APPENDIX C

APPENDIX C

SHORELINE EROSION INVESTIGATION

The following discussion on shoreline erosion and its effect on Pea Patch Island was taken directly from the January 1996 report entitled "Delaware River Main Channel Deepening Project, Design Memorandum Report and Supplemental Environmental Impact Statement, Appendix B, Modeling Efforts/ Hydraulic Analyses" (U.S. Army Corps of Engineers, 1996). The ship generated wave analysis was completed in the Spring, 1997.

Potential shoreline erosion due to the proposed deepening of the Delaware River Main Channel was evaluated in the PED study phase. The purpose of the work was to determine if the channel deepening would induce erosion in areas which presently experience none, or increase shoreline erosion in areas where it is already a problem. The problem was addressed through the application of a 2-dimensional hydrodynamic model of the entire Delaware estuary, with emphasis on the portion of the estuary with several historic shoreline erosion areas.

The shoreline erosion analysis was conducted using RMA-2V, a module of the TABS-2 numerical modeling system. RMA-2V is a two-dimensional finite element hydrodynamic model which has been applied in a wide range of estuarine and fluvial hydraulic investigations within the Corps of Engineers and by others. A complete description of the development and verification of the model of the Delaware Estuary is provided in Appendix B-1C in the above referenced report. The original purpose of the 2-D model development was to provide boundary condition currents for the ship simulation model. However, the model grid scale and coverage, combined with model geometrics representing the existing 40 ft and proposed 45 ft deep channels, made the model ideal for determining if the channel deepening led to current velocity changes, and thus to increased shoreline erosion potential.

Five shoreline locations within Delaware Estuary were evaluated in this analysis. Two of the sites, Pea Patch Island and Oakwood Beach, have existing or historic erosion problems. The other three sites have relatively stable shorelines and were selected to determine if the proposed channel deepening would cause current velocity changes which could lead to erosion. The five sites are indicated on Figure 1. Pea Patch Island is located at River Mile 61, and its eastern shoreline ranges from as little as 200 feet up to about 1200 feet from the west edge of the existing navigation channel. The island is utilized as a historic site by the State of Delaware for the Fort Delaware State Park. The eastern shoreline adjacent to the navigation channel has been the site of persistent erosion over the past several decades, and is unprotected by erosion control works.

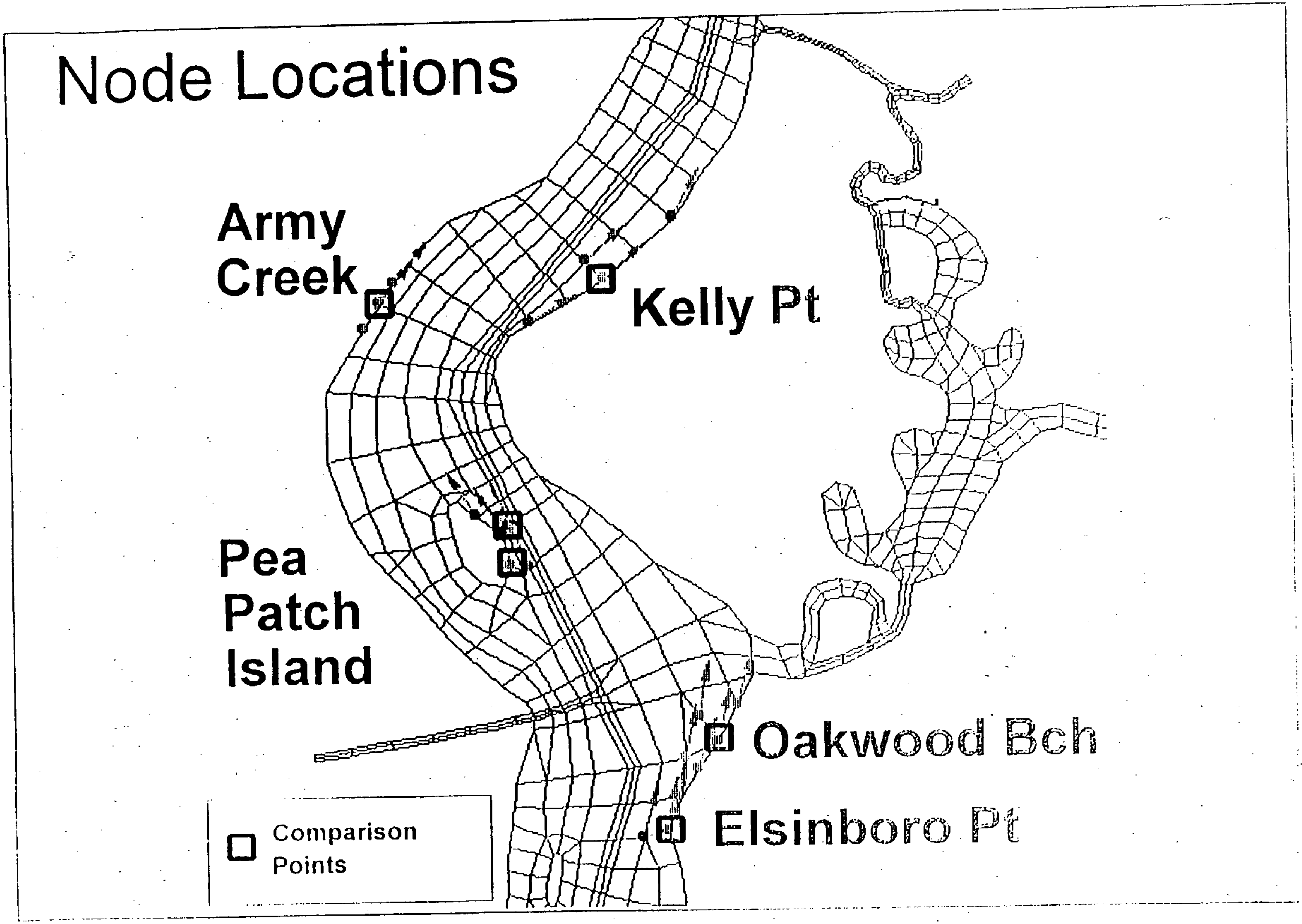

Node Locations
Army Creek
Kelly Pt
Pea Patch Island
Oakwood Bch
Elsinboro Pt
Comparison Points

Figure 1

The Oakwood Beach site is located on the New Jersey shoreline at approximately RM 58. The shoreline at this site ranges between 3000 and 8000 feet from the east edge of the navigation channel, due to changes in the alignment of the channel and shoreline. Oakwood Beach has also suffered from shoreline erosion for at least several decades, but most of its bay frontage has been stabilized in position by a patchwork of locally constructed bulkheads and seawalls. Army Creek, Kelly Point, and Elsinboro Point were the three non-eroding control sites selected in the vicinity of the known erosion problem areas.

The analysis was conducted by selecting several model nodes at each of the five sites. The first model run (Base) utilized a 60-hour (5 tide cycle) spring tide boundary condition data set with the existing 40 ft channel in place. Model-predicted velocity and head values were saved at each of the selected nodes, and incorporated into a spreadsheet. A second model run (Plan) was made, with the only change being the deepening of the navigation channel from 40 to 45 feet. Velocity and head data were saved at the same nodes as in the Base run, and also incorporated into the spreadsheet. Sample model output in spreadsheet format is included in Table 1 for the 40 ft channel at Node 1325, Pea Patch Island. Table 2 contains the model output for Node 1325 for the 45 ft channel alternative. Data from the Plan condition (45 ft channel) were subtracted at each time step from the corresponding values for the Base condition, and tabulated and plotted.

The comparison of Base and Plan velocities showed that the largest predicted changes at any of the five sites were on the order of 0.1 ft/sec, with most of the differences computed to be closer to "zero" ft/sec. Figures 2 and 3 present plots of model-predicted velocities at Pea Patch Island for the 40 ft and 45 ft channel geometrics. Figure 2 shows the velocity comparison at the shoreline (Node 1325), and Figure 3 shows the velocity comparison at model node adjacent to the navigation channel. The close correspondence of the velocity plots for the 40 ft and 45 ft channels is evident. Figure 4 is a plot showing the difference in velocities at Node 1325 at Pea Patch Island, with difference values consistently less than 0.1 ft/sec. Figures 5 through 8 present velocity plots for the 40 ft and 45 ft channel alternatives respectively at Oakwood Beach, Elsinboro Point, Army Creek, and Kelly Point. Comparison of the predicted velocities for the 40 ft and 45 ft channel geometrics at these locations shows negligible velocity differences attributable to the deepened channel. Based on a review of velocity and head comparisons at the five sites investigated, it was concluded that the channel deepening will have a negligible effect on current velocities and water levels at shoreline locations adjacent to the channel, and there will be no shoreline erosion induced or exacerbated by the channel deepening.

VESSEL GENERATED WAVES.

The potential role of ship generated waves on shoreline erosion was also evaluated specifically for the problem area at Pea Patch Island. As described above, the curved eastern shoreline of the island ranges from as little as 200 feet up to about 1200 feet from the west edge of the existing navigation channel. The objective of this investigation was to determine if vessels using the deepened (i.e. , 45 ft) channel would generate larger waves than presently occur with the existing 40 ft channel. Procedures and equations presented in "Bank Protection for Vessel Generated Waves" (Robert Sorensen, 1986, Lehigh University Imbt Hydraulics Laboratory Report IHL-117-86) were utilized for this evaluation.

The principal variables considered in this analysis include vessel shape characteristics, vessel draft, vessel speed, sailing direction, and distance from the shoreline. The analysis assumed that tankers, due to their size, speed, and number of transits, constituted the critical class of vessels for this analysis. Further, based on data developed for the economic analysis of the proposed deepening project, it was assumed that the critical vessel was the same ship for the 40 and the 45 ft channels, with the vessel simply loaded to a five-foot deeper draft in the case of the 45 ft channel.

The results of the this analysis indicated that maximum wave heights at the shoreline of Pea Patch Island would increase only 4% for the case of the design vessel loaded to a five foot greater depth, with the other variables (speed, distance from shore, and sailing direction) held constant. It is concluded here, in the absence of a full understanding of all the physical factors which contribute to the shoreline erosion problem of Pea Patch Island, including naturally high tidal current velocities and existing ship waves, that the predicted vessel generated wave height increase of 4% associated with vessels loaded to five-foot greater draft is negligible with respect to overall Pea Patch Island shoreline erosion problem.

TABLE I

NODE 1325 (PEA PATCH ISLAND) MODEL OUTPUT

40 FT CHANNEL

Time history node data generated by FastTABS.
geometry file name == untitled.geo
solution file name == delextdy.sol
number of time history nodes == 20

Node ID	timestep	vel x	vel y	vel mag	vel flood	head	depth
1325	0	0	0	0	0	204.71	8.21
	0.5	0	0	0	0	204.71	8.21
	1	0	0	0	0	204.71	8.21
	1.5	0	-0.001	0.001	-0.001	204.71	8.209
	2	0	-0.004	0.004	-0.004	204.707	8.206
	2.5	0	-0.018	0.018	-0.018	204.694	8.193
	3	0.002	-0.063	0.063	-0.063	204.654	8.151
	3.5	0.004	-0.166	0.166	-0.166	204.555	8.047
	4	0.009	-0.346	0.346	-0.346	204.363	7.848
	4.5	0.016	-0.583	0.583	-0.583	204.06	7.538
	5	0.022	-0.817	0.817	-0.817	203.658	7.131
	5.5	0.027	-0.991	0.991	-0.991	203.192	6.662
	6	0.029	-1.086	1.087	-1.087	202.698	6.168
	6.5	0.03	-1.12	1.12	-1.12	202.2	5.671
	7	0.03	-1.116	1.116	-1.116	201.706	5.179
	7.5	0.029	-1.09	1.09	-1.09	201.223	4.696
	8	0.028	-1.048	1.049	-1.049	200.753	4.225
	8.5	0.027	-0.994	0.994	-0.994	200.303	3.775
	9	0.025	-0.928	0.928	-0.928	199.881	3.352
	9.5	0.023	-0.851	0.852	-0.852	199.502	2.975
	10	0.02	-0.76	0.76	-0.76	199.196	2.674
	10.5	0.017	-0.632	0.633	-0.633	199.032	2.525
	11	0.01	-0.374	0.374	-0.374	199.149	2.671
	11.5	-0.008	0.294	0.294	0.294	199.682	3.237
	12	-0.028	1.036	1.036	1.036	200.507	4.088
	12.5	-0.043	1.584	1.584	1.584	201.341	4.959
	13	-0.053	1.981	1.982	1.982	202.089	5.745
	13.5	-0.061	2.278	2.279	2.279	202.81	6.498
	14	-0.067	2.474	2.475	2.475	203.532	7.242
	14.5	-0.069	2.549	2.55	2.55	204.22	7.935
	15	-0.067	2.489	2.49	2.49	204.814	8.517
	15.5	-0.062	2.29	2.291	2.291	205.262	8.93
	16	-0.052	1.944	1.945	1.945	205.506	9.119
	16.5	-0.039	1.433	1.434	1.434	205.489	9.035
	17	-0.02	0.747	0.748	0.748	205.174	8.657
	17.5	0.003	-0.107	0.107	-0.107	204.61	8.057
	18	0.023	-0.87	0.87	-0.87	203.946	7.386
	18.5	0.034	-1.251	1.251	-1.251	203.304	6.75

TABLE I

(continued)

TIMESTEP	VELX	VELY	VEL MAG	VEL FLOOD	HEAD	DEPTH
19	0.036	-1.335	1.336	-1.336	202.72	6.177
19.5	0.035	-1.315	1.315	-1.315	202.181	5.647
20	0.034	-1.27	1.27	-1.27	201.67	5.14
20.5	0.033	-1.216	1.217	-1.217	201.181	4.651
21	0.031	-1.153	1.153	-1.153	200.713	4.183
21.5	0.029	-1.079	1.079	-1.079	200.27	3.739
22	0.027	-0.993	0.994	-0.994	199.86	3.329
22.5	0.024	-0.895	0.895	-0.895	199.504	2.977
23	0.021	-0.772	0.772	-0.772	199.26	2.743
23.5	0.015	-0.572	0.572	-0.572	199.251	2.761
24	0.002	-0.06	0.06	-0.06	199.663	3.212
24.5	-0.021	0.784	0.784	0.784	200.487	4.06
25	-0.039	1.457	1.457	1.457	201.401	5.005
25.5	-0.051	1.905	1.905	1.905	202.192	5.836
26	-0.06	2.229	2.229	2.229	202.91	6.588
26.5	-0.066	2.446	2.446	2.446	203.619	7.322
27	-0.068	2.536	2.537	2.537	204.294	8.005
27.5	-0.067	2.481	2.482	2.482	204.875	8.574
28	-0.061	2.281	2.282	2.282	205.303	8.968
28.5	-0.052	1.927	1.927	1.927	205.521	9.131
29	-0.038	1.401	1.401	1.401	205.472	9.014
29.5	-0.019	0.695	0.695	0.695	205.124	8.603
30	0.005	-0.18	0.18	-0.18	204.536	7.982
30.5	0.025	-0.922	0.923	-0.923	203.864	7.304
31	0.034	-1.268	1.269	-1.269	203.223	6.669
31.5	0.036	-1.335	1.335	-1.335	202.64	6.098
32	0.035	-1.308	1.309	-1.309	202.103	5.569
32.5	0.034	-1.262	1.263	-1.263	201.592	5.061
33	0.032	-1.207	1.208	-1.208	201.103	4.573
33.5	0.031	-1.143	1.143	-1.143	200.638	4.106
34	0.029	-1.067	1.068	-1.068	200.199	3.667
34.5	0.026	-0.98	0.98	-0.98	199.798	3.267
35	0.024	-0.877	0.877	-0.877	199.462	2.937
35.5	0.02	-0.741	0.742	-0.742	199.264	2.753
36	0.013	-0.488	0.488	-0.488	199.359	2.879
36.5	-0.005	0.194	0.194	0.194	199.923	3.483
37	-0.028	1.034	1.034	1.034	200.841	4.424
37.5	-0.044	1.649	1.65	1.65	201.76	5.38
38	-0.056	2.072	2.073	2.073	202.552	6.214
38.5	-0.064	2.381	2.382	2.382	203.299	6.996
39	-0.069	2.575	2.576	2.576	204.042	7.764
39.5	-0.071	2.63	2.631	2.631	204.739	8.465
40	-0.068	2.534	2.535	2.535	205.322	9.03
40.5	-0.062	2.289	2.29	2.29	205.731	9.397
41	-0.051	1.883	1.883	1.883	205.904	9.507
41.5	-0.035	1.297	1.297	1.297	205.785	9.314

TABLE I
(concluded)

TIMESTEP	VEL X	VEL Y	VEL MAG	VEL FLOOD	HEAD	DEPTH
42	-0.014	0.528	0.529	0.529	205.354	8.821
42.5	0.01	-0.389	0.389	-0.389	204.705	8.145
43	0.029	-1.073	1.074	-1.074	204.002	7.442
43.5	0.036	-1.343	1.343	-1.343	203.348	6.796
44	0.037	-1.377	1.378	-1.378	202.755	6.216
44.5	0.036	-1.341	1.342	-1.342	202.205	5.673
45	0.035	-1.292	1.292	-1.292	201.68	5.15
45.5	0.033	-1.234	1.235	-1.235	201.177	4.647
46	0.031	-1.166	1.167	-1.167	200.696	4.165
46.5	0.029	-1.088	1.088	-1.088	200.24	3.708
47	0.027	-0.998	0.998	-0.998	199.816	3.284
47.5	0.024	-0.895	0.896	-0.896	199.448	2.92
48	0.021	-0.77	0.77	-0.77	199.196	2.679
48.5	0.015	-0.564	0.564	-0.564	199.194	2.704
49	0.001	-0.021	0.021	-0.021	199.637	3.189
49.5	-0.023	0.84	0.84	0.84	200.505	4.082
50	-0.041	1.516	1.516	1.516	201.449	5.059
50.5	-0.053	1.963	1.964	1.964	202.255	5.906
51	-0.061	2.282	2.283	2.283	202.986	6.67
51.5	-0.067	2.49	2.491	2.491	203.703	7.413
52	-0.069	2.564	2.565	2.565	204.377	8.092
52.5	-0.067	2.484	2.485	2.485	204.943	8.641
53	-0.061	2.254	2.255	2.255	205.338	8.997
53.5	-0.05	1.861	1.862	1.862	205.503	9.102
54	-0.035	1.288	1.288	1.288	205.384	8.913
54.5	-0.014	0.532	0.532	0.532	204.962	8.43
55	0.01	-0.373	0.373	-0.373	204.328	7.769
55.5	0.028	-1.042	1.043	-1.043	203.644	7.084
56	0.035	-1.301	1.302	-1.302	203.009	6.458
56.5	0.036	-1.332	1.332	-1.332	202.434	5.894
57	0.035	-1.294	1.295	-1.295	201.9	5.367
57.5	0.033	-1.243	1.244	-1.244	201.392	4.861
58	0.032	-1.185	1.186	-1.186	200.906	4.375
58.5	0.03	-1.117	1.117	-1.117	200.446	3.914
59	0.028	-1.038	1.038	-1.038	200.016	3.483
59.5	0.025	-0.946	0.947	-0.947	199.629	3.098
60	0.022	-0.836	0.836	-0.836	199.326	2.802

TABLE 2
NODE 1325 (PEA PATCH ISLAND) MODEL OUTPUT
45 FT CHANNEL

Time history node data generated by FastTABS.
geometry file name == untitled.geo
solution file name == delplan1dyn.sol
number of time history nodes == 20

Node ID	timestep	vel x	vel y	vel mag	vel flood	head	depth
1325	0	0	0	0	0	204.71	8.21
	0.5	0	0	0	0	204.71	8.21
	1	0	0	0	0	204.71	8.21
	1.5	0	-0.001	0.001	-0.001	204.709	8.209
	2	0	-0.004	0.004	-0.004	204.706	8.206
	2.5	0.001	-0.019	0.019	-0.019	204.694	8.193
	3	0.002	-0.065	0.065	-0.065	204.653	8.149
	3.5	0.005	-0.17	0.17	-0.17	204.553	8.044
	4	0.01	-0.354	0.355	-0.355	204.358	7.843
	4.5	0.016	-0.596	0.596	-0.596	204.051	7.529
	5	0.022	-0.834	0.834	-0.834	203.645	7.117
	5.5	0.027	-1.01	1.01	-1.01	203.174	6.643
	6	0.03	-1.107	1.107	-1.107	202.675	6.143
	6.5	0.031	-1.141	1.141	-1.141	202.17	5.639
	7	0.031	-1.136	1.137	-1.137	201.671	5.141
	7.5	0.03	-1.109	1.109	-1.109	201.182	4.651
	8	0.029	-1.064	1.065	-1.065	200.707	4.176
	8.5	0.027	-1.006	1.007	-1.007	200.253	3.72
	9	0.025	-0.937	0.937	-0.937	199.827	3.295
	9.5	0.023	-0.856	0.856	-0.856	199.447	2.916
	10	0.02	-0.759	0.759	-0.759	199.143	2.619
	10.5	0.017	-0.624	0.624	-0.624	198.989	2.48
	11	0.009	-0.344	0.344	-0.344	199.124	2.648
	11.5	-0.009	0.352	0.352	0.352	199.678	3.235
	12	-0.029	1.085	1.085	1.085	200.513	4.097
	12.5	-0.044	1.626	1.627	1.627	201.35	4.971
	13	-0.055	2.03	2.031	2.031	202.105	5.763
	13.5	-0.063	2.331	2.331	2.331	202.837	6.526
	14	-0.068	2.526	2.527	2.527	203.567	7.278
	14.5	-0.07	2.596	2.597	2.597	204.258	7.975
	15	-0.068	2.528	2.529	2.529	204.854	8.557
	15.5	-0.062	2.318	2.319	2.319	205.301	8.968
	16	-0.053	1.957	1.958	1.958	205.541	9.152
	16.5	-0.038	1.43	1.431	1.431	205.515	9.058
	17	-0.02	0.727	0.727	0.727	205.188	8.668
	17.5	0.004	-0.146	0.146	-0.146	204.612	8.058
	18	0.024	-0.907	0.908	-0.908	203.94	7.379
	18.5	0.034	-1.282	1.283	-1.283	203.293	6.737
	19	0.037	-1.366	1.366	-1.366	202.703	6.157
	19.5	0.036	-1.344	1.345	-1.345	202.157	5.62

TABLE 2

(continued)

TIMESTEP	VEL X	VEL Y	VEL MAG	VEL FLOOD	HEAD	DEPTH
20	0.035	-1.298	1.298	-1.298	201.639	5.104
20.5	0.033	-1.241	1.242	-1.242	201.142	4.607
21	0.032	-1.173	1.174	-1.174	200.667	4.132
21.5	0.029	-1.094	1.094	-1.094	200.219	3.682
22	0.027	-1.003	1.003	-1.003	199.804	3.268
22.5	0.024	-0.898	0.898	-0.898	199.447	2.916
23	0.021	-0.768	0.768	-0.768	199.207	2.668
23.5	0.015	-0.553	0.554	-0.554	199.213	2.723
24	0	0	0	0	199.648	3.199
24.5	-0.023	0.841	0.842	0.842	200.487	4.062
25	-0.04	1.5	1.501	1.501	201.406	5.012
25.5	-0.052	1.951	1.952	1.952	202.202	5.849
26	-0.061	2.281	2.281	2.281	202.931	6.611
26.5	-0.067	2.498	2.499	2.499	203.649	7.354
27	-0.069	2.584	2.585	2.585	204.328	8.041
27.5	-0.068	2.521	2.522	2.522	204.911	8.61
28	-0.062	2.31	2.311	2.311	205.338	9.002
28.5	-0.052	1.941	1.942	1.942	205.552	9.16
29	-0.038	1.399	1.4	1.4	205.495	9.034
29.5	-0.018	0.675	0.675	0.675	205.135	8.611
30	0.006	-0.216	0.216	-0.216	204.537	7.981
30.5	0.026	-0.957	0.957	-0.957	203.857	7.295
31	0.035	-1.298	1.299	-1.299	203.21	6.654
31.5	0.037	-1.365	1.365	-1.365	202.622	6.076
32	0.036	-1.338	1.338	-1.338	202.077	5.54
32.5	0.035	-1.289	1.29	-1.29	201.558	5.023
33	0.033	-1.232	1.232	-1.232	201.062	4.527
33.5	0.031	-1.162	1.163	-1.163	200.59	4.054
34	0.029	-1.081	1.082	-1.082	200.146	3.61
34.5	0.027	-0.988	0.989	-0.989	199.742	3.206
35	0.024	-0.879	0.879	-0.879	199.406	2.876
35.5	0.02	-0.735	0.735	-0.735	199.215	2.701
36	0.012	-0.462	0.462	-0.462	199.327	2.848
36.5	-0.007	0.258	0.258	0.258	199.915	3.476
37	-0.029	1.088	1.088	1.088	200.844	4.429
37.5	-0.046	1.693	1.694	1.694	201.766	5.389
38	-0.057	2.122	2.123	2.123	202.566	6.231
38.5	-0.065	2.435	2.436	2.436	203.324	7.024
39	-0.071	2.628	2.629	2.629	204.076	7.799
39.5	-0.072	2.677	2.678	2.678	204.776	8.503
40	-0.069	2.573	2.574	2.574	205.36	9.068
40.5	-0.062	2.316	2.316	2.316	205.767	9.432
41	-0.051	1.894	1.895	1.895	205.935	9.535
41.5	-0.035	1.291	1.291	1.291	205.806	9.332
42	-0.014	0.504	0.505	0.505	205.363	8.828
42.5	0.011	-0.425	0.425	-0.425	204.703	8.142

TABLE 2
(concluded)

TIMESTEP	VEL X	VEL Y	VEL MAG	VEL FLOOD	HEAD	DEPTH
43	0.03	-1.107	1.108	-1.108	203.993	7.431
43.5	0.037	-1.374	1.375	-1.375	203.333	6.779
44	0.038	-1.409	1.409	-1.409	202.734	6.192
44.5	0.037	-1.372	1.372	-1.372	202.176	5.641
45	0.036	-1.32	1.321	-1.321	201.643	5.109
45.5	0.034	-1.259	1.26	-1.26	201.132	4.598
46	0.032	-1.186	1.187	-1.187	200.645	4.109
46.5	0.03	-1.102	1.103	-1.103	200.183	3.646
47	0.027	-1.006	1.007	-1.007	199.755	3.219
47.5	0.024	-0.897	0.898	-0.898	199.386	2.854
48	0.021	-0.764	0.765	-0.765	199.139	2.619
48.5	0.015	-0.543	0.543	-0.543	199.153	2.664
49	-0.001	0.043	0.043	0.043	199.622	3.176
49.5	-0.024	0.9	0.9	0.9	200.505	4.084
50	-0.042	1.561	1.561	1.561	201.453	5.065
50.5	-0.054	2.011	2.012	2.012	202.265	5.918
51	-0.063	2.336	2.337	2.337	203.007	6.694
51.5	-0.068	2.543	2.544	2.544	203.734	7.445
52	-0.07	2.612	2.613	2.613	204.412	8.128
52.5	-0.068	2.524	2.525	2.525	204.978	8.677
53	-0.061	2.281	2.282	2.282	205.372	9.03
53.5	-0.05	1.874	1.874	1.874	205.533	9.13
54	-0.034	1.283	1.284	1.284	205.405	8.93
54.5	-0.014	0.51	0.51	0.51	204.971	8.436
55	0.011	-0.407	0.408	-0.408	204.325	7.766
55.5	0.029	-1.075	1.075	-1.075	203.635	7.073
56	0.036	-1.331	1.332	-1.332	202.995	6.44
56.5	0.037	-1.362	1.362	-1.362	202.413	5.87
57	0.036	-1.323	1.323	-1.323	201.872	5.335
57.5	0.034	-1.27	1.27	-1.27	201.355	4.82
58	0.032	-1.208	1.208	-1.208	200.863	4.327
58.5	0.031	-1.135	1.135	-1.135	200.396	3.859
59	0.028	-1.05	1.051	-1.051	199.961	3.423
59.5	0.026	-0.953	0.953	-0.953	199.572	3.036
60	0.022	-0.836	0.836	-0.836	199.27	2.743

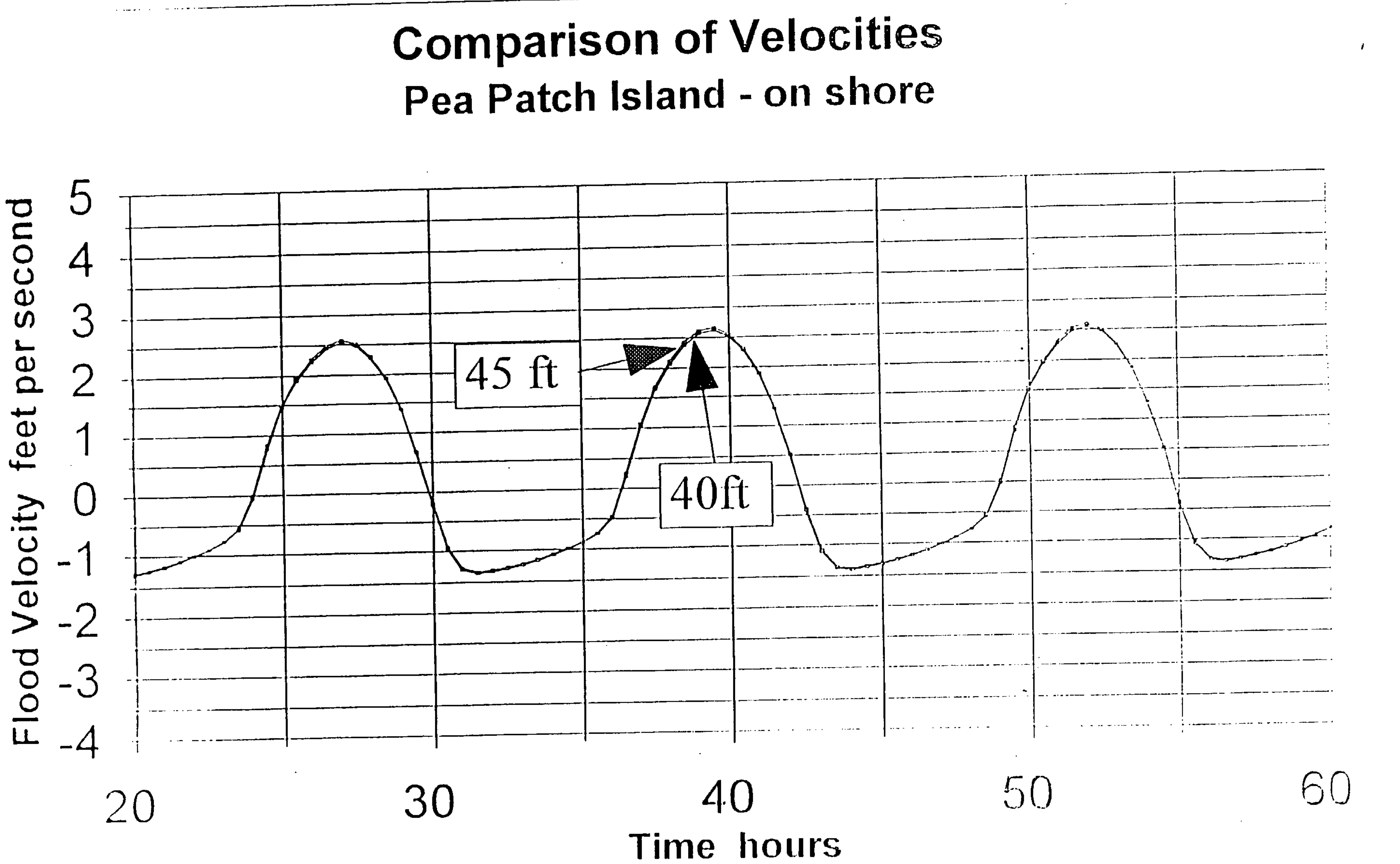

Comparison of Velocities
Pea Patch Island - on shore
Flood Velocity feet per second
5
4
3
2
1
0
-1
-2
-3
-4
45 ft
40ft
20
30
40
50
60
Time hours

Figure 2.

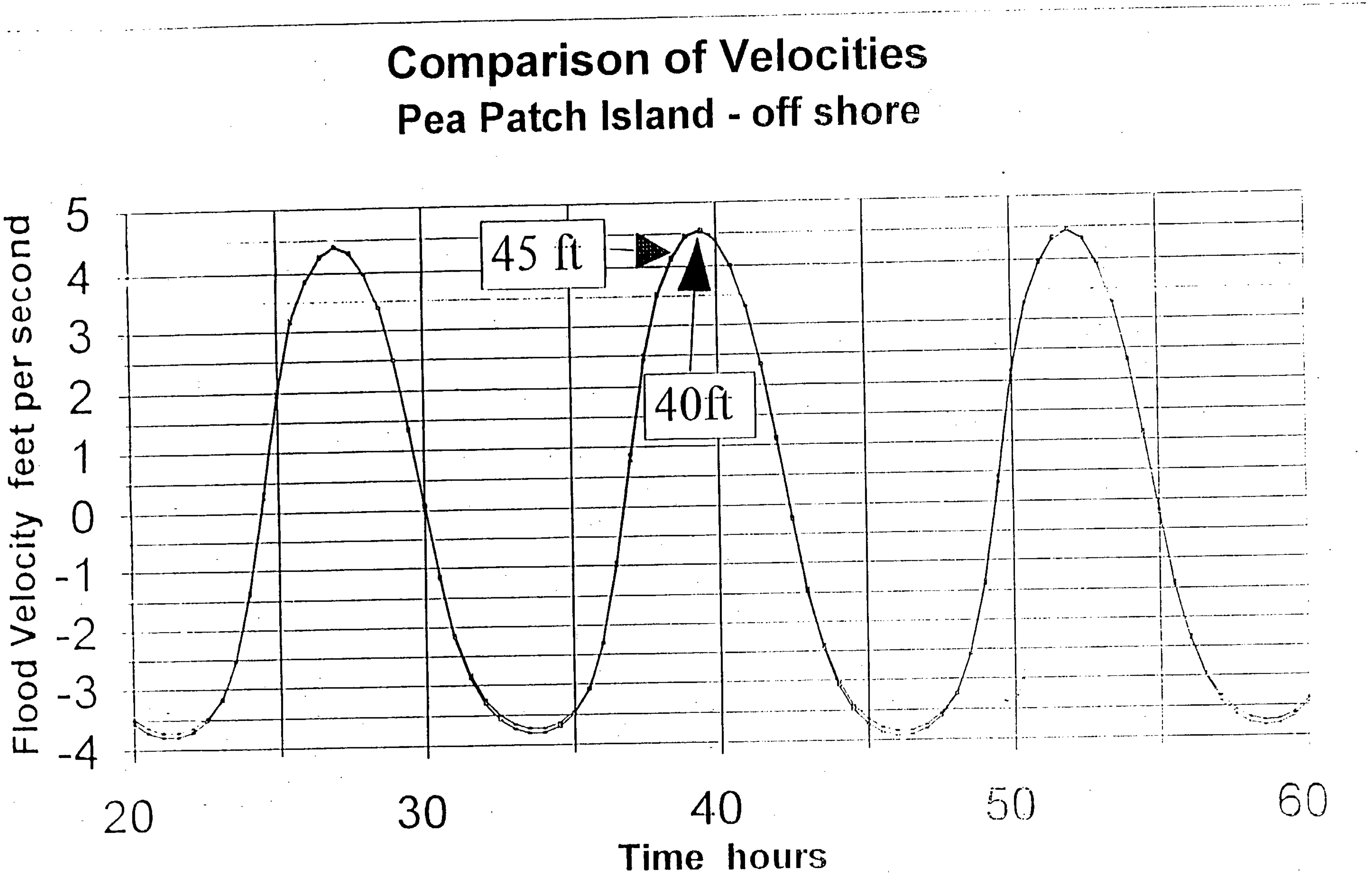

Comparison of Velocities
Pea Patch Island - off shore
45 ft
40ft
Flood Velocity feet per second
5
4
3
2
1
0
-1
-2
-3
-4
20
30
40
50
60
Time hours

Figure 3

NODE 1325

VELOCITY DIFF, 40 VS 45 FT CHAN

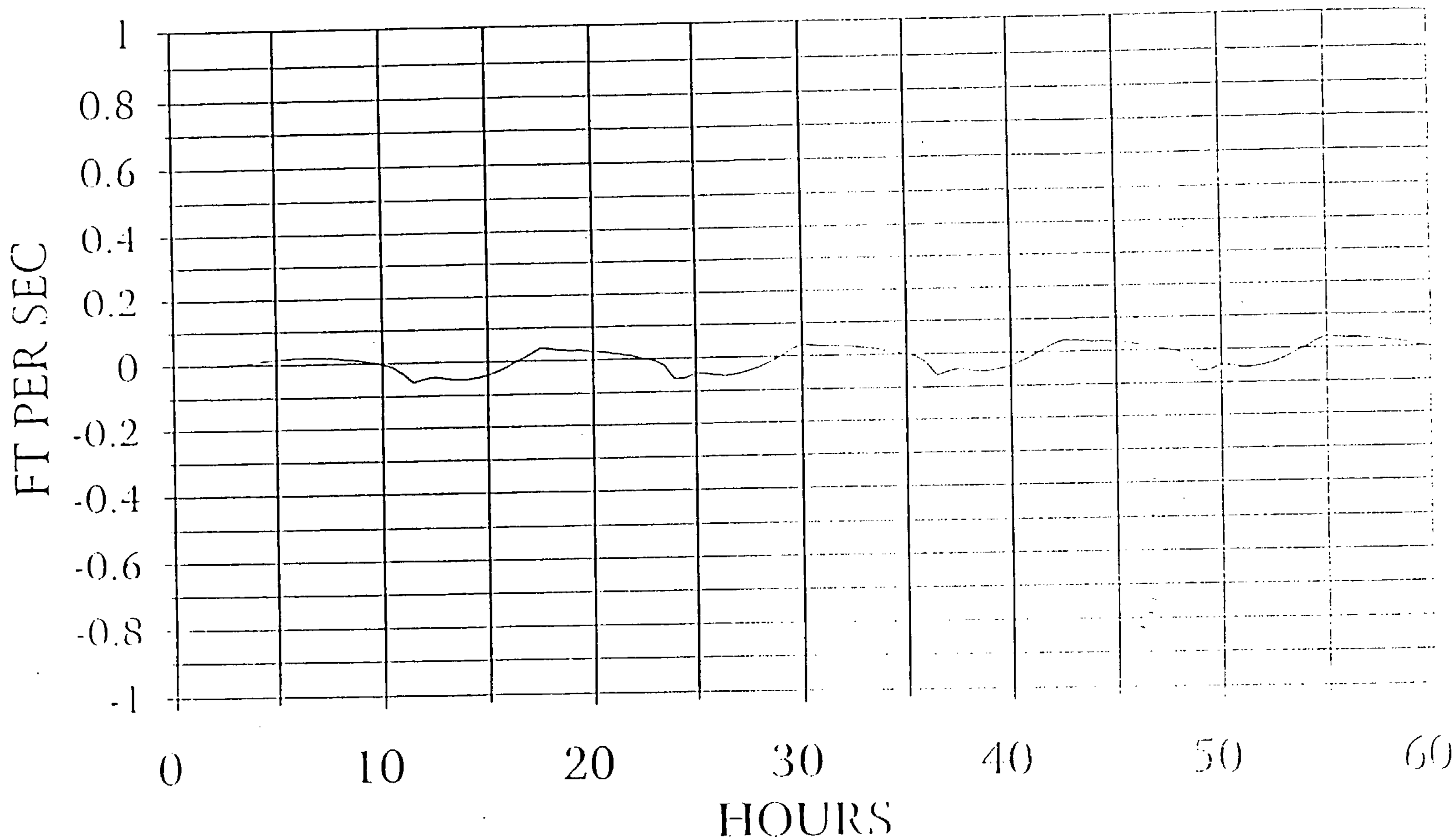


Figure 4.

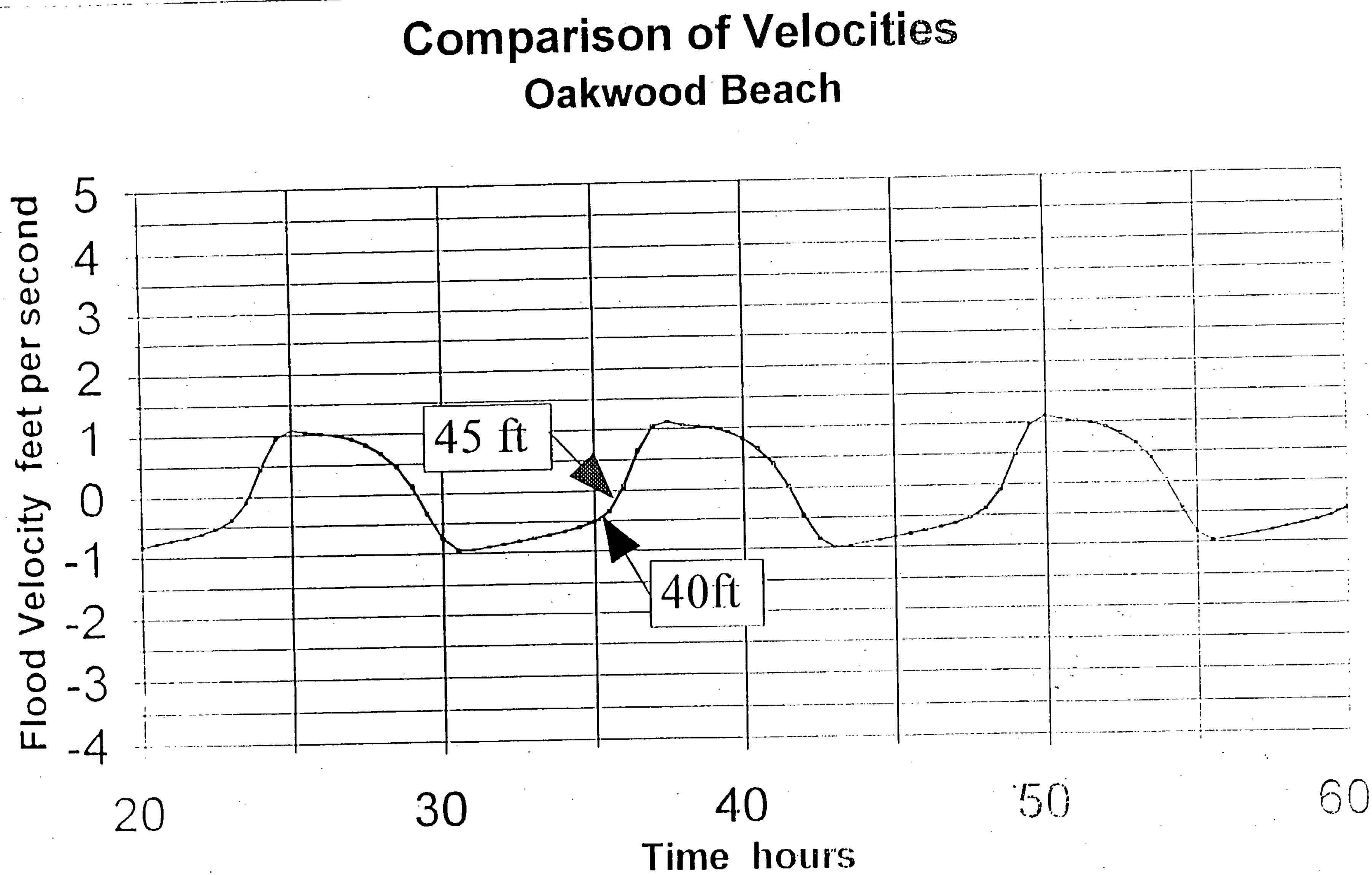

Comparison of Velocities
Oakwood Beach
Flood Velocity feet per second
5
4
3
2
1
0
-1
-2
-3
-4
45 ft
40ft
20
30
40
50
60
Time hours

Figure 5

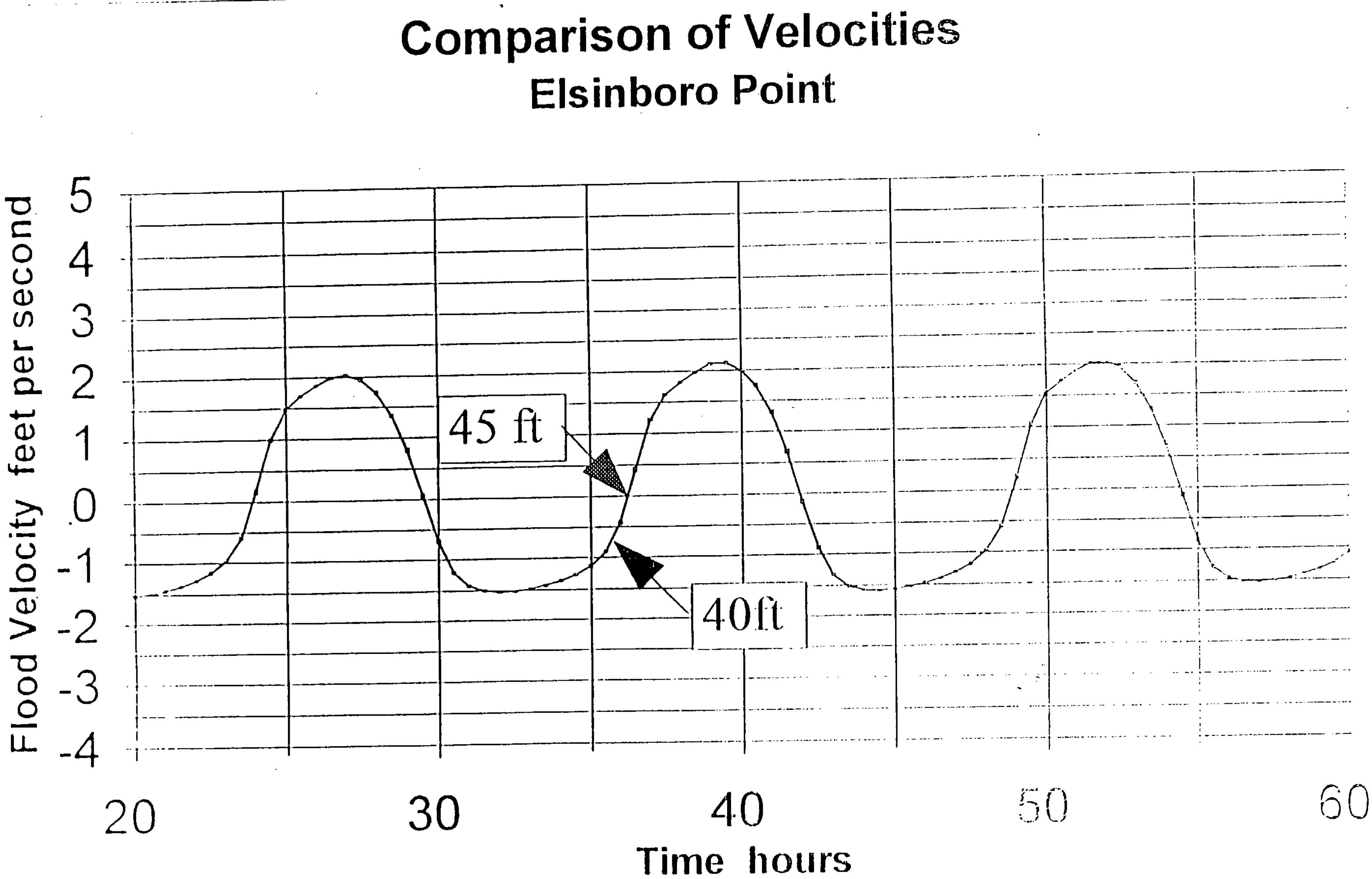
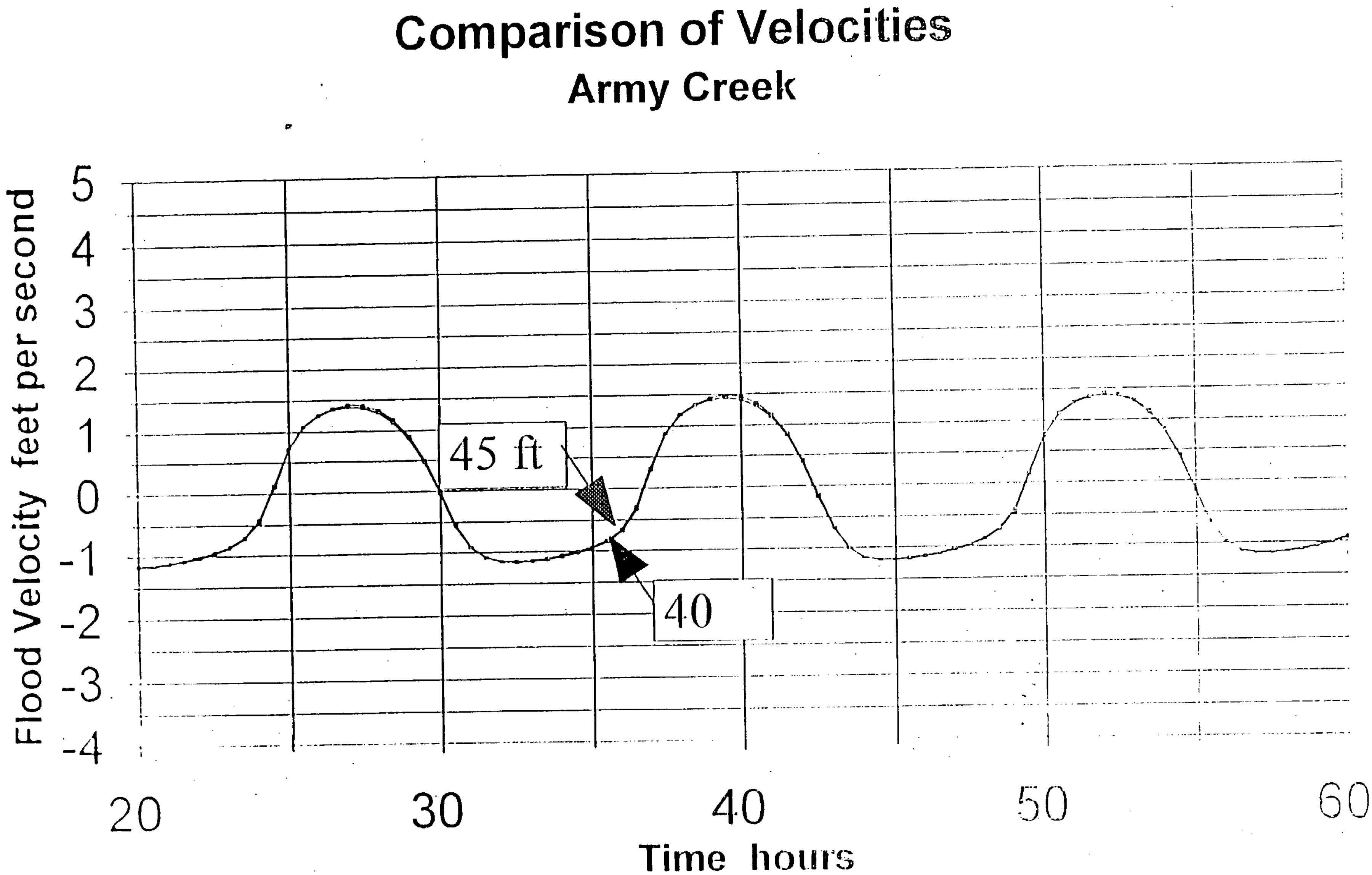

Comparison of Velocities
Elsinboro Point
Flood Velocity feet per second
5
4
3
2
1
0
-1
-2
-3
-4
45 ft
40ft
20
30
40
50
60
Time hours

Figure 6



Comparison of Velocities
Army Creek
Flood Velocity feet per second
5
4
3
2
1
0
-1
-2
-3
-4
45 ft
40
20
30
40
50
60
Time hours

Figure 7.

Comparison of Velocities
Kelly Point