3.3.3. TIDE ANALYSIS

To investigate the model's ability to reproduce field conditions, a thorough comparison between the water levels computed by the model and those measured in the field was performed. A FORTRAN program developed in house was used to resolve the measured water level at each monitoring station into two components, a tidal signal, and a moving-average mean water level. For simplicity, the latter component is referred to as a "mean water level" in this report. However, it should be stressed that a moving-average mean water level is different from, for example, a daily mean water level. A moving-average water level is simply the instantaneous water level (either measured or computed by a computer model) minus the tidal signal. Removing the tidal signal from the measured water level data allows for a clear comparison between the datum of each gage and identify possible problems if they exist.

Figure 3.20 shows the tidal signal measured at the four calibration gauges and the USGS gauge. As expected, the tidal signal is strongest at the USGS gauge. The tidal signal at gauge BA04-56 is slightly smaller than that at the USGS gauge. That is also expected since gauge BA04-56 is slightly more inland than the USGS gauge. As the gauges move further into the marsh, the tidal signal continues to get smaller as confirmed in Figure 3.20. The same behavior of the tidal signal is observed in the numerical model and is shown in Figure 3.21. Therefore, the model is replicating the same physical patterns observed in the field.

To provide a more quantitative assessment of the model performance, a direct comparison between the measured and computed tidal signal is performed and shown in Figures 3.22 through 3.25. As seen in these figures the model compares quite well with the field measurements. Generally speaking, the bathymetry has a significant impact on the tidal signal. Therefore, capturing the tidal signal correctly as shown in Figures 3.22 through 3.25 verifies that the bathymetric data used in the model is adequate.

Figure 3.26 shows the mean water level measured at the four calibration gauges and the USGS gauge. The figure provides strong evidence that the quality of the measured data is rather poor. There are strong deviations among the gauges in the order of several feet. Such difference in the mean water levels is not physically possible along the Louisiana coast, and certainly not among gauges that are spatially very close to each other. These deviations may be attributed to several causes including errors in the gauge's vertical datum, and possible clogging or residual buildup on the sensors. Figure 3.27 on the other hand shows mean water level computed by the numerical model. The figure shows a much more consistent mean water level at all the gauges with the expected hydraulic gradient from south to north. However, for the purpose of completeness, a direct comparison between the measured and computed mean water level is performed and shown in Figures 3.28 through 3.31. The direct comparison of mean water level at each station shows clearly that the computed and measured pattern is almost identical but with a noticeable shift in the magnitude. The difference in the magnitude between the measured and computed mean water level is not consistent throughout the year. That is especially clear in Figure 3.31. At approximately July 20, 2000, there was a significant increase in the measured water level (almost one foot). That indicates a compound problem. First, the vertical datum of the gauges should be verified, second, there is an uncertainty associated with residual build up on the sensors, which might explain the sudden changes in the measured water level after cleaning. Accordingly, a recommendation was made to verify the vertical datum of the monitoring stations. A detailed description of the surveying effort is provided in the following section

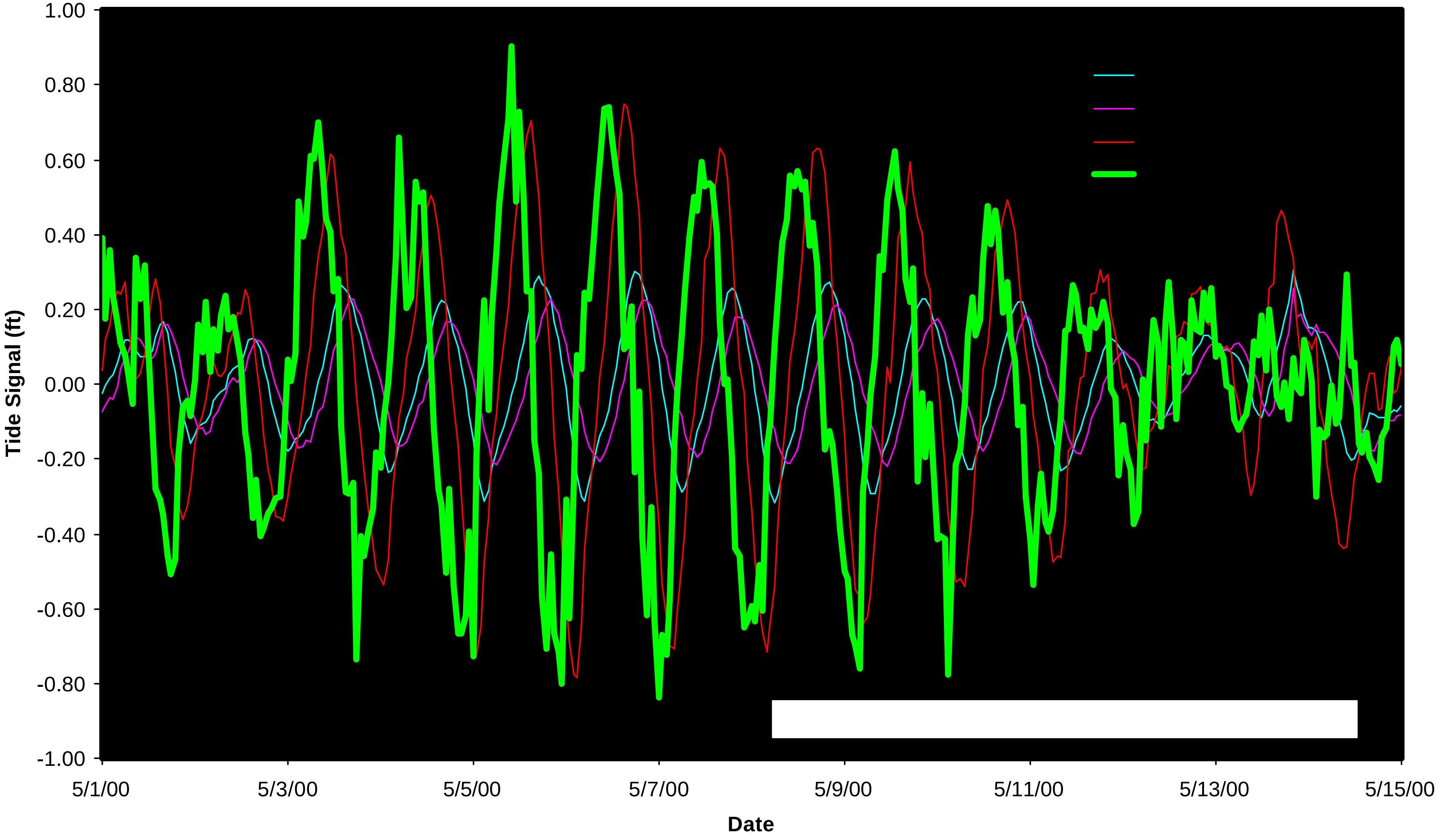

Figure 3.20: Tide Signal at Continuous Recorders (Actual Field Measurements)

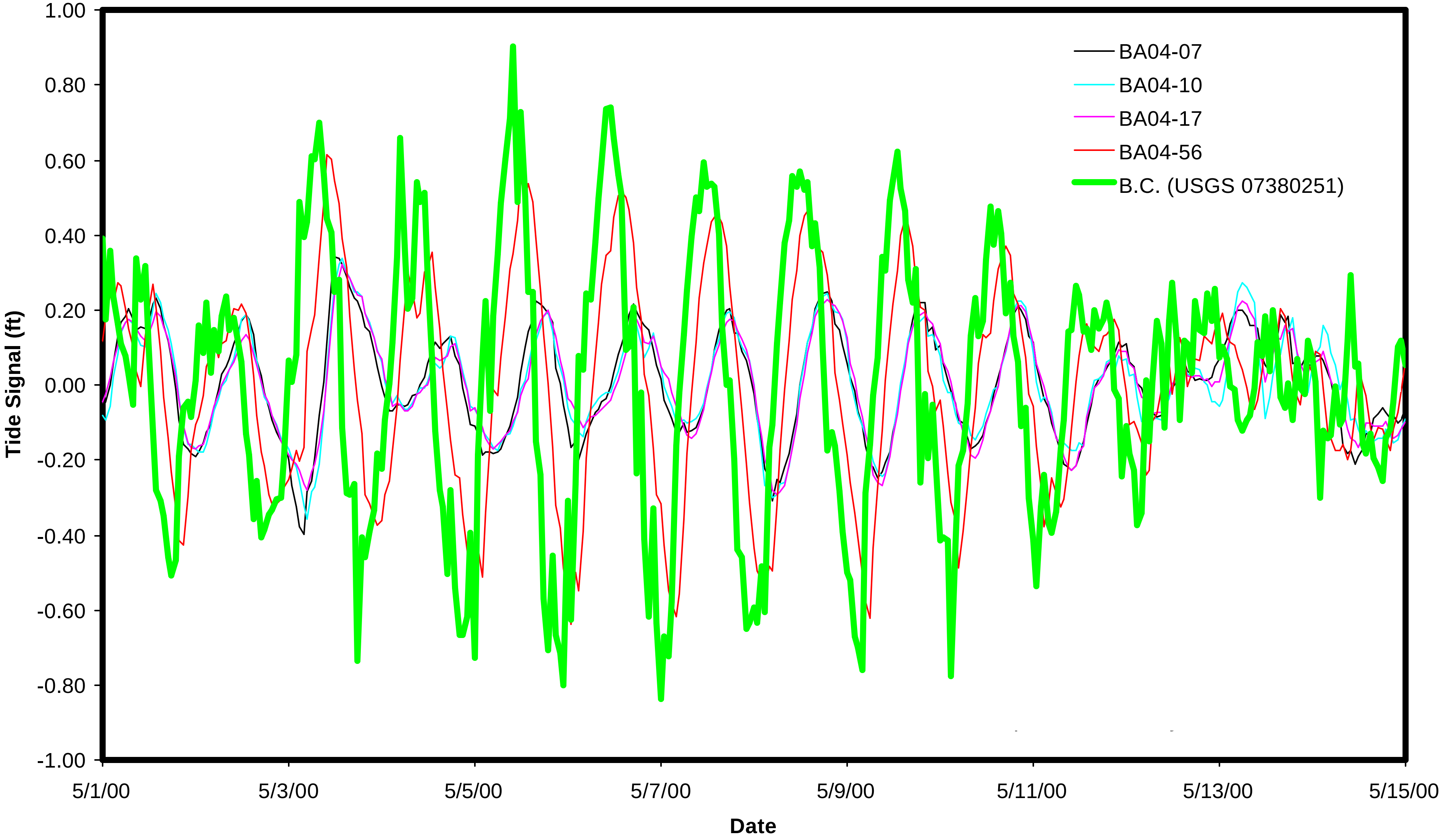

Figure 3.21: Tide Signal at Continuous Recorders (Hourly Model Results)

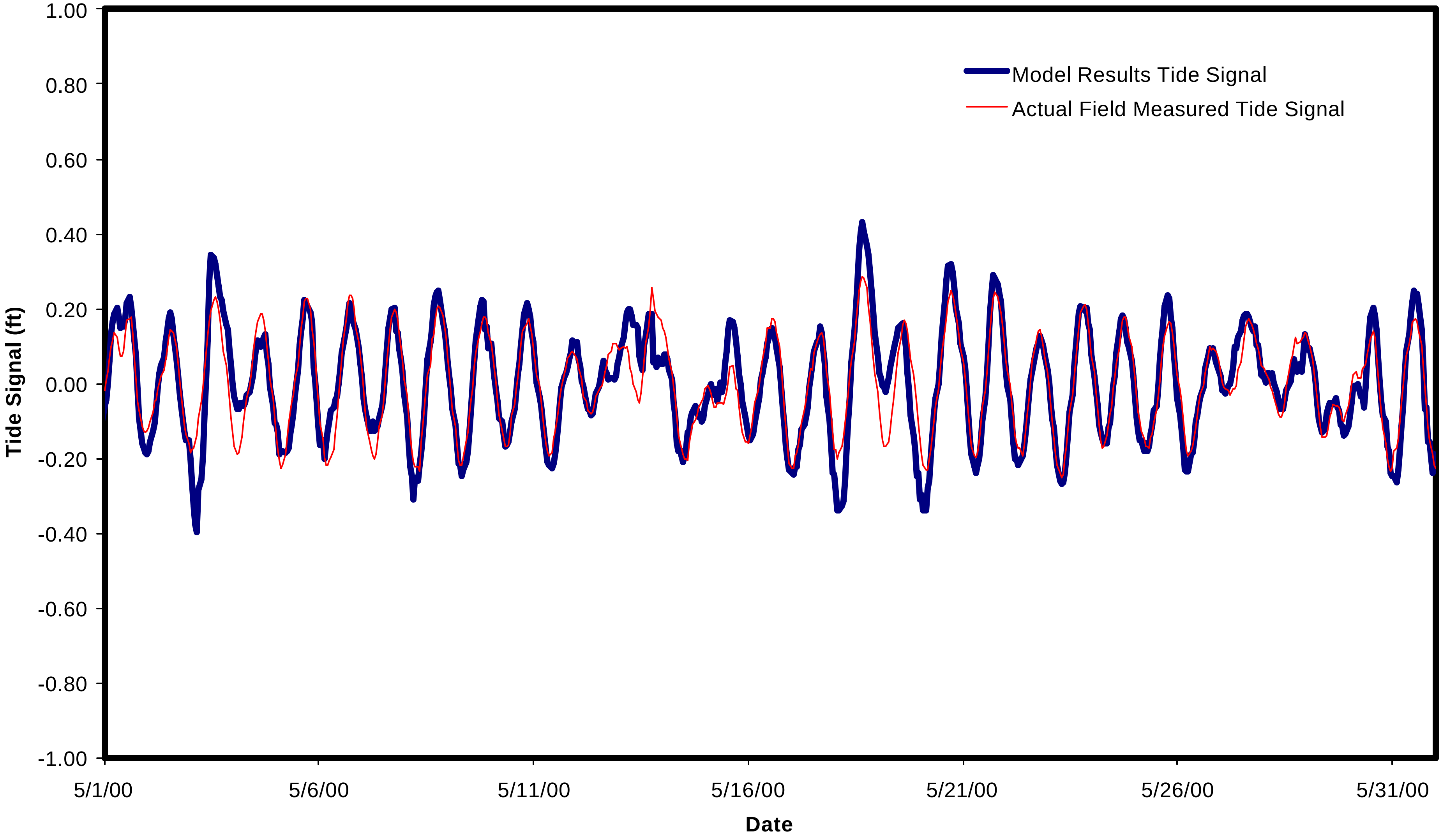

Figure 3.22: BA04-07 Tide Signal- Field Measured Versus Model Results

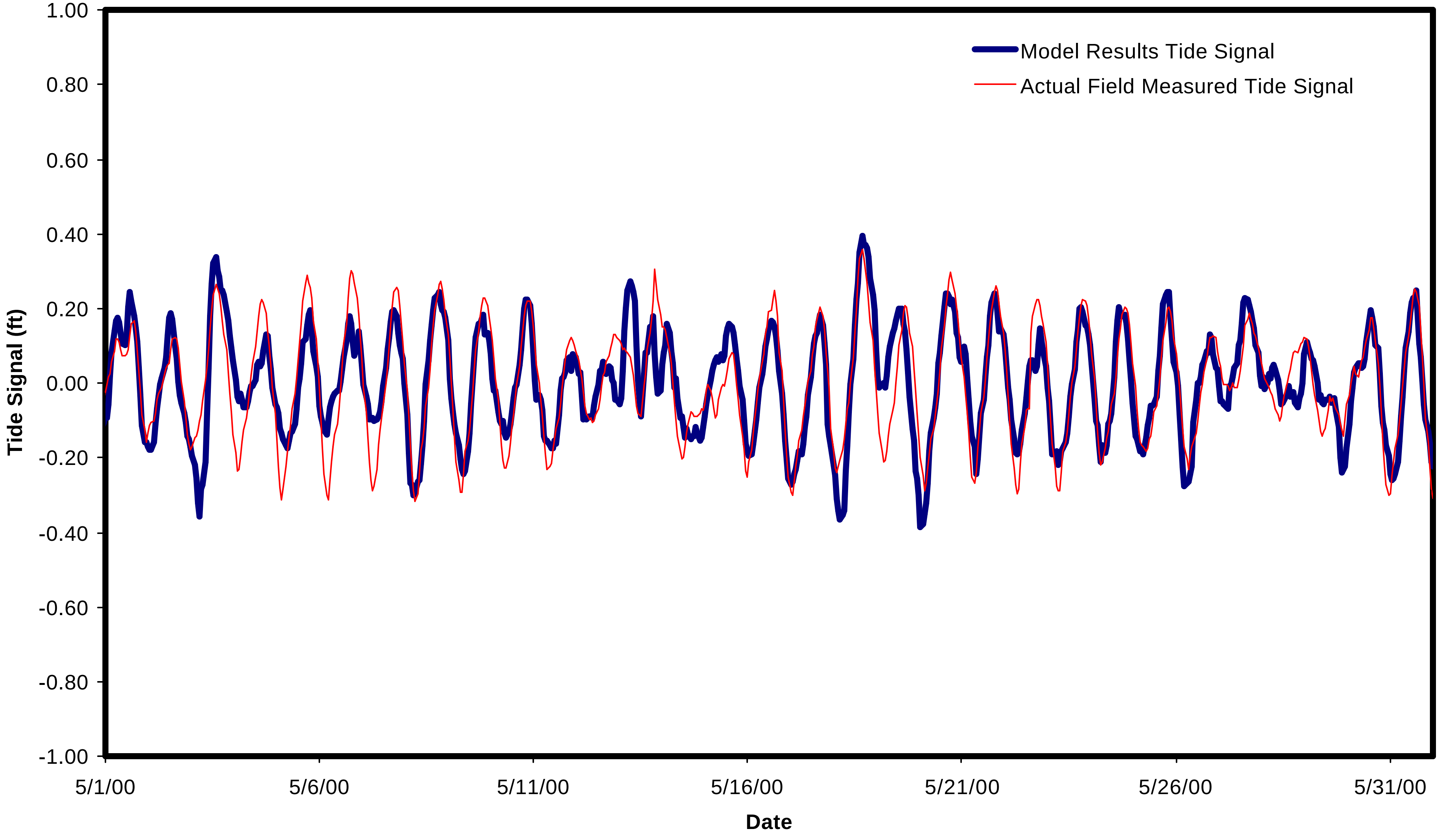

Figure 3.23: BA04-10 Tide Signal- Field Measured Versus Model Results

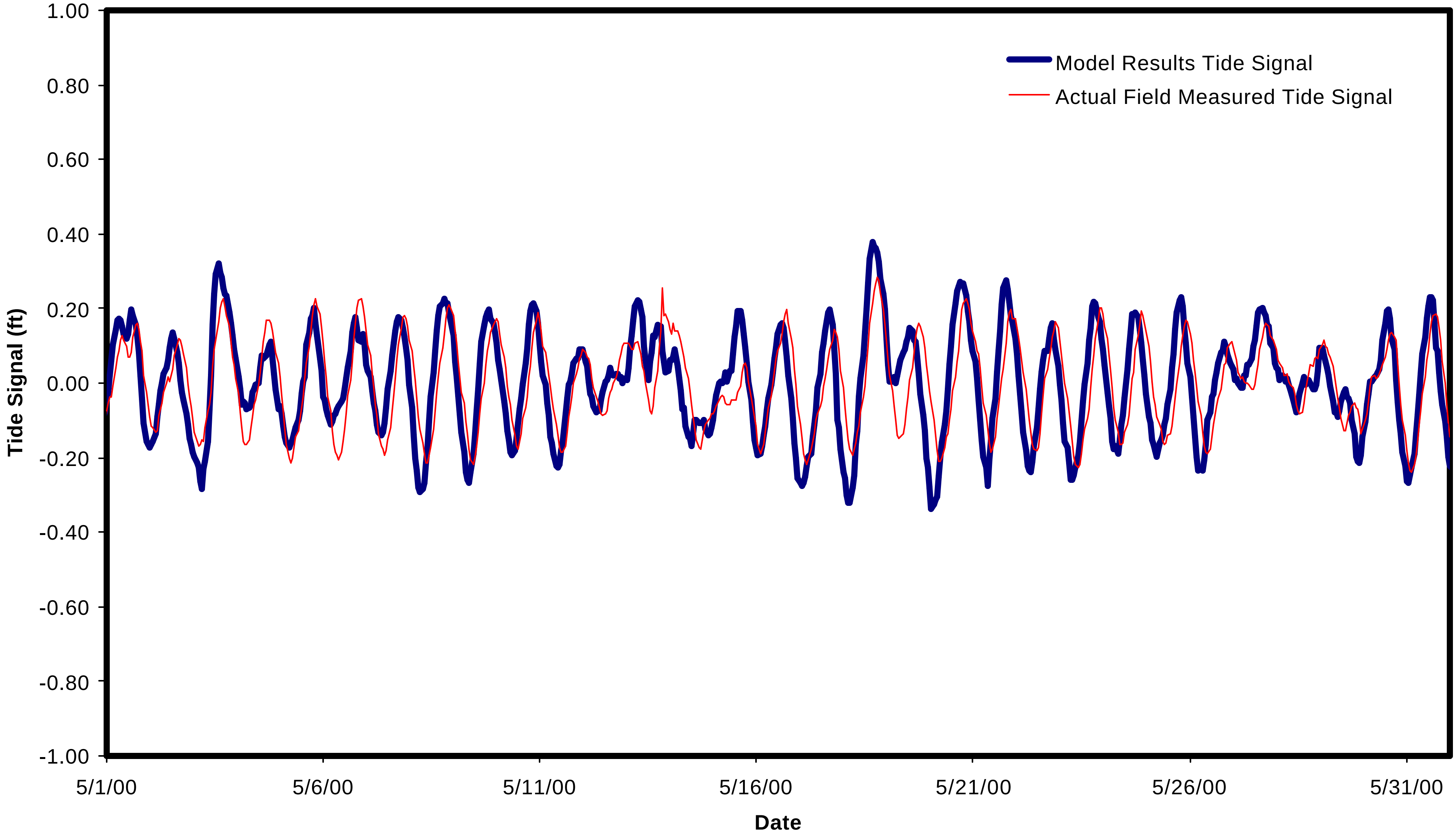

Figure 3.24: BA04-17 Tide Signal- Field Measured Versus Model Results

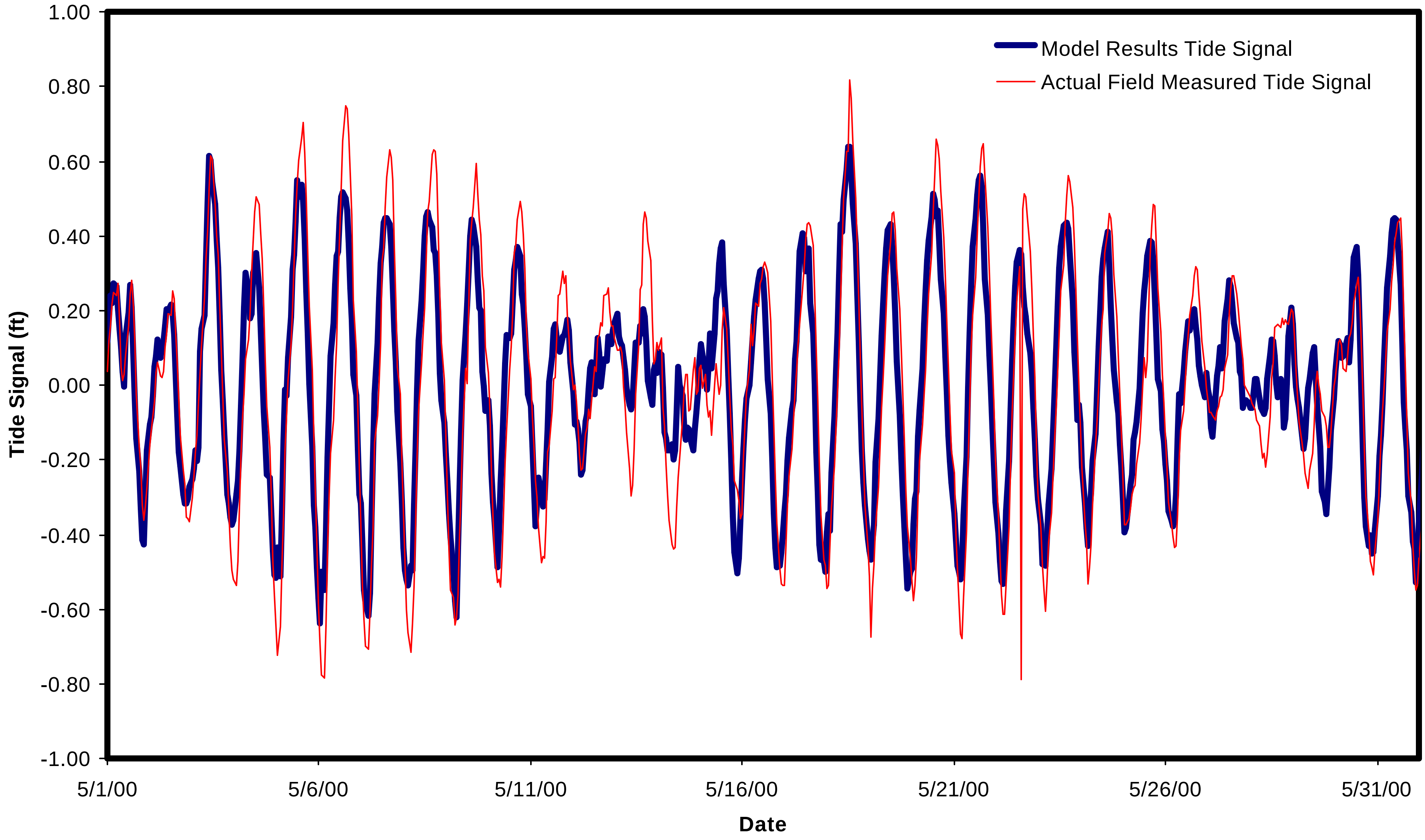

Figure 3.25: BA04-56 Tide Signal- Field Measured Versus Model Results

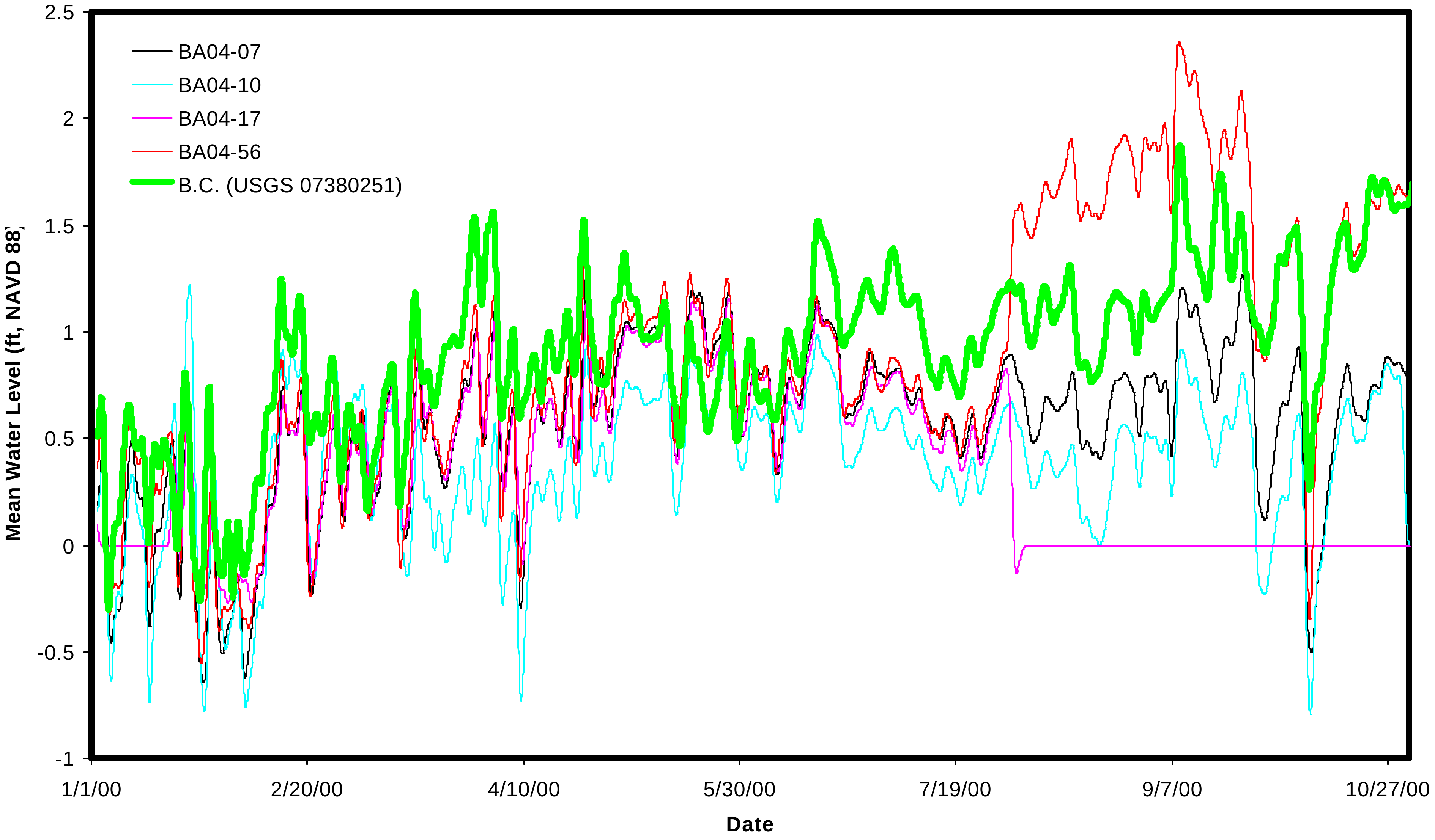

Figure 3.26: Mean Water Level at Continuous Recorders (Actual Field Measurements)

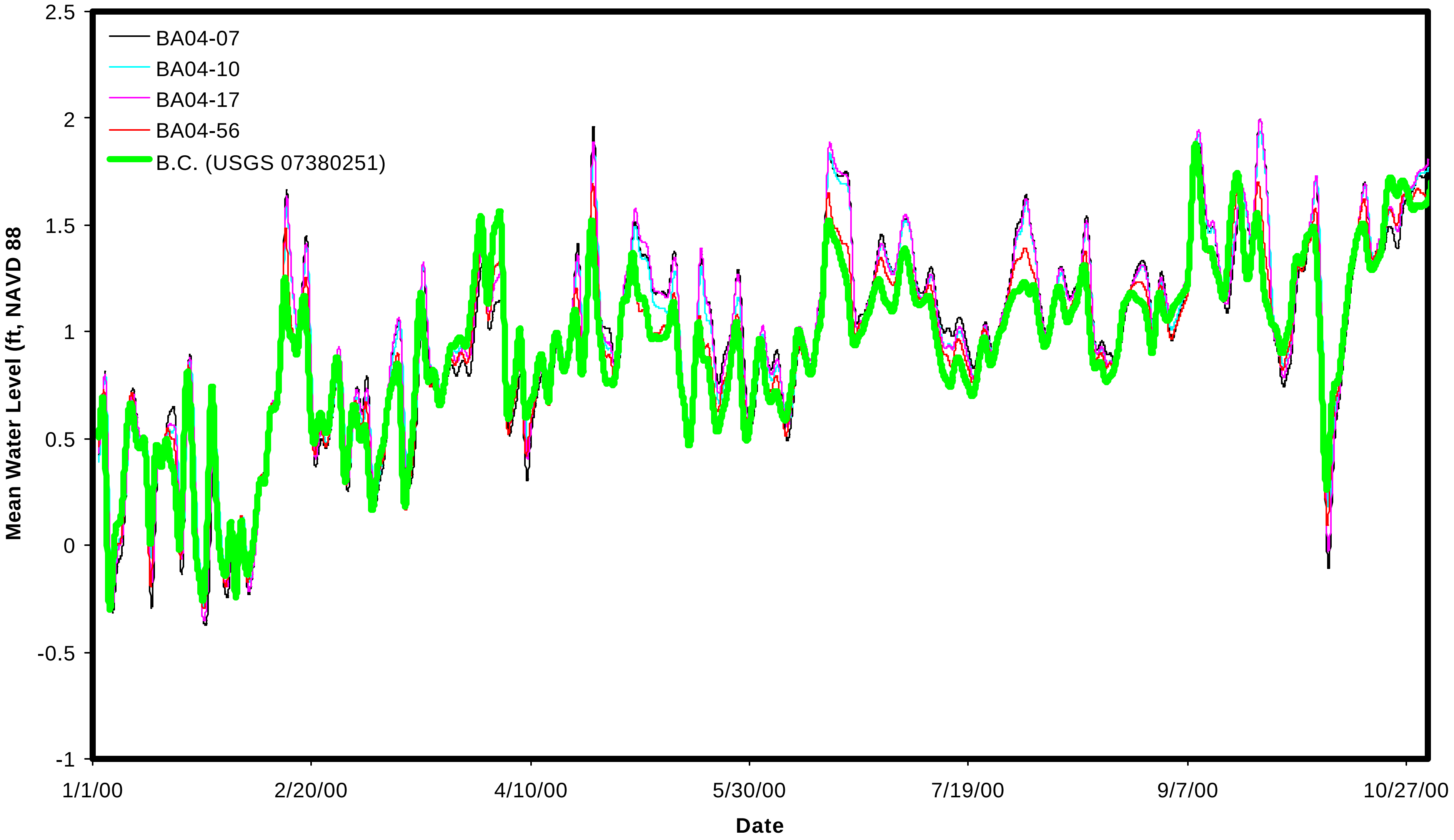

Figure 3.27: Mean Water Level at Continuous Recorders (Model Results)

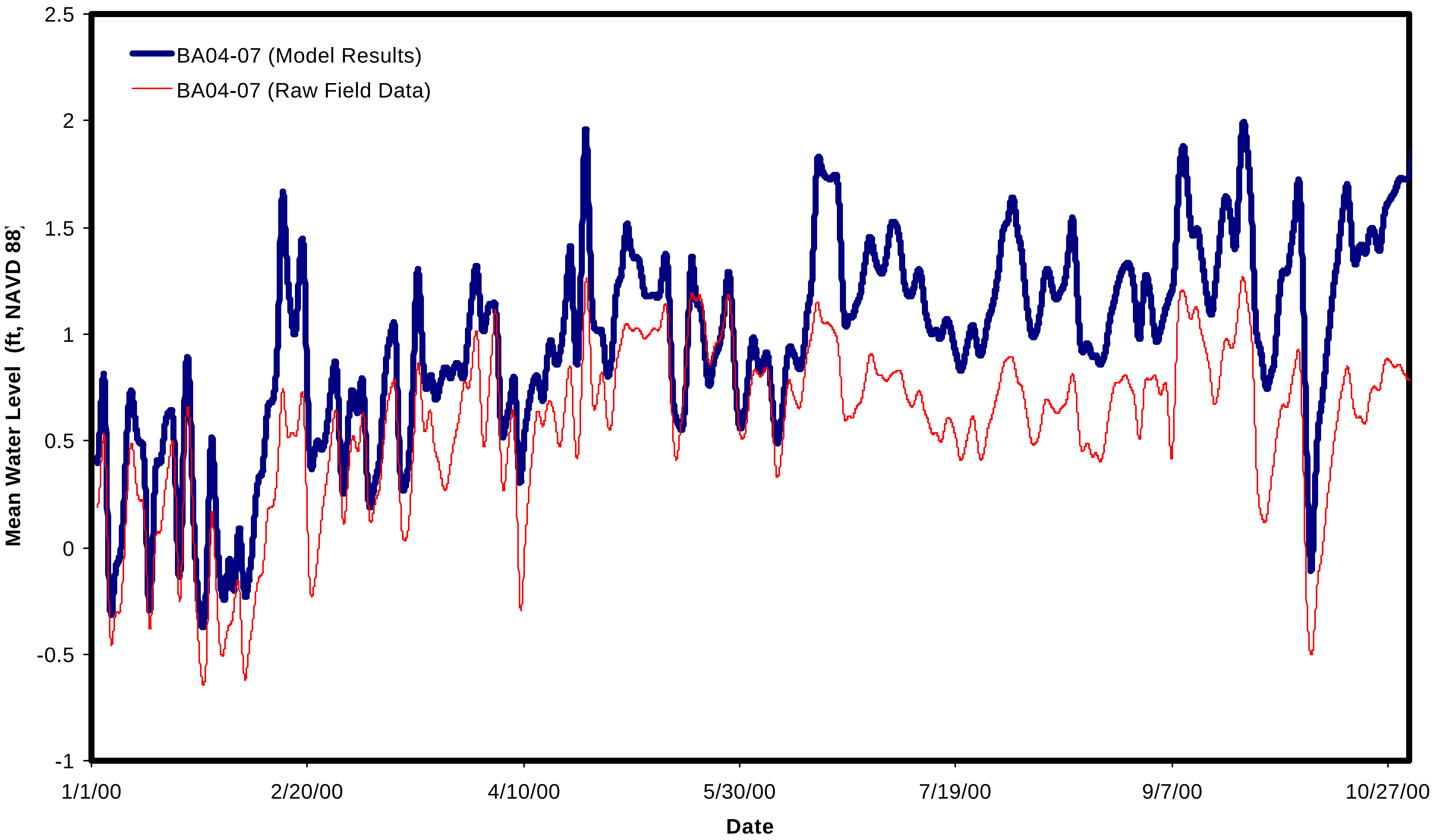

Figure 3.28: BA04-07 Mean Water Level- Field Measured Versus Model Results

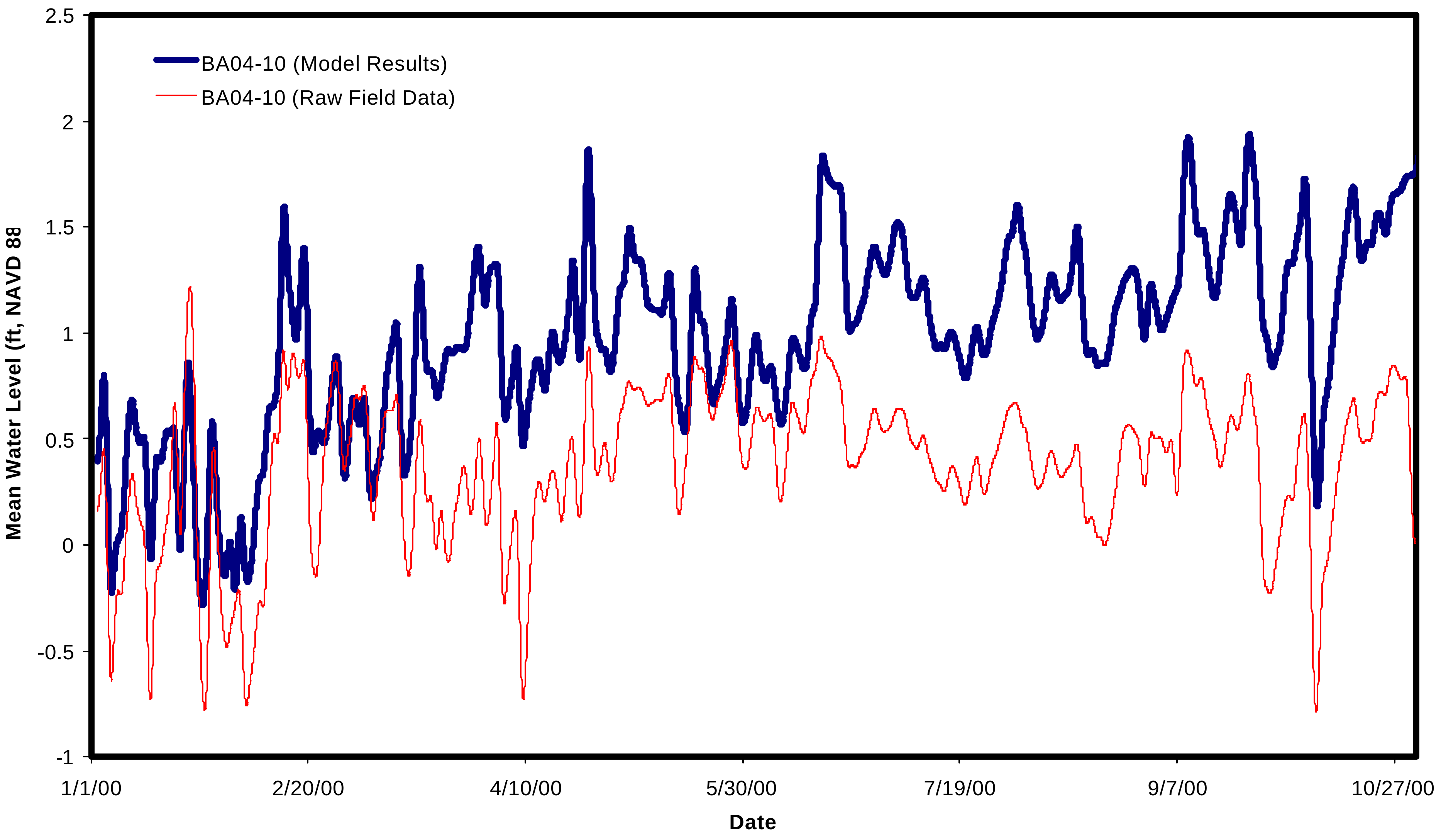

Figure 3.29: BA04-10 Mean Water Level- Field Measured Versus Model Results

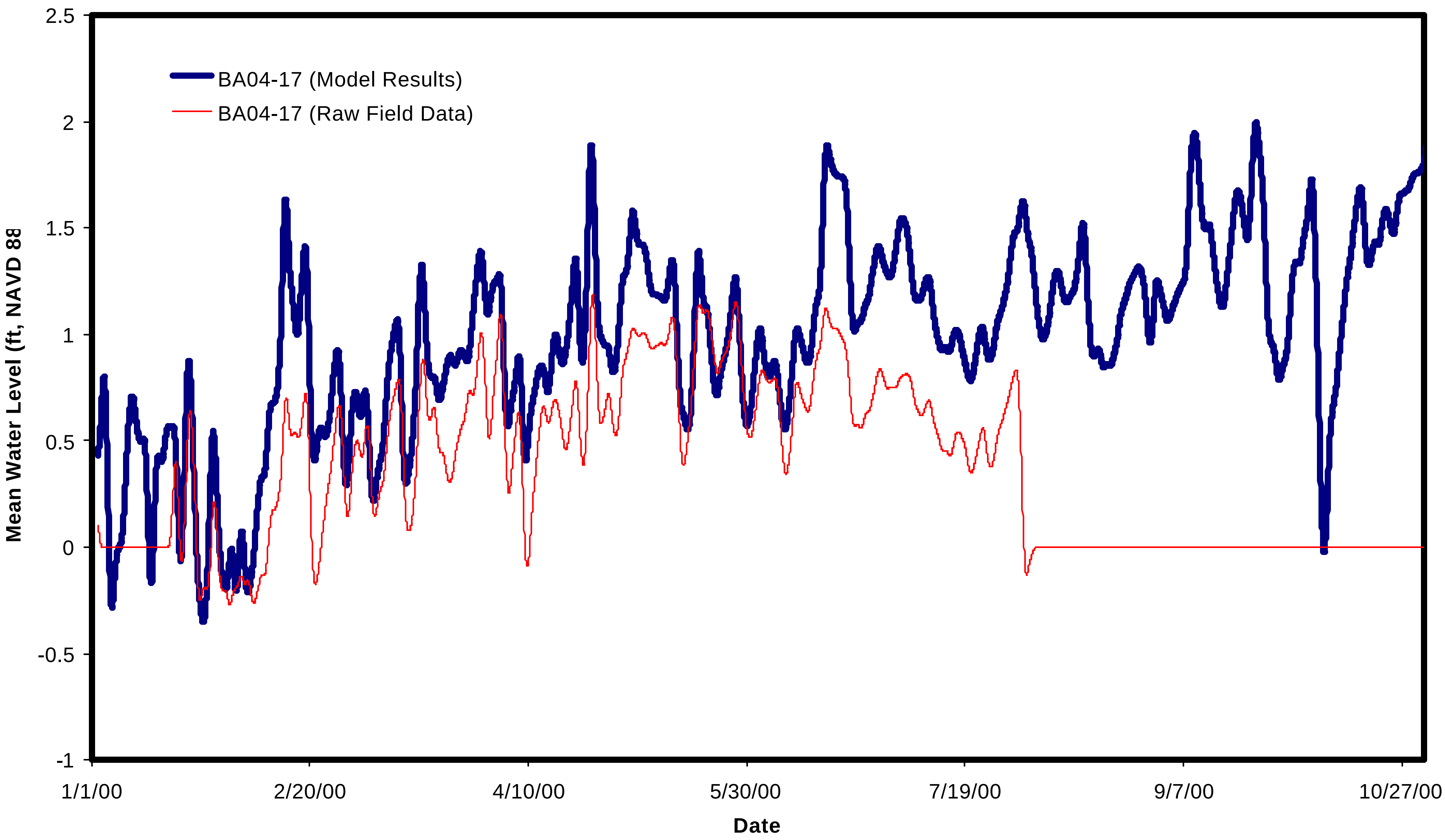

Figure 3.30: BA04-17 Mean Water Level- Field Measured Versus Model Results

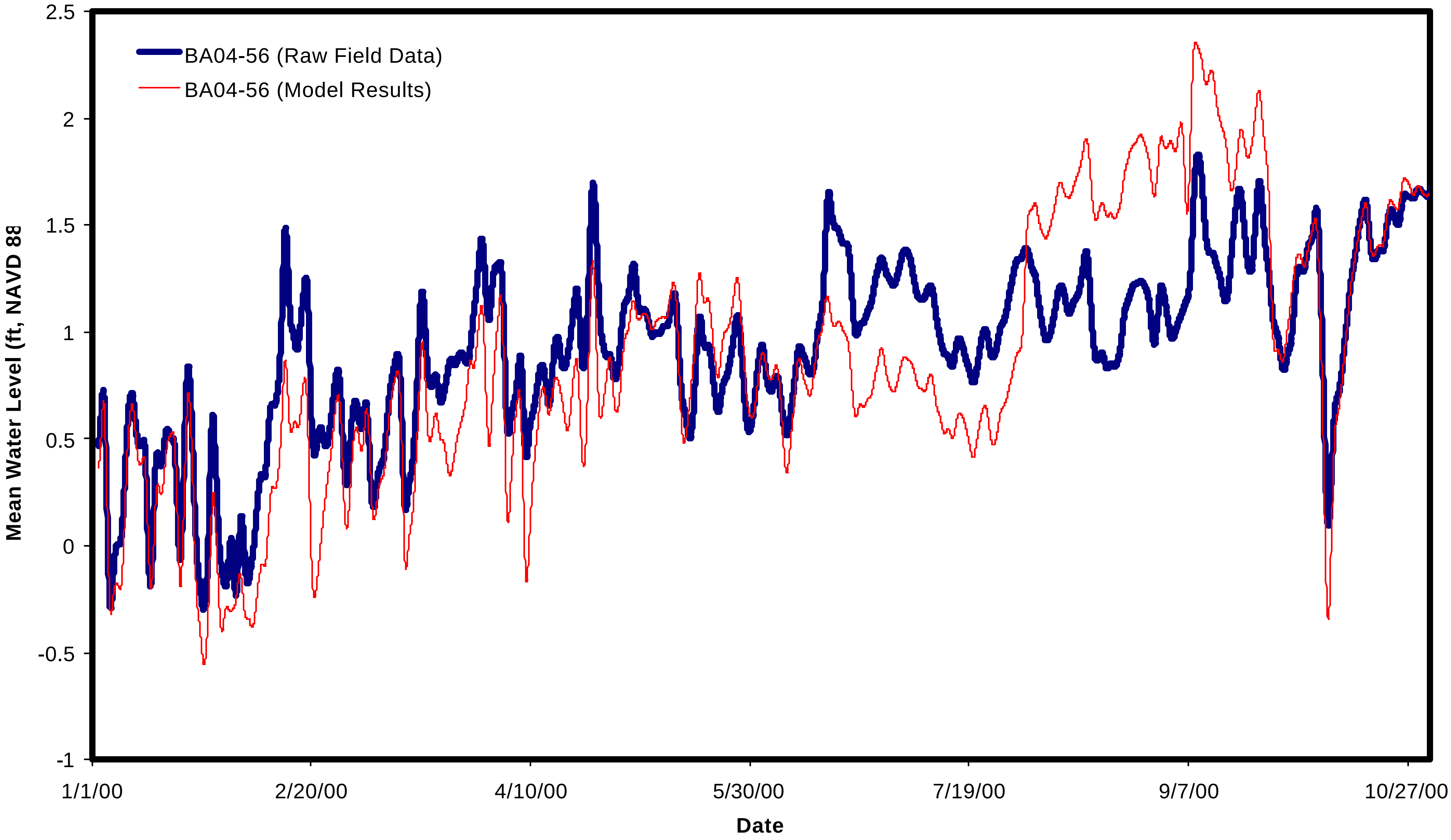

Figure 3.31: BA04-56 Mean Water Level- Field Measured Versus Model Results

3.3.4. SURVEY OF THE MONITORING STATION’S VERTICAL DATUM

Field crews were instructed to install secondary control monuments as per the request of LDNR. The locations of these secondary control monuments are shown on Figure 2.1 (BM-1, BM-2, and BM-3). Each of the three secondary control monuments were surveyed into the primary control network described in Chapter 2 utilizing RTK GPS survey techniques to obtain both horizontal and vertical positioning of the monuments. Utilizing RTK GPS and each of the three secondary control monuments, survey crews began to gather horizontal and vertical positioning of the continuous recorders shown in Table 3.3 on March 8, 2002. Vertical positioning of each continuous recorder was referenced to each recorders datum mark. Table 3.3 below shows the difference between the elevations of the datum marks given by LDNR as compared to those retrieved by CHF. The table also documents the vertical adjustment that was applied to the data sets for each continuous recorder.

Table 3.3

Gauge Name	Elevation of Datum Mark (DNR)	Elevation of Datum Mark (C.H. Fenstermaker)	Adjustment
BA04-07	+3.40’ NAVD 88	+3.59’ NAVD 88	+0.19’
BA04-10	+3.82’ NAVD 88 (Average)	+5.17’ NAVD 88	**
BA04-17	+3.63’ NAVD 88	+3.89’ NAVD 88	+0.26’
BA04-56	+2.69’ NAVD 88	+2.88’ NAVD 88	+0.19’
USGS 07380251	+10.27’ NAVD 88	+10.04’ NAVD 88	-0.23’

** No adjustment was made due to gauge being moved and reset

The adjustments shown in Table 3.3 were applied to all data sets for each of the continuous recorders. By applying these adjustments, modeled water level deviations from the field measurements were reduced. Figure 3.33 shows the calculated mean water levels based on field measurements at all the monitoring gauges after the datum adjustments. It should be noted that adjustments were applied to gauges BA04-07, BA04-17, BA04-56, as well as the USGS gauge. However, it is apparent that gauge BA04-10 was hit[4] by a boat and was relocated, and therefore no adjustments can be applied to data of the year 2000. After the adjustments were applied, the unrealistic variations of water level from one site to another are reduced, but the water level recorded at gauge BA04-10 is showing unrealistically lower water level than the other sites because it could not be adjusted. Moreover, there is no apparent reason for the dramatic increase in water level at gauge BA04-56 after 8/1/2000. Table 3.4 shows the uncertainty statistics after the datum adjustments. As can be seen in the table, the deviation between the model results and the field measurements were significantly reduced at gauges BA04-07 and BA04-17 due to the datum adjustments. It can also be seen that the deviation slightly increased for gauge BA04-56, however, the amount of increase is negligible.

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[4] Information provided to CHF by Mr. Bill Boshart with LDNR

Table 3.4: Uncertainty analysis before and after vertical datum adjustments

Gauge	Water Level Analysis			
	Before Datum Adjustment		After Datum Adjustment	
	Corr. Coeff.	RMS Error	Corr. Coeff.	RMS Error
		%		%
BA04-07	**0.88**	**12**	**0.88**	**6**
BA04-10	**0.74**	**18**	**0.74**	**18**
BA04-17	**0.81**	**13**	**0.81**	**7**
BA04-56	**0.85**	**7**	**0.85**	**9**

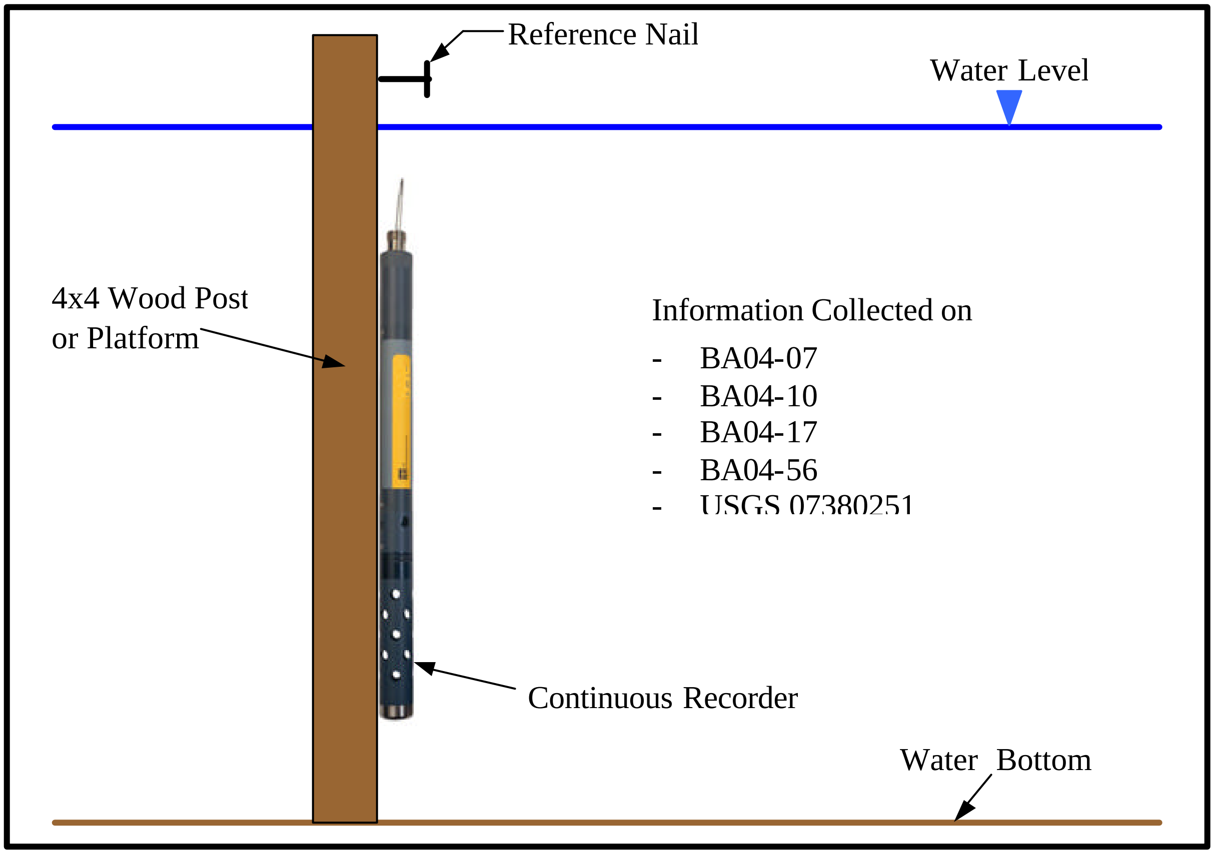

Figure 3.32: Field Survey Requirements for Continuous Recorders

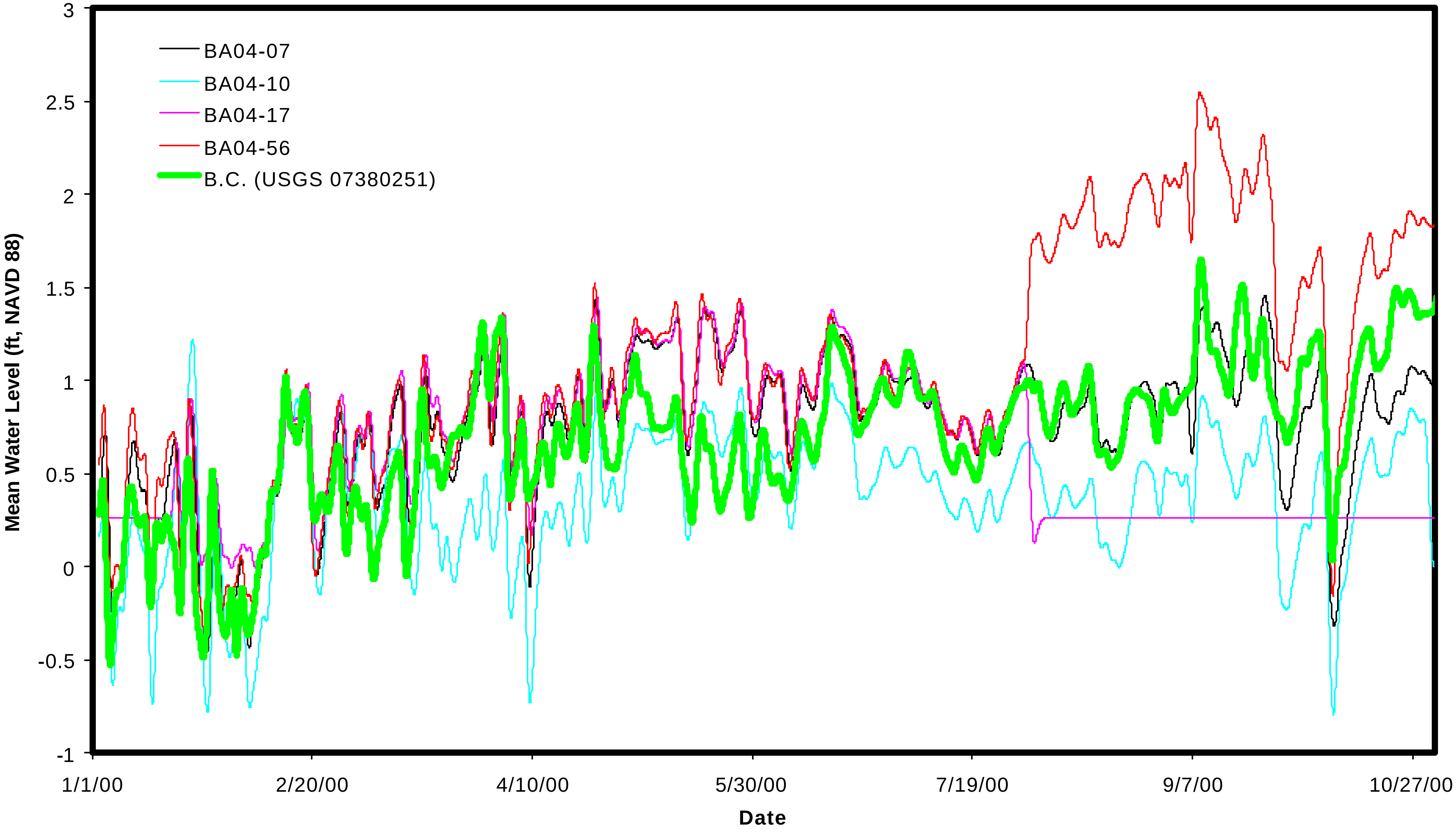

Figure 3.33: Mean Water Level Based on Field Measurements at All Monitoring Stations After Vertical Datum Adjustments.

3.4 DISCUSSION OF THE MODEL CALIBRATION RESULTS

The overall quality of the field measurements during the year 2000 is questionable, and there are several water level and salinity observations during that time period that could not be explained. The overall agreement between the model results and the field data for salinity and water level were reasonable given the uncertainties associated with the field measurements.

The calibration results and the detailed tidal analysis indicate that the resolution of the computational grid and the bathymetric data are adequate to capture the primary hydrological processes and circulation patterns in the project area. The tidal analysis also revealed some questionable water level measurements. Consequently, a recommendation to verify the vertical datum of the monitoring stations was made.

In an attempt to test the model's response to changes in the conditions assigned at the boundaries, the governmental agencies suggested to impose the water level and salinity records from gauge BA04-07 at the southeastern boundary of the project. By implementing this data, there were noticeable changes in the water level and salinity patterns within the project area, however, the deviation between the model results and the field data increased. It was noticed that there was a significant lag and attenuation in the water level and salinity information between the southeastern boundary of the project and gauge BA04-07. Accordingly, by imposing data from gauge BA04-07 at the southeastern boundary without taking such lag and attenuation into account caused significant deviations between the model results and the field measurements. Therefore, it is concluded that the original boundary conditions used are the most suitable data available.

Since the uncertainties in the salinity, water level, and siphon discharge measurements could not be explained or resolved, it was strongly recommended to verify the model performance against the measurements of a second and independent time period. The field data collected from July 2001 to June 2002 is of high quality and can be used to adequately assess the performance of the numerical model. Therefore, a decision was made to use the July 2001 to June 2002 to validate the numerical model. The results of this time frame are presented in the following chapter.

IV. CHAPTER FOUR

4.1 INITIAL ASSESSMENT OF PROJECT FEATURES

To provide an assessment of the project features, the following simulations were performed for the duration of January 2000 to December 2000:

?? Run 1 - Without Project without Siphon: The objective of this simulation is to provide a base-run to which the following three simulations can be compared. It provides a benchmark such that a clear assessment of effectiveness of the siphon and the project features. For this run the following boundary conditions were used:
  ✍ Water level and salinity measurements at USGS Gauge #07380251
  ✍ Zero siphon discharge throughout the year
  ✍ Wind measurements at the USGS Gauge #07380251
  ✍ No project features incorporated

?? Run 2 - Without Project with Siphon: The objective of this simulation is to assess the impact of the siphon on the hydrodynamics and salinity of the system. For this run the following boundary conditions were used:
  ✍ Water level and salinity measurements at USGS Gauge #07380251
  ✍ Siphon discharge was set to 1,000 cfs for the first six months of the year, and then shut down for the remaining six months
  ✍ Wind measurements at the USGS Gauge #07380251
  ✍ No project features incorporated

?? Run 3 - With Project without Siphon: The objective of this simulation is to assess the impact of the project features (in the absence of the siphon) on the hydrodynamics and salinity of the system. For this run the following boundary conditions were used:
  ✍ Water level and salinity measurements at USGS Gauge #07380251
  ✍ Zero siphon discharge throughout the year
  ✍ Wind measurements at the USGS Gauge #07380251
  ✍ All project features incorporated

?? Run 4 - With Project with Siphon: The objective of this simulation is to assess the combined impact of the project features and the siphon on the hydrodynamics and salinity of the system. For this run the following boundary conditions were used:
  ✍ Water level and salinity measurements at USGS Gauge #07380251
  ✍ Siphon discharge was set to 1,000 cfs for the first six months of the year, and then shut down for the remaining six months

✍ Wind measurements at the USGS Gauge #07380251
✍ All project features incorporated

It should be noted that the following conditions were used in the four simulations described above:

?? The bank lines of Bayou Grand Chenier were set at elevation +2.5 ft NAVD88.
?? The dimensions of the structures were based on the original design as described in Chapter One

Figures 4.1 through 4.8 show a comparison between the results of Run 1 and Run 2. In essence, comparing these two simulations provides an assessment of the impact of the siphon on the project area in the absence of the project features. From these figures, two observations can be made. First, there is a significant reduction (in the order of 5 to 10 p.p.t.) in the salinity within the project area when the siphon is operational. Second, the water level increase due to the added fresh water to the project area is negligible (less than 0.10 feet).

To evaluate the effectiveness of the project features, two comparisons are needed. The first run (base run) will be compared to Run No.3, which allowed for an evaluation of the project features in the absence of the siphon. Then a comparison between Run No. 2 and Run No. 4 was made to evaluate the project features with the siphon operational.

A comparison between Run No. 1 and Run No. 3 can be seen in figures 4.9 through 4.16. The following observations can be made. If the salinity inside the project area is high, it takes a slightly longer time to flush out the system when the project features are in existence. It also shows that the project features slow down the salinity intrusion from Barataria Bay. Moreover, the project features reduce the tidal signal within the project area, i.e. the peaks and troughs of the tide are reduced by approximately a tenth of a foot.

Comparisons between Run No. 2 and Run No. 4 are shown in figures 4.17 through 4.24. From these figures it is clear that the project was beneficial throughout the year. While the siphon helps to flush the interior of the project area, the project features reduce the salinity intrusion. However, it should be noted that generally speaking and based on the comparisons provided above, the benefits from the project features are limited. The causes that limit the benefits of the project features include openings to the project area that remain unmanaged, and the opening of weir structures A, B, and C that allow for free exchange of water and salinity.

Finally, to evaluate the combined effect of having the siphon and the project features at the same time, Run No. 1 (base run) is compared to Run No. 4. Figures 4.25 through 4.32 show the comparisons between the two runs. It is very clear that the siphon and the project features reduce salinities in the project area. However, it is evident from the previous comparisons that the salinity reductions are primarily a result of the fresh water introduction through the siphon, while the "preservations" of the lower salinity levels is a combined result of the siphon and the project features. It is also observed in the figures, that impoundment is in the order of 0.1 feet due to either the siphon or the project features. In fact, the project features cause a slight reduction in the peaks and troughs of the tidal signal.

Per the request of NRCS and LDNR, a simulation where the project area is completely encompassed within an artificially high levee has been performed. The purpose and objective of this simulation is to test the response of the numerical model to such an extreme action. The numerical model results for this simulation, as physically anticipated, showed the interior of the project as a static pool of water with neither tidal nor salinity fluctuations. The exercise provided additional evidence of reliability and confidence to the agencies.

After this preliminary assessment of the project features, it was recommended to perform additional simulations for a second data set. It was also recommended to consider revising the design of the project features. The following section presents the details of the additional simulations used to provide a final assessment of the project features.

4.2. FURTHER ASSESSMENT OF PROJECT FEATURES

An independent data set for the time period of July 2001 to June 2002 was used to further validate the model, and to assess the effectiveness of the project features. During this time period, the siphon was operational and delivering a fairly significant amount of fresh water since it has been rehabilitated. Therefore, the July 2001 to June 2002 time period provides an assessment of the project features under actual operation conditions of the siphon.

Two simulations were performed for this time period, namely with and without project conditions. The following configurations were also used for these two simulations:

- The surveyed data for banklines of Bayou Grand Chenier were incorporated into the bathymetry data used in the model instead of the fixed +2.5’ (NAVD88) elevation that was used in earlier simulations of year 2000.
- The actual measured siphon discharge was used as the fresh water input to the model instead of a designed discharge as used in the year 2000 simulations.
- The dimensions for the structures were revised as described in Chapter One.

4.2.1. ANALYSIS OF FIELD DATA FOR JULY 2001 TO JUNE 2002

Prior to discussing the model results for this time period, an evaluation of the quality of the field data is presented. Figures 4.33 and 4.34 show the measured salinity and water level at all the calibration gauges, respectively. Figure 4.33 also includes actual discharge measurements from the siphon.

The salinity measurements appear to be of good quality. There is a strong correlation between the salinity measurements at all the gauges. There is also a strong negative-correlation between the salinity-level at all the gauges and the siphon discharge. Figure 4.34 on the other hand, shows somewhat less quality for the water level measurements. In particular, the measurements at Gauge BA04-10 are questionable (as pointed out by the arrows in the figure). The measurements at Gauge BA04-07 also showed some questionable readings as pointed out by the arrows in the figure. These questionable readings should be kept in mind while these measurements are compared to the model results later in this section.

Figure 4.35 shows the water level measurements at all the calibration gauges and at the USGS station as well. It also shows the longitudinal profile of the interior bank of Bayou Grand Chenier. The purpose of this figure is to show the frequency of the interior bank being overtopped by the tidal cycle. A statistical analysis has been performed to quantify the frequency with which the interior bank is overtopped. The frequency of water level exceeding the average elevation of the interior bank line (+1.07 NAVD88) was calculated. The analysis showed that the water level exceeded the average elevation of the interior bank line nearly 50% of the time.

4.2.2. MODEL VALIDATION FOR JULY 2001 TO JUNE 2002

The model results for this time period are compared to the field measurements. It should be noted that there were no further adjustments to any of the model calibration parameters. Therefore, the comparison provided below serves as a further validation for the numerical model.

Figures 4.36 through 4.39 show a comparison between the model results versus field measurements for salinity, while figures 4.40 through 4.43 show the comparison between the model results versus measurements for water level. The figures show that the model reproduces the overall trend of salinity and water level as observed in the field. It appears that the model smoothes out some of the high-frequency salinity fluctuations.

For a more quantitative assessment of the model performance, an uncertainty analysis has been performed and summarized in Tables 4.1 and 4.2. The table shows that the deviations between the model results and the field measurements are within an acceptable range.

Table 4.1: Statistical Analysis of Model Results (Salinity)

Gauge No.	B (PPT) (BIAS)	FOEX (%) (FACTOR OF EXCEEDANCE)	NMSE (%) (NORMALISED MEAN SQUARE ERROR)	RMS (%) (ROOT MEAN SQUARE)
BA04-56	-0.11	0	3.7	13
BA04-17	0.36	3	14.7	14
BA04-10	-1.87	16	11.7	15
BA04-07	-0.47	22	32	21

$$B ? \frac{1}{N} ?_{i} (P_i ? M_i)$$

$$RMS \text{ Deviation } ? \frac{1}{N} ?_{1}^{N} \frac{\sqrt{?\text{computed - observed}?^2}}{Measured\ Range}$$

$$FOEX ? ? \frac{N(P_i ? M_i)}{N} ? 0.5 ? ? 100$$

$$NMSE ? \frac{1}{N} ?_{i} \frac{?P_i ? M_i?^2}{\overline{P}\,\overline{M}}$$

Table 4.2: Statistical Analysis of Model Results (Water Level)

Gauge No.	B (feet) (BIAS)	FOEX (%) (FACTOR OF EXCEEDANCE)	NMSE (%) (NORMALISED MEAN SQUARE ERROR)	RMS (%) (ROOT MEAN SQUARE)
BA04-56	0.17	24	N/A	5
BA04-17	0.20	31	N/A	7
BA04-10	0.1	15	N/A	7
BA04-07	0.10	13	N/A	6

4.2.3. **FINAL ASSESSMENT OF PROJECT FEATURES**

Another simulation with the project features in place for the time period July 2001 to June 2002 was performed. It should be reiterated that the revised design of the project features were used in this simulation. Figures 4.44 through 4.47 show the model salinity results for with and without project features, while figures 4.48 through 4.51 show the model water level results for with and without project features.

Figures 4.44 through 4.47 show that the project features reduce the salinity within the project area by about one to two parts per thousand. It seems that the benefits of the project features were actually reduced even further when the elevation of the banklines of Bayou Grand Chenier were set to the actual surveyed elevations (which is lower than the uniform elevation of +2.5' NAVD88 used in the year 2000 simulations). The lower bank elevations allowed for free exchange of water between the interior and exterior of the project area, and in a way neutralized the potential benefits that would have been gained through narrowing the structures openings.

It can also be observed in the figures that there is no noticeable impoundment of water as a result of the project features. The opening of the weir structures A, B, and C, the unmanaged openings, and the relatively low-elevations of banklines of Bayou Grand Chenier allow for exchange of water between the interior and the exterior of the project area. Therefore, the lack of water impoundment inside the project area was expected.

To further provide additional evaluations of the impact of the project features on the hydrology of the site, plan-view spatial maps of water level and salinity were produced and stored in an animated format. These animations are provided in a Compact Disc attached to this report. A more detailed discussion of these maps is provided in the following section.

4.2.4. SALINITY AND WATER LEVEL ANIMATION ANALYSIS

As indicated above, the plan-view maps of water level and salinity are intended to provide a different approach of evaluating the impact of the project features on the hydrodynamic and salinity patterns within the site.

One assumption made in all analyses, is that the four locations at Gauges BA04-07, BA04-10, BA04-17, and BA04-56, are fully representative of the entire project area. Producing and analyzing plan-view maps is one of the formal approaches that proves or disproves that the aforementioned assumption is valid.

Two sets of water level and salinity maps were produced. The two sets were stored in an animated form; where one set showed a snap shot of water levels or salinities every four hours, while the other set showed the snap shots every hour. The four-hour increment animations were produced for the time period of November 2001 to April 2002. The one-hour increment animations were produced for two time periods, namely March 4, 2002 to March 15, 2002, and October 14, 2001 to October 25, 2001. These time periods were selected since the siphon was operational with a discharge of approximately 1000 c.f.s. during the March 2002 time period, and was off during the October 2001 time period. Therefore, the animated hourly maps would provide a clear visual assessment of the impact of the project features on the water level and salinity of the project site.

Furthermore, since the animations were produced for “with” and “without” project features in-place, a third set of animations was produced showing the difference in salinity between the “with” and “without” project features simulations. This later set of animations facilitates analyzing the salinity reduction/increase due to the project features everywhere within and in the vicinity of the project area rather than at only four selected locations.

The animations showed project benefits in terms of salinity reduction of approximately two parts per thousand especially when the siphon is off. When the siphon is operational the benefits of the project features are smaller. The siphon reduces the salinity levels within the project area by approximately 5 to 10 PPT leaving little room for additional benefits by the project features. The animations also show that there are no detrimental impacts by the project features regarding either salinity or water level. In other words, there were no increases in salinity or water impoundment caused by the project features. The animations will be provided on a Compact Disk with the final version of the report.

4.2.5. MONTHLY-AVERAGE SALINITY MAPS

Monthly average salinities for the existing conditions and “with project” were computed for the period August 2001 to July 2002. The difference between the monthly average salinities of the existing conditions and “with project” were also computed. The salinity change at each computation point in the model domain for each month was defined as follows

Salinity Change = Monthly average salinity “with project” – Monthly average salinity “existing”

If the mathematical sign of the change is “negative”, that would indicate a reduction in salinity due to the project features, which is a beneficial impact (and vice versa). Twelve monthly-average salinity maps are attached in the appendix. The following remarks can be made:

?? August 2001: During this month, the project features resulted in a reduction of 1 PPT in the western portion of the project area and in certain areas of Bayou Grand Chenier. There was no change in the salinity magnitude for the remainder of the model domain.

?? September 2001: There was slight reduction in salinities in a small area in the western side of the project area. There was no noticeable change elsewhere.

?? October 2001: There was a clear reduction in salinities with 1 PPT in the western and central portion of the project area, and a reduction of 0.5 PPT in the remainder of the project area. There was no change outside the project area.

?? November 2001: Similar to October 2001, there was clear reduction in salinities of 1 PPT. There was also an increase of salinity of less than 1 PPT immediately south of Structure D.

?? December 2001: There was no change in salinities for most of the model domain. There were some areas experiencing reduction in salinities in areas south, south east and west of Bayou Grant Chenier. There were no detrimental impacts (salinity increase) from the project features anywhere in the model domain.

?? January 2002: There was no change in salinity in most of the model domain. There were three areas of increase in salinity due to the project features. These areas experienced an increase of 1 PPT. This may be attributed to the structures reducing the passage of the siphon freshwater from certain routes. That led to reduction in flushing out the high salinities in those waterways. That increase, however, dissipated in the following months.

?? February 2002 and March 2002: There was virtually no change in the monthly average salinities anywhere in the model domain.

?? April 2002: There was a reduction in salinities in large areas north and south of Bayou Grand Chenier. There was no change in salinities (except in very small areas that experienced slight increase in salinities) in the remainder of the model domain.

?? May 2002 through July 2002: There was also reduction in salinities seen in the northern portion of the model domain, and no change elsewhere.

4.3. CONCLUSIONS AND CLOSING REMARKS

The effort presented in this study is aimed to evaluate the performance of the proposed hydraulic structures for the West Point a La Hache Freshwater Introduction Project. The proposed structures include earthen plugs and rock weirs. The intent of these structures is to provide protection to the interior of the project area from excessive tidal action and high salinity events from Barataria Bay. The freshwater is currently introduced to the project site through a siphon structure composed of eight 78” diameter pipes with a nominal maximum discharge of 2,144 cubic feet per second.

A three-dimensional (H3D) computer model was used to perform the evaluation of the effectiveness of the structures mentioned above. The model provides information about the water level, salinity, and flow velocities through the project area. This model was used in other coastal applications and has proven to be an efficient and accurate tool to assess management strategies and restoration plans. The model grid has a resolution of 50 meters (approx. 164 feet) in each of the horizontal directions, while the vertical direction resolution was variable.

The model was initially calibrated and validated for field data collected for the year 2000. To minimize the assumptions made in this study, a detailed survey of the Bayou Grand Chenier banklines was performed. There were significant uncertainties and unexplained observations in the salinities, water level, and siphon discharge of the field data of year 2000. During this year, it should also be mentioned that this area of the state was experiencing a drought period. Therefore, in order to properly assess the model's performance and its ability to mimic the field conditions, an additional model validation for the years of 2001 and 2002 was performed. The field data of July 2001 to June 2002 were of high quality and were adequate to use to validate the numerical model.

The overall conclusion of this study is that the benefits of the siphon are clear in terms of reducing the salinities in the project area in the magnitudes of 5 to 10 p.p.t. The conceptual project features resulted in additional 1 p.p.t. of benefits. Moreover, the siphon and the conceptual hydraulic structures did not cause water impoundments in excess of 0.1 – 0.2 feet.

The analysis presented in this report did not include any biological nor ecological benefits resulting from the project features. Therefore, no comments can be made in that regard.

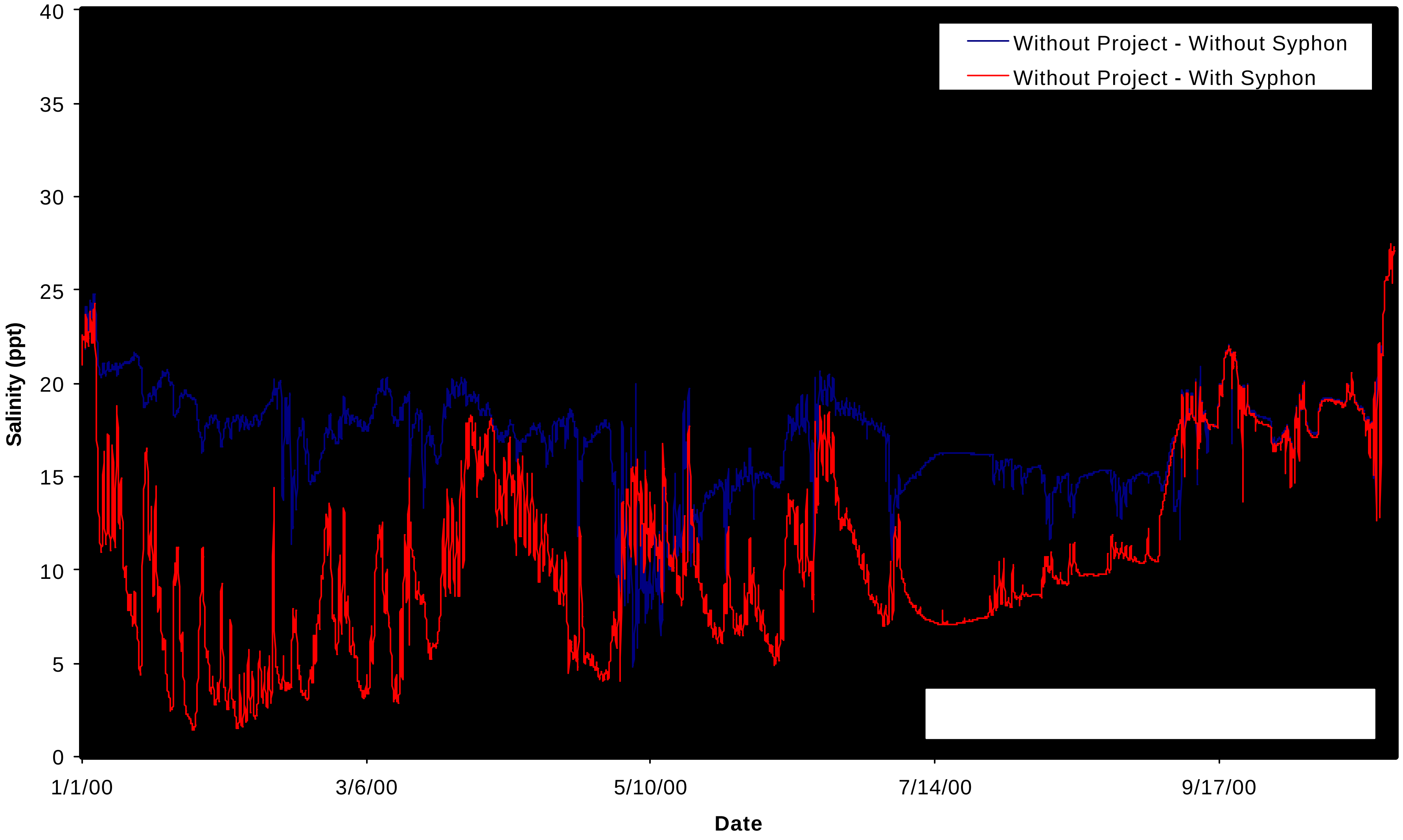

Figure 4.1: BA04-07 Salinity Variations for Run 1 Versus Run 2

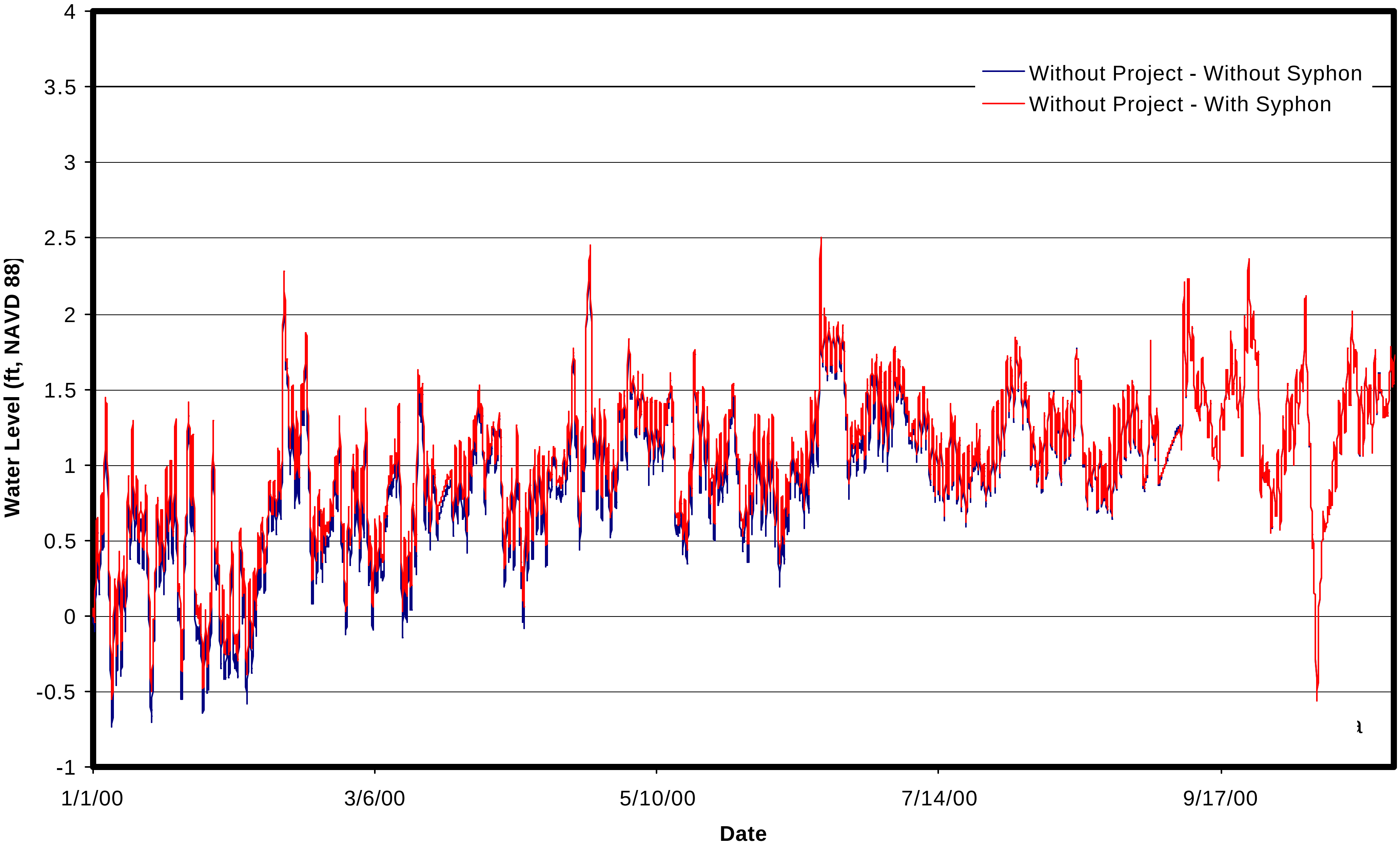

Figure 4.2: BA04-07 Water Level Variations for Run 1 Versus Run 2

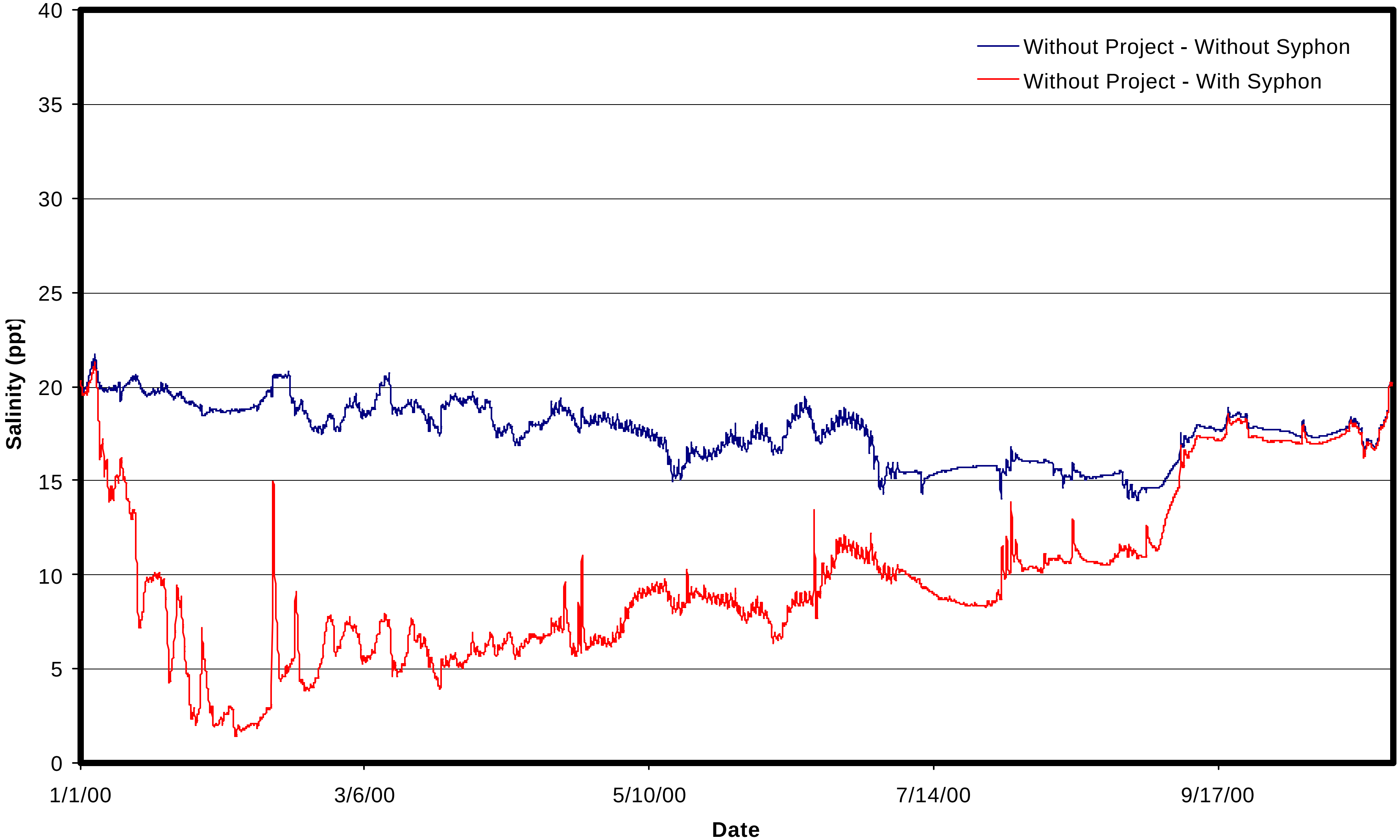

Figure 4.3: BA04-10 Salinity Variations for Run 1 Versus Run 2

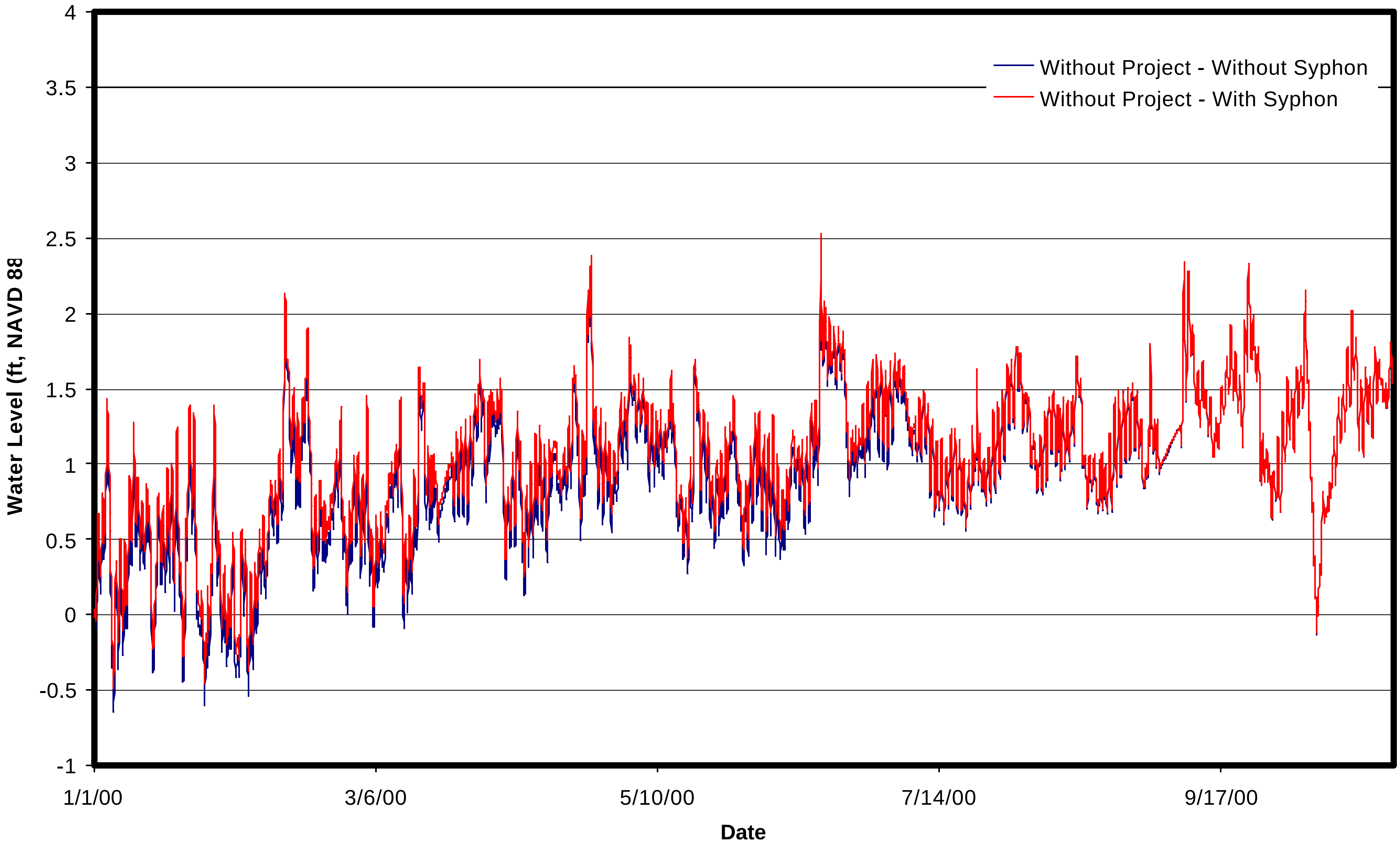

Figure 4.4: BA04-10 Water Level Variations for Run 1 Versus Run 2

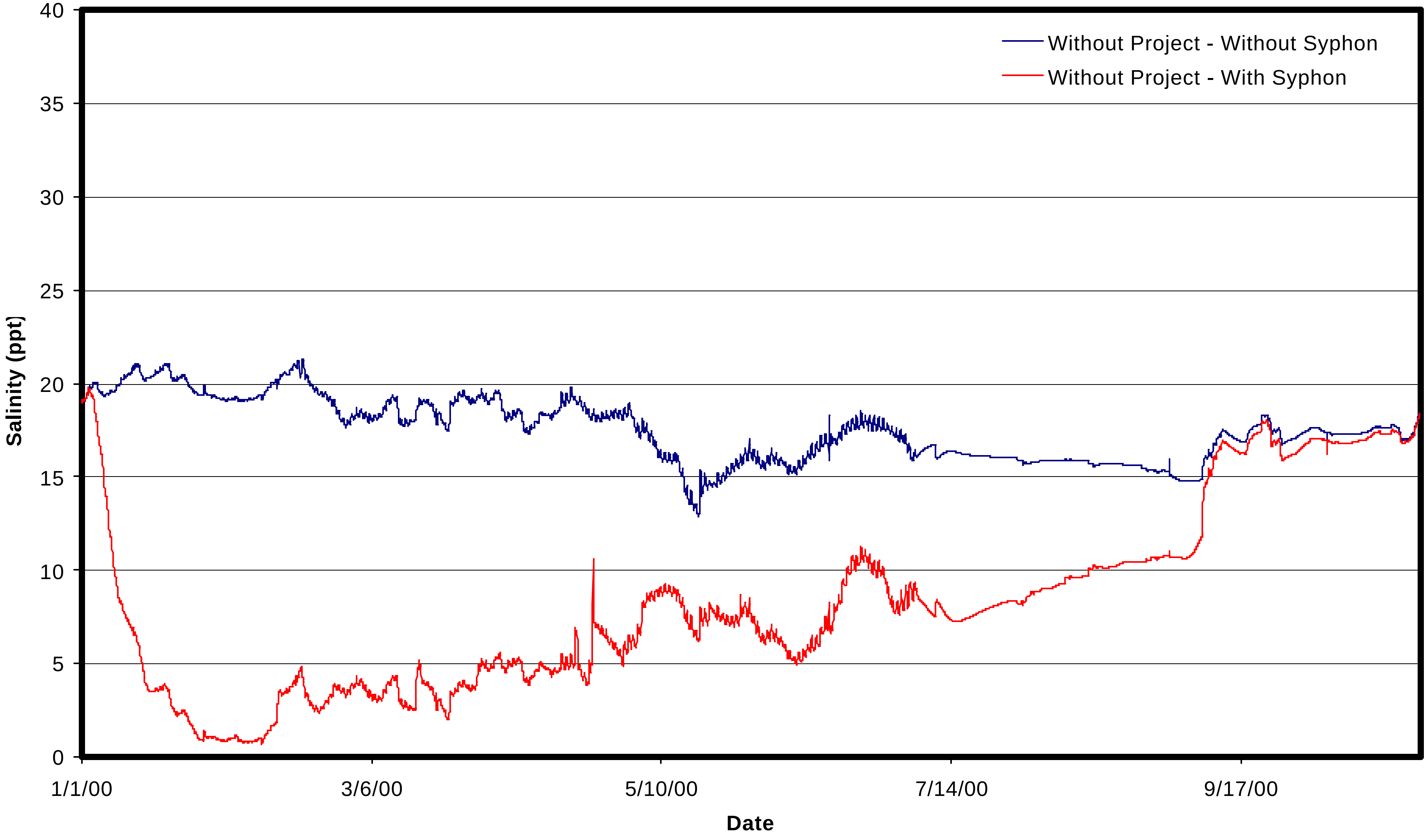

Figure 4.5: BA04-17 Salinity Variations for Run 1 Versus Run 2

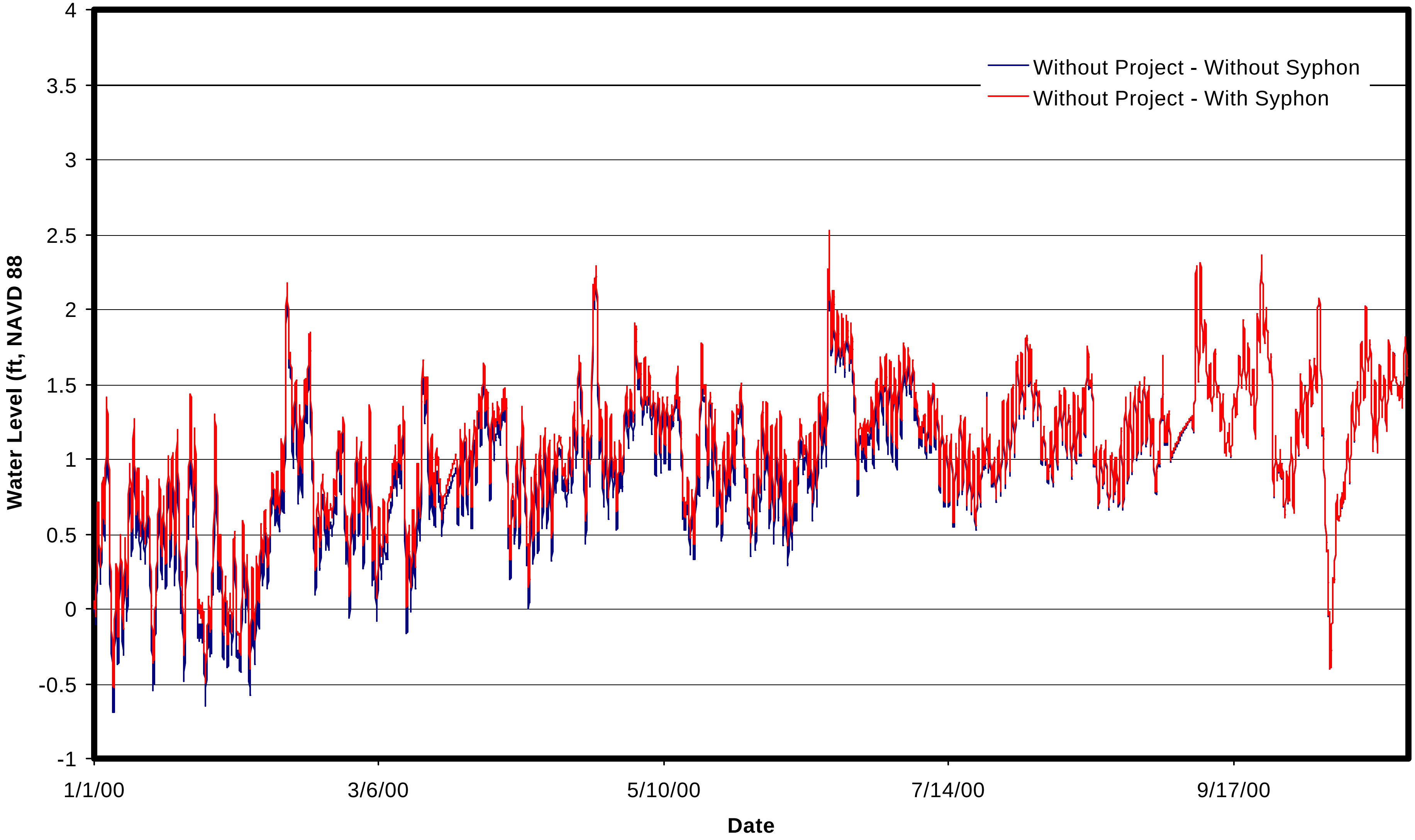

Figure 4.6: BA04-17 Water Level Variations for Run 1 Versus Run 2

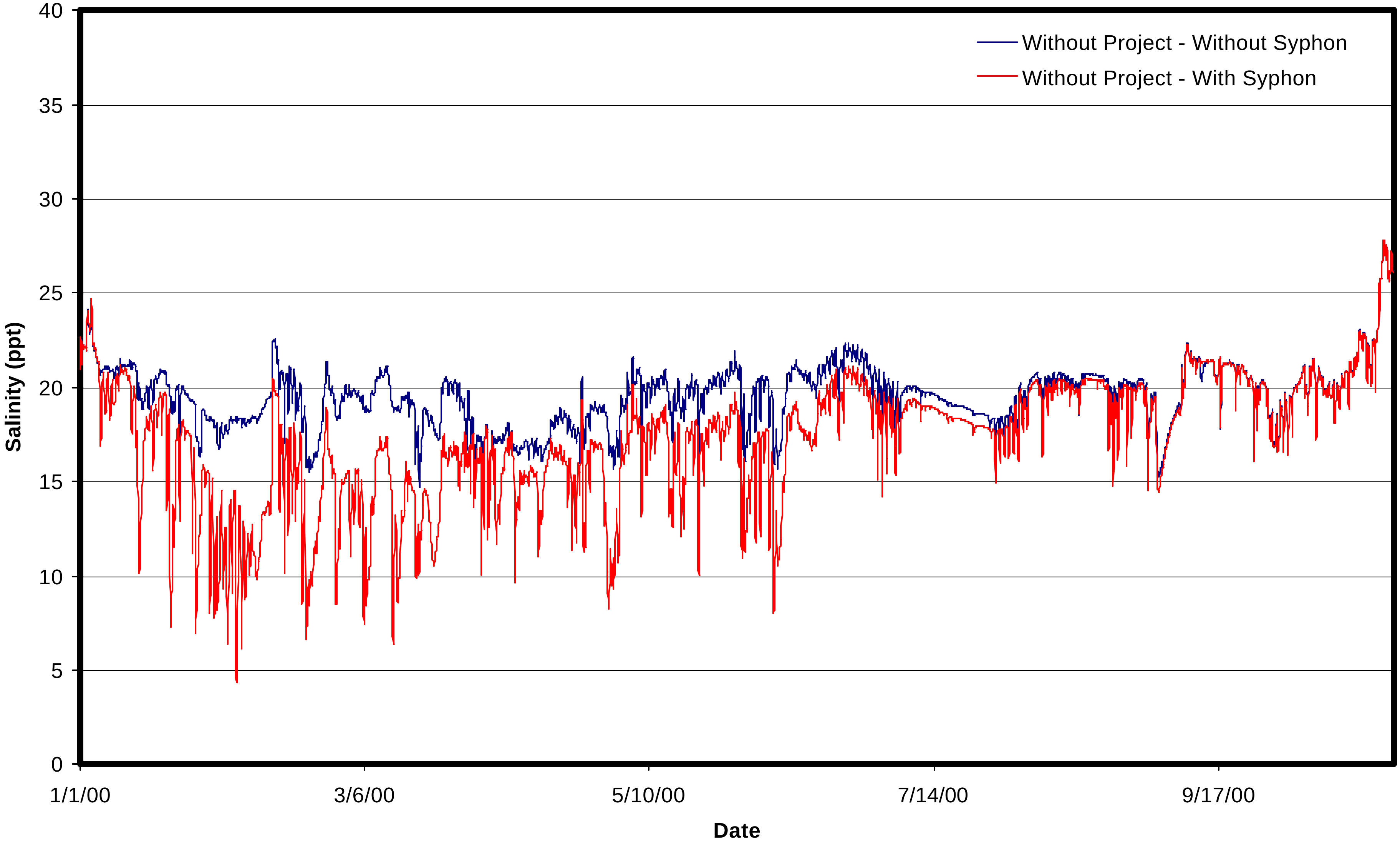

Figure 4.7: BA04-56 Salinity Variations for Run 1 Versus Run 2

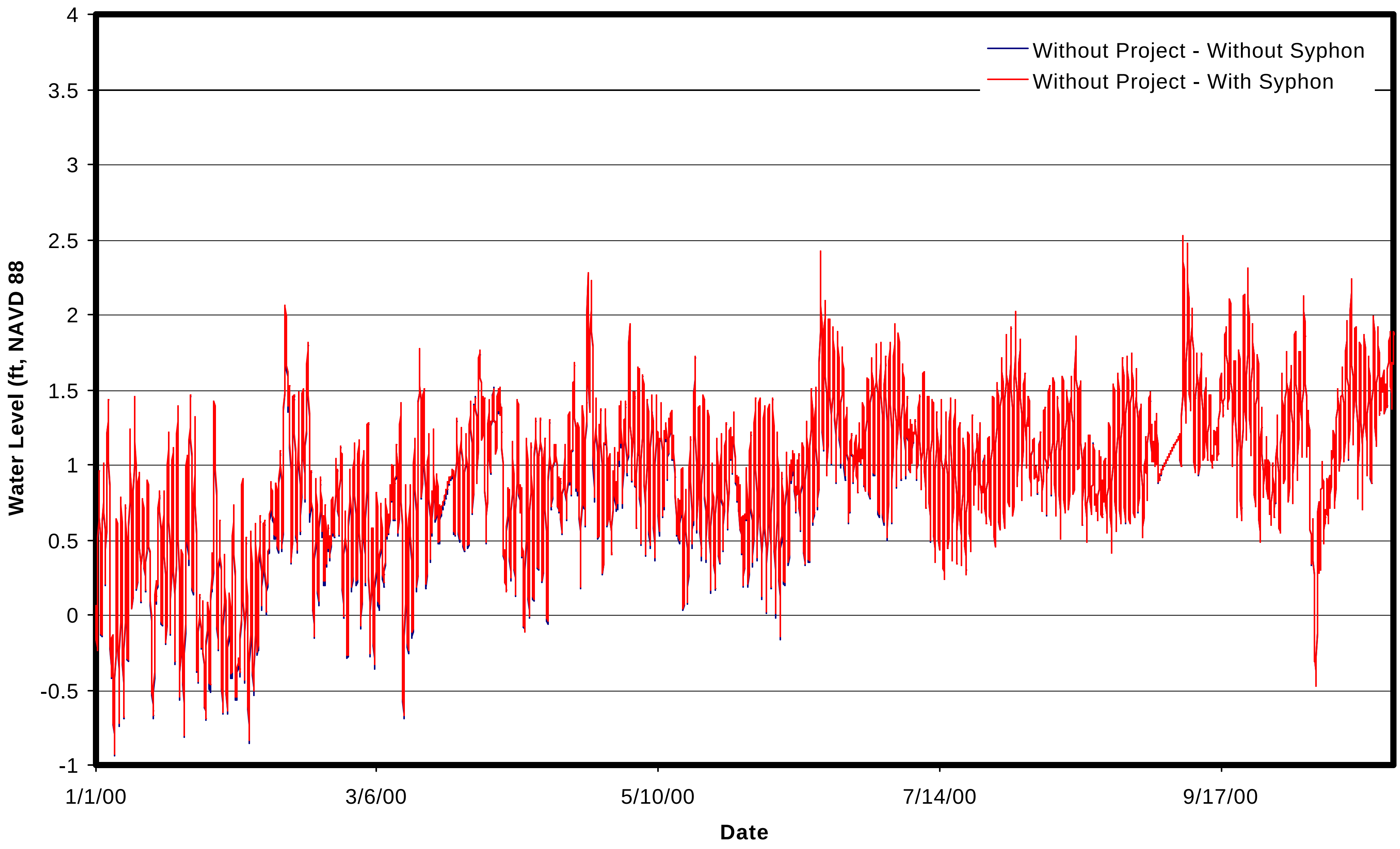

Figure 4.8: BA04-56 Water Level Variations for Run 1 Versus Run 2

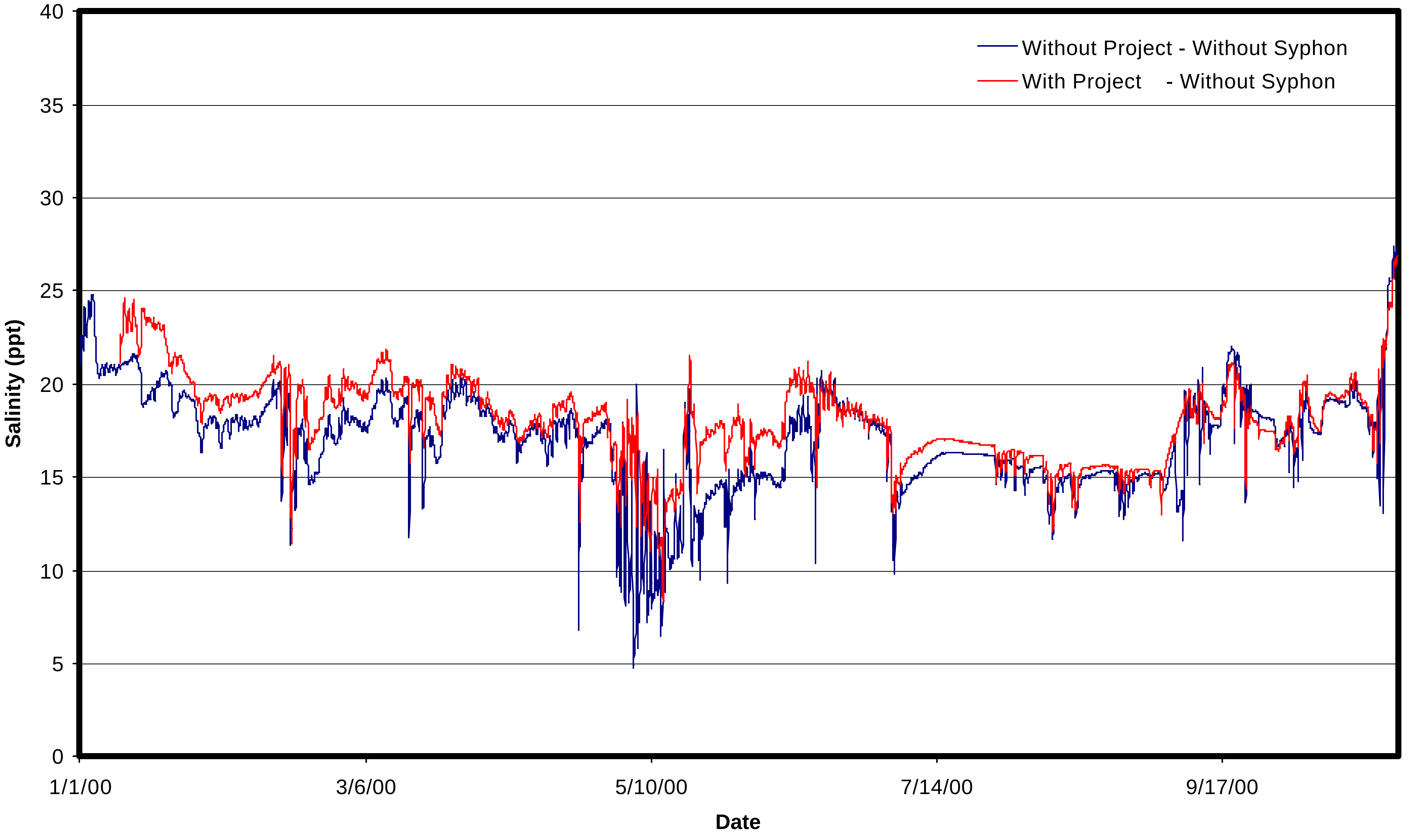

Figure 4.9: BA04-07 Salinity Variations for Run 1 Versus Run 3

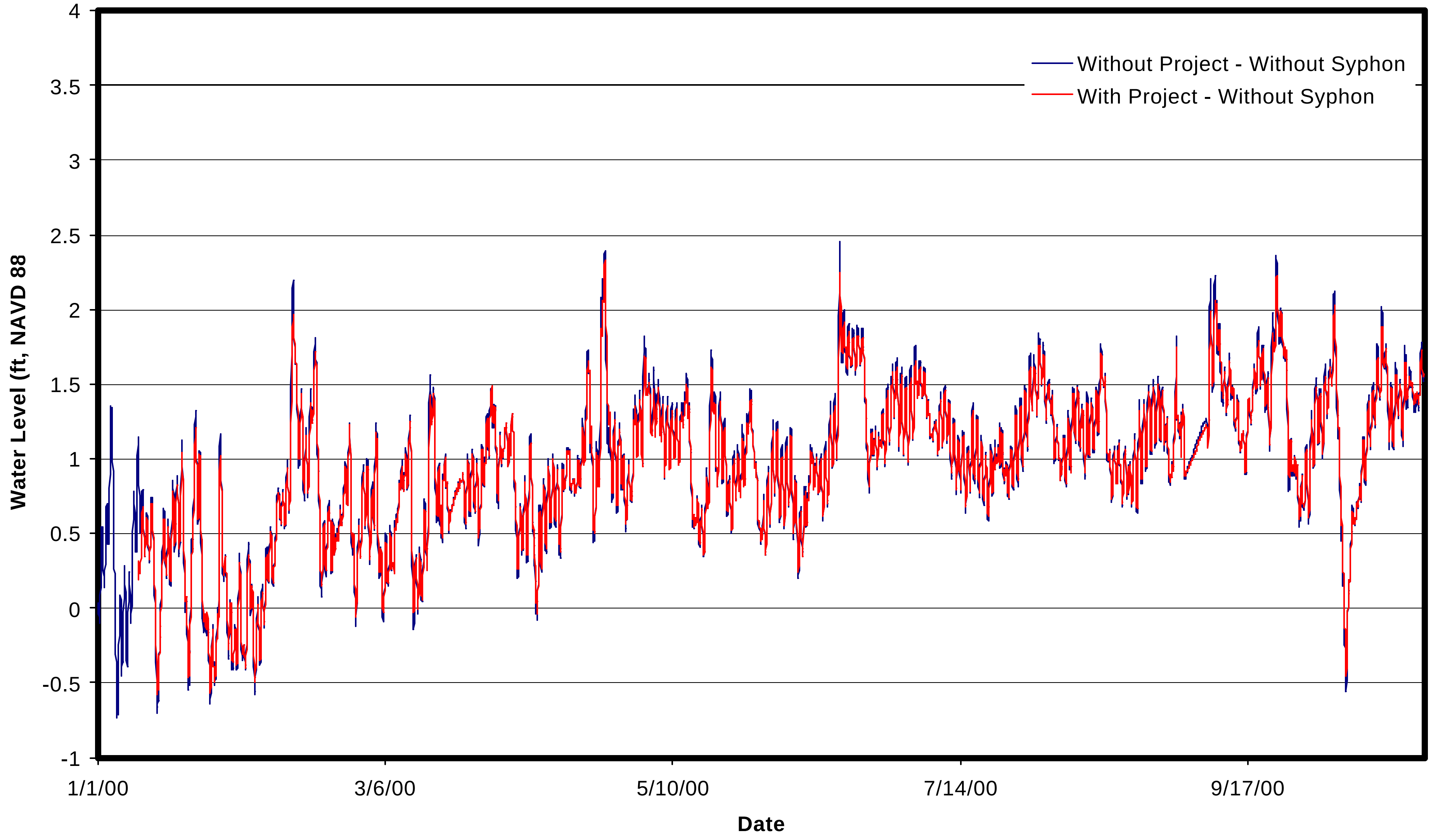

Figure 4.10: BA04-07 Water Level Variations for Run 1 Versus Run 3

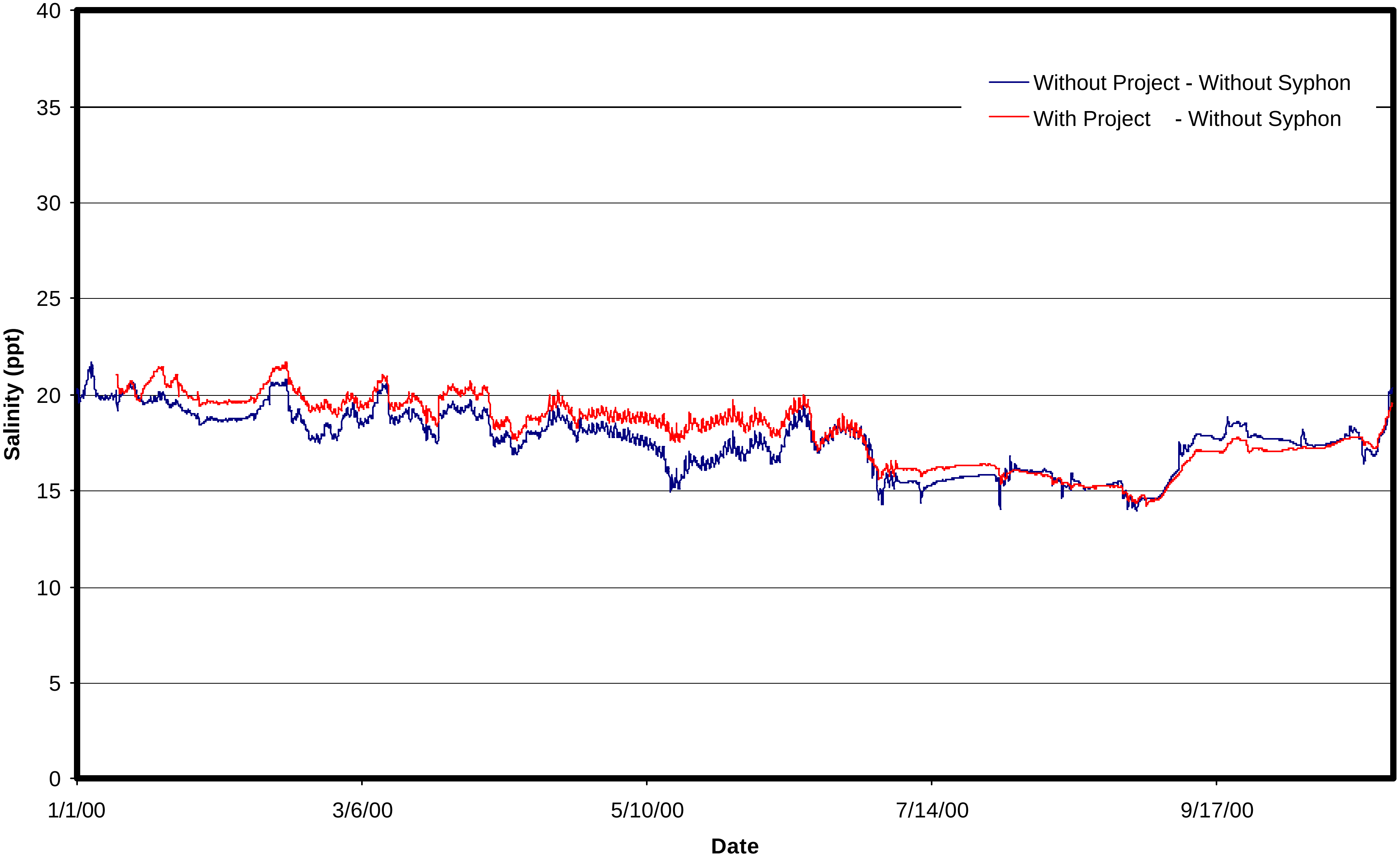

Figure 4.11: BA04-10 Salinity Variations for Run 1 Versus Run 3

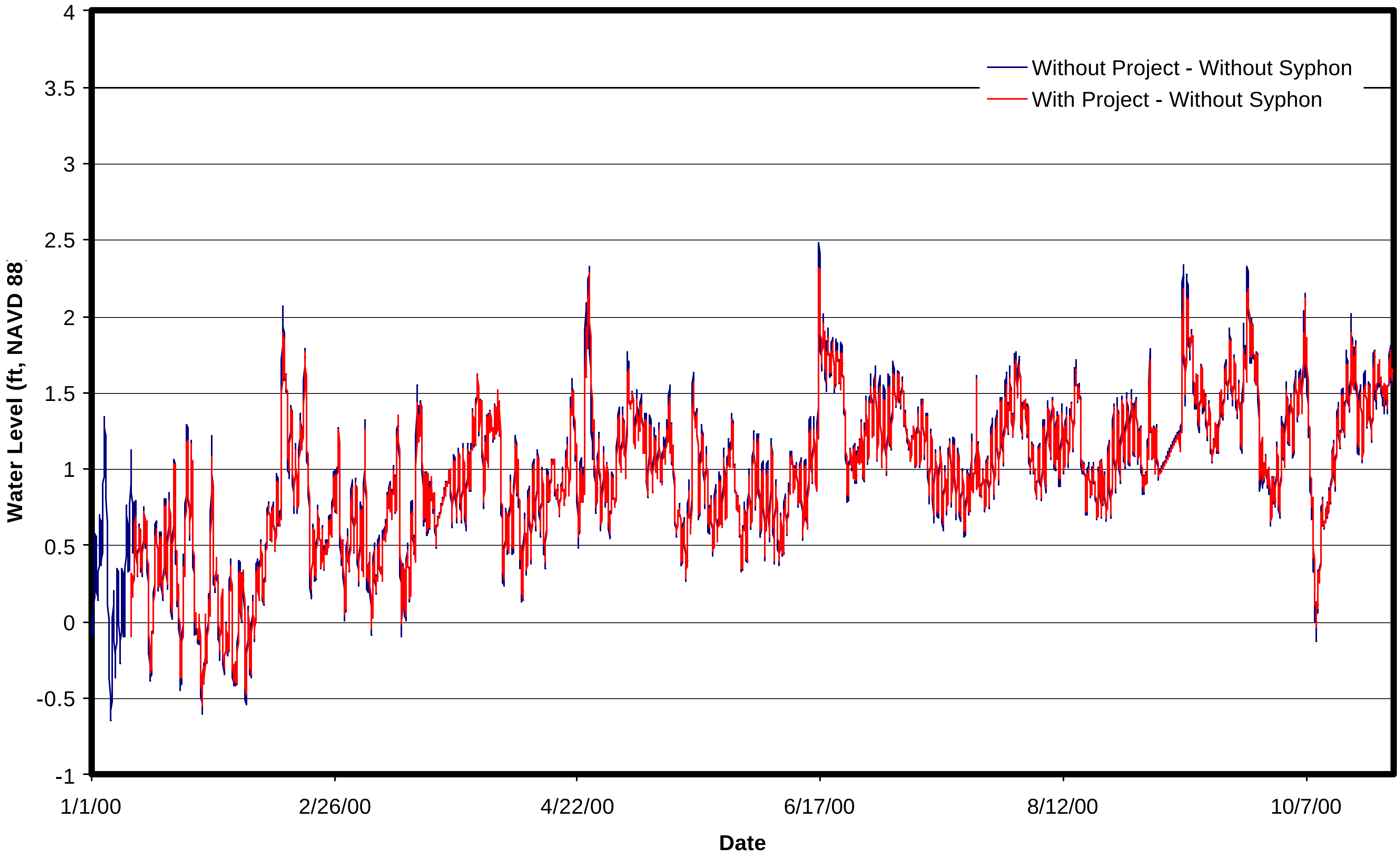

Figure 4.12: BA04-10 Water Level Variations for Run 1 Versus Run 3

Figure 4.13: BA04-17 Salinity Variations for Run 1 Versus Run 3

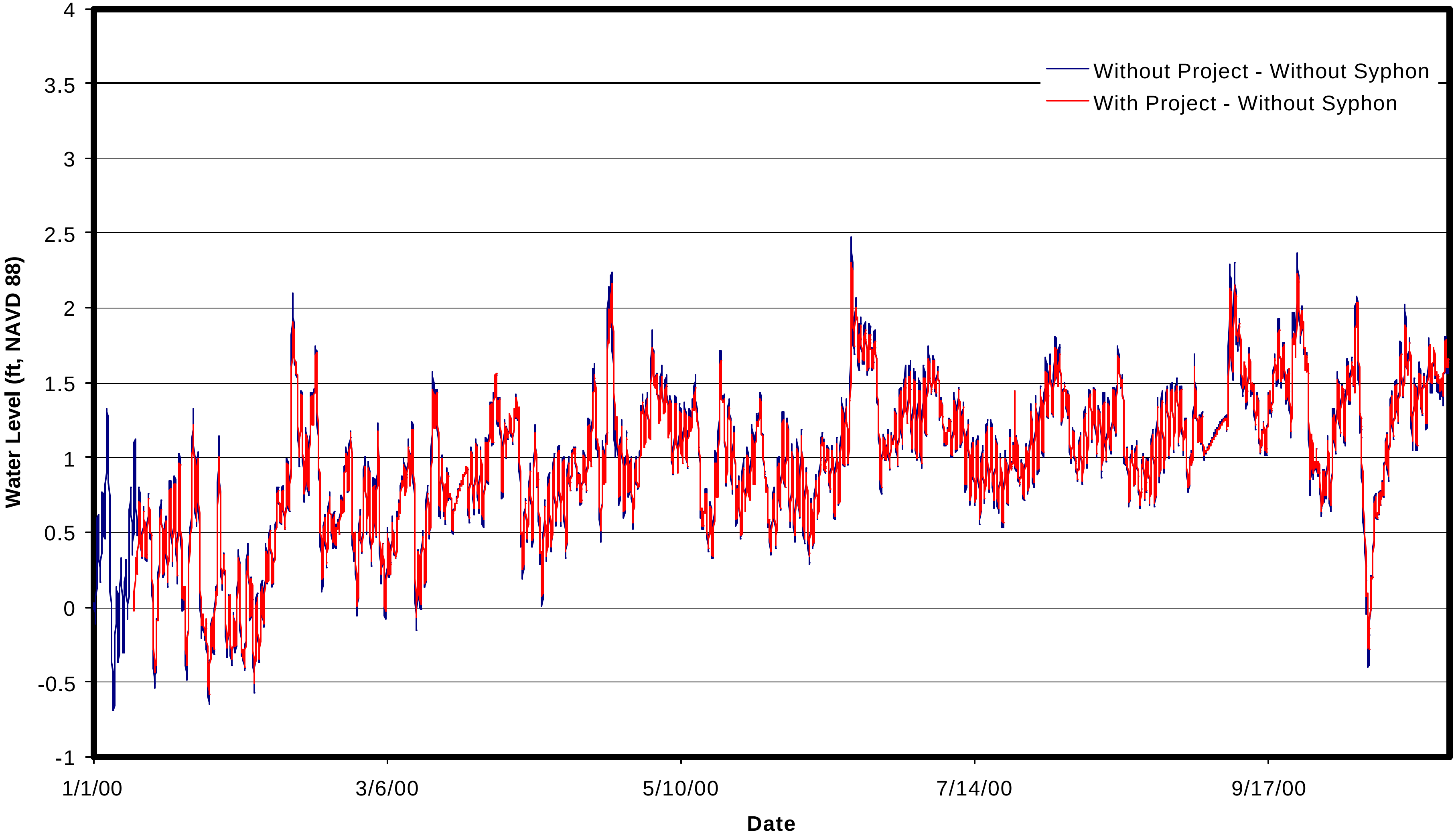

Figure 4.14: BA04-17 Water Level Variations for Run 1 Versus Run 3

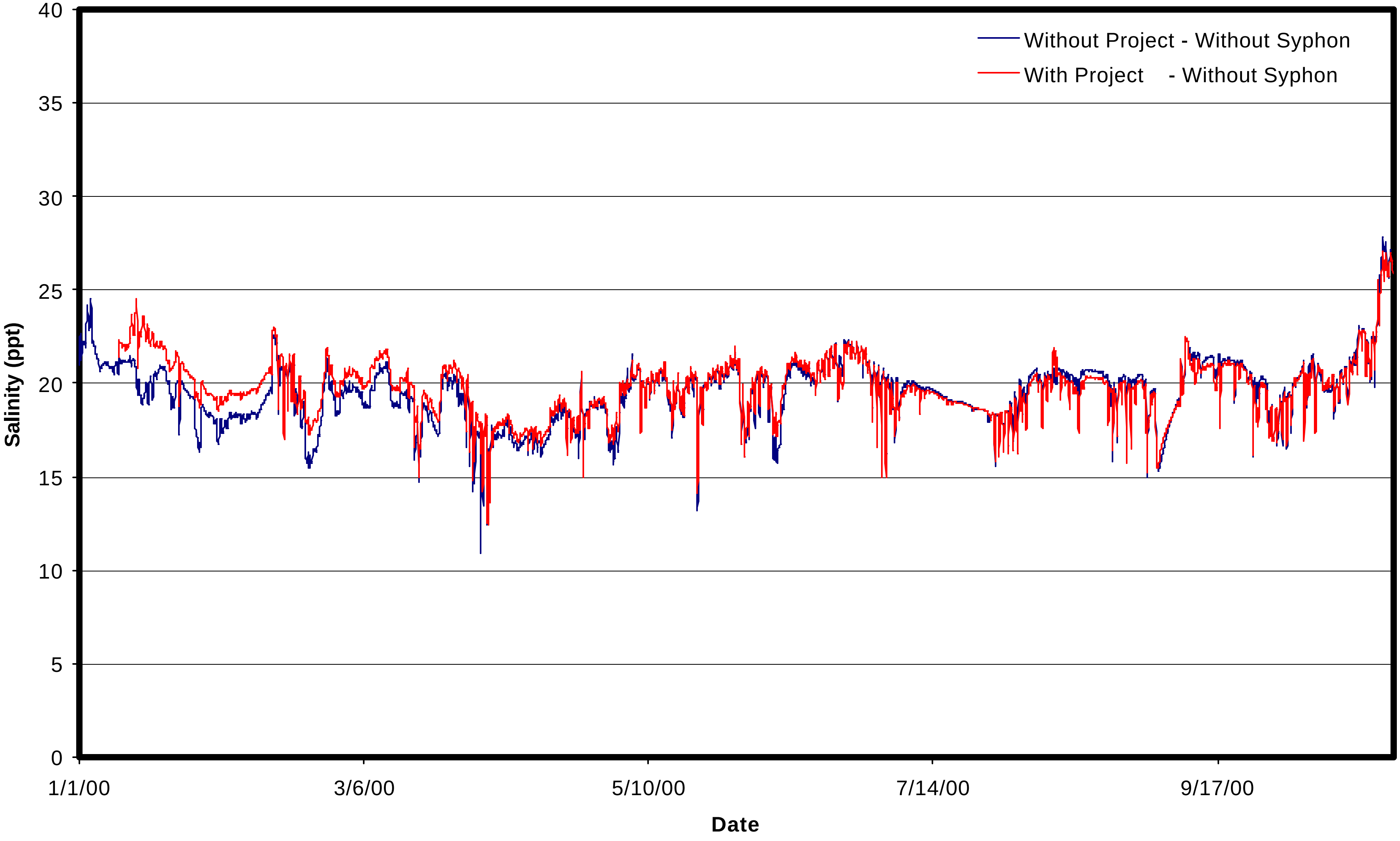

Figure 4.15: BA04-56 Salinity Variations for Run 1 Versus Run 3

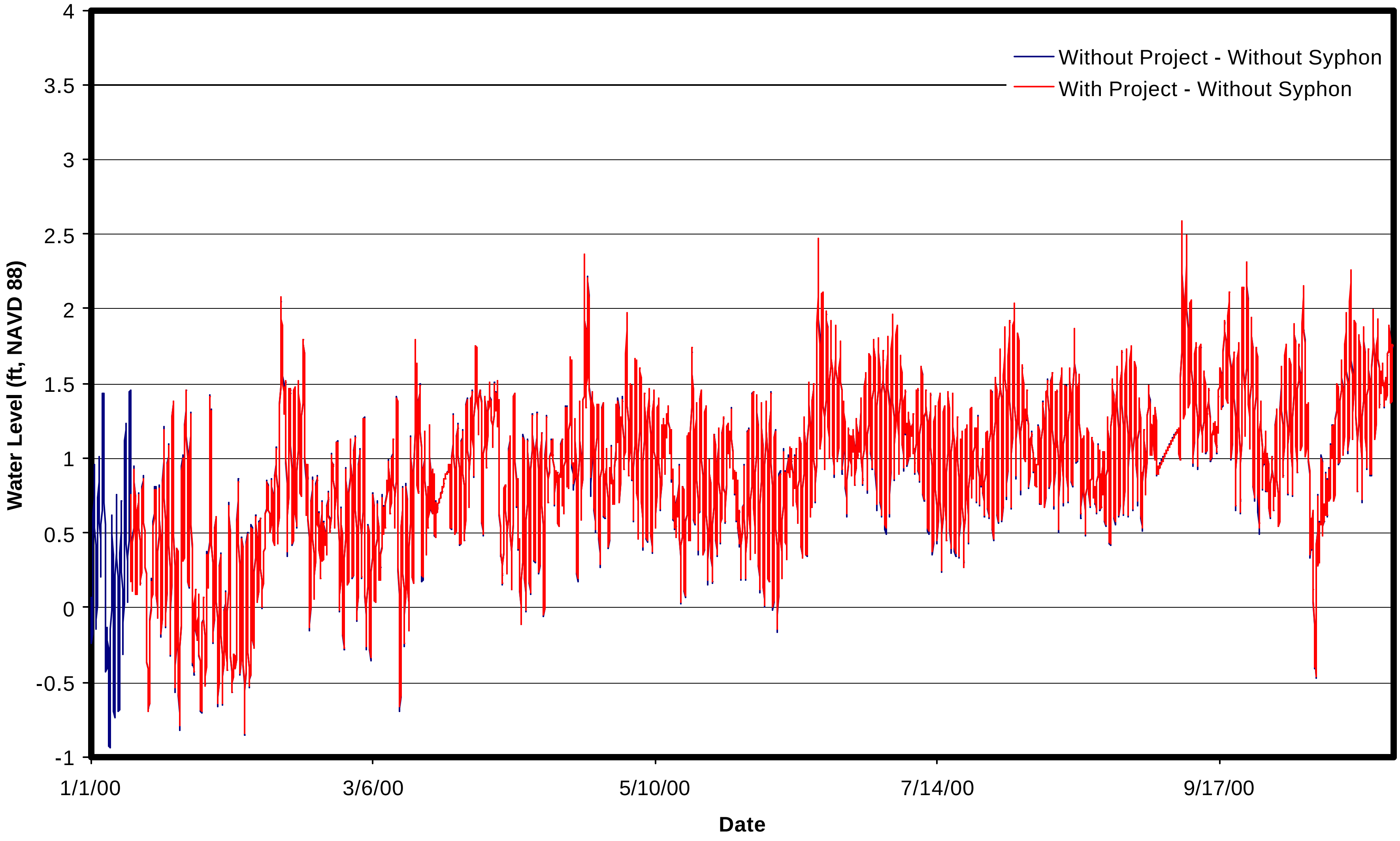

Figure 4.16: BA04-56 Water Level Variations for Run 1 Versus Run 3

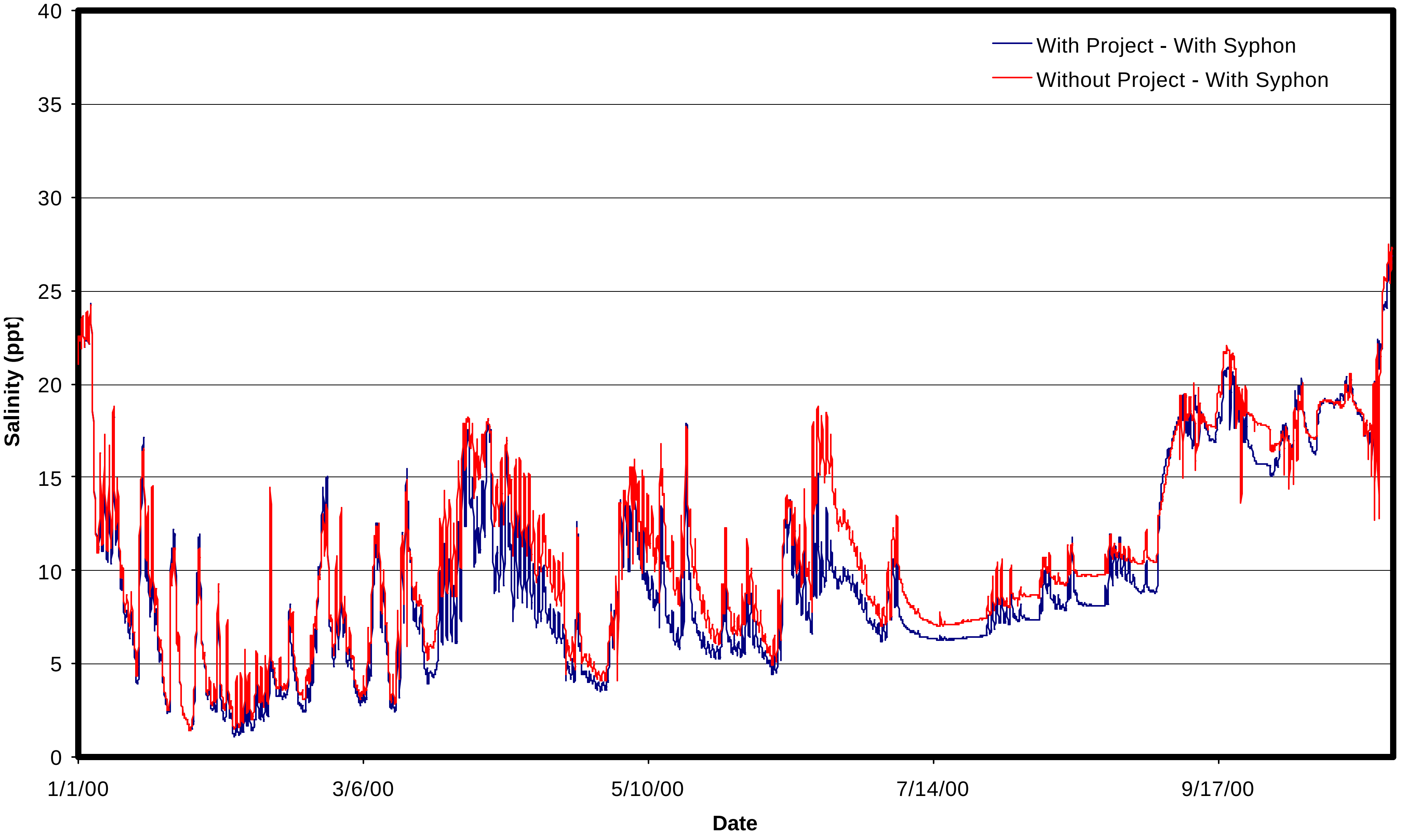

Figure 4.17: BA04-07 Salinity Variations for Run 2 Versus Run 4

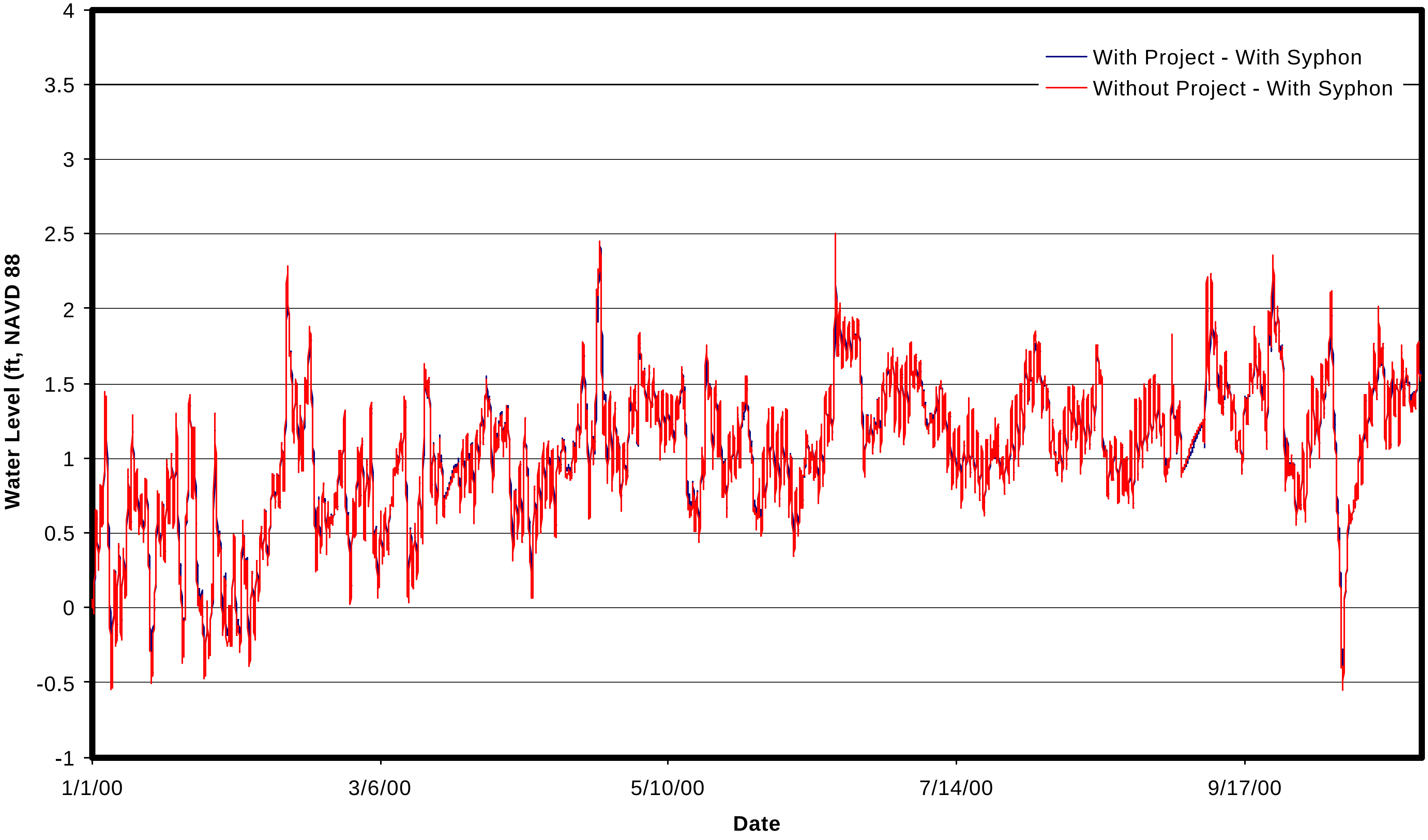

Figure 4.18: BA04-07 Water Level Variations for Run 2 Versus Run 4

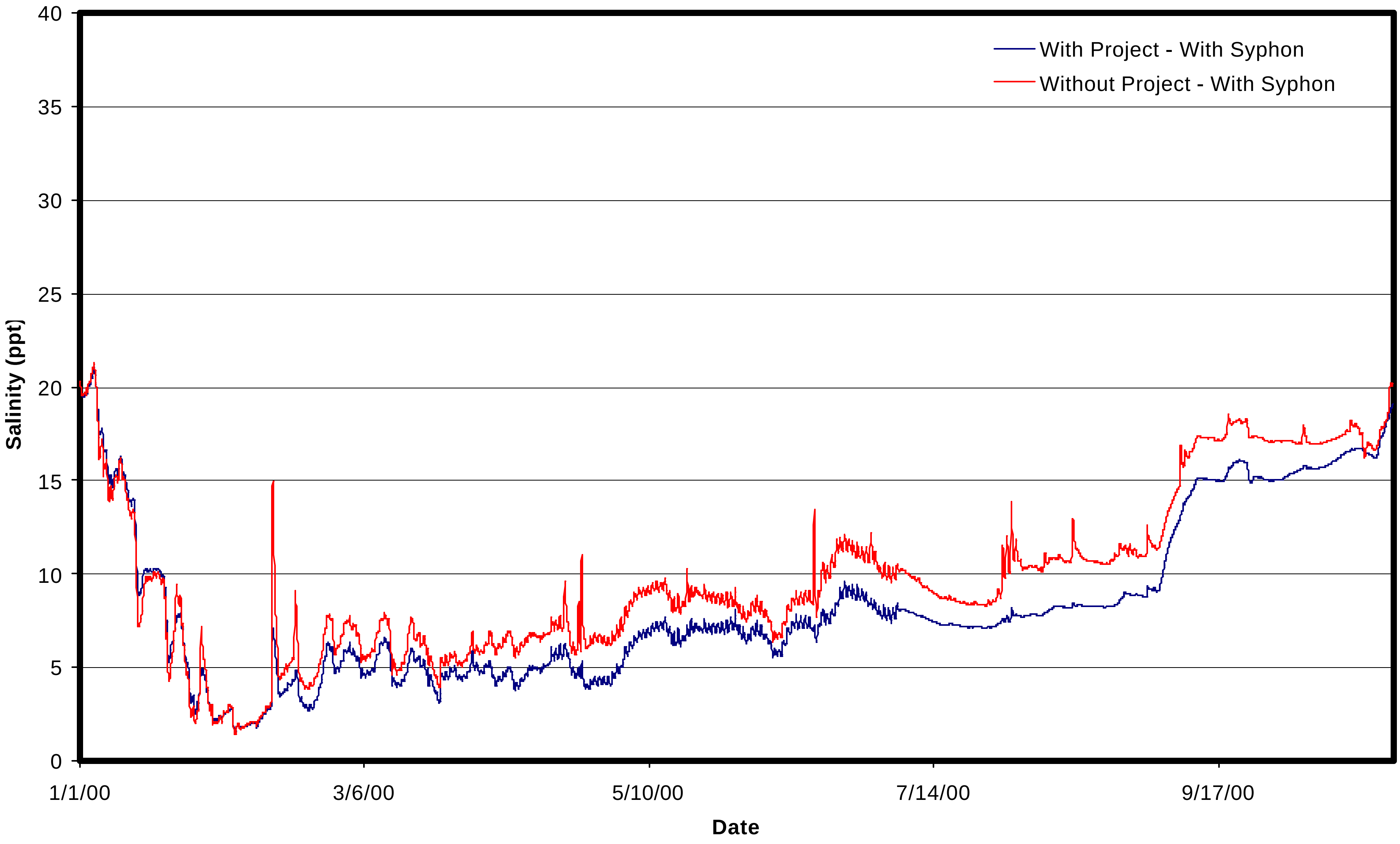

Figure 4.19: BA04-10 Salinity Variations for Run 2 Versus Run 4

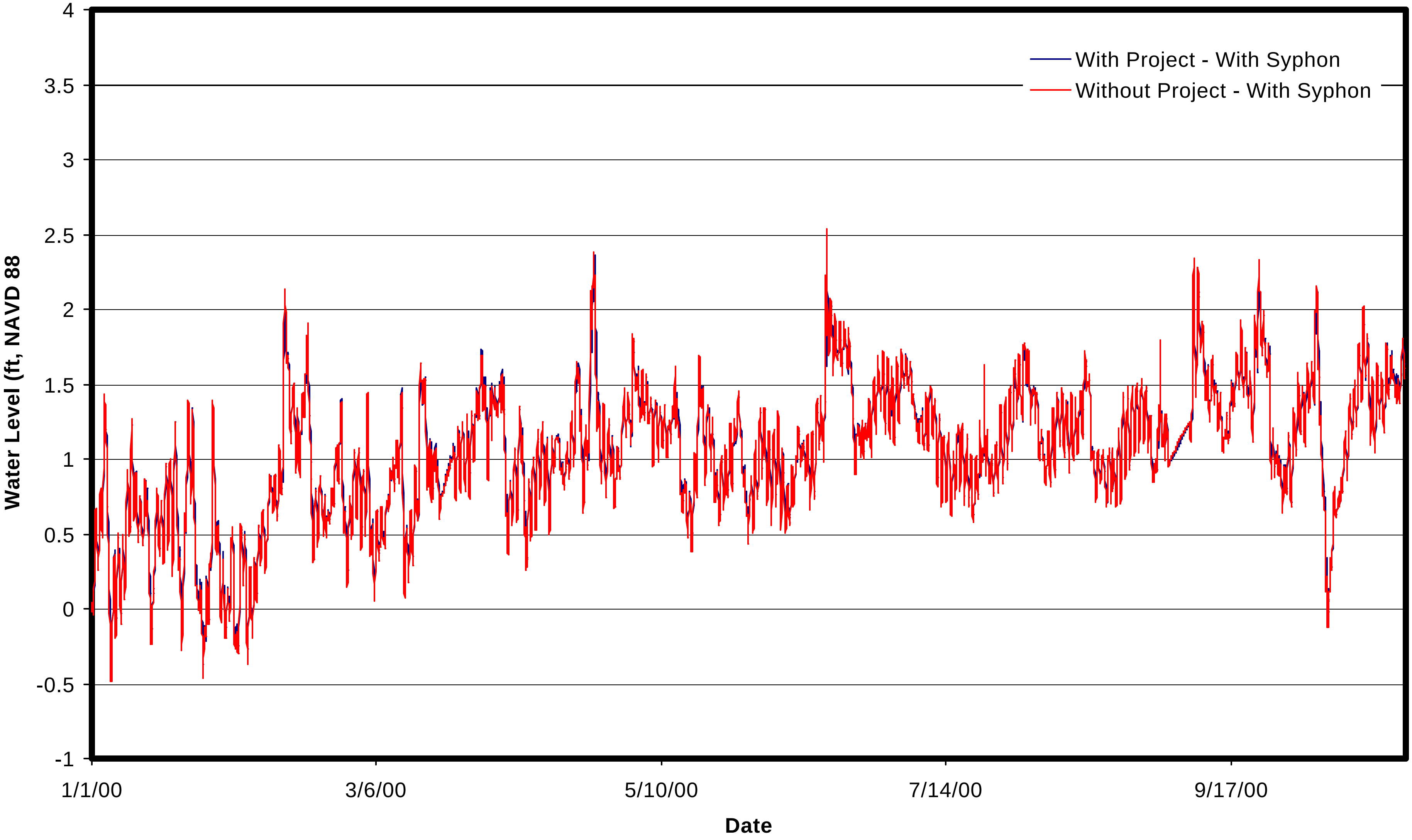

Figure 4.20: BA04-10 Water Level Variations for Run 2 Versus Run 4

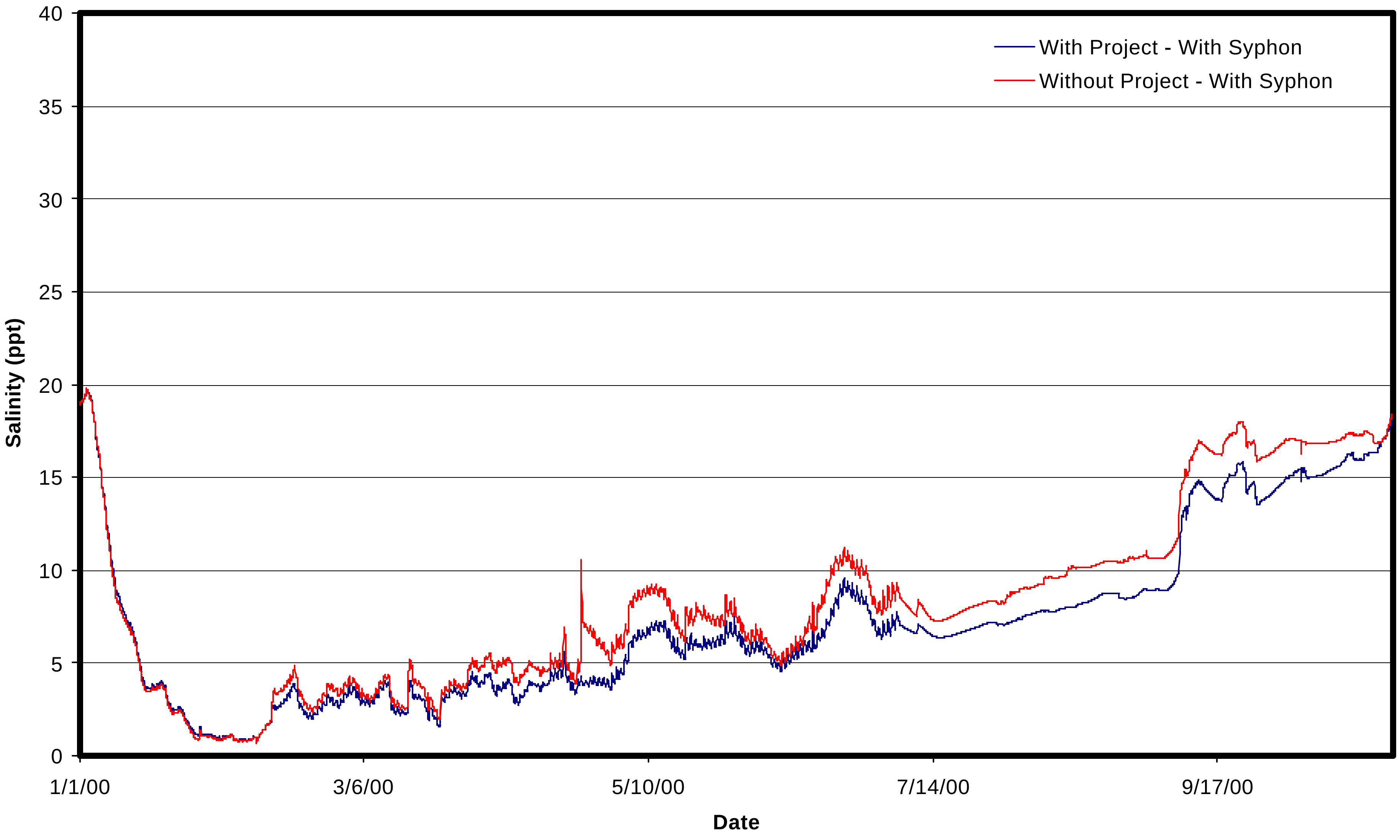

Figure 4.21: BA04-17 Salinity Variations for Run 2 Versus Run 4

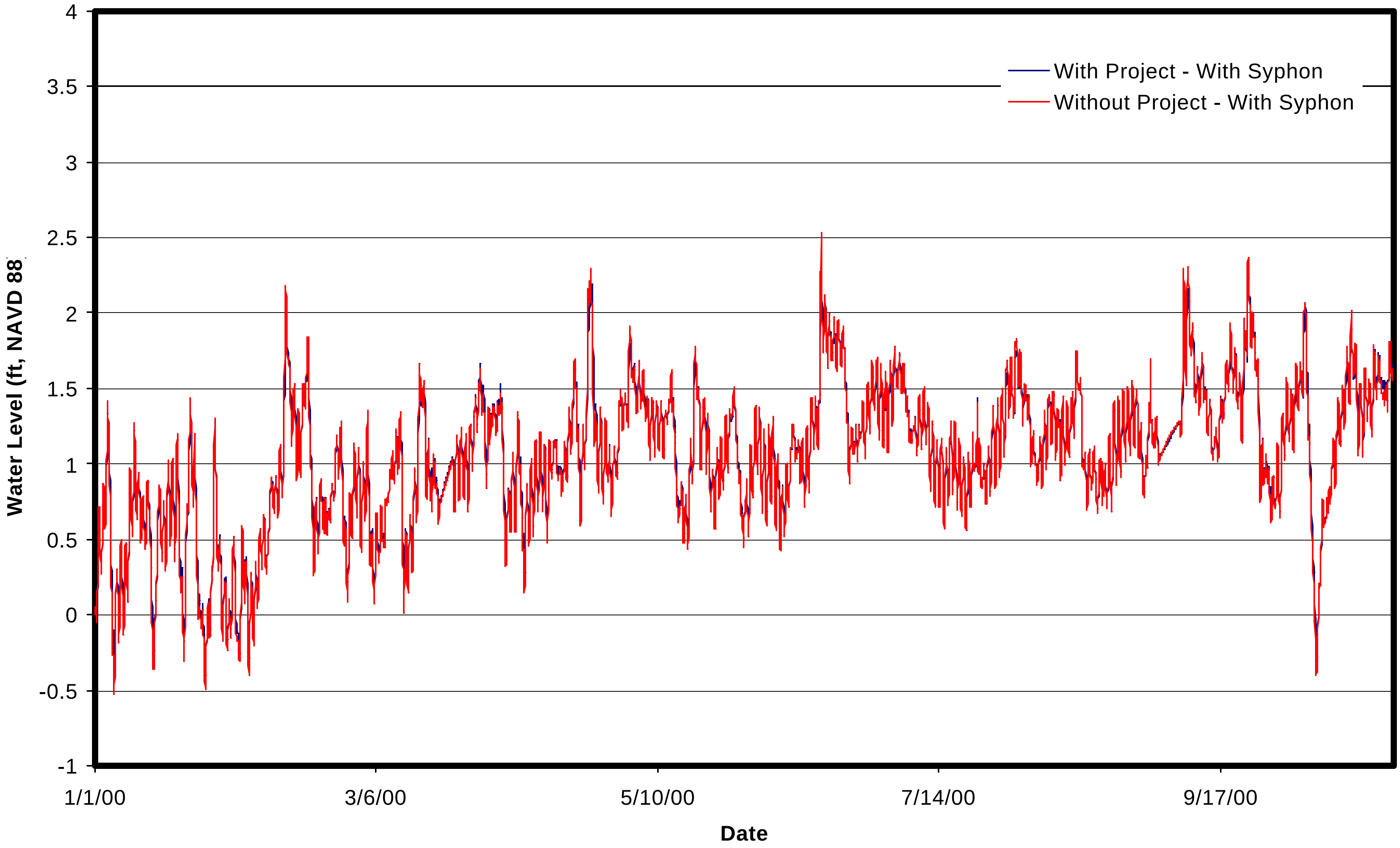

Figure 4.22: BA04-17 Water Level Variations for Run 2 Versus Run 4

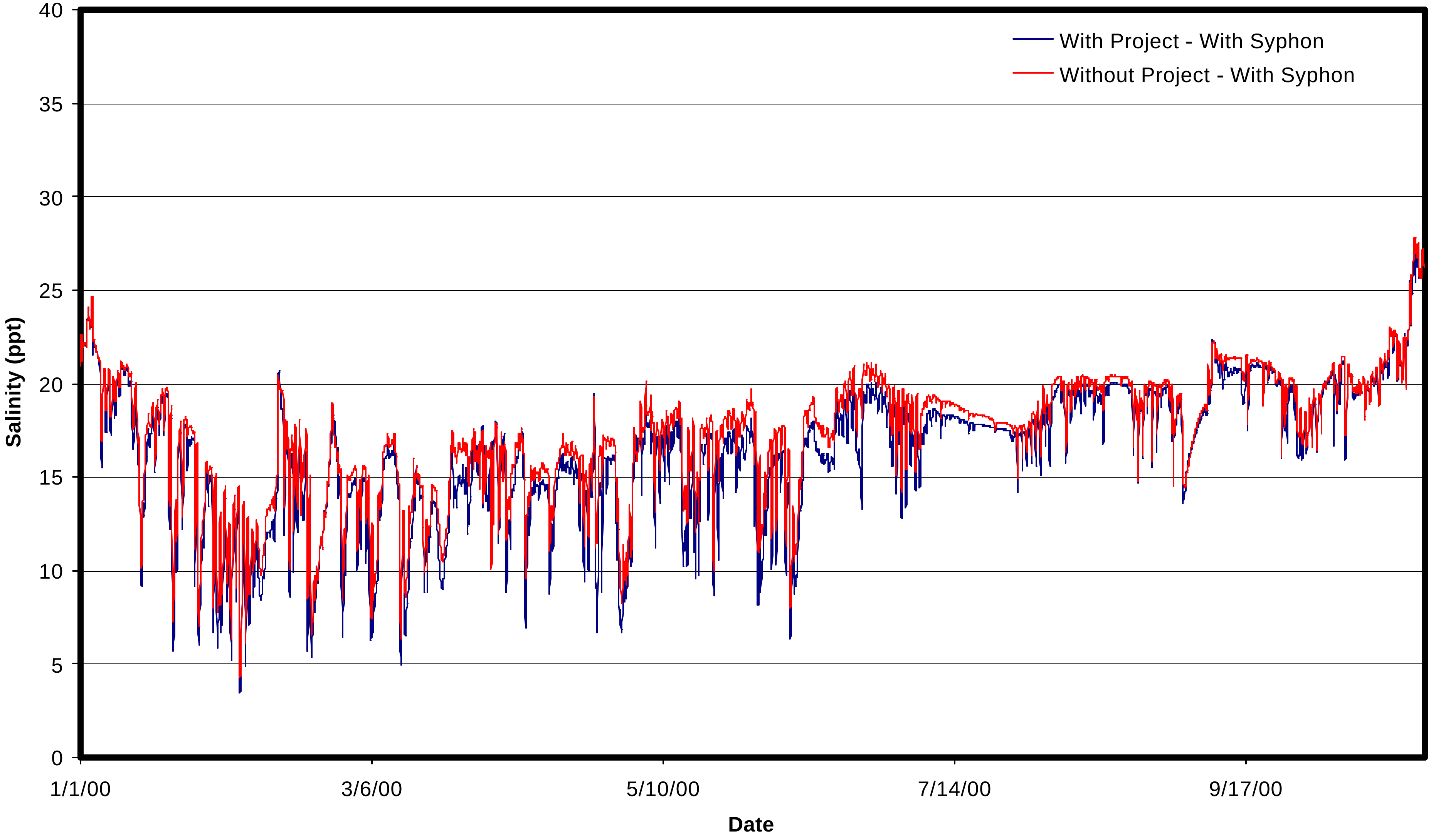

Figure 4.23: BA04-56 Salinity Variations for Run 2 Versus Run 4

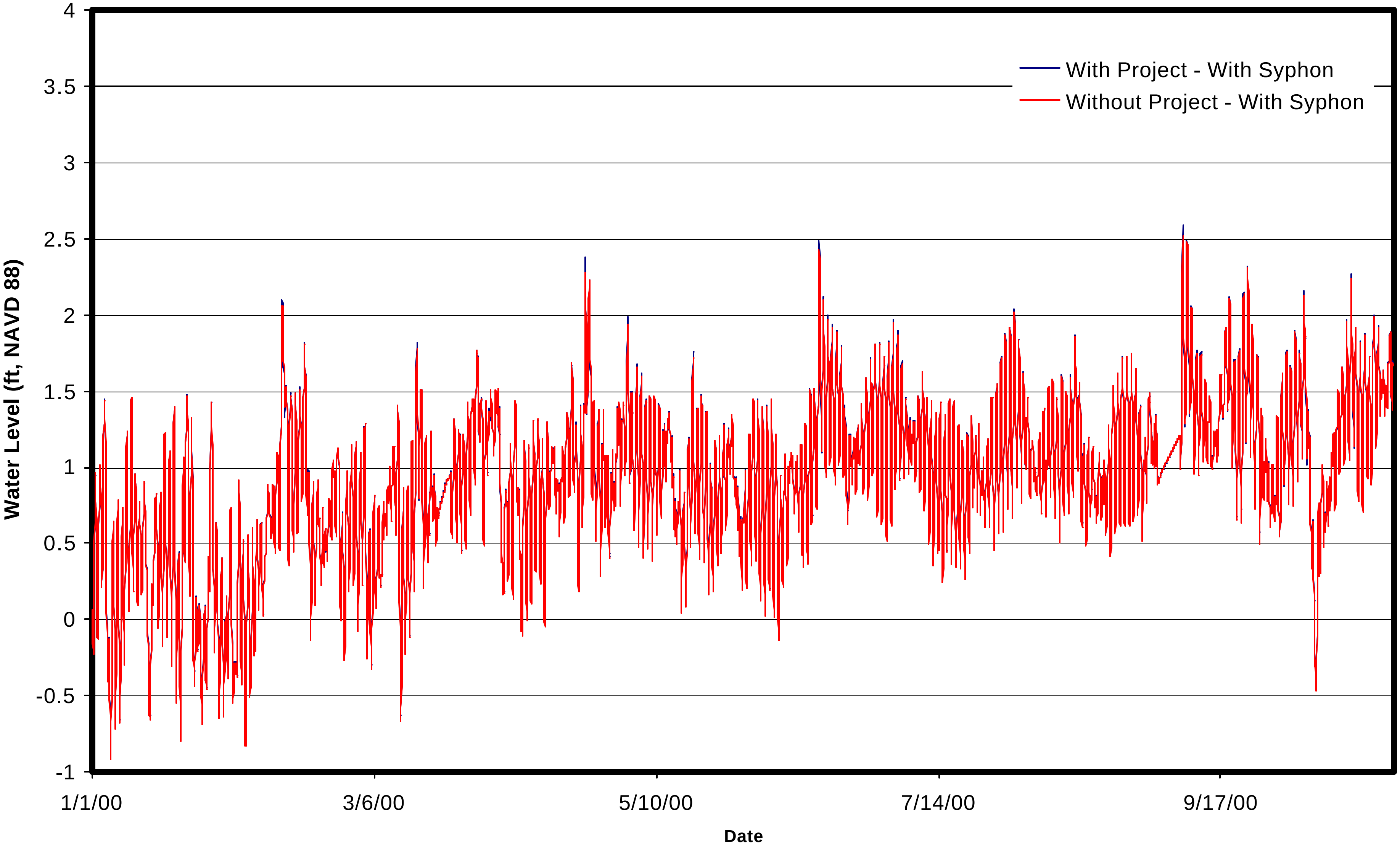

Figure 4.24: BA04-56 Water Level Variations for Run 2 Versus Run 4

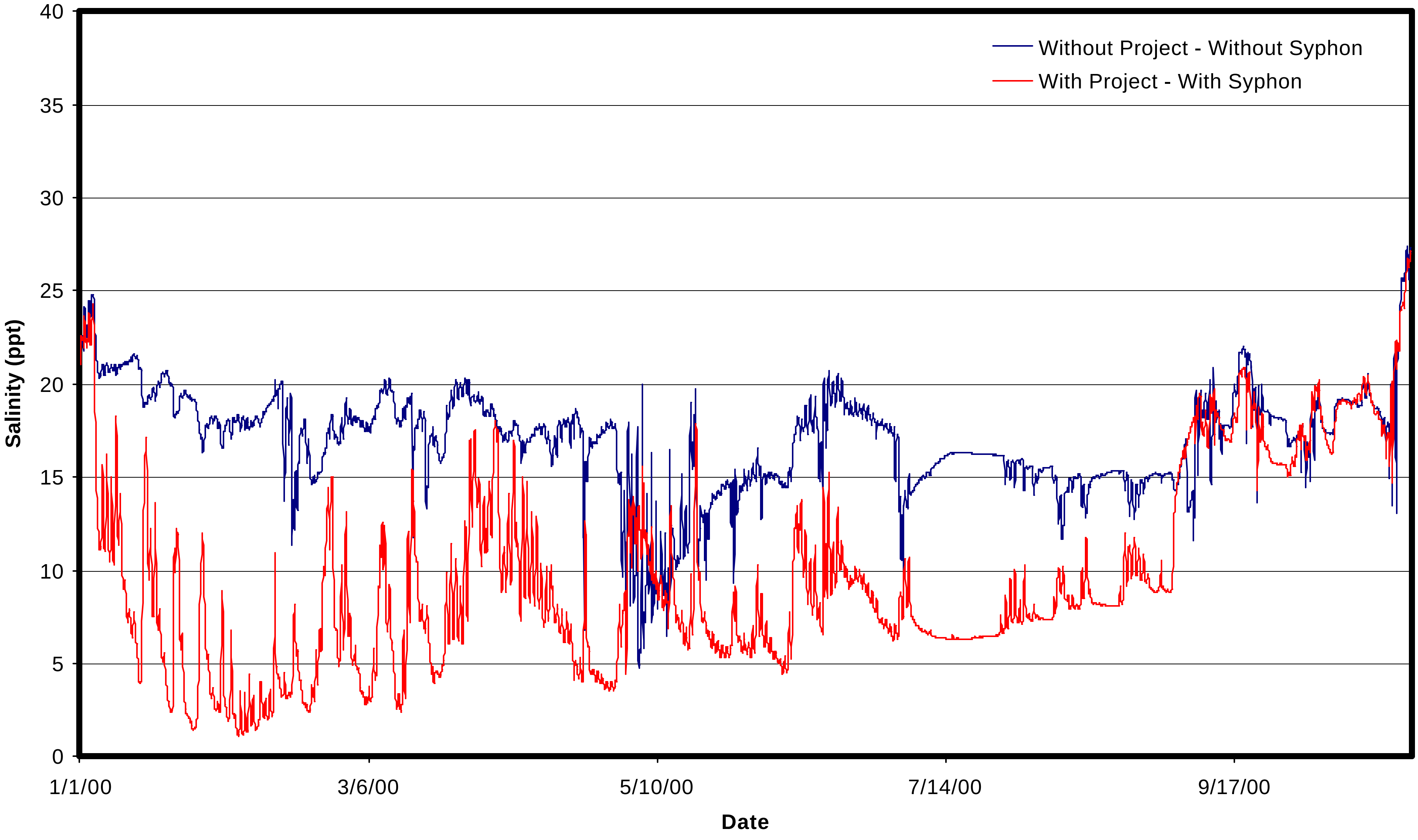

Figure 4.25: BA04-07 Salinity Variations for Run 1 Versus Run 4

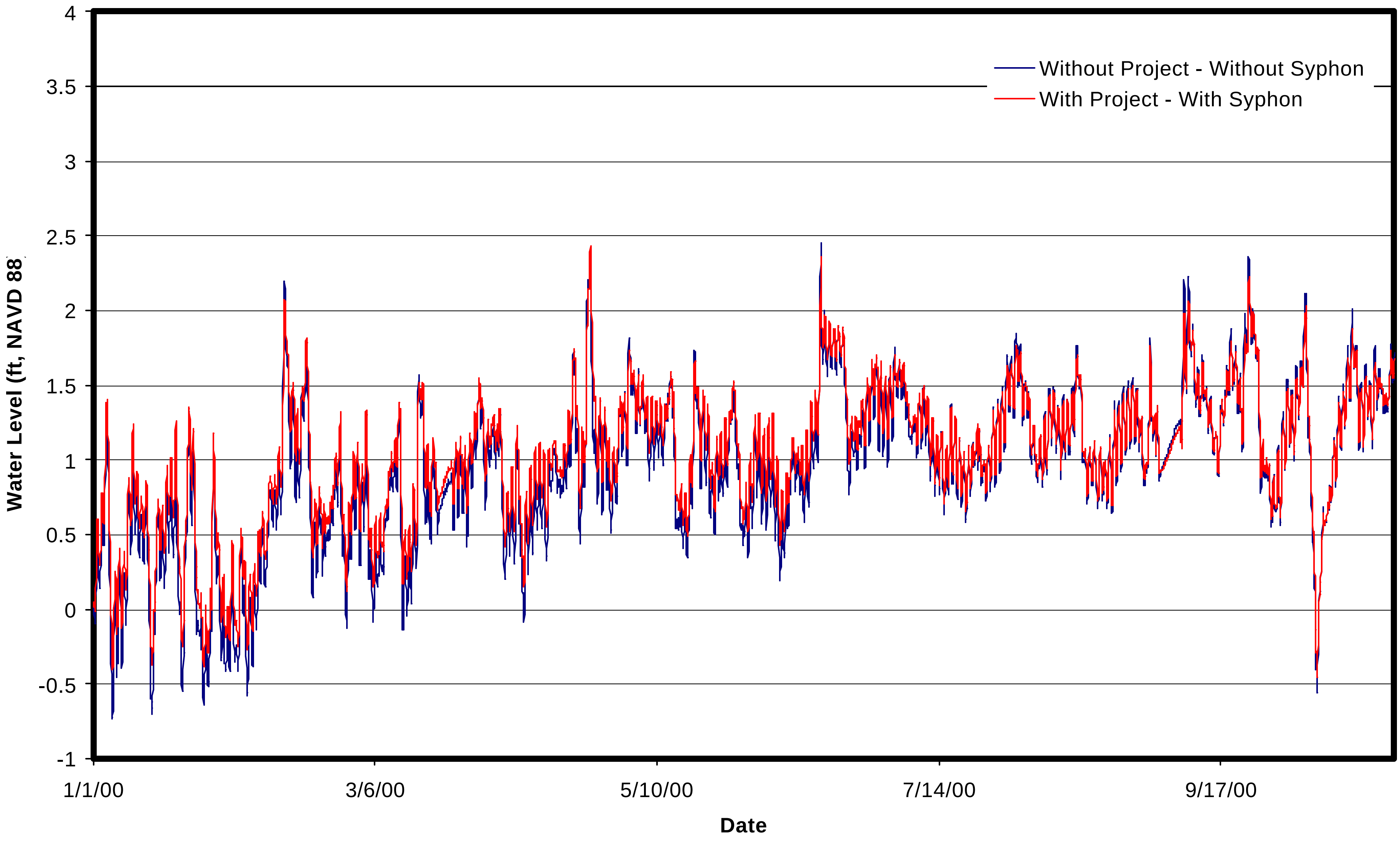

Figure 4.26: BA04-07 Water Level Variations for Run 1 Versus Run 4

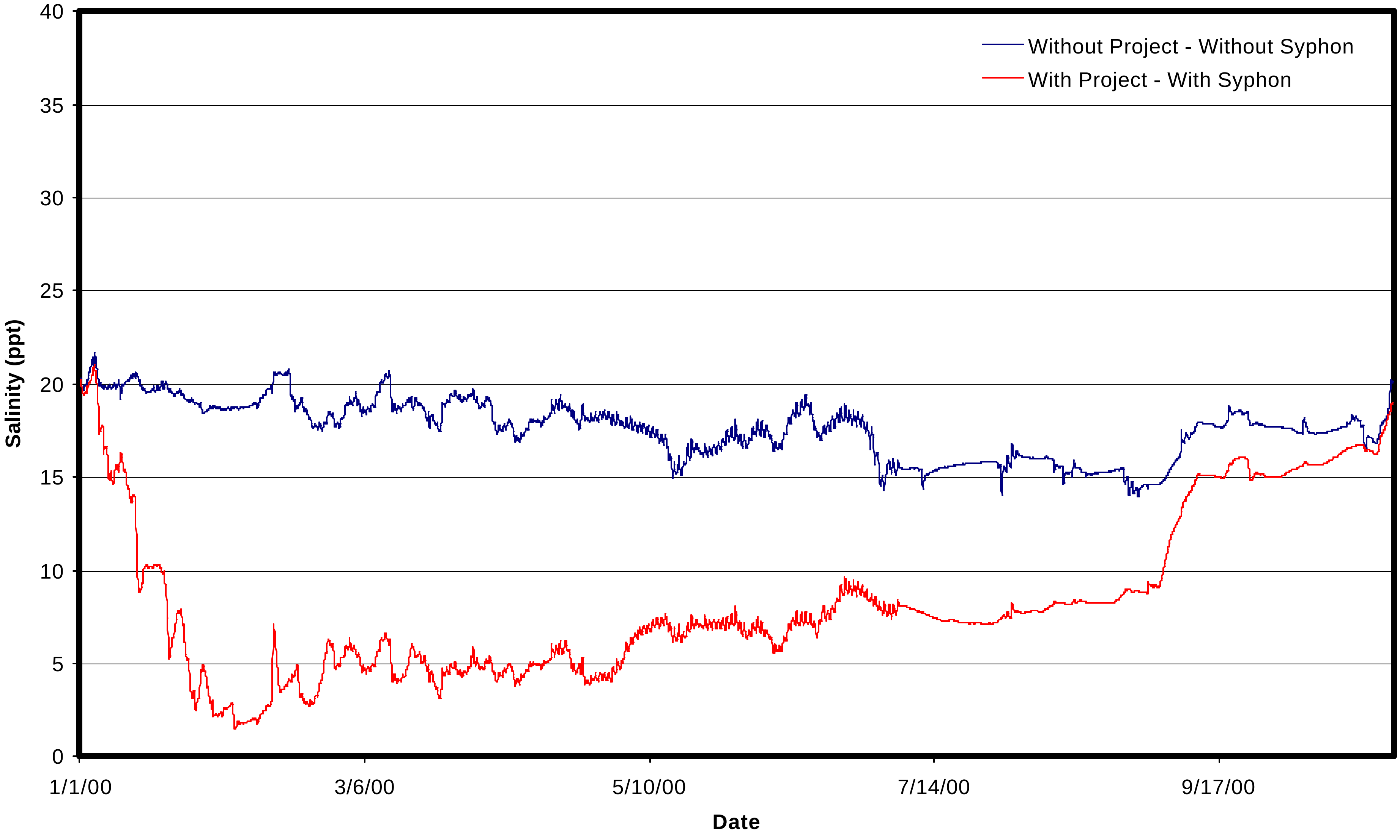

Figure 4.27: BA04-10 Salinity Variations for Run 1 Versus Run 4

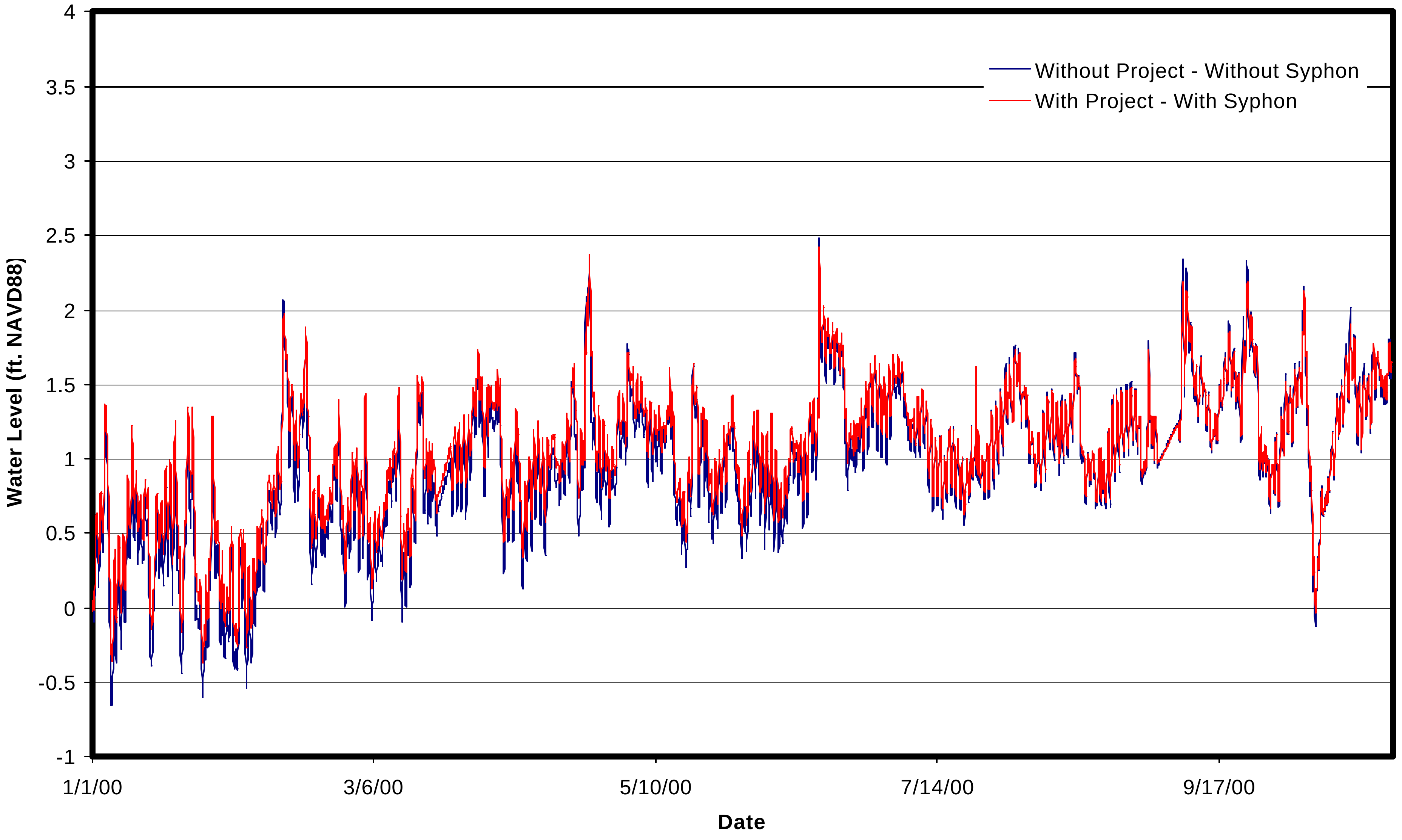

Figure 4.28: BA04-10 Water Level Variations for Run 1 Versus Run 4

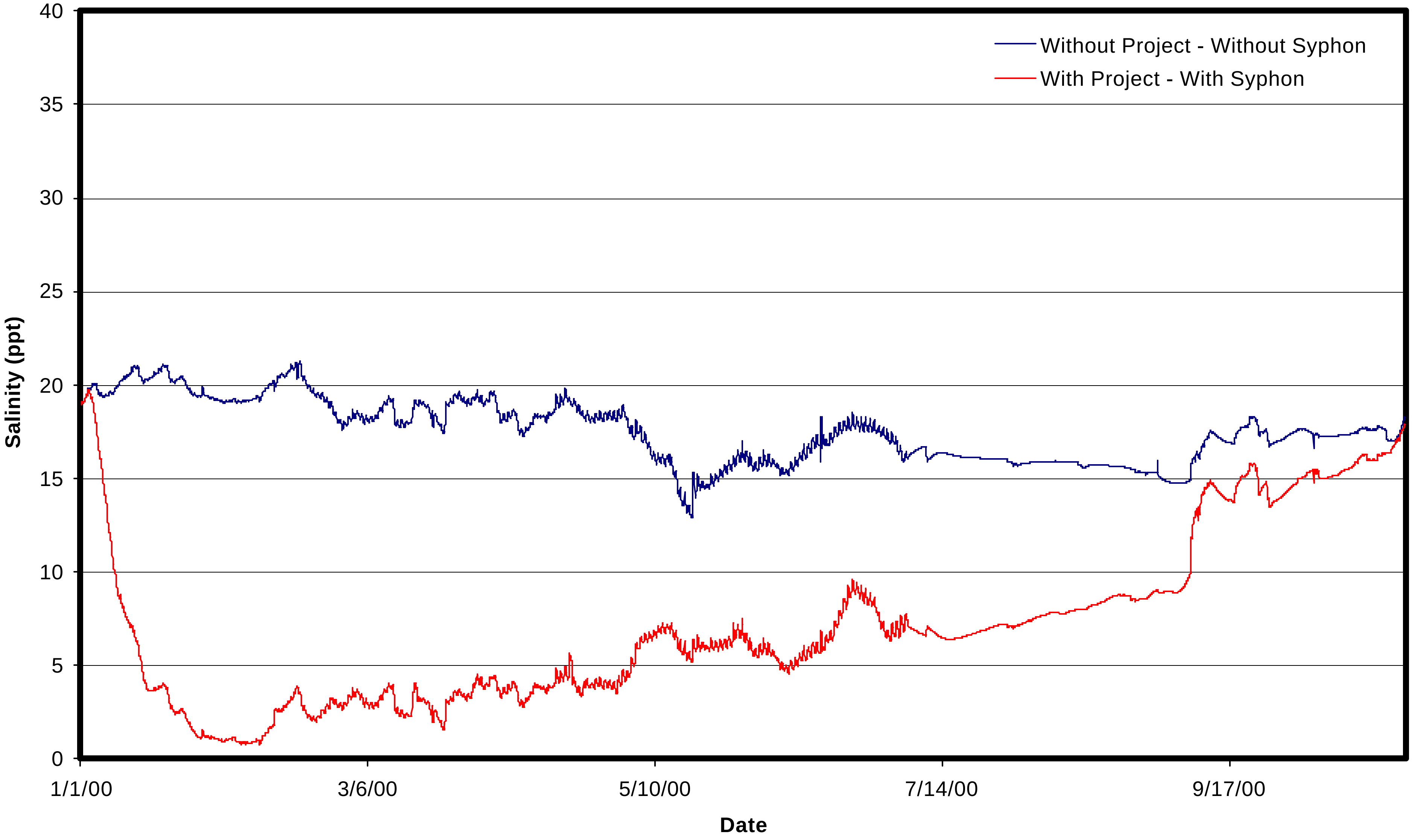

Figure 4.29: BA04-17 Salinity Variations for Run 1 Versus Run 4

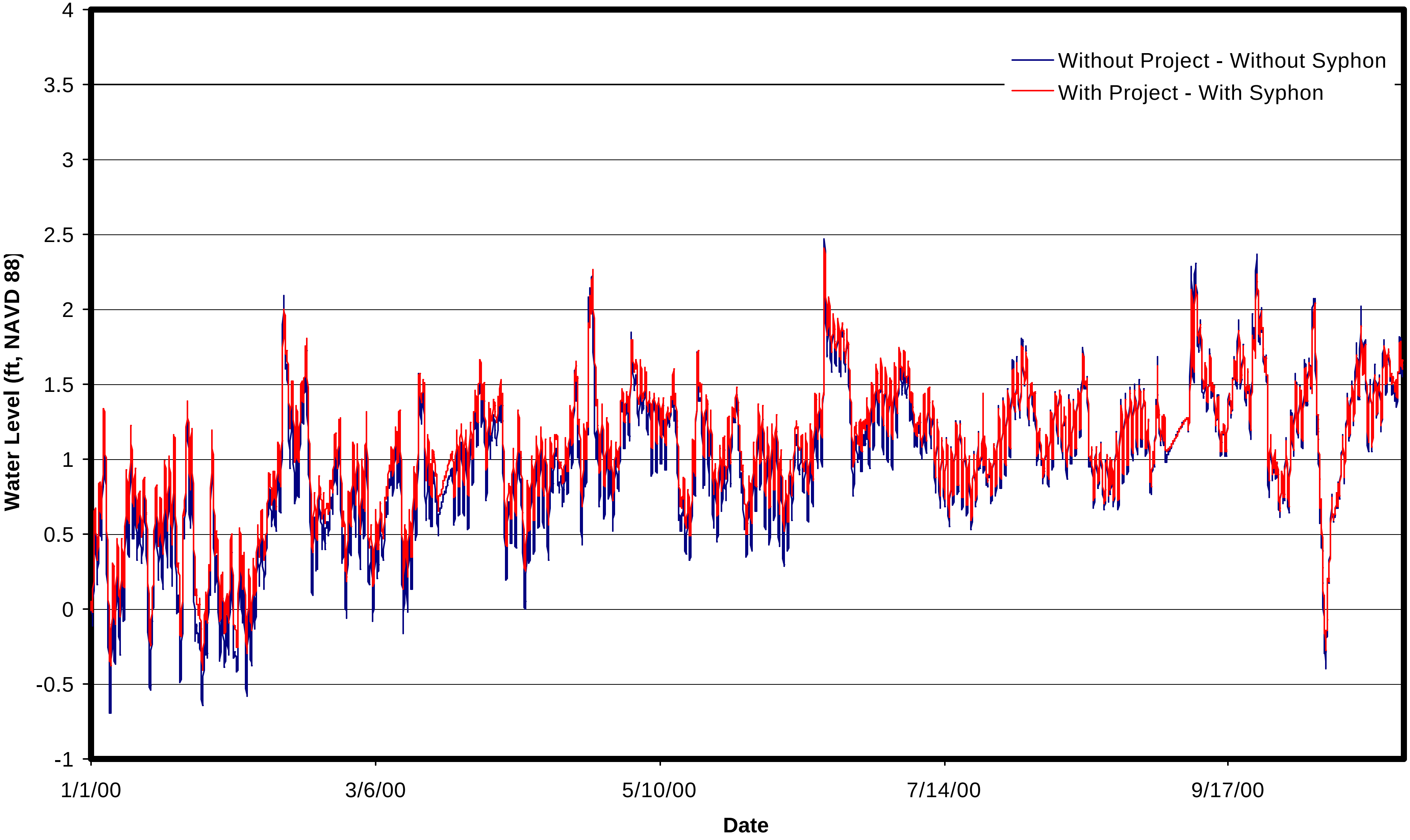

Figure 4.30: BA04-17 Water Level Variations for Run 1 Versus Run 4

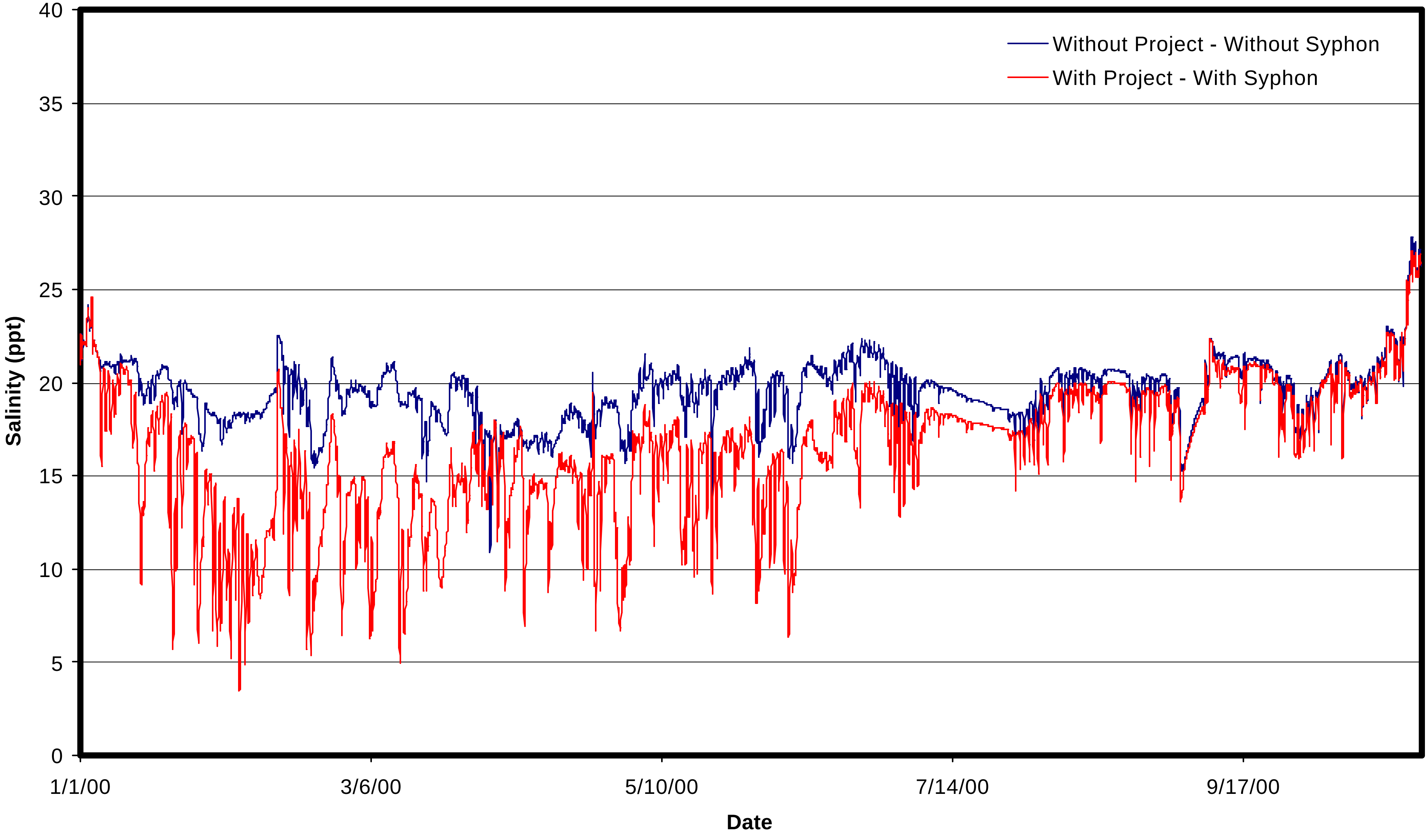

Figure 4.31: BA04-56 Salinity Variations for Run 1 Versus Run 4

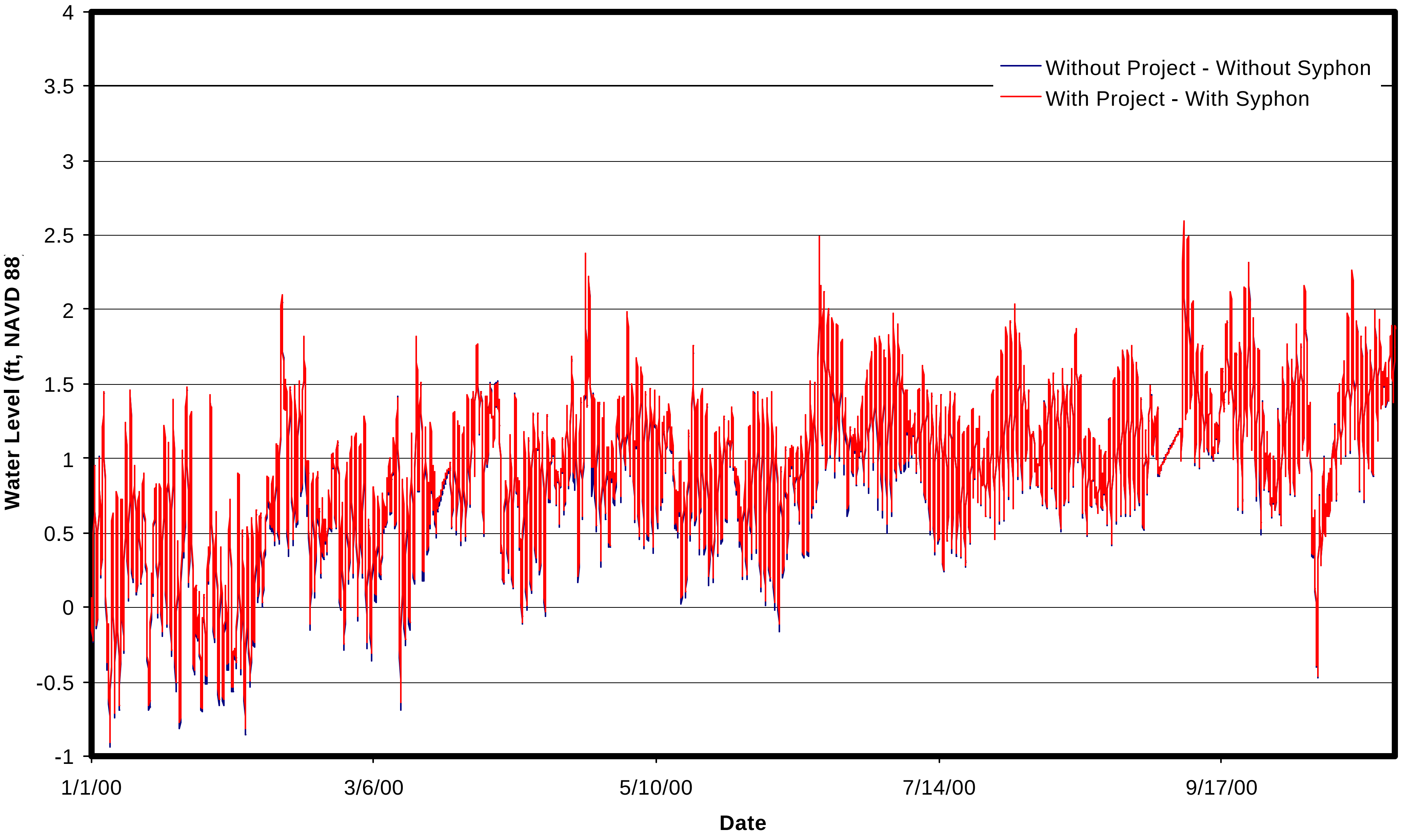

Figure 4.32: BA04-56 Water Level Variations for Run 1 Versus Run 4

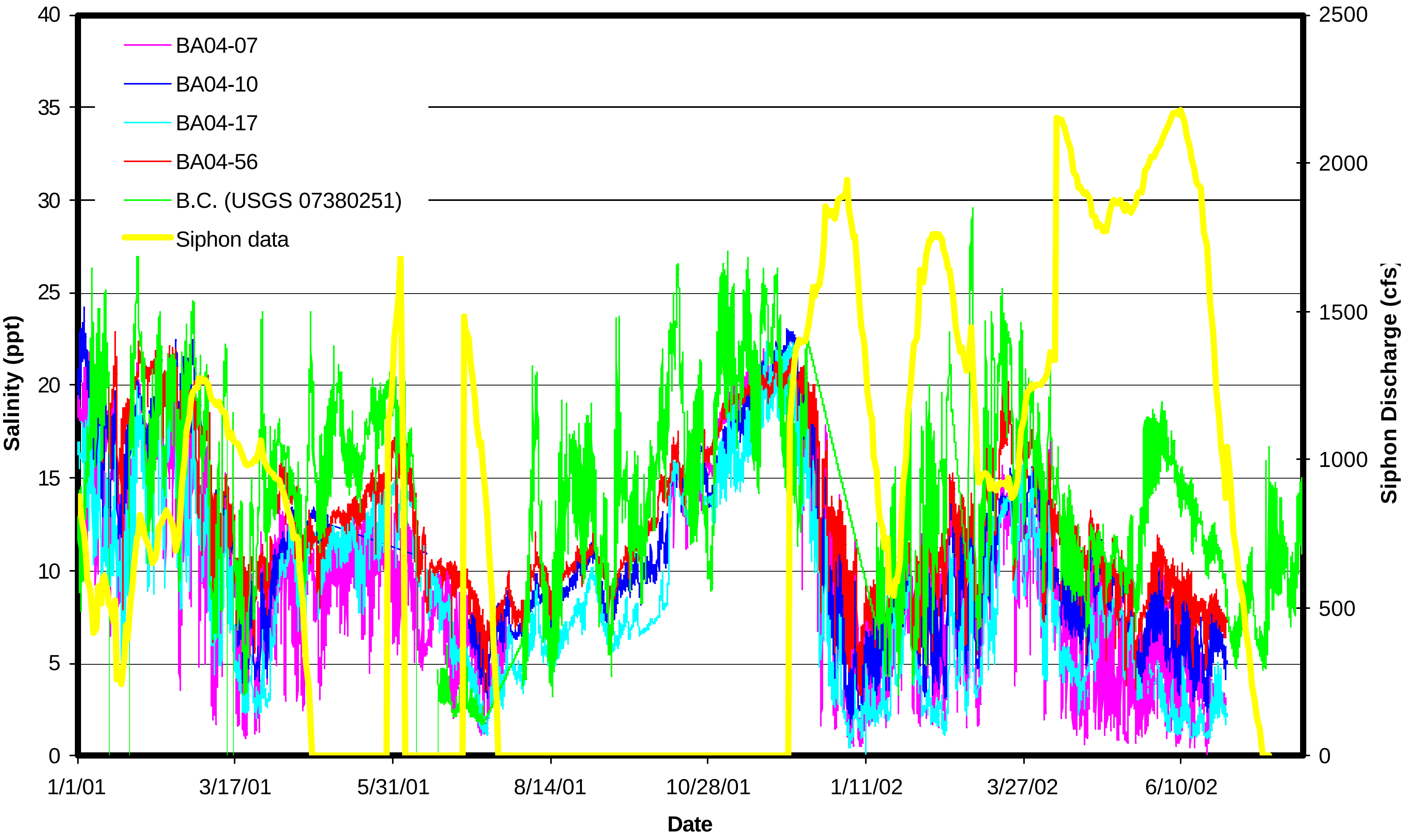

Figure 4.33: Salinity Raw Field Measurements at all Gauges to include Siphon Discharge Data.

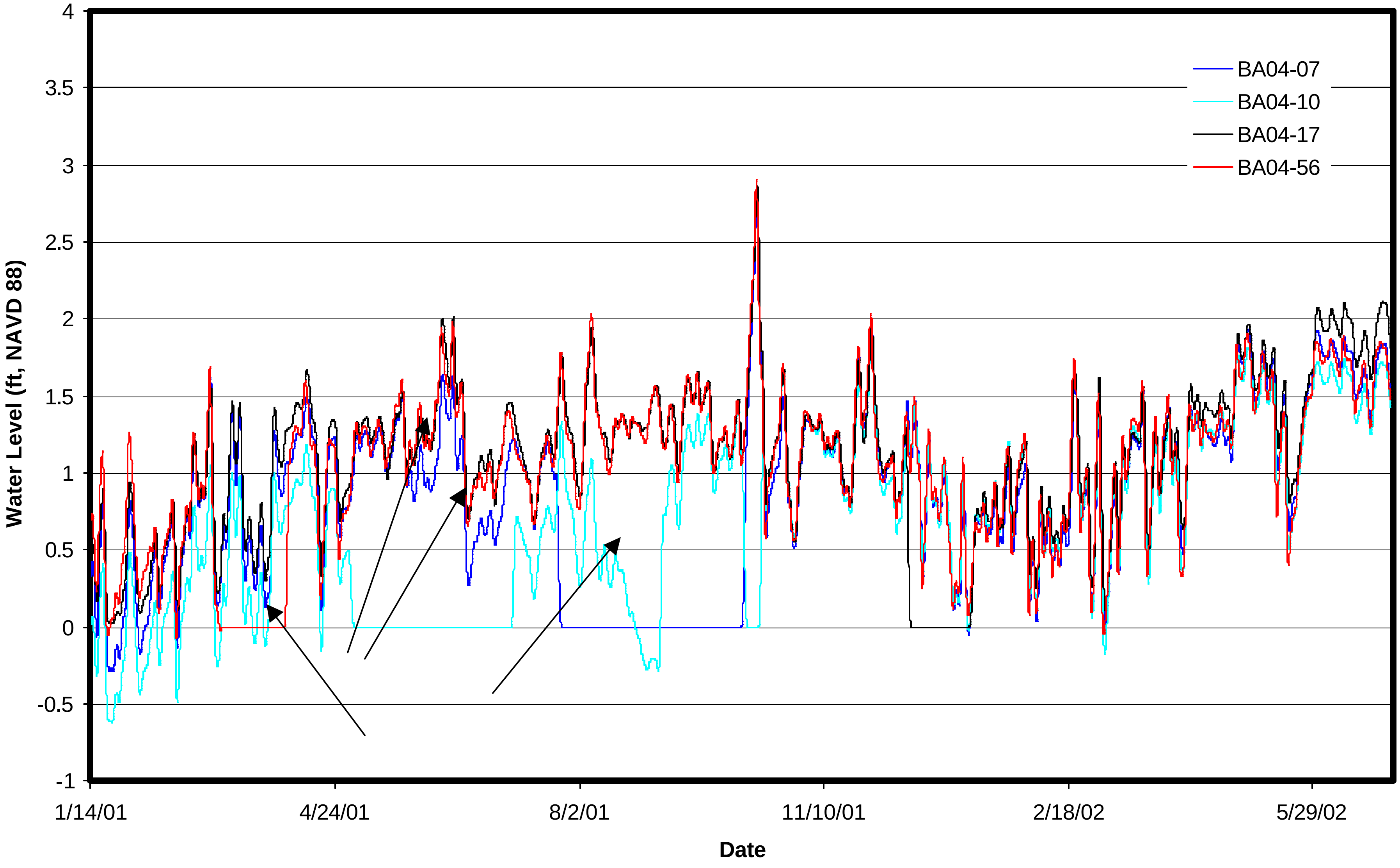

Figure 4.34: Water Level Raw Field Measurements At All Calibration Gauges

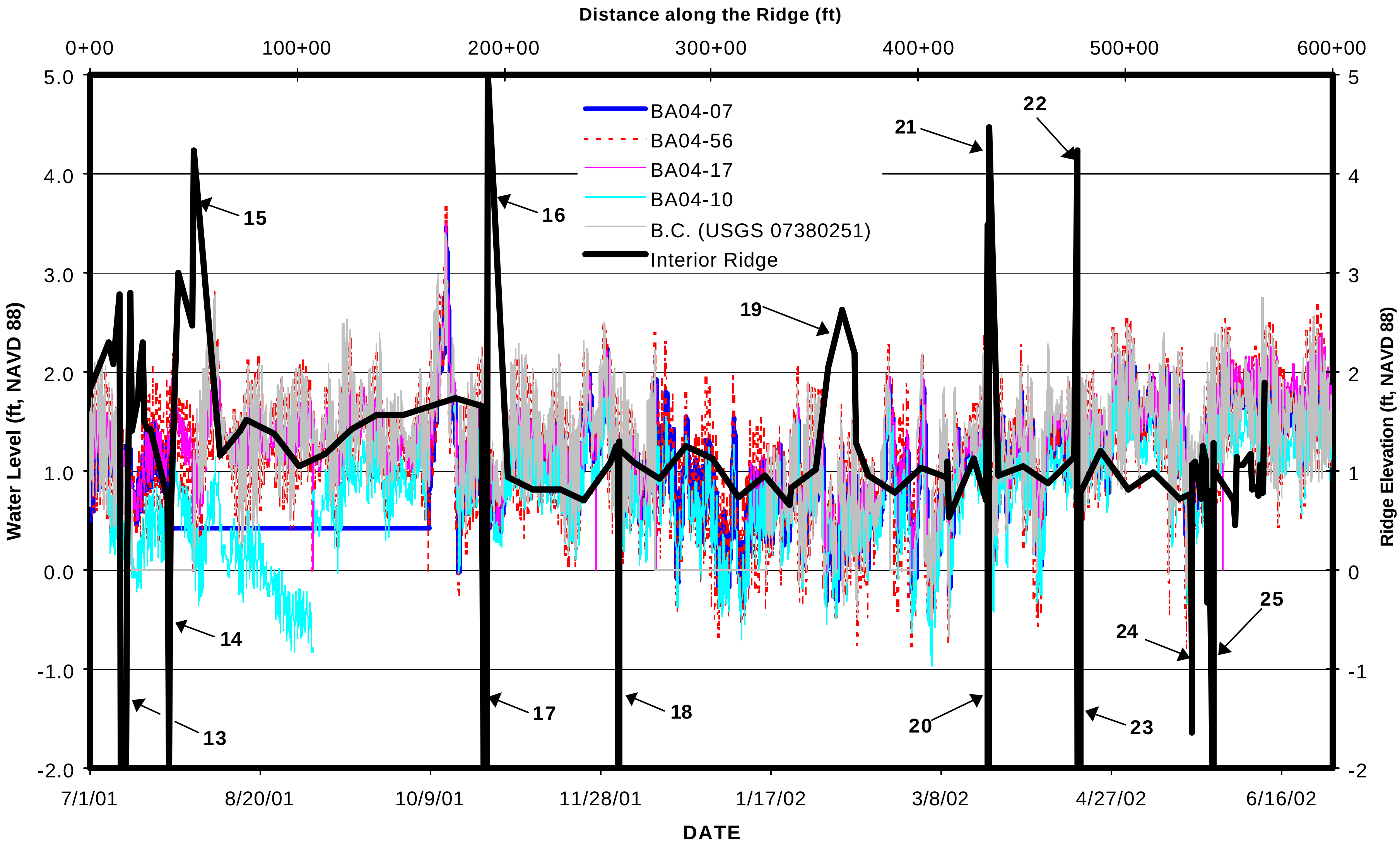

Figure 4.35: Graphic Illustrating Water Levels Of All Gauges to Include the Survey Profile of the Interior Ridge of Bayou Grand Chenier (Refer to Figure 2.3 For The Location of the Ridge)

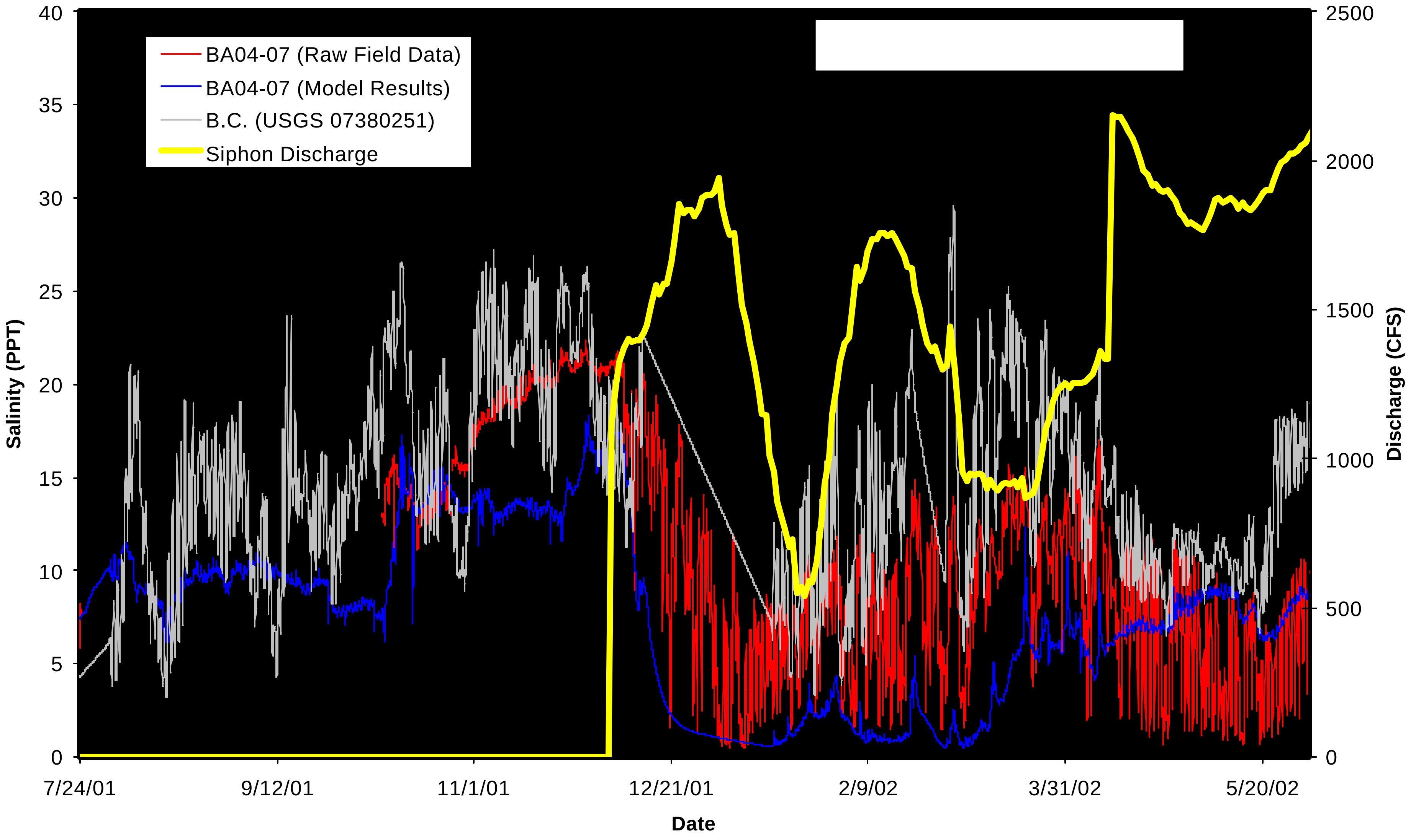

Figure 4.36: Gauge BA04-07 Salinity Variations Between Raw Field Data and Model Results Without Project Conditions as Compared to the USGS Boundary Condition and Siphon Discharge.

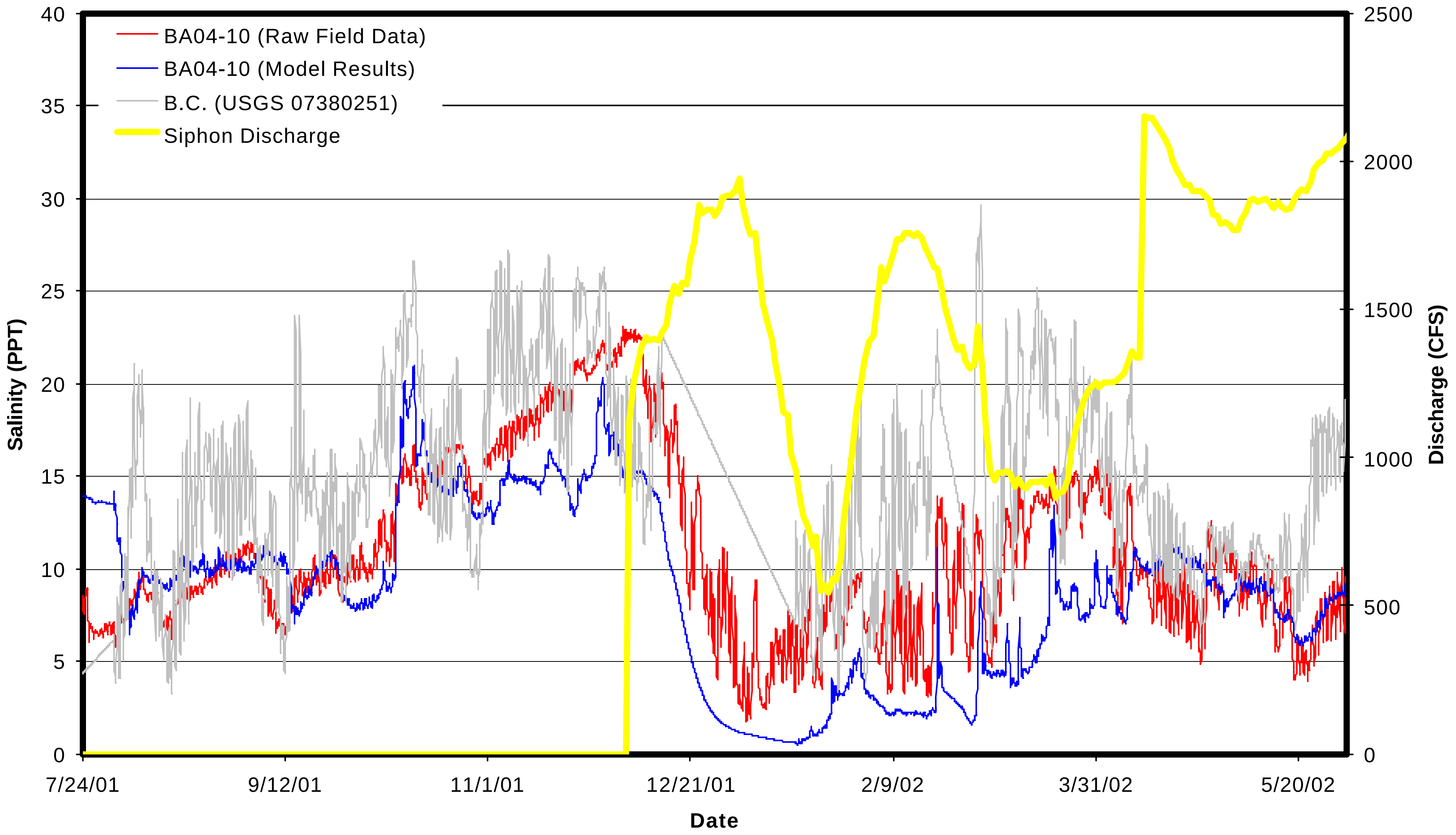

Figure 4.37: Gauge BA04-10 Salinity Variations Between Raw Field Data and Model Results Without Project Conditions as Compared to the USGS Boundary Condition and Siphon Discharge.

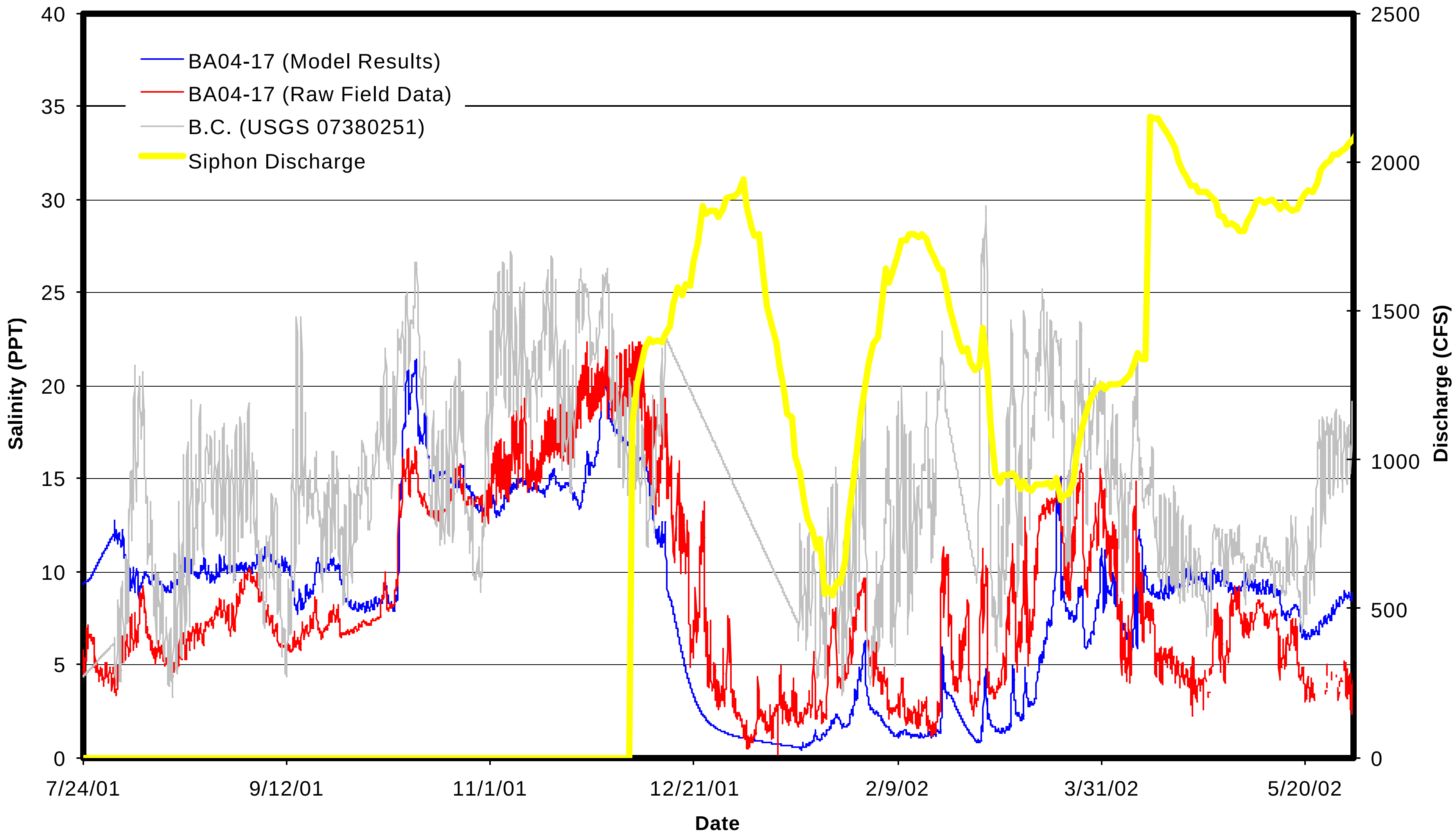

Figure 4.38: Gauge BA04-17 Salinity Variations Between Raw Field Data and Model Results Without Project Conditions as Compared to the USGS Boundary Condition and Siphon Discharge.

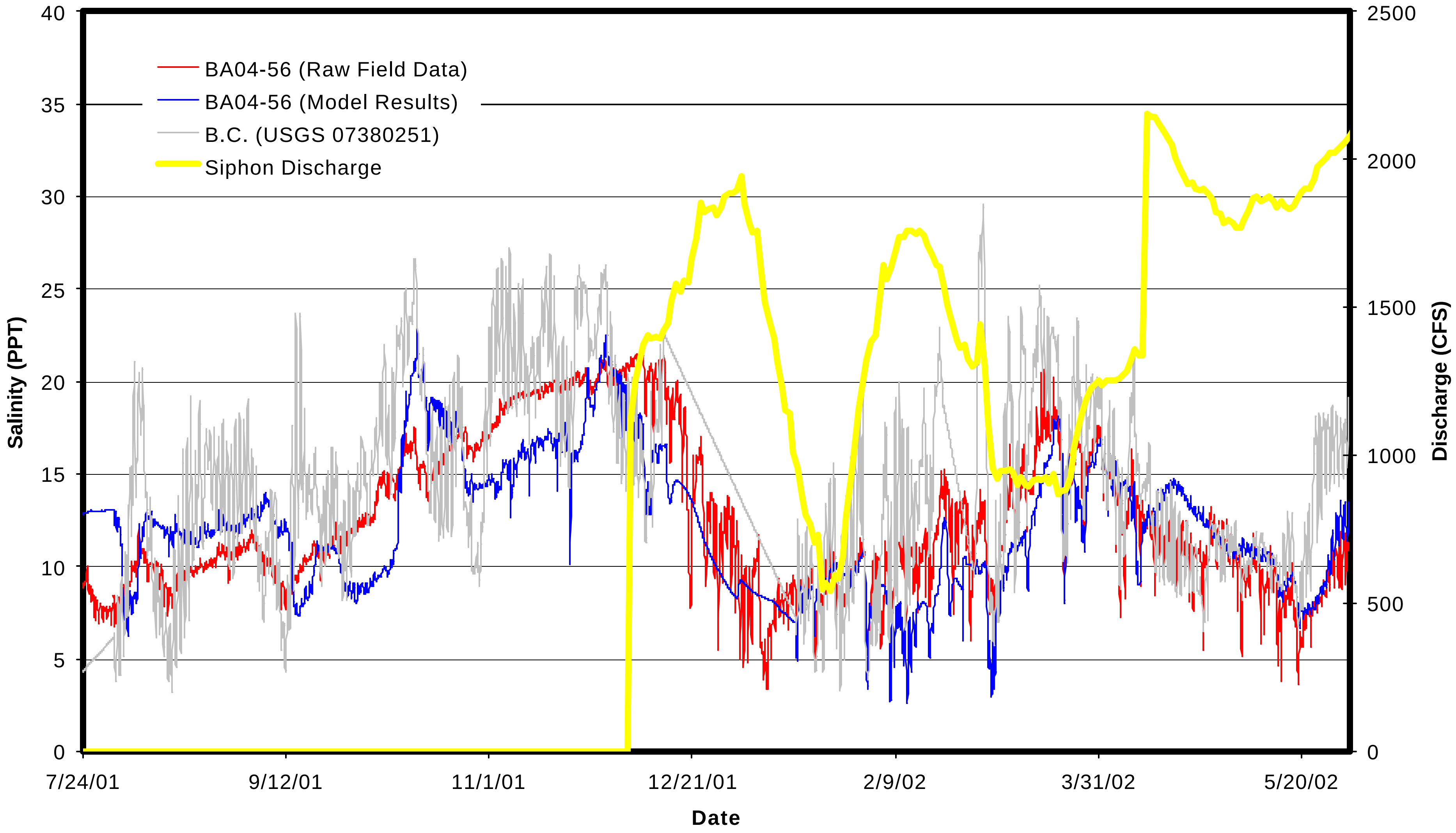

Figure 4.39: Gauge BA04-56 Salinity Variations Between Raw Field Data and Model Results Without Project Conditions as Compared to the USGS Boundary Condition and Siphon Discharge.

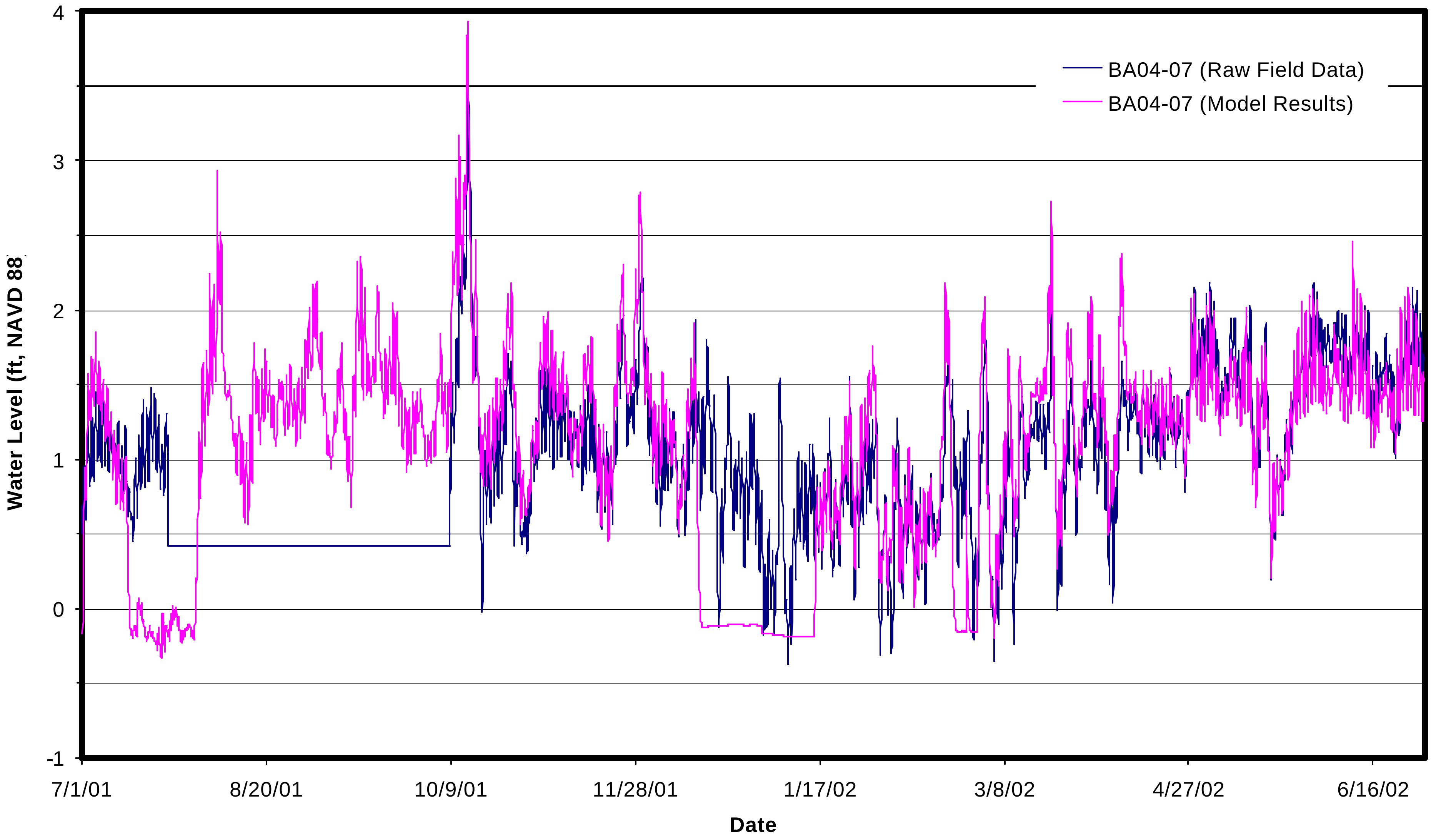

Figure 4.40: Gauge BA04-07 Water Level Comparison between Raw Field Data and Model Results Without Project Conditions

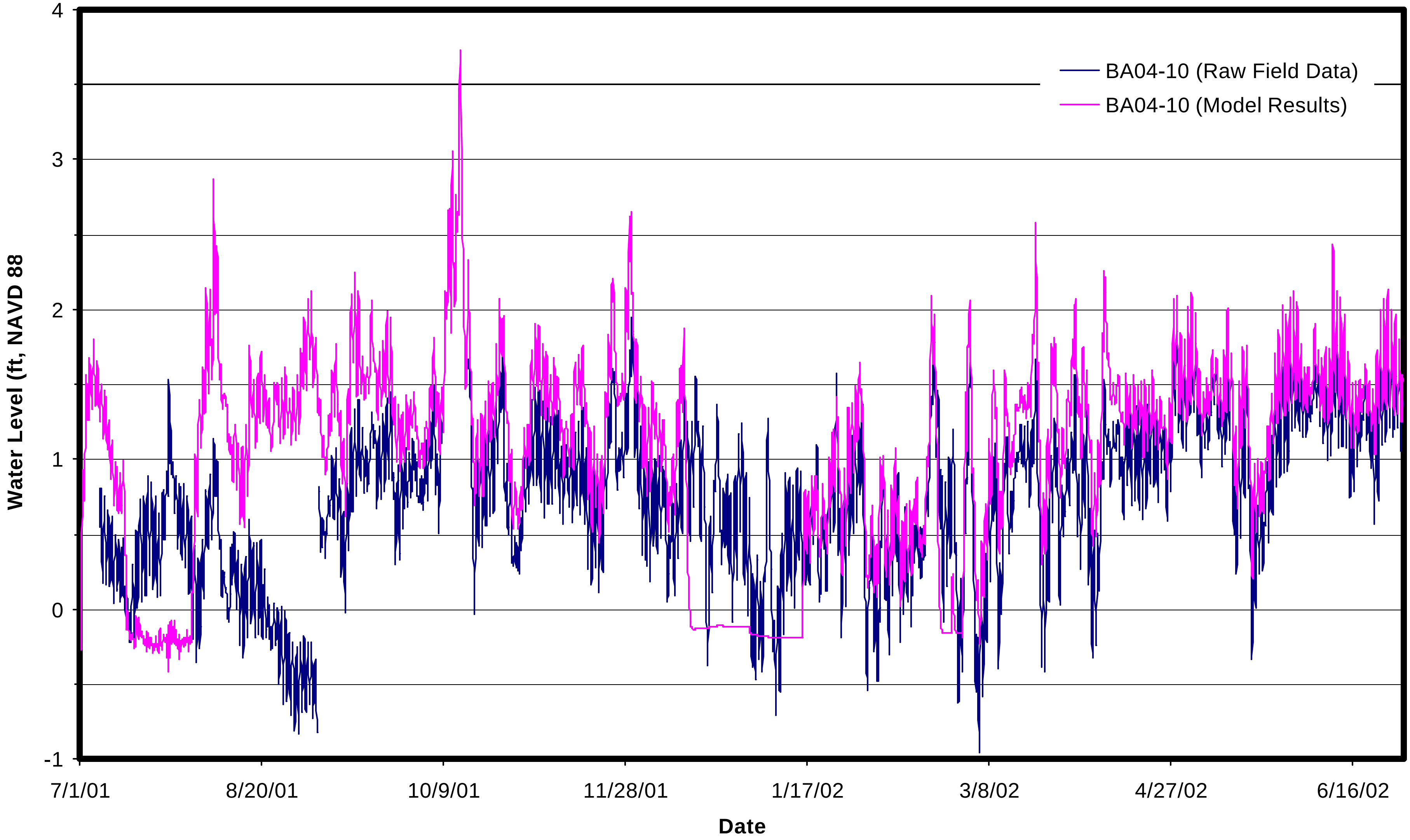

Figure 4.41: Gauge BA04-10 Water Level Comparison between Raw Field Data and Model Results Without Project Conditions

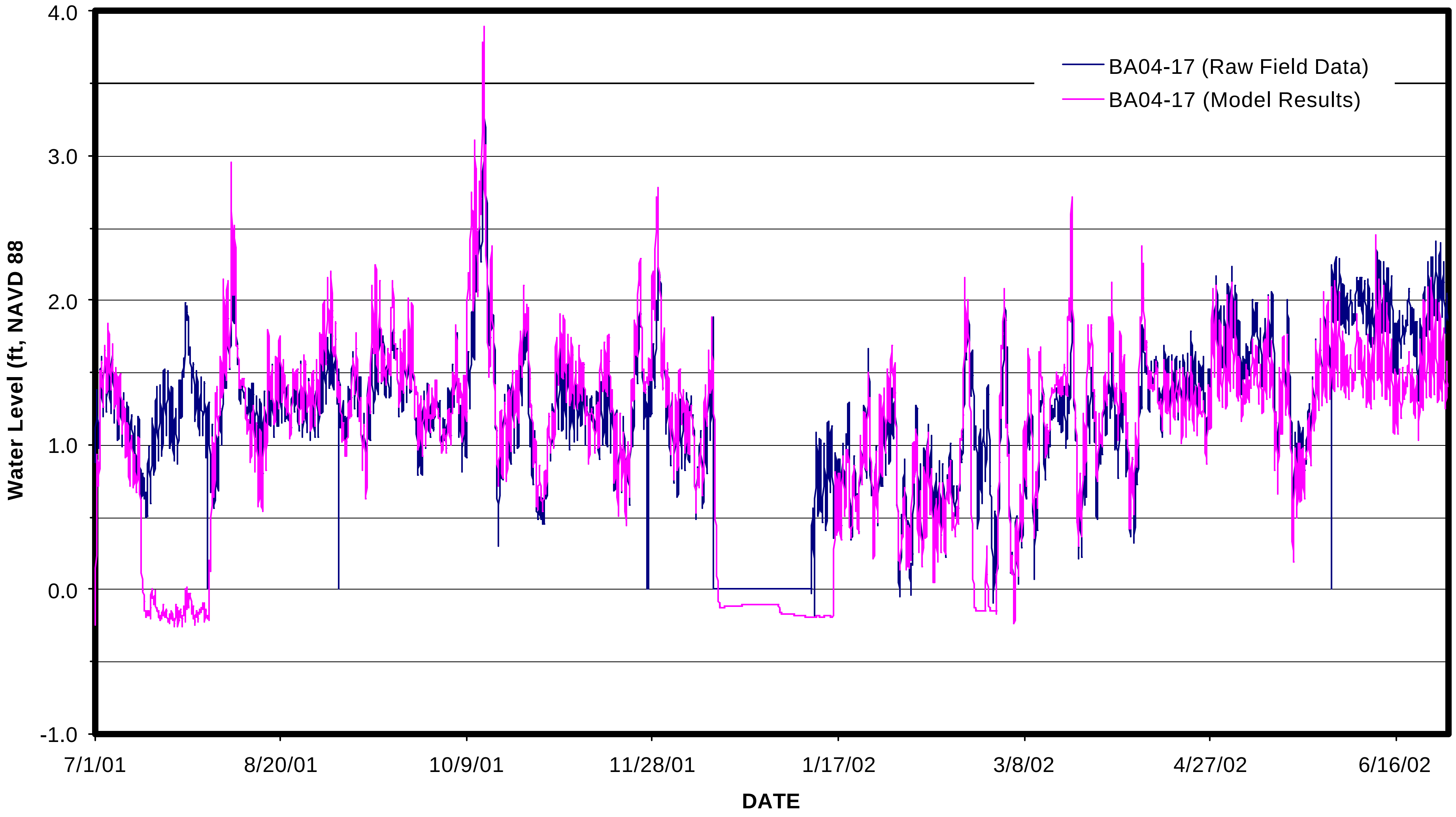

Figure 4.42: Gauge BA04-17 Water Level Comparison between Raw Field Data and Model Results Without Project Conditions

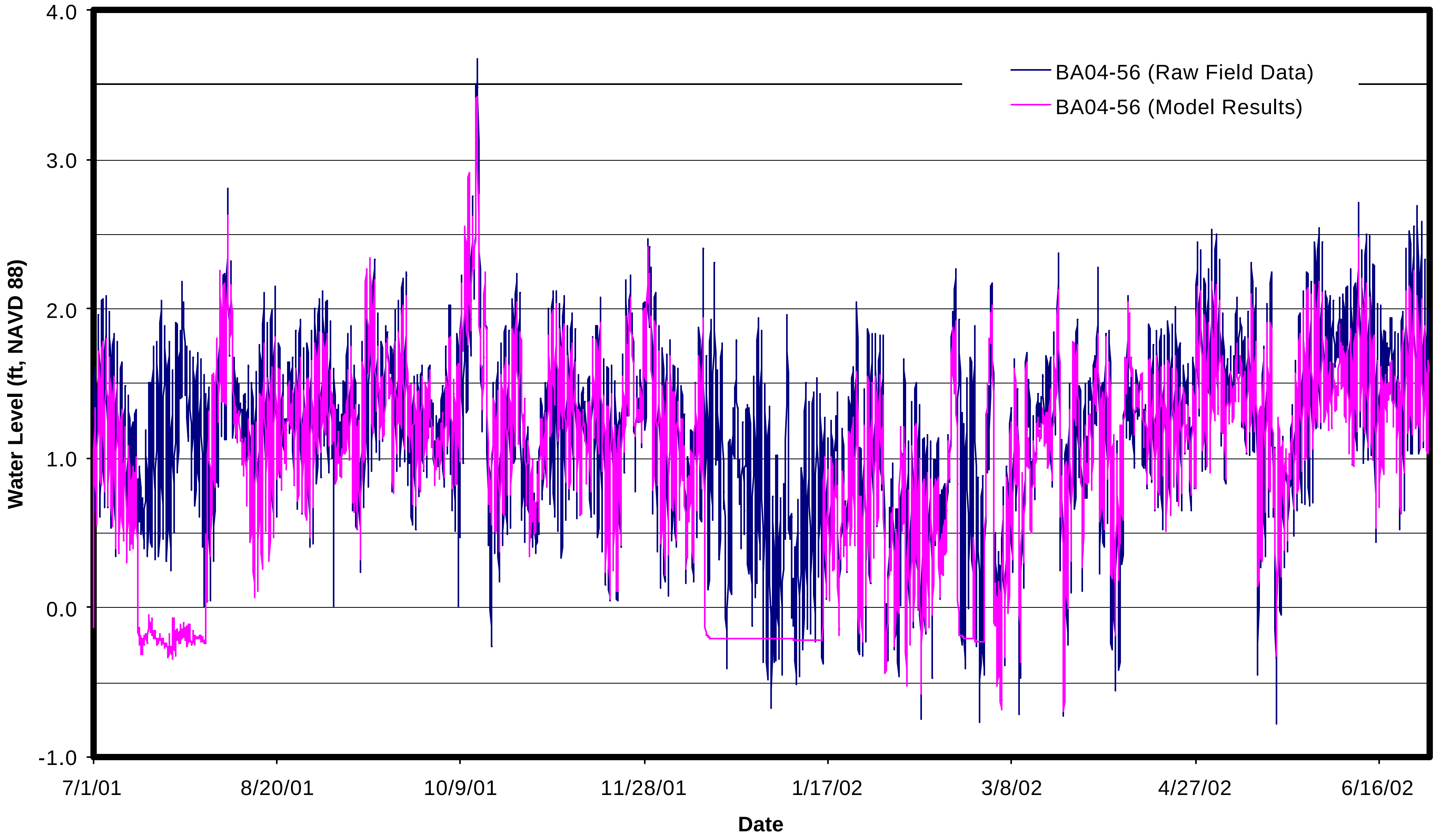

Figure 4.43: Gauge BA04-56 Water Level Comparison between Raw Field Data and Model Results Without Project Conditions

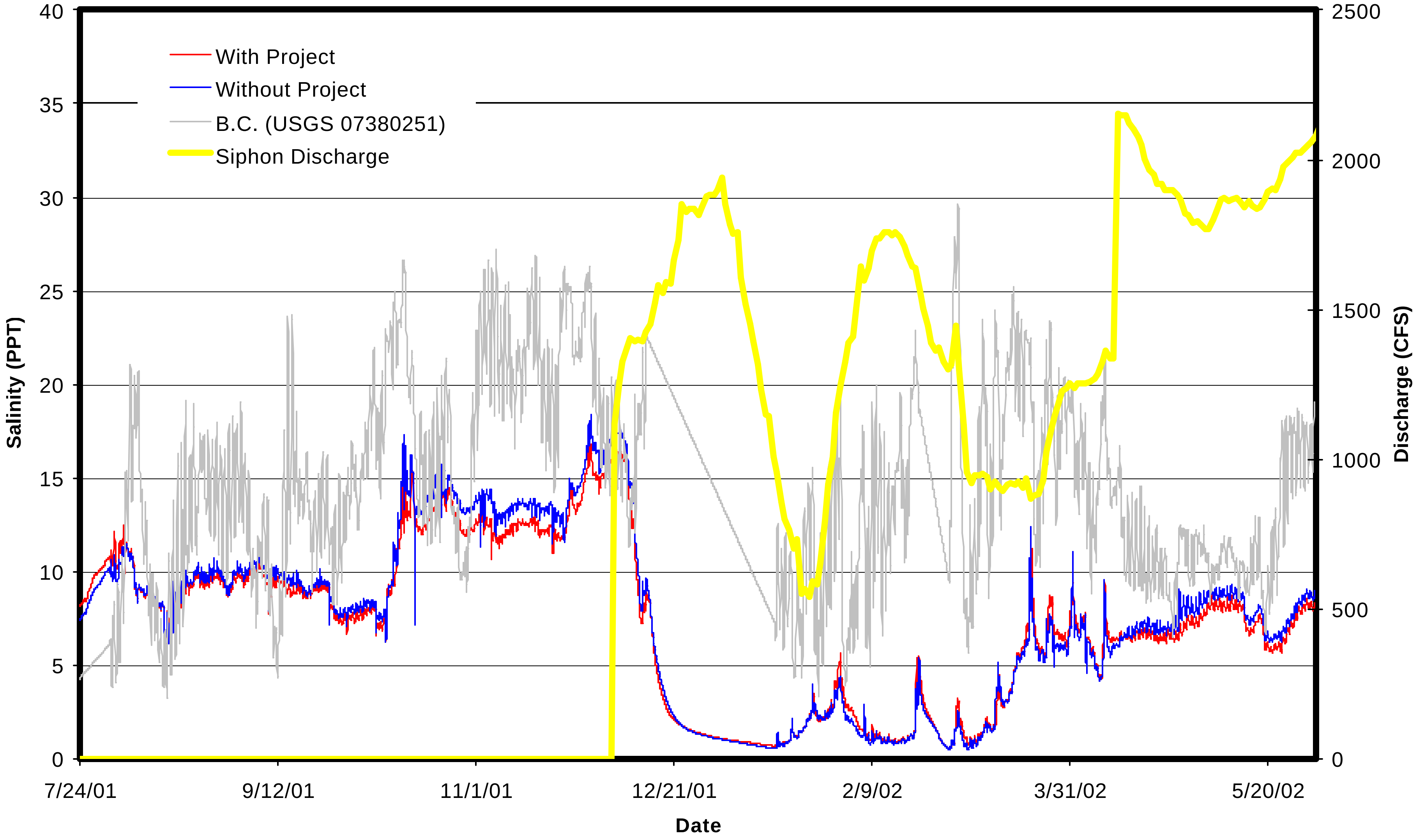

Figure 4.44: Gauge BA04-07 Modeled Salinity Variations Between With and Without Project Conditions as Compared to the USGS Boundary Condition and Siphon Discharge.

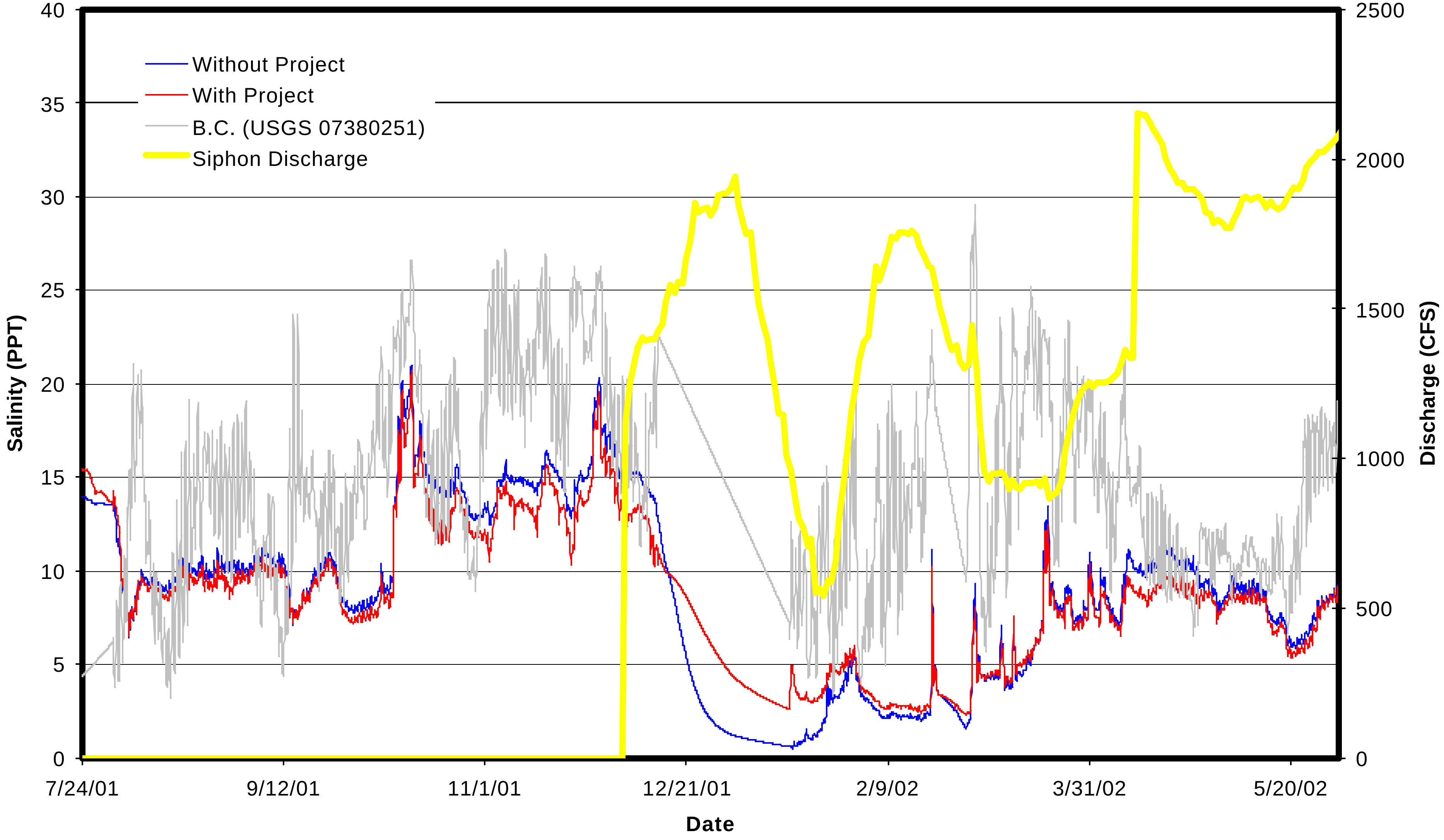

Figure 4.45: Gauge BA04-10 Modeled Salinity Variations Between With and Without Project Conditions as Compared to the USGS Boundary Condition and Siphon Discharge.

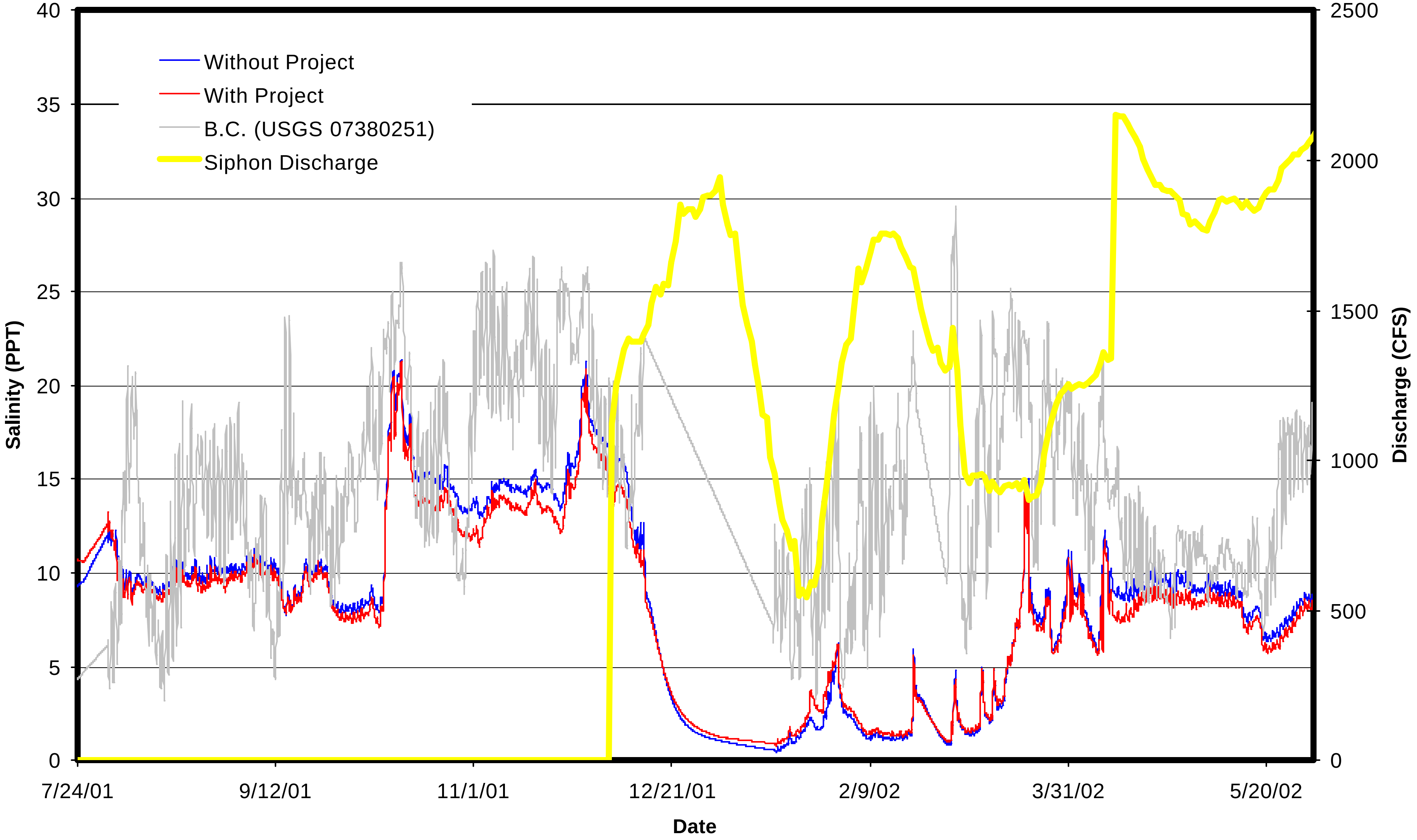

Figure 4.46: Gauge BA04-17 Modeled Salinity Variations Between With and Without Project Conditions as Compared to the USGS Boundary Condition and Siphon Discharge.

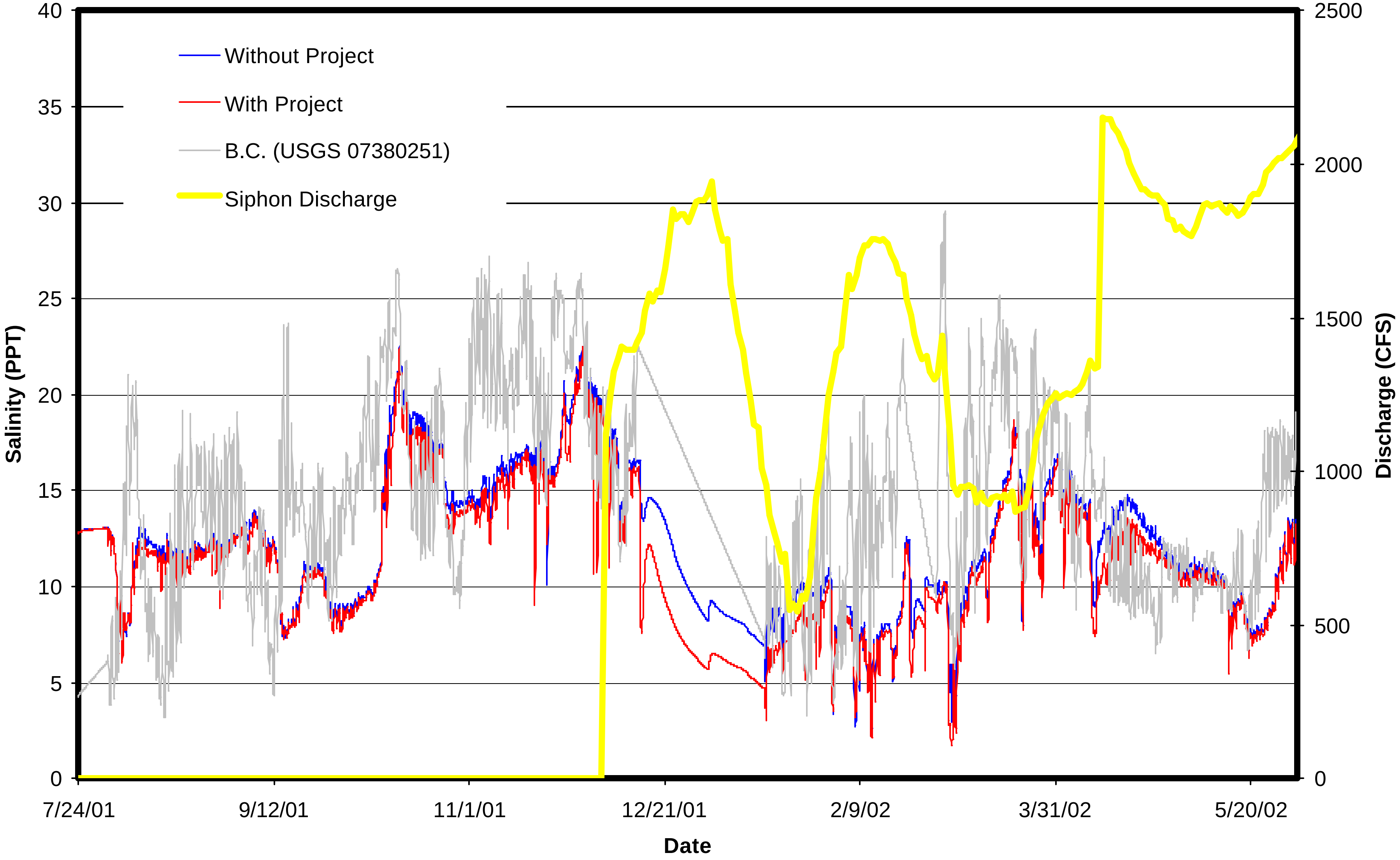

Figure 4.47: Gauge BA04-56 Modeled Salinity Variations Between With and Without Project Conditions as Compared to the USGS Boundary Condition and Siphon Discharge

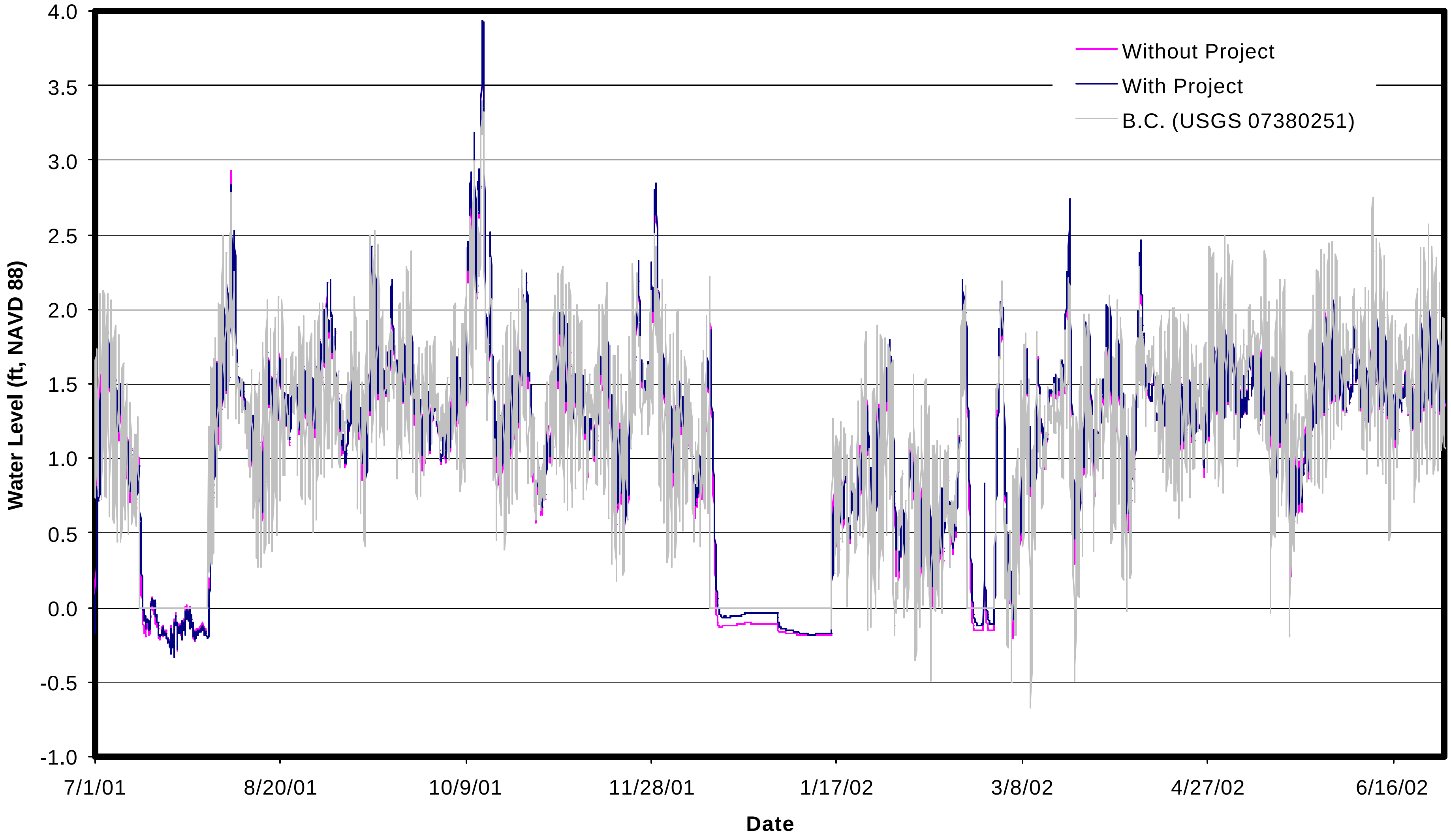

Figure 4.48: Gauge BA04-07 Modeled Water Level Variations Between With and Without Project Conditions as Compared to the USGS Boundary Condition.

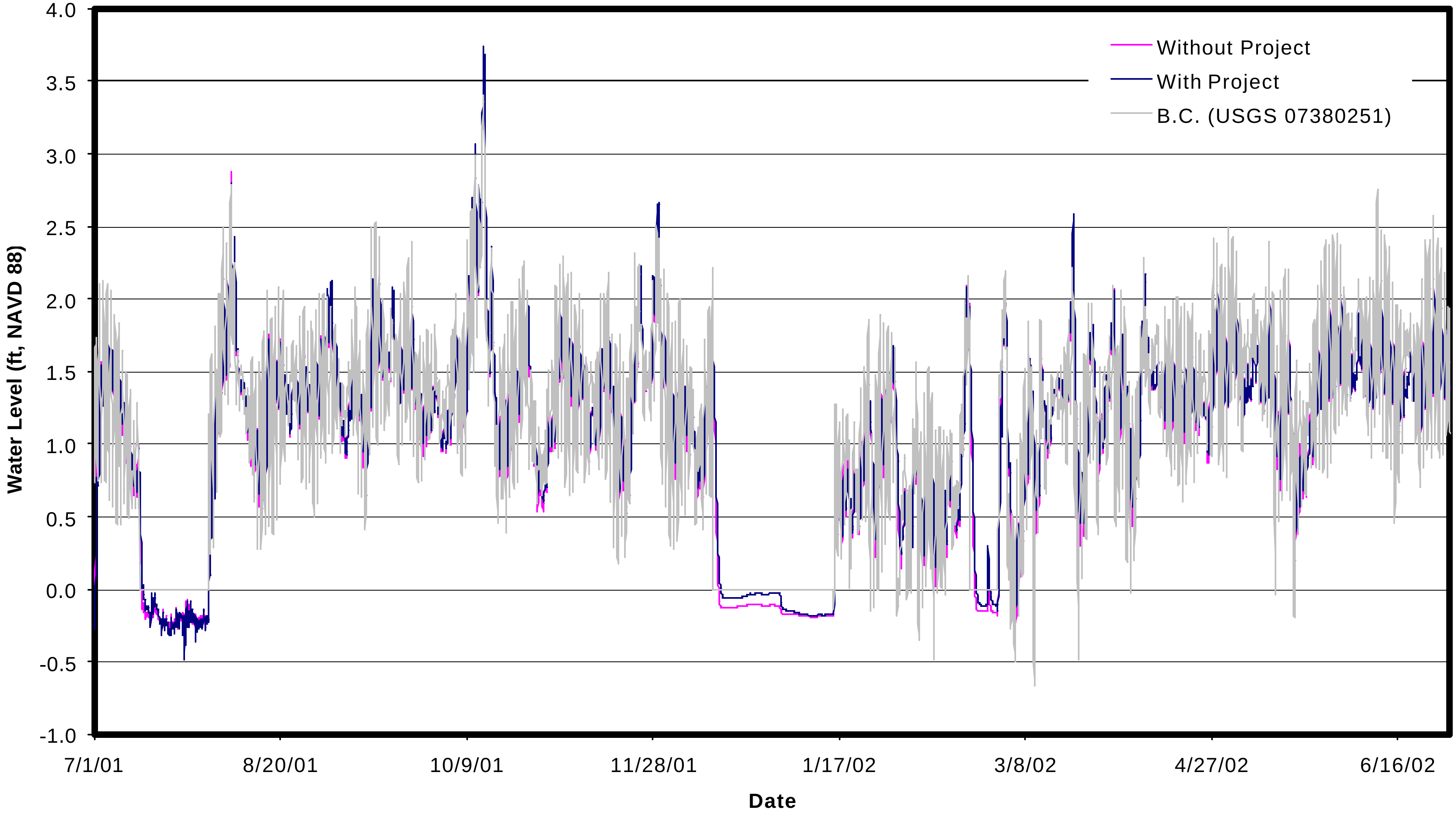

Figure 4.49: Gauge BA04-10 Modeled Water Level Variations Between With and Without Project Conditions as Compared to the USGS Boundary Condition.

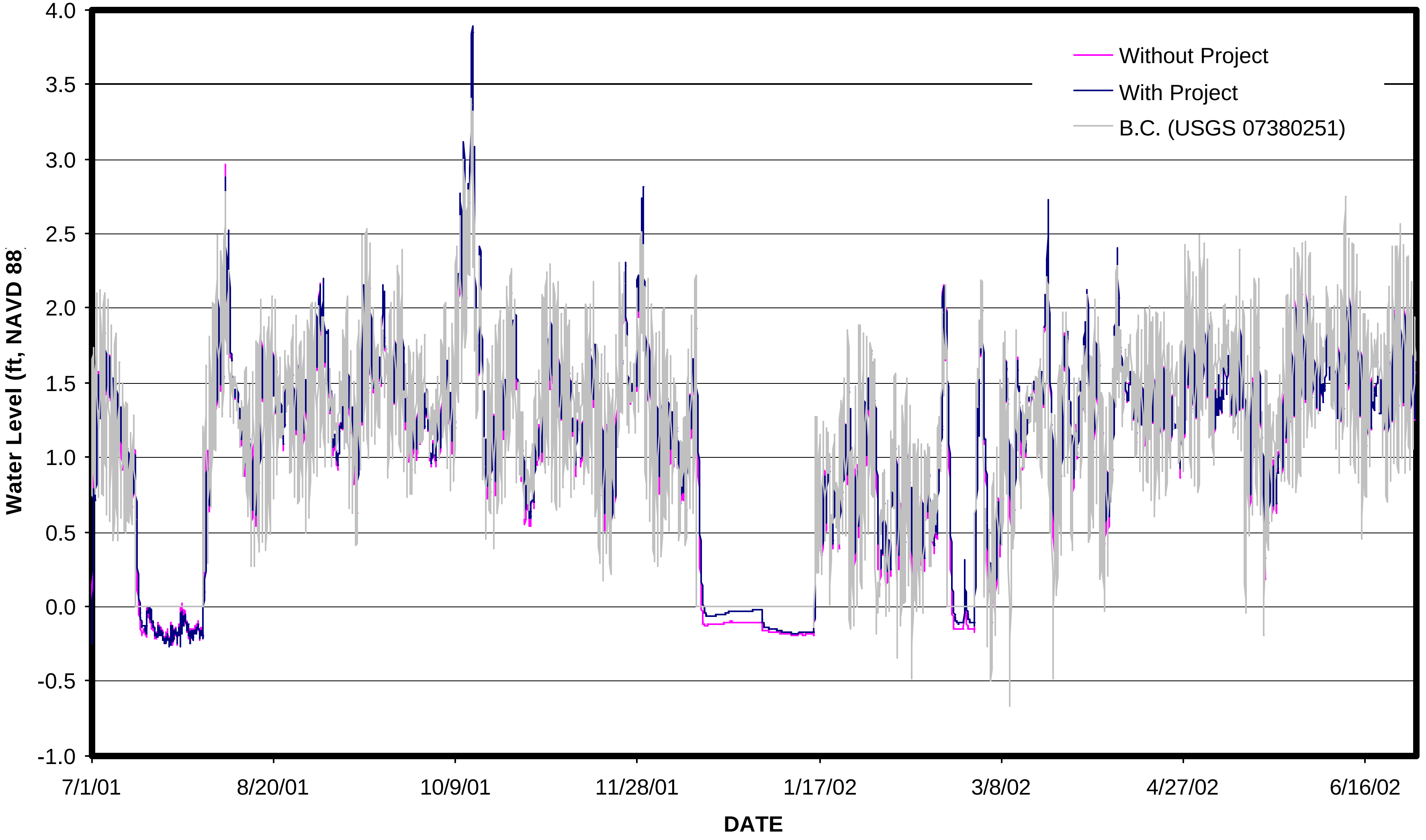

Figure 4.50: Gauge BA04-17 Modeled Water Level Variations Between With and Without Project Conditions as Compared to the USGS Boundary Condition.

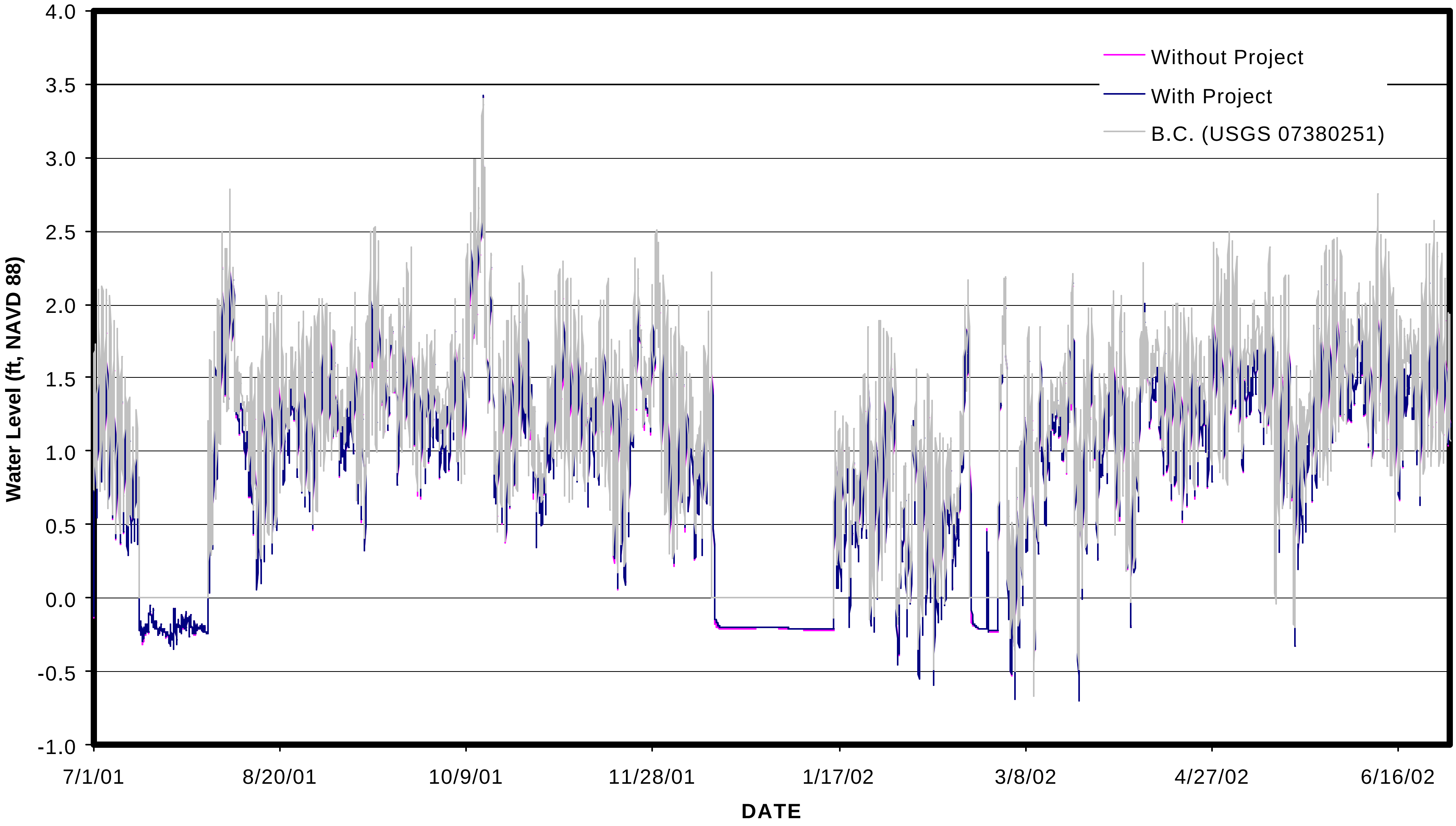

Figure 4.51: Gauge BA04-56 Modeled Water Level Variations Between With and Without Project Conditions as Compared to the USGS Boundary Condition.