



# High Friction Surface Treatments in Pennsylvania

## Keeping You On the Road

# ➤ High Friction Surface Treatments

- Location Selection Criteria
- Contract Development for HFST Projects
- Effectiveness
- Post installation Performance

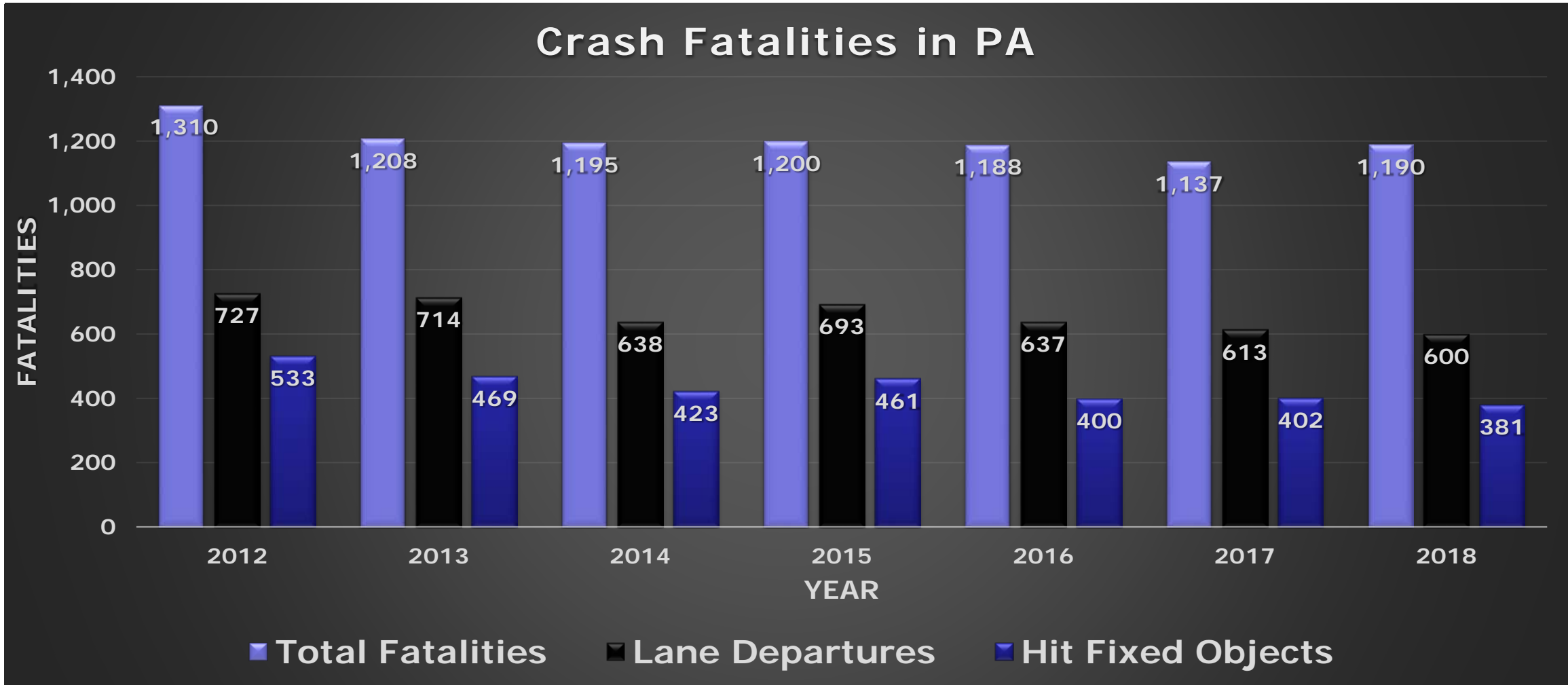


## ➤ Why have High Friction Surface Treatments

- From 2014-2018 there were 635,464 reportable crashes in Pennsylvania
- 5,910 fatalities (0.9%)
- 19,278 suspected serious injuries (3.0%)
- Wet pavement crashes accounted for 108,829 or 17%
- Lane Departure Crashes account for 206,618 or **32.5%**
  - 3,177 Fatalities (**54% of total Fatalities**)
- To reduce the number of wet pavement and lane departure crashes on curves, PennDOT has installed High Friction Surface Treatments on many different highways since 2007.



# Lane Departure Fatalities in Pennsylvania





# ▶ High Friction Surface Treatments

## Implementing Good Safety Improvements



**VEHICLE FRICTION DEMAND:**  
The level of friction needed to  
safely perform braking, steering  
and acceleration maneuvers.

## High Friction Surface Treatment Basics

- High Friction Surface Treatments are applied to an existing pavement surface (asphalt or concrete)
- Pavements must be structurally sound
  - Any new asphalt pavements require a 30 day waiting period
  - New concrete pavements require a 28 day waiting period
- The contractor cleans the area of all debris, fills cracks with resin and then applies a resin binder
- Following that, a fine aggregate (Bauxite) with a high friction coefficient is placed on top of the resin binder
- Typically placed one lane at a time
- Usually takes about 2 to 4 hours to install per lane



## ➤ How Are Locations Selected

### Locations are selected based several conditions:

- Crash Clusters
  - Wet Road Related
  - Lane Departures
  - Hit Fixed Object
- Skid Testing.
  - Crash locations failing a skid test are eligible for HFST if the pavement is still structurally sound



Photo: PA State Police



## ➤ How Are Locations Selected

Other possible factors for HFST

- Excessive braking evidence at intersection approaches at locations with running stop signs, running red light, and rear-end crashes
- Locations where we are unable to move fixed objects to increase clear zone
- Unable to make geometric changes to a curve with known crash history





## ➤ Cost of Installation

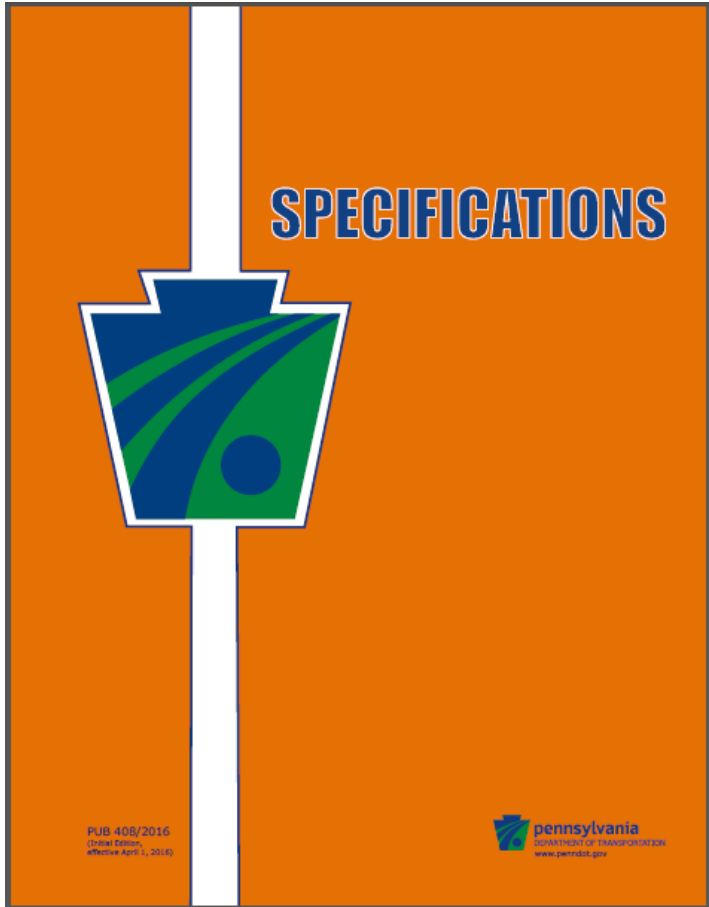
### Based on a 2018 PennDOT study of 47 locations

- Unit cost is about \$36.29/SY
  - Includes MPT, mobilization, inspection trailers, construction narratives, and basic construction survey
- The average installation costs \$65,530 per location
- Average area of 1,805 square yards per location
  - Roughly 24 feet wide (*2 lanes*) x 680 feet long





# ▶ How is a High Friction Surface Treatment Installed



Publication 408 Section  
659

# HFST Application Options

## Publication 408 Section 659

- Tables 3 & 4 – Permissible Methods to Apply HFST  
659.3(f)

**Table 3**  
**Permissible Methods of Application for Roads Under 25,000 ADT**

Site Size (Square Yards)	Main Application Method
Less than 300	Section 659.3(f)1 Hand Mixing and Manual Application, Section 659.3(f)2 Semi Mechanized Application, or Section 659.3(f)3 Automated Continuous Application
300 and above	Section 659.3(f)2 Semi Mechanized Application or Section 659.3(f)3 Automated Continuous Application

**Table 4**  
**Permissible Methods of Application for Roads of 25,000 ADT and Above**

Site Size (Square Yards)	Main Application Method
Less than 300	Section 659.3(f)1 Hand Mixing and Manual Application, Section 659.3(f)2 Semi Mechanized Application, or Section 659.3(f)3 Automated Continuous Application
300 to 1,500	Section 659.3(f)2 Semi Mechanized Application or Section 659.3(f)3 Automated Continuous Application
Larger than 1,500	Section 659.3(f)3 Automated Continuous Application

Basically a 12 feet wide lane that is 225 long.





# HFST Preparation

**(d) Application Conditions.** Do not apply the Binder on a wet surface, if the temperature is below manufacturer's recommendation, or if the anticipated weather conditions would prevent the proper application of the surface treatment.

## **(e) Surface Preparation.**

**1. General.** Cover and protect all existing pavement markings and utilities (manholes/inlets) adjacent to the HFST site as directed before performing surface preparation. Remove pavement markings conflicting with the HFST installation as specified in Section 963.3.

Prepare all pavement surfaces immediately before the installation of HFST. Wash pavement surfaces with a mild detergent solution to remove oils, greases, or other deleterious materials that remained after the surface preparation, rinse with clean potable water, and dry using a hot compressed air lance.

If cracks are present, remove loose material with compressed air and pre-treat cracks 1/4 inch or greater in width with the mixed Binder. Do not overfill cracks, if cracks are overfilled scarify the material to make it flush with the adjacent pavement after the Binder material is cured. Install HFST after the Binder in the pre-treated cracks has gelled.

**2. Asphalt Pavement.** Clean asphalt pavement surfaces using mechanical sweepers and high pressure air wash with sufficient oil traps. Mechanically sweep all surfaces to remove dirt, loose aggregate, debris, and deleterious material. Vacuum sweep or air wash, using a minimum of 180 cubic feet per minute and 80 pounds per square inch of clean and dry compressed air, all surfaces to remove all dust, debris, and deleterious material.

Do not apply HFST applications on new asphalt pavements until after a mandatory 30-day cure period.

**3. Concrete Pavement.** Clean and prepare all concrete pavement surfaces by removing all curing compounds, loosely bonded mortar, surface carbonation, and deleterious material. Comply with the International Concrete Repair Institute (ICRI) standard for surface roughness (CSP) 5. Provide the necessary concrete surface profile chips to visually verify the surface preparation. After preparation, vacuum sweep or air wash using a minimum of 180 cubic feet per minute and 80 pounds per square inch of clean and dry compressed air, all surfaces to remove all dust, debris, and deleterious material.

Do not apply HFST on concrete surfaces or repairs that are less than 28 days of age.





## ➤ High Friction Surface Treatment Cleanup

**(g) Aggregate Cleanup.** After the Binder treatment has cured, and before opening to traffic, reclaim the surplus aggregate, including the shoulder area, by a vacuum sweeper. Collected aggregate can be reused if it is clean, uncontaminated and dry. If contaminated aggregate is mixed with virgin aggregate, all the aggregate in the container will be considered contaminated and not acceptable for use in the HFST.

Between 15 to 30 days after placing the HFST, reclaim all loose aggregate, including the shoulder area, using a vacuum sweeper. This reclaimed aggregate cannot be reused unless it is cleaned of all contamination, dry, and meets the requirements for virgin aggregate.



# High Friction Surface Testing & Acceptance

Department will conduct calibrated skid test between 45 and 120 days after HFST is completed.

**Table 5**  
Number of SN40S Skid Tests per HFST Site, per Lane

HFST Site Length	Number of Runs per Lane	Skid Tests to Obtain per Run
100* feet to 350 feet	2	Run 1 – 2 Skid Tests Run 2 – 1 Skid Test
Greater than 350 feet	1	3

\*For sites less than 100 feet, skid testing is not required.

Acceptance payment will be determined utilizing the factors in Table 6.

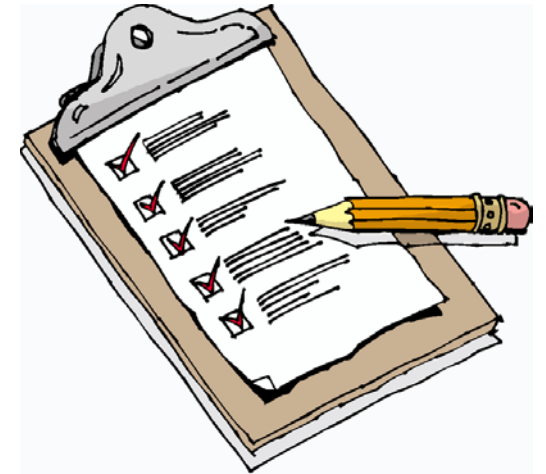
**Table 6**  
Acceptance and Payment Factor per HFST Site

Average SN40S (per HFST site)	HFST Acceptance	Item Pay Factor (%)
SN $\geq$ 70	Yes	100
SN 65 - 69	Yes	90
SN < 65	No	Remove and replace, or reapply, at no additional cost to the Department to obtain acceptable SNs. Manufacturer's technical person must approve all proposed reapplication treatments, and be present during all corrective work. Representative must approve all corrective work plans before implementation.



## HFST Project Development

- HFST contracts usually include multiple locations
- Typically bid out Districtwide or Countywide
  - Ensures good prices
- Basic location plans are drawn
- Detailed quantity tabs are provided
- Doesn't require ROW takes
- No issues with utilities
  - Sewer plates and water access can be worked around
- Easy environmental clearances
- No issues with rail crossings



# HFST Project Development

**PLAN PREPARATION**

PROJECT MANAGER K. KREISER  
 DESIGNER S. SHOVER

DISTRICT	COUNTY	TOWNSHIP	BOROUGH	ROUTE	SECTION	TOTAL SHEETS
8-0	ADAMS	STUBBEN		0394		14
	DAUPHIN	S. HANOVER		2010		
	FRANKLIN	GREENE		0233		
	LANCASTER	VARIOUS		VARIOUS		
	LEBANON	VARIOUS		VARIOUS		
	YORK	VARIOUS		VARIOUS		

MPWS/ECMS NO. 98253

## COMMONWEALTH OF PENNSYLVANIA



## DEPARTMENT OF TRANSPORTATION

### DRAWINGS FOR CONSTRUCTION OF

HIGH FRICTION SURFACE TREATMENT  
ON VARIOUS STATE ROUTES

IN  
ADAMS, DAUPHIN, FRANKLIN, LANCASTER,  
LEBANON AND YORK COUNTIES

**DESIGN DESIGNATION**

HIGHWAY CLASSIFICATION - VARIES  
 DESIGN SPEED - VARIES  
 PAVEMENT WIDTH - VARIES  
 SHOULDER WIDTH - VARIES

**TRAFFIC DATA**  
 CURRENT A. D. T. - VARIES  
 DESIGN YEAR A. D. T. - VARIES  
 D. H. V. - VARIES  
 D - VARIES  
 T - VARIES

PLANS PREPARED BY DISTRICT 8-0 HIGHWAY DESIGN UNIT   STEVEN A. MOORE DISTRICT HIGHWAY DESIGN ENGINEER  DATE: 9 June 2014	RECOMMENDED DATE: 06/05/14 DISTRICT PROJECT MANAGER RECOMMENDED DATE: 6/12/14 District Executive RECOMMENDED DATE: 6/18/14 DEPUTY SECRETARY
	APPROVED DATE: 6/18/14 SECRETARY OF TRANSPORTATION (ON BEHALF OF THE GOVERNOR AS WELL AS HIMSELF)

# Sample contract



# HFST Project Development

## TABULATION OF PROJECT LOCATIONS

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
8-0	VARIOUS	VARIOUS	HFS	2 OF 14
REVISION NUMBER	REVISIONS	DATE	BY	

COUNTY	STATE ROUTE	START WORK SEGMENT/OFFSET	STOP WORK SEGMENT/OFFSET	LINEAL FEET	MILE
ADAMS	SR 0394	0090/1361	0110/0591	2,880	0.55
DAUPHIN	SR 2010	0040/1720	0050/1910	2,698	0.51
FRANKLIN	SR 0233	0190/2305	0220/1670	3,770	0.71
LANCASTER	SR 0072	0380/2133	0390/0655	1,578	0.30
LANCASTER	SR 1055	0020/1964	0030/1946	2,728	0.52
LEBANON	SR 1003	0100/1331	0110/1180	2,308	0.44
LEBANON	SR 4008	0050/1100	0060/2725	4,616	0.87
LEBANON	SR 0241	0210/0765	0210/1485	720	0.14
YORK	SR 2005	0010/0650	0020/1015	2,218	0.42
YORK	SR 3072	0070/0940	0080/1065	3,240	0.61

TOTAL LINEAL FEET = 26,756 LF OR 5.07 MI

### GENERAL NOTES

GOVERNING PUBLICATIONS (ALL LET DATE VERSIONS) FOR PAVEMENT OPERATIONS ARE AS FOLLOWS:  
 PDT PUB. 35 - APPROVED CONSTRUCTION MATERIALS (BULLETIN 15)  
 PDT PUB. 40B - SPECIFICATIONS  
 PDT PUB. 72M - STANDARDS FOR ROAD CONSTRUCTION

ALL WORK IS TO BE CONFINED TO THE EXISTING RIGHT-OF-WAY

ACTUAL QUANTITIES MAY VARY DUE TO ACTUAL FIELD CONDITIONS, AND MAY BE FIELD ADJUSTED AS DIRECTED BY DEPARTMENT ENGINEER IN CHARGE.

LOCATIONS ARE APPROXIMATE. HORIZONTAL CONTROL IS BY RMS INFORMATION. ROADWAYS ARE LISTED IN STRAIGHT LINE DISTANCE. ACTUAL LENGTHS/SEG. OFF. MAY VARY.

PROTECT ALL PAVEMENT MARKINGS FROM APPLICATION PROCESS OF HIGH SURFACE FRICTION TREATMENT AREAS. IT IS THE CONTRACTOR'S RESPONSIBILITY TO REPLACE ANY DAMAGED AND/OR COVERED PAVEMENT MARKINGS.

PREVENT ANY MATERIAL FROM SEALING MANHOLE COVERS.

THIS IS A FEDERAL-AID PROJECT AND SUCH IS SUBJECT TO INSPECTION BY REPRESENTATIVES OF THE FEDERAL HIGHWAY ADMINISTRATION AND THE PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

### LIST OF UTILITIES

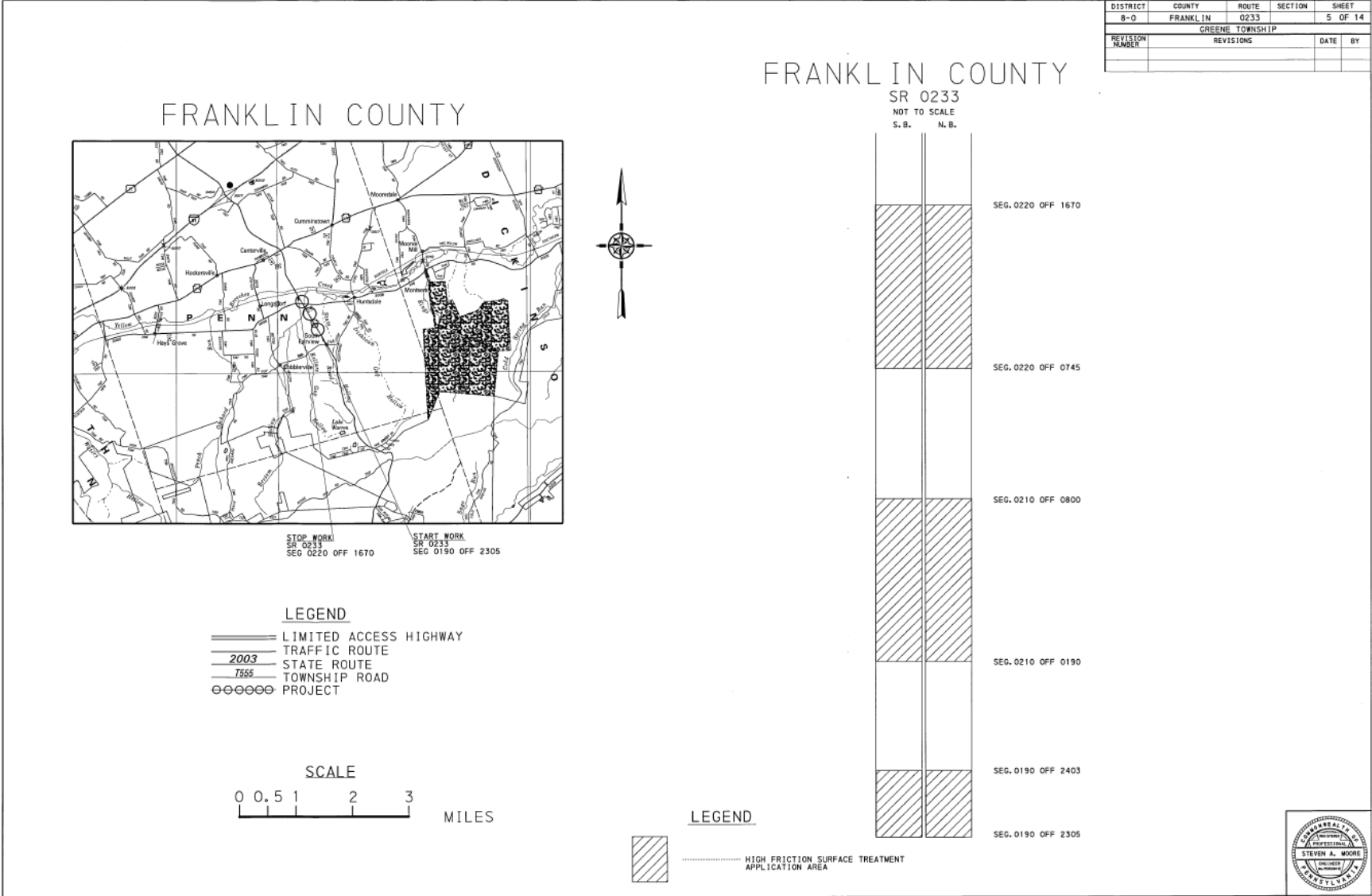
NONE

### INDEX

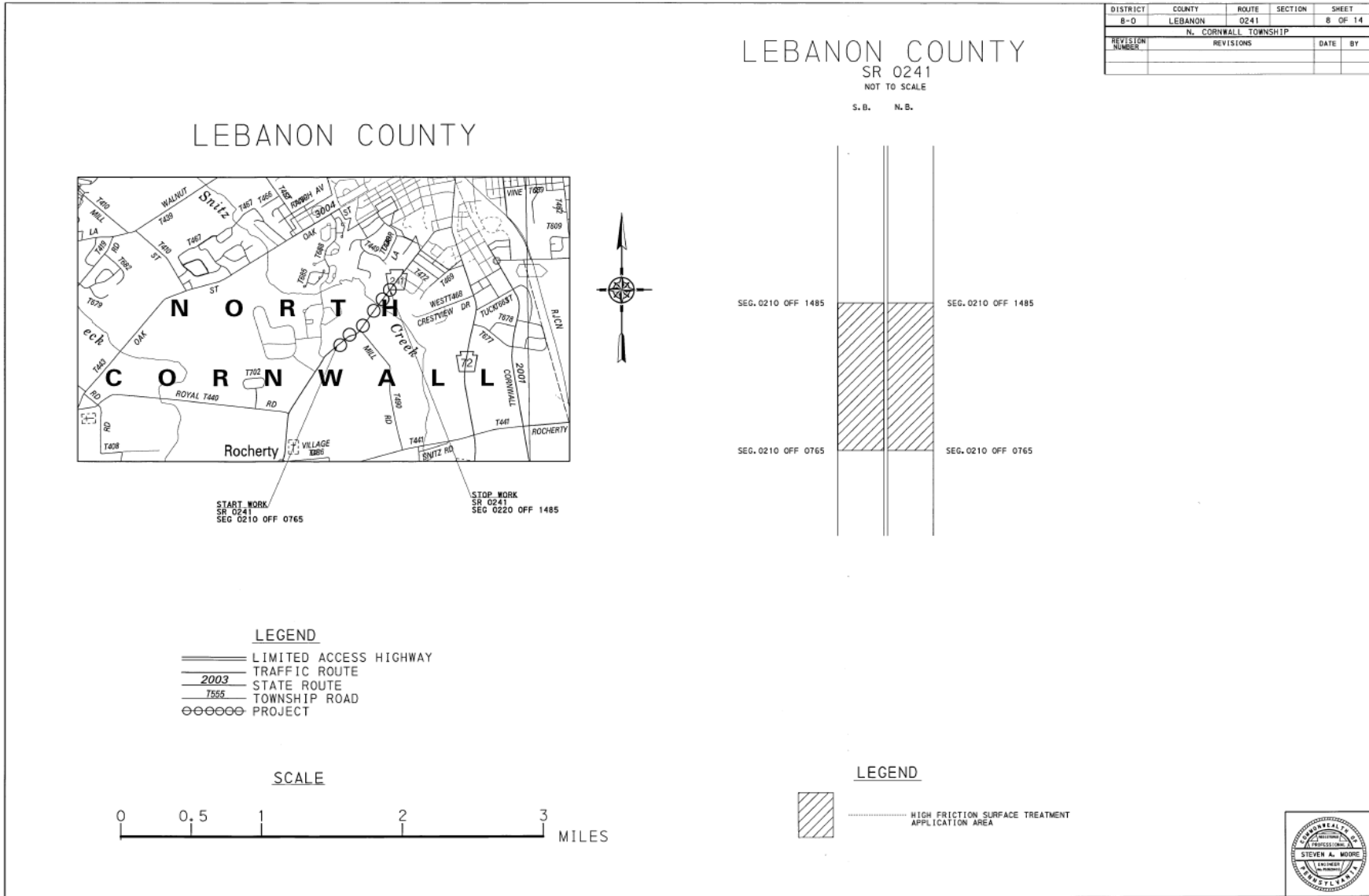
DESCRIPTION	SHEET
TITLE SHEET	1
GENERAL NOTES	2
LOCATION MAP	3 THRU 12
SUMMARY SHEET	13
TABULATION SHEETS	14



# HFST Project Development



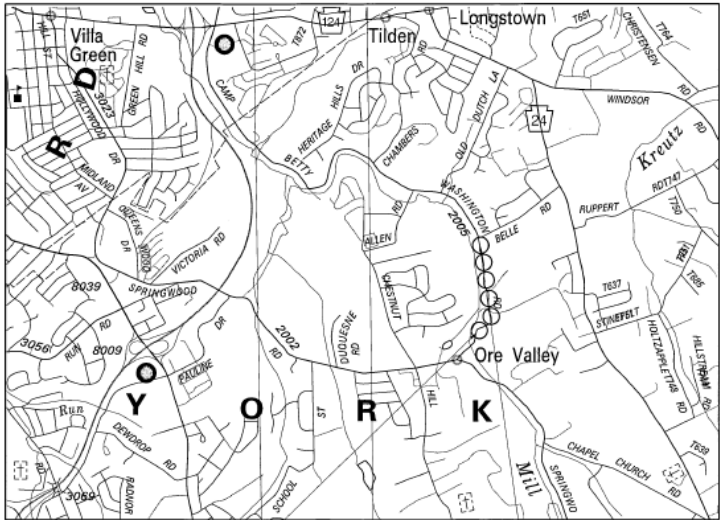
# HFST Project Development



# HFST Project Development

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
8-0	YORK	2005		11 OF 14
YORK TOWNSHIP				
REVISION NUMBER	REVISIONS	DATE	BY	

YORK COUNTY

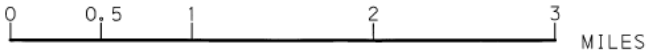


START WORK  
SR 2005  
SEG 0010 OFF 0650

STOP WORK  
SR 2005  
SEG 0020 OFF 1015

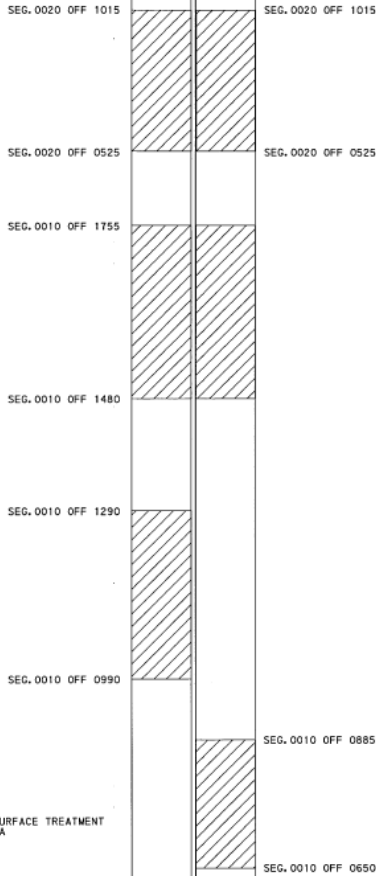
- LEGEND**
- ===== LIMITED ACCESS HIGHWAY
  - ===== 2003 TRAFFIC ROUTE
  - ===== STATE ROUTE
  - ===== TOWNSHIP ROAD
  - PROJECT

**SCALE**



YORK COUNTY

SR 2005  
NOT TO SCALE  
S. B. N. B.



**LEGEND**

- HIGH FRICTION SURFACE TREATMENT APPLICATION AREA





# HFST Project Development

SUMMARY																	REVISION NO	REVISIONS	DATE	BY	DISTRICT	COUNTY	ROUTE	SECTION	SHEET
◆ - SEE SPECIAL PROVISIONS																					8-0	VARIOUS	VARIOUS		13 OF 14
QUANTITY	ITEM NO	DESCRIPTION	DESIGN NO	FOR TAB SEE SHEET	QUANTITY	ITEM NO	DESCRIPTION	DESIGN NO	FOR TAB SEE SHEET	QUANTITY	ITEM NO	DESCRIPTION	DESIGN NO	FOR TAB SEE SHEET	QUANTITY	ITEM NO	DESCRIPTION	DESIGN NO	FOR TAB SEE SHEET						
	0608 0001 LS	MOBILIZATION		NO TAB																					
	0609 0008 LS	INSPECTOR'S FIELD OFFICE AND INSPECTION FACILITIES, TYPE C		NO TAB																					
	0609 0009 LS	EQUIPMENT PACKAGE		NO TAB																					
19579	0689 0001 SY	HIGH FRICTION SURFACE TREATMENT (HFST)		14																					
	0689 0002 LS	NETWORK SCHEDULE		NO TAB																					
	0901 0001 LS	MAINTENANCE AND PROTECTION OF TRAFFIC DURING CONSTRUCTION		NO TAB																					
16540	0901 0320 LF	4" STANDARD PAVEMENT MARKINGS, PAINT & BEADS, YELLOW		14																					
16540	0901 0330 LF	4" STANDARD PAVEMENT MARKINGS, PAINT & BEADS, WHITE		14																					
16540	0962 1000 LF	4" WHITE WATERBORNE PAVEMENT MARKINGS		14																					
16540	0962 1005 LF	4" YELLOW WATERBORNE PAVEMENT MARKINGS		14																					



# HFST Project Development

## TABULATION OF QUANTITIES

### HIGH FRICTION SURFACE TREATMENT

REVISION NO	REVISIONS	DATE	BY	DISTRICT	COUNTY	ROUTE	SECTION	SHEET
				8-0	VARIOUS	VARIOUS		14 OF 14

HIGH FRICTION SURFACE TREATMENT (#'S)										REMARKS	SIDE	SEGMENTS/OFFSETS
0659 0001	0671 0001	0671 0002	0671 0003	0671 0004	0671 0005	0671 0006	0671 0007	0671 0008	0671 0009			
										ADAMS		
		650	650	650	650	650				SR 0394	WB	0090/1361 TO 0090/2006
		400	400	400	400	400				SR 0394	EB	0110/0200 TO 0110/0591
										DAUPHIN		
	189	170	170	170	170	170				SR 2010	EB	0040/1720 TO 0040/1890
	329	300	300	300	300	300				SR 2010	WB	0040/2170 TO 0040/2466
	353	320	320	320	320	320				SR 2010	EB	0050/0590 TO 0050/0908
	222	200	200	200	200	200				SR 2010	WB	0050/1140 TO 0050/1340
	522	470	470	470	470	470				SR 2010	EB	0050/1415 TO 0050/1885
										FRANKLIN		
	261	200	200	200	200	200				SR 0233	NB&S B	0190/2305 TO 0190/2403
	911	820	820	820	820	820				SR 0233	NB&S B	0210/0190 TO 0210/0600
	1027	925	925	925	925	925				SR 0233	NB	0220/0745 TO 0220/1670
										LANCASTER		
	683	520	520	520	520	520				SR 1055	NB&S B	0020/1964 TO 0020/2220
	263	200	200	200	200	200				SR 1055	SB	0020/2724 TO 0030/0175
	360	270	270	270	270	270				SR 1055	SB	0030/0530 TO 0030/0800
	473	350	350	350	350	350				SR 1055	NB	0030/0910 TO 0030/1265
	568	425	425	425	425	425				SR 1055	NB	0030/1520 TO 0030/1946
	489	370	370	370	370	370				SR 0072	EB	0380/2133 TO 0380/2500
	225	170	170	170	170	170				SR 0072	WB	0380/2766 TO 0380/2935
	235	175	175	175	175	175				SR 0072	EB	0380/3000 TO 0380/0120
	513	385	385	385	385	385				SR 0072	EB	0390/0270 TO 0390/0655
										LEBANON		
	1478	1330	1330	1330	1330	1330				SR 4008	EB&W B	0050/1110 TO 0050/1775
	318	290	290	290	290	290				SR 4008	EB	0050/2745 TO 0060/0040
	561	500	500	500	500	500				SR 4008	WB	0060/1120 TO 0060/1625
	211	190	190	190	190	190				SR 4008	EB	0060/1710 TO 0060/1900
										TOTALS		
19579	16540	16540	16540	16540	16540	16540						

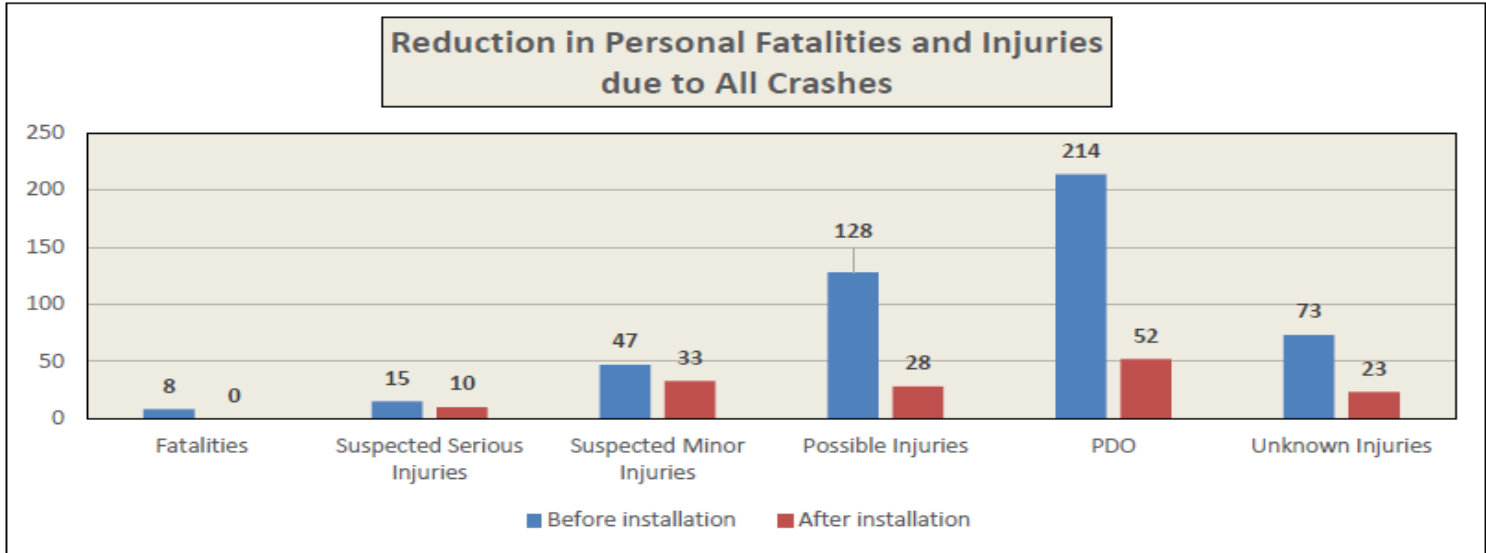


# ➤ PennDOT HFST Before and After Study

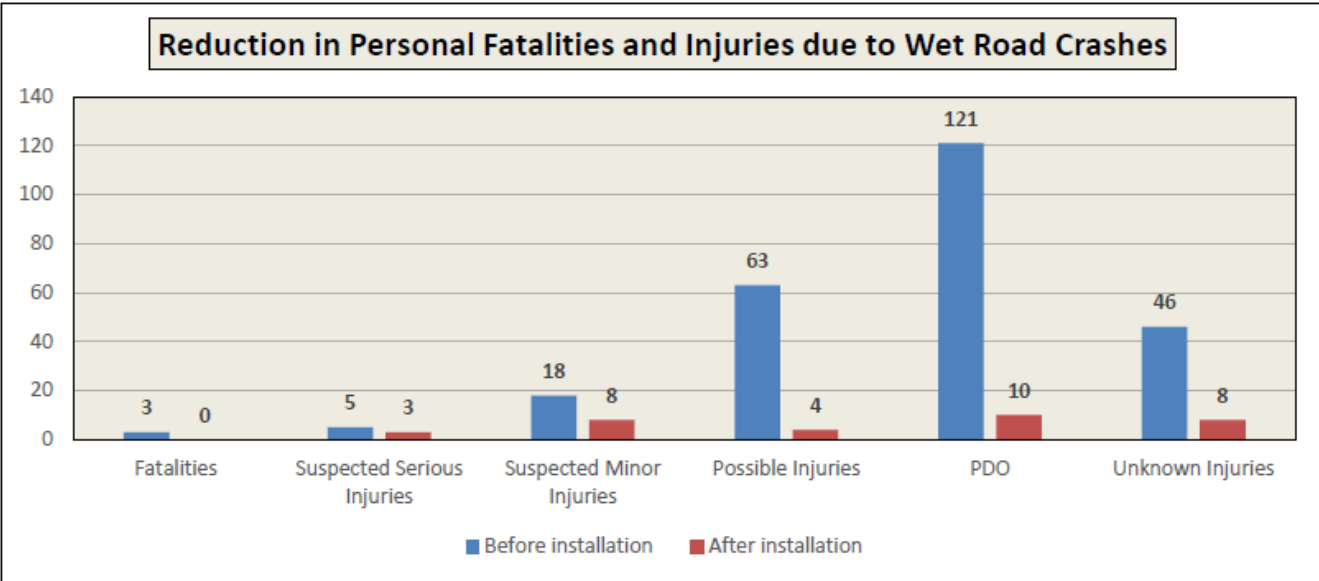
- Completed in September 2018
- Evaluated 47 locations that had between 1 to 5 years of before and after crash data
- Locations from 7 different contracts
- Gathered actual cost data
- Looked the following crashes
  - Wet road
  - Single Vehicle ROR
  - Hit Fixed Object
  - All Crashes



# High Friction Surface Treatments



- Resulted in a Benefit to cost ratio of 5.50 for all crashes based on 2017 crash costs
- Resulted in a Benefit to cost ratio of 2.40 for Wet Road crashes based on 2017 crash costs





# Pending National Study through TPF-5(317)

- Recent study completed by FHWA through the Evaluation of LCSII Pooled Fund Group
  - Official HFST report will be published in Spring 2020
- Looked at HFST locations in 6 states
  - 61 sites from Pennsylvania
- Initial results from study show HFST works better than shown in previous studies

**DRAFT**

**Crash Modification Factors for HFST on curves from the current DCMF study.**

Crash Type	Observed crashes after treatment	EB expected crashes after treatment	Crash Modification Factor	
			<i>Estimate</i>	<i>Standard Error</i>
Total	329	767.84	0.430	0.028
Injury	106	205.02	0.515	0.037
Run-off-road	92	333.49	0.279	0.032
Wet-Road	82	495.54	0.168	0.020
HOSSOD	59	81.29	0.691	0.105

# ▶ PA's High Friction Surface Locations

## Post Installation

- Installed on conventional 2 lane roads or Multi-lane high speed freeways





# ▶ PA's High Friction Surface Locations

Post Installation

- Multi-lane Freeway





## ▶ PA's High Friction Surface Locations

Post Installation

- Multi-lane Freeway





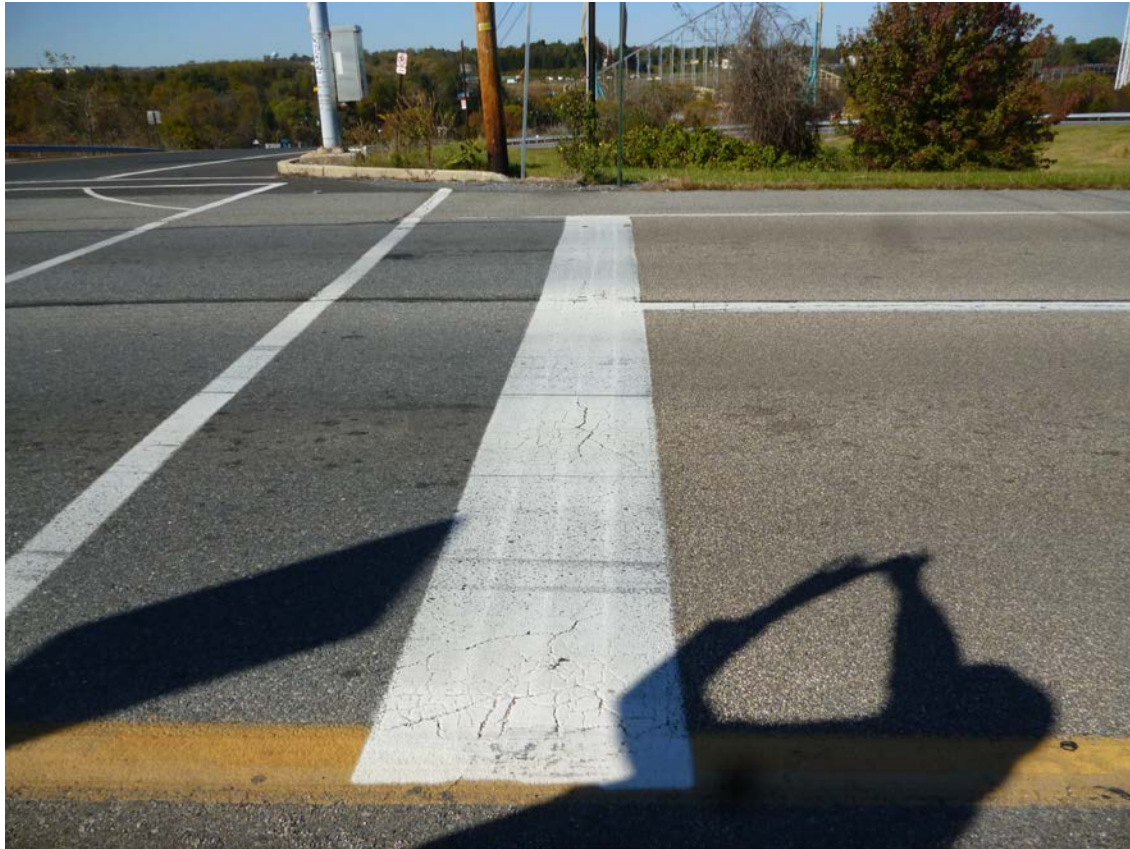
# ▶ PA's High Friction Surface Locations

- Durable starting joints
- Holds up to plow blades in the snow belt areas





# ▶ PA's High Friction Surface Locations



Intersection



Avoiding a Sewer Plate



# ▶ PA's High Friction Surface Locations

## Post Installation





# PA's High Friction Surface Locations

## Post Installation





# Questions

