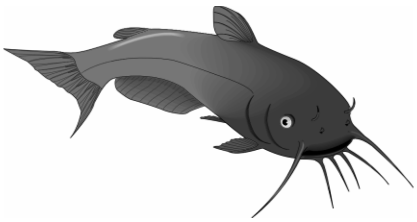
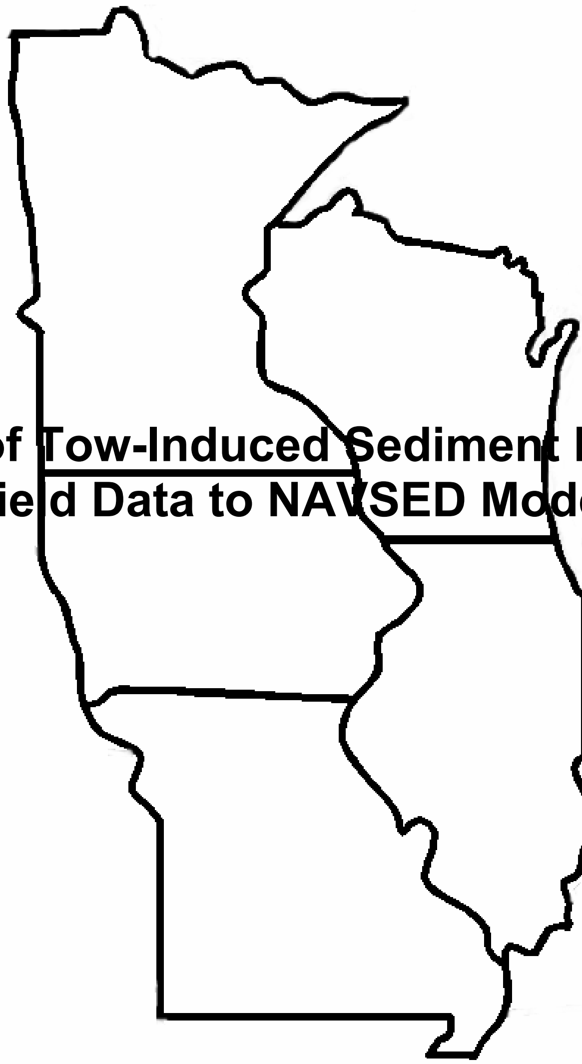
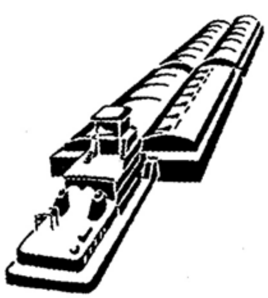
ENV Report 49

Interim Report For The Upper Mississippi River – Illinois Waterway System Navigation Study





Comparison of Tow-Induced Sediment Resuspension Field Data to NAVSED Model



US Army Corps of Engineers®

June 2005

Rock Island District
St. Louis District
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Upper Mississippi River - Illinois Waterway System Navigation Study

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Comparison of Tow-Induced Sediment Resuspension Field Data to NAVSED Model

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Interim report

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ABSTRACT: The NAVSED does *NAVSED* need spelled out the first time it's used? model for tow induced sediment resuspension was evaluated using field data collected at Pool 13 on the Mississippi River and LaGrange Pool on the Illinois Waterway. Sediment concentration, velocity, and water level variation was measured in the near-bank zone where depths were about 0.9 m. Shoreline resuspension at Pool 13 results predominantly from wave action. At LaGrange Pool, the smaller channel size results in return velocity causing a significant contribution to sediment resuspension and the small distance from the sailing line to the shoreline results in the propeller jet resuspension reaching the shoreline. The waves from the tow tend to be smaller at LaGrange due to the lower tow speeds in the smaller channel. Comparisons of observed sediment concentration at Pool 13 were limited to four events that produced significant resuspension at the shoreline gages. Comparisons of observed sediment concentration at LaGrange Pool was conducted for 10 events that produced maximum change in sediment concentration at the shoreline gages ranging from 30 to 230 mg/L. The total sediment resuspended during an event was conservatively estimated by NAVSED. In only a few cases, peak, short-lived, maximum concentrations were underestimated by NAVSED. This report concludes the NAVSED estimates of tow induced sediment resuspension are adequate for the Upper Mississippi River – Illinois Waterway (UMR – IWW) System Navigation study.

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Preface

The work reported herein was conducted as part of the Upper Mississippi River – Illinois Waterway (UMR – IWW) System Navigation Study. The information generated for this interim effort will be considered as part of the plan formulation process for the System Navigation Study.

The UMR-IWW System Navigation Study is being conducted by the U.S. Army Engineer Districts of Rock Island, St. Louis, and St. Paul under the authority of Section 216 of the Flood Control Act of 1970. Commercial navigation traffic is increasing, and in consideration of existing system lock constraints, will result in traffic delays that will continue to grow in the future. The system navigation study scope is to examine the feasibility of navigation improvements to the Upper Mississippi River and Illinois Waterway to reduce delays to commercial navigation traffic. The study will determine the location and appropriate sequencing of potential navigation improvements on the system, prioritizing the improvements for the 50-year planning horizon from 2000 through 2050. The final product of the System Navigation Study is a Feasibility Report which is the decision document for processing to Congress.

This study was conducted in the Coastal and Hydraulics Laboratory (CHL), U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS. The work was conducted under the direction of Mr. Thomas A. Richardson, Director, CHL. This report was written by Dr. Stephen T. Maynord and Mr. Timothy L. Fagerburg CHL, ERDC. Permission was granted by the Chief of Engineers to publish this document.

At the time of publication of this report, COL James R. Rowan, EN, was Commander Executive Director of ERDC. Dr. James R. Houston was Director.

1 Introduction

Background

The Upper Mississippi River-Illinois Waterway (UMR – IWW) System Navigation (Feasibility) Study (U.S. Army Corps of Engineers 1994) is evaluating additional lockage capacity on the UMR – IWW. As part of that study, the effects of increased tow traffic on environmental concerns is being evaluated. One aspect is resuspension of sediments by tows as a result of their return velocity, waves, and propeller jets. NAVSED (Copeland et al. 2001) is an empirical model developed for the UMR-IWW study for estimating sediment concentration versus time due to tow passage. NAVSED provides a sediment concentration time history at each 10 m wide cell across the channel cross section based only on information at that cross section. NAVSED uses hydraulic forces determined from NAVEFF spell out NAVEFF? (Maynord et al. 2004) for propeller jet, return velocity, drawdown, wave height, and hull effects beneath the barges.

Objective

The primary objective of this study is to compare NAVSED sediment concentration predictions to observed data that was not used in the development of the model. This report focuses on comparing time histories of sediment concentration along the shoreline of the main channel.

Approach

Field sediment type data was collected in July 2002 at various sites along the Upper Mississippi River System (UMRS). Sediment samples were analyzed and classified according to the classification system used in the UMRS study given in Parchure, McAnally, and Teeter (2001). From this sampling program, 2 sites on the Mississippi River (in Pools 10 and 13) and one site on the Illinois (in LaGrange Pool) were selected for detailed monitoring of sediment resuspension as a result of tow passage. Tow event data was collected near Mississippi River Mile 542 in Pool 13 (Soupbone Island reach) from 11/7/2002 to 11/11/2002. Tow event data was collected near Illinois Waterway River Mile 95 in LaGrange Pool (Sangamon Bay/Sugar Creek Island reach) from 11/13/2002 to 11/17/2002. Tow event data was attempted to be collected in Mississippi River Pool 10

(Frenchtown Lake reach) but the site experienced constant accumulation of aquatic vegetation on the instruments and could not be used in the comparison. The field data was analyzed and tow events were selected and compared to the NAVSED model.

2 Sediment Sampling at Side Channels and Backwaters

UMRS Sediment Classification

The sediment classification scheme used on the UMRS is presented in Parchure, McAnally, and Teeter (2001). Sediments are classified as non-cohesive, group 1 cohesive, and group 2 cohesive to indicate the relative erodibility of the material. Group 1 cohesive has 70% or more particles finer than 4 microns. None of the UMRS samples fell into Group 1 cohesive. Group 2 cohesive had 70% or more particles finer than 62 microns or 16% or more clay. Non-cohesive sediments had 30% or more particles greater than 62 microns. Group 2 cohesive sediments were classified as either soft, medium, or hard depending on their organic content and bulk density, as shown in Table 1. None of the UMRS group 2 cohesive sediments were classified as hard. Therefore, all UMRS sediments were classified as either non-cohesive, group 2 cohesive soft, or group 2 cohesive medium.

Table 1
Classification of Group 2 Cohesive Sediments

Percentage of Organic Material		
Less than 5%	**5-10%**	**Greater than 10%**
Sediment type based on % organic material and bulk density (BD), kg/cu m		
Soft if BD<1500	Soft if BD<1400	Soft if BD<1300
Medium if BD =1500-2200	Medium if BD =1400-2100	Medium if BD =1300-2000
Hard if BD > 2200	Hard if BD > 2100	Hard if BD > 2000

Sediment Sampling

Pokrefke et al. (2003) identifies backwaters (BW) and secondary channels (SEC) having the potential for impacts regarding infilling with sediment from tow resuspension. Pokrefke identified 12 BW and 4 SEC on the Mississippi River and 6 BW and 15 SEC on the Illinois Waterway having the potential for tow effects. A detailed sediment sampling program was undertaken in July 2002 at 11 BW and SEC on the Mississippi River and 6 BW and SEC on the Illinois Waterway. Many of the selected sample sites were the same sites identified by

Pokrefke et al. (2003) as having the potential for tow impacts. The general sampling scheme near a BW and SEC inlet is shown in Figure 1 and focuses on the near-bank region upstream of the inlet. Results of the sampling are shown in Table 2. Also shown is the sediment classification used in evaluating the BW and SEC in Pokrefke et al. (2003). In all cases, the sediment classification used in the original modeling was either correct or used a sediment type that was more erodible, i.e., showed greater impact than would actually occur.

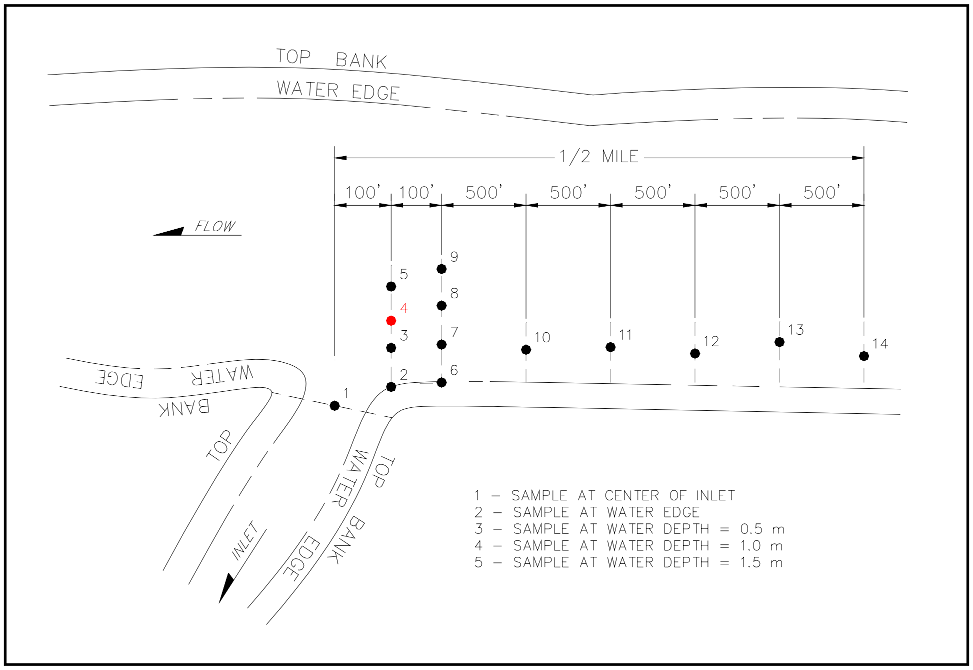

Figure 1. Sampling locations

Site Selection for Tow Event Field Studies

Based on the sediment data and the BW and SEC identified by Pokrefke as having potential impacts, the three sites indicated in the Introduction — Pool 10, Pool 13, and LaGrange Pool — were selected to monitor tow impacts. Tow event data was attempted to be collected in Mississippi River Pool 10 (Frenchtown Lake reach) but the site experienced constant accumulation of aquatic vegetation on the instruments and could not be used in the comparison. I think you should repeat this statement her – In previous sentence, you state that three sites were selected, but then only Pool 13 and LaGrange Pool are discussed below.

Table 2
UMRS Sediment Data Collection, July 2002

Location	Site Name	River Mile	Total No. of Samples	No. of Sample Classed Non-Cohesive	No. of Sample Classed Cohesive	No. of Cohesive Samples Classed		Class. Used for Modeling
						Medium	Soft	
Pool 10, MR	Frenchtown Lake-North	520.3	14	13	1	0	1	Cohesive-Medium
	Frenchtown Lake-South[1]	619.9	17	11	6	6	0	Cohesive-Medium
Pool 11, MR	Island 189	614.0	17	12	5	5	0	Non-Cohesive
	Cassville Slough-North	613.9	11	10	1	1	0	Non-Cohesive
	Cassville Slough Complex	613.1	14	13	1	1	0	Non-Cohesive
	Goetz Slough	612.6	14	10	4	4	0	Non-Cohesive
Pool 13, MR	Big Soupbone Island-South[1]	543.3	14	9	5	5	0	Cohesive-Soft
	Big Soupbone Island-North	542.0	14	4	10	10	0	Cohesive-Soft
	Cook Slough-North	532.7	8	5	3	3	0	Cohesive-Medium
	Cook Slough-South	532.0	14	10	4	4	0	Cohesive-Medium
	Open Impounded Area	528.0	6	4	2	2	0	Cohesive-Soft
LaGrange, IR	Coon Hollow Island	140.9	13	11	2	2	0	Cohesive-Medium
	Bath Chute	113.4	14	8	6	6	0	Cohesive-Medium
	Bach Slough	98.0	14	1	13	13	0	Cohesive-Medium
	Treadway Lake[1]	95.4	14	1	13	13	0	Cohesive-Medium
	Sugar Creek Island[1]	95.3	10	4	6	5	1	Cohesive-Medium
	Wood Slough	91.9	14	3	11	10	1	Cohesive-Medium

[1] Site used for tow traffic data collection.

3 Field Data Collection

General

Detailed results of the field data collection effort are shown in Appendix A. In this report, waves were measured with capacitance staff gages; sediment concentration was measured with Optical Back Scatter (OBS) instruments; water levels were measured with pressure cells; and velocities were measured with Acoustic Doppler Velocimetry (ADV) gages. The description of these instruments is given in Appendix A. Acoustic Doppler Current Profiler (ADCP) was used to determine discharge, cross-sections, and average channel velocities. One of the wave gages was positioned far enough upstream (730 m at Pool 13 and 638 m at LaGrange) of the primary measurement site to allow determination of tow speed from arrival time of the drawdown wave at the two wave gage locations. No information was gathered on the lateral position of the tows.

Pool 13, Upper Mississippi River

Figure 2 shows a schematic of the layout of instruments at the Pool 13 site. Capacitance wave gages Wave-1 and Wave-4 were used to determine speed through the reach based on arrival time of drawdown at each gage and the 730 m between the two gages. Figure 3 shows the cross section measured at the site at RM 542.2 and the cross section used in the previous UMRS NAVEFF modeling at RM 542.5. Figure 4 shows the water level variation during the field study measured at gage Water Level-1. Appendix A shows the depths and locations of the various gages in Pool 13.

Sediment type at the Pool 13 site is cohesive medium.

Based on the log of tow events in Appendix A from Lock 12 (upstream) and Lock 13 (downstream) and observations of tow events during the daytime, the response of the individual tows was correlated to the time histories of water level, sediment, or velocity. For example, a downbound tow would arrive at gage WAVE-1 first and then at the WAVE-4, ADV-139, PRESS-1, and OBS about 3-5 minutes later. The log of tow events was then studied for departure times at Lock 12 and arrival times at Lock 13 to determine which tow passed the site. This technique had to be used for any tow passages when field personnel were not on-site to record the name of tows. In many cases, the tow event could be clearly

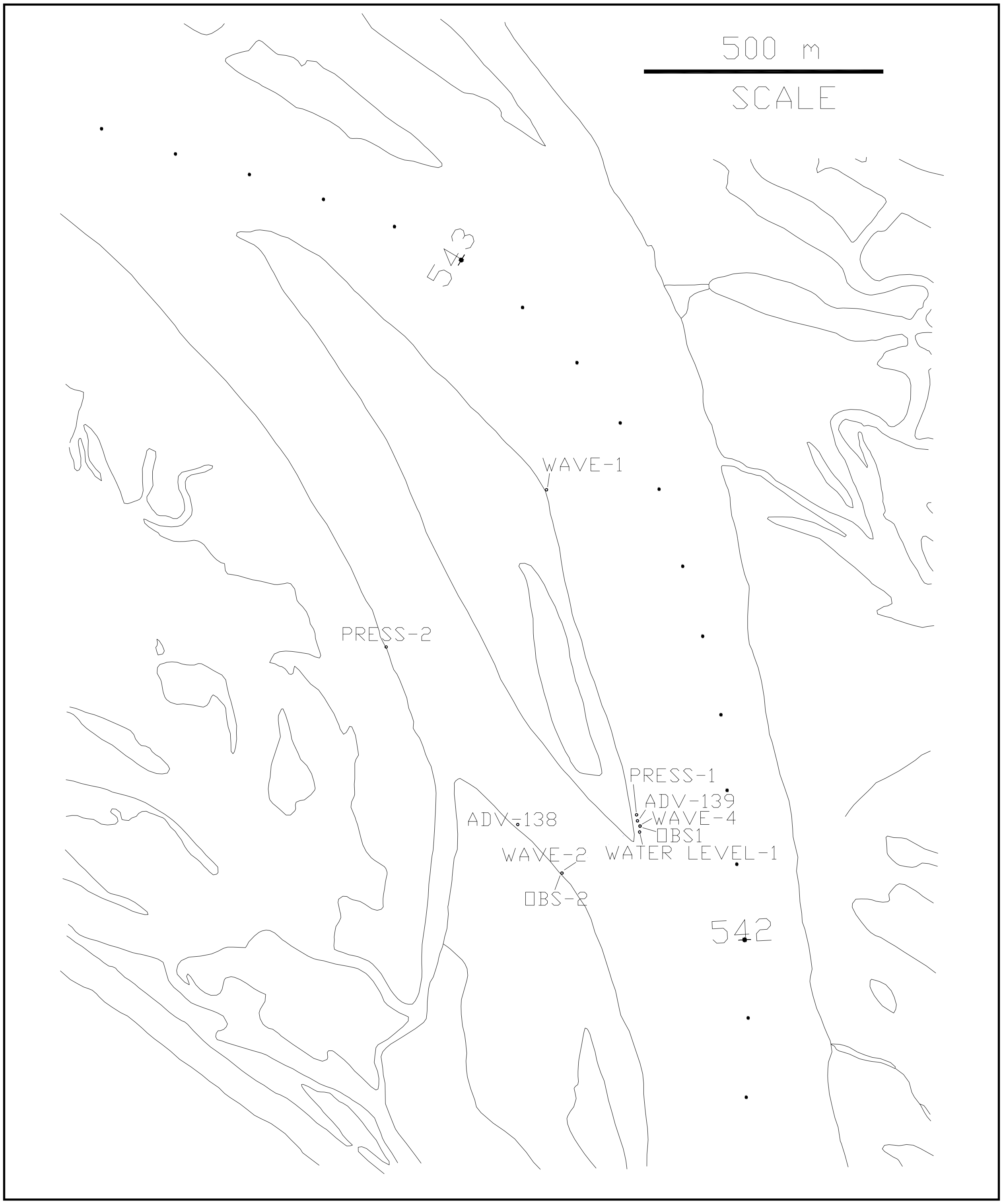

Figure 2. Pool 13 layout of gages

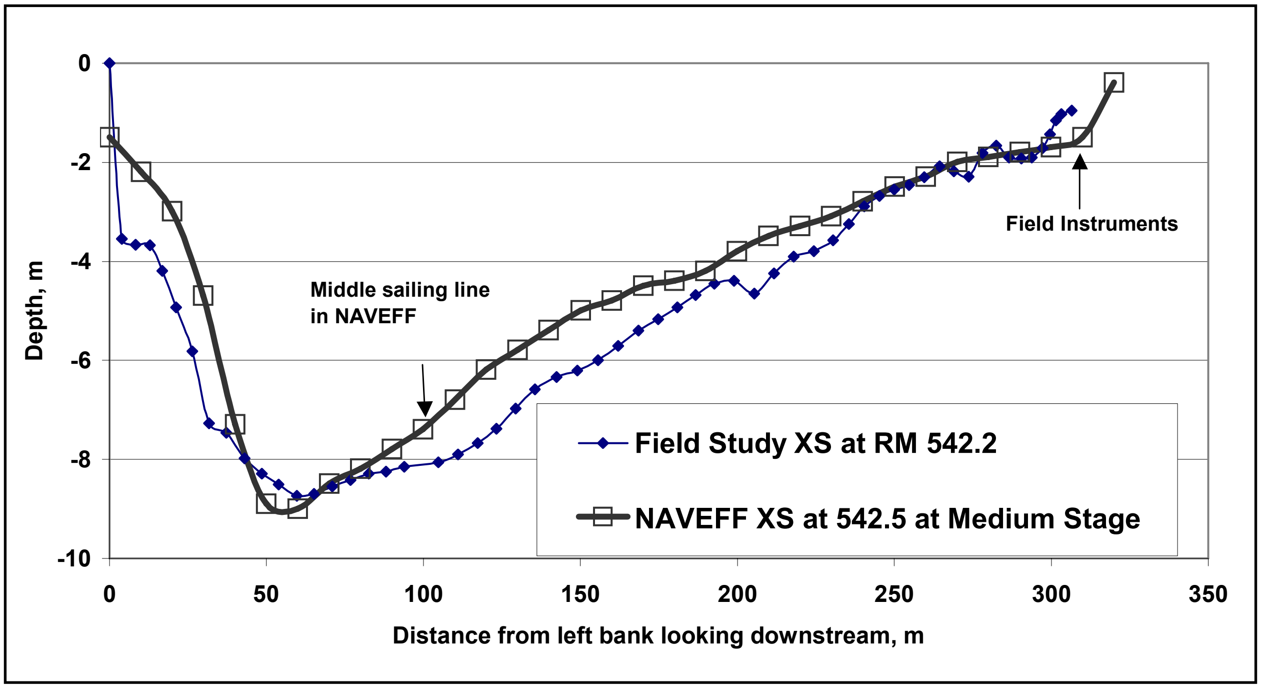

Figure 3. Cross section at Pool 13

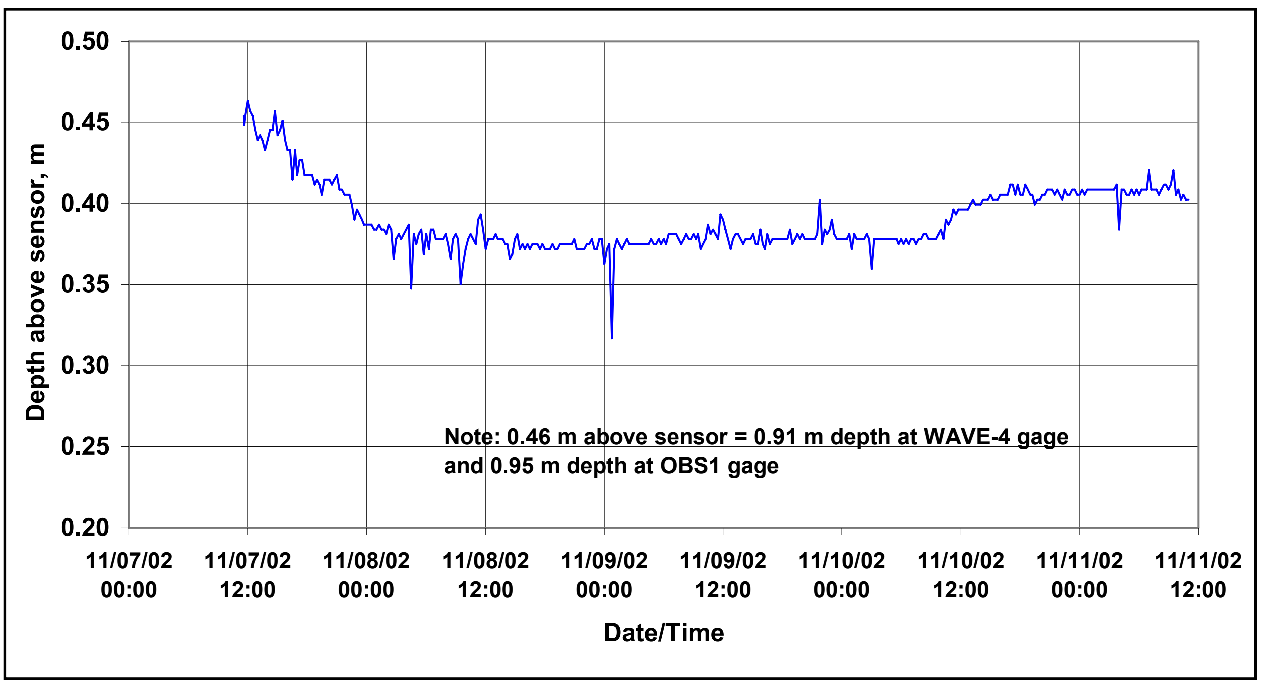

Figure 4. Pool 13, Gage Water Level-1

identified because its lock departure and arrival times were separated from other tows. In other cases, it was uncertain which tow caused the event. From the records of water level and OBS readings, some events were not used in the comparison because it was obvious that two or more tows passed the site at about the same time, and NAVSED is a single event model. Table 3 shows the tow events used in testing the NAVSED model and any other tow event details that could be determined. Time histories of water level and velocity for selected events in Pool 13 are shown in Appendix B. Unfortunately, the ADV velocity gage was not installed when the most significant tow events occurred. Time histories of sediment concentration will be presented subsequently.

Table 3
Tow Events Used in Comparison at Pool 13

Tow name	Date/Time	Direction	No. Loaded/ No. Empty	Speed, mph	Hmax and Drawdown m	Concentration Change, mg/L
Ruth Jones	11/7/2002 1635	up	0/15	?	0.18/<0.03	190
Thomas E. Erickson	11/7/2002 1900	up	1/9	7.8	0.19/0.06	160
R Clayton McWhorter	11/7/2002 2103	down	15/0	5.2	0.06/0.03	<5
Loree Eckstein	11/8/2002 0218	down	14/1	6.4	0.13/0.06	5-10
Phyllis	11/8/2002 0429	up	10/2	4.1	0.07/0.04	140
Show Me State	11/8/2002 0546	up	0/5	9.7	0.41/0.08	770
New Dawn	11/8/2002 0639	up	0/16	?	0.54/0.05	775
Peter Fanchi	11/8/2002 0930	up	0/8	6.0	0.13/0.04	<5
Prosperity	11/8/2002 1507	down	15/0	4.7	0.09/0.03	10
Sierra Dawn	11/8/2002 2101	down	15/0	4.8	0.06/0.05	<5
Cooperative Ambassador	11/8/2002 2246	down	14/1	5.0	0.03/0.03	<5
Santa Elena	11/9/2002 0518	down	12/0	5.1	0.06/0.04	<5
Samuel B Richmond	11/9/2002 0855	down	12/0	5.4	0.05/0.03	<5
Bill Carneal	11/10/2002 2217	down	14/1	4.8	0.03/0.03	<5
River Eagle	11/11/2002 0643	up	0/13	?	0.11/0.03	<5
Susan Ponthier	11/11/2002 0926	up	3/0	6.8	?/0.05	<5

At Pool 13, every downbound loaded tow produced little or no resuspension. With the exception of the tow *River Eagle*, peak values of resuspension occurred for the upbound unloaded tows. Of the only two upbound loaded tows, one produced significant resuspension and the other did not. No downbound unloaded tows were observed.

LaGrange Pool, Illinois Waterway

Figure 5 shows the layout of the instruments at the LaGrange site. Capacitance wave gages WAV3LAG and WAV4LAG were used to determine speed through the reach based on arrival time of drawdown at each gage and the 638 m between the two gages. Figure 6 shows the cross section measured at the site at

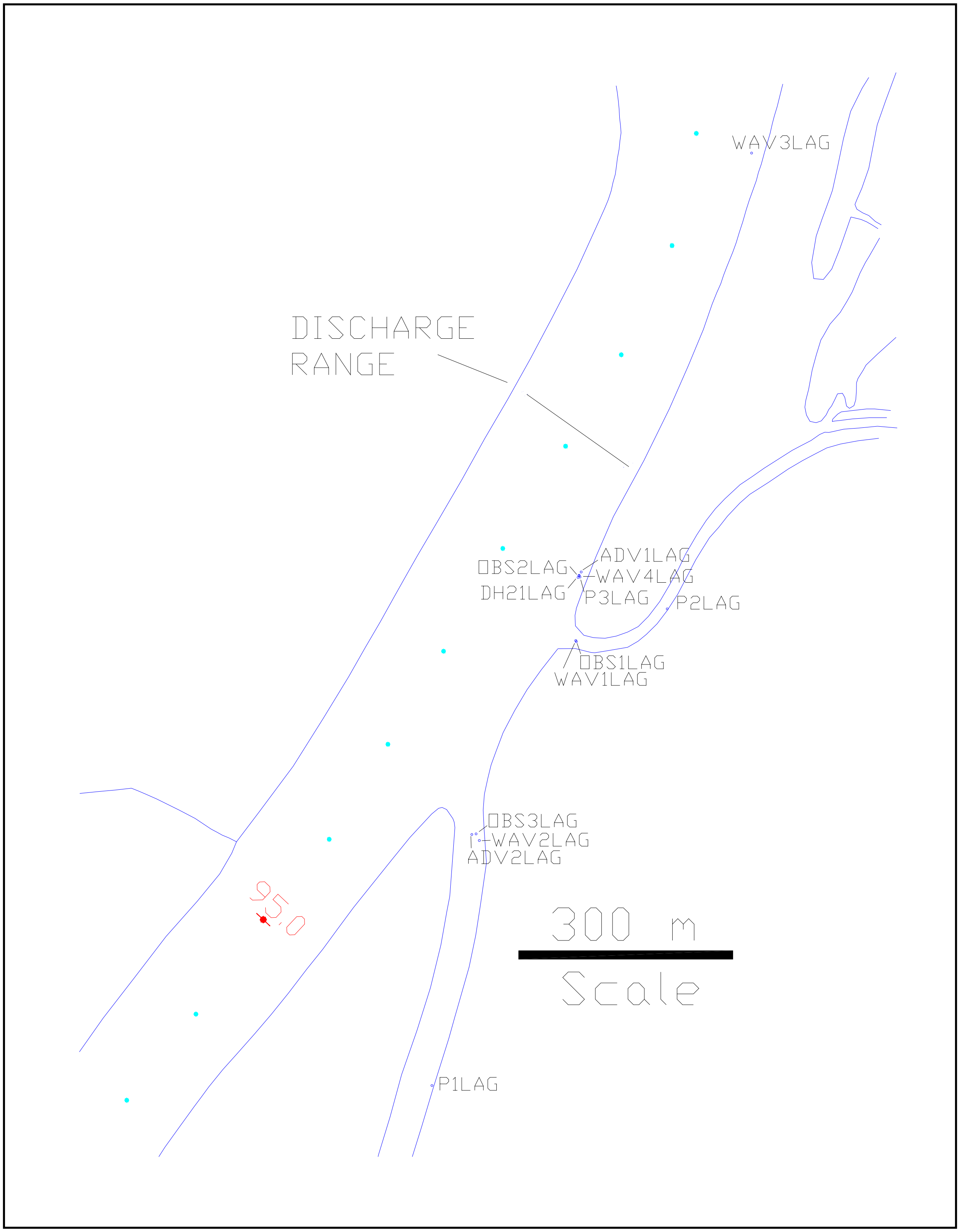

Figure 5. LaGrange layout of gages

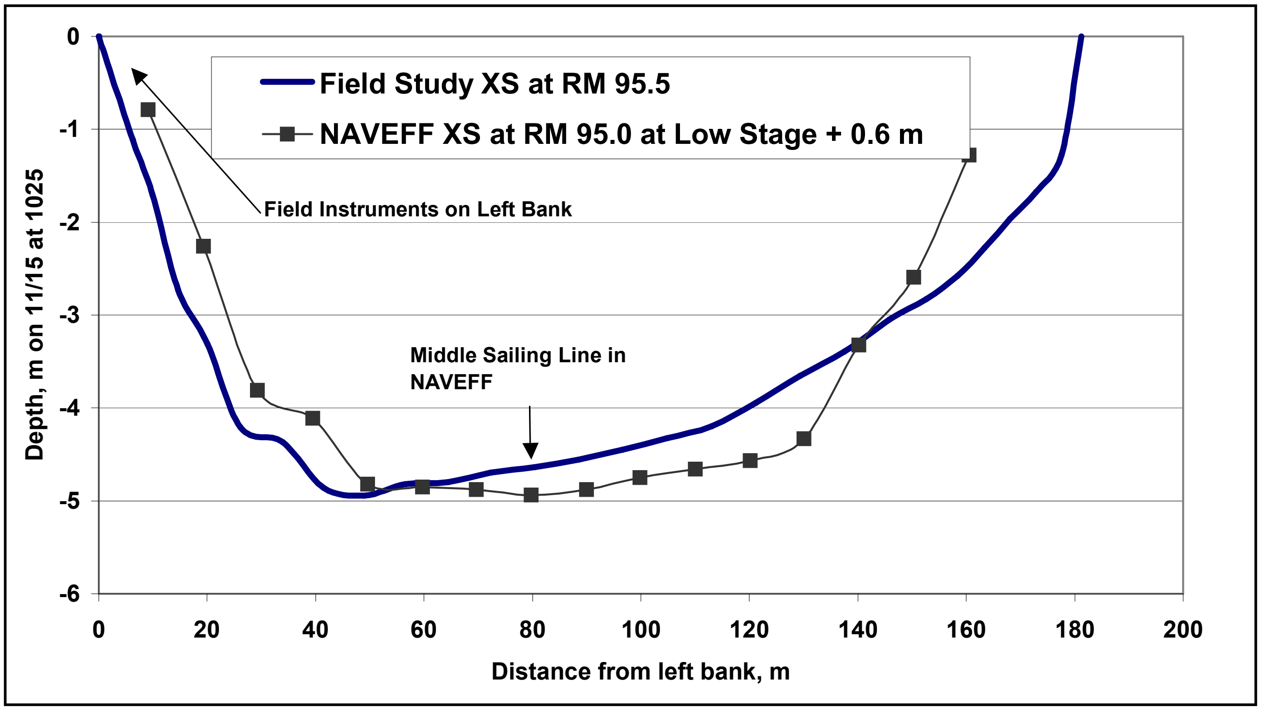

Figure 6. Cross section at LaGrange

RM 95.5 during the field study and the cross section used in the previous NAVEFF modeling at RM 95.0. Figure 7 shows the water level variation during the field study measured at gage DH21LAG. Appendix A shows the depths and locations of the various gages in LaGrange.

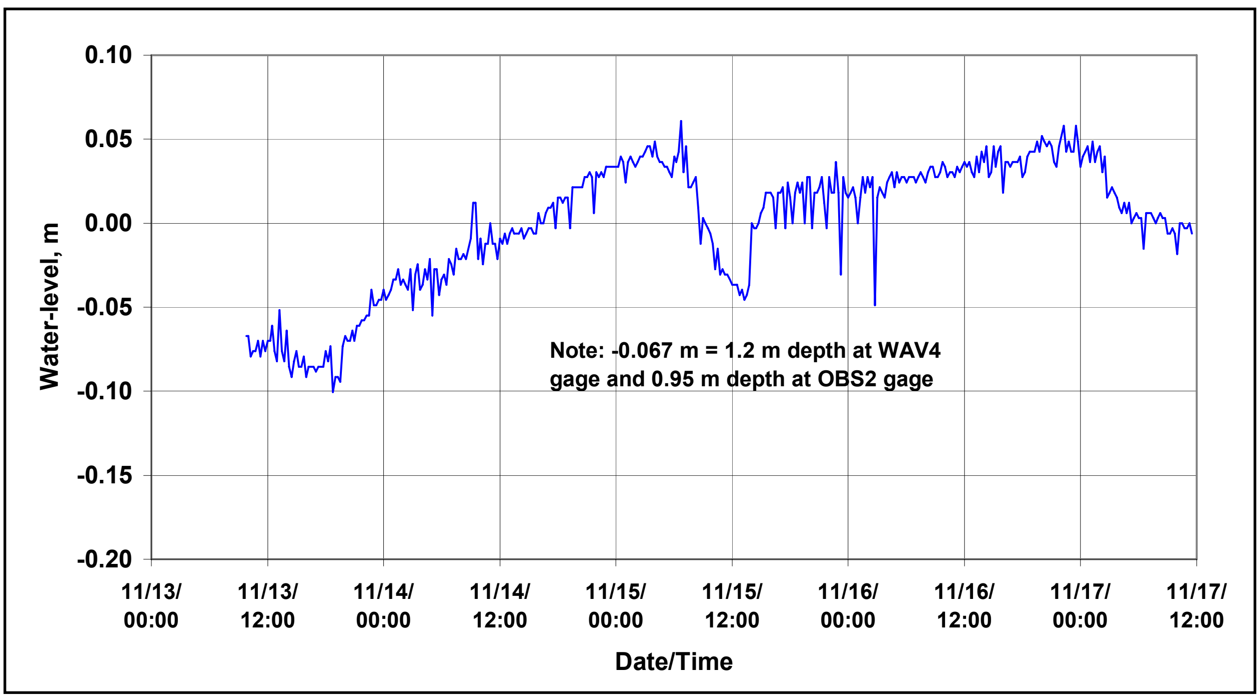

Figure 7. LaGrange, Water Level Gage DH21LAG

Sediment type at the LaGrange site is cohesive medium.

Based on the log of tow events in Appendix A from LaGrange Lock (downstream) and observations of tow events during the daytime, the response of the individual tows was correlated to the time histories of water level, sediment, or velocity. Table 4 shows the tow events used in testing the NAVSED model and any other tow event details that could be determined. Time histories of water level and velocity for selected events in LaGrange are provided in Appendix C. Time histories of sediment concentration will be presented subsequently.

Table 4
Tow Events Used in Comparison at LaGrange

Tow name	Date/Time	Direction	No. Loaded/No. Empty	Speed, mph	Hmax and Drawdown, m	Concentration Change, mg/L
WW Crum	11/13/2002 2046	down	0/2	9.3	0.12/0.12	100
The Admiral	11/14/2002 0932	up	6/0	6.2	0.15/0.14	230
Frank Stegbauer	11/15/2002 0646	up	3/0	6.8	0.13/0.13	195
Martha Mac	11/15/2002 1046	down	11/2	5.3	0.08/0.11	30
Prosperity	11/15/2002 1906	up	8/7	4.3	0.09/0.08	85
Herman Potter	11/15/2002 2314	up	11/5	4.8	0.11/0.12	120
Fred Joerger	11/16/2002 0244	down	13/0	5.4	0.09/0.10	90
S/R Chicago	11/16/2002 2016	up	3/5	5.7	0.12/0.13	180
Decatur Lady	11/17/2002 0840	up	2/14	6.3	0.07/0.11	75
Billy Joe Boling	11/17/2002 0515	down	15/0	5.3	0.14/0.10	100

4 Comparison of Field Data with NAVSED

Description of NAVSED

NAVSED (Copeland et al. 2001) is an empirical model for estimating sediment concentration versus time due to tow passage. The wave algorithm used in NAVSED is presented in Parchure, McAnally, and Teeter (2001). Maynord et al. (2004) compared observed sediment resuspension data to the wave algorithm. Based on that comparison, coefficients a_r and b_r in equation 7 of Parchure, McAnally, and Teeter (2001) were determined as 7.0 and 0.35 for cohesive soft sediments and 6.5 and 0.35 for cohesive medium sediments.

The determination of the two coefficients in Maynord et al. (2004) was based on field data collected in the near shore zone as was done in the study reported herein. The use of these shoreline data points has a significant influence on the coefficients. Consider the LaGrange site where the depth at the shoreline cell was about 1 m. Based on cohesive medium sediment and the a_r = 6.5 and b_r = 0.35 in equation 7 of Parchure, McAnally, and Teeter (2001), resuspension occurs at all wave heights greater than about 0.14 m. This author considers this to be a small wave for any resuspension in 1 m depth. However, resuspension in the shallow area between the 1 m depth and the shoreline is contributing sediment to the near bank region. This resuspended sediment reaches the wave gage located at 1 m depth by ambient flows even though there may have been little sediment resuspended at the gage. While this is not the best physical description of the process, this method works correctly in the relatively simple NAVSED model of an extremely complex process.

At the shoreline where these data were collected, the NAVSED model estimates suspended sediment from the return velocity, propeller jet resuspension, and waves, and combines the three linearly. The NAVSED model was run at LaGrange River Mile 95.0 for these processes individually as shown in Figure 8 for the following:

a. Propeller jet from a typical 3 x 5 loaded tow traveling upstream at 5.5 mph with return velocity and wave height set to zero.

b. Return velocity for the typical 3 x 5 loaded tow equal to 0.64 m/sec with propeller jet and waves set to zero.

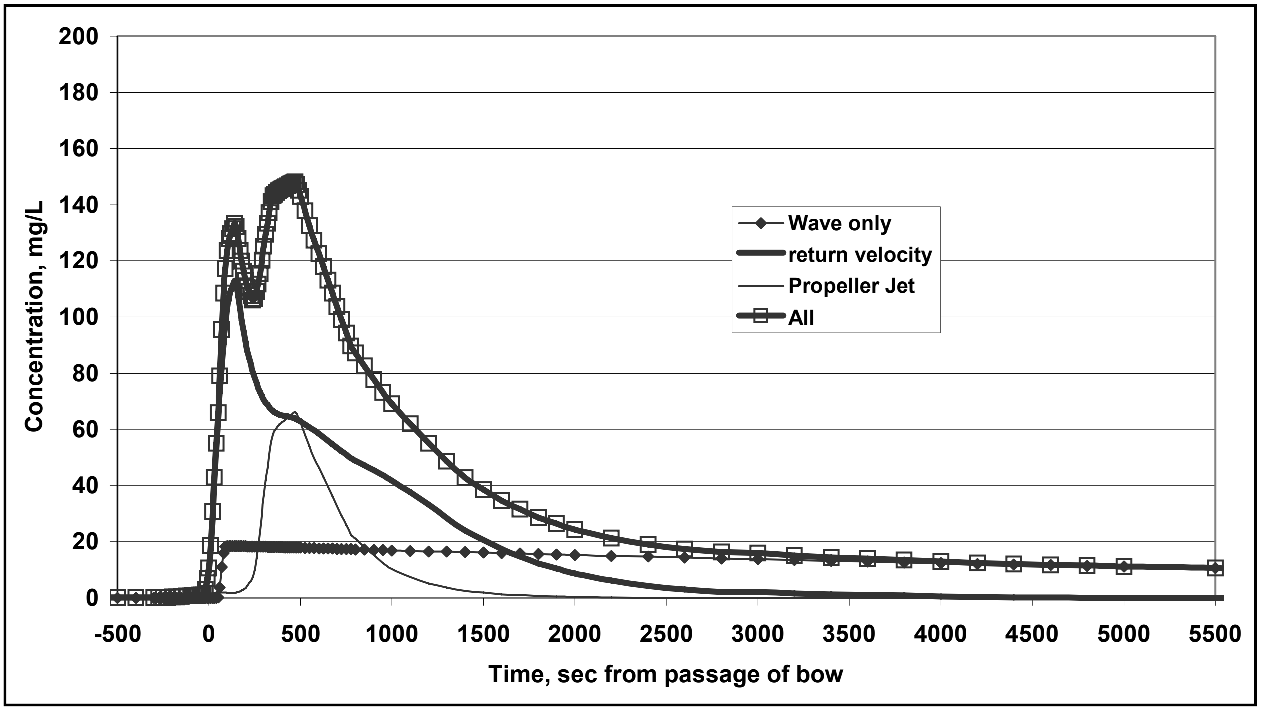

Figure 8. Sediment resuspension from waves, return velocity, and propeller jet

c. Maximum wave height of 0.18 m with propeller jet and return velocity set to zero.

d. The 0.18 m wave height is larger than the wave computed for the 3 x 5 tow of 0.098 m which would not have produced any wave resuspension; and all three processes combined which is the NAVSED output.

Note that return velocity begins first followed by wave resuspension and then propeller jet resuspension. The initial peak of the combined curve occurs as a result of combined peak return velocity and peak waves. The second and maximum peak on the combined curve occurs as a result of combined peak propeller jet, decay of return velocity, and modest decay of waves. For this case, decay of sediment concentration to near zero requires about 35 minutes for the propeller jet and about 1 hour for return velocity. For waves, computed decay is much longer and does not reach zero values at the maximum time of 8,000 sec used in NAVSED.

Because of the larger channel and greater distance from the bank at Pool 13, return velocity will be small and propeller jet effects will not generally reach the bankline. The lower return velocity at Pool 13 compared to LaGrange is confirmed in comparing the field ADV data. The larger channel in Pool 13 will allow greater tow speeds that will create greater wave heights than in the smaller LaGrange channel. The dominant mechanism producing resuspension at Pool 13 will generally be waves. At LaGrange, the smaller channel generally results in lower tow speeds and wave resuspension will be small compared to the dominant mechanisms of return velocity and propeller jet effects.

All NAVSED runs used the middle sailing line used in the UMRS studies that corresponds to the location of 90% of the tows. NAVSED shows no sediment resuspension if the computed increase is less than 5 mg/L.

NAVSED Comparison at Pool 13

Initial runs with NAVSED using a range of tow sizes observed during the field study demonstrated that sediment resuspension was only calculated for waves. Observed return velocity was less than 0.3 m/sec and drawdown was less than 0.06 m. The middle sailing line used in NAVEFF/NAVSED was about 183 m from the gages in a channel that is about 305 m wide which makes unlikely the movement of propeller jet resuspension to the gages. NAVSED at Pool 13 was run with the observed maximum wave height measured during the field study as input rather than using the computed wave height from NAVEFF. Tow size and speed were not used because of the lack of influence of return velocity and propeller jet. Results are shown in Figure 9 through Figure 12 for tows whose wave height was large enough to produce computed sediment resuspension. Correlating the timing of the observed and computed data was done by equating the passage of the bow of the tow.

In NAVSED, time zero is passage of the bow. In the field data, passage of the bow was set equal to the beginning of the drawdown. For tows *Ruth Jones* (Figure 9) and *Thomas E. Erickson* (Figure 10), the NAVSED model computed value was compared to the average of the three OBS sensors. Based on plotting vertical profiles of concentration from the three gages at 0.15, 0.30, and 0.46 m above the bed, the average of the three gave a good estimate of the depth averaged value that is the value determined in NAVSED. For tows *Show Me State* and *New Dawn*, the sensor near the bottom at 0.15 m above the bed reached peak voltage that resulted in no reliable reading at that depth. For these two tows, the NAVSED value was compared to the OBS sensor at 0.3 m above the bed that provides a reasonable estimate of the depth averaged value. The *Ruth Jones*- and *Thomas E. Erickson*- computed sediment resuspension did not capture the peaks in sediment concentration but provided a conservative estimate of the total amount of sediment resuspended during the event. The sediment was elevated for a longer time in NAVSED than in the observed data for both the *Ruth Jones* and the *Thomas E. Erickson*.

The tow event *Shoe Me State* (Figure 11) was an upbound high speed unloaded tow that produced a large set of waves having maximum amplitude of 0.41 m. The NAVSED model provided of good estimate of the observed concentration. Note that the decay of sediment could not be compared for the *Show Me State* because two other tows passed just after the *Show Me State*. The *New Dawn* (Figure 12) was another upbound unloaded tow event that produced a large set of waves having maximum amplitude of 0.54 m. The speed of the event was unable to be determined from the drawdown records in part because the drawdown was small. NAVSED provided a conservative estimate of the observed concentration. The voltages at about 6:41 in the *New Dawn* event appeared to reach peak magnitude which would limit the observed peak concentration. Decay of sediment

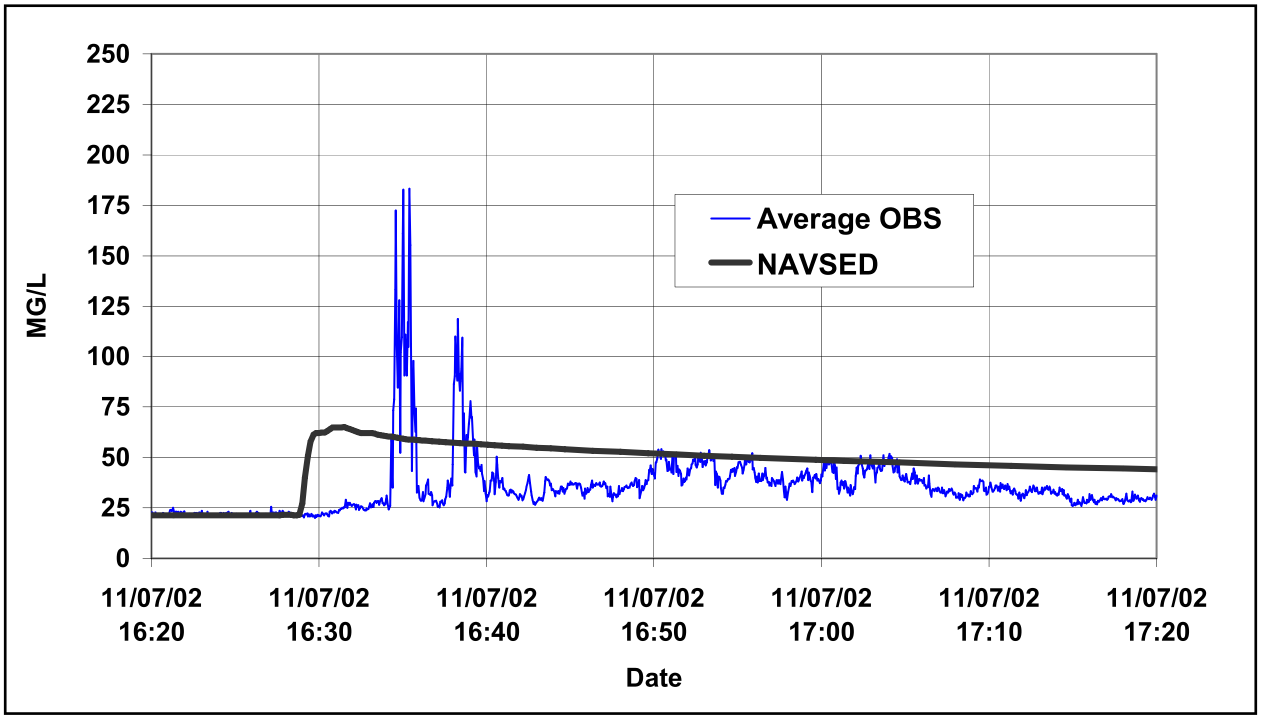

Figure 9. Observed versus computed sediment concentration, Upper Mississippi River, Pool 13, Site 1, OBS, *Ruth Jones*

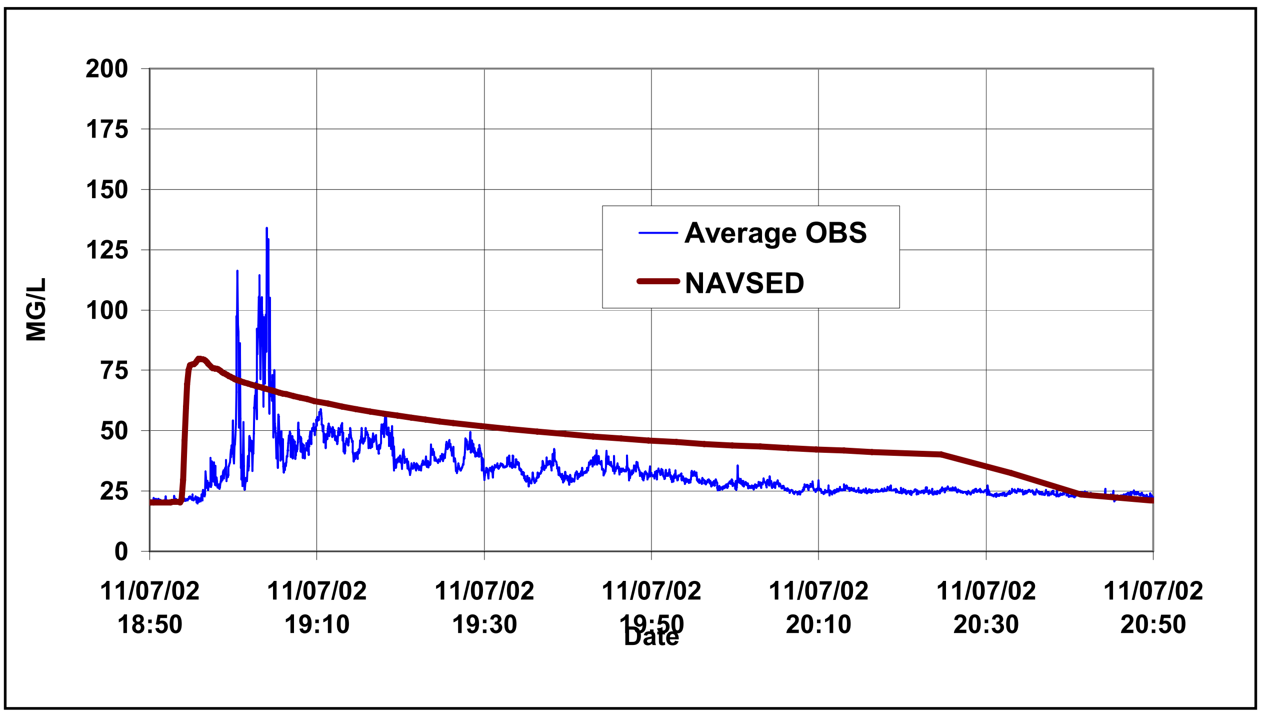

Figure 10. Observed versus computed sediment concentration, Upper Mississippi River, Pool 13, Site 1, OBS, *Thomas E. Erickson*

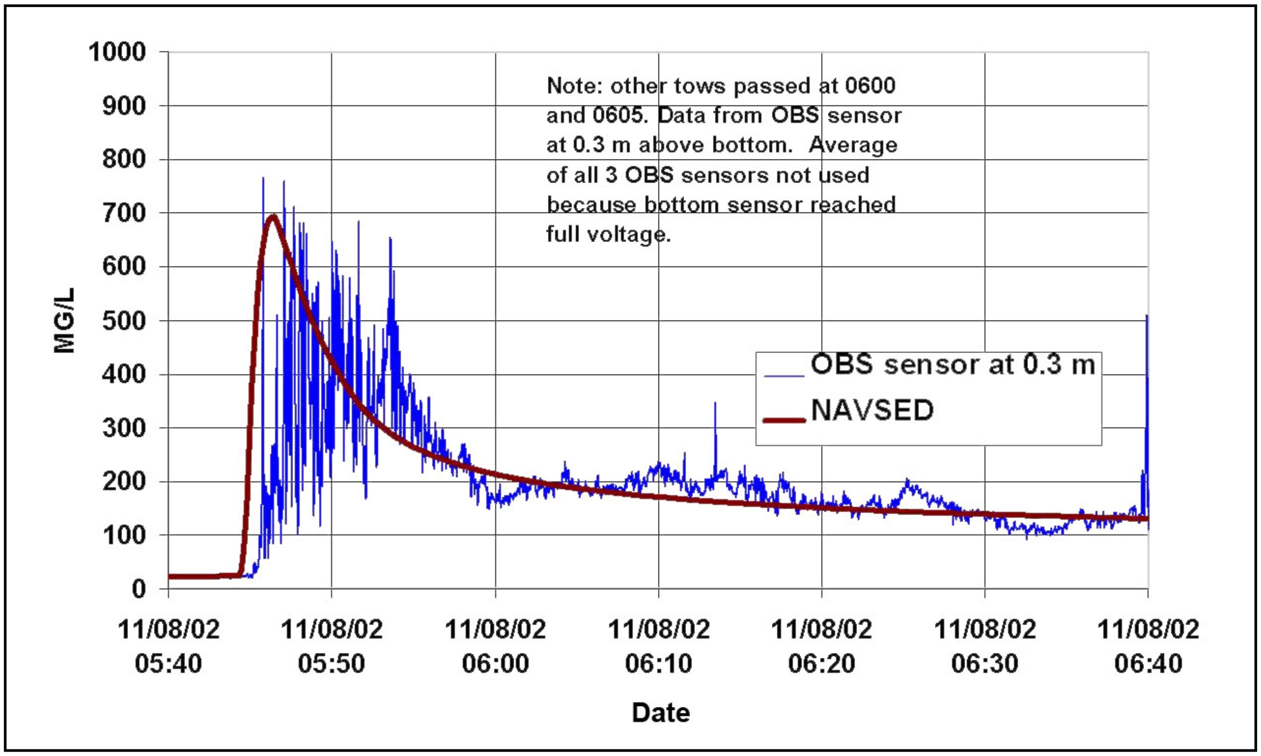

Figure 11. Observed versus computed sediment concentration, Upper Mississippi River, Pool 13, Site 1, OBS, *Show Me State*

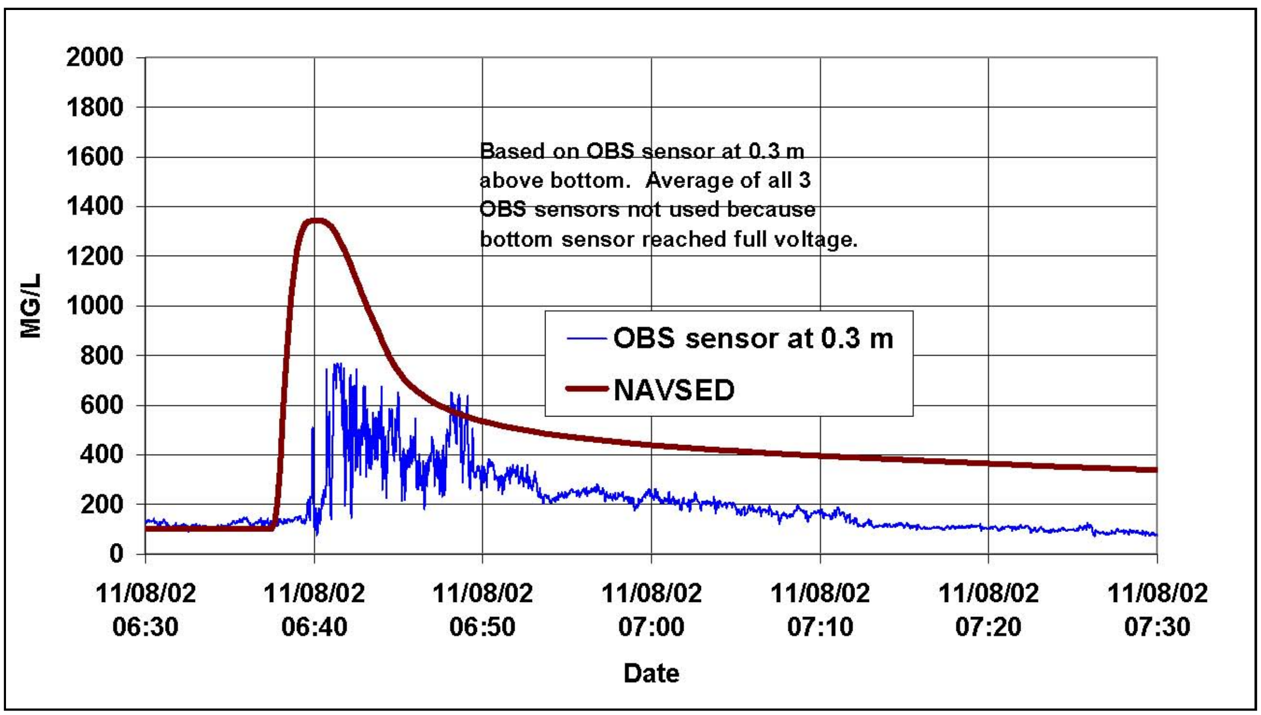

Figure 12. Observed versus computed sediment concentration, Upper Mississippi River, Pool 13, Site 1, OBS, *New Dawn*

concentration for *New Dawn* was much slower in NAVSED than in the observed data.

Figure 13 shows the OBS data for the tow event *Phyllis*. The NAVSED model computed no resuspension for this event because of the small wave height. The OBS records look unusual for tow resuspension.

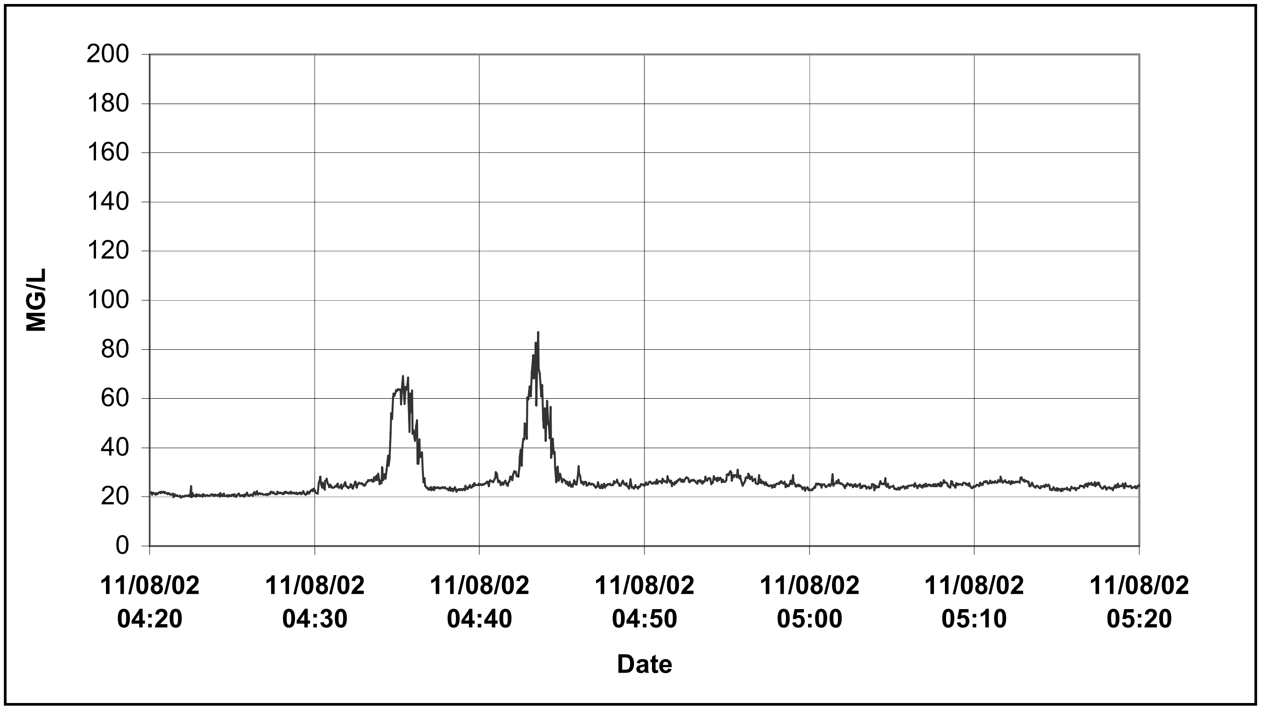

Figure 13. Observed Sediment Concentration, Upper Mississippi River, Pool 13, Site 1, OBS, *Phyllis*

NAVSED Comparison at LaGrange

Initial runs with NAVSED using a range of tow sizes demonstrated that sediment resuspension at LaGrange could result from all three mechanisms of waves, return velocity, and propeller jet. Return velocity was greater than or equal to 0.3 m/sec and drawdown was about 0.12 m. The middle sailing line used in NAVEFF/NAVSED was about 70 m from the gages in a channel that is about 168 m wide which makes likely the movement of propeller jet resuspension to the gages. NAVSED at LaGrange was run with all pertinent parameters of tow speed, size, draft, direction in order to incorporate the effects of return velocity and propeller jet resuspension. The observed maximum wave height measured in the field study was input rather than using the computed wave height from the NAVEFF model. Results are shown in Figures 14 through 23. All events compared the average of the 3 OBS sensors to the depth average value from NAVSED. Only *The Admiral* and the *Billy Joe Boling* produced wave heights large enough to provide some contribution to the sediment resuspension and these were less than 15 mg/L.

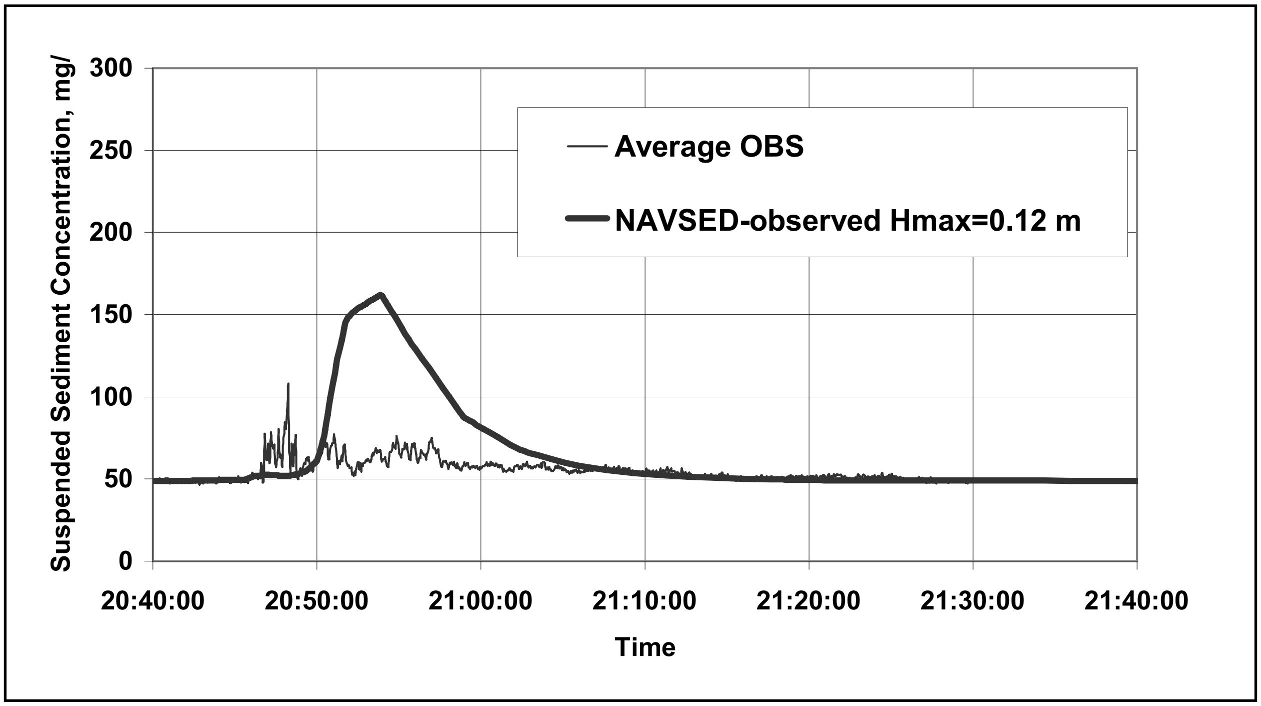

Figure 14. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *WW Crum*, 11/13/2002

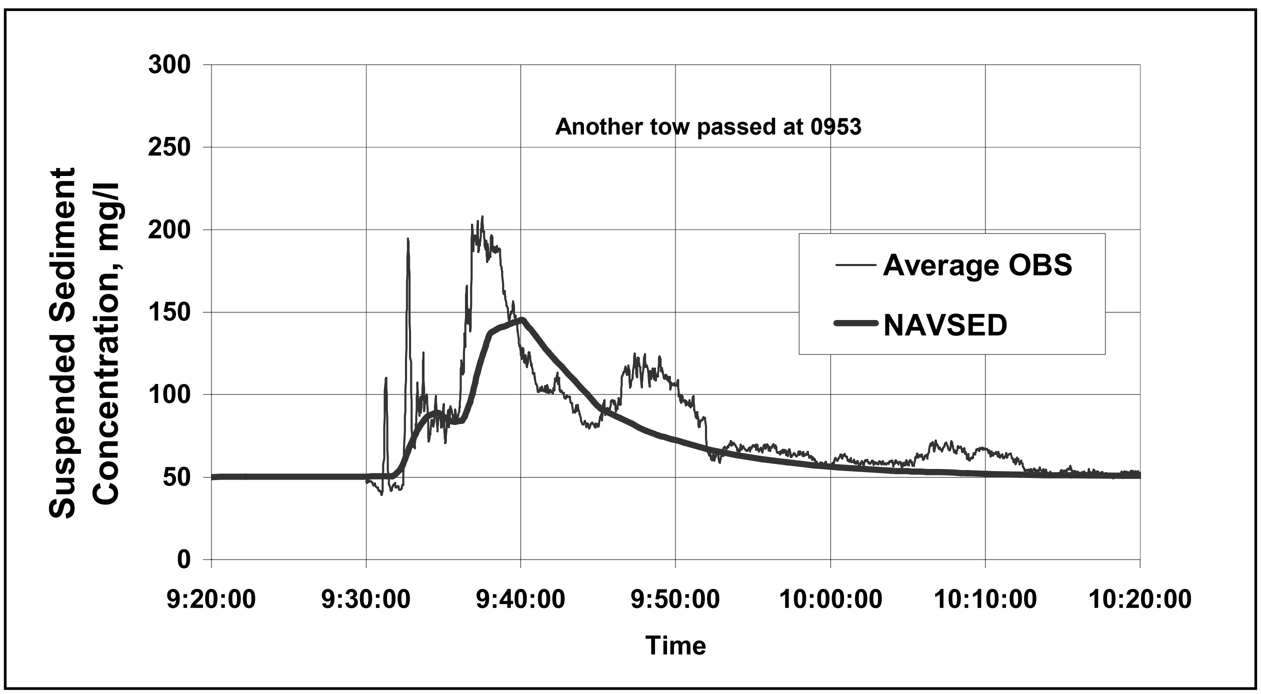

Figure 15. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *The Admiral*, 11/14/2002

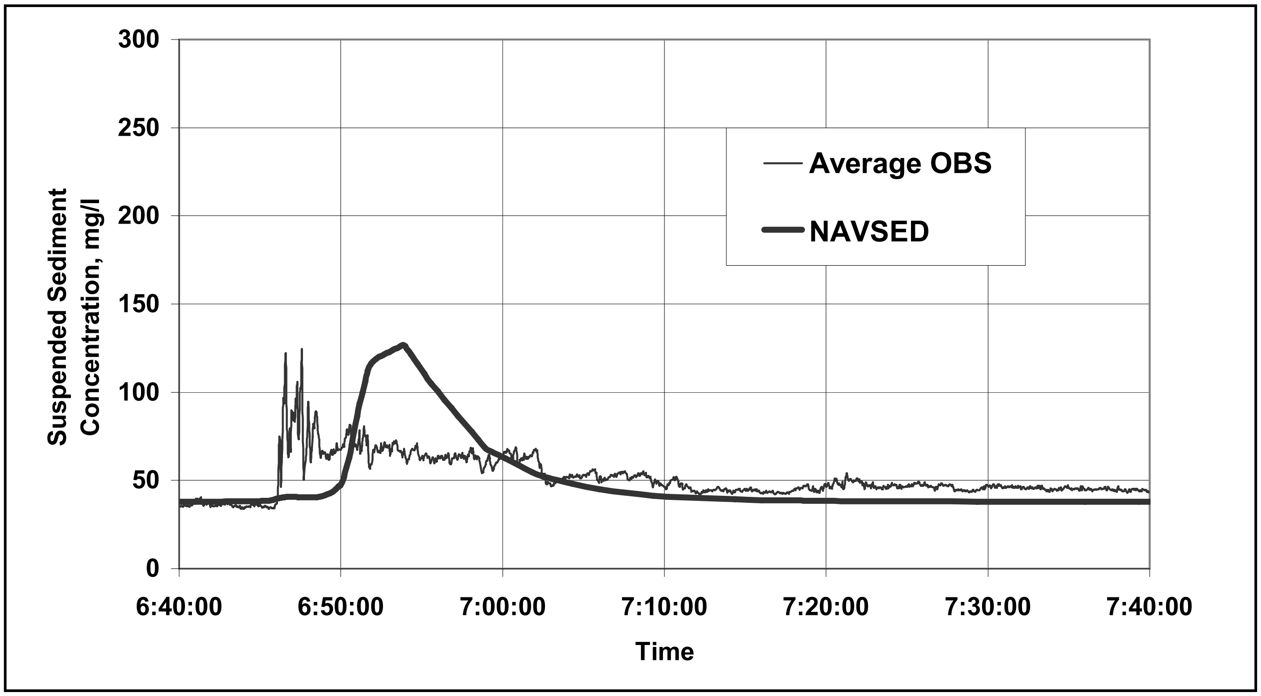

Figure 16. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *Frank Stegbauer*, 11/15/2002

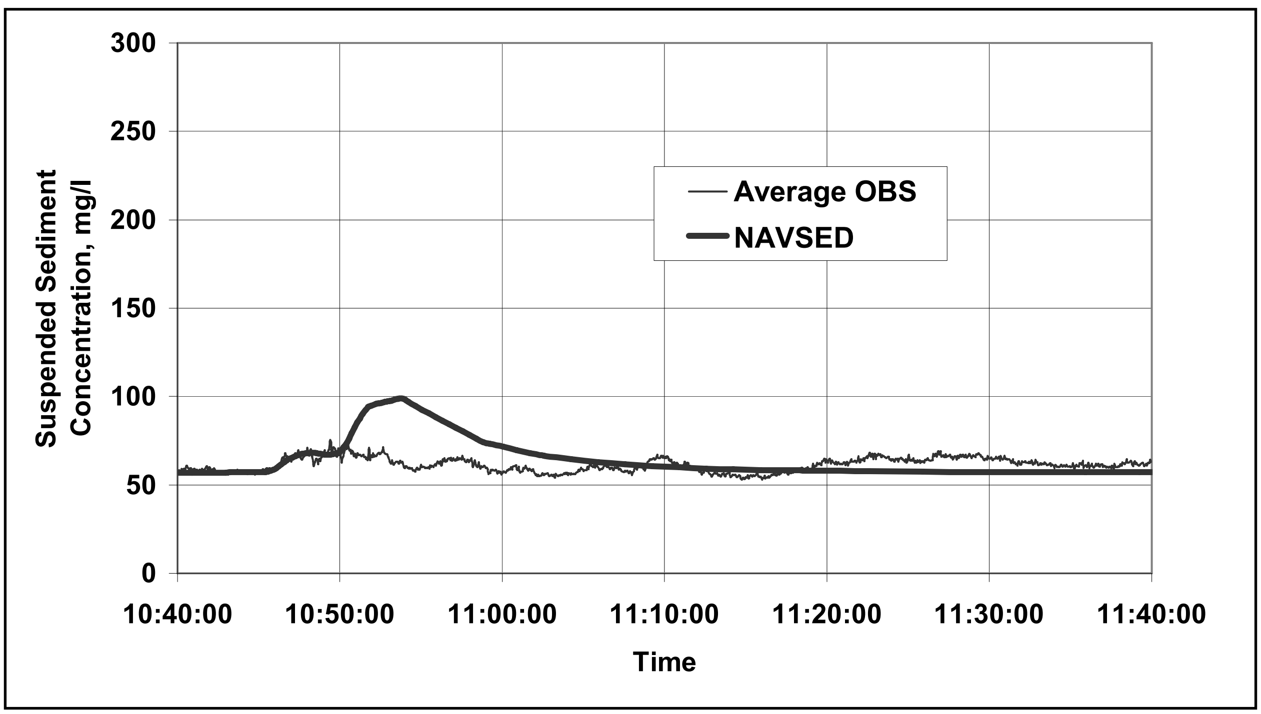

Figure 17. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *Martha Mac*, 11/15/2002

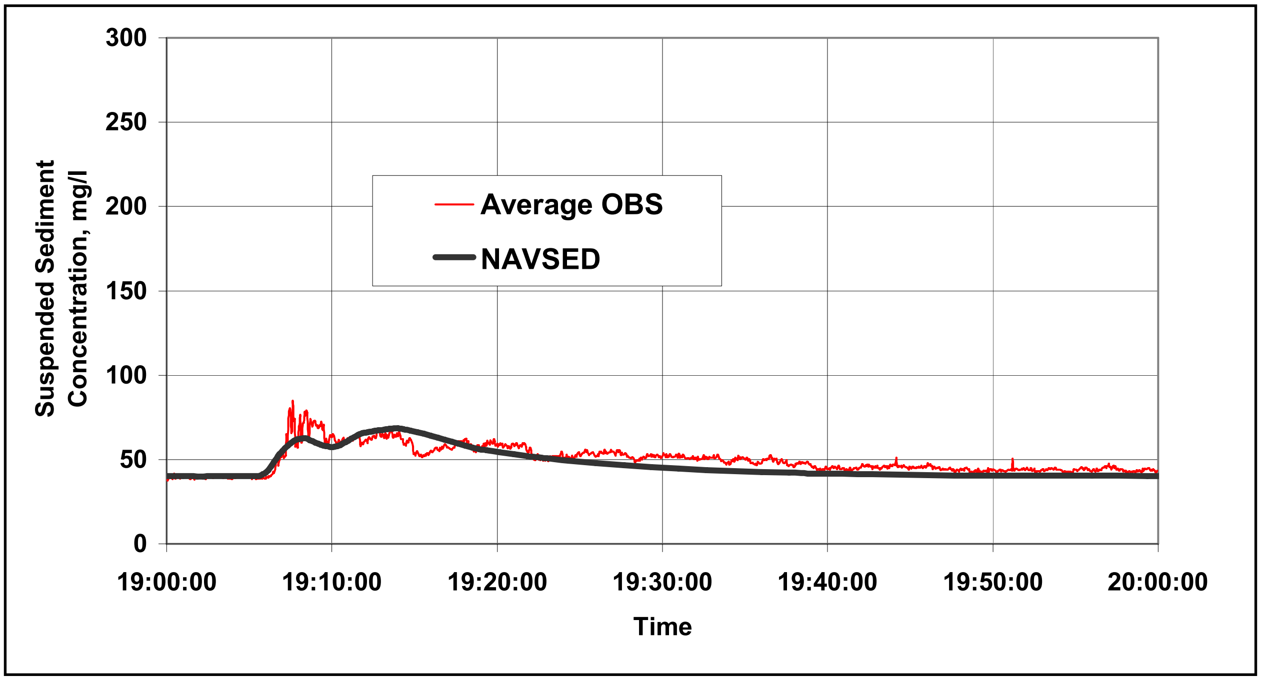

Figure 18. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *Prosperity*, 11/15/2002

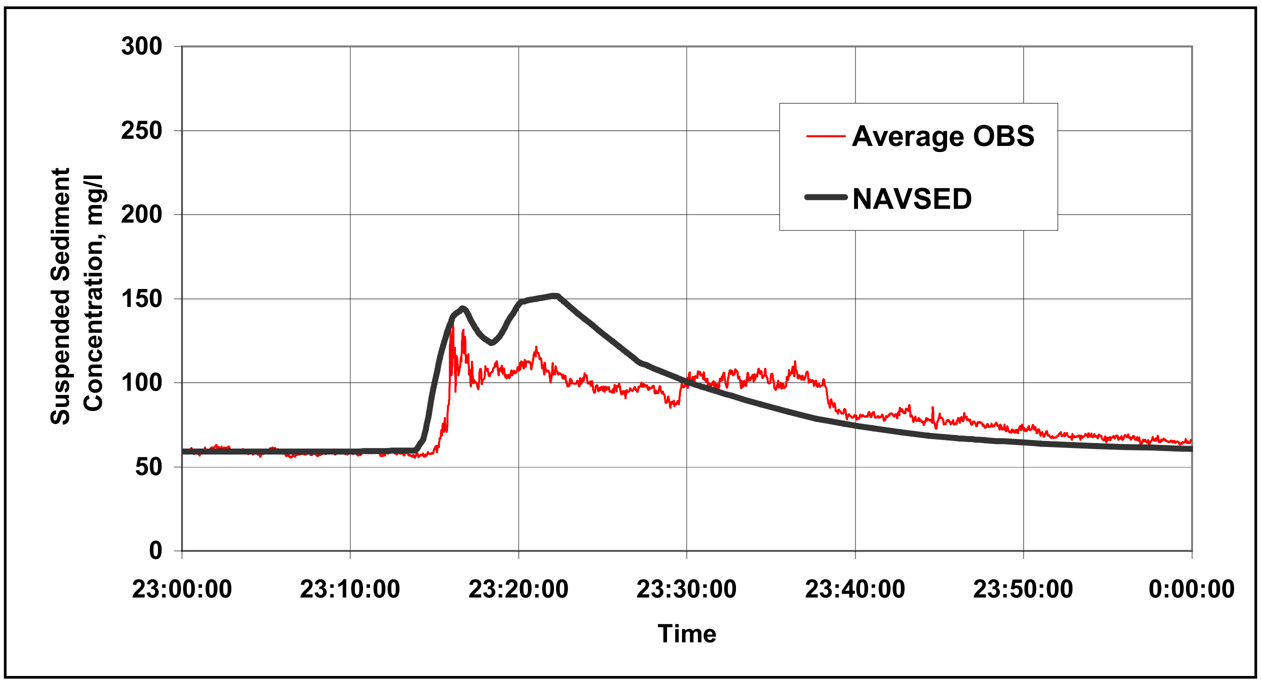

Figure 19. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *Herman Potter*, 11/15/2002

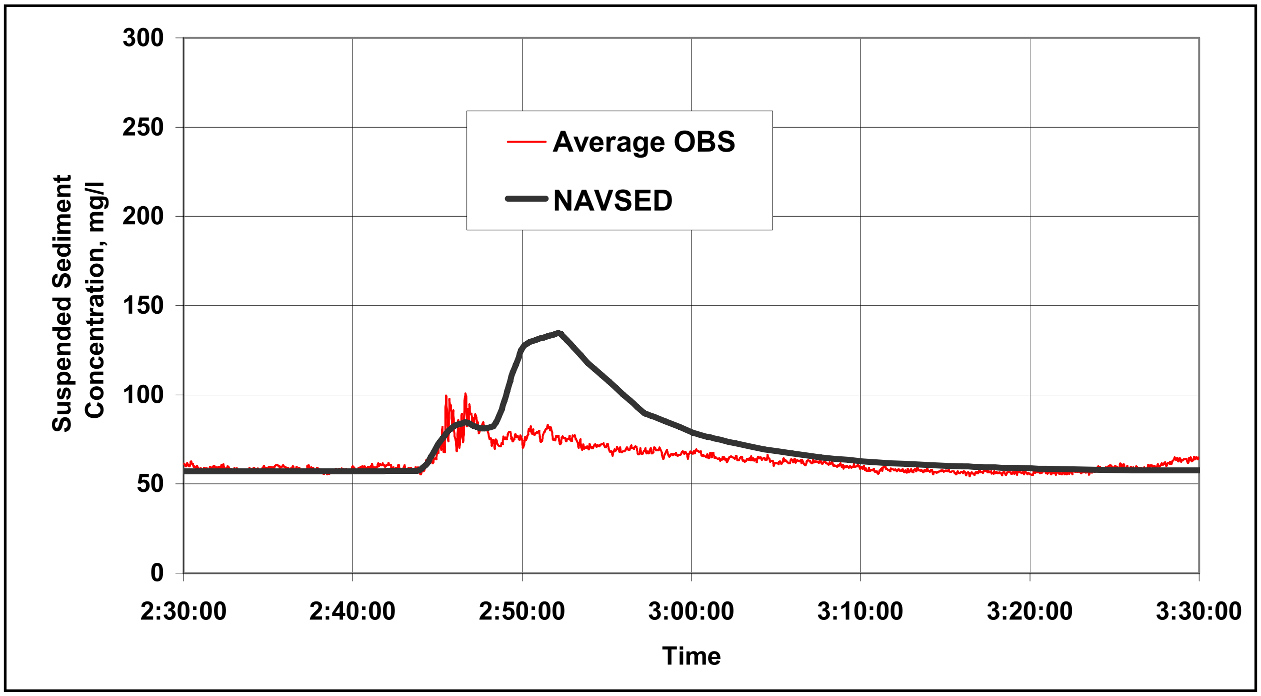

Figure 20. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *Fred Joerger*, 11/16/2002

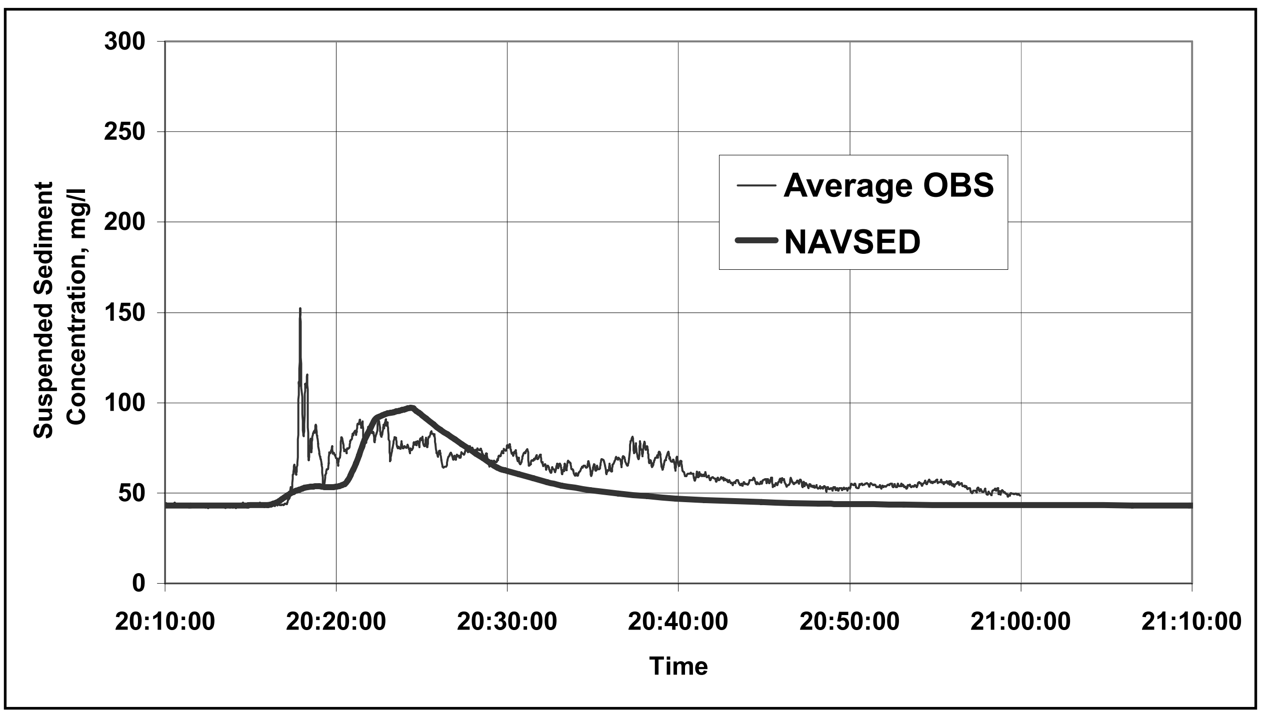

Figure 21. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *S/R Chicago*, 11/16/2002

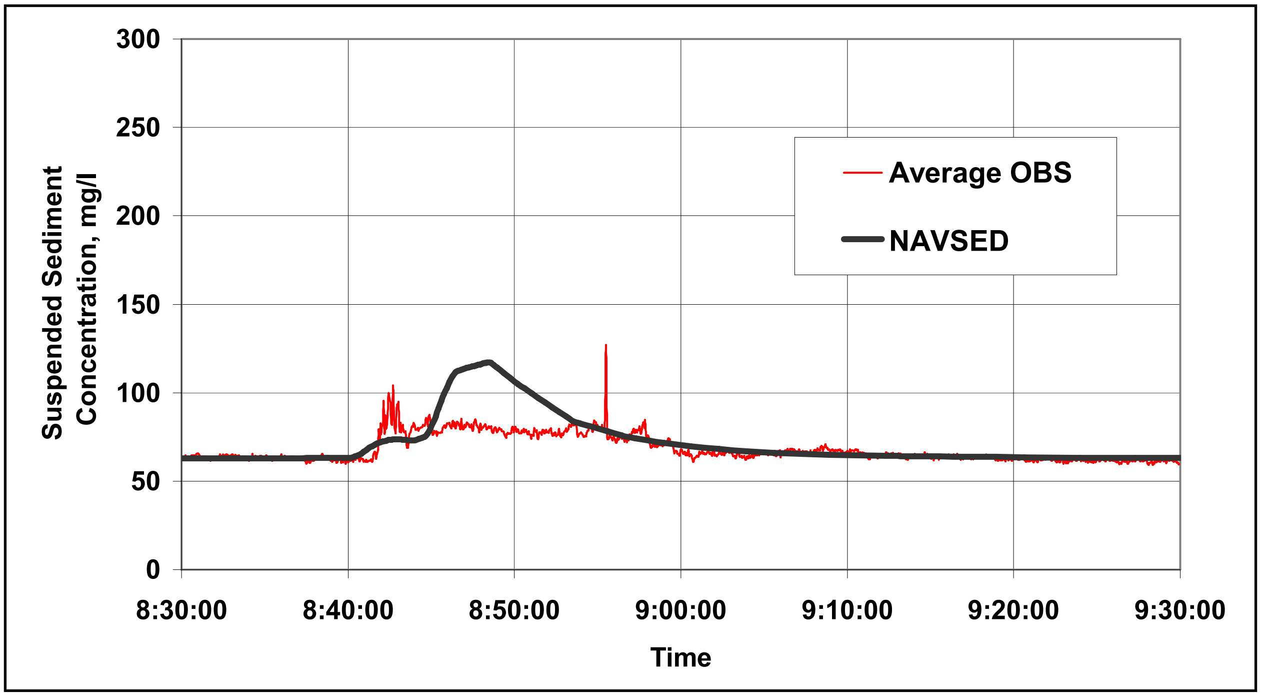

Figure 22. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *Decatur Lady*, 11/17/2002

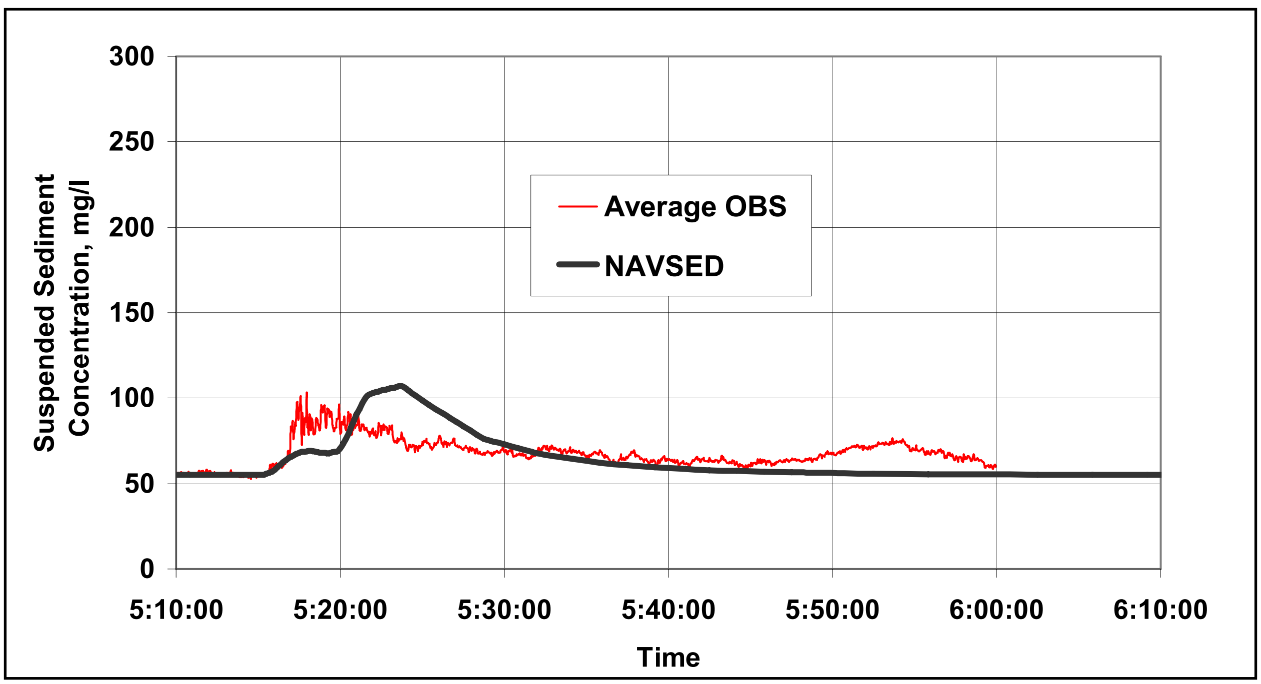

Figure 23. Observed versus Computed Sediment Concentration, Illinois Waterway, LaGrange Pool, OBS Site 1, *Billy Joe Boling*, 11/17/2002

For some of the tows, the resuspension from return velocity was underestimated in NAVSED. Examples are *WW Crum*, *Frank Stegbauer*, *S/R Chicago*, *Decatur Lady*, and *Billy Joe Boling*. One factor contributing to the underestimation of return velocity effects deals with the peak return velocity occurring during peak drawdown. The average drawdown in the LaGrange field tests of about 0.12 m results in excess pore pressures in the bottom sediments that reduces their resistance to erosion. This complexity is not part of the NAVSED model. For some of the tows, the resuspension from propeller jet was overestimated in NAVSED. Examples are *WW Crum*, *Frank Stegbauer*, *Martha Mac*, *Fred Joerger*, *Decatur Lady*, and *Billy Joe Boling*. Only one of the tows, *The Admiral*, appears to underestimate the propeller jet contribution. Computed and observed values are close in two events, the *Prosperity* and the *Herman Potter*. Considering all events in this channel not dominated by waves, decay of sediment concentration in NAVSED was in agreement with the observed data. Considering all events and the total amount of sediment resuspended during the event, the NAVSED model is providing adequate prediction at the LaGrange site.

5 Summary and Conclusions

The NAVSED model for tow induced sediment resuspension was evaluated using recently collected field data. Tow event data was collected at Pool 13 on the Mississippi River and LaGrange Pool on the Illinois Waterway. Sediment concentration, velocity, and water level variation was measured in the near-bank zone where depths were about 0.9 m. Resuspension of sediment from the tow can result from return velocity, waves, and propeller jet, depending on the site characteristics.

The Pool 13 and LaGrange Pool sites differ primarily with respect to the channel size and distance of the tow from the shoreline gage location. At Pool 13, the larger channel size results in small return velocity and thus little contribution to sediment resuspension from return velocity. In addition, the Pool 13 shoreline is a large distance from the sailing line that prevents the propeller jet resuspension from reaching the shoreline. The larger channel size at Pool 13 allows greater tow speeds which tends to increase wave activity. When all factors are considered, shoreline resuspension at Pool 13 results predominantly from wave action.

At LaGrange Pool, the smaller channel size results in return velocity causing a significant contribution to sediment resuspension. In addition, the LaGrange Pool shoreline is a small distance from the sailing line that results in the propeller jet resuspension reaching the shoreline. The waves from the tow tend to be smaller at LaGrange due to the lower tow speeds in the smaller channel. However, this is not always true because unloaded tows can travel at high speeds in some parts of the IWW resulting in significant wave resuspension. The potential for all three mechanisms being significant at sites such as the LaGrange Pool site show the complexity of the problem NAVSED is modeling.

Comparisons of observed sediment concentration at Pool 13 were limited to four events that produced significant resuspension at the shoreline gages. Maximum wave heights from the four events varied from 0.18 m to 0.54 m and maximum concentration change varied from 160 to 775 mg/L. For two events having maximum wave heights of 0.15 and 0.19 m, NAVSED underestimated the short-lived peak concentrations, but the NAVSED total sediment resuspended throughout the events was greater than the observed in both cases. For one event having a maximum wave height of 0.41 m, NAVSED provided a good estimate of the peak concentration and the total sediment resuspended throughout the event. For one event having a maximum wave height of 0.54 m, NAVSED provided an overestimate of the peak concentration and the total sediment resuspended throughout the event.

Comparisons of observed sediment concentration at LaGrange Pool were conducted for 10 events that produced maximum change in sediment concentration at the shoreline gages ranging from 30 to 230 mg/L. Wave induced sediment resuspension for the 10 LaGrange events was small. Of the 10 events, 5 underestimated resuspension from return velocity effects. For six of the tow events, resuspension from the propeller jet was overestimated. Based on all 10 events, the NAVSED model provided a conservative estimate of the total amount of sediment resuspended during the tow event.

The issue that is addressed in this report is whether NAVSED gives adequate estimates of tow induced sediment resuspension for the UMR-IWW study. In almost every tow event evaluated herein, the total sediment resuspended during an event was conservatively estimated by NAVSED. In only a few cases, peak, short-lived, maximum concentrations were underestimated by NAVSED. This report concludes that the NAVSED estimates of tow induced sediment resuspension are adequate for the UMR-IWW study.

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14. ABSTRACT

The NAVSED does *NAVSED* need spelled out the first time it's used? model for tow induced sediment resuspension was evaluated using field data collected at Pool 13 on the Mississippi River and LaGrange Pool on the Illinois Waterway. Sediment concentration, velocity, and water level variation was measured in the near-bank zone where depths were about 0.9 m. Shoreline resuspension at Pool 13 results predominantly from wave action. At LaGrange Pool, the smaller channel size results in return velocity causing a significant contribution to sediment resuspension and the small distance from the sailing line to the shoreline results in the propeller jet resuspension reaching the shoreline. The waves from the tow tend to be smaller at LaGrange due to the lower tow speeds in the smaller channel. Comparisons of observed sediment concentration at Pool 13 were limited to four events that produced significant resuspension at the shoreline gages. Comparisons of observed sediment concentration at LaGrange Pool was conducted for 10 events that produced maximum change in sediment concentration at the shoreline gages ranging from 30 to 230 mg/L. The total sediment resuspended during an event was conservatively estimated by NAVSED. In only a few cases, peak, short-lived, maximum concentrations were underestimated by NAVSED. This report concludes the NAVSED estimates of tow induced sediment resuspension are adequate for the Upper Mississippi River – Illinois Waterway (UMR – IWW) System Navigation study.

15. SUBJECT TERMS

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Field data	Resuspension	

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Appendix A
Summary Report of Upper Mississippi River and Illinois River Field Data Collection Effort (October 31, 2001 through November 17, 2001)

The following is a descriptive summary of the data collection efforts that were performed at the two sites on the Upper Mississippi River (Pool 10 and Pool 13) and the one site on the Illinois River (LaGrange Pool). The data collected during the period October 31, 2001 through November 17, 2001 included turbidity, velocity, wave heights, water level fluctuations, and discharge.

Pool 10, Upper Mississippi River

The first phase of the data collection effort was performed at Pool 10 in the area of Frenchtown Lake. The site of the data collection was located four miles upstream of Lock and Dam 10, Guttenberg, Iowa, as shown in Figure A1. At this location, there was an entrance channel from the main river into the backwater area known as Frenchtown Lake. Two instrument deployment sites, Site 1 and Site 2, were identified, and the instruments were deployed as shown in Figure A2. At each of these sites were deployed an array of OBS sensors to monitor turbidity, an Acoustic Doppler Velocimeter (ADV) to monitor water velocities, a submerged pressure gauge to monitor drawdown effects of passing vessels, and a capacitance gage to monitor waves from passing vessels. In the main river and located approximately ¼ mile upstream of Site 1, a submerged pressure gage was deployed to monitor changes in the water level (stage) during the data collection period for Pool 10. At a distance of approximately ½ mile upstream of Site 1, a third capacitance wave gauge was deployed. The data collected from this gauge will be used in the determination of the vessel speed passing Site 1. In the backwater area of Frenchtown Lake and located

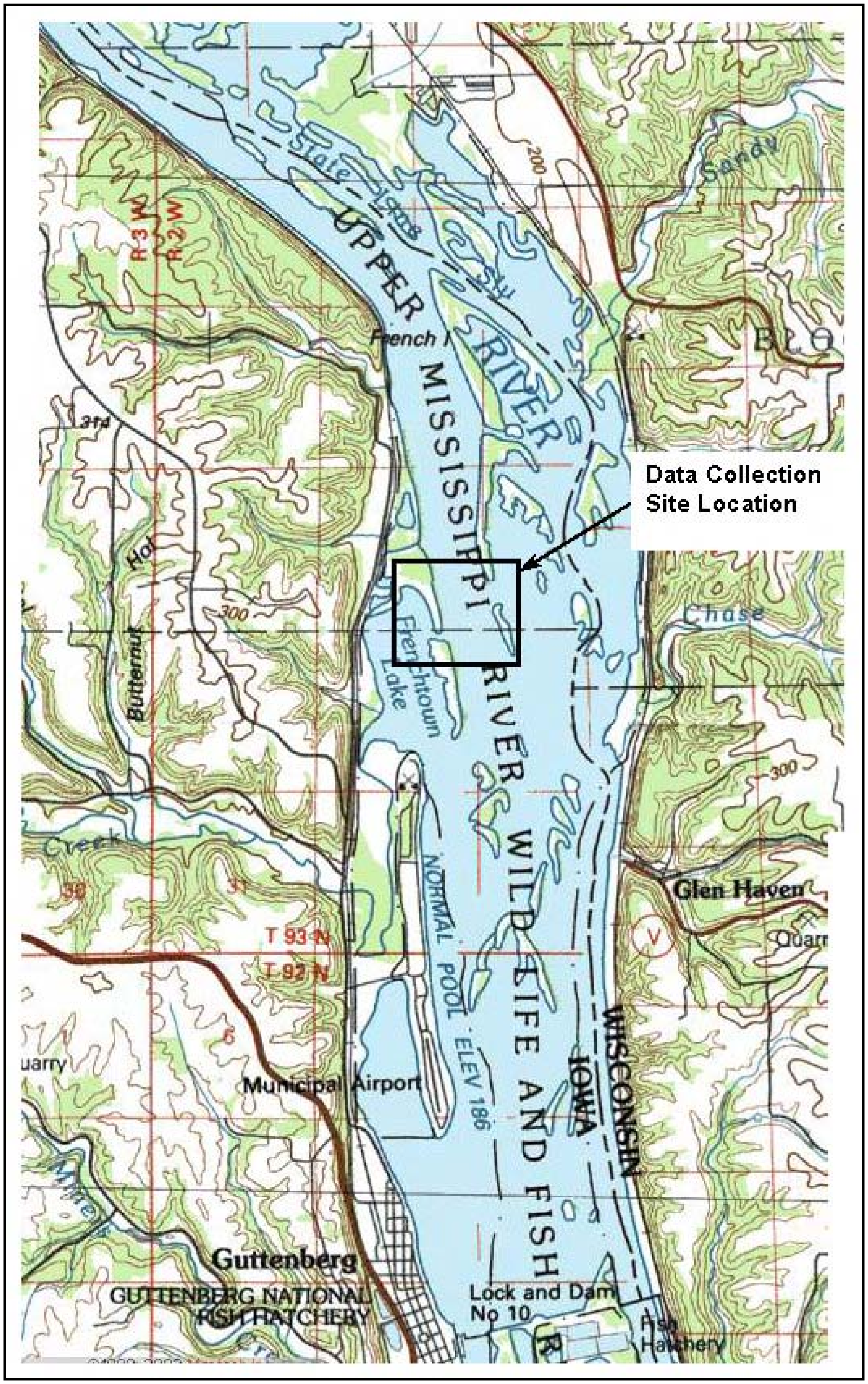

Figure A1. Data collection site location at Frenchtown Lake in Pool 10, Mississippi River

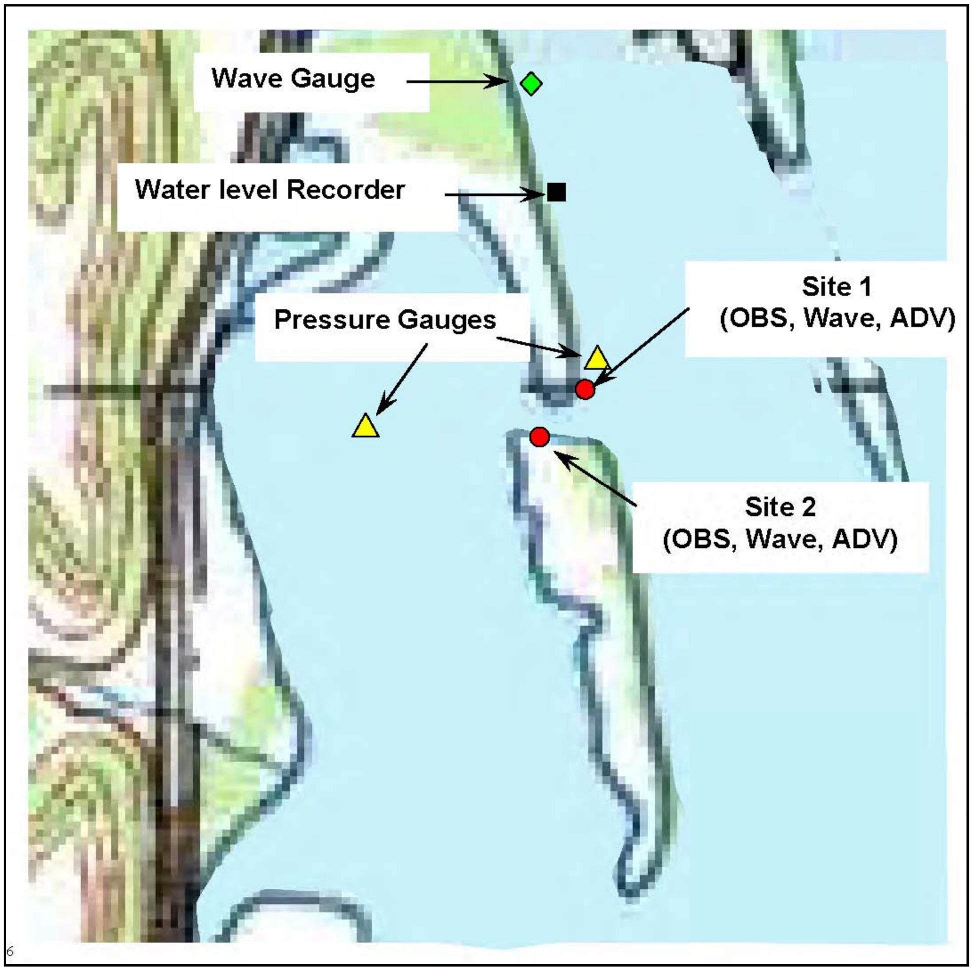

Figure A2. Detail of instrument deployment locations at the Frenchtown Lake site, Pool 10

approximately ¼ mile west from Site 2 at the backwater entrance, a second submerged pressure gage was deployed to monitor changes in the water levels. A meteorological station was deployed near Sites 1 and 2 to record the barometric pressure and temperature changes during the data collection period. Photos A1 through A5 are of the instrument installations for Pool 10 Frenchtown Lake.

Table A1 lists the instrument deployment locations and details about the deployment.

The data collection period at Pool 10 extended from November 2, 2001 through November 6, 2001. The data collection plan for this site involved having the instruments recording data continuously throughout the collection period. After the deployment of the instruments was completed, a data collection boat was used to collect daily river discharge measurements near the Pool 10 sites. In addition, background water samples were collected at three stations across the channel at each instrument site. Between three and five water samples would be collected at three different sampling locations along the cross section. The number of samples obtained across each cross section depended on the depth of the

Photo A1. Installation of OBS sensors at Site 1, Pool 10

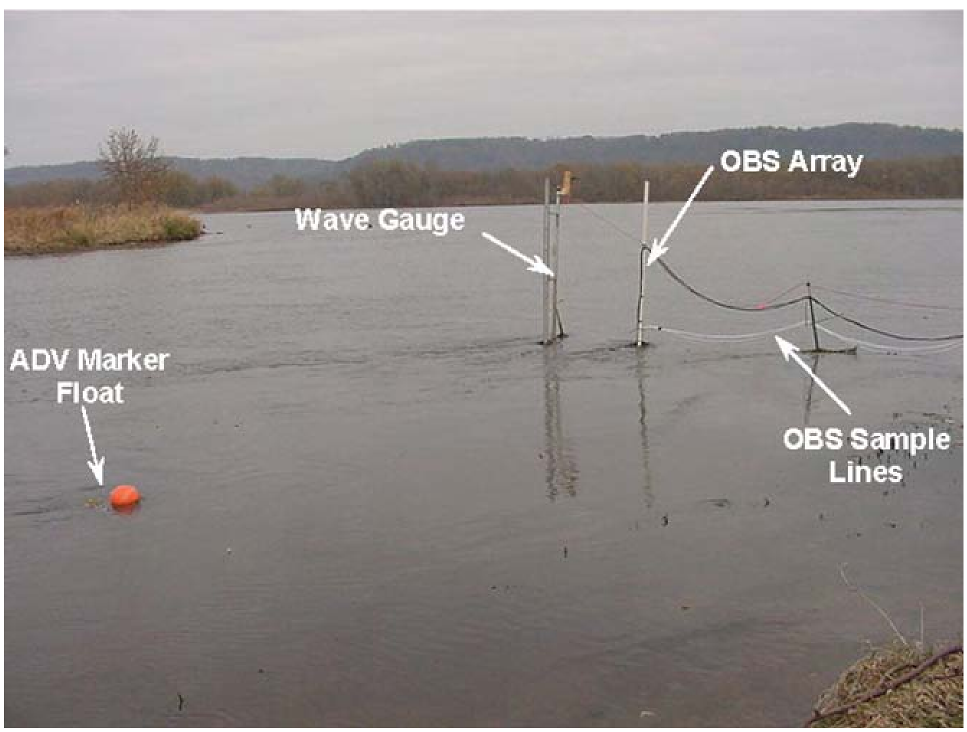

Photo A2. Instrument deployments for Site 1 and Site 2 (Site 2 shown here)

Photo A3. Setting up the data logger for the OBS sensors

Photo A4. Meteorological recording station for Site 1 and 2, Pool 10

Photo A5. Deployment mount with ADV being retrieved for cleaning

Table A1
Pool 10 Instrument Types, Locations, Depths and Deployment Periods

Instrument Name	Instrument Type	Latitude	Longitude	Distance Above Bottom[1]	Depth of Water at Deployment[1]	Date Deployed	Date Retrieved
Site 1							
OBS-1-1	OBS	42° 50' 56.79"	91° 05' 48.29"	0.5	2.8	11/1/2002	11/6/2002
OBS-1-2	OBS	42° 50' 56.79"	91° 05' 48.29"	1.0	2.8	11/1/2002	11/6/2002
OBS-1-3	OBS	42° 50' 56.79"	91° 05' 48.29"	1.5	2.8	11/1/2002	11/6/2002
WAVE-4	Wave Gauge	42° 50' 56.75"	91° 05' 48.22"	0.3	3.2	11/1/2002	11/6/2002
PRESS-1	Press Gauge	42° 50' 56.79"	91° 05' 48.29"	1.0	3.2	11/1/2002	11/6/2002
WAVE-1	Wave Gauge	42° 51' 25.40"	91° 05' 57.95"	0.5	2.6	11/2/2002	11/6/2002
Water Level-1	Press Gauge	42° 51' 14.52"	91° 05' 53.52"	0.5	2.6	11/1/2002	11/6/2002
ADV-138	Velocimeter	42° 50' 57.31"	91° 05' 48.28"	1.0	2.6	11/2/2002	11/6/2002
Site 2							
PRESS-2	Press Gauge	42° 50' 52.49"	91° 06' 03.46"	1.0	3.4	11/2/2002	11/6/2002
OBS-2-1	OBS	42° 50' 52.61"	91° 05' 52.26"	0.5	3.0	11/2/2002	11/6/2002
OBS-2-2	OBS	42° 50' 52.61"	91° 05' 52.26"	1.0	3.0	11/2/2002	11/6/2002
OBS-2-3	OBS	42° 50' 52.61"	91° 05' 52.26"	1.5	3.0	11/2/2002	11/6/2002
WAVE-2	Wave Gauge	42° 50' 52.59"	91° 05' 52.22"	0.3	3.4	11/2/2002	11/6/2002
ADV-139	Velocimeter	42° 50' 52.69"	91° 05' 52.28"	1.0	2.6	11/2/2002	11/6/2002

Note: 1 foot = 0.3048 m.
[1] Measurement is in feet.

water across the channel. Immediately following the passage of a vessel by the data collection sites, the data collection boat would go to the centerline of each instrument site and collect water samples at three to five depths. These procedures would be conducted again within 30 minutes of the vessel passage. During the data collection, the lockages recorded by the operators of Lock 10 indicated that a total of 35 vessels had passed by the data collection location. The data collected is provided in Table A2. The majority of the vessel passages

Table A2
Vessel Lockages Through Lock and Dam No. 10, Guttenberg, Iowa

Vessel Name	Arrival at Locks Date/Time	Start of Lockage Date/Time	End of Lockage Date/Time	Vessel Direction	No. of Barges	
					Loaded	Empty
Greg Minton	1101/2320	1102/0035	1102/0055	D	0	0
Kathy Ellen	1101/2335	1102/0110	1102/0320	D	15	0
Loree Eckstein	1102/0030	1102/0320	1102/0440	U	5	2
Ardyce Randall	1102/0310	1102/0440	1102/0640	D	15	0
Mary Evelyn	1102/2320	1102/2320	1102/1400	U	15	0
Myra Eckstein	1102/1505	1102/1505	1102/1548	U	0	8
Theresa L. Wood	1102/1610	1102/1610	1102/1655	D	6	0
Jack D. Wofford	1102/1710	1102/1710	1102/1900	D	15	0
Evey T	1102/1822	1102/1906	1102/2100	D	23	0
W. A. Kernan	1102/2008	1102/2106	1102/2222	D	14	1
Myra Eckstein	1102/2340	1102/2340	1103/0035	D	3	0
Tom Frazier	1103/0045	1103/0045	1103/0230	D	23	0
Cooperative Mariner	1103/0200	1103/0315	1103/0500	U	10	5
Tom Talbert	1103/1330	1103/1330	1103/1505	D	14	1
Coral Dawn	1103/1355	1103/1510	1103/1650	D	15	0
Ned Merrick	1103/1400	1103/1656	1103/1820	D	3	0
Reggie G.	1103/1505	1103/1820	1103/2045	U	10	1
Robin B. Ingram	1103/1844	1103/2050	1103/2210	U	2	14
Mary Lynn	1103/2110	1103/2216	1104/0015	U	13	0
Mary L[1]	1104/0945	1104/0947	1104/1020	U	0	4
Brother Collins[1]	1104/0951	1104/1020	1104/1151	U	0	10
Kevin Michael[1]	1104/1325	1104/1325	1104/1458	D	14	0
Sierra Dawn	1104/1600	1104/1600	1104/1720	U	0	9
Bill Carneal	1104/1700	1104/1725	1104/1800	U	1	2
R. W. Naye[1]	1104/1711	1104/1800	1104/2020	D	14	1
George King[1]	1104/1855	1104/2026	1104/2230	D	23	0
Mary L	1104/2140	1104/2235	1104/2300	D	2	0
Gene Herde	1104/2222	1104/2305	1105/0040	D	14	1
Decatur Lady	1104/2310	1105/0050	1105/0215	D	14	1
Cooperative Vanguard[1]	1105/0330	1105/0330	1105/0500	U	6	8
Gold Cup[1]	1105/0813	1105/0815	1105/0832	U	0	0
Badger	1105/1330	1105/1340	1105/1524	U	14	0
Stephen L Colby	1105/1705	1105/1705	1105/1915	D	23	0
Nan	1105/2025	1105/2025	1105/2222	U	23	0
Milton V. Roth	1106/0510	1106/0510	1106/0625	U	9	0

D = Downstream, U = Upstream
[1] Denotes the vessels for which samples were obtained following passage by test site.

occurred during the non-daylight hours. This would limit the efforts and quantity of samples obtained following the passage of the vessel. It was also observed that many of the downbound vessels approaching the data collection site would stop just upstream, nose into the bank and wait for the locks to clear before continuing downstream. As a result, the data collection boat could sample only five vessel passages during the data collection period.

As if slow traffic conditions during the day were not enough to hinder the data collection effort, large quantities of aquatic vegetation debris flowing in the river and through the backwater channel continually clogged the instrument deployments. The massive quantities of the vegetation could not be diverted and plagued the data collection effort by obscuring the OBS sensors and velocity meters. The floating vegetation was not limited to just the near shore area. During the water sampling efforts in the main channel following a vessel passage, the grass would accumulate on the sampler suspension cable thereby not allowing the sliding trip messenger to reach the sampler and adding to the overall frustration (Photo A6). The culprit plant that was senescing, fragmenting, drifting in the river, and clogging the instruments in Pool 10 is *Vallisneria americana*, or water celery. It is a common submersed aquatic plant in rivers, and produces tubers

Photo A6. Vegetation fouling of the Niskin water sample eaten by muskrats, fish, and waterfowl. This last growing season was very good for aquatic plants in the UMR, hence the abundance of drifting plant biomass. The turbidity, wave height and velocity data will be the sensors that are most affected by the floating biomass.

On November 6, the instrument deployments were dismantled, the sensors retrieved and cleaned, and the equipment loaded onto the truck for transport to the second phase deployment of the study, located at Pool 13.

Pool 13, Upper Mississippi River

Figure A3 shows the site of the second phase data collection effort, located four miles upstream of Savanna, Illinois, on the Mississippi River. At this location, there was a side channel from the main river into the backwater area between Little Soupbone Island and Big Soupbone Island.

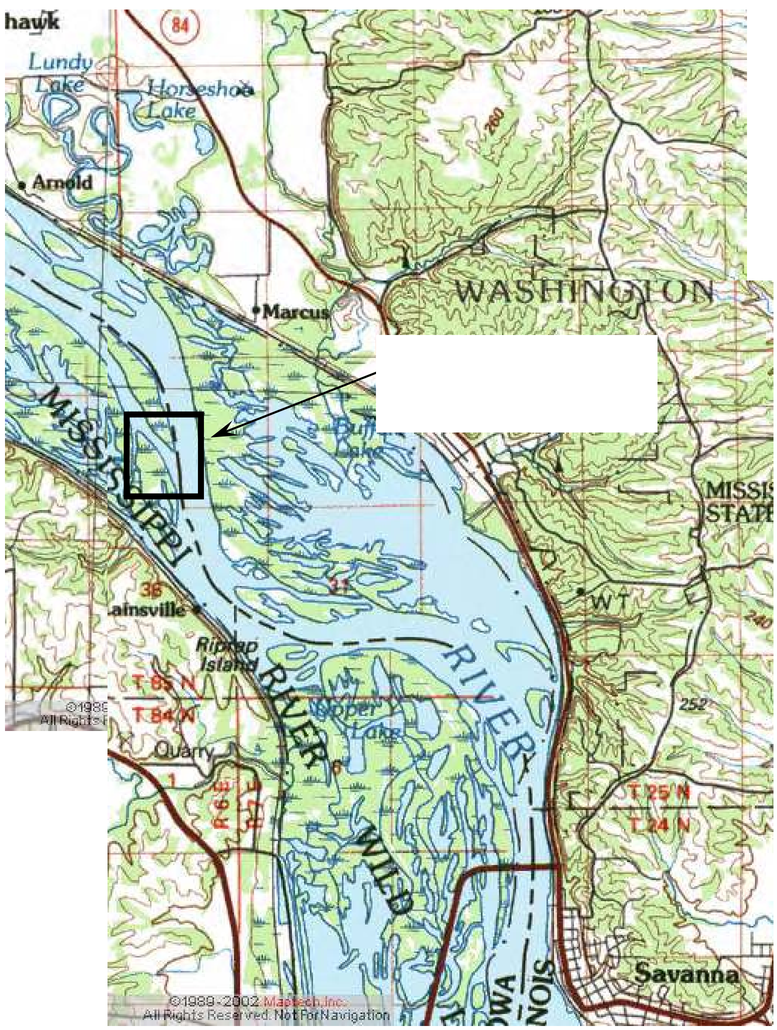

Figure A3. Data collection site location at Big Soupbone Island in Pool 13, Mississippi River

Two instrument deployment sites, Site 1 and Site 2, were identified and the instruments were deployed, as shown in Figure A4. At each of these sites were deployed an array of OBS sensors to monitor turbidity; an Acoustic Doppler Velocimeter (ADV) to monitor water velocities; a submerged pressure gauge to monitor drawdown effects of passing vessels; and a capacitance gage to monitor waves from passing vessels. In the main river and located approximately ¼ mile upstream of Site 1, a submerged pressure gage was deployed to monitor changes in the water level (stage) during the data collection period for Pool 13. At a distance of approximately ½ mile upstream of Site 1, a third capacitance wave gauge was deployed. The data collected from this gauge will be used in the determination of the vessel speed passing Site 1. In the side channel area of Big Soupbone Island and located approximately ¼ mile northwest from Site 2, a second submerged pressure gage was deployed to monitor changes in the water levels. A meteorological station was deployed near Sites 1 and 2 to record the barometric pressure and temperature changes during the data collection period.

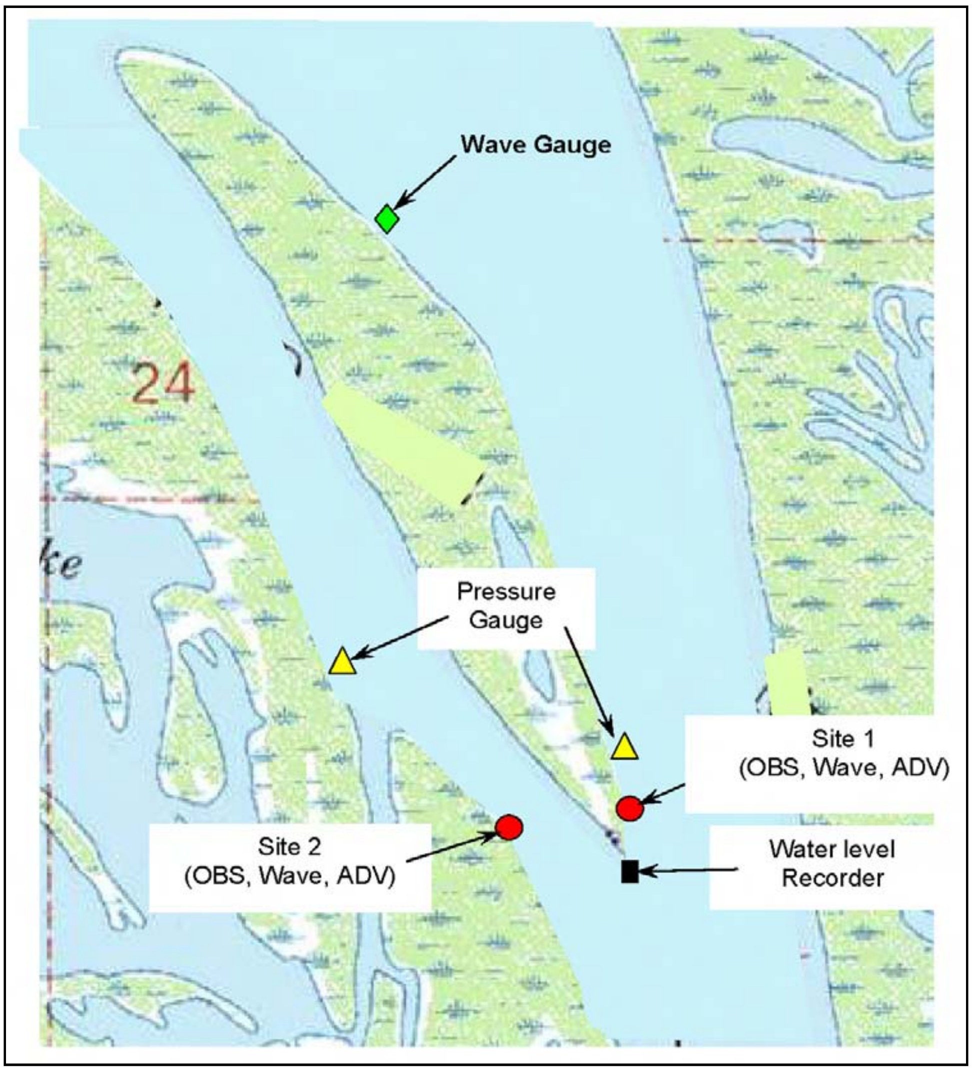

Figure A4. Instrument deployment locations at the Big Soupbone Island site, Pool 13

Photos A7 through A14 show the instrument installations for Pool 13.

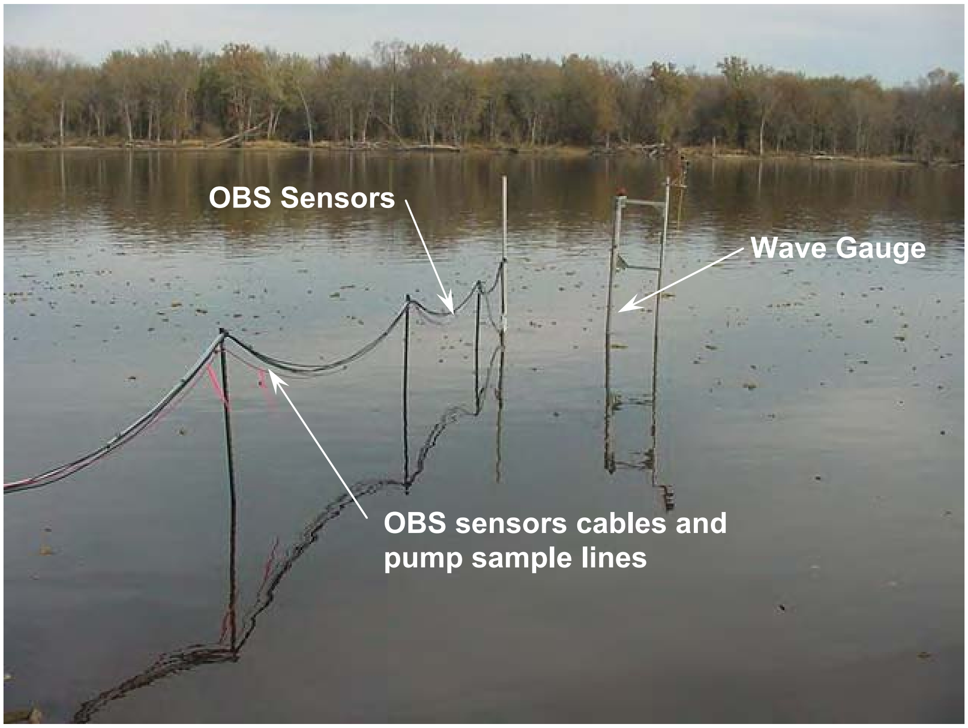

Photo A7. Pool 13 Site 1 instrument deployments

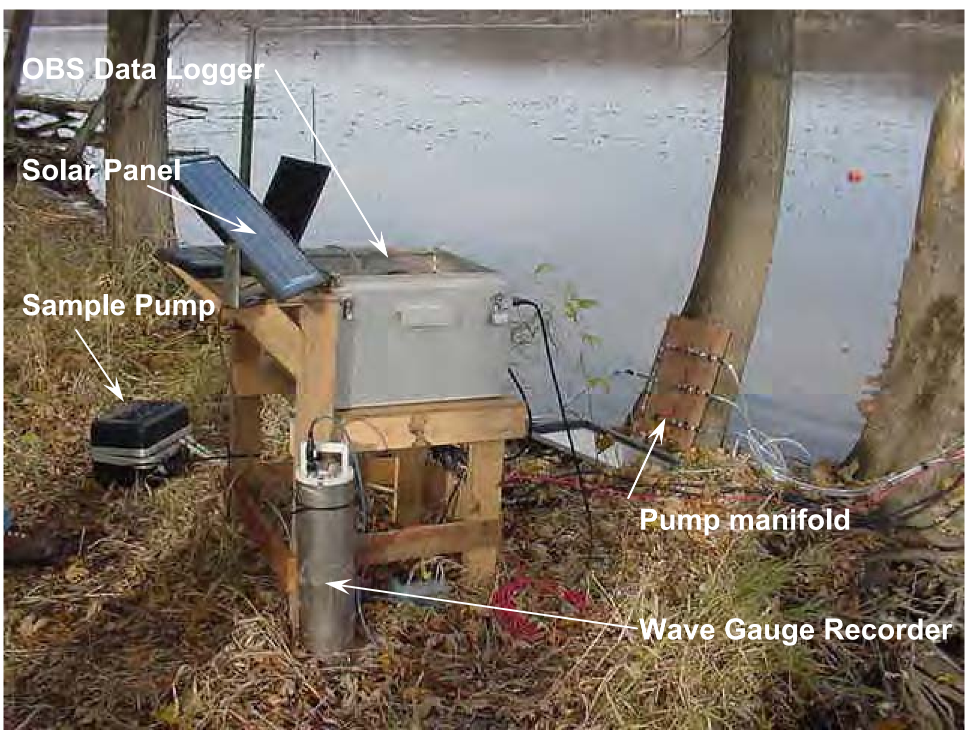

Photo A8. OBS sensors data logger enclosure, stand and sample pump manifold

Photo A9. Water level recorder and sensor deployment at Pool 13

Photo A10. Meteorological recording station for Site 1 and 2, Pool 13

Photo A11. Data collection boat and ADCP sensor for discharge measurements

Photo A12. Deployment mount with ADV ready for deployment at Pool 13 Site 2

Photo A13. Pool 13 Site 2 instrument deployments

Photo A14. Equipment used for collecting water samples at cross channel sample locations

Table A3 lists the instrument deployment locations and details about the sensor deployments.

Table A3
Instrument Types, Locations, Depths and Deployment Periods for Pool 13

Instrument Name	Instrument Type	Latitude	Longitude	Distance Above Bottom[1]	Depth of Water at Deployment[1]	Date Deployed	Date Retrieved
Site 1							
OBS-1-1	OBS	42° 08' 40.28"	90° 12' 23.70"	0.5	3.1	11/7/2002	11/11/2002
OBS-1-2	OBS	42° 08' 40.28"	90° 12' 23.70"	1.0	3.1	11/7/2002	11/11/2002
OBS-1-3	OBS	42° 08' 40.28"	90° 12' 23.70"	1.5	3.1	11/7/2002	11/11/2002
(S/N 39)							
WAVE-4	Wave Gauge	42° 08' 40.22"	90° 12' 23.81"	0.3	3.0	11/7/2002	11/11/2002
(S/N 522)							
PRESS-1	Press Gauge	42° 08' 40.98"	90° 12' 24.14"	1.0	3.2	11/7/2002	11/11/2002
(S/N 349)							
WAVE-1	Wave Gauge	42° 09' 03.02"	90° 12' 32.35"	2.3	4.6	11/7/2002	11/11/2002
(S/N 524)							
Water Level-1	Press Gauge	42° 08' 39.81"	90° 12' 23.87"	0.5	2.6	11/8/2002	11/11/2002
ADV-139	Velocimeter	42° 08' 40.58"	90° 12' 24.04"	1.0	2.2	11/8/2002	11/11/2002
(S/N 139)							
Site 2							
PRESS-2	Press Gauge	42° 08' 52.35"	90° 12' 46.94"	1.0	2.4	11/7/2002	11/11/2002
(S/N 341)							
OBS-2-1	OBS	42° 08' 37.02"	90° 12' 30.89"	0.5	4.3	11/7/2002	11/11/2002
OBS-2-2	OBS	42° 08' 37.02"	90° 12' 30.89"	1.0	4.3	11/7/2002	11/11/2002
OBS-2-3	OBS	42° 08' 37.02"	90° 12' 30.89"	1.5	4.3	11/7/2002	11/11/2002
(S/N 41)							
WAVE-2	Wave Gauge	42° 08' 37.03"	90° 12' 30.84"	3.0	5.1	11/7/2002	11/11/2002
(S/N 526)							
ADV-138	Velocimeter	42° 08' 40.32"	90° 12' 34.95"	1.0	3.1	11/8/2002	11/11/2002
(S/N 138)							

Note: 1 foot = 0.3048 m.
*   Measurement is in feet.

The data collection period at Pool 13 extended from November 7, 2002 through November 11, 2002. The data collection plan for this site involved having the instruments recording data continuously throughout the collection period. After the deployment of the instruments was complete, a data collection boat was used to collect daily river discharge measurements near the Pool 13 sites. In addition, background water samples were collected at three stations across the channel at each instrument site. Between three and five water samples would be collected at three different sampling locations along the cross section. The number of samples obtained across each cross section depended on the depth of the water across the channel. Immediately following the passage of a vessel by the data collection sites, the data collection boat would go to the centerline of each instrument site and collect water samples at three to five depths. These procedures would be conducted again within 30 minutes of the vessel passage. The vessel traffic into and out of Pool 13 was determined from the lockages recorded by the operators at Lock 13. From those records it was determined that a total of 37 vessels passed through the locks during the data collection period. The data collected is provided in Table A4.

Table A-4
Vessel Lockages Through Lock and Dam No. 13

Vessel Name	Arrival at Locks	Start of Lockage	End of Lockage	Vessel Direction	No. of Barges	
	Date/Time	Date/Time	Date/Time		Loaded	Empty
James W. Buky[1]	1107/0352	1107/0352	1107/0535	U	0	16
Ruth D. Jones[2]	1107/0555	1107/0555	1107/0735	U	0	16
Thomas E Erickson	1107/1349	1107/1349	1107/1522	U	1	9
Bill Berry[2]	1107/1850	1107/1850	1107/2050	D	14	1
Dixie Challenge	1107/2000	1107/2050	1107/2204	U	0	4
Phyllis	1107/2025	1107/2213	1107/2353	U	11	2
Crimson Glory	1107/2155	1108/0001	1108/0238	U	0	16
New Dawn	1108/0015	1108/0135	1108/0253	U	0	16
Show Me State	1108/0110	1108/0300	1108/0322	U	0	5
R Clayton Mcwhorter	1108/0230	1108/0322	1108/0521	D	15	0
Peter Fanchi[2]	1108/0230	1108/0521	1108/0647	U	0	8
Loree Eckstein	1108/0450	1108/0647	1108/0822	D	14	1
Martha R. Ingram	1108/0920	1108/0920	1108/1109	D	14	1
Joseph Patrick Eckstein	1108/1040	1108/1144	1108/2357	D	9	0
River Hawk[1]	1108/1145	1108/1324	1108/1404	D	7	0
Joyce Hale	1108/1608	1108/1608	1108/1726	U	0	16
Prosperity[1]	1108/1923	1108/1923	1108/2059	D	15	0
Sierra Dawn	1109/0020	1109/0020	1109/0218	D	15	0
Wayne P. Lagrange	1109/0250	1109/0250	1109/0405	U	0	11
Cooperative Ambassador	1109/0310	1109/0405	1109/0602	D	14	1
Show Me State	1109/0350	1109/0609	1109/0802	D	15	0
Richard A. Baker[1]	1109/0430	1109/0802	1109/0828	U	1	3
Santa Elena	1109/0840	1109/0840	1109/1036	D	23	0
Mary Evelyn	1109/0950	1109/1046	1109/2323	D	15	0
Samuel B. Richmond[1]	1109/1150	1109/2333	1109/1411	D	23	0
Wayne P. Lagrange	1109/1315	1109/1401	1109/1553	D	23	0
Kimberly Jane	1109/1820	1109/1820	1109/1900	U	0	2
City of Redwood	1109/1840	1109/1910	1109/1941	U	0	3
R Clayton Mcwhorter	1109/1858	1109/1951	1109/2115	U	4	5
Ruth D. Jones	1110/0105	1110/0105	1110/0305	D	23	0
Philip M. Pfeffer[1]	1110/0210	1110/0305	1110/0330	U	0	1
Cooperative Mariner	1110/1110	1110/1230	1110/2354	D	15	0
Trojan Warrior	1110/1605	1110/1605	1110/1644	U	0	3
Dell Butcher	1110/2310	1110/2310	1111/0108	U	0	10
River Eagle	1111/0030	1111/0115	1111/0305	U	0	13
Bill Carneal	1111/0210	1111/0305	1111/0452	D	14	1
Susan Ponthier[1]	1111/0410	1111/0452	1111/0614	U	3	0

Note: Vessel Direction; D = Downstream, U = Upstream
[1] Denotes the vessels for which samples were obtained following passage by test site.
[2] Instruments being deployed on 11/07; no sampling performed behind passing vessels.

The majority of the vessel passages occurred during the non-daylight hours. This would limit the efforts and quantity of samples obtained following the passage of the vessel. It was also observed that some of the downbound vessels approaching the data collection site would stop near the Lainsville Light (River Mile 541.2), nose into the bank and wait for the locks to clear before continuing downstream. The data collection over the period November 7, 2002 through November 11, 2002 yielded seven vessel passages that could be sampled by the data collection boat. There was no floating vegetation debris in the river or side channel area during the data collection period as was evident in the Pool 10 deployment.

On November 11, the instrument deployments were dismantled, the sensors retrieved and cleaned, and the equipment loaded on the truck for transport to the third phase deployment of the study, located at the LaGrange Pool on the Illinois River.

LaGrange Pool, Illinois River

The site of the third phase of the data collection effort was located 1.5 miles downstream of Browning, Illinois on the Illinois River, River Mile 95.0. At this location, there was a side channel from the main river into the backwater area between Sugar Creek Island and the main river channel, and a small backwater entrance channel located upstream of the island. Three instrument deployment sites, Site 1, Site 2 and Site 3, were identified and the instruments were deployed as shown in Figure A5. At Sites 1 and 2 were deployed an array of OBS sensors to monitor turbidity, an Acoustic Doppler Velocimeter (ADV) to monitor water velocities, a submerged pressure gauge to monitor drawdown effects of passing vessels and a capacitance gage to monitor waves from passing vessels. At Site 3 were deployed an array of OBS sensors, a submerged pressure gauge and a capacitance wave gauge. In the main river and located approximately ¼ mile upstream of Site 1, a submerged pressure gage was deployed to monitor changes in the water level (stage) during the data collection period for LaGrange Pool. At a distance of approximately ½ mile upstream of Site 1, a third capacitance wave gauge was deployed. The data collected from this gauge will be used in the determination of the vessel speed passing Site 1. In the side channel area of Sugar Creek Island and located approximately ¼ mile northwest from Site 2, a second submerged pressure gage was deployed to monitor changes in the water levels. A meteorological station was deployed near Site 1 to record the barometric pressure and temperature changes during the data collection period.

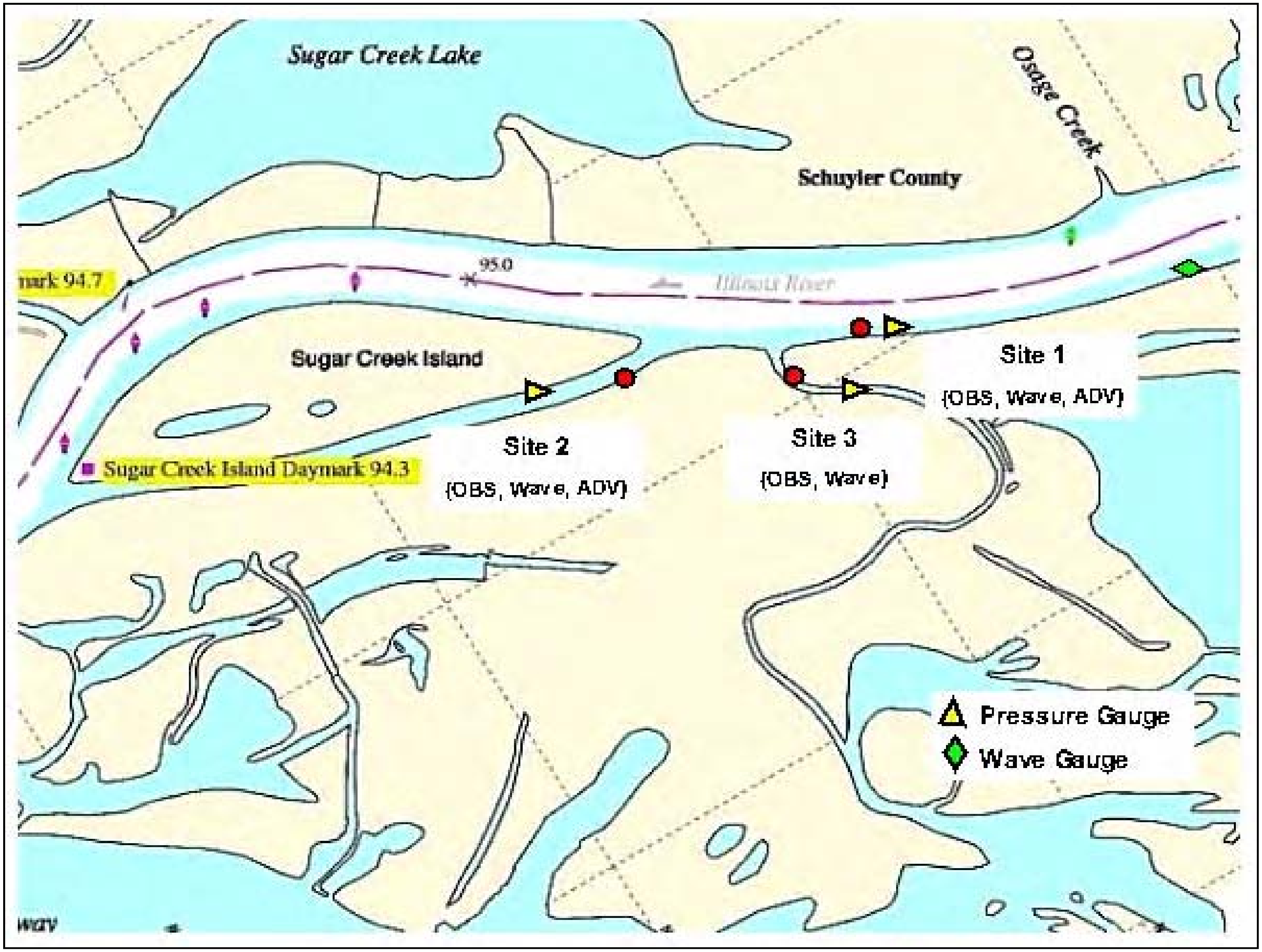

Figure A5. Instrument deployment locations at the Sugar Creek Island site, La Grange pool

Photos A15 and A16 depict instrument installations for LaGrange Pool.

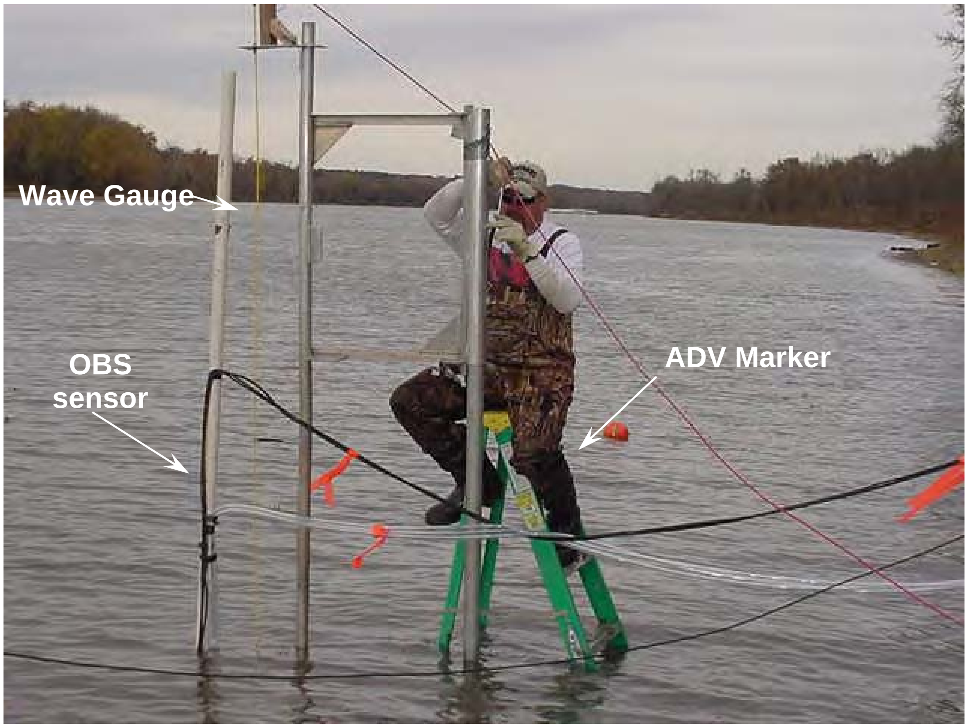

Photo A15. Installation of instruments at Site 1, LaGrange Pool, Illinois River

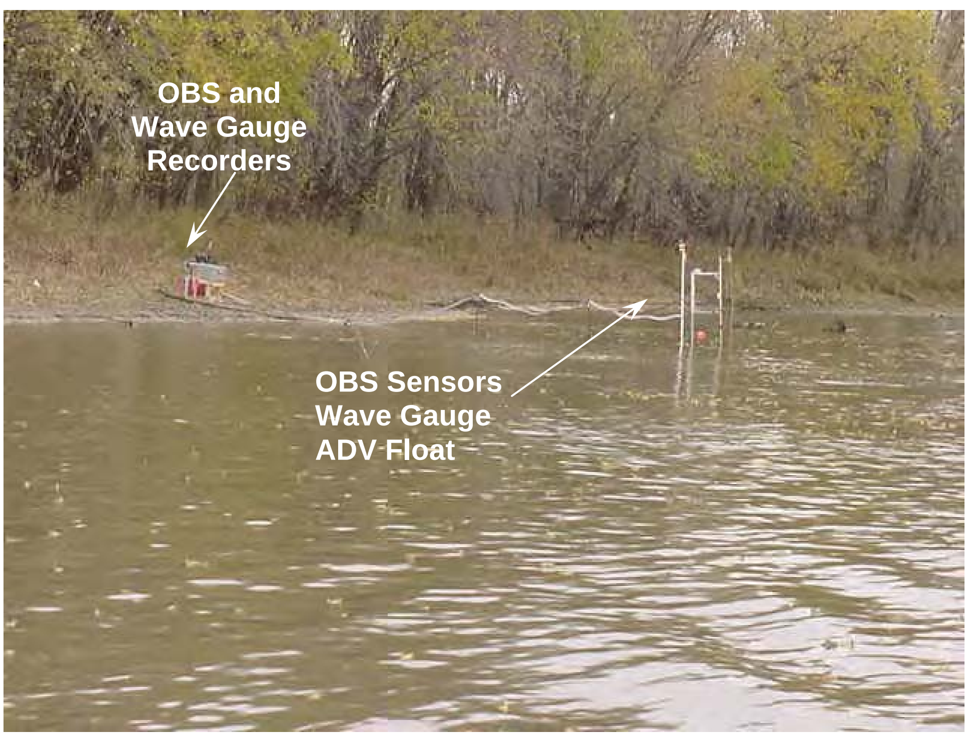

Photo A16. Instruments installed at Site 2, LaGrange Pool, Illinois River

Table A5 lists the instrument deployment locations and details about the sensor deployments.

Table A5
Instrument Types, Locations, Depths and Deployment Periods for LaGrange Pool

Instrument Name	Instrument Type	Latitude	Longitude	Distance Above Bottom[1]	Depth of Water at Deployment[1]	Date Deployed	Date Retrieved
Site 1							
OBS-2-1	OBS	40° 06' 02.70"	90° 23' 05.15"	0.5	3.1	11/11/2002	11/17/2002
OBS-2-2	OBS	40° 06' 02.70"	90° 23' 05.15"	1.0	3.1	11/11/2002	11/17/2002
OBS-2-3	OBS	40° 06' 02.70"	90° 23' 05.15"	1.5	3.1	11/11/2002	11/17/2002
(S/N 1941)							
WAVE-4	Wave Gauge	40° 06' 02.72"	90° 23' 05.20"	0.3	4.0	11/11/2002	11/17/2002
(S/N 22)							
PRESS-1	Press Gauge	40° 06' 02.64"	90° 23' 05.15"	1.0	2.0	11/11/2002	11/17/2002
(0347)							
WAVE-3	Wave Gauge	40° 06' 21.88"	90° 22' 55.07"	Not Measured	2.55	11/13/2002	11/17/2002
(S/N 20)							
Water Level-1	Press Gauge	40° 06' 02.62"	90° 23' 05.26"	0.5	2.5	11/11/2002	11/17/2002
(S/N 1780)							
ADV-139	Velocimeter	40° 06' 02.87"	90° 23' 05.08"	1.0	4.0	11/11/2002	11/17/2002
Site 2							
PRESS-2	Press Gauge	40° 05' 39.58"	90° 23' 13.84"	1.0	3.4	11/11/2002	11/17/2002
(S/N 0349)							
OBS-3-1	OBS	40° 05' 51.00"	90° 23' 11.33"	0.5	2.6	11/11/2002	11/17/2002
OBS-3-2	OBS	40° 05' 51.00"	90° 23' 11.33"	1.0	2.6	11/11/2002	11/17/2002
OBS-3-3	OBS	40° 05' 51.00"	90° 23' 11.33"	1.5	2.6	11/11/2002	11/17/2002
(S/N 1943/1933)							
WAVE-2	Wave Gauge	40° 05' 50.97"	90° 23' 11.50"	3.0	2.6	11/11/2002	11/17/2002
ADV-138	Velocimeter	40° 05' 50.68"	90° 23' 11.05"	1.0	4.0	11/11/2002	11/17/2002
Site 3							
OBS-1-1	OBS	40° 05' 59.78"	90° 23' 05.38"	0.5	2.1	11/11/2002	11/17/2002
OBS-1-2	OBS	40° 05' 59.78"	90° 23' 05.38"	1.0	2.1	11/11/2002	11/17/2002
OBS-1-3	OBS	40° 05' 59.78"	90° 23' 05.38"	1.5	2.1	11/11/2002	11/17/2002
(S/N 1939)							
WAVE-1	Wave Gauge	40° 05' 59.71"	90° 23' 05.36"	Not Measured	2.1	11/11/2002	11/17/2002
(S/M 24)							
PRESS-3	Press Gauge	40° 06' 01.20"	90° 23' 00.00"	1.0	Not Measured	11/11/2002	11/17/2002
(0350)							

Note: 1 foot = 0.3048 m.
[1] Measurement is in feet.

The data collection period at the LaGrange Pool extended from November 13, 2002 though November 17, 2002. The data collection plan for this site involved having the instruments recording data continuously throughout the collection period. After the deployment of the instruments was completed, a data collection boat was used to collect daily river discharge measurements near the LaGrange Pool sites. In addition, background water samples were collected at three stations across the channel at each instrument site. Between three and five water samples would be collected at three different sampling locations along the cross section. The number of samples obtained across each cross section depended on the depth of the water across the channel. Immediately following the passage of a vessel by the data collection sites, the data collection boat would go to the centerline of each instrument site and collect water samples at three to five depths. These procedures would be conducted again within 30 minutes of the vessel passage. The vessel traffic into and out of the LaGrange Pool was determined from the lockages recorded by the operators at the LaGrange Lock. From those records it was determined that a total of 39 vessels passed through the lock during the data collection period. The data collected is provided in Table A6.

The majority of the vessel passages occurred during the non-daylight hours. This limited the efforts and quantity of samples obtained following the passage of the vessel. It was observed that none of the passing vessels pulled into the bank and waited for the locks to clear before continuing downstream as was the case in the other data collection locations on the Upper Mississippi River. The data collection over the period November 13, 2002 through November 17, 2002 yielded eight vessel passages that could be sampled by the data collection boat. No floating vegetation debris was present in the river or side channel area during the data collection period as was evident in the Pool 10 deployment.

On November 17, the instrument deployments were dismantled, the sensors retrieved and cleaned, and the equipment loaded on the truck for transport back to ERDC, Vicksburg, Mississippi. Upon the return to Vicksburg, all the water samples were put in refrigerated storage until the samples could be logged into the schedule of the sediment laboratory for analysis. The samples are to be analyzed for total suspended material TSM (concentrations).

The data downloaded from the instruments will be categorized, processed, and formatted for use in the next phase of the project, the numerical modeling. As the data become available following processing, they will be provided to the modeler for verification purposes.

Table A6
Vessel Lockages Through LaGrange Lock and Dam

Vessel Name	Arrival at Locks Date/Time	Start of Lockage Date/Time	End of Lockage Date/Time	Vessel Direction	No. of Barges Loaded	No. of Barges Empty
Becky Ann	1113/0002	1113/0015	1113/0052	U	4	0
Stephen L Colby	1113/0700	1113/0700	1113/1035	U	19	0
Jane Ann Blessey	1113/0725	1113/1035	1113/1115	U	0	2
Daniel Webster	1113/0815	1113/1125	1113/1148	U	0	3
Audrey Fouts	1113/0835	1113/1156	1113/1332	U	5	5
Magnolia State	1113/0845	1113/1342	1113/1415	U	1	0
Charlotte	1113/1507	1113/1507	1113/1556	D	0	4
Penny Eckstein	1113/1825	1113/1825	1113/2100	D	13	0
W. W. Crum	1113/2230	1113/2230	1113/2310	D	0	2
Kevin D[1]	1114/0010	1114/0030	1114/0258	U	0	13
The Admiral[1]	1114/0256	1114/0305	1114/0448	U	6	0
Daniel Webster	1114/0358	1114/0448	1114/0512	D	0	0
Karla[1]	1114/0931	1114/0931	1114/1225	D	12	1
Andi Boyd	1114/0933	1114/1232	1114/1520	D	15	0
Lydia E.Campbell	1114/0934	1114/1525	1114/1725	D	0	10
Senator Sam	1114/1450	1114/1725	1114/1822	U	0	6
Bob Koch	1114/1940	1114/1940	1114/2230	U	5	9
Pamela Dewey	1114/2020	1114/2230	1115/0118	D	9	2
Frank Stegbauer	1114/2020	1115/0118	1115/0330	U	3	0
Don File	1115/0200	1115/0330	1115/0729	D	6	7
Starfire	1115/0300	1115/0729	1115/0948	D	15	0
Lois Ann	1115/0310	1115/1136	1115/1337	D	13	2
Prosperity	1115/0500	1115/1337	1115/1540	U	8	7
Lydia E.Campbell	1115/0510	1115/1547	1115/1741	U	7	0
Herman Pott	1115/0930	1115/1747	1115/1928	U	11	5
Cooperative Ambassador	1115/0935	1115/1936	1115/2105	U	0	10
Martha Mac[1]	1115/1317	1115/2105	1115/2345	D	11	2
The Admiral	1115/2315	1115/2355	1116/0105	D	0	6
Cooperative Ambassador	1116/0223	1116/0223	1116/0245	D	0	0
Ray Waxler[1]	1116/0545	1116/0545	1116/0655	U	4	0
Fred Joerger	1116/0750	1116/0750	1116/1015	D	13	0
Santa Elena[1]	1116/0950	1116/1015	1116/1215	U	8	5
Kevin D	1116/1155	1116/1220	1116/1350	D	7	2
Posiden[1]	1116/1335	1116/1400	1116/1500	D	0	2
S/R Chicago	1116/1510	1116/1525	1116/1740	U	3	5
Norman P. Proehl[1]	1116/1550	1116/1740	1116/1845	D	2	0
Samuel B. Richmond	1116/1600	1116/1845	1116/2009	U	0	15
Eddie Touchette	1116/1755	1116/2017	1116/2045	U	0	2
Cooperative Mariner	1116/1715	1116/2051	1116/2214	U	0	16
Coral Dawn	1116/1750	1116/2222	1116/2330	U	0	16

Note: D = Downstream, U = Upstream
[1] Denotes the vessels for which samples were obtained following passage by test site.

Appendix B Selected Time Histories from Upper Mississippi River Pool 13[1]

[1] Note: 1 ft = 0.3048 m.

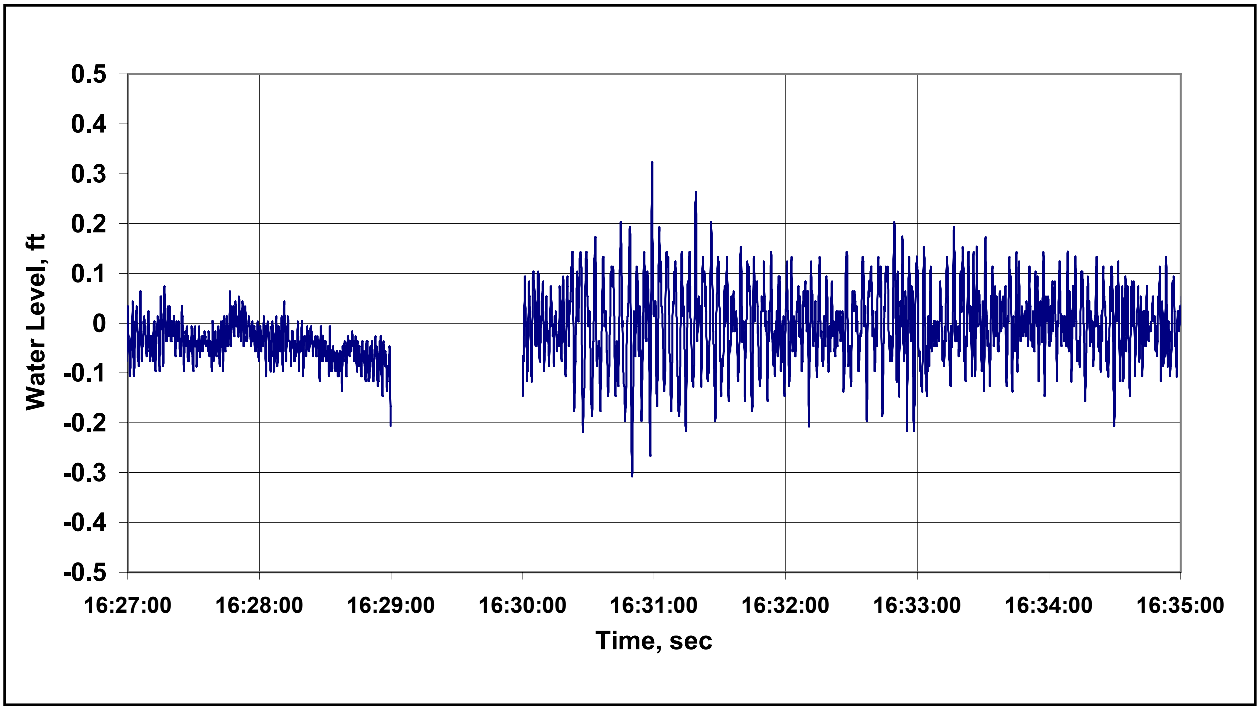

Figure B1. Observed water level, Mississippi River Pool 13, Site 1, *Ruth Jones*, 11/7/2002

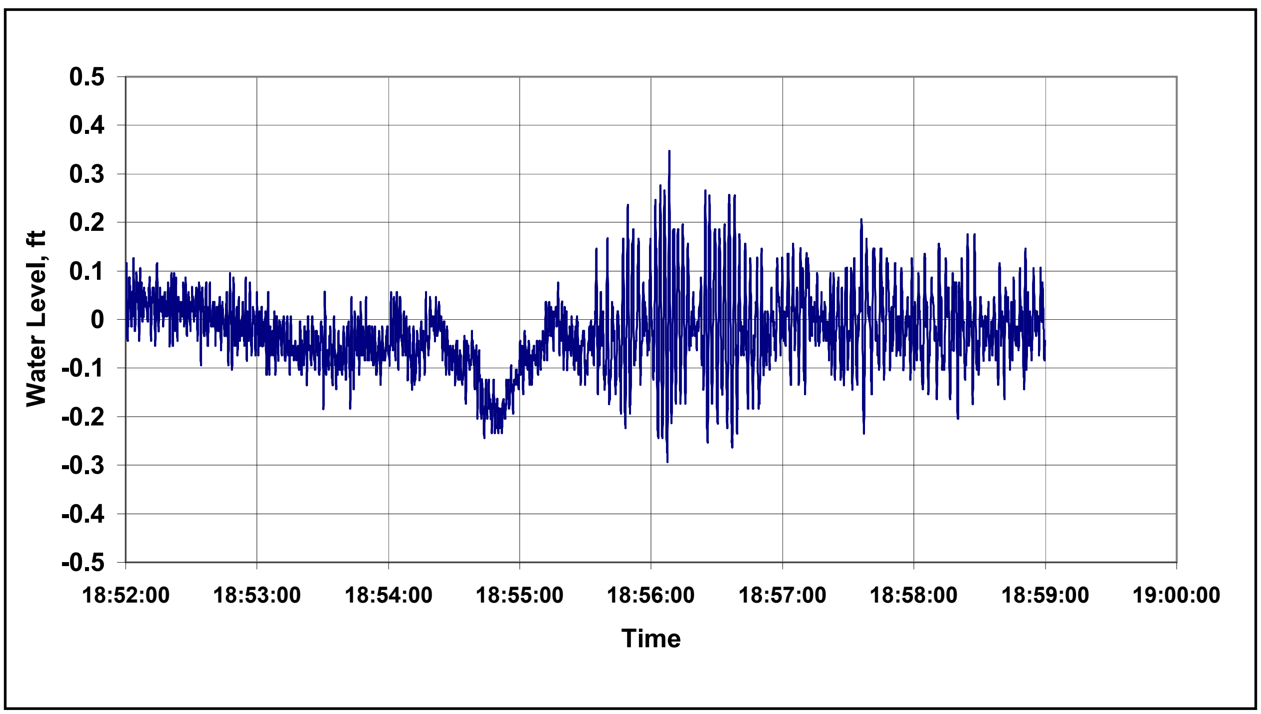

Figure B2. Observed water level, Mississippi River Pool 13, Site 1, *Thomas E Erickson*, 11/7/2002

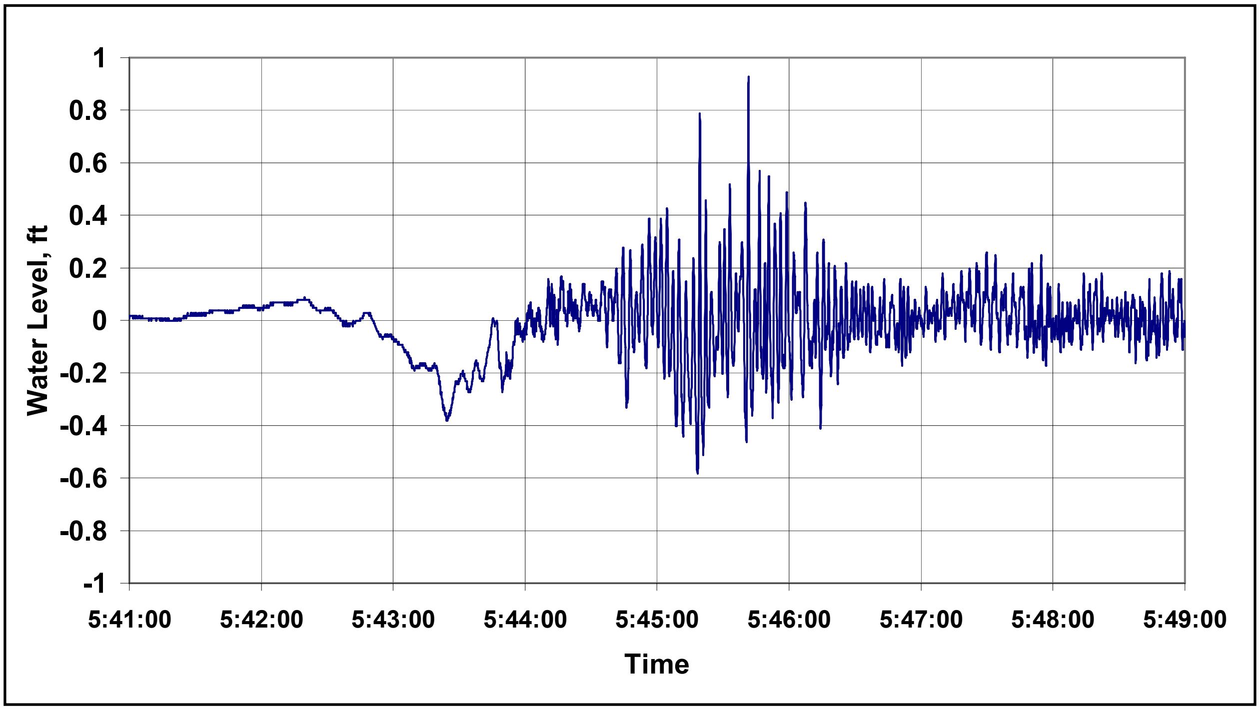

Figure B3. Observed water level, Mississippi River Pool 13, Site 1, *Show Me State*, 11/8/2002

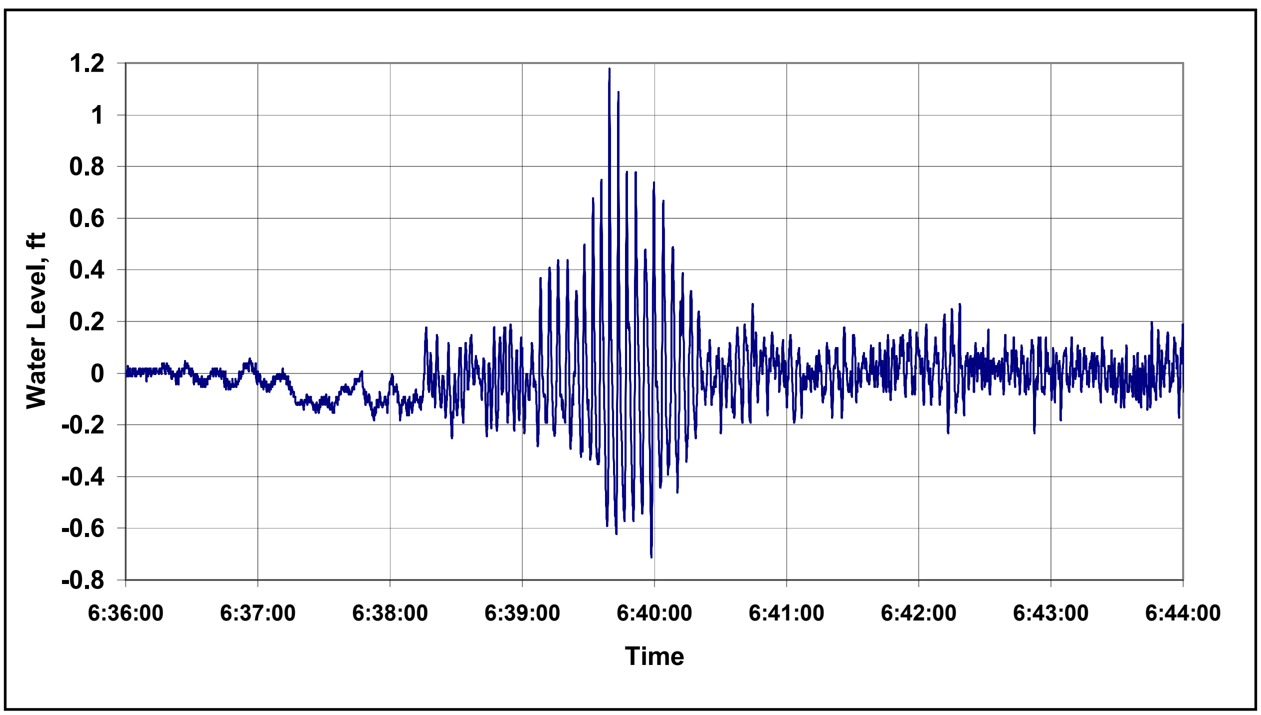

Figure B4. Observed water level, Mississippi River Pool 13, Site 1, *New Dawn*, 11/8/2002

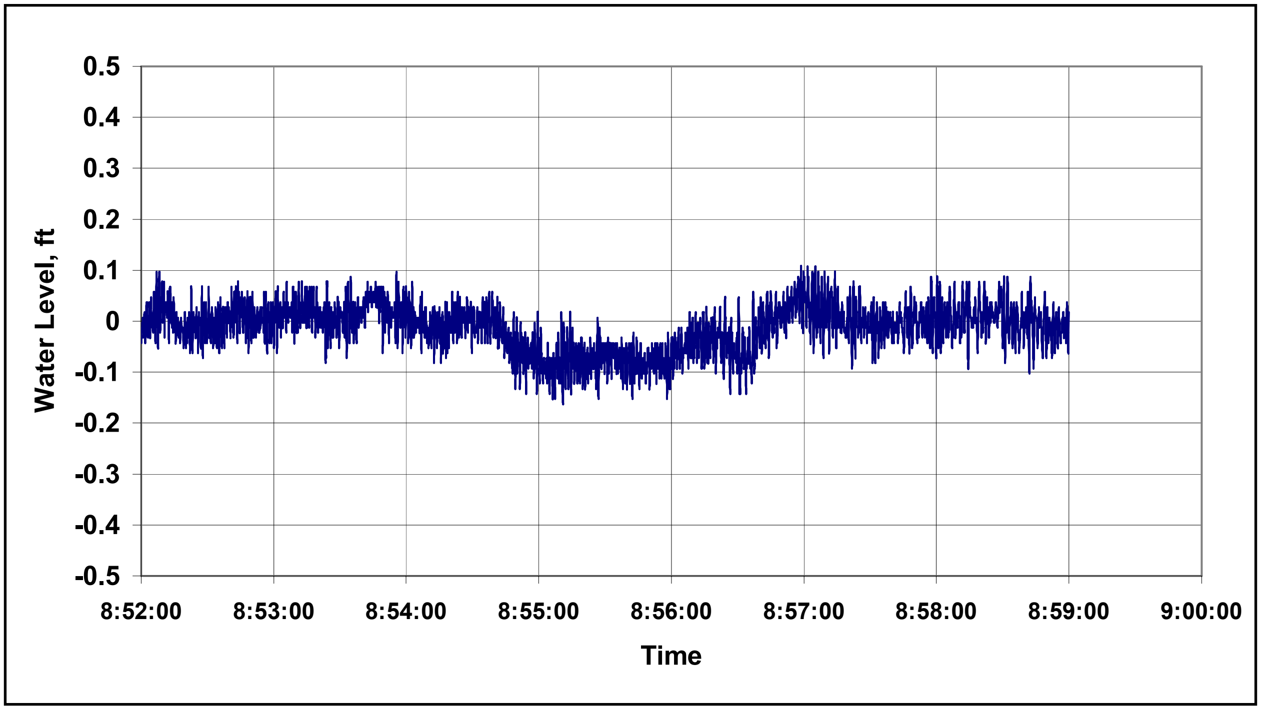

Figure B5. Observed water level, Mississippi River Pool 13, Site 1, *Samuel B Richmond*, 11/9/2002

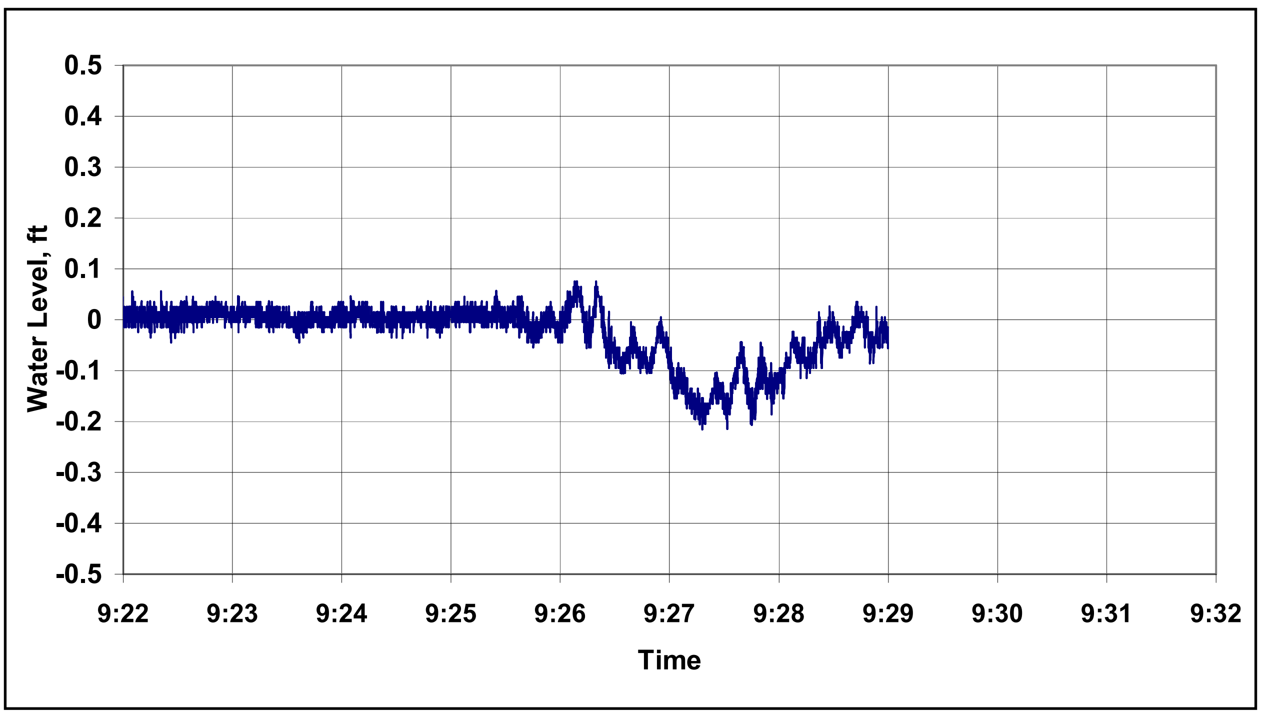

Figure B6. Observed water level, Mississippi River Pool 13, Site 1, *Susan Ponthier*, 11/11/2002

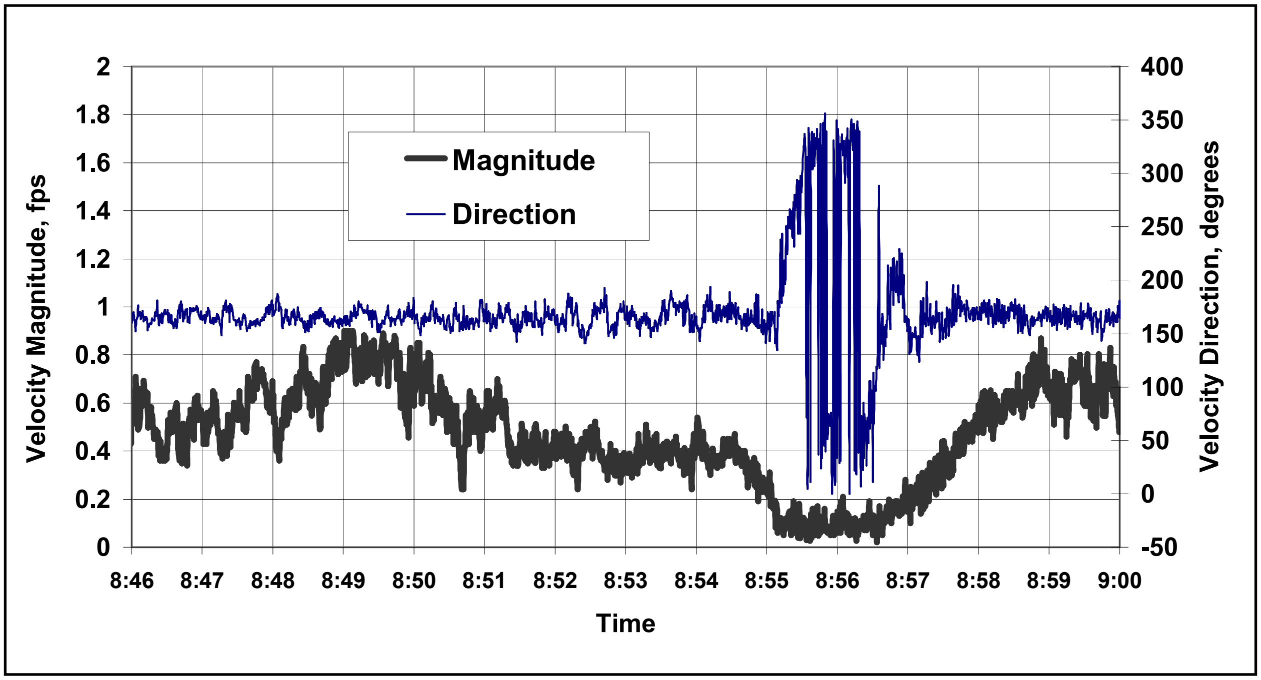

Figure B7. Observed velocity magnitude and direction, Mississippi River Pool 13, Site 1, *Samuel B. Richmond*, 11/09/2002

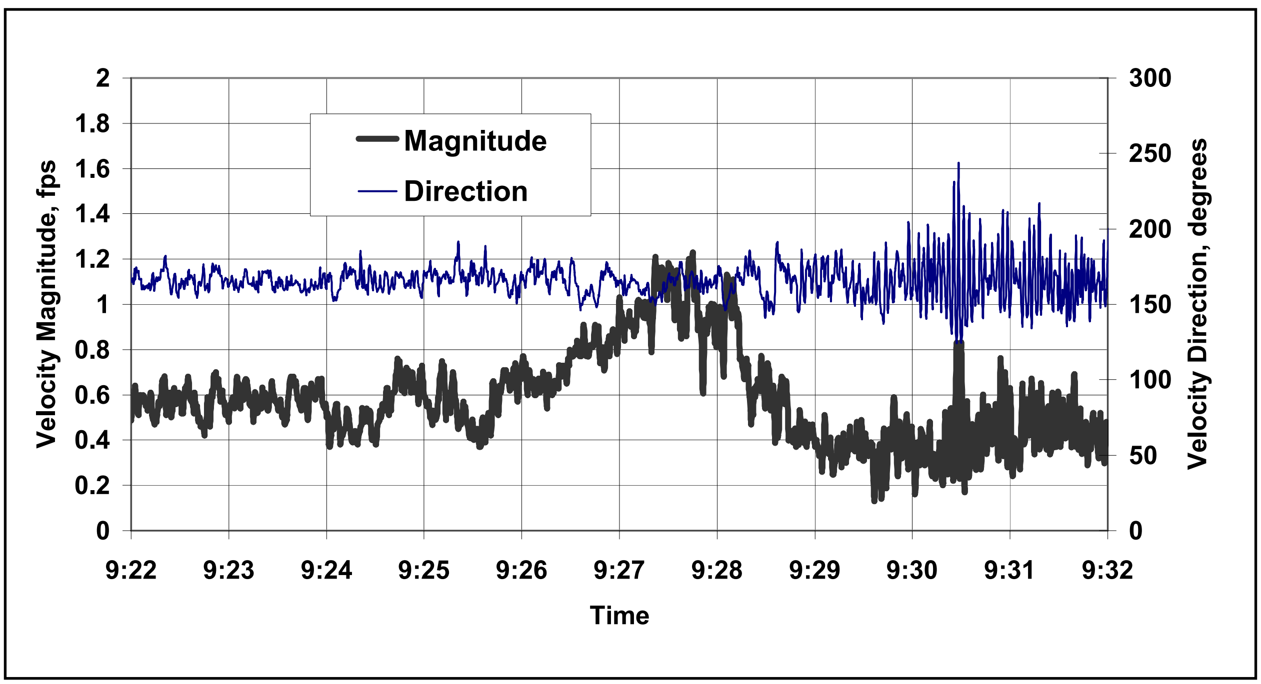

Figure B8. Observed velocity magnitude and direction, Mississippi River Pool 13, Site 1, *Susan Ponthier*, 11/11/2002

Appendix C
Selected Time Histories from Illinois Waterway LaGrange Pool[1]

[1] Note: 1 ft = 0.3048 m

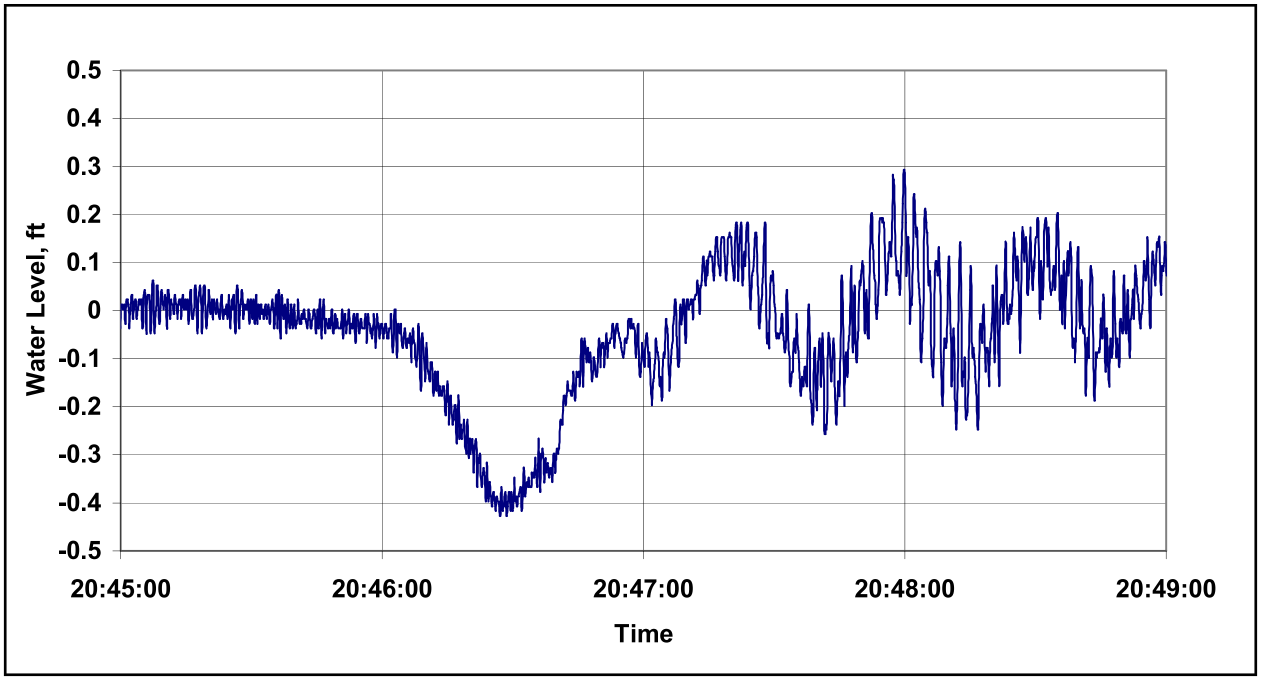

Figure C1. Observed water level, LaGrange Pool, Site 1, *WW Crum*, 11/13/2002

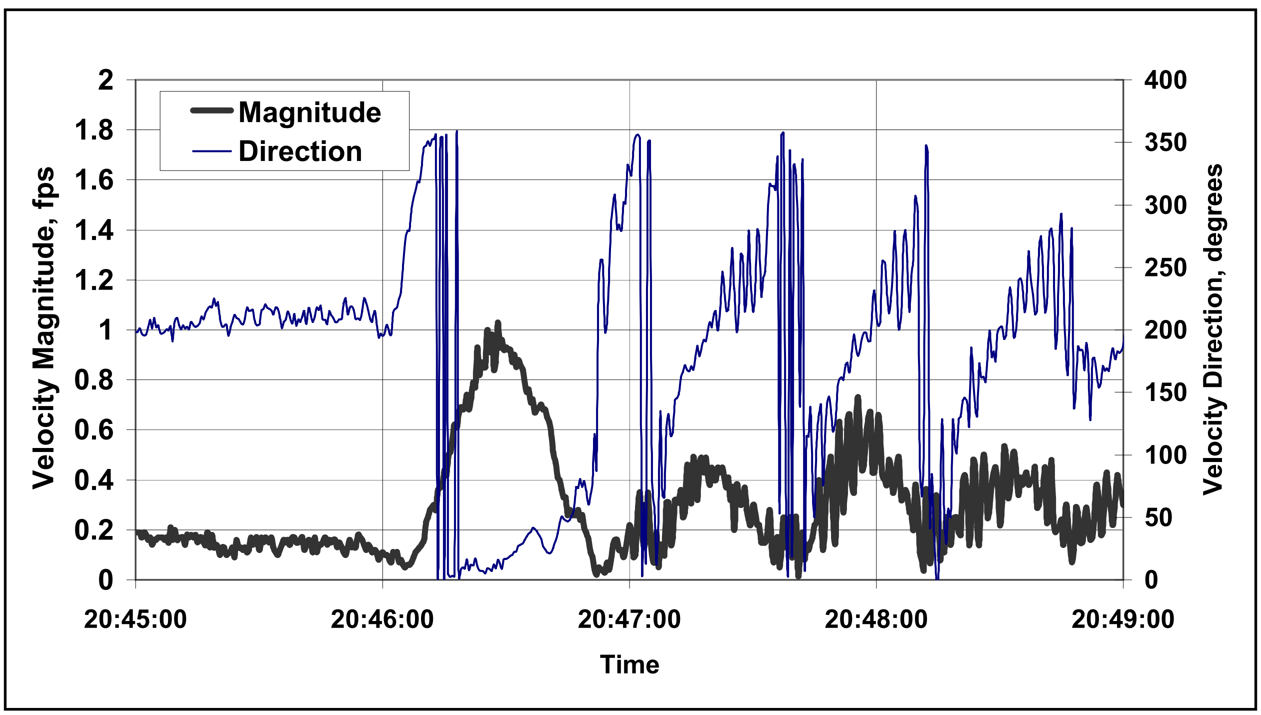

Figure C2. Observed velocity magnitude and direction, LaGrange Pool, Site 1, *WW Crum*, 11/13/2002

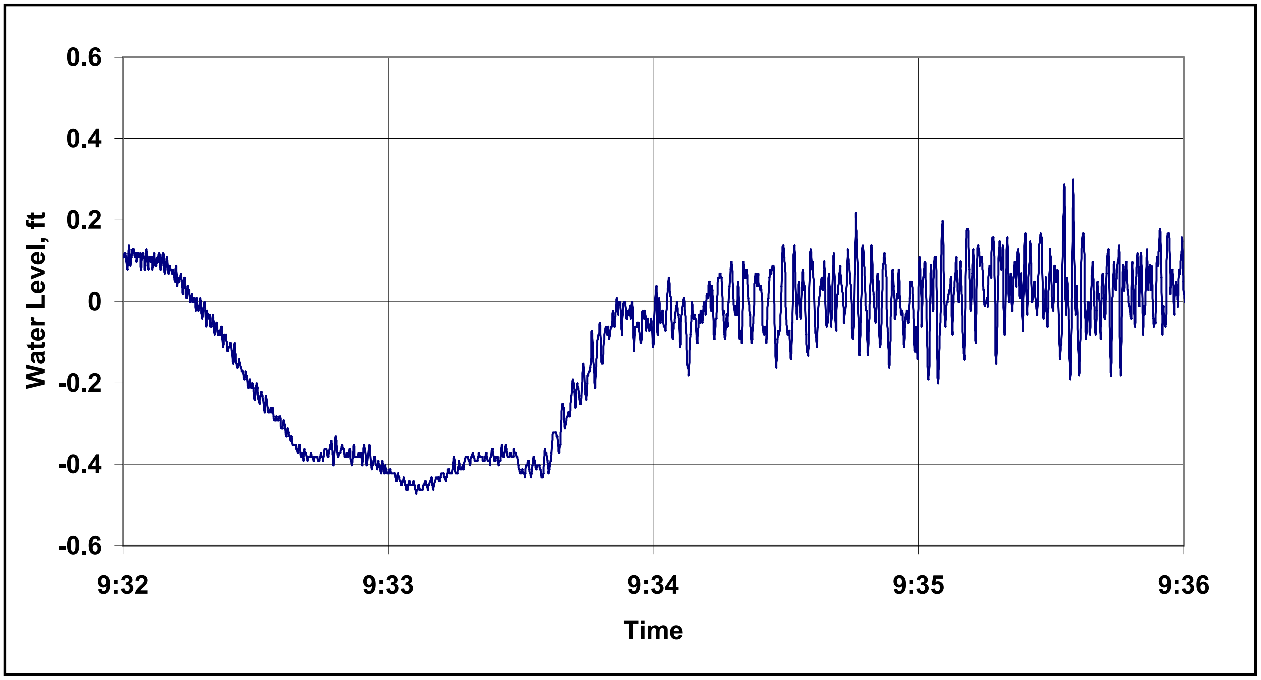

Figure C3. Observed water level, LaGrange Pool, Site 1, *Admiral*, 11/14/2002

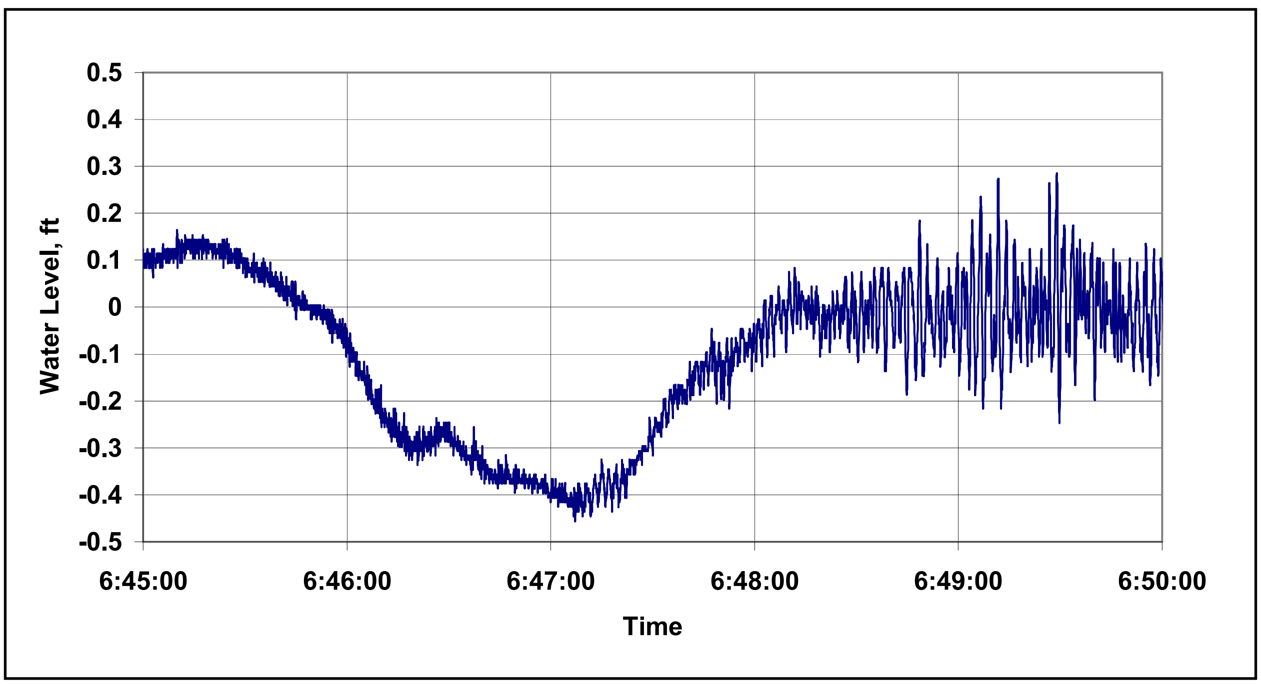

Figure C4. Observed water level, LaGrange Pool, Site 1, *Frank Stegbauer*, 11/15/2002

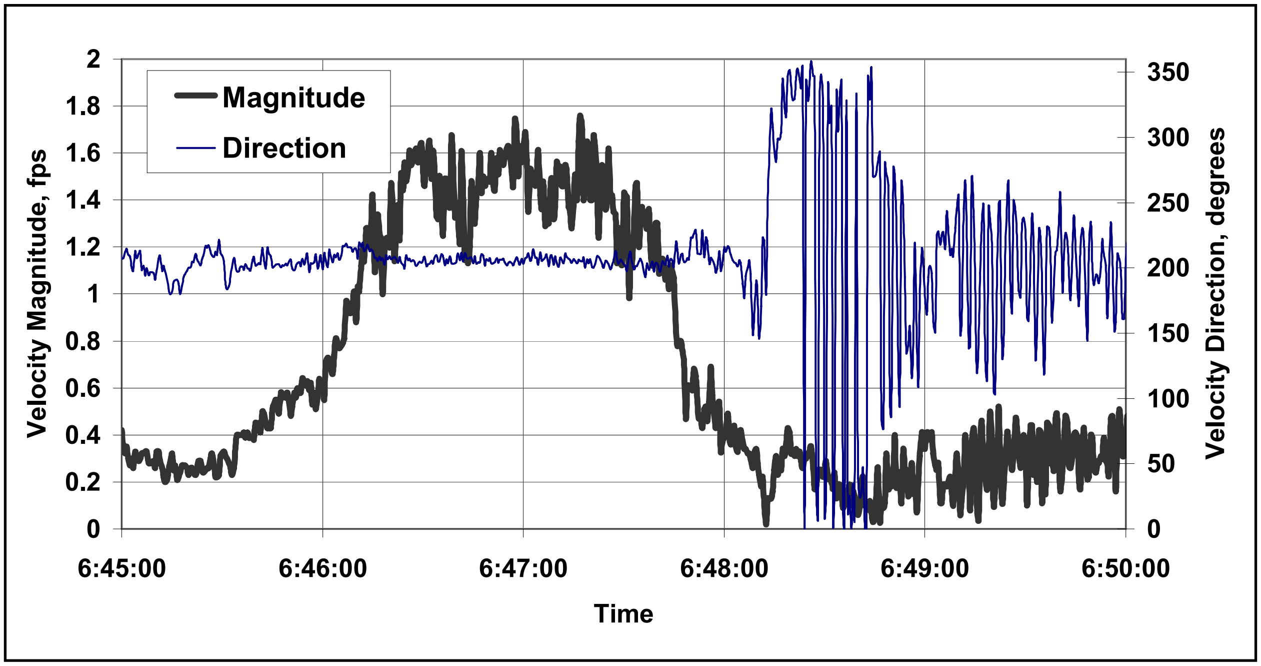

Figure C5. Observed velocity magnitude and direction, LaGrange Pool, Site 1, *Frank Stegbauer*, 11/15/2002

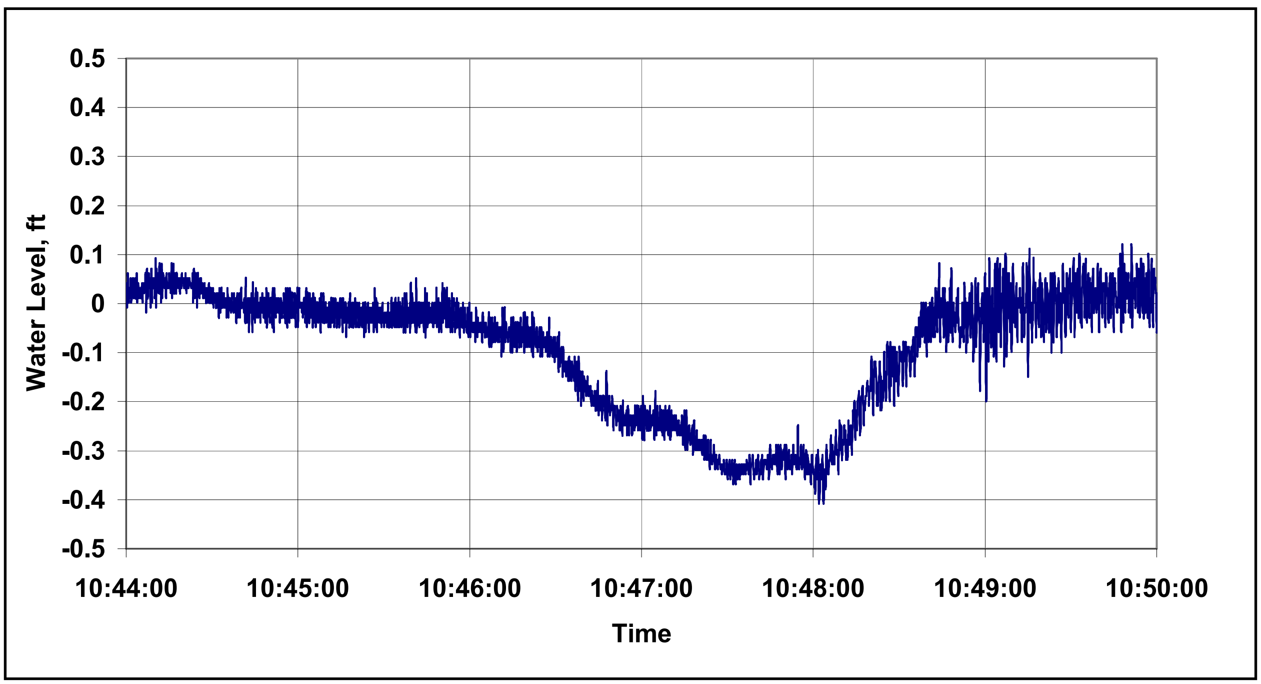

Figure C6. Observed water level, LaGrange Pool, Site 1, *Martha Mac*, 11/15/2002

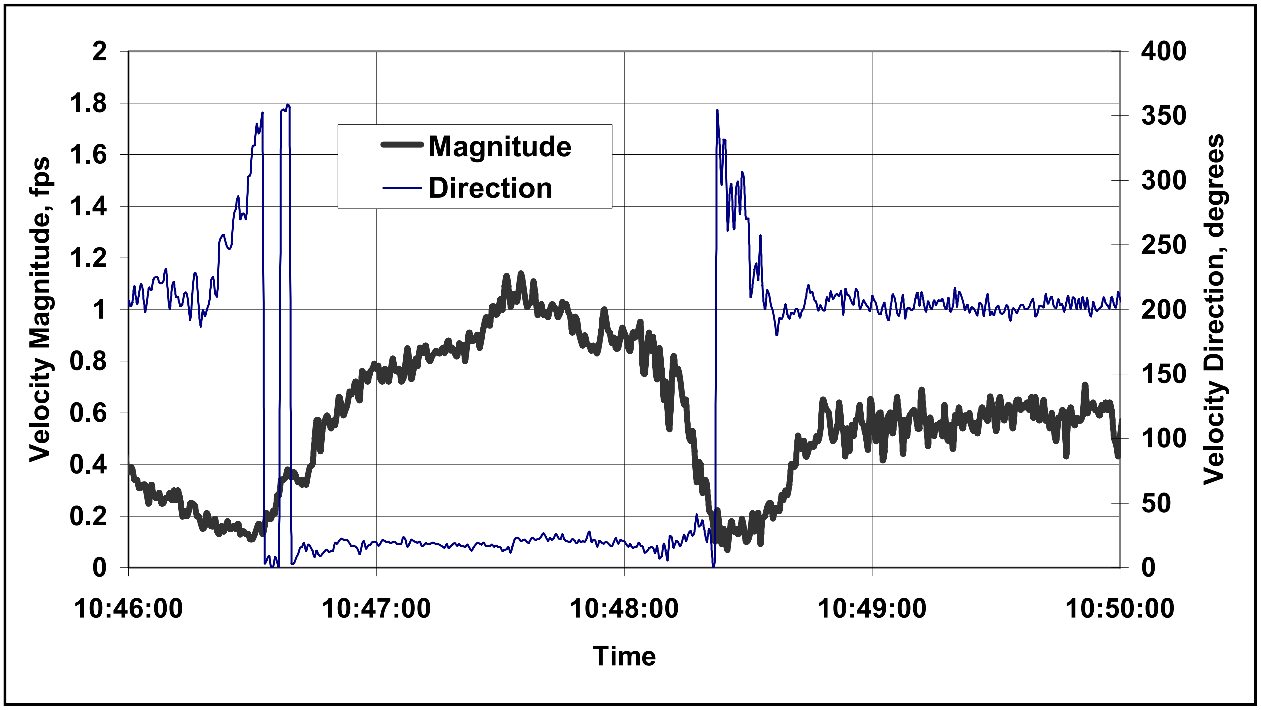

Figure C7. Observed velocity magnitude and direction, LaGrange Pool, Site 1, *Martha Mac*, 11/15/2002

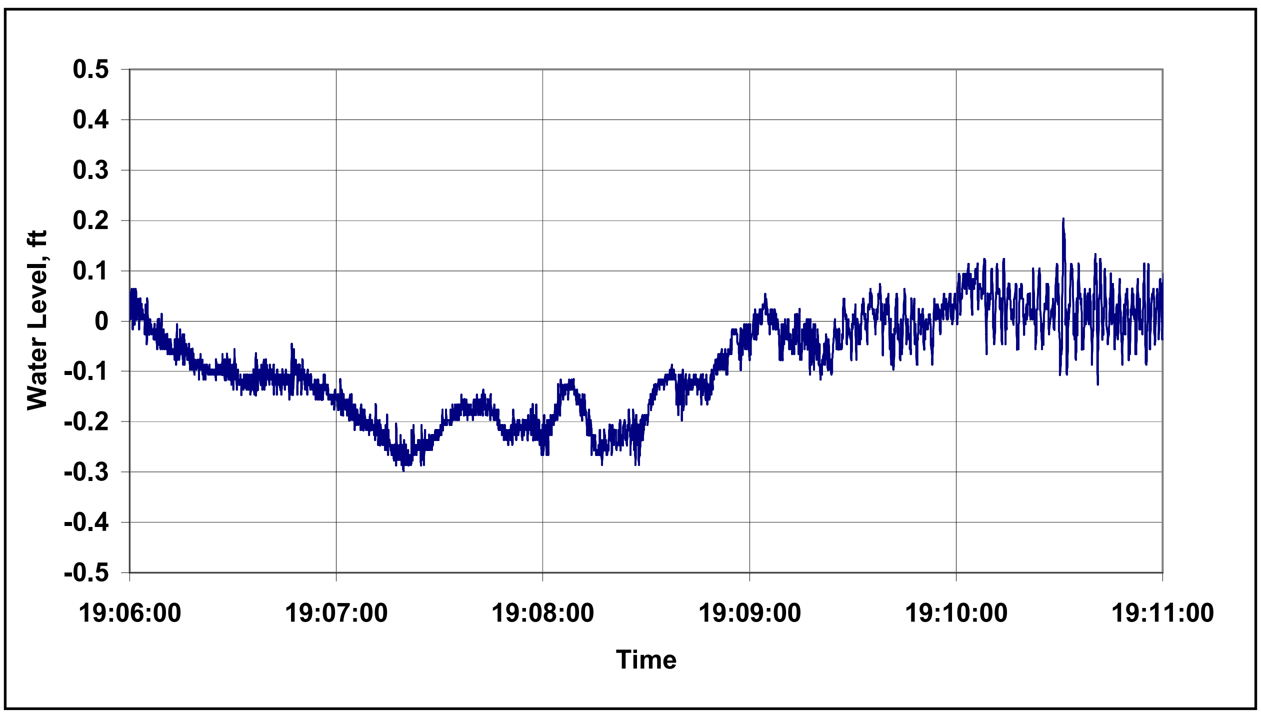

Figure C8. Observed water level, LaGrange Pool, Site 1, *Prosperity*, 11/15/2002

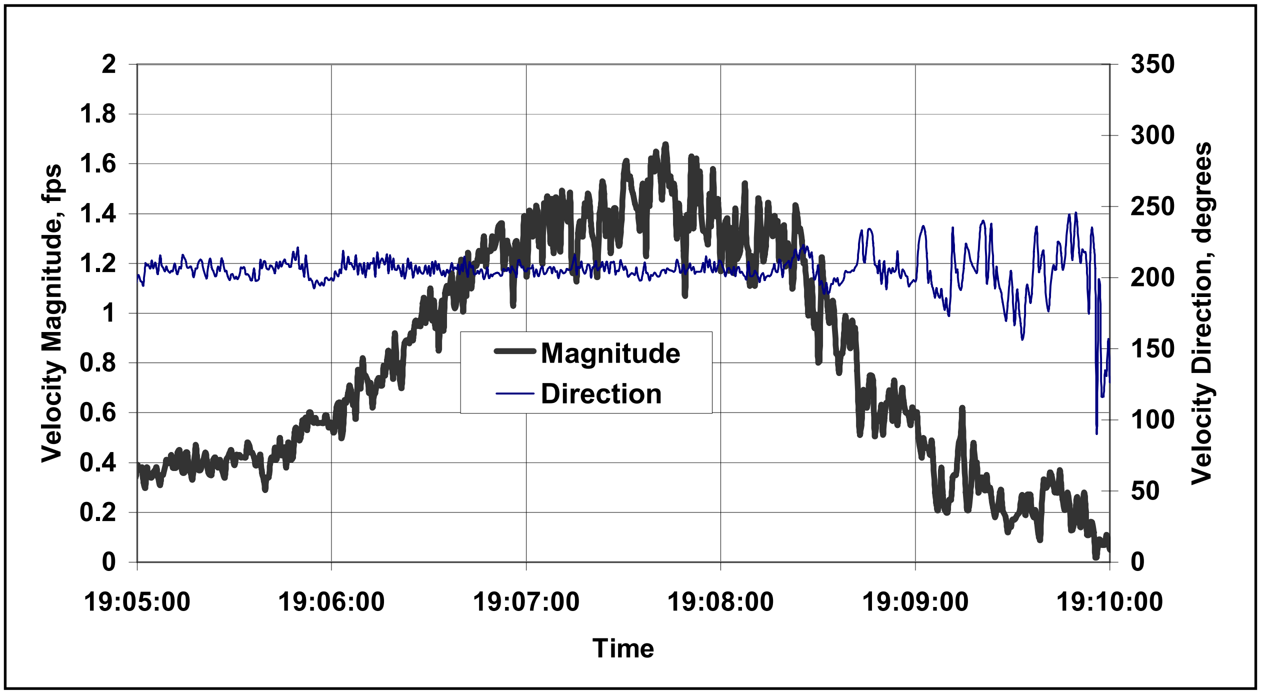

Figure C9. Observed velocity magnitude and direction, LaGrange Pool, Site 1, *Prosperity*, 11/15/2002

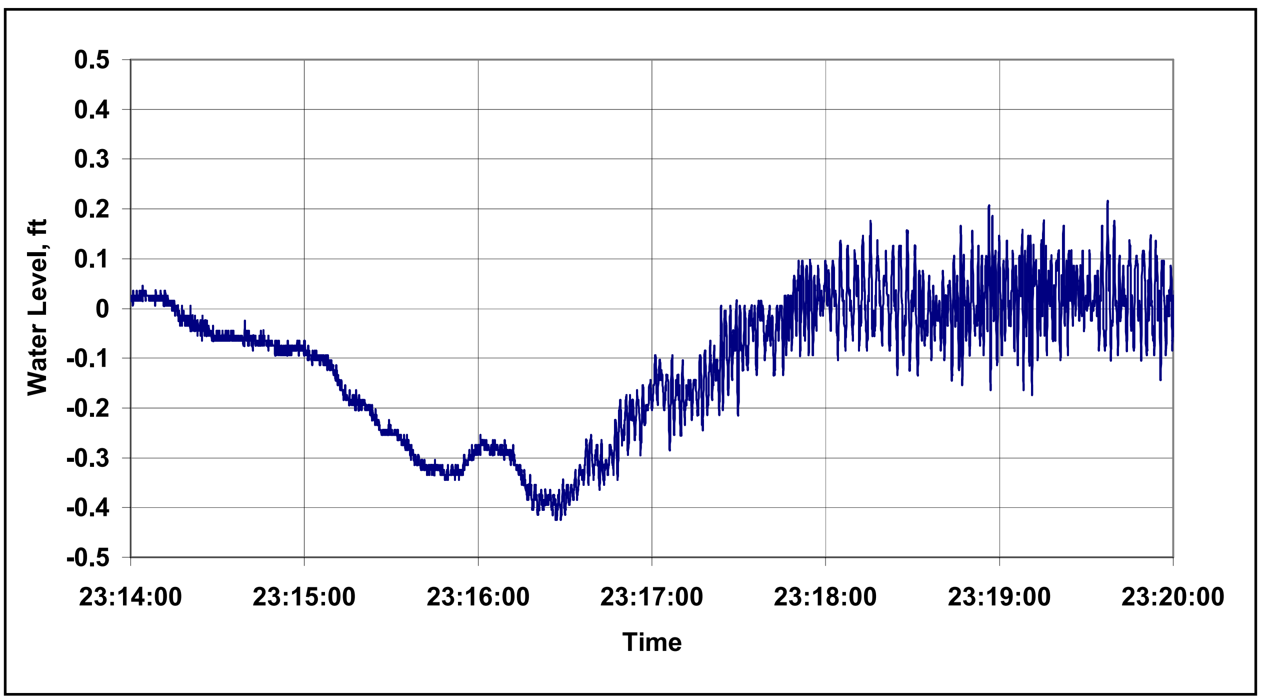

Figure C10. Observed water level, LaGrange Pool, Site 1, *Herman Potter*, 11/15/2002

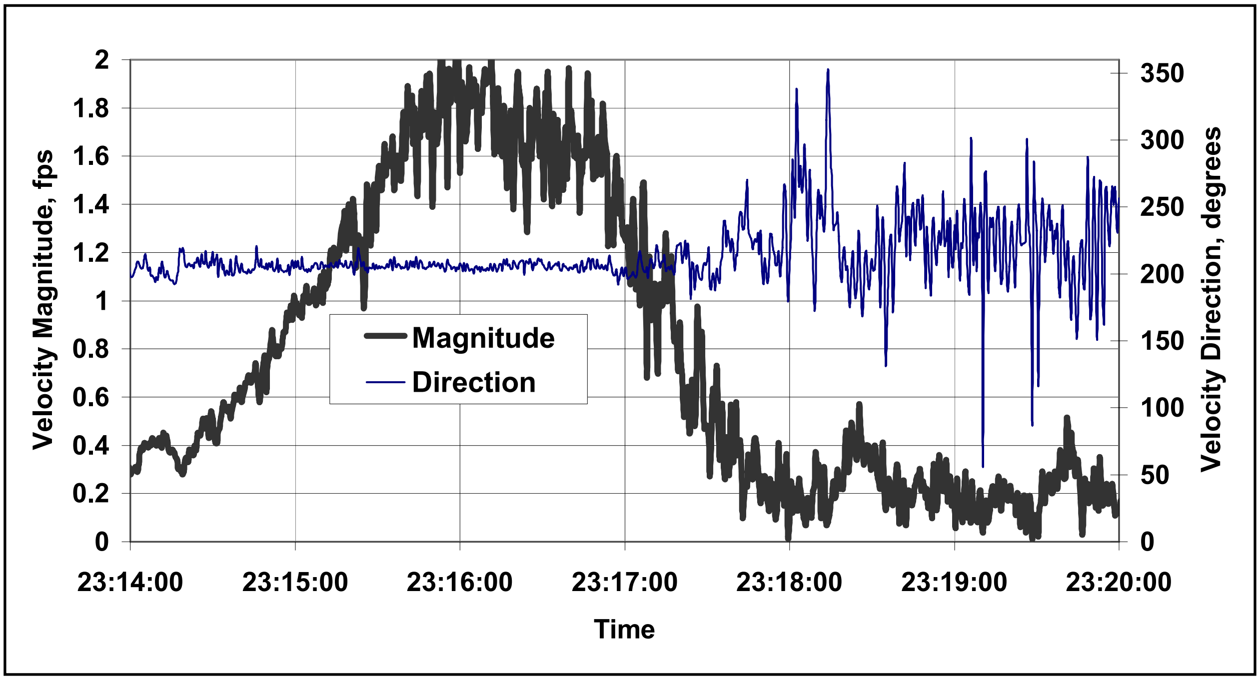

Figure C11. Observed velocity magnitude and direction, LaGrange Pool, Site 1, *Herman Potter*, 11/15/2002

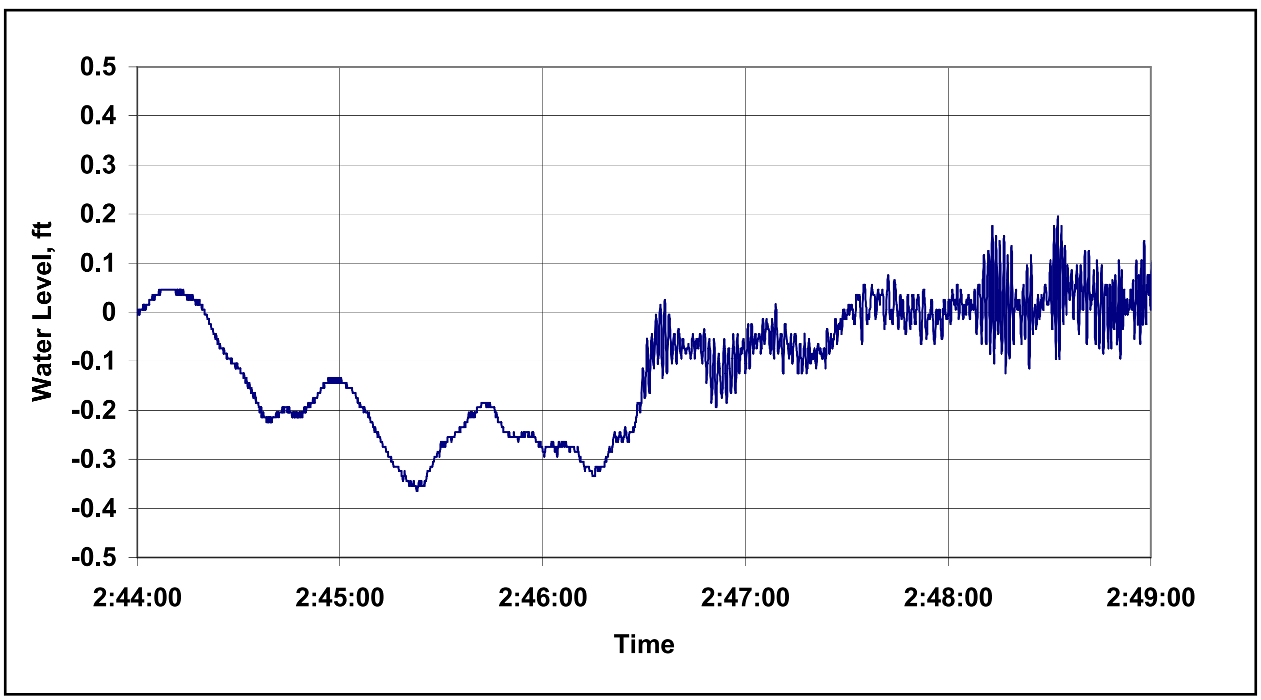

Figure C12. Observed water level, LaGrange Pool, Site 1, *Fred Joerger*, 11/16/2002

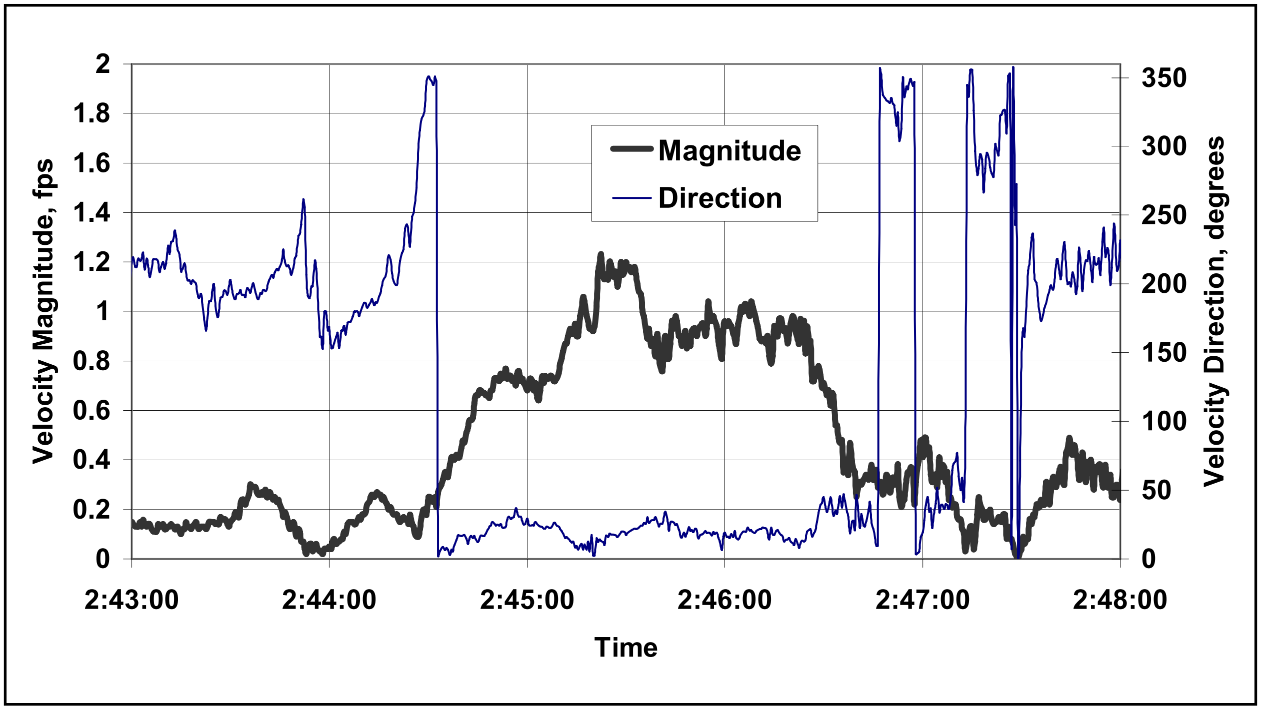

Figure C13. Observed velocity magnitude and direction, LaGrange Pool, Site 1, *Fred Joerger*, 11/16/2002

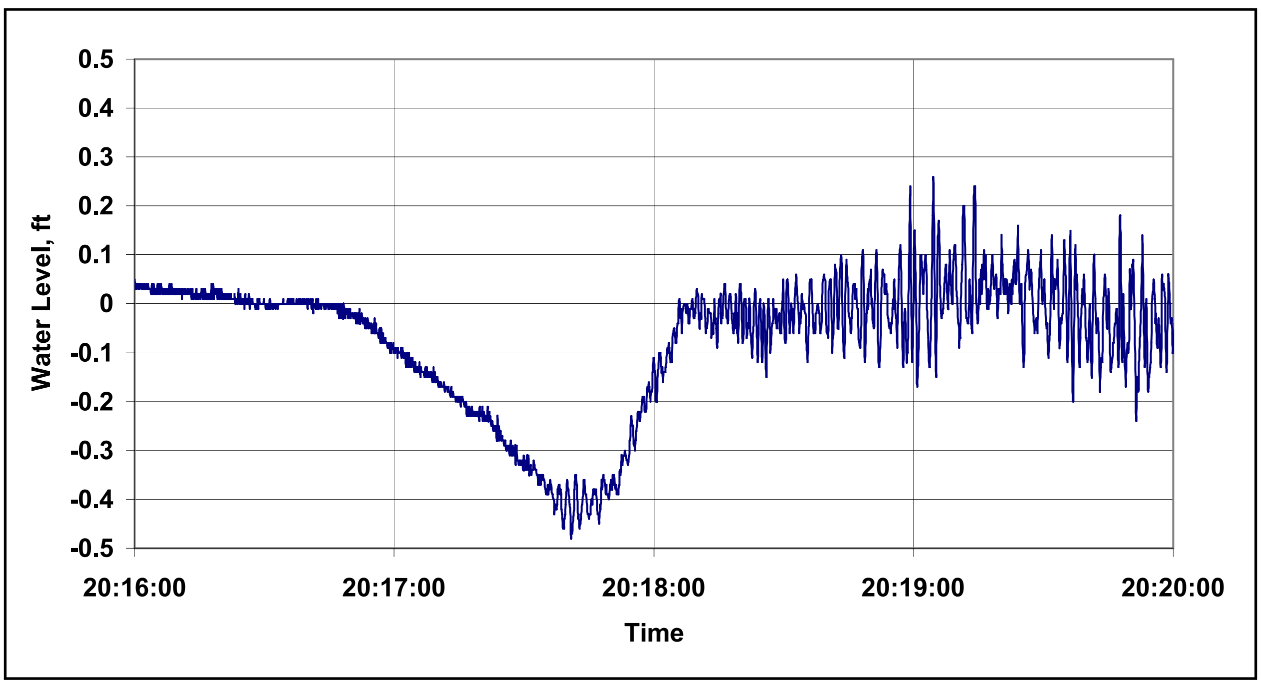

Figure C14. Observed water level, LaGrange Pool, Site 1, *SR Chicago*, 11/16/2002

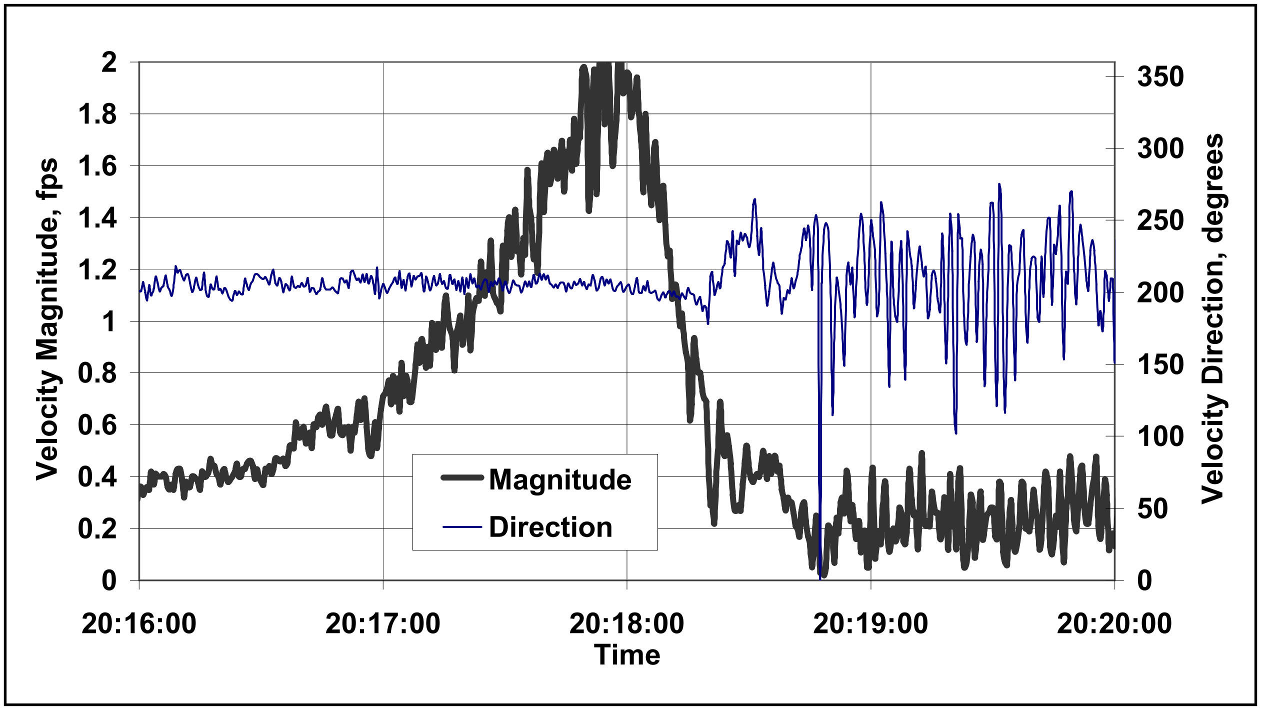

Figure C15. Observed velocity magnitude and direction, LaGrange Pool, Site 1, *SR Chicago*, 11/16/2002

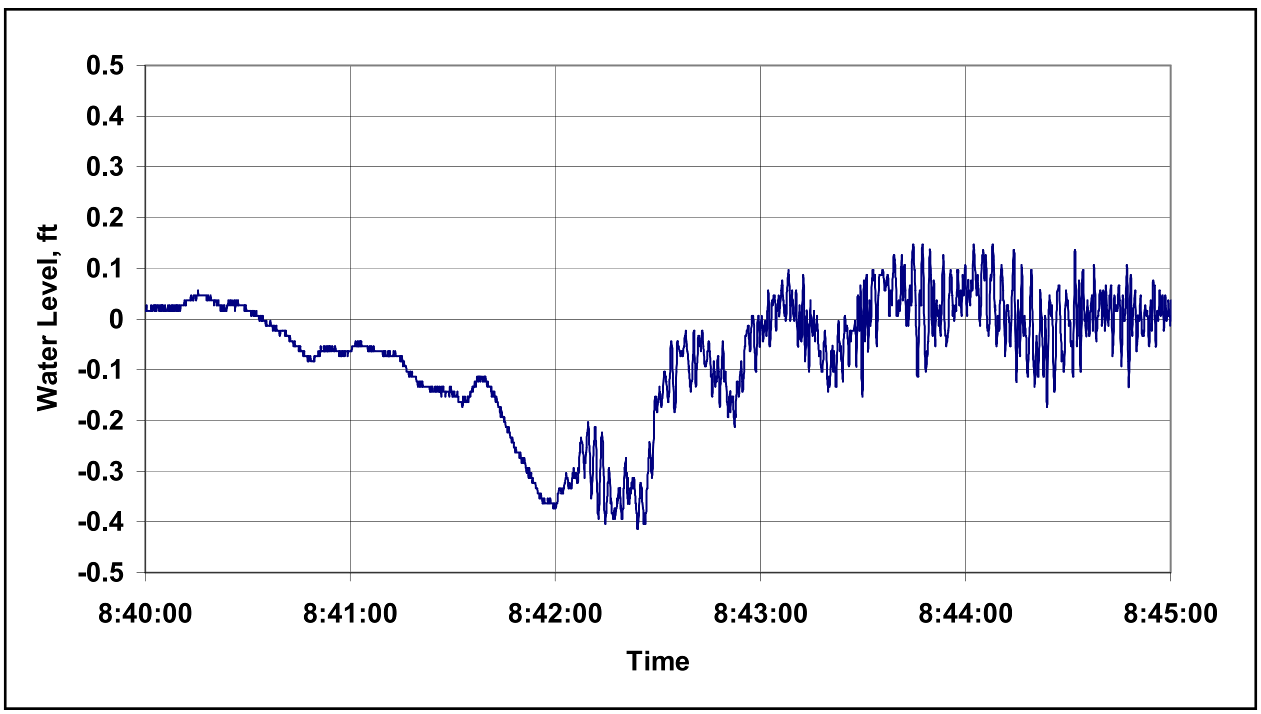

Figure C16. Observed water level, LaGrange Pool, Site 1, *Decatur Lady*, 11/17/2002

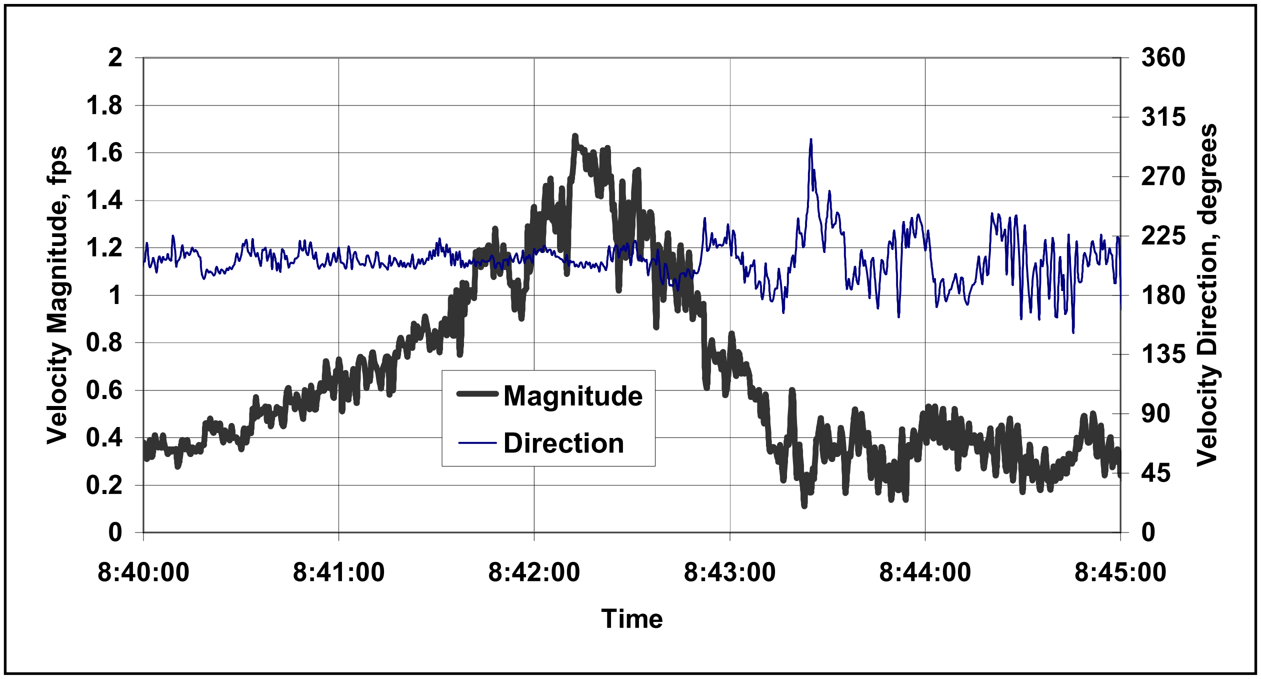

Figure C17. Observed velocity magnitude and direction, LaGrange Pool, Site 1, *Decatur Lady*, 11/17/2002

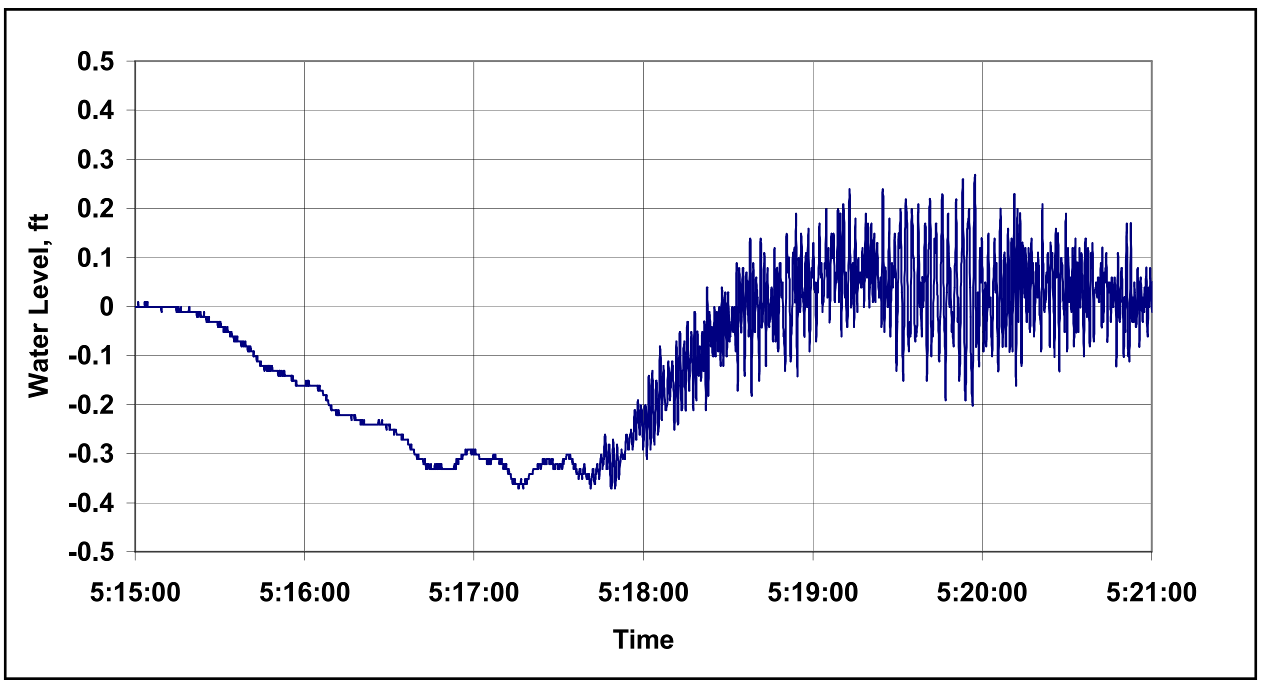

Figure C18. Observed water level, LaGrange Pool, Site 1, *Billy Joe Boling*, 11/17/2002

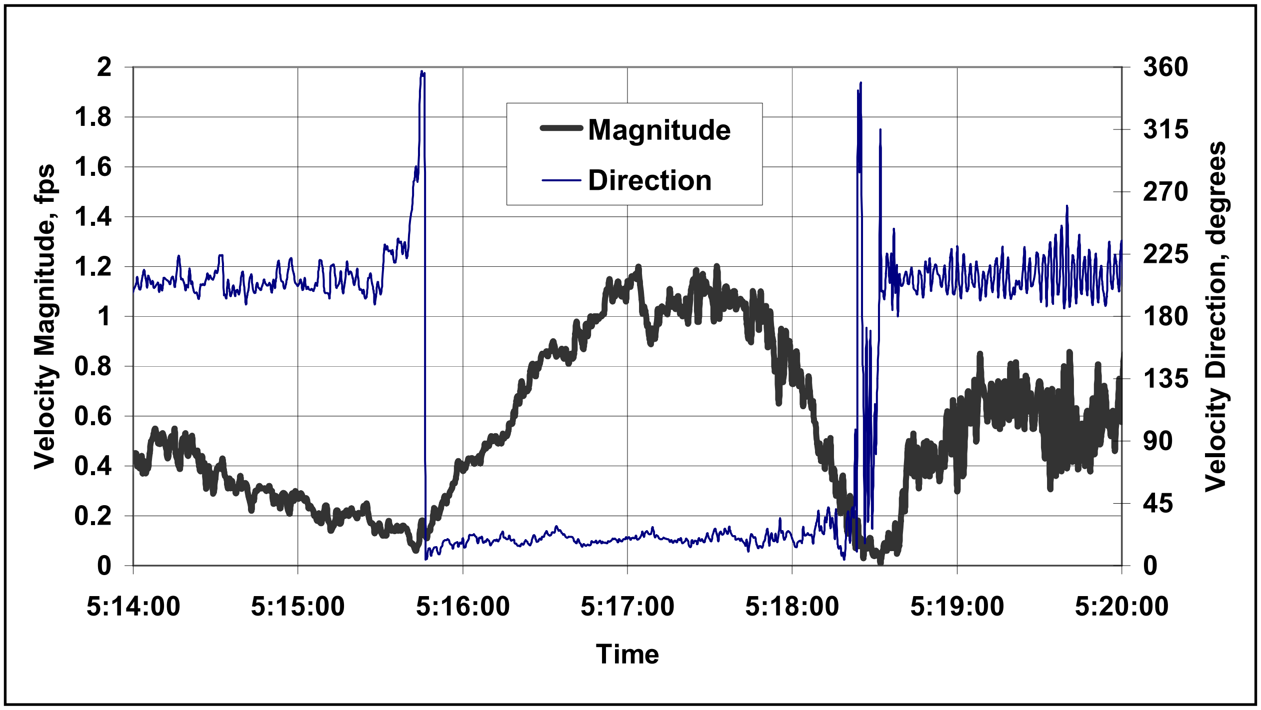

Figure C19. Observed velocity magnitude and direction, LaGrange Pool, Site 1, *Billy Joe Boling*, 11/17/2002