



Pavement Markings for MN State Roadways

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Office of Traffic Engineering

3/18/21



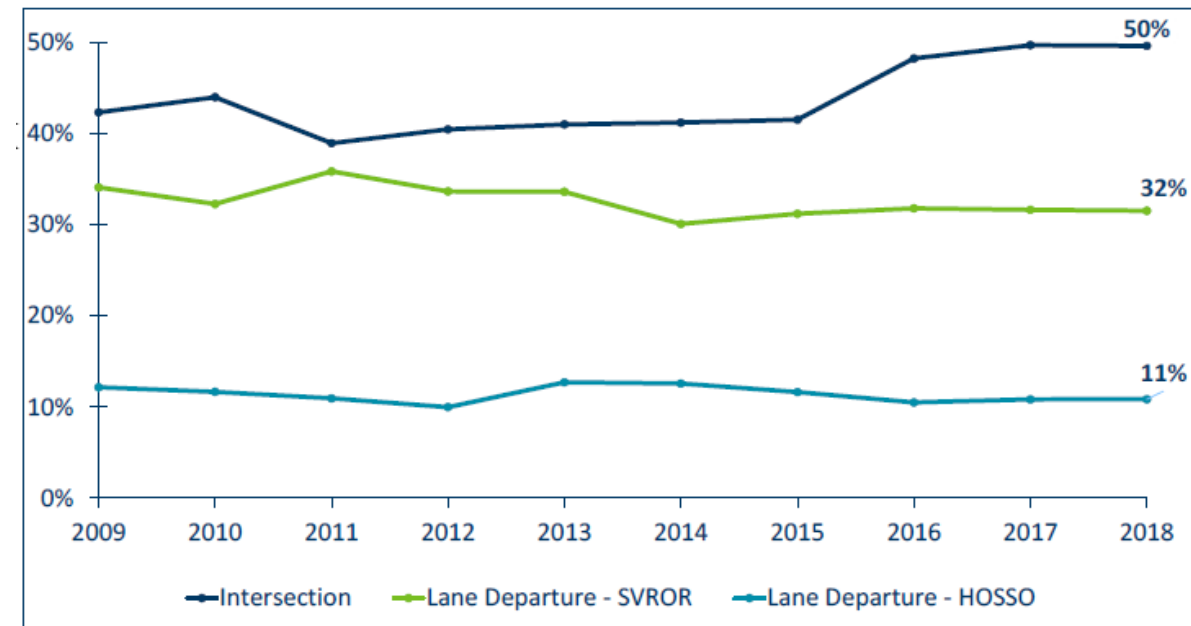
mndot.gov



Importance

- Single vehicle road departures are nearly 30% of all Minnesota fatalities
 - These crashes were widely distributed across the entire state and local network, with horizontal curves making up a disproportionate amount.
 - When looking at how low the crash density (~0.01 severe road departure/mile/year) is, pavement markings are extremely cost effective to cover an entire system.
 - Road departures are especially prevalent on rural county highways, which is why MnDOT has been an advocate for local safety planning and providing HSIP money for locals.
 - It's not the road departure that's the main concern, it's what happens afterwards!

Figure 1: Engineering Focus Areas, Percent of Statewide Death and Serious Injury Crashes (2009-2018)



Note:

- SVROR = single vehicle run off the road
- HOSSO = head-on and sideswipe opposing

When Are Pavement Markings Needed

- According to the MN MUTCD:
 - Center line markings shall be placed on:
 - all paved urban arterials and collectors that have a traveled way of 20 feet or more in width and an Average Daily Traffic (ADT) of 6,000 greater.
 - two-way streets or highways that have three or more lanes for moving motor vehicle traffic
 - Edge line markings shall be placed on paved streets or highways with the following characteristics:
 - Freeways
 - Expressways
 - Rural arterials with a traveled way of 20 feet or more in width and an ADT of 6,000 vehicles per day or greater.

MnDOT's PM Goal

- Due to the safety benefits, MnDOT installs center lines and edge lines on all their paved roads.
- “Provide an appropriate pavement marking on all highways, 365 days per year.”
- An appropriate pavement marking is one that meets or exceeds the standards defined in the MN MUTCD.
- During winter weather events, pavement markings should provide presence after pavement is clear of snow and ice.

MnDOT Provisions for Pavement Marking Operations

Expected Life of Surface Applied Markings

Material	ADT	
	<1,500	>1,500
Latex Paint	>1 yr.	1 yr.
Multi-Component Liquid	>5 yr.	3-5 yr.
Preformed Polymer Tape or Thermoplastic	>5 yr	>5 yr

Expected Life of Recessed Markings

Material	ADT	
	<1,500	>1,500
Latex Paint	>3 yr.	3 yr.
Multi-Component Liquid	>6 yr.	5-7 yr.
Preformed Polymer Tape or Thermoplastic	>7 yr	>7 yr

Retroreflectivity

- Research has shown that the threshold between an acceptable and an unacceptable pavement marking based on nighttime driver visibility needs is between 80 and 120 MCD/m² /lux.
- MnDOT has adopted a minimum performance of 100 MCD/m²/lux for both white and yellow. As markings approach this threshold they will be replaced.
- Minimum initials have been set to get the desired longevity of the pavement markings. These are tested via mobile retroreflectometer.

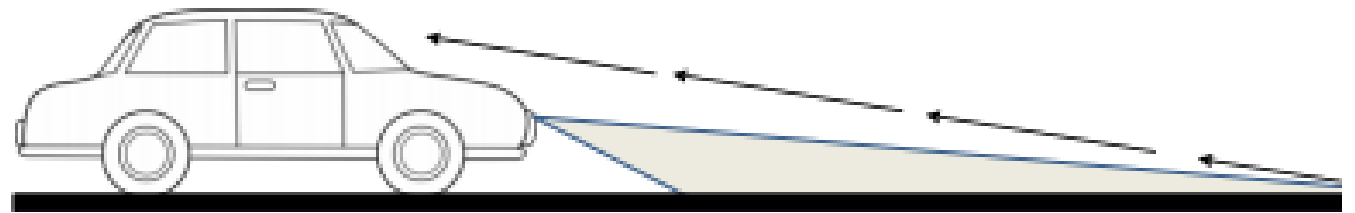
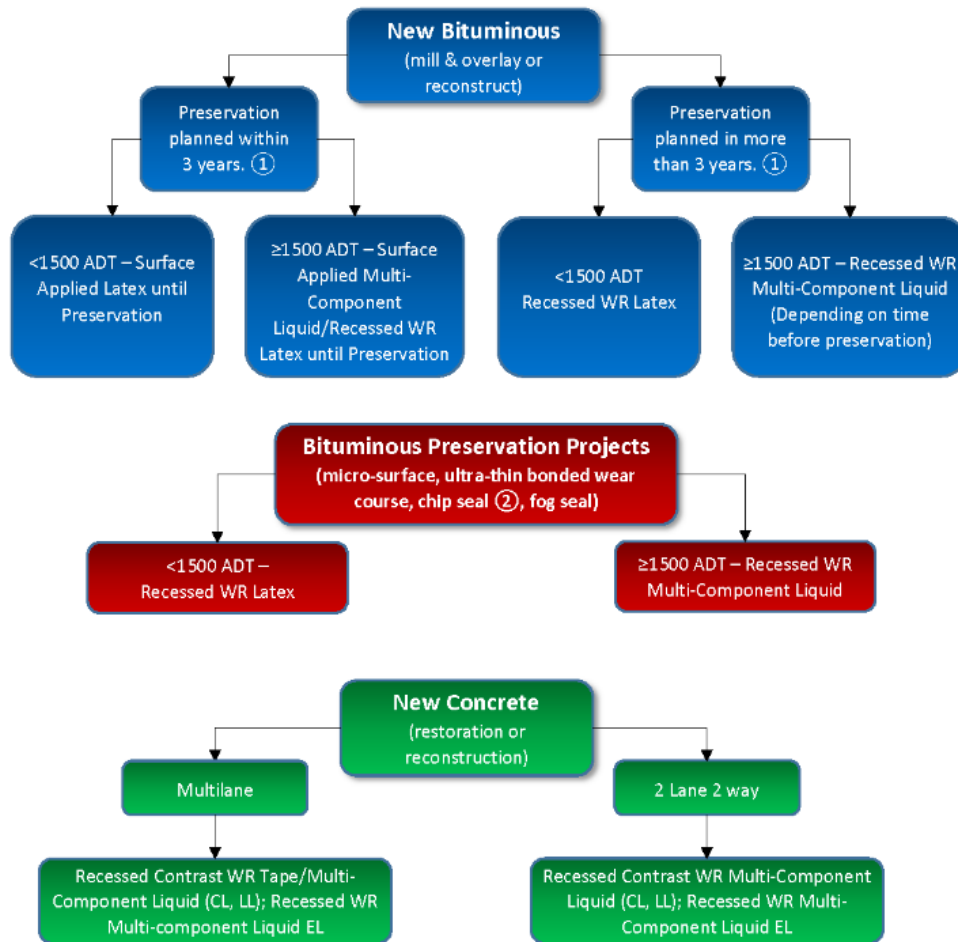


Table 2582.3-3
Minimum Initial Pavement Marking Retroreflectivity

	White	Yellow
PREF TAPE	600 mcd/ m ² /lux	500 mcd/m ² /lux
PREF THERMO	300 mcd/ m ² /lux	200 mcd/ m ² /lux
PREF THERMO, ESR (Enhanced Skid Resistance)	250 mcd/ m ² /lux	150 mcd/ m ² /lux
MULTI COMP	300 mcd/ m ² /lux	200 mcd/ m ² /lux
PAINT	275 mcd/ m ² /lux	180 mcd/ m ² /lux

MnDOT Provisions for Pavement Marking Operations

Longitudinal Striping

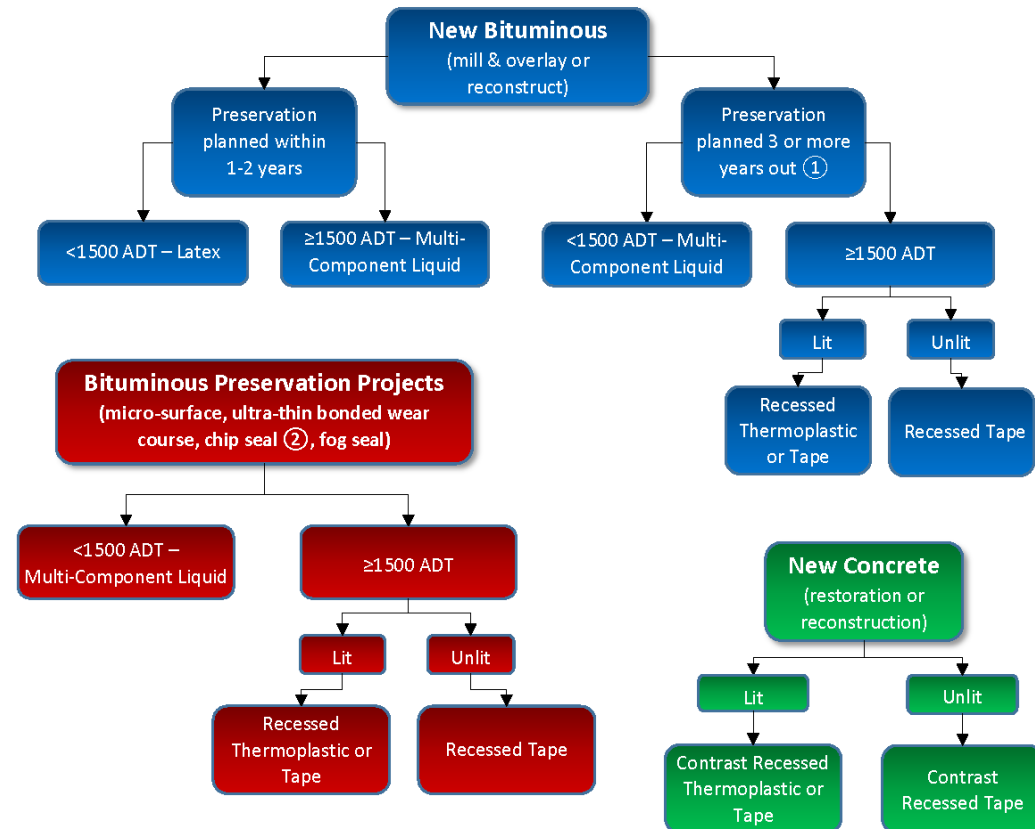


WR = Wet Reflective
CL = Center Line
LL = Lane Line
EL = Edge Line

- ① Based on life of material and suggested optimum time to initial preservation project.
- ② Methods for recessing markings on chip seals are still being developed.

Pavement Messages

(Transverse, gore markings, cat tracks, and roundabouts)



- ① Based on life of material and suggested optimum time to initial preservation project.
- ② Methods for recessing markings on chip seals are still being developed.
- 3. Enhanced skid resistant materials are recommended for roundabouts and crosswalk blocks.

Enhanced Skid Resistance

- Low skid resistance of pavement messages and colored pavements can be an issue for the safety of vulnerable road users (motorcyclists, bicyclists, and pedestrians) when traversing intersections on state roadways.
- The enhanced skid resistance option (added aggregate) is recommended for any situation where deceleration, turning movements, or pedestrian and bicyclist traffic is occurring:
 - Crosswalk blocks
 - Pavement messages in roundabouts
 - Bike lanes that utilize colored pavement
 - Railroad crossing pavement messages
 - Stop lines
 - Stop ahead pavement messages



Wet Retroreflectivity

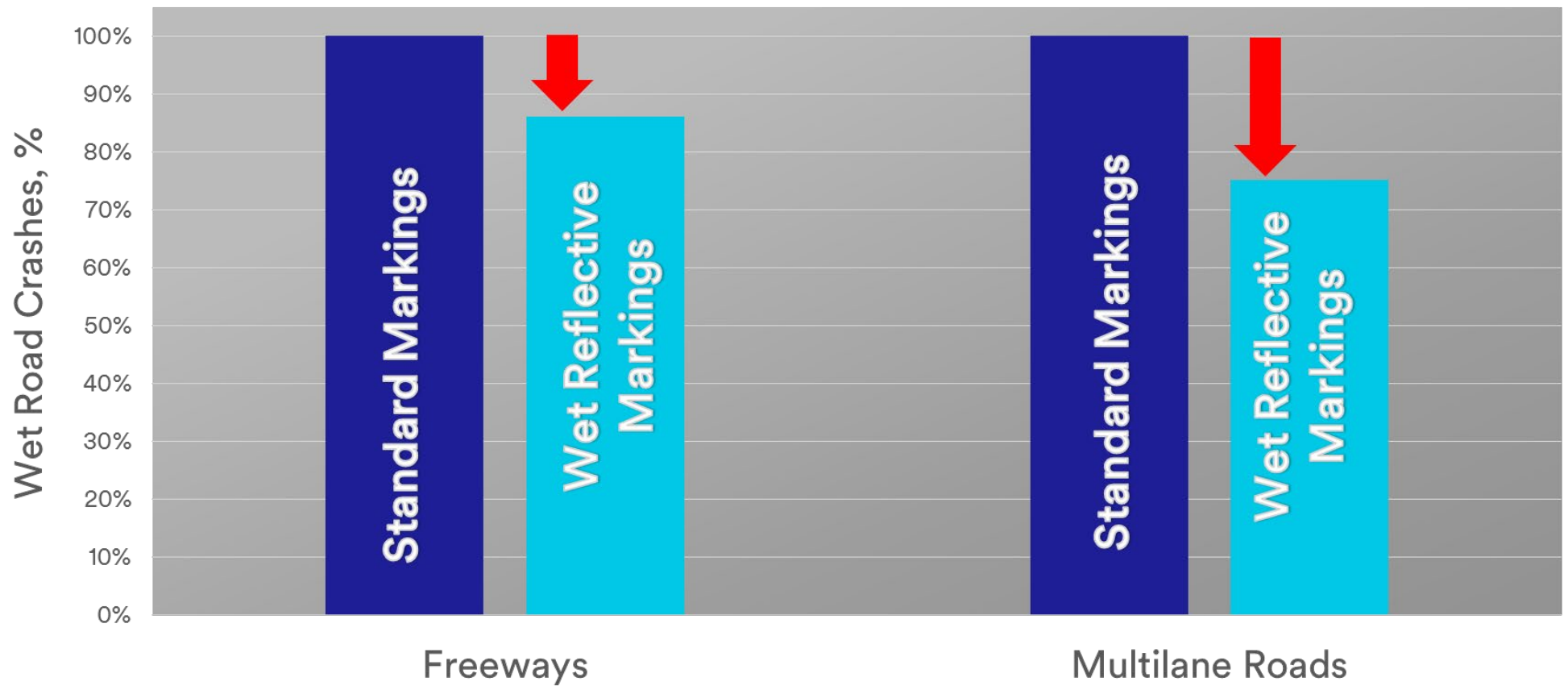
“Pavement Markings - Wet Retroreflectivity Standards” research study

- Through a human factors study found 50 mcd/m²/lux wet continuous retroreflectivity is minimum to make emergency maneuver
- Through analyzing degradation in MN, 200 mcd/m²/lux was suggested for initial install
- Special Provisions was put together to test and require minimum initial
 - WR testing can be done through MRM contractor
 - Limited use to get contractors and manufacturers to work together for ideal installs
 - Currently only one manufacturer can meet initial targets
- First project to include this Special Provision met the initial requirements

Wet Retroreflectivity Benefits

Safety Evaluation of Wet Reflective Pavement Markings

Craig Lyon, Bhagwant Persaud, and Kimberly Eccles. Vanasse Hangen Brustlin, Inc. (VHB) and Persaud Lyon, Inc. 2015
U.S. DoT, FHWA Sponsored Study



Wet Retroreflectivity Benefits



Manual on Uniform Traffic Control Devices (MUTCD) Update

Notice of Proposed Amendment:

- "In the list of widths and patterns of longitudinal lines, FHWA proposes to indicate that 6-inch wide lines are to be used for freeways, expressways, and ramps as well as for all other roadways with speed limits greater than 40 mph and that 4- to 6-inch wide lines are to be used for all other roadways.
- "In Section 3B.09 (existing Section 3B.06), FHWA proposes to add a Guidance recommending that edge lines on two-lane roadways should be at least 6 inches wide, regardless of the width of the normal line used on the roadway."



6" Pavement Markings

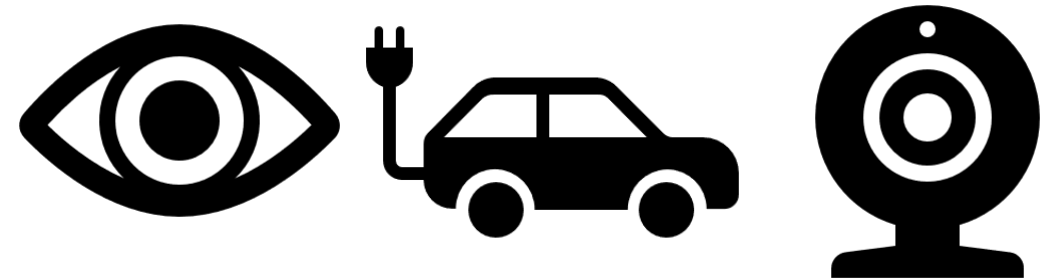
- Severe crashes can be reduced 20-40% by increasing the width of edgelines.
- Research has shown that 6" edgelines provide a Benefit/Cost of ~25:1
- CAVs would also benefit from this moving into the future

Effectiveness

10% to 35% consistent
crash decrease
reported



- From 12/10/20 AASHTO Committee on Traffic Engineering Meeting (Andy Whydell, ZF): **“Automated system cameras are akin to a highly attentive, near-sighted driver.”**
- Cameras largely mimic human vision. Improvements for human vision therefore are improvements for machine vision.



6" Pavement Markings - State of the Practice

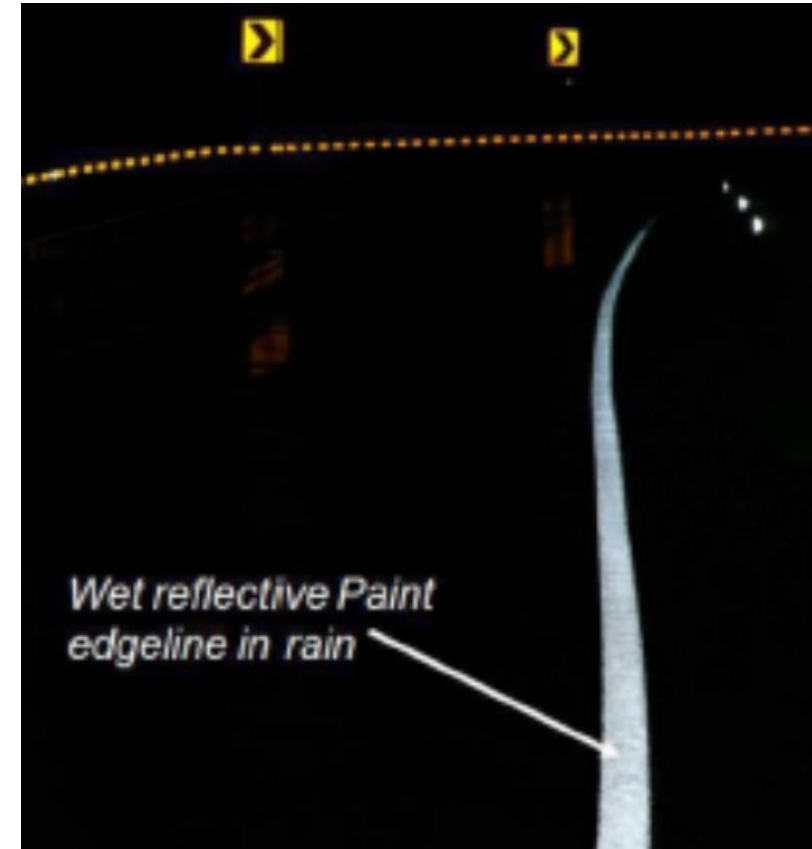
Table 7. Number of Agencies Using Different Marking Width

Number of states using 4-inch normal marking	11	Alaska, Connecticut, Hawaii, Iowa, Montana, New Jersey, Oregon, South Dakota, Washington, Wisconsin, Wyoming
Number of states using 5-inch normal marking	3	Delaware, Georgia, Maryland
Number of states using 6-inch normal marking	7	Arizona, California, Florida, Massachusetts, Mississippi, Puerto Rico, West Virginia
Number of states where normal marking width varies (4 to 5-inch)	1	Indiana
Number of states where normal marking width varies (4 to 6-inch)	29	Alabama, Arkansas, Colorado, District of Columbia, Idaho, Illinois, Kansas, Kentucky, Louisiana, Maine, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia
Number of states where normal marking width varies (6 to 8-inch)	1	Nevada

Cost Difference

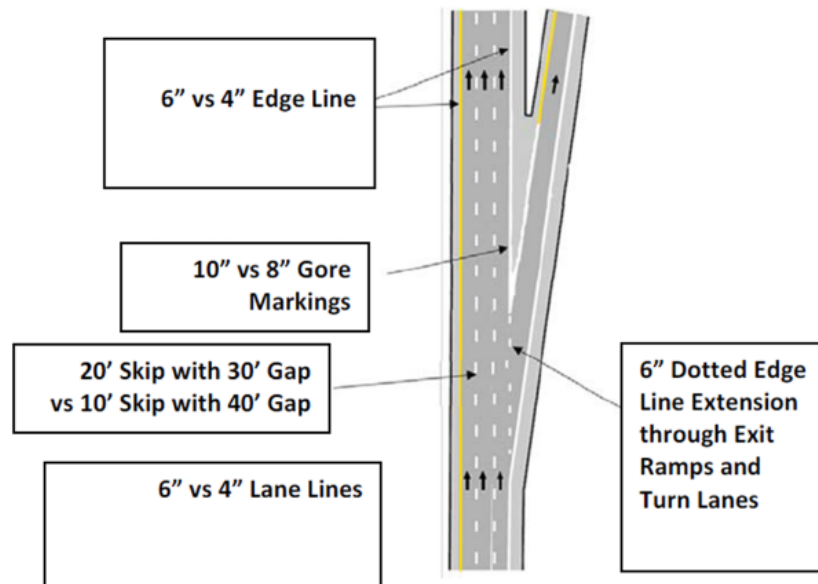
Varies significantly based on material.

- A 6-inch edgeline will cost approximately 25 percent more than the typical 4-inch edgeline.
- Typical per-mile costs:
 - 4-inch latex: \$400
 - 4-inch epoxy: \$1,100
 - 6-inch latex: \$500
 - 6-inch epoxy: \$1,400
 - 6-inch ground-in wet reflective epoxy: \$3,900



Studies Involving Pavement Markings

- Pavement Marking/Colored Pavement Friction Differential and Product Durability
- Pavement Marking Patterns and Widths - Human Factors Study
- Assessing Pavement Markings for Automated Vehicle Readiness
 - I-94 Monticello to Clearwater





Thank you again!

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