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USING NIGHT VIDEOTAPES FOR SRPM MAINTENANCE DECISIONS

Final Report

AUGUST 1997

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16. Abstract

Snowplowable raised pavement markers (SRPM's) provide motorists with valuable, supplementary roadway delineation to painted stripes. Vehicle tires with studs or on heavy trucks, road debris, snowplow accessories, and recurrent freeze/thaw cycles acting with water can cause wear and damage. A videotape method for operations personnel to use to determine when SRPM's require rehabilitation and which SRPM installations are most in need of upgrading is described and evaluated. On State roads, SRPM installations are maintained by replacing all reflectors over a segment of road every so many years, depending on daytime observation and wear history. A practical nighttime sample observation method may offer improvements.

An SRPM installation wear documentation procedure employing nighttime videographics was developed and evaluated. The developed procedure involves a database of SRPM locations, a special van with a clear windshield and a permanent camera mount, a CCD camera with a lens with a very low f-stop capability and "T" value and SP U-Matic recording and editing system, and a proposed procedure for driving, taping, editing, and prioritizing SRPM sites for maintenance. Specialized training is a requirement for taping editing and prioritizing. A digital taping system is recommended.

The need for validation with state of the art, easier to use equipment is noted for future research.

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INTRODUCTION

Snowplowable raised pavement markers (SRPM's) are used on an ever increasing amount of New Jersey roads as well as elsewhere in the United States. These markers provide motorists with valuable, supplementary roadway delineation to painted stripes. However, a variety of factors can cause wear and damage to the reflective insert reducing their reflective properties and the delineation benefits to motorists. These destructive factors include heavy truck vehicle tires, studded tires, road debris, snowplow accessories, and the effect of recurrent freeze/thaw cycles acting with water to work on small cracks from impacts that occur in the surface of the reflectors. This list is not meant to be all inclusive, the purpose of this effort is not to identify or directly attempt to modify the results of any specific events which cause SRPM damage.

The purpose of this project was to develop an effective and efficient method for operations personnel to use to determine when SRPM's require rehabilitation and more importantly, which SRPM installations are most in need of upgrading. To be effective and efficient the procedure must be affordable to run and maintain, in manpower and equipment terms, be uncomplicated in nature, and be repeatable and valid. It is recognized that the real test of a new rests in its use and further development over time. The major goal of this project is to provide constructive information toward uses of review procedures, so that SRPM locations can be maintained with a timeliness that reduces instances of inadequate delineation.

METHODOLOGY DESIGN

At the onset of the project, decisions were made with NJDOT maintenance personnel about the logistics of rehabilitating SRPM installations. Any attempt to evaluate and replace markers on an individual basis was rejected as a method for maintaining the entire system in New Jersey. Evaluating approximately 100,000 SRPM's one-by-one is not likely to be an efficient or utilized methodology. It might seem attractive to have the maintenance crew or contractor determine, on the spot, which reflectors need replacing but this method has pitfalls. Daytime visual inspection can be misleading. Damaged reflectors, even with pieces missing, can continue to provide sufficient reflectivity while those intact can have so much abrasion to the reflective surface to seriously erode the reflective properties. Contractors might find it unacceptable to start a rehab job not knowing in advance how many reflectors will need replacement, making the price of the job uncertain. Additionally, determining when to begin replacement on a given installation would be impractical. It certainly would not be a good use of resources to engage a contractor, setup safety zones, and interfere with traffic only to find

that very few of the reflective inserts need replacement. This method was rejected up front by maintenance managers. Over the years it has been suggested that SRPM installations be maintained by replacing all reflectors over a segment of road after a fixed period. The effectiveness of this method relies on the assumption that wear and damage to the installations are reasonably uniform over the entire state road system, that a given installation wears uniformly over time, and that the cycle chosen is not too soon, squandering resources by replacing reflectors before needed, or too late, leaving the motorists without the delineation benefits that SRPM's provide.

Given the uncertainties involved, maintenance managers asked that a more systematic, repeatable method be developed that would provide some assurance that SRPM installations are being maintained in a timely fashion, and that, at any given time, the most needy locations would be rehabilitated first.

Consensus was reached on a concept that included the development of a photographic technique which would have a panel of judges view videotapes of SRPM installations taken from a moving vehicle, compare what they see with standards showing new and old installations, and the sections of SRPM's rated based on the standards. The rating would be of the ability of whole sections to provide delineation benefits, not for the reflectivity of individual markers. The ratings would then be converted into a ranking of the SRPM installations by need for maintenance. The efficacy of this procedure depends on the following being true or demonstrable:

- The videotapes must show a realistic view of what the driver sees at night.
- The videotapes must show important differences in the delineation condition of the installations.
- Judges ratings should be repeatable and reasonably consistent across the whole panel.
- The entire process should be streamlined enough so as not to strain the already stretched personnel and fiscal resources of the maintenance forces.

EQUIPMENT

The following equipment was used in the development of the videotaping procedure and the ranking and rating methodology.

- Sony DXC-M7k CCD color TV camera
- Angenieux T14 x 9Bl ESM motorized zoom lens

- Sony BVM-8021 Portable 8" color monitor
- Sony BVU-150SP U-Matic Portapack Recorder
- Sony BKU-150 Integral Time Code Card
- Editing and Projection
- Sony BVU-870SP U-Matic Dynamic Tracking Editor
- Barco Vision 1500 Video Projector
- Various cables, adaptors, batteries, battery chargers, mlcrophones and other equipment needed to operate the video, editing, and projection equipment.

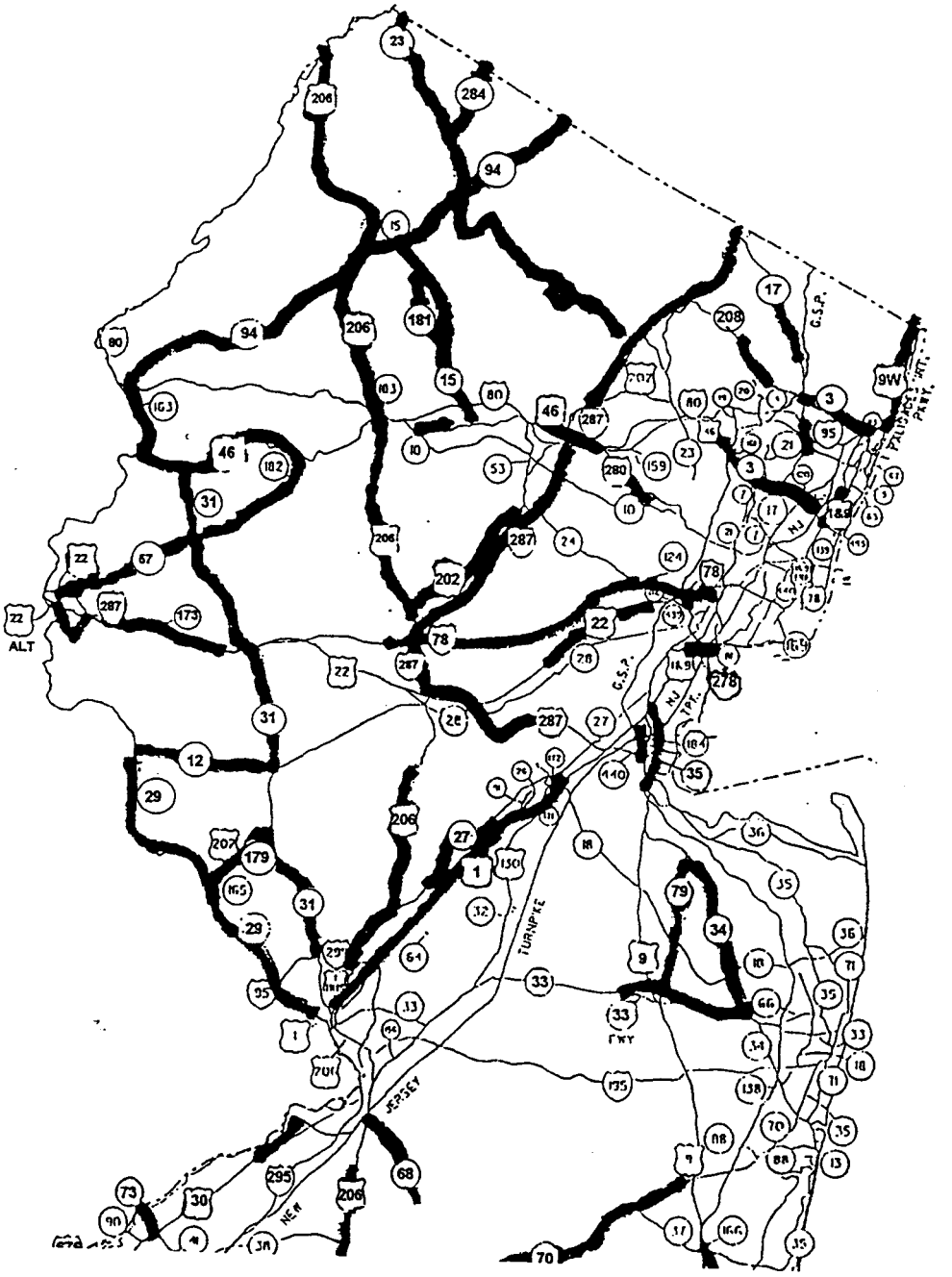
A carryall with a relatively clear windshield to maximize light transmission was used for the videotaping. A sedan did not provide sufficient space for two people and all the equipment needed. The carryall was outfitted with a permanent camera mounting stand that was made by the NJDOT Machine Shop. A room was dedicated for storage of equipment, processing of the videotapes, and the viewing of the edited tapes by judges. The Barco projector was mounted from the ceiling to conserve limited floor space. The equipment for editing and dubbing the tapes to produce versions to be viewed by the judges is maintained and operated by NJDOT video specialists in a separate unit. Final editing and dubbing was performed by that video operations unit.

VIDEOTAPING RESULTS

In order to evaluate the field equipment and provide experience to estimate manpower needs, all of the SRPM installations were videotaped at night. One could consider the Highway Video Inventory to be a similar type of effort. However, the object and the conditions of study are more narrowly defined, and the requirements are more specific.

A list of all SRPM installations on state highways was obtained from Traffic Engineering and can be found in the appendix. The installations were plotted on a state map (Figure 1) and routes were planned to, as efficiently as possible, videotape the entire system. There were more than 1000 miles of state highways with SRPM's in 1992. Pilot runs, testing different camera settings, vehicle speeds, and the use of high and low beam headlights resulted in a procedure which well represented the driver's view of the roadway, the surroundings, the SRPM's and the painted stripes. However, other reflective objects such as signs and lighted objects like signals and car headlights appeared brighter than in reality. Attempts to reduce the enhancement of these objects resulted in the degradation of the view of the remainder of the scene to the point of being unusable. Therefore, it was decided to use the settings which enhance signs and lights and attempt to overcome this obstacle with selective editing of the

FIGURE 1 SRPM Installations on NJ State Highways in 1992



videotapes and instructions to the judges. A list of the settings is in the appendix.

Videotaping occurred during November and December of 1993. Since daylight savings time had ended, taping could start one hour earlier which prevented long nights from going even later into the morning. Figures 2 - 13 show each of the routes taken, the installations filmed, the mileage filmed, and total miles driven each night. Table 1 summarizes this information and the time required for each route in order to estimate the personnel requirements for this part of the procedure. Specific route directions are listed in the appendix.

The videotaping proceeded smoothly, but some interruptions occurred due to equipment problems and inclement weather. Three nights had to be repeated.

Originally, the use of a gyroscope stabilizing system with the camera to produce a smoother product was planned. After two nights of taping, this system was abandoned for the following reasons. While the gyro did give a smoother view, it reacted slowly to curves causing the line of sight to wander off the road and only gradually return. An attempt was made to continuously adjust the camera manually, either by looking through the view finder or by using the monitor located in the back seat. The view finder was located in an inconvenient place in respect to the seating arrangement. The gyro aided setup resulted in uneven and constantly meandering views of the road, with the SRPM's often out of view, and eyestrain and headaches for the camera operator as we filmed for as much as 5-6 hours at a time.

Back in the office, the videotapes were viewed by the driver and camera operator to determine whether they adequately portrayed the road and surrounding environment based on their judgements during taping. Road segments judged inadequate were scheduled for retaping, usually by altering one of the remaining route plans to include the section. On one occasion, since the entire southern portion of the state had been completed, a new night of taping had to be added.

TABLE 1
Videotaping Route Information

Rt. #	Section of State	Mileage Filmed	Total Miles Driven	Hours
1	Northwest	143	290	7
2	Northwest	116	220	6
3	Northwest	134	190	6
4	Northeast	69	200	6
5	Northeast	39	225	6
6	Central	80	180	6
7	Central	94	160	6.5
8	Southwest	96	230	6.5
9	Southwest	62	200	6
10	South	111	290	7
11	Southeast	55	250	7
12	South	114	290	7
3 additional nights of taping due to problems				17
Totals		1113	2725	94

94 hrs. x 2 people = 188 hours x 1.5 (for OverTime) = 288 hrs.
288 person hours = 1.6 person months for videotaping

CAMERA SETTINGS

In order to optimize the viewing of tapes in a dark room so that the SRPM condition will be closest to that which was seen in the field, this particular camera and lens needed the following settings:

- Filter: 1
- White Balance: Auto/A
- Black Balance: Auto
- Gain: 9db
- DCC: On
- A. Iris: Norm
- Knee: Auto
- M. Pedestal: 00
- Shutter: Off
- Zoom: 20
- Focused to Infinity
- Iris: Auto

The Recorder was set for the time code operation to facilitate editing.
The microphone was inserted into channel 1. Microphone volume is controlled by a dial on the front of the recorder.

EDITING VIDEOTAPES

The second part of the SRPM maintenance procedure is the editing of the videotapes to produce versions to be viewed by the judges. A sufficient portion of the total mileage of a road with SRPM's will need to be rated to adequately represent the condition of the entire system. A sufficient portion was assumed to be 20% of the installation on a road. That number, however, may be optimized with experience in taping, editing, and judging.

The first step in the editing process is to view the tapes and gather information on the following:

- Interference caused by traffic, both opposing and same direction, in viewing the markers;

- Overhead lighting; and
- The number of lanes of traffic.

The condition of the SRPM's is not a concern at this point. The milepost markers, which are recorded on the tape at the time of filming, serve as the basis for dividing each highway installation into one mile segments. From the segments which are considered usable, from a traffic standpoint, 20% (or whatever the best number is) are selected randomly. These segments are grouped by their lighting, traffic and lane configuration characteristics and then copied onto 20 minute production tapes with an identifying number prior to each segment and a set of segments at the beginning of the tape for reference. The segments for any given road should not be grouped together, but spread around the different tapes of the same relevant road characteristics.

From editing completed to date, approximately three person weeks was needed to complete the editing task.

RATING PROCEDURE CRITERIA

The purpose of an SRPM rating procedure is to produce a listing of installations prioritized by order of maintenance need. In order to accomplish this, the procedure must:

1. Produce consistent results through repetitive ratings.

2. Produce consistent results between different panels of judges or people. Although this result is not as critical as #1, the same people should not have to be employed to view all of a given years videotapes, allowing more flexibility in scheduling personnel.

3. Differentiate between road segments which have important differences in delineation characteristics. If judges would give the same rating to all the installations, even consistently so, the procedure will not be of any use to maintenance personnel.

4. Adequately represent what motorists see. Human vision is perhaps too complex to be represented well by a performance measurement system which is totally automated and quantitative

RATING PROCEDURE CONSIDERATIONS

The sample size of the number of one mile segments of a given road needed to adequately characterize that road should be sufficient to account for road characteristics relevant to SRPM wear. SRPM wear is different:

- Where lane changes are unusually high,
- Where the lanes in the same direction change, and
- Where heavy truck traffic volume is higher.

SRPM wear will also be different where snowplowing operations are more frequent, if the plows used have accessories that can damage reflectors, such as vertical nose shoes that project out in front of the leading edge and steel load bearing wheels. Since the most observable wear relevant characteristic is the number of lanes, it was used to group the tapes of the road segments.

Consideration should be given to how long a group of judges can view the videotapes before fatigue causes degradation of rating consistency. Although many factors are involved and, in the absence of the research to resolve this issue, common judgement would dictate that the rating sessions should be no longer than forty minutes, the limit of most effective school classes.

The minimum number of judges should be at least three in order to obtain a consensus. However, one qualified judge at a time may have to suffice under reduced human resource conditions. The judges should be qualified as having adequate vision under reduced light conditions as found in a darkened room and be tested to assure that adequate judgements that indicate actual differences in SRPM section wear can be consistently made.

Standard videos should be produced from field examples that represent no fewer than four evenly scaled levels that include 0-25%, 26-50%, 51-75%, and 76-100% wear. This scale is compatible with commonly accepted desires to replace SRPMs below the 50% wear level and provides a sufficient basis for prioritizing. These videos should be running in a loop in view during the rating session, which would necessitate a split screen with two videos running at the same time, one with the four standards and other being the object of rating . This would allow for reasonable differences between projectors and dark room conditions.

Digital tape systems are recommended for this procedure for several reasons, as soon

as they become affordable. Continuously run standard videotapes will deteriorate and require new copies. Copies of the masters of standard analog videotapes will degenerate the necessary original quality.

CONCLUSIONS

Resulting from the experience gained in the taping, editing, and viewing of tapes, several conclusions are made regarding the use of a videotape rating procedure:

The equipment used in the project is effective and reliable in the field and can produce an adequate view of what the motorist actually sees.

The stabilizing gyro improves the quality of the picture, but impairs the facility of the operation in the field.

The labor required for taping all the installations is not unusual or unreasonable, considering the validity of the result.

Editing of tapes for a conducting valid ratings does not require an unusual amount of labor.

Both taping and editing requires specialized training.

Analog videotape is not compatible with the employment of videotaped standards of wear levels.

RECOMMENDATIONS AND DISCUSSION

The rating of SRPM installations by NJDOT forces would require advanced qualification and specialized training, which may be difficult in an environment of frequent reorganization and job mobility. In the present economic climate of cutbacks and changes, a specialized consultant with guaranteed training, qualifications, and personnel stability would seem to be a better choice.

This procedure can be compared to the use of a laser scanning or other more automated technique and a informal method. It is doubtful that a nonvisual

assessment method can attain the same capability to simulate the motorists view, which is the ultimate measure of SRPM effectiveness. Any formal survey method requires field and office labor. The existing method of assessing the need for replacement by casually noticing the condition of installations in the off night time hours or in combination with other night work, cannot lead to a consistent statewide or even regional priority replacement need list.

Whether this procedure is conducted in-house or by consultant, a digital system is recommended in order to guarantee reliable and reproducible videotape standards of wear and to reduce the extra effort that would be needed to produce original master tapes of the standards to replace those that become deteriorated.

FUTURE RESEARCH

Since 1993, better, lower cost, more commonly used, and more portable projectors have come into the market. They should be substituted for the BARCO projector and validated for this use.

Easier to use cameras with the same or better capability and digital tape recording systems should be employed, and new camera and lens settings that best represent the view as seen on dry nights should be determined.

APPENDICES

ROUTE DIRECTIONS FOR VIDEOTAPING

Route #	Directions	Miles Taped
1	31 NB to 46 WB 46 WB to 94 NB to NY border 94 SB to 23 NB to 284 NB to NY border, 284 SB to 23 NB to NY border, 23 SB to I-287 NB to NY border, I-287 SB to 206 SB to Trenton	Rt. 46 mp 10 - 0 Rt. 94 mp 0 - 46 Rt. 284 mp 0 - 7 Rt. 23 mp 53 - 17 I-287 mp 67 - 47 I-287 mp 42 - 18
2	206 NB to NY border 206 SB to 15 SB to 181 SB to 15 NB to mp 14, turnaround 15 SB to 46 WB 46 WB to 10 EB to 53 SB to 202 SB to 202/206 SB to 206 SB to Trenton	Rt. 206 mp 78 - 129 Rt. 15 mp 20 - 14 Rt. 181 mp 8 - 0 Rt. 15 mp 14 - 1 Rt. 46 mp 38 - 35 Rt. 202 mp 44 - 31 Rt. 202/206 mp 30 - 26 Rt. 206 mp 66 - 48
3	I-95 SB to 29 NB to 175 SB to 29 NB to 179 NB to 202 SB to 29 NB to 12 EB to 31 NB to 173 WB to I-78 WB to PA border, I-78 EB to 22 WB to 57 EB to 182 NB to 46 WB to 31 SB to Trenton	Rt. 175 mp 3 - 0 Rt. 29 mp 6 - 19 Rt. 179 mp 0 - 8 Rt. 29 mp 20 - 34 Rt. 12 mp 0 - 12 Rt. 173 mp 12 - 0 I-78 mp 0 - 4 Rt. 22 mp 2 - 3 Rt. 57 mp 0 - 21 Rt. 46 mp 10 - 21 Rt. 31 mp 49 -25 Rt. 31 mp 17 - 6

Route #	Directions	Miles Taped
4	31/202 NB to I-78 WB to mp 29 turnaround, I-78 EB to Exit 48 Morris Ave WB to Springfield Ave EB to 22 WB to mp 42, turnaround 22 EB to 21 NB to I-280 WB to 46 WB to mp 44, turnaround 46 EB to I-287 SB to 1 SB to home	 I-78 mp 29 - 51 Rt. 22 mp 42 - 47 Rt. 22 mp 50 - 52 Rt. 22 mp 57 - 60 Rt. 46 mp 48 - 44 I-287 mp 42 - 10
5	1 NB to 18 EB to TPK to Exit 14 to 1&9 NB to 9W NB to NY border 9W SB to 4 WB tc 208 NB to Russell Ave exit Russell Ave to Wyckoff Ave, left to Franklin Ave (CR 502), right to Franklin Tpk. (CR 507), left to 17 SB to 3 EB past mp 9 turnaround, 3 EB to 46 WB turnaround, 46 EB to 3 EB to GSP to 1 SB to Trenton	 Rt. 1&9 mp 57 - 62 Rt. 9W mp 11 - 4 Rt. 4 mp 10 - 3 Rt. 208 mp 4 - 6 Rt. 17 mp 22 - 16 Rt. 3 mp 9 - 0
6	1 NB to CR571 EB to 33 EB to 33B to 33 EB to 34 NB to 79 SB to 33 WB to 9 NB to 35 SB to 9 NB to I-278 EB to NY border, turnaround I-278 WB to 1 SB to Franklin Corner Rd. to 206 NB to 27 NB to mp 10, turnaround, 27 SB to 206 SB to Trenton	Rt. 33B mp 0 - 5 Rt. 33 mp 29 - 35 Rt. 34 mp 9 - 21 Rt. 79 mp 12 - 1 Rt. 9 mp 132 - 136 Rt. 35 mp 51 - 57 I-278 mp 0 - 1 Rt. 1 mp 28 - 6 Rt. 206 mp 48 - 54 Rt. 27 mp 3 - 10

Route #	Directions	Miles Taped
7	206 SB to 70 WB to circle (541) turnaround, 70 EB to 9 SB to 72 WB to 70 WB to 206 NB to 537 EB to 68 SB to circle 68 NB to 206 NB to Trenton	Rt. 70 mp 10 - 49 Rt. 9 mp 90 - 60 Rt. 72 mp 0 - 21 Rt. 68 mp 0 - 4
8	295 SB to 44 SB to 130 NB to mp 14, turnaround, 130 SB to 48 EB to mp 4, turnaround 48 WB to 130 SB to 140 EB 140 EB to mp 1, turnaround 140 WB to 130 SB to 49 EB to 47 NB to 295 NB to Trenton	Rt. 44 mp 10 - 0 Rt. 130 mp 14 - 4 Rt. 48 mp 0 - 4 Rt. 130 mp 4 - .5 Rt. 140 mp 0 - 1 Rt. 49 mp 2 - 36 Rt-. 47 mp 47 - 73 I-295 mp 26 - 33
9	295 SB to 73 SB to 70 EB to circle (541), turnaround 70 WB to 73 SB to 30 NB to mp 10, turnaround, 30 SB to 73 SB to 322 WB to 54 SB to 40, turnaround, 54 NB to 206 NB to Trenton	Rt. 73 mp 27 - 24 Rt. 70 mp 8 - 14 Rt. 73 mp 24 - 16 Rt. 30 mp 18 - 10 Rt. 73 mp 6 - 0 Rt. 54 mp 0 - 9 Rt. 206 mp 0 - 26
10	295 SB t0 45 SB to 77 SB to mp 1, turnaround 77 NB 56 EB to 47 SB to 47 Alternate to 47 SB to 9 SB to mp 3, turnaround 9 NB to 50 NB to 49 WB to 47 NB to 55 NB to 42 NB to 295 NB to Trenton	Rt. 45 mp 23 - 18 Rt. 77 mp 23 - 1 Rt. 56 mp 0 - 8 Rt. 47 mp 39 - 32 Rt. 47 Alt. all Rt. 47 mp 21 - 5 Rt. 9 mp 3 - 24 Rt. 50 mp 0 - 7 Rt. 49 mp 54 - 36

Route #	Directions	Miles Taped
11	206 SB to 30 EB to 9 SB to 83 WB to 47 NB to CR 548 EB to 49 EB to 50 NB to 30 WB to 206 NB to Trenton	Rt. 30 mp 31 - 36 Rt. 30 mp 40 - 49 Rt. 9 mp 31 - 24 Rt. 83 mp 4 - 0 Rt. 47 mp 21 - 32 Rt. 50 mp 7 - 26
12	I95 EB to CR 539 SB to Lacey Rd. to 9 SB to 322 WB to 40 WB to 45 NB to mp 18, turnaround, 45 SB to 40 WB to 140 to 295NB to 322 EB to 42 NB to 295 NB to 76 NB to 130 NB to 30 WB 30 EB to 130 NB to 73 NB 73 SB to 130 NB tn TrPntnn	Rt. 9 mp 70 - 44 Rt. 40 mp 52 - 10 Rt. 45 mp 9 - 18 Rt. 40 mp 10 - 2 Rt. 322 mp 2 - 24 Rt. 30 mp 4 - 1 Rt. 73 mp 32 - 34 Rt. 130 mp 45 - 47

RT.	Dir.	Tape #	MP Filmed	Miles	MP with SRPMs	Date Filmed	Weather, Pavement	Comments
CR 601	SB	12–10	6 – 0	6		12/13/93	clear,dry	filter 1,adj. h.l.
GSP	SB	14–4	153 – 133	20		12/16/93	clear,dry	filter 1,adj. h.l.
1	SB	10–5	21 – 6	15		11/18/93	clear,dry	filter 1,adj. h.l.
1	SB	10–4	28 – 21	7		11/18/93	clear,dry	filter 1,adj. h.l.
1 & 9	NB	14–1	51 – 62	11	57 – 61	12/16/93	clear,dry	filter 1,adj. h.l.
3	WB	14–3	8 – 0	8		12/16/93	clear,dry	filter 1,adj. h.l.
4	WB	14–2	11 – 3	8		12/16/93	clear,dry	filter 1,adj. h.l.
9	NB	7–5	3 – 18	15		11/04/93	clear,dry	filter 1,adj. h.l.
9	SB	2–3	16 – 0	16		10/19/93	rain,wet	filter 3
9	NB	7–6	18 – 24	6		11/04/93	clear,dry	filter 1,adj. h.l.
9	SB	15–2	31 – 14	17		12/20/93	clear,dry	filter 1,adj. h.l.
9	SB	2–2	31 – 16	15		10/19/93	lgt rain,dry	filter 3
9	SB	8–2	53 – 44	9		11/08/93	clear,dry	filter 1,adj. h.l.
9	SB	8–1	71 – 55	16		11/08/93	clear,dry	filter 1,adj. h.l.
9	SB	4–4	77 – 71	16		10/22/93	clear,dry	filter 1,adj. h.l.
9	SB	4–3	90 – 77	17		10/22/93	clear,dry	filter 1,adj. h.l.
9	NB	10–3	132 – 136	4		11/18/93	clear,dry	filter 1,adj. h.l.
9 W	NB	14–2	4 – 11	7		12/16/93	clear,dry	filter 1,adj. h.l.
9 /GSP	SB	8–2	51 – 48	3		11/08/93	clear,dry	filter 1,adj. h.l.
12	EB	11–3	0 – 11	11		12/09/93	clear,dry	filter 1,adj. h.l.
12	WB	1–6	11 – 0	11		10/18/93	clear,dry	filter 3
15	SB	6–6	7 – 0	7		10/28/93	clear,dry	filter 1,adj. h.l.
15	NB	6–5	7 – 14	7		10/28/93	clear,dry	filter 1,adj. h.l.
15	SB	6–5	14 – 7	7		10/28/93	clear,dry	filter 1,adj. h.l.
15	SB	6–4	20 – 14	6		10/28/93	clear,dry	filter 1,adj. h.l.
17	SB	14–3	4 – 1	3	no markers	12/16/93	clear,dry	filter 1,adj. h.l.
17	SB	14–3	10 – 7	3		12/16/93	clear,dry	filter 1,adj. h.l.
17	SB	14–3	19 – 16	3		12/16/93	clear,dry	filter 1,adj. h.l.
22	EB	1–5	2 – 3	1		10/18/93	clear,dry	filter 3
22	WB	11–5	3 – 2	1		12/09/93	clear,dry	filter 1,adj. h.l.
22	EB	13–2	42 – 47	5		12/14/93	clear,dry	filter 1,adj. h.l.
22	EB	13–2	49 – 52	3		12/14/93	clear,dry	filter 1,adj. h.l.
22	EB	13–2	57 – 60	3		12/14/93	clear,dry	filter 1,adj. h.l.
23	SB	12–7	29 – 13	16		12/13/93	clear,dry	filter 1,adj. h.l.
23	SB	12–6	43 – 29	14		12/13/93	clear,dry	filter 1,adj. h.l.
23	SB	12–5	53 – 43	10		12/13/93	clear,dry	filter 1,adj. h.l.
27	NB	10–6	3 – 10	7		11/18/93	clear,dry	filter 1,adj. h.l.
29	NB	11–1	6 – 19	13		12/09/93	clear,dry	filter 1,adj. h.l.
29	NB	11–2	20 – 30	10		12/09/93	clear,dry	filter 1,adj. h.l.
29	SB	1–7	26 – 9	17		10/18/93	clear,dry	filter 3
29	NB	11–3	30 – 34	4		12/09/93	clear,dry	filter 1,adj. h.l.
29	SB	1–6	34 – 26	8		10/18/93	clear,dry	filter 3
30	EB	8–8	1 – 4	3		11/08/93	clear,dry	filter 1,adj. h.l.
30	EB	9–2	10 – 16	6		11/10/93	clear,dry	filter 1,adj. h.l.
30	EB	9–3	15 – 18	3		11/10/93	clear,dry	filter 1,adj. h.l.
30	EB	2–1	31 – 36	5		10/19/93	clear,dry	filter 3
30	EB	15–1	31 – 36	5		12/20/93	clear,dry	filter 1,adj. h.l.
30	EB	2–1	40 – 50	10	no markers	10/19/93	clear,dry	filter 3
30	EB	15–1	40 – 49	9		12/20/93	clear,dry	filter 1,adj. h.l.
31	NB	1–1	12 – 17	5		10/18/93	clear,dry	filter 3

RT.	Dir.	Tape #	MP Filmed	Miles	MP with SRPMs	Date Filmed	Weather, Pavement	Comments
31	NB	1–1	22 – 31	9		10/18/93	clear,dry	filter 3
31	NB	1–2	31 – 49	18		10/18/93	clear,dry	filter 3
31	SB	11–7	49 – 37	12		12/09/93	clear,dry	filter 1,adj. h.l.
31	SB	11–8	37 – 25	12		12/09/93	clear,dry	filter 1,adj. h.l.
31	SB	11–9	16 – 6	10		12/09/93	clear,dry	filter 1,adj. h.l.
33 B	EB	10–1	0 – 5	5		11/18/93	clear,dry	filter 1,adj. h.l.
33	EB	10–1	29 – 35	6		11/18/93	clear,dry	filter 1,adj. h.l.
34	NB	10–1	9 – 13	4		11/18/93	clear,dry	filter 1,adj. h.l.
34	NB	10–2	13 – 23	10		11/18/93	clear,dry	filter 1,adj. h.l.
35	SB	10–4	54 – 51	3		11/18/93	clear,dry	filter 1,adj. h.l.
35	SB	10–3	57 – 54	3		11/18/93	clear,dry	filter 1,adj. h.l.
40	WB	8–6	6 – 2	4		11/08/93	clear,dry	filter 1,adj. h.l.
40	WB	8–5	22 – 6	16		11/08/93	clear,dry	filter 1,adj. h.l.
40	WB	8–4	39 – 22	17		11/08/93	clear,dry	filter 1,adj. h.l.
40	WB	8–3	52 – 39	13		11/08/93	clear,dry	filter 1,adj. h.l.
44	SB	5–1	10 – 0	10		10/25/93	clear,dry	filter 1,adj. h.l.
45	NB	8–6	9 – 17	8		11/08/93	clear,dry	filter 1,adj. h.l.
45	SB	7–1	23 – 17	6		11/04/93	clear,dry	filter 1,adj. h.l.
46	EB	1–3	0 – 17	17		10/18/93	clear,dry	filter 3
46	WB	12–1	10 – 0	10		12/13/93	clear,dry	filter 1,adj. h.l.
46	WB	11–7	15 – 10	5		12/09/93	clear,dry	filter 1,adj. h.l.
46	EB	1–4	17 – 21	4		10/18/93	clear,dry	filter 3
46	WB	11–6	21 – 15	6		12/09/93	clear,dry	filter 1,adj. h.l.
46	WB	6–6	38 – 35	3		10/28/93	clear,dry	filter 1,adj. h.l.
46	EB	13–3	44 – 46	2		12/14/93	clear,dry	filter 1,adj. h.l.
46	WB	13–3	48 – 44	4		12/14/93	clear,dry	filter 1,adj. h.l.
47	SB	7–4	21 – 4	17		11/04/93	clear,dry	filter 1,adj. h.l.
47	NB	15–3	21 – 32	11		12/20/93	rain,wet	filter 1,adj. h.l.
47	SB	7–3	39 – 32	7		11/04/93	clear,dry	filter 1,adj. h.l.
47	NB	5–5	47 – 63	16		10/25/93	clear,dry	filter 1,adj. h.l.
47	NB	5–6	63 – 73	10		10/25/93	clear,dry	filter 1,adj. h.l.
47 Alt.	SB	7–3	18 – 26	8		11/04/93	clear,dry	filter 1,adj. h.l.
47 Alt.	SB	7–4	26 – 27	1		11/04/93	clear,dry	filter 1,adj. h.l.
48	WB	5–2	5 – 0	5		10/25/93	clear,dry	filter 1,adj. h.l.
49	EB	5–3	2 – 17	15		10/25/93	clear,dry	filter 1,adj. h.l.
49	EB	5–4	17 – 34	17		10/25/93	clear,dry	filter 1,adj. h.l.
49	EB	5–5	34 – 35	1		10/25/93	clear,dry	filter 1,adj. h.l.
49	WB	7–7	48 – 36	12		11/04/93	clear,dry	filter 1,adj. h.l.
49	WB	7–6	54 – 48	6		11/04/93	clear,dry	filter 1,adj. h.l.
50	NB	7–6	0 – 7	7		11/04/93	clear,dry	filter 1,adj. h.l.
50	NB	2–4	0 – 9	9		10/19/93	rain,wet	filter 3
50	NB	15–3	7 – 12	5		12/20/93	rain,wet	filter 1,adj. h.l.
50	NB	2–5	9 – 26	17		10/19/93	rain,wet	filter 3
50	NB	15–4	12 – 26	14		12/20/93	rain,wet	filter 1,adj. h.l.
54	NB	9–3	0 – 7	7		11/10/93	clear,dry	filter 1,adj. h.l.
54	NB	9–4	7 – 10	3		11/10/93	clear,dry	filter 1,adj. h.l.
56	EB	7–2	0 – 5	5		11/04/93	clear,dry	filter 1,adj. h.l.
56	EB	7–3	5 – 8	3		11/04/93	clear,dry	filter 1,adj. h.l.
57	WB	1–5	7 – 0	7		10/18/93	clear,dry	filter 3
57	WB	1–4	11 – 7	4		10/18/93	clear,dry	filter 3