Spring 2015

Forensic Pavement Evaluation for US 31 W, Jefferson County, Kentucky Using Ground Penetrating Radar

Brad W. Rister
University of Kentucky, brad.rister@uky.edu

Kean Ashurst
University of Kentucky, kean.ashurst@uky.edu

R. Clark Graves
University of Kentucky, clark.graves@uky.edu

University of Kentucky
College of Engineering

Kentucky
Transportation
Center

TECHNICAL ASSISTANCE REPORT

Forensic Pavement Evaluation for US 31 W,
Jefferson County, Kentucky

KTC-TA-15-02/KH91-14-1F
DOI: http://dx.doi.org/10.13023/KTC.TA.2015.02

Author(s):

Brad W. Rister, P.E.
RESEARCH ENGINEER
KENTUCKY TRANSPORTATION CENTER

Kean Ashurst, P.E.
RESEARCH ENGINEER
KENTUCKY TRANSPORTATION CENTER

Clark Graves, P.E.
RESEARCH ENGINEER
KENTUCKY TRANSPORTATION CENTER

Sponsoring Agency:
Kentucky Transportation Cabinet

Spring 2015

1. Report No. **KTC-TA-15-02/KH91-14-1F**	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Forensic Pavement Evaluation for US 31W, Jefferson County, KY Using Ground Penetrating Radar		**5. Report Date** **SPRING 2015** **6. Performing Organization Code** **TARKTC-15-02/KH91-14-1F** **8. Performing Organization Report No.**
7. Authors **Brad Rister, Kean Ashurst, Clark Graves**		**10. Work Unit No. (TRIAS)**
9. Performing Organization Name and Address **University of Kentucky** **College of Engineering** **Kentucky Transportation Center** **176 Oliver Raymond Building** **Lexington, KY 40506-0281**		**11. Contract or Grant No.** **KH91-14-1F**
12. Sponsoring Agency Name and Address **Kentucky Transportation Cabinet** **200 Mero Street** **Frankfort, KY 40622**		**13. Type of Report and Period Covered** **14.Sponsoring Agency Code**
15. Supplementary Notes **Prepared in cooperation with the Federal Highway Administration, US Department of Transportation**		

16. Abstract

The Kentucky Transportation Center (KTC) utilized ground penetrating radar technology to provide a forensic evaluation of the existing pavement structure for the US31W pavement rehabilitation Project in Jefferson County, KY. Processed ground penetrating radar data indicated that the integrity of the underlying concrete pavement beneath the asphalt pavement appears to be competent and structurally sound. The clay soil beneath the concrete pavement appears relatively dry and well compacted. The analyzed GPR data also indicated that the average asphalt layer varied by lane throughout the project from 4.89 to 7.59 inches +/- ½ inch and that the underlying concrete layer average varied by lane throughout the project from 6.59 to 8.12 inches +/- ½ inch. This information was shared with design engineers in efforts to select the most appropriate pavement rehabilitation repair.

17. Key Words **Ground Penetrating Radar, Forensic Pavement Evaluation, GPR**		**18. Distribution Statement** **Unlimited, with approval of the Kentucky Transportation Cabinet**	
19. Security Classification (of this report) **None**	**20. Security Classification (of this page)** **None**	**21. No. of Pages** **22**	**22. Price**

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

FINAL REPORT

Forensic Pavement Evaluation for US 31W, Jefferson County, KY Using Ground Penetrating Radar

by

Brad W. Rister P.E.
Research Engineer

Kean Ashurst P.E.
Research Engineer

Clark Graves P.E.
Research Engineer

Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, Kentucky

in cooperation with

Kentucky Transportation Cabinet
Commonwealth of Kentucky

Spring 2015

TABLE OF CONTENTS

LIST OF DIAGRAMS

LIST OF TABLES

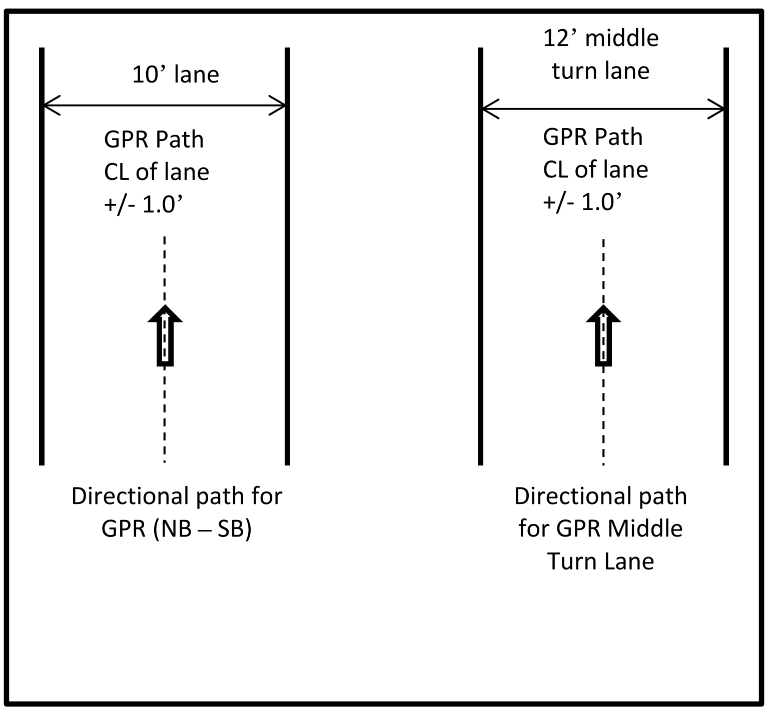
I. INTRODUCTION:

The Kentucky Transportation Cabinet (KYTC) contracted the Kentucky Transportation Center (KTC) to provide a forensic investigation for the US 31W pavement rehabilitation project in Jefferson County otherwise known as Dixie Highway. The purpose of the pavement investigation was to determine the depths and type of the pavement structure/base aggregate through the length of the project. The following report contains the results of the pavement investigation from mileposts 6.6 to 11.7 for US 31W (approximate station numbers 103+67 to 360+40).

II. METHODOLOGY:

KTC utilized Ground Penetrating Radar (GPR) technology to determine the depths of the pavement along the route. Each lane was scanned along a single path using a 900 MHz antenna. The radar signal and the associated distance were recorded every one inch along the lane. The GPR path taken along the two northbound, two southbound, and the center turn lanes were preformed approximately in the center of each lane (see Diagram 1).

Diagram 1: Radar Paths (n.t.s)



A total of five lanes were scanned for the project using GPR. All scans were performed in the lanes direction of normal travel except the middle turn lane. It was scanned in the northbound direction. The northbound scan direction started at pavement change at approximately station number 103+67 and proceeded approximately 25,673 feet to the intersection of Greenwood and Dixie highway, approximate station number 360+40. The lane designations are as follows (Diagram 2):

1. Northbound Right Lane: NBRL
2. Northbound Left Lane: NBLL
3. Northbound Middle Lane: NBML
4. Southbound Right Lane: SBRL
5. Southbound Left Lane: SBLL

Diagram 2: Lanes Scanned with GPR

After the data was collected calibration cores were taken in each lane. In-situ pavement thicknesses were measured and used for calibrating the data for the analysis. A total of seven cores were taken for calibration cores. The measurements are listed in Table 1 below.

Table 1: GPR Calibration Core Measurements

Lane	Direction	Station Number	Asphalt (in.)	Concrete (in.)	DGA (in.)
NB	RL	149+65	6.00	9.00	2.50
NB	LL	107+31	7.375	7.25	N/A
NB	LL	298+15	6.75	7.50	N/A
NB	ML	104+10	9.25	N/A	5.75
NB	ML	298+45	7.75	N/A	8.25
SB	LL	261+10	6.25	6.875	N/A
SB	LL	299+33	7.00	5.875	N/A

III. ANALYSIS:

All data was post processed in the office. The bottoms of all visible pavement layer types were identified by hand within the analysis software. The pavement depth measurements from the cores were used to calibrate the depth measurements in the analysis software. All data was exported into Microsoft Excel to display in graph form and may be viewed in Appendix A. The actual data in spreadsheet form will be delivered to the design consultant for further analysis.

IV. RESULTS:

Each graph shows the pavement depth for a lane along a particular path (Appendix A). The horizontal axis references the mainline station number. The vertical axis is the depth measured in inches from the surface of the pavement to the bottom of the pavement layer type. The data depicted in Appendix A are averaged in Table Two below:

Table 2: Average Layer determined by calibrated GPR Data:

Lane	Avg. Asphalt thickness (in.)	Avg. Concrete thickness (in.)	Avg. DGA thickness (in.)
NBRL	5.03	7.33	6.5 where applicable
NBLL	7.14	6.76	n/a
NBML	7.59	8.12 where applicable	6.14
SBLL	7.04	6.59	n/a
SBRL	4.89	8.00	7.72 where applicable

*where applicable: denoted on graphs in Appendix A

Additional Pavement Observations:

After review of all collected GPR data, it has been determined that approximately seventy-five (75) percent of the total pavement area has an apparent one (1) ft. by six (6) inch wire mesh used for structural reinforcement within the concrete pavement structure. Only the middle turn lane and the outer right-wheel-paths of the right lanes appeared to **not** have any wire mesh reinforcement within the pavement structure.

Field Cores / Subgrade Conditions:

Approximately seven cores were taken for the ground penetrating radar calibration process (Appendix B). In areas where asphalt was placed over concrete, the four to five one inch layers of asphalt appear to be surface overlay mixes and/or apparent 3/8 size mixes (field cores can be made available by request).

The cores also give us some guidance as to how the different sections of roadway have been constructed. First, it appears that one-half of the outer most lanes are non-reinforced concrete pavement beneath an asphalt overlay. This non-reinforced concrete pavement has been placed predominately on a well compacted clay material. The aggregate within this concrete section appears to be crushed limestone. The inner half of these outer lanes towards the center-line of the roadway is comprised of a reinforced concrete pavement (wire-mesh) with an asphalt overlay. The aggregate within this half section of the outer lane towards the center-line appears to be very durable river rock. The inside lanes appear to be a reinforced concrete pavement (wire-mesh) with an asphalt overlay. Again this roadway section was placed on a well compacted clay material, and the aggregate within the concrete appears to be a very durable river rock.

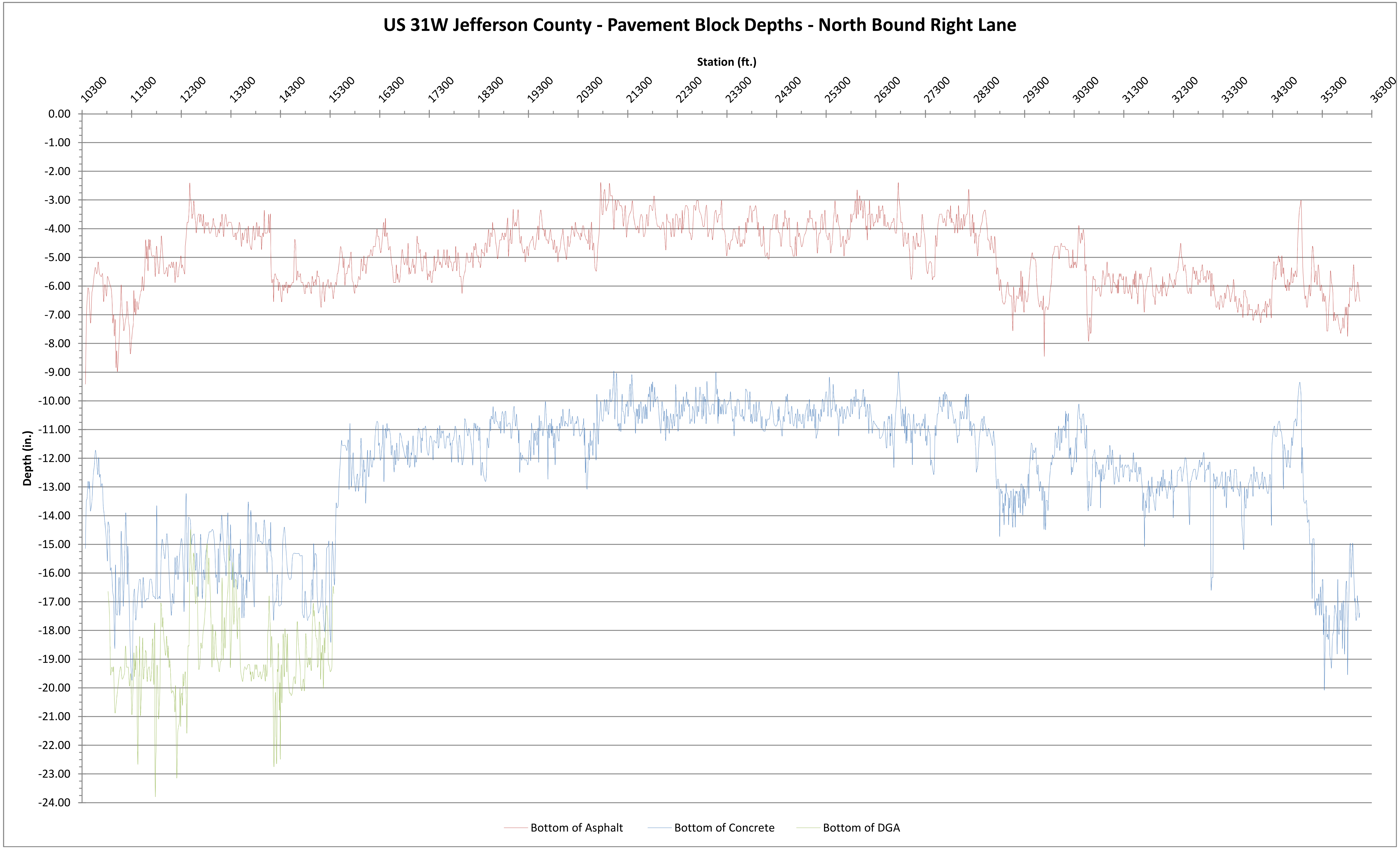
Placing a concrete pavement upon a well compacted clay subgrade was standard practice until mid-1950 per previous highway specifications manuals. The last type of pavement section discovered on the studied area appears in the center turn lane. As shown in Appendix A/B this lane is predominately an asphalt pavement over compacted DGA. Additional pavement core information may be found in Appendix C which was collected by others.

V. CONCLUSION AND RECOMMENDATIONS:

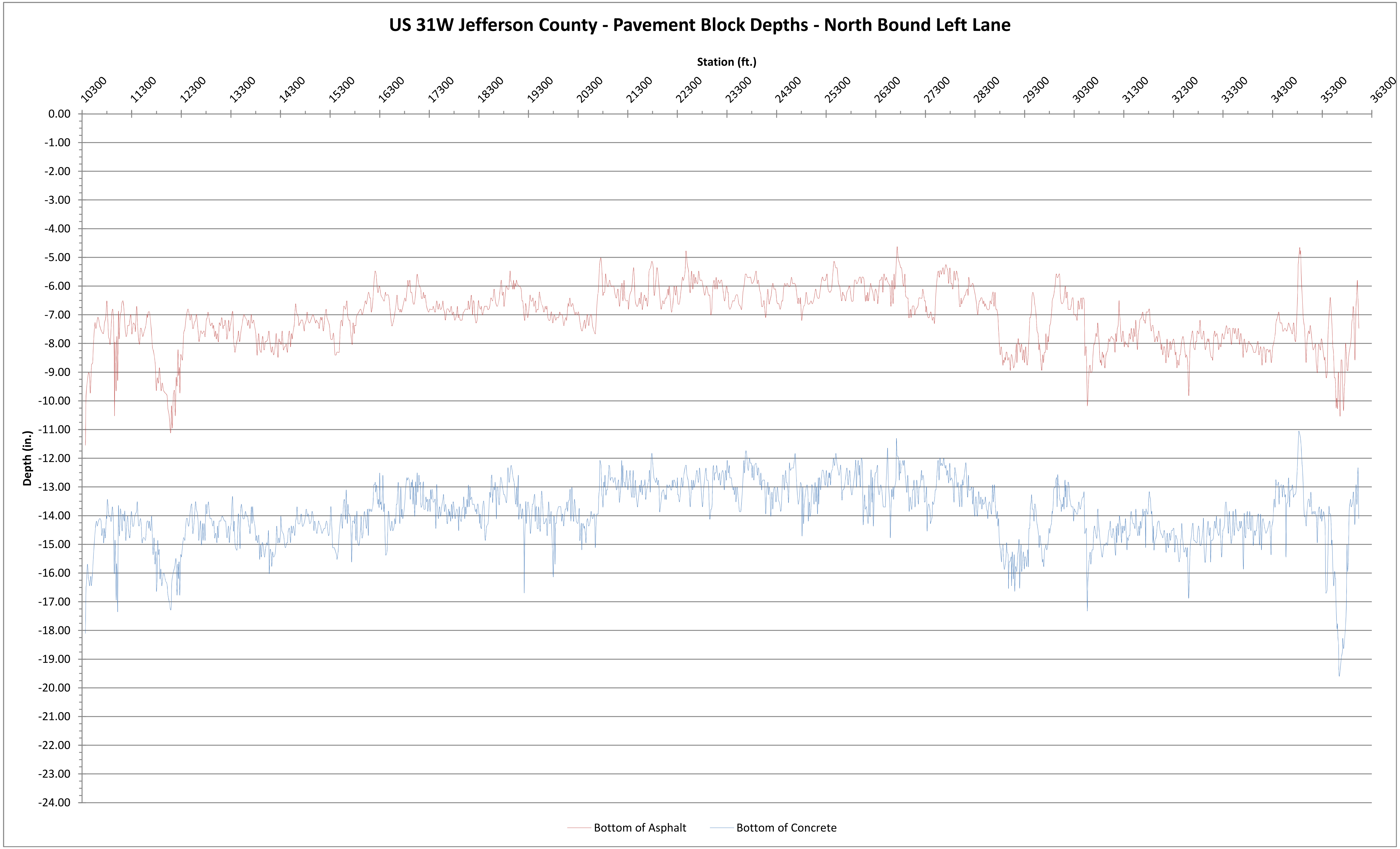
The integrity of the underlying concrete pavement beneath the asphalt pavement appears to be competent and structurally sound. The clay soil beneath the concrete pavement appears relatively dry and well compacted. However, reflective cracking of the concrete joints do appear in the upper asphalt paving surface throughout the project. Provided that this section of roadway has many at-grade entrances and some curb-and-gutter, it is of opinion that there are three options for a pavement repair that could be considered to meet the elevations of the existing curb-and-gutter and entrances:

1. Mill the existing asphalt down to the old concrete and replace with new asphalt.
2. Mill the existing asphalt down to the old concrete and break and seat the old concrete and replace the surface with either concrete or asphalt.
3. Remove all pavement material, stabilize sub-grade, and rebuild complete pavement structure.

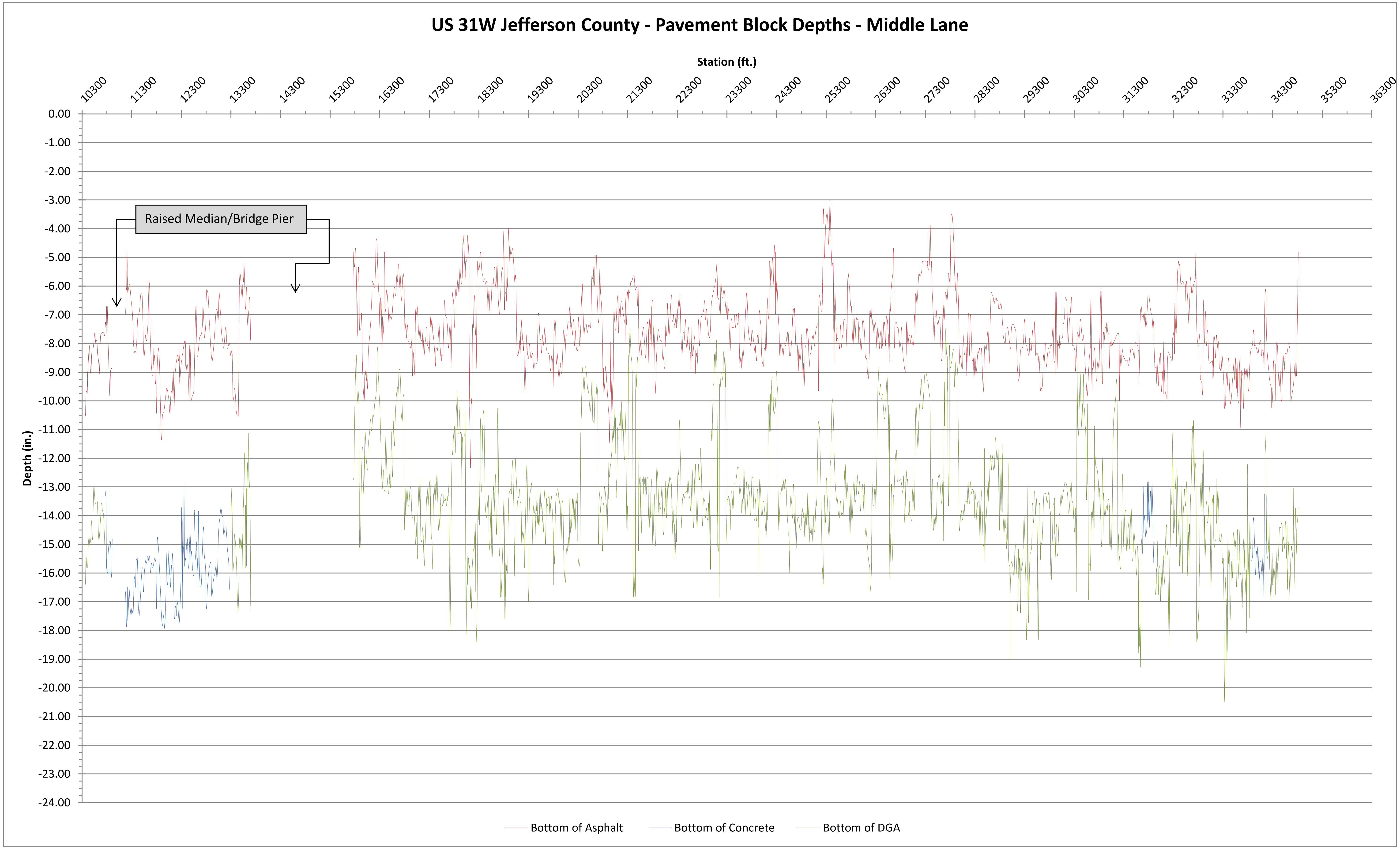
Appendix A

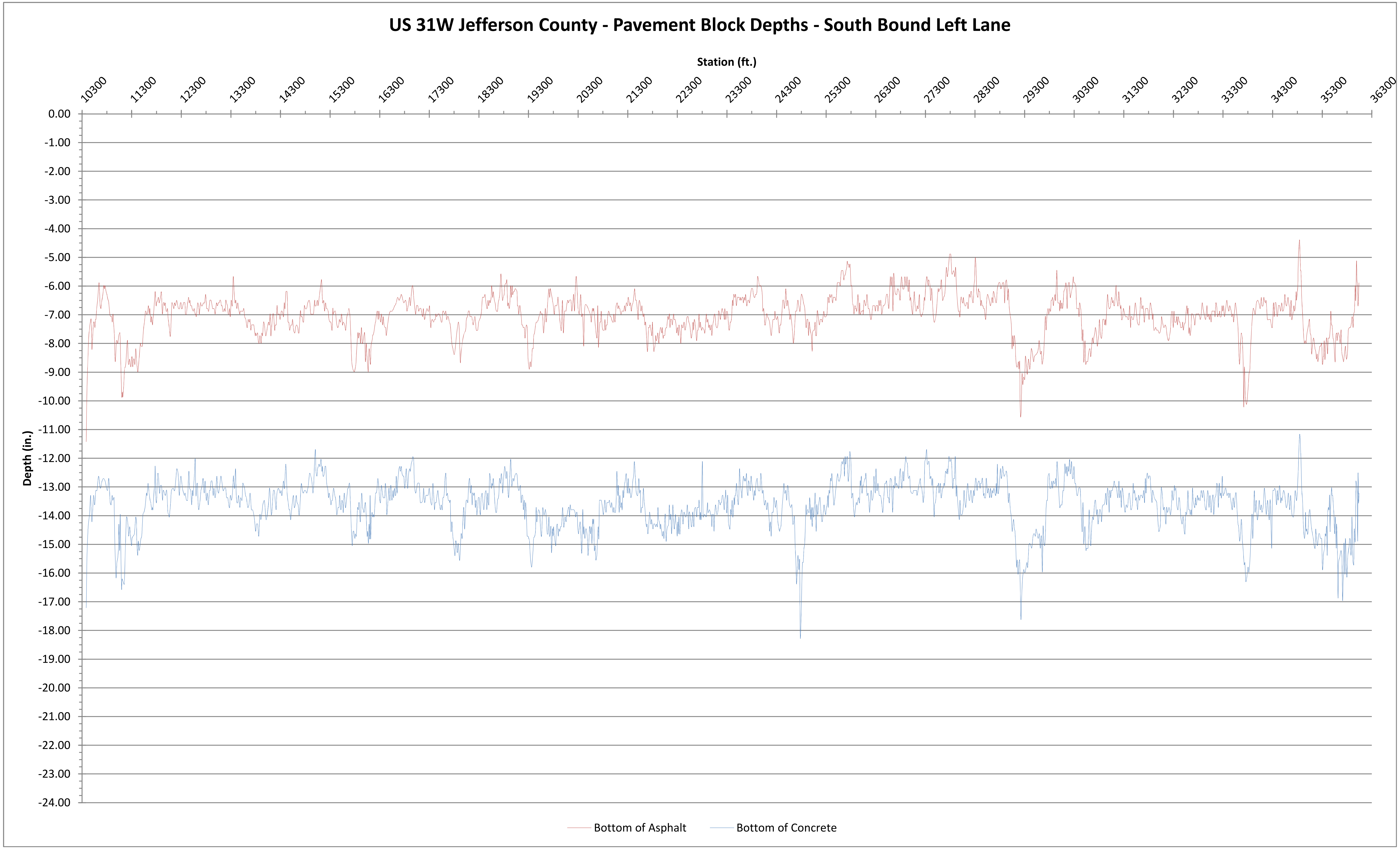


US 31W Jefferson County - Pavement Block Depths - North Bound Right Lane
Station (ft.)
10300
11300
12300
13300
14300
15300
16300
17300
18300
19300
20300
21300
22300
23300
24300
25300
26300
27300
28300
29300
30300
31300
32300
33300
34300
35300
36300
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
-11.00
-12.00
-13.00
-14.00
-15.00
-16.00
-17.00
-18.00
-19.00
-20.00
-21.00
-22.00
-23.00
-24.00
Depth (in.)
Bottom of Asphalt
Bottom of Concrete
Bottom of DGA

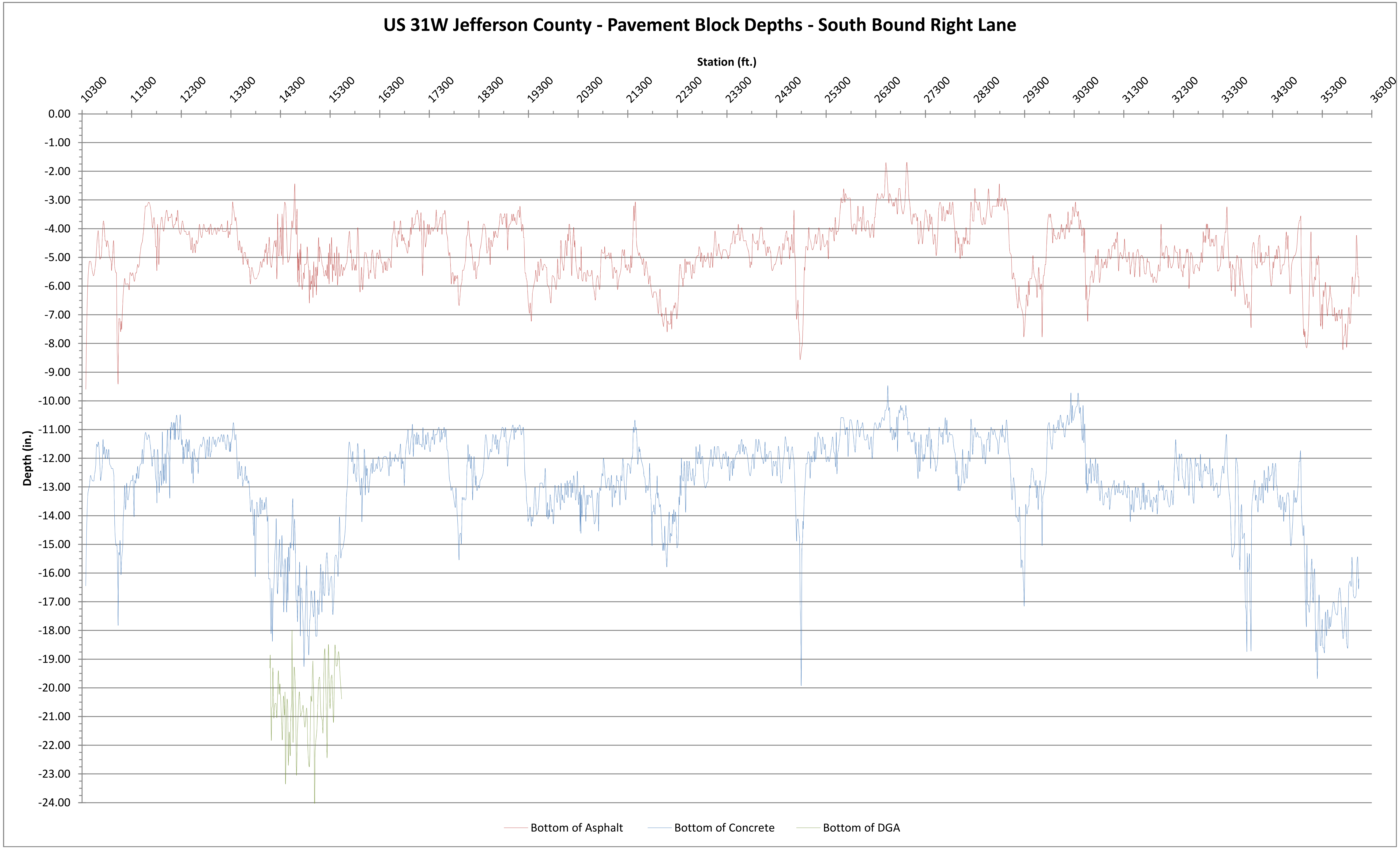


US 31W Jefferson County - Pavement Block Depths - North Bound Left Lane
Station (ft.)
10300
11300
12300
13300
14300
15300
16300
17300
18300
19300
20300
21300
22300
23300
24300
25300
26300
27300
28300
29300
30300
31300
32300
33300
34300
35300
36300
Depth (in.)
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
-11.00
-12.00
-13.00
-14.00
-15.00
-16.00
-17.00
-18.00
-19.00
-20.00
-21.00
-22.00
-23.00
-24.00
Bottom of Asphalt
Bottom of Concrete

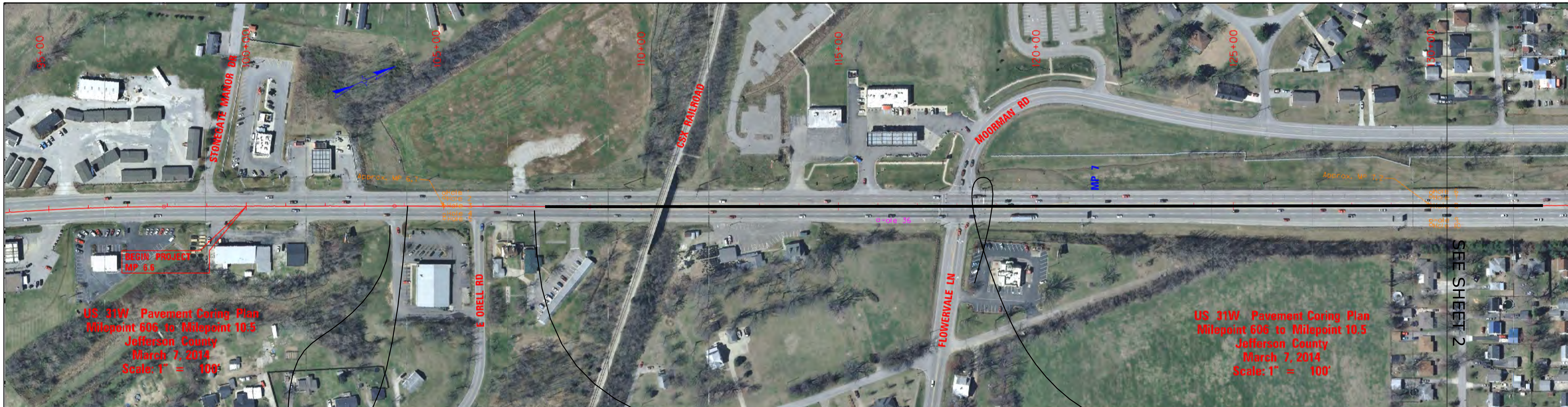

US 31W Jefferson County - Pavement Block Depths - Middle Lane
Station (ft.)
10300
11300
12300
13300
14300
15300
16300
17300
18300
19300
20300
21300
22300
23300
24300
25300
26300
27300
28300
29300
30300
31300
32300
33300
34300
35300
36300
Depth (in.)
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
-11.00
-12.00
-13.00
-14.00
-15.00
-16.00
-17.00
-18.00
-19.00
-20.00
-21.00
-22.00
-23.00
-24.00
Raised Median/Bridge Pier
Bottom of Asphalt
Bottom of Concrete
Bottom of DGA



US 31W Jefferson County - Pavement Block Depths - South Bound Left Lane
Station (ft.)
10300
11300
12300
13300
14300
15300
16300
17300
18300
19300
20300
21300
22300
23300
24300
25300
26300
27300
28300
29300
30300
31300
32300
33300
34300
35300
36300
Depth (in.)
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
-11.00
-12.00
-13.00
-14.00
-15.00
-16.00
-17.00
-18.00
-19.00
-20.00
-21.00
-22.00
-23.00
-24.00
Bottom of Asphalt
Bottom of Concrete


US 31W Jefferson County - Pavement Block Depths - South Bound Right Lane
Station (ft.)
10300
11300
12300
13300
14300
15300
16300
17300
18300
19300
20300
21300
22300
23300
24300
25300
26300
27300
28300
29300
30300
31300
32300
33300
34300
35300
36300
Depth (in.)
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
-11.00
-12.00
-13.00
-14.00
-15.00
-16.00
-17.00
-18.00
-19.00
-20.00
-21.00
-22.00
-23.00
-24.00
Bottom of Asphalt
Bottom of Concrete
Bottom of DGA

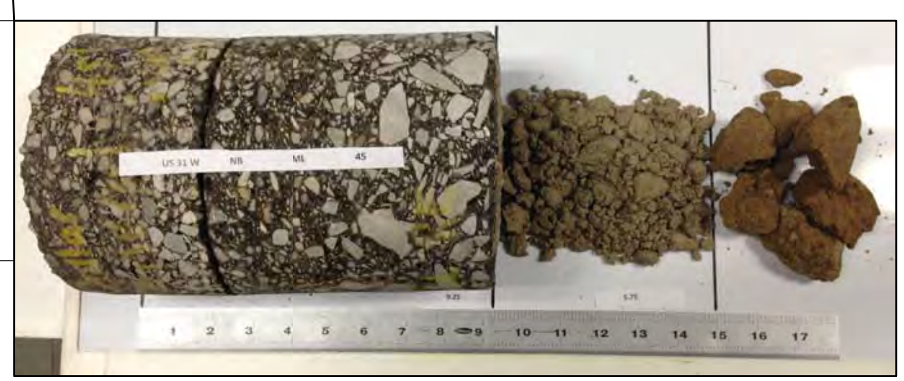
Appendix B



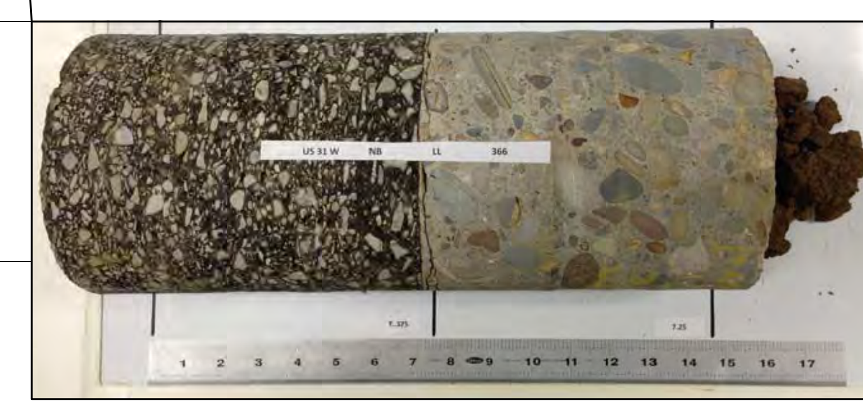
BEGIN GPR SCAN NB LANES, MEDIAN,
END GPR SCAN SB LANES

MEDIAN
STA. 107+58 TO 132+85
AC OVER PCC

NB MEDIAN ~ STA. 104+10
9.25" AC
5.75" DGA
15" SUBGRADE DEPTH



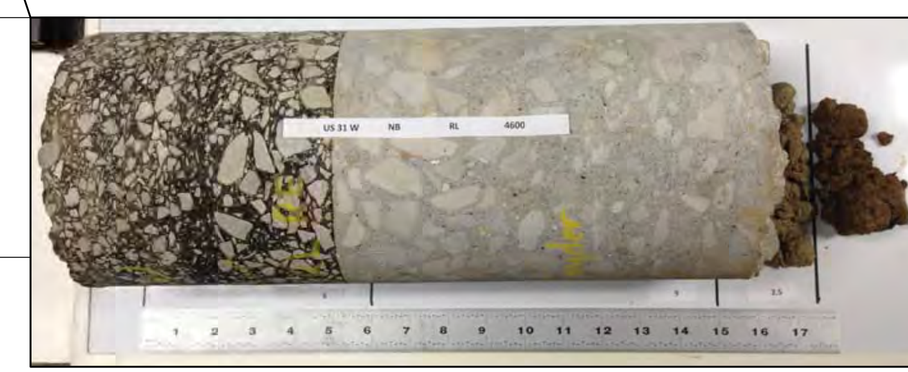
NB LEFT LANE ~ STA. 107+31
7.375" AC
7.25" PCC
14.625" SUBGRADE DEPTH



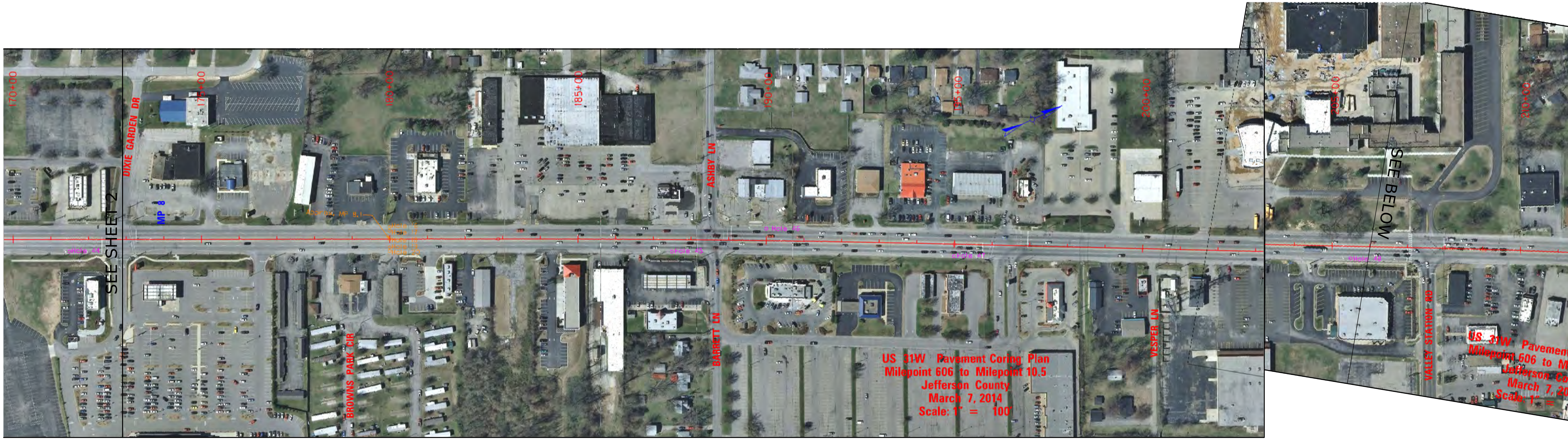
SCALE: 1"=250' (11X17)	GROUND PENETRATING RADAR US 31W (ORELL RD TO KY 1931) CALIBRATION CORE INFORMATION	KENTUCKY TRANSPORTATION CENTER 176 RAYMOND BLDG LEXINGTON, KY 40505 859-257-4513	DATE: 10-24-14 SHEET: 1 OF 6 DRAFTED: T JONES

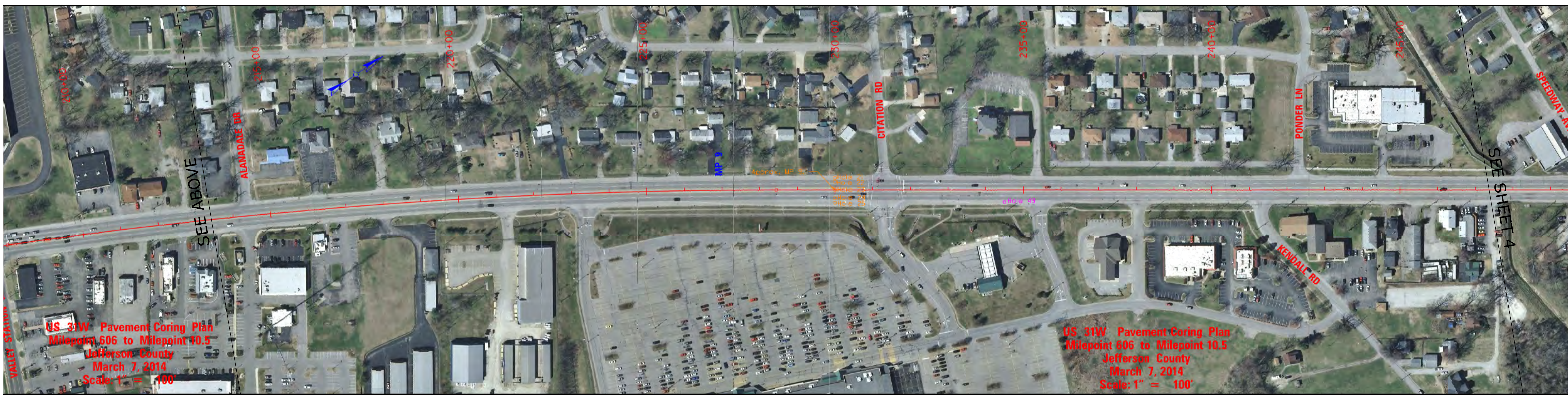
MEDIAN
STA. 107+58 TO 132+85
AC OVER PCC

NB RL ~ STA. 149+65
6" AC
9" PCC
2.5" DGA
17.5" SUBGRADE DEPTH

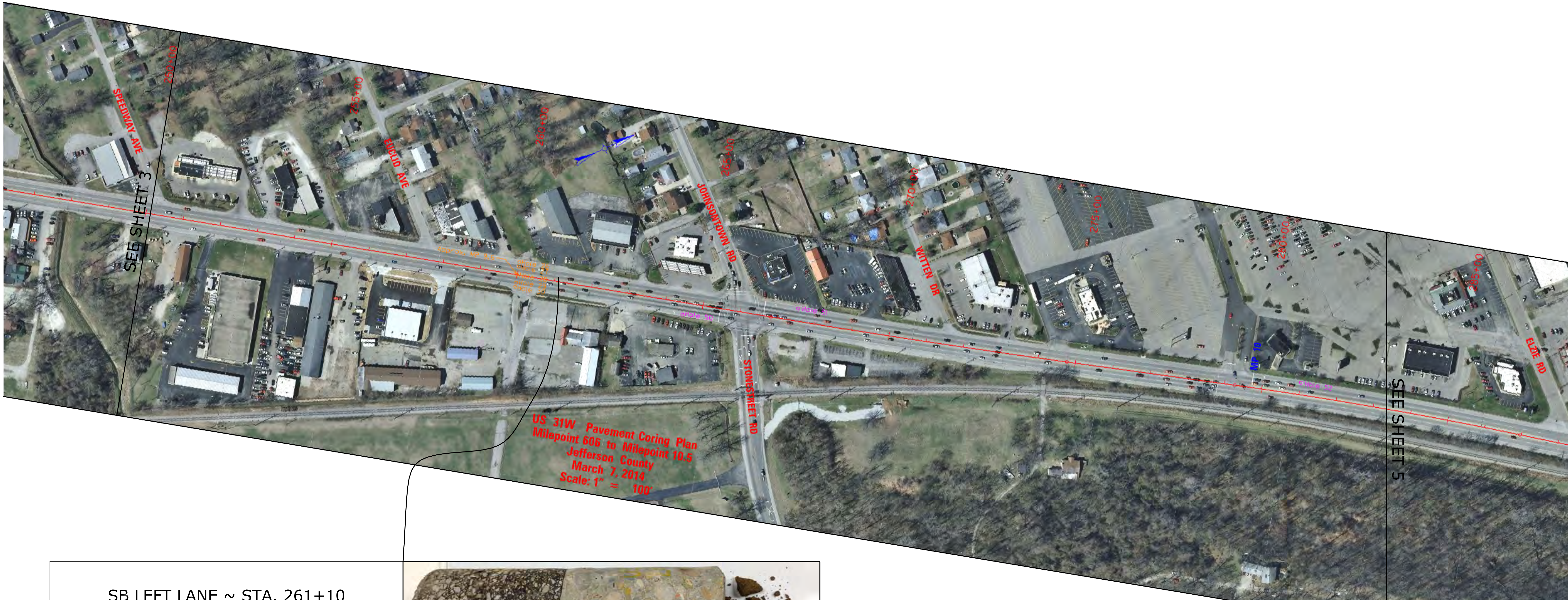


SCALE: 1"=250' (11X17)	GROUND PENETRATING RADAR US 31W (ORELL RD TO KY 1931) CALIBRATION CORE INFORMATION	KENTUCKY TRANSPORTATION CENTER 176 RAYMOND BLDG LEXINGTON, KY 40505 859-257-4513	DATE: 10-24-14 SHEET: 2 OF 6 DRAFTED: T JONES

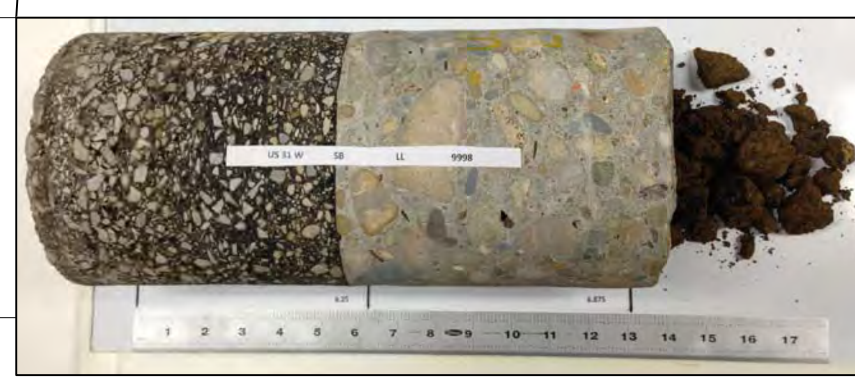




SCALE: 1"=250' (11X17)	GROUND PENETRATING RADAR US 31W (ORELL RD TO KY 1931) CALIBRATION CORE INFORMATION	KENTUCKY TRANSPORTATION CENTER 176 RAYMOND BLDG LEXINGTON, KY 40505 859-257-4513	DATE: 10/24-14 SHEET: 3 OF 6 DRAFTED: T JONES



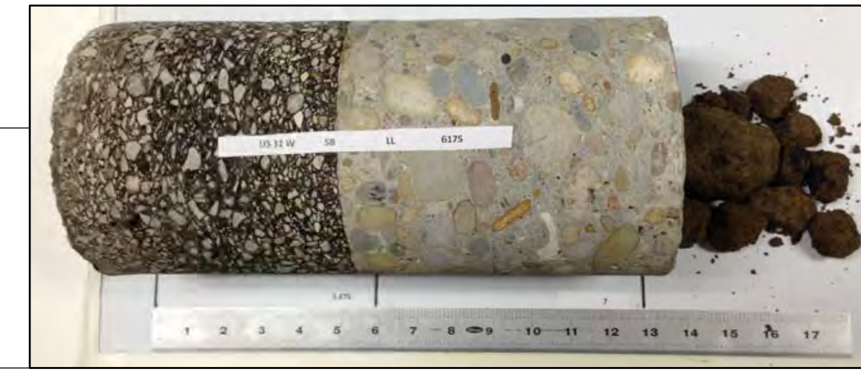
SB LEFT LANE ~ STA. 261+10
6.25" AC
6.875" PCC
13.125" SUBGRADE DEPTH
(SEE CLOSEUP FOR SUBGRADE DETAIL)



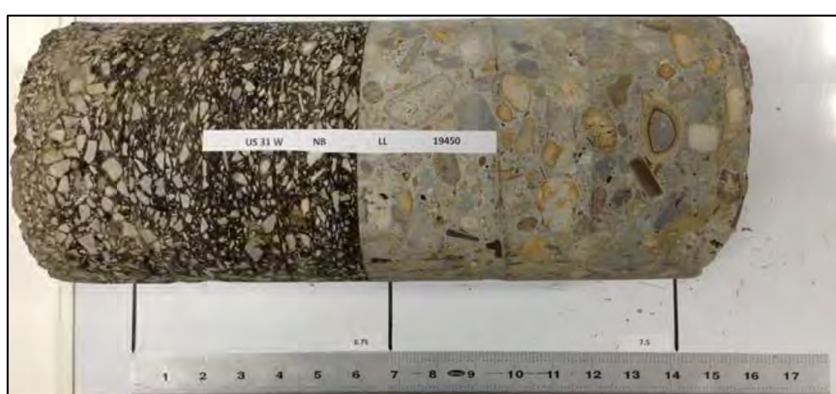
UNKNOWN BITUMINOUS FOUND IN SUBGRADE IN SB LEFT LANES AT ~ STA. 261+10 AND STA. 299+33

SCALE: 1"=250' (11X17)	GROUND PENETRATING RADAR US 31W (ORELL RD TO KY 1931) CALIBRATION CORE INFORMATION	KENTUCKY TRANSPORTATION CENTER 176 RAYMOND BLDG LEXINGTON, KY 40505 859-257-4513	DATE: 10-24-14 SHEET: 4 OF 6 DRAFTED: T JONES

SB LEFT LANE ~ STA. 299+33
5.875" AC
7" PCC
12.875" SUBGRADE DEPTH



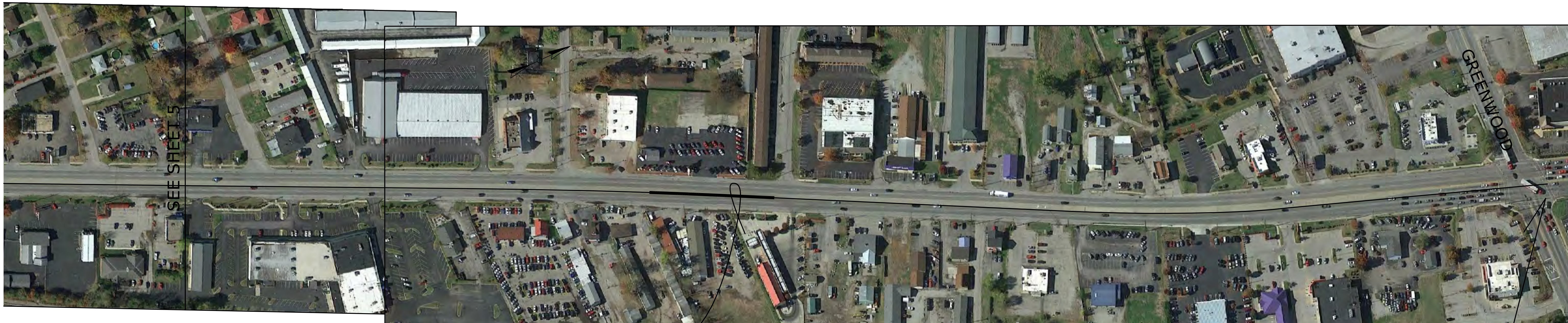
STA. 316+62 TO 319+17
AC OVER PCC IN MEDIAN



NB LEFT LANE ~ STA. 298+15
6.75" AC
7.5" PCC
14.25" SUBGRADE DEPTH

NB MEDIAN ~ STA. 298+45
7.75" AC
8.25" DGA
16" SUBGRADE DEPTH

SCALE: 1"=250' (11X17)	GROUND PENETRATING RADAR US 31W (ORELL RD TO KY 1931) CALIBRATION CORE INFORMATION	KENTUCKY TRANSPORTATION CENTER 176 RAYMOND BLDG LEXINGTON, KY 40505 859-257-4513	DATE: 10-24-14 SHEET: 5 OF 6 DRAFTED: T JONES



STA. 338+13 TO 341+32
AC OVER PCC IN MEDIAN

END PROJECT
~ STA. 361+08

SCALE: 1"=250' (11X17)	GROUND PENETRATING RADAR US 31W (ORELL RD TO KY 1931) CALIBRATION CORE INFORMATION	KENTUCKY TRANSPORTATION CENTER 176 RAYMOND BLDG LEXINGTON, KY 40505 859-257-4513	DATE: 10-24-14 SHEET: 6 OF 6 DRAFTED: T JONES

Appendix C

US 31W Pavement Core Hole Locations
Milepoint 6.6 to Milepoint 10.5
Jefferson County

Hole No.	Approx. Milepoint	Station	Offset Direction	Offset Distance (ft)	Descrption of Location	Asphalt	Concrete
1	6.7	105+00	Left	33	On Outside Shoulder	5 3/4	
2	6.7	105+00	Left	22	Center Outside Lane	7 7/8	6 7/8
3	6.7	105+00	At CL	0	Center Flush Median	8	
4	6.7	105+00	Right	22	Center Outside Lane	7 7/8	6 7/8
5	6.7	105+00	Right	33	On Outside Shoulder	4 1/2	
6	7.2	130+00	Left	33	On Outside Shoulder	6 1/2	
7	7.2	130+00	Left	23	Center Outside Lane	5	6 3/4
8	7.2	130+00	At CL	0	Center Flush Median	8 1/2	
9	7.2	130+00	Right	38	Center Outside Lane		11 1/4
10	7.2	130+00	Right	48	On Outside Shoulder	4	
11	7.5	150+00	Left	40	On Outside Shoulder	8	
12	7.5	150+00	Left	28	Center Outside Lane	6	8 1/4
13	7.5	150+00	Right	4	Center Left Turn Lane	9	
14	7.5	150+00	Right	28	Center Outside Lane	5 3/4	8 1/4
15	7.5	150+00	Right	40	On Outside Shoulder	6 3/4	
16	8.1	180+00	Left	32	On Outside Shoulder	6	
17	8.1	180+00	Left	22	Center Outside Lane	4 3/4	6 3/4
18	8.1	180+00	At CL	0	Center Flush Median	7 1/2	
19	8.1	180+00	Right	22	Center Outside Lane	6	6 7/8
20	8.1	180+00	Right	32	On Outside Shoulder	5 1/2	
21	9.1	230+00	Left	32	On Outside Shoulder	6	
22	9.1	230+00	Left	22	Center Outside Lane	5	7
23	9.1	230+00	At CL	0	Center Left Turn Lane	7 1/2	
24	9.1	230+00	Right	22	Center Outside Lane	5	6 1/2
25	9.1	230+00	Right	32	Center Right Turn Lane	6 3/4	
26	9.6	260+00	Left	34	On Outside Shoulder	4 1/2	
27	9.6	260+00	Left	22	Center Outside Lane	4 3/4	6 3/4
28	9.6	260+00	At CL	0	Center Flush Median	7 1/2	
29	9.6	260+00	Right	22	Center Outside Lane	4	7
30	9.6	260+00	Right	32	On Outside Shoulder	8 1/4	
31	10.4	300+00	Left	34	On Outside Shoulder	6 3/4	
32	10.4	300+00	Left	22	Center Outside Lane	4 1/2	7
33	10.4	300+00	At CL	0	Center Flush Median	6 5/8	
34	10.4	300+00	Right	20	Center Outside Lane	5 3/4	6
35	10.4	300+00	Right	30	On Outside Shoulder	4	

The following pavement core holes are in turn lanes or I-265 ramp tapers along the

Hole No.	Approx. Milepoint	Station	Offset Direction	Offset Distance (ft)	Descrption of Location	Asphalt	Concrete
36	6.9	116+00	Right	35	Center Right Turn Lane	5 7/8	
37	7.3	136+00	Left	50	On Outside Shoulder	6 1/4	
38	7.3	136+00	Left	38	In Ramp Taper	6 1/2	7 3/4
39	7.4	145+00	Left	52	On Outside Shoulder	8 1/4	
40	7.4	145+00	Left	40	In Ramp Taper	6 3/4	8 3/4
41	7.6	154+00	Left	46	On Outside Shoulder	6 3/4	
42	7.6	154+00	Left	36	In Ramp Taper	6 1/2	7 1/2
43	7.7	160+50	Left	32	Center Right Turn Lane	8 1/2	
44	7.9	171+50	Right	32	Center Right Turn Lane	11	
45	8.2	187+50	Right	32	Center Right Turn Lane	7.5	
46	8.3	190+00	Left	32	Center Right Turn Lane	4 3/4	
47	8.4	195+00	Right	32	Center Right Turn Lane	4	
48	8.6	205+50	Right	32	Center Right Turn Lane	7	
49	9.1	234+50	Right	32	Center Right Turn Lane	6	
50	9.7	264+50	Right	32	Center Right Turn Lane	8	
51	9.8	267+50	Left	34	Center Right Turn Lane	8 1/2	
52	10.0	281+00	Left	32	Center Right Turn Lane	10	
53	10.5	305+00	Right	32	Center Right Turn Lane	7.5	