



September 28, 2005

Mr. G. Rudi Rudolph  
Carteret County Shore Protection Office  
PO Box 4297  
Emerald Isle NC 28594

RE: Post-*Ophelia* Beach Changes [CSE 2202]

Dear Rudi,

We have completed a post-*Ophelia* survey of Bogue Banks (16-18 September) as per our proposal to your office dated 15 September. *Ophelia* impacted Bogue Banks on 13-14 September before moving through the area. This letter summarizes our findings.

### **Work Accomplished**

CSE mobilized a field team (Philip McKee and Doug Dusini) to Bogue Banks on 15 September and re-occupied 40 profile lines. All 40 lines were surveyed from the foredune to approximate low tide. A total of 34 lines were surveyed out to (~)30 feet (ft) NGVD or greater. Methods were as described in our proposal.

In general, CSE surveyed every fifth line (ie, 15, 20, 25, etc) previously established along Bogue Banks, plus selected intermediate lines in nourished sections. Offshore data could not be obtained in the time available along eastern Atlantic Beach and Fort Macon State Park.

Profiles were analyzed using five “lenses” and reaches previously identified. Post-*Ophelia* data were compared with CSE’s May 2005 survey. Changes in unit volume were calculated for standard lenses used by CSE in previous work for the CCSPO. Inspections of the May-September profiles showed closure around the -18 ft NGVD contour. Therefore, an outer lens encompassing -11 to -18 ft NGVD was analyzed for the present survey. The primary volume calculation lenses are as follows:

<u>Dune</u>	Crest of dune to toe of dune (at +9 ft NGVD)
<u>Dry Beach</u>	+9 ft to +2 ft NGVD
<u>Wet Beach</u>	+2 ft to -4 ft NGVD
<u>Inshore to Bar</u>	-4 ft to -11ft NGVD
<u>Offshore</u>	-11 ft to -18 ft NGVD



### Typical Response

Figure A shows a typical profile comparison for Pine Knoll Shores. The primary response of the beach during *Ophelia* was profile adjustment with little change in the foredune, modest erosion of the dry beach and inshore zone, and accretion in the offshore zone (-11 ft to -18 ft NGVD). Line 58 at Pine Knoll Shores shows loss of sand along the dry beach (+9 ft to +2 ft) and little change along the wet beach (+2 ft to -4 ft). The outer bar eroded and shifted seaward of the -10 ft contour, leaving a lower crest elevation. While line 58 is typical, there were variations in the profile response from station to station, which are reflected in the volume change results.

### Results

Table A gives the unit volumes, unit volume changes and net volume changes between survey lines for available post-storm profiles. Results are grouped by lenses as defined above, by community, and by subreach within communities (highlighted cells to separate subreaches). Because of missing offshore data at Atlantic Beach, that community was subdivided into east and west reaches. [Note: The dividing line for subreaches is based on nearest available profile to previously defined subreaches.] Table A can be used to identify specific areas with highest sand losses. The rate of loss is most accurately reflected in the unit volume change rather than net volume change because of variations in distances between survey lines.

Table B summarizes the results by community and by calculation lens. As Table B shows, there was relatively little sand loss in the foredunes. Pine Knoll Shores and Atlantic Beach accounted for all the dune losses. The dry beach along Bogue Banks lost nearly 500,000 cy (~3.9 cy/ft) between May and post-*Ophelia*. The intertidal zone (wet beach) exhibited variable responses from community to community with losses averaging ~1-1.5 cy/ft in Emerald Isle, Indian Beach, and Atlantic Beach. In contrast, Pine Knoll Shores accreted by ~5 cy/ft along the wet beach. Erosion between the low tide line and the outer bar ranged from ~7 cy/ft along Emerald Isle and Pine Knoll Shores to 13 cy/ft along eastern Atlantic Beach and ~19 cy/ft along Indian Beach. Seaward of the bar, all communities gained ~10-14 cy/ft in the offshore zone.

Table C provides a further breakdown of volume changes by subreach. In this case, Atlantic Beach East and Fort Macon State Park are excluded from the totals because of missing offshore data. The results show losses between the foredune and wet beach (primary recreational area) totaling nearly 500,000 cy, with Emerald Isle-West (EI-W) accounting for ~94,000 cy and Atlantic Beach-West (AB-W) losing ~115,000 cy. [Both of these reaches were nourished in winter-spring 2005.] When considered to -11 ft NGVD, the depth limit on which the original county nourishment plan was based (CSE Baird-Stroud 1999), *Ophelia* losses totaled ~1,500,000 cy. Losses above -11 ft totaled



~580,000 cy along Emerald Isle, ~300,000 cy along Indian Beach/Salter Path, ~240,000 cy along Pine Knoll Shores, and over 330,000 cy along Atlantic Beach.

Losses to -11 ft were nearly matched by gains in the offshore zone (totaling ~1,400,000 cy). The net changes from the foredune to offshore (-18 ft) between Bogue Inlet and AB-W were remarkably low, totaling only ~42,000 cy (0.4 cy/ft). Variations in net volume loss occurred from subreach to subreach when integrated from the foredune to -18 ft NGVD. AB-W showed the greatest overall sand loss (~155,000 cy, or ~10.7 cy/ft). Indian Beach/Salter Path lost ~ 119,000 cy (~9.2 cy/ft). Emerald Isle East lost ~ 74,000 cy (~6.3 cy/ft).

#### **Final Note**

The present survey and analyses were budget-limited and as per CSE's proposal, time has not permitted a detailed reporting of results. These poststorm data are significant because they provide one of the few comprehensive poststorm surveys available, which documents profile adjustment into deep water. CSE expects this data set to be useful to future researchers in their efforts to model beach response to storms. The full data set will be submitted with CSE's Year 2 monitoring report (expected completion in October).

On behalf of CSE, thank you for the opportunity to perform the survey and submit these results. Please contact Doug Dusini or me if you have any questions about our calculations.

Yours truly,

A handwritten signature in black ink that reads 'Timothy W Kana'. The signature is written in a cursive, flowing style.

Timothy W Kana PhD  
President

Enclosures

cc: Town of Emerald Isle, Frank Rush  
Town of Indian Beach, Buck Fugate  
Town of Pine Knoll Shores, Betty Carr  
Town of Atlantic Beach, Eddie Dawkins  
Fort Macon State Park, Jody Merritt  
Bill Forman  
Doug Dusini  
Philip McKee

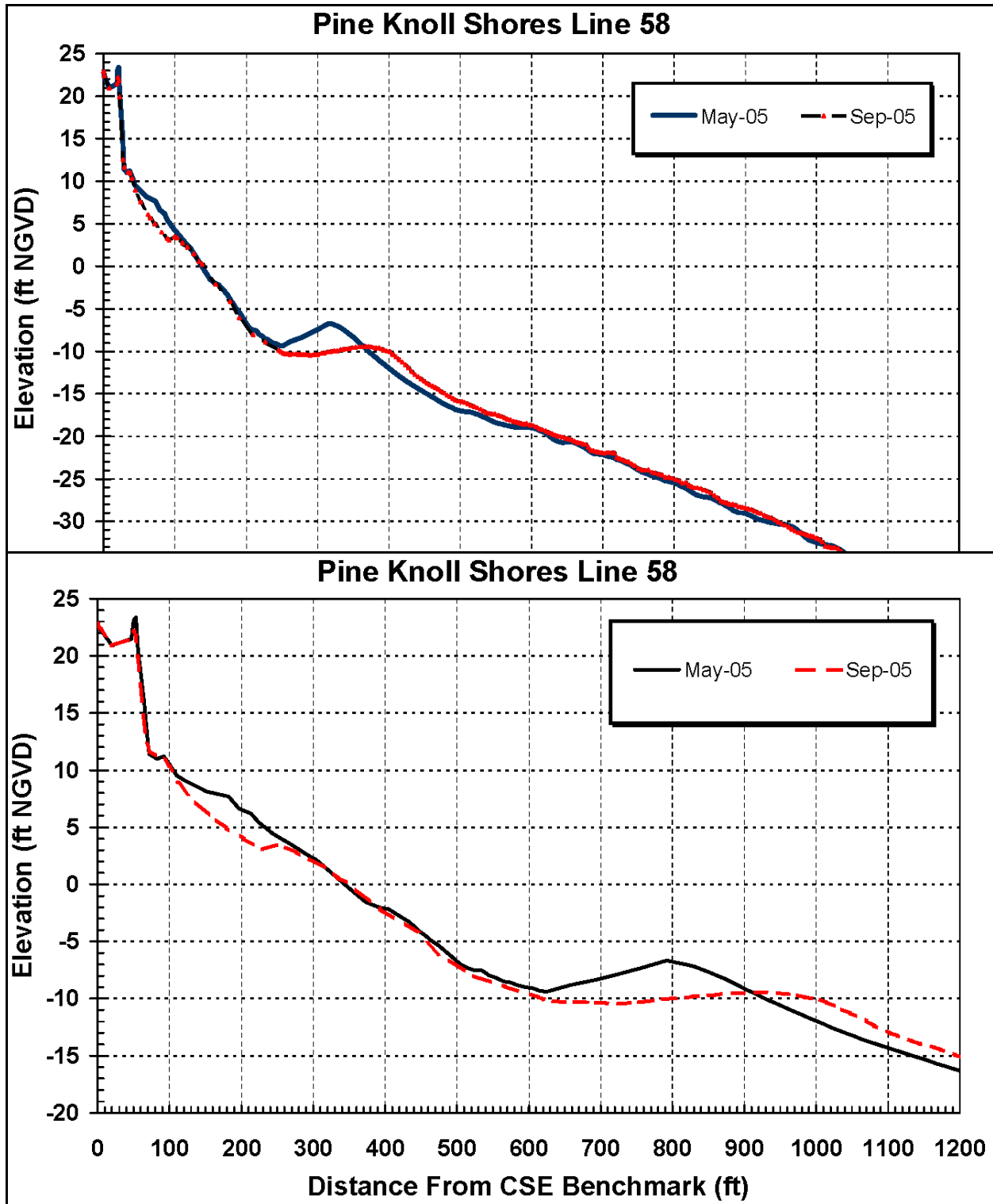


FIGURE A.

TABLE A. Bogue Banks - Post Ophielia Survey 16-18 September

CSE (McKee/Dustin) Reaches by Community: Sub-reaches highlighted.

Boque Banks- Post Ophielia: September 2005. -11 ft to -18 ft NGVD.											
STA	Distance to Next (ft)	Offset (ft) Cutoff (ft)	May 2005 Unit Vol (cy)	Sep 2005 Unit Vol (cy)	May - Sep Net Vol Change (cy)	May - Sep Unit Vol Change (cy/ft)	Distance to Next (ft)	Offset (ft) Cutoff (ft)	May 2005 Unit Vol (cy)	Sep 2005 Unit Vol (cy)	May - Sep Net Vol Change (cy)
1	2,321	0	1,350	0	617	5.24	2,321	0	1,350	0	617
5	5,768	0	1,350	0	33,857	4.76	5,768	0	1,350	0	33,857
9	1,249	155	0	0	-375	-0.37	1,249	155	0	0	-375
10	1,519	0	0	0	-630	-0.42	1,519	0	0	0	-630
11	1,260	0	0	0	-1,569	-1.25	1,260	0	0	0	-1,569
12	2,549	0	0	0	-3,161	-1.24	2,549	0	0	0	-3,161
14	1,349	30	0	0	-824	-0.61	1,349	30	0	0	-824
15	6,986	0	0	0	-1,816	-0.26	6,986	0	0	0	-1,816
20	6,074	0	0	0	-2,065	-0.34	6,074	0	0	0	-2,065
25	7,145	0	0	0	5,823	0.82	7,145	0	0	0	5,823
30	7,340	0	0	0	9,175	1.25	7,340	0	0	0	9,175
35	2,572	0	1,500	0	1,530	0.60	2,572	0	1,500	0	1,530
37	2,213	150	0	0	465	0.21	2,213	150	0	0	465
39	1,096	145	0	0	208	0.19	1,096	145	0	0	208
40	2,213	0	0	0	-1,173	-0.53	2,213	0	0	0	-1,173
42	3,288	40	0	0	-1,808	-0.55	3,288	40	0	0	-1,808
45	1,097	65	0	0	664	0.60	1,097	65	0	0	664
46	1,881	0	0	0	668	0.35	1,881	0	0	0	668
48	57,919	0	0	0	-642	-0.11	57,919	0	0	0	-642
Indian Beach/ Sailer Path											
48	2,792	0	0	0	-405	-0.15	2,792	0	0	0	-405
50	2,524	0	0	0	151	0.06	2,524	0	0	0	151
52	3,895	0	0	0	1,013	0.26	3,895	0	0	0	1,013
55	3,775	0	0	0	-1,302	-0.35	3,775	0	0	0	-1,302
58	12,986	0	0	0	-1,221	-0.09	12,986	0	0	0	-1,221
Pine Knot Shores											
58	2,694	0	0	0	-1,173	-0.44	2,694	0	0	0	-1,173
60	6,487	0	0	0	-3,548	-0.55	6,487	0	0	0	-3,548
65	3,960	11	0	0	-630	-0.16	3,960	11	0	0	-630
68	2,272	0	0	0	-1,157	-0.51	2,272	0	0	0	-1,157
70	1,896	0	0	0	-1,157	-0.61	1,896	0	0	0	-1,157
71	2,829	0	0	0	-962	-0.34	2,829	0	0	0	-962
73	2,717	16	0	0	-82	-0.03	2,717	16	0	0	-82
75	1,111	0	0	0	156	0.14	1,111	0	0	0	156
76	23,986	0	0	0	-18,771	-0.78	23,986	0	0	0	-18,771
Atlantic Beach											
76	2,238	0	0	0	500	0.22	2,238	0	0	0	500
78	2,343	0	0	0	-1,535	-0.65	2,343	0	0	0	-1,535
80	4,814	0	0	0	-3,105	-0.64	4,814	0	0	0	-3,105
85	5,101	-22	0	0	714	0.14	5,101	-22	0	0	714
90	4,827	0	0	0	-5,962	-1.23	4,827	0	0	0	-5,962
95	1,995	0	0	0	-2,523	-0.26	1,995	0	0	0	-2,523
97	2,998	0	0	0	-120	-0.04	2,998	0	0	0	-120
100	2,005	-104	0	0	0	0.00	2,005	-104	0	0	0
102	26,321	0	0	0	-12,020	-0.46	26,321	0	0	0	-12,020
Fort Macon											
102	1,014	0	0	0	1,932	1.91	1,014	0	0	0	1,932
103	1,969	-37	0	0	709	0.36	1,969	-37	0	0	709
105	2,993	0	0	0	-614	-0.21	2,993	0	0	0	-614
110	1,221	0	0	0	-1,319	-1.08	1,221	0	0	0	-1,319
112	7,199	0	0	0	-1,068	-0.15	7,199	0	0	0	-1,068
Boque Banks- Post Ophielia: September 2005. -4 ft to -11 ft NGVD.											
1	2,321	0	1,350	0	22,537	21.29	2,321	0	1,350	0	22,537
5	5,768	0	1,350	0	32,458	5.63	5,768	0	1,350	0	32,458
9	1,249	155	0	0	-245	-0.19	1,249	155	0	0	-245
10	1,519	0	0	0	-375	-0.25	1,519	0	0	0	-375
11	1,260	0	0	0	-1,443	-1.15	1,260	0	0	0	-1,443
12	2,549	0	0	0	-897	-0.35	2,549	0	0	0	-897
14	1,349	30	0	0	-566	-0.42	1,349	30	0	0	-566
15	6,986	0	0	0	-4,638	-0.67	6,986	0	0	0	-4,638
20	6,074	0	0	0	-4,469	-0.74	6,074	0	0	0	-4,469
25	7,145	0	0	0	-2,786	-0.39	7,145	0	0	0	-2,786
30	7,340	0	0	0	-12,478	-1.70	7,340	0	0	0	-12,478
35	2,572	0	1,500	0	-3,666	-1.47	2,572	0	1,500	0	-3,666
37	2,213	150	0	0	-1,095	-0.49	2,213	150	0	0	-1,095
39	1,096	145	0	0	-592	-0.54	1,096	145	0	0	-592
40	2,213	0	0	0	-3,305	-1.50	2,213	0	0	0	-3,305
42	3,288	40	0	0	-2,860	-0.87	3,288	40	0	0	-2,860
45	1,097	65	0	0	1,195	1.18	1,097	65	0	0	1,195
46	1,881	0	0	0	3,841	3.84	1,881	0	0	0	3,841
48	57,919	0	0	0	-1,401	-0.02	57,919	0	0	0	-1,401
Indian Beach/ Sailer Path											
48	2,792	0	0	0	-1,173	-0.42	2,792	0	0	0	-1,173
50	2,524	0	0	0	-4,900	-1.94	2,524	0	0	0	-4,900
52	3,895	0	0	0	-2,824	-0.74	3,895	0	0	0	-2,824
55	3,775	0	0	0	-1,302	-0.35	3,775	0	0	0	-1,302
58	12,986	0	0	0	-9,691	-0.75	12,986	0	0	0	-9,691
Pine Knot Shores											
58	2,694	0	0	0	141	0.05	2,694	0	0	0	141
60	6,487	0	0	0	8,725	1.35	6,487	0	0	0	8,725
65	3,960	11	0	0	21,646	5.47	3,960	11	0	0	21,646
68	2,272	0	0	0	28,483	7.00	2,272	0	0	0	28,483
70	1,896	0	0	0	24,003	6.33	1,896	0	0	0	24,003
71	2,829	0	0	0	14,824	3.82	2,829	0	0	0	14,824
73	2,717	16	0	0	14,047	3.74	2,717	16	0	0	14,047
75	1,111	0	0	0	3,605	3.24	1,111	0	0	0	3,605
76	23,986	0	0	0	110,869	4.58	23,986	0	0	0	110,869
Atlantic Beach											
76	2,238	0	0	0	2,190	0.98	2,238	0	0	0	2,190
78	2,343	0	0	0	-5,877	-2.51	2,343	0	0	0	-5,877
80	4,814	0	0	0	-11,506	-2.39	4,814	0	0	0	-11,506
85	5,101	-22	0	0	-8,545	-1.68	5,101	-22	0	0	-8,545
90	4,827	0	0	0	-9,977	-2.07	4,827	0	0	0	-9,977
95	1,995	0	0	0	-1,304	-0.65	1,995	0	0	0	-1,304
97	2,998	0	0	0	-581	-0.19	2,998	0	0	0	-581
100	2,005	-104	0	0	0	0.00	2,005	-104	0	0	0
102	26,321	0	0	0	-115,536	-4.39	26,321	0	0	0	-115,536
Fort Macon											
102	1,014	0	0	0	-2,900	-2.86	1,014	0	0	0	-2,900
103	1,969	-37	0	0	-1,234	-0.63	1,969	-37	0	0	-1,234
105	2,993	0	0	0	-3,651	-1.22	2,993	0	0	0	-3,651
110	1,221	0	0	0	-2,994	-2.45	1,221	0	0	0	-2,994
112	7,199	0	0	0	-558	-0.08	7,199	0	0	0	-558
Boque Banks- Post Ophielia: September 2005. -1 ft to -4 ft NGVD.											
1	2,321	0	1,350	0	21,291	18.72	2,321	0	1,350	0	21,291
5	5,768	0	1,350	0	32,458	5.63	5,768	0	1,350	0	32,458
9	1,249	155	0	0	-245	-0.19	1,249	155	0	0	-245
10	1,519	0	0	0	-375	-0.25	1,519	0	0	0	-375
11	1,260	0	0	0	-1,443	-1.15	1,260	0	0	0	-1,443
12	2,549	0	0	0	-897	-0.35	2,549	0	0	0	-897
14	1,349	30	0	0	-566	-0.42	1,349	30	0	0	-566
15	6,986	0	0	0	-4,638	-0.67	6,986	0	0	0	-4,638
20	6,074	0	0	0	-4,469	-0.74	6,074	0	0	0	-4,469
25	7,145	0	0	0	-2,786	-0.39	7,145	0	0	0	-2,786
30	7,340	0	0	0	-12,478	-1.70	7,340	0	0	0	-12,478
35	2,572	0	1,500	0	-3,666						

**TABLE B. Bogue Banks - Post Ophelia Survey 16-18 September 2005**

Bogue Banks- Post Ophelia: September 2005. Top of dune to +9 ft NGVD.					
Reach	Length (ft)	May 2005 Unit Vol (cy/ft)	Sep 2005 Unit Vol (cyft)	May - Sep Unit Vol Change (cy/ft)	May - Sep Net Vol Change (cy)
Emerald Isle	57,919	15.94	16.02	0.08	4,686
Indian Beach/ Salter Path	12,986	35.23	35.19	-0.04	-543
Pine Knoll Shores	23,968	16.76	16.06	-0.70	-16,771
Atlantic Beach	26,321	12.77	12.31	-0.46	-12,020
Fort Macon	7,199	16.87	16.97	0.10	709
	128,392	17.44	17.26	-0.19	-23,939

Bogue Banks- Post Ophelia: September 2005. +9 ft to +2 ft NGVD.					
Reach	Length (ft)	May 2005 Unit Vol (cy/ft)	Sep 2005 Unit Vol (cyft)	May - Sep Unit Vol Change (cy/ft)	May - Sep Net Vol Change (cy)
Emerald Isle	57,919	47.32	45.13	-2.19	-126,719
Indian Beach/ Salter Path	12,986	51.06	47.67	-3.39	-44,045
Pine Knoll Shores	23,968	34.71	27.83	-6.87	-167,541
Atlantic Beach	26,321	55.86	51.00	-4.87	-115,536
Fort Macon	7,199	41.61	36.02	-5.58	-40,178
	128,392	46.77	42.85	-3.92	-494,019

Bogue Banks- Post Ophelia: September 2005. +2 ft to -4 ft NGVD.*					
Reach	Length (ft)	May 2005 Unit Vol (cy/ft)	Sep 2005 Unit Vol (cyft)	May - Sep Unit Vol Change (cy/ft)	May - Sep Net Vol Change (cy)
Emerald Isle	57,919	81.35	79.95	-1.40	-81,206
Indian Beach/ Salter Path	12,986	83.99	83.24	-0.75	-9,691
Pine Knoll Shores	23,968	60.62	65.57	4.95	116,069
Atlantic Beach	14,496	82.52	80.87	-1.65	-23,706
Fort Macon	0	0.00	0.00	0.00	0
	109,368	77.28	77.31	0.04	1,466

Bogue Banks- Post Ophelia: September 2005. -4 ft to -11 ft NGVD.*					
Reach	Length (ft)	May 2005 Unit Vol (cy/ft)	Sep 2005 Unit Vol (cyft)	May - Sep Unit Vol Change (cy/ft)	May - Sep Net Vol Change (cy)
Emerald Isle	57,919	157.37	150.41	-6.96	-403,238
Indian Beach/ Salter Path	12,986	166.43	147.62	-18.82	-244,327
Pine Knoll Shores	23,968	140.35	133.45	-6.90	-171,551
Atlantic Beach	14,496	181.97	168.75	-13.22	-190,983
Fort Macon	0	0.00	0.00	0.00	0
	109,368	157.98	148.79	-9.19	-1,010,099

Bogue Banks- Post Ophelia: September 2005. -11 ft to -18 ft NGVD.*					
Reach	Length (ft)	May 2005 Unit Vol (cy/ft)	Sep 2005 Unit Vol (cyft)	May - Sep Unit Vol Change (cy/ft)	May - Sep Net Vol Change (cy)
Emerald Isle	57,919	290.86	304.50	13.63	789,716
Indian Beach/ Salter Path	12,986	291.39	305.22	13.83	179,553
Pine Knoll Shores	23,968	287.84	298.83	10.99	265,678
Atlantic Beach	14,496	340.64	350.73	10.10	150,806
Fort Macon	0	0.00	0.00	0.00	0
	109,368	296.86	309.47	12.61	1,385,753

\* Volumes from +2 to -18 ft NGVD were calculated from lines 1 to 90:  
 EI, IB/SP, PKS, and 14,496 ft of 26,321 ft AB.  
 Volumes to +2 ft NGVD were calculated for the entire project length.

<b>TABLE C. Bogue Banks - Post Ophelia Survey 16-18 September 2005</b>							CSE 27 Sept 2005 (TK/DD/PM)	
May 2005 vs Sept 2005								
<i>Note: The volume change boundaries below match the limits used in the project design (CSE Baird-Stroud 1999).</i>								
			Estimated Volume Changes (cy)				Total	Total
	Applicable	Reach	Dune	Dry Beach	Wet Beach	UW to Bar	To Wet Bch	To Outer Bar
Reach	Profiles	Lgth (ft)	To +9 ft	+9 to +2 ft	+2 to -4 ft	-4 to -11 ft	Dune to -4 ft	Dune to -11 ft
BI	1-9	8,089	-1,067	-33,242	10,079	10,565	-24,230	-13,665
EI-W	9-25	20,986	-9,798	-41,384	-42,762	-153,516	-93,944	-247,460
EI-C	25-37	17,057	16,528	-31,533	-18,929	-86,894	-33,934	-120,828
EI-E	37-48	11,788	-976	-16,908	-9,593	-173,395	-27,477	-200,872
IB/SP	48-58	12,986	-543	-44,045	-9,691	-244,325	-54,279	-298,604
PKS-W	58-65	9,183	-4,741	-40,245	9,466	-22,838	-35,520	-58,358
PKS-E	65-76	14,785	-12,031	-127,296	106,602	-148,713	-32,725	-181,438
AB-W	76-90	14,496	-3,426	-88,046	-23,707	-190,984	-115,179	-306,163
<b>SubTotals</b>		109,370	<b>-16,054</b>	<b>-422,699</b>	<b>21,465</b>	<b>-1,010,100</b>	<b>-417,288</b>	<b>-1,427,388</b>
<b>Wt'd Unit Vol Change (cy/ft)</b>			<b>-0.1</b>	<b>-3.9</b>	<b>0.2</b>	<b>-9.2</b>	<b>-3.8</b>	<b>-13.1</b>
AB-E	90-102	11,825	-8,594	-27,490	ND	ND	-36,084	ND
FMSP	102-112	7,199	708	-40,178	ND	ND	-39,470	ND
Grand Total		128,394	-23,940	-490,371			-492,846	ND
<b>Wt'd Unit Vol Change (cy/ft)</b>			<b>-0.2</b>	<b>-3.8</b>			<b>-3.8</b>	
NOTES:	PKS-E, PKS-W & IB/SP nourished in 2002 (County/Town Project Phase 1)							
	FMSP nourished in 2002 (Harbor Maintenance Disposal)							
	EI-E, EI-C nourished in 2003 (County/Town Project Phase 2)							
	IB/SP; PKS-W nourished in 2004 (Section 933 - Harbor Maintenance)							
	EI-E, EI-C nourished in 2004 (FEMA post-ISABEL)							
	AB-E; AB-W nourished in Spring 2005 (Brandt Island Pumpout & Harbor Maintenance)							
	EI-W nourished in Spring 2005 - Bogue Inlet Realignment (County/Town Project Phase 3)							