Highway Factors Attachment – 2019 Pavement Inspection Report, North Tarrant Expressway, Segment 3, May 2020, prepared by Data Transfer Solutions, LLC

Fort Worth, TX

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(40 pages)

2019 Pavement Inspection Report

North Tarrant Expressway, Segment 3
May 2020

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2019 Pavement Inspection Report
NTE, Segment 3

Chapter 1: Overview and Basic Information

Facility Information

The NTE Segment 3 (NTE3) contracted with Data Transfer Solutions (DTS) to collect roadway asset data for the 2018 pavement inspection report. NTE3 consists of three segments: Segment 3A includes I-35W from the North Tarrant Parkway to I-30, and Segments 3B and 3C include I-35W from SH114 to I-820. This analysis covers Segments 3A and 3B. These surveyed segments include 171.90 lane miles comprised of the following:

Roadbed Type	Lane Miles
Frontage Roads	43.89
General Purpose	59.97
Managed Lanes	38.30
Ramps & Direct Connectors	29.74
Total	171.90

Table 1 – NTE3 Mileage Details

This report includes the following information for the roadbed types listed above:

- Pavement condition survey (TxDOT PMIS Distress Inventory)
- International Roughness Index (IRI)
- Rutting depth
- Skid resistance

Chapter 2: General Project Location

NTE3 improves mobility through Fort Worth and Tarrant County along north I35W, northeast I-820, and SH121/183 Airport Freeway. The project is designed to double capacity and reduce congestion by offering drivers a choice between the general highway lanes and new TEXpress toll-managed lanes. The highway is a major north/south route for local commuters during peak periods as well as with regional, interstate, and international trade traffic.

Highway Name	Direction of Travel	Direction of Increasing Reference Markers
IH 35W	South-North	Northbound
IH 820 (IH Loop)	West-East	Clockwise (from downtown)
SH 121	West-East	Eastbound
SH183	West-East	Eastbound

Table 2 - Direction of Increasing Reference Markers for the NTE 3 Highways

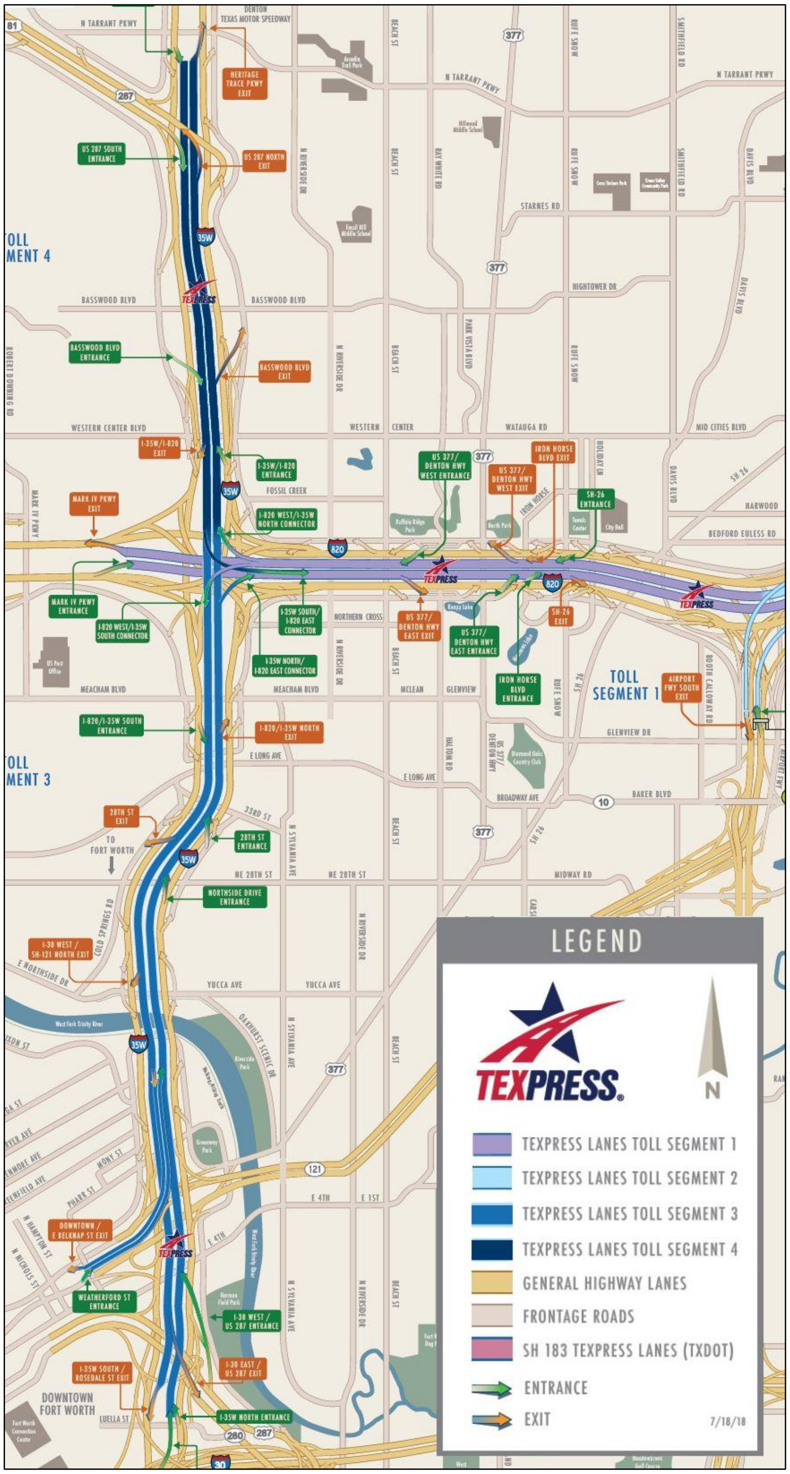

Figure 1 - Total Length of NTE Segments 3A and 3B

A TxDOT roadbed is a road that provides the same type of service, such as mobility, access, traffic capacity, etc. The direction of increasing reference markers determines the letter designation of the roadbed.

Identifying the Rated Lane – TxDOT Roadbed Codes

Table 3 lists the roadbed codes used for all of the NTE3 inspections. Unique codes were established for this project.

Roadbed Type	Roadbed Codes
General Purpose	R/L
Frontage	A/X
Managed Lanes	M/S
Ramps & Direct Connectors	B/Y

Table 3 - PMIS Roadbed Codes used for NTE3

Identifying the Rated Lane – TxDOT Lane Codes

As a result of having multiple lanes per roadbed, roadbed codes and lane numbers were used to distinguish between travel lanes. Unique lane codes were established for this project. Figure 2 displays the TxDOT reference marker directions.

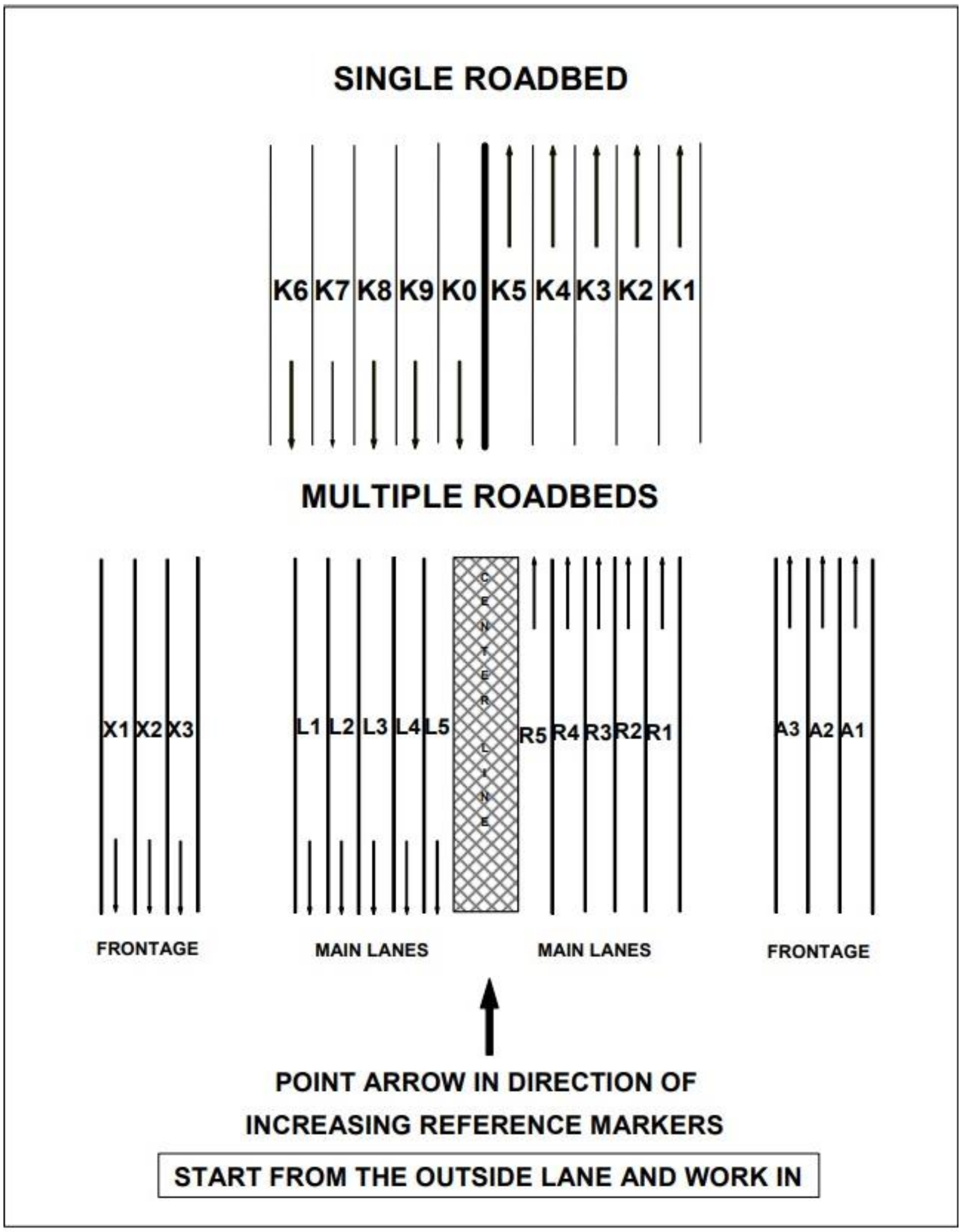

Figure 2 - TxDOT Reference Marker Directions

TxDOT PMIS Pavement Types

TxDOT defines the following broad pavement types:

01 – Continuously Reinforced Concrete Pavement
02 – Jointed Reinforced Concrete Pavement
03 – Joined Plain Concrete Pavement
04 – Thick Asphaltic Concrete Pavement (greater than 5 ½")
05 – Intermediate Thickness Asphaltic Concrete Pavement (2 ½" to 5 ½")
06 – Thin Surfaced Flexible Base Pavement (less than 2 ½")
07 – Asphalt Surfacing with Heavily Stabilized Base
08 – Overlaid and/or Widened Old Concrete Pavement
09 – Overlaid and/or Widened Old Flexible Pavement
10 – Thin Surfaced Flexible Base Pavement (Surface Treatment-Seal Coat Combination)

NTE3 Auditable Sections

NTE3 is divided into auditable sections (0.1 mile) that have assigned, alpha-numeric values. A shapefile of NTE3's auditable sections was provided to DTS. Auditable section numbers were defined as shown below:

- Direction – SB (southbound), NB (northbound), EB (eastbound) or WB (westbound)Construction Segment – 3A or 3B
- Sequential Number – 101, 102, 103, 104, 109, 110, 111, 112

Figure 3 displays an example an auditable section with travel lanes digitized as polygons, provided by NTE3. DTS used these polygons to build a centerline file.

Figure 3 - Example of An Auditable Section with Travel Lanes Digitized as Polygons

A line is created for each lane within the auditable sections in order for distress lines, areas, and points to be assigned to it.

Figure 4 displays an example of four eastbound and four westbound auditable sections with the DTS digitized line work.

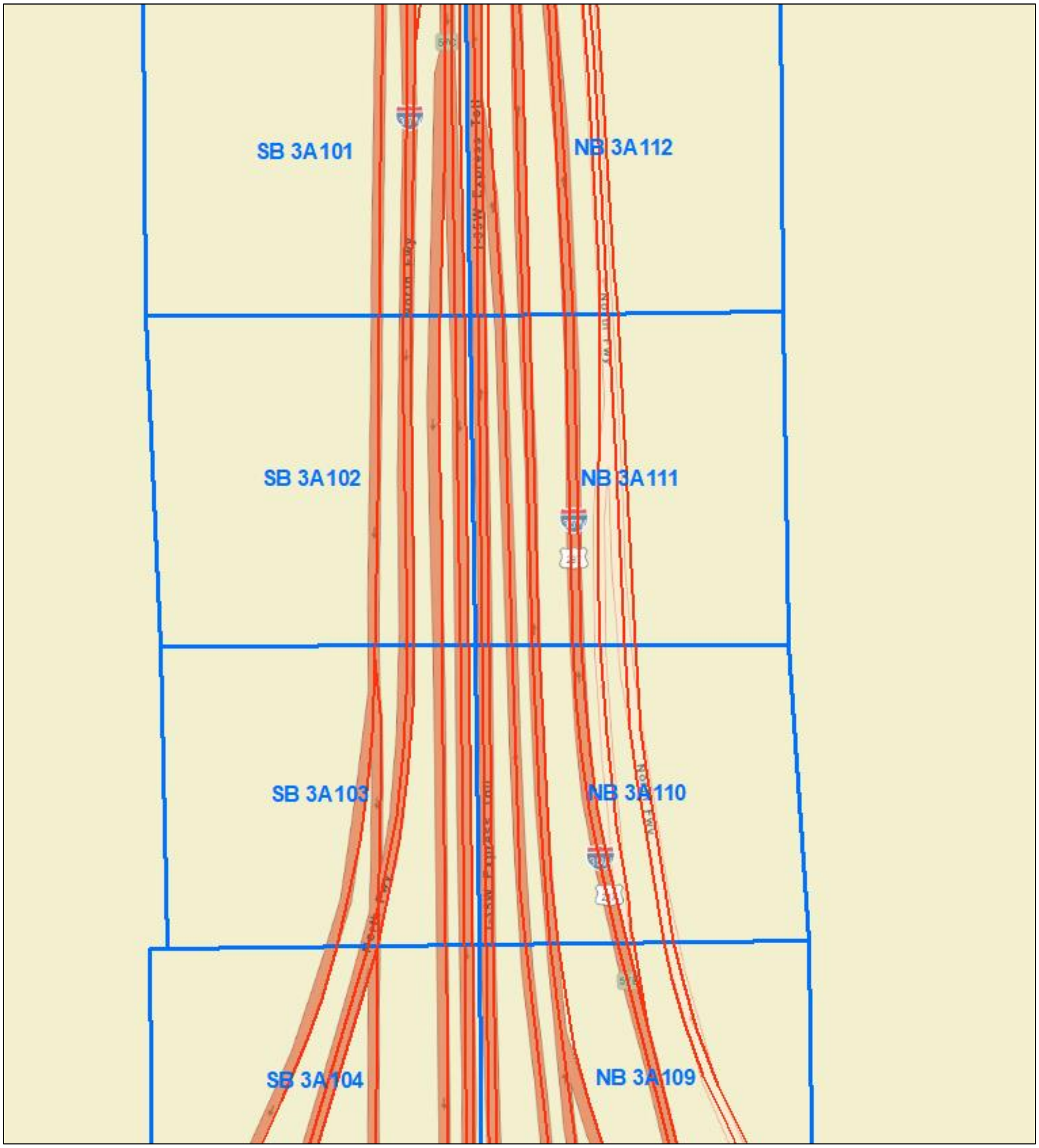

Figure 4 - Example of Four Northbound and Four Southbound Auditable Sections

List of Auditable Sections, by NTE Segment 3

NTE3 defined auditable sections for Segments 3A and 3B as follows:

Segment 3A from North Tarrant Parkway to I-30 (180 total audit sections):

- EB - EB 3A001 - EB 3A202, 1EB001 – 1EB004
- WB - WB 3A001 - WB 3A202, 1WB050 – 1WB053
- NB - NB 3A001 - NB 3A206
- SB - SB 3A001 - SB 3A206

Segment 3B from North Tarrant Parkway to Fossil Creek Boulevard (78 total audit section):

- NB - 3BNB001 - 3BNB103
- SB - 3BSB001 - 3BSB103

Even though, the auditable sections 1EB001 - 1EB004 and 1WB050 – 1WB053 are labelled as pertaining to Segment 1, the General Purpose Lanes (GPL) and Frontage Roads (FR) in these sections fall under the maintenance responsibilities of NTE3.

Chapter 3: Creation of Data Collection Run Files

Description of Data Collection Run Files

Data collection run files were created to direct DTS' data collection efforts. Each lane was collected as a separate run file in order that data points lined up accurately.

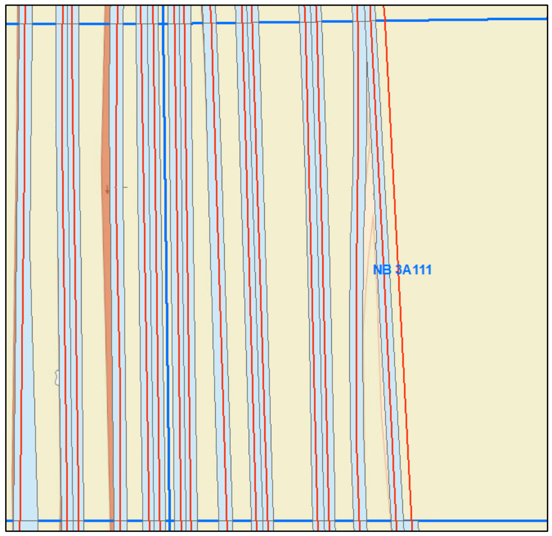

Figure 5 - A Representation of Data Collection Along Lanes of an Auditable Section

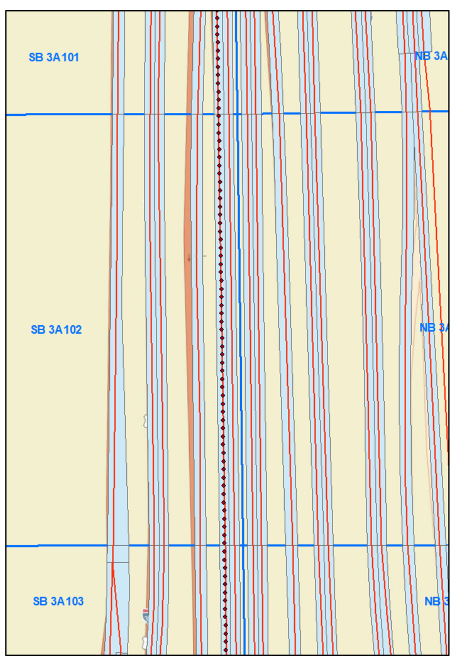

Figure 6 - A Representation of Data Points Along a Lane

Chapter 4: Description of Pavement Inspections and Procedures

Automated Data Collection and Equipment

In order to determine the general distress characteristics of each roadway segment, DTS utilized one of our Mobile Asset Collection (MAC) vehicles to collect street-level right-of-way (ROW) imagery and downward pavement imagery. DTS MAC vehicles combine multiple engineered technologies to collect real-time pavement data, ROW data and images at posted speed limits. This effectively eliminates the need to place pavement inspection technicians in the field in close proximity to vehicle traffic. Some MAC vehicle components include:

Navigation System

- **IMU**: Inertial Measurement Unit generates a true representation of vehicle motion in all three axes; producing continuous, accurate position and orientation information
- **PCS**: POS Computer System enables raw GPS data from as few as one satellite to be processed directly into the system, to compute accurate positional information in areas of intermittent, or no GPS reception
- **GPS Receivers**: Embedded GPS receivers provide heading aiding to supplement the inertial data
- **GPS Antennas**: Two GPS antennas generate raw observables data
- **Sub-meter accuracy:** The system is rated to get 0.3 m accuracy in the X, Y position and 0.5 m in the Z position

Distance Measuring Indicator (DMI)

- Allows for collection of high-resolution imagery at posted speeds and computes wheel rotation information to aid vehicle positioning.

Cameras

- High-definition cameras with precision lenses allow for accurate asset extraction and recording
- Frame rate: 15 images per second, with 1936x1456 color resolution

Pavement Imaging System

- Two line-scan cameras and lasers configured to image 4m transverse road sections with 1 mm resolution (4000 pixel) at speeds that can reach 100 km/h
- Allows fully illuminated pavement image collection even in heavy shadow/canopy areas

Profiler

- International Cybernetics Corporation MDR 4087 (with Geolocator line lasers)
- Texas A&M Transportation Institute - HMA/PCC1 Certification Level
- Consistent with Tex-1001-S specification
- Utilizes 5 lasers to accurately determine IRI and Rutting of travel lanes
- Calibration checks done on a daily basis
- GIS-centric reporting

Figure 7 – DTS MAC Vehicle

Downward-facing pavement imagery was collected to be used in quantifying distress type and extents present on segments of road. The resolution of the imagery allowed for distresses to be easily identified and measured during the analysis portion of the contract.

Mobile image collection of NTE3's roadway network was accomplished through coordination with NTE3's staff. Efforts associated with the mobile image collection included review of client GIS street centerline file, route planning based on GIS street centerline and coordination of existing construction projects along the streets. All MAC image collection routes were reviewed by both DTS and the NTE3's staff to assure all of the streets attained complete image coverage. This effort was accomplished by reviewing a GIS shapefile of the MAC daily GPS point associated to each image collected overlaid on the GIS street centerline file.

DTS MAC image collection included a daily check of the on-board systems. This vehicle component check consisted of a calibration site survey of a nine-point grid in state plane coordinates. Each morning and afternoon, before and after a day's image collection, the MAC vehicle drove over the surveyed location. The MAC technician then extracted each point's location to verify the location of the point extracted was within approximately three feet of the surveyed points. DTS' QA/QC manual includes further details regarding MAC quality control procedures.

Figure 8 - An Example of a 9-Point Calibration Site

The DTS MAC vehicle collected pavement and ROW images every 25 feet along each street segment.

Each day's image and road data collection were recorded on a MAC server and backed up to an external hard drive. The external hard drives were mailed back to DTS' project office where the data was placed on a production server for post-processing of images and data, quality control review and pavement distress inventory.

ROW images were also collected as part of this contract. The MAC vehicle was configured with a four-camera setup; three forward-facing cameras and one rear-facing camera. The images were captured at roughly 25-foot intervals and were post-processed using collected inertial and GPS data. This allowed for more accurate asset extraction to be completed.

The automated data collection effort for NTE3's roadway network began in August 2019 and was completed in October 2019.

Pavement Condition Assessment

The MAC GPS, IMU, DMI, and ROW imagery is post-processed daily. DTS pavement engineers and GIS analysts prepared a project data dictionary that includes all distress types. This data dictionary was provided to trained pavement condition technicians utilized DTS' spatial image analysis software EarthShaper™ to analyze and digitize pavement distress types and extents as a point, line or polygon. Depending on the distress type measurement required by the project data dictionary, each pavement image's distress data was digitized and recorded to a database and associated to the street section that was surveyed. Each distress type and extent are recorded to the project pavement condition database; and each street section's total type and extent is calculated.

This method of pavement distress inventory provides a quantifiable and repeatable process for NTE3 to use in future MAC image collection projects. Each street segment, in conjunction with the pavement and ROW imagery, allows pavement engineers to review each pavement technician's data, allowing for an open quality control process.

TxDOT PMIS Pavement Distress Types

DTS did the pavement distress inspection according to the procedures detailed in TxDOT's Pavement Management Information System Rater's Manual for Fiscal Year 2020 (April 2019). Table 4 lists the PMIS distress types and valid values.

Detailed Pavement Type 01 (CRCP)		Detailed Pavement Type 04-10 (ACP)	
Distress Type	**Valid Values**	**Distress Type**	**Valid Values**
Spalled Cracks	000 to 999	Shallow Rutting	000 to 100
Punchouts	000 to 999	Deep Rutting	000 to 100
Asphalt Patches	000 to 999	Severe Rutting	000 to 100
Concrete Patches	000 to 999	Failure Rutting	000 to 100
Average Crack Spacing	01 to 75	Patching	000 to 100
Detailed Pavement Type 02-03 (JCP)		Failures	00 to 99
Distress Type	**Valid Values**	Block Cracking	000 to 100
Failed Joints and Cracks	000 to 999	Alligator Cracking	000 to 100
Failures	000 to 999	Longitudinal Cracking	000 to 999
Shattered Slabs	000 to 999	Transverse Cracking	00 to 99
Slabs with Longitudinal Cracks	000 to 999	Raveling	0, 1, 2, or 3
Concrete Patches	000 to 999	Flushing	0, 1, 2, or 3
Apparent Joint Spacing	01 to 75		

Table 4 - List of PMIS Distress Types and Valid Values by Pavement Type

Pavement Distress Inventory

A pavement distress inventory consists of identifying specific pavement surface distress types that are associated with the degradation of a pavement surface due to traffic loads, environmental factors, lack of maintenance and other anthropogenic or natural occurrences. Each distress type is quantified in accordance with the protocol established in the Texas Department of Transportation's Pavement Rater's Manual for fiscal year 2020. Visual pavement evaluation was conducted in each lane, for every section within the scope of the project. Below are definitions of distresses.

- ACP Rutting is a longitudinal surface depression in a wheel path. It can be rated with a severity of either shallow or deep.
- ACP Patching refers to the presence of patches, a form of repair made to pavement distresses.
- ACP Block Cracking is a group of interconnecting cracks which form irregularly shaped blocks, varying in size from 1 foot by 1 foot to 10 feet by 10 feet. This condition

is a result of the age hardening of the asphalt coupled with shrinkage of the asphalt concrete or with shrinkage of the cement- or lime-stabilized based courses.

- ACP Alligator Cracking is a group of interconnecting cracks in the wheel path which form small, irregularly shaped blocks which often resemble the patterns found on an alligator's skin. This condition is formed by the repeated flexing of the pavement surface beneath traffic loads.
- ACP Longitudinal Cracking refers to the cracks or breaks that run approximately parallel to the pavement centerline. This condition may occur because of poorly constructed paving lane joints, thermal shrinkage, inadequate support, or the reflection from underlying layers.
- ACP Transverse Cracking refers to the cracks or breaks that travel at approximately right angles to the pavement centerline and span the entire width of the lane. This condition may be caused by differential movement beneath the pavement surface or occasionally by surface shrinkage due to extreme temperature variation.
- ACP Raveling is the progressive disintegration of the surface due to dislodgement of aggregate particles.
- ACP Flushing is the presence of asphalt on the pavement surface.
- ACP Failures refer to localized sections of pavement where the surface has been severely eroded, badly cracked, depressed, or severely shoved.
- CRCP Spalled Crack is a transverse crack that is chipping on either side along some or all its length.
- CRCP Punchouts are typically full-depth blocks of pavement formed when one longitudinal crack crosses two transverse cracks.
- CRCP Asphalt Patches are localized areas of asphalt concrete which have been placed to the full depth of the surrounding concrete slab as a temporary method of correcting surface or structural defects.
- CRCP Concrete Patches are localized areas of newer concrete which have been placed to the full depth of the existing slab as a method of correcting surface or structural defects.
- CRCP Average Crack Spacing is the average distance between transverse cracks, spalled or not, within a section. It is not itself a pavement distress type but is instead a valuable measure of whether a CRCP slab is behaving as designed.
- JCP Failed Joints and Cracks is a transverse joint or crack that shows spalling of greater than 1.0 inch.
- JCP Slabs with Longitudinal Cracks is a slab with a crack that roughly parallels the roadbed centerline.
- JCP Concrete Patches are localized areas of newer concrete which have been placed to the full depth of the existing slab as a method of correcting surface or structural defects.
- JCP Failures are localized areas in which traffic loads do not appear to be transferred across the reinforcing bars and are typically areas of surface distortion or disintegration. Corner breaks, punchouts, asphalt patches, failed concrete patches, durability "D" cracking, severe spalls, and popouts are all considered failures.

- JCP Shattered Slabs are slabs that are so badly cracked that they warrant complete replacement. A slab is considered shattered if it contains five or more failures, or if one or more failures cover more than half of its area.

Rutting Depth and Percentages

For each lane, rutting depth was measured in both wheel paths independently. For the typical 0.1-mile auditable section length and 20-foot measurement interval, there should be approximately 52 data points for each lane segment (0.1 mile × 5,280 feet per mile ÷ 20 feet per measurement × 2 wheel paths).

For rutting depth, each pair of data points was averaged to produce an average rutting depth that was later used for evaluation and further analysis such as calculating the PMIS condition score. The average rutting depth is just a simple arithmetic mean (unweighted average) of the left and right wheel path points.

Each average rutting depth data point was then categorized using the PMIS rut buckets (None, Shallow, Deep, Severe, and Failure) shown in Table 5 below.

Inspection Type	Inspection Item	Units	Valid Values
Rutting Depth – ACP Only	**None (0 to 0.24 inches)**	Percentage of wheel path length	0 to 100
	Shallow Rutting (0.25 to 0.49 inches)	Percentage of wheel path length	0 to 100
	Deep Rutting (0.50 to 0.99 inches)	Percentage of wheel path length	0 to 100
	Severe Rutting (1.00 to 1.99 inches)	Percentage of wheel path length	0 to 100
	Failure Rutting (2.00 inches or more)	Percentage of wheel path length	0 to 100

Table 5 - PMIS Rutting Depth Categories (Rutting Buckets).

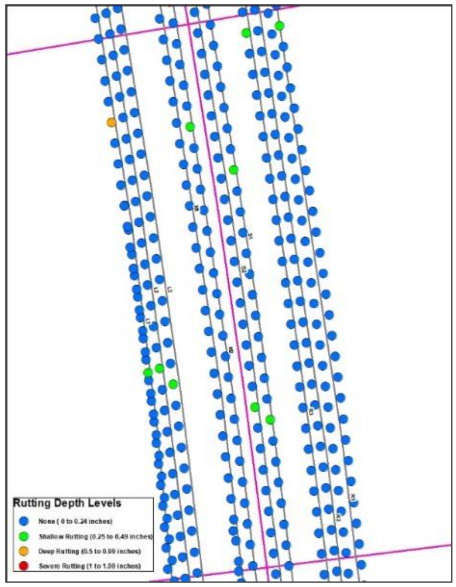

Figure 9 - Average Rutting Depth Data Points Converted into PMIS

The figure above shows an example of average rutting depth data points converted into the PMIS rutting depth categories for a half portion of an auditable section. Table 6 lists the resulting counts.

PMIS Lane	PMIS Rutting Depth Category					Total
	"None"	Shallow	Deep	Severe	Failure	
A1	26	0	0	0	0	**26**
A2	21	3	1	1	0	**26**
A3	24	1	1	0	0	**26**

Table 6 - Example of PMIS Rutting Depth Category Counts

Finally, the counts were converted into percentages of wheel path length for each lane segment, as shown in Table 7.

PMIS Lane	PMIS Rutting (Percentage of Wheel path Length)					Total
	None	Shallow	Deep	Severe	Failure	
A1	100	0	0	0	0	100.00
A2	80	12	4	4	0	100.00
A3	92	4	4	0	0	100.00

Table 7 - Converting Rutting Counts into PMIS Ratings for Rutting

These percentages are the distress ratings used for rutting when determining the PMIS condition score. The PMIS does not use severe rutting or failure rutting at this time. However, these points are used (if present) in the FA rutting performance standards.

Skid Resistance

The goal of this project was to establish current frictional characteristics of the pavements within Segments 3A and 3B and determine which, if any, auditable sections fail to meet the performance criteria laid out in Table 19-2 of the concession agreement.

The first round of data collection was conducted September 13-16, 2018. A locked-wheel skid friction tester was used. It was manufactured by International Cybernetics Corporation that meets all specifications set forth in ASTM E-274, Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire. All tests were performed using an ASTM E-524 smooth testing tire in the right wheel path of each lane. The testing interval for the managed lanes and general purpose lanes was set at 0.05 miles at 50 mph, a speed required by TxDOT but varying from the ASTM E-274 standard. Testing on ramps was done as frequently as possible and at 50 mph. The results collected represent the SN50S (Skid Number at 50 mph as measured with a Smooth tire). Testing on all frontage roads was conducted at 40 mph or the posted speed limit, which was lower. In cases where testing was conducted below 50 mph, data was corrected to an SN50S.

The pavement skid friction tester was manufactured in 2012 and has been maintained in accordance with all manufacturer recommendations since that time. The most recent calibration was conducted by the manufacturer in July 2019. A copy of the calibration report is available upon request.

Figure 10 - Pavement Skid Friction Testing Equipment

Chapter 5: Performing Data Checks, Adjustments, and Exclusions

This chapter describes how the field data (ratings and measurements) were reviewed before analysis and reporting. DTS' standard QC/QA practice for NTE3 included the following:

- Data Checks: Data points that are known not to be reliable are excluded from the analysis. Usually this happens because they were made outside of the normal calibration range of the device (for example, a low-test speed for IRI or a low flowrate for friction data).
- Data Adjustments: Data points that are affected by a known systematic (not random) bias or by a conversion equation issue are adjusted and then included in the analysis.
- Data Exclusions: Data points that the Client has reason to believe are not representative of the actual need for repair are excluded from the analysis. Usually this happens because of nearby factors not necessarily related to the pavement (for example, drainage elements, bridges, and possibly intersections affecting IRI).

The processes were completed in the order listed. Data points had to pass all three processes to be included in the analysis and reporting.

IMPORTANT NOTE: No data points were deleted from the project geodatabase. For checks and exclusions, a flag was set in a field for the data point's record. For adjustments, a new field was defined and contained the adjusted value.

PMIS Distress Ratings

PMIS distress ratings, by definition, are summarized for the entire length of the rating section – in this case, the entire length of the auditable section. Because NTE3 requires inspection data for each lane, each lane has its own set of PMIS distress ratings.

The following data checks were run on the PMIS distress ratings:

- PMIS Detailed Pavement Type Check: Each set of PMIS distress ratings must have had a valid PMIS detailed pavement type value, as previously defined.
- Rating Values Check: All PMIS distress ratings must have had valid values, as previously defined (for example, ACP Patching of 0-100 percent).

No data adjustments were applied to the PMIS distress ratings.

No data exclusions were applied to the PMIS distress ratings.

IRI Measurements

DTS' van stores detailed IRI measurements for left and right wheel paths independently every three inches but reports summarized values every 20 feet. The PCSS vehicle also reports GPS latitude-longitude coordinates every 20 feet to match up with the summary IRI values. This process produces a very dense field of IRI measurements for each 0.1-mile auditable section.

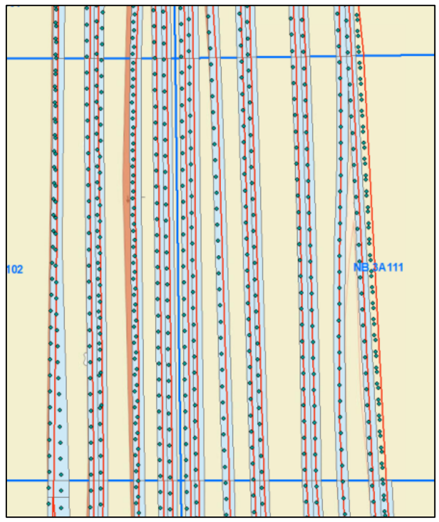

Figure 11 - IRI and Rutting Data Points for a 0.1-Mile Auditable Section

The following data checks were completed on the IRI measurements:

- Average IRI Value Check: IRI measurements were flagged in cases where either wheel path IRI is greater than 459 inches per mile. This was done because TxDOT uses an exponential equation to convert IRI into Serviceability Index (SI) to determine the impact of ride quality on the PMIS Condition Score. IRI values greater than 459 inches per mile convert into negative SI values because the horizontal asymptote of the exponential curve (used for "high" IRI values) is less than zero, which violates the definition of SI (the range is 0.1 to 5.0). Such values cannot be used to determine Condition Score, and thus were not used in the analysis.
- Test Speed Check: IRI/Rut measurements were flagged and excluded when IRI/Rut measurements of test speed were less than 20 miles per hour (mph).

The following data adjustments were made on the IRI measurements, when necessary:

- Low IRI Adjustment: If Serviceability Index (SI) had to be calculated from an IRI that was less than 43 inches per mile, the SI value was set to 5.0.

- Pavement Type Adjustment: For PMIS pavement types of CRCP or JCP, ten inches per mile were subtracted from the IRI measurements to produce an Equivalent ACP IRI.

The Equivalent ACP IRI was used when calculating PMIS condition scores and when comparing IRI and condition score to the CDA Performance Standards.

The Annual Pavement Inspection Report compares current condition to fourteen CDA Performance Standards – IRI figures directly in five of them and indirectly in four more. Ride quality is also the primary factor that the general public uses when evaluating pavement condition. As a result, the IRI results tend to attract great interest.

From the CDA perspective, some high IRI points can be caused by issues ancillary to the pavement. IRI data exclusions try to identify these ancillary points so as to separate spots that are directly related to the pavement. The IRI data exclusions include the following:

- Intersections
- Maintenance Limits
- Work Zones
- Drainage Elements, Single-Point

The following data exclusions were applied to the IRI measurements, when necessary:

- IRI Maintenance Limits Exclusion: All IRI data points taken within 100-feet (or outside) of the maintenance limits of the CDA were excluded from the analysis.
- IRI Work Zones Exclusion: Lane segment, roadbed segments, or auditable sections were removed from the analysis if they could not be safely or accurately tested as a result of construction.
- Drainage Elements, Single-Point Exclusion: IRI data points were removed from the analysis if they were located 30 feet or closer to a single drainage element, provided that the IRI data and the drainage element were in the same lane.
- Bridge Deck Exclusion: IRI data points were excluded from the PMIS condition score calculation if they were located on a bridge deck or on the approach/departure slab.
- Bridge Approach and Departure Slabs Exclusion: IRI data points were excluded from the PMIS condition score calculation if they were located 100 feet or closer to the approach slab or the departure slab of a bridge deck.

Rutting Depth Measurements

Detailed rutting depth measurements were obtained for the left and right wheel paths independently every three inches. However, values are summarized every 20 feet. The PCSS produces a very dense field of rutting depth measurements for each 0.1-mile Auditable Section.

No data checks were made for rutting depth.

No data adjustments were made for rutting depth.

The following data exclusions were performed on the rutting depth measurements, if needed:

- Intersections Exclusion: Rutting depth measurements were taken within at-grade intersections from the analysis. This was done as a result of frequent speed changes (including sudden stops) that often occur in these areas can produce large variations in the measurements.
- Maintenance Limits Exclusion: All rutting depth measurements were excluded if they were located outside of the maintenance limits of the CDA from the analysis.
- Work Zones Exclusion: Lane segments, roadbed segments, or auditable sections were removed from the analysis if they couldn't be accessed safely or tested accurately due to construction.

Skid Resistance Measurements

NTE3 requested that skid resistance measurements were reported every 0.5-mile as the CDA requires. Although the CDA only requires a summary of skid resistance at 0.5-mile intervals, DTS measured skid resistance at 0.1- mile interval to give a more representative sample for each 0.5-mile. The skid resistance values were averaged the 0.1-mile results into 0.5-mile auditable section group.

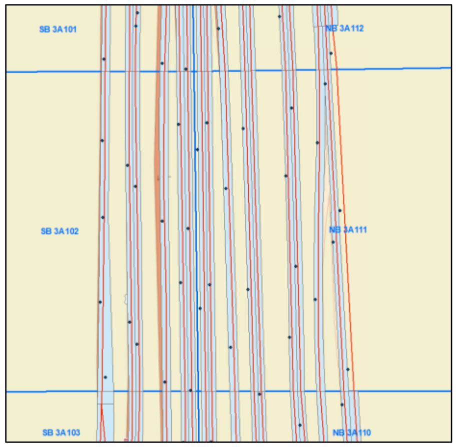

Figure 12 - Skid Data Points for a 0.1-Mile Auditable Section

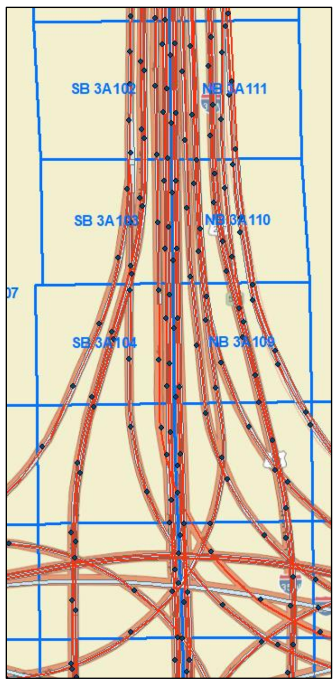

Figure 13 - Skid Data Points for an Auditable Section Group

Skid measurements were checked for the following conditions:

- Average SN Value Check: Skid measurements were flagged when the average SN value was less than one or greater than 70, and excluded them from the analysis.
- Test Speed Check: Skid measurements were flagged when the test speed was not within 30- 60 mph and excluded it from the analysis.
- Flowrate Check: Skid measurement were flagged when the flowrate was not within 20-42 gallons per minute (gpm) and excluded it from the analysis.

Data adjustments were not applied to the skid resistance measurements.

Data exclusions were not applied to the skid resistance measurements.

Chapter 6: Summarizing and Analyzing the Pavement Inspection Data

Table 8 lists the conversion between roadbed average values to auditable section summary groups. Each auditable section will have two average values for PMIS condition score, IRI and skid resistance.

Data	Auditable Section Summary Group	Roadbed Type
PMIS Condition Score	Group 1	Mainlanes & Ramps
	Group 2	Frontage Roads
IRI	Group 1	Mainlanes & Ramps
	Group 2	Frontage Roads
Skid Resistance	Group 1	Mainlanes & Ramps
	Group 2	Frontage Roads

Table 8 - Auditable Section Summary Groups

The PMIS condition scores and IRI were not determined with the same method for each auditable section. In cases where an auditable section contains pavement only, all IRI data that passes checks, adjustments, and exclusions is used. In addition, the first four IRI standards should be applied. The PMIS condition score then is equivalent to the IRI. When an auditable section contains a bridge, all IRI data that passes checks, adjustments, and exclusions is used. Subsequently, the fifth IRI standard should be applied. The PMIS condition score is then calculated from the on-pavement IRI points only (after considering bridge exclusions for the deck and 100 feet from the approach and departure slabs). In cases where the auditable section is a bridge deck, all IRI data that passes checks, adjustments, and exclusions, with an exception of the two bridge exclusions, is used. The fifth IRI standard is then applied.

Chapter 7: Description of TxDOT PMIS Condition Score Calculation Process

DTS referred to TxDOT's Pavement Management Information System (PMIS) Technical Manual when calculating PMIS condition score values for each auditable section. The following section provides a brief overview.

Overview of PMIS Condition Score

PMIS condition scores range from 1 (worst condition) to 100 (best condition), as shown in Table 9 below.

Condition Score Values	Category
90-100	Very Good
70-89	Good
50-69	Fair
35-49	Poor
1-34	Very Poor

Table 9 - TxDOT PMIS Condition Score Values

PMIS condition score is based on the following factors:

- ACP Distress – shallow rutting, deep rutting, patching, failures, block cracking, alligator cracking, longitudinal cracking, transverse cracking
- CRCP Distress – spalled cracks, punchouts, asphalt patches, concrete patches, average crack spacing
- Ride quality – average IRI converted to SI value – uses
- Other factors – average daily traffic and speed limit

Distress Utility Factors

The pavement distress value is converted into a utility factor. Utility factors range in value from 0.01 (least utility) to 1.00 (most utility). Utility factors give weight to pavement distresses.

Ride Quality Utility Factor

Ride quality is a utility factor that is based on the average IRI. The average IRI is converted into a serviceability index ranging from 0.1 (worst) to 5.0 (best). Average daily traffic and speed limit are also considered when assessing ride quality. Table 10 lists the range of average daily traffic per roadbed for each PMIS traffic classification.

Speed Limit	PMIS Traffic Classification		
	Low	Medium	High
30	1 to 916	917 to 5,500	More than 5,500
35	1 to 785	786 to 4,714	More than 4,714
40	1 to 687	688 to 4,125	More than 4,125
45	1 to 611	612 to 3,666	More than 3,666
50	1 to 550	551 to 3,300	More than 3,300
55	1 to 500	501 to 3,000	More than 3,000
60	1 to 458	459 to 2,750	More than 2,750
65	1 to 423	424 to 2,358	More than 2,358
70	1 to 392	393 to 2,357	More than 2,357
75	1 to 366	367 to 2,200	More than 2,200
80	1 to 343	344 to 2,062	More than 2,062
85	1 to 323	324 to 1,941	More than 1,941

Table 10 - Average Daily Traffic (ADT) Ranges per PMIS Classification

PMIS Condition Score

The final PMIS condition score is the product of the pavement distress utility factors and the ride quality utility factor, multiplied by 100 and rounded to an integer value.

Chapter 8: Comparison to CDA Performance Standards

Pavement Condition Score

DTS calculated pavement condition scores for 220 of the 254 auditable sections of the facility due to checks and bridge exclusions. 215 of the auditable sections contained mainlanes, ramps and direct connectors, and 138 of the auditable sections contained frontage roads. Table 11 shows the results for the Pavement Condition Score Performance Standard.

Description	Target	Year 2019 Results
Mainlanes & Ramps: Pavement Condition Score for each Auditable Sections Exceeding: 90	80%	99.07% (213 out of 215)
Frontage Roads: Pavement Condition Score for each Auditable Sections Exceeding: 80	80%	97.10% (134 out of 138)
Mainlanes & Ramps: Pavement Condition Score for Each Auditable Sections Exceeding: 80	100%	100% (215 out of 215)
Frontage Road: Pavement Condition Score for Each Auditable Sections Exceeding: 70	100%	100% (138 out of 138)

Table 11 - Results for the Pavement Condition Score Performance Standard

Equivalent ACP IRI Note: We used the “Equivalent ACP” IRI Adjustment (IRI – 10 inches/mile for PCC) when calculating PMIS Condition Scores for comparison to the CDA Performance Standards.

Rutting

DTS measured left- and right-wheel path rutting depth on 227 of the 254 auditable sections of the facility due to pavement types, checks and exclusions. 222 of the auditable sections contained mainlanes, ramps and direct connectors, and 124 of the auditable sections contained frontage roads. Table 12 shows the results for the rutting performance standard.

Description	Target	Year 2019 Results
Mainlanes & Ramps: Percentage of Rut scores greater than 0.25	0%	0% (0 out of 222)
Frontage Roads: Percentage of Rut scores greater than 0.25	0%	0% (0 out of 124)
Mainlanes & Ramps: Percentage of Rut scores greater than 0.5	0%	0% (0 out of 222)
Frontage Roads: Percentage of Rut scores greater than 0.5	0%	0% (0 out of 124)

Table 12 - Results for the Rutting Performance Standard

Ride Quality

DTS measured left- and right-wheel path IRI on 239 of the 254 auditable sections of the facility due to checks and construction work exclusions. 237 of the auditable sections contained mainlanes, ramps and direct connectors, and 141 of the auditable sections contained frontage roads. NTE3's Comprehensive Development Agreement with TxDOT includes five performance standards for ride quality. The first four standards apply to auditable sections that do not contain bridge decks. The fifth standard applies only to auditable sections with bridge decks. Table 13 shows the results for Ride Quality Performance Standards 1 and 2 (the 80 percent targets), 3 and 4 (the 100% targets) and 5 (Bridge Decks).

Description	Target	Year 2019 Results
Mainlanes & Ramps: Percentage of Auditable Sections with IRI below 95	80%	97.33% (146 out of 150)
Frontage Roads: Percentage of Auditable Sections with IRI below 120	80%	94.89% (130 out of 137)
Mainlanes & Ramps: Percentage of Auditable Sections with IRI below 120	100%	100% (150 out of 150)
Frontage Roads: Percentage of Auditable Sections with IRI below 150	100%	100% (137 out of 137)
Mainlanes & Ramps: Percentage of Auditable Sections Containing a Bridge Deck with IRI below 200	100%	100% (87 out of 87)
Frontage Roads: Percentage of Auditable Sections Containing a Bridge Deck with IRI below 200	100%	100% (4 out of 4)

Table 13 - Results for Ride Quality Performance Standards 1 and 2 (80%), 3 and 4 (100%), and 5 (Bridge Decks).

Note: DTS used the Equivalent ACP IRI adjustment (IRI – 10 inches/mile for PCC) when comparing results to the CDA Performance Standards.

Skid Resistance

DTS measured Skid Resistance (SN50) on 66 equivalent 0.5-mile sections of the facility. Table 14 lists the results for the Skid Resistance Performance Standard.

Description	Target	Year 2019 Results
Mainlanes, Ramps and Direct Connectors: Number of 0.5-mile sections with skid scores below 25	0%	0% (0 out of 47)
Frontage Roads: Number of 0.5-mile sections with skid scores below 25	0%	0% (0 out of 27)
Mainlanes, Ramps and Direct Connectors: Number of 0.5-mile sections with skid scores below 30	0%	10.64% (5 out of 47)
Frontage Roads: Number of 0.5-mile sections with skid scores below 30	0%	3.70% (1 out of 27)

Table 14 - Results for the Skid Resistance Performance Standard.

Table 15 lists the "0.5-mile Auditable Sections" with SN50 below 30 for mainlanes, ramps and direct connectors (Mainlanes & Ramps).

Auditable Section Group	Alignment	Average Skid Number
NB 3A026 - NB 3A030	Mainlanes & Ramps	29
3BSB101 - 3BSB009	Mainlanes & Ramps	29.8
EB 3A201 - SB 3A049	Mainlanes & Ramps	29.2
WB 3A012 - WB 3A008	Mainlanes & Ramps	29.6
EB 3A001 - EB 3A004	Mainlanes & Ramps	29.2

Table 15 - 0.5-Mile Auditable Sections with SN50 Below 30 for Mainlanes & Ramps.

Table 16 lists the "0.5-mile Auditable Sections" with SN50 below 30 for frontage roads.

Auditable Section Group	Alignment	Average Skid Number
1WB050 - WB 3A001	Frontage Roads	25.80

Table 16 - 0.5-Mile Auditable Sections with SN50 Below 30 for Frontage Roads.

Chapter 9: Summary

DTS performed pavement distress, ride quality, rutting depth, and image inspection on NTE3 segments 1, 2 and 3 in August and October 2019, with ARA providing support on skid resistance inspections which took place in September 2019. The summaries of scores calculated based on this inspection are as follows:

Description	Target	Year 2019 Results
Mainlanes & Ramps: Pavement Condition Score for each Auditable Sections Exceeding: 90	80%	99.07% (213 out of 215)
Frontage Roads: Pavement Condition Score for each Auditable Sections Exceeding: 80	80%	97.10% (134 out of 138)
Mainlanes & Ramps: Pavement Condition Score for Each Auditable Sections Exceeding: 80	100%	100% (215 out of 215)
Frontage Road: Pavement Condition Score for Each Auditable Sections Exceeding: 70	100%	100% (138 out of 138)
Mainlanes & Ramps: Percentage of Rut scores greater than 0.25	0%	0% (0 out of 222)
Frontage Roads: Percentage of Rut scores greater than 0.25	0%	0% (0 out of 124)
Mainlanes & Ramps: Percentage of Rut scores greater than 0.5	0%	0% (0 out of 222)
Frontage Roads: Percentage of Rut scores greater than 0.5	0%	0% (0 out of 124)
Mainlanes & Ramps: Percentage of Auditable Sections with IRI below 95	80%	97.33% (146 out of 150)
Frontage Roads: Percentage of Auditable Sections with IRI below 120	80%	94.89% (130 out of 137)
Mainlanes & Ramps: Percentage of Auditable Sections with IRI below 120	100%	100% (150 out of 150)

Description	Target	Year 2019 Results
Frontage Roads: Percentage of Auditable Sections with IRI below 150	100%	100% (137 out of 137)
Mainlanes & Ramps: Percentage of Auditable Sections Containing a Bridge Deck with IRI below 200	100%	100% (87 out of 87)
Frontage Roads: Percentage of Auditable Sections Containing a Bridge Deck with IRI below 200	100%	100% (4 out of 4)
Mainlanes, Ramps and Direct Connectors: Number of 0.5-mile sections with skid scores below 25	0%	0% (0 out of 47)
Frontage Roads: Number of 0.5-mile sections with skid scores below 25	0%	0% (0 out of 27)
Mainlanes, Ramps and Direct Connectors: Number of 0.5-mile sections with skid scores below 30	0%	10.64% (5 out of 47)
Frontage Roads: Number of 0.5-mile sections with skid scores below 30	0%	3.70% (1 out of 27)

Table 17 - Performance Measures Summary for Year 2019.

Working closely with NTE3 allowed DTS to front load the centerline file for collection. This is the basis for the way that DTS operates in terms of pavement data collection and inspection. Having the centerline file finalized at the start of the projects sets everything else downstream up for success. DTS was able to collect data without interruption, except due to weather, throughout August and October of 2019. Once collected, passing the data off to the pavement engineers becomes a very straight forward process.

All analyses detailed in this report were based on certified ratings and calibrated measurements, as previously mentioned. DTS has a time tested and proven methodology that seems to work well for all manners of pavement analysis. Within house TxDOT certified engineers, the process becomes much easier and provides DTS with a solid knowledge base for correctly and accurately rating the data collected.

DTS would like to thank everyone at NTE3 for their guidance and support in throughout the projects, especially while DTS created and finalized the centerline file and worked through the reporting format requirements.

If there are any questions or concerns about the data presented here, please do not hesitate to reach out.

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