# EVALUATING PERFORMANCE OF CONCRETE OVERLAYS FOR PAVEMENT REHABILITATION

November 2020
Final Report

Project number TR202003
MoDOT Research Report number cmr 20-012

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**Technical Report Documentation Page**

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| cmr 20-012 | | |

**4. Title and Subtitle**
Evaluating Performance of Concrete Overlays for Pavement Rehabilitation

**5. Report Date**
October 2020
Published: Nov. 2020

**6. Performing Organization Code**

**7. Author(s)**
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**8. Performing Organization Report No.**

**9. Performing Organization Name and Address**
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**10. Work Unit No. (TRAIS)**

**11. Contract or Grant No.**
MoDOT project # TR202003

**12. Sponsoring Agency Name and Address**
Missouri Department of Transportation (SPR-B)
Construction and Materials Division
P.O. Box 270
Jefferson City, MO 65102

**13. Type of Report and Period Covered**
Final Report
August 2019 – December 2020

**14. Sponsoring Agency Code**

**15. Supplementary Notes**
Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. MoDOT research reports are available in the Innovation Library at https://www.modot.org/research-publications.

**16. Abstract**
The Missouri Department of Transportation (MoDOT) has a long history of concrete overlay use dating back to at least the 1930s, and over the last 20 years has constructed over 40 concrete overlay projects in a range of applications. The goal of this study was to review and evaluate the performance of bonded and unbonded overlays constructed in Missouri as a first step in documenting their performance and working to improve MoDOT's overall concrete overlay selection, design, and construction procedures.

A database of important design, construction, and performance data for 41 selected concrete overlay projects built by the Missouri DOT from 1999 to 2019 was compiled. Three types of concrete overlays were included in this project:

1. Unbonded overlays (UBOLs): concrete overlay with thicknesses of 8 in or greater and conventional joint spacing placed on and separated from an existing concrete or asphalt pavement. A total of 26 UBOL projects were included.
2. Big block overlays (BBOLs): an unbonded concrete overlay with typical 5-in thickness and short panel size (typically 6 ft by 6 ft) and placed on an existing concrete or asphalt pavement. A total of 9 BBOL projects were included.
3. Bonded overlays (BOLs); a thin concrete overlay of typical 4-in thickness and 4 ft by 4 ft panel size bonded to the underlying asphalt or concrete pavement. A total of 6 BOL projects were included.

Time-series smoothness data were available for all projects since the time of their construction while key distress data (cracking, spalling, faulting, patching) were available from 2018. These data were examined for all overlay types and general performance trends and observations were made to identify factors leading to improved performance. Based on the findings, general recommendations to improve the performance of concrete overlays in Missouri were developed.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| Concrete, Concrete overlays, Unbonded overlays, Bonded overlays, Performance, Cracking, Roughness, PWL, Design features | No restrictions. This document is available through the National Technical Information Service, Springfield, VA 22161. |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No of Pages | 22. Price |
|---|---|---|---|
| Unclassified. | Unclassified. | 189 | |

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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**Final Report**


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**October 2020**

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## ACKNOWLEDGMENTS

The authors would like to acknowledge the Missouri Department of Transportation for providing financial support for the project and for providing project data and access to files and video records to complete the study. Special recognition goes to Jennifer Harper, Brent Schulte, John Donahue, Jay Whaley, Jonathan Varner, Jason Blomberg, and Ryan Martin for their invaluable guidance and support throughout the conduct of this project.

# EXECUTIVE SUMMARY

The Missouri Department of Transportation (MoDOT) has a long history of concrete overlay use dating back to at least the 1930s, and over the last 20 years has constructed over 40 concrete overlay projects in a range of applications. The goal of this study was to review and evaluate the performance of bonded and unbonded overlays constructed in Missouri as a first step in documenting their performance and working to improve MoDOT's overall concrete overlay selection, design, and construction procedures. To accomplish that goal, the following objectives were established:

- Inventory the routes and locations of the concrete overlays as detailed in the plans or from virtual site visits via review of ARAN videos and data. The completed inventory should include the travelway ID, direction, route, county, log limits of overlay section, lane number, type of interlayer (if applicable), and other identifying information. MoDOT furnished all of the relevant inventory data.
- Document the thickness of each concrete overlay project, along with the air content and compressive strength, by pulling information from AASHTOWare Project SiteManager QC/QA data or other Construction and Materials records, as available.
- Tabulate the performance histories of the concrete overlays using data from the MoDOT Transportation Management System (TMS) database.
- Review the latest year of video from ARAN and document visible cracking along with patching and maintenance performed on the pavement.
- Estimate the current rehabilitation and maintenance requirements for each project.
- Identify any correlations between the condition/distress of the pavement and key project construction/materials data, including the type of interlayer (where applicable).
- Identify whether coring and construction data correspond with information shown on the construction plans.

Three types of concrete overlays commonly constructed by MoDOT were included in the inventory of overlays for this project.

1. Unbonded overlays (UBOL) are used to restore or increase the structural capacity and can be used on pavements that are moderately to severely deteriorated (Harrington and Fick 2014). Unbonded overlays typically have a bond breaker or interlayer material placed between the overlay and the existing pavement to provide for independent behavior. The concrete overlay essentially performs as a new pavement and is designed as such. MoDOT's UBOL projects are typically 8 in thick and include either a hot-mix asphalt (HMA) or geotextile interlayer, with a panel size of 15 ft long and 12 to 14 ft wide. Underlying pavements include HMA, concrete, and composite (asphalt over concrete) pavements. A total of 26 UBOL projects were included in the study, of which 3 were undoweled and the remaining 23 featured 1.25-in diameter dowel bars.
2. Big block overlays (BBOL) are also considered to be an unbonded overlay but with a typical 5 in thickness and a panel size of 6 ft by 6 ft. Interlayers used on the projects in

the inventory include HMA, geotextile, or none. The underlying pavements include HMA, concrete, and composite (asphalt over concrete) pavements. A total of 9 BBOL projects were included in the study and none of these were doweled.

3. Bonded overlays (BOL) are used to add structural capacity and eliminate surface distress on existing pavements that are in fair to good structural condition (Harrington and Fick 2014). Bonded overlays are thinner than the unbonded variety and rely on a strong bond with the underlying pavement. Proper surface preparation is key to the design and performance of BOL pavements. Typical BOL pavements in this project are 4 in thick with a 4 ft by 4 ft panel size. A total of 6 BOL projects were included in the study. All these BOLs were bonded concrete over asphalt (BCOA) with fibrillated polypropylene fibers and none contained dowel bars.

A database was created in an Excel workbook that included key design, materials, construction, and performance data for each overlay project; characteristics and sources of that data are provided below:

- Design information for each of the overlay projects was extracted from project plans.
- Construction records on portland cement concrete (PCC) strength, air content, and slab thickness were extracted from MoDOT's SiteManager database. No construction records were available for the BOL projects. Percent-Within-Limit (PWL) calculations were made for strength, air content, and thickness for each of the projects where such data were available.
- Faulting and roughness data (expressed in terms of the International Roughness Index, IRI) were extracted from MoDOT's TMS database. The IRI data were averaged over 0.1-mi and project length and time series graphs were prepared. Project averages were computed for faulting. The IRI data were generally available from the time that the overlay was constructed through 2018, while faulting data were available only for 2017 and 2018.
- Traffic data from plans and the ARAN public viewer (MoDOT 2019a) were used to compute estimated equivalent single-axle load (ESAL) repetitions that each concrete overlay had sustained to account for traffic effects across projects.
- ARAN videos were reviewed and pavement distress summaries, following the protocols used under the FHWA LTPP program (Miller and Bellinger 2014), were developed. Overall, most of the overlays included in this research project are performing well, especially when considering the excellent ride quality of the UBOL projects. The BBOL and BOL projects exhibited increased IRI values and cracking and patching compared to UBOL projects.

Although the presence of several confounding variables (e.g., slab thickness, interlayer type, slab width, shoulder type, and traffic loadings) often hindered performance comparisons, some of the key observations from a review of the performance data are shown in table ES-1.

**Table ES-1. MoDOT concrete overlay summary.**

| Overlay Type | Performance Observations | Construction QA/QC Data | Effect of Design Features |
|---|---|---|---|
| UBOL (0.9 to 26.6 million ESALs) | • Observed distresses: transverse and longitudinal cracking<br>− Percent cracked and patched slabs range = 0 to 32%<br>− Predominant distress: longitudinal cracking, occurring predominantly in the middle or right wheelpath (very little transverse cracking)<br>• IRI values low and stable over time.<br>− 2018 mean IRI = 64 in/mi<br>− 2018 range = 36 to 114 in/mi<br>• Negligible faulting | • For slab thickness, PWL values below 90% generally show higher levels of distress<br>• For concrete strength, PWL values did not show a clear relationship to performance. Strength values were generally above 90%, indicating that adequate strength is not an issue for concrete overlay projects.<br>• For concrete air content, PWL values did not show a clear relationship to performance. | • Slab thickness:<br>− UBOL projects with design thickness of 8 in exhibit higher and more variable cracking.<br>− An as-constructed thickness minus one standard deviation value greater than 8.6 in results in less cracking.<br>• Slab Width/Shoulder:<br>− UBOL projects with 14-ft wide slabs and HMA shoulders exhibited higher levels of longitudinal cracking<br>− UBOL projects with PCC shoulders exhibited less longitudinal cracking than those with HMA shoulders<br>• Interlayer/Underlying Pavement:<br>− UBOL projects with geotextile interlayers exhibit less cracking than those using an existing or new HMA interlayer. |
| BBOL (0.2 to 2.8 million ESALs) | • Observed distresses: transverse, longitudinal cracking, corner breaks, and shattered slabs.<br>− Percent cracked and patched slabs range = 0 to 6% (not including project 35N and 35S, modified UBOL)<br>− Predominant distress: longitudinal cracking, most commonly occurring in the right panel of the slab.<br>• IRI values relatively high.<br>− 2018 mean IRI = 131 in/mi<br>− 2018 IRI range = 43 to 284 in/mi<br>• Negligible faulting | • For slab thickness, PWL values below 90% generally show higher levels of distress<br>• For concrete strength, PWL values did not show a clear relationship to performance. Strength values were generally above 90%, indicating that adequate strength is not an issue for concrete overlay projects.<br>• For concrete air content, PWL values did not show a clear relationship to performance. | • Slab thickness:<br>− BBOL projects with 6-in design slab thickness exhibited less cracking than the 5 and 5.5-in thick designs.<br>− A minimum as-constructed thickness of 5.5 in resulted in less cracking.<br>• Slab Geometry:<br>− No conclusions on slab geometry (all designs included 6-ft by 6-ft panels).<br>• Shoulder Type:<br>− No definitive conclusions on effect of shoulder type.<br>• Underlying Pavement.<br>− No definitive conclusions on effect of underlying pavement type. |
| BOL (0.4 to 5.8 million ESALs) | • Observed distresses: transverse, longitudinal, and corner cracking<br>− Percent cracked and patched slabs range = 0 to 25%<br>− Predominant distress: longitudinal and corner cracking, occurring predominantly in the right panel<br>− Significant cracking on 3 of 6 projects despite lower traffic<br>• IRI values high and variable.<br>− 2018 mean IRI = 263 in/mi<br>− 2018 IRI range = 118 to 443 in/mi<br>• Negligible faulting | • QA/QC results were not available for the BOL projects. | • Slab Thickness:<br>− No conclusions on slab thickness (all designs were 4 in thick).<br>• Slab Geometry:<br>− No conclusions on slab geometry (all designs included 4-ft by 4-ft panels).<br>• Shoulder Type:<br>− No definitive conclusions (only 6 projects. |

Based on the observed performance trends, the following items are recommended to improve concrete overlay performance in Missouri. UBOL projects provided more complete information, and there was more diversity in some of the design parameters that allowed for more recommendations. BOL projects had the most limited data.

- MoDOT should revise UBOL and BBOL design thickness procedures to be site specific, building on their mechanistic design procedure for pavements.
- MoDOT should revise UBOL and BBOL thickness construction quality control practices to better control minimum thickness due to the sensitivity of concrete overlays to as-constructed thickness.
- MoDOT should continue the use of geotextiles interlayers as they appear to provide better performance for UBOL projects.

The following research to improve concrete overlay performance is recommended:

- Forensics—MoDOT should consider additional field and records forensics to:
  - Determine the condition of the underlying pavement at the time of overlay.
  - Investigate good and poor performing concrete overlays to determine key design or construction parameters.
- Additional engineering for BOL projects to improve ride and underlying pavement and base support.
- Additional research on the failure mode for BOL projects. The research could determine the cause of cracking and patching that was predominantly located in the right panel for the projects reviewed. Also, could additional or different fibers be used to mitigate the cracking potential of this type of overlay.
- Additional research to optimize the design and selection of geotextiles for interlayers. The research could review geotextile selection and application to improve the performance of concrete overlays.

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| | |
|---|---|
| AADT | Annual Average Daily Traffic |
| AADTT | Average annual daily truck traffic |
| ACP | Asphalt overlay atop concrete composite pavement |
| ARAN | Fugro Automatic Road Analyzer |
| BBOL | Big Block Overlay |
| BCOA | Bonded concrete over asphalt |
| BCOAO | Bonded Concrete on Asphalt Overlay |
| BOL | Bonded Overlay |
| COM_VOL_BY_DIR | Number of trucks (FHWA class 4–13) |
| DHV | Design Hourly Volume |
| $D_L$ | Lane distribution factor |
| ESAL | Equivalent Single Axle Load |
| FDR | Full-depth concrete pavement patch |
| FHWA | Federal Highway Administration |
| HMA | Hot-mix asphalt concrete |
| Job.No. | Job or project number as assigned by MoDOT |
| JPCP | Jointed plain concrete pavement |
| JRCP | Jointed reinforced concrete pavement |
| LSL | Pay factor item lower specification limit |
| MoDOT | Missouri Department of Transportation |
| NRCCP | Nonreinforced Portland cement concrete pavement (also known as JPCP) |
| PCC | Portland Cement Concrete |
| PDR | Partial-depth concrete pavement patch |
| PWL | Percent within limits |
| $PWL_L$ | Lower PWL |
| $PWL_U$ | Upper PWL |
| $Q_L$ | Lower Quality Index |
| QLA | Quality Level Analysis |
| $Q_U$ | Upper Quality Index |
| RFP | Request for Proposals |

| | |
|---|---|
| RPCCP | Reinforced Portland cement concrete pavement (also known as JRCP) |
| TF | Truck factor |
| TMS | MoDOT's Transportation Management System database |
| U.ID. | Project identifier for concrete overlays, defined in tables 2-4, 2-5, and 2-6 |
| UBOL | Unbonded Overlay |
| USL | Pay factor item upper specification limit |

# CHAPTER 1. INTRODUCTION

## 1.1 Background

Highway agencies are increasingly constructing concrete overlays as a cost-effective method of maintaining and preserving their pavement infrastructure. With applications on both existing concrete and existing asphalt roadways, and for pavements ranging in condition from poor to good, concrete overlays offer a long-lasting, sustainable rehabilitation strategy for pavements subjected to all traffic levels.

The Missouri Department of Transportation (MoDOT) has a long history of concrete overlay use dating back to US 40 in Callaway County circa 1932 (Trautman 2017), and over the last 20 years has constructed over 40 concrete overlay projects in a range of applications. The goal of this study was to review and evaluate the performance of bonded and unbonded overlays that have been constructed in Missouri as a first step in documenting their performance and working to improve MoDOT's overall concrete overlay selection, design, and construction procedures.

## 1.2 Problem Statement

The Request for Proposals (RFP) for this study outlined the following objectives:

- Inventory the routes and locations of the concrete overlays as detailed in the plans or from virtual site visits via ARAN videos and data. Many projects consist of a combination of full-depth pavement replacement and overlay, which needs to be distinguished by location and type. The completed inventory should include the travelway ID, direction, route, county, log limits of overlay section, lane number, type of interlayer (if applicable) and other identifying information. A complete list of concrete overlays that have been constructed will be provided by MoDOT.
- Document the thickness of each concrete overlay project, along with the air content and compressive strength, by pulling information from AASHTOWare Project SiteManager QC/QA data or other Construction and Materials records, as available.
- Tabulate the performance histories of the concrete overlays using data from the MoDOT Transportation Management System (TMS) database.
- Review the latest year of video from ARAN and document visible cracking along with patching and maintenance performed on the pavement.
- Estimate the current rehabilitation and maintenance requirements for each project.
- Identify any correlations between the condition/distress of the pavement and key project construction/materials data, including the type of interlayer (where applicable).
- Identify whether coring and construction data correspond with information shown on the construction plans.

## 1.3 Research Methodology

The research project includes the following tasks:

- Task 1: Project Management.
- Task 2: Data Collection of Existing Concrete Overlays.
- Task 3: Create Project Outline for Evaluation.
- Task 4: Conduct Analysis of Field Data.
- Task 5: Develop Interim Report and Research Summary.
- Task 6: Delivery of Final Report and Research Summary.

Further details on the activities involved in each of these work tasks are described below.

### *1.3.1 Task 1: Project Management*

The contractor will facilitate a kick-off meeting with MoDOT to review the work plan, scope, and schedule; and establish a protocol for regular ongoing communications and coordination with the team. The finalized work plan will detail implementation of the following tasks as well as the resources and schedule required to carry them out.

### *1.3.2 Task 2: Data Collection of Existing Concrete Overlays*

The contractor will collaborate with MoDOT on the available project design, construction, materials, and performance data. MoDOT will provide as available:

- ARAN video (accessible in MoDOT Central Office in Jefferson City).
- Access to TMS.
- Construction plans.
- QC/QA data as available from SiteManager.

### *1.3.3 Task 3: Create Project Outline for Evaluation*

The contractor will create list of project data that includes, but not limited to, the following:

- Location Description:
  - Route.
  - County.
  - Log miles.
  - Lane miles.
  - Travelway ID.
  - Direction.
  - Lane Number.
- Design information:
  - Job number.

  - Contract number.
  - Overlay type.
  - Design thickness.
  - Base type.
  - Interlayer type.
  - Lane width / extended slab, if any.
  - Shoulder type (tied or untied).
- Underlying pavement information (type, thickness, width, etc.).
- Construction information.
  - Thickness (from QC/QA cores).
  - Strengths.
- Air content.
- Mix design.

### *1.3.4 Task 4: Conduct Analysis of Field Data*

The contractor will review all available field data, specifically:

- Latest year of ARAN video.
- TMS performance history.
- As-built plans.
- Available QC/QA data from SiteManager.

### *1.3.5 Task 5: Develop Interim Report and Research Summary*

The contractor will draft an interim report describing the data acquisition, analysis, and findings; and recommend further action, if warranted. Upon completion, the contractor will submit the interim report to MoDOT for review. Within two weeks of submittal, contractor and MoDOT will meet to discuss the finding and plan further action as required. At a minimum, the following will be addressed in the report.

- Inventory of concrete overlays.
- Analysis of design information.
- Analysis of pavement condition.
- Correlation between construction/materials and performance.
- Current repair needs.
- Recommendations for future use of concrete overlays.

### *1.3.6 Task 6: Delivery of Final Report and Research Summary*

After MoDOT's review is complete and documents have been edited to MoDOT's satisfaction, the final documents will be submitted as Word documents.

## 1.4 Report Overview

The remainder of the report consists of four additional chapters and eight appendices. Chapter 2 summarizes the data acquired for the various concrete overlays, from pavement design through pavement surficial distress. Chapter 3 discusses data analysis for the project and investigations into possible correlations of performance of the overlays to items such as thickness, slab geometry, interlayer and underlying pavement and base layers, and as-constructed material properties. Chapter 4 provides recommendations to improve the performance of concrete overlays in Missouri as well as additional research to be considered. Chapter 5 provides an overall summary of findings and recommendations.

Eight appendices are provided as a supplement to the main report; these include:

- Appendix A: MoDOT Concrete Overlay Inventory.
- Appendix B: Design Information.
- Appendix C: Construction Quality Assurance Data.
- Appendix D: Transportation Management System (TMS) Performance History Data.
- Appendix E: ESAL Calculations
- Appendix F: IRI Time Series Graphs.
- Appendix G: Current Repair Needs.
- Appendix H: Data Dictionary.

# CHAPTER 2. PROJECT DATA

## 2.1 Introduction

Various types of data were collected for the 41 concrete overlays included in this study. This chapter presents the inventory of information collected for the overlays included in this study, including structural design information, construction quality assurance data, pavement performance history data, and surficial pavement distress ratings from ARAN videos collected in 2018. Summaries of the collected data are presented in this chapter with more detailed data found in Appendix A through Appendix D.

## 2.2 Inventory of Overlays

Three types of concrete overlays were included in the inventory of overlays for this project. The three types are:

1. Unbonded overlays (UBOL) are used to restore or increase the structural capacity and can be used on pavements that are moderately to severely deteriorated (Harrington and Fick 2014). Unbonded overlays typically have a bond breaker or interlayer material placed between the overlay and the existing pavement to provide for independent behavior. The concrete overlay essentially performs as a new pavement and is designed as such. MoDOT's UBOL projects are typically 8 in thick and include either a hot-mix asphalt (HMA) or geotextile interlayer, with a panel size of 15 ft long and 12 to 14 ft wide. Underlying pavements include HMA, concrete, and composite (asphalt over concrete) pavements. A total of 26 UBOL projects were included in the study, of which 3 were undoweled and the remaining 23 featured 1.25-in diameter dowel bars.
2. Big block overlays (BBOL) are also considered to be an unbonded overlay but with a typical 5 in thickness and a panel size of 6 ft by 6 ft. Interlayers used on the projects in the inventory include HMA, geotextile, or none. The underlying pavements include HMA, concrete, and composite (asphalt over concrete) pavements. A total of 9 BBOL projects were included in the study, and none of these were doweled.
3. Bonded overlays (BOL) are used to add structural capacity and eliminate surface distress on existing pavements that are in fair to good structural condition (Harrington and Fick 2014). Bonded overlays are thinner than the unbonded variety and rely on a strong bond with the underlying pavement. Proper surface preparation is key to the design and performance of BOL pavements. Typical BOL pavements in this project are 4 in thick with a 4 ft by 4 ft panel size. A total of 6 BOL projects were included in the study. All these BOLs were bonded concrete over asphalt (BCOA) with fibrillated polypropylene fibers and none contained dowel bars.

Table 2-1 through 2-3 provide the listing of the concrete overlay projects by type, as provided by MoDOT for this project and figure 2-1 shows their location on MoDOT's highway network. A more detailed inventory listing is provided in Appendix A.

**Table 2-1. Inventory of UBOL projects provided by MoDOT.**

| No. | Travelway ID | Direction | Route Designation | Route | County | Begin Log | End Log | Completion Date |
|---|---|---|---|---|---|---|---|---|
| 1 | 10 | WB | IS | 44 | Webster/ Greene | 194.696 | 200.670 | 2000 |
| 2 | 13 | SB | IS | 55 | Pemiscot | 193.053 | 208.152 | 2002 |
| 3 | 1100 | EB | US | 412 | Pemiscot | 29.545 | 37.433 | 2003 |
| 4 | 1100 | EB | US | 412 | Pemiscot | 27.849 | 29.560 | 2003 |
| 5 | 6512 | NB | IS | 255 | St. Louis | 0.000 | 3.750 | 2003 |
| 5 | 6513 | SB | IS | 255 | St. Louis | 0.000 | 3.750 | 2003 |
| 6 | 6040 | NB | MO | 291 | Jackson | 15.343 | 16.927 | 2004 |
| 6 | 6041 | SB | MO | 291 | Jackson | 32.498 | 34.075 | 2004 |
| 7 | 9 | EB | IS | 44 | Lawrence | 33.032 | 37.736 | 2005 |
| 7 | 10 | WB | IS | 44 | Lawrence | 252.490 | 257.218 | 2005 |
| 7R | 9 | EB | IS | 44 | Lawrence | 33.032 | 37.736 | 2018 |
| 7R | 10 | WB | IS | 44 | Lawrence | 252.490 | 257.218 | 2018 |
| 8 | 9 | EB | IS | 44 | Crawford | 204.608 | 213.567 | 2005 |
| 9 | 3560 | EB | US | 36 | Macon | 108.959 | 120.110 | 2005 |
| 10 | 9 | EB | IS | 44 | Laclede | 134.000 | 145.282 | 2006 |
| 11 | 1101 | WB | US | 412 | Dunklin | 22.800 | 27.000 | 2006 |
| 12 | 263 | SB | IS | 57 | Mississippi | 0.276 | 12.747 | 2007 |
| 13 | 6372 | EB | IS | 64 | St. Louis/ St. Louis City | 27.450 | 36.580 | 2007 |
| 13 | 6373 | WB | IS | 64 | St. Louis/ St. Louis City | 4.210 | 13.350 | 2007 |
| 14 | 264 | NB | IS | 57 | Mississippi | 13.032 | 21.925 | 2009 |
| 15 | 10 | WB | IS | 44 | Phelps | 105.653 | 113.884 | 2009 |
| 16 | 12 | NB | IS | 55 | Cape/ Perry | 105.000 | 108.000 | 2010 |
| 17 | 12 | NB | IS | 55 | Pemiscot | 0.000 | 15.068 | 2010 |

**Table 2-1. Inventory of UBOL projects provided by MoDOT (continued).**

| No. | Travelway ID | Direction | Route Designation | Route | County | Begin Log | End Log | Completion Date |
|---|---|---|---|---|---|---|---|---|
| 18 | 4984 | NB | IS | 35 | Clinton | 41.320 | 49.152 | 2010 |
| 18 | 4986 | SB | IS | 35 | Clinton | 65.282 | 73.115 | 2010 |
| 19 | 4984 | NB | IS | 35 | Clay | 24.843 | 33.053 | 2010 |
| 19 | 4986 | SB | IS | 35 | Clay | 81.391 | 89.600 | 2010 |
| 20 | 9 | EB | IS | 44 | Franklin | 251.484 | 256.562 | 2010 |
| 20 | 10 | WB | IS | 44 | Franklin | 33.632 | 38.717 | 2010 |
| 21 | 10 | WB | IS | 44 | Pulaski | 127.879 | 136.082 | 2011 |
| 22 | 12 | NB | IS | 55 | Pemiscot | 15.080 | 18.680 | 2015 |
| 23 | 6039 | NB | IS | 435 | Jackson | 0.045 | 3.345 | 2019 |
| 23 | 6042 | SB | IS | 435 | Jackson | 51.789 | 55.102 | 2019 |
| 24 | 4984 | NB | IS | I-35 | Davies | 68.886 | 78.477 | 2006 |
| 24 | 4986 | SB | IS | I-35 | Davies | 35.973 | 45.521 | 2006 |
| 24R | 4984 | NB | IS | I-35 | Davies | 68.886 | 78.477 | 2013 |
| 24R | 4986 | SB | IS | I-35 | Davies | 35.973 | 45.521 | 2013 |

In table 2-1 through 2-3, the first column labelled "No." is a MoDOT recordkeeping item. Two of the UBOL projects, I-44 in Lawrence County (No. 7 and 7R) and I-35 in Davies County (No. 24 and 24R) are listed twice since there was the original construction of the UBOL and then a rehabilitation project. I-64 in the City and County of St. Louis was constructed as a design-build project. After an initial review of project data availability and project history, the BOL project in Stone County was eliminated from further consideration in the study based on a lack of data.

The second column labelled "Travelway ID" is MoDOT inventory of travelways. Eastbound and westbound roadways on the Interstate have separate Travelway IDs. Many of the project were constructed in both directions on multi-travelway facilities and some BBOL and BOL projects were constructed at intersections and have four directional components and Travelway IDs.

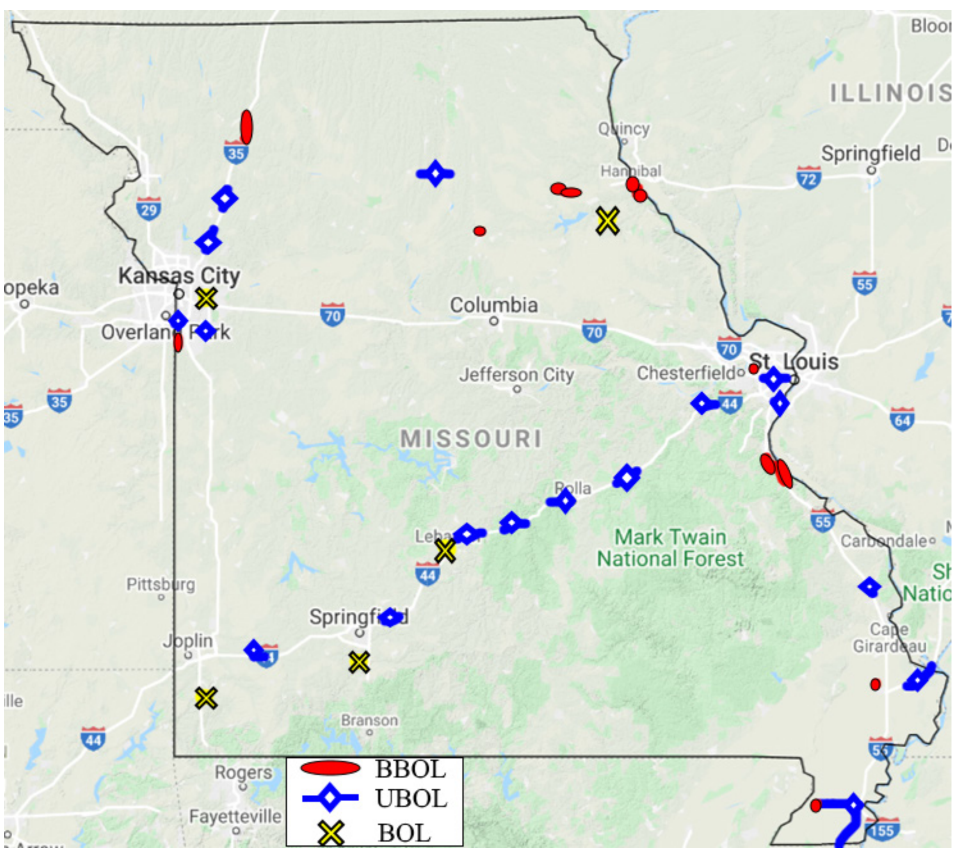
**Table 2-2. Inventory of BBOL provided by MoDOT.**

| No. | Travelway ID | Direction | Route Designation | Route | County | Begin Log | End Log | Completion Date |
|---|---|---|---|---|---|---|---|---|
| 1 | 6102 | SB | RT | D | Cass | 0.051 | 3.131 | 2008 |
| 1 | 6103 | NB | RT | D | Cass | 23.095 | 26.175 | 2008 |
| 2 | 11 | SB | US | 61 | Jefferson/ Ste. Genevieve | 200.738 | 213.576 | 2009 |
| 2 | 7773 | NB | US | 61 | Jefferson/ Ste. Genevieve | 179.479 | 182.444 | 2009 |
| 3 | 3560 | EB | US | 36 | Shelby/ Marion | 162.176 | 169.428 | 2010 |
| 4 | 6365 | NB | MO | 79 | Marion/ Ralls | 78.500 | 86.232 | 2013 |
| 4 | 6366 | SB | MO | 79 | Marion/ Ralls | 1.721 | 9.453 | 2013 |
| 5 | 1975 | SB | MO | 5 | Laclede | 249.980 | 250.000 | 2014 |
| 6 | 6142 | WB | MO | 340 | St. Louis | 9.960 | 10.030 | 2014 |
| 7 | 1100 | EB | US | 412 | Dunklin | 26.880 | 27.260 | 2016 |
| 7 | 1101 | WB | US | 412 | Dunklin | 23.530 | 23.880 | 2016 |
| 8 | 11 | SB | US | 61 | Scott | 318.330 | 318.510 | 2016 |
| 8 | 7773 | NB | US | 61 | Scott | 74.560 | 74.720 | 2016 |
| 9 | 3534 | EB | US | 24 | Randolph | 135.400 | 135.510 | 2010 |
| 9 | 3533 | WB | US | 24 | Randolph | 80.260 | 80.360 | 2010 |
| 9 | 3534 | SB | BUS | 63 | Randolph | 1.030 | 1.110 | 2010 |
| 9 | 3533 | NB | BUS | 63 | Randolph | 8.470 | 8.550 | 2010 |
| 41 | 4984 | NB | | I-35 | Davies | | | 2006 |
| 41 | 4986 | SB | | I-35 | Davies | | | 2006 |

**Table 2-3. Inventory of BOL provided by MoDOT.**

| No. | Travelway ID | Direction | Route Designation | Route | County | Begin Log | End Log | Completion Date |
|---|---|---|---|---|---|---|---|---|
| 1 | 1975 | SB | MO | 5 | Laclede | 250.520 | 250.590 | 2003 |
| 1 | 1976 | NB | MO | 5 | Laclede | 102.160 | 102.220 | 2003 |
| 2 | 54 | SB | MO | 19 | Ralls | 8.411 | 8.480 | 2012 |
| 2 | 55 | NB | MO | 19 | Ralls | 254.320 | 254.400 | 2012 |
| 3 | 6041 | NB | MO | 291 | Jackson | 30.050 | 30.230 | 2003 |
| 3 | 6040 | SB | MO | 291 | Jackson | 19.100 | 19.310 | 2003 |
| 4 | 7783 | WB | US | 60 | Newton | 328.070 | 329.200 | 1999 |
| 4 | 7782 | EB | US | 60 | Newton | 11.570 | 12.700 | 1999 |
| 5 | 1029 | WB | MO | 34 | Cape Girardeau | 14.250 | 14.850 | 2009 |
| 6 | 1978 | WB | MO | 14 | Christian | 94.910 | 94.960 | 2008 |
| 6 | 1977 | EB | MO | 14 | Christian | 24.949 | 24.983 | 2008 |
| 7 | | | BUS | 13 | Stone | | | 2008 |

Number 7 was removed from study.




Map data ©2020 Google

**Figure 2-1. Location map of project overlays**

The project concrete overlays cover approximately 631 of MoDOT's highway network of 77,708 lane-miles (FHWA 2018), slightly less than 1 percent. Approximately 5 percent of MoDOT's Interstate centerline miles have an unbonded concrete overlay (Donahue 2017).

### 2.3 Design Information

The project plans and Summary Sheet for Concrete Paving Project (2-AA) were reviewed for each of the projects. The 2-AA sheets provide a record of construction and design features of a project. To the extent that information was available the following items were extracted from the design information and added to the project database.

- Confirmed overlay type (UBOL, BBOL, BOL).
- Project stationing.
- Overlay omissions due to bridges, intersections, and so on.
- Design thickness.
- Underlying pavement type and thickness.
- Base type and thickness.
- Interlayer type and thickness.
- Slab geometry.
  - Lane width / extended slab, if any.
  - Joint spacing.
- Shoulder type and tiebar design details.
- Dowel bar use and design details.
- Pavement drainage details.
- Design traffic information including annual average daily traffic (AADT), design hourly volume (DHV), percent trucks.

During the review of the design and other information there were some inaccuracies discovered in the original inventory. Table 2-4 through 2-6 contain the revised inventory information for UBOL, BBOL, and BOL, respectively. The far-left column, labeled U.ID., will be used to identify projects throughout this report. U.ID. is a combination of the sequential inventory number of an overlay and the direction of travel. The count of projects included in this study by overlay type are:

- UBOL – 26 projects that contain 36 U.IDs.
- BBOL – 9 projects that contain 19 U.IDs.
- UBOL – 6 projects that contain 11 U. IDs.

**Table 2-4. Revised UBOL inventory with U.ID.**

| U.ID. | No | Travelway ID | Direction | Designation | Route | County | Revised Log.Start | Revised Log.End |
|---|---|---|---|---|---|---|---|---|
| 1W | 1 | 10 | WB | IS | 44 | Webster/ Greene | 197.717 | 203.576 |
| 2S | 2 | 13 | SB | IS | 55 | Pemiscot | 193.100 | 208.123 |
| 3E | 3 | 1100 | EB | US | 412 | Pemiscot | 29.457 | 37.433 |
| 4E | 4 | 1100 | EB | US | 412 | Pemiscot | 27.849 | 29.560 |
| 5N | 5 | 6512 | NB | IS | 255 | St. Louis | 0.323 | 3.750 |
| 5S | 5 | 6513 | SB | IS | 255 | St. Louis | 0.000 | 3.660 |
| 6N | 6 | 6040 | NB | MO | 291 | Jackson | 15.343 | 16.772 |
| 6S | 6 | 6041 | SB | MO | 291 | Jackson | 32.533 | 34.075 |
| 7E | 7 | 9 | EB | IS | 44 | Lawrence | 33.032 | 37.472 |
| 7W | 7 | 10 | WB | IS | 44 | Lawrence | 255.665 | 260.119 |
| 8E | 7R | 9 | EB | IS | 44 | Lawrence | 33.032 | 37.472 |
| 8W | 7R | 10 | WB | IS | 44 | Lawrence | 255.665 | 260.119 |
| 9E | 8 | 9 | EB | IS | 44 | Crawford | 204.608 | 213.799 |
| 10E | 9 | 3560 | EB | US | 36 | Macon | 109.058 | 120.110 |
| 11E | 10 | 9 | EB | IS | 44 | Laclede | 134.600 | 141.077 |
| 12E | 10 | 9 | EB | IS | 44 | Laclede | 141.077 | 145.120 |
| 13W | 11 | 1101 | WB | US | 412 | Dunklin | 22.943 | 26.342 |
| 14S | 12 | 263 | SB | IS | 57 | Mississippi | 0.369 | 12.747 |
| 15E | 13 | 6372 | EB | IS | 64 | St. Louis/ St. Louis City | 27.450 | 36.580 |
| 15W | 13 | 6373 | WB | IS | 64 | St. Louis/ St. Louis City | 4.210 | 13.350 |
| 16N | 14 | 264 | NB | IS | 57 | Mississippi | 13.032 | 21.925 |
| 17W | 15 | 10 | WB | IS | 44 | Phelps | 107.539 | 116.599 |
| 18N | 16 | 12 | NB | IS | 55 | Cape/ Perry | 105.966 | 107.966 |
| 19N | 17 | 12 | NB | IS | 55 | Pemiscot | 0.076 | 15.079 |
| 20N | 18 | 4984 | NB | IS | 35 | Clinton | 41.838 | 48.878 |

**Table 2-4. Revised UBOL inventory with U.ID. (continued).**

| U.ID. | No | Travelway ID | Direction | Designation | Route | County | Revised Log.Start | Revised Log.End |
|---|---|---|---|---|---|---|---|---|
| 20S | 18 | 4986 | SB | IS | 35 | Clinton | 65.539 | 72.555 |
| 21N | 19 | 4984 | NB | IS | 35 | Clay | 24.843 | 33.017 |
| 21S | 19 | 4986 | SB | IS | 35 | Clay | 81.393 | 89.600 |
| 22E | 20 | 9 | EB | IS | 44 | Franklin | 251.534 | 256.562 |
| 22W | 20 | 10 | WB | IS | 44 | Franklin | 36.538 | 41.554 |
| 23W | 21 | 10 | WB | IS | 44 | Pulaski | 130.375 | 139.258 |
| 24N | 22 | 12 | NB | IS | 55 | Pemiscot | 15.080 | 18.680 |
| 25N | 23 | 6039 | NB | IS | 435 | Jackson | 0.045 | 3.330 |
| 25S | 23 | 6042 | SB | IS | 435 | Jackson | 51.789 | 55.080 |
| 26N | 24 | 4984 | NB | IS | I-35 | Daviess | 69.020 | 78.440 |
| 26S | 24 | 4986 | SB | IS | I-35 | Daviess | 35.987 | 45.398 |

The major change in these tables is the start and stop log miles based on video from MoDOT online ARAN Viewer (MoDOT 2019a) available through MoDOT's Data Zone (MoDOT 2016a). This item will be discussed in more detail later in this chapter.

Detailed design information for the concrete overlay projects can be found in Appendix B. A brief description of a few key design elements for the three overlay types is provided below.

### *2.3.1 Thickness*

For the UBOL, the predominant design thickness was 8 in. Projects 2S, 8E, 8W, 15E, 15W, and 24N were designed with a 9 in thickness, while 3E and 4E were designed with a 12 in thickness. Projects 25N and 25S had a thickness cross section that varied from 8.5 to 11 in to improve drainage for that roadway section.

For the BBOL projects, the design thickness was:

- 5.0 in for projects 27S, 27N, 28S, 28N, 29S, 29N, 30S, and 30N.
- 5.5 in for projects 34E, 34W, 34S, and 34N.
- 6.0 in for projects 31S, 31N, 32S, 32N, 33S, and 33N.
- 8.0 in for projects 35N and 35S since this was a rehabilitation of projects 26N and 26S to reduce the slab size.

**Table 2-5. Revised BBOL inventory with U.ID.**

| U.ID. | No | Travelway ID | Direction | Designation | Route | County | Revised Log.Start | Revised Log.End |
|---|---|---|---|---|---|---|---|---|
| 27S | 1 | 6102 | SB | RT | D | Cass | 0.219 | 3.000 |
| 27N | 1 | 6103 | NB | RT | D | Cass | 23.120 | 25.912 |
| 28S | 2 | 11 | SB | US | 61 | Jefferson/ Ste. Genevieve | 200.925 | 213.675 |
| 28N | 2 | 7773 | NB | US | 61 | Jefferson/ Ste. Genevieve | 180.376 | 193.124 |
| 29E | 3 | 3560 | EB | US | 36 | Shelby /Marion | 162.199 | 169.418 |
| 30N | 4 | 6365 | NB | MO | 79 | Marion/ Ralls | 78.520 | 86.141 |
| 30S | 4 | 6366 | SB | MO | 79 | Marion/ Ralls | 1.811 | 9.432 |
| 31S | 5 | 1975 | SB | MO | 5 | Laclede | 250.525 | 250.590 |
| 32W | 6 | 6142 | WB | MO | 340 | St. Louis | 9.960 | 10.030 |
| 33E | 7 | 1100 | EB | US | 412 | Dunklin | 23.532 | 23.879 |
| 33W | 7 | 1101 | WB | US | 412 | Dunklin | 26.912 | 27.270 |
| 33S | 8 | 11 | SB | US | 61 | Scott | 319.163 | 319.322 |
| 33N | 8 | 7773 | NB | US | 61 | Scott | 74.558 | 74.717 |
| 34E | 9 | 3562 | EB | US | 24 | Randolph | 140.897 | 140.980 |
| 34W | 9 | 3563 | WB | US | 24 | Randolph | 80.273 | 80.356 |
| 34S | 9 | 3534 | SB | BUS | 63 | Randolph | 1.030 | 1.110 |
| 34N | 9 | 3533 | NB | BUS | 63 | Randolph | 8.470 | 8.550 |
| 35N | 24R | 4984 | NB | IS | I-35 | Daviess | 69.020 | 78.440 |
| 35S | 24R | 4986 | SB | IS | I-35 | Daviess | 35.987 | 45.398 |

All the BOL projects had a design thickness of 4 in. According to Section 506.10 of the *2019 Standard Specifications for Highway Construction* (MoDOT 2019b), all BCOA overlays contain 3.0 lb/yd$^3$ of fibrillated polypropylene fibers. Trautman (2017) noted that all six BCOA projects constructed since 1999 have fibers.

**Table 2-6. Revised BOL inventory with U.ID.**

| U.ID. | No | Travelway ID | Direction | Designation | Route | County | Revised Log.Start | Revised Log.End |
|---|---|---|---|---|---|---|---|---|
| 36S | 1 | 1975 | SB | MO | 5 | Laclede | 250.520 | 250.590 |
| 36N | 1 | 1976 | NB | MO | 5 | Laclede | 102.146 | 102.220 |
| 37S | 2 | 54 | SB | MO | 19 | Ralls | 8.411 | 8.480 |
| 37N | 2 | 55 | NB | MO | 19 | Ralls | 254.348 | 254.415 |
| 38N | 3 | 6040 | NB | MO | 291 | Jackson | 30.050 | 30.243 |
| 38S | 3 | 6041 | SB | MO | 291 | Jackson | 19.100 | 19.310 |
| 39W | 4 | 7783 | WB | US | 60 | Newton | 328.070 | 328.500 |
| 39E | 4 | 7782 | EB | US | 60 | Newton | 12.280 | 12.700 |
| 40W | 5 | 1029 | WB | MO | 34 | Cape Girardeau | NA | NA |
| 41W | 6 | 1978 | WB | MO | 14 | Christian | 94.910 | 94.960 |
| 41E | 6 | 1977 | EB | MO | 14 | Christian | 24.902 | 24.954 |

### *2.3.2 Slab Geometry*

All of the UBOL projects had transverse joint spacings of 15 ft and the standard design slab width for all UBOL projects was 12 ft, with the exception of:

- 13 ft for projects 16N, 18N, and 19N.
- 13.8 ft for projects 3E, 4E, and 13W.
- 14 ft for projects 10E, 11E, 12E, and 14S.

The BBOL projects had a slab size of 6 by 6 ft, except for project 35N and 35S, that sawed the original 15 by 12 ft UBOL slabs into quarters, resulting in 7.5 by 6 ft slabs.

All the BOL projects had a slab size of 4 by 4 ft.

### *2.3.3 Interlayer*

For UBOL projects, the predominant interlayer type was a 1 in HMA layer, which was present in eighteen projects. Eleven projects used a geotextile, and seven were placed on top of the milled surface of the existing underlying HMA.

The most common interlayer type for BBOL projects was geotextile fabric, which was used by ten projects. Seven projects were placed on the milled surface of existing HMA, and two projects had a 1 in HMA layer.

BOL projects do not have an interlayer, as they are placed directly on top of the existing milled pavement surface.

### *2.3.4 Underlying Pavement and Base*

The underlying pavement structure for the concrete overlay projects included in the study varied between concrete, asphalt, and composite pavements. For most projects, 45 out of 66, the thickness of the underlying pavement was not specified; for those that were, the thickness varied between 6 and 9 in. The distribution of the underlying pavement type for the UBOL projects is:

- 12 projects had a composite asphalt over concrete pavement (ACP) structure.
- 11 projects had a reinforced portland cement concrete pavement (RPCCP) structure.
- 7 projects had a non-reinforced portland cement concrete pavement (NRCCP) structure.
- 5 projects had an HMA pavement structure.
- No details were available for project 18N.

For BBOL projects, the distribution of the type of underlying pavement structures is as follows:

- 9 projects had an HMA structure.
- 4 projects had an ACP structure.
- 4 projects had a concrete underlying structure, 2 were RPCCP and 2 other NRCCP.
- No details were available for two projects, U. ID. 30N and 30S.

All of the BOL projects included in the study had an HMA layer as the underlying pavement type. Section 506.10.1 of the *2019 Standard Specifications for Highway Construction* (MoDOT 2019b) requires that the prepared base asphalt have a minimum thickness of 3 in. MoDOT personnel noted that when milling these intersections for profile there were instances where this minimum base asphalt thickness likely was not met.

In terms of the base layer for the existing underlying pavement structures, such information was not available for 42 of the 66 projects. For those that had a base type specified, they all had a 4 in aggregate base. Two projects (15E and 15W) had a rock base.

### *2.3.5 Shoulder Type*

The UBOL projects had an almost even split between asphalt (16) and concrete shoulder (19) types. Only one project, 17W, did not have details regarding shoulder type. Beside asphalt and concrete shoulders, some BBOL projects had shoulder types classified as curb and gutter (31S, 33E, 33W, 34E, 34W, 34N, and 34S), while two projects (28N and 28S) had aggregate shoulders. BOL projects generally had asphalt or a curb and gutter shoulders.

### *2.3.6 Traffic*

Design traffic data were extracted from project plans and included in the database. Traffic data fields included:

- Average Annual Daily Traffic (AADT):
  - At year zero or year of construction.
  - At year ‘n’, which for most projects was 20 years after construction.
- Design Hourly Volume (DHV).
- Percent trucks.
- Design speed.
- Directional factor.

There were eight BBOL and four BOL projects that only had traffic values for a 10-year design.

## 2.4 Construction Quality Assurance Data

MoDOT’s SiteManager database was queried for construction material testing for the concrete overlay projects. Pertinent data to be used in this study included as-constructed thickness, PCC compressive strength, and PCC entrained air content. Data from SiteManager was extracted by Contract ID and Project Number (or Job Number), suggesting that the data may include testing results not related to the overlay work. This aggregation does not allow for the test results to be broken out by inventory direction (or by Travelway ID) as shown in tables 2-4 through 2-6.

The following actions were taken to extract data more representative of the overlay construction. These items were discussed and confirmed with MoDOT staff before execution.

- The extracted data were filtered to remove test results from non-overlay related pay items.
- The dataset test results labeled as QC testing (performed by the contractor) and QA testing (contained by MoDOT or their designee). These tests results were combined into one pool for analysis to allow for a larger sample size when performing analysis.
- For projects that were designated as metric, the following changes were made to the recorded data:
  - Projects labeled as metric and slump recorded value greater than 10: the recorded value was divided by 25.4 to convert mm to in.
  - Project labeled as metric and thickness recorded value greater than 20: the recorded value was divided by 25.4 to convert mm to in.
  - Project labeled as metric and strength recorded value between 0 and 100: the recorded value was multiplied by 145.0377 to convert MPa to lbf/in$^2$.
- Several imported items had apparent typographical errors, such as added or deleted zeros. Those values were corrected to their apparent values in coordination with MoDOT.

- Several of the PCC strength values were actually a record of the applied force. Those values were divided by the area of the core to obtain a strength value (the diameter of the core was assumed to be 3.98 in).
- A statistical review of the quartile results of the QC/QA data was made, with the following impacts:
  - All core thickness data were maintained.
  - Air content values below 2% were removed.

A summarized listing of the extracted data is provided in Appendix C.

### *2.4.1 Data Completeness*

After performing the data cleaning actions described above, the resultant data coverage is shown in table 2-7. No material quality test values were available for the BOL projects.

**Table 2-7. Summary of extracted SiteManager data coverage.**

| Item | Compressive Strength Tests | PCC Overlay Core Thickness | Air Content |
|---|---|---|---|
| ID with Test Reported | 41 | 40 | 38 |
| Project Number with Test Reported | 25 | 24 | 23 |
| Number of Tests Performed on UBOL | 3978 | 3262 | 1680 |
| Number of Tests Performed on BBOL | 830 | 810 | 284 |
| Number of Tests Performed on BOL | 0 | 0 | 0 |

### *2.4.2 Thickness—By Overlay Type*

Tables 2-8 and 2-9 provide the design thickness, mean concrete overlay measured thickness value, standard deviation, and number of tests performed for the UBOL and BBOL projects, respectively. Note that in some cases multiple U.ID. designations are applied to the same Job.No. and test data for ease of reading. Section 502.10.4.5 of MoDOT's *2019 Standard Specifications for Highway Construction* (MoDOT 2019b) indicates that for determining quality level, the thickness is equal to the plan thickness minus 0.5 in.

**Table 2-8. Concrete overlay thickness for UBOL.**

| U.ID. | Job.No. | Average, in | Standard Deviation, in | Count, No of Observations | Design Thickness, in |
|---|---|---|---|---|---|
| 01W | NA | NA | NA | NA | NA |
| 02S | NA | NA | NA | NA | NA |
| 03E | NA | NA | NA | NA | NA |
| 04E | NA | NA | NA | NA | NA |
| 05N | J6I1486 | 9.51 | 1.23 | 396 | 8 |
| 05S | J6I1486 | NA | NA | NA | NA |
| 06N | NA | NA | NA | NA | NA |
| 06S | NA | NA | NA | NA | NA |
| 07E | J7I0721 | NA | NA | NA | NA |
| 07W | J7I0721 | NA | NA | NA | NA |
| 08E | J7I3074 | 9.93 | 0.72 | 65 | 9 |
| 08W | J7I3074 | NA | NA | NA | NA |
| 09E | J9I0509 | 8.92 | 0.38 | 14 | 8 |
| 10E | J2P0726 | 8.13 | 0.07 | 7 | 8 |
| 11E | J8I0747 | 7.79 | 0.46 | 10 | 8 |
| 12E | NA | NA | NA | NA | NA |
| 13W | J0P0570 | 10.72 | 0.41 | 3 | 8 |
| 14S | J0I0973 | 7.96 | 0.61 | 270 | 8 |
| 15E | NA | NA | NA | NA | NA |
| 15W | NA | NA | NA | NA | NA |
| 16N | J0I0983 | 8.47 | 1.10 | 180 | 8 |
| 17W | J9I2166 | 9.15 | 1.47 | 147 | 8 |
| 18N | J0I2200 | 8.72 | 0.30 | 2 | 8 |
| 19N | J0I2171 | 8.16 | 0.64 | 246 | 8 |
| 20N | J1I1040 | 8.92 | 0.86 | 213 | 8 |
| 20S | J1I1040 | NA | NA | NA | NA |
| 21N | J4I1382 | 8.00 | 0.00 | 210 | 8 |
| 21S | J4I1382 | NA | NA | NA | NA |
| 22E | J6I2011 | 11.10 | 1.76 | 130 | 8 |
| 22W | J6I2011 | NA | NA | NA | NA |
| 23W | J9I2149 | 8.38 | 0.77 | 90 | 8 |
| 24N | J9P2244B | 9.49 | 0.68 | 37 | 9 |
| 25N | NA | NA | NA | NA | NA |
| 25S | NA | NA | NA | NA | NA |
| 26N | J1I0895 | 8.82 | 0.78 | 83 | 8 |
| 26S | J1I0895 | NA | NA | NA | NA |

Multiple U.ID.s are applied to the same Job.No. and tests.

**Table 2-9. Concrete overlay thickness for BBOL.**

| U.ID. | Job.No. | Average, in | Standard Deviation, in | Count, No of Observations | Design Thickness, in |
|---|---|---|---|---|---|
| 27N | J4S2246 | 5.99 | 0.58 | 56 | 5 |
| 27S | J4S2246 | NA | NA | NA | NA |
| 28N | J6S1961 | 5.62 | 0.93 | 175 | 5 |
| 28S | J6S1961 | NA | NA | NA | NA |
| 29E | J3P0792B | 5.65 | 0.62 | 56 | 5 |
| 30N | J3P2193 | 5.22 | 0.88 | 80 | 5 |
| 30S | J3P2193 | NA | NA | NA | NA |
| 31S | NA | NA | NA | NA | NA |
| 32W | NA | NA | NA | NA | NA |
| 33E | J9S3010 | 6.34 | 0.34 | 3 | 6 |
| 33N | J9S3010 | NA | NA | NA | NA |
| 33S | J9S3010 | NA | NA | NA | NA |
| 33W | J9S3010 | NA | NA | NA | NA |
| 34E | J2P0779C | 5.60 | 0.44 | 30 | 5.5 |
| 34N | J2P0779C | NA | NA | NA | NA |
| 34S | J2P0779C | NA | NA | NA | NA |
| 34W | J2P0779C | NA | NA | NA | NA |
| 35N | NA | NA | NA | NA | NA |
| 35S | NA | NA | NA | NA | NA |

Multiple U.ID.s are applied to the same Job.No. and tests.

### *2.4.3 Strength—By Overlay Type*

Tables 2-10 and 2-11 display the mean PCC tested strength value, standard deviation, and number of tests performed for the UBOL and BBOL projects, respectively. Note that multiple U.ID. designations are applied to the same Job.No. and test data for ease of reading. Sections 501.3.8 and 502.10.4.5 of MoDOT's *2019 Standard Specifications for Highway Construction* (MoDOT 2019b) set a minimum compressive strength value of 4,000 lbf/in$^2$.

### *2.4.4 Air Content—By Overlay Type*

Tables 2-12 and 2-13 display the mean PCC air content value, standard deviation, and number of tests performed for the UBOL and BBOL projects, respectively. Note that multiple U.ID.s are applied to the same Job.No. and test data for ease of reading. Section 501.10.2 of MoDOT's *2019 Standard Specifications for Highway Construction* (MoDOT 2019b) sets a minimum value for air content at 4.5% and a maximum value at 7.5%, but concrete with a value of up to 9.0% may be allowed. There were two Job.No. where only one air test was reported in the cleaned data set.

**Table 2-10. PCC overlay strength for UBOL.**

| U.ID. | Job.No. | Average, lbf/in$^2$ | Standard Deviation, lbf/in$^2$ | Count, No of Observations |
|---|---|---|---|---|
| 01W | NA | NA | NA | NA |
| 02S | NA | NA | NA | NA |
| 03E | NA | NA | NA | NA |
| 04E | NA | NA | NA | NA |
| 05N | J6I1486 | 5,358 | 1,117 | 395 |
| 05S | J6I1486 | NA | NA | NA |
| 06N | NA | NA | NA | NA |
| 06S | NA | NA | NA | NA |
| 07E | J7I0721 | 5,136 | 705 | 223 |
| 07W | J7I0721 | NA | NA | NA |
| 08E | J7I3074 | 6,712 | 1,033 | 65 |
| 08W | J7I3074 | NA | NA | NA |
| 09E | J9I0509 | 4,757 | 445 | 80 |
| 10E | J2P0726 | 5,857 | 712 | 126 |
| 11E | J8I0747 | 5,017 | 750 | 95 |
| 12E | J8I0748 | 4,948 | 584 | 30 |
| 13W | J0P0570 | 5,997 | 484 | 3 |
| 14S | J0I0973 | 5,888 | 626 | 278 |
| 15E | NA | NA | NA | NA |
| 15W | NA | NA | NA | NA |
| 16N | J0I0983 | 5,406 | 618 | 180 |
| 17W | J9I2166 | 5,544 | 1,089 | 163 |
| 18N | J0I2200 | 4,745 | 338 | 12 |
| 19N | J0I2171 | 6,393 | 620 | 246 |
| 20N | J1I1040 | 5,108 | 547 | 213 |
| 20S | J1I1040 | NA | NA | NA |
| 21N | J4I1382 | 7,153 | 753 | 210 |
| 21S | J4I1382 | NA | NA | NA |
| 22E | J6I2011 | 5,100 | 865 | 130 |
| 22W | J6I2011 | NA | NA | NA |
| 23W | J9I2149 | 6,094 | 850 | 90 |
| 24N | J9P2244B | 5,834 | 734 | 37 |
| 25N | NA | NA | NA | NA |
| 25S | NA | NA | NA | NA |
| 26N | J1I0895 | 4,836 | 616 | 83 |
| 26S | J1I0895 | NA | NA | NA |

Multiple U.ID.s are applied to the same Job.No. and tests.

**Table 2-11. PCC overlay strength for BBOL.**

| U.ID. | Job.No. | Average, lbf/in$^2$ | Standard Deviation, lbf/in$^2$ | Count, No of Observations |
|---|---|---|---|---|
| 27N | J4S2246 | 5,604 | 259 | 36 |
| 27S | J4S2246 | NA | NA | NA |
| 28N | J6S1961 | 5,721 | 669 | 175 |
| 28S | J6S1961 | NA | NA | NA |
| 29E | J3P0792B | 4,786 | 409 | 56 |
| 30N | J3P2193 | 5,371 | 504 | 80 |
| 30S | J3P2193 | NA | NA | NA |
| 31S | NA | NA | NA | NA |
| 32W | NA | NA | NA | NA |
| 33E | J9S3010 | 6,125 | 1,170 | 18 |
| 33N | J9S3010 | NA | NA | NA |
| 33S | J9S3010 | NA | NA | NA |
| 33W | J9S3010 | NA | NA | NA |
| 34E | J2P0779C | 5,666 | 792 | 30 |
| 34N | J2P0779C | NA | NA | NA |
| 34S | J2P0779C | NA | NA | NA |
| 34W | J2P0779C | NA | NA | NA |
| 35N | NA | NA | NA | NA |
| 35S | NA | NA | NA | NA |

Multiple U.ID.s are applied to the same Job.No. and tests.

## 2.5 Transportation Management System (TMS) Performance History Data

MoDOT's Transportation Management System (TMS) database contains multiple data elements related to the performance of MoDOT's pavement infrastructure. The data are available to the public at the MoDOT Data Zone (MoDOT 2016a) and the ARAN Public Viewer (MoDOT 2019a). Additional information about these data sources can be found in documentation by MoDOT (2016b) and by Richardson et al. (2015).

The data elements shown in table 2-14 were extracted from the TMS database for each of the concrete overlay projects from the year of construction through 2018 based on the revised Log.Start and Log.End identifiers shown in tables 2-4 through 2-6.

Two documents describing the extracted data elements from TMS, AUTO_COND_SURVEY and SS_PAVEMENT_CURRENT, are contained in Appendix D.

### *2.5.1 IRI*

Table 2-15 presents the project average IRI for all of the concrete overlay projects included in the study, from 2009 through 2018. The IRI data are recorded in the TMS database by wheelpath in 0.02 mi increments. Both wheelpath values are averaged to produce the results shown in table 2-14. The complete set of values for all years for the overlay projects are provided in Appendix D.

**Table 2-12. PCC air content for UBOL by U.ID.**

| U.ID. | Job.No. | Average, % | Standard Deviation, % | Count, No of Observations |
|---|---|---|---|---|
| 01W | NA | NA | NA | NA |
| 02S | NA | NA | NA | NA |
| 03E | NA | NA | NA | NA |
| 04E | NA | NA | NA | NA |
| 05N | J6I1486 | 6.03 | 1.24 | 278 |
| 05S | J6I1486 | NA | NA | NA |
| 06N | NA | NA | NA | NA |
| 06S | NA | NA | NA | NA |
| 07E | J7I0721 | 5.84 | 0.89 | 146 |
| 07W | J7I0721 | NA | NA | NA |
| 08E | NA | NA | NA | NA |
| 08W | NA | NA | NA | NA |
| 09E | NA | NA | NA | NA |
| 10E | J2P0726 | 4.73 | 1.87 | 18 |
| 11E | J8I0747 | 6.60 | 0.91 | 20 |
| 12E | J8I0748 | 6.18 | 0.47 | 5 |
| 13W | J0P0570 | 8.25 | 1.47 | 8 |
| 14S | J0I0973 | 5.54 | 0.28 | 29 |
| 15E | NA | NA | NA | NA |
| 15W | NA | NA | NA | NA |
| 16N | J0I0983 | 5.60 | 0.89 | 72 |
| 17W | J9I2166 | 6.38 | 0.70 | 17 |
| 18N | J0I2200 | 6.59 | 0.14 | 8 |
| 19N | J0I2171 | 5.41 | 0.66 | 152 |
| 20N | J1I1040 | 6.24 | 1.54 | 173 |
| 20S | J1I1040 | NA | NA | NA |
| 21N | J4I1382 | 5.00 | 0.57 | 41 |
| 21S | J4I1382 | NA | NA | NA |
| 22E | J6I2011 | 7.37 | 0.82 | 26 |
| 22W | J6I2011 | NA | NA | NA |
| 23W | J9I2149 | 5.42 | 0.38 | 14 |
| 24N | J9P2244B | 5.39 | 1.00 | 7 |
| 25N | NA | NA | NA | NA |
| 25S | NA | NA | NA | NA |
| 26N | J1I0895 | 6.20 | NA | 1 |
| 26S | J1I0895 | NA | NA | NA |

Multiple U.ID.s are applied to the same Job.No. and tests.

**Table 2-13. PCC air content for BBOL by U.ID.**

| U.ID. | Job.No. | Average, % | Standard Deviation, % | Count, No of Observations |
|---|---|---|---|---|
| 27S | J4S2246 | NA | NA | NA |
| 28N | J6S1961 | 6.91 | 1.19 | 75 |
| 28S | J6S1961 | NA | NA | NA |
| 29E | J3P0792B | 6.40 | 0.52 | 4 |
| 30N | J3P2193 | 6.93 | 0.55 | 19 |
| 30S | J3P2193 | NA | NA | NA |
| 31S | NA | NA | NA | NA |
| 32W | NA | NA | NA | NA |
| 33E | J9S3010 | 5.40 | NA | 1 |
| 33N | J9S3010 | NA | NA | NA |
| 33S | J9S3010 | NA | NA | NA |
| 33W | J9S3010 | NA | NA | NA |
| 34E | J2P0779C | 5.80 | 0.83 | 6 |
| 34N | J2P0779C | NA | NA | NA |
| 34S | J2P0779C | NA | NA | NA |
| 34W | J2P0779C | NA | NA | NA |
| 35N | NA | NA | NA | NA |
| 35S | NA | NA | NA | NA |

Multiple U.ID.s are applied to the same Job.No. and tests.

A review of the IRI data in table 2-14 does show some temporal inconsistencies. For example, for project 1W, the IRI exhibits a significant increase in 2010 and a significant decrease in 2017. A similar pattern can be seen in projects 12E and 33W, where the decrease takes place in 2018. Furthermore, for projects 18N and 19N, the overlays appear to have gotten smoother over time rather than rougher. Some of this variation may be due to equipment changes or slight variations in log.mile locations over time, but these do complicate using IRI as a performance indicator.

In looking at just the 2018 data, the UBOL projects are providing a very smooth ride with a mean IRI of 64 in/mi. The BBOL and BOL projects tend to exhibit much higher IRI values (131 in/mi and 263 in/mi respectively) than UBOL projects. This is certainly to be expected with the BOL projects as these are shorter and are often located at intersections, meaning that the construction of the pavement was likely done using forms and with significant hand work, making the ensuing IRI measurements more sensitive to a few surface deviations (such as might be encountered with complex longitudinal profiles).

**Table 2-14. TMS data elements.**

| Data Element |
|---|
| Year |
| TMS_TRAVELWAY_ID |
| TMS_ROUTE |
| DISTRICT_ABBR |
| COUNTY_NAME |
| ARAN_BEGIN_LOG |
| ARAN_END_LOG |
| DATE_COLLECTED |
| CURR_SURVEY_FLAG |
| C_CRACKING_RATING |
| C_PATCHING_RATING |
| D_CRACKING_RATING |
| F_CRACKING_RATING |
| F_PATCHING_RATING |
| PAVEMENT_ROUGH |
| DRIVER_IRI |
| PASSENGER_IRI |
| PRES_SVC_RATING |
| JOINT_COND_RTNG |
| SPALLING_RATING |
| RAVELING_RATING |
| RUT_RATING |
| DRIVER_RUT_DEPTH |
| PASS_RUT_DPTH |
| CONDITION_INDEX |
| LATITUDE |
| LONGITUDE |
| ELEVATION |
| GRADE |
| CROSSFALL |
| CRACK_AREA_LW |

| Data Element |
|---|
| CRACK_AREA_RW |
| FAULTING |
| AREA_DESG_NAME |
| AADT |
| COM_VOL_BY_DIR |
| FUNC_CLASS_NAME |
| DIVIDED_UNDIVIDED |
| ROADWAY_TYPE_NAME |
| TW_SPEED_LIMIT_CD |
| STATE_BRIDGE_ID |
| SURFACE_TYPE |
| SURFACE_DATE |
| SHOULDER_TYPE |
| SHOULDER_WIDTH |
| MAINT_TYPE |
| MAINT_DATE |
| MAINT_JOB_NUMBER |
| SECTION_LANEMILES |
| SECTION_CENTERLINE |
| MAJOR_MINOR |
| TRACKER_CONDITION |
| FHWA_CONDITION |
| USER_ID |
| N_ID |
| TRAVELWAY_ID |
| Dir |
| DESG |
| ROUTE |
| COUNTY |
| BEGIN_LOG |
| END_LOG |

**Table 2-15. Concrete overlay projects mean IRI (in/mi) for 2009 through 2018.**

| U.ID. | Mean IRI (in/mi) 2009 | Mean IRI (in/mi) 2010 | Mean IRI (in/mi) 2011 | Mean IRI (in/mi) 2012 | Mean IRI (in/mi) 2013 | Mean IRI (in/mi) 2014 | Mean IRI (in/mi) 2015 | Mean IRI (in/mi) 2016 | Mean IRI (in/mi) 2017 | Mean IRI (in/mi) 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1W | NA | 134 | 118 | 112 | 126 | 114 | 107 | 119 | 48 | 47 |
| 2S | NA | 58 | 58 | 57 | 70 | 64 | 72 | 70 | 77 | 67 |
| 3E | 60 | 61 | 61 | 62 | 62 | 63 | 63 | 64 | 62 | 63 |
| 4E | 42 | 41 | 41 | 40 | 39 | 37 | 39 | 40 | 36 | 36 |
| 5N | NA | 53 | 62 | 60 | NA | 50 | 63 | 57 | 63 | 55 |
| 5S | NA | 51 | 57 | 60 | 53 | 52 | 59 | 55 | 61 | 55 |
| 6N | NA | 116 | 132 | 117 | 119 | 120 | 118 | 120 | 117 | 114 |
| 6S | 106 | 107 | 110 | 108 | 105 | 106 | 109 | 107 | 104 | 107 |
| 7E | NA | 72 | 66 | 68 | 74 | 71 | 71 | 74 | 69 | NA |
| 7W | NA | 39 | 36 | 35 | 37 | 39 | 46 | 51 | 54 | NA |
| 8E | NA | NA | NA | NA | NA | NA | NA | NA | NA | 37 |
| 8W | NA | NA | NA | NA | NA | NA | NA | NA | NA | 81 |
| 9E | NA | 45 | 45 | 44 | 46 | 53 | 53 | 57 | 67 | 50 |
| 10E | NA | 49 | 50 | 48 | 53 | 51 | 49 | 51 | NA | 45 |
| 11E | NA | 78 | 80 | 76 | 78 | 79 | 83 | 86 | 79 | 61 |
| 12E | NA | 77 | 80 | 76 | 79 | 83 | 86 | 89 | 90 | 51 |
| 13W | 65 | 63 | 68 | 63 | 65 | 71 | 72 | 77 | 75 | 94 |
| 14S | NA | 61 | 60 | 58 | 66 | 70 | 65 | 67 | 59 | 61 |
| 15E | NA | 69 | 68 | 68 | 69 | 71 | 72 | 73 | 77 | 79 |
| 15W | NA | 68 | 69 | 72 | 79 | 75 | 78 | 79 | NA | 87 |
| 16N | NA | 64 | 68 | 67 | 70 | 71 | 66 | 66 | 63 | 68 |
| 17W | NA | 69 | 73 | 77 | NA | 83 | 77 | 79 | 75 | 82 |
| 18N | NA | 61 | 49 | 43 | 44 | 46 | 45 | 40 | 35 | 37 |
| 19N | NA | 62 | 50 | 45 | 42 | 39 | 46 | 47 | 54 | 38 |
| 20N | NA | 72 | 71 | 69 | 72 | 71 | 71 | 73 | 89 | 91 |
| 20S | NA | 52 | 51 | 50 | 49 | 48 | 54 | 53 | 53 | 59 |
| 21N | NA | 60 | 44 | 48 | 45 | 38 | 43 | 40 | 42 | 43 |
| 21S | NA | 59 | 52 | 52 | 52 | 50 | 50 | 50 | 42 | 46 |
| 22E | NA | 76 | 84 | 84 | 89 | 83 | 86 | 83 | 80 | 81 |
| 22W | NA | 82 | 82 | 86 | 89 | 83 | 87 | 83 | 82 | 84 |
| 23W | NA | NA | 61 | 59 | 58 | 59 | 58 | 59 | 47 | 50 |
| 24N | NA | NA | NA | NA | NA | NA | NA | 42 | 40 | 39 |
| 25N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 25S | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 26N | NA | 97 | 100 | 109 | NA | NA | NA | NA | NA | NA |
| 26S | NA | 95 | 110 | 111 | NA | NA | NA | NA | NA | NA |
| 27S | 90 | 96 | 119 | 95 | 98 | NA | 103 | 100 | 87 | NA |
| 27N | 81 | NA | NA | NA | NA | 98 | NA | NA | NA | 90 |

**Table 2-15. Concrete overlay projects mean IRI (in/mi) for 2009 through 2018 (continued).**

| U.ID. | Mean IRI (in/mi) 2009 | Mean IRI (in/mi) 2010 | Mean IRI (in/mi) 2011 | Mean IRI (in/mi) 2012 | Mean IRI (in/mi) 2013 | Mean IRI (in/mi) 2014 | Mean IRI (in/mi) 2015 | Mean IRI (in/mi) 2016 | Mean IRI (in/mi) 2017 | Mean IRI (in/mi) 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| 28S | NA | 85 | 87 | 92 | 95 | NA | 96 | 109 | 105 | 105 |
| 28N | NA | NA | NA | NA | NA | 128 | NA | NA | NA | NA |
| 29E | NA | NA | 73 | 75 | 82 | 93 | 94 | 88 | 75 | NA |
| 30N | NA | NA | NA | NA | 145 | 52 | 54 | 50 | 47 | 43 |
| 30S | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 31S | NA | NA | NA | NA | NA | 225 | NA | 230 | 349 | 284 |
| 32W | NA | 183 | NA | 185 | 225 | 191 | 197 | 265 | NA | 199 |
| 33E | NA | NA | NA | NA | NA | NA | NA | 134 | 59 | NA |
| 33W | NA | NA | NA | NA | NA | NA | NA | NA | 160 | 95 |
| 33S | NA | NA | NA | NA | NA | NA | NA | 150 | 56 | 60 |
| 33N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 34E | NA | NA | NA | NA | 213 | NA | NA | NA | 220 | 224 |
| 34W | NA | 182 | 232 | NA | NA | 185 | 196 | 206 | NA | NA |
| 34S | NA | 206 | NA | NA | NA | NA | NA | 145 | NA | NA |
| 34N | NA | NA | 249 | NA | 135 | 247 | 167 | NA | NA | 194 |
| 35N | NA | NA | NA | NA | 107 | 71 | 71 | 71 | 67 | 72 |
| 35S | NA | NA | NA | NA | 117 | 67 | 70 | 68 | 65 | 72 |
| 36S | NA | 123 | 252 | NA | NA | 225 | NA | 236 | 349 | 284 |
| 36N | NA | NA | NA | 259 | 259 | NA | NA | NA | NA | 445 |
| 37S | NA | NA | NA | NA | NA | NA | NA | NA | NA | 304 |
| 37N | NA | NA | NA | NA | NA | NA | NA | NA | 220 | NA |
| 38N | 156 | 166 | 164 | 181 | 199 | 192 | 205 | 251 | 212 | 237 |
| 38S | 234 | 229 | 209 | 250 | 296 | 256 | 317 | 254 | 295 | 286 |
| 39W | NA | NA | 142 | 161 | 172 | NA | 204 | 190 | 158 | 168 |
| 39E | 129 | 137 | NA | NA | NA | 148 | NA | NA | NA | NA |
| 40W | NA | NA | 95 | 86 | 92 | 104 | 114 | 86 | 91 | 118 |
| 41W | NA | 342 | NA | NA | NA | NA | NA | NA | 320 | NA |
| 41E | NA | NA | NA | 317 | NA | NA | NA | 346 | NA | NA |

### *2.5.2 Faulting*

Faulting values are recorded only for 2017 and 2018 in the TMS database. The values are reported to the nearest 0.001 in. The TMS data reports both positive and negative faulting for the subject concrete overlays. In discussions with MoDOT staff, negative faulting values were treated as zeros for this project. Table 2-16 presents the average faulting values for each of the concrete overlay projects for 2017 and 2018. Only one project (31S) reported faulting for 2017 that would be considered objectionable with a value of 0.152 in, but in 2018 a value of 0.000 in was reported for that same project.

**Table 2-16. Mean faulting from 2017 and 2018 for the concrete overlay projects.**

| U.ID. | 2017 Mean Faulting (in) | 2018 Mean Faulting (in) |
|---|---|---|
| 1W | 0.005 | 0.007 |
| 2S | 0.017 | 0.018 |
| 3E | 0.009 | 0.009 |
| 4E | 0.005 | 0.006 |
| 5N | 0.007 | 0.006 |
| 5S | 0.010 | 0.009 |
| 6N | 0.006 | 0.007 |
| 6S | 0.012 | 0.011 |
| 7E | 0.029 | 0.000 |
| 7W | 0.015 | 0.007 |
| 8E | NA | 0.000 |
| 8W | NA | 0.007 |
| 9E | 0.013 | 0.010 |
| 10E | NA | 0.009 |
| 11E | 0.024 | 0.020 |
| 12E | 0.046 | 0.026 |
| 13W | 0.058 | 0.065 |
| 14S | 0.009 | 0.010 |
| 15E | 0.014 | 0.015 |
| 15W | NA | 0.017 |
| 16N | 0.002 | 0.003 |
| 17W | 0.013 | 0.016 |
| 18N | 0.017 | 0.016 |
| 19N | 0.018 | 0.017 |
| 20N | 0.033 | 0.039 |
| 20S | 0.018 | 0.018 |
| 21N | 0.005 | 0.006 |
| 21S | 0.019 | 0.006 |
| 22E | 0.008 | 0.007 |
| 22W | 0.008 | 0.008 |
| 23W | 0.007 | 0.008 |
| 24N | 0.007 | 0.009 |
| 25N | NA | NA |

| U.ID. | 2017 Mean Faulting (in) | 2018 Mean Faulting (in) |
|---|---|---|
| 25S | NA | NA |
| 26N | NA | NA |
| 26S | NA | NA |
| 27S | 0.010 | NA |
| 27N | NA | 0.016 |
| 28S | 0.008 | 0.009 |
| 28N | NA | NA |
| 29E | 0.015 | NA |
| 30N | 0.007 | 0.008 |
| 30S | NA | NA |
| 31S | 0.152 | 0.000 |
| 32W | NA | 0.022 |
| 33E | 0.003 | NA |
| 33W | 0.018 | 0.012 |
| 33S | 0.001 | 0.001 |
| 33N | NA | NA |
| 34E | 0.030 | 0.011 |
| 34W | NA | NA |
| 34S | NA | NA |
| 34N | NA | 0.012 |
| 35N | 0.028 | 0.033 |
| 35S | 0.025 | 0.029 |
| 36S | 0.152 | 0.000 |
| 36N | NA | 0.010 |
| 37S | NA | 0.004 |
| 37N | 0.012 | NA |
| 38N | 0.012 | 0.016 |
| 38S | 0.012 | 0.020 |
| 39W | 0.021 | 0.062 |
| 39E | NA | NA |
| 40W | 0.006 | 0.009 |
| 41W | 0.011 | NA |
| 41E | NA | NA |

## 2.6 ARAN Video Distress Data

Under Task 4 of the project, the 2018 condition videos from MoDOT's ARAN surveys were reviewed to document the current surface condition for each concrete overlay project included in the study. The review of the video surveys was performed using MoDOT's ARAN workstations located in Jefferson City, MO.

### *2.6.1 Methodology*

For the review of the condition videos, a tailored distress assessment methodology was developed based on the distress identification manual used in FHWA's Long-Term Pavement Performance Program (LTPP) (Miller and Bellinger 2014). This assessment documented the type of distress, its associated severity, and its relative location on the slab. Table 2-16 summarizes the types of distresses from the LTPP manual that were used in the video surveys of each concrete overlay project.

To best define the cracking data among the three overlay types, there was some variation in the manner that the data was collected and recorded.

- UBOL
  - Longitudinal cracking was located within the five zones in each slab shown in figure 2-2.
  - Transverse cracking was located within the five zones in each slab shown in figure 2-2.
- BBOL
  - Shattered slabs, longitudinal cracks, transverse cracks, corner breaks, and patching were in the left or right panel as shown in figure 2-3.
  - Longitudinal cracking was located within the three zones in each panel shown in figure 2-2 (joint zones not included).
  - Transverse cracking was located within the three zones in each panel shown in figure 2-2 (joint zones not included).
  - Longitudinal cracks were identified if they affected a series of consecutive slabs or if they just occurred on single slabs.
  - Corner breaks were noted as being isolated or part of a system connected to a longitudinal crack.
- BOL
  - Distress maps were created that recorded the type and location of the distresses within each project. The goal of these semi-scale, distress maps was to keep a permanent record of the BOL distresses and potentially use them to identify cracking patterns that could suggest underlying distress mechanisms.
  - Shattered slabs, longitudinal cracks, transverse cracks, corner breaks, and patching were in the left, center, or right panel as shown in figure 2-3.
  - Longitudinal cracks were identified if they affected a series of consecutive slabs or if they just occurred on single slabs.
  - Corner breaks were noted as being isolated or part of a system connected to a longitudinal crack.

**Table 2-17. Distress types from the LTPP Guide used in the video surveys.**

| Distress Type | Quantification Method | Severity Level | Relative Position within Slab |
|---|---|---|---|
| Wear & Polish | Comment if present, not present | N/A | NA |
| Joint seal condition | Comment of the overall condition | N/A | NA |
| Durability cracking | Comment if present, not present | N/A | NA |
| Map cracking | Number of affected slabs | N/A | NA |
| Pop-outs | Number of affected slabs | N/A | NA |
| Scaling | Number of affected slabs | N/A | NA |
| Potholes | Number of affected slabs | N/A | NA |
| Shattered slabs | Number of affected slabs | N/A | NA |
| Spalling on transverse joint | Number of affected slabs | M, H | Wheelpath or Non-wheelpath |
| Spalling on longitudinal joint | Number of affected slabs | M, H | NA |
| Spalling on corner | Number of affected slabs | M, H | NA |
| Transverse cracks | Number of affected slabs | L, M, H | Bottom, middle, or top zone of the slab<br>Bottom or top transverse joint |
| Longitudinal cracks | Number of affected slabs | L, M, H | Left wheelpath, center, or right wheelpath zone of the slab<br>Left or right longitudinal joint |
| Corner breaks | Number of affected slabs | L, M, H | Top-right, top-left, bottom-left, or bottom-right quadrant of the slab |
| Patching | Number of affected slabs and area affected | L, M, H | Longitudinal joint, transverse joint, center of slab, corner, or full panel |

Severity Levels: L = low-severity, M = medium-severity, H = high-severity, N/A = Not applicable

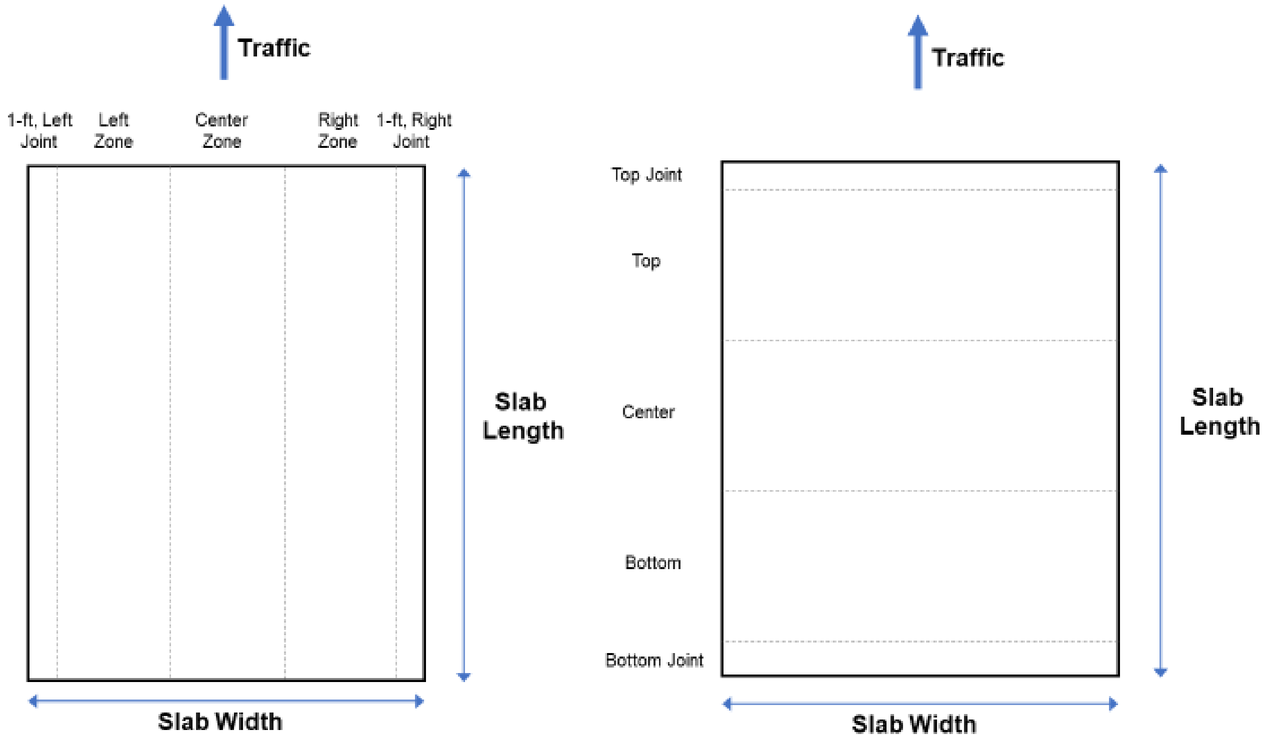



**Figure 2-2. Longitudinal and transverse cracking zones for UBOL slabs and BBOL panels not including joint zones.**

Aside from the standard LTPP distresses, diagonal cracking was defined as a custom distress type that was documented during the video surveys. A diagonal crack is a hybrid between a corner break and a longitudinal crack, and is identified as a longitudinal crack that starts at least 3 ft apart from a corner of the slab and it wanders into one of the longitudinal joints (instead of progressing longitudinally). It is similar to a corner break except that it does not generally intersect both joints at a 45-degree angle.

For each concrete overlay included in the study, 100% of the ARAN footage (where available) was reviewed in one lane only and the type, severity, and location of distress recorded. The ARAN footage consisted of forward-looking right of way images and downward-facing pavement images (see figures 2-4 and 2-5). The total number of slabs affected by each distress was quantified and a percentage of slabs affected was calculated.

A Pavement Surface Evaluation and Rating (PASER) score was assigned to each project at the completion of the visual rating. The PASER score, between 0 and 10, is a subjective pavement condition assessment method that can be used to compare the relative condition of different pavement projects and to track the historical condition of individual sites (Walker 2015).

### *2.6.2 Issues and Challenges*

In the review of the ARAN videos, several issues and challenges emerged, as noted below.

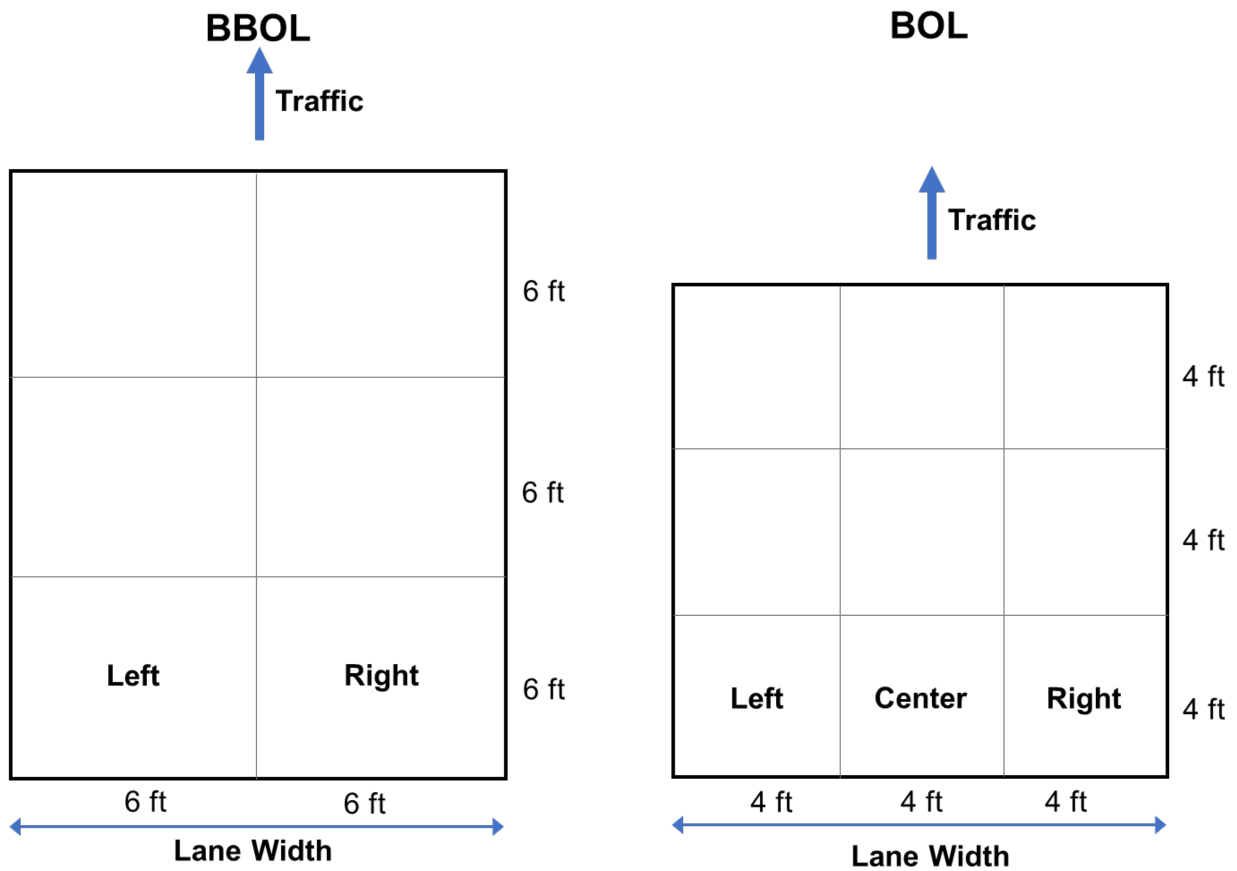



**Figure 2-3. Panel location for BBOL and BOL projects.**

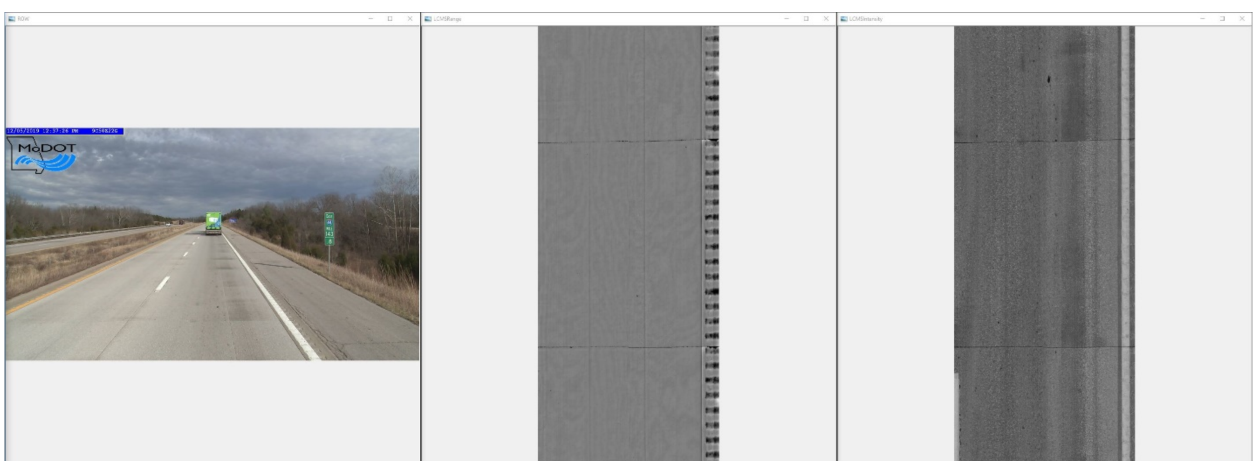



**Figure 2-4. ARAN display of forward camera (left panel), laser measured downward distance (center panel), and laser measure downward intensity (right panel) for project 12E, I-44 in Laclede County with no visible distress.**

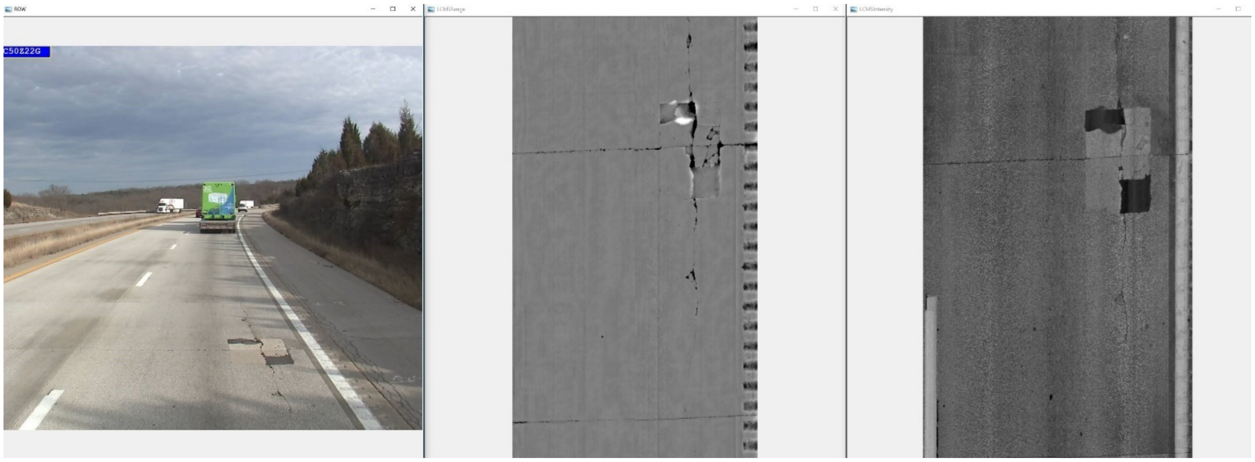


**Figure 2-5. ARAN display of forward camera (left panel), laser measured downward distance (center panel), and laser measure downward intensity (right panel) for project 12E, I-44 in Laclede County with corner patches and longitudinal cracks.**

- Videos were not available for several of the project included in the project. Those projects are noted with a NA in the tables in this section.
- The software used to review the ARAN footage did not have the capability to mark distresses on the downward images or to generate summaries directly. Instead, a spreadsheet was used to manually keep track of the distresses that were identified, a process that considerably slowed the overall rating process.
- The software also did not have a measuring tool to evaluate the dimensions of patches; therefore, the patching sizes had to be estimated based on the location of the patch its comparison to the size of the slab.

### *2.6.3 UBOL—Slab Condition Summary*

Table 2-18 presents a summary of slabs being affected by cracking and patching for UBOL projects. The percentages presented in this table represent the relative number of slabs affected by these types of distresses for only one lane of each project, accounting for shattered slabs, transverse and longitudinal cracks, and corner breaks at all severity levels.

The data showed significant variability in terms of the amount of slabs cracked, ranging from 0% in the case of projects 8W and 18N up to 26.36% exhibited by project 17W. It was interesting to note that some of the oldest projects, 1W and 2S constructed in 2000 and 1986, respectively, exhibiting slab cracking percentages below 0.50%. A similar effect can be observed regarding the percentage of area that has been patched, with nearly half of all projects exhibiting no observed patching and two projects with the patched area exceeding 2%.

No data were available for projects 7E, 7W, 26N, and 26S because these projects had been rehabilitated. Projects 7E and 7W were replaced by another concrete overlay (project 8E and 8W), while project 26N and 26S were rehabilitated by sawing the 15 ft by 12 ft panels into 7.5 ft by 6 ft slabs; that rehabilitated overlay pavement is documented under project 35N and 35S.

**Table 2-18. Cracked and patched slabs for UBOL.**

| U.ID. | Overlay Type | Lane Surveyed | PASER Score | Total Number of Slabs | Total Area, $ft^2$ | % Cracked Slabs | % Patched Slabs | % Patched Area |
|---|---|---|---|---|---|---|---|---|
| 1W | UBOL | DL | 7 | 1,677 | 301,860 | 0.36% | 0.24% | 0.10% |
| 2S | UBOL | DL | 7 | 5,202 | 936,360 | 0.37% | 0.27% | 0.13% |
| 3E | UBOL | DL | 8 | 2,776 | 499,680 | 0.90% | 0.00% | 0.00% |
| 4E | UBOL | DL | 8 | 3,374 | 607,320 | 0.36% | 0.00% | 0.00% |
| 5N | UBOL | CL (2nd from left) | 6 | 1,226 | 220,680 | 3.02% | 0.00% | 0.00% |
| 5S | UBOL | CL (2nd from left) | 6 | 1,246 | 224,280 | 3.53% | 0.08% | 0.03% |
| 6N | UBOL | DL | 8 | 479 | 86,220 | 0.00% | 0.00% | 0.00% |
| 6S | UBOL | DL | 8 | 519 | 93,420 | 0.00% | 0.00% | 0.00% |
| 7E | UBOL | NA | NA | NA | NA | NA | NA | NA |
| 7W | UBOL | NA | NA | NA | NA | NA | NA | NA |
| 8E | UBOL | DL | 7 | 1,567 | 282,060 | 0.13% | 0.00% | 0.00% |
| 8W | UBOL | DL | 8 | 1,559 | 280,620 | 0.00% | 0.00% | 0.00% |
| 9E | UBOL | DL | 4 | 3,203 | 576,540 | 22.73% | 1.56% | 0.74% |
| 10E | UBOL | DL | 6 | 3,817 | 687,060 | 4.95% | 0.13% | 0.13% |
| 11E | UBOL | DL | 5 | 2,252 | 405,360 | 9.55% | 3.73% | 1.05% |
| 12E | UBOL | DL | 5 | 1,346 | 242,280 | 13.74% | 3.71% | 0.85% |
| 13W | UBOL | DL | 7 | 1,113 | 200,340 | 1.62% | 0.00% | 0.00% |
| 14S | UBOL | DL | 5 | 4,044 | 727,920 | 7.37% | 0.79% | 0.63% |
| 15E | UBOL | CL | 7 | 3,106 | 559,080 | 0.16% | 0.06% | 0.06% |
| 15W | UBOL | CL | 7 | 3,102 | 558,360 | 0.68% | 0.19% | 0.17% |
| 16N | UBOL | DL | 7 | 3,095 | 557,100 | 1.55% | 0.00% | 0.00% |
| 17W | UBOL | DL | 4 | 3,035 | 546,300 | 26.36% | 5.27% | 2.08% |
| 18N | UBOL | DL | 8 | 703 | 126,540 | 0.00% | 0.00% | 0.00% |
| 19N | UBOL | DL | 6 | 5,238 | 942,840 | 9.07% | 0.67% | 0.39% |
| 20N | UBOL | DL | 3 | 2,473 | 445,140 | 10.07% | 1.42% | 0.93% |
| 20S | UBOL | DL | 4 | 2,480 | 446,400 | 8.31% | 3.87% | 2.38% |
| 21N | UBOL | DL | 6 | 2,804 | 504,720 | 1.18% | 0.04% | 0.01% |
| 21S | UBOL | DL | 5 | 2,799 | 503,820 | 2.82% | 2.04% | 1.20% |
| 22E | UBOL | DL | 7 | 1,448 | 260,640 | 0.62% | 0.07% | 0.07% |
| 22W | UBOL | CL (2nd from left) | 7 | 1,456 | 262,080 | 1.17% | 0.00% | 0.00% |
| 23W | UBOL | DL | 7 | 3,080 | 554,400 | 1.36% | 0.03% | 0.03% |
| 24N | UBOL | DL | 8 | 1,144 | 205,920 | 0.17% | 0.00% | 0.00% |

**Table 2-18. Cracked and patched slabs for UBOL (continued).**

| U.ID. | Overlay Type | Lane Surveyed | PASER Score | Total Number of Slabs | Total Area, ft$^2$ | % Cracked Slabs | % Patched Slabs | % Patched Area |
|---|---|---|---|---|---|---|---|---|
| 25N | UBOL | CL (2nd from left) | 10 | 1,065 | 191,700 | 0.00% | 0.00% | 0.00% |
| 25S | UBOL | CL (2nd from left) | 10 | 1,061 | 190,980 | 0.00% | 0.00% | 0.00% |
| 26N | UBOL | NA | NA | NA | NA | NA | NA | NA |
| 26S | UBOL | NA | NA | NA | NA | NA | NA | NA |

% Cracked Slabs includes shattered slabs, transverse and longitudinal cracks, and corner breaks.

% Patched Slabs includes longitudinal and transverse joints, mid-panel, and full-panel patches.

% Patched Area includes areas from longitudinal and transverse joints, mid-panel, and full-panel patches.

### *2.6.4 BBOL—Slab Condition Summary*

Table 2-19 presents a summary of slabs being affected by cracking and patching for BBOL projects. The percentages presented in this table represent the relative number of slabs affected by these types of distresses for only one lane of each project, accounting for shattered slabs, transverse and longitudinal cracks, and corner breaks at all severity levels. Since many BBOL projects were constructed on two-lane highways and MoDOT only performs its ARAN survey on one lane, almost all BBOL project data were available for only one direction.

Unlike what was observed with the UBOL projects, BBOL projects had a range of cracked slabs ranging from 0% to just below 9%, much lower than the highest observed percentages on UBOL projects. The projects with the highest percentage of cracked slabs were projects 35N and 35S which were rehabilitation for the UBOL projects 26N and 26S. This cracking is probably more indicative of the performance of the UBOL and not the BBOL. Patching quantities remained relatively low, with the highest observed percentage area at 1.20%.

### *2.6.5 BOL—Slab Condition Summary*

Table 2-20 presents a summary of slabs being affected by cracking and patching for BOL projects. The percentages presented in this table represent the relative number of slabs affected by these types of distresses for only one lane of each project, accounting for shattered slabs, transverse and longitudinal cracks, and corner breaks at all severity levels. Like BBOL projects, MoDOT only collects data for one lane on 2-lane highways, so almost all the BOL projects had data available for only one direction. In the case of project 40W, no video was available.

While the total number of observations available for BOL projects was smaller than for the UBOL and BBOL projects, significant variability was observed in the data, with results ranging from 0 to almost 24%. Patching percentages on BOL projects ranged from 0 to over 10%.

**Table 2-19. Cracked and patched slabs for BBOL.**

| U.ID. | Overlay Type | Lane Surveyed | PASER Score | Total Number of Slabs | Total Area ($ft^2$) | % Cracked Slabs | % Patched Slabs | % Patched Area |
|---|---|---|---|---|---|---|---|---|
| 27S | BBOL | DL | 7 | 4,895 | 176,220 | 0.82% | 0.61% | 0.61% |
| 27N | BBOL | NA | NA | NA | NA | NA | NA | NA |
| 28S | BBOL | DL | 4 | 22,099 | 795,564 | 1.62% | 0.29% | 0.29% |
| 28N | BBOL | NA | NA | NA | NA | NA | NA | NA |
| 29E | BBOL | DL | 6 | 12,708 | 457,488 | 4.48% | 1.20% | 1.20% |
| 30N | BBOL | DL | 7 | 12,866 | 463,176 | 0.54% | 0.11% | 0.11% |
| 30S | BBOL | NA | NA | NA | NA | NA | NA | NA |
| 31S | BBOL | NA | NA | NA | NA | NA | NA | NA |
| 32W | BBOL | DL | 9 | 141 | 5076 | 0.00% | 0.00% | 0.00% |
| 33E | BBOL | DL | 9 | 486 | 17496 | 0.00% | 0.00% | 0.00% |
| 33W | BBOL | DL | 8 | 624 | 22,464 | 0.32% | 0.00% | 0.00% |
| 33S | BBOL | DL | 8 | 141 | 5,076 | 0.00% | 0.00% | 0.00% |
| 33N | BBOL | NA | NA | NA | NA | NA | NA | NA |
| 34E | BBOL | NA | NA | NA | NA | NA | NA | NA |
| 34W | BBOL | DL | 8 | 159 | 5,724 | 4.40% | 0.00% | 0.00% |
| 34S | BBOL | NA | NA | NA | NA | NA | NA | NA |
| 34N | BBOL | DL | 7 | 141 | 5,076 | 5.67% | 0.00% | 0.00% |
| 35N | BBOL | DL | 6 | 11,680 | 420,480 | 8.79% | 0.09% | 0.09% |
| 35S | BBOL | DL | 6 | 12,690 | 456,840 | 8.43% | 0.29% | 0.29% |

% Cracked Slabs includes shattered slabs, transverse and longitudinal cracks, and corner breaks.

% Patched Slabs includes longitudinal and transverse joints, mid-panel, and full-panel patches.

% Patched Area includes areas from longitudinal and transverse joints, mid-panel, and full-panel patches.

## 2.7 Summary

This chapter describes the inventory of data that was collected for the concrete overlay projects included in the study. The sources of all data are provided, and interim steps taken to process the data are summarized. Summaries of the collected data are presented in this chapter with more detailed data found in Appendix A through Appendix D.

**Table 2-20. Cracked and patched slabs for BOL.**

| U.ID. | Overlay Type | Lane Surveyed | PASER Score | Total Number of Slabs | Total Area ($ft^2$) | % Cracked Slabs | % Patched Slabs | % Patched Area |
|---|---|---|---|---|---|---|---|---|
| 36S | BOL | NA | NA | NA | NA | NA | NA | NA |
| 36N | BOL | PL | 7 | 285 | 4562 | 0.35% | 0.00% | 0.00% |
| 37S | BOL | DL | 7 | 238 | 3,802 | 23.99% | 0.00% | 0.00% |
| 37N | BOL | NA | NA | NA | NA | NA | NA | NA |
| 38N | BOL | DL | 6 | 792 | 12,672 | 2.65% | 7.45% | 7.45% |
| 38S | BOL | DL | 5 | 792 | 12,672 | 14.52% | 10.73% | 10.73% |
| 39W | BOL | DL | 7 | 1604 | 25661 | 3.12% | 0.31% | 0.31% |
| 39E | BOL | NA | NA | NA | NA | NA | NA | NA |
| 40W | BOL | NA | NA | NA | NA | NA | NA | NA |
| 41W | BOL | DL | 8 | 198 | 3,168 | 0.00% | 0.00% | 0.00% |
| 41E | BOL | NA | NA | NA | NA | NA | NA | NA |

% Cracked Slabs includes shattered slabs, transverse and longitudinal cracks, and corner breaks.

% Patched Slabs includes longitudinal and transverse joints, mid-panel, and full-panel patches.

% Patched Area includes areas from longitudinal and transverse joints, mid-panel, and full-panel patches.

# CHAPTER 3. DATA ANALYSIS AND DISCUSSION

## 3.1 Introduction

Pavement performance is affected by many items, such as the structural design and included design features, quality of construction, age, traffic loading, and so on. This chapter discusses the analysis of the data collected for the project as outlined in Chapter 2. Unfortunately, there are a number of confounding factors involved in evaluating the performance of the various overlay types (including such things as slab thickness, slab dimensions, interlayer type, shoulder type, geographic location, and traffic loading) that in many cases make it difficult to make direct performance comparisons or draw definitive conclusions. Nevertheless, these different design features as well as various construction and material quality indicators were evaluated in terms of their correlation to performance and the results presented in this chapter. In addition, current repair needs for the different overlays included in the study are presented.

## 3.2 Estimated Equivalent Single Axle Loading

Because traffic loading is an important aspect of pavement performance, and to provide a method of comparing the performance of concrete overlays based on their loading history, it was decided to characterize the traffic loading sustained by each overlay type in terms of the number of equivalent single-axle load (ESAL) repetitions. The ESAL concept is a methodology that has been applied to pavement design and evaluation since the AASHO Road Test conducted in 1958-1960. The use of ESALs converts the loading from a mixed traffic stream into an equivalent number of 18,000-lb single axles. This method can be used to establish pavement damage relationships for axles carrying different loads. MoDOT does not normally use ESAL to quantify truck loading since they use a load spectrum as part of their mechanistic approach to pavement design.

To compare the traffic loading that the different concrete overlays received during their life, estimated ESALs have been calculated for each overlay. The approach described in the 1993 *Guide for Design of Pavement Structures* (AASHTO 1993) has been used for guidance in this calculation. To estimate ESALs, the following methodology was applied:

- Obtain AADT at year 0 (year of construction) from construction plans or the ARAN public viewer (MoDOT 2019a) and then apply the percent of trucks of the AADT to obtain AADTT-0. Based on MoDOT's documentation, COM_VOL_BY_DIR could be considered as AADTT, trucks in FHWA class 4 through 13.
- Use AADTT-n from MoDOT TMS and AADTT-0 to calculate the growth rate and then obtain the growth factor from year-0 to 2018.
- Use assumed truck factors (TF) of 0.75 for interstates, 0.60 for US routes, and 0.50 for all others.
- Use the lane distribution factors ($D_L$) from AASHTO (1993); 1-lane=1.00, 2-lane=0.90, 3-lane=0.70, 4-lane=0.60.
- Growth factor is calculated as GF= $((1+\text{Growth Rate})^{(2018-\text{Year of Construction}+1)}-1)/\text{Growth Rate}$.
- ESAL= (AADTT at Year 0)*365*GF*TF*$D_L$

Table 3-1 presents the estimated accumulated ESALs for the concrete overlay projects from construction through 2018. The estimated ESALs range from about 166,000 for project 30N (the northbound BOL on Missouri 79 in Marion and Ralls counties) to more than 26 million for project 1W (the westbound I-44 in Webster and Greene counties and the oldest project in this study). The estimated ESALs are used through this report to compare the performance of various design features of the concrete overlays.

## 3.3 Construction Quality Assurance

MoDOT, like many other state highway agencies in the U.S., uses a quality level analysis (QLA) as a tool to judge the quality and value of the material incorporated into a highway project. The QLA considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is within the specification tolerance limit. For concrete overlays, MoDOT uses percentage of material that is above the lower specification tolerance limit (LSL) for compressive strength and thickness as part of their normal QLA (MoDOT 2019b). Percent within limits (PWL) is the QLA that MoDOT applies as discussed is Section 502.10.4 of the *2019 Standard Specifications for Highway Construction* (MoDOT 2019b). Additional information on PWL is provided by Burati et al. (2002).

The LSL for PCC compressive strength is 4,000 lbf/in$^2$. As described in chapter 2, the LSL for concrete overlay thickness per MoDOT's specifications (MoDOT 2019b), Section 502.10.4.5, is based off of the design thickness minus 0.5 in. The analysis below will consider the computed PWL using both the design thickness and design thickness minus 0.5 in as the LSL.

The PWL values for measured air content are also calculated, but only for the UBOL and BBOL projects since there were no construction quality data extracted from SiteManager for the BOL projects. MoDOT (2019b) Section 501.10.2, sets a minimum value for air content at 4.5% and a maximum at 7.5%, which will become the LSL and upper specification tolerance limit (USL) respectively.

### *3.3.1 PWL Results*

Table 3-2 presents the PWL for the UBOL projects while table 3-3 presents the PWL for the BBOL projects.

### *3.3.2 PWL Discussion*

For a contractor to receive full payment for concrete pavement under MoDOT's specifications (MoDOT 2019b), Section 502.15.4, the PWL must be equal to or greater than 90%. For the 19 UBOL Job.No.s that reported data from SiteManager, the 90% PWL level was met for thickness for five, strength for eighteen, and air content on seven. For the six BBOL projects, one met the 90% PWL level for design thickness, six for strength, and two for air content.

Figure 3-1 through 3-6 present computed PWL for thickness, strength, and air content for overlay projects with data from tables 3-2 and 3-3, compared to surficial concrete overlay distress as measured by cracked and patched slabs from the ARAN video review.

**Table 3-1. Estimated accumulated ESALs from construction through 2018.**

| Project | Route | County | ESAL |
|---|---|---|---|
| **1W** | 44 | Webster/Greene | 26,576,229 |
| **2S** | 55 | Pemiscot | 14,148,383 |
| **3E** | 412 | Pemiscot | 2,386,571 |
| **4E** | 412 | Pemiscot | 2,528,867 |
| **5N** | 255 | St. Louis | 19,408,184 |
| **5S** | 255 | St. Louis | 19,233,026 |
| **6N** | 291 | Jackson | 3,047,273 |
| **6S** | 291 | Jackson | 3,134,842 |
| **7E** | 44 | Lawrence | 13,865,483 |
| **7W** | 44 | Lawrence | 16,825,070 |
| **8E** | 44 | Lawrence | 880,791 |
| **8W** | 44 | Lawrence | 1,387,091 |
| **9E** | 44 | Crawford | 17,738,333 |
| **10E** | 36 | Macon | 2,773,336 |
| **11E** | 44 | Laclede | 12,012,366 |
| **12E** | 44 | Laclede | 12,328,260 |
| **13W** | 412 | Dunklin | 2,334,411 |
| **14S** | 57 | Mississippi | 10,701,049 |
| **15E** | 64 | St. Louis/ St. Louis City | 18,537,898 |
| **15W** | 64 | St. Louis/ St. Louis City | 20,339,221 |
| **16N** | 57 | Mississippi | 6,878,989 |
| **17W** | 44 | Phelps | 11,351,269 |
| **18N** | 55 | Cape/Perry | 3,947,766 |
| **19N** | 55 | Pemiscot | 9,981,999 |
| **20N** | 35 | Clinton | 6,795,634 |
| **20S** | 35 | Clinton | 8,971,126 |
| **21N** | 35 | Clay | 8,830,726 |
| **21S** | 35 | Clay | 11,568,619 |
| **22E** | 44 | Franklin | 12,118,466 |
| **22W** | 44 | Franklin | 12,915,563 |
| **23W** | 44 | Pulaski | 10,548,205 |
| **24N** | 55 | Pemiscot | 4,973,554 |
| **26N** | I-35 | Daviess | 6,824,510 |
| **26S** | I-35 | Daviess | 7,165,333 |
| **27N** | D | Cass | 502,792 |
| **27S** | D | Cass | 530,974 |
| **28N** | 61 | Jefferson/ Ste. Genevieve | 310,420 |
| **28S** | 61 | Jefferson/ Ste. Genevieve | 212,077 |
| **29E** | 36 | Shelby/Marion | 2,296,733 |
| **30N** | 79 | Marion/Ralls | 166,290 |
| **31S** | 5 | Laclede | 1,752,383 |
| **32W** | 340 | St. Louis | 1,937,984 |
| **33E** | 412 | Dunklin | 1,658,126 |
| **33S** | 61 | Scott | 280,415 |
| **33W** | 412 | Dunklin | 2,186,778 |
| **34E** | 24 | Randolph | 638,761 |
| **34N** | 63 | Randolph | 239,229 |
| **34S** | 63 | Randolph | 305,254 |
| **34W** | 24 | Randolph | 967,470 |
| **35N** | I-35 | Daviess | 2,742,880 |
| **35S** | I-35 | Daviess | 2,870,262 |
| **36N** | 5 | Laclede | 2,259,710 |
| **36S** | 5 | Laclede | 3,227,617 |
| **37N** | 19 | Ralls | 660,424 |
| **37S** | 19 | Ralls | 747,061 |
| **38N** | 291 | Jackson | 4,540,689 |
| **38S** | 291 | Jackson | 5,776,621 |
| **39E** | 60 | Newton | 2,762,825 |
| **39W** | 60 | Newton | 2,495,944 |
| **40W** | 34 | Cape Girardeau | 726,385 |
| **41E** | 14 | Christian | 449,680 |
| **41W** | 14 | Christian | 643,927 |

**Table 3-2. Computed PWL from SiteManager data for UBOL**

| U.ID. | Job.No. | Concrete Overlay Thickness PWL (Design-0.5 in) | Concrete Overlay Thickness PWL (Design) | PCC Strength PWL | PCC Air Content PWL |
|---|---|---|---|---|---|
| 05N | J6I1486 | 95 | 89 | 89 | 77 |
| 05S | J6I1486 | 95 | 89 | 89 | 77 |
| 07E | J7I0721 | NA | NA | NA | NA |
| 07W | J7I0721 | NA | NA | NA | NA |
| 08E | J7I3074 | 98 | 90 | 99 | NA |
| 08W | J7I3074 | 98 | 90 | 99 | NA |
| 09E | J9I0509 | 100 | 99 | 96 | NA |
| 10E | J2P0726 | 100 | 96 | 99 | 49 |
| 11E | J8I0747 | 74 | 50 | 91 | 83 |
| 12E | J8I0748 | NA | NA | 95 | 100 |
| 13W | J0P0570 | 100 | 100 | 100 | 31 |
| 14S | J0I0973 | 77 | 50 | 99 | 100 |
| 16N | J0I0983 | 81 | 66 | 99 | 87 |
| 17W | J9I2166 | 87 | 78 | 92 | 94 |
| 18N | J0I2200 | NA | NA | 99 | 100 |
| 19N | J0I2171 | 85 | 60 | 100 | 92 |
| 20N | J1I1040 | 95 | 86 | 98 | 66 |
| 20S | J1I1040 | 95 | 86 | 98 | 66 |
| 21N | J4I1382 | NA | NA | 100 | 81 |
| 21S | J4I1382 | NA | NA | 100 | 81 |
| 22E | J6I2011 | 98 | 96 | 90 | 56 |
| 22W | J6I2011 | 98 | 96 | 90 | 56 |
| 23W | J9I2149 | 87 | 69 | 99 | 99 |
| 24N | J9P2244B | 93 | 76 | 99 | 79 |
| 26N | J1I0895 | 96 | 85 | 91 | NA |
| 26S | J1I0895 | 96 | 85 | 91 | NA |

Multiple U.ID.s are applied to the same Job.No. and tests.

Figures 3-1 and 3-2 show an apparent relationship between thickness PWL and the performance of UBOL and BBOL projects. PWL values below 90% generally show a higher level of distress. This is especially apparent when comparing the PWL for design thickness rather than design thickness minus 0.5 in as allowed in MoDOT's specifications (MoDOT 2019b). Figure 3-1 should be compared to figure 3-12 through 3-14 (presented later) to judge the effect of as-constructed thickness versus design thickness.

Similar evaluations were done for strength and air content (see Figures 3-3 through 3-6) but these do not appear to show any relationship. Strength PWL values were generally above 90%, showing that projects were being constructed with more than adequate strength. Air content for the concrete overlay projects showed no obvious relationship with cracked and patched slabs. This analysis was limited by the inability to match location of distresses and material test results.

**Table 3-3. Computed PWL from SiteManager data for BBOL**

| U.ID. | Job.No. | Concrete Overlay Thickness PWL (Design-0.5 in) | Concrete Overlay Thickness PWL (Design) | PCC Strength PWL | PCC Air Content PWL |
|---|---|---|---|---|---|
| 27N | J4S2246 | 99 | 96 | 100 | 75 |
| 27S | J4S2246 | 99 | 96 | 100 | 75 |
| 28N | J6S1961 | 89 | 75 | 99 | 67 |
| 28S | J6S1961 | 89 | 75 | 99 | 67 |
| 29E | J3P0792B | 97 | 85 | 98 | 98 |
| 30N | J3P2193 | 80 | 60 | 99 | 85 |
| 30S | J3P2193 | 80 | 60 | 99 | 85 |
| 33E | J9S3010 | 100 | 83 | 97 | NA |
| 33N | J9S3010 | 100 | 83 | 97 | NA |
| 33S | J9S3010 | 100 | 83 | 97 | NA |
| 33W | J9S3010 | 100 | 83 | 97 | NA |
| 34E | J2P0779C | 92 | 59 | 99 | 92 |
| 34N | J2P0779C | 92 | 59 | 99 | 92 |
| 34S | J2P0779C | 92 | 59 | 99 | 92 |
| 34W | J2P0779C | 92 | 59 | 99 | 92 |

Multiple U.ID.s are applied to the same Job.No. and tests.

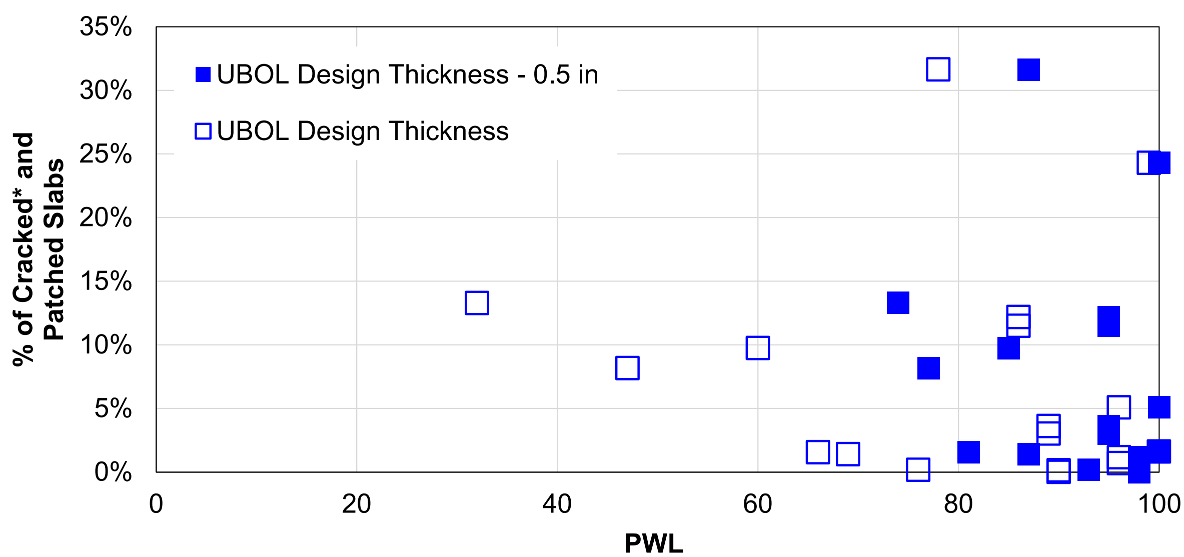



**Figure 3-1. Comparison of concrete overlay thickness PWL to cracked and patched slabs for UBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

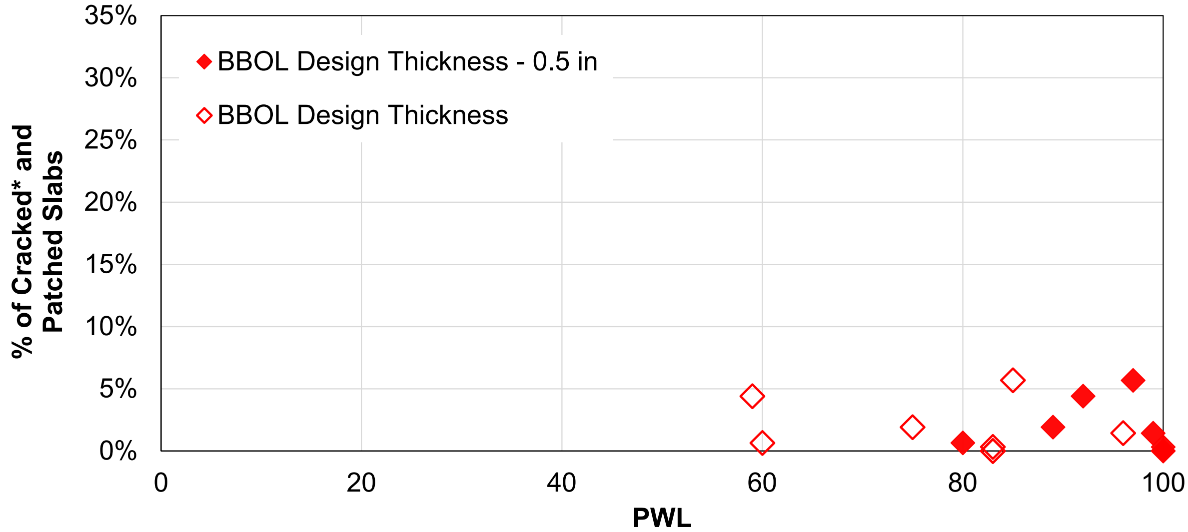



**Figure 3-2. Comparison of concrete overlay thickness PWL to cracked and patched slabs for BBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

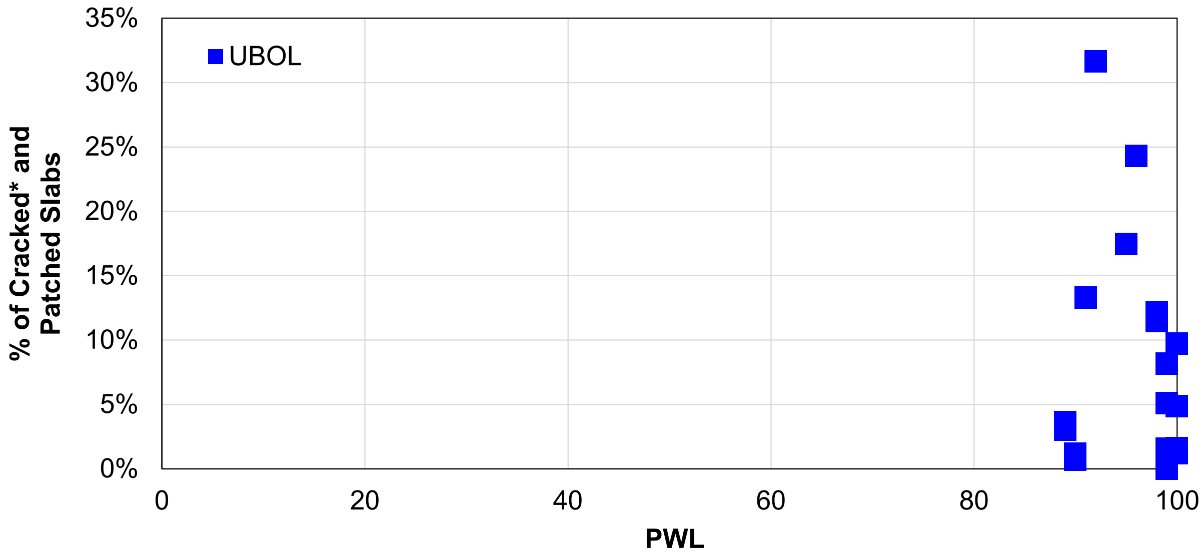



**Figure 3-3. Comparison of PCC strength PWL to cracked and patched slabs for UBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

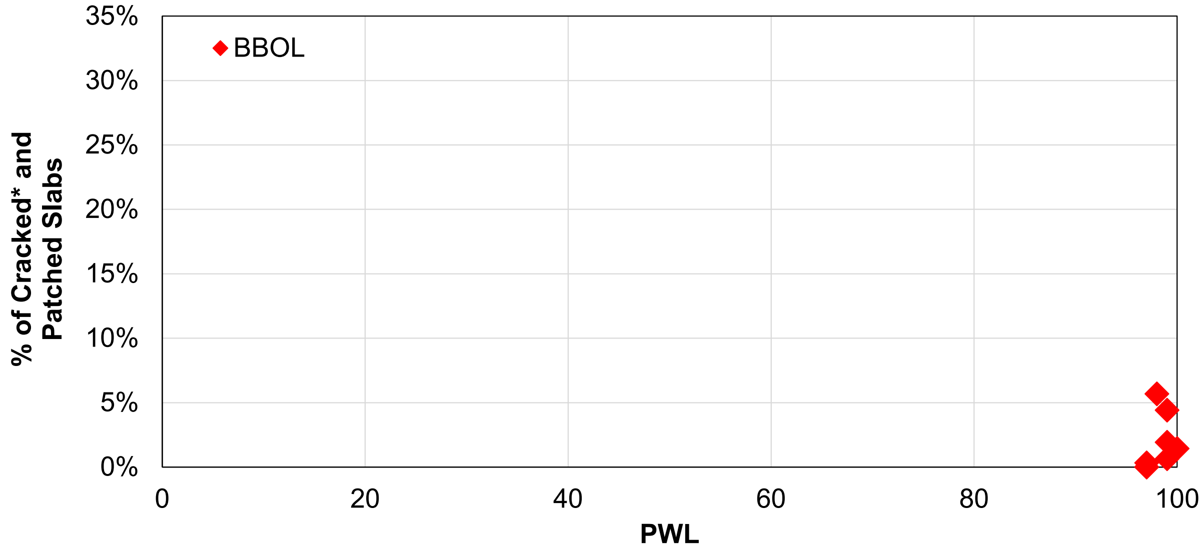



**Figure 3-4. Comparison of PCC strength PWL to cracked and patched slabs for BBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

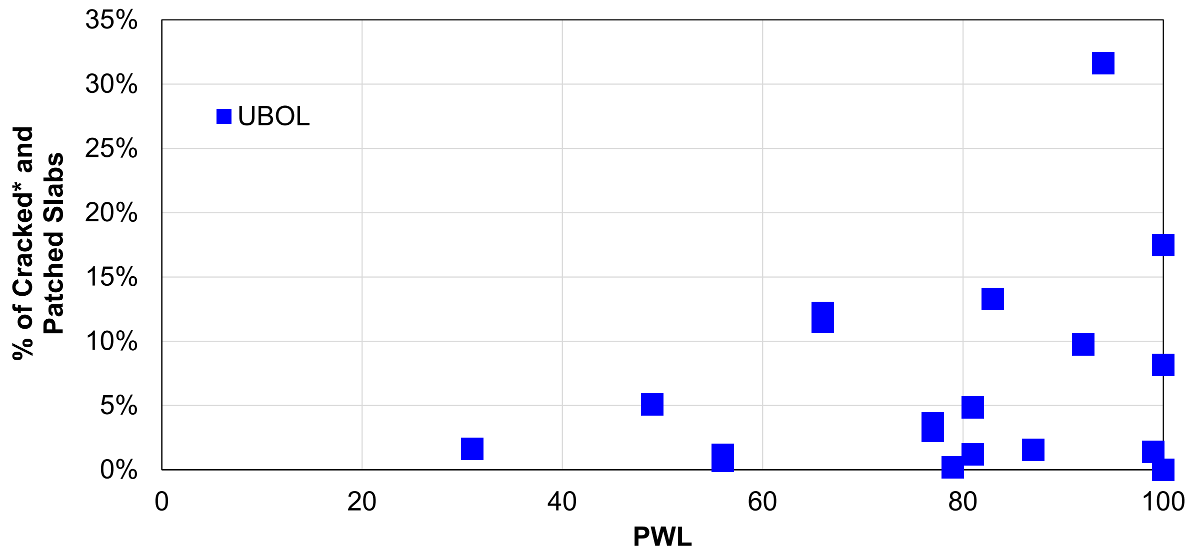



**Figure 3-5. Comparison of PCC air content PWL to cracked and patched slabs for BBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

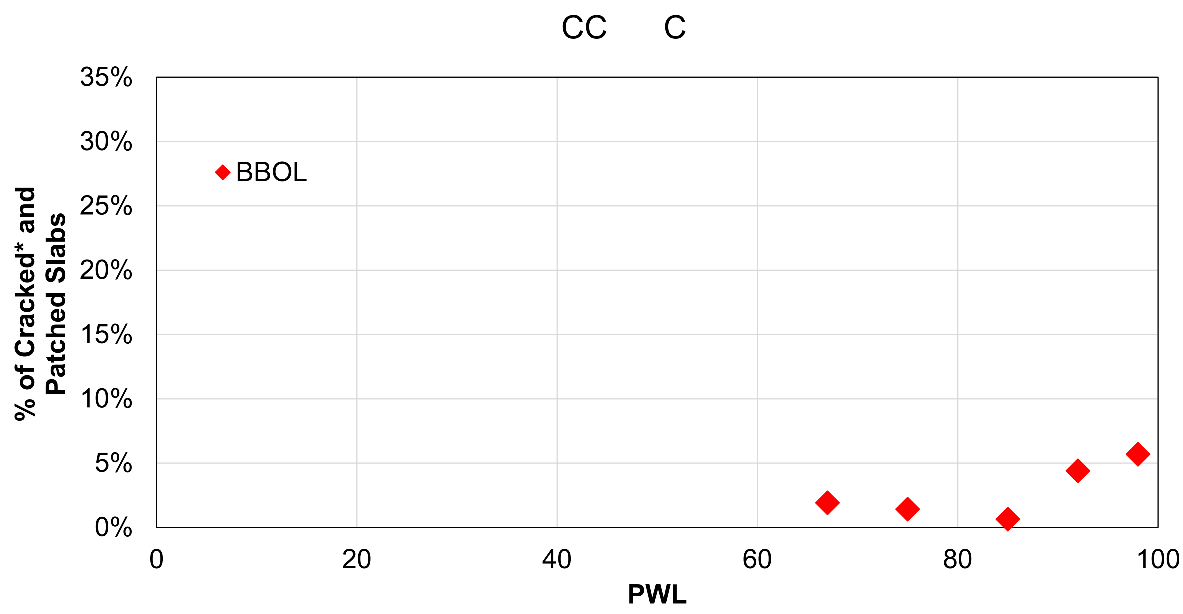



**Figure 3-6. Comparison of PCC air content PWL to cracked and patched slabs for BBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

## 3.4 Performance Correlations

This section discusses the correlation of concrete overlay performance to various design features. Several performance indicators were possible for use in this project, including the percentage of cracked and patched slabs, transverse faulting, and roughness (IRI). The faulting measurements were extremely low and were not expected to provide any meaningful results, but preliminary performance comparisons across all overlay types were developed using both cracked and patched slabs and IRI as performance indicators (see figures 3-7 and 3-8). This generally shows that the percentage of cracked and patched slabs better captures the impacts of traffic loading on performance. As a result, this will serve as the primary performance indicator for the analyses presented in this chapter, with some additional analyses specifically considering the longitudinal and transverse cracking by location within the slab in conjunction with selected design and construction parameters. However, one performance trend of the IRI plot stands out, that of the general stability of the smoothness of the UBOL projects under increasing traffic loading.

### *3.4.1 UBOL*

Most UBOL projects have performed very well, especially in terms of their overall ride quality (as shown in figure 3-7). For cracked and patched slabs, again many of the UBOL projects have performed admirably under heavy loading, but there have been others with less desirable distress states.

#### *3.4.1.1 Interlayer Type*

For the UBOL projects, several different interlayer types were used; these included:

- Existing HMA, using the existing underlying milled or unmilled HMA pavement.

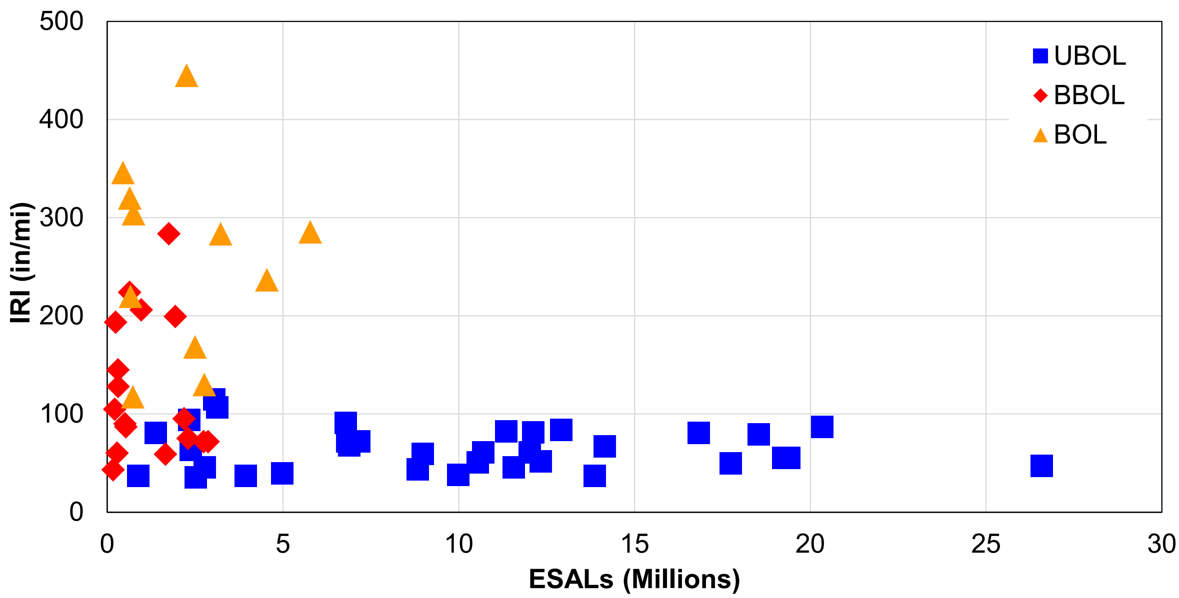



**Figure 3-7. ESALs versus 2018 mean project IRI.**

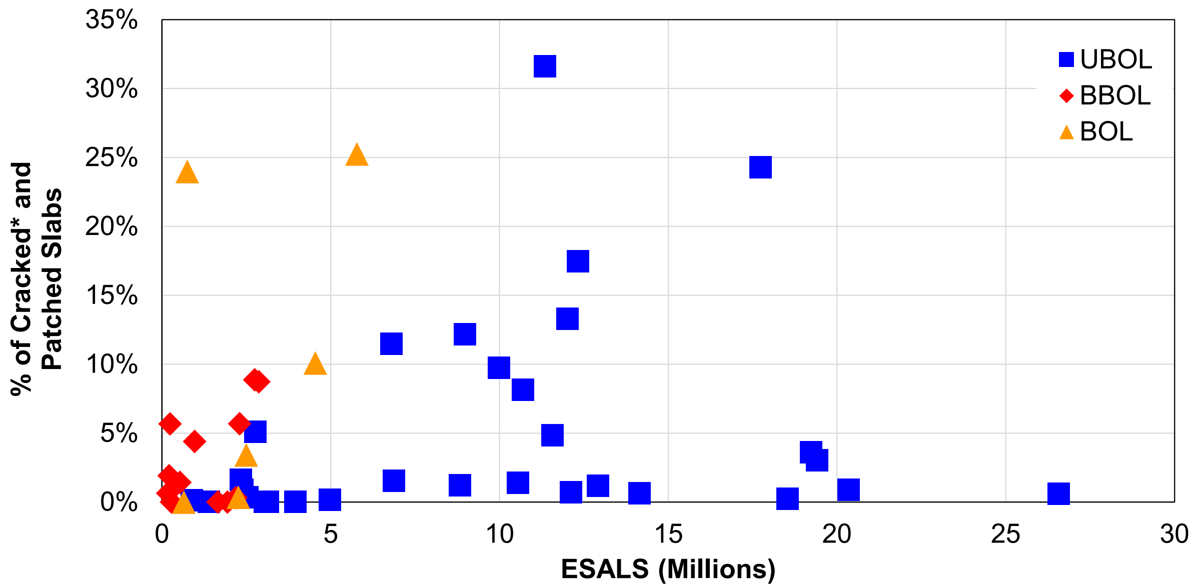



**Figure 3-8. ESALs versus percentage of cracked and patched slabs (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

- A new HMA layer, 1 in thick.
- Geotextile material, in accordance with Section 506.20 of MoDOT's *2019 Standard Specifications for Highway Construction* (MoDOT 2019b).

Figure 3-9 through 3-11 provide a comparison of cracked and patched slabs, longitudinal cracked slabs, and transverse cracked slabs, respectively, to interlayer type and UBOL design thickness. Figure 3-10 shows that most of the cracking distress present in the UBOL projects is longitudinal most likely due to a lack of support in the outer portion of the driving lane. Generally, UBOL projects with geotextile interlayers exhibit less cracking than the existing or new HMA interlayer. Only two of the geotextile projects had cracking levels greater than 5%.

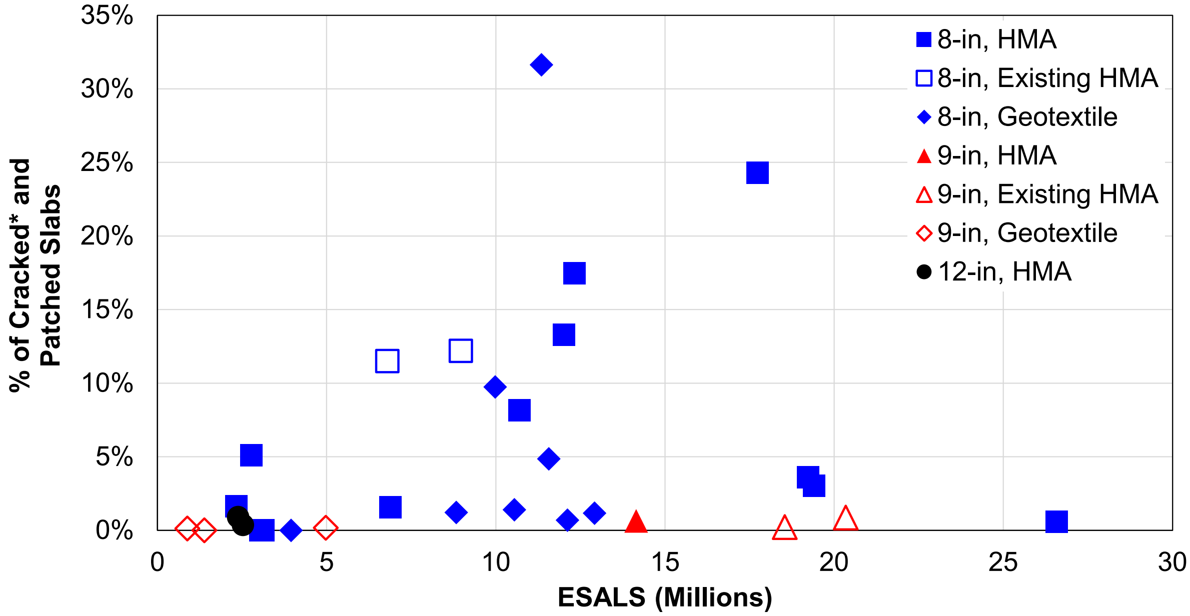



**Figure 3-9. Interlayer type and slab thickness versus cracked and patched slabs for UBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

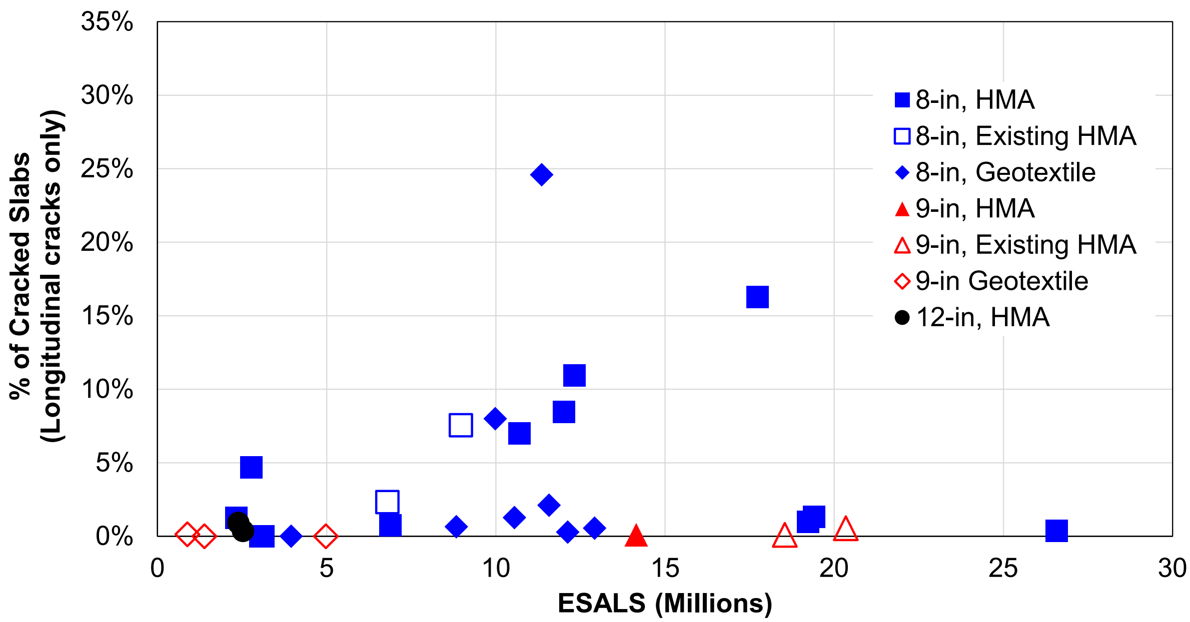



**Figure 3-10. Interlayer type and slab thickness versus longitudinal cracked slabs for UBOL projects.**

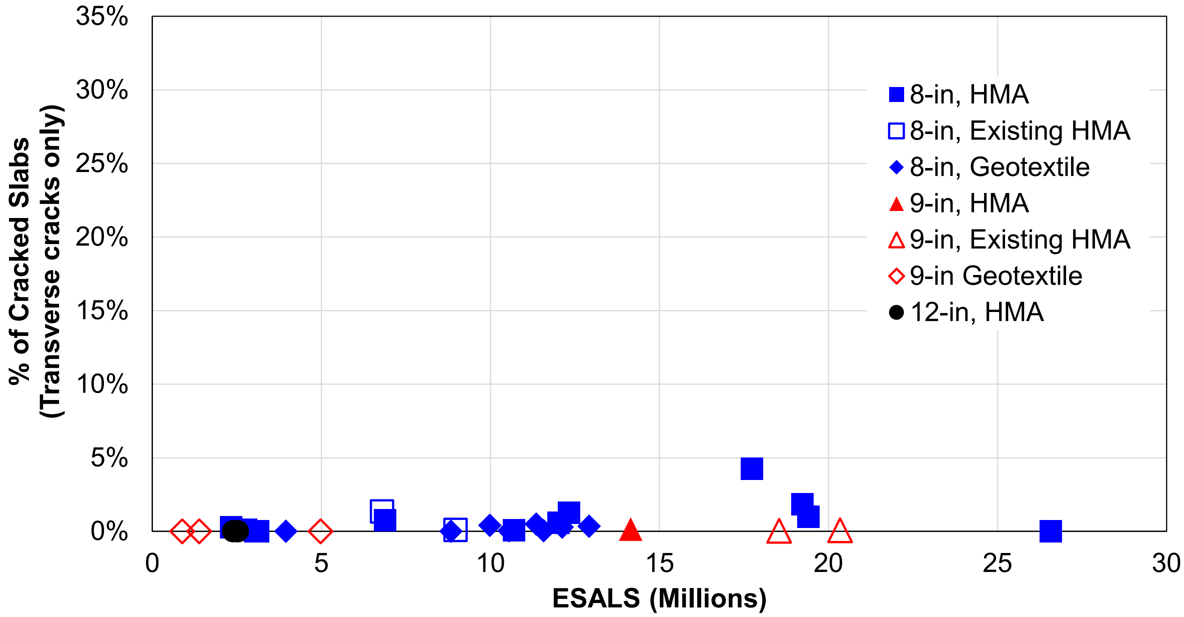



**Figure 3-11. Interlayer type and slab thickness versus transverse cracked slabs for UBOL projects.**

*3.4.1.2 Thickness*

MoDOT UBOL projects were designed with a thickness of either 8 or 9 in, with generally newer projects having the increased thickness. However, two projects (3E and 4E) on US 412 in Pemiscot County were designed with a 12 in thickness. Two other projects (25N and 25S) on I-435 in Jackson County were designed with a variable thickness between 8.5- and 11 in and are not included in any of the thickness graphs because of this variability.

Figure 3-12 shows cracking and patching as a function of design slab thickness. In general, much higher and variable cracking values are observed for the thinner 8-in slabs than for the others. Figure 3-13 presents a similar figure except this time using the mean as-constructed thickness from cores recorded in MoDOT's SiteManager database. The effect of the as-constructed thickness is not as clear, with two pavements with mean thickness values greater than 8.9 in also exhibiting more than 20% cracked and patched slabs. Figure 3-14 examines the thinner parts of these projects by looking at the as-constructed thickness minus one standard deviation. Figure 3-14 indicates that as-constructed thickness minus one standard deviation values greater than 8.6 in results in less cracked and patched slabs for UBOL projects.

Referring to figures 3-10 and 3-11, the increased slab thickness results in fewer slabs with longitudinal and transverse cracking, respectively.

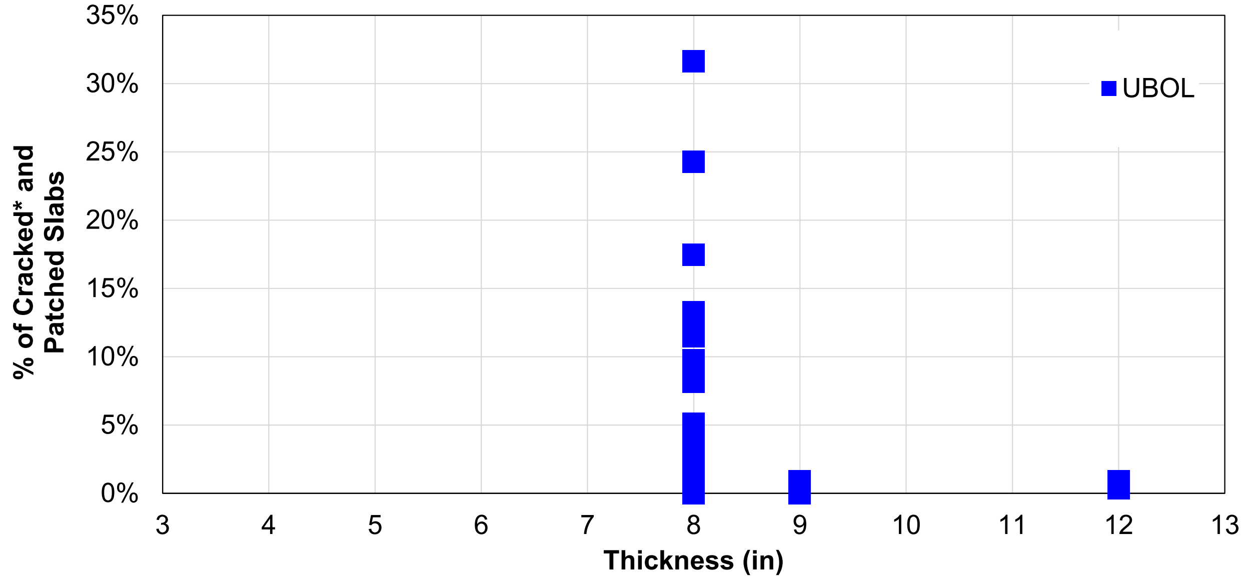



**Figure 3-12. Design slab thickness versus cracked and patched slabs for UBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

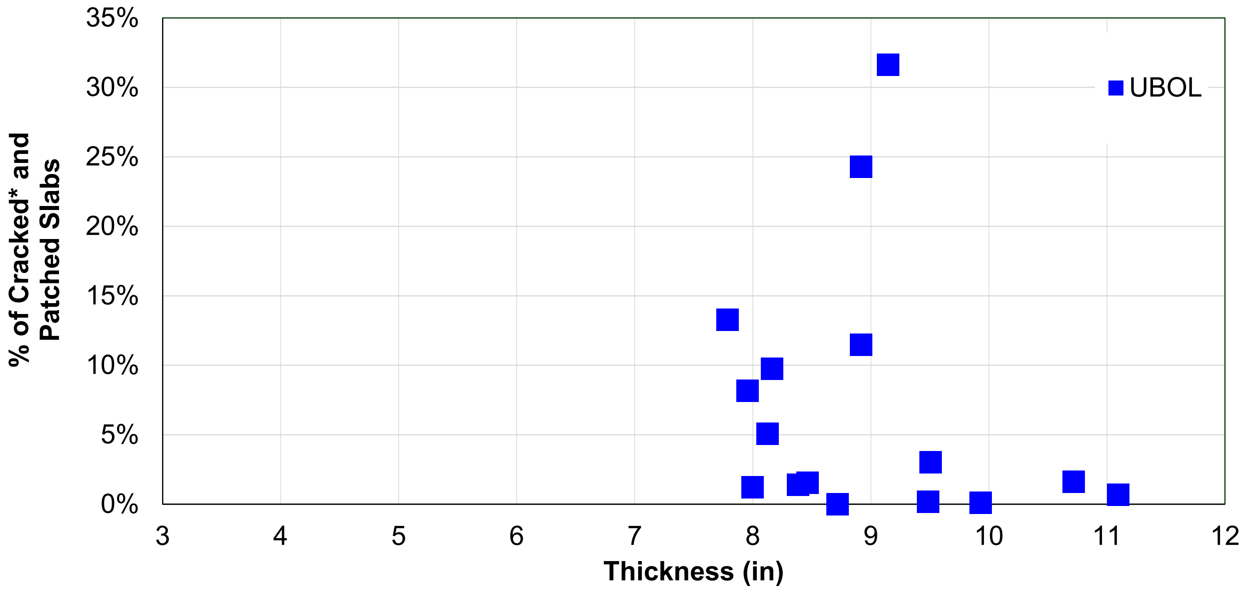



**Figure 3-13. Mean as-constructed slab thickness versus cracked and patched slabs for UBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

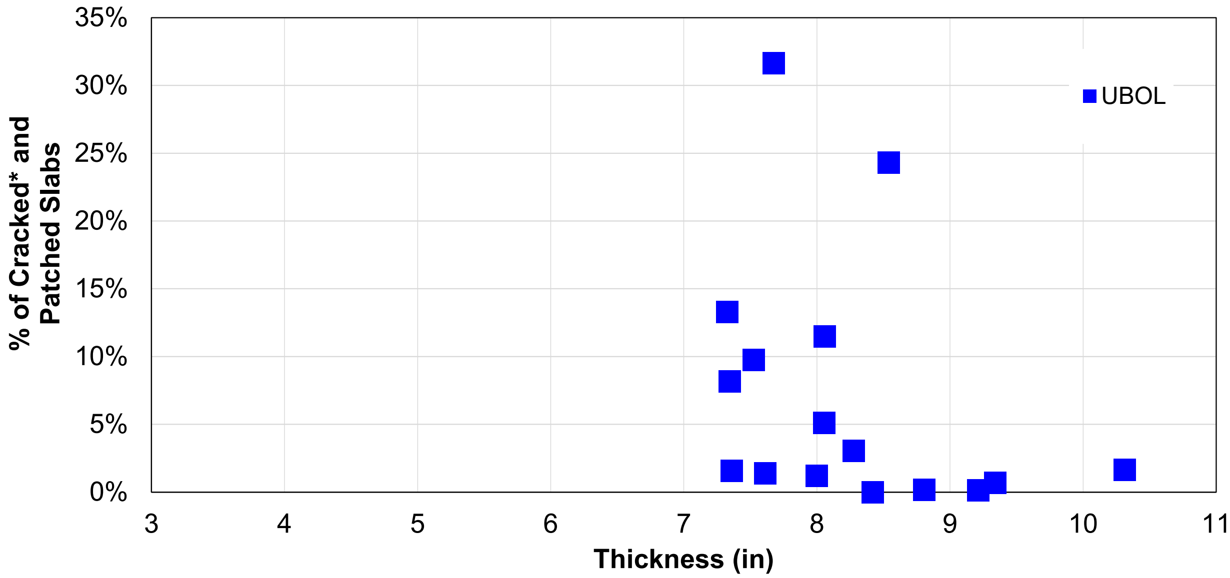



**Figure 3-14. As-constructed slab thickness minus one standard deviation versus cracked and patched slabs for UBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

*3.4.1.3 Slab Geometry*

All the UBOL projects had transverse joint spacings of 15 ft, while the slab widths varied from 12 to 14 ft. The effects of slab widths on slab cracking are shown in figures 3-15 through 3-17, with the additional factor of shoulder type included because PCC shoulders are expected to provide lateral edge support. Figure 3-15 through 3-17 indicate that the 14 ft wide slabs with HMA shoulders had greater cracking than other designs. This was especially true for longitudinal cracking as shown in figure 3-16. A lack of support on the outer part of the slab resulting in a cantilever effect may be contributing to this longitudinal cracking. The widened slabs with PCC shoulders did not display the same levels of distress, suggesting the positive benefits of the additional lateral support.

Figure 3-18 through 3-22 segregate the longitudinal cracking into five zones across the slab (as described in chapter 2): left joint, left wheelpath, center, right wheelpath, and right joint. As expected, most of the longitudinal cracking is in the center and right wheelpath of the slabs. Some of the longitudinal cracking as discussed earlier may be due to non-uniform support of widened lanes contributing to cracking in the right wheelpath.

Transverse cracking was also reviewed by segmenting the panel into five zones: bottom-joint, bottom, middle, top, and top-joint. Essentially all the transverse cracking was in the middle section of the slabs for the UBOL projects as shown in figure 3-23 through 3-27. Overall, little transverse cracking was observed on the UBOL projects, and no underlying pavement support issue was apparent in the distribution of transverse cracking.

#### *3.4.1.4 Shoulder Type*

MoDOT's UBOL projects were either constructed with HMA or PCC shoulders. PCC shoulders tend to have slightly better performance than HMA.

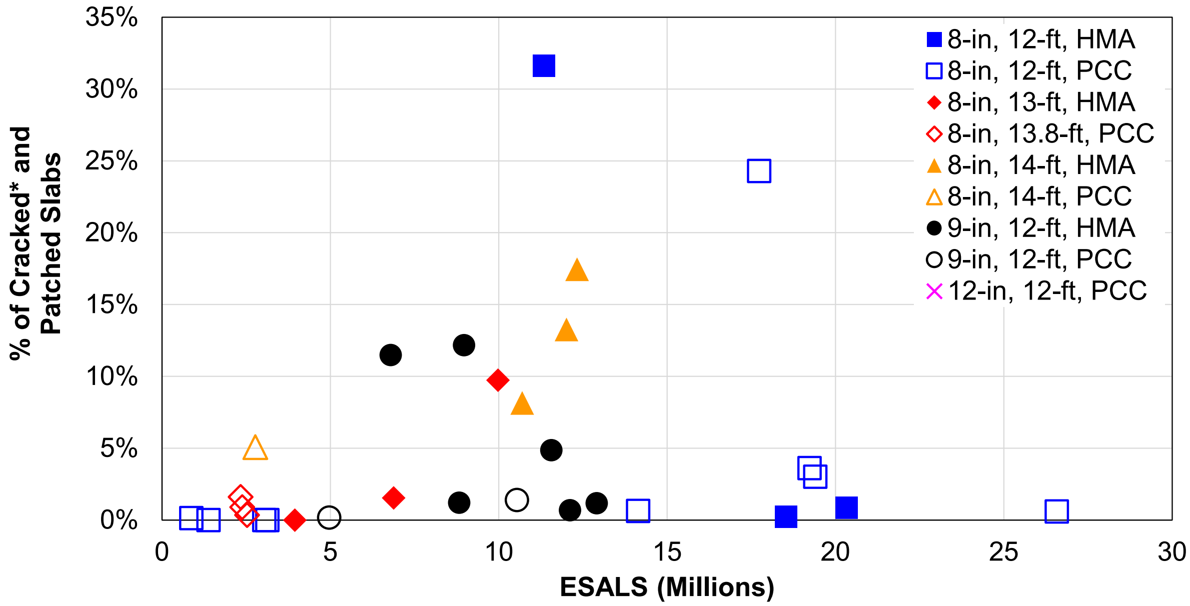



**Figure 3-15. Slab thickness, slab width and shoulder type versus cracked and patched slabs for UBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

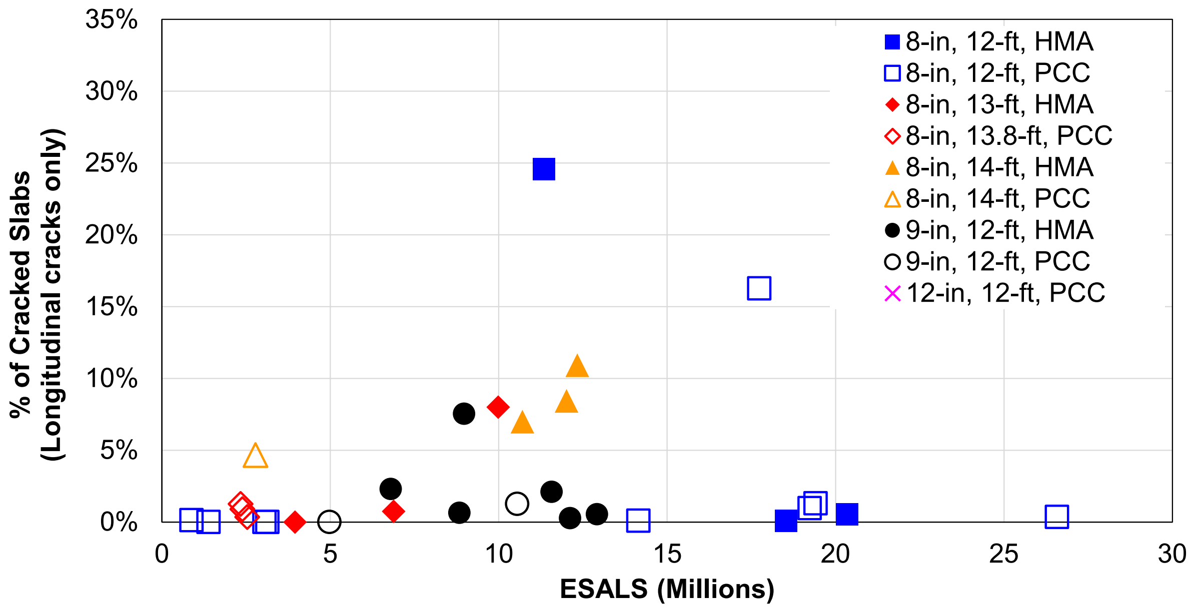



**Figure 3-16. Slab thickness, slab width and shoulder type versus longitudinal cracked slabs for UBOL projects.**

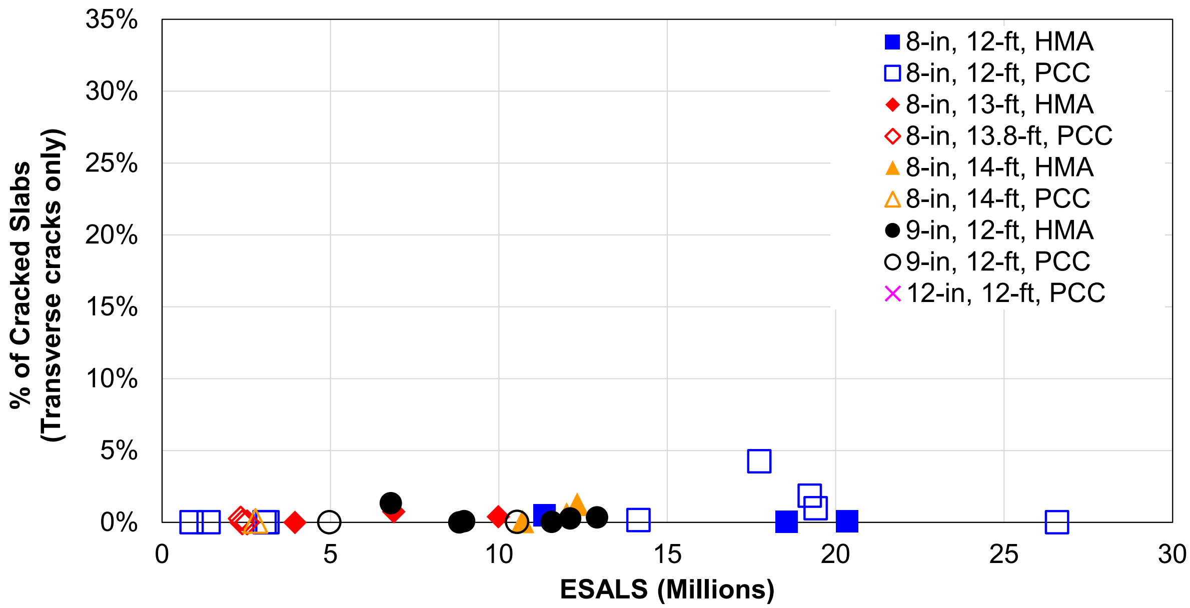



**Figure 3-17. Slab thickness, slab width, and shoulder type versus transverse cracked slabs for UBOL projects.**

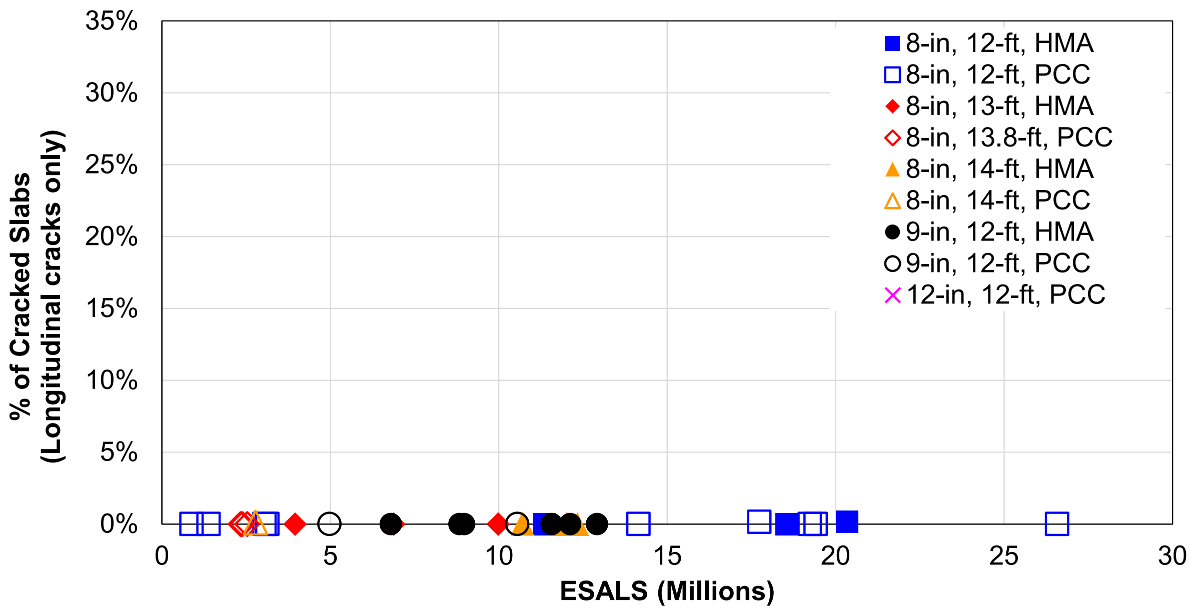



**Figure 3-18. Left joint—slab thickness, slab width and shoulder type versus longitudinal cracked slabs for UBOL projects.**

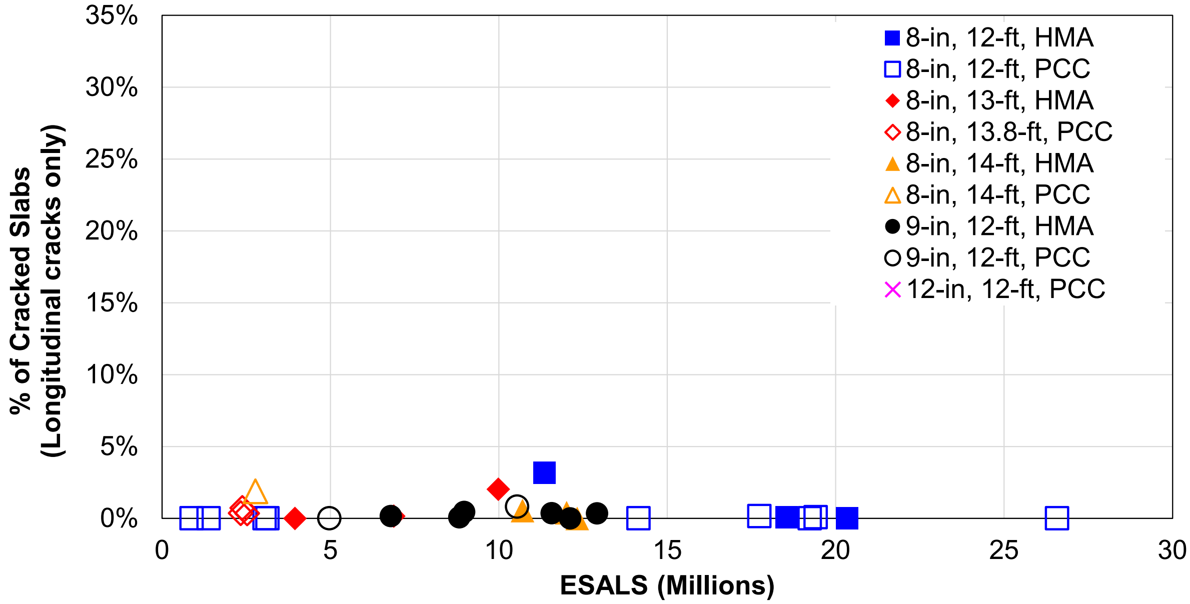



**Figure 3-19. Left wheelpath—slab thickness, slab width and shoulder type versus longitudinal cracked slabs for UBOL projects.**

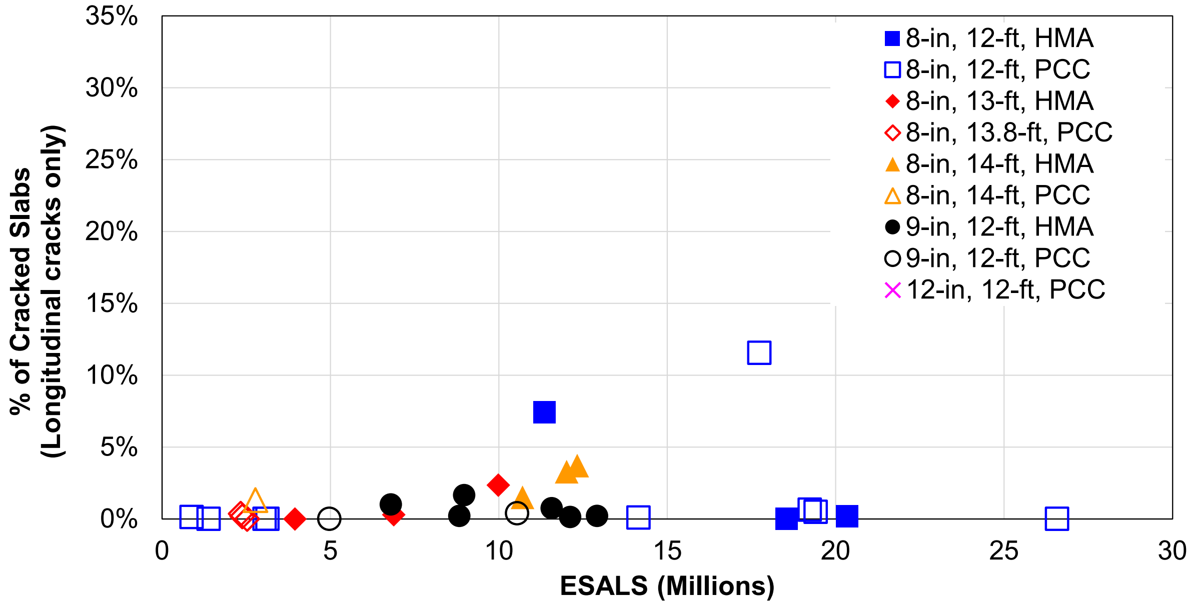



**Figure 3-20. Center slab—slab thickness, slab width and shoulder type versus longitudinal cracked slabs for UBOL projects.**

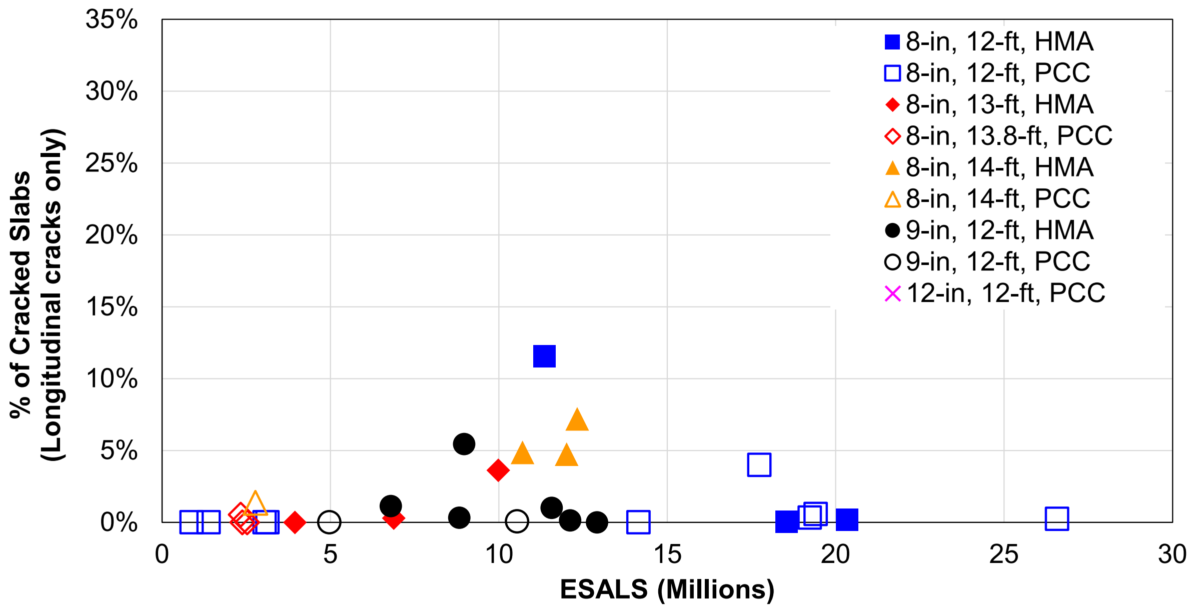



**Figure 3-21. Right wheelpath—slab thickness, slab width and shoulder type versus longitudinal cracked slabs for UBOL projects.**

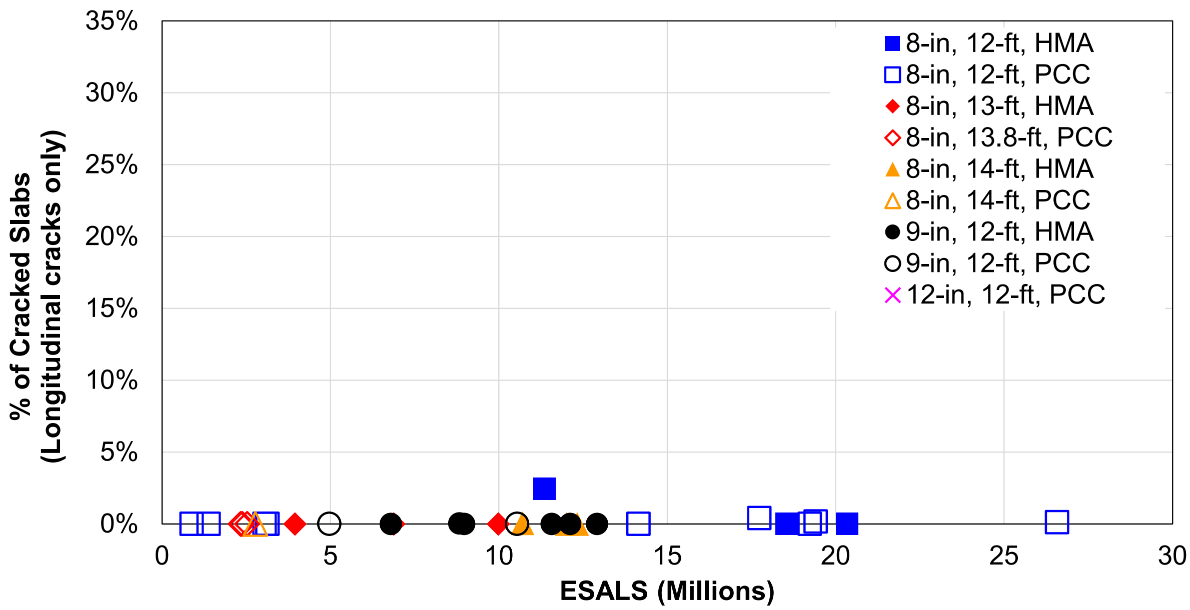



**Figure 3-22. Right joint—slab thickness, slab width and shoulder type versus longitudinal cracked slabs for UBOL projects.**

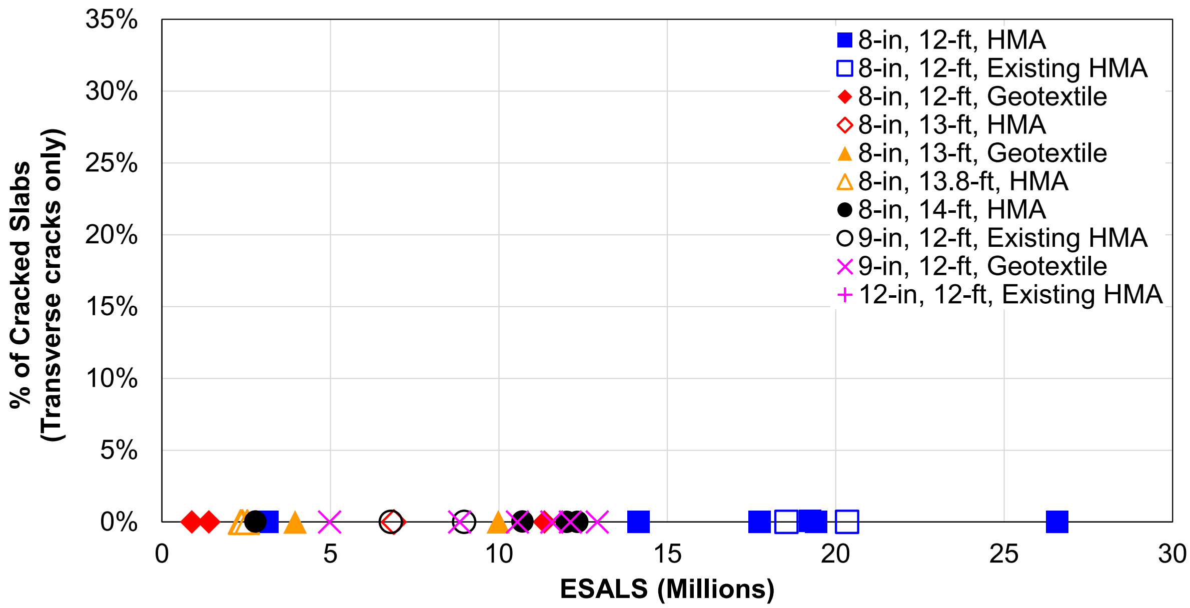



**Figure 3-23. Bottom–joint—transverse cracked slabs versus slab thickness, slab width, and interlayer for UBOL projects.**

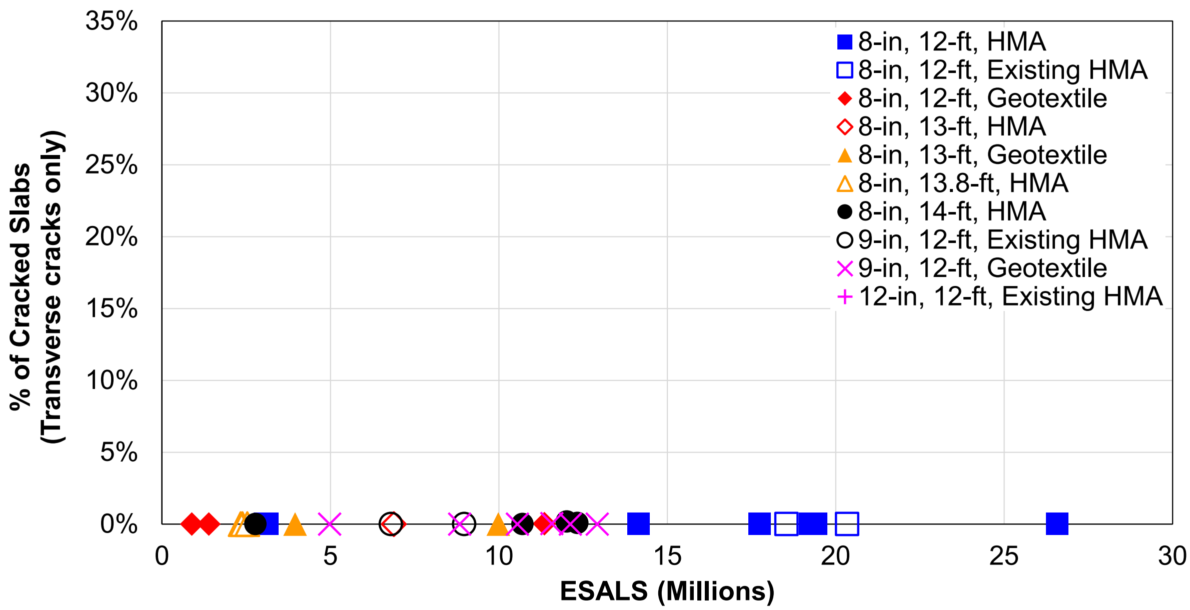



**Figure 3-24. Bottom—transverse cracked slabs versus slab thickness, slab width, and interlayer for UBOL projects.**

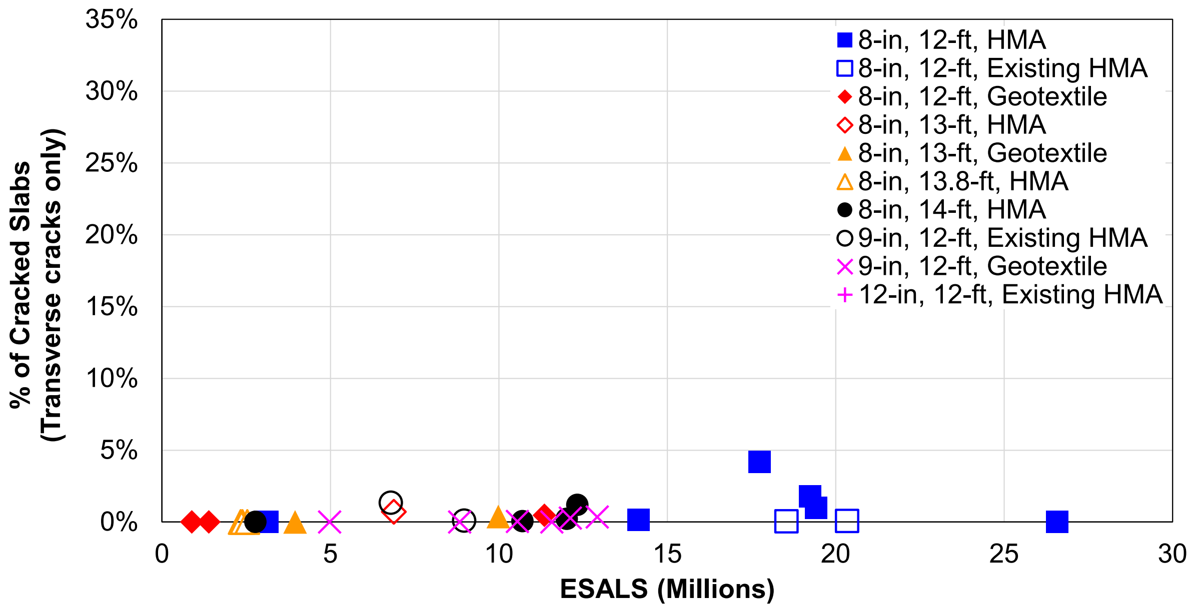



**Figure 3-25. Middle—transverse cracked slabs versus slab thickness, slab width, and interlayer for UBOL projects.**

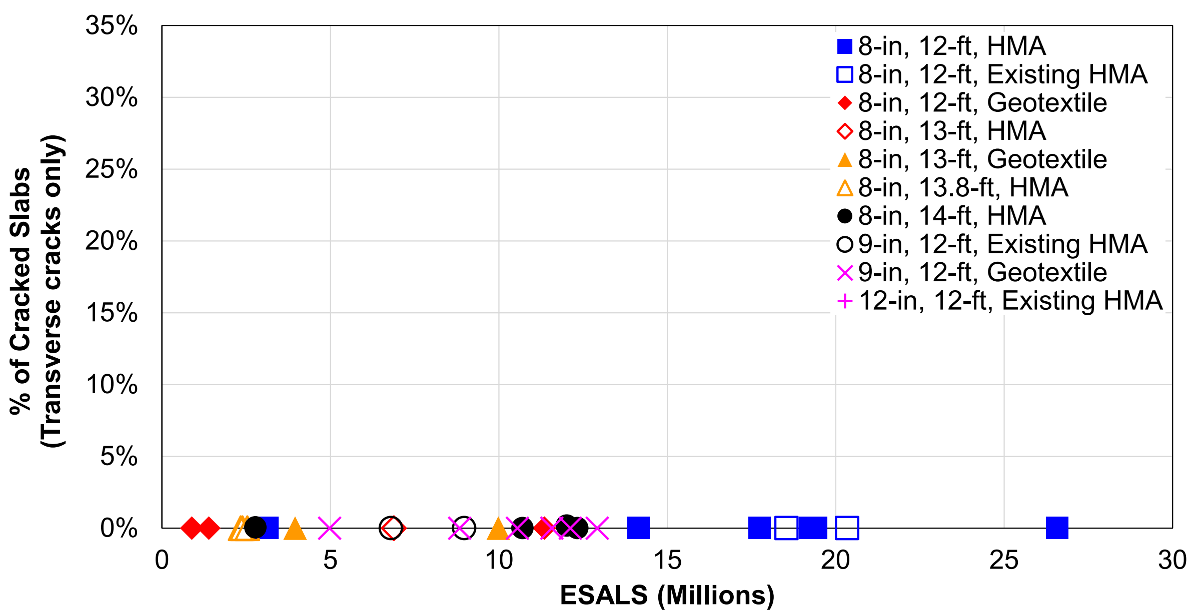



**Figure 3-26. Top—transverse cracked slabs versus slab thickness, slab width, and interlayer for UBOL projects.**

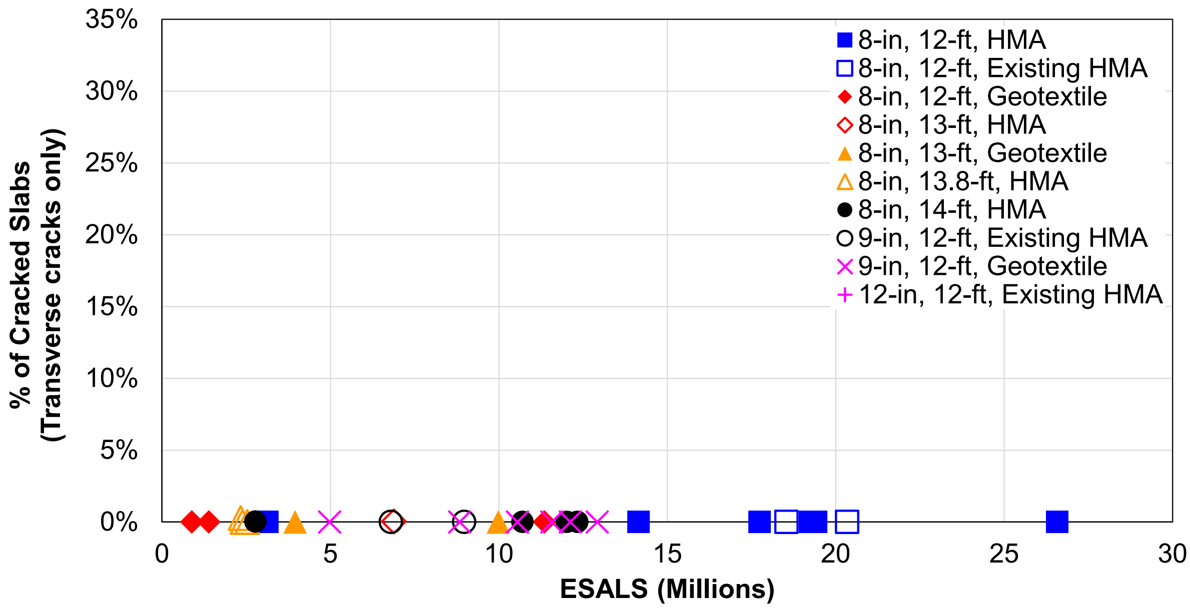



**Figure 3-27. Top–joint—transverse cracked slabs versus slab thickness, slab width, and interlayer for UBOL projects.**

#### *3.4.1.5 Underlying Pavement*

Figure 3-28 shows the effect of the underlying pavement on the cracking performance of the UBOL projects, but without consideration of the sustained traffic loadings. UBOL over NRPCCP exhibited the highest amount of cracked and patched slabs, while overall UBOL over HMA pavement exhibited the least amount of cracked and patched slabs. The lower amounts of cracked and patched slabs for UBOL over RPCCP was somewhat unexpected, as RPCCP tend to have more cracking distress than NRPCCP, which would be expected to affect the performance of an overlay. Distress data for the underlying pavement prior to overlay was not available for analysis.

### *3.4.2 BBOL*

BBOL projects exhibited mixed performance in term of both pavement smoothness and cracked and patched slabs, as shown previously in figures 3-7 and 3-8. The mean 2018 IRI for the BBOL projects was 131 in/mi, but 5 of the projects had values approaching or exceeding 200 in/mi. These higher IRI values were exhibited in spite of the fact that these projects had sustained lower traffic loadings (typically less than 5 million ESALs) than the UBOL counterparts. In terms of cracking performance, all BBOL projects exhibited cracking levels less than 10%, with the majority showing less than 5% cracking.

#### *3.4.2.1 Interlayer Type*

Like UBOL, BBOL projects included in this study were constructed using different interlayer types. These included:

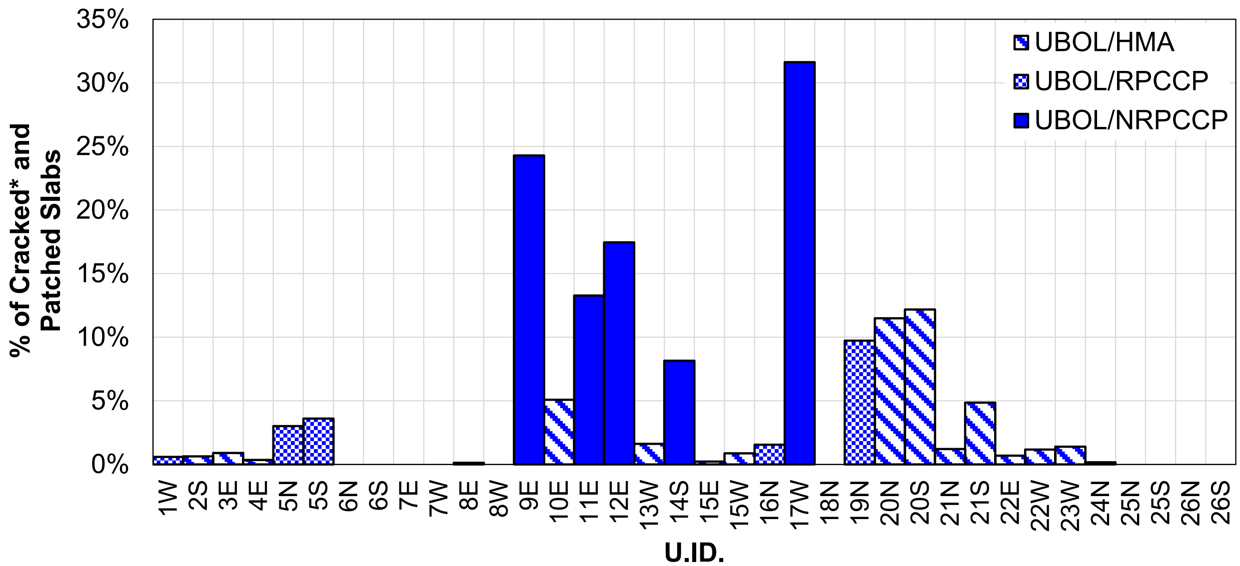



**Figure 3-28. Underlying pavement effect on cracked and patched slabs for UBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

- No interlayer, using the existing underlying HMA pavement.
- Geotextile.
- A new 1-in thick HMA layer was present on the UBOL project that was sawcut into a BBOL project (project 35N and 35S on I-35 in Daviess County). This project is identifiable in the following graphs as the 8 in thick BBOL slab thickness.

The effects of the interlayer type on cracking performance are shown in figure 3-29 through 3-31. Based on these results, there are no clear indications on the effects of interlayer.

### *3.4.2.2 Thickness*

Ignoring the 8-in thick transformed BBOL project, generally the 6-in BBOL pavement designs performed slightly better in terms of cracked and patched slabs than the 5-in designs, as shown in figure 3-32. Figures 3-33 and 3-34 looks at the trends using the as constructed thickness and shows some benefits with minimum thickness greater than 5.5 in.

### *3.4.2.3 Slab Geometry*

All the BBOL included in the study had 6-ft x 6-ft panels, so no further study of slab geometry was possible.

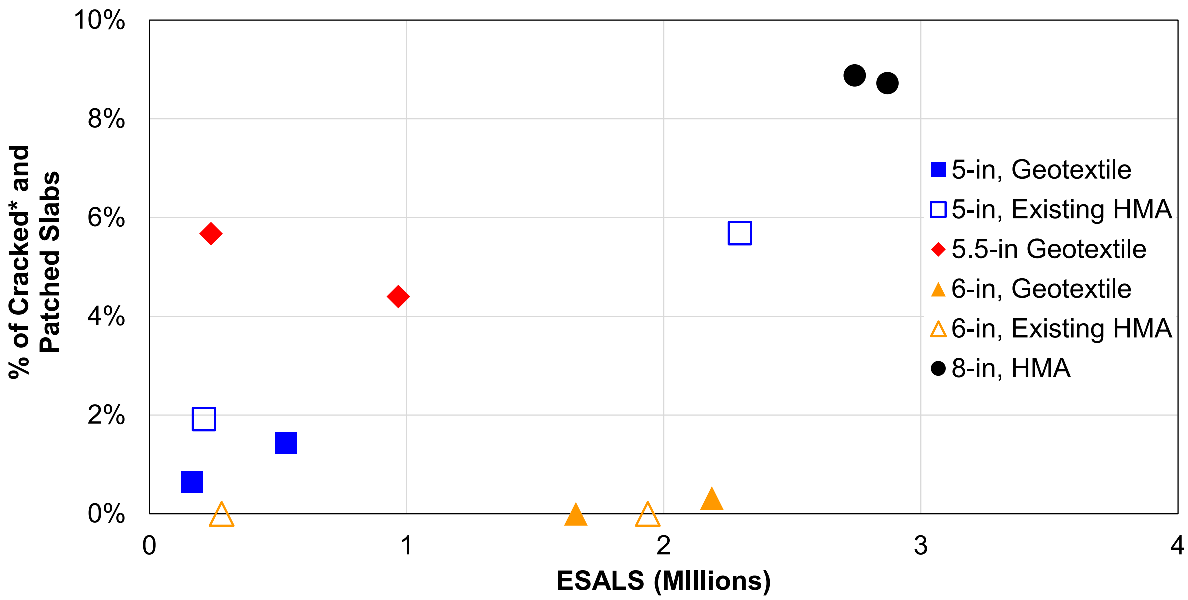



**Figure 3-29. Interlayer type and slab thickness versus cracked and patched slabs for BBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

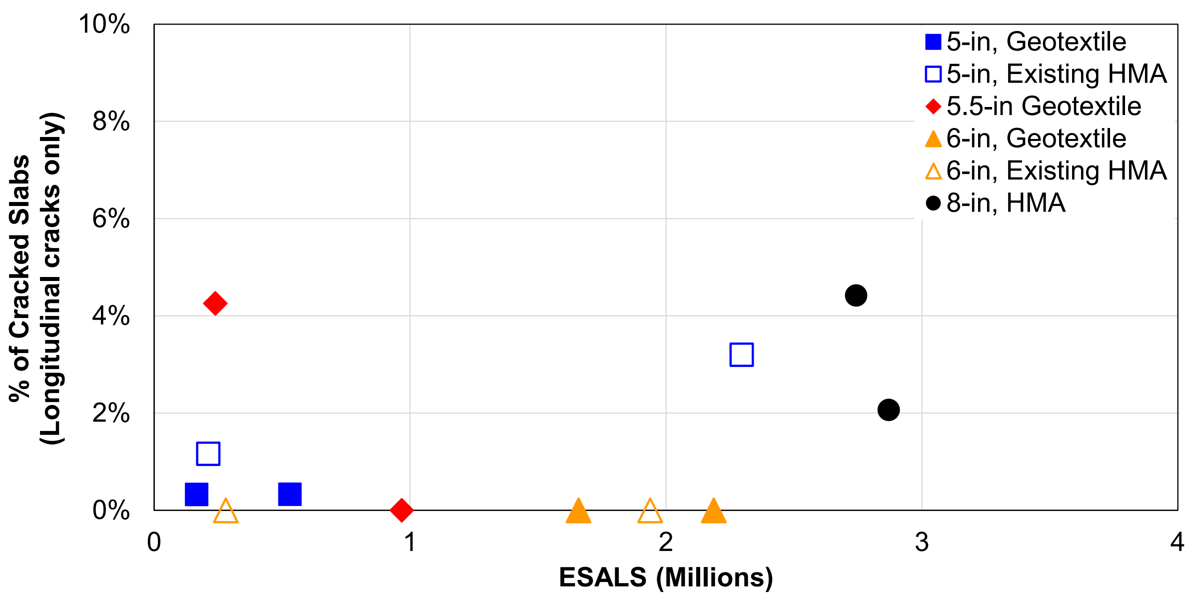



**Figure 3-30. Interlayer type and slab thickness versus longitudinal cracked slabs for BBOL projects.**

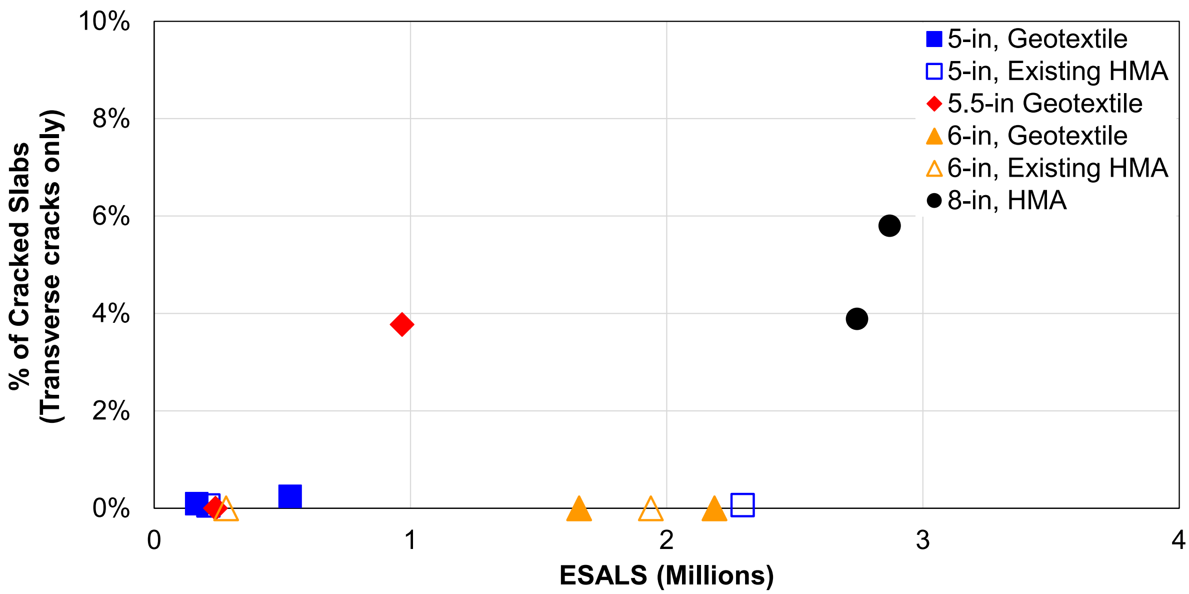



**Figure 3-31. Interlayer type and slab thickness versus transverse cracked slabs for BBOL projects.**

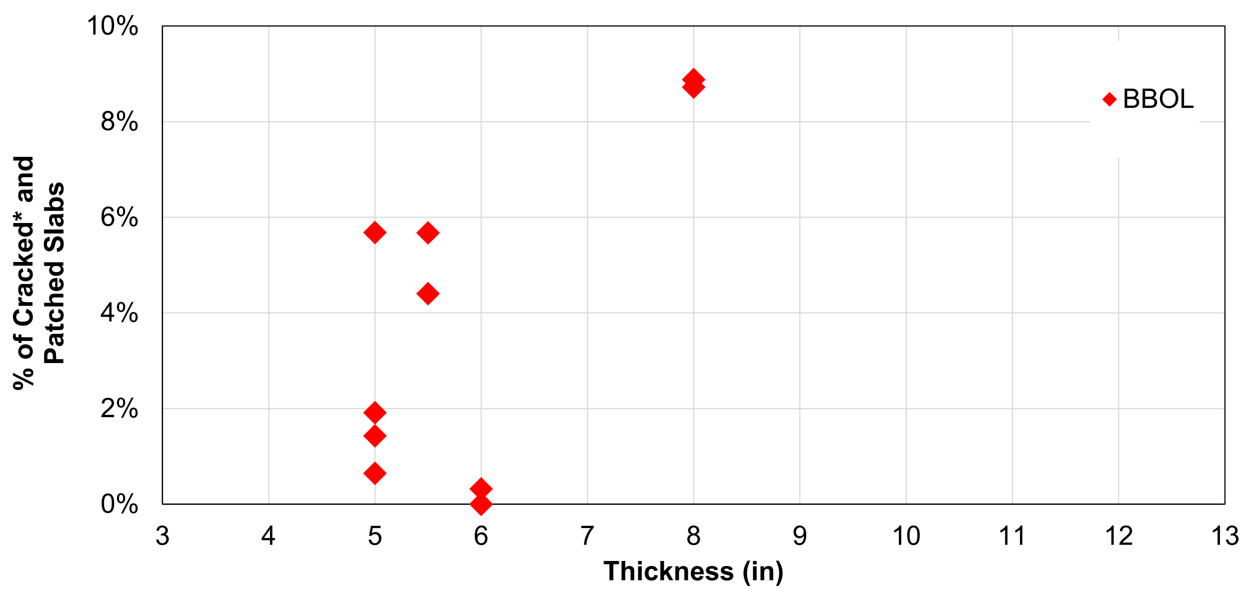



**Figure 3-32. Design slab thickness versus cracked and patched slabs for BBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

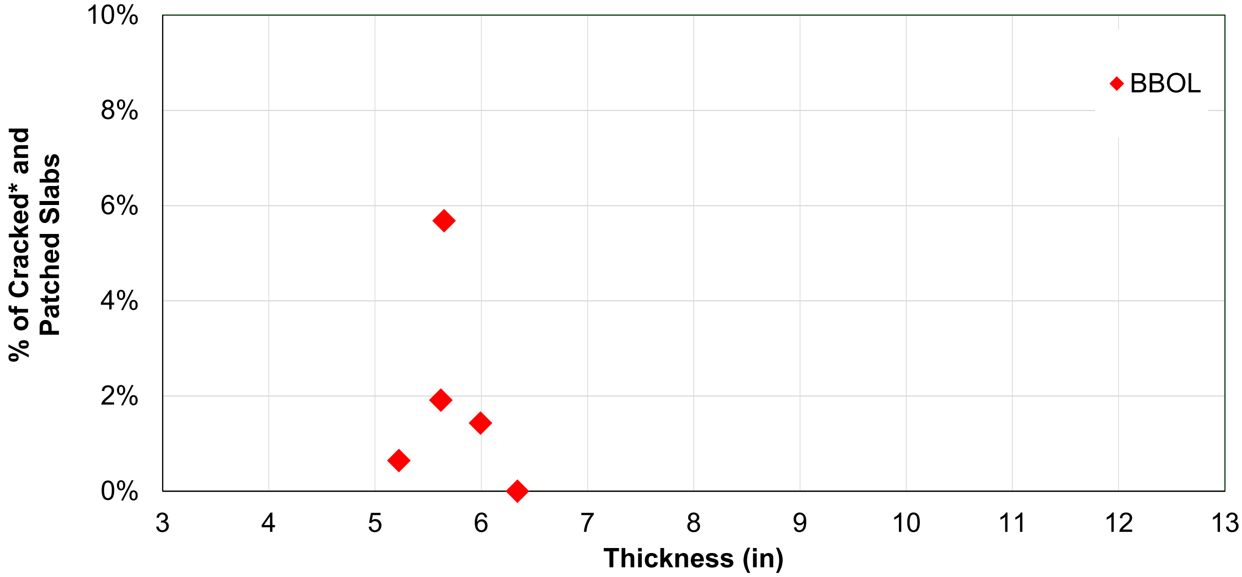



**Figure 3-33. As-constructed slab thickness versus cracked and patched slabs for BBOL projects.**

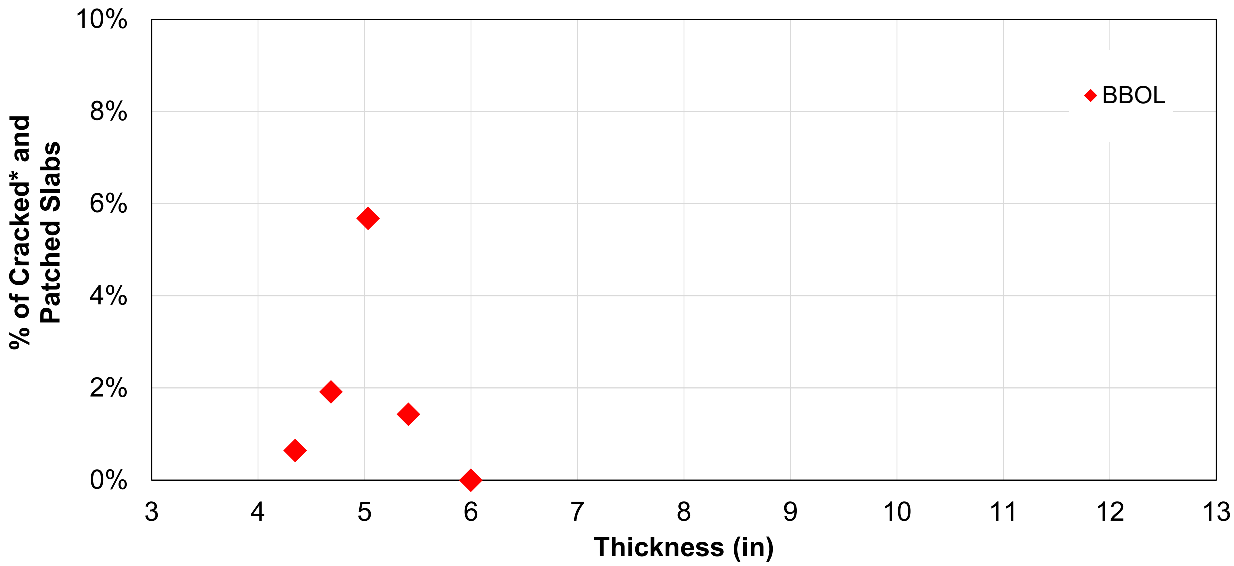



**Figure 3-34. As-constructed minus one standard deviation slab thickness versus cracked and patched slabs for BBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

### *3.4.2.4 Shoulder Type*

BBOL projects were constructed with HMA, PCC, curb and gutter, and aggregate shoulders. Curb and gutter was combined with PCC shoulders for the analysis in this section as they are believed to contribute to the lateral support. The results of the cracking analysis are presented in figures 3-35 through 3-41. As seen from these figures, it is difficult to draw any clear conclusions on the effect of shoulders on the performance of the BBOL projects, largely due to the limited number of BBOL projects in each category and the generally low levels of cracking exhibited. And as noted previously, the 8-in project was a transformed UBOL project that became a BBOL after the slabs were sawed in half as part of a rehabilitation project.

Figures 3-37 and 3-38 present the longitudinal cracking in the left and right panels of the BBOL projects. Figures 3-40 and 3-41 present the transverse cracking in the left and right panels of the BBOL projects. Except for the 5.5-in thick BBOL project, there is little apparent difference in performance between the left and right panels.

*3.4.2.5 Underlying Pavement*

BBOL projects were constructed over HMA, RPCCP, and NRPCCP sections as shown in figure 3-42. Due to the limited data on sections constructed over RPCCP and NRPCCP, no definitive conclusions can be drawn.

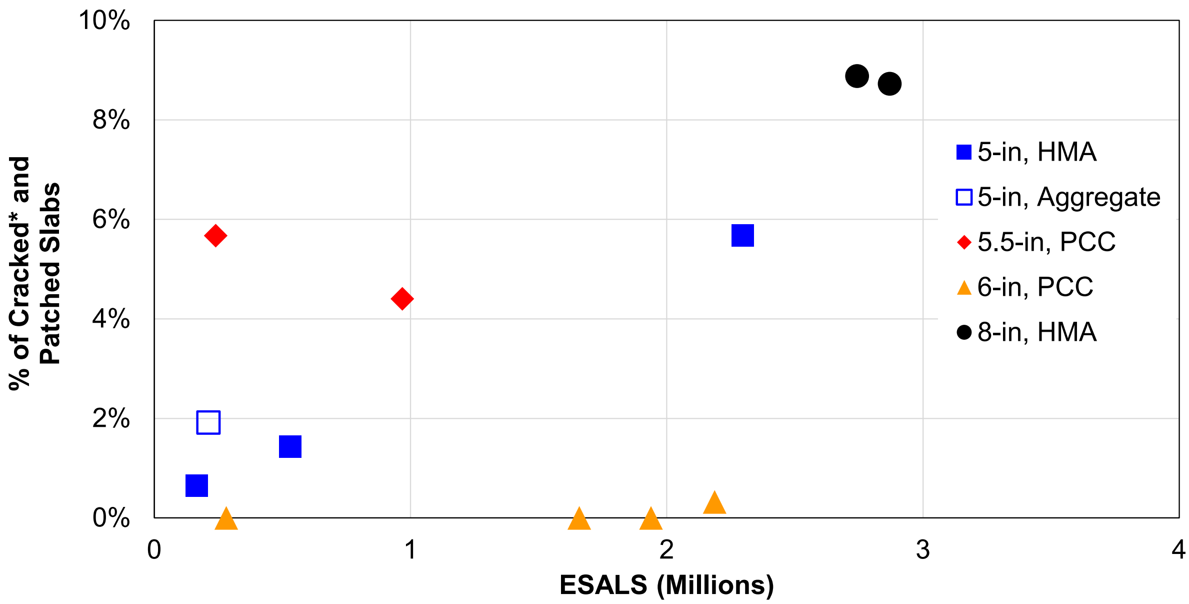



**Figure 3-35. Slab thickness and shoulder type versus cracked and patched slabs for BBOL projects.**

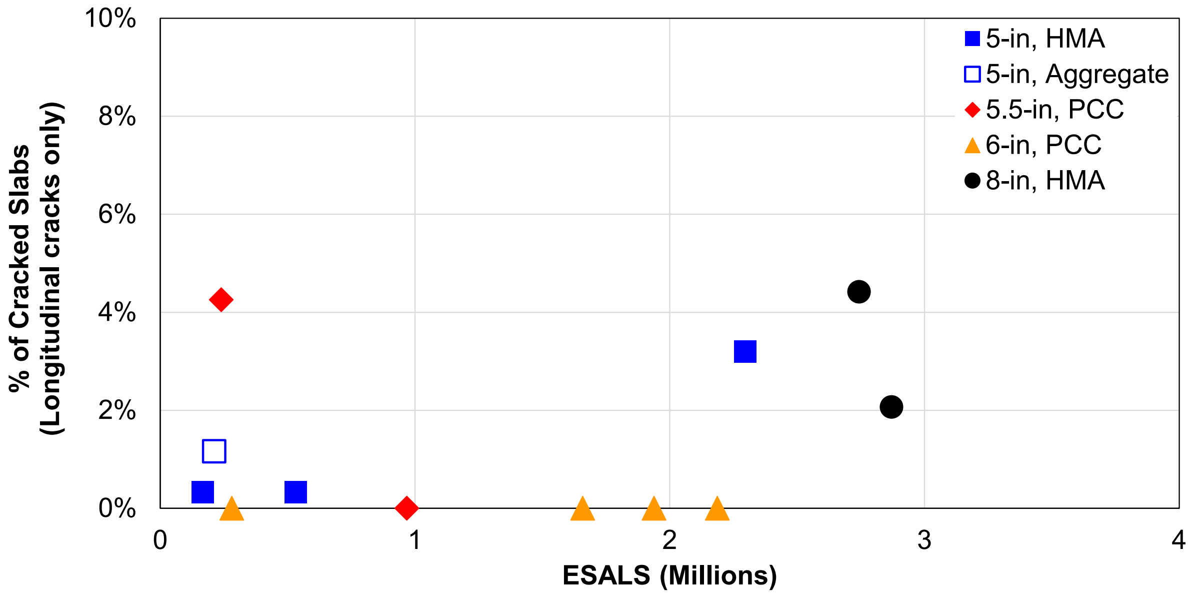



**Figure 3-36. Slab thickness and shoulder type versus longitudinal cracked slabs for BBOL projects.**

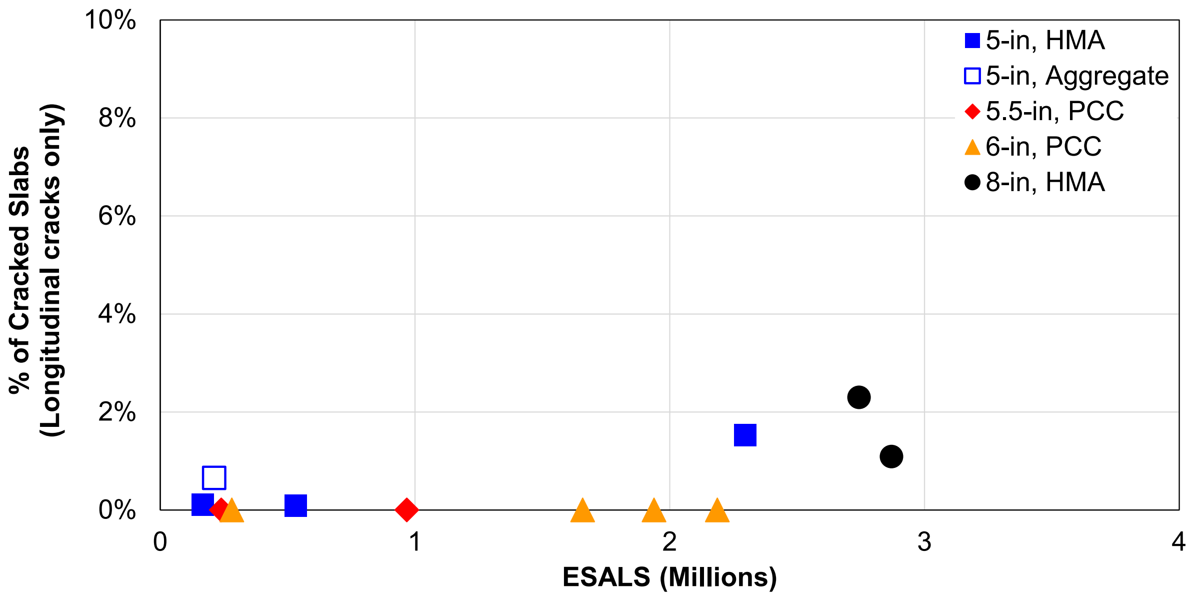



**Figure 3-37. Left panel—slab thickness and shoulder type versus longitudinal cracked slabs for BBOL projects.**

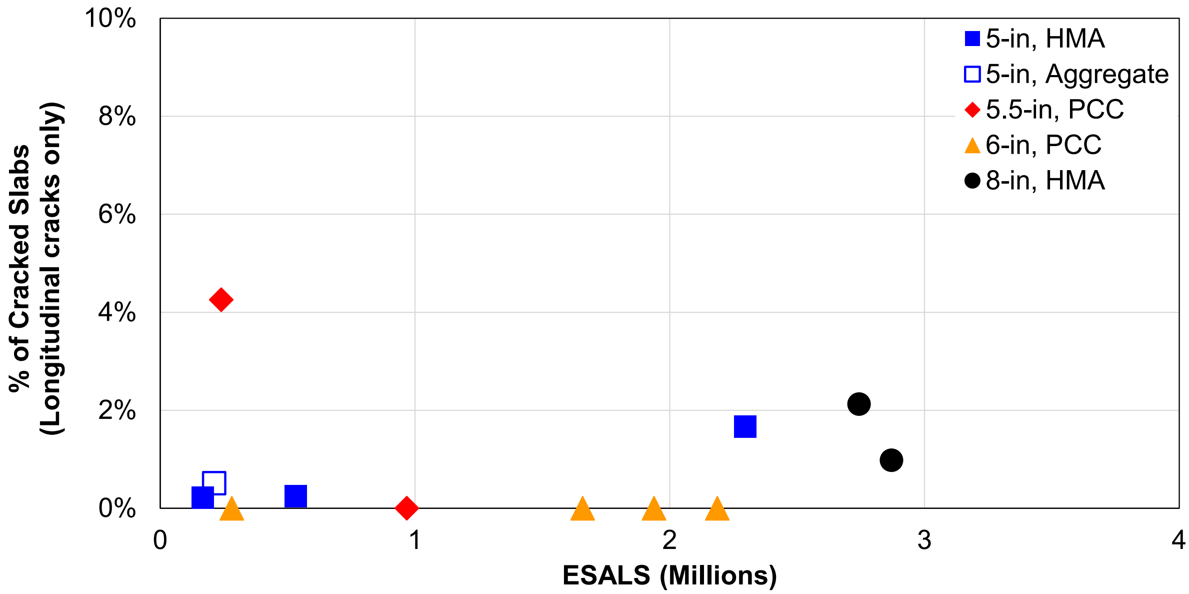



**Figure 3-38. Right panel—slab thickness and shoulder type versus longitudinal cracked slabs for BBOL projects.**

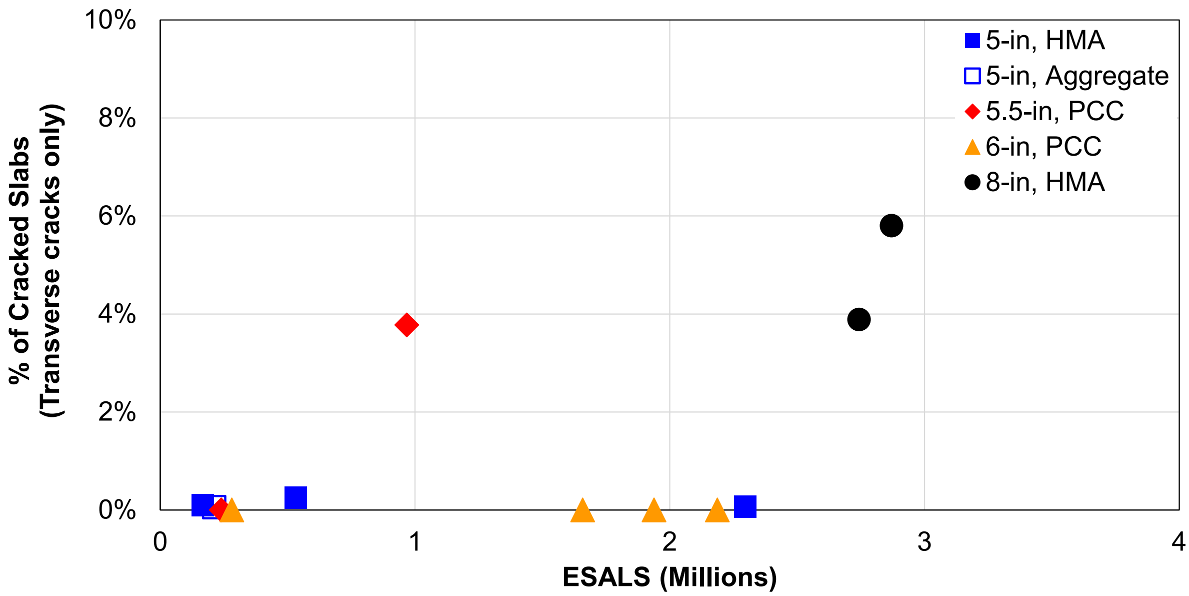



**Figure 3-39. Slab thickness and shoulder type versus transverse cracked slabs for BBOL projects.**

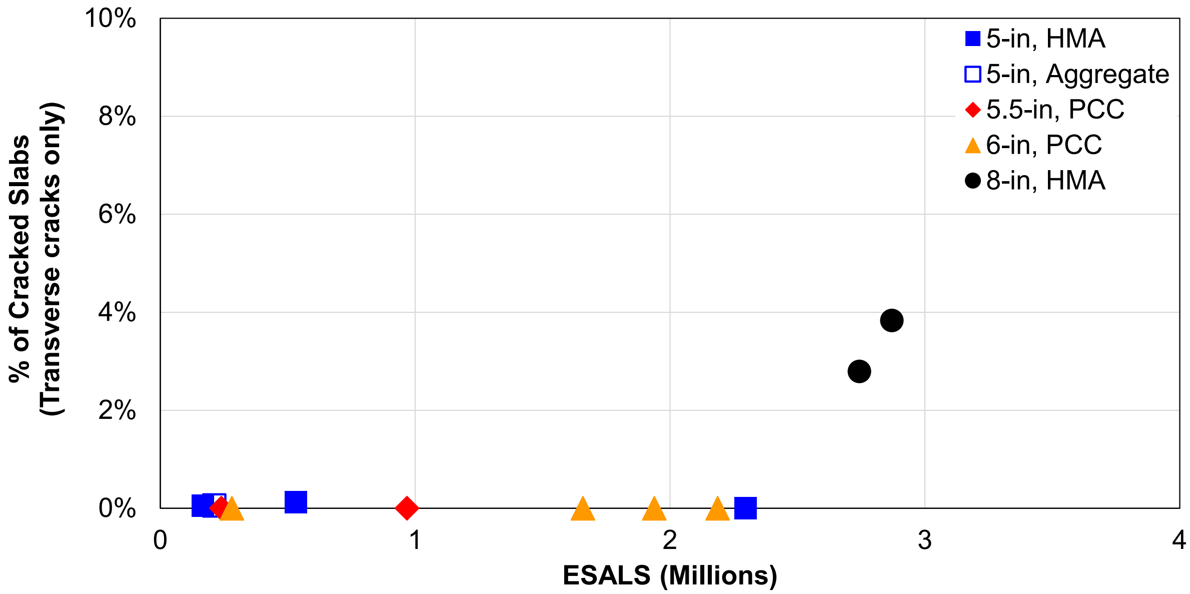



**Figure 3-40. Left panel—slab thickness and shoulder type versus transverse cracked slabs for BBOL projects.**

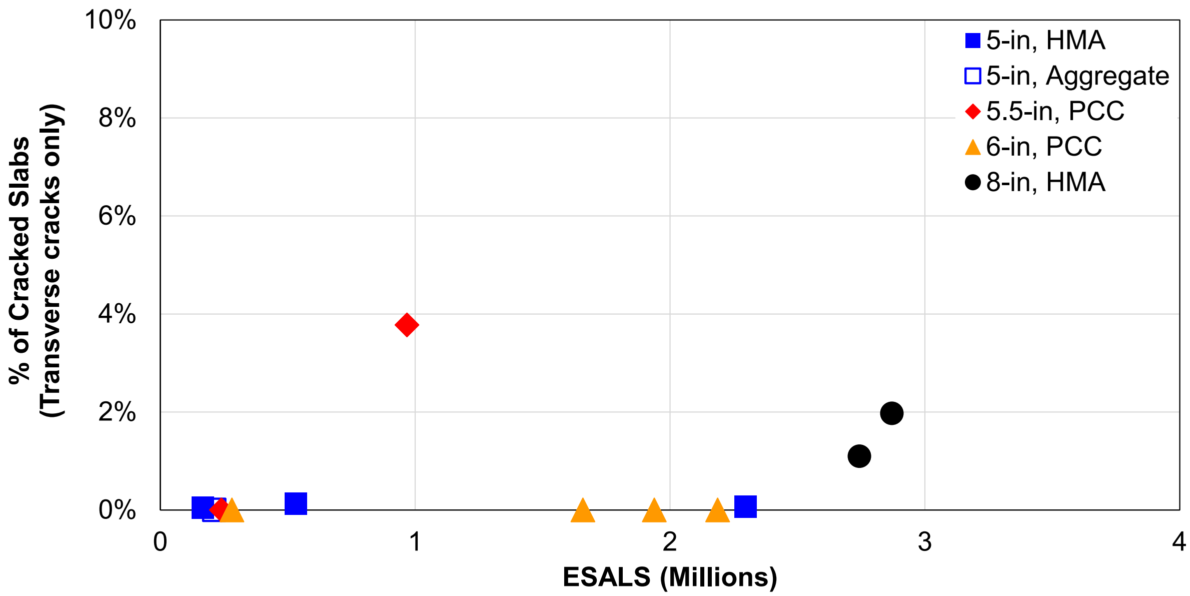



**Figure 3-41. Right panel—slab thickness and shoulder type versus transverse cracked slabs for BBOL projects.**

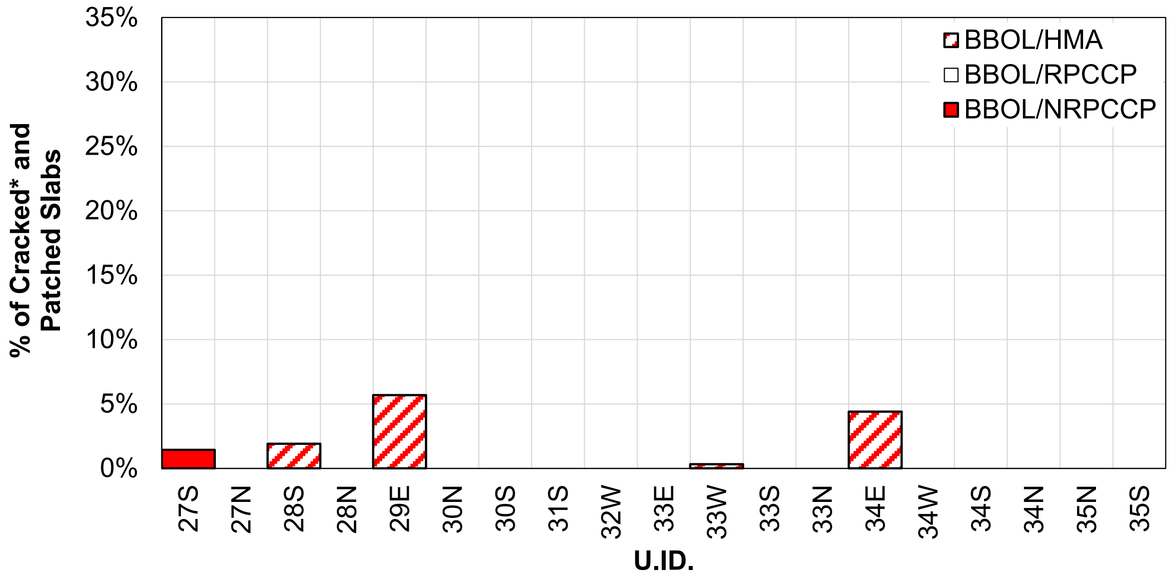



**Figure 3-42. Underlying pavement effect on cracked and patched slabs for BBOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

### *3.4.3 BOL*

BOL projects, like BBOL projects, produced mixed results in terms of both smoothness and cracked and patched slabs (see figures 3-7 and 3-8 presented previously). The smoothness issue can be related to construction factors (small projects, hand pours, utilities, complex longitudinal profiles, etc.) and the difficulty in measuring IRI in and around intersections where many of these were constructed. The mean 2018 IRI for the BOL projects was 263 in/mi, and all had carried less than 7 million ESALs.

For relatively newer projects that are generally exposed to lower traffic levels, 3 of the 6 projects exhibited cracking levels of 10% or greater (see figure 3-8). Part of this may be related to the intersection construction (e.g., complex longitudinal profiles) or could be an indication of poor bond between the overlay and the underlying HMA, meaning that the thin 4-in structure would be solely responsible for carrying the traffic loading.

#### *3.4.3.1 Underlying Pavement and Interlayer Type*

All BOL projects were constructed over HMA without an interlayer. Although no data were available on the condition or thickness of the underlying HMA layer, MoDOT staff indicated that some of these projects may have been milled down close to the base or subgrade layer to achieve the profile grade necessary for an overlay at an intersection.

#### *3.4.3.2 Thickness and Slab Geometry*

All BOL projects were constructed with a 4-in slab thickness and 4-ft x 4-ft panels. As-constructed thickness data were not available for these projects.

*3.4.3.3 Shoulder Type*

The shoulder type was the only design feature that differed between the BOL projects in this study. BOL projects were constructed with HMA, PCC, or curb and gutter as shoulders. Curb and gutter were combined with PCC shoulders for analysis as they provide lateral support to the mainline pavement. Figure 3-44 through 3-51 examine longitudinal and transverse cracking by panel location. Essentially all the longitudinal and transverse cracking is contained in the right panel of the BOL projects.

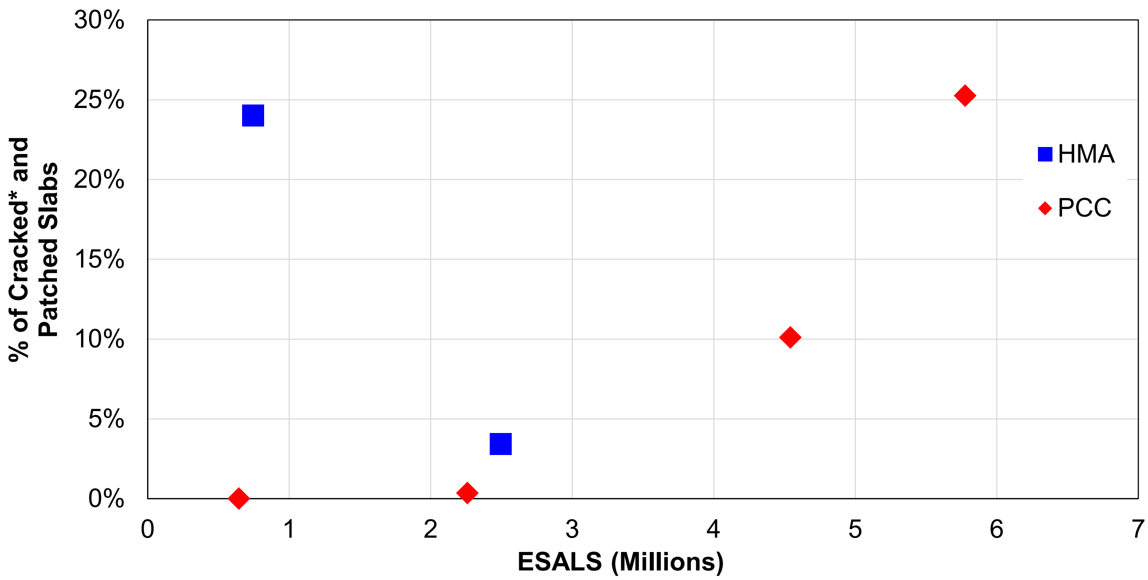



**Figure 3-43. Shoulder type versus cracked and patched slabs for BOL projects (* cracked slabs includes shattered slabs, longitudinal, transverse, diagonal, and corner cracking).**

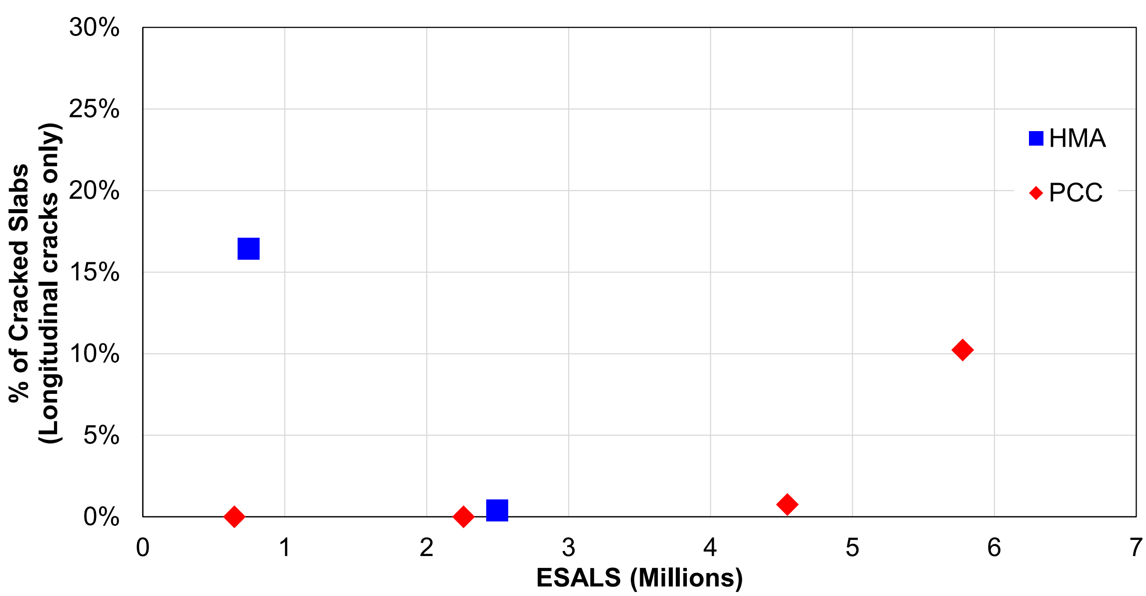



**Figure 3-44. Shoulder type versus longitudinal cracked slabs for BOL projects.**

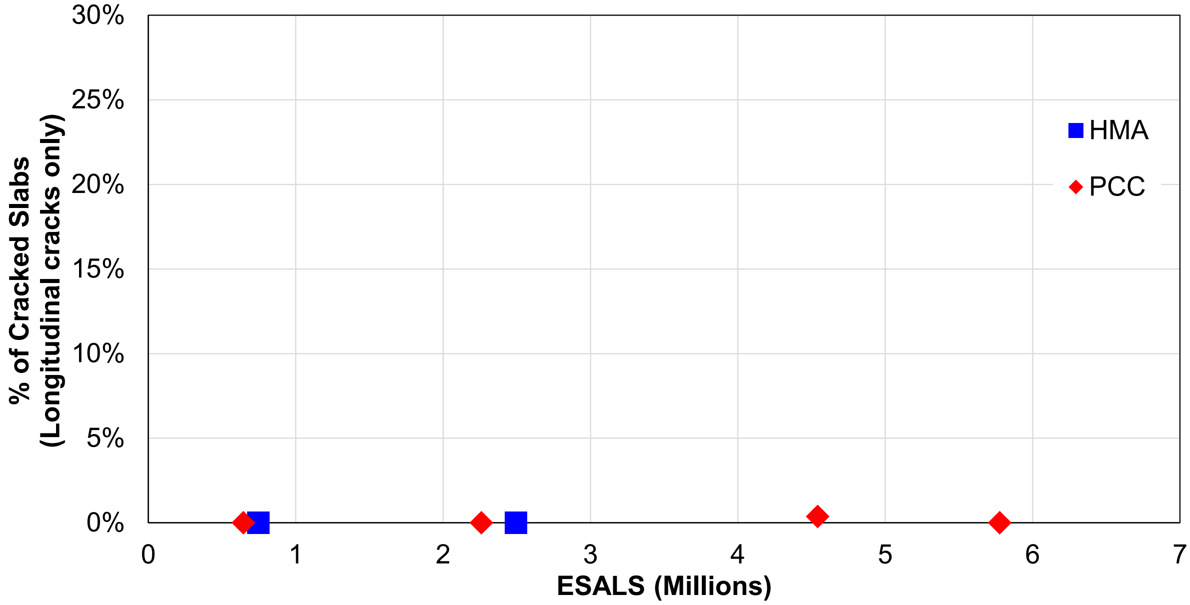



**Figure 3-45. Left panel—shoulder type versus longitudinal cracked slabs for BOL projects.**

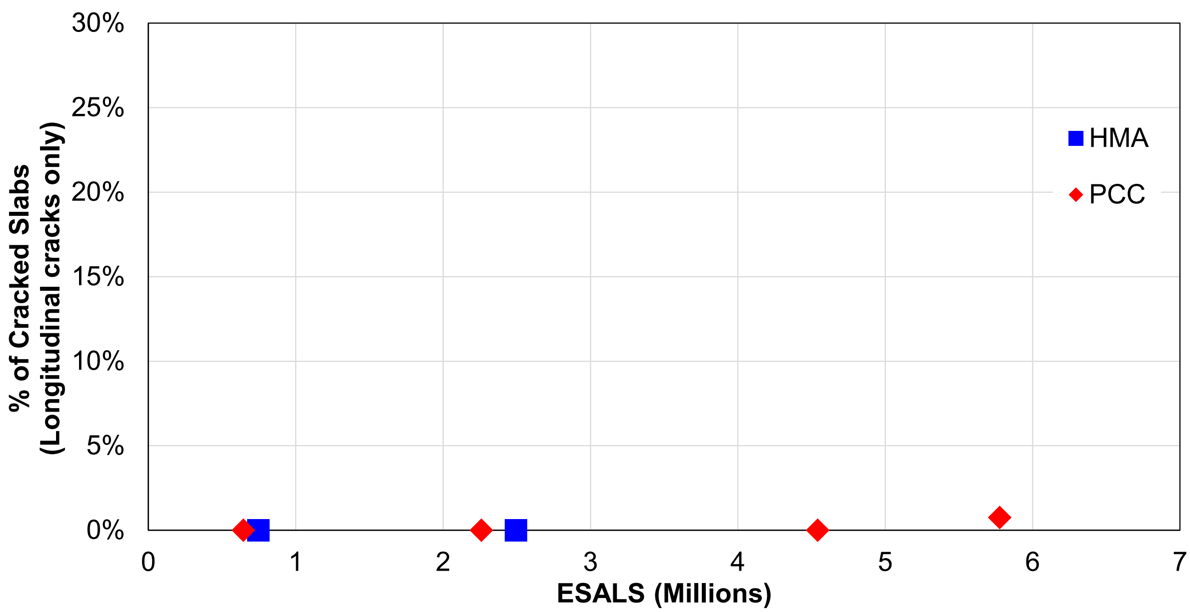



**Figure 3-46. Center panel—shoulder type versus longitudinal cracked slabs for BOL projects.**

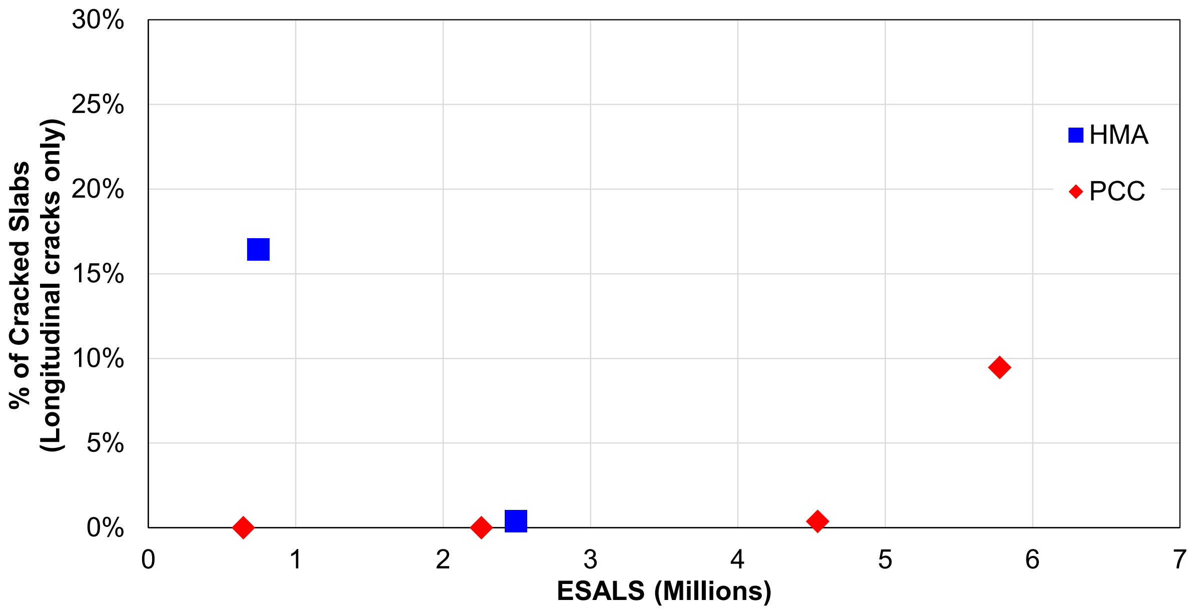



**Figure 3-47. Right panel—shoulder type versus longitudinal cracked slabs for BOL projects.**

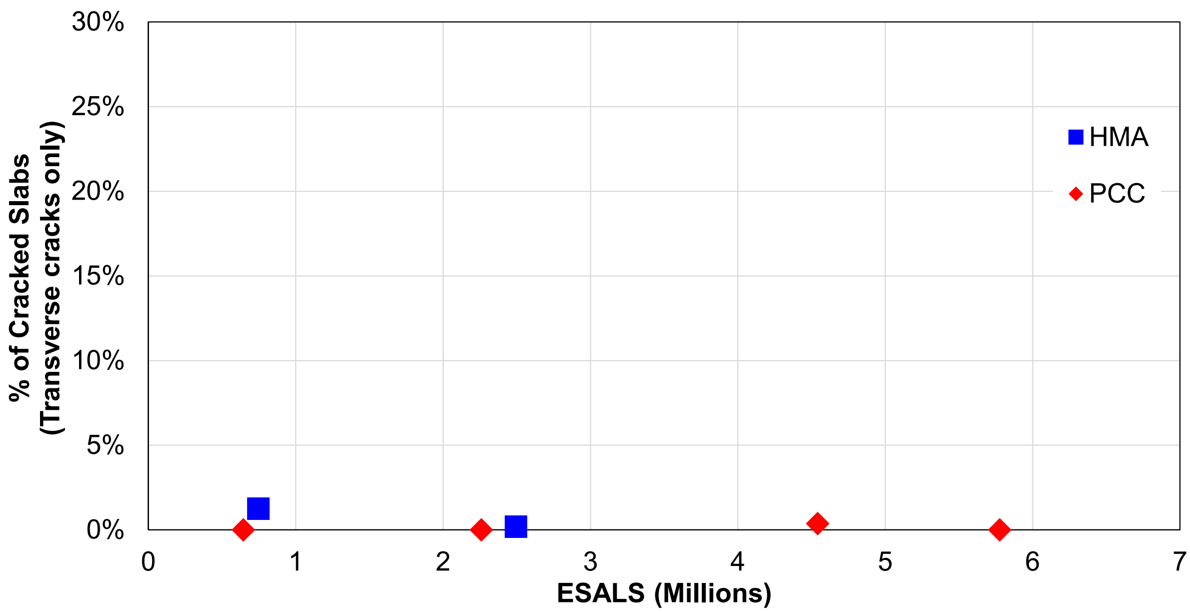



**Figure 3-48. Shoulder type versus transverse cracked slabs for BOL projects.**

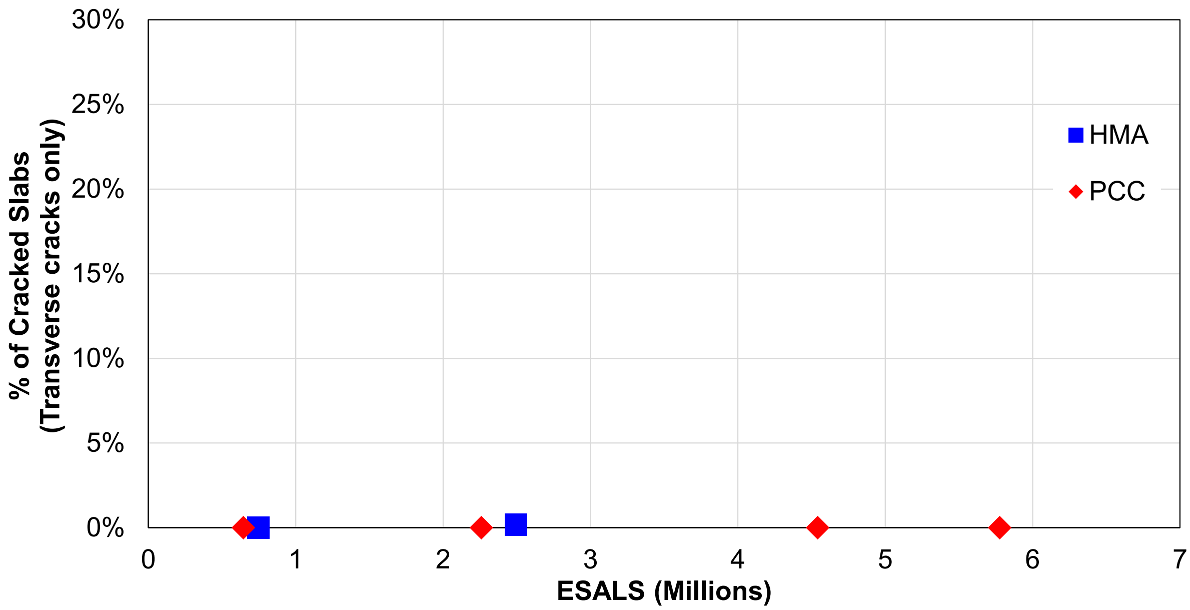



**Figure 3-49. Left panel—shoulder type versus transverse cracked slabs for BOL projects.**

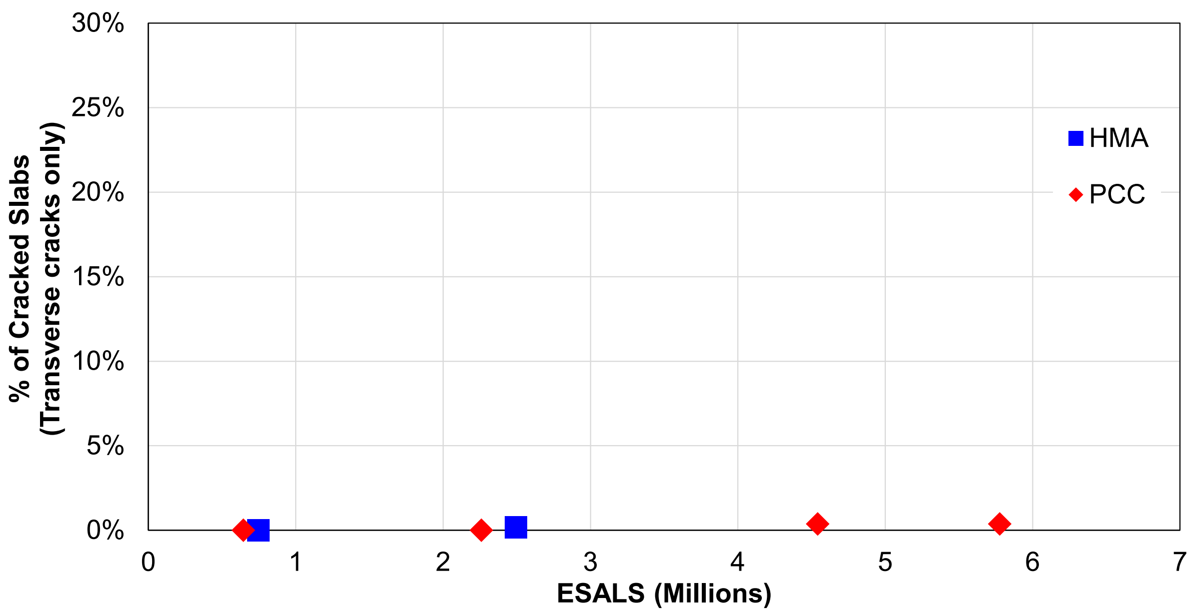



**Figure 3-50. Center panel—shoulder type versus transverse cracked slabs for BOL projects.**

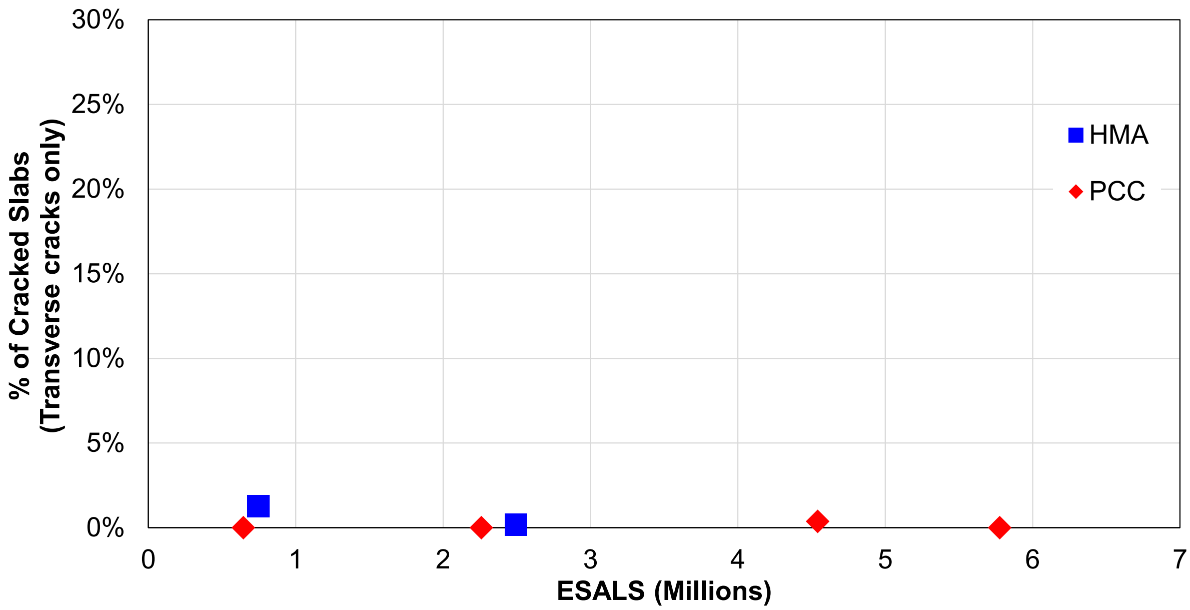



**Figure 3-51. Right panel—shoulder type versus transverse cracked slabs for BOL projects.**

## 3.5 Series IRI Data

### *3.5.1 Time Series IRI Data*

Figure 3-52 through 3-55 provide examples of the time-series IRI data collected by MoDOT for selected UBOL, BBOL, and BOL projects. As discussed in Chapter 2, the UBOL projects that were constructed with low IRI values have generally maintained those values over time, whereas the BBOL and BOL projects have developed more roughness over their service life. Figure 3-54 provides an example illustration of the anomalies occasionally encountered in some of the data, with a high initial value (possibly the result of being measured pre-overlay) and a spike occurring several years after construction. The complete set of time-series IRI graphs is contained in Appendix F.

### *3.5.2 IRI Data Along Projects*

Figures 3-56 and 3-57 present example plots of spatial IRI for selected projects and for individual years. Localized areas of roughness are visible in these graphs, but no trend was apparent from a review of these graphs. Individual wheelpath IRI values were also reviewed, with the expectation that the right wheelpath would produce higher IRI values. Although that was observed on many of the projects, it was not a consistent finding.

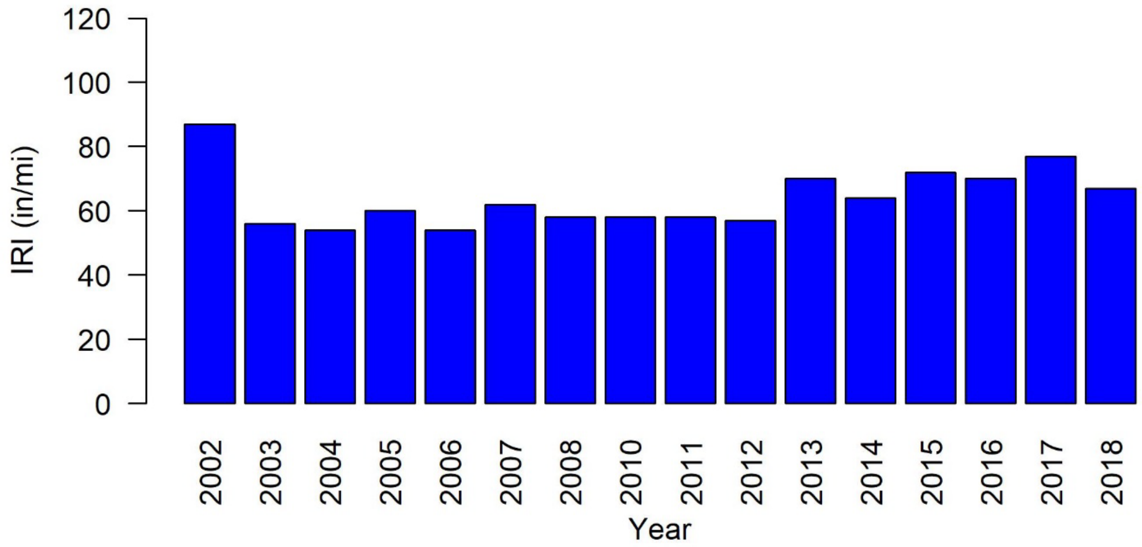



**Figure 3-52. IRI time-series data for project 2S, I-55 UBOL in Pemiscot County.**

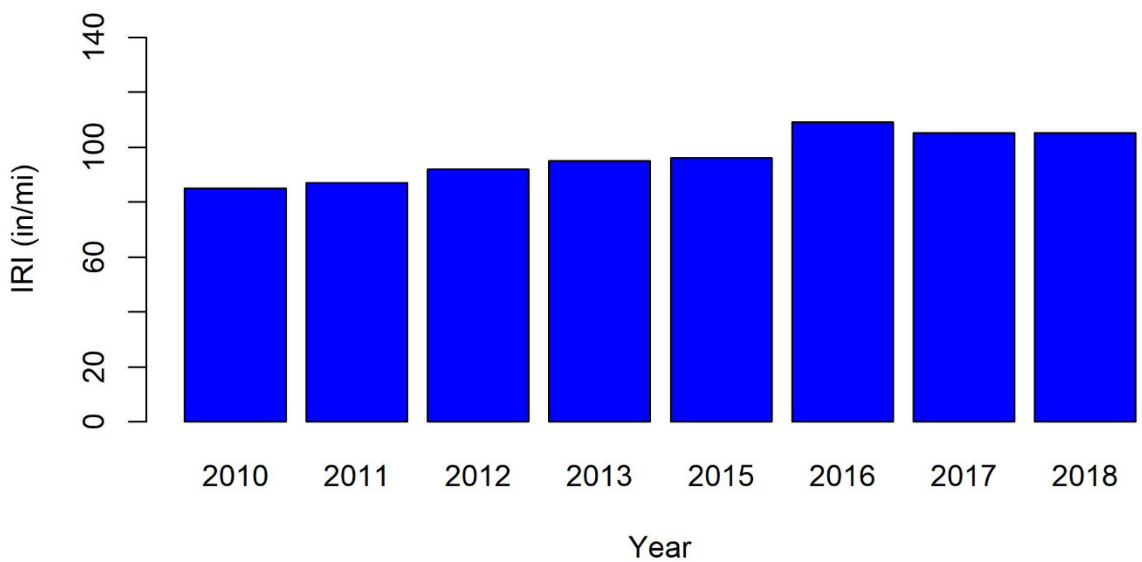



**Figure 3-53. IRI time-series data for project 28S, US 61 BBOL in Jefferson/Ste. Genevieve County.**

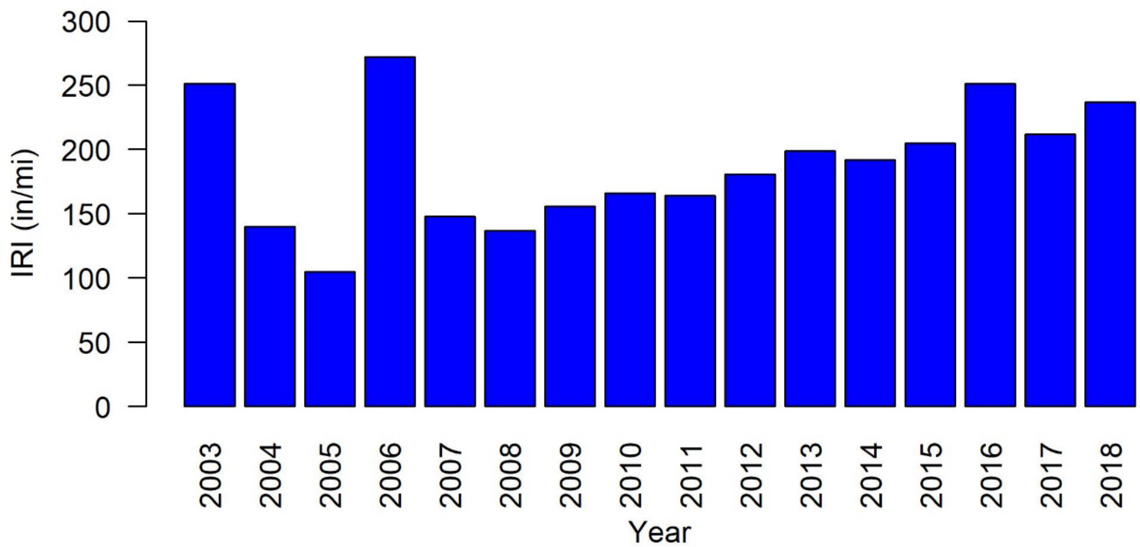



**Figure 3-54. IRI time-series data for project 38N, MO 291 BOL in Jackson County.**

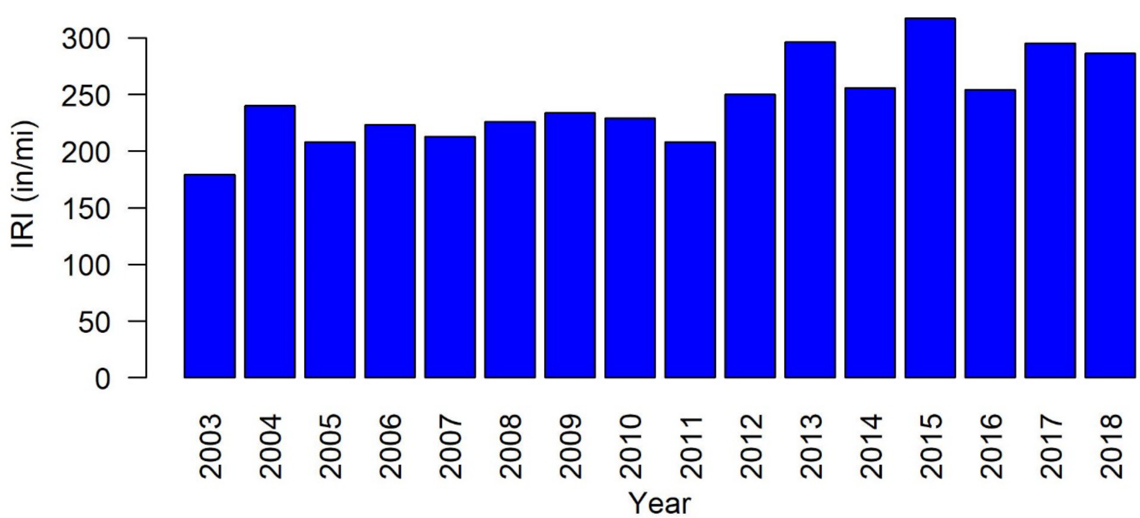



**Figure 3-55. IRI time-series data for project 38S, MO 291 BOL in Jackson County.**

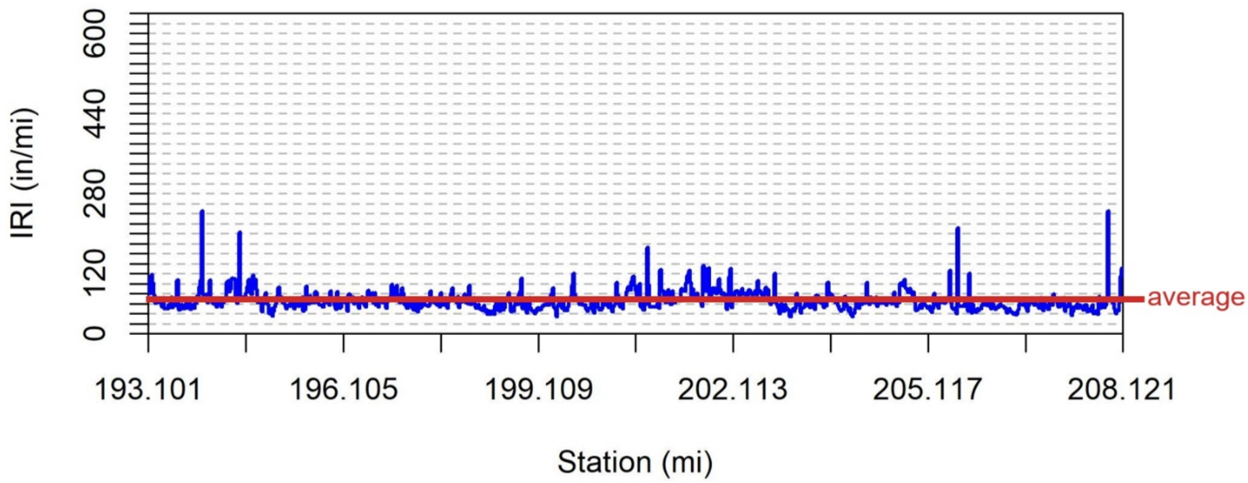



**Figure 3-56. 2018 IRI along project for project 2S, I-55 UBOL in Pemiscot County (the horizontal line is the average IRI for the project and the stepped line is the average IRI for 0.1-mi segments).**

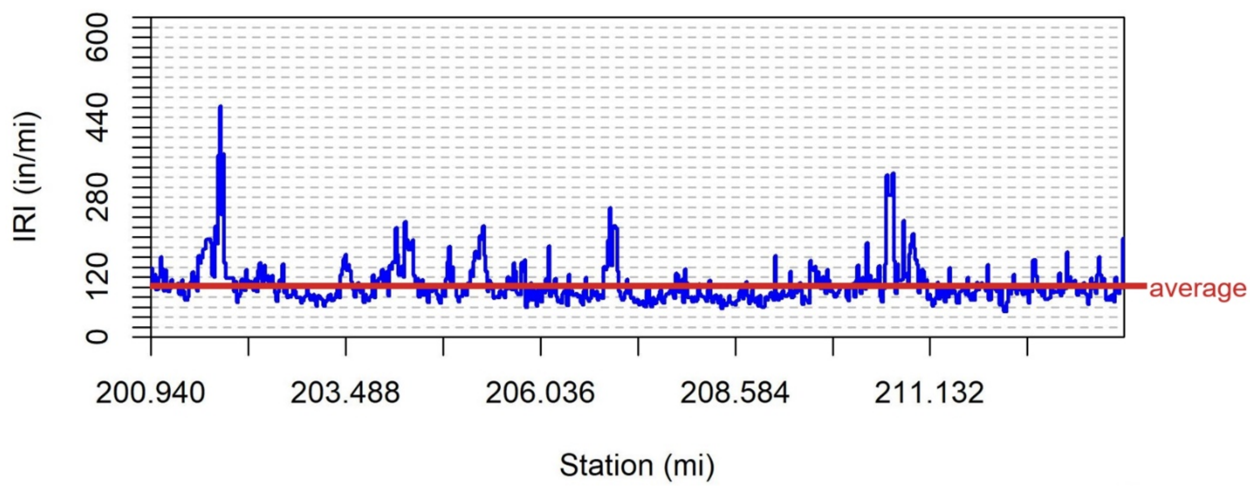



**Figure 3-57. 2018 IRI along project for project 28S, US 61 BBOL in Jefferson/Ste. Genevieve County (the horizontal line is the average IRI for the project and the stepped line is the average IRI for 0.1-mi segments).**

### 3.6 Current Repair Needs

One of the objectives for the study was to estimate the current rehabilitation and maintenance needs for each project. This section provides a summary of global needs for patching and rehabilitation of the concrete overlay projects. The summary is not a design level approach, but rather a planning level, scoping approach to the rehabilitation and maintenance needs of the concrete overlay projects. There are several limitations to the estimate, including the fact that it is based largely on visible distress data (from a limited video survey) without benefit of any supplementary testing data (e.g., deflection, coring), and the distress data are available only for one lane of the pavement (as described in section 2.6 ARAN Video Distress Data).

### *3.6.1 Patching*

Table 3-4 provides a summary of the estimated patching for the UBOL projects. The type of patching applied is based on the following criteria:

- Full-depth repair (FDR).
  - High-severity patching.
  - High-severity transverse cracks.
  - High-severity corner breaks.
  - Shattered slabs.
- Partial-depth repair (PDR).
  - High-severity spalling.

To estimate FDR quantities, the following assumptions were used:

- Shattered slabs require a full slab replacement.
- High-severity patched slabs require a full slab replacement.
- High-severity transverse cracks require a full-depth patch 6 ft long for the full width of the slab.
- High-severity corner breaks require a 3-ft x 3-ft full-depth patch.

To estimate PDR quantities, it is assumed that high severity spalls require a 3-ft x 3-ft partial-depth patch.

Project 20N has the highest level of estimated patching needs at slightly under 6%. All the other UBOL projects were well under 1% patching except for project 9E at 1.778%.

Table 3-5 and 3-6 provide similar patching estimates for the BBOL and BOL projects. No partial-depth patching is provided for BBOL and BOL projects due to the thickness of the overlays. Also, all patching is assumed to be full panels due to the panel size of these overlays. All the projects had estimated patching quantities less than 1%.

### *3.6.2 Rehabilitation*

As discussed previously, patching can be used to resolve many of the surficial distresses that develop in concrete overlays. For projects with more extensive distresses or ride quality issues, more significant rehabilitation—in the form of overlays or diamond grinding—may be a more cost-effective treatment.

**Table 3-4. UBOL estimated current patching needs.**

| U.ID. | Total PDR Area, $ft^2$ | Total PDR, % of Total Area | Total FDR Area, $ft^2$ | Total FDR, % of Total Area |
|---|---|---|---|---|
| 1W | 108 | 0.04% | 0 | 0.00% |
| 2S | 9 | 0.00% | 378 | 0.04% |
| 3E | 0 | 0.00% | 0 | 0.00% |
| 4E | 0 | 0.00% | 0 | 0.00% |
| 5N | 0 | 0.00% | 180 | 0.08% |
| 5S | 18 | 0.01% | 792 | 0.35% |
| 6N | 0 | 0.00% | 0 | 0.00% |
| 6S | 0 | 0.00% | 0 | 0.00% |
| 7E | NA | NA | NA | NA |
| 7W | NA | NA | NA | NA |
| 8E | 0 | 0.00% | 0 | 0.00% |
| 8W | 0 | 0.00% | 0 | 0.00% |
| 9E | 27 | 0.00% | 10251 | 1.78% |
| 10E | 0 | 0.00% | 84 | 0.01% |
| 11E | 126 | 0.03% | 993 | 0.21% |
| 12E | 81 | 0.03% | 1350 | 0.48% |
| 13W | 9 | 0.00% | 248.4 | 0.11% |
| 14S | 144 | 0.02% | 1026 | 0.12% |
| 15E | 0 | 0.00% | 0 | 0.00% |
| 15W | 0 | 0.00% | 0 | 0.00% |
| 16N | 9 | 0.00% | 0 | 0.00% |
| 17W | 99 | 0.02% | 3681 | 0.67% |
| 18N | 0 | 0.00% | 0 | 0.00% |
| 19N | 36 | 0.00% | 2028 | 0.20% |
| 20N | 27 | 0.01% | 26136 | 5.87% |
| 20S | 0 | 0.00% | 2700 | 0.60% |
| 21N | 9 | 0.00% | 9 | 0.00% |
| 21S | 0 | 0.00% | 9 | 0.00% |
| 22E | 9 | 0.00% | 0 | 0.00% |
| 22W | 0 | 0.00% | 0 | 0.00% |
| 23W | 18 | 0.00% | 0 | 0.00% |
| 24N | 0 | 0.00% | 0 | 0.00% |
| 25N | 0 | 0.00% | 0 | 0.00% |
| 25S | 0 | 0.00% | 0 | 0.00% |
| 26N | NA | NA | NA | NA |
| 26S | NA | NA | NA | NA |

**Table 3-5. BBOL estimated current patching needs.**

| U.ID. | Total FDR Area, ft$^2$ | Total FDR, % of Total Area |
|---|---|---|
| 27S | 72 | 0.04% |
| 27N | NA | NA |
| 28S | 1,584 | 0.19% |
| 28N | NA | NA |
| 29E | 2,592 | 0.57% |
| 30N | 180 | 0.04% |
| 30S | NA | NA |
| 31S | NA | NA |
| 32W | 0 | 0.00% |
| 33E | 0 | 0.00% |
| 33W | 36 | 0.16% |
| 33S | 0 | 0.00% |
| 33N | NA | NA |
| 34E | NA | NA |
| 34W | 36 | 0.63% |
| 34S | NA | NA |
| 34N | 36 | 0.71% |
| 35N | 720 | 0.14% |
| 35S | 936 | 0.16% |

**Table 3-6. BOL estimated current patching needs.**

| U.ID. | Total FDR Area, ft$^2$ | Total FDR, % of Total Area |
|---|---|---|
| 36S | NA | NA |
| 36N | 16 | 0.35% |
| 37S | 16 | 0.42% |
| 37N | NA | NA |
| 38N | 0 | 0.00% |
| 38S | 16 | 0.13% |
| 39W | 256 | 1.00% |
| 39E | NA | NA |
| 40W | NA | NA |
| 41W | 0 | 0.00% |
| 41E | NA | NA |

#### *3.6.2.1 Overlays*

There are no hard and fast rules for when a structural overlay is justified versus patching for concrete overlays. All but two of the concrete overlay projects have FDR patching percentages estimated at less than 1 percent of the lane where the distress was measured. For the two projects that do exceed the 1 percent FDR, it is recommended that before extensive patching is conducted on those projects, MoDOT conduct an economic and performance analysis of the pavement structures to determine if a structural overlay may be a more appropriate treatment. Those two projects are 9E (located on Interstate 44 eastbound in Crawford County between log mile 252.490 and 257.218) and 20N (located on Interstate 35 in Clinton County between log mile 41.320 and 49.152).

#### *3.6.2.2 Grinding*

Grinding of concrete pavements or overlays are usually reserved for those projects that have developed an uncomfortable ride for the traveling public. Criteria for considering diamond grinding as a preservation treatment is commonly based on some general guidelines such as (Smith et al. 2014):

- Average transverse joint faulting more than 0.08 in.
- Roughness as measured by IRI more than 160–220 in/mi.
- Wheelpath wear greater than 0.25–0.40 in.
- Surface friction values below agency standards for the roadway facility and location.
- As required in noise sensitive areas.

No project in this study exceeded the average faulting threshold listed above, while four BBOL projects and six BOL projects exceeded the IRI threshold of 160 in/mi. While the BOL projects resulted in the highest recorded IRI values, many of these are shorter, intersection projects making both construction and accurately measuring IRI difficult. Grinding on these projects may have limited benefits to the public. Furthermore, grinding of the four BBOL projects may not be advisable given the relative thinness of the slabs.

# CHAPTER 4. IMPLEMENTATION RECOMMENDATIONS AND FUTURE RESEARCH

## 4.1 Introduction

The goal of this study was to review and evaluate the performance of bonded and unbonded overlays constructed in Missouri as a first step in documenting their performance and working to improve MoDOT's overall concrete overlay selection, design, and construction procedures. Based on some of the observations of performance described in Chapter 3, the following sections present general recommendations for consideration by MoDOT in advancing concrete overlay technologies.

## 4.2 Improve Concrete Overlay Performance in Missouri

### *4.2.1 MoDOT Should Revise UBOL and BBOL Design Thickness Procedures to be Site Specific.*

MoDOT historically has designed UBOL and BBOL pavements by policy. UBOL pavements had an 8-in slab thickness in the past, but more recent UBOL projects were constructed 9 in thick for higher volume overlays (Donahue 2017; Trautman 2017). For BBOL pavements, policy design thickness varied from 5 to 6 in. It is recommended that MoDOT use their mechanistic pavement design methodology to conduct site specific designs, considering traffic, climate, underlying pavement condition and support, and local materials in the thickness design for UBOL and BBOL pavements.

### *4.2.2 MoDOT Should Revise UBOL and BBOL Thickness Construction Quality Control Practices to Better Control Minimum Thickness.*

Since concrete overlays are thinner than conventional new concrete pavement construction, they are more sensitive to deviations in the as-constructed thickness. MoDOT's PWL specification for thickness is based on the design thickness minus 0.5 in and the minimum thickness specification is the design thickness less 10%. It is recommended that MoDOT revise their specifications and practices that control as-constructed concrete overlay thickness considering the following:

- Figure 3-14 demonstrated that an as-constructed thickness minus one standard deviation greater than 8.6 in produced lower cracking and patching for UBOL pavements.
- For BBOL projects (see figure 3-34) there is not a clear recommendation, but the as-constructed thickness minus one standard deviation greater than 5.5 in did appear to produce better performance.

In general, nominal increases in slab thickness are known to not only increase the load-carrying capabilities, but also can help reduce some of the degree of risk associated with marginal or sensitive designs.

#### *4.2.3 MoDOT Should Continue the Use of Geotextiles Interlayers as They Appear to Provide Better Performance for UBOL Projects.*

Figure 3-9 through 3-11 indicate that UBOL projects with a geotextile interlayer provide better performance than HMA interlayers. This recommendation concurs with MoDOT's current practice of using geotextile (Donahue 2017; Trautman 2017).

### 4.3 Recommendations for Additional Research

#### *4.3.1 Forensic Investigations.*

The work done under this project was a first step in collecting and compiling the design, construction, and performance data for MoDOT's concrete overlay projects, but the information was limited to what could be obtained from records and video surveys. Thus, initiating a research project including forensic investigations into the various types of overlays would be helpful to help better document:

- Condition of underlying pavement and base at time of overlay.
- Material properties of underlying pavement and base.
- Thickness of underlying pavement and base, especially for BOL projects.
- Material properties of the interlayer and overlay.

As described above, this current study had a limited scope and budget and was constrained by data availability that could be overcome with record searches and pavement coring and testing. An example of where forensics would have been beneficial was the underlying pavement and base support for UBOL projects. UBOL projects constructed over reinforced concrete pavement displayed the best performance, which is somewhat counterintuitive. The expectation is that the average reinforced concrete would be in a poorer condition than a nonreinforced concrete pavement, but the pre-overlay condition was not available.

A smaller forensics project could be limited to an investigation of the good and poor performing overlays to see what useful information could be extracted. There were several poor performing projects that available data provided no apparent reason for the performance.

#### *4.3.2 Evaluate Additional Engineering for BOL Projects to Ensure Underlying Pavement and Base Support and Profile.*

Many of the BOL projects had much higher IRI values than the UBOL or BBOL projects. In most cases this is due both to the difficulties constructing intersections and measuring IRI in and around intersections. MoDOT staff indicated that there were instances where the BOL may not have adequate underlying pavement and base support due to milling the underlying HMA to meet profile. Work done by Mateos et al. (2019) recommends to only use BCOA when there is a minimum of 3 in of underlying HMA, a recommendation that matches MoDOT's current specification in Section 506.10.1 (MoDOT 2019b). Mateos et al. (2019) further recommends that thin BCOA (4 in) only be used where the underlying HMA pavement thickness exceeded 3 in and is structurally sound.

MoDOT may consider additional engineering investment and using tools such as LIDAR and ground penetrating radar to provide better support and profiles for BOL projects and reduce the risk of premature failure.

#### *4.3.3 Additional Research on the Failure Mode for BOL Projects.*

The research could determine the cause of cracking and patching that was predominantly located in the right panel for the projects reviewed. Also, could additional or different fibers be used to mitigate the cracking potential of this type of overlay.

#### *4.3.4 Additional Research to Optimize the Design and Selection of Geotextiles for Interlayers.*

The research could review geotextile selection and application to improve the performance of concrete overlays.

# CHAPTER 5. SUMMARY AND CONCLUSIONS

The goal of this study was to review and evaluate the performance of bonded and unbonded overlays constructed in Missouri as a first step in documenting their performance and working to improve MoDOT's overall concrete overlay selection, design, and construction procedures. To accomplish this goal the following objectives were established:

- Inventory the routes and locations of the concrete overlays as detailed in the plans or from virtual site visits via review of ARAN videos and data. The completed inventory should include the travelway ID, direction, route, county, log limits of overlay section, lane number, type of interlayer (if applicable), and other identifying information. MoDOT furnished all of the relevant inventory data.
- Document the thickness of each concrete overlay project, along with the air content and compressive strength, by pulling information from AASHTOWare Project SiteManager QC/QA data or other Construction and Materials records, as available.
- Tabulate the performance histories of the concrete overlays using data from the MoDOT Transportation Management System (TMS) database.
- Review the latest year of video from ARAN and document visible cracking along with patching and maintenance performed on the pavement.
- Estimate the current rehabilitation and maintenance requirements for each project.
- Identify any correlations between the condition/distress of the pavement and key project construction/materials data, including the type of interlayer (where applicable).
- Identify whether coring and construction data correspond with information shown on the construction plans.

Overall, most of the overlays included in this research project are performing well, especially when considering the excellent ride quality of the UBOL projects. The BBOL and BOL projects exhibited increased IRI values and cracking and patching compared to UBOL projects.

Although the presence of several confounding variables (e.g., slab thickness, interlayer type, slab width, shoulder type, and traffic loadings) often hindered performance comparisons, some of the key observations from a review of the performance data are listed below and summarized in table 5-1:

- The 2018 reported IRI data shows the UBOL projects providing a very smooth ride with a mean IRI of 64 in/mi. BBOL and BOL projects tend to exhibit much higher mean IRI values (131 in/mi and 263 in/mi, respectively) than the UBOL projects. This is certainly to be expected with the BOL projects as these are shorter and are often located at intersections, meaning that the construction of the pavement was likely done using forms and with significant hand work and the ensuing IRI measurements more sensitive to a few deviations (such as might be encountered with complex longitudinal profiles).
- Cracked and patched slabs were found to be a more reliable indicator of performance than IRI for the overlay projects and is used as the performance indicator in the following bullets.

**Table 5-1. MoDOT concrete overlay summary.**

| Overlay Type | Performance Observations | Construction QA/QC Data | Effect of Design Features |
|---|---|---|---|
| UBOL (0.9 to 26.6 million ESALs) | • Observed distresses: transverse and longitudinal cracking<br>− Percent cracked and patched slabs range = 0 to 32%<br>− Predominant distress: longitudinal cracking, occurring predominantly in the middle or right wheelpath (very little transverse cracking)<br>• IRI values low and stable over time.<br>− 2018 mean IRI = 64 in/mi<br>− 2018 range = 36 to 114 in/mi<br>• Negligible faulting | • For slab thickness, PWL values below 90% generally show higher levels of distress<br>• For concrete strength, PWL values did not show a clear relationship to performance. Strength values were generally above 90%, indicating that adequate strength is not an issue for concrete overlay projects.<br>• For concrete air content, PWL values did not show a clear relationship to performance. | • Slab thickness:<br>− UBOL projects with design thickness of 8 in exhibit higher and more variable cracking.<br>− An as-constructed thickness minus one standard deviation value greater than 8.6 in results in less cracking.<br>• Slab Width/Shoulder:<br>− UBOL projects with 14-ft wide slabs and HMA shoulders exhibited higher levels of longitudinal cracking<br>− UBOL projects with PCC shoulders exhibited less longitudinal cracking than those with HMA shoulders<br>• Interlayer/Underlying Pavement:<br>− UBOL projects with geotextile interlayers exhibit less cracking than those using an existing or new HMA interlayer. |
| BBOL (0.2 to 2.8 million ESALs) | • Observed distresses: transverse, longitudinal cracking, corner breaks, and shattered slabs.<br>− Percent cracked and patched slabs range = 0 to 6% (not including project 35N and 35S, modified UBOL)<br>− Predominant distress: longitudinal cracking, most commonly occurring in the right panel of the slab.<br>• IRI values relatively high.<br>− 2018 mean IRI = 131 in/mi<br>− 2018 IRI range = 43 to 284 in/mi<br>• Negligible faulting | • For slab thickness, PWL values below 90% generally show higher levels of distress<br>• For concrete strength, PWL values did not show a clear relationship to performance. Strength values were generally above 90%, indicating that adequate strength is not an issue for concrete overlay projects.<br>• For concrete air content, PWL values did not show a clear relationship to performance. | • Slab thickness:<br>− BBOL projects with 6-in design slab thickness exhibited less cracking than the 5 and 5.5-in thick designs.<br>− A minimum as-constructed thickness of 5.5 in resulted in less cracking.<br>• Slab Geometry:<br>− No conclusions on slab geometry (all designs included 6-ft by 6-ft panels).<br>• Shoulder Type:<br>− No definitive conclusions on effect of shoulder type.<br>• Underlying Pavement.<br>− No definitive conclusions on effect of underlying pavement type. |
| BOL (0.4 to 5.8 million ESALs) | • Observed distresses: transverse, longitudinal, and corner cracking<br>− Percent cracked and patched slabs range = 0 to 25%<br>− Predominant distress: longitudinal and corner cracking, occurring predominantly in the right panel<br>− Significant cracking on 3 of 6 projects despite lower traffic<br>• IRI values high and variable.<br>− 2018 mean IRI = 263 in/mi<br>− 2018 IRI range = 118 to 443 in/mi<br>• Negligible faulting | • QA/QC results were not available for the BOL projects. | • Slab Thickness:<br>− No conclusions on slab thickness (all designs were 4 in thick).<br>• Slab Geometry:<br>− No conclusions on slab geometry (all designs included 4-ft by 4-ft panels).<br>• Shoulder Type:<br>− No definitive conclusions (only 6 projects. |

- Figures 3-1 and 3-2 does show an apparent relationship between as-constructed thickness PWL and the performance of UBOL and BBOL projects. PWL values below 90% generally show a higher level of cracked and patched slabs, suggesting that achieving the design thickness of a concrete overlay is one important factor influencing performance.
- The PWL for strength and air content did not show a clear relationship to concrete overlay performance. Strength PWL values were generally above 90%, indicating that achieving adequate concrete strength is not an issue for concrete overlay projects.
- UBOL projects with geotextile interlayers exhibit less cracking than those using an existing or new HMA interlayer.
- Figure 3-12 shows much higher and variable cracking values for the UBOL slabs with a design thickness of 8 in. Figure 3-14 indicates that as-constructed thickness minus one standard deviation values greater than 8.6 in results in less cracked and patched slabs for UBOL projects.
- UBOL projects with 14 ft wide slabs and HMA shoulders exhibit higher levels of longitudinal cracking than other designs. The widened slabs with PCC shoulders did not display as much cracking as the HMA shouldered projects.
- The most predominant type of cracking on UBOL overlays was longitudinal, and likely the result of a lack of support in the outer portion of the driving lane. Most of the longitudinal cracking in UBOL projects occurred in the middle or right wheelpath zone of the slab.
- UBOL projects constructed with PCC shoulders displayed less longitudinal cracking than those with HMA shoulders.
- The most common distresses for BBOL projects were longitudinal cracking and shattered slabs.
- BBOL projects with a 6 in design slab thickness exhibited less cracking than the 5 and 5.5 in thick designs. A 5.5 in minimum as-constructed thickness resulted in less cracking.
- Predominant distresses for BOL projects were longitudinal and corner cracking. Essentially all the longitudinal, transverse, and corner cracking is contained in the right panel of the BOL projects.

Based on the observed performance trends, the following items are recommended to improve concrete overlay performance in Missouri. UBOL projects provided more complete information, and there was more diversity in some of the design parameters that allowed for more recommendations. BOL projects had the most limited data.

- MoDOT should revise UBOL and BBOL design thickness procedures to be site specific, building on their mechanistic design procedure for pavements.
- MoDOT should revise UBOL and BBOL thickness construction quality control practices to better control minimum thickness due to the sensitivity of concrete overlays to as-constructed thickness.
- MoDOT should continue the use of geotextiles interlayers as they appear to provide better performance for UBOL projects.

The following research to improve concrete overlay performance is recommended:

- Forensics—MoDOT should consider additional field and records forensics to:
  - Determine the condition of the underlying pavement at the time of overlay.
  - Investigate good and poor performing concrete overlays to determine key design or construction parameters.
- Additional engineering for BOL projects to improve ride and underlying pavement and base support.
- Additional research on the failure mode for BOL projects. The research could determine the cause of cracking and patching that was predominantly located in the right panel for the projects reviewed. Also, could additional or different fibers be used to mitigate the cracking potential of this type of overlay.
- Additional research to optimize the design and selection of geotextiles for interlayers. The research could review geotextile selection and application to improve the performance of concrete overlays.

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# APPENDIX A—MODOT CONCRETE OVERLAY INVENTORY

| No. | Trawy ID | DIR | Desg | Route | County | Begin Log | End Log | Job Number | Comp. Date | Contract ID | Type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10 | WB | IS | 44 | Webster/Greene | 194.696 | 200.67 | J8I0633 | 2000 | F.A.I.-44-2(181) | UBOL |
| 2 | 13 | SB | IS | 55 | Pemiscot | 193.053 | 208.152 | J0I0833 | 2002 | 011214-X02 | UBOL |
| 3 | 1100 | EB | US | 412 | Pemiscot | 29.545 | 37.433 | J0P0600D | 2003 | 011214-X04 | UBOL |
| 4 | 1100 | EB | US | 412 | Pemiscot | 27.849 | 29.56 | J0P0600/600E | 2003 | ? | UBOL |
| 5 | 6512 | NB | IS | 255 | St. Louis | 0 | 3.75 | J6I1486 | 2003 | 030221-601 | UBOL |
| 5 | 6513 | SB | IS | 255 | St. Louis | 0 | 3.75 | J6I1486 | 2003 | 030221-601 | UBOL |
| 6 | 6040 | NB | MO | 291 | Jackson | 15.343 | 16.927 | J4P1421 | 2004 | 030221-405 | UBOL |
| 6 | 6041 | SB | MO | 291 | Jackson | 32.498 | 34.075 | J4P1421 | 2004 | 030221-405 | UBOL |
| 7 | 9 | EB | IS | 44 | Lawrence | 33.032 | 37.736 | J7I0721 | 2005 | 040917-701 | UBOL |
| 7 | 10 | WB | IS | 44 | Lawrence | 252.49 | 257.218 | J7I0721 | 2005 | 040917-701 | UBOL |
| 7R | 9 | EB | IS | 44 | Lawrence | 33.032 | 37.736 | | 2018 | Replaced Drive Lanes of Previous Overlay | UBOL |
| 7R | 10 | WB | IS | 44 | Lawrence | 252.49 | 257.218 | | 2018 | Replaced Drive Lanes of Previous Overlay | UBOL |
| 8 | 9 | EB | IS | 44 | Crawford | 204.608 | 213.567 | J9I0509 | 2005 | 040917-901 | UBOL |
| 9 | 3560 | EB | US | 36 | Macon | 108.959 | 120.11 | J2P0726 | 2005 | 040618-201 | UBOL |
| 10 | 9 | EB | IS | 44 | Laclede | 134 | 145.282 | J8I0747, J8I0748 | 2006 | 051118-803 | UBOL |
| 11 | 1101 | WB | US | 412 | Dunklin | 22.8 | 27 | J0P0570 | 2006 | 051118-X02 | UBOL |
| 12 | 263 | SB | IS | 57 | Mississippi | 0.276 | 12.747 | J0I0973 | 2007 | 070330-X01 | UBOL |
| 13 | 6372 | EB | IS | 64 | St. Louis/St. Louis City | 27.45 | 36.58 | J6I0978 | 2007 | Design Build | UBOL |
| 13 | 6373 | WB | IS | 64 | St. Louis/St. Louis City | 4.21 | 13.35 | J6I0978 | 2007 | Design Build | UBOL |
| 14 | 264 | NB | IS | 57 | Mississippi | 13.032 | 21.925 | J0I0983 | 2009 | 090123-X01 | UBOL |
| 15 | 10 | WB | IS | 44 | Phelps | 105.653 | 113.884 | J9I2166 | 2009 | 090424-901 | UBOL |
| 16 | 12 | NB | IS | 55 | Cape/Perry | 105 | 108 | J0I2200 | 2010 | 091218-X01 | UBOL |
| 17 | 12 | NB | IS | 55 | Pemiscot | 0 | 15.068 | J0I2171 | 2010 | 090424-X02 | UBOL |
| 18 | 4984 | NB | IS | 35 | Clinton | 41.32 | 49.152 | J1I1040 | 2010 | 090120-101 | UBOL |
| 18 | 4986 | SB | IS | 35 | Clinton | 65.282 | 73.115 | J1I1040 | 2010 | 090120-101 | UBOL |
| 19 | 4984 | NB | IS | 35 | Clay | 24.843 | 33.053 | J4I1382 | 2010 | 091218-408 | UBOL |
| 19 | 4986 | SB | IS | 35 | Clay | 81.391 | 89.6 | J4I1382 | 2010 | 091218-408 | UBOL |
| 20 | 9 | EB | IS | 44 | Franklin | 251.484 | 256.562 | J6I2011 | 2010 | 090626-604 | UBOL |

| No. | Trawy ID | DIR | Desg | Route | County | Begin Log | End Log | Job Number | Comp. Date | Contract ID | Type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 10 | WB | IS | 44 | Franklin | 33.632 | 38.717 | J6I2011 | 2010 | 090626-604 | UBOL |
| 21 | 10 | WB | IS | 44 | Pulaski | 127.879 | 136.082 | J9I2149 | 2011 | 101022-805 | UBOL |
| 22 | 12 | NB | IS | 55 | Pemiscot | 15.08 | 18.68 | J9P2244B | 2015 | 150123-H02 | UBOL |
| 23 | 6039 | NB | IS | 435 | Jackson | 0.045 | 3.345 | J4I2337 | 2019 | 171201-C01 | UBOL |
| 23 | 6042 | SB | IS | 435 | Jackson | 51.789 | 55.102 | J4I2337 | 2019 | 171201-C01 | UBOL |
| 24 | 4984 | NB | IS | I-35 | Davies | 68.886 | 78.477 | J1I0895 | 2006 | 051118-104 | UBOL |
| 24 | 4986 | SB | IS | I-35 | Davies | 35.973 | 45.521 | J1I0895 | 2006 | 051118-104 | UBOL |
| 24R | 4984 | NB | IS | I-35 | Davies | 68.886 | 78.477 | J1I2221 | 2013 | 130125-A01<br>Rehab. of Previous Project | UBOL |
| 24R | 4986 | SB | IS | I-35 | Davies | 35.973 | 45.521 | J1I2221 | 2013 | 130125-A01<br>Rehab. of Previous Project | UBOL |
| 1 | 6102 | SB | RT | D | Cass | 0.051 | 3.131 | J4S2246 | 2008 | 080523-412 | BBOL |
| 1 | 6103 | NB | RT | D | Cass | 23.095 | 26.175 | J4S2246 | 2008 | 080523-412 | BBOL |
| 2 | 11 | SB | US | 61 | Jefferson/St. Gen | 200.738 | 213.576 | J6S1961 | 2009 | 081024-601 | BBOL |
| 2 | 7773 | NB | US | 61 | Jefferson/St. Gen | 179.479 | 182.444 | J6S1961 | 2009 | 081024-601 | BBOL |
| 3 | 3560 | EB | US | 36 | Shelby/Marion | 162.176 | 169.428 | J3P0792B | 2010 | 100514-302 | BBOL |
| 4 | 6365 | NB | MO | 79 | Marion/Ralls | 78.5 | 86.232 | J3P2193 | 2013 | 130222-B01 | BBOL |
| 4 | 6366 | SB | MO | 79 | Marion/Ralls | 1.721 | 9.453 | J3P2193 | 2013 | 130222-B01 | BBOL |
| 5 | 1975 | SB | MO | 5 | Laclede | 249.98 | 250 | J5P2237B | 2014 | 131122-D09 | BBOL |
| 6 | 6142 | WB | MO | 340 | St. Louis | 9.96 | 10.03 | J5P2237B | 2014 | 131122-D09 | BBOL |
| 7 | 1100 | EB | US | 412 | Dunklin | 26.88 | 27.26 | J9S3010 | 2016 | 150515-H07 | BBOL |
| 7 | 1101 | WB | US | 412 | Dunklin | 23.53 | 23.88 | J9S3010 | 2016 | 150515-H07 | BBOL |
| 8 | 11 | SB | US | 61 | Scott | 318.33 | 318.51 | J9S3010 | 2016 | 150515-H07 | BBOL |
| 8 | 7773 | NB | US | 61 | Scott | 74.56 | 74.72 | J9S3010 | 2016 | 150515-H07 | BBOL |
| 9 | 3534 | EB | US | 24 | Randolph | 135.4 | 135.51 | J2P0779C | 2010 | 100122-202 | BBOL |
| 9 | 3533 | WB | US | 24 | Randolph | 80.26 | 80.36 | J2P0779C | 2010 | 100122-202 | BBOL |
| 9 | 3534 | SB | BUS | 63 | Randolph | 1.03 | 1.11 | J2P0779C | 2010 | 100122-202 | BBOL |
| 9 | 3533 | NB | BUS | 63 | Randolph | 8.47 | 8.55 | J2P0779C | 2010 | 100122-202 | BBOL |
| 41 | 4984 | NB | | I-35 | Davies | | | J1I0895 | 2006 | 051118-104 (See UBOL list) | BBOL |
| 41 | 4986 | SB | | I-35 | Davies | | | J1I0895 | 2006 | 051118-104 (See UBOL list) | BBOL |
| 1 | 1975 | SB | MO | 5 | Laclede | 250.52 | 250.59 | | 2003 | | BOL |

| No. | Trawy ID | DIR | Desg | Route | County | Begin Log | End Log | Job Number | Comp. Date | Contract ID | Type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1976 | NB | MO | 5 | Laclede | 102.16 | 102.22 | | 2003 | | BOL |
| 2 | 54 | SB | MO | 19 | Ralls | 8.411 | 8.48 | J3P2152 | 2012 | 120120-B02 | BOL |
| 2 | 55 | NB | MO | 19 | Ralls | 254.32 | 254.4 | J3P2152 | 2012 | 120120-B02 | BOL |
| 3 | 6041 | NB | MO | 291 | Jackson | 30.05 | 30.23 | J4P1513 | 2003 | 030321-? | BOL |
| 3 | 6040 | SB | MO | 291 | Jackson | 19.1 | 19.31 | J4P1513 | 2003 | 030321-? | BOL |
| 4 | 7783 | WB | US | 60 | Newton | 328.07 | 329.2 | J7P0683 | 1999 | ? | BOL |
| 4 | 7782 | EB | US | 60 | Newton | 11.57 | 12.7 | J7P0683 | 1999 | ? | BOL |
| 5 | 1029 | WB | MO | 34 | Cape Girardeau | 14.25 | 14.85 | J0U0598C | 2009 | 080229-X02 | BOL |
| 6 | 1978 | WB | MO | 14 | Christian | 94.91 | 94.96 | J8P0878C | 2008 | 080425-803 | BOL |
| 6 | 1977 | EB | MO | 14 | Christian | 24.949 | 24.983 | J8P0878C | 2008 | 080425-803 | BOL |
| 7 | | | BUS | 13 | Stone | | | NA | 2008 | Internal Maintenance | BOL |

# APPENDIX B—DESIGN INFORMATION

| U.ID | No | Twid | Dir | Desg | Route | County | Overlay Type | Construction Date | Job.No | Contract.ID | Revised Log.mi Start | Revised Log.mi End | Year of Log.mi | Number of Lanes | Joint Spacing, ft | Slab Width, ft | Slab Thickness, in | Sealed Joints | Dowels | Interlayer Type | Interlayer Thickness, in | Under Pavement | Under Pavement Thickness, in | Under Pavement Age | Base Type | Base Thickness, in | Shoulder Type | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1W | 1 | 10 | WB | IS | 44 | Webster/ Greene | UBOL | 2000 | J8I0633 | F.A.I.-44-2(181) | 197.717 | 203.576 | 2018 | 2 | 15 | 12 | 8 | YES | 1.25 in | HMA | 1 | RPCCP | 9 | 1969-1970 | Type 3 Aggregate | 4 | PCC, Tied | - |
| 2S | 2 | 13 | SB | IS | 55 | Pemiscot | UBOL | 2002 | J0I0833 | 011214-X02 | 193.100 | 208.123 | 2018 | 2 | 15 | 12 | 9 | YES | 1.25 in | HMA | 1 | ACP | VAR | NA | Aggregate Base | 4 | PCC | - |
| 3E | 3 | 1100 | EB | US | 412 | Pemiscot | UBOL | 2003 | J0P0600D | 011214-X04 | 29.457 | 37.433 | 2018 | 2 | 15 | 13.8 | 12 | YES | 1.25 in | HMA | 1 | HMA | NA | NA | NA | NA | PCC, Tied | Project in metric units |
| 4E | 4 | 1100 | EB | US | 412 | Pemiscot | UBOL | 2003 | J0P0600/ 600E | 031114-X02 | 27.849 | 29.560 | 2018 | 2 | 15 | 13.8 | 12 | YES | 1.25 in | HMA | 1 | HMA | NA | NA | NA | NA | PCC, Tied | Project in metric units |
| 5N | 5 | 6512 | NB | IS | 255 | St. Louis | UBOL | 2003 | J6I1486 | 030221-601 | 0.323 | 3.750 | 2018 | 3 | 15 | 12 | 8 | YES | 1.25 in | HMA | 1 | RPCCP | NA | NA | NA | NA | PCC, Tied | - |
| 5S | 5 | 6513 | SB | IS | 255 | St. Louis | UBOL | 2003 | J6I1486 | 030221-601 | 0.000 | 3.660 | 2018 | 3 | 15 | 12 | 8 | YES | 1.25 in | HMA | 1 | RPCCP | NA | NA | NA | NA | PCC, Tied | - |
| 6N | 6 | 6040 | NB | MO | 291 | Jackson | UBOL | 2004 | J4P1421 | 030221-405 | 15.343 | 16.772 | 2018 | 2 | 15 | 12 | 8 | YES | 1.25 in | HMA | 1 | NRPCCP | 10 | NA | Type 3 Aggregate | 4 | PCC | - |
| 6S | 6 | 6041 | SB | MO | 291 | Jackson | UBOL | 2004 | J4P1421 | 030221-405 | 32.533 | 34.075 | 2018 | 2 | 15 | 12 | 8 | YES | 1.25 in | HMA | 1 | NRPCCP | 10 | NA | Type 3 Aggregate | 4 | PCC | - |
| 7E | 7 | 9 | EB | IS | 44 | Lawrence | UBOL | 2005 | J7I0721 | 040917-701 | 33.032 | 37.472 | 2018 | 2 | 15 | 12 | 8 | YES | 1.25 in | HMA | 1 | RPCCP | 9 | 1964 | Type B Aggregate | 4 | PCC, Tied | - |
| 7W | 7 | 10 | WB | IS | 44 | Lawrence | UBOL | 2005 | J7I0721 | 040917-701 | 255.665 | 260.119 | 2018 | 2 | 15 | 12 | 8 | YES | 1.25 in | HMA | 1 | RPCCP | 9 | 1964 | Type B Aggregate | 4 | PCC, Tied | - |
| 8E | 7R | 9 | EB | IS | 44 | Lawrence | UBOL | 2018 | J7I3074 | Replaced Drive Lanes of Previous Overlay | 33.032 | 37.472 | 2018 | 1 | 15 | 12 | 9 | NO | 1.25 in | Geotextile | NA | RPCCP | 9 | 1964 | Type B Aggregate | 4 | PCC | Rehabilitation of DL from project 7E |
| 8W | 7R | 10 | WB | IS | 44 | Lawrence | UBOL | 2018 | J7I3074 | Replaced Drive Lanes of Previous Overlay | 255.665 | 260.119 | 2018 | 1 | 15 | 12 | 9 | NO | 1.25 in | Geotextile | NA | RPCCP | 9 | 1964 | Type B Aggregate | 4 | PCC | Rehabilitation of DL from project 7W |
| 9E | 8 | 9 | EB | IS | 44 | Crawford | UBOL | 2005 | J9I0509 | 040917-901 | 204.608 | 213.799 | 2018 | 2 | 15 | 12 | 8 | YES | 1.25 in | HMA | 1 | NRPCCP | 9 | NA | NA | NA | PCC, Tied | - |
| 10E | 9 | 3560 | EB | US | 36 | Macon | UBOL | 2005 | J2P0726 | 040618-201 | 109.058 | 120.110 | 2018 | 2 | 15 | 14 | 8 | YES | 1.25 in | HMA | 1 | HMA | NA | NA | NA | NA | PCC | - |
| 11E | 10 | 9 | EB | IS | 44 | Laclede | UBOL | 2006 | J8I0747 | 051118-803 | 134.600 | 141.077 | 2018 | 2 | 15 | 14 | 8 | NO | NONE | HMA | 1 | NRPCCP | 7.75 | 1993 | NA | NA | A2, A1 | - |
| 12E | 10 | 9 | EB | IS | 44 | Laclede | UBOL | 2006 | J8I0748 | 051118-803 | 141.077 | 145.120 | 2018 | 2 | 15 | 14 | 8 | NO | 1.25 in | HMA | 4 | NRPCCP | 7.75 | 1993 | NA | NA | A2, A1 | - |
| 13W | 11 | 1101 | WB | US | 412 | Dunklin | UBOL | 2006 | J0P0570 | 051118-X02 | 22.943 | 26.342 | 2018 | 2 | 15 | 13.8 | 8 | NO | NONE | HMA | 1 | ACP | VAR | NA | NA | NA | PCC | - |
| 14S | 12 | 263 | SB | IS | 57 | Mississippi | UBOL | 2007 | J0I0973 | 070330-X01 | 0.369 | 12.747 | 2018 | 2 | 15 | 14 | 8 | NO | 1.25 in | HMA | 1 | NRPCCP | NA | NA | NA | NA | A2 type | - |
| 15E | 13 | 6372 | EB | IS | 64 | St. Louis/ St. Louis City | UBOL | 2007 | J6I0978 | Design Build | 27.450 | 36.580 | 2018 | 4 | 15 | 12 | 9 | NO | 1.25 in | Existing HMA | NA | ACP | NA | NA | Rock Base | NA | A2 type | Design-Build |
| 15W | 13 | 6373 | WB | IS | 64 | St. Louis/ St. Louis City | UBOL | 2007 | J6I0978 | Design Build | 4.210 | 13.350 | 2018 | 4 | 15 | 12 | 9 | NO | 1.25 in | Existing HMA | NA | ACP | NA | NA | Rock Base | NA | A2 type | Design-Build |
| 16N | 14 | 264 | NB | IS | 57 | Mississippi | UBOL | 2009 | J0I0983 | 090123-X01 | 13.032 | 21.925 | 2018 | 2 | 15 | 13 | 8 | NO | 1.25 in | HMA or Existing HMA | VAR | RPCCP | 9 | NA | Aggregate Base | 4 | A2 type | - |
| 17W | 15 | 10 | WB | IS | 44 | Phelps | UBOL | 2009 | J9I2166 | 090424-901 | 107.539 | 116.599 | 2018 | 2 | 15 | 12 | 8 | NO | 1.25 in | Geotextile | NA | NRPCCP | 8 | NA | NA | NA | NA | - |
| 18N | 16 | 12 | NB | IS | 55 | Cape/ Perry | UBOL | 2010 | J0I2200 | 091218-X01 | 105.966 | 107.966 | 2018 | 2 | 15 | 13 | 8 | NO | 1.25 in | Geotextile | NA | NA | NA | NA | NA | NA | A2 type | - |
| 19N | 17 | 12 | NB | IS | 55 | Pemiscot | UBOL | 2010 | J0I2171 | 090424-X02 | 0.076 | 15.079 | 2018 | 2 | 15 | 13 | 8 | NO | 1.25 in | Geotextile | NA | RPCCP | 8 | NA | Aggregate Base | 4 | A2 Type | - |
| 20N | 18 | 4984 | NB | IS | 35 | Clinton | UBOL | 2010 | J1I1040 | 090120-101 | 41.838 | 48.878 | 2018 | 2 | 15 | 12 | 8 | NO | 1.25 in | Existing HMA | VAR | HMA | NA | NA | NA | NA | A2 Type | - |
| 20S | 18 | 4986 | SB | IS | 35 | Clinton | UBOL | 2010 | J1I1040 | 090120-101 | 65.539 | 72.555 | 2018 | 2 | 15 | 12 | 8 | NO | 1.25 in | Existing HMA | VAR | HMA | NA | NA | NA | NA | A2 Type | - |

| U.ID | No | Twid | Dir | Desg | Route | County | Overlay Type | Construction Date | Job.No | Contract.ID | Revised Log.mi Start | Revised Log.mi End | Year of Log.mi | Number of Lanes | Joint Spacing, ft | Slab Width, ft | Slab Thickness, in | Sealed Joints | Dowels | Interlayer Type | Interlayer Thickness, in | Under Pavement | Under Pavement Thickness, in | Under Pavement Age | Base Type | Base Thickness, in | Shoulder Type | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21N | 19 | 4984 | NB | IS | 35 | Clay | UBOL | 2010 | J4I1382 | 091218-408 | 24.843 | 33.017 | 2018 | 2 | 15 | 12 | 8 | NO | 1.25 in | Geotextile | NA | ACP | NA | NA | NA | NA | A2 Type | - |
| 21S | 19 | 4986 | SB | IS | 35 | Clay | UBOL | 2010 | J4I1382 | 091218-408 | 81.393 | 89.600 | 2018 | 2 | 15 | 12 | 8 | NO | 1.25 in | Geotextile | NA | ACP | NA | NA | NA | NA | A2 Type | - |
| 22E | 20 | 9 | EB | IS | 44 | Franklin | UBOL | 2010 | J6I2011 | 090626-604 | 251.534 | 256.562 | 2018 | 2 | 15 | 12 | 8 | NO | 1.25 in | Geotextile | NA | ACP | VAR | NA | Aggregate Base | 4 | A2 Type | - |
| 22W | 20 | 10 | WB | IS | 44 | Franklin | UBOL | 2010 | J6I2011 | 090626-604 | 36.538 | 41.554 | 2018 | 2 | 15 | 12 | 8 | NO | 1.25 in | Geotextile | NA | ACP | VAR | NA | Aggregate Base | 4 | A2 Type | - |
| 23W | 21 | 10 | WB | IS | 44 | Pulaski | UBOL | 2011 | J9I2149 | 101022-805 | 130.375 | 139.258 | 2018 | 2 | 15 | 12 | 8 | NO | 1.25 in | Geotextile | NA | ACP | VAR | NA | NA | NA | PCC, tied | - |
| 24N | 22 | 12 | NB | IS | 55 | Pemiscot | UBOL | 2015 | J9P2244B | 150123-H02 | 15.080 | 18.680 | 2018 | 2 | 15 | 12 | 9 | NO | 1.25 in | Geotextile | NA | ACP | VAR | NA | Type 3 Aggregate | 4 | PCC | - |
| 25N | 23 | 6039 | NB | IS | 435 | Jackson | UBOL | 2019 | J4I2337 | 171201-C01 | 0.045 | 3.330 | 2018 | 5 | 15 | 12 | 8.5 - 11 | NO | 1.25 in | Existing HMA | NA | ACP | VAR | NA | Aggregate Base | 4 | PCC | X-section shows different slab thicknesses |
| 25S | 23 | 6042 | SB | IS | 435 | Jackson | UBOL | 2019 | J4I2337 | 171201-C01 | 51.789 | 55.080 | 2018 | 5 | 15 | 12 | 8.5 - 11 | NO | 1.25 in | Existing HMA | NA | ACP | VAR | NA | Aggregate Base | 4 | PCC | X-section shows different slab thicknesses |
| 26N | 24 | 4984 | NB | IS | I-35 | Daviess | UBOL | 2006 | J1I0895 | 051118-104 | 69.020 | 78.440 | 2018 | 2 | 15 | 12 | 8 | NO | NONE | HMA | 1 | RPCCP | 9 | 1978 | Type 1 or 2 Agg | 4 | A2 Type | Rehabilitated by project 35N |
| 26S | 24 | 4986 | SB | IS | I-35 | Daviess | UBOL | 2006 | J1I0895 | 051118-104 | 35.987 | 45.398 | 2018 | 2 | 15 | 12 | 8 | NO | NONE | HMA | 1 | RPCCP | 9 | 1978 | Type 1 or 2 Agg | 4 | A2 Type | Rehabilitated by project 35S |
| 27S | 1 | 6102 | SB | RT | D | Cass | BBOL | 2008 | J4S2246 | 080523-412 | 0.219 | 3.000 | 2017 | 1 | 6 | 6 | 5 | NO | NONE | Geotextile | NA | NRPCCP | 8 | NA | Aggregate Base | 4 | A2 Type | - |
| 27N | 1 | 6103 | NB | RT | D | Cass | BBOL | 2008 | J4S2246 | 080523-412 | 23.120 | 25.912 | 2017 | 1 | 6 | 6 | 5 | NO | NONE | Geotextile | NA | NRPCCP | 8 | NA | Aggregate Base | 4 | A2 Type | - |
| 28S | 2 | 11 | SB | US | 61 | Jefferson/ Ste. Genevieve | BBOL | 2009 | J6S1961 | 081024-601 | 200.925 | 213.675 | 2018 | 1 | 6 | 6 | 5 | NO | NONE | Existing HMA | NA | ACP | 6 + 8 | NA | NA | NA | Agg Shldr | - |
| 28N | 2 | 7773 | NB | US | 61 | Jefferson/ Ste. Genevieve | BBOL | 2009 | J6S1961 | 081024-601 | 180.376 | 193.124 | 2018 | 1 | 6 | 6 | 5 | NO | NONE | Existing HMA | NA | ACP | 6 + 8 | NA | NA | NA | Agg Shldr | - |
| 29E | 3 | 3560 | EB | US | 36 | Shelby/ Marion | BBOL | 2010 | J3P0792B | 100514-302 | 162.199 | 169.418 | 2018 | 2 | 6 | 6 | 5 | NO | NONE | Existing HMA | NA | HMA | NA | NA | NA | NA | A3 Type | - |
| 30N | 4 | 6365 | NB | MO | 79 | Marion /Ralls | BBOL | 2013 | J3P2193 | 130222-B01 | 78.520 | 86.141 | 2018 | 1 | 6 | 6 | 5 | NO | NONE | Geotextile | NA | NA | NA | NA | NA | NA | A3 Type | - |
| 30S | 4 | 6366 | SB | MO | 79 | Marion/ Ralls | BBOL | 2013 | J3P2193 | 130222-B01 | 1.811 | 9.432 | 2018 | 1 | 6 | 6 | 5 | NO | NONE | Geotextile | NA | NA | NA | NA | NA | NA | A3 Type | - |
| 31S | 5 | 1975 | SB | MO | 5 | Laclede | BBOL | 2014 | J5P2237B | 131122-D09 | 250.525 | 250.590 | 2018 | 2 | 6 | 6 | 6 | NO | NONE | Existing HMA | NA | HMA | NA | NA | NA | NA | Curb & Gutter, PCC | - |
| 32W | 6 | 6142 | WB | MO | 340 | St. Louis | BBOL | 2006 | J6S1773 | 060428-605 | 9.960 | 10.030 | 2018 | 2 | 6 | 6 | 6 | NO | NONE | Existing HMA | NA | HMA | NA | 1991, 1978 | Aggregate Base | 4 | PCC | - |
| 33E | 7 | 1100 | EB | US | 412 | Dunklin | BBOL | 2016 | J9S3010 | 150515-H07 | 23.532 | 23.879 | 2017 | 2 | 6 | 6 | 6 | NO | NONE | Geotextile | NA | ACP | NA | NA | NA | NA | Curb & Gutter, PCC | - |
| 33W | 7 | 1101 | WB | US | 412 | Dunklin | BBOL | 2016 | J9S3010 | 150515-H07 | 26.912 | 27.270 | 2017 | 2 | 6 | 6 | 6 | NO | NONE | Geotextile | NA | ACP | NA | NA | NA | NA | Curb & Gutter, PCC | - |
| 33S | 8 | 11 | SB | US | 61 | Scott | BBOL | 2016 | J9S3010 | 150515-H07 | 319.163 | 319.322 | 2018 | 1 | 6 | 6 | 6 | NO | NONE | Existing HMA | NA | HMA | NA | NA | NA | NA | PCC | Location of the project is the intersection of US61 with route ZZ and HH |
| 33N | 8 | 7773 | NB | US | 61 | Scott | BBOL | 2016 | J9S3010 | 150515-H07 | 74.558 | 74.717 | 2018 | 1 | 6 | 6 | 6 | NO | NONE | Existing HMA | NA | HMA | NA | NA | NA | NA | PCC | - |
| 34E | 9 | 3562 | EB | US | 24 | Randolph | BBOL | 2010 | J2P0779C | 100122-202 | 140.897 | 140.980 | 2018 | 2 | 6 | 6 | 5.5 | NO | NONE | Geotextile | NA | HMA | NA | NA | NA | NA | Curb & Gutter | BBOL applied only on the intersection of US-24 and BUS-63 |

| U.ID | No | Twid | Dir | Desg | Route | County | Overlay Type | Construction Date | Job.No | Contract.ID | Revised Log.mi Start | Revised Log.mi End | Year of Log.mi | Number of Lanes | Joint Spacing, ft | Slab Width, ft | Slab Thickness, in | Sealed Joints | Dowels | Interlayer Type | Interlayer Thickness, in | Under Pavement | Under Pavement Thickness, in | Under Pavement Age | Base Type | Base Thickness, in | Shoulder Type | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34W | 9 | 3563 | WB | US | 24 | Randolph | BBOL | 2010 | J2P0779C | 100122-202 | 80.273 | 80.356 | 2018 | 2 | 6 | 6 | 5.5 | NO | NONE | Geotextile | NA | HMA | NA | NA | NA | NA | Curb & Gutter | BBOL applied only on the intersection of US-24 and BUS-63 |
| 34S | 9 | 3534 | SB | BUS | 63 | Randolph | BBOL | 2010 | J2P0779C | 100122-202 | 1.030 | 1.110 | 2016 | 2 | 6 | 6 | 5.5 | NO | NONE | Geotextile | NA | HMA | NA | NA | NA | NA | Curb & Gutter | BBOL applied only on the intersection of US-24 and BUS-63 |
| 34N | 9 | 3533 | NB | BUS | 63 | Randolph | BBOL | 2010 | J2P0779C | 100122-202 | 8.470 | 8.550 | 2018 | 2 | 6 | 6 | 5.5 | NO | NONE | Geotextile | NA | HMA | NA | NA | NA | NA | Curb & Gutter | BBOL applied only on the intersection of US-24 and BUS-63 |
| 35N | 24R | 4984 | NB | IS | I-35 | Daviess | BBOL | 2013 | J1I2221 | 130125-A01, Rehab of 051118-104 | 69.020 | 78.440 | 2018 | 2 | 7.5 | 6 | 8 | NO | NONE | HMA | 1 | RPCCP | 9 | 1978 | Type 1 or 2 Agg | 4 | A2 Type | Rehab project for 24N (sawing of existing slabs into new pattern) |
| 35S | 24R | 4986 | SB | IS | I-35 | Daviess | BBOL | 2013 | J1I2221 | 130125-A01, Rehab of 051118-104 | 35.987 | 45.398 | 2018 | 2 | 7.5 | 6 | 8 | NO | NONE | HMA | 1 | RPCCP | 9 | 1978 | Type 1 or 2 Agg | 4 | A2 Type | Rehab project for 24S (sawing of existing slabs into new pattern) |
| 36S | 1 | 1975 | SB | MO | 5 | Laclede | BOL | 2003 | J8P0701 | NA | 250.520 | 250.590 | 2018 | 2 | 4 | 4 | 4 | YES | NONE | NA | NA | HMA | NA | NA | NA | NA | Curb & Gutter | - |
| 36N | 1 | 1976 | NB | MO | 5 | Laclede | BOL | 2003 | J8P0701 | NA | 102.146 | 102.220 | 2018 | 2 | 4 | 4 | 4 | YES | NONE | NA | NA | HMA | NA | NA | NA | NA | Curb & Gutter | - |
| 37S | 2 | 54 | SB | MO | 19 | Ralls | BOL | 2012 | J3P2152 | 120120-B02 | 8.411 | 8.480 | 2018 | 1 | 4 | 4 | 4 | NO | NONE | NA | NA | HMA | NA | NA | NA | NA | HMA | BOL only present at the intersection between MO-19 and roads P and H |
| 37N | 2 | 55 | NB | MO | 19 | Ralls | BOL | 2012 | J3P2152 | 120120-B02 | 254.348 | 254.415 | 2017 | 1 | 4 | 4 | 4 | NO | NONE | NA | NA | HMA | NA | NA | NA | NA | HMA | BOL only present at the intersection between MO-19 and roads P and H |
| 38N | 3 | 6040 | NB | MO | 291 | Jackson | BOL | 2003 | J4P1513 | 030321-403 | 30.050 | 30.243 | 2018 | 2 | 4 | 4 | 4 | YES | NONE | NA | NA | HMA | NA | NA | NA | NA | Curb & Gutter | - |
| 38S | 3 | 6041 | SB | MO | 291 | Jackson | BOL | 2003 | J4P1513 | 030321-403 | 19.100 | 19.310 | 2018 | 2 | 4 | 4 | 4 | YES | NONE | NA | NA | HMA | NA | NA | NA | NA | Curb & Gutter | - |
| 39W | 4 | 7783 | WB | US | 60 | Newton | BOL | 1999 | J7P0683 | NA | 328.070 | 328.500 | 2018 | 1 | 4 | 4 | 4 | YES | NONE | NA | NA | HMA | NA | NA | NA | NA | HMA | - |
| 39E | 4 | 7782 | EB | US | 60 | Newton | BOL | 1999 | J7P0683 | NA | 12.280 | 12.700 | 2018 | 1 | 4 | 4 | 4 | YES | NONE | NA | NA | HMA | NA | NA | NA | NA | HMA | - |
| 40W | 5 | 1029 | WB | MO | 34 | Cape Girardeau | BOL | 2009 | J0U0598C | 080229-X02 | NA | NA | NA | 2 | 4 | 4 | 4 | NO | NONE | NA | NA | HMA | NA | NA | NA | NA | PCC | Project not available on ARAN viewer |
| 41W | 6 | 1978 | WB | MO | 14 | Christian | BOL | 2008 | J8P0878C | 080425-803 | 94.910 | 94.960 | 2017 | 1 | 4 | 4 | 4 | NO | NONE | NA | NA | HMA | NA | NA | NA | NA | Curb & Gutter | - |
| 41E | 6 | 1977 | EB | MO | 14 | Christian | BOL | 2008 | J8P0878C | 080425-803 | 24.902 | 24.954 | 2017 | 1 | 4 | 4 | 4 | NO | NONE | NA | NA | HMA | NA | NA | NA | NA | Curb & Gutter | - |

# APPENDIX C—CONSTRUCTION QUALITY ASSURANCE DATA

**Table C-1. Summary of concrete overlay thickness from SiteManager and PWL.**

| U.ID. | Overlay Type | Job.No. | Average, in | Standard Deviation, in | Count, No of Observations | Design Thickness, in | Delta Thickness, in | $Q_U$ USL = None | $Q_L$ LSL = (design thickness - 0.5) | $PWL_U$ | $PWL_L$ | Design Thickness-0.5 in PWL | Design Thickness PWL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01W | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 02S | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 03E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 04E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 05N | UBOL | J6I1486 | 9.51 | 1.23 | 396 | 8 | 1.51 | 100 | 1.63 | 100 | 95 | 95 | 89 |
| 05S | UBOL | J6I1486 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 89 |
| 06N | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 06S | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 07E | UBOL | J7I0721 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 07W | UBOL | J7I0721 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 100 |
| 08E | UBOL | J7I3074 | 9.93 | 0.72 | 65 | 9 | 0.93 | 100 | 1.99 | 100 | 98 | 98 | 90 |
| 08W | UBOL | J7I3074 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 90 |
| 09E | UBOL | J9I0509 | 8.92 | 0.38 | 14 | 8 | 0.92 | 100 | 2.41 | 100 | 99 | 100 | 99 |
| 10E | UBOL | J2P0726 | 8.13 | 0.07 | 7 | 8 | 0.13 | 100 | 8.91 | 100 | 100 | 100 | 96 |
| 11E | UBOL | J8I0747 | 7.79 | 0.46 | 10 | 8 | -0.21 | 100 | 0.63 | 100 | 74 | 74 | 50 |
| 12E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 13W | UBOL | J0P0570 | 10.72 | 0.41 | 3 | 8 | 2.72 | 100 | 7.91 | 100 | 100 | 100 | 100 |
| 14S | UBOL | J0I0973 | 7.96 | 0.61 | 270 | 8 | -0.04 | 100 | 0.75 | 100 | 77 | 77 | 50 |
| 15E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 15W | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 16N | UBOL | J0I0983 | 8.47 | 1.10 | 180 | 8 | 0.47 | 100 | 0.87 | 100 | 81 | 81 | 66 |
| 17W | UBOL | J9I2166 | 9.15 | 1.47 | 147 | 8 | 1.15 | 100 | 1.12 | 100 | 87 | 87 | 78 |
| 18N | UBOL | J0I2200 | 8.72 | 0.30 | 2 | 8 | 0.72 | 100 | 2.35 | NA | NA | NA | NA |
| 19N | UBOL | J0I2171 | 8.16 | 0.64 | 246 | 8 | 0.16 | 100 | 1.04 | 100 | 85 | 85 | 60 |
| 20N | UBOL | J1I1040 | 8.92 | 0.86 | 213 | 8 | 0.92 | 100 | 1.66 | 100 | 95 | 95 | 86 |
| 20S | UBOL | J1I1040 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 86 |
| 21N | UBOL | J4I1382 | 8.00 | 0.00 | 210 | 8 | 0.00 | 100 | NA | 100 | NA | NA | NA |
| 21S | UBOL | J4I1382 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 22E | UBOL | J6I2011 | 11.10 | 1.76 | 130 | 8 | 3.10 | 100 | 2.05 | 100 | 98 | 98 | 96 |
| 22W | UBOL | J6I2011 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 96 |
| 23W | UBOL | J9I2149 | 8.38 | 0.77 | 90 | 8 | 0.38 | 100 | 1.15 | 100 | 87 | 87 | 69 |
| 24N | UBOL | J9P2244B | 9.49 | 0.68 | 37 | 9 | 0.49 | 100 | 1.45 | 100 | 93 | 93 | 76 |
| 25N | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 25S | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 26N | UBOL | J1I0895 | 8.82 | 0.78 | 83 | 8 | 0.82 | 100 | 1.69 | 100 | 96 | 96 | 85 |
| 26S | UBOL | J1I0895 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 85 |
| 27N | BBOL | J4S2246 | 5.99 | 0.58 | 56 | 5 | 0.99 | 100 | 2.57 | 100 | 99 | 99 | 96 |

| U.ID. | Overlay Type | Job.No. | Average, in | Standard Deviation, in | Count, No of Observations | Design Thickness, in | Delta Thickness, in | $Q_U$ USL = None | $Q_L$ LSL = (design thickness - 0.5) | $PWL_U$ | $PWL_L$ | Design Thickness-0.5 in PWL | Design Thickness PWL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27S | BBOL | J4S2246 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 96 |
| 28N | BBOL | J6S1961 | 5.62 | 0.93 | 175 | 5 | 0.62 | 100 | 1.20 | 100 | 89 | 89 | 75 |
| 28S | BBOL | J6S1961 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 75 |
| 29E | BBOL | J3P0792B | 5.65 | 0.62 | 56 | 5 | 0.65 | 100 | 1.86 | 100 | 97 | 97 | 85 |
| 30N | BBOL | J3P2193 | 5.22 | 0.88 | 80 | 5 | 0.22 | 100 | 0.83 | 100 | 80 | 80 | 60 |
| 30S | BBOL | J3P2193 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 60 |
| 31S | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 32W | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 33E | BBOL | J9S3010 | 6.34 | 0.34 | 3 | 6 | 0.34 | 100 | 2.46 | 100 | 100 | 100 | 83 |
| 33N | BBOL | J9S3010 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 83 |
| 33S | BBOL | J9S3010 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 83 |
| 33W | BBOL | J9S3010 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 83 |
| 34E | BBOL | J2P0779C | 5.60 | 0.44 | 30 | 5.5 | 0.10 | 100 | 1.37 | 100 | 92 | 92 | 59 |
| 34N | BBOL | J2P0779C | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 59 |
| 34S | BBOL | J2P0779C | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 59 |
| 34W | BBOL | J2P0779C | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 59 |
| 35N | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 35S | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 36N | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 36S | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 37N | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 37S | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 38N | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 38S | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 39E | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 39W | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 40W | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 41E | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 41W | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

**Table C-2. Summary of PCC strength data from SiteManager and PWL.**

| U.ID. | Overlay Type | Job.No. | Average, lbf/in² | Standard Deviation, lbf/in² | Count, No of Observations | $Q_U$ USL = none | $Q_L$ LSL = 4,000 lbf/in² | $PWL_U$ | $PWL_L$ | PWL | Average, lbf/in² |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01W | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 02S | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 03E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 04E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 05N | UBOL | J6I1486 | 5,358 | 1,117 | 395 | 100 | 1.22 | 100 | 89 | 89 | 5,358 |
| 05S | UBOL | J6I1486 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 06N | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 06S | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 07E | UBOL | J7I0721 | 5,136 | 705 | 223 | 100 | 1.62 | 100 | 95 | 95 | 5,136 |
| 07W | UBOL | J7I0721 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 08E | UBOL | J7I3074 | 6,712 | 1,033 | 65 | 100 | 2.63 | 100 | 99 | 99 | 6,712 |
| 08W | UBOL | J7I3074 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 09E | UBOL | J9I0509 | 4,757 | 445 | 80 | 100 | 1.7 | 100 | 96 | 96 | 4,757 |
| 10E | UBOL | J2P0726 | 5,857 | 712 | 126 | 100 | 2.61 | 100 | 99 | 99 | 5,857 |
| 11E | UBOL | J8I0747 | 5,017 | 750 | 95 | 100 | 1.36 | 100 | 91 | 91 | 5,017 |
| 12E | UBOL | J8I0748 | 4,948 | 584 | 30 | 100 | 1.63 | 100 | 95 | 95 | 4,948 |
| 13W | UBOL | J0P0570 | 5,997 | 484 | 3 | 100 | 4.13 | 100 | 100 | 100 | 5,997 |
| 14S | UBOL | J0I0973 | 5,888 | 626 | 278 | 100 | 3.02 | 100 | 99 | 99 | 5,888 |
| 15E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 15W | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 16N | UBOL | J0I0983 | 5,406 | 618 | 180 | 100 | 2.28 | 100 | 99 | 99 | 5,406 |
| 17W | UBOL | J9I2166 | 5,544 | 1,089 | 163 | 100 | 1.42 | 100 | 92 | 92 | 5,544 |
| 18N | UBOL | J0I2200 | 4,745 | 338 | 12 | 100 | 2.21 | 100 | 99 | 99 | 4,745 |
| 19N | UBOL | J0I2171 | 6,393 | 620 | 246 | 100 | 3.87 | 100 | 100 | 100 | 6,393 |
| 20N | UBOL | J1I1040 | 5,108 | 547 | 213 | 100 | 2.03 | 100 | 98 | 98 | 5,108 |
| 20S | UBOL | J1I1040 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 21N | UBOL | J4I1382 | 7,153 | 753 | 210 | 100 | 4.19 | 100 | 100 | 100 | 7,153 |
| 21S | UBOL | J4I1382 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 22E | UBOL | J6I2011 | 5,100 | 865 | 130 | 100 | 1.28 | 100 | 90 | 90 | 5,100 |
| 22W | UBOL | J6I2011 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 23W | UBOL | J9I2149 | 6,094 | 850 | 90 | 100 | 2.47 | 100 | 99 | 99 | 6,094 |
| 24N | UBOL | J9P2244B | 5,834 | 734 | 37 | 100 | 2.5 | 100 | 99 | 99 | 5,834 |
| 25N | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 25S | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 26N | UBOL | J1I0895 | 4,836 | 616 | 83 | 100 | 1.36 | 100 | 91 | 91 | 4,836 |
| 26S | UBOL | J1I0895 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 27N | BBOL | J4S2246 | 5,604 | 259 | 36 | 100 | 6.2 | 100 | 100 | 100 | 5,604 |
| 27S | BBOL | J4S2246 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 28N | BBOL | J6S1961 | 5,721 | 669 | 175 | 100 | 2.58 | 100 | 99 | 99 | 5,721 |
| 28S | BBOL | J6S1961 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 29E | BBOL | J3P0792B | 4,786 | 409 | 56 | 100 | 1.93 | 100 | 98 | 98 | 4,786 |

| U.ID. | Overlay Type | Job.No. | Average, lbf/in$^2$ | Standard Deviation, lbf/in$^2$ | Count, No of Observations | $Q_U$ USL = none | $Q_L$ LSL = 4,000 lbf/in$^2$ | $PWL_U$ | $PWL_L$ | PWL | Average, lbf/in$^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 30N | BBOL | J3P2193 | 5,371 | 504 | 80 | 100 | 2.72 | 100 | 99 | 99 | 5,371 |
| 30S | BBOL | J3P2193 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 31S | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 32W | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 33E | BBOL | J9S3010 | 6,125 | 1,170 | 18 | 100 | 1.82 | 100 | 97 | 97 | 6,125 |
| 33N | BBOL | J9S3010 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 33S | BBOL | J9S3010 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 33W | BBOL | J9S3010 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 34E | BBOL | J2P0779C | 5,666 | 792 | 30 | 100 | 2.11 | 100 | 99 | 99 | 5,666 |
| 34N | BBOL | J2P0779C | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 34S | BBOL | J2P0779C | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 34W | BBOL | J2P0779C | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 35N | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 35S | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 36N | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 36S | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 37N | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 37S | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 38N | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 38S | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 39E | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 39W | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 40W | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 41E | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 41W | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

**Table C-3. Summary of PCC air data from SiteManager and PWL.**

| U.ID. | Overlay Type | Job.No. | Average, % | Standard Deviation, % | Count, No of Observations | $Q_U$ USL = 7.5% | $Q_L$ LSL = 4.5% | $PWL_U$ | $PWL_L$ | PWL | Average, % | Standard Deviation, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01W | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 02S | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 03E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 04E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 05N | UBOL | J6I1486 | 6.03 | 1.24 | 278 | 1.18 | 1.23 | 88 | 89 | 77 | 6.03 | 1.24 |
| 05S | UBOL | J6I1486 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 06N | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 06S | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 07E | UBOL | J7I0721 | 5.84 | 0.89 | 146 | 1.86 | 1.50 | 97 | 93 | 90 | 5.84 | 0.89 |
| 07W | UBOL | J7I0721 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 08E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 08W | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 09E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 10E | UBOL | J2P0726 | 4.73 | 1.87 | 18 | 1.48 | 0.12 | 94 | 55 | 49 | 4.73 | 1.87 |
| 11E | UBOL | J8I0747 | 6.60 | 0.91 | 20 | 0.99 | 2.31 | 84 | 99 | 83 | 6.60 | 0.91 |
| 12E | UBOL | J8I0748 | 6.18 | 0.47 | 5 | 2.80 | 3.57 | 100 | 100 | 100 | 6.18 | 0.47 |
| 13W | UBOL | J0P0570 | 8.25 | 1.47 | 8 | -0.51 | 2.56 | 31 | 100 | 31 | 8.25 | 1.47 |
| 14S | UBOL | J0I0973 | 5.54 | 0.28 | 29 | 6.96 | 3.68 | 100 | 100 | 100 | 5.54 | 0.28 |
| 15E | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 15W | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 16N | UBOL | J0I0983 | 5.60 | 0.89 | 72 | 2.12 | 1.23 | 98 | 89 | 87 | 5.60 | 0.89 |
| 17W | UBOL | J9I2166 | 6.38 | 0.70 | 17 | 1.60 | 2.68 | 95 | 99 | 94 | 6.38 | 0.70 |
| 18N | UBOL | J0I2200 | 6.59 | 0.14 | 8 | 6.73 | 15.39 | 100 | 100 | 100 | 6.59 | 0.14 |
| 19N | UBOL | J0I2171 | 5.41 | 0.66 | 152 | 3.19 | 1.38 | 100 | 92 | 92 | 5.41 | 0.66 |
| 20N | UBOL | J1I1040 | 6.24 | 1.54 | 173 | 0.82 | 1.13 | 79 | 87 | 66 | 6.24 | 1.54 |
| 20S | UBOL | J1I1040 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 21N | UBOL | J4I1382 | 5.00 | 0.57 | 41 | 4.38 | 0.88 | 100 | 81 | 81 | 5.00 | 0.57 |
| 21S | UBOL | J4I1382 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 22E | UBOL | J6I2011 | 7.37 | 0.82 | 26 | 0.16 | 3.49 | 56 | 100 | 56 | 7.37 | 0.82 |
| 22W | UBOL | J6I2011 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 23W | UBOL | J9I2149 | 5.42 | 0.38 | 14 | 5.49 | 2.43 | 100 | 99 | 99 | 5.42 | 0.38 |
| 24N | UBOL | J9P2244B | 5.39 | 1.00 | 7 | 2.11 | 0.88 | 98 | 81 | 79 | 5.39 | 1.00 |
| 25N | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 25S | UBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 26N | UBOL | J1I0895 | 6.20 | NA | 1 | NA | NA | NA | NA | NA | 6.20 | NA |
| 26S | UBOL | J1I0895 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 27N | BBOL | J4S2246 | 6.15 | 1.31 | 32 | 1.03 | 1.26 | 85 | 90 | 75 | 6.15 | 1.31 |
| 27S | BBOL | J4S2246 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 28N | BBOL | J6S1961 | 6.91 | 1.19 | 75 | 0.50 | 2.02 | 69 | 98 | 67 | 6.91 | 1.19 |
| 28S | BBOL | J6S1961 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| U.ID. | Overlay Type | Job.No. | Average, % | Standard Deviation, % | Count, No of Observations | $Q_U$ USL = 7.5% | $Q_L$ LSL = 4.5% | $PWL_U$ | $PWL_L$ | PWL | Average, % | Standard Deviation, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29E | BBOL | J3P0792B | 6.40 | 0.52 | 4 | 2.13 | 3.68 | 98 | 100 | 98 | 6.40 | 0.52 |
| 30N | BBOL | J3P2193 | 6.93 | 0.55 | 19 | 1.04 | 4.41 | 85 | 100 | 85 | 6.93 | 0.55 |
| 30S | BBOL | J3P2193 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 31S | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 32W | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 33E | BBOL | J9S3010 | 5.40 | NA | 1 | NA | NA | NA | NA | NA | 5.40 | NA |
| 33N | BBOL | J9S3010 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 33S | BBOL | J9S3010 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 33W | BBOL | J9S3010 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 34E | BBOL | J2P0779C | 5.80 | 0.83 | 6 | 2.06 | 1.57 | 98 | 94 | 92 | 5.80 | 0.83 |
| 34N | BBOL | J2P0779C | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 34S | BBOL | J2P0779C | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 34W | BBOL | J2P0779C | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 35N | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 35S | BBOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 36N | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 36S | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 37N | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 37S | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 38N | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 38S | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 39E | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 39W | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 40W | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 41E | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 41W | BOL | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

# APPENDIX D—TRANSPORTATION MANAGEMENT SYSTEM (TMS) PERFORMANCE HISTORY DATA

# AUTO_COND_SURVEY

**DATE CREATED:** 04/08/2004
**DATE MODIFIED:** 09/19/2016
**AUTO_COND_SURVEY**

## Description

This table contains automated condition survey (ARAN) data. **NOTE:** *This table contains information that is protected from disclosure by federal law, 23 USC Section 409 and the Missouri Open Records Law (Sunshine Act), Section 610.021 RSMo. Please review MoDOT's policy and procedure manual on the Sunshine Act before releasing any of the information contained herein.*

| *NAME* | *DESCRIPTION* |
|---|---|
| ARC_ID | This is the id of the arc where the beginning point of this data resides. When the beginning point of the data is exactly on a node, the correct arc is on the one it's going to, rather than coming from. This is necessary to maintain proper log miles during the travelway maintenance process. |
| ARC_REF | This represents whether the data is going in the same direction as the arc or in the opposite direction of the arc. The letter 'G' means it is going with the arc (with 0 being the beginning of the arc and 100 being the end) and the letter 'L' means it is going the opposite direction of the arc. This is necessary to maintain proper log miles during the travelway maintenance process. |
| AUTO_COND_SURV_ID | Unique identifier for an Automated Condition Survey record. |
| AVERAGE_RUT | The average of the driver and passenger rut depth. |
| AVERAGE_RUT_SI | The metric equivalent of the average of the driver and passenger rut depth. |
| C_CRACKING_RATING | The rating of cracks for concrete pavement. Ratings are derived from a visual analysis of severity and extent and range from 0.0 (worst) to 5.0 (best). |
| C_PATCHING_RATING | The rating of patching for concrete pavement. Ratings are derived from a visual analysis of severity and extent and range from 0.0 (worst) to 5.0 (best). |
| CONDITION_INDEX | The sum of distresses that apply to a pavement. For asphalt, it is the sum of F Cracking, F Patching, Raveling, and Rut Index. For concrete, it is the sum of Joint Condition, C Cracking, C Patching, D Cracking and Spalling. |

| | |
|---|---|
| CROSSFALL | Slope of the road. |
| CURR_SURVEY_FLAG | Identifies a record as the most current. Y = current; N = Not current. |
| D_CRACKING_RATING | The rating of D Cracking for a pavement. Ratings are derived from a visual analysis of severity and extent and range from –5.0 (worst) to 0.0 (no D-Cracking). **Note:** that the value is negative. |
| DATA_ID | This is a unique identifier that relates the location back to the detail record in the business table. Having the DATA_ID on the location table allows there to be multiple locations for one detail record. (For example, a construction project can impact several routes). |
| DATE0 | Date the automated condition (ARAN) survey was conducted. |
| DRIVER_IRI | International Roughness Index Number indicating roughness statistics in the left wheel path. |
| DRIVER_RUT_DEPTH | Maximum rut depth measured in the left wheel path of a particular lane of flexible pavement. (Measured to a tenth of an inch). |
| DRIVER_RUT_DPTH_SI | The metric value of the Driver Rut Depth. |
| ELEVATION | The height of a given level. |
| EVENT_NUMBER | Number of events within an interval for the Automated Condition Survey. |
| F_CRACKING_RATING | The rating of cracks for flexible pavement. Ratings are derived from a visual analysis of severity and extent and range from 0.0 (worst) to 5.0 (best). |
| . F_PATCHING_RATING | The rating of patching for flexible pavement. Ratings are derived from a visual analysis of severity and extent and range from 0.0 (worst) to 5.0 (best). |
| GRADE | The incline or decline of a roadway. |
| IMAGE_NUMBER | Original image file from ARAN computer. |
| JOINT_COND_RTNG | The condition rating of joints. Ratings are derived from a visual analysis of severity and extent and range from 0.0 (worst) to 5.0 (best). |

| | |
|---|---|
| LAST_CHANGE_DATE | (DD-MON-YYYY HH:mi:ss) this is the date of the last time the auto condition survey record was changed in any way. |
| LAST_CHANGE_USER | This is the user ID of the last person to change the auto condition survey record in any way. |
| LATITUDE | This represents the latitude of the location in decimal degrees. |
| LONGITUDE | This represents the longitude of the location in decimal degrees. |
| PASS_RUT_DEPTH_SI | The metric value for Passenger Rut Depth. |
| PASS_RUT_DPTH | Maximum rut depth measured in the right wheel path of a particular lane of flexible pavement. (Measured to nearest tenth of an inch). |
| PASSENGER_IRI | International Roughness Index Number indicating roughness statistics in the right wheel path. |
| PAVEMENT_ID | Identifies the type of pavement. Values are AC = Asphaltic Concrete; PCC = Portland Cement Concrete. |
| PAVEMENT_ROUGH | The rating of pavement smoothness derived from the Automated Condition Survey axel acceleration (ride). Ratings range from 0.0 (worst) to 5.0 (best). |
| POS | This is a number that represents the location of the beginning point along the arc. It is determined as a percentage with 0 being the beginning of the arc and 100 being the end of the arc. This is necessary to maintain proper log miles during the travelway maintenance process. |
| PRES_SVC_RATING | A 40-point scale representing relative pavement condition. PSR id developed from ratings of individual distresses and roughness weight and combined to form a single value. |
| RAVELING_RATING | The rating of raveling of a pavement. Raveling is the progressive loss of pavement material from the surface. Ratings are derived from a visual analysis of severity and extent and range from 0.0 (worst) to 5.0 (best). |
| RUNFILE | Unique ARAN file number. |
| RUT_DEPTH_SI_UOM | The metric unit of measure for driver and passenger rut depth. |
| RUT_DEPTH_UOM | Unit of measure for driver and passenger rut depth. |

| | |
|---|---|
| RUT_RATING | The rating of measured rut depth ranging from 0.0 (worst) to 5.0 (best). |
| SEALING_INDICATOR | Indicates whether or not the cracks are sealed. |
| SHAPE | This column allows the data to be drawn in ArcGIS without having to create a route event. |
| SPALLING_RATING | A rating of spalling at joint and cracks. Spalling is the loss of piece(s) of concrete pavement from the surface or along the edges of cracks and joints. Ratings are derived from a visual analysis of severity and extent and range from 0.0 (worst) to 5.0 (best). |
| TW_LANE_ID | Unique identifier for a Travelway Lane record. ***Joins with*** **TRAVELWAY_LANE** |
| VISUAL_LANE_NO | Number assigned to the lane (visibly how the lanes "stack up" horizontally). This number begins with one from the leftmost side to the right of the travelway (following the direction of travel. |
| YEAR | The year the data was collected. |

# SS_PAVEMENT_CURRENT

**DATE CREATED:** 09/16/2011

**DATE MODIFIED:** 06/22/2018

**SS_PAVEMENT_CURRENT**

## *Description*

Each SS_PAVEMENT record represents pavement breaks on a Traffic Information Segment. A pavement break may be caused by a change in surface type, surface width, city limits, etc. This is one of the tables used to generate our yearly State of the System report.

| *NAME* | *DESCRIPTION* |
|---|---|
| AADT | This is the Annual Average Daily Traffic which is the estimate of typical daily traffic on a road segment for all days of the week, Sunday through Saturday, over a period of one year. |
| AADT_YEAR | This is the calendar year that the data was collected of the AADT. |
| ACCESS_CAT_NAME | Describes the accessibility of a pavement record on a particular route. |
| ARAN_YEAR | Year the ARAN data was collected. |
| ARC_ID_BEGIN | This is the ID of the arc where the beginning point of this data resides. When the beginning point of the data is exactly on a node, the correct arc is the one it's going to, rather than coming from. This is necessary to maintain proper log miles during the travelway maintenance process. |
| ARC_ID_END | This is the ID of the arc where the ending point of this data resides. When the ending point of the data is exactly on a node, the correct arc is the one it's coming from, rather than going to. This is necessary to maintain proper log miles during the travelway maintenance. |
| ARC_REF_BEGIN | This represents whether the data is going in the same direction as the arc or in the opposite direction of the arc. The letter 'G' means it is going with the arc (with 0 being the beginning of the arc and 100 being the end) and the letter 'L' means it is going the opposite direction of the arc. This is necessary to maintain proper log miles during the travelway maintenance process. |
| ARC_REF_END | This represents whether the data is going in the same direction as the arc or in the opposite direction of the arc. The letter 'G' means it is going with the arc and the letter 'L' means it is going the opposite direction of the arc. This is necessary to maintain proper log miles during the travelway maintenance process. |

| | |
|---|---|
| AREA_DESG_NAME | This field is used to describe an area based on population for the pavement record. |
| AREA_ENGINEER | Name of the area engineer where the pavement record resides. |
| AVERAGE_IRI | Average of driver and passenger wheel path (International Roughness Index). |
| BEG_CONTINUOUS_LOG | This is the continuous log mile the represents the beginning location of a piece of range data. All routes start with a beginning log of 0 and accumulate without gaps to the end of the route. |
| CENTERLINE | Centerline mileage for each pavement record. Centerline mileage is calculated for travelways with directions of south and east. |
| CITY_ID | - |
| CITY_NAME | The city in the City's official mailing address where the pavement record resides. |
| CNTL_BEG_CONT_LOG | This is the continuous log mile that represents the controlling beginning location of a piece of range data. All routes start with a beginning log of 0 and accumulate without gaps to the end of the route. |
| CNTL_END_CONT_LOG | This is the continuous log mile that represents the controlling ending location of a piece of range data. All routes start with a beginning log of 0 and accumulate without gaps to the end of the route. |
| CNTL_TW_DESG | This is the designation of the controlling route. The designation helps identify the route and determine its hierarchy. |
| CNTL_TW_DIRECTION | This field indicates the direction for the controlling route from the nearest intersecting street, roadway or landmark. |
| CNTL_TW_ID | Unique route identifier for the controlling route. |
| CNTL_TW_NAME | Name of the controlling route. |
| CNTL_TW_OFFSET | The offset direction for the controlling route indicates which direction the outer road resides from the main route it is associated with. For example, the outer roads for IS 70 are either north or south of IS 70. |
| COM_VOL_BY_DIR | The total commercial volume for a specific travelway segment by direction. |
| CONDITION_INDEX | The sum of distresses that apply to a pavement. For Asphalt it is the sum of 'F Cracking', 'F Patching', 'Raveling', and 'Rut Index'. For Concrete, it is the sum of 'Joint Condition', 'C Cracking', 'C Patching', 'D Cracking' and 'Spalling'. |

| | |
|---|---|
| COUNTY_NAME | This is the official name of the county that the pavement record resides. ***Joins in* COUNTY** |
| COUNTY_NUMBER | Unique identifier assigned to the county within the state where the pavement record resides. |
| CRACK_INDEX_FLEX | Rating assigned to the amount of cracking on asphaltic concrete. |
| CRACK_INDEX_RIGID | Rating assigned to amount of cracking on PCC (Portland Cement Concrete). Ratings are derived from a visual analysis of severity and extent with 0.0 (worst) to 5.0 (best). |
| CRACKING_PERCENT | The square feet of distress cracking in the wheel paths as a percentage of the total square feet of the lane. |
| DESG_BYWAY_CLS_NM | Names and identifies a designated scenic byway classification. Valid values are as follows: 'Federal Designated Scenic Byway' and 'State Designated Scenic Byway'. |
| DESG_TRUCK_RTE_NM | Classification for the travelways for federal or state designated truck routes. Valid values are as follows: 'Federal Designated Truck Route' and 'State Designated Truck Route'. |
| DIRECTIONAL | Indicates the direction of the inventory route. |
| DISTRICT | The MoDOT District number (1-7) that the pavement record falls in. |
| DISTRICT_ABBR | This is the two-letter abbreviation for the seven districts. Valid values are as follows: 'NW', 'NE', 'KC', 'CD', 'SL', 'SW', and 'SE'. |
| DIVIDED_UNDIVIDED | Indicates if the travelway is divided or undivided. A divided travelway is a travelway with any type of barrier or four-foot or greater flush median. |
| END_CONTINUOUS_LOG | This is the continuous log mile that represents the ending location of a piece of range data. All routes start with a beginning log of 0 and accumulate without gaps to the end of the route. |
| FAP_SYS_CLASS_NAME | This represents what the Federal Aid Primary System looked like in 1991. After that time, the definition changed to be based on functional class. |
| FAULTING | The average faulting measured in the section of pavement. |
| FED_AID_ELIGIBLE | This identifies what roads are eligible for federal aid based on functional class. |
| FED_CLS_NFS | Federal System Classification name – 'National Forest System'. |
| FED_CLS_NHS | Federal System Classification name – 'National Highway System'. |

| | |
|---|---|
| FED_CLS_PRIORITY | Federal System Classification name – 'Congressional Priority’. |
| FED_CLS_STRAHCON | Federal System Classification name – 'Strategic Highway Network Connector’. |
| FED_CLS_STRAHNET | Federal System Classification name – 'Strategic Highway Network' that is assigned to truck routes. |
| FED_CLS_UNCLASS | Federal System Classification name – ‘Intermodal Connector’. |
| FED_SYS_CLS_NAME | A unique identifier assigned to the federal system classification. |
| FHWA_CONDITION | The ‘Good’, ‘Fair’, or ‘Poor’ rating as defined by the new PM2 Federal Highway definitions. |
| FUNC_CLASS_NAME | This table names and describes the type of functional classification used to categorize a travelway. |
| INTERCHANGE_ID | Unique identifier assigned to the interchange if the pavement record falls within an interchange. |
| INTERSECTION_NO | Unique identifier assigned to the travelway intersection pavement record. |
| JOINT_INDEX_RIGID | Rating assigned to amount of joints on PCC (Portland Cement Concrete). Ratings are derived from a visual analysis of severity and extent, and a range from 0.0 (worst) to 5.0 (best). |
| LANE_COLLECTED | Visual lane number that the ARAN data was collected. |
| LANE_MILES | The number of lane miles the project will cover. |
| LANE_WIDTH | The length of the lane measured in width. |
| LAST_CHANGED_DATE | (DD-MON-YYYY HH:mi:ss) this is the date of the last time the pavement record was changed in any way. |
| LAST_CHANGED_USER | The user ID of the individual who made the change to the pavement data. |
| LEFT_SHOULDER_TYPE | The type of shoulder on the left side of the travelway where the pavement record resides. |
| LEFT_SHOULDER_WIDTH | The width of the shoulder on the left side of the travelway where the pavement record resides. |
| LENGTH | Length of the pavement segment. |
| LRPT | Long Range Planning Transportation. Valid values are as follows: ‘NHS’, ‘OTHER Arterial’, ‘COLLECTOR’ or ‘NOS’. |
| MAINT_DATE | The date of a maintenance treatment for the pavement record. |

| | |
|---|---|
| MAINT_LOCATION | The maintenance building responsible for the travelway where the pavement record is located. |
| MAINT_JOB_NUMBER | This is the job number of the maintenance completed on the pavement. |
| MAINT_OWNER_NAME | This is the owner of the pavement record was having maintenance on. |
| MAINT_OWNER_TYPE | This is the owner of the pavement record. Valid values are: 'CITY', 'COUNTY' and 'STATE'. |
| MAINT_TYPE | The type of maintenance treatment performed on the pavement. |
| MAJOR_MINOR | Major is established by functional class of Principal Arterial and above. The lower classes are considered 'Minor'. |
| MSHP_TROOP | Unique identifier assigned to the Highway Patrol Troop (A-I). |
| NUMBER_OF_LANES | Number of lanes per pavement record. |
| OVERLAPPING_IND | Used to indicate if a route is controlling or on an overlapping situation. 'Primary (P)', 'Secondary (S)' or 'Null'. |
| PATCH_INDEX_FLEX | Rating assigned to the amount of patching on asphaltic concrete. |
| PATCH_INDEX_RIGID | Rating assigned to the amount of patching on PCC (Portland Cement Concrete). Ratings are derived from a visual analysis of severity and extent, and a range from 0.0 (worst) to 5.0 (best). |
| PLANNING_ORG | Name of the planning organization that the pavement record resides. |
| PLANNING_ORG_NO | Unique identifier assigned to the planning organization. |
| PLANNING_ORG_TYPE | Type of planning organization such as 'MPO' (Metropolitan Planning Organization) or 'RPC' (Regional Planning Commission). |
| POS_BEGIN | This is a number that represents the location of the beginning point along the arc. It is determined as a percentage with 0 being the beginning of the arc and 100 being the end of the arc. This is necessary to maintain proper log miles during the travelway maintenance. |
| POS_END | This is a number that represents the location of the ending point along the arc. It is determined as a percentage with 0 being the beginning of the arc and 100 being the end of the arc. This is necessary to maintain proper log miles during the travelway maintenance process. |
| PRIOR_COUNTY | Previous county name where the pavement record was located. |
| PSR | A 40-point scale representing overall pavement condition. PSR is developed from ratings of individual distresses and roughness, weighted and combined to form a single value. |

| | |
|---|---|
| RAVEL_INDEX_FLEX | Rating assigned to the amount of raveling on asphaltic concrete. |
| ROADWAY_TYPE_NAME | Name of the roadway type for the pavement record. ***Joins with* ROADWAY_TYPE** |
| RUT_DEPTH | Displacement of material in a wheel path measured as the difference in elevation of both sides less the elevation of the displaced area with 0.0 (worst) to 5.0 (best). |
| RUT_INDEX | Number assigned to average rutting based on average rut depth. |
| SHAPE | This column allows the data to be drawn in ArcGIS without having to create a route event. |
| SHOULDER_TYPE | Name of the type of material from which the shoulder is constructed. |
| SHOULDER_WIDTH | The width of the shoulder surface measured in feet. |
| SPALL_INDEX_RIGID | Rating assigned to amount of spalling on PCC (Portland Cement Concrete). Ratings are derived from a visual analysis of severity and extent and range from 0.0 (worst) to 5.0 (best). Spalling is the loss of pieces of concrete pavement from the surface of along the edges of cracks and joints. |
| SS_PAVEMENT_ID | Unique identifier assigned to the pavement record. |
| STATE_BRIDGE_ID | Unique identifier assigned to a state bridges. |
| STATE_SYSTEM_CLASS | Describes how a travelway is classified by the Missouri Dept. of Transportation. Valid values are as follows: ‘INTERSTATE’, ‘PRIMARY’, ‘SUPPLEMENTARY’, or ‘NOT ON SYSTEM’. |
| SUBAREA_LOCATION | The maintenance subarea where the pavement record is located. |
| SURFACE_DATE | Date that the pavement surface was laid. |
| SURFACE_TYPE | The name of the type of material from which the pavement surface is constructed. |
| THROUGH_LANES | A lane that continues to the next segment without any right or left handed turns. |
| TMA_NON_TMA | This is the Transportation Management Area with populations over 250,000 (for example, Kansas City or St. Louis). |
| TOTAL_AADT | The volume for both sides of a travelway added together (divided and undivided). |
| TRACKER_CONDITION | The three tracker measures are ‘GOOD’, ‘NOT GOOD’, and ‘NA’. This represents whether the segment of road is considered good for the tracker. |

| | |
|---|---|
| TRAVELWAY_DESG | This is the designation of the route. The designation helps identify the route and determine its hierarchy. |
| TRAVELWAY_DIR | This field indicates the direction from the nearest intersecting street, roadway or landmark. |
| TRAVELWAY_ID | This is a unique ID that represents a route (for example, IS 70 East has a TRAVELWAY_ID = 19). |
| TRAVELWAY_NAME | The name of the route the pavement record resides on (for example, 'Main St.', '54', or 'AA'). |
| TRAVELWAY_OFST_DIR | The offset direction indicates which direction the outer road resides from the main route it is associated with (for example, IS 70 the outer roads are either north or south of IS 70). |
| TRF_INFO_SEG_DESC | Describes the intersecting street of each traffic segment. |
| TRF_INFO_SEG_ID | Unique sequence number for the traffic segment that each SS_PAVEMENT resides on. |
| TRF_INFO_SEG_SEQ | Unique system generated identifier behind TRF_INFO_SEG_ID. |
| TW_ALIAS_NAME | A name given to a particular part of a travelway granted by the commission or legislature. |
| TW_CNTL_STAT_NAME | Describes the status of a route. |
| TW_DSGN_PVMT_NAME | Indicates the pavement design based on the number of trucks on the roadway. |
| TW_LANE_JOB_NUMBER | Unique identifier assigned to the lane job. |
| TW_OWNER_ID | Describes who owns the travelway. |
| TW_SPEED_LIMIT_CD | The speed limit where the pavement record resides. |
| URBAN_AREA_NAME | Rural (area with population less than 5,000), Urban (area with population 5,000 – 50,000). |
| YEAR | Calendar year the data represents. |

**Table D-1. Mean IRI (in/mi) by year.**

| U.ID. | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1W | 71 | 42 | 41 | 38 | 36 | 38 | 37 | 38 | NA | 134 | 118 | 112 | 126 | 114 | 107 | 119 | 48 | 47 |
| 2S | NA | 87 | 56 | 54 | 60 | 54 | 62 | 58 | NA | 58 | 58 | 57 | 70 | 64 | 72 | 70 | 77 | 67 |
| 3E | NA | NA | 63 | NA | 63 | 58 | 64 | 60 | 60 | 61 | 61 | 62 | 62 | 63 | 63 | 64 | 62 | 63 |
| 4E | NA | NA | 147 | 97 | 62 | 53 | 46 | 44 | 42 | 41 | 41 | 40 | 39 | 37 | 39 | 40 | 36 | 36 |
| 5N | NA | NA | 162 | 60 | 56 | 52 | 52 | 54 | NA | 53 | 62 | 60 | NA | 50 | 63 | 57 | 63 | 55 |
| 5S | NA | NA | 128 | 60 | 57 | 52 | 52 | 53 | NA | 51 | 57 | 60 | 53 | 52 | 59 | 55 | 61 | 55 |
| 6N | NA | NA | NA | 119 | 117 | 142 | 118 | 157 | NA | 116 | 132 | 117 | 119 | 120 | 118 | 120 | 117 | 114 |
| 6S | NA | NA | NA | 110 | 143 | 107 | 146 | 105 | 106 | 107 | 110 | 108 | 105 | 106 | 109 | 107 | 104 | 107 |
| 7E | NA | NA | NA | NA | 78 | 74 | 70 | 67 | NA | 72 | 66 | 68 | 74 | 71 | 71 | 74 | 69 | NA |
| 7W | NA | NA | NA | NA | 46 | 38 | 34 | 34 | NA | 39 | 36 | 35 | 37 | 39 | 46 | 51 | 54 | NA |
| 8E | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 37 |
| 8W | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 81 |
| 9E | NA | NA | NA | NA | 57 | 46 | 42 | 40 | NA | 45 | 45 | 44 | 46 | 53 | 53 | 57 | 67 | 50 |
| 10E | NA | NA | NA | NA | 86 | 58 | 52 | 48 | NA | 49 | 50 | 48 | 53 | 51 | 49 | 51 | NA | 45 |
| 11E | NA | NA | NA | NA | NA | 81 | 77 | 75 | NA | 78 | 80 | 76 | 78 | 79 | 83 | 86 | 79 | 61 |
| 12E | NA | NA | NA | NA | NA | 74 | 69 | 68 | NA | 77 | 80 | 76 | 79 | 83 | 86 | 89 | 90 | 51 |
| 13W | NA | NA | NA | NA | NA | 136 | NA | 65 | 65 | 63 | 68 | 63 | 65 | 71 | 72 | 77 | 75 | 94 |
| 14S | NA | NA | NA | NA | NA | NA | 89 | 58 | NA | 61 | 60 | 58 | 66 | 70 | 65 | 67 | 59 | 61 |
| 15E | NA | NA | NA | NA | NA | NA | 116 | 116 | NA | 69 | 68 | 68 | 69 | 71 | 72 | 73 | 77 | 79 |
| 15W | NA | NA | NA | NA | NA | NA | 115 | 114 | NA | 68 | 69 | 72 | 79 | 75 | 78 | 79 | NA | 87 |
| 16N | NA | NA | NA | NA | NA | NA | NA | NA | NA | 64 | 68 | 67 | 70 | 71 | 66 | 66 | 63 | 68 |
| 17W | NA | NA | NA | NA | NA | NA | NA | NA | NA | 69 | 73 | 77 | NA | 83 | 77 | 79 | 75 | 82 |
| 18N | NA | NA | NA | NA | NA | NA | NA | NA | NA | 61 | 49 | 43 | 44 | 46 | 45 | 40 | 35 | 37 |
| 19N | NA | NA | NA | NA | NA | NA | NA | NA | NA | 62 | 50 | 45 | 42 | 39 | 46 | 47 | 54 | 38 |
| 20N | NA | NA | NA | NA | NA | NA | NA | NA | NA | 72 | 71 | 69 | 72 | 71 | 71 | 73 | 89 | 91 |
| 20S | NA | NA | NA | NA | NA | NA | NA | NA | NA | 52 | 51 | 50 | 49 | 48 | 54 | 53 | 53 | 59 |
| 21N | NA | NA | NA | NA | NA | NA | NA | NA | NA | 60 | 44 | 48 | 45 | 38 | 43 | 40 | 42 | 43 |
| 21S | NA | NA | NA | NA | NA | NA | NA | NA | NA | 59 | 52 | 52 | 52 | 50 | 50 | 50 | 42 | 46 |
| 22E | NA | NA | NA | NA | NA | NA | NA | NA | NA | 76 | 84 | 84 | 89 | 83 | 86 | 83 | 80 | 81 |
| 22W | NA | NA | NA | NA | NA | NA | NA | NA | NA | 82 | 82 | 86 | 89 | 83 | 87 | 83 | 82 | 84 |
| 23W | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 61 | 59 | 58 | 59 | 58 | 59 | 47 | 50 |
| 24N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 42 | 40 | 39 |
| 25N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 25S | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 26N | NA | NA | NA | NA | NA | 77 | 72 | 74 | NA | 97 | 100 | 109 | NA | NA | NA | NA | NA | NA |
| 26S | NA | NA | NA | NA | NA | 74 | 77 | 73 | NA | 95 | 110 | 111 | NA | NA | NA | NA | NA | NA |
| 27S | NA | NA | NA | NA | NA | NA | NA | 196 | 90 | 96 | 119 | 95 | 98 | NA | 103 | 100 | 87 | NA |

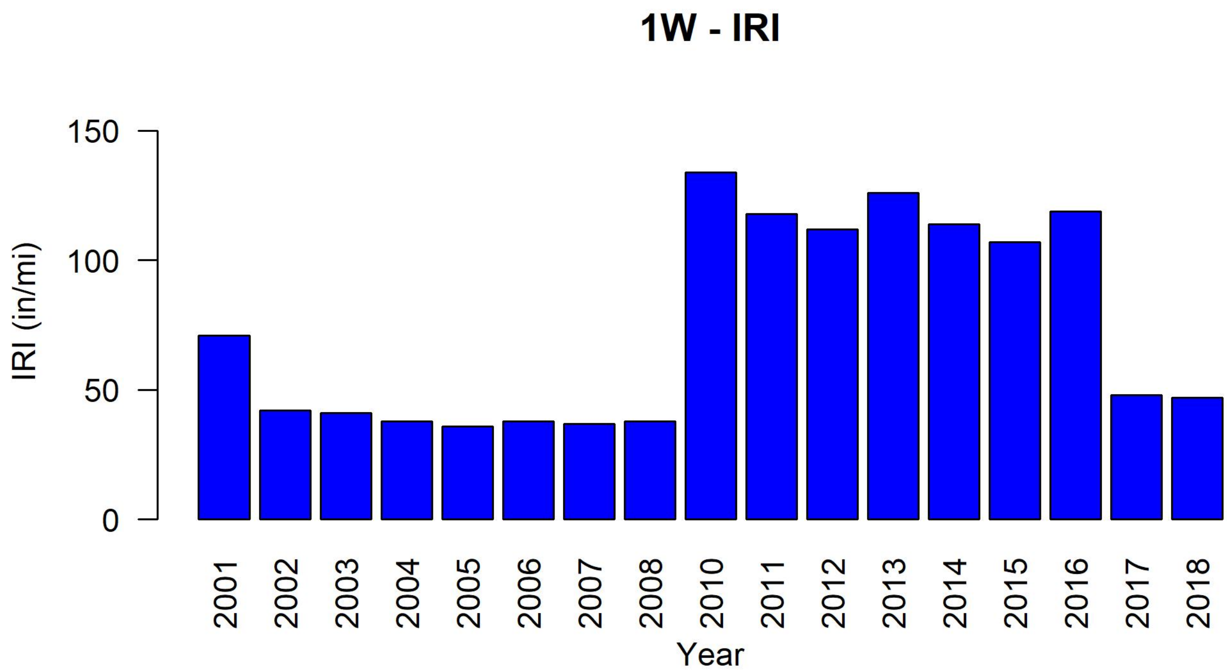
| U.ID. | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27N | NA | NA | NA | NA | NA | NA | NA | 204 | 81 | NA | NA | NA | NA | 98 | NA | NA | NA | 90 |
| 28S | NA | NA | NA | NA | NA | NA | NA | NA | NA | 85 | 87 | 92 | 95 | NA | 96 | 109 | 105 | 105 |
| 28N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 128 | NA | NA | NA | NA |
| 29E | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 73 | 75 | 82 | 93 | 94 | 88 | 75 | NA |
| 30N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 145 | 52 | 54 | 50 | 47 | 43 |
| 30S | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 31S | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 225 | NA | 230 | 349 | 284 |
| 32W | NA | NA | NA | NA | NA | NA | 194 | 191 | NA | 183 | NA | 185 | 225 | 191 | 197 | 265 | NA | 199 |
| 33E | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 134 | 59 | NA |
| 33W | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 160 | 95 |
| 33S | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 150 | 56 | 60 |
| 33N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 34E | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 213 | NA | NA | NA | 220 | 224 |
| 34W | NA | NA | NA | NA | NA | NA | NA | NA | NA | 182 | 232 | NA | NA | 185 | 196 | 206 | NA | NA |
| 34S | NA | NA | NA | NA | NA | NA | NA | NA | NA | 206 | NA | NA | NA | NA | NA | 145 | NA | NA |
| 34N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 249 | NA | 135 | 247 | 167 | NA | NA | 194 |
| 35N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 107 | 71 | 71 | 71 | 67 | 72 |
| 35S | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 117 | 67 | 70 | 68 | 65 | 72 |
| 36S | NA | NA | 93 | 200 | NA | 268 | NA | NA | NA | 123 | 252 | NA | NA | 225 | NA | 236 | 349 | 284 |
| 36N | NA | NA | 71 | 296 | NA | NA | 272 | NA | NA | NA | NA | 259 | 259 | NA | NA | NA | NA | 445 |
| 37S | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 304 |
| 37N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 220 | NA |
| 38N | NA | NA | 251 | 140 | 105 | 272 | 148 | 137 | 156 | 166 | 164 | 181 | 199 | 192 | 205 | 251 | 212 | 237 |
| 38S | NA | NA | 179 | 240 | 208 | 223 | 213 | 226 | 234 | 229 | 209 | 250 | 296 | 256 | 317 | 254 | 295 | 286 |
| 39W | NA | NA | NA | 77 | 142 | NA | 137 | 132 | NA | NA | 142 | 161 | 172 | NA | 204 | 190 | 158 | 168 |
| 39E | 139 | 95 | 137 | NA | NA | 146 | NA | NA | 129 | 137 | NA | NA | NA | 148 | NA | NA | NA | NA |
| 40W | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 95 | 86 | 92 | 104 | 114 | 86 | 91 | 118 |
| 41W | NA | NA | NA | NA | NA | NA | NA | NA | NA | 342 | NA | NA | NA | NA | NA | NA | 320 | NA |
| 41E | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 317 | NA | NA | NA | 346 | NA | NA |

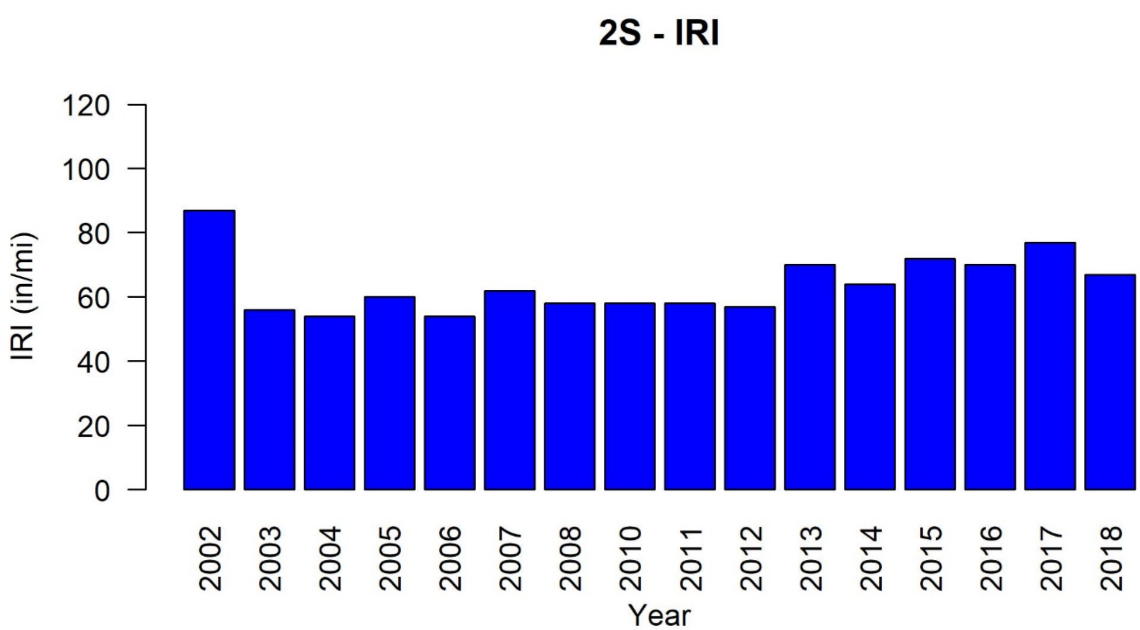
# APPENDIX E—ESAL CALCULATIONS

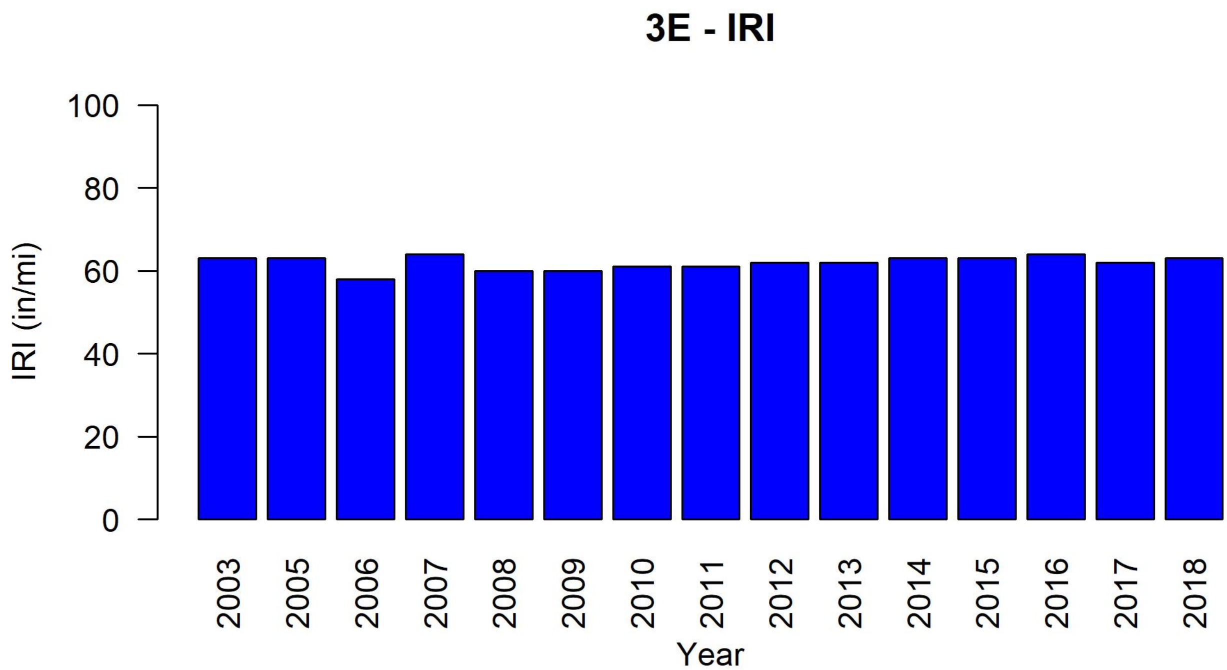
| U.ID. | Twid | Direction | Designation | Route | County | Lanes | Construction Year-0 | Year-n | AADTT at Year 0 | AADTT at Year n | Annual Growth Rate | Growth Factor Year 0-2018 | TF | DL | ESAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1W | 10 | WB | IS | 44 | Webster/ Greene | 2 | 2000 | 2018 | 4535 | 7,156 | 2.43% | 23.79 | 0.75 | 0.90 | 26,576,229 |
| 2S | 13 | SB | IS | 55 | Pemiscot | 2 | 2002 | 2018 | 3067 | 3,753 | 1.19% | 18.73 | 0.75 | 0.90 | 14,148,383 |
| 3E | 1100 | EB | US | 412 | Pemiscot | 2 | 2003 | 2018 | 683 | 847 | 1.36% | 17.74 | 0.60 | 0.90 | 2,386,571 |
| 4E | 1100 | EB | US | 412 | Pemiscot | 2 | 2003 | 2018 | 683 | 953 | 2.11% | 18.79 | 0.60 | 0.90 | 2,528,867 |
| 5N | 6512 | NB | IS | 255 | St. Louis | 3 | 2003 | 2018 | 5222 | 7,764 | 2.51% | 19.40 | 0.75 | 0.70 | 19,408,184 |
| 5S | 6513 | SB | IS | 255 | St. Louis | 3 | 2003 | 2018 | 5221 | 7,626 | 2.40% | 19.22 | 0.75 | 0.70 | 19,233,026 |
| 6N | 6040 | NB | MO | 291 | Jackson | 2 | 2004 | 2018 | 1420 | 1,048 | -2.00% | 13.07 | 0.50 | 0.90 | 3,047,273 |
| 6S | 6041 | SB | MO | 291 | Jackson | 2 | 2004 | 2018 | 1353 | 1,185 | -0.88% | 14.11 | 0.50 | 0.90 | 3,134,842 |
| 7E | 9 | EB | IS | 44 | Lawrence | 2 | 2005 | 2018 | 4434 | 3,575 | -1.53% | 12.69 | 0.75 | 0.90 | 13,865,483 |
| 7W | 10 | WB | IS | 44 | Lawrence | 2 | 2005 | 2018 | 4283 | 5,630 | 1.97% | 15.94 | 0.75 | 0.90 | 16,825,070 |
| 8E | 9 | EB | IS | 44 | Lawrence | 2 | 2018 | 2018 | 3575 | 3,575 | 0.00% | 1.00 | 0.75 | 0.90 | 880,791 |
| 8W | 10 | WB | IS | 44 | Lawrence | 2 | 2018 | 2018 | 5630 | 5,630 | 0.00% | 1.00 | 0.75 | 0.90 | 1,387,091 |
| 9E | 9 | EB | IS | 44 | Crawford | 2 | 2005 | 2018 | 5325 | 4,938 | -0.54% | 13.52 | 0.75 | 0.90 | 17,738,333 |
| 10E | 3560 | EB | US | 36 | Macon | 2 | 2005 | 2018 | 544 | 1,799 | 8.92% | 25.88 | 0.60 | 0.90 | 2,773,336 |
| 11E | 9 | EB | IS | 44 | Laclede | 2 | 2006 | 2018 | 4026 | 3,445 | -1.19% | 12.11 | 0.75 | 0.90 | 12,012,366 |
| 12E | 9 | EB | IS | 44 | Laclede | 2 | 2006 | 2018 | 3972 | 3,709 | -0.53% | 12.60 | 0.75 | 0.90 | 12,328,260 |
| 13W | 1101 | WB | US | 412 | Dunklin | 2 | 2006 | 2018 | 719 | 1,175 | 3.85% | 16.47 | 0.60 | 0.90 | 2,334,411 |
| 14S | 263 | SB | IS | 57 | Mississippi | 2 | 2007 | 2018 | 3391 | 3,902 | 1.18% | 12.81 | 0.75 | 0.90 | 10,701,049 |
| 15E | 6372 | EB | IS | 64 | St. Louis/ St. Louis City | 4 | 2007 | 2018 | 8939 | 9,977 | 0.92% | 12.63 | 0.75 | 0.60 | 18,537,898 |
| 15W | 6373 | WB | IS | 64 | St. Louis/ St. Louis City | 4 | 2007 | 2018 | 8939 | 12,126 | 2.57% | 13.85 | 0.75 | 0.60 | 20,339,221 |
| 16N | 264 | NB | IS | 57 | Mississippi | 2 | 2009 | 2018 | 2941 | 2,617 | -1.16% | 9.49 | 0.75 | 0.90 | 6,878,989 |
| 17W | 10 | WB | IS | 44 | Phelps | 2 | 2009 | 2018 | 3636 | 6,014 | 5.16% | 12.67 | 0.75 | 0.90 | 11,351,269 |
| 18N | 12 | NB | IS | 55 | Cape/Perry | 2 | 2010 | 2018 | 1753 | 1,815 | 0.39% | 9.14 | 0.75 | 0.90 | 3,947,766 |
| 19N | 12 | NB | IS | 55 | Pemiscot | 2 | 2010 | 2018 | 4871 | 4,067 | -1.98% | 8.32 | 0.75 | 0.90 | 9,981,999 |
| 20N | 4984 | NB | IS | 35 | Clinton | 2 | 2010 | 2018 | 2861 | 3,333 | 1.71% | 9.64 | 0.75 | 0.90 | 6,795,634 |
| 20S | 4986 | SB | IS | 35 | Clinton | 2 | 2010 | 2018 | 3578 | 4,686 | 3.04% | 10.18 | 0.75 | 0.90 | 8,971,126 |
| 21N | 4984 | NB | IS | 35 | Clay | 2 | 2010 | 2018 | 3897 | 4,091 | 0.54% | 9.20 | 0.75 | 0.90 | 8,830,726 |
| 21S | 4986 | SB | IS | 35 | Clay | 2 | 2010 | 2018 | 4335 | 6,479 | 4.57% | 10.83 | 0.75 | 0.90 | 11,568,619 |
| 22E | 9 | EB | IS | 44 | Franklin | 2 | 2010 | 2018 | 5390 | 5,561 | 0.35% | 9.13 | 0.75 | 0.90 | 12,118,466 |
| 22W | 10 | WB | IS | 44 | Franklin | 2 | 2010 | 2018 | 4698 | 7,470 | 5.29% | 11.16 | 0.75 | 0.90 | 12,915,563 |
| 23W | 10 | WB | IS | 44 | Pulaski | 2 | 2011 | 2018 | 5824 | 4,783 | -2.43% | 7.35 | 0.75 | 0.90 | 10,548,205 |
| 24N | 12 | NB | IS | 55 | Pemiscot | 2 | 2015 | 2018 | 5158 | 4,865 | -1.45% | 3.91 | 0.75 | 0.90 | 4,973,554 |
| 26N | 4984 | NB | IS | I-35 | Daviess | 2 | 2006 | 2018 | 2515 | 1,735 | -2.81% | 11.02 | 0.75 | 0.90 | 6,824,510 |
| 26S | 4986 | SB | IS | I-35 | Daviess | 2 | 2006 | 2018 | 2607 | 1,852 | -2.60% | 11.16 | 0.75 | 0.90 | 7,165,333 |
| 27N | 6103 | NB | RT | D | Cass | 1 | 2008 | 2018 | 203 | 317 | 4.12% | 13.57 | 0.50 | 1.00 | 502,792 |
| 27S | 6102 | SB | RT | D | Cass | 1 | 2008 | 2017 | 203 | 336 | 5.17% | 14.33 | 0.50 | 1.00 | 530,974 |

| U.I.D. | Twid | Direction | Designation | Route | County | Lanes | Construction Year-0 | Year-n | AADTT at Year 0 | AADTT at Year n | Annual Growth Rate | Growth Factor Year 0-2018 | TF | DL | ESAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28N | 7773 | NB | US | 61 | Jefferson/ Ste. Genevieve | 1 | 2012 | 2014 | 144 | 198 | 11.20% | 9.84 | 0.60 | 1.00 | 310,420 |
| 28S | 11 | SB | US | 61 | Jefferson/ Ste. Genevieve | 1 | 2012 | 2018 | 108 | 187 | 8.16% | 8.97 | 0.60 | 1.00 | 212,077 |
| 29E | 3560 | EB | US | 36 | Shelby/Marion | 2 | 2010 | 2017 | 1248 | 1,343 | 0.93% | 9.34 | 0.60 | 0.90 | 2,296,733 |
| 30N | 6365 | NB | MO | 79 | Marion/Ralls | 1 | 2013 | 2018 | 166 | 133 | -3.57% | 5.49 | 0.50 | 1.00 | 166,290 |
| 31S | 1975 | SB | MO | 5 | Laclede | 2 | 2012 | 2018 | 1525 | 1,523 | -0.02% | 7.00 | 0.50 | 0.90 | 1,752,383 |
| 32W | 6142 | WB | MO | 340 | St. Louis | 2 | 2006 | 2018 | 909 | 906 | -0.03% | 12.98 | 0.50 | 0.90 | 1,937,984 |
| 33E | 1100 | EB | US | 412 | Dunklin | 2 | 2012 | 2017 | 1131 | 1,275 | 2.02% | 7.44 | 0.60 | 0.90 | 1,658,126 |
| 33S | 11 | SB | US | 61 | Scott | 1 | 2012 | 2018 | 187 | 178 | -0.74% | 6.85 | 0.60 | 1.00 | 280,415 |
| 33W | 1101 | WB | US | 412 | Dunklin | 2 | 2012 | 2018 | 1694 | 1,447 | -2.23% | 6.55 | 0.60 | 0.90 | 2,186,778 |
| 34E | 3562 | EB | US | 24 | Randolph | 2 | 2010 | 2018 | 288 | 466 | 5.49% | 11.25 | 0.60 | 0.90 | 638,761 |
| 34N | 3533 | NB | BUS | 63 | Randolph | 2 | 2010 | 2018 | 209 | 114 | -6.49% | 6.99 | 0.50 | 0.90 | 239,229 |
| 34S | 3534 | SB | BUS | 63 | Randolph | 2 | 2010 | 2016 | 209 | 205 | -0.24% | 8.91 | 0.50 | 0.90 | 305,254 |
| 34W | 3563 | WB | US | 24 | Randolph | 2 | 2010 | 2016 | 910 | 329 | -13.53% | 5.39 | 0.60 | 0.90 | 967,470 |
| 35N | 4984 | NB | IS | I-35 | Daviess | 2 | 2013 | 2018 | 1945 | 1,735 | -1.89% | 5.72 | 0.75 | 0.90 | 2,742,880 |
| 35S | 4986 | SB | IS | I-35 | Daviess | 2 | 2013 | 2018 | 2008 | 1,852 | -1.34% | 5.80 | 0.75 | 0.90 | 2,870,262 |
| 36N | 1976 | NB | MO | 5 | Laclede | 2 | 2003 | 2018 | 1667 | 321 | -9.78% | 8.25 | 0.50 | 0.90 | 2,259,710 |
| 36S | 1975 | SB | MO | 5 | Laclede | 2 | 2003 | 2018 | 1002 | 1,523 | 2.65% | 19.61 | 0.50 | 0.90 | 3,227,617 |
| 37N | 55 | NB | MO | 19 | Ralls | 1 | 2012 | 2017 | 509 | 525 | 0.52% | 7.11 | 0.50 | 1.00 | 660,424 |
| 37S | 54 | SB | MO | 19 | Ralls | 1 | 2012 | 2018 | 575 | 598 | 0.56% | 7.12 | 0.50 | 1.00 | 747,061 |
| 38N | 6040 | NB | MO | 291 | Jackson | 2 | 2002 | 2018 | 1344 | 1,988 | 2.33% | 20.57 | 0.50 | 0.90 | 4,540,689 |
| 38S | 6041 | SB | MO | 291 | Jackson | 2 | 2002 | 2018 | 1385 | 3,073 | 4.80% | 25.39 | 0.50 | 0.90 | 5,776,621 |
| 39E | 7782 | EB | US | 60 | Newton | 1 | 1999 | 2014 | 432 | 786 | 3.81% | 29.20 | 0.60 | 1.00 | 2,762,825 |
| 39W | 7783 | WB | US | 60 | Newton | 1 | 1999 | 2018 | 401 | 806 | 3.55% | 28.43 | 0.60 | 1.00 | 2,495,944 |
| 40W | 1029 | WB | MO | 34 | Cape Girardeau | 2 | 2007 | 2018 | 387 | 347 | -0.91% | 11.41 | 0.50 | 0.90 | 726,385 |
| 41E | 1977 | EB | MO | 14 | Christian | 1 | 2008 | 2016 | 224 | 224 | 0.00% | 11.00 | 0.50 | 1.00 | 449,680 |
| 41W | 1978 | WB | MO | 14 | Christian | 1 | 2008 | 2017 | 337 | 305 | -0.99% | 10.47 | 0.50 | 1.00 | 643,927 |

# APPENDIX F—IRI TIME SERIES GRAPHS


1W - IRI
IRI (in/mi)
0
50
100
150
2001
2002
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year


2S - IRI
IRI (in/mi)
0
20
40
60
80
100
120
2002
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year


3E - IRI
IRI (in/mi)
100
80
60
40
20
0
2003
2005
2006
2007
2008
2009
2010
2011
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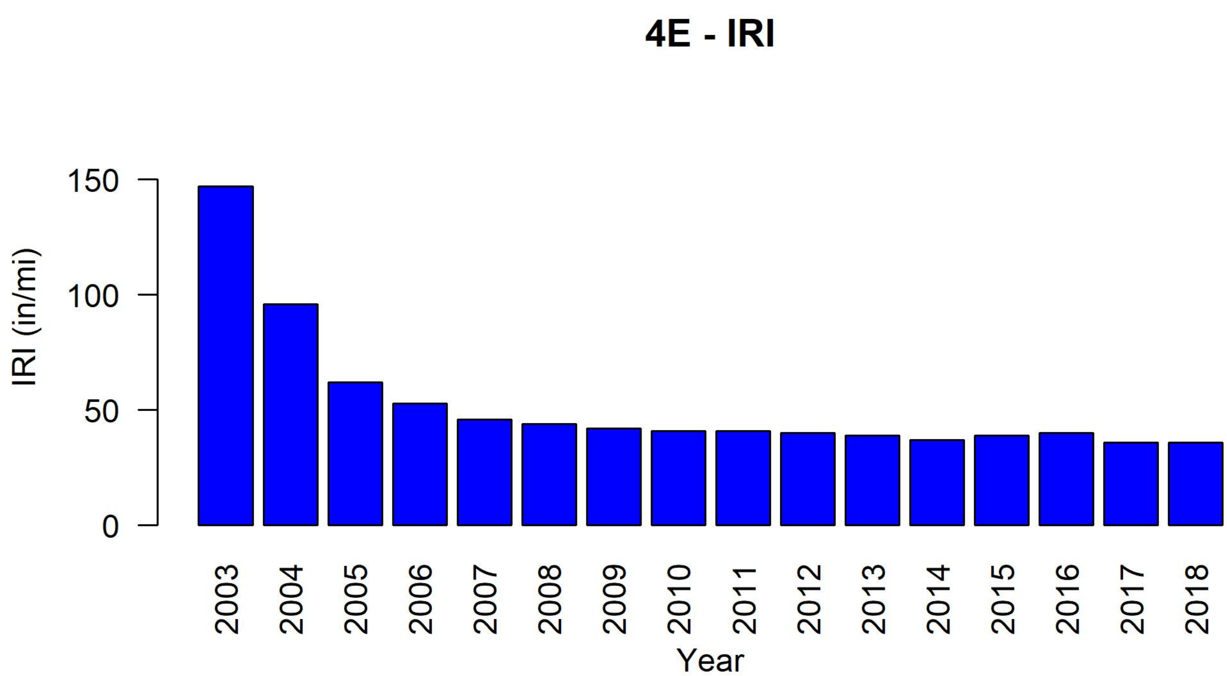
2013
2014
2015
2016
2017
2018
Year


4E - IRI
IRI (in/mi)
150
100
50
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
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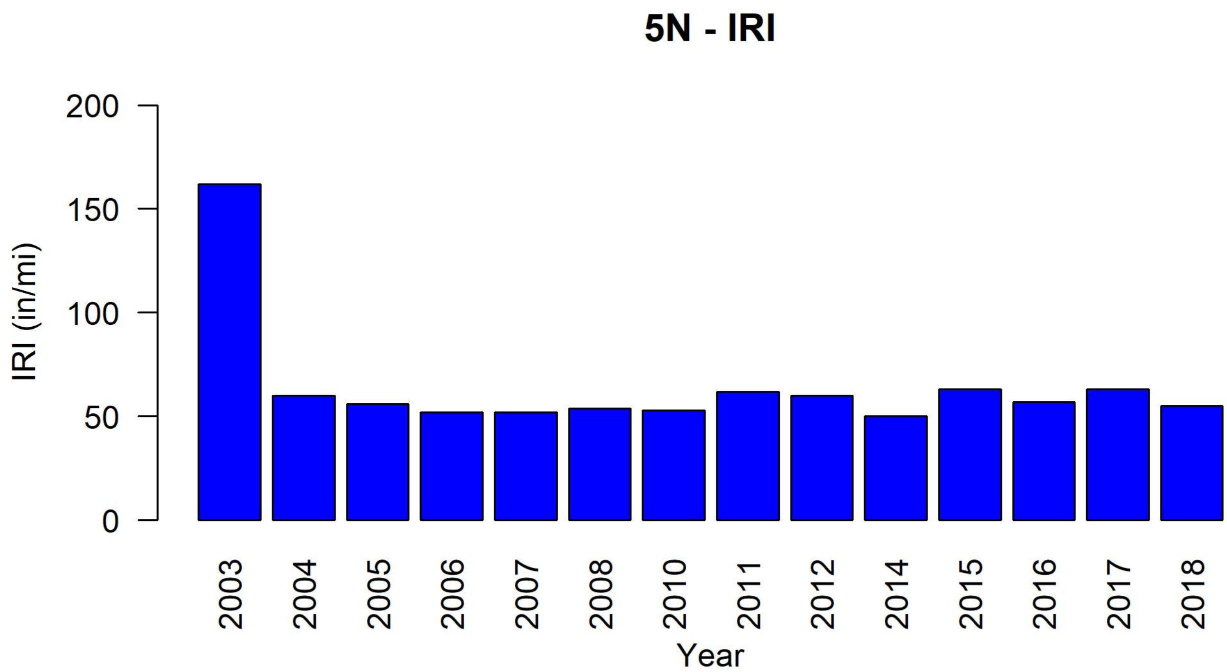
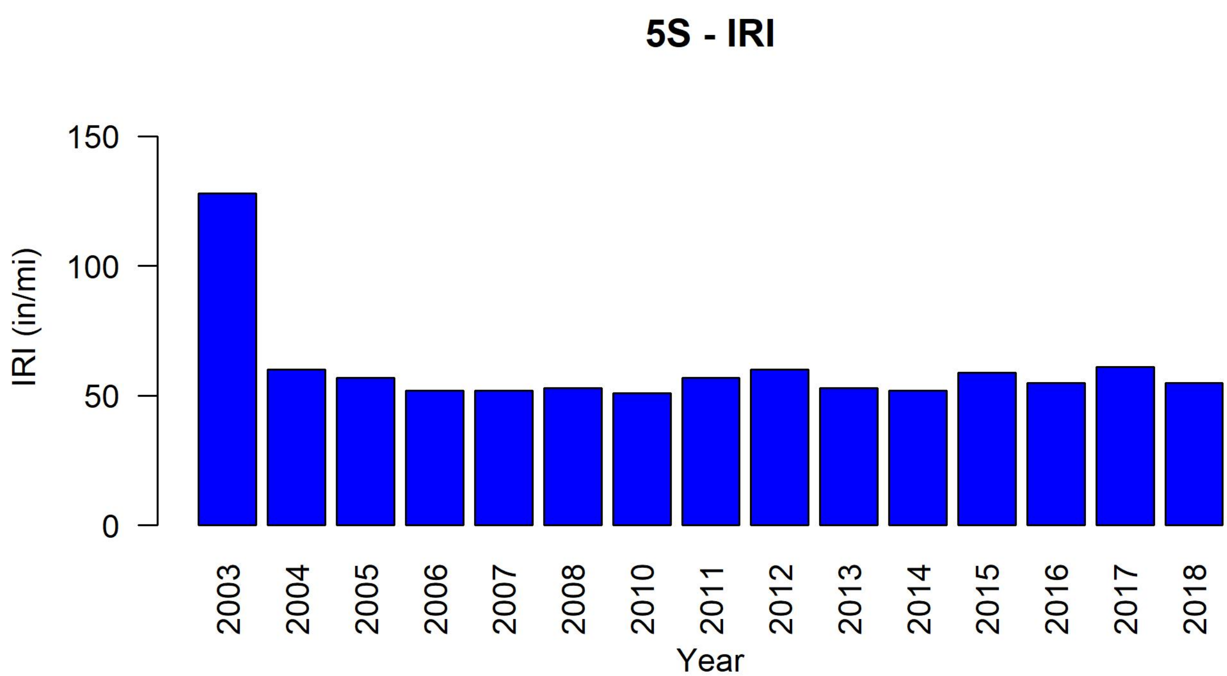
2015
2016
2017
2018
Year


5N - IRI
200
150
100
50
0
IRI (in/mi)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2014
2015
2016
2017
2018
Year


5S - IRI
150
100
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0
IRI (in/mi)
2003
2004
2005
2006
2007
2008
2010
2011
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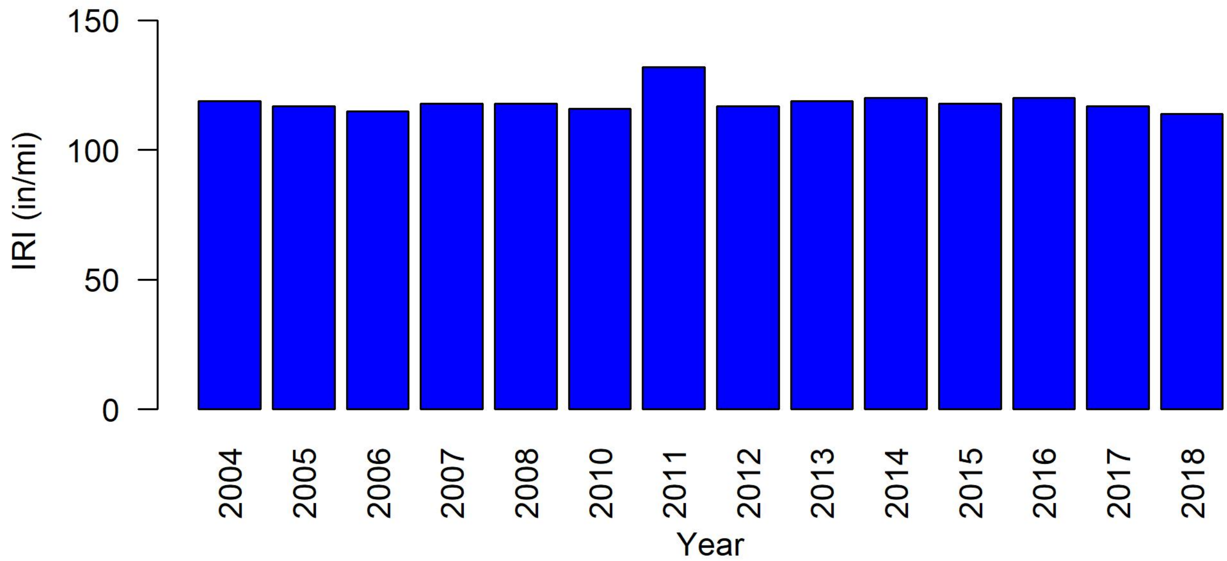
2015
2016
2017
2018
Year

**6N - IRI**


IRI (in/mi)
150
100
50
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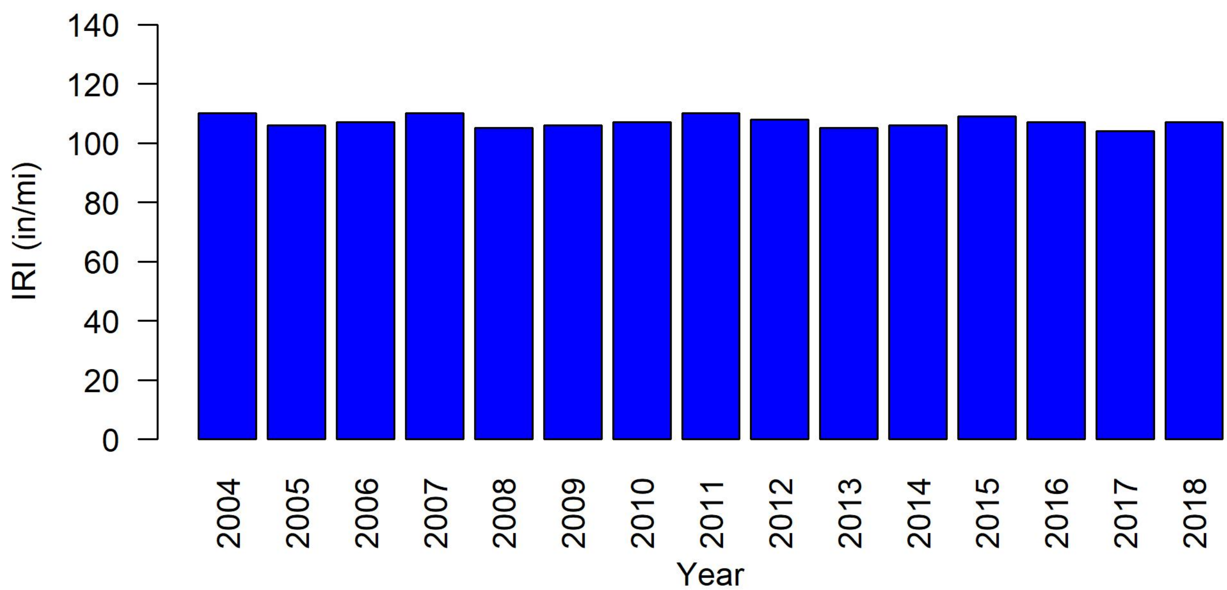
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year

**6S - IRI**


IRI (in/mi)
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120
100
80
60
40
20
0
2004
2005
2006
2007
2008
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2016
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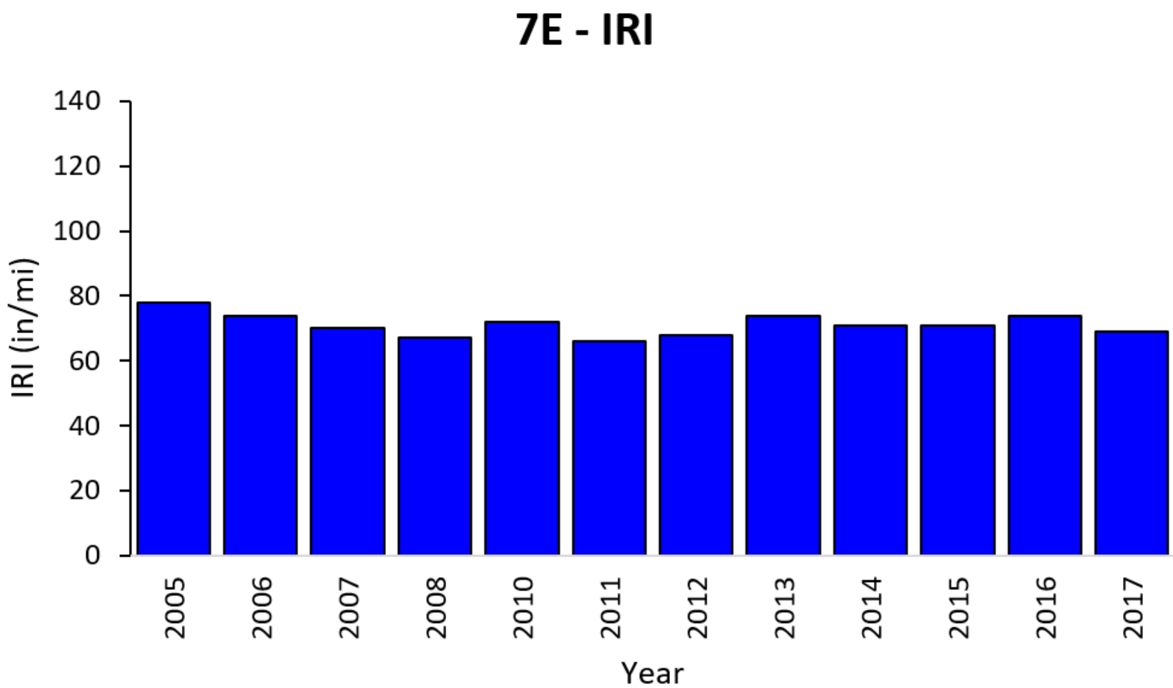
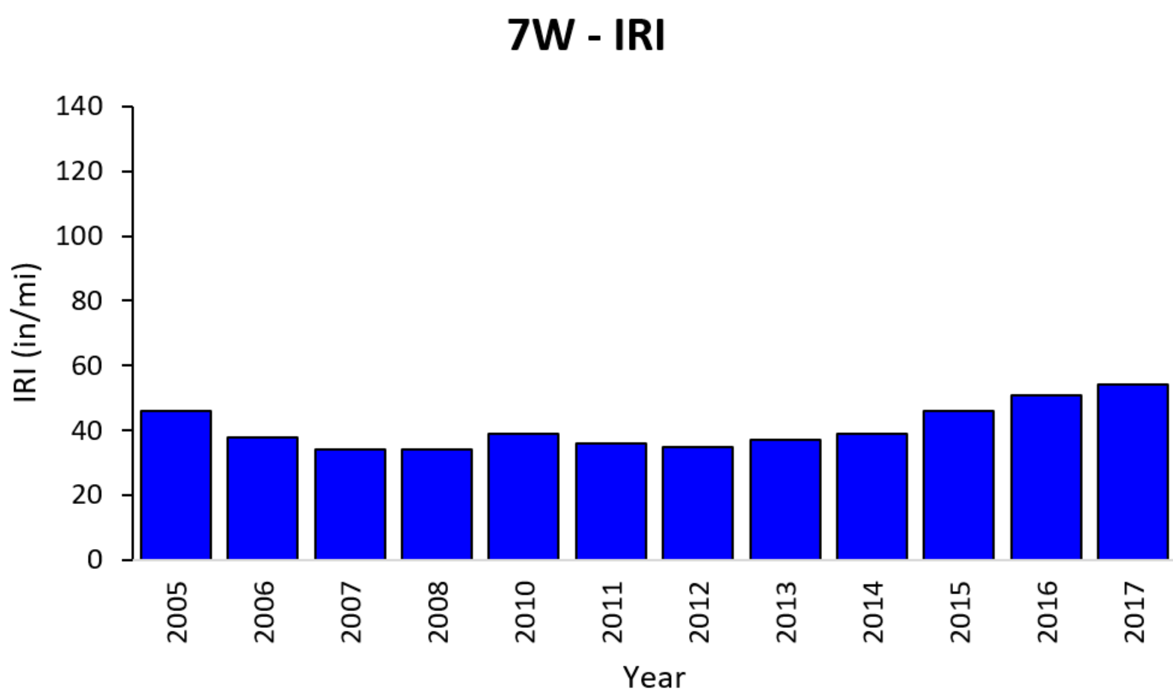
2018
Year


7E - IRI
140
120
100
80
60
40
20
0
IRI (in/mi)
2005
2006
2007
2008
2010
2011
2012
2013
2014
2015
2016
2017
Year


7W - IRI
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IRI (in/mi)
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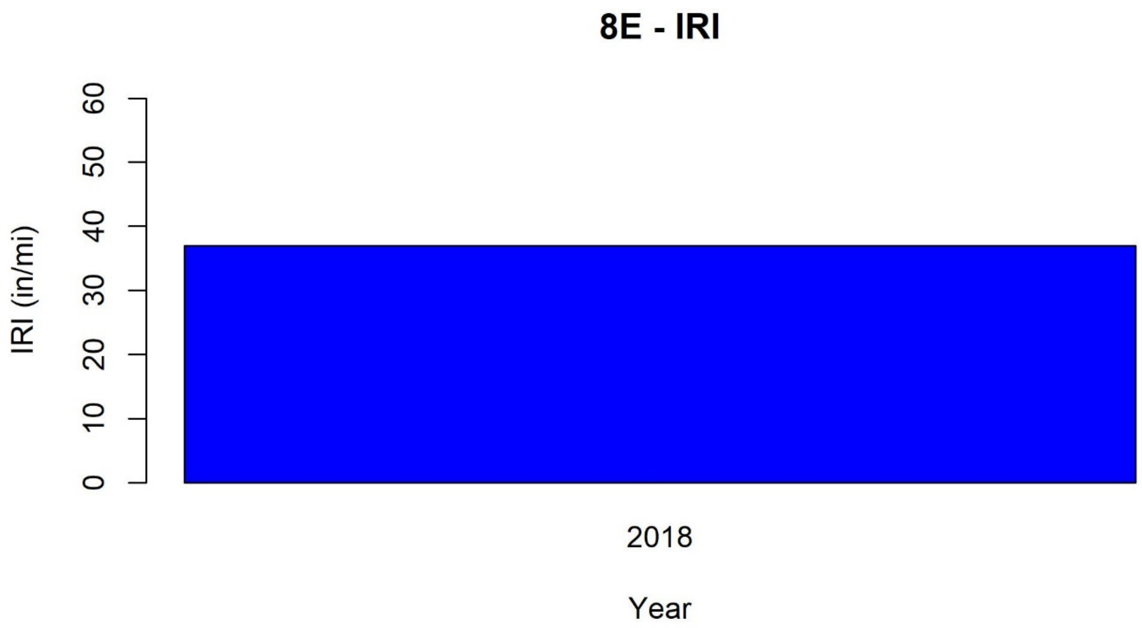
8E - IRI
IRI (in/mi)
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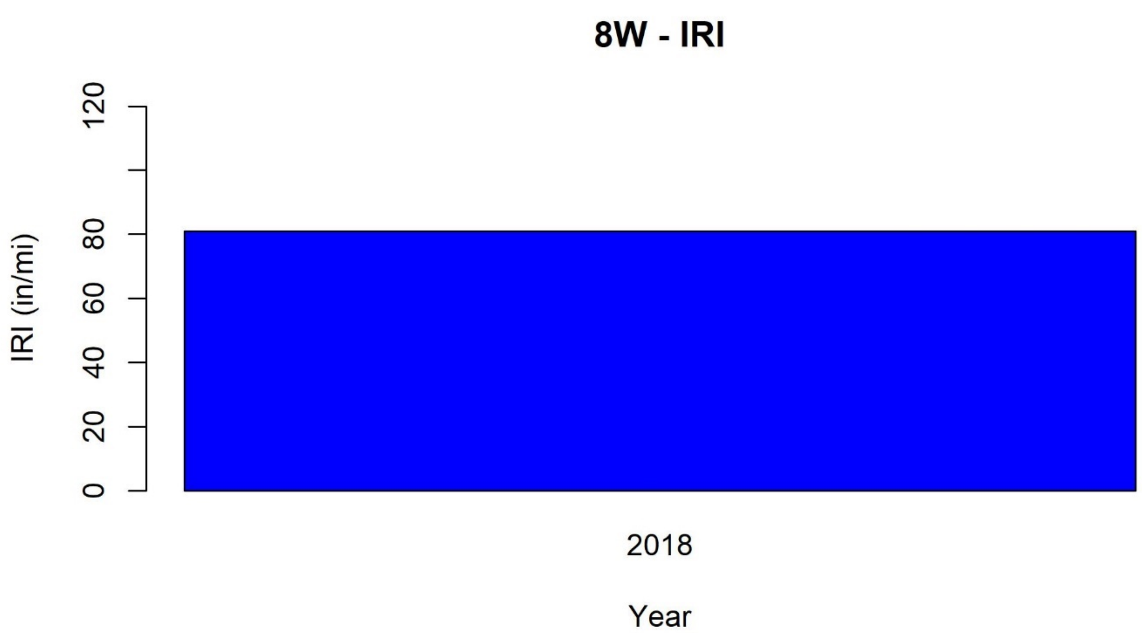
2018
Year


8W - IRI
IRI (in/mi)
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2018
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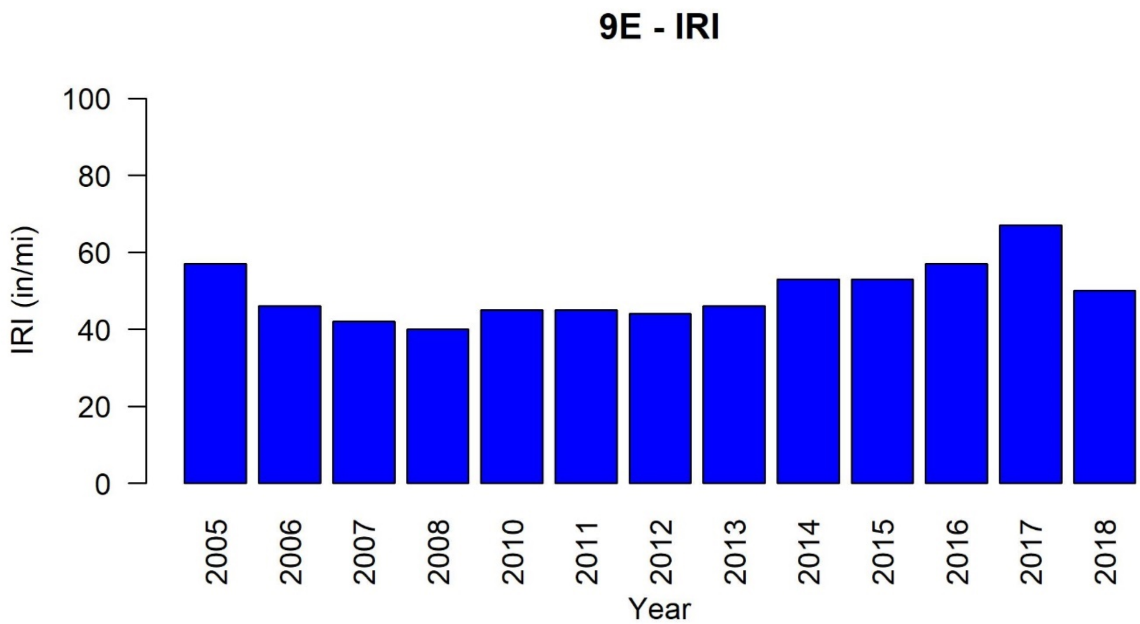
9E - IRI
IRI (in/mi)
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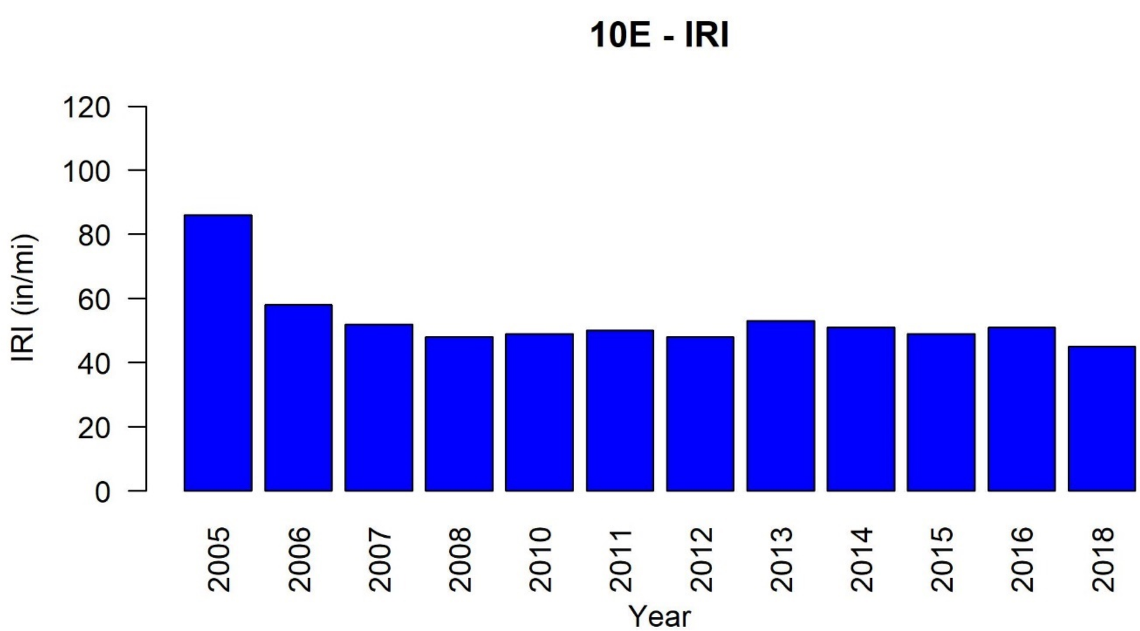
10E - IRI
IRI (in/mi)
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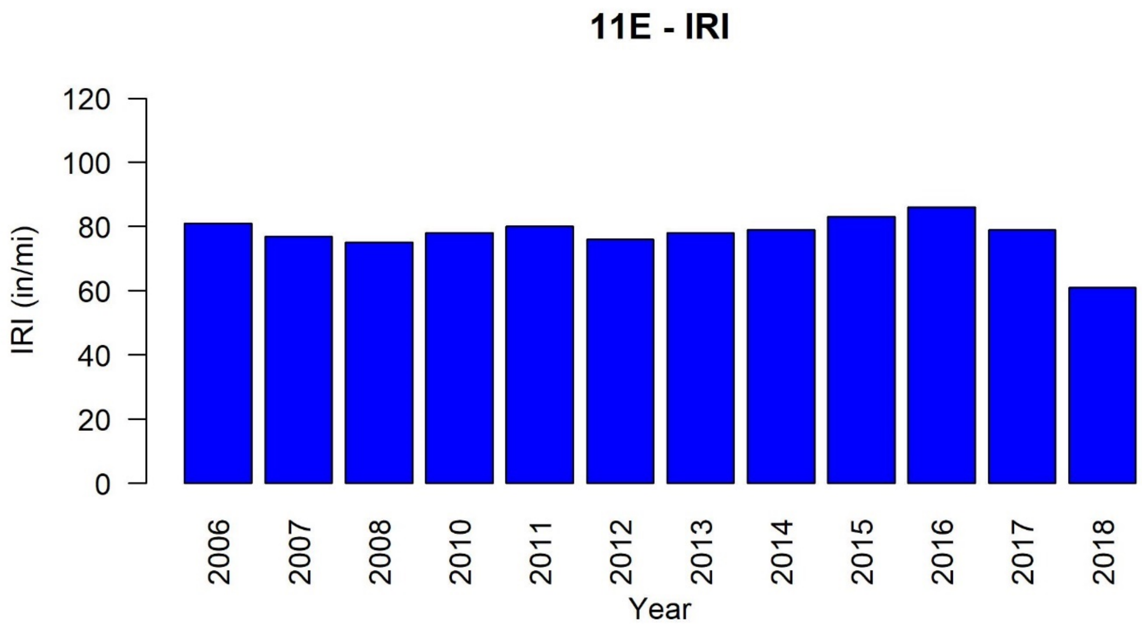
11E - IRI
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IRI (in/mi)
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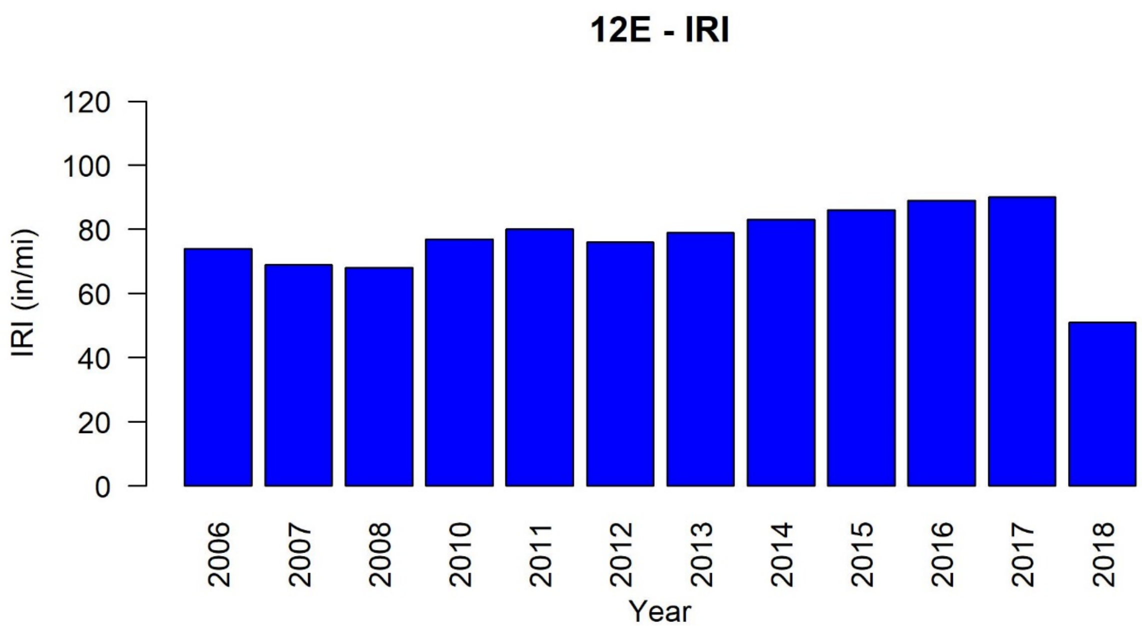
12E - IRI
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IRI (in/mi)
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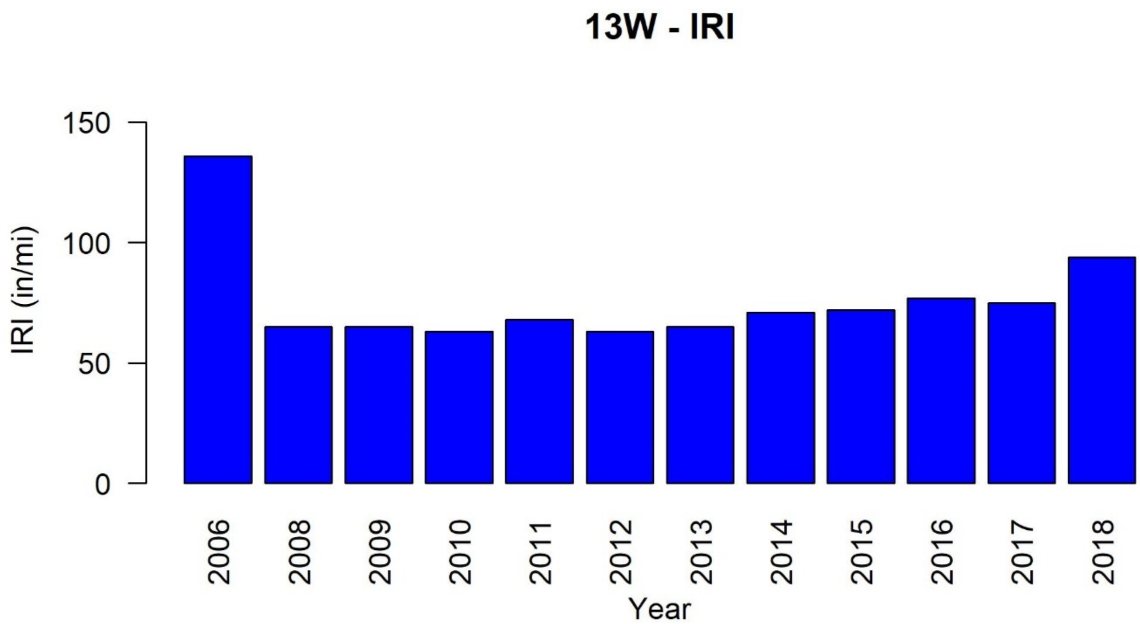
13W - IRI
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IRI (in/mi)
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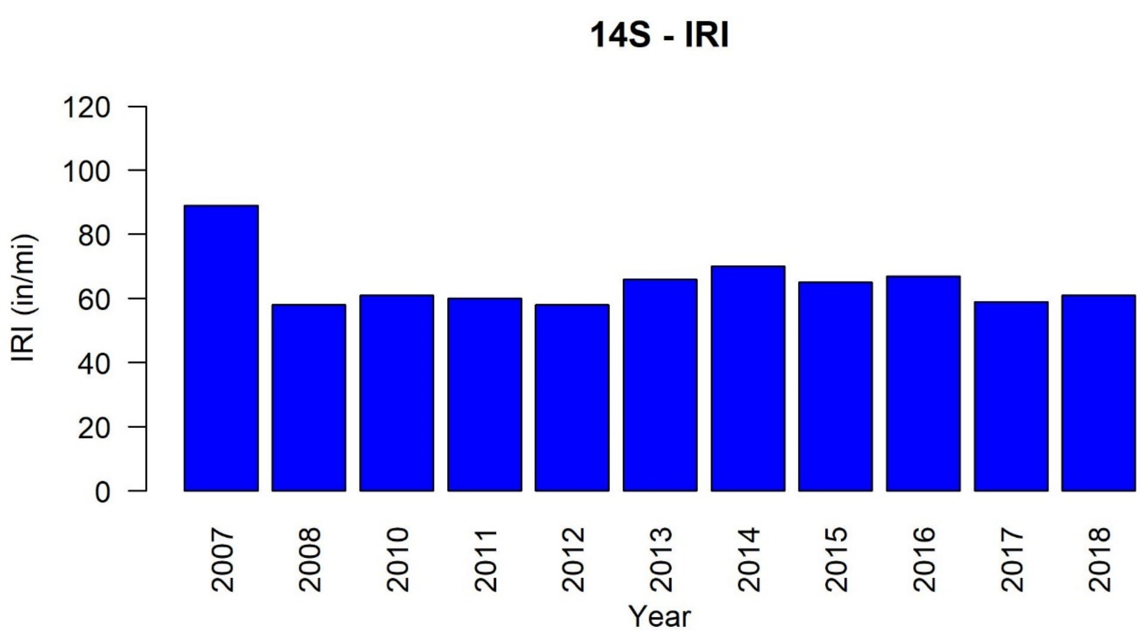
14S - IRI
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IRI (in/mi)
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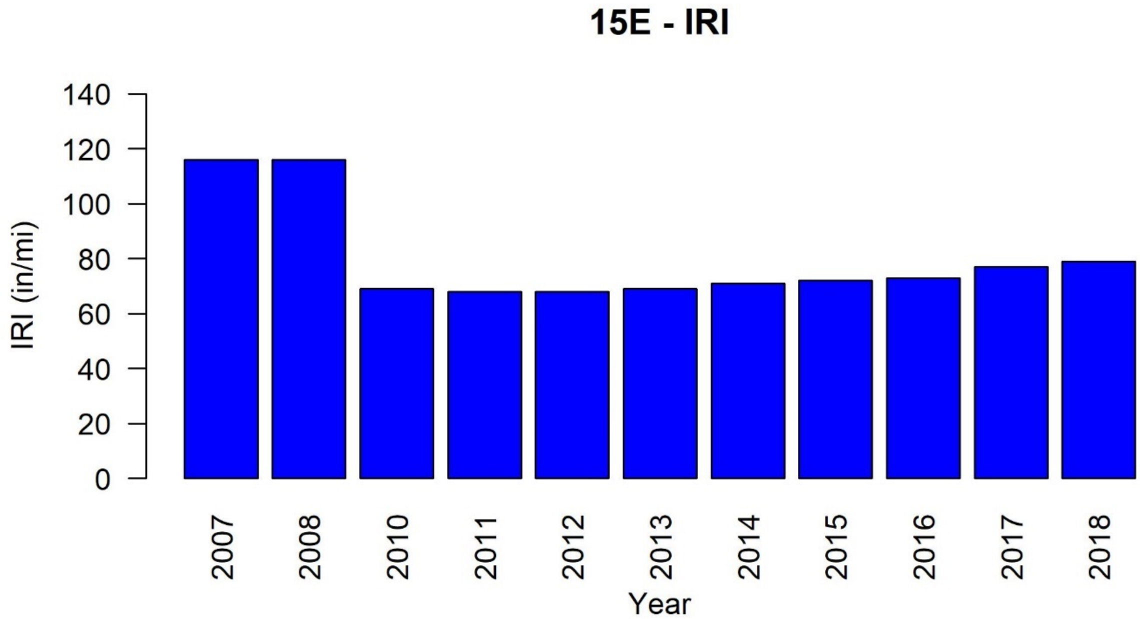
15E - IRI
IRI (in/mi)
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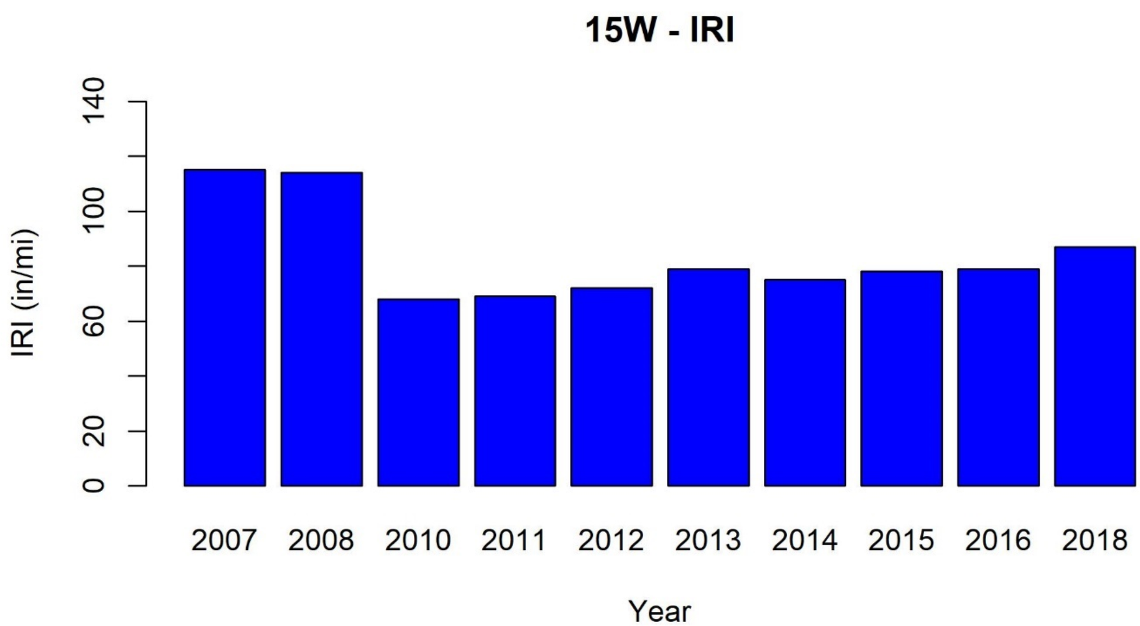
15W - IRI
IRI (in/mi)
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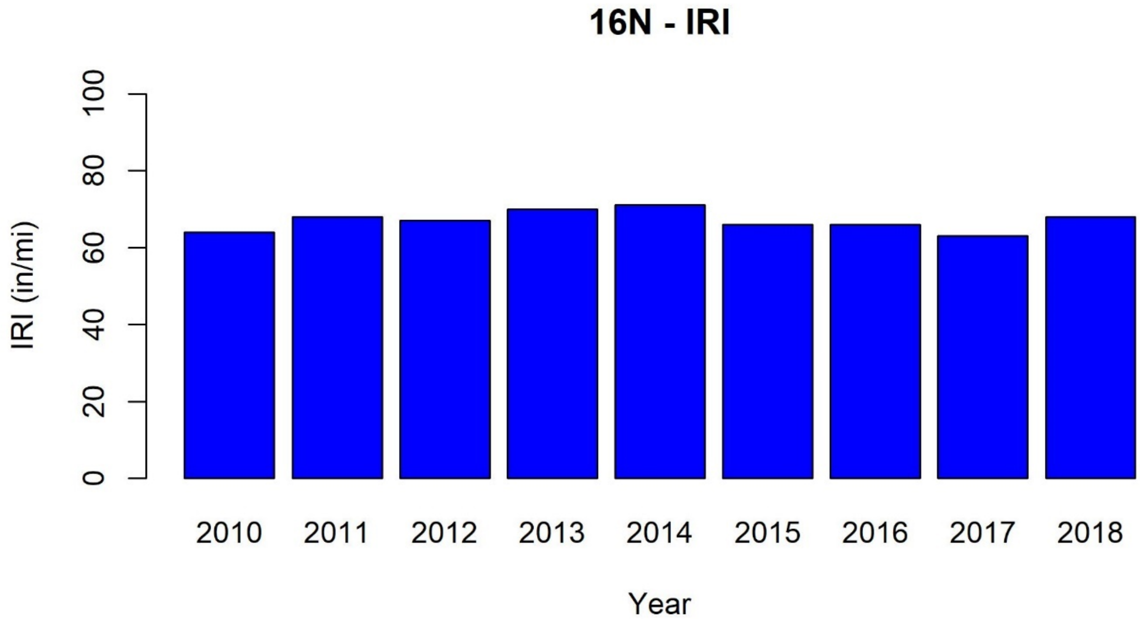
16N - IRI
IRI (in/mi)
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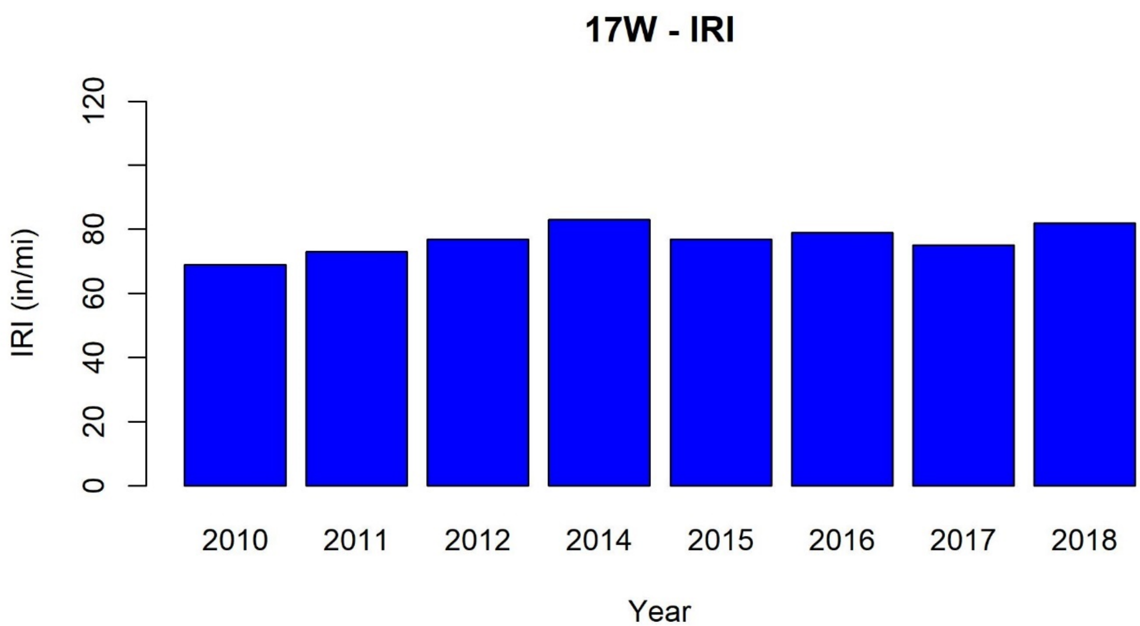
17W - IRI
IRI (in/mi)
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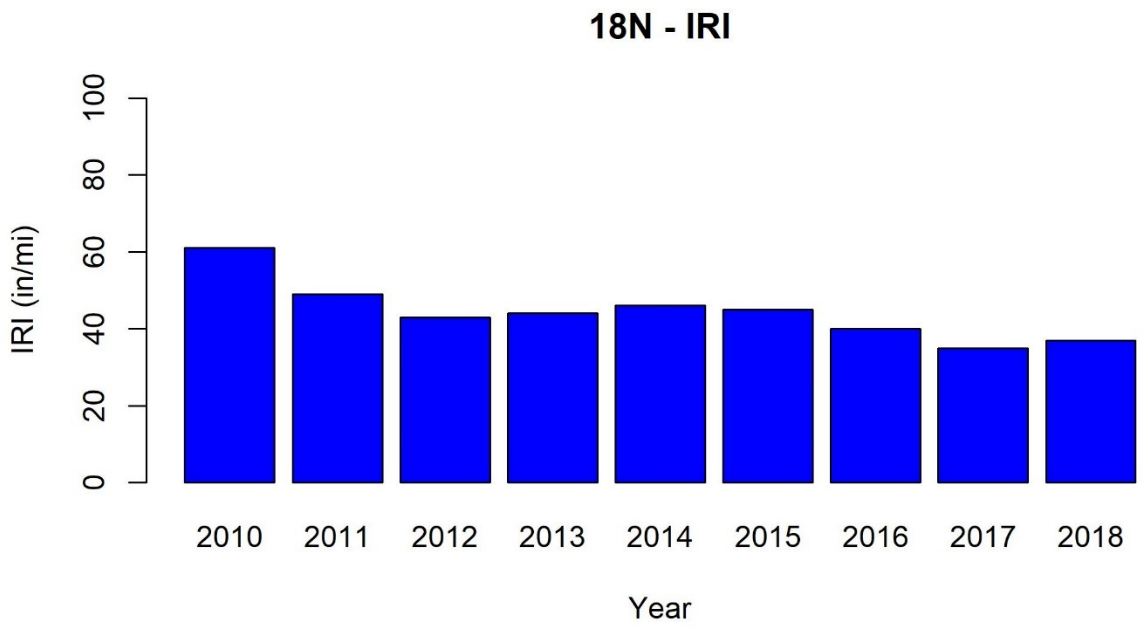
18N - IRI
IRI (in/mi)
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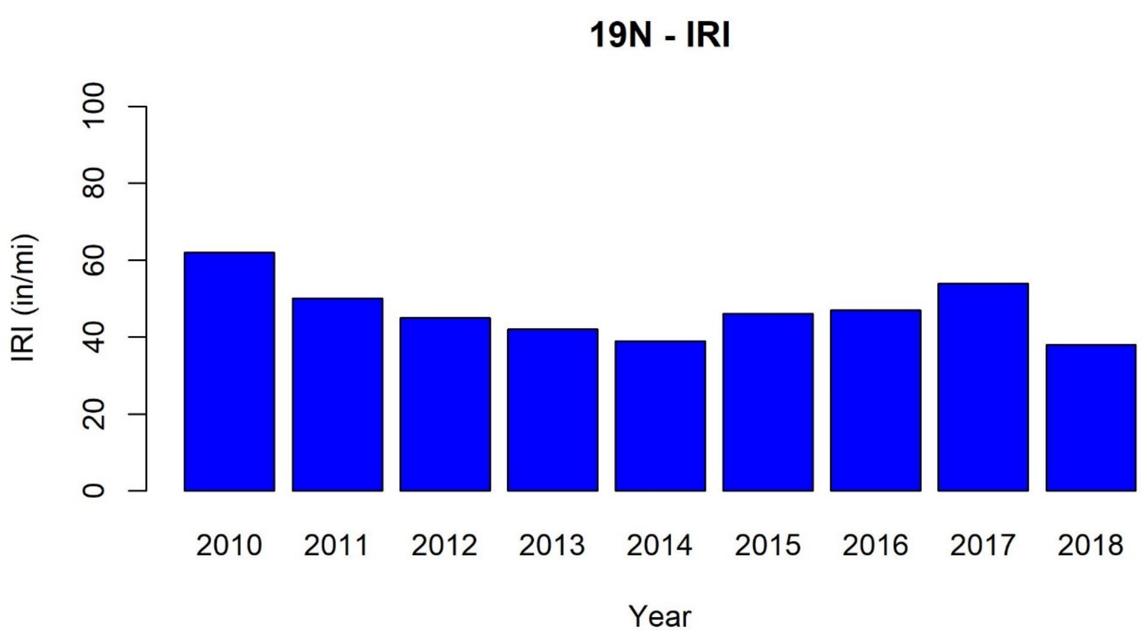
19N - IRI
IRI (in/mi)
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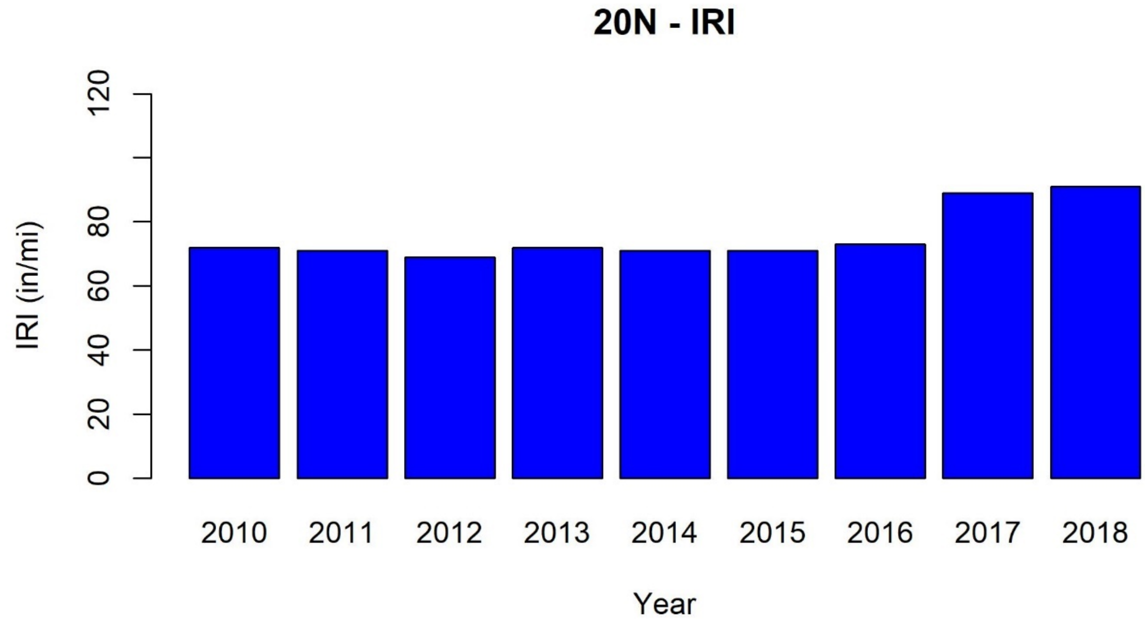
20N - IRI
IRI (in/mi)
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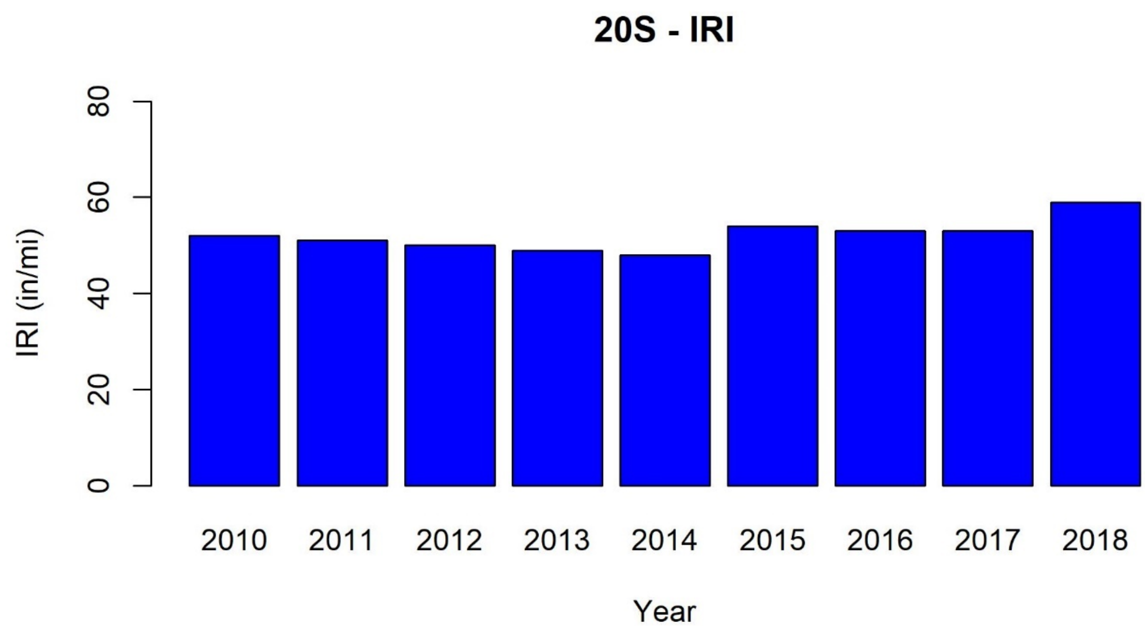
20S - IRI
IRI (in/mi)
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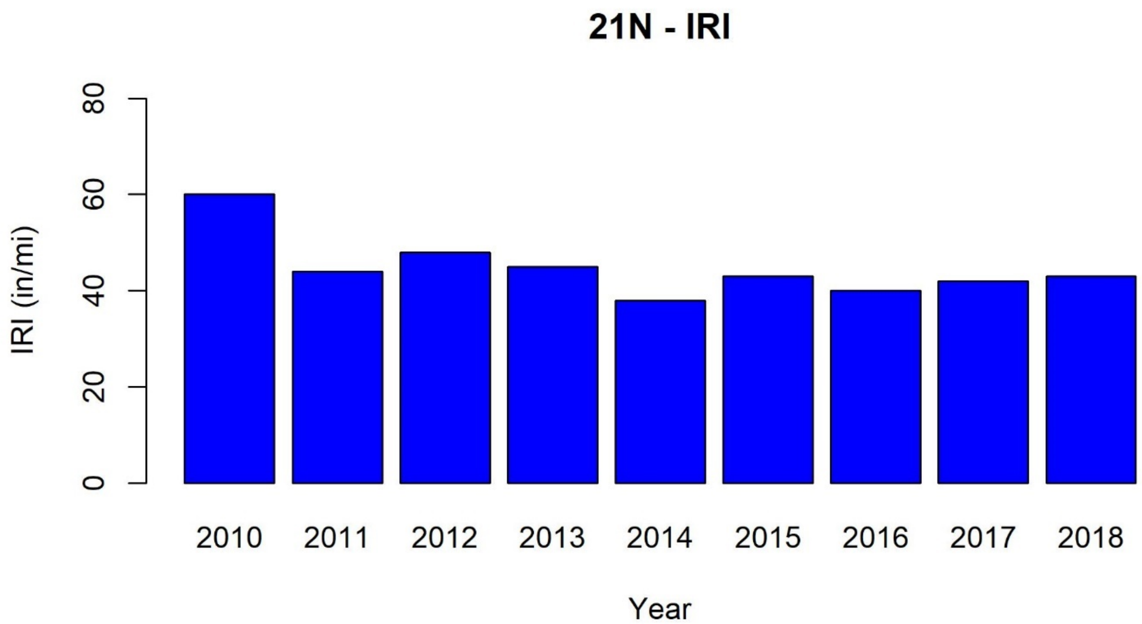
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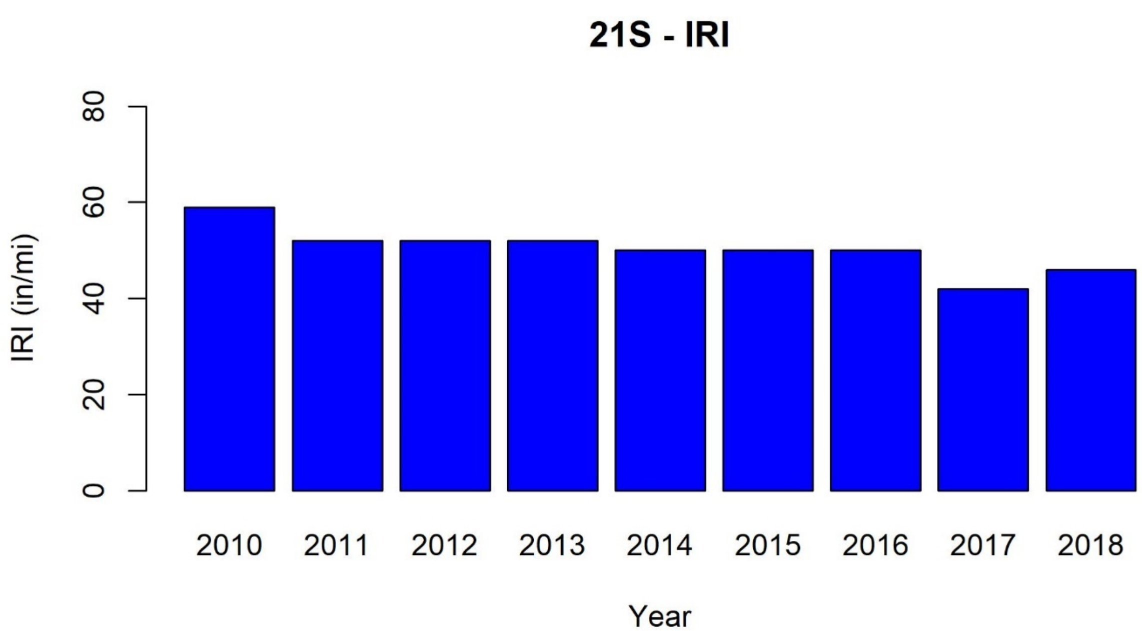
21S - IRI
IRI (in/mi)
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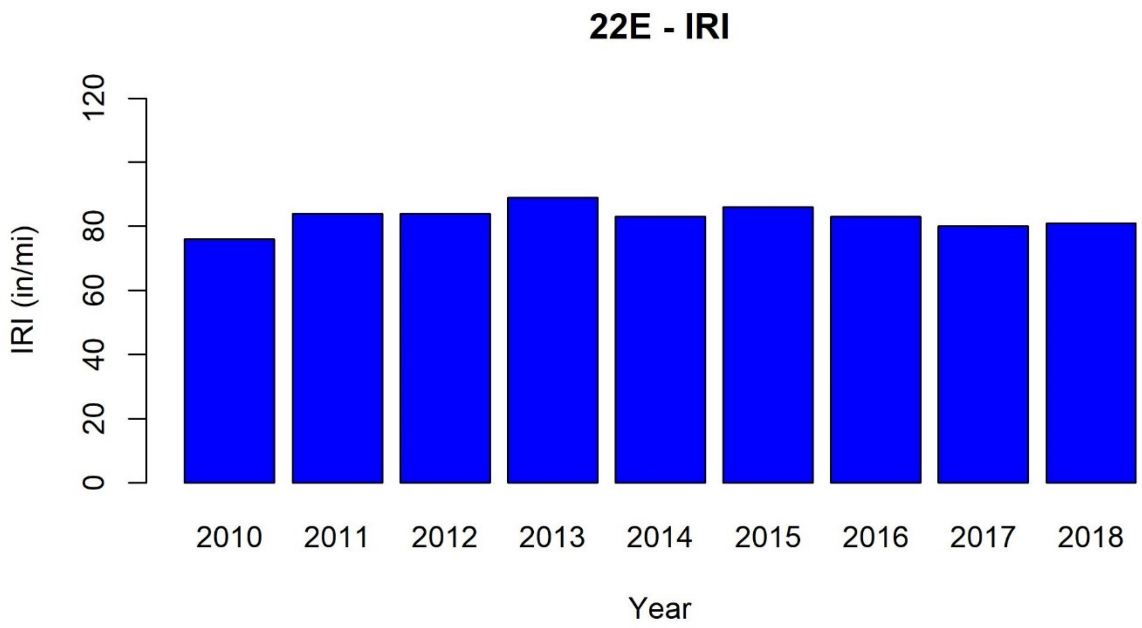
22E - IRI
IRI (in/mi)
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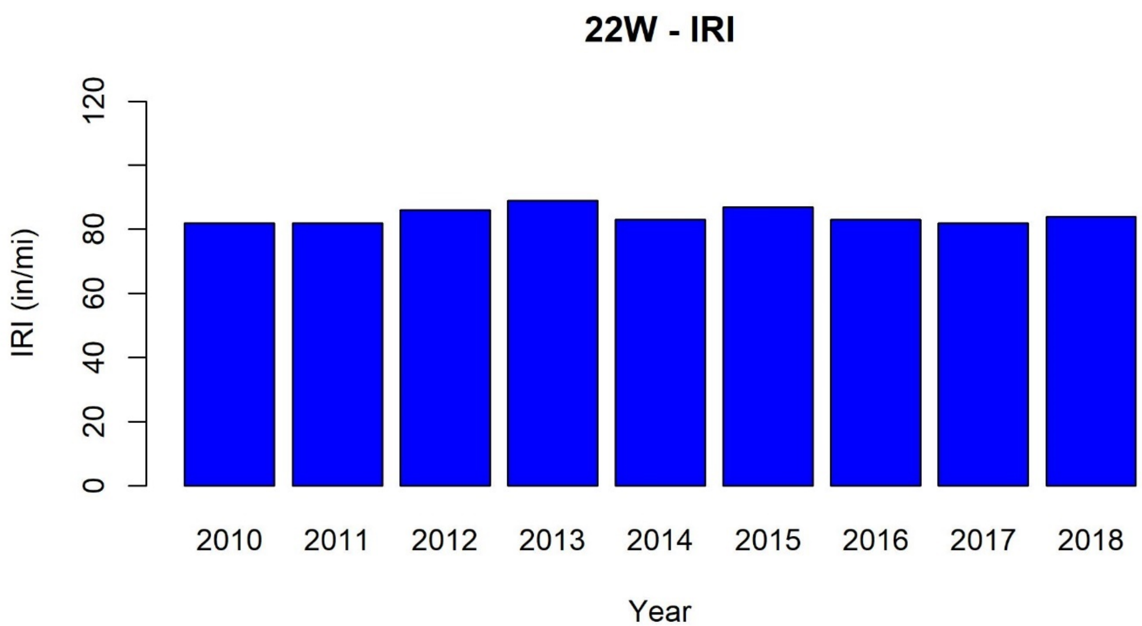
22W - IRI
IRI (in/mi)
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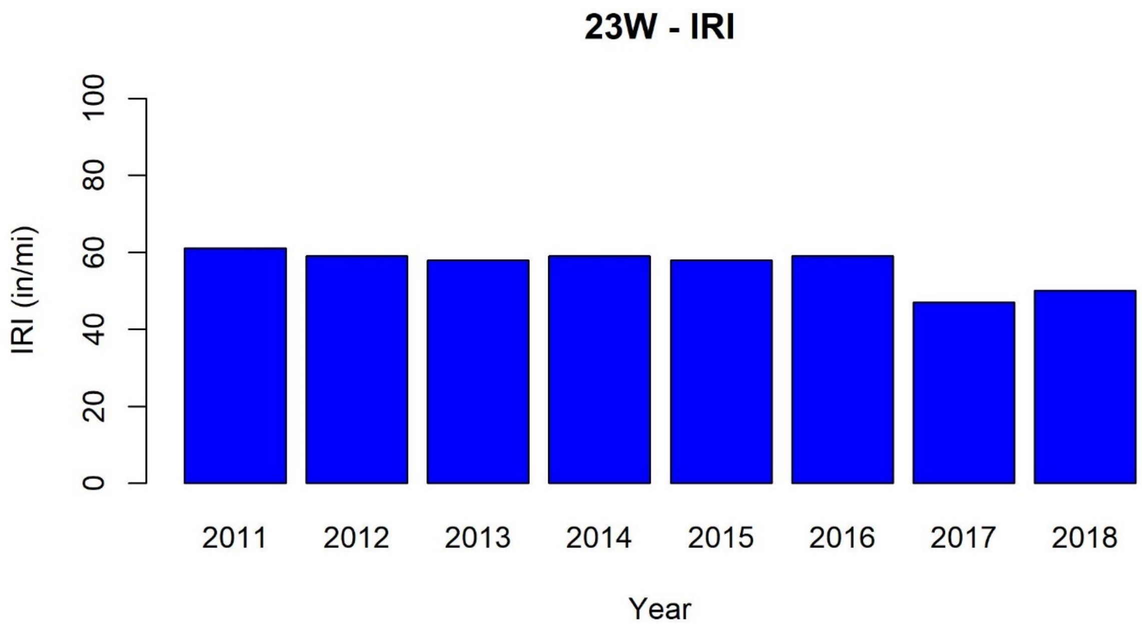
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IRI (in/mi)
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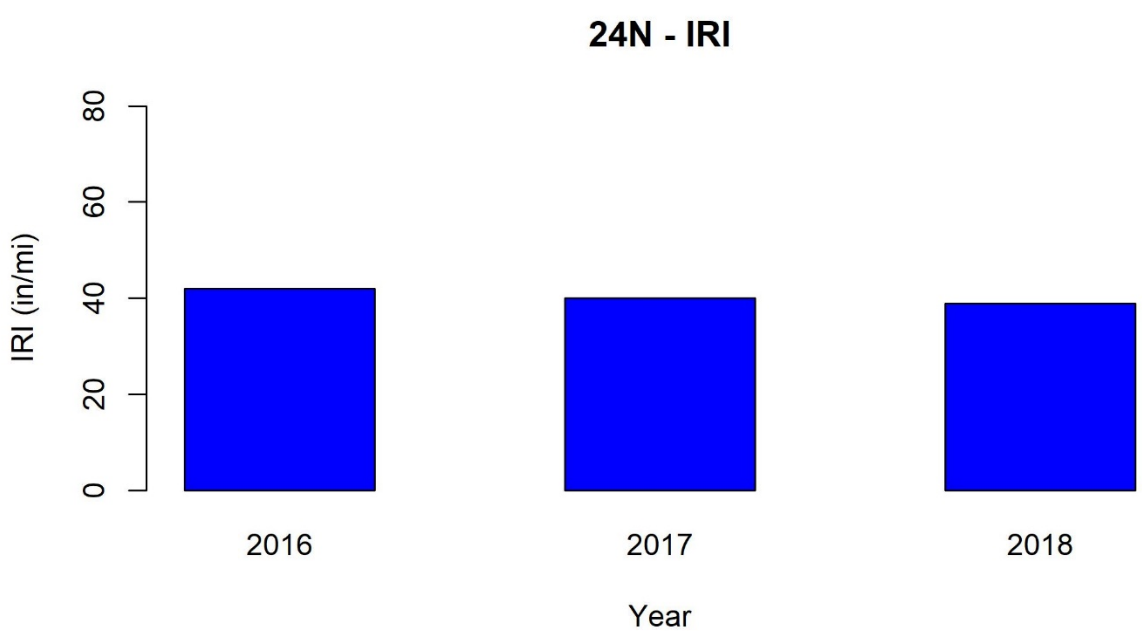
24N - IRI
IRI (in/mi)
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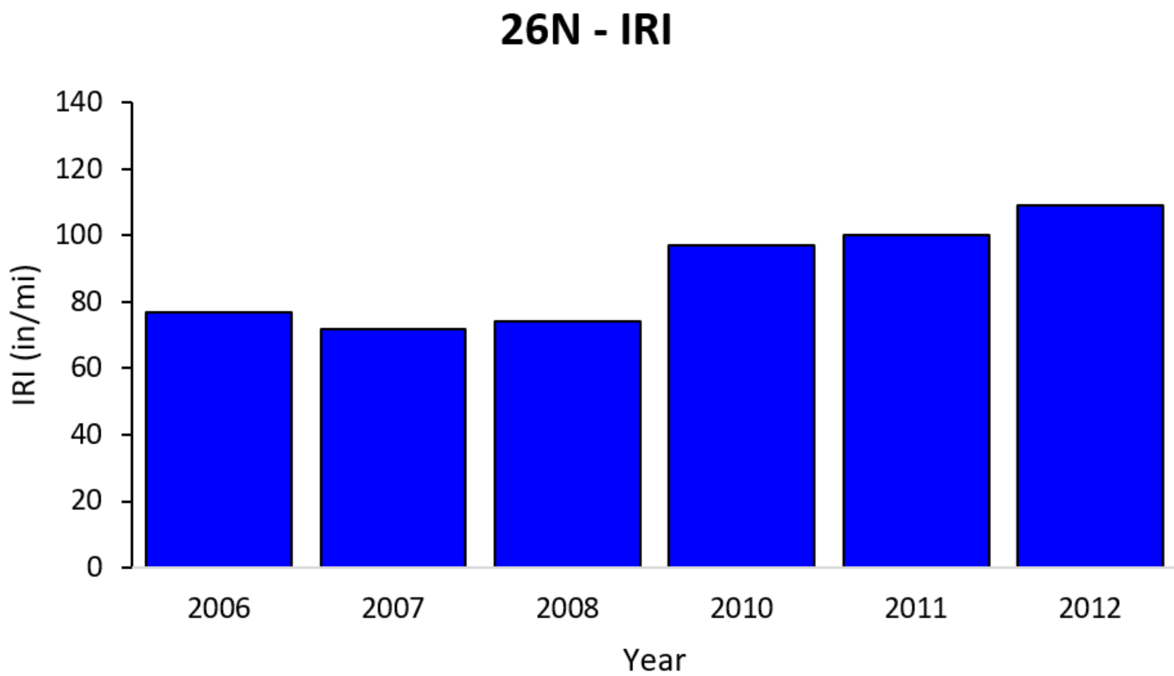
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IRI (in/mi)
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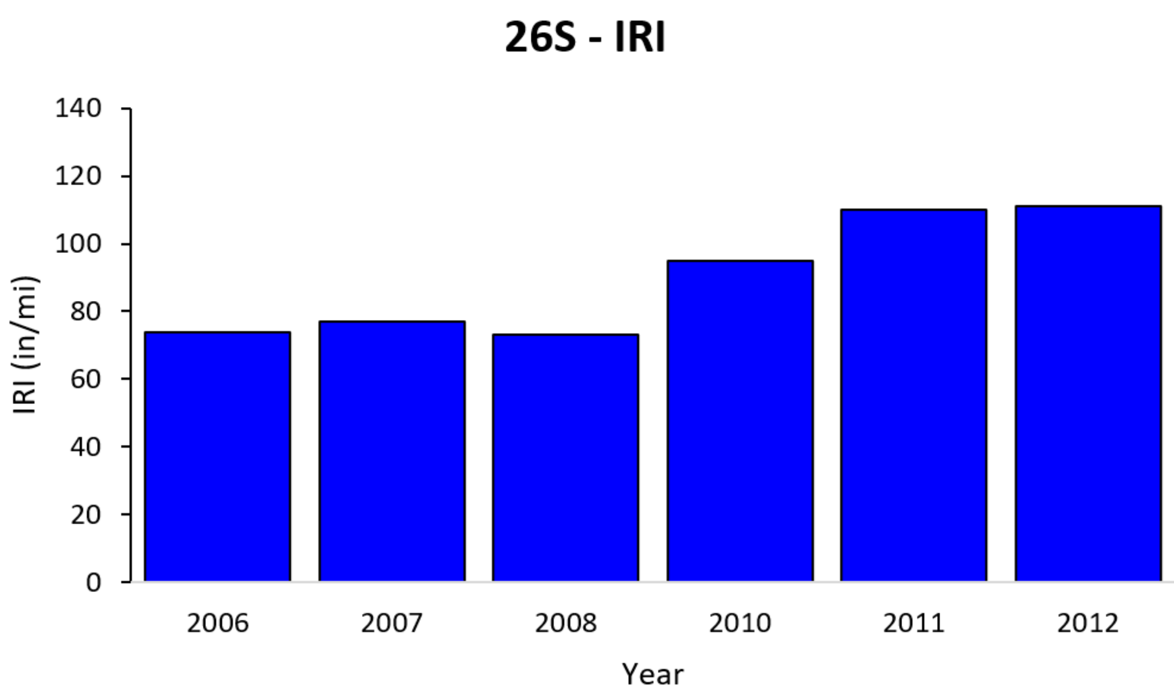
26S - IRI
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IRI (in/mi)
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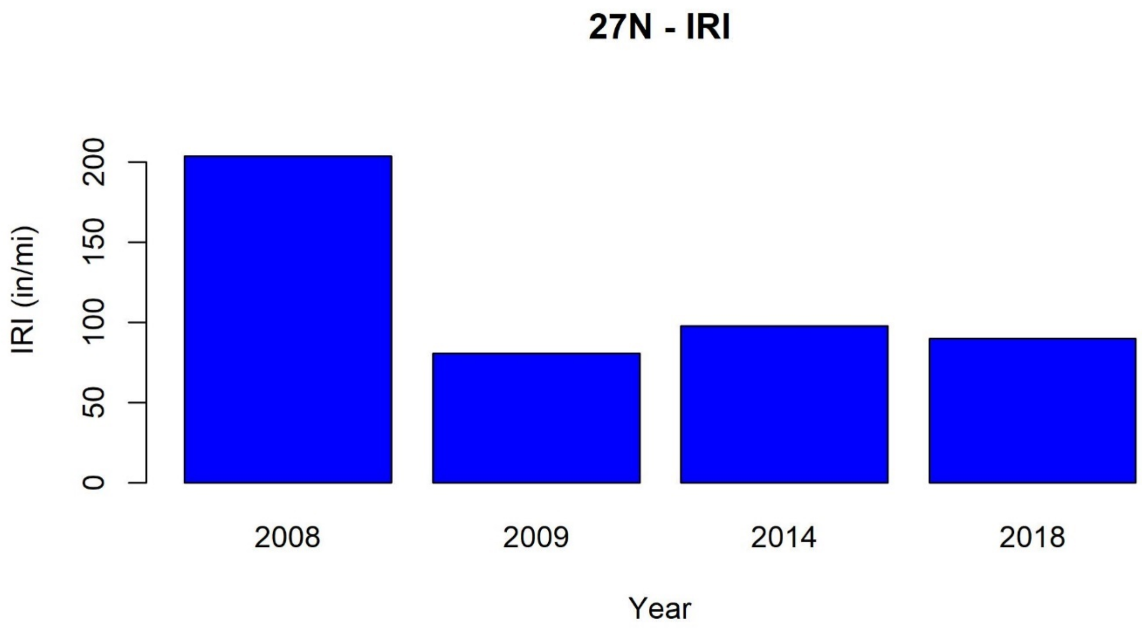
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IRI (in/mi)
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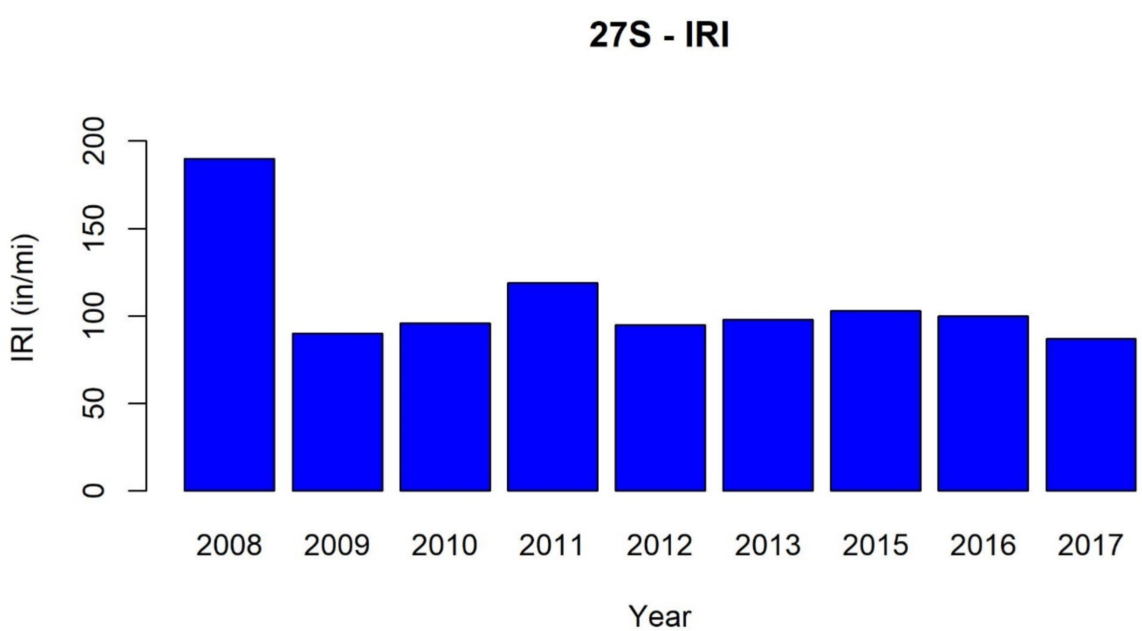
27S - IRI
IRI (in/mi)
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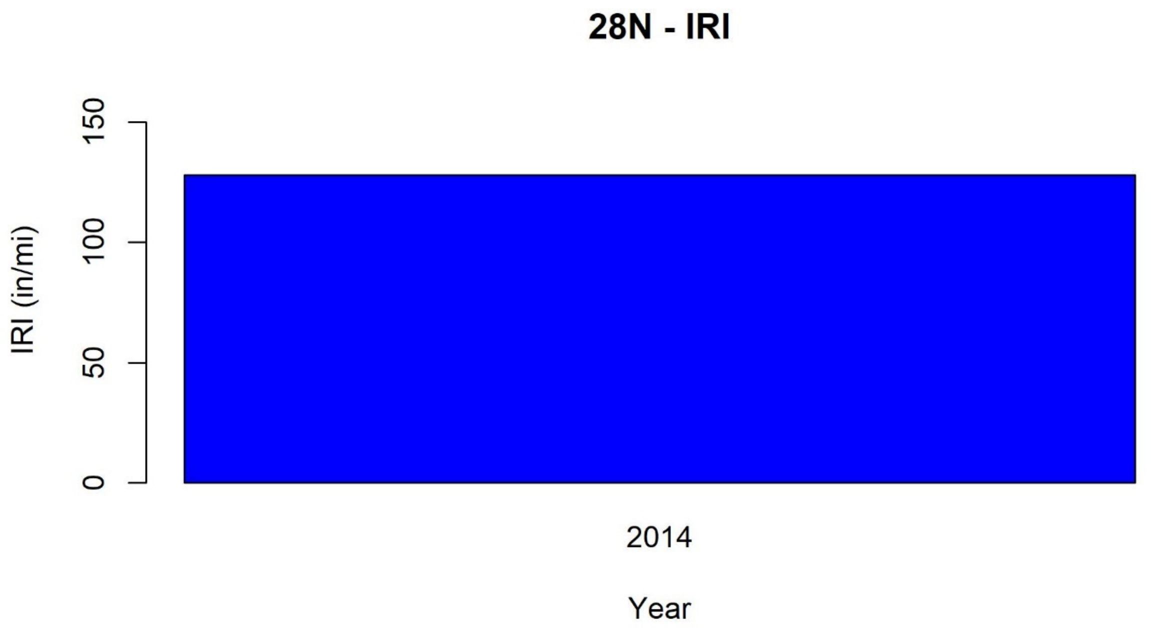
28N - IRI
IRI (in/mi)
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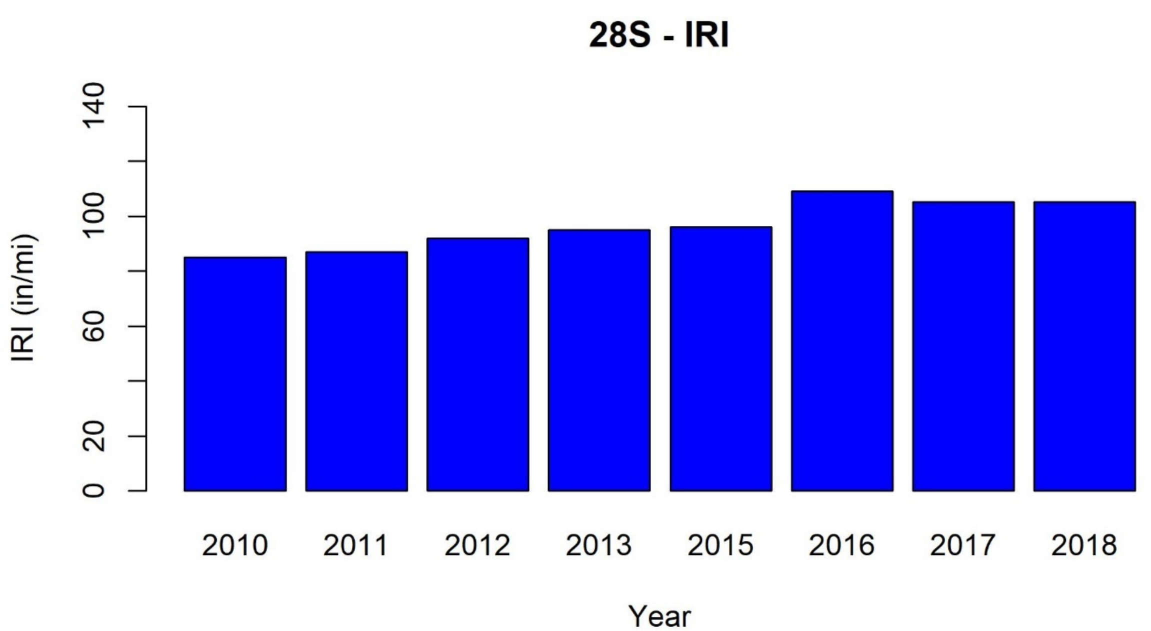
28S - IRI
IRI (in/mi)
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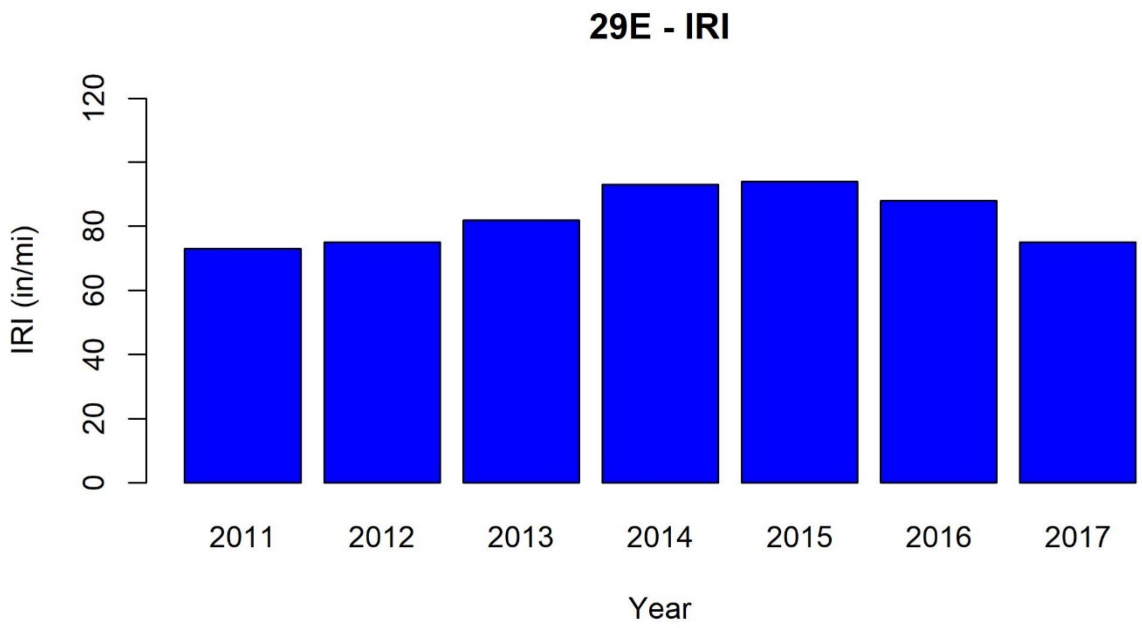
Year


29E - IRI
IRI (in/mi)
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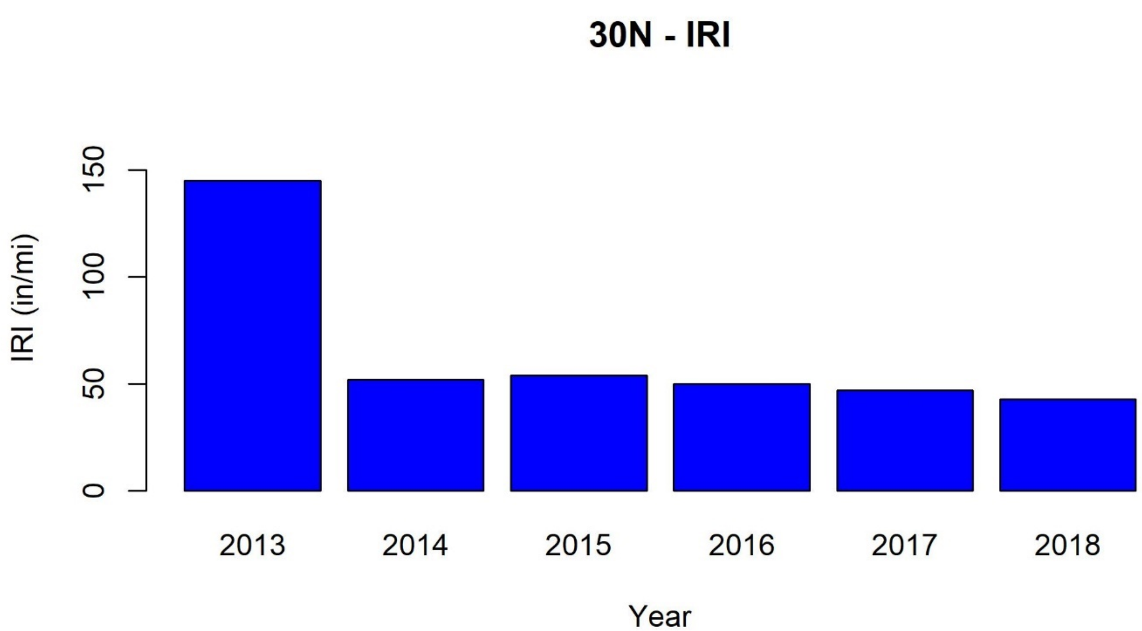
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IRI (in/mi)
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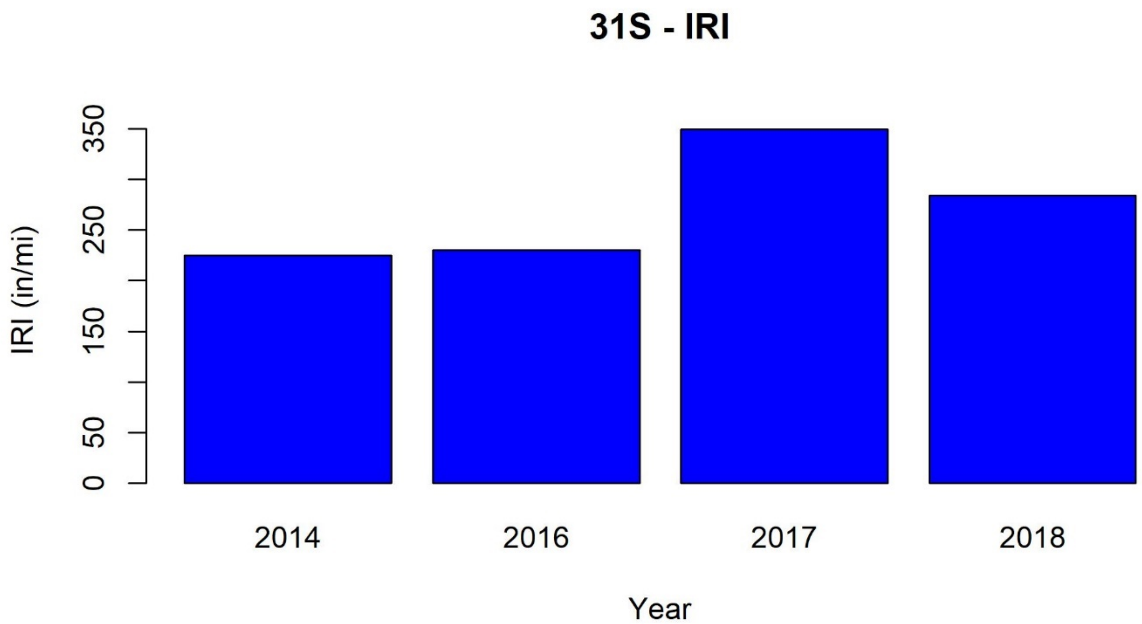
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IRI (in/mi)
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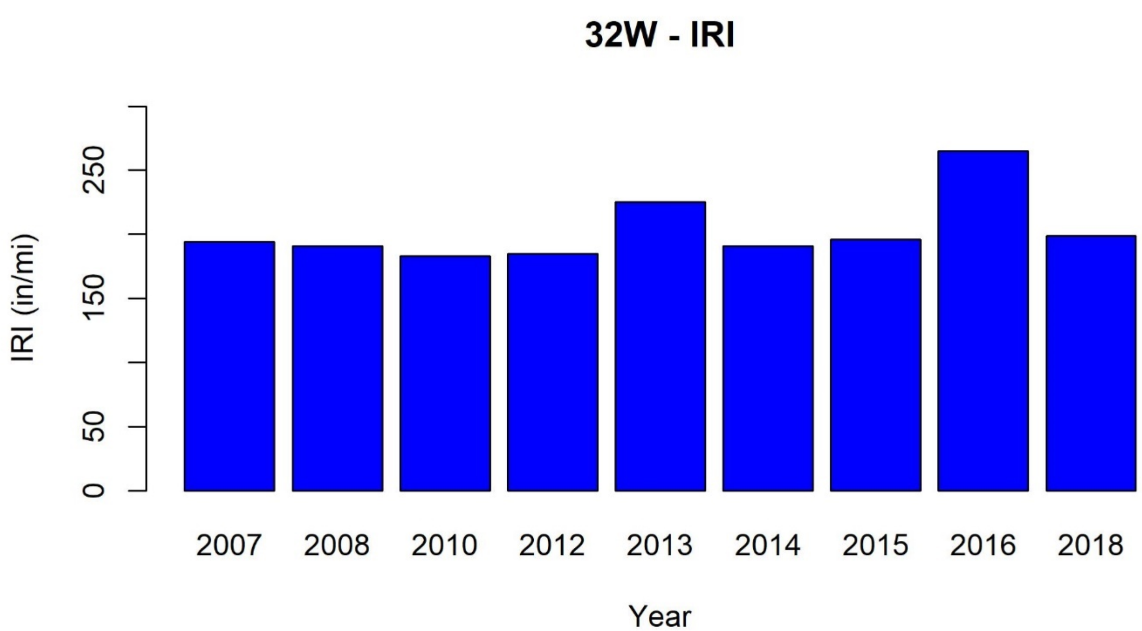
Year


32W - IRI
IRI (in/mi)
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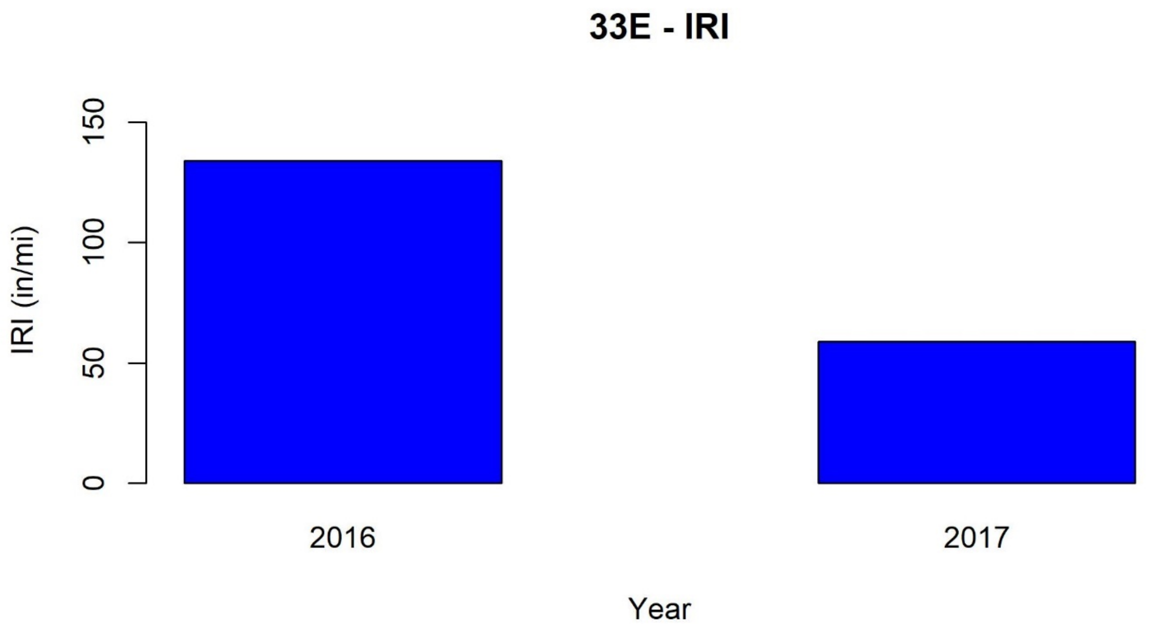
33E - IRI
IRI (in/mi)
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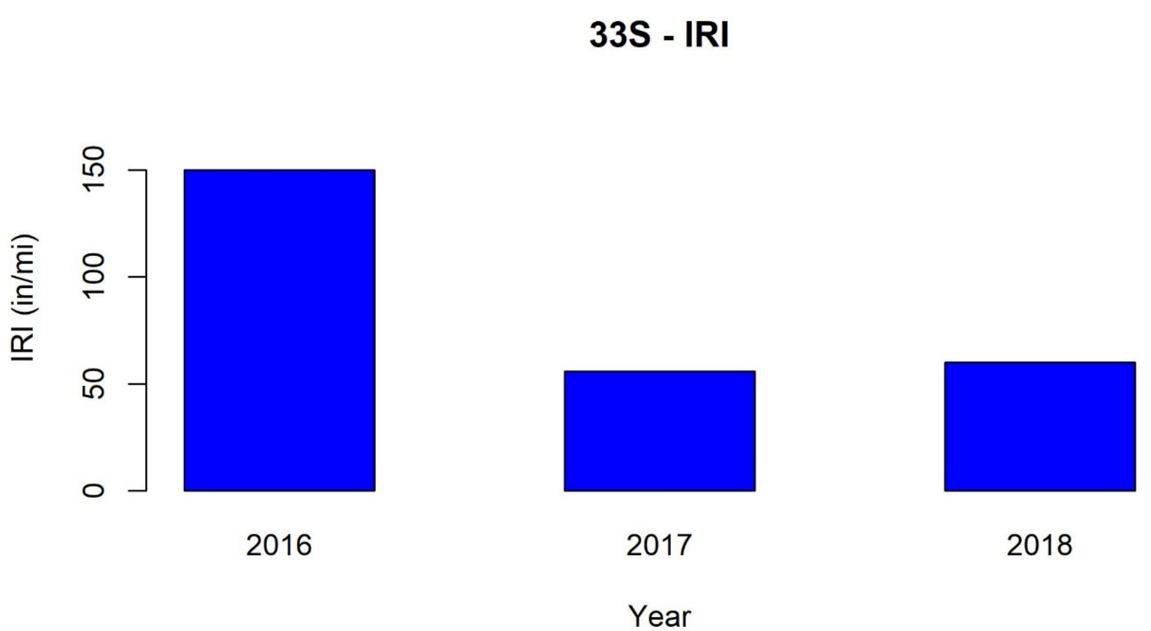
2016
2017
Year


33S - IRI
IRI (in/mi)
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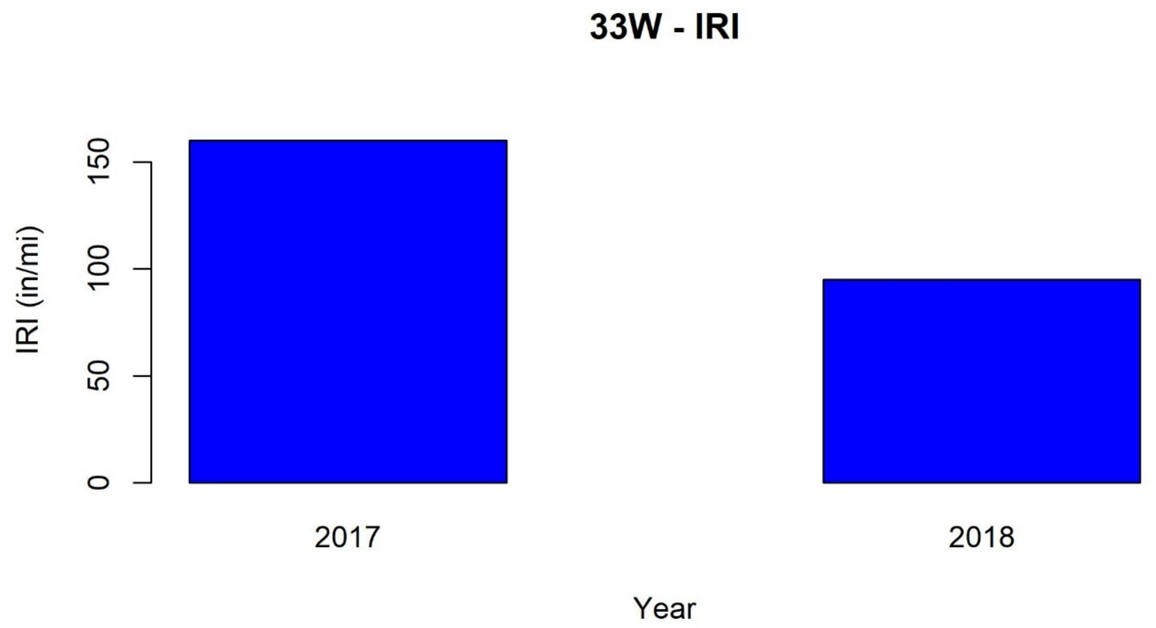
33W - IRI
IRI (in/mi)
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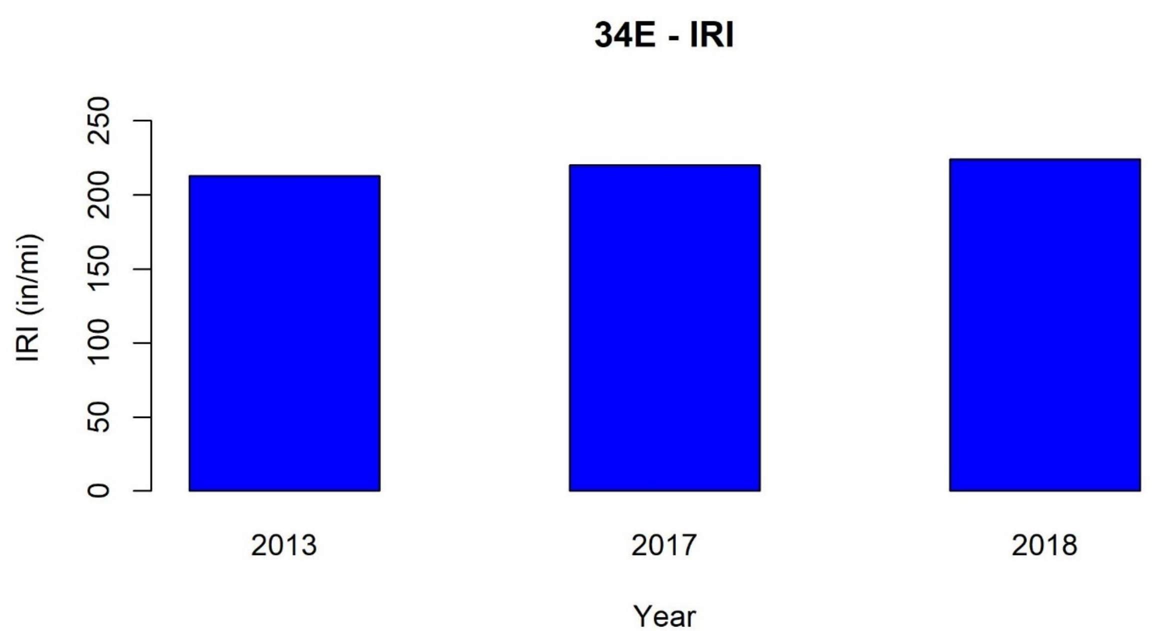
34E - IRI
IRI (in/mi)
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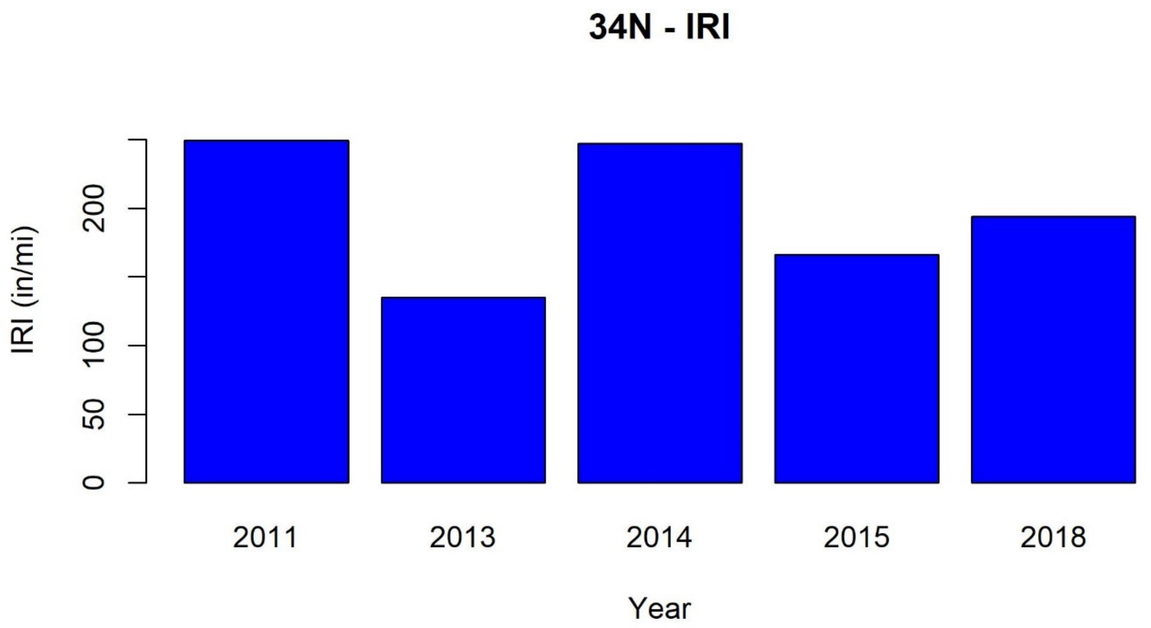
34N - IRI
IRI (in/mi)
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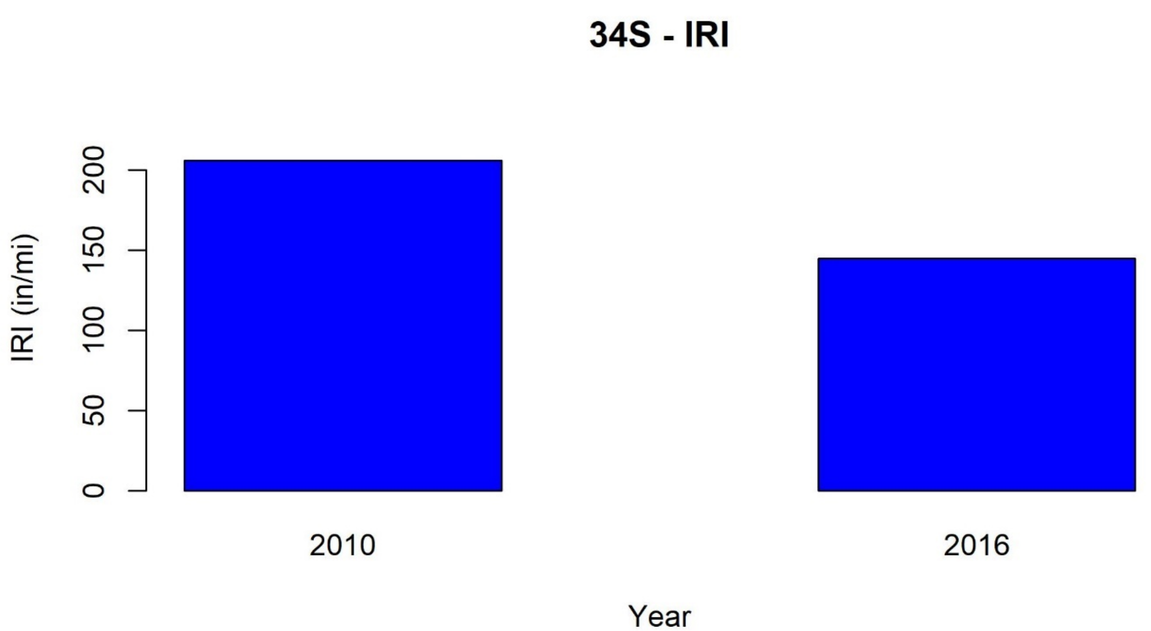
34S - IRI
IRI (in/mi)
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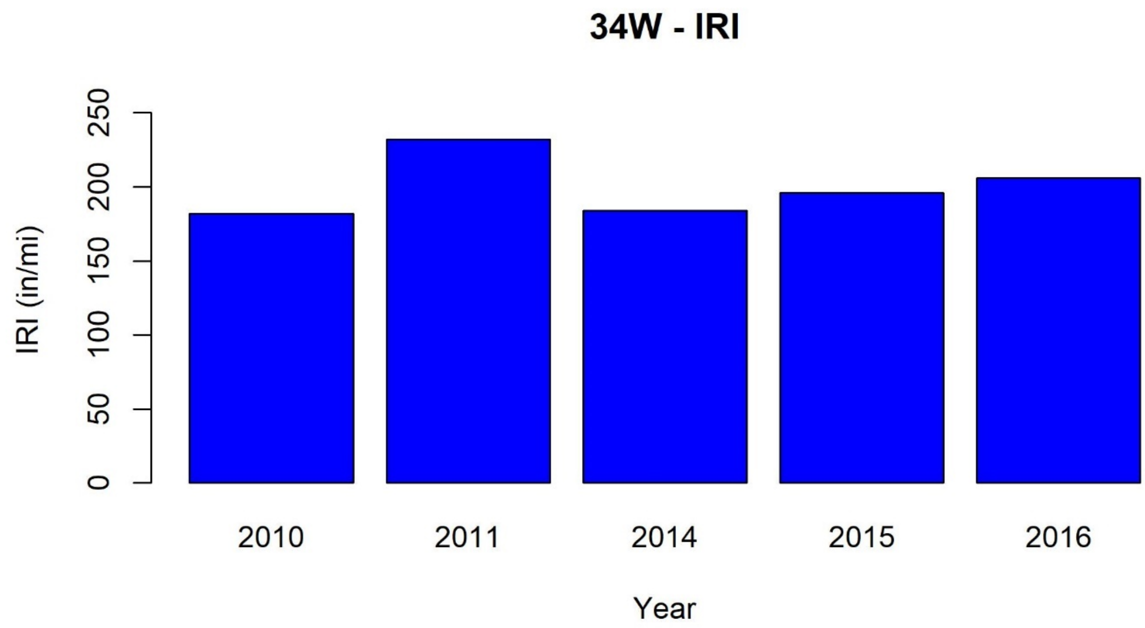
34W - IRI
IRI (in/mi)
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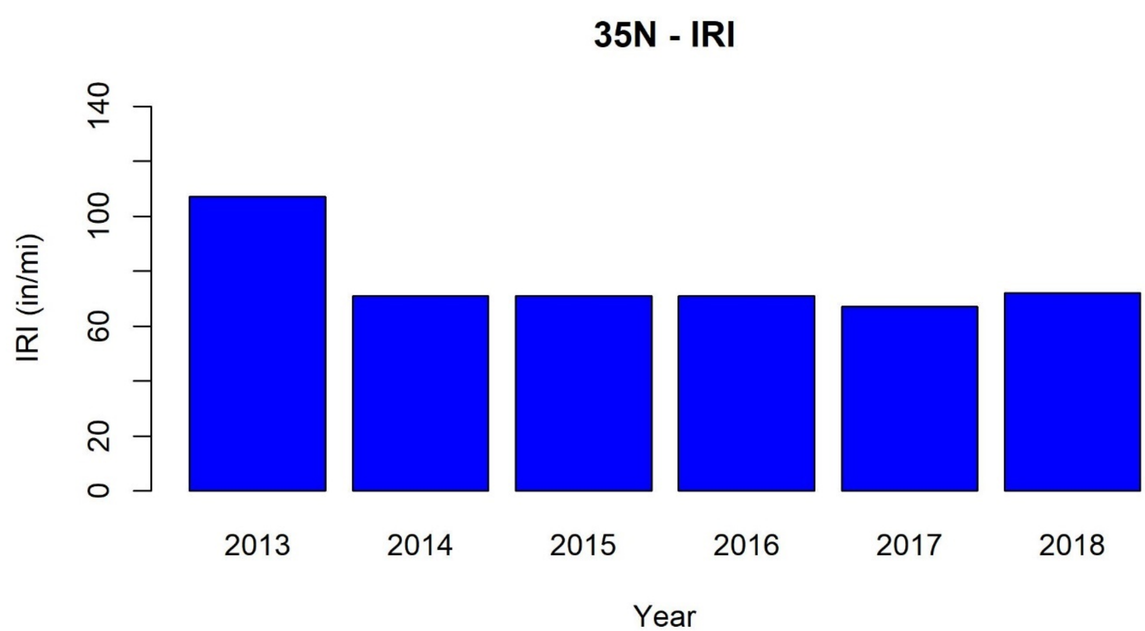
35N - IRI
IRI (in/mi)
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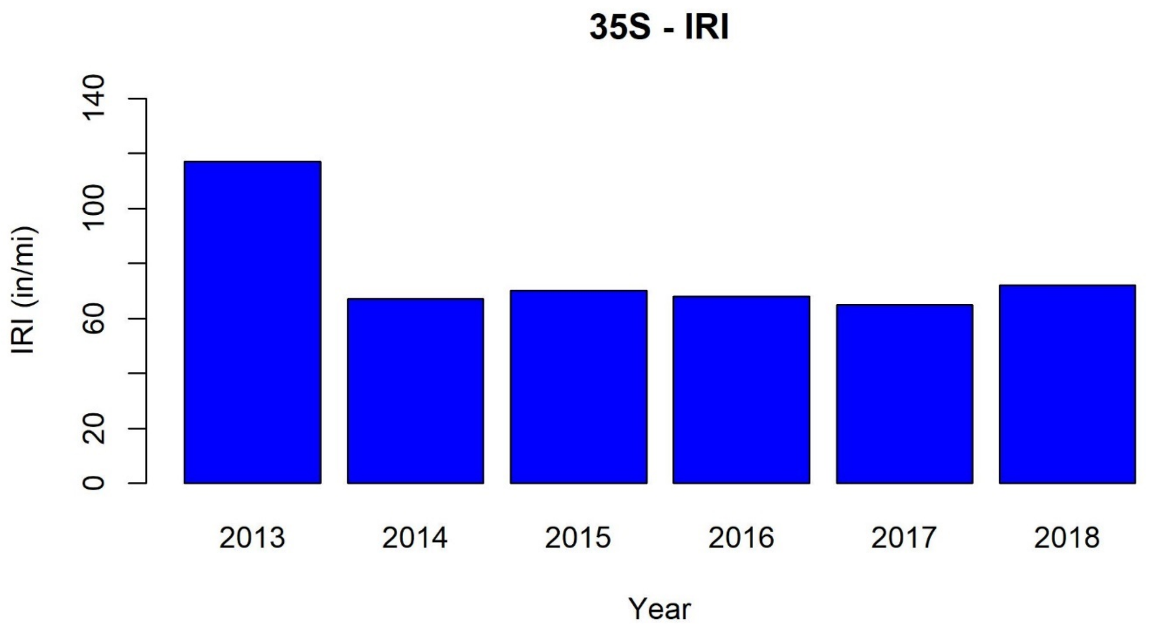
35S - IRI
IRI (in/mi)
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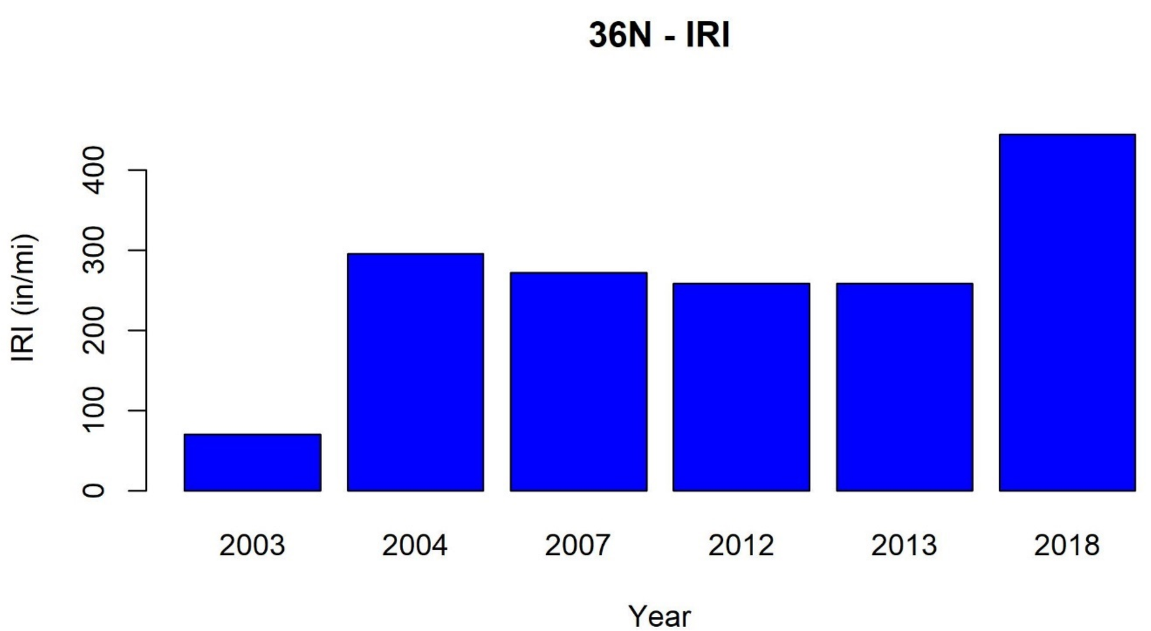
36N - IRI
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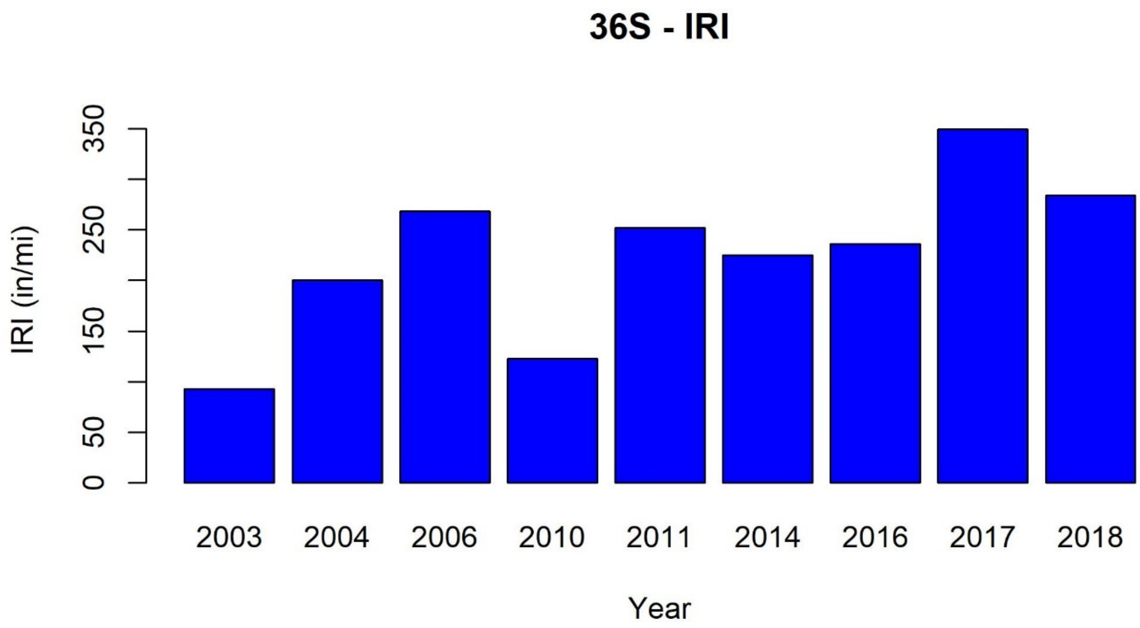
36S - IRI
IRI (in/mi)
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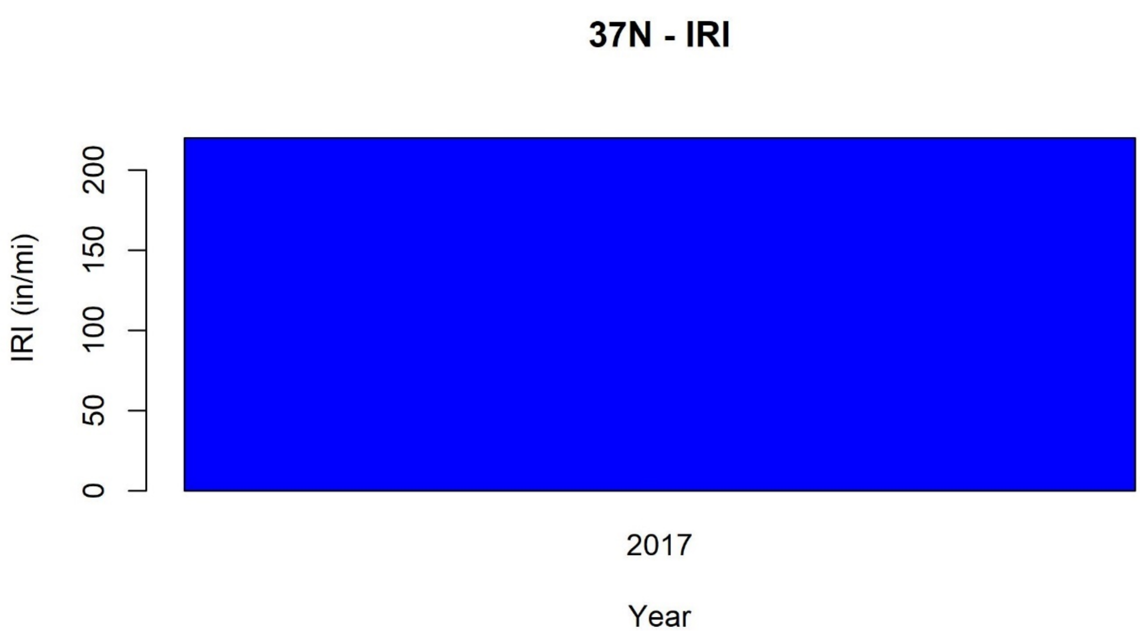
37N - IRI
IRI (in/mi)
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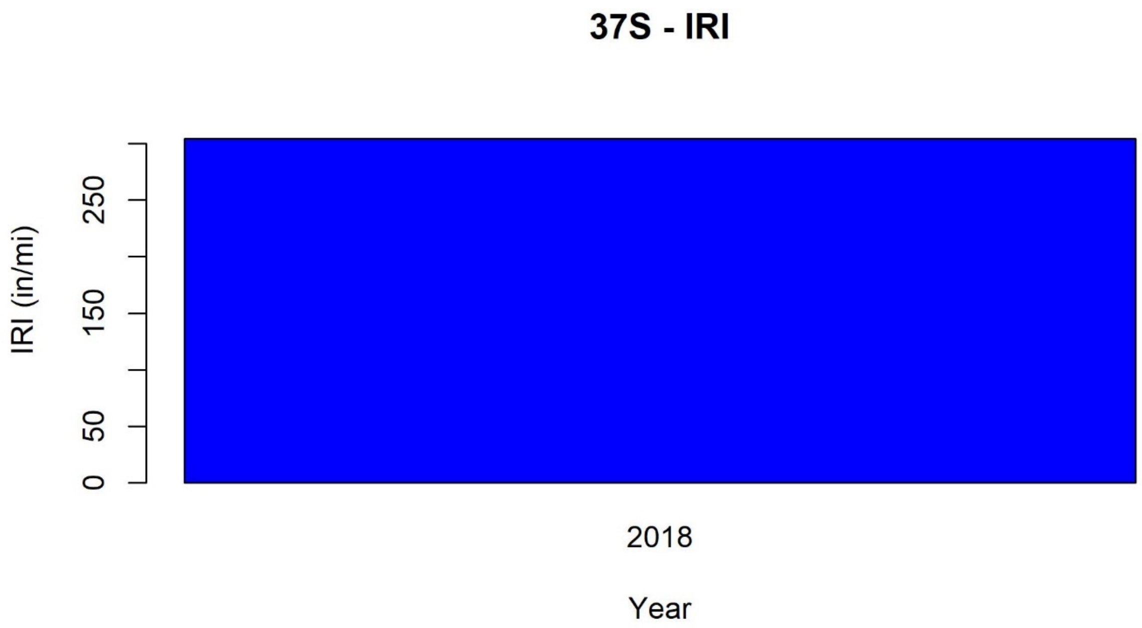
37S - IRI
IRI (in/mi)
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2018
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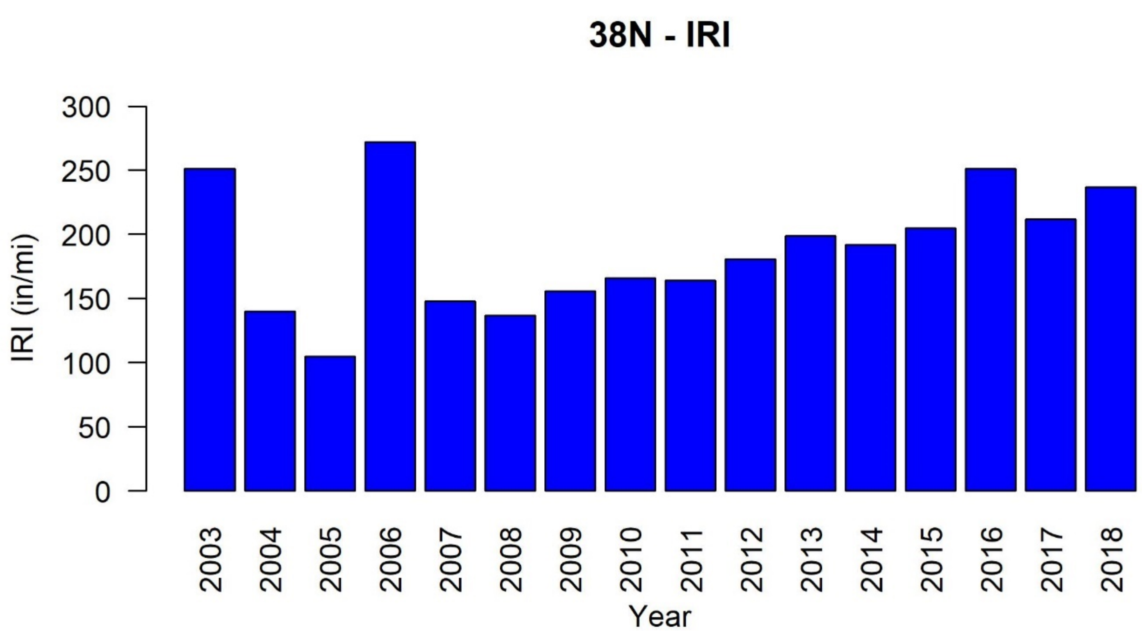
38N - IRI
IRI (in/mi)
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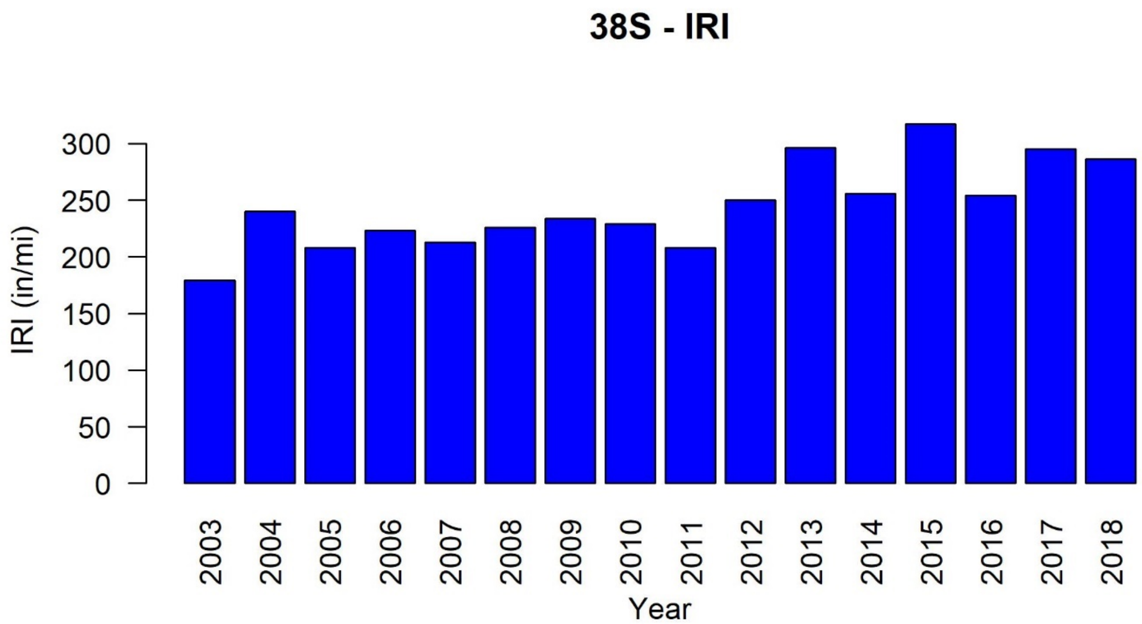
38S - IRI
IRI (in/mi)
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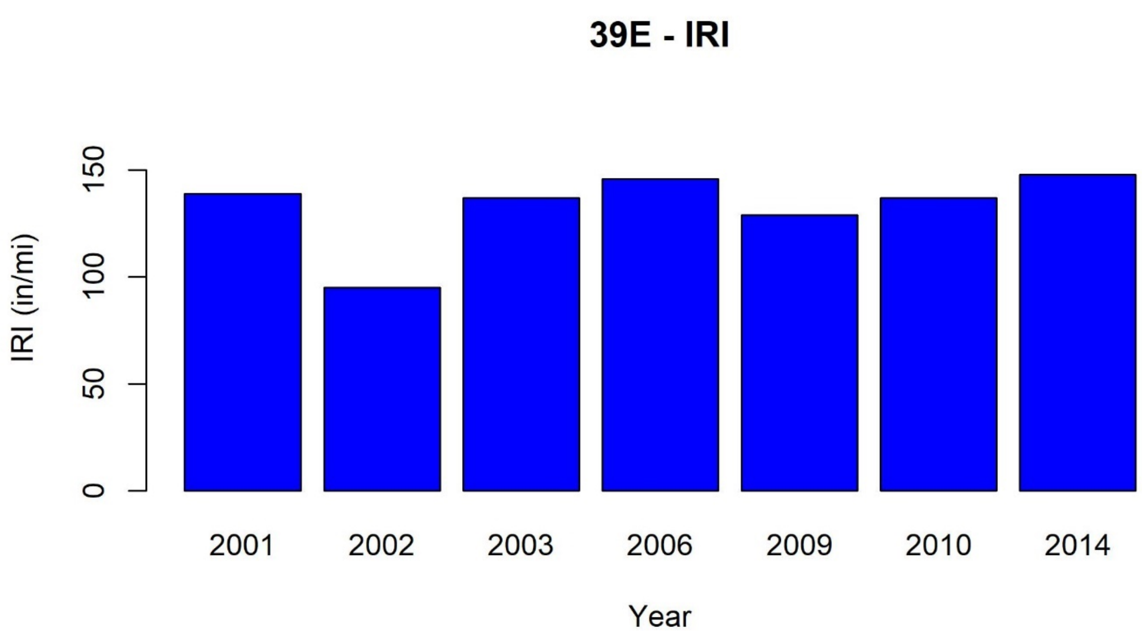
39E - IRI
IRI (in/mi)
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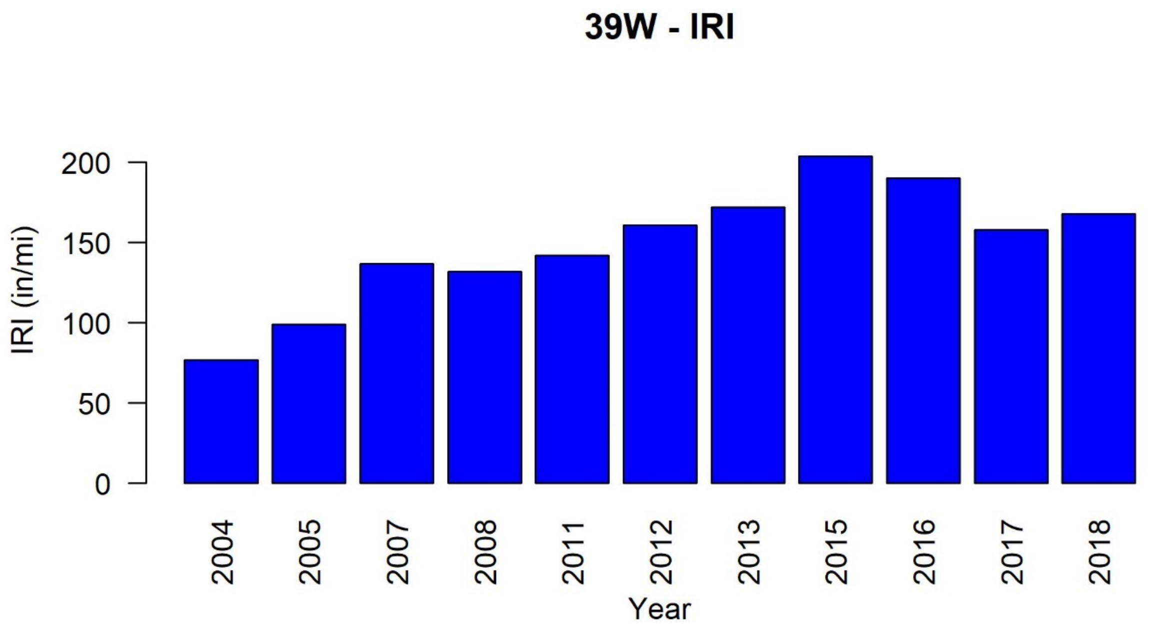
39W - IRI
IRI (in/mi)
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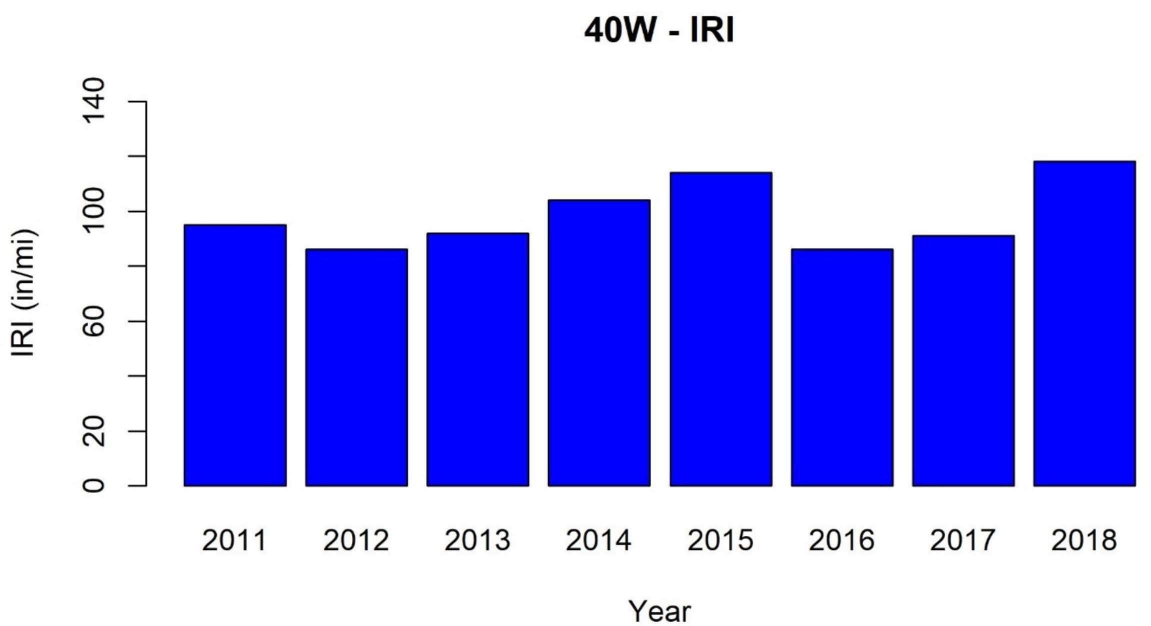
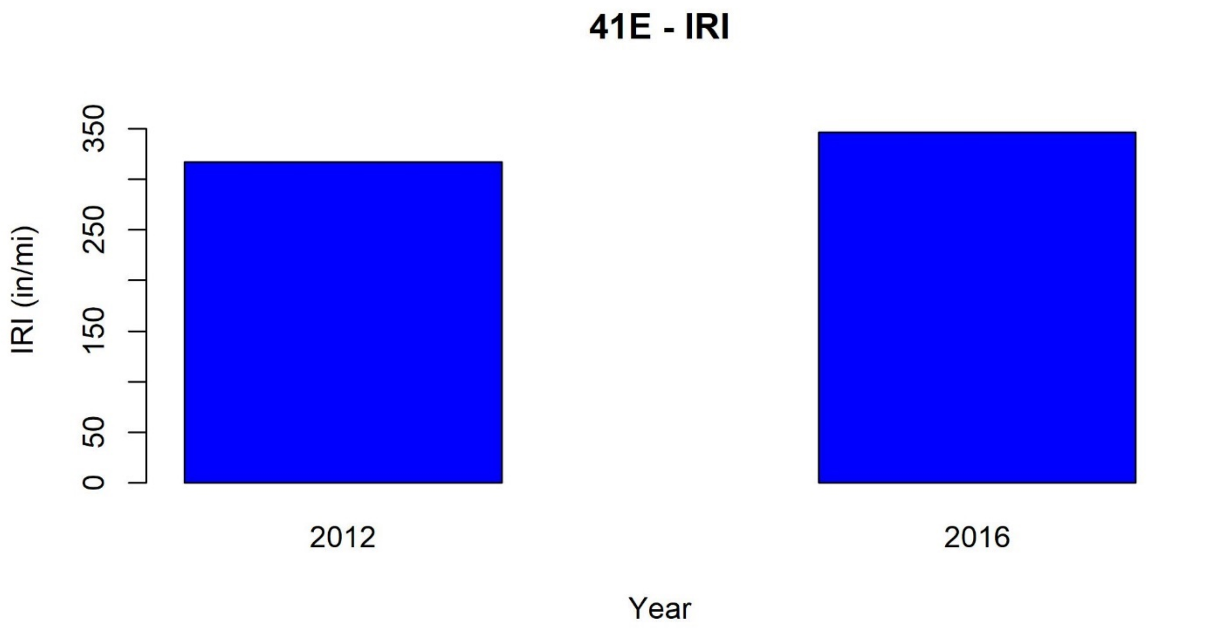
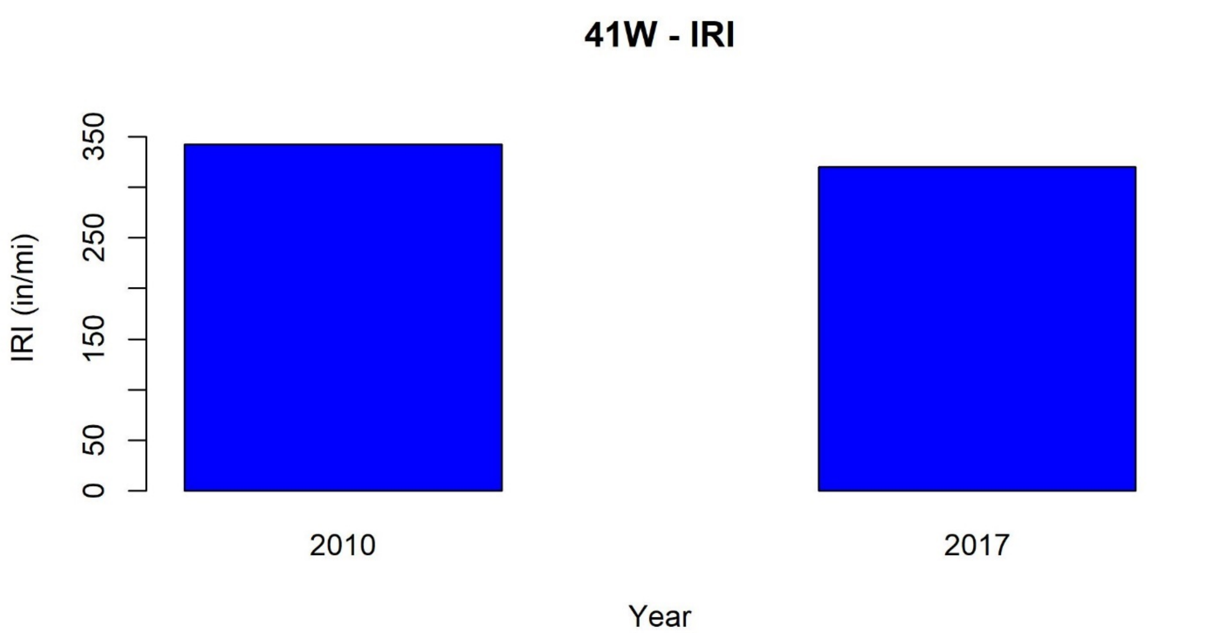

40W - IRI
IRI (in/mi)
0
20
60
100
140
2011
2012
2013
2014
2015
2016
2017
2018
Year


41E - IRI
IRI (in/mi)
0
50
150
250
350
2012
2016
Year


41W - IRI
IRI (in/mi)
0
50
150
250
350
2010
2017
Year

# APPENDIX G—CURRENT REPAIR NEEDS

**Table G-1. UBOL current patching needs.**

| U.ID. | Total No. of Slabs | Joint Spacing, ft | Slab Width, ft | Total Area, ft$^2$ | Patch Area Sp-[H] PDR 3 ft x 3 ft | Patch Area, ft$^2$ Corner Breaks FDR 3 ft x 3 ft | Patch Area, ft$^2$ Transverse Crack FDR 6 ft x width | Patch Area, ft$^2$ Transverse Crack FDR 6 ft x width | Total PDR Area, ft$^2$ | Total PDR, % of Total Area | Total FDR Area, ft$^2$ | Total FDR, % of Total Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1W | 1,677 | 15 | 12 | 301,860 | 108 | 0 | 0 | 0 | 108 | 0.036% | 0 | 0.000% |
| 2S | 5,202 | 15 | 12 | 936,360 | 9 | 18 | 0 | 360 | 9 | 0.001% | 378 | 0.040% |
| 3E | 2,776 | 15 | 13.8 | 574,632 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 4E | 3,374 | 15 | 13.8 | 698,418 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 5N | 1,226 | 15 | 12 | 220,680 | 0 | 0 | 0 | 180 | 0 | 0.000% | 180 | 0.082% |
| 5S | 1,246 | 15 | 12 | 224,280 | 18 | 0 | 72 | 720 | 18 | 0.008% | 792 | 0.353% |
| 6N | 479 | 15 | 12 | 86,220 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 6S | 519 | 15 | 12 | 93,420 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 7E | NA | NA | NA | NA | 0 | 0 | NA | NA | NA | NA | NA | NA |
| 7W | NA | NA | NA | NA | 0 | 0 | NA | NA | NA | NA | NA | NA |
| 8E | 1,567 | 15 | 12 | 282,060 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 8W | 1,559 | 15 | 12 | 280,620 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 9E | 3,203 | 15 | 12 | 576,540 | 27 | 27 | 144 | 10080 | 27 | 0.005% | 10251 | 1.778% |
| 10E | 3,817 | 15 | 14 | 801,570 | 0 | 0 | 84 | 0 | 0 | 0.000% | 84 | 0.010% |
| 11E | 2,252 | 15 | 14 | 472,920 | 126 | 153 | 0 | 840 | 126 | 0.027% | 993 | 0.210% |
| 12E | 1,346 | 15 | 14 | 282,660 | 81 | 90 | 0 | 1260 | 81 | 0.029% | 1350 | 0.478% |
| 13W | 1,113 | 15 | 13.8 | 230,391 | 9 | 0 | 248 | 0 | 9 | 0.004% | 248.4 | 0.108% |
| 14S | 4,044 | 15 | 14 | 849,240 | 144 | 18 | 168 | 840 | 144 | 0.017% | 1026 | 0.121% |
| 15E | 3,106 | 15 | 12 | 559,080 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 15W | 3,102 | 15 | 12 | 558,360 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 16N | 3,095 | 15 | 13 | 603,525 | 9 | 0 | 0 | 0 | 9 | 0.001% | 0 | 0.000% |
| 17W | 3,035 | 15 | 12 | 546,300 | 99 | 9 | 72 | 3600 | 99 | 0.018% | 3681 | 0.674% |
| 18N | 703 | 15 | 13 | 137,085 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 19N | 5,238 | 15 | 13 | 1,021,410 | 36 | 0 | 78 | 1950 | 36 | 0.004% | 2028 | 0.199% |
| 20N | 2,473 | 15 | 12 | 445,140 | 27 | 36 | 0 | 26100 | 27 | 0.006% | 26136 | 5.871% |
| 20S | 2,480 | 15 | 12 | 446,400 | 0 | 0 | 0 | 2700 | 0 | 0.000% | 2700 | 0.605% |
| 21N | 2,804 | 15 | 12 | 504,720 | 9 | 9 | 0 | 0 | 9 | 0.002% | 9 | 0.002% |
| 21S | 2,799 | 15 | 12 | 503,820 | 0 | 9 | 0 | 0 | 0 | 0.000% | 9 | 0.002% |
| 22E | 1,448 | 15 | 12 | 260,640 | 9 | 0 | 0 | 0 | 9 | 0.003% | 0 | 0.000% |
| 22W | 1,456 | 15 | 12 | 262,080 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 23W | 3,080 | 15 | 12 | 554,400 | 18 | 0 | 0 | 0 | 18 | 0.003% | 0 | 0.000% |
| 24N | 1,144 | 15 | 12 | 205,920 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 25N | 1,065 | 15 | 12 | 191,700 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |

| U.ID. | Total No. of Slabs | Joint Spacing, ft | Slab Width, ft | Total Area, $ft^2$ | Patch Area Sp-[H] PDR 3 ft x 3 ft | Patch Area, $ft^2$ Corner Breaks FDR 3 ft x 3 ft | Patch Area, $ft^2$ Transverse Crack FDR 6 ft x width | Patch Area, $ft^2$ Transverse Crack FDR 6 ft x width | Total PDR Area, $ft^2$ | Total PDR, % of Total Area | Total FDR Area, $ft^2$ | Total FDR, % of Total Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25S | 1,061 | 15 | 12 | 190,980 | 0 | 0 | 0 | 0 | 0 | 0.000% | 0 | 0.000% |
| 26N | NA | NA | NA | NA | 0 | 0 | NA | NA | NA | NA | NA | NA |
| 26S | NA | NA | NA | NA | 0 | 0 | NA | NA | NA | NA | NA | NA |

**Table G-2. BBOL current patching needs.**

| U.ID. | Total No. of Slabs | Joint Spacing, ft | Slab Width, ft | Total Area, ft$^2$ | FDR Area Full-Panel, ft$^2$ | Total FDR Area, ft$^2$ | Total FDR, % of Total Area |
|---|---|---|---|---|---|---|---|
| 27S | 4,895 | 6 | 6 | 176,220 | 72 | 72 | 0.041% |
| 27N | NA | NA | NA | NA | NA | NA | NA |
| 28S | 22,099 | 6 | 6 | 795,564 | 1,584 | 1,584 | 0.189% |
| 28N | NA | NA | NA | NA | NA | NA | NA |
| 29E | 12,708 | 6 | 6 | 457,488 | 2,592 | 2,592 | 0.567% |
| 30N | 12,866 | 6 | 6 | 463,176 | 180 | 180 | 0.039% |
| 30S | NA | NA | NA | NA | NA | NA | NA |
| 31S | NA | NA | NA | NA | NA | NA | NA |
| 32W | 141 | 6 | 6 | 5,076 | 0 | 0 | 0 |
| 33E | 486 | 6 | 6 | 17,496 | 0 | 0 | 0 |
| 33W | 624 | 6 | 6 | 22,464 | 36 | 36 | 0.160% |
| 33S | 141 | 6 | 6 | 5,076 | 0 | 0 | 0.000% |
| 33N | NA | NA | NA | NA | NA | NA | NA |
| 34E | NA | NA | NA | NA | NA | NA | NA |
| 34W | 159 | 6 | 6 | 5,724 | 36 | 36 | 0.629% |
| 34S | NA | NA | NA | NA | NA | NA | NA |
| 34N | 141 | 6 | 6 | 5,076 | 36 | 36 | 0.709% |
| 35N | 11,680 | 7.5 | 6 | 525,600 | 720 | 720 | 0.137% |
| 35S | 12,690 | 7.5 | 6 | 571,050 | 936 | 936 | 0.160% |

**Table G-3. BOL current patching needs.**

| U.ID. | Total No. of Slabs | Joint Spacing, ft | Slab Width, ft | Total Area, $ft^2$ | FDR Area Full-Panel, $ft^2$ | Total FDR Area, $ft^2$ | Total FDR, % of Total Area |
|---|---|---|---|---|---|---|---|
| 36S | NA | 4 | 4 | NA | NA | NA | NA |
| 36N | 285 | 4 | 4 | 4,562 | 16 | 16 | 0.351% |
| 37S | 238 | 4 | 4 | 3,802 | 16 | 16 | 0.421% |
| 37N | NA | 4 | 4 | NA | NA | NA | NA |
| 38N | 792 | 4 | 4 | 12,672 | 0 | 0 | 0.000% |
| 38S | 792 | 4 | 4 | 12,672 | 16 | 16 | 0.126% |
| 39W | 1,604 | 4 | 4 | 25,661 | 256 | 256 | 0.998% |
| 39E | NA | 4 | 4 | NA | NA | NA | NA |
| 40W | NA | 4 | 4 | NA | NA | NA | NA |
| 41W | 198 | 4 | 4 | 3,168 | 0 | 0 | 0.000% |
| 41E | NA | 4 | 4 | NA | NA | NA | NA |

# APPENDIX H—DATA DICTIONARY

## DATA DICTIONARY Version 7/14/2020

| Data Sheet | Design Revised Log. mi |
|---|---|
| U.ID. | Unique ID, unique consecutive number identifier for each project followed with a letter I to specify the direction (N-North, S-South, E-East, W-West). |
| No | Number associated with the original project listing given by MoDOT. |
| Twid | Travelway ID, from MoDOT's TMS database. |
| Dir | Direction of travel. |
| Desg | Road designation, from MoDOT's TMS database (Interstate, US Numbered Routes, Missouri Numbered Routes). |
| Route | Route number, from MoDOT's TMS database. |
| County | County name. |
| Overlay Type | Overlay type, UBOL – Unbounded Overlay, BBOL – Big Block Overlay, BOL – Bonded Overlay. |
| Construction Date | Date of project construction. |
| Job.No | Job number associated with MoDOT's TMS database. |
| Contract.ID | Contract number associated with MoDOT's TMS database. |
| Original Log.mi Start | Original Log mile starting point associated with the original project listing. |
| Original Log.mi End | Original Log mile endpoint associated with the original project listing. |
| Revised Log.mi Start | Revised Log mile starting point. |
| Revised Log.mi End | Revised Log mile endpoint. |
| Year of Log.mi | Year of the data on the ARAN explorer used to extract the "Revised Log.mi Start" and the "Revised Log.mi End". |
| Number of Lanes | Number of lanes associated with each project. |

| Data Sheet | Design Revised Log. mi |
|---|---|
| Start Station | Beginning station for each project extracted from plans and/or 2-AA sheets. |
| End Station | Ending station for each project extracted from plans and/or 2-AA sheets. |
| Traffic Metric | Type of traffic metric obtained from project plans and/or 2-AA sheets. |
| Year0 | Initial year associated with the traffic metric. |
| Traffic at Year0 | Traffic volume in the initial year. |
| Yearn | End year associated with the traffic metric. |
| Traffic at Yearn | Traffic volume at the end year. |
| DHV | Design Hourly Volume, %. |
| Percent Trucks | Percent of trucks (FHWA class 4 to 13) out of total traffic volume, %. |
| Design Speed | Design speed in miles per hour, or kilometers per hour for those projects constructed following metric units. |
| Directional | Directional traffic volume, %. |
| Joint Spacing | Longitudinal joint spacing, ft. |
| Slab Width | Typical slab width, ft. |
| Slab Thickness | Slab thickness, in. |
| Sealed Joints | YES or NO field, depending on the year of construction. Projects constructed before 2006 were designated as YES, all others as NO. |
| Dowels | Dowel diameter, in. Based on MoDOT's Standard Plan 502.05 (MoDOT 2020), projects with a slab thickness of 7 in or more were recorded as having dowels. |
| Interlayer Type | Type of interlayer pavement:<br>• HMA – Hot Mix Asphalt.<br>• ACP – Asphalt Concrete Pavement.<br>• NRPCCP – Non-reinforced Portland Cement Concrete Pavement.<br>• RPCCP – Reinforced Portland Cement Concrete Pavement. |

| Data Sheet | Design Revised Log. mi |
|---|---|
| Interlayer Thickness | Thickness of the interlayer in inches. Projects with a variable thickness interlayer were assigned as ‘VAR’. |
| Under Pavement | Type of underlying pavement:<br>• HMA – Hot Mix Asphalt.<br>• ACP – Asphalt Concrete Pavement.<br>• NRPCCP – Non-reinforced Portland Cement Concrete Pavement.<br>• RPCCP – Reinforced Portland Cement Concrete Pavement. |
| Under Pavement Thickness | Thickness of the underlying pavement in inches. Projects with a variable thickness underlying pavement were assigned as ‘VAR’. |
| Base Type | Material type of the base layer, as shown in project plans or 2-AA sheets. |
| Base Thickness | Thickness of the base layer in inches. |
| Shoulder Type | Type of Shoulder:<br>• PCC – Portland Cement Concrete.<br>• A1, A2, A3 – Standard shoulder design as per MoDOT standard plan 401.00C.<br>• Agg Shldr – Aggregate Shoulder.<br>• HMA – Hot Mix Asphalt. |

| Data Sheet | Strength PWL, Thickness PWL, and Air Content PWL<br>PWL definitions are based out of MoDOT's General Specifications 502.10.4 (MoDOT 2019b) |
|---|---|
| U.ID. | Unique ID, unique consecutive number identifier for each project followed with a letter I to specify the direction (N-North, S-South, E-East, W-West). |
| Strength | Compressive strength measured from field cores, lbf/in$^2$. |
| Thickness | In-place thickness measured from field cores, in. |
| Design Thickness | Thickness value as specified by the project plans, in. |
| Delta Thickness | Thickness difference between design thickness and in-place thickness. |
| Air Content | In-place air content measured from field cores, %. |
| USL | Upper Specification Limit. |
| LSL | Lower Specification Limit. |
| $Q_U$ | Upper-Quality Index. |
| $Q_L$ | Lower-Quality Index. |
| PWL | Percent Within Limits. |
| $PWL_U$ | Upper PWL. |
| $PWL_L$ | Lower PWL. |

| Data Sheet | Faulting, IRI, AADT, and Traffic Analysis<br>The following items refer to variables coming from MoDOT's TMS database, and the ESAL analysis derived from it. |
|---|---|
| U.ID. | Unique ID, unique consecutive number identifier for each project followed with a letter I to specify the direction (N-North, S-South, E-East, W-West). |
| Faulting | Elevation difference on the transverse joint between consecutive slabs (in). |
| IRI | International Roughness Index, in/mi. |
| AADT | Annual Average Daily Traffic. |
| AADTT | Annual Average Daily Truck Traffic. |
| Growth Rate | Calculated average annual growth rate between $Year_0$ and $Year_n$, %. |
| Growth Factor (GF) | Compounded traffic growth factor as a function of growth rate and the number of years. GF= ((1+Growth Rate) *(2018-Year of Construction+1)-1)/ (Growth Rate) |
| Truck Factor (TF) | Truck Factor with the following assumed values:<br>• 0.75 – Interstates.<br>• 0.60 – US routes.<br>• 0.50 – All other routes. |
| Lane Distribution Factor (DL) | Percent of total traffic flowing through the design lane; assumed values:<br>• 1.00 – 1-lane per direction.<br>• 0.90 – 2-lane per direction.<br>• 0.70 – 3-lane per direction.<br>• 0.60 – 4-lane per direction.<br>• 0.50 – More than 4 lanes per direction. |
| ESAL | Equivalent Single Axle Load. ESAL= (AADTT at $Year_0$) *365*GF*TF*$D_L$ |

| **Data Sheet** | **UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014)** |
|---|---|
| U.ID. | Unique ID, unique consecutive number identifier for each project followed with a letter I to specify the direction (N-North, S-South, E-East, W-West). |
| Lane Surveyed | Lane surveyed for each project:<br>• DL – Driving Lane.<br>• CL – Center Lane.<br>• PL – Passing Lane. |
| PASER Score | 0-10 condition score based on the University of Wisconsin PASER Manual—Concrete Roads (Walker 2015). |
| Total No of Slabs | Estimated total number of slabs between the log.mi limits of each project. Calculated using the length of each project and the typical size of the slabs. |
| Total Area | Estimated total surface area between the log.mi limits of each project. Calculated using the length of each project and the typical lane width. |
| Percentage of Cracked Slabs | Percentage out of the total number of slabs that are cracked. Cracking types accounted for this metric include shattered slabs, longitudinal and transverse cracking, and corner breaks. |
| Percentage of Patched Slabs | Percentage out of the total number of slabs that are patched. Patching types included are longitudinal and transverse joints, mid-panel, and full panel. |
| Percentage of Patched Area | Percentage out of the total area that is patched. Patching types included are longitudinal and transverse joints, mid-panel, and full panel. |
| Map Cracking | If present, map cracking was recorded with a general comment. |
| Pop-Outs | Pop-out recorded as the number of slabs affected, with no severity levels. |
| Scaling | Scaling recorded as the number of slabs affected, with no severity levels. |
| Potholes | Potholes recorded as the number of slabs affected, with no severity levels. |
| Wear & Polish | If present, wear & polish was recorded with a general comment. |

| **Data Sheet** | **UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014)** |
|---|---|
| Joint Seal Condition | Joint seal condition was assessed based on the overall observed condition and registered as general good/fair/poor comment. |
| D-Cr | Durability cracking, as defined by the LTPP Distress Identification Manual. |
| Shattered Slab | Slab has broken into 3 or more pieces and with interconnected crack. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |
| Sp-[M] Tr-Jt, WP | Medium severity spalling on transverse joints on the wheel-path. For BOL projects there is no wheel-path distinction. |
| Sp-[M] Tr-Jt, No-WP | Medium severity spalling on transverse joints, not on the wheel-path. |
| Sp-[M] Long-Jt | Medium severity spalling on longitudinal joints. |
| Sp-[M] Corner | Medium severity spalling on corners. |
| Sp-[H] Tr-Jt, WP | High severity spalling on transverse joints on the wheel-path. For BOL projects, there is no wheel-path distinction. |
| Sp-[H] Tr-Jt, No-WP | High severity spalling on transverse joints, not on the wheel-path. |
| Sp-[H] Long-Jt | High severity spalling on longitudinal joints. |
| Sp-[H] Corner | High severity spalling on corners. |
| Tr-Cr-[L] Bottom | Low severity transverse crack on the bottom third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |
| Tr-Cr-[L] Center | Low severity transverse crack on the middle third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |

| Data Sheet | UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014) |
|---|---|
| Tr-Cr-[L] Top | Low severity transverse crack on the top third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |
| Tr-Cr-[L] Bottom-Jt | Low severity transverse crack within 1 ft of the bottom transverse joint. Applicable only to UBOL projects. |
| Tr-Cr-[L] Top-Jt | Low severity transverse crack within 1 ft of the top transverse joint. Applicable only to UBOL projects. |
| Tr-Cr-[M] Bottom | Medium severity transverse crack on the bottom third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |
| Tr-Cr-[M] Center | Medium severity transverse crack on the middle third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |
| Tr-Cr-[M] Top | Medium severity transverse crack on the top third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |
| Tr-Cr-[M] Bottom-Jt | Medium severity transverse crack within 1 ft of the bottom transverse joint. Applicable only to UBOL projects. |
| Tr-Cr-[M] Top-Jt | Medium severity transverse crack within 1 ft of the top transverse joint. Applicable only to UBOL projects. |
| Tr-Cr-[H] Bottom | High severity transverse crack on the bottom third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |
| Tr-Cr-[H] Center | High severity transverse crack on the middle third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |
| Tr-Cr-[H] Top | High severity transverse crack on the top third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, this can apply to the left-, center-, or right-side panels. |

| **Data Sheet** | **UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014)** |
|---|---|
| Tr-Cr-[H] Bottom-Jt | High severity transverse crack within 1 ft of the bottom transverse joint. Applicable only to UBOL projects. |
| Tr-Cr-[H] Top-Jt | High severity transverse crack within 1 ft of the top transverse joint. Applicable only to UBOL projects. |
| Lg-Cr-[L] Left | Low severity longitudinal crack on the left third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, there is no distinction regarding the location of longitudinal cracks within the slab. For both BBOL and BOL projects, the number of consecutive slabs showing longitudinal cracks was recorded by adding a 1-6 numbering, each number represents the number of consecutive slabs affected by longitudinal cracks. |
| Lg-Cr-[L] Center | Low severity longitudinal crack on the middle third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, there is no distinction regarding the location of longitudinal cracks within the slab. For both BBOL and BOL projects, the number of consecutive slabs showing longitudinal cracks was recorded by adding a 1-6 numbering, each number represents the number of consecutive slabs affected by longitudinal cracks. |
| Lg-Cr-[L] Right | Low severity longitudinal crack on the right third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, there is no distinction regarding the location of longitudinal cracks within the slab. For both BBOL and BOL projects, the number of consecutive slabs showing longitudinal cracks was recorded by adding a 1-6 numbering, each number represents the number of consecutive slabs affected by longitudinal cracks. |
| Lg-Cr-[L] Left-Jt | Low severity longitudinal crack within 1 ft of the left longitudinal joint. Applicable only to UBOL projects. |
| Lg-Cr-[L] Right-Jt | Low severity longitudinal crack within 1 ft of the right longitudinal joint. Applicable only to UBOL projects. |

| Data Sheet | UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014) |
|---|---|
| Lg-Cr-[M] Left | Medium severity longitudinal crack on the left third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, there is no distinction regarding the location of longitudinal cracks within the slab. For both BBOL and BOL projects, the number of consecutive slabs showing longitudinal cracks was recorded by adding a 1-6 numbering, each number represents the number of consecutive slabs affected by longitudinal cracks. |
| Lg-Cr-[M] Center | Medium severity longitudinal crack on the middle third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, there is no distinction regarding the location of longitudinal cracks within the slab. For both BBOL and BOL projects, the number of consecutive slabs showing longitudinal cracks was recorded by adding a 1-6 numbering, each number represents the number of consecutive slabs affected by longitudinal cracks. |
| Lg-Cr-[M] Right | Medium severity longitudinal crack on the right third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, there is no distinction regarding the location of longitudinal cracks within the slab. For both BBOL and BOL projects, the number of consecutive slabs showing longitudinal cracks was recorded by adding a 1-6 numbering, each number represents the number of consecutive slabs affected by longitudinal cracks. |
| Lg-Cr-[M] Left-Jt | Medium severity longitudinal crack within 1 ft of the left longitudinal joint. Applicable only to UBOL projects. |
| Lg-Cr-[M] Right-Jt | Medium severity longitudinal crack within 1 ft of the right longitudinal joint. Applicable only to UBOL projects. |
| Lg-Cr-[H] Left | High severity longitudinal crack on the left third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, there is no distinction regarding the location of longitudinal cracks within the slab. For both BBOL and BOL projects, the number of consecutive slabs showing longitudinal cracks was recorded by adding a 1-6 numbering, each number represents the number of consecutive slabs affected by longitudinal cracks. |

| **Data Sheet** | **UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014)** |
|---|---|
| Lg-Cr-[H] Center | High severity longitudinal crack on the middle third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, there is no distinction regarding the location of longitudinal cracks within the slab. For both BBOL and BOL projects, the number of consecutive slabs showing longitudinal cracks was recorded by adding a 1-6 numbering, each number represents the number of consecutive slabs affected by longitudinal cracks. |
| Lg-Cr-[H] Right | High severity longitudinal crack on the right third of the slab. For BBOL projects, this can apply to either the left- or right-side panels. For BOL projects, there is no distinction regarding the location of longitudinal cracks within the slab. For both BBOL and BOL projects, the number of consecutive slabs showing longitudinal cracks was recorded by adding a 1-6 numbering, each number represents the number of consecutive slabs affected by longitudinal cracks. |
| Lg-Cr-[H] Left-Jt | High severity longitudinal crack within 1 ft of the left longitudinal joint. Applicable only to UBOL projects. |
| Lg-Cr-[H] Right-Jt | High severity longitudinal crack within 1 ft of the right longitudinal joint. Applicable only to UBOL projects. |
| Cor-Cr-[L] Top-Right | Low severity corner break on the top-right corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was 'isolated' or as part of a 'system', denoted by the abbreviation 'sys'. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Cor-Cr-[L] Top-Left | Low severity corner break on the top-left corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was 'isolated' or as part of a 'system', denoted by the abbreviation 'sys'. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Cor-Cr-[L] Bottom-Left | Low severity corner break on the bottom-left corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was 'isolated' or as part of a 'system', denoted by the abbreviation 'sys'. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |

| Data Sheet | UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014) |
|---|---|
| Cor-Cr-[L] Bottom-Right | Low severity corner break on the bottom-right corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was ‘isolated’ or as part of a ‘system’, denoted by the abbreviation ‘sys’. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Cor-Cr-[M] Top-Right | Medium severity corner break on the top-right corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was ‘isolated’ or as part of a ‘system’, denoted by the abbreviation ‘sys’. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Cor-Cr-[M] Top-Left | Medium severity corner break on the top-left corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was ‘isolated’ or as part of a ‘system’, denoted by the abbreviation ‘sys’. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Cor-Cr-[M] Bottom-Left | Medium severity corner break on the bottom-left corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was ‘isolated’ or as part of a ‘system’, denoted by the abbreviation ‘sys’. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Cor-Cr-[M] Bottom-Right | Medium severity corner break on the bottom-right corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was ‘isolated’ or as part of a ‘system’, denoted by the abbreviation ‘sys’. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Cor-Cr-[H] Top-Right | High severity corner break on the top-right corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was ‘isolated’ or as part of a ‘system’, denoted by the abbreviation ‘sys’. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |

| Data Sheet | UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014) |
|---|---|
| Cor-Cr-[H] Top-Left | High severity corner break on the top-left corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was 'isolated' or as part of a 'system', denoted by the abbreviation 'sys'. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Cor-Cr-[H] Bottom-Left | High severity corner break on the bottom-left corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was 'isolated' or as part of a 'system', denoted by the abbreviation 'sys'. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Cor-Cr-[H] Bottom-Right | High severity corner break on the bottom-right corner of the slab. For BBOL and BOL projects, the survey also kept track of whether a corner break was 'isolated' or as part of a 'system', denoted by the abbreviation 'sys'. An isolated corner break does not connect to or is associated with, any adjacent longitudinal or transverse crack, or corner break. |
| Diagonal Cracks | Diagonal cracking is not an LTPP standard distress, but rather a distress type defined specifically for this project. A diagonal crack is a hybrid between a corner break and a longitudinal crack, it is identified as a longitudinal crack that starts at least 3 ft apart from a corner of the slab, and, instead of progressing longitudinally, it wanders into one of the longitudinal joints. It is similar to a corner break except that it does not generally intersect both joints at a 45-degree angle. |
| Dia-Cr-[L] Top-Right | Low severity diagonal crack on the top-right quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[L] Top-Left | Low severity diagonal crack on the top-left quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[L] Bottom-Left | Low severity diagonal crack on the bottom-left quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[L] Bottom-Right | Low severity diagonal crack on the bottom-right quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[M] Top-Right | Medium severity diagonal crack on the top-right quadrant of the slab. Applicable only to UBOL projects. |

| Data Sheet | UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014) |
|---|---|
| Dia-Cr-[M] Top-Left | Medium severity diagonal crack on the top-left quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[M] Bottom-Left | Medium severity diagonal crack on the bottom-left quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[M] Bottom-Right | Medium severity diagonal crack on the bottom-right quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[H] Top-Right | High severity diagonal crack on the top-right quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[H] Top-Left | High severity diagonal crack on the top-left quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[H] Bottom-Left | High severity diagonal crack on the bottom-left quadrant of the slab. Applicable only to UBOL projects. |
| Dia-Cr-[H] Bottom-Right | High severity diagonal crack on the bottom-right quadrant of the slab. Applicable only to UBOL projects. |
| Patch-[L] Lg-Jt | Low severity patch on a longitudinal joint. Dimensions assumptions:<br>• UBOL 6 ft x 15 ft. |
| Patch-[L] Tr-Jt | Low severity patch on a transverse joint. Dimensions assumptions:<br>• UBOL 12 ft x 6 ft. |
| Patch-[L] Mid-Panel | Low severity patch in the middle of the slab transversely oriented. Dimensions assumptions:<br>• UBOL 12 ft x 6 ft. |
| Patch-[L] Corner | Low severity patch on a corner of the slab. Dimensions assumptions:<br>• UBOL 3 ft x 3 ft. |

| Data Sheet | UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014) |
|---|---|
| Patch-[L] Full-Panel | Low severity full-panel patch. Applicable to all project types. Dimensions assumptions:<br>• UBOL 12 ft x 15 ft.<br>• BBOL 6 ft x 6 ft.<br>• BOL 4 ft x 4 ft. |
| Patch-[M] Lg-Jt | Medium severity patch on a longitudinal joint. Dimensions assumptions:<br>• UBOL 6 ft x 15 ft. |
| Patch-[M] Tr-Jt | Medium severity patch on a transverse joint. Dimensions assumptions:<br>• UBOL 12 ft x 6 ft. |
| Patch-[M] Mid-Panel | Medium severity patch in the middle of the slab transversely oriented. Dimensions assumptions:<br>• UBOL 12 ft x 6 ft. |
| Patch-[M] Corner | Medium severity patch on a corner of the slab. Dimensions assumptions:<br>• UBOL 3 ft x 3 ft. |
| Patch-[M] Full-Panel | Medium severity full-panel patch. Applicable to all project types. Dimensions assumptions:<br>• UBOL 12 ft x 15 ft.<br>• BBOL 6 ft x 6 ft.<br>• BOL 4 ft x 4 ft. |
| Patch-[M] Lg-Jt | High severity patch on a longitudinal joint. Dimensions assumptions:<br>• UBOL 6 ft x 15 ft. |
| Patch-[M] Tr-Jt | High severity patch on a transverse joint. Dimensions assumptions:<br>• UBOL 12 ft x 6 ft. |

| Data Sheet | **UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014)** |
|---|---|
| Patch-[M] Mid-Panel | High severity patch in the middle of the slab transversely oriented. Dimensions assumptions:<br>• UBOL 12 ft x 6 ft. |
| Patch-[M] Corner | High severity patch on a corner of the slab. Dimensions assumptions:<br>• UBOL 3 ft x 3 ft. |
| Patch-[M] Full-Panel | High severity full-panel patch. Applicable to all project types. Dimensions assumptions:<br>• UBOL 12 ft x 15 ft.<br>• BBOL 6 ft x 6 ft.<br>• BOL 4 ft x 4 ft. |
| Joint Spacing | Longitudinal joint spacing, ft. |
| Slab Width | Typical slab width, ft. |
| PDR Area Sp-[H] | Partial-Depth Repair area derived from high-severity spalling, $ft^2$. Assumes a 3 ft by 3 ft patch size. Applicable only to UBOL projects. |
| FDR Area Cor-Cr-[H] | Full-Depth Repair area derived from high-severity corner breaks, $ft^2$. Assumes a 3 ft by 3 ft patch size. Applicable only to UBOL projects. |
| FDR Area Tr-Cr-[H] | Full-Depth Repair area derived from high-severity transverse cracks, $ft^2$. Assumes a patch size that is 6 ft long and a width of the full width of the slab. Applicable only to UBOL projects. |

| **Data Sheet** | **UBOL Cracking Summary, UBOL Percentages, UBOL Crack Counts, UBOL Repair Needs, BBOL Cracking Summary, BBOL Percentages, BBOL Crack Counts, BBOL Repair Needs, BOL Cracking Summary, BOL Percentages, BOL Crack Counts, and BOL Repair Needs. Distress identification followed FHWA's Distress Identification Manual for the Long-Term Pavement Performance Program (FHWA, 2014)** |
|---|---|
| FDR Area Full-Panel | Full-Depth Repair area, $ft^2$. Assumes a patch size equal to full length and width of the original slab. The distresses considered for full-panel patches include:<br>• UBOL shattered slabs and high-severity permanent patches.<br>• BBOL shattered slabs, high-severity spalling, high-severity transverse and longitudinal cracks, high-severity corner breaks, and high-severity permanent patches.<br>• BOL shattered slabs, high-severity spalling, high-severity transverse and longitudinal cracks, high-severity corner breaks, and high-severity permanent patches. |
| Total PDR Area | Total sum of Partial-Depth Repair area, $ft^2$. Applicable only to UBOL projects. |
| Total PDR, % of Total Area | Total sum of Partial-Depth Repair area as percentage of total area, %. Applicable only to UBOL projects. |
| Total FDR Area, $ft^2$ | Total sum of Full-Depth Repair area, $ft^2$. |
| Total FDR, % of Total Area | Total sum of Full-Depth Repair area as percentage of total area, %. |