Hurricane Surge Modeling

Purpose:

The purpose of the hurricane surge modeling is to determine the impacts of deepening the navigation channel and its effect on the propagation of a hurricane storm surge traveling upstream through the estuary and river system.

Model Boundary Conditions:

The tidal boundary was modified to incorporate a synthetic storm surge. The modeling time period selected was late August of 1997 (8-18-97 to 8-23-97). This time period was selected for several reasons:

1. 1997 closely represents historic average flow conditions at Clyo (the upstream flow boundary),
2. August is close to peak hurricane season when the likelihood of a large storm hitting the Savannah coastline would be more probable, and
3. spring tidal conditions occur on August 19.

The hurricane surge data set was developed by Applied Technology and Management, Inc. (ATM). The data set is based on measured water surface elevations collected at the USGS Customs House gage located in Charleston, SC during Hurricane Hugo which made landfall on September 21, 1989. ATM separated the hurricane storm surge component from the harmonic tidal component. The max increase in water surface elevation for the hurricane storm surge component collected at this gauging station is 7.69 ft. However, the storm surge as Hurricane Hugo made landfall varied with some places receiving a near 20 ft storm surge. Due to the difficulty in directly applying the storm surge gage data in Charleston to Savannah the data set was ratioed by ATM to create three synthetic storm surges with peaks of 5 ft, 10 ft, and 15 ft. These storm surge data sets were then added to the harmonic tide in Savannah to create a synthetic storm surge scenario. Six storm event scenarios were developed from the data set. Three had the 5 ft, 10 ft, and 15 ft peak surges occurring on top of the peak spring tidal condition. The fluctuation in water surface elevation in Savannah is so large that this peak-on-peak condition allowed evaluation of a worst case scenario. Three additional scenarios were also evaluated that had the 5 ft, 10 ft, and 15 ft peak storm surges occurring on the falling limb of the spring peak tide. The off-peak scenario would create a tidal surge that had a lower peak than the surge during the peak-on-peak scenario, but would have a longer duration. There are likely some areas where a longer duration storm would be a worst case scenario rather than a shorter peak surge.

Model Limitations:

The EFDC grid created for this study was not formed with emphasis on hurricane surge modeling. The shipping channel and smaller side channels including marsh areas are described in detail in the grid. However the higher banks and beaches are not accounted for in the model. These areas would likely be impacted during a hurricane and would have a direct effect on the propagation of a storm surge through the river system and navigation channel. The model is useful as a comparison tool to evaluate different deepening scenarios, however it should only be used for relative comparative purposes and not to describe where flooding would occur during a hurricane.

Findings:

The results from the hurricane surge modeling show that the change in water surface elevation due to the deepening is not significant. The existing depth is compared to the 48 ft deepening scenario (deepening an additional 6 ft) for all of the 6 storm events scenarios simulated. The maximum difference between the two water surface elevations, is 0.90 ft, which occurs during the 15 ft surge, coinciding peak simulations at the I-95 Bridge.

Table 1:
Comparison for 48 ft Deepening Scenario (All Simulated Events)

	Ft. Jackson Difference in Water Surface Elevations		I-95 Bridge Difference in Water Surface Elevations	
	Max – (High Tide)	Max + (Low Tide)	Max – (High Tide)	Max + (Low Tide)
5 ft surge				
Peak on peak	-0.095 m (-0.312 ft)	0.093m (0.305 ft)	-0.204m (-0.669 ft)	0.162m (0.531 ft)
Off set peaks	-0.090m (-0.295 ft)	0.096m (0.315 ft)	-0.210m (-0.689 ft)	0.136m (0.446 ft)
10 ft surge				
Peak on peak	-0.092m (-0.302 ft)	0.097m (0.318 ft)	-0.234m (-0.768 ft)	0.154m (0.505 ft)
Off set peaks	-0.093m (-0.305 ft)	0.101m (0.331 ft)	-0.236m (-0.774 ft)	0.142m (0.466 ft)
15 ft surge				
Peak on peak	-0.094m (-0.308 ft)	0.119m (0.390 ft)	-0.275m (-0.902 ft)	0.160m (0.525 ft)
Off set peaks	-0.099m (-0.325 ft)	0.111m (0.364 ft)	-0.257m (-0.843 ft)	0.165m (0.541 ft)
Overall	-0.099m (-0.325 ft)	0.119m (0.390 ft)	-0.275m (-0.902 ft)	0.165m (0.541 ft)

** The difference in water surface elevations were calculated as Difference = Existing – 48 ft Deepening.*

In addition to modeling the existing and 48 ft deepening scenarios, the other deepening scenarios (44, 45, 46, and 47 ft) were also modeled for the event that had the greatest difference in water surface elevation, the 15 ft surge during a peak on peak condition.

Table 2:
Comparison for Several Deepening Scenarios (15 ft Surge, Peak on Peak Conditions)

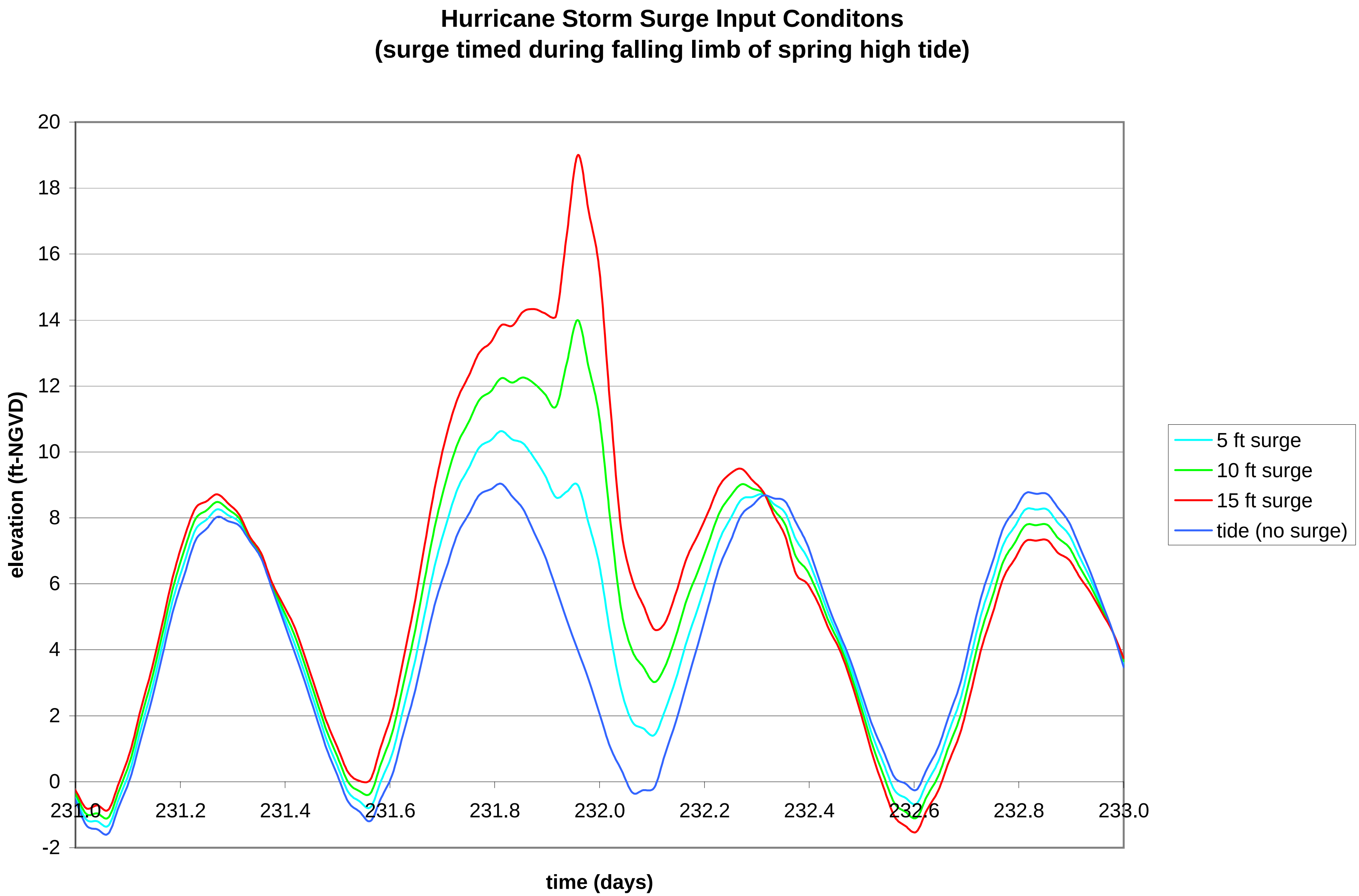
	Ft. Jackson Difference in Water Surface Elevations		I-95 Bridge Difference in Water Surface Elevations	
	Max – (High Tide)	Max + (Low Tide)	Max – (High Tide)	Max + (Low Tide)
44 ft Deepening	-0.035m (-0.114 ft)	0.040m (0.131 ft)	-0.091m (-0.298 ft)	0.069m (0.226 ft)
45 ft Deepening	-0.050m (-0.163 ft)	0.069m (0.227 ft)	-0.143m (-0.468 ft)	0.094m (0.307 ft)
46 ft Deepening	-0.066m (-0.217 ft)	0.081m (0.265 ft)	-0.181m (-0.595 ft)	0.116m (0.379 ft)
47 ft Deepening	-0.080m (-0.261 ft)	0.099m (0.324 ft)	-0.232m (-0.760 ft)	0.139m (0.455 ft)
48 ft Deepening	-0.094m (-0.308 ft)	0.119m (0.390 ft)	-0.275m (-0.902 ft)	0.160m (0.525 ft)

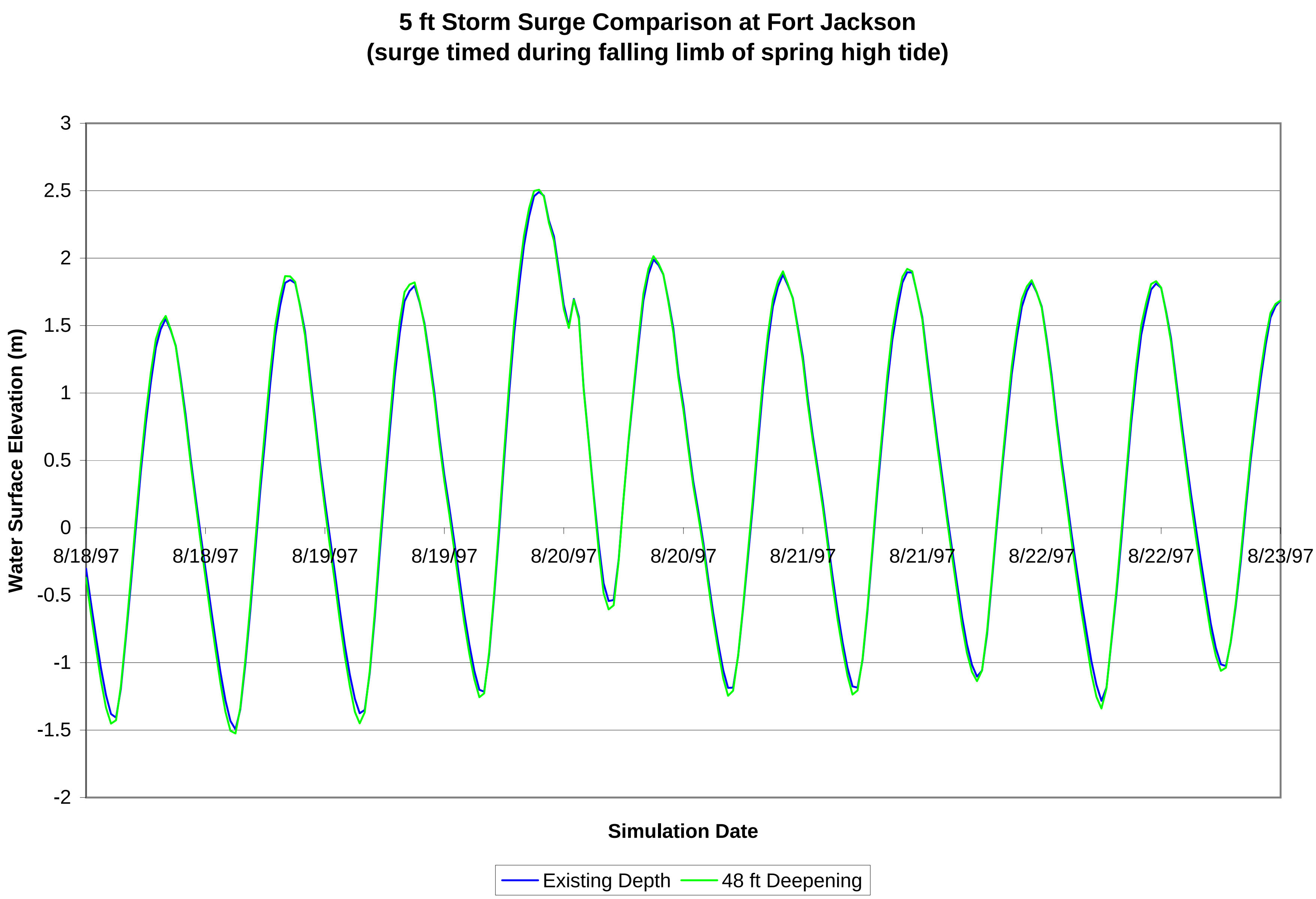
** The difference in water surface elevations were calculated as Difference = Existing – Deepening.*

The high tide peaks are slightly higher for the deepened channel and the low tide lows are slightly lower for the deepened channel as compared to the existing depth condition. However, the difference is not significant. The minimal difference is due to the larger volumes of water being transported through the system during the tidal cycle and storm surge. These larger volumes cause a slight increase in peaks during high tide and surge and slight decrease in lows during low tide. In conclusion, the hurricane surge modeling shows no significant adverse impacts, due to harbor deepening, to a propagated storm surge as it travels upstream through the river system and navigation channel.

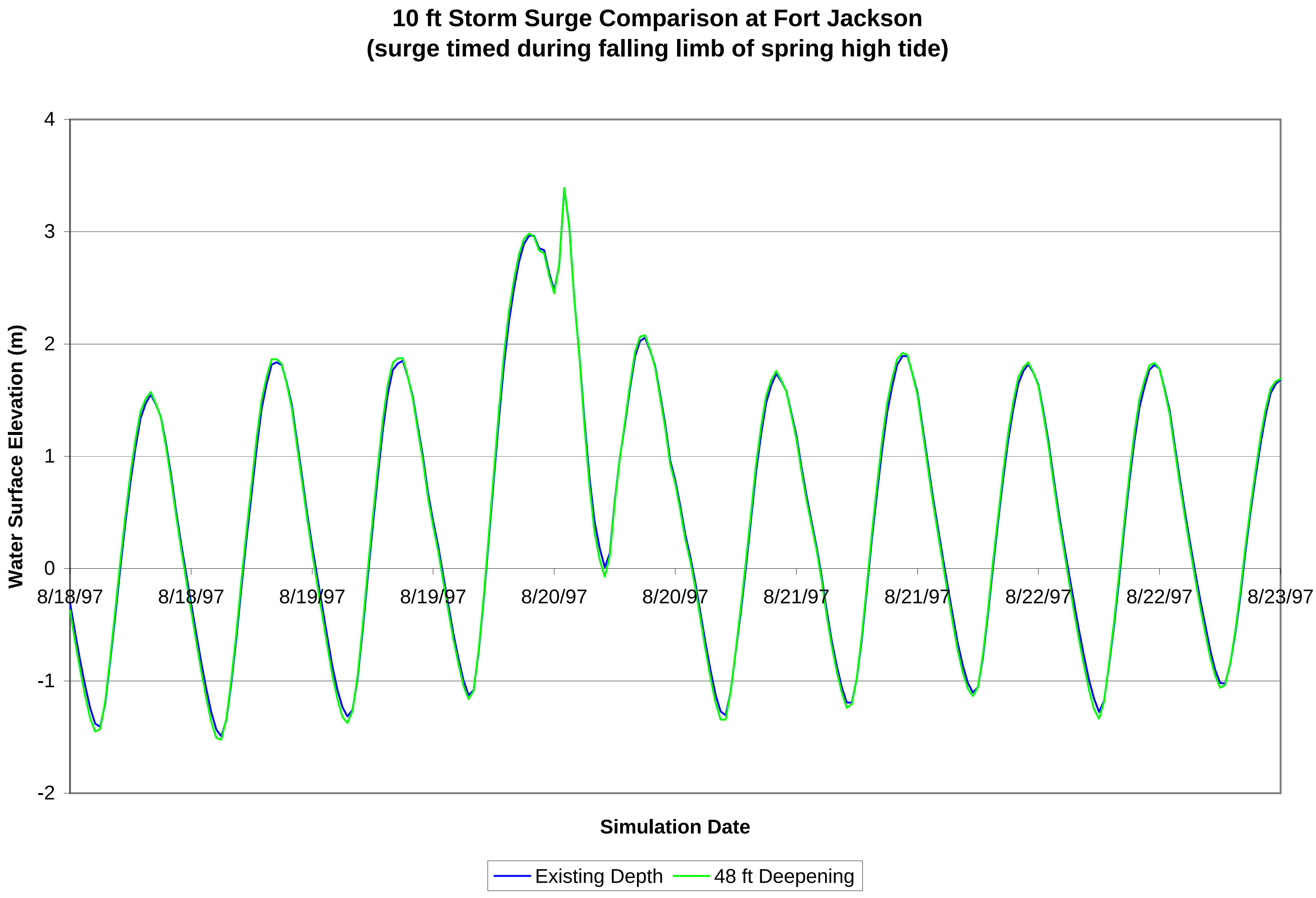
Input & Output Data

Water Surface Elevations for Existing and 48 ft Deepening
(surge timed during falling limb of spring high tide)

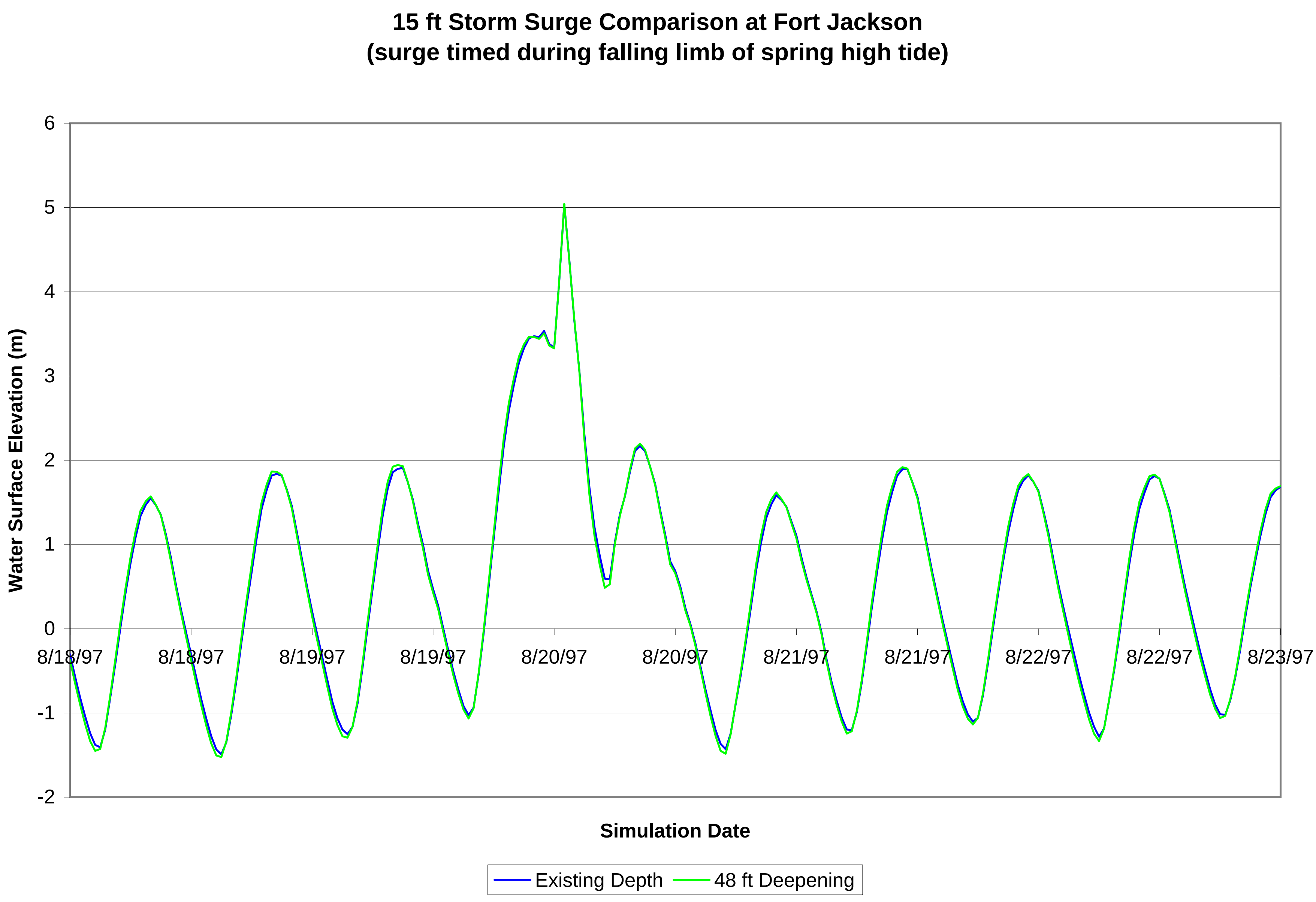

Hurricane Storm Surge Input Conditons
(surge timed during falling limb of spring high tide)
elevation (ft-NGVD)
time (days)
20
18
16
14
12
10
8
6
4
2
0
-2
231.0
231.2
231.4
231.6
231.8
232.0
232.2
232.4
232.6
232.8
233.0
5 ft surge
10 ft surge
15 ft surge
tide (no surge)

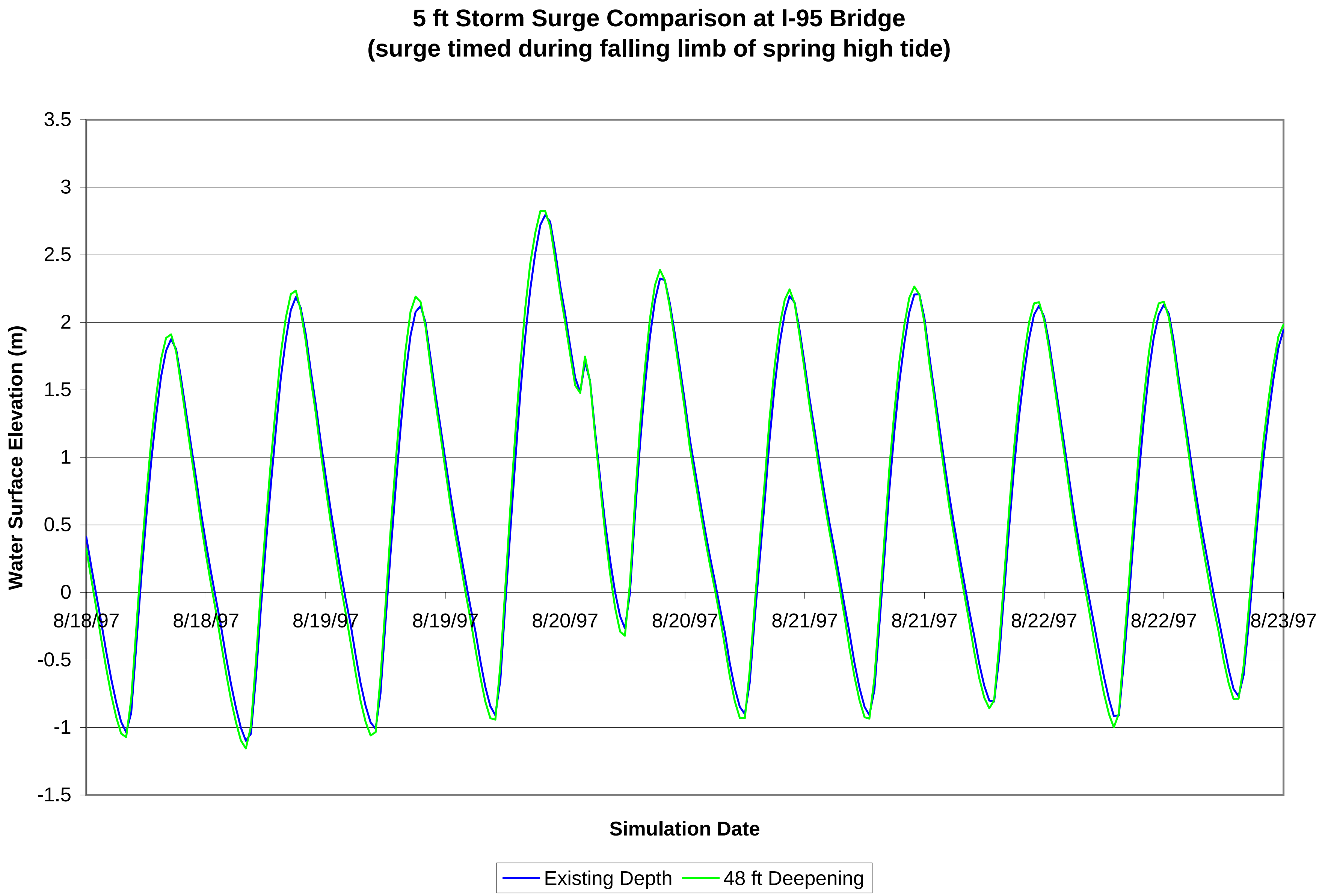


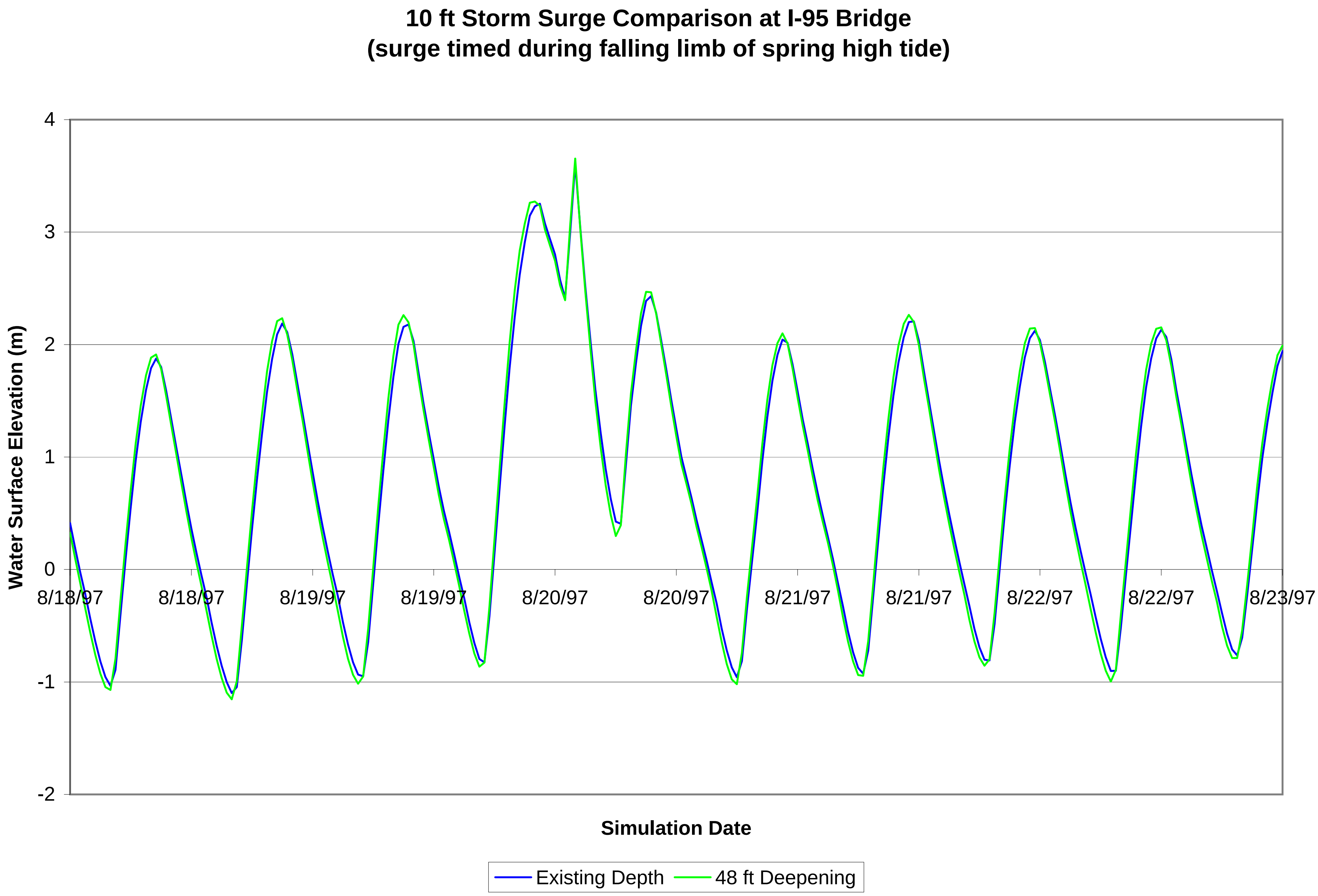
5 ft Storm Surge Comparison at Fort Jackson
(surge timed during falling limb of spring high tide)
Water Surface Elevation (m)
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening



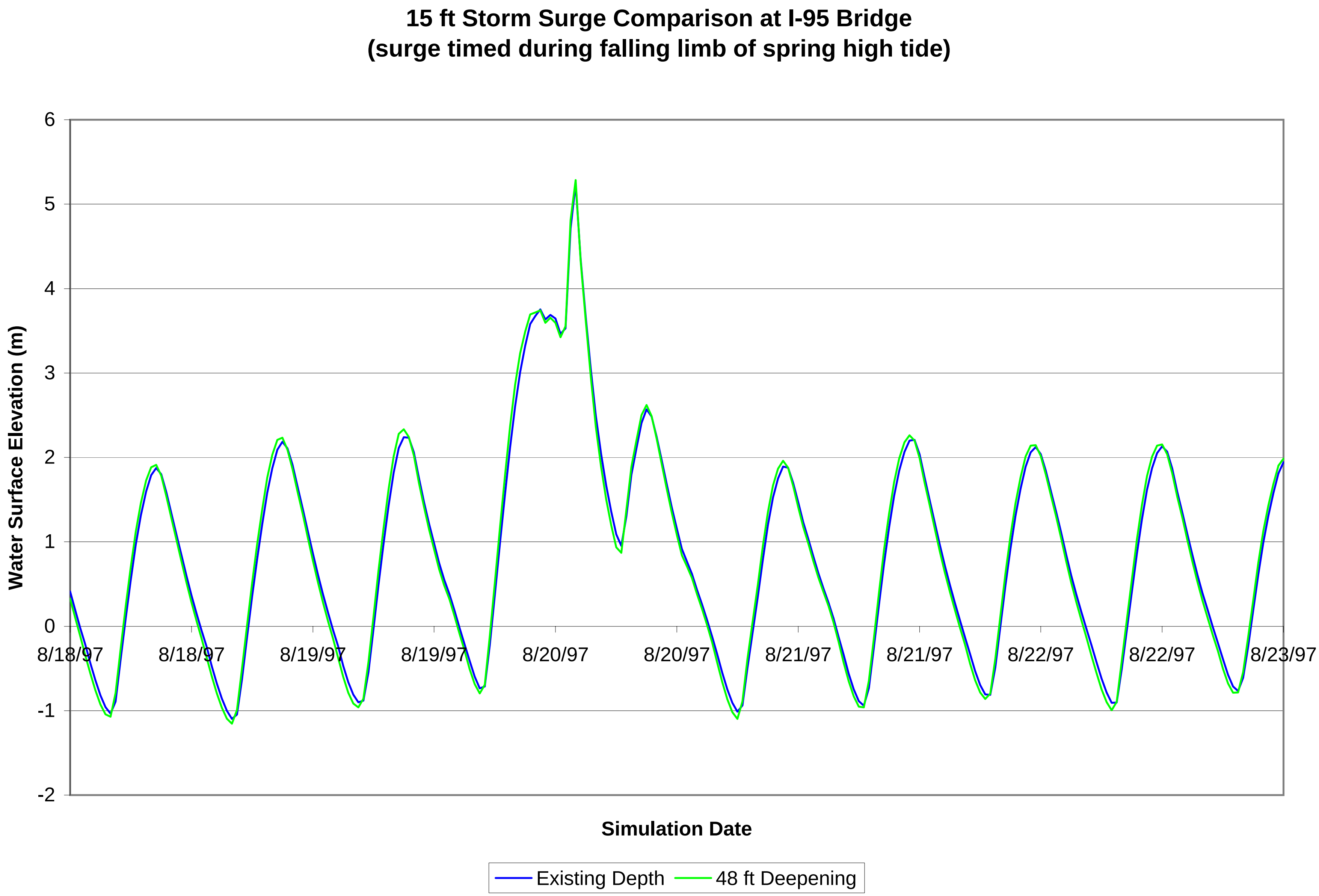
10 ft Storm Surge Comparison at Fort Jackson
(surge timed during falling limb of spring high tide)
Water Surface Elevation (m)
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening


15 ft Storm Surge Comparison at Fort Jackson
(surge timed during falling limb of spring high tide)
Water Surface Elevation (m)
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening


5 ft Storm Surge Comparison at I-95 Bridge
(surge timed during falling limb of spring high tide)
Water Surface Elevation (m)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening



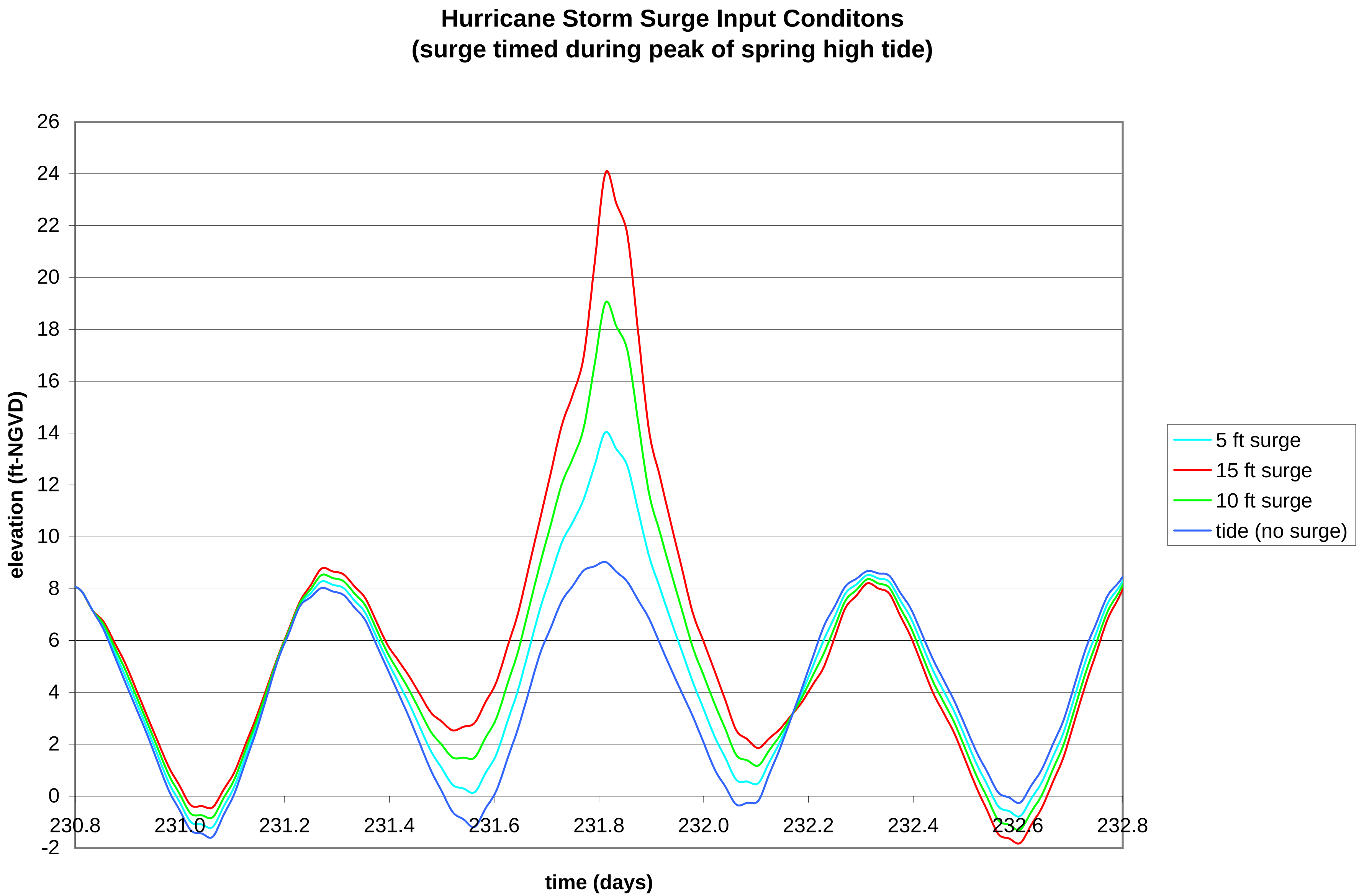
10 ft Storm Surge Comparison at I-95 Bridge
(surge timed during falling limb of spring high tide)
Water Surface Elevation (m)
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening



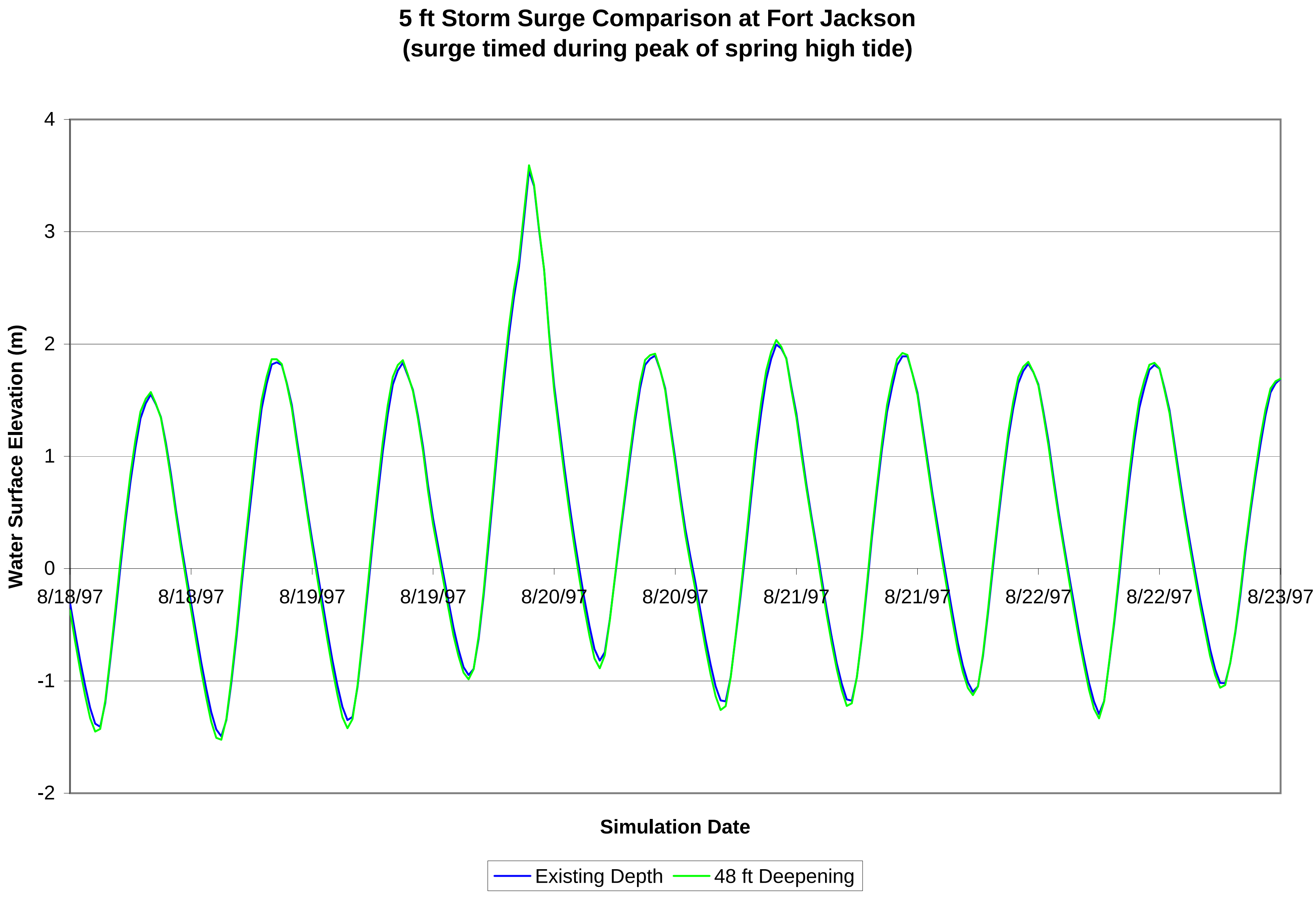
15 ft Storm Surge Comparison at I-95 Bridge
(surge timed during falling limb of spring high tide)
Water Surface Elevation (m)
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening

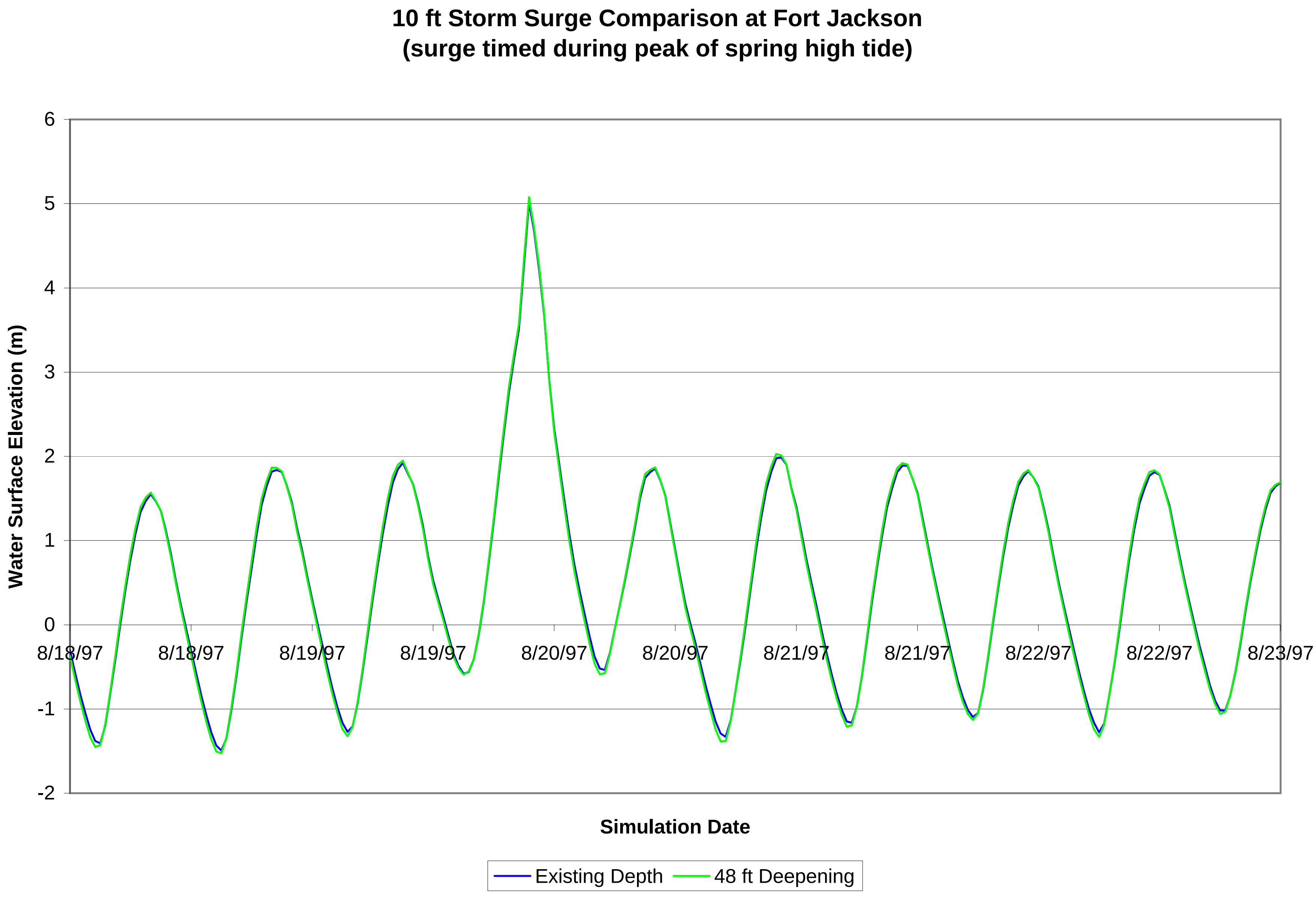
Input & Output Data

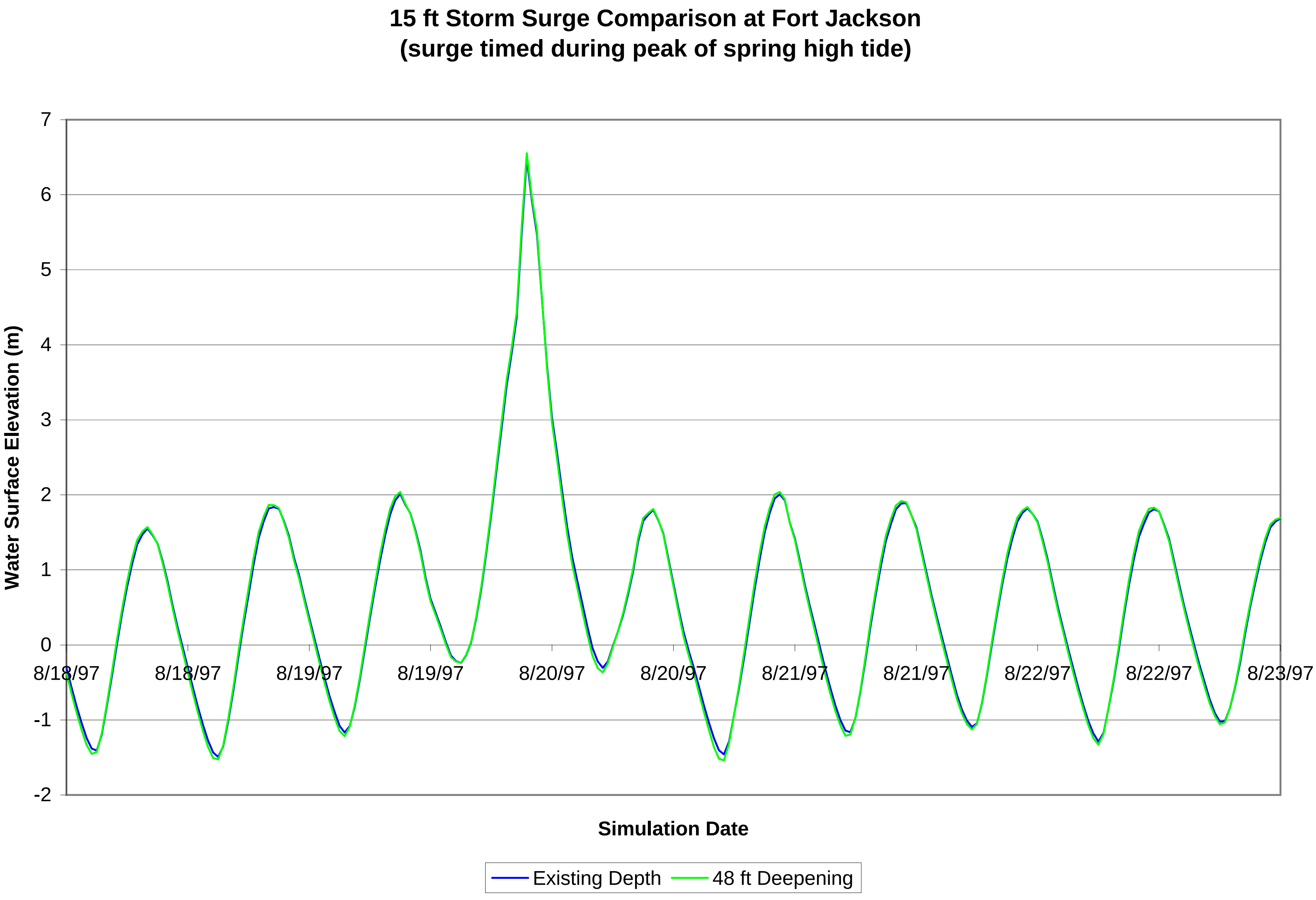
Water Surface Elevations for Existing and 48 ft Deepening (surge timed during peak of spring high tide)

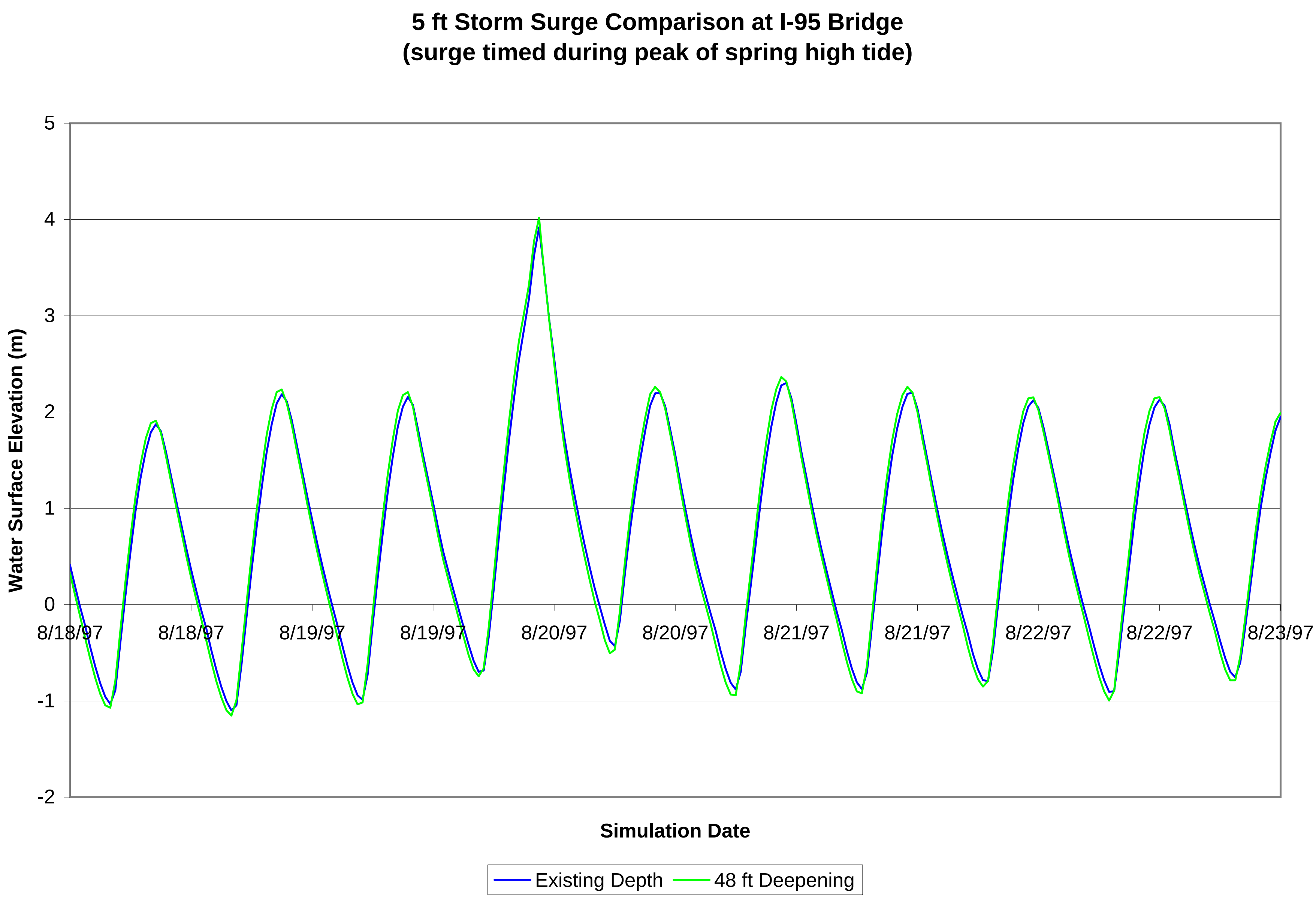


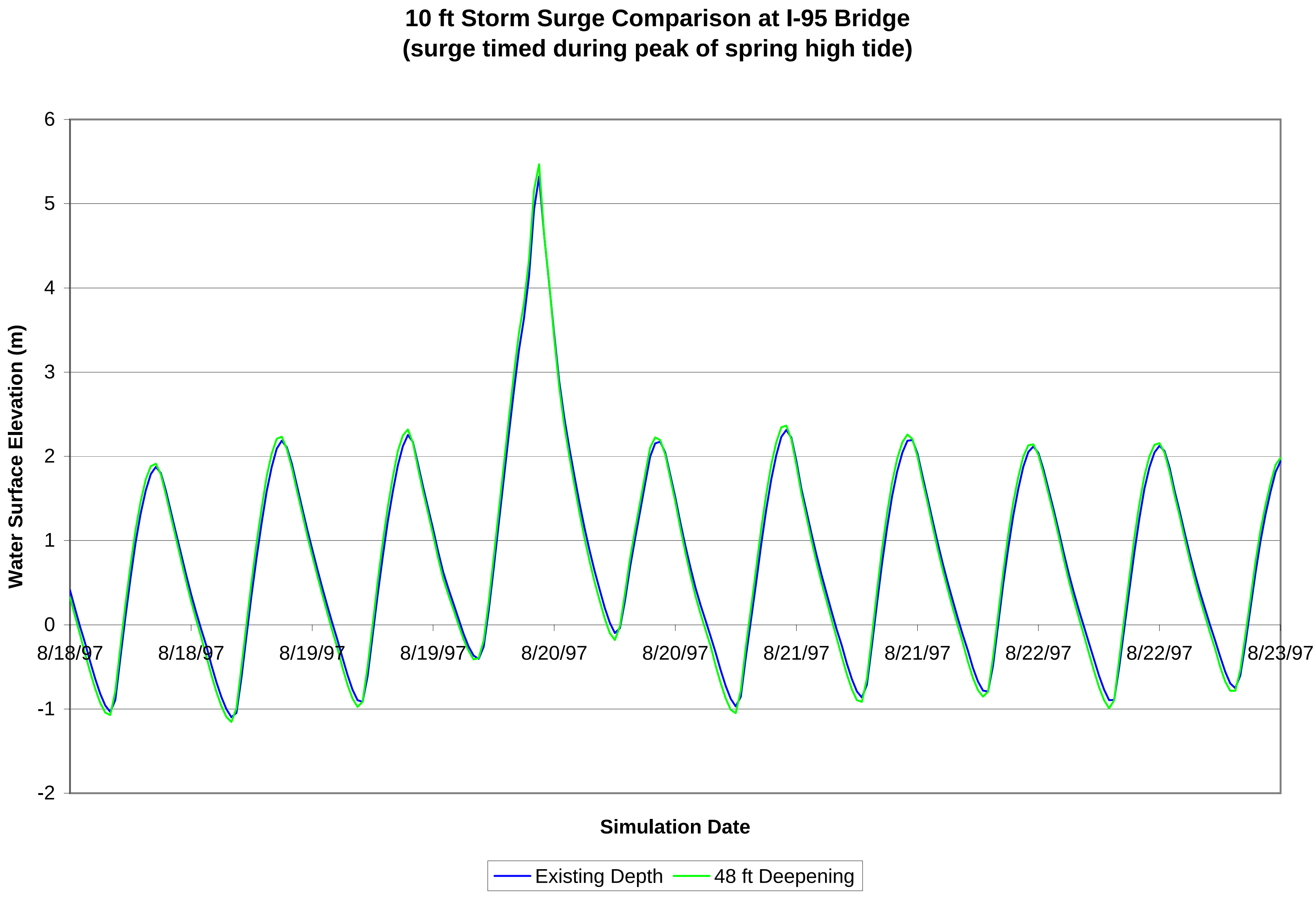
Hurricane Storm Surge Input Conditons
(surge timed during peak of spring high tide)
elevation (ft-NGVD)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
230.8
231.0
231.2
231.4
231.6
231.8
232.0
232.2
232.4
232.6
232.8
time (days)
5 ft surge
15 ft surge
10 ft surge
tide (no surge)


5 ft Storm Surge Comparison at Fort Jackson
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening

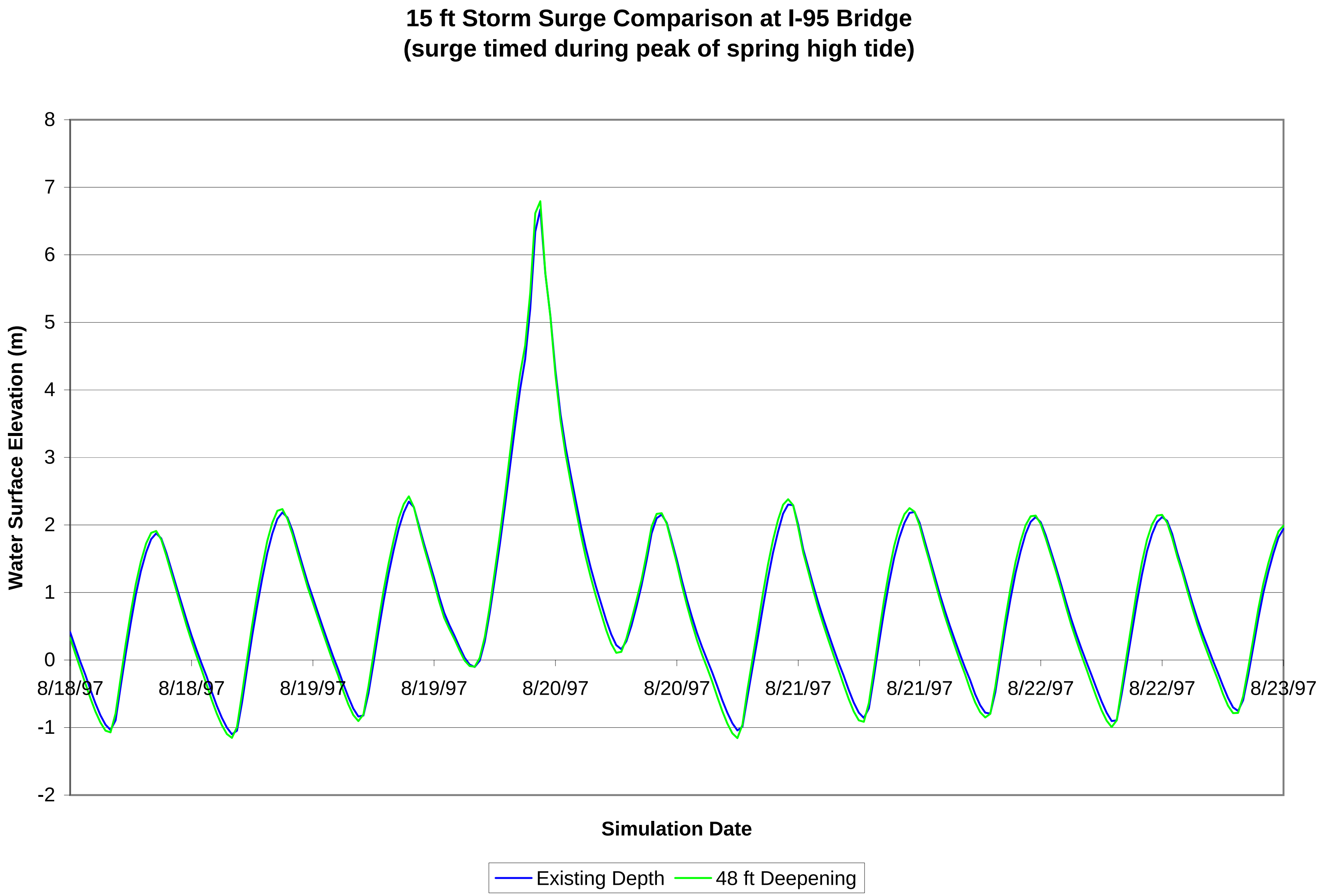

10 ft Storm Surge Comparison at Fort Jackson
(surge timed during peak of spring high tide)
6
5
4
3
2
1
0
-1
-2
Water Surface Elevation (m)
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening


15 ft Storm Surge Comparison at Fort Jackson
(surge timed during peak of spring high tide)
7
6
5
4
3
2
1
0
-1
-2
Water Surface Elevation (m)
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening


5 ft Storm Surge Comparison at I-95 Bridge
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening

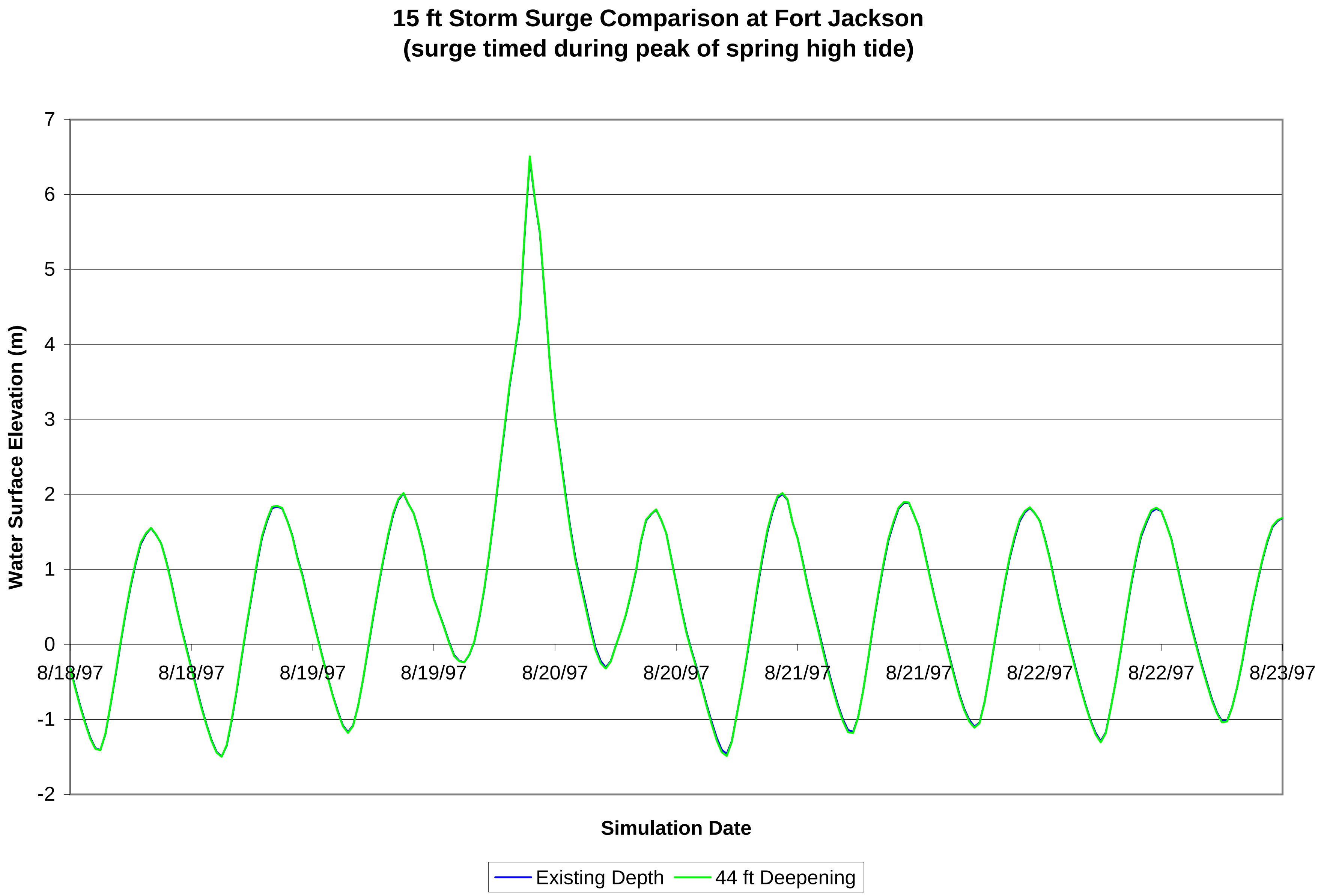


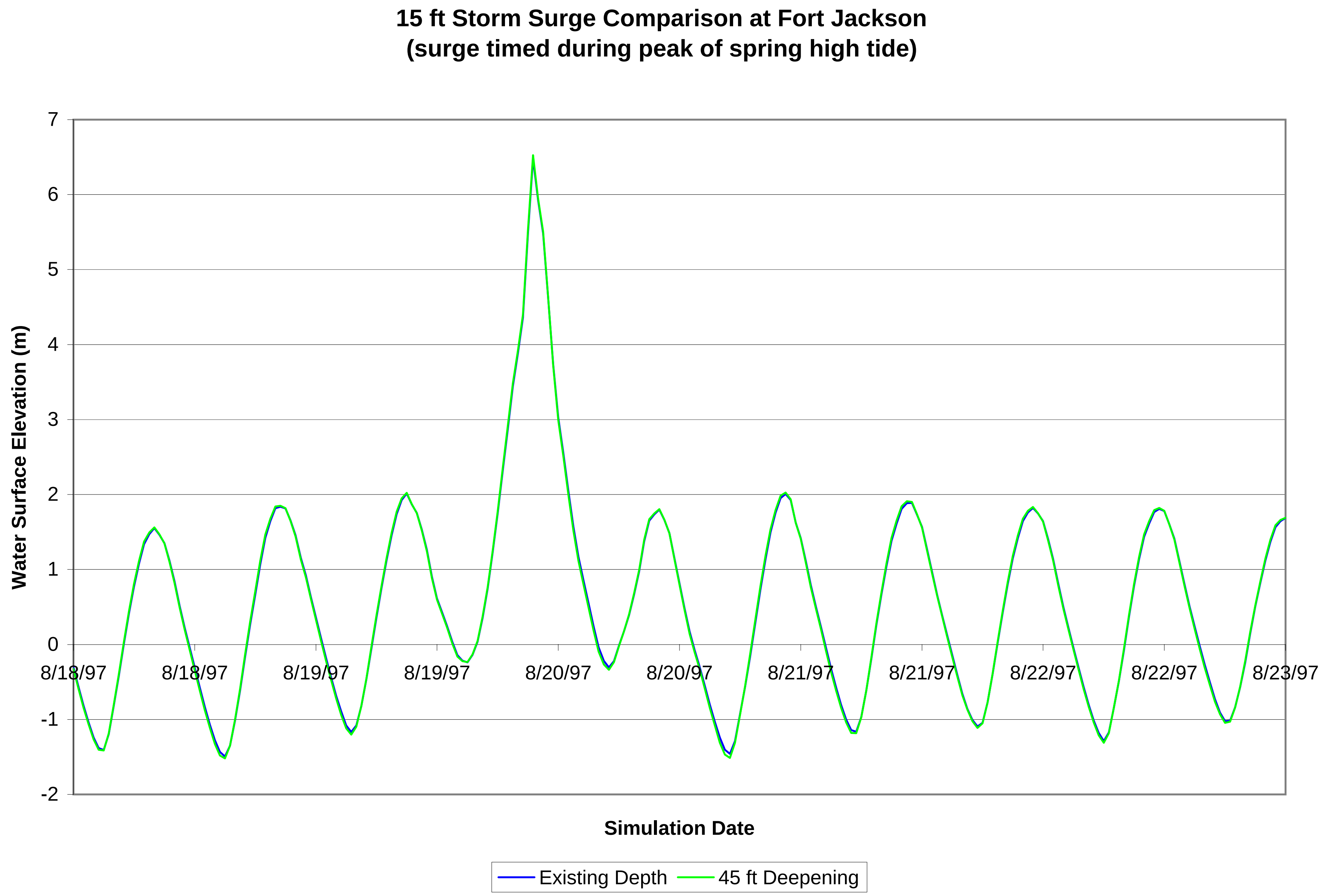
10 ft Storm Surge Comparison at I-95 Bridge
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening

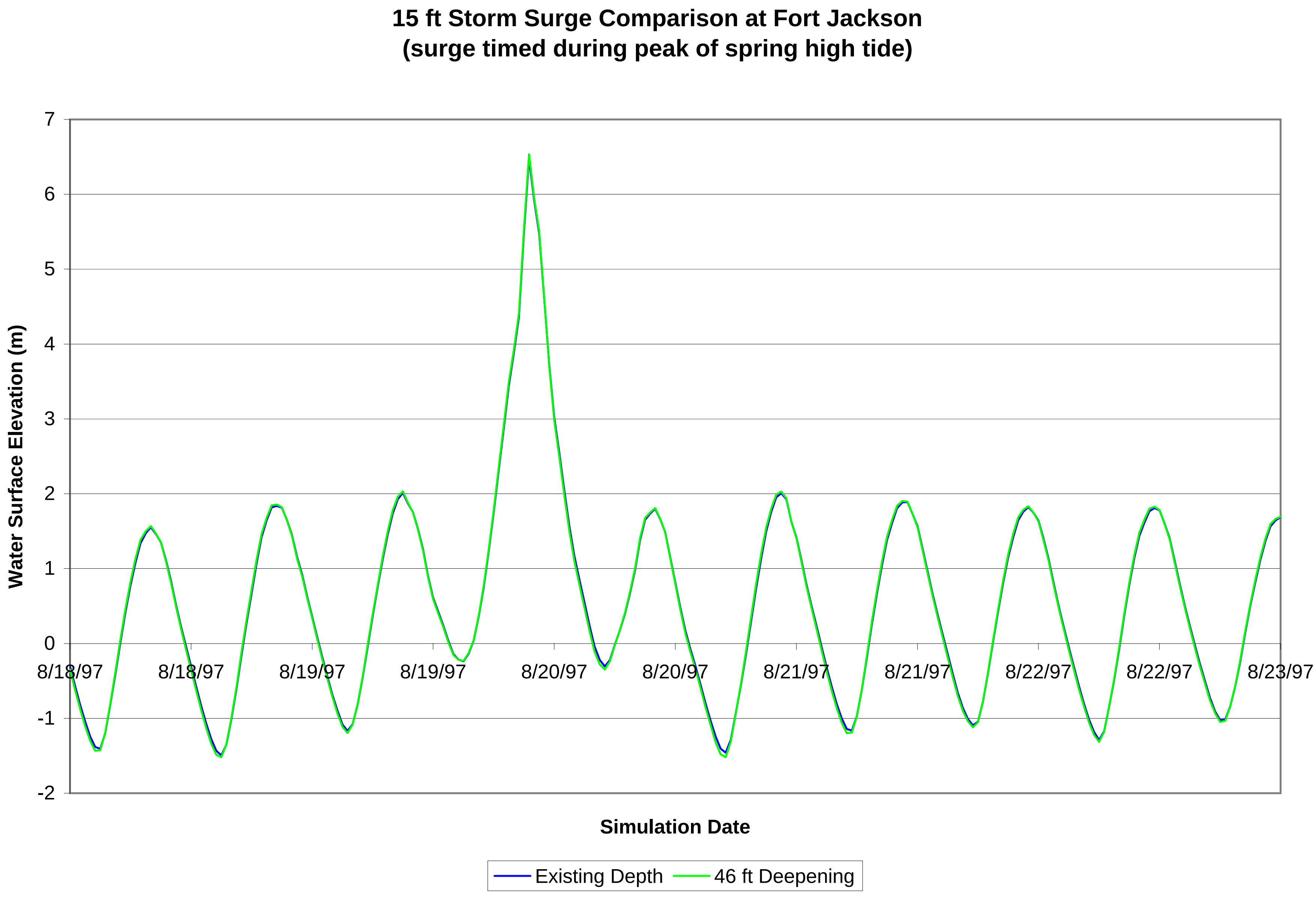

15 ft Storm Surge Comparison at I-95 Bridge
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
8
7
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
48 ft Deepening

Output Data

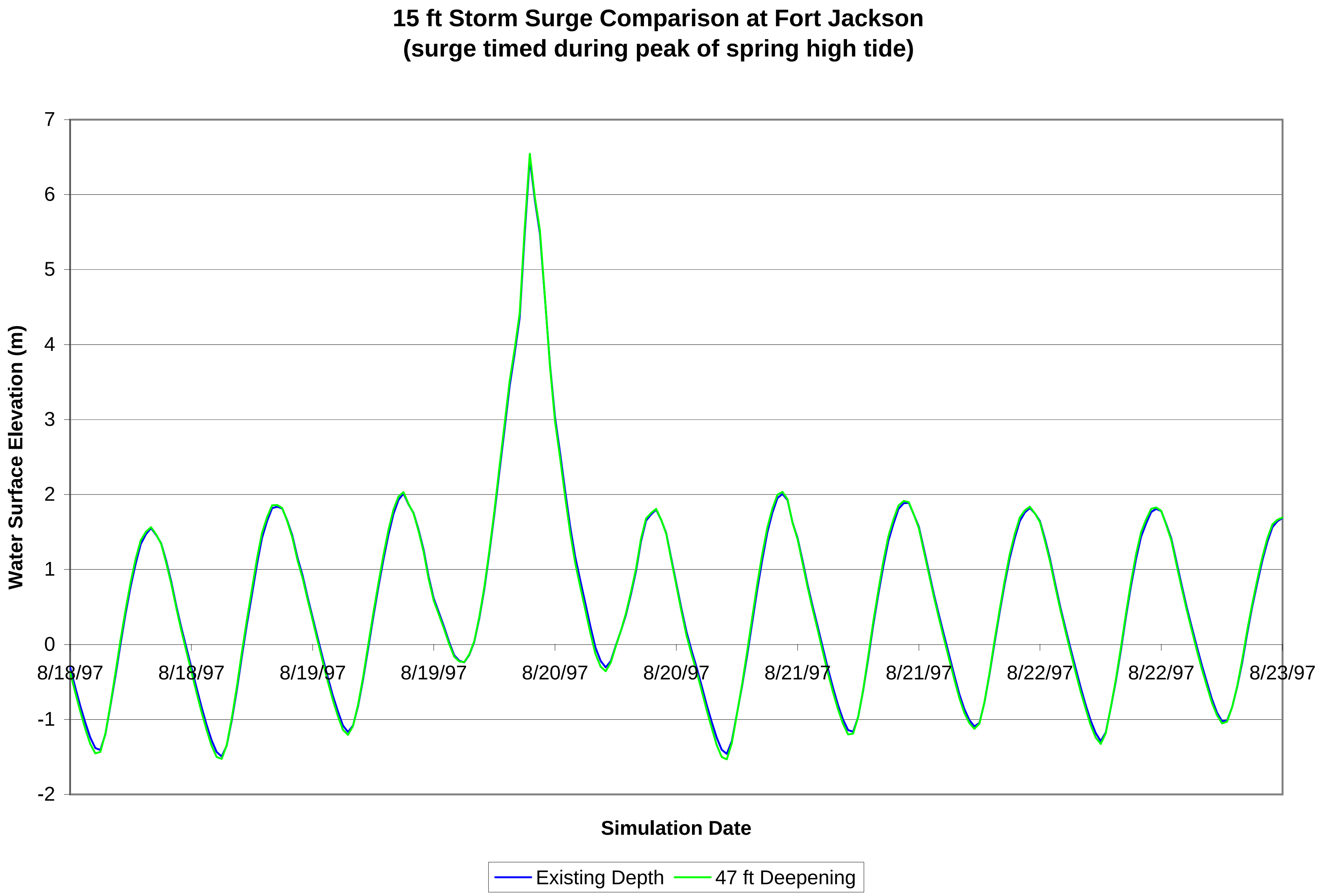
Water surface Elevations for Existing and
47, 46, 45, and 44 ft Deepening
(15 ft surge only, timed during peak of spring high tide)

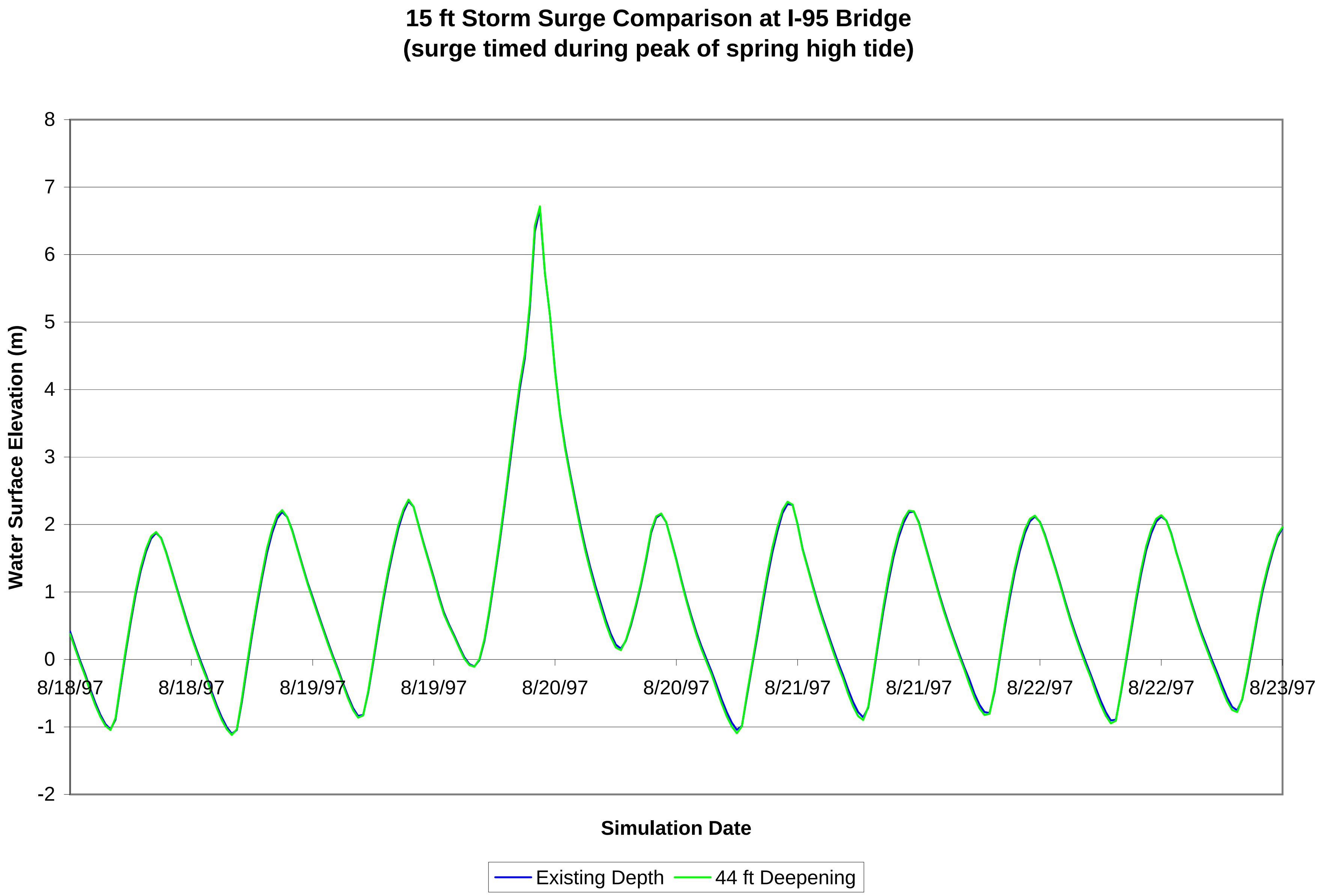

15 ft Storm Surge Comparison at Fort Jackson
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
7
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
44 ft Deepening

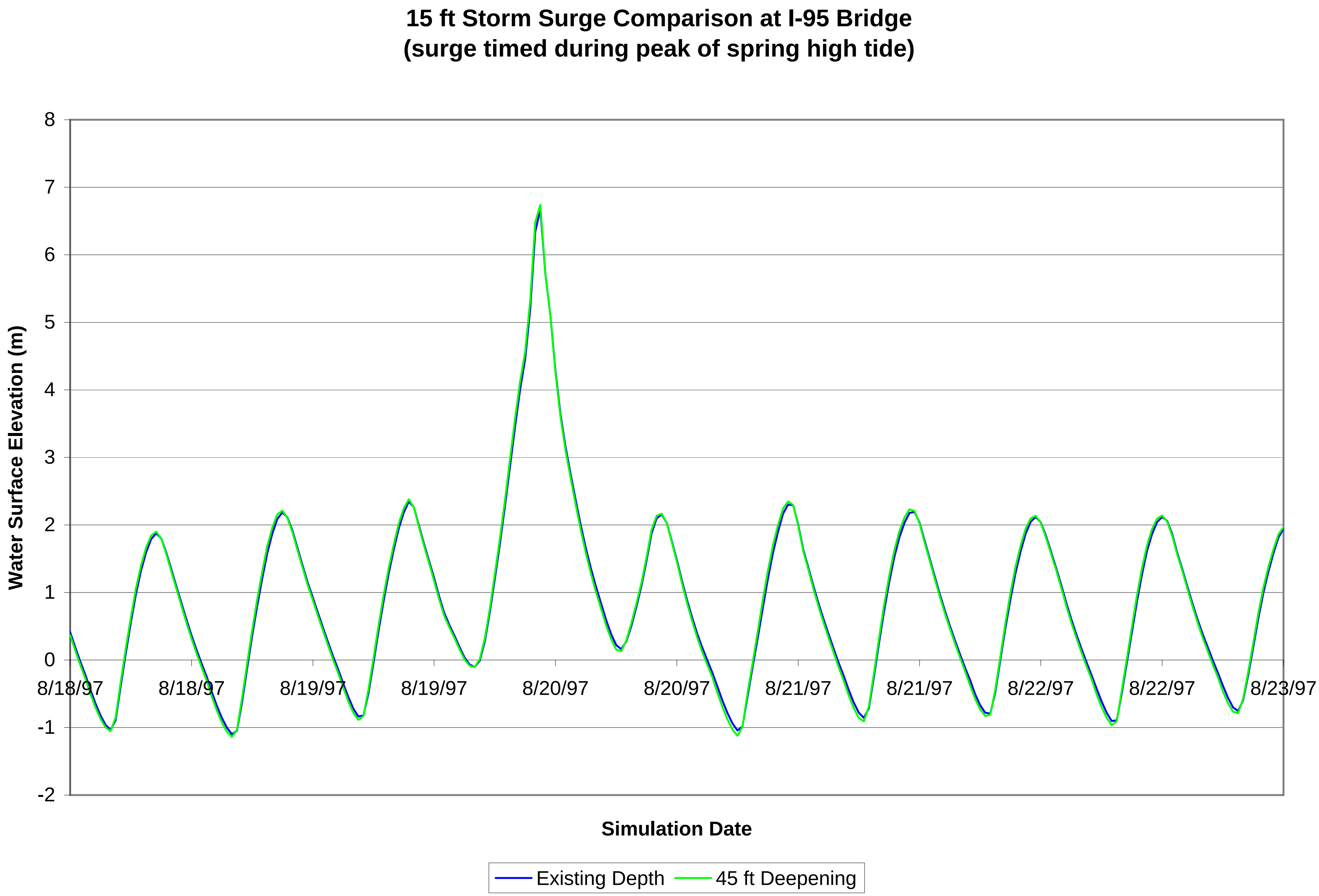

15 ft Storm Surge Comparison at Fort Jackson
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
7
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
45 ft Deepening

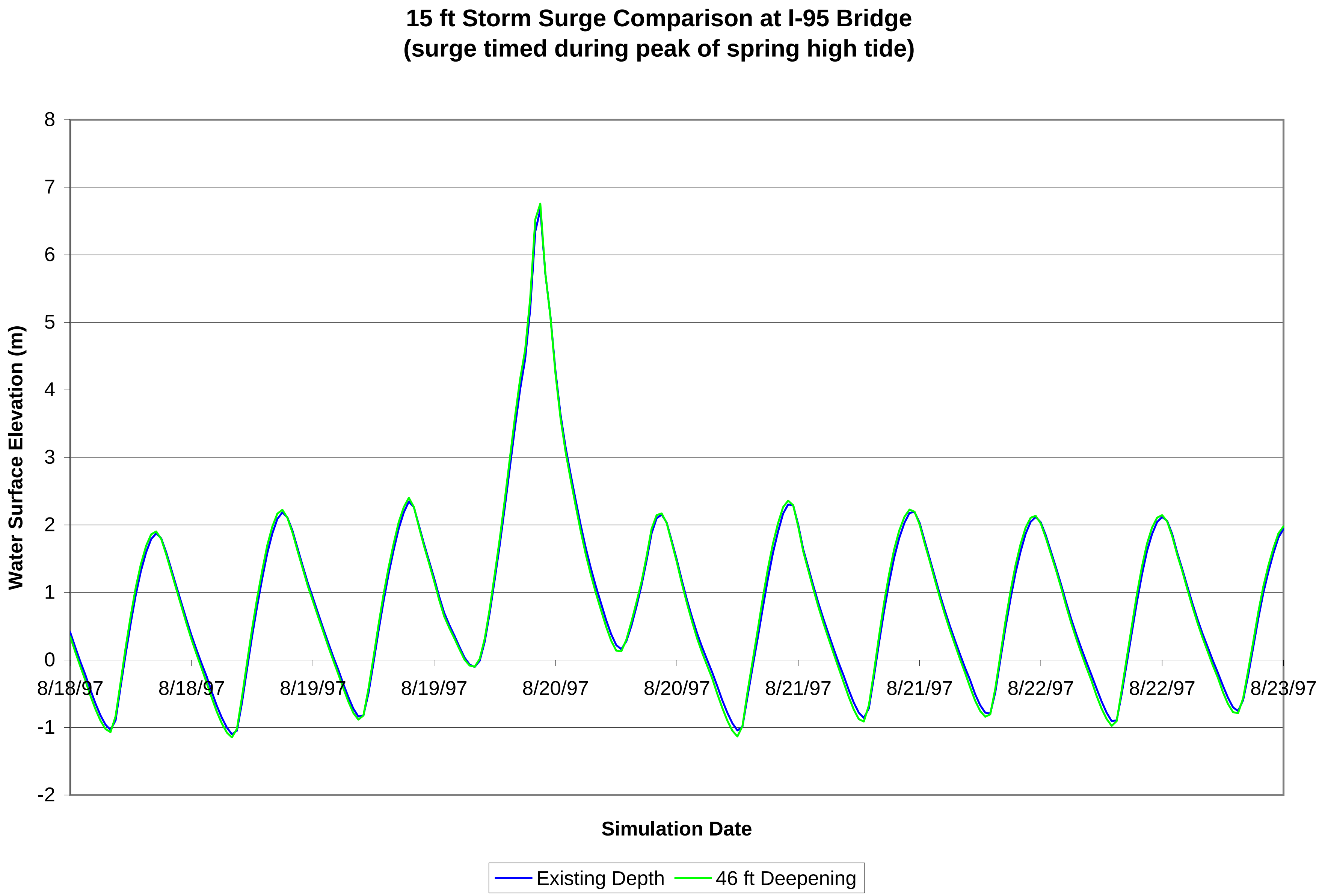


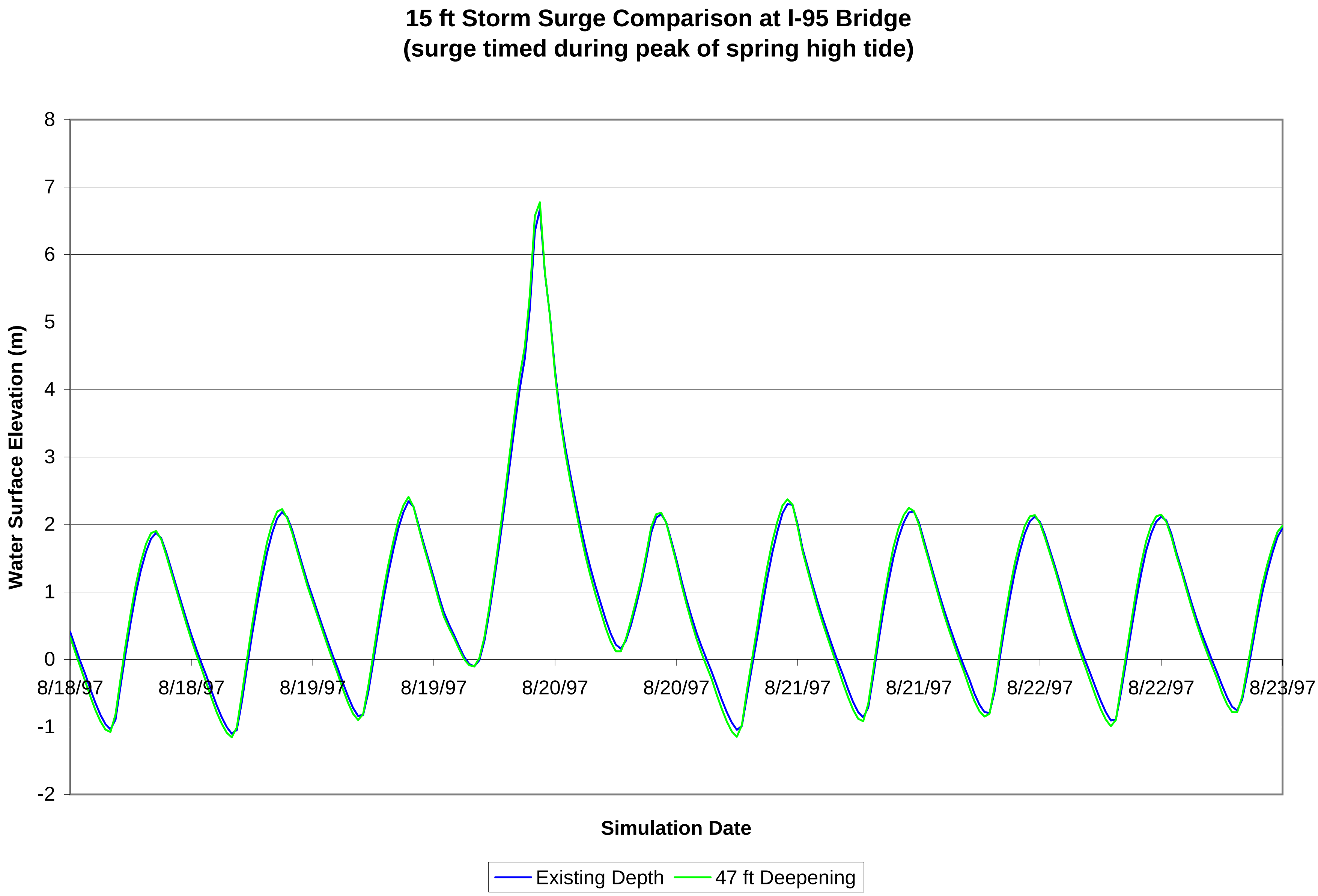
15 ft Storm Surge Comparison at Fort Jackson
(surge timed during peak of spring high tide)
7
6
5
4
3
2
1
0
-1
-2
Water Surface Elevation (m)
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
46 ft Deepening


15 ft Storm Surge Comparison at Fort Jackson
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
7
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
47 ft Deepening


15 ft Storm Surge Comparison at I-95 Bridge
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
8
7
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
44 ft Deepening


15 ft Storm Surge Comparison at I-95 Bridge
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
8
7
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
45 ft Deepening


15 ft Storm Surge Comparison at I-95 Bridge
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
8
7
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
46 ft Deepening


15 ft Storm Surge Comparison at I-95 Bridge
(surge timed during peak of spring high tide)
Water Surface Elevation (m)
8
7
6
5
4
3
2
1
0
-1
-2
8/18/97
8/18/97
8/19/97
8/19/97
8/20/97
8/20/97
8/21/97
8/21/97
8/22/97
8/22/97
8/23/97
Simulation Date
Existing Depth
47 ft Deepening