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Ice observations on the Allegheny and Monongahela Rivers

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PREFACE

This report was prepared by Michael A. Bilello, Meteorologist, Science and Technology Corporation, Hampton, Virginia; Lawrence W. Gatto, Geologist, Geological Sciences Branch, Steven F. Daly, Research Hydraulic Engineer, Ice Engineering Research Branch, and John J. Gagnon, Civil Engineering Technician, Ice Engineering Research Branch, U.S. Army Cold Regions Research and Engineering Laboratory. The work was funded by the Office of the Chief of Engineers, Directorate of Civil Works, under the River Ice Management (RIM) Program, CWIS 32228, *Remote Ice Monitoring System*, and CWIS 32227, *Forecasting Ice Conditions on Inland Rivers*.

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inch	25.4	millimeter
foot	0.3048	meter
foot ³ /second	0.02831685	meter ³ /second
mile	1609.347	meter
degrees Fahrenheit	$T^{\circ}\text{C} = (T^{\circ}\text{F} - 32)/1.8$	degrees Celsius



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Ice Observations on the Allegheny and Monongahela Rivers

MICHAEL A. BILELLO, LAWRENCE W. GATTO, STEVEN F. DALY AND JOHN J. GAGNON

INTRODUCTION

Detailed information on daily ice conditions along entire lengths of navigable rivers is often nonexistent or difficult to recover from data archives. In this report ground observations of ice conditions recorded at a series of U.S. Army Corps of Engineers Lock and Dam sites along the Allegheny River in Pennsylvania and the Monongahela River in Pennsylvania and West Virginia were compiled from archives, graphed, analyzed and compared to ice data obtained from aerial videotapes and Landsat images.

The objectives of this study were 1) to determine the annual variability in river ice conditions for selected winters as observed from the ground, 2) to compare ice data acquired from the ground, videotapes and Landsat images, and 3) to develop a computer program to graphically portray the ground data so that these data, when collected in the future, could be quickly displayed and disseminated as an aid for navigation during the winter. This study was a part of the CRREL River Ice Management (RIM) program, a program that examined several rivers in the United States where ice causes winter navigation problems.

DATA SOURCES, COMPILATION AND ANALYSIS

Ground observations

Ground observations of river ice conditions were routinely obtained from eight U.S. Army Corps of Engineers Lock and Dam (L&D) sites on the Allegheny River and nine L&D sites on the Monongahela River, and occasionally from three National Weather Service (NWS) sites located above L&D 9 on the Allegheny

River. These Corps and NWS sites cover the rivers from Pittsburgh to West Hickory, Pennsylvania, about 158 miles upstream on the Allegheny River, and from Pittsburgh to Opekiska, West Virginia, about 115 miles upstream on the Monongahela River (Fig. 1).

The Corps ground observers use a five-element alphanumeric code (Table 1) to describe ice conditions each day and send the codes to Corps and NWS central offices located around Pitts-

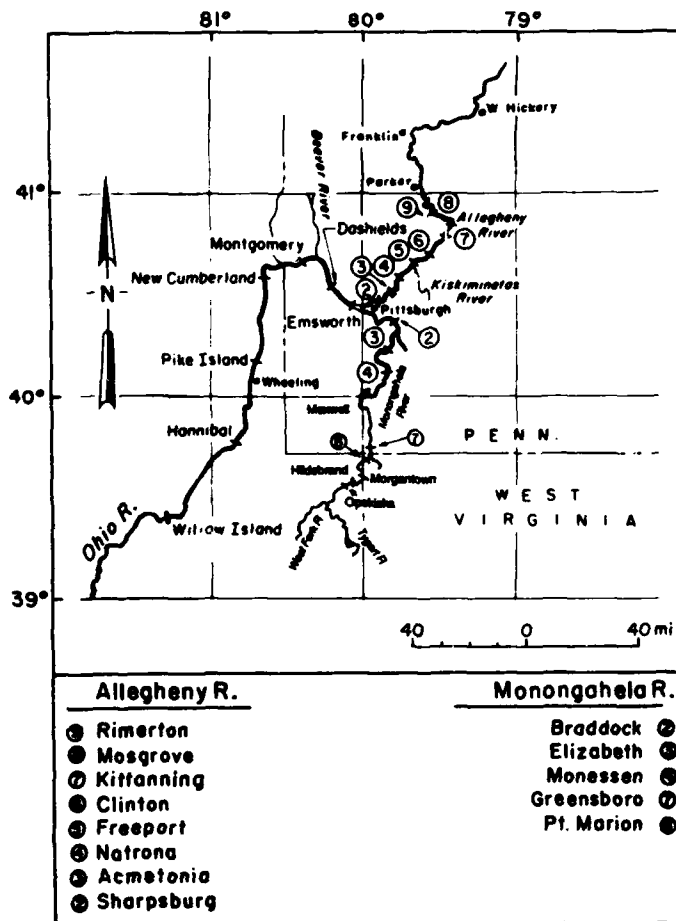


Figure 1. Location map (circled numbers are L&D numbers).

Table 1. Corps of Engineers alphanumeric ice code.

Amount (coverage)	Type	Thickness	Structure	Extent
0-None	R-Running (floating)	In inches	B-Breaking	In miles
1-Scattered	A-Stationary		H-Honeycombed	upstream
2-2 tenths	P-Stopped		T-Rotten	
3-3 tenths	J-Jammed		L-Layered	
4-4 tenths	F-Formed locally		C-Clear	
5-5 tenths	S-Shore			
6-6 tenths				
7-7 tenths	Examples:			
8-8 tenths				
9-9 tenths	1 S 1/2 T X means scattered shore ice, 1/2 in. thick, rotten and extending an un-			
10-10 tenths, full	known distance upstream; unknown data in any category are shown as "X"; 3 R 2 H 4 means 3 tenths of the river is covered by running ice, 2 in. thick, honeycombed, and extending 4 miles upstream.			

Table 2. Partial record of ice conditions on the Monongahela River, January 1985.

Date	Braddock	Elizabeth	Monessen	Maxwell	Greensboro	Pt. Marion	Morgantown	Hildebrand	Opekisa
19									7F 1/2 CX
20						1F 1/8 CX	1F 1/4 CX		9A 1 CX
21	9A 1/2 CX	2F 1/2 CX	10A 1 CX	10A 2 CX	10F 1 CX	10F 1 CX	10F 2 CX	10F 2 CX	10A 2 CX
22	10A 1 CX	6R 1 CX	10A 2 CX	10A 3 CX	10F 1 CX	10F 4 CX	10F 4 CX	10F 4 CX	10A 3 CX
23	10A 1 CX	5R 2 CX	10A 2 1/2 CX	10A 3 1/2	10R BX	10F 5 CX	10F 5 CX	10F 4 CX	10A 3 CX
24	10A 1 CX	5R 2 C10	10A 3 C18	10A 3 1/2 CX	1R 1 C2	10F 5 C11	10F 4 C8	10F 3 C7	10A 4 C14
25	9A 2 C5	6R 3 C10	10R 3 L18	10A 3 C22	1R 1 B5	10F 5 C10	10F 4 C8	10F 3 C7	10A 3 CX
26	9A 2 C5	6R 2 C10	10R 3 L18	10A 1 C22	10A 1 C1	10F 5 B10	10F 5 B6	10F 3 C7	10A 4 C14
27	9A 2 C4	2R 2 C10	10A 3 L18	10A 3 L22	5A 1 B2	10F 5 C10	10F 5 C8	10F 4 C8	10A 5 C14
28	8A 2 B2	2R 2 C10	10P 4 L18	10A 3 L22	8R 2 B3	10F 5 C10	10F 4 1/2 C8	10F 4 C8	10A 7 C14
29	no ice	5R 2 B10	10P 4 L18	10A 3 L22	10A 2 L5	10F 4 C10	10F 4 C8	10F 4 C8	10A 6 C14

burgh. The data are then issued to users by computer modem and are archived at Corps and NWS offices as chronological listings of the ice observations at each of the sites (e.g., Table 2; Appendix A). The data, however, have two major omissions. The ice observers at some sites often did not collect data on weekends, and they frequently could not determine how far upstream a particular ice type existed. We hope that these data gaps can be reduced in the future. Although these ground observations are available beginning with the 1961-62 winter, the records for the seven consecutive winters from 1979-80 to 1985-86 are most complete and are used in this study.

Since it is difficult for a user to visualize and understand the distribution of ice conditions from tables, we developed a way to graph the data. Graphs of ice observations for the Allegheny (Fig. 2a) and Monongahela (Fig. 2b) Rivers during the 1985-86 winter that employ our method

are shown here. Other methods have been used in the past to graph river-ice conditions (Bates et al. 1968, Michel 1971, Starosolszky 1985, Canadian Coast Guard 1986).

Our review of the Corps' ice code (Table 1) indicated that most of the information given can be displayed graphically, although in preparing the hand-drawn graphs (Fig. 2a and b), it was necessary to drop the ice structure element of the code, and to reduce the number of amount and type categories for the sake of readability. Amount was reduced from eleven categories to four: 0 (area clear of ice), 1 through 5 tenths (10-50%), 6 through 9 tenths (60-90%), and 10 tenths (100%). Type was reduced from six to three: running or floating ice; stationary, stopped, jammed or formed locally (any one of the four); and shore ice. We also included discharge and air temperature data to show the relationships between temperature, discharge and ice conditions.

Aerial videotapes

Videotapes (1/2-in. VHS) of the rivers were taken vertically with a Panasonic 777 video camera fitted with a 12:1 zoom lens. A Cessna 172 fixed-wing aircraft, flying at an altitude between 2000 and 3500 ft above the river, depending on cloud conditions and the width of the river, carried the camera. An experienced ice interpreter viewed the tapes on a TV monitor and visually classified ice conditions into six units (Table 3) that were readily identifiable, that satisfactorily described the range of ice that usually occurs on these rivers, and that did not require ground truth data for verification. The interpreter did not attempt to infer characteristics from the tapes that could only be measured on the ground (e.g., porosity, strength or ice thickness).

Boundaries between the units were mapped and the area of each unit was measured. For units comprising both ice and open water—*solid ice cover with open-water areas, fragmented ice with open-water areas and ice floes or frazil slush and pans*—the surface concentration of ice was also visually estimated.

Table 3. Ice conditions as observed on videotapes (from Gatto et al. 1986).

Map unit	Description
	River is ice-free, no ice apparent.
	River is completely covered (100%) with ice; no individual ice pans, blocks or chunks are visible; ice may be snow-covered.
	River is partially covered with solid ice (as described above) but has open (ice-free) areas.
	River is completely covered (100%) with ice that has distinct, variably sized, individual ice pans, blocks or chunks.
	River is partially covered with fragmented ice (as described above) but has open (ice-free) areas.
	River is primarily open (ice-free) with floating ice floes, slush or pans.

Landsat images

Five Landsat satellites have provided images of the rivers since 1972. Each Landsat has two imaging sensors: either a Multispectral Scanner (MSS) with an Instantaneous Field of View (IFOV) of approximately 260 by 260 ft and a Return Beam Vidicon (RBV) with an IFOV of either 262 by 262 ft or 131 by 131 ft, or a MSS (same IFOV) and a Thematic Mapper (TM), with an IFOV of 98 by 98 ft. Gray tones and patterns in river ice are most visible to the eye on images from the 0.6- to 0.7- μ m MSS, 0.580- to 0.680- μ m RBV (Landsat 1 and 2), 0.505- to 0.750- μ m RBV (Landsat 3), and 0.63- to 0.69- μ m TM (Landsat 4 and 5).

Images of the same location were taken every 18 days by Landsat 1, 2 and 3. When more than one was operating simultaneously, images of the same location were taken about every 9 days. During simultaneous Landsat 4 and 5 operations, images of the same location were taken every 8 days; images were taken every 16 days when one satellite was operating.

We analyzed black and white Landsat film positives (9 by 9 in.) using traditional photographic interpretation techniques. No special computer enhancements or analytical techniques were used (Gatto 1985). Reaches of the rivers appeared as black, gray or white with textures and patterns within these tones sometimes apparent, but the subtleties that differentiate the six ice conditions that are visible on videotapes were not apparent on Landsat images. To determine which types of river ice usually produced these tones, textures and patterns, we compared ice conditions shown on aerial photographs (Gatto and Daly 1986) and videotapes taken on dates as close as possible to those for which Landsat images were available.

These comparisons show that when the river appeared black on an image and had no discernible textures and patterns, the river was open (ice free). It is possible, however, that thin, transparent ice, which appears black from above and cannot be distinguished from open water in Landsat images, covered part or all of particular river reaches in some instances. Ice conditions that appear gray on Landsat images can vary from fragmented ice (usually thin) with large, interspersed open areas to ice floes, pans or slush mixed with open areas. The gray tone usually had a patchy or mottled appearance, or showed textures or patterns.

When the river appeared white (or nearly white), ice conditions could vary from solid to

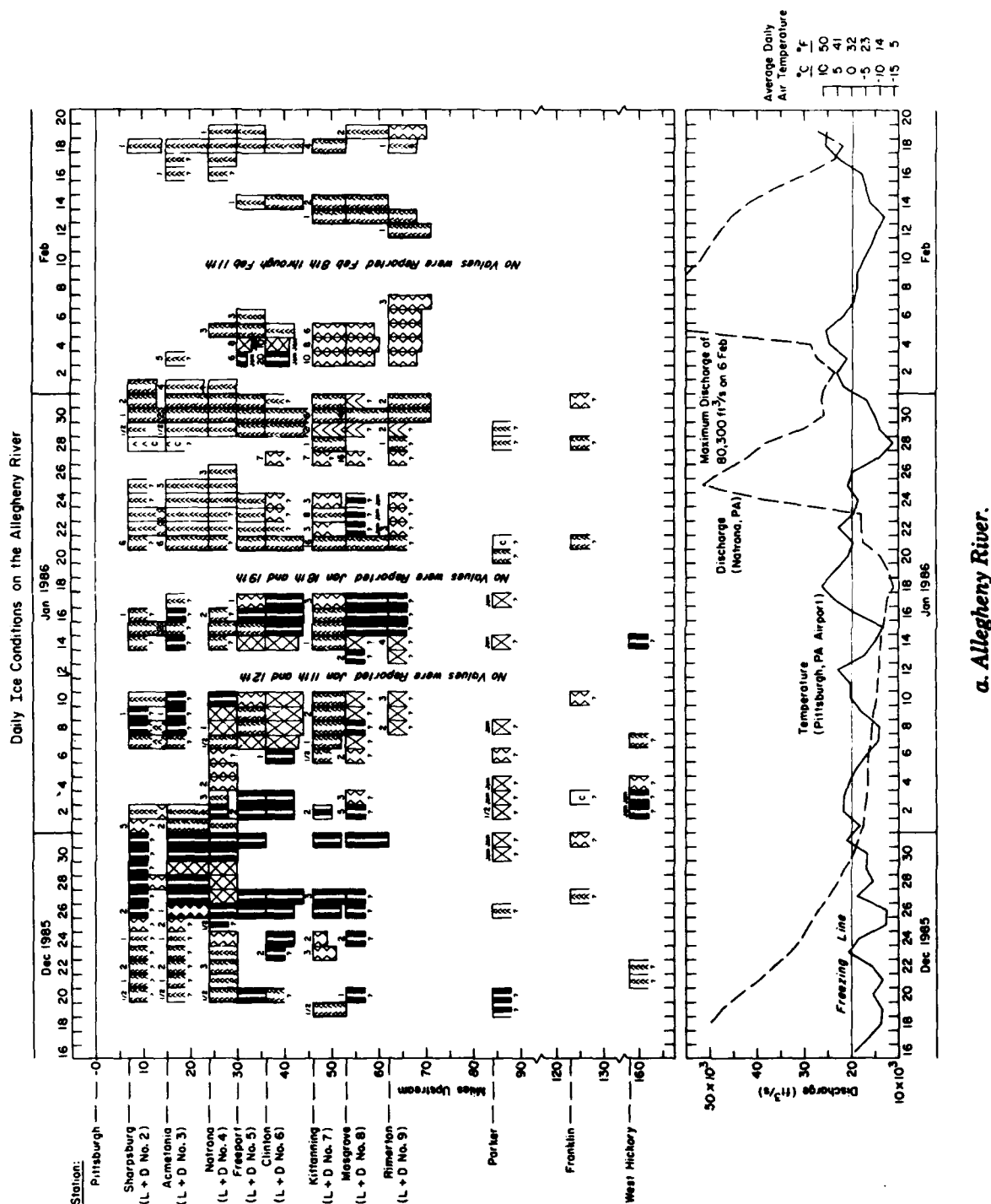
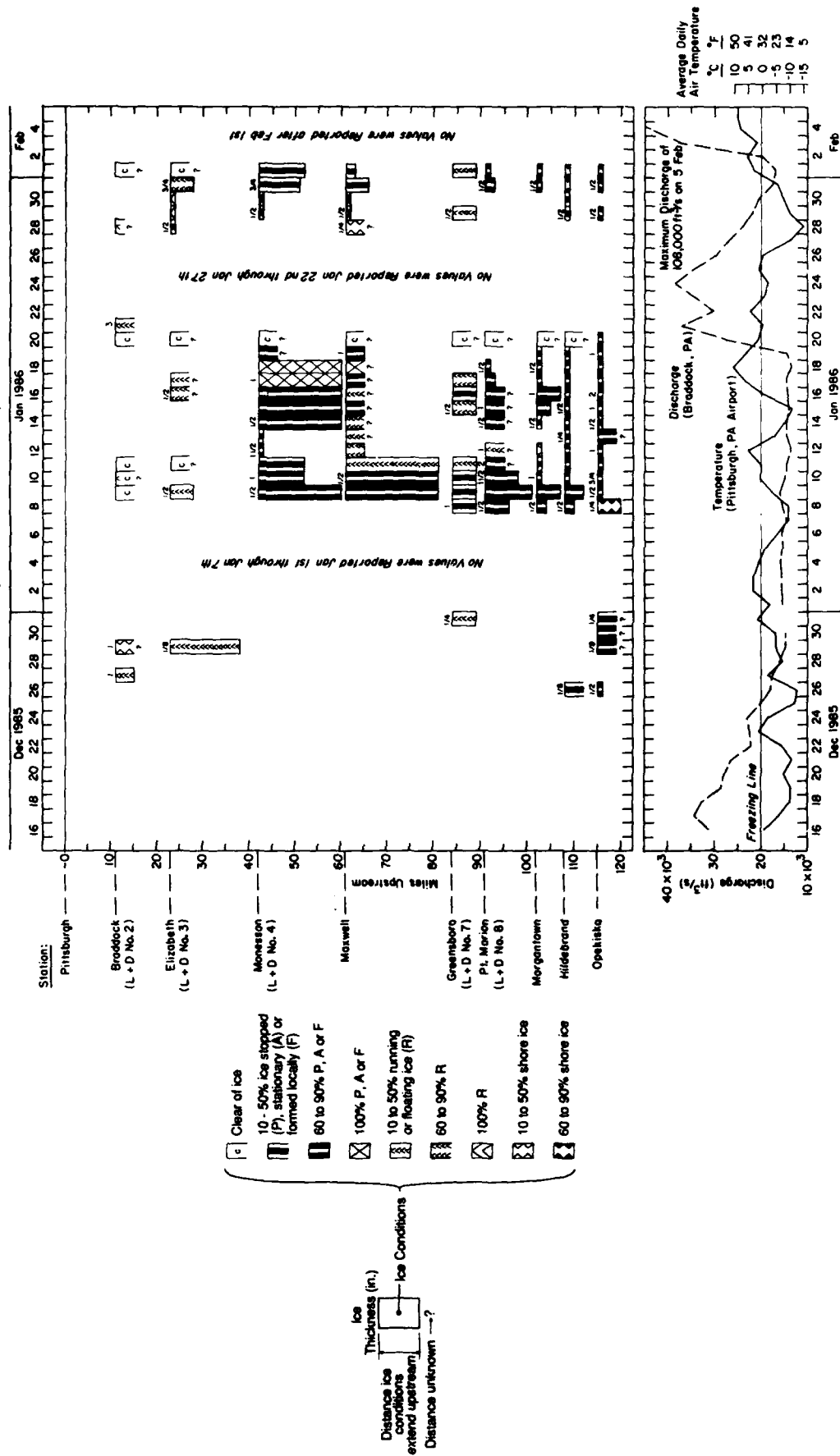


Figure 2. Daily ice conditions observed during the 1985-86 winter with air temperatures (U.S. Department of Commerce 1985 and 1986) and river discharges (U.S. Department of the Interior 1985 and 1986).

a. Allegheny River.

Daily Ice Conditions on the Monongahela River



b. Monongahela River.

Figure 2 (cont'd).

fragmented ice (usually thicker than gray ice). A white tone could include scattered open water areas that are smaller than the Landsat sensor IFOVs, or fewer open water areas than occur where a gray tone is observed. A white tone could also mean that the ice was snow-covered. For example, thin ice in a Landsat scene may be transparent, appear black and be classified as open water. This same ice cover viewed after a light snowfall would appear white.

RESULTS

Ice conditions from ground observations

The Corps and NWS ice observations for the winters from 1979–80 through 1985–86 (Appendix A) were examined to determine the dates of initial ice formation and final clearance of ice on the Allegheny and Monongahela Rivers. First ice occurred as early as 19 December and as late as 20 January on the Allegheny, and as early as 21 December and as late as 3 February on the Monongahela. Final ice was observed as early as 8 February and as late as 20 March on the Allegheny, and as early as 20 January and as late as 4 March on the Monongahela.

Although ice formed on the rivers during all seven winters, the severity of the ice conditions varied each season. Both rivers had the least ice cover in the 1982–83 winter, and the most in 1983–84. During four of the winters, ice formed on the Allegheny River earlier than on the Monongahela, and during all seven winters, ice remained on the Allegheny from 1 to 20 days longer than on the Monongahela. An inspection of the total number of days that ice was observed at each of the L&D sites revealed that approximately the lower 20 miles of the Monongahela and the lower 10 miles of the Allegheny River have the fewest number of days with ice.

The type and structure of ice given in the ice code (Table 1) made it possible to note the times and locations of ice jams and the frequency of running or stationary ice throughout the winter. Also, we could statistically summarize the percent of ice coverage on the rivers.

Ice jams were recorded on the Allegheny at the following locations (Fig. 1): above Rimerton in January 1981, above Mosgrove in March 1982, at Parker in January 1985, and near Natrona in February 1985. An ice jam was observed on the Monongahela in January 1984 at Maxwell.

Ice on both rivers is generally in motion; there are frequently changing intervals of either solid

or partial ice cover with occasional occurrences of open water throughout the winter. A comparison between complete and partial ice covers indicates that, on the Allegheny River above Rimerton, a complete ice cover occurs approximately during 75% of the total days when ice is reported. In contrast, below Acmetonia, a complete ice cover is observed during only about 27% of the total days. On the Monongahela River near Opekiska, a complete ice cover occurs during about 70% of the days when ice is reported, and near Elizabeth and Braddock, about 21%.

Comparisons of river ice observations

It is clear that information on ice type (including movement), thickness and structure (Table 1) can only be obtained by ground observations, although inferences regarding some of these characteristics could be made from aerial videotapes by an experienced interpreter. Because of the dynamic nature of river ice and the limited view upstream of a ground observer, the ground observations apply only for the location near the observation site and only as far upstream as is visible, although the ice conditions as seen near the dams were usually assumed to persist upstream. Sometimes other upstream observers reported ice conditions beyond the view of the observer at the locks and dams.

The aerial videotapes give more accurate information on the areal coverage and extent of different ice types than do the ground observations. Landsat images also show the areal distributions of ice as do the videotapes, but with much less detail and frequency. We have compared data from these three data sets collected during 1984–85 and 1985–86 to illustrate their advantages and disadvantages.

Winter of 1984–85

Ground observers reported ice on the Allegheny River for 49 days from 10 January to 25 February (Fig. A6) and on the Monongahela River for 37 days from 14 January to 20 February (Fig. A13). Ice was observed on videotapes taken of the lower 7 miles of the Allegheny River on 11 days from 23 January to 24 February. A 28 February tape showed no ice. Ice was apparent on videotapes of the lower 66 miles of the Monongahela River taken on five days from 28 January to 24 February. A 16 January Landsat image was the only one taken this entire winter when ice was present. There were no days this winter when ground observations, videotapes and Landsat images were acquired on the same day.

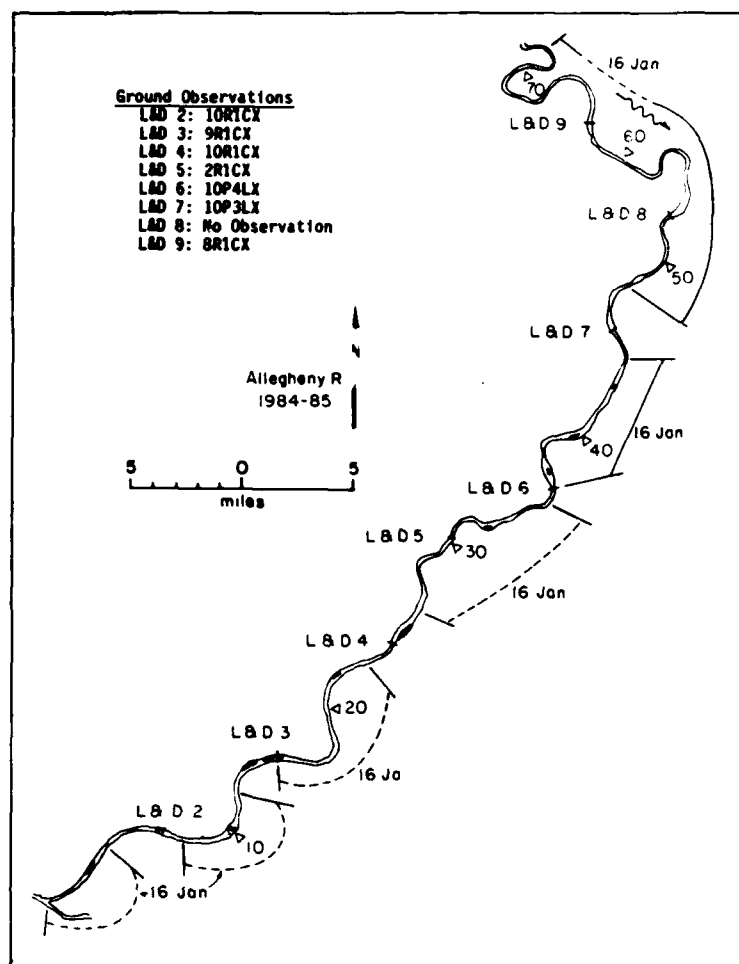
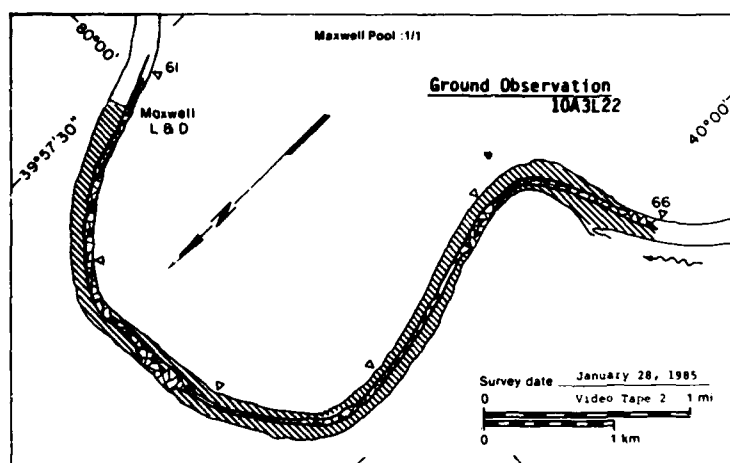


Figure 3. Ice conditions on the Allegheny River on 16 January 1985 as observed by ground observers and on a Landsat image (dashed line is gray ice, solid line is white ice).

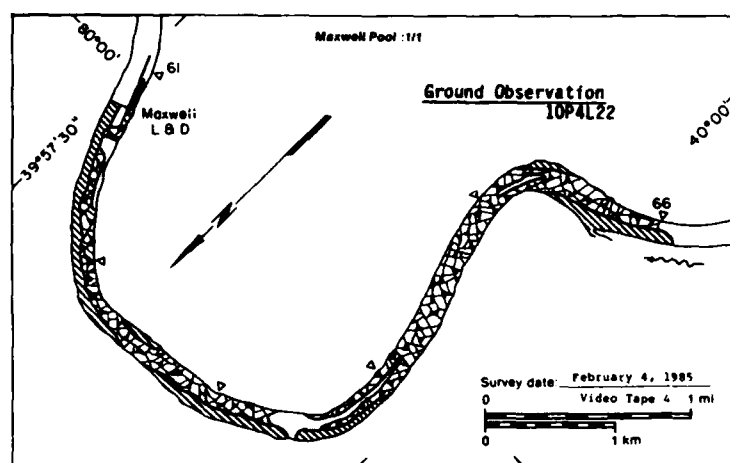
The 16 January Landsat image showed that 70% of the Allegheny River below L&D 6 was covered with gray ice and 30% was open (Fig. 3). White ice and gray ice covered 88% of the river upstream of L&D 6 to river mile 72, while 12% of this section was open. Ground observations made on 16 January at the four L&D sites below L&D 6 showed 1-in.-thick, clear, running ice covering 20–100% (average coverage 80%) of the river some unknown distance upstream from each site. Between L&D 6 and L&D 8 was 3- to 4-in.-thick, layered, stopped ice covering all of the river and extending upstream an unknown distance. Above L&D 9 (some unknown distance) was 1-in.-thick, clear, running ice covering 80% of the river.

The gray ice apparent on the Landsat image was composed of this thin, clear, moving ice, while the white ice consisted of the thicker, layered ice that was stopped. When used together, Landsat and ground observations provide details of the ice and its extent upstream not available from either source alone.

The 16 January Landsat image showed only 6 miles of gray ice on the Monongahela River above Opekiska L&D. The ground observation at Opekiska L&D showed shore ice, $\frac{1}{2}$ in. thick and clear, covering 70% of the river some unknown distance upstream. Ground observers also reported $\frac{1}{8}$ to $\frac{1}{4}$ -in.-thick, clear, locally formed ice and shore ice covering 10% of the river for unknown distances upstream of L&D 7, L&D 8 and



a. 28 January 1985.



b. 4 February 1985.

Figure 4. Ice conditions on the lower 5 miles of Maxwell Dam pool, Monongahela River, as observed on videotapes and by ground observers (see Table 3 for definitions of ice symbols).

Morgantown L&D. No other ground observations were made. It is not surprising that this thin, clear ice below Opekiska L&D was not apparent on the Landsat image.

Ice conditions 5 miles upstream of Maxwell L&D on the Monongahela River as observed from videotape and the ground were compared for 28 January and 4 February. The videotape from 28 January shows 69% of this reach covered with solid ice, 28% with fragmented ice with interspersed open areas and 3% open water. The ground observer at Maxwell reported 100% of the

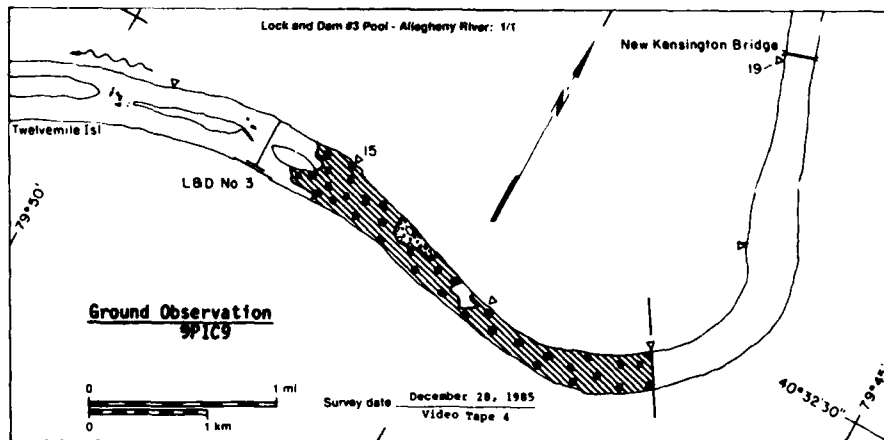
river covered with stationary ice, 3 in. thick and layered, and extending 22 miles upstream (Fig. 4a). The 4 February tape shows 27% of this reach covered with solid ice, 62% covered with fragmented ice with interspersed open areas and 11% being open water (Fig. 4b). A Maxwell ground observer reported on 4 February that 100% of the river was covered with stopped ice that was 4 in. thick and layered, extending 22 miles upstream.

For the first 5 miles upstream of Maxwell L&D, the tapes and ground observations showed nearly complete ice cover on both dates, with the ground observer reporting stationary ice on 28 January and stopped ice on 4 February. This suggests that the ice was moving between 28 January and 4 February, which would explain why the 4 February tape (Fig. 4b) showed more fragmented ice than the 28 January tape (Fig. 4a). As with Landsat and ground observations, the videotapes and ground observations are also complementary and provide a more detailed view of ice conditions than either one alone.

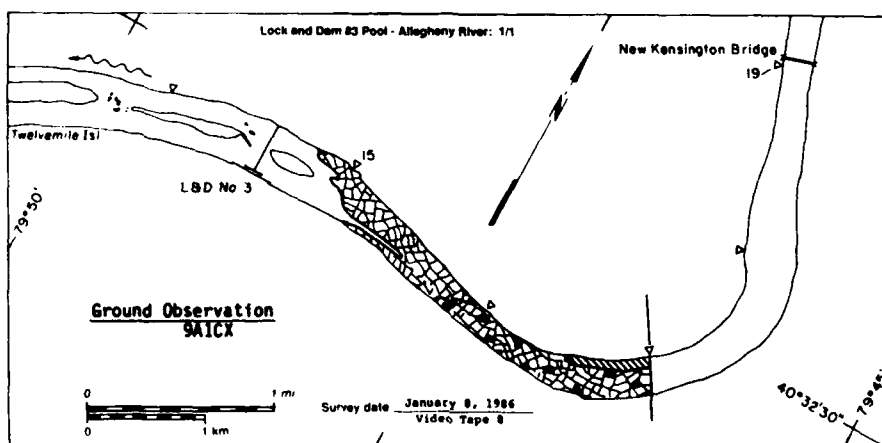
Winter of 1985-86

Ground observers reported ice on the Allegheny River for 63 days from 19 December to 19 February (Fig. 2a, A7) and on the Monongahela River for 39 days from 26 December to 1 February (Fig. 2b, A14). Videotapes were taken of the lower 17 miles of the Allegheny River and of the lower 13 miles of the Monongahela River on 9 days when ice was apparent from 28 December to 28 January. Landsat images taken on 3 and 19 January and 4 and 20 February were not useful because the ground was cloud-covered. The only Landsat image that showed ice was taken on 8 March 1986, after the last videotape was taken and the last ground observation was made.

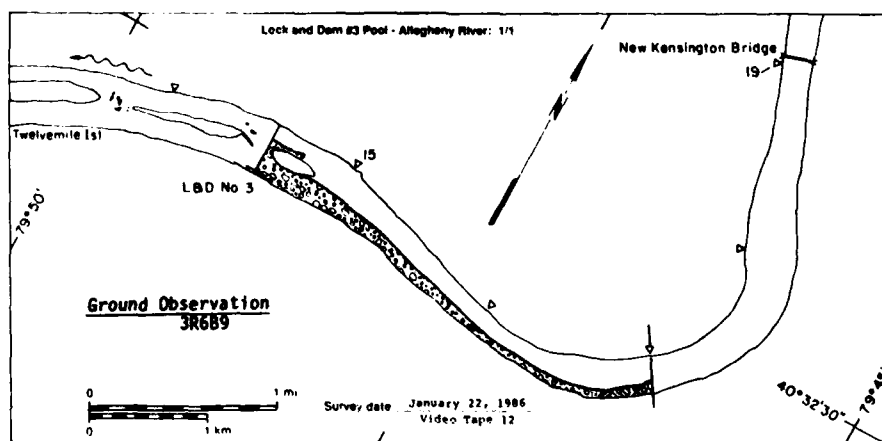
The 8 March Landsat image showed gray ice on 92% of the Allegheny River above L&D 8, on



a. 28 December 1985.



b. 8 January 1986.



c. 22 January 1986.

Figure 5. Ice conditions on the lower 2.5 miles of L&D 3 pool, Allegheny River, as observed on videotapes and by ground observers (see Table 3 for definitions of ice symbols).

32% of the Allegheny at L&D 4 pool, and on 11% of the Monongahela River at L&D 2 pool. Since no ground observations or videotapes were taken on this day, we cannot compare them to the Landsat-derived data. However, we can compare data from videotapes and ground observations from other days.

Ground observers at the Allegheny River L&D 3 would have a visual range of at least 2.5 miles upstream of the dam, which is the extent of the videotape coverage for this pool. On 28 December 1985, the videotape showed 82% of this reach covered by solid ice with interspersed open areas, 4% covered by ice floes, slush and pans, and 14% open water (Fig. 5a). The ground observer reported 90% of the river covered with 1-in.-thick, clear ice that was stopped, and that extended upstream 9 miles. On 8 January, the videotape showed 4% solid ice, 33% fragmented ice, 37% fragmented ice with interspersed open areas, and 26% open water (Fig. 5b). The ground observer reported a 90% cover of stationary, 1-in.-thick, clear ice that extended an unknown dis-

tance upstream. On 22 January (Fig. 5c), video showed 39% covered with ice floes, slush and pans, and 61% open water. The ground observer reported 30% coverage with running ice that was 6 in. thick and breaking, and that extended 9 miles upstream.

Computer-generated graphs

It became obvious during preparation of Figure 2 that because of the extensive hand-drafting required, use of the future ground observations would be limited. To expedite preparation of graphs of future data, a computer graphics program was developed to use the same ice codes as were used to prepare the hand-drawn graphs. In the computer-generated graphs (Fig. 6; Appendix A), the order of the L&D locations is reversed (see Fig. 1), the ice code symbols are slightly different (see Fig. 2), and ice thicknesses were not included because of space limitations. The use of a multi-colored diagram will allow thickness to be added (Bilello et al. 1988).

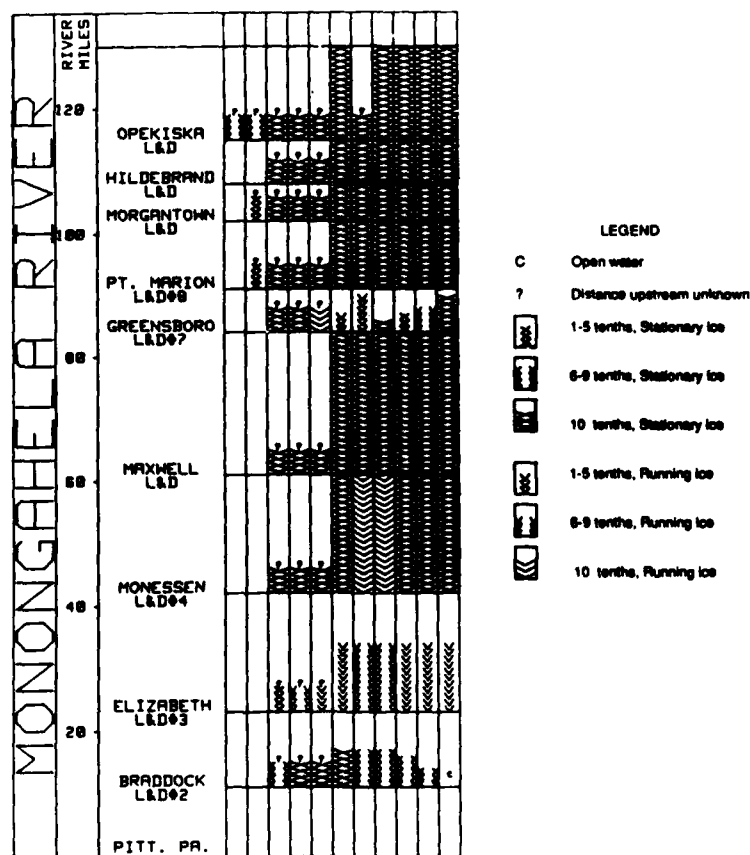


Figure 6. Part of the computer-generated diagram of daily ice conditions, Monongahela River, January 1985.

SUMMARY AND CONCLUSIONS

The river ice conditions on the Allegheny and Monongahela Rivers were highly variable, as shown by the graphs of the ground observations. The observed ice was largely in motion, although there was much stationary ice and major periods of open water. The graphs provide a convenient way of showing these wide variations, in space and time.

Each method of observation—ground, aerial video and Landsat—has certain advantages and disadvantages (Table 4). Ground observations have the advantage that data on thickness, movement and structure can be frequently obtained, and, generally, ground observations are not affected by the weather. The major limitation of ground observation is the line-of-sight of the observer, which is often no more than several miles. Given the wide variability of ice conditions, this limitation can be critical.

Aerial video observation has the advantages of providing detailed views of large river reaches, at frequent intervals, and at reasonable cost. The video image is relatively easy to interpret, but training or experience is essential. The disadvantages are the lack of ice thickness and the adverse effect of bad weather, especially low cloud ceilings. Given these restrictions, aerial video is perhaps the best means of closely observing ice conditions on large rivers and, when

combined with ground observations, the two methods provide an excellent means of recording and analyzing river ice.

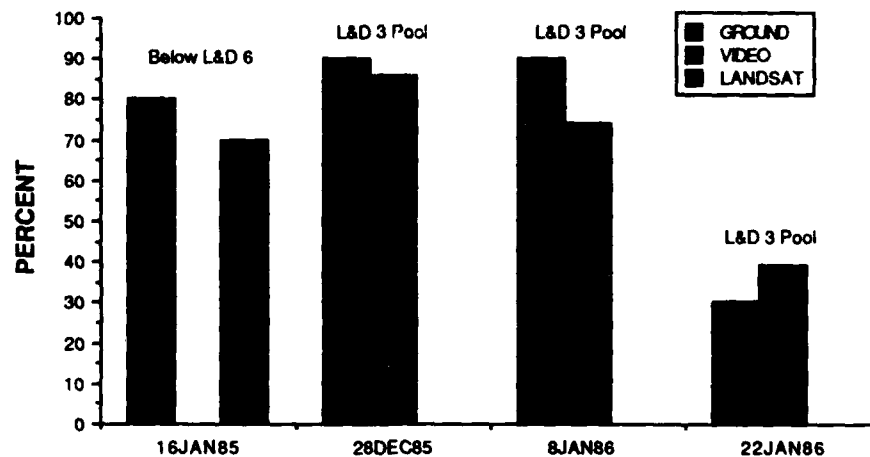
Landsat imagery has the advantage of providing images of large reaches of a river that can be easily interpreted. There is a good data base of usable images starting in 1972. Disadvantages are the infrequent coverage, the obscuration by clouds and poor resolution of the images, which limit the level of detailed information. Thin, clear ice, for example, is often undetected. Ice conditions determined from Landsat are recorded as either white or gray in tone so that ice details that are obtained by either ground observers or aerial videos are not apparent from Landsat images.

Despite differences in the detail obtainable from the three methods, they generally agree on the overall extent of ice coverage. For example, the total percentage of selected pools covered by ice as determined on selected dates is shown in Figure 7. It can be seen that, except for 16 January 1985 on the Monongahela River, the methods are within 15% of each other. The Landsat observation on 16 January 1985 (Fig. 7b) indicates much more ice than the ground observation.

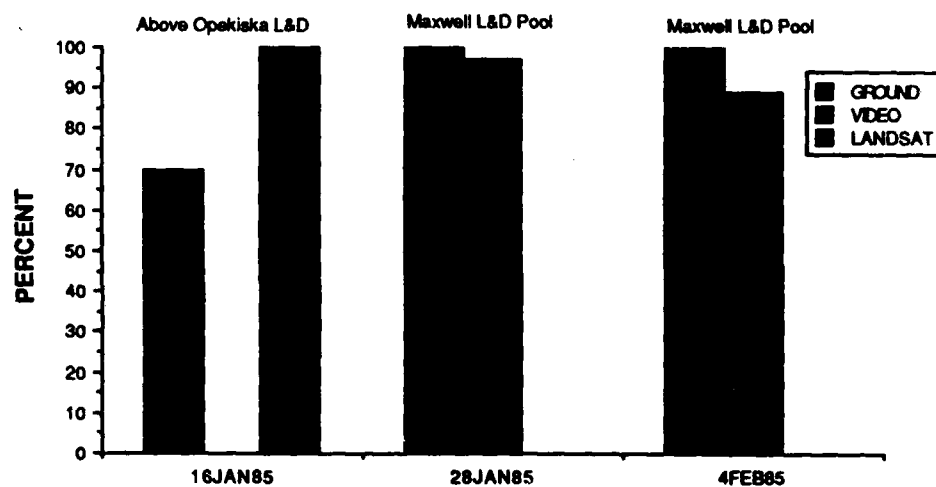
This study has illustrated the importance of three observation techniques for monitoring river-ice conditions. Each method provides useful data and, when analyzed together, they give a more

Table 4. Advantages and disadvantages of the three data sets.

	<i>Advantages</i>	<i>Disadvantages</i>
Landsat	Synoptic view of large reaches of the river	Poor IFOV gives limited, not detailed information
	Good data base of images since 1972	Infrequent acquisition
	Easy to interpret images	Cloud cover can obscure river
Video		Snow cover obscures ice
	View of large reaches of the river	Cannot provide ice thickness
	Good IFOV gives as much detail as is required	Cannot acquire tapes if cloud ceiling is too low
	Easy to interpret, but experienced interpreter is required	Snow cover obscures ice
Ground	Frequent acquisition	
	Detailed ice data	Limited horizontal view
	Frequent observations	Data quality depends on observer
	Not weather-dependent	Data must be graphed to be useful



a. Allegheny River.



b. Monongahela River.

Figure 7. Percent of river ice cover as observed on the ground, from videotapes and from Landsat images.

complete understanding of a dynamic river-ice regime than would be possible with one method alone.

With the computer-graphics capability developed for this study, there may be increased use of the ground observations if they are quickly graphed and available for rapid dissemination where navigation on ice-prone rivers throughout the winter is required. This potential for expanded use of these data may result in the receipt of better and more complete information from the ice observers.

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APPENDIX A: ICE CODE RECORDS AND COMPUTER-GENERATED GRAPHS OF DATA

LEGEND

C	Open water
?	Distance upstream unknown
	1-5 tenths, Stationary ice
	6-9 tenths, Stationary ice
	10 tenths, Stationary ice
	1-5 tenths, Running ice
	6-9 tenths, Running ice
	10 tenths, Running ice

Allegheny River

1979-80

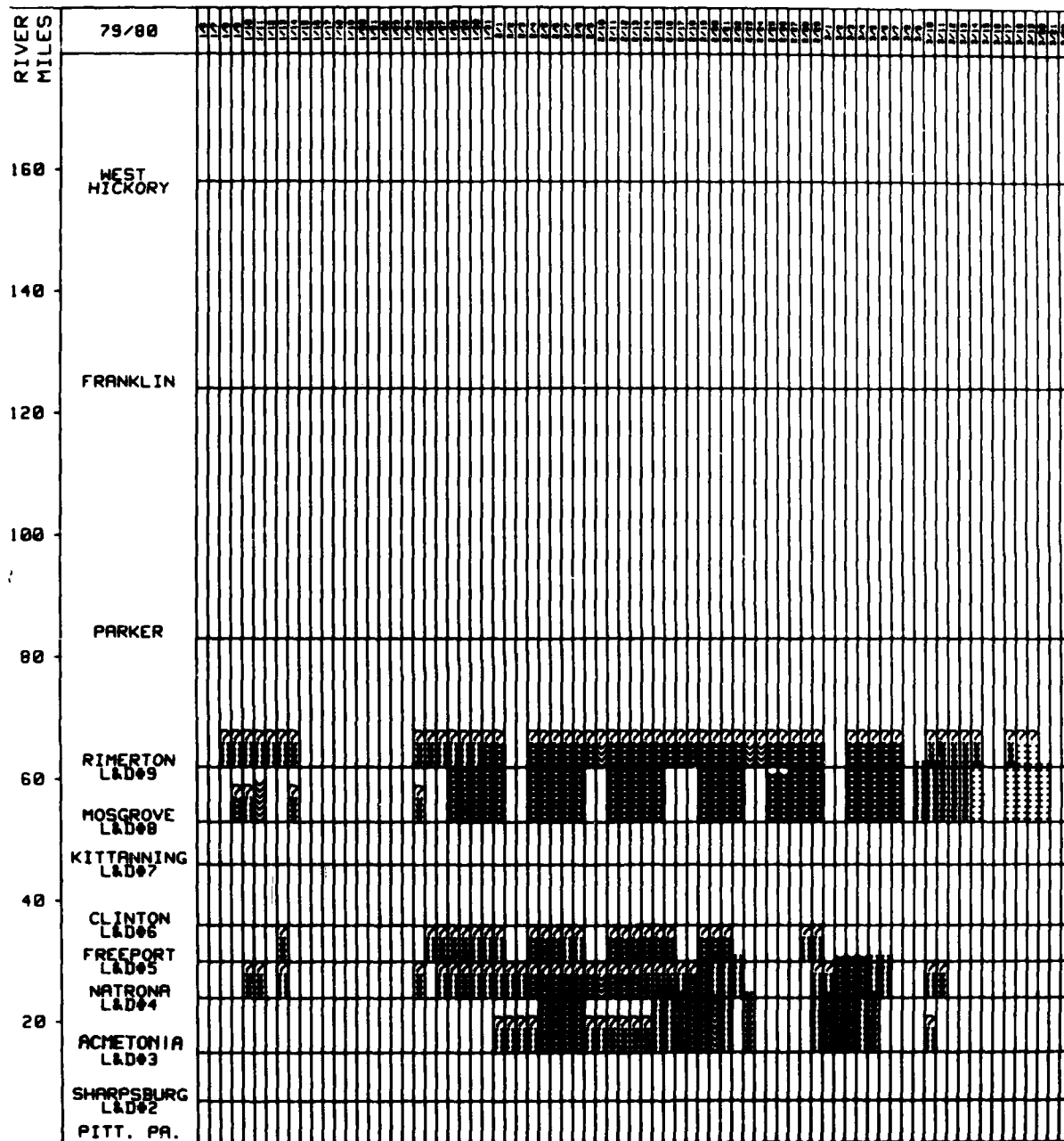


Figure A1.

DATE	SHOPSING	ACHTONIA	WYTHAM	FREEPORT	CLINTON	KITTING	MOSGROVE	RIPIERTON	PURKER	FRANKLIN	W. HICK
1/6											
1/7											
1/8								981CX			
1/9							10P1LX	981CX			
1/10			981CX				981CX	981CX			
1/11			181CX				10J3LX	981CX			
1/12								981CX			
1/13			982TX	282CX				981CX			
1/14							181CX	181CX			
1/15											
1/16											
1/17											
1/18											
1/19											
1/20											
1/21											
1/22											
1/23											
1/24											
1/25			181CX				981CX	981CX			
1/26				981CX				981CX			
1/27			981CX	981CX				981CX			
1/28			981CX	981CX			10P3CX	981CX			
1/29			981CX	981CX			10P3CX	981CX			
1/30			981CX	981CX			10P3CX	981CX			
1/31			981CX	981CX			10P3CX	10J3LX			
2/1		792CX	981CX	981CX			10P3CX	10J3LX			
2/2		792CX	981CX								
2/3		982CX	982CX								
2/4		982CX	10P2CX	10P1CX			10P5CX	10J5LX			
2/5		10P2CX	10P2CX	10P1CX			10P5CX	10J5LX			
2/6		10P2CX	10P2CX	10P1CX			10P5CX	10J6LX			
2/7		10P2CX	10P2CX	981CX			10P5CX	10J6LX			
2/8		10P2CX	10P2CX	981CX			10P5CX	10J6LX			
2/9		792CX	10P2CX					10J6LX			
2/10		984CX	10P1CX					10J6LX			
2/11		984CX	10P1CX	10P2CX			10P6CX	10J6LX			
2/12		984CX	10P1CX	10P3CX			10P6CX	10J6LX			
2/13		984CX	10P1CX	10P3CX			10P6CX	10J6LX			
2/14		985CX	982CX	10P3CX			10P6CX	10J9LX			
2/15		984CX	984CX	10P3CX			10P6CX	10J9LX			
2/16		984CX	984CX	10P3CX				10J9LX			
2/17		984CX	794CX					10J9LX			
2/18		10P4CX	10P4CX					10J9LX			
2/19		10P4CX	10P4CX	10P3CX			10P6CX	10J9LX			
2/20		10P4CX	10P4CX	10P3CX			10P5CX	10J9LX			
2/21		10P4CX	10P4CX	10P2CX			10P5CX	10J9LX			
2/22			984TX				10P4CX	10J9LX			
2/23		982TX						10J9LX			
2/24								10J9LX			
2/25							10P4CX	10J9LX			
2/26							10P4CX	10J9LX			
2/27							10P4CX	10J9LX			
2/28				981CX			10P4CX	10J9LX			
2/29		981CX	981CX	981CX			10P4CX	10J9LX			
3/1		10P1CX	982CX								
3/2		10P2CX	10P2CX								
3/3		10P2CX	10P2CX				10P5CX	10J70LX			
3/4		982CX	10P2CX				10P5CX	10J70LX			
3/5		982TX	982TX				10P4CX	10J70LX			
3/6			792TX				10P4CX	10J70LX			
3/7							10P4CX	10J70LX			
3/8											
3/9							984TX				
3/10		794TX	982TX				984TX	10P5LX			
3/11			102TX				984TX	10P5LX			
3/12							984TX	981CX			
3/13							984TX	982LX			
3/14							254TX	102LX			
3/15											
3/16											
3/17							254TX	103TX			
3/18							254TX	104TX			
3/19							254TX	105TX			
3/20							194TX				
3/21											
3/22											

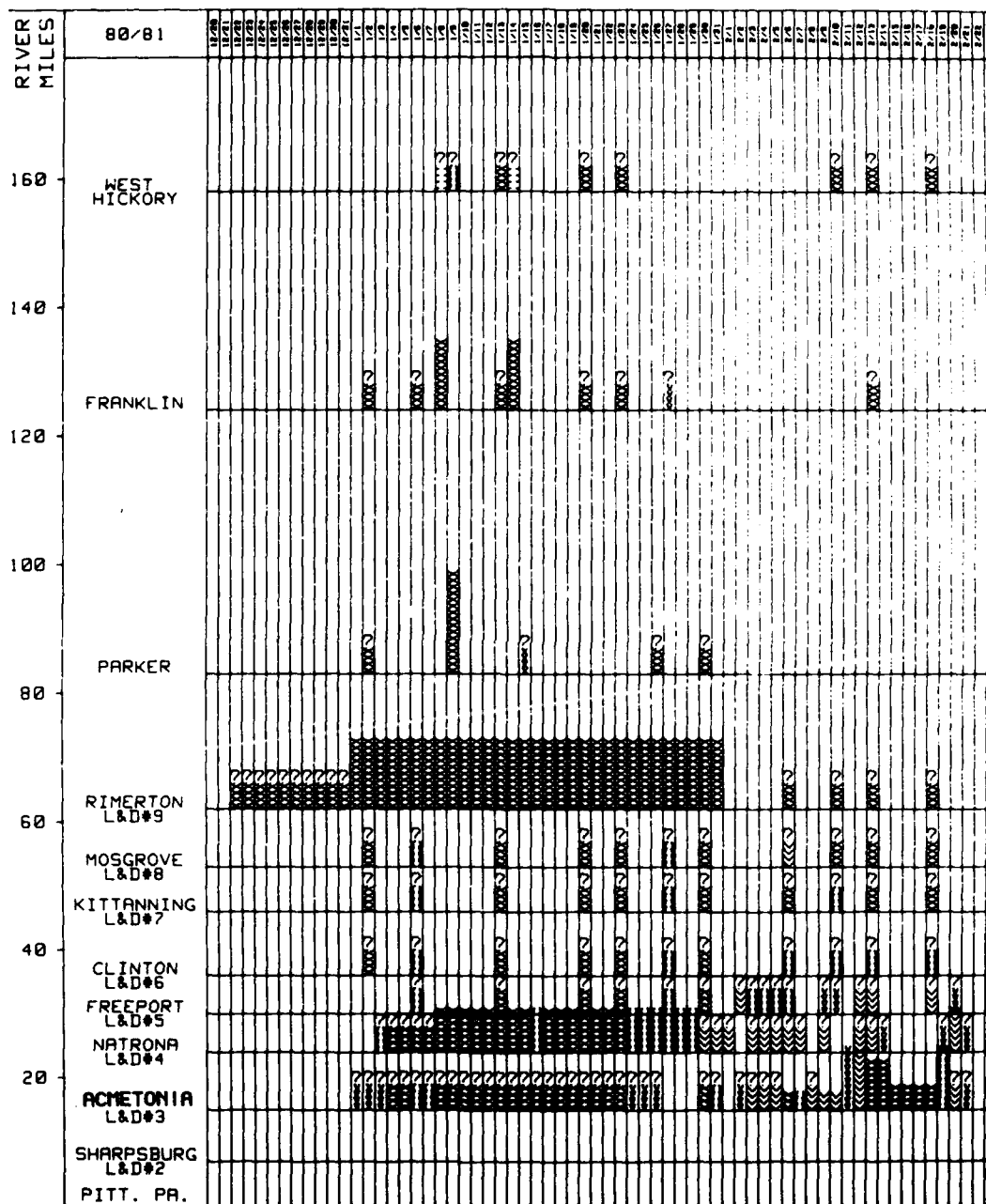


Figure A2.

DATE	SHIPSIDE	ACTIVATOR	WATSON	FREEPORT	CLINTON	KITTING	ROSEBOWE	RYERSON	PARKER	FRANKLIN	U. NICK
12/20											
12/21											
12/22								1072CX			
12/23								1072CX			
12/24								1072CX			
12/25								1072CX			
12/26								1072CX			
12/27								1072CX			
12/28								1072CX			
12/29								1072CX			
12/30								1072CX			
12/31								1072CX			
1/1		103CX						1071C10			
1/2		103CX			1071CX	1071CX	1071CX	1071C10	10J10CX	10J10CX	
1/3		503CX	601CX					1075C10			
1/4		10P1CX	10P1CX					1075C10			
1/5		10P2CX	10P2CX					1075C10			
1/6		902CX	10F3LX	0P3CX	0P3CX	9P3CX	9P3CX	1075C10		10J10CX	
1/7		602CX	10F3LX					1076C10			
1/8		10P3CX	10F4L6					1076C10		10J30L10	10J2LX
1/9		10P4CX	10F4L6					1076C10	10P20X15		7010CX
1/10		10P4CX	10F5L6					1076C10			
1/11		10P5CX	10F6L6					1076C10			
1/12		10P5CX	10F7L6					1076C10			
1/13		10P6LX	10F7L6	10P6CX	10P6CX	10P6CX	10P6CX	1076C10		10J10CX	10J10CX
1/14		10P6LX	10F7L6					1076C10		10J30L10	1510CX
1/15		10P6LX	10F7L6					1076C10	SP10CX		
1/16		10P6LX	9F7L6					1076C10			
1/17		10P6LX	10F7L6					1076C10			
1/18		10P7LX	10F7L6					1076C10			
1/19		10P7LX	10F7L6					1076C10			
1/20		10P7LX	10F7L6	10P5CX	10P5CX	10P5CX	10P5CX	1076C10		10J10CX	10J10CX
1/21		10P7LX	10F7L6					1076C10			
1/22		10P7LX	10F6L6					1076C10			
1/23		10P7LX	10F6L6	10P6CX	10P6CX	10P6CX	10P6CX	1076C10		10J10CX	10J10CX
1/24		2077X	7F6L6					1076C10			
1/25		2077X	7F6L6					1076C10			
1/26		1077X	7F6L6					1076C10	1000CX		
1/27			7F6L6	005CX	005CX	005CX	005CX	1076C10		2000CX	
1/28			7F6L6					1076C10			
1/29			0F5L6					1076C10			
1/30		10P1CX	10P1CX	10P4CX	10P4CX	10P4CX	10P4CX	1077C10	10J10CX		
1/31		002CX	10P1CX					1077C10			
2/1			10P1CX								
2/2		0027X		10P1CX							
2/3		10P1CX	10P1CX	001CX							
2/4		10P2CX	10P1CX	003CX							
2/5		10P2CX	10P1CX	003CX							
2/6		10P6L2	10P1CX	003CX	005CX	10P5CX	10P5CX	10P5CX			
2/7		6J6L2	10P1CX								
2/8		10J6L3									
2/9		10J6L2	10P2CX	0027X							
2/10		10J6L2		005CX	005CX	10P5CX	10P5CX			10J10CX	
2/11		10P19									
2/12		10P1C9	10P2CX	10P1CX							
2/13		10P1C7	10P1CX	10P1CX	005CX	10P5CX	10P5CX	10P5CX		10P5CX	10J10CX
2/14		10P1C7	001CX								
2/15		10P2L3									
2/16		10J5L3									
2/17		10J5L3									
2/18		10J5L3		10P137X	0P5CX	10P5CX	10P5CX	10P5CX			10J10CX
2/19		706L9	5057X								
2/20		10P7LX	10P7L6	20127X							
2/21		3037X	1037X								
2/22											
2/23											

1981-82

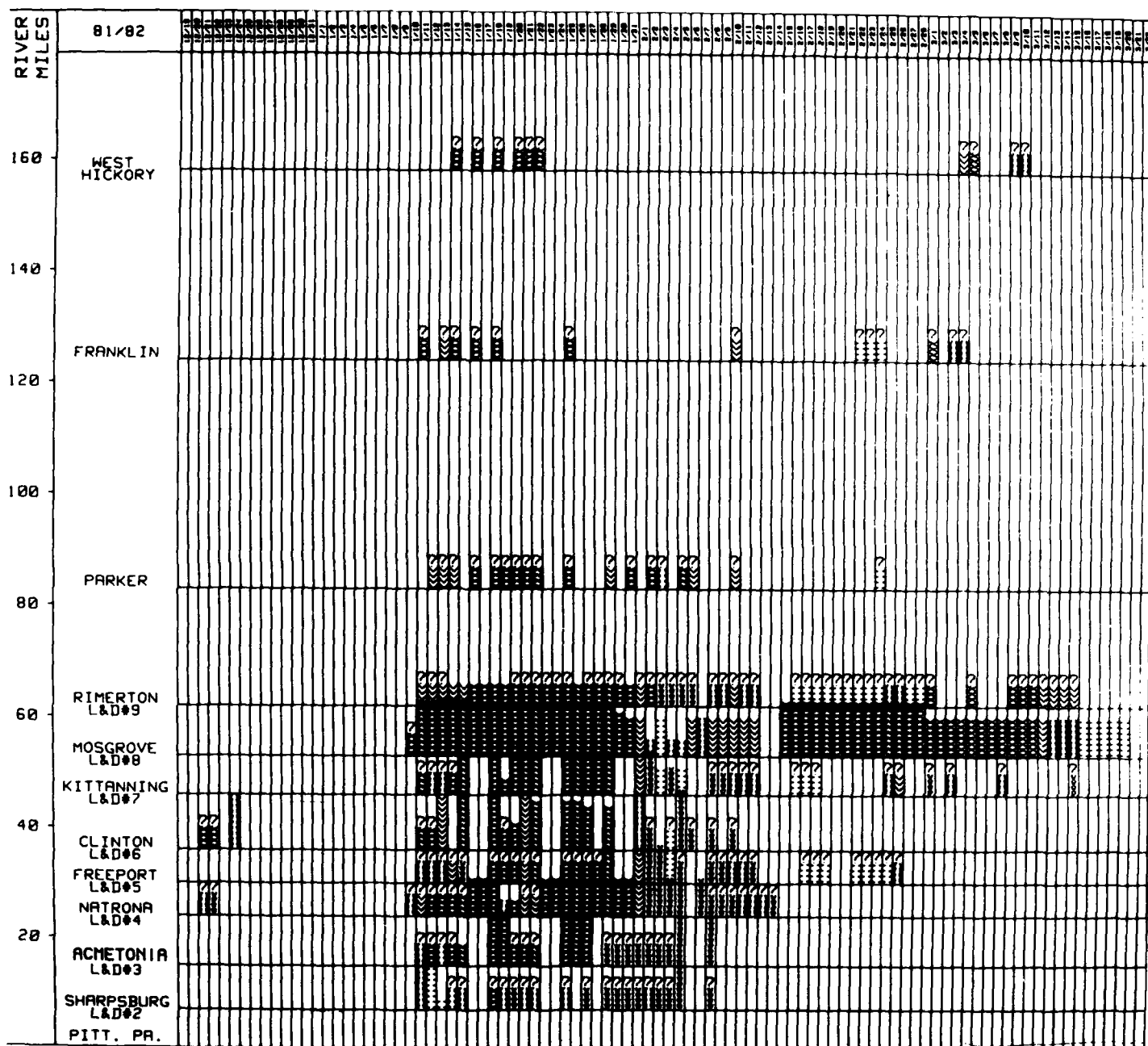


Figure A3.

DATE	SAMPLES	ACTIVITY	WIND	PRECIP	CLIM	CLIMING	RESERVE	EXERCISE	PRICE	FINANCIAL	U. HICK
12/19	12/19										
12/20	12/20										
12/21	12/21										
12/22	12/22										
12/23	12/23										
12/24	12/24										
12/25	12/25										
12/26	12/26										
12/27	12/27										
12/28	12/28										
12/29	12/29										
12/30	12/30										
12/31	12/31										
1/1	1/1										
1/2	1/2										
1/3	1/3										
1/4	1/4										
1/5	1/5										
1/6	1/6										
1/7	1/7										
1/8	1/8										
1/9	1/9										
1/10	1/10										
1/11	1/11										
1/12	1/12										
1/13	1/13										
1/14	1/14										
1/15	1/15										
1/16	1/16										
1/17	1/17										
1/18	1/18										
1/19	1/19										
1/20	1/20										
1/21	1/21										
1/22	1/22										
1/23	1/23										
1/24	1/24										
1/25	1/25										
1/26	1/26										
1/27	1/27										
1/28	1/28										
1/29	1/29										
1/30	1/30										
2/1	2/1										
2/2	2/2										
2/3	2/3										

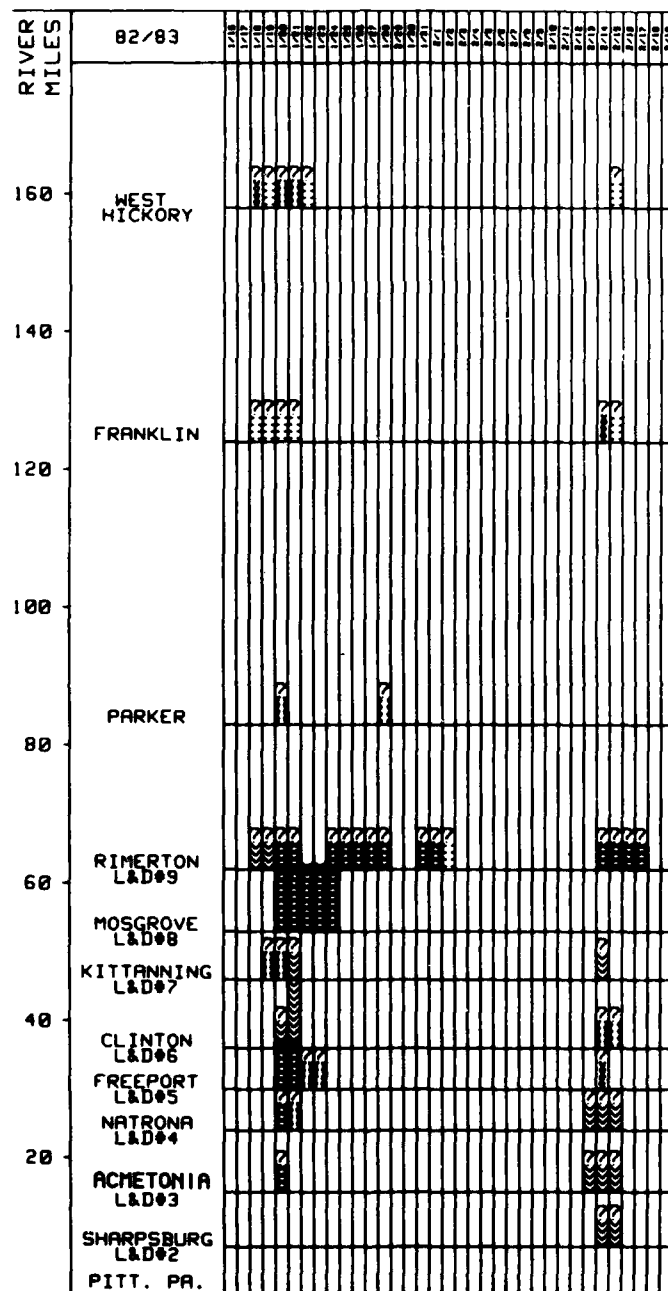


Figure A4.

DATE	SHIPSORG	ACANTONIA	ANTHONY	FREEPORT	CLINTON	KITTING	MOSGROVE	RIVERTON	PARKER	FRANKLIN	U. HICK
1/16											
1/17											
1/18								TOPICK		1STXK	1R1XK
1/19						7R1CK		TOPICK		2STXK	3STXK
1/20		TOPICK	TOPICK	TOPICK	TOPICK	TOPICK	TOPICK	TOPICK	8R1XK	4STXK	7R1XK
1/21			6R1CK	TOPICK	TOPICK	TOPICK	TOPICK	TOPICK		4STXK	7R1XK
1/22				8R1CK			TOPICK				3STXK
1/23				8R1CK			TOPICK				
1/24							TOPICK				
1/25							TOPICK				
1/26							TOPICK				
1/27							TOPICK				
1/28							TOPICK		2STXK		
2/29											
1/30											
1/31								TOPICK			
2/1								TOPICK			
2/2								1STXK			
2/3											
2/4											
2/5											
2/6											
2/7											
2/8											
2/9											
2/10											
2/11											
2/12											
2/13		TOPICK	TOPICK								
2/14	TOPICK	TOPICK	TOPICK	4R1CK	9R1CK	TOPICK		TOPICK		2STXK	
2/15	TOPICK	TOPICK	TOPICK		8STCK			TOPICK		2STXK	1STXK
2/16								TOPICK			
2/17								TOPICK			
2/18											
2/19											

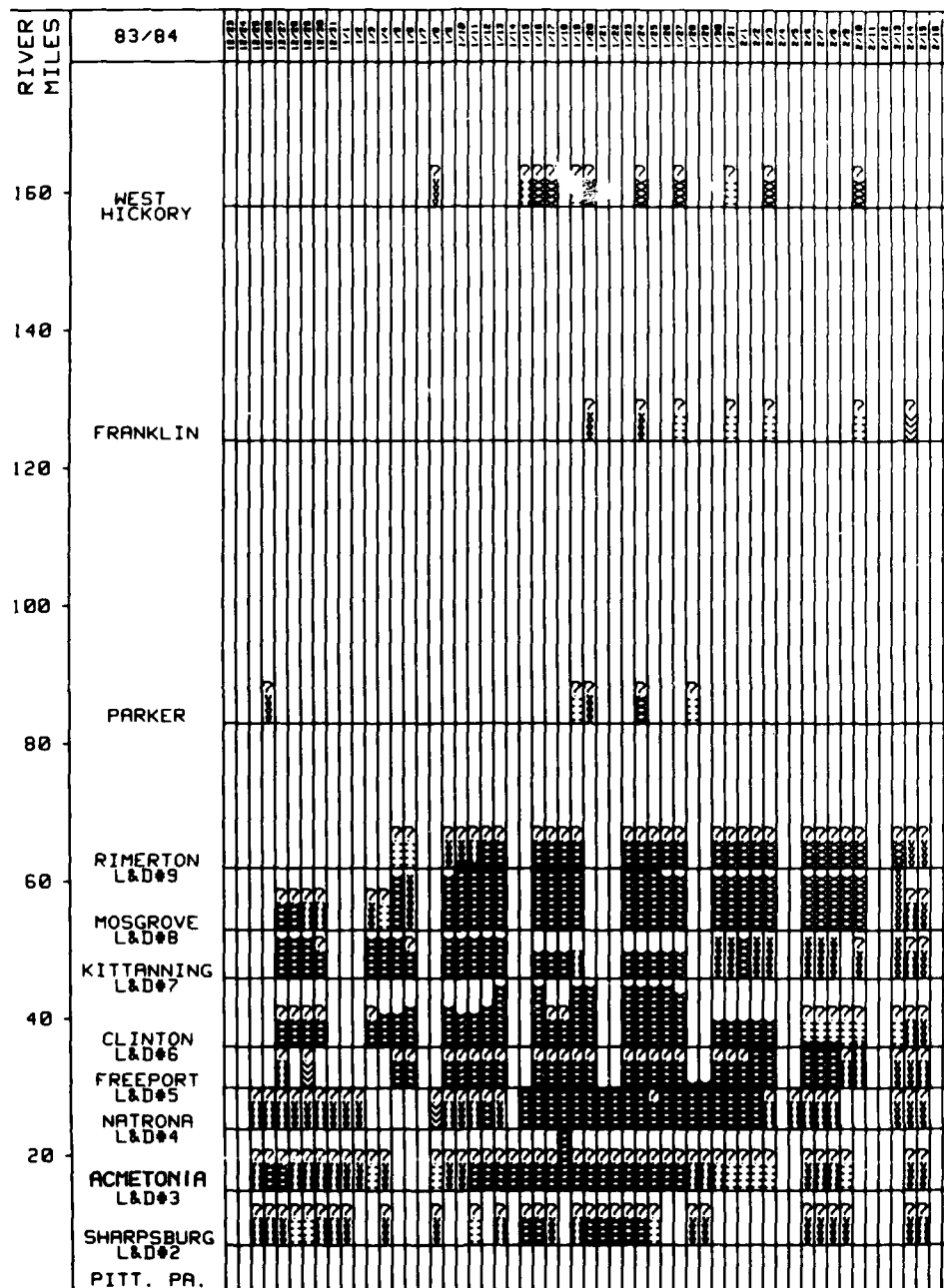


Figure A5.

DATE	SHIPPERS	ACHTONIA	WATSON	FREEPORT	CLINTON	KITTING	HOSGROVE	RIBERTON	PARKER	FRANKLIN	U. HICK
12/23											
12/24											
12/25	6R1CX	6R1CX	7R1CX						9R1CX		
12/26	9R2CX	10P2CX	8R2CX								
12/27	5R2CX	10P2CX	8R1CX	6R2CX	10R2CX	10P8L5	10P4LX				
12/28	25R4CX	7R2CX	4R1CX		10R2CX	10P8L5	10P4LX				
12/29	35R4CX	7R5CX	1R2CX	10R3TX	10R2CX	10P8L5	9P4LX				
12/30	9R5CX	7R5CX	7R2CX		10R4CX	10P8LX	9P4LX				
12/31	7R5CX	7R5LX	3R2CX								
1/1	2R5CX	3R3CX	1R1CX								
1/2		1R1CX	1R1CX								
1/3		15R3CX			10R5LX	10P8L5	5P4R4X				
1/4	1R5CX	1R5CX			10R5L4	10P8L5	35R4R4X				
1/5				10R3CX	10R5L4	10P8L5	10J487	25ZLX			
1/6				10R3CX	10R5L5	10P8LX	3J487	25ZLX			
1/7											
1/8	2R3CX	25ZLX	10R2CX								5R1CX
1/9		1R2TX	7R1CX	10R3CX	10R5L5	10P8C5	10J487	4R1CX			
1/10		2R2TX	3R2TX	10R3CX	10R5L4	10P8L5	10J419	4R1LX			
1/11	35ZLX	10R1CX	9R1CX	10R3CX	10R5L4	10P8L5	10J489	8P1LX			
1/12		10R3CX	10R2CX	10R3CX	10R5L5	10P8L5	10J489	10P1CX			
1/13	7R1CX	10R3CX	3R1CX	10R3CX	10R5L8	10P8L5	10J489	10P1CX			
1/14		10R3CX									
1/15	10R1CX	10R3CX	10R4C5								851CX
1/16	10P1CX	10P4CX	10R4C5	10P3CX	10R5L8	10R1C3	10J4C9	10P3CX			10P1CX
1/17	5P1CX	10P4CX	10P4C5	10P3CX	10R5LX	10R1C3	10J4C9	10P3CX			10J1CX
1/18		10P4C5	10P4C5	10P3CX	10R5LX	10R1C3	10J4C9	10P4CX			
1/19	9P2CX	10P5CX	10P4C5	10P3CX	10R5L8	8R2C3	10J5C9	10R5LX	551CX		10J1CX
1/20	10P2CX	10P5CX	10P4C5	10P4CX	10R6L8				1P1CX	3P1CX	10P1CX
1/21	10P3CX	10P6CX	10P5C5								
1/22	10P4CX	10P7CX	10P6C5								
1/23	10P4CX	10P7CX	10P7C5	10P4CX	10R6L8	10R5B3	10J4L9	10R1LX			
1/24	10P4CX	10P7CX	10P7C6	10P4CX	10R6L8	10R5C3	10J4L9	10R1LX	10P1CX	3P1CX	10P1CX
1/25	35R4LX	10P7CX	10P7CX	10R3CX	10R5L8	10R5L3	10J7L9	10R1LX			
1/26		10P7CX	10P7C6	10R3CX	10R5L8	10R5B3	10J4L7	10R1LX			
1/27		10P7CX	10P7C6	10P4CX	10R5L7	10R5P3	10J4L7	10R1LX		251CX	10P1CX
1/28	3R4CX	6R5CX	10P7C6						351CX		
1/29	1R5CX	8R7CX	10P7C6								
1/30		757CX	10P7C6	10R4CX	10R3L3	5P18L5	10J4L7	10R1LX			
1/31		357CX	10P7C6	10R4CX	10R3L3	5P18L5	10J4L7	10R1LX		251CX	10J1CX
2/1		357CX	10P7C6	10R4CX	10R3L3	10P18L5	10J4L7	10R1LX			
2/2		357CX	10P7C6	10R4C6	10R3L3	5P18L5	10J4L7	10R1LX			
2/3		357CX	7R7CX	10R4C6	10R3L3	5P18L5	10J4L7	10R1LX		251CX	10P1CX
2/4											
2/5			7R7CX								
2/6	1R1CX	1R1CX	8R1CX	10R3C6	35R4LX	4P18L5	10J4L7	10R1LX			
2/7	5R1CX	7R4CX	8R1CX	10R3C6	35R4LX	4P18L5	10J4L7	10R1LX			
2/8	8R1CX	6R5CX	8R1CX	10R3C6	35R4LX	4P18L5	10J4L7	10R1LX			
2/9	3R1CX	35R3CX		6R2CX	35R4LX		10R4L7	10R1ZLX			
2/10				6R2L6	35R4LX	4P18LX	10J4L7	10R1ZLX		251CX	10P1CX
2/11											
2/12											
2/13			1R1TX	1R3TX	35R4LX	4P18L5	3R4L9	10R18LX			
2/14	3R4CX	5R4TX	3R1TX	1R3LX	7R5LX	6P18LX	6P5LX	3R4TX		10P1CX	
2/15	6R4TX	1R6TX	4R1TX	8R4TX	1R6TX	2R5TX	1R9TX	3R2TX			
2/16											
2/17											

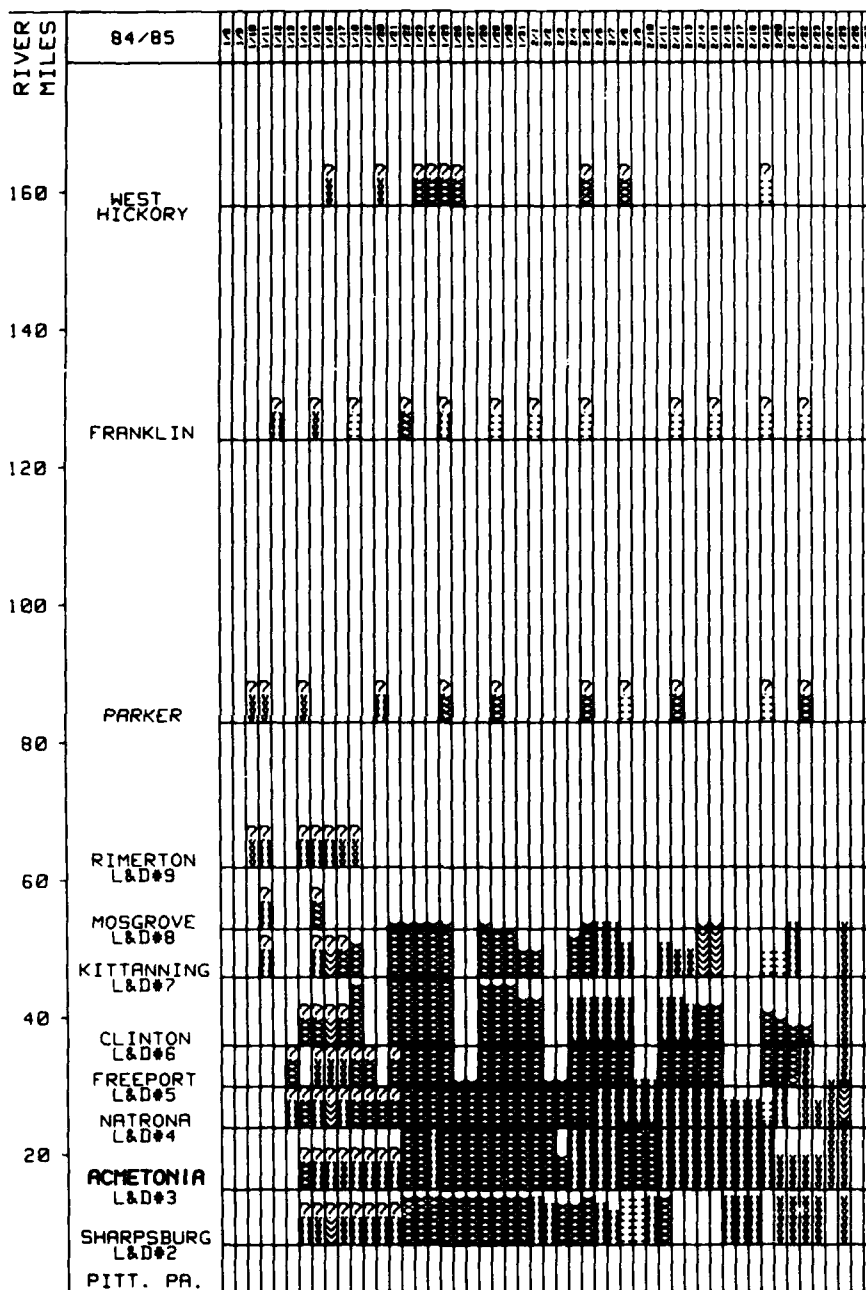


Figure A6.

DATE	SHOPSING	ACTONIA	WATERMAN	FREEPORT	CLINTON	KITTING	ROSGROVE	RIMERTON	PARKER	FRANKLIN	W. HICK
1/8											
1/9											
1/10								SR20X	1R10X		
1/11						BR1CX	BR1TX	BR1TX	2R10X		
1/12										BR10X	
1/13			BR1CX	1R10X							
1/14	7R1CX	1R10X	1R10X		1R10X			6R1CX	1R1CX		
1/15	3R1CX	BR1CX	BR1CX	SR1CX	1R10X	BR1CX	1R10X	BR1CX		SR10X	
1/16	1R10X	BR1CX	1R10X	2R1CX	1R10X	1R10X		BR1CX			1R10X
1/17	SR1CX	SR1CX	BR1CX	2R1CX	1R10X	1R10X		SR1CX			
1/18	6R1CX	SR1CX	1R10X	1R10X	1R10X	1R10X		SR1CX		2S10X	
1/19	6R1CX	SR1CX	1R10X	1R10X							
1/20	SR2CX	SR2CX	1R10X						SR10X		SR10X
1/21	SR2CX	SR2CX	1R10X	1R10X	1R10X	1R10X					
1/22	1R10X	1R10X	1R10X	1R10X	1R10X	1R10X				1R10X	
1/23	1R10X	1R10X	1R10X	1R10X	1R10X	1R10X					1R10X
1/24	1R10X	1R10X	1R10X	1R10X	1R10X	1R10X					1R10X
1/25	1R10X	1R10X	1R10X	1R10X	1R10X	1R10X			1R10X	6S10X	1R10X
1/26	1R10X	1R10X	1R10X								1R10X
1/27	1R10X	1R10X	1R10X								
1/28	1R10X	1R10X	1R10X	1R10X	1R10X	1R10X					
1/29	1R10X	1R10X	1R10X	1R10X	1R10X	1R10X			1R10X	2S10X	
1/30	1R10X	1R10X	1R10X	1R10X	1R10X	1R10X					
1/31	1R10X	1R10X	1R10X	1R10X	1R10X	1R10X					
2/1	BR1CX	1R10X	1R10X	1R10X	1R10X	1R10X				5S10X	
2/2	BR1CX	1R10X	1R10X								
2/3	1R10X	1R10X	1R10X								
2/4	1R10X	BR1CX	1R10X	1R10X	BR1CX	BR1CX					
2/5	1R10X	BR1CX	1R10X	1R10X	BR1CX	BR1CX			1R10X	3S10X	1R10X
2/6	BR1CX	BR1CX	BR1CX	1R10X	BR1CX	BR1CX					
2/7	BR1CX	BR1CX	BR1CX	1R10X	BR1CX	BR1CX					
2/8	2S10X	1R10X	BR1CX	1R10X	BR1CX	BR1CX			1S10X		1R10X
2/9	3S10X	1R10X	BR1CX								
2/10	SR1CX	1R10X	BR1CX								
2/11	1R10X	BR1CX	BR1CX	1R10X	BR1CX	BR1CX					
2/12		BR1CX	BR1CX	1R10X	BR1CX	BR1CX			1R10X	2S10X	
2/13		BR1CX	BR1CX	1R10X	BR1CX	BR1CX					
2/14		BR1CX	BR1CX	1R10X	BR1CX	BR1CX					
2/15		BR1CX	BR1CX	1R10X	BR1CX	BR1CX				3S10X	
2/16	BR1CX	BR1CX	BR1CX								
2/17	BR1CX	BR1CX	BR1CX								
2/18	BR1CX	BR1CX	BR1CX								
2/19		BR1CX	1R10X	1R10X	1R10X	1R10X			1R10X	2S10X	2S10X
2/20	3R10X	BR1CX	BR1CX	1R10X	1R10X	1R10X					
2/21	3R10X	BR1CX		1R10X	1R10X	1R10X					
2/22	3R10X	BR1CX	1R10X	2R10X	1R10X				1R10X	1S10X	
2/23	3R10X	1R10X	2R10X								
2/24		1R10X	2R10X								
2/25	SR10X	BR1CX	1R10X	3R10X	3R10X	3R10X					
2/26											
2/27											

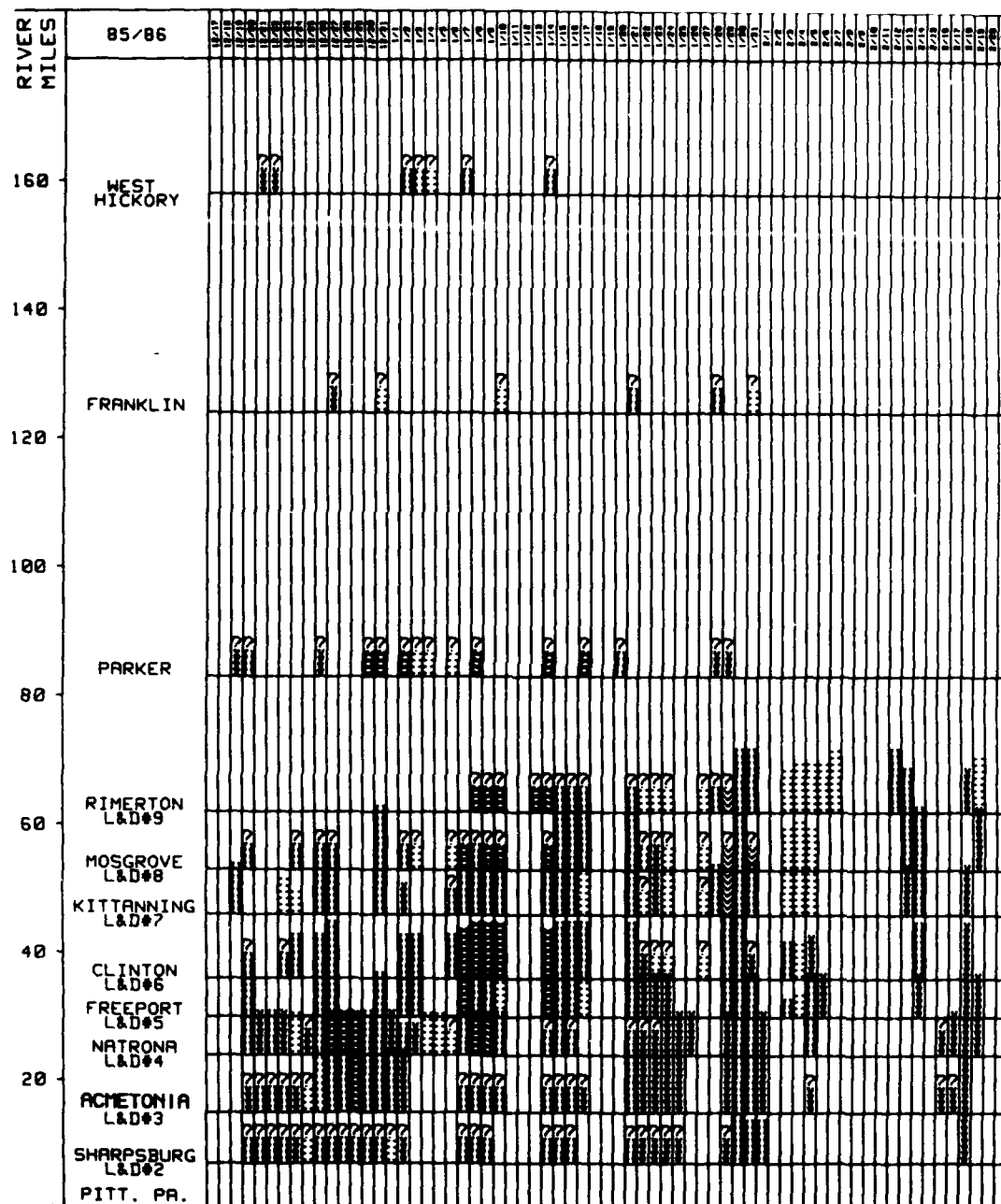


Figure A7.

DATE	SHIP/SIDE	ACT/OTHER	WAT/PORT	FREEPORT	CL/IN/TH	KE/TH/ING	POSS/ONE	ED/ERT/TH	POSS/ER	FIN/IN/CL/TH	U. N/CK
12/17											
12/18											
12/19						791C7				271XK	
12/20	691CX	591CX	691CS	591CS	591CX		591CX			671XK	
12/21	691CX	591CX	591CS								591XK
12/22	692CX	592CX	693L6								591XK
12/23	692CX	692CX	593L6		592L8	253L5					
12/24	181L8	181L8	153L6		592L6	252L3	692CX				
12/25	151CX		591CX								
12/26	592CX	591CX	592CS	591CS	592CS	592CS	593CX		291XK		
12/27	592CX	591CX	1892CS	592CS	592L8	593C7	595CX			591XK	
12/28	592CX	591CX	1892CS								
12/29	592CX	1891CX	1892CS								
12/30	592CX	591CX	592CS						1891XK		
12/31	592CX	591CX	592CS	592CS		593CS	596CX		1891XK	151XK	
1/1	155L8	692CX	592CS								
1/2	595L8	182CX	793C9	592CS	592L6	272L9	795CX		1891XK		511XK
1/3			593CX	592CS	592L6		593CX		1891XK		511XK
1/4			152CX						1891XK		251XK
1/5			152CX								
1/6			152CX		591L6	591CX	352CX		351XK		
1/7	591CX	591CX	591CS	1891CS	1891L7	591CS	1893CX				591XK
1/8	591CX	591CX	1891CS	591CS	1892L8	591C7	594CX	1892CX	1891XK		
1/9	591CX	591CX	1891CS	691CS	1892L8	592C7	1895CX	1892L8			
1/10		591CX	691CS	151CS	1892L8	592C7	1894CX	1893L8		351XK	
1/11											
1/12											
1/13								1893L8			
1/14	591CX	591CX	591CX	1891CS	1891C7	591C7	1893CX	1894L8	1891XK		671XK
1/15	592CX	592CX	591CS	591CS	591CX	591C7	593CX	595L8			
1/16	591CX	592CX	592CX	591CS	592CX	591C7	594CX	596L8			
1/17		592L8		251CS	592CX	15387	594CX	596L8	1891XK		
1/18											
1/19											
1/20									591XK		
1/21	5967X	5967X	5927X	591876	591688	591687	591689	593L8		791XK	
1/22	5968X	5968X	283L8	28286	28888	153L8	751688	153L8			
1/23	1867X	1867X	183L8	292CX	15888	28887	511688	253L8			
1/24	1867X	1867X	283L6	18316	151888	253L7	411688	253L8			
1/25	1867X	1837X	183L6								
1/26			18316								
1/27					15788	15788	151688	153L8			
1/28						591C7		591L8	1891XK	591XK	
1/29	591CX	591CX	591CS	591CS	594L9	1892C7	1892CX	1892L8	1891XK		
1/30	69178	7927X	59376	59176	596L9	596L7	594CX	592L9			
1/31	59276	7927X	59376	591CS	596L8	596L7	1895CX	592L9		151XK	
2/1	592CS	59478	29176								
2/2											
2/3				516L2	5178L5	2518L7	394CS	252L6			
2/4				1878L3	18778L5	258L7	394C7	152L7			
2/5		395L8	79376	59876	18676	158L7	394CS	152L7			
2/6				18876				152L7			
2/7								153L9			
2/8											
2/9											
2/10											
2/11											
2/12								691CX			
2/13						591C7	592CX	591CS			
2/14				591L6	592L8	592C7	593CX				
2/15											
2/16		591CX	593CX								
2/17		5917X	59376								
2/18	29177	5917X	18376	59276	18178	189L7		291L6			
2/19			18176	18176			182CX	153L8			
2/20											
2/21											

Monongahela River

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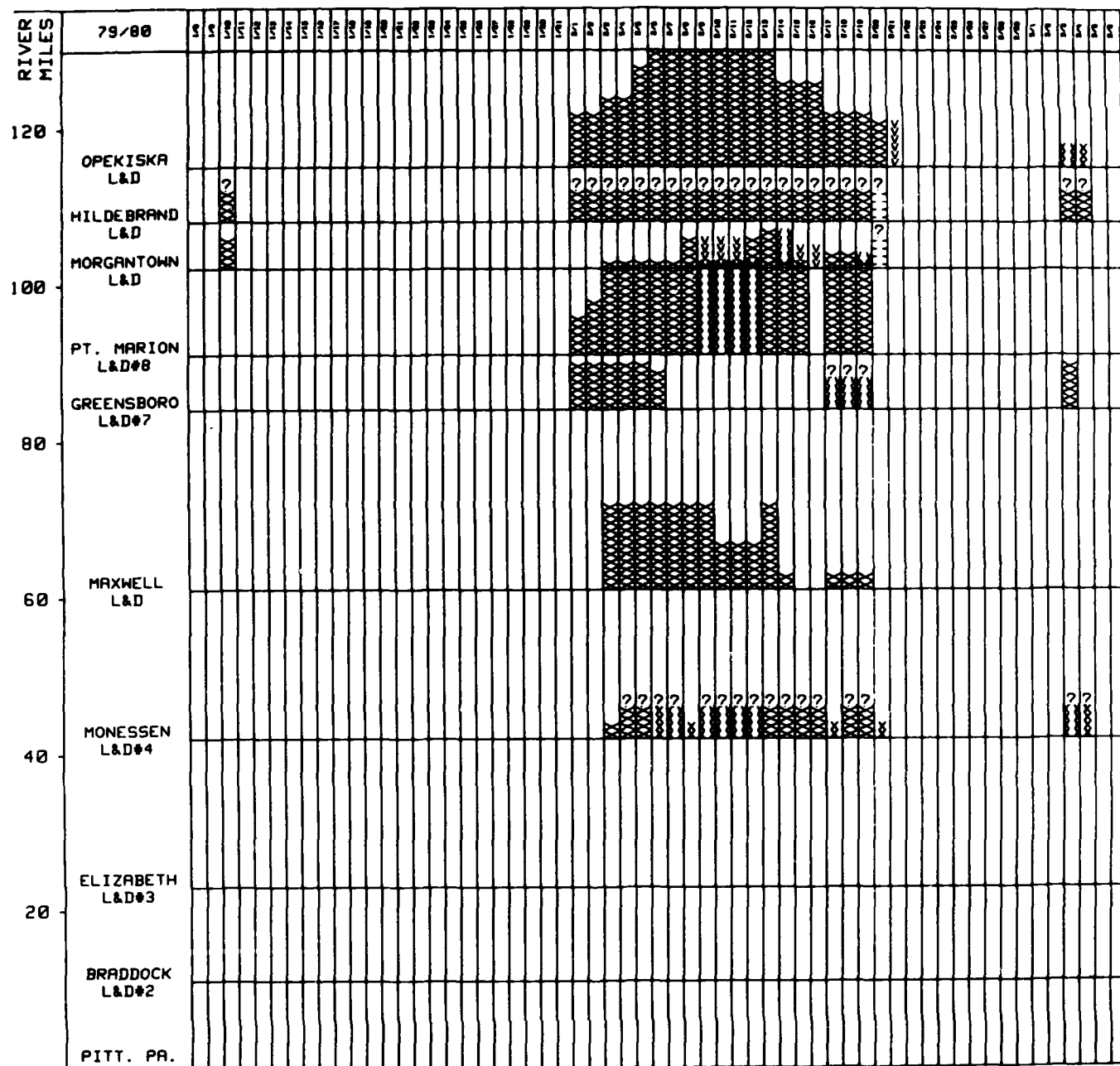


Figure A8.

DATE	BARROCK	ELIZBETH	POHESSEN	POHRELL	GRANDSON	PT. PIER	POHNTOWN	WILDERING	OPERATION
1/8									
1/9									
1/10							100113	100110	
1/11									
1/12									
1/13									
1/14									
1/15									
1/16									
1/17									
1/18									
1/19									
1/20									
1/21									
1/22									
1/23									
1/24									
1/25									
1/26									
1/27									
1/28									
1/29									
1/30									
1/31									
2/1					100115	100114		100110	100116
2/2					100115	100115		100110	100116
2/3	100111	1001110	100115	100111				100110	100116
2/4	100110	1001110	100215	100111				100110	100116
2/5	100110	1001110	100115	100211				100110	100112
2/6	300110	1001110	100114	100211				100210	100214
2/7	700110	1001110		100111				100210	100214
2/8	300111	1001110		100111	100213			100210	100214
2/9	900110	1001110		900111	500213			100210	100214
2/10	000110	100215		900111	500213			100210	100214
2/11	700110	100115		900111	500113			100210	100214
2/12	900110	100115		900111	100213			100210	100214
2/13	100210	1001110		100111	100214			100210	100314
2/14	100210	100111		100111	700214			100310	100310
2/15	100210			100111	500112			100210	100310
2/16	100210				500112			100210	100310
2/17	500211	100111	900110	100111	100111			100210	100310
2/18	100210	100111	900110	100111	100111			100310	100316
2/19	100210	100111	900110	100111	700111			100310	100316
2/20	500211				550110	550110			100315
2/21									500315
2/22									
2/23									
2/24									
2/25									
2/26									
2/27									
2/28									
2/29									
3/1									
3/2									
3/3		700110		100115			100110	700112	
3/4		500110					100110	500112	
3/5									
3/6									

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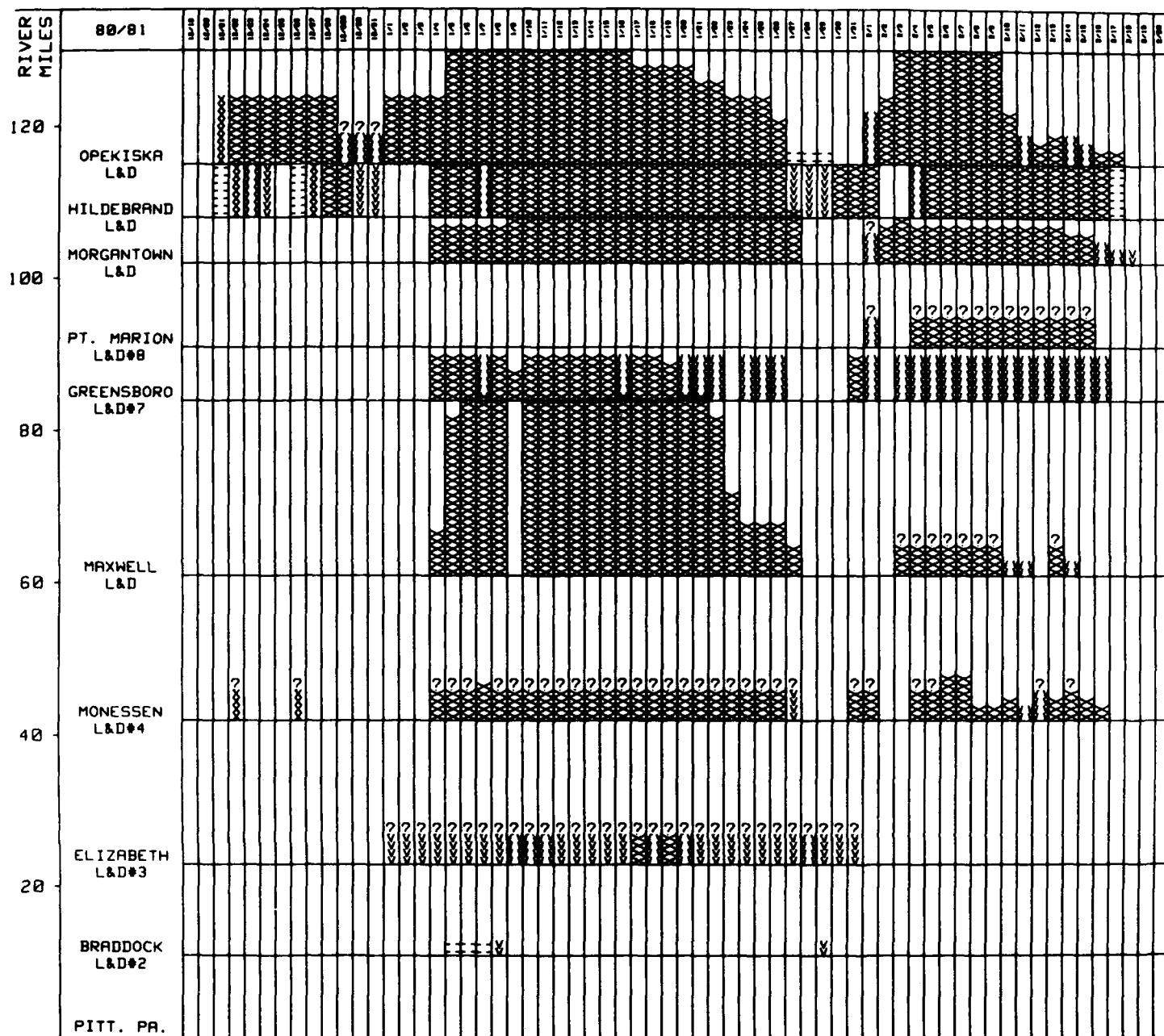


Figure A9.

DATE	BARBOCK	ELIZBETH	HONESSEN	MURMELL	GRAYBRO	Pt. HBR	HGANTDAN	HLDRAND	OPERISK
12/19									
12/20									
12/21								351C6	5F1T8
12/22			3F1C6					3F1C6	10P1C8
12/23								7F1N6	10P1C8
12/24								201N6	10P1C8
12/25									10P1C8
12/26			3F1C6					551C6	10P1C8
12/27								5F1N6	10P1C8
12/28								10P1N6	10P1C8
12/29								10P1N6	9P1TX
12/30								501N6	9P1TX
12/31								201N6	9P1TX
1/1		501N6							10P1T8
1/2		501N6							10P1T8
1/3		501N6							10P1T8
1/4		501N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C8
1/5	551N6	502N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/6	451N6	402N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/7	552N6	502N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/8	401N6	402N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/9		702N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/10		702N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/11		702N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/12		502N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/13		302N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/14		502N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/15		302N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/16		202N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C4
1/17		702N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C2
1/18		702N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C2
1/19		702N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C2
1/20		702N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C2
1/21		302N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/22		202N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/23		202N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/24		202N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/25		10P1N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/26		10P1N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/27		10P1N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/28		702N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/29	10P1N6	10P1N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/30		10P1N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
1/31		10P1N6	10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/1			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/2				10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/3				10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/4			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/5			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/6			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/7			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/8			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/9			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/10			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/11			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/12			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/13			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/14			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/15			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/16			10P1N6	10P1N6	10P1N6		10P1N6	10P1N6	10P1C0
2/17							10P1N6	10P1N6	10P1C0
2/18							10P1N6	10P1N6	10P1C0
2/19							10P1N6	10P1N6	10P1C0
2/20							10P1N6	10P1N6	10P1C0

DATE	BRADDOCK	ELIZABETH	MONTESSON	MONMELL	GRAYSBORO	PT. MON	HEMANTON	ALDRAND	OPKISSA
12/19									
12/20									
12/21			7F1XK	7F1XK	7B1K2			SS1X6	
12/22									
12/23									
12/24									
12/25									
12/26									
12/27									
12/28									
12/29									
12/30									
12/31									
1/1									
1/2									
1/3									
1/4									
1/5									
1/6									
1/7									
1/8									
1/9									
1/10									
1/11		1R2XK	1OR1XK	1OR1XK	OR1X5	1OR1XK	1OR1X5	1OR1X6	
1/12	OP3XK	1R2CX	1OR2CX	1OR2CX	OR1LS	1OR2CX	1OR2CX	1OR1C6	1OR1R1
1/13	9P3XK	1R1XK	1OR2XK	1OR2XK	9R1X5	1OR2XK	1OR2X5	1OR2X6	1OR1X6
1/14	2R3XK	2R1BK	1OR3CX	1OR2CX	9R1R1	1OR2CX	1OR2CX	1OR3CX	1OR1C6
1/15	1R3XK	3R1BK	1OR3LX	1OR2L23	9R2R5	1OR3CX	1OR2CX	1OR2C6	1OR2C7
1/16		3R1XK	1OR3XK	1OR2L23	9R2R5	1OR4CX	1OR2CX	1OR3CX	1OR2C12
1/17		3R3XK	1OR4XK	1OR4X23	9R2R5	1OR5CX	1OR4X5	1OR3X6	1OR3X12
1/18	1OR3CX	3R3XK	1OR5LX	1OR4L23	7R2R5	1OR6CX	1OR4CX	1OR4C6	1OR3CX
1/19		4R4XK	1OR5XK	1OR4X23	5R3X6	1OR6XK	1OR4X5	1OR4X6	1OR4XK
1/20	2R3LX	6P3XK	1OR5LX	1OR4L10	3R3X6	1OR6CX	1OR4CX	1OR4C6	1OR4CX
1/21		4R2XK	1OR5XK	9R4R14	9R3X6	1OR4XK	1OR4X5	1OR4X6	1OR4XK
1/22		4R2XK	1OR5XK	9R4R10		1OR5XK	1OR5X5	1OR5X6	1OR5XK
1/23		4R2XK	1OR7XK	9R4R10	9R3X6	1OR5XK	1OR5X5	1OR5X6	9R4XK
1/24		4R6XK	4R7XK				2R5X3	2R5X6	
1/25	6R3XK	1R3XK							
1/26		1R2XK					1OR1X3		1R1XK
1/27		1R2XK	1F1BK	1F1BK	4R1R6	5F1CX	5F1CX	5F1CX	4R1CX
1/28			1OR2XK		3R1X6	3R1XK			SS171
1/29			7R2LX		1R1R6				
1/30									
1/31									

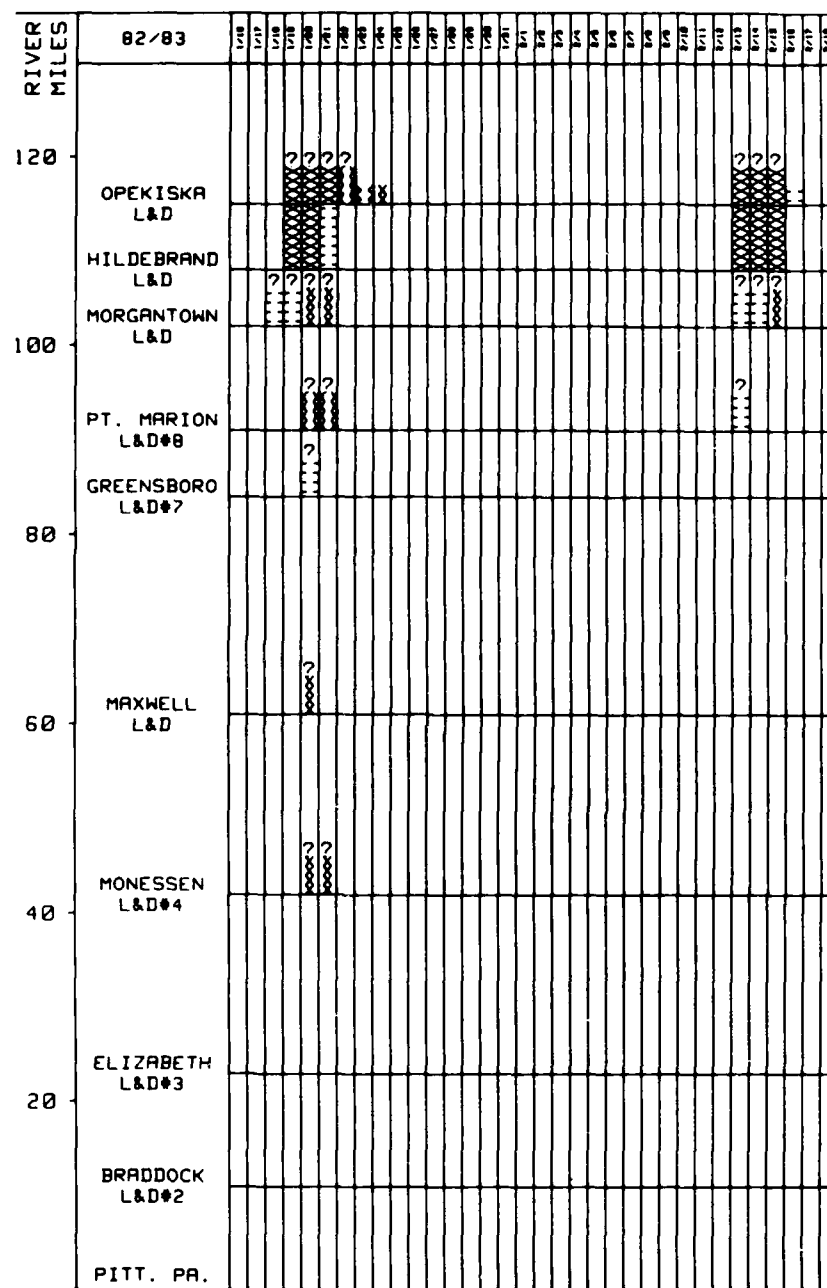


Figure A11.

DATE	BRADDOCK	ELIZBETH	HOMESSEN	MARWELL	GRAYSON	PI. MAR	MCINTOSH	ALDRIDGE	OPEKISHA
1/16									
1/17									
1/18							151CK		
1/19							151CK	10F1C6	10F1CK
1/20			1F1CK	1F1CK	251CK	0F1CK	1F1CK	10F1C6	10F1CK
1/21			1F1CK			0F1CK	1F1CK	151C6	10F1CK
1/22									9F1CK
1/23									75111
1/24									2F111
1/25									
1/26									
1/27									
1/28									
1/29									
1/30									
1/31									
2/1									
2/2									
2/3									
2/4									
2/5									
2/6									
2/7									
2/8									
2/9									
2/10									
2/11									
2/12									
2/13						251CK	1051CK	10F1C6	10F1CK
2/14							1051CK	10F1C6	10F1CK
2/15							1F1CK	10F1C6	10F1CK
2/16									35111
2/17									
2/18									

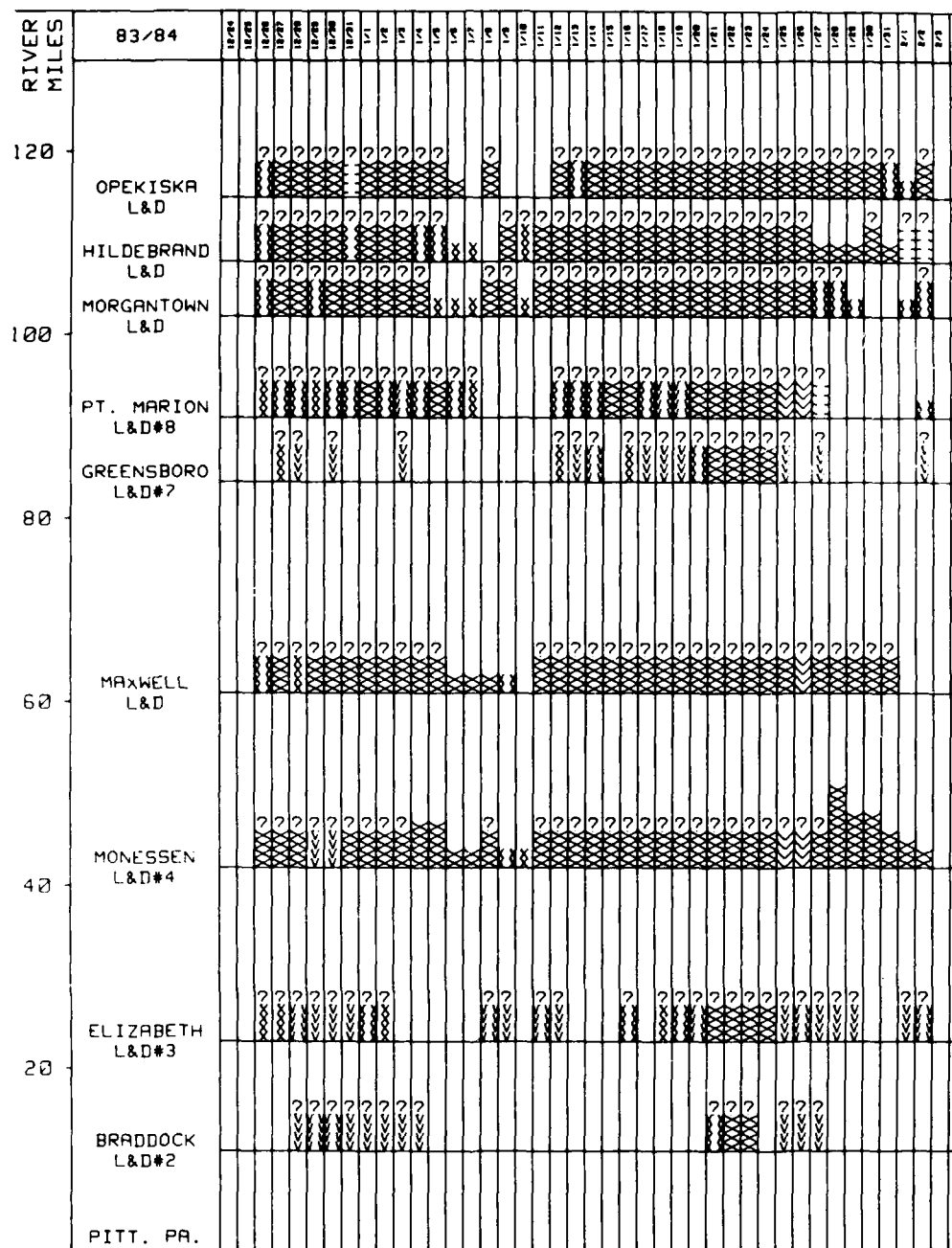


Figure A12.

DATE	BROADBENT	ELIZABETH	HOMESSEN	MONAGHAN	GRANBORN	PT. MAN	WINTHROP	HOLBROOK	DEKISTON
12/24									
12/25									
12/26		1F1CX	10F1CX	9F1CX		4F1CX	9F1CX	9F1CX	9F1CX
12/27		4P2BX	10F2BX	10P2BX	1A1BX	9F2CX	10F1CX	10F1CX	10F1CX
12/28	5A2BX	9A2BX	10A2LX	5A2BX	3A1BX	9F2CX	10F1CX	10F1CX	10F1CX
12/29	8A3BX	1A1BX	1A2LX	10A3LX		3P2CX	7F1CX	10F1CX	10F1CX
12/30	8A3BX	4A1BX	4A3LX	10A3LX	5A1BX	9P1CX	10P2CX	10P2CX	10J1CX
12/31	4A3BX	5A1BX	10A3LX	10A4LX		9P2CX	10P2CX	6S2CX	10J2CX
1/1	3A3BX	8A2LX	10A3LX	10A4LX		10J3CX	10P2CX	10F2CX	10J2CX
1/2	2A2TX	2P2BX	10A3LX	10A3LX		9J3LX	10P3CX	10F2CX	10J2CX
1/3	2A2TX		10A3LX	10A3LX	1A1BX	9J3LX	10P3CX	10F2CX	10J2CX
1/4	1A1TX		10A3LX	10A2LX		9J2LX	10P3CX	9F2BX	10P2CX
1/5			10A3LX	10A2LX		10J2BX	1P3TX	7F2TX	10P2CX
1/6			10A2TX	10A2LX		9J2LX	1P2TX	3P2TX	10P2CX
1/7			10A2TX	10A2LX		2J2TX	1P2TX	2P2TX	
1/8		8A1BX	10A3LX	10A2LX			10F1CX		10F1CX
1/9		4A1BX	7A2TX	8P2LX			10F1CX	10F1CX	
1/10			5A2TX				1P1TX	1F1TX	
1/11		7A1BX	10A1CX	10A1CX			10F1CX	10F1CX	
1/12		4A1BX	10A1LX	10A1LX	4A1BX	9A1CX	10F1CX	10F1CX	10F1CX
1/13			10A1LX	10A1LX	4A1TX	9F1CX	10F1CX	10F1CX	8F1CX
1/14			10A2LX	10A1LX	8A1TX	9F1CX	10F1CX	10F1CX	10F1CX
1/15			10A2LX	10A1LX		10F2CX	10F1CX	10F1CX	10F1CX
1/16		9A1CX	10A3LX	10A2LX	5F1CX	10F3CX	10F2CX	10F1CX	10F2CX
1/17			10A3LX	10A2LX	5A1CX	9F3CX	10F2CX	10F1CX	10F2CX
1/18		2A2CX	10A3LX	10A2LX	2A1CX	9J3CX	10F2CX	10F1CX	10F2CX
1/19		6A1CX	10A4LX	10A3LX	2A1CX	9J3TX	10F2CX	10F1CX	10F3CX
1/20		8A2CX	10A4LX	10A3LX	8P1CX	10F4CX	10F3CX	10F3CX	10F3CX
1/21	9A1CX	10A1CX	10A5LX	10A5LX	10P1CX	10F4CX	10F3CX	10F3LX	10F3CX
1/22	10P1CX	10P2CX	10P5LX	10P5LX	10F2CX	10F4CX	10F3CX	10F3LX	10F4CX
1/23	10P2CX	10P2CX	10P5LX	10P5LX	10F2CX	10F4CX	10F3CX	10F3CX	10F3CX
1/24		10P2CX	10P5LX	10P5LX	10P2CX	10F4CX	10F3CX	10F3CX	10F3CX
1/25	4A2BX	4A1BX	10J5BX	10P5BX	1A2TX	10J4BX	10F3TX	10F3CX	10F2CX
1/26	3A3BX	6A1BX	10J5BX	10J5BX		10J4BX	10F3TX	10F3TX	10F2CX
1/27	1A1BX	2A1BX	10P5BX	10J5BX	1A1CX	1S1BX	8P1TX	10P3TX	10F2TX
1/28		1A1BX	10P5LX	10J5BX			8J2LX	10P2TX	10P2TX
1/29		1A1BX	10P5LX	10J5BX			9P2LX	10P2TX	10F1TX
1/30			10P5LX	10J5BX				10P2TX	10F1TX
1/31			10P5LX	10J5BX				10P2TX	8F1TX
2/1		2A1BX	10P5LX				7F1CX	10S1CX	8F1TX
2/2		6A1BX	10P5LX		2A1TX	8P1LX	9F1CX	10S1CX	10F1CX
2/3									
2/4									

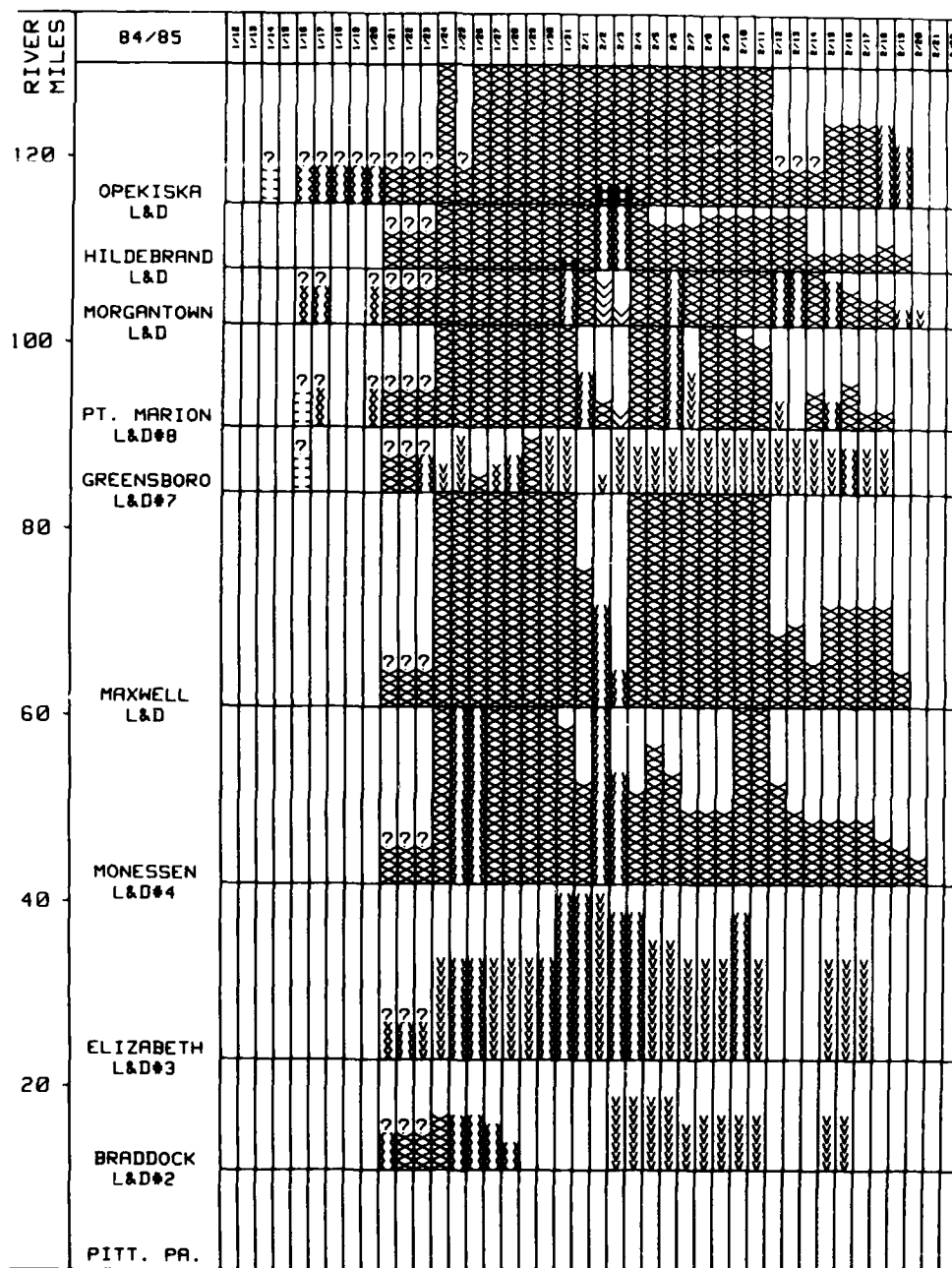


Figure A13.

DATE	BRADDOCK	ELIZABETH	HOMESSEN	MUMMELL	GRYSBORO	PT. HOB	HAWTOWN	HLOPPING	OPEKISKI
1/12									
1/13									
1/14									SSICK
1/15									
1/16					15ICK	15ICK	17ICK		75ICK
1/17						17ICK	77ICK		87ICK
1/18									87ICK
1/19									77ICK
1/20						17ICK	17ICK		91ICK
1/21	981CK	271CK	1081CK	1082CK	1071CK	1071CK	1072CK	1072CK	1082CK
1/22	1081CK	681CK	1082CK	1083CK	1071CK	1074CK	1074CK	1074CK	1083CK
1/23	1081CK	582CK	1083CK	1084CK	9818K	1075CK	1075CK	1074CK	1083CK
1/24	1081CS	582C10	1083C10	1083C22	181C2	1075C11	1074C6	1073C7	1084C14
1/25	982CS	683C10	983L10	1081C22	18185	1075C10	1074C6	1073C7	1083CK
1/26	982CS	682C10	983L10	1081C22	1081C1	1075810	107586	1073C7	1084C14
1/27	982C4	282C10	1083L10	1083L22	58182	1075C10	1075C6	1074C8	1085C14
1/28	88282	282C10	1084L10	1083L22	88283	1075C10	1075C6	1074C8	1087C14
1/29		582810	1084L10	1083L22	1082L5	1074C10	1074C6	1074C8	1086C14
1/30		884810	1084L10	1083L22	18215	1075C10	107486	1074C8	1086C14
1/31		684817	1084L16	1083L22	18185	1084L10	984C6	1074C8	1085C14
2/1		684817	1084L10	1083L14		98415	108415	1074C8	1083114
2/2		584817	984819	983810	28111	108412	108414	88418	1083114
2/3	48387	784815	984811	98483	28315	1084L1	1084L1	98518	1084C14
2/4	58387	984815	108489	1084L22	58314	1081C10	1081C5	108518	1085L14
2/5	385L7	484812	1084L14	1084L22	58314	1082C10	1082C5	108514	1084L14
2/6	38587	384812	1084L11	1082L22	28214	782110	88215	108414	1084L14
2/7	18384	484810	1084L7	1082L22	18215	38285	1082L5	108314	1083L14
2/8	18385	384810	1084L7	1082L22	38285	1083L10	1083L5	1083L5	1083L14
2/9	28385	384810	1084L7	1083L22	48285	1084110	1084L5	1083L5	1085L14
2/10	183L5	984815	1085L10	1083L22	28385	108489	1084L5	1083L5	1084L14
2/11	18385	384818	1085L10	1083822	28715	1084800	1084L5	1083L5	1085L14
2/12			1085810	108387	18115	38282	883L5	1083L5	1085L14
2/13			108587	108380	18115		783L5	1083L5	108480
2/14			108586	108384	18115	108183	1083L5	1083L1	108584
2/15	58485	284810	108586	1083810	18284	671C2	883L4	1083L1	108480
2/16	18485	284810	108586	1083810	67184	1081C4	1083L3	1083L1	108480
2/17		284810	108586	1083810	18284	108181	1083L2	1083L1	108480
2/18			108584	1083810	18284	108181	1083L2	108312	98380
2/19			108483	108383			98211	108311	68386
2/20			108382				18211		
2/21									
2/22									

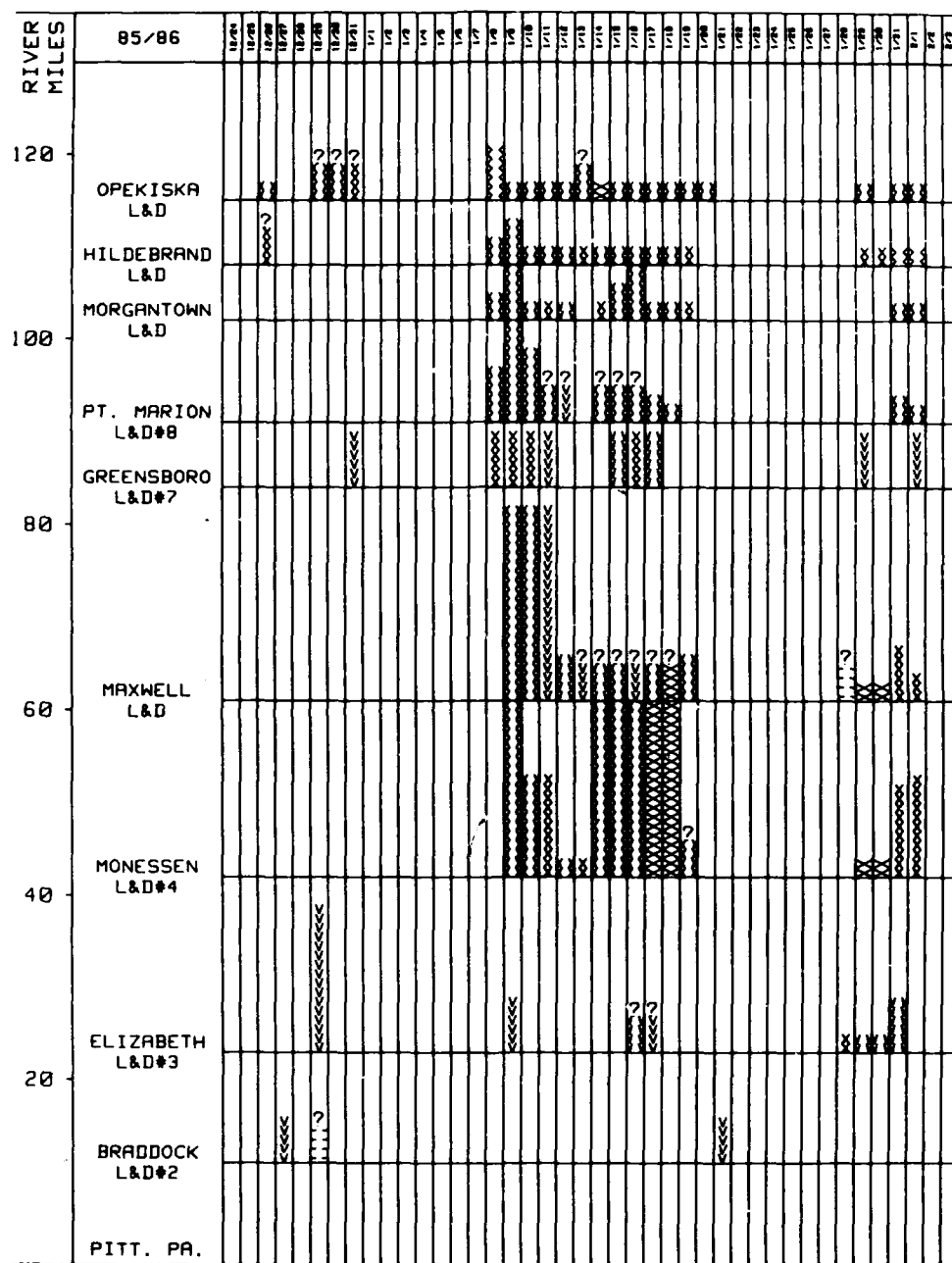


Figure A14.

DATE	BRADDOCK	ELIZABETH	HOMESSEN	HOWELL	GRYSARD	PT. HOB	HEWITMAN	HELDORNO	OPKISKA
12/24									
12/25									
12/26								571CX	971W
12/27	371L4								
12/28									
12/29	151TX	281B15							971CX
12/30									971CX
12/31					181B5				171CX
1/1									
1/2									
1/3									
1/4									
1/5									
1/6									
1/7									
1/8					181CS	771CS	771C2	871C2	951CS
1/9		181B5	881L18	881B20	981CS	971C10	971CS	971C4	981C1
1/10			981C10	881B20	981CS	872C7	771C1	871C1	981C1
1/11			581B10	281B20	181CS	872C8	571C1	871C1	981C1
1/12			982B1	881B4		381B8	781T1	671T1	981B1
1/13			982B1	381B8				171T1	881B8
1/14			981B18	881B8		671B8	273B1	971T1	1871C1
1/15			981B18	981B8	781CS	871B8	771C3	971C1	971B1
1/16		981B8	982B18	582B8	581CS	971C8	971CS	971C1	972C1
1/17		381B8	1871C18	981B8	981CS	971C2	971C7	971T1	972C1
1/18			1871C18	1871B8		971T1	871T1	871T1	972C1
1/19			981CX	981B4			571T1	571T1	671W1
1/20									671W1
1/21	182B4								
1/22									
1/23									
1/24									
1/25									
1/26									
1/27									
1/28		171B1		151B8					
1/29		981B1	1871C1	1871B1	181B5			971C1	871C1
1/30		981B1	1871L1	1871B1				571C1	
1/31		981B5	171L9	171CS		671C2	771C1	751C1	871C1
2/1			171L18	571L2	381B5	771C1	871C1	751C1	871C1
2/2									
2/3									