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EVALUATING ALL-WEATHER PAVEMENT MARKINGS IN ILLINOIS: VOLUME 2

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Evaluating All-Weather Pavement Marking Tape in Illinois

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16. Abstract
The project evaluated two pre-manufactured pavement marking tapes (380AW and XRP-R) over three winter seasons at two different Illinois DOT locations (central and southern Illinois). The two products were installed on I-80 within a recessed groove in contrast to IL-3 where they were rolled in with the last pass of the asphalt finishing machine. Retroreflectivity was measured under three standard conditions including dry, wet-recovery, and continuously wetted. The 380AW tape measured 148 mcd under continuously wetted conditions after 3 winters on I-80 and overall measured significantly higher than the XRP-R tape under the two wet conditions (recovery and continuously wetted). The XRP-R tape performed well under dry conditions; however, wet-recovery retroreflectivity was below 100 mcd (after initial conditions) and continuously wetted retroreflectivity did not exceed 100 mcd. Short of a minimum retroreflectivity threshold for wet conditions, these findings will support IDOT decision making in terms of product selection where trying to enhance safety through providing higher levels of wet night visibility. The findings also highlight the potential negative impacts on performance when rolling these products in as opposed to placing them within a groove.

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- Kelly Morse, (TRP Chair), IDOT, Bureau of Materials and Physical Research
- Thomas Schaefer, IDOT District 3
- Jeff Abel, IDOT District 8
- Kyle Armstrong, IDOT, Operations
- Filiberto Sotelo, IDOT, Safety Engineering
- Ryan Sheley, IDOT, Bureau of Construction
- Dean Mentjes, FHWA
- Field staff from IDOT Districts 3 Princeton Yard
- Field staff from IDOT District 8 Hecker Yard

EXECUTIVE SUMMARY

This project evaluated specialized pavement marking tapes which provide wet night visibility referred to as wet retroreflectivity. IDOT is considering using these new tapes on the white centerline skips on high-speed volume roadways. The evaluation considered pavement-marking performance in terms of retroreflectivity and durability over time and exposed to three winter seasons at two different locations (central and southern Illinois).

Installation

Approximately 1,000 feet of two different preformed, premanufactured, all-weather pavement-marking tapes (380AW and XRP-R) were installed on each of two different Illinois DOT roadways (I-80 and IL-3), see Figure 1 below. The two pavement-marking-tapes were added to active IDOT resurfacing contracts with the all-weather tapes on I-80 installed within a recessed groove versus the IL-3 tapes being rolled into the driving surface with the asphalt finishing machine.

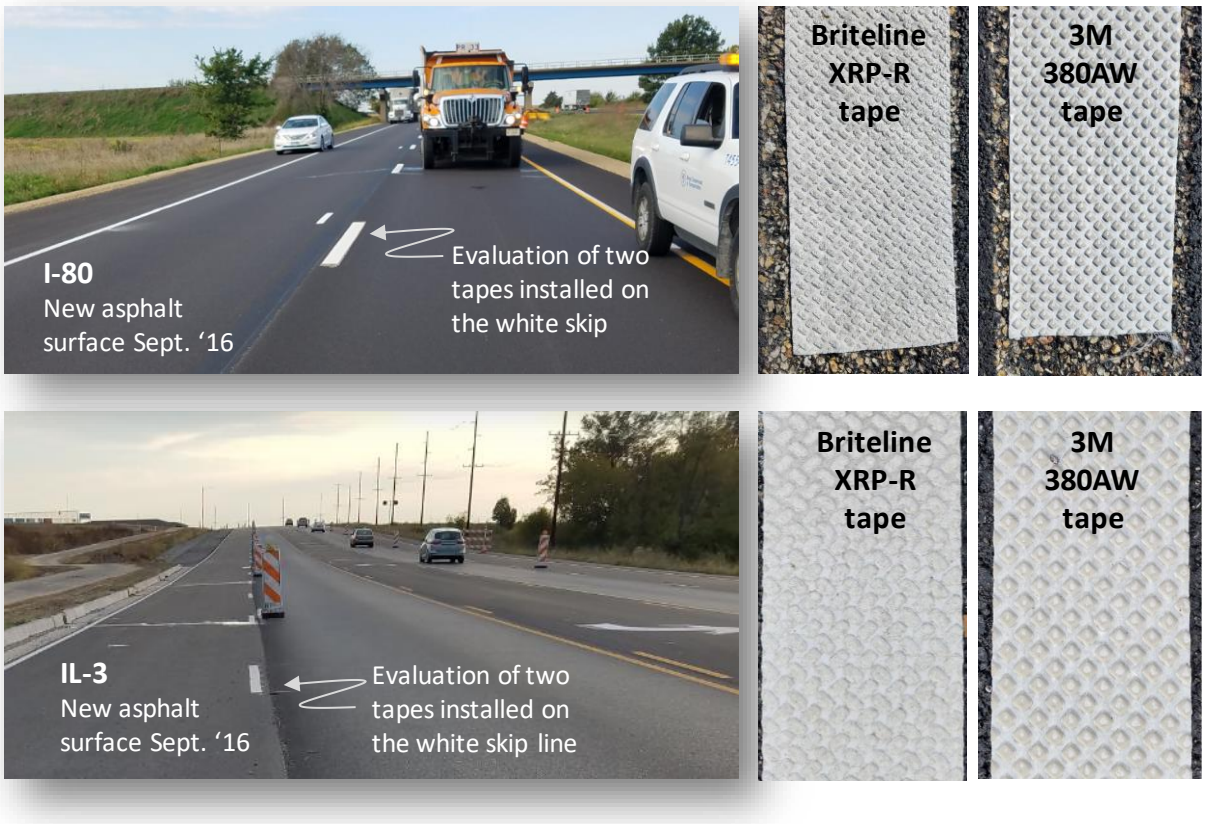

Figure 1. Installation information per test deck.

Performance

Pavement marking tape performance was evaluated over time and measured in terms of presence and retroreflectivity. Specific to presence, no missing pieces or sections were observed after three winters, however, there was both bead loss and deformation of the raised ridges that make up the profile of the tape materials. Figure 2 shows the tape conditions by roadway and product after 3-winters.

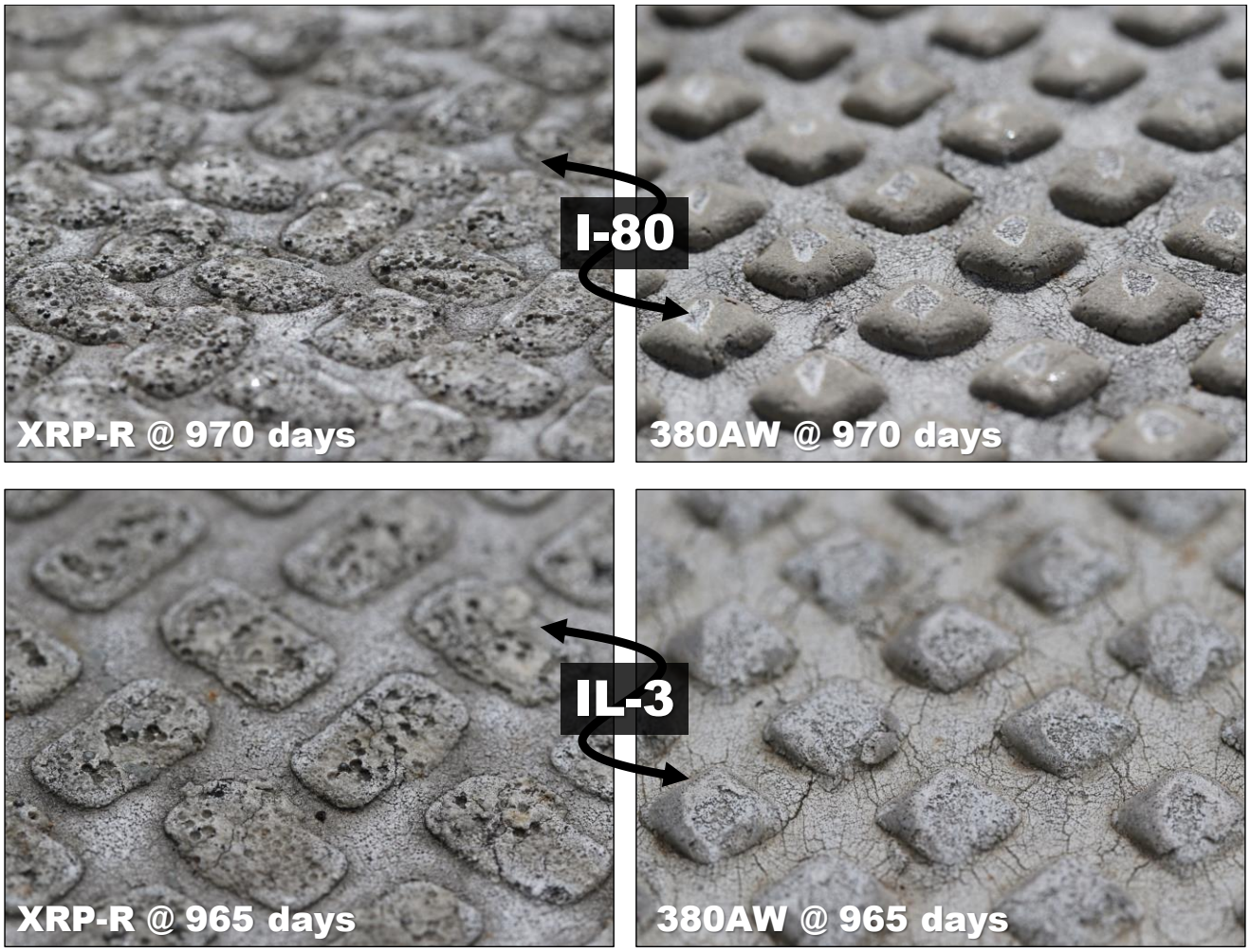

Figure 2. Tape products after 3 winters by roadway.

Retroreflectivity was measured under three standard conditions including dry, wet-recovery, and continuously wetted. Table 1 shows the results organized by roadway, product, time, and three measurement conditions.**Error! Reference source not found.** The colored data bar, within each cell, is a conditional format to illustrate the relative numeric values. With a priority on wet retroreflectivity, notice the higher retroreflectivity values for the 380AW product both initially and over time.

Table 1. All-Weather Tape Retroreflectivity Over Time.

Illinois DOT Roadway	Tape Product	Dry Retroreflectivity (Avg. mcd)					Recovery Retroreflectivity (Avg. mcd)					Continuous Wetting (Avg. mcd)				
		Oct. '16 Initial	May '17 1-winter	May '18 2 winters	Sept. '18 2 years	May '19 3 winters	Oct. '16 Initial	May '17 1-winter	May '18 2 winters	Sept. '18 2 years	May '19 3 winters	Oct. '16 Initial	May '17 1-winter	May '18 2 winters	Sept. '18 2 years	May '19 3 winters
I-80	**380AW**	1,786	2,139	2,061	1,988	1,736	510	438	263	229	167	468	413	230	181	148
IL-3	**380AW**	687	1,251	1,236	1,331	368	354	385	315	294	49	288	371	299	270	35
I-80	**XRP-R**	1,183	724	633	565	460	123	79	50	34	26	86	40	35	16	14
IL-3	**XRP-R**	776	665	460	471	239	180	93	52	47	18	99	45	28	22	11

Conclusions

This evaluation provides data from Illinois roadways showing that after three winter seasons there are tape products that can provided both dry and all-weather (wet) retroreflectivity performance. However, this performance was found to vary by roadway with indications that in-laying these tapes as opposed to recessing them within a groove can negatively impact performance.

The 380AW tape measured significantly higher than the XRP-R tape under all conditions, especially for recovery and continuously wetted conditions. The XRP-R tape performed well under dry conditions; however, when measured under wet-recovery or continuously wetted conditions, the performance fell below 100 mcd after the initial measurement.

Short of a minimum retroreflectivity threshold for wet conditions, these findings will support IDOT decision making in terms of product selection. The 380AW tape was the only product which performed at 100 mcd or higher under continuously wetted conditions. The findings also highlight the potential negative impacts on performance when in-laying these products as opposed to recessing them within a groove.

Recommendations

Based on these results, only one tape (380AW) provided acceptable performance under continuously wetted conditions. Given that there is no current minimum retroreflectivity threshold, the fact that the XRP-R did not exceed 50 mcd after initial measurement, supports this recommendation.

These results show that tape performance is significantly impacted by the installation method for all conditions (dry, wet recovery, and continuously wetted). IDOT should consider only recessing these products to ensure performance integrity.

The two tapes evaluated were produced prior to September of 2016. As technology continues to advance and agencies continue to address safety and roadway departure crashes there will be future tape products which claim wet retroreflectivity performance. To this point, IDOT should consider a simplified (non-roadway) testing procedure to consider product suitability in terms of wet recovery and continuously wetted retroreflectivity performance.

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

The Illinois Department of Transportation (IDOT) project titled Evaluating All-Weather Pavement Markings in Illinois: Volume 1 quantified the performance of various all-weather pavement markings on Illinois roadways. This volume 2 report provides the results of two additional all-weather pavement-marking test decks, focused solely on premanufactured all-weather pavement-marking tapes.

1.2 OBJECTIVE

The project objective is to identify, install, and monitor the performance of premanufactured all-weather pavement-marking tapes over time. The evaluation is exclusive to white skip (centerline) markings, based on IDOTs interest in the performance of all-weather tape products on centerline skips (on multilane roadways). Of interest is how the tape product balances dry versus wet retroreflectivity and their ability to perform on IDOT roadways over time. This information will support material selection and overall decision support at IDOT.

1.3 SCOPE

The evaluation considers pavement-marking performance in terms of retroreflectivity of the white skip (centerline) marking under dry, recovery, and continuous wetted conditions over three winters and at two different locations (central and southern Illinois). The efforts listed below were completed to meet the project objectives:

- Test-Deck Locations: Identify existing resurfacing projects in which an all-weather pavement-marking tape could be added to the project for evaluation (centerline white skip). Identify manufacturers who are able to participate, on short notice, and coordinate product delivery, submittals, and installation support to the Contractor.
- Field Evaluation: Conduct a multiseason field evaluation of different all-weather pavement-marking tapes on Illinois roadways under continuous traffic conditions and winter operations. This process includes measuring field retroreflectivity after installation as well as after each winter season.
- Analysis: Tabulate findings from each test location by product and time along with an analysis of results as presented and discussed with the project's Technical Review Panel (TRP). The analysis includes material type, location, and performance over time in terms of presence and retroreflectivity (dry, recovery, and wet).

1.4 SURVEY OF RELEVANT LITERATURE

Pavement markings provide guidance to drivers on the intended vehicle path (Lyon et al. 2015). They have significant impacts on safety performance and reducing crash rates (Pike and Schwenn 2012; Bektas et al. 2016). During dry conditions, glass beads in the pavement marking reflect light from the headlights back to the driver; however, once water is introduced on a pavement marking, it can reflect and refract the light, which reduces the retroreflectivity and creates a distracting glare (Gibbons et al. 2005, 2012; Pike and Schwenn 2012; Lyon et al. 2015). To overcome these limitations, new pavement markings include ceramic elements, in addition to glass beads, to better reflect light back toward motorists (Lyon et al. 2015).

Although the impact of wet night conditions on pavement-marking visibility is well recognized, limited studies have documented the performance of pavement markings during wet night conditions and its impact on traffic safety. Gibbons (2006) conducted a study to evaluate the performance of four pavement-marking technologies, including a wet retroreflective tape. In the experiment, vehicles were driven by older participants; and visibility was measured based on the detection distances of the beginning or ending of a continuous edge marking. The results indicate that a specifically designed wet-retroreflective tape performed better than the commonly used paint-and-glass-bead technology. Moreover, two instruments were used in the experiment to measure roadway illuminance: an illuminance meter and a Charged Coupled Device (CCD) photometer. A log-linear relationship exists between the retroreflectivity and the detection distance. From this relationship, it appears that a minimal additional benefit to the driver can be accomplished after a level of 200 millicandelas per square meter per lux (mcd/m2/lx) which is shortened in this report to (mcd), is reached for speeds equal to or less than 45 mph.

More recently, Gibbons and coworkers (Gibbons and Williams 2011; Gibbons et al. 2012) conducted a project to develop a specification for the minimum retroreflectivity of pavement markings in wet nighttime conditions. Similar to the approach used in the previous study, the performance was measured based on the detection distances of the beginning or ending of a continuous edge marking. This investigation reached the following conclusions: (a) The materials developed over recent years showed an improved performance over those tested previously. (b) The log-linear relationship found previously was functional for the data provided. Two models were developed. The model with no intercept provided a more constrictive boundary at low levels of retroreflectivity. (c) A retroreflectivity value above 250 mcd provided limited return in terms of detection distance. (d) A specification limit of 150 mcd provided adequate visibility for 55 mph in dry conditions and 40 mph in wet conditions with standard dry-retroreflectivity measurements and 1-inch-per-hour measurements for wet conditions. This value should be the minimum maintained over the life of the marking. (e) The retroreflectivity specifications for a white and a yellow material should be equal. (f) The rumble stripe showed a significant recovery-time improvement over the other tested materials. A minimum retroreflectivity of 150 mcd for white and yellow pavement markings in both dry and wet nighttime conditions is recommended.

CHAPTER 2: STUDY METHODOLOGY

2.1 PRODUCT SELECTION

The research team worked with IDOT, the TRP, and manufacturers to identify wet-reflective tape products. This effort required finding manufacturers who were able to participate on such short notice and who could coordinate product delivery, submittals, and installation support to contractors on current IDOT resurfacing projects. Given these conditions, the following all-weather tape products were provided in September of 2016 and installed:

- Brite-Line Technologies LLC: Deltaline XRP-R Extended Reflective Performance (referred to in this report as **XRP-R**)
- 3M: 3M Stamark All Weather Tape 380AW (referred to in this report as **380AW**)

2.2 FIELD TESTING

This evaluation includes measuring field retroreflectivity both initially and following each winter season, with the exception being one additional reading in the fall of 2018. The following sections describe the field-installation process, physical locations, and installations.

Conducting a multiseason evaluation under traffic is a significant activity which requires a dedicated safety focused team who can consistency complete these operations. To this point, IDOTs District 3 and 8 helped manage these safety risks so that the organization can understand material performance to improve safety statewide.

2.2.1 Testing Locations

Meeting the project schedule required finding a resurfacing contract that had already been awarded and included pavement-marking material installation as a bid item. Accordingly, IDOT and the TRP identified two suitable existing resurfacing projects to use for this tape evaluation. The suitability included a preference of weather diversity, within the state, as well as flexibility in schedule to accommodate marking-material substitutions with all-weather tape. The test-deck locations selected are on Interstate 80 (I-80) near Princeton and Illinois Route 3 (IL-3) in Waterloo, as described below:

- **I-80** in Bureau County, west of Princeton, beginning at MP 48 in the eastbound direction of travel, see Figure 3. The annual average daily traffic (AADT) for this section of road is 20,200 (in 2017), source: Illinois DOT. IDOT Contract #66975, Construction Project #: C-93-135-09. IDOT Contact: Thomas Schaefer, traffic operations engineer.
- **IL-3** within the City of Waterloo, beginning at Moore Street in the northbound direction of travel only, see Figure 4. The AADT for this section of road is 15,800 (in 2017), source: Illinois DOT. IDOT Contract #76817. IDOT contact: Jeffrey L. Abel, traffic operations engineer

Figure 3. I-80 test deck, beginning location (looking east).

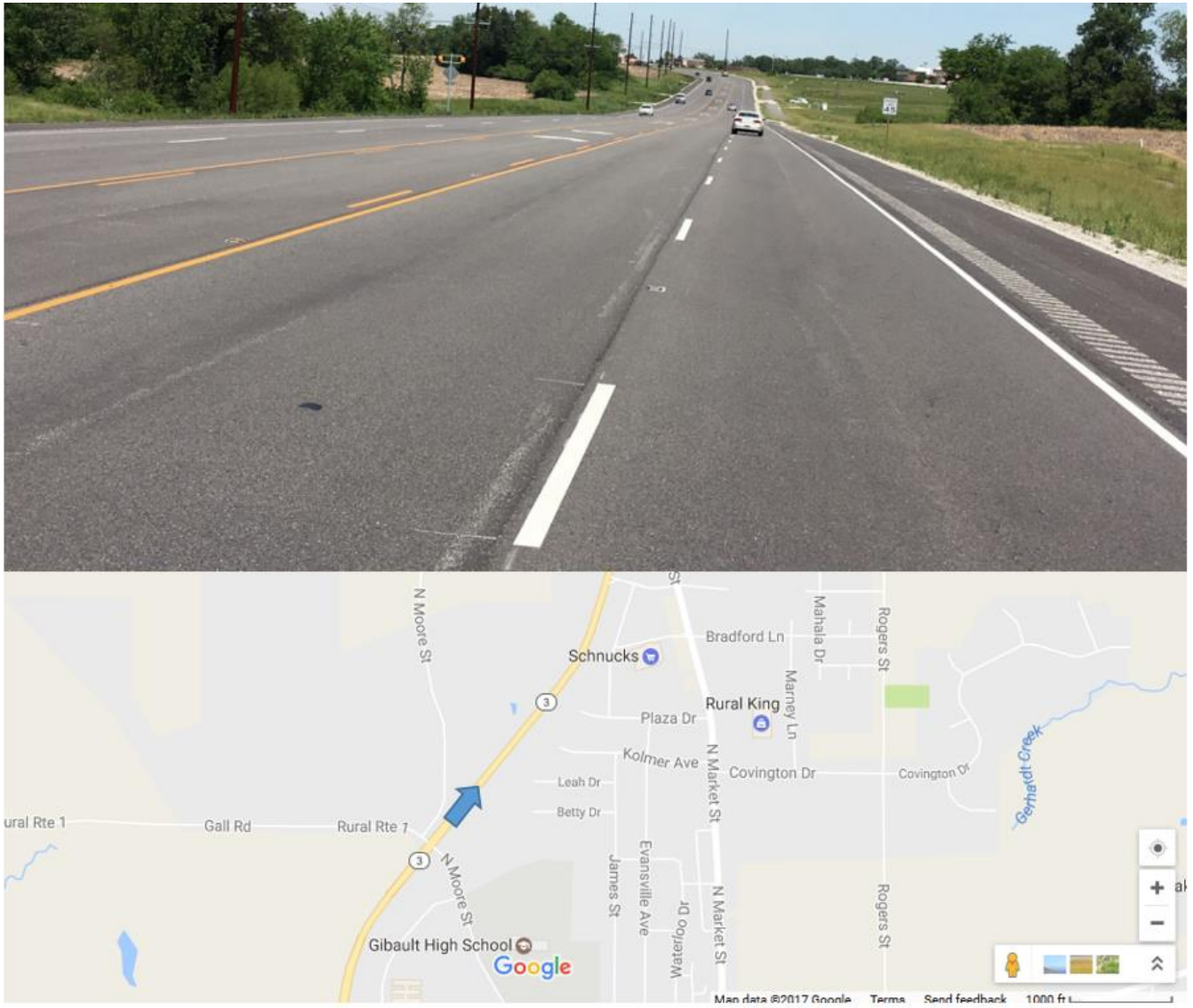

Figure 4. IL-3 test deck, beginning location (looking northeast).

2.2.2 Installation

Information specific to the installation of all-weather tape for each roadway follows.

I-80 Test Deck

The I-80 test segment was part of a major asphalt-resurfacing effort that originally included grooved, 6-inch-wide, standard Briteline XRP tape for the white centerline skip 1,000 feet of each all-weather tape product, which was also 6 inches in width.

The contractor installation was completed on Saturday, September 24, 2016. Figure 5 shows that the test deck begins at mile post 48 in the eastbound direction, with 25 skips installed per product. The first 1,000 feet is XRP-R, followed by 1,000 feet of 380AW. A representative from Briteline was on the job site during installation of the XRP-R. Both materials were placed within a groove, which varied in depth from 0.110 to 0.200 inches or in this report 110 to 200 mils (where a "mil" is a unit of thickness equal to one thousandth of an inch (.001 inch).

Figure 5. I-80 test-deck layout.

IL-3 Test Deck

The IL-3 test segment was a major asphalt-resurfacing project that originally included in-laid 4-inch-wide, standard Briteline XRP tape for all lane lines. The contract tape for the white centerline skip was replaced by 1,000 feet of each 4” wide all-weather tape product.

The contractor installation was completed on Tuesday, September 27, 2016. Figure 6 shows the test deck begins at Moore Street and proceeds in the northeast direction, with 25 skips installed per product. The limits are along northbound IL-3, with 3M tape from 2118+90 to 2128+90 and Brite-Line tape from 2128+90 to 2138+90. These tape markings were rolled in with a couple of passes of the finish roller.

Figure 6. IL-3 test-deck layout.

2.3 EVALUATION

The evaluation includes measurements of field retroreflectivity both initially and following each winter season, with one additional reading in the fall of 2018.

2.3.1 Measurement Methodology

Based on input from the TRP, a field-evaluation methodology was developed and applied to each of the test decks and product types using a hand-held retroreflectometer (LTL-X). The field-measurement methodology included

- From the beginning point, and in the direction of travel, beginning with the fourth skip, measure every other skip in the following sequence:
    - Dry ASTM 1710, then Recovery ASTM 2177, followed by Continuous Wetting ASTM E2832-12
- Repeat the above procedure for six white centerline skips unless there is a need to adjust in the field. Label the measurements 1 to 6 per product.
- Repeat the above process for each of the two tape products.

2.3.2 Measurement Frequency

Each test segment and product type was measured as follows:

- Initial: At a time less than 1 month after installation
- One year: After one winter season
- Two years: After two winter seasons
- Three years: After three winter seasons

CHAPTER 3: TEST DECK EVALUATION

3.1 TIMELINE

The evaluation was supported through a time-series of pavement-marking retroreflectivity measurements on two test roadways (I-80 and IL-3). This section identifies measurement frequency, along with selected images of marking presence and condition over time by test deck.

I-80 IDOT District 3 staff provided traffic control while the white centerline skip lines were being measured. Table 2 notes the installation and measurement milestones.

Table 2. Timeline for I-80 Test Deck

Roadway	Action	Milestone	Date	Days after Installation
I-80	Installation		Sept. 24, 2016	0
I-80	Field measure 1	Initial	Oct. 11, 2016	17
I-80	Field measure 2	After 1 winter	May 16, 2017	234
I-80	Field measure 3	After 2 winters	May 24, 2018	607
I-80	Field measure 4	After 2 years	Sept. 25, 2018	731
I-80	Field measure 5	After 3 winters	May 22, 2019	970

IL-3 IDOT District 8 staff provided traffic control while the white centerline skip lines were being measured. Table 3 notes the installation and measurement milestones.

Table 3. Timeline for IL-3 Test Deck

Roadway	Action	Milestone	Date	Days after Installation
IL-3	Installation		Sept. 27, 2016	0
IL-3	Field measure 1	Initial	Oct. 11, 2016	14
IL-3	Field measure 2	After 1 winter	May 15, 2017	230
IL-3	Field measure 3	After 2 winters	May 23, 2018	603
IL-3	Field measure 4	After 2 years	Sept. 24, 2018	727
IL-3	Field measure 5	After 3 winters	May 20, 2019	965

3.2 EVALUATION

The evaluation data consist of pavement-marking presence (images) and retroreflectivity (data) over time.

3.2.1 Presence

The field-evaluation information includes images of pavement-marking condition over time. There were no observed areas of significant material loss for either product after three winters. However, some discoloration, contamination, and deformity was observed as reported by roadway below.

I-80

Figure 7 includes images for both tape products from the initial measurement (17 days after installation) to after the first winter (234 days after installation). Note that the XRP-R material has some non-uniformity in the shape of the raised profiles which are assumed to be as provided (observed initially on both test decks).

Figure 8 shows the XRP-R marking after 2 years (731 days after installation). The typical discoloration due to wear is shown along with bead loss. Both Figure 9 and Figure 10 show the XRP-R marking after 3 winters (970 days after installation) with visible degradation in terms of bead loss and wear on the raised profiles.

Figure 11 shows the 380AW marking after 2 years (731 days after installation) where discoloration from wear can be seen along with some material cracking. The integrity and wear of the raised ridges and ceramic elements appear uniform with only a few exceptions. Both Figure 12 and Figure 13 show the 380AW marking after 3 winters (970 days after installation) with degradation in terms of cracking and breaking at the edges of some of the raised profiles.

IL-3

Figure 14 includes images for both tape products from the initial measurement (14 days after installation) to after the first winter (230 days after installation).

Both Figure 15 and Figure 16 show the XRP-R marking after 2 winters (603 days after installation). The typical discoloration due to wear can be seen, along with some apparent bead loss and deformation of the raised ridges in the profile material. Figure 17 shows the XRP-R marking at 2 years (727 days after installation), with both bead loss and profile deformation present. Both Figure 18 and Figure 19 show the XRP-R marking after 3 winters (965 days after installation) with visible degradation in terms of bead loss and profile deformation.

Both Figure 20 and Figure 21 show the 380AW marking after 2 winters (603 days after installation). Cracking of the material can be seen around and between each raised profile. The wear of each raised profile and the amount of ceramic element intact appear consistent. Figure 22 shows the 380AW marking at 727 days, with more discoloration but similar physical observations to the 603-day images. Both Figure 23 and Figure 24 show the 380AW marking after 3 winters (965 days after installation) with degradation visible in terms of bead loss, cracking, and profile deformation.

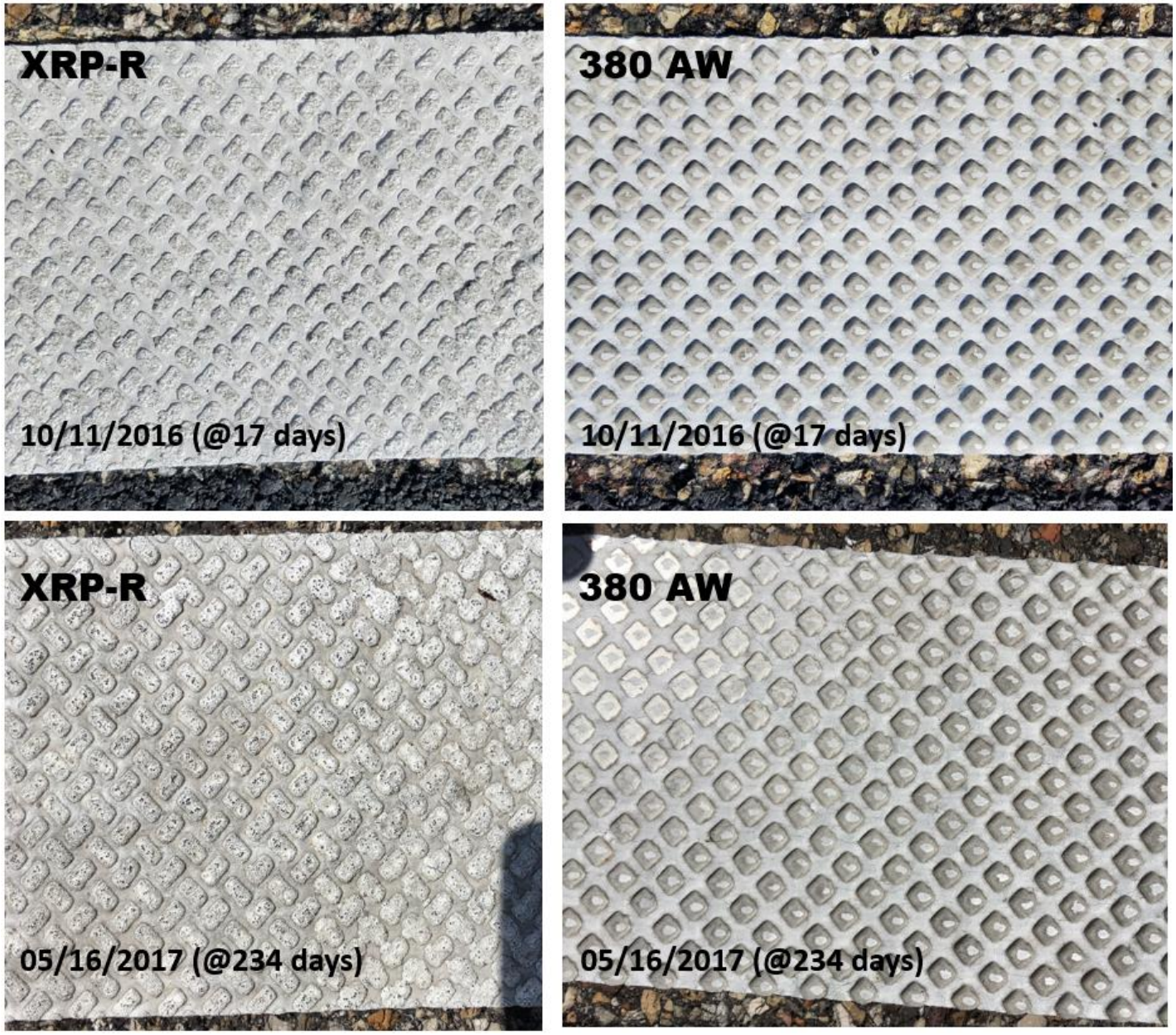

Figure 7. I-80 white skip-line images over time.

Figure 8. I-80 XRP-R presence at 731 days after installation.

Figure 9. I-80 XRP-R presence at 970 days after installation.

Figure 10. I-80 XRP-R presence at 970 days after installation.

Figure 11. I-80 380AW presence at 731 days after installation.

Figure 12. I-80 380AW presence at 970 days after installation.

Figure 13. I-80 380AW presence at 970 days after installation.

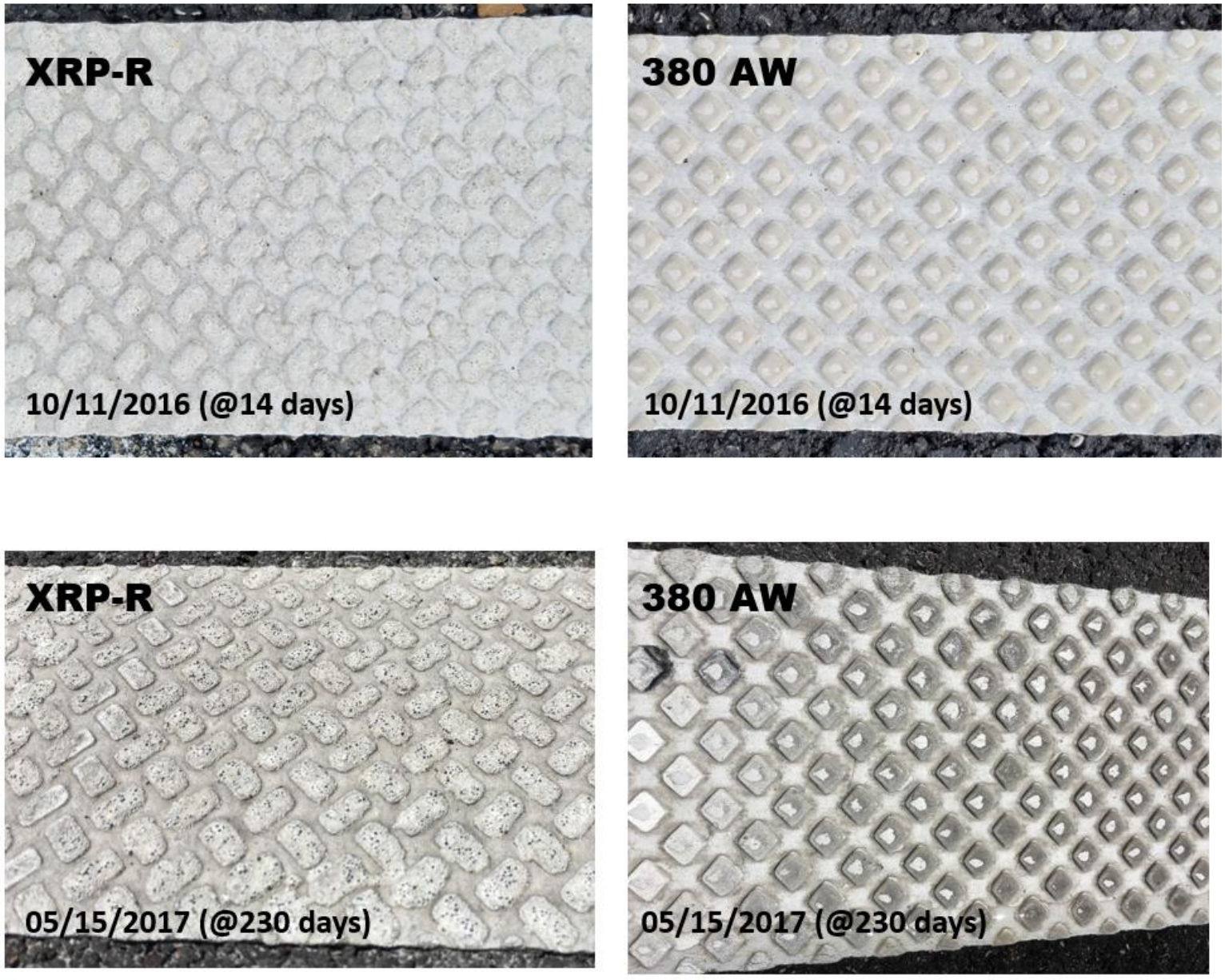

Figure 14. IL-3 white skip-line images over time.

IL-3
XRP-R
05/23/2018
(@603 days)

Figure 15. IL-3 XRP-R presence at 603 days.

Figure 16. IL-3 XRP-R presence at 603 days.

Figure 17. IL-3 XRP-R presence at 727 days.

Figure 18. IL-3 XRP-R presence at 965 days.

Figure 19. IL-3 XRP-R presence at 965 days.

Figure 20. IL-3 380AW presence at 603 days.

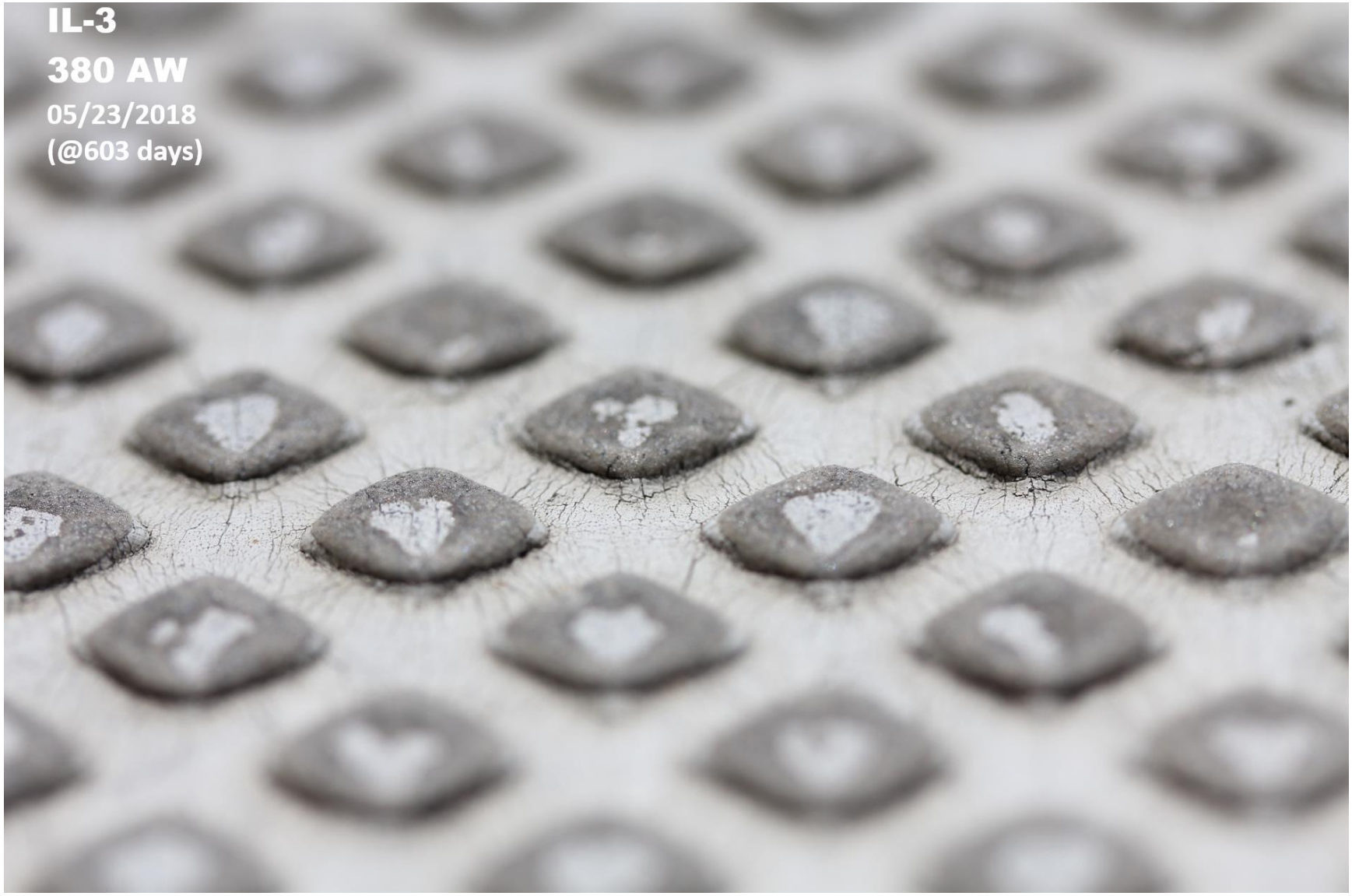

Figure 21. IL-3 380AW presence at 603 days.

Figure 22. IL-3 380AW presence at 727 days.

Figure 23. IL-3 380AW presence at 965 days.

Figure 24. IL-3 380AW presence at 965 days.

3.2.2 Retroreflectivity

This project is focused on pavement marking tapes which provide both dry and wet retroreflectivity with the emphasis on visibility during wet conditions. Each field-measured value was tabulated by roadway, tape product, date measured, and retroreflectivity (dry, recovery, and continuous wet) in millicandelas per meter squared per lux (mcd). The markings were measured both initially (within one month of installation) and after consecutive winters with the results organized below by measurement condition.

3.2.2.1 Retroreflectivity (Dry)

Both Table 4 and Figure 25 show average retroreflectivity (dry) over time by roadway and product resulting in a wide range of performance.

Overview: Even with bead loss and deformation of the raised profiles over time, these tapes provide dry retroreflectivity after 3 winters even though over a wide range (from 239 mcd up to 1,736 mcd). The 380AW tape, on I-80, had significantly higher retroreflectivity for all time periods. The installation method on IL-3 appears to have negatively impacted the performance of both tapes.

Variation by Roadway: The performance of both tape products varied significantly between the two roadway locations. When comparing the same tape across the two different roadways, the initial 380AW readings were 2.6 times higher on I-80 versus IL-3 with this difference increasing to 4.7 after 3 winters. Figure 25 shows this wide variation in 380AW performance in contrast to the XRP-R tape. The initial XRP-R measurements were 1.5 times higher on I-80 versus IL-3 with this difference increasing to 1.9 after 3 winters.

Discussion among the project TRP led to the idea that this varied performance, of the same product on different roadways, is attributed to the installation method. The I-80 tapes were placed in a groove as opposed to IL-3 tapes being rolled-in with the final pass of the asphalt-finishing machine.

It is important to note that the IL-3 initial readings were 14 days after installation, however, this section of road was not yet fully opened to traffic yet, curb lanes were still closed, and the research team did observe an oil sheen on the new roadway surface due to the paving process. We can only speculate that the conditions of the new untraveled surface influenced the initial retroreflectivity measurements given that the 380AW tape increased by a factor of 1.8 between the first (687 mcd in October 2016) and second measurements (1,251 mcd May 2017). The above assumption, however, is moderated by the fact that the XRP-R tape, on the same section of IL-3, did not show a similar increase in retroreflectivity between first and second measurements. In addition, the 380AW tape on I-80 also increased, by 354 mcd, between the first and second (after 1-winter) measurements.

Variation by Product: A comparison of the tape products on the same roadway shows that the I-80 380AW tape measured 1.5 (initial) to 3.8 times (after 3 winters) higher than the XRP-R tape. On IL-3 the XRP-R tape measured 1.1 times higher (initially) than 380AW, see possible explanation in the paragraph above. After 3 winters, the IL-3 380AW tape measured 1.5 times higher retroreflectivity than then XRP-R tape. Over the last winter, the retroreflectivity of the IL-3 380AW tape dropped sharply from 1,331 (Sept. ’18) down to 368 mcd (May ’19). A review of weather, from the National

Weather Service (for St. Louis, MO), shows that the period from November 2018 through April 2019 had 24.2 inches of snow which is 6.5 inches higher than normal. As a comparison, the first and second winters of this evaluation saw 3.2 and 7.1 inches total respectively.

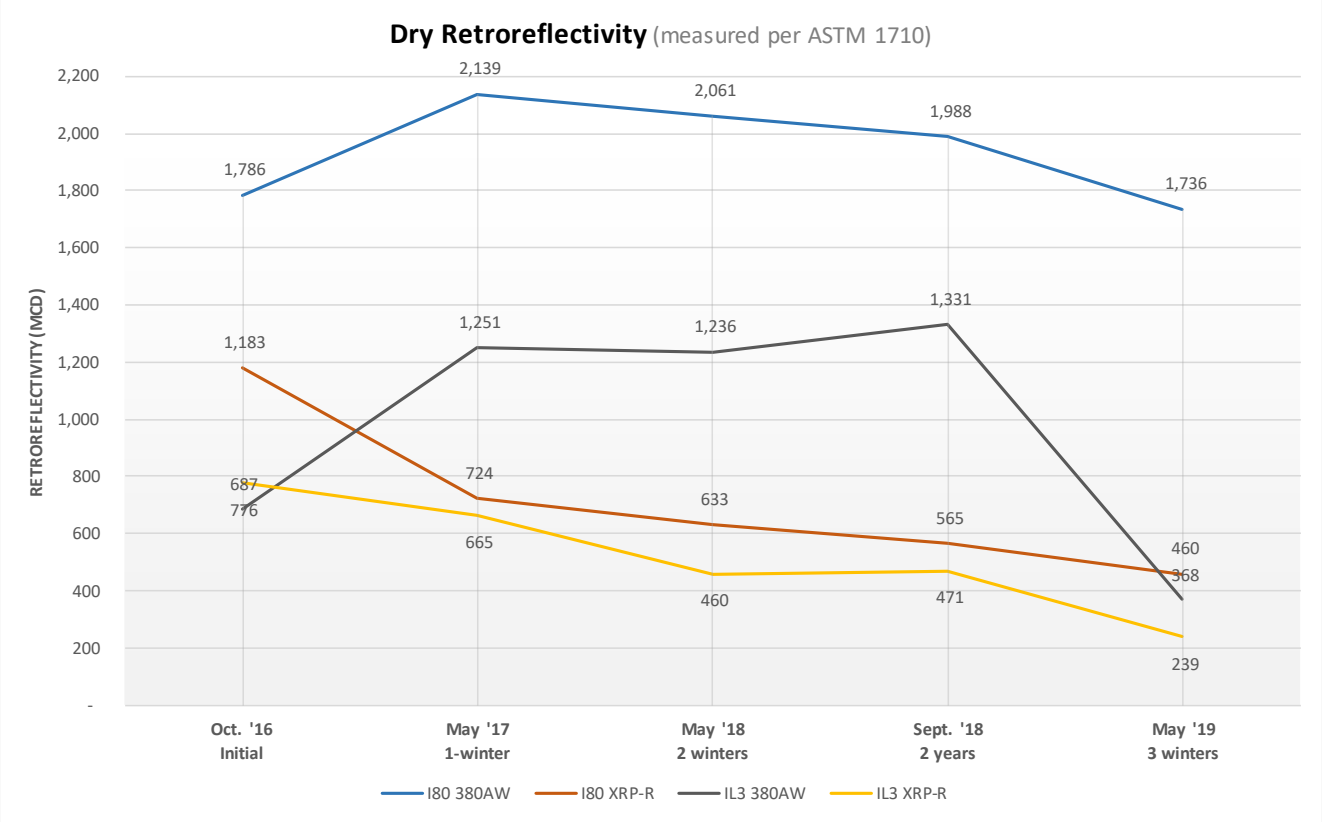

Figure 25. Dry retroreflectivity over time.

3.2.2.2 Retroreflectivity (Recovery)

Both Table 5 and Figure 26 show average retroreflectivity (wet recovery) over time by roadway and product. As shown, a considerable range in performance exists.

Overview: The 380AW tape wet recovery measured significantly higher than the XRP-R for all time periods. After 3 winters, the I-80 380AW tape measured 167 mcd. Beyond the initial measurements, none of the XRP-R values exceeded 100 mcd for either roadway. From the 2-year measurement, and beyond, no XRP-R values exceeded 50 mcd. In contrast to XRP-R tape, the 380AW tape performance between roadways varied over time.

Variation by Roadway: The performance of both tape products varied between the two roadway locations. The initial 380AW readings were 1.4 times higher on I-80 versus IL-3 with this difference increasing to 3.4 after 3 winters. In contrast, the initial XRP-R readings were 1.5 times higher on IL-3 as opposed to I-80. This trend (IL-3 values higher for the XRP-R) continued up to the last measurement (after 3 winters) where the I-80 values measured 1.4 times higher than IL-3 (very low

values). Figure 26 shows that, following the initial readings, the wet-recovery performance of the XRP-R tape was consistent between roadways.

Variation by Product: When contrasting the performance between tape products on the same roadway, the I-80 380AW tape measured 4.2 (initial) to 6.4 times (after 3 winters) higher than the XRP-R tape. On IL-3, the 380AW tape measured 2.0 (initial) to 2.7 times (after 3 winters) higher than the XRP-R tape.

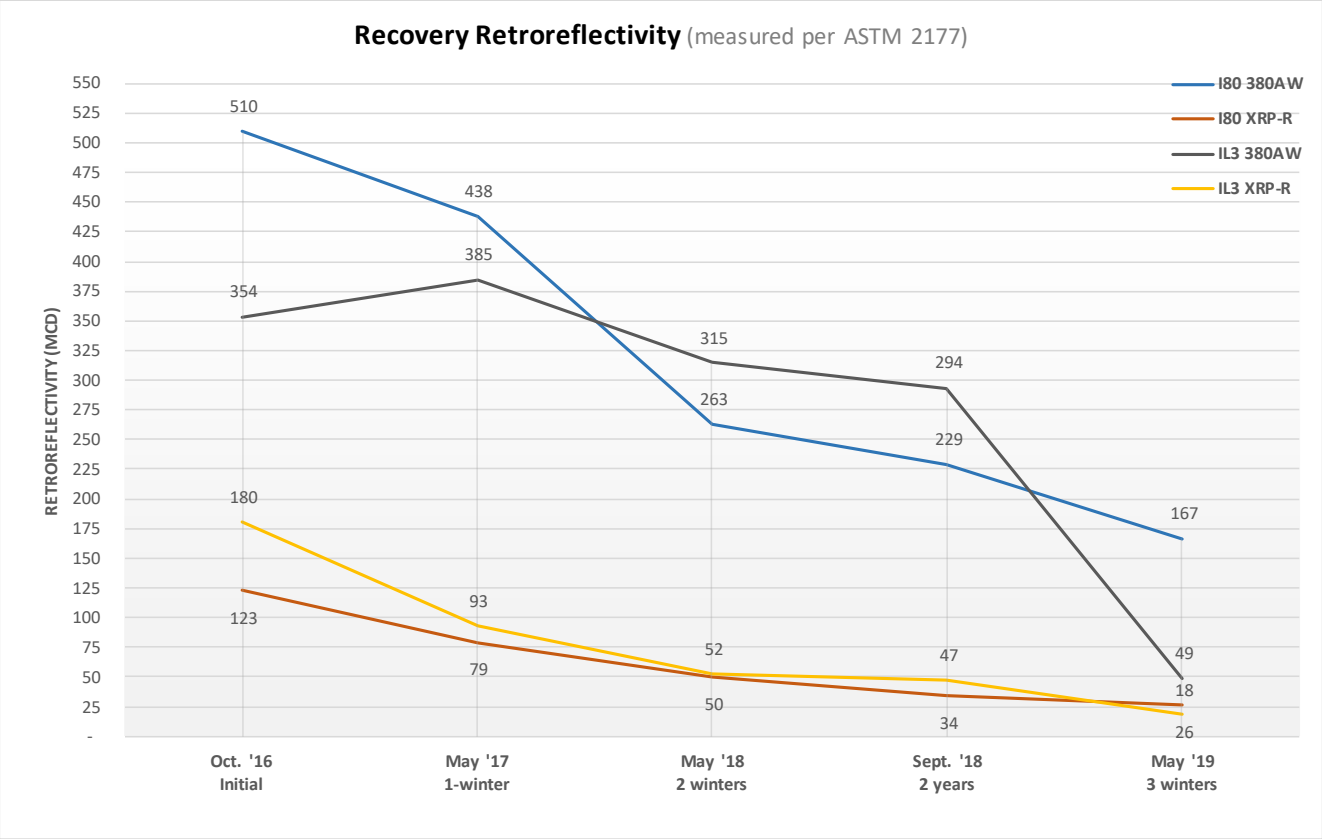

Figure 26. Recovery retroreflectivity over time.

3.2.2.3 Retroreflectivity (Wet)

Both Table 6 and Figure 27 show average retroreflectivity (measured under a continuously wetted condition) over time by roadway and by product. As shown, a considerable range in performance exists.

Overview: I-80 380AW provided retroreflectivity under continuous wetted conditions from 468 mcd (initial) to 148 mcd (after 3 winters). Performance of the 380AW varied by roadway and measurement period. The wet retroreflective performance of the XRP-R tape was consistent between roadways, however, below 50 mcd for all but the initial measurement.

Variation by Roadway: The performance of both tape products varied significantly between the two roadway locations. The initial 380AW readings were 1.6 times higher on I-80 versus IL-3 with this difference ending up at 4.2 time higher after 3 winters. However, In contrast, the initial XRP-R readings were 1.2 times higher on IL-3 as opposed to I-80. Figure 27 shows that the wet retroreflectivity performance of the XRP-R tape was consistent between roadways and below 50 mcd for all but the initial measurement.

Variation by Product: When contrasting the performance between tape products on the same roadway, Figure 27 also shows the sizeable differences measured. On I-80, 380AW tape measured 5.5 (initial) to 10.4 times (after 3 winters) higher than the XRP-R tape. On IL-3, the 380AW tape measured 2.9 (initial) to 3.3 times (after 3 winters) higher than the XRP-R tape. Beyond the initial measurements, none of the XRP-R values exceeded 50 mcd for either roadway. Over the last winter, the wet retroreflectivity of the IL-3 380AW tape dropped sharply from 270 (Sept. ’18) down to 35 mcd (May ’19).

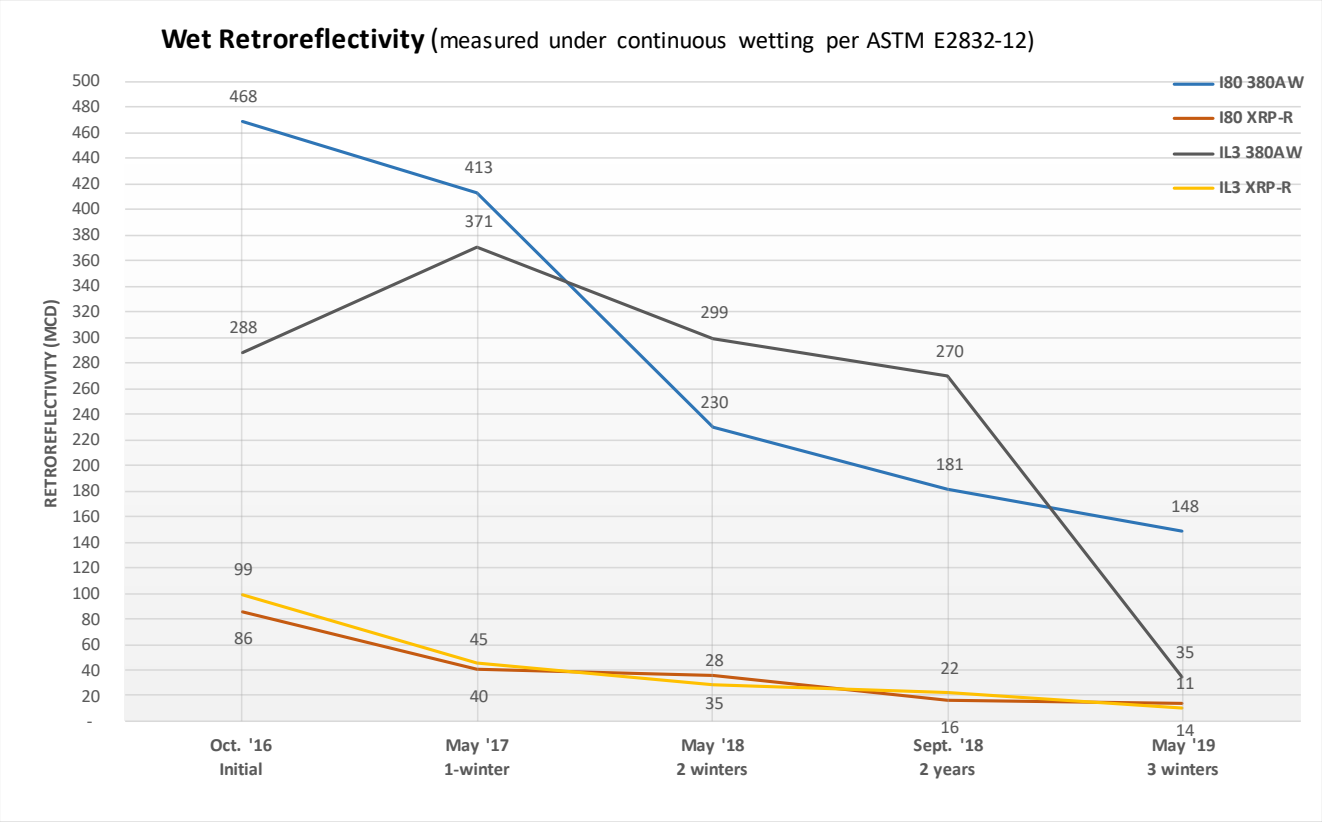

Figure 27. Wet retroreflectivity over time.

Table 4. Dry Retroreflectivity Over Time

							Dry Retroreflectivity (Avg. mcd)				
Road	Road Surface	Installed	Travel Direction	Tape Mfg.	Product	Line Type	Oct. '16 Initial	May '17 1 winter	May '18 2 winters	Sept. '18 2 years	May '19 3 winters
I-80	New ACC	Grooved	EB	3M	380AW	WSL	1,786	2,139	2,061	1,988	1,736
I-80	New ACC	Grooved	EB	Brite-Line	XRP-R	WSL	1,183	724	633	565	460
IL-3	New ACC	Rolled in	NB	3M	380AW	WSL	687	1,251	1,236	1,331	368
IL-3	New ACC	Rolled in	NB	Brite-Line	XRP-R	WSL	776	665	460	471	239

mcd = millicandelas per meter squared per lux

Table 5. Recovery Retroreflectivity Over Time

							Recovery Retroreflectivity (Avg. mcd)				
Road	Road Surface	Installed	Travel Direction	Tape Mfg.	Product	Line Type	Oct. '16 Initial	May '17 1 winter	May '18 2 winters	Sept. '18 2 years	May '19 3 winters
I-80	New ACC	Grooved	EB	3M	380AW	WSL	510	438	263	229	167
I-80	New ACC	Grooved	EB	Brite-Line	XRP-R	WSL	123	79	50	34	26
IL-3	New ACC	Rolled In	NB	3M	380AW	WSL	354	385	315	294	49
IL-3	New ACC	Rolled In	NB	Brite-Line	XRP-R	WSL	180	93	52	47	18

mcd = millicandelas per meter squared per lux

Table 6. Wet Retroreflectivity Over Time

							Continuous Wetting (Avg. mcd)				
Road	Road Surface	Installed	Travel Direction	Tape Mfg.	Product	Line Type	Oct. '16 Initial	May '17 1 winter	May '18 2 winters	Sept. '18 2 years	May '19 3 winters
I-80	New ACC	Grooved	EB	3M	380AW	WSL	468	413	230	181	148
I-80	New ACC	Grooved	EB	Brite-Line	XRP-R	WSL	86	40	35	16	14
IL-3	New ACC	Rolled in	NB	3M	380AW	WSL	288	371	299	270	35
IL-3	New ACC	Rolled in	NB	Brite-Line	XRP-R	WSL	99	45	28	22	11

CHAPTER 4: DISCUSSION OF RESULTS AND RECOMMENDATIONS

4.1 FIELD EVALUATION

This evaluation of all-weather tapes included measuring field retroreflectivity, both initially and following three winter seasons. Approximately 1,000 feet of two different preformed, premanufactured, all-weather pavement-marking tapes (380AW and XRP-R) were installed on each of two different Illinois DOT roadways (I-80 and IL-3). The project considered only white skip-line markings. The two pavement-marking-tapes were added to active IDOT resurfacing contracts. The all-weather tapes on I-80 were installed within a recessed groove, which was between 120 and 200 mils deep. In contrast, the IL-3 tapes were rolled in with the asphalt-surface finishing machine.

4.2 PERFORMANCE

The performance of the pavement-marking tape was evaluated over time and measured in terms of presence and retroreflectivity. Specific to presence, no missing pieces or sections were observed after three winters, however, there was both bead loss and deformation of the raised ridges that make up the profile of the tape materials. Figure 28 summarizes the documented conditions after 3-winters.

Tape retroreflectivity was measured three ways—under dry, wet-recovery, and continuously wetted conditions, as shown in Table 7. In each condition, the data reveal considerable differences in performance.**Error! Reference source not found.** The colored data bar, within each cell, is a conditional format to illustrate the relative numeric value by measured condition category (Dry, Recovery, Continuous Wetting).

Table 7. All-Weather Tape Retroreflectivity Over Time

Illinois DOT Roadway	Tape Product	Dry Retroreflectivity (Avg. mcd)					Recovery Retroreflectivity (Avg. mcd)					Continuous Wetting (Avg. mcd)				
		Oct. '16 Initial	May '17 1-winter	May '18 2 winters	Sept. '18 2 years	May '19 3 winters	Oct. '16 Initial	May '17 1-winter	May '18 2 winters	Sept. '18 2 years	May '19 3 winters	Oct. '16 Initial	May '17 1-winter	May '18 2 winters	Sept. '18 2 years	May '19 3 winters
I-80	**380AW**	1,786	2,139	2,061	1,988	1,736	510	438	263	229	167	468	413	230	181	148
IL-3	**380AW**	687	1,251	1,236	1,331	368	354	385	315	294	49	288	371	299	270	35
I-80	**XRP-R**	1,183	724	633	565	460	123	79	50	34	26	86	40	35	16	14
IL-3	**XRP-R**	776	665	460	471	239	180	93	52	47	18	99	45	28	22	11

Dry Retroreflectivity – The I-80 380AW tape retroreflectivity ranged from a high of 2,139 down to a low of 1,736 mcd after 3 winters. The IL-3 380AW tape retroreflectivity ranged from a high of 1,251 down to a low of 368 mcd after 3 winters. The difference in performance of the 380AW tape is related to the installation method (tapes were recessed on I-80 versus in-laid on IL-3). The I-80 XRP-R tape retroreflectivity ranged from a high of 1,183 down to a low of 460 mcd after 3 winters. The IL-3 XRP-R tape retroreflectivity ranged from a high of 776 down to a low of 239 mcd after 3 winters. The difference in performance of the XPR-R tape is related to the installation method (tapes were recessed on I-80 versus in-laid on IL-3).

Recovery Retroreflectivity – The 380AW tape wet recovery measured significantly higher than the XRP-R for all time periods. After 3 winters, the I-80 380AW tape measured 167 mcd. Beyond the initial measurements, none of the XRP-R values exceeded 100 mcd. From the 2-year measurement, and beyond, no XRP-R values exceeded 50 mcd. In contrast to XRP-R tape, the 380AW tape performance varied between roadways. Over the last winter, the retroreflectivity of the IL-3 380AW tape dropped sharply from 294 (Sept. ’18) down to 49 mcd (May ’19).

Wet Retroreflectivity – On I-80, the 380AW tape retroreflectivity, measured under continuous wetted conditions, ranged from 468 mcd (initial) to 148 mcd (after 3 winters). Performance of the 380AW varied by roadway and measurement period. Over the last winter, the retroreflectivity of the IL-3 380AW tape dropped sharply from 270 (Sept. ’18) down to 35 mcd (May ’19). The wet retroreflectivity performance of the XRP-R tape was consistent between roadways, however, below 50 mcd for all but the initial measurement.

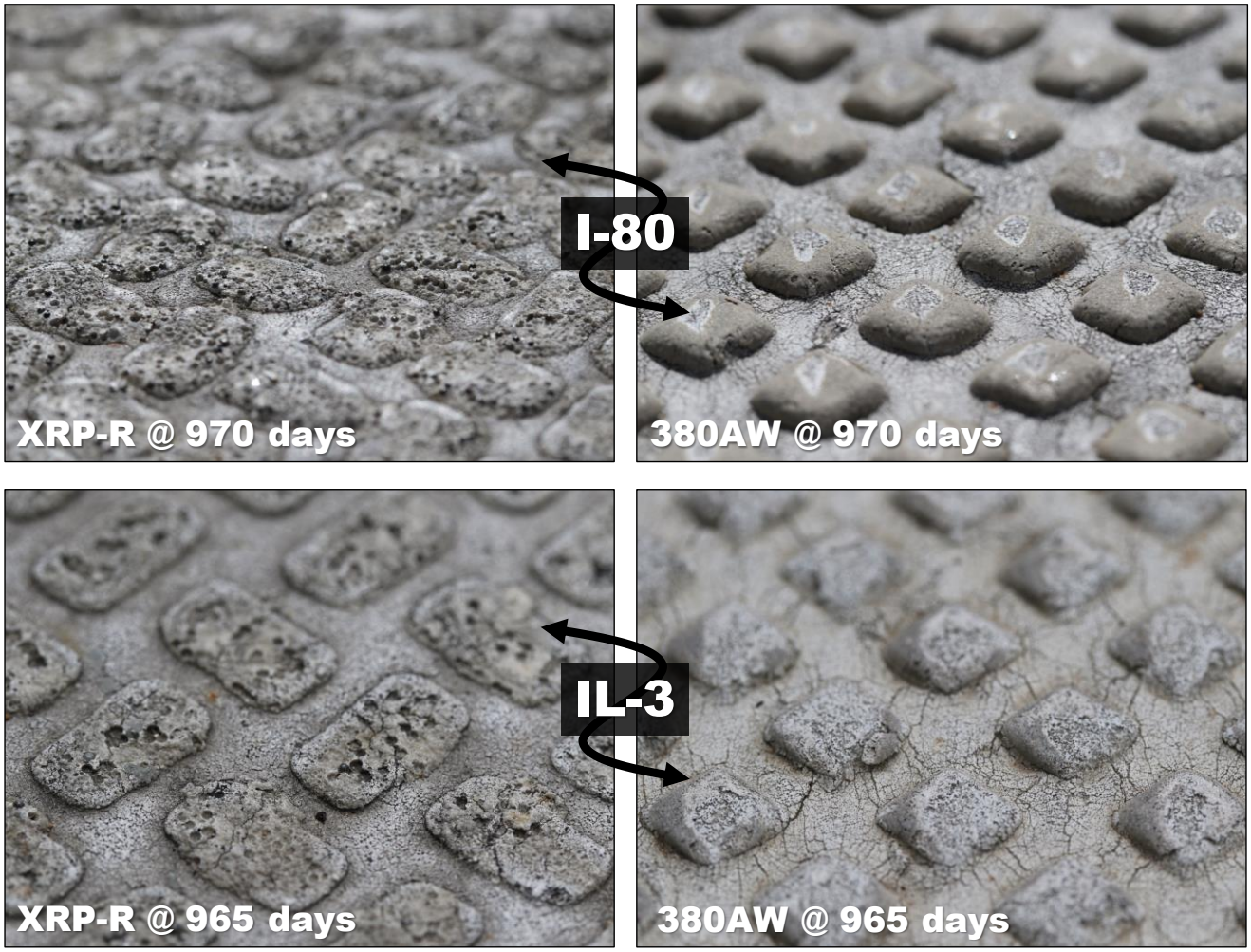

Figure 28. Tape products after 3 winters by roadway.

4.3 CONCLUSIONS

This evaluation provides data from Illinois roadways showing that after three winter seasons there are tape products that can provided both dry and all-weather (wet) retroreflectivity performance. However, this performance was found to vary by roadway with indications that in-laying these tapes as opposed to recessing them within a groove can negatively impact performance.

The 380AW tape measured significantly higher than the XRP-R tape under all conditions, especially for recovery and continuously wetted conditions. The XRP-R tape performed well under dry conditions; however, when measured under wet-recovery or continuously wetted conditions, the performance fell below 100 mcd after the initial measurement.

Short of a minimum retroreflectivity threshold for wet conditions, these findings will support IDOT decision making in terms of product selection. The 380AW tape was the only product which performed at 100 mcd or higher under continuously wetted conditions. The findings also highlight the potential negative impacts on performance when in-laying these products as opposed to recessing them within a groove.

4.4 RECOMMENDATIONS

Based on these results, only one tape (380AW) provided acceptable performance under continuously wetted conditions. Given that there is no current minimum retroreflectivity threshold, the fact that the XRP-R did not exceed 50 mcd after initial measurement, supports this recommendation.

These results show that tape performance is significantly impacted by the installation method for all conditions (dry, wet recovery, and continuously wetted). IDOT should consider only recessing these products to ensure performance integrity.

The two tapes evaluated were produced prior to September of 2016. As technology continues to advance and agencies continue to address safety and roadway departure crashes there will be future tape products which claim wet retroreflectivity performance. To this point, IDOT should consider a simplified (non-roadway) testing procedure to consider product suitability in terms of wet recovery and continuously wetted retroreflectivity performance.

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