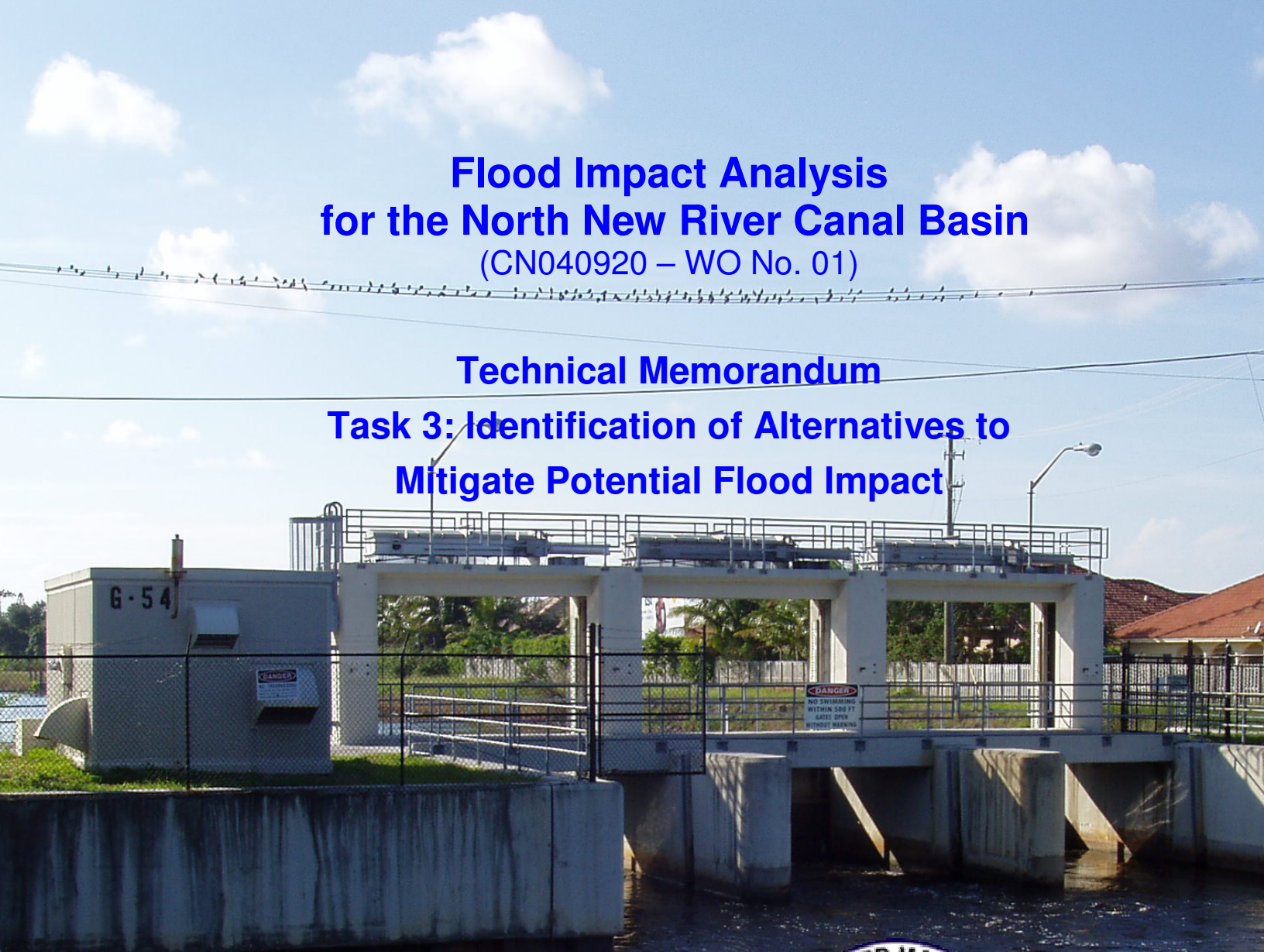
Flood Impact Analysis for the North New River Canal Basin

(CN040920 – WO No. 01)

Technical Memorandum

Task 3: Identification of Alternatives to Mitigate Potential Flood Impact



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September, 2005

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Earth Tech Project No. 81375

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1.0 INTRODUCTION

The 2003 Everglades Protection Area Tributary Basins Long-Term Plan for achieving Water Quality Goals recommends discontinuing the use of G-123 to pump runoff into the Water Conservation Area (WCA) 3A, other than as may be absolutely necessary for water supply emergencies. North New River Canal (NNRC) Basin stakeholders have expressed concerns that discontinuing the use of the G-123 Pump Station may reduce flood protection in the basin.

Earth Tech has been contracted to evaluate the impact of the operation of the G-123 Pump Station on the flooding that occurs in the NNRC Basin during storm events. For that purpose, a screening-level XP-SWMM computer model is being used to simulate two recorded events and to assess flooding conditions under two scenarios for each storm: with and without the G-123 pump operation.

The NNRC Basin covers an area of approximately 19,000 acres (30 square miles) in eastern Broward County. The basin is located southeast of WCA 2B, west of the Florida Turnpike, and north of Interstate Highway 595. The NNRC Basin is located immediately to the north of the C-11 West Basin, separated only by the NNRC. A map of the NNRC Basin is presented on Figure 1.

The review and analysis of the available data pertaining to the NNRC Basin, and the collection of the data needed to construct a hydraulic model of the NNRC Basin, were reported in the memorandum summarizing the first task of this assignment. The District and the stakeholders reviewed the memorandum. It was then finalized and submitted to the District in February 2005.

Under the second task of this study, a technical memorandum was prepared to document the development of the XP-SWMM model for the NNRC Basin and the hydraulic analysis performed to evaluate the impact of the operation of the G-123 Pump Station on the flooding in the NNRC Basin. The District and the stakeholders reviewed the memorandum. It was then finalized and submitted to the District in July 2005.

The present technical memorandum was prepared in accordance with Task 3 of Work Order CN040920-WO01, as revised by the South Florida Water Management District (SFWMD) in August 2005. The results of the Task 2 modeling point to a reduction of head losses as a possible mitigation for the flooding in the NNRC Basin. Two alternatives previously proposed, pump stations at the G-54 Structure, or at the S-124 Structure, will not be evaluated, as they do not appear feasible at this time. The following activities are included as part of the revised Task 3:

a. Simulation of North New River Canal Conveyance Improvements:

- Reduction in the roughness coefficient (Manning's n) to 0.035, which would be representative of a cleared channel, free of excessive vegetation and irregularities.
- Lowering of the canal bottom to simulate a dredging operation. Incremental analysis was performed to estimate benefits of dredging (1) the NNRC from G-54 Structure to the C-42 Canal, (2) the C-42 Canal to the S-125 Structure, and (3) the NNRC from the C-42 Canal to the S-124 Structure.

A conceptual level cost of the improvements required to offset the potential flood impact has been developed for planning purposes.

b. Limited use of G-123 during extreme flood events: The frequency and magnitude of discharge through the G-123 Pump Station has been estimated based on the frequency analysis performed in Task 1.

2.0 NORTH NEW RIVER CANAL CONVEYANCE IMPROVEMENTS

2.1 Introduction

The results of the simulation performed under Task 2 show that the G-123 Pump Station is capable of lowering the water level in the NNRC and C-42 Canals between approximately 6 and 9 inches during the storm events simulated, i.e., the Hurricane Irene (October 15, 1999), an event slightly smaller than a 10-year storm event, and the No-Name Storm (October 3, 2000), which is slightly less than a 5-year storm. The impact of the G-123 Pump Station on the NNRC Basin flooding at a key point is summarized on Table 1 below.

Table 1 – Impact of G-123 on Flooding

Structure	Impact of G-123 Pumping Station on peak stage at key controlled points (ft) ("without" - "with" pumping)	
	Hurricane Irene	No-Name Storm
G-123	0.77	0.65
S-124	0.69	0.57
S-125	0.53	0.44

2.2 Modifications to the XP-SWMM Model

The initial XP-SWMM simulations performed for the purpose of this task indicated that a reduction in head losses along the canal might have a significant impact on the conveying capacity of the canal. Preliminary results of simulations with canal improvements showed a large discharge increase at the G-54 Structure. The water level downstream of that structure, which was taken as a boundary condition for Task 2, may be affected by the increased discharge. It was recognized that the historical stage records for the considered events may no longer represent the hydraulic conditions associated with an improved canal conveyance.

In order to take into account this possible effect, the lower NNRC Basin would need to be simulated, including approximately 7 miles of river to the mouth. This modeling is clearly outside the scope of the present study. While it is recognized that a rating curve cannot be well defined in a tidal situation, the study is mainly concerned with extreme water levels. For the purpose of better approximating peak stages, the recorded water stages downstream of G-54 were plotted against the discharges at G-54.

Using the largest discharges for each storm (Irene and No-Name), an envelope-rating curve was developed as shown in Figure 2. It is anticipated that during the initial phase of the storms the simulated water level in the canal would not be significantly affected as the G-54 gates control it. It is also estimated that during the period of peak stage along the canal, the use of the rating curve will provide a better approximation of the water stage resulting from the increased discharge through G-54.

Using the calibrated model, the use of the rating curve shown on Figure 2 was tested by comparing the resulting peak stages at G-123, S-124 and S-125 for each storm, with the actual records. The results of this comparison are shown in Table 2 below. These results are estimated to be an acceptable fit to the actual records.

Table 2 – Revised Simulated Peak Stages

Structure	Hurricane Irene		No-Name Storm	
	Observed Stage (ft-NGVD)	Simulated Stage (ft-NGVD)	Observed Stage (ft-NGVD)	Simulated Stage (ft-NGVD)
G-123	8.56	8.47	6.56	6.57
S-124	8.19	8.46	6.70	6.63
S-125	8.16	8.21	6.88	6.79

Improvements to the conveyance of the NNRC and the C-42 Canal were simulated in five steps for each storm as listed below.

- ***Clearing of the canals*** – For this simulation the Manning's n was lowered to 0.035. A map of the considered improvement is shown on Figure 3.
- ***Removal of sediment accumulation*** - The November 2004 echo-sounding, performed by the District, indicates that the lower reach of the NNRC, from approximately Pine Island Road to the G-54 Structure, may locate the bottom at a higher level than that indicated on the older surveys. The bottom is shown to be between -3.0 and 0.0 ft-NGVD. For this simulation, the cross-sections along that 2.5-mile-long reach were modified to have a 70-foot-wide bottom at an elevation of -5.0 ft-NGVD; the location of this improvement is shown on Figure 4. The simulations for this improvement are referred to as Dredged#1. Profiles of the NNRC bottom surveyed in October 2004 and of the proposed improvement are shown on Figure 5.
- ***Lowering of the NNRC bottom from the G-54 Structure to the C-42 Canal*** – The location of this improvement is shown on Figure 6. The canal bottom along that 4.4-mile reach was lowered to -8.0 ft-NGVD over a 50-foot width. The current canal bottom along this reach is estimated to be between -7.0 and -4.5 ft-NGVD. A profile showing this improvement is presented on Figure 7. The simulations for this improvement are referred to as Dredged#2.
- ***Lowering of the C-42 Canal bottom to the S-125 Structure*** – In addition to the previous improvement, the canal bottom along the 2.7-mile-long reach of the C-42 Canal, from the NNRC to Sunrise Boulevard, was lowered to -6.0 ft-NGVD over a 15-foot width. The canal bottom between Sunrise Boulevard and the S-125 Structure was sloped from -6.0 to -2.0 ft-NGVD. A map of this improvement is shown on Figure 8. The current canal bottom along the C-42 Canal is estimated to be between -4.0 and -1.0 ft-NGVD. A profile showing the simulated improvement of Canal C-42 is presented on Figure 9. The simulations for this improvement are referred to as Dredged#3.
- ***Lowering of the NNRC bottom from the C-42 Canal to the S-124 Structure*** – The location of this improvement is shown on Figure 10. The canal bottom along that 4.4-mile long reach was lowered to -8.0 ft-NGVD over a 50-foot width. The current canal bottom along this reach is estimated to be between -7.0 and -4.0 ft-NGVD. A profile showing the improvement along the NNRC is presented on Figure 11. The simulations for this improvement are referred to as Dredged#4.

2.3 XP-SWMM Simulation Results

2.3.1 Canal Clearing

This improvement was simulated by lowering the Manning's n to 0.035 along all the canal reaches. The results of the simulations are shown in Figures 12 and 13 for Hurricane Irene and the No-Name Storm, respectively. A summary of the peak stages reached during the events is presented in Table 3 below. The table presents the actual records, and the simulation results under the existing conditions, as well as for the simulation with and without the G-123 Pump Station in operation.

Table 3 – Impact of the Clearing of the Canals

	Hurricane Irene			No-Name Storm		
	Peak Stage at G-123 (ft-NGVD)	**Peak Stage at S-124 (ft-NGVD)**	**Peak Stage at S-125 (ft-NGVD)**	**Peak Stage at G-123 (ft-NGVD)**	**Peak Stage at S-124 (ft-NGVD)**	**Peak Stage at S-125 (ft-NGVD)**
Recorded Stage	8.56	8.19	8.16	6.56(*)	6.70(*)	6.88(*)
Existing Conditions without G-123	8.47	8.46	8.21	7.39	7.36	7.37
Existing Conditions with G-123 at Full Capacity (400 cfs)	7.56	7.61	7.54	6.39	6.49	6.75
Cleared Canals without G-123 (Figures 3 and 4)	**7.99**	**7.98**	**7.67**	**7.05**	**7.02**	**7.13**

(*)With G-123 pumping approximately 300 cfs

The simulations indicate an average lowering of the peak stage of 0.50 ft and 0.27 ft for Hurricane Irene and the No-Name Storm, respectively. This improvement would not have been sufficient to offset the G-123 pumping operation at full discharge capacity (400 cfs).

2.3.2 Sediment Removal

This improvement was simulated by lowering the bottom of the NNRC to -5.0 ft-NGVD along the 2.5-mile long downstream reaches, from approximately the Pine Island Road Bridge to the G-54 Structure. The results of the simulations are shown in Figures 14 and 15 for Hurricane Irene and the No-Name Storm, respectively. A summary of the peak stages reached during the events is presented on Table 4 below. The table presents the actual records and the simulation results under the existing conditions, as well as for the simulation with and without the G-123 Pump Station in operation.

Table 4 – Impact of Sediment Removal in Lower NNRC

	Hurricane Irene			No-Name Storm		
	Peak Stage at G-123 (ft-NGVD)	**Peak Stage at S-124 (ft-NGVD)**	**Peak Stage at S-125 (ft-NGVD)**	**Peak Stage at G-123 (ft-NGVD)**	**Peak Stage at S-124 (ft-NGVD)**	**Peak Stage at S-125 (ft-NGVD)**
Recorded Stage	8.56	8.19	8.16	6.56(*)	6.70(*)	6.88(*)
Simulation Existing Conditions without G-123 Pump Station	8.47	8.46	8.21	7.39	7.36	7.37
Simulated Existing Conditions with G-123 Pump Station at Full Capacity (400 cfs)	7.56	7.61	7.54	6.39	6.49	6.75
After Sediment Removal without G-123 (Figures 5 and 6)	**7.85**	**7.83**	**7.46**	**6.79**	**6.76**	**6.78**

(*)With G-123 pumping approximately 300 cfs

The simulations indicate an average lowering of the peak stage of 0.67 ft and 0.60 ft for Hurricane Irene and the No-Name Storm, respectively. When considering water stages at the G-123 and S-124 Structures, this improvement would not have been sufficient to offset the G-123 pumping operation at full discharge capacity (400 cfs); however, the simulations show the improvement would have lowered the peak stage at the S-125 Structure sufficiently to offset the operation of G-123.

2.3.3 Canal Deepening

The analysis for these improvements was performed incrementally. The first improvement was simulated by lowering the bottom of the NNRC to -8.0 ft-NGVD along the 4.4-long downstream reaches, from the junction with the C-42 Canal to the G-54 Structure. The results of the simulations are shown in Figures 7 and 8 for Hurricane Irene and the No-Name Storm, respectively. The second improvement consists of lowering the bottom of the C-42 Canal to -6.0 ft-NGVD from its junction with the NNRC up to the Sunrise Boulevard culvert, a 2.7-mile long reach. The remaining portion of the C-42 Canal, approximately 1.1-mile long, was sloped from -2.0 ft-NGVD at the S-125 Structure to -6.0 ft-NGVD, at the Sunrise Boulevard Culvert. For the purpose of the simulation, the culverts at Sunrise Boulevard and Broward Boulevard were not modified. The third improvement was simulated by lowering the bottom of the NNRC to -8.0 ft-NGVD along the 4.4-long reach, from the S-124 Structure to the junction with the C-42 Canal. The results of the simulations are shown in Figures 9 and 10 for Hurricane Irene and the No-Name Storm, respectively. A summary of the peak stages reached during the events is presented in Table 5 below. The table presents the actual records and the simulation results under the existing conditions, as well as the results of simulations run with and without the G-123 Pump Station in operation.

Table 5 – Impact of Canal Deepening

	Hurricane Irene			No-Name Storm		
	Peak stage at G-123 (ft-NGVD)	**Peak stage at S-124 (ft-NGVD)**	**Peak stage at S-125 (ft-NGVD)**	**Peak stage at G-123 (ft-NGVD)**	**Peak stage at S-124 (ft-NGVD)**	**Peak stage at S-125 (ft-NGVD)**
Recorded Stage	8.56	8.19	8.16	6.56(*)	6.70(*)	6.88(*)
Existing Conditions without G-123	8.47	8.46	8.21	7.39	7.36	7.37
Existing Conditions with G-123 at Full Capacity (400 cfs)	7.56	7.61	7.54	6.39	6.49	6.75
Deepen NNRC from C-42 to G-54 without G-123 (Figures 7 and 8)	**7.79**	**7.77**	**7.37**	**6.70**	**6.67**	**6.67**
Deepen NNRC from C-42 to G-54 and Deepen C-42 without G-123 (Figures 9 and 10)	**7.79**	**7.77**	**7.37**	**6.65**	**6.62**	**6.60**
Deepen NNRC from S-124 to G-54 and Deepen C-42 without G-123 (Figures 9 and 10)	**7.65**	**7.63**	**7.44**	**6.56**	**6.53**	**6.57**

(*)With G-123 pumping approximately 300 cfs

The simulations of the deepening of the NNRC lower reach indicate an average lowering of the peak stages of 0.73 ft and 0.70 ft for Hurricane Irene and the No-Name Storm, respectively. This improvement would not have been sufficient to offset the G-123 pumping operation at full discharge capacity (400 cfs) at the G-123 and S-124 Structures. It would have, however, lowered the peak stage at the S-125 Structure sufficiently to offset the operation of G-123. The dredging of the C-42 Canal would not have had an impact during Hurricane Irene and, on average it would have lowered the water level during the No-Name storm by 0.75 ft. The dredging to -8.0 ft-NGVD of the full length of the NNRC between the S-124 and G-54 Structures in addition to the dredging of the C-42 Canal to -6.0 ft-NGVD would have resulted in lowering the average peak stage by 0.78 ft and 0.79 ft for Hurricane Irene and the No-Name Storm relative to the "without" simulations, respectively. The impact of the improvement is not the same at all locations. The operation of the G-123 Pump Station would have been completely offset at the S-125 Structure. The peak water stages at G-123 would have remained 0.09 ft and 0.17 ft above the expected water level when the pumps are in operation at full capacity, for Hurricane Irene and the No-Name Storm, respectively. The peak water stages at S-124 would have remained 0.02 ft and 0.04 ft above the expected water level when the pumps are operating at full capacity, for Hurricane Irene and the No-Name Storm, respectively.

2.4 Costs of Improvements

For each of the alternative improvements, the quantity estimates of material to be excavated were obtained from the XP-SWMM simulation by computing the volume differences between canal cross-sections. The quantities are presented in Table 6 below.

Table 6 – Quantities for Conveyance Improvements

	Canal Length to be cleared (miles)	Sediment Removal (cu yd)	Excavation (cu yd)
Clearing of Canals	12.4	-	-
Sediment Removal from Pine Island Bridge to G-54	12.4	103,000	-
Deepening of NNRC from C-42 to G-54	12.4	103,000	237,000
Deepening of NNRC from C-42 to G-54 and Deepening of C-42	12.4	103,000	307,000
Deepening of NNRC from S-124 to G-54 and Deepening of C-42	12.4	103,000	537,000

Unit costs for each of the three main items were obtained from a similar project in South Florida. For the purpose of estimating the implementation cost of these improvements, allowances of 18% for incidental related construction costs (including maintenance of traffic, mobilization and demobilization, insurance and bonds, testing and miscellaneous services), 25% for contingencies, 7% for engineering and 10% construction management services were added to the estimate. The cost estimates for each of the improvements are shown in Table 7 below.

The clearing costs cover the removal of aquatic vegetation and debris on the NNRC upstream of G-54 Structure to the S-124 Structure, and on the C-42 canal from its junction with the NNRC to the S-125 Structure.

The sediment removal is anticipated to be a dredging operation: 25% of the material is assumed to be disposed in a landfill located within a 20-mile radius from the canal. A $30 per ton tipping fee has been included in the estimate. The remaining material is anticipated to be transported and placed for unspecified beneficial reuse within 10 miles of the project. It is also assumed that the material would be disposed of free of charge.

For the canal deepening, the excavated material will be stockpiled and partially drained prior to being transported to a disposal area within 10 miles of the project. It is assumed that the excavated material can be ripped using conventional, readily available excavation equipment. Similar to the sediment it is assumed that the material can be placed for an unspecified beneficial reuse free of charge. Transportation cost of that material has been included in the estimate.

Table 7 – Conceptual Level Cost Estimates

	Clearing of Canals	Sediment Removal from Pine Island to G-54	Deepening of NNRC from C-42 to G-54	Deepening of NNRC from C-42 to G-54 & Deepening of C-42	Deepening of NNRC from S-124 to G-54 & Deepening of C-42
Clearing Costs	$300,000	$300,000	$300,000	$300,000	$300,000
Sediment Removal Costs	-	$4,854,000	$4,854,000	$4,854,000	$4,854,000
Excavation Costs	-	-	$11,851,000	$15,351,000	$26,851,000
Other Related Costs (18%)	$54,000	$928,000	$3,060000	$3,690,000	$5,760,000
Contingencies (25%)	$104,000	$1,790,000	$5,904,000	$7,120,000	$11,113,000
Engineering and Administration (17%)	$63,000	$1,077,000	$3,552,000	$4,283,000	$6,685,000
Total Budget Estimate	**$521,000**	**$8,949,000**	**$29,521,000**	**$35,598,000**	**$55,563,000**

These preliminary cost estimates were prepared at the planning level for the purpose of screening alternatives. The details of these calculations are presented in Appendix A.

3.0 LIMITED USE OF G-123 DURING EXTREME FLOOD EVENTS

3.1 Historical Use of G-123

It has been estimated that within 28 separate events, between 1993 and 2003, a total volume of 203,200 acre-feet of water was pumped through the G-123 Pump Station. While the majority of this volume was intended for water supply purposes, based on a comparison of these events with the corresponding rainfall data, it is found to be likely that 13 pumping events might have had the added benefit of flood control. Table 8 lists each of the events, considered to be flood control related, and their corresponding pumped volumes totaling 75,600 acre-feet.

The events selected as flood control events were selected based on the amount of rain recorded on the basin on the day of, and day prior to, the onset of the pumping event. If over an inch of rain was recorded during that window of time, the event was listed as a flood control event. An exception was made for the July/August event in 2001. During this event, though rain was recorded at the onset of the pumping event, the amount of rain did not warrant the lengthy period of time when pumping occurred. A second exception was made in the inclusion of pumping during the No-Name storm. It appears that pumping had started prior to the storm; however, after the spike of rain attributed to the storm, pumping increased and continued considerably. The volume pumped after the spike of rain was included in the flood control volume total.

Table 8 – Estimated Pumped Volume for Flood Control Purpose

Event Dates	Total Volume (Acre-Feet)	S-124 HW Stage at Start of Event (ft-NGVD)	S-124 TW Peak Stage during the Event (ft-NGVD)	Return Period (yr)
Sept 12, 93 –Oct 12, 93	14,100	4.73	4.98	1.25
July 21, 94 – Aug 23, 94	12,000	4.73	4.68	<1
Apr 14, 97 – Apr 23, 97	2,500	5.54	4.84	1
Apr 28, 97 – Apr 30, 97	470	5.03	4.83	1
May 13, 97 – May 27, 97	2,540	5.21	4.56	<1
Jun 2, 97 – Jun 18, 97	6,540	5.04	4.70	<1
Oct 3, 2000 – Nov 7, 2000 (No-Name)	10,800	5.26	6.28	8
Dec 10, 2000 – Dec 20, 2000	5,640	5.10	4.53	<1
Mar 19, 2001 – Apr 11, 2001	9,400	4.14	4.63	<1
May 4, 2001 – May 20, 2001	6,330	4.41	4.99	1.25
Sept 13, 2001 – Sept 16, 2001	1,400	6.12	4.50	<1
Sept 29, 2001 – Oct 1, 2001	1,540	5.81	4.86	1.1
May 27, 2003 – Jun 7, 2003	2,260	4.92	5.42	2.5
Flood Control Total Volume	**75,600**	**-**	**-**	**-**

As indicated in the Technical Memorandum No.1, the stage at the headwater of the S-124 Structure is one of the criteria used to start operation of the G-123 pumps. Table 8 also shows the water level at the headwater of S-124 when the pumps were turned on for that event. In order to assess the severity of the storms, an attempt was made to indicate the return period of each event. For that purpose, the peak tailwater stage at S-124, for which a frequency analysis was performed under Task No.1, and the return periods for the S-124 tailwater stage are indicated on Table 8.

Over the same 11-year period from January 1993 to December 2003, the total volume discharged through the G-54 Structure was approximately 1,821,000 acre-feet, or 166,000 acre-feet per year. It is therefore estimated that on average, approximately 3.7% of the water leaving the NNRC west of G-54 was pumped into the Water Conservation Areas for the purpose of flood control.

3.2 Evaluation of Alternative Operational Rules for G-123

For the purpose of evaluating alternative operational rules for the G-123 Pumping Station, a set of stage thresholds ranging from 5.00 ft-NGVD to 6.25 ft-NGVD was applied to the headwater stage of S-124. The rule would be to start pumping when the threshold level is reached and to operate the pumps at full capacity until either the water level dropped below the threshold, or there is a day without precipitation, whichever comes first. In order to calculate the expected volume that would be pumped under this rule, the 11-year period data was reviewed and each day where the water elevation was recorded as being above the threshold was selected. From those selected dates, days that were consecutive were grouped together. The first day of each group, each consecutive day following when rainfall was recorded, and one additional day, were counted. It was assumed that pumping on those dates would have been sufficient to drop elevations to a level below the threshold. The resulting average annual pumped volumes through G-123 for the various thresholds are indicated on Table 9 below. The table also shows the average number of pumping events per year for each of the thresholds.

Table 9 – G-123 Pumped Volumes with Operational Rules

Threshold HW Stage at S-124 (ft-NGVD)	Average Annual Pumped Volume (ac-ft/yr)	Frequency (Pumping Events per Year)	Percentage of Annual Runoff	Percentage of Current Operation
5.00	25,100	9.7	13.6%	120%
5.25	22,200	9.3	12.1%	106%
5.50	13,600	5.6	7.4%	65%
5.75	7,430	2.9	4.0%	36%
6.00	2,810	1.2	1.5%	13%
6.25	1,440	0.6	0.8%	7%

On this table the average annual pumped volume for each evaluated scenario has been compared to the total annual runoff on the NNRC Basin computed as the sum of the pumped volume through the G-123 and the volume released through the G-54. For example, in the case of the 6.00 ft-NGVD threshold, 2,810 ac-ft per year would have been pumped through G-123, which is approximately 1.5% of the annual NNRC Basin runoff. The average annual volumes to be pumped with the proposed operational rules were also compared to the actual pumped volume for the period 1993 to 2003. In the case of the 6.00 ft-NGVD threshold, the average annual pumped volume would represent approximately 13% of the historical operation. It should be noted that the alternative operational rules did not consider the water level in the WCA. The SFWMD structure book which outlines the operating rules for the control structures in the District indicates that pumping at G-123 must be curtailed if the tailwater stage rises to 11.5 ft-NGVD; however, the purpose of the rule is not explicit and may not be related to flood control. For this reason, it is assumed that G-123 pumping could be allowed for flood control purpose.

The alternative operational rules defined in the previous paragraph were tested using the XP-SWMM model during Hurricane Irene. The implementation of the alternative rules would have delayed the start of the pumping operation at G-123. For example, the start-up would have been delayed by approximately 13 hours in the case of the 6.25 ft-NGVD threshold. The simulations of these scenarios indicate a minor increase of the water stages along the canal over those when pumping starts earlier. The increase of the water level ranges from 0.02 ft with a threshold stage of 5.75 ft-NGVD to 0.05 ft with a threshold at 6.25 ft-NGVD. The results of the simulations are presented in Table 10 below. The similar scenarios were not tested for the No-Name Storm, as the actual pumping at G-123 affected the stage at the headwater of the S-124 Structure, and would have artificially delayed the start of the pumping operation.

Table 10 – XP-SWMM Simulation Results with Alternative Operating Rules

	Hurricane Irene		
	Peak stage at G-123 (ft-NGVD)	**Peak stage at S-124 (ft-NGVD)**	**Peak stage at S-125 (ft-NGVD)**
Exist. Conditions without G-123	8.47	8.46	8.21
Exist. Conditions with G-123 Operating with 6.25 ft-NGVD Threshold	7.61	7.65	7.60
Exist. Conditions with G-123 Operating with 6.00 ft-NGVD Threshold	7.59	7.64	7.58
Exist. Conditions with G-123 Operating with 5.75 ft-NGVD Threshold	7.57	7.62	7.55
Exist. Conditions with G-123 at Full Capacity (400 cfs)	7.56	7.61	7.54

These simulations indicate that the alternative operational rules may be effective in reducing the volume of water pumped from the NNRC Basin into the Water Conservation Areas while still maintaining a similar level of flood protection in the Basin.

A combination of "Dredged#1" alternative improvement and G-123 modified operational rules such as starting at a higher stage, e.g., 6.25 ft-NGVD, has been simulated at the preliminary level. The results of the simulation for Hurricane Irene indicate that such combination would have a significant impact on the flood levels of service in the basin and it would also significantly reduce the runoff volume discharged to the WCA.

4.0 CONCLUSIONS AND RECOMMENDATIONS

From the results presented in Task 2 of this study, it appears that the G-123 pump station is capable of lowering the water level in the NNRC and C-42 Canals between approximately 6 and 9 inches. The simulation indicates that during the No-Name Storm (less than a 5-year storm event), the water levels would have been between 0.44 and 0.65 feet higher if the pump station had not extracted approximately 300 cfs from the system. It also indicates that during Hurricane Irene (smaller than a 10-year storm event) the water levels could have been between 0.53 and 0.77 feet lower if the pump station had extracted 400 cfs from the system. This means that discontinuing the use of G-123 Pump Station would have an adverse impact on the flood protection in the North New River Basin during storm events of similar magnitude. It should be noted, however, that the simulations have not considered that pumping might not have been allowable during Hurricane Irene, as the water level in WCA 2B (11.8 ft-NGVD) was already higher than recommended by the operating procedures, which call for recharge operations to cease when WBA 2B levels exceed 11.5 ft-NGVD.

The work performed under this task consisted of simulating five conveyance improvement alternatives for the NNRC, and providing preliminary conceptual cost estimates for these improvements. The operational rules of G-123 for flood control purposes were reviewed and preliminary alternative rules were evaluated.

- Among the alternative conveyance improvements, it appears the improvement referred to as "Dredged#1" would mitigate the effect of decommissioning G-123 at S-125. This improvement consists of the clearing of aquatic vegetation and debris on the NNRC between G-54 and S-124, and on the C-42 Canal, combined with the removal of approximately 100,000 cubic yards of sediment on the NNRC Canal between G-54 and the Pine Island Bridge. Water levels at other locations along the NNRC are considerably lower than those recorded during the simulated storms, but not low enough to fully mitigate the effect of decommissioning of G-123. The cost for this improvement is estimated to be approximately ***$9,000,000***.
- A detailed survey of the canal cross-sections should be performed to confirm the assumption made for the simulation model and to improve the accuracy of the hydraulic calculations; this survey will also improve the accuracy of the dredging quantities and cost estimates. This survey may be extended downstream of G-54, to simulate and evaluate the possible impact on water stages downstream of G-54 of the NNRC improvements.
- The alternative conveyance improvement corresponding to the dredging of the NNRC between G-54 and S-124, and the dredging of the C-42 Canal, at a preliminary cost estimate of ***$55,500,000***, is close to fully mitigating the flood impact resulting from the non-use of G-123 in the future. The results obtained for this alternative with the model are comparable to those obtained for the "with G-123" alternative given the level of accuracy of the model and the available information.

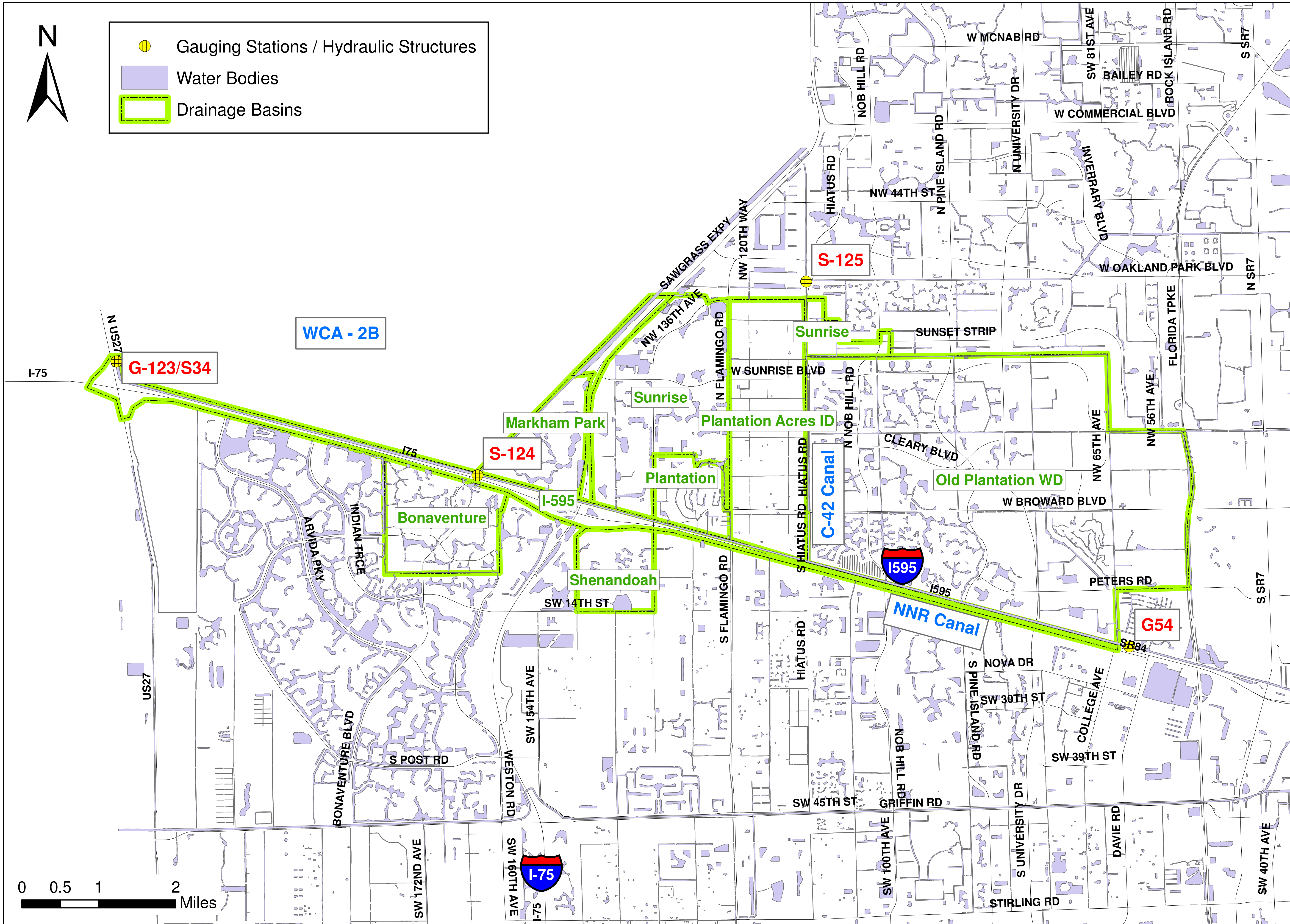
- As an alternative to this costly improvement, several operating protocols for G-123 were tried out using headwater levels at S-124 as the triggering factor. Although a more detailed modeling would be required to assess the full impact on flooding in the NNRC Basin, the preliminary work performed under this task, indicates that pumping at G-123 can be initiated at stages higher than 5.50 ft-NGVD without negatively impacting the flood level of service and considerably reducing the total runoff volume discharged into the WCA.
- A combination of "Dredged#1" and G-123 modified operational rules such as starting at a higher stage, e.g., 6.25 ft-NGVD, is an alternative worth studying further because it would significantly reduce the runoff volume discharged to the WCA and actually improve the flood levels of service in the basin. A detailed model fully driven by rainfall, covering the NNRC basin, would provide the tool necessary to assess not only the current and proposed flood level of service, but it would also provide the data to quantify the long-term volume discharged into the WCA under several alternative operational rules for G-123.

The results of this task confirm the recommendations of Task 2 for future action by the SFWMD to optimize flood protection and to incorporate in its maintenance program the inspection and survey necessary to identify the potential sources of head losses, including:

1. Research should first be performed to investigate whether improvements made after October of 2000 have improved the canal's conveyance since the modeled events.
2. Detailed inspection of the canal by boat to identify potential obstructions and restriction of the flow.
3. Bathymetric survey of the canal to better define the existing canal invert and sediment deposition profiles and cross-sections. This survey is also required to develop more detailed canal improvement schemes and cost estimates.
4. If the bathymetric study confirms it, a geotechnical evaluation of the canal is recommended to determine the level of effort of the dredging/cleaning activities.
5. Perform a steady-state head loss measurement with a controlled release at Structure S-34. This would include stage measurements at regular intervals along the canal, and possibly upstream and downstream of each bridge.
6. Initiate the development of a detailed hydrologic\hydraulic model of the basin. This would mainly consist of incorporating more detailed canal cross-sections from above mentioned survey or bathymetry and defining the hydrology of the basins currently modeled by historical pump records. The model developed as part of the present effort could be readily expanded to model the hydrologic response of all the basins, thereby allowing the simulation of design storm events. Other models within the region of study have been created for various purposes and could help in the overall assessment of the pump operation. These models include the 2x2 SFWMM model, the ICPR stormwater model developed for the City of Sunrise Drainage Master Plan and the MIKE SHE & MIKE 11 model developed to simulate the water management practices in Central Broward Co.

This Work Order is related to the Long-Tern Plan recommendation to discontinue the use of G-123 to pump stormwater runoff into the WCA 3A. Items 1-6 above relate to maintenance and conveyance capacity issues that are not within the scope of this work order, but have been included to aid SFWMD in maintaining long-term flood protection for this basin.

FIGURES



Flood Impact Analysis for the North New River Canal Basin

North New River Canal Basin Map

Figure 1

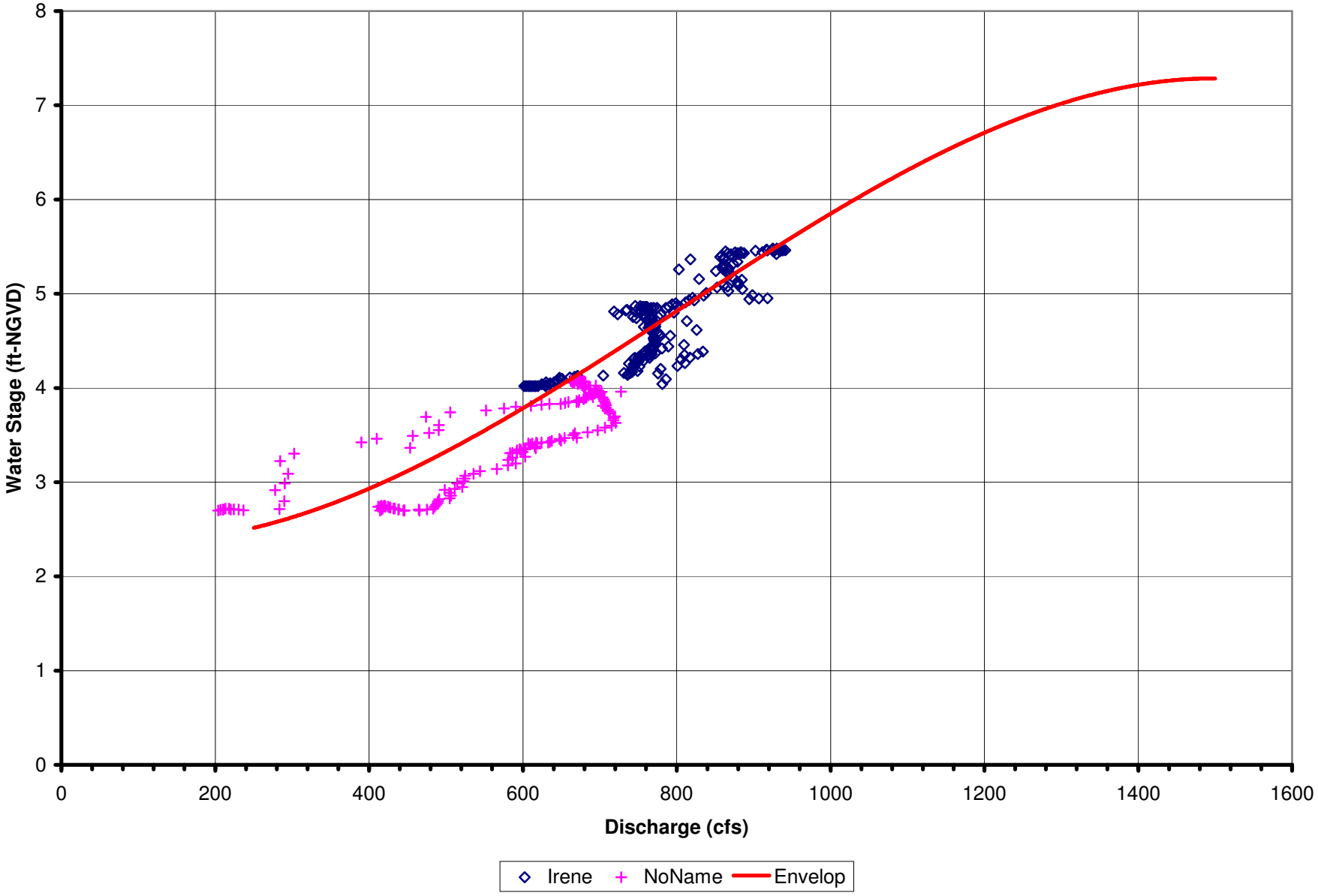


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Figure 2 - Envelop Tailwater Rating Curve at G-54 Structure

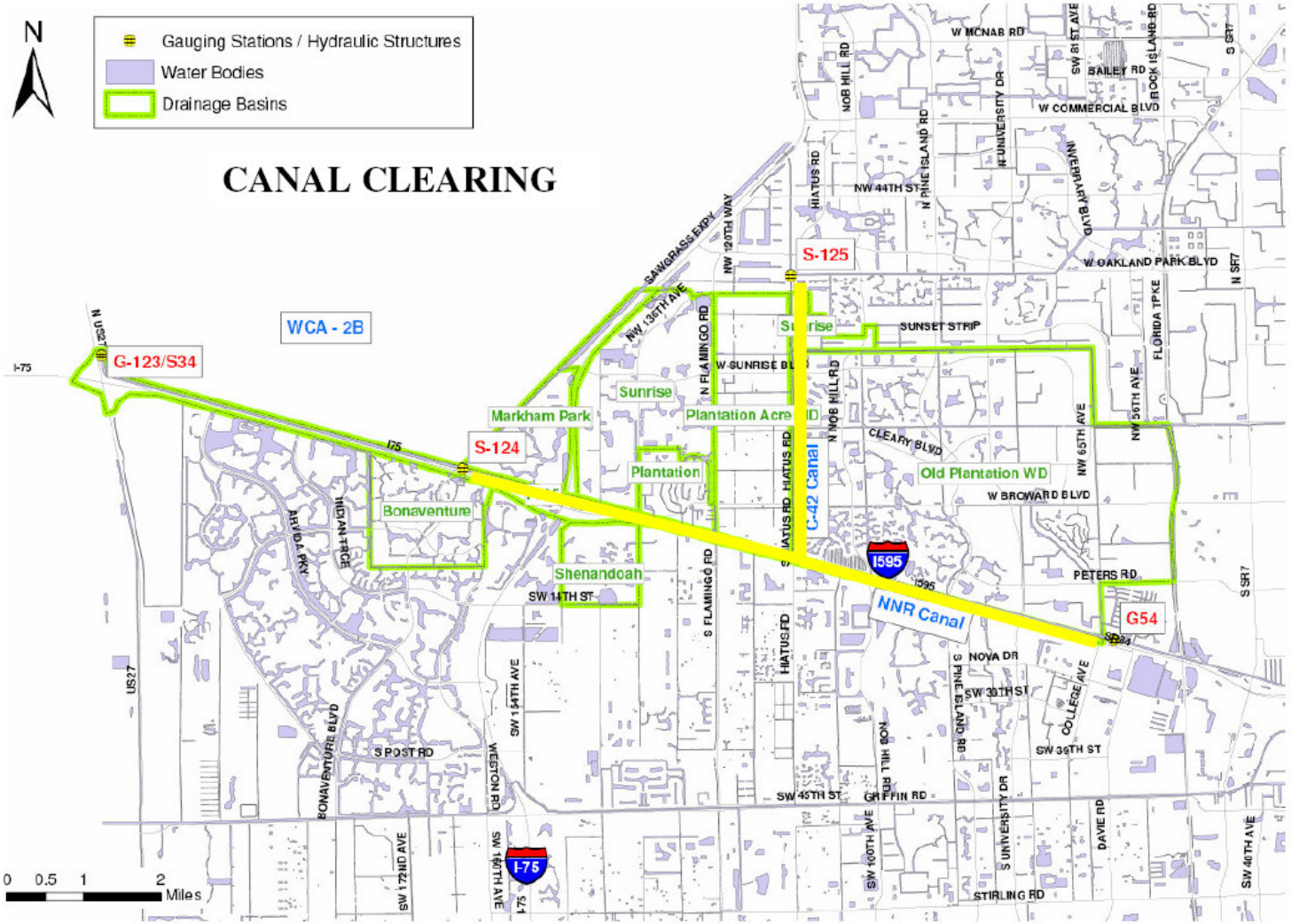

Figure 3 – NNRC Improvements - Map of Canal Clearing

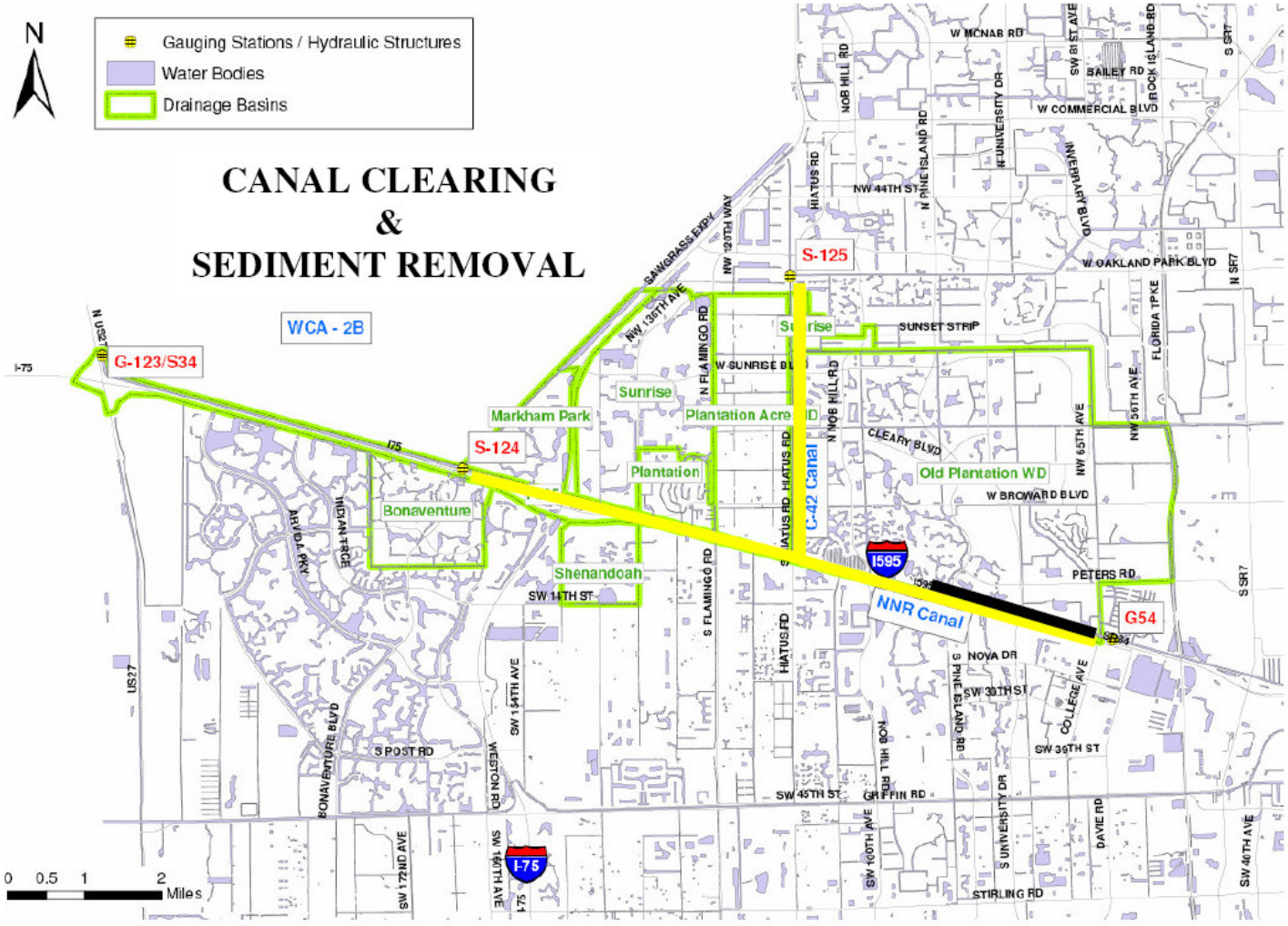

Figure 4 – NNRC Improvements – Map of Sediment Removal

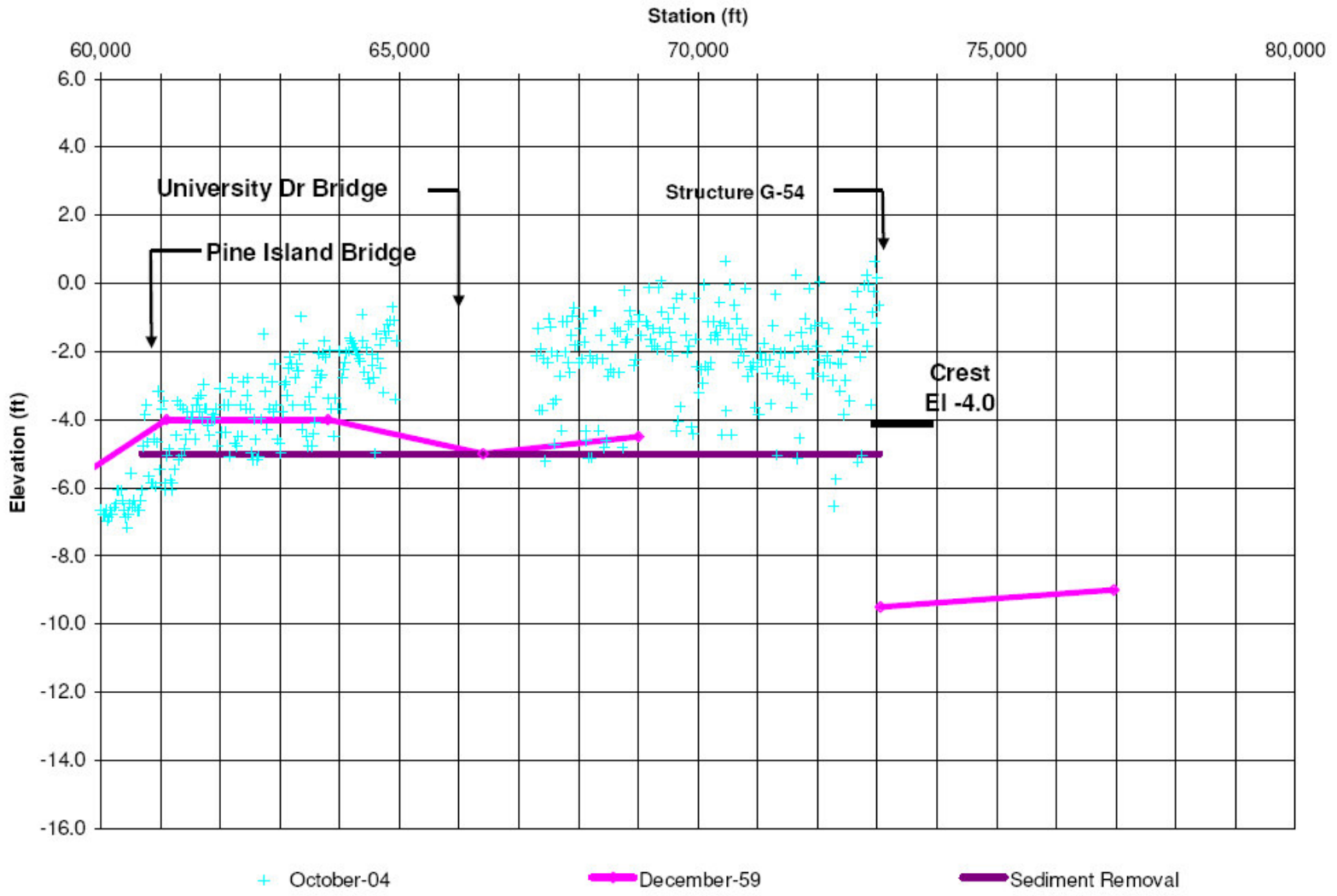

Figure 5 – NNRC Improvements – Profile of Sediment Removal

Figure 6 – NNRC Improvements – Map of the Lower NNRC Deepening

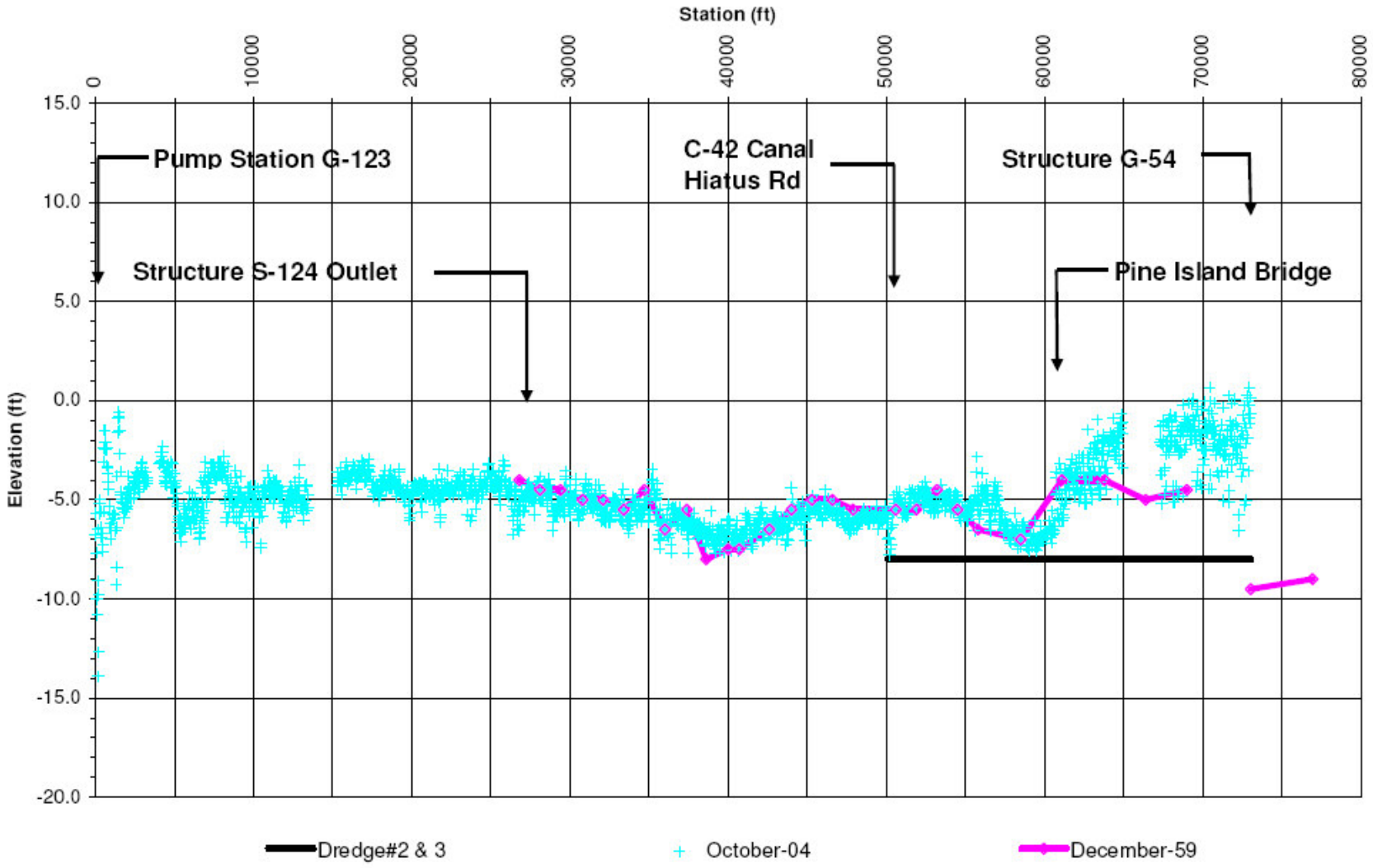

Figure 7 – NNRC Improvements – Profile of the Lower NNRC Deepening

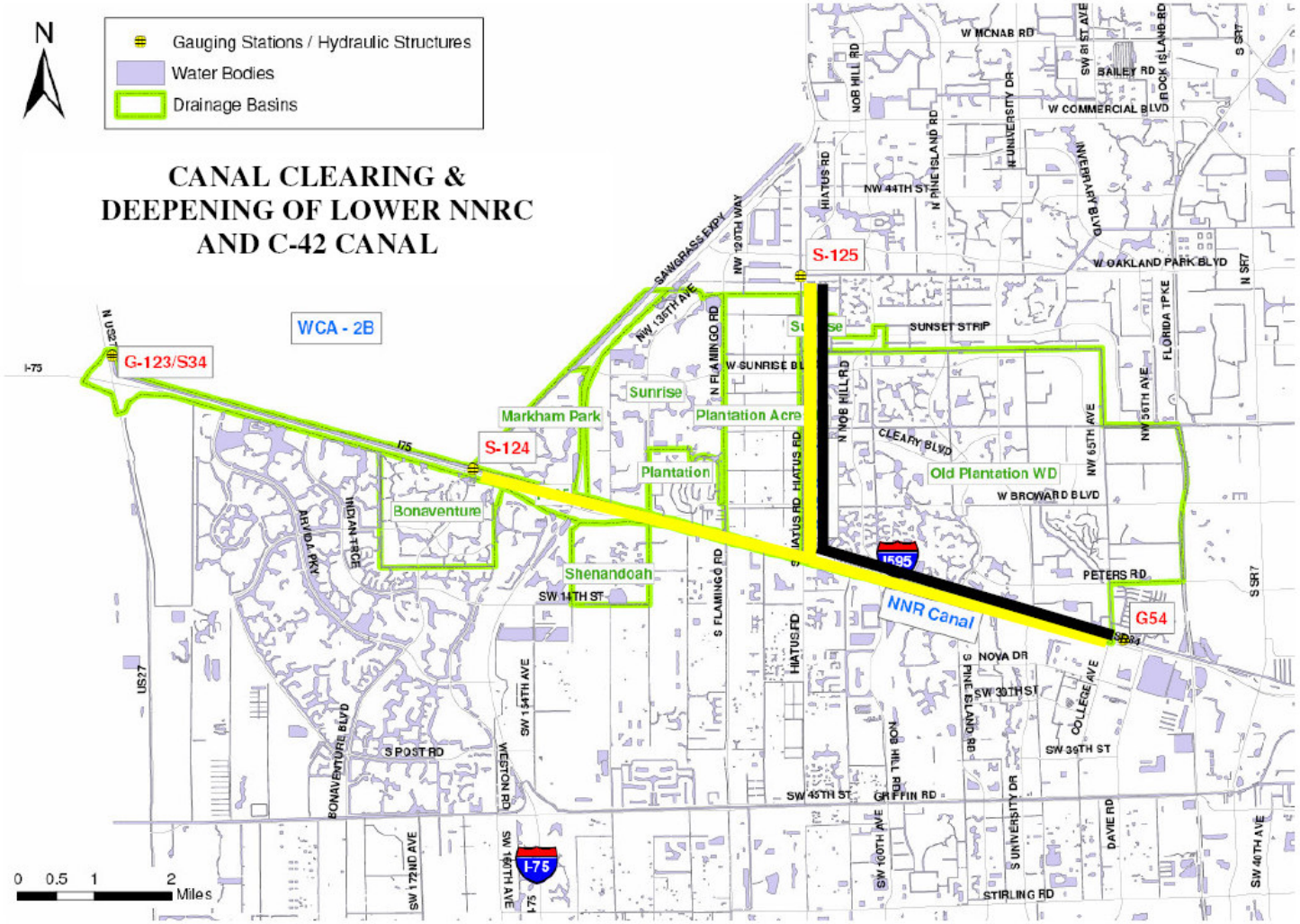

Figure 8 – NNRC Improvements – Map of the C-42 Canal and Lower NNRC Deepening

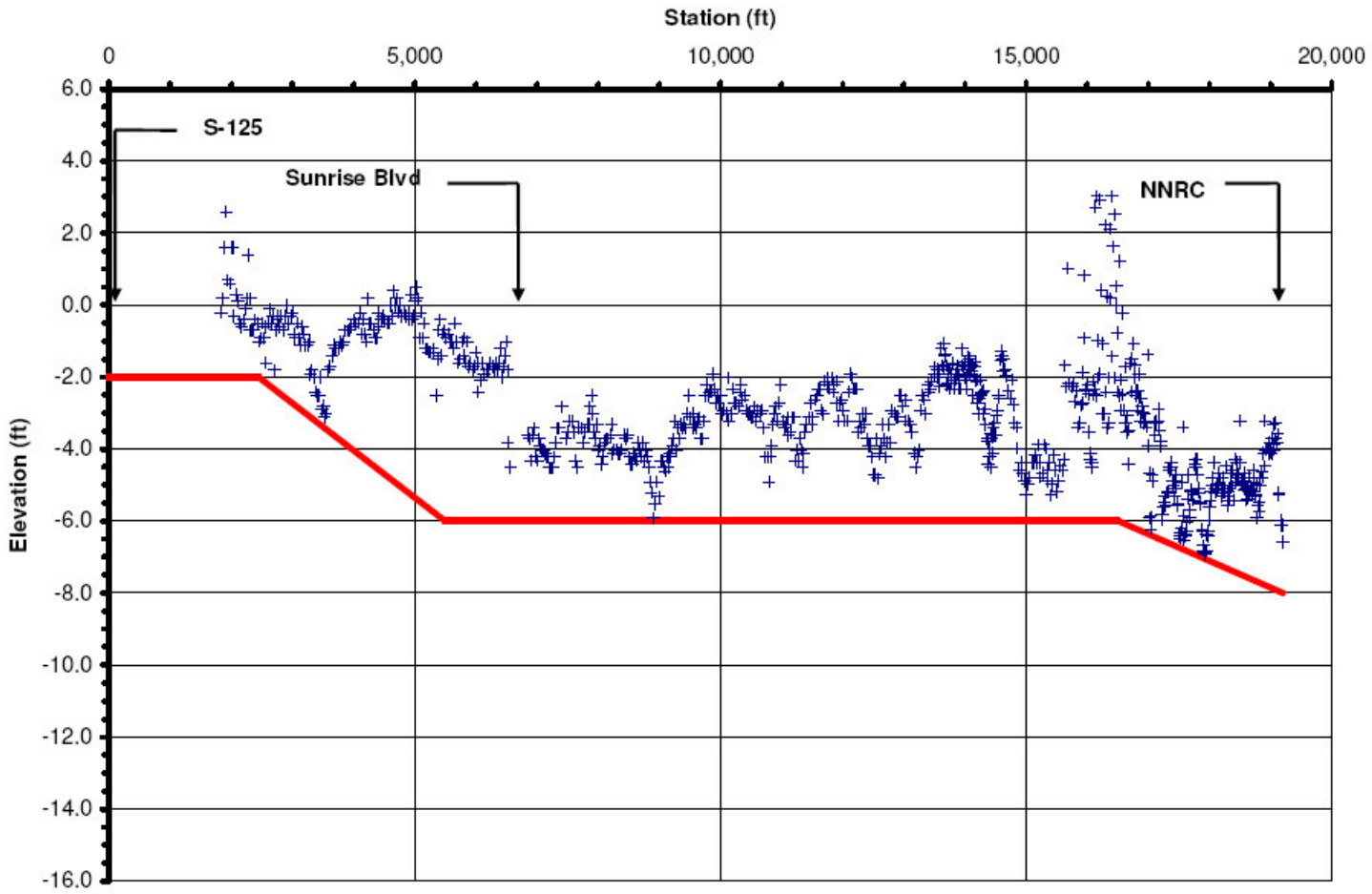

Figure 9 – NNRC Improvements – Profile of the C-42 Canal Deepening

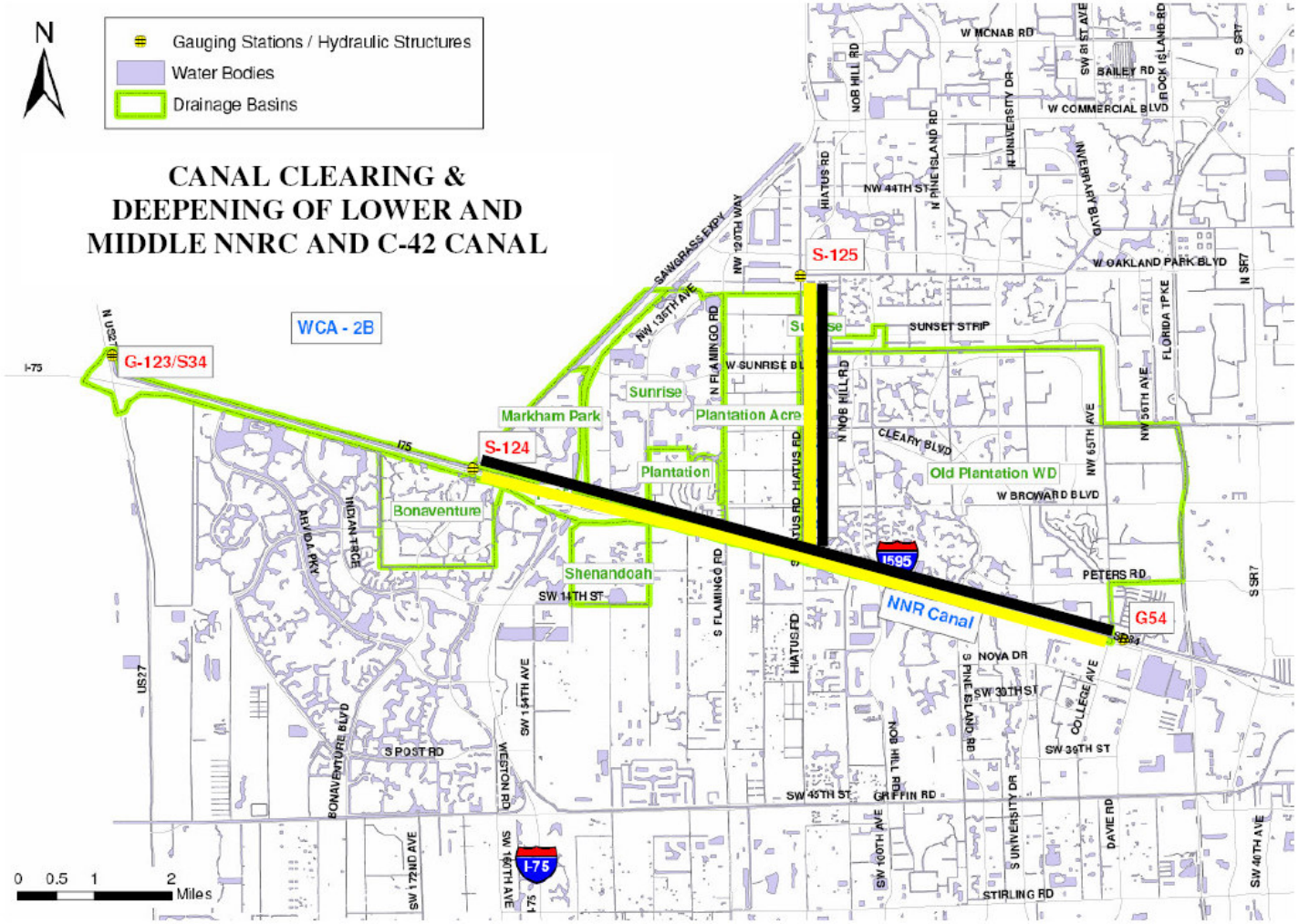

Figure 10 – NNRC Improvements – Map of the Middle and Lower NNRC and the C-42 Canal Deepening

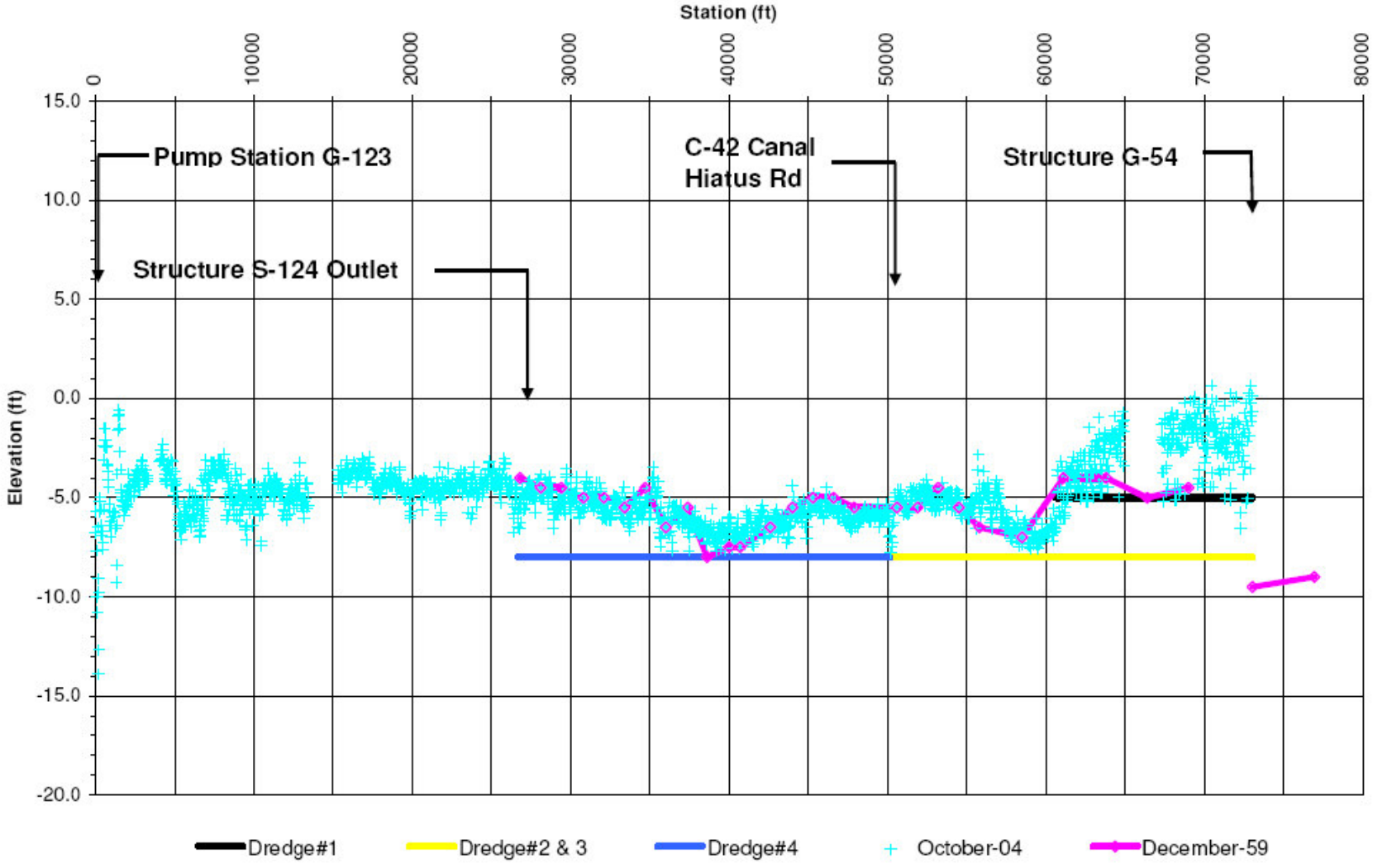

Figure 11 – NNRC Improvements – Profile of the Middle and Lower NNRC Deepening

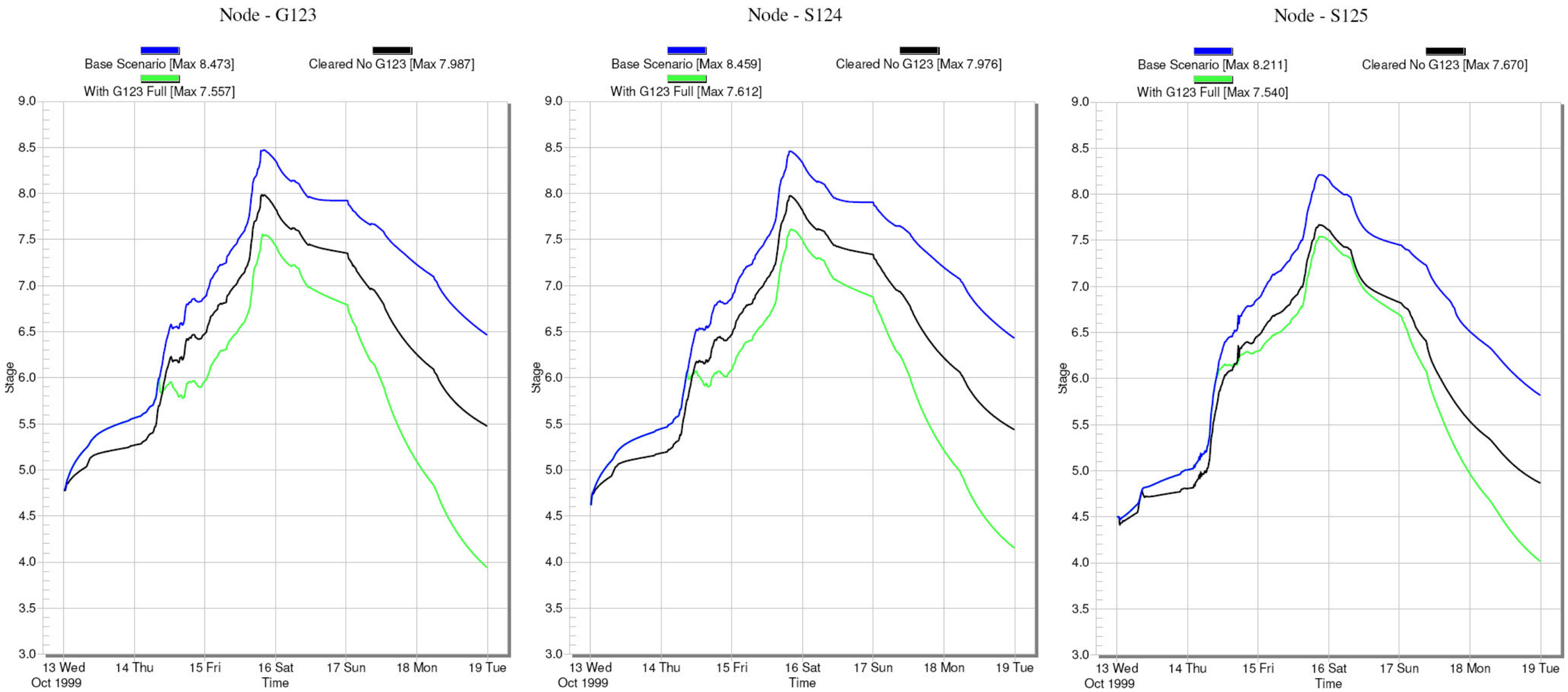

Figure 12 – XP-SWMM Results - Hurricane Irene
Simulation of Cleared Canals without G-123 Pump Station

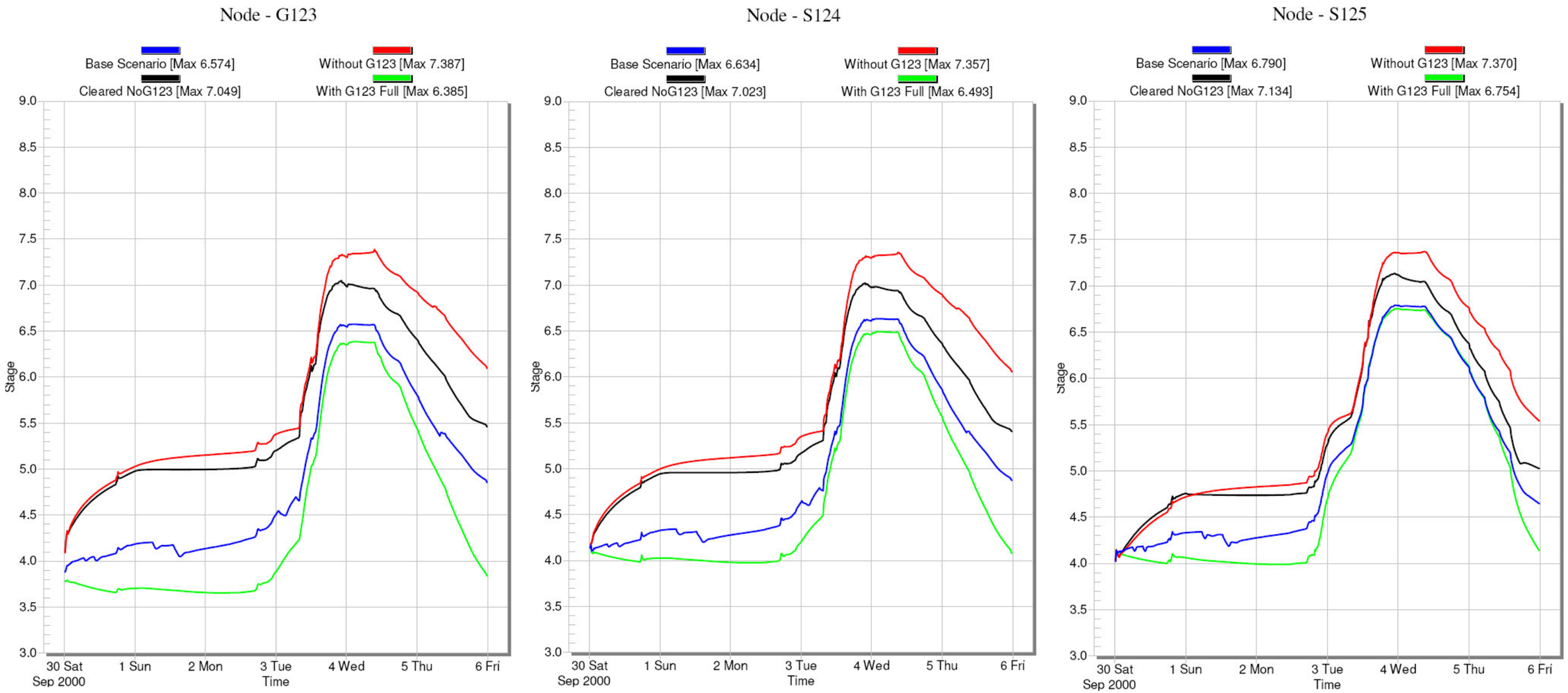

Figure 13 – XP-SWMM Results - No-Name Storm
Simulation of Cleared Canals without G-123 Pump Station

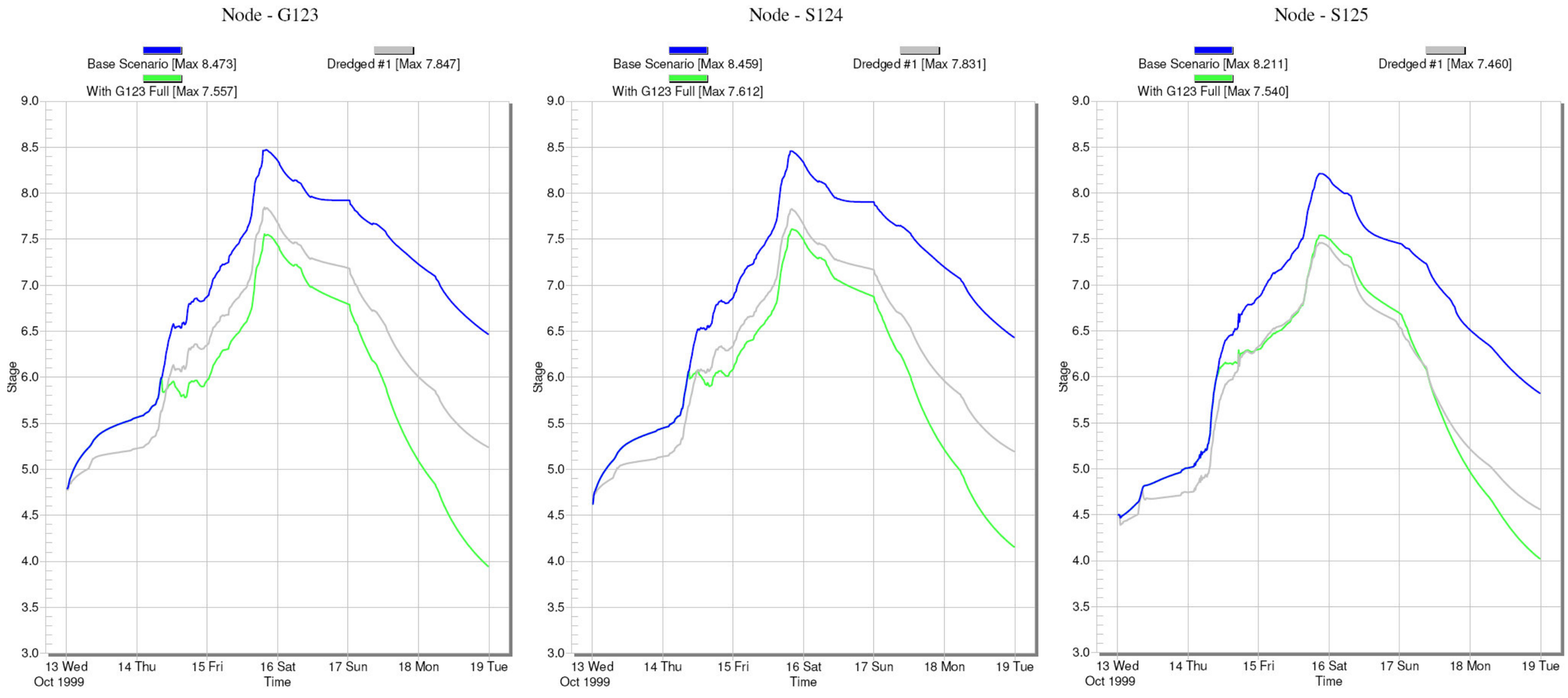

Figure 14 – XP-SWMM Results - Hurricane Irene
Simulation after Sediment Removal without G-123 Pump Station

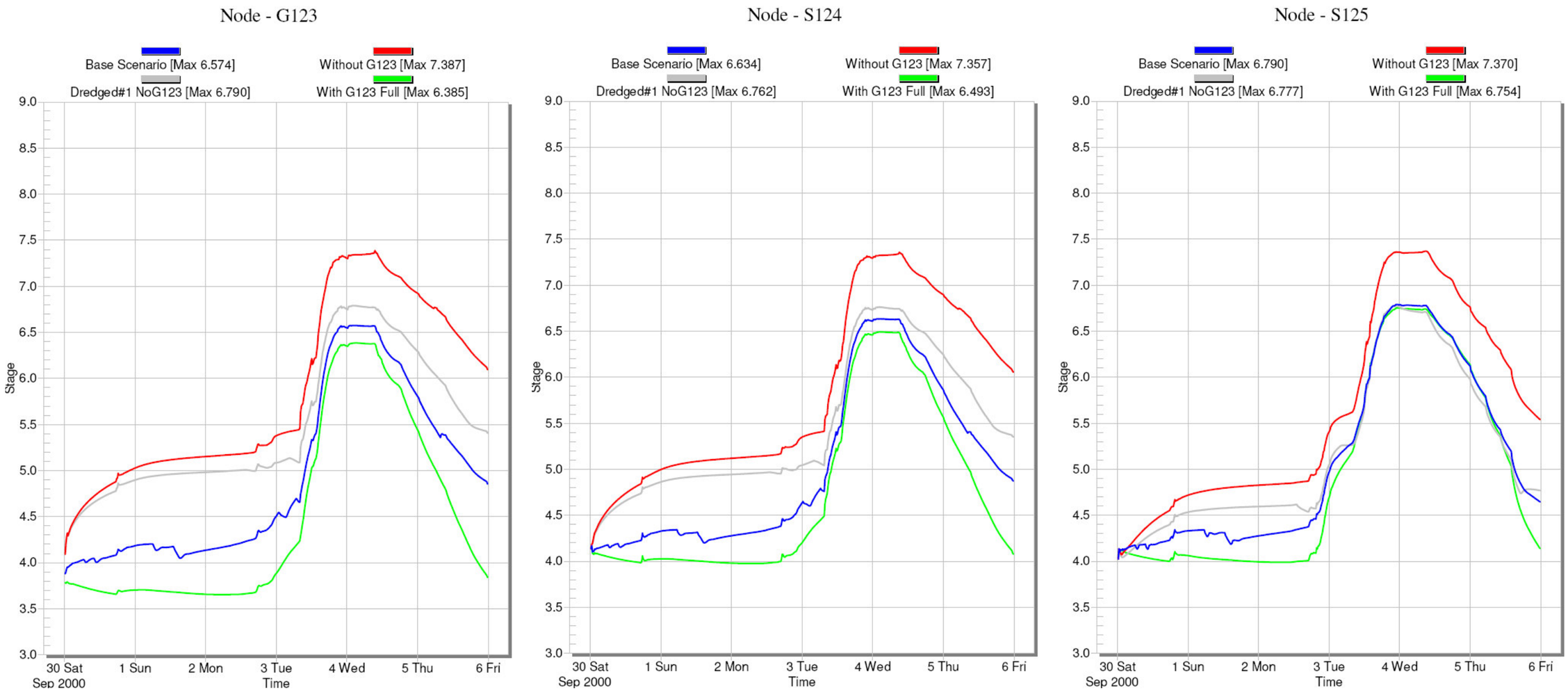

Figure 15 – XP-SWMM Results - No-Name Storm
Simulation after Sediment Removal without G-123 Pump Station

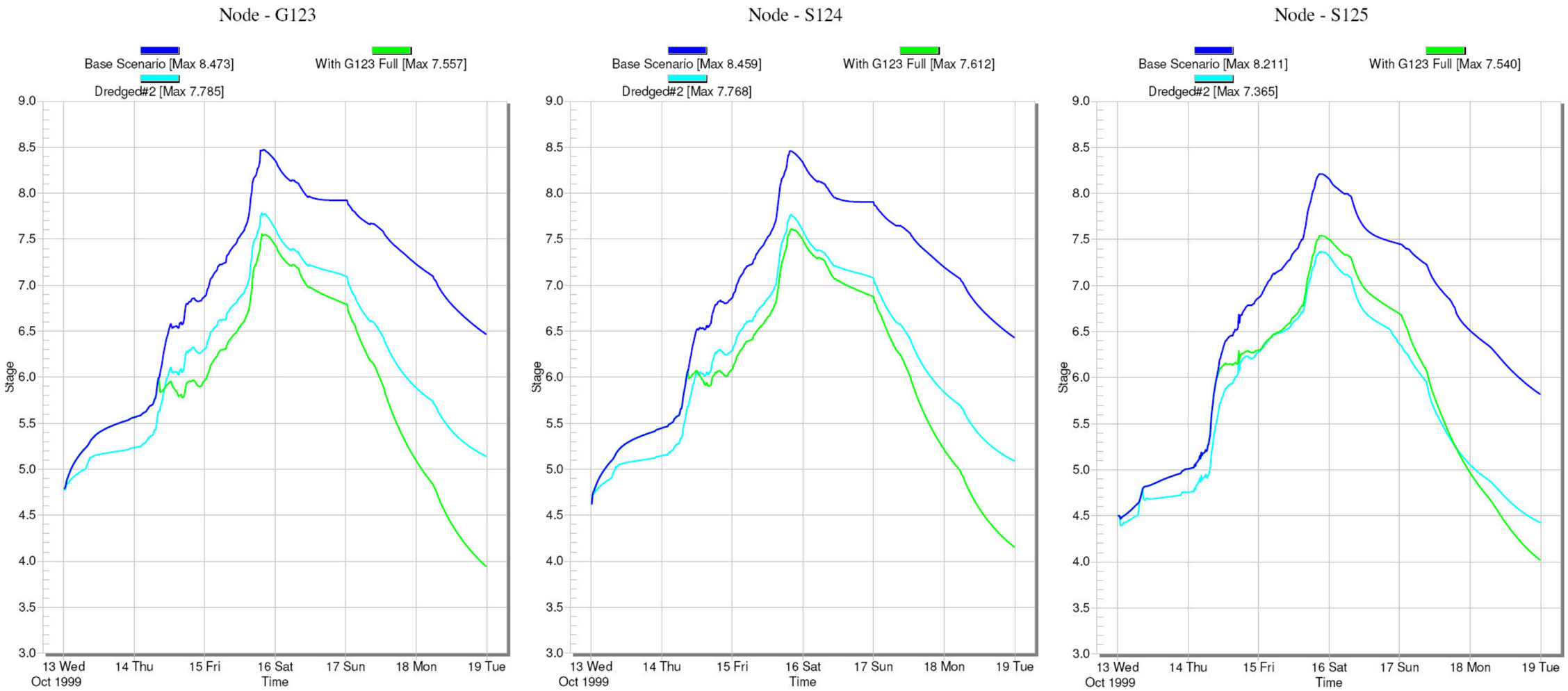

Figure 16 – XP-SWMM Results - Hurricane Irene
Simulation with Deeper NNRC from C-42 to G-54 without G-123 Pump Station

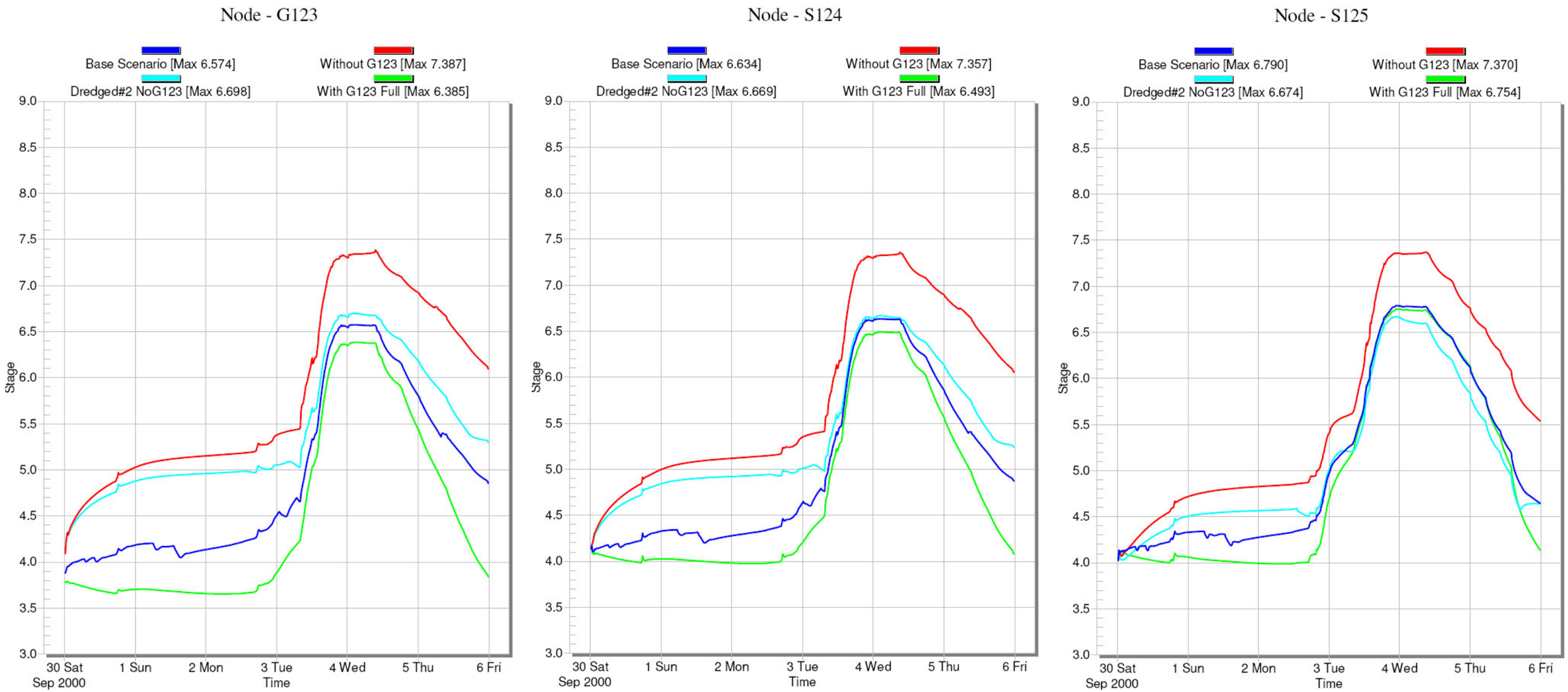

Figure 17 – XP-SWMM Results - No-Name Storm
Simulation with Deeper NNRC from C-42 to G-54 without G-123 Pump Station

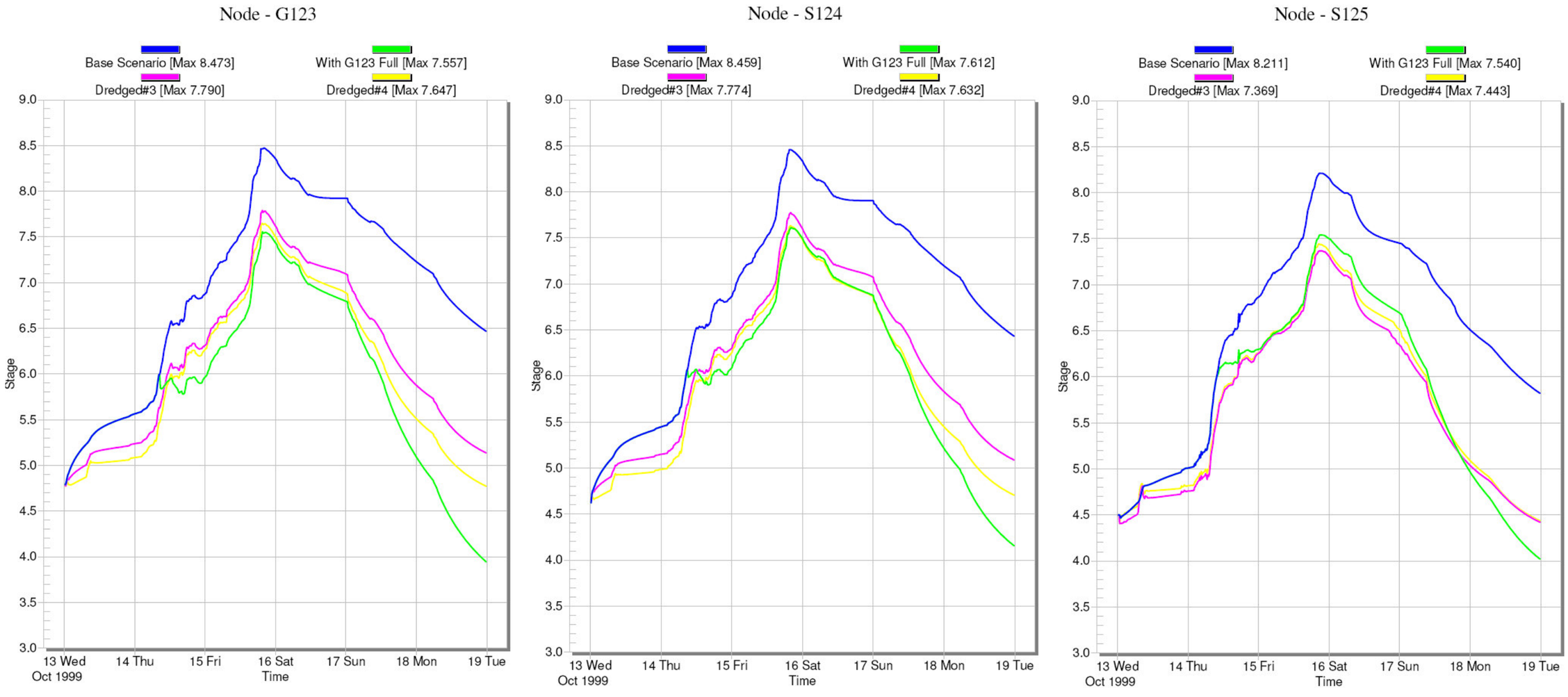

Figure 18 – XP-SWMM Results - Hurricane Irene
Simulation with Deeper NNRC from S-124 to G-54 and Deeper C-42 without G-123 Pump Station

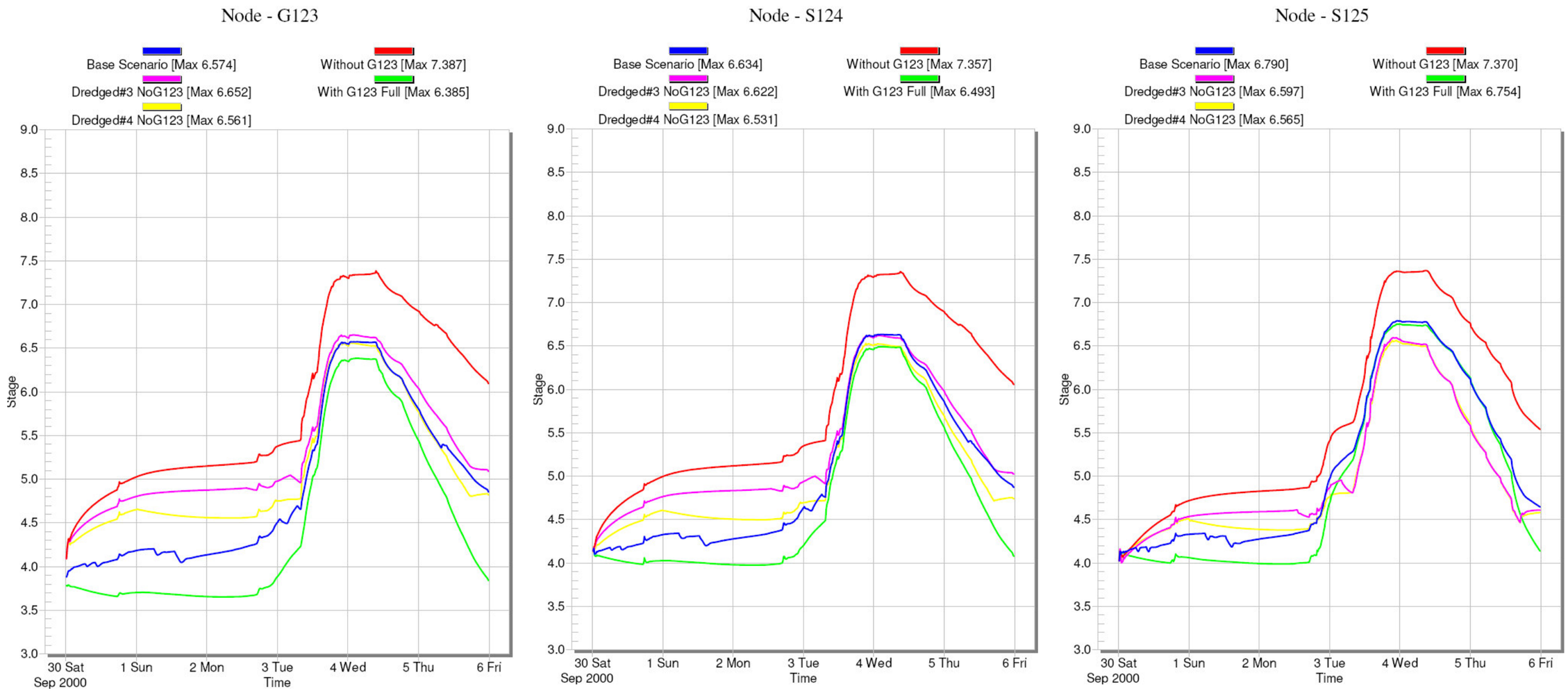

Figure 19 – XP-SWMM Results - No-Name Storm
Simulation with Deeper NNRC from S-124 to G-54 and Deeper C-42 without G-123 Pump Station

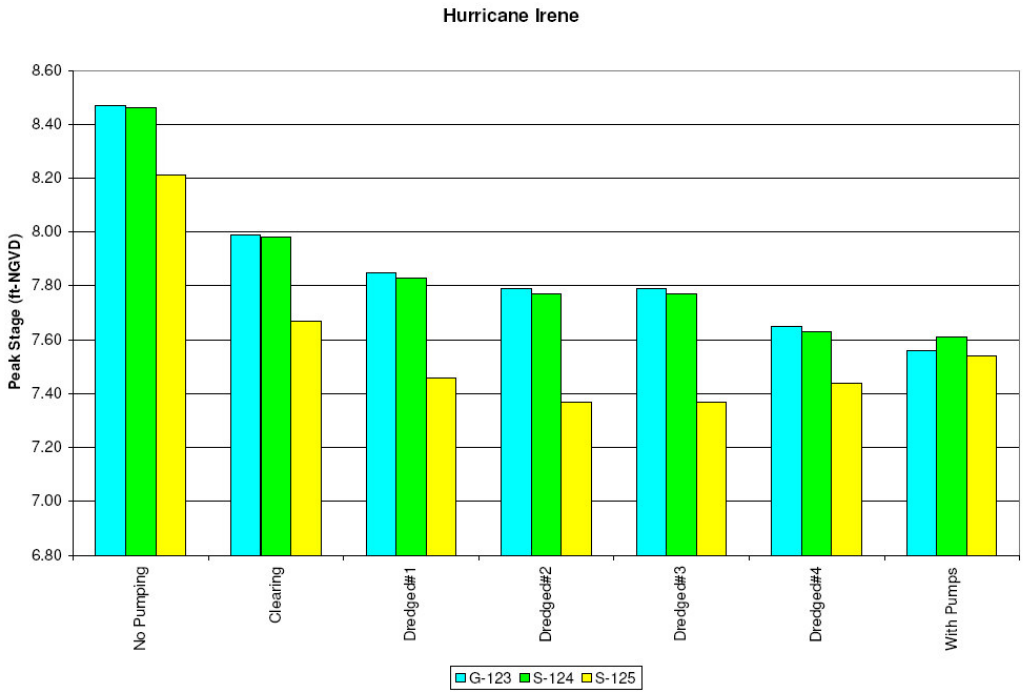

Figure 20 – XP-SWMM Results – Hurricane Irene
Improvement Simulation Comparative Results

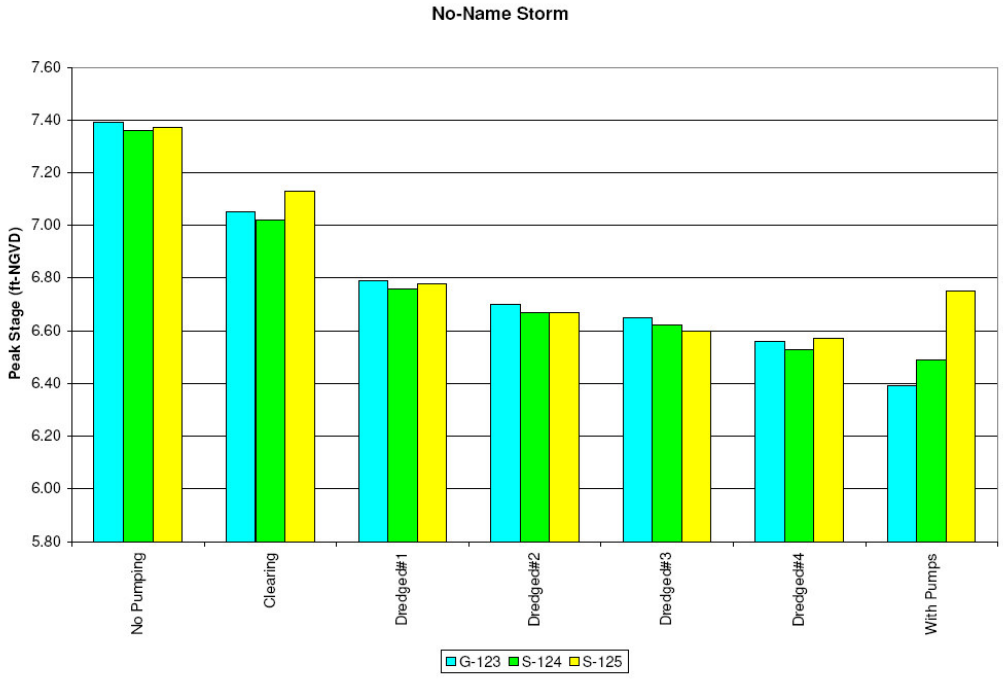

Figure 21 – XP-SWMM Results – No-Name Storm
Improvement Simulation Comparative Results

APPENDIX A

Conceptual Level Cost Estimates

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September 2005

NORTH NEW RIVER CANAL

Conveyance Improvement

Present Worth Cost Estimate

ALTENATIVE #:	**Canal Clearing**
DESCRIPTION:	Clearing of aquatic vegetation and other debris from the North New River Canal and the C-42 Canal
LOCATION:	NNRC from G-54 to S-124 Structures and C-42
BASIN:	NNRC
PRE-CONSTRUCTION COST :	**$25,000**
TOTAL CAPITAL COST :	**$521,000**

Present Worth Calculation		
Life:	20	(3)
Interest:	5.625%	(3)
Total Capital Cost:	$ 521,000	
Total Operating Cost *:	$ -	
Present Worth Cost:	**$ 521,000**	
Amortization Period :	**20**	years
Annualized Cost:	**$ 44,050**	

Source of Cost Information:

1) SFWMD - Evaluation Methodology for Water Quality Improvement Strategies - Final (Revised) 07/31/2002.
2) Broward County Standard Drainage Cost Form Rev. 12-31-03
3) WRDA Interest Rate 2002
4) Assumes beneficial reuse of 75 % of dredged sediment
5) Assumes 1.25 Tons/Cubic Yard
6) Based on a 10 CY/ hour yield, Hoe Excavation
7) Assumes dredged sediment (75%) and excavated material are disposed off within a 10-mile radius free of charge

*:Operational Costs have been neglected since the structures do not represent additional O &M efforts to SFWMD

Item/Task	Unit	Unit Cost	Quantity	Total	Comments/Explanation
PRE - CONSTRUCTION COSTS					
Pre-construction costs including surveying, design, geotechnical investigation and permitting	7%			$ 25,000	
SUB TOTAL - PRE CONSTRUCTION COSTS	Lump Sum			**$ 25,000**	
CONSTRUCTION COSTS					
Canal Clearing	acre	$ 2,000.00	150	$ 300,000	
Sediment Removal	CY	$ 20.00	-	$ -	
Canal Deepening	CY	$ 31.80	-	$ -	(6)
Residuals Management					
Transport Semi-Wet/Wet Sediments to Landfill	CY	$ 16.40	-	$ -	(4), 20-mile hauling
Tipping Fees	TON	$ 30.00	$0	$0	(5)
Temporary stockpiling/processing of Excavated material	CY	$ 10.00	$0	$0	
Transport Excavated Material	CY	$ 8.20	$0	$0	(7) 10-mile hauling
SUB-TOTAL				**$300,000**	
Maintenance of Traffic - MOT	5%			$ 15,000	(2)
Mobilization and Demobilization	6%			$ 18,000	(2)
Insurance and Bonds	5%			$ 15,000	
Testing and Miscellaneous Services	2%			$ 6,000	(2)
SUB-TOTAL				**$ 379,000**	
Construction Management Services	10%			$ 38,000	
Project Contingencies	25%			$ 104,000	
TOTAL CAPITAL COSTS				**$ 521,000**	

NORTH NEW RIVER CANAL

Conveyance Improvement

Present Worth Cost Estimate

ALTENATIVE #:	**Canal Clearing and Sediment Removal**
DESCRIPTION:	In addition to the clearing of aquatic vegetation and other debris from the North New River Canal and the C-42 Canal, this improvement includes the removal of sediment in the 2.5-mile long reach of the lower NNRC between G-54 and Pine Island Bridge
LOCATION:	NNRC from G-54 to S-124 Structures and C-42
BASIN:	NNRC
PRE-CONSTRUCTION COST :	**$426,000**
TOTAL CAPITAL COST :	**$8,949,000**

Present Worth Calculation		
Life:	20	(3)
Interest:	5.625%	(3)
Total Capital Cost:	$ 8,949,000	
Total Operating Cost *:	$ -	
Present Worth Cost:	**$ 8,949,000**	
Amortization Period :	**20**	years
Annualized Cost:	**$ 756,632**	

Source of Cost Information:

1) SFWMD - Evaluation Methodology for Water Quality Improvement Strategies - Final (Revised) 07/31/2002.
2) Broward County Standard Drainage Cost Form Rev. 12-31-03
3) WRDA Interest Rate 2002
4) Assumes beneficial reuse of 75 % of dredged sediment
5) Assumes 1.25 Tons/Cubic Yard
6) Based on a 10 CY/ hour yield, Hoe Excavation
7) Assumes dredged sediment (75%) and excavated material are disposed off within a 10-mile radius free of charge

*:Operational Costs have been neglected since the structures do not represent additional O &M efforts to SFWMD

Item/Task	Unit	Unit Cost	Quantity	Total	Comments/Explanation
PRE - CONSTRUCTION COSTS					
Pre-construction costs including surveying, design, geotechnical investigation and permitting	7%			$ 426,000	
SUB TOTAL - PRE CONSTRUCTION COSTS	Lump Sum			**$ 426,000**	
CONSTRUCTION COSTS					
Canal Clearing	acre	$2,000.00	150	$ 300,000	
Sediment Removal	CY	$ 20.00	103,000	$ 2,060,000	
Canal Deepening	CY	$ 31.80	-	$ -	(6)
Residuals Management					
Transport Semi-Wet/Wet Sediments to Landfill	CY	$ 16.40	25,750	$ 422,000	(4), 20-mile hauling
Tipping Fees	TON	$ 30.00	$32,188	$966,000	(5)
Temporary stockpiling/processing of Excavated material	CY	$ 10.00	$77,250	$773,000	
Transport Excavated Material	CY	$ 8.20	$77,250	$633,000	(7) 10-mile hauling
SUB-TOTAL				**$5,154,000**	
Maintenance of Traffic - MOT	5%			$ 258,000	(2)
Mobilization and Demobilization	6%			$ 309,000	(2)
Insurance and Bonds	5%			$ 258,000	
Testing and Miscellaneous Services	2%			$ 103,000	(2)
SUB-TOTAL				**$ 6,508,000**	
Construction Management Services	10%			$ 651,000	
Project Contingencies	25%			$ 1,790,000	
TOTAL CAPITAL COSTS				**$ 8,949,000**	

NORTH NEW RIVER CANAL

Conveyance Improvement

Present Worth Cost Estimate

ALTENATIVE #:	**Canal Clearing, Sediment Removal and Deepening of NNRC between C-42 and G-54**
DESCRIPTION:	In addition to the clearing of aquatic vegetation and other debris from the North New River Canal and the C-42 Canal, this improvement includes the removal of sediment, and the deepening of the NNRC between the junction with the C-42 Canal and G-54 to lower the bottom to -8.0 ft-NGVD.
LOCATION:	NNRC from G-54 to S-124 Structures and C-42
BASIN:	NNRC
PRE-CONSTRUCTION COST :	**$1,405,000**
TOTAL CAPITAL COST :	**$29,521,000**

Present Worth Calculation		
Life:	20	(3)
Interest:	5.625%	(3)
Total Capital Cost:	$ 29,521,000	
Total Operating Cost *:	$ -	
Present Worth Cost:	**$ 29,521,000**	
Amortization Period :	**20**	years
Annualized Cost:	**$ 2,495,980**	

Source of Cost Information:

1) SFWMD - Evaluation Methodology for Water Quality Improvement Strategies - Final (Revised) 07/31/2002.
2) Broward County Standard Drainage Cost Form Rev. 12-31-03
3) WRDA Interest Rate 2002
4) Assumes beneficial reuse of 75 % of dredged sediment
5) Assumes 1.25 Tons/Cubic Yard
6) Based on a 10 CY/ hour yield, Hoe Excavation
7) Assumes dredged sediment (75%) and excavated material are disposed off within a 10-mile radius free of charge

*:Operational Costs have been neglected since the structures do not represent additional O &M efforts to SFWMD

Item/Task	Unit	Unit Cost	Quantity	Total	Comments/Explanation
PRE - CONSTRUCTION COSTS					
Pre-construction costs including surveying, design, geotechnical investigation and permitting	7%			$ 1,405,000	
SUB TOTAL - PRE CONSTRUCTION COSTS	Lump Sum			**$ 1,405,000**	
CONSTRUCTION COSTS					
Canal Clearing	acre	$ 2,000.00	150	$ 300,000	
Sediment Removal	CY	$ 20.00	103,000	$ 2,060,000	
Canal Deepening	CY	$ 31.80	237,000	$ 7,537,000	(6)
Residuals Management					
Transport Semi-Wet/Wet Sediments to Landfill	CY	$ 16.40	25,750	$ 422,000	(4), 20-mile hauling
Tipping Fees	TON	$ 30.00	$32,188	$966,000	(5)
Temporary stockpiling/processing of Excavated material	CY	$ 10.00	$314,250	$3,143,000	
Transport Excavated Material	CY	$ 8.20	$314,250	$2,577,000	(7) 10-mile hauling
SUB-TOTAL				**$17,005,000**	
Maintenance of Traffic - MOT	5%			$ 850,000	(2)
Mobilization and Demobilization	6%			$ 1,020,000	(2)
Insurance and Bonds	5%			$ 850,000	
Testing and Miscellaneous Services	2%			$ 340,000	(2)
SUB-TOTAL				**$ 21,470,000**	
Construction Management Services	10%			$ 2,147,000	
Project Contingencies	25%			$ 5,904,000	
TOTAL CAPITAL COSTS				**$ 29,521,000**	

NORTH NEW RIVER CANAL
Conveyance Improvement

Present Worth Cost Estimate

ALTENATIVE #:	**Canal Clearing, Sediment Removal and Deepening of NNRC between C-42 and G-54 and Deepening of C-42**
DESCRIPTION:	In addition to the clearing of aquatic vegetation and other debris from the North New River Canal and the C-42 Canal, this improvement includes the removal of sediment, and the deepening of the NNRC between the junction with C-42 and G-54 to lower the bottom to -8.0 ft-NGVD and the deepening of the C-42 Canal to lower the bottom to -6.0 ft-NGVD.
LOCATION:	NNRC from G-54 to S-124 Structures and C-42
BASIN:	NNRC
PRE-CONSTRUCTION COST :	**$1,694,000**
TOTAL CAPITAL COST :	**$35,598,000**

Present Worth Calculation		
Life:	20	(3)
Interest:	5.625%	(3)
Total Capital Cost:	$ 35,598,000	
Total Operating Cost *:	$ -	
Present Worth Cost:	**$ 35,598,000**	
Amortization Period :	**20**	years
Annualized Cost:	**$ 3,009,786**	

Source of Cost Information:

1) SFWMD - Evaluation Methodology for Water Quality Improvement Strategies - Final (Revised) 07/31/2002.
2) Broward County Standard Drainage Cost Form Rev. 12-31-03
3) WRDA Interest Rate 2002
4) Assumes beneficial reuse of 75 % of dredged sediment
5) Assumes 1.25 Tons/Cubic Yard
6) Based on a 10 CY/ hour yield, Hoe Excavation
7) Assumes dredged sediment (75%) and excavated material are disposed off within a 10-mile radius free of charge

*:Operational Costs have been neglected since the structures do not represent additional O &M efforts to SFWMD

Item/Task	Unit	Unit Cost	Quantity	Total	Comments/Explanation
PRE - CONSTRUCTION COSTS					
Pre-construction costs including surveying, design, geotechnical investigation and permitting	7%			$ 1,694,000	
SUB TOTAL - PRE CONSTRUCTION COSTS	Lump Sum			**$ 1,694,000**	
CONSTRUCTION COSTS					
Canal Clearing	acre	$ 2,000.00	150	$ 300,000	
Sediment Removal	CY	$ 20.00	103,000	$ 2,060,000	
Canal Deepening	CY	$ 31.80	307,000	$ 9,763,000	(6)
Residuals Management					
Transport Semi-Wet/Wet Sediments to Landfill	CY	$ 16.40	25,750	$ 422,000	(4), 20-mile hauling
Tipping Fees	TON	$ 30.00	$32,188	$966,000	(5)
Temporary stockpiling/processing of Excavated material	CY	$ 10.00	$384,250	$3,843,000	
Transport Excavated Material	CY	$ 8.20	$384,250	$3,151,000	(7) 10-mile hauling
SUB-TOTAL				**$20,505,000**	
Maintenance of Traffic - MOT	5%			$ 1,025,000	(2)
Mobilization and Demobilization	6%			$ 1,230,000	(2)
Insurance and Bonds	5%			$ 1,025,000	
Testing and Miscellaneous Services	2%			$ 410,000	(2)
SUB-TOTAL				**$ 25,889,000**	
Construction Management Services	10%			$ 2,589,000	
Project Contingencies	25%			$ 7,120,000	
TOTAL CAPITAL COSTS				**$ 35,598,000**	

NORTH NEW RIVER CANAL

Conveyance Improvement

Present Worth Cost Estimate

ALTENATIVE #:	**Canal Clearing, Sediment Removal, Deepening of NNRC between S-124 and G-54 and Deepening of C-42**
DESCRIPTION:	In addition to the clearing of aquatic vegetation and other debris from the North New River Canal and the C-42 Canal, this improvement includes the removal of sediment, and the deepening of the NNRC between Structure S-124 and G-54 to lower the bottom to -8.0 ft-NGVD and the deepening of the C-42 Canal to lower the bottom to -6.0 ft-NGVD.
LOCATION:	NNRC from G-54 to S-124 Structures and C-42
BASIN:	NNRC
PRE-CONSTRUCTION COST :	**$2,644,000**
TOTAL CAPITAL COST :	**$55,563,000**

Present Worth Calculation		
Life:	20	(3)
Interest:	5.625%	(3)
Total Capital Cost:	$ 55,563,000	
Total Operating Cost *:	$ -	
Present Worth Cost:	**$ 55,563,000**	
Amortization Period :	**20**	years
Annualized Cost:	**$ 4,697,812**	

Source of Cost Information:

1) SFWMD - Evaluation Methodology for Water Quality Improvement Strategies - Final (Revised) 07/31/2002.
2) Broward County Standard Drainage Cost Form Rev. 12-31-03
3) WRDA Interest Rate 2002
4) Assumes beneficial reuse of 75 % of dredged sediment
5) Assumes 1.25 Tons/Cubic Yard
6) Based on a 10 CY/ hour yield, Hoe Excavation
7) Assumes dredged sediment (75%) and excavated material are disposed off within a 10-mile radius free of charge

*:Operational Costs have been neglected since the structures do not represent additional O &M efforts to SFWMD

Item/Task	Unit	Unit Cost	Quantity	Total	Comments/Explanation
PRE - CONSTRUCTION COSTS					
Pre-construction costs including surveying, design, geotechnical investigation and permitting	7%			$ 2,644,000	
SUB TOTAL - PRE CONSTRUCTION COSTS	Lump Sum			**$ 2,644,000**	
CONSTRUCTION COSTS					
Canal Clearing	acre	$ 2,000.00	150	$ 300,000	
Sediment Removal	CY	$ 20.00	103,000	$ 2,060,000	
Canal Deepening	CY	$ 31.80	537,000	$ 17,077,000	(6)
Residuals Management					
Transport Semi-Wet/Wet Sediments to Landfill	CY	$ 16.40	25,750	$ 422,000	(4), 20-mile hauling
Tipping Fees	TON	$ 30.00	$32,188	$966,000	(5)
Temporary stockpiling/processing of Excavated material	CY	$ 10.00	$614,250	$6,143,000	
Transport Excavated Material	CY	$ 8.20	$614,250	$5,037,000	(7) 10-mile hauling
SUB-TOTAL				**$32,005,000**	
Maintenance of Traffic - MOT	5%			$ 1,600,000	(2)
Mobilization and Demobilization	6%			$ 1,920,000	(2)
Insurance and Bonds	5%			$ 1,600,000	
Testing and Miscellaneous Services	2%			$ 640,000	(2)
SUB-TOTAL				**$ 40,409,000**	
Construction Management Services	10%			$ 4,041,000	
Project Contingencies	25%			$ 11,113,000	
TOTAL CAPITAL COSTS				**$ 55,563,000**	