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From:
Kirk Lowery, P.E.

Date: June 21, 2017
Arcadis Project No.: LA003315.0000

Subject:
June 2017 Summary Report of Inclinator Readings
Remediation Design of Levee Floodplain Failure within the
Upper Brownsville Levee Reach Lower Rio Grande Flood
Control Project – IBM15D0001 – IBM15T0015

1. Introduction

Arcadis U.S., Inc. (Arcadis), is pleased to submit this summary technical memorandum including data charts of the slope inclinometer readings at the IBWC site. The baseline readings for the new inclinometers, ARC-1, ARC-2, ARC-3 and ARC-4, were taken in June 2016 and the tenth set of readings were measured on June 14, 2017. Under the current scope of work, these inclinometers will be measured one final time next month.

Exact readings for the existing inclinometers, I-32, I-33 and I-34, were not made when Arcadis visited the site June 14, 2017. However, the probe was placed in the inclinometer casings and the depth at which it would not pass was recorded. Arcadis measured the depth range in which the inclinometer probe could not pass through the constricted area of the pipe and are as follows:

I-32 (Top of the Levee): Depth Range: 32 feet

I-33 (Toe of the Levee): Depth Range: 38 feet

I-34 (Below Toe of Levee): Depth Range: 30 feet to 31 feet

In this month's visit to the IBWC site, the tension cracks that have been monitored since February 2017 could not be measured. The entire site was mowed and the mowing removed the 16 pin flags that were previously placed. In addition, it appears that the movement of the mowing equipment has caused some of the surface cracks to close. Due to these circumstances, Arcadis installed 26 pin flags where the surficial

cracks were visible. The locations of the cracks and the new set of pin flags are shown in Attachment B while Attachment C presents photos of the surface cracks. Some of these cracks have the same locations as those previously observed and monitored. These new pin flags will be used as a reference to measure over the next month to observe if the cracks widen or lengthen.

Table 1 summarizes the pin flags location along the cracks.

Table 1. Pin Flag Locations

Pin Flag No.	Pin Location
1B and 2B	3.33' south of inclinometer ARC-1. 8.5" between the two pin flags.
3B and 4B	11.25' south of inclinometer ARC-1. 9.5" between the two pin flags.
5B	GPS coordinates N25.898212°, W-97.496628°
6B and 7B	7' south of 5B. 9.0" between the two pin flags.
8B and 9B	16' south of 5B. 9.75" between the two pin flags.
10B	24' south of 5B.
11B	GPS coordinates N25.897973°, W-97.496493°
12B and 13B	12' south of 11B. 11.0" between the two pin flags.
14B and 15B	42' south of 11B. 10.5" between the two pin flags.
16B	57' south of 11B.
17B	6' west of 14B and 15B
18B and 19B	10.5' south of 17B. 11.75" between the two pin flags.
20B	21' south of 17B.
21B	GPS coordinates N25.897669°, W-97.496309°
22B and 23B	18' south of 21B. 9.75" between the two pin flags.
24B and 25B	54' south of 21B. 10.0" between the two pin flags.
26B	72' south of 21B.

The readings for each inclinometer are reflected in the graphical displays provided in Attachment A. Attachment A includes both incremental and cumulative displacement plots. Attachment B shows the inclinometer locations on a Google Map.

The incremental displacement plot compares the mean deviation data to the baseline survey file. This plot reveals the exact depth where displacements are actually occurring. The cumulative displacement is the sum of the displacements from the base of the borehole. This plot shows the change in the position of the casing from the first set of readings.

The A-axis charts in the displacement plots show displacements in the plane perpendicular to the levee while the B-axis charts show displacements in the plane parallel with the levee. A positive reading in the A-axis chart indicates displacement to the west heading toward the Rio Grande River, and a positive reading in the B-axis chart indicates displacement to the north heading toward the Gateway Bridge.

2. Digitilt AT Inclinometer

Digitilt AT system was used to survey the inclinometers. The system components include an inclinometer probe, control cable, a Bluetooth reel and the Digitilt Reader app for certified Android-based tablet computer. The equipment is shown in Figure 1.

Figure 1: Digitilt AT System Components.



3. June 2017 Inclinometers Assessment

The depth of the casing restriction for the USACE installed inclinometers, I-32, I-33 and I-34 appears to be the same depth as the previous readings.

Data collected on June 14, 2017 followed the same trend as the baseline reading measured in June 2016. The monthly displacement plots recorded between July through June are presented in Attachment A. Data comparisons for each inclinometer are described below:

Inclinometer ARC-1: The base readings for inclinometer ARC-1 were collected on June 22, 2016. The ARC-1 cumulative plot in the A-Axis direction shows a slight progressive movement starting at depths between 28 and 30 feet. This depth corresponds with the interpreted Alluvium/Pleistocene interface presented in Figure 2 of Arcadis' December 2, 2016 *Draft Geotechnical Assessment Report*. Comparing the measurements taken in April 2017 to June 2017, the displacement increases 0.012 inches towards the Rio Grande (A-Axis) at a depth of 28 feet. This inclinometer will continue to be monitored on the normally scheduled frequency to determine if there is any increase in cumulative displacements. The displacement parallel to the levee are comparatively smaller and does not show any sign of movement in this month's readings.

Inclinometer Arc-2: The base readings for inclinometer ARC-2 were collected on June 17, 2016. The ARC-2 cumulative displacement plot in the A-Axis direction shows a slight displacement between the depths of 38 feet to 40 feet. This depth corresponds with the interpreted Alluvium/Pleistocene interface presented in Figure 2 of Arcadis' December 2, 2016 *Draft Geotechnical Assessment Report*. Comparing the measurements taken in April 2017 to June 2017, the displacement increases 0.018 inches towards the Rio Grande (A-Axis) at a depth of 38 feet. This inclinometer will continue to be monitored on the normally scheduled frequency to determine if there is any increase in cumulative displacements. The displacement parallel to the levee are comparatively smaller and does not show any sign of movement in this month's readings.

Inclinometer ARC-3: The base readings for inclinometer ARC-3 were collected on June 17, 2016. The ARC-3 cumulative and incremental displacement does not show any sign of movement on the plane perpendicular to the levee nor on the plane parallel to the levee.

Inclinometer ARC-4: The base readings for inclinometer ARC-4 were collected on June 22, 2016. The ARC-4 cumulative and incremental displacement does not show any sign of movement on the plane perpendicular to the levee nor on the plane parallel to the levee.

ATTACHMENTS:

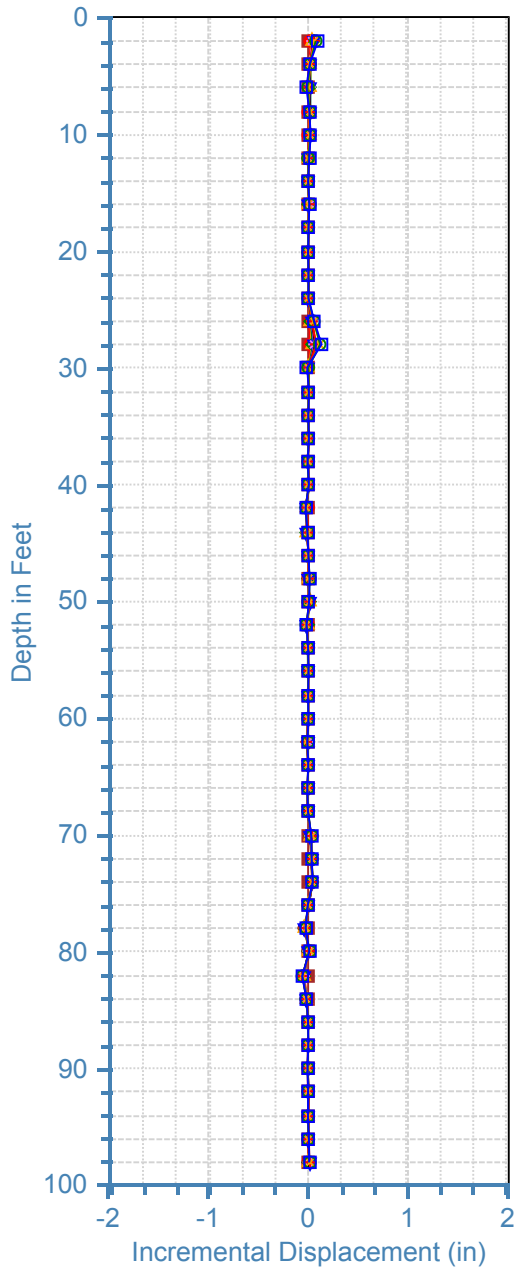
A – Inclinometer Plots

B – Inclinometer and Levee Cracking Location Map

C – Photos of Surface Tension Cracks

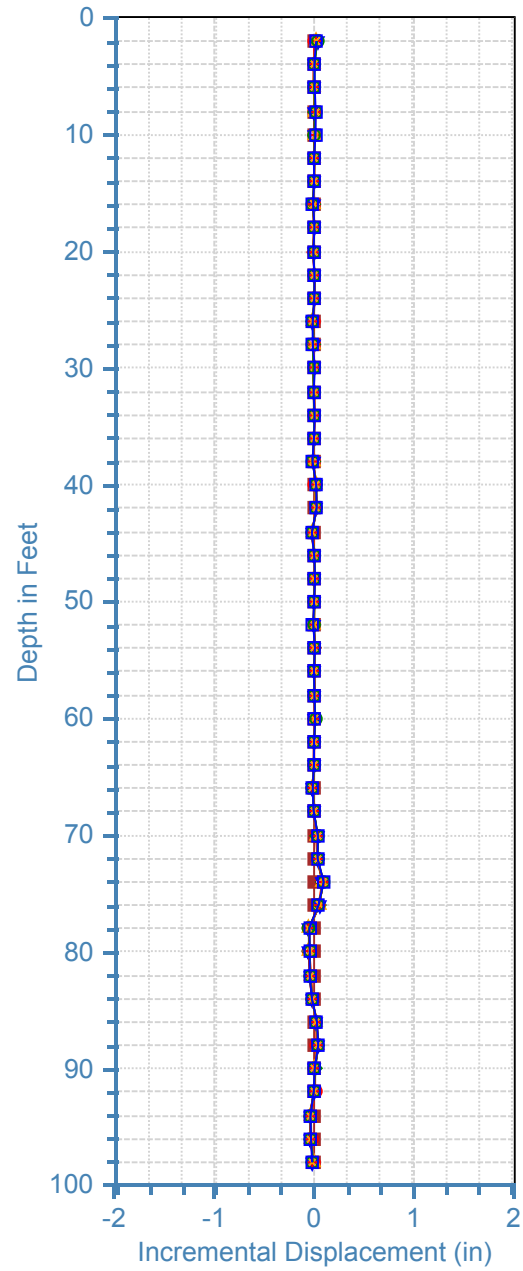
ATTACHMENT A
INCLINOMETER PLOTS

IBWC Arc-1 A - Axis



6/22/2016 11:22:30 AM	7/25/2016 3:17:20 PM
8/25/2016 1:34:40 PM	9/22/2016 1:35:22 PM
10/27/2016 2:18:50 PM	11/14/2016 1:34:00 PM
12/22/2016 3:53:53 PM	2/8/2017 9:25:00 AM
3/17/2017 12:20:09 PM	4/10/2017 3:12:10 PM
5/9/2017 2:13:46 PM	6/14/2017 12:51:51 PM

IBWC Arc-1 B - Axis

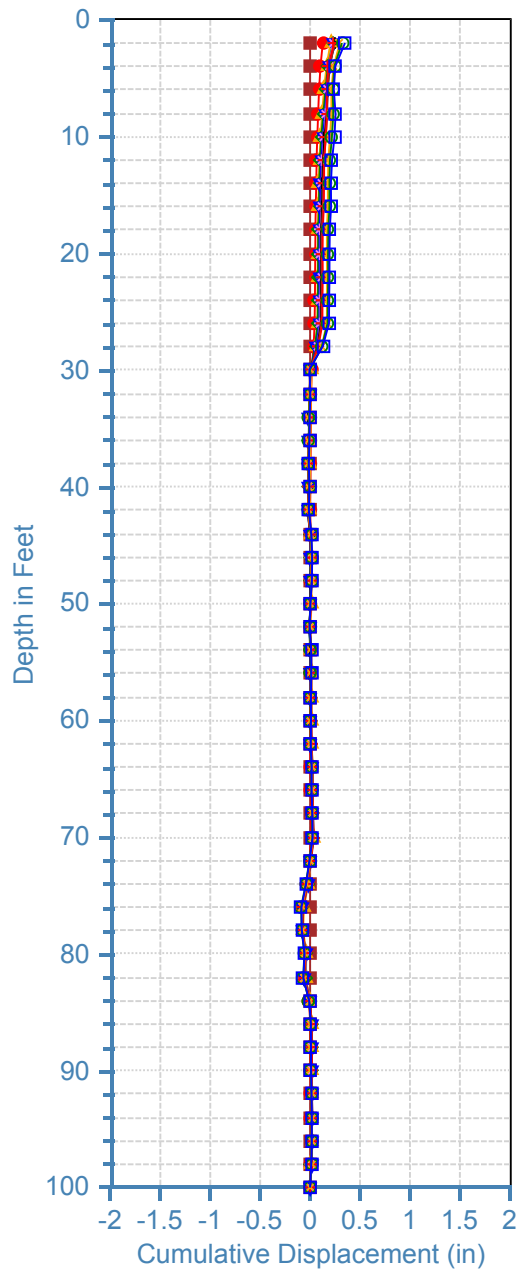


6/22/2016 11:22:30 AM	7/25/2016 3:17:20 PM
8/25/2016 1:34:40 PM	9/22/2016 1:35:22 PM
10/27/2016 2:18:50 PM	11/14/2016 1:34:00 PM
12/22/2016 3:53:53 PM	2/8/2017 9:25:00 AM
3/17/2017 12:20:09 PM	4/10/2017 3:12:10 PM
5/9/2017 2:13:46 PM	6/14/2017 12:51:51 PM

Base reading on 6/22/2016

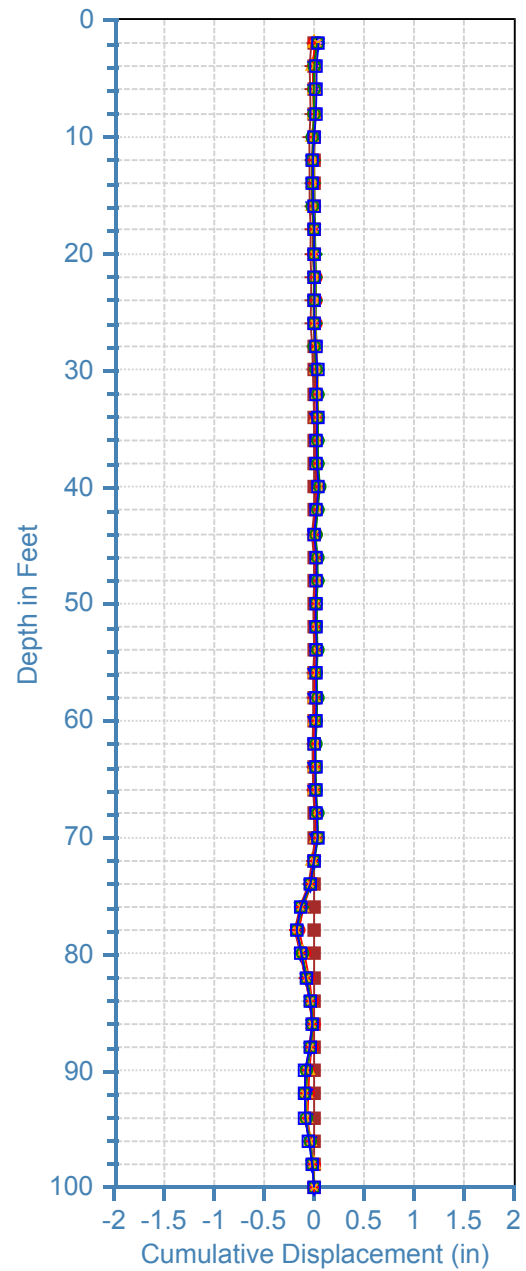


IBWC Arc-1 A - Axis



6/22/2016 11:22:30 AM	7/25/2016 3:17:20 PM
8/25/2016 1:34:40 PM	9/22/2016 1:35:22 PM
10/27/2016 2:18:50 PM	11/14/2016 1:34:00 PM
12/22/2016 3:53:53 PM	2/8/2017 9:25:00 AM
3/17/2017 12:20:09 PM	4/10/2017 3:12:10 PM
5/9/2017 2:13:46 PM	6/14/2017 12:51:51 PM

IBWC Arc-1 B - Axis

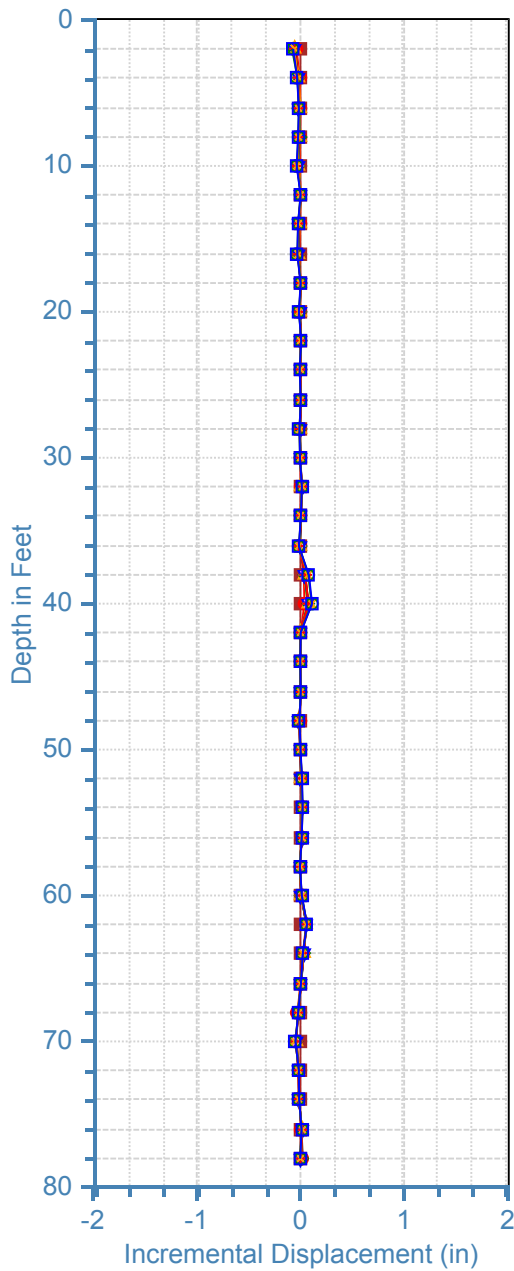


6/22/2016 11:22:30 AM	7/25/2016 3:17:20 PM
8/25/2016 1:34:40 PM	9/22/2016 1:35:22 PM
10/27/2016 2:18:50 PM	11/14/2016 1:34:00 PM
12/22/2016 3:53:53 PM	2/8/2017 9:25:00 AM
3/17/2017 12:20:09 PM	4/10/2017 3:12:10 PM
5/9/2017 2:13:46 PM	6/14/2017 12:51:51 PM

Base reading on 6/22/2016

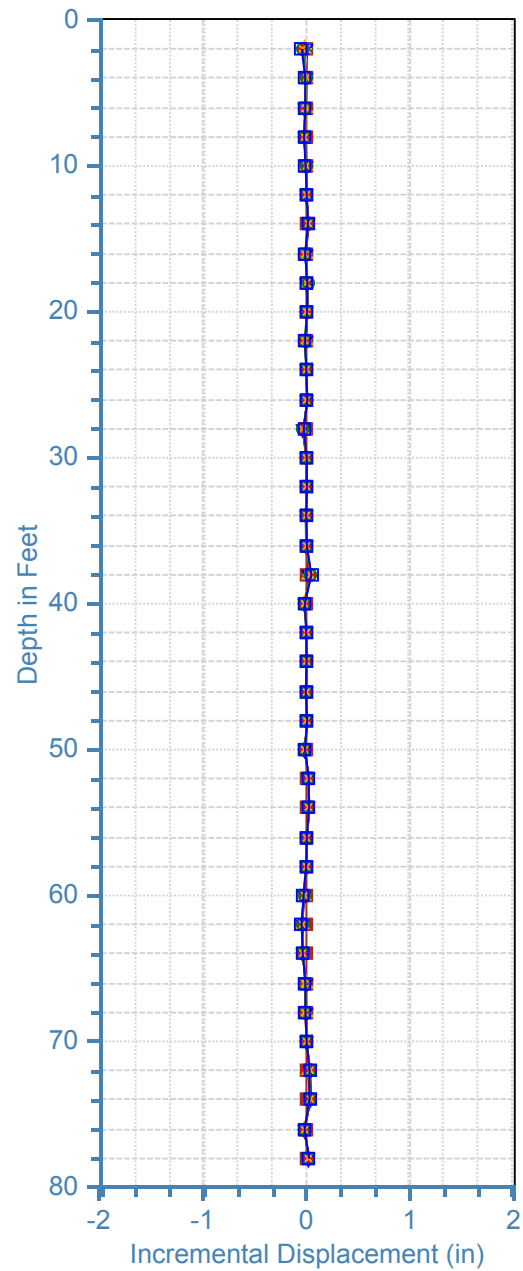


IBWC Arc-2 A - Axis



6/17/2016 6:27:13 PM	7/25/2016 3:57:11 PM
8/25/2016 2:02:22 PM	9/22/2016 2:05:40 PM
10/27/2016 2:44:45 PM	11/14/2016 1:57:25 PM
12/22/2016 4:18:54 PM	2/8/2017 9:52:21 AM
3/17/2017 11:58:39 AM	4/10/2017 2:47:48 PM
5/9/2017 1:53:54 PM	6/14/2017 1:13:37 PM

IBWC Arc-2 B - Axis

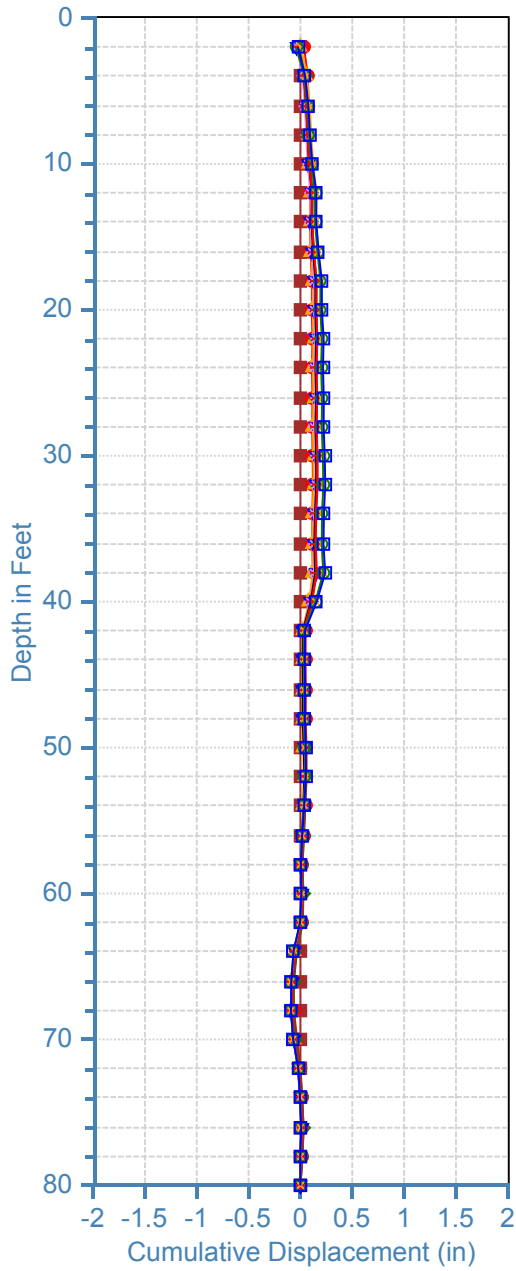


6/17/2016 6:27:13 PM	7/25/2016 3:57:11 PM
8/25/2016 2:02:22 PM	9/22/2016 2:05:40 PM
10/27/2016 2:44:45 PM	11/14/2016 1:57:25 PM
12/22/2016 4:18:54 PM	2/8/2017 9:52:21 AM
3/17/2017 11:58:39 AM	4/10/2017 2:47:48 PM
5/9/2017 1:53:54 PM	6/14/2017 1:13:37 PM

Base reading on 6/17/2016

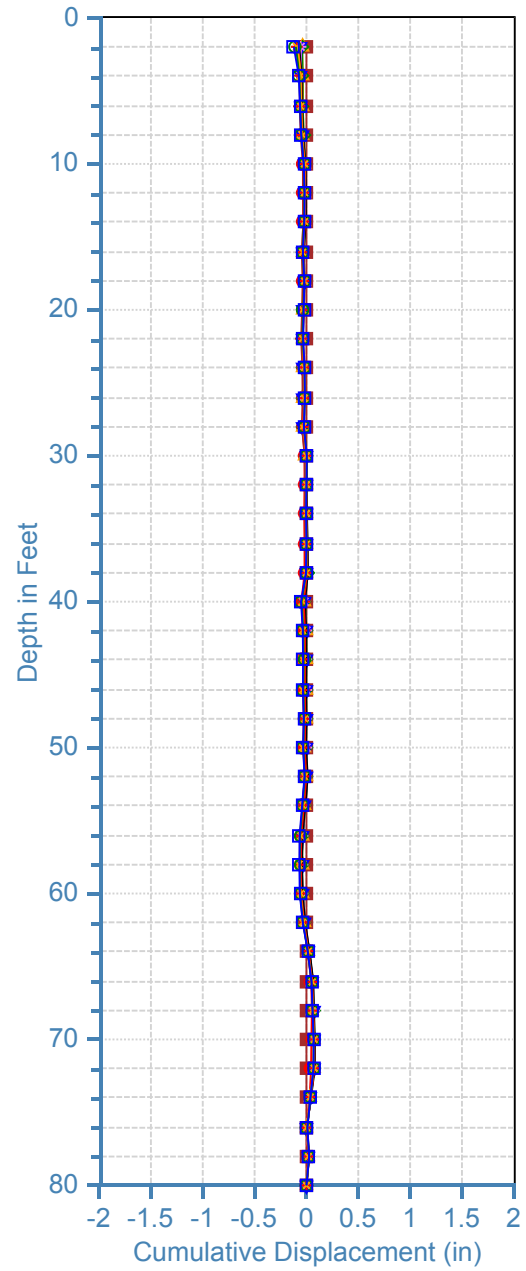


IBWC Arc-2 A - Axis



6/17/2016 6:27:13 PM	7/25/2016 3:57:11 PM
8/25/2016 2:02:22 PM	9/22/2016 2:05:40 PM
10/27/2016 2:44:45 PM	11/14/2016 1:57:25 PM
12/22/2016 4:18:54 PM	2/8/2017 9:52:21 AM
3/17/2017 11:58:39 AM	4/10/2017 2:47:48 PM
5/9/2017 1:53:54 PM	6/14/2017 1:13:37 PM

IBWC Arc-2 B - Axis

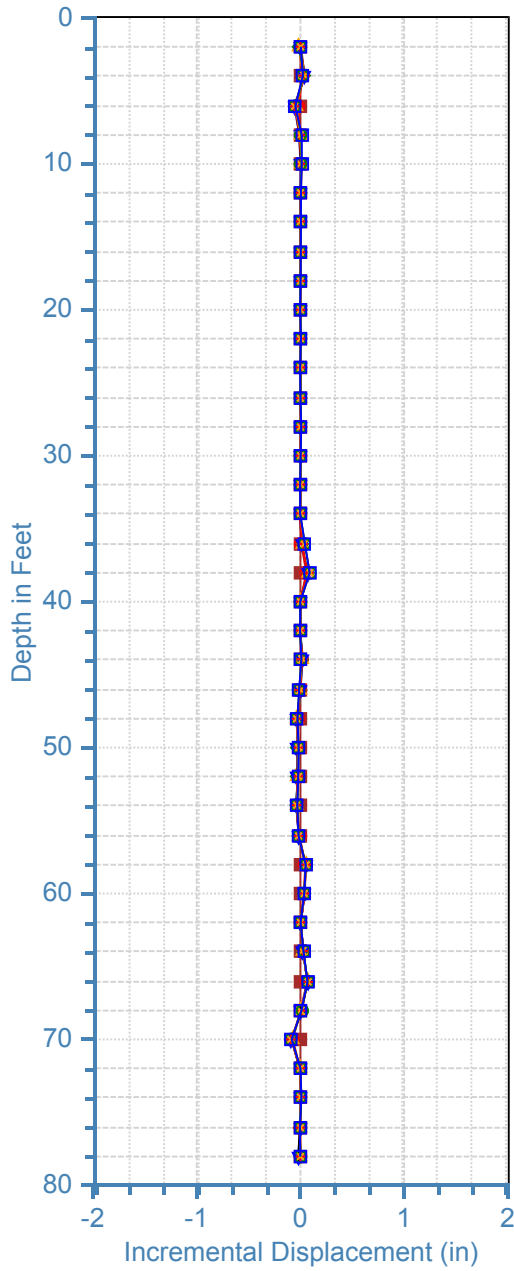


6/17/2016 6:27:13 PM	7/25/2016 3:57:11 PM
8/25/2016 2:02:22 PM	9/22/2016 2:05:40 PM
10/27/2016 2:44:45 PM	11/14/2016 1:57:25 PM
12/22/2016 4:18:54 PM	2/8/2017 9:52:21 AM
3/17/2017 11:58:39 AM	4/10/2017 2:47:48 PM
5/9/2017 1:53:54 PM	6/14/2017 1:13:37 PM

Base reading on 6/17/2016

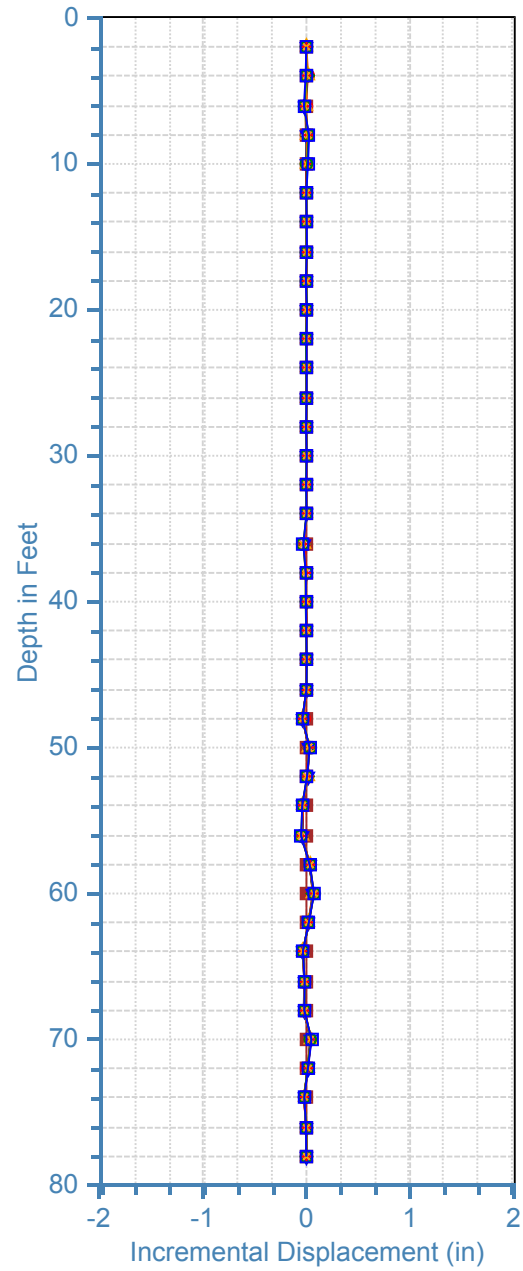


IBWC Arc-3 A - Axis



6/17/2016 7:05:22 PM	7/25/2016 4:28:56 PM
8/25/2016 2:41:46 PM	9/22/2016 2:36:13 PM
10/27/2016 3:17:17 PM	11/14/2016 2:27:09 PM
12/22/2016 4:38:15 PM	2/8/2017 10:12:24 AM
3/17/2017 11:40:50 AM	4/10/2017 2:26:29 PM
5/9/2017 1:36:04 PM	6/15/2017 3:53:45 PM

IBWC Arc-3 B - Axis

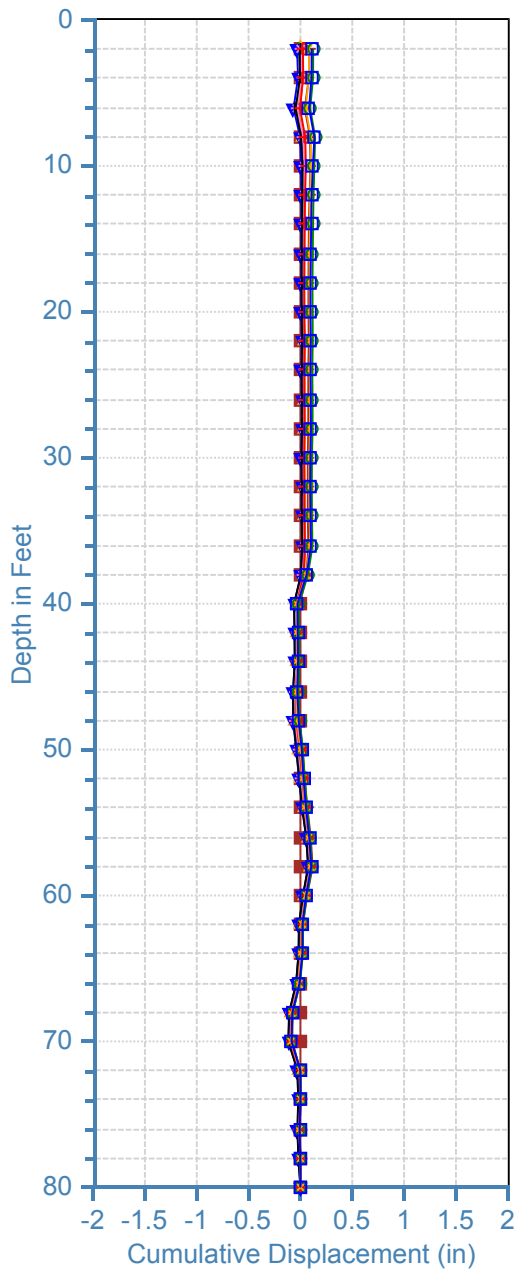


6/17/2016 7:05:22 PM	7/25/2016 4:28:56 PM
8/25/2016 2:41:46 PM	9/22/2016 2:36:13 PM
10/27/2016 3:17:17 PM	11/14/2016 2:27:09 PM
12/22/2016 4:38:15 PM	2/8/2017 10:12:24 AM
3/17/2017 11:40:50 AM	4/10/2017 2:26:29 PM
5/9/2017 1:36:04 PM	6/15/2017 3:53:45 PM

Base reading on 6/17/2016

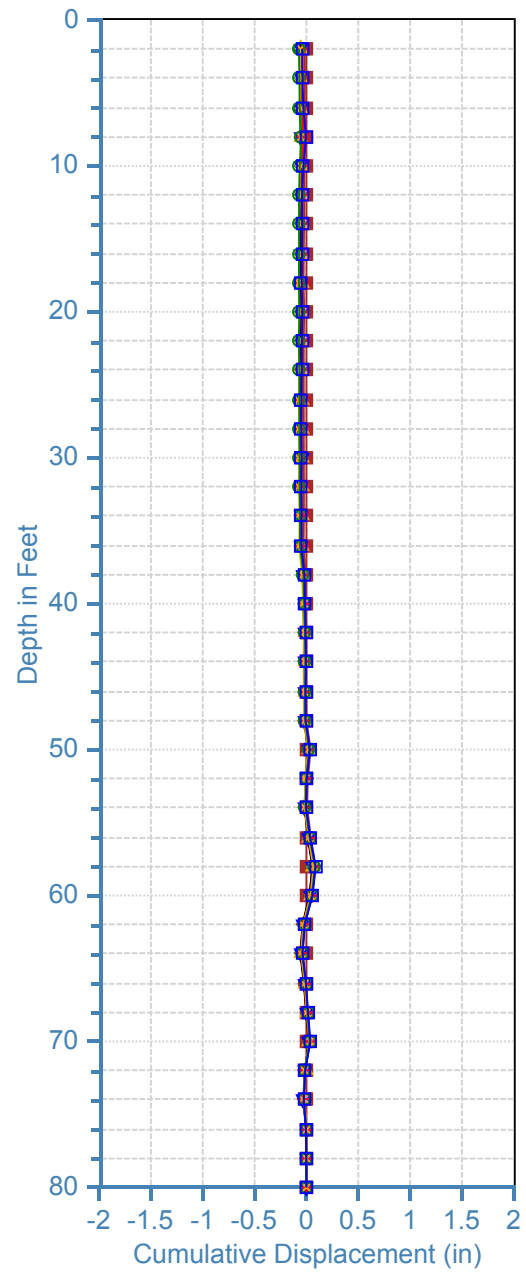


IBWC Arc-3 A - Axis



6/17/2016 7:05:22 PM	7/25/2016 4:28:56 PM
8/25/2016 2:41:46 PM	9/22/2016 2:36:13 PM
10/27/2016 3:17:17 PM	11/14/2016 2:27:09 PM
12/22/2016 4:38:15 PM	2/8/2017 10:12:24 AM
3/17/2017 11:40:50 AM	4/10/2017 2:26:29 PM
5/9/2017 1:36:04 PM	6/15/2017 3:53:45 PM

IBWC Arc-3 B - Axis

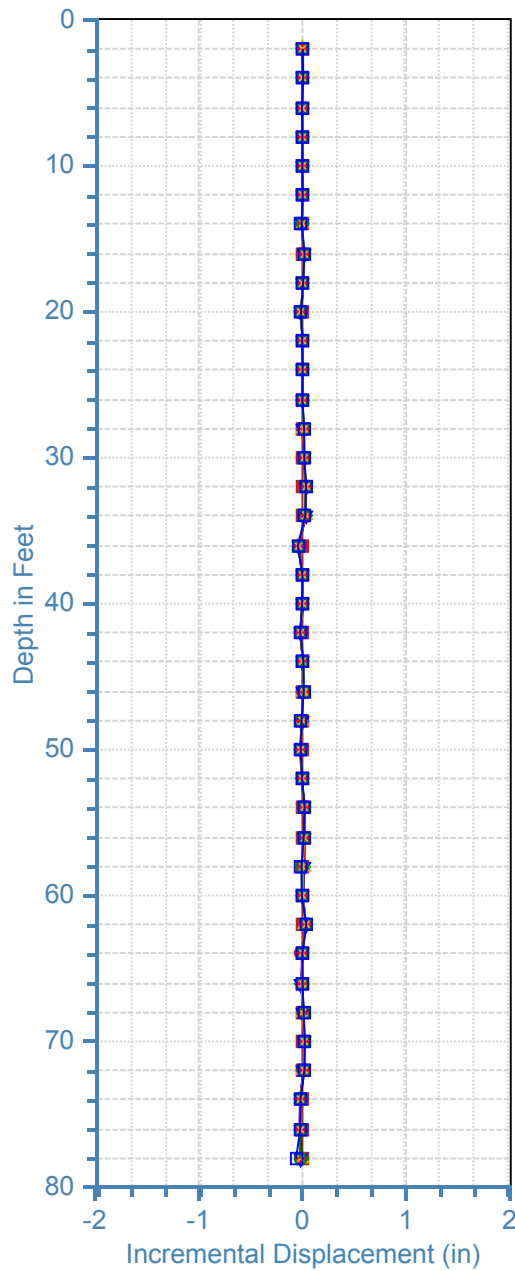


6/17/2016 7:05:22 PM	7/25/2016 4:28:56 PM
8/25/2016 2:41:46 PM	9/22/2016 2:36:13 PM
10/27/2016 3:17:17 PM	11/14/2016 2:27:09 PM
12/22/2016 4:38:15 PM	2/8/2017 10:12:24 AM
3/17/2017 11:40:50 AM	4/10/2017 2:26:29 PM
5/9/2017 1:36:04 PM	6/15/2017 3:53:45 PM

Base reading on 6/17/2016

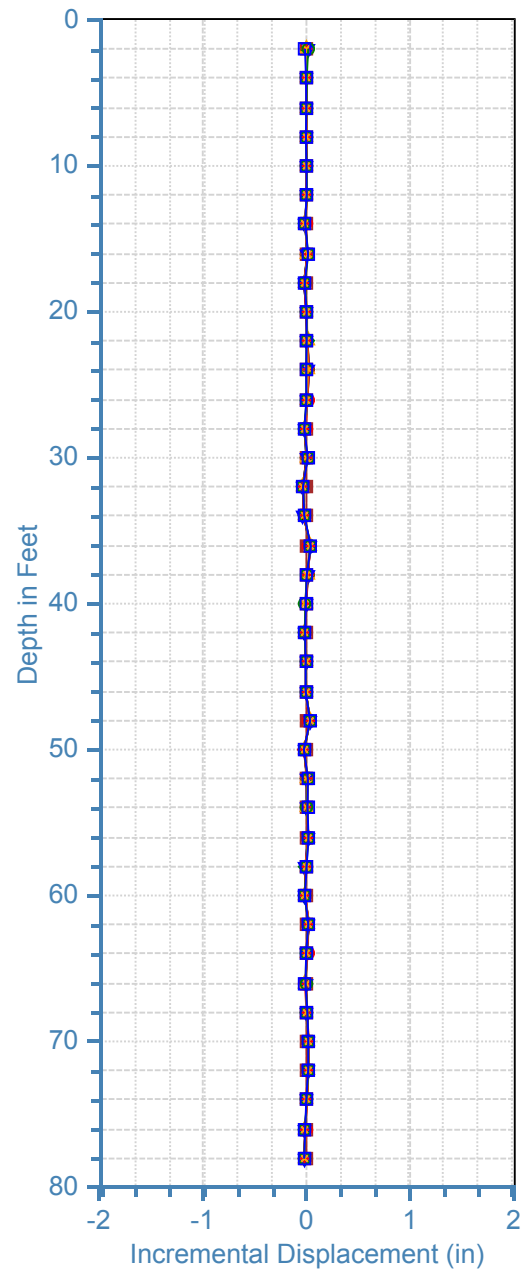


IBWC Arc-4 A - Axis



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8/25/2016 3:15:23 PM	9/22/2016 3:09:20 PM
10/27/2016 3:58:37 PM	11/14/2016 3:00:46 PM
12/22/2016 5:00:01 PM	2/8/2017 10:34:24 AM
3/17/2017 11:22:03 AM	4/10/2017 2:04:56 PM
5/9/2017 1:18:23 PM	6/14/2017 1:48:14 PM

IBWC Arc-4 B - Axis

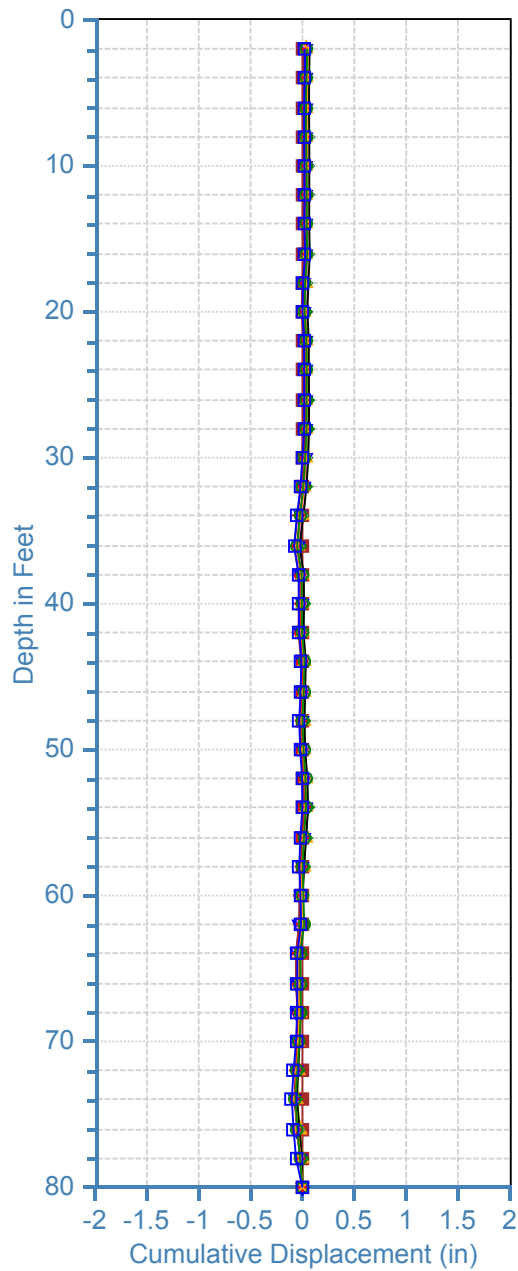


6/22/2016 10:48:04 AM	7/25/2016 5:08:42 PM
8/25/2016 3:15:23 PM	9/22/2016 3:09:20 PM
10/27/2016 3:58:37 PM	11/14/2016 3:00:46 PM
12/22/2016 5:00:01 PM	2/8/2017 10:34:24 AM
3/17/2017 11:22:03 AM	4/10/2017 2:04:56 PM
5/9/2017 1:18:23 PM	6/14/2017 1:48:14 PM

Base reading on 6/22/2016

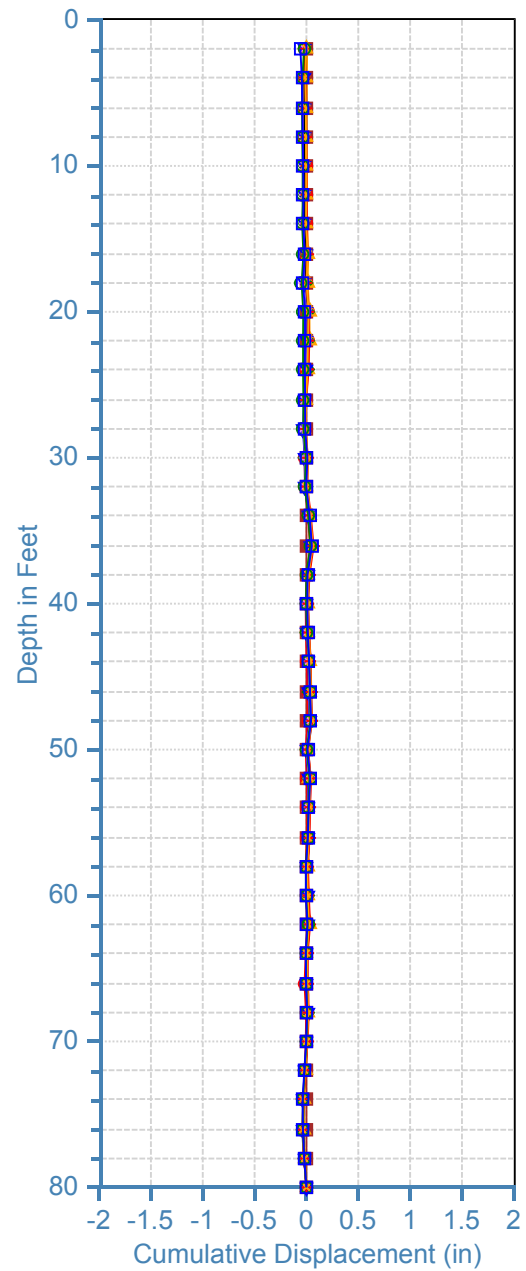


IBWC Arc-4 A - Axis



6/22/2016 10:48:04 AM	7/25/2016 5:08:42 PM
8/25/2016 3:15:23 PM	9/22/2016 3:09:20 PM
10/27/2016 3:58:37 PM	11/14/2016 3:00:46 PM
12/22/2016 5:00:01 PM	2/8/2017 10:34:24 AM
3/17/2017 11:22:03 AM	4/10/2017 2:04:56 PM
5/9/2017 1:18:23 PM	6/14/2017 1:48:14 PM

IBWC Arc-4 B - Axis



6/22/2016 10:48:04 AM	7/25/2016 5:08:42 PM
8/25/2016 3:15:23 PM	9/22/2016 3:09:20 PM
10/27/2016 3:58:37 PM	11/14/2016 3:00:46 PM
12/22/2016 5:00:01 PM	2/8/2017 10:34:24 AM
3/17/2017 11:22:03 AM	4/10/2017 2:04:56 PM
5/9/2017 1:18:23 PM	6/14/2017 1:48:14 PM

Base reading on 6/22/2016



ATTACHMENT B
INCLINOMETER AND LEVEE CRACKING LOCATION MAP



LEGEND:

B-1: 100 FEET BOREHOLE DRILLED AT THE TOP OF THE LEVEE

ARC-1: 98 FEET INCLINOMETER CASING INSTALLED WITHIN BORING B-1

B-2: 80 FEET BOREHOLE DRILLED AT THE TOE OF THE LEVEE

ARC-2: 78 FEET INCLINOMETER CASING INSTALLED WITHIN BORING B-2

B-3: 80 FEET BOREHOLE DRILLED AT THE THE EDGE OF THE RIVERBANK

ARC-3: 78 FEET INCLINOMETER CASING INSTALLED WITHIN BORING B-3

B-4: 80 FEET BOREHOLE DRILLED NEAR THE NORTH ABUTMENT OF THE GATEWAY BRIDGE

ARC-4: 78 FEET INCLINOMETER CASING INSTALLED WITHIN BORING B-4

IBWC
SUMMARY REPORT OF INCLINOMETER READINGS

REMEDATION DESIGN OF LEVEE FLOODPLAIN FAILURE
WITHIN THE UPPER BROWNSVILLE LEVEE REACH
LOWER RIO GRANDE FLOOD CONTROL PROJECT

INCLINOMETER & LEVEE CRACKING LOCATION

 **ARCADIS**

ATTACHMENT

B

NOT TO SCALE

ATTACHMENT C

PHOTOS OF SURFACE TENSION CRACKS



Photo 1 - Looking North - Surface Tension Crack of Pin Flags 1B through 4B.



Photo 2 - Looking South - Surface Tension Crack of Pin Flags 5B through 10B



Photo 3 - Looking North - Surface Tension Crack of Pin Flags 11B through 20B.

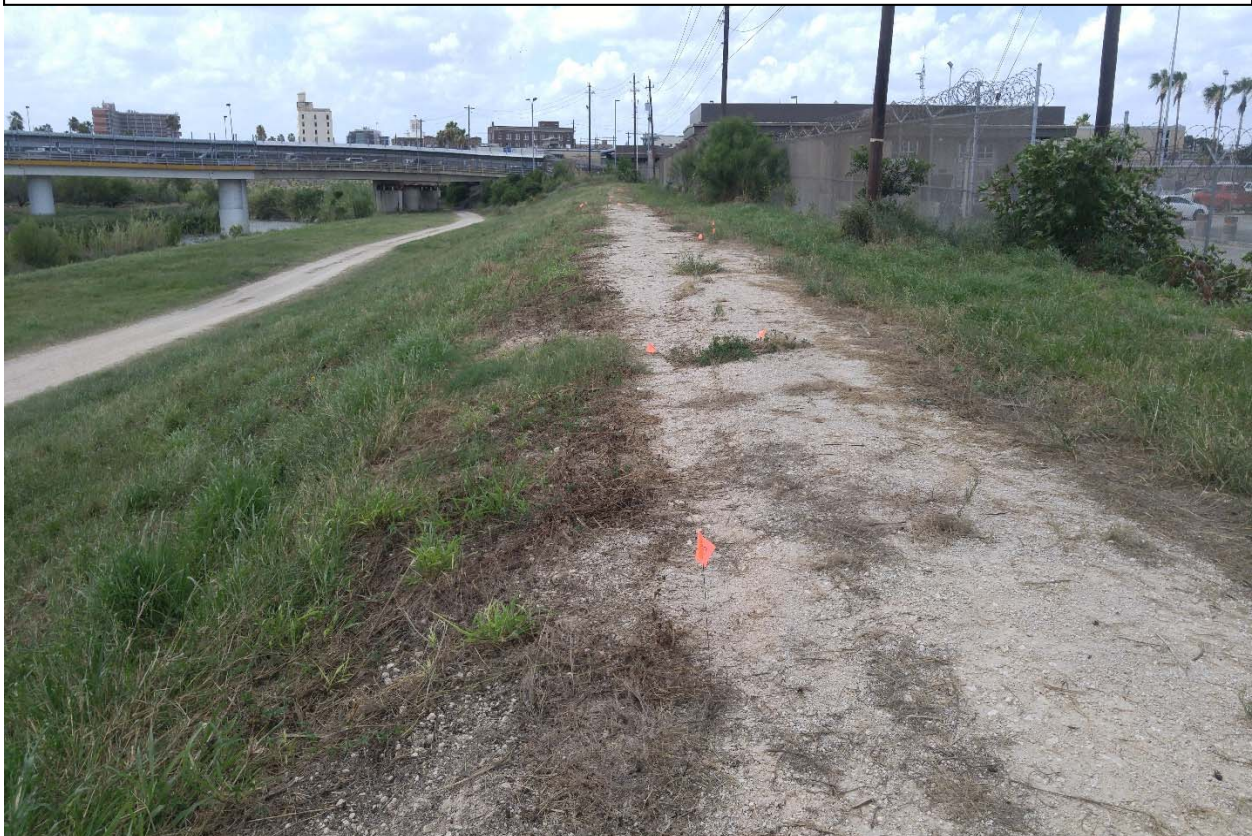


Photo 4 - Looking North - Surface Tension Crack of Pin Flags 21B through 26B.