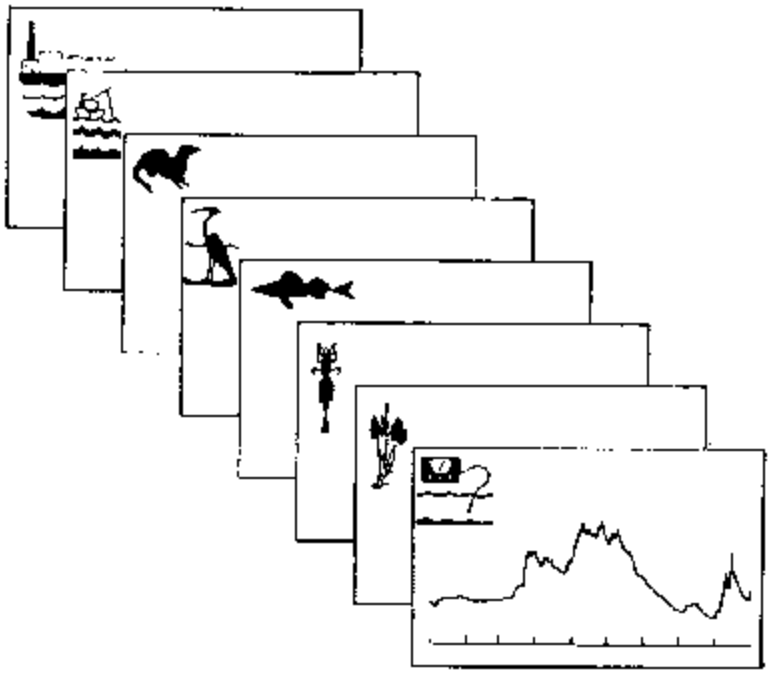
ENVIRONMENTAL MANAGEMENT PROGRAM

LONG TERM RESOURCE MONITORING PROGRAM
UPPER MISSISSIPPI RIVER SYSTEM



PHYSICAL IMPACTS OF NAVIGATION
OHIO RIVER FIELD DATA COLLECTION

WILLIAM C. BOGNER, TA WEI SOONG, AND NANI G. BHOWMIK

FEBRUARY 1988

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This report summarizes the data collected by the Illinois State Water Survey from the Ohio River to determine the physical impacts of navigation. The Louisville District of the U.S. Army Corps of Engineers initiated the field project on the Ohio River in which various physical, chemical, and biological data were collected in connection with the movement of tows with barges. The Illinois State Water Survey participated in the collection of physical data with respect to barge traffic. Barges with tows of varying horsepower were rented by the Corps of Engineers and navigated up and down the Ohio River at predetermined frequencies at the test site. This experimental river traffic was controlled as to speed, direction, and frequency. The following physical impacts data were collected by Water Survey engineers and scientist: a) nearshore velocity structure: magnitude, direction change, and turbulence intensity; b) wave characteristics: amplitude, period, duration, and relative magnitude; and c) resuspension of sediment: point and depth-integrated suspended sediment samples were collected within the channel border area for determination of sediment concentration and particle size distribution. No analyses of the data have been performed for this report.

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PREFACE

This report was prepared for the Long Term Resource Monitoring Program (LTRMP) of the Upper Mississippi River System (UMRS). The UMRS is composed of the navigable reaches of the Upper Mississippi, Illinois, Kaskaskia, Black, St. Croix and Minnesota rivers. The LTRMP is a part of the Environmental Management Program authorized under the Water Resources Development Act of 1986 (Public Law 99-662).

The report was prepared by William C. Bogner, Ta Wei Soong and Nani G. Bhowmik, all of the Illinois State Water Survey, under cooperative agreement to the U.S. Fish & Wildlife Service, Environmental Management Technical Center (EMTC) in LaCrosse, Wisconsin. The report was prepared under the general supervision of Joseph F. Scott, EMTC Program Manager. The report was reviewed by Jerry L. Rasmussen, Assistant Program Manager (Ecology) and Kenneth S. Lubinski, both of the U.S. Fish & Wildlife Service.

This project was completed in two parts. An opportunity existed in the summer of 1987 to collect physical data on the effects of navigation in conjunction with a similar project being conducted on the Ohio River by the U.S. Army, Corps of Engineers. It was felt that these physical data would be useful in the development of impact models for use on the UMRS. The procedures used in these data collection efforts are summarized in this report. Analysis of samples and data collected for this project are presented under a separate cover. Early publication of the procedures used for data collection are published herewith because they represent state-of-the-art methodology which others may find useful in their current research.

Please direct any questions regarding this project to the Project Officer:

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Illinois State Water Survey Division
SURFACE WATER SECTION

SWS Contract Report 443

PHYSICAL IMPACTS OF NAVIGATION: OHIO RIVER FIELD DATA COLLECTION

Completion Report Submitted to the
U.S. Fish and Wildlife Service
through the Illinois Department of Conservation

Project Directors: Nani G. Bhowmik
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Champaign, Illinois
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Illinois Department of Energy and Natural Resources

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PHYSICAL IMPACTS OF NAVIGATION: OHIO RIVER FIELD DATA COLLECTION

INTRODUCTION

The Louisville District of the U.S. Army Corps of Engineers initiated a field project on the Ohio River in which various physical, chemical, and biological data were collected in connection with the movement of tows with barges. The Illinois State Water Survey participated in the collection of physical data with respect to barge traffic. Barges with tows were rented by the Corps of Engineers, Louisville District, and navigated up and down the Ohio River at predetermined frequencies near the test site. This experimental river traffic was controlled as to speed, direction, and frequency. This experimental setup directly relates to many of the areas included under Major Work Tasks PA(NE)l, PA(NE)4, and PA(NE)7 of the Operating Plan of the Long Term Resource Monitoring Program for the Upper Mississippi River System by Rasmussen and Wlosinski (1988). The following physical effect data were collected by Water Survey engineers and scientists:

A. Nearshore velocity structure: magnitude, directional changes, and turbulence intensity.

B. Wave characteristics: amplitude, period, duration, and relative magnitude.

C. Resuspension of sediment due to navigation traffic: point and depth-integrated suspended sediment samples were collected within the channel border area for determination of the concentration and particle size distribution of the suspended sediment.

The Corps of Engineers, Louisville District, collected other related data which will be made available to Water Survey engineers and scientists in the near future.

This report summarizes the field data collection activities conducted in the initial phase of the project sponsored by the U.S. Fish and Wildlife Service. No analyses or evaluation of the data were proposed or carried out within this phase of the project.

Acknowledgments

This field investigation was conducted as part of the authors' regular duties at the Water Survey. Rich Allgire and Ed Delisio of the Surface Water Section assisted in the field data collection program. Jerry Rasmussen and Gail Carmody of the U.S. Fish and Wildlife Service were instrumental in initiating the project. Terry Siemsen of the Corps of Engineers, Louisville District, organized this field program and provided tremendous help to the Water Survey field crew in their data collection effort.

Site Description

The Corps of Engineers selected a site for these studies on the Ohio River at approximately River Mile 581 (below Pittsburgh). Figure 1 shows the study site with the project area identified. This location is immediately above Eighteen Mile Island and 25 miles above McAlpin Lock and Dam at Louisville. The channel bottom in this area is naturally terraced with well-defined benches of varying depths. This terracing allowed location of barge tracks in both shallower (15-foot) and deeper (25-foot) water without completely obstructing the navigation channel. Most of the navigation channels on the

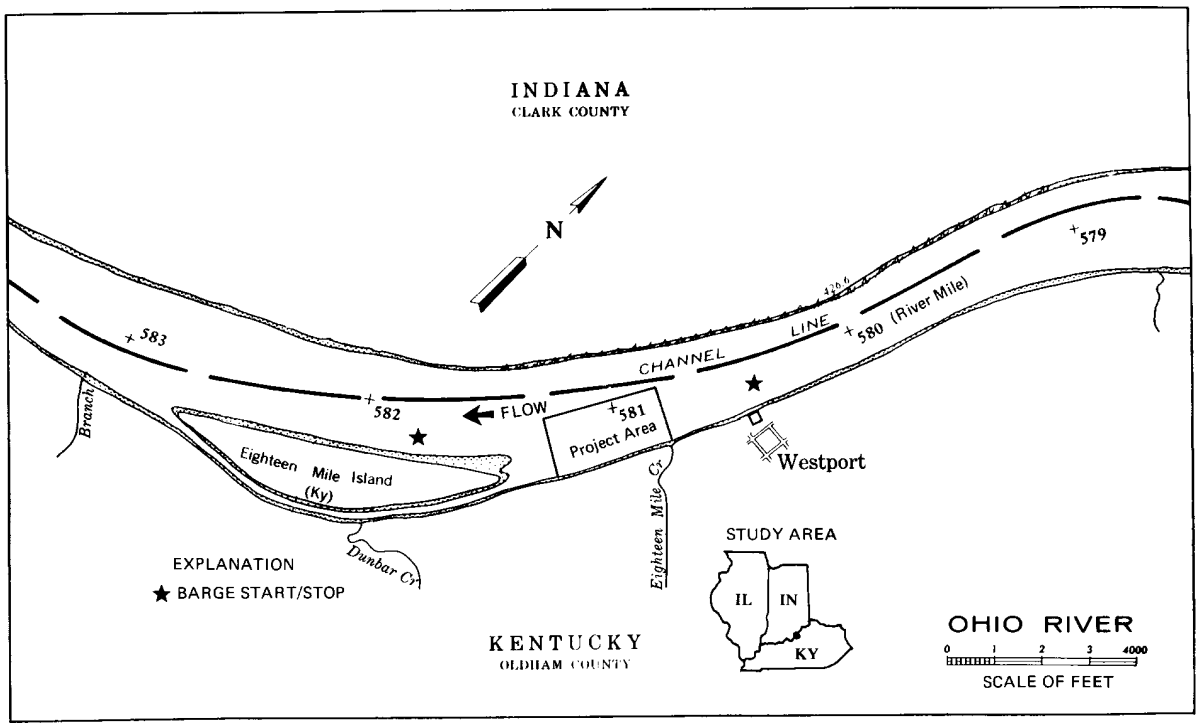

Figure 1. Location of the study area

Mississippi and Illinois River systems do not have terraced cross sections. The river cross sections are usually trapezoidal in shape with a smooth transition between the bankline and the transverse bed profile of the river.

The project area was located along the left descending bank on the 0.5-mile segment of the river extending from Eighteen Mile Creek to the head of Eighteen Mile Island (figure 1).

The general layout of the project area is shown in figure 2. Five guide buoys were placed to indicate the planned barge track. For all passages, the barge navigated to the easterly side of the buoy line. Two additional buoys were installed perpendicular and to the east of the five guide buoys to locate the equipment to be set by divers. The barges ran between these two buoys, and the Corps' main data collection effort was located along this line.

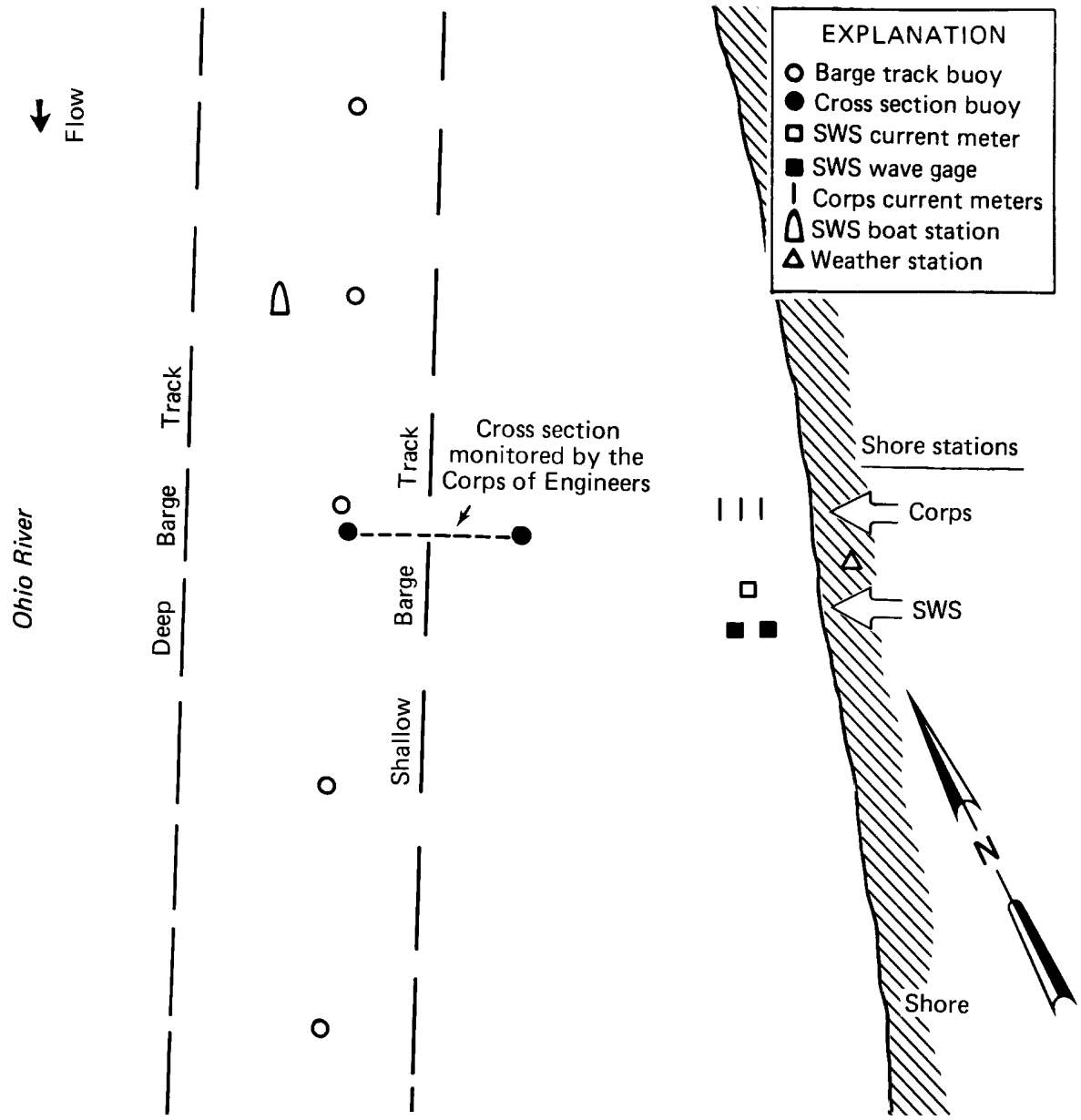

Figure 2. Plan view of project area at Ohio River, Mile 581 (buoy and boat location shown for shallow barge track only)

Equipment Setups

Illinois State Water Survey (ISWS) shore station - The ISWS shore station was located on the left descending bank immediately downstream of the Corps' monitored cross section on this test reach (figure 2). Figure 3 shows a photograph of the ISWS shore station. Note the electronics, computer, and cables needed for the wave gage and current meter.

U.S. Armny Corps of Engineers (COE) Shore Station - This shore station was located on the left descending bank on the monitored cross section and upstream of the ISWS shore station as shown in figure 2.

ISWS Boat Station - The SWS research boat "Monitor" was located along the Corps' monitored cross section on the first day of 1500 HP runs and was located upstream and adjacent to one of the guide buoys

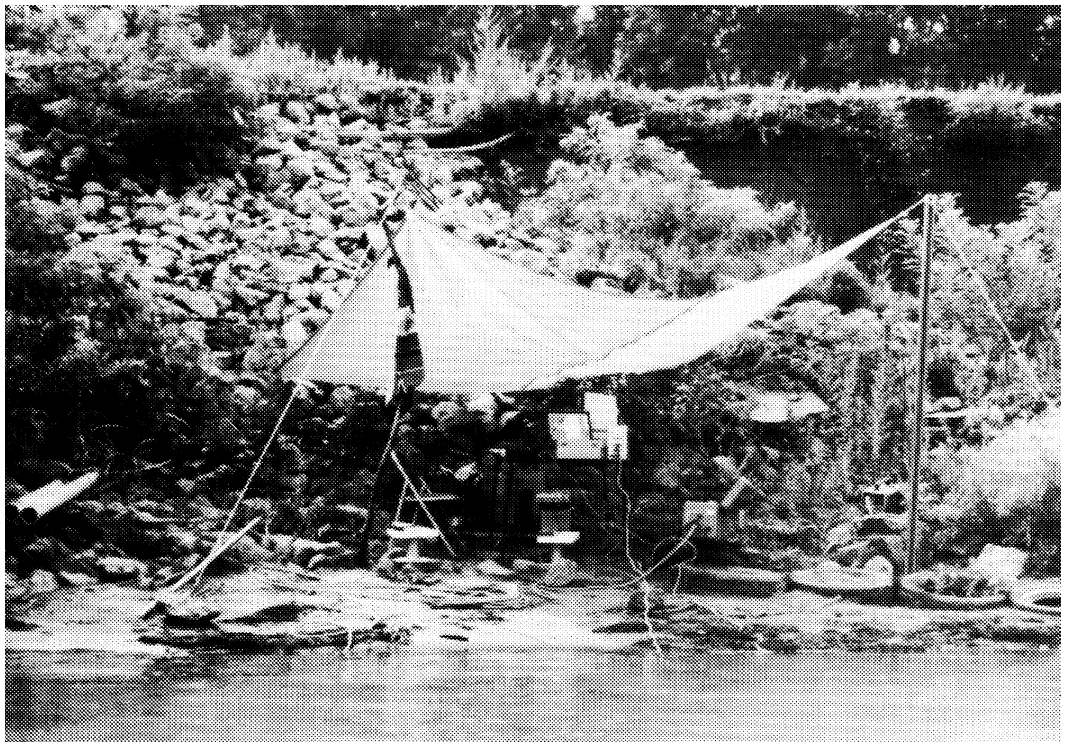

Figure 3. Shore station setup of the Illinois State Water Survey

on all subsequent days. Figure 4 shows the boat during one of the sampling runs.

COE Water Quality Station - The Corps had two boats collecting water quality data. An open runabout followed the barge track, then anchored and sampled at the monitored cross section. Following the barge passage, the other Corps boat, a 23-foot MonArk, criss-crossed the barge track immediately upstream of the monitored cross section. The "Data Collection Routines" section of this report describes the coordination of the Corps' in-stream data collection in more detail.

COE Current Meter Setup - Three small boats were positioned perpendicular to the barge track and extended to the westerly direction along the monitored cross section. For the 5600 HP run the monitoring boats were arranged on the east of the barge track.

Figure 4. The Water Survey research boat "Monitor" with sampling booms at the bow and stern

The MonArk boat of the Corps of Engineers was anchored off track to monitor bottom currents. Figure 5 shows the Corps of Engineers sampling stations on July 29, 1987.

COE Scour Pins - Scour pins were set by divers between the two cross section buoys (figure 2).

Figure 5 is a photograph taken during the July 29 passage of the 1500 HP tow. The two buoys in the foreground are at the intersection of the Corps monitored cross section (figure 2) and the line of barge track buoys. The two buoys in the background mark the southern end of the barge track. The two smaller Corps boats in the foreground were collecting velocity data, and the Corps' MonArk boat is in the background.

Figure 6 shows the empty barge that was used in the field experiment. Figure 7a shows the study area looking upstream and figure 7b shows the sampling boats during the field experiment.

Figure 5. Corps of Engineers' sampling stations on July 29, 1987

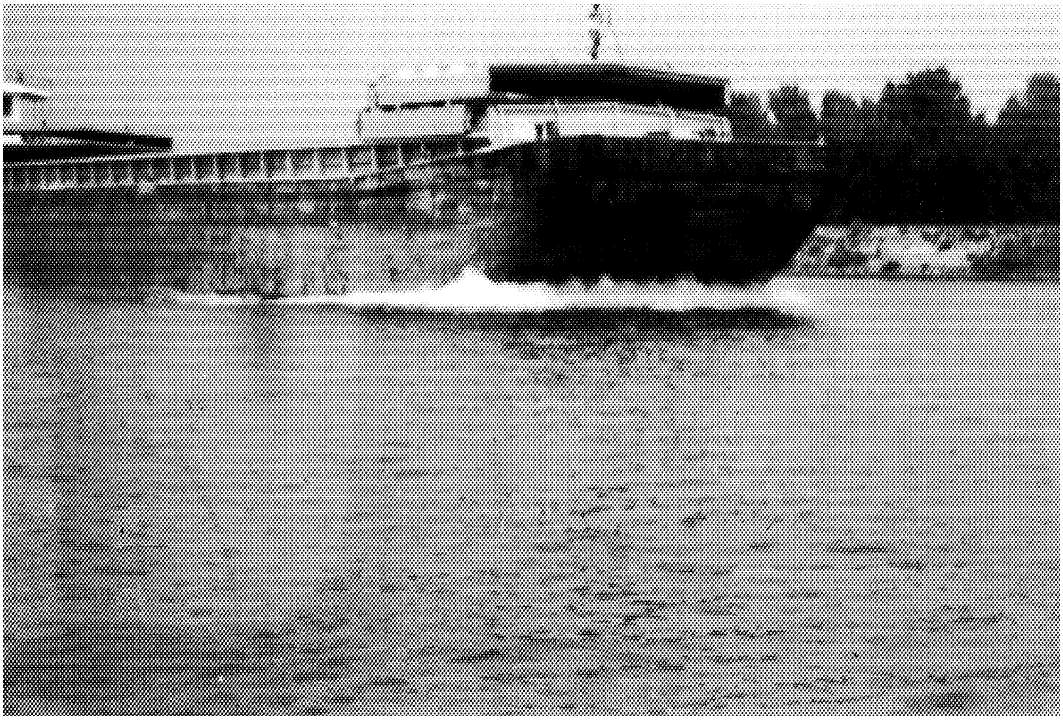

Figure 6. Empty barge used in the field experiment

Data Collection Routines

The data collection program was conducted on July 28–31 and August 4–5, 1987. During these periods, three barges leased by the COE, Louisville District, ran a standard series of passes through the project area.

Each tow was attached to one empty barge (figures 5 and 6) and was used for two days. The horsepower (HP) of the tows was increased during the study period with a 1500 HP tow on July 28–29, a 3000 HP tow on July 30–31, and a 5600 HP tow on August 4–5.

A standard series of runs included the following:

1. Runs were generally made in sets of two (one upstream and one downstream). The tows always ran on the eastern side of the buoy line, and the boat sampling outside of the barge track concentrated on the western side of the buoy line (see figure 2).

(a)

(b)

Figure 7. Study area and field data collection

With the exception of August 5, two buoy lines were set each day, with a shallow water track in the morning and a deep water track in the afternoon.

2. The first day that each tow operated, the Corps conducted water quality sampling. One set of runs was made on each track line with a 30-minute break between runs to allow the river system to stabilize.

3. The second day that each tow operated, the Corps conducted current meter measurements. Runs were made with only enough break between runs to allow the tow to turn and come back. For the 1500 HP and the 3000 HP tows, three throttle settings were run per track line.

4. The second day of the 5600 HP tow was organized differently from the other day-2 runs. One track was used, and loads and throttle settings were varied. For each configuration, an upstream-downstream set of runs was made at 100 RPM and another set at 150 RPM. The runs were made by:
   - one empty barge
   - one full barge
   - one commercial barge (downstream only)
   - three full barges

Data from only one commercial tow with barges were collected by both the Water Survey and the COE. The configuration of these barges was 3 x 5, i.e., 3 barges wide and 5 barges long. The total planform area was 105 feet by 975 feet, compared to a planform area of 35 feet by 195 feet for a single barge. A three-barge setup was used by the COE for data collection on August 5, 1987. The configurations of these barges are shown in figure 8.

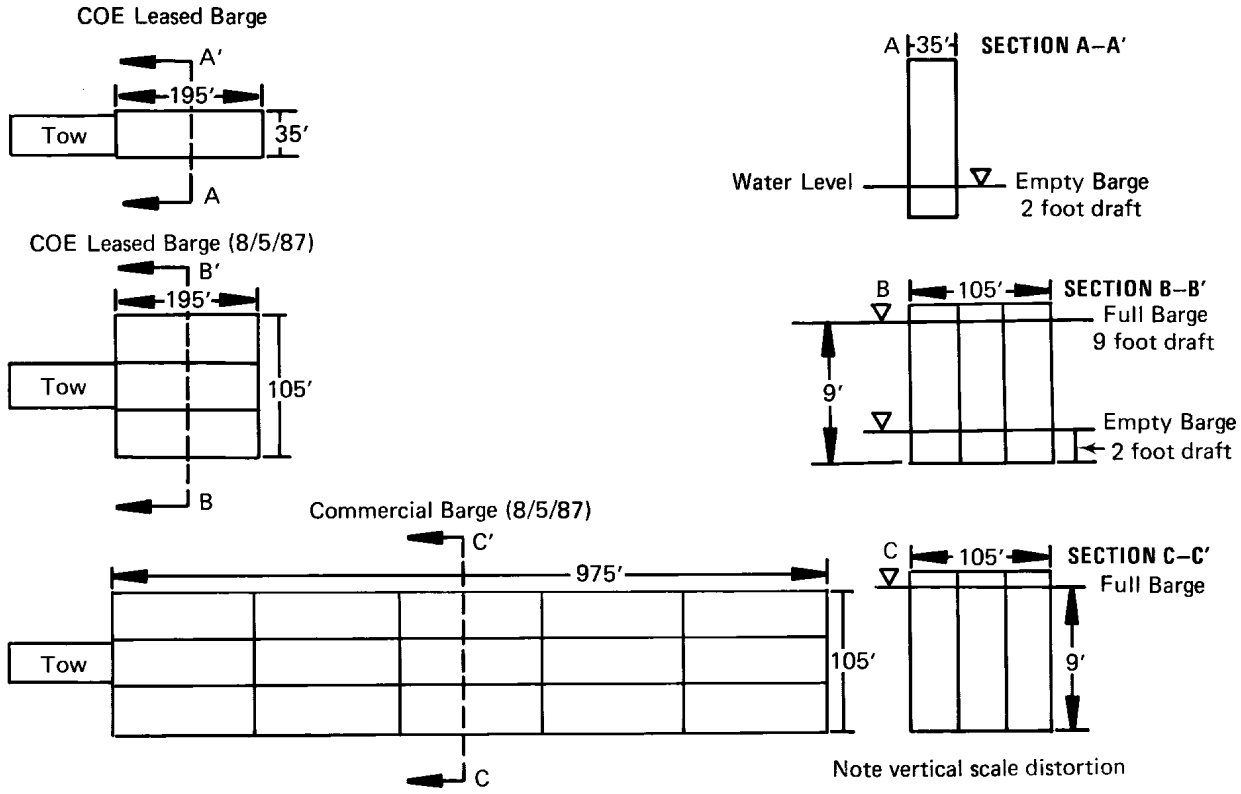

Figure 8. Barge configurations

Site and Event Surveying

All the site and event surveying was conducted by a crew from the Corps. A general site layout was prepared prior to the field data collection. This general layout included definition of land and marine terrain as well as information on streambed characteristics as described by divers during the data collection period.

Event surveying included location of all data collection equipment, location of buoys, and barge tracking, which included event timing.

DATA COLLECTION BY ISWS

Wave and Velocity Structure

Instrumentation. In this study two types of electronic devices were used: a wave gage which measured wave amplitude and length, and a Marsh-McBirney 527 current meter which measured the velocity. Both systems are driven by a microcomputer, and data can be collected continuously at selected intervals and then saved on cassette tapes.

For wave measurements, the profile of a wave was recorded as the wave submerged electronic contacts on the wave gage (figure 9). Figure 9 shows this setup in the field and a sketch of the wave gage. Two wave gages were used (figure 10) with a 3- or 5-foot span of sensing board. The sensing board has electronic probes at intervals of 0.05 feet and is mounted on PVC pipes. Mounting brackets are used to attach the gages to posts driven into the river bed. Detailed information on these wave gages is given by Bhowmik et al. (1981). Figure 11 shows the propagation of waves near the wave gages.

The Marsh-McBirney 527 (MM527) current meter measures two velocity vectors and the orientation of the main axis of the meter from magnetic north simultaneously. The accuracy of the MM527 is within 2% of full scale over the velocity range (the selectable full scale ranges are ±2, ±5, and ±10 ft/sec). A detailed description of this instrument is given by Demissie et al. (1986).

Instrumentation Setup. The wave gages and MM527 generate electrical signals which are processed by interface units and recorded by a Commodore CBM 80032 microcomputer which also controls data logging rates. Processed data are stored on cassette tapes for later analysis. Figure 12 illustrates the units at the shore station. These components include the microcomputer and a cassette tape recorder; wave gage interface; current meter interface; current meter signal processor; and power generator.

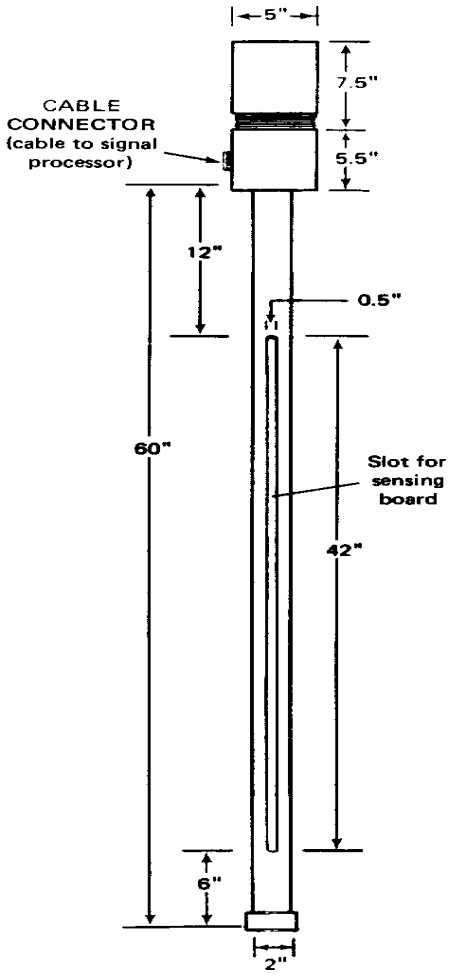

Figure 9. Field setup of wave gage, and wave gage configuration

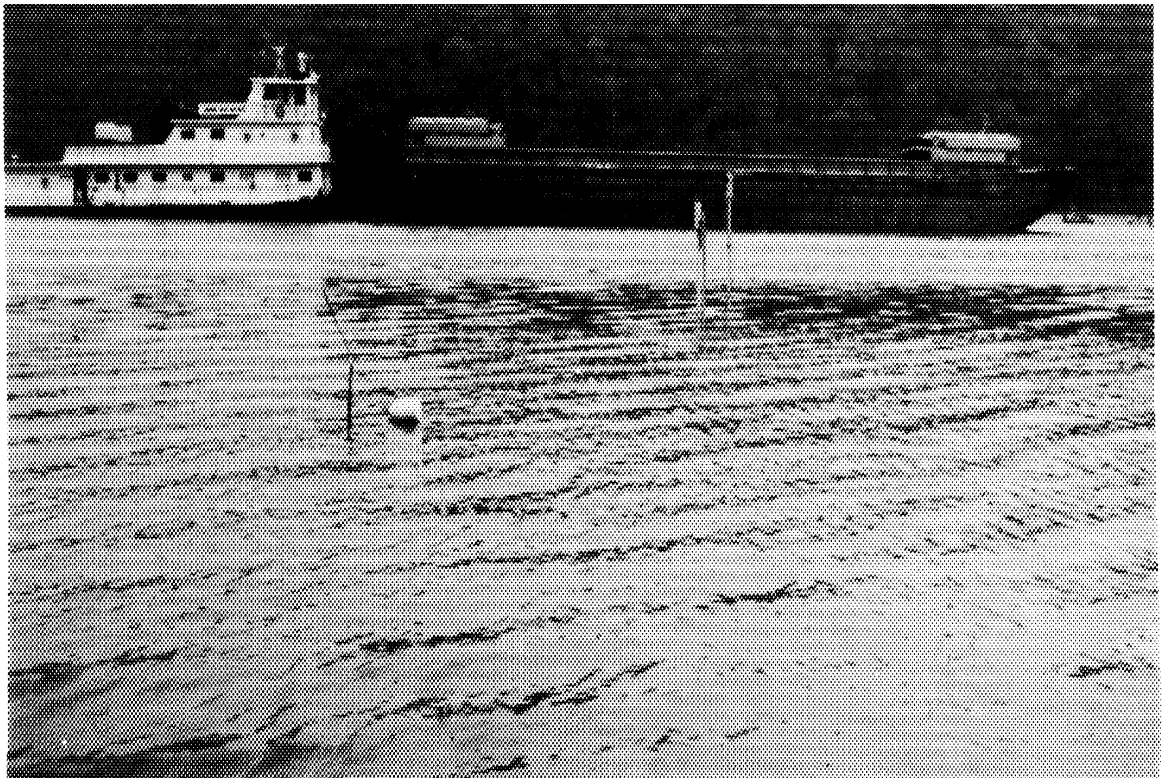

Figure 10. Wave gages used in the field

Figure 11. Tow-induced waves at the wave gages

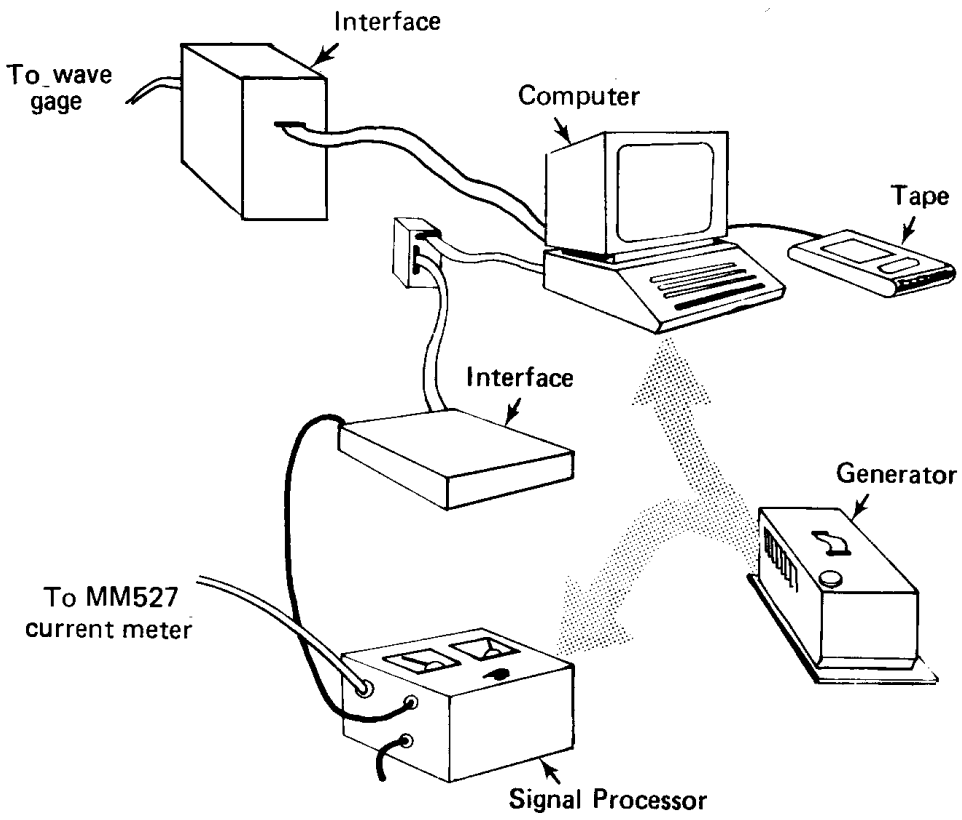

Figure 12. Shore station setup

Each wave gage is attached to a fence post (figures 9, 10, and 11) and a cable is connected between the wave gage and the wave interface. In this investigation, these two wave gages were placed in a line perpendicular to the shore line at distances of approximately 40 and 60 feet from the shore. The depth at each location was set so the wave fluctuations would not top over or go under the sensing board.

The MM527 is supported by a mobile support structure (movable unit), which consists of a 12-foot aluminum stepladder, an aluminum platform with a pole guide, two aluminum side braces, and a sliding pole to which the MM527 is attached. Figure 13 shows this configuration and figure 14 shows this setup in the field. The ladder system was placed approximately 20 feet upstream of the outer wave

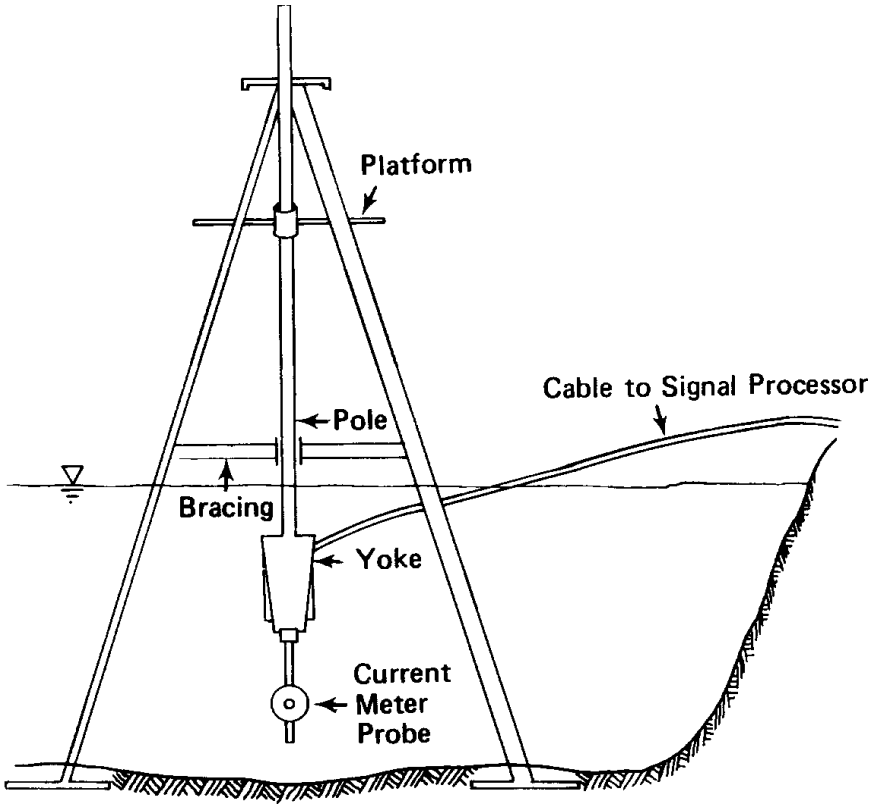

Figure 13. Current meter setup

gage, and the sensor sphere of the MM527 was placed about 1 foot below the water surface (figure 13). These distances were selected to prevent interference from other devices as well as to allow for easy observation by the operator. The layout of the instruments' locations is shown in figure 2. During this survey, a third system was used, called the "float system." This was composed of a partially filled bottle, a fixed pole, and a string connecting these two. This bottle is shown in the foreground in figure 10. The movement of the bottle clearly shows the operator what the direction of flow is, Figure 15 shows the setup of the wave gages and current meter in the field.

Data Collection Procedures. Each barge run was called an "event" in the recordings. Because of the setup of the data collection system, only wave data or velocity data could be collected for each

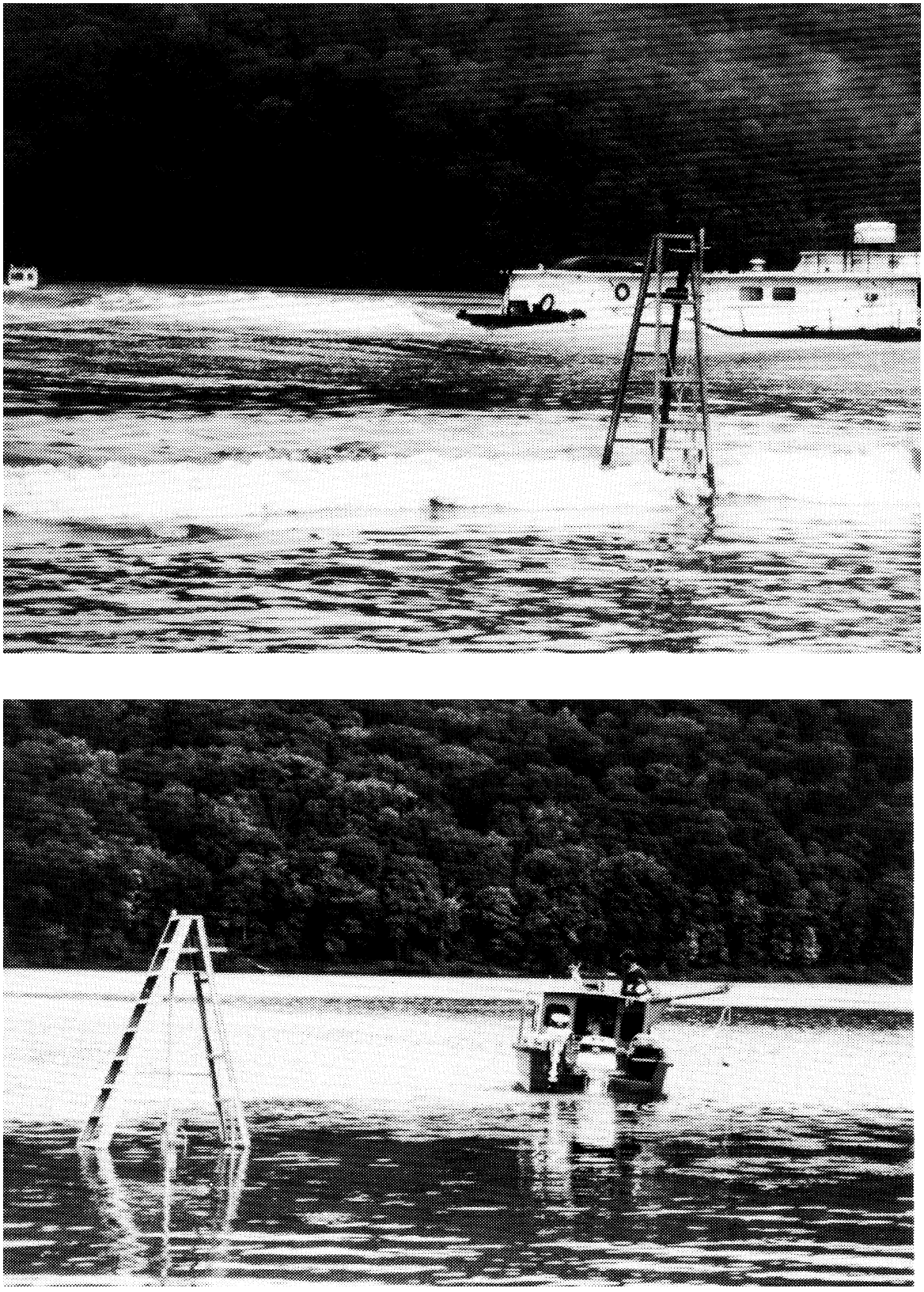

Figure 14. Current meter setup in the field

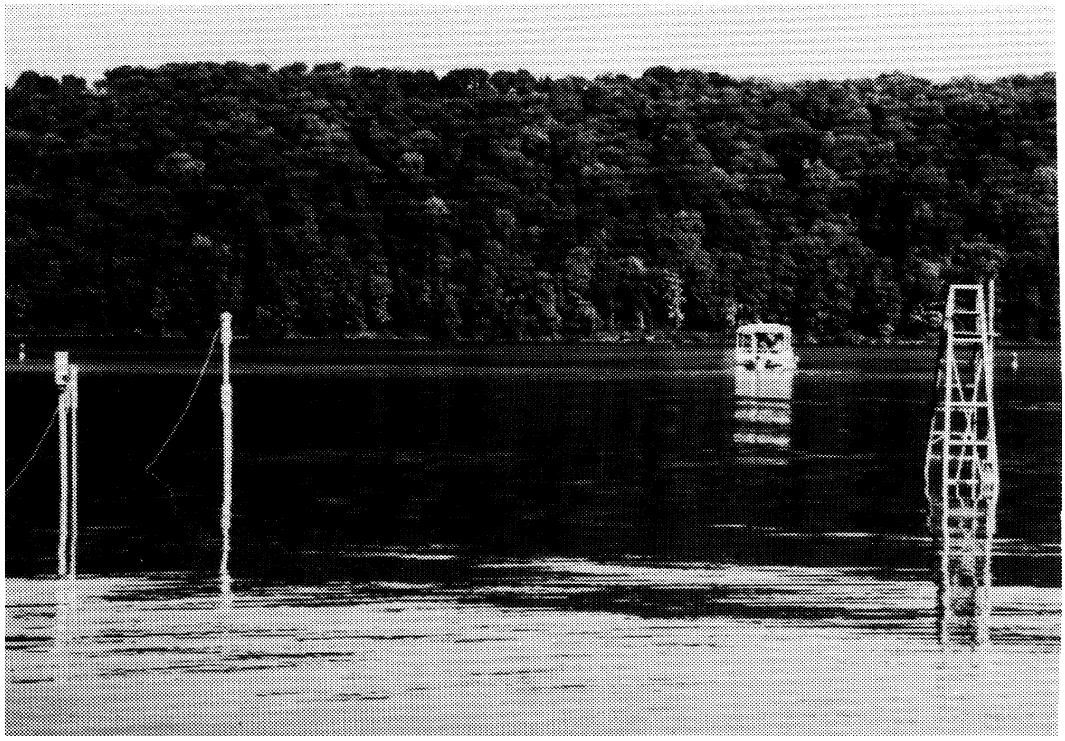

Figure 15. Setup of wave gages and current meter in the field

event. Data collection procedures involve running specially designed programs on the microcomputer (Bhowmik et al., 1981; Demissie et al., 1986). One thing to be noted is the recorded starting time for each event. During each event, the starting time was entered as the real time when the crew's coordinator issued a "zero" signal. However, the timing to initiate data collection on the microcomputer depended on the judgment of the operator and the proximity of the tow with barges to the equipment setup. It should be noted that there is a time lag between event time zero and the arrival of the waves or the alteration of the velocity field near the measuring equipment. One person operated all the wave and velocity data collection equipment. Thus, the starting times for each set of data were always consistent.

The sampling frequency for the wave gages is fixed at 1/10 of a second. The current meter has an adjustable keyboard in the interface which varies the sampling frequency from 0.3 to 17 samples per second. A frequency of 2.5 samples per second was used in this study.

Data Collected. All barge events are classified by the horsepower of the tow boat, RPM of the run, distance from the shore line, number and load condition of barges, and upstream or downstream direction. A total of 72 events are listed in table 1. Of these 72 events, 58 (including one commercial barge passage) were fully monitored by the Corps, 11 were instrument calibration runs, and 3 were commercial barge passages monitored only by the SWS shore station. For 5 of these 72 events no data were collected by the shore station. Table 2 presents a listing of field observations for each event.

Instream Suspended Sediment, Water Quality, and Velocity Data

Instream monitoring for the Ohio River Navigation Impact Study consisted of data collection for velocity changes, water quality changes, and changes in sediment concentration and particle size. The layout of the data collection equipment on the research boat "Monitor" is shown in figure 16. The boat with its equipment setup is shown in figure 4 and in the bottom part of figure 14. The current meter was deployed off the bow of the boat and monitored in the cabin; the Hydrolab water quality sonde (temperature (T), dissolved oxygen (DO), pH, and conductivity) was deployed off the port side and monitored in the cabin; and the ISCO pump samplers were set on the aft-starboard gunwale above the trays of sampling bottles.

Water Sampling. The primary emphasis of the water sampling was the determination of sediment concentration changes near the channel bottom. A total of 1026 pint water samples were collected. Nineteen particle size distribution samples were collected (9 background and 10 event samples).

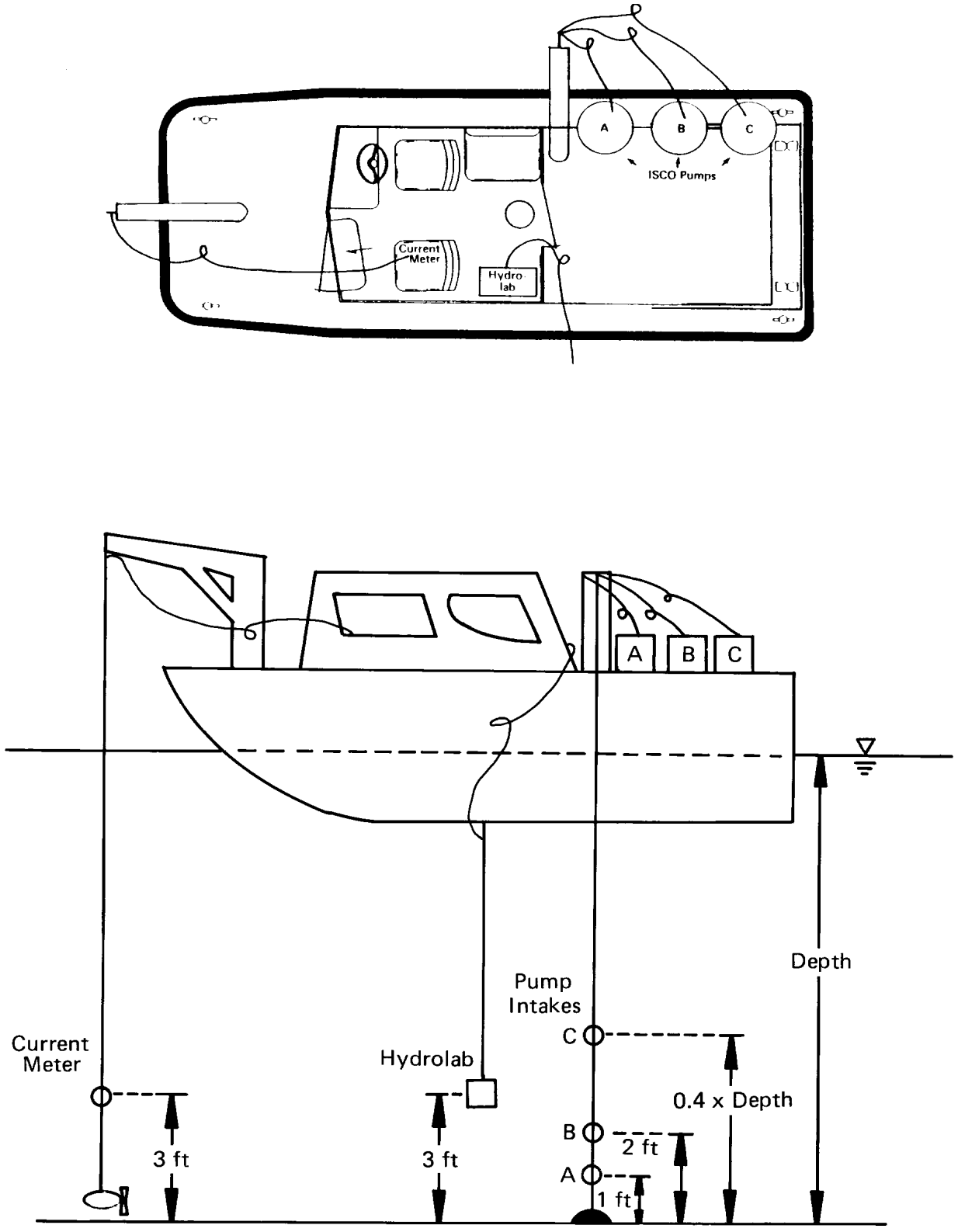

Figure 16. Plan and profile views of the instream monitoring equipment

All concentration and particle size samples were taken from one of the three pump samplers. The intakes for the pumps (figure 16) were set at 1 foot and 2 feet above the bottom and at 0.4 of the water depth above the bottom. Samples were labelled A, B, and C, with A coming from the 1-foot intake, B from the 2-foot intake, and C from the 0.4 intake. Concentration samples were collected at intervals of 3 minutes (one pump sampled every minute) for detailed sampling, and at intervals of 5 minutes (all 3 pumps at one time) during less intensive sampling.

Particle size samples were generally collected in sets of background and event with the background sample taken before the barge passage and the event sample immediately following passage. Each of the particle size samples took 10-15 minutes to collect. Except for the 5600 HP runs, only the 2-foot level was sampled for particle size. During the 5600 HP runs, background and event samples were collected for all three intake levels.

Hydrolab. A hydrolab was used to determine variability of water quality parameters with barge passage. Parameters measured were temperature, pH, dissolved oxygen, and conductivity. Monitoring of the Hydrolab during early data collection indicated that DO was the only parameter that showed variability as a tow with barges passed the experimental site. Based on this early observation, it was decided that during all subsequent data collection, only DO levels would be monitored to determine the impact of tow traffic on water quality at the monitoring site. It should be noted that the field observations indicated that the variability in DO induced by commercial traffic and recreational crafts was higher than that induced by the experimental barges. These data will be analyzed and presented in the data analysis report.

Current Meter. Measurements of current speed were made with a MarshMcBirney 201D one-dimensional current meter. The instrument was deployed off the bow davit on the Monitor by using an A-reel and 15-pound sounding weight. Water depth was measured and the instrument was set 1.0 meter above the bed. Background velocity readings were taken only at the set depth. During data collection, readings were made at intervals of 15 seconds, 30 seconds, one minute, or longer intervals. Readings were made every 15 seconds immediately before and for 10 minutes after tow passage, and less frequently otherwise.

In-Stream Data Collection. A summary of in-stream data collection by the Water Survey is given in table 3. In table 3, the event numbers correspond to the event numbers used in table 1. The field event number is the identification number used by the boat crew during field data collection. Of the total of 72 events, 58 were fully monitored by the Corps. All but the first of these 58 were monitored by the boat station.

The data collection routines indicated in table 3 have been described in the three previous sections. Because of delays in equipment setup, no data were collected by the boat crew for the first passage of the 1500 HP tow. No Hydrolab measurements were made on August 4 because of difficulties in deploying the sonde. For field event 4 (data set 9), pump intake 'C' (0.6 of depth) was not set.

DATA COLLECTED BY THE U.S. ARMY CORPS OF ENGINEERS

The Corps sampling for water quality (day 1) consisted of one boat following on the barge track and taking point water samples, and the Corps MonArk criss-crossing the barge path monitoring turbidity. The Corps sampling for velocity changes (day 2) involved using two MM527 current meters on the bottom near the barge path and monitored in the

MonArk, and three small boats with two MMB one-dimensional meters on poles along a line perpendicular to the barge path. The poles were oriented to flow by using a compass, but no allowance was made for lateral flows. For all runs, divers set scour pins prior to barge passage, which were remeasured at the end of the morning/afternoon data collection session.

The U.S. Army Corps of Engineers shore station was located approximately 100 yards upstream from the Illinois State Water Survey shore station (figure 2). The Corps collected wave data, current velocity data, and water quality data from this shore station.

For the current velocity measurements, the Corps used Marsh-McBirney 511 current meters. These meters measure two-dimensional velocity vectors but do not measure orientation. The Corps' crew fixed three wood frames in the river at selected distances and perpendicular to shore. Then they mounted two MM511's on each frame and set the orientations by using a compass. Each MM511 was connected by cable to a signal processor, which was directly connected to a data logging device. The data were saved into the data log automatically once the system was turned on.

For the wave data, the Corps used a bottom-mounted pressure sensor type of device to measure the wave heights.

SUMMARY

The Illinois State Water Survey (ISWS) participated in field experimentation for the determination of the physical impacts of navigation on the Ohio River. The data were collected near Eighteen Mile Island at approximately River Mile 581. The U.S. Army Corps of Engineers, Louisville District, initiated this field experiment and

also collected a substantial amount of data. Data collected by the ISWS included wave structure, velocity distribution, resuspension of sediment, and barge-induced alteration of the flow field. Data were collected for tows with empty barges pushed by towboats having horsepowers of 1500, 3000, and 5600. All the data from the ISWS data collection effort are now stored at the Survey. Data were also collected for a commercial barge which passed the experimental site. Except for some analyses for determination of the sediment concentration of the water samples, no analyses have yet been performed for this project.

Table 1. Types of Data Collected by ISWS from the Shore Station

Event no.	Date	Time	Tow HP	Propeller RPM	U/S or D/S[1]	Distance from shore[2]	Barge load[3]	Wave data[4]	Velocity data
1	7/28/87	10:25:00	1500	310	U/S	shallow track	1x1 empty		
2	7/28	11:05:00	1500	310	D/S	shallow track	1x1 empty		
3	7/28	11:22:15	--	--				MWL	
4	7/28	11:50:00	1500	310	U/S	shallow track	1x1 empty	yes	
5	7/28	12:00	1500	310	D/S	shallow track	1x1 empty	yes	
6	7/28		1500	310	U/S	shallow track	1x1 empty		
7	7/28		1500	310	D/S	shallow track	1x1 empty		
8*	7/28	12:25	unknown	unknown	U/S	other side of the river	2x4		yes
9	7/28	14:07:30	1500	310	U/S	deep track	1x1 empty		yes
10	7/28	14:40:45	1500	310	D/S	deep track	1x1 empty	yes	
11	7/28	15:08:00	1500	310	U/S	deep track	1x1 empty	yes	
12	7/28	15:17:45	1500	310	D/S	deep track	1x1 empty	yes	
13	7/28	15:23:00	1500	310	U/S	deep track	1x1 empty	yes	
14	7/28	15:32:00	1500	310	D/S	deep track	1x1 empty	yes	
15*	7/28	15:56:45	unknown	unknown	U/S	other side of the river	loaded		
16	7/29	09:25:30	--	--	--	shallow track		MWL	
17	7/29	10:29:05	1500	155	U/S	shallow track	1x1 empty	yes	
18	7/29	10:52:00	1500	155	D/S	shallow track	1x1 empty	yes	
19	7/29	11:11:14	1500	230	U/S	shallow track	1x1 empty	yes	
20	7/29	11:25:23	1500	230	D/S	shallow track	1x1 empty	yes	
21	7/29	11:34:35	1500	310	U/S	shallow track	1x1 empty	yes	
22	7/29	11:50:11	1500	310	D/S	shallow track	1x1 empty	yes	
23	7/29	14:21:40	--	--	--			MWL	
24	7/29	14:40:02	1500	155	U/S	deep track	1x1 empty	yes	
25	7/29	14:59:20	1500	155	D/S	deep track	1x1 empty	yes	
26	7/29	15:15:23	1500	230	U/S	deep track	1x1 empty	yes	
27	7/29	15:34:38	1500	230	D/S	deep track	1x1 empty	yes	
28	7/29	15:47:11	1500	310	U/S	deep track	1x1 empty	yes	
29	7/29	15:57:06	1500	310	D/S	deep track	1x1 empty	yes	
30	7/29	16:07:46	1500	310	U/S	deep track	1x1 empty	yes	
31	7/30	09:00:45	--	--	--			MWL	
32	7/30	10:10:54	3000	235	U/S	shallow track	1x1 empty	yes	

Table 1. (Continued)

Event no.	Date	Time	Tow HP	Propeller RPM	U/S or D/S[1]	Distance from shore[2]	Barge load[3]	Wave data[4]	Velocity data[5]
33	7/30/87	11:19:41	3000	235	D/S	shallow track	1x1 empty	yes	
34	7/30	15:05:10	3000	235	U/S	deep track	1x1 empty	yes	
35	7/30	15:47:50	3000	235	D/S	deep track	1x1 empty	yes	
36	7/31	09:20:35	--	--	--			MWL	
37	7/31	09:36:55	--	--	--				MV
38	7/31	11:07:41	3000	100	U/S	shallow track	1x1 empty		yes
39	7/31	11:23:08	3000	100	D/S	shallow track	1x1 empty		yes
40	7/31	11:34:31	3000	160	U/S	shallow track	1x1 empty		yes
41	7/31	11:50:08	3000	160	D/S	shallow track	1x1 empty		yes
42	7/31	12:04:54	3000	225	U/S	shallow track	1x1 empty		yes
43	7/31	12:20:00	3000	225	D/S	shallow track	1x1 empty		yes
44	7/31	15:15:40	3000	--	--			MWL	
45	7/31	15:31:14	3000	100	U/S	deep track	1x1 empty	yes	
46	7/31	15:50:10	3000	100	D/S	deep track	1x1 empty	yes	
47	7/31	16:05:44	3000	160	U/S	deep track	1x1 empty	yes	
48	7/31	16:17:00	3000	160	D/S	deep track	1x1 empty	yes	
49	7/31	16:33:00	3000	225	U/S	deep track	1x1 empty	yes	
50	7/31	16:47:34	3000	225	D/S	deep track	1x1 empty	yes	
51	8/04	09:35:30	--	--	--			MWL	
52	8/04	09:45:20	--	--	--				MV
53	8/04	10:29:58	5600	150	U/S	shallow track	1x1 empty	yes	
54	8/04	11:16:57	5600	150	D/S	shallow track	1x1 empty	yes	
55*	8/04	12:16:30	unknown	unknown	U/S	other side of the river	3x4 empty		yes
56	8/04	13:38:41	5600	100	U/S	deep track	1x1 empty	yes	
57	8/04	14:25:19	5600	100	D/S	deep track	1x1 empty	yes	
58	8/05	09:12:45	--	--	--			MWL	
59	8/05	09:19:45	--	--	--				MV
60	8/05	11:18:44	5600	100	U/S	shallow to deep track[6]	1x1 empty		yes
61	8/05	11:37:10	5600	100	D/S	shallow to deep track	1x1 empty		yes
62	8/05	11:55:22	5600	150	U/S	shallow to deep track	1x1 empty	yes	

Table 1. (Concluded)

Event no.	Date	Time	Tow HP	Propeller RPM	U/S or D/S[1]	Distance from shore[2]	Barge load[3]	Wave data[4]	Velocity data
63	8/05/87	12:09:33	5600	150	D/S	shallow to deep track	1x1 empty	yes	
64	8/05	13:24:00	5600	100	U/S	shallow to deep track	1x1 loaded	yes	
65	8/05	13:40:51	5600	100	D/S	shallow to deep track	1x1 loaded	yes	
66	8/05	14:00:19	5600	150	U/S	shallow to deep track	1x1 loaded	yes	
67	8/05	14:15:23	5600	100	D/S	shallow to deep track	1x1 loaded	yes	
68*	8/05	15:17	unknown	165	D/S	shallow to deep track	3x5 loaded		
69	8/05	15:49:10	5600	100	U/S	shallow to deep track	3x1 loaded	yes	
70	8/05	16:08:32	5600	100	D/S	shallow to deep track	3x1 loaded	yes	
71	8/05	16:28:23	5600	150	U/S	shallow to deep track	3x1 loaded	yes	
72	8/05	16:44:52	5600	150	D/S	shallow to deep track	3x1 loaded	yes	

[1]D/S = downstream; U/S = upstream

[2]Distances were measured by the Corps and the exact distances will be included in the second report

[3]Configurations of barges are described as 1 x 1, 2 x 4, etc., denoting number of barges in width and length, respectively

[4]MWL = mean water level

[5]MV = mean velocity

[6]On August 5, the COE operated the experimental barge running in a south-north direction (and vice versa), thus intersecting the shallow and deep tracks as shown in figure 2

*Commercial barge

Table 2. Observations Made at the Shore Station

Event no.	Observations
1	Drawdown is obvious, no data taken
2	Drawdown is obvious, no data taken
3	Run for zero readings to get still water level
4	No observation
5	One commercial barge 3x5, loaded, moving U/S, one commercial barge 3x5, empty, moving D/S, will probably affect results
6	
7	
8	One commercial barge 2x4, loaded, moving upstream at far end
9	Velocity data not recorded (keyboard malfunction)
10	Mild drawdown, waves are severe
11	Surface waves are small and the intervals are short, drawdown is negligible
12	Surface waves are larger than No. 11, the intervals are approx. the same, drawdown is negligible
13	Drawdown is short and not obvious, waves are strong and coming in long after the barge passed
14	Surface waves come in fairly late, no drawdown is observed
15	Error - no data taken, waves' magnitudes are small, but intervals are large
16	Run for zero readings to obtain ambient velocity
17	No obvious surface waves, no drawdown
18	Same as No. 17
19	Drawdown (water line recedes about 1 ft), small waves, some breaking waves, weeds are pushed toward shore
20	Noticeable drawdown but immediate takeover by a wave, moderate magnitude of waves
21	Significant drawdown (water line recedes about 20 ft), large surface waves and wave breaks, visible sediment movement near shoreline area
22	Same as No. 21
23	Calibration runs for velocity
24	Small waves
25	No observable changes, initial water surface is disturbed by wind waves
26	Obvious drawdown and surface waves, water line recedes about 10 ft, surface waves come in fairly early
27	Small surface waves, computer error, no data taken
28	Magnificent drawdown, surface waves, water line recedes about 20 ft with breaking waves, sediment resuspension is obvious
29	Moderate drawdown, large surface waves, breaking waves and sediment resuspension are obvious
30	Large drawdown and large surface waves, obvious breaking waves and sediment resuspension
31	Run for still water level
32	Severe drawdown and waves, obvious sediment movement and breaking waves, resuspension in the weed zone
33	Severe drawdown and waves (similar but stronger than U/S run, and drawdown period is much shorter)
34	Large waves, obvious resuspension at weed zone
35	Similar to U/S run No. 34
36	Calibration run for still water level
37	Calibration run for current velocity
38	No observable drawdown and surface waves

Table 2. (Concluded)

Event no.	Observations
39	No observable changes
40	Obvious drawdown (recedes about 15 ft), moderate waves, resuspension and breaking waves occur near shore area
41	Affected by U/S-going barges (events are mixed)
42	Large waves, resuspension in shallow zone, the ladder fell and recording stopped
43	Huge drawdowns and waves
44	Still water readings for ambient velocities
45	Mild drawdowns and waves
46	Negligible drawdown and waves
47	No obvious drawdown but surface waves are strong, breaking waves and sediment movements are obvious
48	Same as No. 47
49	Magnificent event, ladder fell down again
50	Magnificent event
51	Still water reading for water level
52	Still water reading for current velocities
53	Good event, keyboard malfunction, very obvious second drawdown, resuspension and breaking waves are obvious
54	Good event, keyboard malfunction (similar to No. 53)
55	No major waves
56	Large drawdown (waterline recedes about 20-25 ft) and strong surface waves. The first wave that comes in after drawdown generates most of the sediment movements. Clearly there is a second drawdown.
57	Similar to No. 56, but second drawdown can not be seen this time
58	Still water reading for water level
59	Still water reading for ambient velocities
60	Gentle waves, no obvious drawdown
61	No data taken, download has not been completed yet
62	Moderate drawdown and waves, breaking waves are generated, obvious resuspension at weed zone
63	Similar to No. 62, but the magnitudes are smaller
64	No significant waves
65	Generator out of gas
66	No obvious drawdown, some moderate waves came in very late
67	No obvious drawdown, breaking waves are observed
68	Not recorded
69	No observable variations
70	No observable variations
71	Gentle waves
72	Medium waves, resuspension seems very severe at weed zone; but the initial condition is not clear

Table 3. Types of Data Collected[1] by ISWS from the Boat Station

Event no.	Field event number	Current speed	Hydrolab		Concentration		Particle size	
			Full	DO	3 minute	5 minute	1 point	3 point
1	1							
2	2	x	x		x			
3					x			
4	3	x	x		x			
5	3	x	x			x		
6	3	x	x			x		
7	3	x	x			x		
8								
9	4	x	x		x[2]			
10	5	x	x		x			
11	6	x	x			x		
12	6	x	x			x		
13	6	x	x			x		
14	6	x	x			x		
15								
16								
17	7	x	x		x		x	
18	7	x	x			x		
19	7	x	x			x		
20	7	x	x			x		
21	7	x	x			x		
22	7	x	x			x		
23								
24	8	x	x		x		x	
25	8	x	x			x		
26	8	x	x			x		
27	8	x	x			x		
29	8	x	x			x		
30	8	x	x			x		
31								
32	9	x	x		x		x	
33	10	x	x		x			
34	11	x	x		x			
35	12	x	x		x			
36								
37								
38	13	x		x	x		x	
39	13	x		x		x		
40	13	x		x		x		
41	13	x		x		x		
42	13	x		x	x			
43	13	x		x	x			
44								
45	14	x		x	x			

Table 3. (Concluded)

Event no.	Field event number	Current speed	Hydrolab		Concentration		Particle size	
			Full	DO	3 minute	5 minute	1 point	3 point
46	14	x		x		x		
47	14	x		x		x		
48	14	x		x		x		
49	14	x		x	x			
50	14	x		x	x			
51								
52								
53	15	x			x			x
54	16	x			x			
55								
56	17	x			x			x
57	18	x			x			
58								
59								
60	19	x		x	x			
61	19	x		x	x			
62	19	x		x	x			
63	19	x		x	x			
64	20	x		x	x			
65	20	x		x	x			
66	20	x		x	x			
67	20	x		x	x			
68	21	x		x	x			
69	22	x		x	x			
70	22	x		x	x			
71	22	x		x	x			
72	22	x		x	x			

[1]For event descriptions, see table 1
[2]Only 2 pumps working

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