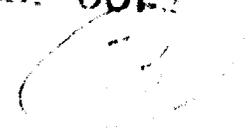
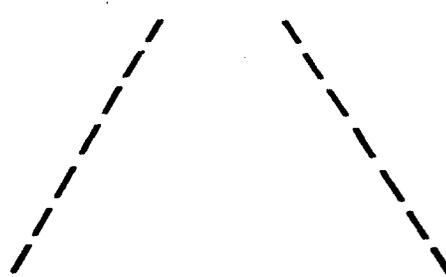


ST. CLAIR RIVER
Aerial Drogue Survey
Surface Velocities and Directions
Spring of 1982

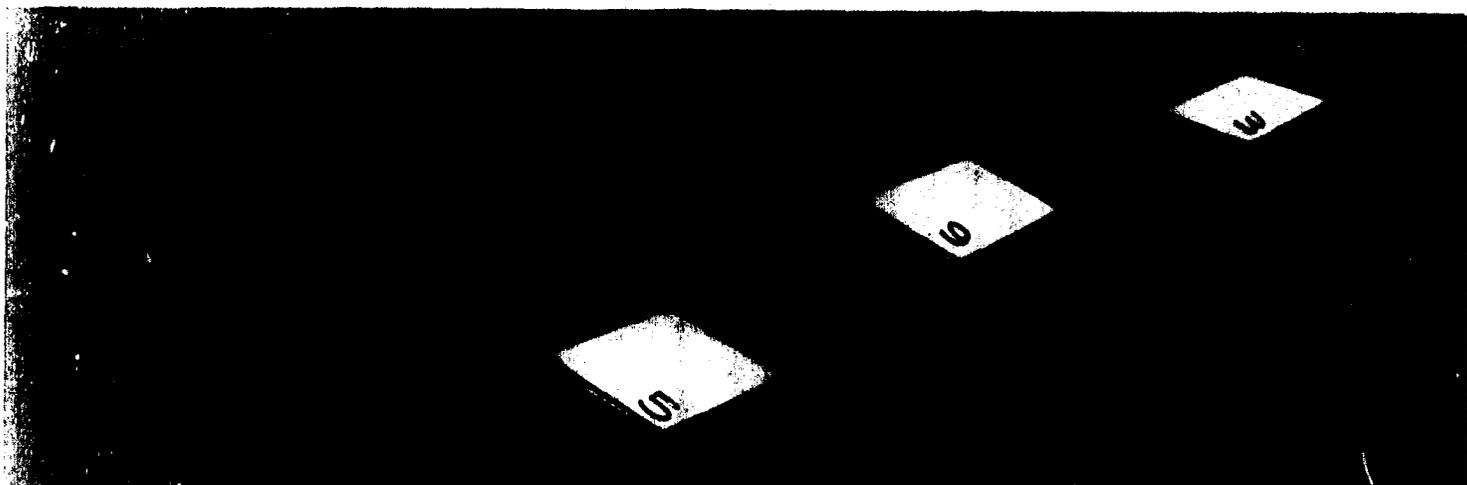
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**US Army Corps
of Engineers**

Detroit District

Great Lakes Hydraulics and Hydrology Branch

September 1983

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REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION / AVAILABILITY OF REPORT	
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE		Approved for public release; distribution unlimited	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)		5. MONITORING ORGANIZATION REPORT NUMBER(S)	
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Engineer District, Detroit	6b. OFFICE SYMBOL (if applicable) CENCE-ED-L	7a. NAME OF MONITORING ORGANIZATION	
6c. ADDRESS (City, State, and ZIP Code) Detroit District P.O. Box 1027 Detroit, MI 48231		7b. ADDRESS (City, State, and ZIP Code)	
8a. NAME OF FUNDING / SPONSORING ORGANIZATION U.S. Army Corps of Engineers	8b. OFFICE SYMBOL (if applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c. ADDRESS (City, State, and ZIP Code) Detroit District P.O. Box 1027 Detroit, MI 48231		10. SOURCE OF FUNDING NUMBERS	
		PROGRAM ELEMENT NO.	PROJECT NO.
		TASK NO.	WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) St. Clair River - Aerial Drogue Survey, Surface Velocities and Direction, Spring of 1982			
12. PERSONAL AUTHOR(S) Great Lakes Hydraulics and Hydrology Branch, Detroit District			
13a. TYPE OF REPORT Final	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) September 1983	15. PAGE COUNT 39
16. SUPPLEMENTARY NOTATION			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	Water Surface Currents, St. Clair River, Drogues, Aerial Time-Lapse Photography, Flow Pattern	
19. ABSTRACT (Continue on reverse if necessary and identify by block number)			
<p>This report presents the results of a St. Clair River open water surface current study and briefly describes the procedures used. The collection of data involved tracking of drogues via aerial time-lapse photography along the entire St. Clair River. The report contains drogue charts displaying drogue tracking through the major channels of the St. Clair River. The data enables the user to quickly assess the flow pattern of the river at various locations, thus allowing prediction of the movement and behavior of possible pollutants so counter measures can be taken. They are also useful to navigational interests, both commercial and recreational, as well as aiding in search and rescue operations of the Coast Guard.</p>			
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Thomas Freitag		22b. TELEPHONE (Include Area Code) (313) 226-7590	22c. OFFICE SYMBOL CENCE-PD-BA

ST. CLAIR RIVER
AERIAL DROGUE SURVEY
SURFACE VELOCITIES AND DIRECTIONS
SPRING OF 1982

BY
U.S. ARMY CORPS OF ENGINEERS
DETROIT DISTRICT
GREAT LAKES HYDRAULICS AND HYDROLOGY BRANCH
SEPTEMBER 1983

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Date of Report	
Project No.	
Field No.	<input checked="" type="checkbox"/>
Completed	<input type="checkbox"/>
Justification	<input type="checkbox"/>
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Description	
Availability Codes	
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ST. CLAIR RIVER
AERIAL DROGUE SURVEY
SPRING OF 1982

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ST. CLAIR RIVER
AERIAL DROGUE SURVEY
SPRING OF 1982

INTRODUCTION

The mission of the Great Lakes Hydraulics and Hydrology Branch of the Detroit District Corps of Engineers' Engineering Division includes the collection and analysis of technical data related to the movement of waters of the Great Lakes. As such, the branch was requested to collect and analyze surface current data (directionals and velocities) under open water conditions for the St. Clair River. These data are useful to a number of interests including: the Coast Guard, to determine the probable areas that would be impacted by an oil or toxic substance spill under varying flow and meteorological conditions; local communities and engineers, in the design of sewer outfall and water intake; those involved in pollution studies and design of dredge disposal sites; and both commercial and recreational navigation interests.

PURPOSE AND SCOPE

The purpose of this report is to present the results of a St. Clair River open water surface current study and to briefly describe the procedures utilized in this undertaking. The collection of data was conducted in May and June 1982 and involved the tracking of drogues via aerial time-lapse photography along the entire river.

STUDY AREA DESCRIPTION

The St. Clair River has three distinct reaches. The upper reach, extending downstream from Lake Huron to a point about three miles below the Blue Water Bridge, is approximately 800 feet wide at its narrowest point and has mid-channel depths varying from 30 to 70 feet. Maximum velocities in this reach occur near the Blue Water Bridge. The middle reach, which extends downriver for the next 27 miles, is approximately one-half mile wide, with channel depths ranging from 27 to 50 feet. Located in this reach are Fawn Island, Stag Island and a middle ground shoal opposite the City of St. Clair, Michigan. The lower reach continues downstream for the next nine miles to Lake St. Clair, where it divides into a number of channels which flow across a delta called the St. Clair Flats. Average velocities in the St. Clair River range from two to six feet per second, depending upon the reach and controlling characteristics.

FIELD PROGRAM

ESTABLISHMENT OF SURVEY REACHES

Prior to the start of the drogue survey, the entire St. Clair River was divided into nine survey reaches, varying in length from 2 to 24 miles. To insure uniform coverage of the river system as the job progressed, additional subdivisions of these nine reaches were made at the discretion of the survey crew. These further partitions left the original number of survey reaches unchanged. Sufficient horizontal control was accomplished through a constraint that at least one, and preferably both, of the shorelines appear in aerial photographs. Vertical control information was provided by the existing water level gage network on the St. Clair River.

DATA ACQUISITION

A 35-foot survey launch, the "Korkigian", and a 21-foot "MonArk" trihull were used to deploy drogues at the upstream end of the respective survey reaches. An airplane was used to take aerial time-lapse photographs. The Drogues, 4'x4' pieces of plywood, have a line down to a weighted vane, painted white for visibility and individually numbered for identification (See Figure 1), were released at equal intervals across the river. After deployment, the boat crew either followed or preceded the drogues until the photographic crew asked for a reset or pick up of the targets (drogues). This method allowed for the servicing of those drogues which ran aground in shoal areas or were upended by passing vessels and insured that any crossover between the drogue paths would be quickly detected and recorded.

The photographic operations involved repeated passes of an airplane over each of the reaches until the track of the drogues over an entire reach was captured in aerial photos. Timing was such that the maximum distance traveled by the drogues between passes would not exceed 2,000 feet. The typical photo scale employed was 1:9960 with a standard 60% overlap between photos.

Coordination between the airplane's photographic crew and the boat's crew was maintained by radio. For accurate data, minimal cloud cover at the preselected flight altitude was needed. This insured adequate light for drogue identification, while still maintaining sufficient shoreline configuration coverage for control purposes. Other constraints included releasing the drogues only when the surface waves were below 0.5 feet in height and near surface winds were less than 10 miles per hour.

TYPICAL AERIAL DROGUE

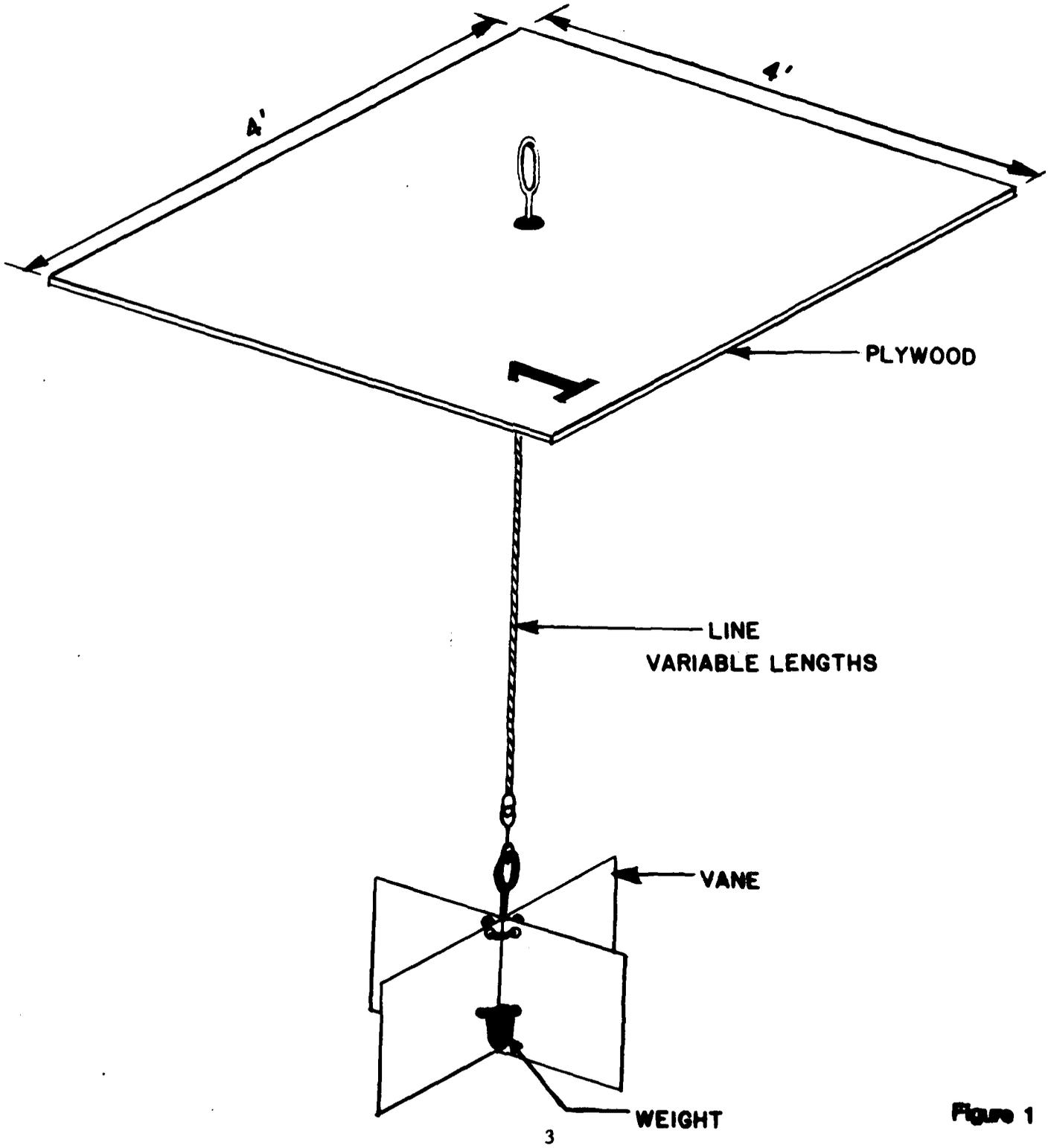


Figure 1

DATA REDUCTION

Drogue positions were scaled from the individual photos and were accurately plotted on drogue charts. The positions deduced from each exposure, combined with the recorded time to the nearest second, gave the path and velocity of each target as it floated downstream. As a final product, these data were transferred onto wash-off mylar sheets. The scale chosen for the drogue charts was 1:10,000.

RESULTS AND ANALYSIS

Drogue tracking, through the major channels of the St. Clair River, is displayed on drogue charts (see sheets 1-29). Velocities are depicted in units of feet per second, along with their associated vectors. Vector lengths on the 1:10,000 scale drogue charts are such that 0.10 inch corresponds to one foot per second of velocity. All vectors are portrayed in the direction of the plotted surface flow. An index chart, divided into twenty-nine sectors each of which represents a given drogue chart, is also attached and can be found directly after Figure 2 (Wind Graph). Sectors proceed downstream from the Blue Water Bridge to the delta of the river.

Average flow in the St. Clair River, from river gage calculations, during the period of study (May-June 1982) was 189,000 cubic feet per second (cfs) and all of the plotted velocities are based on this flow. Any deviation from the 189,000 cfs flow can be assumed to yield a corresponding deviation from the plotted velocities; i.e., a 10% flow change would account for a 10% velocity change for any given point on the river. This is a simplification of the actual velocity change due to variations in flow and should be considered as an approximate value.

Wind conditions during this study were less than 10 miles per hour and wave heights were less than one foot. Changes in wind direction and velocity will effect the flow patterns shown in this study. In the event of an oil or toxic substance spill, wind patterns of the study area should be seriously considered. For that purpose a wind graph has been imposed on the drogue charts, sheets 1-29. The wind graph for this study uses the 16 principal points of the compass showing the relative frequency and strength of winds from these directions. The wind speed and direction observations used for this graph were recorded at the Detroit, Michigan, City Airport. For interpretation of the wind graph see Figure 2.

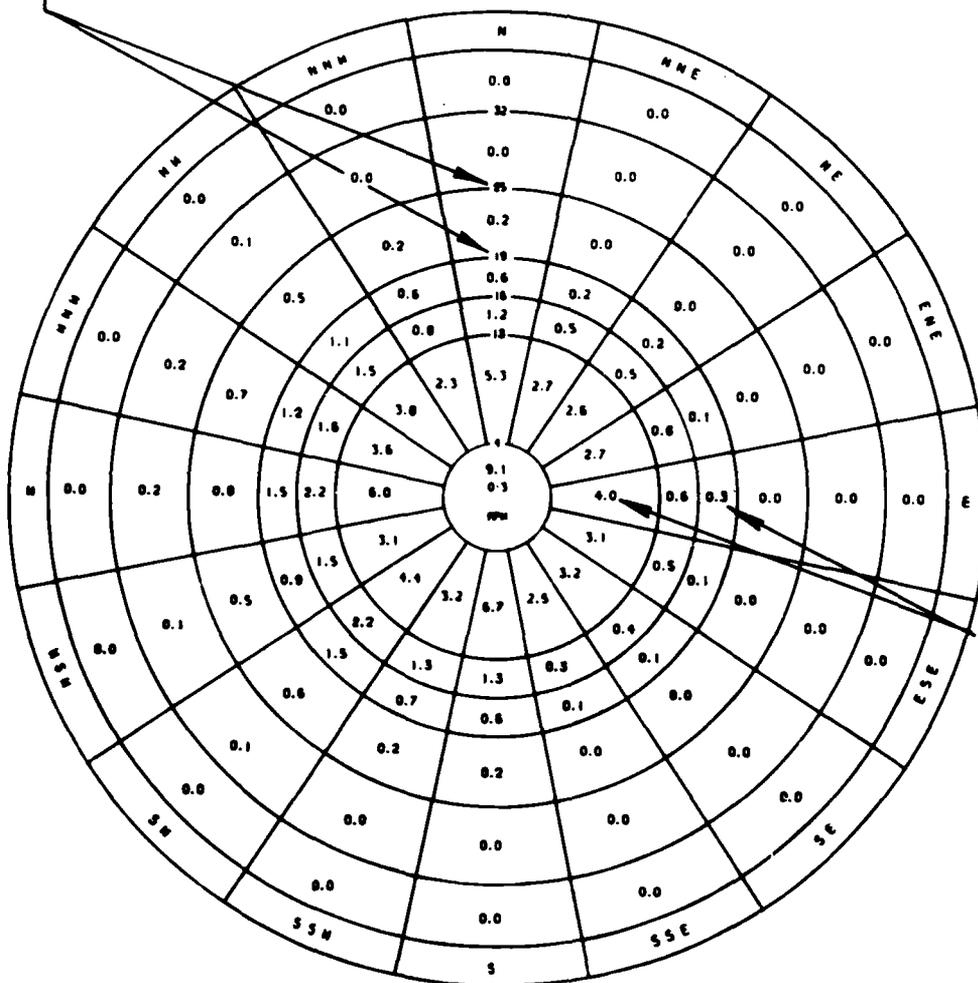
CONCLUSIONS

This study provides useful surface current data needed by many St. Clair River interests. These data are presented as vectors that indicate velocity and direction on charts of the St. Clair River system. Also presented is a wind graph. The data enables the user to quickly assess the flow pattern of the river at various locations; and thus will allow for prediction of the movement and behavior of possible pollutants so countermeasures can be enacted. These data are also useful to navigational interests, both commercial and recreational, as well as aiding in search and rescue operations of the Coast Guard.

WIND GRAPH

(Detroit, Michigan City Airport)

**WIND SPEED
RANGE LIMITS IN MPH**

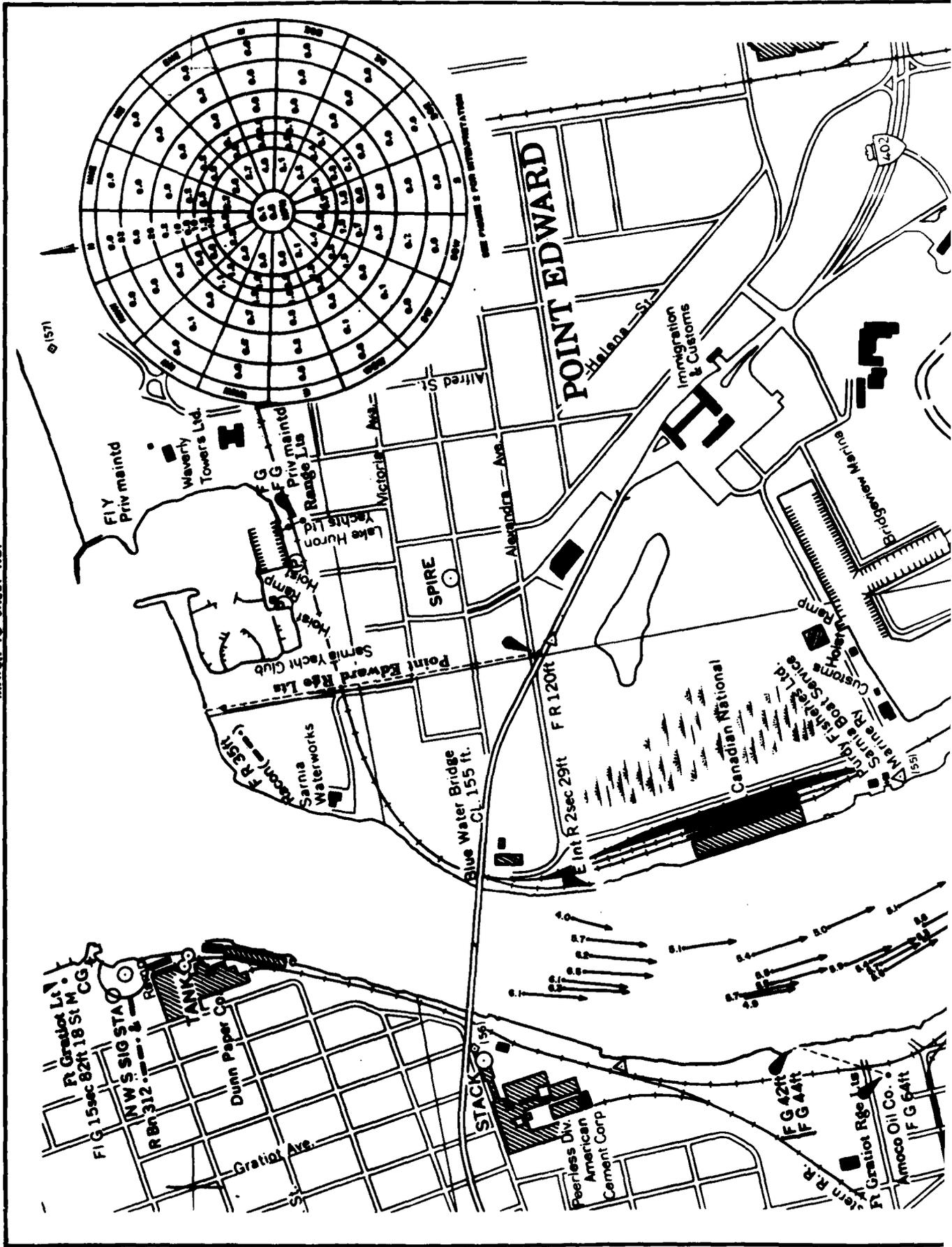


**FREQUENCY
IN %**

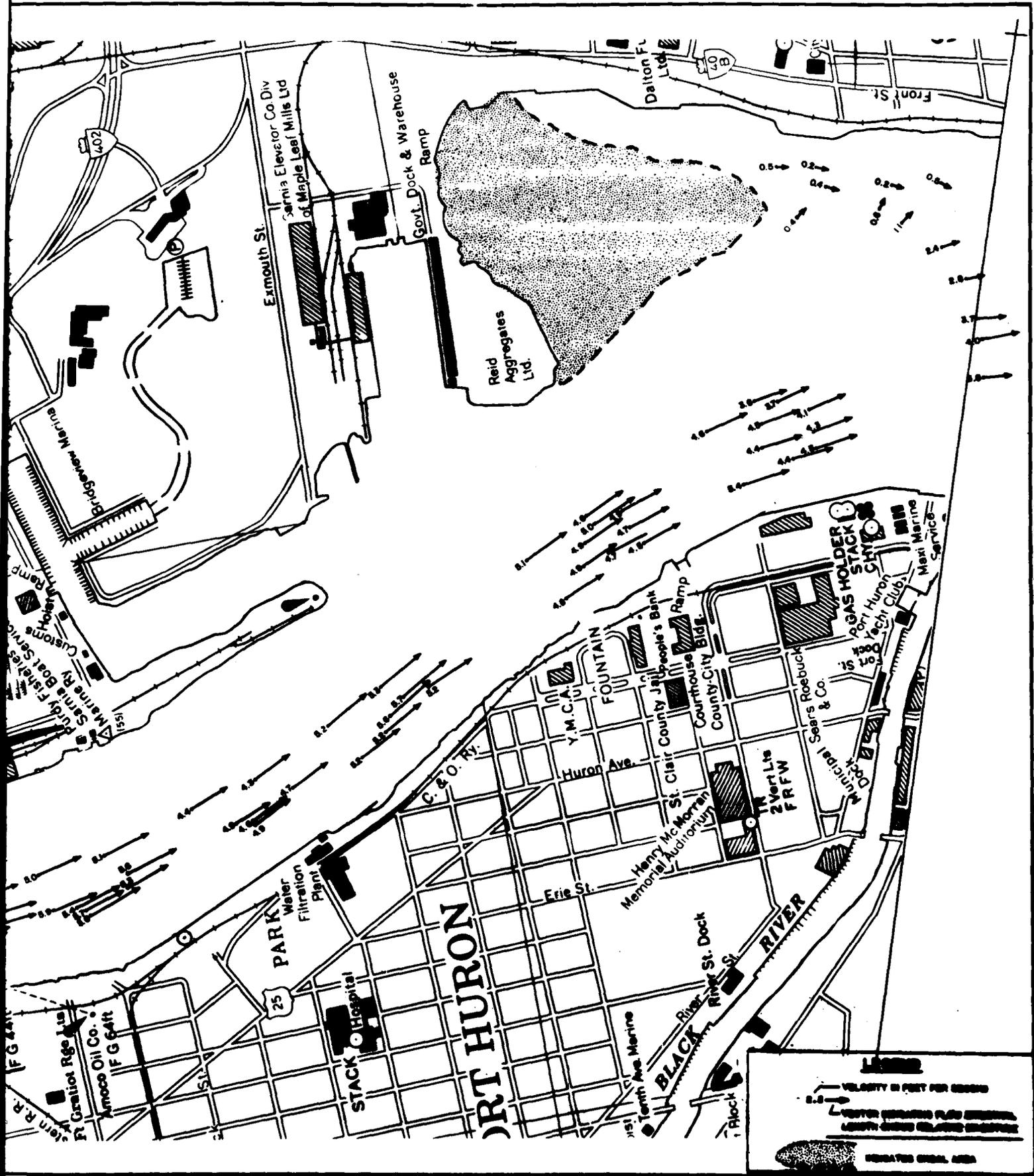
All ceiling and visibility conditions

Figure 2

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SCALE 1

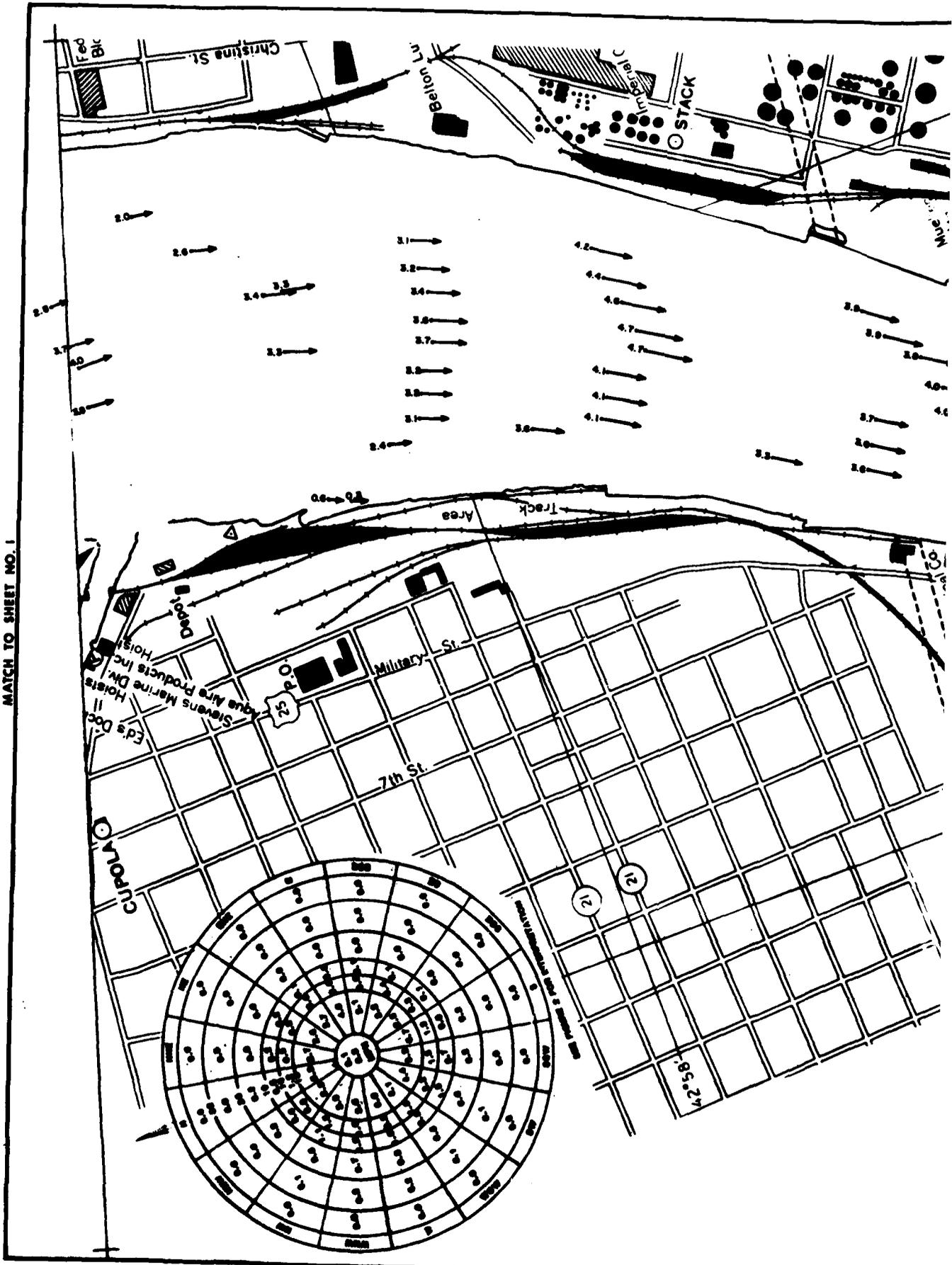


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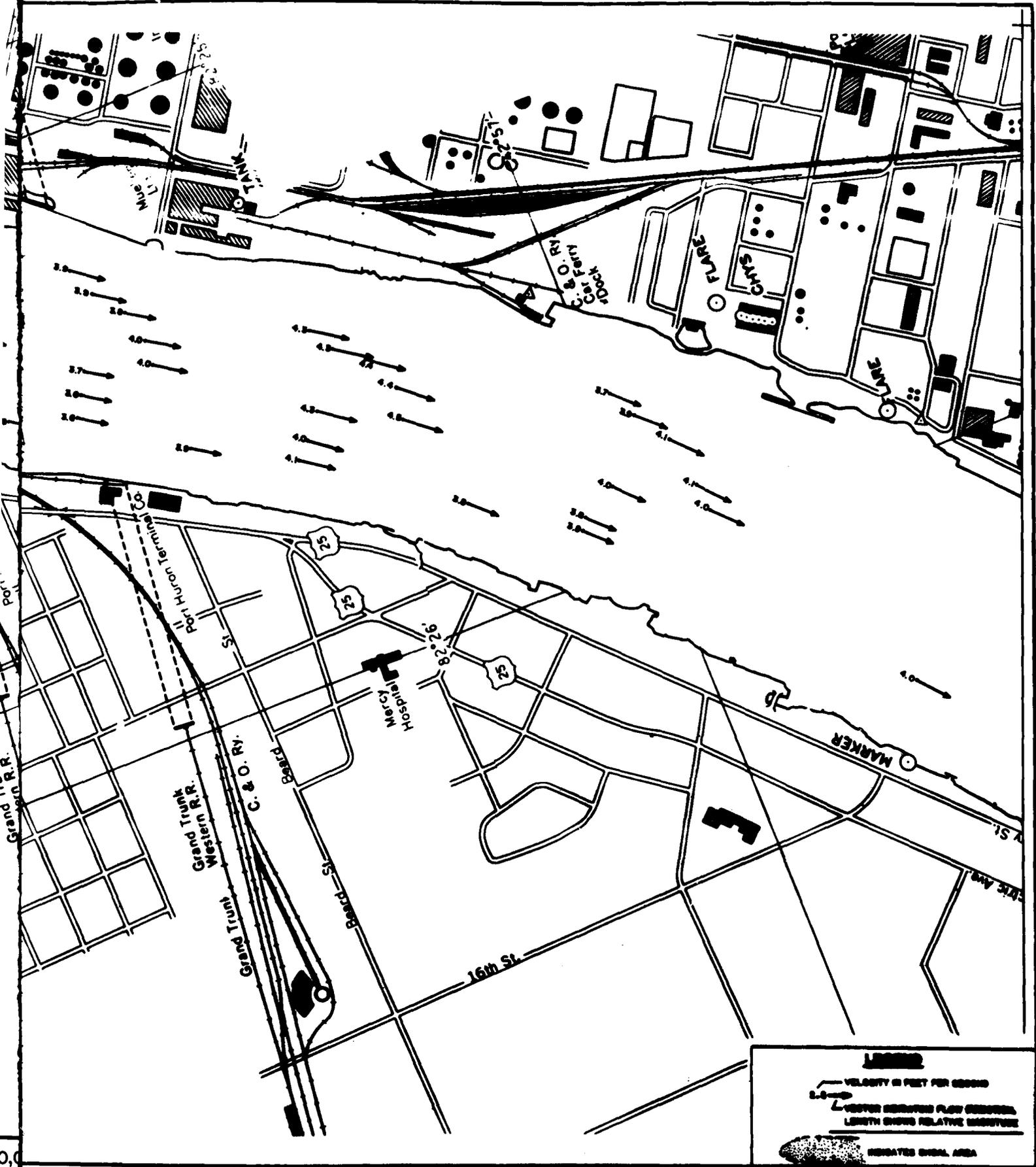
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MATCH TO SHEET NO. 1



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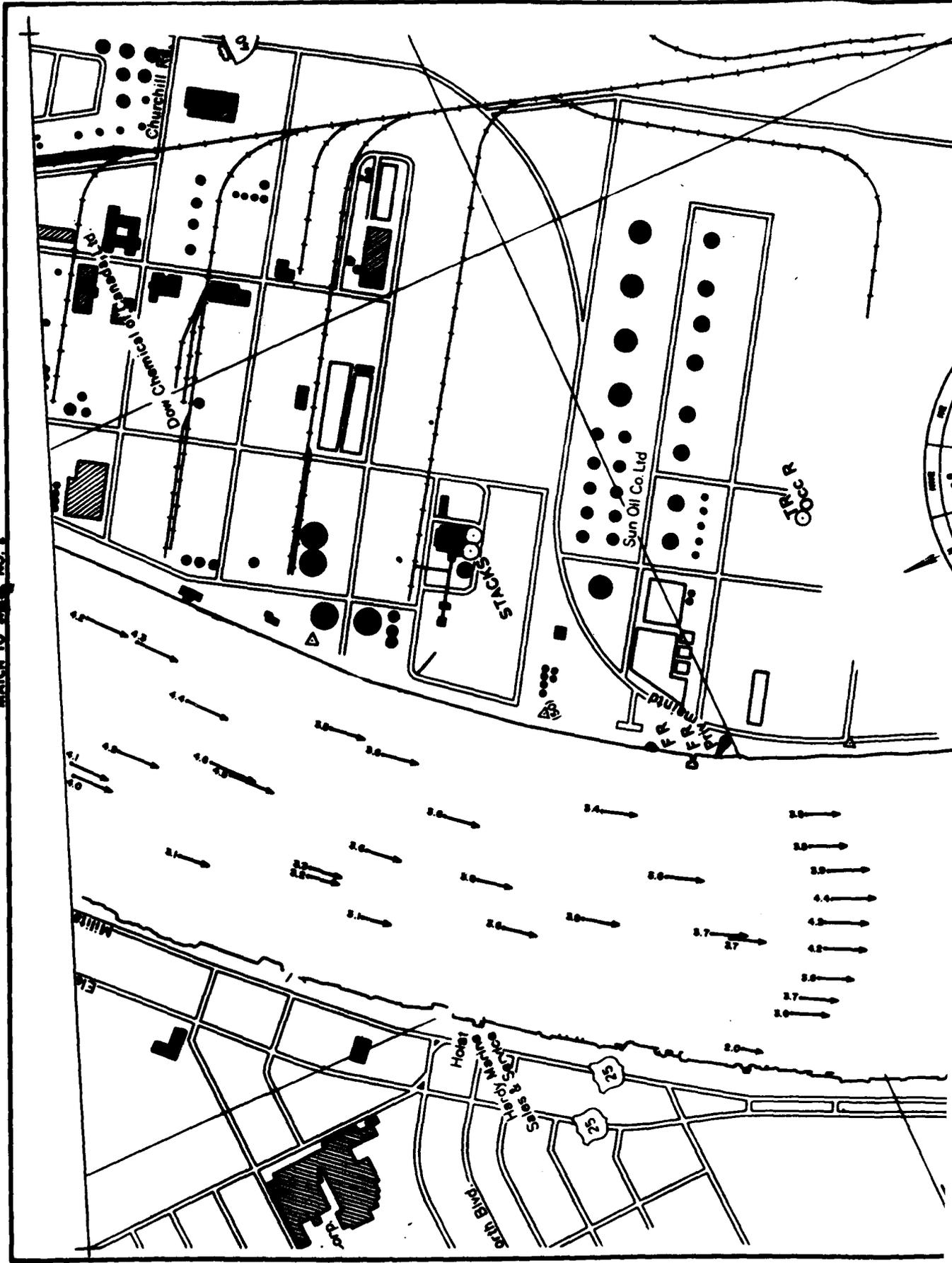


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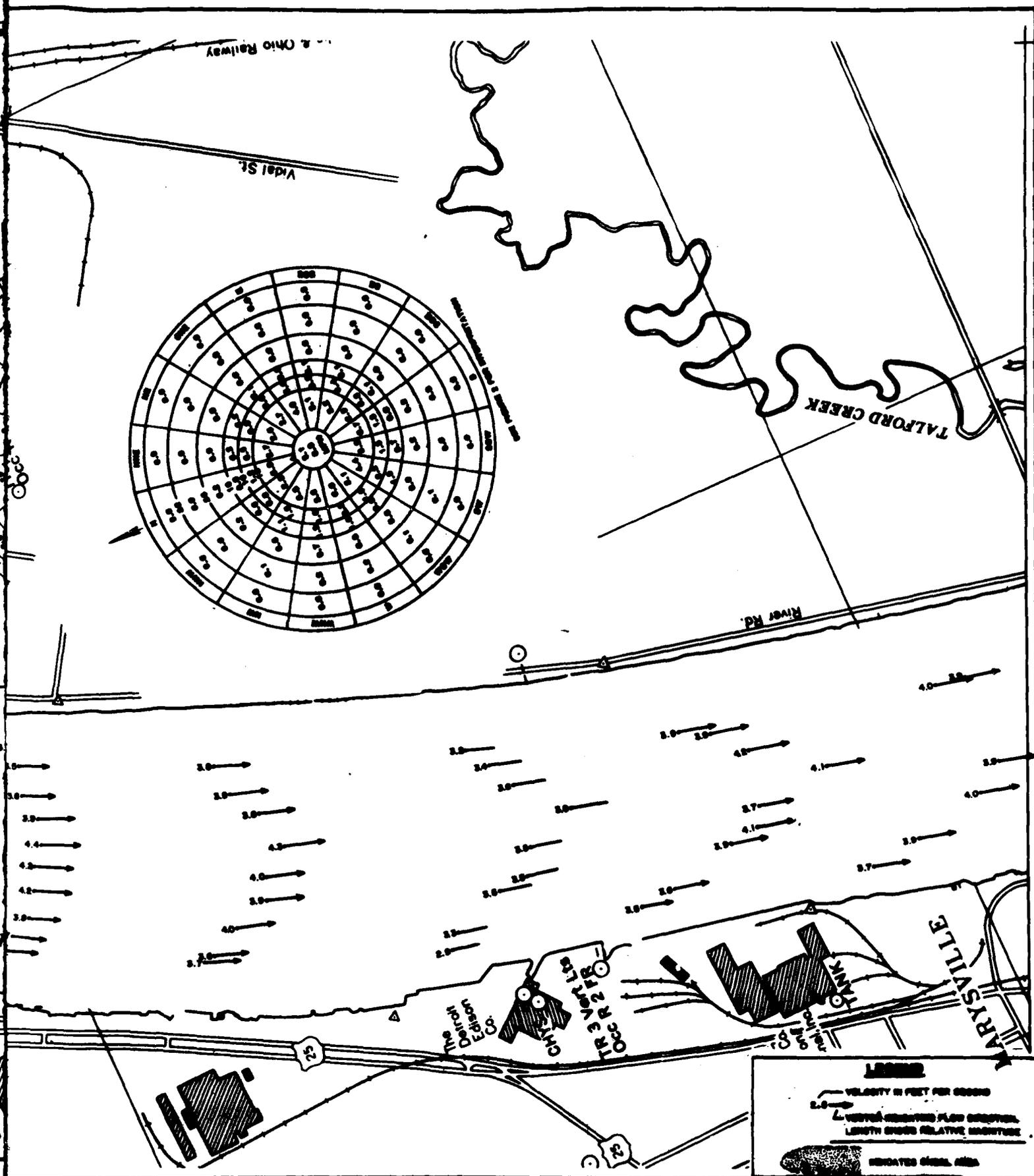
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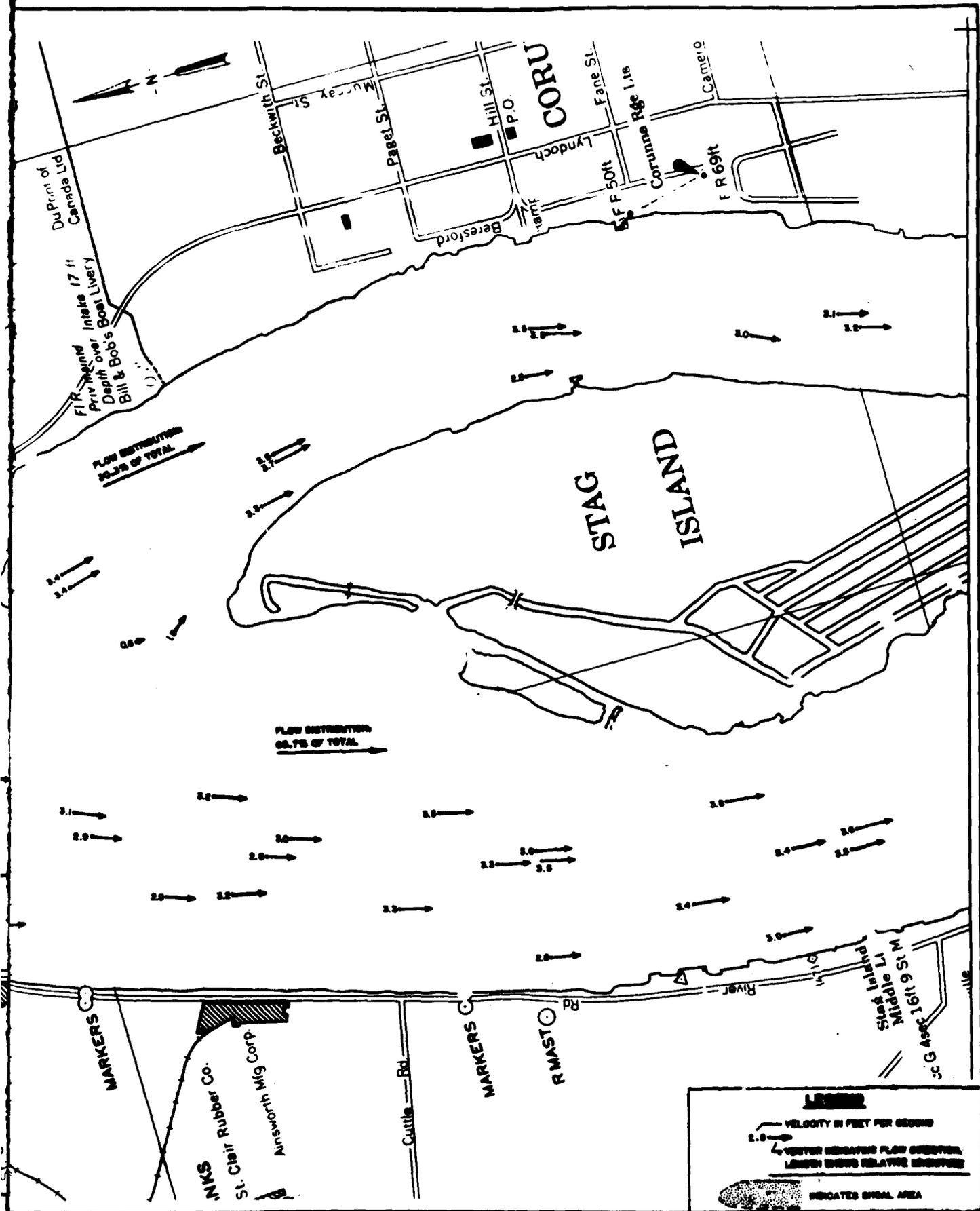
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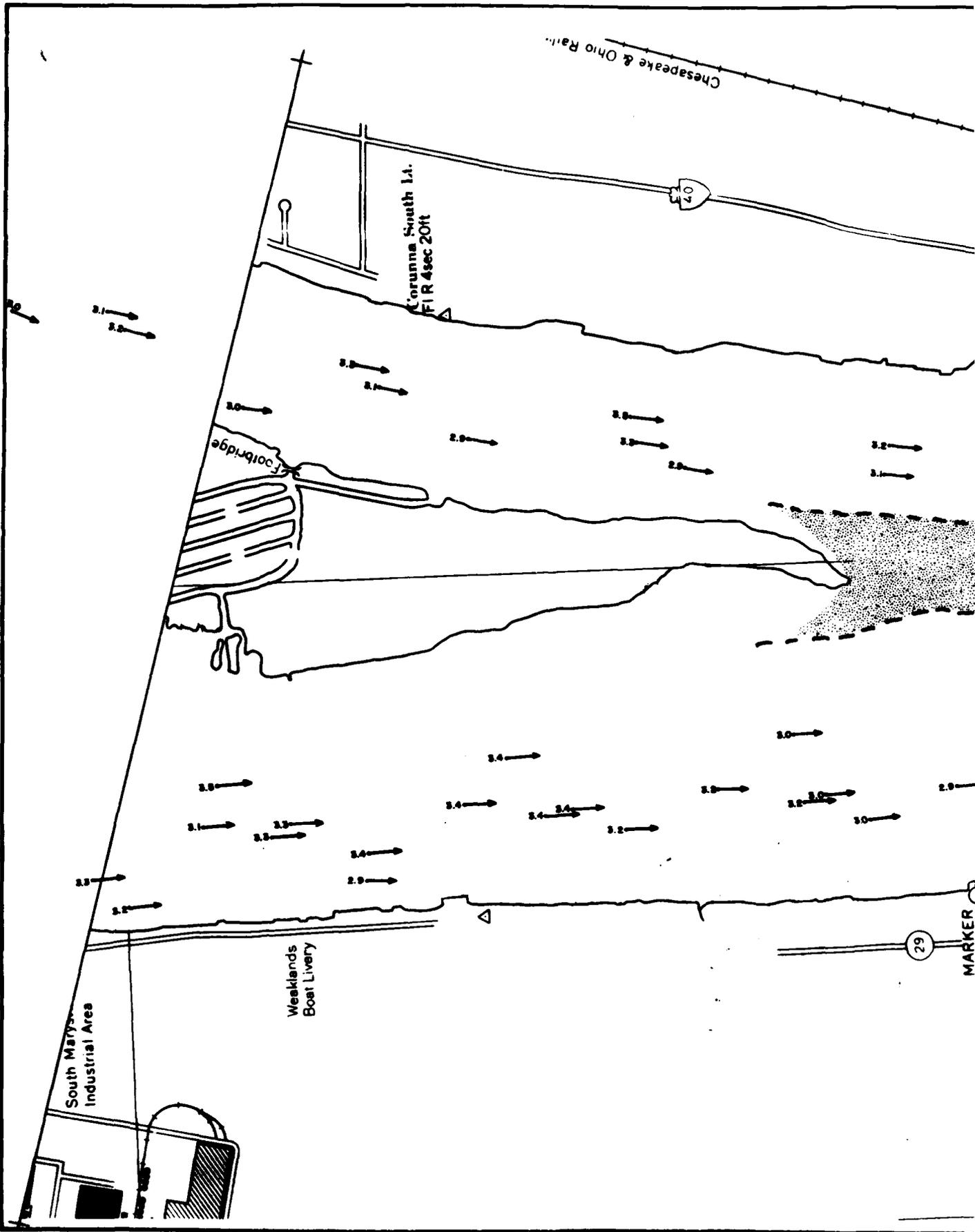


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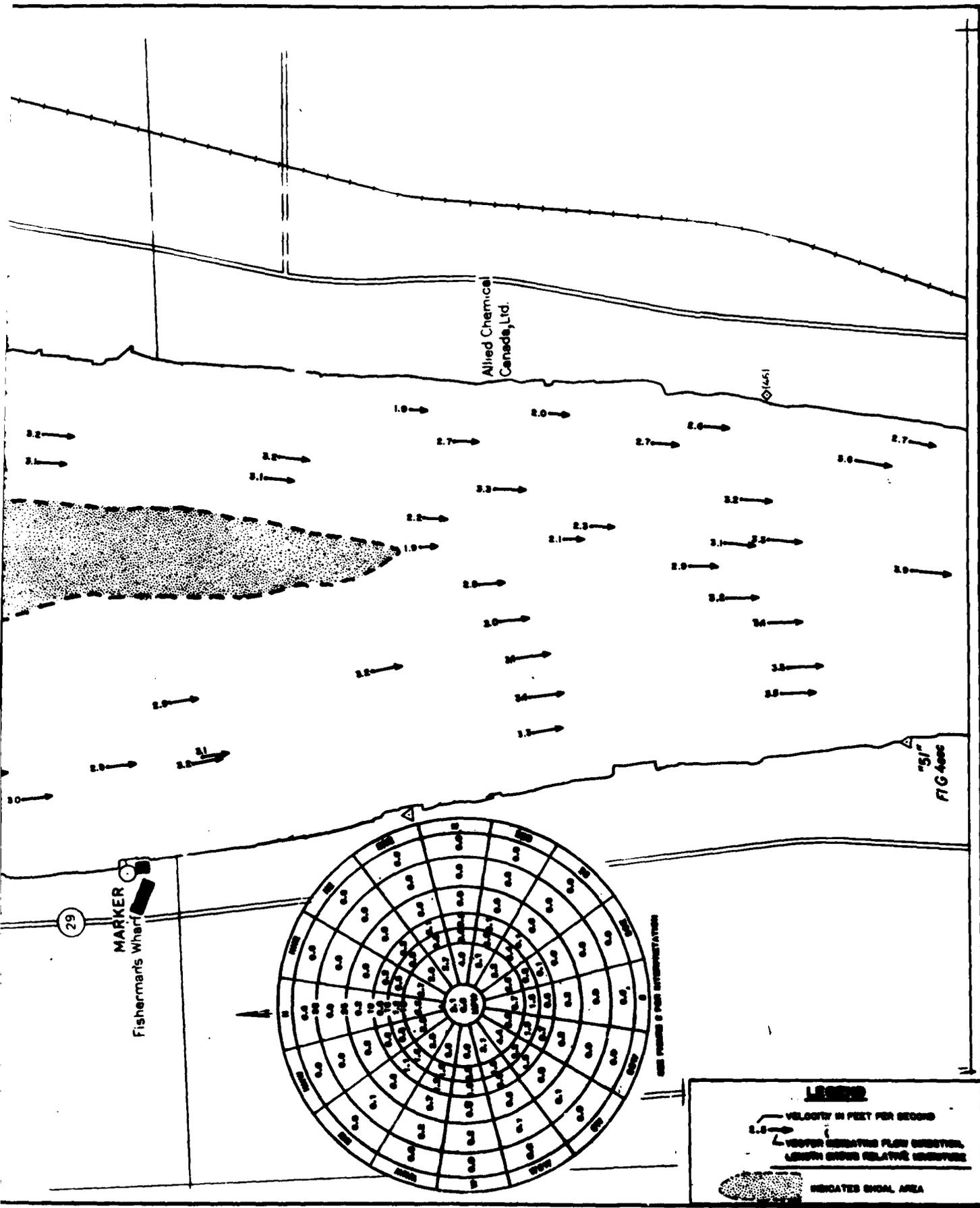
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SHEET NO. 4

MATCH TO SHEET NO. 4



SCALE 1 : 10,000



MATCH TO SHEET NO. 6

SCALE 1 : 10,000

SHEET NO. 5

CREEK

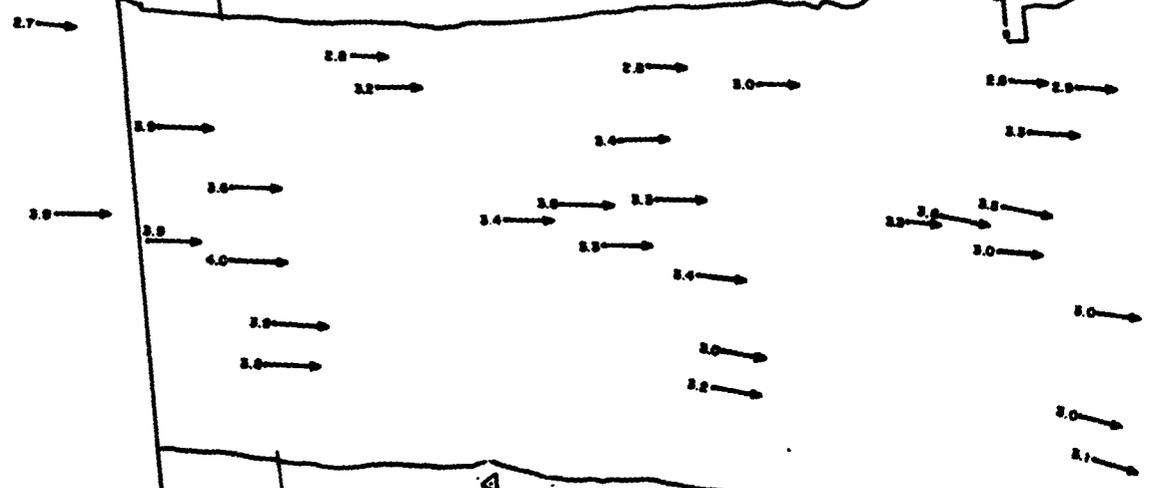
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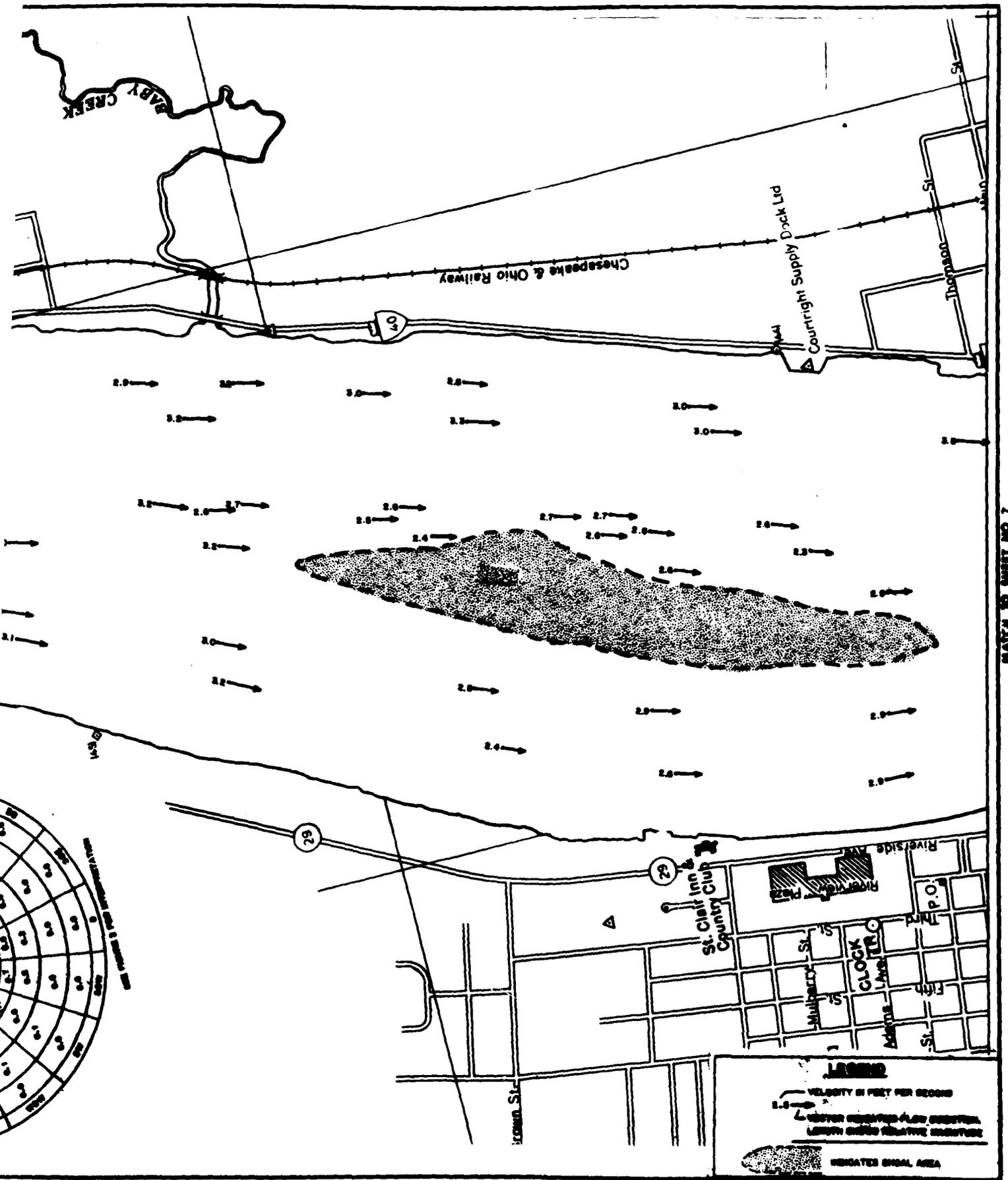
FLY 30ft

Ramp

425.14

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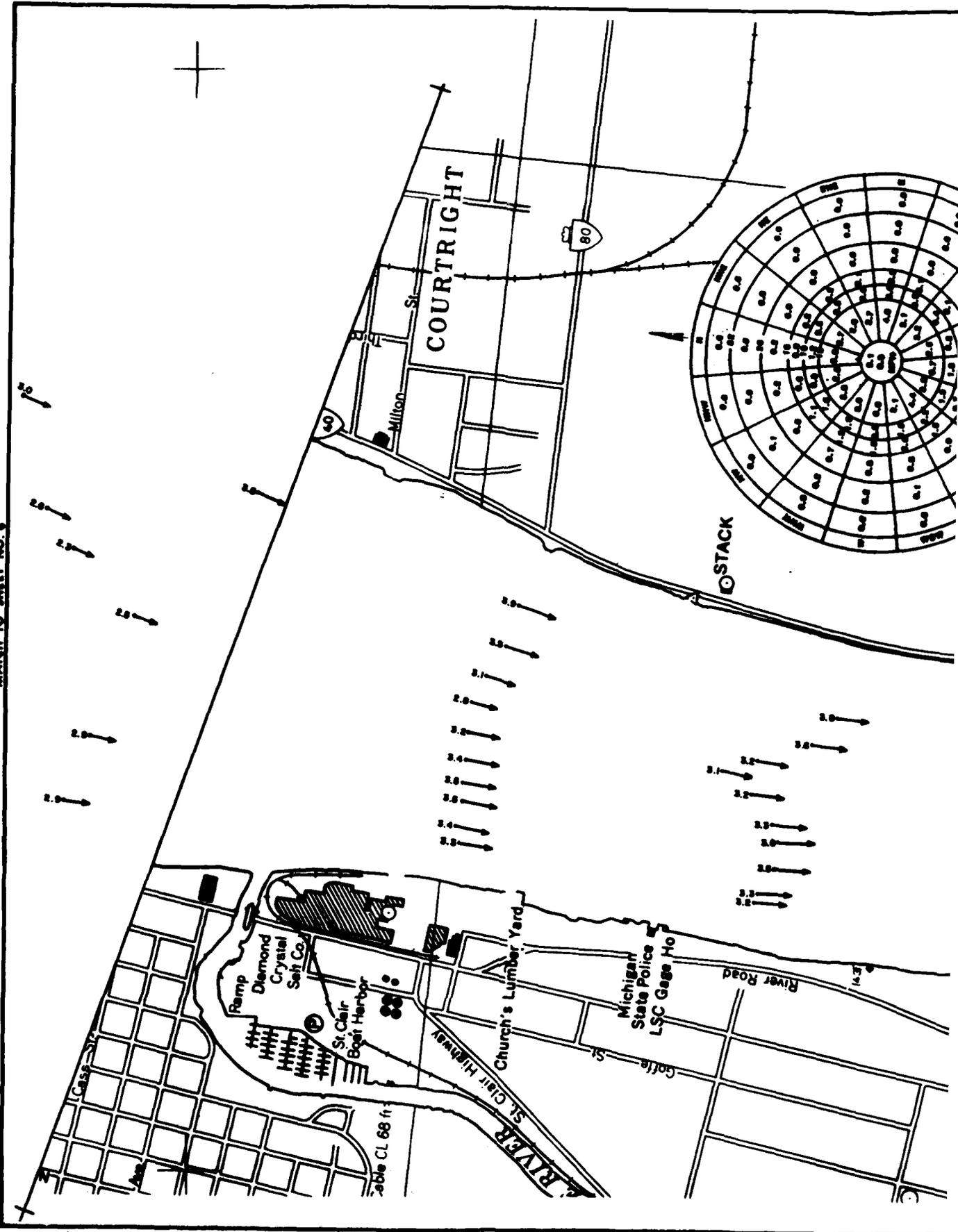


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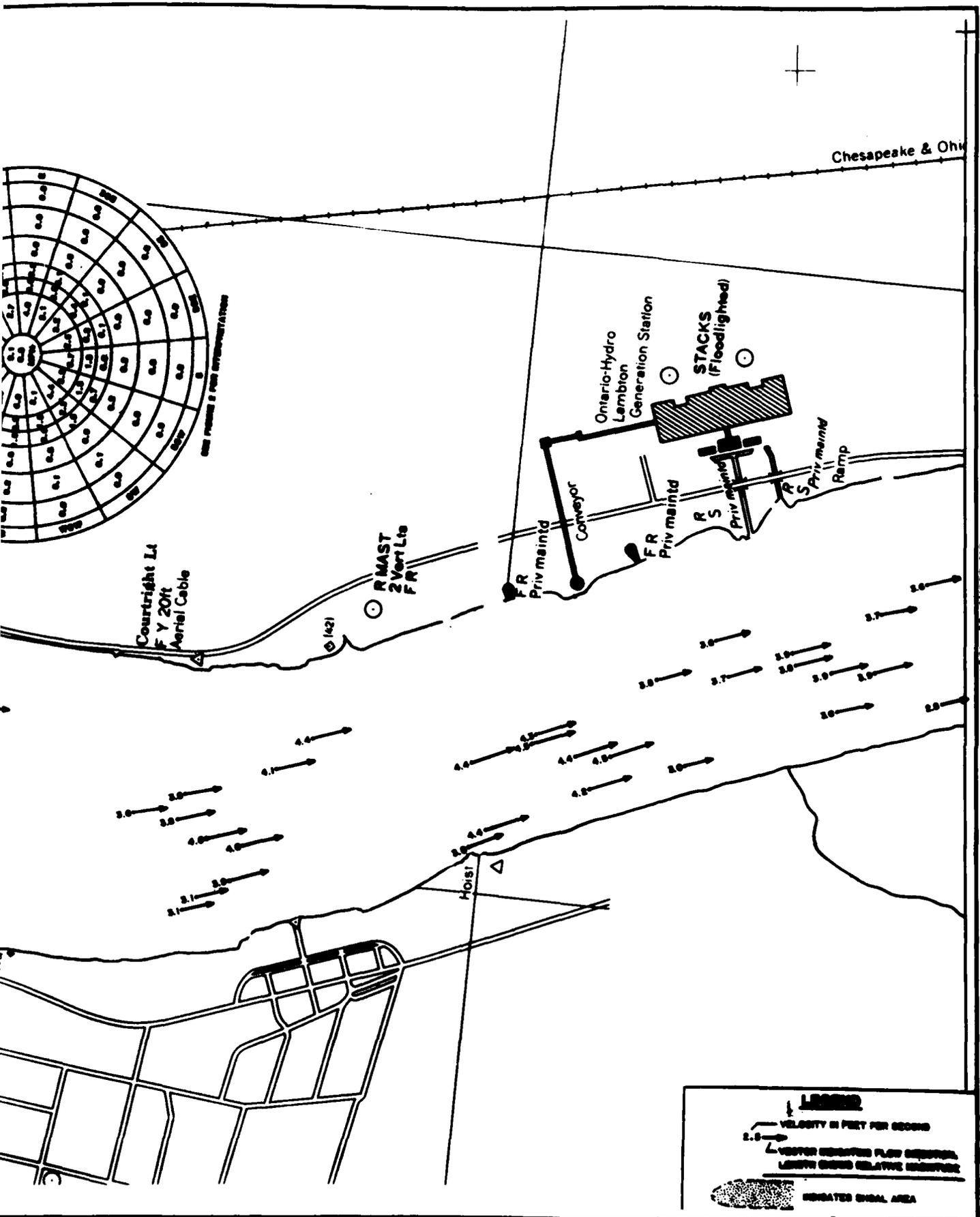
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MATCH TO SHEET NO. 7

MATCH TO SHEET NO. 6



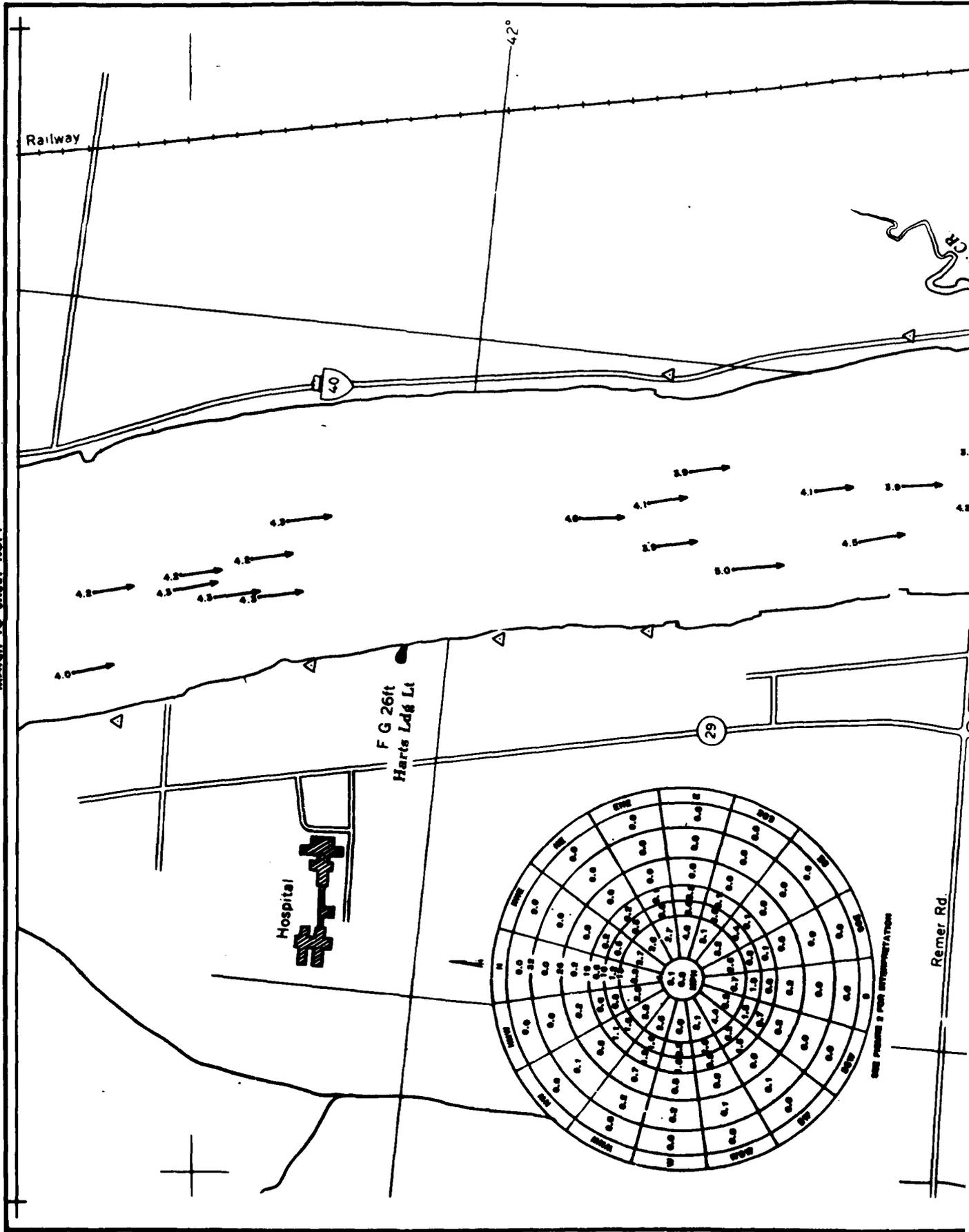
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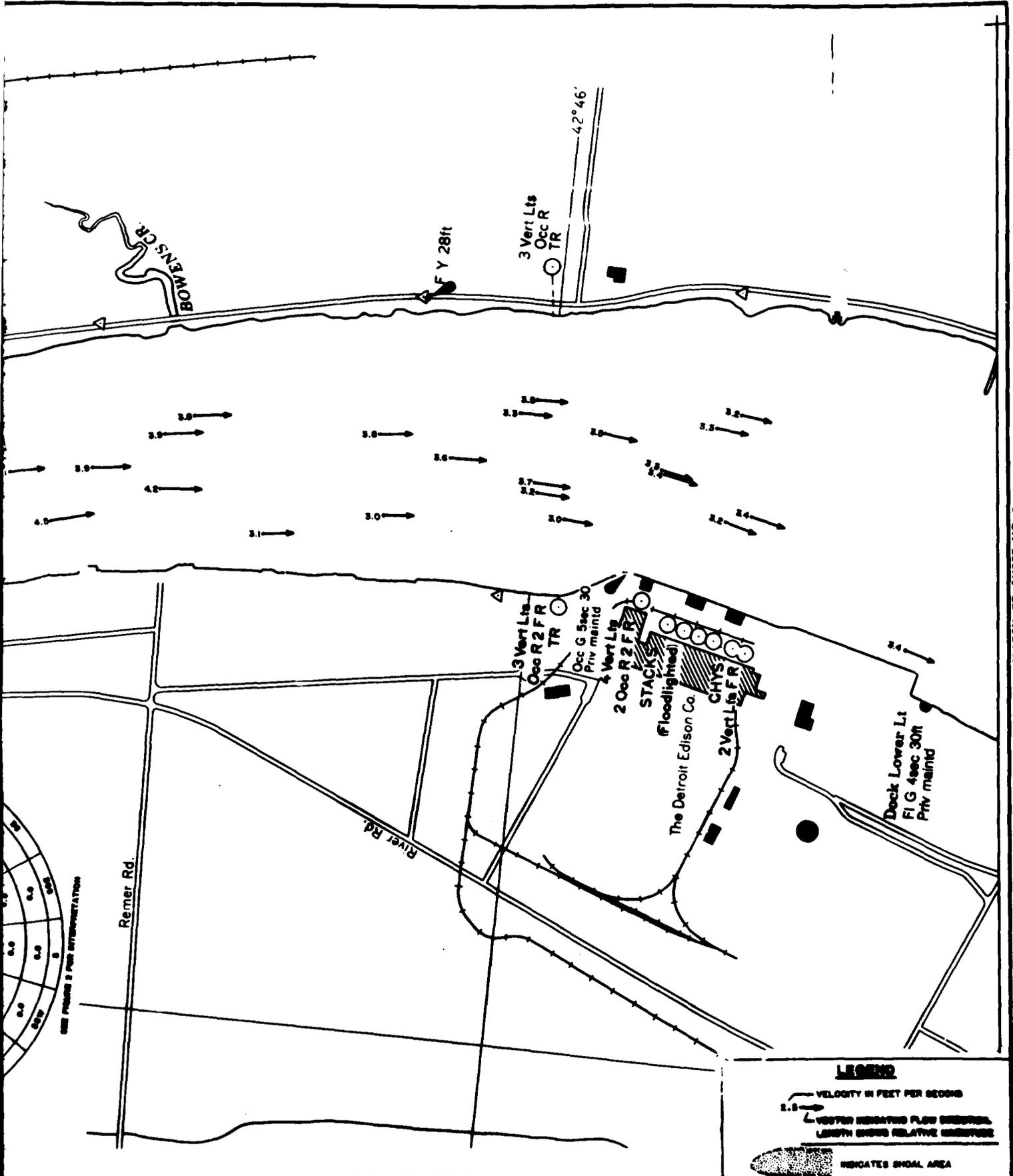
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MAINT TO SHEET NO. 7



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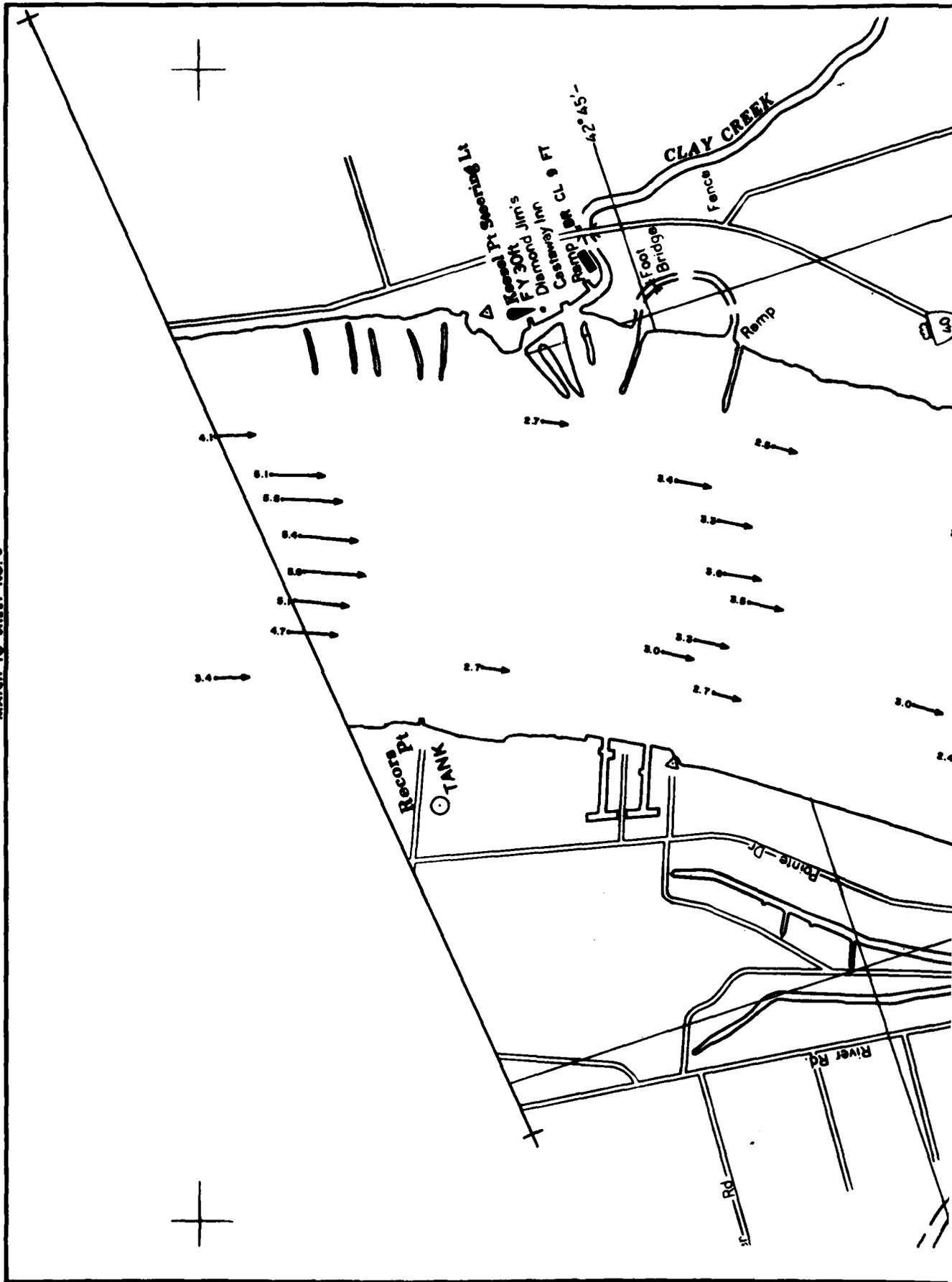


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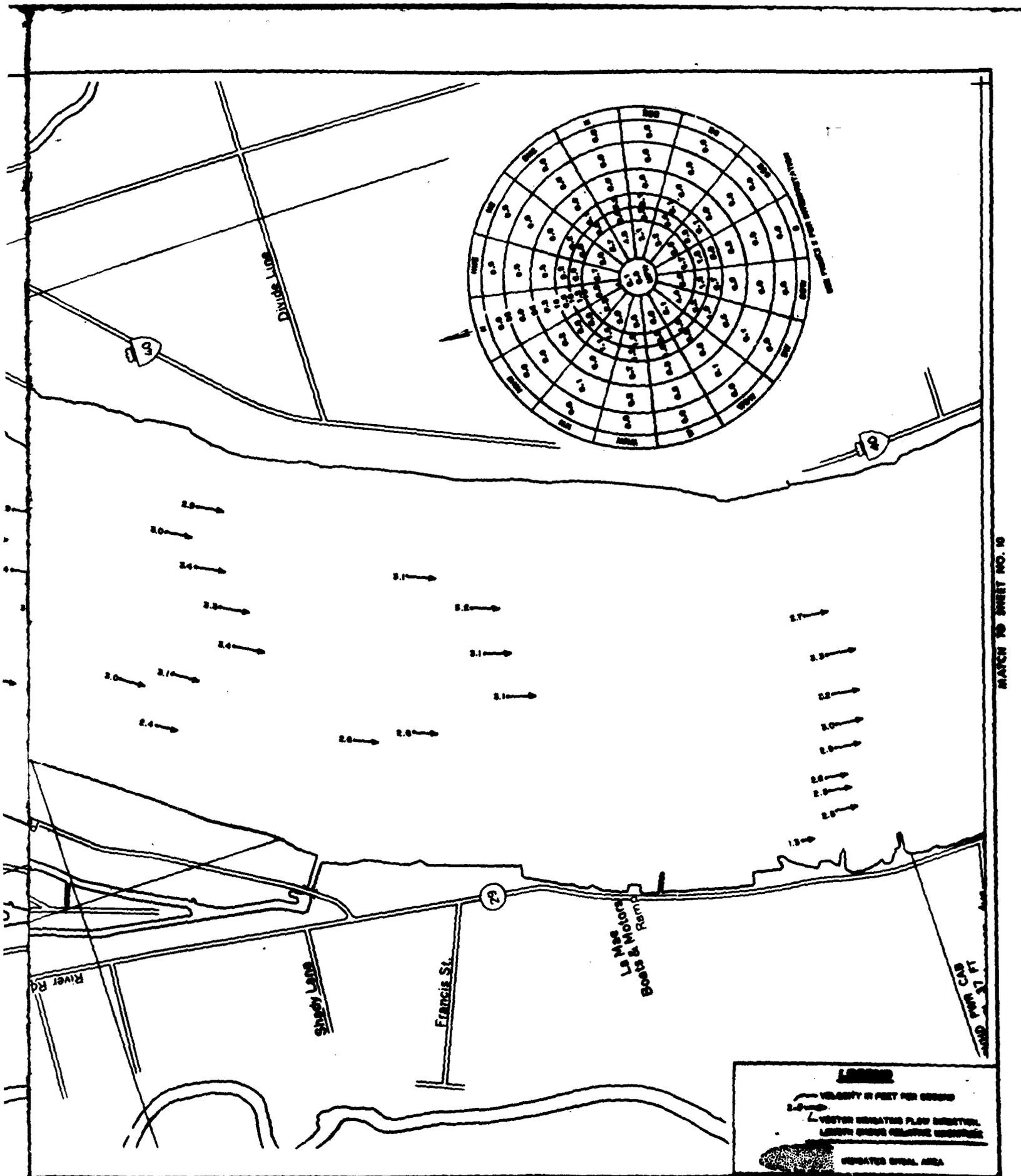
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MATCH TO SHEET NO. 8



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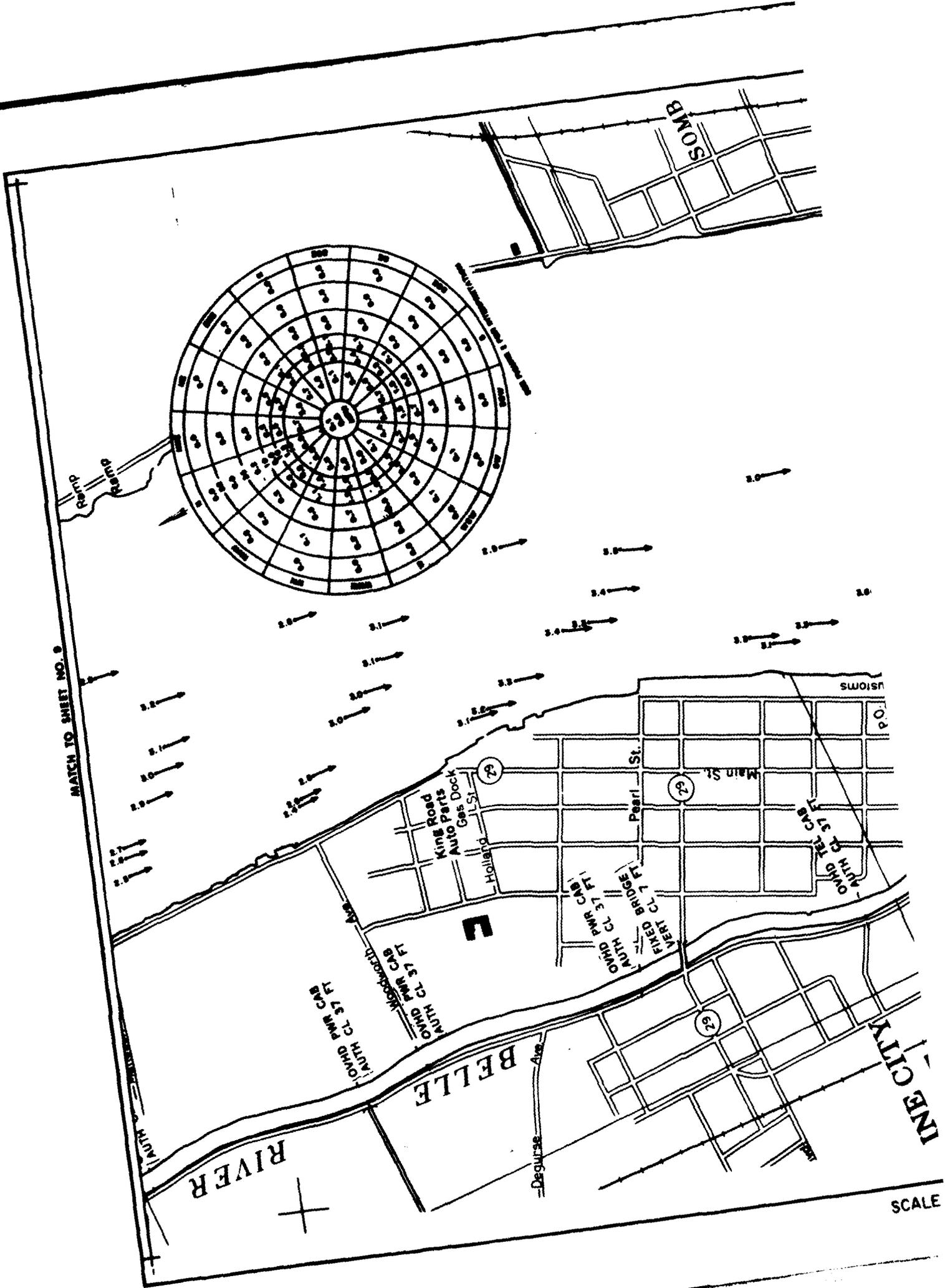


MATCH TO SHEET NO. 10

10,

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SHEET NO. 9



MACH TO SHEET NO. 9

SOMB

RIVER

BELLE

THE CITY

CUSTOMS

PEARL ST.

MAIN ST.

HOLLAND ST.

KING ROAD

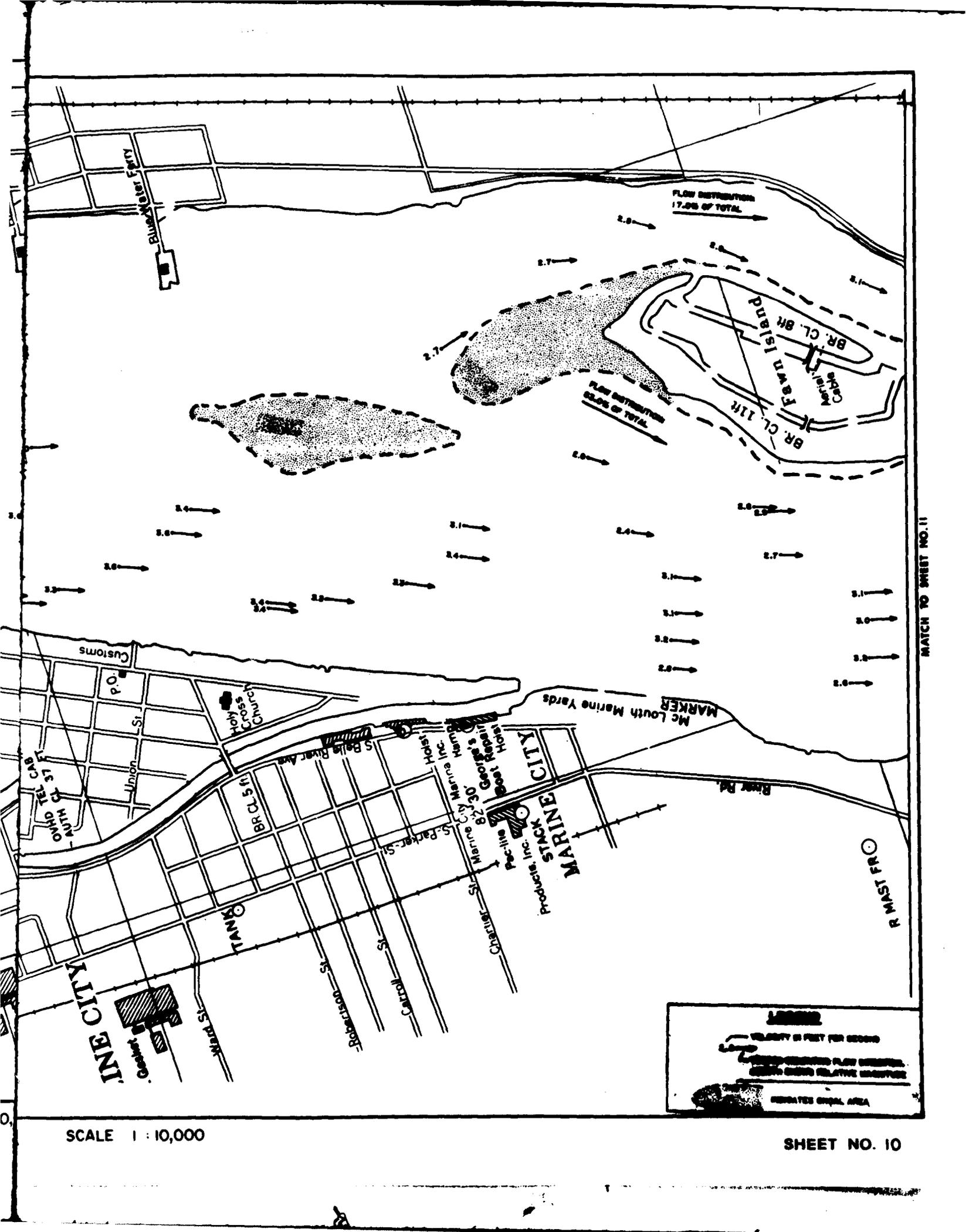
AUTO PARTS

GAS DOCK

FIXED BRIDGE

OLD PWR CAB

SCALE



Blue Water Ferry

FLOW DISTRIBUTION
17.0% OF TOTAL

FLOW DISTRIBUTION
17.0% OF TOTAL

Customs

Holy Cross Church

Mc Louth Marine Yards
MARKER

MARIEN CITY

MARIEN CITY
SPANCK

LEGEND

VELOCITY IN FEET PER SECOND

FLOW DIRECTION

DEPTH

STIPPLED AREA

SCALE 1 : 10,000

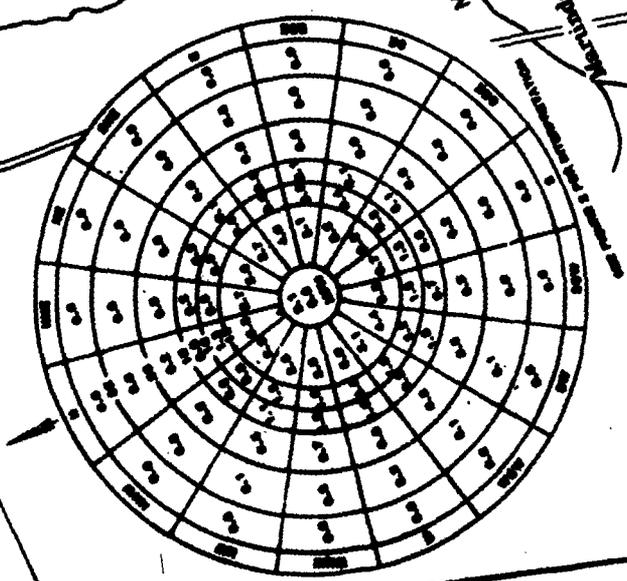
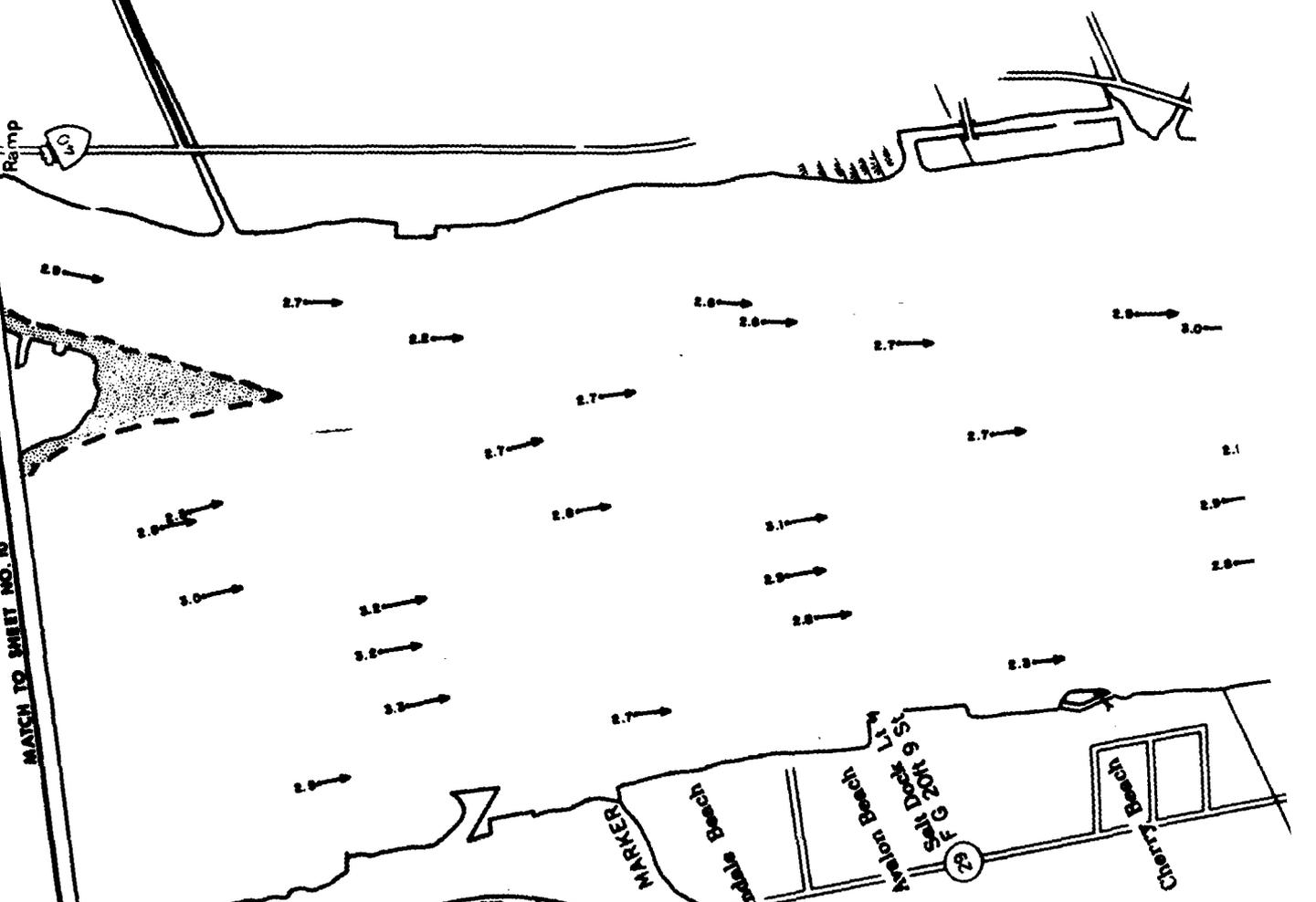
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MATCH TO SHEET NO. 11

Chesapeake & Ohio Railway

Ramp

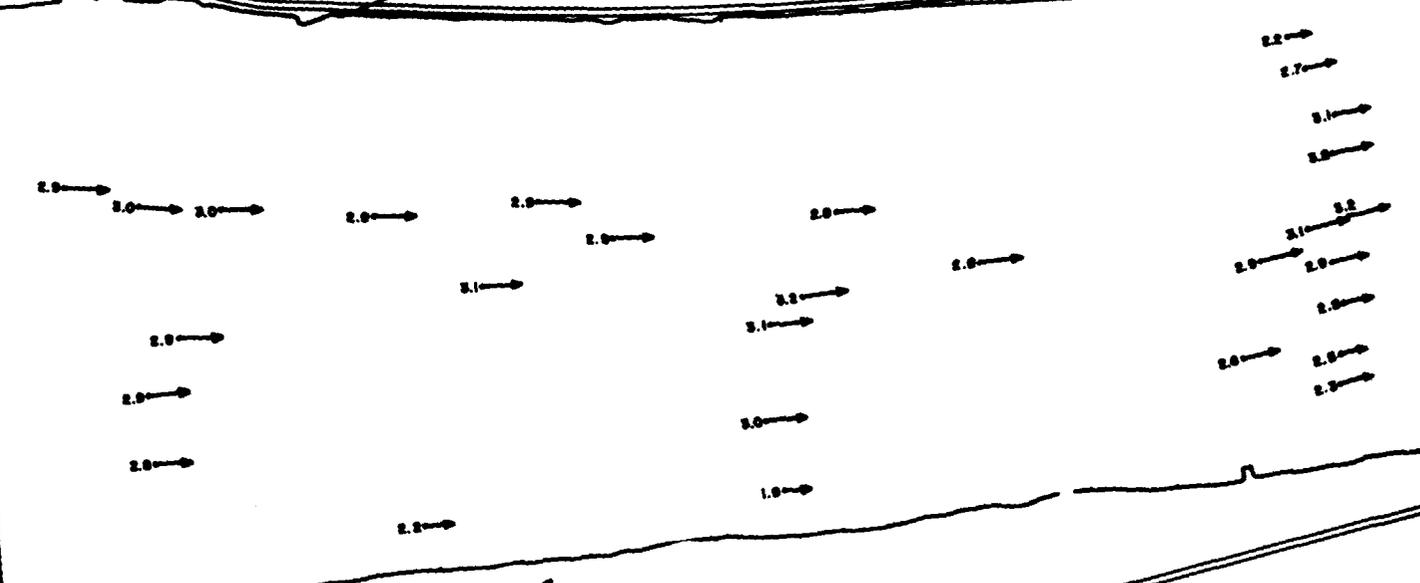
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SCALE 1:1

Marshy Creek

MATCH TO SHEET NO. 12



Cherry Beach

River Rd.

Broadbridge Rd.

Broadbridge Station

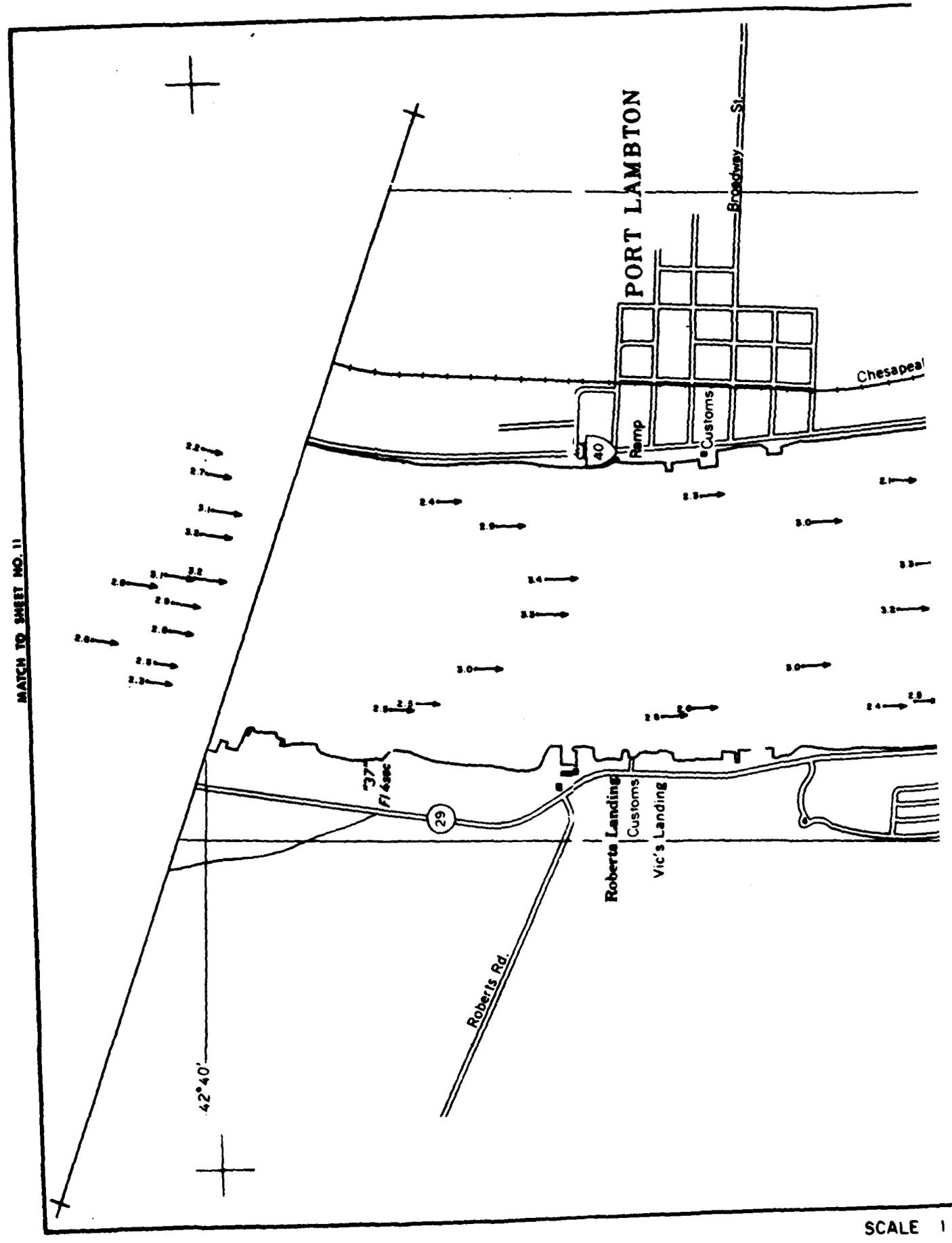
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- VELOCITY IN FEET PER SECOND
- WATER SURFACE ELEVATION
- CHANNEL CROSS SECTION
- INDICATED SPECIAL AREA

SHEET NO. 11

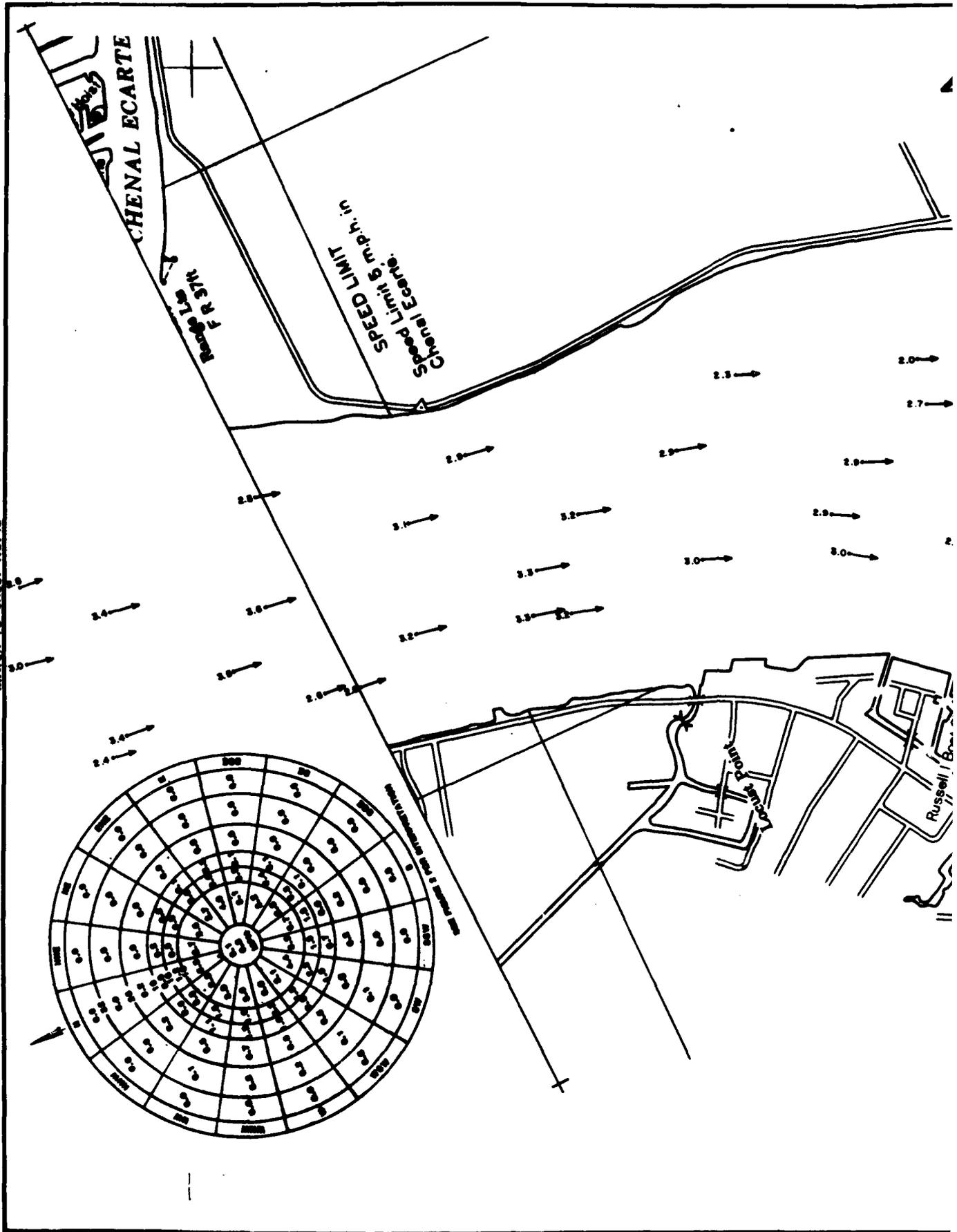
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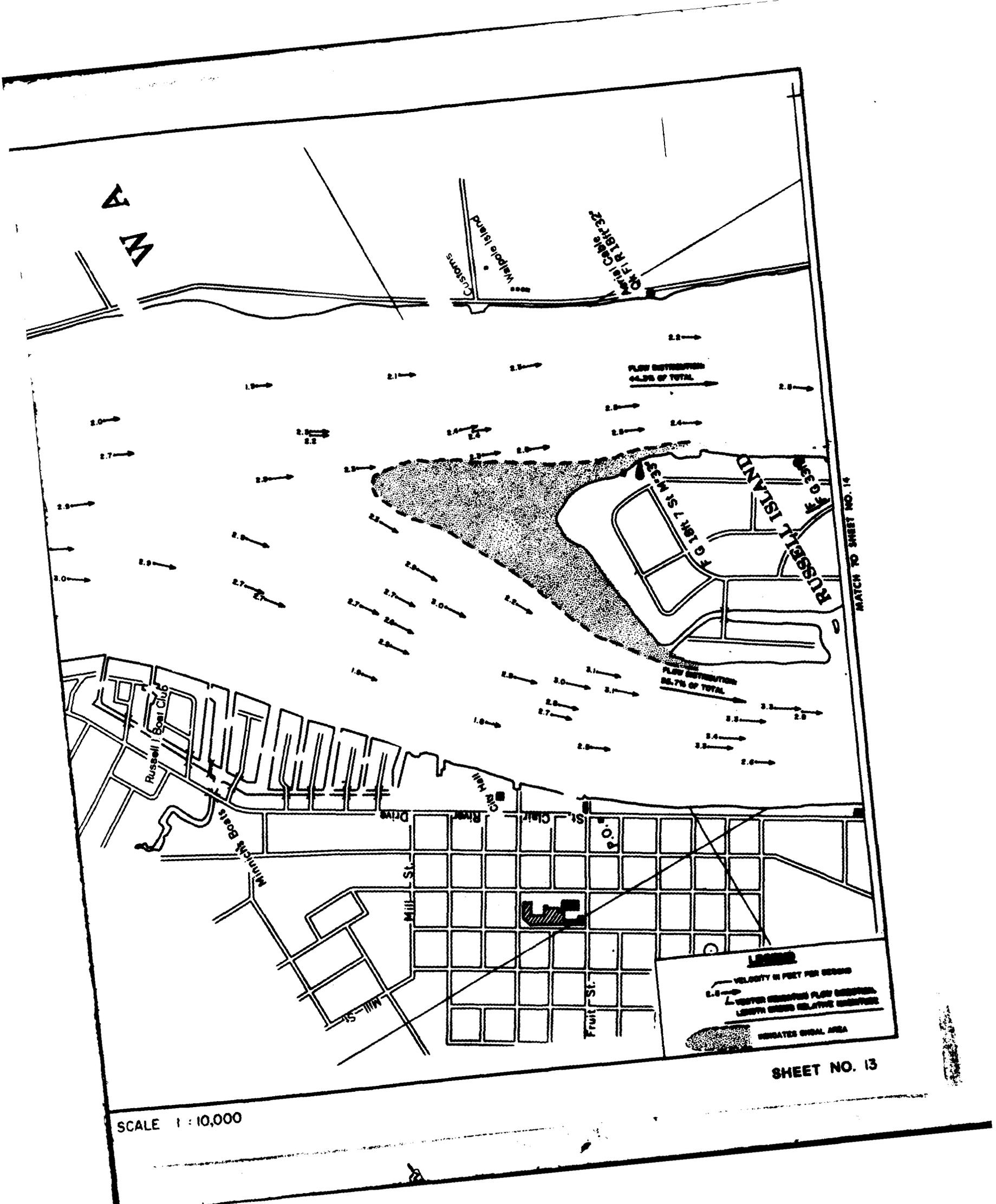


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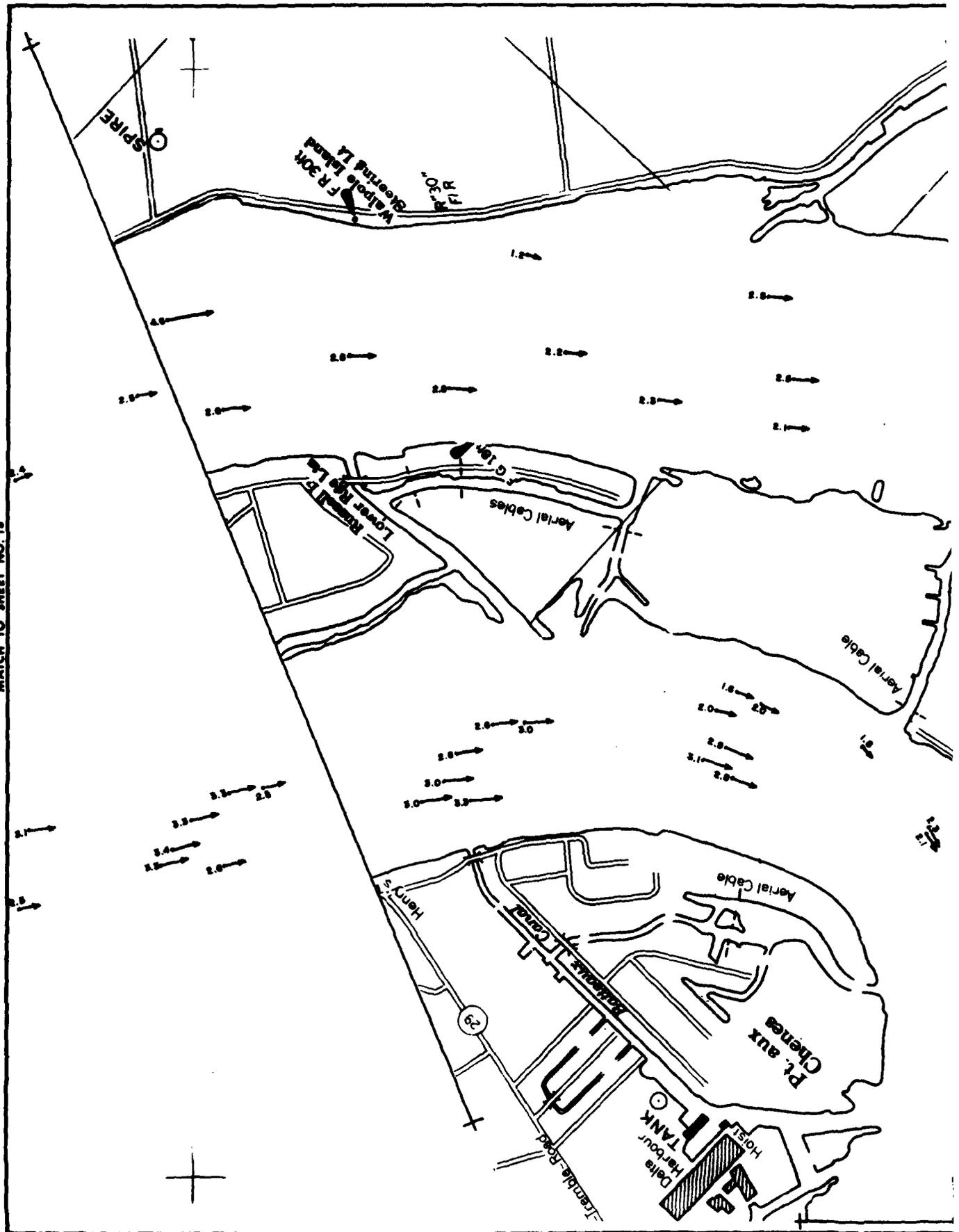


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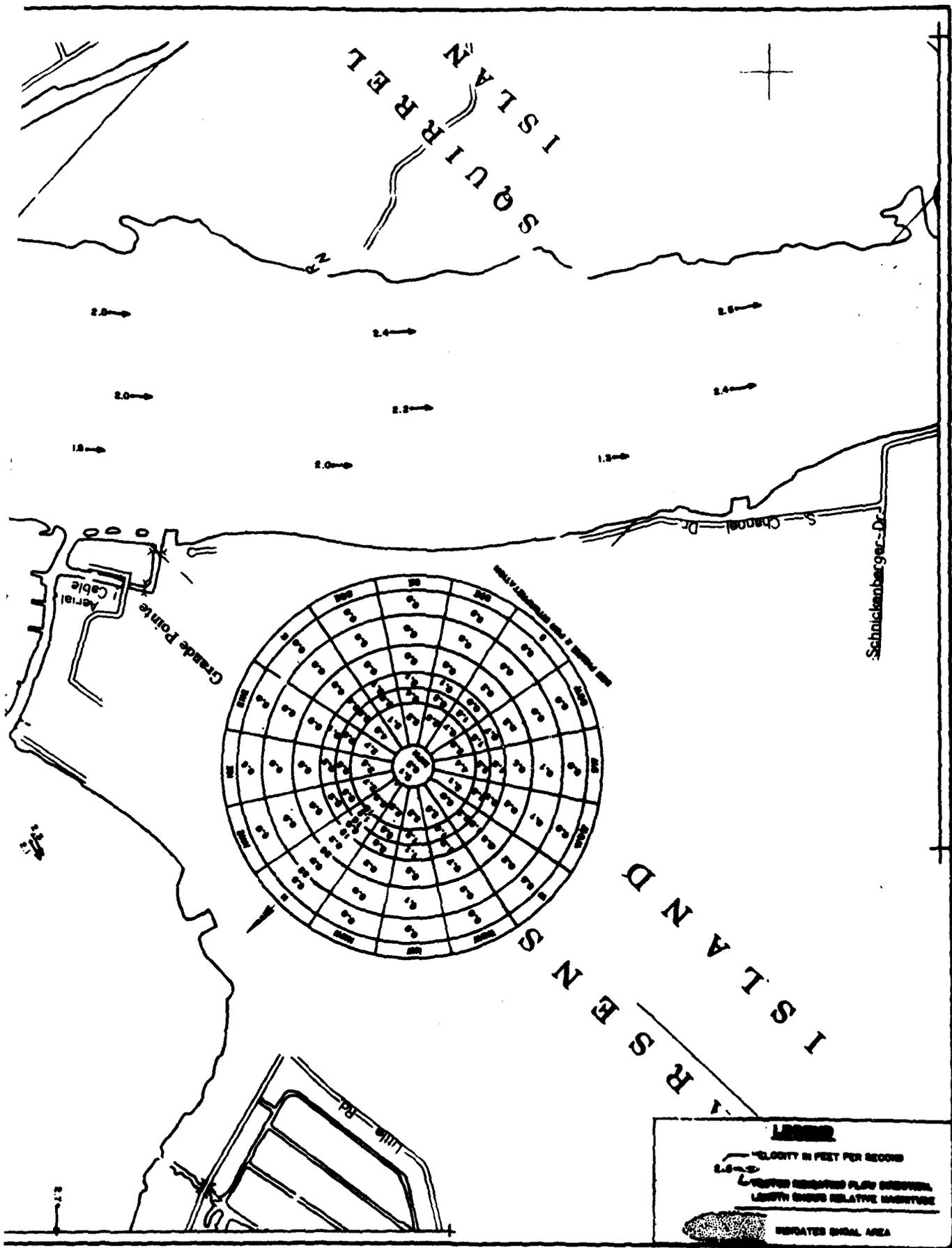
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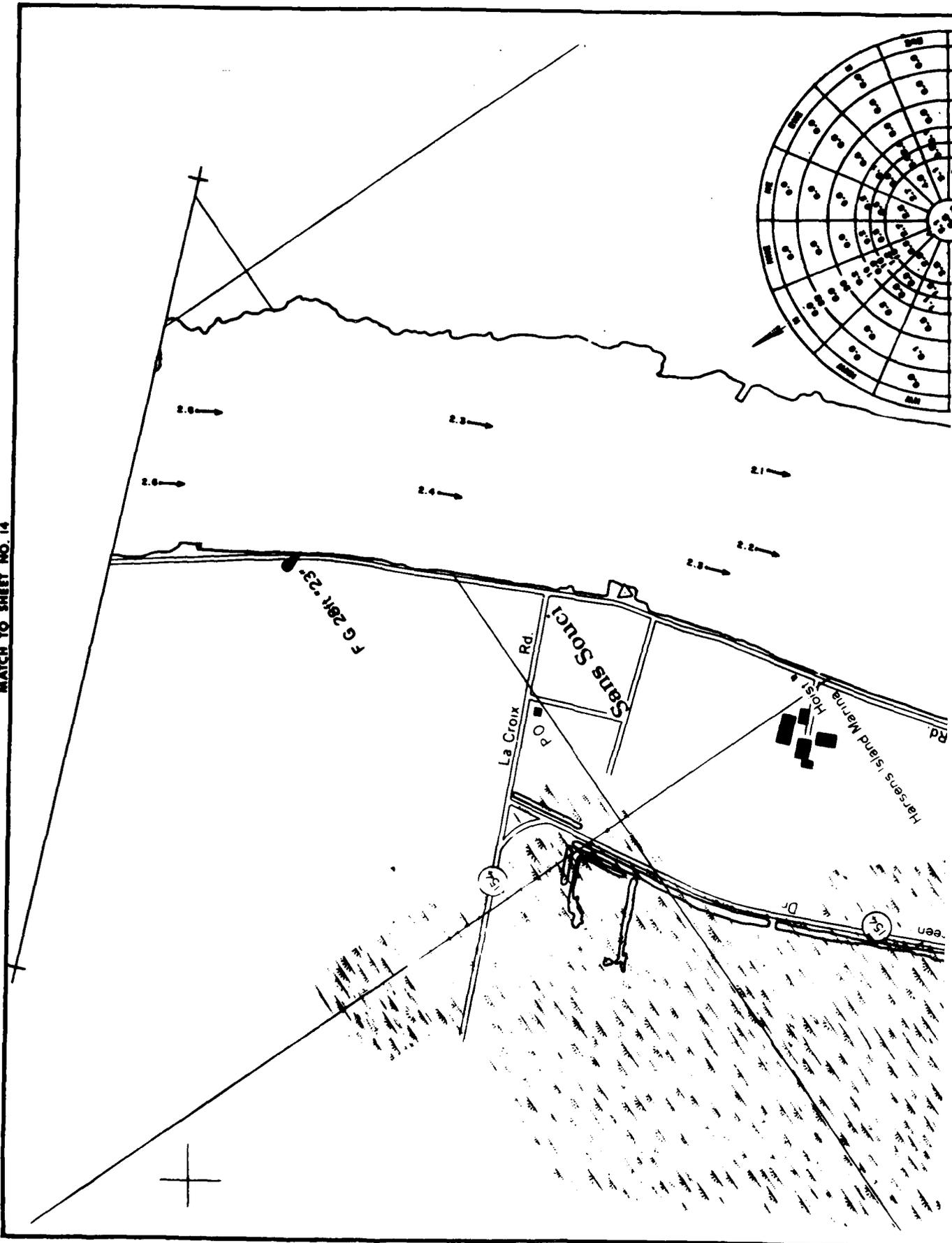
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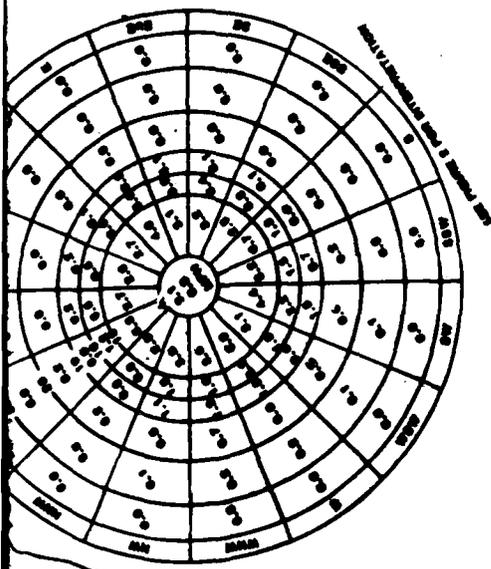
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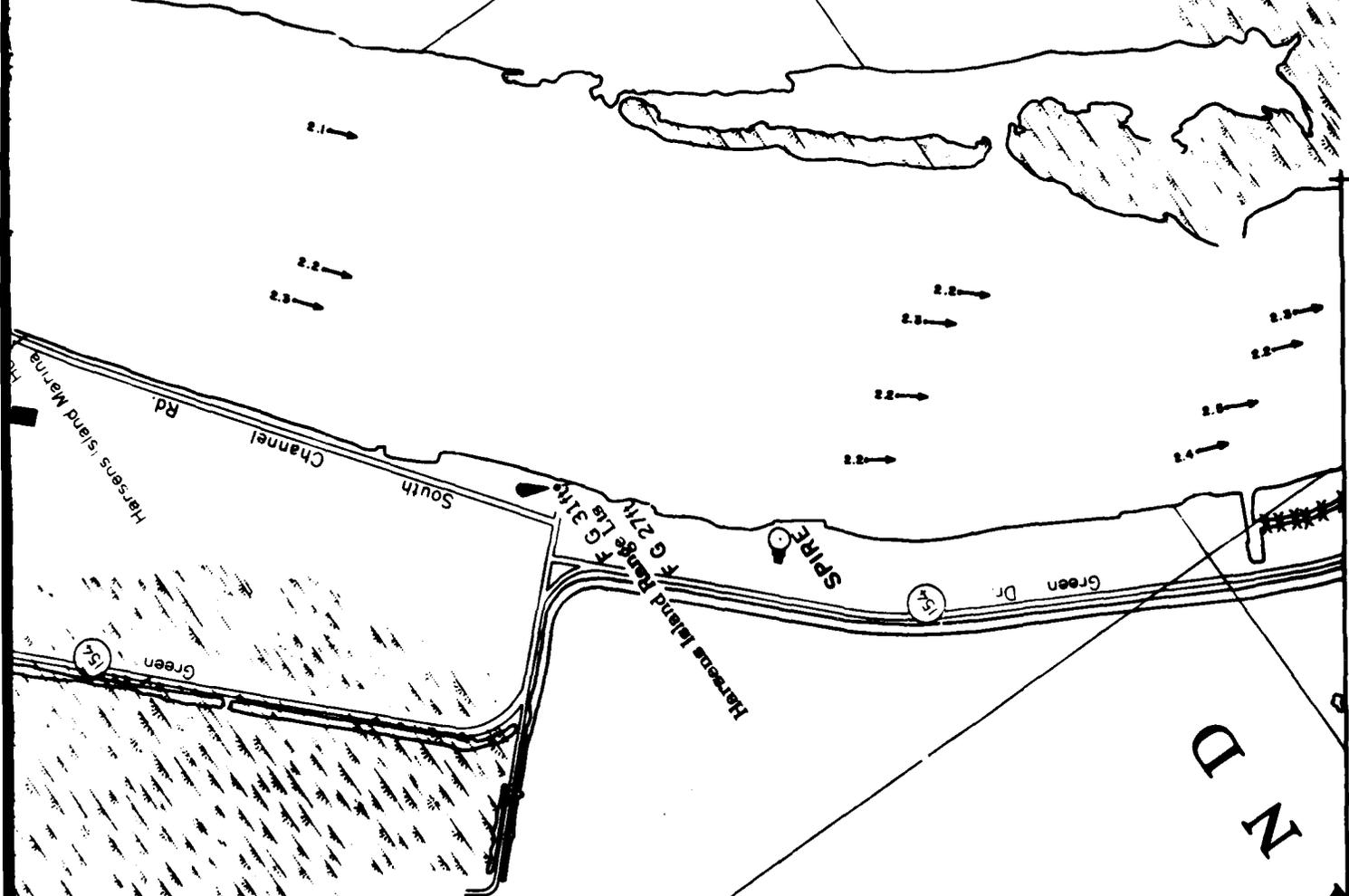
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SCALE 1



FRIDAY



MATCH TO SHEET NO. 14

LEGEND

— VELOCITY IN FEET PER SECOND

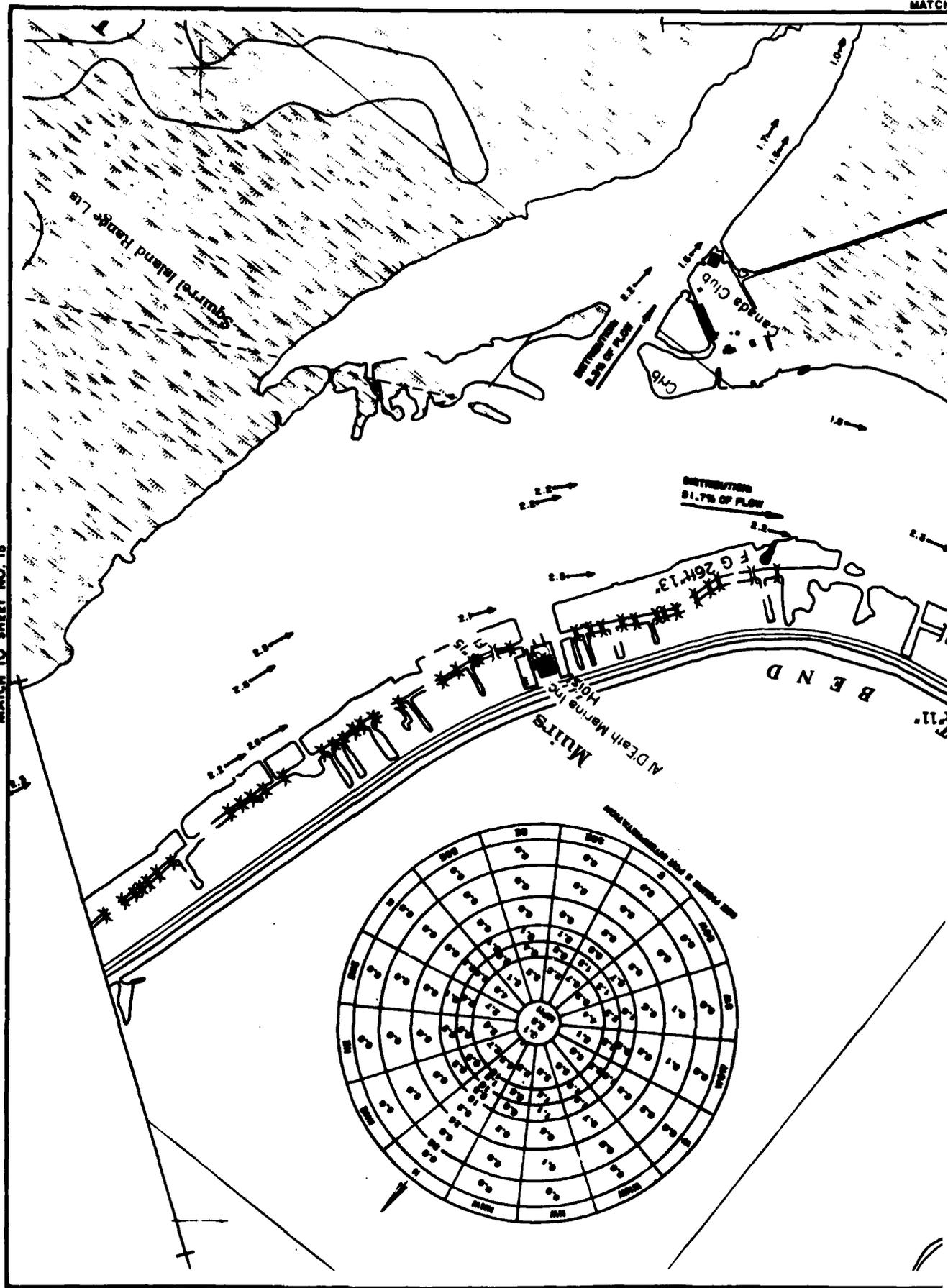
→ VECTOR INDICATING FLOW DIRECTION, LENGTH SHOWS RELATIVE MAGNITUDE

▨ INDICATES SHOAL AREA

SCALE 1 : 10,000

SHEET NO. 15

MATCH TO SHEET NO. 15



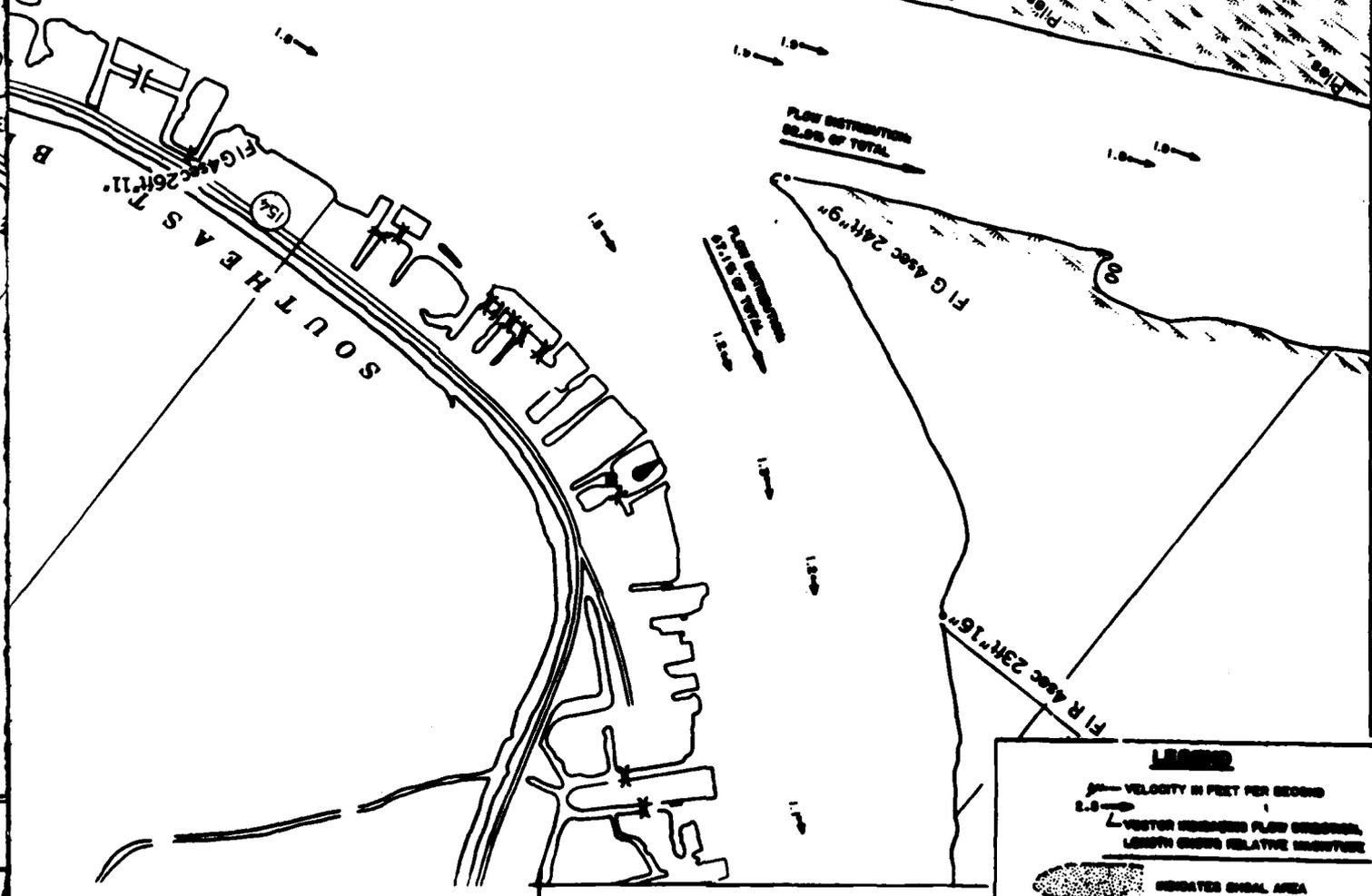
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WESTERN BASSETS

232

100
10

MATCH TO SHEET NO. 17



LEGEND

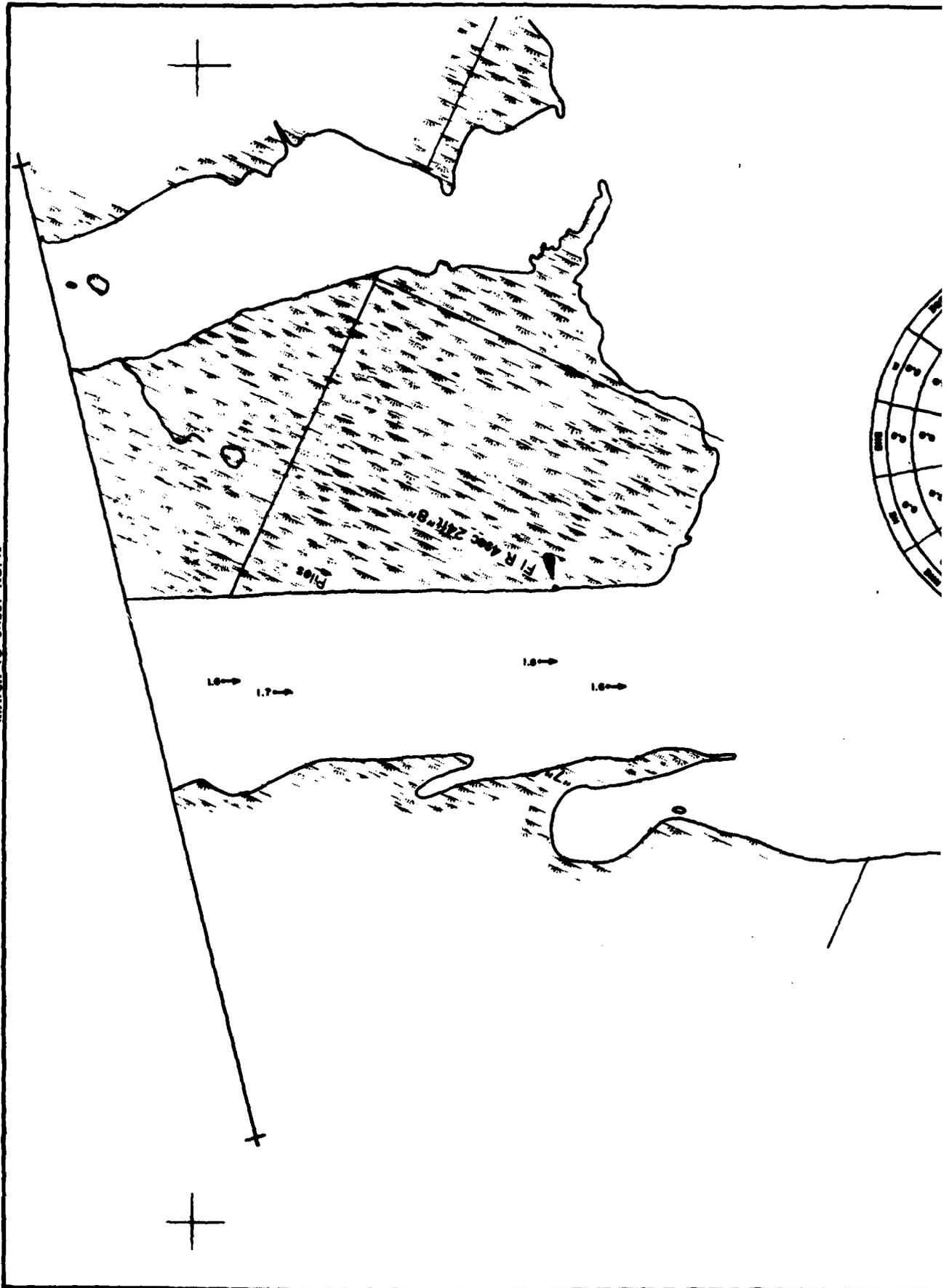
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- LENGTHS CROSS RELATIVE MAGNITUDE
- SHADES SPECIAL AREA

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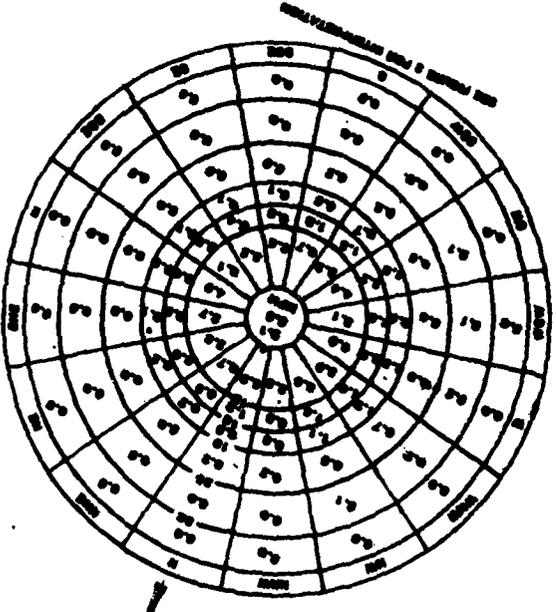
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SHEET NO. 16

MATCH TO SHEET NO. 16



SCALE



ISLAND

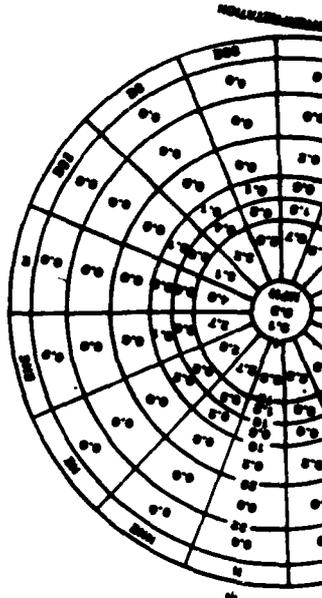
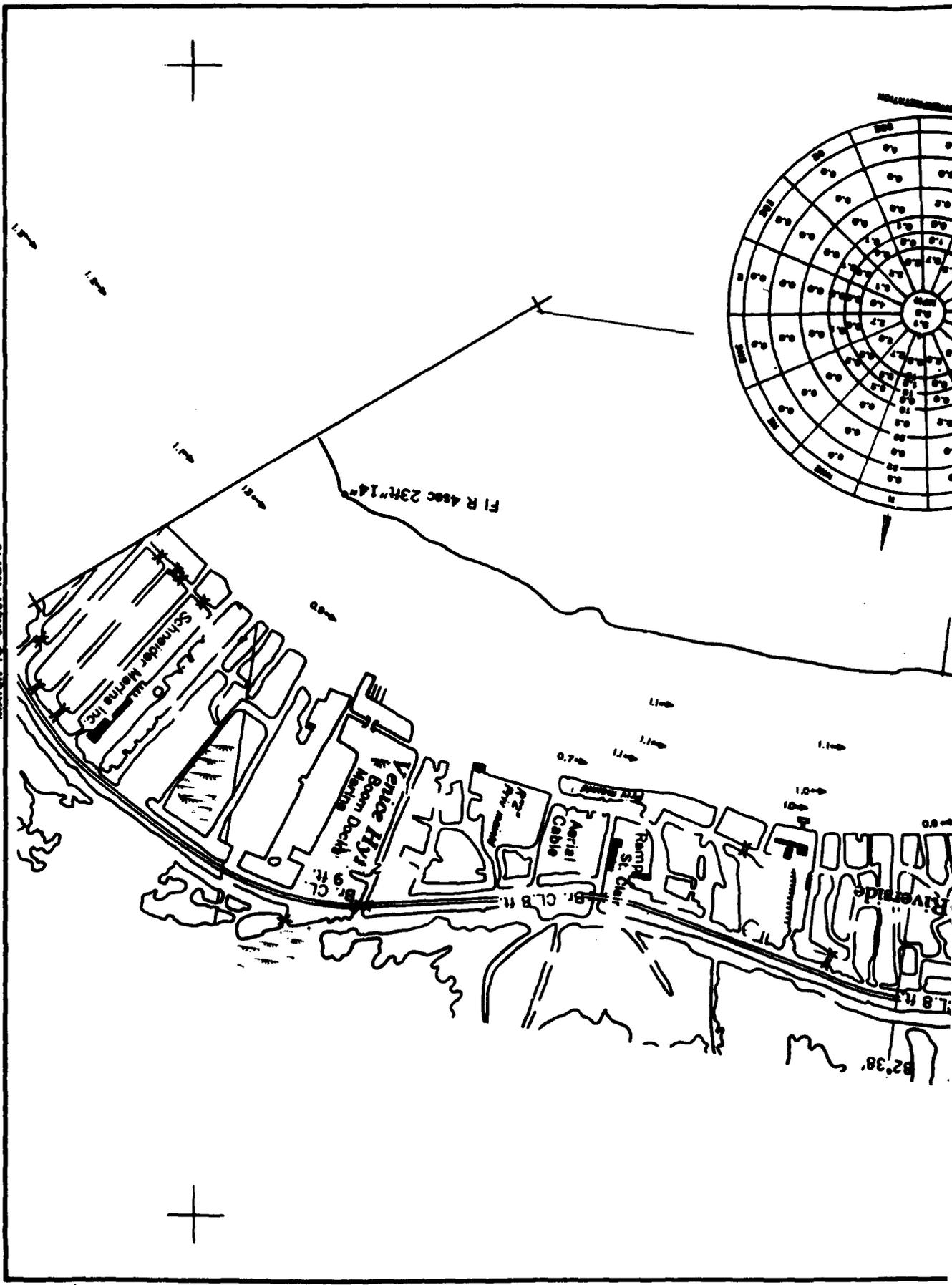
SEAWAY

LEGEND

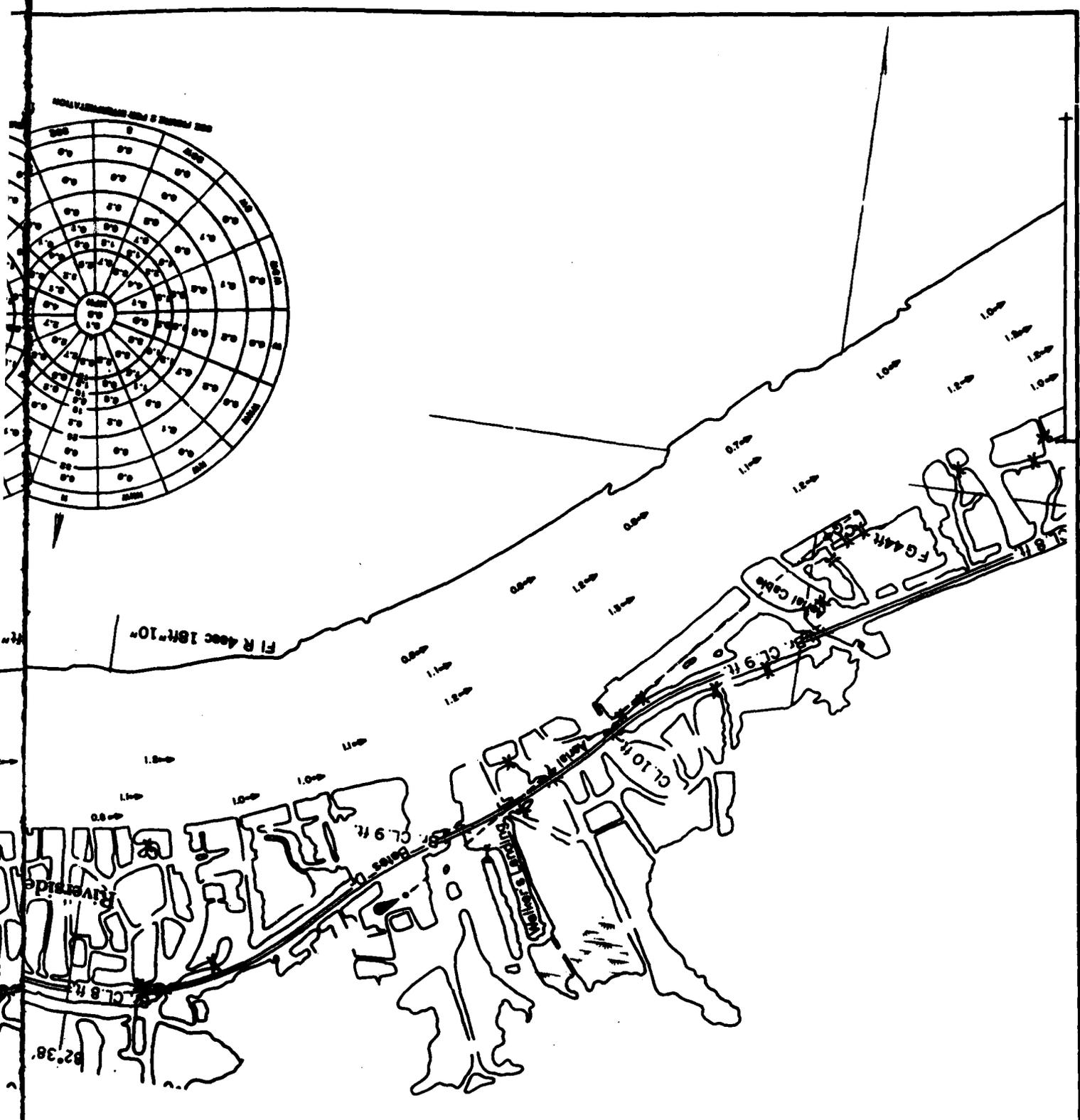
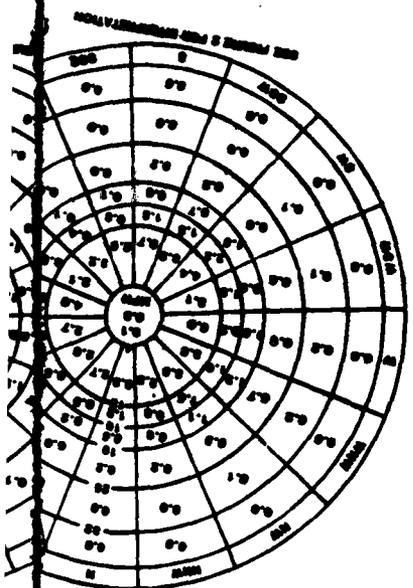
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- VELOCITY VECTOR: FLUX DIRECTION, LENGTH SHOWS RELATIVE MAGNITUDE
- ▨ REVEALED BRUSH AREA

MATCH TO SHEET NO.

MATCH TO SHEET NO. 16



SCALE



MATCH TO SHEET NO. 15

LEGEND

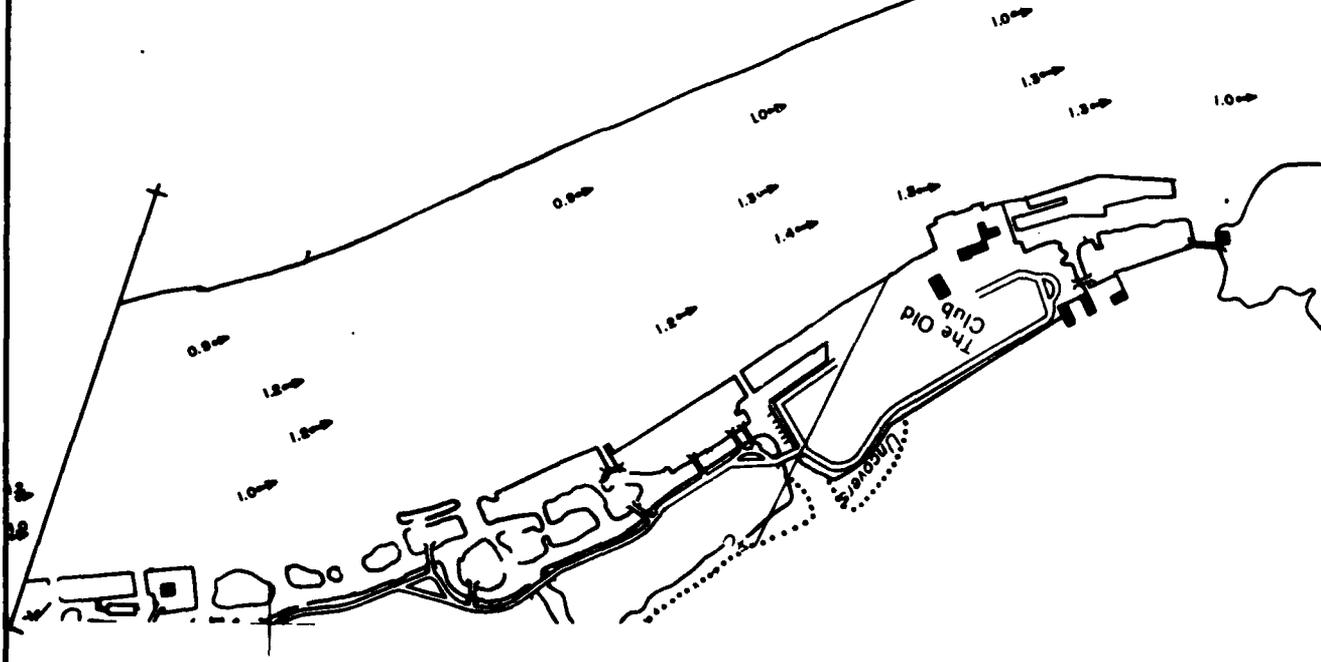
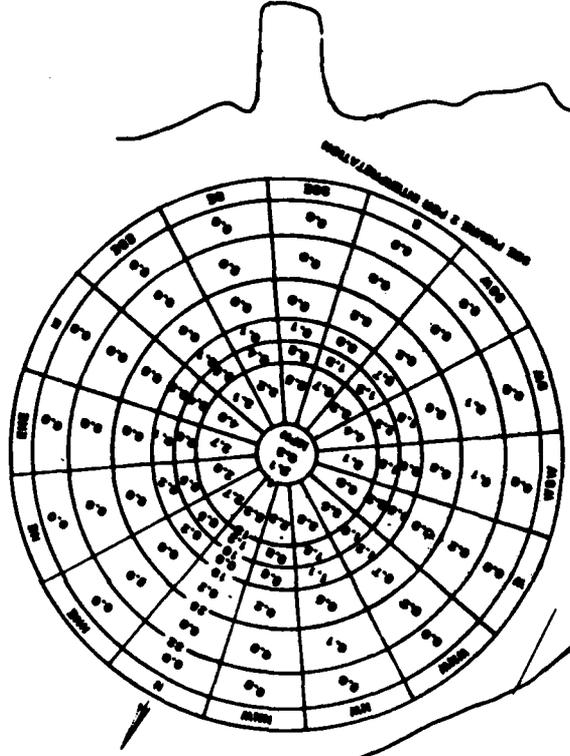
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- VECTOR INDICATES FLOW DIRECTION, LENGTH SHOWS RELATIVE MAGNITUDE
- SHADDED CHAN. AREA

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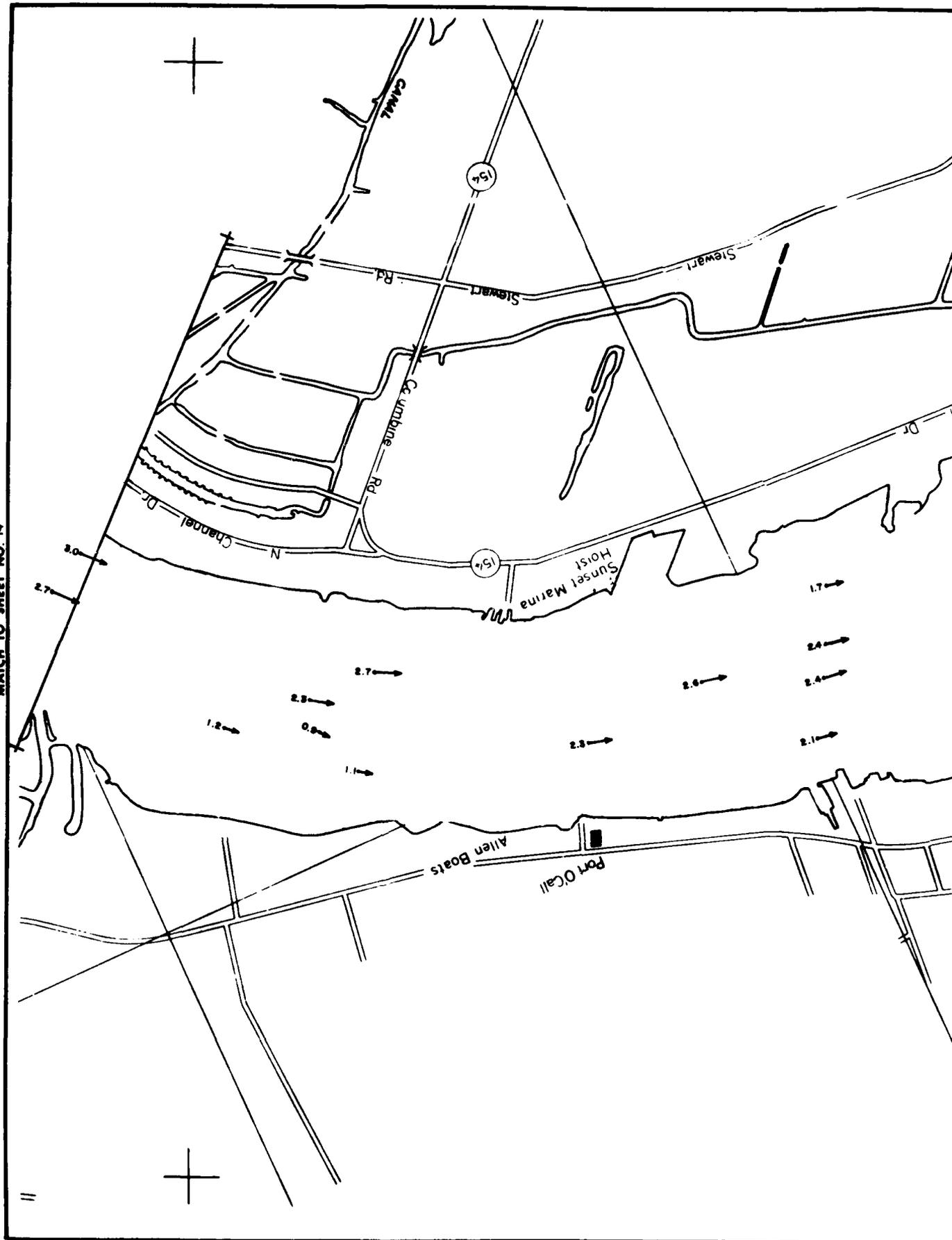
SHEET NO. 18



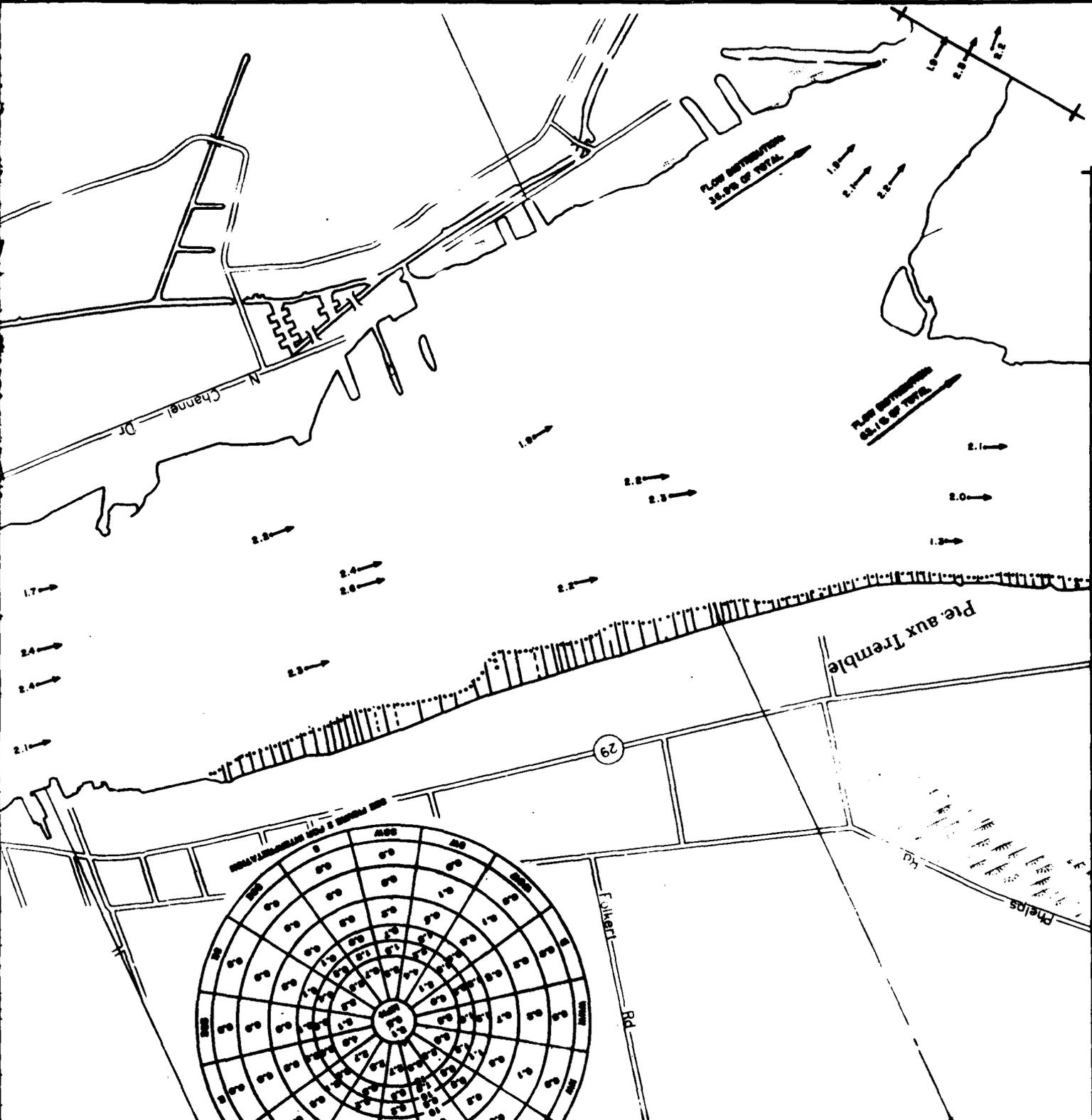
MATCH TO SHEET NO. 18



SCALE

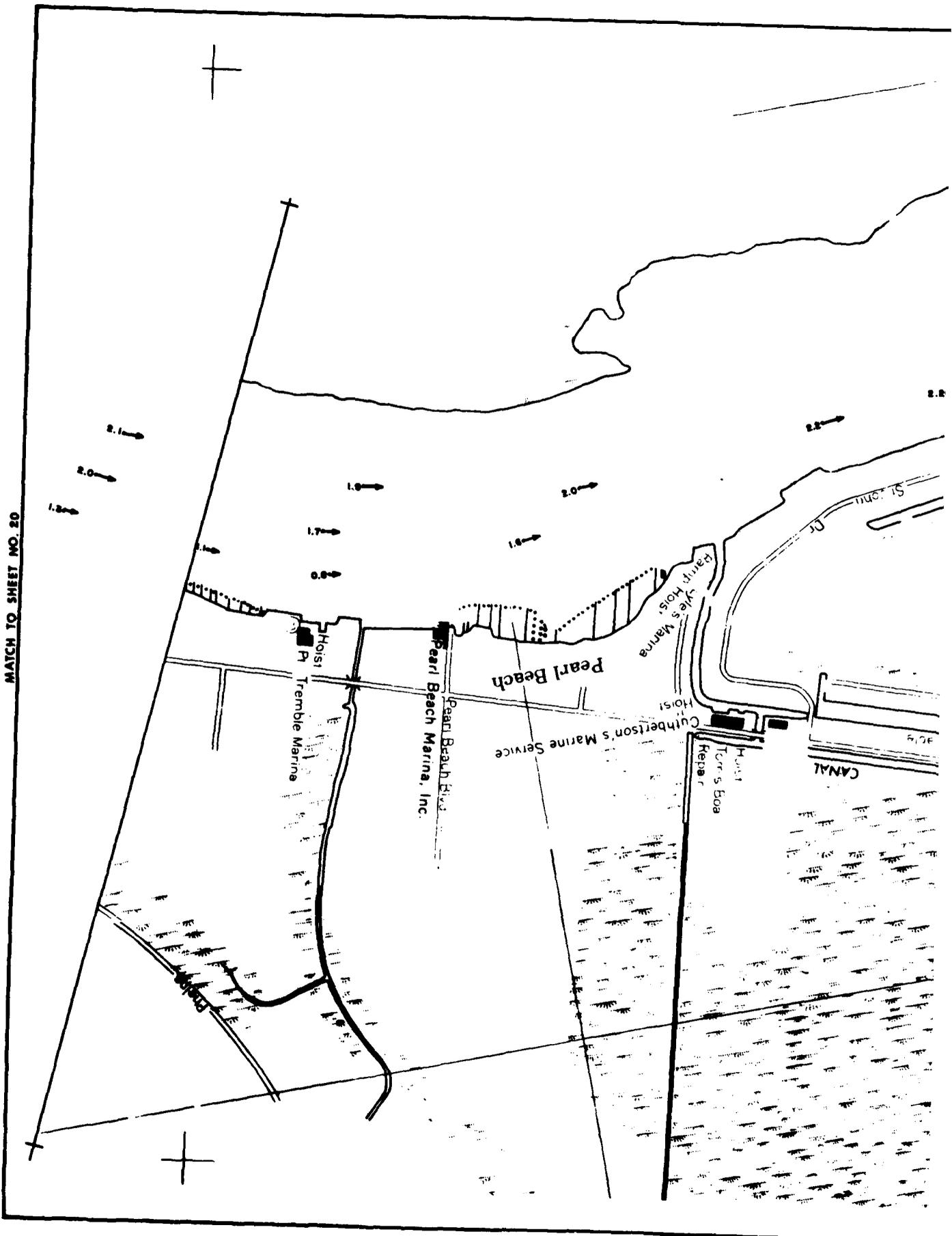


SCALE 1 :



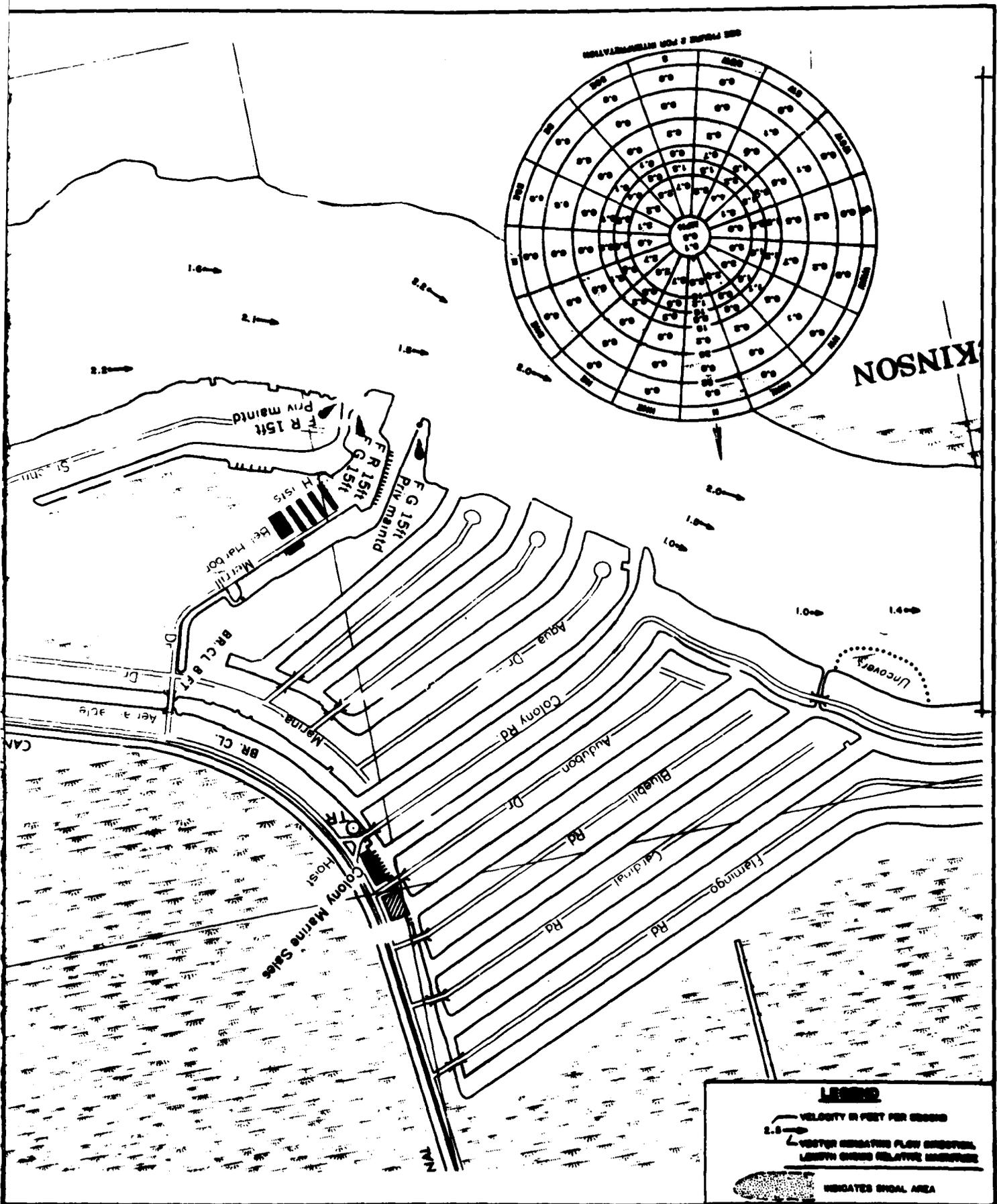
LEGEND

- VELOCITY IN FEET PER SECOND
- VECTOR INDICATES FLOW DIRECTION, LENGTH SHOWS RELATIVE VELOCITY
- ▨ INDICATES SHOAL AREA



MATCH TO SHEET NO. 20

SCALE 1 : 1



KINSON

MATCH TO SHEET NO. 22

LEGEND

— VELOCITY IN FEET PER SECOND

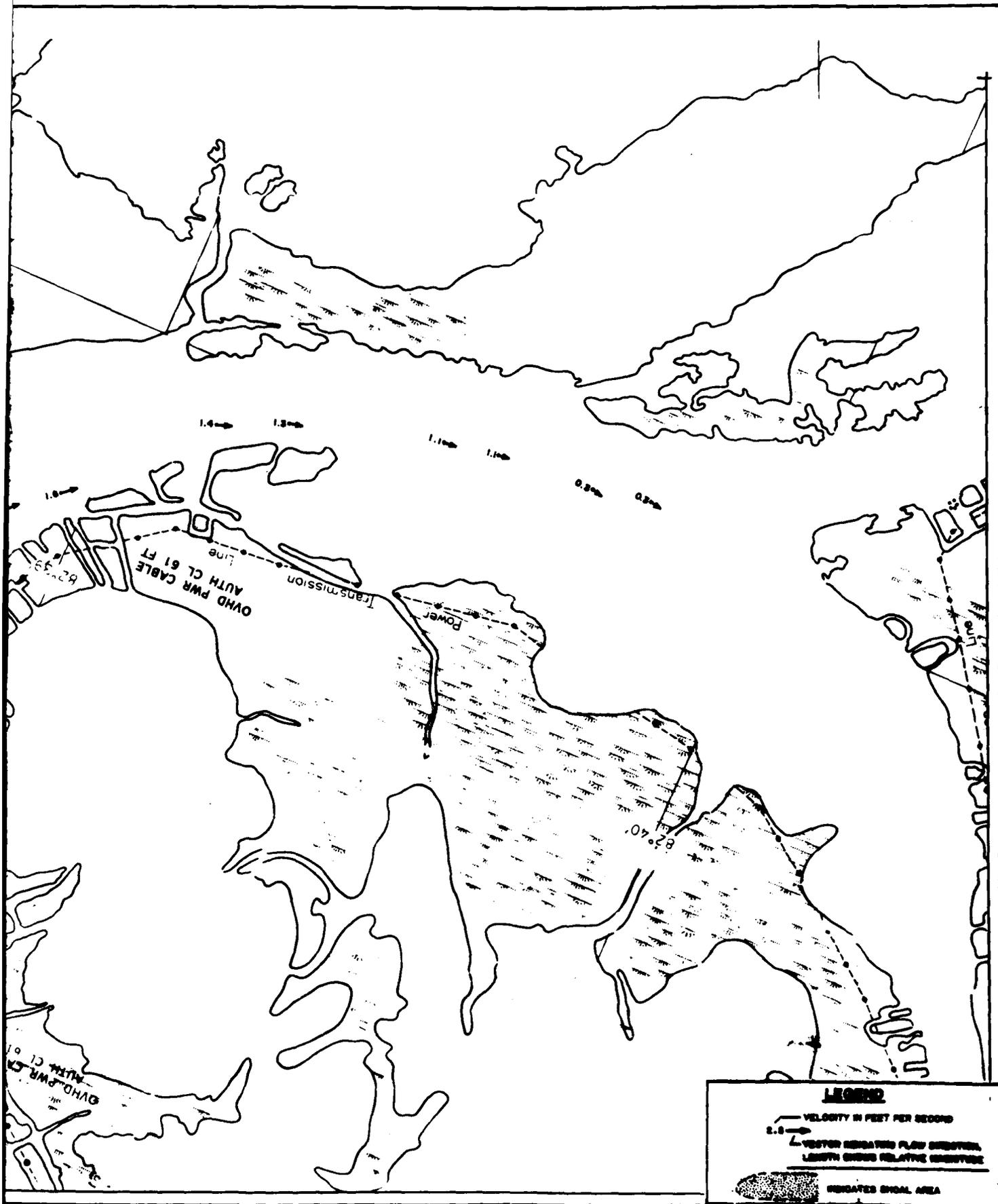
2.5 —

— VECTOR INDICATING FLOW DIRECTION, LENGTH SHOWS RELATIVE VELOCITY

▨ INDICATED SPECIAL AREA

SCALE 1 : 10,000

SHEET NO. 21



MATCH TO SHEET NO. 23

LEGEND

— VELOCITY IN FEET PER SECOND

2.0 →

→ VECTORS INDICATE FLOW DIRECTION, LENGTH SHOWS RELATIVE VELOCITY

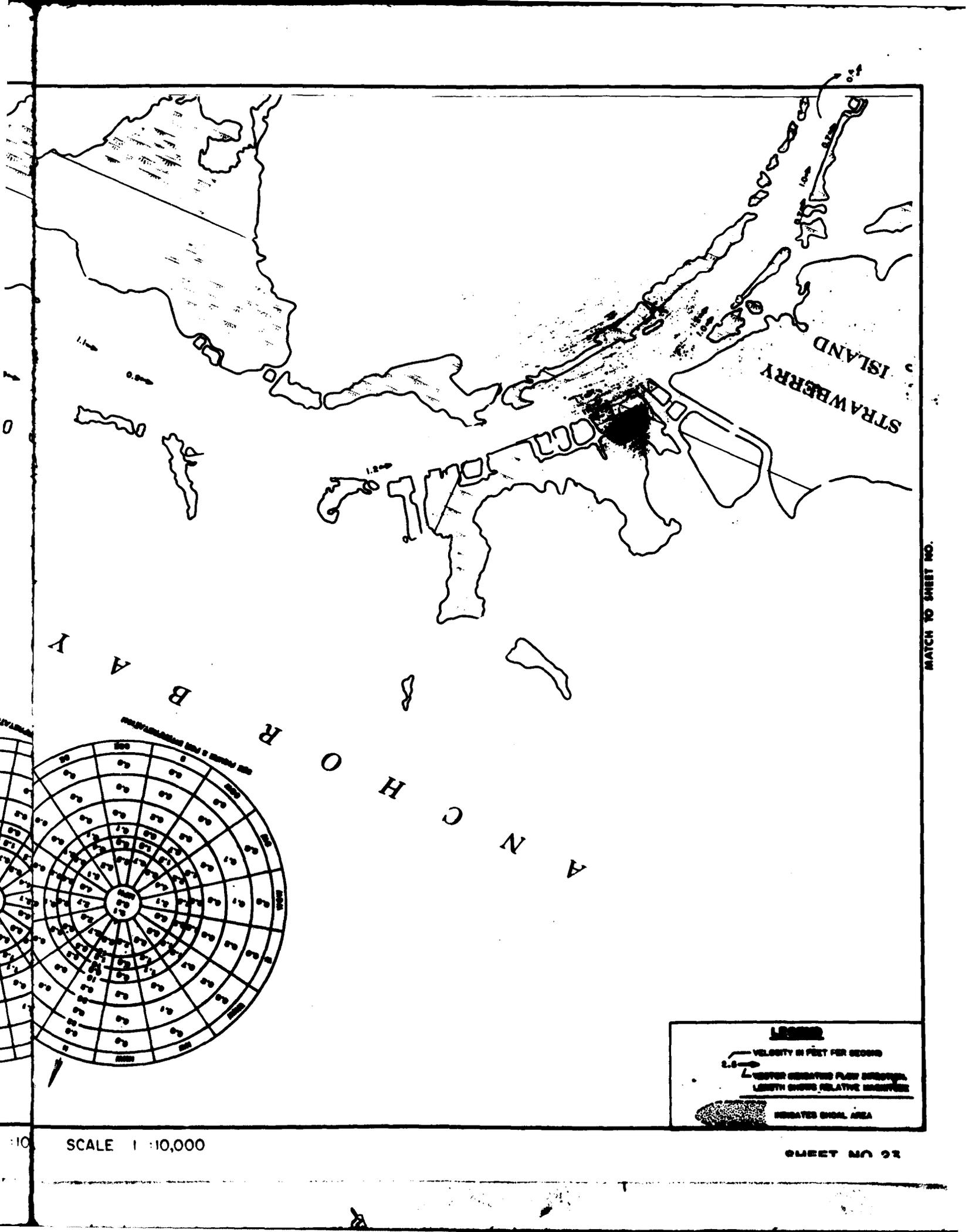
▨ HAZARDOUS SIGNAL AREA

SCALE 1:10,000

MATCH TO SHEET NO. 24

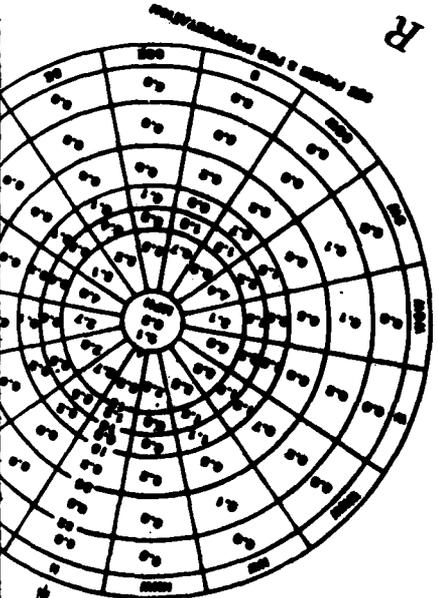
SHEET NO. 22





STRAWBERRY ISLAND

HAWAIIAN ISLANDS



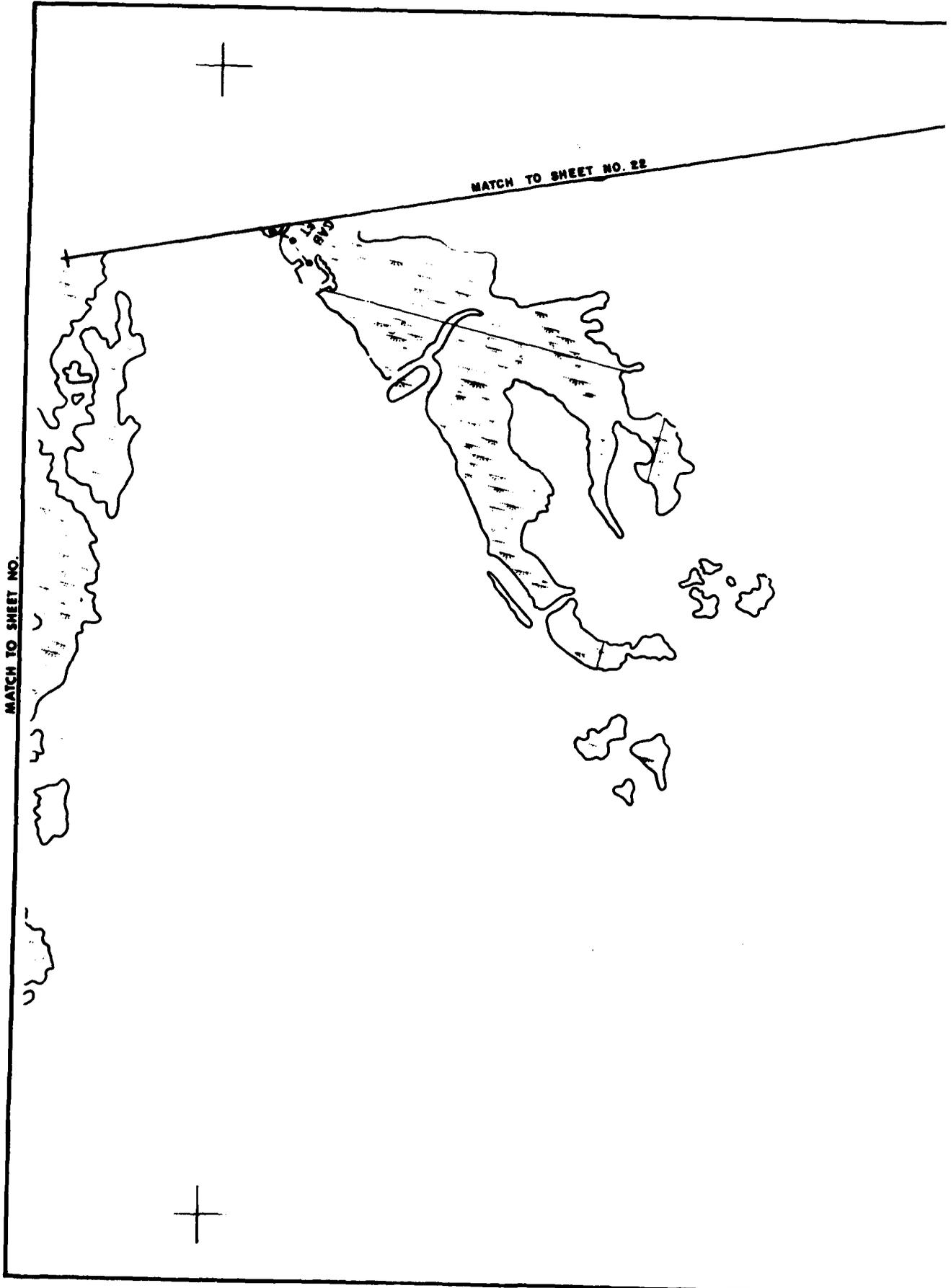
LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY INDICATING FLOW DIRECTION, LENGTH SHOWS RELATIVE MAGNITUDE
- INDICATES SHALOW AREA

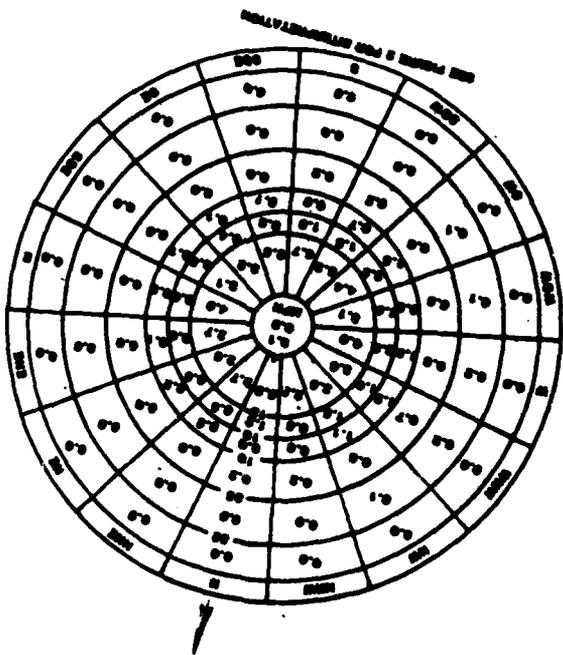
SCALE 1:10,000

SHEET NO. 22

MATCH TO SHEET NO.



SCAL



LEGEND

— VELOCITY IN FEET PER SECOND

2.0 →

↗ VECTOR INDICATING FLOW DIRECTION
LENGTH SHOWS RELATIVE MAGNITUDE

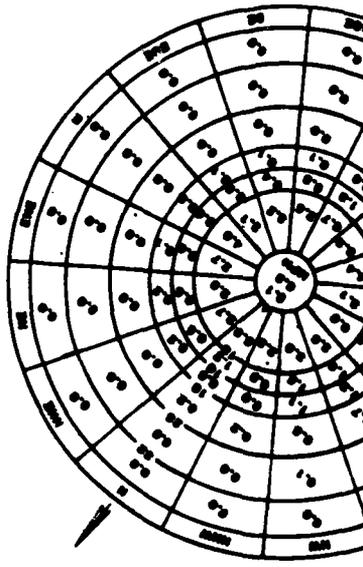
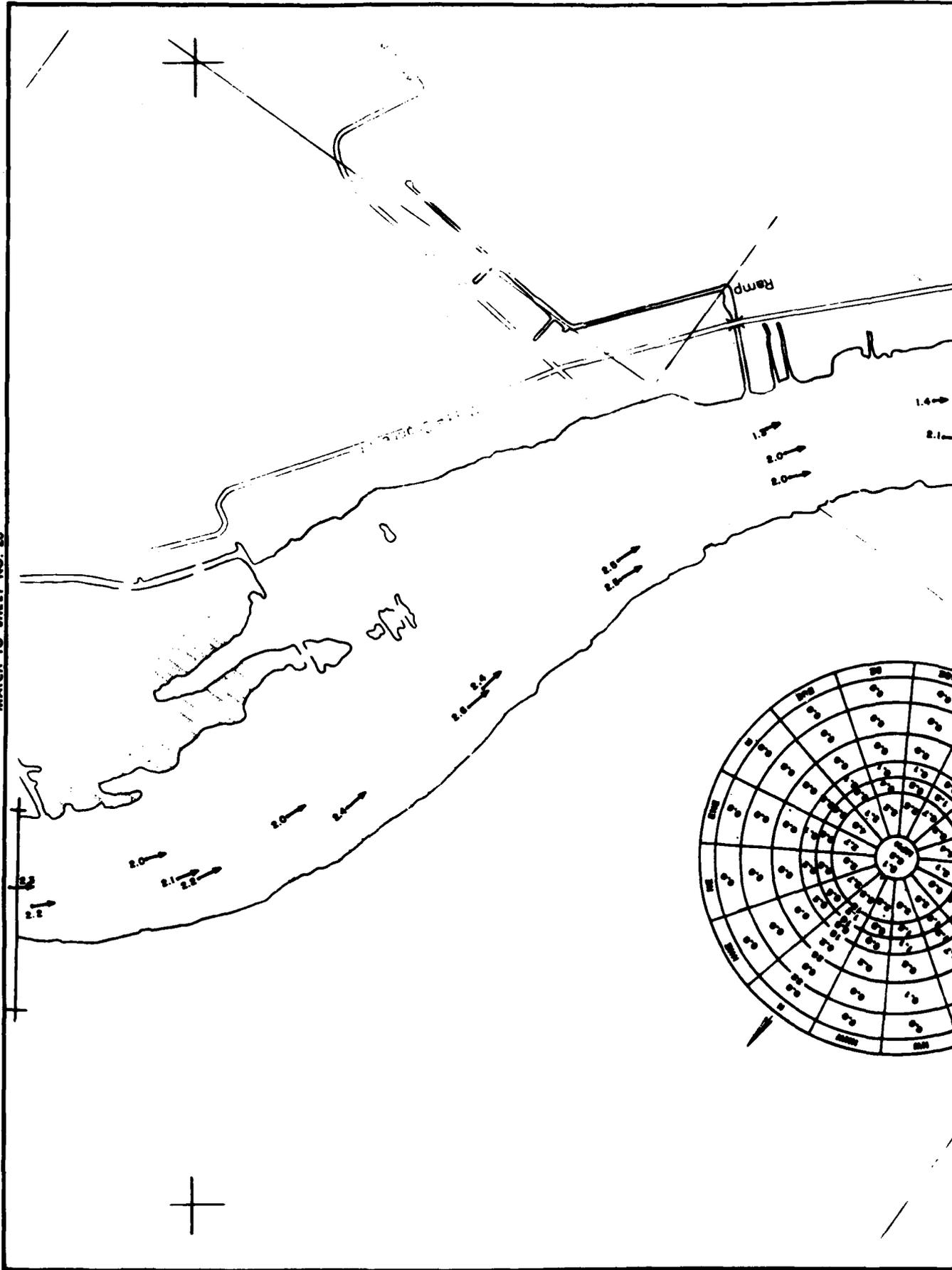
▨ INDICATES EQUAL AREA

MATCH TO SHEET NO. 4

SCALE 1 : 10,000

SHEET NO. 24

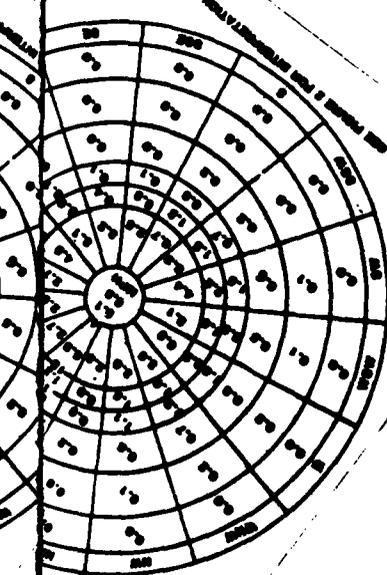
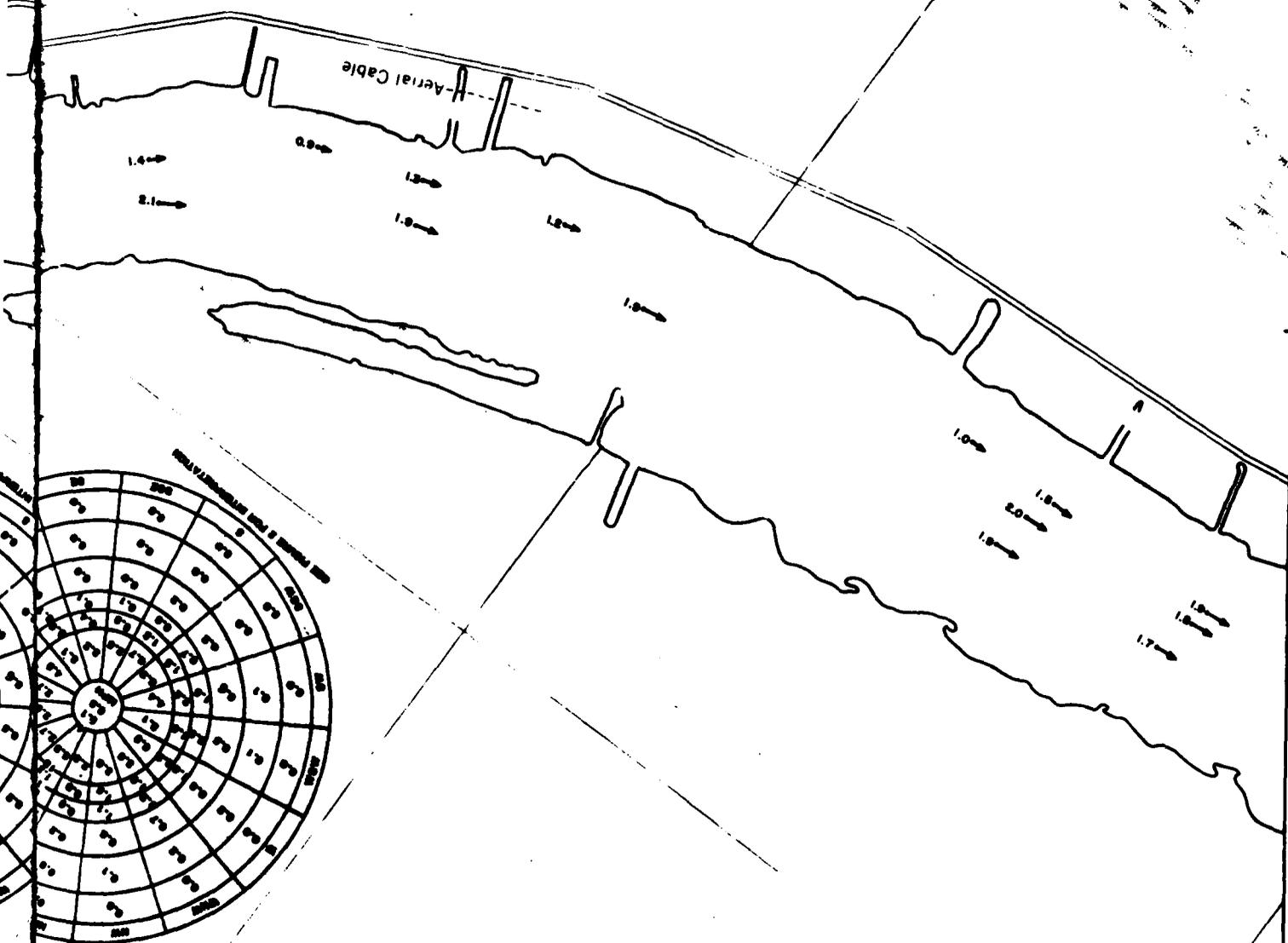
MATCH TO SHEET NO. 20



SCALE

H A R B O R

Aerial Cable



MARCH 1950 SHEET NO. 25

LEGEND

— VELOCITY IN FEET PER SECOND

2.5 —

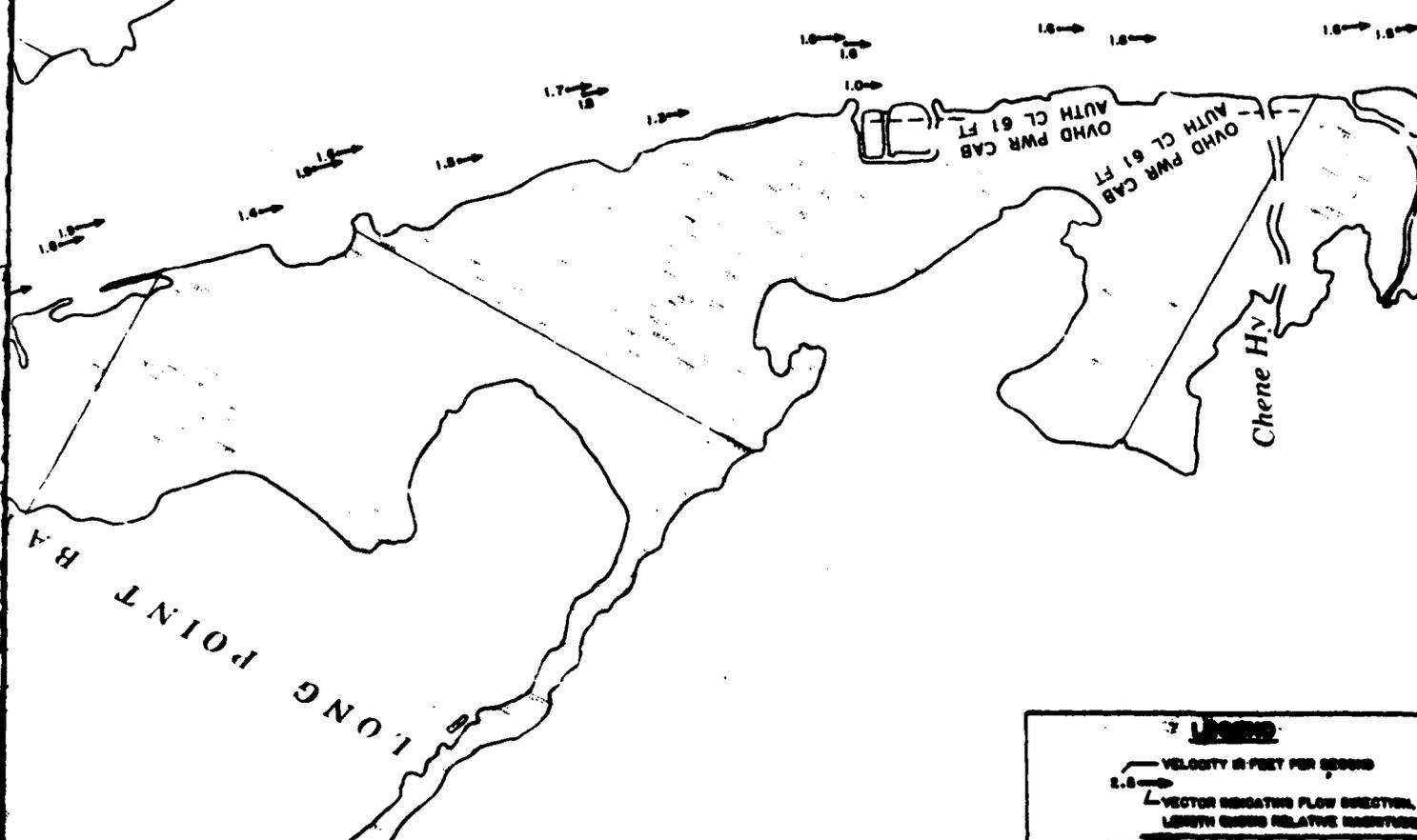
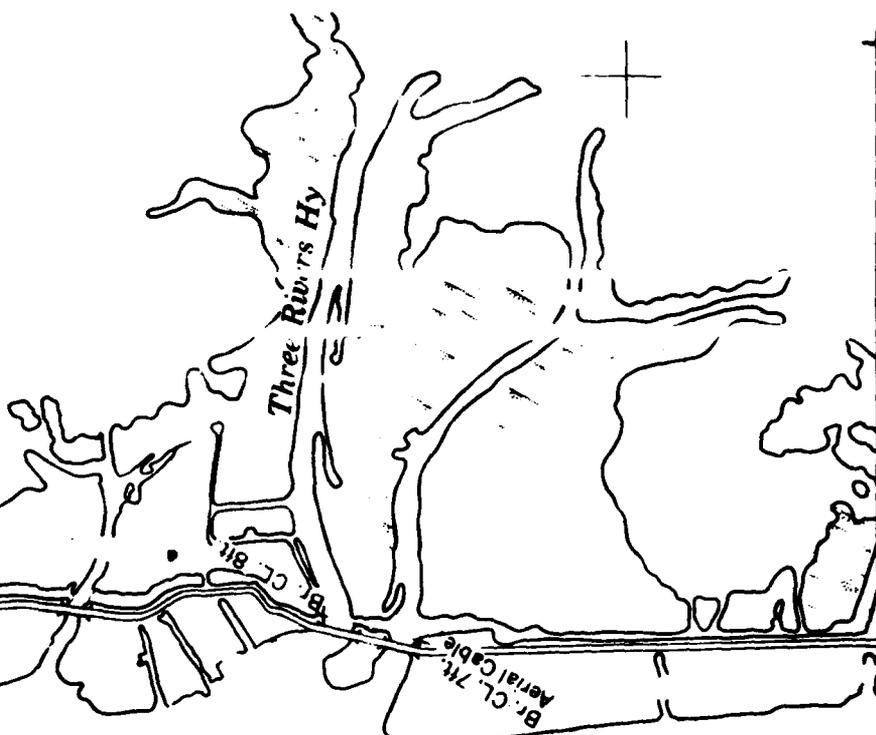
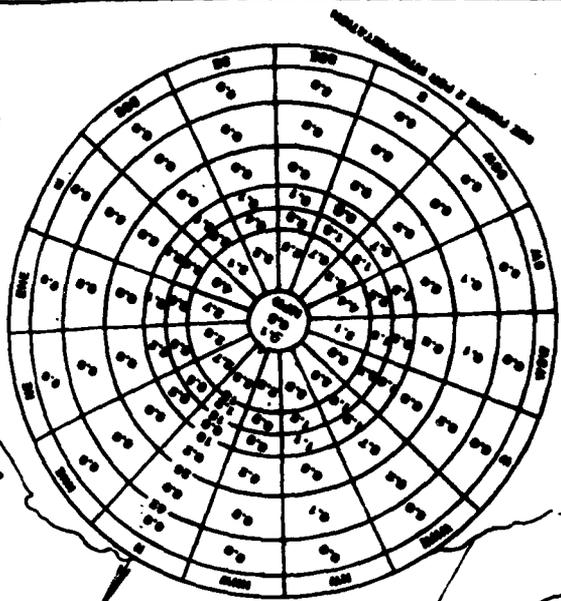
— VELOCITY INDICATING FLOW DIRECTION

— LENGTH SHOWS RELATIVE VELOCITY

— Hatched area

SCALE 1:10,000

SHEET NO. 25



Legend

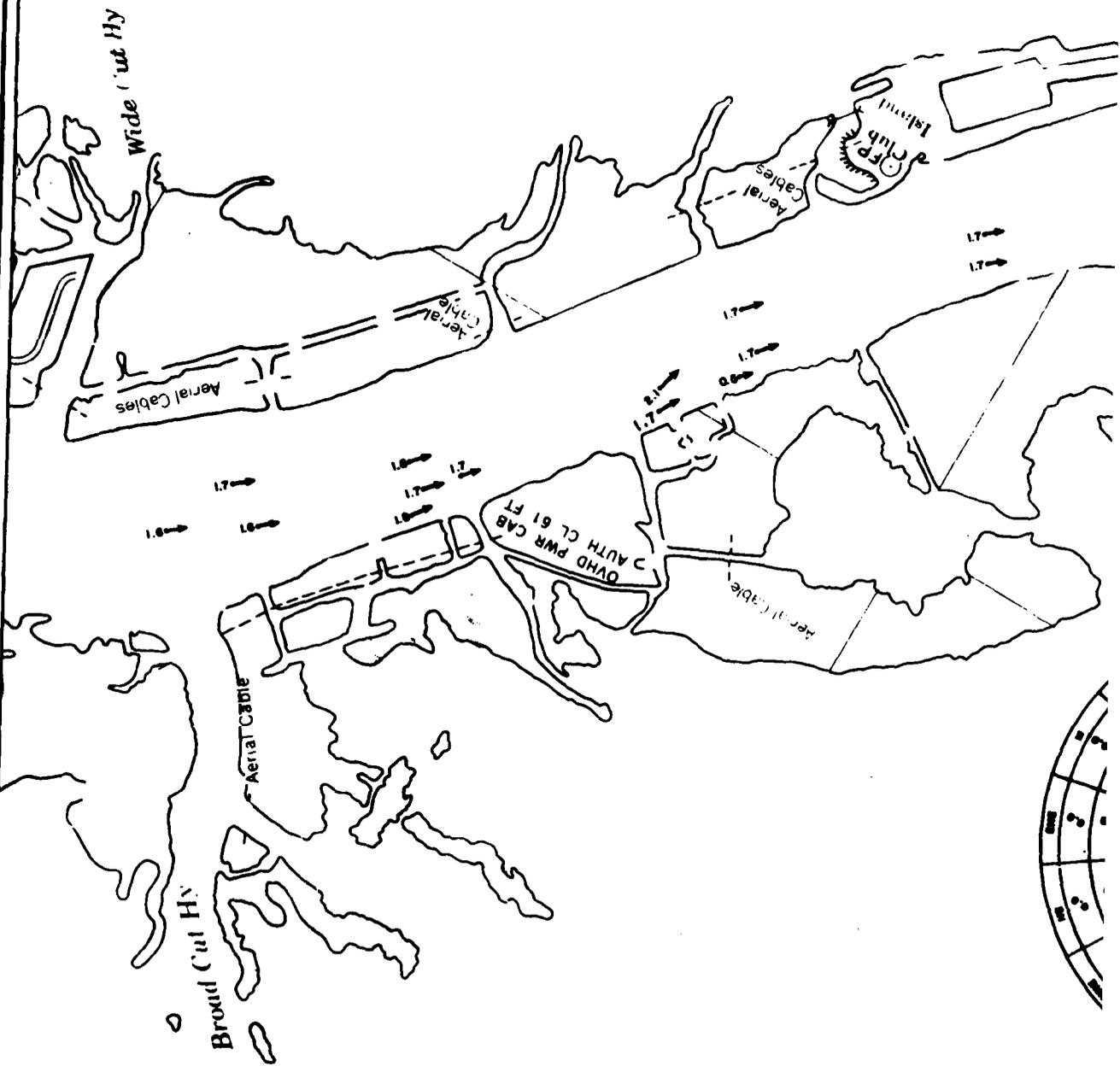
- VELOCITY IN FEET PER SECOND
- VECTOR INDICATING FLOW DIRECTION, LENGTH SHOWS RELATIVE MAGNITUDE
- INDICATES SHAD. AREA

SCALE 1 : 10,000

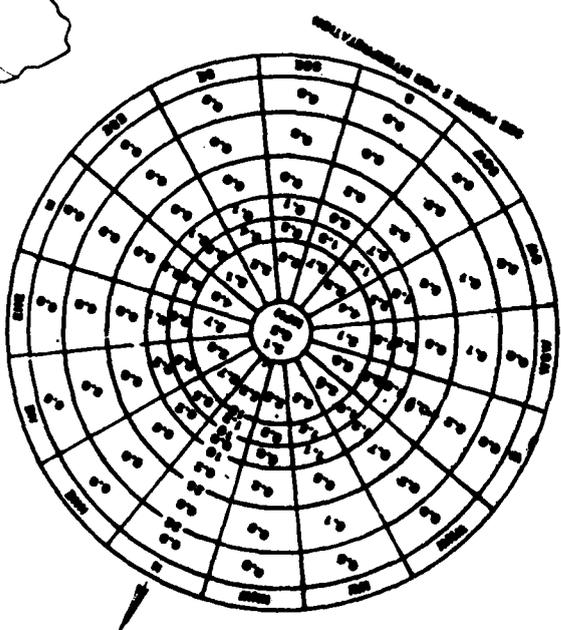
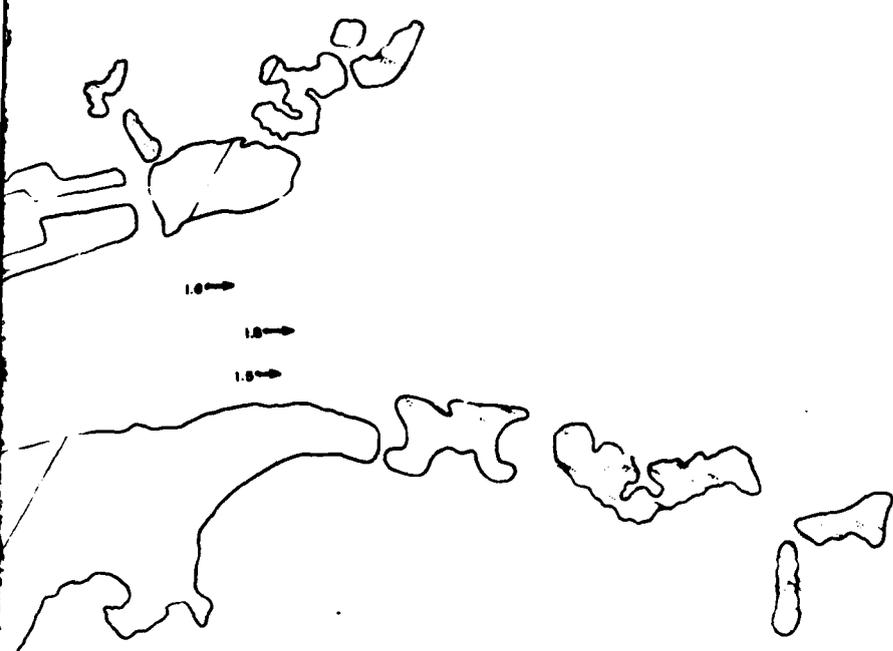
SHEET NO. 26

MATCH TO SHEET NO. 27

MATCH TO SHEET NO. 25



SCALE



MATCH TO SHEET NO.

LEGEND

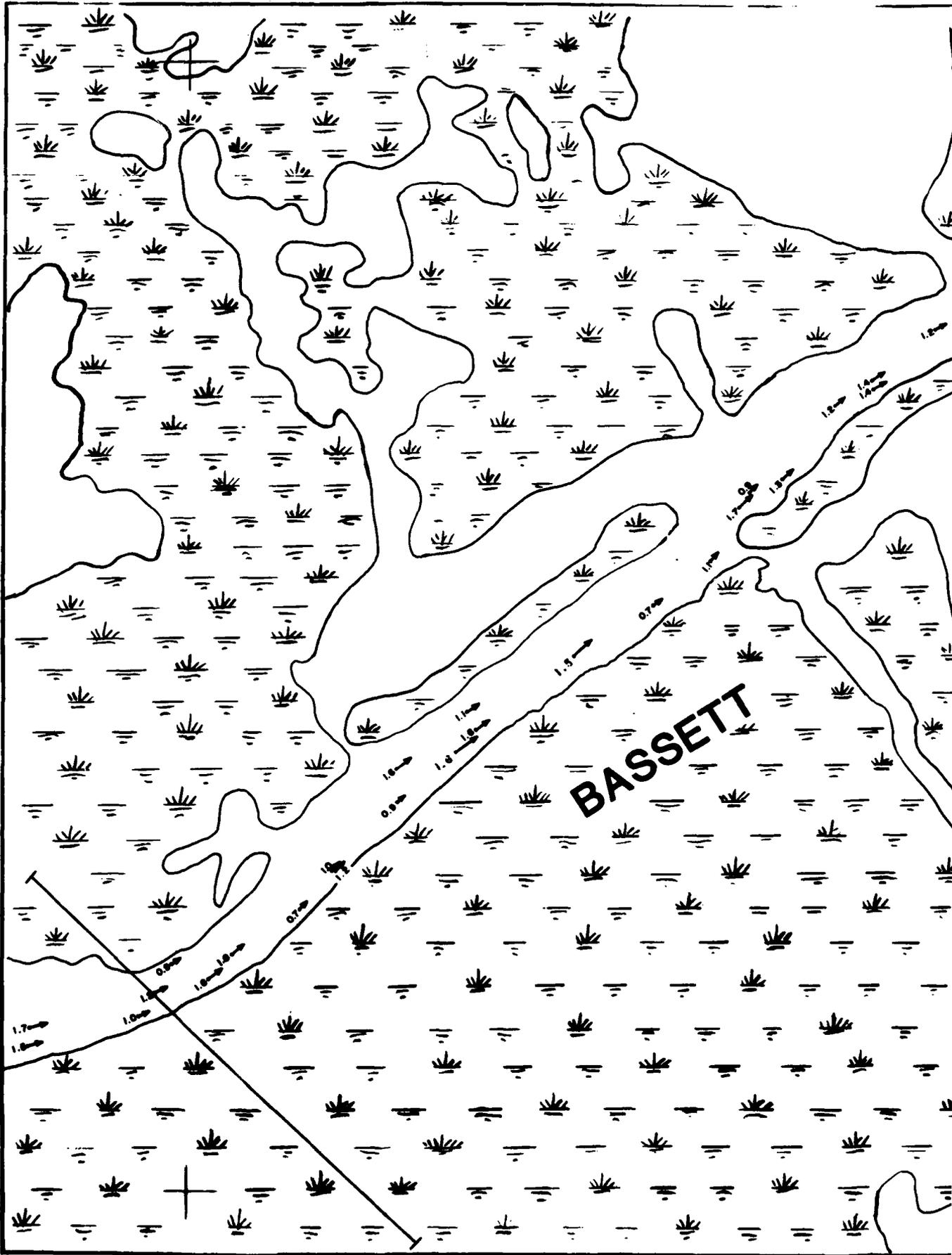
— VELOCITY IN FEET PER SECOND

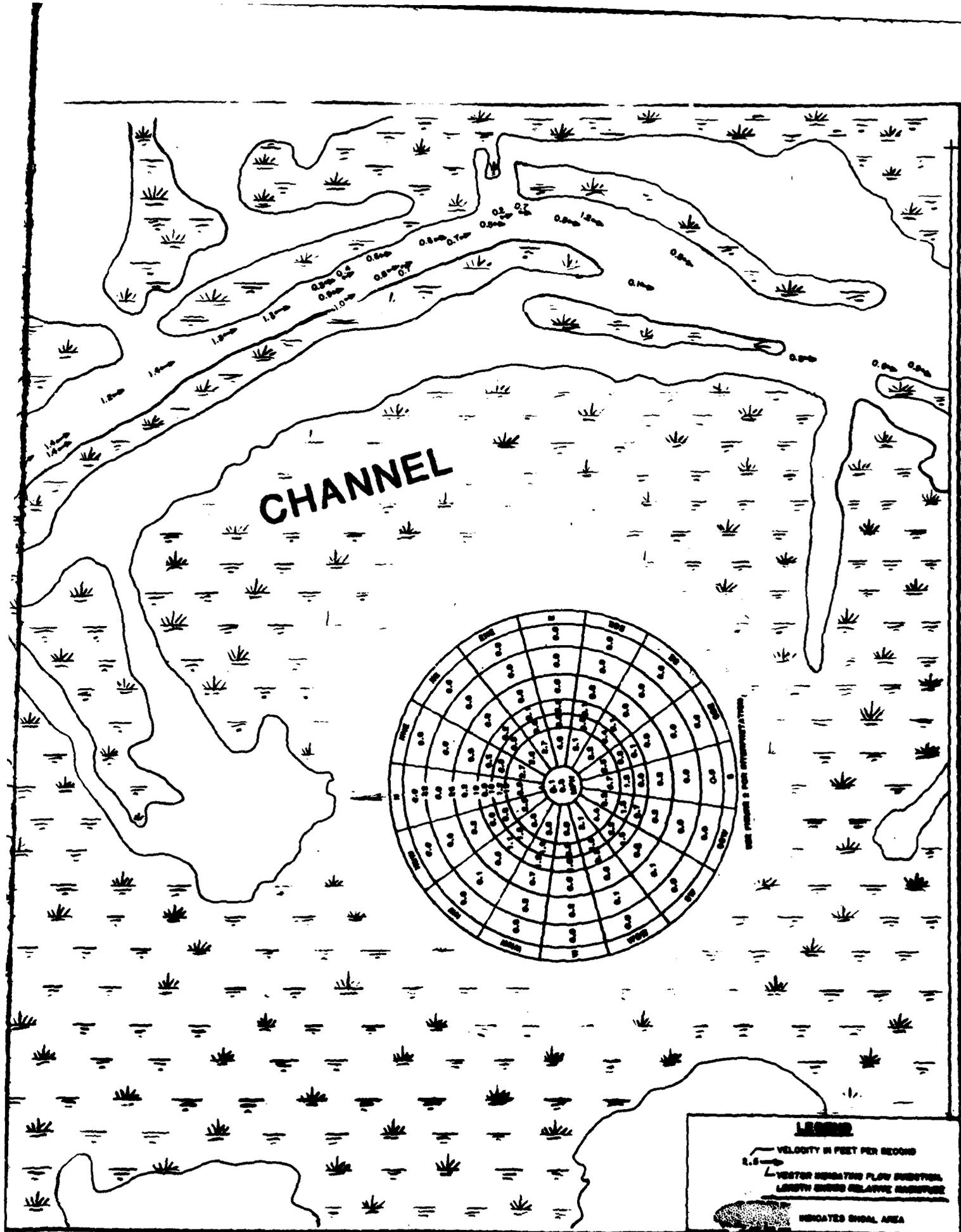
2.0 —

— VECTOR INDICATING FLOW DIRECTION,
LENGTH BEING RELATIVE VELOCITY

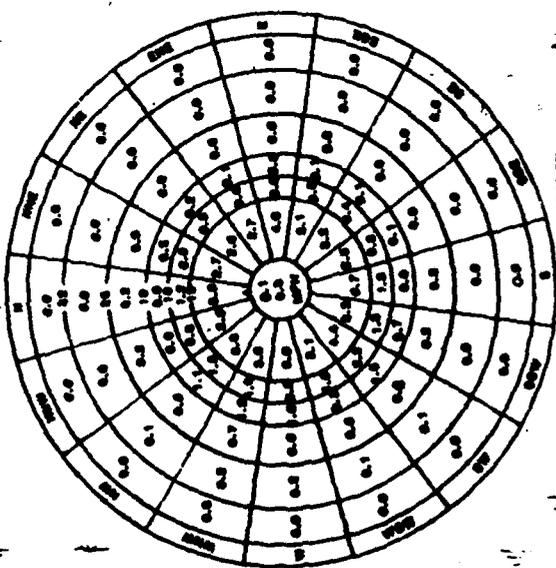
▨ INDICATES SHAL AREA

SCALE 1 : 10,000





CHANNEL



LEGEND

— 2.5 — VELOCITY IN FEET PER SECOND

—> VECTOR INDICATING FLOW DIRECTION
LENGTH SHOWS RELATIVE MAGNITUDE

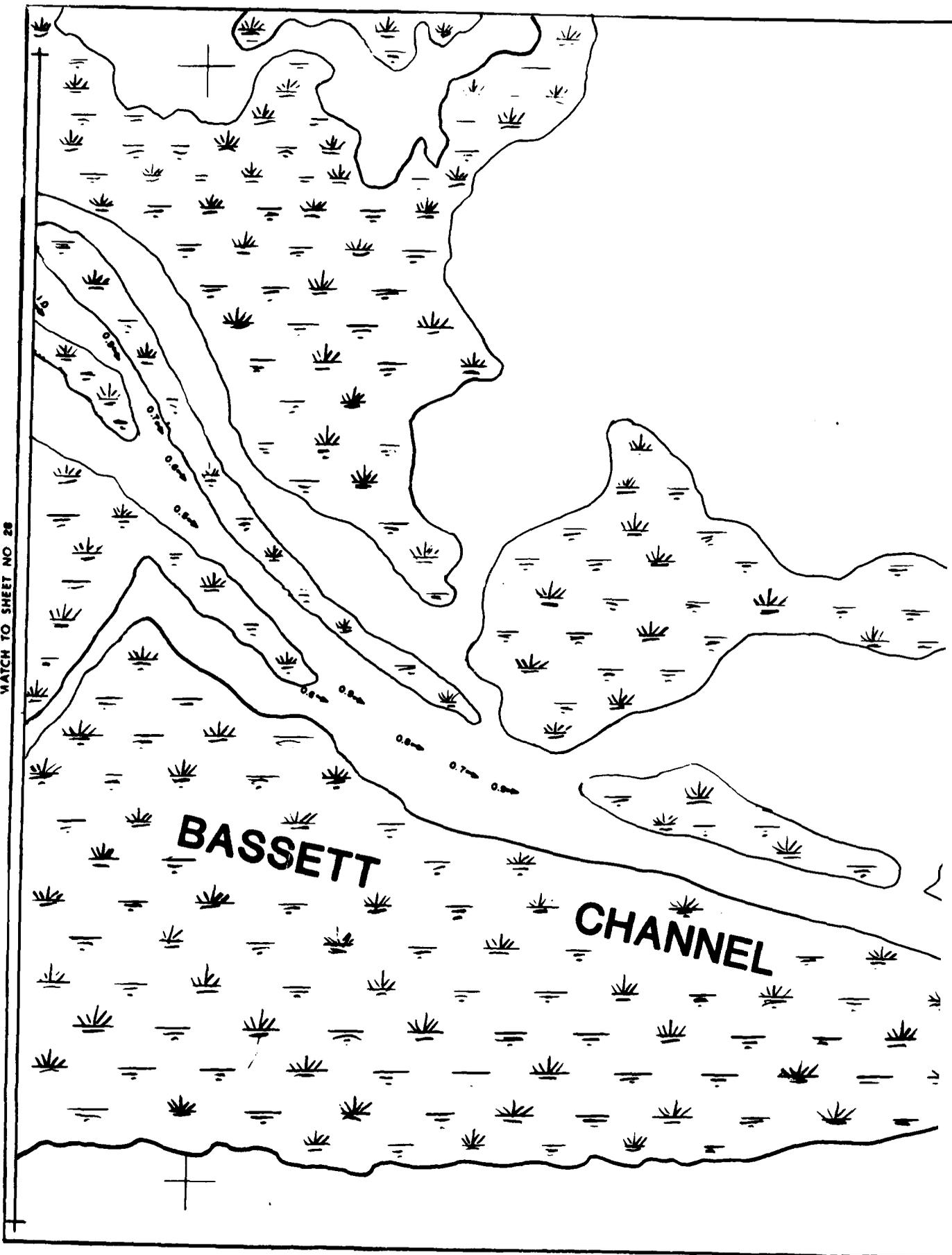
■ INDICATED SIGNAL AREA

MATCH TO SHEET NO. 20

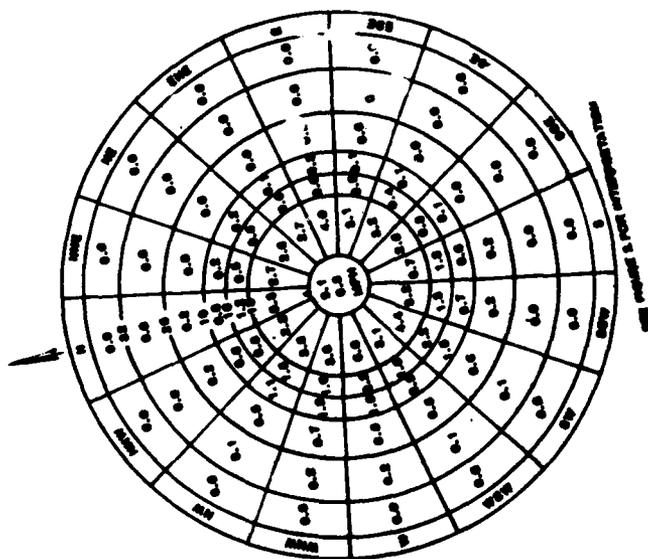
SCALE 1:10,000

SHEET NO. 20

MATCH TO SHEET NO 28



SCALE 1



LEGEND

- VELOCITY IN FEET PER SECOND
- 2.5 —
- VECTOR INDICATES FLOW DIRECTION, LENGTH SHOWS RELATIVE VELOCITY
- INDICATES OBSTACLE AREA

MATCH TO SHEET NO.

SCALE 1 : 10,000

SHEET NO 29