand is the number of vehicles and other modes using the road network. For the purpose and statewide scale of this AMP, the focus is on motor vehicles. Understanding how system demand changes over time enables NHDOT to model performance of the system and anticipate funding needs. One method to estimate system demand, Vehicle-Miles Traveled (VMT), approximates the amount of vehicular travel for a geographic area. An increase in VMT will tend to accelerate the deterioration rate of pavements and bridges. Figure 3-1 illustrates the amount of VMT in New Hampshire since 1997. It is important to note that the reported VMT includes travel on the entire roadway network in New Hampshire; however, the AMP focuses on NHS assets and the demand for these assets. It is expected for demand on the NHS to follow similar trends as illustrated in Figure 3-1.

New Hampshire has experienced growth in total VMT over the past two decades, with a few drops in VMT related to the 2008 recession. Specifically, New Hampshire experienced an increase of about 29 percent in VMT between 1990 and 2011[3]. Since 2011, VMT has started to grow again, but at a moderate rate. The national growth in total VMT is projected to be approximately 0.61 percent annually over the next 30 years[4] (2014-2044). This minor growth in New Hampshire will increase the rate of asset deterioration slightly though it is not expected to require any significant changes to strategies.

Figure 3-1 VMT Trend in New Hampshire



Source: VMT (vehicle travel) data from Highway Performance Management System (HPMS).

[3] TRIP, New Hampshire Transportation by the Numbers, February 2013
[4] Office of Highway Policy and Information, FHWA, May 2, 2016

3.3 Pavements

3.3.1 Inventory

The NHS is extremely important as those roads link the State's major cities, ensuring the flow of commerce to national and international markets, and play a vital role in many people's daily commute. The entire interstate and most of the non-interstate NHS is managed by NHDOT, either through highway maintenance districts or turnpikes. A small portion of the non-interstate NHS is managed by municipalities though NHDOT collects inventory and condition information for the entire NHS. NHDOT coordinates with municipalities directly and through MPOs/RPCs as part of the planning process (section 2.4).

Table 3-1 presents a summary of New Hampshire's NHS pavement by ownership and maintenance responsibility. The categories include the centerline miles of Interstate and non-Interstate NHS pavements.

- **State Maintained:** These are roadways under the jurisdiction of the Bureau of Highway Maintenance through its six constituent districts;
- **Turnpike Maintained:** These are roadways under the jurisdiction of the Bureau of Turnpikes. The turnpikes are managed under a separate Bureau within the NHDOT; and
- **Municipal Maintained:** These are NHS roadways under the jurisdiction of municipalities within the state.

Table 3-1 Asset Register – NHS Pavement Inventory by Jurisdiction

Category	NHDOT State Maintained		NHDOT Turnpike Maintained		Municipal Maintained		Total Miles
	Miles	%	Miles	%	Miles	%	
Interstate	**484**	**83**	**102**	**17**	**0**	**0**	586
Non-Interstate NHS	**666**	**74**	**151**	**17**	**80**	**9**	897
Total NHS	1149	78	253	17	80	5	1,483

Source: GISOWNER.ASSET_2019_ROADS, NHDOT

3.3.2 Pavement Data Collection

NHDOT personnel collect pavement data on a two-year cycle with a Data Collection Vehicle. The vehicle currently used was purchased in 2009. While some conditions are collected every other year, data for Interstates are collected every year. Compliant with current HPMS protocols, non-interstate NHS pavement conditions are also collected every year, however, this may be relaxed in future years in response to the lower frequency specified in the PM2 Rule. Pavement data collected before the current Data Collection Vehicle was purchased are rarely used.

Most roads in New Hampshire, including every mile of the NHS, are surfaced with asphalt pavements. Conditions on asphalt pavements are measured using three datasets: roughness, rutting, and cracking. Roughness (International Roughness Index, or IRI) and rutting are both measured using sensors. Sensors produce data that can be closely reproduced regardless of who is collecting.

Cracking data is collected using a semi-automatic process that does not use sensors.

The process uses the Data Collection Vehicle to automatically take photos of the pavement surface for manual rating in an office environment. It is a time-intensive process that requires significant involvement and uses sampling techniques to reduce the workload. Sampling of cracking data is no longer permitted by the PM2 Rule and NHDOT has adjusted collection practices.

The PM2 Rule describes a phase-in that allows for a progressive approach to integrating rutting and cracking. As Table 3-2 highlights, rutting and cracking will be used to assess performance of the Interstate system at the mid-point of the first performance period (the end of 2019) and for the remainder of the NHS in the second performance period. The phase-in removes 2-year Interstate target setting and allows for estimation in setting 4 year Interstate targets. IRI is used in estimation to leverage the Departments existing experience with roughness data and because it is in line with the method described for non-Interstate NHS pavements in the first performance period.

Table 3-2 NHPP Pavement Performance Metrics and Transition Timeline

Category	Performance Measure	Implementation Time Frame and Metric Used for Reporting		
		Now	**Short Term (2019)**	**Medium Term (2021)**
Interstate	Percentage of Pavements on the Interstate System in Good Condition Percentage of Pavements on the Interstate System in Poor Condition	IRI	IRI, Rutting, and Cracking Percent	IRI, Rutting, and Cracking Percent
Non-Interstate NHS	Percentage of Pavements on the Non-Interstate NHS in Good Condition Percentage of Pavements on the Non-Interstate NHS in Poor Condition	IRI	IRI	IRI, Rutting, and Cracking Percent

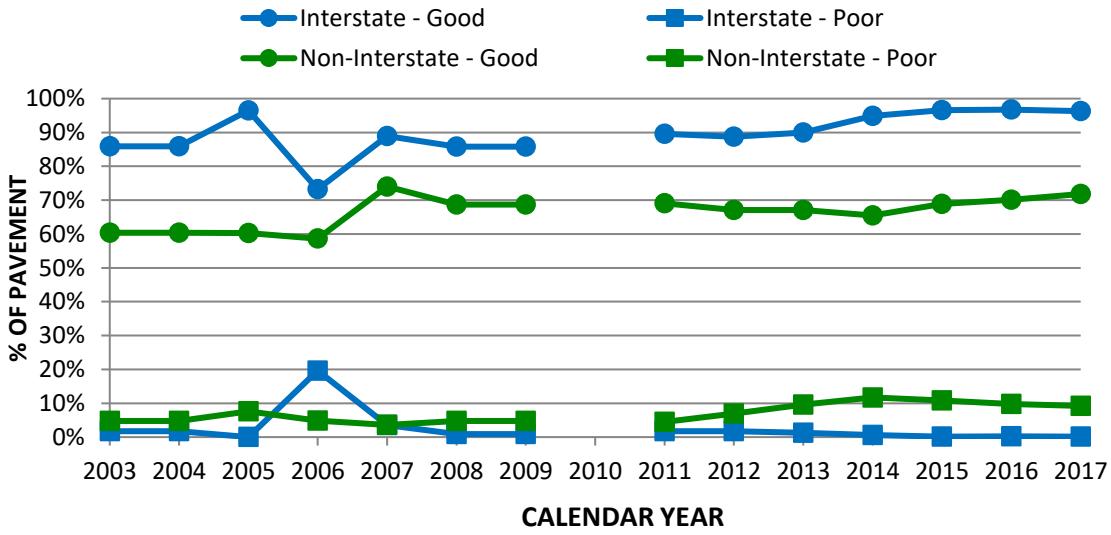
3.3.3 Pavement Condition

As previously noted, roughness is the metric currently used to determine pavement condition on all roads managed by the Department. Roughness is how a road feels to the motoring public. As a road becomes rougher, the IRI value increases. As such, good roads have low IRI while poor roads have high IRI. Interstates have a high percentage of good condition pavements. This high percentage of good condition pavements is the direct result of many years of investment decisions focused on the Interstate system. NHDOT has focused on the Interstate system because it conveys the majority of commuter, tourism, and freight traffic throughout the state and nation.

Figure 3-2 illustrates over a decade historical trend for the condition of New Hampshire's NHS pavements. Thresholds described in the PM2 rule for IRI data are used to determine good and poor conditions. The method aligns with baseline estimates used for target setting on Interstates in the phase in and for non-Interstates in the first performance period. Intermittent problems with the data collection vehicle in 2005 manifested as problems with the 2006 data submission to HPMS. Engineers determined

that erroneously high roughness values overinflated the number of roads in poor condition and underestimated the number of roads in good condition.

Figure 3-2 NHS Pavements Classified "Good" and "Poor" by IRI



Source: HPMS, Table HM-47. (Note: 1994 is the first year for which data was collected for a "provisional NHS." Due to changes in the HPMS reporting standards, Table HM-47 was not published for 2010.)

Overall, the condition of the New Hampshire NHS has remained relatively stable over time since funding has been prioritized for the NHS. As part of the MAP-21 requirements, the NHS was expanded to include additional roadways. This change in the requirement partially explains the increase in poor condition for non-Interstate roadways. These additional NHS miles will count toward NHPP performance measures and may require additional funding to manage the system and achieve established performance targets.

3.3.3.1 Current Condition

As previously mentioned, NHDOT reports pavement condition data to HPMS annually. The existing conditions (by miles and percentage) of pavement assets, at the network-level, are presented in

Table 3-3. These conditions are based on IRI and centerline miles. Additional metrics will be used in the future to report conditions using lane miles.

Table 3-3 Current (2018) Pavement Conditions

	Good		Poor	
	Miles	%	Miles	%
Interstate	436	97	1	0.2
Non-Interstate NHS	588	74	68	9
Total NHS	**1024**	**82**	**69**	**6**

Source: 2018 HPMS Submission.

3.3.3.2 Description of Additional Metrics

As required by the PM2 rules, NHDOT will report using the additional metrics of rutting and cracking in accordance with the phase-in timeline presented in Table 3-2. Pavement roughness (IRI) is easily experienced and understood by road users; however, the other metrics are more technical and have direct effects on safety and the structural capacity of pavements. For example, rutting, which is a key pavement distress, measures the depression or sags in road surfaces created along the wheel paths. These depressions can retain water leading to hydroplaning and other safety issues. Cracking results from many factors, and are characterized by their cause and appearance. Pavements with extensive cracking allow water to penetrate the pavement and wash away materials that support the pavement, reducing the expected service life of the asset. As NHDOT gathers data to measure these distresses, the metrics will be combined to measure the overall conditions of pavement assets according to the categories listed in Table 3-4.

Table 3-4 NHPP Pavement Condition Rating Procedure

Pavement Category	Condition Metric Combination	Measure
Good	All three metrics are rated "Good"	Percentage of lane-miles in "Good" condition
Fair	All other combinations of metrics	Percentage of lane-miles in "Fair" condition
Poor	≥ two metrics are rated "Poor"	Percentage of lane-miles in "Poor" condition

3.3.4 Pavement National Performance Goal

The NHPP sets national performance goals for pavement conditions. This allows for State DOTs to maintain their system in a state of good repair. To support this goal, the PM2 Rule sets minimum standards of performance for Interstate pavements. Specifically, State DOTs may not exceed 5% poor condition for interstate pavements. As shown in Table 3-5 the existing pavement conditions measure 0.1 percent of Interstate pavements in New Hampshire are in Poor condition, indicating that NHDOT satisfies the minimum national performance requirement (based on IRI only). The final rule also specifies penalties for States that do not meet this minimum threshold. For example, if a State is not able to meet this required threshold over a statutorily-designated period, the State will be required to allocate portions of its NHPP funding for NHS pavements or transfer funds from their Surface Transportation Block Grant Program (STBG) to the NHPP fund until this threshold is met.

Table 3-5 Pavement Performance Goal

Measure	Baseline Condition	Threshold	Gap
Interstate Poor	0.1%	5.0%	None

3.3.5 Pavement Performance Target Setting

Pavement performance targets enable NHDOT to monitor progress towards Department and national goals for pavements. The PM2 rule requires State DOTs to set performance targets to support long-range planning. Working with the MPOs in NH, NHDOT established two-year and four-year performance targets for the NHS pavements in accordance with the timelines stipulated in the final rules. The targets were adopted by all 4 MPOs in NH. In addition, the Department seeks to maintain those targets for the long-term and established long-term SOGR targets. The targets shown in Table 3-6 will guide the Department in assessing financial needs and developing efficient investment strategies to manage performance and customer expectations in the long term.

Table 3-6 Pavement Condition Targets

Measure	Baseline Condition	2 yr. Target	4 yr. Target	SOGR Target
Interstate Good	96.7%	Not Applicable	95.0%	95.0%
Interstate Poor	0.2%	Not Applicable	0.8%	0.8%
Non-Interstate NHS Good	73.1%	65.0%	65.0%	65.0%
Non-Interstate NHS Good	9.1%	12.0%	12.0%	12.0%

Targets are based on IRI (as described in Table 3-2). NHDOT utilized condition data for 5 prior years (2013-2017), along with subject matter expertise, as the basis for establishing the 4 year target for the interstates as well as the 2 & 4 year targets for non-interstate NHS pavement condition. NHDOT will continue to utilize the best available data along with knowledge of past and anticipated investments to establish targets that are reasonable and align with the desired SOGR.

Specific outreach and coordination that occurred includes:

1. External Outreach & Coordination
    a. August, 2016 through April 2017: Coordinate with MPOs, RPCs, and FHWA through the SHRP2 performance initiative and Partnering for Performance in NH regarding initial concepts, requirements, and data;
    b. May, 2017: Review requirements, data, processes, and discussions to date at a colloquium involving MPOs, RPCs, FHWA, other interested regional and municipal officials, and the public.
    c. February, 2018: Review the target setting requirements, data, and anticipated approach with MPO & RPC Directors.
    d. March, 2018: Review data, trends, and draft targets with FHWA.
    e. April, 2018: Review data, trends, and draft targets with MPO & RPC personnel as part of interagency consultation. Also coordinate with MassDOT for the Boston UZA related measures.

f. Summer, 2018: Review of final measures with MPOs and coordination for development of regional targets or adoption of State targets.

g. September, 2018: Review targets and methodologies with FHWA NH Division and finalize.

2. Internal Coordination

a. September, 2017: Document the target setting need in the NHDOT Implementation Plan and assign it to the Pavement Management Committee.

b. January, 2018 through March, 2018: Pavement Management Committee review of condition data and recommendation of targets.

c. March, 2018: Performance Workgroup review of documentation and targets.

d. April, 2018: Commissioner's Office review and approval of targets.

e. Summer, 2018: Review FHWA Transportation Performance Management reporting tool responses with the Performance Workgroup.

3.4 Bridges

3.4.1 Inventory

As of the beginning of 2019, there were 724 structures on the NHS that meet the federal definition of a bridge. By count, the bridges only represent 19 percent of the inventory; however, they represent 57 percent of the inventory by deck area at 7.3 million square feet.

NHS bridges, like roads, are managed by multiple owners. Table 3-7 illustrates the distribution of area of NHS bridges in New Hampshire by owner. The entire interstate and most of the non-interstate NHS is managed by NHDOT. A small portion of the non-interstate NHS is managed by municipalities. The State coordinates with these municipalities through their respective MPOs, rural planning commissions, and directly to set meaningful performance targets.

Table 3-7 Asset Register - Bridge Area and Percent by Owner of the Facility

Owner	Area	Percentage
State	4,677,004	64%
Turnpikes	2,055,306	28%
Municipal	549,928	8%
Total	**7,282,238**	**100%**

Source: NBI Submission (2018)

3.4.2 Bridge Data Collection

Bridge inspection data has been consistently collected in accordance with the FHWA "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges," which specifies the data to be collected and reported to the National Bridge Inventory (NBI). Historic bridge inspection data is available in an electronic format from

the early 1990's to present. NHDOT personnel collect data on all highway bridges, generally on a two-year cycle, using four regional bridge inspection crews. Structurally Deficient bridges are inspected on a shorter interval. By state law RSA 234:25-b, state owned bridges that are structurally deficient are inspected twice per year, while municipally owned structurally deficient bridges are inspected annually.

Conditions of NBI items and element level data are collected during inspections. NBI items provide coarse overviews of condition. Items 58 – Deck, 59 Superstructure, and 60 – Substructure are used to determine the condition of non-culvert bridges. Culverts that meet the definition of a bridge are assessed with item 62 – Culverts. Element level data collection assesses the condition of many parts of each bridge; such as bearings, bridge rail, stringers, or diaphragms. These two types of ratings are collected using separate scales and qualifiers (descriptions of condition) and both provide vital input to asset management.

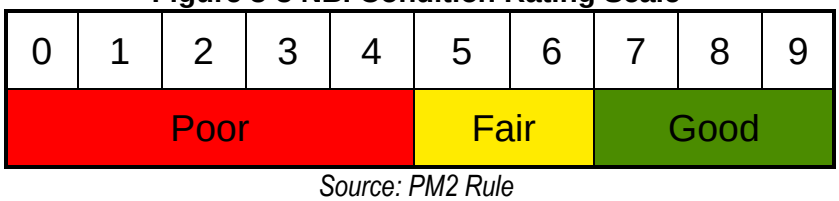
Condition ratings for NBI items are determined on a scale of 0 – 9; where 9 represents an excellent condition and 0 represents a failed condition. The value represents the condition of the entire component, not localized or nominally occurring conditions. The data has been collected with the same definition for a long time and generally electronic records are available for bridges from 1993 onward

Determining the condition of elements and items relies on human interpretation, so more variability is expected in bridge condition data than sensor derived values, which are available with some other assets. Variability is reduced through periodic training, experience, and review of inspection data by office personnel. Bridge inspectors must achieve several years of experience and attend an intensive FHWA-approved two-week bridge inspection training course in order to become a team leader, and they are required to attend FHWA-approved bridge inspection refresher training at least once every 5 years to maintain Team Leader status. A Team Leader must be present during the inspection of every federal definition bridge. The inspection program is reviewed annually by FHWA in accordance with the "Metrics for Oversight of the National Bridge Inspection Program" to determine compliance/noncompliance with National Bridge Inspection Standards (NBIS) per 23 CFR Part 650 subpart C.

3.4.3 Bridge Condition

NBI items are used to determine the conditions of bridges. Bridges are rated for the three components (deck, superstructure, substructure). Culverts that meet the definition of a bridge are rated on the culvert element (NBI Item 62). Whether a bridge or a culvert, the condition of each major element ranges from 0 - 9, with 0 indicating a failed condition and 9 indicating an excellent condition (see Figure 3-3). The overall condition of each bridge is determined by the minimum rating of the NBI component items. A designation of "poor" corresponds to a bridge with one or more NBI items rated less than or equal to 4. A designation of "good" requires that all NBI items are greater than or equal to 7.

Figure 3-3 NBI Condition Rating Scale

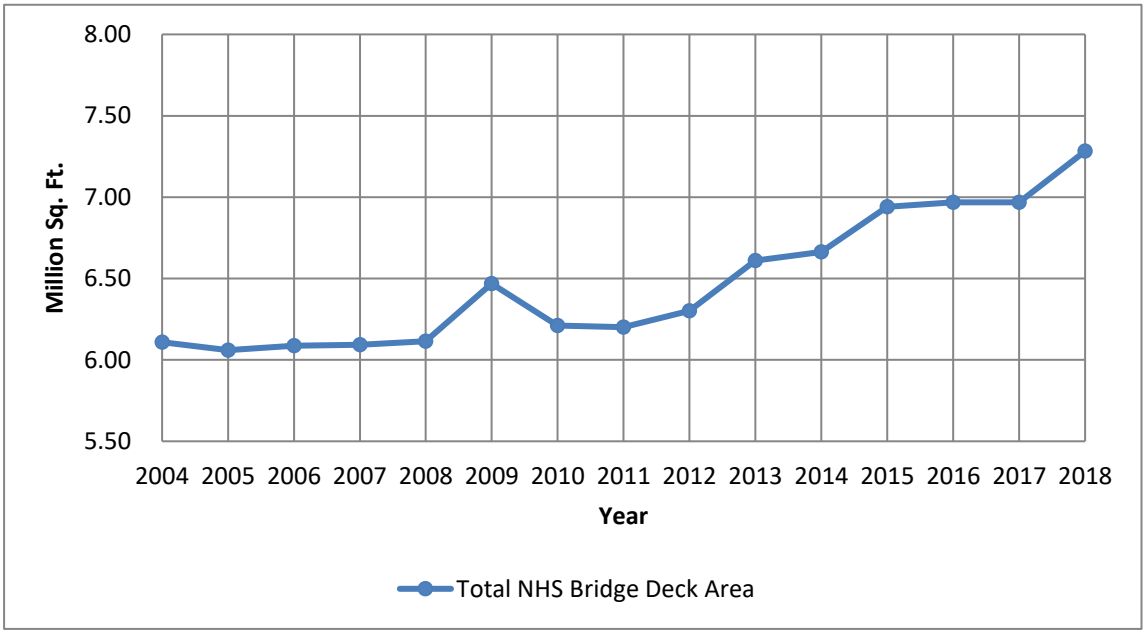


Source: PM2 Rule

Figure 3-4 to Figure 3-6 illustrate a historical trend for the condition of New Hampshire's NHS bridge area. The figures use the PM2 Rule minimum condition reporting criteria to determine "Good' and "Poor" conditions. As indicated by the trend line for the growth of

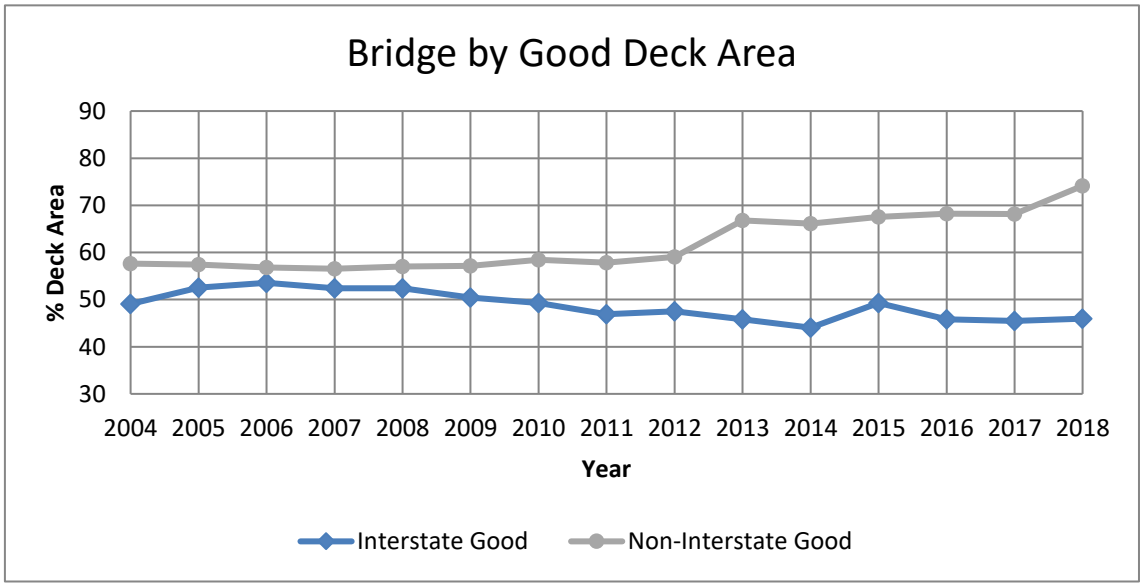
NHS bridge deck area (Figure 3-4), there has been a significant expansion of NHS deck area since 2012 in New Hampshire. As previously noted, the NHS underwent recent changes and expanded. These additional NHS bridges will count toward NHPP performance measures and may require additional funding to manage the system and achieve desired performance targets.

Figure 3-4 Total NHS Bridge (Deck Area) Trend



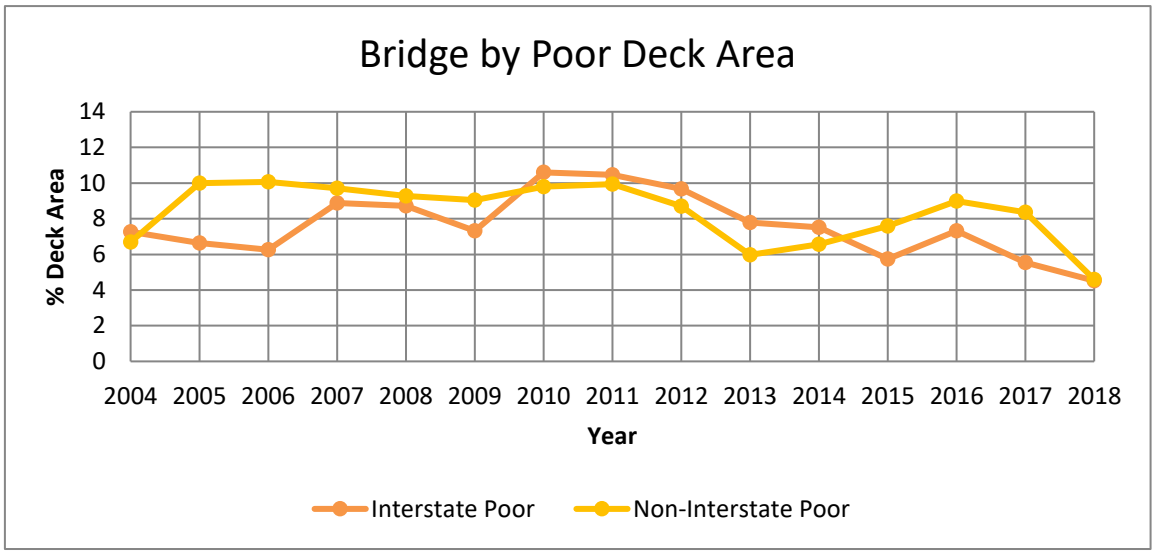
Source: NBI data (2018)

Figure 3-5 NHS Bridge (Deck Area) "Good" Historic Condition Trend



Source: NBI Submission (2018)

Figure 3-6 NHS Bridge (Deck Area) "Poor" Historic Condition Trend



Source: NBI Submission (2018)

3.4.3.1 Source: NBI data Current Condition

As previously mentioned, NHDOT reports bridge condition data to the NBI annually. The existing conditions (by deck area and percentage) of NHS bridges, at the network-level, are presented in Table 3-8. These conditions are based on the federal definition of bridges including bridges on ramps.

Table 3-8 Current (2018) NHS Bridge Condition (Federal Definition) by Deck Area

	Good		Poor		Total
NHS	Deck Area, SF	%	Deck Area, SF	%	Deck Area, SF
	4,452,673	61.1	332,493	4.6	7,282,238

Source: NBI Submission (2018)

3.4.4 Bridge National Performance Goal

The NHPP sets national performance goals for bridge conditions. This allows for State DOTs to maintain their system in state of good repair by setting minimum standards for performance which includes a minimum condition level for bridges based on the deck area of SD bridges. The limit applies to the NHS bridge population. The NHPP requires that no more than 10 percent of the deck area in the state's NHPP Bridge Population can be classified as SD for three consecutive years. As shown in Table 3-9 about 7 percent of deck area in the New Hampshire NHS Bridge Population was classified as SD in 2018.

Table 3-9 Bridge Performance Goal

Measure	Baseline Condition	Threshold	Gap
NHS Structurally Deficient	7.0%	10.0%	None

3.4.5 Bridge Performance Target Setting

Working with the MPOs, NHDOT developed two-year and four-year performance targets for the NHS bridges to meet the AM rules. The targets were adopted by all 4 MPOs in NH. In addition, the Department seeks to maintain those targets for the long-term and established long-term SOGR targets. The targets shown in Table 3-10 will guide the Department in developing efficient investment strategies to manage performance and customer expectations, and enable long-term planning. These targets will be developed while engaging other managers of the NHS, such as MPOs and local transportation agencies.

Table 3-10 Bridge Condition Targets

Measure	Baseline Conditions	2 yr. Target	4 yr. Target	SOGR Target
NHS Good	57.0%	57.0%	57.0%	57.0%
NHS Poor	7.0%	7.0%	7.0%	7.0%

NHDOT used NBI component condition data for 5 prior years (2013-2017), along with information from subject matter experts, as the basis for establishing the 2 & 4 year targets for NHS bridge condition.

Specific outreach and coordination that occurred includes:

1. External Outreach & Coordination
    a. August, 2016 through April 2017: Coordinate with MPOs, RPCs, and FHWA through the SHRP2 performance initiative and Partnering for Performance in NH regarding initial concepts, requirements, and data;
    b. May, 2017: Review requirements, data, processes, and discussions to date at a colloquium involving MPOs, RPCs, FHWA, other interested regional and municipal officials, and the public.
    c. February, 2018: Review the target setting requirements, data, and anticipated approach with MPO & RPC Directors.
    d. March, 2018: Review data, trends, and draft targets with FHWA.
    e. April, 2018: Review data, trends, and draft targets with MPO & RPC personnel as part of interagency consultation.
    f. Summer, 2018: Review of final measures with MPOs and coordination for development of regional targets or adoption of State targets.
    g. September, 2018: Review targets and methodologies with FHWA NH Division and finalize.

2. Internal Coordination
    a. September, 2017: Document the target setting need in the NHDOT Implementation Plan and assign it to the Bridge Management Committee.
    b. March, 2018: Bridge Management Committee review of condition data and recommendation of targets.

c. March, 2018: Performance Workgroup review of documentation and targets.

d. April, 2018: Commissioner's Office review and approval of targets.

e. Summer, 2018: Review FHWA Transportation Performance Management reporting tool responses with the Performance Workgroup.

4 Lifecycle Planning

This chapter describes NHDOT's approach to managing transportation assets over their whole life. Whole life Management or lifecycle planning is a strategic and proactive process that incorporates the collection, analysis, and application of data at each phase of the assets' life into existing asset management practices. It relates asset deterioration to work (i.e., cost and action) and environment (e.g., freeze/thaw) over time to understand how decisions impact condition and expenditures. The Department is using this information to:

- Make reasoned strategic and tactical decision based on quantitative information (as opposed to "worst-first" or "Firefighter Mentality");
- Minimize the cost of work and maximize its benefits over the long-term; and
- Reduce uncertainty in asset cost and service life.

Transportation assets go through different phases over their whole life including planning, designing, construction, operation (i.e., maintenance, preservation, and rehabilitation or reconstruction), and disposal. Lifecycle planning considerations, or whole life management of assets, recognizes that assets must be addressed holistically at every phase of their lifespan.

The remainder of the chapter presents the following:

- NHDOT's approach to identifying **System Needs** for bridge and pavement assets.
- The **Work Types** NHDOT uses to address bridge and pavement needs.
- **Pavement Whole Life Management** describing the process NHDOT uses to identify pavement needs and treatments.
- **Bridge Whole Life Management** describing the processes NHDOT uses to identify bridge needs and treatments.

4.1 System Needs

Assets require different treatment due to age, remaining service life, purpose, or criticality. Over the years, the transportation system in New Hampshire has developed organically, through new additions, modifications, and expansions. The evolution has contributed to a complicated system that requires NHDOT to employ various management standards and methods to minimize cost, maximize system performance, and manage risks.

The Department's highest priorities involve applying low-cost preservation treatments at the right time to keep assets in good/fair conditions. In some cases, work is deferred in anticipation of larger projects that will replace assets through reconstruction. Data is collected to evaluate these alternatives, assess network needs, and to develop deterioration rates. Generally, lifespan, or estimated service life, is understood. Specific site conditions, such as environment and level of usage introduce variability.

Asset deterioration, mobility requirements, and safety concerns present system needs. Needs are prioritized differently between assets. For example, bridge deterioration poses higher safety risks than pavement deterioration, which is more of a serviceability concern. The public, however, is often more aware of poor condition pavements because of how ride quality is affected. Addressing particular needs may have indirect

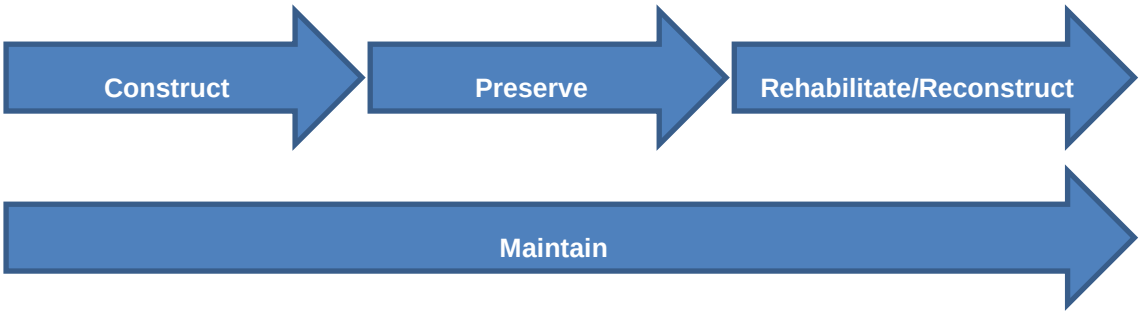
positive impacts on others. Optimizing work, therefore, requires comparing scenarios and projected outcomes. NHDOT uses a whole life management approach to address these needs holistically, with a long-term goal of minimizing overall cost.

4.2 Work Types

NHDOT applies five work types to pavement and bridge assets. They include initial construction, maintenance, preservation, rehabilitation, and reconstruction. After assets are constructed investments keep them operational at the appropriate level of service for as long as possible. Preservation activities keep good and fair condition assets in a state of good repair. Maintenance activities reduce deterioration and may address specific deficiencies. Rehabilitation activities restore poor assets to conditions that can be preserved.

As shown in Figure 4-1 the general work order throughout the life cycle of an asset involves construction, preservation, and rehabilitation. Maintenance may be performed at any time during the life of an asset.

Figure 4-1 Work Order Throughout the Life Cycle of an Asset



Costs and outcomes for the different work types vary with maintenance generally being lowest cost, preservation generally providing the highest level of service, and reconstruction generally being very expensive. Site specific conditions such as traffic management, initial construction methods, and right of way purchasing produce variability in costs, which can affect how reasonable potential work is. For example, when temporary bridges or night construction are required total project costs may outweigh anticipated benefits.

Planning work throughout an assets lifecycle requires asset management systems that use quality data. Qualitative inputs address site-specific concerns. The types of data leveraged, and the conditions reacted to, are different between pavements and bridges. Bridges generally deteriorate slowly, have a wide range of components, and are measured using coarse metrics that may take many years to change. Pavements, on the other hand, deteriorate quickly and are measured using consistent high-resolution metrics that will change throughout a single year.

Work accomplishments are also realized differently between pavements and bridges. Work executed on pavement nearly always changes condition in a measurable way; the pavement is smoother. Work on a bridge may extend the useful service life for many years, but may not be measurable by any standard methods.

4.3 Pavement Whole Life

Whole life management of pavement assets keeps roadway surfaces serviceable and protects investments. When possible, the Department preserves pavements because rehabilitation and reconstruction involve much higher costs than preservation or

maintenance activities. When pavement cannot be preserved, it tends to deteriorate faster and must be maintained to provide a reasonable level of service and to prevent future rapid degradation. The Department utilizes data pertaining to condition and performance along with feedback from field personnel and stakeholders to make pavement investment decisions.

Generally, pavements perform better on constructed roads. Constructed roads have strong base materials that facilitate prolonged preservation for keeping good roads in good condition. Building a constructed road involves placing select materials that have a range of gradation. Aging removes fine particles from the select materials, which deplete roadway structure and diminish performance. Preservation and maintenance protect the Departments investments by preventing deficiencies, like water infiltration through cracking, from accelerating the aging process. Most roads on the NHS are constructed.

Pavements that cannot be preserved are rehabilitated, reconstructed, or maintained above a minimum service level. While minimum service levels are not clearly defined by NHDOT, the goal for interstate condition is that at least 95% remains in good condition (IRI based) and that there is no more than 10% poor condition on the non-interstate NHS (IRI based). Rehabilitations return pavements from poor conditions to conditions that can be preserved. Reconstructions replace select material and may involve realigning or expanding roads. Reconstruction and rehabilitation projects are limited in application because they are cost prohibitive. If neither can be justified pavement will still be maintained.

4.3.1 Identification of Pavement Needs

Identifying pavement needs is a data driven process that is supplemented by subject matter expertise. The process begins with using condition data (IRI), work history, and local engineering input to identify eligible sections. Eligible sections are prioritized and treatment recommendations are developed. Budget and treatment costs affect how many sections are paved in a year. After sections are selected, they are bundled and advertised as projects. Paving also occurs outside of the process as part of projects focusing on other improvements such as safety, mobility, or emergency repair.

The time since the road was last paved as well as roughness, rutting, and cracking data described in Chapter 3 are used to determine work type eligibilities. Condition data is also reviewed when developing paving recommendations for other projects. When conditions and performance are good, either because the road is constructed or behaves as constructed, the road is eligible for preservation paving. If condition and performance are not good, roads are eligible for maintenance or rehabilitation.

Maintenance district input and subject matter expertise are leveraged to prioritize eligible sections for inclusion in the paving program. The Pavement Management Section works with maintenance districts to consider information not explicit in the data, for example the local significance, type of traffic, or deterioration that has developed since the last data collection. The focus of prioritization is to achieve network goals and to ensure that the work type applied has the benefit of reducing future costs. Outside of the paving program, reconstruction is prioritized as part of the typical project development process and is usually associated with safety or capacity improvements.

4.3.2 Pavement Deterioration

Deterioration models are developed by analyzing the impacts from various work types, using both data and input from subject matter experts, on the range of pavement performances. As shown in Figure 4-2, treatments on well preserved built roads take significantly longer to deteriorate to poor conditions after paving. The graphic also

shows that the “reset” condition; or the condition that is achieved from new pavement, is higher in well preserved built roads than in poor performing unbuilt roads meaning investments in those pavements go further. Few pavements, apart from the Interstates, meet these particular definitions and often pavement performs somewhere in between poor-performing unbuilt and well-preserved built roads as shown in the dashed lines.

Figure 4-2 Pavement Treatment Deteriorations

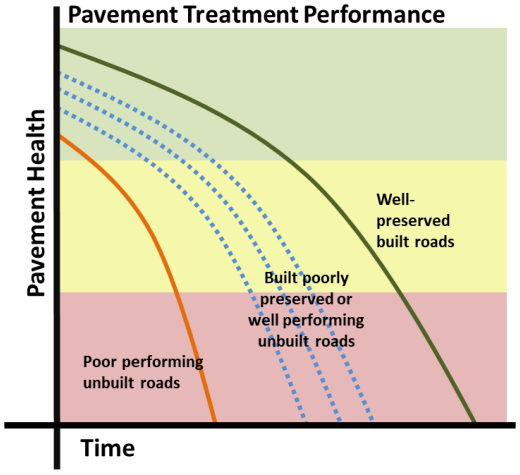


Figure 4-3 shows that employing preservation treatments at the appropriate time operates the road in good condition for a long period of time. Figure 4-4, on the other hand, shows that ignoring preservation requires more frequent reconstruction and operates the road in both fair and poor conditions during the lifecycle.

Figure 4-3: Preservation Strategy

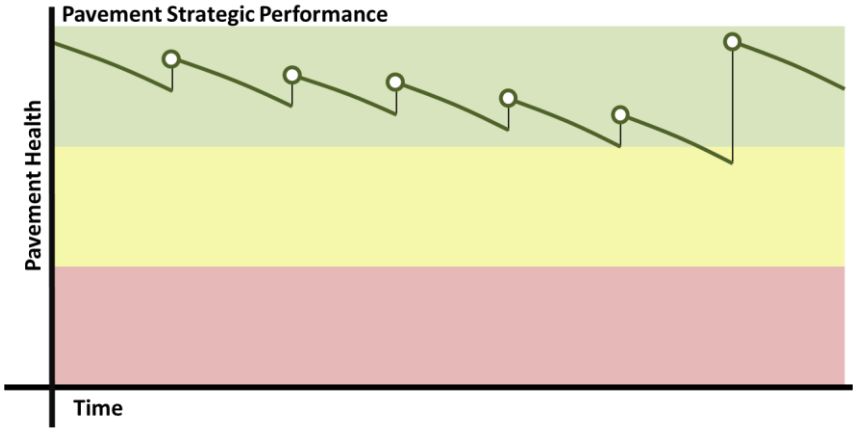
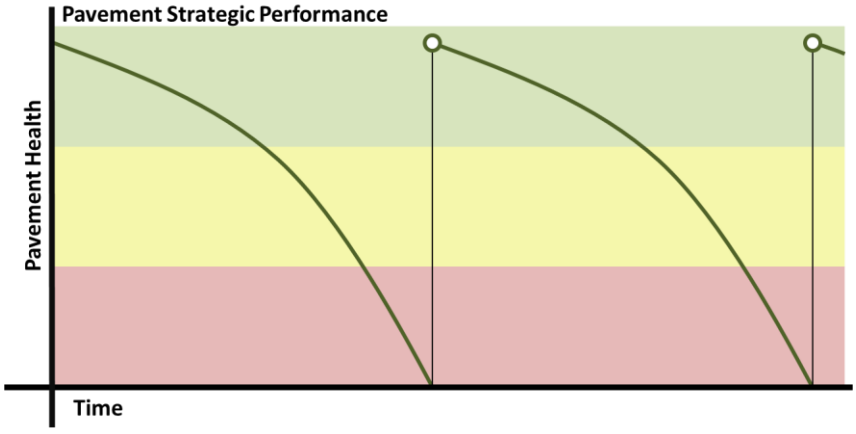


Figure 4-4: Reconstruction Strategy



Preservation is not eligible on all pavements. When applied to unbuilt roads or poor performing built roads preservation treatments either cannot function as designed or must be applied at a cost prohibitive frequency. In those cases, maintenance is used. Maintenance keeps the pavement serviceable by returning conditions to good. However, the subsequent performance varies widely. When applied to poorly performing unbuilt roads, as shown in Figure 4-5, the good condition does not last very long and the roads is operated in both fair and poor conditions. When applied to better performing roads before poor conditions appear, as shown in Figure 4-6, good conditions last longer.

Figure 4-5: Maintenance Strategy on Poor Performing Road

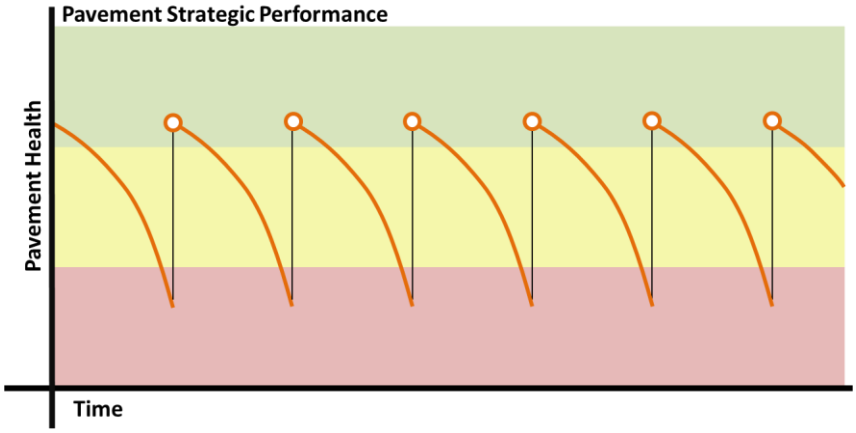
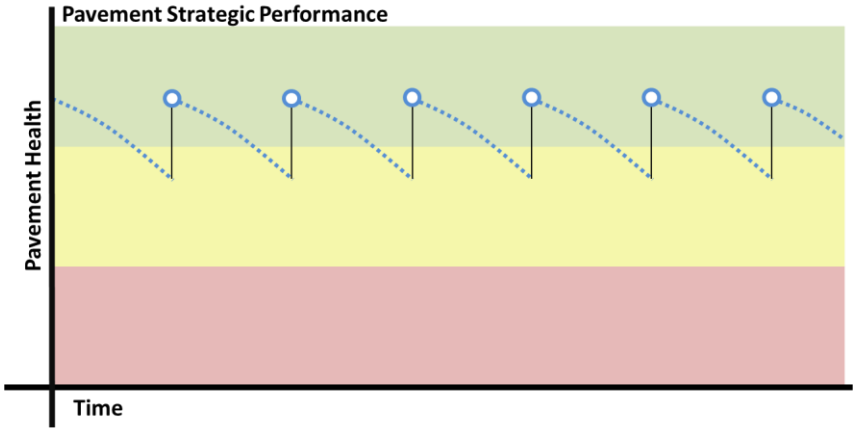


Figure 4-6: Maintenance Strategy on Moderately Performing Road



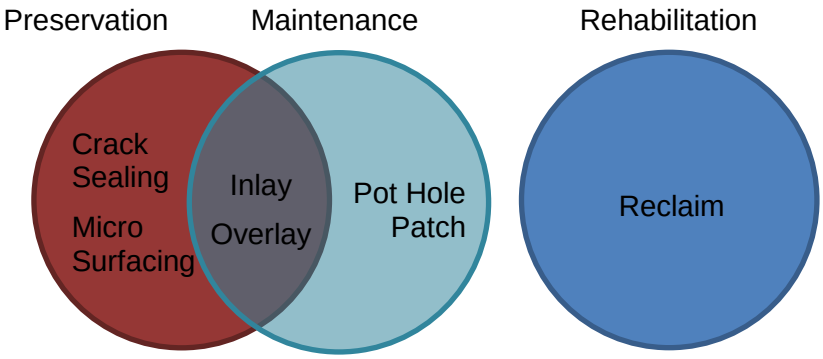
Pavement health is a composite condition that is comprised of the metrics used for national condition reporting; IRI, rutting, and cracking percent. Deterioration models specific to those metrics are under development by NHDOT. Paving treatments that were applied in the past are being researched and categorized by work types so that statistically significant samples can be correlated with condition archives. When complete, the curves derived from these correlations will be incorporated into the pavement management system. Modeling allows for improved treatment selection and strategic development as well as more precise forecasting and target setting.

4.3.3 Pavement Treatments

Paving occurs through the application of treatments. Under preservation and maintenance strategies, treatments are bundled together and applied over approximate time periods to develop mixes of fixes. Rehabilitations and reconstructions are used to move pavement to preservation eligibility through the application of one or more treatments at a single point in time. Treatments address specific deficiencies or cater to

specific challenges which may be common to both preservation and maintenance eligible pavements, therefore some are included in multiple strategies as shown in Figure 4-7.

Figure 4-7 Pavement Treatments by Strategy



Preservation treatments typically address specific concerns and must be applied at the appropriate moments in time. For example, crack sealing is used to prevent water infiltration but is not suitable on roads with moderate to high cracking. Maintenance actions keep roads driveable and plowable. Maintenance may involve planned actions, like paver shimming, which are executed as part of the District paving. Overlays are often used for maintenance paving. However, inlays may be used in situations where geometry is restrictive, for example under low bridges or where guardrail height or curb reveal is already limited.

Rehabilitation treatments, like reclaims or cold in place recycling, involve high costs and will make roads preservation eligible. Network goals and the cost effectiveness of subsequent preservation treatments must be quantified to justify the high costs of rehabilitations. Reconstructions create preservation eligible pavements and may alter long-term condition and maintenance obligations. Ten-year plan projects often address mobility or safety concerns by adding features like additional lanes, sidewalks, or by realigning intersections which in turn create additional pavement surface to be maintained and preserved.

4.4 Bridge Whole Life

Whole life management of bridges efficiently extends useful life through data driven approaches. The bridge inventory is made up of various bridge types that are built with many types of materials. The inventory developed over a long period and many components that are decades old are still functioning in the field today. Diversity in the bridge population coupled with very long lives and coarse condition metrics produce significant challenges in bridge management. Unlike some assets that are continuously maintained above a minimum service life, all bridges will age and deteriorate in condition to a point where replacement is the most efficient action.

Given the age distribution of the bridge population, many bridges were designed for smaller and lighter loads. Reconstructing or replacing these bridges generally involve building larger structures to handle today's traffic. As described in Chapter 3, the bridge network has grown at a faster pace than the road network. This growth regularly increases the Departments bridge preservation and maintenance obligations. Regardless of growth, bridge replacements and reconstructions are complicated processes. Temporary bridges and additional land acquisition are often needed to maintain traffic during the construction period.

Properly timed maintenance and preservation extends the useful life of bridges. Bridges will require rehabilitation about half way through the service life and replacements or reconstructions at the end. In some situations, the transportation network surrounding the bridge has developed to a point where it is not essential from a traffic perspective.

4.4.1 Identification of Bridge Needs[5]

Identifying bridge needs is a data driven process that is supplemented by subject matter expertise. Identifying eligible structures for preservation, rehabilitation, and reconstruction work begins with using condition data, recent accomplishments, and field observations. Maintenance work will occur regularly throughout the life of a bridge regardless of condition or recent work. Eligible structures are then prioritized and treatment recommendations are developed. Budget, costs, and level of effort affect how much work can be accomplished in a year.

Bridges in poor condition, or expected to be in poor condition relatively soon, are eligible for rehabilitation or reconstruction. Rehabilitations are effective when the cause of poor condition is isolated to a few elements. When many elements are in poor condition, or when a bridge no longer meets modern traffic demands, reconstruction is more appropriate. Bridges that are in good or fair condition are generally eligible for preservation. NHDOT has established programs for addressing maintenance, preservation, and rehabilitation/reconstruction of bridges that are included in the STIP.

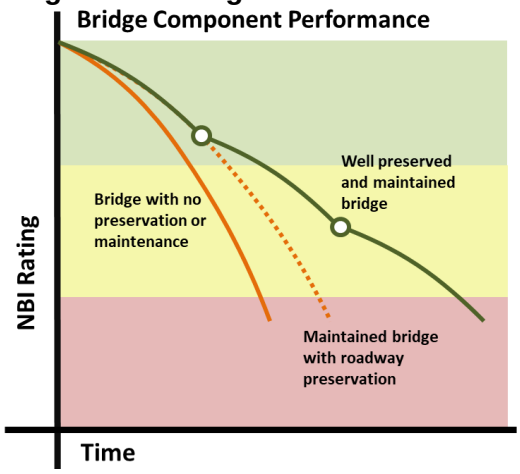
NHDOT utilizes a process that is based on importance (e.g., facility type, traffic volume), risk (e.g., scour criticality), capacity (e.g., weight restrictions), bridge type/size, and condition to develop an initial prioritization for bridge investments. Most data elements used in the process come from NBI with weighting that was developed by engineers at NHDOT. Recent and planned work is then used to adjust the numeric rankings to create a final prioritization.

4.4.2 Bridge Deterioration

Deterioration models are developed by analyzing the impacts from various work types on the range of bridge performances, using both actual data and input from subject matter experts. Figure 4-8 shows the deterioration of a bridge deck. Decks are a general focus because they deteriorate faster than superstructure or substructure. As shown in the figure, maintenance and roadway preservation extend life a moderate amount by slowing deterioration. Other bridge specific preservations extend life much further by correcting deficiencies and resetting the condition trajectory. Leveraging both maximizes life span by approximately doubling it compared to a bridge receiving no maintenance or preservation.

[5] Additional information relating to the processes utilized by NHDOT for the identification of bridge needs and prioritization is looked at: https://www.nh.gov/dot/org/projectdevelopment/bridgedesign/documents.htm

Figure 4-8 Bridge Deck Performance



Proper maintenance and preservation of bridge decks protect substructures and superstructures which extends the overall life of the bridge. Figure 4-9 and Figure 4-10 compare the overall life span of a bridge that has been properly maintained and preserved to a bridge that has not received any preservation or maintenance. The major rehabilitation in each figure is a deck replacement, which resets the condition of that component. Receiving the full schedule of maintenance and preservation approximately doubles the life of all components.

Figure 4-9: Bridge Performance without Preservation and Maintenance

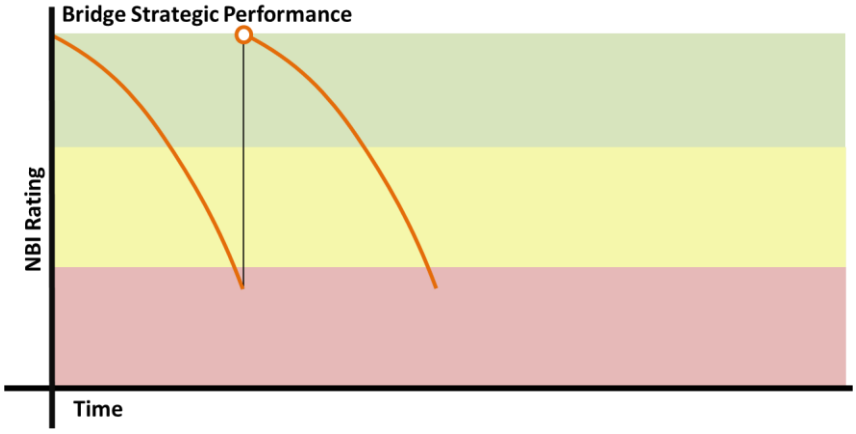
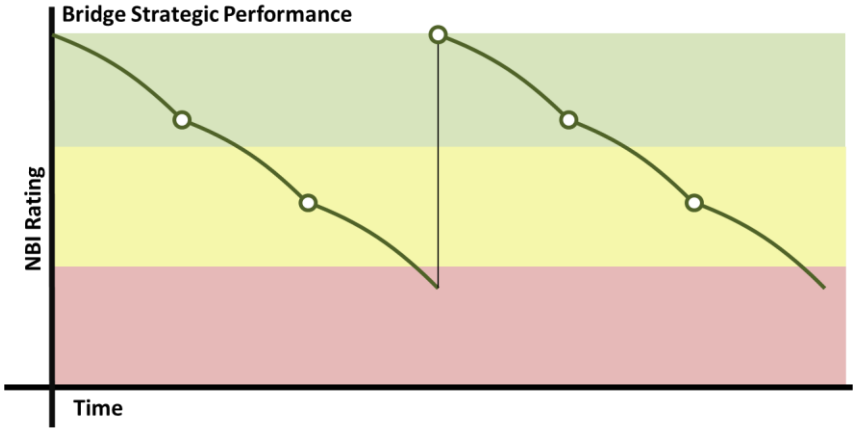


Figure 4-10**: Bridge Performance with Preservation and Maintenance**



The specific life span of components and overall bridges are determined by bridge type and adherence to recommended investment schedules. The example below compares girder type bridges. Figure 4-11 shows the approximate 80 year life that occurs without deck patching and membrane replacement. Figure 4-12 shows the same bridge with an approximate 120 year life span because it has received the deck patching and membrane replacement. Note the bridge receives maintenance and roadway preservation in both figures. If no preservation or maintenance occurred the expected life span would be limited to about 60 years.

Figure 4-11: Complete Maintenance and only Roadway Preservation

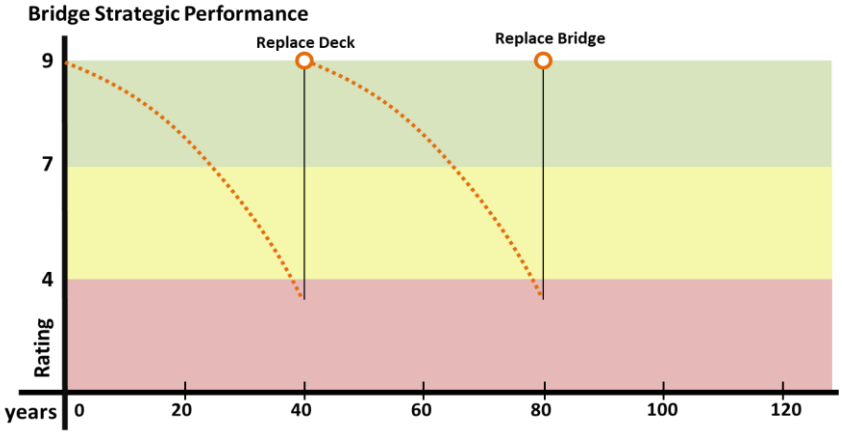
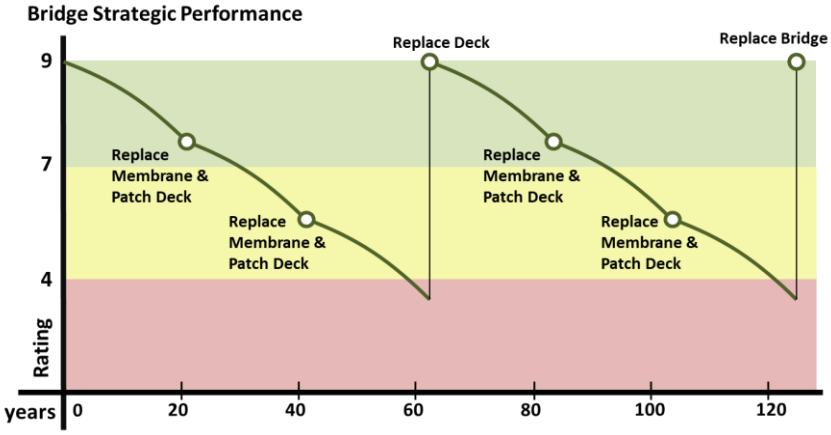


Figure 4-12: Complete Maintenance and Preservation



Actual adherence to recommended investment schedules varies from structure to structure. Additional models that consider the broader range are under development as well as curves that incorporate other components (superstructure, substructure, and culvert). Curves based on NBI conditions allow the department to forecast the very conditions used for target setting. However, curves based on National Bridge Elements will support much more robust bridge management. Combinations of National Bridge Elements are specific to individual bridges and conditions change measurably after elements are treated allowing for significantly more complex analysis.

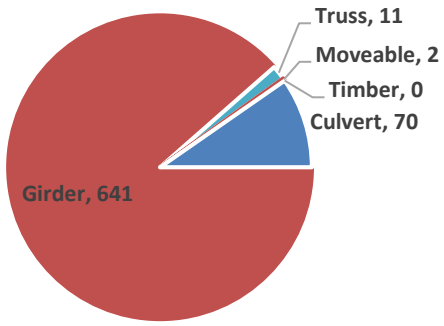
4.4.3 Bridge Treatments

Every bridge, regardless of where within life cycle, requires routine maintenance to extend life. Preservation, rehabilitation, and reconstruction work, however, are required at specific moments in a bridges life cycle. Yearly removal of salt to prevent accelerated corrosion is an example of maintenance work, which is prescriptive because it is not a

response to condition. Painting, membrane replacing, and deck repair are examples of preservation that responds to current conditions.

For simplicity in managing bridges, NHDOT classifies the bridge inventory into five major types; girder, truss, moveable, culvert, and timber. The distribution is shown in Figure 4-13 below. Many treatments are unique to the bridge types, for example repairs of electrical components are isolated to moveable bridges and invert repairs are unique to culverts. As noted, bridge data is coarse and complicated creating a stronger reliance on field observations to plan bridge work. Often, deficiencies not explicit in the data are identified through field observations that trigger specific treatments. As shown in the figure, most of the bridges on the NHS are girder type bridges and culverts while there are no timber bridges.

Figure 4-13 Five Major Types of Bridges (NHS)



Source: NBI data (2018) & NHDOT Bridge Program Definitions of Program Strategies and Terms (2018)

Each treatment applied to a bridge represents investments in extending the bridges service life. As such, the Department has developed Recommended Investment Schedules (RIS) for each of the major bridge types. The general schedule is described below. Actions unique to one or more bridge type are noted:

- Preservation / Maintenance
  - Wash and Oil Every Year
  - Crack Seal the Pavement (every 10 years starting in year 5)
  - Inlay the Bridge Pavement (every 10 years starting in year 10)
  - Replace Membrane and Expansion Joints (every 20 years)
  - Repair Electrical and Mechanical Parts, if any (every 25 years)
  - Patch Concrete or Repair Inverts on Culverts (every 10 years)
  - Paint exposed steel, if any (every 20 years)
- Rehabilitation
  - Replace Worn Out Components (every 25 years)
  - Replace concrete decks (year 60)
- Reconstruction
  - Completely Replace Girder Type Bridges (year 120)
  - Completely Replace Culvert Type Bridges (year 60)
  - Completely Replace Moveable & Truss Type Bridges (year 100)
  - Completely Replace Timber Type Brides (year 80)

5 Risk Assessment

FHWA defines risk as "the positive or negative effects of uncertainty or variability upon agency objectives."[6] Accounting for this uncertainty is essential to Whole Life Asset Management. Planning for risk will not only allows the NHDOT to engage in educated preparation for future conditions, but will also allow the Department to communicate sources of uncertainty to stakeholders and the public. MAP-21 requires that a AMP include a Risk Management Plan, and NHDOT is committed to managing risk and uncertainty as an integral part of its asset management program.

This chapter discusses risks that directly cause asset damage and service interruption (e.g., extreme events, asset failures, bridge scour, etc.), as well as risks associated with delivering asset management programs and projects. Risks can be positives (e.g., unexpected grant funding) or negative. NHDOT will continue its work to incorporate these uncertainties into decision-making.

To implement a Risk Management Approach across the Department's functions, NHDOT is building a process that will:

- Manage risk across various levels, including risks to the Department, programs, and assets;
- Develop a risk register that establishes priority for management and mitigation; and
- Develop a comprehensive decision-making process that includes risk assessment as a part of budget setting for bridge and road assets.

The remainder of this chapter is organized under the following headings:

- **5.1 Risk Management Process:** This section describes the steps NHDOT will take to identify and manage sources of risk;
- **5.2 Risks:** This section identifies and defines the risks in the Risk Register;
- **5.3 Risk Register:** This section presents the Risk Register and describes how NHDOT developed it. This includes the process by which risks were assessed and prioritized; and
- **5.4 Monitoring and Mitigating Risk:** This section describes NHDOT's vision for developing a formal Risk Management Approach and incorporating risk management into priority-setting and decision making moving forward.

5.5 Assets Damaged by Successive Events (Part 667): This section outlines the process NHDOT uses to identify assets that have been damaged by successive declared emergency events as well as specific strategies for known locations of damage.

5.1 Risk Management Process

The sections below describe stages to the development of NHDOT's Risk Management Approach. The stages include:

- Identifying Risk;
- Analyzing Risk;

[6] *Risk-Based Transportation Asset Management – Report 1*, June 2012

- Evaluating Risk; and
- Monitoring and Mitigating Risk.

Each description also briefly accounts NHDOT's current practice.

5.1.1 Identifying Risk

The Department has formally identified the risks that could affect its goal areas, including engagement with MPOs and other stakeholders (see section 2.4). Risks can range from external influences like construction price changes, legislative actions, economic changes, climatic events, seismic events, or malevolent acts. Risks also can be internal such as operational failures, data failures, conflicting internal program objectives, or a lack of trained personnel for key tasks. The Risk Register contains risks identified by staff at the asset, program, and Department levels.

NHDOT has identified risks for inclusion in the AMP and Risk Register through workshops with participation from different levels of seniority and different silos and by polling subject matter experts. The list covers both internal and external risks. The Department developed positive and negative risks but has not scored or prioritized positive risks.

Emergency events are considered broadly at the asset level as part of the Risk Register through the criteria described below. In addition, NHDOT has evaluated the impacts of emergency events at a site specific level at any location impacted more than once since January1, 1997 (23 CFR 667).Analyzing Risk

The Department has evaluated the probability of risk with its consequence. Risk was scored based on the likelihood of the event occurring multiplied by the impact of the event on safety, condition (damage to assets), geographic scope, mobility (disruption to travel), and financial value (additional cost). Bridge and Pavement subject matter experts used their engineering experience to develop these scores. The details of the scoring ranges are described in Section 5.3.

$$\textbf{Risk Score} = P \times [(S + C + G + M + F)/5] * 4$$

Where the following values of likelihood and consequence are scored 0-5 (The score is multiplied by 4 to achieve a hundred-point scale):

- P = Likelihood;
- S = Safety;
- C = Condition - degree of damage to assets;
- G = Geographic Scope;
- M = Mobility – degree of disruption to local and regional travel; and
- F = Financial Value.

The higher the risk score, the more important it is to develop a strategy or formalize an existing strategy to mitigate it. Section 5.3 provides detailed definitions of each category and each score.

Scores in the Risk Register were developed from a poll of bridge and pavement subject matter experts, and were refined through discussions with the AMPS Office and senior leadership at NHDOT.

5.1.2 Evaluating Risk

The Department will work to feed information and analysis from the Risk Register into its priority-setting and decision-making processes. As a part of this stage, NHDOT will assess its tolerance for risk in each category (asset, program, and Department) and how each risk varies across projects, investments, and regions. For instance, regular freeze/thaw damage is a risk the Department already mitigates through several processes, but these processes should be evaluated to identify potential improvements. They should also be documented to ensure the continuity of best practices.

The AMPS Office and subject matter experts will continue to develop a sense of risk tolerance through discussions with engineering staff. Through these discussions, the Department will further improve at integrating risk into prioritization and decision-making.

5.1.3 Monitoring and Mitigating Risk

The final stage in the process is to consider the mitigation or treatment options, which can be summarized as the "Five Ts": Treat, Tolerate, Terminate, Transfer, or Take advantage of the risk:

- **Treat:** Action will be taken to manage the risk;
- **Tolerate:** No action will be taken to manage the risk. Typically, this option is used when likelihoods and/or consequences are low, and the risk is monitored;
- **Terminate:** Action will be taken to eliminate the risk. Often, this option is unavailable or cost-prohibitive;
- **Transfer:** Action will be taken to shift the consequence or accountability of the risk to another party; and
- **Take Advantage**: In some cases, risks may create opportunity for the improvement of the system (e.g., outside funds become available).

Internal and external risk management communication processes should be identified and agreed upon. This allows information to flow up and down through the agency and externally with key stakeholders.

A complete discussion of the methods NHDOT uses to monitor and mitigate key risks is included in Table 5-3. Moving forward, the AMPS Office and other subject matter experts will continue to refine the Risk Register through discussions with engineering staff.

5.2 Risks

This section describes risks as they apply at the asset, program, and Department levels, defined as follows:

- **Asset Risks:** These risks involve damage to bridges and pavement and can pose a direct danger to travelers. Examples include weather (both extreme and routine), natural disasters, vehicle impacts and incidents, and impact damage to bridge and pavement resulting from the failure of other nearby assets;
- **Program Risks:** Affects NHDOT's ability to deliver projects and meet targets within a program. These may include organizational and systemic issues as well as revenue and economic uncertainties that in general cause projects to be delayed; and

- **Department (Strategic, Corporate) Risks:** These affect mission, vision, and overall results of the asset management program.

5.2.1 Asset Risks

The following risks are assessed and scored in the Risk Register. They are described here in greater detail, categorized by the source of damage to assets:

5.2.1.1 Weather

A. Pavement is damaged by frost.

B. Bridges are structurally damaged (immediate repair required) by frost.

Frost effects, such as frost heave and cracking caused by repeated freeze/thaw cycles, are an unavoidable consequence of the New Hampshire climate. These risks are certain to occur, and specific conditions in regions of the State or over a particular winter increase the scale and cost of necessary repair.

5.2.1.2 Natural Forces

C. Bridges are structurally damaged (immediate repair required) by floods and scour.

D. Pavement is damaged by floods.

Both bridges and pavement are undermined by floodwaters. While some deterioration due to scour is expected for bridges, floods or failure of flow management devices can unexpectedly increase its severity, necessitating repair. These incidents can also carry a significant risk to property and safety. As a result of climate change, the frequency and severity of flooding associated with severe weather events and, in coastal areas, compounded by sea level rise, is likely increasing.

5.2.1.3 Vehicles

E. Bridges or pavement are damaged due to overweight loadings.

F. Bridges are structurally damaged by ship crashes.

G. Bridges are structurally damaged (immediate repair required) by motor vehicle crashes.

H. Pavement is damaged by vehicle crashes (fire, contaminants).

Vehicle crashes can impact bridges and pavement both through structural damage caused by forceful impact, by fires, contaminants, and other secondary effects of the incidents. These incidents can also carry a significant risk to property and life safety.

5.2.1.4 Other Assets

I. Culverts or other drainage facilities fail (not due to flooding), damaging pavement.

J. Ancillary structures fail (overhead signs, water mains), excluding drainage, damaging bridges or pavement.

K. Retaining walls, slopes, or rock walls fail, damaging bridges or pavement.

L. ITS or traffic safety systems fail (signals), damaging bridges or pavement.

If an asset other than bridges or pavement suffers complete structural failure, it could either fall upon, undermine, or otherwise impact nearby bridges and pavement. These incidents can also carry a significant risk to property and safety.

5.2.2 Program Risks

The following risks are assessed and scored in the Risk Register. They are described here in greater detail, categorized by the source of uncertainty.

5.2.2.1 Program Risks Relating to Management Systems

M. Poor bridge and pavement deterioration modelling reduces NHDOT's ability to deliver bridge and pavement programs.

N. Poor data/information flow reduces NHDOT's ability to deliver bridge and pavement programs.

This set of risks concerns asset data. Asset management for bridges and pavement ideally involves treating deterioration when it is most economical to do so, before costly intervention is required to address critical deficiencies. If the Department fails to accurately predict condition, or if it fails to make the latest version of necessary data available to decision-makers and project managers, it could fail to address maintenance needs during the most cost-effective opportunities.

5.2.2.2 Program Risks Relating to Cost Increases

O. Unexpected variation in project costs (from project inception) reduces funds available for the bridge and pavement programs.

P. Unexpected costs of new technology reduce NHDOT's ability to deliver bridge and pavement programs.

Q. Limited contractor ability increases NHDOT's bridge and pavement costs or decreases the amount of bridge and pavement work bid.

Cost increases reduce the amount of funds within a program available to apply treatments. Cost increases can come from a variety of sources like scope creep, new technologies, or limited contractor availabilities. Some treatments may only be within the ability of one or two available contractors which limits bids and increases costs, a problem more likely to occur in small markets like New Hampshire, especially in the northern part of the State.

5.2.2.3 Program Risks from within NHDOT

R. Inaccurate cost estimates reduce NHDOT's ability to deliver bridge and pavement programs.

S. Poor project management (on time, budget, and scope) reduces NHDOT's ability to deliver projects.

T. Staff turnover reduces NHDOT's ability to deliver bridge and pavement programs.

While NHDOT is confident in its project management process, not every cost estimate, budget request, schedule, and scope will be perfect. Project planning issues can impact the budget twice – first when costs exceed what was planned, and again due to

opportunity when the Department must extend schedules, spend more time managing a project and forgo funding for other projects.

Staff turnover reduces NHDOT's ability to deliver bridge and pavement programs – it requires considerable investment for new hires to fully understand business processes.

5.2.2.4 Program Risks from the Federal Government

U. Federal officials mandate unfunded programs that reduce funds available for bridge and pavement program.

In addition to unfunded mandates, the Federal Government (i.e., FHWA) also can reduce States' flexibility to assign and match Federal Aid across their budgets. For instance, a portion of Federal Aid is passed through the Department, for management of recreation trails. If the required amount increases without an increase in Federal funding, it would change the Department's current budgeting scheme for bridge and pavement programs.

5.2.3 Department Risks

The following risks are assessed and scored in the Risk Register. They are described here in greater detail, categorized by the source of uncertainty.

5.2.3.1 Department Risks from Within NHDOT

V. Diversion of funds to high-profile projects reduces available funds for bridge and pavement programs.

W. Inflation in project costs (from project inception) effectively reduces available funds agency-wide.

X. Funding streams do not produce projected revenue.

While NHDOT has a mature project planning and management process, large projects present large challenges. Budget overruns, schedule delays, and increases in scope can all reduce the amount of funding available for the Department's overall program.

This set of risks also concerns prediction of overall costs and revenues. NHDOT tracks project cost inflation using the Construction Cost Index (CCI). While inflation is accounted for during project scoping and budgeting, the Department may not make accurate predictions. If construction costs rise across the board, the Department may not be able to fund all its commitments. Similarly, if NHDOT's funding mechanisms (e.g., State Road Toll, vehicle registration and licensure fees, tolls, etc.) produce less revenue than budgeted, the Department may not be able to fund all its commitments.

5.2.3.2 Department Risks from State Government

Y. State officials propose maintenance obligations/capital improvements for NHDOT without additional funding.

Z. Turnover in key legislative or oversight positions (Public Works/Governor and Council/Governor) reduces NHDOT's ability to operate effectively.

AA. State officials commit NHDOT to operating costs (benefits, raises, overtime) without additional funding.

NHDOT maintains a positive relationship with the legislature and makes a significant effort to communicate with elected and appointed officials. The Department collaborates with the Governor, Executive Councilors, and legislators to develop the biennial budget

and Ten Year Plan, both of which establish priorities for program and project investment. Nonetheless, a decision by any of those groups to propose maintenance obligations/capital improvements without additional funding would necessarily restrict the Departments ability to fully fund its other commitments. In addition, it takes time to bring new officials up-to-speed on the challenges and opportunities facing the Department.

5.2.3.3 Department Risks from the Federal Government

BB. Federal officials reduce funds across the board for transportation; and

CC. Failure to meet regulatory standards leads to reduced flexibility with funds (e.g., certification).

While the Federal Government has committed to a transportation reauthorization bill through 2021, it is still possible that overall funding levels will be reduced in the future, limiting NHDOT's ability to fund its capital projects. In addition, failing to meet the requirements of Federal legislation would hinder the State's ability to seek and use Federal funding for new and emerging projects.

5.2.3.4 Department Risks from Stakeholders and the Public

DD. Bridge and pavement performance is not adequately communicated or defended to stakeholders and the public.

EE. The State is obligated to spend resources on municipal assets that are of State significance.

FF. Stakeholder and public opinion on bridge and pavement performance is not adequately communicated to NHDOT.

A failure to communicate bridge or pavement performance can be either a failure to communicate pressing capital and maintenance needs, or a failure to communicate the effectiveness and impact of investments. Failure to obtain representative stakeholder and public opinion could lead to NHDOT failing to respond to it. Over the long term, this could harm public and official perception of the Department and reduce State investment in transportation.

Cities and towns in New Hampshire own and maintain both bridges and roads, including segments of the NHS. Municipalities may lack the funding and expertise to manage these assets sufficiently. In cases where significant municipal bridges and pavement have deteriorated critically, NHDOT may have to divert its resources to resolve the deficiencies.

5.2.4 Positive Risks

Many of the risks outlined in the sections above have a counterfactual positive risk. For example, consider the risk that federal funds are reduced. It is possible that federal funds could instead be increased through a special program (e.g., TIGER), new legislation (e.g., FAST Act), or redistribution. For NHDOT to efficiently handle such an increase, the Department must be prepared in advance. The Risk Register does not acknowledge these positive risks specifically – they have not been scored or prioritized – but NHDOT recognizes the need to address them moving forward.

5.3 Risk Register

The Risk Register for NHDOT drew from prior work performed by the members of the Department's consultant team for the Colorado, Florida, and South Carolina DOTs, among others. The first draft list of risks was drawn from these precedents, with the consultants and the Department customizing for NHDOT's unique challenges. Some risks (e.g., such as reductions in Federal funding, unfunded mandates, bridge scour, etc.) are common across States. Other risks (e.g., rock falls and landslides in Colorado, hurricanes in Florida) are more or less dependent on geographic regions. The most important of these State-specific risks in New Hampshire concerned freeze/thaw cycles and diversion of funds to high-profile capital projects.

The Risk Register was refined through discussions within NHDOT's asset management team. The Department also collected input from subject matter experts during a prioritization workshop attended by personnel from maintenance, finance, pavement, bridge, traffic and safety, and other groups that have some specific asset-related expertise. During the workshop, participants quantitatively assessed the likelihood of each risk as well as five elements of its consequence: Public Safety, Asset Condition, Geographic Scope, Mobility, and Finance.

Each of these six components was scored from 1 - 5 as described in Table 5-1. The metrics were combined into an overall score by averaging the consequences and multiplying by the likelihood, then by 4 to apply a 0 - 100 scale:

$$\text{Risk Score} = P \times [(S + C + G + M + F)/5] * 4$$

Table 5-1 Explanation of Scoring for Likelihood and Consequence of Risks

Score	Likelihood	Public Safety	Asset Condition	Geographic Scope	Mobility	Finance
1	Fewer than 1 instance over 10 years	No injuries (property damage only)	No direct asset damage or Deferred maintenance accumulates over 1 year	Damage (or reduction of funding) affects a single asset	Situation affects a small (neighborhood or town) number of travelers for a short time (hours)	Lowers transportation network value by < 1% or costs <$1M per year
2	Approximately 1 instance over 10 years	Possible injury or injuries	Direct asset damage requires minor repair or Deferred maintenance accumulates over 2 years	Damage (or reduction of funding) affects several co-located assets	Situation affects a small number of travelers for a moderate time (days)	Lowers transportation network value by < 2% or costs > $1M per year
3	Approximately 2 instances over 10 years	Non-incapacitating injury or injuries	Direct asset damage requires moderate repair or Deferred maintenance accumulates over 5 years	Damage (or reduction of funding) affects several assets in a small area	Situation affects a small number of travelers for a long time (month(s))	Lowers transportation network value by < 3% or costs > $10M per year
4	Approximately 5 instances over 10 years	Incapacitating injury or injuries	Direct asset damage necessitates closure or major repair or Deferred maintenance accumulates over 10 years	Damage (or reduction of funding) affects many assets on a road corridor, river segment, or larger area	Situation affects a large (multiple towns or metropolitan region) number of travelers for a short time (hours)	Lowers transportation network value by < 4% or costs > $25M per year
5	One or more instances per year (10 per 10 years)	Fatality or fatalities	Asset is unfit for service or destroyed or Deferred maintenance accumulates over more than 10 years	Damage (or reduction of funding) affects many assets across a region	Situation affects many travelers for a moderate time (days)	Lowers transportation network value by > 4% or costs > $50M per year

Table 5-2 Risk Register

	Risks	Likelihood	Consequence Scores					Overall Score
			Public Safety	Asset Condition	Geo. Scope	Mobility	Finance	
Asset Risks								
C	Bridges are structurally damaged (immediate repair required) by floods and scour.	5	5	4	2	2	2	60
A	Pavement is damaged by frost.	5	1	2	5	3	2	55
E	Bridges or pavement are damaged due to overweight loadings.	5	2	3	5	1	2	52
D	Pavement is damaged by floods.	5	2	4	3	2	2	51
I	Culverts or other drainage facilities fail (not due to flooding), damaging pavement.	5	2	3	1	2	2	40
F	Bridges are structurally damaged by ship crashes.	3	5	5	1	5	3	39
B	Bridges are structurally damaged (immediate repair required) by frost.	5	1	2	4	2	1	38
G	Bridges are structurally damaged (immediate repair required) by motor vehicle crashes.	5	2	4	1	2	1	38
J	Ancillary structures fail (overhead signs, water mains), excluding drainage, damaging bridges or pavement.	5	1	2	1	1	1	24
H	Pavement is damaged by vehicle crashes (fire, contaminants).	5	1	2	1	1	1	22
K	Retaining walls, slopes, or rock walls fail, damaging bridges or pavement.	3	2	3	1	2	1	21
L	ITS or traffic safety systems fail (signals), damaging bridges or pavement.	1	1	1	1	1	1	4

	Risks	Likelihood	Consequence Scores					Overall Score
			Public Safety	Asset Condition	Geo. Scope	Mobility	Finance	
Program Risks								
R	Inaccurate cost estimates reduce NHDOT's ability to deliver bridge and pavement programs.	5	2	2	3	2	3	44
M	Poor bridge and pavement deterioration modelling reduces NHDOT's ability to deliver bridge and pavement programs.	4	1	2	3	3	3	35
N	Poor data/information flow reduces NHDOT's ability to deliver bridge and pavement programs.	5	0	2	5	0	1	32
U	Federal officials mandate unfunded programs that reduce funds available for bridge and pavement program.	5	1	1	2	2	1	26
S	Poor project management (on time, budget, and scope) reduces NHDOT's ability to deliver projects.	4	1	2	3	1	1	23
T	Staff turnover reduces NHDOT's ability to deliver bridge and pavement programs.	5	1	1	2	0	1	20
P	Unexpected variation in project costs (from project inception) reduces funds available for the bridge and pavement program.	3	1	2	2	0	1	15
Q	Limited contractor ability increases NHDOT's bridge and pavement costs or decreases the amount of bridge and pavement work bid.	2	1	2	2	1	2	12
Department Risks								
Y	State officials propose maintenance obligations/capital improvements for NHDOT without additional funding.	5	0	2	5	0	3	40
V	Diversion of funds to high-profile projects reduces available funds for bridge and pavement programs.	5	0	2	5	0	3	40
Z	Turnover in key legislative or oversight positions (Public Works/Governor and Council/Governor) reduces NHDOT's ability to operate effectively.	4	0	1	5	1	3	32
DD	Bridge and pavement performance is not adequately communicated or defended to stakeholders and the public.	4	0	3	5	0	2	32
W	Inflation (CCI) in project costs (from project inception) effectively reduces available funds agency-wide.	4	0	2	5	0	2	29
EE	The State is obligated to spend resources on municipal assets that are of State significance.	5	0	0	5	0	2	28
AA	State officials commit NHDOT to operating costs (benefits, raises, overtime) without additional funding.	4	0	1	5	0	2	26

	Risks	Likelihood	Consequence Scores					Overall Score
			Public Safety	Asset Condition	Geo. Scope	Mobility	Finance	
BB	Federal officials reduce funds across the board for transportation.	4	0	1	5	0	1	22
CC	Failure to meet regulatory standards leads to reduced flexibility with funds (e.g. certification).	2	0	2	5	1	2	16
FF	Stakeholder and public opinion on bridge and pavement performance is not adequately communicated to NHDOT.	4	0	0	0	2	0	6
X	Funding streams do not produce projected revenue.	1	0	0	5	0	1	5

5.4 Monitoring and Mitigating Risk

Using this analysis, the Department can prioritize areas that need mitigation or contingency planning in the context of asset management efforts. Moving forward, NHDOT will continue to refine the Risk Register, and will use it to develop a sense of the Department's risk tolerance, as well as monitoring and mitigation strategies for the highest priority risks.

In general, monitoring and mitigation strategies can be summarized as the "Five Ts": Treat; Tolerate; Terminate; Transfer; and Take Advantage. Briefly, these can be defined as:

- **Treat:** Action will be taken to manage the risk;
- **Tolerate:** No action will be taken to manage the risk. Typically, this option is used when likelihoods and/or consequences are low, and the risk is monitored;
- **Terminate:** Action will be taken to eliminate the risk. Often, this option is unavailable or cost-prohibitive;
- **Transfer:** Action will be taken to shift the consequence or accountability of the risk to another party; and
- **Take Advantage**: In some cases, risks may create opportunity for the improvement of the system (e.g., outside funds become available).

It should be noted that many varieties of action may be considered to satisfy each definition above. While monitoring and mitigation are typically performed in advance as a preventive maintenance or response planning, some risks are also addressed after-the-fact. Common strategies for risk management include:

- Maintaining accurate and timely asset and financial data;
- Utilizing robust inspection programs that include both routine inspection as well as post-event inspections;
- Performing regular modelling of asset deterioration and response to various environmental scenarios;
- Using current and future asset condition, among other factors, to identify high-risk assets and locations;

- Performing mature project planning and management;
- Performing mature financial planning and management; and
- Communicating Department performance and financial needs to stakeholders, legislators, and the public, using data to make compelling and justifiable requests.

The fifteen risks identified as the highest-priority by NHDOT's collaborative scoring process are listed in Table 5-3. Addressing these risks will be the Department's focus in the immediate future as it builds a Risk Management Approach. Mitigations are documented in the right most column.

Table 5-3 Identified Mitigation Strategies for High-Priority Risks

Risk	Score	Owner	Mitigation
Bridges are structurally damaged (immediate repair required) by floods and scour.	60	Administrator of Bridge Design	In general, bridges are designed with scour protection. Scour critical bridges each have an individual plan. The plans provide recommended actions for bridges such as flood monitoring, increased inspection frequency and/or post flood inspection. Scour is monitored through inspections according to NBIS.
Pavement is damaged by frost.	55	Chief of Pavement Management	Pavement surfaces are kept sealed, reducing freeze/thaw damage, through preservation treatments and crack sealing on roads as appropriate.
		Administrator of Highway Maintenance	Certain roads may be posted during frost seasons to prevent escalation of freeze/thaw damage from heavy vehicles.
Bridges or pavements are damaged due to overweight loadings.	52	Chief of Pavement Management	High-strength pavement is used in known freight acceleration and deceleration lanes.
		Administrator of Highway Maintenance	The online permitting system for overweight and oversized loads is maintained.
Pavement is damaged by floods.	51	Administrator of Highway Maintenance	Drainage components are maintained and poor drainage is rehabilitated when funding is available. Ensure slope protection is in place and properly maintained. NHDOT will investigate designing drainage for longer storm events.
Inaccurate cost estimates reduce NHDOT's ability to deliver bridge and pavement programs.	44	Director of Project Development	Cost estimates are reviewed to identify problems throughout design phases. An Estimate Review Board (ERB) may also review estimates for potential issues. Cost histories will also be made more accessible to designers and decision makers through software improvements.
Culverts or other drainage facilities fail (not due to flooding), damaging pavement.	40	Chief of Specialty Section	NHDOT continues to develop an inventory of culverts and other drainage structures. The Culvert Management Committee develops and monitors prioritized programs for improvements.
State officials propose maintenance obligations/capital improvements for NHDOT without additional funding.	40	Director of Project Development	The Department communicates pavement and bridge needs when working with State officials to develop the budget and the Ten Year Plan. Competency level training will educate officials of when particular obligations may compete with existing bridge and pavement program priorities.
Diversion of funds to high-profile projects reduces available funds for bridge and pavement programs.	40	Director of Project Development	The Department communicates pavement and bridge needs when working with State officials to develop the budget and the Ten Year Plan. Communications throughout this process will highlight where diversion would reduce funds available for bridge and pavement programs.
Bridges are structurally damaged by ship crashes.	39	Chief of Existing Bridge Section	Fenders protect bridge components exposed to this damage type. Current design standards will be assessed to ensure protection is applied in all the

Risk	Score	Owner	Mitigation
			correct instances.
Bridges are structurally damaged (immediate repair required) by frost.	38	Administrator of Bridge Maintenance	Freeze/thaw damage is reduced by maintaining scuppers and joints and membranes reduce water flow into bridge decks.
Bridges are structurally damaged (immediate repair required) by motor vehicle crashes.	38	Chief of Existing Bridge Section	Height restrictions are posted on approaches to bridges with low elevations to reduce impacts to the superstructure. Substructures are typically protected using concrete barrier.

5.5 Assets Damaged by Successive Events (Part 667)

5.5.1 23 CFR Part 667 Requirements

Rulemaking for the asset management plan includes additional requirements regarding facilities that are damaged and require repair due to declared emergency events. These requirements are codified as 23 CFR Part 667 and require each state department of transportation to:

1. Identify the location of infrastructure repairs associated with emergency events that are declared by the governor or president since January 1, 1997;
2. Maintain the inventory of locations with every new declared event;
3. For any locations damaged more than once, identify the root cause of the vulnerability and develop a mitigation strategy; and
4. Incorporate the results of this evaluation into the project development process and the asset management plan.

The requirements are phased in over two periods with an evaluation of the National Highway System (NHS) due by November 23, 2018. The second period, beginning November 23, 2020 and covering the balance of the federal aid system, requires that NHDOT address item #3 (above) for any locations before developing projects in the vicinity of those locations.

5.5.2 Damage Catalog and Analysis

NH DOT maintains a GIS data layer of Transportation Infrastructure damaged by emergency events. This includes:

- Event date and description
- Type, location, and extent of infrastructure damage
- If the infrastructure is part of the NHS
- Nature of damage to infrastructure
- Project details to repair damaged infrastructure

Once an extent of infrastructure is identified as having been damaged by a declared emergency event, a spatial analysis is conducted to determine if that infrastructure had

been damaged previously by another declared event. This analysis is run at least once each calendar month to capture any changes or updates to the events data layer.

5.5.3 Locations of Successive Damage on the NHS

5.5.3.1 NH Route 9 in Roxbury

The analysis identified one location on the NHS, NH Route 9 in Roxbury NH. The area, approximately 1,200 feet north of Houghton Ledge Rd, was damaged in 2005 (DR-1610) and 2007 (DR-1695) when high flows in Otter Brook damaged the embankment and roadway.

A project (10439) was developed to address the embankment issues as well as other concerns along the corridor. Through the project development process various alternatives were evaluated for aspects including risk, cost, and environmental impact. As shown in Figure 5-1 the project included large stone riprap keyed several feet below the streambed to reduce the likelihood of future undermining. Completion of the project is anticipated in 2020.

Figure 5-1 Erosion Prevention Along NH 9 in Roxbury

6 Financial Plan

This chapter summarizes the flow of financial resources and funding mechanisms for NHDOT regarding asset management. Specifically, this chapter will describe the following:

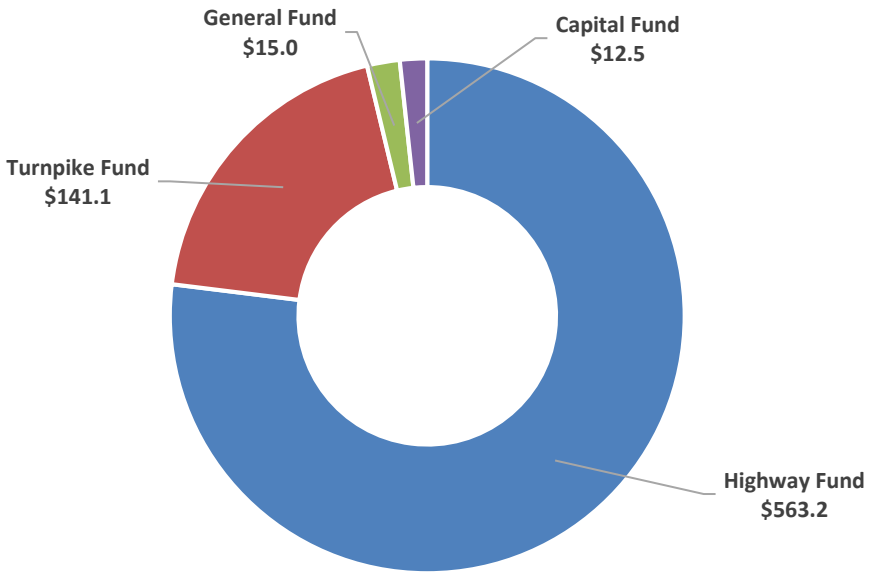
- **Revenue Acquisition:** Where does NHDOT's revenue come from, and in what amounts? How are different funding sources directed toward specific uses?
- **Funding for Highway Infrastructure:** What are the mechanisms for paying for highway and turnpike maintenance and construction, and how much has been distributed to these activities over time?
- **Revenue Distribution Process:** How does NHDOT decide where money allocated for highway and bridge construction and maintenance is applied? What documentation and reporting occur on these processes?
- **Future Funding Levels:** What are the projections for future funding beyond FY2018, and how are they generated?
- **Asset Valuation Process:** How is NHDOT going to estimate the replacement cost of their assets?

NHDOT's overall financial portfolio as stated in this document comes from the Statement of Appropriations for the State of NH and follows the State fiscal year. This portfolio is subdivided into four individual pools of funds. These funds do not conform to modes, types of assets, or to the tiering system. Rather, they reflect the way financial resources flow throughout the Department. They include:

- **General Fund:** The General Fund is reserved for non-highway functions of NHDOT (aeronautics, rail, and transit). Its revenues are primarily restricted grants from several Federal modal agencies.
- **Highway Fund:** A portion of the Highway Fund flows to NHDOT and supports construction, maintenance, and operations of NHDOT's highways, including pavement and bridges. Its primary sources of revenue are the State Road Tolls (gas tax), driver fees, such as vehicle registration, and Federal-Aid programs. The Highway Fund also covers expenses that are mandated by the Legislature for NHDOT, primarily municipal aid, debt service and including labor costs (e.g., salaries, salary increases, healthcare coverage, benefits, and overtime).
- **Turnpike Fund:** The Turnpike Fund exclusively supports capital, operations, maintenance and debt service spending on the New Hampshire Turnpike System. Its primary source of revenue is tolls from Turnpike users, collected and managed by NHDOT's Bureau of Turnpikes.
- **Capital Fund:** The Capital Fund represents State of New Hampshire General Obligation bonds that support a limited number of non-Highway NHDOT construction and other projects.

The size of these funds in FY2018 revenue is illustrated in Figure 6-1.

Figure 6-1 FY2018 Revenue for NHDOT Funds (millions)



Source: NHDOT Annual Report and Statement of Appropriations (2018)

6.1 Revenue Acquisition

In FY2018, NHDOT received approximately $732 million in revenue. Of that total, approximately $704 million accumulated in the Highway Fund and the Turnpike Fund; those dedicated to highways, pavements, and bridges. For both funds, overall revenue falls into three categories:

- **Unrestricted revenue within each fund** can be apportioned at the discretion of NHDOT with the approval of the New Hampshire Legislature to any operations or construction use at any location (in practice, this funding is used almost exclusively for operating costs). Unrestricted revenue is entirely generated from State-administered tolls, fines, taxes, and user fees. The amount available to NHDOT is calculated by subtracting the following:
    - *Revenue that is apportioned or transferred* is either designated for a non-NHDOT use by statute (e.g., Apportionment A/B municipal aid funds[7]) or is used to pay the operating budget of a sister agency – i.e., Department of Safety (DOS). A portion of the DOS operating budget is paid for by the Highway Fund.
    - *Debt service* from each fund is designated by the terms of the bond or loan.
- **Restricted revenue** can be applied within each fund only where allowed by rules and conditions. Restricted revenue covers most construction and maintenance activities on NHDOT's highway system and turnpikes. All Federal Aid and

[7] According to New Hampshire Statute RSA 235:23, 12 percent of gross total highway revenues from the prior year ("Apportionment A") are reserved for distribution in the State Highway Block Grant Aid program for municipalities. A much smaller "Apportionment B" is set at $400,000 annually. Apportionment A funds are distributed among municipalities according to population and high-capacity road mileage. Apportionment B funds are distributed using discretion among municipalities with high roadway mileage and low property value (and therefore low municipal revenues). Because the Apportionment B pool is so small, "Municipal Aid Apportioned" in this document is taken as 12 percent of revenue.

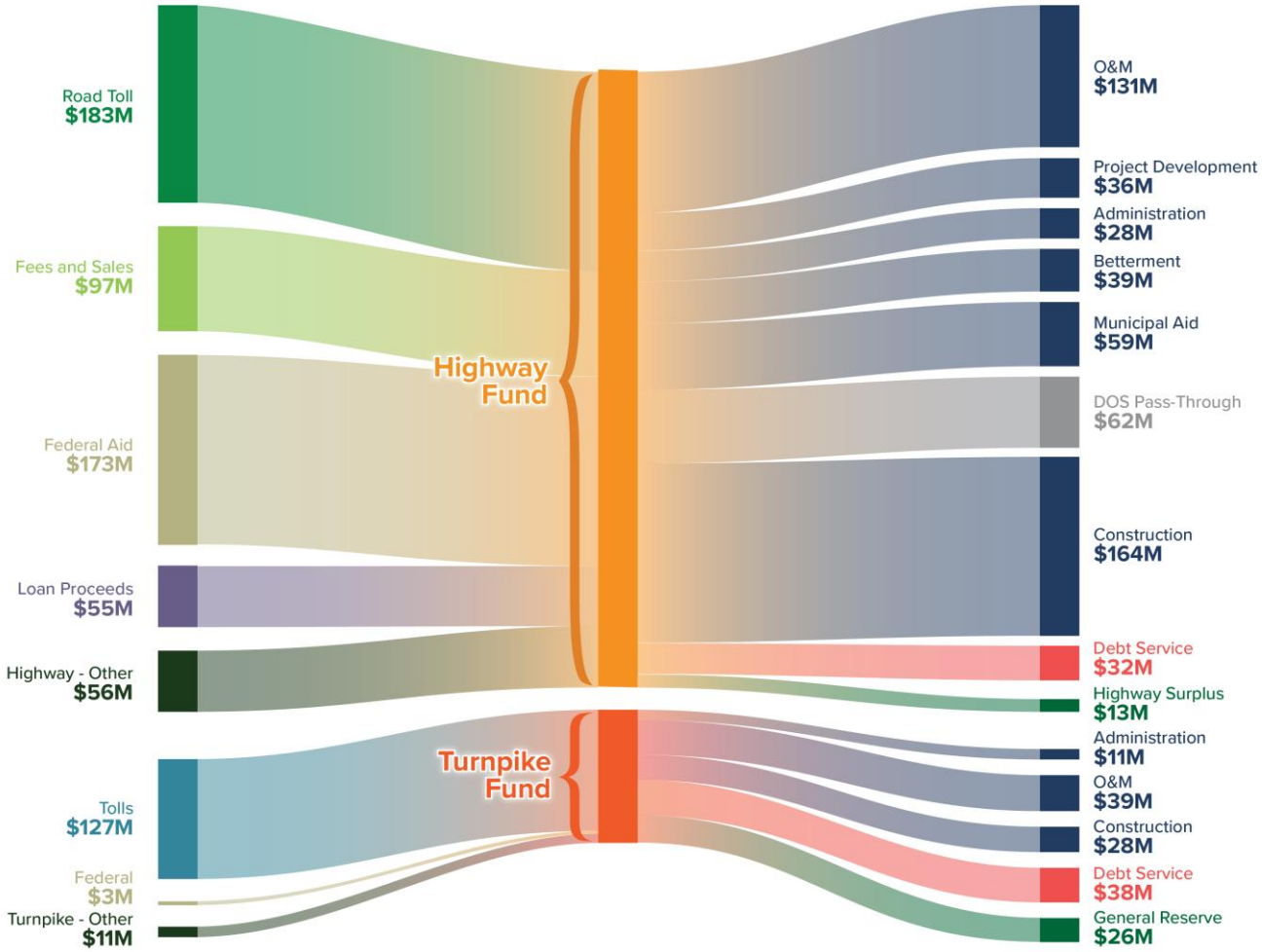
unrestricted turnpike funds, as well as some limited State, local, and private funds fall into this category.

- **Bonds** are issued with the authority of the State Legislature. These funds are restricted, but are accounted for separately.

The Highway Fund collects approximately equal amounts of restricted and unrestricted revenue. However, once apportionments, transfers, and debt services are subtracted from NHDOT revenue, the majority of the Highway Fund available to NHDOT is from restricted sources. For the Turnpike Fund, a much larger share of revenue is unrestricted, reflecting the fact that toll revenue is unrestricted.

Figure 6-2 shows the flow of funds based on the FY2018 Legislative Budget and rounded for clarity. Revenue sources appear on the left edge of the diagram, and the flows are colored by source throughout. Programs appear in the center, grouped into the separately administered Highway and Turnpike funds. The right edge of the diagram illustrates the general purposes of Department spending, independent of fund or highway system, using accounting categories consisting of groups of related programs.

Figure 6-2 Flow of Funds (millions) through NHDOT in FY2018



Source: NHDOT Annual Report and Statement of Appropriations (2018)

It should also be noted that the Highway Fund's revenue is collected by Departments other than NHDOT – DOS, Road Toll Bureau collects the road toll and DOS, the Division of Motor Vehicles collects Fees and Sales. In FY2019, the cost of collection is budgeted at $30 million, of which $3.5 million (0.3 cents per gallon of the Road Toll) is reserved for the Road Toll Bureau.

6.1.1 State Road Toll (State Gas Tax)

New Hampshire's State Road Toll is currently set at $0.222 per gallon of fuel, and can only be modified through an act of the State Legislature. It is collected by the DOS from fuel providers upon delivery of fuel to service stations. In addition to the Road Toll, New Hampshire gasoline taxes include an additional $.0163 for environmental remediation related to oil discharge, spillover, and cleanup, for a total of $0.2383 per gallon. These additional assessments are not accounted by NHDOT.

A portion of the Road Toll is restricted as detailed below, with the remaining portion unrestricted and available for appropriation by the Legislature to fund operating costs.

- Per RSA 235:23 12 percent of the gross road toll revenue (2.7 cents) and motor vehicle fees collected in the preceding fiscal year are distributed to municipalities.
- After the 12 percent municipal aid is removed, per RSA 235:23-a, 2.6 cents of the New Hampshire Road Toll is deposited in the State Highway and Bridge Betterment Account.
- Per RSA 260:32-a and b; and as amended in Chapter 276:210 Laws of 2015, after the 12 percent for municipal aid is removed, 3.7 cents is restricted for I-93 project debt service, and other state construction priorities.
- Accordingly, of the overall 22.2 cent/gallon NH Road Toll, the rate of 12.9 cents is available for appropriation to cover Operating Costs.

6.1.2 Fees and Sales

Most of motor vehicle fees and sales come from registration fees collected by DOS. The sales revenue come from proceeds from the sale of vehicles owned by NHDOT and NHDOS to outside buyers. As with the road toll, the size of each fee is determined through legislative action. Twelve percent of fees and sales are apportioned to municipal aid.

6.1.3 Tolls

Tolls on New Hampshire's three turnpikes are collected by NHDOT's Bureau of Turnpikes. Toll revenue includes both cash collected at toll plazas, as well as electronic collections through the E-ZPASS system that are managed by a NHDOT contractor. Toll revenue is primarily used to construct, operate, and maintain the turnpikes. In addition, a share of this revenue covers administrative costs of the tolling program, as well as bureau operations, some operations of related agencies (e.g., DOS), and rest area/welcome center maintenance. Any changes to toll rates are approved by the Governor and Executive Council and the Legislature controls the location and number of toll collection facilities.

6.1.4 Other Unrestricted Revenue

Unrestricted revenue not drawn from the above sources includes motor vehicle fines collected by the New Hampshire Judicial Branch for the Highway Fund and proceeds from the sale of property.

6.1.5 Federal Aid

All Federal Aid allocated to NHDOT is restricted. Most aid falls into the "consolidated Federal Aid" category, which is available for use only on the Federal Aid Highway System or on programs designated by FHWA. Broad program areas funded by Federal Aid allocation include:

- Individual Projects in the TYP and the STIP, often to improve safety and mobility.
- Pavement and bridge preservation, preventative maintenance, and rehabilitation.
- Interstate 93 Widening and Reconstruction.
- Federal Programs (e.g., congestion mitigation, air quality, safety).
- Engineering (e.g., general engineering services unrelated to a specific project).
- Debt Service.

6.1.6 Other Restricted Revenue

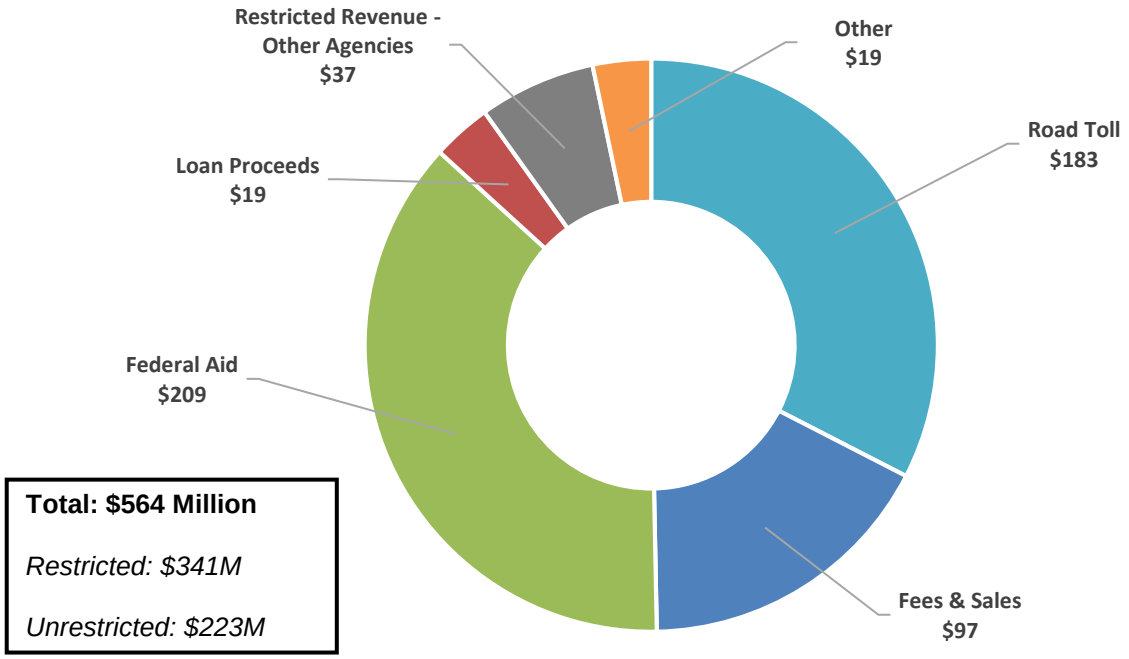
Restricted revenue not drawn from Federal Aid includes the following major sources:

- **Revolving Funds** that take in user fees for a specific program, with the proceeds to be spent on that same program.
- **Private and Local Funds** that are directed for specific uses but are accounted for in the Highway Fund.
- **Interagency Transfers** are generally reimbursements for work performed or services rendered by NHDOT.
- **Agency Income** that is directed for specific uses, including ROW property sales.

6.1.7 Overall Distribution of Revenue

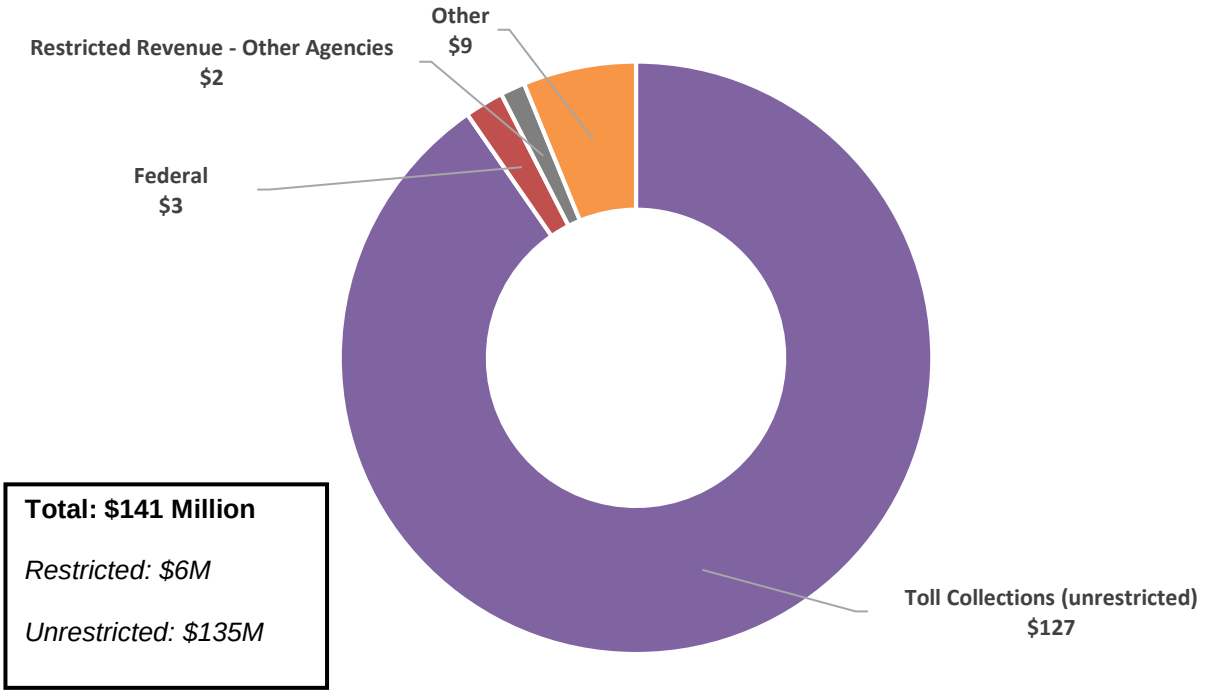
Figure 6-3 and Figure 6-4 show the FY2018 distribution of revenue among these categories for the Highway and Turnpike Funds, respectively.

Figure 6-3 Highway Fund Revenue (FY2018) by Restriction (millions)



Source: NHDOT Annual Report and Statement of Appropriations (2018)

Figure 6-4 Turnpike Fund Revenue (FY2018) by Restriction (millions)

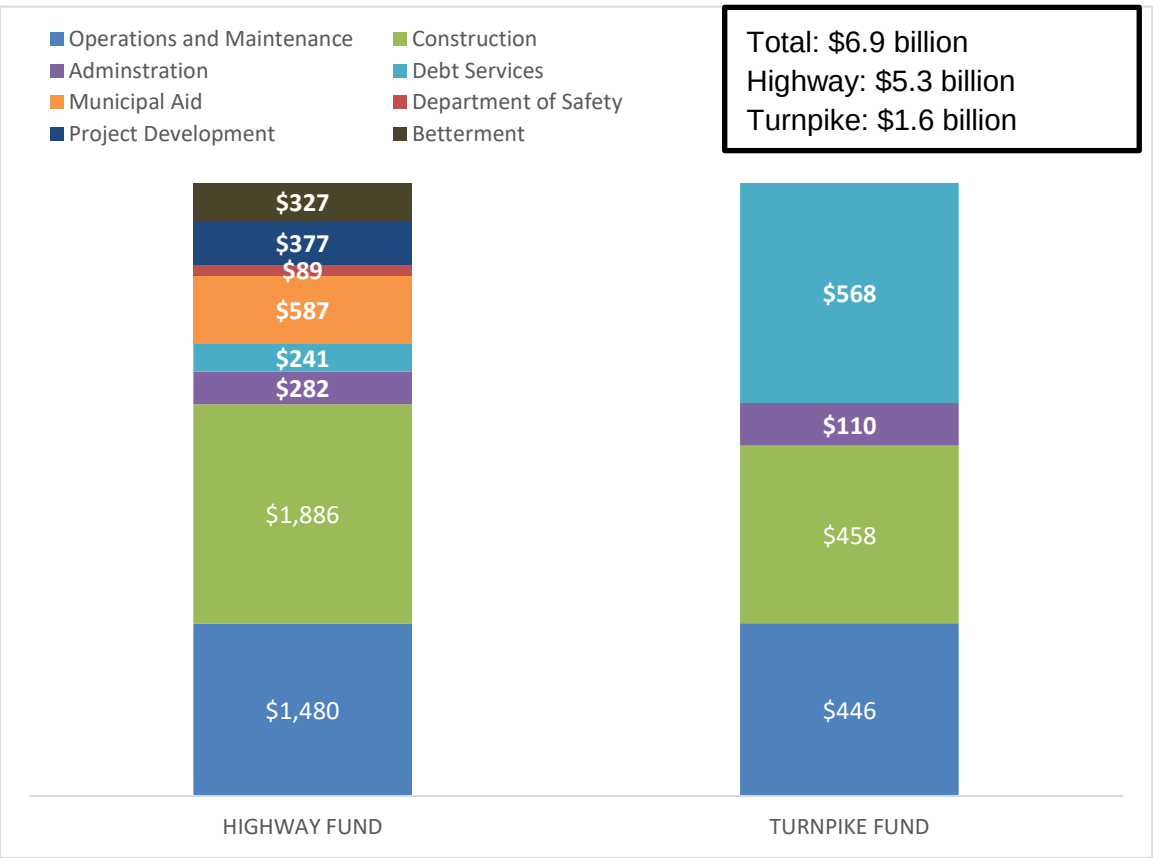


Source: NHDOT Annual Report and Statement of Appropriations (2018)

6.2 Investment in Highway Infrastructure

Over the decade from 2009 to 2018, NHDOT spent approximately $6.9 billion (2019$[8]) from the Highway Fund and approximately $1.6 billion (2019$) from the Turnpike Fund. Figure 6-5 illustrates the general distribution of these funds, using accounting categories consisting of groups of related programs. Due to inflation, the historical dollars were adjusted into constant dollars to compare the purchasing power of historic and current dollars.

Figure 6-5 Distribution of NHDOT Funding, 2009-2018 (2019$ millions)



Source: NHDOT Annual Reports and Statement of Appropriations (2009-2018)

Expenditures for the Operations Budget (i.e., Operations and Maintenance, Project Development, and Administration) totaled approximately $2 billion for highways and $0.5 billion for Turnpikes between 2009 and 2018. Expenditures for the Construction Budget totaled approximately $1.8 billion for highways and $0.39 billion for Turnpikes over that period.

The general categories in Figure 6-5 account for numerous funded programs within NHDOT (the transfers include programs in DOS). A subset of these programs addresses construction and maintenance of pavement and bridge assets. The remainder of this section assesses the ten-year trend and next three years for the categories of investment in Figure 7-5, using the same dataset.

[8] Inflation to 2019 dollars was calculated using annual average Consumer Price Index for All Urban Consumers (CPI-U) for all metropolitan areas in the United States, taken in January of each year. The selection of nationwide CPI-U was intended to reflect the general inflation of the dollar, as opposed to the specific buying power of the Department. Projections for future years were discounted at a 2 percent New Hampshire Gross State Product (GSP) growth rate.

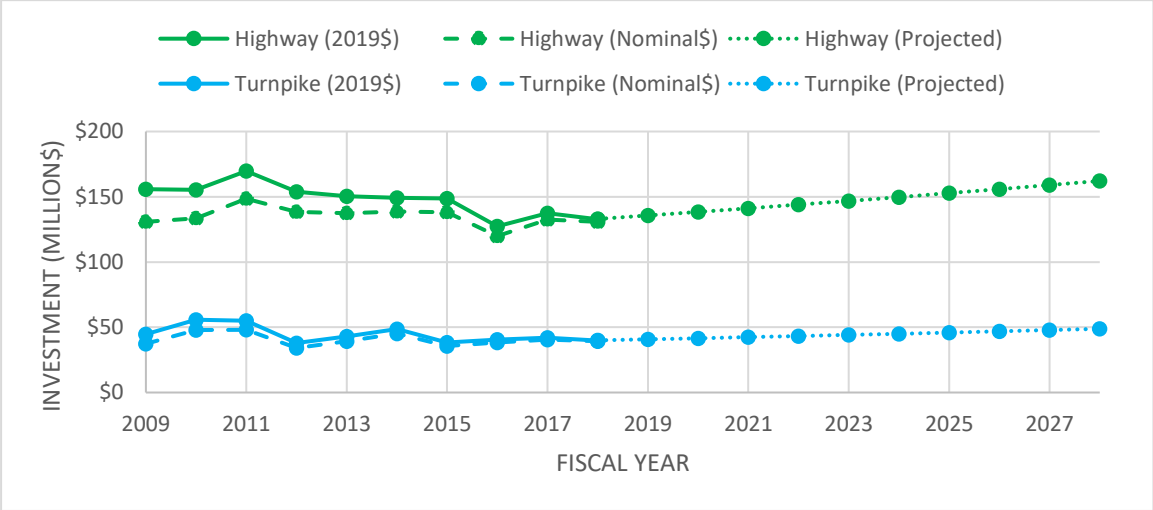
6.2.1 Investment in Operations and Maintenance

Functions supported by investments in Operations and Maintenance include:

- **Operations:** Operations include non-construction strategies for maintaining system performance (i.e., mobility and safety) of the system's assets. Activities that optimize performance and existing capacity include service patrols, incident management, bridge posting, signal operations, winter plowing, toll collection, and Transportation Systems Management and Operations (TSMO), and
- **Maintenance:** Maintenance is defined as repair and upkeep of NHDOT System assets (e.g., bridges, pavement, facilities, and equipment). The goal of maintenance is to retain these assets in a condition as near as possible to the condition of their initial construction or subsequent improvement. Maintenance includes preservation. Examples include mowing, cleaning bridges, and pothole patching.

Historic, adjusted, and projected investment in Operations and Maintenance from the Highway and Turnpike Funds is shown in. The historic data was gathered from NHDOT budget reports and Statement of Appropriations (SOA) for the stated years and adjusted for inflation to reflect 2019 dollars. Assuming future investments in operations and maintenance remain flat, the projected investment for years 2019-2028 was estimated by applying a constant annual growth of 2 percent to the base year to account for inflation.

Figure 6-6 Investment in Operations and Maintenance



Source: NHDOT Annual Reports and Statement of Appropriations (2009-2018)

6.2.2 Investment in Project Development

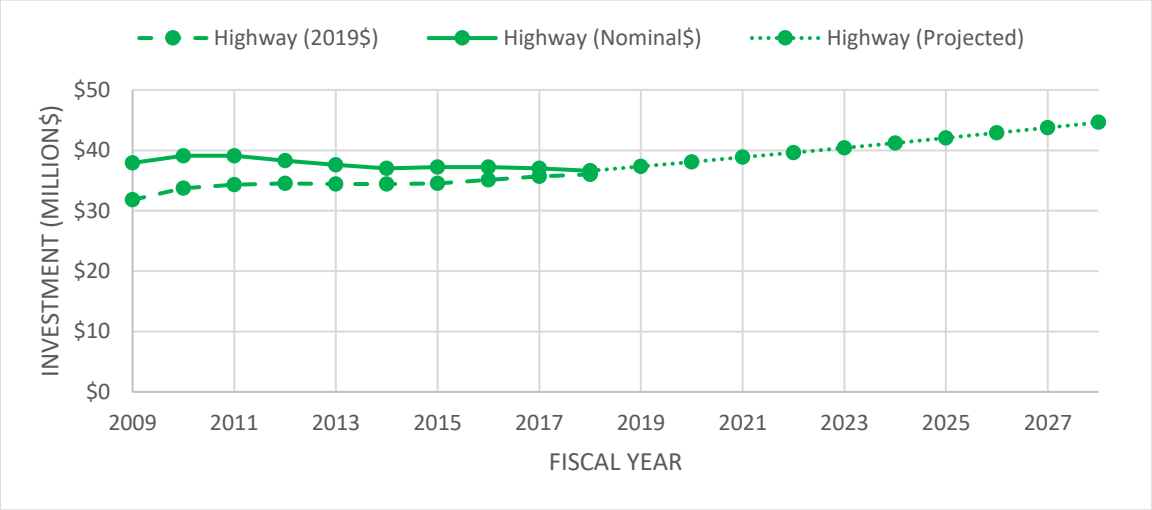
Functions supported by investments in Project Development include:

- **Engineering:** Engineering includes professional services related to planning, designing, and inspecting transportation assets. Examples include engineering plan reviews, right-of-way incidentals, preliminary design, track inspections of privately-owned railroads, and geotechnical and environmental investigation; and
- **Acquisition:** Acquisition includes activities related to the management, purchase, transfer, or sale of assets owned by the NHDOT or on behalf of other entities.

Historic, adjusted, and projected investment in Project Development from the Highway Fund is shown in Figure 6-7. Assuming future investments in Project Development

remain flat, the projected investment for years 2019-2028 was estimated by applying a constant annual growth of 2 percent to the base year to account for inflation.

Figure 6-7 Investment in Project Development (Highway Only)



Source: NHDOT Annual Reports and Statement of Appropriations (2009-2028)

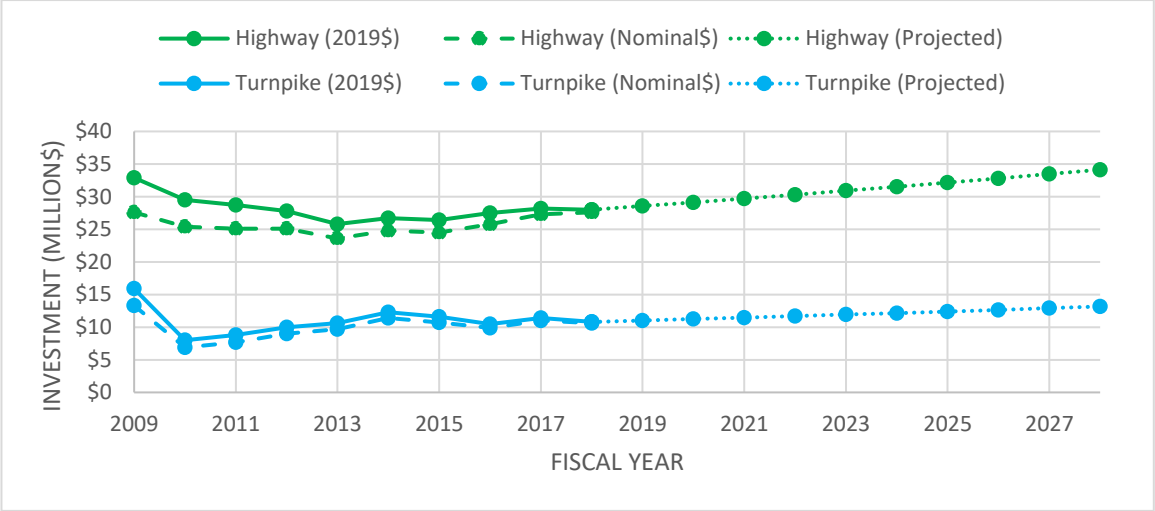
6.2.3 Investment in Administration

Functions supported by investments in Administration include:

- **Administration:** Administration includes all activities performed by the Commissioner's Office, the Division of Finance, and Division of Policy and Administration, and the administration of the Turnpike System. These areas work to define, create, enforce, and communicate strategic objectives, rules, and regulations across the Department. This includes communication and coordination internally within NHDOT and externally to legislative, public, private, and federal entities; and are included with the Indirect Cost Allocation Plan (ICAP).
- **Workforce Planning and Development:** Workforce planning is the process used by NHDOT to address the Department's competencies against its current and future needs. The program is used to build the competencies of the individuals within the organization and to recruit new entrants with needed competencies to meet current and future needs of the organization. Examples include conducting and attending training, safety and health protection activities, and the HR classification process.

Historic, adjusted, and projected investment in Administration from the Highway and Turnpike Funds is shown in Figure 6-8. The projected estimates were derived using the same assumptions in the previous sections.

Figure 6-8 Investment in Administration



Source: NHDOT Annual Reports and Statement of Appropriations (2009-2018)

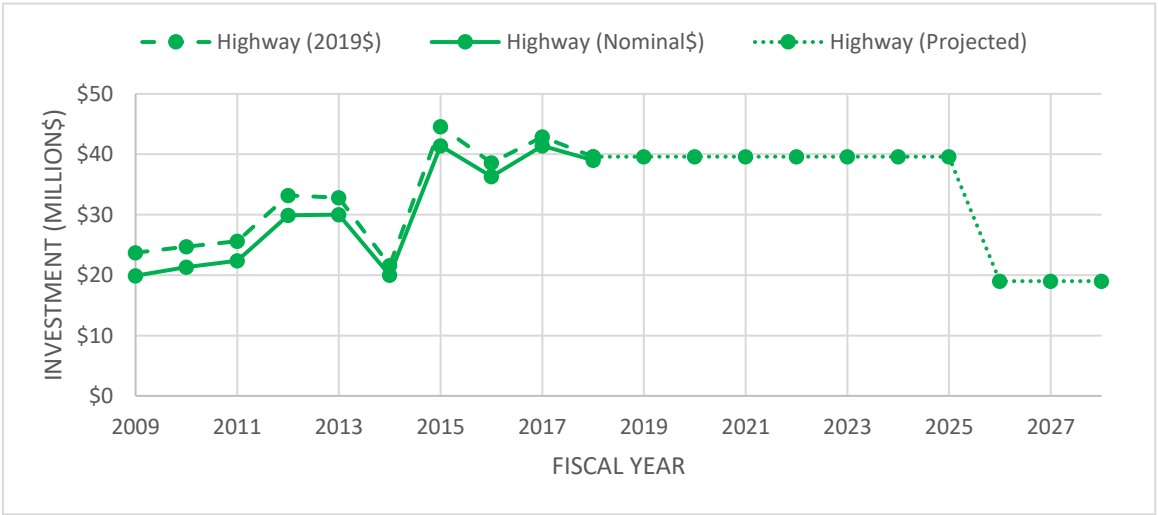
6.2.4 Investment in Betterment

The State Highway and Bridge Betterment Account ("Betterment") is used for small capital projects or for maintenance. These funds are intended to ensure adequate maintenance and improvement of the portion of the State highway system that is not supported by Federal Aid (i.e., lower tiers of roadway). In some cases, these funds are expended on federal aid roads because federal funds are insufficient. Activities covered by Betterment include highway construction, reconstruction, resurfacing, highway maintenance, bridge construction, bridge reconstruction, and bridge maintenance.

In 2014, the New Hampshire Legislature enacted Chapter 17 Laws of 2014 (SB367). SB367 addressed several transportation issues as well as approving to raise the Road Toll by 4.2 cents per gallon. A portion of the additional funds generated through SB367 have been dedicated to betterment activities on rural roads. Beginning in 2026 those, funds approximately $21M annually, will instead be used to pay back debt service on TIFIA financing for the I-93 improvement project.

The Turnpike Fund does not support Betterment. Historic, adjusted, and projected investment in Betterment from the Highway Fund is shown in Figure 6-9.

Figure 6-9 Investment in Betterment



Source: NHDOT Annual Reports and Statement of Appropriations (2009-2028)

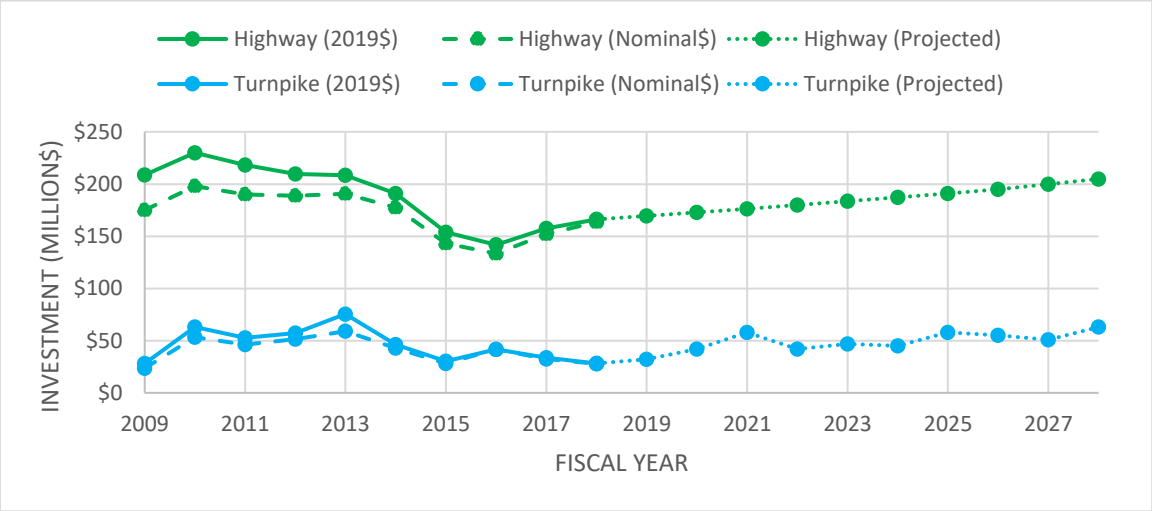
6.2.5 Investment in Construction

As an investment category, Construction includes activities that fall under the construction function when performed on State-owned assets. These activities include the work to build or create assets (e.g., roads, bridges, and facilities) excluding engineering. Construction includes adding capacity, replace-in-kind, toll equipment upgrades and rehabilitation work. Examples of construction activities include: roadway widening, installing new drainage, and bridge rehabilitation.

In May 2016, NHDOT successfully negotiated a Transportation Infrastructure Finance and Innovation Act (TIFIA) Loan. Under the TIFIA loan, NHDOT is expected to receive additional funding (approximately $200 million), beginning in 2016 for the expansion of I-93.

Historic, adjusted, and projected investment in construction from the Highway and Turnpike Funds is shown in Figure 6-10. Funding in this category for Highway is expected to increase because of the TIFIA loan.

Figure 6-10 Investment in Construction



Source: NHDOT Annual Reports and Statement of Appropriations (2009-2028)

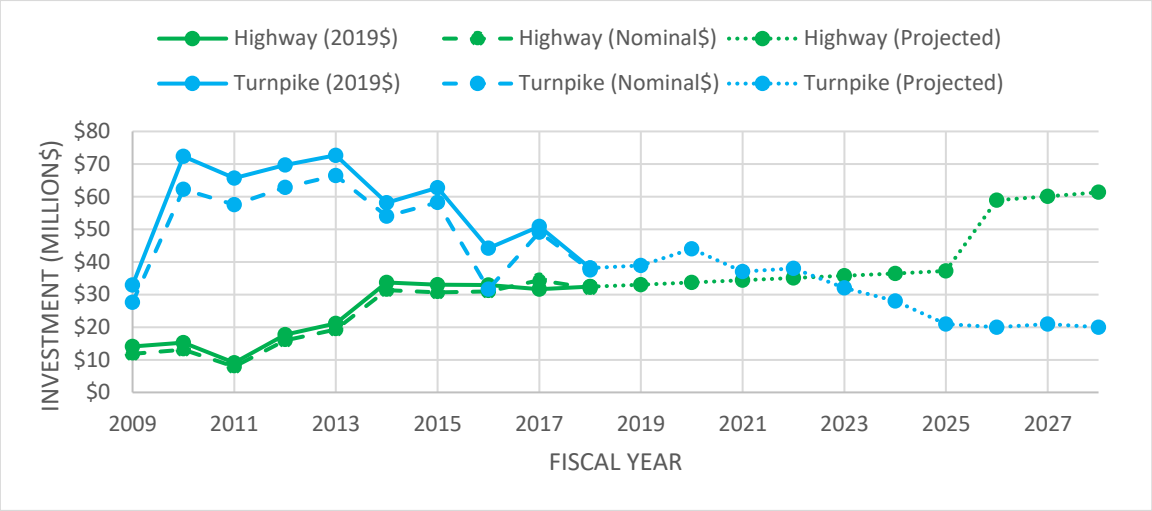
6.2.6 Investment in Debt Service

Debt Service from the Highway Fund is on General Obligation (GO) and GARVEE bonds, as well as the TIFIA loan issued on behalf of the Department. The GO bonds fund the construction of sheds and maintenance facilities, underground storage tank replacement, software and equipment upgrades, energy efficiency improvements, and various other needs while the GARVEE and TIFIA loan are used for road and bridge construction projects, namely the I-93 Salem to Manchester project.

In the 2008-2009 biennium, it was clear that Highway Fund Revenue was insufficient to cover the required State match to Federal Aid. The Legislature authorized a $60M GO bond to match the Federal Aid Program and advance construction on Municipal Bridges.

Turnpike Debt Service is on revenue bonds and general obligation bonds to support the 10-year highway construction and reconstruction plan for the Turnpike System authorized by the Legislature. Also included is debt associated with the acquisition of a portion of I-95 by the Turnpike System. Historic, adjusted, and projected investment in Debt Service is shown in Figure 6-11.

Figure 6-11 Investment in Debt Service



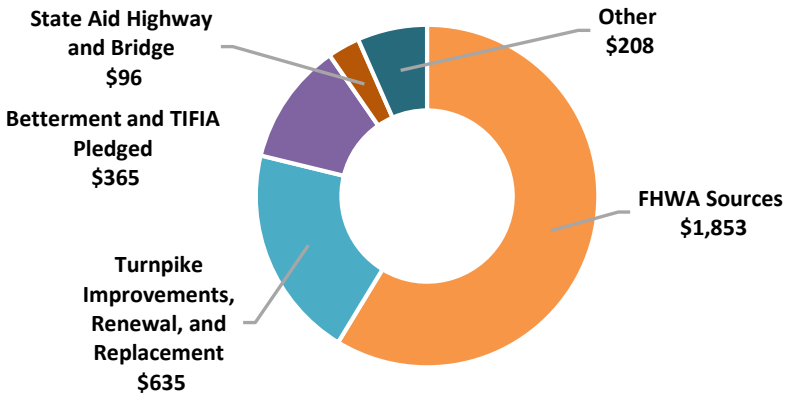
Source: NHDOT Annual Reports and Statement of Appropriations (2009-2028)

6.3 Revenue Distribution Process

NHDOT's approach to highway infrastructure financing moving forward is reflected in the Department's TYP and STIP. The TYP is a mid-term (10-year) capital plan – investment in maintenance, operations, administration, etc. are not addressed. Highway infrastructure financing in the TYP is provided by four (or five including "Other Matching Funds") primary programmatic sources, with Federal Aid being the largest. The distribution is illustrated in Figure 6-12. The STIP is a short-term (four-year) plan that includes projects with federal funds and those that have been deemed regionally significant. Projects generally flow from the TYP into the STIP and both are updated on a biennial basis.

The development of these plans considers many risks regarding revenue and costs for NHDOT. While revenue streams for NHDOT are fairly well-established, there exists a level of inherent uncertainty associated with projections. This is particularly true for Federal Aid. Further, costs inflate over time and can vary in response to external economic factors. The Risk chapter addresses these issues in detail.

Figure 6-12 Distribution of Revenue for Highway and Bridge in the 2019-2028 TYP (millions)



Source: NHDOT Ten Year Plan (2019-2028)

6.3.1 Development of the TYP

The TYP is updated every 2 years, serves as the basis for the vast majority of the capital investments in New Hampshire, and is required by state law.

The TYP is part of the coordinated and continuous planning process in New Hampshire. The process begins with input from the RPCs and MPOs in New Hampshire. The MPOs utilize their long-range transportation plans and public processes to identify projects for consideration in the TYP. The NHDOT evaluates the projects identified by the RPCs and MPOs along with system needs of state-wide significance, including system preservation, congestion, and safety to develop a draft TYP. The draft TYP is reviewed at various public hearings around the state as part of a review by the Governor's Advisory Commission on Intermodal Transportation (GACIT). After the GACIT review, the TYP is considered by the Governor and the Legislature with the final step being proposed as state law and signed by the Governor.

6.3.2 Development of the STIP

The STIP is required by federal law for most projects receiving federal aid from both FHWA and the Federal Transit Administration (FTA) as well as for any projects that are considered regionally significant. The STIP is updated every 2 years following the update to the TYP through a collaborative process with the four MPOs in NH.

Programs and projects identified in the STIP are closely connected with performance expectations and requirements of the transportation system. Programs for the maintenance and preservation of pavements and bridges, including those on the NHS, are identified and in the STIP. Also included are the Highway Safety Improvement Program (HSIP), Congestion Mitigation and Air Quality Program (CMAQ), and other programs and funding sources (NHPP) with strong connections to FHWA performance measures. These programs are developed in consideration of system performance, risk, and lifecycle discussed in earlier chapters.

6.3.2.1 Toll Credits

For the past ten years, NHDOT has replaced the state match for federal projects dollars with turnpike toll credits. Federal law allows states to use construction spending on their turnpike systems to offset the state matching funds normally required for federal projects. This effectively reduces the funds available for capital projects in New Hampshire.

6.4 Future Funding Levels

Each TYP and STIP update requires NHDOT to consider forecasted funding scenarios. There are key elements to each:

- Projection of available Federal Aid (and State matching funds), and
- Projection of available State highway and turnpike revenues.

These projected elements were recently based upon the following methodology:

- **Federal Aid** was estimated based on trends observed in the behavior of the FHWA and the US Congress. Under current funding conditions, Federal Aid funding is typically projected to remain flat. Matching funds for projects are not projected to be available throughout the Ten Year Plan, necessitating the use of Toll Credits and effectively reducing the number of projects that can be funded with Federal Aid. In addition, a portion of indirect costs for administration also are

reimbursed from Federal Aid. Should Federal Aid be reduced, projects may be delayed.

- **State Funds,** including all state revenue sources (State Road Toll, Fees and Sales, etc.), was estimated by DOS by projecting traffic volume and the price of gasoline over ten and twenty-year study periods. These forecasts were used to project the State Road Toll (gas tax). Some other State Funds is set by statute and is forecast as stable over time.

NHDOT then allocates the anticipated funding across pavements, bridges, and other assets, taking into account the forecasted needs and the relative investment priorities. The anticipated funding needs to achieve the SOGR for NHS pavements and bridges is described in sections 7.1.3 and 7.1.5. The priorities for investment in those assets by work type are described in sections 7.1.2 and 7.1.4. Table 6-1 and Table 6-2 illustrate the planned investments included in the approved TYP.

Table 6-1 Bridge Ten Year Plan Future Funding Levels (Millions)

	Asset Strategies	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Avg.
HIB	Maintenance & Preservation	$9	$9	$5	$3	$3	$3	$3	$3	$3	$3	$4
	Rehabilitation & Reconstruction	$20	$17	$17	$0.3	$6	$10	$8	$15	$13	$16	$12
Tier 1 & 2	Maintenance & Preservation	$8	$8	$8	$8	$8	$8	$8	$8	$8	$8	$8
	Rehabilitation & Reconstruction	$28	$33	$32	$15	$15	$6	$14	$2	$20	$9	$17

Source: NHDOT Ten Year Plan (2019-2028)

Table 6-2 Pavement Ten Year Plan Future Funding Levels (Millions)

	Asset Strategies	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Avg.
Tier 1	Maintenance & Preservation	$12	$13	$13	$13	$13	$13	$13	$13	$13	$13	$13
	Rehabilitation & Reconstruction	$5	$5	$10	$7	$4	$4	$16	$11	$0	$0	$7
Tier 2	Maintenance & Preservation	$21	$21	$21	$21	$21	$21	$21	$21	$21	$21	$21
	Rehabilitation & Reconstruction	$0	$4	$4	$3	$3	$3	$3	$3	$3	$3	$3

Source: NHDOT Ten Year Plan (2019-2028)

6.5 Asset Valuation Process

In contrast to a more standard approach (such as GASB), NHDOT selected an asset valuation process which incorporates the condition of our assets. This approach enables the Department to use valuation as a way to monitor or express the current health of our pavements and bridges. These condition-based approaches will also provide a tool to evaluate the effectiveness of future investment scenarios and condition forecasts once they are developed. Finally, asset valuation provides a mechanism to convey the significance of the transportation system to the public and decision makes as well as to do so using a unit (dollars) which is familiar to everyone.

6.5.1 Pavement Valuation

NHDOT values its pavements in three component layers: base, structure, and surface. Not every road segment is comprised of all three layers – roads that are "unbuilt" have no structure, and NHDOT assumes that some additional roads have lost their structure based upon their ride quality as measured by the International Roughness Index (IRI).

Figure 6-13 (next page) breaks down all of the assumptions and values used in computing the value of a segment of pavement, but in general the layers are handled as follows (all values vary by highway tier):

- Base | The value of the base is calculated as difference between observed 2014 average reconstruction and rehabilitation costs, as the former replaces all layers and the latter only replaces surface and structure. This value is multiplied by 75% if the road is unbuilt.
- Structure | The value of structure is calculated as the difference between observed 2014 average rehabilitation and resurfacing costs. These were observed on Interstates – for non-Interstates this value is multiplied by 65.4%. Unbuilt roads and roads on which current IRI exceeds 100 are assumed to have no structure (or a structure of no value).
- Surface | The as-new value of surface was observed directly in 2014. The current value varies linearly with IRI from the as-new value at IRI = 100 to $0 at IRI = 350.

The total value of the NHS roads in New Hampshire is $8.68 billion dollars by this method.

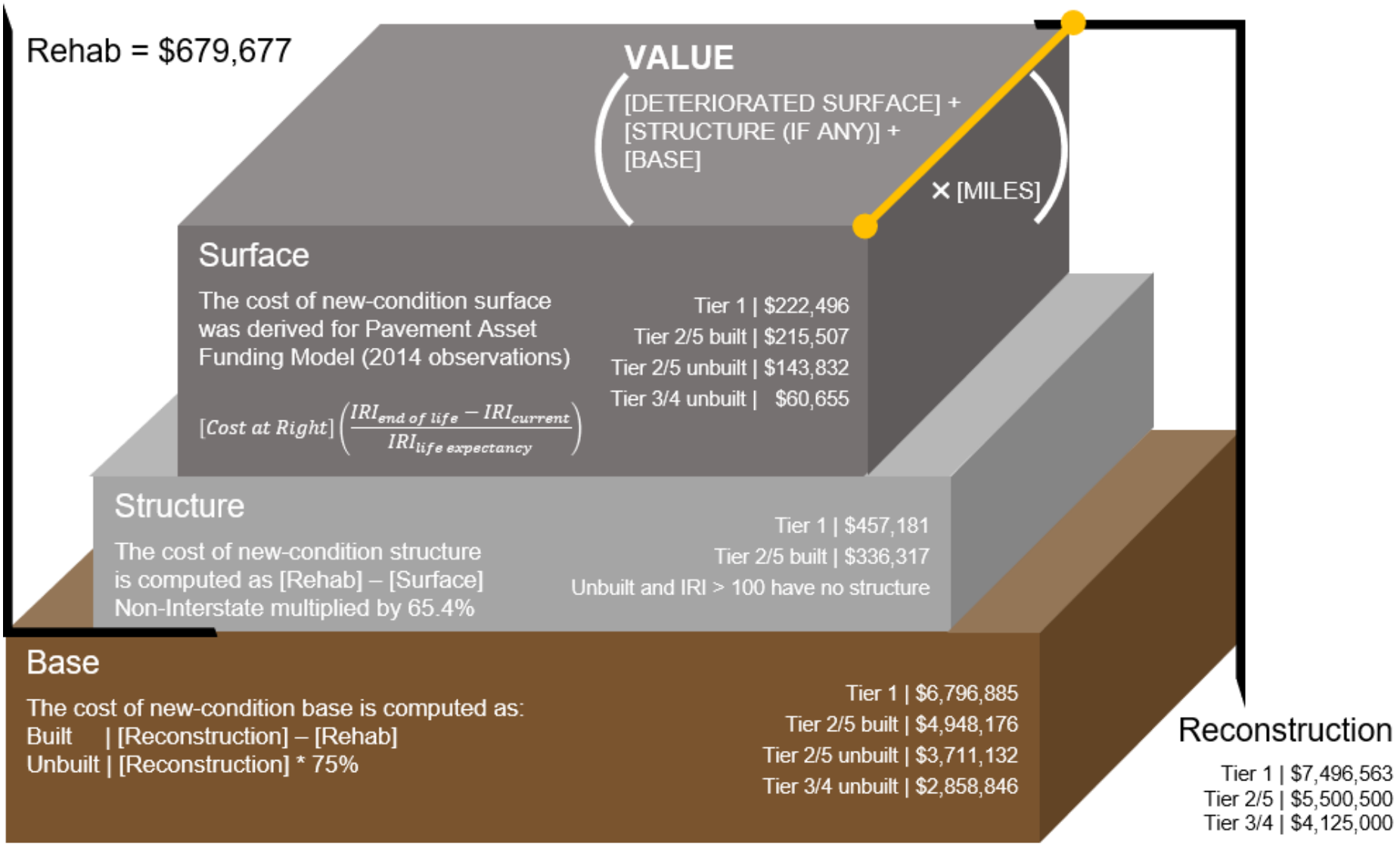


Figure 6-13 Pavement Valuation Methodology

6.5.2 Bridge Valuation

Every bridge on the New Hampshire highway network has value to users measured in time, money, and convenience. A bridge's value to NHDOT is a function of:

- The size of the bridge, the material it is made of, and its structural design.
- The condition of its major components.
- The age of the bridge in comparison to its service life.

This methodology is used to summarize the value of the bridge network to the State of New Hampshire. It uses the following data:

- Expected costs for projects advertised by NHDOT in 2019.
- NBI bridge ratings by component derived from NHDOT bridge inspections.

A bridge's current value (CV) reflects its replacement value, its sufficiency rating, and its age relative to service life. It is computed as:

$$CV = RV \times \frac{Sufficiency\ Rating}{100} \times \left(1 - 0.25 * \frac{Year\ Today - Year\ Built}{120}\right)$$

Replacement Value	Sufficiency Rating
Cost to reconstruct the bridge	See below – based on NBI condition by component, AADT, and detour length

6.5.2.1 Replacement Value

Replacement value is defined as the cost to fully replace the bridge or superstructure and is computed as:

$$RV = Deck\ Area * Unit\ Cost$$

Unit cost was computed based on a review of recent project estimates for 30 structures of different types. The estimates included all costs associated with the structures. Table 6-3 shows the unit replacement costs based on this review.

Table 6-3 Unit Replacement Costs by Roadway Tier and Structure Type

Bridge Type	Replacement Cost ($/ft^2)
Culvert	$4,046
Girder	$1,096
Moveable	$1,440
Timber	$500
Truss	$3,835

6.5.2.2 Sufficiency Rating

Sufficiency Rating is the sum of the following four values and ranges from 0-100:

- **S1 – Structural Adequacy and Safety |** Value from 0-55 that represents the condition of the superstructure, substructure, or culvert as applicable as recorded in NBI Items 59, 60, and 62, as well as the load rating of the bridge as recorded in NBI Item 66.
- **S2 – Serviceability and Functional Obsolescence |** Value from 0-30 that represents the following: the rating of the structure defined by the condition of the deck as recorded in NBI Item 58, the structural evaluation (relating bridge condition to traffic served) as recorded in NBI Item 67, the deck geometry, underclearances, waterway adequacy, and approach alignment as recorded in NBI Items 68-69, and 71-72; the roadway width insufficiency defined by the relationship between ADT, lane width, approach width, bridge width, and structure type using NBI Items 29, 28, 32, 51, and 43; and the vertical clearance insufficiency defined by the relationship between the vertical clearance and STRAHNET highway designation as recorded in NBI Items 53 and 100.
- **S3 – Essentiality for Public Use |** Value from 0-15 that reflects the detour length as recorded in NBI Item 19, the average daily traffic as recorded in NBI Item 29, and the STRAHNET Highway Designation as recorded in NBI Item 100.
- **S4 – Special Reductions |** A negative value from 0-13 that modifies the total of the other components in response to detour length as recorded in NBI Item 19, the structure type as recorded in NBI Item 43B, and the absence of safety devices as recorded in NBI Item 36.

6.5.2.3 Age of Structure

NHDOT assumes that a brand new bridge has complete functionality and that a 120-year-old bridge has 75% of its original functionality, regardless of the bridge's observed condition. This assumption reflects obsolescence – advances in bridge technology over such a period render it inherently less functional. NHDOT further assumes that this degradation due to obsolescence occurs linearly – at a steady rate – over the 120-year period.

6.5.2.4 Results

By this methodology, New Hampshire's bridges have a current value of $6 billion and a replacement value of $8.3 billion. This valuation includes 724 bridges that carry an NHS roadway. The results of the analysis are summarized in Table 6-4.

Table 6-4 Results of Bridge Valuation

	Count	Deck Area	% Deck Area	Replacement Value	Average Age (yr)	Current Value
Total	724	7,351,496	100%	$9,392,020,727	47	$6,657,584,996
Culvert	70	155,261	2%	$628,186,317	55	$160,790,050
Girder	641	6,749,371	92%	$7,397,310,253	46	$5,686,823,183
Moveable	2	144,969	2%	$208,755,610	50	$163,922,385
Timber						
Truss	11	301,895	4%	$1,157,768,547	71	$646,049,378

7 Investment Strategies

7.1 Overview

This chapter describes the elements for developing, evaluating, and recommending investment strategies that preserve and add value to the existing transportation infrastructure, as well as minimize lifecycle cost. Investment strategies that are goal-achieving are fundamental to NHDOT's AM program. NHDOT's investment strategies consider the unified goals of the entire organization regarding bridge and pavement assets. The investment strategies help the Department to identify priorities and direct funds towards options that offer a reasonable return on investment, with emphasis on preservation, sustainable performance, risk management, and long-term cost.

The development of investment strategies begins with review of the Department's goals, performance targets, strategies, SOGR targets, and treatment options for bridge and pavement assets. NHDOT also assess performance gaps to determine if any changes are necessary to better align with targets. NHDOT applies cost-effective treatments based on asset performance, which are constrained by forecasted revenues, to manage asset performance toward achieving performance targets.

7.1.1 Highway & Bridge Tiers

The prioritization of investments is an integral part of the Department's investment strategy. While there are many aspects and more complex processes to determining specific priorities, NHDOT has also adopted a simplified approach for network level priorities know as Tiers. The Tiers are used to generally prioritize investments and to build statewide investment programs. Tier 1 and 2 contain most of the NHS and virtually all of the State-owned NHS, as shown in the list below.)

- Tier 1 – Interstates, Turnpikes, and Divided Highways
    - These multi-lane, divided highways convey the majority of commuter, tourist, and freight traffic throughout the state. (55.5% of the overall NHS length)
- Tier 2 – Statewide Corridors
    - The corridors carry passengers and freight between regions of the state as well as to and from neighboring states. These roads can have moderate to high traffic volumes, particularly during morning and afternoon commutes. (38.7% of the overall NHS length)
- Tier 3 – Regional Transportation
    - The corridors provide travel within regions, access statewide corridors, and support moderate traffic volumes at moderate speeds. (0.4% of the overall NHS length)
- Tier 4 – Local Connectors
    - Secondary highways and unnumbered routes as well as the bridges along them are local connectors and they provide travel between and within communities. (0.0% of the overall NHS length)
- Tier 5 – Local Roads

- Locally owned roads and bridges or State-owned roads within compact limits provide varying travel functions and are maintained by communities. (5.4% of the overall NHS length)

- Tier 6 – Off Network
  - The Department needs to track work accomplished on off network assets such as park 'n' rides, patrol sheds, or rest stop parking lots. (0.0% of the overall NHS length)

7.1.2 Pavement Strategies

The selection of pavement investment strategies is underpinned by two strategic principles, and are explained in the paragraphs below: Highway Priorities and Making Sustainable Investment. These strategies and principles, in conjunction with utilizing data and subject matter expertise, contribute to the analyses that inform the development of the Department's TYP and STIP. Building on these existing practices, NHDOT will continue to identify opportunities to improve upon the process.

- **Highway Priorities:** NHDOT prioritizes investments and treats pavements according to a tiered classification system. Most of the NHS assets fall under Tier 1 and 2 (also referred to as the high priority highways) of this classification system. This principle allows the Department to prioritize investment strategies with the goal of alleviating potential operational and reputation risks. The tier classification process is informed by indicators such as the volume of traffic using the roadway, level of roadway connectivity, the economic importance of roadway, etc. The NHS pavements score higher in these criteria since they tend to be Interstates and high-volume arteries. As such, the NHS receives higher priority in resource allocation and performance sustainability.

- **Making Sustainable Investment:** This principle guides the Department to consider investment decisions that meet current pavement needs while making provision for future pavement demand. As such, NHDOT recommends treatment interventions by considering existing pavement conditions, projected future performance, and performance targets. This approach enables the Department to select strategies that maximize the useful life of pavements at a minimum practical cost. NHDOT applies **preservation** activities to keep "Good" pavements in "Good" condition, **rehabilitation** activities to restore "Poor" pavements, and **reconstruction** to build "New" pavements:
  - ***Preservation:*** this treatment enables NHDOT to keep "Good" roads "Good". Preservation treatments encompass a variety of low-cost activities to keep roads in good working condition for an extended practical period of time. These treatments are only recommended for pavements that are in "Good" condition. Beyond the long-term agency cost savings associated with applying preservation activities, road users also benefit from minimal operational disruption from road closures due to construction time required for such treatments as well as consistent high levels of service.
  - ***Rehabilitation:*** this treatment enables the Department to restore "Poor" pavements to "New" pavement status, such that the pavement can be preserved for an extended period. This moderate cost activity is generally recommended for pavements that have already deteriorated beyond a condition that can be restored to "Good" pavement status with the application of preservation activities. Unlike preservation treatments, rehabilitation treatments require an extensive amount of time to complete. Hence, applying these treatments

causes longer disruptions to traffic operations. The selection of these treatments are significantly influenced by the tier, cost of rehabilitation, and expected outcome of the treatment. Accordingly, each case is evaluated independently to make an economically feasible, beneficial decision.

- ***Reconstruction:*** this treatment enables the Department to upgrade roads that lack a good foundation, which is required for pavements to be preserved and sustained for longer useful life. Reconstruction activities involve a high-cost investment and longer time (usually more than a year) to complete. Due to the high cost (agency cost) and longer road disruption time (delays resulting in user cost), this treatment can be cost prohibitive. As a result, NHDOT does not consider this treatment a priority for investment, as the Department seeks to make effective use of available paving budgets.
- ***Light Capital Paving*****:** NHDOT adopts a set of periodic, low-cost paving treatments for the purposes of preventative maintenance to keep roads in working order and extend the useful life. This type of investment strategy targets roads that are not built to support existing load conditions and traffic demands. These roads are highly susceptible to frost action, pavement rutting, cracking, and potholes. However, they are not suitable for preservation treatments, and rehabilitation has proved to be cost prohibitive. Accordingly, NHDOT addresses these issues to keep the roads in working condition by routinely assessing pavement conditions and traffic volume.

The application of these strategies is guided by the decision matrix in Table 7-1. Tiers with high priority indicate that pavements on that tier are considered for the specific treatment before NHDOT commits resources to pavements on the other tiers with moderate to low order of priority. The decision matrix was developed through a multiple-objective decision analysis. The process utilized information pertaining to costs, condition, public perception, and financial resources.

Table 7-1 Pavement Strategy Decision Matrix

Pavement Strategies	Tier 1	Tier 2	Tier 3	Tier 4
Preservation	High	High	High	High
Rehabilitation	High	Moderate	Low	Low
Reconstruction	-	-	-	-
Light Capital Paving	-	High	Moderate	Moderate

Source: NHDOT Pavement Strategy Summary (2017)

7.1.3 Pavement Investment Need

Determining overall needs for managing pavement assets involves analyzing the range of conditions throughout the network. The most appropriate treatments vary by timing as noted in section 4.3 as well as by Tier. Subject matter expertise is used to consider combinations of treatments, also known as mixes of fixes, applied to pavements within each tier over a 40-year period. Life cycle costs are minimized by excluding costly

alternatives that do not provide an expected additional life extension proportionate to the higher costs.

The determination of network need for Tier 1 preservation is shown below. Weighted averages of cost effective strategies are used to determine the unit cost and the overall number of miles is determined by IRI.

- Tier 1 preservation cost per year; $22,700/mile
- Tier 1 preservation miles; 516 miles

The number of miles will vary slightly over time as pavements deteriorate and are rehabilitated. However, the general distribution is expected to remain similar enough that current levels can be used to project future needs. Multiplication of unit costs and miles produce typical yearly needs as shown below.

- Total cost to preserve Tier 1; $11.7M

Funding is combined across maintenance and preservation work types. Tier 1 contains no maintenance needs. The overall cost to preserve and maintain Tier 1 is therefore equal to preservation costs.

- Pavement maintenance and preservation need for Tier 1; $11.7M

Yearly needs across tiers and work types applicable to the NHS are shown in the table below;

Table 7-2 Typical Yearly Pavement Need (Millions)

Network	Asset Strategies	Typical Need
Tier 1	Maintenance and Preservation	$11.7
	Rehabilitation and Reconstruction	$5.9
Tier 2	Maintenance and Preservation	$20.0
	Rehabilitation and Reconstruction	$3.0

All system needs are compared and prioritized as described in section 7.1.2. Ultimately, the funding described in the Financial Plan is applied as described in section 6.4.

7.1.4 Bridge Strategies

Like pavement management, the development of bridge investment strategies is guided by three strategic principles and decision processes that use the road tier classification system (High Investment Bridge - HIB, Tier 1&2, and Tier 3&4). By applying this system of classification, the NHS bridges receive priority; hence, mitigating the potential impact of risk resulting from the operation or failure of a bridge. The bridge investment principles ensure that bridges are prioritized based on condition, importance, risk, capacity, type, and size.

Table 7-3 represents the decision matrix that guides the selection and prioritization of bridge investment. The decision matrix was developed through a multiple-objective decision analysis including strategies developed through a combination of data and subject matter expertise. The process utilized information pertaining to costs, condition, public perception, and financial resources.

Table 7-3 Bridge Strategy Decision Matrix

Bridge Strategies	HIB	Tier 1	Tier 2	Tier 3	Tier 4
Maintenance	High	High	High	High	High
Preservation	High	High	High	High	High
Rehabilitation	High	High	High	Moderate	Low
Reconstruction	High	High	Moderate	Low	Low

Source: NHDOT Bridge Strategy Summary (2015)

The three strategic principles include:

- **Bridge Priorities:** NHDOT applies the tiered system and defines an additional priority level (HIB) in prioritizing strategic investments that give priority to the most critical bridges on the road network. The HIB category represents the largest and most costly bridges; bridges with a deck area over 30,000 square feet or with a lift mechanism. Bridges are inspected— at least once every two years—and the condition data is used to inform the development of an annual Priority List for bridges and bridge prioritization process. The regular condition assessment enables NHDOT to identify structurally deficient (SD) and post weight restricted (WR) bridges. Bridges identified as SD are added to the NHDOT's Red List, which qualifies for more frequent inspections depending on the condition. These bridges are consistently evaluated for rehabilitation or reconstruction utilizing additional decision variables, such as condition, importance, risk, capacity, type and size.
- **Making Sustainable Investment:** With a strategic goal to extend the expected useful life of recently constructed bridges to 120 years, and to maximize returns on bridge investment, NHDOT applies sustainable, low- and moderate-cost treatments to maintain, add value to the existing bridge infrastructure, and achieve performance targets. Like pavement treatments, NHDOT applies **maintenance and preservation** activities to keep "Good" and "Fair" bridges in a state of good repair, **rehabilitation** activities to restore "Poor" bridges, and **reconstruction** to build "New" bridges.
    - ***Maintenance and Preservation*** is a long-term strategy that uses a variety of low-cost, small- to mid- sized efforts to extend the expected life of a bridge. Maintenance includes activities like washing and sealing a bridge, cleaning drainage ways, and keeping vegetation controlled. Preservation includes activities like replacing expansion joints, sealing cracks, and replacing the membrane protecting the bridge deck.
    - ***Rehabilitation*** is a one-time activity that significantly improves the condition of the major parts of a bridge while keeping the underlying structure in place. NHDOT utilizes this treatment when major parts of a bridge need to be replaced, but there is some service life remaining in other parts of the bridge. These activities involve moderate-cost actions and require significant road disruption to users.

- ***Reconstruction*** involves the complete replacement of an existing bridge with a new structure. This strategy requires high-cost activities and significantly impacts traffic operations due to extensive road or lane closures and long-term detours. As such, this treatment is considered as the last investment option when other effective maintenance and preservation strategies are not considered to be cost-effective or sustainable in the long term.

- **Non-Essential**: Over time, some bridges have become non-essential and isolated from the critical network leaving them with limited operational impact on system performance. It is, therefore, essential for NHDOT to identify these bridges to allow investment priority to focus on critical bridges for traffic use. This investment approach considers the need to undertake network analysis and evaluate the impact of each bridge investment on network performance outcomes. This network analysis enables NHDOT to evaluate and emphasize the long-term economic justification to invest in non-essential bridges.

In support of these principles, NHDOT has also established recommended investment schedules for different bridge types. This schedule is for girder type bridges; however, the actual selection or application of treatment depends on prevailing geographic conditions, bridge condition, and type of bridge structure. As such, the Department relies on data and engineering judgement in selecting and prioritizing each work effort. Table 7-4 shows NHDOT's typical bridge recommended investment for a girder-type bridge. The table shows that most of the investment actions emphasize preservation/maintenance in meeting agency goals.

Table 7-4 NHDOT's Bridge Recommended Investment Schedule (girder-type)

Category	Work Effort
Preservation/Maintenance	Wash and Oil every year Crack Seal Bridge Pavement (every 10 years starting in year 5) Replace the Bridge Pavement (every 10 years starting in year 10) Replace Membrane and Expansion Joints (every 20 years) Repair Electrical and Mechanical Parts, if any (every 25 years) Paint exposed steel, if any (every 20 years)
Rehabilitation	Replace Worn Out Components (every 60 years)
Reconstruction	Completely Replace Girder Type Bridges (year 120)

Source: NHDOT Bridge Strategy-Definitions (2015)

7.1.5 Bridge Investment Need

Determining overall needs for managing bridge assets involves applying Recommended Investment Schedules (RIS) to the network. RIS developed by subject matter experts extend bridge lifespan while minimizing cost as described in section 4.4. Treatment

frequencies and expected life spans are unique by bridge type; Timber, Culvert, Girder, Moveable, and Truss. Square foot unit costs by bridge type are derived from samples through dividing previously incurred costs by the deck areas associated with those costs. Overall needs are the summation of those square foot costs applied at the frequencies in the RIS to all bridges.

The determination of network need for Tier 1 and 2 maintenance and preservation is shown below. Weighted averages are used to simplify the example;

- Tier 1 maintenance and preservation cost per year; $2.20/SF
- Tier 1 bridge area (all bridge types); 2,323,436 SF
- Tier 2 maintenance and preservation cost per year; $3.36/SF
- Tier 2 bridge area (all bridge types); 2,027,865 SF

Bridge area is expected to increase over time but at a low rate so the overall area is assumed to be constant. Multiplication of unit costs and areas produce typical yearly needs as shown below.

- Tier 1 cost to maintain and preserve: $5,120,000
- Tier 2 cost to maintain and preserve: $6,810,000

Funding is combined across tiers and maintenance and preservation work types. The overall cost is therefore the summation of maintenance and preservation costs for Tier 1 and 2.

- Bridge maintenance and preservation need for Tier 1 & Tier 2: $11,930,000

Yearly needs across tiers and work types applicable to the NHS are shown in the table below. Note that High Investment Bridges are handled separately;

Table 7-5 Typical Yearly Bridge Need (Millions)

Network	Asset Strategies	Typical Need
HIB	Maintenance and Preservation	$2.6
	Rehabilitation and Reconstruction	$9.2
Tier 1	Maintenance and Preservation	$5.1
	Rehabilitation and Reconstruction	$15.7
Tier 2	Maintenance and Preservation	$6.8
	Rehabilitation and Reconstruction	$19.2

All system needs are compared and prioritized as described in section 7.1.5. Ultimately, the funding described in the Financial Plan is applied as described in section 6.4.

7.2 Gap Analysis

The Department monitors performance gaps as well as gaps in other areas, such as those between forecasted funding needs and anticipated funding availability. When gaps are identified an analysis helps to provide additional information to decision makers such as the cause of the gap, potential long-term outcomes, and to identify solutions or ways to mitigate the gap.

7.2.1 Pavement Gap Analysis

As shown in Table 3-5, current pavement conditions are outperforming 2 & 4 year targets as well as the long-term SOGR. The gap is likely the result of two factors: the conservative approach to target setting adopted by NHDOT, and 2) the short-term investment of additional funds in paving projects above the anticipated needs.

1. The specific target setting process required for 2 & 4 years targets was only recently established by FHWA and this was the first application of that process by NHDOT. The Department adopted a conservative approach by setting targets that were already being outperformed.
2. Paving projects, when compared with many other projects, require less time to design than other projects. When additional funding becomes available paving projects are often selected to advance to construction. The risk associated with this type of outperformance is that the funds could be better allocated to other assets. Since bridge targets are also achieved the Department will need to look at other assets or other performance areas.

In addition to performance gaps, the Department also monitors funding levels to identify risks to the long-term condition of assets. Table 7-2 shows the projected investment needed to achieve the Department's SOGR. When comparing those needs to the committed funding levels shown in Table 6-2 there is substantial alignment.

7.2.2 Bridge Gap Analysis

As shown in Table 3-6, current bridge conditions are aligned with 2 & 4 year targets as well as the long-term SOGR. The Department will continue to routinely monitor conditions and review any gaps if they are identified.

While current conditions and trends are aligned with targets there are potential risks for the long-term condition based on misalignments between projected investment needs (Table 7-5) and committed funding levels (Table 6-1). In particular, there are gaps for Tier 1 & 2 work types.

Regarding maintenance and preservation, the Department will continue to prioritize committed funds to tier 1 bridges before tier 2 bridges and to NHS tier 2 bridges before non-NHS bridges. As the BMS is enhanced, the Department will gain a better understanding of the potential implications of this type of gap. In addition, the gap will continue to be part of the TYP discussion regarding funding allocations.

For rehabilitation and reconstruction, the committed funds shown in Table 6-1 include all of the anticipated needs on a per bridge basis over the upcoming 10-year period. This gap highlights the need for the Department to adopt a more sophisticated BMS that can better consider short, mid, and long term needs for bridges. In particular, due to the slow deterioration of bridges, the broad system-wide need over the entire lifespan of bridges (120 years) does not translate well to the actual needs over any given 10-year period.

8 AM Enhancements

8.1 Introduction

This chapter discusses anticipated improvements to the AMP and to AM at NHDOT. The objective of the current AMP is to meet the requirements of an AMP as described in the Asset Management Final rule (23 CFR 515.11). The AMP will be used for consistency certification and is due on June 30, 2019. Required AMP elements are listed in Table 8-1.

Table 8-1 Asset Management Plan Elements

1. Asset management objectives
2. Asset management measures & targets
3. NHS pavement and bridge conditions
4. Performance gap analysis
5. Risk analysis
6. Life-cycle planning
7. Financial Plan
8. Investment Strategies

Source: FHWA AMP Development Processes Certification and Recertification Guidance

The chapters in this document have been organized in a way that categorizes topics by the required AMP elements. As shown in Table 8-2, some chapters have incorporated more than one element. Chapters are used to categorize improvements in these remaining sections.

Table 8-2 Asset Management Plan Components

AMP Chapter	AMP Element - 23 CFR 515.9(d)
Chapter 2: **Asset Management**	Asset Management Objectives
Chapter 3: **State of the System**	Measures and Targets NHS Pavement and Bridge Conditions Performance Gap Identification
Chapter 4: **Lifecycle Planning**	Life Cycle Planning
Chapter 5: **Risk Assessment**	Risk Analysis Damage by Successive Events
Chapter 6: **Financial Plan**	Financial Plan
Chapter 7: **Investment Strategies**	Investment Strategies

8.2 AM Process Areas and Enhancement Actions

The AMP will be used to certify NHDOTs asset management process and to certify consistency. AMP processes are described in 23 CFR 515.7 and are listed in Table 8-3.

Table 8-3 AMP Required Processes

AMP Processes (23 CFR 515.7)
1. Process to complete a performance gap analysis and to identify strategies to close gaps
2. Process to complete life cycle planning
3. Process to complete a risk analysis and develop a risk management plan
4. Process to develop a financial plan covering at least a 10-year period
5. Process to develop investment strategies
6. Process for obtaining necessary data from NHS owners other than the State DOT
7. Process for ensuring the AMP is developed with the best available data and the State DOT uses bridge and pavement management systems meeting the requirements in 23 CFR 515.17 to analyze NHS bridge and pavement conditions.

Source: FHWA AMP Development Processes Certification and Recertification Guidance

Table 8-4 State of the System and Enhancement Actions

Chapter 3: State of the System		Timeline
Action 3-1	Upgrade BMS and PMS to incorporate asset management data sets.	2020 (RFP underway)
Action 3-2	Final documentation of process for obtaining asset improvement from NHS owners other than NHDOT.	2021

Table 8-5 Lifecycle Planning and Enhancement Actions

Chapter 4: Lifecycle Planning		Timeline
Action 4-1	Enhance unit costs for work types.	2020 (ongoing effort)
Action 4-2	Enhance work type deterioration curves for pavement and bridge asset classes.	2020 (ongoing effort)
Action 4-3	Conduct network level analysis in PMS and BMS.	2021 (post 3-1)
Action 4-5	Describe method for conducting lifecycle analysis.	2021 (post 3-1)
Action 4-6	Enhance management strategies for each asset class to minimize the lifecycle costs while achieving	2022 (post 4-3)

Chapter 4: Lifecycle Planning		Timeline
	performance targets for condition.	
Action 4-7	Develop and analyze investment scenarios to provide information regarding outcomes at different funding levels.	2022 (post 4-3)

Table 8-6 Risk Assessment and Enhancement Actions

Chapter 5: Risk Assessment		Timeline
Action 5-1	Document process for monitoring top priority risks.	2020

Table 8-7 Financial Planning and Enhancement Actions

Chapter 6: Financial Plan		Timeline
Action 6-1	Incorporate the asset valuation approach with the new BMS and PMS.	2021 (post 3-1)

Table 8-8 Investment Planning and Enhancement Actions

Chapter 7: Investment Strategies		Timeline
Action 7-1	Document process used for determining Statewide performance targets for NHS assets.	2020 (ongoing)

Appendix A – Glossary

Asset: Property that is owned, operated, and maintained by a transportation agency. This includes all physical highway infrastructure located within the right-of-way corridor of a highway. This includes all components necessary for the operation of a highway including pavements, highway bridges, tunnels, signs, ancillary structures, and other physical components of a highway.

Asset Depreciation: The loss of the value of an asset as it deteriorates due to usage and time.

Asset Management: (AM): A strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the lifecycle of the assets at minimum practicable cost.

Asset Management System: An integrated set of procedures, tools, software, and data intended to support proactive management decision making regarding the preservation, improvement, and replacement of assets.

Asset Renewal Ratio: The ratio of planned expenditures to those expenditures needed to both halt further depreciation of an asset and to restore that asset to a state of good repair.

Capital Investment: A type of investment that generally involves construction or major repair; includes the construction of new assets, reconstruction or replacement of existing assets, structural and functional improvements to existing assets, and rehabilitation of existing assets; when precision is required, capital refers to work that is funded under the agency's capital budget according to agency policy.

Depreciated Replacement Cost (DPC): The cost necessary to restore an asset to a desired performance threshold.

Deterioration Model: A mathematical model to predict the future condition of an asset or asset element, if no action, or only un-programmed maintenance, is performed.

Enhancement: An action taken to accomplish two goals: 1) To help achieve and sustain a state of good repair over the life cycle of an asset; and 2) to improve and preserve the condition of the National Highway System.

Gap Analysis: A set of techniques to examine and describe the gap between current performance and desired future goals.

Indirect Costs: The cost of implementing a programmed activity, including direct and indirect costs. In capital budgeting analyses, initial cost is interpreted as the direct reduction in available budget because of a commitment to the activity.

Lane-Miles: This total reflects all roadway under the given jurisdiction, regardless of public access. It includes ramps.

Level of Service (LOS): Qualitative measures related to the public's perception of asset condition or of agency services; used to express current and target values for maintenance and operations activities.

Life Cycle: A length of time that spans the stages of asset construction, operation, maintenance, rehabilitation, and reconstruction or disposal/abandonment; when associated with analyses, refers to a length of time sufficient to span these several

stages and to capture the costs, benefits, and long-term performance impacts of different investment options.

Part 667 Analysis: The federal rule requiring State DOTs to evaluate if there are reasonable alternatives to roads, highways, and bridges that have needed repair and reconstruction activities on two or more occasions due to emergency events.

Performance: Characteristic of an asset that reflects its functionality or its serviceability as perceived by transportation users; may be related to condition.

Performance Gaps: The gaps between the current asset condition and State DOT targets for asset condition, and the gaps in system performance effectiveness that are best addressed by improving the physical assets.

Performance Measure: An indicator, preferably quantitative, of service provided by the transportation system to users; the service may be gauged in several ways (e.g. quality of ride, efficiency and safety of traffic movements, services at rest areas, quality of system condition, etc.).

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 do restore the overall condition of the transportation facility.

Preventive Maintenance: Preventive maintenance is a cost-effective means of extending the useful life of the Federal-aid highway. (23 U.S.C. § 116 (e)).

Prioritization: Arrangement of investment candidates in descending order according to their importance to the agency mission (usually represented by an objective function or benefit measure) in relation to their initial cost.

Rehabilitation: An event consisting of multiple treatments intended to correct physical or functional defects that impair the satisfaction of a level of service standard that the asset may previously have satisfied. It may include replacement of parts of the asset but not the entire asset, and is generally understood to be more significant in scale than a repair.

Repair: Treatment applied to correct a physical or functional defect that impairs the satisfaction of a level of service standard that the asset may previously have satisfied. Repairs are usually understood as intermediate in scale between maintenance and rehabilitation. Specific instances of repairs may be programmed or un-programmed according to agency policy.

Replacement: Disposal of an existing asset and substitution of a new asset serving the same functional requirements and possibly additional requirements in the same location; replacement-in-kind is a type of replacement where the new asset is substantially similar in function to the old asset, following the principle of modern engineering equivalence.

Risk (of an asset): The possibility of adverse consequences related to an asset from natural or man-made hazards. Generally, this consists of the likelihood of the hazard, the consequences of the hazard to the asset, and the impact of asset damage or malfunction on the mission of the asset or on life, property, or the environment.

Risk Register: A table that indicates how various asset risks are scored, according to both the likelihood and the consequences of them occurring.

Routine Maintenance: Routine maintenance encompasses work that is performed in reaction to an event, season, or over all deterioration of the transportation asset. This work requires regular reoccurring attention.

State of Good Repair (SOGR): The desired long-term condition of pavement and bridge assets based on the goals and objectives of NHDOT.

Strategic: A view of assets that is policy-based, performance-driven, long-term, and comprehensive.

Sustainable Investment: An investment that maximizes the useful life of an asset at minimum practical cost.

Targets: A fixed benchmark against which NHDOT evaluates past, present, and future performance.

Whole Life Management: Also known as Life Cycle Planning, this is a process that incorporates the collection, analysis, and application of data at each phase of an asset's life.

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