PILOT PROJECT REPORT

EVALUATION
OF THE
URETEK DEEP INJECTION (UDI) PROCESS
FOR
IMPROVING PERFORMANCE OF
CARDINAL DRIVE
(US 69 NORTH FRONTAGE ROAD)
Beaumont, TX

Prepared by

Randall W. Brown, PhD, PE
Stephen S. Reed
URETEK ENGINEERING GROUP

A COOPERATIVE EFFORT EXECUTED BY
THE TEXAS DEPARTMENT OF TRANSPORTATION (TXDOT)
AND URETEK USA, INC.

PUBLIC RELEASE VERSION (18 SEPTEMBER 2011)

To: Michael R. Vinton (Vice President – Sales)

Subject: Pilot Project Report for US 69 North Frontage Road (aka Cardinal Drive and Cardinal Lane) near Florida Street, Beaumont TX

Date: Thursday, September 15, 2011

INTRODUCTION

Per your request, the URETEK Engineering Group assembled this report documenting the cited project. In an effort to make the large volume and variety of data palatable and useful to the reader, this report employs a format of a concise summary backed by detailed attachments.

REPORT ORGANIZATION

- **Attachment A – Project Location Photo**
- **Attachment B – Dynamic Cone Penetrometer (DCP)**
- **Attachment C – Falling Weight Deflectometer (FWD) Results (pre-treatment)**
- **Attachment D – Boring Log**
- **Attachment E – Injection Report**
- **Attachment F – Photos During Project**
- **Attachment G – FWD Results (post-treatment)**

DISCUSSION

- **Attachment A provides a satellite image of Cardinal Drive with the project site marked in red.**

- **Attachment B presents information regarding DCP testing for this project:**

  - **Map depicting pre-treatment DCPs located within the final test site**
  - **Results of the 5 pre-treatment DCPs – data used for final site selection and injection planning**
  - **Memorandum providing details about the DCP used by URETEK USA. URETEK USA employs the DPM 30-20 Model DCP manufactured by Pagani Geotechnical Equipment of Piacenza, Italy.**

- **Attachment C is comprised of the pre-treatment load transfer efficiency (LTE) data spreadsheets developed by TXDOT from their FWD testing and transmitted to URETEK USA (E-mail from Dave Collins, Assistant Area Engineer – TXDOT Beaumont, 4 April 2011, 2:52 PM CT)**

- **Attachment D presents a TXDOT boring log from an investigation done in the vicinity of the project on 8 June 2011**

- **Attachment E is a site map showing the injection locations, the joints being tested, and slab designations**

- **Attachment F provides photographs of project execution (29-30 June 2011)**

- **Attachment G is comprised of the following:**

  - **The post-treatment LTE data spreadsheet developed by TXDOT from their FWD testing and transmitted to URETEK USA (E-mail from Dave Collins, Assistant Area Engineer – TXDOT Beaumont, 31 August 2011, 8:28 AM CT)**

  - **Summary of LTE Data**
    - **Pre-treatment LTE for the test site**
    - **Post-treatment LTE for the test site**
    - **Percent Improvement in LTE**

PROJECT SUMMARY

- **Project Location / Designation**
  - **US 69 North Frontage Road (aka Cardinal Drive and Cardinal Lane) near Florida Street, Beaumont TX**
  - **URETEK USA Job Number: 11TX02016**

- **TXDOT Contacts**

  - **Duane Browning – Director of Construction and Operations, Beaumont District, Duane.Browning@txdot.gov**
  - **Chris Caron – Beaumont Area Engineer, Chris.Caron@txdot.gov**
  - **Dave Collins – Beaumont Assistant Area Engineer**
    Dave.Collins@txdot.gov
    Office: 409-924-6525
    Cell: 409-790-1876
  - **Peter Jungen – Beaumont Pavement Engineer**

- **URETEK USA Contacts**

  - **Michael R. Vinton, Vice President – Sales, 281-841-6555**
  - **Jim Reid, Regional Representative – Sales, 281-389-3087**
  - **Randall W. Brown, PhD, PE, Vice President – Engineering, 281-415-4760**
  - **Stephen S. Reed, Engineering Assistant – Engineering, 281-705-6399**

- **Project Description**

  As a pilot project for TXDOT Beaumont, the soils underlying a concrete roadway were stabilized using the URETEK Deep Injection (UDI) process. The objective of the pilot project was to determine if UDI was a cost effective alternative to reconstruction for the distressed slabs on the US 69 North Frontage Road (aka Cardinal Drive and Cardinal Lane). TXDOT engineers report there are a significant number of lane-miles in the Beaumont area that suffer deterioration due to inadequate slab support and poor load transfer.

  TXDOT conducted FWD testing before the UDI treatment and after the UDI treatment to evaluate the effectiveness of the UDI process.

- **Project Execution**
  - **January 2011**
    - **Visit Potential Pilot Project Sites – Brown, Reid, Browning, and Collins**
  - **February 2011**
    - **Reconnaissance visit – Reid and Reed**
    - **Prepare pavement distress and profile drawings – Reed**
    - **Prepare memorandum on Site Selection and FWD Testing – Brown**
    - **Pre-treatment FWD testing to aid in Site Selection – TXDOT**
  - **March – May 2011**
    - **Review and Compile FWD data – TXDOT, Reed, and Brown**
    - **Discussions on Project Execution Issues – ALL**
      - **Budget**
      - **Scheduling**
      - **Final Site Selection**
      - **Traffic Control**
  - **June 2011**
    - **Soil Borings (8 June 2011) – TXDOT**
    - **DCP Testing (14 June 2011) – URETEK USA**
    - **Develop Injection Plan – URETEK USA**
    - **Polymer Injections (29-30 June 2011) – URETEK USA**
  - **July 2011**
    - **Post-treatment FWD testing – TXDOT**
  - **August 2011**
    - **Compile and analyze post-injection FWD data – TXDOT**
    - **TXDOT sends first set of raw data files to URETEK USA (23 August 2011)**
  - **September 2011**
    - **TXDOT sends summary spreadsheet containing post-treatment LTE values for the joints in the test site (1 September 2011)**
    - **Brown and Reed begin preparation of this Pilot Project Report (3 September 2011)**

- **Project Notes**
    - **TXDOT performed FWD testing between Stations 177+00 and 189+00 for Cardinal Drive (near Florida Street) for all 3 lanes to aid in determining the location for the Beaumont UDI Pilot Project**
    - **TXDOT Beaumont Pavement Engineer Peter Jungen offered the following assessment of the pre-treatment FWD data (Attachment C). This e-mail was forwarded to URETEK USA by Dave Collins on 21 March 2011:**

      Dave, I've analyzed the FWD data and recorded the load transfer efficiency at each joint for all three lanes. Research shows where LTE < 40%, a high severity of subsidence/settlement is usually occurring, and for LTE > 80%, little settlement is occurring. We like our LTEs to be nearer the 100% end. You can use this data to help map our possible URETEK injection or slab replacement sites, and I recommend recollecting FWD at same locations after this job is complete to recheck LTE and effectiveness of the polymer material. If you have any questions, call me. Thanks, Pete

    - **In addition to looking for a site with low LTEs, Dr. Brown (URETEK USA) suggested additional site selection criteria in a memorandum dated 22 February 2011**
        - **Select 9 contiguous slabs having the same construction method, materials, and construction time period to minimize those variables**
        - **Select slabs with little to no structural distresses to ensure the integrity of the slab is still intact**
    - **The site selected met all the criteria except ultimately only 6 slabs (8 joints) were chosen so the project could remain within the established budget and traffic closure constraints**
    - **Soil boring (Attachment D) and DCP testing (Attachment B) were performed by TXDOT and URETEK USA, respectively, to acquire additional data for developing the injection plan**
    - **Pavement Information**
        - **Typical Slab in Lane 2 (middle lane)**
            - **Length of Slab = 16'**
            - **Width of Slab = 13'**
            - **Slab Thickness = 10"**

- **Typical Slab in Lane 3 (outside lane)**
  - **Length of Slab = 16'**
  - **Width of Slab = 10.5'**
  - **Slab Thickness = 10"**

- **Foundation Soils (see Attachments B and D)**
  - **Single Digit DCP Blow Counts to a depth near 10' (best case)**
  - **Low plasticity clay – CL**

- **Injection Information (details in Attachment E)**

  - **Polymer = URETEK 486 STAR**
  - **Injection depths of 36" & 72"**

- **Project Results**

Joint	Pre-treatment LTE	Post-treatment LTE	% Improvement
20-2	17.43	89.20	411.76
20-3	81.53	88.16	8.13
21-2	15.73	87.82	458.30
21-3	55.43	86.35	55.78
22-2	50.34	83.69	66.25
22-3	64.71	88.47	36.72
23-2	33.22	92.21	177.57
23-3	30.47	88.18	189.40

CONCLUSIONS

- **UDI dramatically improved LTE by stabilizing the foundation soils under the concrete slabs at the Cardinal Drive test site.**

- **The UDI treatment improved the performance of all 8 joints in the test area to well beyond the 80% acceptance criteria established by the TXDOT Beaumont Pavement Engineer.**

- **UDI is a cost-effective alternative to reconstruction of the rigid pavements on Cardinal Drive.**

Please advise if I can assist further.

Randall W. Brown

Randall W. Brown, PhD, PE
Vice President for Engineering

- **Attachment A – Project Location Photo**
- **Attachment B – Dynamic Cone Penetrometer (DCP)**
- **Attachment C – Falling Weight Deflectometer (FWD) Results (pre-treatment)**
- **Attachment D – Boring Log**
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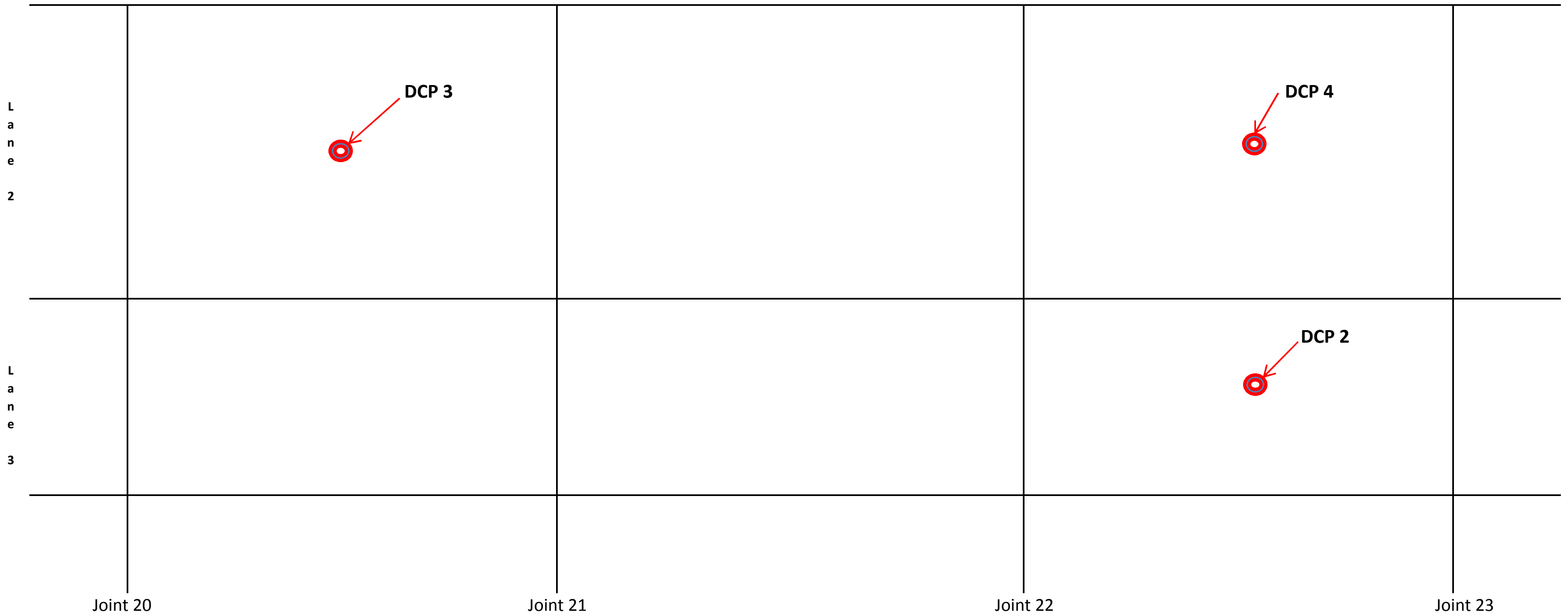
ATTACHMENT A
PROJECT LOCATION PHOTO

Florida Ave
Florida Ave
Florida Ave
PROJECT SITE
US-287 N
US-287 N
W Cardinal Dr
W Cardinal Dr
W Cardinal Dr
W Cardinal Dr
W Cardinal Dr
W Cardinal Dr
287
96
69
US-287 S
US-287 S
US-287 S
50 feet
25 m

ATTACHMENT B
DYNAMIC CONE PENETROMETER (DCP)

(USED IN SITE SELECTION AND INJECTION PLANNING)

CARDINAL LANE - LOCATION OF PRE TREATMENT DCP'S



NOTE: **5 DYNAMIC CONE PENETROMETER (DCP) TESTS WERE EXECUTED DURING SITE SELECTION.**
DCP'S 2,3, & 4 WERE LOCATED WITHIN THE FINAL PROJECT SITE.

The Engineering Group at URETEK USA Inc.

Cardinal Lane DCP Results						
* = NOT LOCATED WITHIN FINAL TEST SITE SELECTION						
DCP Depth in Feet	DCP 1*	DCP 2	DCP 3	DCP 4		DCP 5*
1.31		1	**10**	**6**		**2**
1.64	2	3	4	4		4
1.97	3	3	3	3		4
2.30	3	4	6	5		2
2.62	2	3	8	6		3
2.95	4	3	7	5		2
3.28	6	2	7	6		2
3.61	7	2	8	6		4
3.94	7	3	5	5		3
4.26	7	4	7	3		3
4.59	6	3	8	2		3
4.92	3	3	5	2		3
5.25	4	2	9	2		3
5.58	3	4	14	3		3
5.90	3	4	10	0.2		4
6.23	5	5	8	0.2		4
6.56	5	5	12	0.2		3
6.89	5	6	8	0.2		3
7.22	7	5	7	0.2		4
7.54	5	7	6	0.2		3
7.87	3	6	8	6		3
8.20	10	6	8	8		4
8.53	18	6	7	6		3
8.86	24	8	8	5		4
9.18	27	10	9	6		3
9.51	20	7	25	6		4
9.84	7	7	13	7		3
10.17	6	7	15	6		4
10.50	7	6	27	6		3
10.82	6	6	17	6		3
11.15	5	5	11	5		5
11.48	5	6	7	4		8
11.81	5	7	6	5		5
12.14	8	9	7	4		6
12.46	8	10	7	6		7
12.79	9	12	6	5		6
13.12	8	12	7	5		6
13.45	8	14	8	5		8
13.78	8	16	9	6		5
14.10	10	17	10	5		8
14.43	13	17	11	6		11
14.76	14	16	10	7		14
15.09	17	19	11	7		16
15.42	19	19	12	5		17
15.74	20	19	14	6		15
16.07	20	22	15	7		15
16.40				8		17
16.73				9		33
17.06				10		23
17.38				11		19
17.71				13		35
18.04				15		21
18.37				16		23
18.70				17		14
19.02				19		20
19.35						25
19.68						22
20.01						27
20.34						57
Orange = Blow Counts < 10						

To: URETEK USA Sales Force

CC: Mike Vinton, Vice President – Sales, URETEK USA

Subject: Questions regarding the URETEK Dynamic Cone Penetrometer (DCP)

Date: Friday, December 31, 2010

Ladies and Gentlemen:

The purpose of this memorandum is address questions regarding the URETEK Dynamic Cone Penetrometer (DCP). Please feel free to share the information with your clients.

1) Who manufactures the URETEK DCP?
URETEK employs the DPM 30-20 Model DCP manufactured by Pagani Geotechnical Equipment of Piacenza, Italy.

2) What are the specifications for the URETEK DCP?

Diameter of Cone Tip = 35.6 mm (1.40 inches)
Angle of Cone Tip, B = 60 degrees
Area of Cone Tip, A = 10 square cm (1.55 square inches)

Diameter of Rods = 20 mm (0.7874 inches)
Length of Rods = 1 m (39.37 inches)
Weight of Rods = 2.4 kg (5.29 pounds)

Weight of Drop Hammer = 30 kg (66 pounds)
Free Fall Drop Height = 20 cm (7.874 inches)

3) How does the URETEK DCP work?

a) A 3.81 cm (1.5 inch) diameter hole is drilled in the pavement.

b) A sacrificial cone and rods (incremented every 10 cm or 3.937 inches) are inserted into the hole.

c) The cone and the rods are driven into the soil by a percussive head (weighing 30 kg or 66 pounds) dropped 20 cm (7.874 inches).

The percussive head is lifted by a mechanical arm driven by an electrical motor.

d) The number of drops of the percussive head required to drive the rod 10 cm (3.937 inches) is recorded.

e) These blow counts provide information about soil strength. Moreover, these blow counts can be correlated to the N-value associated with the Standard Penetration Test (SPT) by using a relationship developed by the manufacturer:

N (SPT) = 0.766 x N (DCP)

4) How is the DCP information used?

DCP results are used to:

a) Identify weak layers in the soil mass so an injection pattern can be developed.

b) Contribute to the development of material estimates. Weaker soils typically require more polyurethane than stronger soils.

c) Assist in evaluating the effectiveness of polyurethane injection by comparing pre-injection DCP results to post-injection DCP results. Other evaluative tools (e.g., the Falling Weight Deflectometer – FWD) are used in conjunction with the DCP, when available.

I hope this information proves useful to you and your clients. Please contact me if I can assist further.

Randall W. Brown

Randall W. Brown, PhD, PE
Vice President for Engineering

ATTACHMENT C
FALLING WEIGHT DEFLECTOMETER (FWD) RESULTS
(PRE-TREATMENT)

Pre Treatment LTE DATA USED IN TEST SITE SELECTION

SOURCE : TXDOT - EMAIL 4 APR 11 2:52 PM Dave.Collins@txdot.gov

US 69 NB FR Outside Lane (X1)			
Joint #	W1 (mm)	W2 (mm)	LTE (%)
1	6.86	6.06	88.34
2	6.33	5.67	89.57
3	6.63	5.52	83.26
4	7.77	6.22	80.05
		Avg LTE	84.29
5	6.57	5.17	78.69
6	5.78	5.00	86.51
7	5.19	4.48	86.32
8	5.65	5.03	89.03
9	9.72	6.99	71.91
10	8.65	6.77	78.27
11	7.34	6.51	88.69
12	11.57	8.85	76.49
13	6.39	6.00	93.90
14	9.54	7.09	74.32
15	7.64	6.43	84.16
16	6.37	5.13	80.53
17	6.61	5.70	86.23
18	9.83	6.03	61.34
19	7.94	5.95	74.94
20	7.85	6.40	81.53
21	12.43	6.89	55.43
22	11.22	7.26	64.71
23	25.11	7.65	30.47
24	13.02	8.93	68.59
25	8.02	7.88	98.25
		Avg LTE	67.70
26	6.39	5.68	88.89
27	8.33	6.03	72.39
28	7.87	6.47	82.21
29	11.61	6.11	52.63
30	12.27	5.39	43.93
31	8.11	6.27	77.31
32	5.81	5.02	86.40
33	5.48	4.97	90.69
34	7.28	5.36	73.63
35	11.82	7.23	61.17
36	7.57	6.17	81.51
37	7.09	6.10	86.04
38	5.20	4.84	93.08
39	6.44	5.18	80.43
40	5.91	5.32	90.02
41	4.12	3.74	90.78
42	4.02	3.67	91.29
43	5.92	5.48	92.57
44	6.42	5.83	90.81
45	7.45	6.58	88.32
46	8.04	6.13	76.24
47	6.73	5.85	86.92
48	7.32	5.09	69.54
49	7.15	6.67	93.29
50	5.99	4.94	82.47
51	4.69	4.22	89.98
52	5.16	4.65	90.12
53	4.61	4.21	91.32
54	5.70	5.17	90.70
55	5.73	4.90	85.51
56	6.26	5.72	91.37
57	5.54	4.94	89.17
58	6.56	5.65	86.13
59	6.22	5.04	81.03
60	4.94	4.52	91.50
61	6.91	5.16	74.67
		Avg LTE	86.26
62	6.46	5.03	77.86
63	7.45	4.98	66.85
64	5.40	4.76	88.15
65	5.54	4.90	88.45
66	5.61	4.87	86.81
67	5.33	4.17	78.24
68	4.17	4.04	96.88

US 69 NB FR Middle Lane (X2)			
Joint #	W1 (mm)	W2 (mm)	LTE (%)
1	7.66	5.86	76.50
2	6.10	5.27	86.39
3	5.54	4.81	86.82
4	5.19	4.13	79.58
		Avg LTE	84.26
5	6.55	4.48	68.40
6	7.59	4.56	60.08
7	7.50	5.92	78.93
8	7.99	3.55	44.43
9	9.82	4.08	41.55
10	7.84	6.69	85.33
11	9.63	8.22	85.36
12	6.49	5.56	85.67
13	8.01	5.49	68.54
14	14.89	7.44	49.97
15	12.56	10.82	86.15
16	7.70	6.35	82.47
17	10.22	8.80	86.11
18	3.44	3.43	99.71
19	9.99	3.46	34.63
20	14.69	2.56	17.43
21	16.85	2.65	15.73
22	13.23	6.66	50.34
23	11.35	3.77	33.22
24	8.40	7.02	83.57
25	7.13	6.57	92.15
		Avg LTE	53.35
26	6.52	5.73	87.88
27	8.39	7.06	84.15
28	7.81	6.69	85.66
29	5.33	4.80	90.06
30	4.59	4.31	93.90
31	4.87	4.62	94.87
32	4.70	4.30	91.49
33	5.61	5.24	93.40
34	5.20	4.66	89.62
35	5.47	4.98	91.04
36	4.81	3.97	82.54
37	5.33	4.92	92.31
38	7.64	6.50	85.08
39	5.81	5.17	88.98
40	5.29	4.81	90.93
41	5.10	4.59	90.00
		Avg LTE	88.81

US 69 NB FR Inside Lane (X3)			
Joint #	W1 (mm)	W2 (mm)	LTE (%)
1	10.09	7.67	76
2	11.01	9.69	88
3	8.28	7.12	86
4	8.80	6.91	79
5	7.52	5.93	79
6	10.54	3.84	36
7	17.36	5.28	30
8	10.29	8.78	85
		Avg LTE	70

NOTE: **JOINTS FOR SITE SELECTED BY TXDOT AND URETEK USA FOR THIS STUDY ARE HIGHLIGHTED IN PINK**

ATTACHMENT D
BORING LOG

DRILLING LOG

WinCore
Version 3.1

County	Jefferson	Hole	1	District	20
Highway	US 69	Structure	pavement	Date	6-8-11
CSJ	0819-01-096	Station	294' S. of Florida Rd	Grnd. Elev.	13.00 ft
		Offset	6' W of Pavement	GW Elev.	N/A

Elev. (ft)	Depth	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
			CLAY, Gray w/Tan Clay (CL)							
11.										PP 2.0
			CLAY, Gray & Tan Clay (CL)							
8.	5	8 (6) 8 (6)				20.9				PP 3.5 -200=7.8%
			CLAY, Tan & Dark Tan Clay (CL)							
6.										PP 2.0
			CLAY, Tan & Light Gray Slickensided Clay							
4.						30				PP 1.5
			CLAY, Tan w/Light Gray Slickensided Clay (CL)							
	10	5 (6) 6 (6)								
2.						35				PP 1.25
			CLAY, Tan w/Light Gray Slickensided Clay (CL)							
-						31				PP 1.0
			CLAY, Reddish Brown Clay (CL)							
	15	10 (6) 10 (6)								
-5.						24	46	27		PP 1.25 -200=4.1%
			SAND, Brown w/clay							
-7.	20	17 (6) 28 (6)								

Remarks: elevation is approx.

The ground water elevation was not determined during the course of this boring.

Driller: G Vail

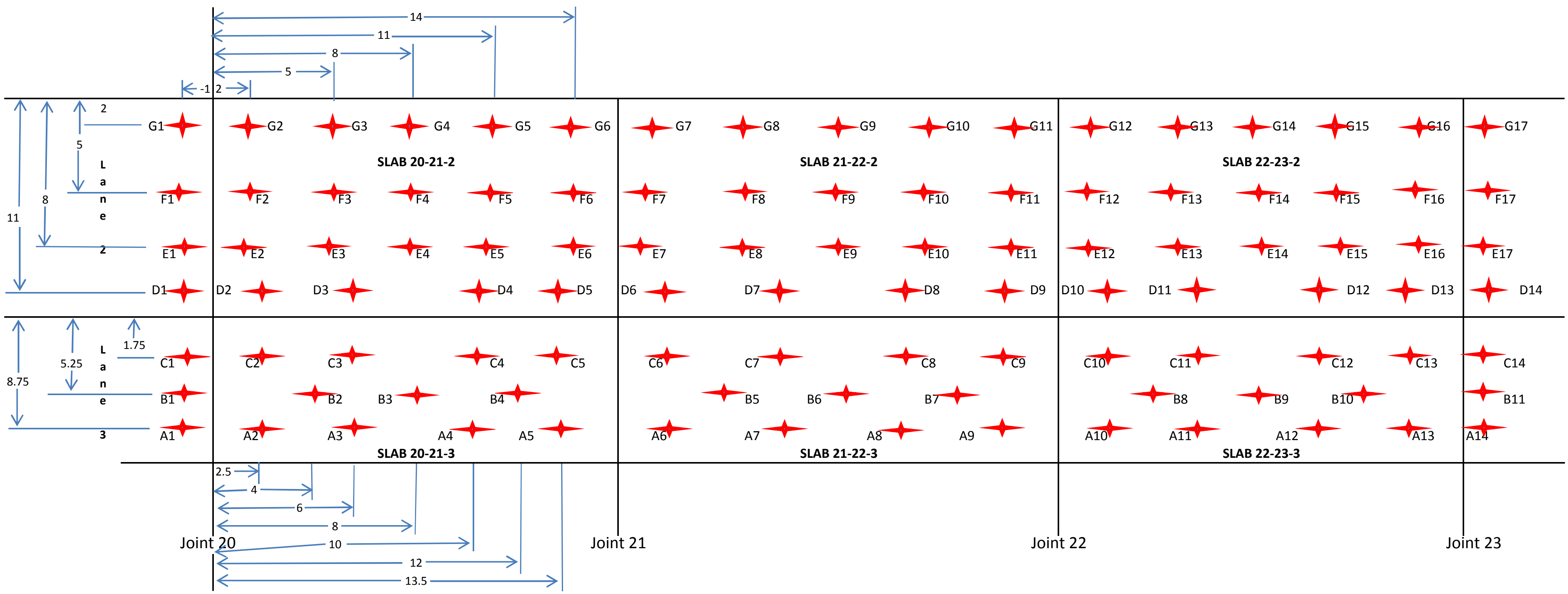
Logger: F McKenzie

Organization: TXDOT

U:\word\Geotechnical\Wincore 3.1\0813-01-096 US96 6-8-11.CLG

ATTACHMENT E
INJECTION REPORT

Cardinal Lane Injection Locations



ATTACHMENT F
PHOTOS DURING PROJECT


DIRECTV
Texas Department of Transportation
20-3715-J
SPEED LIMIT 50
URETEK
STOP

Compromise Made Easy
TEXAS BED
COMPANY
SPEED
LIMIT
50
Regular
3.45
V-Power
FastLane
Shell
STOP
STOP
STOP
STOP


MILLER ME
STOP
STOP
DCP
2

ATTACHMENT G
FWD RESULTS
(POST TREATMENT)

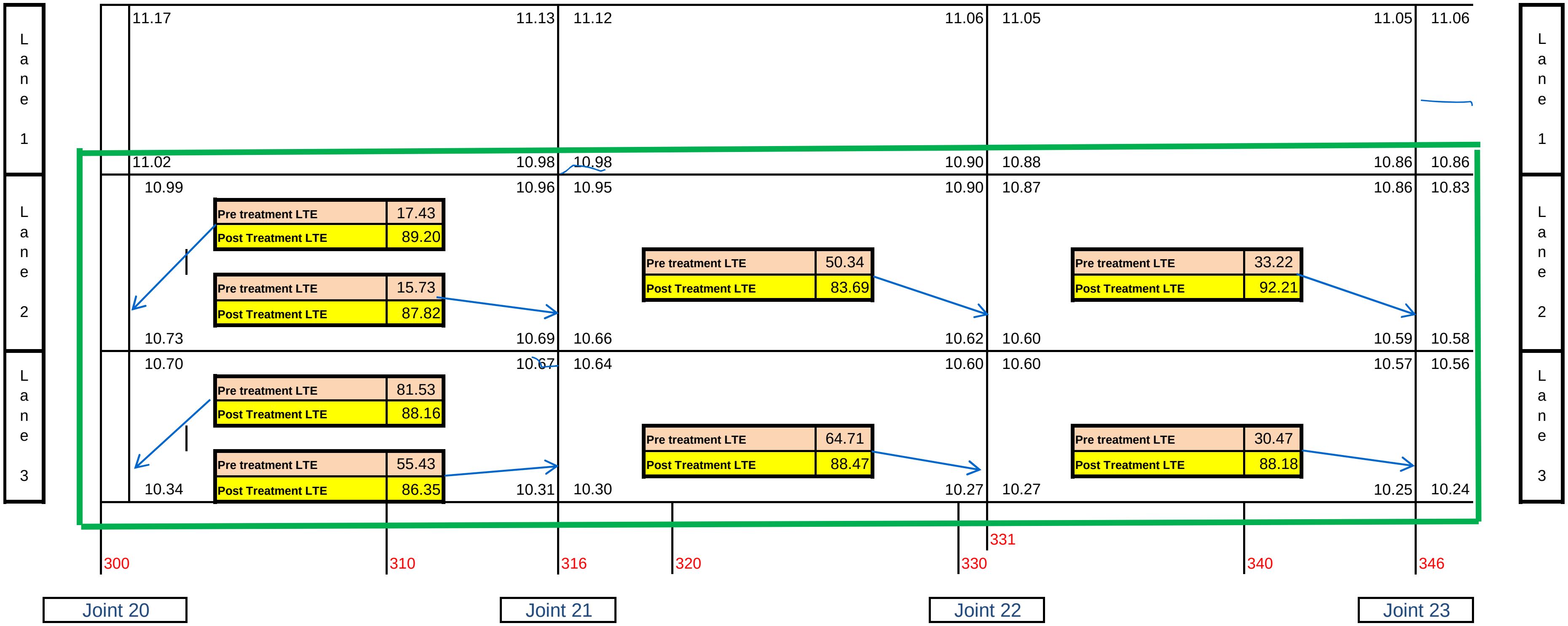
Post Treatment LTE

SOURCE : TXDOT - EMAIL 31 AUG 11 8:28 AM Dave.Collins@txdot.gov

US 69 NB FR Outside Lane (X1)				**US 69 NB FR Middle Lane (X2)**			
Joint #	W1 (mm)	W2 (mm)	LTE (%)	Joint #	W1 (mm)	W2 (mm)	LTE (%)
20	5.49	4.84	88.16	20	7.78	6.94	89.20
21	6.52	5.63	86.35	21	6.65	5.84	87.82
22	6.33	5.60	88.47	22	7.54	6.31	83.69
23	15.14	13.35	88.18	23	6.93	6.39	92.21

SUMMARY OF LOAD TRANSFER EFFICIENCY (LTE) DATA

TX DOT Cardinal Lane Beaumont TX



% Improvement in LTE	
Joint 20 Lane 2	411.76
Joint 20 Lane 3	8.13
Joint 21 Lane 2	458.30
Joint 21 Lane 3	55.78
Joint 22 Lane 2	66.25
Joint 22 Lane 3	36.72
Joint 23 Lane 2	177.57
Joint 23 Lane 3	189.40

GREEN = OUTLINE OF TEST AREA
BEIGE = PRE TREATMENT LTE
YELLOW = POST TREATMENT LTE
DARK BLUE = JOINT LOCATIONS
BLACK = ELEVATIONS
RED = LINEAR DISTANCE
ORANGE = PERCENT IMPROVEMENT IN LTE AFTER TREATMENT

$$\text{\% IMPROVEMENT} = \frac{\text{LTE post-LTE pre}}{\text{LTE pre}} * 100\%$$