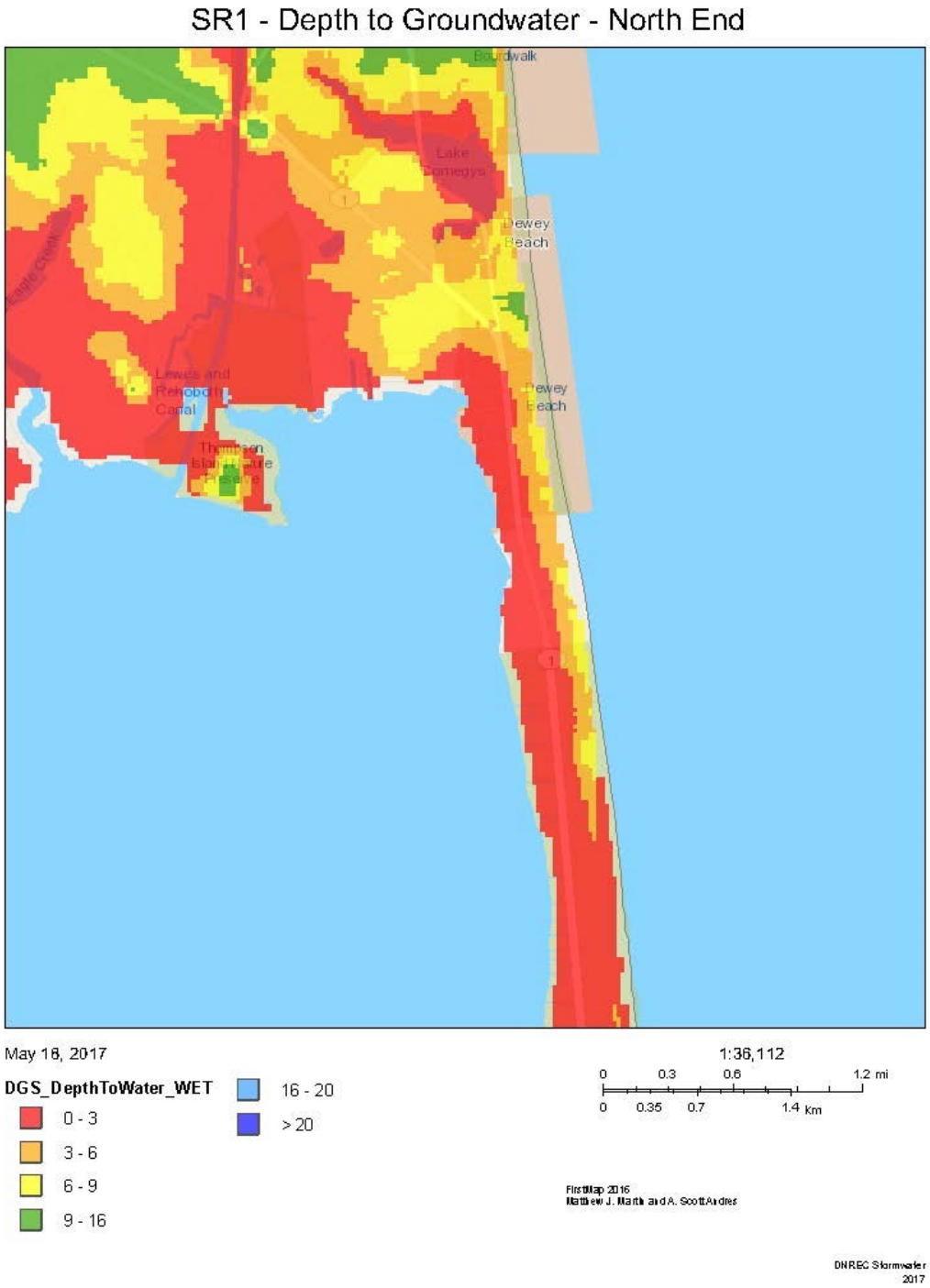
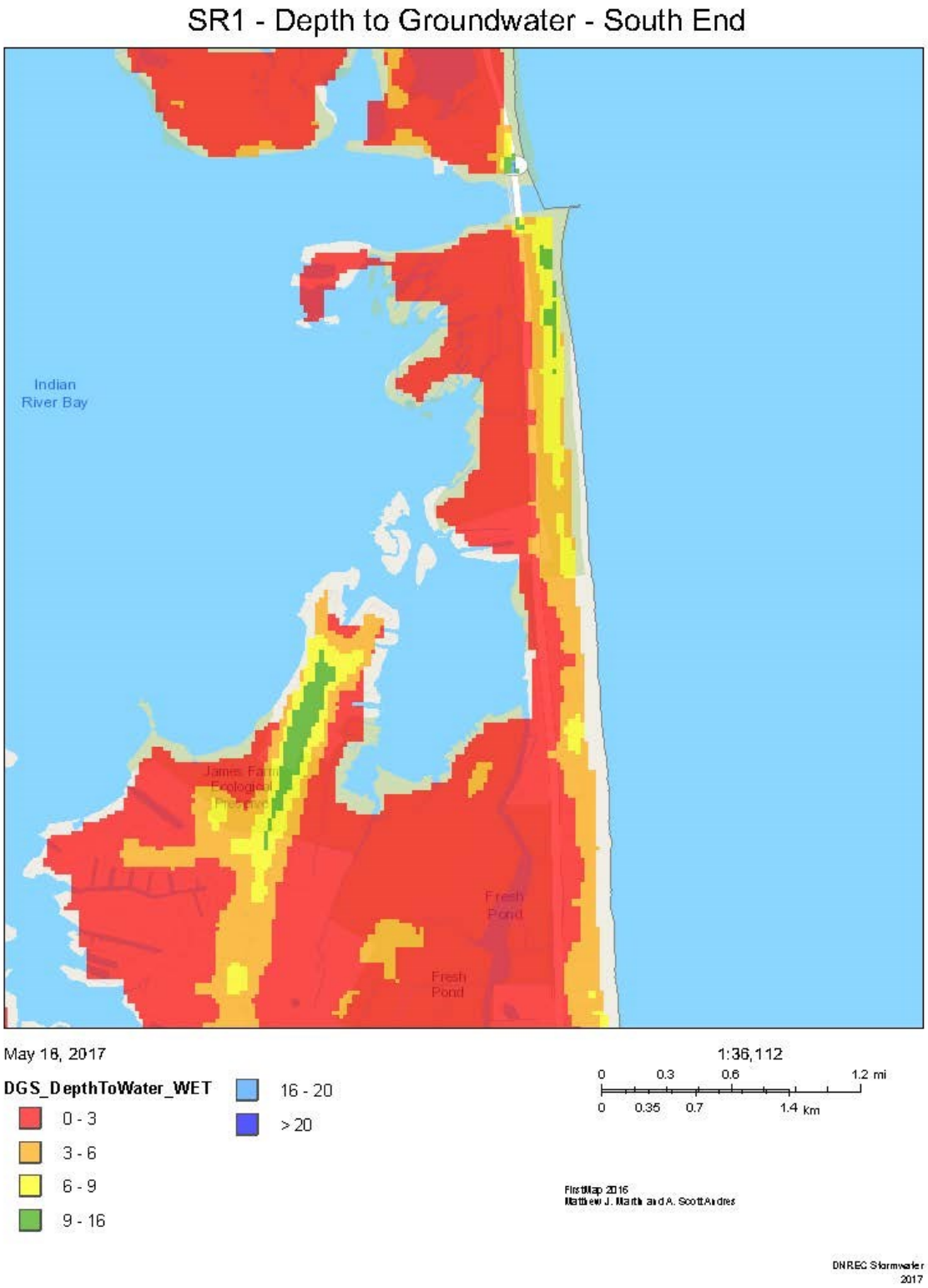
IX. Technical Appendices

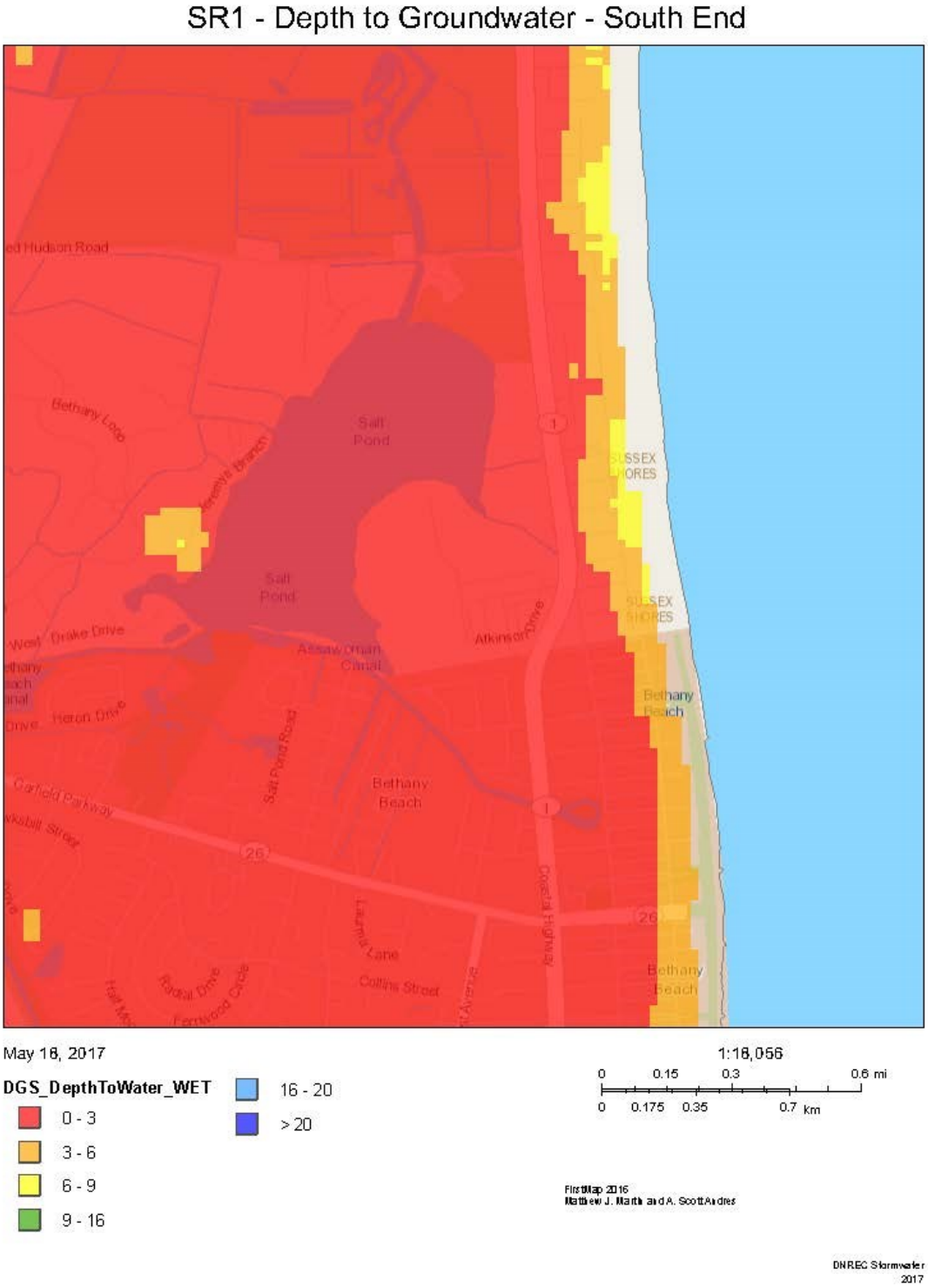
Appendix A – Planning Level Methods Analysis



Source: Delaware Department of Natural Resources and Environmental Compliance (DNREC)



Source: DNREC

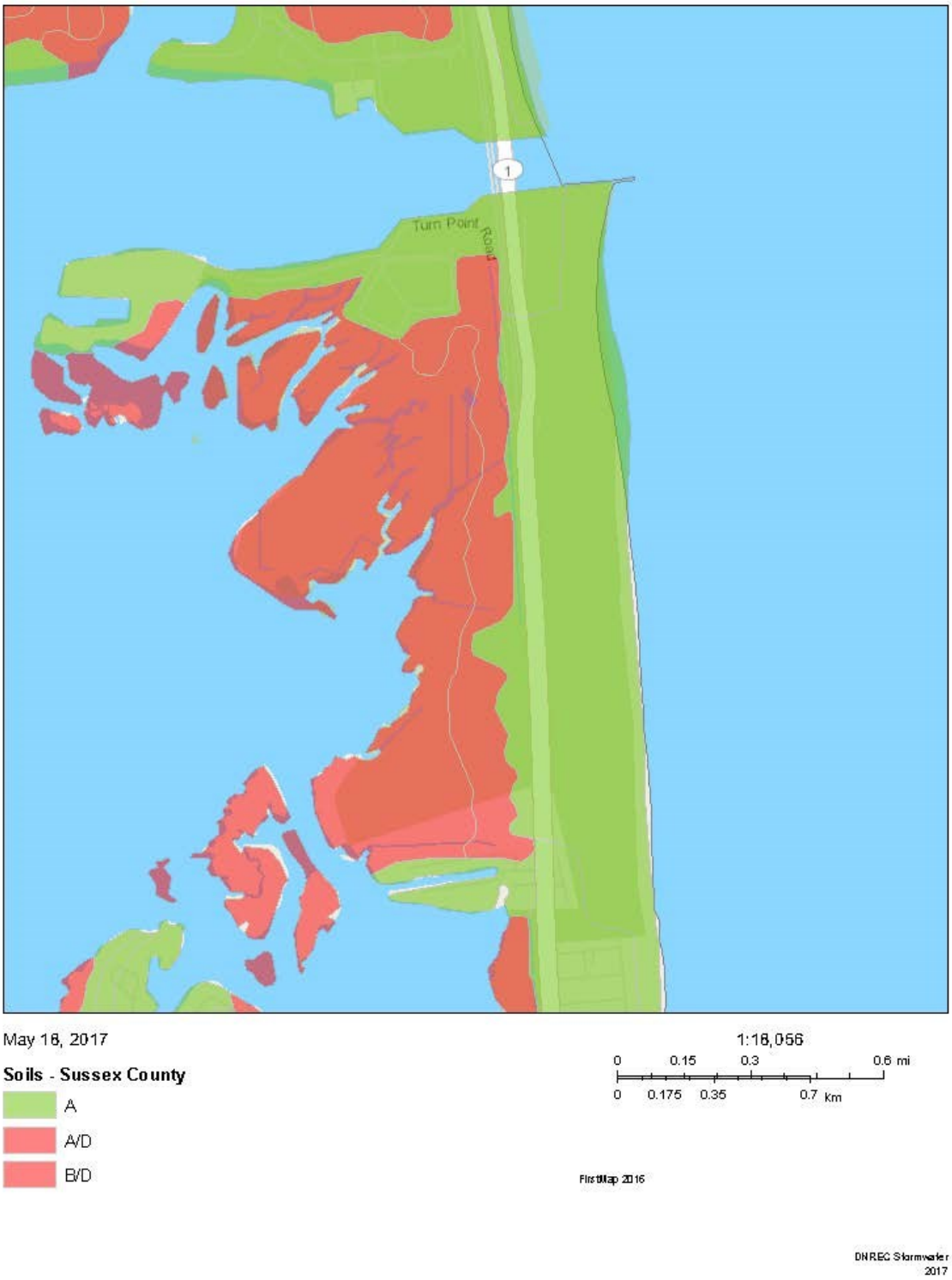


Source: DNREC

SR1 - Soil Types - North End

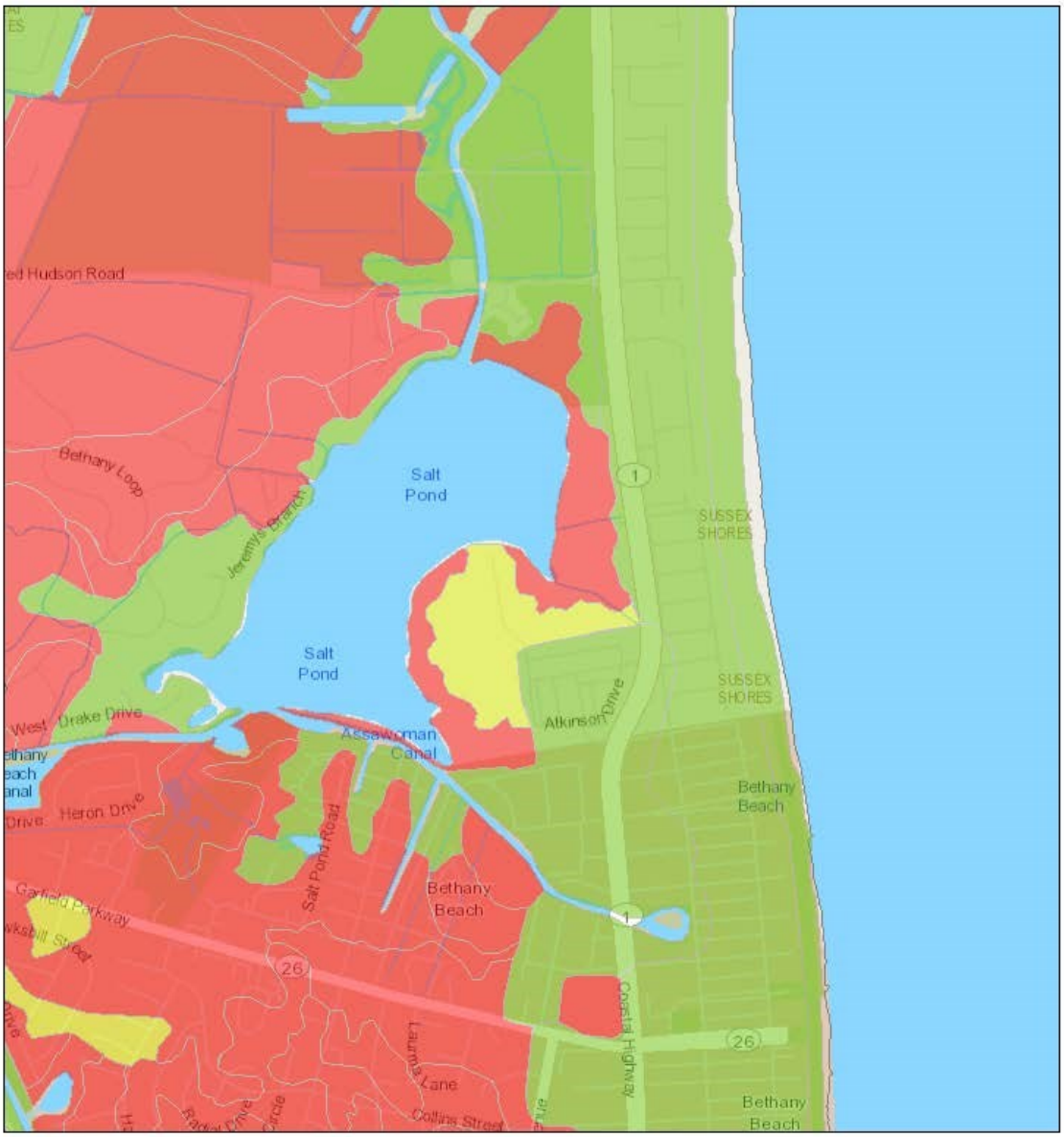
Source: DNREC

SR1 - Soil Types - Central

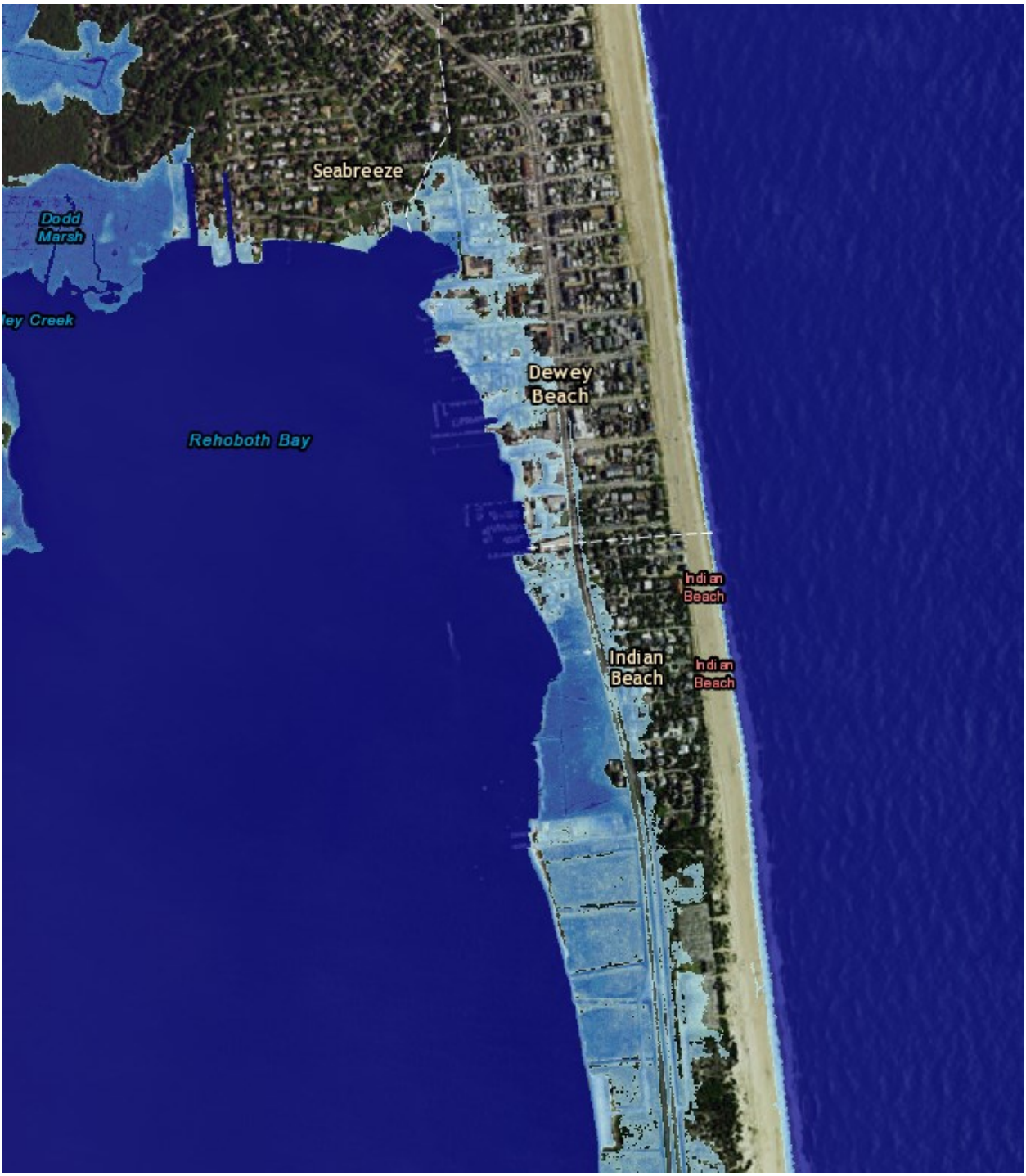


Source: DNREC

SR1 - Soil Types - South End



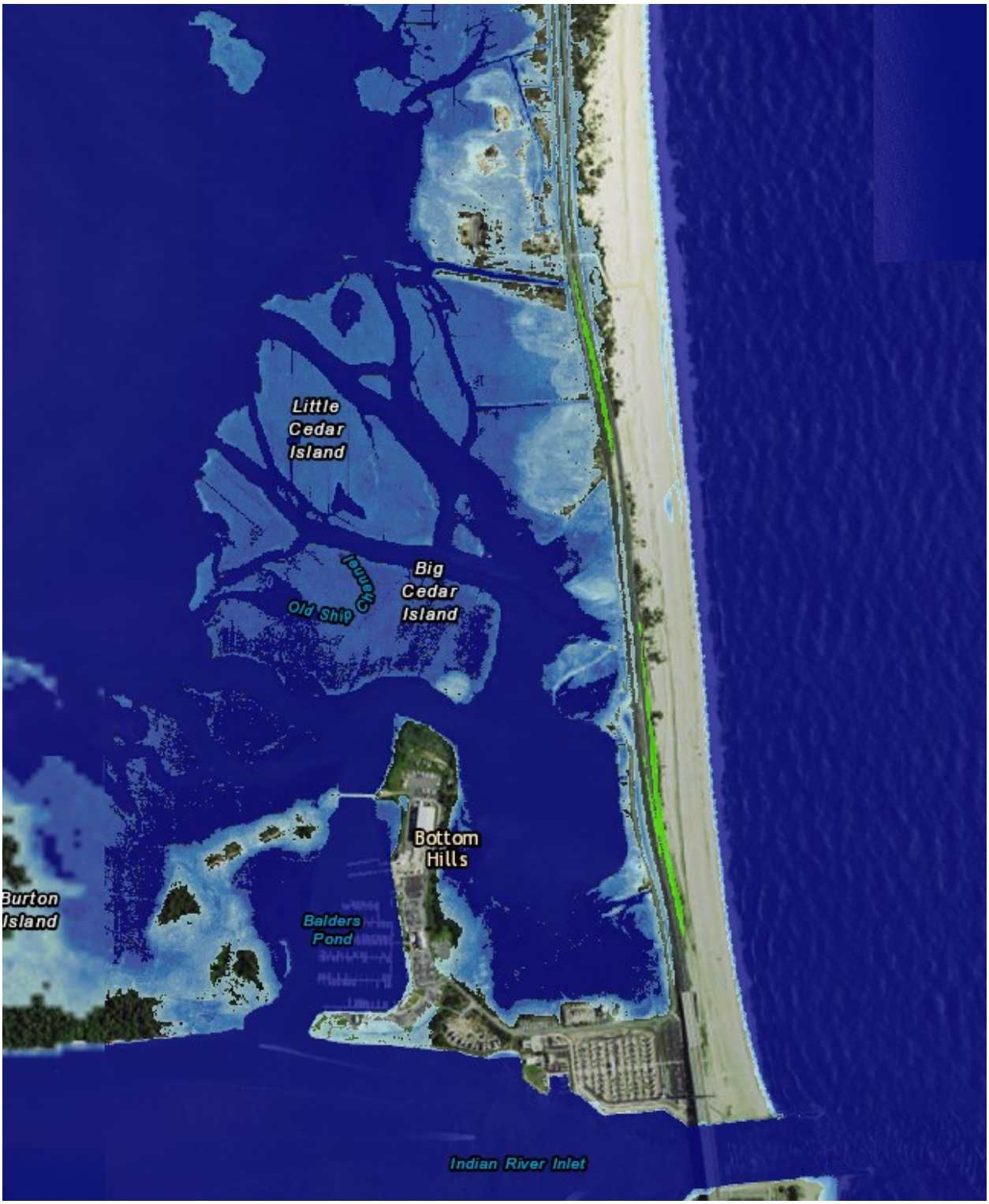
Source: DNREC



Sea Level Rise – 1m. Source: NOAA Sea Level Rise Viewer.

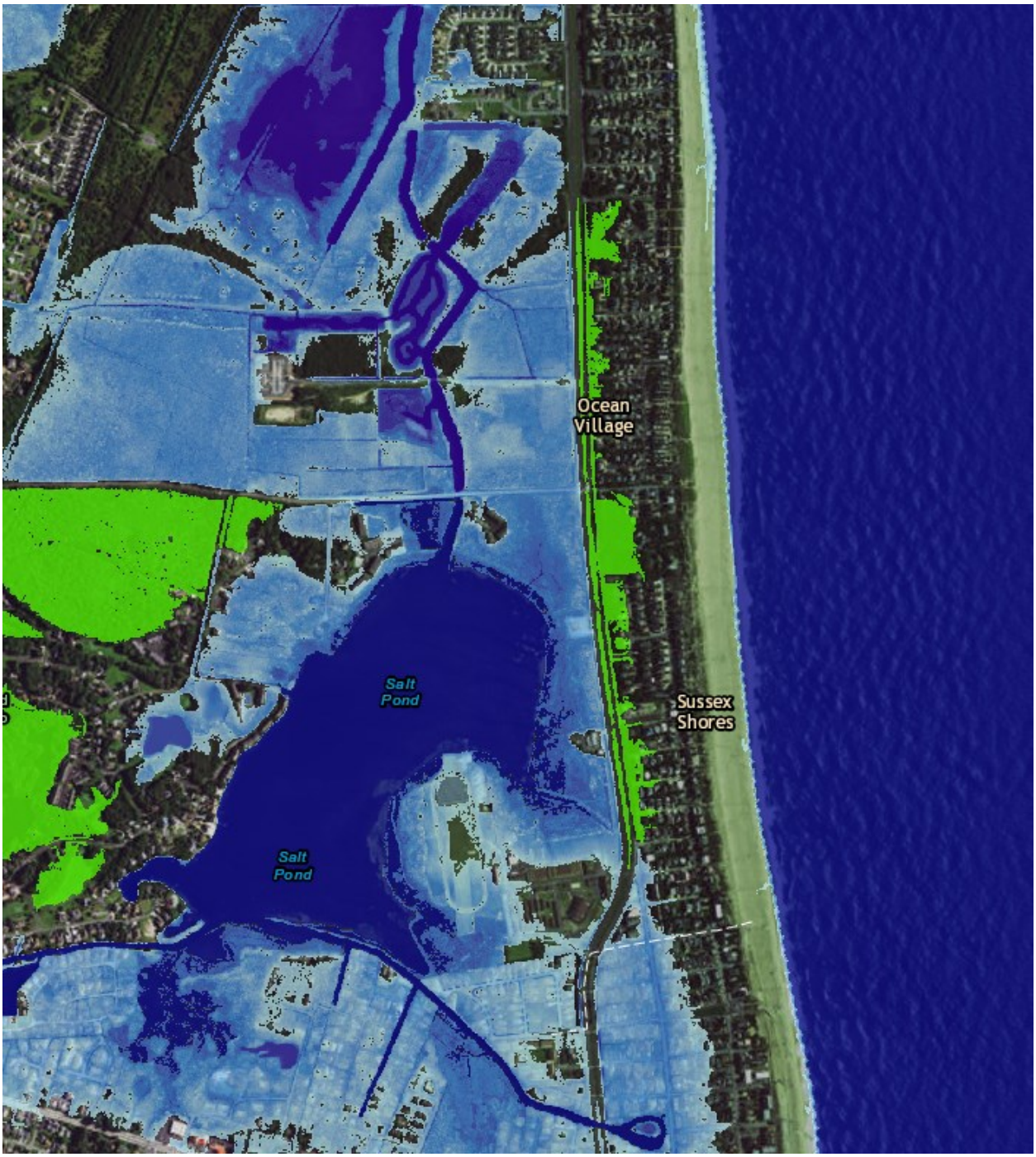
Sea Level Rise – 1m. Source: NOAA Sea Level Rise Viewer.

Sea Level Rise – 1m. Source: NOAA Sea Level Rise Viewer.



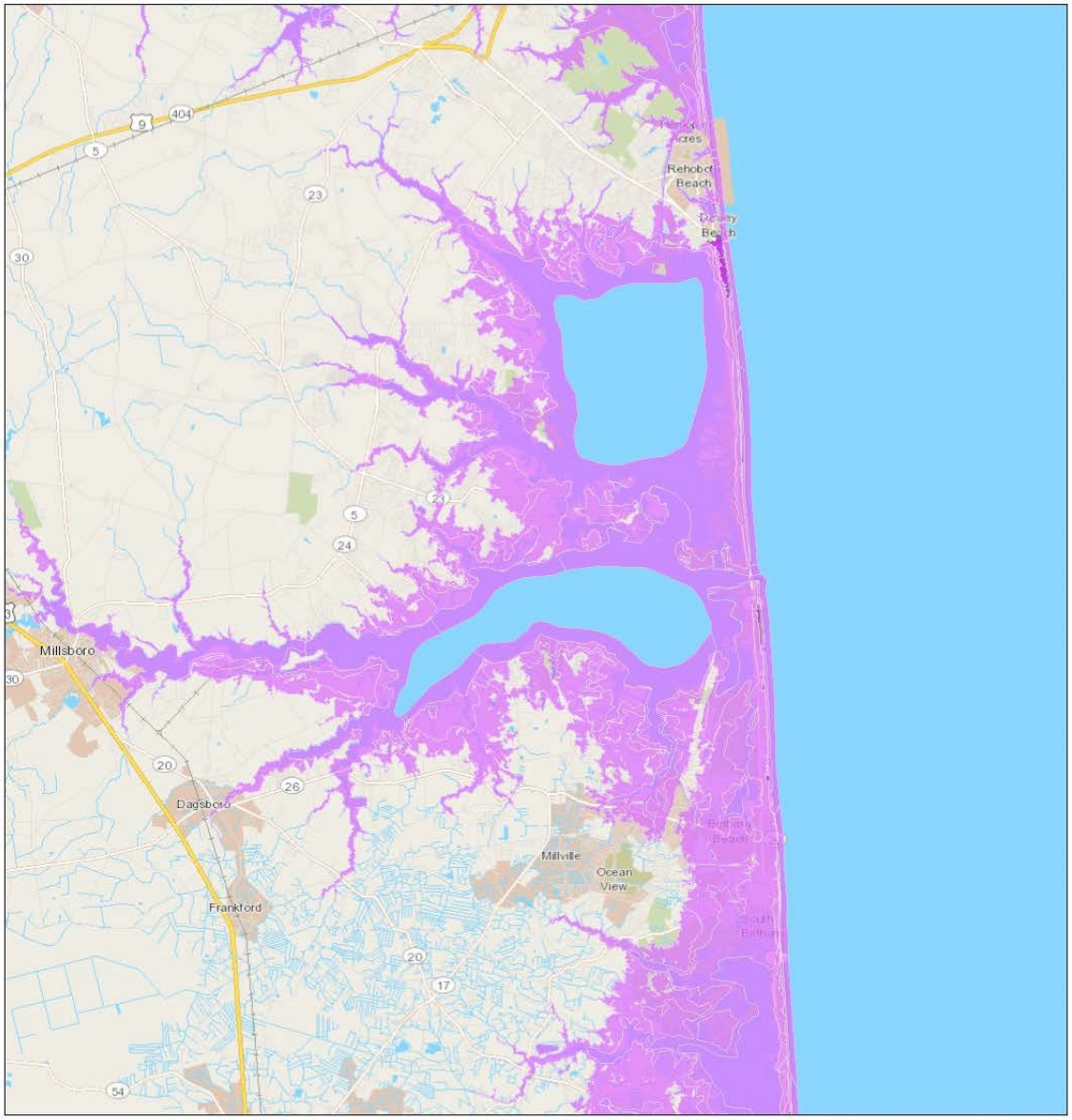
Sea Level Rise – 1m. Source: NOAA Sea Level Rise Viewer.

Sea Level Rise – 1m. Source: NOAA Sea Level Rise Viewer.



Sea Level Rise – 1m. Source: NOAA Sea Level Rise Viewer.

FRAM Location Map



May 19, 2017

Delaware Flood Risk Adaptation Map

Combined Flood Hazard Elevation

Combined Flood Hazard Depth

1:144,448

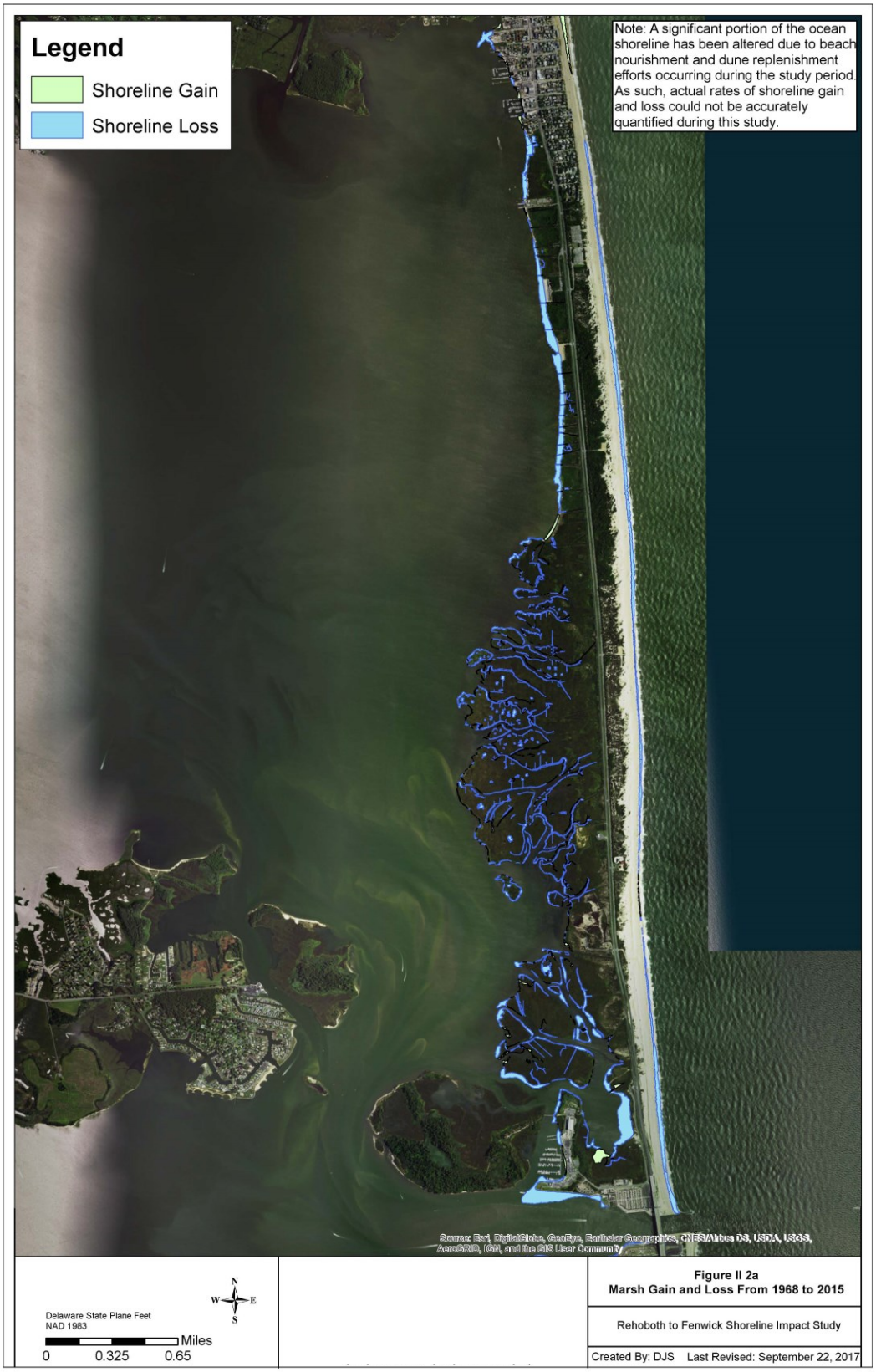
0 1.25 2.5 5 mi

0 1.25 2.5 5 km

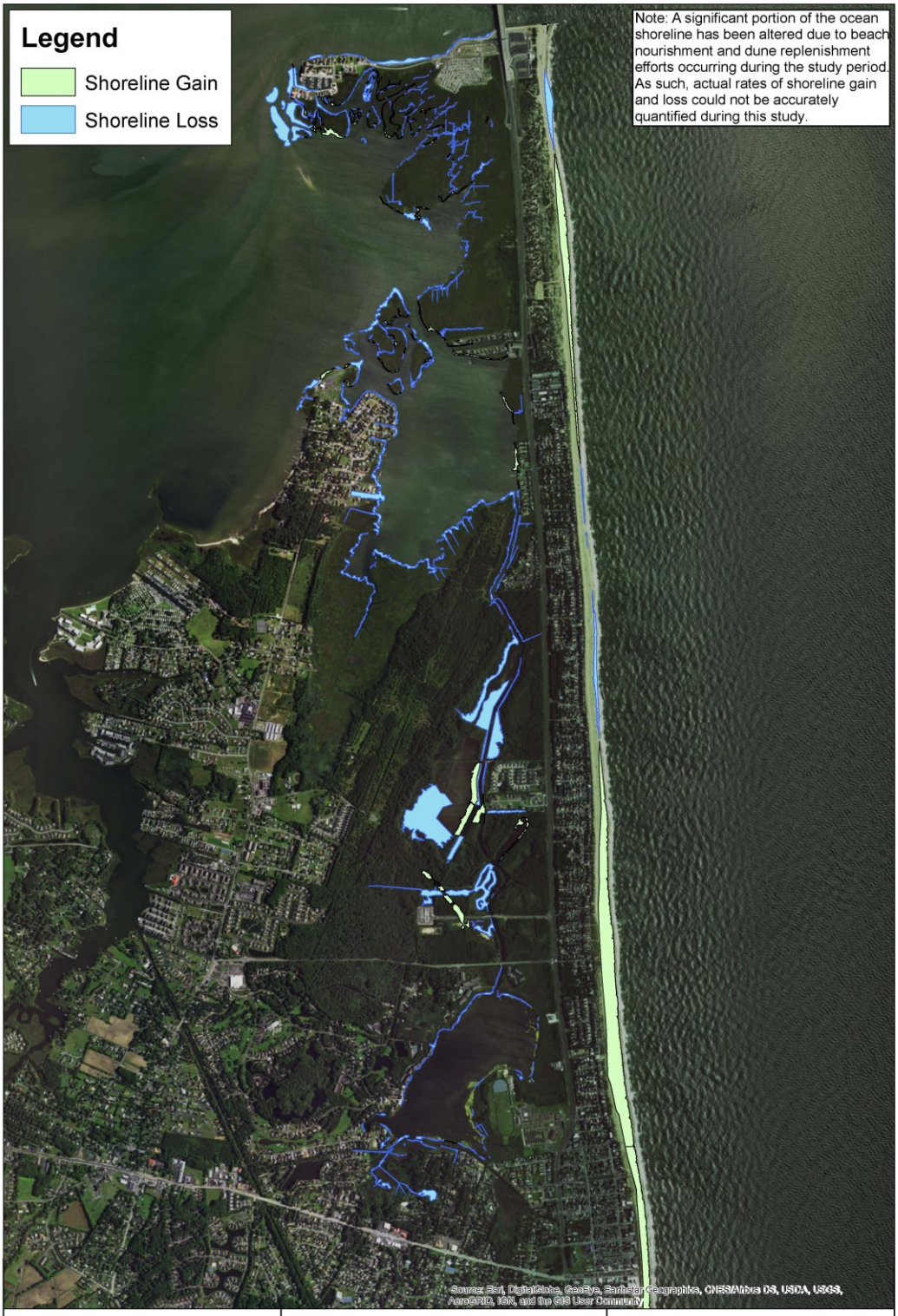
FirstMap 2016
Digital Aerial Solutions, LLC

FirstMap Delaware
2016

Source: Sovereign Consulting Inc.



Source: Sovereign Consulting Inc.



Delaware State Plane Feet
NAD 1983

N W E S

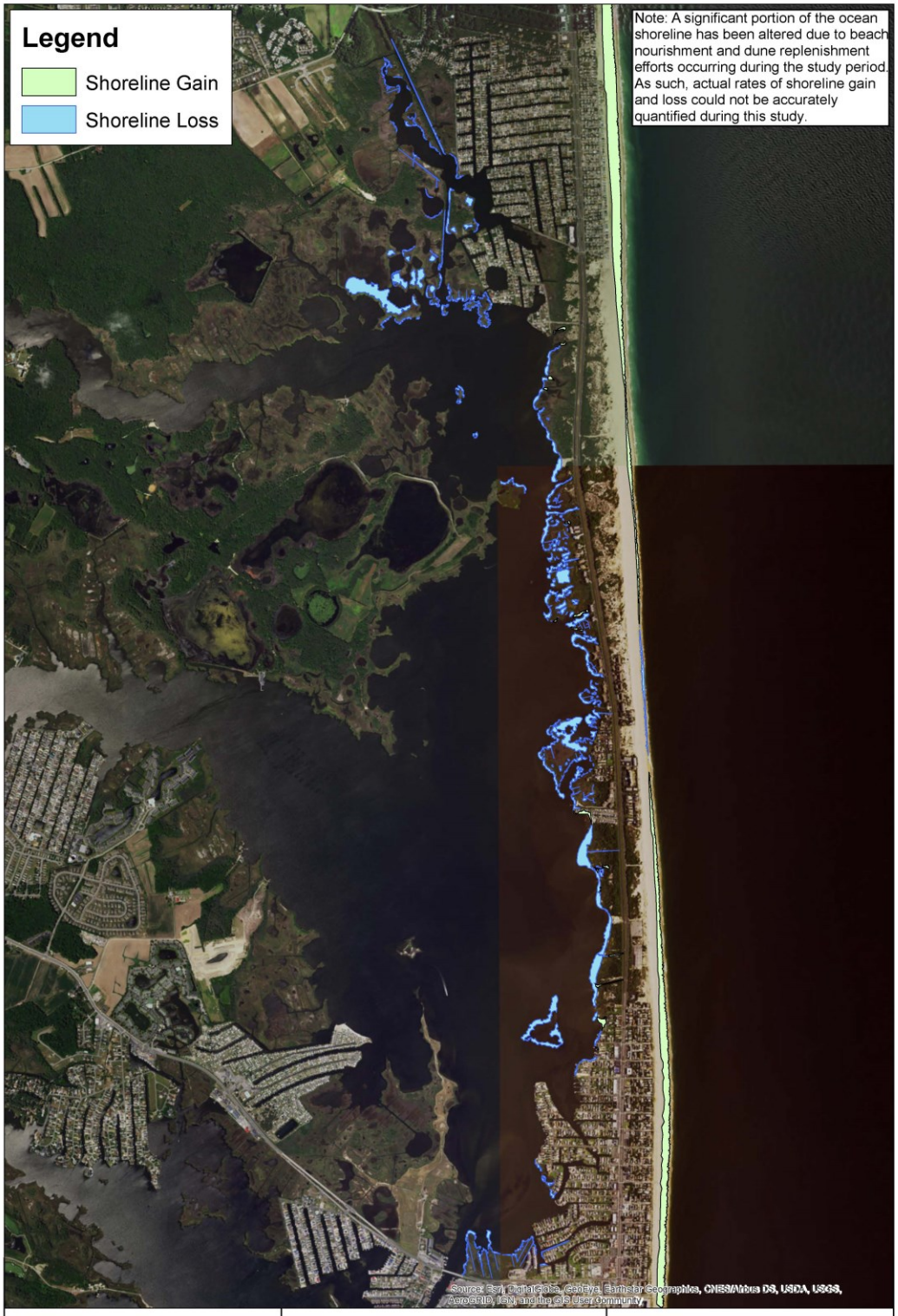
Miles
0 0.275 0.55

Source: Sovereign Consulting Inc.

Figure II 2b
Marsh Gain and Loss From 1968 to 2015

Rehoboth to Fenwick Shoreline Impact Study

Created By: DJS Last Revised: September 22, 2017

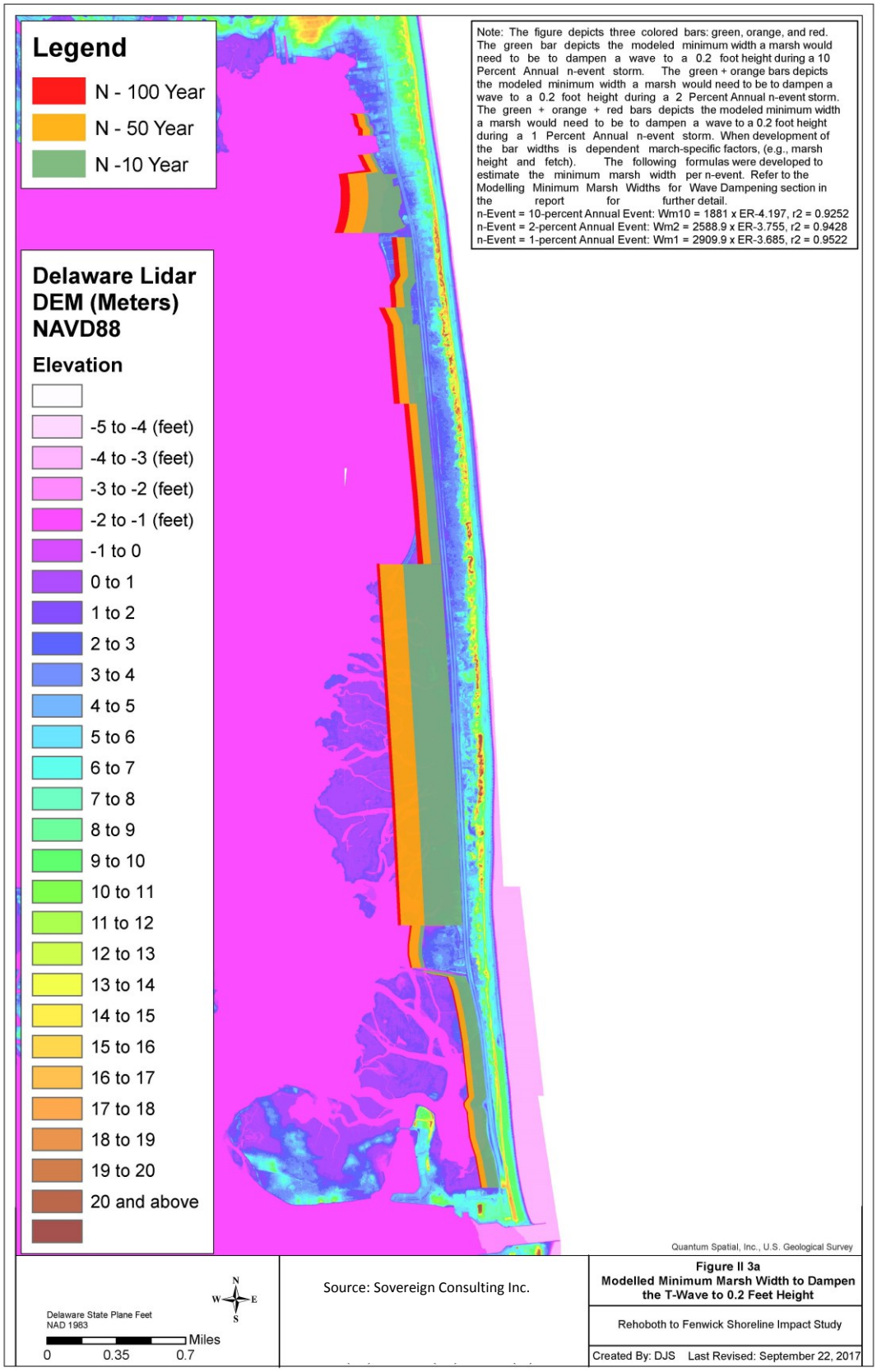


Source: Sovereign Consulting Inc.

Figure II 2c
Marsh Gain and Loss From 1968 to 2015

Rehoboth to Fenwick Shoreline Impact Study

Created By: DJS Last Revised: September 22, 2017


Legend
N - 100 Year
N - 50 Year
N -10 Year
Note: The figure depicts three colored bars: green, orange, and red. The green bar depicts the modeled minimum width a marsh would need to be to dampen a wave to a 0.2 foot height during a 10 Percent Annual n-event storm. The green + orange bars depicts the modeled minimum width a marsh would need to be to dampen a wave to a 0.2 foot height during a 2 Percent Annual n-event storm. The green + orange + red bars depicts the modeled minimum width a marsh would need to be to dampen a wave to a 0.2 foot height during a 1 Percent Annual n-event storm. When development of the bar widths is dependent march-specific factors, (e.g., marsh height and fetch). The following formulas were developed to estimate the minimum marsh width per n-event. Refer to the Modelling Minimum Marsh Widths for Wave Dampening section in the report for further detail.
n-Event = 10-percent Annual Event: Wm10 = 1881 x ER-4.197, r2 = 0.9252
n-Event = 2-percent Annual Event: Wm2 = 2588.9 x ER-3.755, r2 = 0.9428
n-Event = 1-percent Annual Event: Wm1 = 2909.9 x ER-3.685, r2 = 0.9522
Delaware Lidar DEM (Meters) NAVD88
Elevation
-5 to -4 (feet)
-4 to -3 (feet)
-3 to -2 (feet)
-2 to -1 (feet)
-1 to 0
0 to 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 6
6 to 7
7 to 8
8 to 9
9 to 10
10 to 11
11 to 12
12 to 13
13 to 14
14 to 15
15 to 16
16 to 17
17 to 18
18 to 19
19 to 20
20 and above
Quantum Spatial, Inc., U.S. Geological Survey
N
W
E
S
Delaware State Plane Feet
NAD 1983
Miles
0
0.35
0.7
Source: Sovereign Consulting Inc.
Figure II 3a
Modelled Minimum Marsh Width to Dampen the T-Wave to 0.2 Feet Height
Rehoboth to Fenwick Shoreline Impact Study
Created By: DJS Last Revised: September 22, 2017

Legend
N - 100 Year
N - 50 Year
N -10 Year
Delaware Lidar DEM (Meters) NAVD88
Elevation
-5 to -4 (feet)
-4 to -3 (feet)
-3 to -2 (feet)
-2 to -1 (feet)
-1 to 0
0 to 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 6
6 to 7
7 to 8
8 to 9
9 to 10
10 to 11
11 to 12
12 to 13
13 to 14
14 to 15
15 to 16
16 to 17
17 to 18
18 to 19
19 to 20
20 and above
Note: The figure depicts three colored bars: green, orange, and red. The green bar depicts the modeled minimum width a marsh would need to be to dampen a wave to a 0.2 foot height during a 10 Percent Annual n-event storm. The green + orange bars depicts the modeled minimum width a marsh would need to be to dampen a wave to a 0.2 foot height during a 2 Percent Annual n-event storm. The green + orange + red bars depicts the modeled minimum width a marsh would need to be to dampen a wave to a 0.2 foot height during a 1 Percent Annual n-event storm. When development of the bar widths is dependent march-specific factors, (e.g., marsh height and fetch). The following formulas were developed to estimate the minimum marsh width per n-event. Refer to the Modelling Minimum Marsh Widths for Wave Dampening section in the report for further detail.
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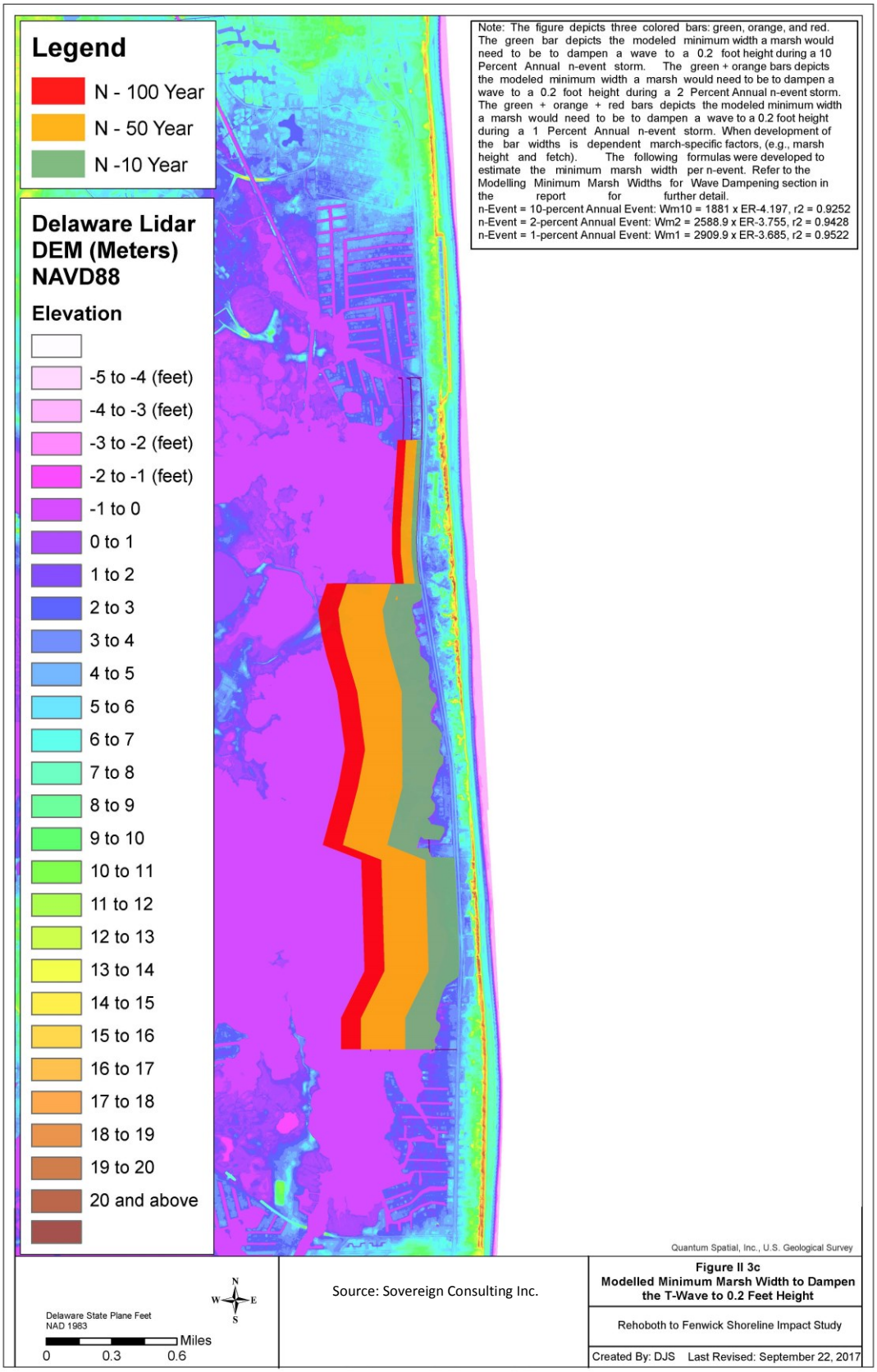
n-Event = 1-percent Annual Event: Wm1 = 2909.9 x ER-3.685, r2 = 0.9522
Quantum Spatial, Inc., U.S. Geological Survey
N
W
E
S
Delaware State Plane Feet
NAD 1983
Miles
0
0.25
0.5
Source: Sovereign Consulting Inc.
Figure II 3b
Modelled Minimum Marsh Width to Dampen the T-Wave to 0.2 Feet Height
Rehoboth to Fenwick Shoreline Impact Study
Created By: DJS Last Revised: September 22, 2017


Legend
N - 100 Year
N - 50 Year
N -10 Year
Delaware Lidar DEM (Meters) NAVD88
Elevation
-5 to -4 (feet)
-4 to -3 (feet)
-3 to -2 (feet)
-2 to -1 (feet)
-1 to 0
0 to 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 6
6 to 7
7 to 8
8 to 9
9 to 10
10 to 11
11 to 12
12 to 13
13 to 14
14 to 15
15 to 16
16 to 17
17 to 18
18 to 19
19 to 20
20 and above
Note: The figure depicts three colored bars: green, orange, and red. The green bar depicts the modeled minimum width a marsh would need to be to dampen a wave to a 0.2 foot height during a 10 Percent Annual n-event storm. The green + orange bars depicts the modeled minimum width a marsh would need to be to dampen a wave to a 0.2 foot height during a 2 Percent Annual n-event storm. The green + orange + red bars depicts the modeled minimum width a marsh would need to be to dampen a wave to a 0.2 foot height during a 1 Percent Annual n-event storm. When development of the bar widths is dependent march-specific factors, (e.g., marsh height and fetch). The following formulas were developed to estimate the minimum marsh width per n-event. Refer to the Modelling Minimum Marsh Widths for Wave Dampening section in the report for further detail.
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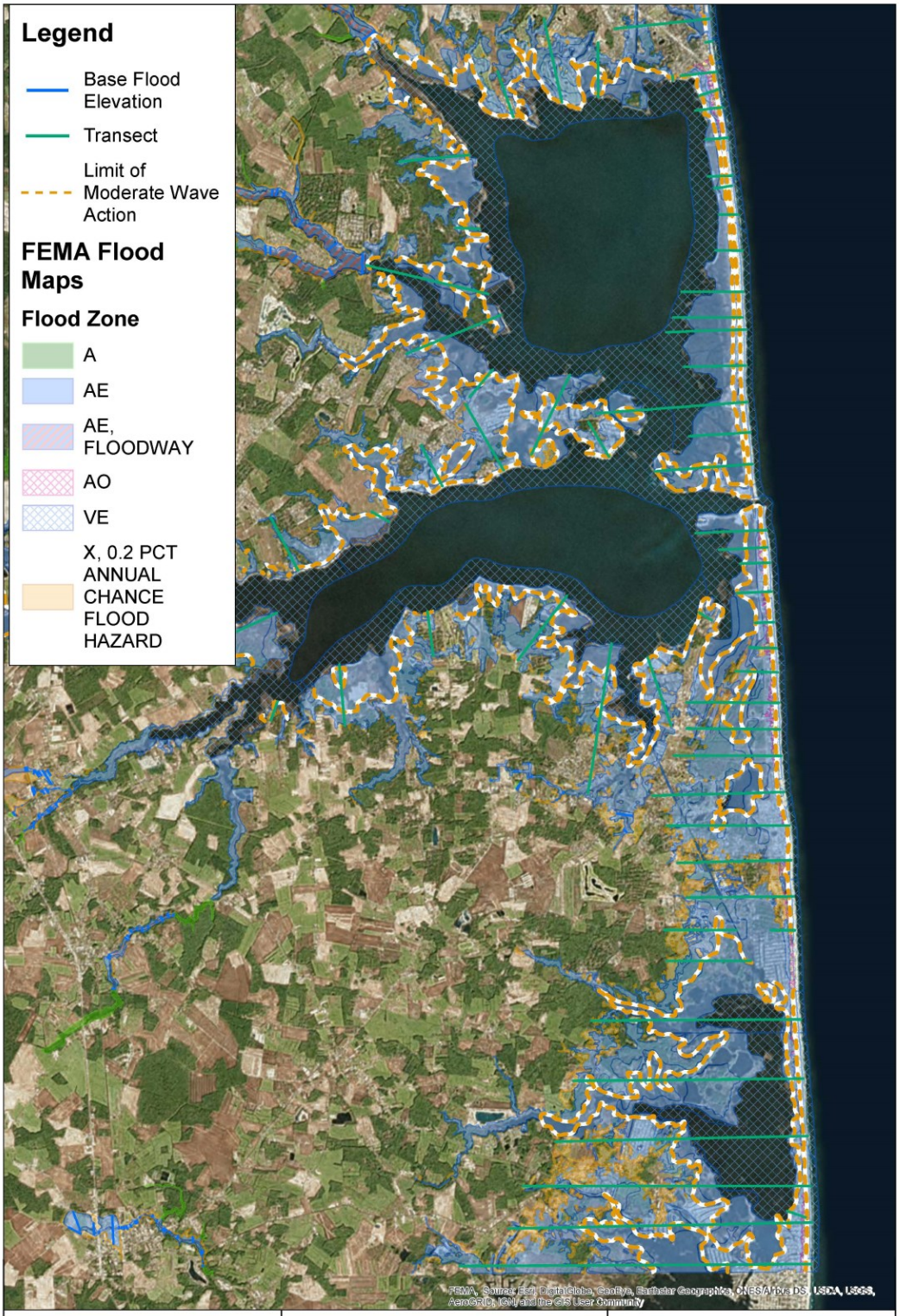
n-Event = 1-percent Annual Event: Wm1 = 2909.9 x ER-3.685, r2 = 0.9522
Quantum Spatial, Inc., U.S. Geological Survey
N
W
E
S
Delaware State Plane Feet
NAD 1983
Miles
0
0.3
0.6
Source: Sovereign Consulting Inc.
Figure II 3c
Modelled Minimum Marsh Width to Dampen the T-Wave to 0.2 Feet Height
Rehoboth to Fenwick Shoreline Impact Study
Created By: DJS Last Revised: September 22, 2017

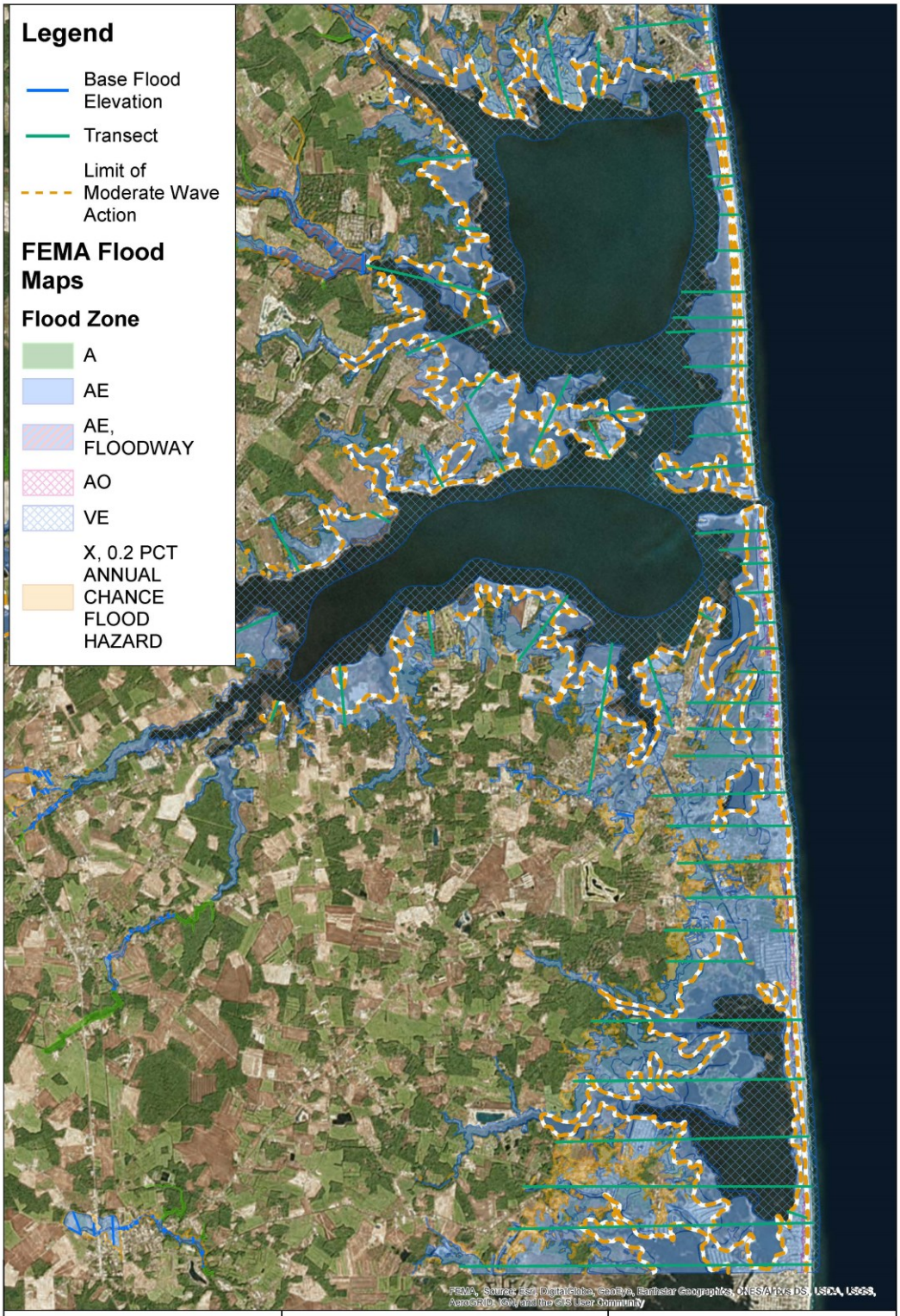


Source: Sovereign Consulting Inc.

Figure II 4
Delaware FIRM Maps

Rehoboth to Fenwick Shoreline Impact Study

Created By: DJS Last Revised: September 22, 2017

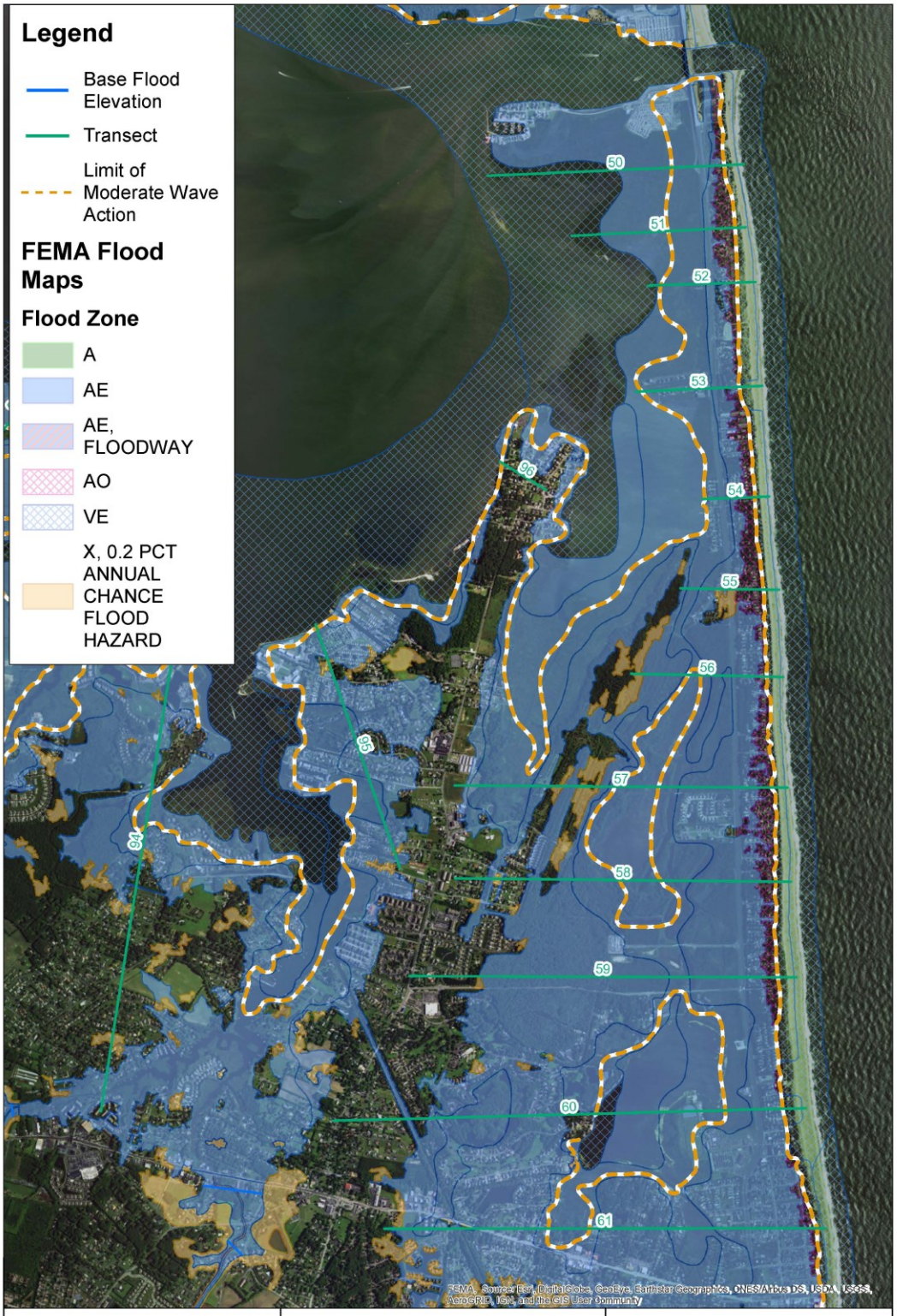


Source: Sovereign Consulting Inc.

Figure II 4
Delaware FIRM Maps

Rehoboth to Fenwick Shoreline Impact Study

Created By: DJS Last Revised: September 22, 2017



Delaware State Plane Feet
NAD 1983

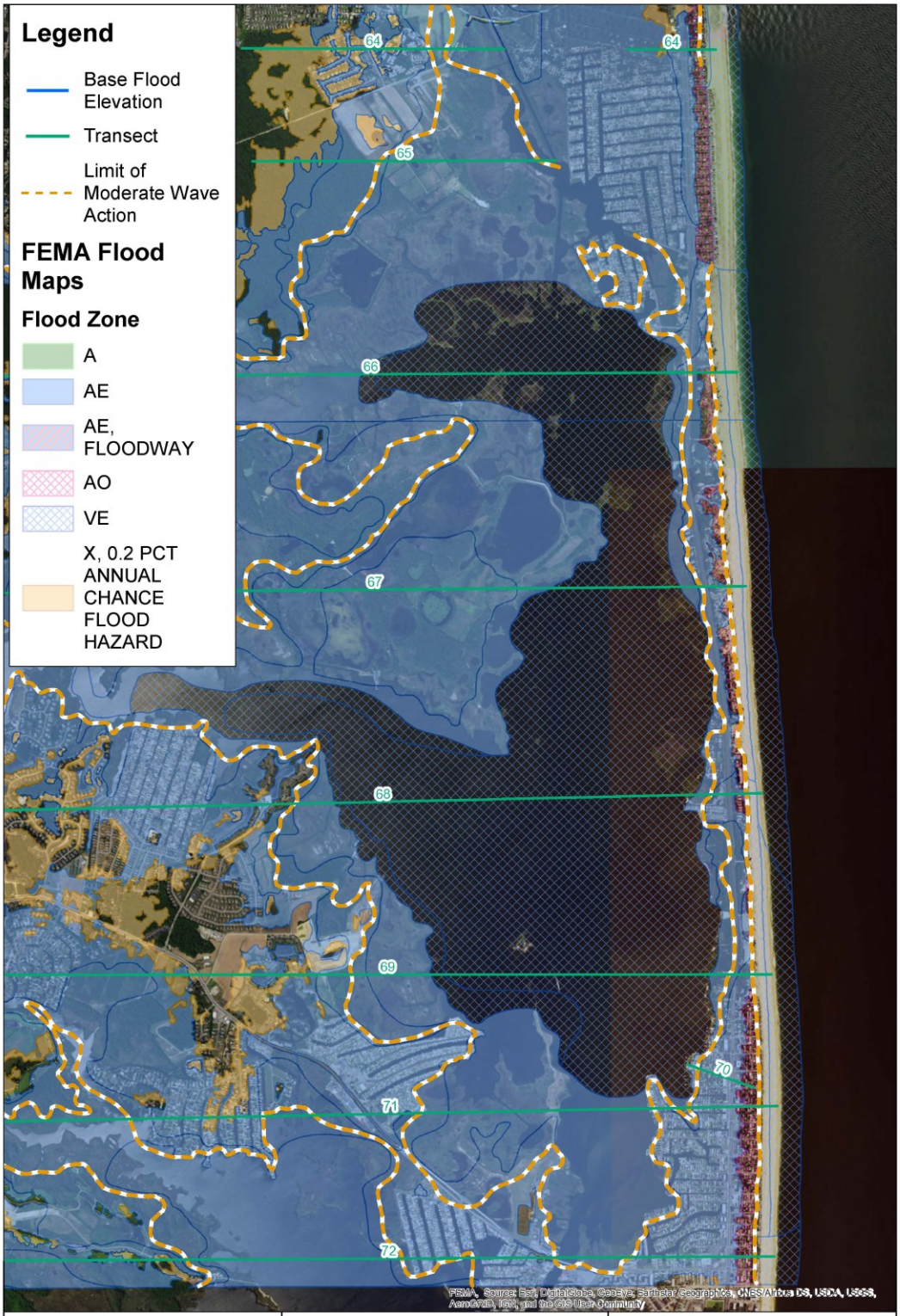
Miles
0 0.275 0.55

Source: Sovereign Consulting Inc.

Figure II 4b
Delaware FIRM Maps

Rehoboth to Fenwick Shoreline Impact Study

Created By: DJS Last Revised: September 22, 2017



Source: Sovereign Consulting Inc.

Figure II 4c
Delaware FIRM Maps

Rehoboth to Fenwick Shoreline Impact Study

Created By: DJS Last Revised: September 22, 2017

Appendix B – Vulnerability Methods Output Tables

Table II-1 - Modeling Summary Page : N Event = 10 Percent Event

Location	Start Lat	Start Long	End Lat	End Long	FEMA Transect Number	Still-water Storm Tide Elevation, S*(ft.) NAVD88	Fetch (miles)	Fetch Direction	Fetch Factor, F	Initial Wave Height (ft) NAVD88 (H1)	S + H1 (ft) NAVD88	Breakwater Top Elevation (ft.), zb NAVD88	Eq. (4) Transmitted Wave Height (ft.), Hb	Marsh Fringe Elevation (ft), zm NAVD88	Marsh Fringe Average Width, w (ft)	Marsh Fringe Plant Height (ft)	Marsh Fringe Plant Width (in)	Marsh Fringe Plant Spacing (in)	Eq. (4) Transmitted Wave Height (ft.), Hm	Marsh Platform Elevation (ft), zm NAVD88	Marsh Platform Average Width, w (ft)	Marsh Platform Plant Height (ft)	Marsh Platform Plant Width (in)	Marsh Platform Plant Spacing (in)	Eq. (4) Transmitted Wave Height (ft.), Hm	Modeled Minimum Marsh Width To Reduce (n) H2 Wave to 0.2ft	Dune Top Elevation (ft), zd NAVD88	Eq. (4) Transmitted Wave Height (ft.), Hd	Eq. (1) n-year Flood Elevation (ft.)
BS-01	753849.31	252138.97	749799.19	251805.38	36.00	3.90	4.83	NNW	0.79	2.41	6.31	2.19	1.33	0.00	0.00	3.20	0.40	2.00	1.33	0.00	0.00	2.00	0.35	2.50	1.33	N/A	3.43	0.37	4.16
BS-02	753935.17	251066.59	749873.35	250938.89	36.00	3.90	4.68	NNW	0.79	2.40	6.30	0.00	2.40	3.20	154.00	0.00	0.00	0.00	0.06	2.95	301.00	2.00	0.35	2.50	0.03	106.70	4.45	0.00	3.90
BS-03	754411.86	248954.48	750347.74	248955.27	36.00	3.90	4.47	NW	0.78	2.37	6.27	0.00	2.37	0.98	62.00	3.20	0.40	2.00	0.74	1.31	669.00	2.00	0.35	2.50	0.18	753.00	4.45	0.00	3.90
BS-04	754665.66	247010.96	750601.23	247011.72	40.00	4.00	4.25	NW	0.77	2.41	6.41	0.00	2.41	0.00	0.00	0.00	0.00	0.00	2.41	2.79	677.00	2.00	0.35	2.50	0.05	165.50	3.20	0.05	4.04
BS-05	754878.38	245109.01	750813.61	245109.75	40.00	4.00	4.15	SW	0.77	2.40	6.40	0.00	2.40	0.00	0.00	0.00	0.00	0.00	2.40	2.46	482.00	2.00	0.35	2.50	0.11	267.00	1.80	0.11	4.08
BS-06	755081.79	242825.39	751016.68	242826.08	40.00	4.00	4.40	SW	0.78	2.43	6.43	0.00	2.43	1.96	50.00	3.20	0.40	2.00	0.51	2.79	321.00	2.00	0.35	2.50	0.09	165.50	1.30	0.09	4.06
BS-07	755708.10	235423.25	751641.87	235421.76	44.00	3.90	4.95	SW	0.80	2.42	6.32	0.00	2.42	2.29	160.00	3.20	0.40	2.00	0.12	0.98	3300.00	2.00	0.35	2.50	0.04	960.00	1.40	0.04	3.93
BS-08	756021.39	229387.91	751954.22	229382.59	44.00	3.90	3.28	SW	0.73	2.23	6.13	0.00	2.23	0.00	0.00	0.00	0.00	0.00	2.23	2.95	1120.00	2.00	0.35	2.50	0.02	106.00	2.75	0.02	3.91
BS-09	756619.77	224916.46	752551.89	224928.42	44.00	3.90	0.45	W	0.42	1.29	5.19	0.00	1.29	0.00	0.00	0.00	0.00	0.00	1.29	3.28	175.00	2.00	0.35	2.50	0.08	64.75	2.25	0.08	3.96
BS-10	757476.14	218400.24	753407.27	218412.36	51.00	4.70	7.30	W	0.86	3.14	7.84	0.00	3.14	1.14	50.00	0.00	0.00	0.00	1.22	1.15	2500.00	2.00	0.35	2.50	0.11	1450.00	4.45	0.11	4.78
BS-11	757741.57	213723.83	753672.16	213729.36	51.00	4.70	0.90	NW	0.53	1.95	6.65	0.00	1.95	1.14	81.00	0.00	0.00	0.00	0.75	1.31	304.00	2.00	0.35	2.50	0.42	1265.00	4.45	0.20	4.84
BS-12	758594.60	199396.21	754526.71	199393.98	70.00	2.70	0.35	W	0.38	0.81	3.51	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.81	2.62	1991.00	2.00	0.35	2.50	0.00	6.97	4.45	0.00	2.70
BS-13	759853.16	183537.56	755785.27	183546.25	70.00	2.70	1.38	W	0.60	1.26	3.96	0.00	1.26	0.00	0.00	0.00	0.00	0.00	1.26	2.62	613.00	2.00	0.35	2.50	0.00	7.80	4.45	0.00	2.70
BS-14	760481.17	176662.35	756405.72	176652.02	70.00	2.70	1.95	NW	0.65	1.37	4.07	0.00	1.37	0.98	50.00	0.00	0.00	0.00	0.35	0.33	550.00	2.00	0.35	2.50	0.15	590.00	4.33	0.00	2.70
BS-15	760648.49	166498.43	756571.96	166535.39	70.00	2.70	0.51	NW	0.44	0.93	3.63	2.46	0.19	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.19	N/A	4.34	0.00	2.70
OS-01	753916.13	250043.59	756993.69	250055.27	37.00	5.90	20.00	E	1.01	4.66	10.56	0.00	4.60	0.00	0.00	0.00	0.00	0.00	4.60	0.00	0.00	0.00	0.00	0.00	4.60	N/A	14.66	0.00	5.90
OS-02	755035.85	240552.35	758114.53	240564.16	42.00	6.00	20.00	E	1.01	4.74	10.74	0.00	4.68	0.00	0.00	0.00	0.00	0.00	4.68	0.00	0.00	0.00	0.00	0.00	4.68	N/A	27.17	0.00	6.00
OS-03	755528.13	233787.02	758607.61	233798.88	45.00	6.20	20.00	E	1.01	4.90	11.10	0.00	4.84	0.00	0.00	0.00	0.00	0.00	4.84	0.00	0.00	0.00	0.00	0.00	4.84	N/A	22.87	0.00	6.20
OS-04	757303.24	216414.08	760384.76	216426.14	48.00	6.20	20.00	E	1.01	4.90	11.10	0.00	4.84	0.00	0.00	0.00	0.00	0.00	4.84	0.00	0.00	0.00	0.00	0.00	4.84	N/A	12.89	0.00	6.20
OS-05	756241.27	227061.33	759321.54	227073.27	52.00	6.00	20.00	E	1.01	4.74	10.74	0.00	4.68	0.00	0.00	0.00	0.00	0.00	4.68	0.00	0.00	0.00	0.00	0.00	4.68	N/A	15.88	0.00	6.00
OS-06	758018.74	202404.42	761101.91	202416.54	59.00	6.30	20.00	E	1.01	4.98	11.28	0.00	4.91	0.00	0.00	0.00	0.00	0.00	4.91	0.00	0.00	0.00	0.00	0.00	4.91	N/A	17.68	0.00	6.30
OS-07	758251.36	196746.83	761335.19	196758.97	61.00	6.50	20.00	E	1.01	5.14	11.64	0.00	5.07	0.00	0.00	0.00	0.00	0.00	5.07	0.00	0.00	0.00	0.00	0.00	5.07	N/A	17.13	0.00	6.50
OS-08	759454.52	181201.32	762540.17	181213.60	66.00	6.30	20.00	E	1.01	4.98	11.28	0.00	4.91	0.00	0.00	0.00	0.00	0.00	4.91	0.00	0.00	0.00	0.00	0.00	4.91	N/A	21.62	0.00	6.30

Table II-2 - Modeling Summary Page : N Event = 2 Percent Event

Location	Start Lat	Start Long	End Lat	End Long	FEMA Transect Number	Still-water Storm Tide Elevation, S*(ft.) NAVD88	Fetch (miles)	Fetch Direction	Fetch Factor, F	Initial Wave Height (ft) NAVD88 (H1)	S + H1 (ft) NAVD88	Breakwater Top Elevation (ft.), zb NAVD88	Eq. (4) Transmitted Wave Height (ft.), Hb	Marsh Fringe Elevation (ft), zm NAVD88	Marsh Fringe Average Width, w (ft)	Marsh Fringe Plant Height (ft)	Marsh Fringe Plant Width (in)	Marsh Fringe Plant Spacing (in)	Eq. (4) Transmitted Wave Height (ft.), Hm	Marsh Platform Elevation (ft), zm NAVD88	Marsh Platform Average Width, w (ft)	Marsh Platform Plant Height (ft)	Marsh Platform Plant Width (in)	Marsh Platform Plant Spacing (in)	Eq. (4) Transmitted Wave Height (ft.), Hm	Modeled Minimum Marsh Width To Reduce (n) H2 Wave to 0.2ft	Dune Top Elevation (ft), zd NAVD88	Eq. (4) Transmitted Wave Height (ft.), Hd	Eq. (1) n-year Flood Elevation (ft.)
BS-01	753849.31	252138.97	749799.19	251805.38	36.00	4.60	4.83	NNW	0.79	2.84	7.44	2.19	1.88	0.00	0.00	3.20	0.40	2.00	1.88	0.00	0.00	2.00	0.35	2.50	1.88	N/A	3.43	0.91	5.24
BS-02	753935.17	251066.59	749873.35	250938.89	36.00	4.60	4.68	NNW	0.79	2.83	7.43	0.00	2.83	3.20	154.00	0.00	0.00	0.00	0.11	2.95	301.00	2.00	0.35	2.50	0.07	310.00	4.45	0.07	4.65
BS-03	754411.86	248954.48	750347.74	248955.27	36.00	4.60	4.47	NW	0.78	2.80	7.40	0.00	2.80	0.98	62.00	3.20	0.40	2.00	1.04	1.31	669.00	2.00	0.35	2.50	0.29	1235.00	4.45	0.12	4.68
BS-04	754665.66	247010.96	750601.23	247011.72	40.00	4.60	4.25	NW	0.77	2.77	7.37	0.00	2.77	0.00	0.00	0.00	0.00	0.00	2.77	2.79	677.00	2.00	0.35	2.50	0.11	375.00	3.20	0.11	4.68
BS-05	754878.38	245109.01	750813.61	245109.75	40.00	4.60	4.15	SW	0.77	2.76	7.36	0.00	2.76	0.00	0.00	0.00	0.00	0.00	2.76	2.46	482.00	2.00	0.35	2.50	0.21	521.00	1.80	0.21	4.75
BS-06	755081.79	242825.39	751016.68	242826.08	40.00	4.60	4.40	SW	0.78	2.79	7.39	0.00	2.79	1.96	50.00	3.20	0.40	2.00	0.79	2.79	321.00	2.00	0.35	2.50	0.19	375.00	1.30	0.19	4.73
BS-07	755708.10	235423.25	751641.87	235421.76	44.00	4.70	4.95	SW	0.80	2.92	7.62	0.00	2.92	2.29	160.00	3.20	0.40	2.00	0.26	0.98	3300.00	2.00	0.35	2.50	0.07	1580.00	1.40	0.07	4.75
BS-08	756021.39	229387.91	751954.22	229382.59	44.00	4.70	3.28	SW	0.73	2.69	7.39	0.00	2.69	0.00	0.00	0.00	0.00	0.00	2.69	2.95	1120.00	2.00	0.35	2.50	0.07	347.00	2.75	0.07	4.75
BS-09	756619.77	224916.46	752551.89	224928.42	44.00	4.70	0.45	W	0.42	1.55	6.25	0.00	1.55	0.00	0.00	0.00	0.00	0.00	1.55	3.28	175.00	2.00	0.35	2.50	0.24	216.00	2.25	0.24	4.87
BS-10	757476.14	218400.24	753407.27	218412.36	51.00	5.30	7.30	W	0.86	3.54	8.84	0.00	3.54	1.14	50.00	0.00	0.00	0.00	1.54	1.15	2500.00	2.00	0.35	2.50	0.15	2000.00	4.45	0.15	5.41
BS-11	757741.57	213723.83	753672.16	213729.36	51.00	5.30	0.90	NW	0.53	2.20	7.50	0.00	2.20	1.14	81.00	0.00	0.00	0.00	0.95	1.31	304.00	2.00	0.35	2.50	0.55	1775.00	4.45	0.55	5.68
BS-12	758594.60	199396.21	754526.71	199393.98	70.00	4.20	0.35	W	0.38	1.26	5.46	0.00	1.26	0.00	0.00	0.00	0.00	0.00	1.26	2.62	1991.00	2.00	0.35	2.50	0.03	257.00	4.45	0.00	4.20
BS-13	759853.16	183537.56	755785.27	183546.25	70.00	4.20	1.38	W	0.60	1.96	6.16	0.00	1.96	0.00	0.00	0.00	0.00	0.00	1.96	2.62	613.00	2.00	0.35	2.50	0.09	274.00	4.45	0.00	4.20
BS-14	760481.17	176662.35	756405.72	176652.02	70.00	4.20	1.95	NW	0.65	2.13	6.33	0.00	2.13	0.98	50.00	0.00	0.00	0.00	0.92	0.33	550.00	2.00	0.35	2.50	0.39	1670.00	4.33	0.00	4.20
BS-15	760648.49	166498.43	756571.96	166535.39	70.00	4.20	0.51	NW	0.44	1.45	5.65	2.46	1.36	0.00	0.00	0.00	0.00	0.00	1.36	0.00	0.00	0.00	0.00	0.00	1.36	N/A	4.34	0.00	4.20
OS-01	753916.13	250043.59	756993.69	250055.27	37.00	7.30	20.00	E	1.01	5.77	13.07	0.00	5.69	0.00	0.00	0.00	0.00	0.00	5.69	0.00	0.00	0.00	0.00	0.00	5.69	N/A	14.66	0.00	7.30
OS-02	755035.85	240552.35	758114.53	240564.16	42.00	7.40	20.00	E	1.01	5.85	13.25	0.00	5.77	0.00	0.00	0.00	0.00	0.00	5.77	0.00	0.00	0.00	0.00	0.00	5.77	N/A	27.17	0.00	7.40
OS-03	755528.13	233787.02	758607.61	233798.88	45.00	7.50	20.00	E	1.01	5.93	13.43	0.00	5.85	0.00	0.00	0.00	0.00	0.00	5.85	0.00	0.00	0.00	0.00	0.00	5.85	N/A	22.87	0.00	7.50
OS-04	757303.24	216414.08	760384.76	216426.14	48.00	7.50	20.00	E	1.01	5.93	13.43	0.00	5.85	0.00	0.00	0.00	0.00	0.00	5.85	0.00	0.00	0.00	0.00	0.00	5.85	N/A	12.89	0.00	7.50
OS-05	756241.27	227061.33	759321.54	227073.27	52.00	7.20	20.00	E	1.01	5.69	12.89	0.00	5.62	0.00	0.00	0.00	0.00	0.00	5.62	0.00	0.00	0.00	0.00	0.00	5.62	N/A	15.88	0.00	7.20
OS-06	758018.74	202404.42	761101.91	202416.54	59.00	7.50	20.00	E	1.01	5.93	13.43	0.00	5.85	0.00	0.00	0.00	0.00	0.00	5.85	0.00	0.00	0.00	0.00	0.00	5.85	N/A	17.68	0.00	7.50
OS-07	758251.36	196746.83	761335.19	196758.97	61.00	7.60	20.00	E	1.01	6.01	13.61	0.00	5.93	0.00	0.00	0.00	0.00	0.00	5.93	0.00	0.00	0.00	0.00	0.00	5.93	N/A	17.13	0.00	7.60
OS-08	759454.52	181201.32	762540.17	181213.60	66.00	7.20	20.00	E	1.01	5.69	12.89	0.00	5.62	0.00	0.00	0.00	0.00	0.00	5.62	0.00	0.00	0.00	0.00	0.00	5.62	N/A	21.62	0.00	7.20

Table II-3 - Modeling Summary Page : N Event = 1 Percent Event

Location	Start Lat	Start Long	End Lat	End Long	FEMA Transect Number	Still-water Storm Tide Elevation, S*(ft.) NAVD88	Fetch (miles)	Fetch Direction	Fetch Factor, F	Initial Wave Height (ft) NAVD88 (H1)	S + H1 (ft) NAVD88	Breakwater Top Elevation (ft.), zb NAVD88	Eq. (4) Transmitted Wave Height (ft.), Hb	Marsh Fringe Elevation (ft), zm NAVD88	Marsh Fringe Average Width, w (ft)	Marsh Fringe Plant Height (ft)	Marsh Fringe Plant Width (in)	Marsh Fringe Plant Spacing (in)	Eq. (4) Transmitted Wave Height (ft.), Hm	Marsh Platform Elevation (ft), zm NAVD88	Marsh Platform Average Width, w (ft)	Marsh Platform Plant Height (ft)	Marsh Platform Plant Width (in)	Marsh Platform Plant Spacing (in)	Eq. (4) Transmitted Wave Height (ft.), Hm	Modeled Minimum Marsh Width To Reduce (n) H2 Wave to 0.2ft	Dune Top Elevation (ft), zd NAVD88	Eq. (4) Transmitted Wave Height (ft.), Hd	Eq. (1) n-year Flood Elevation (ft.)
BS-01	753849.31	252138.97	749799.19	251805.38	36.00	4.90	4.83	NNW	0.79	3.03	7.93	2.19	2.11	0.00	0.00	3.20	0.40	2.00	2.11	0.00	0.00	2.00	0.35	2.50	2.11	N/A	3.43	1.15	5.70
BS-02	753935.17	251066.59	749873.35	250938.89	36.00	4.90	4.68	NNW	0.79	3.01	7.91	0.00	3.01	3.20	154.00	0.00	0.00	0.00	0.14	2.95	301.00	2.00	0.35	2.50	0.10	435.00	4.45	0.10	4.97
BS-03	754411.86	248954.48	750347.74	248955.27	36.00	4.90	4.47	NW	0.78	2.98	7.88	0.00	2.98	0.98	62.00	3.20	0.40	2.00	1.18	1.31	669.00	2.00	0.35	2.50	0.34	1475.00	4.45	0.34	5.14
BS-04	754665.66	247010.96	750601.23	247011.72	40.00	4.90	4.25	NW	0.77	2.95	7.85	0.00	2.95	0.00	0.00	0.00	0.00	0.00	2.95	2.79	677.00	2.00	0.35	2.50	0.15	510.00	3.20	0.15	5.01
BS-05	754878.38	245109.01	750813.61	245109.75	40.00	4.90	4.15	SW	0.77	2.94	7.84	0.00	2.94	0.00	0.00	0.00	0.00	0.00	2.94	2.46	482.00	2.00	0.35	2.50	0.27	681.00	1.80	0.27	5.09
BS-06	755081.79	242825.39	751016.68	242826.08	40.00	4.90	4.40	SW	0.78	2.97	7.87	0.00	2.97	1.96	50.00	3.20	0.40	2.00	0.93	2.79	321.00	2.00	0.35	2.50	0.25	511.00	1.30	0.25	5.07
BS-07	755708.10	235423.25	751641.87	235421.76	44.00	4.80	4.95	SW	0.80	2.98	7.78	0.00	2.98	2.29	160.00	3.20	0.40	2.00	0.28	0.98	3300.00	2.00	0.35	2.50	0.08	1667.00	1.40	0.08	4.85
BS-08	756021.39	229387.91	751954.22	229382.59	44.00	4.80	3.28	SW	0.73	2.74	7.54	0.00	2.74	0.00	0.00	0.00	0.00	0.00	2.74	2.95	1120.00	2.00	0.35	2.50	0.07	389.00	2.75	0.07	4.85
BS-09	756619.77	224916.46	752551.89	224928.42	44.00	4.80	0.45	W	0.42	1.59	6.39	0.00	1.59	0.00	0.00	0.00	0.00	0.00	1.59	3.28	175.00	2.00	0.35	2.50	0.27	248.00	2.25	0.27	4.99
BS-10	757476.14	218400.24	753407.27	218412.36	51.00	5.50	7.30	W	0.86	3.68	9.18	0.00	3.68	1.14	50.00	0.00	0.00	0.00	1.65	1.15	2500.00	2.00	0.35	2.50	0.17	2200.00	4.45	0.17	5.62
BS-11	757741.57	213723.83	753672.16	213729.36	51.00	5.50	0.90	NW	0.53	2.28	7.78	0.00	2.28	1.14	81.00	0.00	0.00	0.00	1.02	1.31	304.00	2.00	0.35	2.50	0.59	1965.00	4.45	0.59	5.91
BS-12	758594.60	199396.21	754526.71	199393.98	70.00	4.70	0.35	W	0.38	1.41	6.11	0.00	1.41	0.00	0.00	0.00	0.00	0.00	1.41	2.62	1991.00	2.00	0.35	2.50	0.05	455.00	4.45	0.05	4.74
BS-13	759853.16	183537.56	755785.27	183546.25	70.00	4.70	1.38	W	0.60	2.19	6.89	0.00	2.19	0.00	0.00	0.00	0.00	0.00	2.19	2.62	613.00	2.00	0.35	2.50	0.16	481.00	4.45	0.16	4.81
BS-14	760481.17	176662.35	756405.72	176652.02	70.00	4.70	1.95	NW	0.65	2.39	7.09	0.00	2.39	0.98	50.00	0.00	0.00	0.00	1.14	0.33	550.00	2.00	0.35	2.50	0.49	2150.00	4.33	0.29	4.90
BS-15	760648.49	166498.43	756571.96	166535.39	70.00	4.70	0.51	NW	0.44	1.62	6.32	2.46	1.62	0.00	0.00	0.00	0.00	0.00	1.62	0.00	0.00	0.00	0.00	0.00	1.62	N/A	4.34	0.28	4.90
OS-01	753916.13	250043.59	756993.69	250055.27	37.00	7.90	20.00	E	1.01	6.24	14.14	0.00	6.16	0.00	0.00	0.00	0.00	0.00	6.16	0.00	0.00	0.00	0.00	0.00	6.16	N/A	14.66	0.00	7.90
OS-02	755035.85	240552.35	758114.53	240564.16	42.00	8.00	20.00	E	1.01	6.32	14.32	0.00	6.24	0.00	0.00	0.00	0.00	0.00	6.24	0.00	0.00	0.00	0.00	0.00	6.24	N/A	27.17	0.00	8.00
OS-03	755528.13	233787.02	758607.61	233798.88	45.00	8.10	20.00	E	1.01	6.40	14.50	0.00	6.32	0.00	0.00	0.00	0.00	0.00	6.32	0.00	0.00	0.00	0.00	0.00	6.32	N/A	22.87	0.00	8.10
OS-04	757303.24	216414.08	760384.76	216426.14	48.00	8.10	20.00	E	1.01	6.40	14.50	0.00	6.32	0.00	0.00	0.00	0.00	0.00	6.32	0.00	0.00	0.00	0.00	0.00	6.32	N/A	12.89	0.00	8.10
OS-05	756241.27	227061.33	759321.54	227073.27	52.00	7.80	20.00	E	1.01	6.17	13.97	0.00	6.08	0.00	0.00	0.00	0.00	0.00	6.08	0.00	0.00	0.00	0.00	0.00	6.08	N/A	15.88	0.00	7.80
OS-06	758018.74	202404.42	761101.91	202416.54	59.00	8.00	20.00	E	1.01	6.32	14.32	0.00	6.24	0.00	0.00	0.00	0.00	0.00	6.24	0.00	0.00	0.00	0.00	0.00	6.24	N/A	17.68	0.00	8.00
OS-07	758251.36	196746.83	761335.19	196758.97	61.00	8.10	20.00	E	1.01	6.40	14.50	0.00	6.32	0.00	0.00	0.00	0.00	0.00	6.32	0.00	0.00	0.00	0.00	0.00	6.32	N/A	17.13	0.00	8.10
OS-08	759454.52	181201.32	762540.17	181213.60	66.00	7.70	20.00	E	1.01	6.09	13.79	0.00	6.01	0.00	0.00	0.00	0.00	0.00	6.01	0.00	0.00	0.00	0.00	0.00	6.01	N/A	21.62	0.00	7.70

Table II - 4						
Reach	n-Event = 10-percent Annual Event		n-Event = 2-percent Annual Event		n-Event = 1-percent Annual Event	
	Flood Event Clearence* (feet)	Flood Class**	Flood Event Clearence* (feet)	Flood Class**	Flood Event Clearence* (feet)	Flood Class**
BS-01	-0.73	HV	-1.81	HV	-2.27	HV
BS-02	0.55	V	-0.20	HV	-0.52	HV
BS-03	0.55	V	-0.23	HV	-0.69	HV
BS-04	-0.84	HV	-1.48	HV	-1.81	HV
BS-05	-2.28	HV	-2.95	HV	-3.29	HV
BS-06	-2.76	HV	-3.43	HV	-3.77	HV
BS-07	-2.53	HV	-3.35	HV	-3.45	HV
BS-08	-1.16	HV	-2.00	HV	-2.10	HV
BS-09	-1.71	HV	-2.62	HV	-2.74	HV
BS-10	-0.33	HV	-0.96	HV	-1.17	HV
BS-11	-0.39	HHV	-1.23	HV	-1.46	HV
BS-12	1.75	R	0.25	V	-0.29	HV
BS-13	1.75	R	0.25	V	-0.36	HV
BS-14	1.63	R	0.13	V	-0.57	HV
BS-15	1.64	R	0.14	V	-0.56	HV
OS-01	8.76	HR	7.36	HR	6.76	HR
OS-02	21.17	HR	19.77	HR	19.17	HR
OS-03	16.67	HR	15.37	HR	14.77	HR
OS-04	6.69	HR	5.39	HR	4.79	HR
OS-05	9.88	HR	8.68	HR	8.08	HR
OS-06	11.38	HR	10.18	HR	9.68	HR
OS-07	10.63	HR	9.53	HR	9.03	HR
OS-08	15.32	HR	14.42	HR	13.92	HR

* Flood Event Clearance = Dune/Slope Top Elevation - n-Year Flood Event Elevation (NAVD88).

** Flood Class: HR-Highly Flood Resilient; R-Flood Resilient; V-Flood Vulnerable; HV-Highly Flood Vulnerable

Table II-5						
Reach	n-Event = 10-percent Annual Event		n-Event = 2-percent Annual Event		n-Event = 1-percent Annual Event	
	TransmittedWave Hieght (ft.)	T-Wave Class*	TransmittedWave Hieght (ft.)	T-Wave Class*	TransmittedWave Hieght (ft.)	T-Wave Class*
BS-01	0.37	MD	0.91	D	1.15	D
BS-02	0.00	ND	0.07	ND	0.10	ND
BS-03	0.00	ND	0.12	ND	0.34	MD
BS-04	0.05	ND	0.11	ND	0.15	ND
BS-05	0.11	ND	0.21	MD	0.27	MD
BS-06	0.09	ND	0.19	ND	0.25	MD
BS-07	0.04	ND	0.07	ND	0.08	ND
BS-08	0.02	ND	0.07	ND	0.07	ND
BS-09	0.08	ND	0.24	MD	0.27	MD
BS-10	0.11	ND	0.15	ND	0.17	ND
BS-11	0.20	MD	0.55	D	0.59	D
BS-12	0.00	ND	0.00	ND	0.05	ND
BS-13	0.00	ND	0.00	ND	0.16	ND
BS-14	0.00	ND	0.00	ND	0.29	MD
BS-15	0.00	ND	0.00	ND	0.28	MD
OS-01	0.00	ND	0.00	ND	0.00	ND
OS-02	0.00	ND	0.00	ND	0.00	ND
OS-03	0.00	ND	0.00	ND	0.00	ND
OS-04	0.00	ND	0.00	ND	0.00	ND
OS-05	0.00	ND	0.00	ND	0.00	ND
OS-06	0.00	ND	0.00	ND	0.00	ND
OS-07	0.00	ND	0.00	ND	0.00	ND
OS-08	0.00	ND	0.00	ND	0.00	ND

* Classes: SD-Significantly Destructive; D-Destructive; MD-Minimally Destructive; ND-Non Destructive.

Table II-6 - Bayside Marsh Area and Horizontal Change Summary Sheet (1968 to 2015)

Bay Area (Acres)

Reach Section ID	Total Loss for Reach (acres)	Total Loss for Reach Per Year (acres)	Total Gain for Reach (acres)	Total Gain for Reach Per Year (acres)	Net Loss/Gain (acres)	Net Loss/Gain Per Year (acres)	Gain/Loss
BS-01	-1.73	-0.04	0.67	0.01	**-1.06**	**-0.02**	L
BS-02	-0.20	0.00	0.87	0.02	**0.66**	**0.01**	G
BS-03	-4.12	-0.09	0.00	0.00	**-4.12**	**-0.09**	L
BS-04	-1.51	-0.03	0.17	0.00	**-1.34**	**-0.03**	L
BS-05	-8.86	-0.19	0.25	0.01	**-8.61**	**-0.18**	L
BS-06	-8.79	-0.19	1.43	0.03	**-7.35**	**-0.16**	L
BS-07	-28.38	-0.60	5.32	0.11	**-23.06**	**-0.49**	L
BS-08	-0.05	0.00	0.39	0.01	**0.33**	**0.01**	G
BS-09	-43.15	-0.92	6.10	0.13	**-37.04**	**-0.79**	L
BS-10	-21.19	-0.45	6.00	0.13	**-15.19**	**-0.32**	L
BS-11	-16.28	-0.35	3.46	0.07	**-12.82**	**-0.27**	L
BS-12	-5.91	-0.13	0.05	0.00	**-5.87**	**-0.12**	L
BS-13	-18.24	-0.39	0.55	0.01	**-17.69**	**-0.38**	L
BS-14	-33.49	-0.71	2.30	0.05	**-31.19**	**-0.66**	L
BS-15	-3.49	-0.07	0.00	0.00	**-3.49**	**-0.07**	L
BS-11A	-38.90	-0.83	8.61	0.18	**-30.29**	**-0.64**	L
BS-12A	-4.61	-0.10	0.00	0.00	**-4.61**	**-0.10**	L
Total	-238.90	-5.08	36.16	0.77	**-202.73**	**-4.31**	L

Bay Shoreline (Feet)

Reach Section ID	Average Horizontal Loss/Gain (ft)	Average Horizontal Loss/Gain Per Year (ft)	Existing Width of Marsh	Percent Average Horizontal Loss/Gain Per Year (ft)	Loss/Gain
BS-01	-24.71	**-0.53**	**0.00**	**0.00**	L
BS-02	19.50	**0.41**	**455.00**	**0.09**	G
BS-03	-86.57	**-1.84**	**731.00**	**-0.25**	L
BS-04	-31.95	**-0.68**	**677.00**	**-0.10**	L
BS-05	-158.52	**-3.37**	**482.00**	**-0.70**	L
BS-06	-73.05	**-1.55**	**371.00**	**-0.42**	L
BS-07	-9.41	**-0.20**	**3460.00**	**-0.01**	L
BS-08	3.28	**0.07**	**1120.00**	**0.01**	G
BS-09	-159.43	**-3.39**	**175.00**	**-1.94**	L
BS-10	-72.58	**-1.54**	**2550.00**	**-0.06**	L
BS-11	-12.93	**-0.28**	**385.00**	**-0.07**	L
BS-12	-13.57	**-0.29**	**1991.00**	**-0.01**	L
BS-13	-60.82	**-1.29**	**613.00**	**-0.21**	L
BS-14	-58.13	**-1.24**	**600.00**	**-0.21**	L
BS-15	-17.62	**-0.37**	**0.00**	**0.00**	L
BS-11A	-87.37	**-1.86**	**N/A**	**N/A**	L
BS-12A	-17.72	**-0.38**	**N/A**	**N/A**	L
Total	-54.52	**-1.16**	**N/A**	**N/A**	L

Table II-7 - Comparison Between Existing Marsh Width and Modelled Minimum Required Marsh Width to Dampen T-Wave to 0.2 ft. Height (n-Event = 10-percent Annual Event)

Reach Section ID	Fringe Marsh Width (ft.)	Platform Marsh Width (ft.)	Total Marsh Width (ft.)	Modelled Minimum Marsh Width to Reduce T-Wave Height to 0.2 ft.	Average Net Loss/Gain Per Year (acres)	Average Horizontal Loss/Gain Per Year (ft)	Corrected Minimum Marsh Width to Reduce T-Wave Height to 0.2 ft. for N-Life = 50 years	Difference	Percent Varience = Difference/Modelled Width x 100	Class**
BS-01*	0.0	0.0	0.0	N/A	0.0	-0.5	N/A	N/A	N/A	N/A
BS-02	154.0	301.0	455.0	106.7	0.0	0.4	84.5	370.5	347.2	HR
BS-03	62.0	669.0	731.0	753.0	-0.1	-1.8	853.9	-122.9	-16.3	HV
BS-04	0.0	677.0	677.0	165.5	0.0	-0.7	202.4	474.6	286.8	HR
BS-05	0.0	482.0	482.0	267.0	-0.2	-3.4	454.0	28.0	10.5	V
BS-06	50.0	321.0	371.0	165.5	-0.2	-1.6	258.9	112.1	67.8	HR
BS-07	160.0	3300.0	3460.0	960.0	-0.5	-0.2	1019.1	2440.9	254.3	HR
BS-08	0.0	1120.0	1120.0	106.0	0.0	0.1	101.8	1018.2	960.6	HR
BS-09	0.0	175.0	175.0	64.8	-0.8	-3.4	313.2	-138.2	-213.4	HV
BS-10	50.0	2500.0	2550.0	1450.0	-0.3	-1.5	1559.5	990.5	68.3	HR
BS-11	81.0	304.0	385.0	1265.0	-0.3	-0.3	1306.0	-921.0	-72.8	HV
BS-12	0.0	1991.0	1991.0	7.0	-0.1	-0.3	33.9	1957.1	28079.0	HR
BS-13	0.0	613.0	613.0	7.8	-0.4	-1.3	110.1	502.9	6447.0	HR
BS-14	50.0	550.0	600.0	590.0	-0.7	-1.2	718.2	-118.2	-20.0	HV
BS-15*	0.0	0.0	0.0	N/A	-0.1	-0.4	N/A	N/A	N/A	N/A

Table II-8 - Comparison Between Existing Marsh Width and Modelled Minimum Required Marsh Width to Dampen T-Wave to 0.2 ft. Height (n-Event = 2-percent Annual Event)

Reach Section ID	Fringe Marsh Width (ft.)	Platform Marsh Width (ft.)	Total Marsh Width (ft.)	Modelled Minimum Marsh Width to Reduce T-Wave Height to 0.2 ft.	Average Net Loss/Gain Per Year (acres)	Average Horizontal Loss/Gain Per Year (ft)	Corrected Minimum Marsh Width to Reduce T-Wave Height to 0.2 ft. for N-Life = 50 years	Difference	Percent Varience = Difference/Modelled Width x 100	Class**
BS-01*	0.0	0.0	0.0	N/A	0.0	-0.5	N/A	N/A	N/A	N/A
BS-02	154.0	301.0	455.0	310.0	0.0	0.4	287.8	167.2	53.9	HR
BS-03	62.0	669.0	731.0	1235.0	-0.1	-1.8	1335.9	-604.9	-49.0	HV
BS-04	0.0	677.0	677.0	375.0	0.0	-0.7	411.9	265.1	70.7	HR
BS-05	0.0	482.0	482.0	521.0	-0.2	-3.4	708.0	-226.0	-43.4	HV
BS-06	50.0	321.0	371.0	375.0	-0.2	-1.6	468.4	-97.4	-26.0	HV
BS-07	160.0	3300.0	3460.0	1580.0	-0.5	-0.2	1639.1	1820.9	115.2	HR
BS-08	0.0	1120.0	1120.0	347.0	0.0	0.1	342.8	777.2	224.0	HR
BS-09	0.0	175.0	175.0	216.0	-0.8	-3.4	464.4	-289.4	-134.0	HV
BS-10	50.0	2500.0	2550.0	2000.0	-0.3	-1.5	2109.5	440.5	22.0	R
BS-11	81.0	304.0	385.0	1775.0	-0.3	-0.3	1816.0	-1431.0	-80.6	HV
BS-12	0.0	1991.0	1991.0	257.0	-0.1	-0.3	283.9	1707.1	664.2	HR
BS-13	0.0	613.0	613.0	274.0	-0.4	-1.3	376.3	236.7	86.4	HR
BS-14	50.0	550.0	600.0	1670.0	-0.7	-1.2	1798.2	-1198.2	-71.7	HV
BS-15*	0.0	0.0	0.0	N/A	-0.1	-0.4	N/A	N/A	N/A	N/A

Table II-9 - Comparison Between Existing Marsh Width and Modelled Minimum Required Marsh Width to Dampen T-Wave to 0.2 ft. Height (n-Event = 1-percent Annual Event)

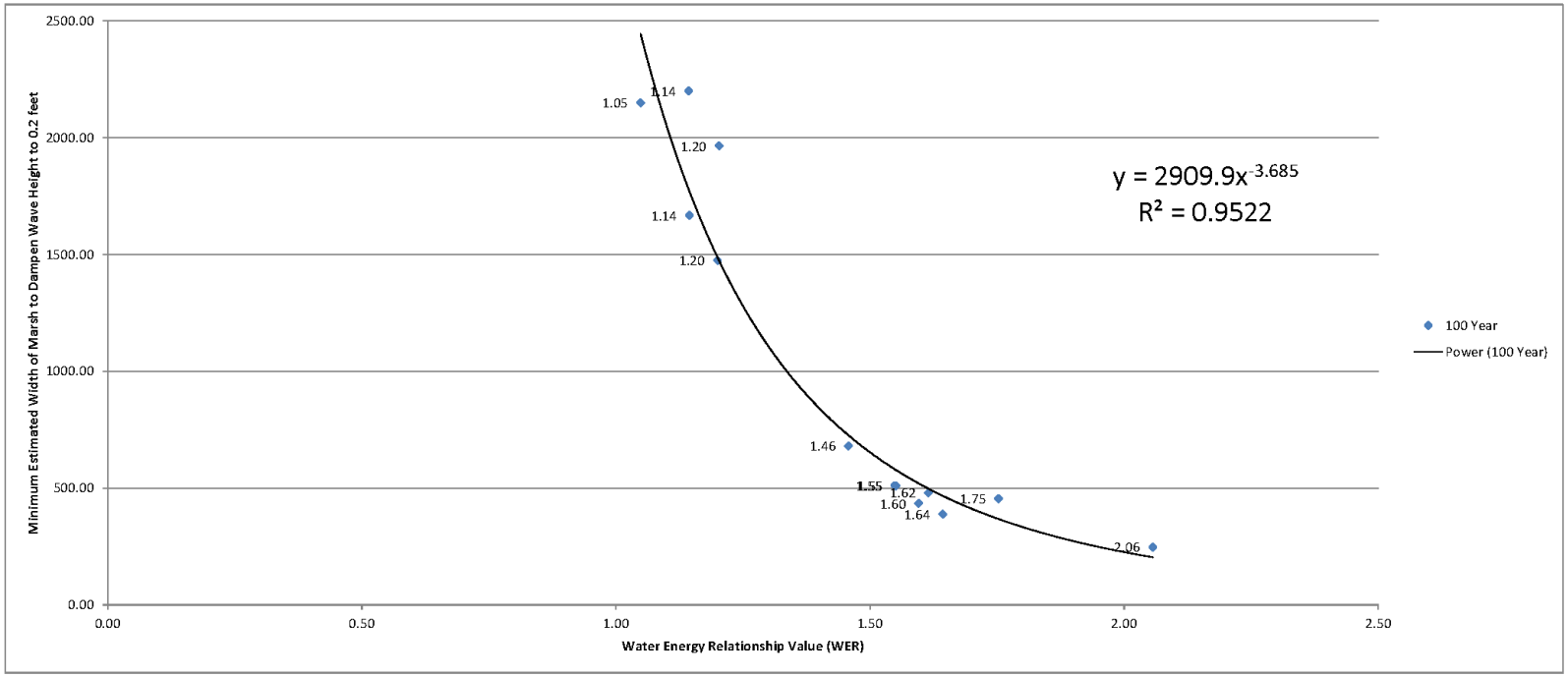
Reach Section ID	Fringe Marsh Width (ft.)	Platform Marsh Width (ft.)	Total Marsh Width (ft.)	Modelled Minimum Marsh Width to Reduce T-Wave Height to 0.2 ft.	Average Net Loss/Gain Per Year (acres)	Average Horizontal Loss/Gain Per Year (ft)	Corrected Minimum Marsh Width to Reduce T-Wave Height to 0.2 ft. for N-Life = 50 years	Difference	Percent Varience = Difference/Corrected Modelled Width x 100	Class**
BS-01*	0.0	0.0	0.0	N/A	0.0	-0.5	N/A	N/A	N/A	N/A
BS-02	154.0	301.0	455.0	435.0	0.0	0.4	412.8	42.2	9.7	V
BS-03	62.0	669.0	731.0	1475.0	-0.1	-1.8	1575.9	-844.9	-57.3	HV
BS-04	0.0	677.0	677.0	510.0	0.0	-0.7	546.9	130.1	25.5	R
BS-05	0.0	482.0	482.0	681.0	-0.2	-3.4	868.0	-386.0	-56.7	HV
BS-06	50.0	321.0	371.0	511.0	-0.2	-1.6	604.4	-233.4	-45.7	HV
BS-07	160.0	3300.0	3460.0	1667.0	-0.5	-0.2	1726.1	1733.9	104.0	HR
BS-08	0.0	1120.0	1120.0	389.0	0.0	0.1	384.8	735.2	189.0	HR
BS-09	0.0	175.0	175.0	248.0	-0.8	-3.4	496.4	-321.4	-129.6	HV
BS-10	50.0	2500.0	2550.0	2200.0	-0.3	-1.5	2309.5	240.5	10.9	R
BS-11	81.0	304.0	385.0	1965.0	-0.3	-0.3	2006.0	-1621.0	-82.5	HV
BS-12	0.0	1991.0	1991.0	455.0	-0.1	-0.3	481.9	1509.1	331.7	HR
BS-13	0.0	613.0	613.0	481.0	-0.4	-1.3	583.3	29.7	6.2	V
BS-14	50.0	550.0	600.0	2150.0	-0.7	-1.2	2278.2	-1678.2	-78.1	HV
BS-15*	0.0	0.0	0.0	N/A	-0.1	-0.4	N/A	N/A	N/A	N/A

Table II-10															
n-Event	**Reaches**														
	BS-01	**BS-02**	**BS-03**	**BS-04**	**BS-05**	**BS-06**	**BS-07**	**BS-08**	**BS-09**	**BS-10**	**BS-11**	**BS-12**	**BS-13**	**BS-14**	**BS-15**
10-Percent Annual Event															
Flooding	4	3	3	4	4	4	4	4	4	4	4	2	2	2	2
Wave Energy	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1
Buffer Resilience	4	1	4	1	3	1	1	1	4	1	4	1	1	4	4
Total	10	5	8	6	8	6	6	6	9	6	10	4	4	7	7
2-Percent Annual Event															
Flooding	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3
Wave Energy	3	1	2	1	2	2	1	1	2	1	3	1	1	2	2
Buffer Resilience	4	1	4	1	4	4	1	1	4	2	4	1	1	4	4
Total	11	6	10	6	10	10	6	6	10	7	11	5	5	9	9
1-Percent Annual Event															
Flooding	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Wave Energy	3	1	2	1	2	2	1	1	2	1	3	1	1	2	2
Buffer Resilience	4	3	4	2	4	4	1	1	4	2	4	1	3	4	4
Total	11	8	10	7	10	10	6	6	10	7	11	6	8	10	10
Grand Total	32	19	28	19	28	26	18	18	29	20	32	15	17	26	26

Appendix C – Wave Limited Empirical Relationships

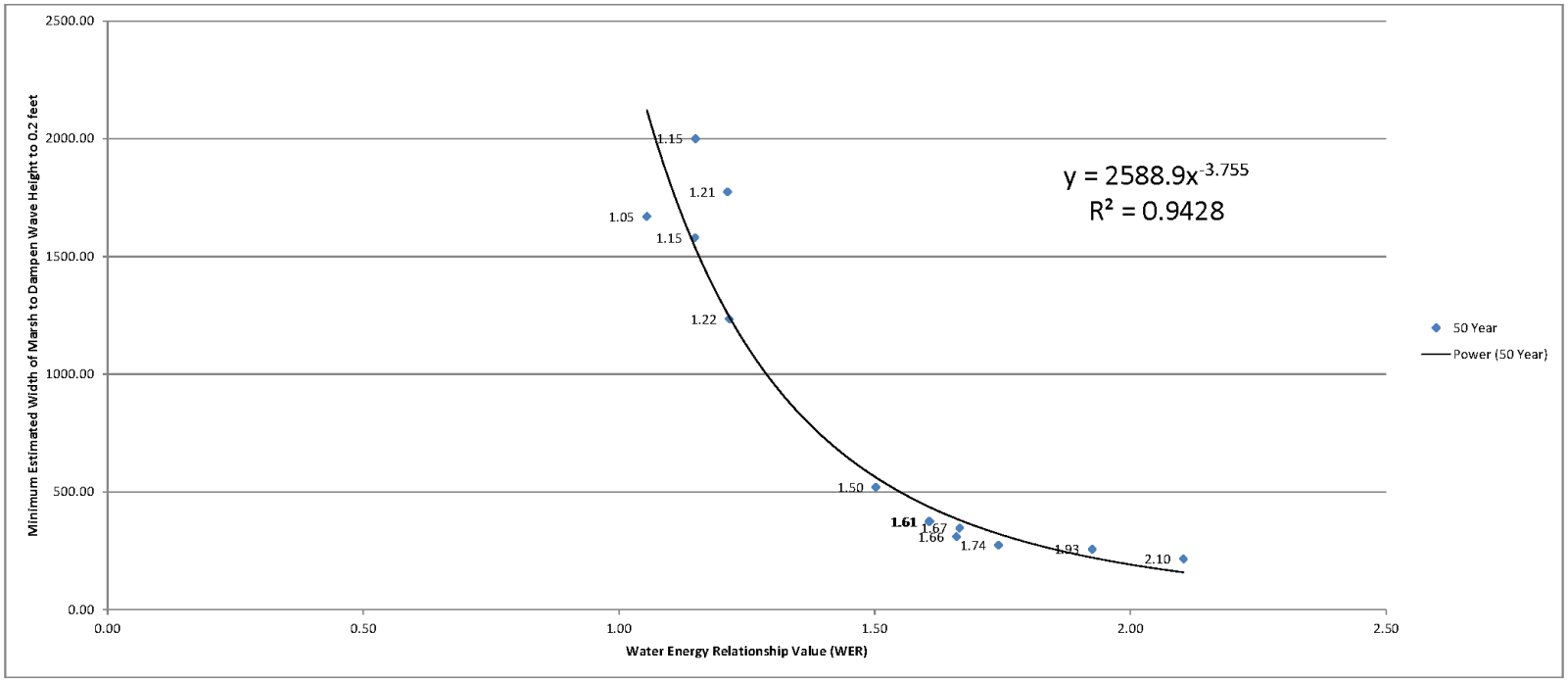
N-Event = 1-percent Annual Event

Cross Section	BS-02	BS-03	BS-04	BS-05	BS-06	BS-07	BS-08	BS-09	BS-10	BS-11	BS-12	BS-13	BS-14
Still-water Storm Tide Elevation (S) (ft. NAVD88) From FEMA FIS Study	4.90	4.90	4.90	4.90	4.90	4.80	4.80	4.80	5.50	5.50	4.70	4.70	4.70
Initial Wave (H1) (ft. NAVD88) NAS Method	3.01	2.98	2.95	2.94	2.97	2.98	2.74	1.59	3.68	2.28	1.41	2.19	2.39
S+H1 (Initial Wave Crest Elevation) (WC)	7.91	7.88	7.85	7.84	7.87	7.78	7.54	6.39	9.18	7.78	6.11	6.89	7.09
Low Marsh Platform Average Height (ft. NAVD88) (d) from LIDAR 2016	2.95	1.31	2.79	2.46	2.79	0.98	2.95	3.28	1.15	1.31	2.62	2.62	0.33
WC/d = Freedbord (Fb)	4.96	6.57	5.06	5.38	5.09	6.80	4.59	3.11	8.03	6.47	3.49	4.27	6.76
Water Energy Relationship Value (WER) = WC/Fb	1.60	1.20	1.55	1.46	1.55	1.14	1.64	2.06	1.14	1.20	1.75	1.62	1.05
Minimum Estimated Width of Marsh to Dampen Wave Height to 0.2 feet	435.00	1475.00	510.00	681.00	511.00	1667.00	389.00	248.00	2200.00	1965.00	455.00	481.00	2150.00



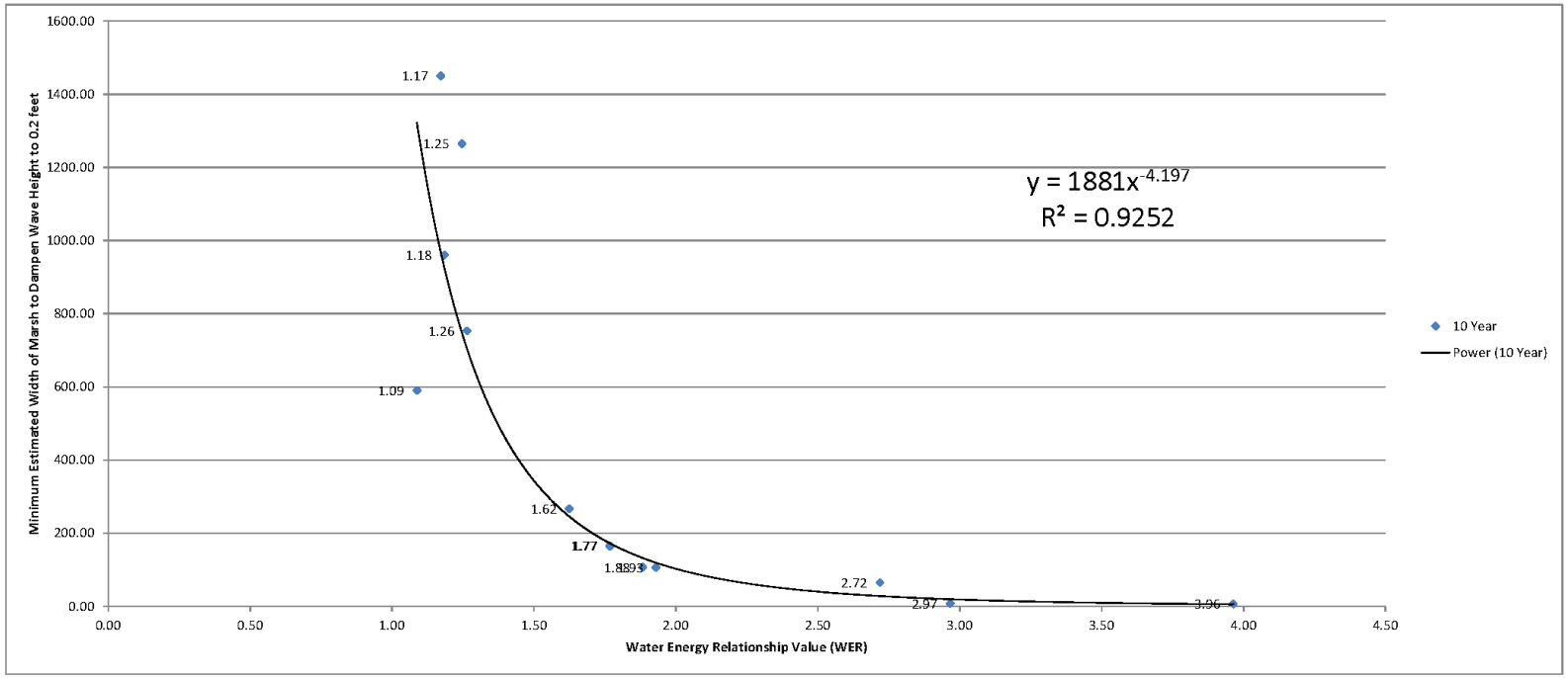
N-Event = 2-percent Annual Event

Cross Section	BS-02	BS-03	BS-04	BS-05	BS-06	BS-07	BS-08	BS-09	BS-10	BS-11	BS-12	BS-13	BS-14
Still-water Storm Tide Elevation (S) (ft. NAVD88) From FEMA FIS Study	4.60	4.60	4.60	4.60	4.60	4.70	4.70	4.70	5.30	5.30	4.20	4.20	4.20
Initial Wave (H1) (ft. NAVD88) NAS Method	2.83	2.80	2.77	2.76	2.79	2.92	2.69	1.55	3.54	2.20	1.26	1.96	2.13
S+H1 (Initial Wave Crest Elevation) (WC)	7.43	7.40	7.37	7.36	7.39	7.62	7.39	6.25	8.84	7.50	5.46	6.16	6.33
Low Marsh Platform Average Height (ft. NAVD88) (d) from LIDAR 2016	2.95	1.31	2.79	2.46	2.79	0.98	2.95	3.28	1.15	1.31	2.62	2.62	0.33
WC/d = Freedbord (Fb)	4.47	6.09	4.58	4.90	4.60	6.64	4.43	2.97	7.69	6.18	2.84	3.53	6.01
Water Energy Relationship Value (WER) = WC/Fb	1.66	1.22	1.61	1.50	1.61	1.15	1.67	2.10	1.15	1.21	1.93	1.74	1.05
Minimum Estimated Width of Marsh to Dampen Wave Height to 0.2 feet	310.00	1235.00	375.00	521.00	375.00	1580.00	347.00	216.00	2000.00	1775.00	257.00	274.00	1670.00

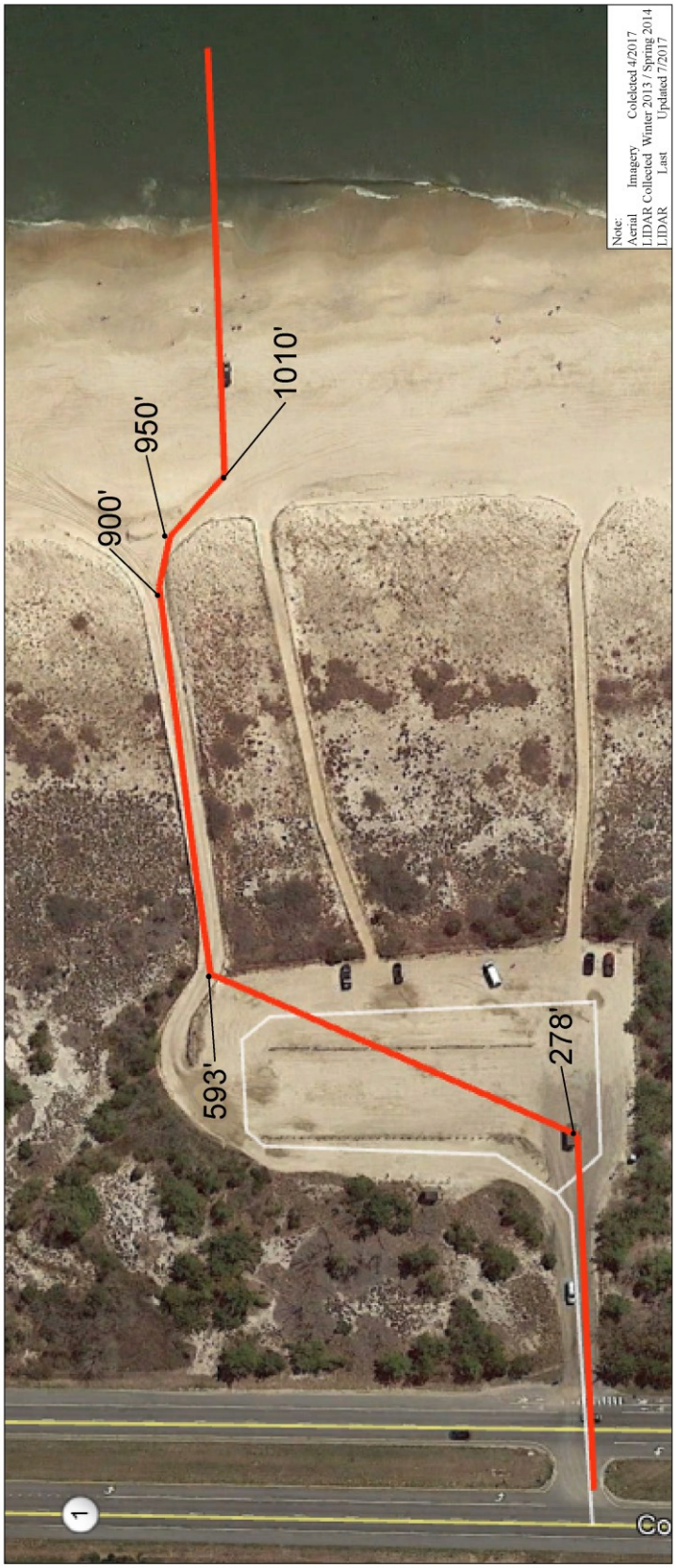


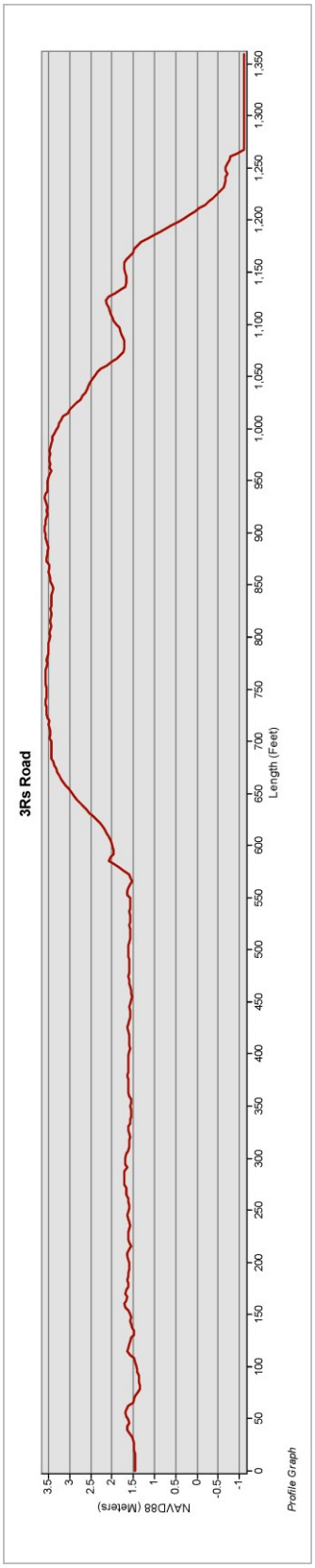
N-Event = 10-percent Annual Event

Cross Section	BS-02	BS-03	BS-04	BS-05	BS-06	BS-07	BS-08	BS-09	BS-10	BS-11	BS-12	BS-13	BS-14
Still-water Storm Tide Elevation ft. NAVD88 From FEMA FIS Study (S)	3.90	3.90	4.00	4.00	4.00	3.90	3.90	3.90	4.70	4.70	2.70	2.70	2.70
Initial Wave Height ft. NAVD88 NAS Method (H1)	2.40	2.37	2.41	2.40	2.43	2.42	2.23	1.29	3.14	1.95	0.81	1.26	1.37
Initial Wave Crest Elevation (S+H1 = WC)	6.30	6.27	6.41	6.40	6.43	6.32	6.13	5.19	7.84	6.65	3.51	3.96	4.07
Low Marsh Platform Average Height ft. NAVD88 from LIDAR 2016 (d)	2.95	1.31	2.79	2.46	2.79	0.98	2.95	3.28	1.15	1.31	2.62	2.62	0.33
Freedbord (WC/d = Fb)	3.34	4.96	3.62	3.94	3.64	5.34	3.18	1.91	6.69	5.34	0.89	1.33	3.74
Water Energy Relationship Value (WC/Fb = WER)	1.88	1.26	1.77	1.62	1.77	1.18	1.93	2.72	1.17	1.25	3.96	2.97	1.09
Minimum Estimated Width of Marsh to Dampen Wave Height to 0.2 feet	106.75	753.00	165.50	267.00	165.50	960.00	106.00	64.75	1450.00	1265.00	6.97	7.80	590.00

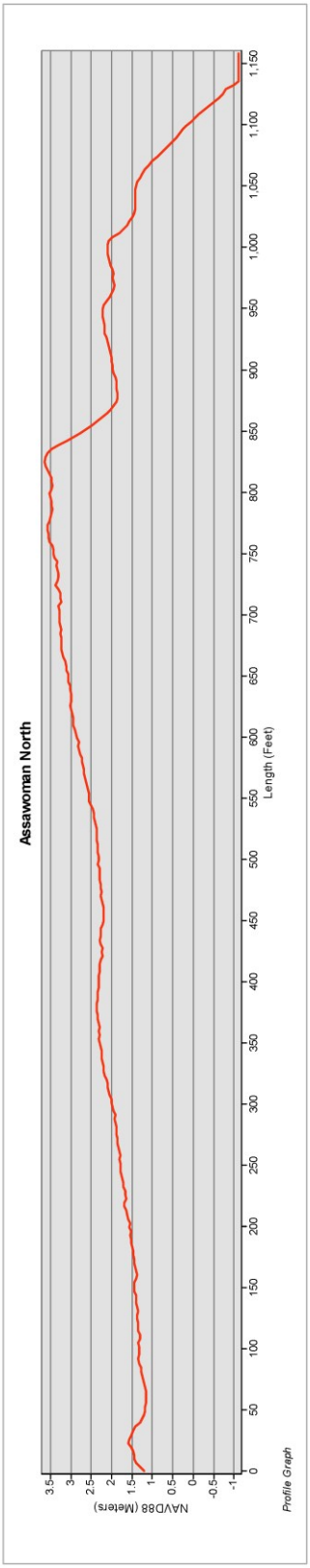


Appendix D – Eastern Dune System Geometry

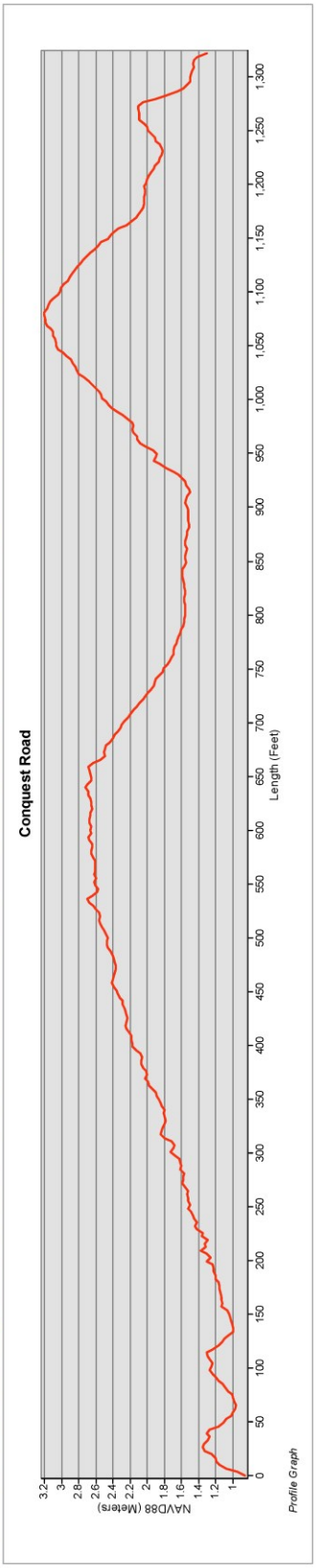

Note:
Aerial Imagery Colelcted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
1010'
950'
900'
593'
278'
1


3Rs Road
NAVD88 (Meters)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1,000
1,050
1,100
1,150
1,200
1,250
1,300
1,350
Length (Feet)
Profile Graph

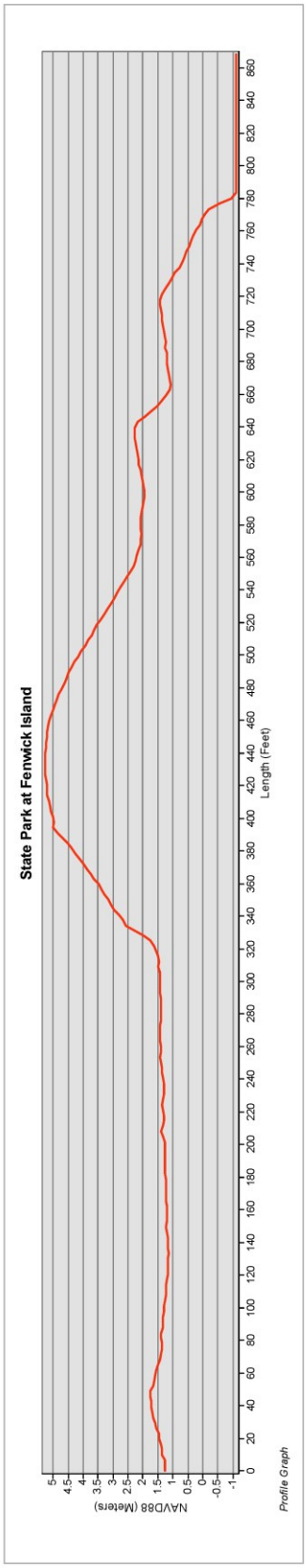
Note:
Aerial Imagery Colelcted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
379'
566'
1
Coastal Hwy


Assawoman North
NAVD88 (Meters)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1,000
1,050
1,100
1,150
Length (Feet)
Profile Graph

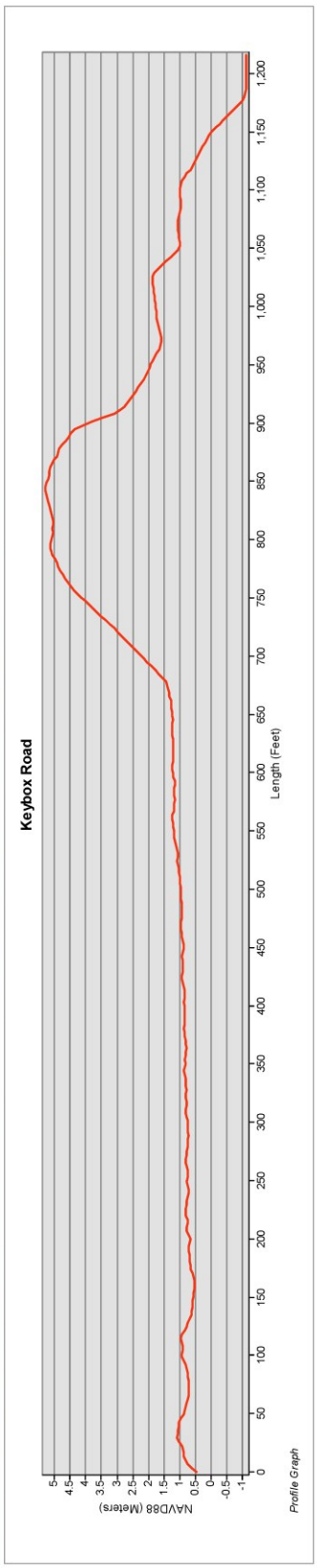
Red line depicts old foot print
from LIDAR Circa 2013/2014
Note:
Aerial Imagery Coleleted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
600'
126'
Conquest Rd
1140'
1090'
946'


Conquest Road
NAVD88 (Meters)
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1,000
1,050
1,100
1,150
1,200
1,250
1,300
Length (Feet)
Profile Graph

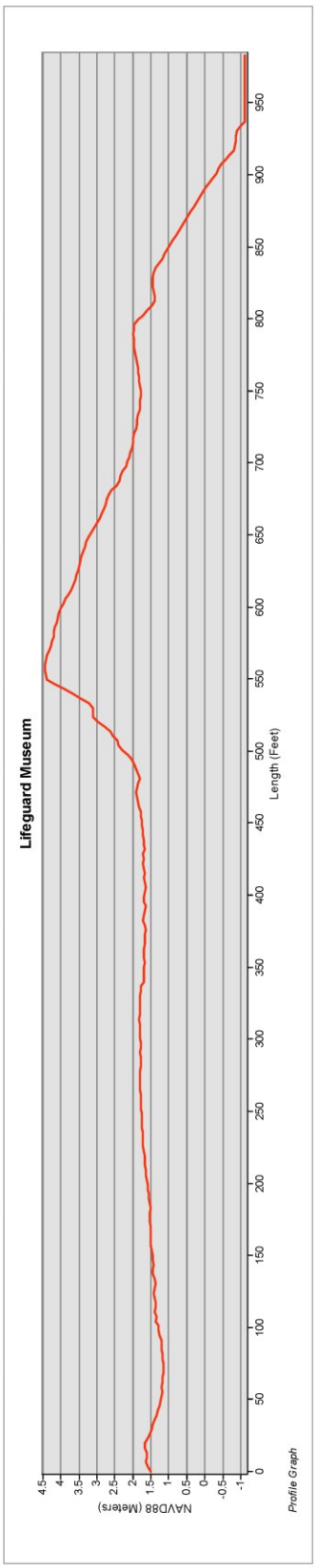
Note:
Aerial Imagery Colelcted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
521'
394'
315'

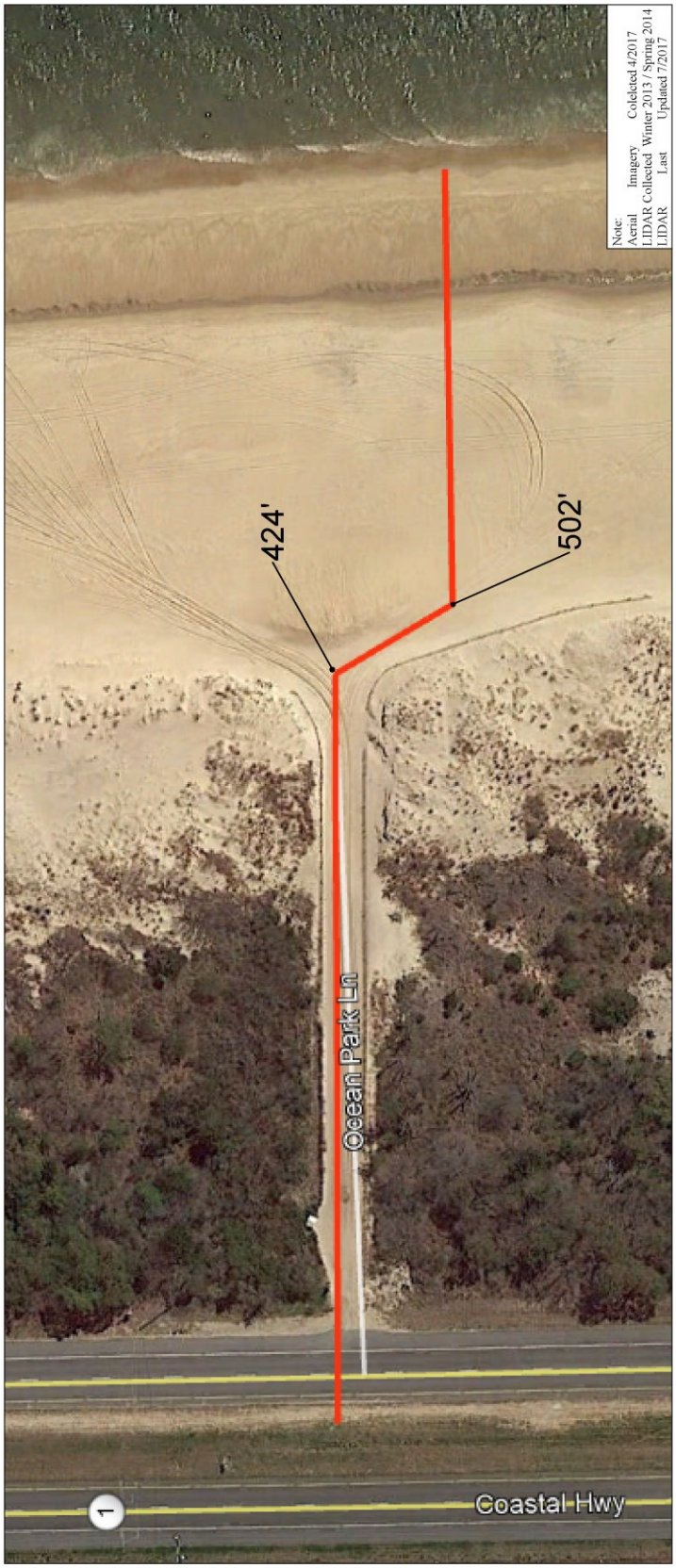

State Park at Fenwick Island
NAVD88 (Meters)
Length (Feet)
Profile Graph

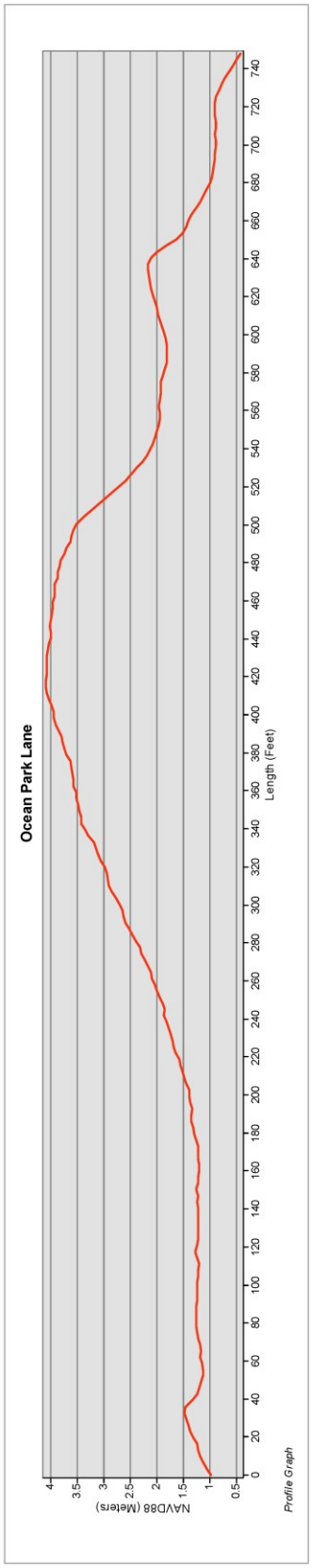
Keybox Rd
Coastal Hwy
1
Note:
Aerial Imagery Colelcted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017

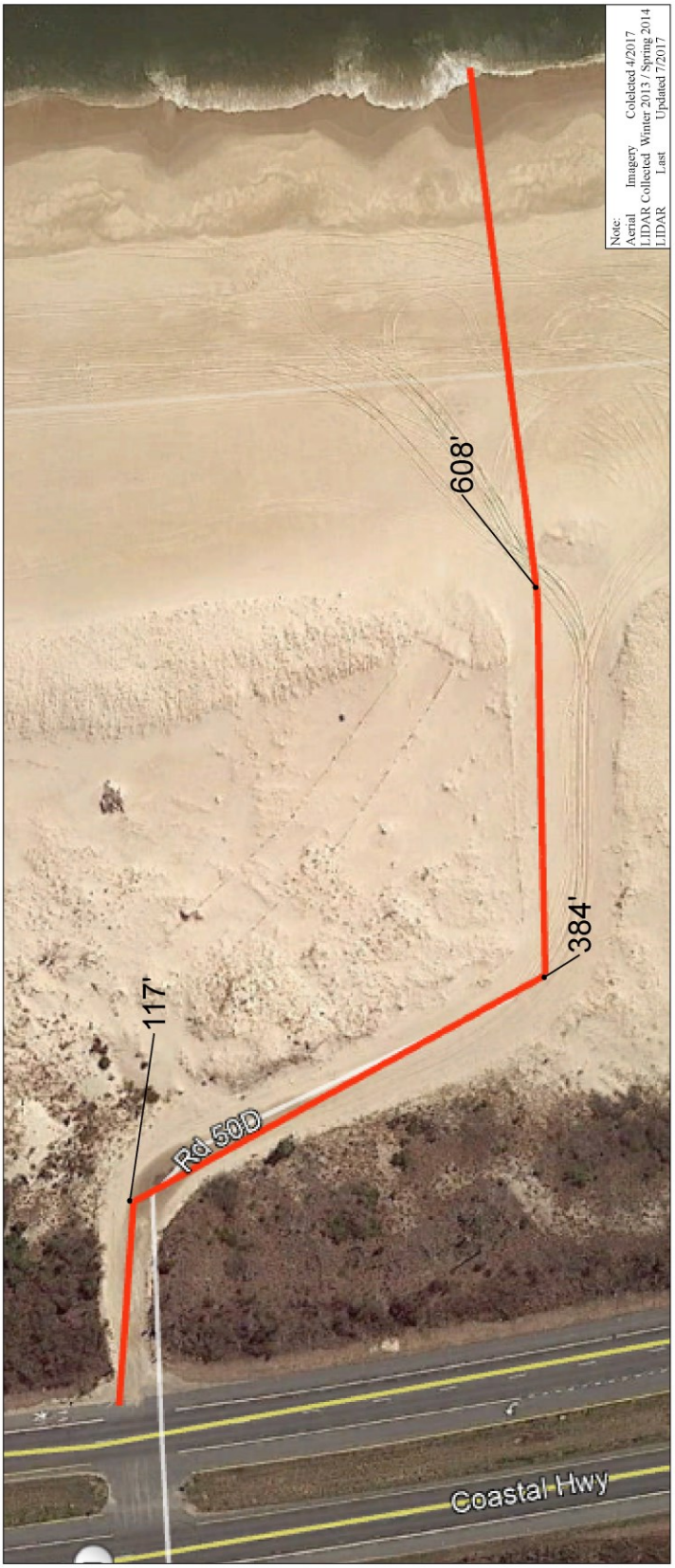

Keybox Road
NAVD88 (Meters)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1,000
1,050
1,100
1,150
1,200
Length (Feet)
Profile Graph

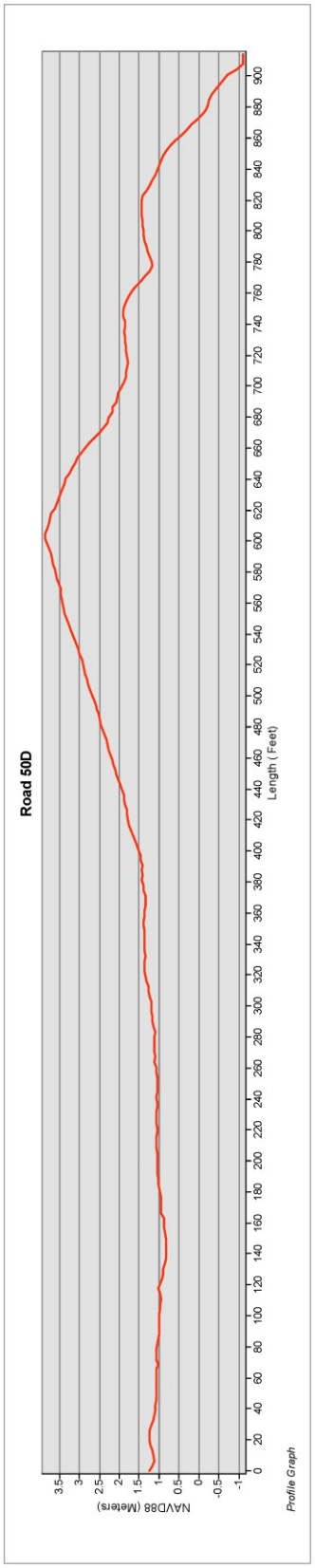
Note:
Aerial Imagery Coleleted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
365'
105'
Coastal Hwy

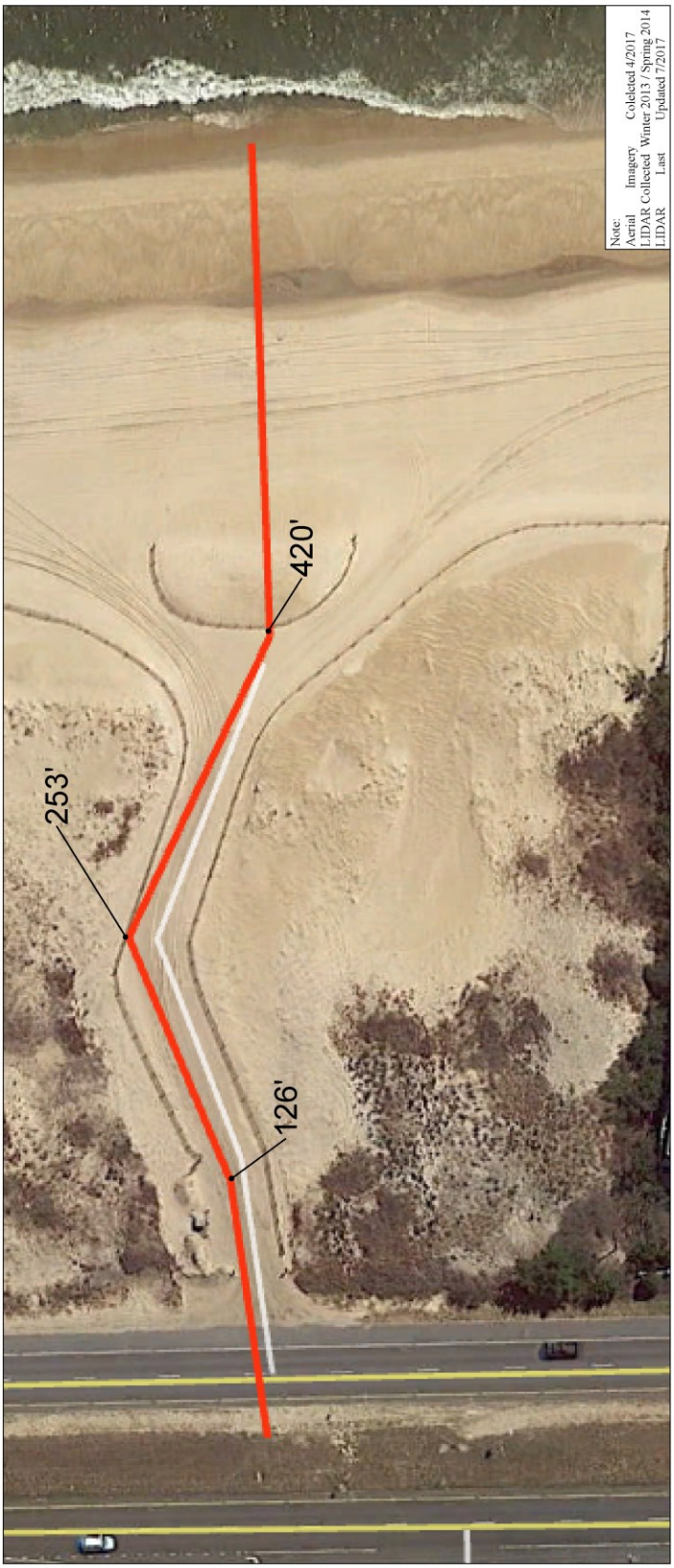

Lifeguard Museum
NAVD88 (Meters)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
Length (Feet)
Profile Graph

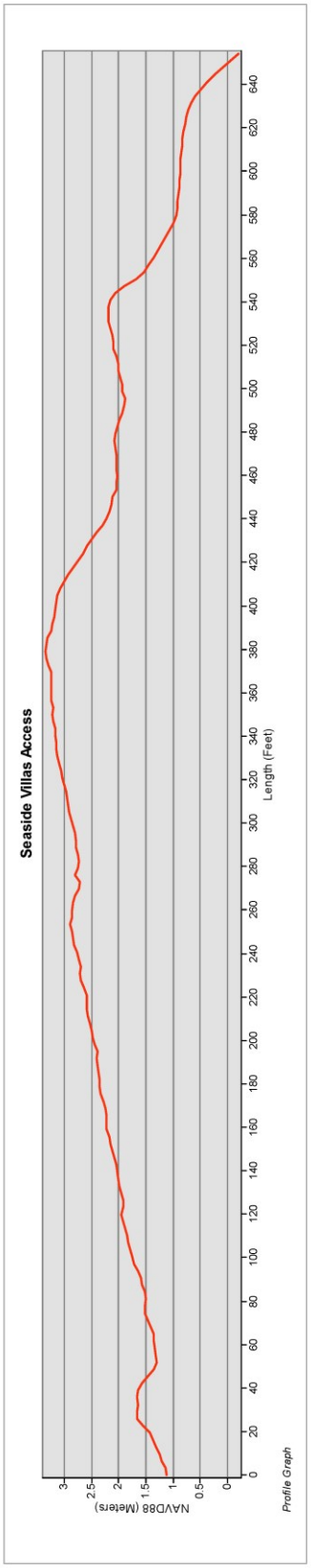

Note:
Aerial Imagery Colelcted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
424'
502'
Ocean Park Ln
Coastal Hwy
1


Ocean Park Lane
NAVD88 (Meters)
4
3.5
3
2.5
2
1.5
1
0.5
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Length (Feet)
Profile Graph

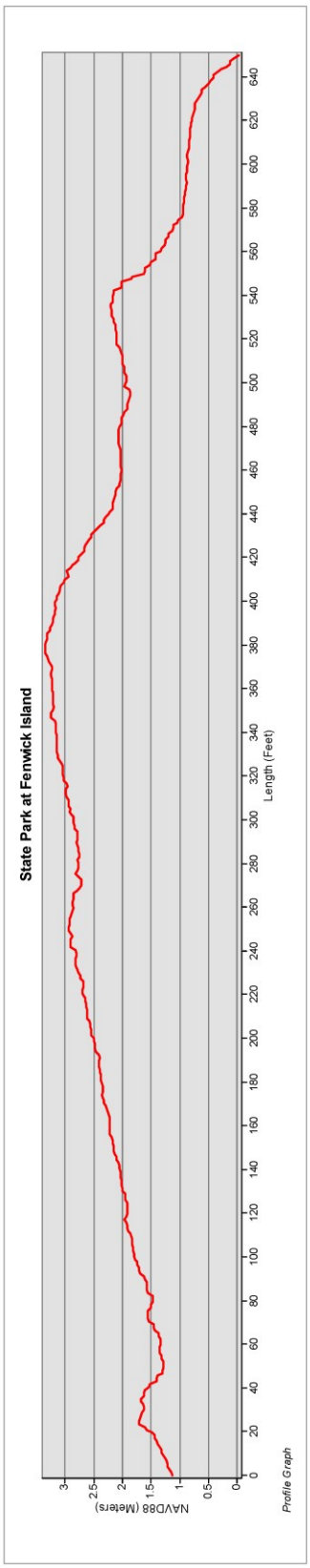

Note:
Aerial Imagery Colelcted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
117'
Rd 50D
384'
608'
Coastal Hwy


Road 50D
NAVD88 (Meters)
Length (Feet)
Profile Graph

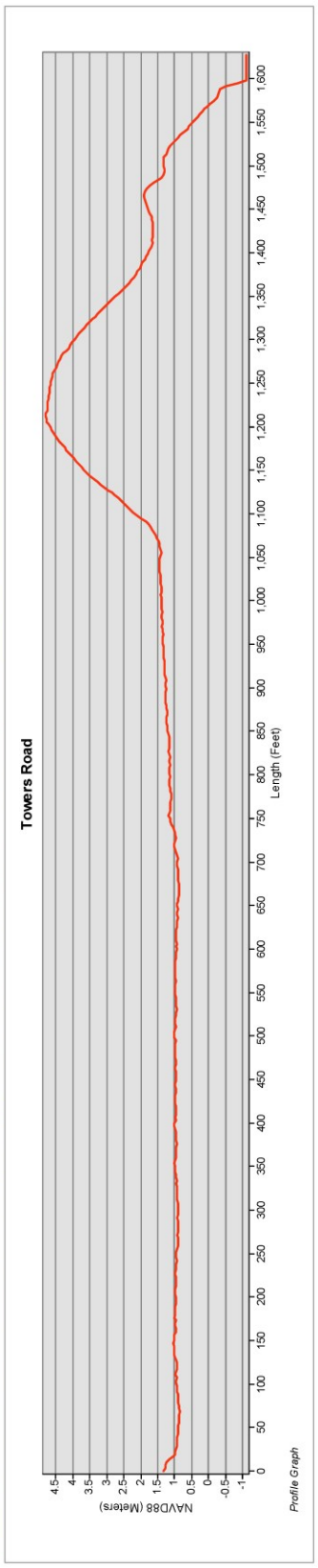

Note:
Aerial Imagery Coleleted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
253'
126'
420'


Seaside Villas Access
NAVD88 (Meters)
3
2.5
2
1.5
1
0.5
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
Length (Feet)
Profile Graph

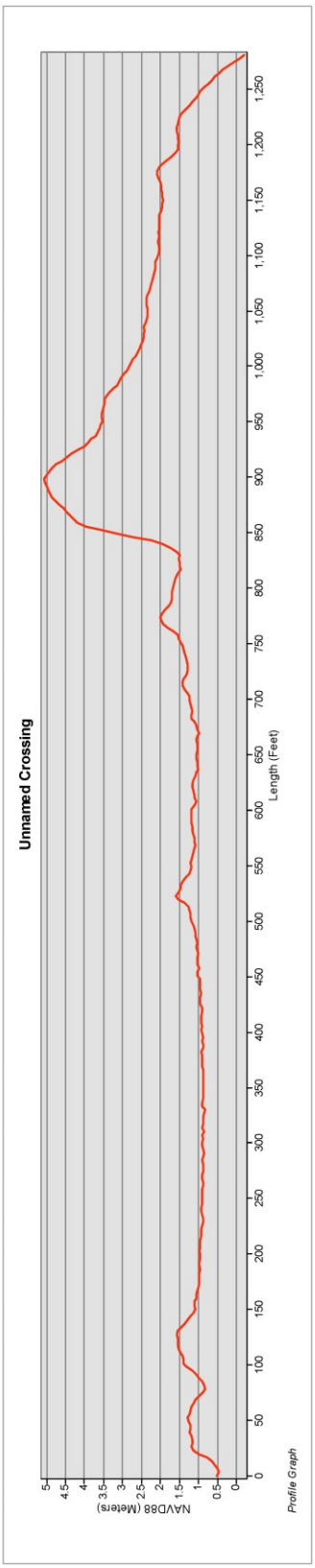
Note:
Aerial Imagery Colelcted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
521'
394'
315'


State Park at Fenwick Island
NAVD88 (Meters)
Length (Feet)
Profile Graph

Note:
Aerial Imagery Coleleted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
1056'
971'
724'
113'
Towers Rd


Towers Road
NAVD88 (Meters)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1,000
1,050
1,100
1,150
1,200
1,250
1,300
1,350
1,400
1,450
1,500
1,550
1,600
Length (Feet)
Profile Graph

Note:
Aerial Imagery Colelcted 4/2017
LIDAR Collected Winter 2013 / Spring 2014
LIDAR Last Updated 7/2017
500'
757'
1
Coastal Hwy


Unnamed Crossing
NAVD88 (Meters)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1,000
1,050
1,100
1,150
1,200
1,250
Length (Feet)
Profile Graph

Appendix E – Read Avenue Cost Estimates

Two project cost estimates were developed for the Reach Avenue site project. The near-term cost estimate reflects costs associated with the design presented in this document. The long-term estimate includes design elements presented in this report as well as additional drainage infrastructure upstream of the SR 1 right-of-way that will enhance the system's overall hydraulic capacity. Each scenario is listed in this Appendix.

Reach Avenue Project Cost Estimate – Short-Term Scenario

Material Item (Furnish & Install)	Amount	Unit	Unit Cost	Cost
A. General				
Mobilization	1	LS	$11,700.00	$11,700.00
Construction Stakeout	1	LS	$1,500.00	$1,500.00
Temp Orange Const. Fence	300	LF	$3.00	$900.00
B. Read Ave.				
Excavation and Embankment Required	115	CY	$25.00	$2,875.00
Sand	230	CY	$40.00	$9,200.00
Riprap	50	TON	$110.00	$5,500.00
Marsh plantings - Spartina Alterniflora	960	PLUG	$2.50	$2,400.00
Braided Reef (inc. shell bags)	50	LF	$400.00	$20,000.00
MIL Flood barrier (3x3x15)	7	EA	$500.00	$3,500.00
MIL Flood barrier (2x2x10)	1	EA	$300.00	$300.00
Oyster Shell Bags (not used in Braided Reef)	640	EA	$3.75	$2,400.00
4x8 Box Culvert	50	LF	$575.00	$28,750.00
3x7 Box Culvert	10	LF	$475.00	$4,750.00
Tide gate	1	EA	$30,000.00	$30,000.00
E&S Controls	1	LS	$4,000.00	$4,000.00
MOT	1	LS	$3,000.00	$3,000.00
			Cost (A & B)	$130,775.00
			Contingency & Incidental Costs (30%)	$39,300.00
			Total Cost	**$170,075.00**

Reach Avenue Project Cost Estimate – Long-Term Scenario **Material Item (Furnish & Install)**	**Amount**	**Unit**	**Unit Cost**	**Cost**
A. General				
Mobilization	1	LS	$41,400.00	$41,400.00
Construction Stakeout	1	LS	$1,500.00	$1,500.00
Temp Orange Const. Fence	300	LF	$3.00	$900.00
B. Read Ave.				
Excavation and Embankment Required	115	CY	$25.00	$2,875.00
Sand	230	CY	$40.00	$9,200.00
Riprap	40	TON	$110.00	$4,400.00
Marsh plantings - Spartina Alterniflora	960	PLUG	$2.50	$2,400.00
Braided Reef (inc. shell bags)	50	LF	$400.00	$20,000.00
MIL Flood barrier (3x3x15)	7	EA	$500.00	$3,500.00
MIL Flood barrier (2x2x10)	1	EA	$300.00	$300.00
Oyster Shell Bags (not used in Braided Reef)	640	EA	$3.75	$2,400.00
4x8 Box Culvert	50	LF	$575.00	$28,750.00
3x7 Box Culvert	580	LF	$475.00	$275,500.00
24" RCP	80	LF	$200.00	$16,000.00
Sawcuts	80	LF	$20.00	$1,600.00
Inlet Grates	5	EA	$2,000.00	$10,000.00
Tide gate	1	EA	$30,000.00	$30,000.00
E&S Controls	1	LS	$4,000.00	$4,000.00
MOT	1	LS	$3,000.00	$3,000.00
			Cost (A & B)	$457,725.00
			Contingency & Incidental Costs (30%)	$137,400.00
			Total Cost	**$595,125.00**