APPENDIX A: AASHTO PROVISIONAL STANDARDS FOR CRACK SEALANT TESTS

- TP 85-10, *Apparent Viscosity of Hot-Poured Bituminous Crack Sealant Using Brookfield Rotational Viscometer RV Series Instrument*—Apparent viscosity at the recommended installation temperature.
- TP 86-10, *Accelerated Aging of Bituminous Sealants and Fillers with a Vacuum Oven*—Simulates sealant weathering in the field.
- TP 87-10, *Measure Low Temperature Flexural Creep Stiffness of Bituminous Sealants and Fillers by Bending Beam Rheometer (BBR)*—Evaluate a sealant's creep properties at low temperatures.
- TP 88-10, *Evaluation of the Low-Temperature Tensile Property of Bituminous Sealants by Direct Tension Test*—Characterize a sealant's low-temperature extendibility.
- TP 90-10, *Measuring Interfacial Fracture Energy of Hot-Poured Crack Sealant Using a Blister Test*, and TP 89-10, *Measuring Adhesion of Hot-Poured Crack Sealant Using Direct Adhesion Tester*—Evaluate the bonding between sealant and its substrate.

APPENDIX B: PHYSICAL REQUIREMENTS OF MNDOT SEALANTS (AFTER, MNDOT, 2016) PHYSICAL REQUIREMENTS OF MNDOT 3719 SEALANT

Provide crack sealer meeting the requirements of ASTM D 6690, Type I with the following modifications in Table 3719-1 after one cycle of heating to the manufacturer's maximum heating temperature, cooling, and reheating to the manufacturer's maximum heating temperature.

Table 3719-1
ASTM D 6690, Type I Modifications

Test	Specification
Recycled rubber, mass	≥ 18% of asphaltic components
Bond Test, 50% extension at 0° F [-18° C]*	No adhesion or cohesion bond failure after 5 cycles
Resilience at 77° F [25° C]	≥ 40%
Softening point	≥ 180 °F [82° C]

* Use sawed cement mortar blocks or asphalt HMA blocks prepared using the method found in the MnDOT Laboratory Manual.

Physical requirements of MnDOT 3723 Sealants

Provide sealant meeting the requirements of ASTM D 6690, Type II and the following modifications:

Table 3723-1
ASTM D 6690, Type II Modifications

Test	Requirement
Cone penetration at 77 °F [25 °C], 150 g, 5 s	60 – 90 dmm
Bond at −20 °F [−29 °C], 3 cycles, 100% extension	No adhesion or cohesion bond failure after 3 cycles
Mandrel bend test at −29 °F [−34 °C], 1 in [25 mm] mandrel	No cracking
Resilience at 77 °F [25 °C]	≥ 40%

Physical requirements of MnDOT 3725 Sealants

Provide sealant meeting the requirements of ASTM D 6690 Type IV with the following modifications in Table 3725-1.

Table 3725-1
ASTM D 6690 Type IV Modifications

Test	Requirement
Cone Penetration at 77° F [25° C], ASTM D 5329	100 – 150 dmm
Cone Penetration at 0° F [-18° C], ASTM D 5329 modified	≥ 25 dmm
Resilience, ASTM D 5329	30% – 60%
NOTE: Ensure the material meets the requirements of Table 3725-1 after heating for 6 h with constant mixing in a laboratory melter at the manufacturer's maximum heating temperature.	

APPENDIX C: PRELIMINARY SURVEY - GOOGLE FORM

Data Request Form for Crack Sealing Project (MnDOT Contract 1003325, Work Order 24)

The University of Minnesota Duluth is conducting a LRRB funded research project to study the effectiveness of different crack sealing methods, for example, 'clean-and-seal' and 'rout-and-seal' crack sealing methods. The successful completion of this project will lead to the development of a criterion for selecting the most appropriate crack sealing method based on road type, age, traffic and crack conditions. In order to complete this project, we need some data on the performance of different crack sealing methods. It would be a great help if you could please go through the following few questions and provide your responses. For any questions, please call or email the Principal Investigator of this project, Dr. Manik Barman, Assistant Professor, Department of Civil Engineering, University of Minnesota Duluth; Email: mbarman@d.umn.edu; Phone (218 726 6437 (O) and 412 370 7019 (Cell). The research team and technical advisory panel of this project appreciate your cooperation.

Email *

Phone *

Agency Information/MnDOT district/ County/ City and address

Proper selection of crack sealing method can save dollars and increase the life of pavement.

Proper selection of crack sealing method can save dollars and increase the life of pavement.

Q1. Between different crack sealing methods, which one do you use more?

Q2. Do you follow any criteria for deciding on the sealing method? (e.g., crack width, crack depth, crack density, pavement age, pre-determined schedule, etc.,)

Q3. What is the typical life of the sealants when cracks are sealed with clean-and-seal method?

Q4. What is the typical life of the sealants when cracks are sealed with rout-and-seal method?

Q5. Would you be able provide some additional information related to the performance and cost of the sealants for some of your previous and or current projects?

- Yes; we will contact you with a follow-up survey.
- No

APPENDIX D: SECONDARY SURVEY FORM

UMD
UNIVERSITY OF MINNESOTA DULUTH
Driven to Discover

University of Minnesota Duluth
Swenson College of Science and Engineering
Department of Civil Engineering

Data Request Form for Crack Sealing Project (MnDOT Contract 1003325, Work Order 24)

Project information

Agency Name:	Contact Person:	Contact Phone/Email:
Project Location (Route no., road point, section length, etc.):		Crack Sealing Date (month/year)

Pavement layer/overlay on which sealing was performed.

Thickness (if available):____ _____; Mixture designation (e.g., SPWEB540C): _____ ,if not known, then grade of the binder used_____.

Pavement layer/overlay age during sealing:_____

Pavement quality index (PQI) or ride quality index (RQI) and surface rating (SR) at time of sealing:

PQI_____ RQI_____ SR_____

Crack Conditions

Avg crack width (e.g., ¼", ½", ¾" inch):_____

Working crack? / if so, average annual horizontal movement (inch):_____

Approximate depth of the crack (e.g., 1/3, ¾ inch, etc.):_____

Approximate density of cracks (crack length/lane mile): _____

Severity of cracks (e.g., low/ medium/ high):_____

Edge deterioration (e.g., presence of secondary cracks/spalls): _____

Major locations of cracks (e.g., wheel path, lane joints, transverse cracks, etc.):_____

Distresses responsible for the crack(s) (e.g., bottom up fatigue, top down fatigue, thermal, reflective, others (specify)):

_____

Sealing Procedure

	Cleaning (e.g., Air compressor, Sandblaster, Hot-air lance, Wire Brush, None, other)	**Placement Configuration** (e.g., Flush, Capped, Band-aid, Recessed, other)	**Routed reservoir dimensions** (width x depth)
Filling			
Clean-and-seal			
Rout-and-seal			

Secondary Survey Form (Cont'd…)

Sealant Materials

Sealant used (e.g., MnDOT 3725, 3723, 3719, specify if other): _____ If other, please specify any material specifications that are met (e.g. ASTM D6690): _____
Methods used to prevent pull-out or tracking (blotter, sand, delay traffic, specify if other):
List any other materials used:
Criteria for sealant material selection:
Temperature policy (e.g., min air temp., max. pavement temp., etc.,):

Sealant Cost

Amount of sealing material used: _____	Unit cost of sealing material: _____
Cost for labor: _____	Cost per linear foot of repair: _____
Duration of lane closure: _____	Cost associated with detour: _____

Note: we need the above-mentioned information for making a cost-comparison between different crack sealing methods; if any (or all) of these information are not available, please help us by providing with other relevant information (or any source of information).

Pavement performance information during service life of the sealant.

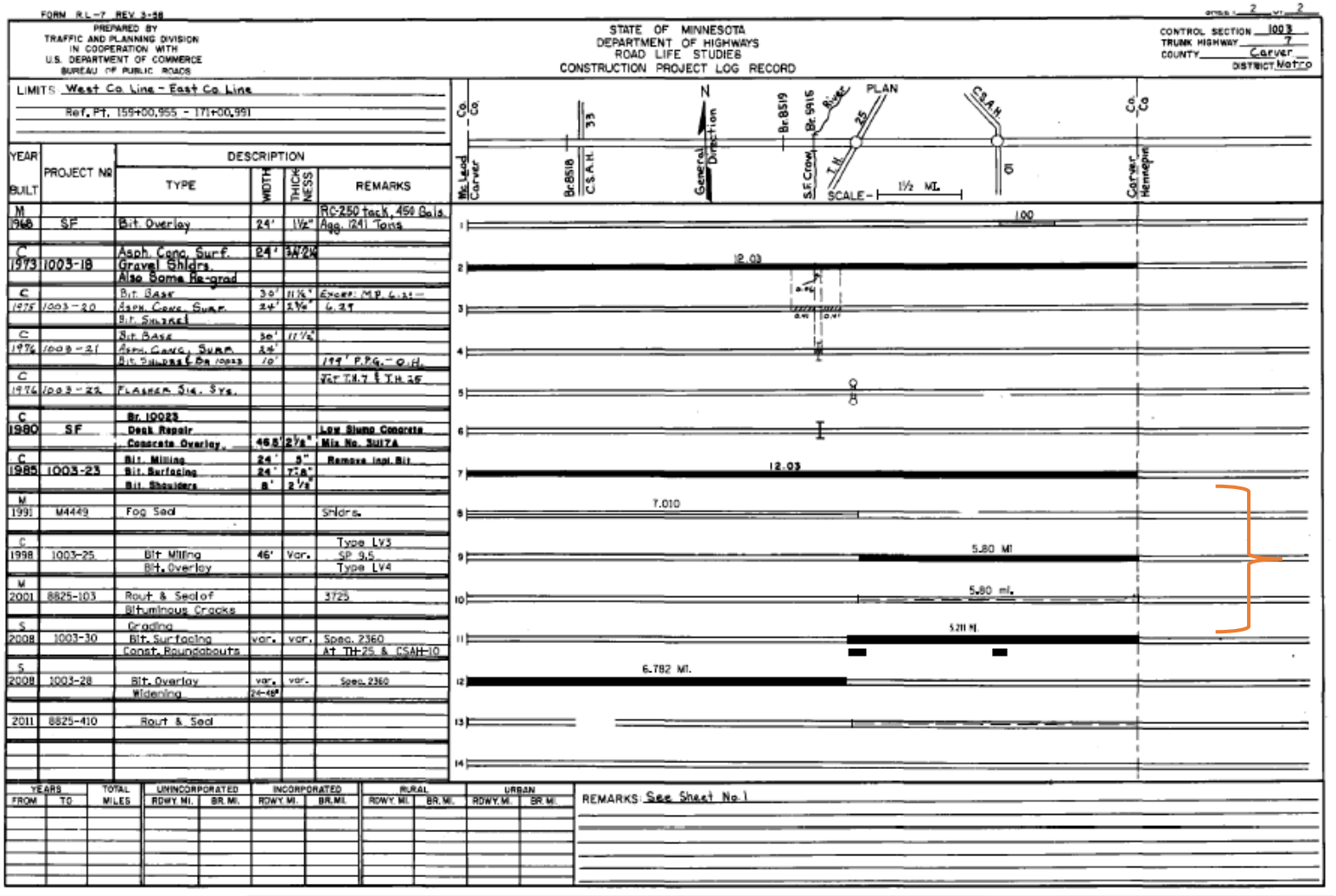
Age (months/years since the day of sealing, up to 8 years), add row if necessary.	PQI or RQI and SR PQI	RQI	SR	Type of seal failures *see note below*
Age_____				Adhesive___ Cohesive___ Tracking___ Overband wear, ___Specify if other_____
				Adhesive___ Cohesive___ Tracking___ Overband wear, ___Specify if other_____
				Adhesive___ Cohesive___ Tracking___ Overband wear, ___Specify if other_____
				Adhesive___ Cohesive___ Tracking___ Overband wear, ___Specify if other_____
				Adhesive___ Cohesive___ Tracking___ Overband wear, ___Specify if other_____

Note: Adhesive failure: Between sealant and pavement crack edge; cohesive failure: failure within the sealants itself; Tracking: loss of material due to sticking to tires; Overband wear: loss of material from snowplows; Others: secondary cracks, potholes, spalls, etc.

Please provide the following miscellaneous information, if possible.

Typical future repair/maintenance/ rehabilitation works that is performed once the cracks are deteriorate and sealing is not an option any more: _____
Any recommendation on best sealing material/method or material-method combination?
Describe any crack sealant installation or performance problems you've experienced, along with identified causes and proposed or implemented solutions if applicable.
Have you tried anything other than your standard crack sealing materials or practices, and what was the result? Is there anything unique that you do that you feel improves performance, increases efficiency, etc. Please provide as much detail as possible to share your knowledge with the research team.
Your opinion on the pavement life that can be extended by sealing cracks (months/years/ none):
Are there any other relevant information you think we have forgotten to request but you want to share?

APPENDIX E: MNDOT DATABASE - RESOURCES



FORM RL-7 REV 3-58

PREPARED BY
TRAFFIC AND PLANNING DIVISION
IN COOPERATION WITH
U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

STATE OF MINNESOTA
DEPARTMENT OF HIGHWAYS
ROAD LIFE STUDIES
CONSTRUCTION PROJECT LOG RECORD

CONTROL SECTION 1003
TRUNK HIGHWAY 7
COUNTY Carver
DISTRICT Metro

LIMITS West Co. Line - East Co. Line
Ref. Pt. 159+00.955 - 171+00.991

PLAN
N
General Direction
Co. Co.
Br. 8518
C.S.A.H. 33
Br. 8519
Br. 9916
S.F. Crow River
T.H. 25
C.S.A.H. 10
Co. Co.
Mc Leod Carver
Carver Hennepin
SCALE - 1½ MI.

YEAR BUILT	PROJECT NR	DESCRIPTION TYPE	WIDTH	THICKNESS	REMARKS
M 1965	SF	Bit. Overlay	24'	1½"	RC-250 tack, 450 Gals. Agg. 1241 Tons
C 1973	1003-18	Asph. Conc. Surf. Gravel Shldrs. Also Some Re-grad	24'	3½"2½"	
C 1975	1003-20	Bit. Base Asph. Conc. Surf. Bit. Shldrs.	36' 24'	11½" 1½"	Except: M.P. 6.21 - 6.27
C 1976	1003-21	Bit. Base Asph. Conc. Surf. Bit. Shldrs. & Br. 10023	36' 24' 10'	11½"	199' P.P.G. - O.H.
C 1976	1003-22	Flasher Sig. Sys.			W. of T.H. 7 & T.H. 25
C 1980	SF	Br. 10023 Deck Repair Concrete Overlay	46.8'	2½"	Low Slump Concrete Mix No. 3U17A
C 1985	1003-23	Bit. Milling Bit. Surfacing Bit. Shoulders	24' 24' 8'	5" 1¾" 2½"	Remove Impl. Bit
M 1991	M4449	Fog Seal			Shldrs.
C 1998	1003-25	Bit. Milling Bit. Overlay	46'	Var.	Type LV3 SP 9.5 Type LV4
M 2001	8825-103	Rout & Seal of Bituminous Cracks			3725
S 2008	1003-30	Grading Bit. Surfacing Const. Roundabouts	var.	var.	Spec. 2360 At TH-25 & CSAH-10
S 2008	1003-28	Bit. Overlay Widening	var. 24-48'	var.	Spec. 2360
2011	8825-410	Rout & Seal			

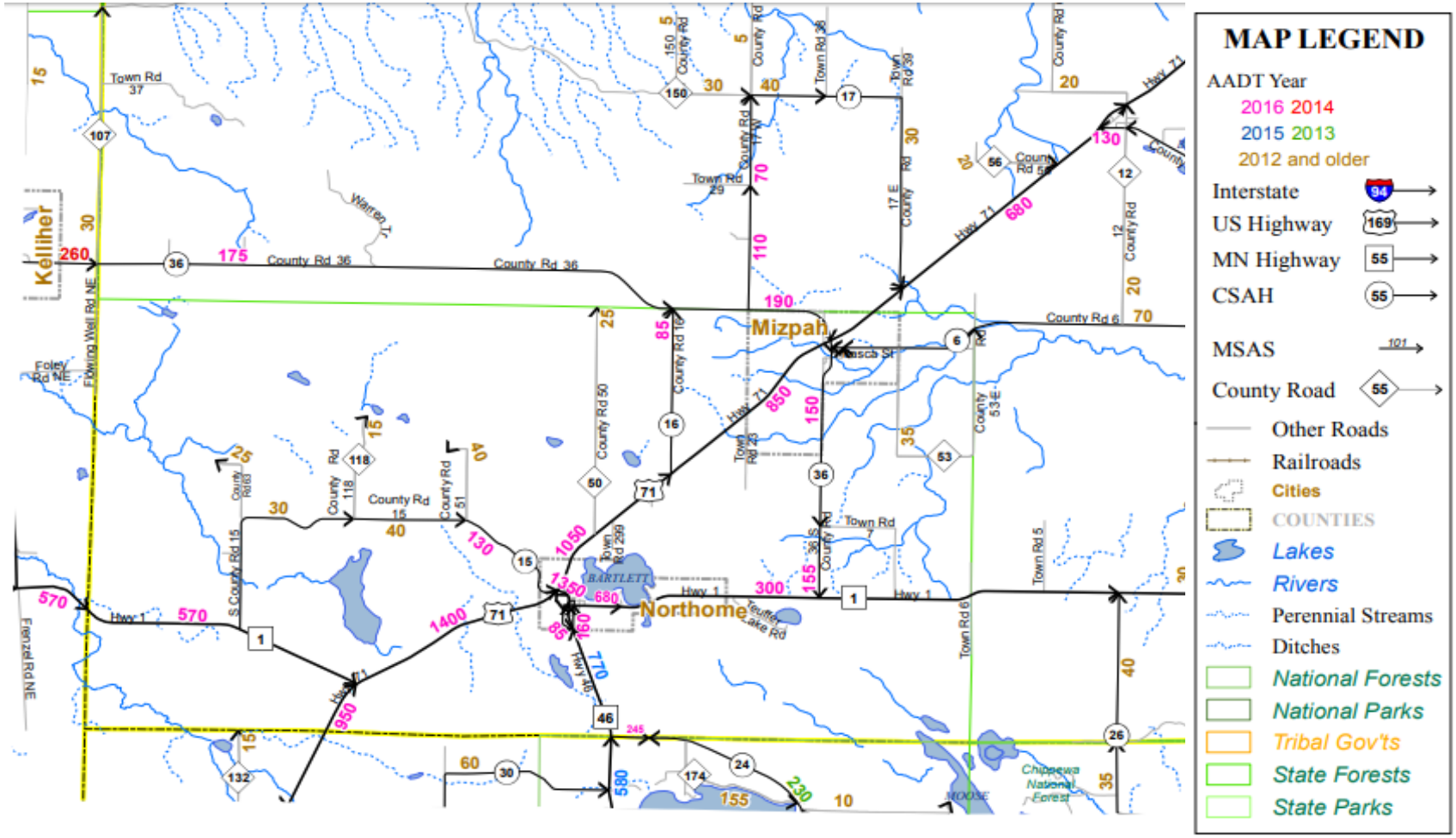
1.00
12.03
0.42
0.41
12.03
7.010
5.80 MI
5.80 mi.
5.211 M.
6.782 MI.

YEARS FROM	YEARS TO	TOTAL MILES	UNINCORPORATED RDWY. MI.	UNINCORPORATED BR. MI.	INCORPORATED RDWY. MI.	INCORPORATED BR. MI.	RURAL RDWY. MI.	RURAL BR. MI.	URBAN RDWY. MI.	URBAN BR. MI.

REMARKS See Sheet No. 1

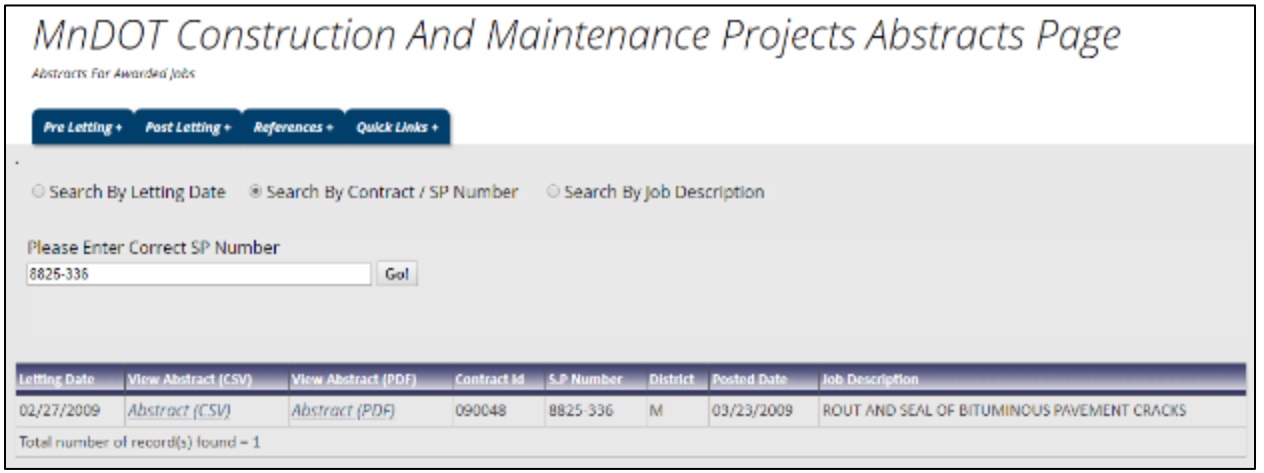
Sample Construction log showing work history of a crack sealing project

MnDOT Database – Resources (Cont'd…)



Sample Traffic data from traffic forecast and analysis website of MnDOT

MnDOT Database – Resources (Cont'd…)



Sample awarded abstract search page of bid-letting website

APPENDIX F: PROJECT INFORMATION - CRACK SEALING METHODS

S. No.	ID	District/County	Project Location		Control Section #	State Project #	Route
1	1AK06	D1: Aitkin County	Jct T.H 169 to S.Jct T.H. 65		106	M01242, 8821-58	Mn-200
2	1AK21	D1: Aitkin County	W.Jct.T.H.65 at W corp. Limits of McGregor-E.Co.line		121	M96144	Mn-210
3	1CT05	D1: Carlton County	Jct T.H 35 to Jct T.H. 45 in Cloquet		905	8821-31	Mn-33
4	1CT14	D1: Carlton County	W. Co. Line - Jct. T.H. 73 in Cromwell		914	M97200	Mn-210
5	1CT0b	D1: Carlton County	CSAH 4-Carlton/St. Louis Co. Line		980b	M94177	I-35
6	1CO01	D1: Cook County	W. County Line - Jct. Cr-35		1601	8821-142	Mn-61
7	1CO02	D1: Cook County	Jct. Cr-35 - E. Lim. Grand Marais		1602	8821-142	Mn-61
8	1CO04	D1: Cook County	NE. End Br-5307 - S. End Br-5923		1604	8821-142, 8825-410	Mn-61
9	1KC06	D1: Koochiching County	E. Jct. US-71 – E. Shore Dove Island		3606	8821-71	Mn-11
10	1KC08	D1: Koochiching County	E. County Line – S. Jct. Mn-11		3608	8821-58	US-53
11	IKC09	D1: Koochiching County	S. County Line – Jct. US-71		3609	8821-58	Mn-65
12	1KC12	D1: Koochiching County	Jct. Mn-6 – Jct. Mn-65		3612	M96152	US-71
13	1KC13	D1: Koochiching County	Jct. Mn-65 – W. Jct. Mn-11		3613	M96152	US-71
14	1LA01	D1: Lake County	W. County Line – Tomahawk Road		3801	8821-58	Mn-1

15	1LA02	D1: Lake County	Jct. Tomahawk Road – Jct. NFD-172	3802	M01242	Mn-1
16	1SL05	D1: Saint Louis County	Jct. 3rd Ave. – E. County Line	6905	8821-58	Mn-1
17	1SL06	D1: Saint Louis County	W. County Line – N. Jct. Mn-73	6906	8821-58	US-2
18	1SL07	D1: Saint Louis County	N. Jct. Mn-73 – Jct. Mn-33	6907	6907-01242	US-2
19	1SL08	D1: Saint Louis County	Jct. Mn-33 – W. Corp. Limits of Duluth	6908	8821-31	US-2
20	1SL21	D1: Saint Louis County	E. Jct. Mn-1 – Gheen Corner	6921	M04566	US-53
21	1SL22	D1: Saint Louis County	Gheen Corner – W. County Line	6922	8821-221	US-53
22	1SL26	D1: Saint Louis County	N. Limits Duluth – E. County Line	6926	8821-71	Mn-61
23	1SL27	D1: Saint Louis County	S. County Line – E. Jct. US-2	6927	8821-71	Mn-73
24	1SL33	D1: Saint Louis County	E. Jct. US-53 – Jct. Mn-23	6933	8821-31	Mn-194
25	2BT08	D2: Beltrami County	S. Jct. US-71 - S. County Line	408	8822-12	US-2

Project Information - Crack Sealing Methods (Cont'd...)

S. No.	ID	District/County	Project Location	Control Section #	State Project #	Route
26	2BT10	D2: Beltrami County	N. Jct. US-2 - Jct. Mn-72	410	M95278	US-71
27	2BT11	D2: Beltrami County	Jct. Mn-72 - N. County Line	411	0411-95278	US-71
28	2CA18	D2: Cass County	S. Jct. Mn-87 - S. Jct. Mn-200	1118	8823-100	Mn-371

29	2CW06	D2: Clearwater County	Jct. Mn-200 - Jct. US-2	1506	M98293	Mn-92
30	2CW06b	D2: Clearwater County	Jct. Mn-200 - Jct. US-2	1506	M99049	Mn-92
31	2HB06	D2: Hubbard County	W. Jct. MN-200 - E. Jct. MN-200	2906	M4522	US-71
32	2HB06b	D2: Hubbard County	W. Jct. MN-200 - E. Jct. MN-200	2906	M4522	US-71
33	2HB08	D2: Hubbard County	E. Jct. US-71 - E. County Line	2908	2908-26	Mn-200
34	2HB12	D2: Hubbard County	N. County Line - E. County Line	2912	8822-12	US-2
35	2IC14	D2: Itasca County	W. County Line - N. County Line	3114	M95278	US-71
36	2KS08	D2: Kittson County	S. County Line – 0.24 Mi. N of S Limits of Hallock	3508	M95278	US-75
37	2KC10	D2: Koochiching County	S. County Line – 0.06 Mi. S. of N. Jct. Mn-1	3610	M95278	US-71
38	2KC11	D2: Koochiching County	0.06 Mi. S. of N. Jct. Mn-1 – Jct. Mn-6	3611	M96152	US-71
39	2KC11b	D2: Koochiching County	0.06 Mi. S. of N. Jct. Mn-1 – Jct. Mn-6	3611	M95278	US-71
40	2LW01	D2: Lake of the Woods County	W. County Line – E. Jct. Mn-72	3901	M4520	Mn-11
41	2LW01b	D2: Lake of the Woods County	W. County Line – E. Jct. Mn-72	3901	8822-12	Mn-11
42	2MS08	D2: Marshall County	E. County Line – N. County Line	4508	4508-26	Mn-89
43	2MS11	D2: Marshall County	S. County Line – E. Jct. Mn-1	4511	M95278	Mn-220
44	2NM08	D2: Norman County	Jct. Mn-200 – N. County Line	5408	5408-93214	Mn-9

45	2PK03	D2: Polk County	Jct. Mn-9 – Jct. Mn-32	6003	6003-28	US-2
46	2PK07	D2: Polk County	Jct. Mn-102 – N. County Line	6007	6007-11	Mn-32

Project Information - Crack Sealing Methods (Cont'd...)

S. No.	ID	District/County	Project Location	Control Section #	State Project #	Route
47	2PK12	D2: Polk County	S. County Line – Jct. US-2	6012	M4492	US-75
48	2PK17	D2: Polk County	W. Jct. US-2 – N. County Line	6017	6017-95278	Mn-220
49	2PK17b	D2: Polk County	W. Jct. US-2 – N. County Line	6017	6017-95278	Mn-220
50	2RL01	D2: Red Lake County	S. County Line – N. County Line	6301	6301-04521	Mn-32
51	3AT02	D3: Aitkin County	N. Jct. US-169 - N. Jct. Mn-47	102	8823-41	Mn-18
52	3CA04	D3: Cass County	W. Jct. 200 - W. Jct. County Line- E. County Line	1104	8823-84	Mn-6
53	3CA09	D3: Cass County	210 - Jct. Mn-210 - Jct. Mn-87	1109	8823-41	Mn-64
54	3CA10	D3: Cass County	371 - Jct. Mn-371 - Jct. Mn-87	1110	8823-41	Mn-84
55	3CA11	D3: Cass County	87 - Jct. Mn-87 - Jct. Mn-200	1111	8823-41	Mn-84
56	3CA14	D3: Cass County	N. Jct. 371 - N. Jct. Mn-84	1114	8823-53	Mn-87

57	3CA18	D3: Cass County	S. Jct. Mn-87 - S. Jct. Mn-200	1118	8823-84	Mn-371
58	3CR04	D3: Crow Wing County	County Line - S. County Line - E. County Line-E. County Line	1804	8823-53	US-169
59	3IT06	D3: Itasca County	S. County 3: Itasca County: S. County Line - S. County Line - E. US-2	3106	8823-84	Mn-6
60	3KA10	D3: Kandiyohi County	County L- N. County Line – E. County Line-3: Kandiyohi County: N. County Line – E. County Line	3410	8823-15	Mn-55
61	3MI14	D3: Mille Lacs County	County: N. Jct. 27 - N. Jct. County Line-27 – N. County Line	4814	8823-53	US-169
62	3SH02	D3: Sherburne County	W. Jct. - W. Jct. US-169	7102	8823-15	US-10

Project Information - Crack Sealing Methods (Cont'd…)

S. No.	ID	District/County	Project Location	Control Section #	State Project #	Route
63	3SH03	D3: Sherburne County	County Li- W. County Line – N. Limits Becker-3: Sherburne County: W. County Line – N. Limits Becker	7103	8823-15	US-10
64	3SH08	D3: Sherburne County	3: Sherburne County: S. County Li- S. County Line – Jct. US-10	7108	8823-15	Mn-24

65	3ST12	D3: Stearns County	W. County 3: Stearns County: W. County Lin-W. County Line – E. US-71	7312	8823-15	Mn-55
66	3ST13	D3: Stearns County	E. Jct. 71- E. Jct. County Line-71 – S. County Line	7313	8823-15	Mn-55
67	3ST14	D3: Stearns County	County Line- W. County Line – S. County Line-3: Stearns County: W. County Line – S. County Line	7314	8823-15	Mn-55
68	7LS04	D7: Le Sueur County	W. End of Br-40001 – Jct. Mn-13	4004	8827-21	Mn-19
69	7LS12	D7: Le Sueur County	S. County Line – S. Jct. US-169	4012	8827-37	Mn-22
70	7NC02	D7: Nicollet County	W. County Line – Jct. Mn-99	5202	8827-68	US-14
71	7WW04	D7: Watonwan County	S. Jct. Mn-60 – N. Jct. Mn-60	8304	8827-78	Mn-15

Project Information - Crack Sealing Methods (Cont'd...)

S. No.	ID	District/County	Project Location	Control Section #	State Project #	Route
72	7FA80a	D7: Faribault County	W. County Line - Jct. Mn-254	2280a	8827-37	I-90
73	7NC03	D7: Nicollet County	Jct. Mn-99 – N. County Line	5203	8827-68	US-14
74	7NO05	D7: Nobles County	S. State Line – N. Jct. US-59	5305	8827-85	Mn-60
75	7WW03	D7: Watonwan County	S. County Line – S. Jct. Mn-60	8303	8827-78	Mn-15
76	MAN08	Metro : Anoka County	Jct. US-10 - N. County Line	208	8825-336	Mn-65
77	MAN08b	Metro : Anoka County	Jct. US-10 - N. County Line	208	8825-103	Mn-65
78	MAN15	Metro : Anoka County	E. Jct. US-169, W. Jct. Mn-47 - E. Jct. Mn-47	215	8825-103	US-10
79	MAND 83	Metro : Anoka County	N. Jct. I-35E, I-35W - E. County Line	283	8825-102	I-35
80	MCV003	Metro : Carver County	W. County Line - E. County Line	1003	8825-103	Mn-7
81	MCH302	Metro : Chisago County	S. County Line - Jct. I-35	1302	8825-336	US-61
82	MHP733	Metro : Hennepin County	Jct. I-494 - Jct. CSAH-158	2733	8825-336	Mn-100
83	8CA03	D8: Carver County	W. County Line - E. County Line	1003	8825-103	Mn-7
84	8KA04	D8: Kandiyohi County	Jct. US-71 – E. County Line	3404	3404-54	US-12

APPENDIX G: CONSTRUCTION HISTORY OF CRACK SEALING METHODS

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
1	1AK06	1999	Bit. Surfacing (2350)	1.5	2001	Crack Sealing	16.216	2012	Bit. Overlay
2	1AK21	1993	Bit. Surfacing	Var.	1996	Bit. Crack Sealing	12.755	2011	Overlay
3	1CT05	1995	Bit. Overlay (2347)	1.5-3	2000	Rout and Seal (Spec 2332)	1.122	2001	Crack Sealing
4	1CT14	1991	Bit. Overlay (Spec 2341)	3	1997	Crack Repair	8.95	2001	Overlay
5	1CT0b	1990	Bit. Overlay (2361)	1	1994	Crack Repair	9.538	2002	Overlay
6	1CO01	2003	Bit. Overlay (Spec 2360)	2	2006	Crack Seal (Type 3725)	19.183	2012	Seal Coat (3723 & FA-2)
7	1CO02	2001	Bit. Overlay (Spec 2350)	Var.	2006	Crack Seal (Type 3725)	12.672	2014	Overlay
8	1CO04	2001	Bit. Overlay (Spec 2350)	Var.	2006	Crack Seal (Type 3725)	16.63	2008	Seal Coat
9	1KC06	2000	Bit. Overlay (Spec 2350)	Var.	2007	Crack Seal (Type 3725)	5.738	2015	Bit. Surfacing (Spec. 2360)

10	1KC08	2000	Bit. Overlay (Spec 2350)	Var.	2001	Crack Seal	17.996	2015	Overlay

Construction History of Crack Sealing Methods (Cont'd…)

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
11	IKC09	2000	Bit. Overlay (Spec 2350)	1.5	2001	Crack Seal	37.188	2008	Overlay
12	1KC12	1990	Bit. Overlay (Spec 2341)	1.5	1996	Crack Repair	19.129	2012	Overlay
13	1KC13	1990	Bit. Overlay (Spec 2341)	1.5	1996	Crack Repair	8.23	2012	Overlay
14	1LA01	1997	Bit. Overlay (Spec 2331)	1.5	2001	Crack Seal	3.052	2014	Overlay
15	1LA02	2000	Bit. Overlay (2350)	2.5	2001	Crack Seal	19.81	2007	Bit. Surfacing
16	1SL05	1970	Bit. Surfacing	1.5	2001	Crack Sealing	7.618	2014	Bit. Overlay

17	1SL06	1998	Bit. Overlay (2350, 2360)	Var.	2001	Crack Sealing	8.869	2014	Milling+Seal Coat
18	1SL07	1995	Bit. Overlay (2347)	3.5	2001	Crack Sealing	24.08	2009	Overlay
19	1SL08	1997	Bit. Overlay (2350)	3.5	2000	Crack Sealing	11.83	2001	Crack Sealing
20	1SL21	1986	Bit. Surfacing (2341)	1.5	1992	Bit. Crack Sealing	10.477	2001	Overlay

Construction History of Crack Sealing Methods (Cont'd…)

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
21	1SL22	2001	Bit. Overlay (2350)	3.5	2012	Crack Repair (3723)+Seal Coat	7.717	2015	Bit. Surfacing
22	1SL26	2002	Bit. Overlay	Var.	2007	Crack Seal (3725)	5.481	2010	Agg. Seal Coat (FA-2)
23	1SL27	2000	Bit. Reclaim (2350)	4	2007	Crack Seal (3725)	9.314	2013	Bit. Overlay (Spec. 2360)
24	1SL33	1999	Bit. Overlay (2350)	2	2000	Crack Sealing	1.09	2001	Crack Sealing

25	2BT08	1995	Bit. Overlay (2347)	1.5	2000	Rout and Seal	0.87	2009	Bit. Overlay (Spec. 2360)
26	2BT10	1992	Bit. Overlay (2341)	1.5	1995	Bit. Crack Repair	3.67	2003	Bit. Overlay
27	2BT11	1989	Bit Surfacing (2331, 2341)	3.5	1995	Bit. Crack Repair	7.564	2004	Bit Overlay (spec 2360)
28	2CA18	2003	Bit. Overlay (2360)	3	2006	Rout and Seal (spec. 3725)	7.271	2007	Agg. Seal Coat (FA-2)
29	2CW06	1995	Bit. Overlay (2341)	3	1998	Rout and Seal	5.139	2005	Bit. Seal Coat + Agg. Seal
30	2CW06b	1996	Bit. Overlay (2341)	1.5	1999	Crack Repair	9.889	2005	Bit. Seal Coat + Agg. Seal

Construction History of Crack Sealing Methods (Cont'd…)

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
31	2HB06	1986	Bit. Overlay (2341)	1.5	1993	Bit. Crack Repair	13.736	2002	Bit. Overlay (1st Half of Segment)
32	2HB06b	1986	Bit. Overlay (2341)	1.5	1993	Bit. Crack Repair	13.736	2008	Bit. Overlay (2nd Half of Segment)

33	2HB08	1990	Bit. Surfacing (2331)	3	1998	Crack Sealing	5.12	2008	Bit. Overlay
34	2HB12	1995	Bit. Surfacing (2331, 2347)	1.5	2000	Rout and Seal	1.25	2009	Bit. Overlay (Spec. 2360)
35	2IC14	1990	Bit. Overlay (2341)	1	1995	Crack Repair	5.129	2004	Bit. Overlay
36	2KS08	1993	Bit. Overlay (2341, upon Concrete)	3	1995	Crack Repair	14.373	2004	Bit. Seal Coat
37	2KC10	1989	Bit. Overlay (2341)	1.5	1995	Crack Repair	3.79	2006	Bit. Overlay
38	2KC11	1988	Bit. Surfacing (2331)	3.5	1995	Crack Repair	0.536	2005	Bit. Overlay
39	2KC11b	1989	Bit. Overlay (2341)	Var.	1995	Crack Repair	0.824	2006	Bit. Overlay
40	2LW01	1989	Bit. Overlay (2341)	1.5	1992	Crack Repair	9.238	1997	Bit. Overlay

Construction History of Crack Sealing Methods (Cont'd…)

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
41	2LW01b	1997	Bit. Overlay (Spec. 2341)	Var.	2000	Rout and Seal	10.36	2005	Bit. Seal Coat (F2)
42	2MS08	2003	Bit. Overlay (2350)	3	2006	Rout and Seal (Spec. 3725)	16.51	2009	Bit. Surfacing (Spec. 2360)
43	2MS11	1992	Bit. Overlay (2341)	1.5	1995	Crack Repair	1.516	2010	Bit. Overlay
44	2NM08	1991	Bit. Overlay (2341)	1.5	1993	Crack Repair	13.95	2002	Bit. Seal Coat
45	2PK03	2001	Bit. Overlay (2350,2360)	9	2004	Crack Repair	11.9	2010	Bit. Surfacing
46	2PK07	1996	Bit. Overlay (2341)	2	2001	Bit. Crack Sealing	14.5	2005	Bit. Seal Coat
47	2PK12	1989	Bit. Overlay (2341)	1.5	1991	Surface Repair	15.791	2002	Bit. Seal Coat
48	2PK17	1991	Bit. Overlay (2341)	1.5	1995	Bit. Crack Repair	3.84	2010	Bit. Overlay
49	2PK17b	1992	Bit. Surfacing (2331)	10.5	1995	Bit. Crack Repair	11.54	2010	Bit. Overlay
50	2RL01	1989	Bit. Overlay (2341)	1.5	1992	Crack Repair	7.494	2001	Bit. Seal Coat

Construction History of Crack Sealing Methods (Cont'd…)

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
51	3AT02	2000	Bit. Surfacing (2350)	3	2003	Rout and Seal (3725)	12.639	2005	Fog Seal (2355), Bit. Seal Coat (2356)
52	3CA04	1989	Bit. Overlay, 2331(2")+2341(1")	3	2006	Rout and Seal (3725)	10.795	2007	Agg. Seal (FA-2)
53	3CA09	2000	Bit Surfacing (2350)	1.5	2003	Rout and Seal (3725)	33.839	2005	Fog Seal (2355), Bit. Seal Coat (2356)
54	3CA10	1999	Bit. Overlay (2350)	2.5	2003	Rout and Seal (3725)	11.019	2006	Bit. Seal Coat (2356)
55	3CA11	1999	Bit. Overlay (2350)	2.5	2003	Rout and Seal (3725)	18.744	2006	Bit. Seal Coat (2356)

56	3CA14	2000	Bit. Overlay (2350)	3	2004	Rout and Seal (3725)	7.835	2006	Bit. Seal Coat (2356)
57	3CA18	2003	Bit. Overlay (2360)	3	2006	Rout and Seal (3725)	7.271	2007	Agg. Seal
58	3CR04	2001	Bit. Overlay (2350)	1.5	2004	Rout and Seal (3725)	5.463	2006	Bit. Seal Coat & Fog Seal (2356)
59	3IT06	2002	Bit. Overlay (2350)	Var.	2006	Rout and Seal (3725)	10.275	2007	Agg. Seal (FA-2)

Construction History of Crack Sealing Methods (Cont'd…)

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
60	3KA10	1997	Bit. Overlay	3	2000	Rout and Seal (3725)	6.18	2003	Seal Coat (FA-3)
61	3MI14	2001	Bit. Overlay (2350)	1.5	2004	Rout and Seal (3725)	13.6	2006	Fog Seal/Bit. Seal Coat
62	3SH02	2000	Bit. Overlay (2350)	2	2000	Rout and Seal (3725)	20.116	2003	Micro Surfacing
63	3SH03	1997	Bit. Overlay (2347)	4.5	2000	Rout and Seal (3725)	7.609	2002	Bit Seal Coat

64	3SH08	1997	Bit. Overlay (2347)	2-4"	2000	Rout and Seal (3725)	3.09	2003	Bit Seal Coat
65	3ST12	1997	Bit. Overlay	1.5	2000	Rout and Seal (3725)	8.283	2003	Agg. Seal FA-2
66	3ST13	1997	Bit. Overlay	1.5	2000	Rout and Seal (3725)	6.015	2003	Agg. Seal FA-2
67	3ST14	1997	Bit. Overlay	1.5	2000	Rout and Seal (3725)	2.725	2003	Bit Seal Coat
68	7LS04	2000	Bit. Overlay (2350)	3.5	2002	Rout&Seal	13.105	2013	Agg. Seal (T F2)
69	7LS12	2000	Bit. Overlay (2350)	3	2003	Rout&Seal	3.006	2013	Bit. Seal Coat
70	7NC02	2004	Bit. Overlay	4	2006	Rout&Seal	13.377	2013	Fog Seal

Construction History of Crack Sealing Methods (Cont'd…)

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
71	7WW04	2004	Bit. Overlay (2360)	4.5	2006	Rout&Seal (3725)	5.679	2012	Bit. Overlay (2360)
72	7FA80a	1999	Bit. Overlay (Spec. 2360)	5	2003	Rout and Seal	3.9	2006	Bit. Overlay (Spec. 2360)
73	7NC03	2005	Bit. Overlay (Spec. 2360)	2	2006	Rout and Seal	1.064	2012	Bit. Surfacing (Spec. 2360)
74	7NO05	2005	Bit. Overlay (Spec. 2360)	3	2007	Crack Seal (Spec. 3725)	8.44	2011	Bit. Surfacing (Spec. 2360)
75	7WW03	1998	Bit. Overlay (Spec. 2350)	Var.	2006	Rout and Seal (Spec. 3725)	1.033	2012	Bit. Overlay (Spec. 2360)
76	MAN08	2006	Bit surfacing and overlay (2360)	Varies	2009	Rout and Seal	9.867	2012	Milling and Bit. Surfacing
77	MAN08b	1999	Bit. overlay	1.5	2001	Rout and seal spec 3725	6.797	2007	Micro surfacing
78	MAN15	1997	Bit. overlay (2347)	Varies	2001	Rout and seal spec 3725	2.9	2009	Bit. Surfacing

Construction History of Crack Sealing Methods (Cont'd…)

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
79	MAND 83	1997	Bit. Surfacing (61WEA75100)	1.5	2001	Rout and seal, 3725	1.417	2009	Mill and overlay
80	MCV003	1998	Bit. overlay	varies	2001	Rout and seal,3725	5.8	2008	Bit. Surfacing
81	MCH302	2004	Bit. Overlay (spec 2360)	3	2009	Rout and Seal	3.25	2012	Bit. Surfacing
82	MHP733	2000	Bit. Overlay (2350)	3	2009	Rout and Seal	3.776	2015	Mill and Overlay spec 2360
83	8CA03	1998	Bit. Overlay (LV3, LV4)	Var.	2001	Rout and Seal (Spec. 3725)	5.43	2008	Bit. Overlay (Spec. 2360)
84	8KA04	2005	Bit. Overlay (Spec. 2360)	3	2007	Rout and Seal (Spec. 3725)	11.941	2016	Bit. Surfacing (Spec. 2360)

APPENDIX H: PROJECT INFORMATION: FINAL ROUT-AND-SEAL PROJECTS

S. No.	ID	District/County	Project Location	Control Section #	State Project #	Route
1	1CO01	D1: Cook County	W. County Line - Jct. Cr-35	1601	8821-142	Mn-61
2	1CO02	D1: Cook County	Jct. Cr-35 - E. Lim. Grand Marais	1602	8821-142	Mn-61
3	1KC06	D1: Koochiching County	E. Jct. US-71 – E. Shore Dove Island	3606	8821-71	Mn-11
4	1SL26	D1: Saint Louis County	N. Limits Duluth – E. County Line	6926	8821-71	Mn-61
5	1SL27	D1: Saint Louis County	S. County Line – E. Jct. US-2	6927	8821-71	Mn-73
6	2BT08	D2: Beltrami County	S. Jct. US-71 - S. County Line	408	8822-12	US-2
7	2HB12	D2: Hubbard County	N. County Line - E. County Line	2912	8822-12	US-2
8	2LW01b	D2: Lake of the Woods County	W. County Line – E. Jct. Mn-72	3901	8822-12	Mn-11
9	2MS08	D2: Marshall County	E. County Line – N. County Line	4508	4508-26	Mn-89
10	7LS04	D7: Le Sueur County	W. End of Br-40001 – Jct. Mn-13	4004	8827-21	Mn-19
11	7LS12	D7: Le Sueur County	S. County Line – S. Jct. US-169	4012	8827-37	Mn-22
12	7NC02	D7: Nicollet County	W. County Line – Jct. Mn-99	5202	8827-68	US-14
13	7WW04	D7: Watonwan County	S. Jct. Mn-60 – N. Jct. Mn-60	8304	8827-78	Mn-15
14	MAN08	Metro: Anoka County	Jct. US-10 - N. County Line	208	8825-336	Mn-65
15	MAN08b	Metro: Anoka County	Jct. US-10 - N. County Line	208	8825-103	Mn-65

16	MAN15	Metro: Anoka County	E. Jct. US-169, W. Jct. Mn-47 - E. Jct. Mn-47	215	8825-103	US-10
17	MAND 83	Metro: Anoka County	N. Jct. I-35E, I-35W - E. County Line	283	8825-102	I-35
18	MCV003	Metro: Carver County	W. County Line - E. County Line	1003	8825-103	Mn-7

Project Information: Final Rout-and-seal Projects (Cont'd…)

S. No.	ID	District/County	Project Location	Control Section #	State Project #	Route
19	MCH302	Metro: Chisago County	S. County Line - Jct. I-35	1302	8825-336	US-61
20	MHP733	Metro: Hennepin County	Jct. I-494 - Jct. CSAH-158	2733	8825-336	Mn-100
21	MAND 83	Metro: Anoka County	N. Jct. I-35E, I-35W - E. County Line	283	8825-102	I-35
22	MCV003	Metro: Carver County	W. County Line - E. County Line	1003	8825-103	Mn-7
23	MCH302	Metro: Chisago County	S. County Line - Jct. I-35	1302	8825-336	US-61
24	MHP733	Metro: Hennepin County	Jct. I-494 - Jct. CSAH-158	2733	8825-336	Mn-100
25	8CA03	D8: Carver County	W. County Line - E. County Line	1003	8825-103	Mn-7
26	8KA04	D8: Kandiyohi County	Jct. US-71 – E. County Line	3404	3404-54	US-12

APPENDIX I: CONSTRUCTION HISTORY OF CRACK SEALING METHODS: FINAL ROUT-AND-SEAL PROJECTS

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
1	1CO01	2003	Bit. Overlay (Spec. 2360)	2	2006	Crack Seal (Type 3725)	19.183	2012	Seal Coat (3723 & FA-2)
2	1CO02	2001	Bit. Overlay (Spec. 2350)	Var.	2006	Crack Seal (Type 3725)	12.672	2014	Bit. Overlay (Spec. 2360)
3	1KC06	2000	Bit. Overlay (Spec. 2350)	Var.	2007	Crack Seal (Type 3725)	5.738	2015	Bit. Surfacing (Spec. 2360)
4	1SL26	2002	Bit. Overlay	Var.	2007	Crack Seal (Type 3725)	5.481	2010	Agg. Seal Coat (FA-2)
5	1SL27	2000	Bit. Reclaim (Spec. 2350)	4	2007	Crack Seal (Type 3725)	9.314	2013	Bit. Overlay (Spec. 2360)
6	2BT08	1995	Bit. Overlay (Spec. 2347)	1.5	2000	Rout and Seal	0.87	2009	Bit. Overlay (Spec. 2360)
7	2HB12	1995	Bit. Surfacing (2331, 2347)	1.5	2000	Rout and Seal	1.25	2009	Bit. Overlay (Spec. 2360)
8	2LW01b	1997	Bit. Overlay (Spec. 2341)	Var.	2000	Rout and Seal	10.36	2005	Bit. Seal Coat (F2)
9	2MS08	2003	Bit. Overlay (Spec. 2350)	3	2006	Rout and Seal (Spec. 3725)	16.51	2009	Bit. Surfacing (Spec. 2360)

10	7LS04	2000	Bit. Overlay (2350)	3.5	2002	Rout and Seal	13.105	2013	Agg. Seal (T F2)
11	7LS12	2000	Bit. Overlay (2350)	3	2003	Rout and Seal	3.006	2013	Bit. Seal Coat
12	7NC02	2004	Bit. Overlay	4	2006	Rout and Seal	13.377	2013	Fog Seal

Construction History of Crack Sealing Methods: Final Rout-and-seal Projects (Cont'd…)

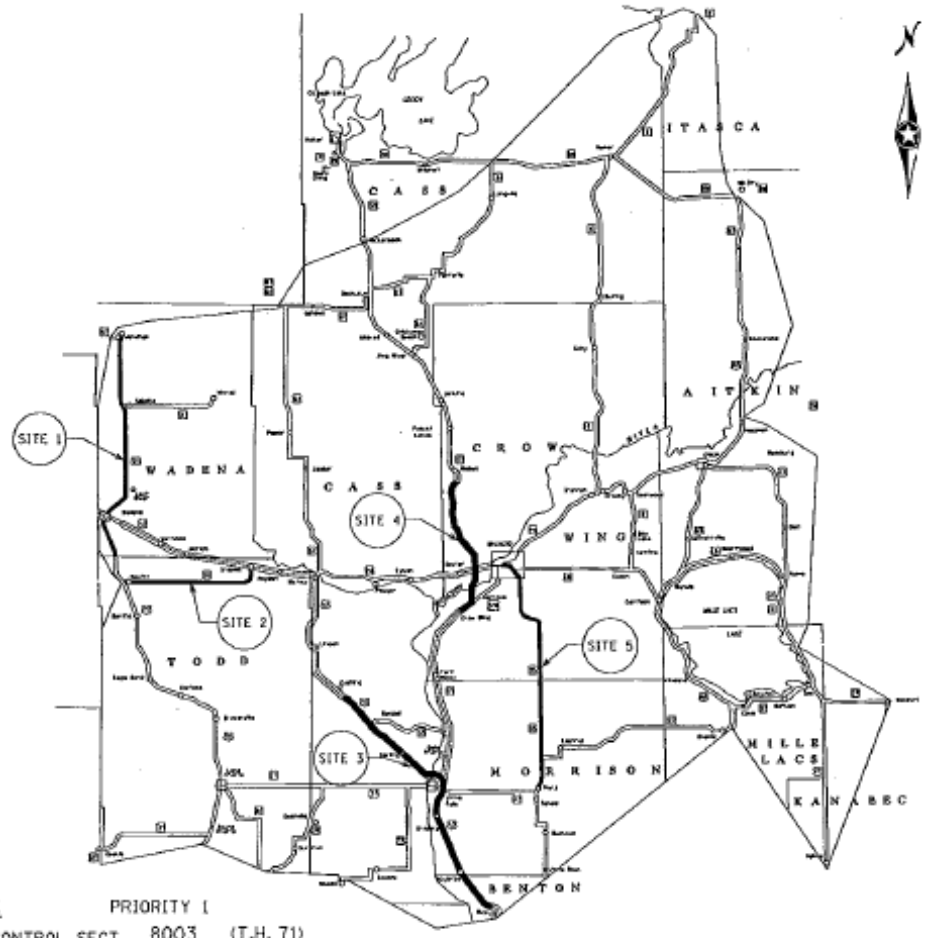
S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
13	7WW04	2004	Bit. Overlay (2360)	4.5	2006	Rout and Seal (3725)	5.679	2012	Bit. Overlay (2360)
14	MAN08	2006	Bit. surfacing and overlay (2360)	Varies	2009	Rout and Seal	9.867	2012	Milling and Bit. Surfacing
15	MAN08b	1999	Bit. overlay	1.5	2001	Rout and seal spec 3725	6.797	2007	Micro surfacing
16	MAN15	1997	Bit. overlay (2347)	Varies	2001	Rout and seal spec 3725	2.9	2009	Bit. Surfacing
17	MAND 83	1997	Bit. Surfacing (61WEA75100)	1.5	2001	Rout and seal, 3725	1.417	2009	Mill and overlay

18	MCV003	1998	Bit. overlay	varies	2001	Rout and seal,3725	5.8	2008	Bit. Surfacing
19	MCH302	2004	Bit. Overlay (spec 2360)	3	2009	Rout and Seal	3.25	2012	Bit. Surfacing
20	MHP733	2000	Bit. Overlay (2350)	3	2009	Rout and Seal	3.776	2015	Mill and Overlay spec 2360

Construction History of Crack Sealing Methods: Final Rout-and-seal Projects (Cont'd…)

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description
21	MAND 83	1997	Bit. Surfacing (61WEA75100)	1.5	2001	Rout and seal, 3725	1.417	2009	Mill and overlay
22	MCV003	1998	Bit. overlay	varies	2001	Rout and seal,3725	5.8	2008	Bit. Surfacing
23	MCH302	2004	Bit. Overlay (spec 2360)	3	2009	Rout and Seal	3.25	2012	Bit. Surfacing
24	MHP733	2000	Bit. Overlay (2350)	3	2009	Rout and Seal	3.776	2015	Mill and Overlay spec 2360
25	8CA03	1998	Bit. Overlay (LV3, LV4)	Var.	2001	Rout and Seal (Spec. 3725)	5.43	2008	Bit. Overlay (Spec. 2360)
26	8KA04	2005	Bit. Overlay (Spec. 2360)	3	2007	Rout and Seal (Spec. 3725)	11.941	2016	Bit. Surfacing (Spec. 2360)

APPENDIX J: SAMPLE WORK-PLAN SHOWING CLEAN-AND-SEAL PROJECT SITES



SITE 1 PRIORITY 1

CONTROL SECT. 8003 (T.H. 71)
GROSS LENGTH....24103.20 FEET..4.565 MILES
BRIDGES-LENGTH.....FEET.....MILES
EXCEPTIONS-LENGTH.....FEET.....MILES
NET LENGTH.....24103.20 FEET..4.565 MILES
REF. POINT..219+00.639..TO REF. POINT.224+00.200

CONTROL SECT. 8004/8005 (T.H. 71)
GROSS LENGTH....118995.36 FEET. 22.537 MILES
BRIDGES-LENGTH.....264.00 FEET..0.050 MILES
EXCEPTIONS-LENGTH.....FEET.....MILES
NET LENGTH.....118731.36 FEET. 22.487 MILES
REF. POINT..225+00.069..TO REF. POINT.247+00.605

SITE NET LENGTH. 142834.56 FEET. 27.052 MILES

SITE 2 PRIORITY 2

CONTROL SECT. 7701 (T.H. 210)
GROSS LENGTH....84241.68 FEET. 15.956 MILES
BRIDGES-LENGTH.....126.72 FEET..0.024 MILES
EXCEPTIONS-LENGTH.....FEET.....MILES
NET LENGTH.....84120.96 FEET. 15.932 MILES
REF. POINT..77+00.512..TO REF. POINT.93+00.468

SITE 3 PRIORITY 3

T.H. 10
CONTROL SECT. 4901/4902/4903/0502
GROSS LENGTH....171077.28 FEET. 32.401 MILES
BRIDGES-LENGTH....2249.28 FEET..0.426 MILES
EXCEPTIONS-LENGTH.....FEET.....MILES
NET LENGTH.....168828.00 FEET. 31.975 MILES
REF. POINT..131+00.198..TO REF. POINT.162+00.061

SITE 4 PRIORITY 4

CONTROL SECT. 1809/1810 (T.H. 371)
GROSS LENGTH....96148.80 FEET. 18.210 MILES
BRIDGES-LENGTH.....528.00 FEET..0.100 MILES
EXCEPTIONS-LENGTH.....FEET.....MILES
NET LENGTH.....95620.80 FEET. 18.110 MILES
REF. POINT..22+00.737..TO REF. POINT.44+00.752

SITE 5 PRIORITY 5

CONTROL SECT. 4911/1808 (T.H. 25)
GROSS LENGTH....146192.64 FEET. 27.688 MILES
BRIDGES-LENGTH.....211.20 FEET..0.040 MILES
EXCEPTIONS-LENGTH.....FEET.....MILES
NET LENGTH.....145981.44 FEET. 27.648 MILES
REF. POINT..129+00.420..TO REF. POINT.157+00.108

GENERAL LAYOUT
CERTIFIED BY Darren Hess LIC. NO. 44261
LICENSED PROFESSIONAL ENGINEER

STATE PROJ. NO. 8823-273 SHEET NO. 2 OF 5 SHEETS

APPENDIX K: PROJECT INFORMATION: FINAL CLEAN-AND-SEAL PROJECTS

S. No.	ID	District/County	Project Location	Control Section #	State Project #	Route
1	1SL32	D1: Saint Louis County	Jct. T.H. 2 - W. Jct. T.H. 53	6932	8821-221	Mn-194
2	3CW09	D3: Crow Wing County	S. County Line - Jct. Mn-210	1809	8823-273	Mn-371
3	3CW10	D3: Crow Wing County	W. Jct. Mn-210 - W. County Line	1810	8823-273	Mn-371
4	3MR01	D3: Morrison County	S. County Line – Jct. Mn-371	4901	8823-273	US-10
5	3MR02	D3: Morrison County	Jct.Mn-371 – Jct. Mn-115	4902	8823-273	US-10
6	3MR03	D3: Morrison County	Jct. Mn-115 – W. County Line	4903	8823-273	US-10
7	3TD01	D3: Todd County	W. County Line – Jct. US-10	7701	8823-273	Mn-210
8	3WD03	D3: Wadena County	S. County Line – Jct. US-10	8003	8823-273	US-71
9	3WD04	D3: Wadena County	Jct. US-10 – Jct. Mn-227	8004	8823-273	US-71
10	3WD05	D3: Wadena County	Jct. Mn-227 – N. County Line	8005	8823-273	US-71
11	6DD01	D6: Dodge County	Steele/Dodge Co. Line - Jct TH 56 in Dodge C.	2001	2001-33	US-14
12	6HS01	D6: Houston County	Fillmore/Houston Co.in - Jct. USTH-61	2801	2801-86	Mn-16

APPENDIX L: CONSTRUCTION HISTORY OF CRACK SEALING METHODS: FINAL CLEAN-AND-SEAL PROJECTS

S. No.	ID	Pavement Surface Layer			Crack Sealing			Follow-up Treatment	
		Year Paved	Description	Thickness (Inch)	Year Treated	Description	Length (miles)	Year Treated	Description*
1	1SL32	2007	Bit. Overlay (2360)	4	2012	Crack Repair Spl. 1 (Spec. 3723)	7.601	2018	-
2	3CW09	2003	Bit. Surfacing (2360)	6.5	2013	Clean and Seal (Spec. 3723)	9.626	2018	-
3	3CW10	2011	Bit. Surfacing (2360)	3	2013	Clean and Seal (Spec. 3723)	13.8	2018	-
4	3MR01	2011	Bit. Overlay (2360)	3	2013	Clean and Seal (Spec. 3723)	4.313	2018	-
5	3MR02	2011	Bit. Overlay (2360)	Var.	2013	Clean and Seal (Spec. 3723)	2.531	2018	-
6	3MR03	2004	Bit. Surfacing (2360)	2.1	2013	Clean and Seal (Spec. 3723)	6.175	2018	-
7	3TD01	2009	Bit. Overlay (2360)	2.5	2013	Clean and Seal (Spec. 3723)	15.932	2018	-
8	3WD03	2006	Bit. Surfacing (2360)	1.75	2013	Clean and Seal (Spec. 3723)	4.565	2018	-
9	3WD04	2006	Bit. Surfacing (2360)	1.75	2013	Clean and Seal (Spec. 3723)	13.287	2018	-

10	3WD05	2007	Bit. Surfacing (2360)	3	2013	Clean and Seal (Spec. 3723)	9.137	2018	
11	6DD01	2006	Bit. Overlay (Spec 2360)	1.5	2007	Crack Treatment (Clean and Seal)	6.42	2018	-
12	6HS01	2003	Bit. Overlay (2360)	1.5	2008	Crack Seal (Type 3723)	1.31	2018	-

* No follow-up treatment was recorded in the construction log website of MnDOT, and the Pavement Quality Index (PQI) of these sections were found to be in good condition according to 2016 Pavement management data of MnDOT

APPENDIX M: TRAFFIC (AADT) FOR CRACK SEALING PROJECT LOCATIONS

S. No.	ID	Traffic (AADT)								
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Avg.
1	1AK06		1300	1350	1400	1250	1300	1250		1308
2	1AK21	6200	6200	6300	6700	6400	5400			6200
3	1CT05	6300								6300
4	1CT14	3550								3550
5	1CT0b	17000								17000
6	1CO01				3050	3000	3250	3700		3250
7	1CO02				4600	4800	4700	4600	4900	4720
8	1CO04									-
9	1KC06					5000	4900	4700	4600	4800
10	1KC08									-
11	IKC09		220	240	240	265				241
12	1KC12									-
13	1KC13									-
14	1LA01									-
15	1LA02		470	450	420					447

16	1SL05									-
17	1SL06									-
18	1SL07		4000	4300	4650	4650	4400			4400
19	1SL08									-
20	1SL21									-
21	1SL22							1700	1700	1700
22	1SL26							10500	10100	10300
23	1SL27				1600	1550	1400	1250		1450
24	1SL33									-

Traffic (AADT) for Crack Sealing Project Locations (Cont'd…)

S. No.	ID	Traffic (AADT)								
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Avg.
25	2BT08	8400	10300	10300	9900	9550	9550	9000	9000	9500
26	2BT10	6100	6100	6100	6100	6100	6650	7900	7900	6619
27	2BT11	1100	1100	1100	1100	1100	1100	1150	1200	1119
28	2CA18	5200	5200							5200

29	2CW06	840	840	990		1150	1150	770		957
30	2CW06b	1250	1450	1550	1550	1300	1400	1400	1350	1406
31	2HB06									1700
32	2HB06b									2800
33	2HB08									2250
34	2HB12	6200	6200	4000		7200	7200	7300	7400	6500
35	2IC14									1100
36	2KS08									1050
37	2KC10									1000
38	2KC11									800
39	2KC11b									800
40	2LW01									2200
41	2LW01b	2200		1650		1650				1833
42	2MS08	520		560						540
43	2MS11									960
44	2NM08									1150
45	2PK03	3300	3300	3200		3000				3200

Traffic (AADT) for Crack Sealing Project Locations (Cont'd…)

S. No.	ID	Traffic (AADT)								
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Avg.
46	2PK07	900	770		820	820				828
47	2PK12									1200
48	2PK17									3300
49	2PK17b									1900
50	2RL01									1450
District 3 Traffic was not extracted as all of the projects were seal coated within 1-2 years										
68	7LS04	3050	3050	2900	3000	3000	3500	3500	3200	3150
69	7LS12		8100	10200	8100	8100	8600	8300	8700	8586
70	7NC02				6700	6700	7100	6800	6800	6820
71	7WW04					6900	7200	8600	9000	7925
72	7FA80a	7,700	8,200	8,200						8,033
73	7NC03	18,100	18,100	15,300	12,800	13,200	13,700	13,700		14,986

74	7NO05	4,650	4,300	4,000	4,200	4,300				4,290
75	7WW03	8,400	8,400	8,500	8,600	8,700	8,400	8,200		8,457
76	MAN08	30,700	30,900	30,900	30,000					30,625
77	MAN08b	47,000	47,000	49,000	49,000	49,000	49,000			48,333
78	MAN15	90,000	90,000	93,000	93,000	93,000	93,000	86,000	86,000	90,500

Traffic (AADT) for Crack Sealing Project Locations (Cont'd…)

S. No.	ID	Traffic (AADT)								
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Avg.
79	MAN83	75,000	75,000	83,000	83,000	86,000	86,000	79,000	79,000	80,750
80	MCV03	9,000	9,000	9,500	9,500	10,600	10,600	10,100		9,757

81	MCH02	8,300	10,700	10,700	10,700					10,100
82	MHP33	85,200	85,200	85,200	83,400	81,800	91,000	79,750		84,507
83	8CA03	9,000	9,000	9,000	9,500	9,500	10,500	10,500	10,100	9,638
84	8KA04	6,200	6,200	6,100	5,900	5,900	6,000	6,000	5,900	6,043

APPENDIX N: TRAFFIC (AADT) FOR FINAL ROUT-AND-SEAL SECTIONS

S. No.	ID	Traffic (AADT)								
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Avg.
1	1CO01	3,050	3,000	3,250	3,700					3,250
2	1CO02	4,600	4,800	4,700	4,600	4,900				4,720
3	1KC06	5,000	4,900	4,700	4,600					4,800
4	1SL26	10,500	10,100							10,300
5	1SL27	1,600	1,550	1,400	1,250					1,450
6	2BT08	8,400	10,300	10,300	9,900	9,550	9,550	9,000	9,000	9,500
7	2HB12	6,200	6,200	4,000	7,200	7,200	7,300	7,400		6,500
8	2LW01b	2,200	1,650	1,650						1,833
9	2MS08	520	560							540
10	7LS04	3,050	3,050	2,900	3,000	3,000	3,500	3,500	3,200	3,150
11	7LS12		8,100	10,200	8,100	8,100	8,600	8,300	8,700	8,586
12	7NC02				6,700	6,700	7,100	6,800	6,800	6,820
13	7WW04					6,900	7,200	8,600	9,000	7,925
14	MAN08	30,700	30,900	30,900	30,000					30,625
15	MAN08b	47,000	47,000	49,000	49,000	49,000	49,000			48,333

16	MAN15	90,000	90,000	93,000	93,000	93,000	93,000	86,000	86,000	90,500
17	MAN83	75,000	75,000	83,000	83,000	86,000	86,000	79,000	79,000	80,750
18	MCV03	9,000	9,000	9,500	9,500	10,600	10,600	10,100		9,757
19	MCH02	8,300	10,700	10,700	10,700					10,100
20	MHP33	85,200	85,200	85,200	83,400	81,800	91,000	79,750		84,507

Traffic (AADT) for Final Rout-and-seal Sections (Cont'd…)

S. No.	ID	Traffic (AADT)								
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Avg.
21	MAN83	75,000	75,000	83,000	83,000	86,000	86,000	79,000	79,000	80,750
22	MCV03	9,000	9,000	9,500	9,500	10,600	10,600	10,100		9,757
23	MCH02	8,300	10,700	10,700	10,700					10,100
24	MHP33	85,200	85,200	85,200	83,400	81,800	91,000	79,750		84,507
25	8CA03	9,000	9,000	9,000	9,500	9,500	10,500	10,500	10,100	9,638
26	8KA04	6,200	6,200	6,100	5,900	5,900	6,000	6,000	5,900	6,043

APPENDIX O: TRAFFIC (AADT) FOR FINAL CLEAN-AND-SEAL SECTIONS

S. No.	ID	Traffic (AADT)								
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Avg.
1	1SL32	24,770	22,300							23,535
2	3CW09	11,600	12,300							11,950
3	3CW10	12,200	12,700							12,450
4	3MR01	21,200	22,100							21,650
5	3MR02	8,900	8,600							8,750
6	3MR03	6,400	6,900							6,650
7	3TD01	820	830							825
8	3WD03	5,000	5,300							5,150
9	3WD04	3,200	3,400							3,300
10	3WD05	4,100	4,300							4,200
11	6DD01	7,900	7,500	7,800	7,800					7,750
12	6HS01	7,600	7,900	7,900	8,000	8,100				7,900

APPENDIX P: SUMMARY OF DATA FOR PERFORMANCE EFFECTIVENESS ANALYSIS: ROUT-AND-SEAL SECTIONS

S. No.	ID	Route	Pavement Surface Layer			Year Crack Sealed	Follow-up Treatment		Service Life of Crack Sealing (Years)	Pavement Age @ Crack Sealing (Years)	Traffic (AADT)
			Year Paved	Description	Thickness (Inch)		Year Treated	Description			
1	1CO01	Mn-61	2003	Bit. Overlay (Spec. 2360)	2	2006	2012	Seal Coat (3723&FA-2)	6	3	3,250
2	1CO02	Mn-61	2001	Bit. Overlay (Spec. 2350)	Var.	2006	2014	Bit. Overlay (Spec. 2360)	8	5	4,720
3	1KC06	Mn-11	2000	Bit. Overlay (Spec. 2350)	Var.	2007	2015	Bit. Surfacing (Spec. 2360)	8	7	4,800
4	1SL26	Mn-61	2002	Bit. Overlay	Var.	2007	2010	Agg. Seal Coat (FA-2)	3	5	10,300
5	1SL27	Mn-73	2000	Bit. Reclaim (Spec. 2350)	4	2007	2013	Bit. Overlay (Spec. 2360)	6	7	1,450
6	2BT08	US-2	1995	Bit. Overlay (Spec. 2347)	1.5	2000	2009	Bit. Overlay (Spec. 2360)	9	5	9,500
7	2HB12	US-2	1995	Bit. Surfacing (2331, 2347)	1.5	2000	2009	Bit. Overlay (Spec. 2360)	9	5	6,500
8	2LW01b	Mn-11	1997	Bit. Overlay (Spec. 2341)	Var.	2000	2005	Bit. Seal Coat (F2)	5	3	1,833

Summary of Data for Performance Effectiveness Analysis: Rout-and-seal Sections (Cont'd…)

S. No.	ID	Route	Pavement Surface Layer			Year Crack Sealed	Follow-up Treatment		Service Life of Crack Sealing (Years)	Pavement Age @ Crack Sealing (Years)	Traffic (AADT)
			Year Paved	Description	Thickness (Inch)		Year Treated	Description			
9	2MS08	Mn-89	2003	Bit. Overlay (2350)	3	2006	2009	Bit. Surfacing (Spec. 2360)	3	3	540
10	7LS04	Mn-19	2000	Bit. Overlay (2350)	3.5	2002	2013	Agg. Seal (T F2)	11	2	3,150
11	7LS12	Mn-22	2000	Bit. Overlay (2350)	3	2003	2013	Bit. Seal Coat	10	3	8,586
12	7NC02	US-14	2004	Bit. Overlay	4	2006	2013	Fog Seal	7	2	6,820
13	7WW04	Mn-15	2004	Bit. Overlay (2360)	4.5	2006	2012	Bit. Overlay (2360)	6	2	7,925
14	MAN08	Mn-65	2006	Bit surfacing and overlay (2360)	Varies	2009	2012	Milling and Bit. Surfacing	3	3	30,625
15	MAN08b	Mn-65	1999	Bit. overlay	1.5	2001	2007	Micro surfacing	6	2	48,333
16	MAN15	US-10	1997	Bit. overlay (2347)	Varies	2001	2009	Bit. Surfacing	8	4	90,500

Summary of Data for Performance Effectiveness Analysis: Rout-and-seal Sections (Cont'd…)

S. No.	ID	Route	Pavement Surface Layer			Year Crack Sealed	Follow-up Treatment		Service Life of Crack Sealing (Years)	Pavement Age @ Crack Sealing (Years)	Traffic (AADT)
			Year Paved	Description	Thickness (Inch)		Year Treated	Description			
17	MAND 83	I-35	1997	Bit. Surfacing (61WEA75100)	1.5	2001	2009	Mill and overlay	8	4	80,750
18	MCV003	Mn-7	1998	Bit. overlay	varies	2001	2008	Bit. Surfacing	7	3	9,757
19	MCH302	US-61	2004	Bit. Overlay (spec 2360)	3	2009	2012	Bit. Surfacing	3	5	10,100
20	MHP733	Mn-100	2000	Bit. Overlay (2350)	3	2009	2015	Mill and Overlay spec 2360	6	9	84,507
21	MAND 83	I-35	1997	Bit. Surfacing (61WEA75100)	1.5	2001	2009	Mill and overlay	8	4	80,750

Summary of Data for Performance Effectiveness Analysis: Rout-and-seal Sections (Cont'd…)

S. No.	ID	Route	Pavement Surface Layer			Year Crack Sealed	Follow-up Treatment		Service Life of Crack Sealing (Years)	Pavement Age @ Crack Sealing (Years)	Traffic (AADT)
			Year Paved	Description	Thickness (Inch)		Year Treated	Description			
22	MCV003	Mn-7	1998	Bit. overlay	varies	2001	2008	Bit. Surfacing	22	MCV003	Mn-7
23	MCH302	US-61	2004	Bit. Overlay (spec 2360)	3	2009	2012	Bit. Surfacing	23	MCH302	US-61
24	MHP733	Mn-100	2000	Bit. Overlay (2350)	3	2009	2015	Mill and Overlay spec 2360	24	MHP733	Mn-100
25	8CA03	Mn-7	1998	Bit. Overlay (LV3, LV4)	Var.	2001	2008	Bit. Overlay (Spec. 2360)	25	8CA03	Mn-7
26	8KA04	US-12	2005	Bit. Overlay (Spec. 2360)	3	2007	2016	Bit. Surfacing (Spec. 2360)	26	8KA04	US-12

APPENDIX Q: SUMMARY OF DATA FOR PERFORMANCE EFFECTIVENESS ANALYSIS: CLEAN-AND-SEAL SECTIONS

S. No.	ID	Route	Pavement Surface Layer			Year Crack Sealed	Follow-up Treatment		Service Life of Crack Sealing (Years)	Pavement Age @ Crack Sealing (Years)	Traffic (AADT)
			Year Paved	Description	Thickness (Inch)		Year Treated	Description			
1	1SL32	Mn-194	2007	Bit. Overlay (2360)	4	2012	2018	-	6	5	23,535
2	3CW09	Mn-371	2003	Bit. Surfacing (2360)	6.5	2013	2018	-	5	10	11,950
3	3CW10	Mn-371	2011	Bit. Surfacing (2360)	3	2013	2018	-	5	2	12,450
4	3MR01	US-10	2011	Bit. Overlay (2360)	3	2013	2018	-	5	2	21,650
5	3MR02	US-10	2011	Bit. Overlay (2360)	Var.	2013	2018	-	5	2	8,750
6	3MR03	US-10	2004	Bit. Surfacing (2360)	2.1	2013	2018	-	5	9	6,650
7	3TD01	Mn-210	2009	Bit. Overlay (2360)	2.5	2013	2018	-	5	4	825
8	3WD03	US-71	2006	Bit. Surfacing (2360)	1.75	2013	2018	-	5	7	5,150

Summary of Data for Performance Effectiveness Analysis: Clean-and-seal Sections (Cont'd…)

S. No.	ID	Route	Pavement Surface Layer			Year Crack Sealed	Follow-up Treatment		Service Life of Crack Sealing (Years)	Pavement Age @ Crack Sealing (Years)	Traffic (AADT)
			Year Paved	Description	Thickness (Inch)		Year Treated	Description			
9	3WD04	US-71	2006	Bit. Surfacing (2360)	1.75	2013	2018	-	5	7	3,300
10	3WD05	US-71	2007	Bit. Surfacing (2360)	3	2013	2018		5	6	4,200
11	6DD01	US-14	2006	Bit. Overlay (Spec 2360)	1.5	2007	2018	-	11	1	7,750
12	6HS01	Mn-16	2003	Bit. Overlay (2360)	1.5	2008	2018	-	10	5	7,900
Average									**6.0**	**5.0**	**9509**

APPENDIX R: DATA COLLECTION FORM FOR SEAL PERFORMANCE

Site ___

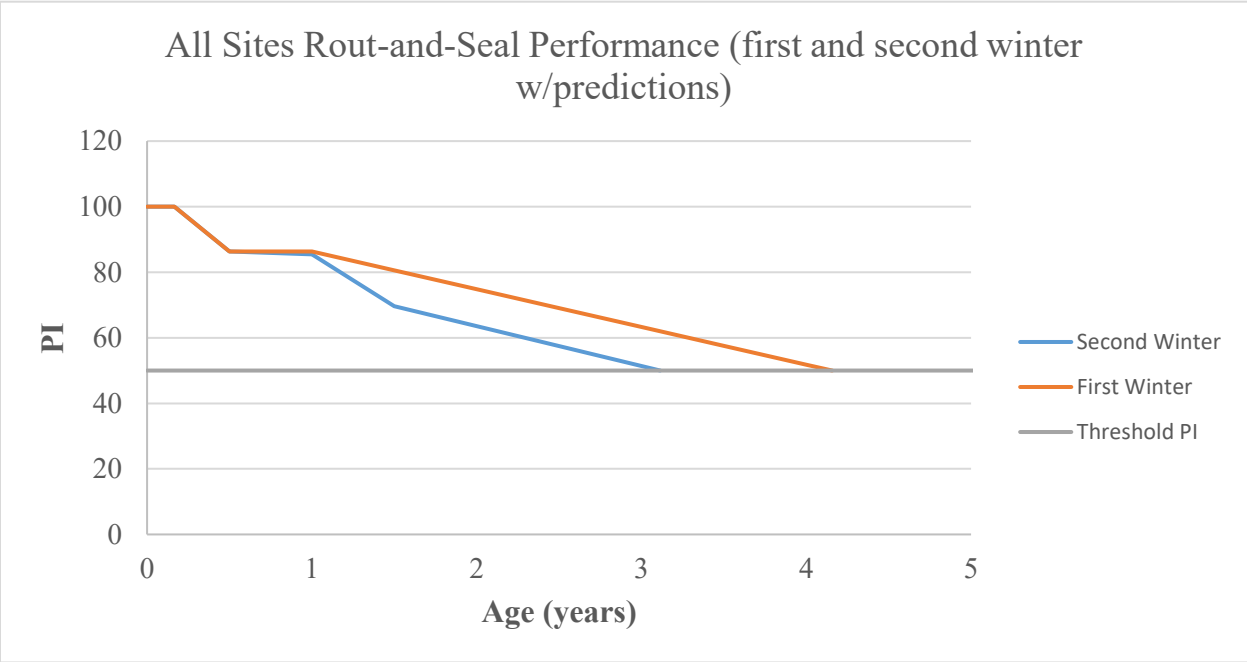
Location	Site ID	__-1	__-2	__-3	__-4	__-5
	Roadway					
	GPS Coordinates					
	Address or mile #					
	Lane					
	Crack Length					
Time	Date	__/__/2018	__/__/2018	__/__/2018	__/__/2018	__/__/2018
	Time					
Weather	Temperature					
	Rain or Damp Pavement	Yes___ No___	Yes___ No___	Yes___ No___	Yes___ No___	Yes___ No___
Seal Performance	Overband Wear (length)					
	Wheelpath flushing (yes/no)					
	Pullout Failure (length)					
	Full-Depth Adhesion Failure (length)					
	Partial-Depth Adhesion Failure (length)					
	Cohesion Loss (length)					
	Spalling (length)					
	Heaving (mm,in)					

APPENDIX S: DATA COLLECTION FORM FOR SEAL INSTALLATION

Site ___

Location	Site ID	___-1	___-2	___-3	___-4	___-5
	Roadway					
	GPS Coordinates					
	RP					
	Lane	NB__ SB__	NB__ SB__	NB__ SB__	NB__ SB__	NB__ SB__
Time	Date	__/__/2017	__/__/2017	__/__/2017	__/__/2017	__/__/2017
	Time					
Weather	Temperature					
	Rain or Damp Pavement	Yes___ No___	Yes___ No___	Yes___ No___	Yes___ No___	Yes___ No___
Crack Characteristics	Distress (thermal, fatigue, reflective…)					
	Location (lane (joint, wheelpath.)					
	Direction	Transverse____ Longitudinal___ Diagonal____	Transverse____ Longitudinal___ Diagonal____	Transverse____ Longitudinal___ Diagonal____	Transverse____ Longitudinal___ Diagonal____	Transverse____ Longitudinal___ Diagonal____
	Crack Severity	L, M, H	L, M, H	L, M, H	L, M, H	L, M, H
	Edge Deterioration	L,M,H	L,M,H	L,M,H	L,M,H	L,M,H
	Crack Length					
	Crack Width (mm)	1____ 2____ 3____ 4____ Avg._____	1____ 2____ 3____ 4____ Avg._____	1____ 2____ 3____ 4____ Avg._____	1____ 2____ 3____ 4____ Avg._____	1____ 2____ 3____ 4____ Avg._____
	Crack Depth (mm)	1____2____ 3____4____ Avg._____	1____ 2____ 3____ 4____ Avg._____	1____ 2____ 3____ 4____ Avg._____	1____ 2____ 3____ 4____ Avg._____	1____ 2____ 3____ 4____ Avg._____
	Working crack	Y____ N____	Y____ N____	Y____ N____	Y____ N____	Y____ N____
	Pavement Temp.					
Repair Method	Repair Type	Seal__ Fill__	Seal__ Fill__	Seal__ Fill__	Seal__ Fill__	Seal__ Fill__
	Crack Prep.	Clean___ Air Lance___ Other_____	Clean___ Air Lance___ Other_____	Clean___ Air Lance___ Other_____	Clean___ Air Lance___ Other_____	Clean___ Air Lance___ Other_____
	Routed	Y___ N___	Y___ N___	Y___ N___	Y___ N___	Y___ N___
	Reservoir Dims.	___x___	___x___	___x___	___x___	___x___
	Backer Rods	Y___ N___	Y___ N___	Y___ N___	Y___ N___	Y___ N___
	Blotter Material	_____, N__	_____, N__	_____, N__	_____, N__	_____, N__
	Sealant Type	MNDOT 3725___ MNDOT 3723___ MNDOT 3719___ Other_____	MNDOT 3725___ MNDOT 3723___ MNDOT 3719___ Other_____	MNDOT 3725___ MNDOT 3723___ MNDOT 3719___ Other_____	MNDOT 3725___ MNDOT 3723___ MNDOT 3719___ Other_____	MNDOT 3725___ MNDOT 3723___ MNDOT 3719___ Other_____
	Placement Configuration	Flush___ Capped___ Band-aid___ Other	Flush___ Capped___ Band-aid___ Other	Flush___ Capped___ Band-aid___ Other	Flush___ Capped___ Band-aid___ Other	Flush___ Capped___ Band-aid___ Other

APPENDIX T: PERFORMANCE EVALUATION OF NEWLY-INSTALLED CRACK SEALING PROJECTS (PHASE 3)



Site D

Site D is located on TH 53 between miles 22 and 24. This site was sealed on July 17th of 2017. The weather was 75°F and sunny. A rout-and-seal method was used on transverse thermal cracks. Clean-and-seal was used on longitudinal cracks. Three trucks were used during this operation. One truck would drive 10-15 minutes ahead of the other two, filling the routed reservoirs half-full with sealant. The second truck would fill the reservoir and apply a band-aid and blotter after allowing the sealant from the first pass to settle into the crack. The third truck performed sealing on longitudinal cracks in a single pass. The most recent construction data of this site includes an 8-inch concrete resurfacing in 2008 and a bituminous surfacing in 2012.

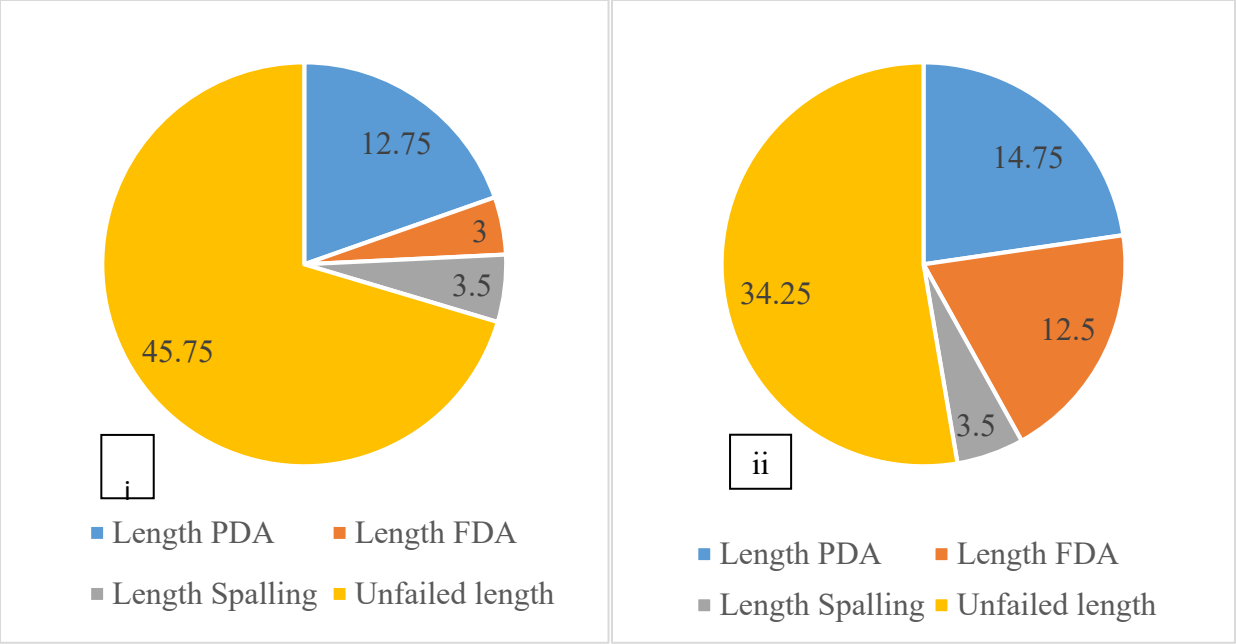
The site contains eight documented cracks. Six of the cracks are transverse and sealed with the rout-and-seal method. Two longitudinal cracks were sealed with the clean-and-seal method. The severity of the cracks was mostly medium. The tables and figures below within this subsection, Site D, provide details of the seal performance for the eight cracks considered in Site D.

Site D Cracks Documented

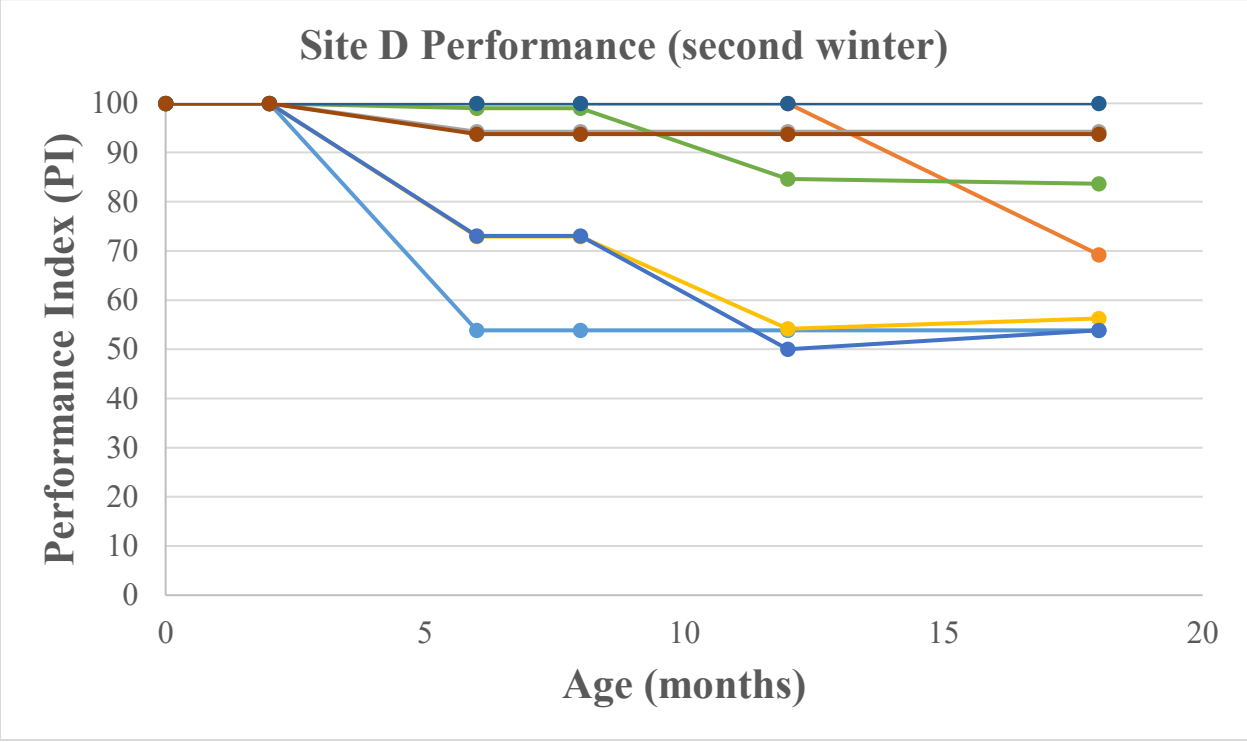
Site D							
ID#	**Crack Location**	**Cack Type**	**AVG Width (mm)**	**Severity**	**AADT**	**Repair Type**	**Sealant Material**
D-1	**TH 53 RP 23.9**	Thermal	**15.5**	**medium**	**7800**	Rout-and-Seal	**MNDOT 3725**
D-2	**TH 53 RP 23.9**	Thermal	**11.5**	**medium**	**7800**	Rout-and-Seal	**MNDOT 3725**
D-3	**TH 53 RP 23.9**	Thermal	**4.75**	**low**	**7800**	Rout-and-Seal	**MNDOT 3723**
D-4	**TH 53 RP 23.7**	Lane Joint	**7**	**low**	**7800**	Clean-and-Seal	**MNDOT 3725**
D-5	**TH 53 RP 23.7**	Thermal	**10.5**	**medium**	**7800**	Rout-and-Seal	**MNDOT 3725**
D-6	**22 and 24**	Thermal	**13.25**	**medium**	**7800**	Rout-and-Seal	**MNDOT 3725**
D-7	**TH 53 RP 22.01**	Lane Joint	**6**	**low**	**7800**	Clean-and-Seal	**MNDOT 3723**
D-8	**TH 53 RP 22.01**	Fatigue	**7.25**	**low**	**7800**	Clean-and-Seal	**MNDOT 3725**

Site D seal Performance after Second Winter

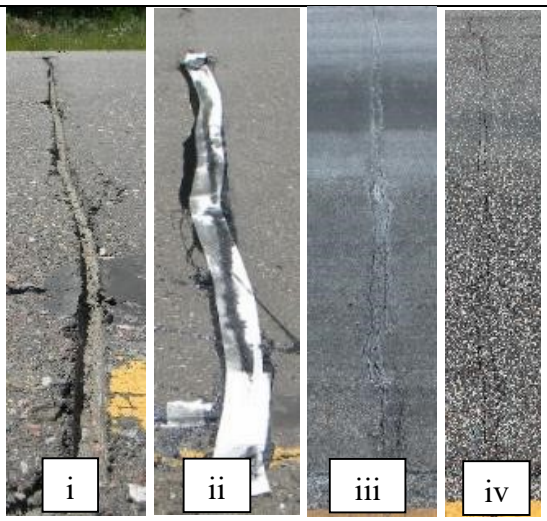
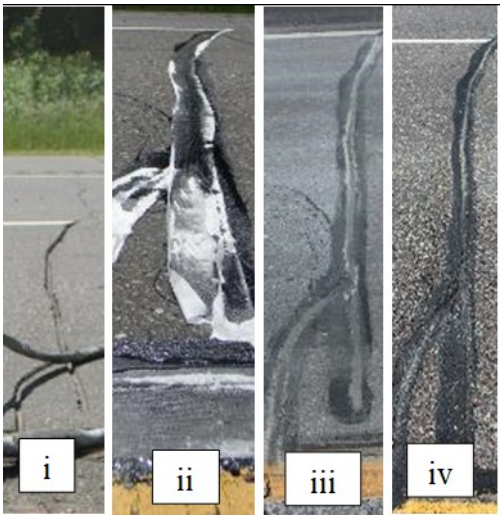
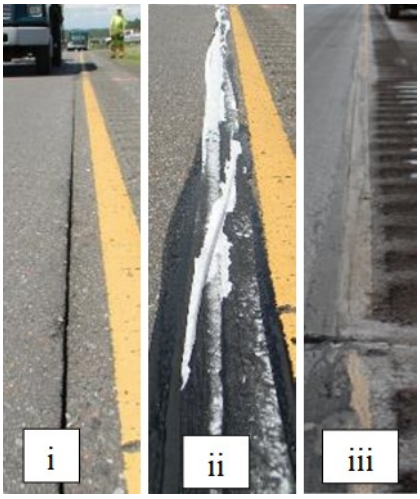
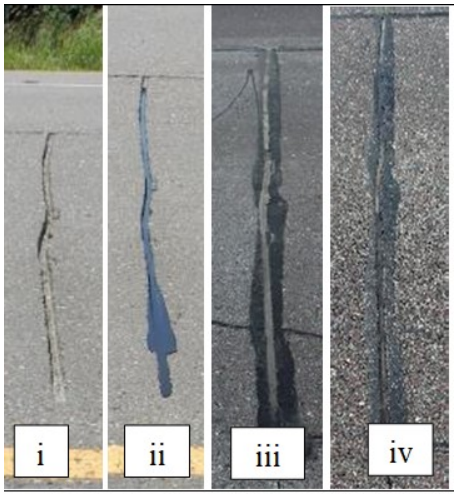
Site D Performance (end of 2nd Winter)						
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Unfailed length	Performance Index
D-1	13	12	0	0	1	53.8
D-2	13	2	3	0	8	69.2
D-3	25	1.5	0	0	23.5	94.2
D-4	13	0.5	5	0	7.5	56.3
D-5	13	0	2.5	3.5	7	53.8
D-6	13	0.25	2	0	10.75	83.7
D-7	38	0	0	0	38	100.0
D-8	10	1.25	0	0	8.75	93.8
sum	65	14.75	12.5	3.5	34.25	63.4

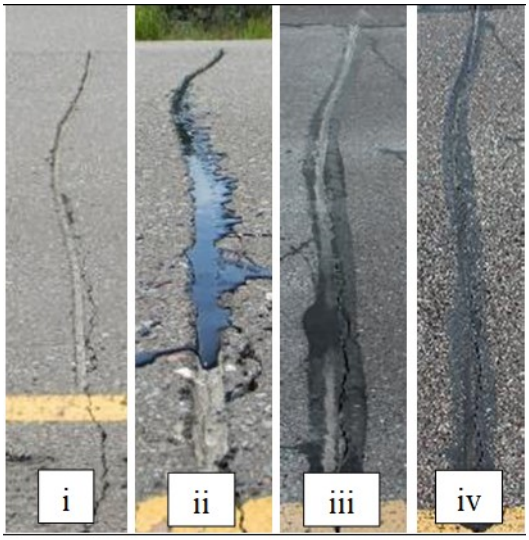


Seal Performance at Site D after First Winter (i) and Second Winter (ii)

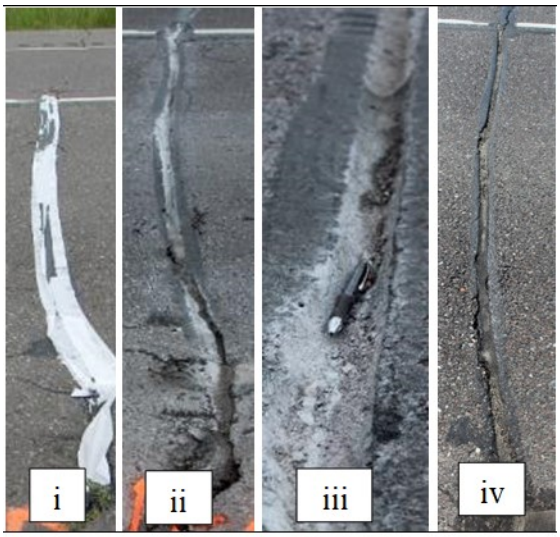


Performance at Site D after Second Winter

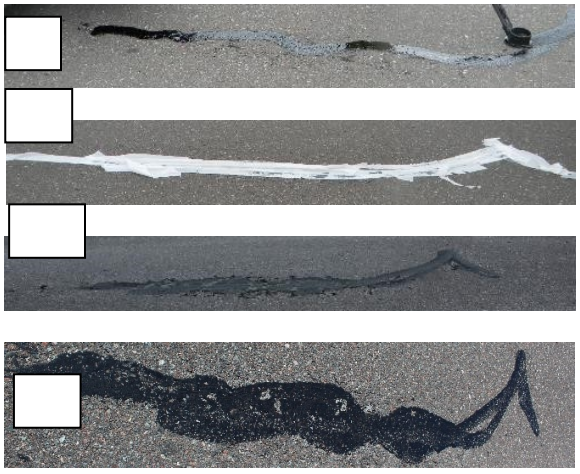
D-1	D-2
	
D-3	D-4
	
D-5	D-6



D-7



D-8



Figu

Photographic documentation of seal performance at Site D. D-1-i Shows Crack D-1 prior to being sealed. D-1-ii shows Crack D-1 immediately after being sealed. D-1-iii shows Crack D-1 at the end of its first winter after being sealed, and D-1-iv shows Crack D-1 fter its second winter of service. This same sequence of photos follows for cracks D-2, D-4, D-5, and D-8. The images presneted for Cracks D-4 and D-7 show the cracks prior to being sealed, immeditaeyl after being sealed, and during the frist winter since being sealed. D-6-iii shows the

reservoir deeply recessed during the first winter inspection due to crack expansion, indicating a tough adhesion capability of the sealant.

Site E

Site E is located on TH 200 between miles 176 and 180. The site contains ten documented cracks. Nine of the cracks were sealed with the rout-and-seal method. These cracks ran in the transverse direction and were of low severity. A rout-and-seal method was used on transverse thermal cracks. Clean-and-seal was used on longitudinal cracks. Three trucks were used during this operation. One truck would drive 10-15 minutes ahead of the other two, filling the routed reservoirs half full of sealant. The second truck would fill the reservoir and apply toilet paper. The third truck performed sealing on longitudinal cracks in a single pass.

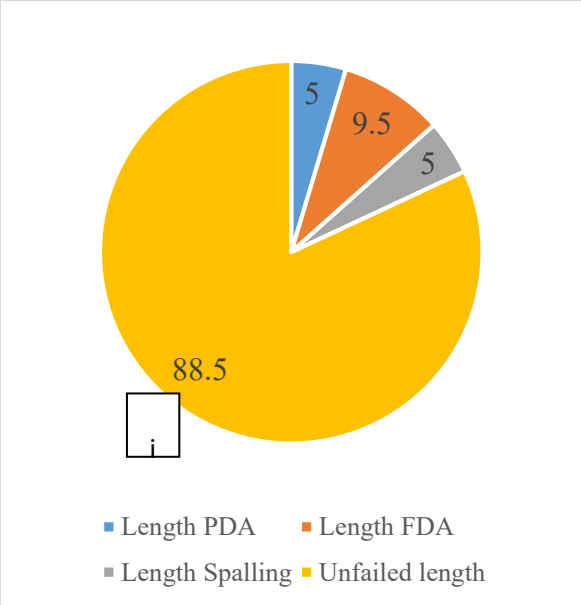
The most recent construction data for this site includes a bituminous surfacing in 1999 followed by crack sealing in 2001. The next rehabilitation performed on this section of road was a 1.5-inch mill and 3.5-inch bituminous overlay in 2012. The site contains ten documented cracks. Nine of these cracks were transverse, with one being on a lane joint. Site visits following installation have shown that a noticeable amount of adhesion and spalling failures have occurred in this test section in the first winter. The tables and figures below within this subsection, Site E, provide details of the seal performance for the ten cracks considered in Site E.

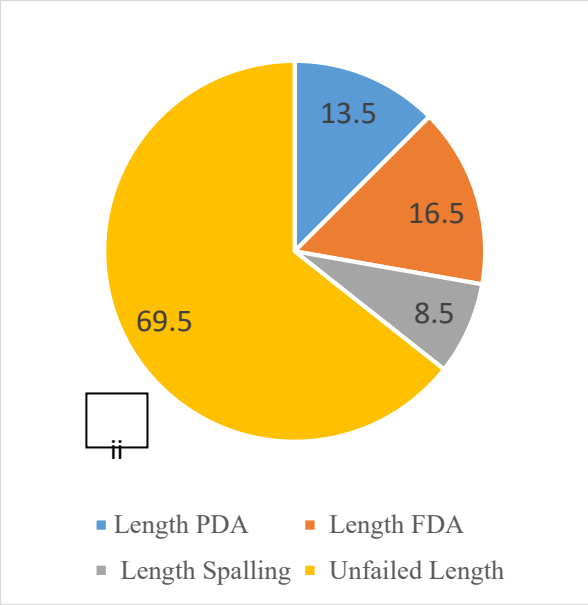
Site E Cracks Documented

Site E							
ID#	Crack Location	Cack Type	AVG Width (mm)	Severity	AADT	Repair Type	Sealant Material
E-1	TH 200 RP 176.95	Thermal	3.25	low	1200	Rout-and-Seal	MNDOT 3725
E-2	TH 200 RP 176.95	Thermal	3.75	low	1200	Rout-and-Seal	MNDOT 3725
E-3	TH 200 RP 177.01	Thermal	7.5	low	1200	Rout-and-Seal	MNDOT 3725
E-4	TH 200 RP 177.05	Thermal	7	low	1200	Rout-and-Seal	MNDOT 3725
E-5	TH 200 RP 177.10	Lane Joint	6.5	low	1200	none	MNDOT 3725
E-6	TH 200 RP 179.95	Thermal	4.25	low	1200	Rout-and-Seal	MNDOT 3725
E-7	TH 200 RP 179.95	Thermal	6	low	1200	Rout-and-Seal	MNDOT 3725
E-8	TH 200 RP 180	Thermal	5.5	low	1200	Rout-and-Seal	MNDOT 3725
E-9	TH 200 RP 180	Thermal	5	low	1200	Rout-and-Seal	MNDOT 3725
E-10	TH 200 RP 180	Thermal	5	low	1200	Rout-and-Seal	MNDOT 3725

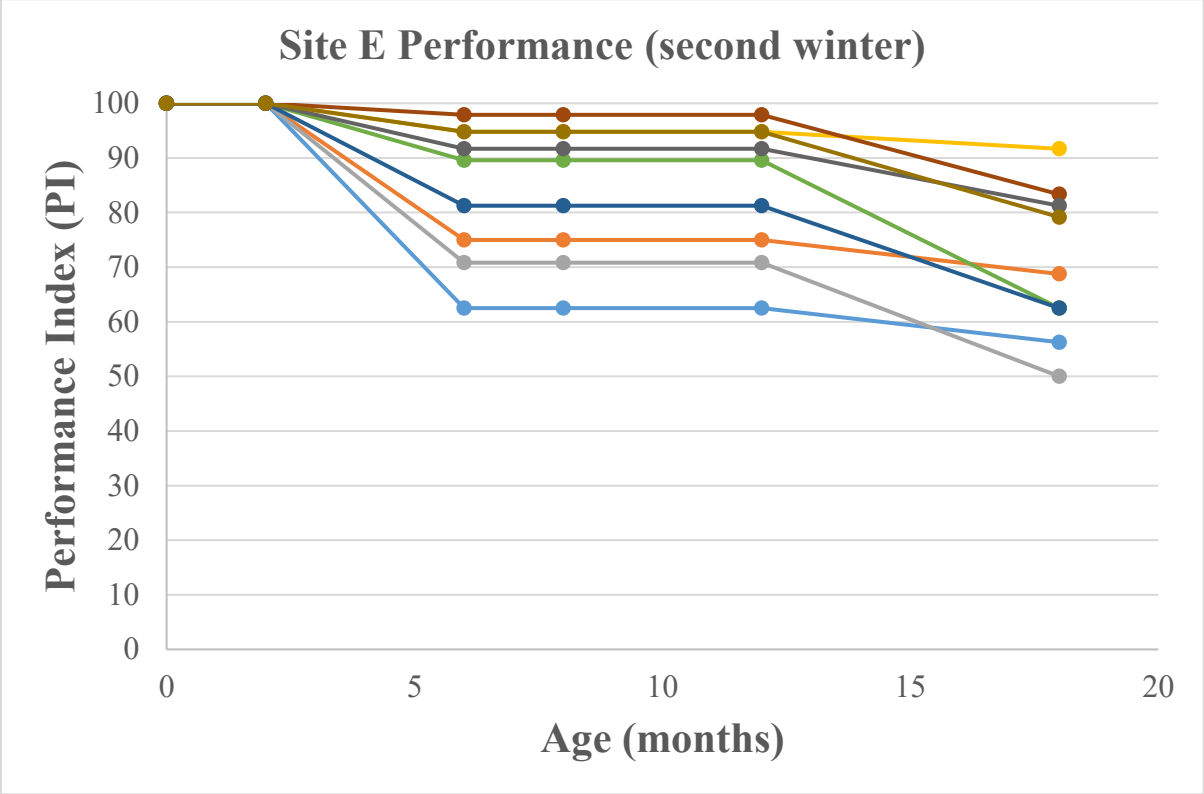
Performance of Site E after First Winter

Site E Performance (end of 2nd Winter						
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Unfailed length	Performance Index
E-1	12	1.5	3	1.5	6	56
E-2	12	1.5	3	0	7.5	69
E-3	12	2	3	2	5	50
E-4	12	0	1	0	11	92
E-5	90				90	x
E-6	12	1	3	1	7	63
E-7	12	1	3	1	7	63
E-8	12	3	0	0.5	8.5	83
E-9	12	0.5	0	2	9.5	81
E-10	12	3	0.5	0.5	8	79
sum	108	13.5	16.5	8.5	69.5	71

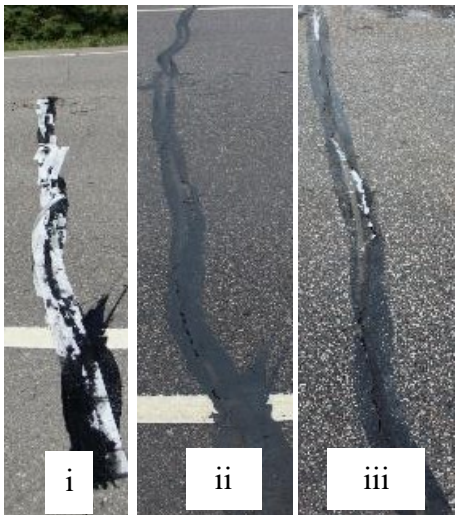
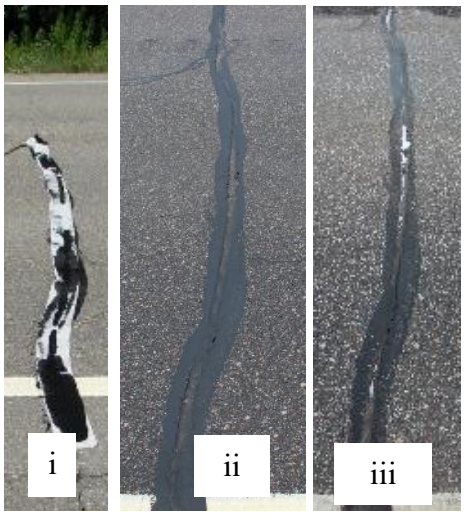


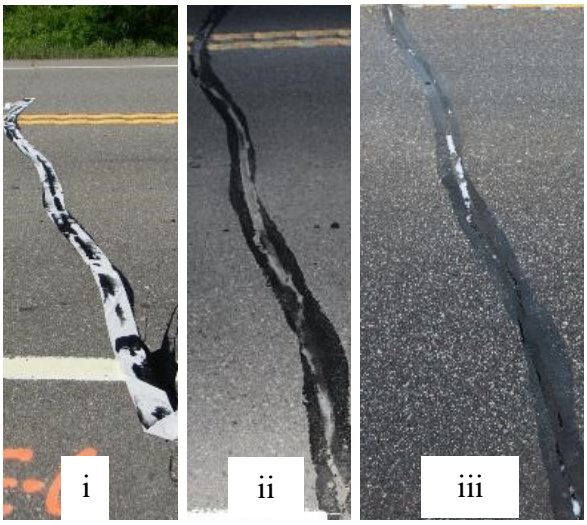
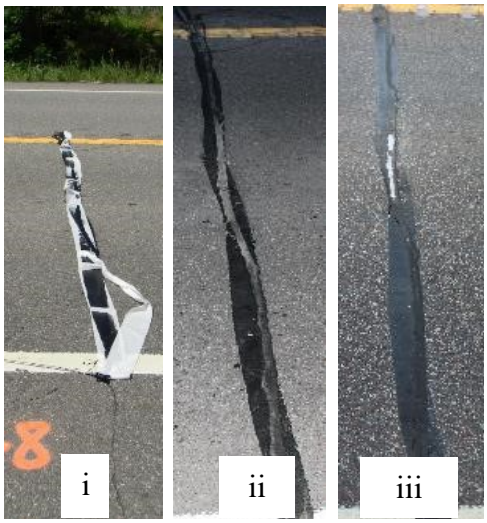


Seal Performance at Site E after First Winter (i) and Second Winter (ii)



Site E Performance Index of Site E after First Winter

E-1	E-2
	
E-3	E-4
	
E-5	E-6

	
E-7	E-8
	
E-9	E-10

Photographic Performance Documentation of Site E. E-1-i Shows Crack E-1 upon being sealed. E-1-ii and E-1-iii shows Crack E-1 at the end of its first winter and during the second winter after being sealed. This same sequence of photos follows for cracks E-2, E-3, E-4, E-5, E-6, E-7, E-8, E-9, and E-10. E-10-iv shows the seal performance at the end of the first winter compared to the mid-winter performance presented in E-10-iii.

Site F

Site F is located on TH 169 between miles 316 and 322. A rout-and-seal method was used on transverse thermal cracks. Clean-and-seal was used on longitudinal cracks. Three trucks were used during this operation. One truck would drive 10-15 minutes ahead of the other two, filling the routed reservoirs half full of sealant. The second truck would fill the reservoir and apply a toilet paper blotter. The third truck performed sealing on longitudinal cracks in a single pass.

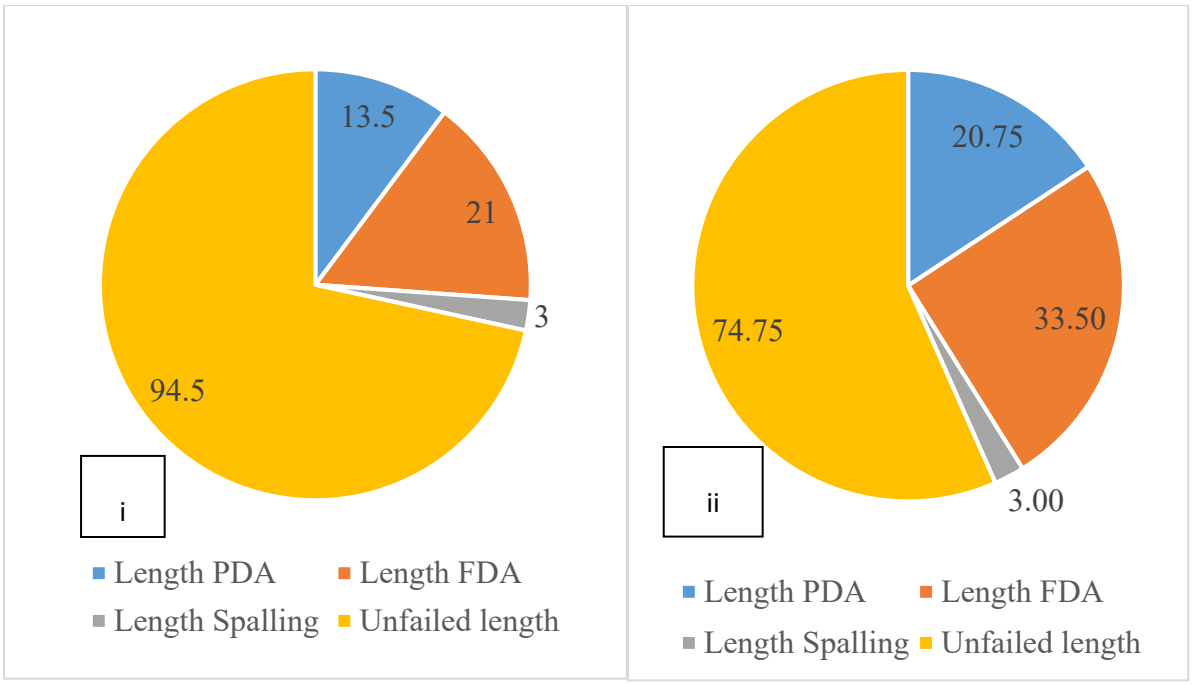
The most recent construction data from this site includes 10-inch reclamation and bituminous surfacing in 2010. The site contains ten documented cracks. Eight of the ten are transverse, while the other two lies on a lane joint. The severity of the cracks was low. Site visits following installation have shown that over 25% of the total length of seals has failed in adhesion, while another fraction has suffered spalling failures in the first winter. The tables and figures below within this subsection, Site F, provide details of the seal performance for the ten cracks considered in Site F.

Site F Cracks Documented

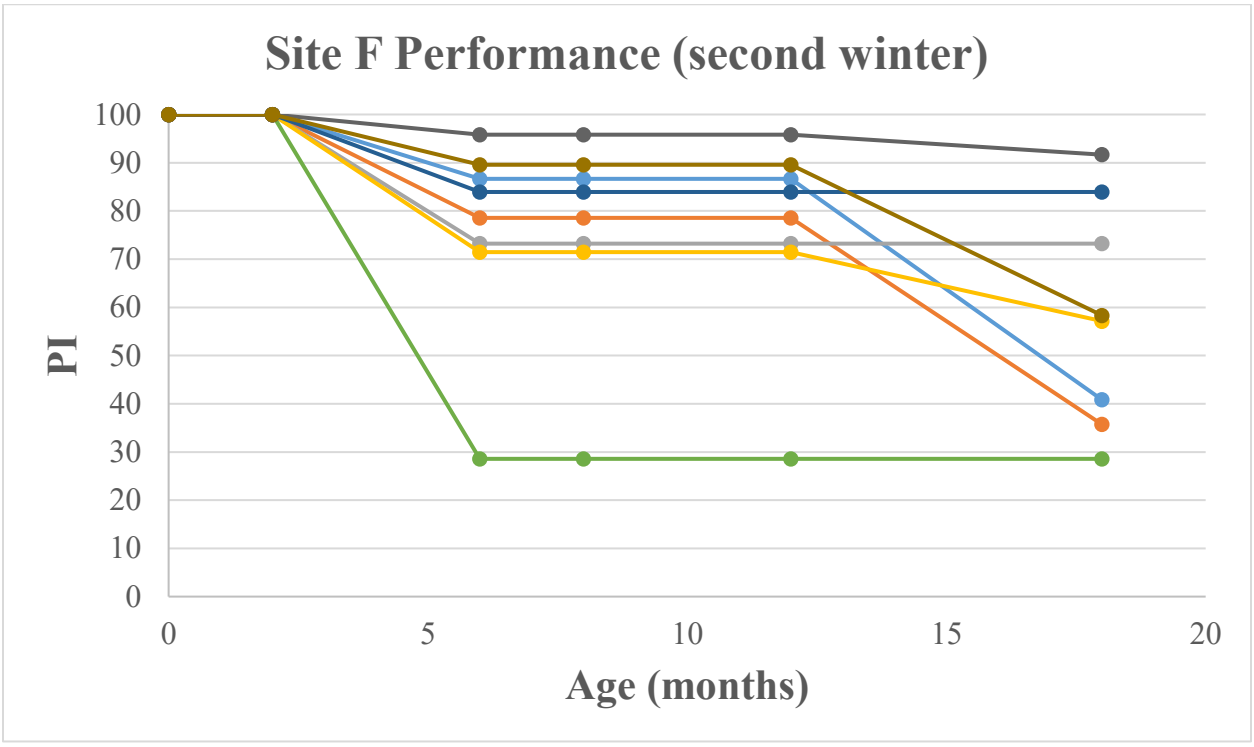
Site F							
ID#	**Crack Location**	**Cack Type**	**AVG Width (mm)**	**Severity**	**AADT**	**Repair Type**	**Sealant Material**
F-1	TH 169 RP 321.8	Thermal	5.25	low	6100	Rout-and-Seal	MNDOT 3725
F-2	TH 169 RP 321.8	Thermal	6.25	low	6100	Rout-and-Seal	MNDOT 3725
F-3	TH 169 RP 321.4	Thermal	5.25	low	6100	Rout-and-Seal	MNDOT 3725
F-4	TH 169 RP 321.3	Thermal	12.25	low	6100	Rout-and-Seal	MNDOT 3725
F-5	TH 169 RP320.8	Lane Joint	4.5	low	6100	none	MNDOT 3725
F-6	TH 169 RP 319.15	Thermal	3.25	low	6300	Rout-and-Seal	MNDOT 3725
F-7	TH 169 RP 319.1	Thermal	3.5	low	6300	Rout-and-Seal	MNDOT 3725
F-8	TH 169 RP 318.5	Lane Joint	7.5	low	6300	none	none
F-9	TH 169 RP 318.1	Thermal	4	low	6300	Rout-and-Seal	MNDOT 3725
F-10	TH 169 RP 316.95	Thermal	3	low	6300	Rout-and-Seal	MNDOT 3723

Seal Performance at Site F after Second Winter

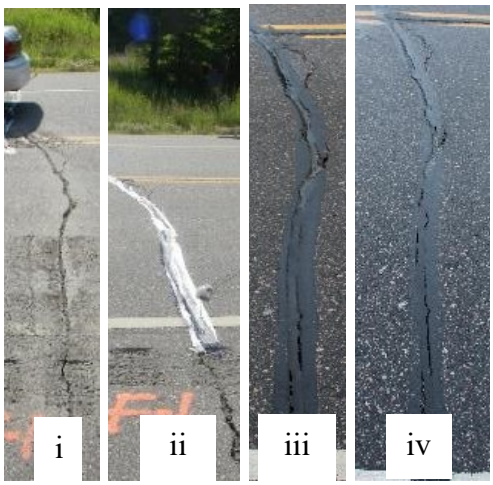
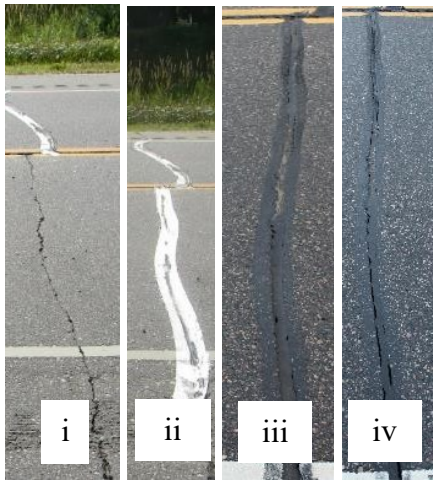
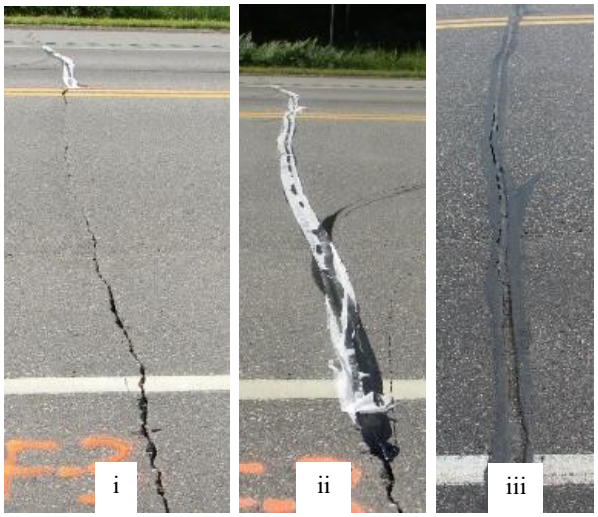
Site F Performance (end of 2nd Winter)						
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Unfailed length	Performance Index
F-1	15	0.75	5.50	3.00	5.75	41
F-2	14	2	8	0	4	36
F-3	14	1.5	3	0	9.5	73
F-4	25	2	5	0	18	57
F-5	100				100	
F-6	14	0	10	0	4	29
F-7	14	1.5	1.5	0	11	84
F-8	100				100	
F-9	24	4	0	0	20	92
F-10	12	9	0.5	0	2.5	58
sum	132	20.75	33.50	3.00	74.75	59

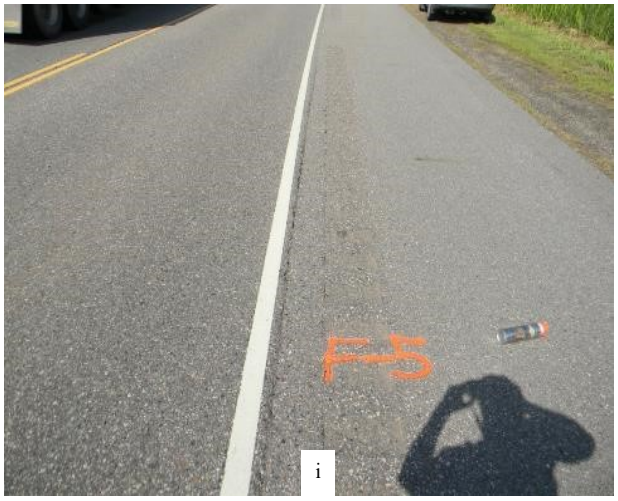


Seal Performance at Site F after First Winter (i) and Second Winter (ii)



Performance Index at Site F after First Winter

F-1	F-2
	
F-3	F-4
	
F-5	F-6

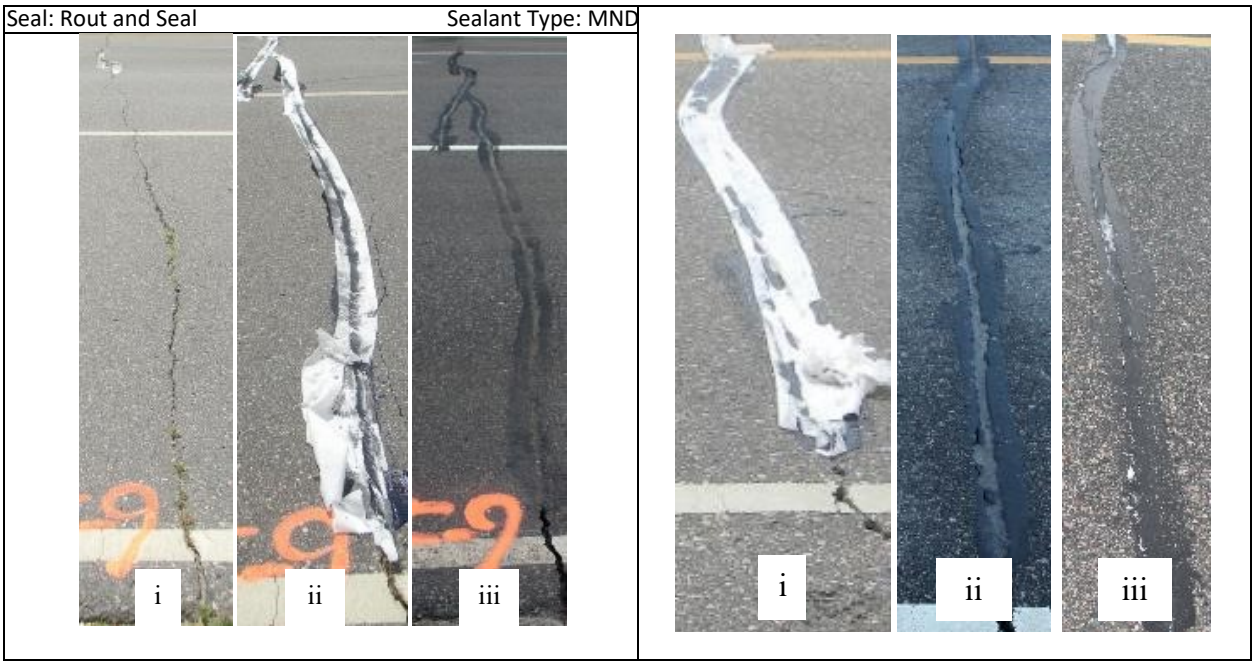


F-7

F-8

F-9

F-10



Photographic performance documentation of Site F. F-1-i shows Crack F-1 prior to being Sealed. F-1-ii shows Crack F-1 immediately after being sealed. F-1-iii and F-1-iv show Crack F-1 at the end of its first and second winter after being sealed. This same sequence of photos follows for Cracks F-2 and F-3. F-4-1 shows Crack F-4 immidiately after being sealed. F-4-ii and F-4-iii show Crack F-4 after the first and second winter since being sealed. Tis same sequence follows for F-6, F-7, F-9 and F-10. Cracks F-5 and F-9 were not sealed and saw no noticeable deterioration over the two-year analysis.

Site G

Site G is located on TH 1 just outside of Ely Between miles 284 and 278. A rout-and-seal method was used on transverse thermal cracks. Clean-and-seal was used on longitudinal cracks. There were two different rout-and-seal methods used on this project due to one of the heater trucks being down for repair in the morning. Cracks G-1through G-10 were sealed using only a single pass rout-and-seal, which left most reservoirs recessed rather than flush with the pavement. Cracks G-11 through G-20 were sealed with the standard two-pass approach described in previous sites. The most recent construction data of this site includes a 3-inch mill and overlay and a 3-inch reclamation in 2014.

The site contains 20 documented cracks, all of which are transverse except for one. Cracks G-1 through G-9 were sealed in the morning with a single pass, again due to a heater truck being down. Cracks G-11through G-20 were sealed with two passes. Site visits following installation have shown almost 50%

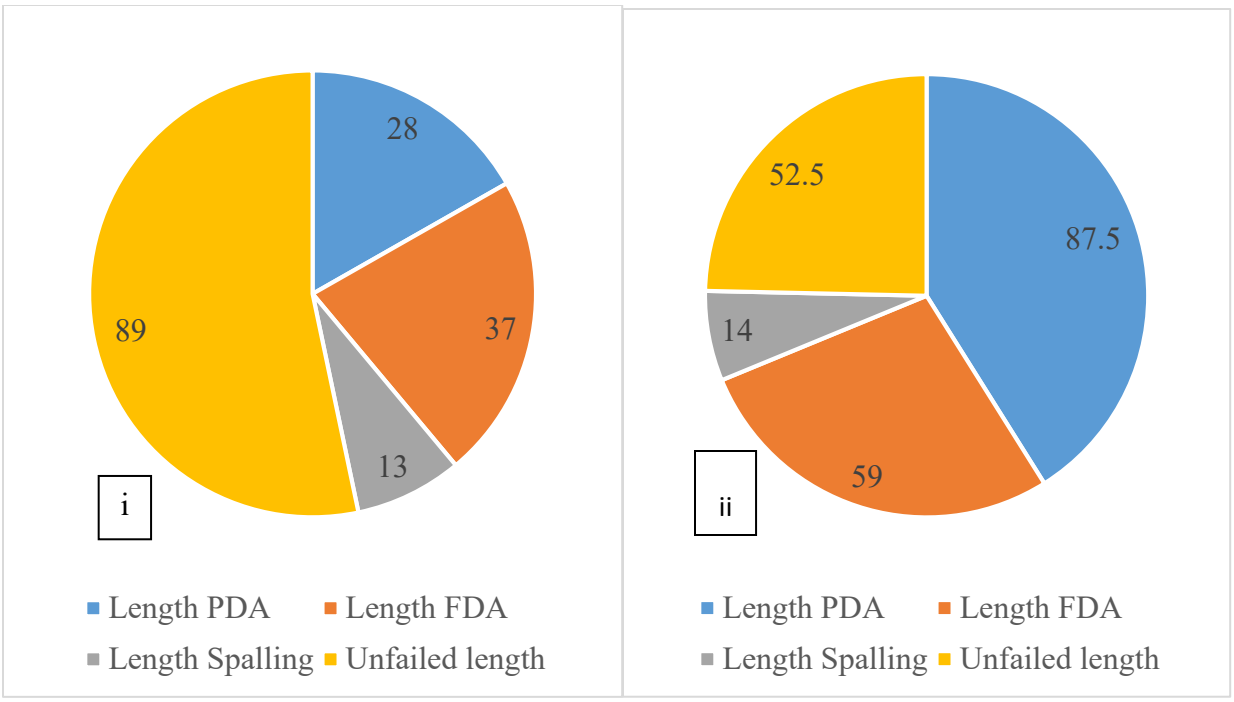
of failure after the first winter since being sealed. A majority of the failure occurred as adhesion, while a noticeable portion occurred due to spalling. The tables and figures below within this subsection, Site G, provide details of the seal performance for the 20 cracks considered in Site G.

Site G Cracks Documented

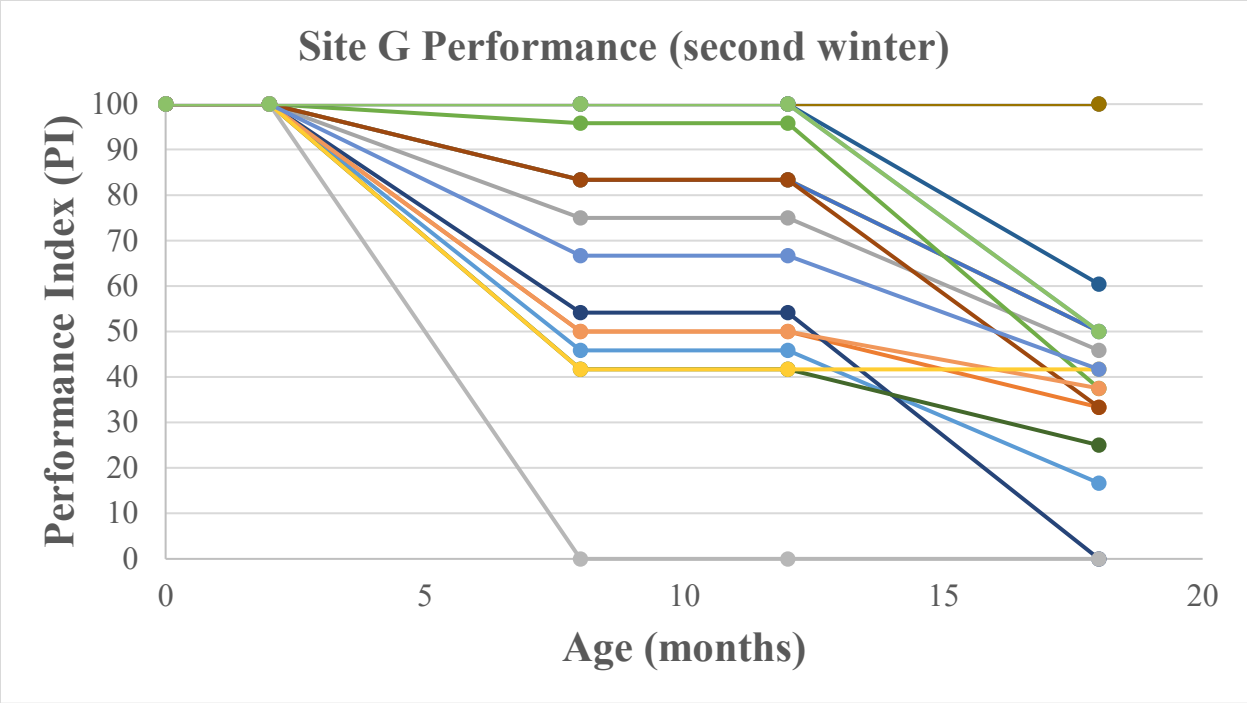
Site G								
ID#	Crack Location	Cack Type	AVG Width (mm)	Severity	AADT	Repair Type	Sealant Material	Special Considerations
G-1	TH 1 RP 278.7	Thermal	4.75	low	2300	Rout-and-Seal	MNDOT 3725	Single pass only
G-2	TH 1 RP 279.8	Thermal	6.75	low	2300	Rout-and-Seal	MNDOT 3725	Single pass only
G-3	TH 1 RP 279.85	Thermal	4	low	2300	Rout-and-Seal	MNDOT 3725	Single pass only
G-4	TH 1 RP 279.9	Thermal	3.25	low	2300	Rout-and-Seal	MNDOT 3725	Single pass only
G-5	TH 1 RP 280.05	Thermal	2.25	low	2300	Rout-and-Seal	MNDOT 3725	Single pass only
G-6	TH 1 RP 283.9	Thermal	3	low	3900	Rout-and-Seal	MNDOT 3725	Single pass only
G-7	TH 1 RP 283.95	Thermal	5.25	low	3900	Rout-and-Seal	MNDOT 3725	Single pass only
G-8	TH 1 RP 283.95	Thermal	4	low	3900	Rout-and-Seal	MNDOT 3725	Single pass only
G-9	TH 1 RP 283.95	Thermal	3.5	low	3900	Rout-and-Seal	MNDOT 3725	Single pass only
G-10	TH 1 RP 283.98	Fatigue	6	low	3900	Clean-and-Seal	MNDOT 3723	Single pass only
G-11	TH 1 RP 281.1	Thermal	4.25	low	2300	Rout-and-Seal	MNDOT 3725	
G-12	TH 1 RP 281.1	Thermal	4.75	low	2300	Rout-and-Seal	MNDOT 3725	
G-13	TH 1 RP 281.0	Thermal	2.5	low	2300	Rout-and-Seal	MNDOT 3725	
G-14	TH 1 RP 281.0	Thermal	8	low	2300	Rout-and-Seal	MNDOT 3725	
G-15	TH 1 RP 280.9	Thermal	3.75	low	2300	Rout-and-Seal	MNDOT 3725	
G-16	TH 1 RP 281.5	Thermal	8	low	2300	Rout-and-Seal	MNDOT 3725	
G-17	TH 1 RP 281.5	Thermal	3.5	low	2300	Rout-and-Seal	MNDOT 3725	
G-18	TH 1 RP 281.2	Thermal	3.75	low	2300	Rout-and-Seal	MNDOT 3725	
G-19	TH 1 RP 281.1	Thermal	1.5	low	2300	Rout-and-Seal	MNDOT 3725	
G-20	TH 1 RP 280.0	Thermal	5	low	2300	Rout-and-Seal	MNDOT 3725	

Performance of Site G after Second Winter

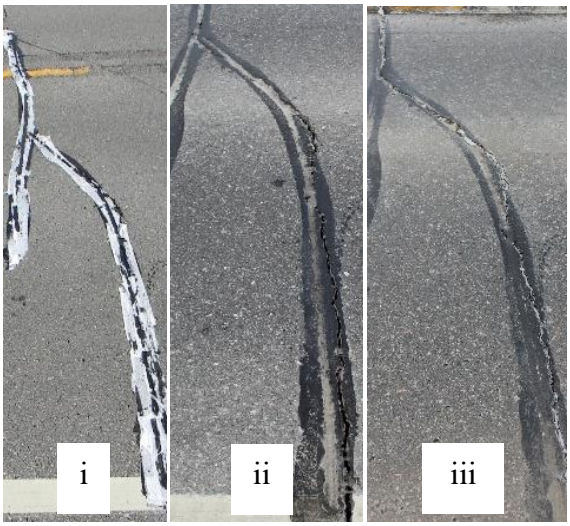
Site G Performance (end of 2nd Winter)						
Crck ID	crack length	Length PDA	Length FDA	Length Spalling	Unfailed length	Performance Index
G-1	12	2	3	6	1	17
G-2	12	8	4	0	0	33
G-3	12	3	2	3	4	46
G-4	12	12	0	0	0	50
G-5	12	12	0	0	0	50
G-6	12	9	3	0	0	38
G-7	12	7.5	1	0	3.5	60
G-8	12	0	8	0	4	33
G-9	6	0	0	0	6	100
G-10	25			0	25	NA
G-11	12	0	12	0	0	0
G-12	12	0	7	0	5	25
G-13	3	3	0	0	0	50
G-14	12	9	3	0	0	38
G-15	12	0	8	4	0	0
G-16	12	0	6	1	5	42
G-17	12	10	2	0	0	42
G-18	12	12	0	0	0	50
G-19	12	0	0	0	12	NA
G-20	12	0	0	0	12	NA
sum	213	87.5	59	14	52.5	40

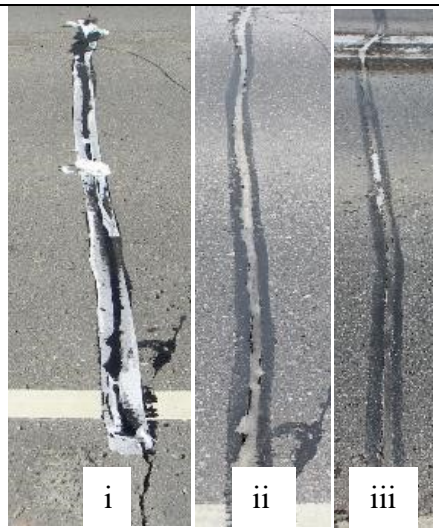
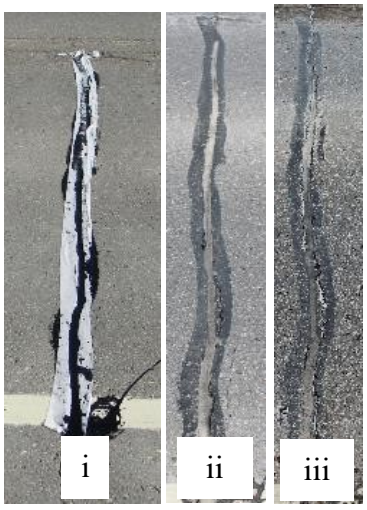
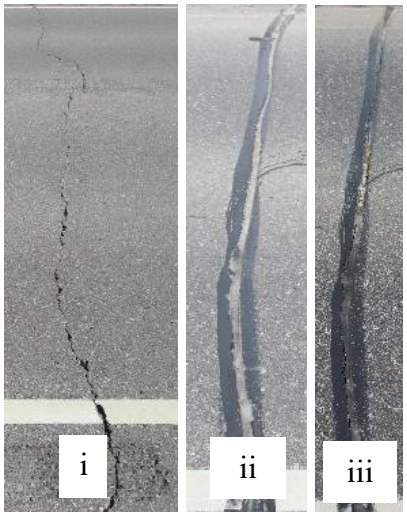


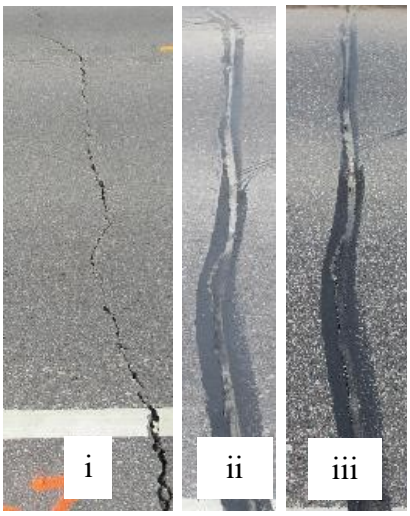
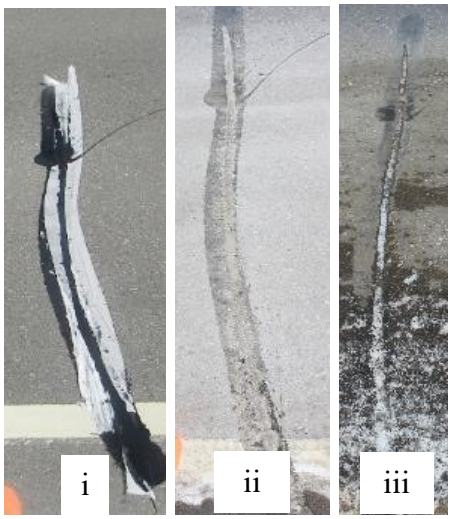
Seal Performance at Site G after First Winter (i) and Second Winter (ii)

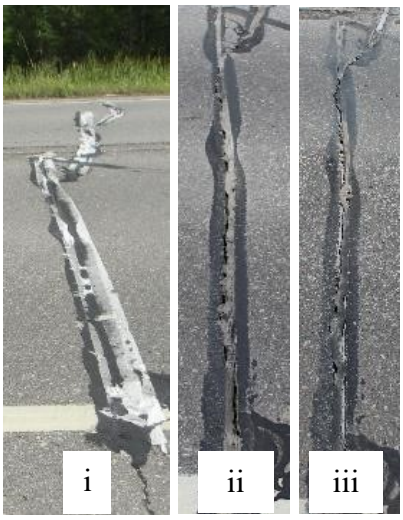
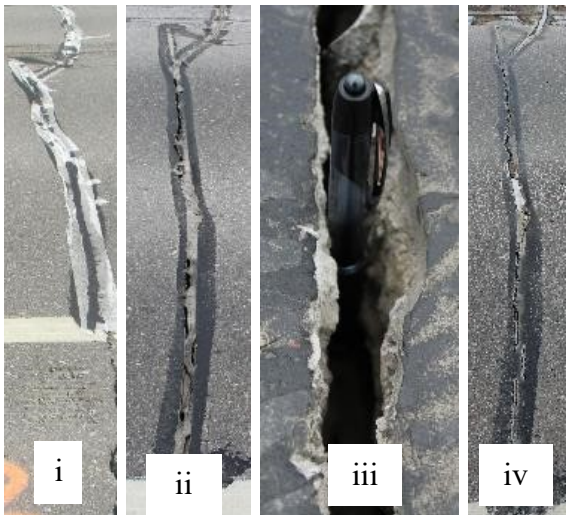


Performance Index of Site G after Second Winter

G-1	G-2
	of Seal: Rout and Seal Sealant Type: MNDOT 

G-3	G-4
	 G-6
G-5	G-6
	
G-7	G-8

	
G-9	G-10
	
G-11	G-12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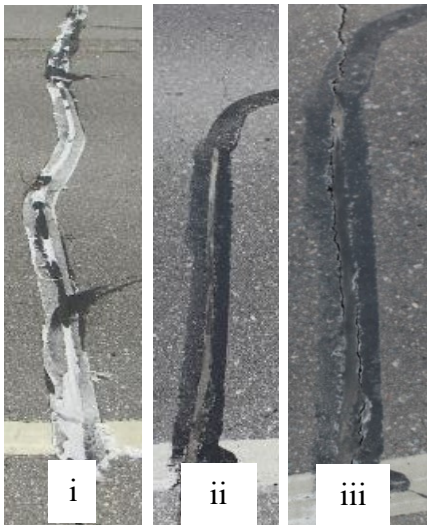
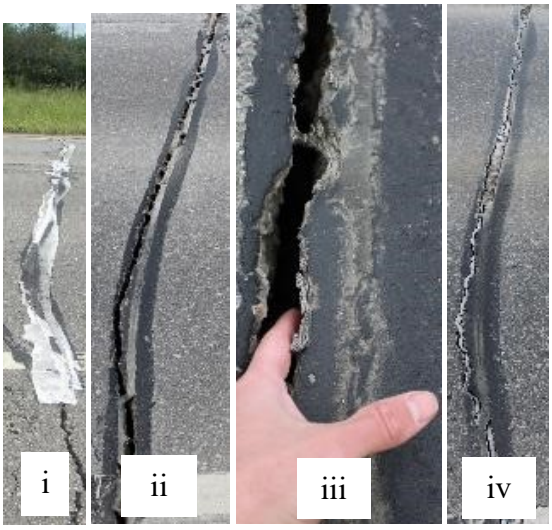
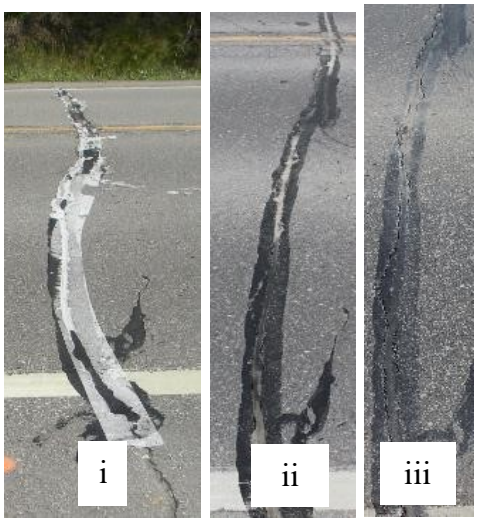
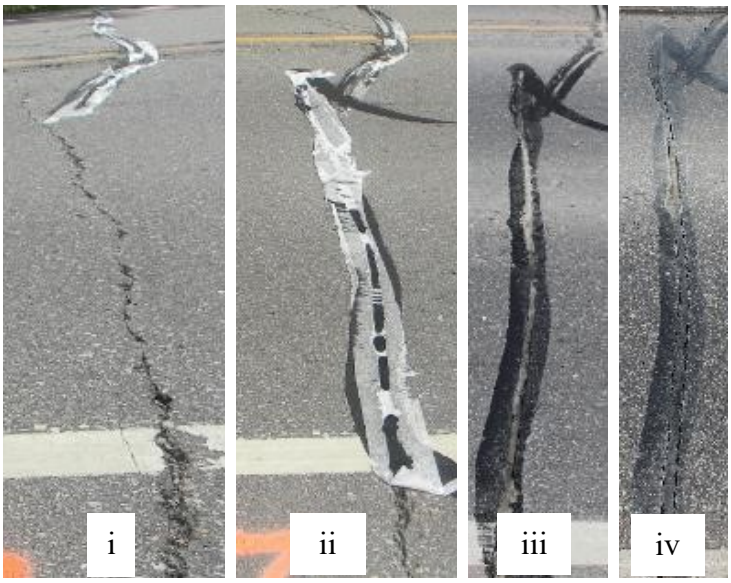
	
G-15	G-16





G-17



Photographic perforamnce documentation of Site G. G-1-I shows crack G-1 immediately after being sealed. G-1-ii and G-1-iii show Crack G-1 during the first and second winter since seal installation. This same sequence follows for Cracks G-3, G-4, G-5, G-6, G-7, G-8, G-9, G-10, G-11, G-13, G-14, and G-16. Photos i, ii, and iv of cracks G-15 and G-15 show the seal immidiately after installation and during the first and second winter since installation, while photo iii shows a close-up of seal failure in each crack. Crack G-17 shows images before, after amd during the first and second winter.

Site H

Site H is located in Eveleth on TH 53 on mile 60. Rout-and-seal method was used on transverse thermal cracks. Clean-and-seal was used on longitudinal cracks. Three trucks were used during this operation. One truck would drive 10-15 minutes ahead of the other two, filling the routed reservoirs half full of sealant. The second truck would fill the reservoir and apply toilet paper blotter material. The third truck performed sealing on longitudinal cracks in a single pass. The most recent construction data from this section of road is a 1.5-inch milling in 1999. There appears to be a lack of information at this site, as the pavement appears to be much newer than this.

The site contains ten documented cracks. Eight of these ten are transverse, while the other two lies along lane joint and were left unsealed. The severity of the cracks at this site was low. The tables and figures below within this subsection, Site H, provide details of the seal performance for the ten cracks considered in Site H.

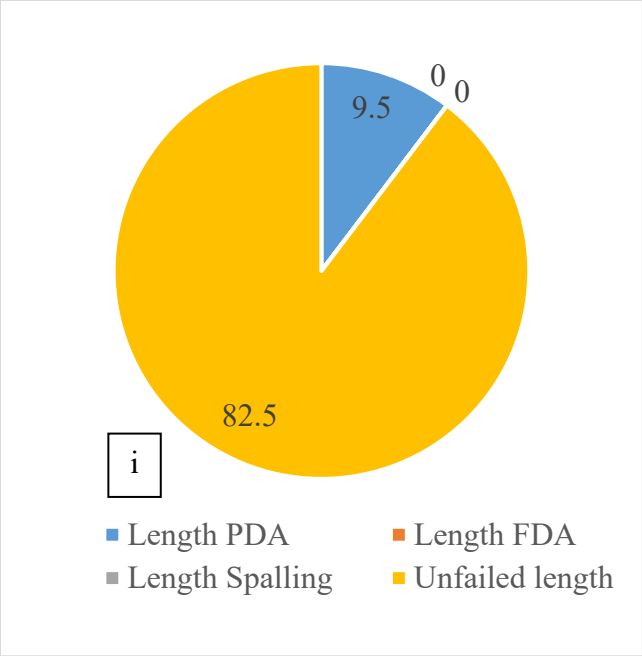
Site H Cracks Documented

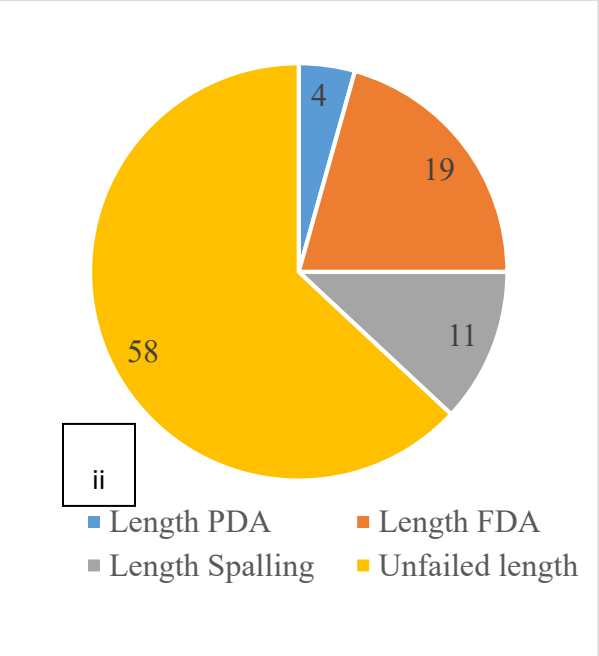
Site H							
ID#	Crack Location	Cack Type	AVG Width (mm)	Severity	AADT	Repair Type	Sealant Material
H-1	TH 53 RP 60.6	Thermal	4.75	low	10600	Rout-and-Seal	MNDOT 3725
H-2	TH 53 RP 60.6	Thermal	3.75	low	10600	Rout-and-Seal	MNDOT 3725
H-3	TH 53 RP 60.6	Lane Joint	2.75	low	10600	none	none
H-4	TH 53 RP 60.6	Thermal	4	low	10600	Rout-and-Seal	MNDOT 3725
H-5	TH 53 RP 60.6	Thermal	3.25	low	10600	Rout-and-Seal	MNDOT 3725
H-6	TH 53 RP 60.5	Thermal	6.5	low	10600	Rout-and-Seal	MNDOT 3725
H-7	TH 53 RP 60.5	Thermal	2.5	low	10600	Rout-and-Seal	MNDOT 3725
H-8	TH 53 RP 60.5	Lane Joint	3.75	low	10600	none	none
H-9	TH 53 RP 60.5	Thermal	2.33	low	10600	Rout-and-Seal	MNDOT 3725
H-10	TH 53 RP 60.5	Thermal	3	low	10600	Rout-and-Seal	MNDOT 3725

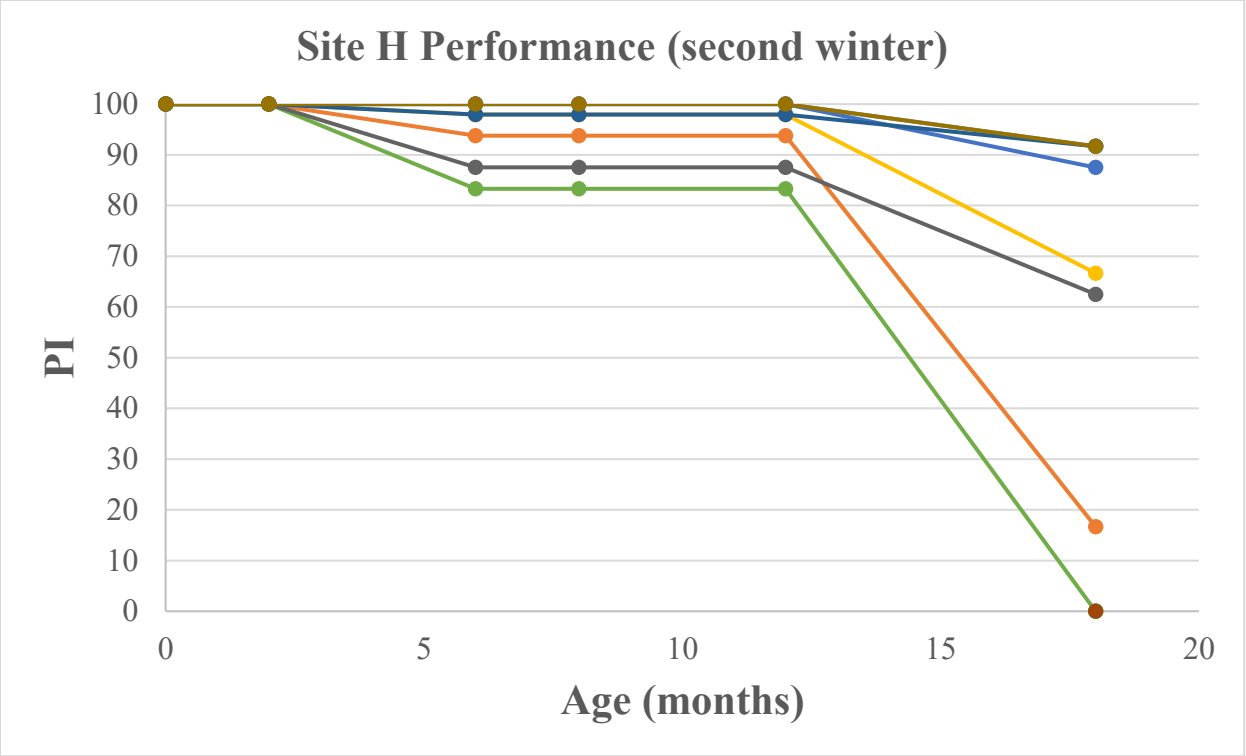
Seal Performance at Site H after Second Winter

Site H Performance (end of 2nd Winter						
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Unfailed length	Performance Index
H-1	12	0	1	0	11	91.67
H-2	12	2	3	6	1	16.67
H-3	30	0	0	0	30	0.00
H-4	12	0	4	0	8	66.67
H-5	12	0	0	0	12	87.50
H-6	12	0	8	4	0	0.00
H-7	12	2	0	0	10	91.67
H-8	30	0	0	0	30	0.00
H-9	8	0	3	0	5	62.50
H-10	12	0	0	1	11	91.67
sum	92	4	19	11	58	63.54

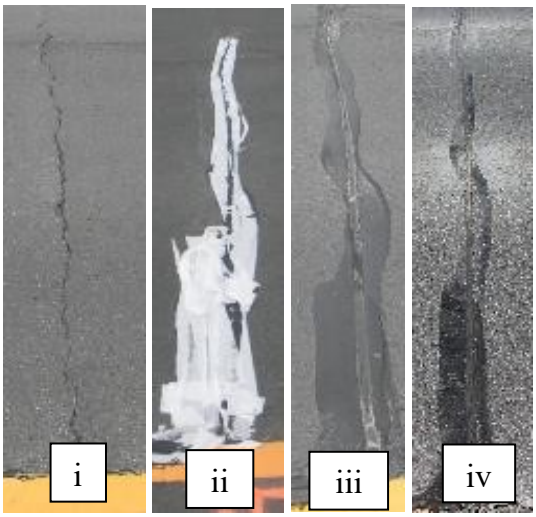
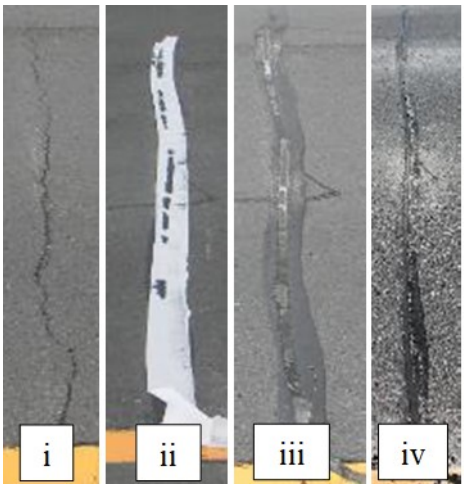
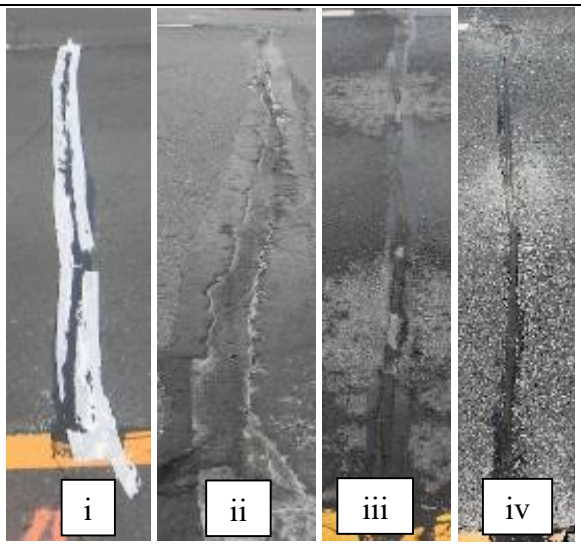
Seal Performance at Site H after First Winter (i) and Second Winter (ii)

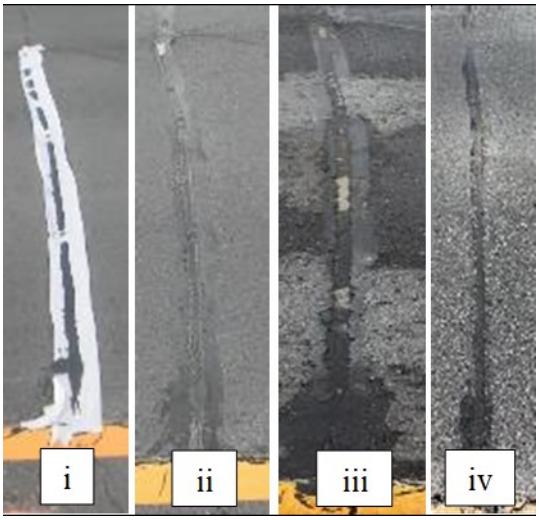
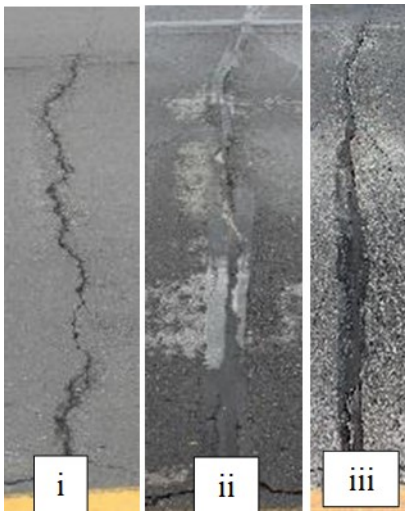


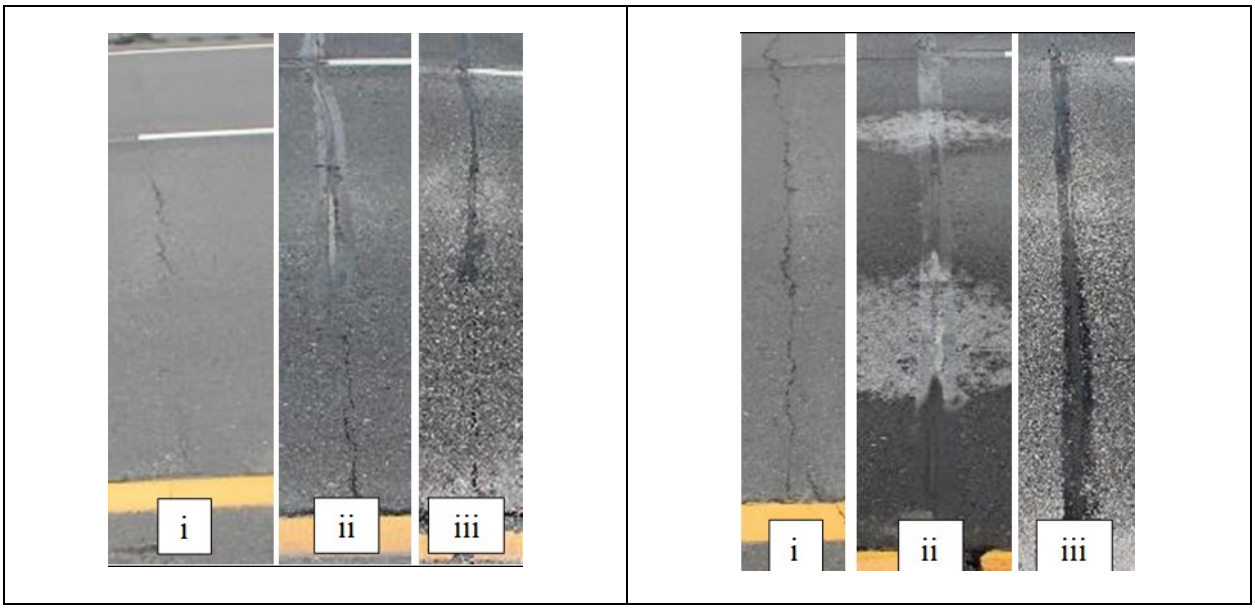




Performance Index of Site H after Second Winter

H-1	H-2
	
H-3	H-4
	
H-5	H-6

	
H-7	H-8
	
H-9	H-10



Photographic documentaion of site H performance. Photos i, ii, iii, and iv show cracks H-1, H-2, and H-6 before, after, and during the first and second winter. Photos i and ii show cracks H-3 and H-8, left unsealed, during the first and second winter. Crack H-4 is represented by photos immediately after sealing, a close up during the first winter, and overviews of the first and second winter. Crack H-5 is represented by four photos taken immeditaly after being sealed, during the first summer, and the first and second winter. Crack H-7 is represented immeditaely after being sealed, then during the first and second winter. Cracks H-9 and H-10 are depicted by photos taken before being sealed, then during the first and second winters.

Site I

Site I occupies the northbound lane of County Road 5 exiting the town of Fillmore, MN. This site was sealed by the county maintenance crew using a mix of both clean-and-seal and rout-and-seal. Rather than a toilet paper blotter being used, the maintenance crew sprayed soapy water onto the seals.

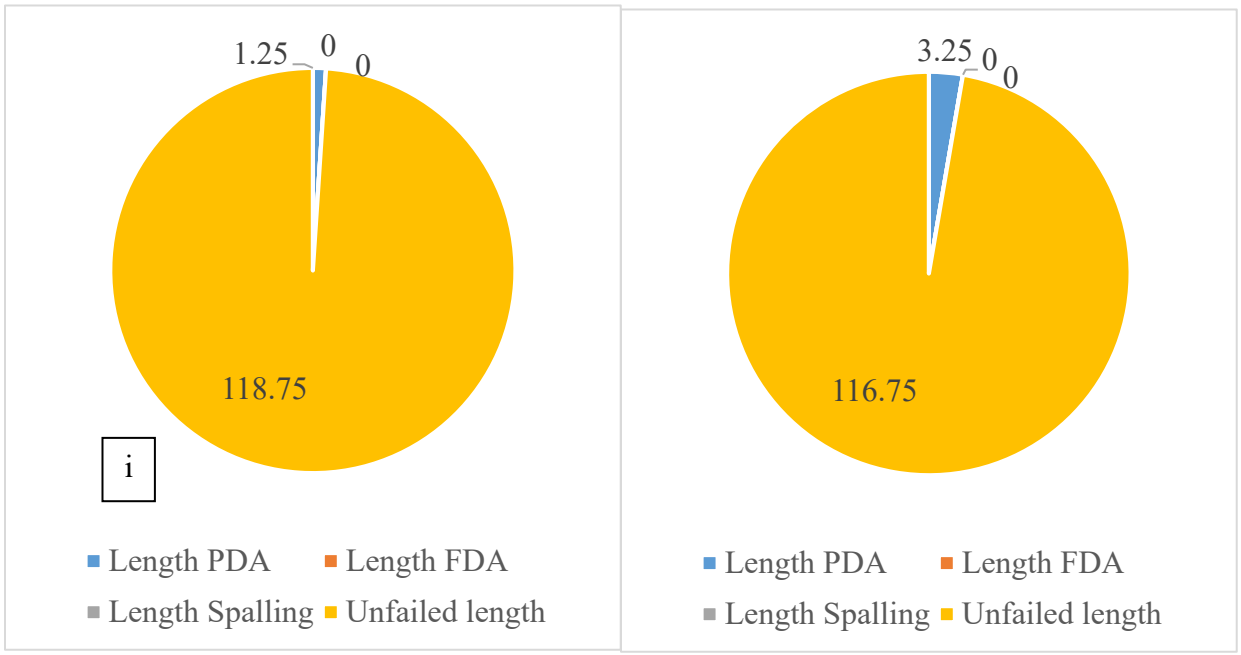
The general pavement and crack conditions were poor. The pavement was well aged, and cracks were severe and tightly spaced. Some of the cracks were wider than the standard ¾-inch routing bit. The site consists of 20 documented cracks. Ten of these cracks were sealed with clean-and-seal, while the other ten were sealed with rout-and-seal. Upon site investigation during the second winter, the only noticeable difference between rout-and-seal and clean-and-seal was that about a two-foot section of crack I-18 (rout-and-seal) had experienced a pullout failure of the sealant over the first winter. The tables and figures below within this subsection, Site I, provide details of the seal performance for the 20 cracks considered in Site I.

Site I Cracks Documented

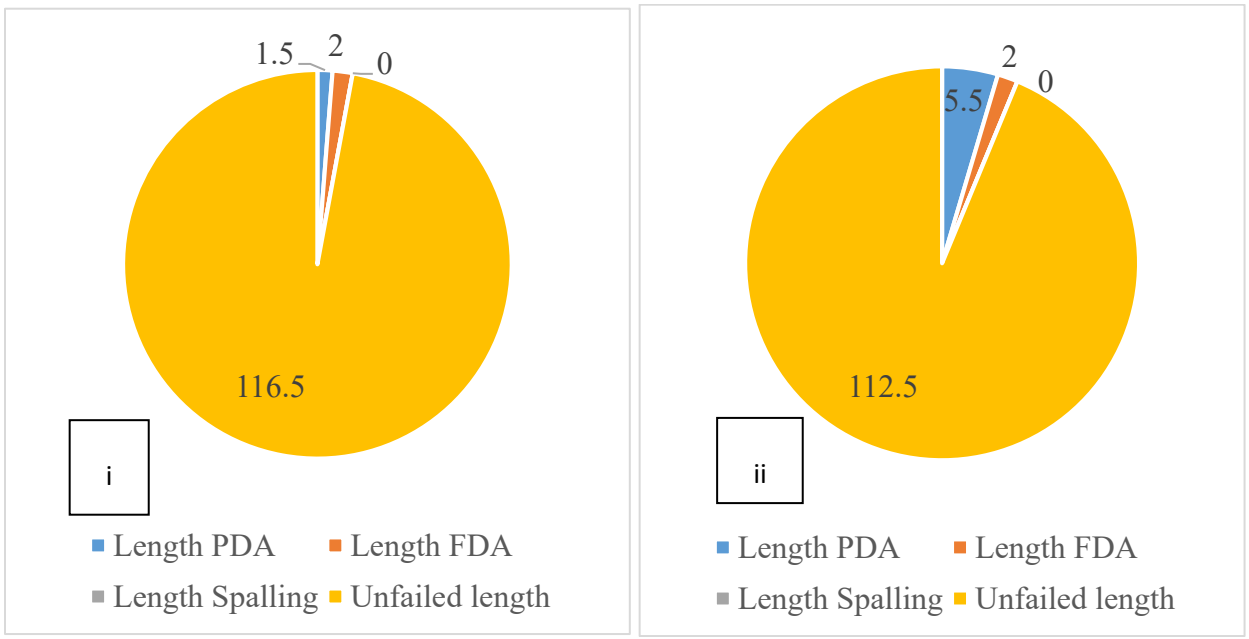
Site I							
ID#	**Crack Location**	**Cack Type**	**AVG Width (mm)**	**Severity**	**AADT**	**Repair Type**	**Sealant Material**
I-1	CR 5 NB Fillmore	Thermal	20	high	600	Clean-and-Seal	MnDOT 3725
I-2	CR 5 NB Fillmore	Thermal	21	high	600	Clean-and-Seal	MnDOT 3725
I-3	CR 5 NB Fillmore	Thermal	17	high	600	Clean-and-Seal	MnDOT 3725
I-4	CR 5 NB Fillmore	Thermal	22	high	600	Clean-and-Seal	MnDOT 3725
I-5	CR 5 NB Fillmore	Thermal	13	high	600	Clean-and-Seal	MnDOT 3725
I-6	CR 5 NB Fillmore	Thermal	13	high	600	Clean-and-Seal	MnDOT 3725
I-7	CR 5 NB Fillmore	Thermal	25	high	600	Clean-and-Seal	MnDOT 3725
I-8	CR 5 NB Fillmore	Thermal	23	high	600	Clean-and-Seal	MnDOT 3725
I-9	CR 5 NB Fillmore	Thermal	24	high	600	Clean-and-Seal	MnDOT 3725
I-10	CR 5 NB Fillmore	Thermal	24	high	600	Clean-and-Seal	MnDOT 3725
I-11	CR 5 NB Fillmore	Thermal	23	high	600	Rout-and-Seal	MnDOT 3725
I-12	CR 5 NB Fillmore	Thermal	9.5	high	600	Rout-and-Seal	MnDOT 3725
I-13	CR 5 NB Fillmore	Thermal	15.5	high	600	Rout-and-Seal	MnDOT 3725
I-14	CR 5 NB Fillmore	Thermal	20	high	600	Rout-and-Seal	MnDOT 3725
I-15	CR 5 NB Fillmore	Thermal	22.5	high	600	Rout-and-Seal	MnDOT 3725
I-16	CR 5 NB Fillmore	Thermal	15	high	600	Rout-and-Seal	MnDOT 3725
I-17	CR 5 NB Fillmore	Thermal	22	high	600	Rout-and-Seal	MnDOT 3725
I-18	CR 5 NB Fillmore	Thermal	22	high	600	Rout-and-Seal	MnDOT 3725
I-19	CR 5 NB Fillmore	Thermal	22	high	600	Rout-and-Seal	MnDOT 3725
I-20	CR 5 NB Fillmore	Thermal	41	high	600	Rout-and-Seal	MnDOT 3725

Performance of Site I after Second Winter

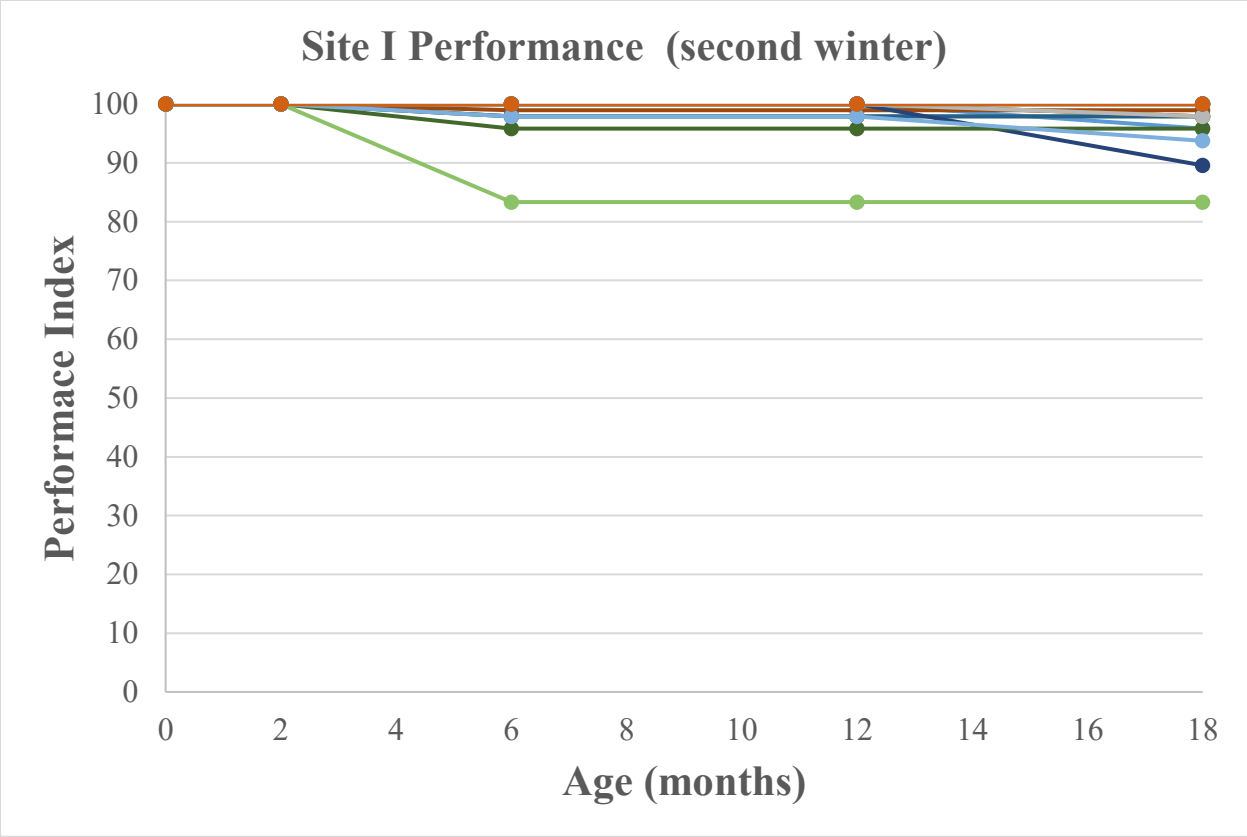
Site I Performance (2nd Winter) (clean-and-seal)						
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Unfailed length	Performance Index
I-1	12	1	0	0	11	96
I-2	12	0.5	0	0	11.5	98
I-3	12	0	0	0	12	100
I-4	12	0	0	0	12	100
I-5	12	0	0	0	12	100
I-6	12	0.5	0	0	11.5	98
I-7	12	0.5	0	0	11.5	98
I-8	12	0.5	0	0	11.5	99
I-9	12	0.25	0	0	11.75	100
I-10	12	0	0	0	12	98
sum	120	3.25	0	0	116.75	99
Site I Performance (2nd Winter) (rout-and-seal						
I-11	12	2.5	0	0	9.5	90
I-12	12	1	0	0	11	96
I-13	12	1.5	0	0	10.5	94
I-14	12	0	0	0	12	100
I-15	12	0.5	0	0	11.5	98
I-16	12	0	0	0	12	100
I-17	12	0	0	0	12	100
I-18	12	0	2	0	10	83
I-19	12	0	0	0	12	100
I-20	12	0	0	0	12	100
sum	120	5.5	2	0	112.5	96



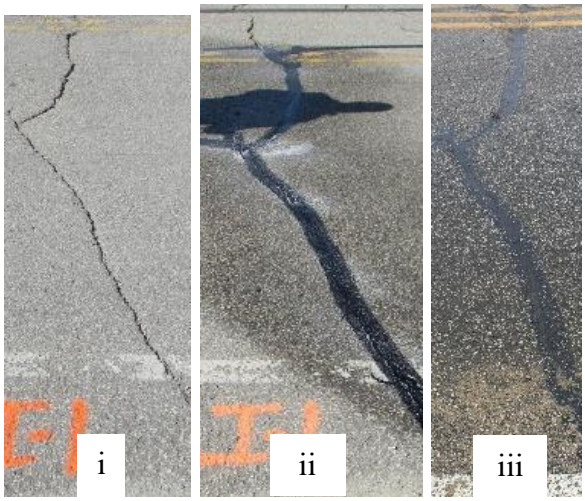
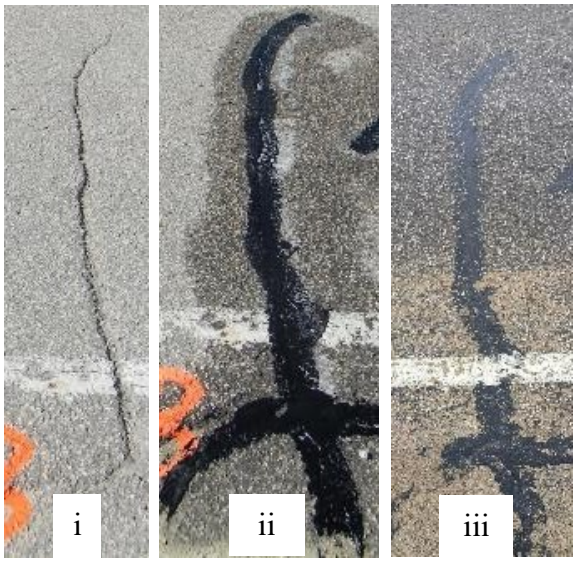
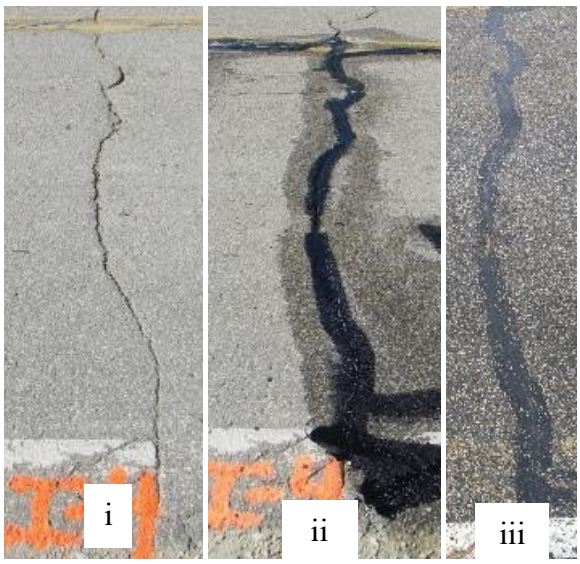
Site I Clean-and-Seal Performance during First Winter (i) and Second Winter (ii)

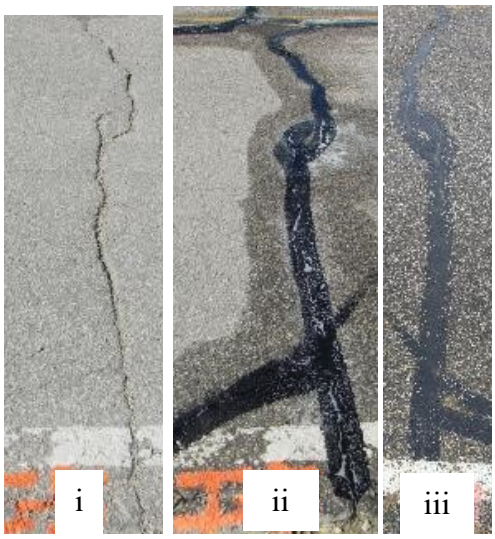
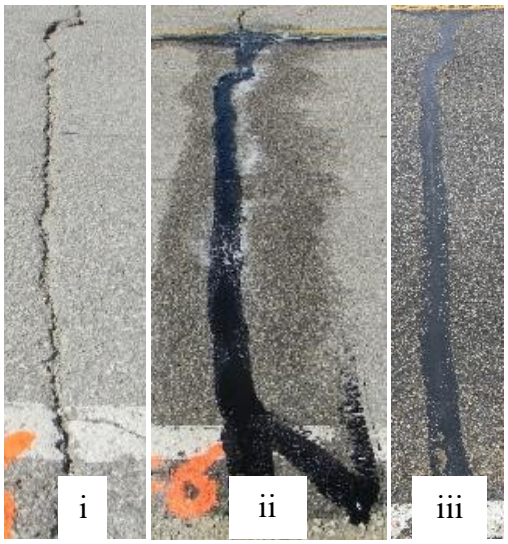
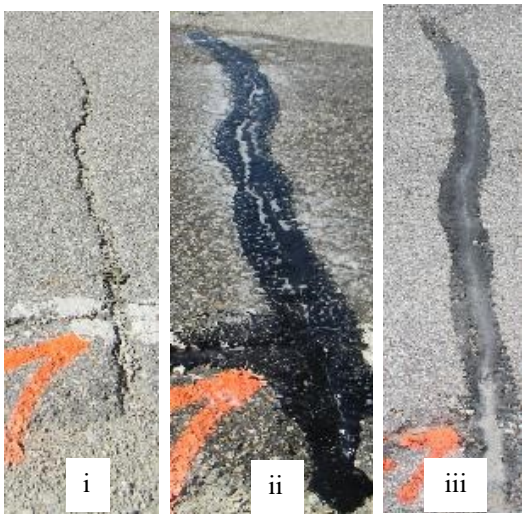
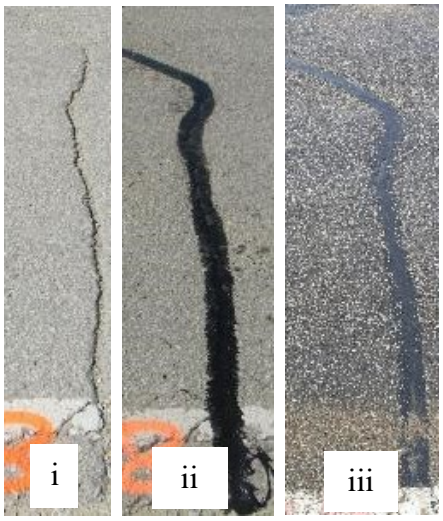


Site I Rout-and-Seal Performance After First Winter (i) and Second Winter (ii)



Site I Performance Index after Second Winter

I-1	I-2
	
I-3	I-4
	
I-5	I-6

	
I-7	I-8
	
I-9	I-10

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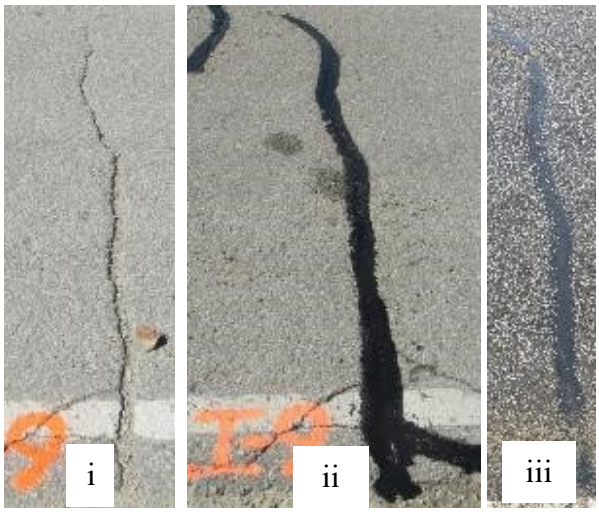
<tr><td> 
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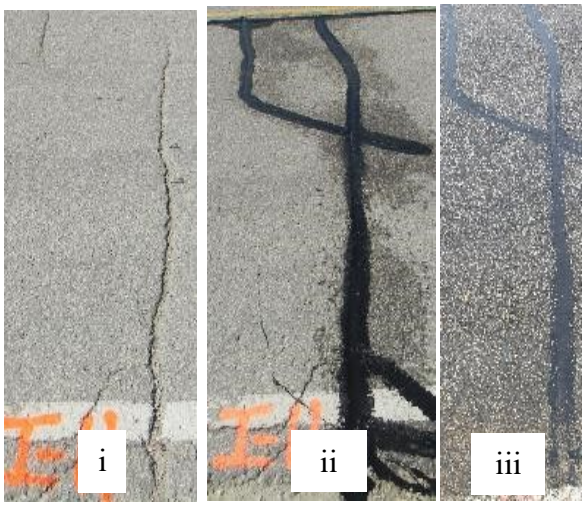
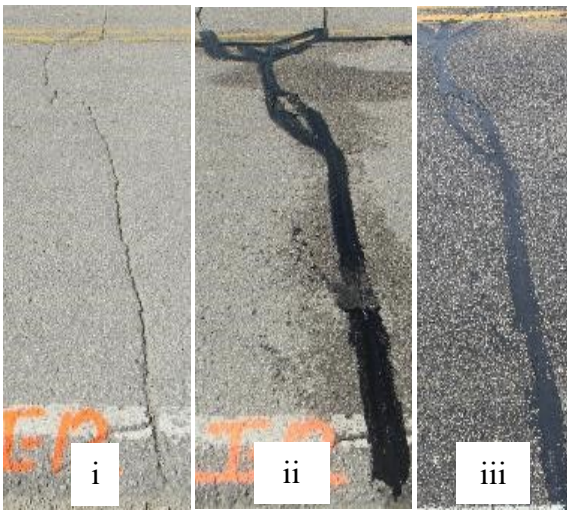
<tr><td> 
</td><td> 
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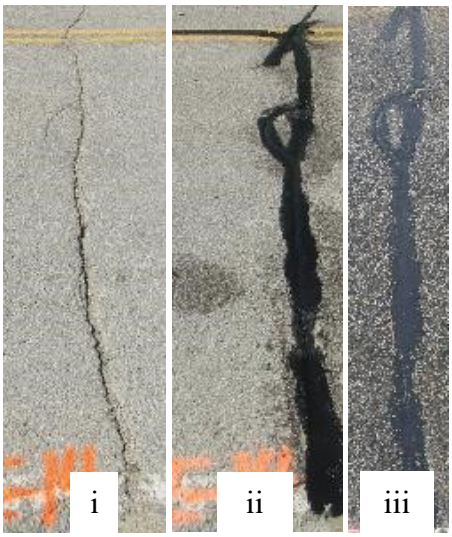
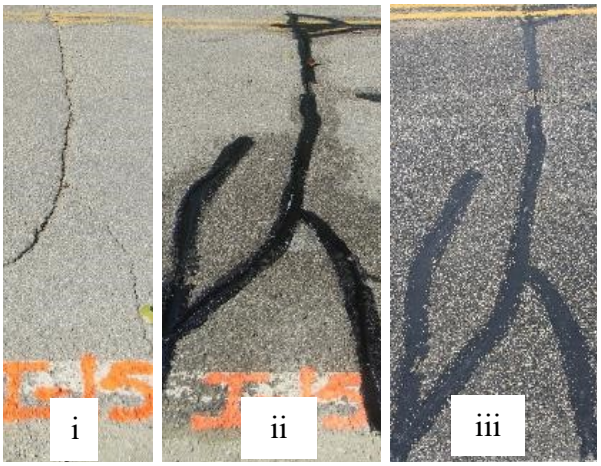
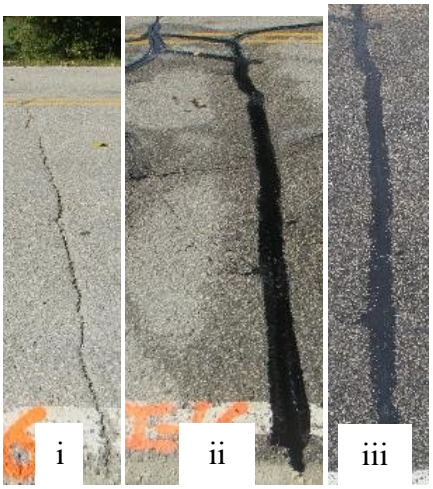
I-15



I-16



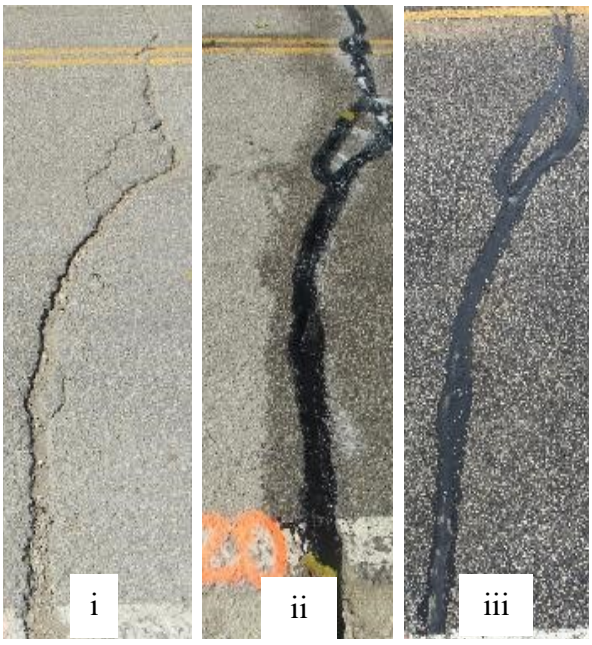
I-17



I-18

I-19

I-20



Photographic Performance Documentation of Site I. I-1-i Shows Crack I-1 prior to being Sealed. I-1-ii Shows Crack I-1 immediately after being Sealed. I-1-iii Shows Crack I-1 after the First Winter since being Sealed. This same sequence of photos follows for cracks I-2 through I-20.

Site M

Site M lies on a residential cul-de-sac (Locust Hills Pl) in Wayzata, MN. This road was considered to include a very low traffic residential street. The exact traffic data is not known for this site, but it is assumed that the only traffic on this road is from the five homes (and theirs guests) that this road serves. The severity of the cracks at this site was medium. A total of six cracks were documented. Three cracks were rout-and-sealed and other three were clean-and-sealed. The tables and figures below within this subsection, Site M, provide details of the seal performance for the six cracks considered in Site M.

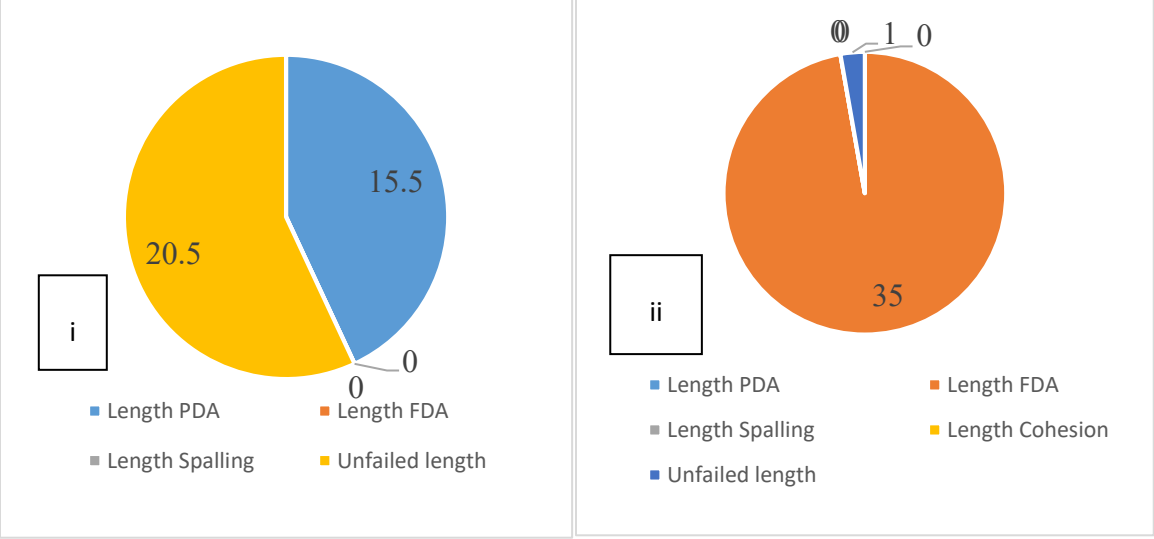
Site M Cracks Documented

Site M							
ID#	Crack Location	Cack Type	AVG Width (mm)	Severity	ADT	Repair Type	Sealant Material
M-1	Locust Hills Pl	Thermal	x	medium	x	Clean-and-Seal	x
M-2	Locust Hills Pl	Thermal	x	medium	x	Clean-and-Seal	x
M-3	Locust Hills Pl	Thermal	x	medium	x	Clean-and-Seal	x
M-4	Locust Hills Pl	Thermal	x	medium	x	Rout-and-Seal	x
M-5	Locust Hills Pl	Thermal	x	medium	x	Rout-and-Seal	x
M-6	Locust Hills Pl	Thermal	x	medium	x	Rout-and-Seal	x

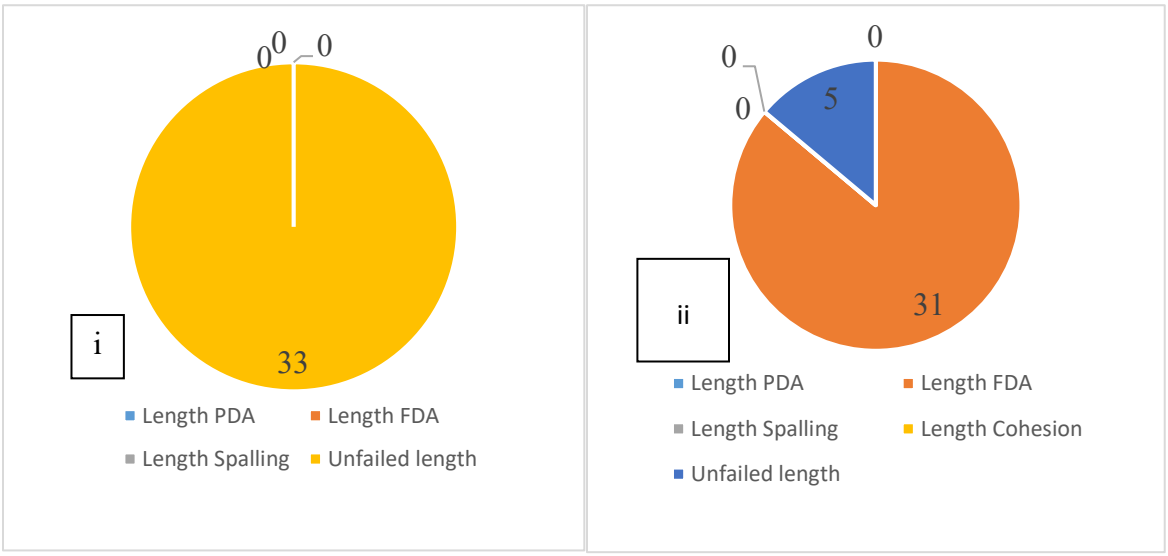
Site inspections following installation have shown that this site is experiencing about 25% of the total length of the seal to be suffering from partial-depth adhesion failure. Three cracks with rout-and-seal have performed slightly better than the other three with clean-and-seal.

Seal performance at Site M after Second Winter

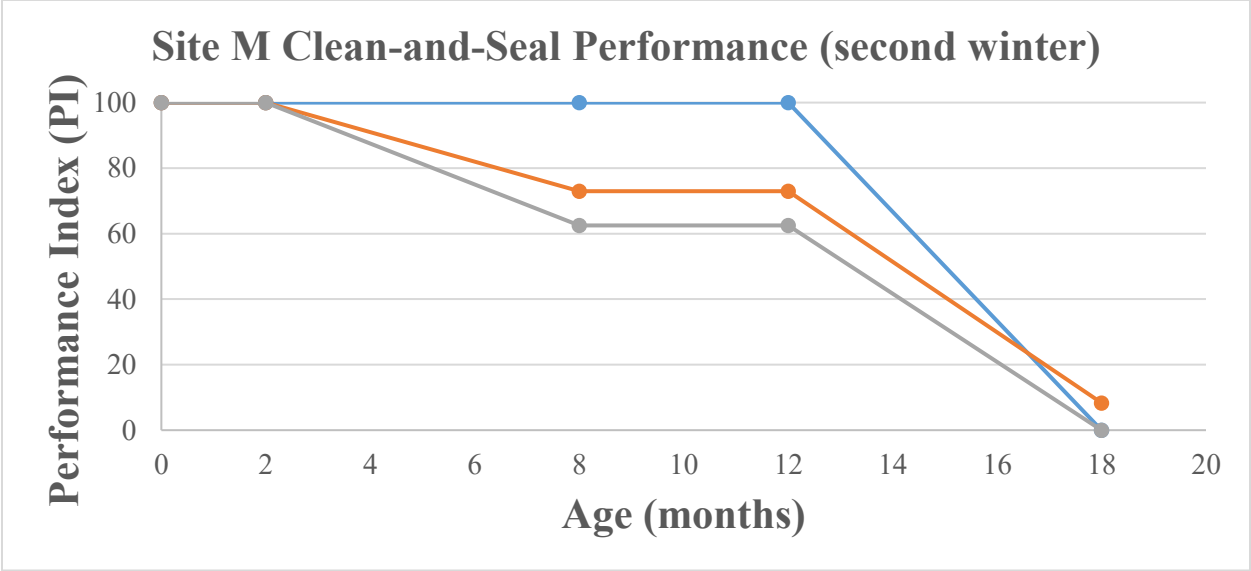
Site M Performance (end of 2nd Winter)							
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Length Cohesion	Unfailed length	Performance Index
Clean-and-Seal							
M-1	12	0	12	0	0	0	0.00
M-2	12	0	11	0	0	1	12.00
M-3	12	0	12	0	0	0	5.50
sum	36	0	35	0	0	1	5.83
Rout-and-Seal							
M-4	12	0	10.75	0	0	1.25	3.00
M-5	12	0	10.75	0	0	1.25	20.50
M-6	12	0	9.5	0	0	2.5	0.00
sum	36	0	31	0	0	5	7.83



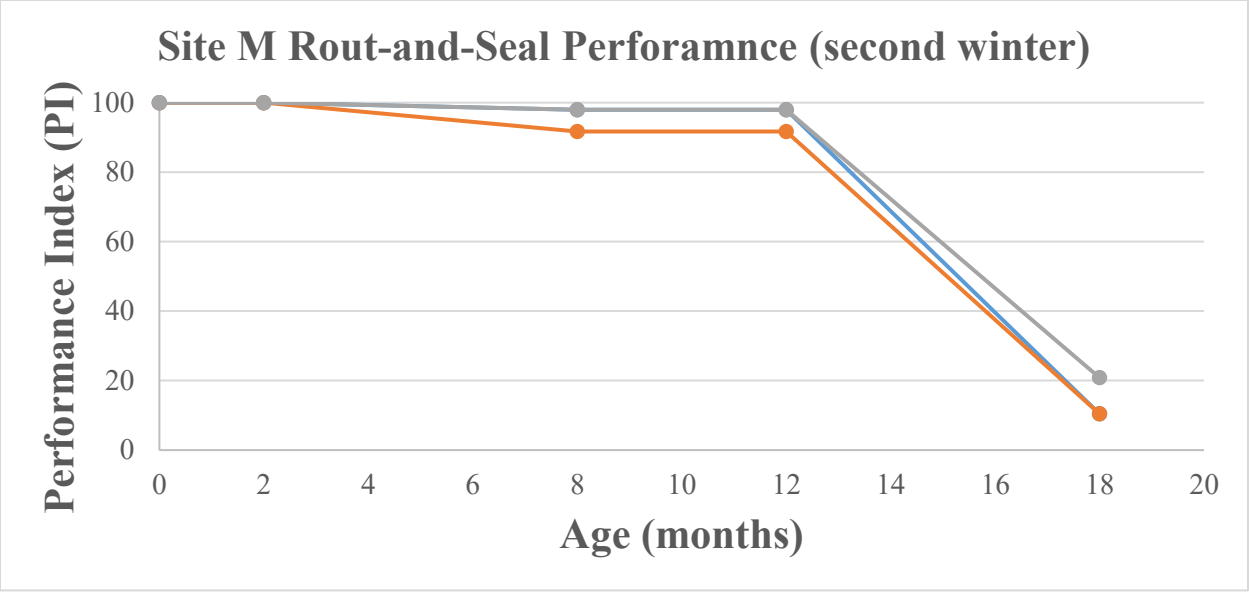
Site M Clean-and-Seal Performance after First Winter (i) and Second Winter (ii)



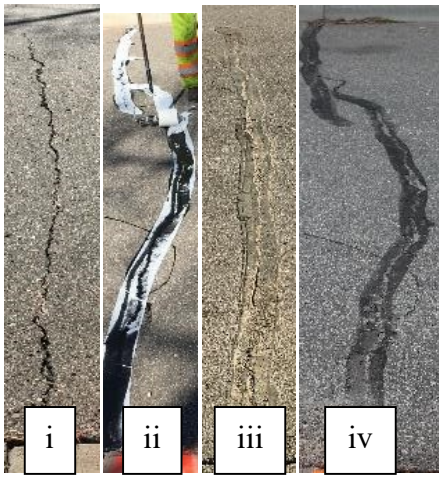
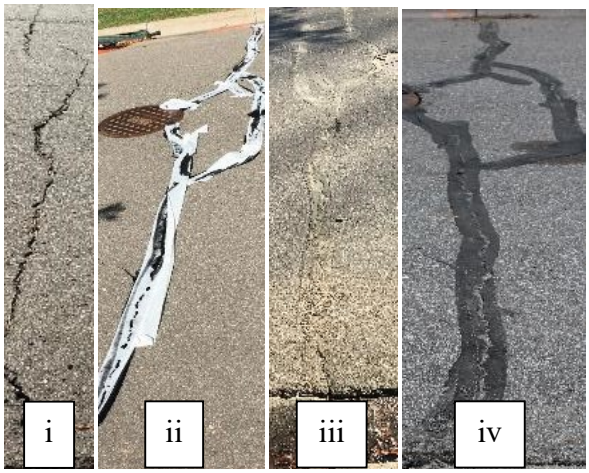
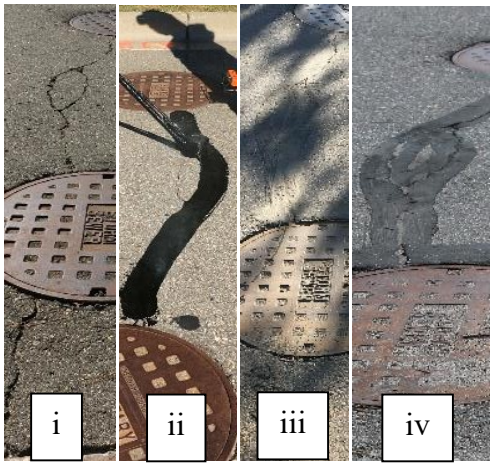
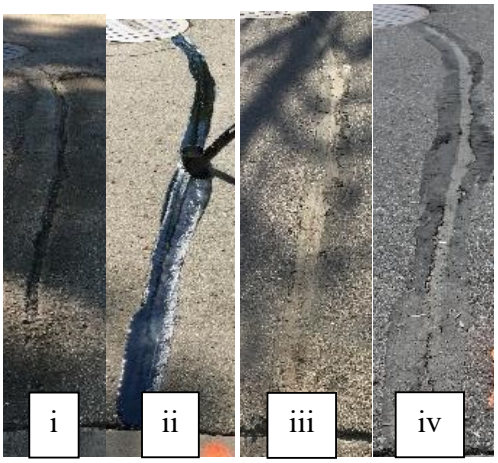
Site M Rout-and-Seal Performance after First Winter (i) and Second Winter (ii)

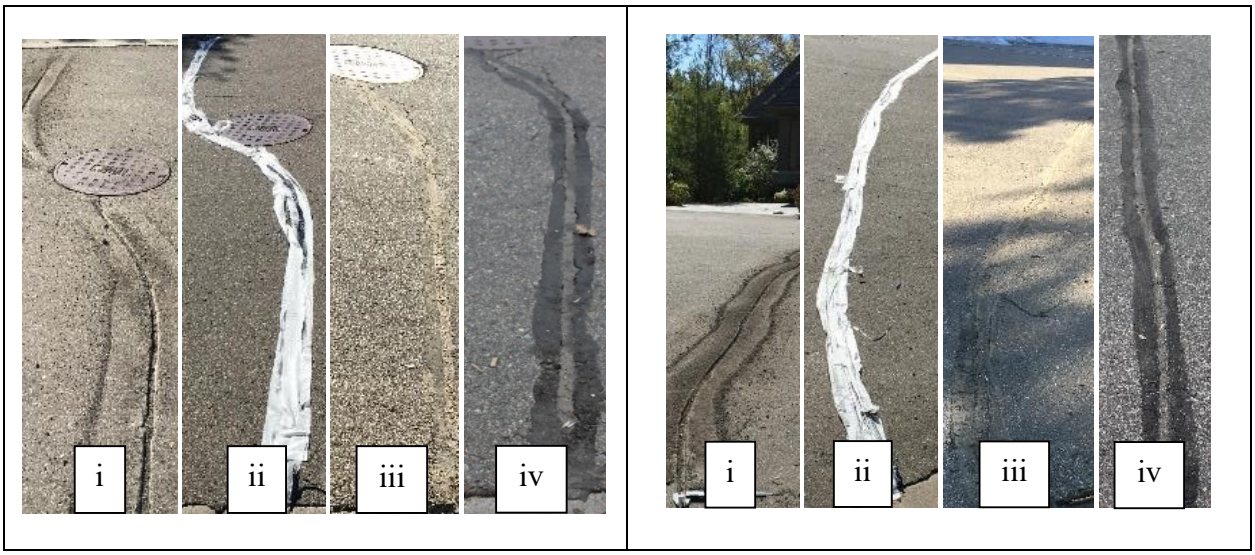


Performance Index at Site M after Second Winter (Clean-and-Seal)



Performance Index of Site M after Second Winter (Rout-and-Seal)

M-1	M-2
	
M-3	M-4
	
M-5	M-6



Photographic performance documentation of Site M. M-1-i Shows Crack M-1 prior to being sealed. M-1-ii shows Crack M-1 immediately after being sealed. M-1-iii and M-1-iv show Crack M-1 at the end of its first and second winter after being sealed. M-1-This same sequence of photos follows for cracks M-2, M-3, M-4, M-5, and M-6.

Site N

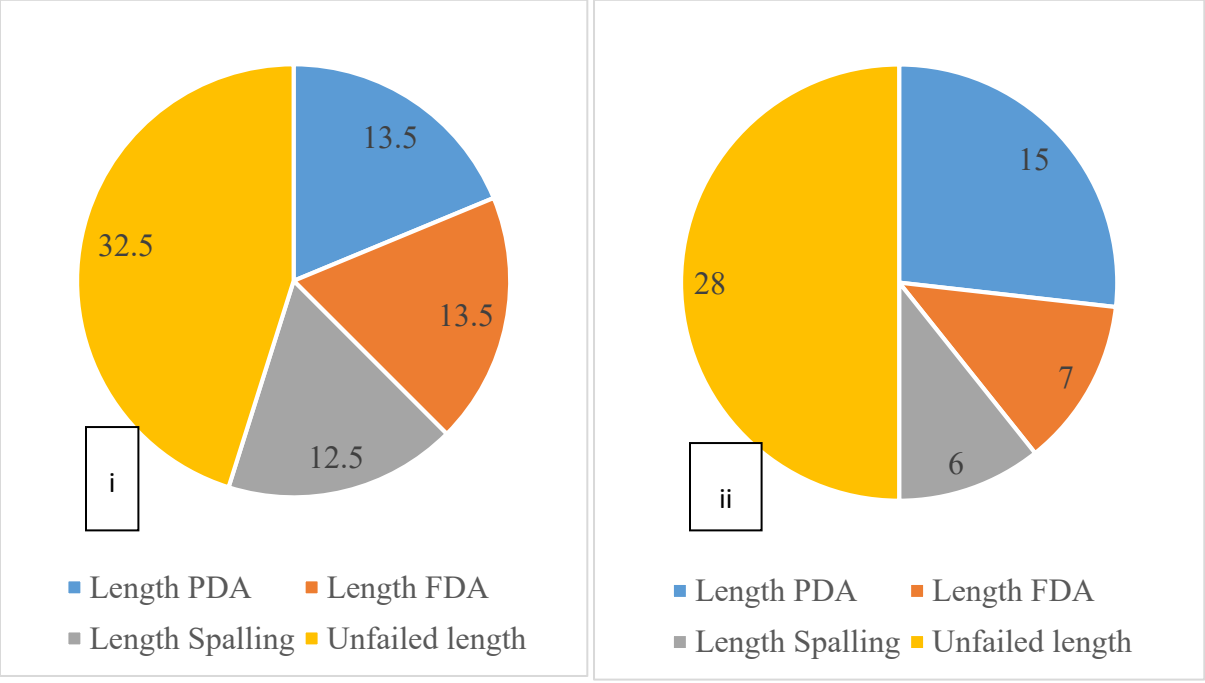
Site N lies along Holliday Road near the intersection of Excelsior Blvd in Minnetonka, MN, again a residential street. Traffic data was unable to be located for this site. The general severity of the cracks at this site was low. The site contains 11 documented cracks. Ten of these cracks runs in the transverse direction of the pavement, while the other is a longitudinal crack. Three of the transverse cracks were sealed with clean-and-seal, while the remaining used rout-and-seal. The pavement structure at this location currently remains unknown. Site visit at the end of the first winter showed that the seals at this site are experiencing both adhesion and spalling failures. The tables and figures below within this subsection, Site N, provide details of the seal performance for the ten cracks considered in Site N.

Site N Cracks Documented

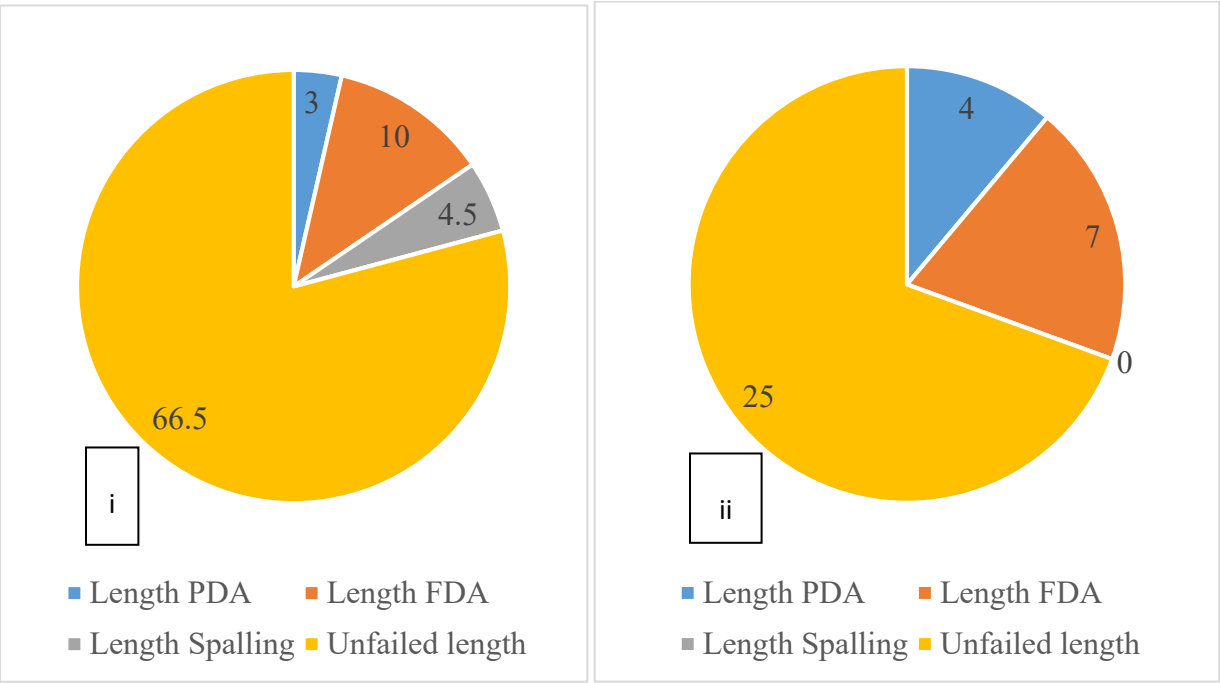
Site N						
ID#	Crack Location	Cack Type	AVG Width (mm)	Severity	AADT	Repair Type
N-1	Holliday Road	Thermal		low	NA	Clean-and-Seal
N-2	Holliday Road	Thermal		low	NA	Clean-and-Seal
N-3	Holliday Road	Thermal		low	NA	Clean-and-Seal
N-4	Holliday Road	Thermal		low	NA	Rout-and-Seal
N-5	Holliday Road	Longitudinal		low	NA	Clean-and-Seal
N-6	Holliday Road	Thermal		low	NA	Rout-and-Seal
N-7	Holliday Road	Thermal		low	NA	Rout-and-Seal
N-8	Holliday Road	Thermal		low	NA	Rout-and-Seal
N-9	Holliday Road	Thermal		low	NA	Rout-and-Seal
N-10	Holliday Road	Thermal		low	NA	Rout-and-Seal
N-11	Holliday Road	Thermal		low	NA	Rout-and-Seal

Seal Performance at Site N after First Winter

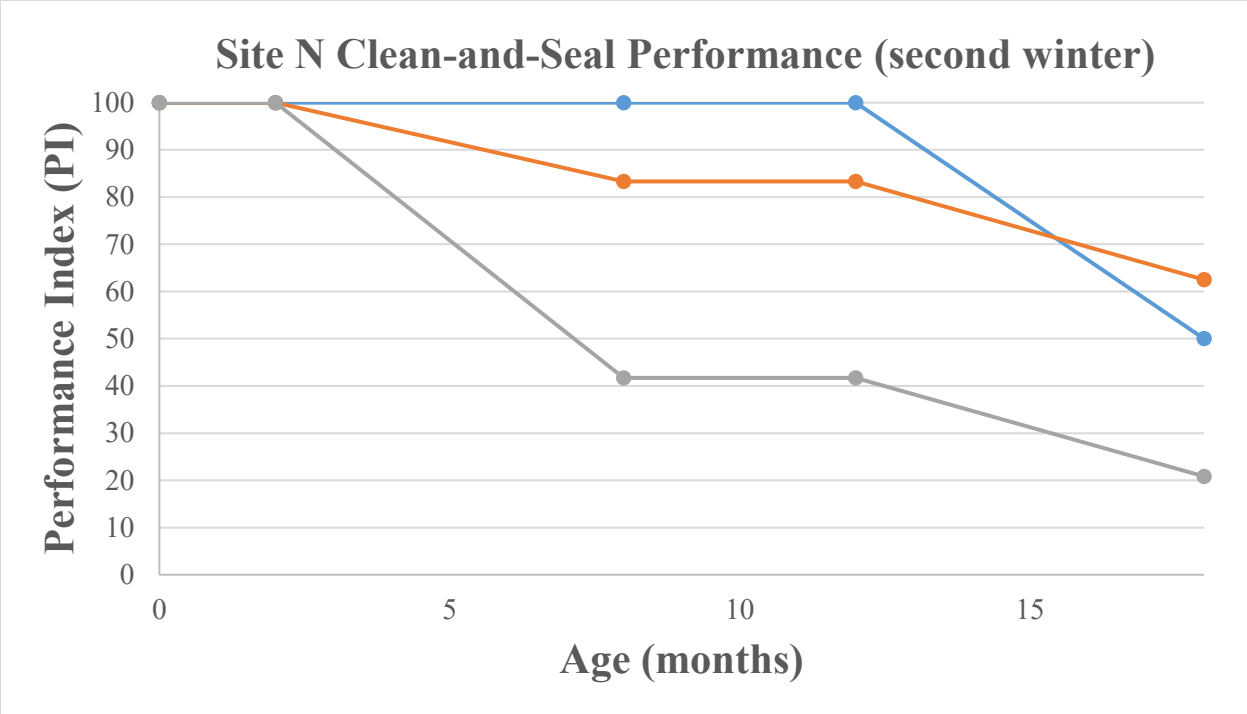
Site N Performance (2nd Winter) (Rout-and-Seal)						
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Unfailed length	Performance Index
N-4	12	0	10	0	2	17
N-6	12	3	1.5	2	5.5	58
N-7	12	3	2	3.5	3.5	42
N-8	12	1	0	1	10	88
N-9	12	4.5	0	0	7.5	63
N-10	12	2	0	6	4	42
N-11	12	x	x	x	x	x
sum	72	13.5	13.5	12.5	32.5	51
Site N Performance (2nd Winter) (Clean-and-Seal)						
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Unfailed length	Performance Index
N-1	12	0	0	6	6	50
N-2	12	9	0	0	3	63
N-3	12	5	7	0	0	21
N-5	20	1	0	0	19	100
sum	36	15	7	6	28	58



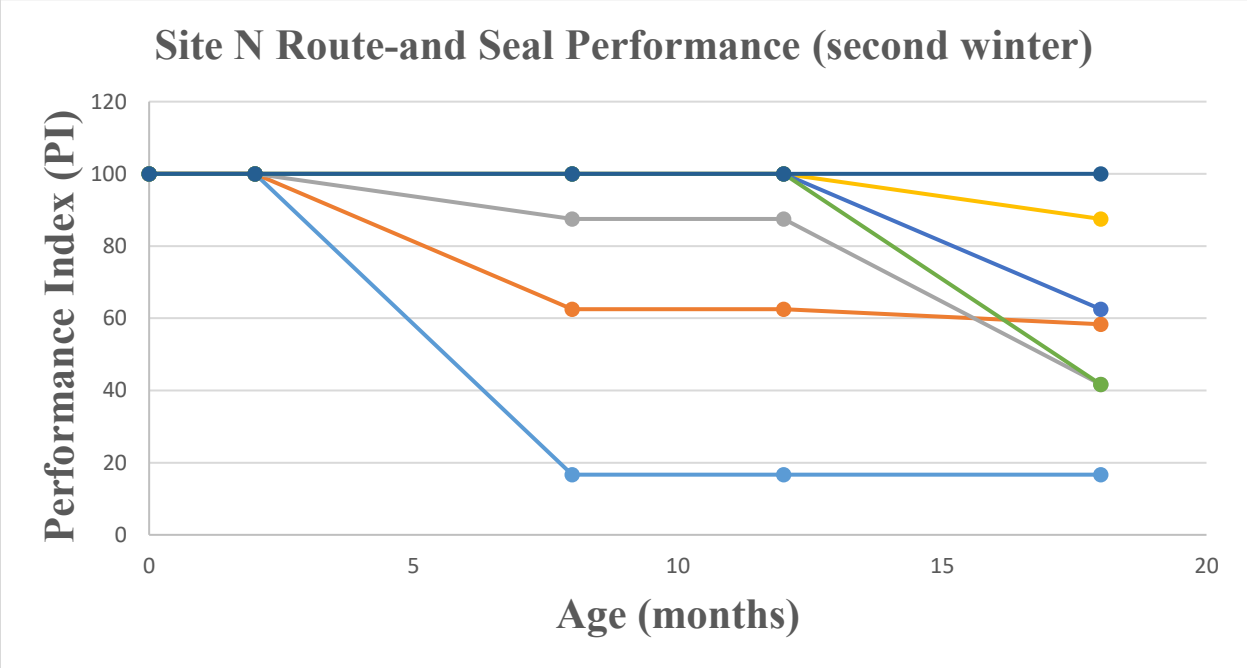
Site N Clean-and-Seal Performance After First Winter (i) and Second Winter (ii)



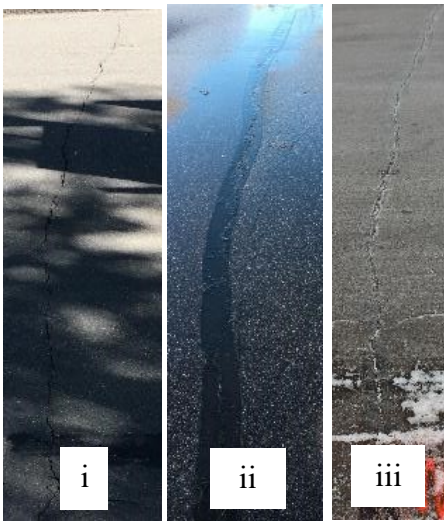
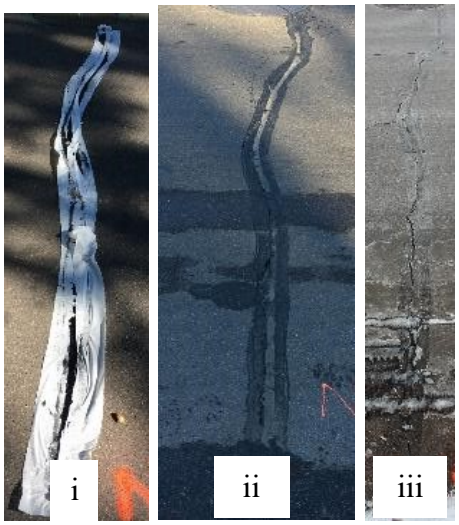
Site N Rout-and-Seal Performance After First Winter (i) and Second Winter (ii)

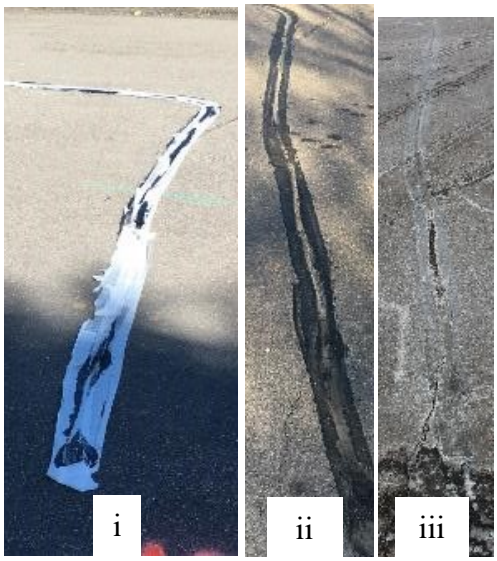
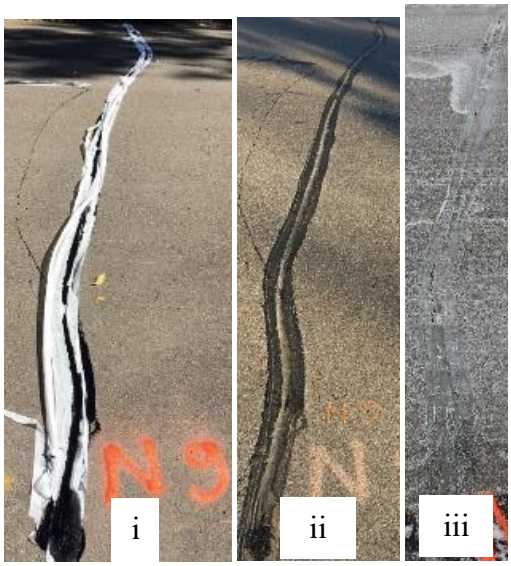


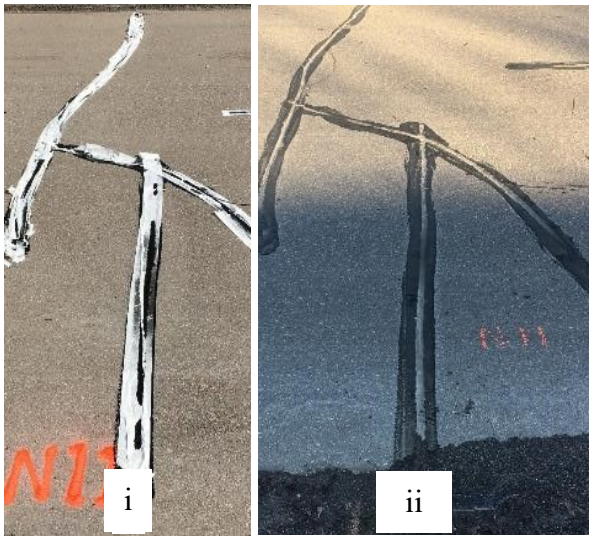
Performance Index at Site N after First Winter (Clean-and-seal)



Performance Index at Site N after First Winter (Rout-and-seal)

N-1	N-3
	
N-4	N-5
	
N-6	N-7

	
N-8	N-9
	
N-10	N-11



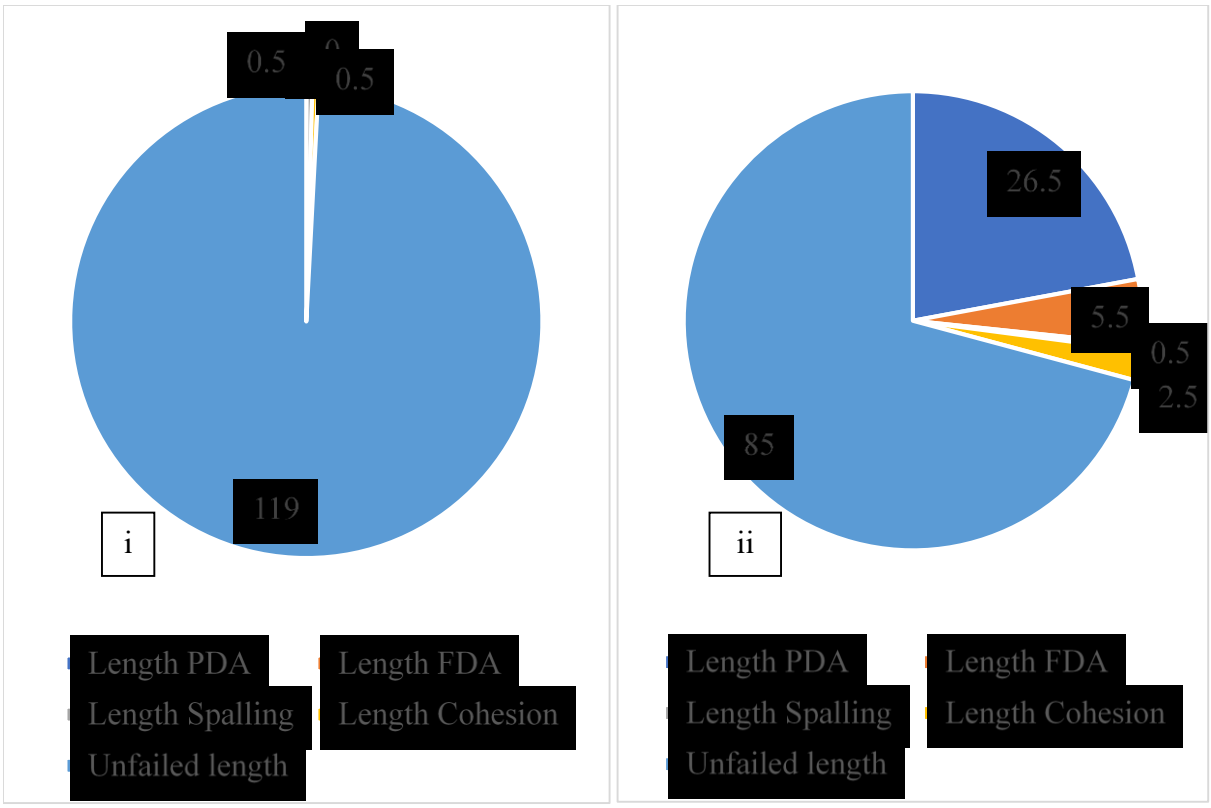
Photographic performance documentation of Site N. N-4-i shows Crack N-4 immediately after being sealed. N-4-ii and N-4-iii show crack N-4 after the first and second winter since being sealed. This same sequence follows for cracks N-5, N-6, N-7, N-8, N-9, and N-10. and N-11. N-1-i and N-2-ii show crack N-1 after being sealed and during the second winter. N-3-I shows Crack N-3 before being sealed. N-11 is shows immediately after being sealed and during the first winter.

Site O

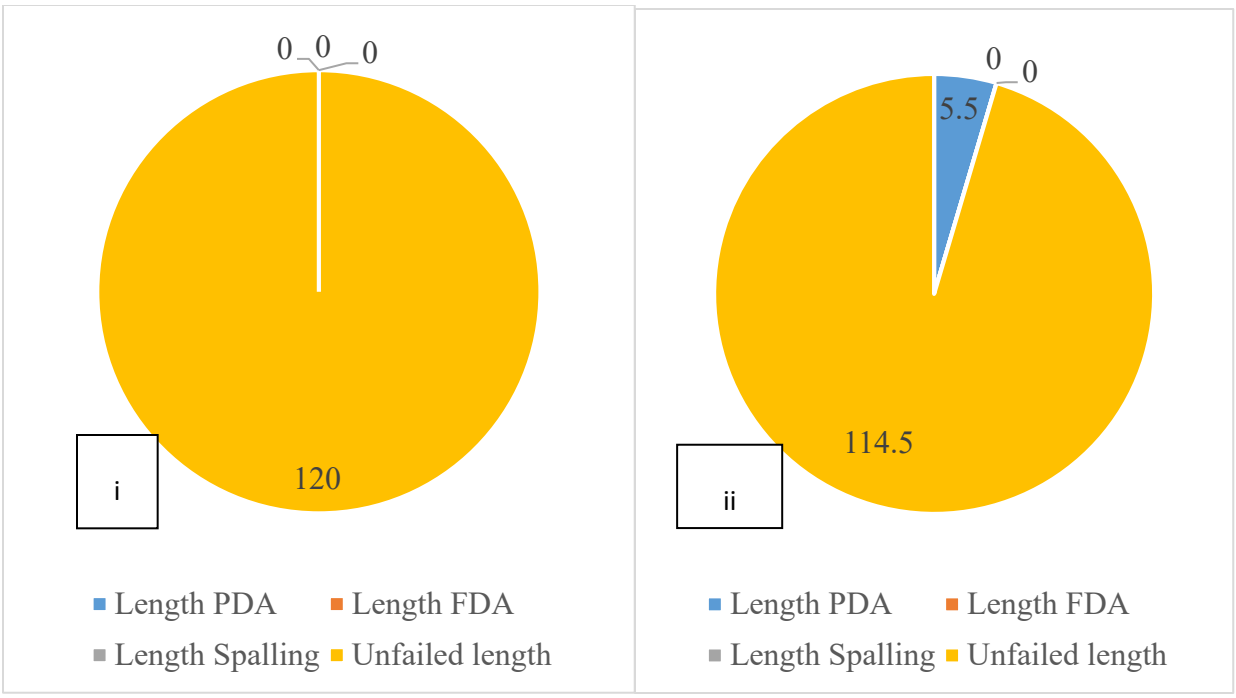
Site O lies on CR 10 in Koochiching County, MN. The site consists of 20 documented cracks. All cracks run in the transverse direction. Ten of the twenty were sealed with clean-and-seal. The remaining ten were sealed with rout-and-seal. This is a rural section of road. The AADT is around 100, and no construction history was found. The pavement surface appears to be quite old though. The tables and figures below within this subsection, Site O, provide details of the seal performance for the 20 cracks considered in Site O.

Site O							
ID#	**Crack Location**	**Cack Type**	**AVG Width (mm)**	**Severity**	**AADT**	**Repair Type**	**Sealant Material**
O-1	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-2	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-3	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-4	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-5	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-6	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-7	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-8	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-9	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-10	**CR 10**	thermal		**med**	**80**	Clean-and-Seal	
O-11	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	
O-12	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	
O-13	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	
O-14	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	
O-15	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	
O-16	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	
O-17	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	
O-18	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	
O-19	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	
O-20	**CR 10**	thermal		**med**	**80**	Rout-and-Seal	

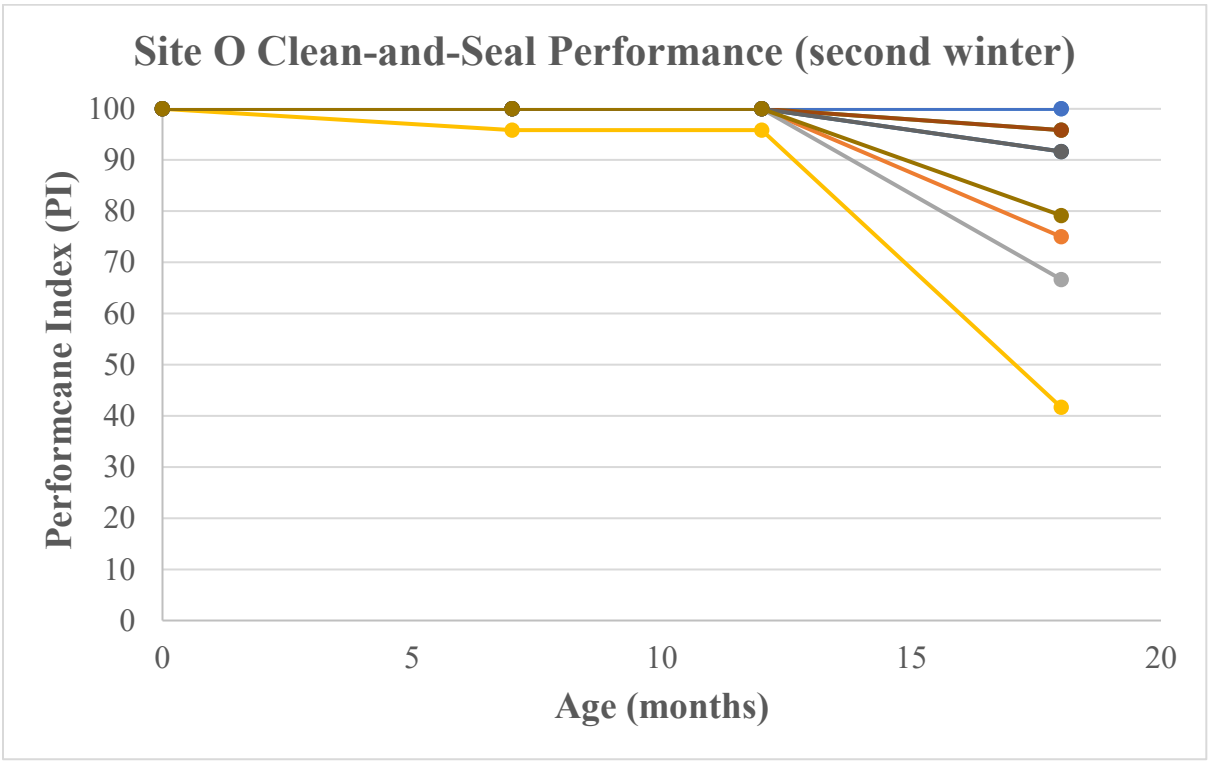
Site O Performance (end of 2nd Winter) (clean-and-seal)							
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Length Cohesion	Unfailed length	Performance Index
O-1	12	0	0	0	0	12	100.0
O-2	12	6	0	0	0	6	75.0
O-3	12	8	0	0	0	4	66.7
O-4	12	2	5.5	0.5	1	3	41.7
O-5	12	3	0	0	1	8	100.0
O-6	12	1	0	0	0	11	95.8
O-7	12	2	0	0	0	10	91.7
O-8	12	1	0	0	0	11	95.8
O-9	12	1	0	0	0	11	91.7
O-10	12	2.5	0	0	0.5	9	79.2
sum	120	26.5	5.5	0.5	2.5	85	83.8
Site O Performance (end of 2nd Winter) (rout-and-seal)							
Crack ID	crack length	Length PDA	Length FDA	Length Spalling	Length Cohesion	Unfailed length	Peformance Index
O-11	12	0	0	0	0	12	100.0
O-12	12	0	0	0	0	12	100.0
O-13	12	1	0	0	0	11	95.8
O-14	12	0	0	0	0	12	100.0
O-15	12	0	0	0	0	12	100.0
O-16	12	1	0	0	0	11	95.8
O-17	12	1	0	0	0	11	95.8
O-18	12	1.5	0	0	0	10.5	93.8
O-19	12	0	0	0	0	12	100.0
O-20	12	1	0	0	0	11	99.5
sum	120	5.5	0	0	0	114.5	98.1

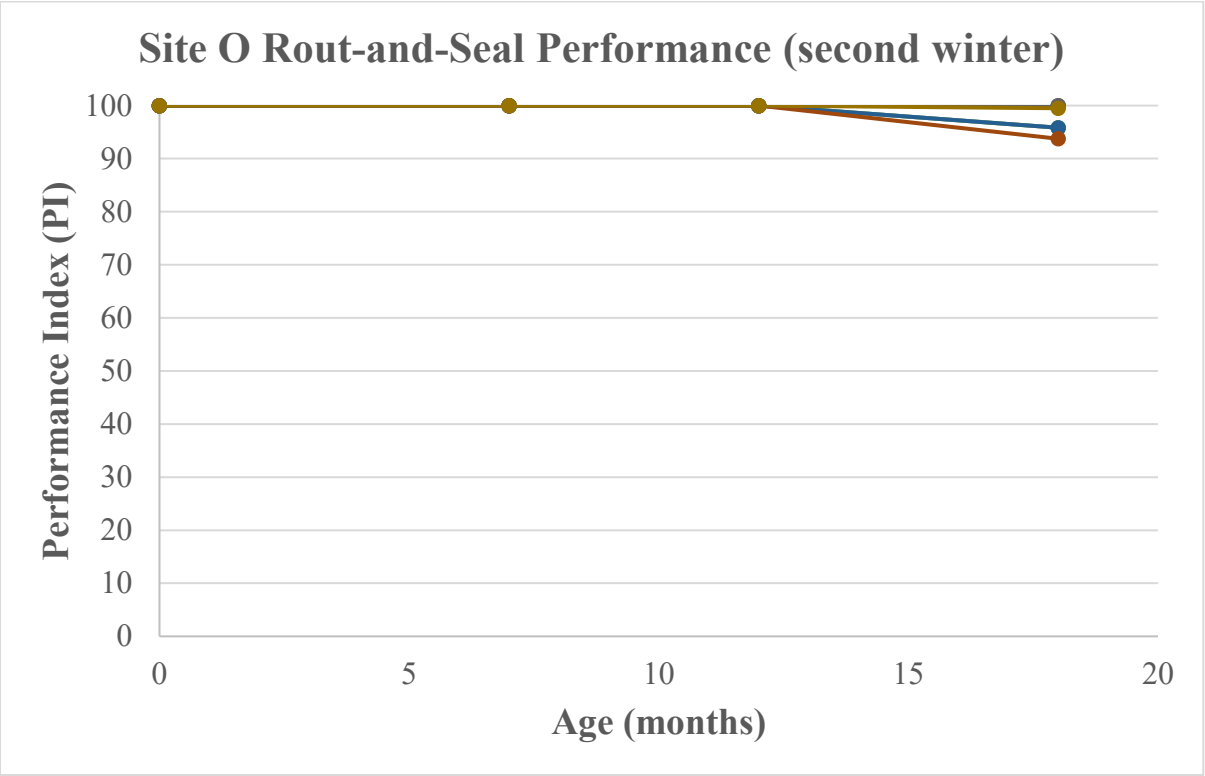


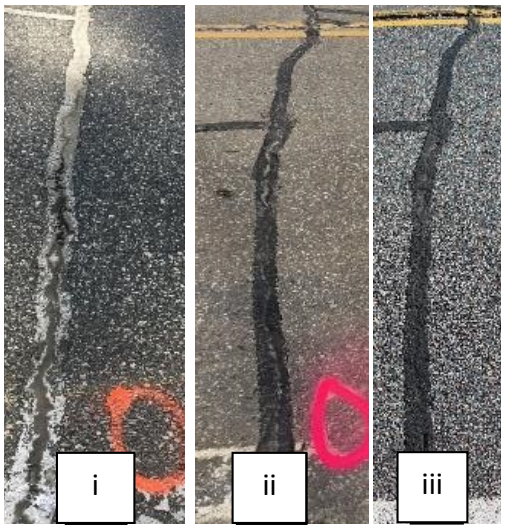
Site O Clean-and-Seal Performance After First Winter (i) and Second Winter (ii)

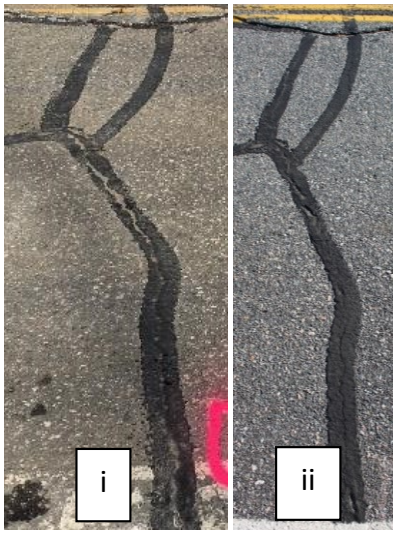


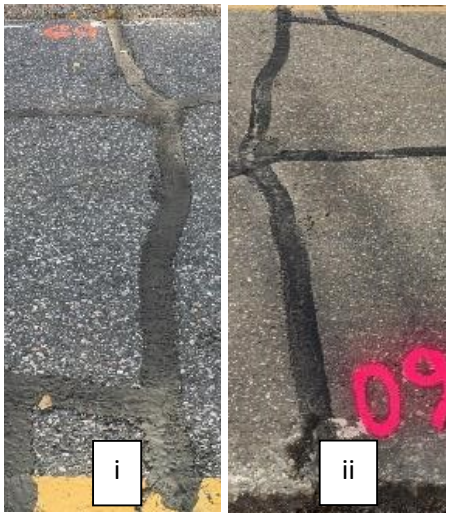
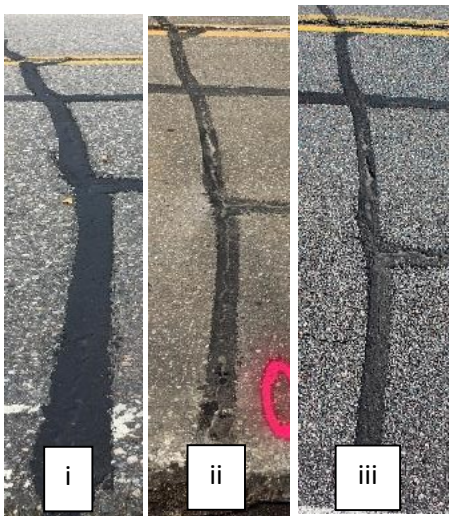
Site O Rout-and-Seal Performance After First Winter (i) and Second Winter (ii)

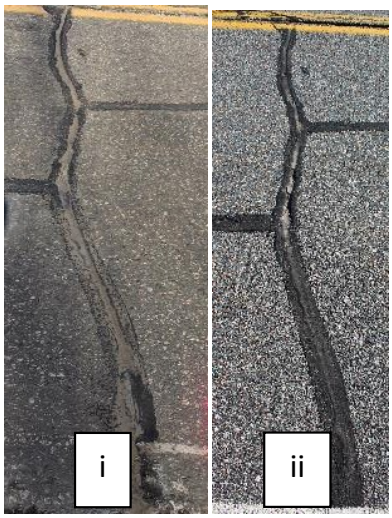


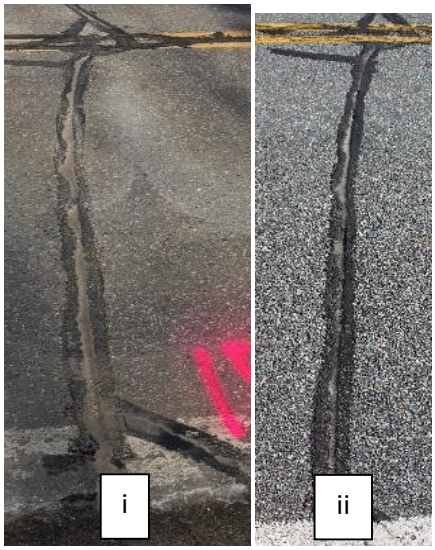

Site O Rout-and-Seal Performance (second winter)
Performance Index (PI)
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
Age (months)

O-1	O-2
	
O-3	O-4
 iv iii	
O-5	O-6

	
O-7	O-8
	
O-9	O-10

	
O-11	O-12
	
O-13	O-14

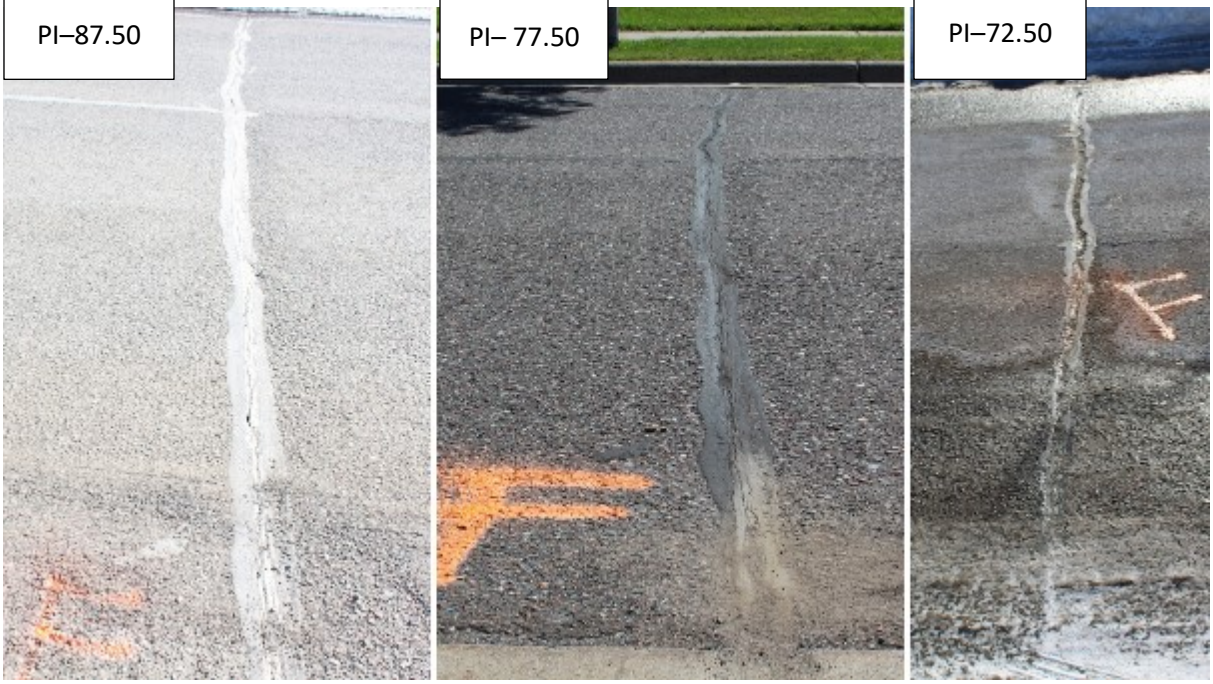
	
O-15	O-16
	
O-17	O-18



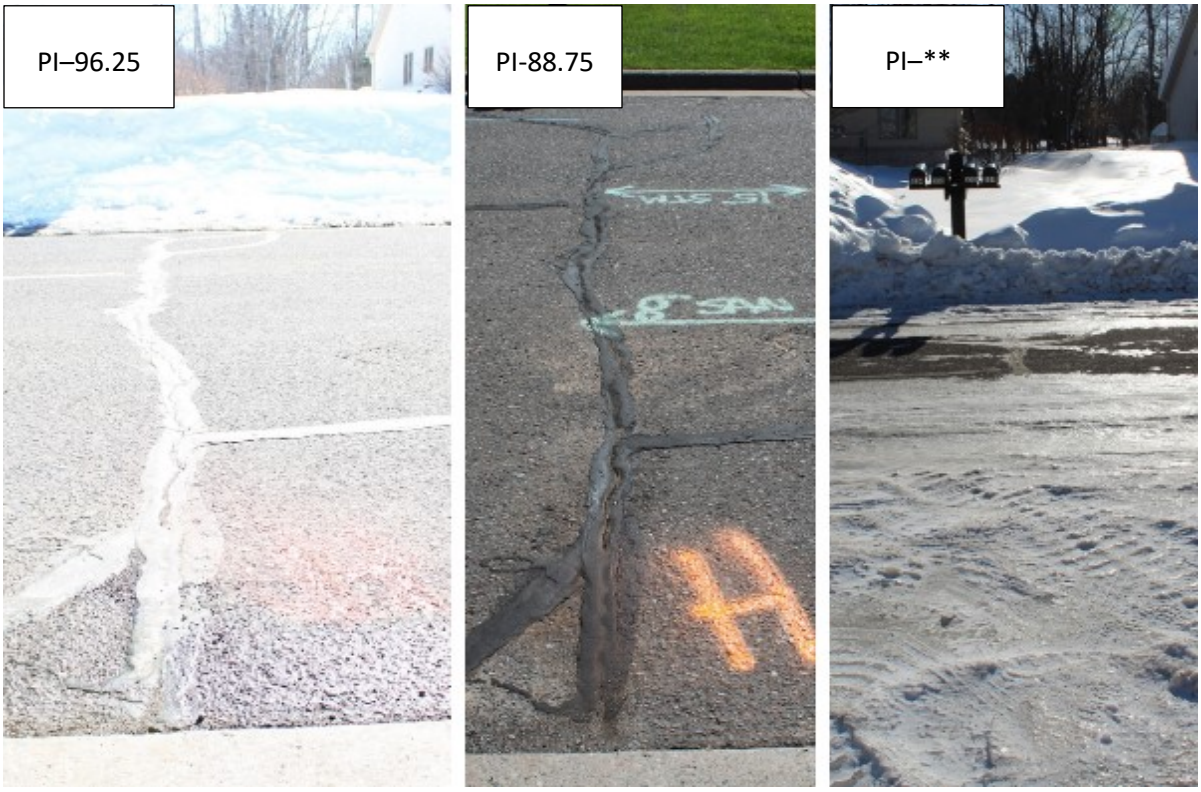
O-20

Photographic documentation of seal performance at Site O. O-2-i and O-2-ii show Crack O-2 during the first and second winter after being sealed. This same sequence follows for Cracks O-3, O-5, O-6, P-7, O-9, O-11, O-12, O-13, O-14, O-15, O-16, O-17, O-19, and O-20. Cracks O-1, O-8, and O-10 are shown a week after being sealed, then during the first and second winter. Crack O-4 is shown in this same manner, with the addition of a close-up of a spalling failure in image O-4-iii.

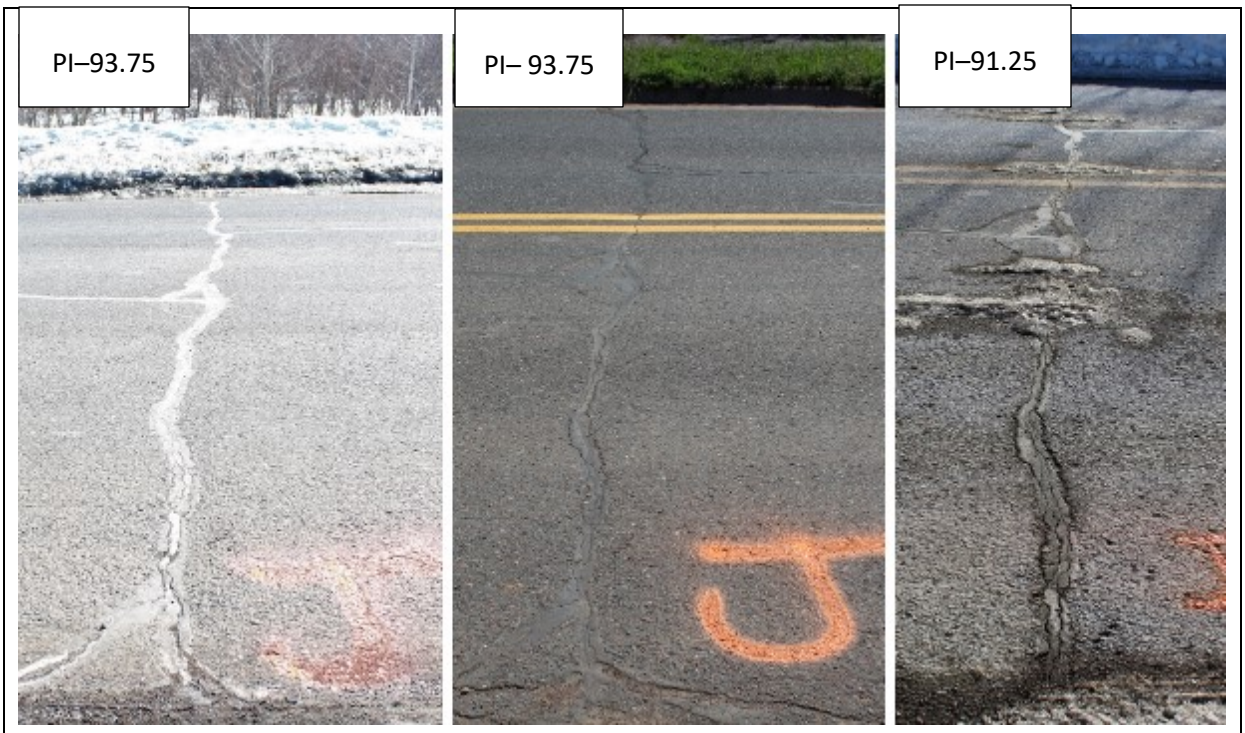
APPENDIX U: PERFORMANCE EVALUATION OF OLD CRACK SEALING PROJECTS (PHASE 4)



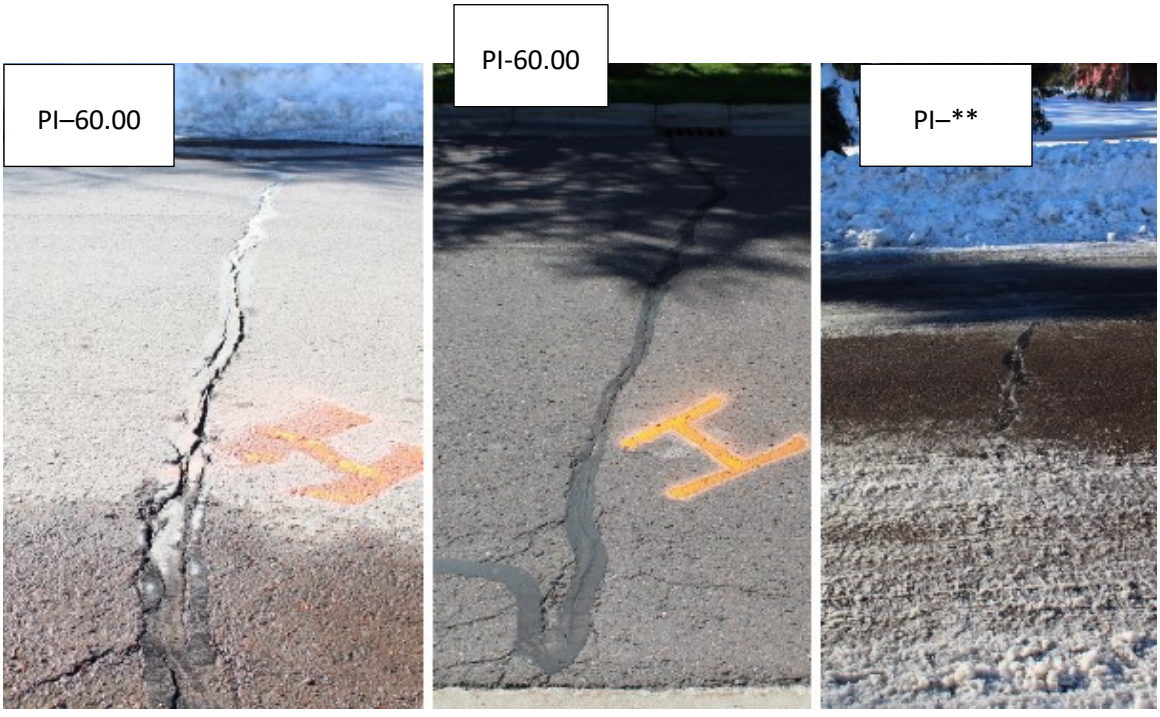
(a) Site F: Northridge Dr., Duluth; Crack Sealing Year - 2014



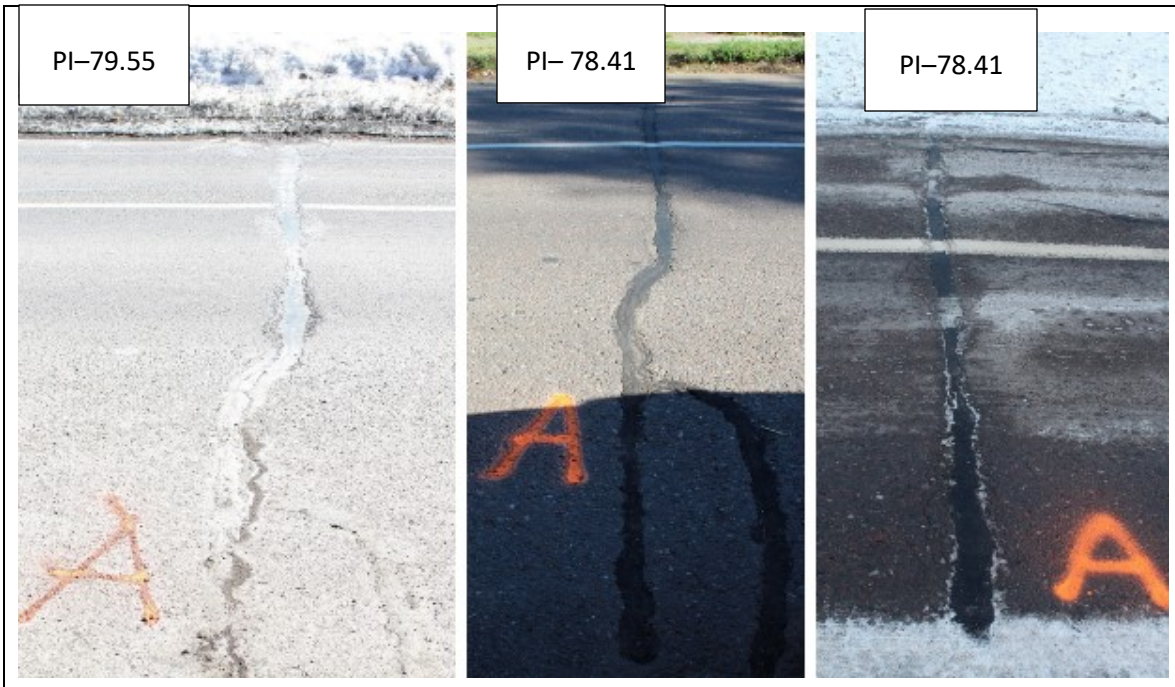
(b) Site H: Hickory St., Duluth; Crack Sealing Year – 2014; **Snow cover



(c) Site J: E Palm St., Duluth; Crack Sealing Year - 2014

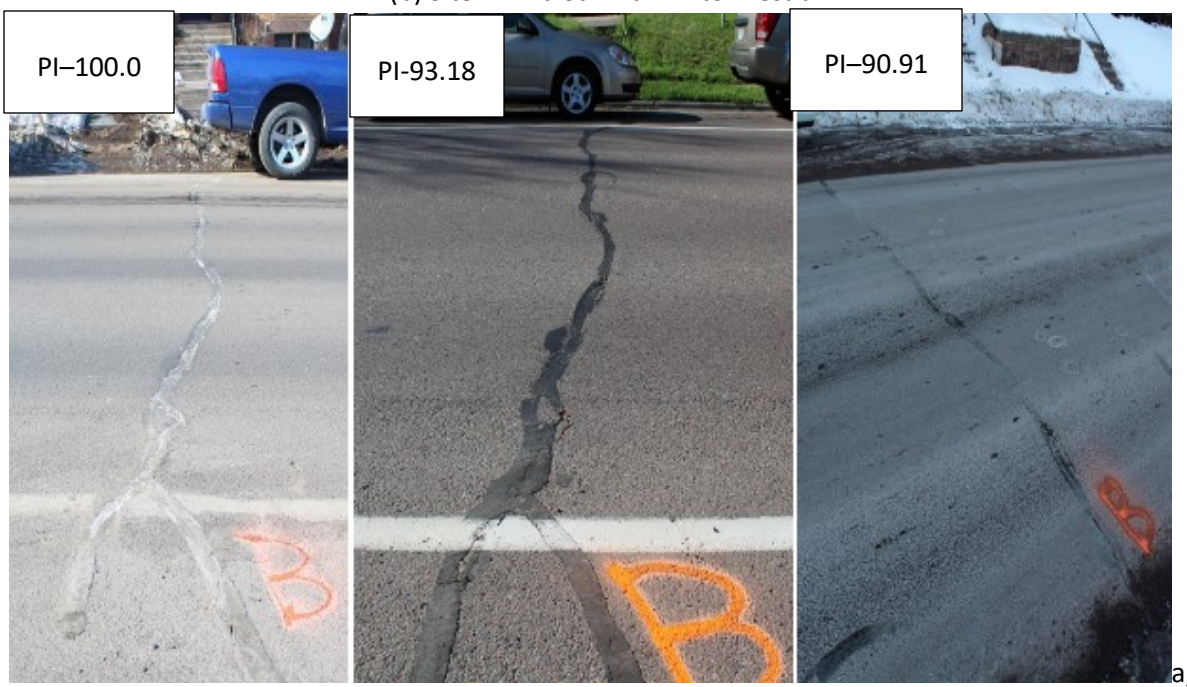


(d) Site I: S Blackman St., Duluth; Crack Sealing Year – 2014; **Snow cover



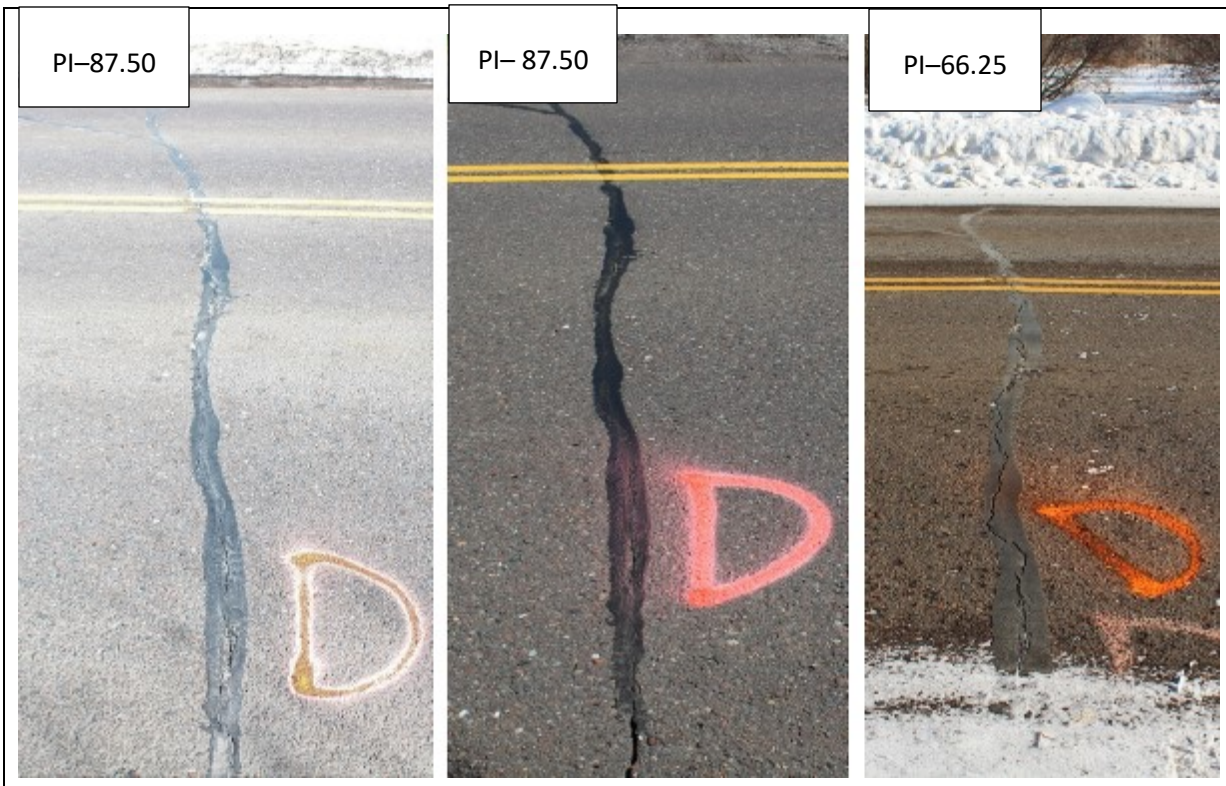
(e) Site A: 3rd St:21st AE to 1st AE, Duluth; Crack Sealing Year - 2014

(b) Site B: 2nd St: 24th AE to Mesab

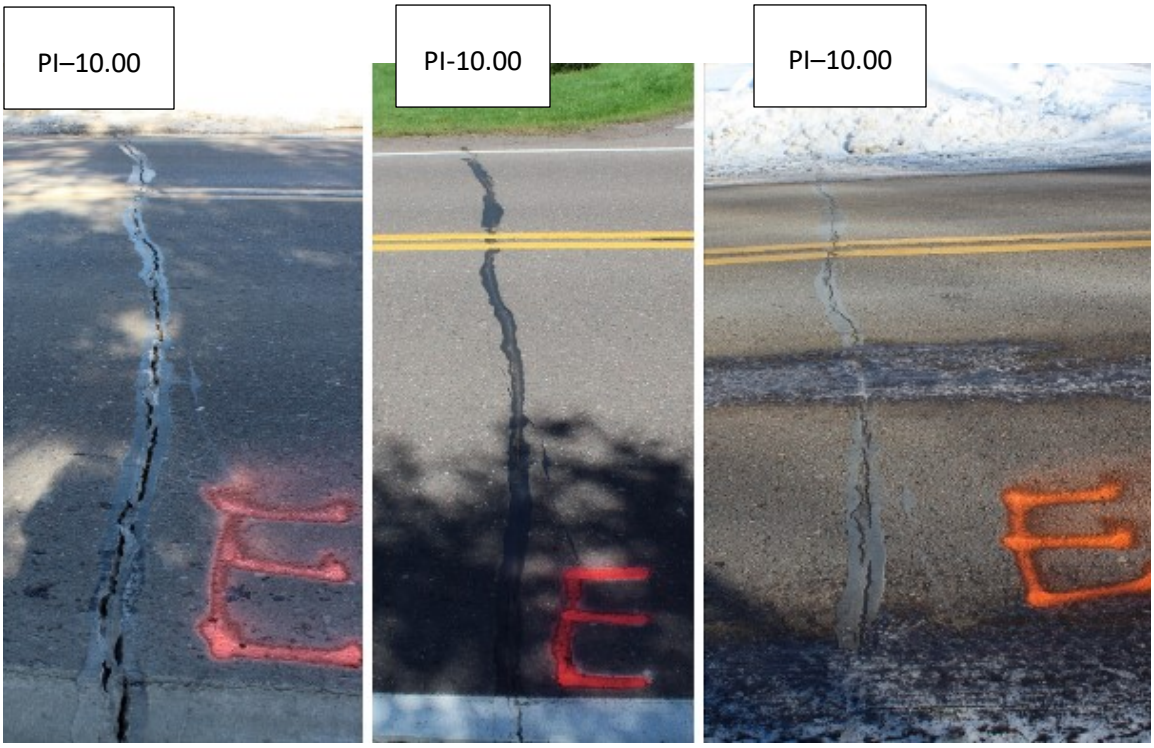


a, Duluth; Crack Sealing Year – 2014

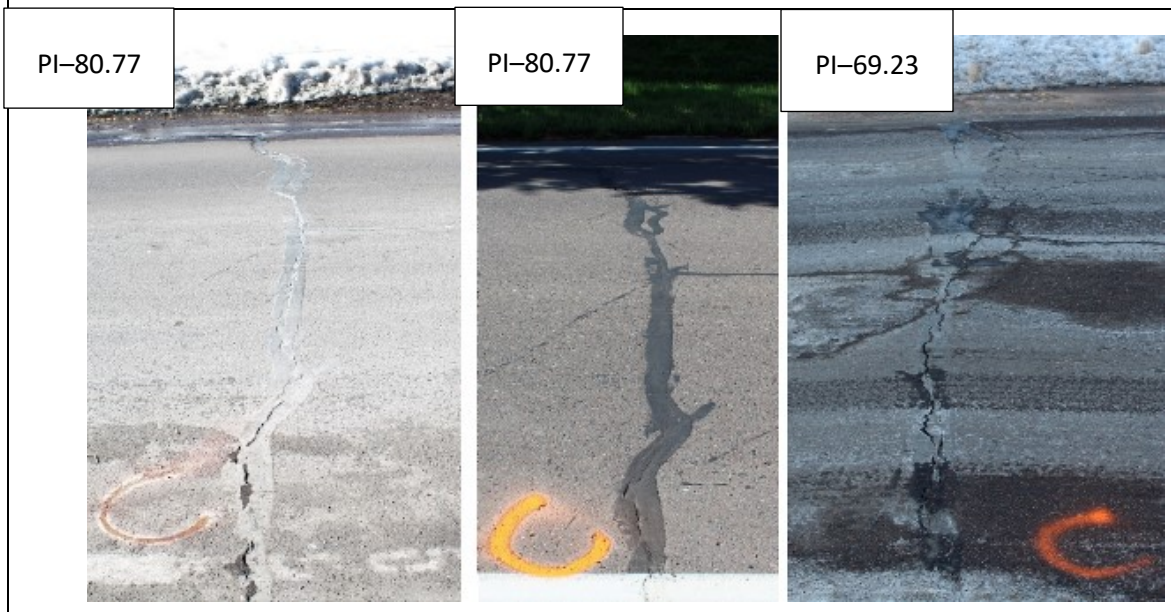
Pictures of Performance Evaluation: Old crack sealing sites of year 2014



(a) Site D: Sundby Rd., Duluth; Crack Sealing Year - 2015

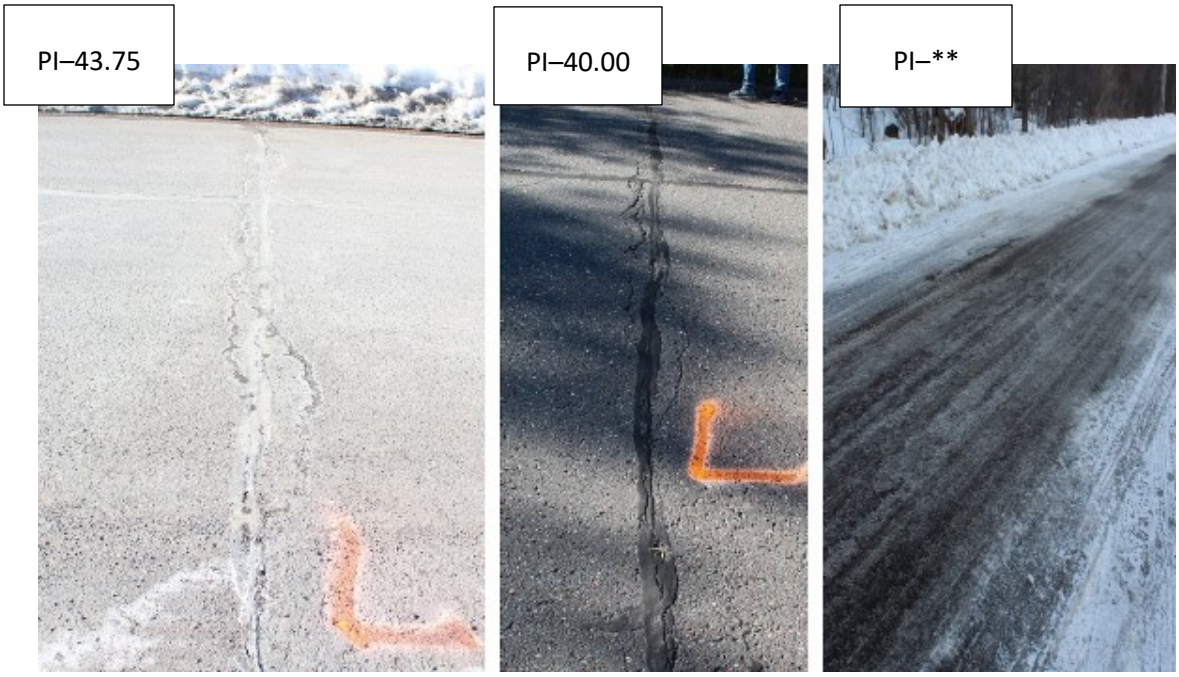


(b) Site E: Swan Lk Rd.: Arrowhead to Basswood., Duluth; Crack Sealing Year – 2015

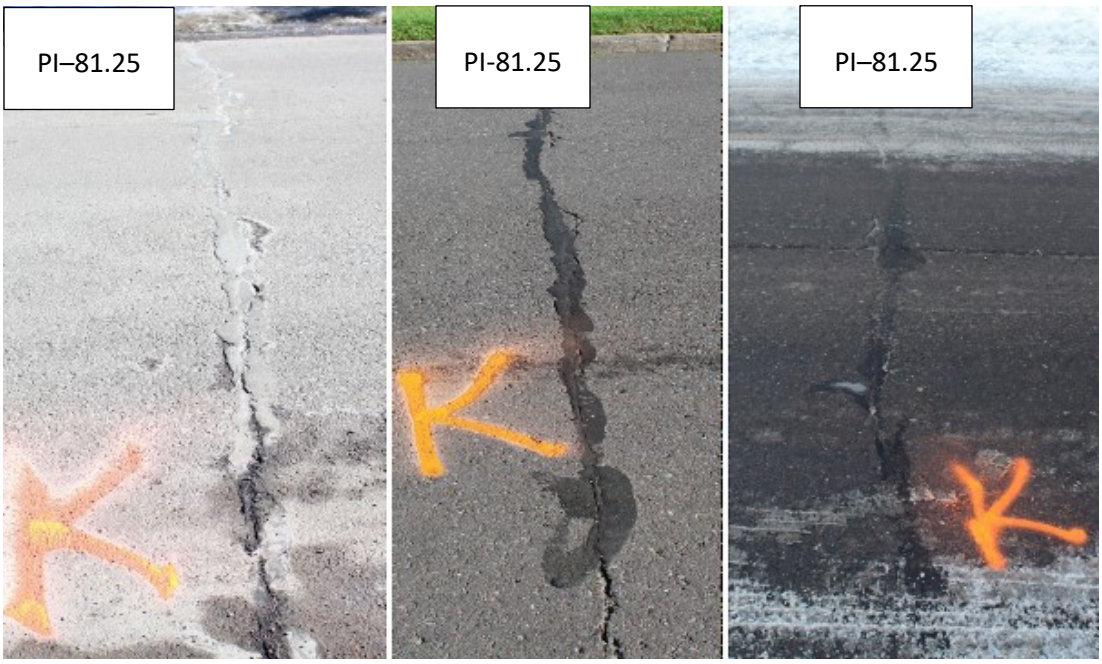


(c) Site C: 1st St.: 21AE-8th AE, Duluth; Crack Sealing Year - 2015

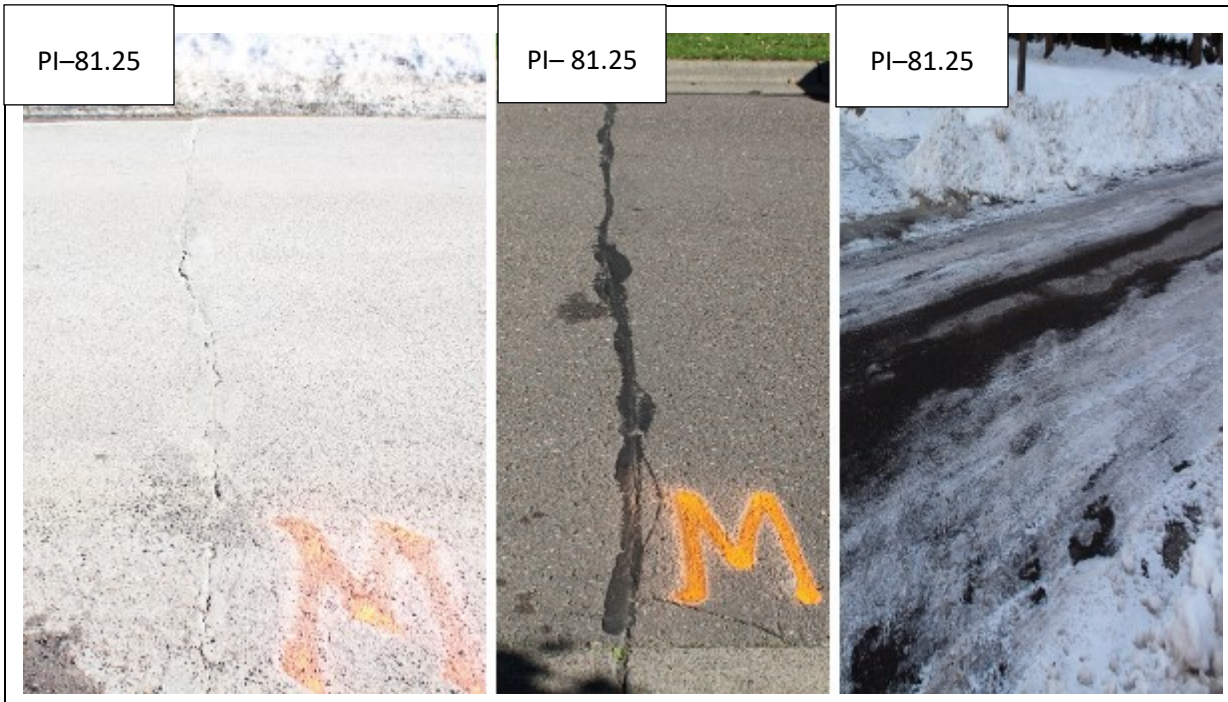
Pictures of Performance Evaluation: Old crack sealing sites of year 2015



(a) Site L: 1st St.: 24- 26 AE., Duluth; Crack Sealing Year – 2016;**Snow Cover



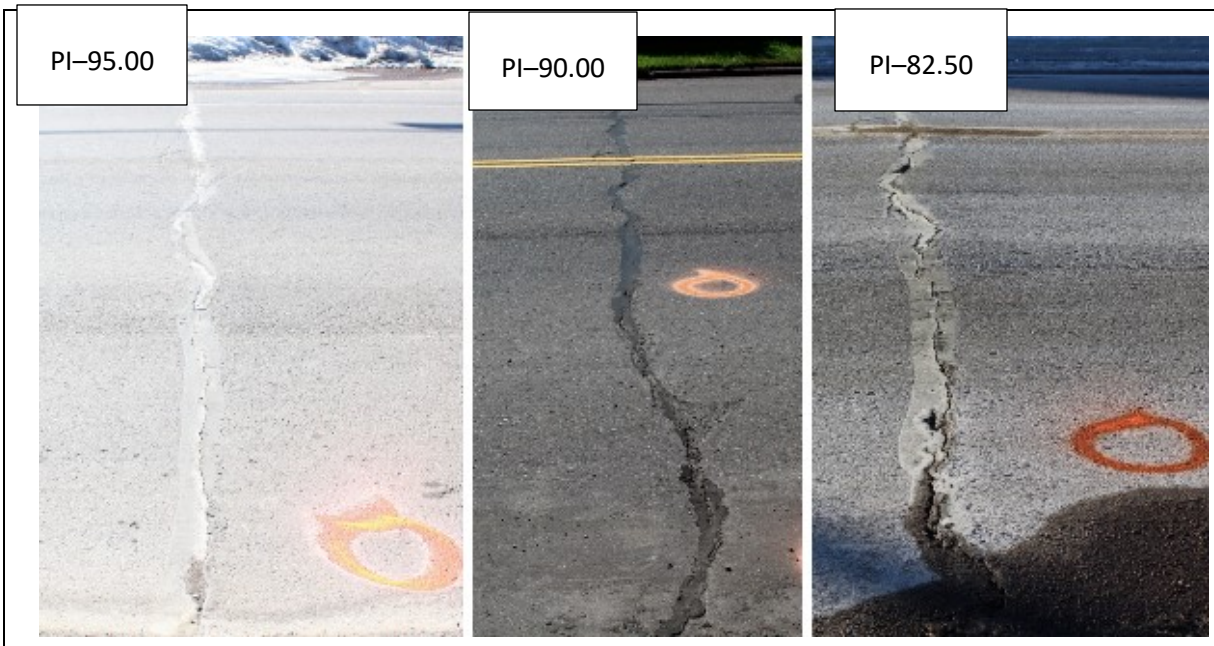
(b) Site K: 2nd St.: 24-26 AE, Duluth; Crack Sealing Year – 2016



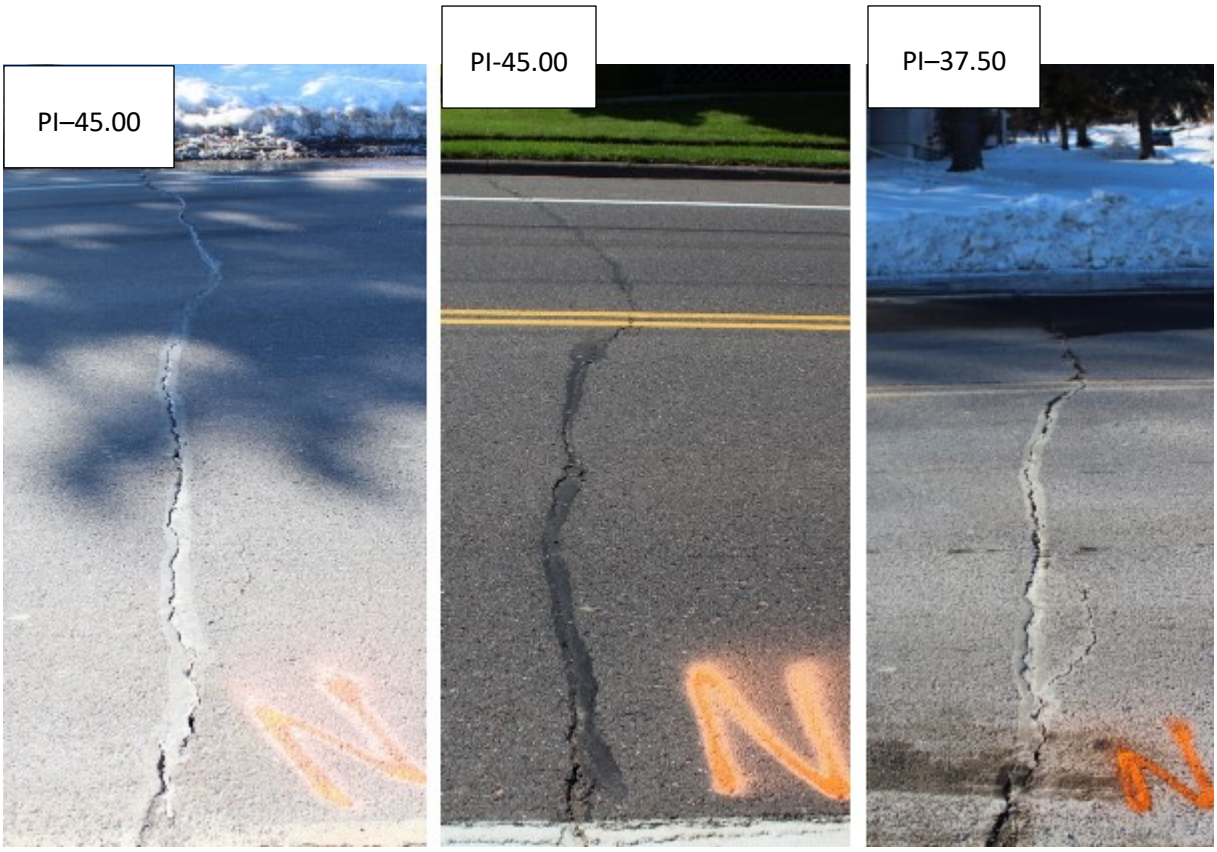
(c) Site M: 3rd St.: 24-26AE, Duluth; Crack Sealing Year - 2016

(d) Site Q: 43AE Glenwood to Superior St., Duluth; Crack Sealing Year – 2016

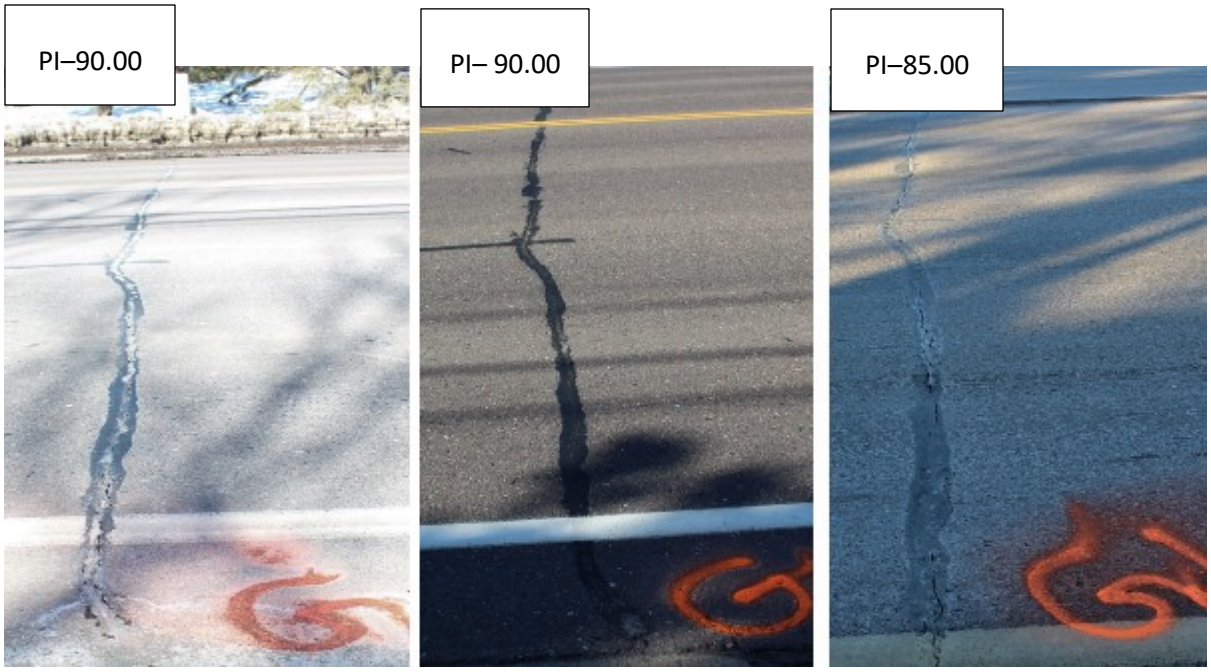
(e) Site P: 45AE Glenwood to Superior St., Duluth; Crack Sealing Year – 2016



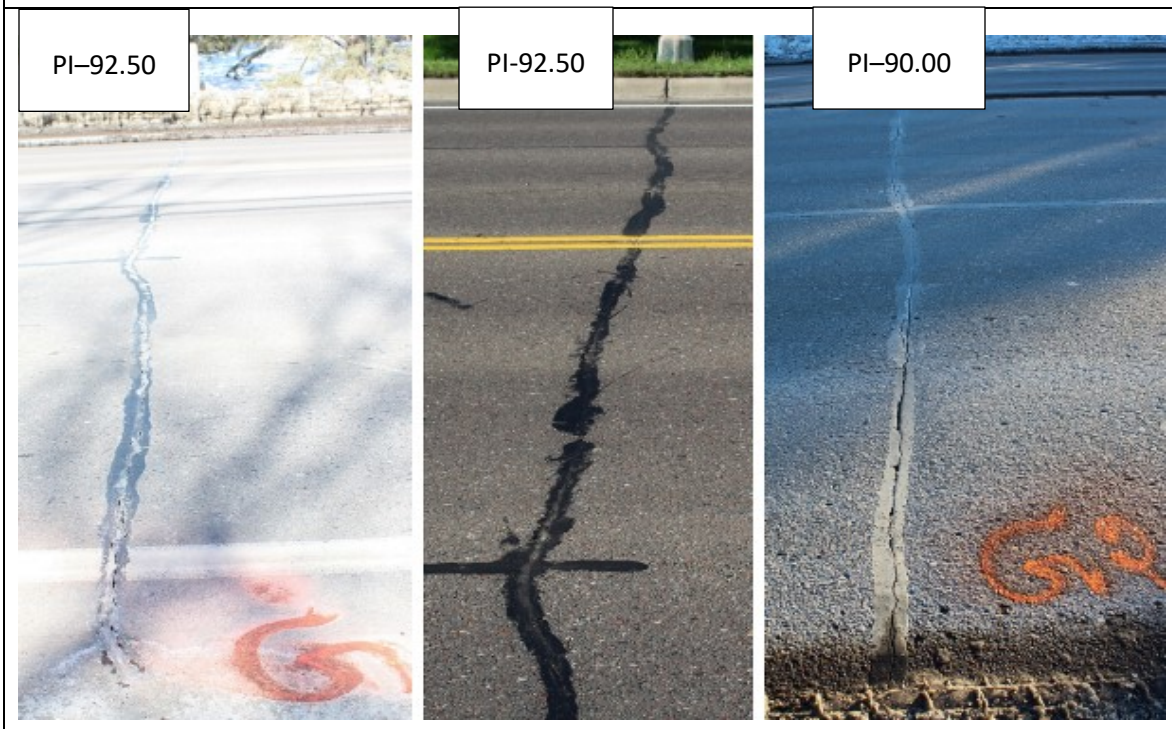
(f) Site O: 47AE Glenwood to Superior St., Duluth; Crack Sealing Year – 2016



(g) Site N: 52AE Oakley to Superior St., Duluth; Crack Sealing Year – 2016



(h) Site M: 3rd St.: 24-26AE, Duluth; Crack Sealing Year - 2016



(i) Site Q: 43AE Glenwood to Superior St., Duluth; Crack Sealing Year – 2016

Pictures of Performance Evaluation: Old crack sealing sites of year 2016