Exhibit SDWA- 257

Technical Report

March 2017

Evaluation of Impacts of the HORB Modifications Proposed For The CWF

Prepared By:

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Prepared For:

The South Delta Water Agency Parties

Part 1, Rebuttal Case
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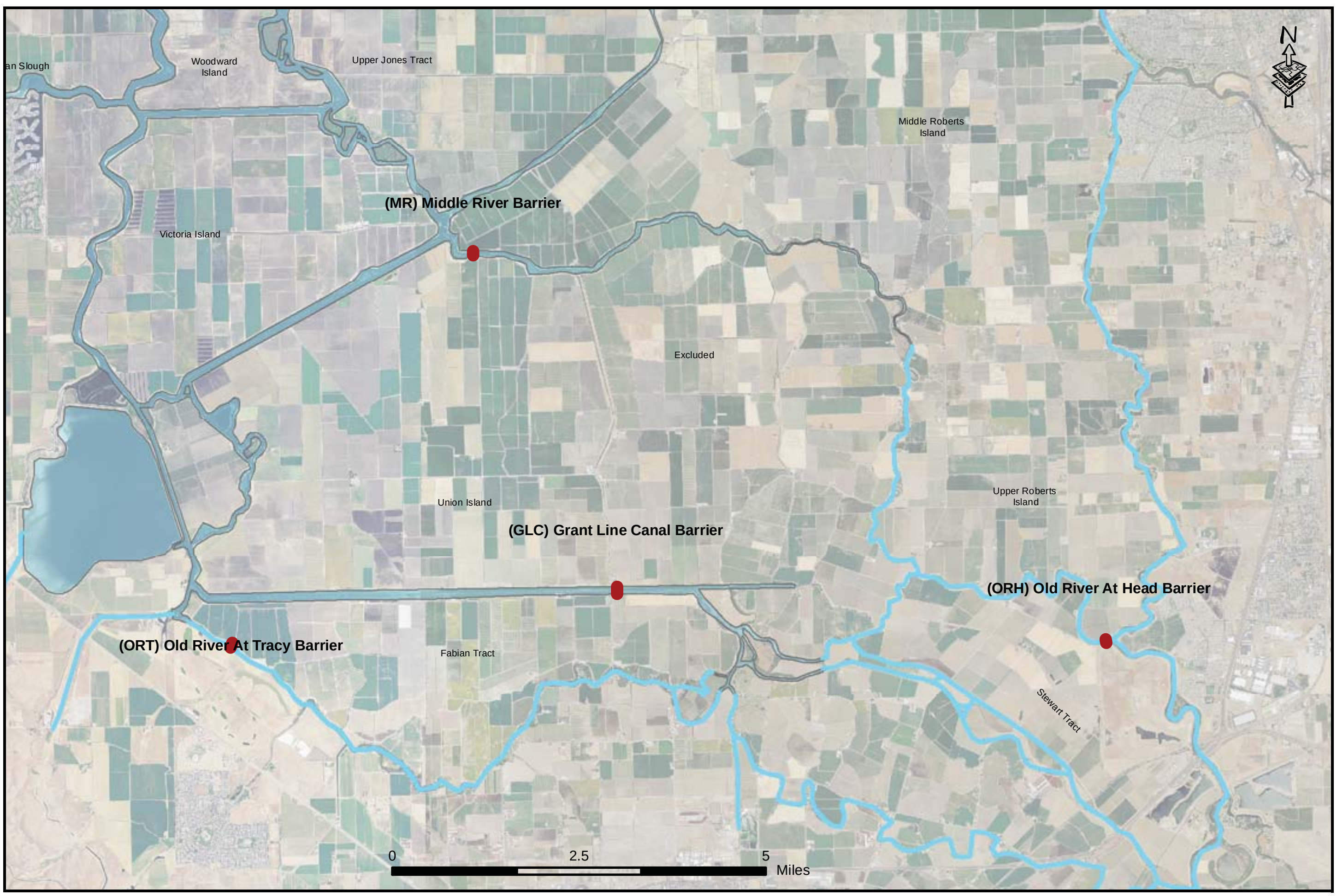

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1. Introduction

This technical memorandum has been prepared on behalf of the SWDA Parties as part of their rebuttal case for Part 1 of the California WaterFix ("CWF") Change Petition Proceedings. The CWF includes the installation and operation of a permanent barrier at the head of Old River ("HORB"). The proposed permanent HORB would replace the temporary rock barrier which is typically installed and removed twice each year.

During Part 1A of the proceedings, Petitioners attempted to demonstrate that operation of the HORB, in conjunction with the proposed North Delta Diversion ("NDD"), will not cause injury to other legal users of water by asserting that any drawdown in stage or increase in salinity below the HORB would be insignificant. The evidence put forth by Petitioners in this regard was inaccurate, incorrect and incomplete. The purpose of this technical memorandum is to provide evidence to rebut Petitioners' assertions. As discussed in more detail below, this technical memorandum compares the impacts on stage, flow, and, by implication, water quality from the HORB by comparing the No Action Alternative ("NAA") and the Preferred Alternative ("PA") of the Biological Assessment that was developed for the project.

2. Head of Old River Operations

The existing Head of Old River Barrier (HORB) is a rock structure that is primarily used to divert water down the San Joaquin River to facilitate the upstream and downstream migration of Chinook Salmon. The barrier helps to prevent fish from entering Old River and being drawn into the State Water Project ("SWP") and Central Valley Project ("CVP") export pumps. It also helps to improve the oxygen level and temperature in the San Joaquin River during the migration. The HORB has been installed in Old River at the Confluence with the San Joaquin River in most years since 1968. The barrier is installed for approximately a month in the spring and then removed. The HORB is subsequently installed again in the fall for roughly one and a half months and then removed. The actual installation and removal dates for the HORB is a function of flow in the San Joaquin River and observation of fish migration patterns by NOAA Fisheries and the California Department of Fish and Wildlife. The actual historic installation and removal schedule of the existing rock barrier is provided in Appendix A. The installation periods as modeled in the CWF scenarios developed for the BA are shown in Table 1. The schedule is shown graphically in Table 2, with a more detailed implementation schedule provided in Appendix B. As can be seen in the figure, the operation of the HORB will change significantly for the CWF PA. This change in operation, as well as physical configuration has impacts that are felt downstream in the channels of the South Delta.

Table 1 Spring and Fall HORB Schedule in the NAA and PA as Implemented in the CWF DSM2 Models.

	Existing Condition (NAA Model		CWF Condition (PA Model)	
Period	**Installation**	**Removal**	**Installation**	**Removal**
Spring Barrier	April 15	May 16	Jan 1	June 15
Fall Barrier	September 15	November 30	October 16	November 15

Table 2 Spring and Fall HORB Schedule In The NAA And PA as Incorporated In The CWF DSM2 Models.

Scenario	Jan		Feb		March		April		May		June	
	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4
CWF PA	Spring Barrier											
CWF NAA								Spring Barrier				

Scenario	July		August		September		October		November		December	
	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4
CWF PA								Fall Barrier				
CWF NAA						Fall Barrier SJR						

3. Modeling

The effects of the new operating regime of the proposed permanent HORB on the hydrodynamics in the south Delta were simulated using the DSM2 hydrodynamic model developed by the California Department of Water Resources (DWR). Two DSM2 model scenarios were developed as part of the work to support the Biological Assessment ("BA") for the CWF project. The models consisted of the No Action Alternative ("NAA"), which simulated the existing condition, and the Preferred Alternative ("PA"), which represents the Petitioners' preferred operating alternative for the CWF project. We ran the PA and the NAA models, as developed by THE PETITIONERS, and compared the output from each, to assess the difference in river stage that was predicted for each scenario.

Both model simulations were run over an 82 year period, from water year 1922 to 2003. To model the hydraulic and water quality effects of the HORB, by necessity, the operation of the barrier was fixed by a set of rules that were programmed into DSM2 for each scenario. These rules also took into account the flow of the San Joaquin River. The model adjusted the operation of the barrier to respond dynamically to the historic San Joaquin River flow for each year of the 82 year period.

The features of the existing and proposed barrier are provided below. It should be noted that the features of the permanent barrier as described in the BA and CWF documents do not match what has been incorporated into the DSM2 PA model.

<u>Existing NAA HORB Features in DSM2:</u>

Fall Barrier: 168' wide gate

Spring Barrier: 200' wide gate

Fall Notch: 32' wide gate

Pipes: 6 - 4' dia pipes

<u>Proposed PA Permeant HORB Features:</u>

Proposed In PA:

5-25' Wide Bottom Hinged Gates, Top of Gate = 15. Ft.

20' Wide Boat Lock

10' wide Fish Ladder

Modeled in DSM2:

Fall Barrier: 168' wide gate

Fall Notch: 32' wide gate

Spring Barrier: 200' wide gate

Pipes: 6 - 5' dia pipes

4. Impact of the HORB on South Delta Stage

The Impact of the new HORB as defined in the PA was evaluated by looking at the river stage that was predicted by the PA and NAA scenarios at specific locations in the Delta downstream of the HORB. The difference in minimum daily stage between the two scenarios was then compared for each day over the 82 year period of record that was simulated by the DSM2 model. Table 3 is a listing of the sites that were evaluated in this analysis. Figure 1 is a map of the Delta showing the location of each analysis point.

Table 3 – Stage Analysis Location Points

No.	River Name	Channel Number	Description
1	Old River	54	Downstream of the HORB Structure
2	Old River	58	Old River US of Middle River
3	Old River	60	Old River
4	Old River	71	Old River At Tracy
5	Old River	79	Old River US of Old River At Tracy Barrier
6	Old River	80	Old River DS of Old River at Tracy Barrier
7	Old River	85	Old River Adjacent To Clifton Court
8	Old River	90	Old River DS of Clifton Court
9	Grant Line Canal	206	Grant Line Canal US of Ag Barrier
10	Grant Line Canal	208	Grant Line Canal DS of Ag Barrier
11	Grant Line Canal	213	Grant Line Canal
12	Middle River	125	Middle River DS of Old River
13	Middle River	130	Middle River
14	Middle River	136	Middle River
15	San Joaquin River	9	San Joaquin River
16	San Joaquin River	12	San Joaquin River

Figure 2 is a plot of the difference in minimum daily stage between the PA and the NAA at Site No. 1. The difference in stage is computed by subtracting the NAA stage from the stage for the PA. As such, a negative difference represents a reduction in channel depth that would result from the CWF PA. As can be seen in the figure, there is a significant amount of time over that 82 year period where the difference is negative. Figure 3 is a blow up of Figure 2, showing the difference in river stage for the 1992 and 1993 water years, which represent a dry and an average water year. This figure is typical of most years and provides more information than Figure 2 for the timing of the stage reduction over the year.

To represent the percentage of time that the PA would lower the stage in the channel, a probability analysis was developed for the stage difference at each site. To help isolate the stage effects from the HORB, the data used to develop the probability analysis were the stage differences that only occurred while the HORB was in place for either the PA or the NAA. The resulting time frame for the HORB analysis was January 1 through June 15 and September 16 through December 1 of each year. Figure 4 is a probability plot showing the percent of time that the stage would be lowered by the CWF PA.

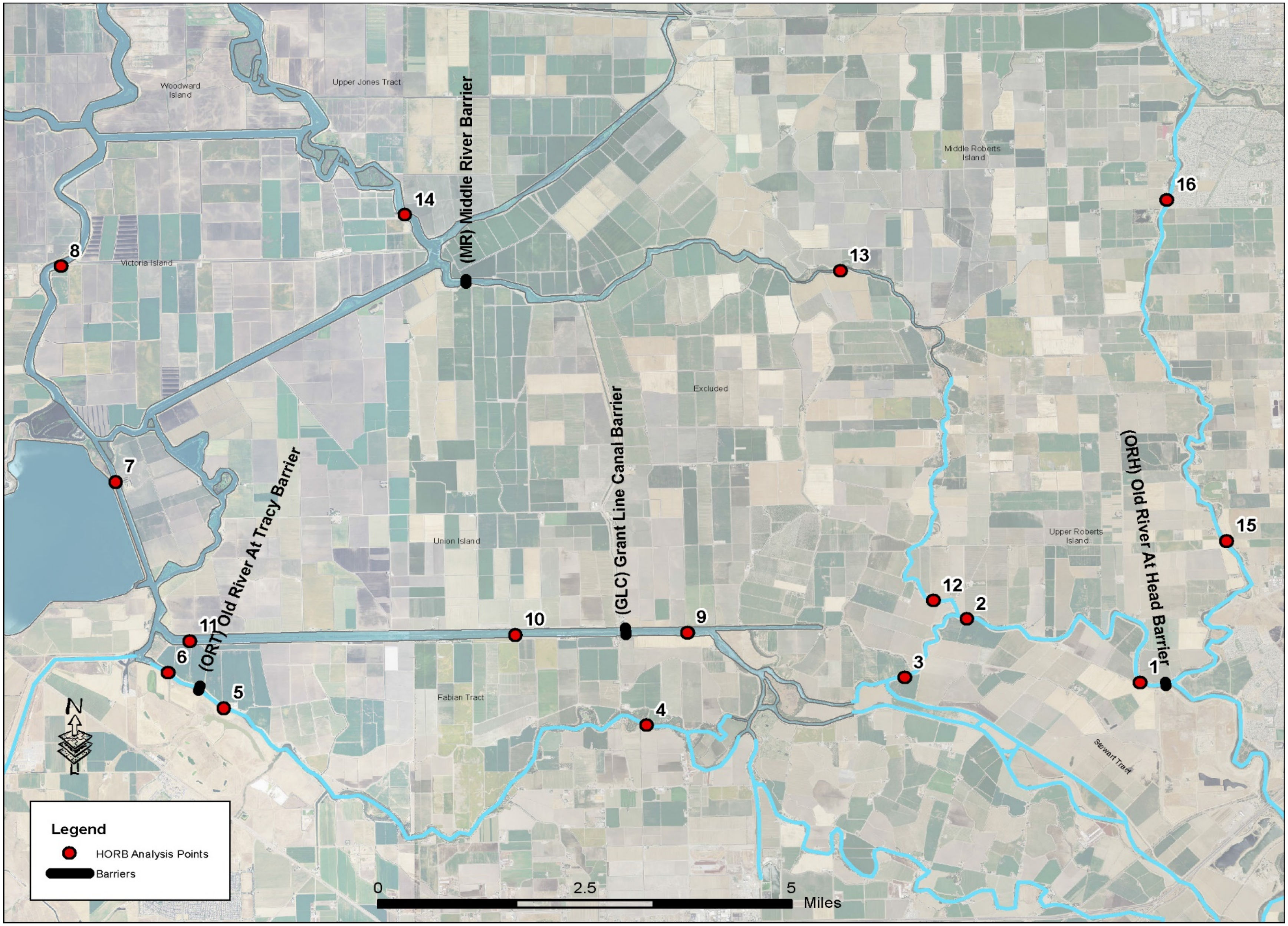


Figure 1 Location of Analysis Points

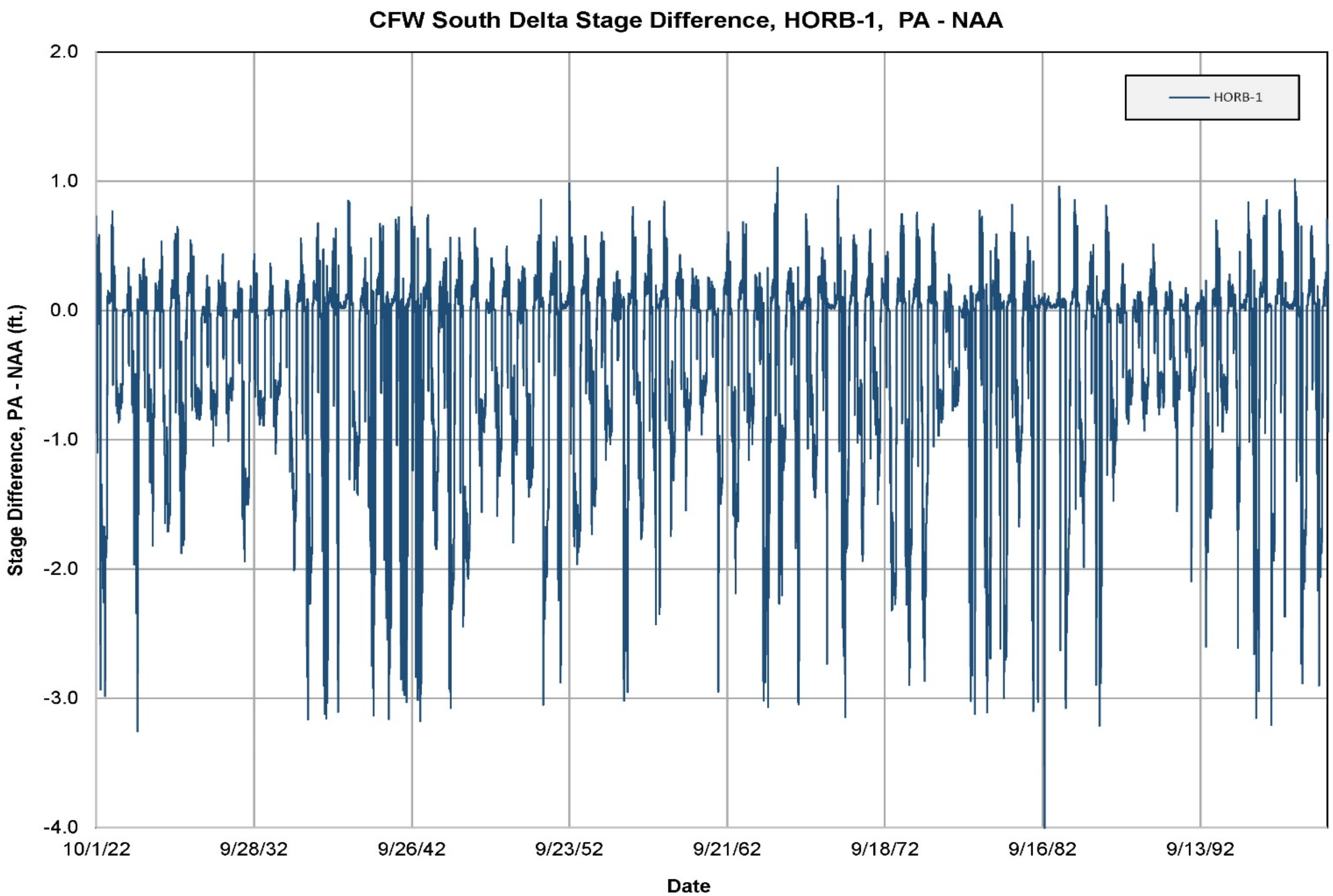


Figure 2 Stage Difference Plot for Site: HORB-1

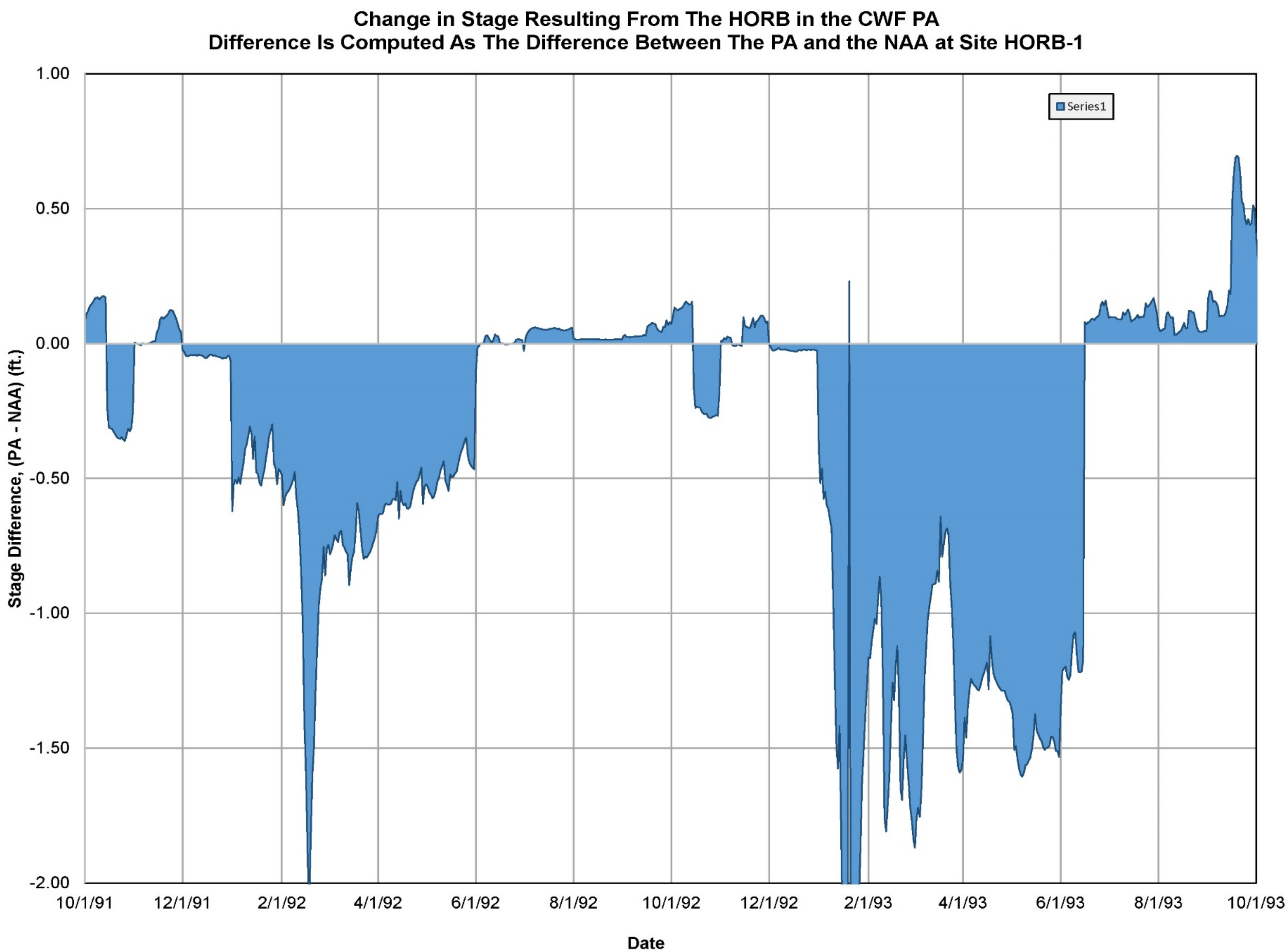


Figure 3 Stage Difference Plot for Site: HORB-1, Water Year 1991

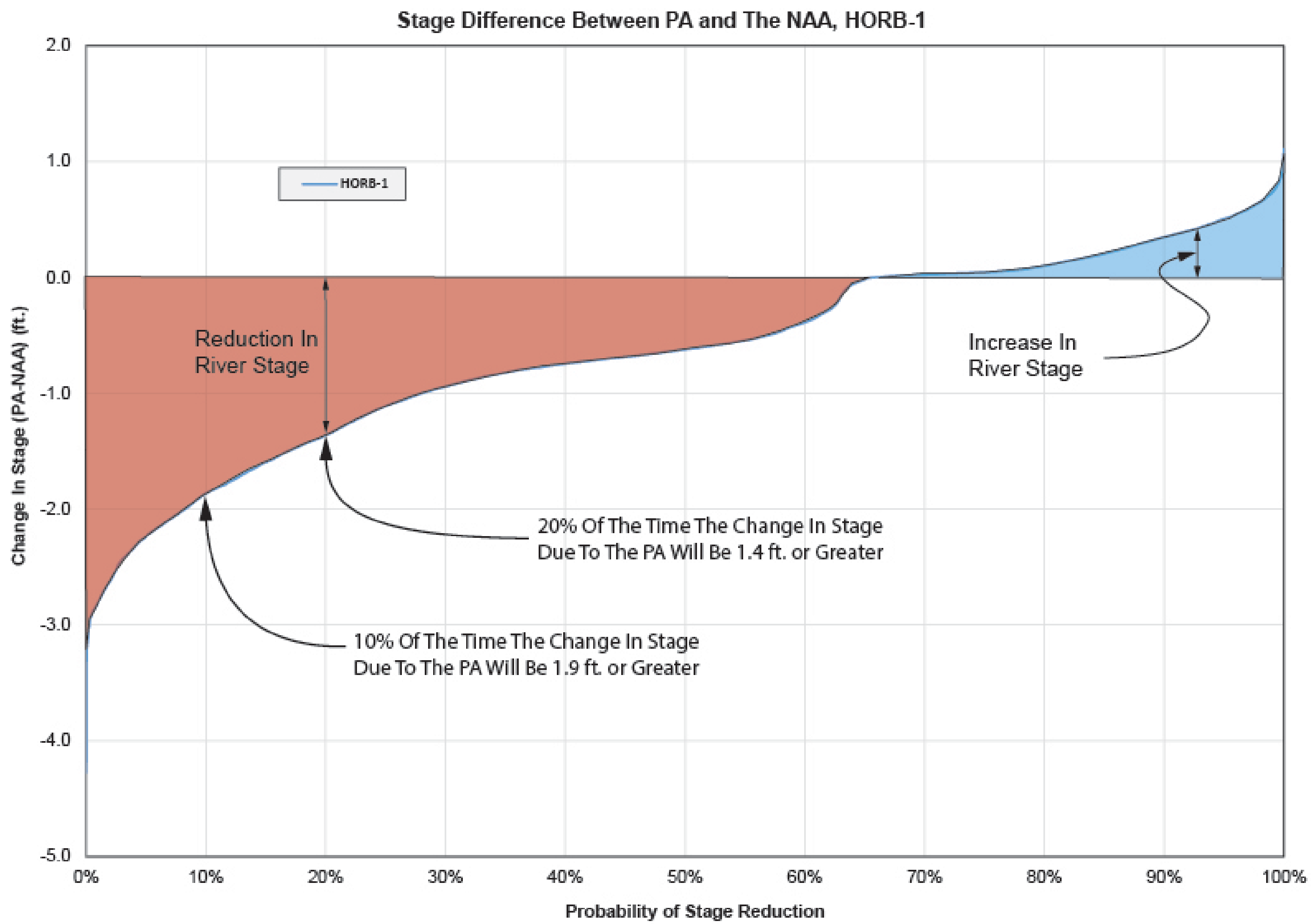


Figure 4 Stage Difference Probability Plot for Site HORB-1

As can be seen in Figure 4, the stage at this location, could be reduced by as much as 3 feet, although that would not be a common occurrence. A more likely analysis of the impact would be to view the stage reduction that would occur 10 or 20 percent of the time. Looking at the plot, it is evident that the stage would be reduced 1.4 feet or more over 20 percent of the time. Over 10 percent of the time, the stage would be reduced 1.9 feet or more. There are times when the stage will increase due to the CWF, but as can be seen by the plot, that will occur much less often, and for not as great a magnitude. The area under the probability curve provides a relative view of the amount of time that the stage would be lowered at this site vs the amount of time that it would increase. The area colored in red shows the percent of time and magnitude of the stage reduction due to the HORB as implemented in the PA. The area colored in blue shows the magnitude and frequency that the stage would increase due to the HORB as implemented in the PA. Similar stage difference plots and stage difference probability curves are provided for the other sites and are included in Appendix C.

Table 4 below is a listing of the magnitude and frequency of stage reduction due to the CWF HORB operations in the PA for each of the sites analyzed. The table shows the minimum stage reduction that would occur for 10 percent, 20 percent, and 50 percent of the time. For example, at Site 1, 10 percent of the time, the river stage will be lowered by 1.87 ft. or more. At Site 12, 20% of the time, the river stage will be lowered 0.62 ft. or more.

This frequency analysis was conducted using the 82 year period of record that were simulated by the two scenarios, but only data from those days when the HORB was operating were included in the stage reduction analysis.

Table 4 Change In River Stage That Will Be Exceeded 10%, 20%, and 50% Of The Time For The PA As Compared To The NAA.

Minimum Reduction in River Stage Between The PA and The NAA (ft.)			
	Exceedance Value		
Site No.	10%	20%	50%
1	-1.87	-1.36	-0.62
2	-1.12	-0.75	-0.31
3	-0.79	-0.53	-0.20
4	-0.25	-0.17	-0.03
5	-0.15	-0.08	0.04
6	-0.06	-0.03	0.09
7	-0.04	-0.01	0.08
8	-0.03	-0.01	0.07
9	-0.30	-0.21	-0.05
10	-0.20	-0.13	0.01
11	-0.07	-0.03	0.08

Minimum Reduction in River Stage Between The PA and The NAA (ft.)			
	Exceedance Value		
Site No.	10%	20%	50%
12	-0.93	-0.62	-0.25
13	-0.16	-0.10	-0.01
14	-0.02	-0.01	0.06
15	-0.12	0.01	0.49
16	-0.02	0.02	0.18
Example: For Site No. 1, 10% of the time there will be a 1.87 ft. or greater reduction in stage. For Site No. 12, 20% of the time there will be a 0.62 ft. reduction in stage.			

The focus of this analysis on the river stage is due to the importance in maintaining the stage of the river for the existing irrigation infrastructure to function. The majority of irrigators in the South Delta divert water from the river using either a pump or a siphon. For these to work, there must be a minimum specific depth of water above the intake to the pump or siphon. An example of this is shown in Figure 5.

When there is an adequate depth of water over the inlet to the pump, the pump can operate effectively, as shown in Figure 5a. But as the water starts to approach a minimum depth above the pump inlet, a vortex will begin to form and air is drawn into the pump and the pump begins to cavitate, which can cause damage to the pump and impeller. This condition is getting close to occurring in Figure 5b. Long before the water level gets down to the pump inlet, the pump will lose suction and become ineffective. The larger the pump, the greater the depth of water over the inlet that is required.

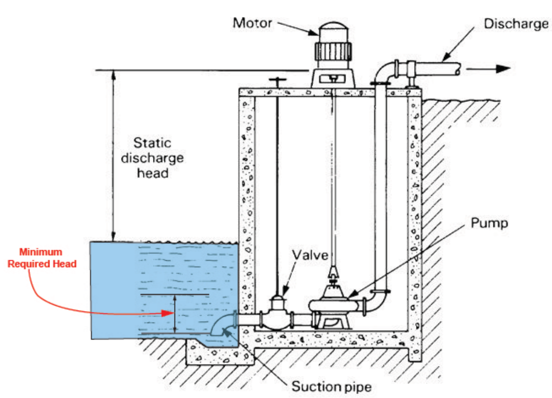


Fig 5a

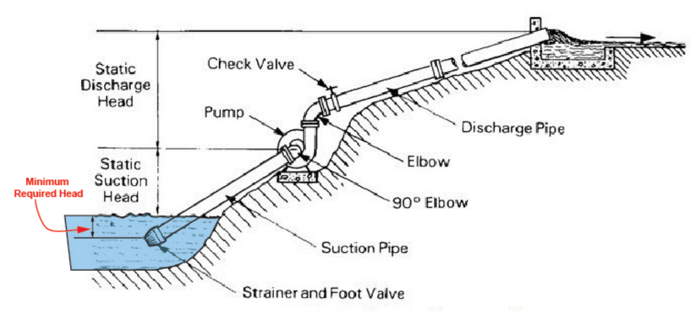


Fig 5b

Figure 5 Pump Inlet and Water Depth Scenarios

In the South Delta, many of the channels are shallow and during low tide have very little depth. Under those shallow conditions, inches start to make the difference between the ability for a farmer to irrigate his field. Given the tidal nature of the Delta, the low tide condition typically determines the effectiveness of any given irrigation pump. That is why the stage analysis, as previously described, focused on the change to the daily low tide at the different computation points.

Figures 6 through 8 are photos of some of the shallow sections on Middle River. These photos were taken by Chip Salmon, and provided by the South Delta Water Agency. As can be seen in the pictures, the depth of water in the channel can get quite low. At the depth reflected in the photos, it would be hard for any irrigation pump or siphon to work. At this location, the PA results in a half a foot or more reduction in depth 20 percent of the time. That is a large percentage of the existing channel depth. The location of these photos are shown in Figure 9.

Figure 6 Middle River at Undine Bridge, April 1, 2007

Figure 7 Middle River at Undine Bridge, Nov 29, 2007

Figure 8 Middle River at Undine Bridge, Nov 30, 2007

Figure 9 Location of South Delta Photos Shown in Figures 6-9.

5. Channel Geometry Used In the DSM2 Model

The ability to correctly assess the potential impact from the proposed changes to the HORB, and the CWF operations in general, rely to a great extent on the ability of the DSM2 model to correctly simulate the hydrodynamics of the Delta. If the hydrodynamics cannot be simulated correctly, the impacts from the CWF cannot be meaningfully assessed .Of concern is the ability of DSM2 to model the river depth in the channels which comprise the south Delta. The geometry of many of these channels has changed over the years and the channel invert that is used in the model does not appear to accurately reflect the existing conditions. The model has been calibrated to a great extent to match the water surface elevation in the channels. However, calibrating the DSM2 model to the water surface elevation does not guarantee that you are modeling the correct depth. If the flow depth is inaccurate in the model, the computed flow rate may be inaccurate as well This inaccurate flow may be one of the contributing factors in the DSM2 models problems in simulating salinity correctly in the south delta.

An example of these changed conditions can be seen in Middle River. Figure 10 is a plot of the bottom of the river (channel invert) from the confluence of Old River downstream to Howard Road Bridge. On the plot, the solid black line represents the channel invert that is used by the DSM2 model. Also plotted on the graph are channel bottom surveys that were con ducted in 1998, 1997, and 1999. These points are plotted in red on the graph.

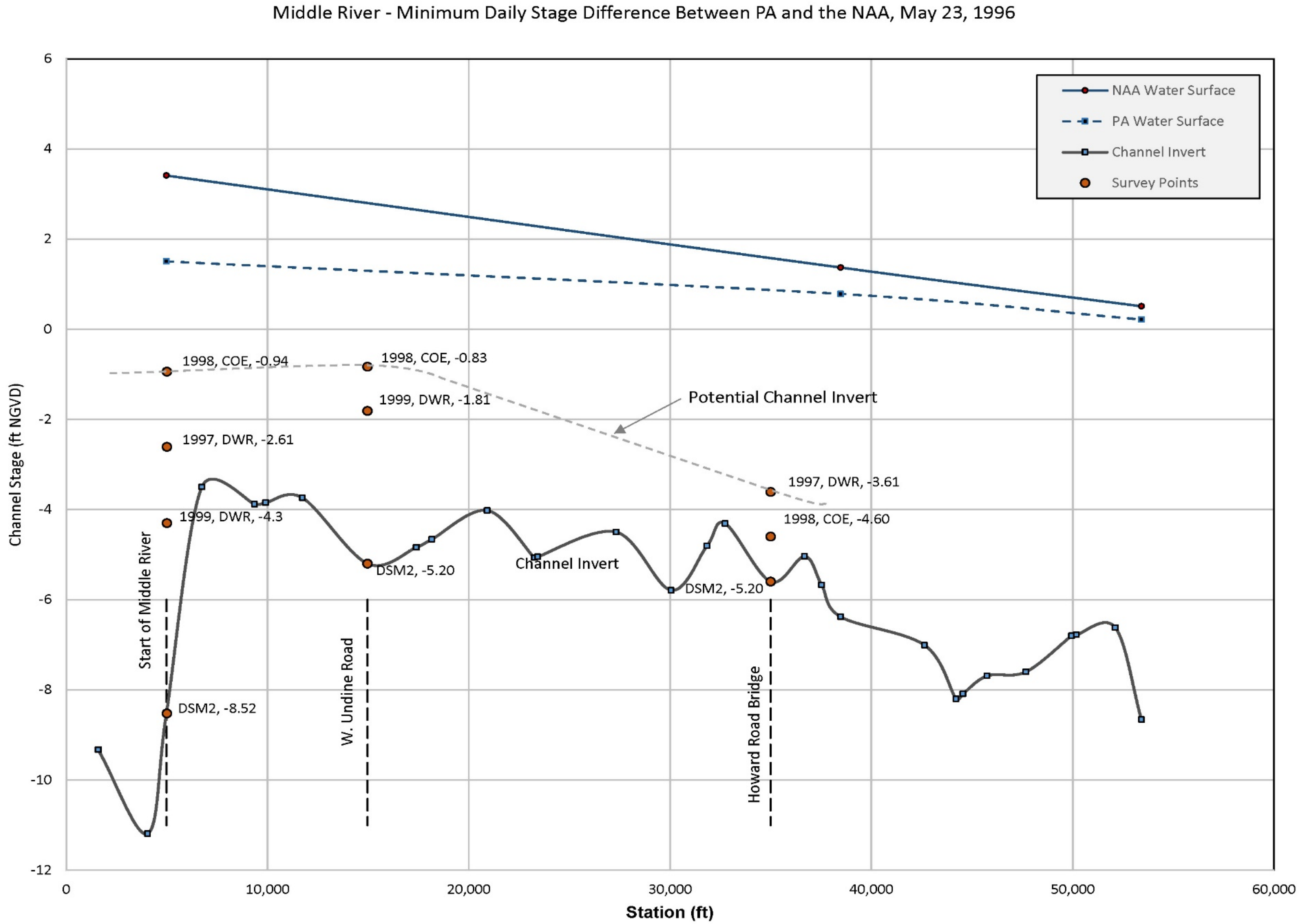


Figure 10 Middle River Profile of Channel Invert and Minimum Daily Stage for the PA and NAA of the CWF

As can be seen in the graph, there is a considerable difference in elevation between the red dots which represent the different survey points and the solid black line that represents the elevation that is used in the DSM2 model. No dredging activities have been conducted in this area since the 1990's surveys were conducted, so it is likely that additional siltation may have occurred since these surveys were completed. The effect of these higher channel invert elevations, is that the depth of water in the channel is decreasing, making it harder to conduct reliable irrigation operations.

Also plotted on Figure 10 is the water surface profiles from the two DSM2 models that represent NAA and the PA. These profiles show the minimum water surface elevation that was simulated for May 23, 1996 in each model. This day was selected to show the reduction in minimum stage resulting from the new HORB operations of the CWF. The water surface profile for the NAA is plotted as a solid blue line. The water surface profile for the PA is plotted as a dashed blue line. The difference between these two lines is the reduction in minimum water stage in the Middle River on this day.

As evidenced in the plot, the *reduction* in minimum water surface elevation, computed as the difference between the PA and NAA water surface elevations at Undine Road is approximately 1.5 feet. Given the -5.2 ft. channel invert used in the DSM2 model, this 1.5 ft. reduction represents about 19% of the total depth of 8 feet. However, if the channel invert is accurately reflected by the survey data collected in the channel in 1998, a 1.5 ft. decrease represents approximately 39% reduction in water depth of the 3.8 ft. of water available under the NAA water surface elevation. By any measure this would encompass a large percentage of the available channel depth.

The channel photos shown in Figures 6 through 8 were taken near Undine Road. As can be seen in these photographs, it is likely that the 3.8 feet of water depth, that should be present from even the highest of the channel survey elevations, is not present. It is likely that additional siltation has occurred since these survey points were collected, making the situation even worse than the worst case scenario in Figure 10 presents.

6. Impact of HORB on Flow and Delta Flushing

The Impact of the new HORB on flushing flow in the South Delta was evaluated by looking at the net downstream river flow at specific locations downstream of the HORB for both the PA and the NAA. The net downstream flow provides a metric for evaluating the positive flushing flow that is important to prevent the water from stagnating within the system. A low flushing flow will result in the build-up of nutrients and contaminants in the channel system. It also results in the water remaining in the channel system longer, allowing it to heat up. The combination of increased nutrient concentration and elevated temperatures result in accelerated algal growth which can affect available oxygen levels for aquatic species, diminish water quality, and exacerbate odor problems. Recent algal problems in the Delta involving cyanobacteria and toxic blue-green algae could be directly affected by the conditions resulting from reduced flushing rates.

The difference in net daily downstream flow between the two scenarios was compared for each day over the full 82 year period of record simulated by the DSM2 model. From that dataset, the days during which the HORB was installed in either the PA or NAA were extracted for analysis. Table 3 above, is a listing of the sites that were evaluated in this analysis. Figure 1 is a map of the Delta showing the location of each analysis point.

Figure 11 below is a plot of the difference in net downstream flow between the PA and the NAA at Site No. 2. The difference in flow is computed by subtracting the NAA daily flow from the daily flow for the PA. As such, a negative difference represents a reduction in downstream flow that would result from the CWF PA. As can be seen in the figure, there is a significant amount of time over that 82 year period where there is a reduction in downstream flow. Figures 12-14 below shows the details of the flow change for a dry, average, and wet water year. The change in flow on January 1^{st} when the PA HORB is raised is evident in the plots. Detailed plots for the other sites are provided in Appendix E.

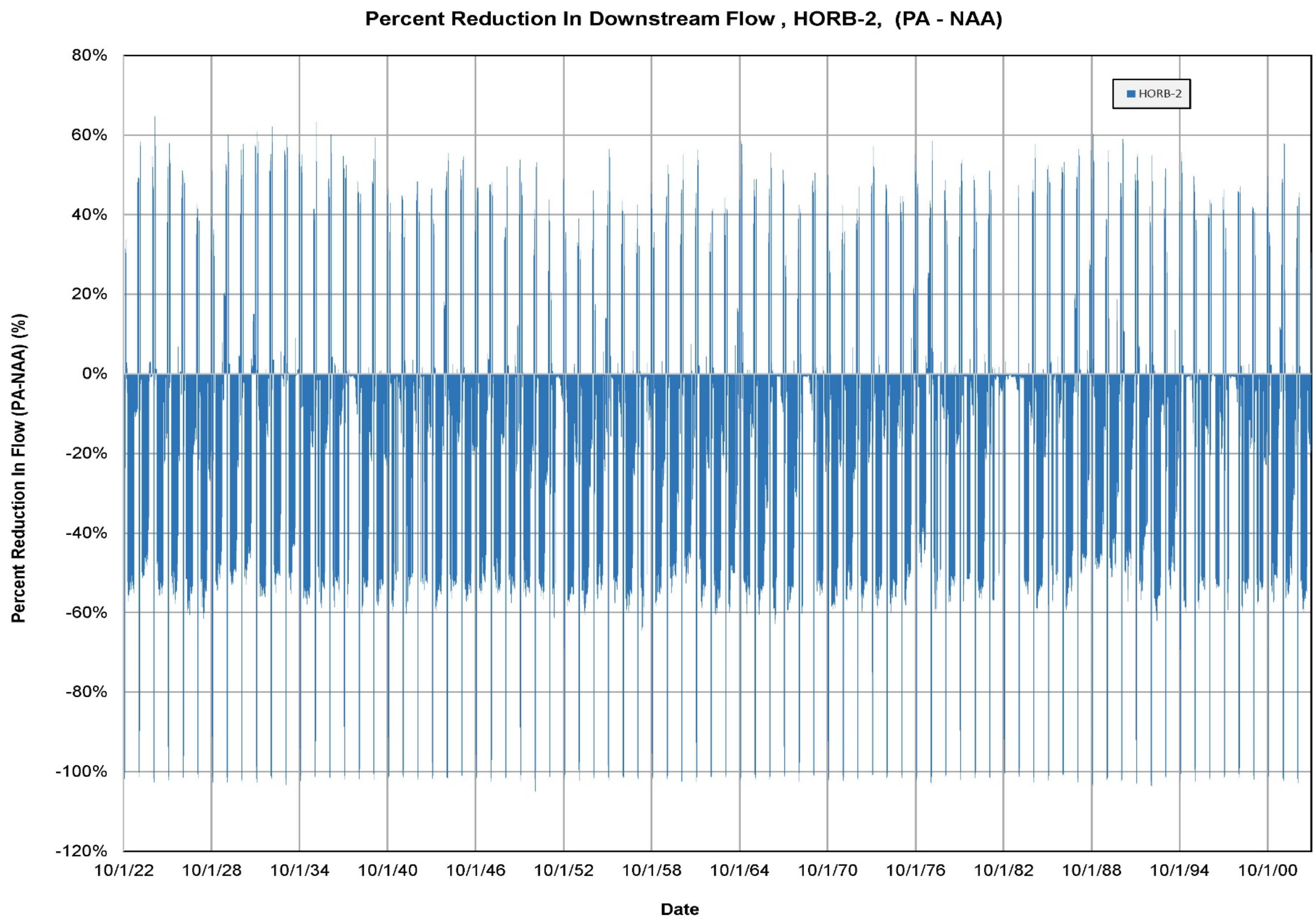

Percent Reduction In Downstream Flow , HORB-2, (PA - NAA)
HORB-2
Percent Reduction In Flow (PA-NAA) (%)
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
-120%
10/1/22
10/1/28
10/1/34
10/1/40
10/1/46
10/1/52
10/1/58
10/1/64
10/1/70
10/1/76
10/1/82
10/1/88
10/1/94
10/1/00
Date

Figure 11

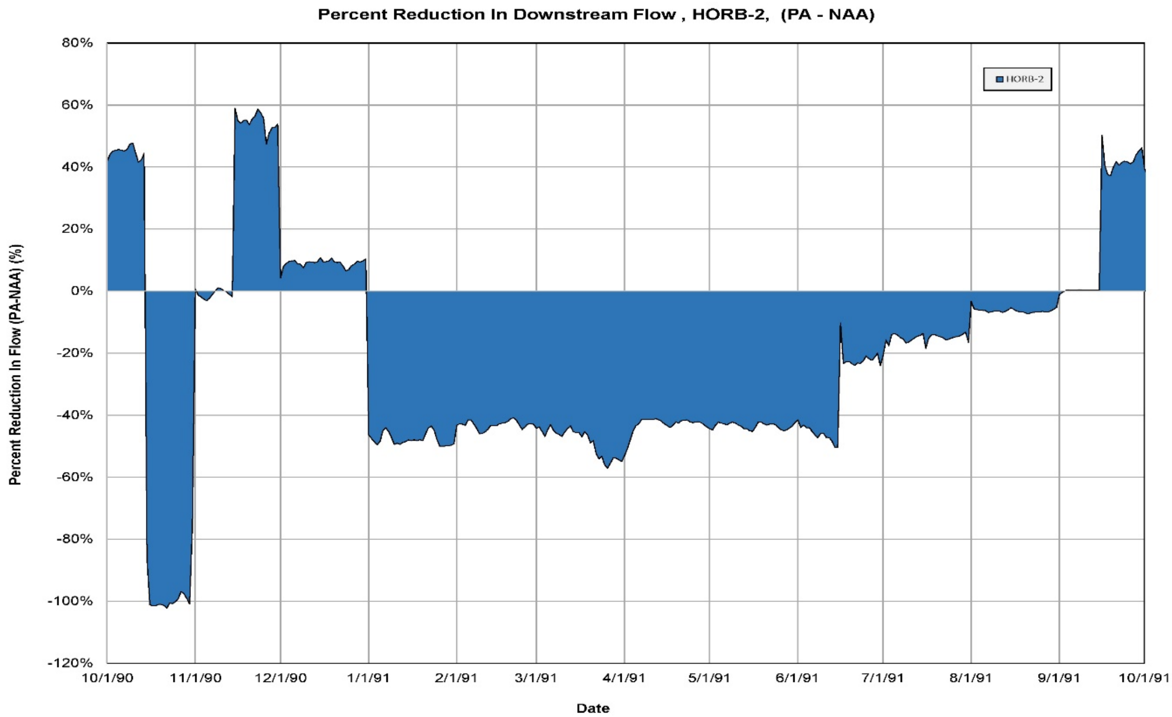


Figure 12 Downstream Flow Change Resulting From the PA of the CWF, Dry Water Year

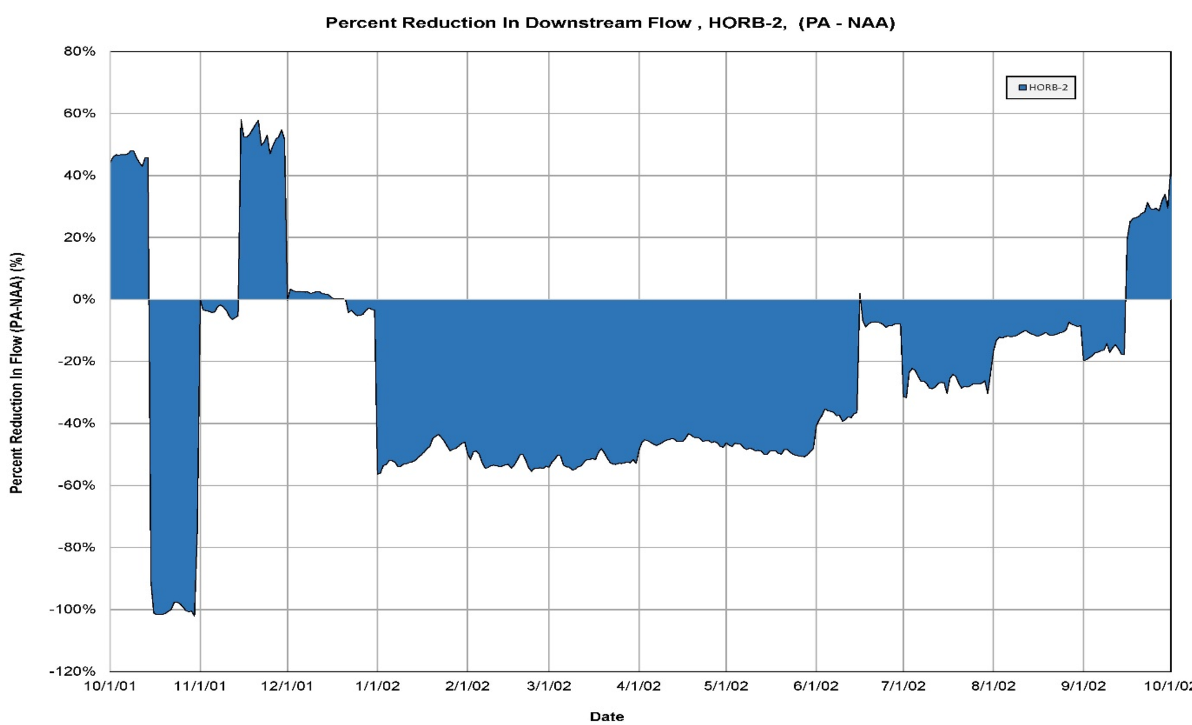


Figure 13 Downstream Flow Change Resulting From the PA of the CWF, Average Water Year

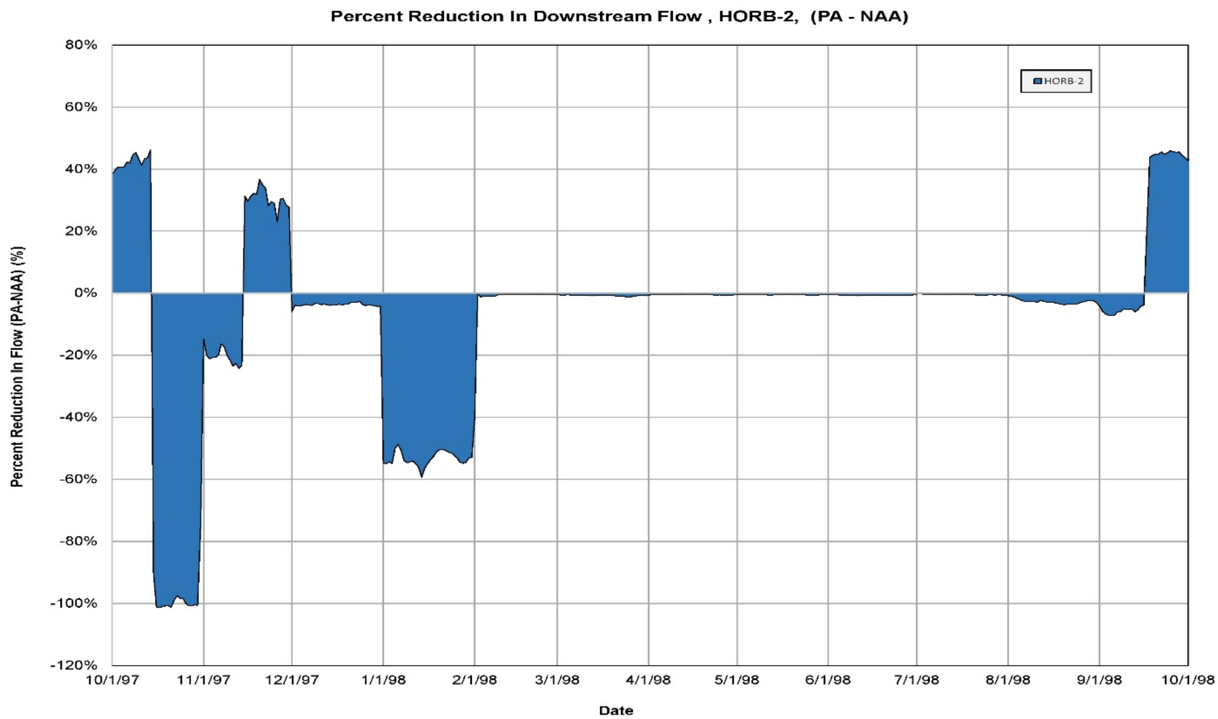


Figure 14 Downstream Flow Change Resulting From the PA of the CWF, Wet Water Year

To evaluate the magnitude of the change in flow and the frequency of same, a frequency analysis was conducted of the daily flow change. The data used in the frequency analysis includes only days when the HORB was in place. This allows for a better representation of the impacts due to the HORB. The result of that analysis for Site No. 2 is shown in Figure 15. This figure shows the percent of time that the flow would be reduced by a specific percentage. Plots for additional sites have been provided in Appendix D.

Based on the analysis of the flow change between the two model scenarios, the percent reduction that would occur 10%, 20%, and 50% of the time was computed for all of the sites. That percent reduction in flow is shown in Table 5. As an example, for Site No. 2, 10 percent of the time, there would be a 57 percent reduction in positive flushing flow at this location. Twenty percent of the time there would be a 54 percent reduction in flushing flow at the site, and 50 percent of the time there would be a 48 percent reduction in flushing flow at the site.

As demonstrated by the data presented in Table 5, there is a significant reduction in flushing flow at most of the sites in the study.

As stated above, decreased downstream flow caused by an HORB would in general translate into less flushing and the consequent impacts to water quality. However, the operation of the three agricultural rock barriers (if present during such decreased downstream flows) and the quality of the San Joaquin

River water would determine the degree to which flushing, stagnation or the concentration of pollutants would occur. DWR's failure to analyze all the relevant data means that the actual, anticipated impacts to water quality remain unexamined and unknown

Table 5 The Percent Reduction In Positive Downstream Flushing Flow That Will Be Exceeded 10%, 20%, and 50% Of The Time For The PA As Compared To The NAA.

Percent Change In Flow Between The PA and the NAA (%)			
	Exceedance Value		
Site	**10%**	**20%**	**50%**
1	-57%	-54%	-48%
2	-57%	-54%	-48%
3	-58%	-54%	-49%
4	-83%	-57%	-46%
5	-164%	-86%	-47%
6	-163%	-86%	-47%
7	-118%	-97%	-30%
8	-122%	-98%	-30%
9	-67%	-60%	-51%
10	-68%	-60%	-51%
11	-72%	-62%	-50%
12	-64%	-54%	-34%
13	-245%	-130%	-59%
14	-114%	-90%	-26%
15	-23%	0.3%	57%
16	-23%	0.3%	58%

Example: For Site No. 1, 10% of the time there will be a 57% or greater reduction in positive downstream flushing flow. For Site No. 6, 10% of the time there will be a 163% reduction in positive downstream flushing flow. You can only have a value greater than 100% if the net downstream flow is completely reversed. For example, if a 100 cfs downstream flow under the NAA becomes a -40 cfs upstream flow under the PA, you would have a -140% flow change.

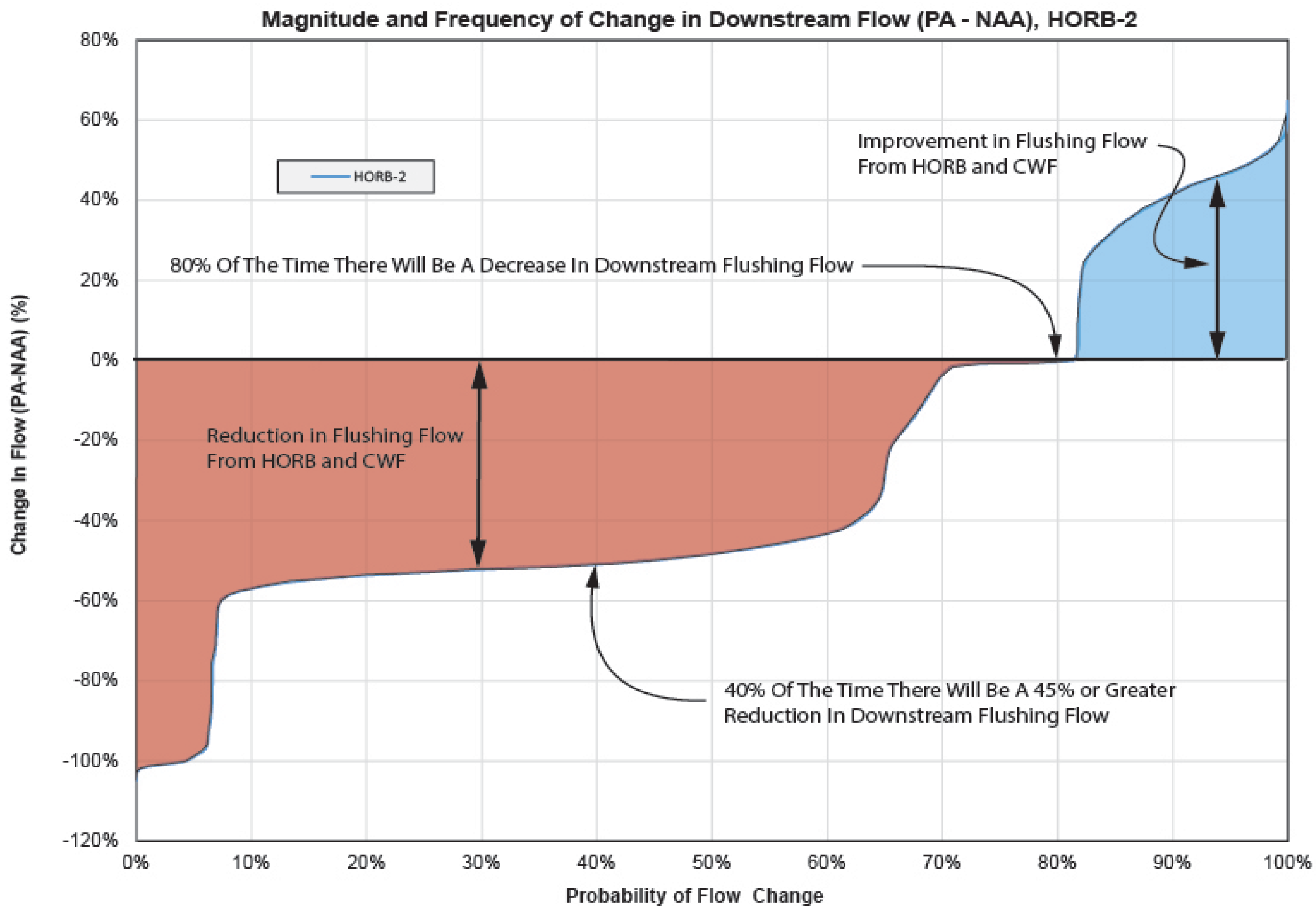


Figure 15 Percent Reduction in Downstream Flushing Flow and Frequency of Occurrence for Site No. 2.

7. Summary

This analysis evaluated the changes to the hydrodynamics in the Southern Delta due to the modifications proposed for the HORB in the Preferred Alternative (PA) of the proposed California Water Fix (CWF). The changes were evaluated by comparing the PA to the No Action Alternative (NAA) which generally represents the existing condition and operation of the State and Federal Water Projects. The hydrodynamic model, DSM2, was used to develop this comparison. The DSM2 model was used to simulate hydrodynamics in the Delta for both the PA and the NAA. These two DSM2 models were developed for the analysis of the PA in the Biological Assessment of the CWF project that was developed by THE PETITIONERS. Those models were used as they were developed by the THE PETITIONERS, no modifications to these two models were made for this study.

7.1 Stage Impacts

The analysis of the change in stage and in flushing flow show that the new operation of the HORB is going to have an adverse effect on the water quality and water availability in the Southern Delta. The change in stage, which in some areas can be more than one foot, directly affects the ability for farmers to irrigate. The lower water surface and resulting lower channel depth limits farmers' ability to pump from the channels resulting in potential crop losses as well as cavitation and damage to pumps and diversion equipment.

7.2 Model Representation of Channel Invert

There are locations in the south Delta where the channel geometry is used in the DSM2 model do not match surveyed channel elevations. Some of these channels have been observed to be silting up, making the resulting channel shallower for any given water surface elevation. One good example is Middle River. Several surveys in that vicinity show that the channel invert may be 2 to 3 feet higher than what is being used in the model. This reduction in depth, and resulting flow area, make the impacts of the changes to the HORB to be greater than what the model is presently portraying. These surveys, that show the siltation to Middle River, were prepared approximately 20 years ago. . Given the lack of dredging the past twenty years, it is very likely that siltation conditions are worse than what the survey data show. Photographs of the Middle River show that the channel depth is much lower than what is being portrayed by the DSM2 model or even the survey data that show ongoing siltation.

7.3 Impacts to Flushing Flow

The analysis of the DSM2 model simulations show that the changes to the HORB as proposed for the BA will have a negative impact on positive flushing flow in most channels in the Southern Delta. The flushing flow for most channels will be reduced by more than half, 20 percent of the time. Some channels will see a reduction of flushing flow of 90 percent. This reduction in flushing flow adversely effects water quality, temperature, algal growth, aquatic habitat, and odor.

Appendices

Appendix A – Historic Head of Old River Installation and Removal Schedule

Table A1 – Historic Spring Head of Old River Installation

Year	Spring Head of Old River					
	Installation			Removal		
	Started	Closed	Completed	Started	Breached	Completed
1987						
1988						
1989						
1990						
1991						
1992	15-Apr boat port on		23-April @ 4 ft 26-April @ 6 ft 1-May	2-Jun		8-Jun
1993						
1994	21-Apr boat port on		23-April @ 10 ft 1-May	18-May		20-May
1995			(vii)			
1996	6-May		11-May	16-May		03-Sep (iv)
1997	9-Apr		16-Apr	15-May		19-May
1998	(vii)					
1999	(vii)					
2000	5-Apr		16-Apr	19-May		2-Jun
2001	17-Apr		26-Apr	23-May		30-May
2002	2-Apr		18-Apr	22-May	24-May	7-Jun
2003	1-Apr	15-Apr	21-Apr	16-May	18-May	3-Jun
2004	1-Apr	15-Apr	21-Apr	19-May	24-May	10-Jun
2005	(xi)	(xi)	(xi)	(xi)	(xi)	(xi)
2006	(xi)	(xi)	(xi)	(xi)	(xi)	(xi)
2007	11-Apr	20-Apr	26-Apr	19-May	22-May	6-Jun
2008	(xiv)	(xiv)	(xiv)	(xiv)	(xiv)	(xiv)
2009	(xv)	(xv)	(xv)	(xv)	(xv)	(xv)

Year	Spring Head of Old River					
	Installation			Removal		
	Started	Closed	Completed	Started	Breached	Completed
2010	5-Apr (xv)	(xv)	16-Apr (xv)	(xv)	(xv)	(xv)
2011	(xvii)	(xvii)	(xvii)	(xvii)	(xvii)	(xvii)
2012	15-Mar	1-Apr	11-Apr	1-Jun	4-Jun	20-Jun
2013	(xxii)	(xxii)	(xxii)	(xxii)	(xxii)	(xxii)
2014	25-Mar	8-Apr	11-Apr	28-May	9-Jun	26-Jun
2015	16-Mar	3-Apr	8-Apr	27-May	1-Jun	8-Jun

Table A2 – Historic Fall Head of Old River Barrier Installation

Year	Fall Head of Old River (v)						
	Installation			Notched	Removal		
	Started	Closed	Completed		Started	Breached	Completed
1968(ix)	30-Sep		3-Oct		15-Nov		21-Nov
1969							
1970	1-Oct		6-Oct		13-Nov		14-Nov
1971	24-Sep		1-Oct		8-Nov		12-Nov
1972	25-Sep		29-Sep		7-Nov		10-Nov
1973	1-Oct		5-Oct		14-Nov		15-Nov
1974	12-Sep		18-Sep		1-Nov		9-Nov
1975	17-Sep		26-Sep		1-Nov		4-Nov
1976	28-Oct		1-Nov		22-Nov		23-Nov
1977			27-Oct				5-Dec
1978							
1979			1-Oct				29-Nov
1980							
1981			15-Oct				25-Nov
1982							
1983							
1984	5-Sep		8-Sep				19-Oct
1985							
1986							
1987	9-Sep		11-Sep				28-Nov
1988	22-Sep		28-Sep				2-Dec

Year	Fall Head of Old River (v)						
	Installation			Notched	Removal		
	Started	Closed	Completed		Started	Breached	Completed
1989	27-Sep		28-Sep		27-Nov		30-Nov
1990	10-Sep		11-Sep				27-Nov
1991	9-Sep		13-Sep		22-Nov		27-Nov
1992	8-Sep		11-Sep		30-Nov		4-Dec
1993	08-Nov (vi)		11-Nov		3-Dec		7-Dec
1994	6-Sep		8-Sep		28-Nov		30-Nov
1995	(vii)						
1996	30-Sep		3-Oct		18-Nov		22-Nov
1997							
1998	(vii)						
1999	(viii)						
2000	27-Sep		7-Oct		27-Nov		8-Dec
2001	24-Sep		6-Oct		22-Nov	22-Nov	2-Dec
2002	24-Sep		4-Oct		11-Nov	12-Nov	21-Nov
2003	2-Sep	15-Sep	18-Sep	16-Sep	3-Nov	4-Nov	13-Nov
2004	7-Sep	27-Sep	29-Sep	28-Sep	1-Nov	2-Nov	12-Nov
2005	19-Sep	28-Sep	30-Sep	29-Sep	7-Nov	8-Nov	15-Nov
2006	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2007	5-Oct	17-Oct	18-Oct	18-Oct	9-Nov	10-Nov	29-Nov
2008	1-Oct	16-Oct	16-Oct	16-Oct	3-Nov	3-Nov	9-Nov
2009	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2010	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2011	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2012	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2013	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2014	22-Sep	1-Oct	2-Oct	1-Oct	10-Nov	11-Nov	15-Nov
2015	3-Sep	13-Sep	17-Sep		12-Nov	12-Nov	18-Nov

(i) Barrier notched on Sept. 28, 1991. Construction resumed on Oct. 10 and finished on Oct. 13.
(ii) Barrier notched on Sept. 30, 1992. Construction resumed on Oct. 2 and finished on Oct. 9.
(iii) Construction was delayed on 5/17 and resumed on 6/5 due to high flows.
(iv) Barrier was breached on 5/ 16 on an emergency basis, but complete removal wasn't done until 9/3, after Corps demanded permit compliance of complete removal.
(v) Barrier was installed in previous years.
(vi) Installation delayed due to high flows.
(vii) Not intalled due to high San Joaquin River flows.
(viii) Not installed upon DFG's request.
(ix) In 1963 and 1964 an old rock barge was intentionally flooded and sunk at the head of Old River in an

experiment to see if it could serve as a temporary barrier. Results were not promising and rock was placed directly for the 1968 barrier. No barriers were in place in 1965, 1966 or 1967.
(x) Flashboards adjusted to allow minimum 6-inches flow for fish passage.
(xi) Spring Head of Old River not installed due to high flows in the San Joaquin River.
(xii) Only above water portion of boat ramps constructed due to hgh flows. North abutment not installed until full closure of barrier. No "partial" barrier configuration for 2005.
(xiii) Fall Head of Old River not installed because existing flows and dissolved oxygen levels in the San Joaquin River were sufficient for Chinook Salmon.
(xiv) Not installed in accordance with Wanger decision to protect Delta Smelt.
(xv) Non Physical "Bubble Barrier" installed as a pilot test to prevent salmon from entering Old River.
(xvi) Includes installation of new culverts in the Middle River barrier north and south abutments.
(xvii) The Non-Physical Barrier was planned but could not be installed due to high velocity currents in the San Joaquin River that posed excessively dangerous conditions for divers and ruled out the possibility of installing the necessary equipment on the channel bottom.
(xviii) Started Grantline Canal barrier south abutment construction to replace culverts, using barge and crane from shoreline.
(xix) Due to high flows the Grantline Canal barrier fish flashboard structure washed out and will be re-constructed at a later date. The weir section elevation had to be reduced to accommodate the high flow. All 6 culverts were in tidal position (closed).
(xx) The Grantline Canal barrier weir section was completed back to it's designed weir elevation (1.0 ft NGVD) and all 6 culvert flap-gates were tied open.
(xxi) The Grantline Canal flashboard structure was washed out earlier in the year and the California Department of Fish and Game did not require a notch this year due to high flows.
(xxii) The 2013 spring Head of Old River Rock Barrier was not installed due to uncertainty about the benefits of installing the barrier to salmonid survival through the Delta.

Appendix B – HORB Spring and Fall Implementation Schedule

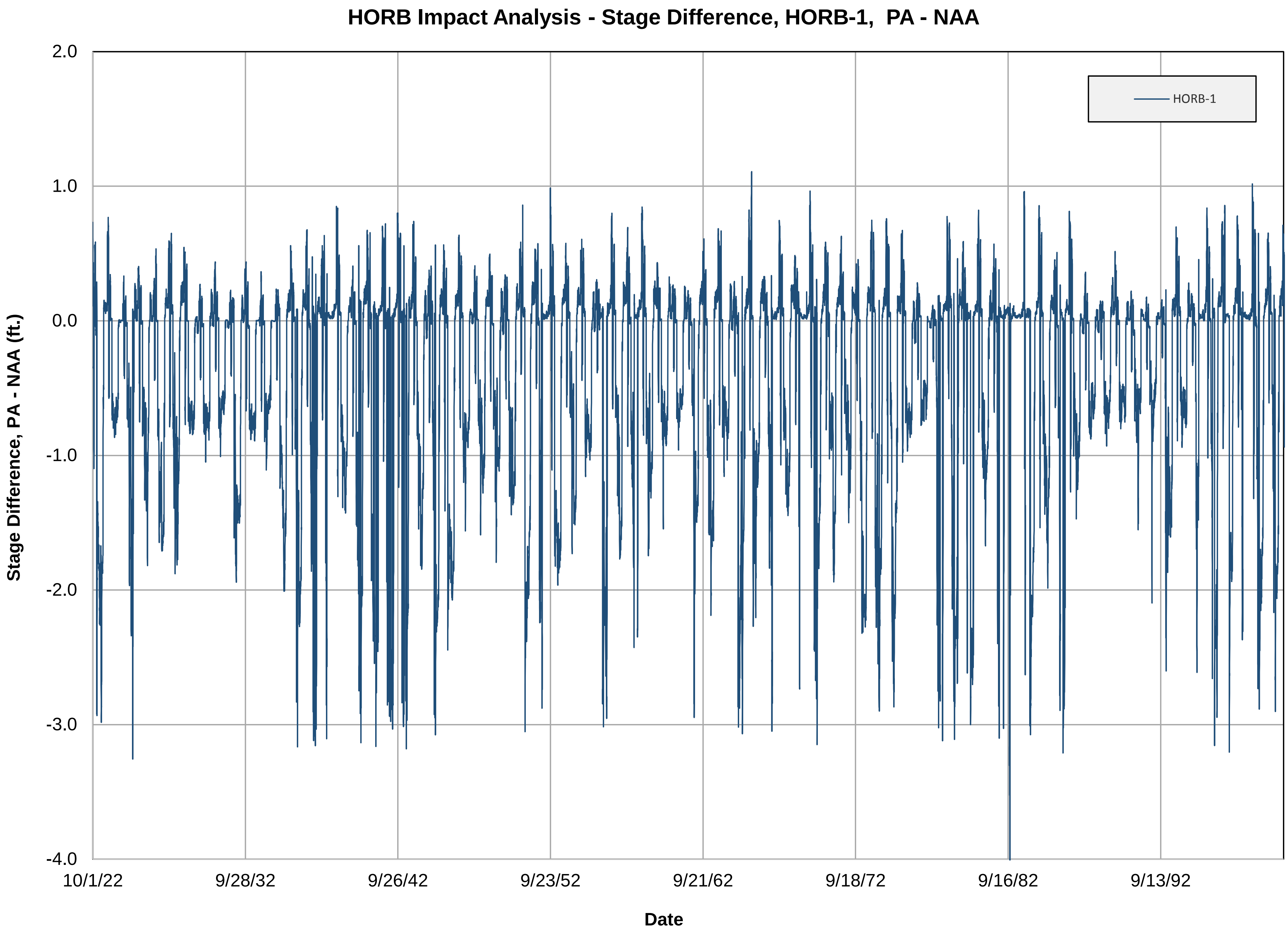
California Water Fix - Old River At Head Structure Schedule

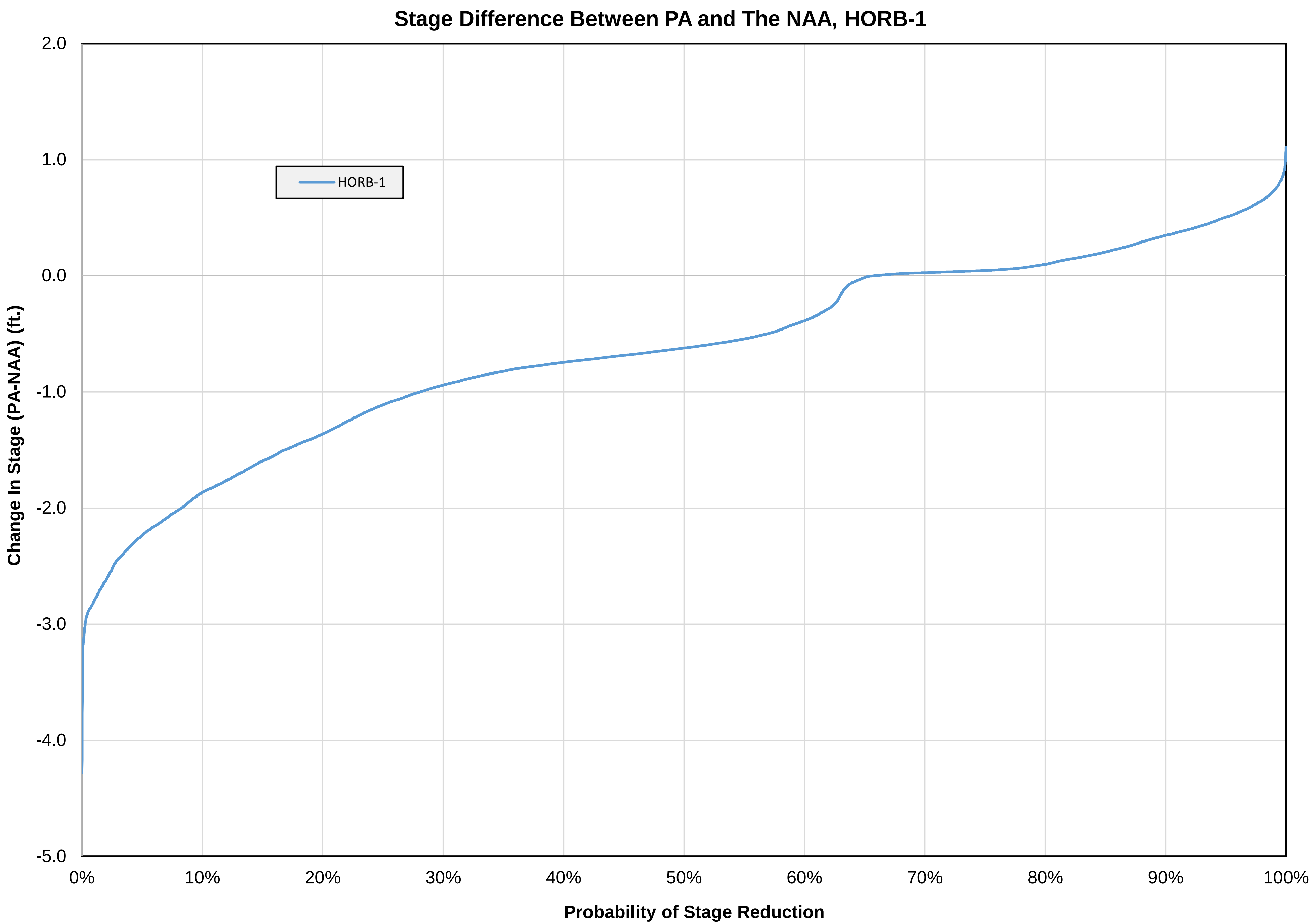
Nov Post Pulse: October 31 - November 16
Spring Mon: January 1 - June 15
October Pulse: October 15 - November 1

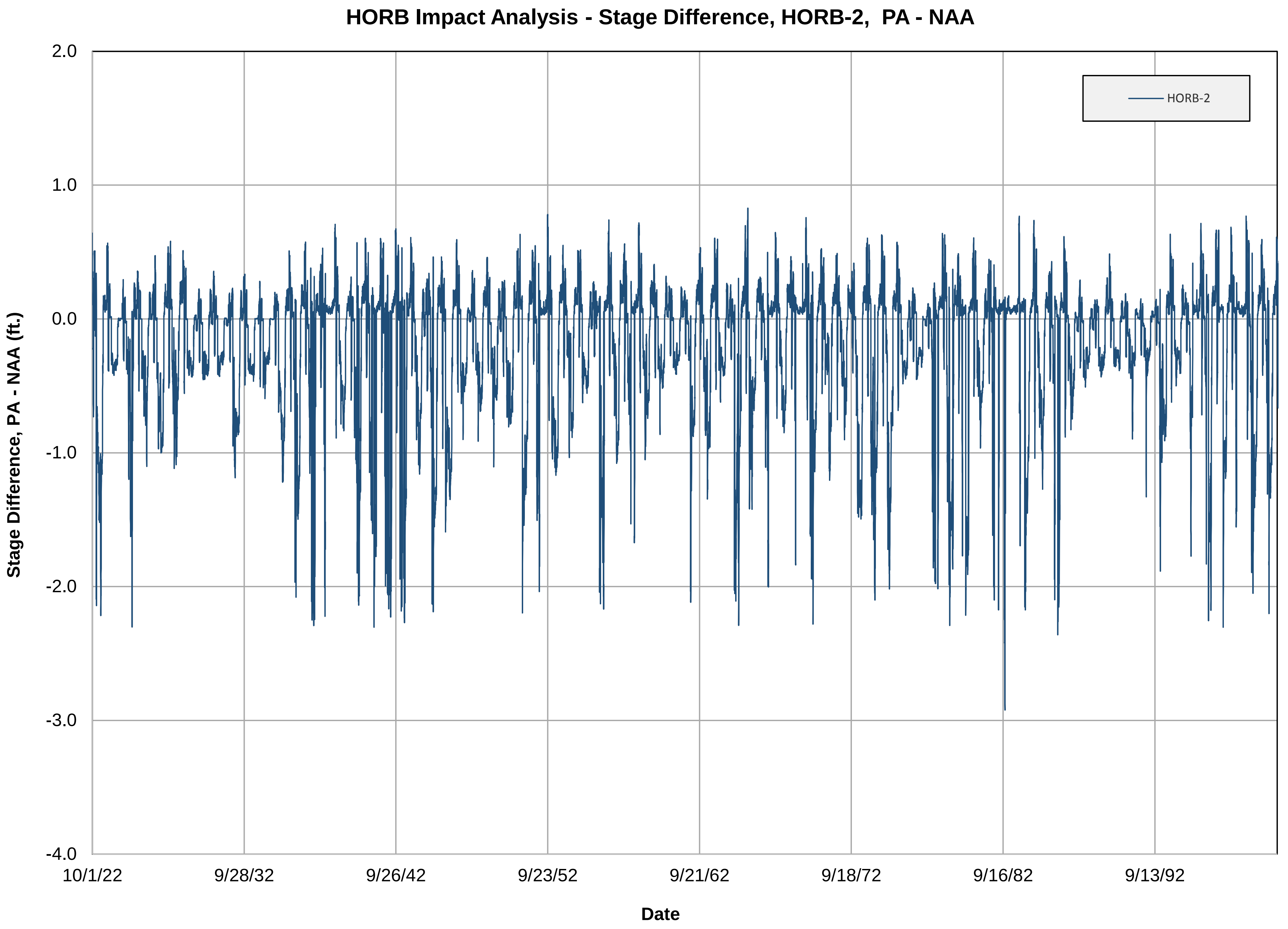
																					Oct Pulse	Nov Pulse			
		Jan		Feb		March		April		May		June		July		August		September		October		November		December	
		Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4	Week 1-2	Week 3-4
CWF, BA PA																									
																					1		Open Fall Barrier , SJR<10,000 cfs		
																					1		Open Fall Notch , SJR<10,000 cfs		
																					2		Set Pipes = -5 , SJR<10,000 cfs		
																				3			Remove Spring BarrierDuring Fa;;		
	4	Install Barrier General, SJR<10,000 cfs											4							4	Install Barrier General		Install Barrier General , SJR<10,000 cfs		
	5	Remove Barrier											Remove Barrier									5	Remove Barrier		
	6	Install Spring Barrier, SJR<10,000 cfs											6												
		Spring Pipes = -4, Coef = 0.71 , SJR<10,000 cfs											7,8,9												
		Remove Fall Barrier											10												
																				11		Close Fall Barrier			
																				11		Close Fall Notch			
																				12		Close Fall Pipes			
																				13		Open Pipes "NOT" In This Period , SJR<10,000 cfs			
CWF, BA NAA																									
								1	Spring Barrier To 10		SJR < 7,500														
								2	Spring Barrier To 11		SJR> 7,500														
																		3	Fall Barrier SJR< 5,000						
																		3	Fall Notch SJR< 5,000						
																		4	Fall Pipes to -5 SJR< 5,000						
																		5	Close Spring Barrier						
																		6	Install Barrier General, SJR < 5,000						
		Remove Barrier									Remove Barrier								Remove Barrier, SJR>8,500					Remove Barrier	
								8	Spring Barrier		, SJR<5,000 cfs														
								9	Pipes To -4		, SJR<5,000 cfs														
								10	Fall Barrier Close		, SJR<5,000 cfs														
								11	Fall Notch Close		, SJR<5,000 cfs														

Appendix C

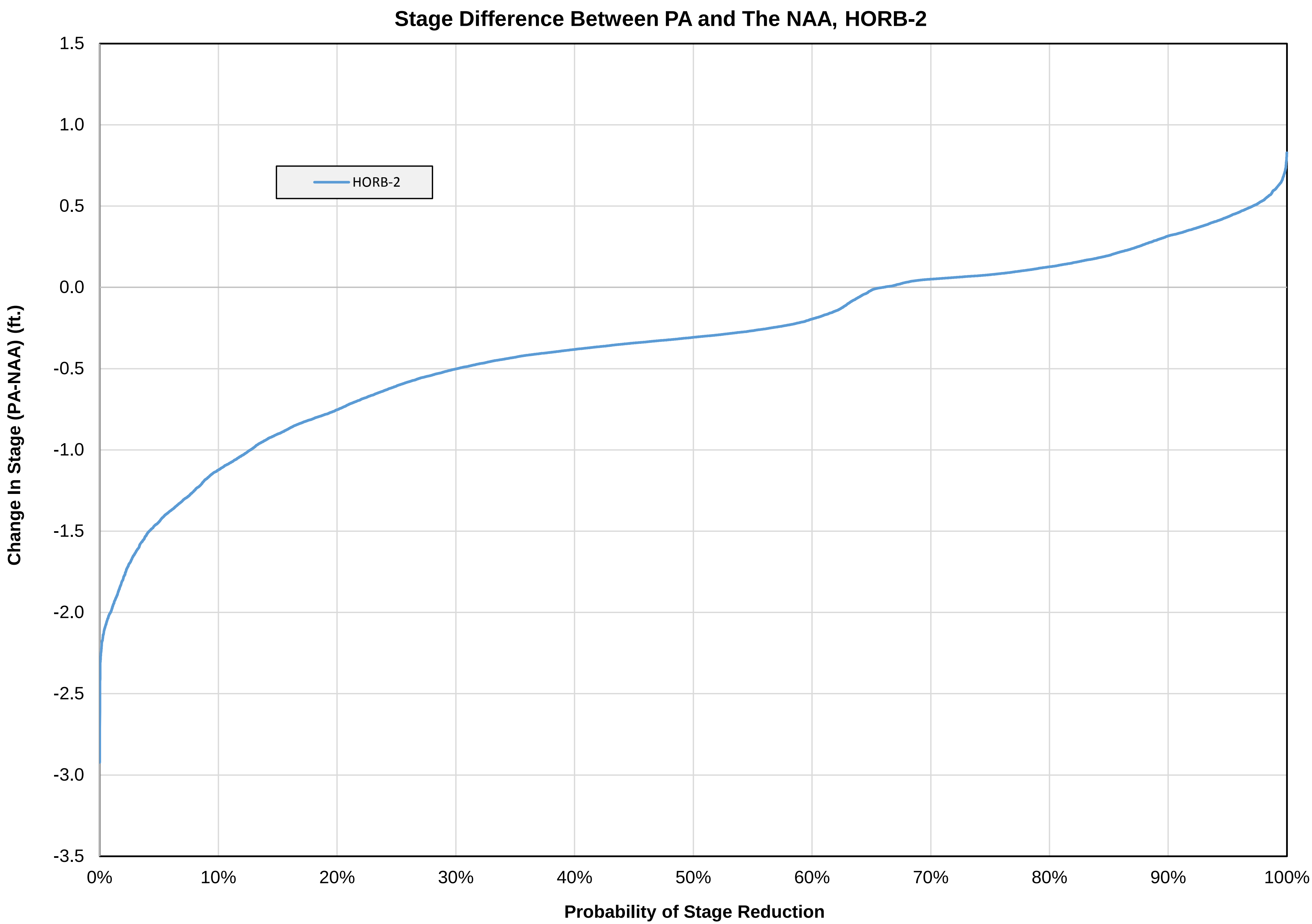
Plots Of the Difference in Stage between The PA and NAA

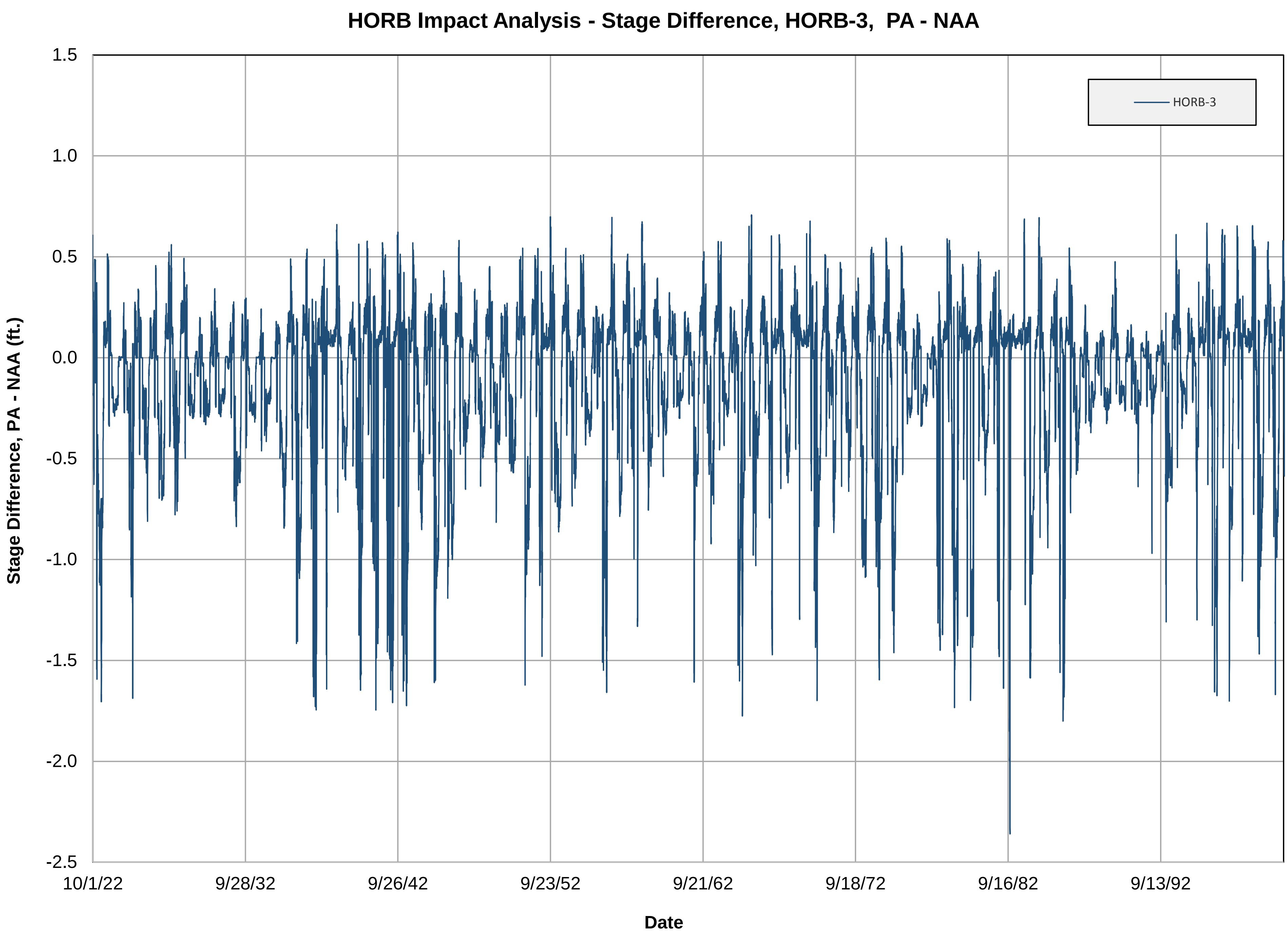

HORB Impact Analysis - Stage Difference, HORB-1, PA - NAA
HORB-1
Stage Difference, PA - NAA (ft.)
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
10/1/22
9/28/32
9/26/42
9/23/52
9/21/62
9/18/72
9/16/82
9/13/92
Date

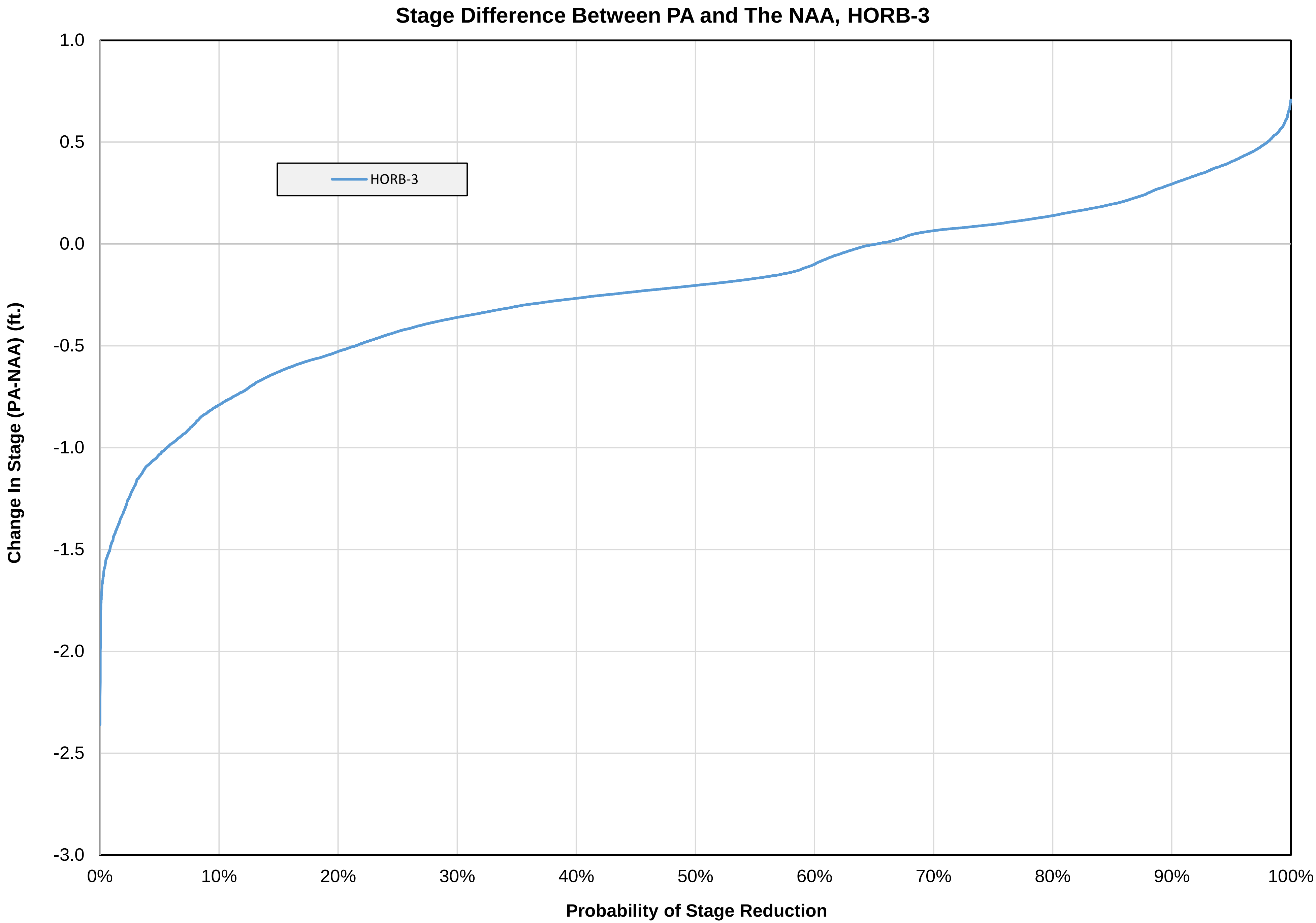

Stage Difference Between PA and The NAA, HORB-1
HORB-1
Change In Stage (PA-NAA) (ft.)
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction

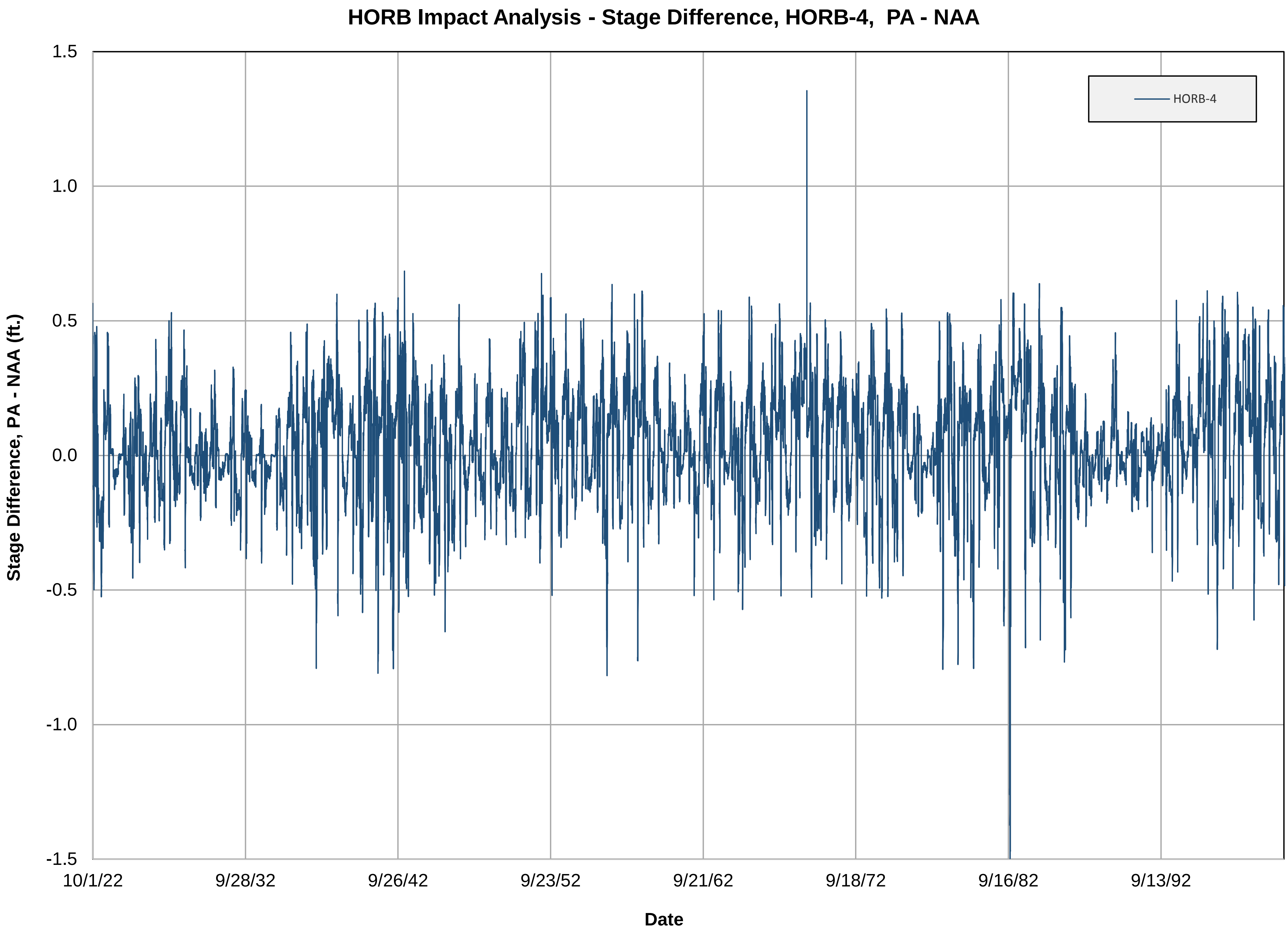


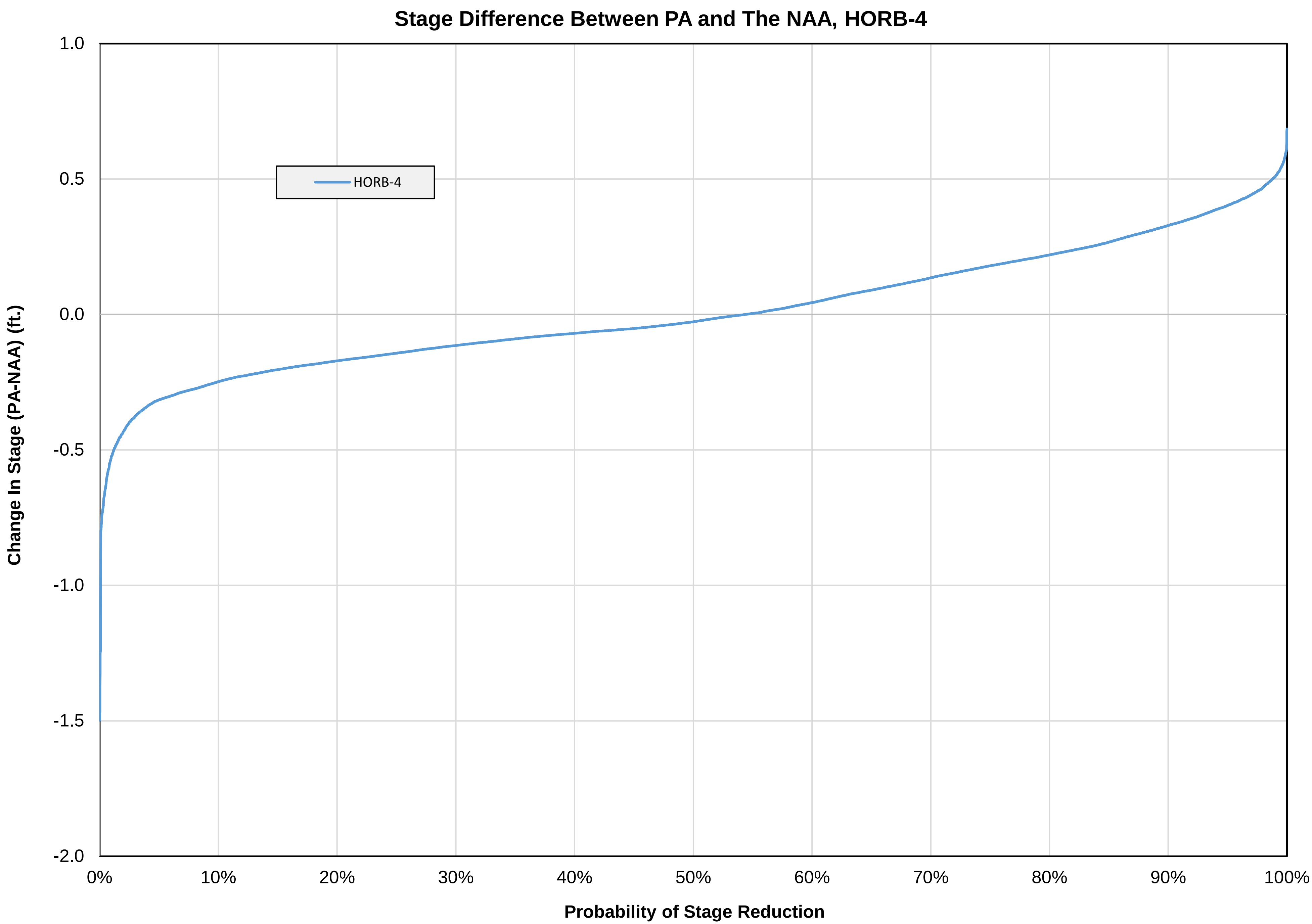
HORB Impact Analysis - Stage Difference, HORB-2, PA - NAA
HORB-2
Stage Difference, PA - NAA (ft.)
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
10/1/22
9/28/32
9/26/42
9/23/52
9/21/62
9/18/72
9/16/82
9/13/92
Date

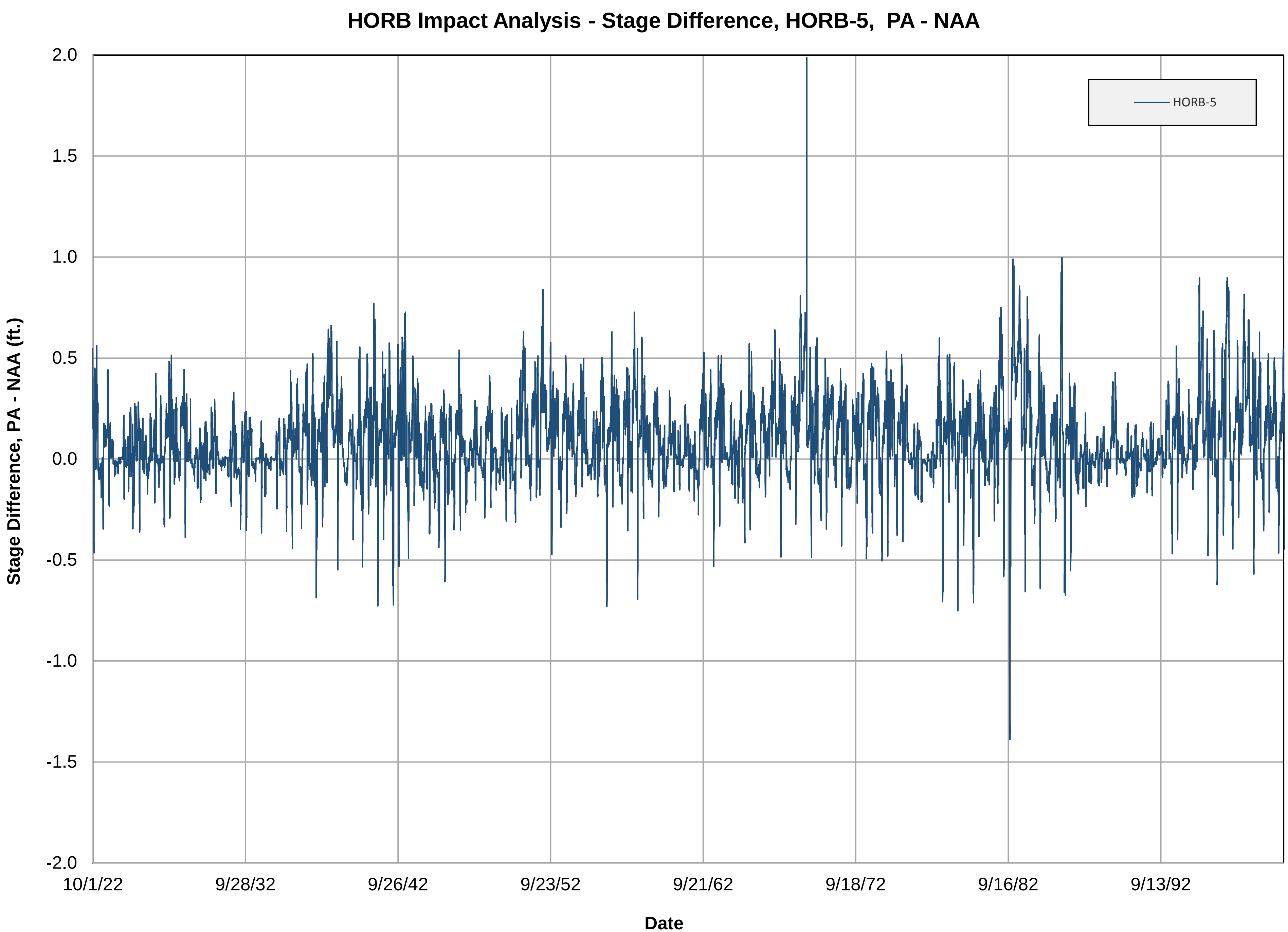

Stage Difference Between PA and The NAA, HORB-2
HORB-2
Change In Stage (PA-NAA) (ft.)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction


HORB Impact Analysis - Stage Difference, HORB-3, PA - NAA
HORB-3
Stage Difference, PA - NAA (ft.)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
10/1/22
9/28/32
9/26/42
9/23/52
9/21/62
9/18/72
9/16/82
9/13/92
Date

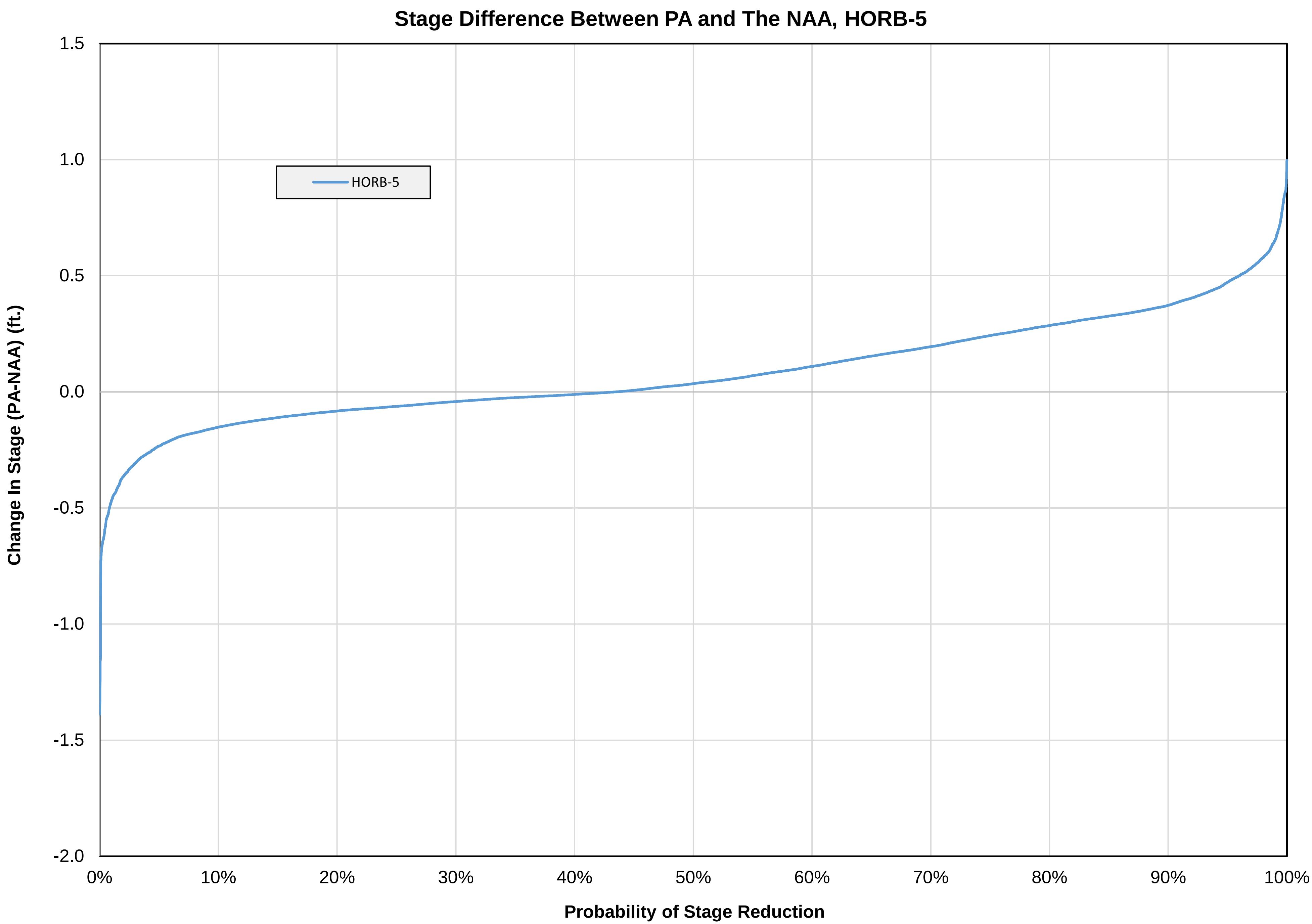

Stage Difference Between PA and The NAA, HORB-3
HORB-3
Change In Stage (PA-NAA) (ft.)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction


HORB Impact Analysis - Stage Difference, HORB-4, PA - NAA
HORB-4
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
Stage Difference, PA - NAA (ft.)
10/1/22
9/28/32
9/26/42
9/23/52
9/21/62
9/18/72
9/16/82
9/13/92
Date

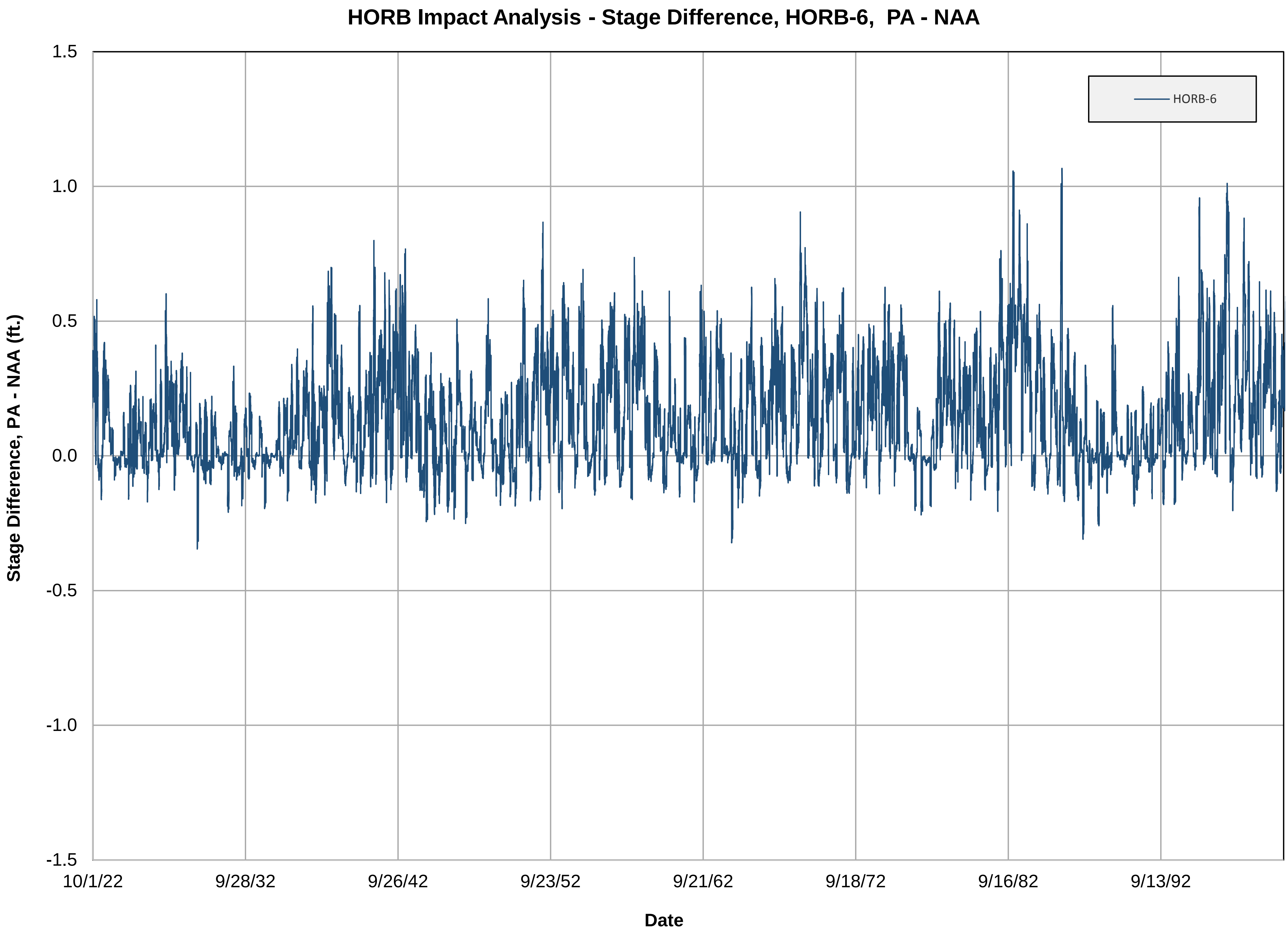

Stage Difference Between PA and The NAA, HORB-4
HORB-4
Change In Stage (PA-NAA) (ft.)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction



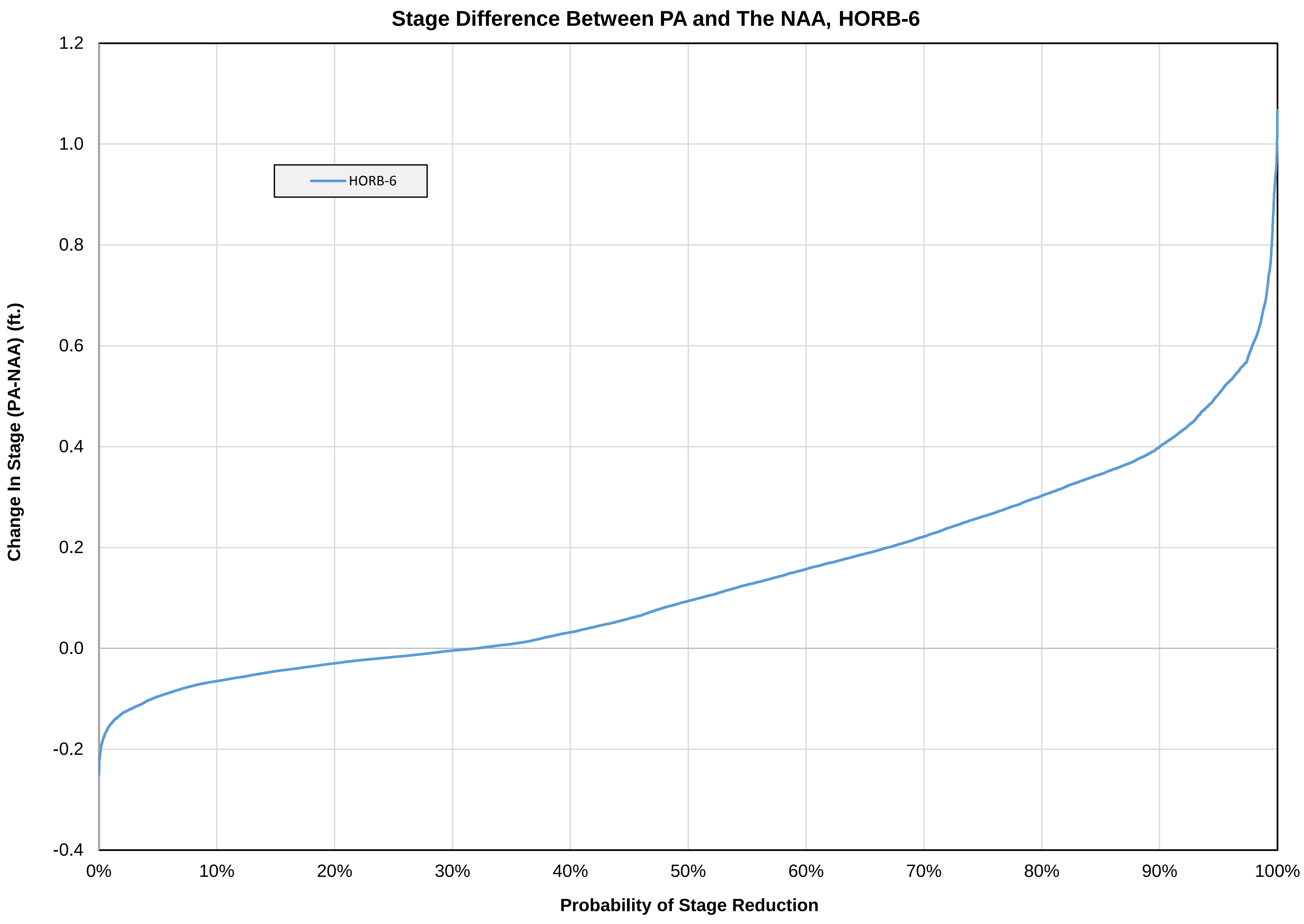
HSI **Hydrologic Systems**

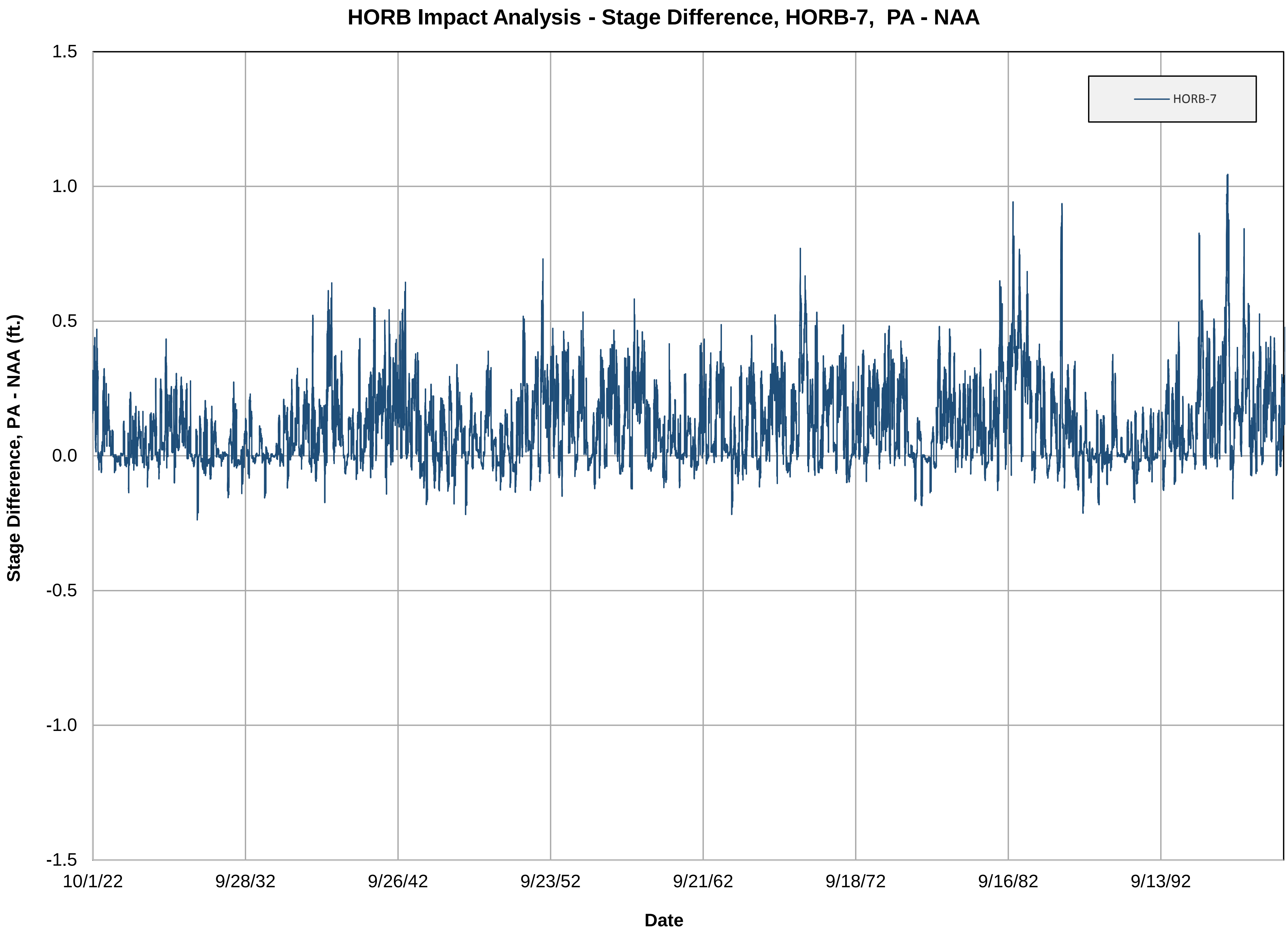


Stage Difference Between PA and The NAA, HORB-5
HORB-5
Change In Stage (PA-NAA) (ft.)
Probability of Stage Reduction
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

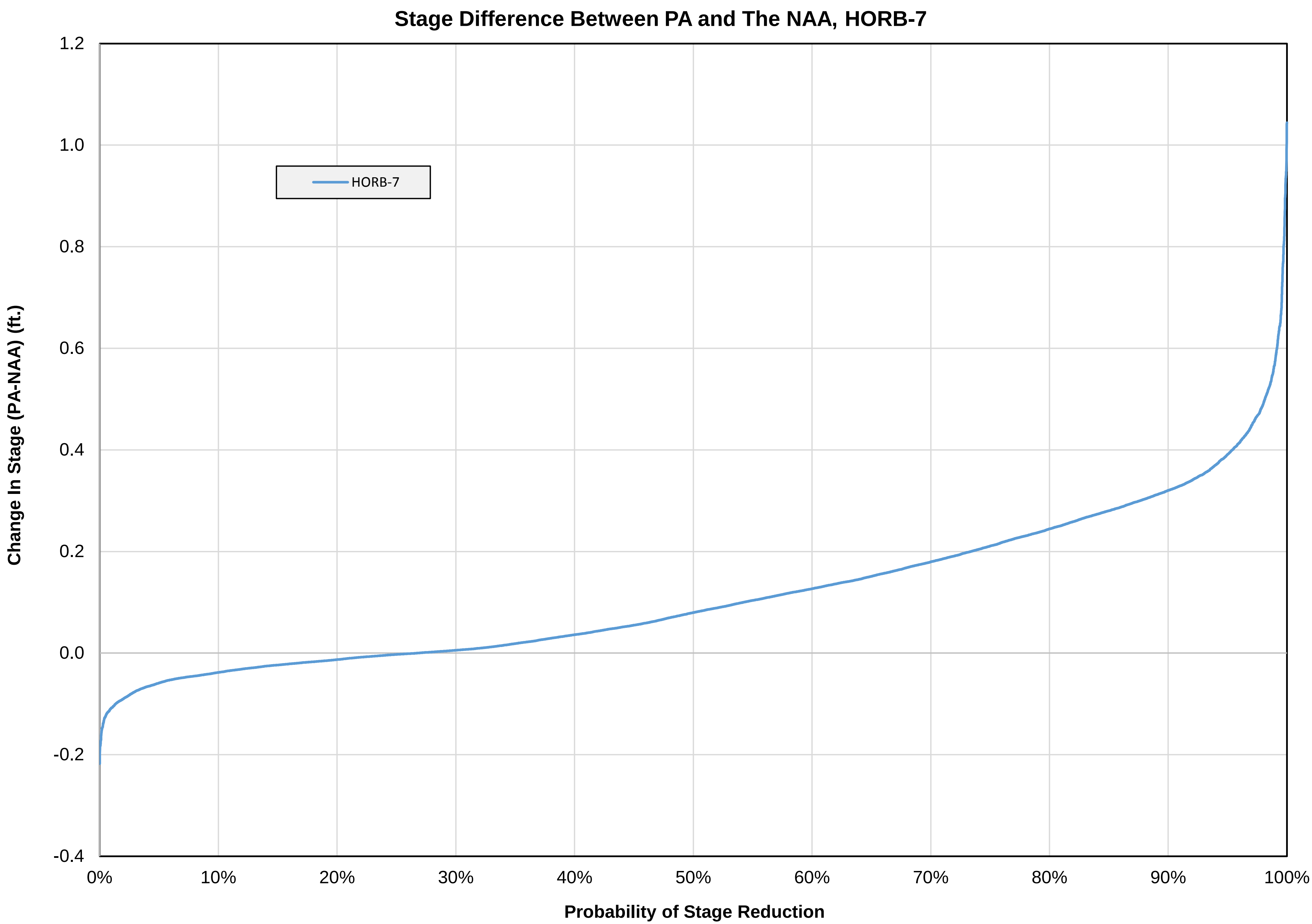


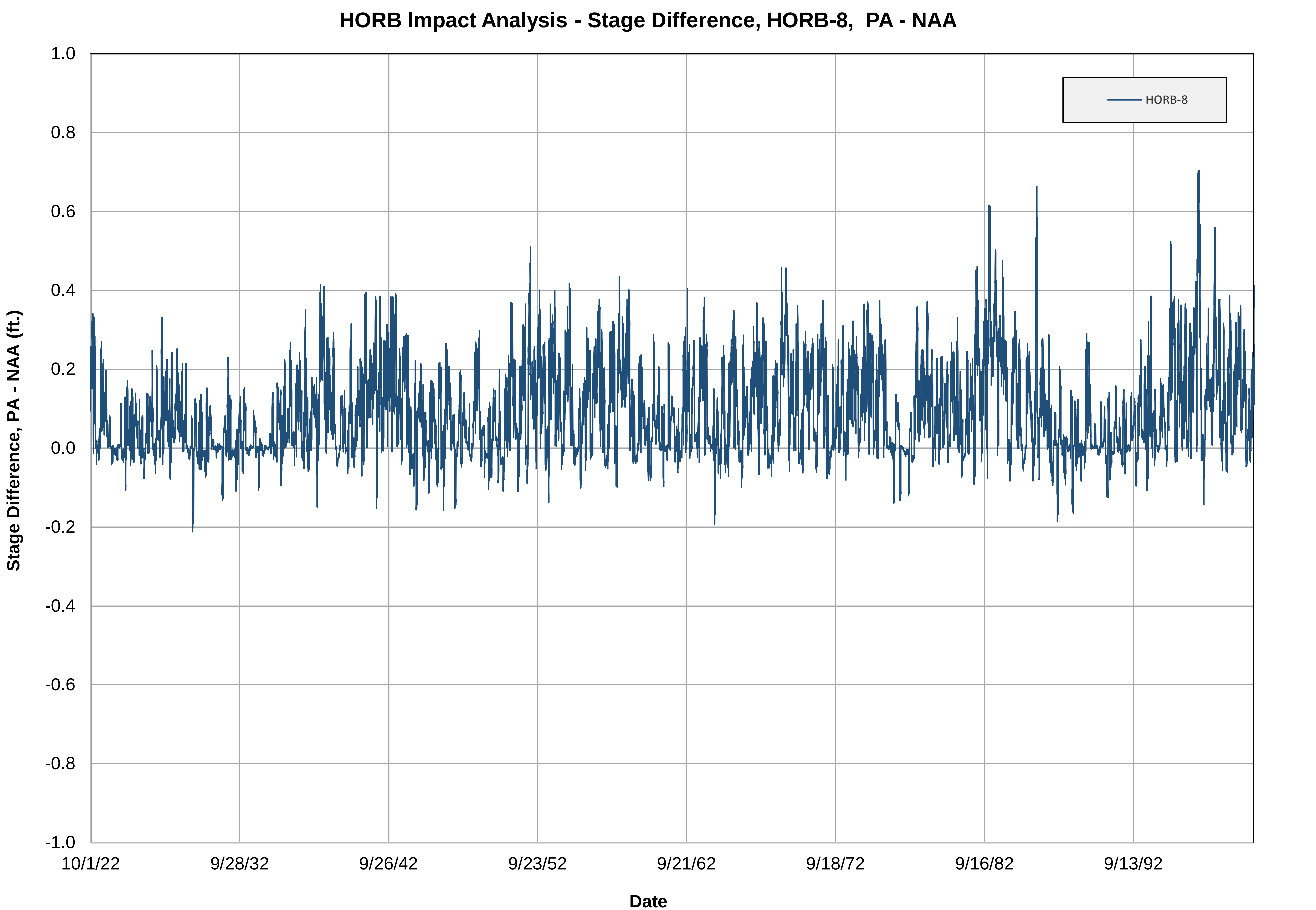
HSI Hydrologic Systems


Stage Difference Between PA and The NAA, HORB-6
HORB-6
Change In Stage (PA-NAA) (ft.)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction

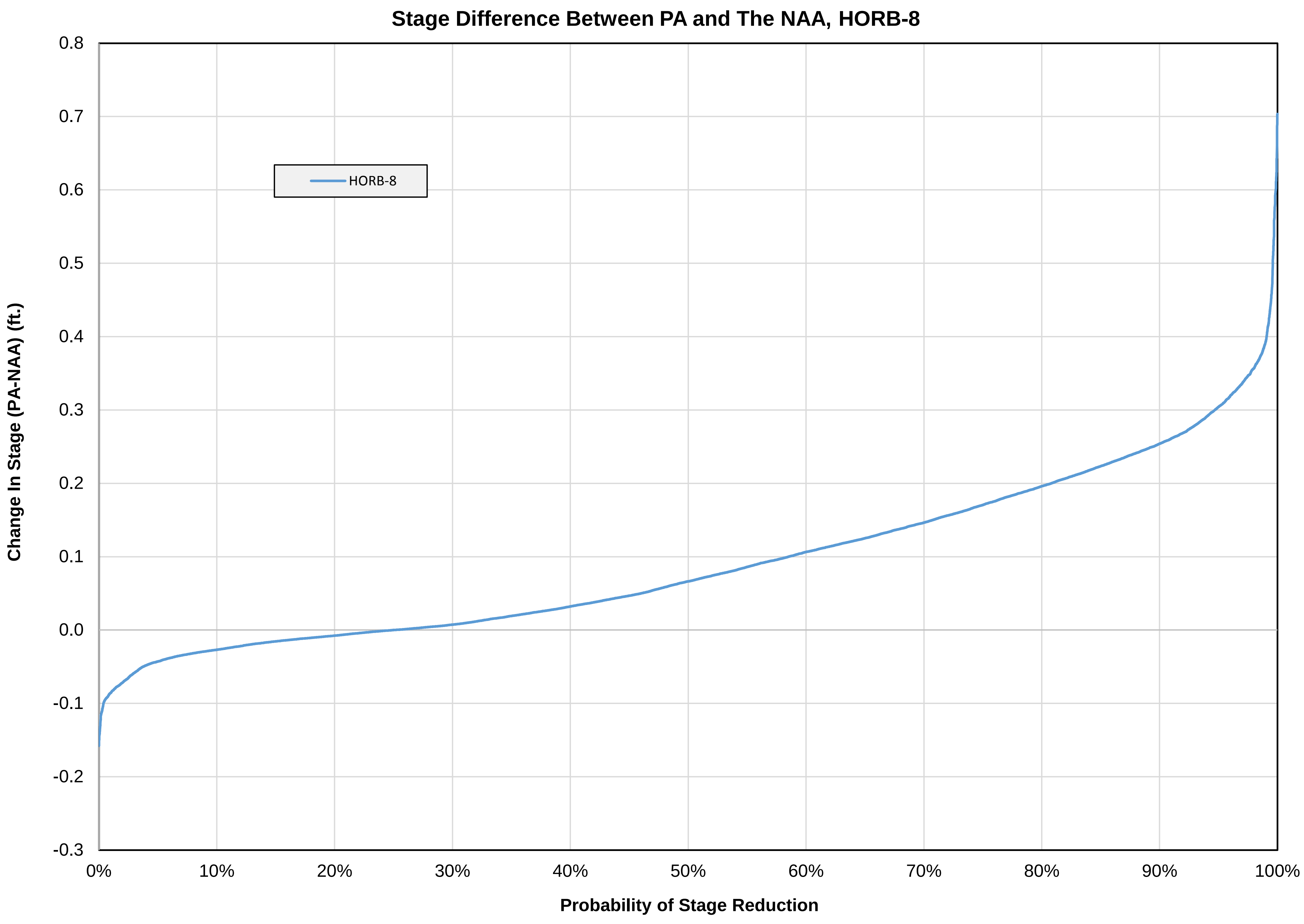


HSI **Hydrologic Systems**

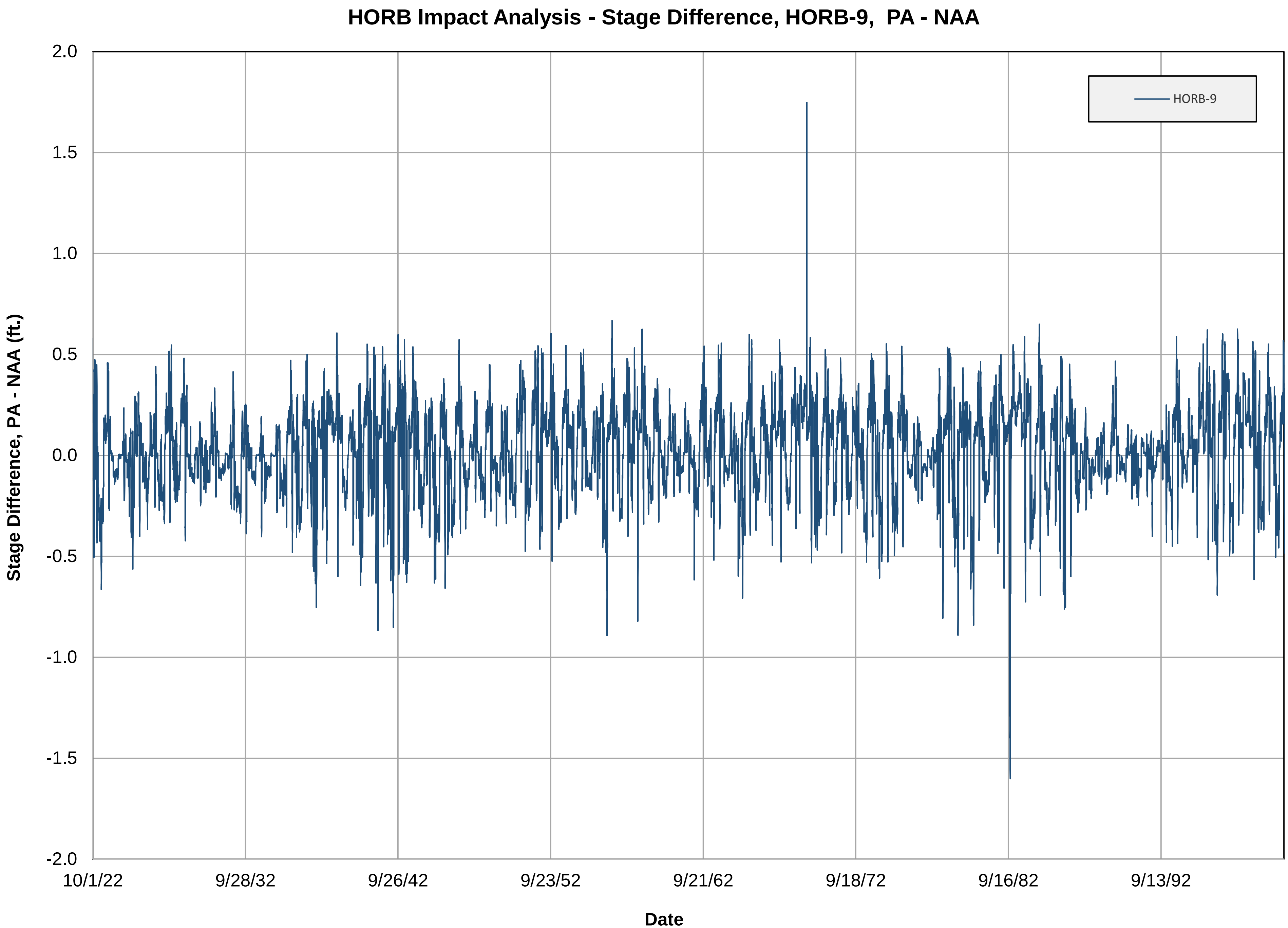

Stage Difference Between PA and The NAA, HORB-7
HORB-7
Change In Stage (PA-NAA) (ft.)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction

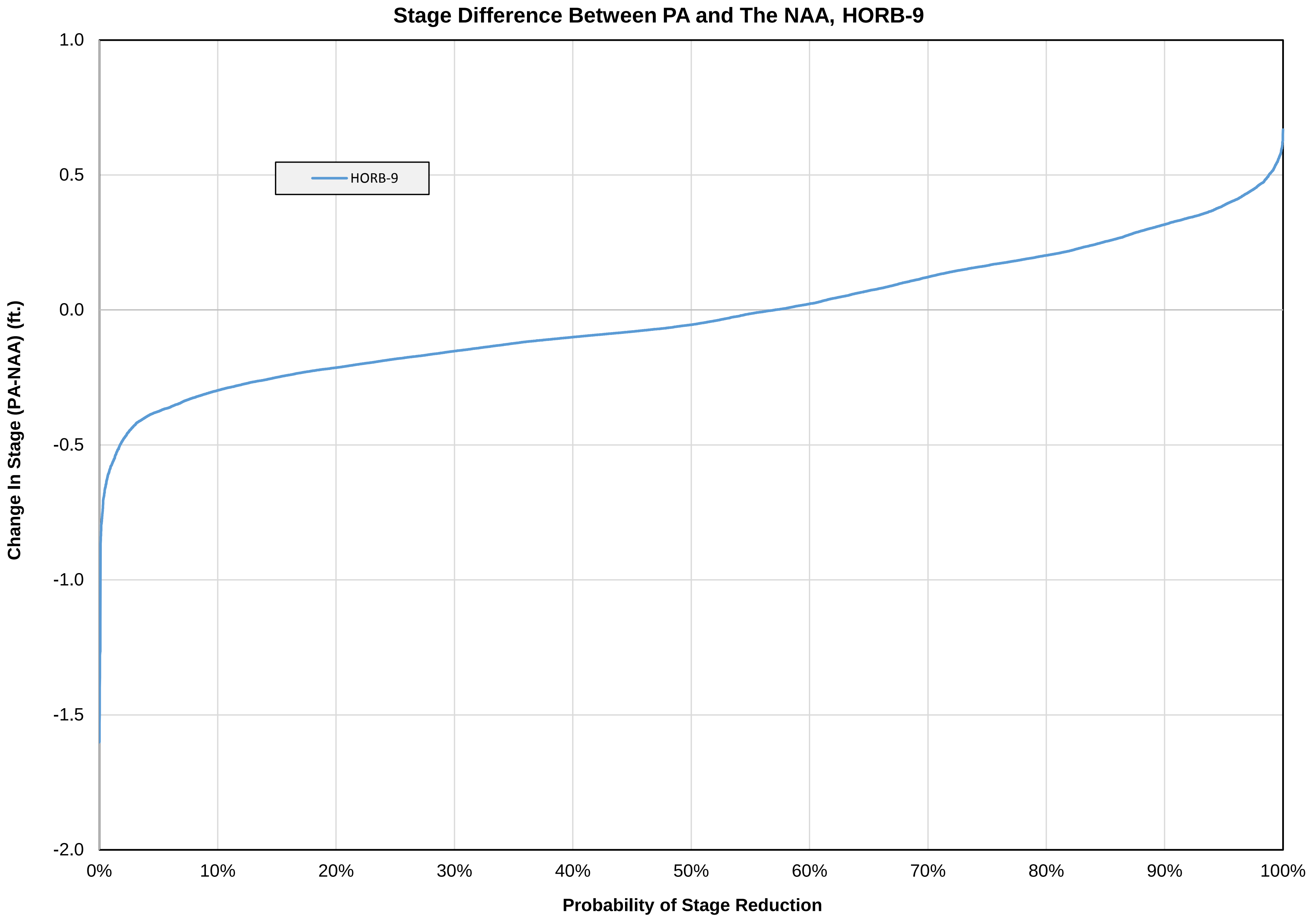


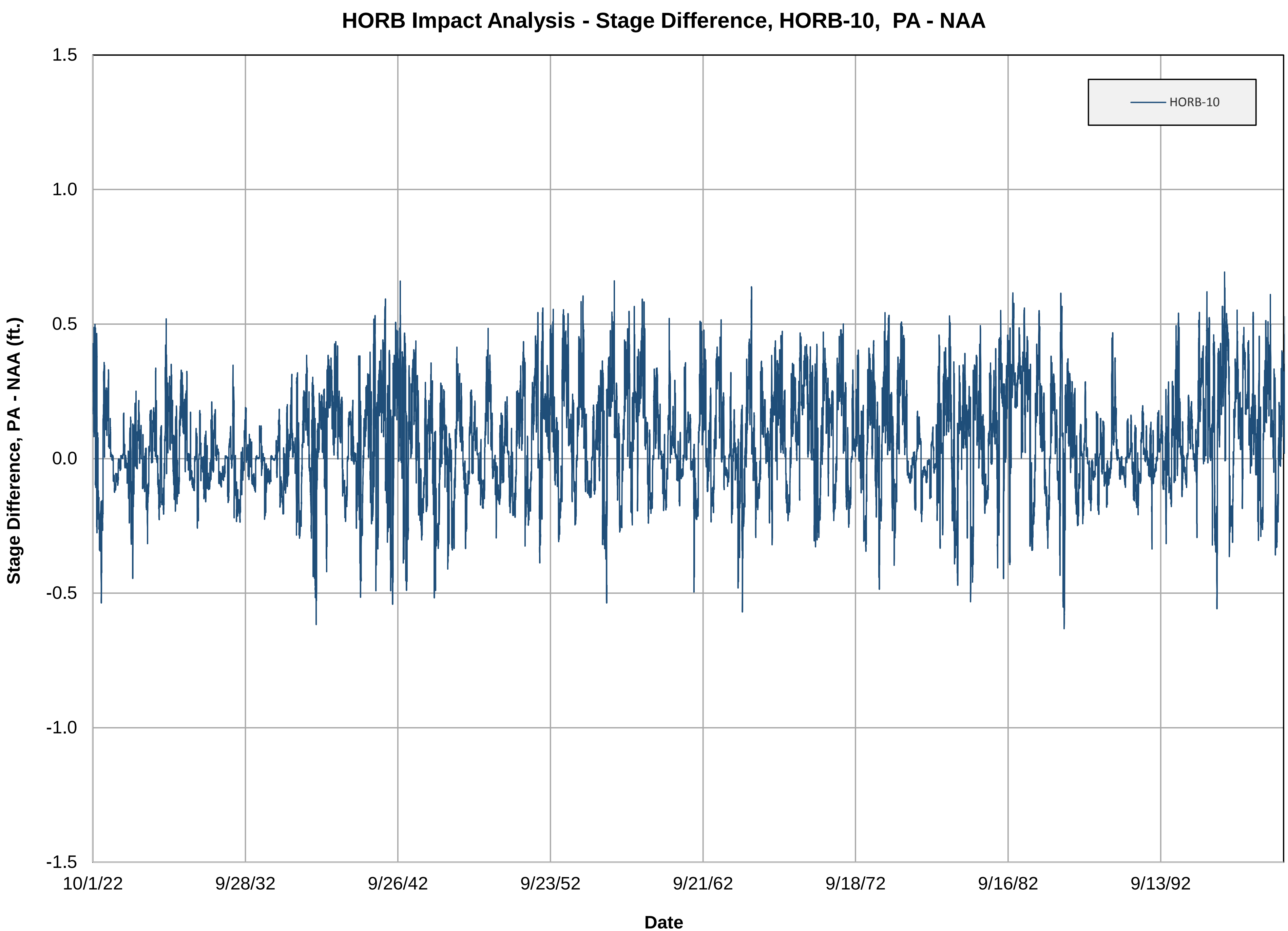
HSI **Hydrologic Systems**



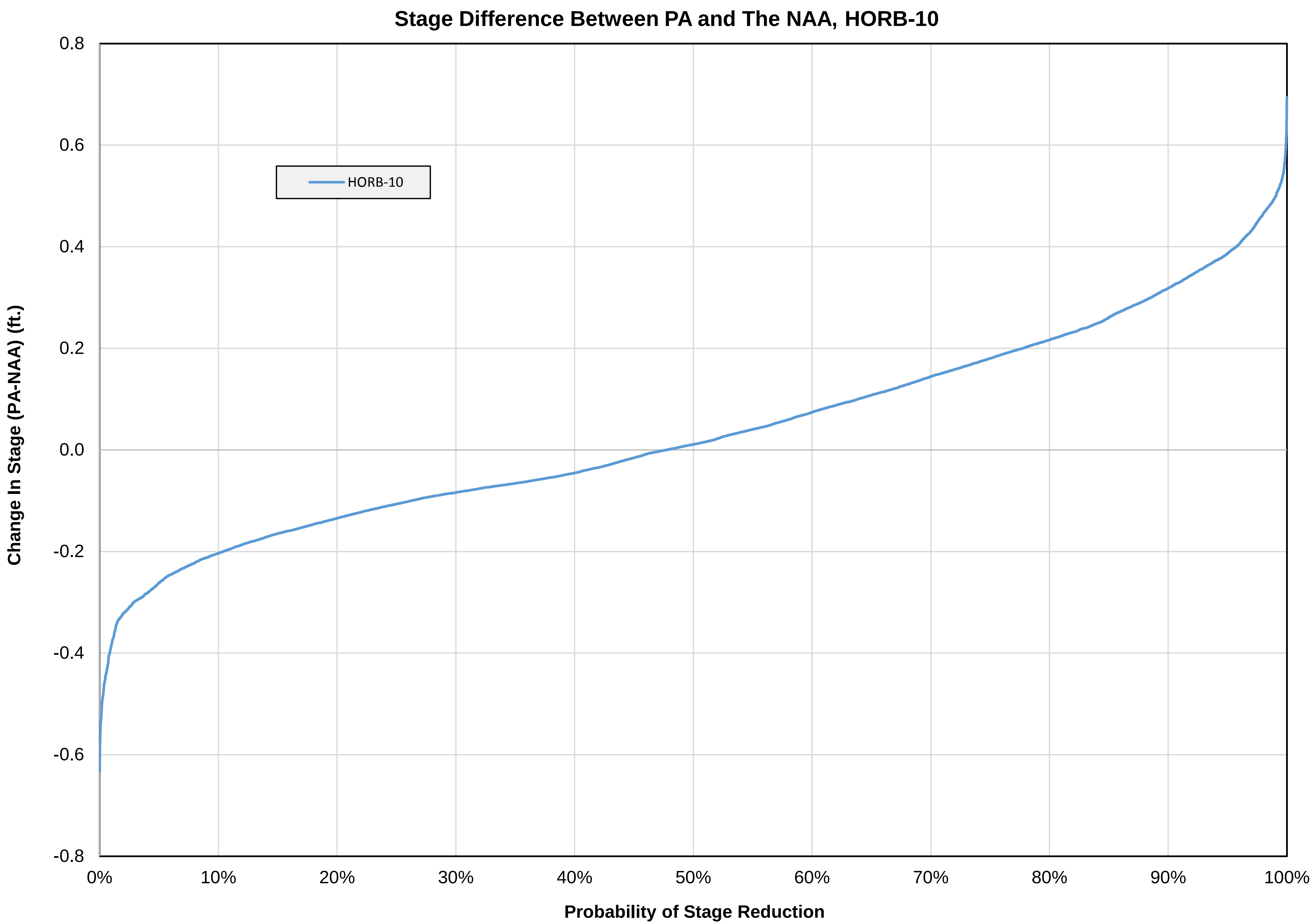
Stage Difference Between PA and The NAA, HORB-8
HORB-8
Change In Stage (PA-NAA) (ft.)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction

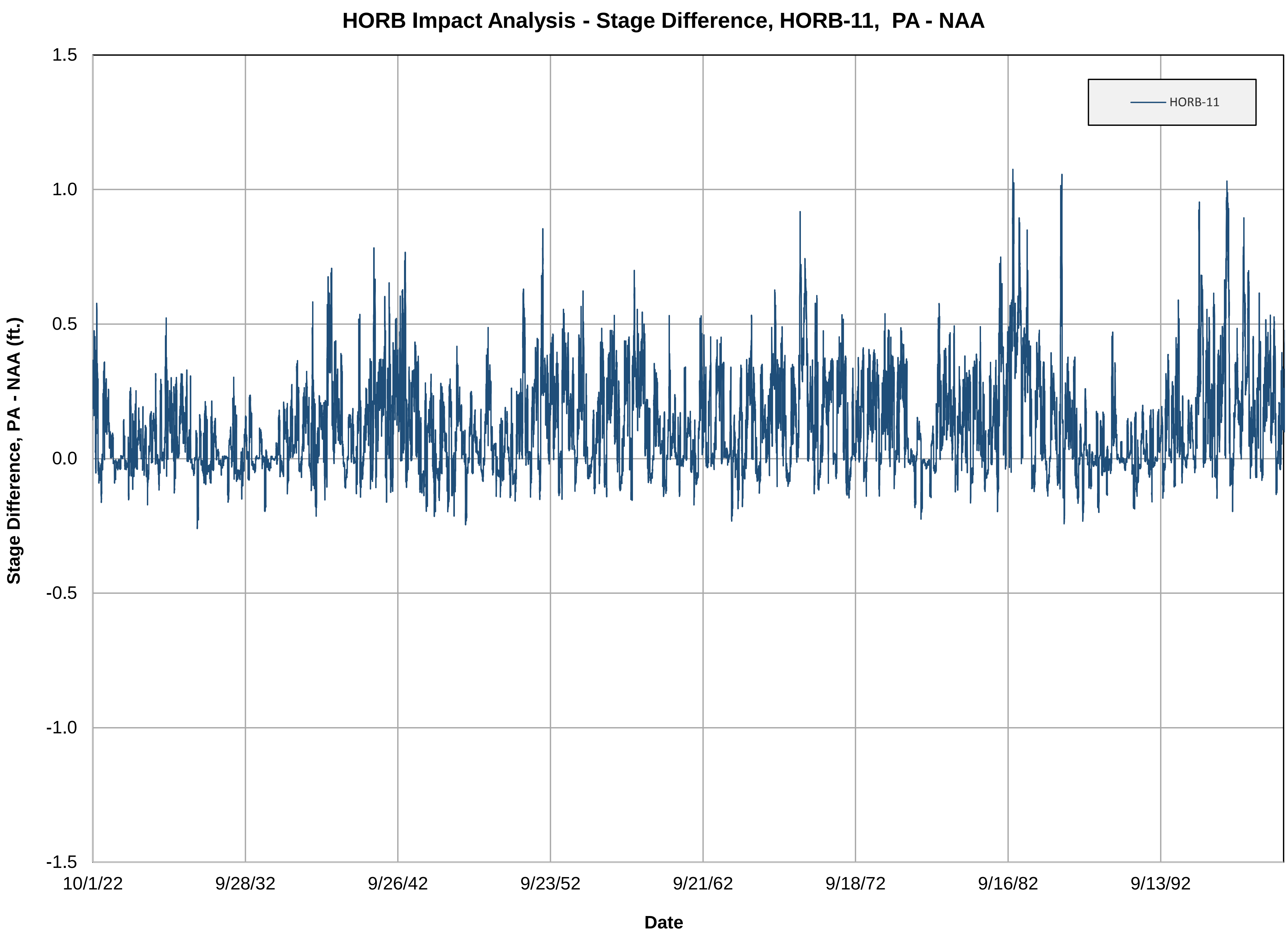

HORB Impact Analysis - Stage Difference, HORB-9, PA - NAA
HORB-9
Stage Difference, PA - NAA (ft.)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
10/1/22
9/28/32
9/26/42
9/23/52
9/21/62
9/18/72
9/16/82
9/13/92
Date


Stage Difference Between PA and The NAA, HORB-9
HORB-9
Change In Stage (PA-NAA) (ft.)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction

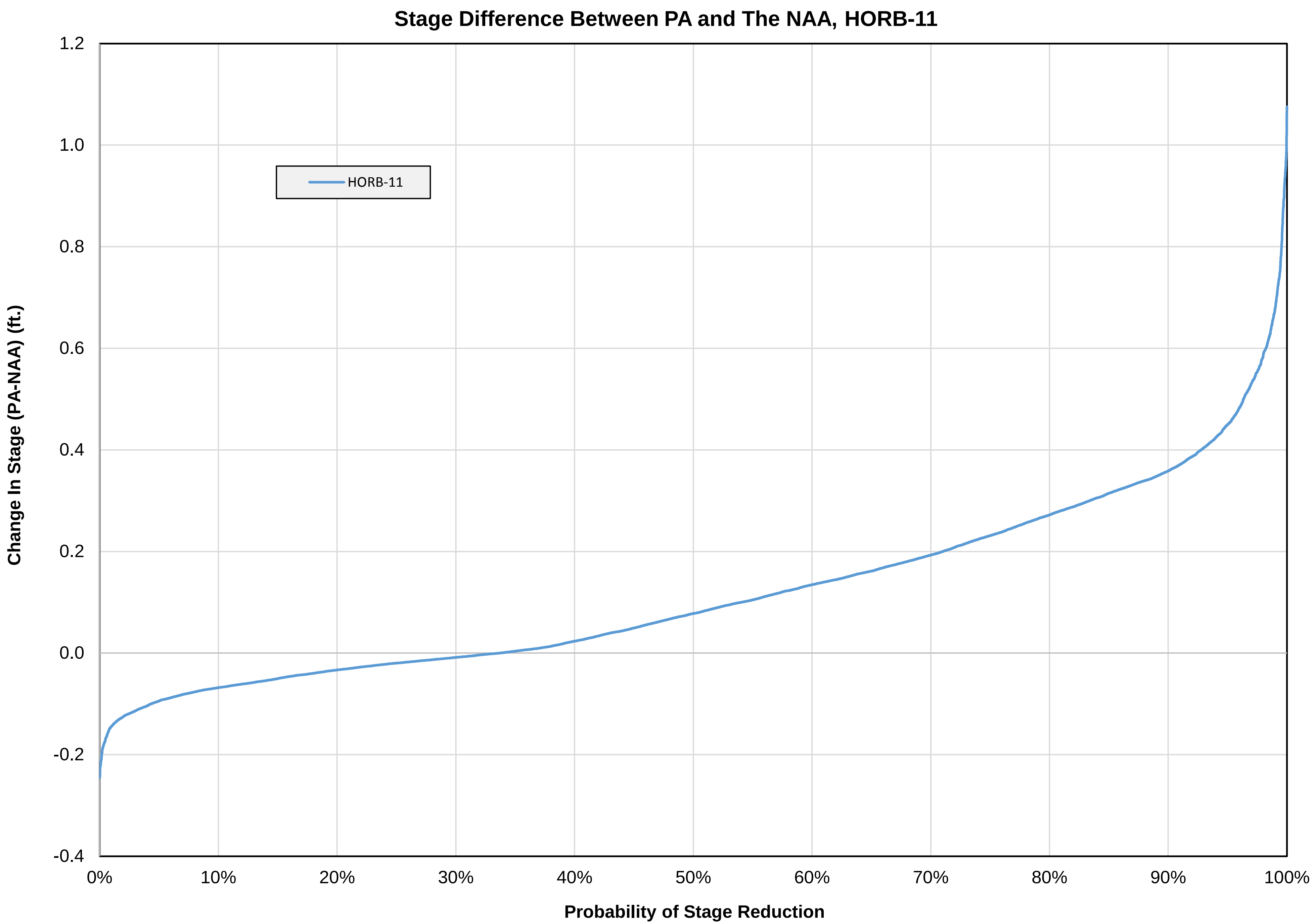


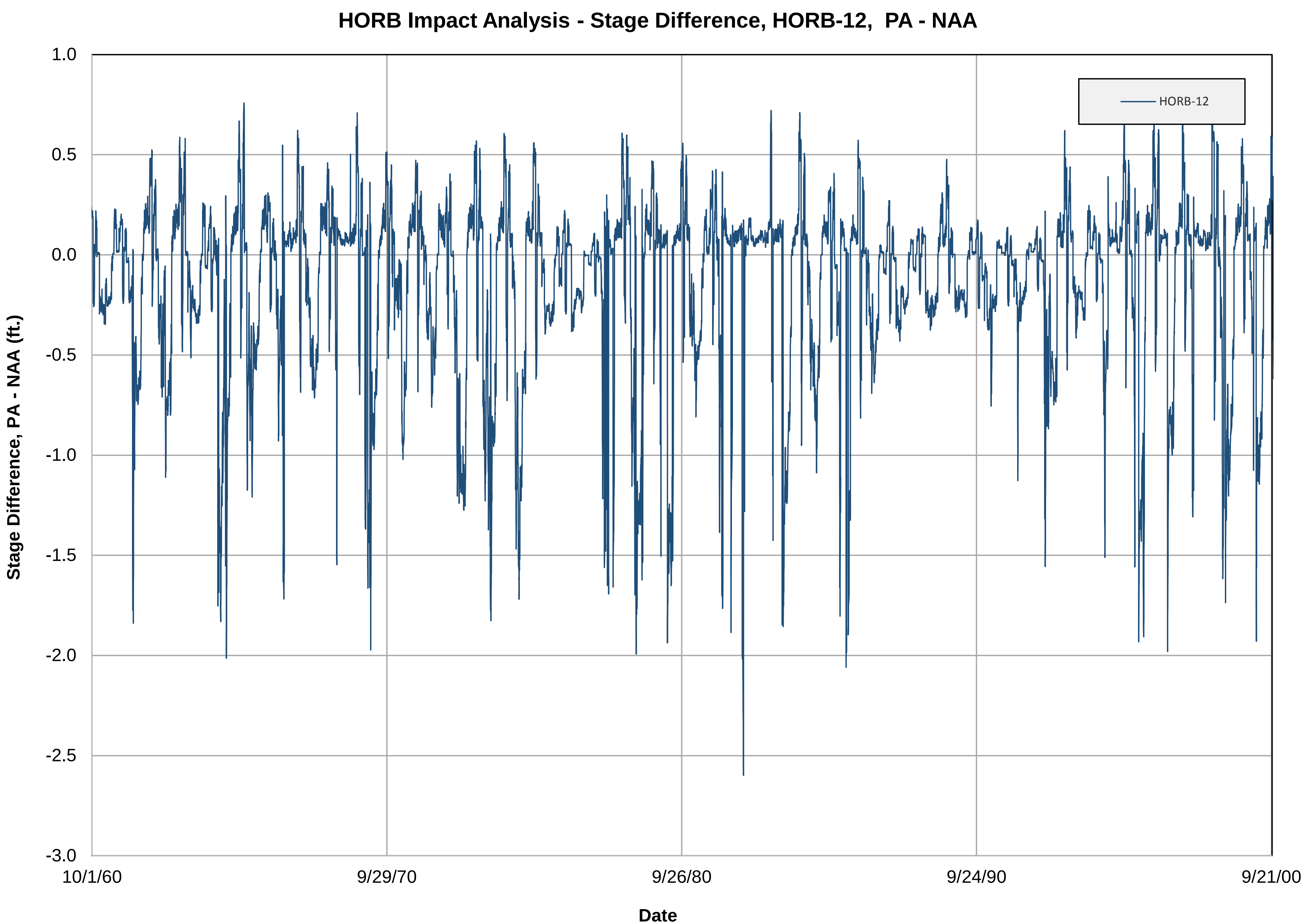
HORB Impact Analysis - Stage Difference, HORB-10, PA - NAA
HORB-10
Stage Difference, PA - NAA (ft.)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
10/1/22
9/28/32
9/26/42
9/23/52
9/21/62
9/18/72
9/16/82
9/13/92
Date

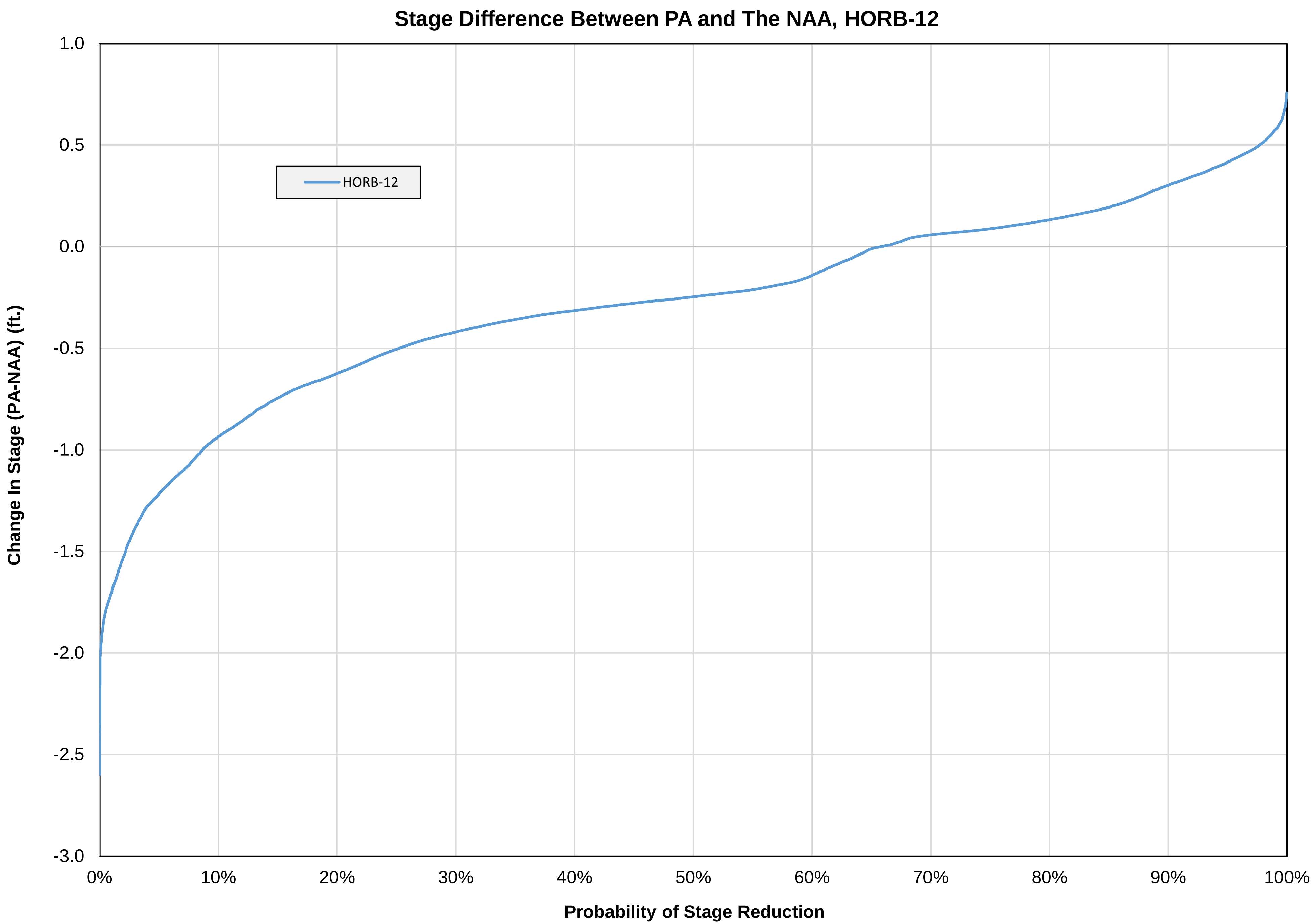

Stage Difference Between PA and The NAA, HORB-10
HORB-10
Change In Stage (PA-NAA) (ft.)
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction



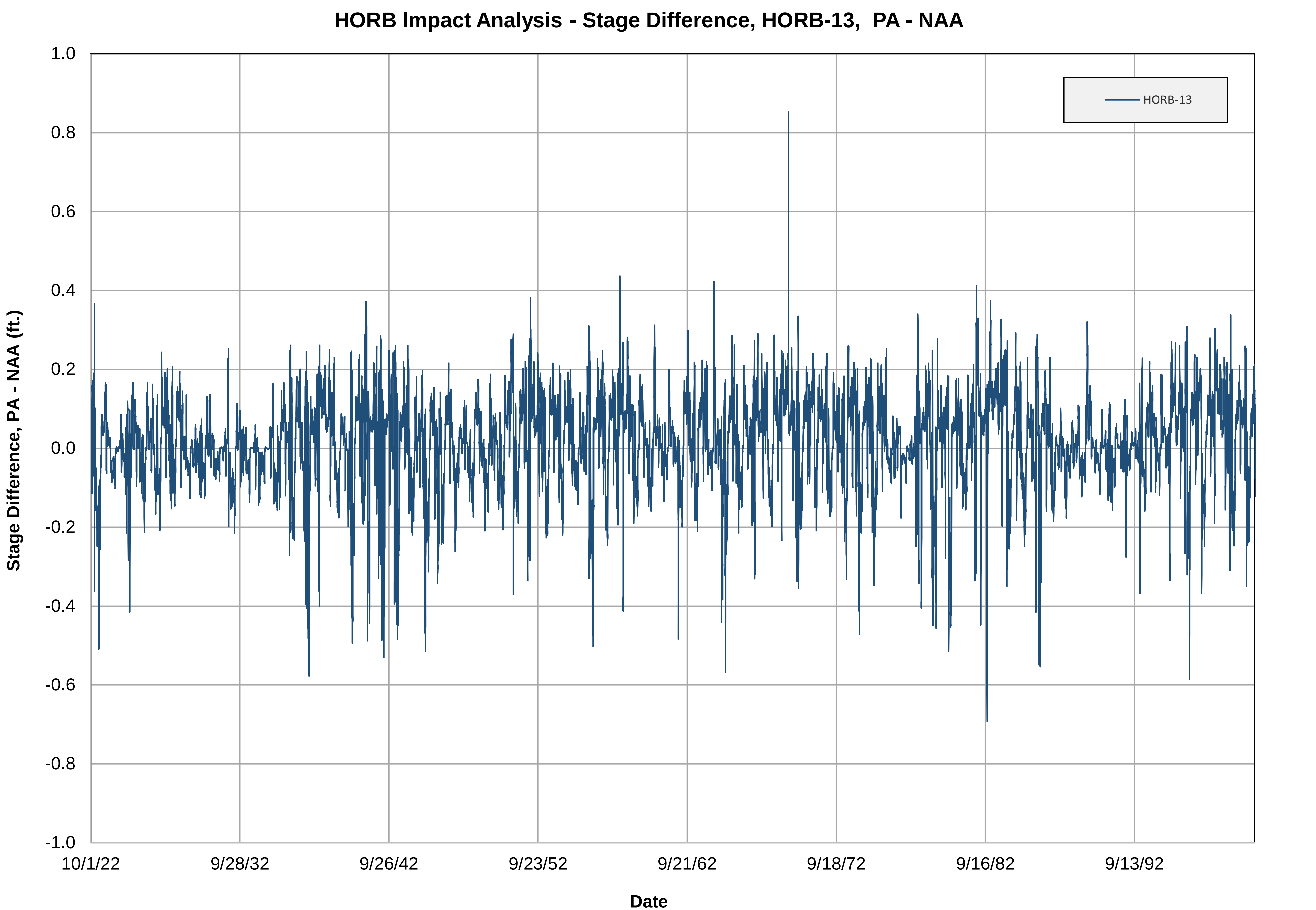
HORB Impact Analysis - Stage Difference, HORB-11, PA - NAA
Stage Difference, PA - NAA (ft.)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
10/1/22
9/28/32
9/26/42
9/23/52
9/21/62
9/18/72
9/16/82
9/13/92
Date
HORB-11

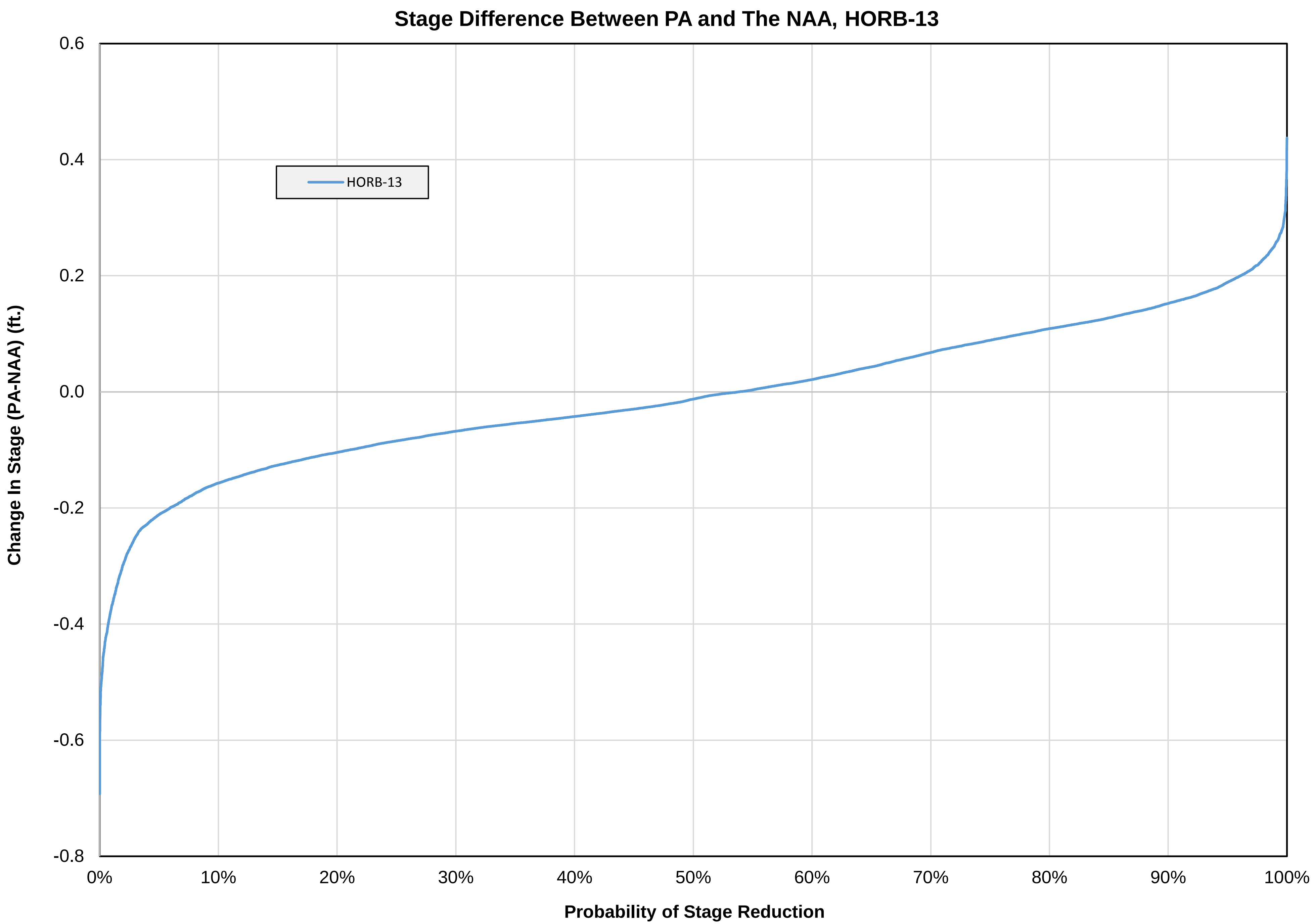

Stage Difference Between PA and The NAA, HORB-11
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Change In Stage (PA-NAA) (ft.)
HORB-11
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction


HORB Impact Analysis - Stage Difference, HORB-12, PA - NAA
HORB-12
Stage Difference, PA - NAA (ft.)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
10/1/60
9/29/70
9/26/80
9/24/90
9/21/00
Date

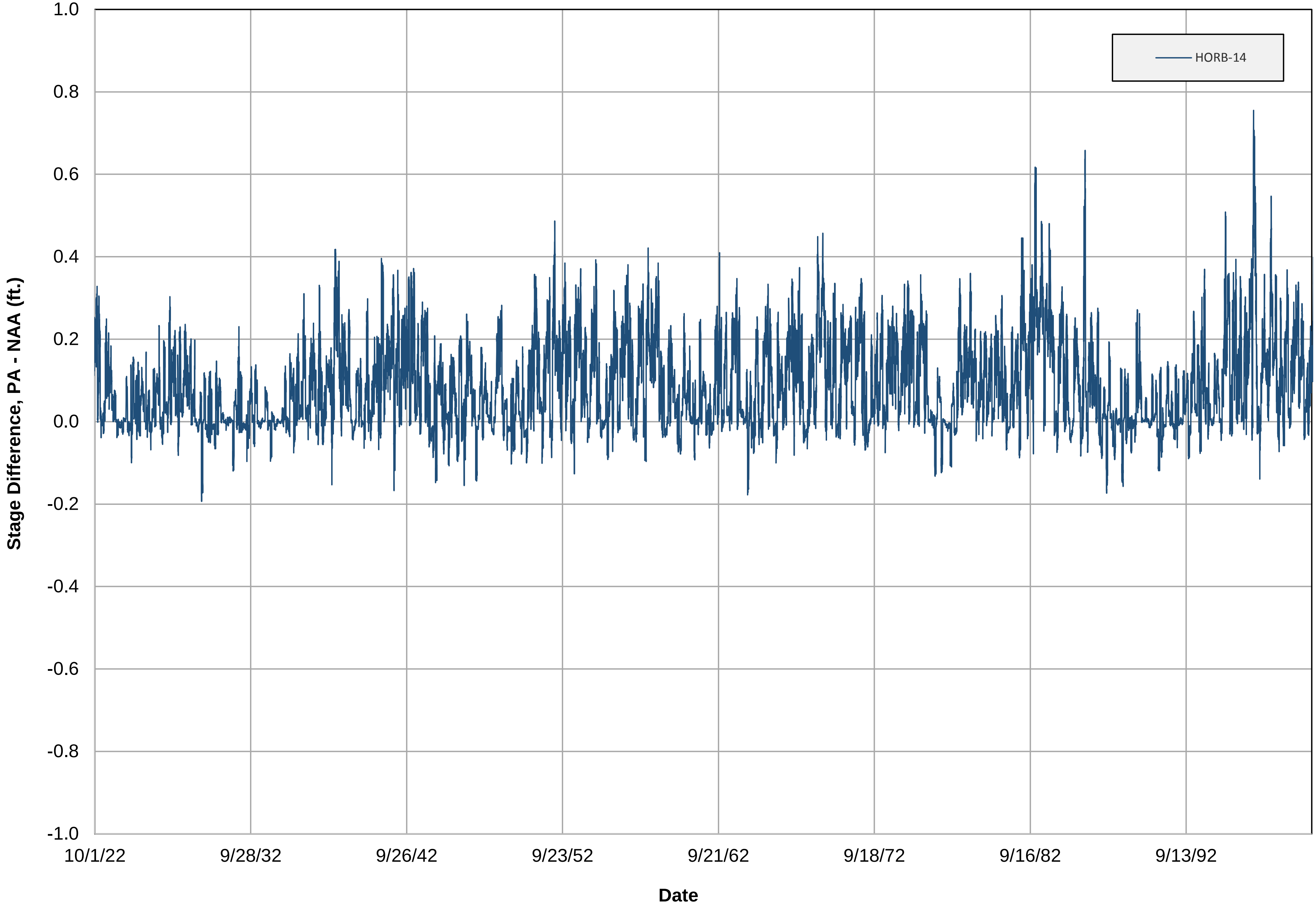


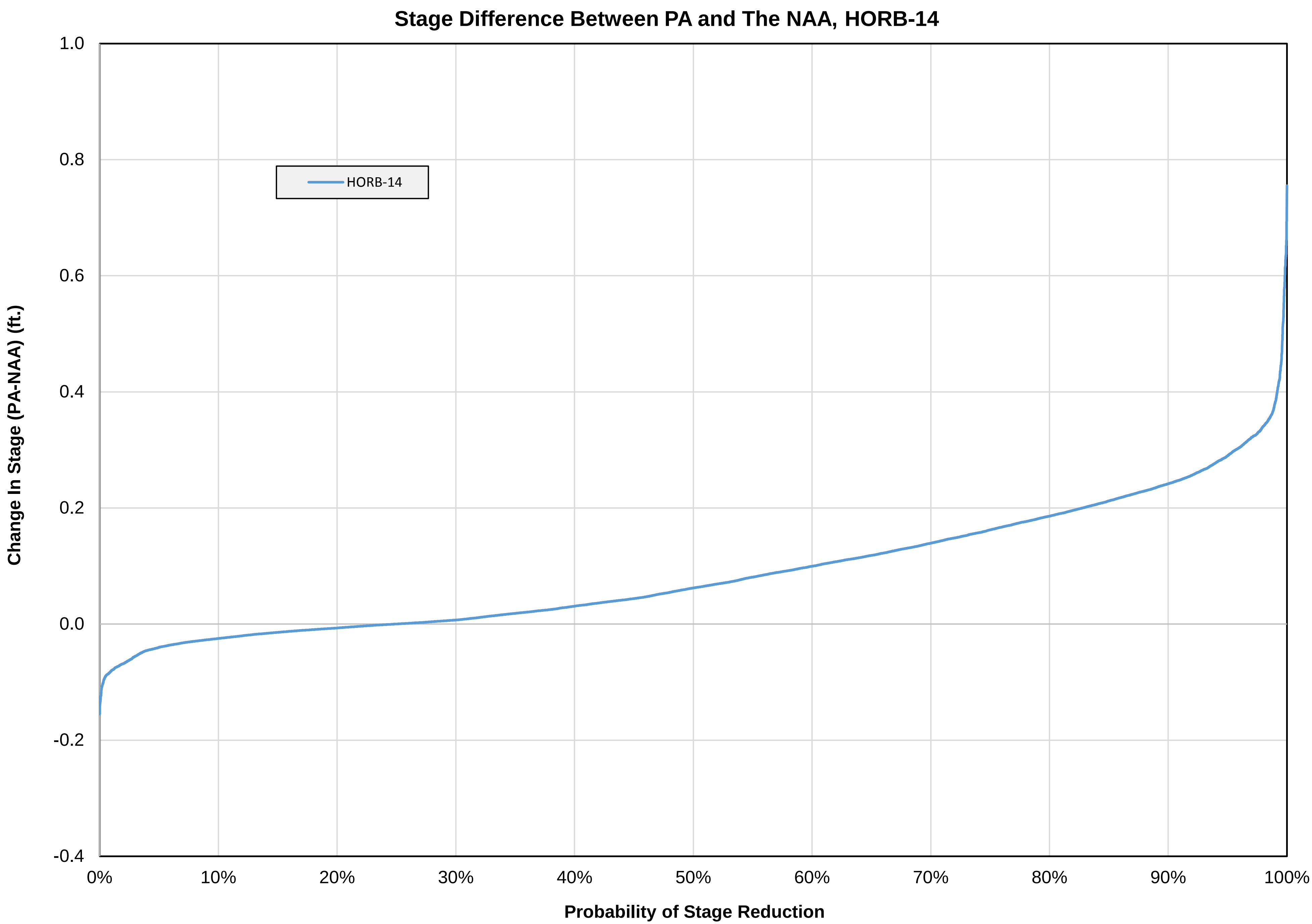
Stage Difference Between PA and The NAA, HORB-12
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
Change In Stage (PA-NAA) (ft.)
HORB-12
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction


HORB Impact Analysis - Stage Difference, HORB-13, PA - NAA
HORB-13
Stage Difference, PA - NAA (ft.)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
10/1/22
9/28/32
9/26/42
9/23/52
9/21/62
9/18/72
9/16/82
9/13/92
Date


Stage Difference Between PA and The NAA, HORB-13
HORB-13
Change In Stage (PA-NAA) (ft.)
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction

HORB Impact Analysis - Stage Difference, HORB-14, PA - NAA

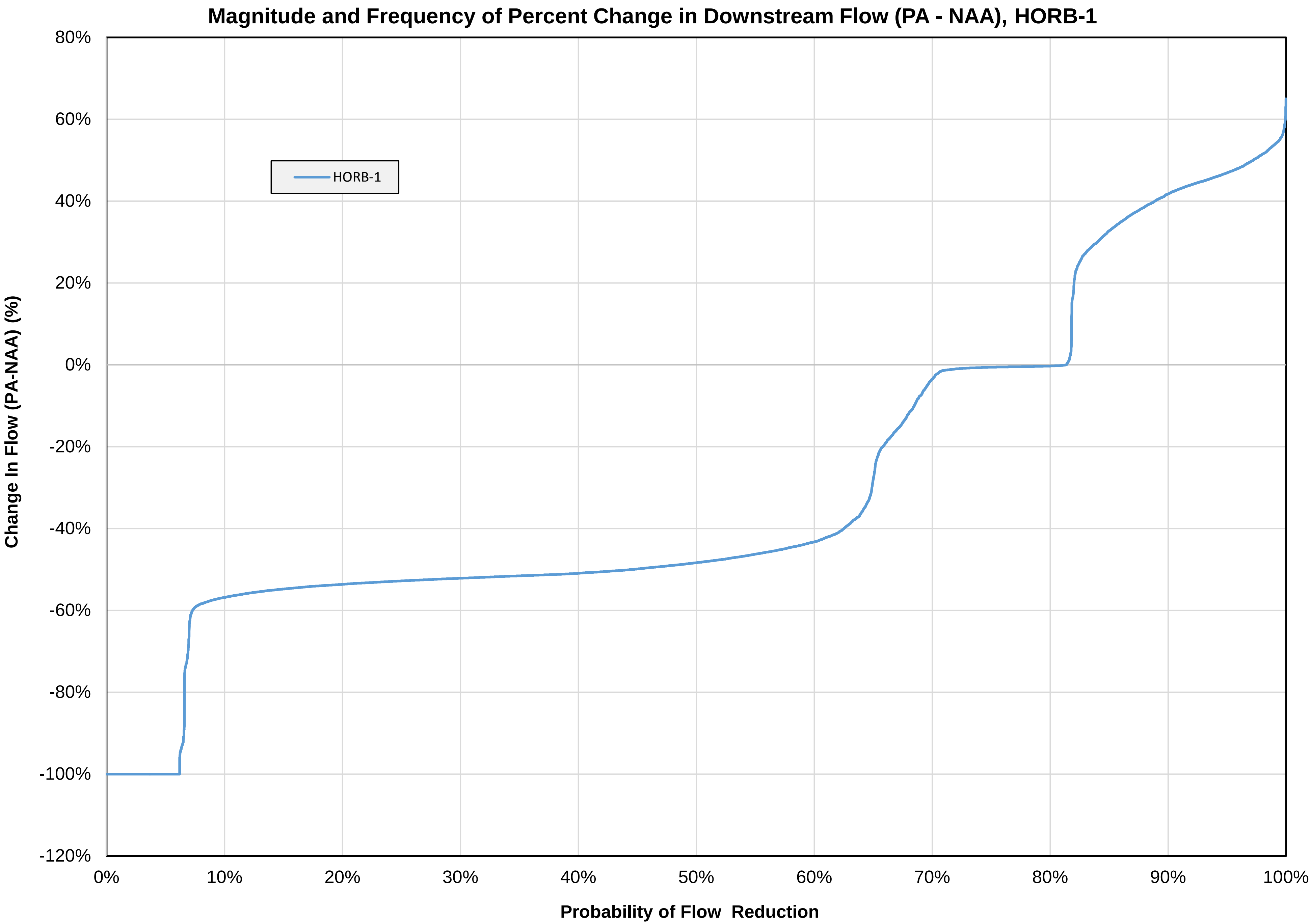




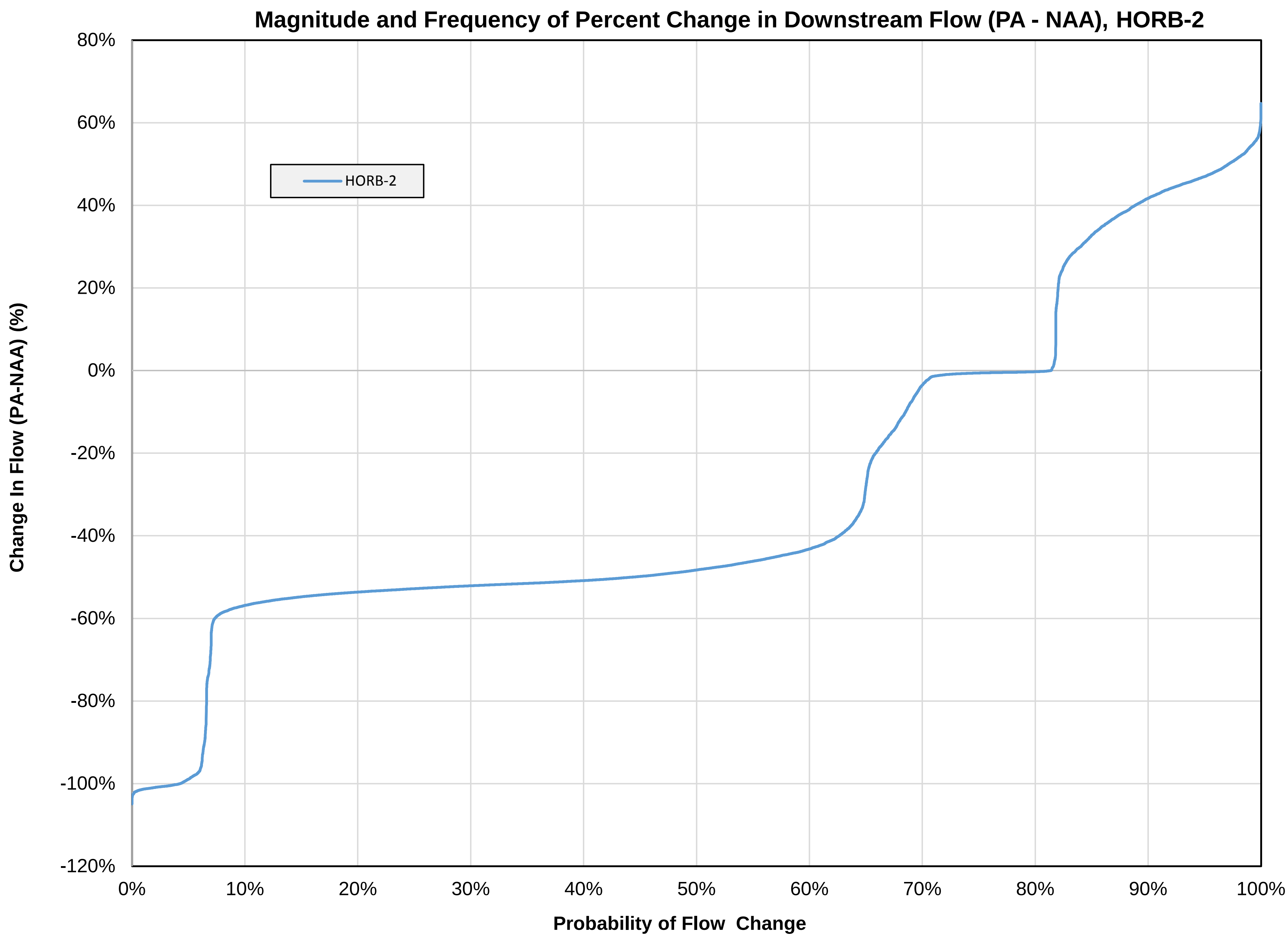
Stage Difference Between PA and The NAA, HORB-14
HORB-14
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Change In Stage (PA-NAA) (ft.)
Probability of Stage Reduction

Appendix D

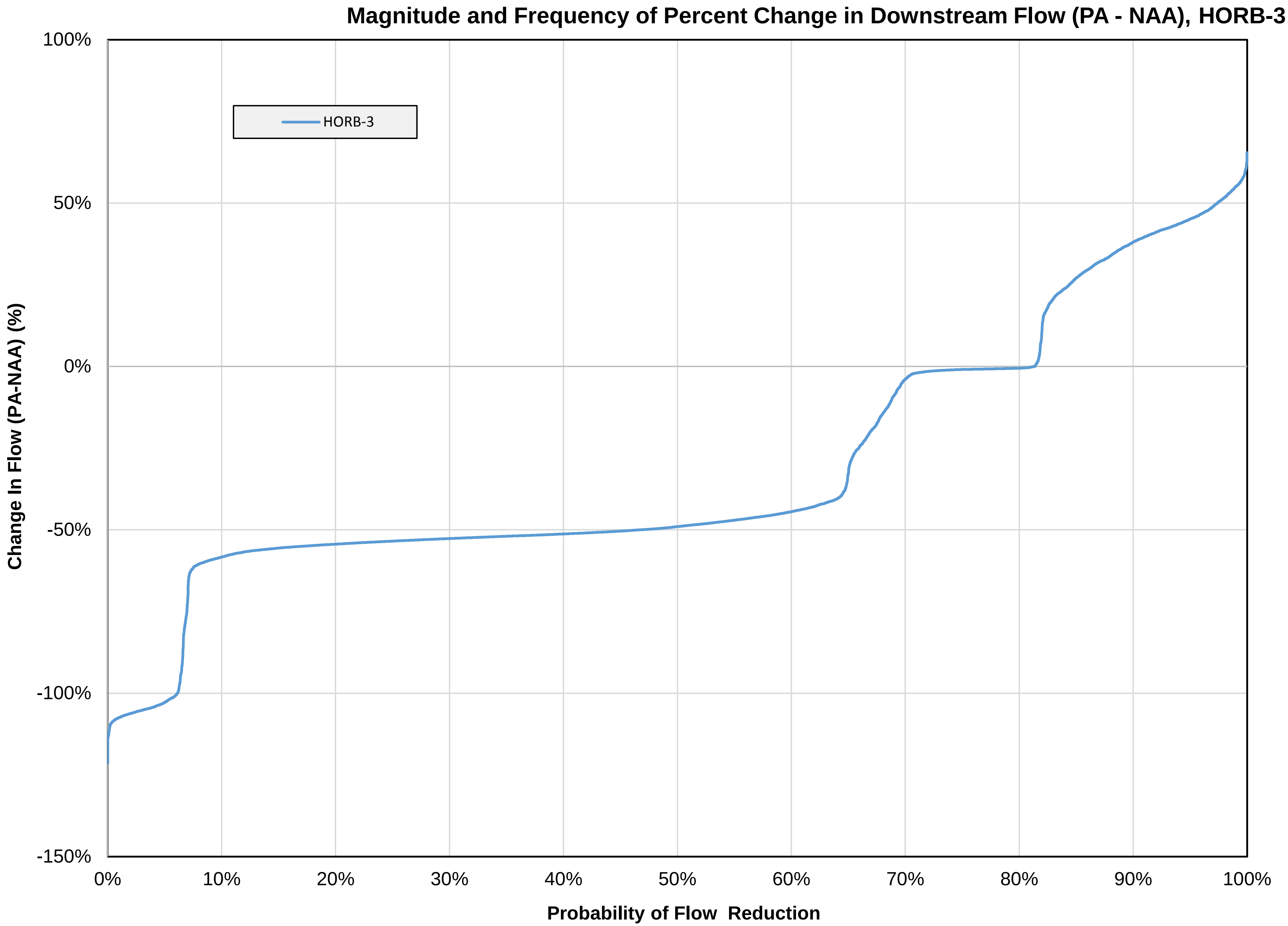
Plots Of The Magnitude and Frequency of Percent Change in Downstream Flow Between The PA and the NAA



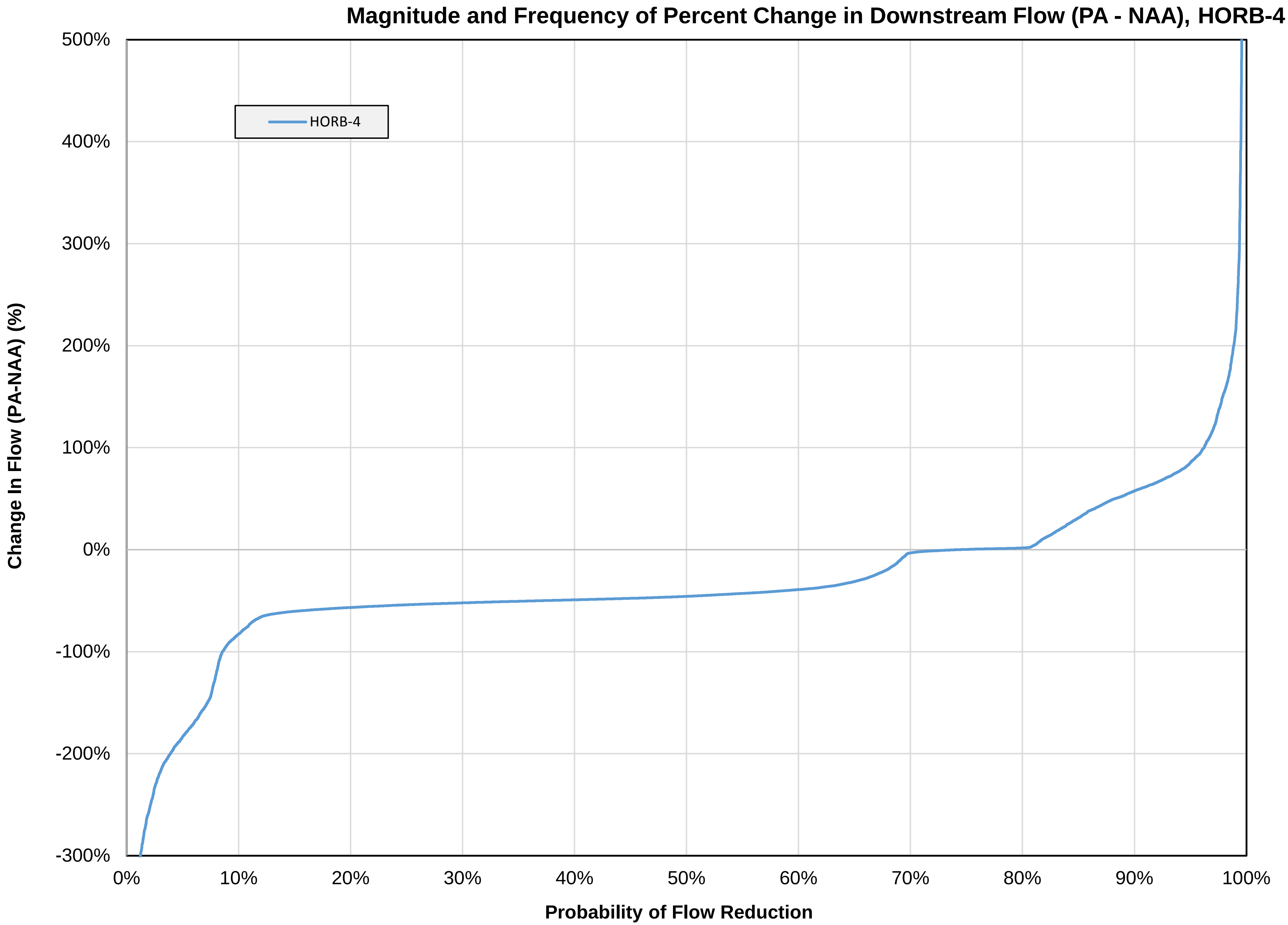
Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-1
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
-120%
HORB-1
Change In Flow (PA-NAA) (%)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Flow Reduction



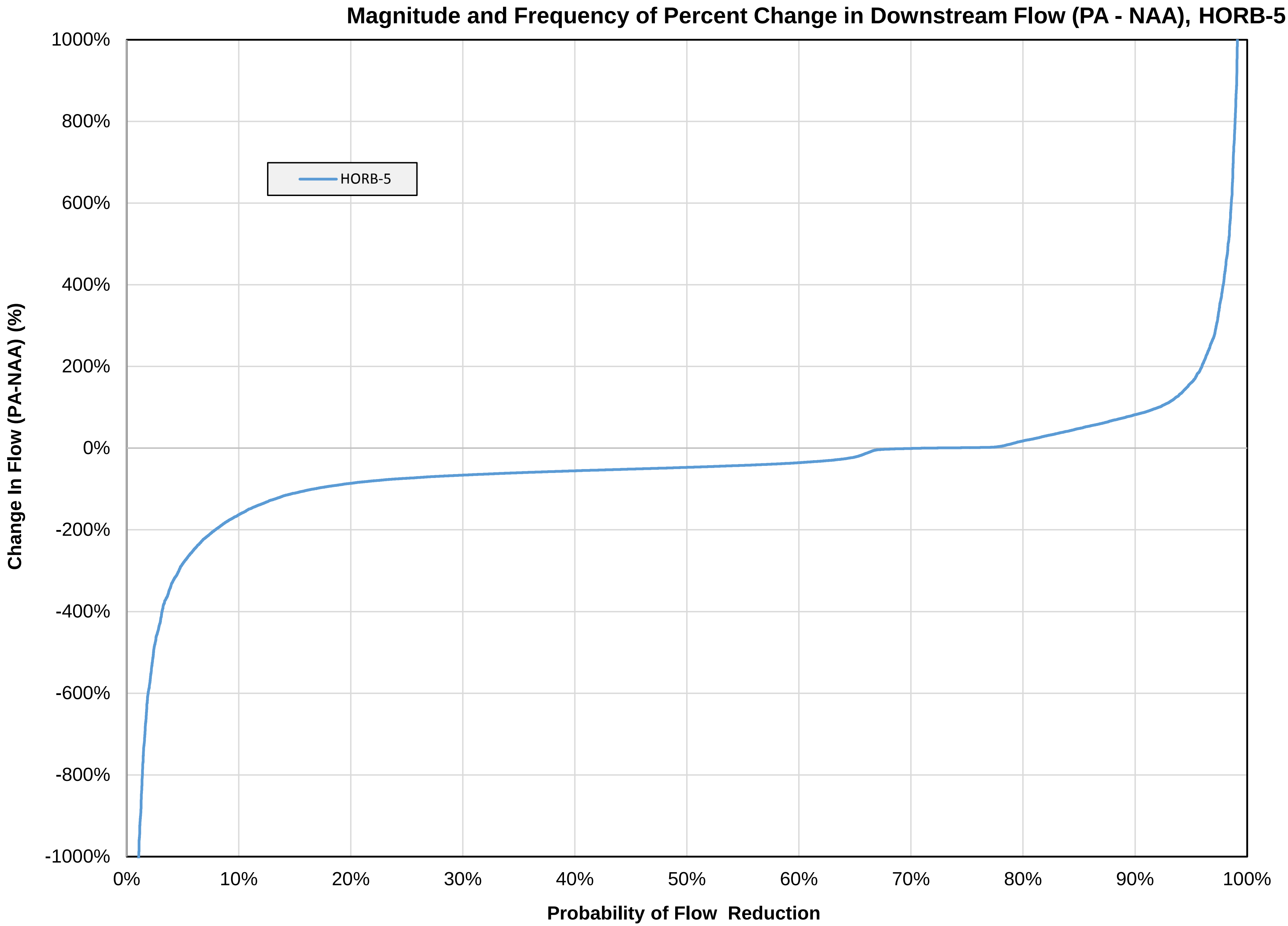
Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-2
HORB-2
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
-120%
Change In Flow (PA-NAA) (%)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Flow Change



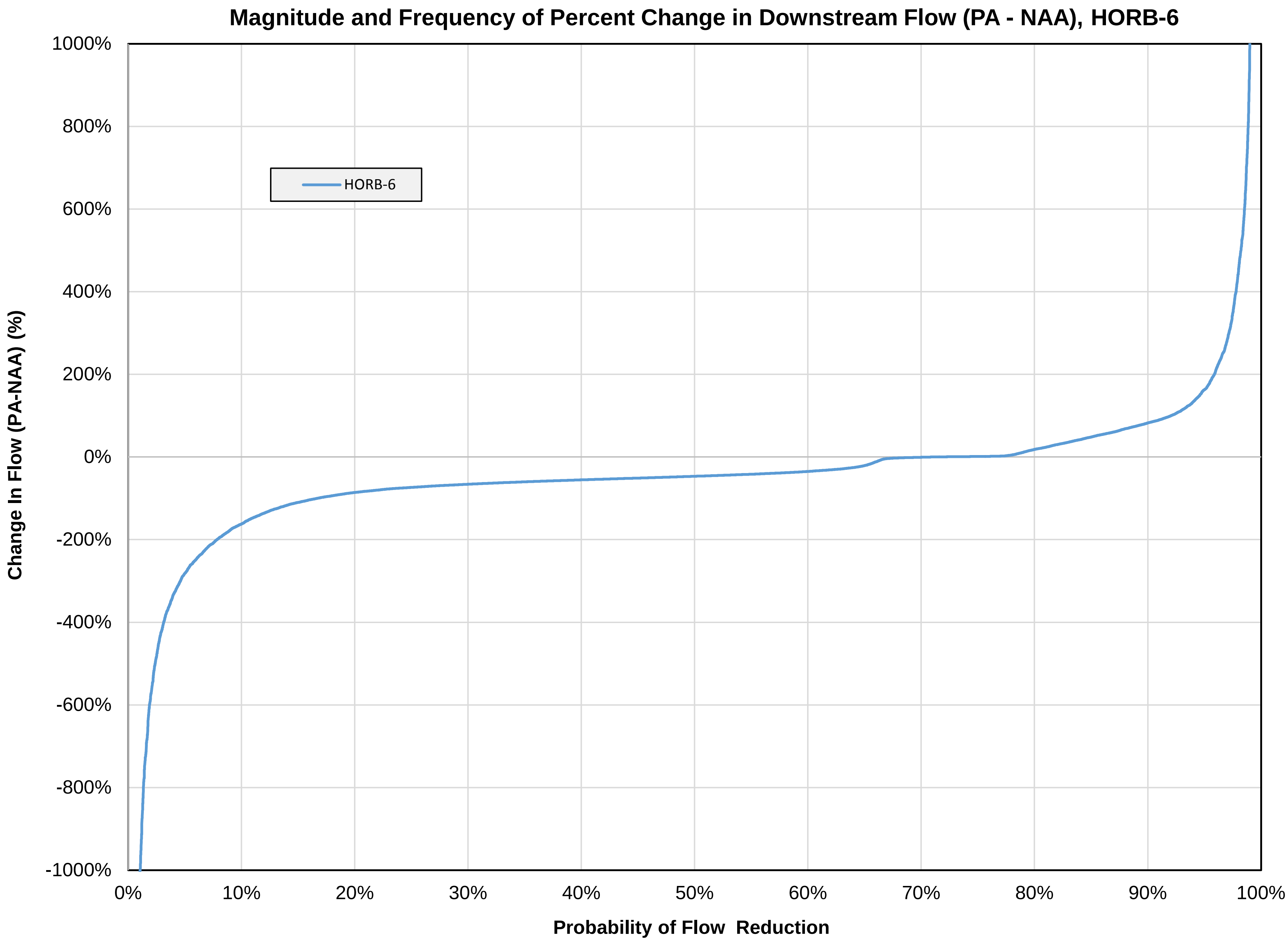
Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-3
HORB-3
100%
50%
0%
-50%
-100%
-150%
Change In Flow (PA-NAA) (%)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Flow Reduction



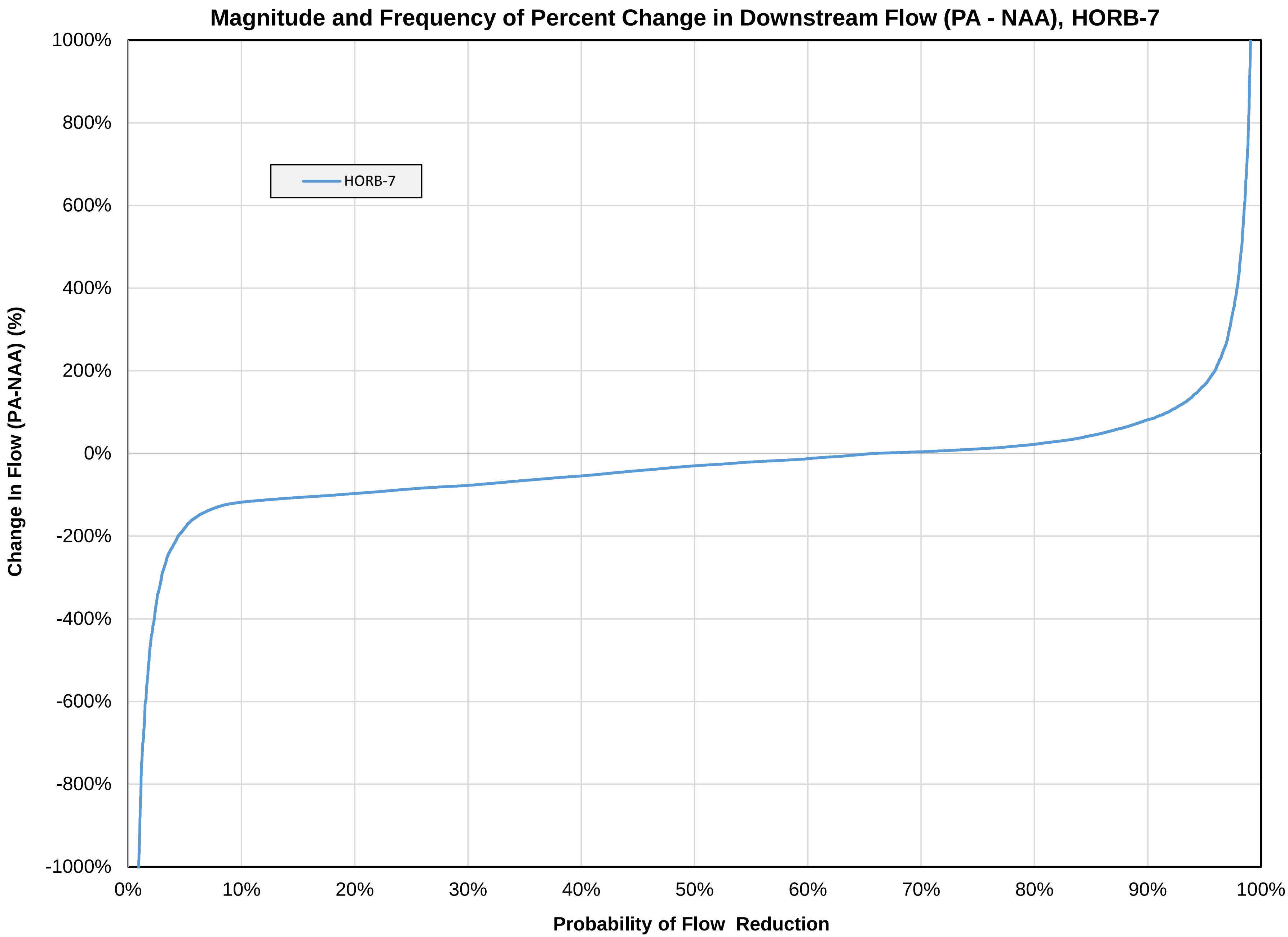
Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-4
HORB-4
500%
400%
300%
200%
100%
0%
-100%
-200%
-300%
Change In Flow (PA-NAA) (%)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Flow Reduction



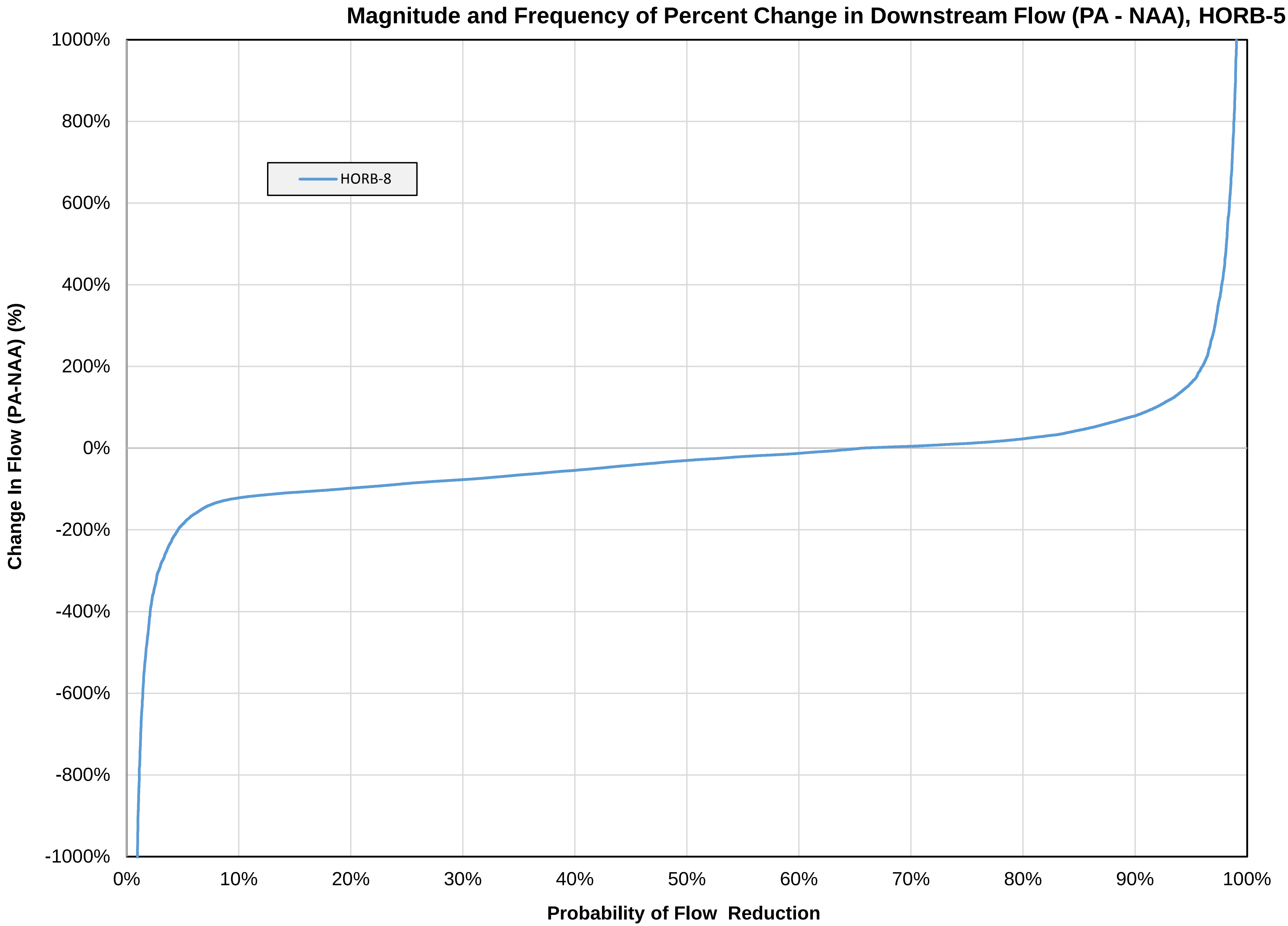
Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-5
1000%
800%
600%
400%
200%
0%
-200%
-400%
-600%
-800%
-1000%
HORB-5
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Change In Flow (PA-NAA) (%)
Probability of Flow Reduction

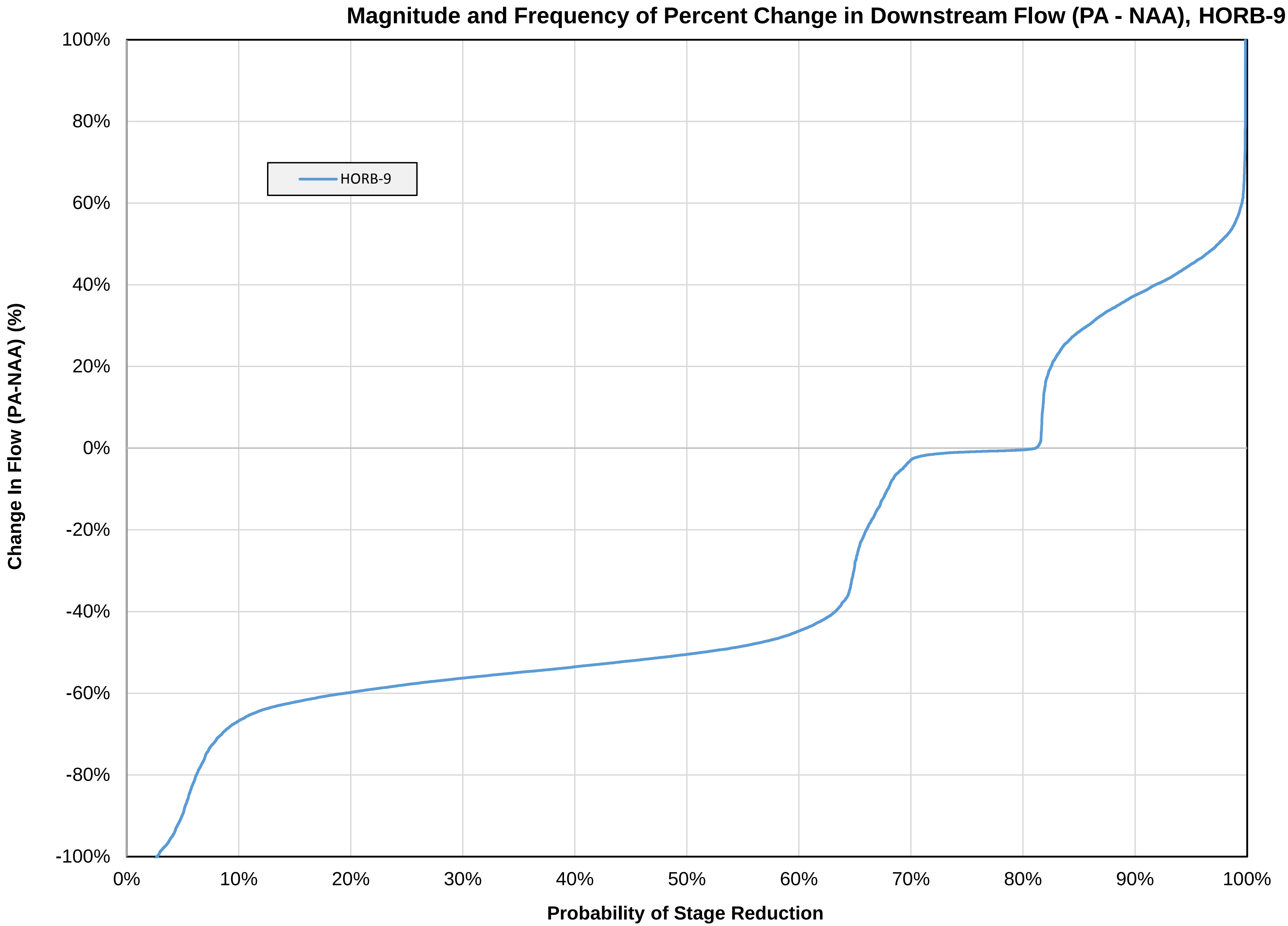


Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-6
1000%
800%
600%
400%
200%
0%
-200%
-400%
-600%
-800%
-1000%
HORB-6
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Flow Reduction
Change In Flow (PA-NAA) (%)

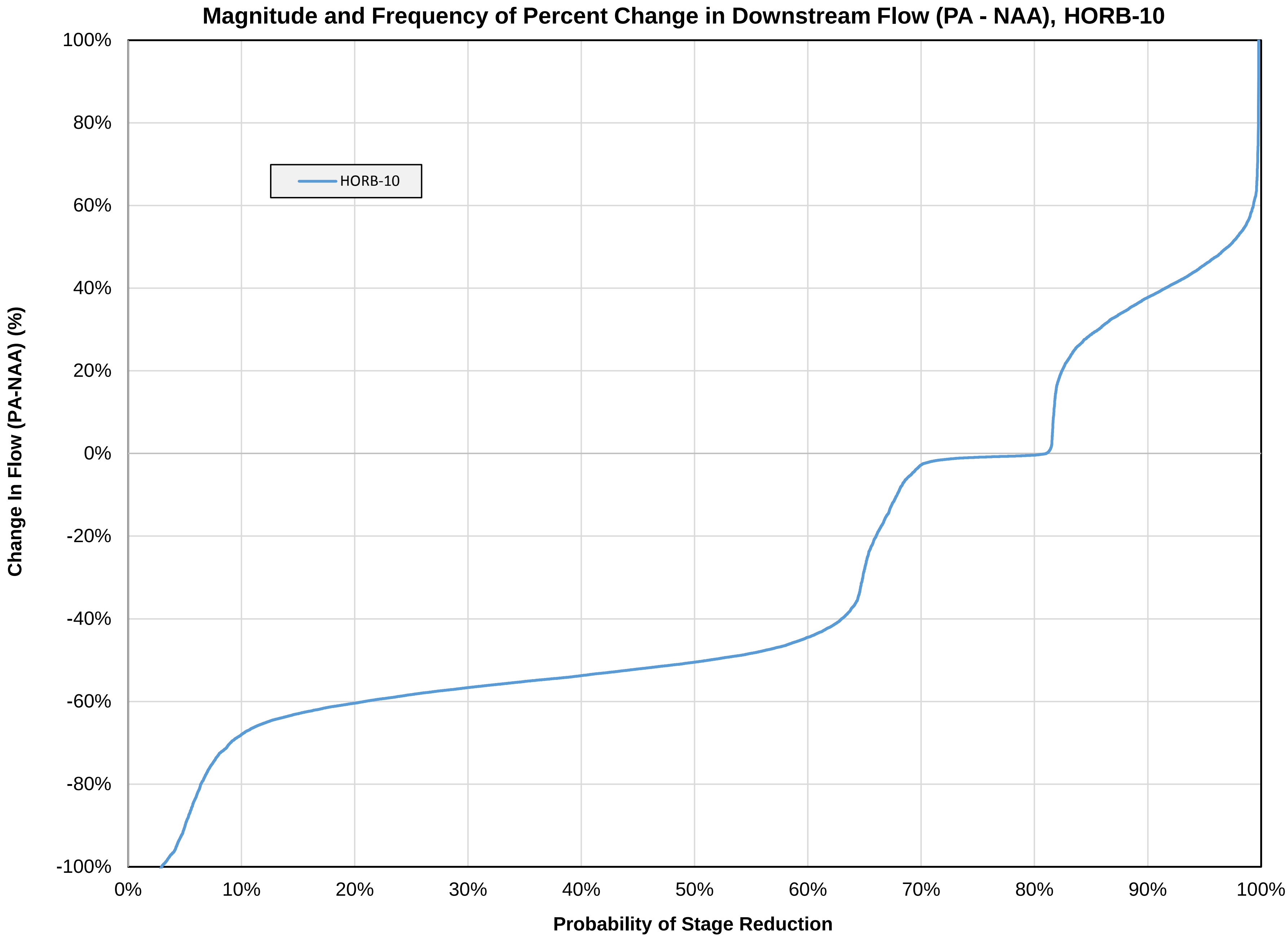


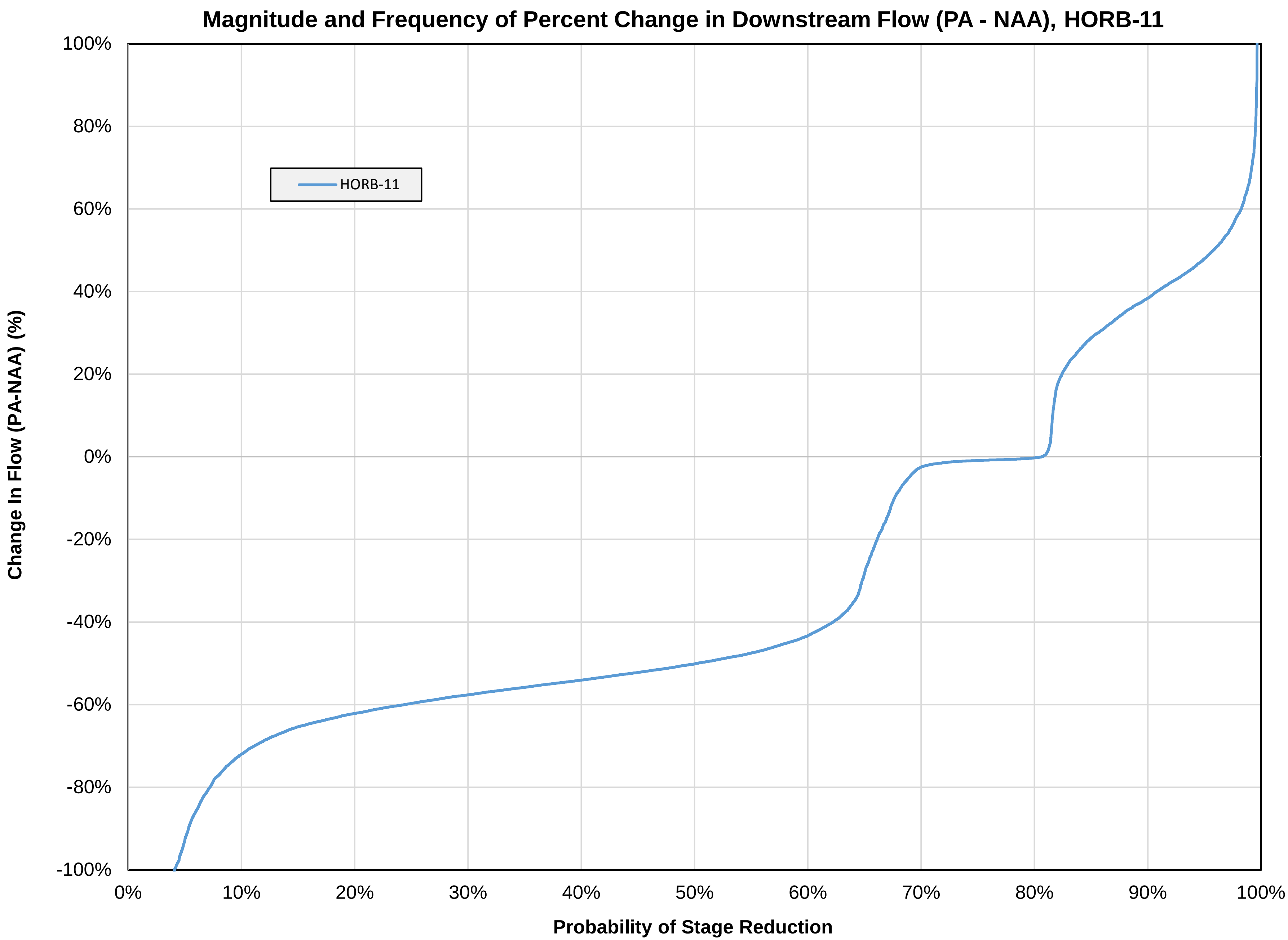
Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-7
1000%
800%
600%
400%
200%
0%
-200%
-400%
-600%
-800%
-1000%
HORB-7
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Change In Flow (PA-NAA) (%)
Probability of Flow Reduction


Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-5
HORB-8
1000%
800%
600%
400%
200%
0%
-200%
-400%
-600%
-800%
-1000%
Change In Flow (PA-NAA) (%)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Flow Reduction

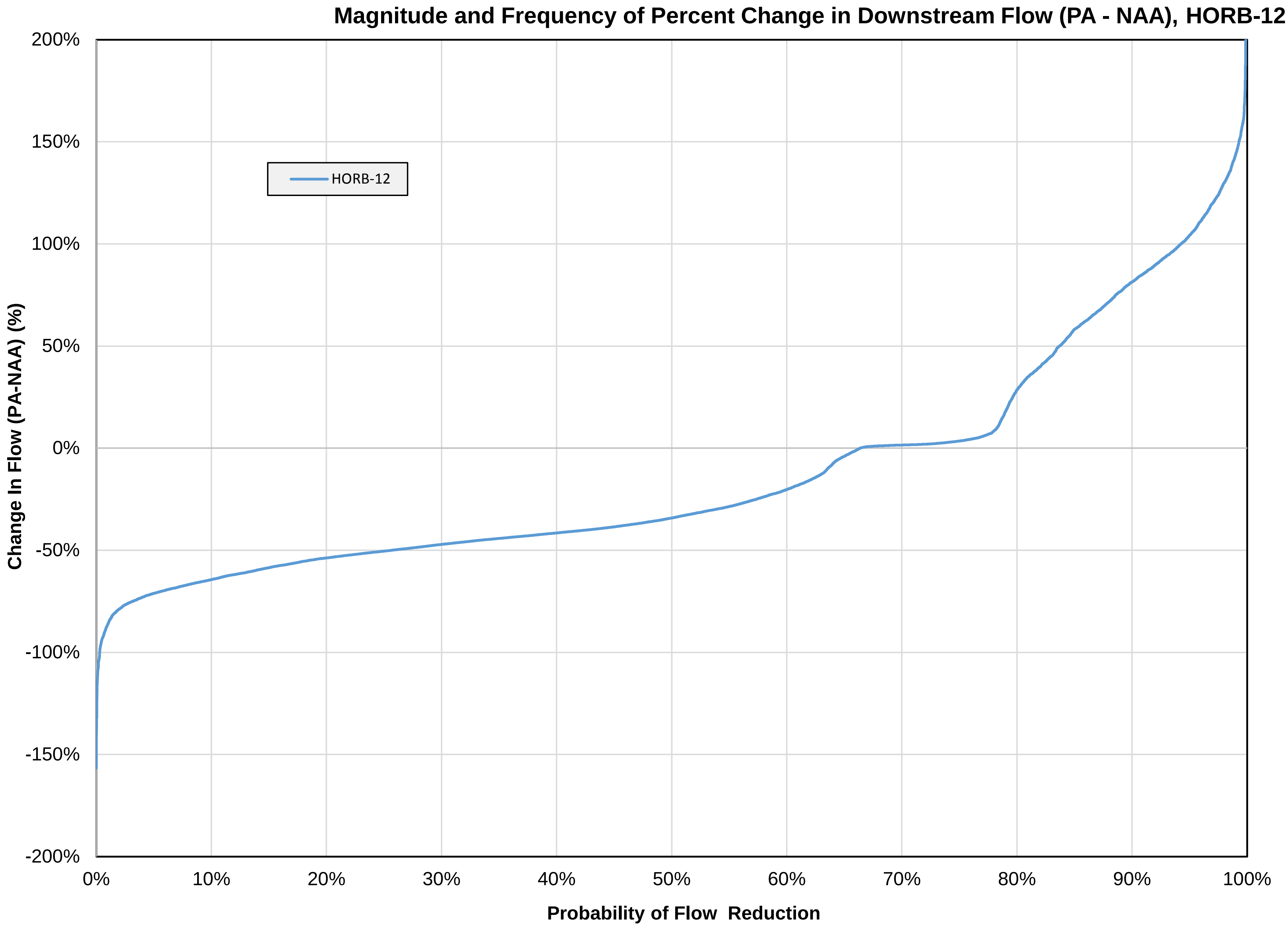


Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-9
HORB-9
Change In Flow (PA-NAA) (%)
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction

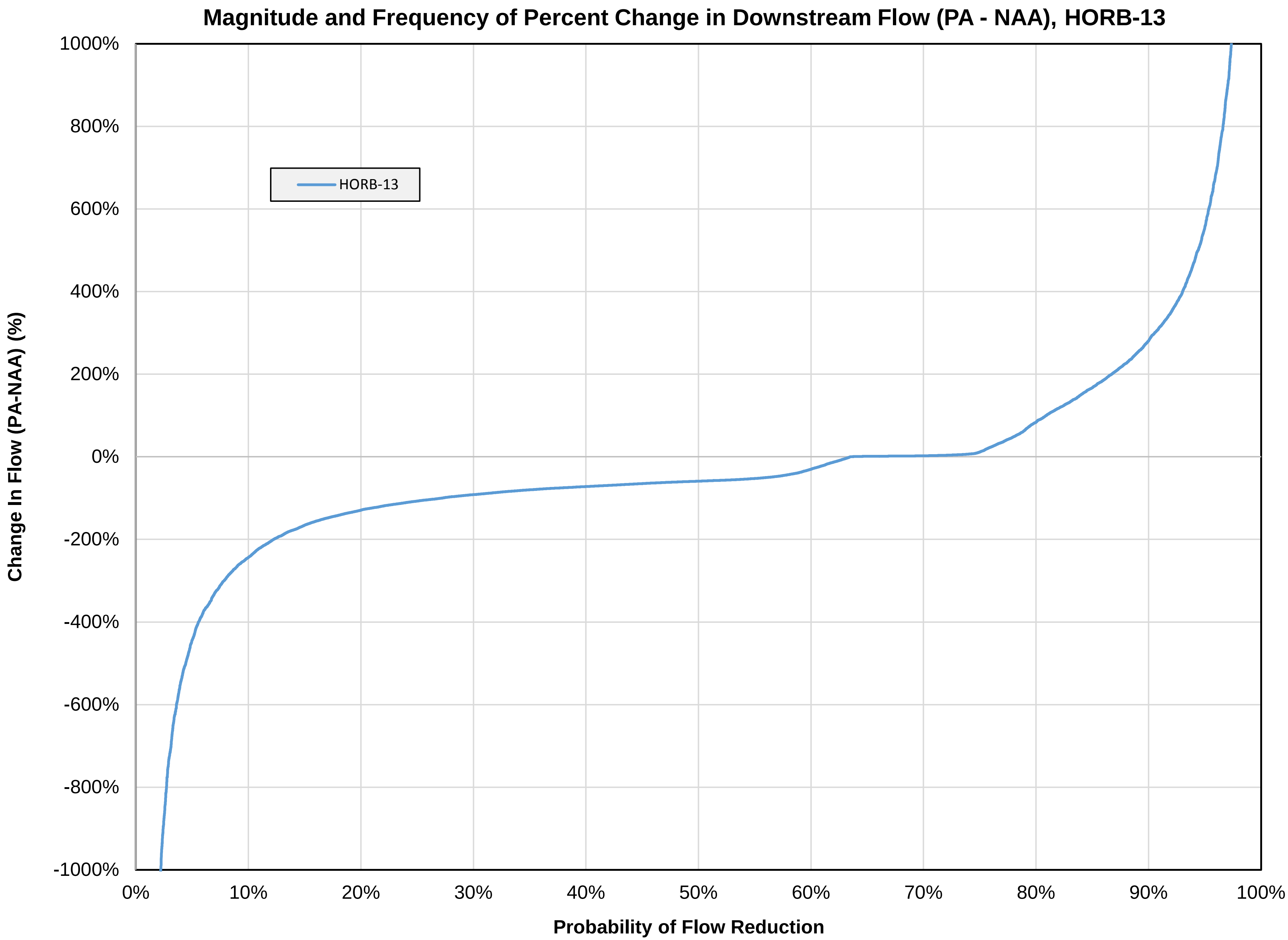

Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-10
HORB-10
Change In Flow (PA-NAA) (%)
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction



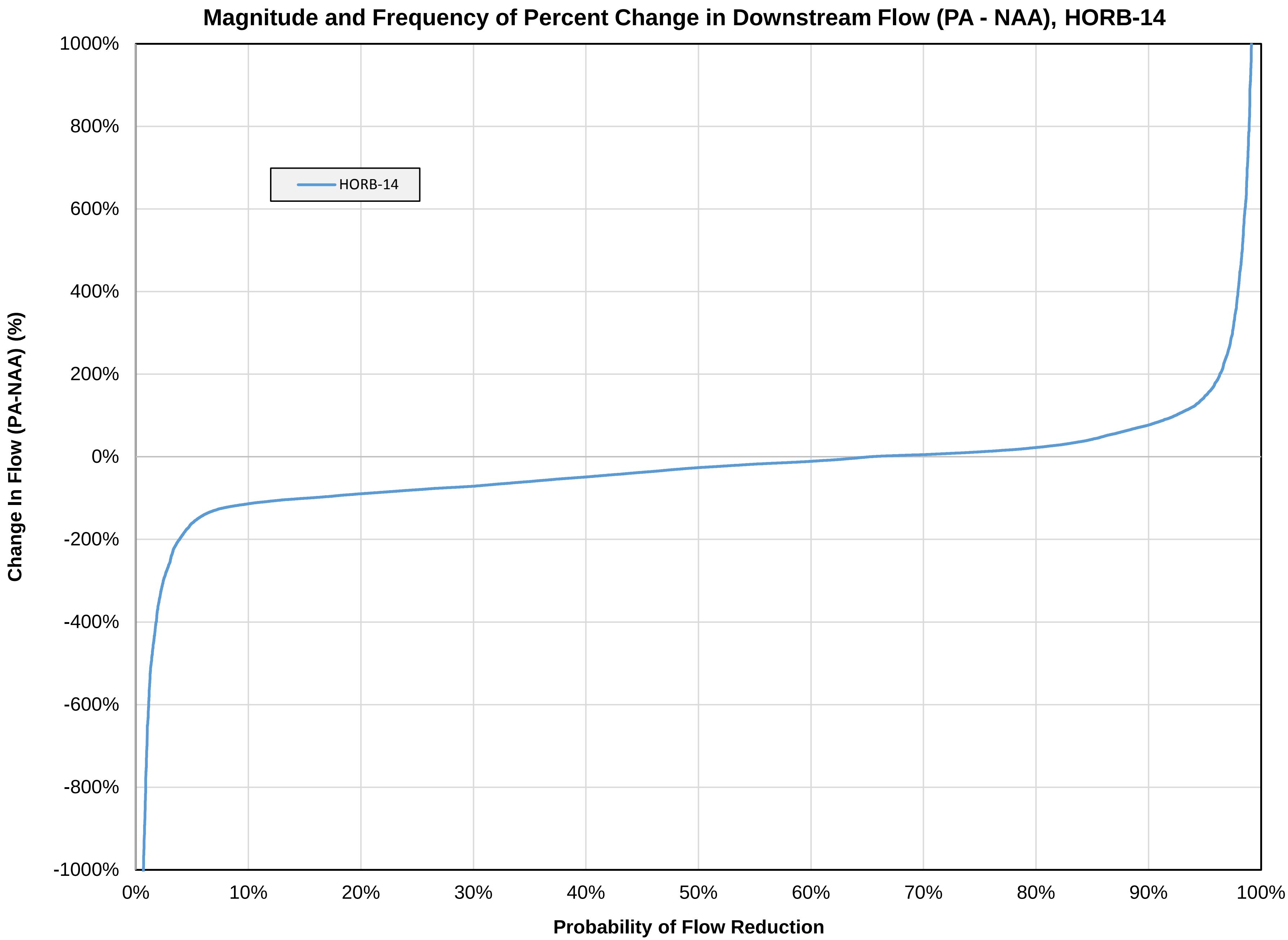
Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-11
HORB-11
Change In Flow (PA-NAA) (%)
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Stage Reduction



Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-12
200%
150%
100%
50%
0%
-50%
-100%
-150%
-200%
HORB-12
Change In Flow (PA-NAA) (%)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Flow Reduction

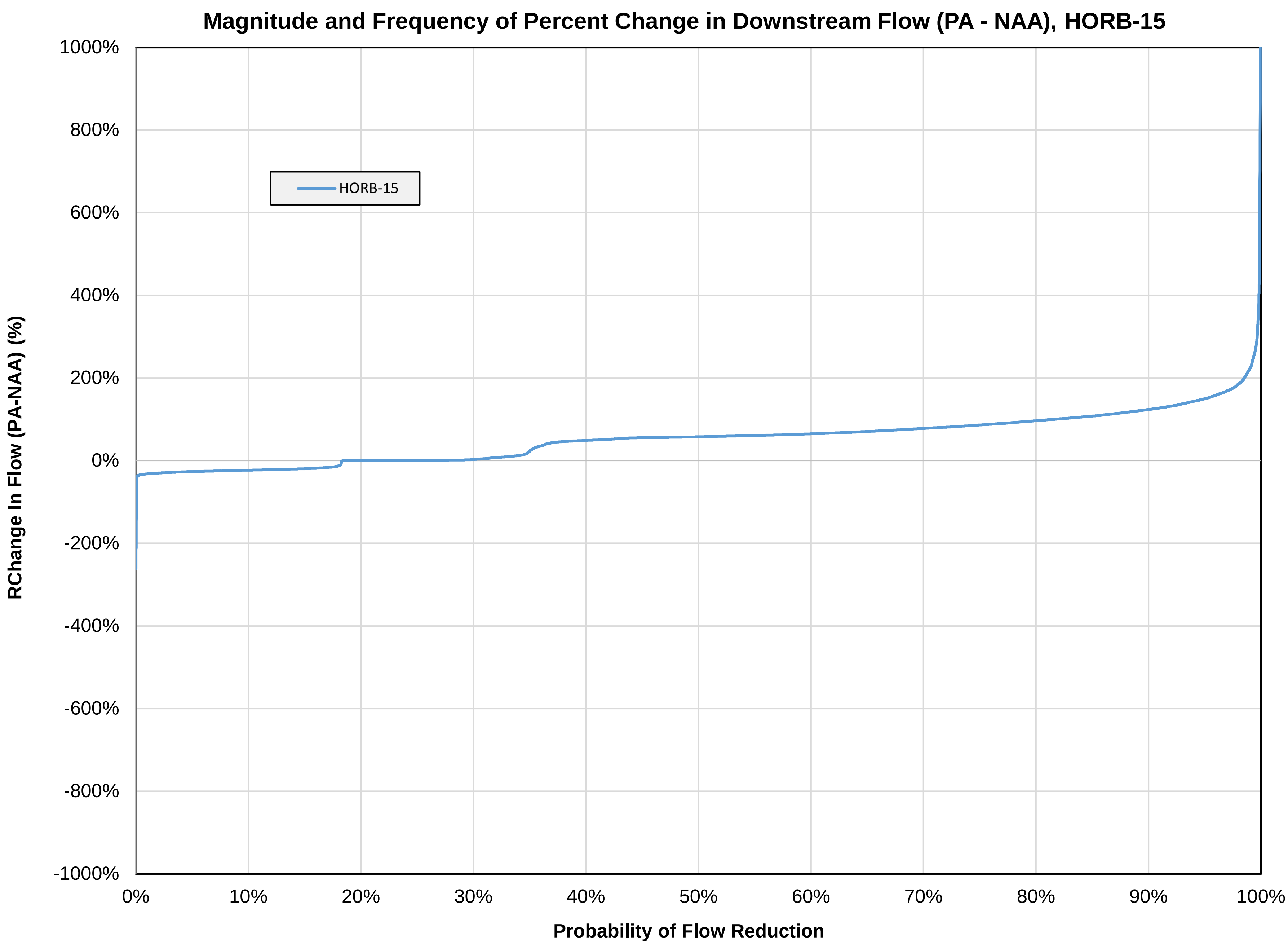


Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-13
HORB-13
Change In Flow (PA-NAA) (%)
1000%
800%
600%
400%
200%
0%
-200%
-400%
-600%
-800%
-1000%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Flow Reduction



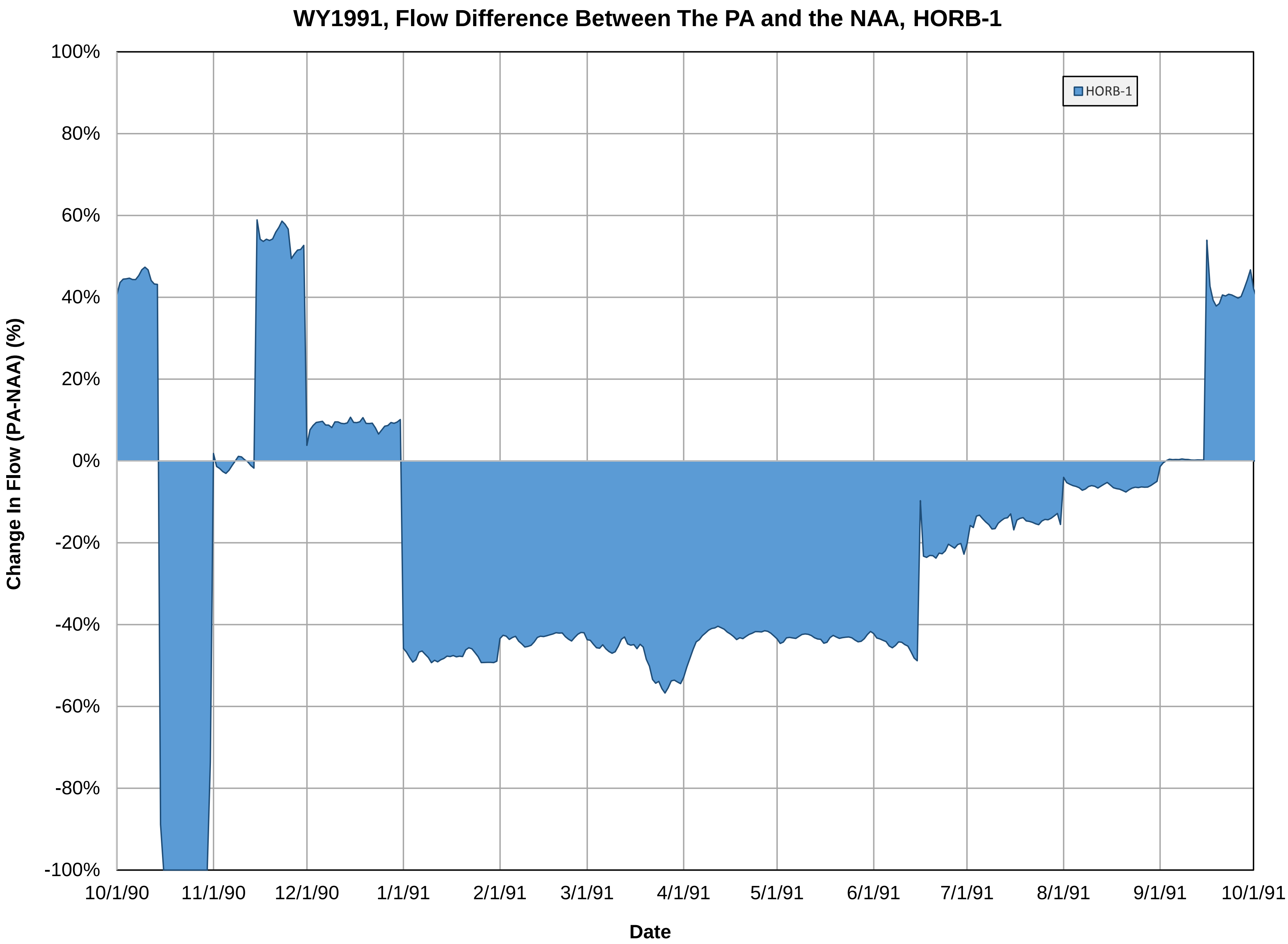
Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-14
HORB-14
1000%
800%
600%
400%
200%
0%
-200%
-400%
-600%
-800%
-1000%
Change In Flow (PA-NAA) (%)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Flow Reduction

Magnitude and Frequency of Percent Change in Downstream Flow (PA - NAA), HORB-15

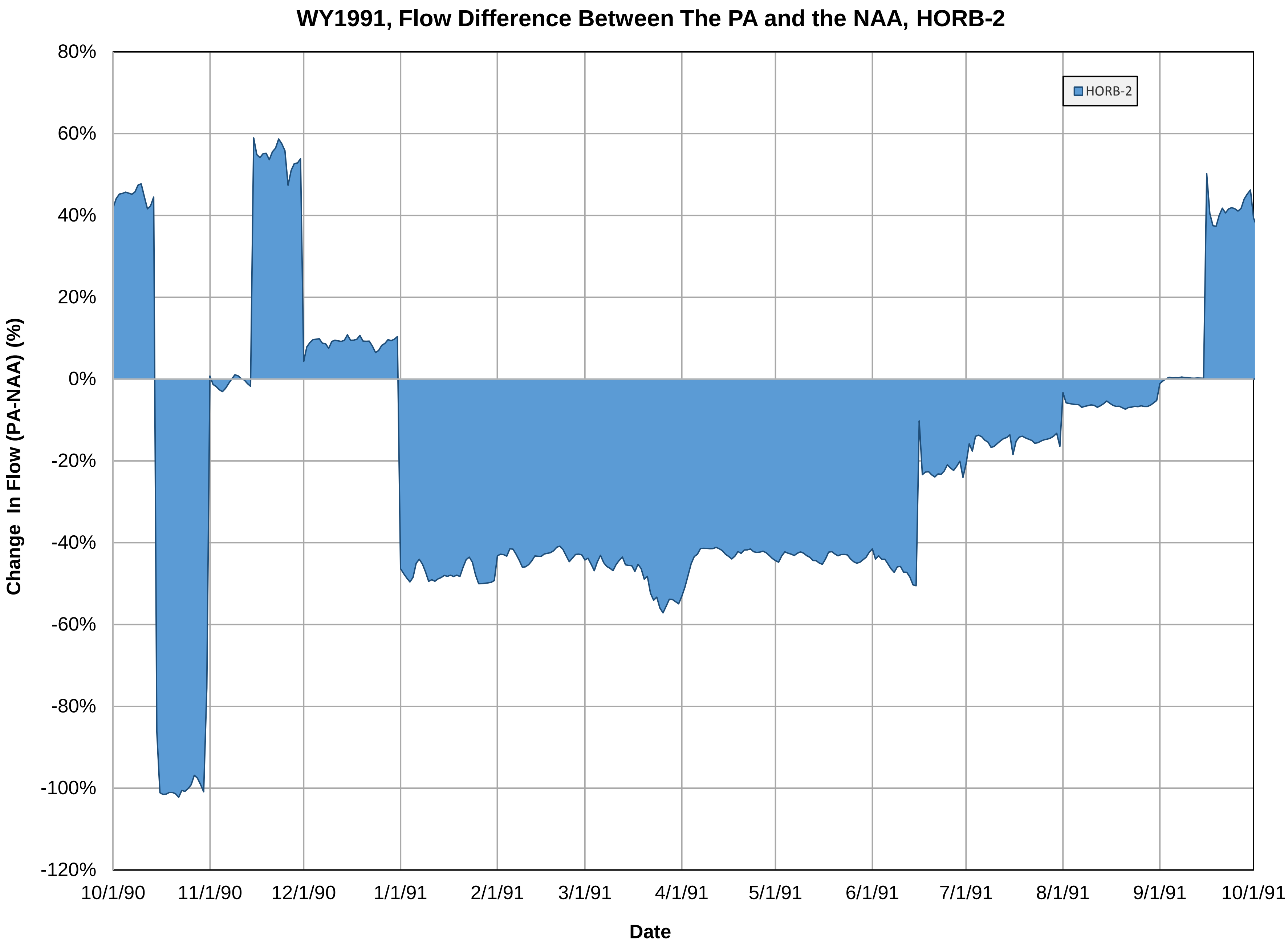


Appendix E

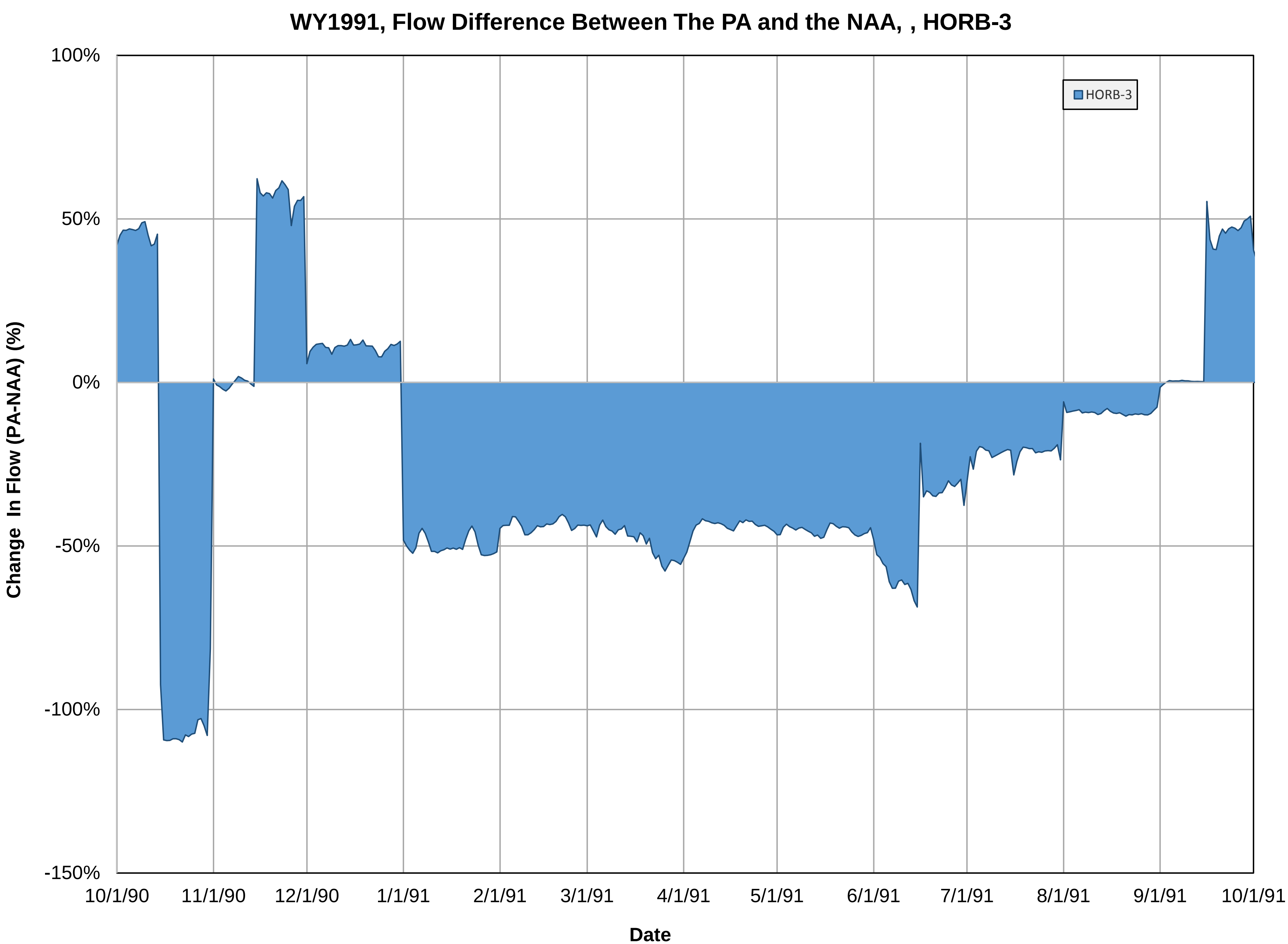
Detail Plots of the Change in Downstream Flushing Flow Between The PA and the NAA, WY 1991

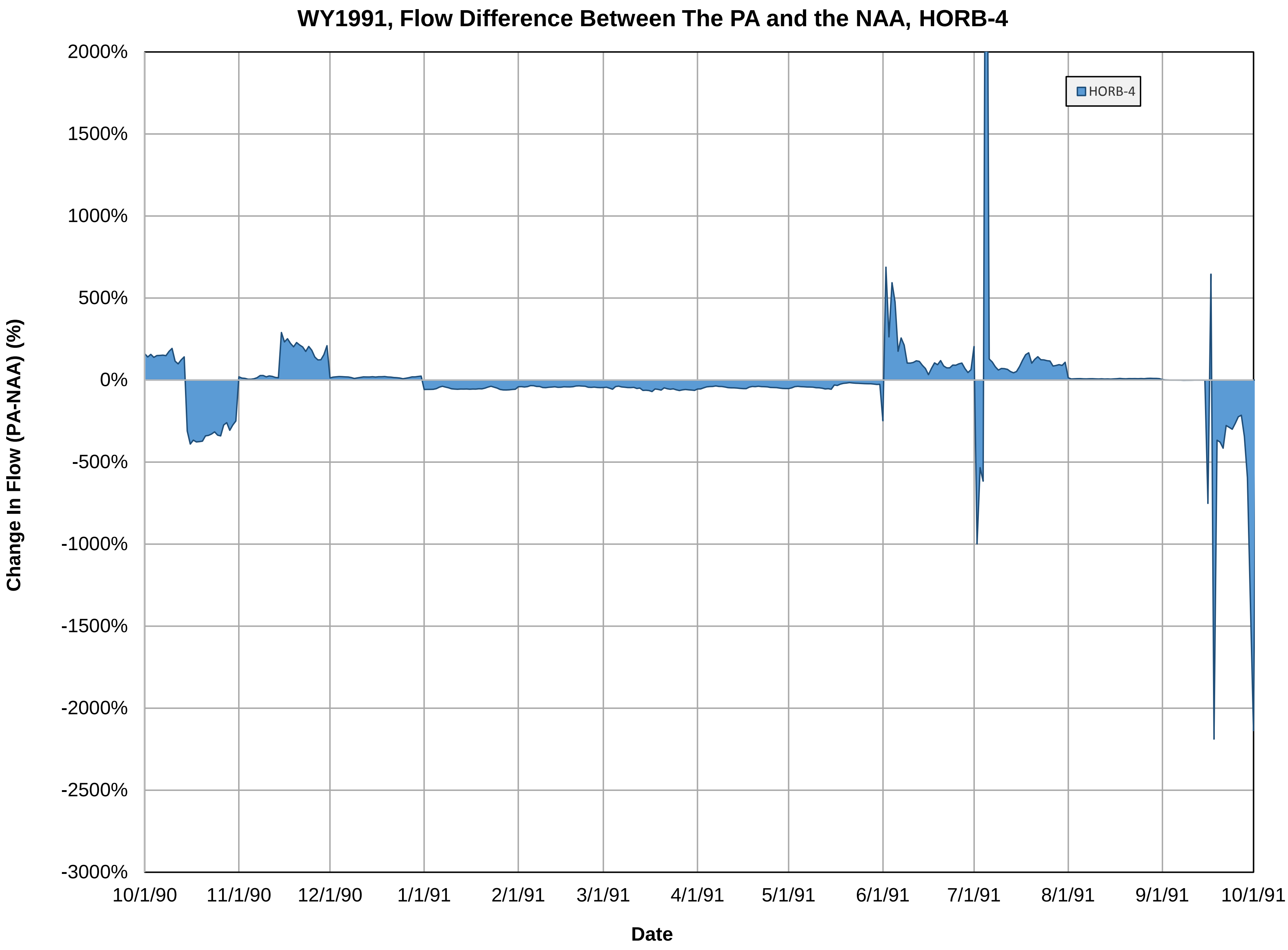


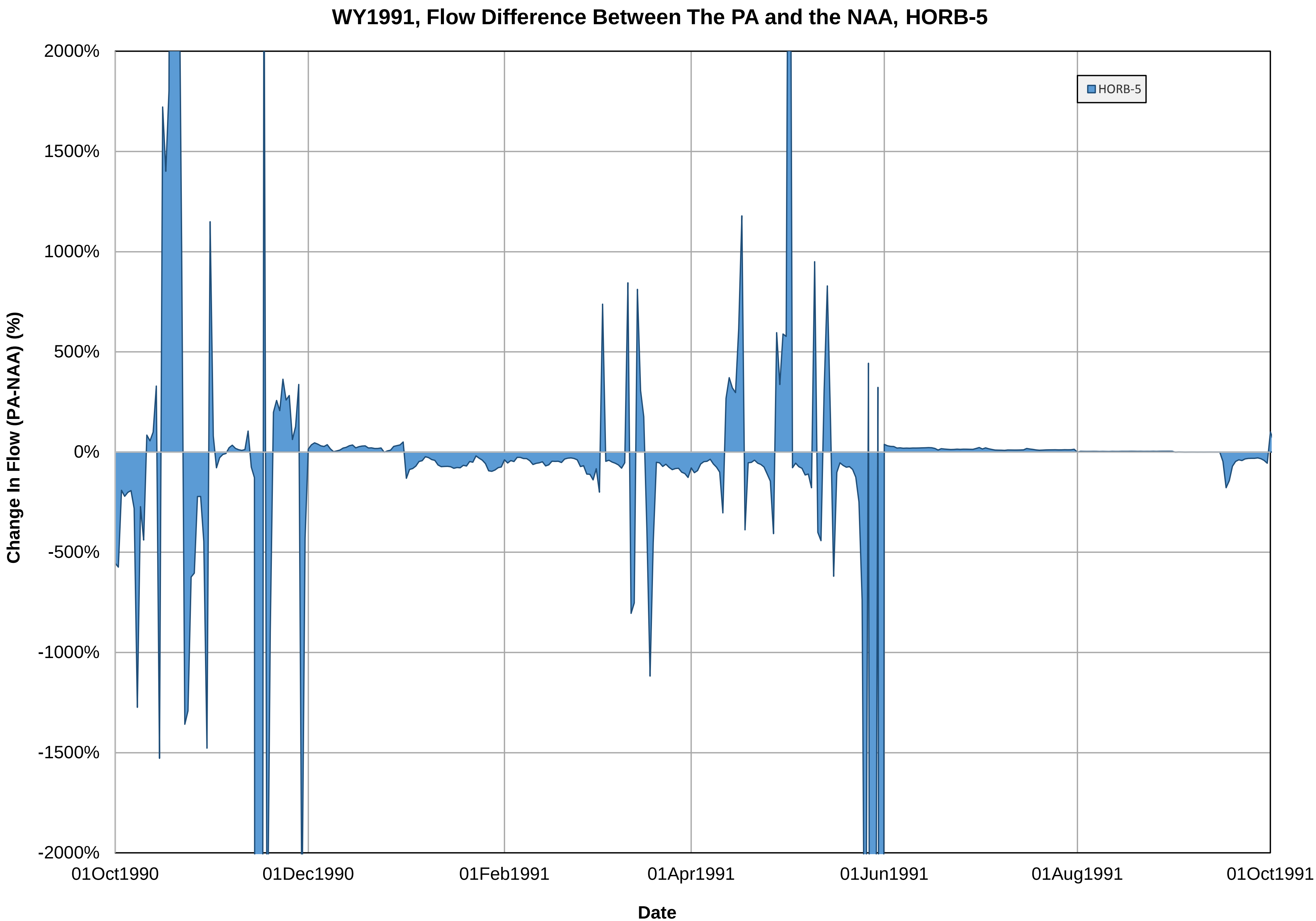
WY1991, Flow Difference Between The PA and the NAA, HORB-1
HORB-1
Change In Flow (PA-NAA) (%)
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
10/1/90
11/1/90
12/1/90
1/1/91
2/1/91
3/1/91
4/1/91
5/1/91
6/1/91
7/1/91
8/1/91
9/1/91
10/1/91
Date

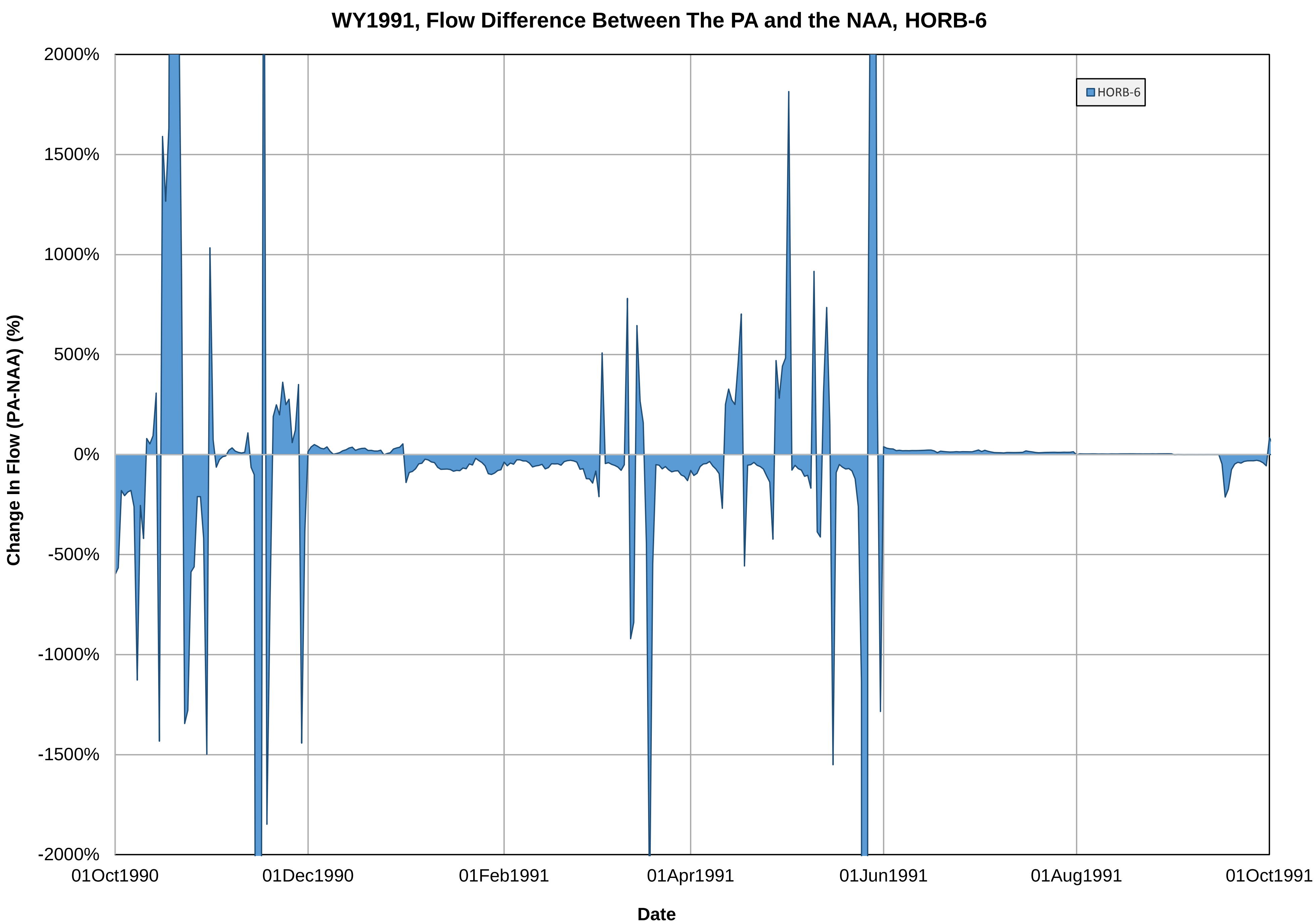


WY1991, Flow Difference Between The PA and the NAA, HORB-2
HORB-2
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
-120%
Change In Flow (PA-NAA) (%)
10/1/90
11/1/90
12/1/90
1/1/91
2/1/91
3/1/91
4/1/91
5/1/91
6/1/91
7/1/91
8/1/91
9/1/91
10/1/91
Date

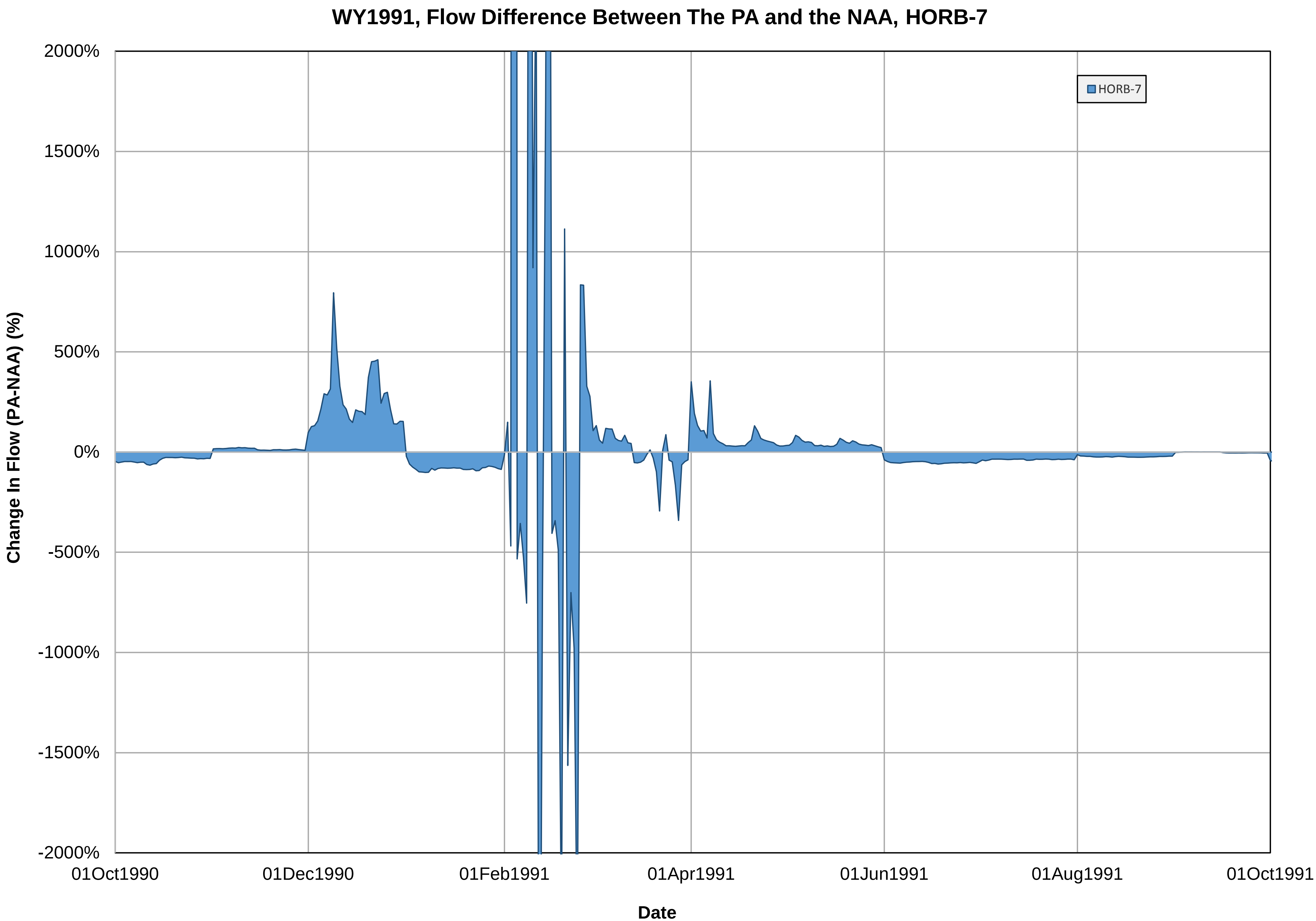

WY1991, Flow Difference Between The PA and the NAA, , HORB-3
100%
50%
0%
-50%
-100%
-150%
Change In Flow (PA-NAA) (%)
HORB-3
10/1/90
11/1/90
12/1/90
1/1/91
2/1/91
3/1/91
4/1/91
5/1/91
6/1/91
7/1/91
8/1/91
9/1/91
10/1/91
Date


WY1991, Flow Difference Between The PA and the NAA, HORB-4
HORB-4
2000%
1500%
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
-2500%
-3000%
Change In Flow (PA-NAA) (%)
10/1/90
11/1/90
12/1/90
1/1/91
2/1/91
3/1/91
4/1/91
5/1/91
6/1/91
7/1/91
8/1/91
9/1/91
10/1/91
Date

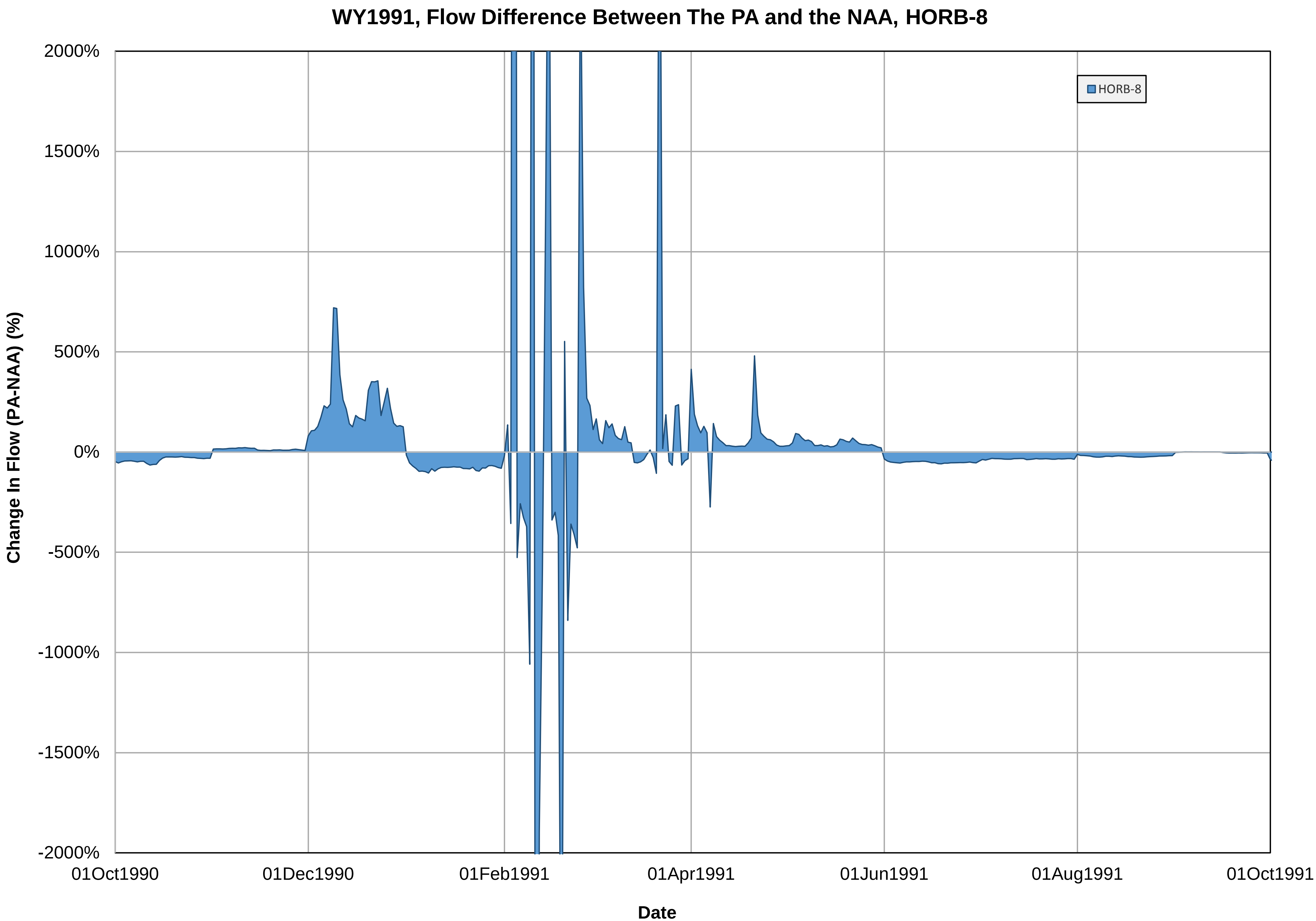

WY1991, Flow Difference Between The PA and the NAA, HORB-5
2000%
1500%
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
Change In Flow (PA-NAA) (%)
01Oct1990
01Dec1990
01Feb1991
01Apr1991
01Jun1991
01Aug1991
01Oct1991
Date
HORB-5



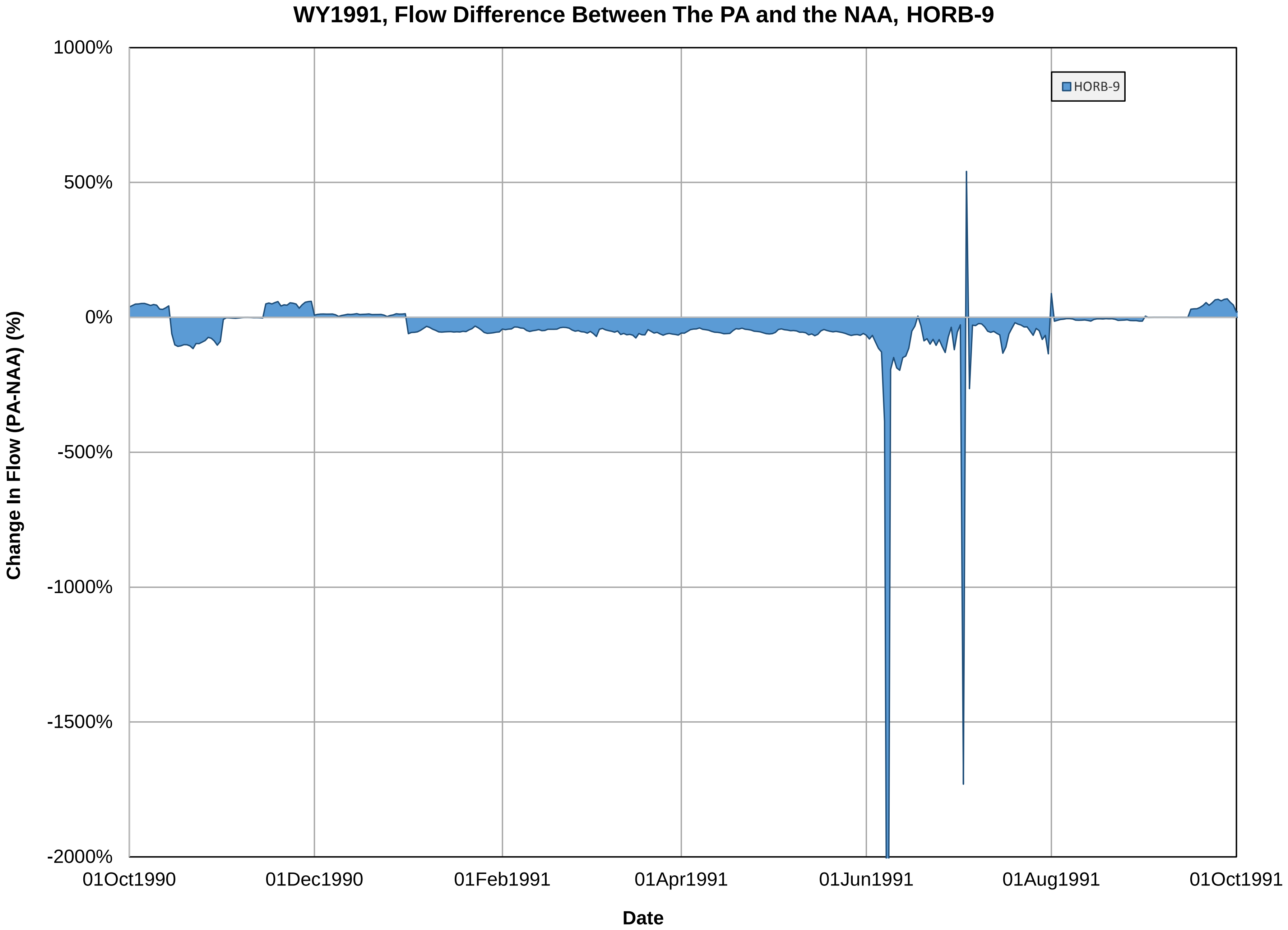
WY1991, Flow Difference Between The PA and the NAA, HORB-6
2000%
1500%
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
Change In Flow (PA-NAA) (%)
01Oct1990
01Dec1990
01Feb1991
01Apr1991
01Jun1991
01Aug1991
01Oct1991
Date
HORB-6



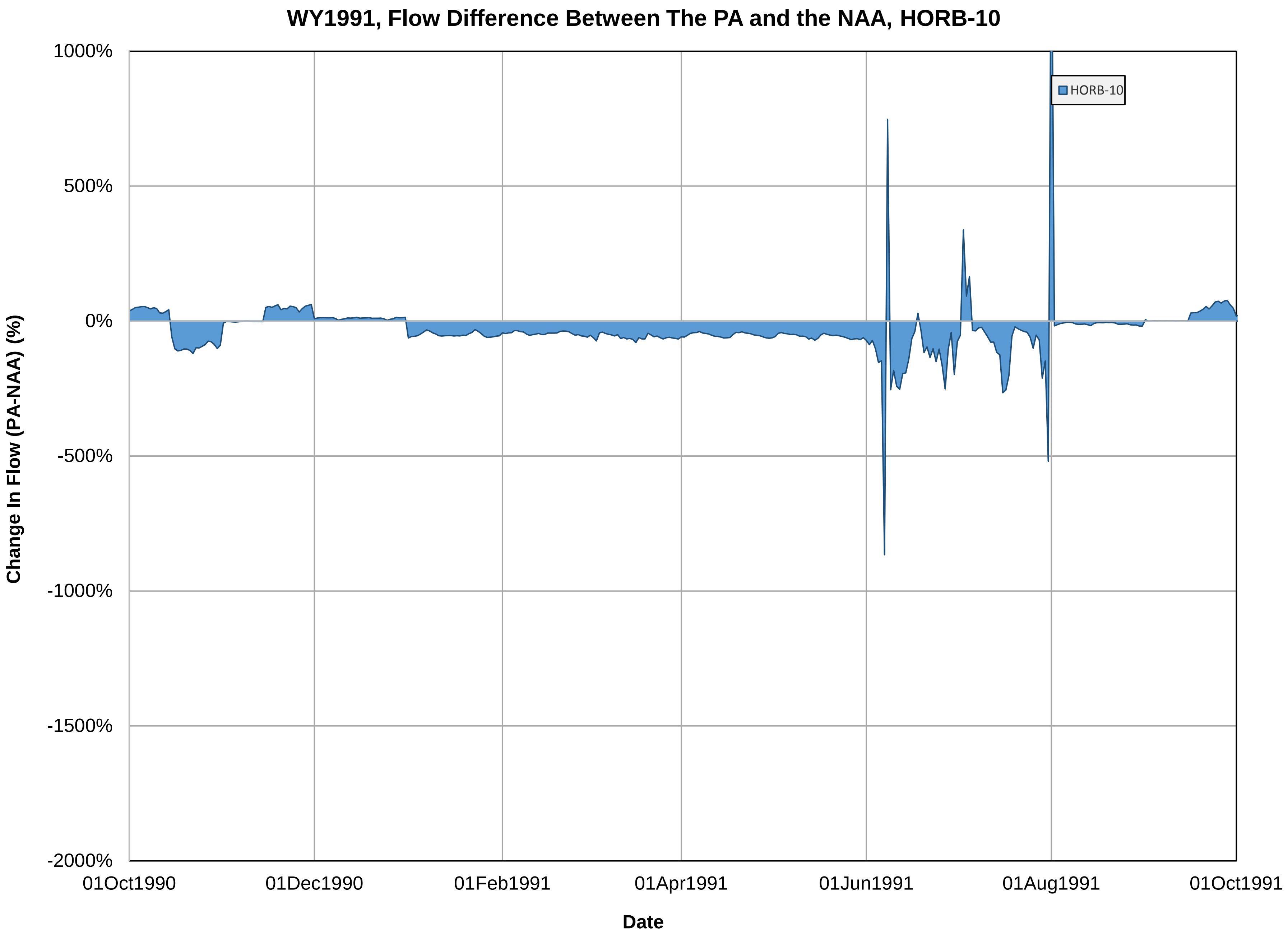
WY1991, Flow Difference Between The PA and the NAA, HORB-7
2000%
1500%
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
Change In Flow (PA-NAA) (%)
01Oct1990
01Dec1990
01Feb1991
01Apr1991
01Jun1991
01Aug1991
01Oct1991
Date
HORB-7



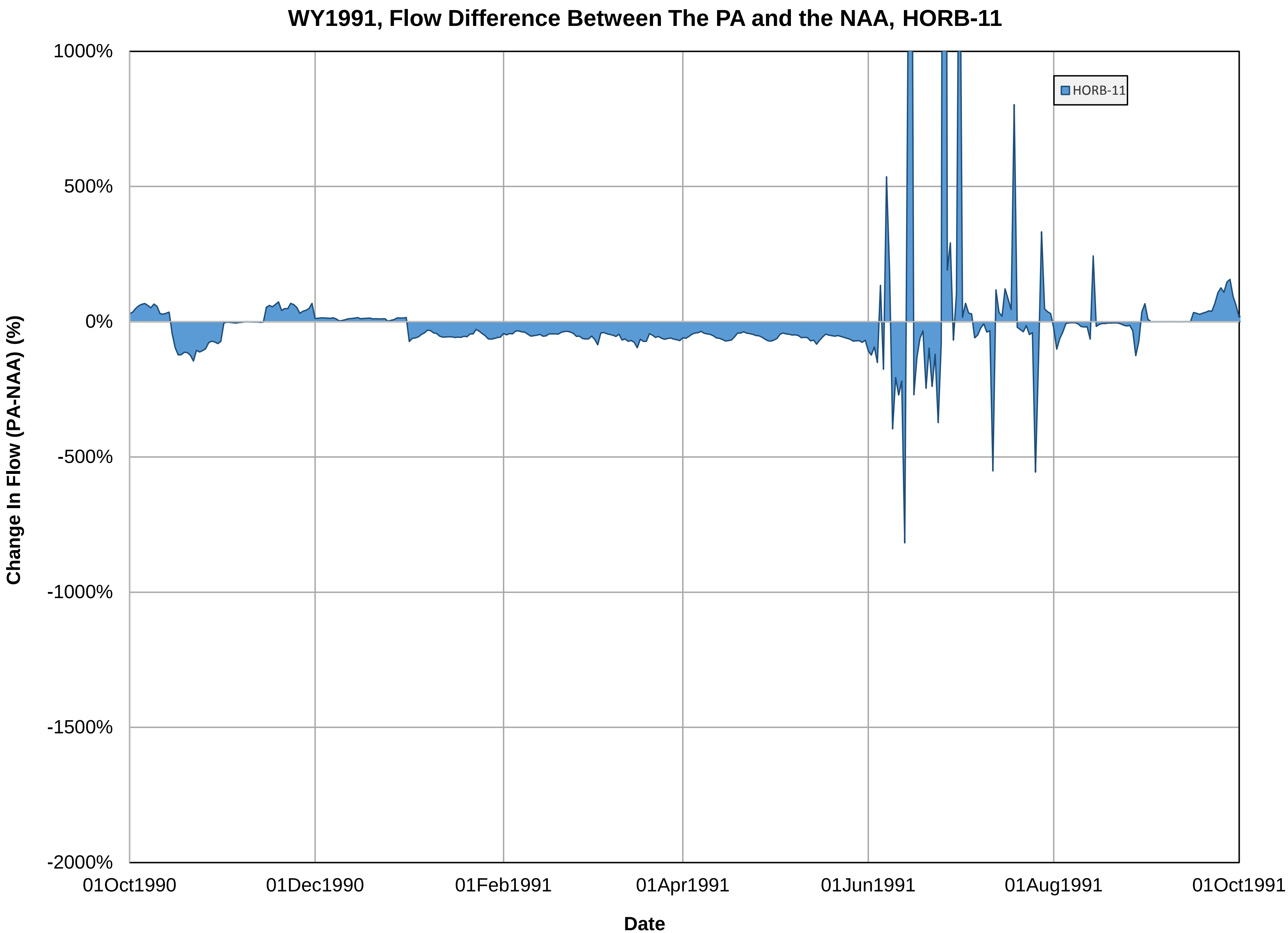
WY1991, Flow Difference Between The PA and the NAA, HORB-8
2000%
1500%
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
Change In Flow (PA-NAA) (%)
HORB-8
01Oct1990
01Dec1990
01Feb1991
01Apr1991
01Jun1991
01Aug1991
01Oct1991
Date

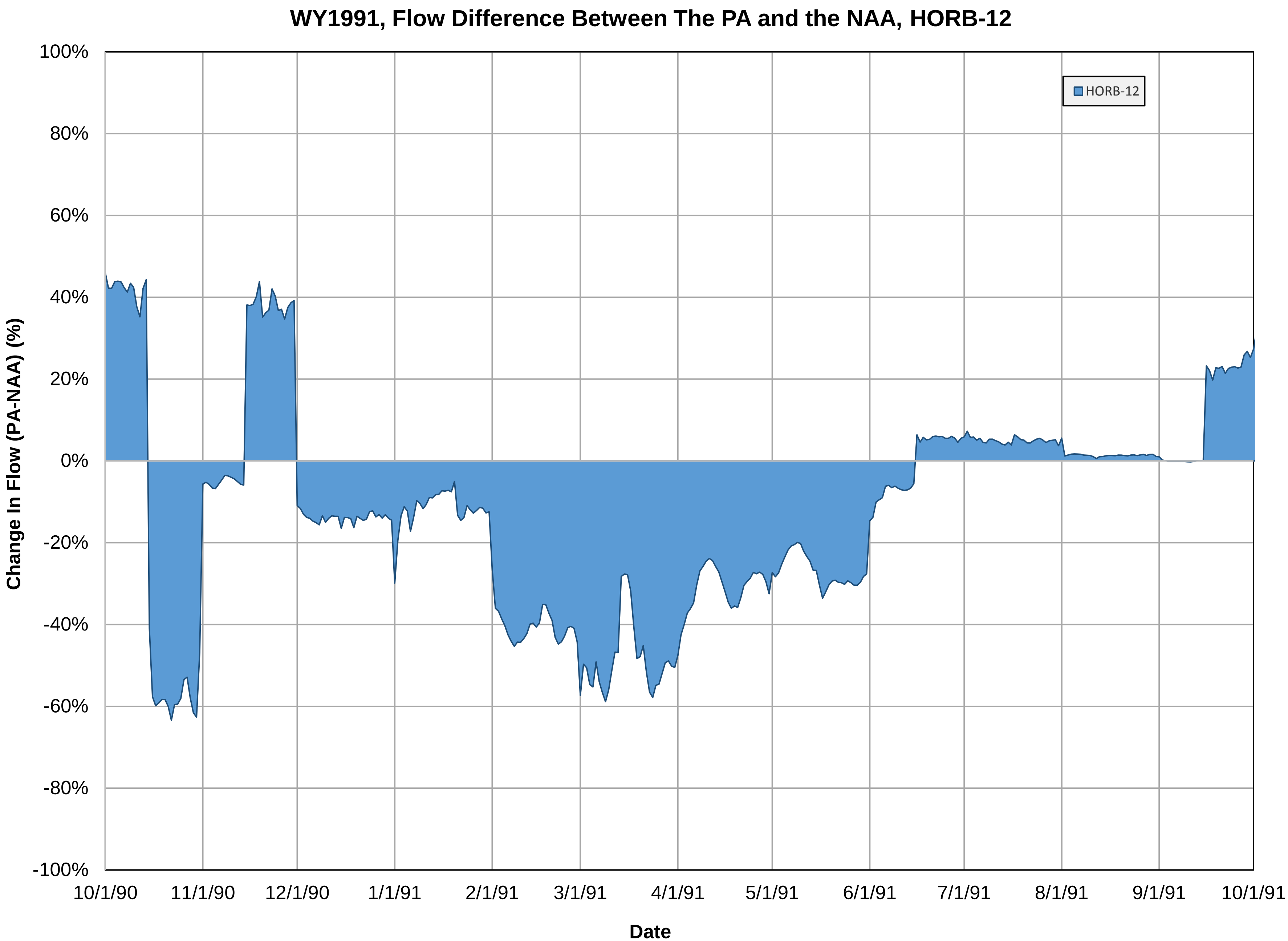


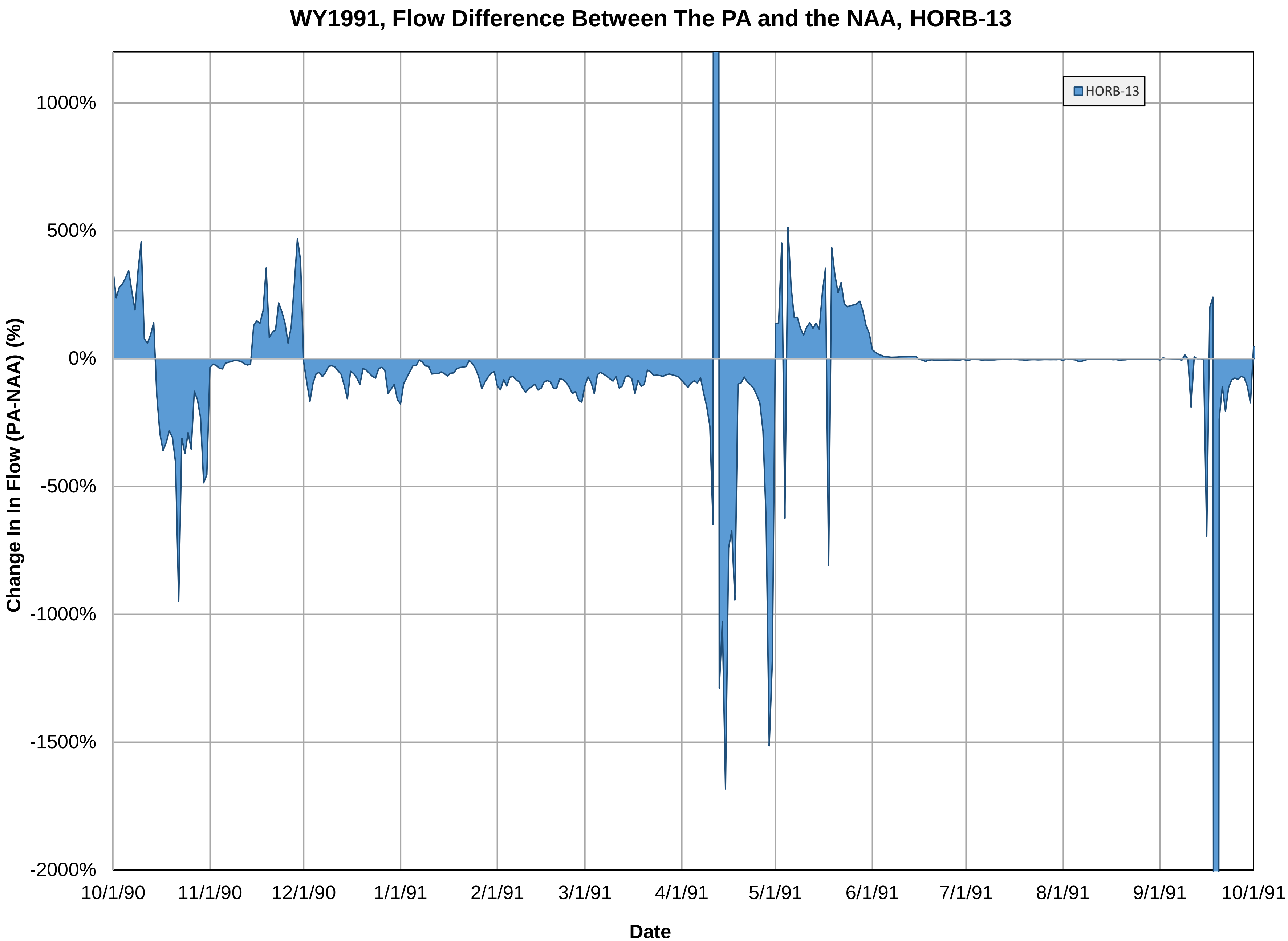
WY1991, Flow Difference Between The PA and the NAA, HORB-9
HORB-9
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
Change In Flow (PA-NAA) (%)
01Oct1990
01Dec1990
01Feb1991
01Apr1991
01Jun1991
01Aug1991
01Oct1991
Date

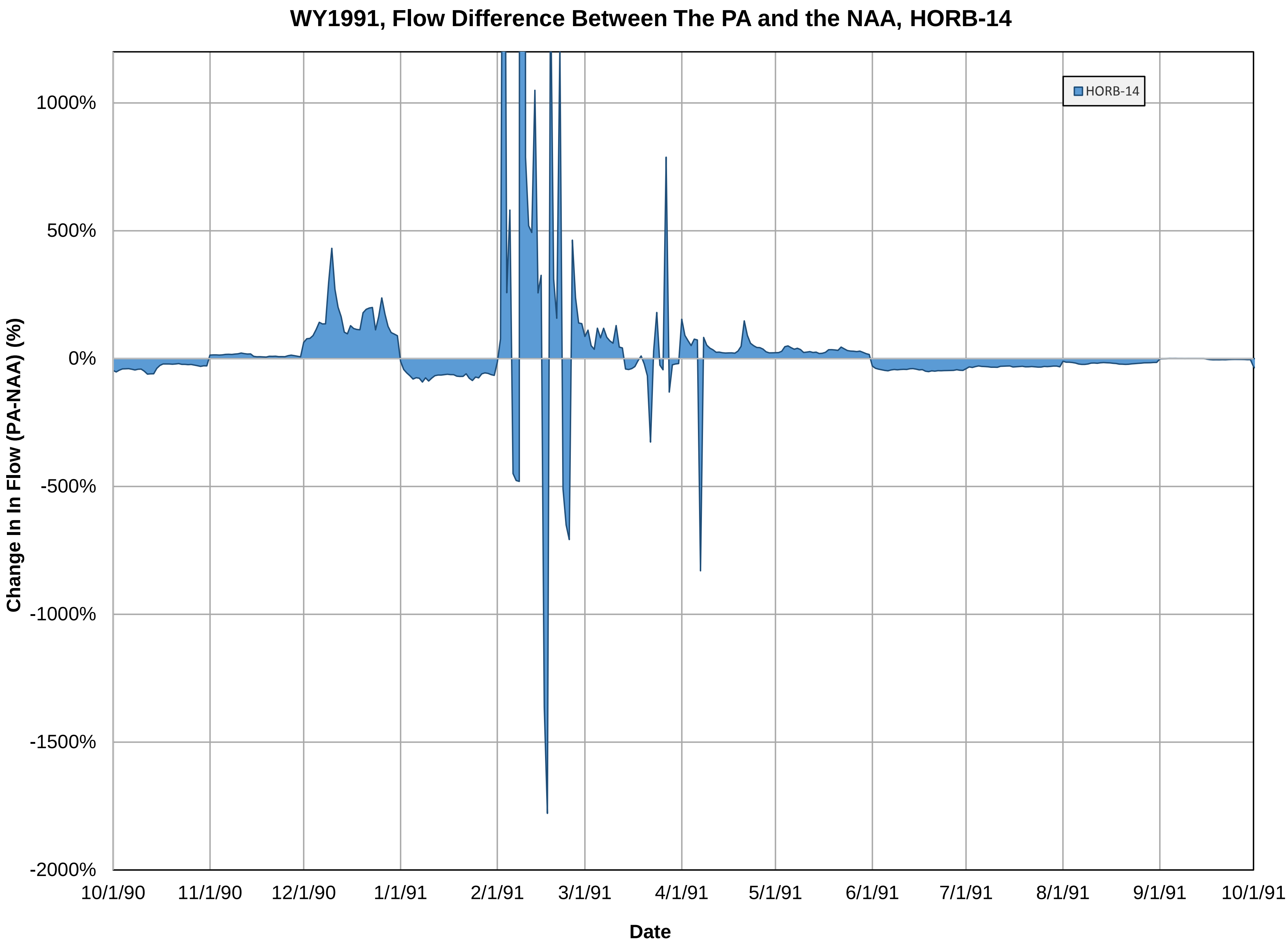


WY1991, Flow Difference Between The PA and the NAA, HORB-10
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
Change In Flow (PA-NAA) (%)
01Oct1990
01Dec1990
01Feb1991
01Apr1991
01Jun1991
01Aug1991
01Oct1991
Date
HORB-10


WY1991, Flow Difference Between The PA and the NAA, HORB-11
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
Change In Flow (PA-NAA) (%)
HORB-11
01Oct1990
01Dec1990
01Feb1991
01Apr1991
01Jun1991
01Aug1991
01Oct1991
Date


WY1991, Flow Difference Between The PA and the NAA, HORB-12
HORB-12
Change In Flow (PA-NAA) (%)
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
10/1/90
11/1/90
12/1/90
1/1/91
2/1/91
3/1/91
4/1/91
5/1/91
6/1/91
7/1/91
8/1/91
9/1/91
10/1/91
Date


WY1991, Flow Difference Between The PA and the NAA, HORB-13
HORB-13
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
Change In In Flow (PA-NAA) (%)
10/1/90
11/1/90
12/1/90
1/1/91
2/1/91
3/1/91
4/1/91
5/1/91
6/1/91
7/1/91
8/1/91
9/1/91
10/1/91
Date


WY1991, Flow Difference Between The PA and the NAA, HORB-14
HORB-14
Change In In Flow (PA-NAA) (%)
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
10/1/90
11/1/90
12/1/90
1/1/91
2/1/91
3/1/91
4/1/91
5/1/91
6/1/91
7/1/91
8/1/91
9/1/91
10/1/91
Date