Connecticut Annual Pavement Report

Prepared by:
Donald A Larsen, PE,
Alexander Bernier PE,
James Mahoney

Date of the Report
April 7, 2020

Name of the performing organization
Connecticut Advanced Pavement Laboratory
Connecticut Transportation Institute
School of Engineering
University of Connecticut

Submitted to:
Connecticut Department of Transportation
Bureau of Engineering and Construction
Pavement Management Unit

John W. Henault, PE
Transportation Supervising Engineer

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipients Catalog No.
4. Title and Subtitle Connecticut Annual Pavement Report		5. Report Date April 7, 2020 6. Performing Organization Code
7. Author(s) Donald A Larsen, PE, Alexander Bernier PE, James Mahoney		8. Performing Organization Report No. CAPLAB 11-2019
9. Performing Organization Name and Address University of Connecticut Connecticut Transportation Institute 270 Middle Turnpike, U-5202 Storrs, Connecticut 06269-5202		10. Work Unit No. (TRIS) N/A 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06131-7546		13. Type of Report and Period Covered Final- December 2018-October 2019 14. Sponsoring Agency Code

15. Supplementary Notes
A report generated in cooperation with the U.S. Department of Transportation and Federal Highway Administration

16. Abstract
Presented herein is the first annual administrative report on pavements for the Connecticut Department of Transportation (CTDOT). This report provides a summary of the current condition (2018 data) of pavements for two roadway systems; 1) the entire CTDOT-maintained roadway network (including state NHS) and 2) the National Highway System (NHS) designated roads in Connecticut (state- and town-maintained NHS). Also described within are CTDOT's paving programs, condition projections and targets, anticipated available funding, and projections of future activity in Connecticut resulting from the use of the CTDOT Pavement Management program. This annual report will be used to produce Transportation Asset Management Plan (TAMP) updates on a yearly cycle.

17. Key Words Network Asset Management, Pavement Management, Pavement Preservation, Pavement Performance, State of Good Repair	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA. 22161

19. Security Classif. (Of this report)	20. Security Classif.(Of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	81	N/A

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not reflect the official views or policies of the State of Connecticut or the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

ACKNOWLEDGEMENTS

This report was prepared by the University of Connecticut, in cooperation with the Connecticut Department of Transportation and the United States Department of Transportation, Federal Highway Administration. The opinions, findings and conclusions expressed in the publication are those of the author(s) and not necessarily those of the Connecticut Department of Transportation or the Federal Highway Administration. This publication is based upon publicly supported research and is copyrighted. It may be reproduced in part or in full, but it is requested that there be customary crediting of the source.

FOREWORD

Except where noted otherwise, the information presented in this document for mileage, pavement type distributions, pavement condition ratings, future condition performance projections, treatment costs, and vehicle miles of travel is determined using calendar year 2018 data. Where 2018 data were not yet available, such as for 2-year and 4-year target projections, information is reported from the Connecticut Transportation Asset Management Plan (TAMP), published in August 2019. Generally, the TAMP information was derived using calendar-year 2017 data.

METRIC CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

TABLE OF CONTENTS

List of Figures

List of Tables

1. INTRODUCTION AND BACKGROUND

Purpose of Annual Report

Presented herein is the first annual administrative report on pavements for the Connecticut Department of Transportation, for the calendar year 2019. This report provides executive level management and outside parties with information about Connecticut's pavement conditions (both current and the past few years). Also described within are CTDOT's paving programs, funding, and projections of future activity in Connecticut resulting from the use of the Connecticut Department of Transportation (CTDOT) Pavement Management program. This annual pavement report provides a summary of the current condition of pavements for two roadway systems; 1) the entire CTDOT-maintained roadway network (including state NHS) and 2) the National Highway System (NHS) designated roads in Connecticut (state- and town-maintained NHS). Except where otherwise noted, the current information presented in this document, such as pavement condition, treatment costs, etc. is derived from calendar year 2018 data. For this first iteration only, the condition report is published in April. However, future versions of this pavement report shall be published by August 31st of each year (e.g., next report expected publication: August 31, 2020).

Some of the pavement data and information included in CTDOT's Transportation Asset Management Plan (TAMP), (described later in this report) are adapted here in this first annual pavement condition report. In future years, this CTDOT Annual Pavement Report will be the prerequisite document used to produce TAMP updates on a yearly cycle. The currently published TAMP (August 2019) contains data from calendar year 2017.

Asset Management Objectives for Maintaining "State of Good Repair"

'Pavement' is the layered structure that comprises the road. Pavements are designed to support anticipated traffic loads and provide a safe and relatively smooth driving surface. Pavement roughness (smoothness) is expressed as a summation of irregularities in the pavement surface that affects the ride quality experienced by users in a motor vehicle. Roughness is an important pavement characteristic because it affects even more than just the ride quality. It also influences vehicle delay costs, fuel consumption, pavement maintenance costs, and vehicle maintenance costs. Maintaining pavements in a smooth and good condition lengthens their life, enhances safety, and helps reduce road user operating costs.

A formal Pavement Management System (PMS) is employed for the analysis of collected pavement-rating data and then reports on the current and projected conditions of the highway network. Also, a PMS can be used to evaluate the effectiveness of planning and funding priorities and to provide guidance in the decision-making process.

Monitoring and measuring pavement conditions (as well as other transportation asset conditions) enables CTDOT to assess the performance of the transportation system, analyze deficiencies and predict future needs, allocate funding, and schedule projects to address what is known as the 'State of Good Repair' (SOGR). CTDOT has adopted a set of Transportation Asset Management (TAM) objectives that are in line with the vision and mission of the agency. The CTDOT TAM objectives are:

- Attain the best asset conditions achievable given available resources, while striving towards a State of Good Repair
- Deliver an efficient and effective program to optimize the life of our infrastructure
- Improve communication and transparency regarding decisions and outcomes
- Achieve and maintain compliance with Federal requirements regarding asset management

Performance measures, projections, targets, and goals are being developed to help achieve CTDOT TAM objectives. These are being linked so that CTDOT can operate more effectively, and simultaneously make progress towards federal requirements and state goals. This also allows for the establishment of funding priorities and targets that are achievable. A summary of performance measures and targets for Connecticut pavements on designated NHS routes is provided later in Table 1-3.

The Evolution from "Worst-first" to Preservation First

Connecticut's official highway network started over 120 years ago with the establishment of the first Connecticut Highway Commission in 1895. A road census conducted then by the state determined that there were 14,088 miles of road, but that only 463 miles were stone or macadam. By the end of 1895, almost $31,000 had been spent and 35 miles of road had been built. (CTDOT 2019) Looking back today, it is found that approximately 35% of CTDOT's paved roads were constructed prior to 1950 and another 44% were constructed between 1950 and 1980. A majority of these pavements were built with a 20-year design life.

Based on the results of studies over the past 15 years, prioritizing repair work by "worst-first," which emphasizes treating pavements in poor condition, is now recognized to be the least effective means of maintaining a highway network and expending limited highway funds. According to FHWA, state DOTs should consider applying treatments well before pavements reach threshold conditions of deterioration. Therefore, FHWA recommends that states should prioritize the distribution of highway funding to meet preservation needs before rehabilitation or reconstruction of roadways. (FHWA 2015)

In 2010, CTDOT began transitioning to a more balanced program of pavement maintenance, preservation, overlays, and rehabilitation. The intent is to move away from the "worst first" strategy. CTDOT's preservation program strives to extend the life of pavements in good condition. Within its rehabilitation and resurfacing programs, CTDOT has been working to extend the useful life of pavements, through increased use of preservation treatments. The main objective is to keep road segments from slipping into a reconstruction-needed category, which typically costs four to five times higher per lane mile than mill and fill, for instance (see Table 1-1 and Figure 1-1). By overlaying a road before it significantly deteriorates, 15 to 20 years of useful life can be added at a substantial cost savings over reconstruction. Once a road has deteriorated to the point that it must be reconstructed, the opportunity for preventive maintenance and preservation is lost.

Table 1-1 contains the relative costs of various treatments used for roadways in Connecticut. Preservation treatments, such as mill and fill, ultra-thin bonded overlays and asphalt-rubber chip seals cost between 50 and 90 percent less, both on a unit cost and per-mile basis than more complex activities associated with rehabilitation and reconstruction. Figure 1-1 illustrates graphically the relationships between effectiveness, costs and appropriate timing of various treatments.

Table 1-1 General Illustration of Treatments and 2018 Unit Costs for Showing Relative Life Cycles (see also Figure 1-1)*

FHWA Work Type	**CTDOT Treatment**	**Expected Surface Life (years)**	**Approx. Cost per Year of Life, ($)**
Initial Construction	New Construction	20	300,000
Reconstruction	Reconstruction Flexible	10-20	240,000
Reconstruction	Reconstruction Composite	10-20	260,000
Rehabilitation	Structural Rehabilitation	15	67,000
Preservation	Mill and Fill	8-10	61,000
Preservation	Ultra-thin bonded overlay	7	25,000
Preservation	Asphalt Rubber Chip Seal	5	20,000
Preservation	Crack and Joint Fill & Seal	3	8,333
Maintenance**	Pothole repair,	1-5	N/A
Maintenance**	Emergency overlays	1-3	100,000

* contains approximate costs only for illustrative purposes, as costs can vary significantly by project, location and timing.
**These items are not necessarily eligible for federal funds

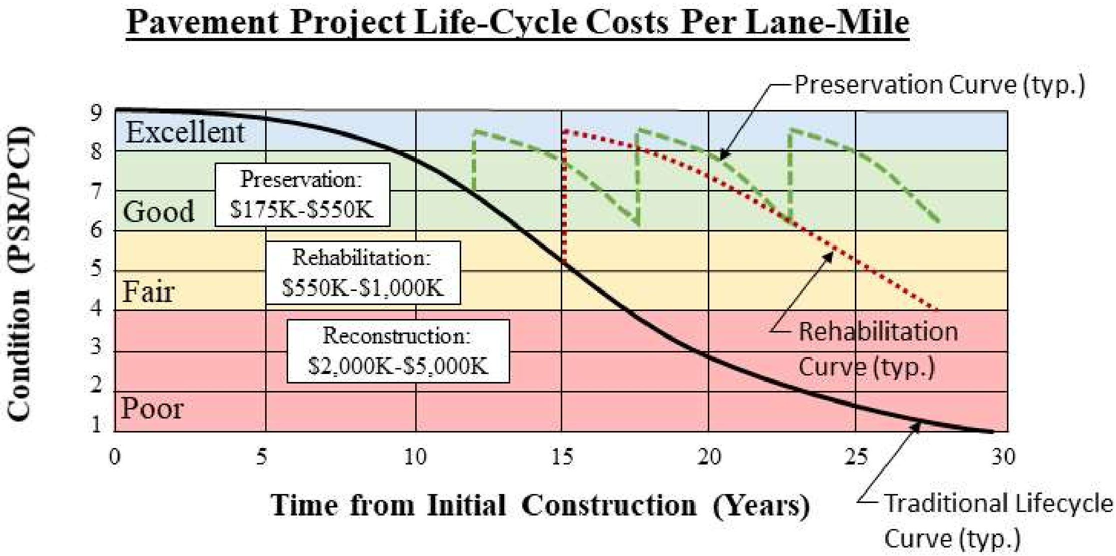


Figure 1-1 Illustration of General Costs and Appropriate Timing for Pavement Remediation (Lane-miles)

Note: The majority of existing state-maintained roads were designed with a 20-year structural design life. Through rehabilitation and resurfacing programs, CTDOT has managed to extend original expectations.

Technology Resources

Data Collection

Data flows into the CTDOT Pavement Management System (PMS) from several sources (Figure 1-2). Data include inventory data (e.g., lane widths, route mileage, intersection locations), pavement condition data (e.g., level of distress present), and activity data (e.g., maintenance, paving, or construction). The pavement condition data are collected by the Photolog Unit in the Bureau of Policy and Planning, Roadway Information Systems Section, using two (2) specially equipped Fugro Roadware Automatic Road Analyzer (ARAN) vans (Figure 1-3). The entire CTDOT-maintained road network, as well as municipally-owned segments of the NHS, are surveyed each year.

CTDOT is one of the pioneers, and has over thirty years of experience, in photolog technology. The technology evolved to become one of the most critically important and prominent tools in use by CTDOT and in many other state DOTs. The equipment enables the collection of highly technical, detailed and complex pavement condition and infrastructure data. Focusing upon the immediate past, beginning with the 2015 data collection, the ARANs were updated to provide 3D imaging using a Laser Crack Measurement System, which includes two scanning lasers. This provides for greater detail in the measurement of cracking, which has enabled refinements to CTDOT's condition indices described later in this report. The pavement images captured by the ARANs are processed to identify the presence of different types of pavement distress, including wheel path rutting, cracking, patching, raveling, faulting, as well as surface cross slope. (Faulting is applicable to concrete pavements only, which make up approximately 0.5% by centerline miles of CTDOT's pavement network.)

Also, starting in 2015, the ARANs were updated to include sensors that feature laser line sensing (versus point laser sensing) located along each wheel path to collect longitudinal profiles used to compute roughness measures. Table 1-2 lists the equipment components contained within the two latest CTDOT ARAN vehicles (vans 8 and 9).

Pavement condition data are collected according to the CTDOT Data Quality Management Plan (DQMP) that was approved by FHWA on August 22, 2018. The DQMP addresses the following critical areas:

- Data collection equipment calibration and certification;
- Certification process for persons performing manual data collection;
- Data quality control measures to be conducted before data collection begins and periodically during the data collection program;
- Data sampling, review and checking processes; and
- Error resolution procedures and data acceptance criteria.

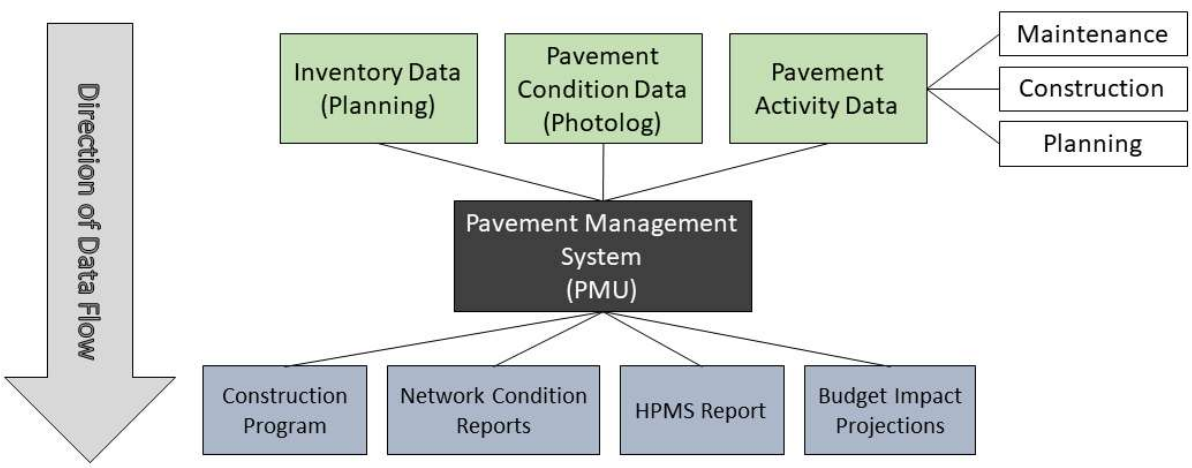


Figure 1-2 CTDOT Pavement Data Information Flow Chart

Figure 1-3 CTDOT Photolog Vehicle (One of Two Vehicles Currently Utilized)

Table 1-2 CTDOT ARAN 9000 Series Vans and Latest Equipment Installed on each (CTDOT 2018b))

CTDOT ARAN System Component	Component Description
Geographic Coordinates	Real-Time Differential GPS +POS LV Inertial Positioning System (1-meter accuracy) using OmniStar
Distance	Wheel-mounted Distance Measurement Instrument Measures linear distance within ± 0.005%
Roughness (IRI)/Longitudinal Profile	South Dakota Profiler RoLine – 4" Footprint Line Laser (Laser SDP/2) in Front Bumper Enclosure. Class 1 Profiler under ASTM E950, AASHTO R56-10 Certification & ASTM E1926
Crack Detection, Classification & Rating, Texture, Rutting & Transverse Profile	Pave3D Pavemetrics Laser Crack Measurement System (LCMS)
Right of Way (Front View) Imagery	SONY HD Camera w/90 Degree Field of View Lens

**Two current generation CTDOT vehicles are named 'Van 8', and 'Van 9.' The two vehicles are identical except for chassis: Van 8: 2010 Dodge Sprinter; Van 9: 2015 Mercedes Benz Sprinter.*

Data Analysis

The condition data collected with the ARANs in the Photolog Unit are processed in the Pavement Management Unit and combined with existing meta-data specific to each roadway segment to calculate International Roughness Index (IRI) (roughness), rutting, cracking (structural and environmental), faulting, and cross slope and grade indices used for determining drainage adequacy. The above information is converted into representative indices used to calculate the Pavement Condition Index (PCI) described later in this report, as well as for data used to report the condition of the NHS. Condition ratings are collected every five linear meters along the roadway surface, aggregated by tenth-mile sections and then again by defined pavement-analysis sections, and ultimately stored in a Structured Query Language (SQL) database. Condition data are summarized by lane-miles for federal Highway Performance Monitoring System (HPMS) reporting, and FHWA subsequently uses the reported data to determine the Federal performance measures. Condition data are summarized by centerline miles (aka road miles) for State performance measures. In many cases, for comparison purposes, data are shown both ways in this annual report.

CTDOT uses a customized version of Deighton Total Infrastructure Management System (dTIMS®) software to analyze, present the current, and predict the future condition of both CTDOT-maintained pavements and the designated NHS in Connecticut. The system was initially implemented in 1998 and has been upgraded since. It provides capabilities for storing, reporting, and viewing pavement inventory and condition information. As noted earlier, primary data sources for dTIMS and the PMS include basic road inventory data from the CTDOT Road Inventory System, pavement condition data collected each year with the photolog vans described earlier, and pavement treatment history information. In addition, dTIMS includes soil classification information by town (poor or good) provided by the CTDOT Soils and Foundation Unit. dTIMS is also used for analyzing alternative investment scenarios and for assisting with planning a single- or multi-year program of projects for pavements. More details about the dTIMS application and database are provided in Table 1-3:

Table 1-3 Deighton Total Infrastructure Management System (dTIMS®) (CTDOT 2019b)

Data Type	Description
Pavement Inventory	Width; Number of Lanes
Road Inventory	Functional Class; NHS Designation; Overlaps (parent routes carried); Divided/Undivided Status; Administrative District; Annual Average Daily Traffic (AADT); Percent Heavy Trucks
Pavement Construction History and Composition	Year of Original Construction; Pavement Type and Thickness; Year of Last Resurfacing
Soil Assessment	By Town
Detailed (0.1 mile) Pavement Condition	Cracking (Length and Orientation by Road Zone); Cross Slope; Roughness (IRI); Rutting; Faulting (on Concrete Pavements Only)
Summarized Pavement Condition	PCI (1-9 scale: based on IRI (ride quality), Rutting, Cracking, Disintegration, Drainage); Structural Index; Environmental Index; IRI
Pavement Activity	• Maintenance Vendor-in-Place (VIP) Projects (Initial, monthly, and final reports– includes milling and filling depth) • Construction Projects with greater than 300 tons of Hot Mix Asphalt (HMA)
Decision Tree Rules	Types of treatments recommended for pavement sections based on their condition indices
Unit Costs	Used to calculate costs for each of the of pavement treatment types for unconstrained needs or scenario analysis;
Deterioration Performance Models	Used to predict changes in pavement condition over time for each pavement family (*)
Planned or Programmed Pavement Projects	Used within scenario analysis to assist in scheduling of future projects; also used to support development of resource-constrained work programs

*Over 100 pavement families are defined in dTIMS according to climatic zone, pavement type, pavement thickness, traffic volume and soil condition.

Transportation Asset Management Plan (TAMP)

Rather than continuing to rely solely on a decentralized approach in which individual units collect, store and report on data to meet their individual operational needs, CTDOT is moving toward an enterprise approach to make the best use of agency data for informed decision-making. The initial Transportation Asset Management Plan (TAMP) (published in July 2018) for roads, bridges and other assets such as signs, traffic signals, and pavement markings demonstrates that CTDOT is moving in that direction. The FHWA and federal legislation direct that states must develop an asset management plan that is supported by a pavement management system. The TAMP is the federally-required plan intended to document transportation asset management practices and processes at CTDOT. Rules outlined in "Moving Ahead for Progress in the 21st Century Act" (MAP-21) and "Fixing America's Surface Transportation Act" (FAST) require reporting by all states for bridges and pavements contained on the NHS.

In addition to NHS-required information, CTDOT opted to include in its initial 2018 TAMP traffic signals, signs, sign supports, and pavement markings, as well as all of its state-maintained network of pavement and bridges. Highway Building assets were added to the 2019 TAMP, published in August 2019. Additional assets such as guiderail, illumination, etc. will also be included in future versions of CTDOT's TAMP.

Specific to pavement assets, the TAMP includes:

- Inventory and condition
- Data management
- Asset valuation
- Use of performance measures
- Performance targets
- Performance gap analysis
- Life cycle planning
- Risk management
- Financial planning, and investment strategies

According to MAP-21 and FAST, states must also have documented procedures for collecting, processing, storing, and updating inventory and condition data for NHS assets. States are required to use pavement management systems, such as described earlier for CTDOT, which, in addition to other capabilities, collect, process, store, and update inventory and condition data.

The Connecticut TAMP addresses assets on the two previously-noted overlapping highway systems: CTDOT-maintained roads and the NHS designated routes. Even though the NHS in Connecticut is primarily composed of CTDOT-maintained roads, 159 lane miles of the NHS are maintained locally by towns.

2. CONNECTICUT ROADWAY NETWORK CONDITIONS

Overview of Network Mileage

According to (FHWA 2015), in 2012, the Nation's public road network included 4,109,418 miles of roadways: 223,257 miles of this network (5 percent) was designated as the National Highway System (NHS); and 47,714 miles (1 percent) represents the Interstate System, which carries 25 percent of the total Vehicle Miles Traveled (VMT) in the United States.

Statistics on the extent and length of Connecticut's roadway network in centerline (road) miles and lane-miles, including the NHS, the state-maintained roadways and the municipally-owned roads, are provided in Table 2-1, below. Although Connecticut is the third smallest state in terms of area, it is ranked 44th for length of network centerline road mileage (USDOT 2017a). Connecticut's network mileage is obviously significantly smaller than larger states (e.g., California, New York, Pennsylvania, Illinois, Wisconsin). In fact, these states have more than 5 times the mileage of Connecticut. On the other hand, in New England, only two states (Massachusetts and Maine) have longer road networks than Connecticut.

Vehicle Miles Traveled (VMT) can be used to normalize network travel to population, (see later section *Vehicle Miles of Travel*) due to high population density, Connecticut ranks as 37th overall in the U.S. for vehicle miles of travel on the network (USDOT 2017c). For example, Wisconsin, which has five times the road mileage length of Connecticut, only carries total annual VMT that is slightly more than twice Connecticut's. Another example, Maine, which has a roadway network length only 6% longer than Connecticut, has less than ½ the total annual VMT of Connecticut.

Table 2-1 Connecticut Centerline (Roadway) Miles and Lane-Miles* (2018)

Classification	**Centerline Miles**	**Lane-Miles****
CTDOT-Maintained state ***routes and roads (excluding ramps)***	***3,719***	***9,839***
State Routes and Roads	2,313	***5,425****
State NHS	1,406	***5,018***
Interstate	*346*	***1,882***
Non-interstate NHS (state only)	*1,060*	***3,136***
Total Town Road Miles	17,419	***35,291***
Town NHS	56	***159***

* All figures have been rounded to nearest whole mile. These mileages are from CTDOT Bureau of Policy and Planning Public Road Mileage as officially reported to the FHWA on Dec 31, 2018. The exact mileage on the ground, used for inventory, measured with automated equipment, and analyzed with software varies slightly from these reported figures. These totals exclude 110 centerline miles of Federal roads.

**Lane-miles are defined as centerline (road) miles multiplied by number of lanes. These miles do not count shoulders as lanes.

***State Routes and Roads Lane Miles includes 279 miles of bridges and ramps.

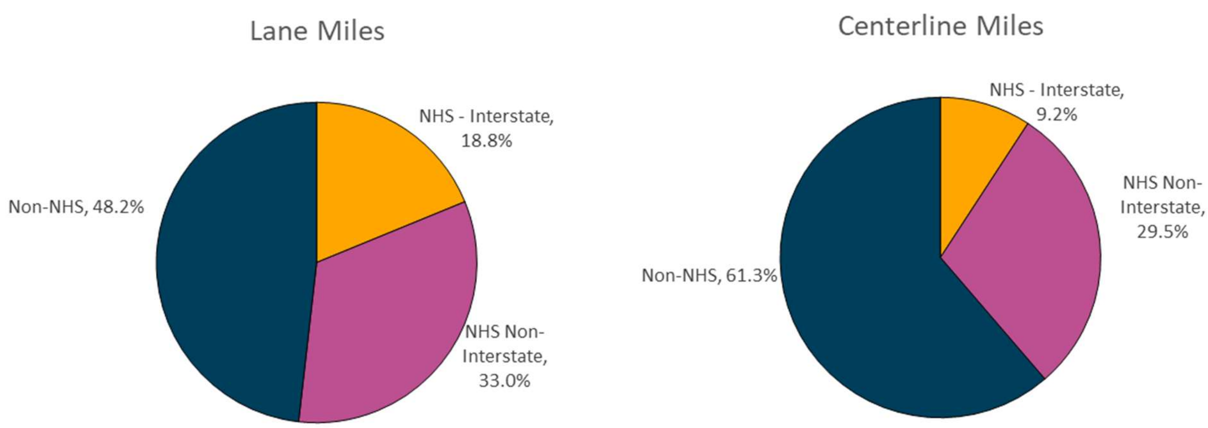
Table 2-2 provides the number of centerline miles and lane-miles in Connecticut within in each of the four CTDOT designated maintenance/construction districts. Maps showing CTDOT district boundaries, as well as regional planning agencies within Connecticut can be found in Appendix 4.

Table 2-2 Centerline (Roadway) Miles and Lane-Miles by CTDOT District (2018)*

	Centerline Miles	Lane-Miles
District 1	794	2,462
District 2	1,132	2,693
District 3	706	2,191
District 4	1,086	2,494
Total**	3,719	9,839

Notes:* These mileages are from CTDOT Bureau of Policy and Planning Public Road Mileage
** The mileage varies slightly from these totals due to rounding errors.

Figure 2-1 below shows the relative distribution of NHS and non-NHS roadways in Connecticut as of December 31, 2018, the latest available year-end dataset. This excludes Federal roads, and CTDOT maintained bridges and ramps.



Connecticut	*Centerline (Road) Miles*	*Lane-Miles*
NHS Interstate	346	1,882
NHS Non-interstate	1,115	3,296
Total NHS (state + town)	1,462	5,177
Non NHS (state mileage)	2,313	4,822
Total NHS (town + state) + Non NHS (state mileage)	3,774	9,999

Figure 2-1 Distribution of all NHS and CTDOT Maintained non-NHS Roadways in Connecticut (2018)

The CTDOT-Maintained network average surface age from 2008-2018 can be seen in Figure 2-2 CTDOT-Maintained Network Average Surface Age Over Time. It is noteworthy that the scale of the y-axis is only 8.6 to 10, in that the fluctuation in age is relatively tight. In fact, a regression model of age versus time suggests a trend line slope of 0.83, indicating that our network pavement surface is in fact getting younger at a rate of 0.17 years per year.

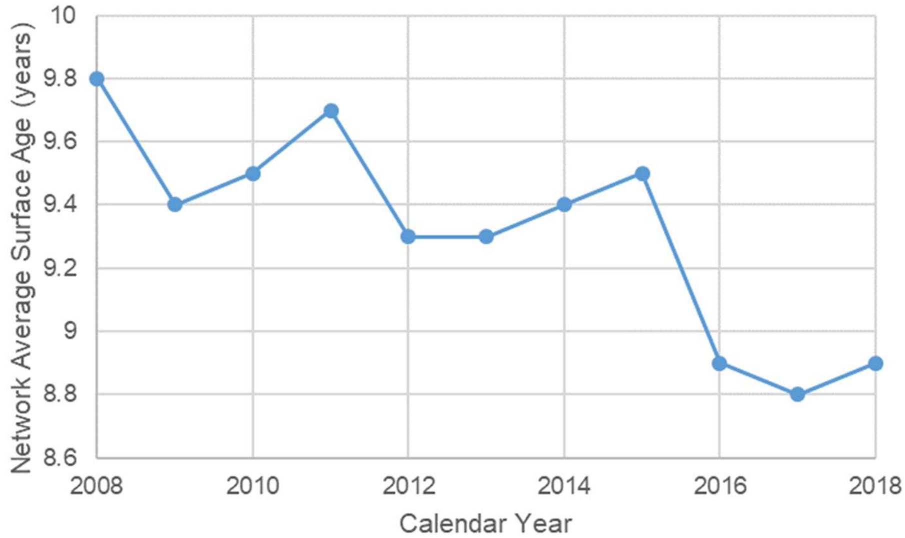


Figure 2-2 CTDOT-Maintained Network Average Surface Age Over Time

Functional Classification System for Roadways

The FHWA defines the highway functional classification system in the 2016 HPMS Field Manual (USDOT 2016 & FHWA 2013). *Access control is a major factor in defining the functional classification system.* However, the use of the word "access" in this context refers to the ability to access the roadway (not the abutting land use). The functional classification system groups roadways into a so-called "logical series of decisions" based upon the character of travel service the roads provide. Detailed definitions for the seven rural and urban functional classification categories can be found in Appendix 6.

The centerline miles of state-maintained roadways in Connecticut as categorized by the federal functional classification system are given in Table 2-3 below.

Table 2-3 CTDOT Centerline (Roadway) Miles* by Functional Classification (Rural and Urban)(2018)**

	Functional Classification & Code							
CODE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
CLASS	*Interstate*	*Other Freeways & Expressways*	*Other Principal Arterial*	*Minor Arterial*	*Major Collector*	*Minor Collector*	*Local*	***Total***
RURAL	29	36	121	216	738	22	7	1170
URBAN	318	244	658	939	368	10	13	2549
TOTAL	347	279	779	1155	1106	32	20	3719

* Mileage excludes ramps
** Mileages from CTDOT Bureau of Policy and Planning Public Road Mileage

Vehicle Miles of Travel

In 2010, CTDOT expressways, which include all limited access highways plus the interstates, equaled 16% of the CTDOT-maintained mileage length in Connecticut, but carried 60% of annual VMT. When local roads are also considered, where 82% of total mileage in Connecticut is composed of locally maintained roads (17,419 road miles, see Table 2-1) these local roads carry only 24% of total VMT. Stated another way, 76% of motor vehicle travel occurs on the CTDOT-maintained network of roads, which represents less than 20% of total mileage in Connecticut. (CTDOT 2010)

Total annual and daily VMT on CTDOT roadways for selected years between 1995 and 2017 are given in Table 2-4 below.

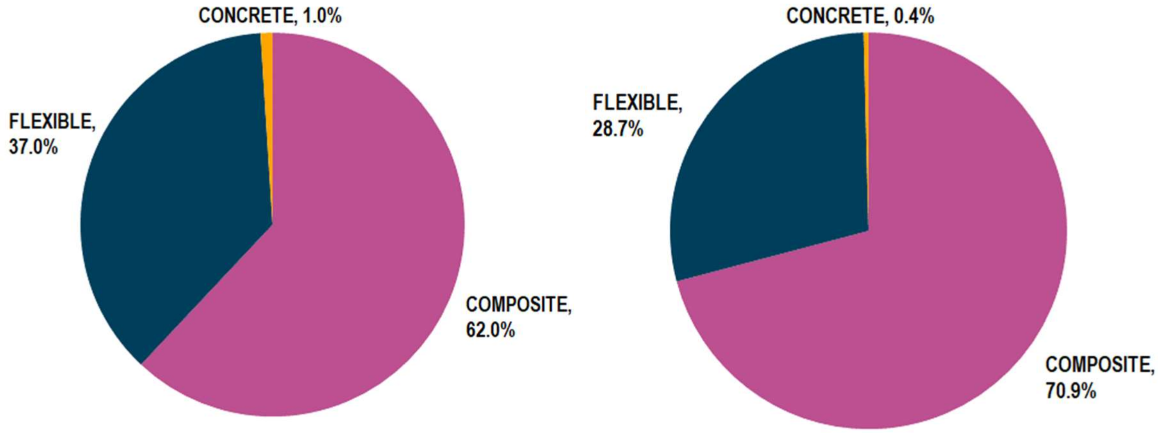
Table 2-4 Total Annual & Daily VMT on Connecticut Roadways (1995 to 2018)

Year	*CTDOT Annual VMT (millions miles traveled)*		*CTDOT Average Daily VMT (millions miles travelled)*	
	NHS only	*Entire Network*	*NHS only*	*Entire Network*
2018	33,340	38,441	91.3	105.3
2017	33,452	38,582	91.6	105.7
2016	33,471	38,582	91.7	105.7
2015	32,855	37,867	90.0	103.7
2010*	31,300	n/a	85.8	n/a
2005*	31,700	n/a	86.8	n/a
2000*	30,800	n/a	84.4	n/a
1995*	28,000	n/a	76.7	n/a

*1995-2010 derived from FHWA Highway Statistics Table VM-2 (USDOT 2017c). Annual Vehicle Miles traveled equals average daily traffic multiplied by miles of roadway multiplied by number of days per year (365) for each roadway category (e.g., interstate) then summed for all categories, excluding local roads.

Distribution of Pavement Surface Type

The distribution of roadway mileage by pavement type in Connecticut for both lane-miles and centerline miles is shown in Figure 2-3 below. This demonstrates that the predominant pavement surface type is flexible (asphalt concrete). However, there is a considerable amount of composite pavement as well, which is defined as Portland Cement Concrete (PCC) overlaid with bituminous (asphalt concrete) pavement. The amount of PCC (rigid pavement) remaining uncovered in Connecticut is less than 1% of the network.



% Total Lane Miles *% Total Centerline Miles*

Figure 2-3 Distribution of CTDOT Pavement Network Surface Type by Centerline and Lane-Miles

Condition of Statewide CTDOT-maintained Roadway Network

CTDOT's internal performance measure for the overall category of CTDOT-maintained roads is the percentage of centerline miles in a state of good repair (SOGR)**.** SOGR was adopted by CTDOT in 2018 as the measure for all state assets reported in the TAMP.

The SOGR (also defined as SGR) is a term that was initially used by the Federal Transit Administration. According to "Transit Asset Management Practices" (FTA, 2010), SGR is defined as "a state in which a transit agency preserves its physical assets in compliance with a policy that minimizes asset life-cycle costs while preventing adverse consequential impacts to its service." In 2013, the American Public Transportation Association (APTA) developed a much simpler definition for SGR: "SGR is a condition in which assets are fit for the purpose for which they were intended" (APTA, 2013). SOGR has also been adopted by FHWA following the FAST Act, and as defined in Code of Federal Regulations 23 CFR 490.313, National Performance Management Measures, (April 2017) and is now required to be included in the TAMP.

CTDOT uses a composite rating system, referred to as the Pavement Condition Index (PCI) to express the condition of CTDOT-maintained pavements. A PCI is calculated for each 0.1 mile segment based on five pavement characteristic sub-indices; the overall PCI is a weighted average; the weights for the constituent indices which comprise the overall PCI are shown in Table 2-5, and described below.

Table 2-5 Relative Weights of Pavement Characteristics (Metrics) used in PCI

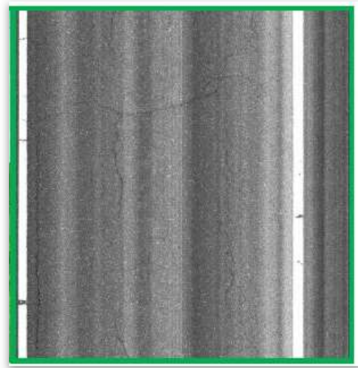
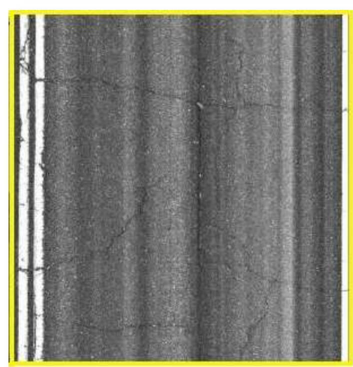
Index_Roughness [IRI] (10%)
Index_Rutting (15%)
Index_Cracking (25%)
Index_Disintegration (30%)
Index_Drainage (20%)

Index Roughness (based on International Roughness Index), Index_rutting and Index_cracking are similar to the FHWA metrics described later for the NHS. Index_Disintegration is the wearing away of the pavement surface caused by age, traffic, and weather exposure. In the CTDOT PMS, Index_disintegration is currently calculated using pavement age as a proxy for factors which are more challenging to interpret using automated data collection techniques. Drainage refers to the ability of the surface of the roadway to properly transport rainwater from the pavement structure. CTDOT uses information collected on pavement transverse cross slope and longitudinal grade to compute the index_drainage metric. CT DOT and the University of Connecticut are currently modernizing the PCI to have higher reliability and sensitivity to the metrics currently mandated from the FHWA and overall changes in the network condition.

The PCI and each constituent index are scales from 1.0 to 9.0, where a pavement without defects would be scored as 9.0. A pavement section for which the PCI is calculated at 6.0 or higher is classified as being in a SOGR (see Figure 2-4). The numerical relationship of the PCI score for defining Good, Fair or Poor roadways is also indicated in Figure 2-4.

Figure 2-4 PCI Ratings used to define SOGR and Pavement Condition

Figure 2-5 illustrates the difference in Connecticut road surfaces rated as being good, fair and poor. These are for illustration purposes only, since some elements of the PCI, namely roughness (IRI), and drainage are typically not a 'visible' condition, yet can affect the overall PCI rating.

Good (PCI ≥ 6) Sample Section: CT Route 20 Mile point: 7.564 Sample PCI: 6.9	Pavements in Good condition exhibit minimal quantities of the measured distresses and low to moderate distress severities. A Good pavement requires a pavement preservation project to maintain or improve the pavement condition and delay costlier treatments.	 
Fair (4< PCI <6) Sample Section: CT Route 41 Mile Point: 9.890 Sample PCI: 5.4	Pavements in Fair condition exhibit moderate to large quantities of the measured distresses and a range of distresses severities. A Fair pavement tends to be beyond the scope of a preservation project and requires a pavement rehabilitation project when the PCI values are at the lower-end of the PCI range in order to improve the pavement condition.	 

Poor (PCI ≤ 4)

Sample Section:
CT Route 179

Mile Point: 9.310

Sample PCI: 3.5

Pavements in Poor condition exhibit large quantities of the measured distresses and high distress severities. In particular, structural failures. A Poor pavement is beyond the scope of a preservation project and requires either a major rehabilitation project or reconstruction to improve the pavement condition.

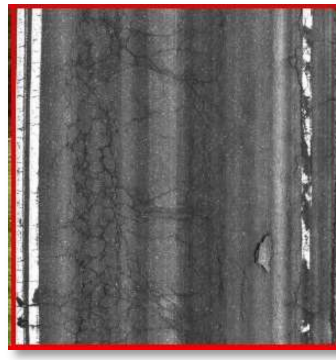


Figure 2-5 Illustrative Comparison of Good, Fair and Poor CTDOT-maintained Roads

The centerline miles of CTDOT-maintained roads in good, fair and poor condition are tabulated for all sections at 0.1-mile increments to determine the overall percentage of pavement in good, fair and poor condition. The results for 2018 conditions are shown in Table 2-6 below. The percentage of sections on the CTDOT maintained roads in 2018 that are in a SOGR (i.e., PCI >= 6 and rating of 'good') is 63.1%. It is worth noting again that these figures are for CTDOT-maintained roads only, therefore the condition of the 17,419 miles of municipal roads are not included in these percentages, nor are conditions for federal roads or state roads that are not maintained by CTDOT. For a side-by-side comparison of the condition of the CTDOT-maintained roads by centerline mile versus lane-mile, see Figure 2-6.

Table 2-6 Connecticut Inventory and Conditions (2018) of CTDOT-Maintained Roadways Using the PCI by Centerline Miles (Excludes Towns)

Route Category	*Centerline Miles Good*	*% Good**	*Centerline Miles Fair*	*% Fair**	*Centerline Miles Poor*	*% Poor**	*Total Centerline Miles*
INTERSTATE	304	87.8%	39	11.2%	3	1.0%	347
NON INTERSTATE NHS	732	69.3%	302	28.6%	21	2.0%	1059
NHS	1036	73.9%	341	24.3%	25	1.8%	1406
NON_NHS	1311	56.5%	907	39.1%	101	4.4%	2313
ENTIRE_NETWORK	2347	63.1% SOGR	1248	33.5%	126	3.4%	3719

Notes: *These Good, Fair and Poor percentages were calculated using CTDOT's Pavement Condition Index.

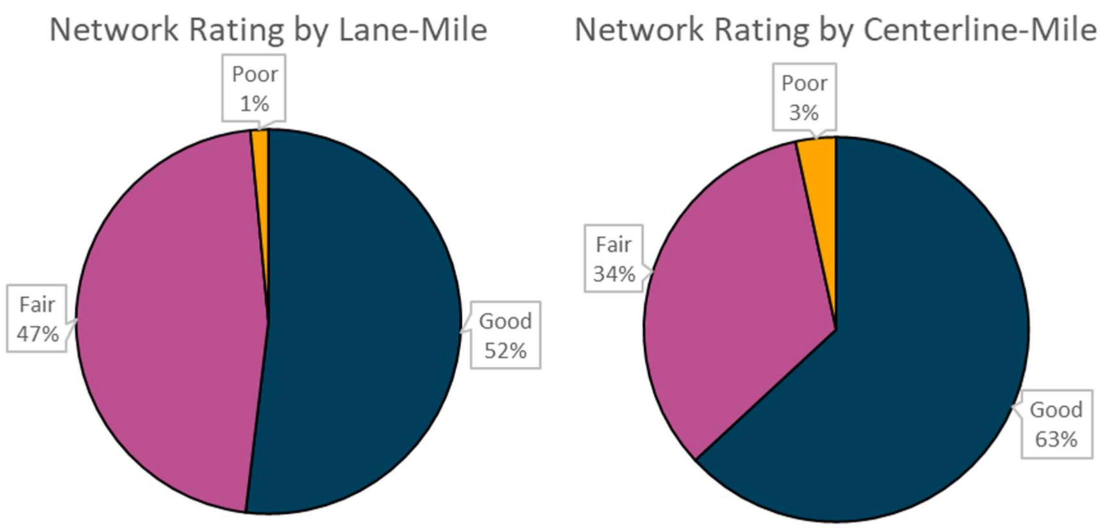


Figure 2-6 Conditions (2018) of CTDOT-Maintained Roadways Using the PCI by Lane Mile and Centerline Miles (Excludes Towns)

Condition of National Highway System (NHS) in Connecticut

The FHWA defines the National Highway System (NHS) as consisting of the Interstate Highway System and other roads important to the nation's economy, defense, and mobility. The NHS was developed by the U.S. Department of Transportation in cooperation with the states, local officials, and metropolitan planning organizations (MPOs). For Connecticut, the NHS includes interstates, other principal arterials, strategic highway network (STRAHNET), major strategic highway network connectors, and intermodal connectors. Examples of these designations as well as a map of Connecticut NHS routes can be found in Appendix 4.

For flexible (asphalt concrete), composite (PCC overlaid with asphalt concrete) and rigid (PCC surface) pavements, the metrics shown in Table 2-7 are used to calculate the pavement condition performance measures used for the NHS.

Table 2-7 NHS Performance Measure Metrics for Flexible, Composite and Rigid* Pavements

Performance Metric	Pavement Type		
	Flexible	*Composite*	*Rigid**
Ride Quality (International Roughness index-IRI)	Pavement roughness experienced by road users traveling over the pavements, computed from a single longitudinal profile.	Same as Flexible	Same as Flexible
Rutting	The depth of ruts (longitudinal surface depression) within and along the wheelpath**).	Same as Flexible	N/A
Cracking	The percentage of cracked pavement surface. The percentage of the total area exhibiting all severities of visible fatigue type cracking, in the wheelpath.**	Same as Flexible	The percentage of slabs in the section that exhibit transverse cracking
Faulting	N/A	N/A	Average vertical misalignment of adjacent slabs

* In Connecticut less than 0.5% of center-line mileage is composed of rigid surface (see Figure 2-6)
** There is a left and right wheelpath, with each wheelpath being 1 meter wide, and the center of each wheelpath being separated by 70 inches. However, it should be noted that this definition was different prior to 2017, and due to an unforeseen error, the 2018 data used the definition for wheelpath that existed before 2017. That definition is as follows: each wheelpath was 0.87 meters wide (34 in.). This results in more cracking being classified as being outside the wheel paths (vs. inside the wheelpaths) for 2018 vs. 2017. This also results in lower Percent Cracking values for 2018 vs. 2017.

For each of the above metrics, FHWA has established thresholds for good, fair and poor condition (see Table 2-8). The pavement condition metrics are used to calculate the FHWA performance measures for pavement condition. Conditions are assessed using these criteria for each 1/10-mile long pavement section. Unlike the CTDOT maintained network, which is summarized by centerline miles, per requirement of FHWA, the NHS condition is summarized and reported by lane-miles.

The FHWA performance measures can be transcribed into a good-fair-poor rating as well (Figure 2-7). An individual section is rated as being in good overall condition if all of the metrics for that section are rated as good. An individual section is rated in poor condition when two or more metrics are rated as poor. For all other combinations, the individual sections are rated as fair.

FHWA Good/Fair/Poor Criteria for Performance Measures

Condition Rating	Constituent Ratings (IRI, Cracking, Rutting)
Good	All three metrics rated "Good"
Fair	Up to one metric rated "poor"
Poor	≥ 2 metrics rated "Poor"

Figure 2-7 FHWA Performance Measure Criteria for Good/Fair/Poor Ratings

Table 2-8 Pavement Condition Thresholds for MAP21 Reporting used on the NHS in Connecticut

Metric	Good	Fair	Poor
IRI (in./mile)	<95	95-170	>170
Rutting (in.)	<0.20	0.20-0.40	>0.40
Cracking (%)			
-Asphalt	<5	5-20	>20
-Jointed Concrete	<5	5-15	>15
Cont. Reinforced Conc.	<5	5-10	>10
Faulting (in.)	<0.10	0.10-0.15	>0.15

The lane miles in good, fair and poor condition are tabulated for all NHS sections to determine the overall percentage of pavement on the NHS in good, fair and poor condition. Again, all of the methodology for the NHS described above is that prescribed by the FHWA in MAP21.

The resultant overall conditions for the NHS in 2018 are shown in Table 2-9.

Figure 2-8 provides more detail about the condition of the NHS, broken down into interstate and non-interstate NHS in Connecticut, using the categories delineated by FHWA. Specifically, CTDOT has adopted the FHWA's pavement condition performance measures for the NHS pavements, as indicated in

Figure 2-8.

Table 2-9 Overall Connecticut NHS Inventory and Conditions (2018) (Includes State and Town NHS)

	Lane miles	Good	Fair	Poor
NHS Pavement*	5,177	51.9%	46.6%	1.5%

*Note: The Good, Fair, and Poor percentages were calculated using MAP-21/Fast Act. The percentages were based on NHS lane miles excluding bridges.

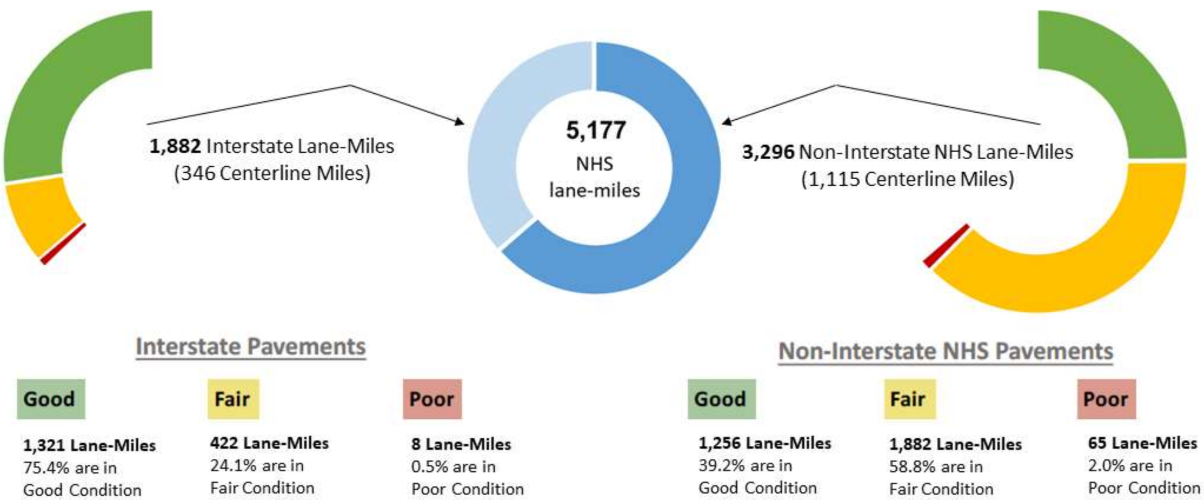


Figure 2-8 Connecticut NHS Pavement Inventory and Conditions as Required for FHWA Reporting (Excluding Bridges) (2018)

Condition of Roads by VMT

The Vehicle Miles Traveled on roads of various levels of condition can be an indicator of the roadway users' (motorists') experience. If, for example, a majority of travel occurs on poor condition roads, than the user experience is presumed to be less than satisfactory. On the other hand, a large amount of travel on roads in a SOGR is more desirable, as well as likely contribute to lower overall user costs for the motorist. Since the larger amount of travel occurs on interstates and expressways in Connecticut, keeping those facilities in SOGR benefits the greatest number of users. Yet this cannot be the only consideration for network upkeep, otherwise those living in more rural areas (e.g., Norfolk or Woodstock) would be traveling on generally poorer roads than either the through-state motorists or those residing in urban areas. An equitable balance needs to be achieved for the entire roadway network using constrained optimization modeling.

Table 2-10 Percent of VMT driven on poor pavement (IRI >170 in/mi) (2016-2018)

YEAR	Interstate	Non-Interstate NHS	Non-NHS State-Maintained Roads	All State-Maintained Roads
2016	2.70%	7.30%	19.20%	6.40%
2017	2.60%	7.50%	19.50%	6.40%
2018	2.50%	7.80%	21.90%	6.80%

Table 2-11 Percent of VMT driven on good pavement (IRI <95 in/mi) (2015-2018)

YEAR	Interstate	Non-Interstate NHS	Non NHS	All Roads
2016	78.00%	62.40%	25.80%	65.90%
2017	78.00%	62.60%	24.10%	65.90%
2018	79.20%	62.30%	23.20%	66.20%

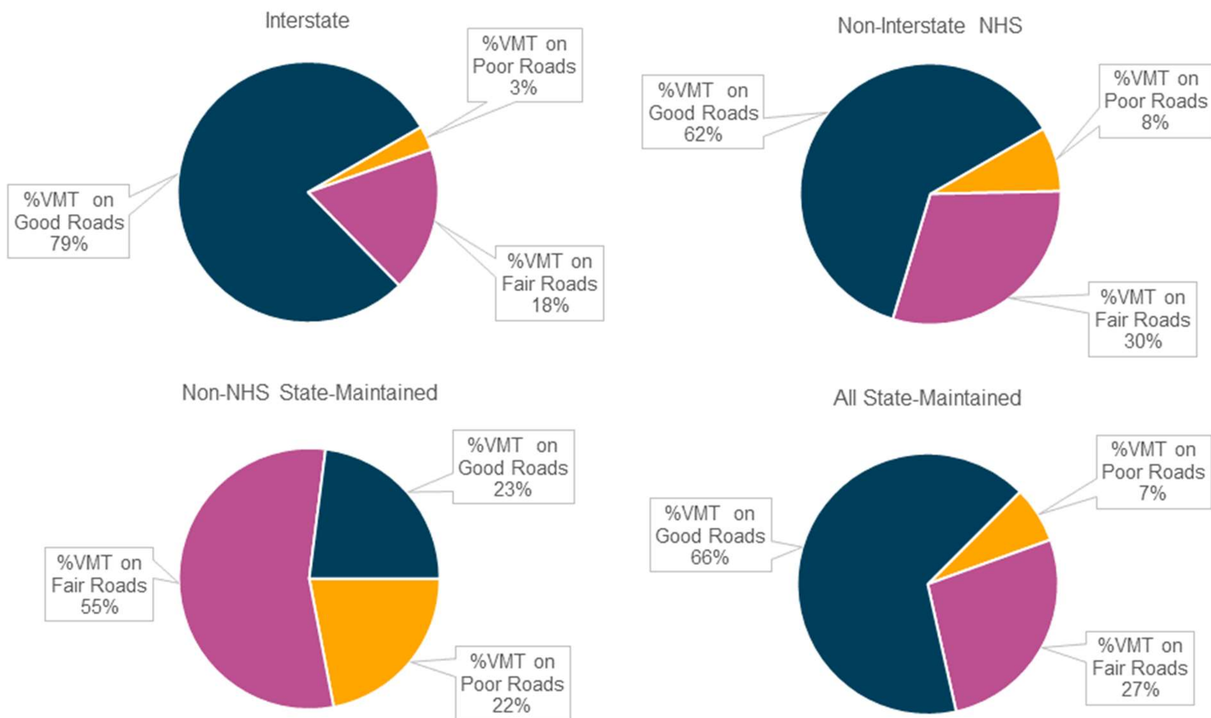


Figure 2-9 Percent of VMT driven on Good (IRI<95 in/mi), Fair (95≤IRI≤170 in/mi), or poor pavement (IRI >170 in/mi) (2018)

Historical Presentation of Pavement Performance Measures

Prior to the advent of TAMP, and even before MAP21 was enacted, CTDOT, reported the following two pavement performance measures to represent the condition of the road network:

- Percent of State Maintained Roads with Acceptable or Better Ride Quality <=170 in/mi (NHS)
- Percent of State Maintained Roads with Acceptable or Better Ride Quality <=170 in/mi (Entire Network)

The definition of acceptable or better (<170 in/mi) is utilized by FHWA for reporting the HPMS ride quality in their Highway Statistics Series reports (USDOT 2017). Since 2009, these along with many other transportation system measures have been reported at CTDOT's performance measures web site at *https://www.ct.gov/dot/cwp/view.asp?a=3815&q=448402*.

The above-cited pavement measures are based on ride quality only. As discussed briefly, earlier in this report, ride quality refers to the pavement's smoothness over a short stretch of roadway. If a roadway isn't smooth over a stretch of roadway, one might refer to its roughness or unevenness; therefore, smoothness and roughness/unevenness are often referred to synonymously when speaking of ride quality.

A roadway characteristic known as the International Roughness Index (IRI) is obtained from longitudinal profile measurements along the two-wheel paths of a travel lane. In CT, this is done with the CTDOT ARAN vehicle. The left wheelpath and right wheelpath IRI values are averaged to determine the IRI metric for the individual roadway segment being considered. The ride quality using IRI is a well-established indicator of current roadway pavement condition as it is experienced by road users, it is reported in change of height (inches) per mile of roadway, where a lower measured value indicates a smoother road.

To compute the CTDOT performance measures, the percentage of roadway centerline-miles having an IRI of less than or equal to 170 in/mile is calculated. That percentage represents the Percent of State Maintained Roads with Acceptable or Better Ride Quality.

Figure 2-10 below shows the conditions of the CTDOT maintained network and the NHS elements of the network over the past 8 years. Note again: the PCI is not included in these particular graphs. In addition, the Ride Quality (IRI) values reported in this graphic use a 3-year moving average.

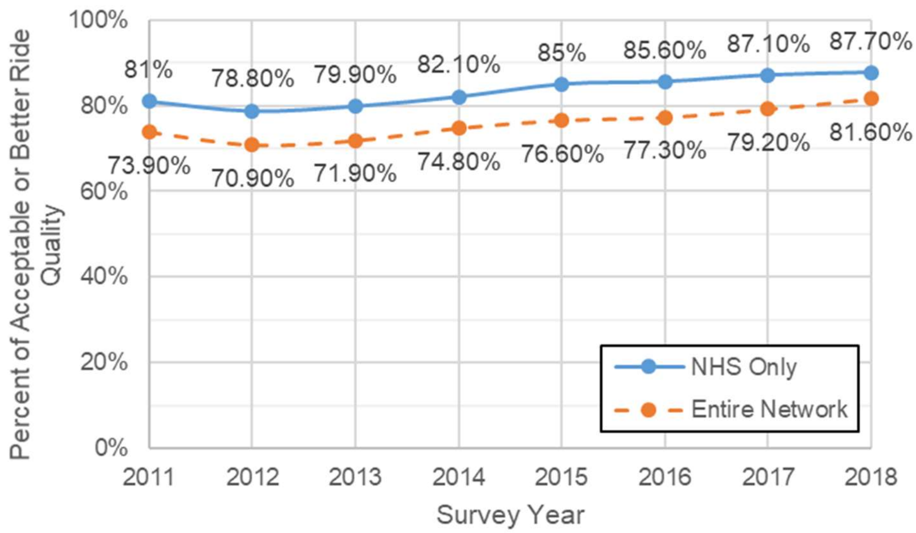


Figure 2-10 Ride Quality (IRI) Using 3-year Moving Average for the NHS Systems, and the Entire CTDOT-maintained Network, for Calendar Years 2011 through 2018.

Performance Projections for the Future

As defined in federal regulation 23 CFR 490.313, the FHWA requires states to include targets (as well as the measures discussed previously) for the condition of NHS pavements reported in the TAMP. Connecticut performance targets have been set to be aligned with both the federal requirements and state goals and objectives, **and are based on anticipated funding levels projected to be available** for transportation. The targets help guide Connecticut in allocating resources to projects and programs, to make progress toward the goals.

Using the measures of condition defined by FHWA, consistent with state asset management objectives, State DOTs must also specify their desired "state of good repair" for the 10-year analysis period of the TAMP. The desired SOGR must also support progress toward achieving goals.

Additionally, as part of the federal rule (23 CFR Part 490), states must set two and four-year asset condition performance targets. These targets must be included in the TAMP, as well as be reported separately to FHWA. In addition, states are also required to maintain NHS pavements to meet federally-established minimum condition levels. **The federal minimum condition level for pavements is to ensure that no more than 5 percent of pavement lane miles on the Interstate system are in poor condition**. Finally, the FHWA also requires that states establish a performance gap analysis process for the TAMP.

Federal Minimum Condition Level for Interstate System Highway Pavements
Maximum of 5% of pavement lane-miles in poor condition

Figure 2-11 Federal Minimum Condition Level for Interstate Pavements

Two and Four Year Performance Targets

Anticipated two- and four-year performance targets for CTDOT-maintained roads are shown in Table 2-12. This table shows the percentage of the road mileage projected to be in a SOGR in the target year. Two- and four-year performance targets for Connecticut's designated NHS pavements are shown in Table 2-13. **Note that these target values are not necessarily desirable target values but instead are predictions of what is likely to occur based on projected funding (assuming no increase in funding over the time period).**

Table 2-12 Performance Projections for CTDOT-Maintained Roads (Percent of Centerline Miles Projected to be in SOGR)

CTDOT Maintained Roads	**State of Good Repair**	
	2-Year Projection (12/31/2020)	**4-Year Projection (12/31/2022)**
Pavement (Centerline Miles)	66.4%	58.1%

Table 2-13 Performance Targets for Connecticut NHS (Percent of Lane-miles Projected to be in Good and Poor Condition)

	Baseline Condition (2017 Data)		2-Year Targets (2020)		4-Year Targets (2022)	
	Good	Poor	Good	Poor	Good	Poor
Interstate Pavement (lane-miles)	n/a	n/a	n/a	n/a	64.4%	2.6%
Non-interstate NHS Pavement (lane-miles)	42.9%	17.0%	36.0%	6.8%	31.9%	7.6%

Ten Year Performance Goals

The ten-year Performance Goal for SOGR on CTDOT-maintained roads is presented in Table 2-14. The 10-year performance goals, based on national measures, for NHS are presented in Table 2-15. Table 2-15 shows the desired percentage of NHS in good and poor condition. The values shown in the table were determined based on review of a set of performance projections performed at varying funding levels. The values reflect federal requirements and state goals and, if achieved, will satisfy the minimum NHS condition levels defined by FHWA. CTDOT recognizes adjustments to these long-term goals (for both NHS and the CTDOT network) will be needed over time as the asset management process matures and funding strategies change with future needs.

Table 2-14 10-Year Performance Goal, SOGR, CTDOT-maintained Roads

	SOGR
Pavement (Centerline Miles)	*80.0%*

Table 2-15 10-Year Federal PM Goals, Good and Poor, NHS Pavements

	Good	*Poor*
Interstate Pavement (lane miles)	*75.0%*	*<5.0%*
Non-Interstate NHS Pavement (lane miles)	*50.0%*	*<8.0%*

3. RECAP OF ANNUAL EFFORTS (2019)

Valuation of Total Pavement Assets

FHWA requires state DOTs to include an estimate of asset value for NHS pavements. The financial plan must also calculate the investment needed to maintain asset value. FHWA has acknowledged that there are many ways to estimate asset value and are leaving it to State DOT's to select their methodology. CTDOT chose to take a replacement value approach to calculate asset valuation. The asset valuation uses the asset inventory unit multiplied by the unit replacement cost and the non-asset related project cost factor that results in the replacement value. The replacement value is equal to the asset valuation for the asset. Unfortunately, this method of asset valuation does not reflect changes in asset condition. CTDOT is using this asset valuation data strictly as a means to fulfill federal requirements and communicate the importance of investment relative to the magnitude of the value of the assets. It is anticipated that non-asset related cost factors will be refined for future TAMP updates to account for costs related to design, rights of way, project administration, utilities, maintenance, protection of traffic, etc.

The average Connecticut NHS pavement structure was constructed 47 years ago (USDOT 2016), and the average surface age is 8.9 years old (see Figure 2-2). The replacement value for Connecticut's NHS pavement, as calculated and reported in the August 2019 TAMP, is $4,781,304,000. The replacement value for state maintained roads other than the NHS is estimated at $5,019,696,000. The total replacement value for the two programs, i.e., estimated value of the 3,718 centerline miles of CTDOT-maintained pavement is $9,801,000,000. (CTDOT 2019b)

Table 3-1 Pavement Asset Valuation Estimates* (CTDOT 2019b)

Pavement Asset	**Inventory Unit (Square Yards)**	**Asset Valuation Replacement Cost**
NHS Pavement	48,296,000	$4,781,304,000
CTDOT Maintained Pavement (includes NHS)	99,000,000	$9,801,000,000

** NOTES: The unit replacement cost used in the calculation is $99/sy, and the non-asset related cost factor used is 1.0.*

<u>Pavement Treatments Specified by CTDOT</u>

Generally speaking, the pavement program categories used in Connecticut are:

- **Preservation** -- Keeping good roads good -- "apply the right treatment on the right road at the right time" To be effective, preservation treatments should be applied to roads in good condition without serious structural deficiencies.
- **Structural Overlays** –resurfacing program that could include mill and replace, straight overlay, or mill and fill
- **Rehabilitation** - restores pavements, in poor or fair condition, that have significant structural deficiencies.
- **Reconstruction** - removes the entire existing pavement structure to subgrade and replaces it with new materials.
- **New Construction** – New alignment or brand new full design of non-existing road
- **Other** Specialized Treatments or activities -- for less common situations encountered, or for unique projects special treatments or combinations of treatments are developed, such as Rubblization, full depth reclamation, diamond grinding and others

As there are multiple sources of funds for any given pavement treatment type, neither the pavement program listed above nor sources of funding can be used to directly define pavement treatments deployed in the state. Sources of funds are discussed later in this report.

Table 3-2 contains a list of pavement treatments by program category that have been prescribed by CTDOT for DOT projects. There is, however, overlap between some treatments for certain categories, for example, specialized treatments can be used for preservation, rehabilitation or reconstruction, and overlays could be used for preservation and reconstruction depending upon the complexity of a specific project. There are a number of other treatments in use by other state DOTs, and even within local municipalities in Connecticut, such as slurry seals, fog seals, crack and seat, whitetopping, cold in place recycling that are not specified routinely in CTDOT, and, therefore, are not included in Table 3-2. These other treatments, however, are considered and evaluated individually for possible implementation in CT, via special research studies.

Table 3-2 Connecticut Typical Pavement Treatments by Program Category

Program	***Treatment***
Maintenance	Pothole Patching
	Emergency Overlays and Repairs
	Crack Seal
Preservation	Crack Seal or Crack Fill
	Asphalt Rubber Chip Seal
	Ultra-Thin Bonded Overlay
	Mill and Fill
	Microsurfacing
Rehabilitation	Structural Overlay
	Functional Overlay
	Structural + Joint Repairs
Reconstruction	Light, Medium, Heavy (Flexible)
	Light, Medium, Heavy (Composite)
	Widening
New Construction	New Construction
Other Special	Rubblization
	Diamond Grinding
	Full Depth Reclamation
	In-Place Recycling

<u>Maintenance Resurfacing Paving Program</u>

A fairly substantial number of CTDOT miles of paving is accomplished each year under a paving program called the Maintenance Resurfacing Program. Over the years, this paving program has gone by other names such as the Vendor-in-Place (VIP) program, and Capital resurfacing program, and was originally started over 38 years ago. These are primarily state-funded projects using state bond financing. Although this has traditionally been an annual paving program developed approximately 18 months before the actual paving, there is a process underway to transition this effort to a five-year program, which will involve pavement preservation projects as well (see also next section) and allow for better and more efficient planning and programming.

The original premise behind the Maintenance VIP program beginning around 1981 was to overlay 10 percent of the state-maintained road network each year, which would be approximately 350 centerline miles. The actual miles paved has varied over the years based on fluctuations in available funding and CTDOT resources for planning and oversite of the program. The paving generally occurs between April 1st and November 30th, each year. This paving program was traditionally developed and overseen entirely in the CTDOT Office of Maintenance. More recently, the paving program has also involved data and information collected with the CTDOT PM program, and most recently (2018 and 2019) involved the CTDOT Office of Construction, for field implementation.

For calendar year 2019, bonds approved by the Governor during the spring led to paving approximately 422-lane-miles on 69 sections of 54 state roads. During the previous calendar year (2018) approximately 522 lane-miles were resurfaced. Generally, the pavement overlay is placed at 1 to 3 inches thick, including in some cases a leveling course followed with the surface layer. Using a cost estimate from the Office of Maintenance for 2019 of $305,000 per 2-lane-miles per 2 inch of pavement thickness, the amount expended for these 422 lane-miles (157 centerline miles) is approx. $62.74 million. A summary of the 2019 Resurfacing program is contained below in Table 3-3. The complete list of route segments planned to be paved during 2019 can be found in Appendix 2.

Table 3-3 Summary of Planned Maintenance Resurfacing Paving Program (2019)

Treatment Type	Location	Number of state roads	Centerline Miles	Lane-Miles*	Approx. Material Quantities (tons)***	Approx. Cost ($million)**
Overlay	District 1	12	35.78	95.24	191,000	15.284
Overlay	District 2	12	42.84	112.92	193,500	15.464
Overlay	District 3	9	20.65	79.84	152,800	12.215
Overlay	District 4	21	57.68	134.30	247,000	19.778
Grand Total		**54**	**156.95**	**422.30**	**784,300**	**62.74**

Notes: * Mileage excludes ramps
**These are estimated costs from bids rather than actual payments.
*** Estimated cost of $80/ton

CTDOT Pavement Preservation Program

As noted earlier in the section titled "Evolution from Worst First…" pavement preservation is the preferred prioritization program, in that every mile of road that is preserved defers the higher cost of rehabilitation. Additionally, using network preservation techniques,the condition of the roads are maintained in a SOGR, which in turn reduces the user costs due to driving on smoother pavements. CTDOT has begun to prioritize and implement preservation projects utilizing a 3-year condition/funding projection. Three types of preservation treatments have been employed to-date; asphalt-rubber chip seals, ultra-thin bonded overlays, and mill and fill (overlay). Table 3-4 below contains a list of areas where pavement preservation was utilized in 2019. A complete list of preservation projects for years 2018 (82 lane-miles) and 2019 (226 lane-miles) can be found in Appendix 3, as well as a map of prospective projects for calendar year 2020.

Table 3-4 Summary of Planned Pavement Preservation Program (2019)

Treatment Type*	Location	Number of state roads	Centerline Miles	Lane-Miles**	Material Quantities	Approx. Cost ($million)
UTBO	District 2 District 4	3 2	34.26 18.05	77.58 41.05	612,407 sy 340,814 sy	9.97 4.85
ARCS	District 2 District 4	6 2	16.61 8.73	32.96 17.45	270,072 sy 162,480 sy	3.04 1.51
M&F & UTBO	District 1	1	13.30	56.53	95,000 tons 47,000 sy	20.47
Grand Total		**14**	**90.95**	**225.57**		**39.84**

*Notes:*UTBO=Utra-thin bonded Polymer Modified Asphalt (PMA)overlay*
ARCS=Asphalt-rubber chip seal
M&F=Mill and Fill (2-3in.)
*** Mileage excludes ramps*

Budget and Funding Sources (2017-2020)

Transportation funding in Connecticut comes primarily from federal and state gas tax revenues. The federal gas tax is the main revenue stream for federal highway programs through the Highway Trust Fund. In recent years the Highway Trust Fund has been supported with transfers from the General Fund. Connecticut’s state gas tax revenue, gross receipts tax on petroleum products, a portion of the new car sales tax revenue, and other fees are directed to a transportation-related state account, the Special Transportation Fund (STF), which is used to fund a wide variety of transportation programs. This includes asset management activities through the Fix-it-First legislative authorization, among others. Connecticut sells bonds to finance transportation projects and pays the debt service using revenue from the STF. Currently, CTDOT is monitoring risks to its budget and seeking increased revenue through the legislature to replenish the (STF) so that investment can continue to be made for infrastructure.

Funding for roadway maintenance and improvements in Connecticut comes from three programs: The STF (described above), a second program specifically gives priority to roadways in poor condition, and the third program funds projects addressing maintenance and preservation needs as well as system expansion.

The 2018 TAMP assumed that 58% of the Maintenance Resurfacing pavement projects would take place on the NHS during the 10-year period of the TAMP. (CTDOT 2018a) The basis for this assumption is that of the Maintenance Resurfacing pavement projects that took place from 2011 to 2015, on average 58% were on the NHS. The 2018 TAMP also assumed that 85% of pavement preservation projects would take place on the NHS during the 10-year period of the TAMP. The basis for this assumption is as follows: During the period of 2009 to 2015 about 96% of pavement preservation projects took place on the NHS. However, future preservation program expenditures are expected to focus on non-NHS preservation treatments in the near term.

Applying 58% to CTDOT's expected $69M in Maintenance Resurfacing funding and 85% to $25M in preservation funding yields a result of $61M future annual spending on NHS pavements. An additional $33M is projected to be available for non-NHS state roads each year. These figures are shown in Table 3-5, with all values reported based on 2018 dollars. Due to a continued focus on expansion of the pavement preservation program, the mix of preservation and maintenance resurfacing is projected to vary over the next 10 years as shown in more detail in Table 3-5, Funding Uses, taken from the 2019 TAMP. Even with the variations indicated, the totals (maintenance and preservation) are still projected to be $94M (2018 dollars) each year.

Table 3-5 Funding Uses (CTDOT 2019b)

	2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
Treatment	*Actual*	*Planned*			*Estimated*						
Initial Construction	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance	$ 76	$ 69	$ 60	$ 56	$ 51	$ 47	$ 43	$ 38	$ 34	$ 29	$ 25
Preservation	$ 18	$ 25	$ 34	$ 38	$ 43	$ 47	$ 51	$ 56	$ 60	$ 65	$ 69
Rehabilitation*	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25
Reconstruction (Replacement)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total	$ 119	$ 119	$ 119	$ 119	$ 119	$ 119	$ 119	$ 119	$ 119	$ 119	$ 119
Project work recommended outside of the pavements analysis	$ 2	$ 83	$ 37	$ 110	$ 24	$ 31	$ 42	$ 48	$ 60	n/a	n/a

**Estimates based on projects with multi-disciplinary work items, cost multipliers and incidental [temporary] pavement quantities make the actual investment to the network difficult to quantify.*

Life-Cycle Planning

Life cycle planning (LCP) strategies for pavement are developed using predictive models for how pavements will deteriorate if no treatments are performed, as well as how they deteriorate under different treatment strategies. A treatment strategy is a sequence of maintenance, preservation, and rehabilitation events selected over the analysis period based on inputs like funding constraints and priorities as well as indicated distresses and pavement section work history. CTDOT models pavement condition and deterioration using the Deighton dTIMS PMS. As noted earlier in this report, dTIMS is CTDOT's primary tool for storing, managing, analyzing and reporting pavement condition information. The dTIMS model predicts future pavement condition from current conditions using individual condition indices (transformations of distress measurements) which are understood by pavement managers to reflect pavement performance and consequently enable the application of treatments and prediction of performance.

CTDOT uses dTIMS as a primary component of its LCP strategy for pavements and to perform network condition projections. As part of the analysis for the 2018 TAMP, CTDOT staff attempted for the first time to model the Maintenance Resurfacing Program in dTIMS to obtain a network-wide forecast that is more aligned with actual programming practices. After planned pavement rehab projects were committed, analyses/budget scenarios were run so dTIMS could select preservation treatments with a projected budget for preservation over 10 years. This allows for the comparison of the outcomes achieved with actual programming practice versus the outcomes possible with a strategy that optimizes life-cycle cost.

Performance Projections Based on Various Funding Levels

In what is called a scenario analysis, dTIMS is used to examine what treatments each pavement segment is eligible to receive for each year (including future years), and develops possible strategies for each road segment over the scenario time horizon. These strategies are driven by the performance curves and the amount of improvement assigned to each treatment. Each strategy calculates an incremental benefit/cost value that represents maximum benefit-to-cost ratio. dTIMS then compares across strategies to select an optimal set of treatments based on benefit/cost. Benefits are normalized using the AADT, recognizing that, in this way, benefits will accrue to a larger number of users. As indicated earlier in Table 2-14 and Table 2-15, network condition projections using a stagnant total annual funding level of $94 million for pavement projects in CTDOT are anticipated to lead to declining conditions in the years ahead. In fact, if the present level of funding is maintained and not increased, it can be expected to lead to a decline of both the SOGR rating for the CTDOT-maintained network and the percent of good roads for the NHS. This will also result in an increase of roads in poor condition, which will cause the overall network condition to approach the NHS threshold shown in Figure 2-11. This is indicated in the four-year target projections (see Table 2-14 and Table 2-15).

For the 2019 TAMP, a 10-year projection using three levels of funding was calculated to illustrate the long term sensitivity of the network condition to varying funding levels between zero and an elevated 'preferred' level. This is reproduced below as Figure 3-1, for the entire CTDOT maintained network. The three scenarios presented in the TAMP using 2017 data are

- zero funding,
- current funding ($94 million/year) and
- what has been defined in the TAMP as 'preferred' funding ($475 million/year).

Note that in Figure 3-1 the preferred funding ($475M) includes reconstruction, whereas the current funding ($94M) only includes maintenance and preservation.

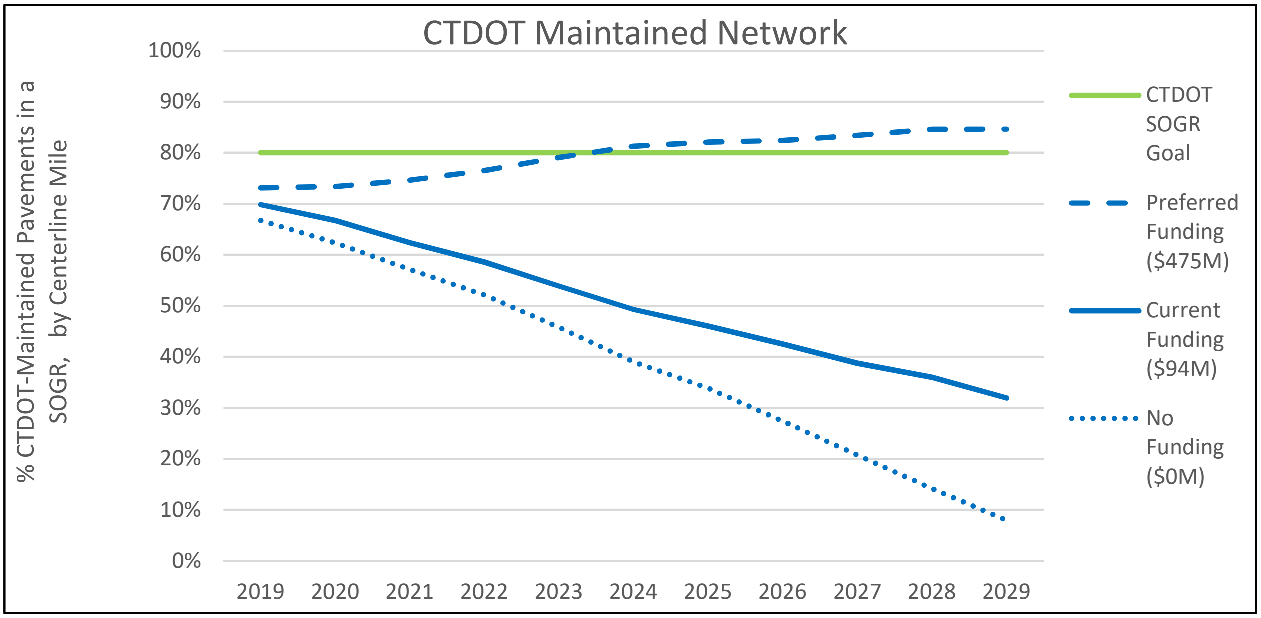


Figure 3-1 Connecticut Pavement Performance Projections for the CTDOT Maintained Network (from 2019 TAMP, 2017 Data)

Table 3-6 CTDOT Maintained Network Performance Projections at Current Funding Level ($94M Budget)

Year	**2019**	**2020**	**2021**	**2022**	**2023**	**Goal**
SOGR	**69.8%**	**66.7%**	**62.3%**	**58.6%**	**53.8%**	**80.0%**

Table 3-7 NHS Performance Projections at Current Funding Level ($94M Budget)

Year	**2018**	**2019**	**2020**	**2021**	**2022**	**Goal**
Interstate Good	**70.9%**	**71.8%**	**71.6%**	**72.1%**	**70.0%**	**75.0%**
Interstate Poor	**0.2%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**<5.0%**
Non-Int NHS Good	**40.1%**	**37.7%**	**34.9%**	**33.3%**	**26.8%**	**50.0%**
Non-Int NHS Poor	**2.5%**	**3.1%**	**3.4%**	**3.9%**	**4.4%**	**<8.0%**

With zero funding, using 2017 condition data, it can be seen that the network condition will decline rapidly between 2018 and 2023. Even under the ‘current’ funding level, the network is predicted to decline significantly over the next ten years reaching a SOGR of 36% by 2028, well below the SOGR goal of 80%. Again using 2017 data, the level of funding required to reach the ten-year target for SOGR at 80% has been estimated at $475 million/year (total of reconstruction, maintenance and preservation).

A similar routine using dTIMS was run using 2018 data, as well, but only for the entire CTDOT Maintained Network. The results of the analysis are presented in Figure 3-2. Several additional funding scenarios are included in this projection. The six scenarios plotted in Figure 3-2 include:

- $450M/yr,
- $250M/yr,
- $94M/yr (Current Funding),
- 25% increase in funding ($118M/yr),
- 25% decrease in funding ($70M/yr),
- $0 funding

The projected percent of centerline miles in a SOGR for every year from 2019 through 2029 under each of the six scenarios can be seen in Figure 3-2.

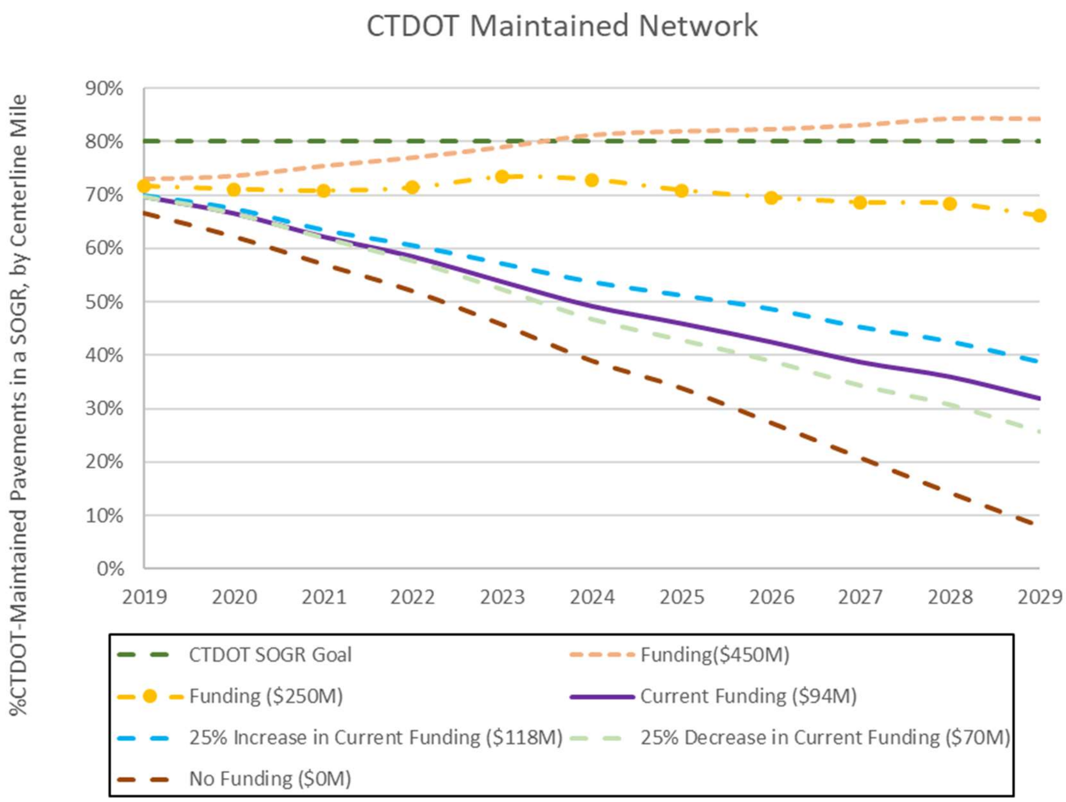


Figure 3-2 SOGR Pavement Performance Projections for CTDOT-Maintained Network Using PCI (2018 data)

4. OTHER DOT PAVEMENT-RELATED ACTIVITIES (2018-2019)

New Technology

As noted previously, Connecticut has demonstrated its desire to be a leader in adopting and using automated technology for road inventory and analysis, i.e., products that eventually led the CTDOT to purchase and use ARANs for network data collection. CTDOT has been collecting network level roadway images and data since the early 1970s.

Collecting visual, or surface-, distress data on pavement networks has been a relatively straight-forward digitization and automation. Pavement engineers' ability to assess the structural capacity of pavements has been, for many years, relegated to discrete data collection by means of Falling-Weight Deflectometers (devices which measure a discrete pavement deflection under a given point load). Deflectometers for collecting data at traffic speeds have been in existence for several decades, but initially struggled to collect data at the requisite resolution for meaningful evaluation, or required overly-complicated post-processing. Connecticut participated in preliminary studies with the Federal Highway Administration's Rolling-Weight Deflectometer for example. In 2018, the University of Connecticut in partnership with CT DOT deployed a modern traffic speed deflectometer on over 1,000 miles of state roadway, establishing for the first time ever in CT a network-level assessment of the state's roadway structural health This is for pavements on-grade and does not apply to the condition of bridges. Figure 4-1 below is excerpted from the interface developed by the particular company who developed the Traffic Speed Deflectometer (TSD) used in CT.

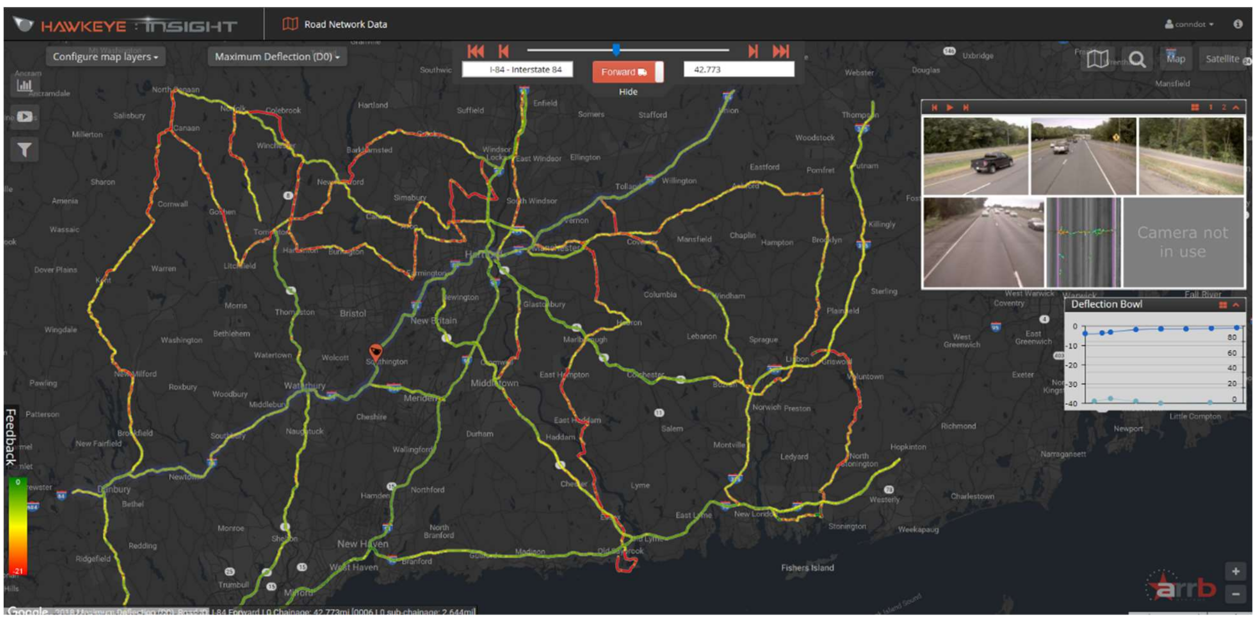


Figure 4-1 Output Map of Traffic Speed Deflectometer, Routes Traversed in Connecticut during 2018

Another technological development in the state pertaining to the improvement of the pavement network is the on-going deployment of Uniform Compaction (UC) devices. This technology employs temporal location data for the equipment used to place and compact Asphalt Concrete Pavements (pavers and rollers,). This technology collects additional information such as pavement temperature (asphalt must be compacted while hot), and vehicle speed. While the equipment operators can be aided by this data in the field, it also provides the state with an additional layer of quality assurance in the placement of asphalt pavements that is comprehensive and previously un-quantifiable.

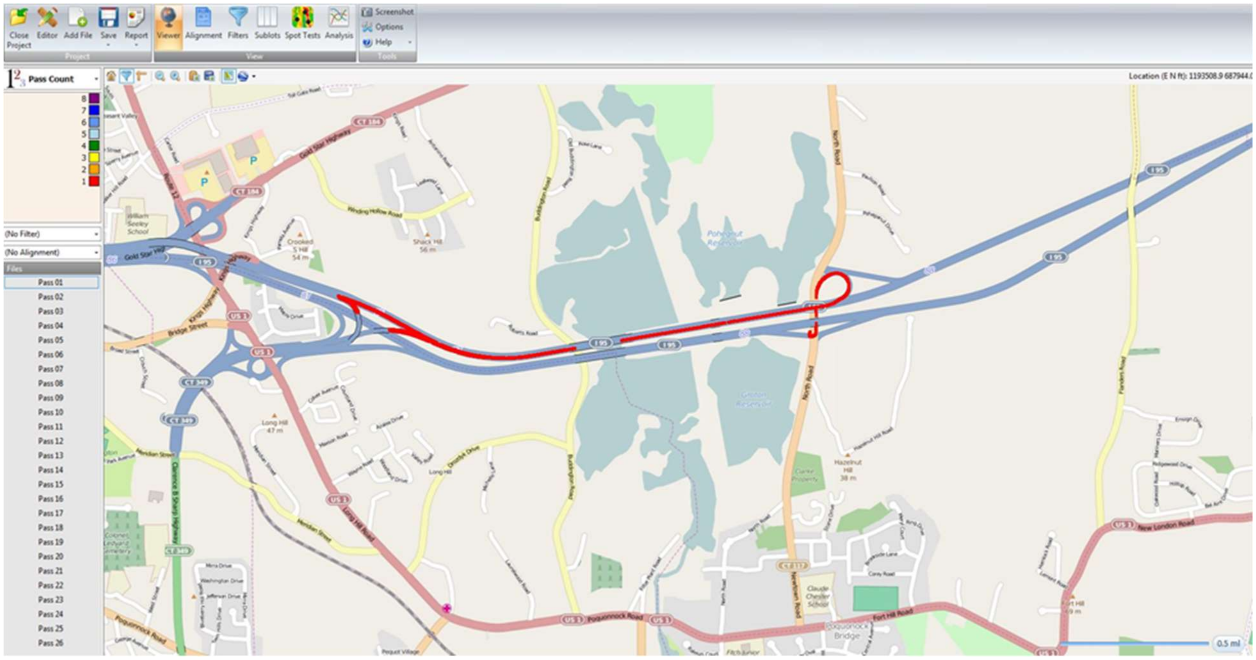


Figure 4-2 Example of VETA Software Output, I-95 Groton

<u>Research Initiatives in Pavement Management, Maintenance and Preservation</u>

<u>Traffic Speed Deflectometer for Existing Pavement Structure Data</u>

The Traffic-Speed Deflectometer (TSD) contains a known load on the trailer of an articulated 53-foot truck which travels at highway speeds. A "measurement beam" inside the trailer continually records the deflection slopes of the pavement. Other variables are also simultaneously measured. The advantage of the TSD is that it is a non-destructive, continuous measurement device that does not cause traffic disruptions (this is in comparison to wider-accepted methodologies which are discrete and require traffic lane closures). Modern TSD trucks can survey approximately 300 miles of road per day. The TSD system, in theory, has great potential, particularly at the network level, to supplement known historical information about roadways. For example, layer thickness and structure integrity (both of which are useful for determining the needs of future rehabilitation), as well as the adequacy of previous overlays that may have been placed with little knowledge of the underlying conditions, can be determined with the TSD.

The data derived from the field work was analyzed as part of the project. This dataset provided valuable information to quantify the condition of the road structures over which an overlay had been placed. A more detailed review of selected sites is also being performed to determine if information available for selected sections of road from the historical record using Digital Highway (and other sources) reasonably matches the data collected from the TSD. Cores obtained at various projects over approximately the past five years are also being used to validate TSD section information at selected sites. This work will continue through 2019.

Development and Implementation of Quality Management Plan for Pavement Data Collection

In response to federal requirements and an internal need to ensure quality data for pavements, during 2018, a data quality management plan (DQMP) for pavements was developed. Quality Control (QC) is conducted by the CTDOT Photolog Unit. Quality Acceptance (QA) is conducted primarily by CTDOT's Pavement Management Unit. The DQMP identifies key activities, processes, and procedures for ensuring quality. Under 23 CFR 490.319(c), the CTDOT was required to develop a DQMP that addressed the following minimum critical areas:

A. Data collection equipment calibration and certification;
B. Certification process for persons performing manual data collection;
C. Data quality control measures to be conducted before data collection begins and periodically during the data collection program;
D. Data sampling, review and checking processes; and
E. Error resolution procedures and data acceptance criteria.,

which will be updated from time to time. The DQMP (CTDOT 2018b) was submitted to FHWA in May 2018, revised and received formal approval of FHWA in August 2018.

Calculation of Smoothness Values (Rideability) for CTDOT Construction Projects

Roadway users are the primary beneficiaries of smooth roads via reduced user costs for vehicle operation, safer conditions, and quieter and comfortable transport. A smooth riding surface is also beneficial to the owner agency in that initially smooth pavements tend to last longer than rough surfaced pavements. In the long term this reduces the cost of maintaining and rehabilitating the subject roadway. In order to ensure a smooth and highly functional pavement surface that provides the most effective and desirable ride for the users, a CTDOT special provision titled, "Hot Mix Asphalt Smoothness Adjustment" was developed several years ago to be part of CTDOT construction specifications. This special provision is used on selected projects, at the discretion of CTDOT engineers. The special provision contains a table for rideability pay factor schedule that is used to determine pay adjustment based upon the universally recognized scale of measurement for rideability, the International Roughness Index (IRI).

Approximately 3-5 projects per year have recently been awarded containing the smoothness adjustment special provision. The special provision rewards those contractors that produce a highly desirable smooth pavement riding surface by paying them a bonus. There is also a penalty assessment for pavements that don't provide acceptable rideability (>80 in/mi). For those pavements constructed as merely acceptable (60 – 80 in/mile) no penalty is assessed or bonus awarded.

CTDOT is currently revising and updating this special provision. Smoothness data was collected on a number of paving projects in 2018 to determine how closely the contractors are able to meet or exceed specified requested smoothness (IRI < 60 in/mile).

Pavement Design Handbook and Interactive Pavement Preservation Computer Application

The CT DOT in partnership with the University of Connecticut's Transportation Institute is developing a Pavement Design Handbook. The handbook will provide all information necessary to perform a pavement design in conformance with CTDOT requirements.

Additionally, a pavement preservation computer application is under development based upon CTDOT Pavement Preservation practices. The software will enable users, tasked with making decisions regarding choice of Pavement Preservation treatments, to decide which treatments are appropriate for different types and levels of distresses and roadway settings.

Sustainability

The use of warm mix asphalt, and the performance of in-place recycling and other common recycling techniques can improve the quality, environmental footprint, and cost efficiency of road projects. Many areas in the United States utilize these activities extensively, particularly local municipalities. CTDOT has utilized several of these technologies on a project-by-project basis.

Warm Mix Asphalt

Production of warm mix asphalt (WMA) is considered a "greener" solution for the environment as a result of both reduced energy consumption and greenhouse gas emissions. WMA asphalt is identical to conventional hot mix asphalt, except that through a special mixing process it is produced at a temperature approximately 50 to 100 degrees cooler than conventional hot mix asphalt. This mixing process for asphalt aids in compaction during paving, assists in preventing premature aging and slows the aging process of asphalt. Other benefits of paving with WMA are the ability to extend the paving season in colder weather, longer haul distances, and better road performance.

CTDOT currently allows the use of WMA on all projects at contractor discretion provided the additives meet contract specifications.

Recycling

Many materials that may otherwise be sent to a landfill can be incorporated into Asphalt Pavements. These specific materials are controlled and often processed, but may actually provide performance benefits to pavements in particular environments (traffic and climate). The materials described below are all part of the permissible mix design methods in accordance with the current CTDOT Specification 4.06 :

Reclaimed Asphalt Pavement (RAP)

the term given to removed and/or reprocessed pavement materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities. When properly crushed and screened, RAP consists of high-quality, well-graded aggregates coated by asphalt cement that can be reused as a substitute for a portion of virgin materials in asphalt and aggregate base. CTDOT permits RAP in accordance with project specifications.

Recycled Asphalt Shingles (RAS)

Shingles incorporated into the mix are derived from two sources: ‘tear-offs’, removed from residential or commercial roofs and ‘factory seconds’ from manufacturing. The preferred source is manufacturing waste, as these are modern products free of hazards like asbestos. Additionally, manufacturing waste has undergone minimal oxidation of the asphalt component as compared to tear-offs. Shingles used in asphalt pavement are ground into a state resembling coffee grounds and are incorporated into the liquid asphalt binder prior to full production with aggregate. Shingles can offset a significant portion of virgin asphalt material but have stiffness and moisture sensitivity concerns that must be controlled for. Currently, there are maximum amounts of RAS permissible in a mix and this maximum is reduced if RAS and RAP are used in combination. A challenge associated with this product is the availability of a geographically feasible processing/stockpiling facility, as most producers do not use this material reliably enough to drive a profitable recycling industry.

Polymer Modification

Liquid Asphalt Binder is a derivative of crude oil. It is a visco-elastic material, meaning it behaves as a liquid or an elastic solid based on temperature and load amplitude. Bearing these two constraints in mind, there is a wide variability in material behavior due to crude source and depending on the environment in which an asphalt pavement is placed. Polymer modification has been developed over the past few decades and has really ‘hit stride’ in the past 15 years. Incorporating polymers (essentially plastics like Styrene-Butadiene-Styrene [SBS]) into liquid asphalt binder at concentrations of 0.5% to 6%, depending on the intended outcome, has proven very beneficial to resist rutting, and has the probability to improve the lifespan of a pavement. As this technology has improved, CTDOT has embraced Polymer Modification, especially in heavily-trafficked areas to assist with mitigation of rutting/deformation. Current CTDOT Specifications only permit the use of SBS modification for polymer-modified binders.

5. ON-GOING EFFORTS AND STATE FY20 OUTLOOK

Projected Pavement Improvement Activities for FY20 and Beyond

A list of known, as well as possible, future activities related to improving pavements in Connecticut is provided in Table 5-1

Table 5-1 Pavement Improvement Activities for State FY20 and Beyond

A	Develop a comprehensive 3-year program identifying Preservation and Maintenance Resurfacing projects by year, to be updated annually.
B	Develop a 10-year Reconstruction and Rehabilitation program identifying projects by year, to be updated annually.
C	Refine pavement analysis methodology, including improvements in forecasting future conditions of pavements
D	Improve tracking of paving work of all kinds including maintenance activities.
E	Re-evaluate and update pavement performance target goals
F	Analyze new and expanded data from cores, trenching, and the use of non-destructive testing procedures, such as the Traffic Speed Deflectometer described previously, that could provide more information about history and hidden underlying conditions.
G	Further evaluation of the effect of new construction materials, such as polymer-modified asphalts, and techniques, such as UC equipment, on pavement performance.
H	Coordinate with FHWA and adjacent states to improve reporting methods for pavement performance, including for HPMS
I	Improve ability to demonstrate the impact of funding variability on future pavement conditions using dTIMS and other modeling programs
J	Utilize and improve upon optimization models for the selection and programming of paving projects
K	Perform pavement forensic studies (detailed investigation for a pavement that is not performing as well as desired, or alternatively for ones that are performing much better than expected)
L	Re-assess and modernize the pavement condition index (PCI) score currently used for CTDOT-maintained roadways
M	Complete the pavement design handbook for use by consultants and internal staff to standardize handling of pavement designs for CTDOT roads.
N	Accumulate better quality condition data over time to provide a better understanding of the cost-effectiveness of different pavement treatment strategies.
O	Develop a database structure table to record core tests, non-destructive tests, photographs, construction data, material data and inspector notes for project level analysis of Pavement Preservation projects.
P	Participate in development of CTDOT Enterprise TED
Q	Perform analysis of how tolls may change the traffic makeup and performance of bypass routes
R	Prepare additional roadway condition/needs reports for legislature or other jurisdiction, upon request

6. SUMMARY AND CONCLUSIONS

Some of the pavement data presented in this annual pavement condition report is from CTDOT's TAMP, published in August 2019. Any condition data reproduced from the 2019 TAMP is from year 2017. In future years, this CTDOT Annual Pavement Report will be the prerequisite document(s) used to update the TAMP on an annual cycle, per Federal requirements. Due to the timing of annual seasonal data collection, the data presented in each TAMP will be from two years prior to publication, for each annual update. To serve that purpose, much of the data in this 2019 pavement publication is from year 2018, unless otherwise noted as being from the 2019 TAMP.

Based on the results of studies over the past 15 years, prioritizing repair work by "worst-first," which emphasizes treating pavements in poor condition, is now recognized to be the least effective means of maintaining a highway network and expending limited highway funds. Maintaining pavements in smooth and good condition lengthens their life, enhances safety, helps reduce road users' operating costs, and reduces vehicle emissions. Through its rehabilitation and resurfacing programs, CTDOT has been working to extend the useful life of pavements, particularly through increased use of pavement preservation treatments and improved condition surveys as well as forecasting by means of deterioration modeling.

CTDOT has over thirty years of photolog technology experience, in fact many other state DOTs look to Connecticut as a leader in this field. Implementation of photolog has evolved to become a critically important and prominent tool in use by CTDOT. CTDOT equipment enables the collection of highly technical, detailed and complex pavement condition and infrastructure data. Data collection vehicles were extensively updated in 2015 to provide even greater detail in the measurement of cracking and roughness, which will support future refinements to CTDOT's condition indices. CTDOT is also currently moving towards an enterprise data approach for asset management (including pavements) in order to make best use of agency data for informed decision-making.

Although Connecticut is geographically a small state, the relatively high population density leads to Connecticut's roadway network to be ranked at 37th for travel volumes (vehicle miles traveled). This traffic level, as well as a relatively severe climate, hasten the wear and tear on Connecticut roadways with respect to many other states. Therefore, keeping roads in a state of good repair (SOGR) requires a significant level of diligence and resources.

For 2019, CTDOT programmed to pave 248 centerline miles of roadway through its Pavement Preservation and Capital Resurfacing programs (Table 3-3 and Table 3-4). The two programs addressed 226 and 422 lane miles of pavement, respectively, to keep them in a SOGR. The costs for pavement placement and peripherally-related activities was approximately $100 million.

The CTDOT stated goals for SOGR as published in the August 2019 TAMP are shown below

Targets and Goals for CTDOT Maintained Roads	**Percent of Network in State of Good Repair (SOGR)**		
	2-Year Projection (12/31/2020)	**4-Year Target (12/31/2022)**	**10-Year Goal (2029)**
Pavement (Centerline Miles)	66.4%	58.1%	80.0%

Targets and Goals for NHS Roads	**Percent of NHS in Good and Poor Condition**							
	Baseline Condition (2017 Data)		**2-Year Targets (2020)**		**4-Year Targets (2022)**		**10-Year Goal (2029)**	
	Good	**Poor**	**Good**	**Poor**	**Good**	**Poor**	**Good**	**Poor**
Interstate Pavement (lane-miles)	n/a	n/a	n/a	n/a	64.4%	2.6%	75%	<5%
Non-interstate NHS Pavement (lane-miles)	42.9%	17.0%	36.0%	6.8%	31.9%	7.6%	50%	<8%

The actual CTDOT pavement conditions reported using 2018 data (PCI for CTDOT maintained centerline miles, and FHWA HPMS format for NHS lane-miles) are shown below.

Current CTDOT/ PCI Conditions	**Centerline Miles**	**Good**	**Fair**	**Poor**
CTDOT-maintained Roads	3,719	63.1% **SOGR**	33.5%	3.4%

Current FHWA/ HPMS Conditions	**Lane miles**	**Good**	**Fair**	**Poor**
NHS Pavement	5,177	51.9%	46.6%	1.5%

Another method to show the effects of pavement condition on users is to present the amount of vehicle miles traveled (derived from traffic volumes) on pavements in various condition. Thus, VMT on roads of various levels of condition can be an indicator of the roadway users' (motorists') experience. If, for example, a majority of travel occurs on poor condition roads, than the user experience is presumed to be less than satisfactory. On the other hand, a large amount of travel on SOGR roads would be expressed as being more desirable, as well as likely having lower overall user costs for the motorist. Since the larger amount of travel occurs on interstates and expressways in Connecticut, keeping those facilities in SOGR benefits the greatest number of users.

When condition data are presented based on VMT, the following findings are made. Nearly 80 percent of the total miles travelled on the Connecticut interstate system during 2018 were driven on interstate roads that are in good condition, (ride quality IRI of < 95 in/mile). That is because a relatively high percentage of interstate roads are in good condition, and a large amount of travel occurs on them. On the other hand, one-third of total annual travel that occurs on all types of CTDOT maintained roads occurs on roads rated less than good for ride quality (IRI > 95 in/mi.) Also, 6% of travel occurs on CTDOT maintained roads of all types combined that are rated in poor condition for ride quality (i.e., IRI > 170 in/mi.)

In order to be able to reach and maintain the pavement conditions that are stated for the ten-year goals, Connecticut would need to expend an estimated $4.75 billion between 2020 and 2030. At the current projected level of spending on pavements it is anticipated that the condition of pavements will actually decline over the next ten years. This is a problem that is not unique to Connecticut, as most states face the same fate, too few programmed resources to maintain a SOGR. For example, according to the American Society of Civil Engineers in the 2017 Infrastructure Report Card, at least $170 billion of annual capital investment is needed nationwide to address deteriorating conditions, system performance, and highway congestion. According to ASCE "The U.S. has been underfunding its highway system for years, resulting in a $836 billion backlog of highway and bridge capital needs. The bulk of the backlog ($420 billion) is in repairing existing highways." (ASCE 2017)

REFERENCES

AASHTO. (1985). Guidelines on Pavement Management, American Association of State Highway and Transportation Officials, Washington D.C., 1985.

APTA. (2013). Defining a Transit Asset Management Framework to Achieve a State of Good Repair. Recommended Practice. APTA SGR-TAM-RP-002-13. APTA Standards Development Program. Working Group: Transit Asset Management. http://www.apta.com/gap/fedreg/Documents/Defining.a.transit.asset.management.framework.to.achieve.a.state.of.good.repair.pdf

ASCE. (2017). "2017 Infrastructure Report Card: Roads. pp 77" American Society of Civil Engineers, New York, NY. https://www.infrastructurereportcard.org/wp-content/uploads/2017/01/Roads-Final.pdf (accessed October 24, 2019).

CTDOT. (2010). "Traffic and Congestion in Connecticut", Connecticut Department of Transportation, Bureau of Policy and Planning, Newington, CT, April 2010, http://ct.gov/opm/lib/opm/2010_ctdot_congestion.pps (accessed April 3, 2019)

CTDOT. (2015). *Connecticut…On the Move: Transportation FASTfacts 2015*, Connecticut Department of Transportation, Newington, CT, 2015.

CTDOT. (2018a). TAMP, "Connecticut Department of Transportation, Highway Transportation Asset Management Plan", Connecticut Department of Transportation, Newington, CT, July 2018.

CTDOT. (2018b). *Network-Level Pavement Condition Data Collection Quality Management Plan*, Connecticut Department of Transportation, Aug 2018.

CTDOT. (2019a) *Connecticut DOT History, Birth of the State Highway Commission, 1895-1912, The Good Roads Act*, https://www.ct.gov/dot/cwp/view.asp?A=1380&Q=259694 (accessed April 23, 2019)

CTDOT. (2019b). TAMP, "Connecticut Department of Transportation, Highway Transportation Asset Management Plan", Connecticut Department of Transportation, Newington, CT, August 2019.

FHWA. (2013). Highway Functional Classification Concepts, Criteria and Procedures; Section 3, Criteria, https://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/section03.cfm#Toc336872980 (accessed September 30, 2019)

FHWA.(2015). *2015 Status of the Nation's Highways, Bridges and Transit: Conditions and Performance, Executive Summary, Report to Congress*, US Department of Transportation, Washington, D.C.,

FTA. (2010). Transit Asset Management Practices: A National and International Review. US Department of Transportation. https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/TAM_A_National_and_International_Review_-_6.10_FINAL_0.pdf.

NCHRP. (2009). An Asset-Management Framework for the Interstate Highway System, NCHRP Report 632, Transportation Research Board, National Academy of Sciences, Washington D.C., (2009)

USDOT. (2016). Highway Performance Monitoring System: Field Manual. Federal Highway Administration, Office of Highway Policy Information, Office of Management & Budget (OMB) Control No. 2125-0028, December 2016.

USDOT. (2017a). "Highway Statistics-2017", Section 4: Highway Infrastructure, Public Road Length, Mileage by Ownership, (**Table HM-10**), U.S. Department of Transportation, Federal Highway Administration, http://www.fhwa.dot.gov/policyinformation/statistics/2017 (accessed April 23, 2019).

USDOT. (2017b). "Highway Statistics- 2017," Section 4: Highway Infrastructure, State Highway Agency-owned Public Roads – 2017, Miles by Functional System (**Table HM-80**), U.S. Department of Transportation, Federal Highway Administration, https://www.fhwa.dot.gov/policyinformation/statistics/2017/hm80.cfm (accessed April 23, 2019)

USDOT. (2017c). "Highway Statistics- 2017," Section 5: State Tables, Highway Travel-Vehicle Miles of Travel by Functional System (**Table VM-2**), U.S. Department of Transportation, Federal Highway Administration, https://www.fhwa.dot.gov/policyinformation/statistics/2017/ (accessed April 23, 2019)

APPENDIX 1. ACRONYMS/DEFINITIONS/GLOSSARY

AADT – (Annual Average Daily Traffic) - The total yearly traffic volume on a given highway segment divided by the number of days in a year. AADT is expressed in vehicles per day, and in limited cases is measured directly, but for many roads is estimated from a traffic samples collected over a 24 to 48 hour time period.

ARAN – (Automatic Road Analyzer) – Vendor-built data collection vehicle used in Connecticut and several other states to collect roadway condition data at highway speeds.

Centerline (Roadway) Mile – A mile of highway, without considering the number of lanes in the facility.

Cracking – A fissure or discontinuity of the pavement surface not necessarily extending through the entire thickness of the pavement. CTDOTs method of identifying and extracting flexible pavement cracking data is from AASHTO **PP67-16 "**Standard Practice for Quantifying Cracks in Asphalt Pavement Surfaces from Collected Pavement Images Utilizing Automated Methods," and AASHTO **R55-10** "Standard Practice for Quantifying Cracks in Asphalt Pavement Surfaces," 2013 2017. On flexible pavements, fatigue-type cracking is identified and used for performance measurement on the NHS. However, cracking on rigid pavements is reported as the percentage of slabs within the section that exhibit transverse cracking.

dTIMS CT® – Proprietary customizable asset management software used by many States. dTIMS-CT was purchased by CDOT for the purpose of calculating benefit/cost analyses used to recommend projects. dTIMS provides assistance in making funding decisions by finding the optimal set of strategies to apply to a network under a given set of constraints such as costs. dTIMS also provides a mechanism for analyzing a variety of maintenance, rehabilitation, and reconstruction treatments over a period of time and assists in the selection of the most cost-effective treatments for a range of budget scenarios.

Faulting – A difference in elevation across a joint or crack in slabs of PCC pavement. Usually the approach slab is higher than the leave slab causing a drop off of the departure end of one slab onto the leading edge of the next slab. Faulting adversely affects the ride quality (smoothness) of the surface of pavements.

FAST Act– (Fixing Americas Surface Transportation). a federal funding and authorization bill from 2015 to govern United States federal surface transportation spending.

Flexible Pavement – Pavement constructed with asphalt concrete, also known as 'bituminous,' 'flexible' HMA, or 'black' pavement.

Functional Classification – the process by which streets and highways are grouped into systems according to the character of traffic service that they are intended to provide. Each roadway is classified in two ways. First by whether it is 'urban' or 'rural.' Then into one of three groups according to its function within the network. The three groups as defined by the FHWA are: arterial, collector, and local.

FY State – (State Fiscal Year) – Administrative year used in Connecticut government covering period of July 1 through June 30.

FY Federal– (Federal Fiscal Year) - Administrative year used in federal government covering period of October 1 through September 30.

HMA – (Hot Mix Asphalt) - A combination of stone, sand, or gravel bound together by asphalt cement, also called ‘bituminous,’ ‘flexible’ or ‘black’ pavement.

HPMS – (Highway Performance Monitoring System) - According to FHWA, the HPMS is a national level highway information system that includes data on the extent, condition, performance, use and operating characteristics of the nation's highways.

IRI – (International Roughness Index) - A standardized method of measuring the roughness of the pavement surface developed by the World Bank and expressed in inches per mile or centimeters per kilometer. It can also be termed a measure of highway smoothness. The lower the number, the smoother the road surface.

Lane Mile – A pavement measuring one mile long and one lane wide is an example of a lane mile. Other examples: a one mile stretch of a two-lane road equals two lane miles; a ten mile section composed of four lanes is measured as forty lane miles.

MAP21 – (Moving Ahead for Progress in the 21st Century Act) a federal funding and authorization bill from 2012 to govern United States federal surface transportation spending.

NHS (National Highway System) – includes the Interstate Highway System as well as other roads important to the nation's economy, defense, and mobility. The NHS routes in Connecticut were designated by the US Department of Transportation in cooperation with CTDOT, local officials, and metropolitan planning organizations.

Pavement Preservation – the FHWA defines pavement preservation as 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 transportation facility’s overall condition.

Pavement Rehabilitation – Measures to improve, strengthen or salvage existing deficient pavements which allow service to continue with only routine maintenance. Deficient pavements exhibit distress in excess of what can be handled through routine maintenance or preservation. Rehabilitation extends the life by 10 or more years.

PCC (Portland Cement Concrete) – Pavement constructed with PCC, also known as ‘concrete’ or ‘rigid’ pavement.

PCI – (Pavement Condition Index) An index developed specifically within and for CTDOT. The CTDOT PCI is composed of five weighted metrics: IRI (10%), Rutting (15%), Cracking (25%), Disintegration (30%), Drainage (20%). Note: this index is not equivalent to the PCI developed by the US Army Corps of Engineers, which is now ASTM D6433-11: "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys."

Performance Curves – A performance curve is a deterioration model based on data collected over a period of time. Performance curves can be used to estimate future conditions and the time period to reach certain threshold values.

PMS – (Pavement Management System) -- AASHTO defines pavement management as "the effective and efficient directing of the various activities involved in providing and sustaining pavements in a condition acceptable to the traveling public at the least life cycle cost" [18] The FHWA defines pavement management systems as providing an ability to: Identify and prioritize maintenance and rehabilitation needs; evaluate the cost effectiveness of various strategies; and recommend projects and treatments under various budget scenarios.

Preventative Maintenance – According to the definition of the AASHTO Standing Committee on Highways in 1997, it is "a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing the structural capacity)."

Rigid pavement – Pavement constructed with Portland Cement Concrete (PCC), also known as 'concrete' or 'PCC' pavement.

Rutting – A longitudinal depression in the wheel path caused by the consolidation or lateral movement of either roadbed or surface material under heavy loads. The two types of rutting are mix rutting and subgrade rutting. Mix rutting occurs when the pavement surface exhibits wheelpath depressions as a result of compaction/mix design problems. Subgrade rutting occurs when the roadbed exhibits wheelpath depressions due to loading.

SOGR (SGR) (State of Good Repair) –A condition in which pavements both individually and as a system are functioning as designed and can be sustained through regular maintenance, preservation and replacement programs. Currently, in CTDOT roads designated as SOGR have a condition score (PCI) of 6 or higher on a scale of 1 to 9.

STF – (Special Transportation Fund) – a dedicated fund used to finance Connecticut's transportation infrastructure program and operate CTDOT

TAM (Transportation Asset Management) -- Transportation Asset Management is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life cycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well defined objectives. [19]

TED – (Transportation Enterprise Database) CTDOT SQL Server data warehouse that contains geospatial information

TSD (Traffic Speed Deflectometer) A roadway survey device which collects structural deflection data as it traverses a pavement's surface at normal speeds. Continuous measurements are made of the deflection basin from a partially-loaded tractor trailer at one of the rear wheel paths.

UC (Uniform Compaction)/IC (Intelligent Compaction): Intelligent Compaction (IC) uses real-time GPS to track paving equipment during the placement and compaction of the pavement. A monitor is mounted on the rolling equipment that provides instantaneous information to the operator, including where the roller has been, how many roller passes have taken place in that location, roller speed and the temperature of the pavement. IC also utilizes accelerometers mounted to the rollers to measure the pavement's stiffness. Uniform Compaction (UC) is Intelligent Compaction excepting the use of the accelerometers. UC is used to ensure that the pavement receives approximately the same amount of compactive effort in all locations, at the appropriate temperatures and speeds.

VIP (Vendor-in-Place) Connecticut's maintenance resurfacing program was formerly called the vendor in place paving program.

VMT (Vehicle Miles Traveled) – the amount of travel by vehicles on a specified network of roads, (such as within a geographic region), over a given period of time, typically a one-year period. VMT can be calculated as the sum of the length of sections of a highway network multiplied by the Annual Average Daily Traffic per section.

Worst First – Giving roadway pavement rated the poorest (or lowest score) the highest priority for repairs.

APPENDIX 2. LIST OF MAINTENANCE RESURFACING PAVING PROJECTS (2019)

Districts 1 and 2

DIST	RTE	DIR	TOWNS	TERMINI	BEG MI	END MI	LaneMile	DEPTH	Est. Cost
1	44	E+W	MANCHESTER	BGN OVLP US 6 TO RT83	59.33	61.91	3.21	2.00	$979,050.00
1	32	N+S	WILLIMANTIC	N JCT RT 66(COLUMBIA AVE) TO MANSFIELD TL	30.02	31.09	1.55	2.00	$472,750.00
1	32	N+S	WILLINGTON	RT 74 (TOLLAND TPKE) TO THE TOLLAND TL	43.16	46.99	3.83	2.00	$1,168,150.00
1	84	E/B	VERNON	MANCHESTER TL TO .06 MI W/O BRIDGE #04270	72.61	74.25	4.98	3.00	$2,278,350.00
1	502	E+W	EAST HARTFORD	NB US 5 (MAIN ST) TO FORBES ST	0.52	2.85	4.31	2.00	$1,314,550.00
1	530	E+W	HARTFORD	WETHERSFIELD AVE TO BRAINARD RD	0.00	0.58	1.62	2.00	$494,100.00
1	140	E+W	ELLINGTON,STAFFORD	.08 MI W/O BUFF CAP RD TO RT 190	19.18	22.50	3.32	2.00	$1,012,600.00
1	0	N+S	EAST HARTFORD	BROOKSIDE LANE-ROBERT ST TO GATE AT CUL-DE-SAC	0.00	0.22	0.22	2.00	$67,100.00
1	5	N+S	MERIDEN	WALLINGFORD TL TO BGN OVLP TO RT 15	15.07	19.30	5.16	2.00	$1,573,800.00
1	69	N+S	WOLCOTT	WATERBURY TL TO OP MAD RIVER	18.93	21.33	2.46	2.00	$750,300.00
1	69	N+S	WOLCOTT,BRISTOL	.02 MI N/O NORTH ST TO .01 MI N/O N JCT OLD WOLCOTT RD	18.93	25.77	7.78	2.00	$2,372,900.00
1	71	N+S	MERIDEN	WEST MAIN ST#2 TO END OP I-691	3.84	4.60	0.86	2.00	$262,300.00
1	71	N+S	NEW BRITIAN	RT 175 (ALLEN RD) TO SB ACC TO RT 9 SB	15.01	17.39	2.89	2.00	$881,450.00
1	71	N+S	WEST HARTFORD	.02 MI S/O CHATFIELD DR TO RT 173	18.70	19.19	1.00	2.00	$305,000.00
1	411	E+W	ROCKY HILL	RT 3 (CROMWELL AVE) TO RT 99 (MAIN ST)	0.00	1.98	2.90	2.00	$884,500.00
1	536	E+W	PLAINVILLE	RT 372 TO WHITE OAK AVE	0.00	1.13	1.53	2.00	$466,650.00
									$15,283,550.00
2	695	E+W	KILLINGLY	JCT I-395 TO JCT US 6	0.00	4.49	8.98	1.50	$2,054,175.00
2	438	N+S	PUTNAM,THOMPSON	US 44 TO QUADDICK TOWN FARM RD	0.00	2.90	2.90	1.00	$442,250.00
2	434	E+W	EAST HADDAM	RT 82 TO TOWN FARM RD	0.00	4.20	4.20	1.00	$640,500.00
2	439	N+S	EAST HAMPTON	HURD PARK RD TO RT 151	0.00	0.56	0.56	1.00	$85,400.00
2	2	E/B	COLCHESTER	OP RT 85 TO EB ACCESS FROM RT 354	24.88	25.25	0.63	3.00	$288,225.00
2	89	N+S	ASHFORD,UNION	N JCT WESTFORD HILL RD TO RT 190	12.69	16.25	3.56	2.00	$1,085,800.00
2	395	N+S	PUTNAM	KILLINGLY TL TO THOMPSON TL (INCL RMPS)	43.98	47.78	9.77	2.00	$2,979,850.00
2	66	E+W	PORTLAND	RT 17A TO RT 17	7.96	9.96	4.18	2.00	$1,274,900.00
2	82	E+W	EAST HADDAM,LYME	RT 151 TO RT 148	5.34	9.26	3.92	2.00	$1,195,600.00
2	12	N+S	PUTNAM	HERITAGE RD TO BGN OVLP US 44	44.65	45.58	0.93	2.00	$283,650.00
2	80	E+W	KILLINGWORTH,DEEP RIVER	RT 81 TO RT 154	18.19	25.91	7.72	2.00	$2,354,600.00
2	156	E+W	WATERFORD	END OP NIANTIC RV TO US 1	20.04	22.76	3.44	2.00	$1,049,200.00
2	395	S/B	LISBON, GRISWOLD	.01 MI S/O BGN OP RT 97 TO BGN OP PACHAUG RV	18.16	23.83	5.67	2.00	$1,729,350.00
									$15,463,500.00

Districts 3 and 4

DIST	RTE	DIR	TOWNS	TERMINI	BEG MI	END MI	LaneMile	DEPTH	Est. Cost
3	34	E+W	NEW HAVEN	BGN OP US1 & CSX TO END OP US 1 & CSX - BRIDGE 00333	23.75	23.88	0.52	2.50	$198,250.00
3	1	N+S	MADISON	RT 79 (DURHAM RD) TO SB SR 450 (HAMMONASSET CON)	67.85	69.87	2.15	2.00	$655,750.00
3	1	N+S	ORANGE,WEST HAVEN	RT 114 (RACEBROOK RD) TO TUTHILL ST	43.20	44.74	4.09	2.00	$1,247,450.00
3	1	N+S	MILFORD	RT 121 TO ORANGE TL (OMIT 41.08-41.24)	39.20	41.60	6.06	2.00	$1,848,300.00
3	1	N+S	NEW HAVEN	BGN OP METRO NORTH BR #00334 TO OLIVE ST	48.28	48.44	0.18	2.00	$54,900.00
3	337	E+W	EAST HAVEN	NEW HAVEN TL TO COE AVE (LOCAL)	2.82	4.51	1.72	2.00	$524,600.00
3	142	E+W	EAST HAVEN	VISTA DR TO WHEATON RD	1.14	1.76	0.62	2.00	$189,100.00
3	5	N+S	NORTH HAVEN,WALLINGFO RD	.07 MI S/O WALLINGFORD TL TO WARD ST	9.19	11.09	3.81	2.00	$1,162,050.00
3	10	N+S	HAMDEN	DIXWELL AVE #1 (LOCAL) TO MATHER ST	5.00	6.53	3.67	2.00	$1,119,350.00
3	95	N+S	MILFORD	.04 MI S/O OP BR 00136 TO BGN OP SCHOOL HOUSE RD	35.33	35.85	2.43	2.00	$741,150.00
3	8	S/B	BRIDGEPORT	.03 MI N/O OP I-95 TO .15 MI S/O SB-BGN OP NB RT 25	0.35	3.80	7.34	2.00	$2,238,700.00
3	1	N+S	STAMFORD	GREENWICH TL TO CLINTON AVE	5.67	6.81	1.91	2.00	$582,550.00
3	1	N+S	WESTPORT	NORWALK TL TO RT 136	17.99	19.84	3.69	2.00	$1,125,450.00
3	110	N+S	STRATFORD	RT 113 TO .10 MI S/O N JCT MAIN ST-PUTNEY	1.30	3.00	1.73	2.00	$527,650.00
									$12,215,250.00
4	10	N+S	AVON	FARMINGTON TL TO US 44	36.10	40.16	5.18	2.00	$1,579,900.00
4	44	E+W	WINCHESTER	W JCT RT 183 TO JCT RT 183 (NB)	26.74	28.89	3.65	2.00	$1,113,250.00
4	159	N+S	SUFFIELD	WINDSOR LOCKS TL TO N JCT RT 190	10.49	14.43	3.99	2.00	$1,216,950.00
4	44	E+W	NEW HARTFORD,CANTO	RT 219 TO RT 179	34.43	38.77	4.53	2.00	$1,381,650.00
4	183	N+S	WINCHESTER,COLE BROOK	END OVLP US 44 TO RT 182	10.35	14.01	3.66	2.00	$1,116,300.00
4	254	N+S	THOMASTON	SR 807 TO LITCHFIELD TL	1.07	3.15	2.10	2.00	$640,500.00
4			THOMASTON	DISTRICT IV HQ PARKING LOT	0.00		0.52	2.00	$158,600.00
4	167	N+S	AVON	SUNRISE DR TO EXIT FROM AVON HIGH	1.65	2.65	1.00	1.00	$152,500.00
4	202	N+S	NEW HARTFORD	TORRINGTON TL TO SOUTHEAST RD	47.19	52.30	6.24	2.00	$1,903,200.00
4	84	E/B	WATERBURY	END VIADUCT TO OP WASHINGTON ST	32.56	33.68	2.20	1.00	$335,500.00
4	34	E+W	DERBY	CAMPTOWN RD TO THIRD ST	13.50	13.70	0.20	2.00	$61,000.00
4	6	E+W	WOODBURY	SCUPPO RD TO RT47	25.39	27.60	2.31	2.00	$704,550.00
4	490	E+W	NEWTOWN	DR TO W.A. GARNER CORR INSTITUTION TO RT	0.00	1.10	1.18	2.00	$359,900.00
4	860	E+W	NEWTOWN	RT 25 TO SSR 490 (NUNNAWAUK RD)	0.00	1.07	1.33	2.00	$405,650.00
4	69	N+S	BURLINGTON	BRISTOL TL TO RT 4	30.77	35.16	4.39	2.00	$1,338,950.00
4	801	E+W	WATERBURY	.06 MI W/O NEWINGTON AVE TO AUSTIN RD	0.00	1.57	1.67	2.00	$509,350.00
4	68	E+W	NAUGATUCK	RT 63 TO SR 723 (GOLDEN CT)	0.00	0.61	0.69	2.00	$210,450.00
4	723	N+S	NAUGATUCK	NORTH MAIN ST TO END SR 723	0.00	0.16	0.16	2.00	$48,800.00
4	710	N+S	NAUGATUCK	SR 723 TO HOPKINS ST	0.00	0.31	0.31	2.00	$94,550.00
4	8	N+S	SEYMOUR	.02 MI S/O GEN. D. HUMPHREYS BR TO SB X TO OP RIMMON BK	18.21	19.32	2.64	2.00	$805,200.00
4	8	N/B	WATERBURY	NB-JCT WB RT 73 TO WATERTOWN TL	31.22	33.02	2.12	2.00	$646,600.00
4	8	S/B	THOMASTON,LITCH FIELD,HARWINTON	SB-BGN OP FENN RD TO UP RT 118	41.02	46.82	6.70	2.00	$2,043,500.00
4	6	E+W	NEWTOWN	W JCT RT 25 (SB) TO E JCT RT 25	11.56	14.26	3.10	2.00	$945,500.00
4	25	N+S	NEWTOWN	SR 860 (MILE HILL RD) TO US 6 (CHURCH HILL	19.10	20.16	1.12	2.00	$341,600.00
4	67	E+W	NEW MILFORD,BRIDGEW ATER	US 202&RT 67 TO ROXBURY TL	0.50	5.22	4.75	2.00	$1,448,750.00
4	4	E+W	BURLINGTON	BGN WB TCL TO .03 MI W/O RT 179	34.80	36.21	1.41	1.00	$215,025.00
									$19,777,725.00

APPENDIX 3. CURRENT AND FUTURE PAVEMENT PRESERVATION PROJECTS

Appendix 3A. List of Pavement Preservation Projects (2019)

Mill and Overlay (2019)

MILL AND OVERLAY							
DISTRICT 1							
ROUTE	DIRECTION	TOWN	LOG TERMINI	START MILE POINT	END MILE POINT	CENTERLINE MILES	LANE MILES
91	N	WINDSOR	NB-END OP CAPEN ST TO WINDSOR - WINDSOR LOCKS TL	44.12	48.58	13.30	56.53
		WINDSOR LOCKS	WINDSOR - WINDSOR LOCKS TL TO WINDSOR LOCKS - EAST WINDSOR TL	48.58	49.77		
		EAST WINDSOR	WINDSOR LOCKS - EAST WINDSOR TL TO 0.19 MI S/O NB EXIT TO RTE 140 (104)	49.77	50.77		
	S	WINDSOR	SB-END OP CAPEN ST TO WINDSOR - WINDSOR LOCKS TL	44.12	48.58		
		WINDSOR LOCKS	WINDSOR - WINDSOR LOCKS TL TO WINDSOR LOCKS - EAST WINDSOR TL	48.58	49.77		
		EAST WINDSOR	WINDSOR LOCKS - EAST WINDSOR TL TO .01 MI S/O SB EXIT TO US 5 (103)	49.77	50.77		
MILL AND OVERLAY TOTALS						**13.30**	**56.53**

Ultra-Thin Bonded Overlays (2019) (District 2)

ULTRA THIN BONDED PMA (DISTRICT 2)

ROUTE	DIRECTION	TOWN	LOG TERMINI	START MILE	END MILE	CENTER LINE	LANE MILE
2	E	COLCHESTER	.06 MI E/O EB ACC FR RTE 354 (050) TO COLCHESTER - LEBANON TL	25.35	28.53	9.93	20.64
		LEBANON	COLCHESTER - LEBANON TL TO .13 MI E/O EB EXIT TO SCOTT HILL RD (056)	28.53	30.79		
	W	COLCHESTER	.25 MI E/O WB EXIT TO RTE 354 (049) TO COLCHESTER - LEBANON TL	25.52	28.53		
		LEBANON	COLCHESTER - LEBANON TL TO .32 MI E/O WB-END OP CAMP MOOWEEN RD	28.53	30.01		
9	N	ESSEX	.05 MI S/O NB-BGN OP RTE 153 & 154 TO ESSEX - DEEP RIVER TL	3.83	5.47	14.50	35.16
		DEEP RIVER	ESSEX - DEEP RIVER TL TO DEEP RIVER - CHESTER TL	5.47	7.72		
		CHESTER	DEEP RIVER - CHESTER TL TO .06 MI S/O UP EB RTE 82 & RTE 82 TR 801	7.72	10.63		
	S	ESSEX	.03 MI S/O SB-BGN OP RTE 153 (PLAINS RD) TO ESSEX - DEEP RIVER TL	3.84	5.47		
		DEEP RIVER	ESSEX - DEEP RIVER TL TO DEEP RIVER - CHESTER TL	5.47	7.72		
		CHESTER	DEEP RIVER - CHESTER TL TO CHESTER - HADDAM TL (SB)	7.72	11.54		
395	N	WATERFORD	.03 MI N/O OP OIL MILL BK (8' RC BOX) TO WATERFORD - MONTVILLE TL	0.61	4.98	9.83	21.78
		MONTVILLE	WATERFORD - MONTVILLE TL TO .06 MI N/O NB-JCT SR 693 (MONTVILLE CON)	4.98	5.58		
	S	WATERFORD	.10 MI N/O OP OIL MILL BK (8' RC BOX) TO WATERFORD - MONTVILLE TL	0.68	4.98		
		MONTVILLE	WATERFORD - MONTVILLE TL TO .08 MI N/O SB-JCT SR 693 (MONTVILLE CON)	4.98	5.54		
TOTALS						**34.26**	**77.58**

Ultra-Thin Bonded Overlays (2019) (District 4)

ULTRA THIN BONDED PMA (DISTRICT 4)

ROUTE	DIRECTION	TOWN	LOG TERMINI	START MILE POINT	END MILE POINT	CENTERLINE MILES	LANE MILES
6	E/W	WOODBURY	RTE 47 (WASHINGTON RD) TO WOODBURY - WATERTOWN TL	27.60	32.36	4.76	9.52
8	N	TORRINGTON	.05 MI S/O NB-BGN OP KENNEDY DR TO TORRINGTON - WINCHESTER TL	51.74	55.98	13.29	31.53
		WINCHESTER	TORRINGTON - WINCHESTER TL TO NB-JCT US 44 & RTE 8 (SOUTH MAIN ST)	55.98	58.51		
	S	TORRINGTON	.01 MI S/O SB-BGN OP KENNEDY DR TO TORRINGTON - WINCHESTER TL	51.79	55.98		
		WINCHESTER	TORRINGTON - WINCHESTER TL TO SB-JCT US 44 (SOUTH MAIN ST)	55.98	58.31		
TOTALS						**18.05**	**41.05**

Asphalt Rubber Chip Seals (2019) (District 2)

ASPHALT RUBBER CHIP SEAL (DISTRICT 2)

ROUTE	DIRECTION	TOWN	LOG TERMINI	START MILE POINT	END MILE POINT	CENTERLINE MILES	LANE MILES
149	N/S	COLCHESTER	.08 MI N/O SSR 429 (PECK LA) TO END RTE 149	8.65	11.70	3.05	5.84
165	E/W	PRESTON	.07 MI W/O RTE 164 (PRESTON PLAINS RD) TO PRESTON - GRISWOLD TL	5.09	7.87	5.08	10.16
		GRISWOLD	PRESTON - GRISWOLD TL TO .02 MI E/O RTE 201 (GLASGO RD)	7.87	10.17		
171	E/W	EASTFORD	UNION - EASTFORD TL TO EASTFORD - WOODSTOCK TL	6.93	8.54	2.57	5.14
		WOODSTOCK	EASTFORD - WOODSTOCK TL TO .03 MI W/O W JCT RTE 198 (EASTFORD RD)	8.54	9.50		
201	N/S	STONINGTON	RTE 184 (PROVIDENCE TPKE) TO STONINGTON - NORTH STONINGTON TL	0.00	1.94	1.94	3.88
203	N/S	WINDHAM	RTE 32 (WINDHAM RD) TO RTE 14 (BRICK TOP RD)	0.00	2.52	2.52	5.04
77	N/S	GUILFORD	.7 MI N/O RTE 80 (BRANFORD RD) TO LAKE DR #2	6.16	7.61	1.45	2.90
TOTALS						**16.61**	**32.96**

Asphalt-Rubber Chip Seals (2019) (District 4)

ASPHALT RUBBER CHIP SEAL (DISTRICT 4)							
ROUTE	DIRECTION	TOWN	LOG TERMINI	START MILE POINT	END MILE POINT	CENTERLINE MILES	LANE MILES
4	E/W	GOSHEN	.49 MI W/O MILTON RD TO GOSHEN - TORRINGTON TL	15.36	19.70	4.34	8.67
39	N/S	SHERMAN	RTE 37 (BARNES HILL RD) TO END RTE 39 (RTE 55)	18.37	22.76	4.39	8.78
TOTALS						8.73	17.45

Appendix 3B. List of Pavement Preservation Projects (2018)

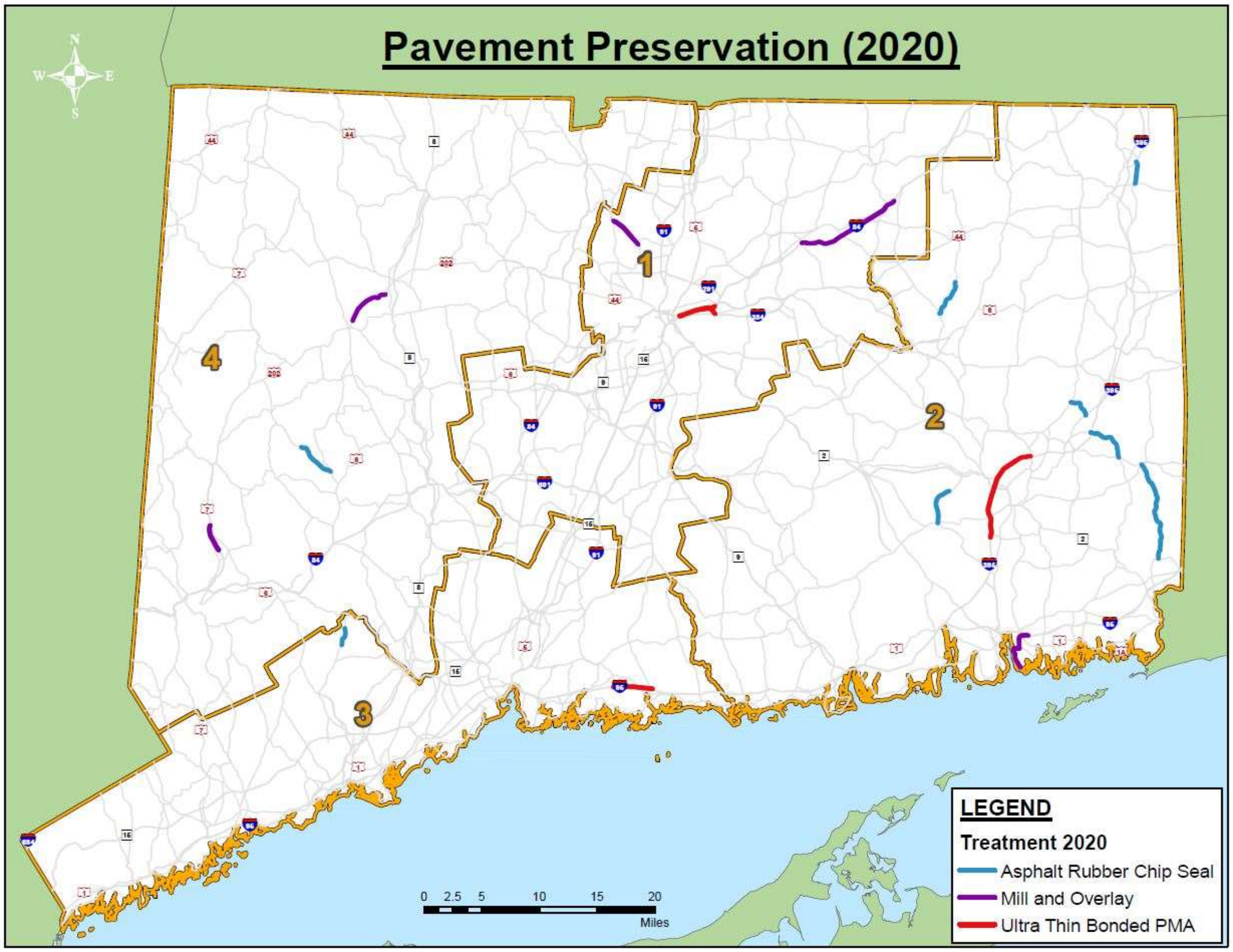
Mill and Fill (2018)

DISTRICT 1							
ROUTE	DIRECTION	TOWN	APPROXIMATE LOG TERMINI	START MILE POINT	END MILE POINT	APPROX. CENTERLINE MILES	APPROX. 1-LANE MILES
66	E/W	Middlefield	.12 MI E/O WB EXIT TO EAST MAIN ST #1 (004) TO .10 MI E/O JACKSON HILL RD	1.34	3.40	3.65	16.26
66	E/W	Middlefield	.10 MI E/O JACKSON HILL RD TO MIDDLETOWN TL	3.40	4.24		
66	E/W	Middletown	MIDDLEFIELD TL TO .23 MI E/O CAMP ST	4.24	4.99		
DISTRICT 2							
ROUTE	DIRECTION	TOWN	APPROXIMATE LOG TERMINI	START MILE POINT	END MILE POINT	APPROX. CENTERLINE MILES	APPROX. 1-LANE MILES
95	N	Groton	.09 MI N/O NB EXIT TO SR 614 (ALLYN ST) (269) TO .04 MI S/O NB EXIT TO RTE 27 (273)	99.95	101.04	2.02	4.30
95	S	Groton		99.95	100.88		
DISTRICT 3							
ROUTE	DIRECTION	TOWN	APPROXIMATE LOG TERMINI	START MILE POINT	END MILE POINT	APPROX. CENTERLINE MILES	APPROX. 1-LANE MILES
7	N	Norwalk	.02 MI N/O SB-END OP RTE 123 (NEW CANAAN AVE) TO BGN OP METRO NORTH RR	1.88	4.03	4.30	9.94
7	S	Norwalk		1.88	4.03		
DISTRICT 4							
ROUTE	DIRECTION	TOWN	APPROXIMATE LOG TERMINI	START MILE POINT	END MILE POINT	APPROX. CENTERLINE MILES	APPROX. 1-LANE MILES
20	E/W	East Granby	.13 MI W/O RTE 187 (MAIN ST) TO .08 MI W/O EB EXIT TO NB SSR 401 (TR 801)	25.45	27.40	1.95	8.74
44	E/W	Avon	.01 MI E/O RTE 167 (BUSHY HILL RD) TO .04 MI W/O BGN OP FARMINGTON RV	42.30	44.67	2.37	9.67

Asphalt Rubber Chip Seals (2018)

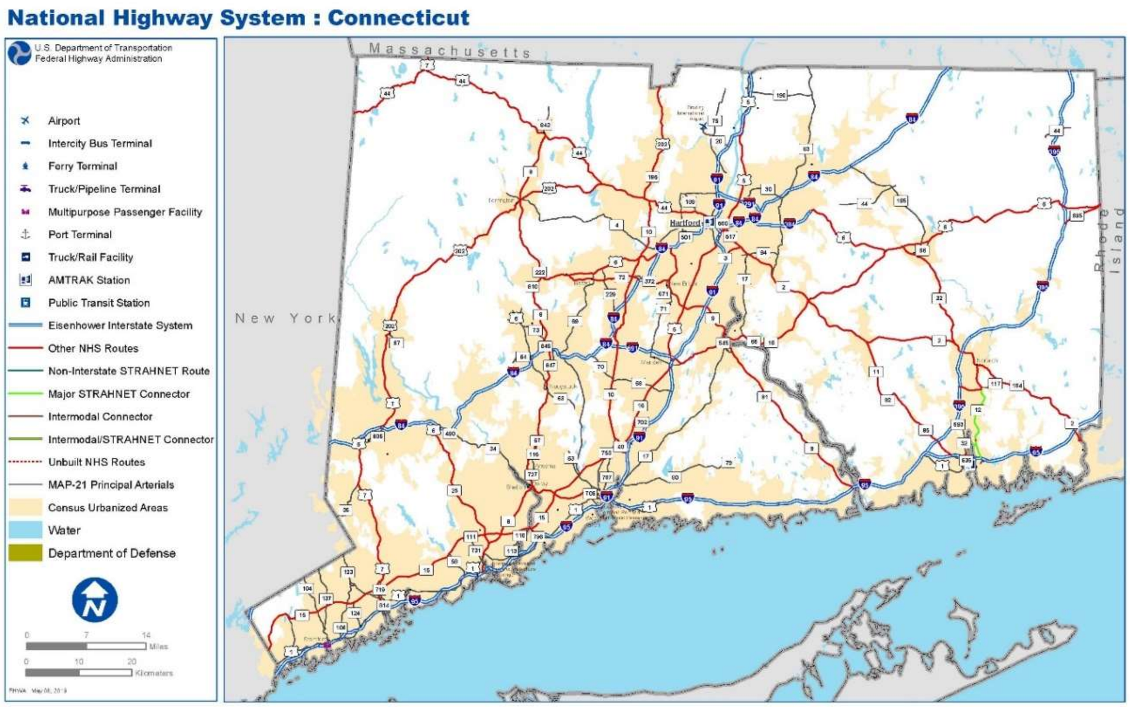
DISTRICT 2							
ROUTE	DIRECTION	TOWN	APPROXIMATE LOG TERMINI	START MILE POINT	END MILE POINT	APPROX. CENTERLINE MILES	APPROX. 1-LANE MILES
12	N/S	Thompson	.04 MI N/O RTE 131 (QUINEBAUG RD) TO END RTE 12 (MASSACHUSETTS SL)	51.99	54.46	2.47	4.94
184	E/W	North Stonington	STONINGTON - NORTH STONINGTON TL TO .03 MI W/O BOOM BRIDGE RD	10.44	14.96	4.52	9.04
354	E/W	Colchester	RTE 85 (NEW LONDON RD/SOUTH MAIN ST) TO .01 MI E/O STANAVAGE RD	0.00	3.04	3.04	6.08
616	E/W	Lebanon	COLCHESTER - LEBANON TL TO SR 608 (NORWICH AVE)/MCGRATH LA #1	3.67	6.70	3.03	6.06

Appendix 3C. Map of Connecticut: Planned Pavement Preservation Projects (2020)



APPENDIX 4. REFERENCE MAPS

Appendix 4A. Map of Connecticut: National Highway System (as of May 2019)

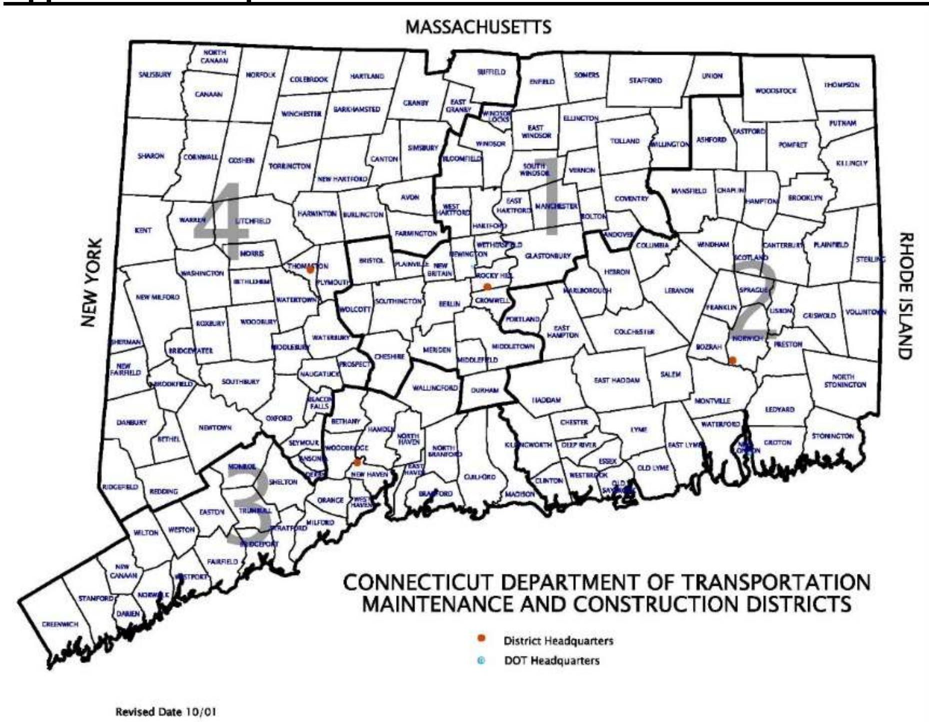


Examples of NHS categories

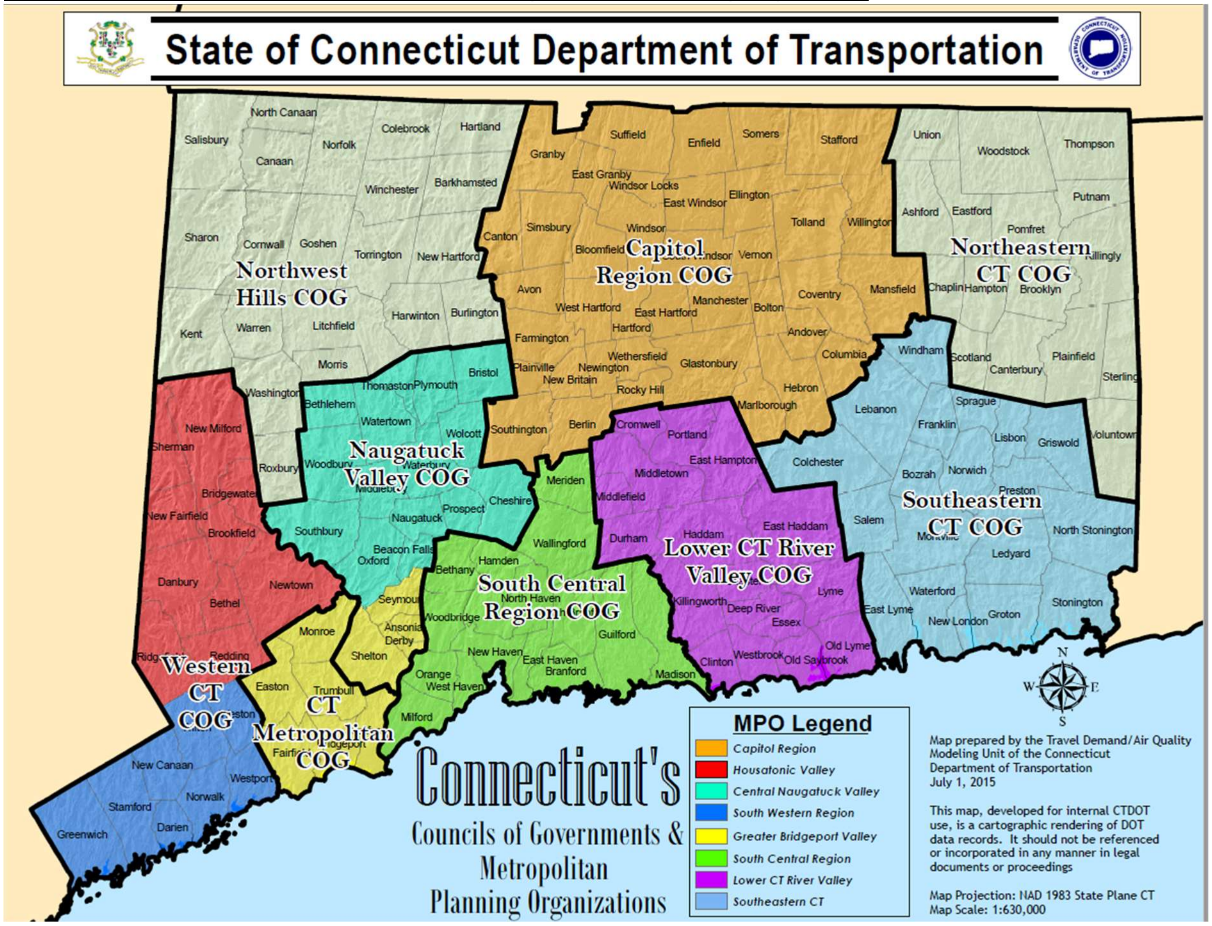
- ***Interstate:*** *The Dwight D. Eisenhower National System of Interstate and Defense Highways. e.g., I-91, I-84, I-95, I-395, I-291, I-691*
- ***Other Principal Arterials:*** *These are highways in rural and urban areas which provide access between an arterial and a major port, airport, public transportation facility, or other intermodal transportation facility. e.g., Rt 20, U.S. 6, U.S. 44, Rt 9*
- ***Non-interstate Strategic Highway Network (STRAHNET):*** *This is a network of highways which are important to the United States' strategic defense policy and which provide defense access, continuity and emergency capabilities for defense purposes. e.g., I-395,*
- ***Major STRAHNET Connectors:*** *These are highways which provide access between major military installations and highways which are part of the Strategic Highway Network. e.g. Rt 12*

- ***<u>Intermodal Connectors:</u>*** *<u>These highways provide access between major intermodal facilities and the other four subsystems making up the National Highway System.</u>*

<u>Appendix 4B. Map of Connecticut: Maintenance/ Construction Districts</u>



Appendix 4C. Map of Connecticut Regional Planning Agencies



APPENDIX 5. GOOD-FAIR-POOR (G-F-P) PAVEMENT RATINGS IN CONNECTICUT FOR 2017 AND 2018

Overall G-F-P Ratings by Lane-Miles

Pavement GFP (Lane Miles) for 2018

Route Category	LaneMiles Good Miles	LaneMiles% Good	LaneMiles Fair Miles	LaneMiles % Fair	LaneMiles Poor Miles	LaneMiles % Poor	LaneMiles Total Miles
INTERSTATE	1459.7	71.2%	583.2	28.4%	8.2	0.4%	2051
NON_INTERSTATE NHS	1416.9	41.1%	1970.1	57.2%	58.3	1.7%	3455
NHS	2876.6	52.3%	2553.3	46.5%	66.5	1.2%	5506
NON_NHS	1005.0	20.3%	3768.0	76.3%	167.0	3.4%	4962
ENTIRE_NETWORK	3868.5	37.1%	6332.1	60.7%	234.3	2.2%	10469

Pavement GFP (Lane Miles) for 2017

Route Category	LaneMiles Good Miles	LaneMiles% Good	LaneMiles Fair Miles	LaneMiles % Fair	LaneMiles Poor Miles	LaneMiles % Poor	LaneMiles Total Miles
INTERSTATE	1443.6	70.3%	599.9	29.2%	8.9	0.4%	2054
NON_INTERSTATE NHS	1346.8	40.0%	1916.8	57.0%	102.1	3.0%	3424
NHS	2790.4	51.5%	2516.8	46.5%	110.9	2.0%	5478
NON_NHS	1029.3	20.9%	3641.9	73.9%	254.8	5.2%	5009
ENTIRE_NETWORK	3819.7	36.9%	6158.7	59.5%	365.7	3.5%	10488

Ride Quality (IRI) G-F-P Ratings by Lane-Miles

Pavement GFP (Lane Miles) for 2018

Route Category	LaneMiles Good Miles	LaneMiles% Good	LaneMiles Fair Miles	LaneMiles % Fair	LaneMiles Poor Miles	LaneMiles % Poor	LaneMiles Total Miles
INTERSTATE	1651.0	80.5%	356.8	17.4%	43.3	2.1%	2051
NON_INTERSTATE NHS	1580.3	45.9%	1342.6	39.0%	522.3	15.2%	3455
NHS	3231.3	58.8%	1699.4	30.9%	565.7	10.3%	5506
NON_NHS	1091.7	22.1%	2689.2	54.4%	1160.5	23.5%	4962
ENTIRE_NETWORK	4323.0	41.4%	4388.6	42.0%	1726.2	16.5%	10469

Pavement GFP (Lane Miles) for 2017

Route Category	LaneMiles Good Miles	LaneMiles% Good	LaneMiles Fair Miles	LaneMiles % Fair	LaneMiles Poor Miles	LaneMiles % Poor	LaneMiles Total Miles
INTERSTATE	1637.8	79.8%	370.4	18.1%	44.1	2.1%	2054
NON_INTERSTATE NHS	1551.2	46.1%	1335.0	39.6%	482.1	14.3%	3424
NHS	3189.0	58.8%	1705.4	31.5%	526.2	9.7%	5478
NON_NHS	1157.9	23.5%	2752.8	55.9%	1017.5	20.6%	5009
ENTIRE_NETWORK	4346.9	42.0%	4458.2	43.1%	1543.7	14.9%	10488

Rutting G-F-P Ratings by Lane-Miles

Pavement GFP (Lane Miles) for 2018							
Route Category	LaneMiles Good Miles	LaneMiles% Good	LaneMiles Fair Miles	LaneMiles % Fair	LaneMiles Poor Miles	LaneMiles % Poor	LaneMiles Total Miles
INTERSTATE	1772.9	88.3%	223.8	11.1%	12.3	0.6%	2051
NON_INTERSTATE NHS	2935.1	86.0%	459.7	13.5%	17.4	0.5%	3455
NHS	4708.0	86.8%	683.4	12.6%	29.7	0.5%	5506
NON_NHS	4139.0	83.5%	781.3	15.8%	39.5	0.8%	4962
ENTIRE_NETWORK	8847.0	85.2%	1464.8	14.1%	69.2	0.7%	10469

Pavement GFP (Lane Miles) for 2017							
Route Category	LaneMiles Good Miles	LaneMiles% Good	LaneMiles Fair Miles	LaneMiles % Fair	LaneMiles Poor Miles	LaneMiles % Poor	LaneMiles Total Miles
INTERSTATE	1803.2	89.6%	195.6	9.7%	12.8	0.6%	2054
NON_INTERSTATE NHS	2910.6	86.2%	436.6	12.9%	30.8	0.9%	3424
NHS	4713.9	87.5%	632.2	11.7%	43.6	0.8%	5478
NON_NHS	4264.5	85.2%	711.4	14.2%	30.7	0.6%	5009
ENTIRE_NETWORK	8978.4	86.4%	1343.5	12.9%	74.3	0.7%	10488

Cracking G-F-P Ratings by Lane-Miles

Pavement GFP (Lane Miles) for 2018							
Route Category	LaneMiles Good Miles	LaneMiles% Good	LaneMiles Fair Miles	LaneMiles % Fair	LaneMiles Poor Miles	LaneMiles % Poor	LaneMiles Total Miles
INTERSTATE	1814.5	88.5%	219.5	10.7%	17.1	0.8%	2051
NON_INTERSTATE NHS	2562.3	74.2%	792.8	22.9%	100.2	2.9%	3455
NHS	4376.8	79.5%	1012.3	18.4%	117.3	2.1%	5506
NON_NHS	3040.2	61.3%	1659.7	33.5%	260.4	5.2%	4962
ENTIRE_NETWORK	7417.1	70.9%	2672.0	25.5%	377.6	3.6%	10469

Pavement GFP (Lane Miles) for 2017							
Route Category	LaneMiles Good Miles	LaneMiles% Good	LaneMiles Fair Miles	LaneMiles % Fair	LaneMiles Poor Miles	LaneMiles % Poor	LaneMiles Total Miles
INTERSTATE	1789.8	87.1%	223.3	10.9%	41.1	2.0%	2054
NON_INTERSTATE NHS	2292.4	67.0%	899.0	26.3%	230.0	6.7%	3424
NHS	4082.2	74.6%	1122.3	20.5%	271.1	5.0%	5478
NON_NHS	2773.5	55.4%	1706.2	34.1%	527.1	10.5%	5009
ENTIRE_NETWORK	6855.6	65.4%	2828.5	27.0%	798.1	7.6%	10488

Overall G-F-P Ratings by Centerline Miles

Pavement GFP (Centerline Miles) for 2018							
Route Category	CTLineMiles Good Miles	CTLineMiles% Good	CTLineMiles Fair Miles	CTLineMiles% Fair	CTLineMiles Poor Miles	CTLineMiles% Poor	Total CTLineMiles Miles
INTERSTATE	254.0	73.3%	90.7	26.2%	1.8	0.5%	347
NON_INTERSTATE NHS	401.1	38.0%	633.9	60.0%	20.8	2.0%	1059
NHS	655.1	46.7%	724.6	51.7%	22.6	1.6%	1406
NON_NHS	477.6	20.6%	1761.9	76.0%	78.0	3.4%	2326
ENTIRE_NETWORK	1132.7	30.5%	2486.5	66.8%	100.6	2.7%	3732

Pavement GFP (Centerline Miles) for 2017							
Route Category	CTLineMiles Good Miles	CTLineMiles% Good	CTLineMiles Fair Miles	CTLineMiles% Fair	CTLineMiles Poor Miles	CTLineMiles% Poor	Total CTLineMiles Miles
INTERSTATE	252.2	72.9%	91.8	26.5%	2.0	0.6%	347
NON_INTERSTATE NHS	370.6	36.0%	624.1	60.7%	33.8	3.3%	1046
NHS	622.8	45.3%	715.9	52.1%	35.8	2.6%	1393
NON_NHS	487.1	21.1%	1704.4	73.8%	117.0	5.1%	2341
ENTIRE_NETWORK	1109.9	30.1%	2420.3	65.7%	152.8	4.1%	3734

IRI G-F-P Ratings by Centerline Miles

Pavement GFP (Centerline Miles) for 2018							
Route Category	CTLineMiles Good Miles	CTLineMiles% Good	CTLineMiles Fair Miles	CTLineMiles% Fair	CTLineMiles Poor Miles	CTLineMiles% Poor	Total CTLineMiles Miles
INTERSTATE	280.0	80.8%	59.3	17.1%	7.2	2.1%	347
NON_INTERSTATE NHS	446.2	42.3%	445.9	42.2%	163.7	15.5%	1059
NHS	726.2	51.8%	505.2	36.0%	170.9	12.2%	1406
NON_NHS	518.1	22.3%	1268.0	54.7%	532.1	23.0%	2326
ENTIRE_NETWORK	1244.3	33.4%	1773.2	47.7%	703.0	18.9%	3732

Pavement GFP (Centerline Miles) for 2017							
Route Category	CTLineMiles Good Miles	CTLineMiles% Good	CTLineMiles Fair Miles	CTLineMiles% Fair	CTLineMiles Poor Miles	CTLineMiles% Poor	Total CTLineMiles Miles
INTERSTATE	280.5	81.1%	58.7	17.0%	6.8	2.0%	347
NON_INTERSTATE NHS	431.0	41.9%	446.8	43.4%	151.4	14.7%	1046
NHS	711.5	51.7%	505.5	36.8%	158.2	11.5%	1393
NON_NHS	547.1	23.7%	1297.2	56.2%	465.0	20.1%	2341
ENTIRE_NETWORK	1258.6	34.2%	1802.7	48.9%	623.2	16.9%	3734

Rutting G-F-P Ratings by Centerline Miles

Pavement GFP (Centerline Miles) for 2018							
Route Category	CTLineMiles Good Miles	CTLineMiles% Good	CTLineMiles Fair Miles	CTLineMiles% Fair	CTLineMiles Poor Miles	CTLineMiles % Poor	Total CTLineMiles Miles
INTERSTATE	299.2	88.0%	38.5	11.3%	2.3	0.7%	347
NON_INTERSTATE NHS	913.2	86.7%	135.2	12.8%	4.4	0.4%	1059
NHS	1212.3	87.0%	173.7	12.5%	6.7	0.5%	1406
NON_NHS	1947.5	83.8%	358.7	15.4%	18.3	0.8%	2326
ENTIRE_NETWORK	3159.9	85.0%	532.4	14.3%	25.0	0.7%	3732

Pavement GFP (Centerline Miles) for 2017							
Route Category	CTLineMiles Good Miles	CTLineMiles% Good	CTLineMiles Fair Miles	CTLineMiles% Fair	CTLineMiles Poor Miles	CTLineMiles % Poor	Total CTLineMiles Miles
INTERSTATE	307.79	90.5%	30.21	8.9%	2	0.6%	347
NON_INTERSTATE NHS	904.6	87.1%	125.8	12.1%	8.2	0.8%	1046
NHS	1212.3	87.9%	156.0	11.3%	10.2	0.7%	1393
NON_NHS	2003.0	85.6%	323.3	13.8%	13.6	0.6%	2341
ENTIRE_NETWORK	3215.3	86.5%	479.3	12.9%	23.8	0.6%	3734

Cracking G-F-P Ratings by Centerline Miles

Pavement GFP (Centerline Miles) for 2018							
Route Category	CTLineMiles Good Miles	CTLineMiles% Good	CTLineMiles Fair Miles	CTLineMiles% Fair	CTLineMiles Poor Miles	CTLineMiles% Poor	Total CTLineMiles Miles
INTERSTATE	310.8	89.7%	33.4	9.6%	2.3	0.7%	347
NON_INTERSTATE NHS	761.5	71.9%	260.0	24.5%	37.9	3.6%	1059
NHS	1072.3	76.3%	293.4	20.9%	40.2	2.9%	1406
NON_NHS	1426.0	61.3%	777.5	33.4%	121.4	5.2%	2326
ENTIRE_NETWORK	2498.4	67.0%	1070.8	28.7%	161.6	4.3%	3732

Pavement GFP (Centerline Miles) for 2017							
Route Category	CTLineMiles Good Miles	CTLineMiles% Good	CTLineMiles Fair Miles	CTLineMiles% Fair	CTLineMiles Poor Miles	CTLineMiles% Poor	Total CTLineMiles Miles
INTERSTATE	303.1	87.5%	37.5	10.8%	5.9	1.7%	347
NON_INTERSTATE NHS	666.8	63.8%	297.5	28.5%	81.0	7.7%	1046
NHS	969.9	69.7%	335.0	24.1%	86.9	6.2%	1393
NON_NHS	1303.3	55.7%	794.0	33.9%	242.7	10.4%	2341
ENTIRE_NETWORK	2273.2	60.9%	1129.0	30.3%	329.6	8.8%	3734

APPENDIX 6. TYPICAL AVERAGE CTDOT PAVEMENT TREATMENT COSTS BASED ON RECENTLY BID PROJECTS

Table 5-6. Pavement Treatment Costs using Estimator

Treatment	Unit	Unit Cost
Ultra Thin Treatment	SY	$7.57
Mill and Fill /Maintenance Resurfacing (2 in.)	SY	$22.13
Mill and Fill (2 inches)	SY	$22.13
Mill and Fill (3 inches)	SY	$33.33
Rubblization	SY	$134.74
Structural Rehabilitation + Joint Repair	SY	$57.24
Structural Rehabilitation	SY	$56.05
Reclamation	SY	$45.73
Reconstruction (light, flexible)	SY	$82.87
Reconstruction (medium, flexible)	SY	$98.70
Reconstruction (heavy, flexible)	SY	$118.79
Reconstruction (light, composite)	SY	$91.41
Reconstruction (medium, composite)	SY	$107.67
Reconstruction (heavy, composite)	SY	$128.62
Diamond Grinding	SY	$45.32
Diamond Grinding + Joint Repair	SY	$51.30
Concrete Pavement Repairs and Structural Overlay	SY	$48.47
Rubberized Chip Seal	SY	$7.69
Thin Overlay	SY	$16.35
Microsurfacing	SY	$7.28

APPENDIX 7. HIGHWAY FUNCTIONAL CLASSIFICATION DEFINITIONS AND CHARACTERISTICS [21]

Functional Class	Definition	Context
ARTERIALS		
Class 1 -- Interstates	All routes that comprise the Dwight D. Eisenhower National System of Interstate and Defense Highways	Interstates are the highest classification of Arterials and were designed and constructed with mobility and long-distance travel in mind. Roadways in this functional classification category are officially designated as Interstates by the U.S. Secretary of Transportation
Class 2 -- Other Freeways and Expressways	Contain directional travel lanes that are usually separated by some type of physical barrier, and their access and egress points are limited to on- and off-ramp locations or a very limited number of at-grade intersections.	Like Interstates, these roadways are designed and constructed to maximize their mobility function, and abutting land uses are not directly served by them.
Class 3 --Other Principal Arterials	Serve major centers of metropolitan areas, provide a high degree of mobility and can also provide mobility through rural areas.	Unlike Interstates and Other Freeways, abutting land uses can be served directly. Forms of access for Other Principal Arterial roadways include driveways to specific parcels and at-grade intersections with other roadways.
Class 4 -- Minor Arterials	Provide service for trips of moderate length, serve geographic areas that are smaller than their higher Arterial counterparts and offer connectivity to the higher Arterial system.	In an urban context, they interconnect and augment the higher Arterial system, provide intra-community continuity and may carry local bus routes. In rural settings, Minor Arterials should be identified and spaced at intervals consistent with population density, so that all developed areas are within a reasonable distance of a higher level Arterial. Additionally, Minor Arterials in rural areas are typically designed to provide relatively high overall travel speeds, with minimum interference to through movement.
NON ARTERIALS		
Class 5 -- Major Collectors	Gather traffic from Local Roads and funnel them to the Arterial network. Urban major collectors Serve both land access and traffic circulation in *higher* density residential, and commercial/industrial areas.	Generally, Major Collector routes are longer in length; have lower connecting driveway densities; have higher speed limits; are spaced at greater intervals; have higher annual average traffic volumes; and may have more

Functional Class	Definition	Context
	Rural major collectors provide service to any county seat not on an Arterial route, to the larger towns not directly served by the higher systems and to other traffic generators of equivalent intra-county importance such as consolidated schools, shipping points, county parks and important mining and agricultural areas	travel lanes than their Minor Collector counterparts.
Class 6 -- Minor Collectors	Gather traffic from Local Roads and funnel them to the Arterial network.	Urban Minor Collectors serve both land access and traffic circulation in *lower* density residential and commercial/industrial areas. Rural minor collectors are spaced at intervals, consistent with population density, to collect traffic from Local Roads and bring all developed areas within reasonable distance of a Collector.
Class 7 -- Local Roads	Provide direct access to abutting land, and are often designed to discourage through traffic.	Locally classified roads account for the largest percentage of all roadways in terms of mileage. They are not intended for use in long distance travel. Local Roads are often classified by default; once all Arterial and Collector roadways have been identified, all remaining roadways are classified as Local Roads

APPENDIX 8. METHODOLOGY FOR CALCULATION OF CTDOT PAVEMENT CONDITION INDEX (PCI)[1]

What is PCI?

• The PCI attempts to categorize the overall condition of a section of pavement based on environmental and structural distresses. Pavement Condition is calculated based on five components:
– Cracking
– Ride [International Roughness Index (IRI)]
– Rutting [Distortion in the Wheel Paths]
– Raveling [Disintegration]
– Drainage

How is it Calculated?

• Asphalt Surfaced Pavements
– Index Cracking: 25%
– Index Distortion: 15%
– Index Disintegration: 30%
– Index Drainage: 20%
– Index Ride: 10%
• Concrete Surfaced Pavements
– Index Ride: 100%

Index Cracking

• If Index_Environmental < Index_Structural
Then Index_Cracking = Index_Environmental
Else Index_Cracking = Index_Structural

Index Environmental

• *Asphalt Pavements*

– Index_Environmental =

 • 9 - Env_Ded_Med

– Env_Ded_Med =

 • Log_Equn

– Log_Equn =

 • 1.3445 * LOG(Index_Envr_Ext_M) + 0.6214

– Index_Envr_Ext_M =

 • Env_Ext_Flex / 100_Pct_Env_Ext_ft * 100.0

– Env_Ext_Flex =

 • T_Total + 0.25*(L_RE_Low + L_RE_Med + L_RE_Hi) + T_Tot_div_Data_Interval_ft_minus_1 *(L_LE_Low + L_LE_Med + L_LE_Hi + L_CTR_Low + L_CTR_Med + L_CTR_Hi)

– T_Tot_div_Data_Interval_ft_minus_1 =

 • T_Total/Data_Interval_Length_ft – 1

Index Environmental

• *Composite/Concrete Pavements*

– Index_Environmental =

 • 9 - Env_Ded_Med

– Env_Ded_Med =

 • Log_Equn

– Log_Equn =

 • 1.3445 * LOG(Index_Envr_Ext_M) + 0.6214

– Index_Envr_Ext_M =

 • Env_Ext_Comp / 100_Pct_Env_Ext_ft * 100.0

– Env_Ext_Comp =

 • iif(T_Total < Trans) + iif(L_TOTAL < FLEQ_ft)

– Trans =

 • 0.5* (T_RE_Low + T_RE_Med + T_RE_Hi) + Lane_Width_ft * FLEQ_ft / Slab_Len_ft

– Slab_Len_ft =

 • min(Slab_Len_ft)

 • In most cases we won't have a road specific slab length, for these use default.

 • If Slab_Len_ft is Null set Slab_Len_ft = Slab_Len_ft_Default

Index Structural

• *Asphalt Pavements*

– Index_Structural =
- 9.0 - Str_Ded_Med

– Str_Ded_Med =
- 1.5489 * LOG(Index_Strc_Ext_M)+0.3521

– Index_Strc_Ext_M =
- Index_Strc_Ext_M / 100_Pct_Str_Ext_ft *100.0 (Convert to Percent)

– Index_Strc_Ext_M =
- Str_Ext_Flex

– Str_Ext_Flex =
- L_LWP_Low + L_LWP_Med + L_LWP_Hi +
- L_RWP_Low + L_RWP_Med + L_RWP_Hi +
- 0.75 * (L_RE_Low + L_RE_Med + L_RE_Hi) +
- A_LWP_Low + A_LWP_Med + A_LWP_Hi + A_RWP_Low + A_RWP_Med + A_RWP_Hi + A_RE_Low + A_RE_Med +A_RE_Hi + A_LE_Low + A_LE_Med + A_LE_Hi + A_CTR_Low + A_CTR_Med + A_CTR_Hi +
- (0.25 + 0.25 * (1.0 - 1/Str_Log_Express)) * (L_CTR_Low + L_CTR_Med + L_CTR_Hi + 0.5*(L_LE_Low + L_LE_Med +L_LE_Hi)) +
- (0.00 + 0.25 * (Str_Log_Express)) * (T_LWP_Low + T_LWP_Med + T_LWP_Hi + T_RWP_Low + T_RWP_Med + T_RWP_Hi)

Index Structural

• *Composite/Concrete Pavements*

– Index_Structural =
- 9.0 - Str_Ded_Med

– Str_Ded_Med =
- 1.5489 * LOG(Index_Strc_Ext_M)+0.3521

– Index_Strc_Ext_M =
- Str_Ext_Comp

– Index_Strc_Ext_M =
- Index_Strc_Ext_M / 100_Pct_Str_Ext_ft *100.0 (Conversion to Percent)

Index Structural

• *Composite/Concrete Pavements*

– Str_Ext_Comp =
  - Max_Tot + Max_Right + Max_Left

– Max_Tot =
  - T_Total - Lane_Width_ft * FLEQ_ft/Slab_Len_ft

– Max_Right =
  - L_RE_Low + L_RE_Med + L_RE_Hi + L_RWP_Low + L_RWP_Med + L_RWP_Hi + A_RE_Low +A_RE_Med + A_RE_Hi + A_RWP_Low + A_RWP_Med + A_RWP_He - FLEQ_ft

– Max_Left =
  - L_LE_Low + L_LE_Med + L_LE_Hi + L_LWP_Low + L_LWP_Med + L_LWP_Hi + A_LE_Low +A_LE_Med + A_LE_Hi + A_LWP_Low + A_LWP_Med + A_LWP_Hi - FLEQ_ft

– FLEQ_ft = Data_Interval_Length_ft

– Slab_Len_ft =
  - min(Slab_Len_ft)
  - In most cases we won't have a road specific slab length, for these use default.
  - If Slab_Len_ft is Null set Slab_Len_ft = Slab_Len_ft_Default

3 Year Cracking Resets

- Where Index_Surface_Age< 3.0
- Index_Cracking =
  – 9.0 – (Index_Surface_Age / 3.0) * (9.0 -3yr_Default_Crk_Index)
- Index_Environmental =
  – 9.0 - (Index_Surface_Age / 3.0) * (9.0 -3yr_Default_Env_Index)
- Index_Structural =
  – 9.0 – (Index_Surface_Age / 3.0) * (9.0 -3yr_Default_Str_Index)

3 Year Cracking Resets

- 3yr_Default_Crk_Index = avg(Index_Cracking)
  - where PTYPE = 'FLEX‘
  - or PTYPE = 'COMP'
  - or PTYPE = 'OTHER'
  - and [Index_Surface_Age] = 3.
- 3yr_Default_Env_Index = avg(Index_Environmental)
  - where PTYPE = 'FLEX'
  - or PTYPE = 'COMP'
  - or PTYPE = 'OTHER'
  - and [Index_Surface_Age] = 3.
- 3yr_Default_Str_Index = avg(Index_Structural)
  - where PTYPE = 'FLEX'
  - or PTYPE = 'COMP'
  - or PTYPE = 'OTHER'
  - and [Index_Surface_Age] = 3.

Index Distortion

- Index_Distortion =
  - 9.0 - (10.4 * Index_Rut_Avg + 0.1)
- Index_Rut_Avg =
  - (RutRAvg + RutLAvg) / 2.0

Index Disintegration

- Index_Disintegration =
  - When (9. - (Current_Yr - Index_Surface_Year) *0.348) > 1.
  - Then (9. - (Current_Yr - Index_Surface_Year) *0.348)
  - Else 1.0

Index Drainage

- Index_Drainage =
  - When abs(SLOPAVG) >= 2.0 then 8.0
  - When abs(SLOPAVG) >= 1.0 then 6.0
  - When abs(SLOPAVG) >= 0.5 and abs(GRADE) >= 3.0 then 6.0
  - When abs(SLOPAVG) >= 0.5 and abs(GRADE) < 3.0 then 3.0
  - When SLOPAVG is NULL then NULL
  - When abs(SLOPAVG) >= 0.5 then 3.0
  - Else 1.0

Index Ride

- Index_Ride =
  - (-0.0000704 * Index_IRI_Avg * Index_IRI_Avg) - (0.0041561 *Index_IRI_Avg) + 10.0
- Index_IRI_Avg =
  - ([L_IRI] + [R_IRI]) / 2.0 where L_IRI > 0 and R_IRI > 0
  - [R_IRI] where R_IRI > 0 and L_IRI <= 0
  - [L_IRI] where L_IRI > 0 and R_IRI <= 0

[1] CTDOT's PCI (0 to 9 scale) is not related to the PCI defined in ASTM Designation D6433-07 "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys" The PCI for roads and parking lots was developed by the U.S. Army Corps of Engineers. It is based upon a rating scale of 0 to 100.