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SAINT LAWRENCE SEAWAY NAVIGATION-AID SYSTEM STUDY
Volume II - Appendix B - User's Manual and Documentation of Seaway Capacity and Capacity Analysis Programs

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FINAL REPORT

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16. Abstract

The requirements for a navigation guidance system which will effect an increase in the ship processing capacity of the Saint Lawrence Seaway (Lake Ontario to Montreal, Quebec) are developed. The requirements include a specification of system positioning accuracy and the type and frequency of information which must be displayed to the master of each ship in the Seaway. A detailed development of the logic used to compute Seaway capacity as a function of the guidance system positioning accuracy is presented. A computer program is given which follows this logic and is used to compute Seaway capacity as a function of positioning accuracy for two classes of ships. Various sensitivity analyses are presented. It is shown that the capacity of the Seaway could be increased by up to 30 percent through the use of a navigation guidance system. Volume I, 116 pages, contains the main text and Appendixes A and D. Volume III, 108 pages, contains Appendix C.

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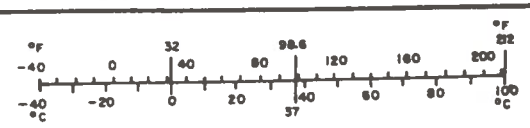
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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NOMENCLATURE

B	Ship beam
H/T	Ratio of water depth to ship draft
L	Ship length
M	Ship maneuvering width for Seaway reach
N	Ship turning moment
N_v	$\partial N/\partial_v$
N_{yo}	$\partial N/\partial_{y_o}$
N_δ	$\partial N/\partial_\delta$
	Ship maneuverability derivatives
W	Minimum channel width for reach
v	Transverse component of resultant ship velocity
$\bar{x}$	Center of action of Y_o, $\bar{x} = N_o/Y_o L$
Y	Ship side force
Y_v	$\partial Y/\partial_v$
Y_{yo}	$\partial Y/\partial_{y_o}$
Y_δ	$\partial Y/\partial_\delta$
	Ship maneuverability derivatives
Y_o'	Dimensionless side force due to ship operating in narrow channel, shallow waters; $Y_o' = Y_o/(\frac{1}{2}\rho LTV^2)$
y_o	Transverse distance from channel centerline
α	Correction factor to Y_o'
δ	Rudder angle
ε	Ship positioning accuracy for reach
ρ	Mass density of water

B.1 GENERAL INFORMATION

B.1.1 Summary

A Seaway capacity model was developed to determine the navigational guidance system performance requirements which would allow improvement in the capacity of the St. Lawrence Seaway. This capacity model provided the relationship between Seaway capacity, maneuvering room requirements and electronic navigation positioning accuracy. The annual Seaway capacity was analyzed taking into account the restraints of high winds, low visibility, ice, and the removal of floating, lighted navigation aids during the winter months.

Program AWCAP (All Weather CAPacity) computes the capacity of the St. Lawrence Seaway for ships using visual only navigation and for ships using visual plus electronic navigation. The input to AWCAP includes Seaway reach characteristics, meteorological data, and ship characteristics. The ship characteristics which include hydrodynamic force coefficients are used to determine the ship maneuvering requirements in those reaches whose currents and winds can be considered constant. For those reaches whose currents and winds cannot be considered constant, the maneuvering requirements are determined using program MANVER, discussed in Appendix C.

Reach and ship input data are entered on punched cards. Meteorological data consists of punched cards for the water temperature data and magnetic tapes for the weather data.

The capacity and constraining reach for a given daily time interval are the basic output of program AWCAP. The analysis of the capacity results is provided by program ANAWCAP (ANalysis of All Weather CAPacity).

Program ANAWCAP sums the daily time interval capacity results to obtain the daily, weekly, yearly, normal season, and extended season capacities. ANAWCAP also determines the number of times each reach constrains capacity (the capacity is equal to zero) for the entire year, the normal season, and for the extended season.

Program AWCAP required approximately 12 CP* seconds to compile and 350 CP seconds to calculate the annual capacity of the Seaway. Program ANAWCAP requires approximately 2 CP seconds to compile and 15 CP seconds to analyze the annual capacity results obtained from AWCAP.

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* Times quoted are for a CDC-6500 computer

B.1.2 Environment

A. User Organizations:

Transportation Systems Center
Kendall Square
Cambridge, Massachusetts 02142
Attention: George Haroules

St. Lawrence Seaway Development Corporation
Federal Office Building #10, Room 836F
800 Independence Avenue, SW
Washington, D.C. 20591
Attention: David C. N. Robb

B. Program was developed at the computer center located at:

Naval Surface Weapons Center
New Hampshire Avenue
White Oak, Maryland 20910
CDC-6500 Computer System

B.1.3 References

A. Project Request: Contract No. DOT-TSC-1395

B. Related Projects Documentation:

1. Lewis, Jack W., "Saint Lawrence Seaway, System Plan for All-Year Navigation (SPAN)," ARCTEC, Incorporated, July 1975.

2. Fips Publication 38, "Guidelines for Documentation of Computer Programs and Automated Data Systems," February 1976.

3. Doggett, L.E., et al., "Almanac for Computers for the Year 1978," Nautical Almanac Office, U. S. Naval Observatory.

4. Tippetts-Abbett-McCarthy-Stratton, "Study of Stability of Ice Cover - Phase II, Hydraulics Under Ice-Free Conditions," October 1972.

5. Grumblatt, J.L., "Great Lakes Water Temperatures, 1966-1975," Great Lakes Environmental Research Laboratory, NOAA Technical Memorandum ERL-GLERL-11.

6. Majewski, W., et al., "A Study of the Thermal Balance of the Saint Lawrence River by Digital Simulation," National Research Council, Division of Mechanical Engineering, Report LTR-HY-5, March 1976.

7. "Principles of Naval Architecture," Revised, Third Printing, Society of Naval Architects and Marine Engineers, 1974.

8. Farwell, Capt. R. F., "Farwell's Rules of the Nautical Road," Naval Institute Press, Annapolis, Maryland, Fifth Edition.

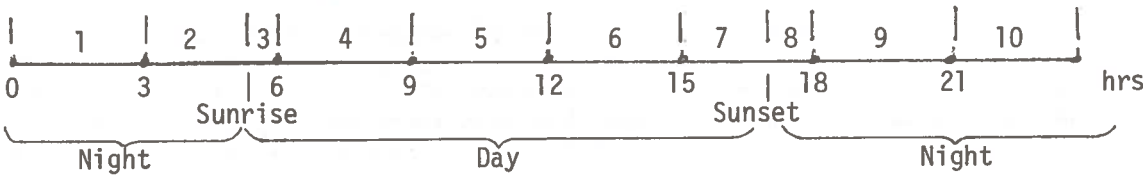
B.2 APPLICATION

B.2.1 Description of Programs AWCAP and ANAWCAP

The two programs--AWCAP and ANAWCAP--were developed at the request of TSC and SLSDC to determine the effect of electronic navigation accuracy on the yearly capacity of the St. Lawrence Seaway. This annual capacity was analyzed taking into account the restraints of high winds, low visibility, ice, and the removal of floating, lighted aids during the winter months.

This analysis was performed as follows:

- the day was divided into ten periods as shown below



- the Seaway was divided geographically into 103 reaches and meteorologically into 3 sectors

- the meteorological data was then utilized to estimate the levels of visibility and wind speeds for a particular time period and Seaway sector

- average capacities--ships per unit time--were calculated based on visibility, wind, reach characteristics, and ship characteristics

- the total number of ships processed was summed using program ANAWCAP to obtain the annual Seaway capacity

B.2.2 Equipment

Programs AWCAP and ANAWCAP can be run on the Control Data Corporation 6400, 6500, 6700 computer systems. All weather data has been stored on 7-track magnetic tapes that are unlabeled and have a density of 800 bpi. Permanent files may be created from these tapes.

B.2.3 Structure

Program AWCAP calls five subroutines and two function statements. Figure 1 shows the calling hierarchy for the various subroutines and function statements.

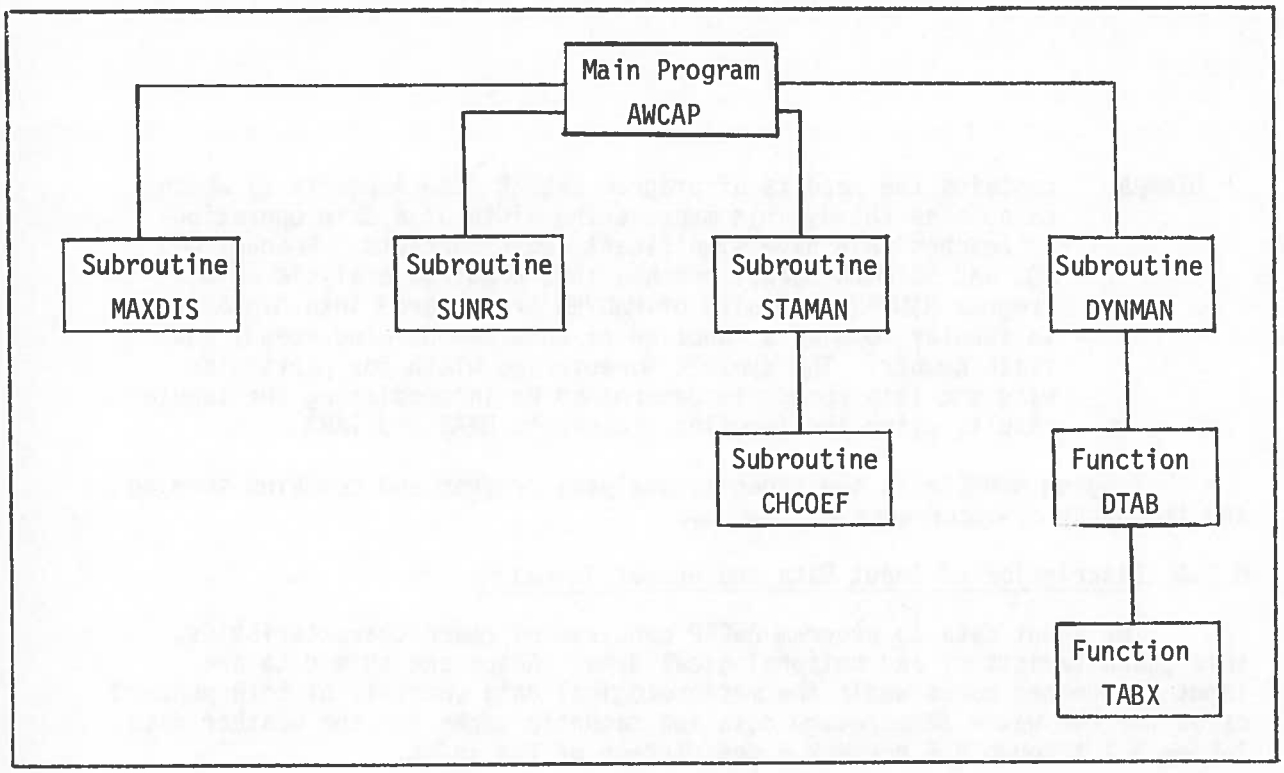


FIGURE B.1 STRUCTURE OF PROGRAM AWCAP

The function of various subroutines and function statements are enumerated below.

Subroutine

MAXDIS checks all the reaches of the Seaway and finds the maximum distance which includes a sufficient number of navigation aids to fix position visually over the entire Seaway.

SUNRS calculates the times of sunrise and sunset for each day of the year.

STAMAN calculates the static maneuvering width required for a ship to operate in a particular reach under given wind, current, and visibility conditions.

CHCOEF is an interpolation algorithm that generates the forces and moments acting on ship operating in shallow waters and narrow channels. A detailed explanation of CHCOEF is given in Appendix C.

DYNMAN contains the results of program MANVER (see Appendix C) which calculates the dynamic maneuvering width of a ship operating in reaches that have significant cross currents. Reaches 44, 50, and 56 were Seaway reaches that required analysis using program MANVER. Results of MANVER are entered into DYNMAN in tabular form as a function of ship speed, wind speed, and reach number. The dynamic maneuvering width for particular wind and ship speeds is determined by interpolating the tabular results using the function statements DTAB and TABX.

Program ANAWCAP is the capacity analysis program and contains summing and frequency-of-occurrence algorithms.

B.2.4 Description of Input Data and Output Results

The input data to program AWCAP consists of reach characteristics, ship characteristics, and meteorological data. Reach and ship data are input as punched cards while the meteorological data consists of both punched cards for the water temperature data and magnetic tapes for the weather data. Tables B.1 through B.6 present a description of the input.

The input data to ANAWCAP is the output from AWCAP. This data consists of the day, time of day, capacity, and constraining reach for each of 10 daily time periods for an entire year.

The output of ANAWCAP consists of the weekly, daily, yearly, normal season, and extended season capacities. ANAWCAP also determines the number of times a particular reach becomes constraining (capacity drops to zero) for the entire year, the normal season, and the extended season. A sample of the output from ANAWCAP is presented in Section B.5.

TABLE B.1 SHIP MANEUVERABILITY DATA

NWPB	Number of observations in NYPB array
NXALP	Number of observations in XWPB array
XWPB	Channel width/ship beam array, W/B
NYPB	Number of observations for each channel width/ship beam parameter
XYOP(I,J,1)	Distance from channel centerline/ship beam
XYOP(I,J,2)	Dimensionless side force, Y_o'
XALPHA(I,1)	Water depth/ship draft, H/T
XALPH(I,2)	$\overline{x}$
XALPH(I,3)	α

TABLE B.2 SEAWAY REACH CHARACTERISTICS ARRAY

Reach (I,N) I = Reach Number (I = 1 to 103)

N	Element Description
1	Reach Type: 0 - lock 1 - two-way dynamic reach 2 - two-way static reach 3 - one-way dynamic reach 4 - one-way static reach 5 - non-constraining bridge
2	Upbound course, °T
3	Minimum width, ft
4	Minimum depth, ft
5	Beginning reach mileage, statute miles
6	Ending reach mileage, statute miles
7	Upbound speed limit, mph
8	Downbound speed limit, mph
9	Current speed, fps
10	Current direction, °T
11	Minimum distance which includes sufficient number of navigational aids to fix position visually during normal season, day, upbound; miles, statute miles
12	Same as 11 - downbound, day
13	Same as 11 - extended season, upbound, day
14	Same as 11 - extended season, downbound, day
15	Same as 11 - normal season, upbound, night
16	Same as 11 - normal season, downbound, night
17	Same as 11 - extended season, upbound, night
18	Same as 11 - extended season, downbound, night
19	Electronic navigation accuracy of reach, ft
20	Daytime visual navigation accuracy, ft
21	Night-time visual navigation accuracy, ft
22	Indicator noting whether reach could have ice problems (no river steam when ice is present) during extended season operations 0 - No 1 - Yes

NOTE: This could also be used to store ice thickness data which could then be used to determine if maneuverability is a problem. Leave this for later time, however.

TABLE B.3 SHIP CHARACTERISTICS ARRAY

Ship (I,N) I = Ship Number 1 - Salty 2 - Laker

N	Element Description	
1	Length, ft	
2	Beam, ft	
3	Sail area of ballast draft, ft^2	
4	Ballast draft, ft	
5	Sail area at deep draft, ft^2	
6	Deep draft, ft	
7	Normal season locking time - up, min	
8	Normal season locking time - down, min	
9	Extended season locking time - up, min	
10	Extended season locking time - down, min	
11	Y_v	Hydrodynamic force coefficients used in equation of ship motion.
12	N_v	
13	Y_δ	
14	N_δ	
15	Y_{yo}	
16	N_{yo}	
17	A1	Coefficients used to determine ship speed as a function of visibility.
18	A2	
19	A3	

TABLE B.4 EXTENDED SEASON EVENTS ARRAY

EXTSEA (I)

I	Element Description
1	Number of days after 1 October when floating navigation aids are pulled
2	Number of days after 1 October when ice forms
3	Number of days after 1 October when ice lockage begins
4	Number of days after 1 October when ice lockage stops
5	Number of days after 1 October when ice disappears
6	Number of days after 1 October when floating navigation aids are reinstalled

TABLE B.5 LOCK AND SHIP PARAMETERS

TTRNBK	Time for lock to turnback, minutes	
TICELK	Time for lock to lock through a load of ice, minutes	
D1,D2,D3	RATIO = D1+D2*NDAY+D3*NDAY**2 Ratio of upbound ship transits to total ship transits	
NELEC	Integer indicating that ship is fixing position visually only (0) or both visually and with an electronic navigation aid (1)	
ID	Ship identification	1 - Salty 2 - Laker
IDRAFT	Draft identification	4 - Ballast 6 - Loaded

TABLE B.6 WATER TEMPERATURE AND WEATHER DATA ARRAYS

WATEM(I),I=1,366 Daily water temperature for the entire year for Seaway Sector 2

(IYEAR,MONTH,IDAY,IH,(WXTAPE(I,J,K))

IYEAR	YEAR
MONTH	MONTH
IDAY	DAY
IH	HOUR
WXTAPE(I,J,K)	K = Weather Station Number 1 2 3
	J = Weather Time Interval 1-8
	I = Element Number 1 - visibility, statute miles 2 - wind speed, mph 3 - wind direction, °T 4 - air temperature, °F

B.3 PROGRAM INITIATION AND EXECUTION

B.3.1 Initiation of AWCAP

To begin processing AWCAP in the BATCH mode, the following control cards must be implemented along with the main program deck, input data deck, and 3 permanent files or tapes of the weather data.

```
JOB CARD              XXXX,CM70000,T2000.
USER CARD             USER,508.
FILE ID CARD          ATTACH(TAPE7=WX1) (DORVAL WEATHER)
FILE ID CARD          ATTACH(TAPE8=WX2) (MASSENA WEATHER)
FILE ID CARD          ATTACH(TAPE9=WX3) (WATERTOWN WEATHER)
TAPE ID CARD          REQUEST,TAPE10,F=I,LB=KU,D=HY,PO=W,VSN=100.
FORTRAN CARD          FTN.
LGO CARD              LGO.
7-8-9 CARD            7-8-9
MAIN PROGRAM DECK          PROGRAM AWCAP (          )
                                  "
                                  "
                           END
7-8-9 CARD            7-8-9
INPUT DATA DECK       INPUT DATA
6-7-8-9 CARD          6-7-8-9
```

B.3.2 Initiation of ANAWCAP

To process ANAWCAP in the BATCH mode, the following control cards must be implemented.

```
JOB CARD              XXXX,CM60000,T100.
USER CARD             USER,508.
TAPE ID               REQUEST,TAPE10,F=I,LB=KU,D=HY,PO=RE,VSN=100.
FTN CARD              FTN(PL=50000).
LGO CARD              LGO.
7-8-9 CARD            7-8-9
MAIN PROGRAM DECK          PROGRAM ANAWCAP (            )
                                  "
                                  "
                           END
6-7-8-9 CARD          6-7-8-9
```

B.3.3 Execution of AWCAP and ANAWCAP

Execution of the program AWCAP can be modified by changing certain controls in the input data deck. The program is approximately 1200 executable statements long and compilation time is approximately 12 CP seconds.

All AWCAP capacity results are written onto a 7-track magnetic tape. This tape is then used as input to program ANAWCAP.

Program ANAWCAP is approximately 155 executable statements long and compiles in 1.4 seconds.

B.4 SUMMARY OF CAPACITY VERSUS ACCURACY RESULTS

A summary of the computer runs made using program AWCAP is presented in Table B.7. Results of these runs can be found in Tables B.8 through B.16 and in Figures B.2 and B.3.

TABLE B.7 SUMMARY OF COMPUTER RUNS FOR NAV-AID SYSTEM STUDY

Ship Type	Ship Condition	$T_{ice\ lock}$	Ship Speed Assumption	No Elec-tronics	Electronic Navigation Positioning Accuracy (ft)								
					0	30	60	100	150	200	250	300	Modified* 100'
SALTY	LOADED	0.0	V = f(VISIBILITY)	✓		✓	✓	✓					
SALTY	LOADED	0.0	$V = V_{speed\ limit}$	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
LAKER	LOADED	0.0	V = f(VISIBILITY)	✓		✓	✓	✓					
LAKER	LOADED	0.0	$V = V_{speed\ limit}$	✓		✓	✓	✓					
SALTY	BALLAST	0.0	V = f(VISIBILITY)	✓				✓					
SALTY	BALLAST	0.0	$V = V_{speed\ limit}$	✓				✓					
LAKER	BALLAST	0.0	V = f(VISIBILITY)	✓				✓					
LAKER	BALLAST	0.0	$V = V_{speed\ limit}$	✓				✓					

* All reaches had 100 ft accuracy except Reaches 1, 20, and 56 with 60 ft accuracy and Reach 44 with a 30 ft accuracy.

TABLE B.8 SALTY SEAWAY CAPACITY AS A FUNCTION OF NAVIGATION SYSTEM POSITIONING ACCURACY

RUN		CAPACITY								
Salty Class Ship $T_{ice\ lock}=0$ $V_{ship}=V_{speed\ limit}$		NORMAL			EXTENDED			ALL YEAR		
Year	Condition	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg
1 2 3 4	No electronic navigation aids	8131 8163 8227 7715	8059	NA	1762 1723 1631 1428	1636	NA	9893 9886 9858 9143	9695	NA
1 2 3 4	0'	9555 9586 9557 9558	9564	18.7	3134 3019 3035 2881	3017	84.4	12689 12605 12592 12439	12581	29.8
1 2 3 4	30'	9541 9581 9550 9555	9557	18.6	3129 3020 3035 2881	3016	84.4	12670 12601 12585 12435	12573	29.7
1 2 3 4	60'	9257 9286 9188 9078	9202	14.2	2934 2895 2938 2880	2912	78.0	12191 12181 12126 11958	12114	25.0
1 2 3 4	100'	9066 9133 9072 8829	9025	12.0	2748 2767 2768 2724	2752	68.2	11814 11900 11840 11553	11777	21.5
1 2 3 4	150'	8918 8887 8875 8572	8813	9.4	2709 2642 2667 2670	2672	63.3	11627 11529 11542 11242	11485	18.5

TABLE B.8 SALTY SEAWAY CAPACITY AS A FUNCTION OF NAVIGATION SYSTEM POSITIONING ACCURACY (Continued)

RUN		CAPACITY								
Salty Class Ship $T_{ice\ lock}=0$ $V_{ship}=V_{speed\ limit}$		NORMAL			EXTENDED			ALL YEAR		
Year	Condition	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg
1	200'	8711	8524	5.8	2470	2205	34.8	11181	10729	10.7
2		8605			2216			10821		
3		8586			2131			10717		
4		8194			2003			10197		
1	250'	8554	8434	4.7	1930	1789	9.4	10484	10223	5.4
2		8537			1863			10400		
3		8573			1754			10327		
4		8072			1609			9681		
1	300'	8462	8325	3.3	1771	1661	1.5	10233	9986	3.0
2		8409			1761			10170		
3		8499			1656			10155		
4		7930			1456			9386		

TABLE B.9 FREQUENCY ANALYSIS OF NUMBER OF TIME INTERVALS
A NON-LOCK REACH CONSTRAINED SALTY SEAWAY CAPACITY

Salty, Loaded $T_{ice\ lock} = 0.0$ $V_{ship} = V_{speed\ limit}$ Year 3

Constraining Reach	No Elec Nav-Aid	Electronic Navigation Positioning Accuracy							
		0'	30'	60'	100'	150'	200'	250'	300'
1	14				14	14	14	14	14
20	77				77	77	77	77	77
21	25						10	25	25
22	251								251
24	57								
26								16	8
27								13	5
34								211	
37	6								
39							94		
42	41						59	44	43
43	59							68	65
44	19			111	99	99	44	10	19
47							6		
48	56						62	56	56
50	56						77	66	66
56					11	11			
73	4								
80	70								
81	49								
83	2								
84	3						51	39	35
85						33			
86						24			
87								16	16
88	6								20
89	2								2
90	5								14
92									20
93							17	17	
95							21	5	1
100	24								

TABLE B.10 SALTY SEAWAY CAPACITY AS A FUNCTION OF SHIP SPEED ASSUMPTION

RUN		CAPACITY								
Salty Loaded $T_{ice\ lock} = 0$		NORMAL			EXTENDED			ALL YEAR		
Year	Condition	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg
1 2 3 4	30' $V = V_{speed\ limit}$	9541 9581 9550 9555	9557	18.6	3129 3020 3035 2881	3016	84.4	12670 12601 12585 12435	12573	29.7
1 2 3 4	30' $V_{ship} = f(VIS)$	9421 9481 9438 9426	9442	17.2	3078 2986 2994 2864	2981	82.2	12499 12467 12432 12289	12422	28.1
1 2 3 4	60' $V = V_{speed\ limit}$	9257 9286 9188 9078	9202	14.2	2934 2895 2938 2880	2912	78.0	12191 12181 12126 11958	12114	25.0
1 2 3 4	60' $V = f(VIS)$	9250 9263 9187 9075	9194	14.1	2917 2874 2907 2864	2891	76.7	12167 12137 12095 11439	12085	24.7
1 2 3 4	100' $V = V_{speed\ limit}$	9066 9133 9072 8829	9025	12.0	2748 2767 2768 2724	2752	68.2	11814 11900 11840 11553	11777	21.5
1 2 3 4	100' $V = f(VIS)$	9062 9115 9072 8829	9020	11.9	2734 2753 2748 2707	2736	67.2	11796 11868 11820 11537	11755	21.2

TABLE B.11 FREQUENCY ANALYSIS OF NUMBER OF TIME INTERVALS
A NON-LOCK REACH CONSTRAINED SALTY SEAWAY CAPACITY
SHOWING THE EFFECT OF SHIP SPEED ASSUMPTION

Salty, Loaded Year 3 $T_{ice\ lock} = 0.0$

Constraining Reach	No Elec Nav-Aid	Electronic Navigation Positioning Accuracy					
		$V_{ship} = f(VISIBILITY)$			$V_{ship} = V_{speed\ limit}$		
		30'	60'	100'	30'	60'	100'
1	14	6	6	14			14
20	77			77			77
21	25						
22	251						
24	57						
26							
27							
34							
37	6						
39							
42	41	8	8	6			
43	59						
44	19	12	105	95		111	99
47							
48	56						
50	56						
56		2		11			11
73	4						
80	70	11	11	7			
81	49						
83	2						
84	3						
85							
86							
87							
88	6						
89	2						
90	5						
92							
93							
95							
100	24						

TABLE B.12 LAKER SEAWAY CAPACITY AS A FUNCTION OF NAVIGATION SYSTEM POSITIONING ACCURACY

RUN		CAPACITY								
		NORMAL			EXTENDED			ALL YEAR		
Year	Condition	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg
1 2 3 4	Laker, Loaded No electronic navigation aids	7462 7490 7550 7081	7396	-	1645 1613 1527 1340	1531	-	9107 9103 9076 8421	8927	-
1 2 3 4	Laker, Loaded 30' $V_{ship}=V_{speed\ limit}$	8751 8785 8757 8761	8764	18.5	2915 2821 2836 2702	2819	84.1	11666 11606 11592 11463	11583	29.7
1 2 3 4	Laker, Loaded 30' $V_{ship}=f(VIS)$	8639 8693 8622 8600	8639	16.8	2868 2790 2797 2686	2785	81.9	11507 11483 11419 11286	11424	28.0
1 2 3 4	60'	8492 8515 8426 8323	8439	14.1	2736 2707 2745 2702	2723	77.9	11228 11222 11172 11025	11162	25.0
1 2 3 4	Laker, Loaded 60' $V_{ship}=f(VIS)$	8486 8493 8425 8320	8431	14.0	2720 2688 2716 2686	2703	76.6	11206 11182 11141 11006	11134	24.7
1 2 3 4	100'	8325 8393 8333 8119	8293	12.1	2565 2588 2588 2555	2574	68.1	10889 10980 10922 10674	10867	21.7
1 2 3 4	Laker, Loaded 100' $V_{ship}=f(VIS)$	8321 8375 8333 8119	8287	12.0	2551 2574 2567 2539	2558	67.1	10872 10949 10900 10658	10845	21.5

TABLE B.13 FREQUENCY ANALYSIS OF NUMBER OF TIME INTERVALS A NON-LOCK REACH CONSTRAINED LAKER SEAWAY CAPACITY SHOWING THE EFFECT OF SHIP SPEED ASSUMPTION

Laker, Loaded Year 3 $T_{ice\ lock} = 0.0$

Constraining Reach	No Elec Nav-Aid	Electronic Navigation Positioning Accuracy					
		$V_{ship} = f(VISIBILITY)$			$V_{ship} = V_{speed\ limit}$		
		30'	60'	100'	30'	60'	100'
1	14	6	6	14			14
20	77			77			77
21	25						
22	251						
24	57					6	
29							
37							
42	41	8	8	6			
43	59						
44	19	23	105	95		111	99
48	56						
50	56	2					
56				11			11
73	4						
80	70	11	11	7			
81	49						
83	2						
84	3						
88	6						
89	2						
90	5						
100	24						

TABLE B.14 SALTY SEAWAY CAPACITY AS A FUNCTION OF LOADING CONDITION

RUN		CAPACITY								
		NORMAL			EXTENDED			ALL YEAR		
$T_{ice\ lock} = 0$										
Year	Condition	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg
1 2 3 4	Salty, Loaded No electronic navigation aids	8131 8163 8227 7715	8059	NA	1762 1723 1631 1428	1636	NA	9893 9886 9858 9143	9695	NA
1 2 3 4	Salty, Ballast No electronic Navigaiton aids	8131 8163 8225 7715	8059	NA	1762 1727 1631 1428	1637	NA	9893 9890 9856 9143	9696	NA
1 2 3 4	Salty, Loaded $V=V_{speed\ limit}$ 100'	9066 9133 9072 8829	9025	12.0	2748 2767 2768 2724	2752	68.2	11814 11900 11840 11553	11777	21.5
1 2 3 4	Salty, Ballast 100' $V=V_{speed\ limit}$	9065 9133 9070 8829	9024	11.9	2751 2770 2764 2724	2752	68.1	11816 11903 11834 11553	11776	21.5
1 2 3 4	Salty, Loaded 100' V = f(VIS)	9062 9115 9072 8829	9020	11.9	2734 2753 2748 2707	2736	67.2	11796 11868 11820 11537	11755	21.2
1 2 3 4	Salty, Ballast 100' V = f(VIS)	9061 9115 9070 8829	9019	11.9	2737 2757 2744 2707	2736	67.1	11798 11872 11814 11536	11755	21.2

TABLE B.15 LAKER SEAWAY CAPACITY AS A FUNCTION OF LOADING CONDITION

RUN		CAPACITY								
		NORMAL			EXTENDED			ALL YEAR		
Year	Condition	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg
1 2 3 4	Laker, Loaded No Electronic Navigation Aids	7462 7490 7550 7081	7396	NA	1645 1613 1527 1340	1531	NA	9107 9103 9076 8421	8927	NA
1 2 3 4	Laker, Ballast No Electronic Navigation Aids	7462 7490 7550 7081	7396	NA	1645 1615 1526 1340	1532	NA	9107 9105 9076 8421	8928	NA
1 2 3 4	Laker, Loaded $V=V_{speed\ limit}$ 100'	8325 8393 8333 8119	8293	12.1	2565 2588 2588 2555	2574	68.1	10889 10980 10922 10674	10867	21.7
1 2 3 4	Laker, Ballast $V=V_{speed\ limit}$ 100'	8325 8392 8334 8119	8293	12.1	2567 2591 2587 2555	2575	68.1	10892 10983 10921 10674	10868	21.7
1 2 3 4	Laker, Loaded V = f(VIS) 100'	8321 8375 8333 8119	8287	12.0	2551 2574 2567 2539	2558	67.1	10872 10949 10900 10658	10845	21.5
1 2 3 4	Laker, Ballast V = f(VIS) 100'	8321 8375 8334 8118	8287	12.0	2554 2577 2568 2539	2560	67.1	10875 10952 10902 10657	10847	21.5

TABLE B.16 SEAWAY CAPACITY FOR A SYSTEM WITH 100-FT ACCURACY EXCEPT IN REACHES NOTED

RUN			CAPACITY								
Salty, Loaded V = $V_{speed\ limit}$			NORMAL			EXTENDED			ALL YEAR		
Year	Condition Reach	Accuracy	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg	Yearly	4 yr avg	% Increase Over 4 yr avg
1	1	60'	9375			3041			12416		
2	20	60'	9432	9391	16.5	2973	2973	81.2	12405	12364	27.5
3	44	30'	9402			2996			12397		
4	56	60'	9354			2881			12235		
	others	100'									

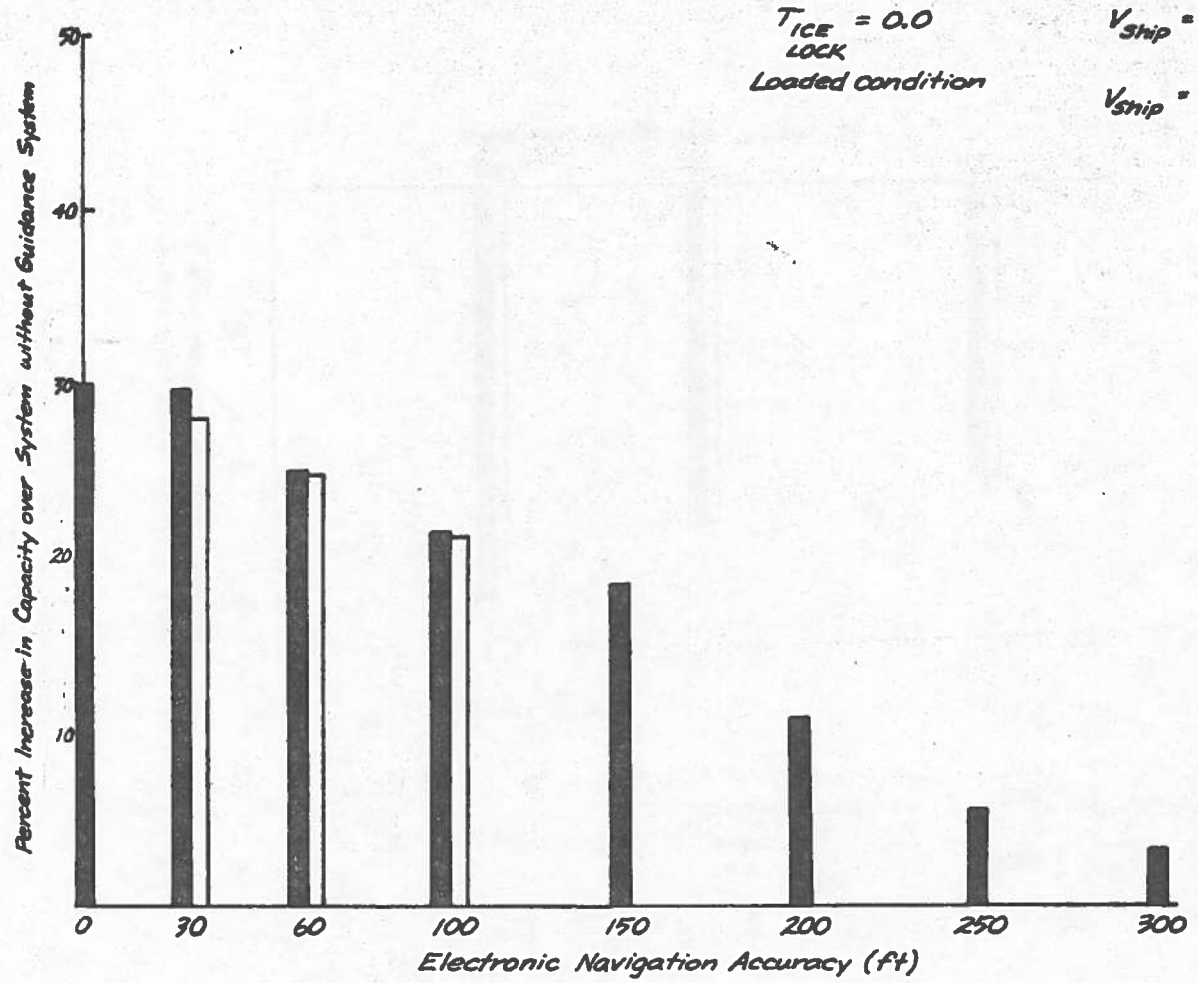


Figure B.2. Salty Seaway Capacity as a Function of Navigational System Positioning Accuracy

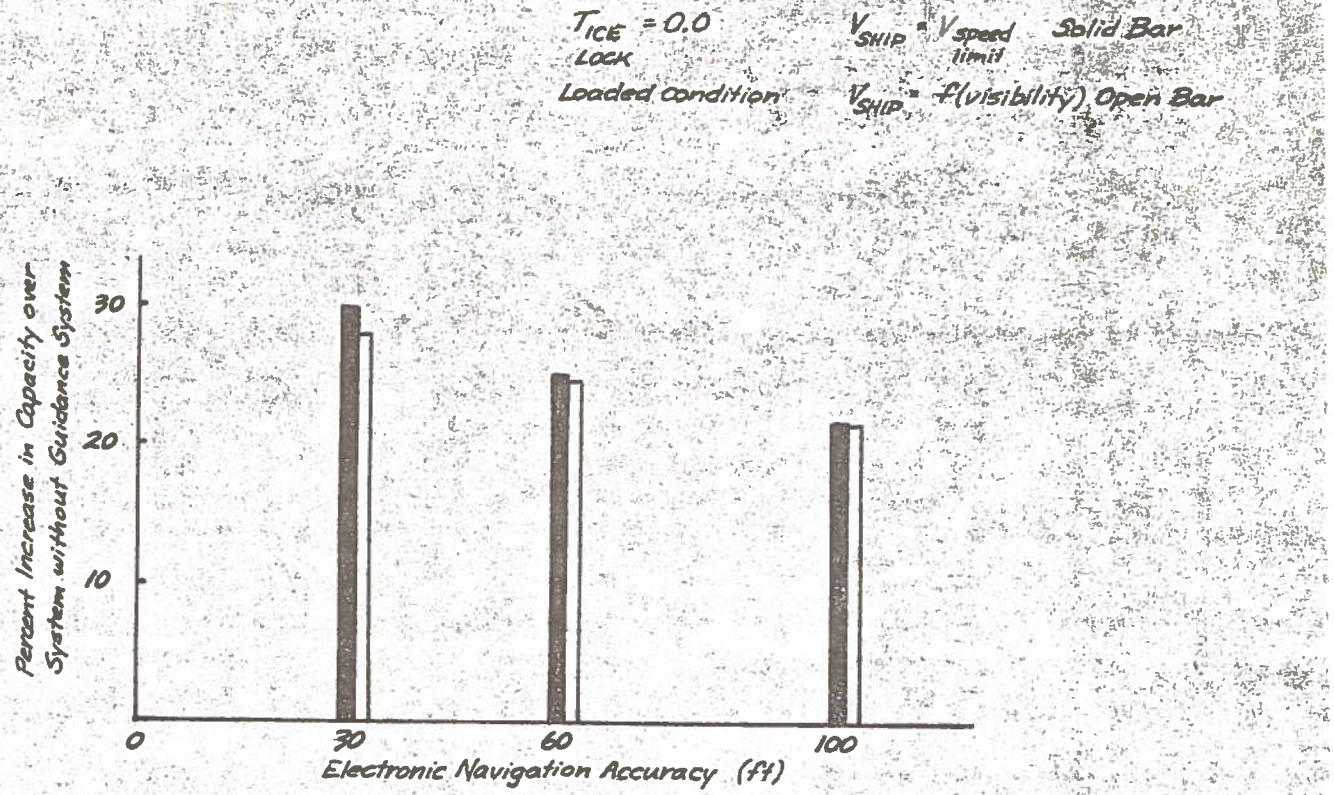
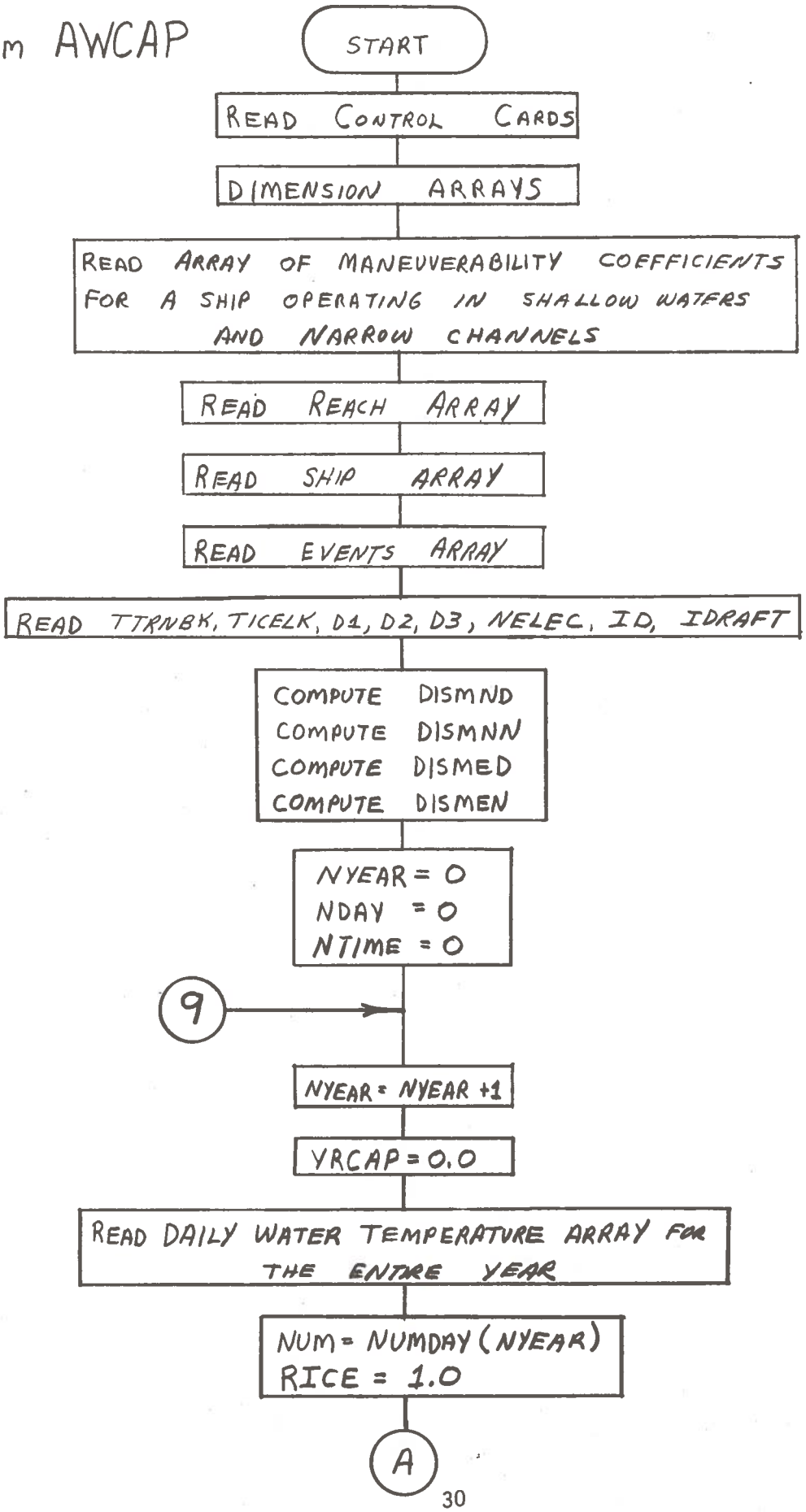
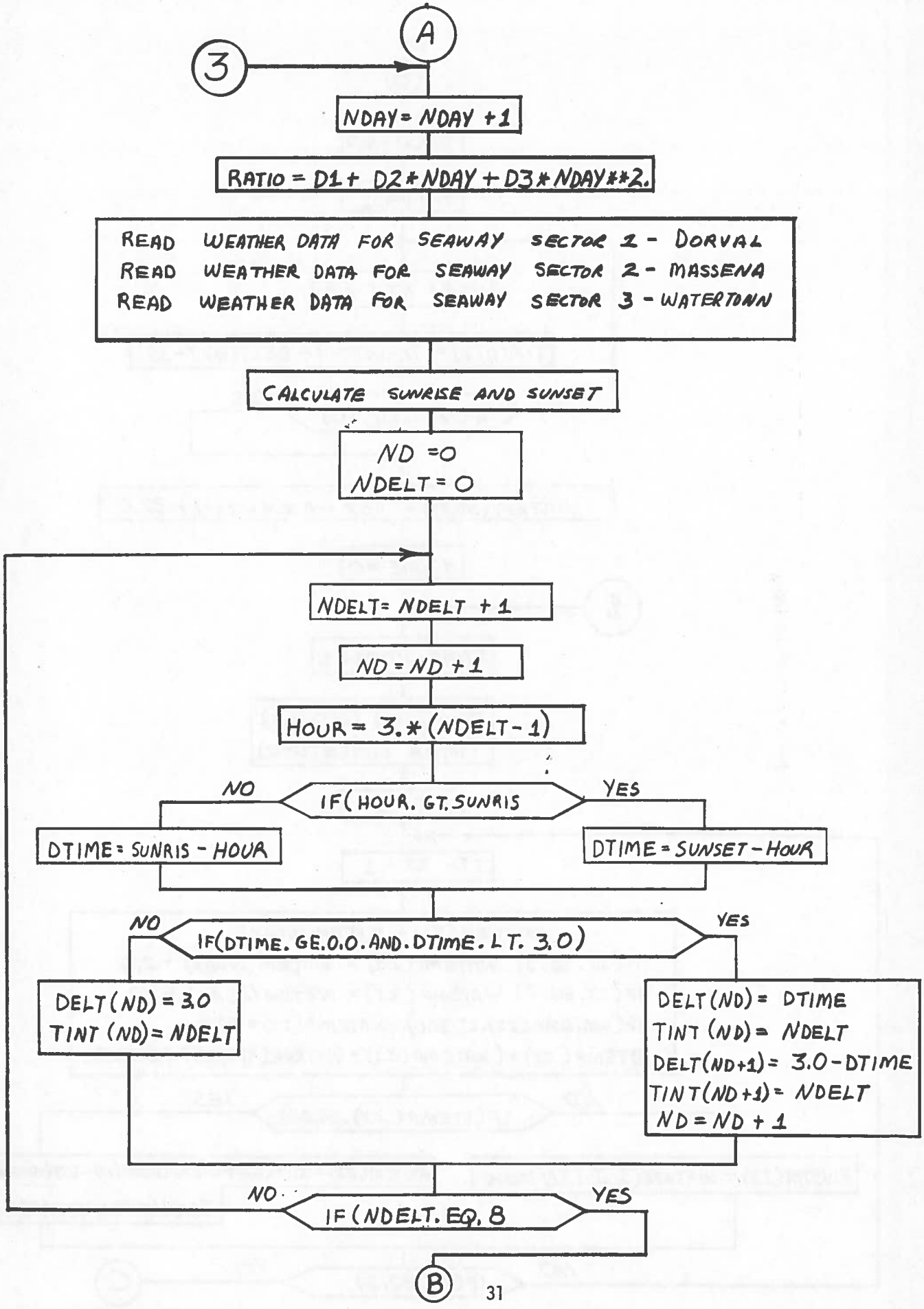


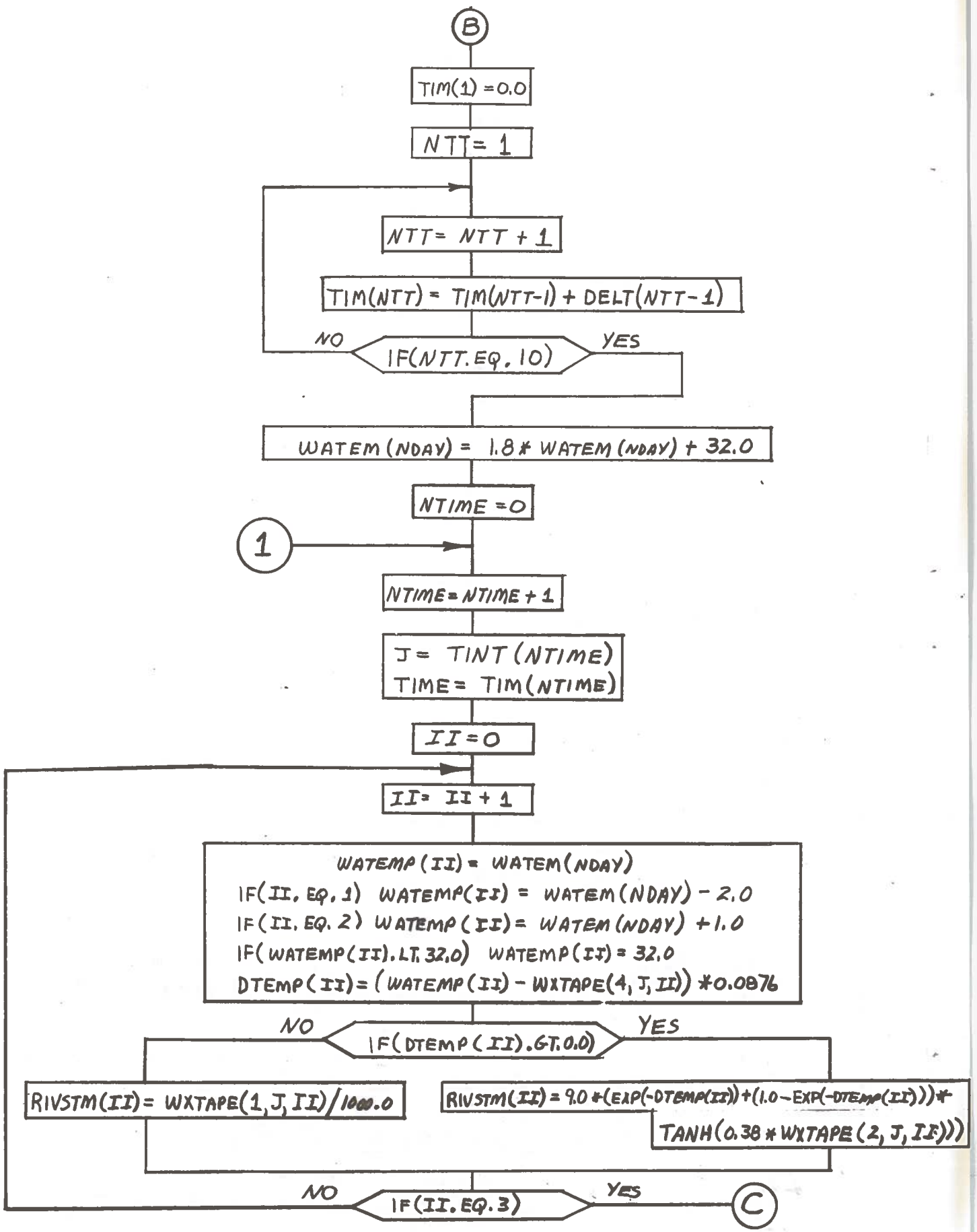
Figure B.2. Laker Seaway Capacity as a Function of Navigational Positioning Accuracy

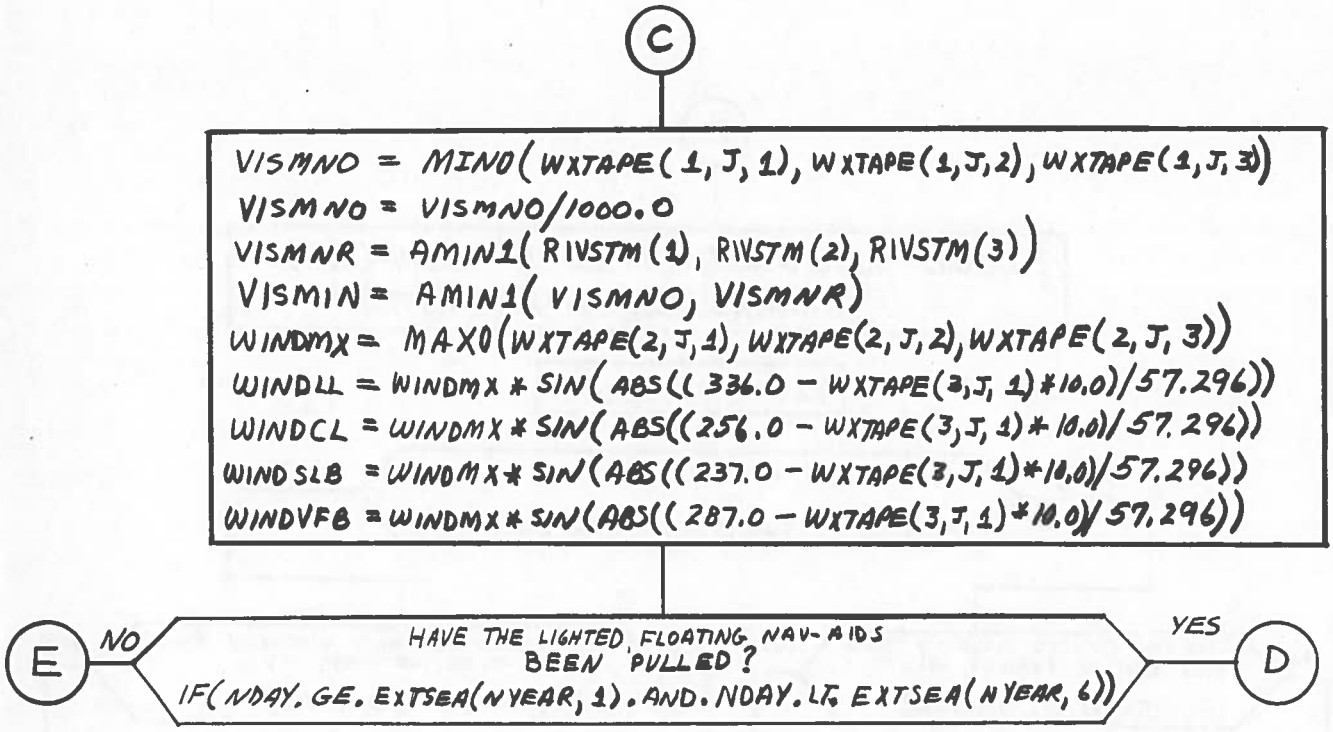
B.5 FLOW CHARTS

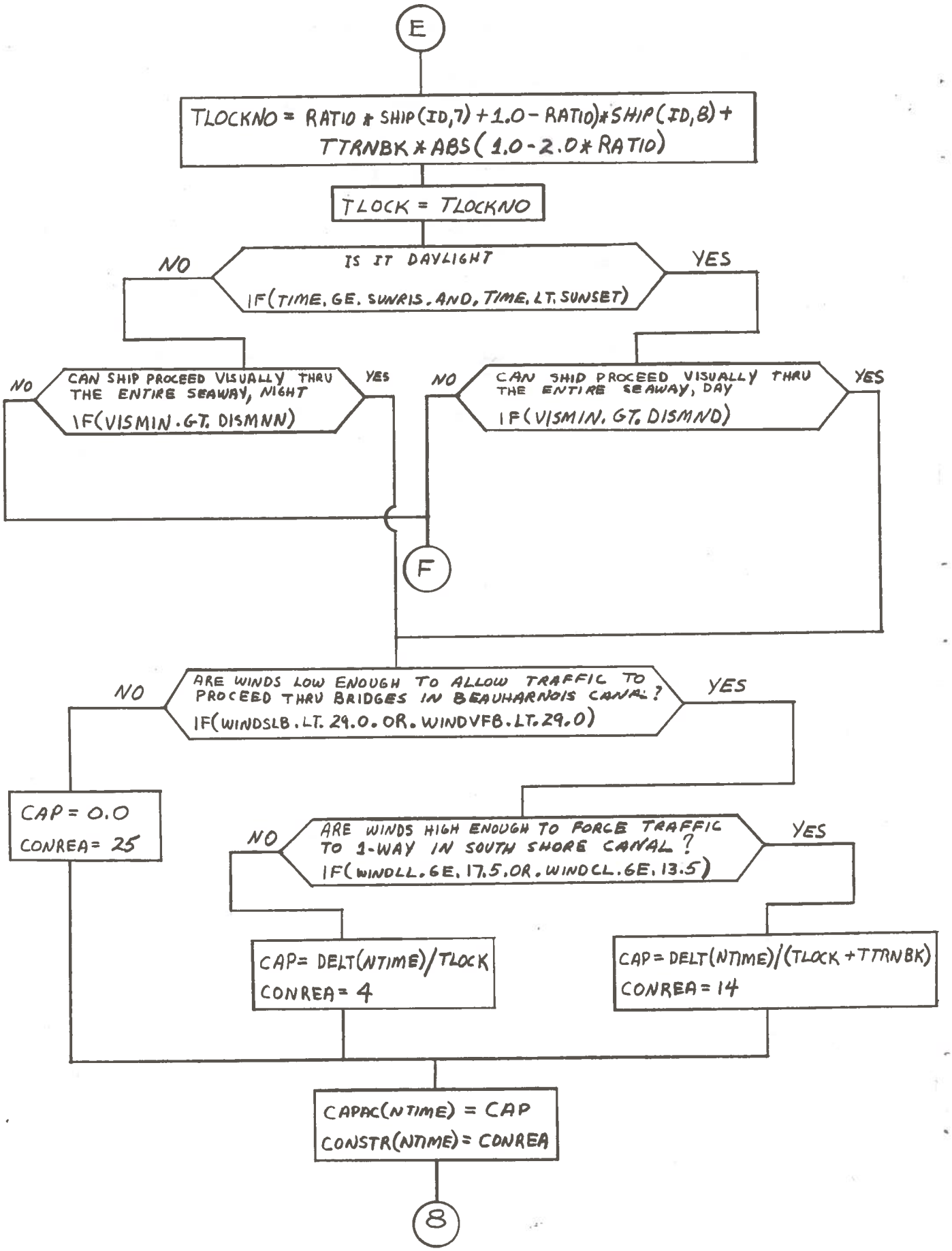
PROGRAM AWCAP

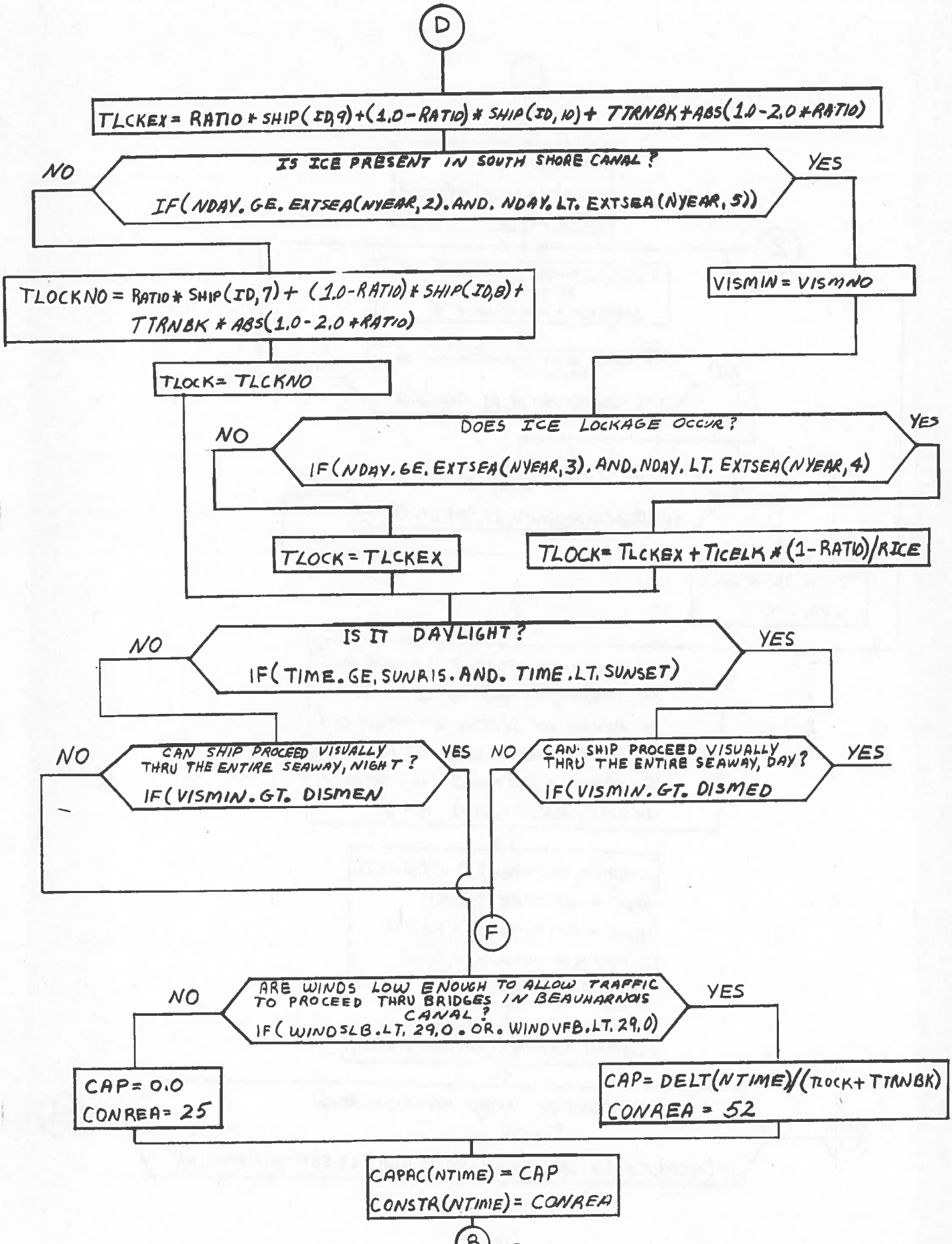


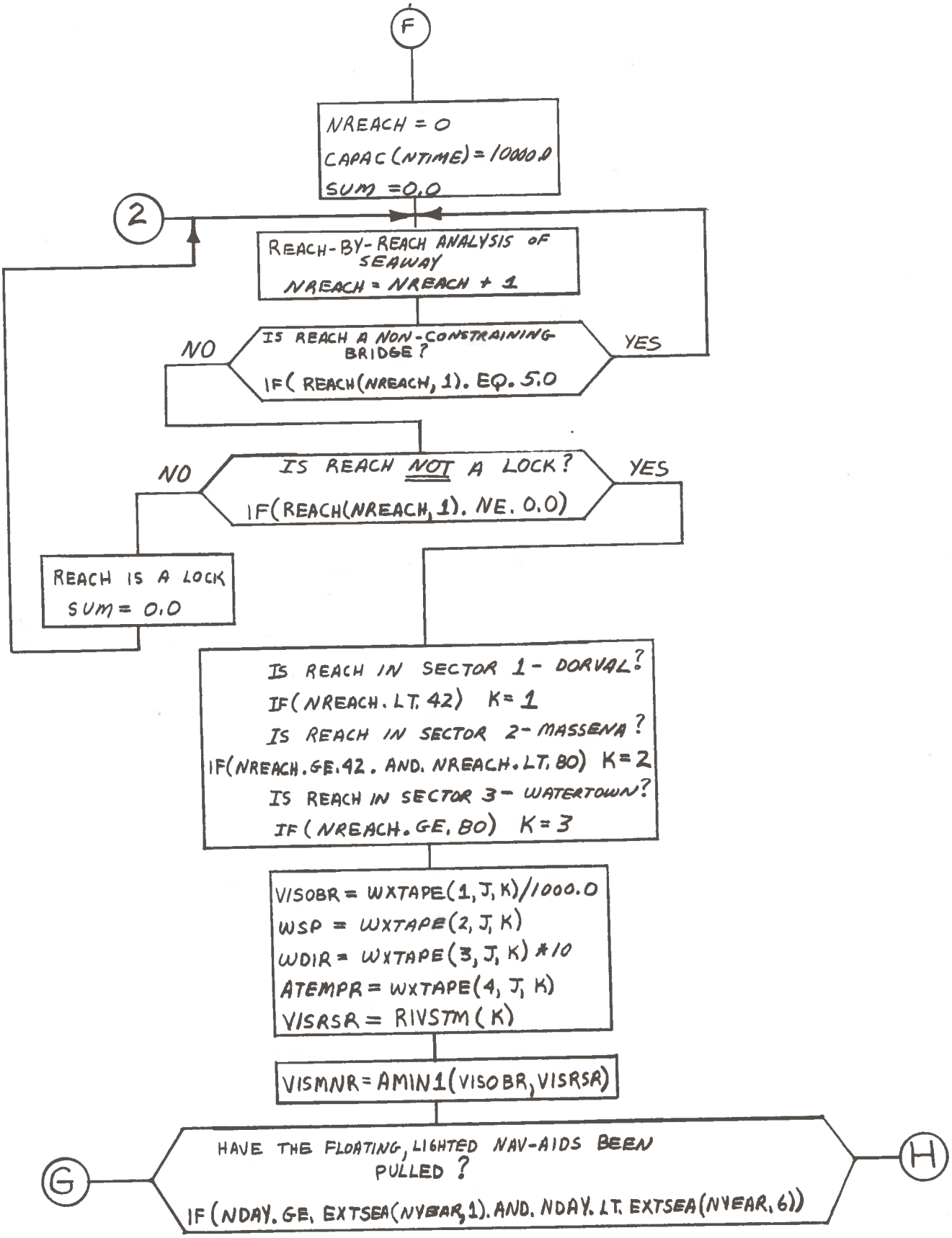

3
A
NDAY = NDAY + 1
RATIO = D1 + D2 * NDAY + D3 * NDAY**2.
READ WEATHER DATA FOR SEAWAY SECTOR 1 - DORVAL
READ WEATHER DATA FOR SEAWAY SECTOR 2 - MASSENA
READ WEATHER DATA FOR SEAWAY SECTOR 3 - WATERTOWN
CALCULATE SUNRISE AND SUNSET
ND = 0
NDELT = 0
NDELT = NDELT + 1
ND = ND + 1
HOUR = 3. * (NDELT - 1)
NO
IF (HOUR. GT. SUNRIS
YES
DTIME = SUNRIS - HOUR
DTIME = SUNSET - HOUR
NO
IF (DTIME. GE. 0.0. AND. DTIME. LT. 3.0)
YES
DELT (ND) = 3.0
TINT (ND) = NDELT
DELT (ND) = DTIME
TINT (ND) = NDELT
DELT (ND+1) = 3.0 - DTIME
TINT (ND+1) = NDELT
ND = ND + 1
NO
IF (NDELT. EQ. 8
YES
B

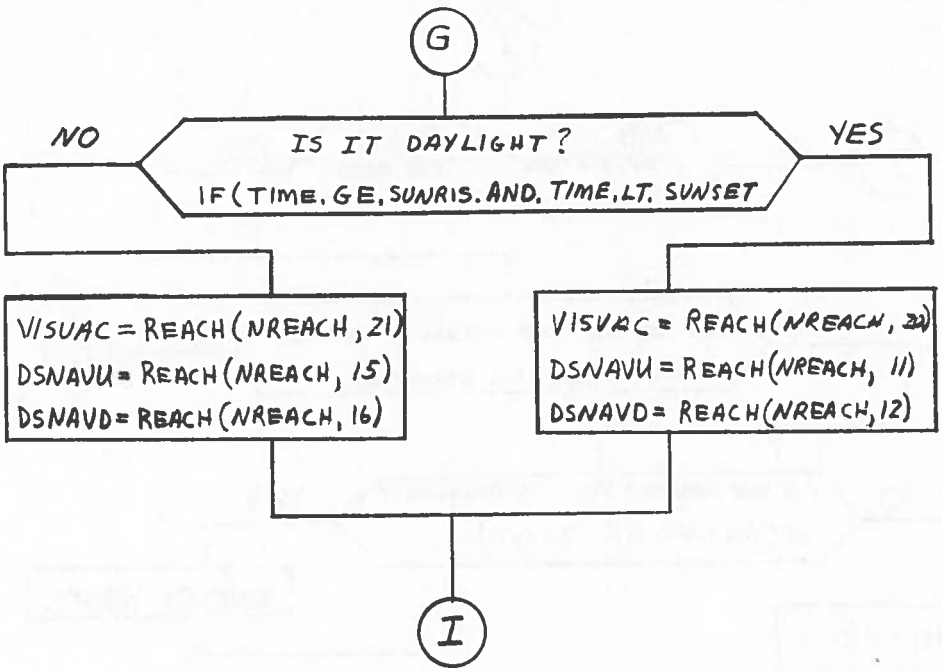

B
TIM(1) =0.0
NTT= 1
NTT= NTT + 1
TIM(NTT) = TIM(NTT-1) + DELT(NTT-1)
NO
IF(NTT.EQ.10)
YES
WATEM(NDAY) = 1.8 * WATEM(NDAY) + 32.0
NTIME =0
1
NTIME= NTIME + 1
J= TINT(NTIME)
TIME= TIM(NTIME)
II=0
II= II + 1
WATEMP(II) = WATEM(NDAY)
IF(II.EQ.1) WATEMP(II) = WATEM(NDAY) - 2.0
IF(II.EQ.2) WATEMP(II) = WATEM(NDAY) +1.0
IF(WATEMP(II).LT.32.0) WATEMP(II) = 32.0
DTEMP(II) = (WATEMP(II) - WXTAPE(4,J,II)) *0.0876
NO
IF(DTEMP(II).GT.0.0)
YES
RIVSTM(II) = WXTAPE(1,J,II)/1000.0
RIVSTM(II) = 9.0 +(EXP(-DTEMP(II)) +(1.0-EXP(-DTEMP(II))) *
TANH(0.38 * WXTAPE(2,J,II)))
NO
IF(II.EQ.3)
YES
C

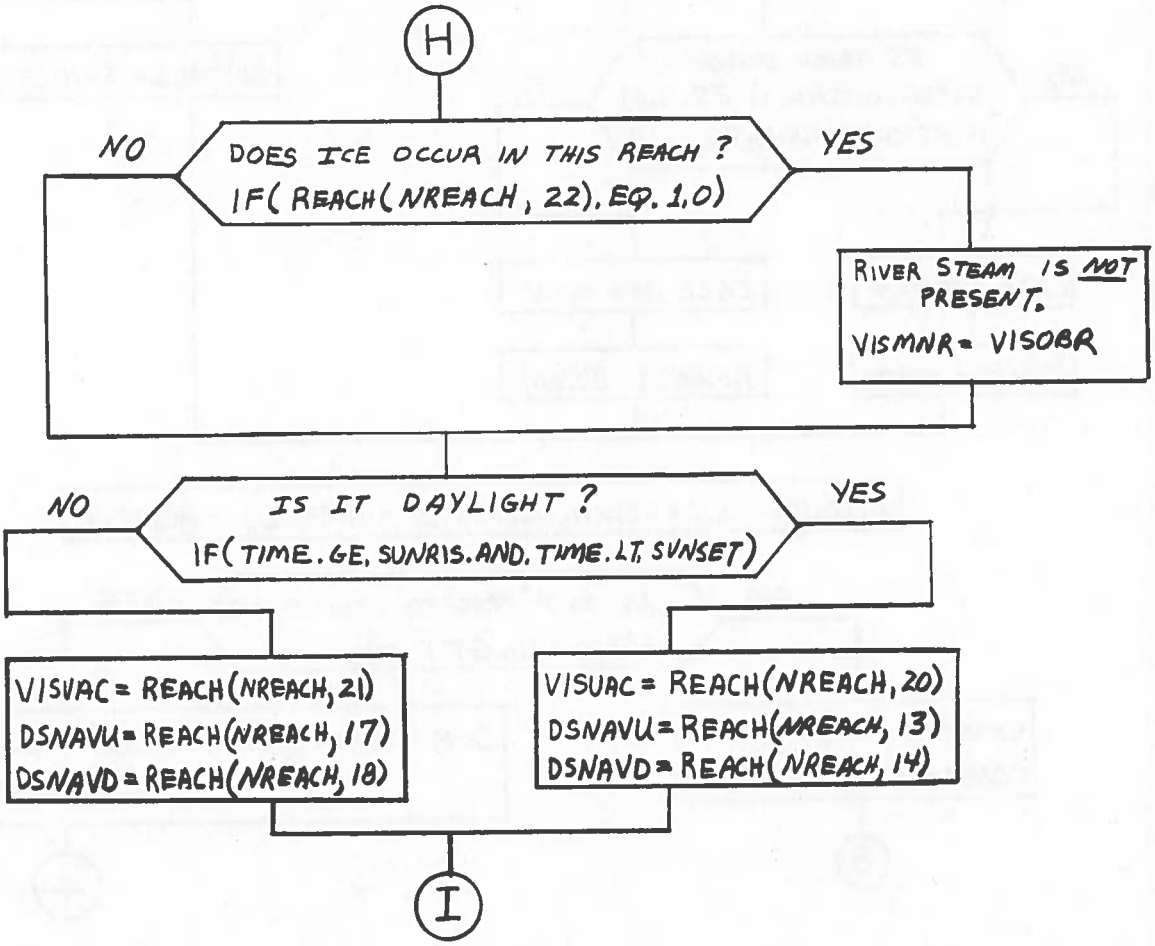

C
VISMNO = MINO(WXTAPE(1,J,1), WXTAPE(1,J,2), WXTAPE(1,J,3))
VISMNO = VISMNO/1000.0
VISMNR = AMIN1(RIVSTM(1), RIVSTM(2), RIVSTM(3))
VISMIN = AMIN1(VISMNO, VISMNR)
WINDMX = MAX0(WXTAPE(2,J,1), WXTAPE(2,J,2), WXTAPE(2,J,3))
WINDLL = WINDMX * SIN(ABS((336.0 - WXTAPE(3,J,1)*10.0)/57.296))
WINDCL = WINDMX * SIN(ABS((256.0 - WXTAPE(3,J,1)*10.0)/57.296))
WINDSLB = WINDMX * SIN(ABS((237.0 - WXTAPE(3,J,1)*10.0)/57.296))
WINDVFB = WINDMX * SIN(ABS((287.0 - WXTAPE(3,J,1)*10.0)/57.296))
E
NO
HAVE THE LIGHTED, FLOATING NAV-AIDS BEEN PULLED?
IF(NDAY.GE.EXTSEA(NYEAR,1).AND.NDAY.LT.EXTSEA(NYEAR,6))
YES
D

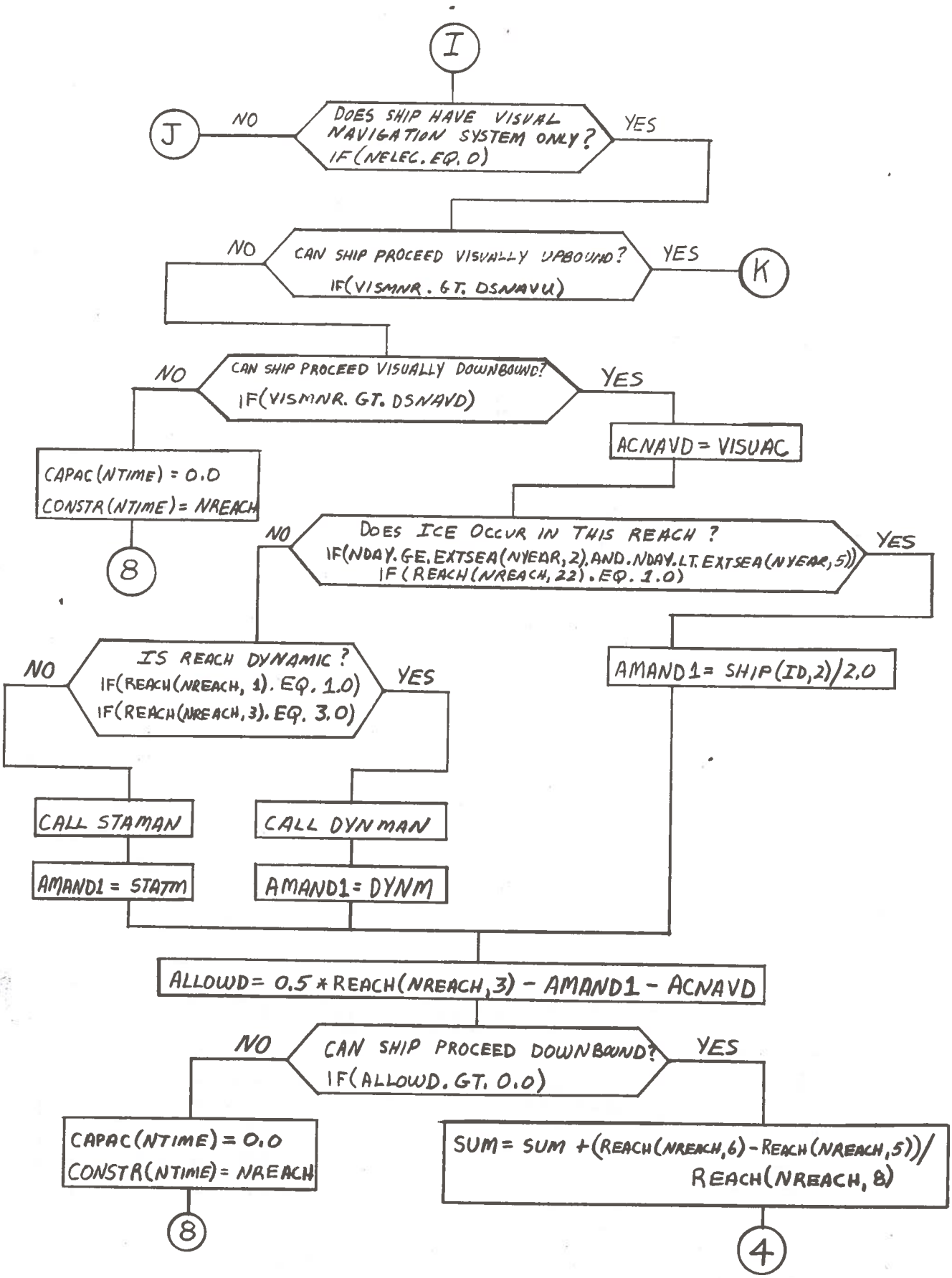

E
TLOCKNO = RATIO * SHIP(ID,7) + 1.0 - RATIO) * SHIP(ID,8) + TTRNBK * ABS(1.0 - 2.0 * RATIO)
TLOCK = TLOCKNO
IS IT DAYLIGHT
IF(TIME.GE.SUNRIS.AND.TIME.LT.SUNSET)
NO
YES
CAN SHIP PROCEED VISUALLY THRU THE ENTIRE SEAWAY, NIGHT
IF(VISMIN.GT.DISMNN)
NO
YES
CAN SHIP PROCEED VISUALLY THRU THE ENTIRE SEAWAY, DAY
IF(VISMIN.GT.DISMND)
NO
YES
F
ARE WINDS LOW ENOUGH TO ALLOW TRAFFIC TO PROCEED THRU BRIDGES IN BEAUHARNOIS CANAL?
IF(WINDSLB.LT.29.0.OR.WINDVFB.LT.29.0)
NO
YES
CAP = 0.0
CONREA = 25
ARE WINDS HIGH ENOUGH TO FORCE TRAFFIC TO 1-WAY IN SOUTH SHORE CANAL?
IF(WINDLL.GE.17.5.OR.WINDCL.GE.13.5)
NO
YES
CAP = DELT(NTIME)/TLOCK
CONREA = 4
CAP = DELT(NTIME)/(TLOCK + TTRNBK)
CONREA = 14
CAPAC(NTIME) = CAP
CONSTR(NTIME) = CONREA
8

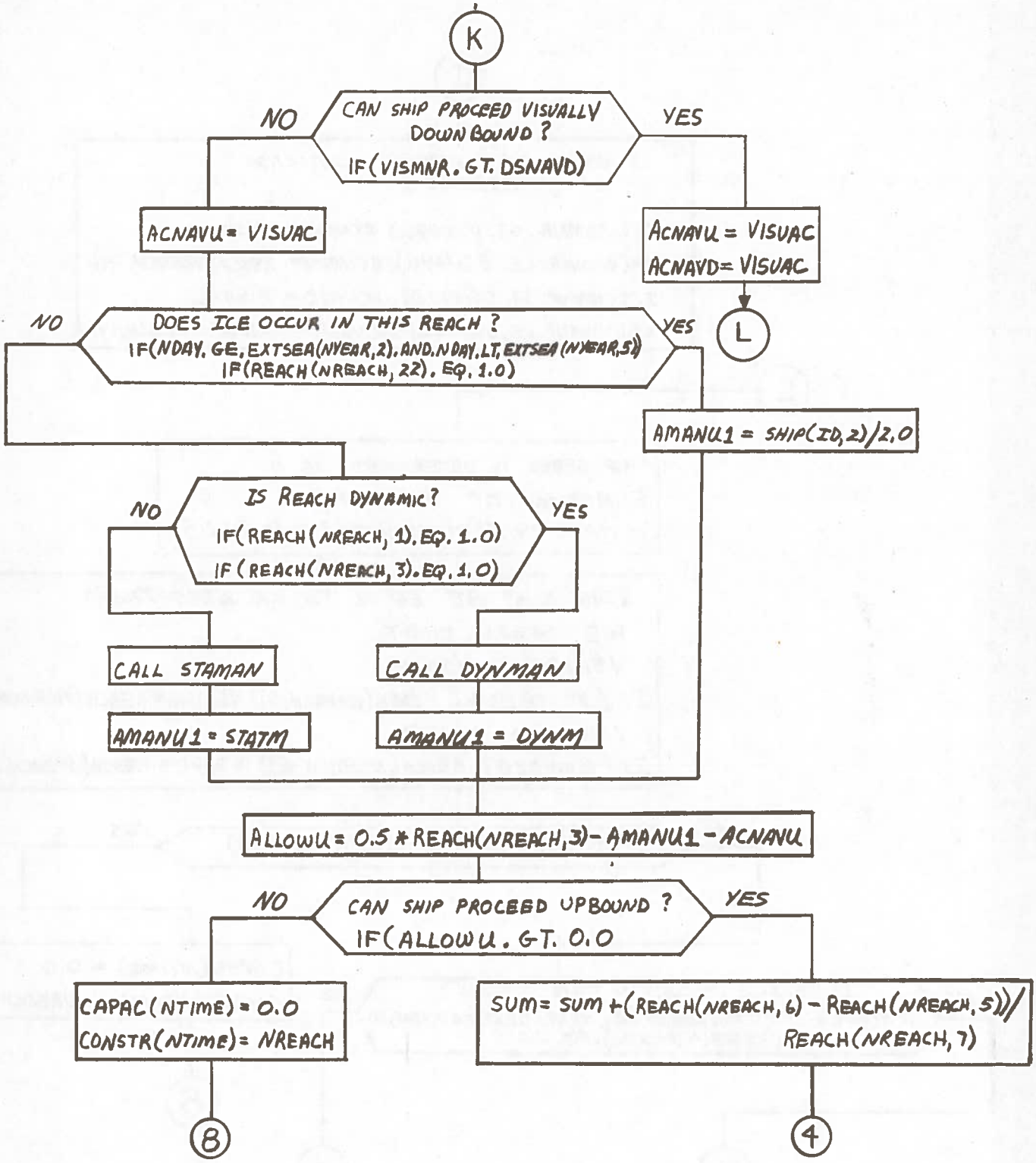

D
TLCKEX = RATIO * SHIP(ID,9) + (1.0 - RATIO) * SHIP(ID,10) + TTRNBK + ABS(1.0 - 2.0 * RATIO)
IS ICE PRESENT IN SOUTH SHORE CANAL ?
IF(NDAY. GE. EXTSEA(NYEAR,2). AND. NDAY. LT. EXTSEA(NYEAR,5))
NO
YES
TLOCKNO = RATIO * SHIP(ID,7) + (1.0-RATIO) * SHIP(ID,8) + TTRNBK * ABS(1.0 - 2.0 + RATIO)
VISMIN = VISMNO
TLOCK = TLCKNO
DOES ICE LOCKAGE OCCUR ?
IF(NDAY. GE. EXTSEA(NYEAR,3). AND. NDAY. LT. EXTSEA(NYEAR,4)
NO
YES
TLOCK = TLCKEX
TLOCK = TLCKEX + TICELK * (1-RATIO)/RICE
IS IT DAYLIGHT ?
IF(TIME. GE. SUNRIS. AND. TIME. LT. SUNSET)
NO
YES
CAN SHIP PROCEED VISUALLY THRU THE ENTIRE SEAWAY, NIGHT ?
IF(VISMIN. GT. DISMEN
NO
YES
CAN SHIP PROCEED VISUALLY THRU THE ENTIRE SEAWAY, DAY ?
IF(VISMIN. GT. DISMED
NO
YES
F
ARE WINDS LOW ENOUGH TO ALLOW TRAFFIC TO PROCEED THRU BRIDGES IN BEAUHARNOIS CANAL ?
IF(WINDSLB. LT. 29,0 . OR. WINDVFB. LT. 29.0)
NO
YES
CAP = 0.0
CONREA = 25
CAP = DELT(NTIME)/(TLOCK + TTRNBK)
CONREA = 52
CAPAC(NTIME) = CAP
CONSTR(NTIME) = CONREA
8

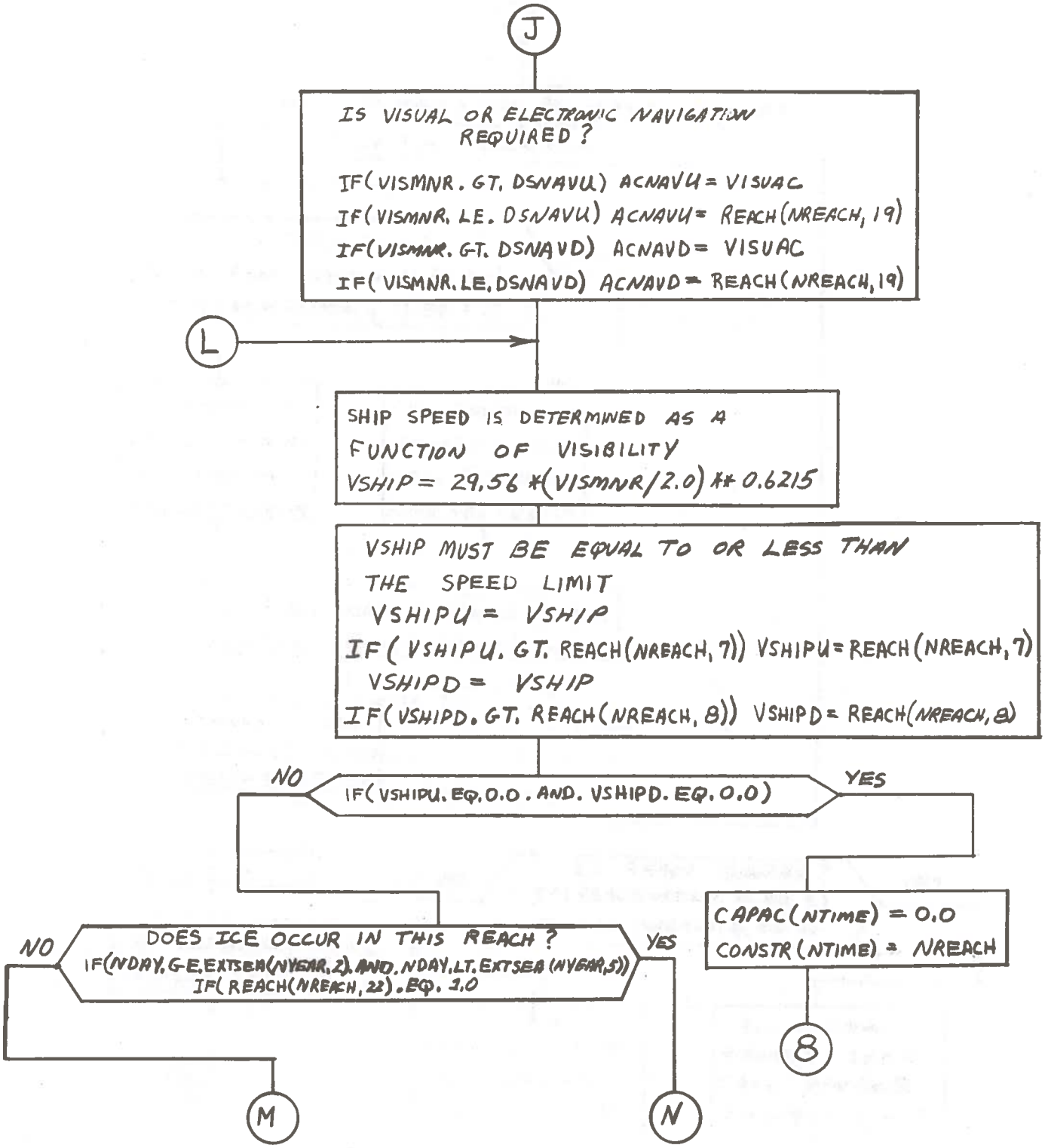

F
NREACH = 0
CAPAC (NTIME) = 10000.0
SUM = 0.0
2
REACH-BY-REACH ANALYSIS OF SEAWAY
NREACH = NREACH + 1
NO
IS REACH A NON-CONSTRAINING BRIDGE?
IF(REACH(NREACH, 1). EQ. 5.0
YES
NO
IS REACH NOT A LOCK?
IF(REACH(NREACH, 1). NE. 0.0)
YES
REACH IS A LOCK
SUM = 0.0
IS REACH IN SECTOR 1 - DORVAL?
IF(NREACH. LT. 42) K = 1
IS REACH IN SECTOR 2 - MASSENA ?
IF(NREACH. GE. 42. AND. NREACH. LT. 80) K = 2
IS REACH IN SECTOR 3 - WATERTOWN?
IF (NREACH. GE. 80) K = 3
VISOBR = WXTAPE(1, J, K)/1000.0
WSP = WXTAPE(2, J, K)
WDIR = WXTAPE(3, J, K) *10
ATEMPR = WXTAPE(4, J, K)
VISRSR = RIVSTM (K)
VISMNR = AMIN1(VISOBR, VISRSR)
G
HAVE THE FLOATING, LIGHTED NAV-AIDS BEEN PULLED ?
IF (NDAY. GE. EXTSEA(NYEAR, 1). AND. NDAY. LT. EXTSEA(NYEAR, 6))
H

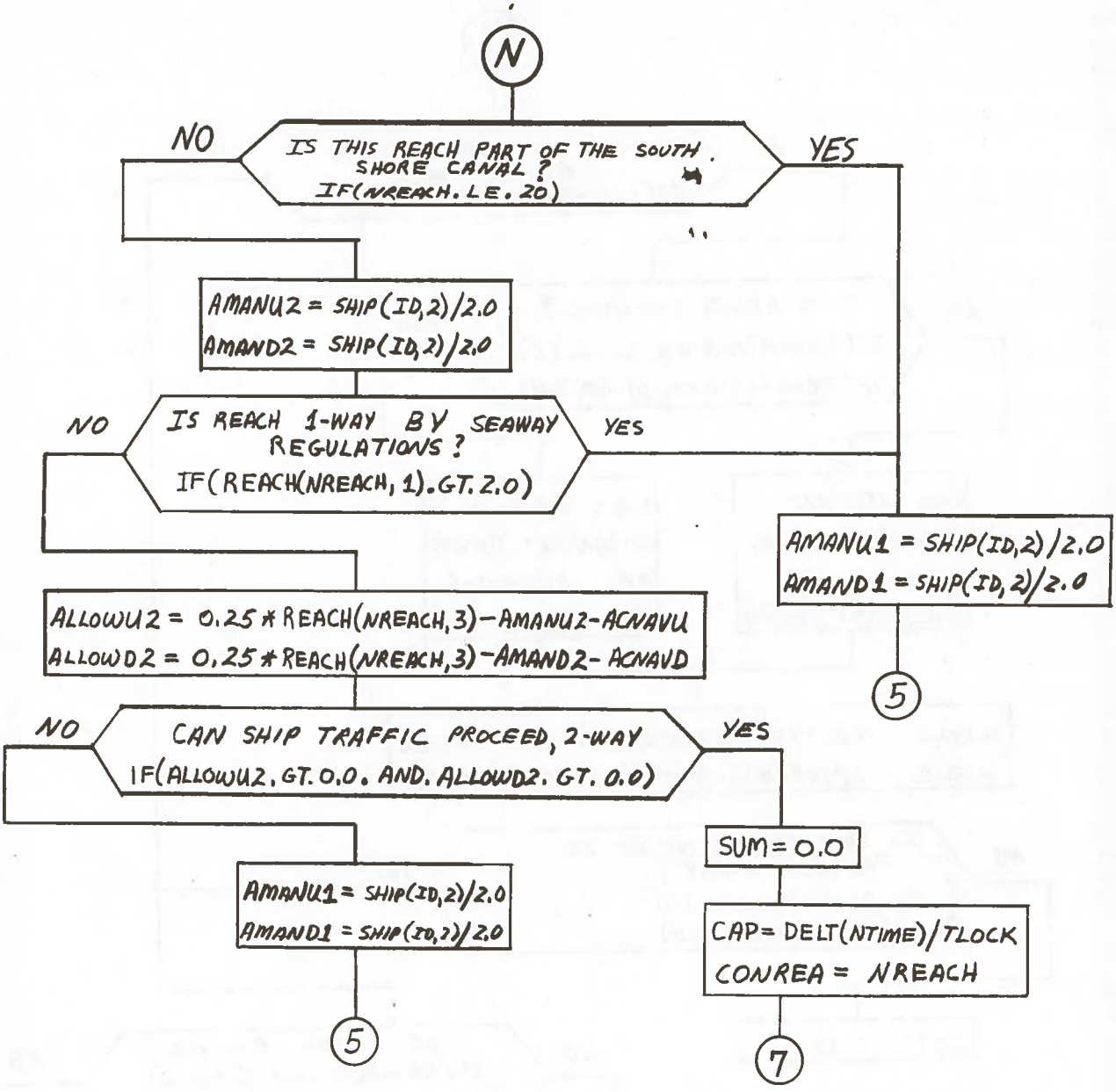

G
IS IT DAYLIGHT ?
IF(TIME.GE.SUNRIS.AND.TIME.LT.SUNSET
NO
YES
VISVAC = REACH(NREACH, 21)
DSNAVU = REACH(NREACH, 15)
DSNAVD = REACH(NREACH, 16)
VISVAC = REACH(NREACH, 22)
DSNAVU = REACH(NREACH, 11)
DSNAVD = REACH(NREACH, 12)
I

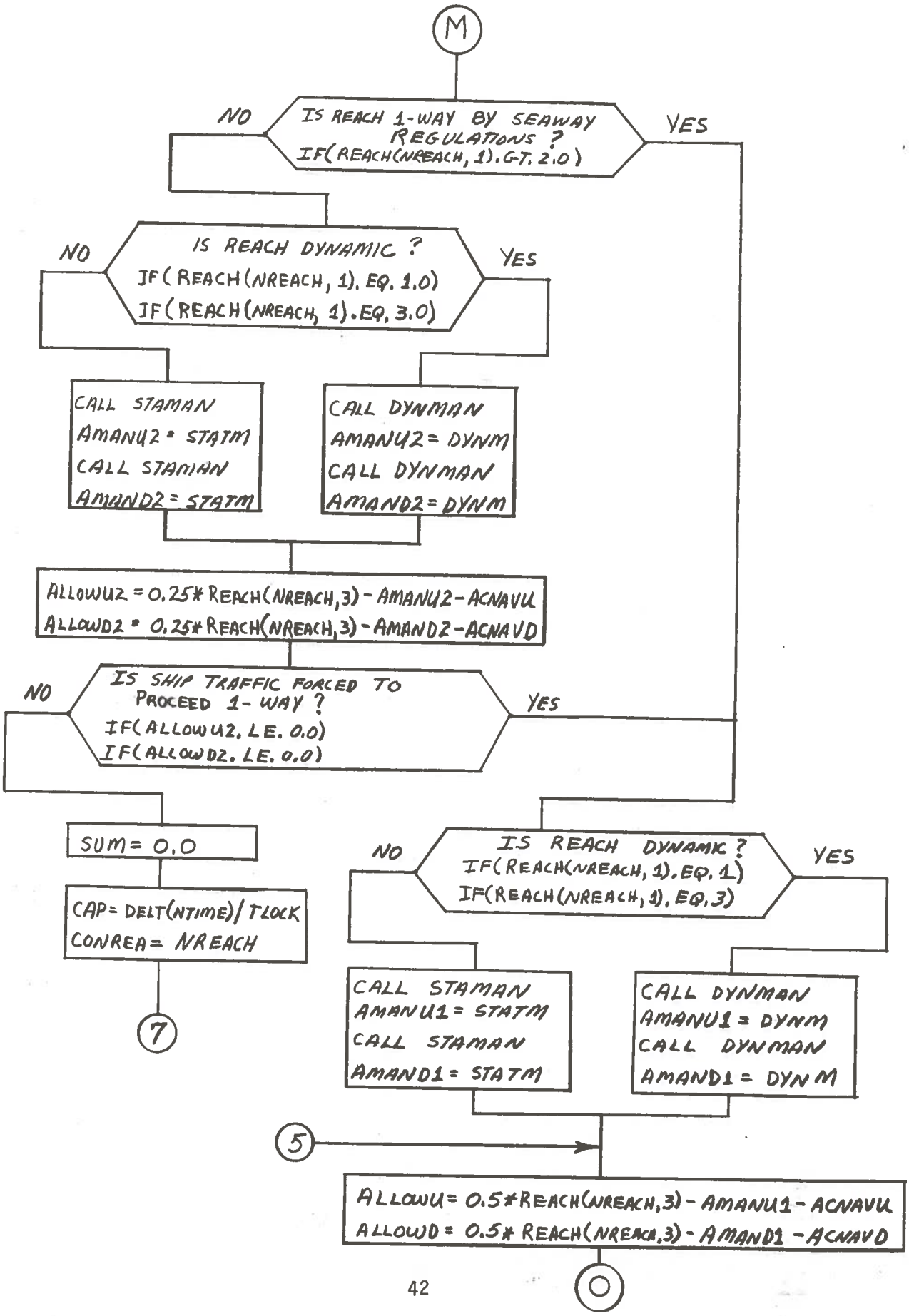

H
DOES ICE OCCUR IN THIS REACH ?
IF(REACH(NREACH, 22). EQ. 1.0)
NO
YES
RIVER STEAM IS NOT PRESENT.
VISMNR = VISOBR
IS IT DAYLIGHT ?
IF(TIME.GE.SUNRIS.AND.TIME.LT.SUNSET)
NO
YES
VISVAC = REACH(NREACH, 21)
DSNAVU = REACH(NREACH, 17)
DSNAVD = REACH(NREACH, 18)
VISVAC = REACH(NREACH, 20)
DSNAVU = REACH(NREACH, 13)
DSNAVD = REACH(NREACH, 14)
I

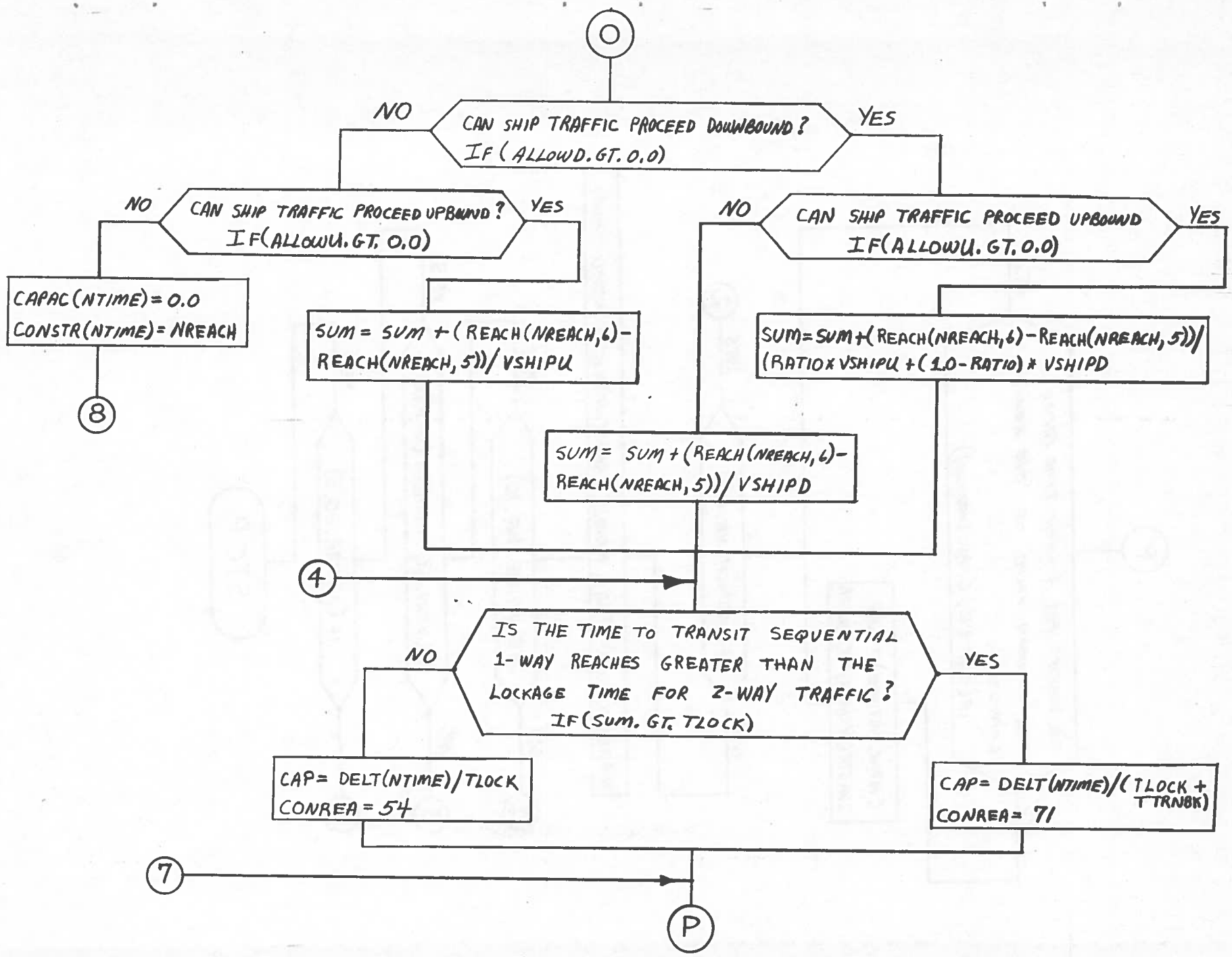

I
J
NO
DOES SHIP HAVE VISUAL NAVIGATION SYSTEM ONLY?
IF(NELEC.EQ.0)
YES
NO
CAN SHIP PROCEED VISUALLY UPBOUND?
IF(VISMNR.GT.DSNAVU)
YES
K
NO
CAN SHIP PROCEED VISUALLY DOWNBOUND?
IF(VISMNR.GT.DSNAVD)
YES
ACNAVD = VISUAC
CAPAC(NTIME) = 0.0
CONSTR(NTIME) = NREACH
8
NO
DOES ICE OCCUR IN THIS REACH ?
IF(NDAY.GE.EXTSEA(NYEAR,2).AND.NDAY.LT.EXTSEA(NYEAR,5))
IF(REACH(NREACH,22).EQ.1.0)
YES
NO
IS REACH DYNAMIC ?
IF(REACH(NREACH,1).EQ.1.0)
IF(REACH(NREACH,3).EQ.3.0)
YES
AMAND1 = SHIP(ID,2)/2.0
CALL STAMAN
CALL DYNMAN
AMAND1 = STATM
AMAND1 = DYNM
ALLOWD = 0.5 * REACH(NREACH,3) - AMAND1 - ACNAVD
NO
CAN SHIP PROCEED DOWNBOUND?
IF(ALLOWD.GT.0.0)
YES
CAPAC(NTIME) = 0.0
CONSTR(NTIME) = NREACH
8
SUM = SUM + (REACH(NREACH,6) - REACH(NREACH,5))/
REACH(NREACH,8)
4

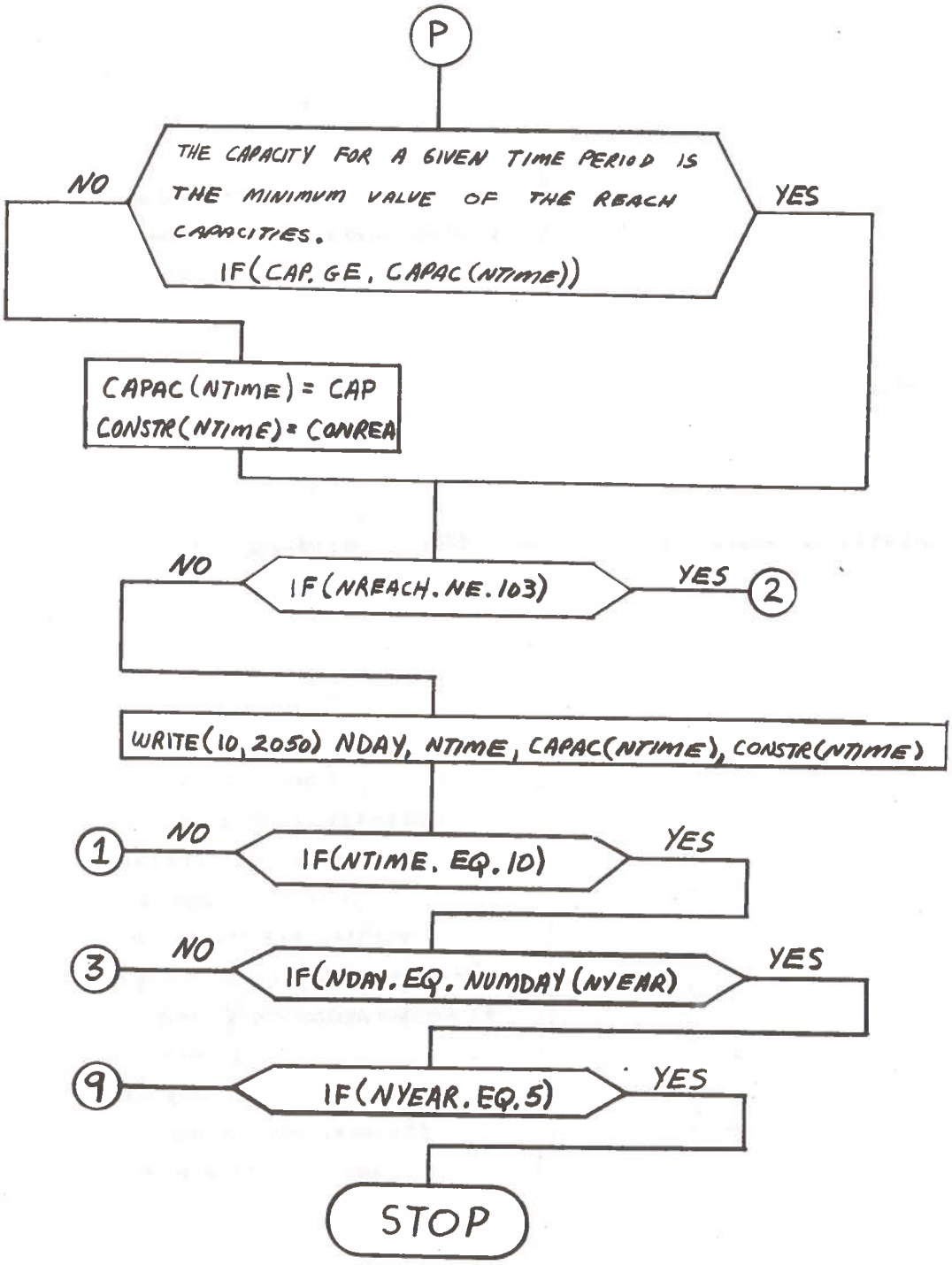

K
CAN SHIP PROCEED VISUALLY DOWN BOUND ?
IF(VISMNR.GT.DSNAVD)
NO
YES
ACNAVU = VISUAC
ACNAVU = VISUAC
ACNAVD = VISUAC
L
DOES ICE OCCUR IN THIS REACH ?
IF(NDAY.GE.EXTSEA(NYEAR,2).AND.NDAY.LT.EXTSEA(NYEAR,5))
IF(REACH(NREACH,22).EQ.1.0)
NO
YES
AMANU1 = SHIP(ID,2)/2.0
IS REACH DYNAMIC?
IF(REACH(NREACH,1).EQ.1.0)
IF(REACH(NREACH,3).EQ.1.0)
NO
YES
CALL STAMAN
CALL DYNMAN
AMANU1 = STATM
AMANU1 = DYNM
ALLOWU = 0.5 * REACH(NREACH,3) - AMANU1 - ACNAVU
CAN SHIP PROCEED UPBOUND ?
IF(ALLOWU.GT.0.0
NO
YES
CAPAC(NTIME) = 0.0
CONSTR(NTIME) = NREACH
SUM = SUM + (REACH(NREACH,6) - REACH(NREACH,5))/
REACH(NREACH,7)
8
4


J
IS VISUAL OR ELECTRONIC NAVIGATION REQUIRED ?
IF(VISMNR.GT.DSNAVU) ACNAVU=VISUAC
IF(VISMNR.LE.DSNAVU) ACNAVU=REACH(NREACH,19)
IF(VISMNR.GT.DSNAVD) ACNAVD=VISUAC
IF(VISMNR.LE.DSNAVD) ACNAVD=REACH(NREACH,19)
L
SHIP SPEED IS DETERMINED AS A FUNCTION OF VISIBILITY
VSHIP=29.56*(VISMNR/2.0)**0.6215
VSHIP MUST BE EQUAL TO OR LESS THAN THE SPEED LIMIT
VSHIPU=VSHIP
IF(VSHIPU.GT.REACH(NREACH,7)) VSHIPU=REACH(NREACH,7)
VSHIPD=VSHIP
IF(VSHIPD.GT.REACH(NREACH,8)) VSHIPD=REACH(NREACH,8)
NO
IF(VSHIPU.EQ.0.0.AND.VSHIPD.EQ.0.0)
YES
CAPAC(NTIME)=0.0
CONSTR(NTIME)=NREACH
8
NO
DOES ICE OCCUR IN THIS REACH ?
IF(NDAY.GE.EXTSEA(NYEAR,2).AND.NDAY.LT.EXTSEA(NYEAR,5))
IF(REACH(NREACH,22).EQ.1.0
YES
M
N

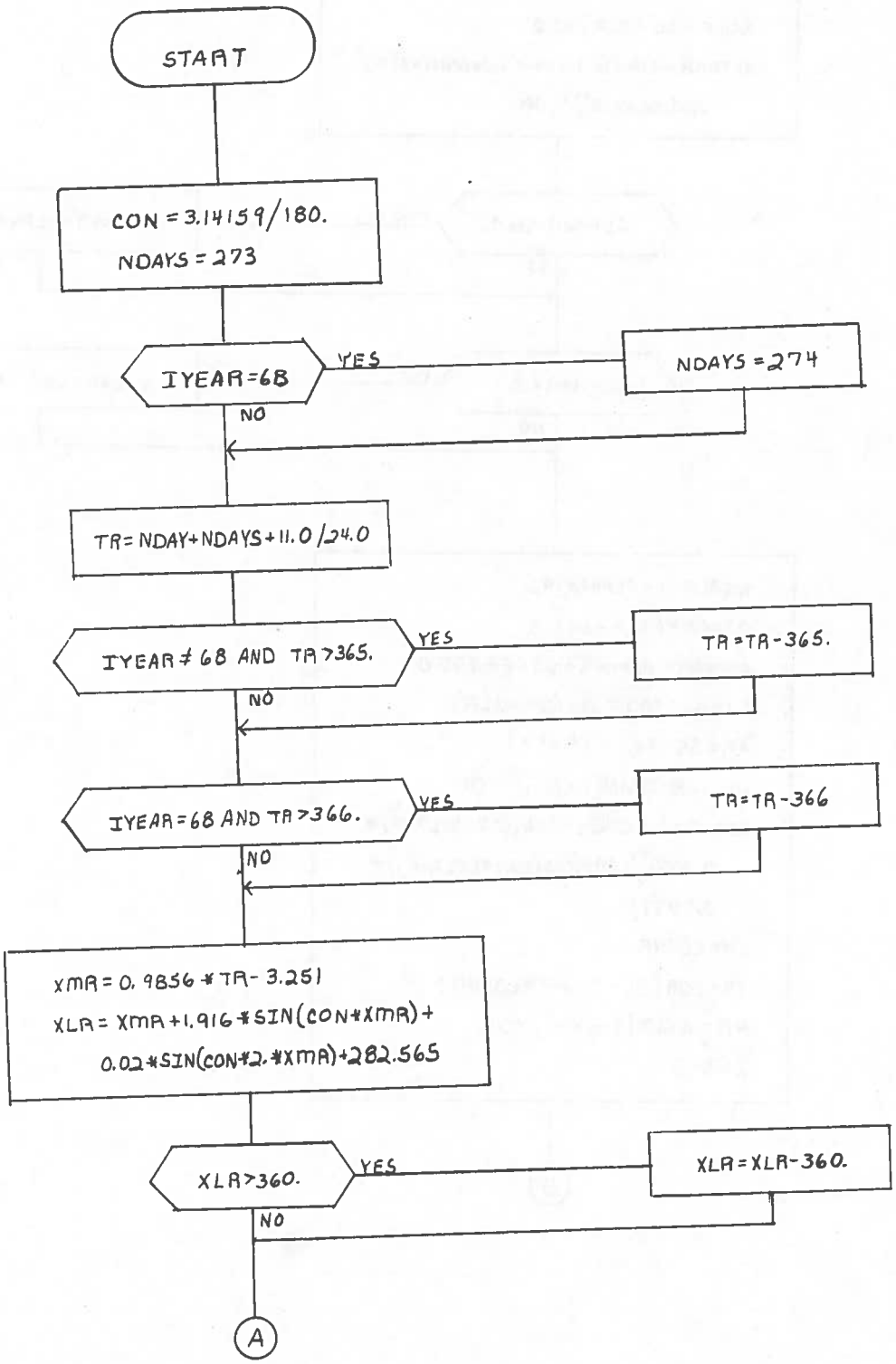

N
NO
IS THIS REACH PART OF THE SOUTH SHORE CANAL ?
IF(NREACH.LE.20)
YES
AMANU2 = SHIP(ID,2)/2.0
AMAND2 = SHIP(ID,2)/2.0
NO
IS REACH 1-WAY BY SEAWAY REGULATIONS ?
IF(REACH(NREACH,1).GT.2.0)
YES
AMANU1 = SHIP(ID,2)/2.0
AMAND1 = SHIP(ID,2)/2.0
5
ALLOWU2 = 0.25*REACH(NREACH,3)-AMANU2-ACNAVU
ALLOWD2 = 0.25*REACH(NREACH,3)-AMAND2-ACNAVD
NO
CAN SHIP TRAFFIC PROCEED, 2-WAY
IF(ALLOWU2.GT.0.0.AND.ALLOWD2.GT.0.0)
YES
SUM = 0.0
AMANU1 = SHIP(ID,2)/2.0
AMAND1 = SHIP(ID,2)/2.0
CAP = DELT(NTIME)/TLOCK
CONREA = NREACH
5
7

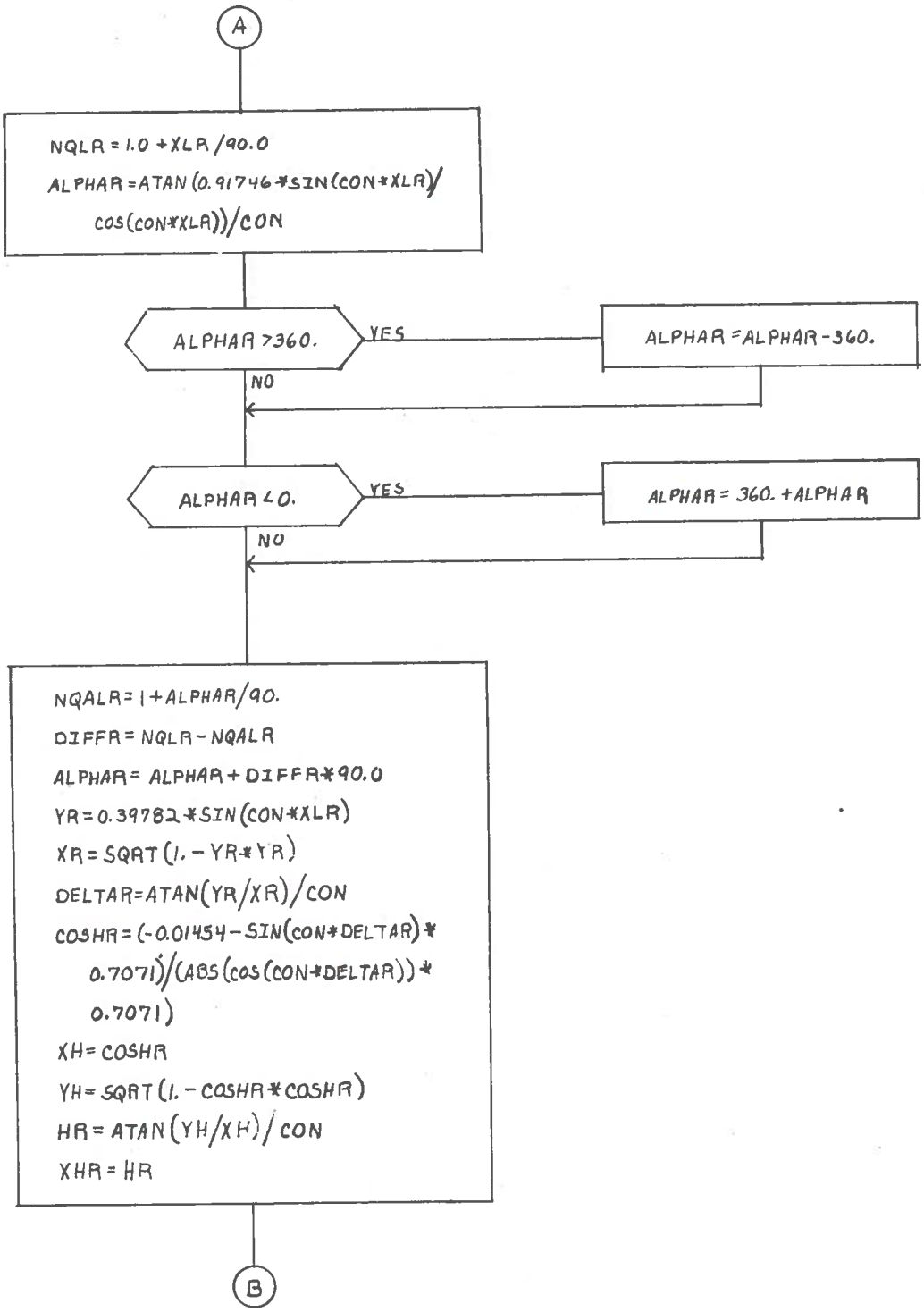

M
IS REACH 1-WAY BY SEAWAY REGULATIONS ?
IF(REACH(NREACH, 1).GT. 2.0)
NO
YES
IS REACH DYNAMIC ?
IF(REACH(NREACH, 1).EQ. 1.0)
IF(REACH(NREACH, 1).EQ. 3.0)
NO
YES
CALL STAMAN
AMANU2 = STATM
CALL STAMAN
AMAND2 = STATM
CALL DYNMAN
AMANU2 = DYNM
CALL DYNMAN
AMAND2 = DYNM
ALLOWU2 = 0.25*REACH(NREACH,3) - AMANU2 - ACNAVU
ALLOWD2 = 0.25*REACH(NREACH,3) - AMAND2 - ACNAVD
IS SHIP TRAFFIC FORCED TO PROCEED 1-WAY ?
IF(ALLOWU2. LE. 0.0)
IF(ALLOWD2. LE. 0.0)
NO
YES
SUM = 0.0
CAP = DELT(NTIME)/TLOCK
CONREA = NREACH
7
IS REACH DYNAMK ?
IF(REACH(NREACH, 1).EQ. 1)
IF(REACH(NREACH, 1), EQ. 3)
NO
YES
CALL STAMAN
AMANU1 = STATM
CALL STAMAN
AMAND1 = STATM
CALL DYNMAN
AMANU1 = DYNM
CALL DYNMAN
AMAND1 = DYNM
5
ALLOWU = 0.5*REACH(NREACH,3) - AMANU1 - ACNAVU
ALLOWD = 0.5*REACH(NREACH,3) - AMAND1 - ACNAVD
O

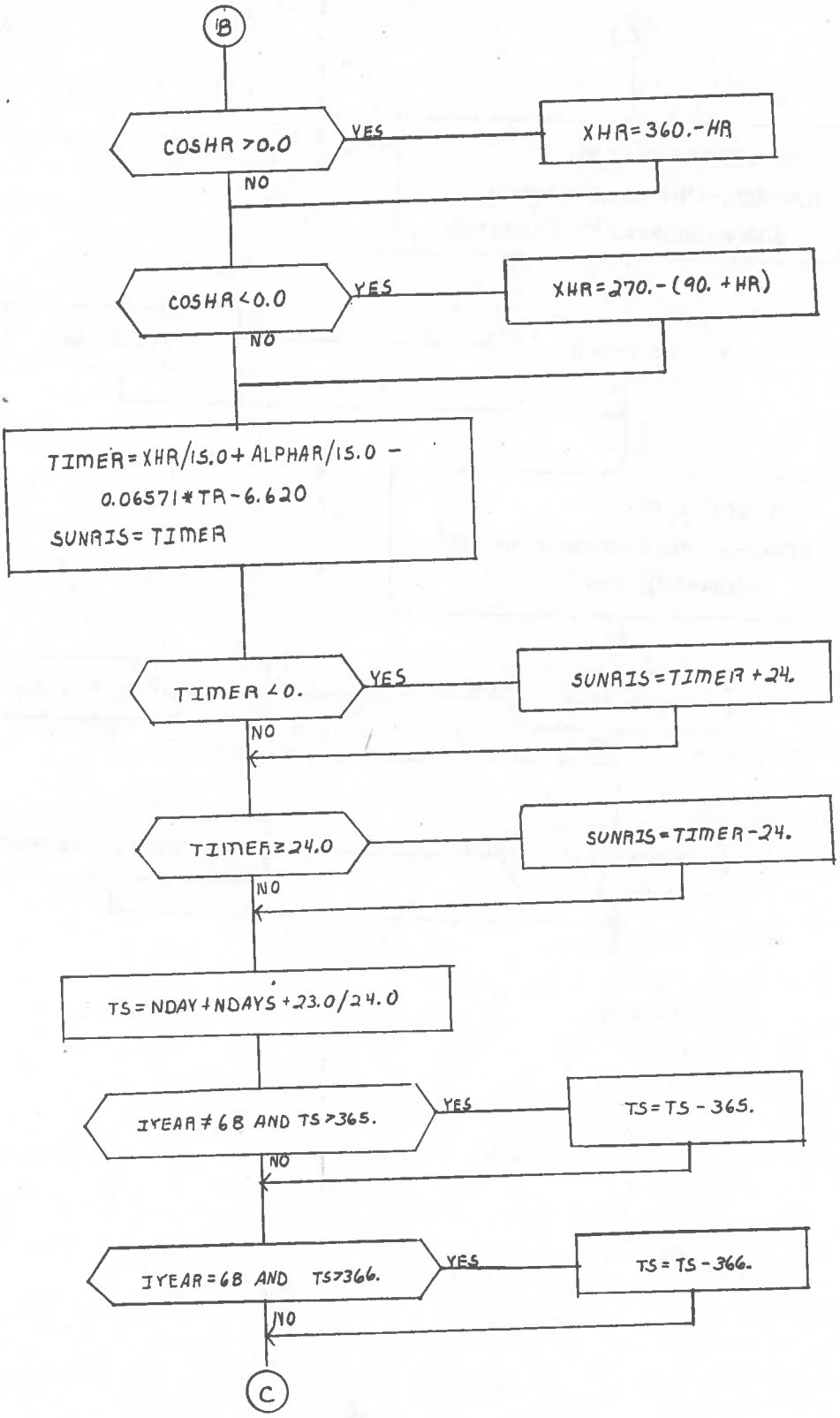

0
CAN SHIP TRAFFIC PROCEED DOWNBOUND?
IF (ALLOWD.GT.0.0)
NO
YES
CAN SHIP TRAFFIC PROCEED UPBOUND?
IF(ALLOWU.GT.0.0)
NO
YES
CAPAC(NTIME)=0.0
CONSTR(NTIME)=NREACH
8
SUM = SUM + (REACH(NREACH,6)-
REACH(NREACH,5))/VSHIPU
CAN SHIP TRAFFIC PROCEED UPBOUND
IF(ALLOWU.GT.0.0)
NO
YES
SUM=SUM+(REACH(NREACH,6)-REACH(NREACH,5))/
(RATIO*VSHIPU+(1.0-RATIO)*VSHIPD
SUM = SUM + (REACH(NREACH,6)-
REACH(NREACH,5))/VSHIPD
4
IS THE TIME TO TRANSIT SEQUENTIAL
1-WAY REACHES GREATER THAN THE
LOCKAGE TIME FOR 2-WAY TRAFFIC?
IF(SUM.GT.TLOCK)
NO
YES
CAP= DELT(NTIME)/TLOCK
CONREA=54
CAP= DELT(NTIME)/(TLOCK+
TTRNBK)
CONREA=71
7
P

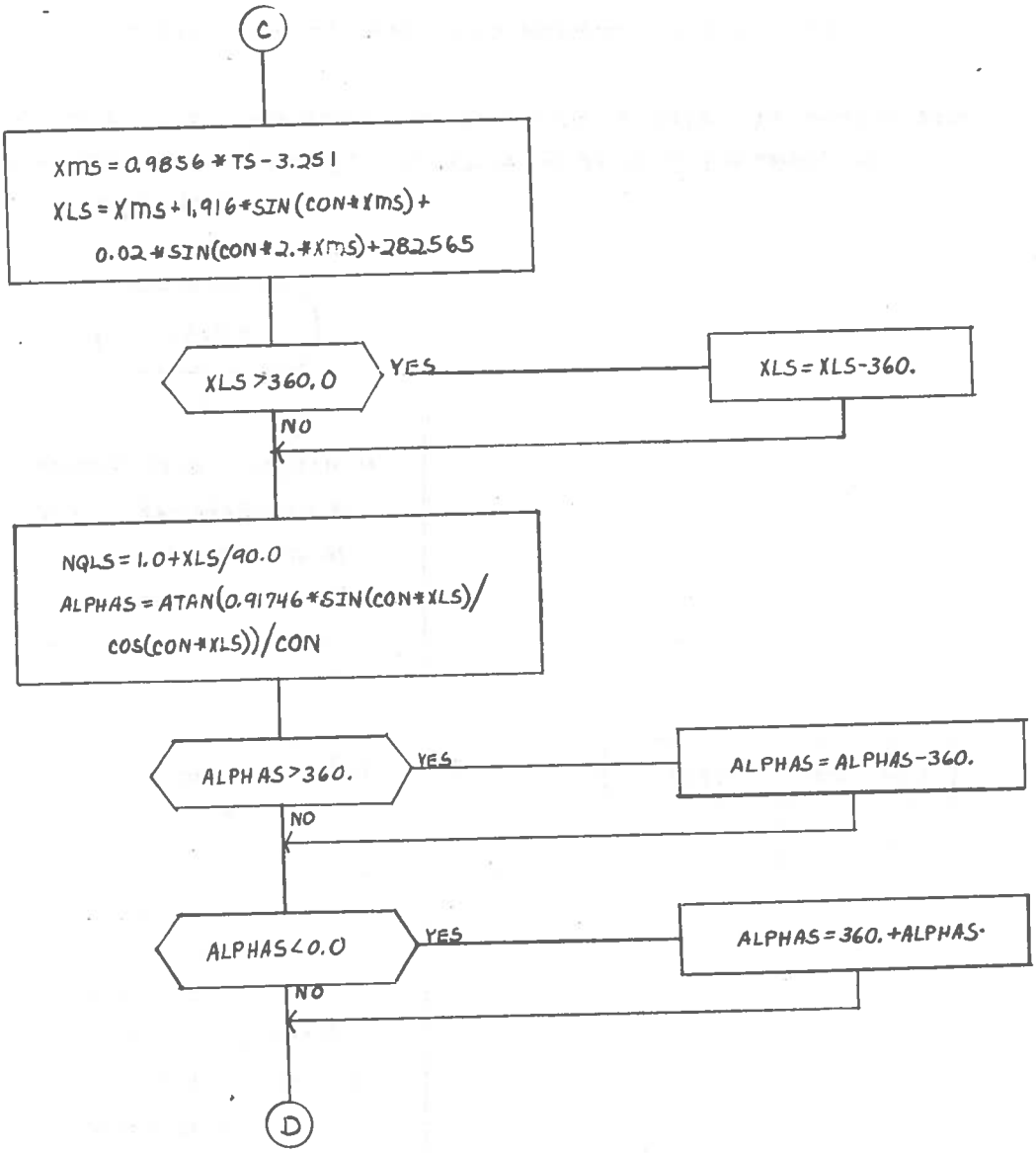

P
THE CAPACITY FOR A GIVEN TIME PERIOD IS THE MINIMUM VALUE OF THE REACH CAPACITIES.
IF(CAP. GE. CAPAC(NTIME))
NO
YES
CAPAC(NTIME) = CAP
CONSTR(NTIME) = CONREA
NO
IF(NREACH. NE. 103)
YES
2
WRITE(10, 2050) NDAY, NTIME, CAPAC(NTIME), CONSTR(NTIME)
1
NO
IF(NTIME. EQ. 10)
YES
3
NO
IF(NDAY. EQ. NUMDAY(NYEAR)
YES
9
IF(NYEAR. EQ. 5)
YES
STOP

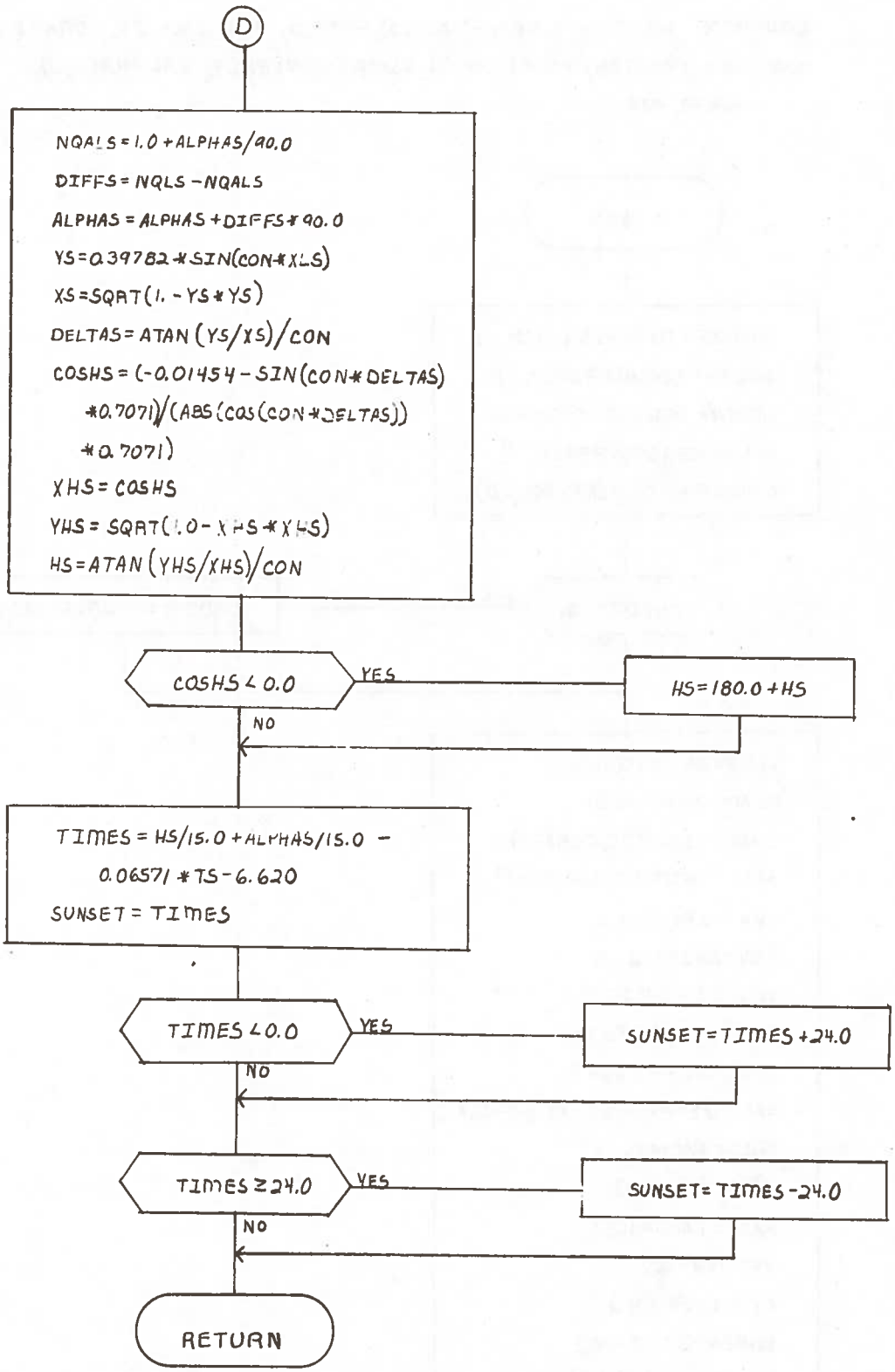
SUBROUTINE SUNRS(NDAY, IYEAR, SUNRIS, SUNSET)




A
NQLR = 1.0 + XLR / 90.0
ALPHAR = ATAN (0.91746 * SIN (CON * XLR) / COS (CON * XLR)) / CON
ALPHAR > 360.
YES
ALPHAR = ALPHAR - 360.
NO
ALPHAR < 0.
YES
ALPHAR = 360. + ALPHAR
NO
NQALR = 1 + ALPHAR / 90.
DIFFR = NQLR - NQALR
ALPHAR = ALPHAR + DIFFR * 90.0
YR = 0.39782 * SIN (CON * XLR)
XR = SQRT (1. - YR * YR)
DELTAR = ATAN (YR / XR) / CON
COSHR = (-0.01454 - SIN (CON * DELTAR) * 0.7071) / (ABS (COS (CON * DELTAR)) * 0.7071)
XH = COSHR
YH = SQRT (1. - COSHR * COSHR)
HR = ATAN (YH / XH) / CON
XHR = HR
B

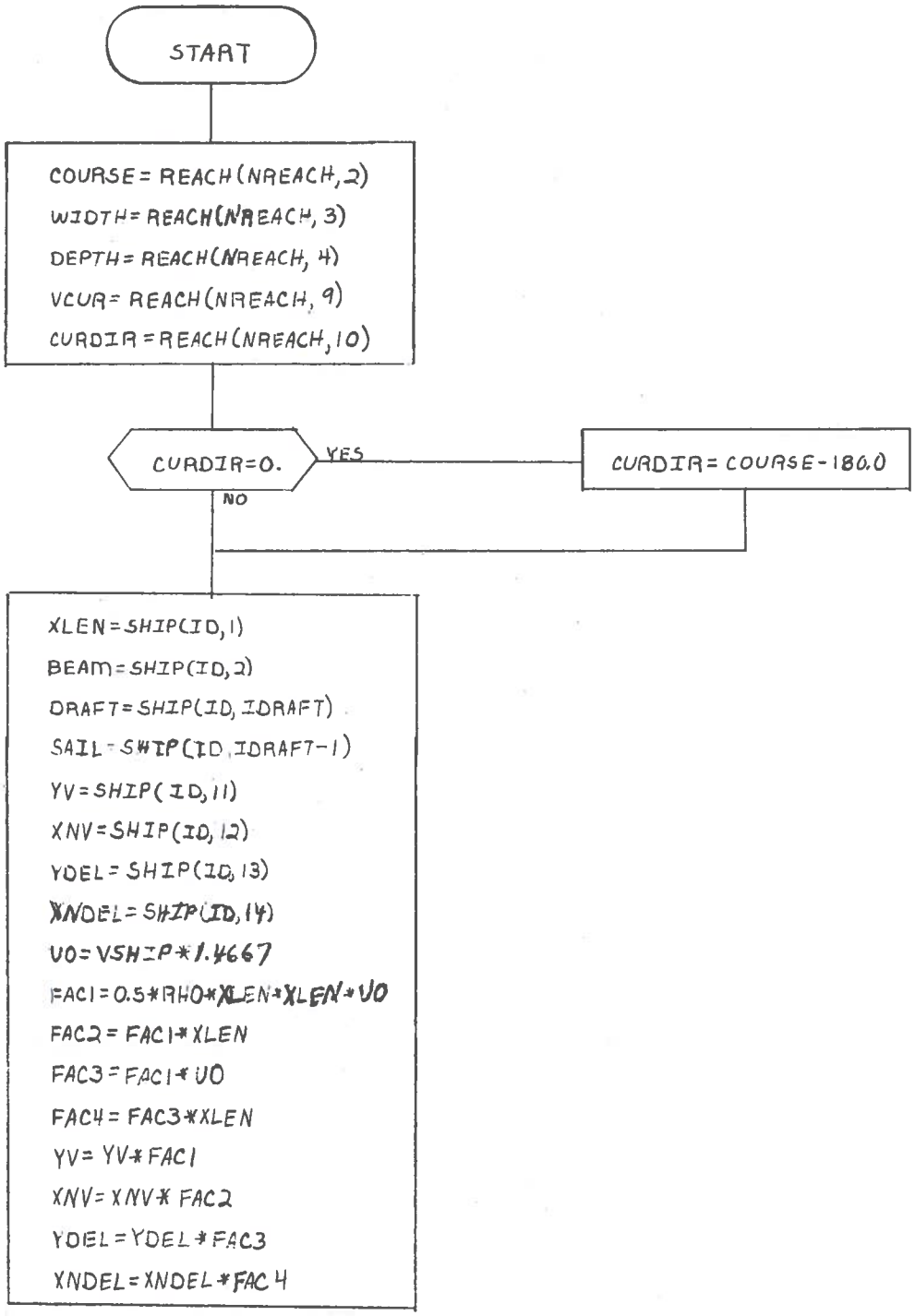

B
COSHR > 0.0
YES
XHR = 360. - HR
NO
COSHR < 0.0
YES
XHR = 270. - (90. + HR)
NO
TIMER = XHR/15.0 + ALPHAR/15.0 - 0.06571 * TR - 6.620
SUNRIS = TIMER
TIMER < 0.
YES
SUNRIS = TIMER + 24.
NO
TIMER ≥ 24.0
SUNRIS = TIMER - 24.
NO
TS = NDAY + NDAYS + 23.0/24.0
IYEAR ≠ 68 AND TS > 365.
YES
TS = TS - 365.
NO
IYEAR = 68 AND TS > 366.
YES
TS = TS - 366.
NO
C


C
XMS = 0.9856 * TS - 3.251
XLS = XMS + 1.916 * SIN (CON * XMS) +
0.02 * SIN(CON * 2. * XMS) + 282.565
XLS > 360.0
YES
XLS = XLS - 360.
NO
NQLS = 1.0 + XLS/90.0
ALPHAS = ATAN(0.91746 * SIN(CON * XLS)/
COS(CON * XLS))/CON
ALPHAS > 360.
YES
ALPHAS = ALPHAS - 360.
NO
ALPHAS < 0.0
YES
ALPHAS = 360. + ALPHAS
NO
D

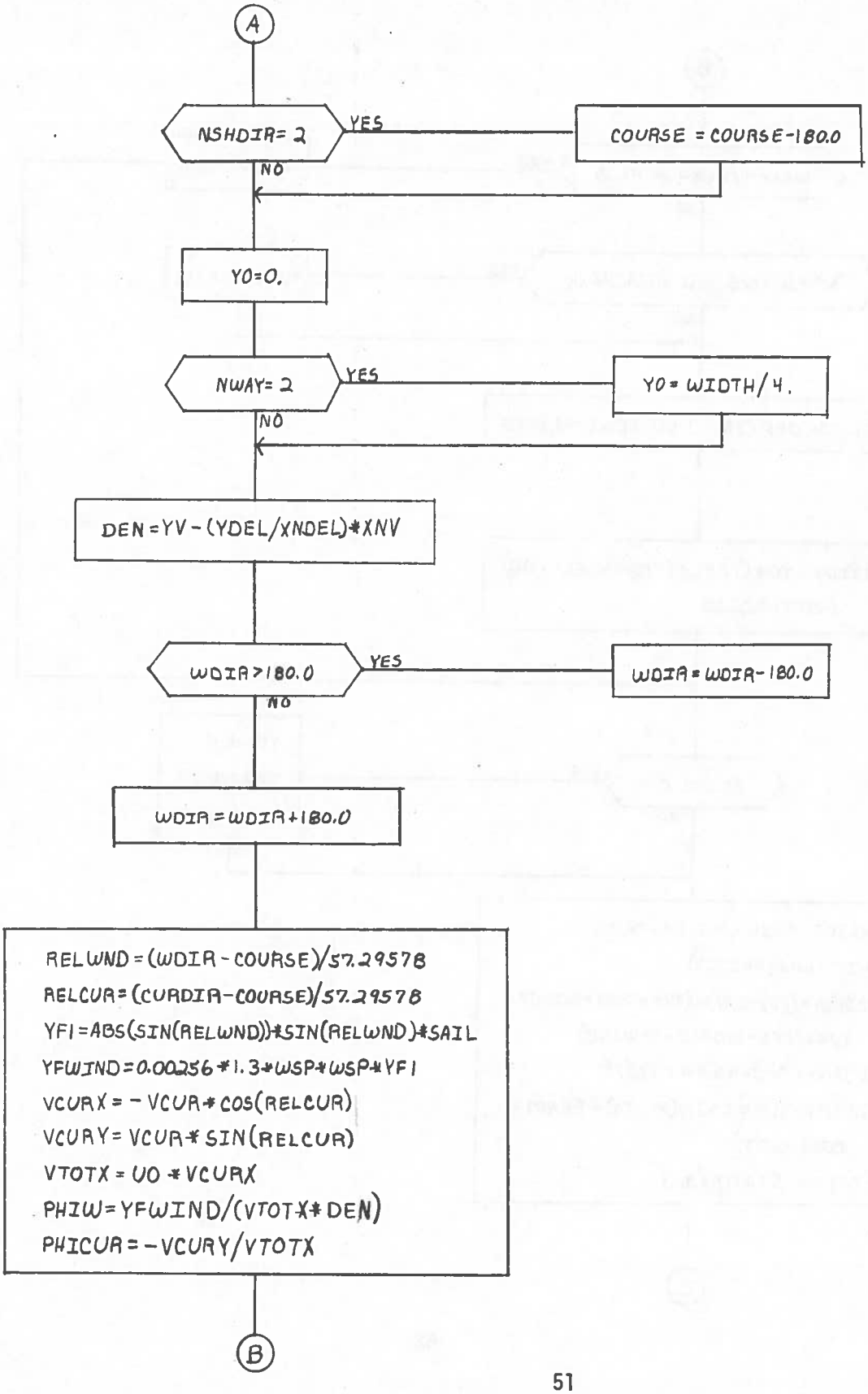

D
NQALS = 1.0 + ALPHAS/90.0
DIFFS = NQLS - NQALS
ALPHAS = ALPHAS + DIFFS * 90.0
YS = 0.39782 * SIN(CON * XLS)
XS = SQRT(1. - YS * YS)
DELTAS = ATAN (YS/XS)/CON
COSHS = (-0.01454 - SIN(CON * DELTAS)
*0.7071)/(ABS(COS(CON * DELTAS))
* 0.7071)
XHS = COSHS
YHS = SQRT(1.0 - XHS * XHS)
HS = ATAN (YHS/XHS)/CON
COSHS < 0.0
YES
HS = 180.0 + HS
NO
TIMES = HS/15.0 + ALPHAS/15.0 -
0.06571 * TS - 6.620
SUNSET = TIMES
TIMES < 0.0
YES
SUNSET = TIMES + 24.0
NO
TIMES ≥ 24.0
YES
SUNSET = TIMES - 24.0
NO
RETURN

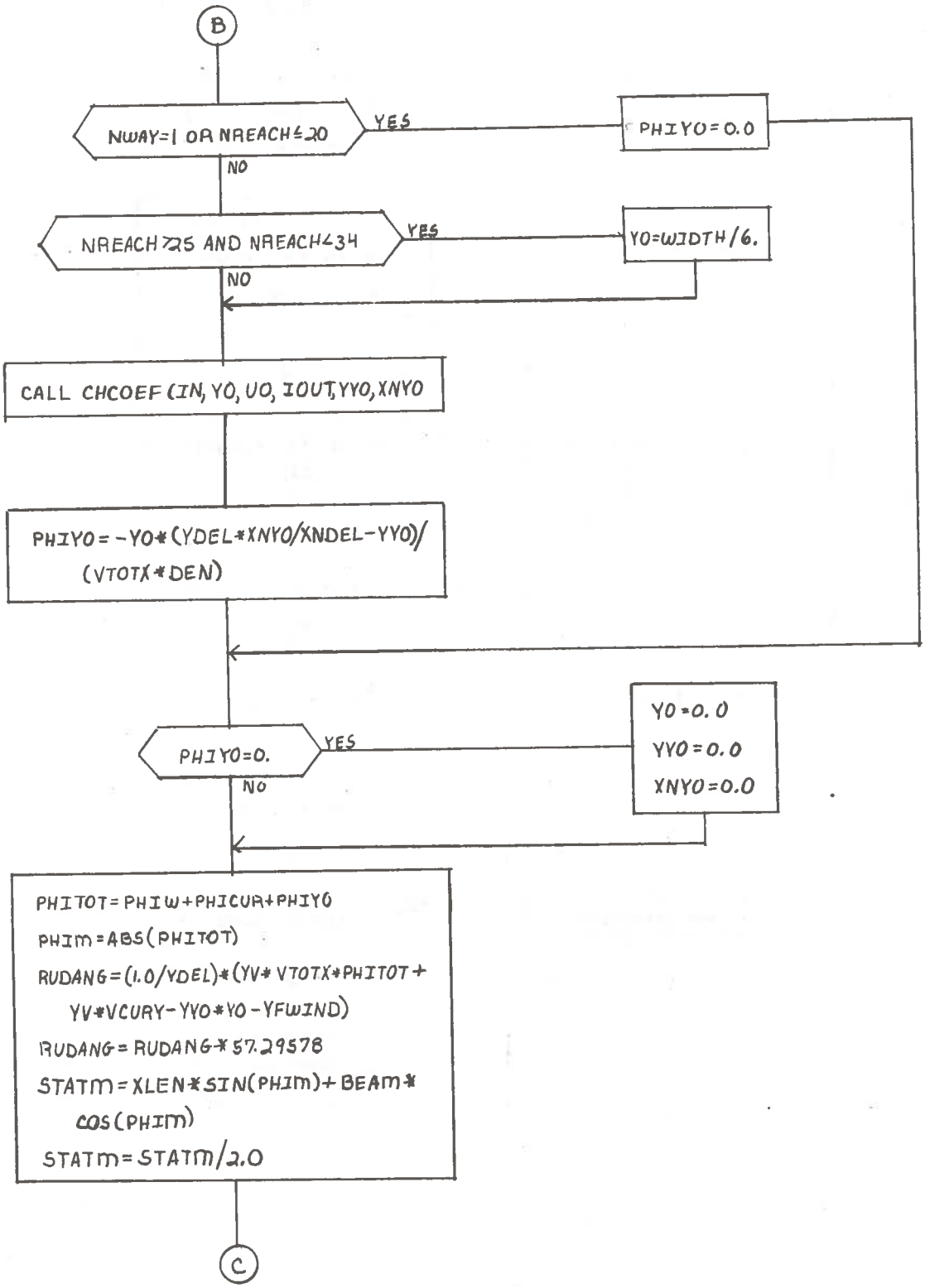
SUBROUTINE STAMAN (NWAY, NSHDIR, VSHIP, STATM)

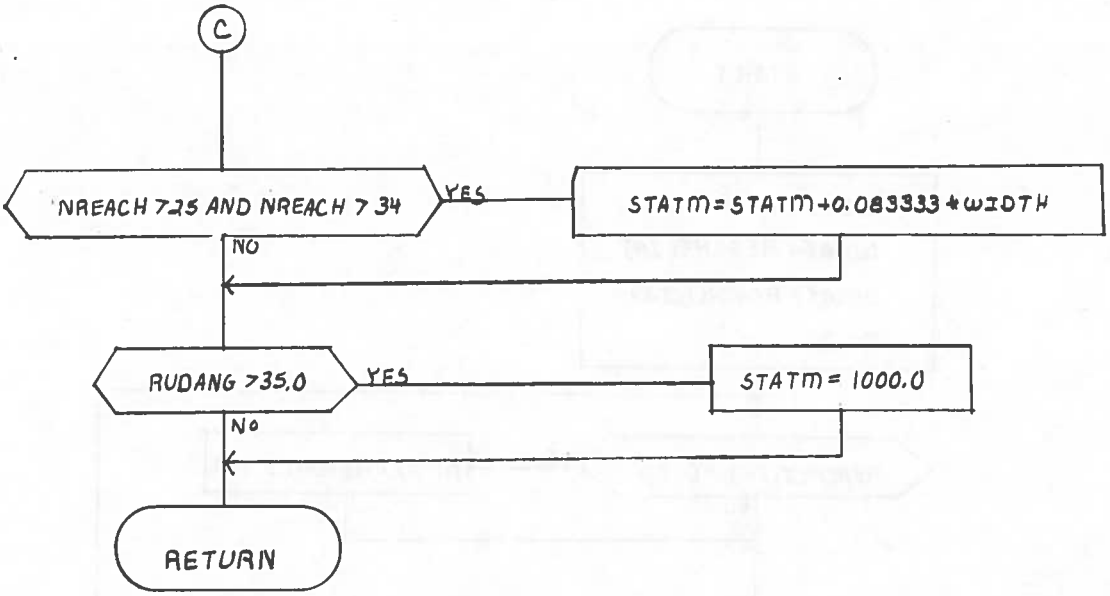
COMMON WSP, WDIR, REACH(103,22), SHIP(2,19), NREACH, ID, IDRAFT, RHO
common /COEFCH/ XYOP(7,11,2), XWPB(7), NYPB(7), XALPHA(11,3),
NWPB, NXALP



(4)

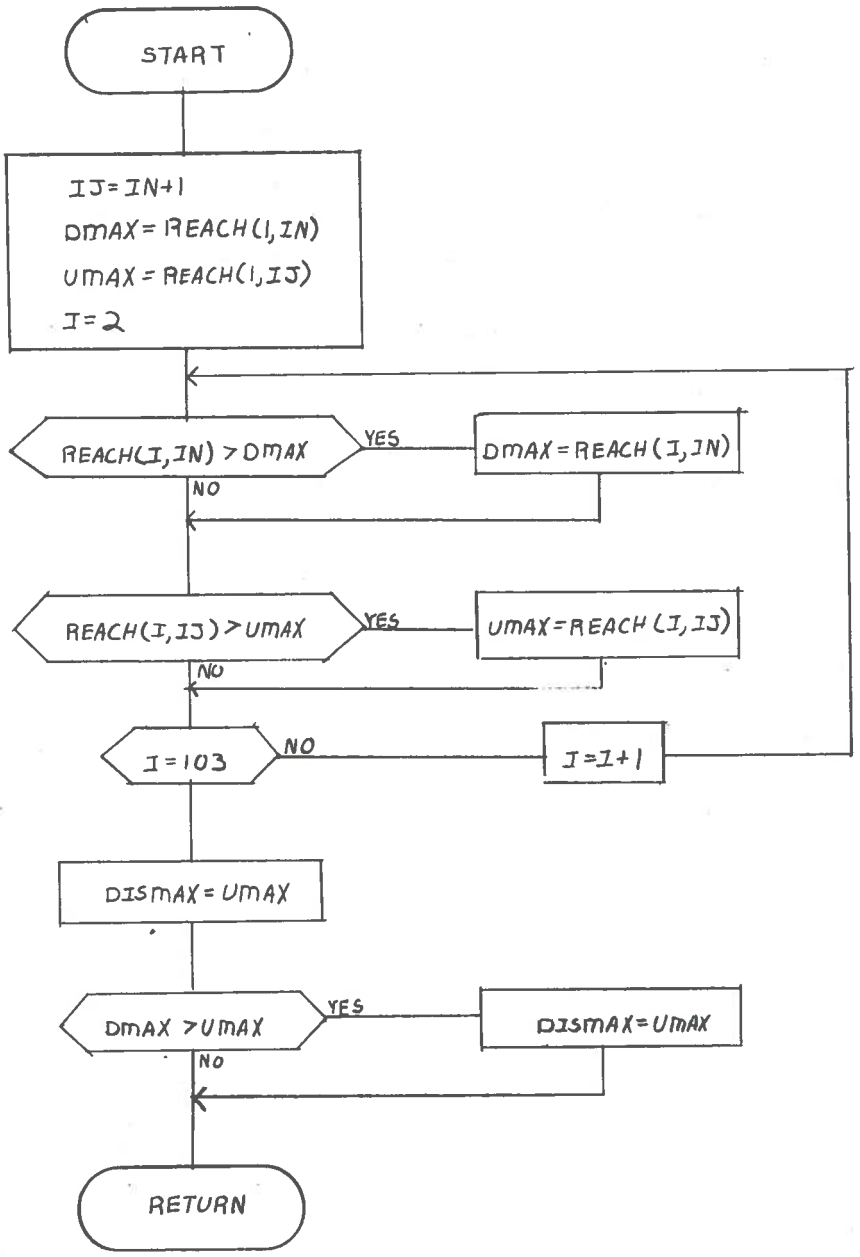

A
NSHDIR= 2
YES
COURSE = COURSE-180.0
NO
YO=0.
NWAY= 2
YES
YO = WIDTH/4.
NO
DEN=YV-(YDEL/XNDEL)*XNV
WDIR>180.0
YES
WDIR=WDIR-180.0
NO
WDIR=WDIR+180.0
RELWND=(WDIR-COURSE)/57.2957B
RELCUR=(CURDIR-COURSE)/57.2957B
YFI=ABS(SIN(RELWND))*SIN(RELWND)*SAIL
YFWIND=0.00256*1.3*WSP*WSP*YFI
VCURX=-VCUR*COS(RELCUR)
VCURY=VCUR*SIN(RELCUR)
VTOTX=UO*VCURX
PHIW=YFWIND/(VTOTX*DEN)
PHICUR=-VCURY/VTOTX
B


B
NWAY=1 OR NREACH≤20
YES
PHIYO=0.0
NO
NREACH≥25 AND NREACH≤34
YES
YO=WIDTH/6.
NO
CALL CHCOEF(IN, YO, UO, IOUT, YYO, XNYO
PHIYO=-YO*(YDEL*XNYO/XNDEL-YYO)/(VTOTX*DEN)
PHIYO=0.
YES
YO=0.0
YYO=0.0
XNYO=0.0
No
PHITOT=PHIW+PHICUR+PHIYO
PHIM=ABS(PHITOT)
RUDANG=(1.0/YDEL)*(YV*VTOTX*PHITOT+YV*VCURY-YYO*YO-YFWIND)
RUDANG=RUDANG*57.29578
STATM=XLEN*SIN(PHIM)+BEAM*COS(PHIM)
STATM=STATM/2.0
C

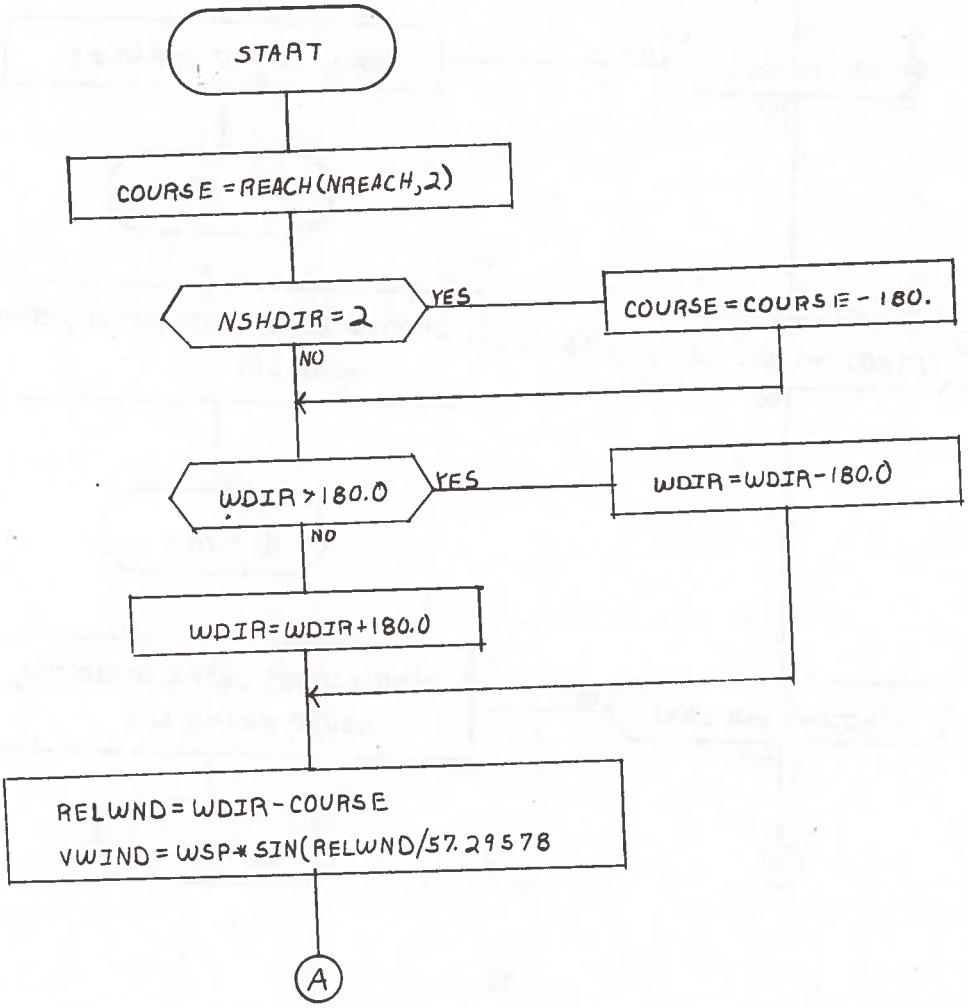

C
NREACH 725 AND NREACH 734
YES
STATM=STATM+0.083333*WIDTH
NO
RUDANG >35.0
YES
STATM = 1000.0
NO
RETURN

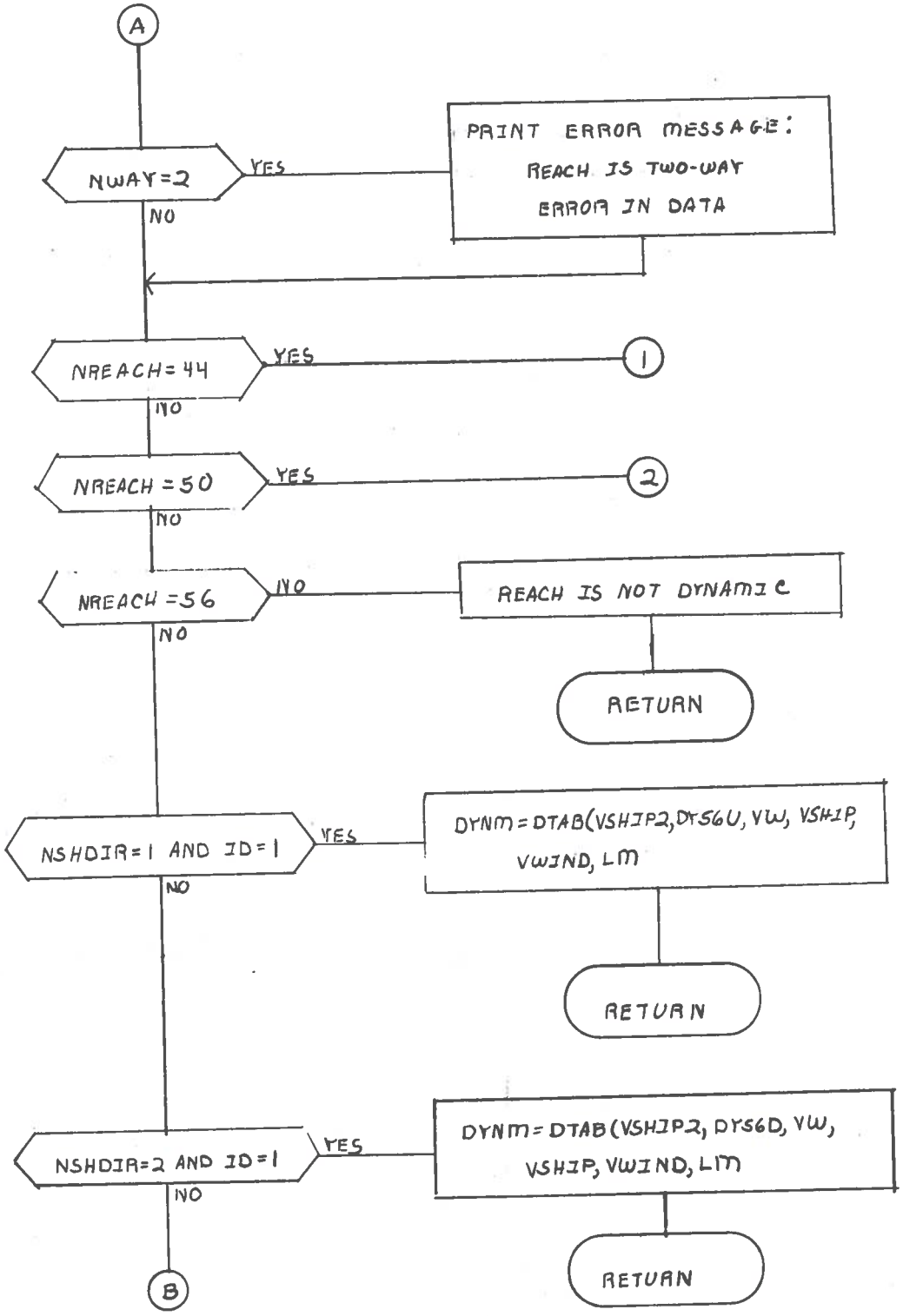
SUBROUTINE MAXDIS (IN, DISMAX)

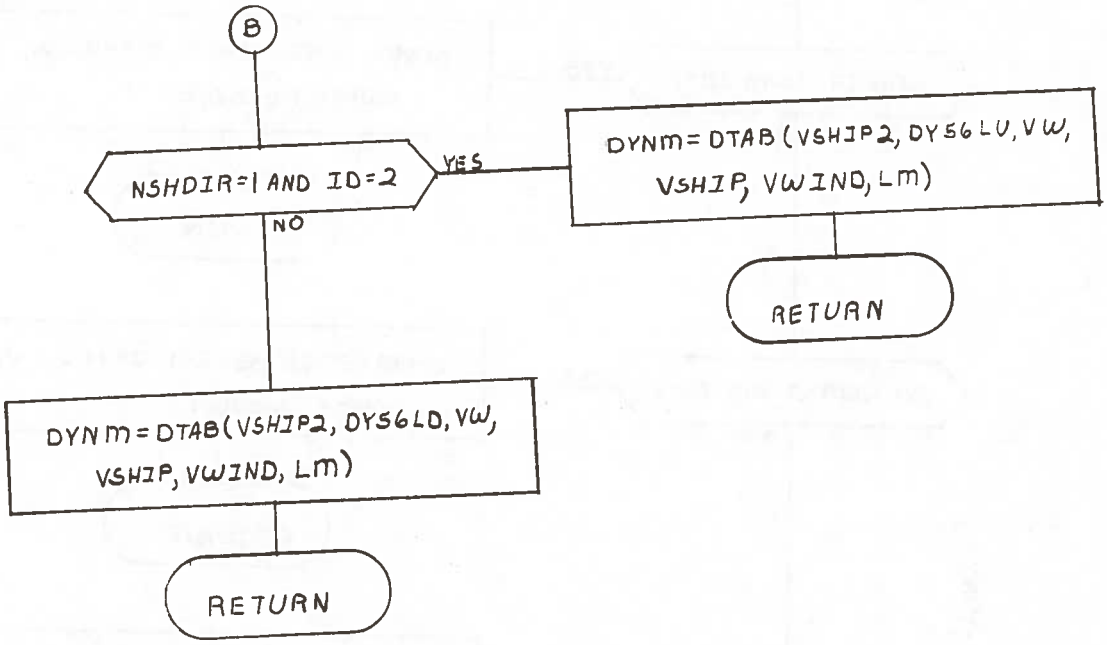
COMMON WSP, WDIR, REACH(103,22), SHIP(2,19), NREACH,
ID, IDRAFT, RHO

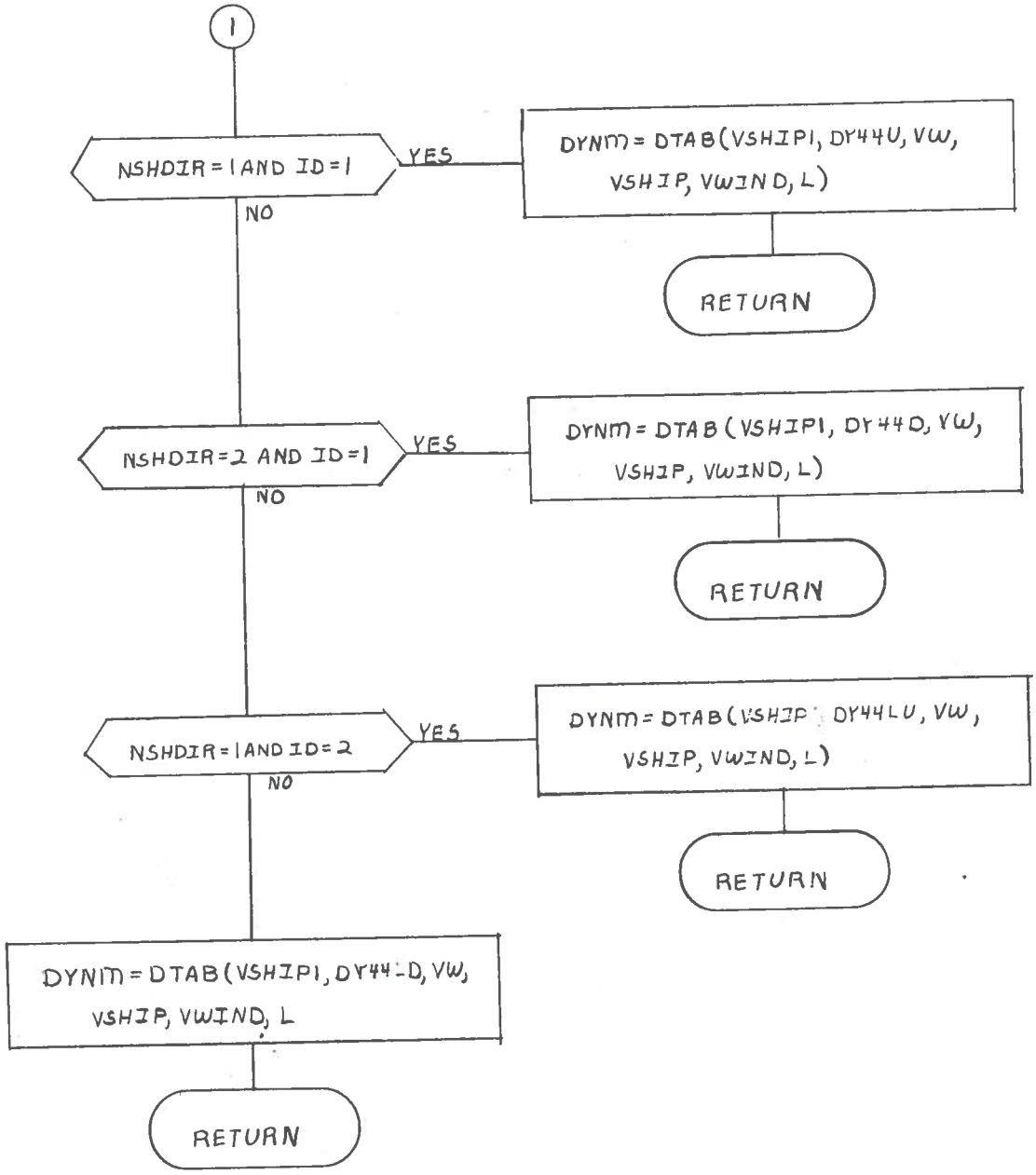


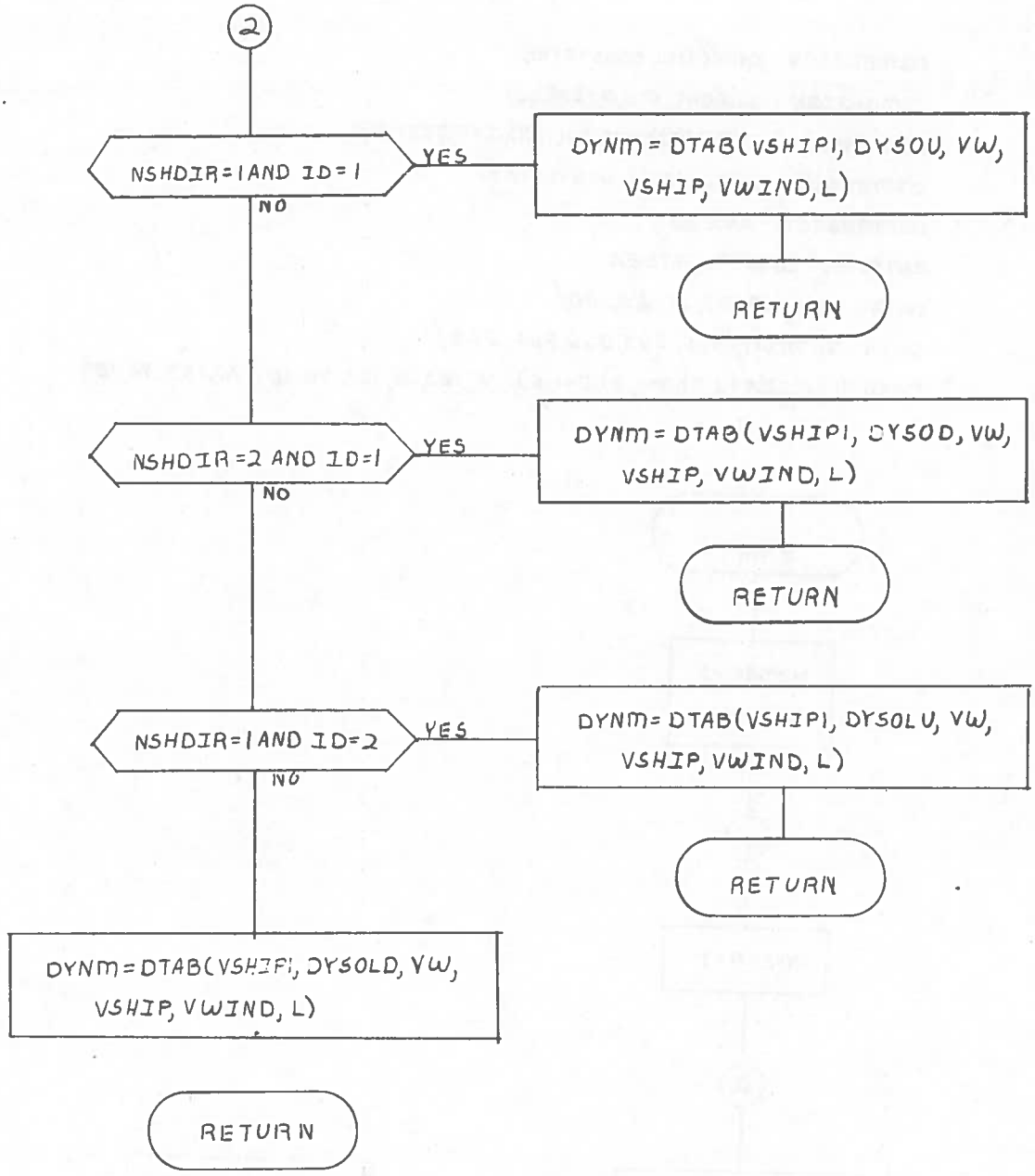
```
      SUBROUTINE DYNMAN (NWAY, NSHDIR, VSHIP, DYNM)

COMMON  WSP, WDIR, REACH(103,22), SHIP(2,19), NREACH, ID, IDRAFT,
     RHO
DIMENSION  VW(7), VSHIP1(28), VSHIP2(35), DY44U(28), DY44D(28),
     DY50U(28), DY50D(28), DY56U(35), DY56D(35)
DIMENSION  DY44LU(28), DY44LD(28), DY50LU(28), DY50LD(28)
DIMENSION  DY56LU(35), DY56LD(35)
DIMENSION  L(4), LM(4)

      INITIALIZE DATA ARRAYS  VW, VSHIP1, VSHIP2, DY56U,
     DY56D, DY50U, DY50D, DY44U, DY44D, DY44LU, DY44LD,
     DY50LU, DY50LD, DY56LU, DY56LD, L, LM
```




A
NWAY=2
YES
PRINT ERROR MESSAGE:
REACH IS TWO-WAY
ERROR IN DATA
NO
NREACH=44
YES
1
NO
NREACH=50
YES
2
NO
NREACH=56
NO
REACH IS NOT DYNAMIC
NO
RETURN
NSHDIR=1 AND ID=1
YES
DYNM=DTAB(VSHIP2,DYS6U,VW, VSHIP,
VWIND, LM
NO
RETURN
NSHDIR=2 AND ID=1
YES
DYNM=DTAB(VSHIP2, DYS6D, VW,
VSHIP, VWIND, LM
NO
RETURN
B

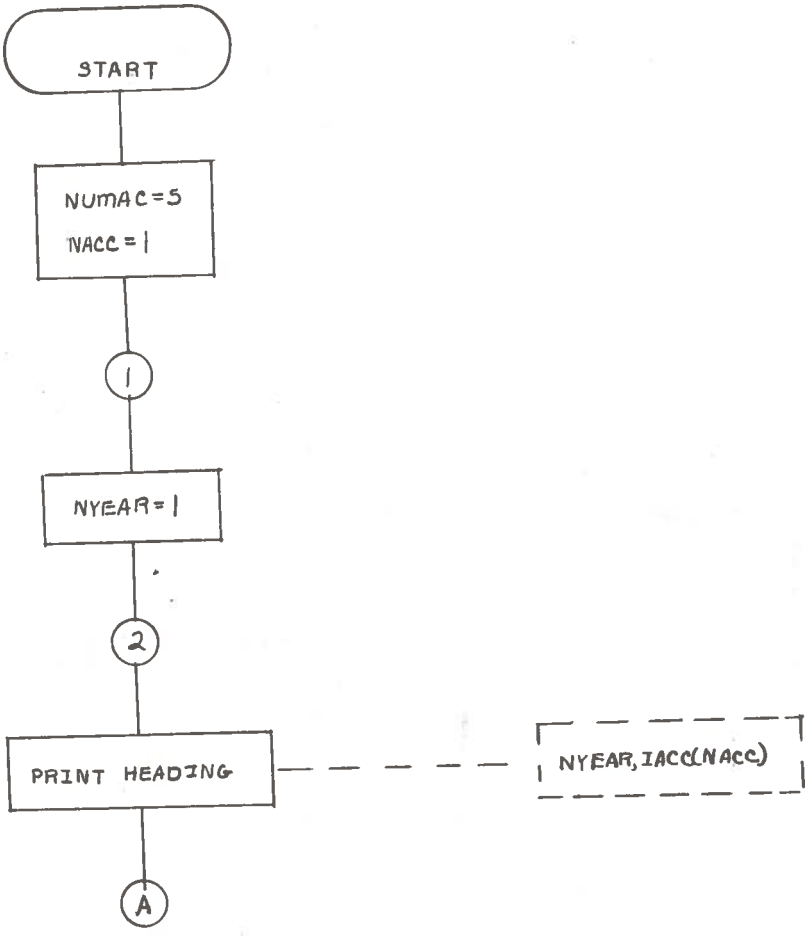

B
NSHDIR=1 AND ID=2
YES
NO
DYNm = DTAB (VSHIP2, DYSGLU, VW, VSHIP, VWIND, Lm)
RETURN
DYNm = DTAB(VSHIP2, DYSGLD, VW, VSHIP, VWIND, Lm)
RETURN

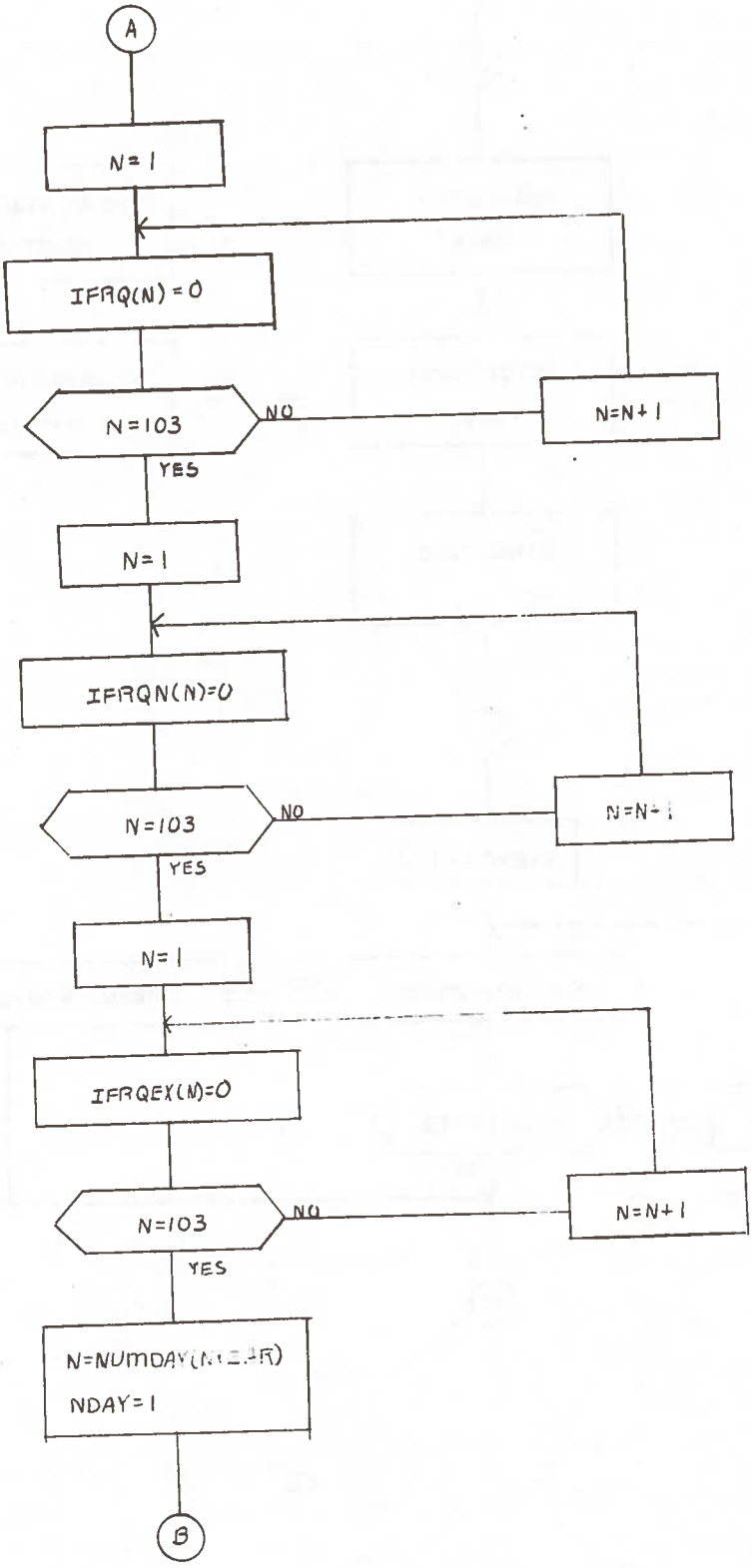

1
NSHDIR = 1 AND ID = 1
YES
NO
DYNM = DTAB(VSHIP1, DY44U, VW, VSHIP, VWIND, L)
RETURN
NSHDIR = 2 AND ID = 1
YES
NO
DYNM = DTAB (VSHIP1, DY44D, VW, VSHIP, VWIND, L)
RETURN
NSHDIR = 1 AND ID = 2
YES
NO
DYNM = DTAB (VSHIP1, DY44LU, VW, VSHIP, VWIND, L)
RETURN
DYNM = DTAB (VSHIP1, DY44LD, VW, VSHIP, VWIND, L
RETURN

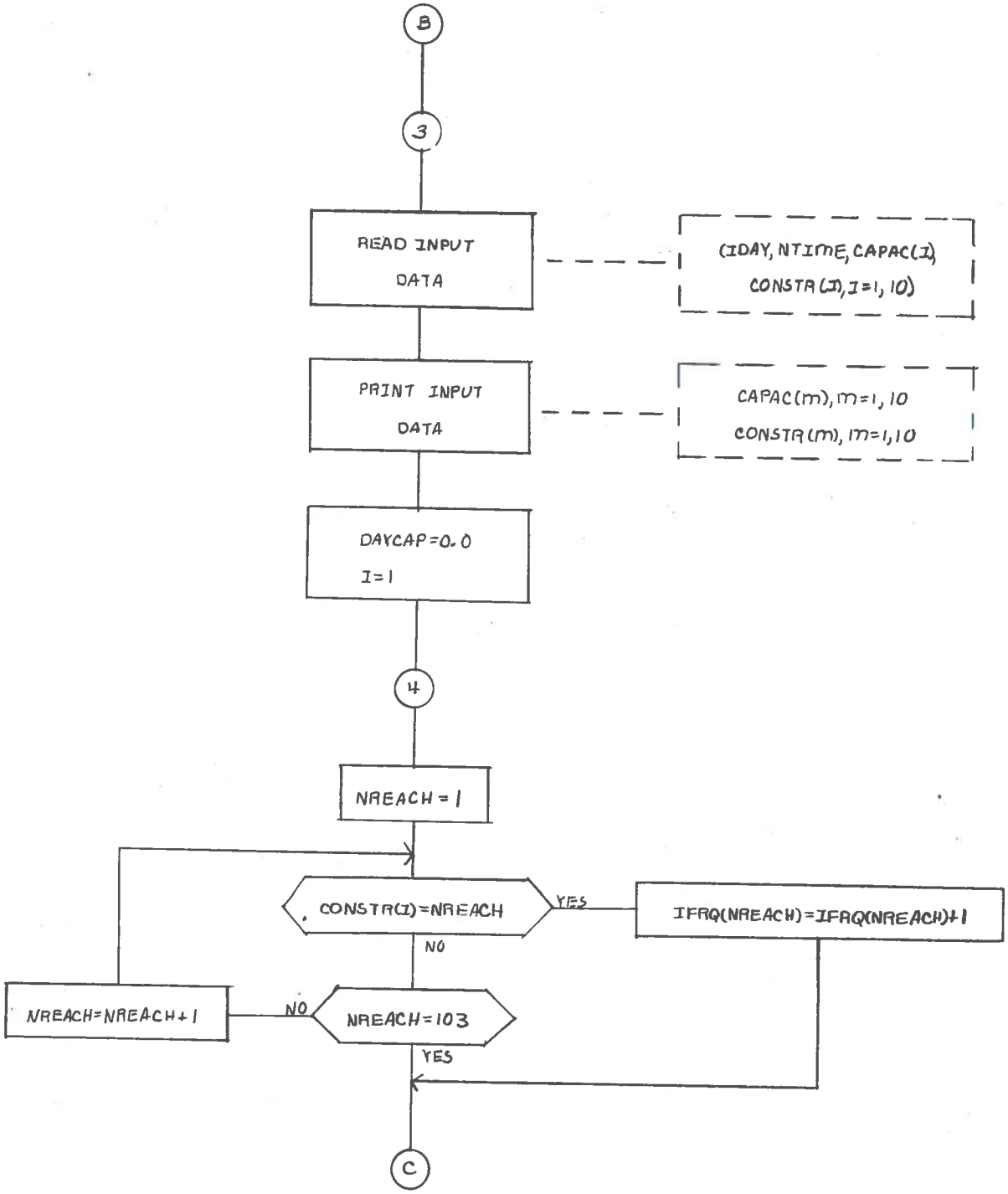

2
NSHDIR=1 AND ID=1
YES
NO
DYNM = DTAB(VSHIP1, DYSOU, VW, VSHIP, VWIND, L)
RETURN
NSHDIR=2 AND ID=1
YES
NO
DYNM = DTAB(VSHIP1, DYSOD, VW, VSHIP, VWIND, L)
RETURN
NSHDIR=1 AND ID=2
YES
NO
DYNM= DTAB(VSHIP1, DYSOLU, VW, VSHIP, VWIND, L)
RETURN
DYNM=DTAB(VSHIP1, DYSOLD, VW, VSHIP, VWIND, L)
RETURN

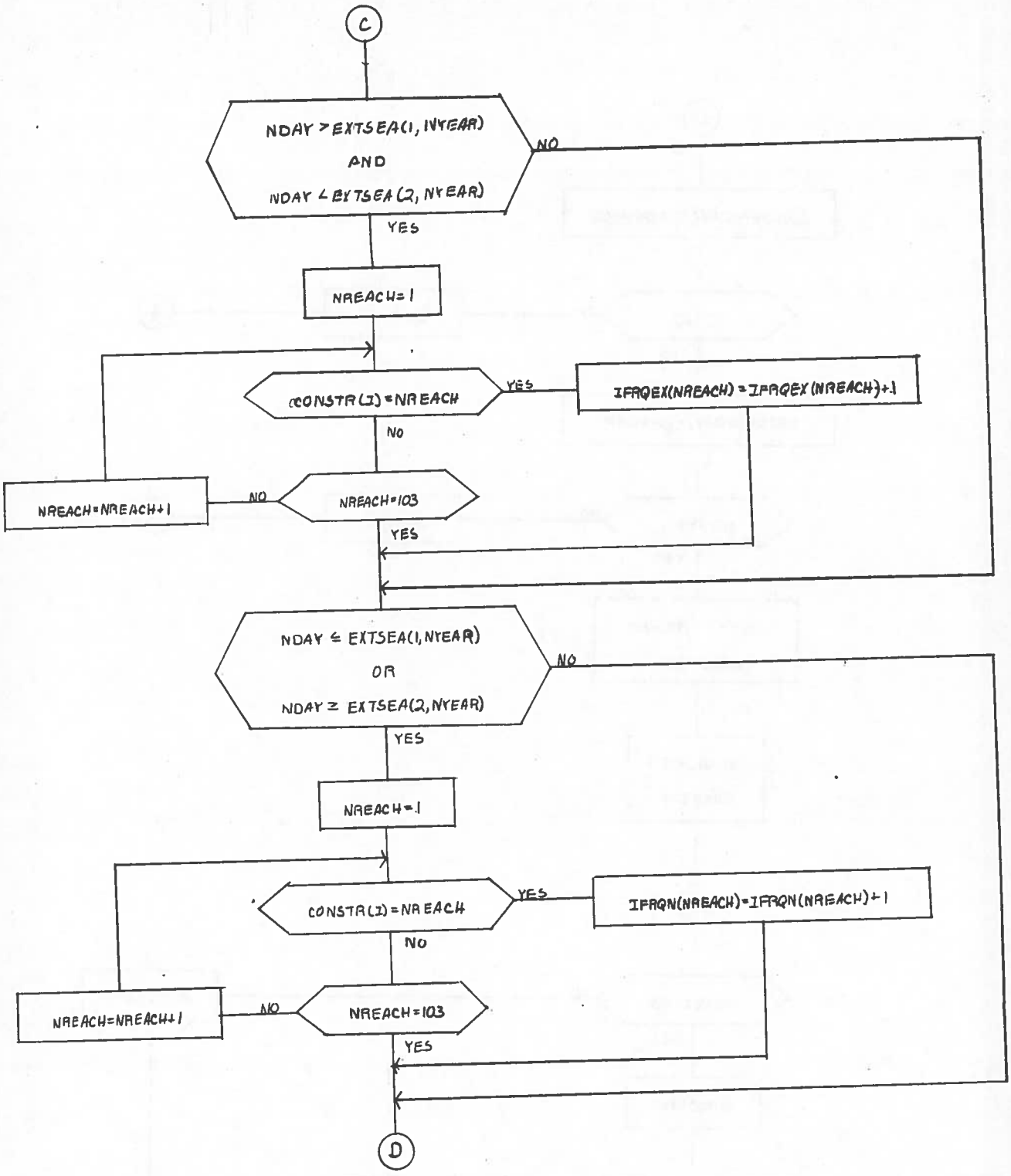
ANAWCAP

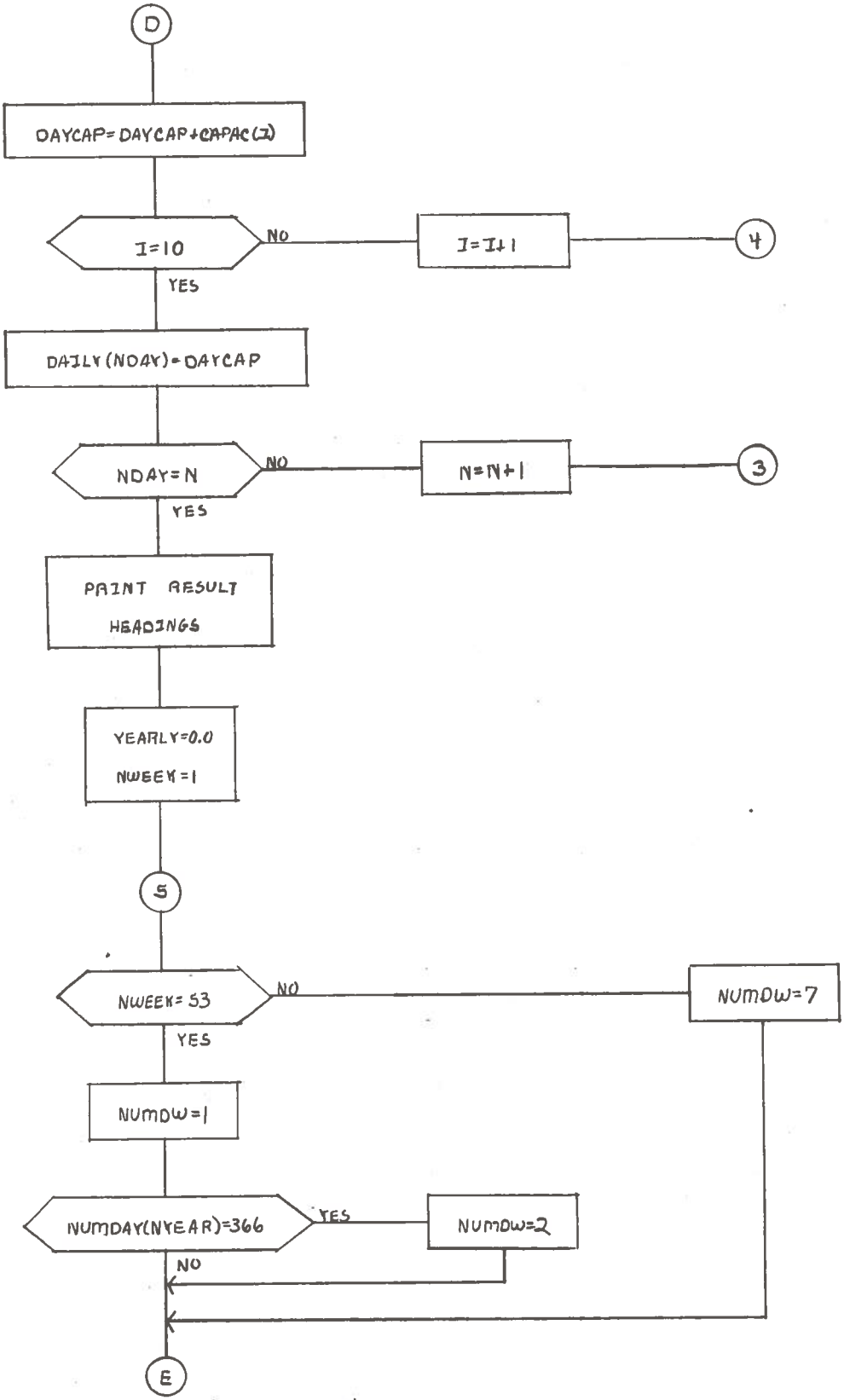
```
DIMENSION  CAPAC(10), CONSTR(10)
DIMENSION  NUMDAY(5), EXTSEA(2,5)
DIMENSION  IFRQ(103), IFRQN(103), IFRQEX(103)
DIMENSION  DAILY(366), WEEKLY(63)
DIMENSION  IACC(5)
INTEGER  CONSTR, EXTSEA
DATA  IACC/60,100,30,60,100/
DATA  NUMDAY/365,365,366,365,365/
DATA  ((EXTSEA(I,J),I=1,2),J=1,5)/76,183,76,183,76,184,76,183,76,183/
```

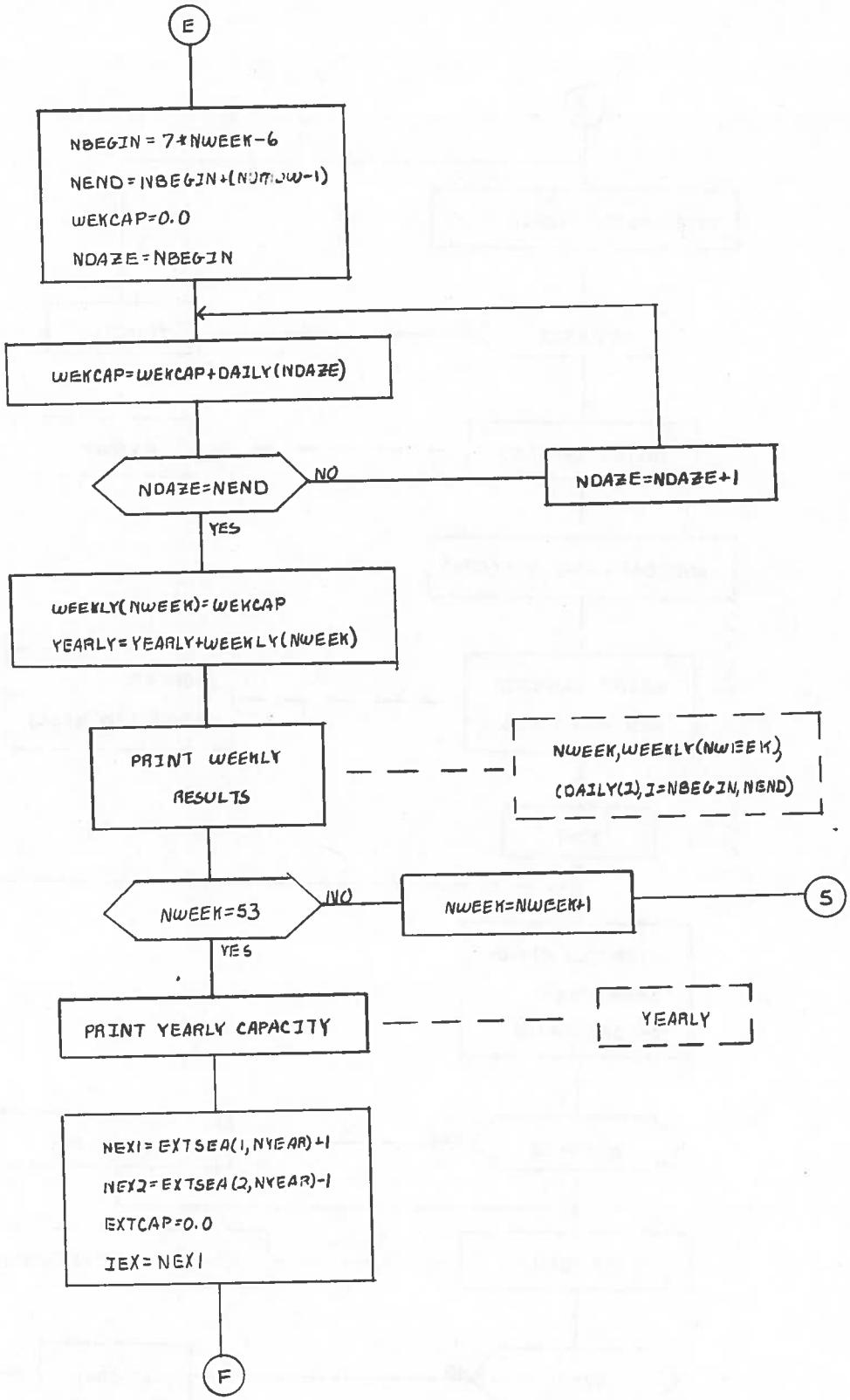


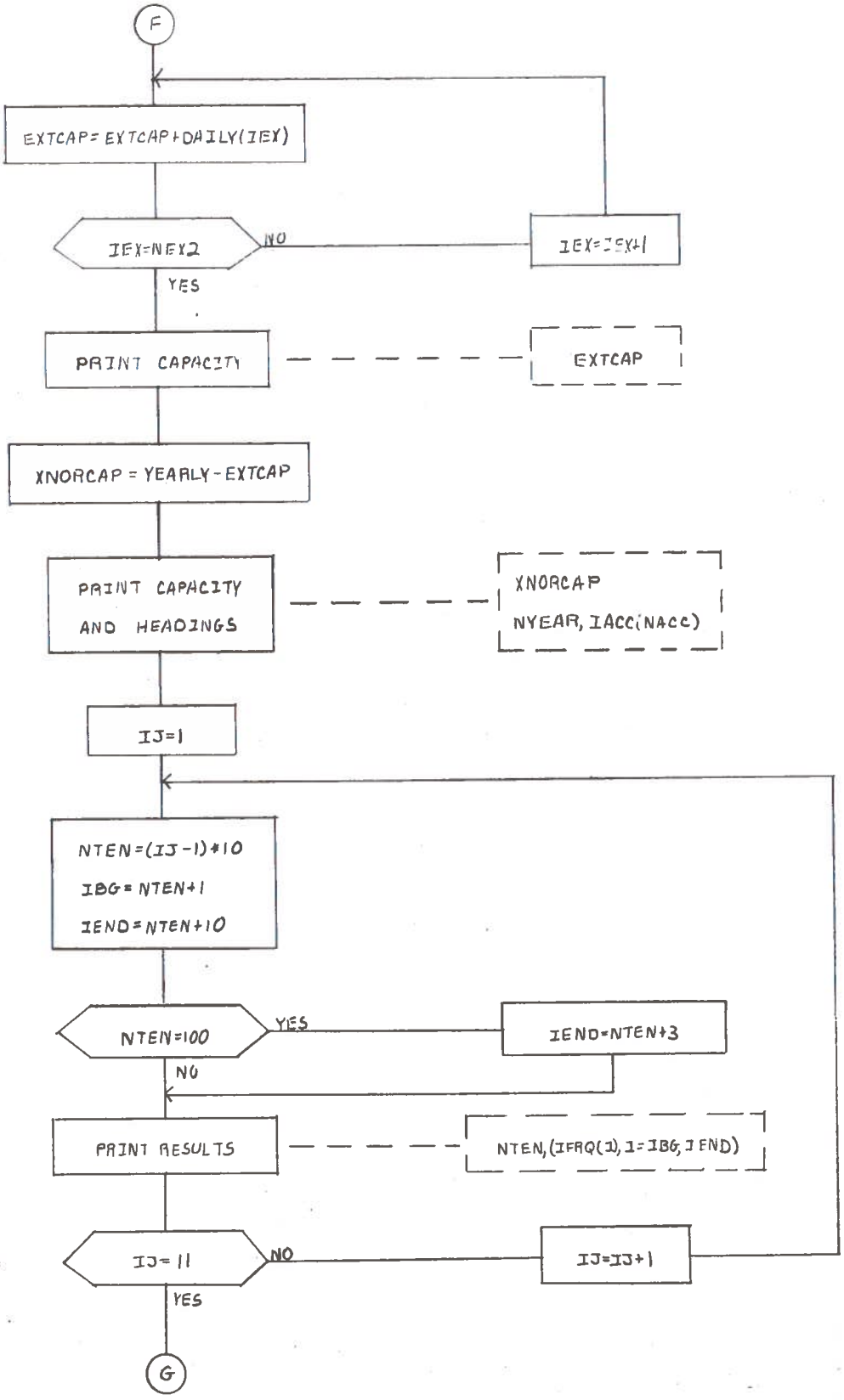

A
N=1
IFRQ(N)=0
N=103
NO
N=N+1
YES
N=1
IFRQN(N)=0
N=103
NO
N=N+1
YES
N=1
IFRQEX(M)=0
N=103
NO
N=N+1
YES
N=NUMDAY(NUMYR)
NDAY=1
B

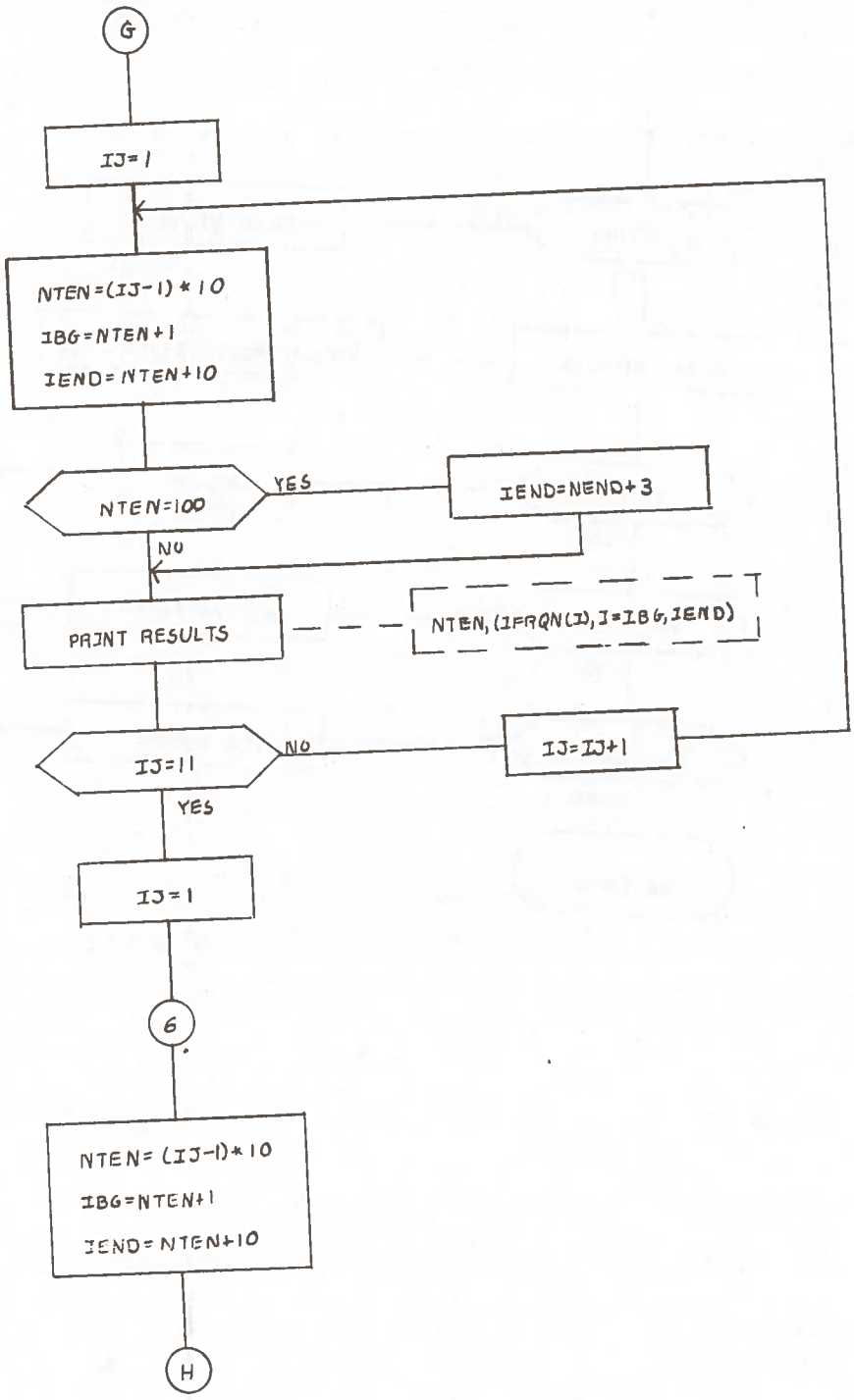

B
3
READ INPUT DATA
(IDAY, NTIME, CAPAC(I), CONSTR(I), I=1, 10)
PRINT INPUT DATA
CAPAC(m), m=1, 10
CONSTR(m), m=1, 10
DAYCAP=0.0
I=1
4
NREACH=1
CONSTR(I)=NREACH
YES
IFRQ(NREACH)=IFRQ(NREACH)+1
NO
NREACH=NREACH+1
NO
NREACH=103
YES
C

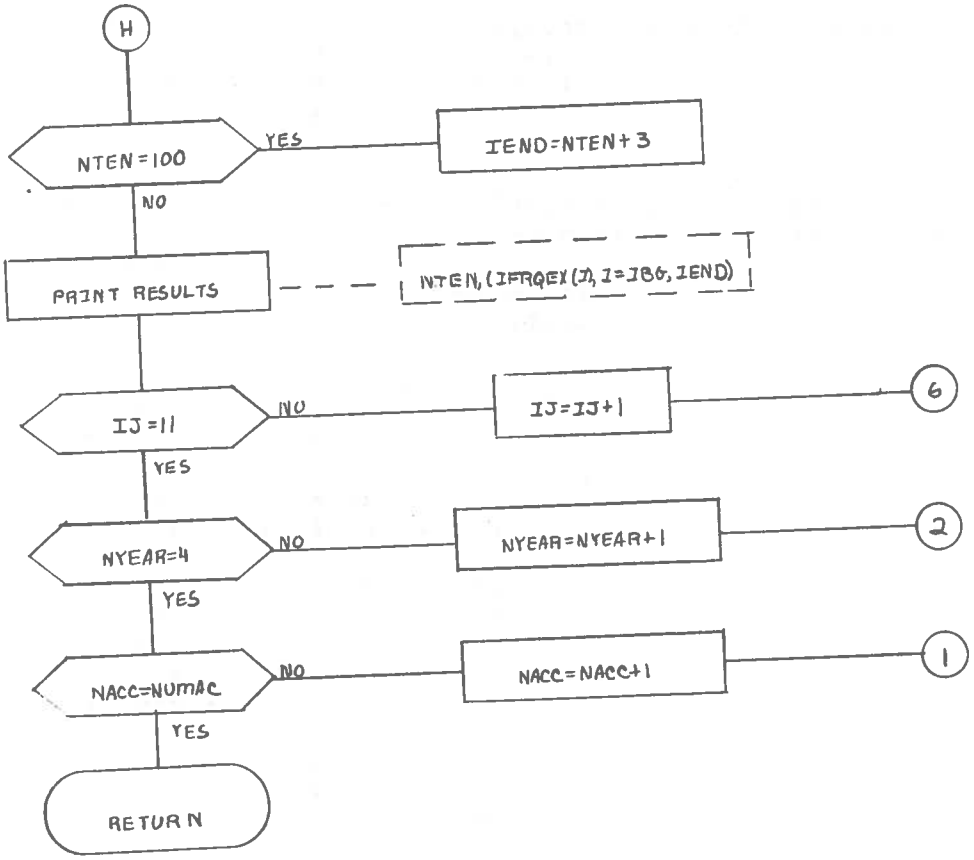

C
NDAY > EXTSEA(1, NYEAR)
AND
NDAY < EXTSEA(2, NYEAR)
NO
YES
NREACH=1
CONSTR(I)=NREACH
YES
IFRQEX(NREACH)=IFRQEX(NREACH)+1
NO
NREACH=NREACH+1
NO
NREACH=103
YES
NDAY ≤ EXTSEA(1, NYEAR)
OR
NDAY ≥ EXTSEA(2, NYEAR)
NO
YES
NREACH=1
CONSTR(I)=NREACH
YES
IFRQN(NREACH)=IFRQN(NREACH)+1
NO
NREACH=NREACH+1
NO
NREACH=103
YES
D


D
DAYCAP=DAYCAP+CAPAC(I)
I=10
NO
I=I+1
4
YES
DAILY(NDAY)=DAYCAP
NDAY=N
NO
N=N+1
3
YES
PRINT RESULT HEADINGS
YEARLY=0.0
NWEEK=1
5
NWEEK=53
NO
NUMDW=7
YES
NUMDW=1
NUMDAY(NYEAR)=366
YES
NUMDW=2
NO
E


E
NBEGIN = 7*NWEEK-6
NEND = NBEGIN+(NUMDOW-1)
WEKCAP=0.0
NDAZE=NBEGIN
WEKCAP=WEKCAP+DAILY(NDAZE)
NDAZE=NEND
NO
NDAZE=NDAZE+1
YES
WEEKLY(NWEEK)=WEKCAP
YEARLY=YEARLY+WEEKLY(NWEEK)
PRINT WEEKLY RESULTS
NWEEK,WEEKLY(NWEEK),
(DAILY(I),I=NBEGIN,NEND)
NWEEK=53
NO
NWEEK=NWEEK+1
5
YES
PRINT YEARLY CAPACITY
YEARLY
NEXI = EXTSEA(1,NYEAR)+1
NEX2 = EXTSEA(2,NYEAR)-1
EXTCAP=0.0
IEX=NEX1
F


F
EXTCAP=EXTCAP+DAILY(IEX)
IEX=NEX2
NO
IEX=IEX+1
YES
PRINT CAPACITY
EXTCAP
XNORCAP = YEARLY - EXTCAP
PRINT CAPACITY
AND HEADINGS
XNORCAP
NYEAR, IACC(NACC)
IJ=1
NTEN=(IJ-1)*10
IBG=NTEN+1
IEND=NTEN+10
NTEN=100
YES
IEND=NTEN+3
NO
PRINT RESULTS
NTEN,(IFRQ(I),I=IBG,IEND)
IJ=11
NO
IJ=IJ+1
YES
G


G
IJ=1
NTEN=(IJ-1)*10
IBG=NTEN+1
IEND=NTEN+10
NTEN=100
YES
IEND=NEND+3
NO
PRINT RESULTS
NTEN,(IFRQN(I),I=IBG,IEND)
IJ=11
NO
IJ=IJ+1
YES
IJ=1
6
NTEN=(IJ-1)*10
IBG=NTEN+1
IEND=NTEN+10
H


H
NTEN=100
YES
IEND=NTEN+3
NO
PRINT RESULTS
NTEN,(IFREQ(J),I=IBG,IEND)
IJ=11
NO
IJ=IJ+1
6
YES
NYEAR=4
NO
NYEAR=NYEAR+1
2
YES
NACC=NUMAC
NO
NACC=NACC+1
1
YES
RETURN

B.6 LISTING OF PROGRAMS, INPUT DATA, AND SAMPLE OUTPUT

```
)GRAM AWCAP      73/73   OPT=1                                FTN 4.6+428

      PROGRAM AWCAP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7,TAPE8,
     1TAPE9)
      DIMENSION          WXTAPE(4,8,3),DELT(10),DTEMP(3),
     *TINT(10),RIVSTM(3),EXTSEA(5,6),CAPAC(10),CONSTR(10),ITITLE(30)
      DIMENSION WATEM(366), WATEMP(3)
      DIMENSION TIM(10)
      DIMENSION NUMDAY(5)
C
      COMMON WSP,WDIR,REACH(103,22),SHIP(2,19),NREACH,ID,IDRAFT,RHO
      COMMON/COEFCH/XYOP(7,11,2),XWPB(7),NYPB(7),XALPHA(11,3),
     *NWPB,NXALP
      INTEGER EXTSEA,CONREA,CONSTR,WXTAPE
      DATA NUMDAY/365,365,366,365,365/
C
C
      RHO=1.932
C      READ IN CHCOEF ARRAYS
C
C        READ NWPB AND NXALP
      READ(5,5)(ITITLE(I),I=1,30)
    5 FORMAT(30A2)
      WRITE(6,5)(ITITLE(I),I=1,30)
      READ(5,5)(ITITLE(I),I=1,30)
      WRITE(6,5)(ITITLE(I),I=1,30)
      READ(5, *)NWPB,NXALP
   75 FORMAT(2I5)
      WRITE(6,75)NWPB,NXALP
C        READ XWPB ARRAY
      READ(5,5)(ITITLE(I),I=1,30)
      WRITE(6,5)(ITITLE(I),I=1,30)
      READ(5, *)(XWPB(I),I=1,NWPB)
   80 FORMAT(7F10.2)
      WRITE(6,80)(XWPB(I),I=1,NWPB)
C        READ NYPB ARRAY
      READ(5,5)(ITITLE(I),I=1,30)
      WRITE(6,5)(ITITLE(I),I=1,30)
      READ(5, *)(NYPB(I),I=1,NWPB)
   85 FORMAT(7I5)
      WRITE(6,85)(NYPB(I),I=1,NWPB)
C        READ XYOP ARRAY
      READ(5,5)(ITITLE(I),I=1,30)
      WRITE(6,5)(ITITLE(I),I=1,30)
      DO 95 I=1,NWPB
      JT=NYPB(I)
      READ(5, *)(XYOP(I,J,1),J=1,JT)
      WRITE(6,90)(XYOP(I,J,1),J=1,JT)
   90 FORMAT(6F10.3)
      READ(5, *)(XYOP(I,J,2),J=1,JT)
      WRITE(6,90)(XYOP(I,J,2),J=1,JT)
   95 CONTINUE
C        READ XALPHA ARRAY
      READ(5,5)(ITITLE(I),I=1,30)
      WRITE(6,5)(ITITLE(I),I=1,30)
      READ(5,5)(ITITLE(I),I=1,30)
      WRITE(6,5)(ITITLE(I),I=1,30)
      DO 99 I=1,NXALP
      READ(5, *)(XALPHA(I,J),J=1,3)
```

```
      WRITE(6,97)(XALPHA(I,J),J=1,3)
   97 FORMAT(3F10.2)
   99 CONTINUE
C      READ REACH ARRAY
      DO 10 N=1,22
      READ (5,5)(ITITLE(I),I=1,30)
      WRITE(6,5)(ITITLE(I),I=1,30)
      READ(5,1000) (REACH(I,N),I=1,103)
      WRITE(6,1000)(REACH(I,N),I=1,103)
   10 CONTINUE
 1000 FORMAT(10F8.3)
C      READ SHIP ARRAY
      DO 20 N=1,19
      READ(5,1010)((ITITLE(I),I=1,10),(SHIP(I,N),I=1,2))
      WRITE(6,1010)((ITITLE(I),I=1,10),(SHIP(I,N),I=1,2))
   20 CONTINUE
 1010 FORMAT(10A2,2F10.4)
C      READ EXTSEA ARRAY
      DO 30 I=1,6
      READ(5,1020)((ITITLE(L),L=1,10),(EXTSEA(IYEAR,I),IYEAR=1,5))
      WRITE(6,1020)((ITITLE(L),L=1,10),(EXTSEA(IYEAR,I),IYEAR=1,5))
   30 CONTINUE
 1020 FORMAT(10A2,5I10)
C
      READ(5,1030)WINDM1,WINDM2,TTRNBK,TICELK,D1,D2,D3
 1030 FORMAT(7F10.4)
      WRITE(6,50) WINDM1                    thru bridges in Beauharnois Canal
   50 FORMAT( 46H MAX WIND SPD FOR 1-WAY TRAFFIC SO SHORE CANAL,F10.4)
      WRITE(6,51) WINDM2                          in St. Lambert Section of
   51 FORMAT( 46H MAX WIND SPD FOR 2-WAY TRAFFIC SO SHORE CANAL,F10.4)
      WRITE(6,52) TTRNBK
   52 FORMAT( 23H TURNBACK TIME IN MIN  ,F10.4)
      WRITE(6,53) TICELK
   53 FORMAT( 26H ICE LOCKAGE TIME IN MIN  ,F10.4)
      WRITE(6,54) D1,D2,D3
   54 FORMAT( 35H UPBOUND SHIP RATIO    COEFFICIENTS,3F10.4)
      READ(5,1040) NELEC,ID,IDRAFT,NOMDAY,NYEAR
 1040 FORMAT(5I5)                          OUT    OUT
      WRITE(6,55) NELEC
   55 FORMAT( 38H IS NAV SYSTEM ELECTRONIC  1-YES  0-NO, I5)
      WRITE(6,56) ID
   56 FORMAT( 32H TYPE OF SHIP  1-SALTY  2-LAKER, I5)
      WRITE(6,57) IDRAFT
   57 FORMAT( 32H SHIP DRAFT  4-BALLAST  6-LOADED, I5)
      WRITE(6,58) NOMDAY
   58 FORMAT( 32H NUMBER OF DAYS IN SPECIFIC YEAR, I5)---> OUT
      WRITE(6,59) NYEAR
   59 FORMAT( 39H SPECIFIC YEAR 1-52 2-65 3-67 4-68 5-69, I5)---> OUT
C  TIMES ARE CONVERTED TO HOURS
      SHIP(ID, 7) = SHIP(ID, 7) / 60.0
      SHIP(ID, 8) = SHIP(ID, 8) / 60.0
      SHIP(ID, 9) = SHIP(ID, 9) / 60.0
      SHIP(ID,10) = SHIP(ID,10) / 60.0
      TTRNBK = TTRNBK/60.0
      TICELK = TICELK/60.0
      TICELK = 0.0
C
```

```
C       COMPUTATION OF MAXIMUM DISTANCE THROUGHOUT SEAWAY NORMAL
C       SEASON DAY WHICH INCLUDES A SUFFICIENT NUMBER OF NAVIGATION
C       AIDS TO FIX POSITION VISUALLY
C
        CALL MAXDIS(11,DISMAX)
C
        DISMND=DISMAX
C       COMPUTE NORMAL SEASON NIGHT, EXTENDED SEASON DAY, AND
C       EXTENDED SEASON NIGHT MAXIMUM DISTANCE
C
        CALL MAXDIS(15,DISMAX)
C
        DISMNN=DISMAX
C
        CALL MAXDIS(13,DISMAX)
C
        DISMED=DISMAX
C
        CALL MAXDIS(17,DISMAX)
C
        DISMEN=DISMAX
C
DAILY   DO 105 NYEAR= 1,1   (5)
        YRCAP = 0.0
C  READ WATER TEMPERATURE ARRAY   Temp Readings Taken at Ogdensburg, New York.
        READ(5,5)(ITITLE(I),I=1,30)
        WRITE(6,5)(ITITLE(I),I=1,30)
        READ(5,40) (WATEM(I),I=1,366)
        WRITE(6,40) (WATEM(I),I=1,366)
   40   FORMAT(10F8.3)
C
        NUM = NUMDAY(NYEAR)
        RICE = 1.0
        NUM = 1 ---- out
        DO 100 NDAY=1,NUM
        RATIO=D1+D2*NDAY+D3*NDAY**2.
C        READ WXTAPE ARRAY
        DO 108 J=1,8
        READ(7,1050) (IYEAR,MONTH,IDAY,IH,(WXTAPE(I,J,1),I=1,4))
  108   CONTINUE
        DO 109 J=1,8
        READ(8,1050) (IYEAR,MONTH,IDAY,IH,(WXTAPE(I,J,2),I=1,4))
  109   CONTINUE
        DO 111 J=1,8
        READ(9,1050) (IYEAR,MONTH,IDAY,IH,(WXTAPE(I,J,3),I=1,4))
  111   CONTINUE
 1050   FORMAT(4I2,I6,3I4)
C
        CALL SUNRS(NDAY,IYEAR,SUNRIS,SUNSET)
C       WRITE(6, * ) NDAY,IYEAR,SUNRIS,SUNSET
        ND=0
        DO 140 NDELT=1,8
        ND=ND+1
        HOUR=3.*(NDELT-1)
        IF(HOUR.GT.SUNRIS)GO TO 110
        DTIME=SUNRIS-HOUR
        GO TO 120
```

```
  110 CONTINUE
      DTIME=SUNSET-HOUR
  120 CONTINUE
      IF(DTIME.GE.0.0.AND.DTIME.LT.3.0)GO TO 130
      DELT(ND)=3.0
      TINT(ND)=NDELT
      GO TO 140
  130 CONTINUE
      DELT(ND)=DTIME
      TINT(ND)=NDELT
      DELT(ND+1)=3.0-DTIME
      TINT(ND+1)=NDELT
      ND=ND+1
  140 CONTINUE
C     WRITE(6,61) (TINT(I),DELT(I),I=1,10)
C  61 FORMAT(2F10.4)
      TIM(1)  = 0.0
      DO 145 NTT = 2,10
  145 TIM (NTT) = TIM (NTT-1) + DELT(NTT-1)
      WATEM(NDAY) = 1.8*WATEM(NDAY) + 32.0
      DAYCAP = 0.0
      DO 150 NTIME =1,1
      J = TINT(NTIME)
      TIME = TIM(NTIME)
      DO 170 II=1,3
      WATEMP(II) = WATEM(NDAY)
      IF(II.EQ.1) WATEMP(II) = WATEM(NDAY) - 2.0
      IF(II.EQ.3) WATEMP(II) = WATEM(NDAY) + 1.0
      IF(WATEMP(II).LT.32.0) WATEMP(II) = 32.0
      DTEMP(II) = (WATEMP(II)-WXTAPE(4,J,II)) * 0.0876
      IF(DTEMP(II).GT.0.0)GO TO 160
      RIVSTM(II)=WXTAPE(1,J,II) / 1000.0
      GO TO 170
  160 CONTINUE
      RIVSTM(II)=9.0*(EXP(-DTEMP(II))+(1.0-EXP(-DTEMP(II)))*
     1TANH(0.38*WXTAPE(2,J,II)))
  170 CONTINUE
C
C      SELECTION OF MINIMUM VISIBILITY AND MAXIMUM WIND SPEED
C      OCCURING ON THE SEAWAY
C
      VISMNO= MIN0(WXTAPE(1,J,1),WXTAPE(1,J,2),WXTAPE(1,J,3))
      VISMNO = VISMNO/1000.0
      VISMNR=AMIN1(RIVSTM(1),RIVSTM(2),RIVSTM(3))
      VISMIN=AMIN1(VISMNO,VISMNR)
      WINDMX= MAX0(WXTAPE(2,J,1),WXTAPE(2,J,2),WXTAPE(2,J,3))
      WINDLL = WINDMX*SIN(ABS((336.0-WXTAPE(3,J,1)*10.0)/57.296))
      WINDCL = WINDMX*SIN(ABS((256.0-WXTAPE(3,J,1)*10.0)/57.296))
      WINDSLB= WINDMX*SIN(ABS((237.0-WXTAPE(3,J,1)*10.0)/57.296))
      WINDVFB= WINDMX*SIN(ABS((287.0-WXTAPE(3,J,1)*10.0)/57.296))
C
C      IS IT THE EXTENDED SEASON?
      IF(NDAY.GE.EXTSEA(NYEAR,1).AND.NDAY.LT.EXTSEA(NYEAR,6)) GO TO 250
C      NORMAL SEASON
      TLCKNO=RATIO*SHIP(ID,7)+(1.0-RATIO)*SHIP(ID,8)+
     *TTRNBK*ABS(1.0-2.0*RATIO)
      TLOCK=TLCKNO
```

```
C       IS IT DAYLIGHT>
        IF(TIME.GE.SUNRIS.AND.TIME.LT.SUNSET)GO TO 180
C       CAN YOU PROCEED VISUALLY AT NIGHT THROUGH THE ENTIRE SEAWAY>
        IF(VISMIN.GT.DISMNN)GO TO 190
        GO TO 350
  180 CONTINUE
C       CAN YOU PROCEED VISUALLY DURING THE DAY THROUGH ENTIRE SEAWAY>
        IF(VISMIN.GT.DISMND)GO TO 190
        GO TO 350
  190 CONTINUE
        IF(WINDSLB.LT.29.0.OR.WINDVFB.LT.29.0) GO TO 205
        CAP=0.0
        CONREA=  25
        GO TO 220
  205 CONTINUE
        IF(WINDLL.GE.17.5.OR.WINDCL.GE.13.5) GO TO 200
        CAP=DELT(NTIME)/TLOCK
        CONREA= 4
        GO TO 220
  200 CONTINUE
        CAP=DELT(NTIME)/(TLOCK+TTRNBK)
        CONREA= 14
        GO TO 220
  210 CONTINUE
  220 CONTINUE
        CAPAC(NTIME) = CAP
        CONSTR(NTIME) = CONREA
C       WRITE(6, * )VISMNO,VISMNR,VISMIN,WINDMX,WINDM1,WINDM2,TLOCK,
C      1DELT(NTIME),CAP,CONREA
C       WRITE(6, * ) DISMNN,DISMND
        GO TO 900
C
C       EXTENDED SEASON
C
  250 CONTINUE
        TLCKEX=RATIO*SHIP(ID,9)+(1.0-RATIO)*SHIP(ID,10)+
     *TTRNBK*ABS(1.0-2.0*RATIO)
C       IS ICE PRESENT IN SOUTH SHORE CANAL>
        IF(NDAY.GE.EXTSEA(NYEAR,2).AND.NDAY.LT.EXTSEA(NYEAR,5)) GO TO 260
        TLCKNO=RATIO*SHIP(ID,7)+(1.0-RATIO)*SHIP(ID,8)+
     *TTRNBK*ABS(1.0-2.0*RATIO)
        TLOCK = TLCKNO
        GO TO 290
  260 CONTINUE
        VISMIN=VISMNO
C       DOES ICE LOCKAGE OCCUR>
        IF(NDAY.GE.EXTSEA(NYEAR,3).AND.NDAY.LT.EXTSEA(NYEAR,4)) GO TO 280
        TLOCK=TLCKEX
        GO TO 290
  280 CONTINUE
        TLOCK=TLCKEX+TICELK*(1.0-RATIO)/RICE
  290 CONTINUE
C       IS IT DAYLIGHT>
        IF(TIME.GE.SUNRIS.AND.TIME.LT.SUNSET)GO TO 310
C       CAN YOU PROCEED VISUALLY AT NIGHT THRU ENTIRE SEAWAY>
        IF(VISMIN.GT.DISMEN)GO TO 320
        GO TO 350
```

```
  310 CONTINUE
C       CAN YOU PROCEED VISUALLY DURING DAY THRU ENTIRE SEAWAY?
      IF(VISMIN.LE.DISMED) GO TO 350
  320 CONTINUE
C       CAN YOU PROCEED 1-WAY THRU SOUTH SHORE CANAL?
      IF(WINDSLB.LT.29.0.OR.WINDWFB.LT.29.0) GO TO 330
      CAP=0.0
      CONREA= 25
      GO TO 340
  330 CONTINUE
      CAP=DELT(NTIME)/(TLOCK+TTRNBK)
      CONREA= 52
  340 CONTINUE
      CAPAC(NTIME) = CAP
      CONSTR(NTIME) = CONREA
C     WRITE(6, * )VISMNO,VISMNR,VISMIN,WINDMX,WINDM1,WINDM2,TLOCK,
C    1DELT(NTIME),CAP,CONREA
C     WRITE(6, * ) DISMEN,DISMED
      GO TO 900
  350 CONTINUE
C
C   REACH BY REACH ANALYSIS OF SEAWAY CAPACITY
C
      NREACH=0
      CAPAC(NTIME) = 10000.0
      SUM=0.0
  400 CONTINUE
      NREACH=NREACH+1
C       IS REACH A NONCONSTRAINING BRIDGE
      IF(REACH(NREACH,1).EQ.5.0) GO TO 400
C       IS REACH A LOCK
      IF(REACH(NREACH,1).NE.0.0) GO TO 410
      SUM=0.0
      GO TO 400
  410 CONTINUE
C       IS REACH IN DORVAL SECTOR?
      IF(NREACH.LT.42) K=1
C       IS REACH IN MASSENA SECOTR?
      IF(NREACH.GE.42.AND.NREACH.LT.80)K=2
C       IS REACH IN TIBBITS POINT SECTOR?
      IF(NREACH.GE.80) K=3
C
      VISOBR=WXTAPE(1,J,K) / 1000.0
      WSP=WXTAPE(2,J,K)
      WDIR=WXTAPE(3,J,K) * 10
      ATEMPR=WXTAPE(4,J,K)
      VISRSR=RIVSTM(K)
      VISMNR=AMIN1(VISOBR,VISRSR)
C     WRITE(6, * ) NREACH,VISOBR,VISRSR,VISMNR,WSP,WDIR,WATEMP(K),
C    1ATEMPR,J,K
  430 CONTINUE
C       IS IT EXTENDED SEASON?
      IF(NDAY.GE.EXTSEA(NYEAR,1).AND.NDAY.LT.EXTSEA(NYEAR,6)) GO TO 450
C       IS IT DAY?
      IF(TIME.GE.SUNRIS.AND.TIME.LT.SUNSET)GO TO 440
      VISUAC=REACH(NREACH,21)
      DSNAVU=REACH(NREACH,15)
```

```
      DSNAVD=REACH(NREACH,16)
      GO TO 470
  440 CONTINUE
      VISUAC=REACH(NREACH,20)
      DSNAVU=REACH(NREACH,11)
      DSNAVD=REACH(NREACH,12)
      GO TO 470
  450 CONTINUE
C      DOES ICE OCCUR IN THIS REACH DURING EXTENDED SEASON?
      IF(REACH(NREACH,22).EQ.1.0)VISMNR = VISOBR
C      IF IS DAY?
      IF(TIME.GE.SUNRIS.AND.TIME.LT.SUNSET)GO TO 460
      VISUAC=REACH(NREACH,21)
      DSNAVU=REACH(NREACH,17)
      DSNAVD=REACH(NREACH,18)
      GO TO 470
  460 CONTINUE
      VISUAC=REACH(NREACH,20)
      DSNAVU=REACH(NREACH,13)
      DSNAVD=REACH(NREACH,14)
  470 CONTINUE
C      IS ELECTRONIC SYSTEM AVAILABLE?
      IF(NELEC.EQ.0)GO TO 480
      IF(VISMNR.GT.DSNAVU)ACNAVU=VISUAC
      IF(VISMNR.LE.DSNAVU)ACNAVU=REACH(NREACH,19)
      IF(VISMNR.GT.DSNAVD)ACNAVD=VISUAC
      IF(VISMNR.LE.DSNAVD)ACNAVD=REACH(NREACH,19)
      GO TO 650
  480 CONTINUE
C      CAN SHIP PROCEED VISUALLY UPBOUND?
      IF(VISMNR.GT.DSNAVU)GO TO 550
C      CAN SHIP PROCEED VISUALLY DOWNBOUND?
      IF(VISMNR.GT.DSNAVD)GO TO 490
      CAPAC(NTIME) = 0.0
      CONSTR(NTIME) = NREACH
C     WRITE(6, * ) NREACH,VISMNR,DSNAVU,DSNAVD,ACNAVU,ACNAVD
      GO TO 900
  490 CONTINUE
      ACNAVD=VISUAC
C      DOES ICE OCCUR IN THE REACH?
      IF(NDAY.GE.EXTSEA(NYEAR,2).AND.NDAY.LT.EXTSEA(NYEAR,5))GO TO 495
      GO TO 497
  495 IF(REACH(NREACH,22).EQ.1.0) GO TO 510
  497 CONTINUE
C      IF REACH DYNAMIC?
      IF(ABS(REACH(NREACH,1)-1.0).LT.0.001)GO TO 500
      IF(ABS(REACH(NREACH,1)-3.0).LT.0.001)GO TO 500
C
      CALL STAMAN(1,2,REACH(NREACH,8),STATM)
C
      AMAND1=STATM
      GO TO 520
  500 CONTINUE
C
      CALL DYNMAN(1,2,REACH(NREACH,8),DYNM)
C
      AMAND1=DYNM
```

```
      GO TO 520
  510 CONTINUE
      AMAND1=SHIP(ID,2)/2.0
  520 CONTINUE
      ALLOWD = 0.5*REACH(NREACH,3) - AMAND1 - ACNAVD
C      CAN SHIP PROCEED DOWNBOUND?
      IF(ALLOWD.GT.0.0)GO TO 530
      CAPAC(NTIME) = 0.0
      CONSTR(NTIME) = NREACH
C     WRITE(6, * ) NREACH,ALLOWD,AMAND1,REACH(NREACH,3),ACNAVD
      GO TO 900
  530 CONTINUE
      SUM=SUM+((REACH(NREACH,6)-REACH(NREACH,5))/REACH(NREACH,8))
C     WRITE(6,*) NREACH,SUM
      GO TO 800
  550 CONTINUE
C      CAN SHIP PROCEED VISUALLY DOWNBOUND?
      IF(VISMNR.GT.DSNAVD)GO TO 560
      GO TO 570
  560 CONTINUE
      ACNAVU=VISUAC
      ACNAVD=VISUAC
      GO TO 650
  570 CONTINUE
      ACNAVU=VISUAC
C      DOES ICE OCCUR IN THIS REACH?
      IF(NDAY.GE.EXTSEA(NYEAR,2).AND.NDAY.LT.EXTSEA(NYEAR,5))GO TO 575
      GO TO 577
  575 IF(REACH(NREACH,22).EQ.1.0) GO TO 590
  577 CONTINUE
C      IS REACH DYNAMIC?
      IF(REACH(NREACH,1).EQ.1.0) GO TO 580
      IF(REACH(NREACH,1).EQ.3.0) GO TO 580
C
      CALL STAMAN(1,1,REACH(NREACH,7),STATM)
C
      AMANU1=STATM
      GO TO 600
  580 CONTINUE
C
      CALL DYNMAN(1,1,REACH(NREACH,7),DYNM)
C
      AMANU1=DYNM
      GO TO 600
  590 CONTINUE
      AMANU1=SHIP(ID,2)/2.0
  600 CONTINUE
      ALLOWU = 0.5*REACH(NREACH,3) - AMANU1 - ACNAVU
C      CAN SHIP PROCEED UPBOUND?
      IF(ALLOWU.GT.0.0)GO TO 610
      CAPAC(NTIME) = 0.0
      CONSTR(NTIME) = NREACH
C     WRITE(6, * ) NREACH,ALLOWU,AMANU1,REACH(NREACH,3),ACNAVU
      GO TO 900
  610 CONTINUE
      SUM=SUM+((REACH(NREACH,6)-REACH(NREACH,5))/REACH(NREACH,7))
C     WRITE(6,*) NREACH,SUM
```

```
      GO TO 800
  650 CONTINUE
C     VSHIP = 29.56*(VISMNR/2.0)**0.6215
      VSHIP = 1000.0
C      DETERMINE UPBOUND AND DOWNBOUND SPEED
      VSHIPU=VSHIP
C      IS VSHIPU > SPEED LIMIT (UP)
      IF(VSHIPU.GT.REACH(NREACH,7))VSHIPU=REACH(NREACH,7)
      VSHIPD=VSHIP
C      IS VSHIPD > SPEED LIMIT (DOWN)
      IF(VSHIPD.GT.REACH(NREACH,8))VSHIPD=REACH(NREACH,8)
C     WRITE(6, * ) NREACH,VISMNR,VSHIP,VSHIPU,VSHIPD
      IF(VSHIPU.EQ.0.0.AND.VSHIPD.EQ.0.0)  CAPAC(NTIME) = 0.0
      IF(VSHIPU.EQ.0.0.AND.VSHIPD.EQ.0.0)  CONSTR(NTIME) = NREACH
      IF(VSHIPU.EQ.0.0.AND.VSHIPD.EQ.0.0)  GO TO 900
C      IS SEASON EXTENDED≥
      IF(NDAY.GE.EXTSEA(NYEAR,2).AND.NDAY.LT.EXTSEA(NYEAR,5)) GO TO 655
      GO TO 680
C      DOES ICE OCCUR IN THIS REACH DURING EXTENDED SEASON≥
  655 IF(REACH(NREACH,22).EQ.0.0) GO TO 680
C      IS THIS REACH PART OF SOUTH SHORE CANAL≥
      IF(NREACH.LE.20)GO TO 670
      AMANU2=SHIP(ID,2)/2.0
      AMAND2=SHIP(ID,2)/2.0
C      IS REACH 1-WAY BY SEAWAY REGULATIONS≥
      IF(REACH(NREACH,1).GT.2.0)GO TO 670
      ALLOWU2 = 0.25*REACH(NREACH,3) - AMANU2 - ACNAVU
      ALLOWD2 = 0.25*REACH(NREACH,3) - AMAND2 - ACNAVD
C      CAN SHIP PROCEED 2-WAY
C     WRITE(6, * ) NREACH,ALLOWU2,REACH(NREACH,3),AMANU2,ACNAVU
C     WRITE(6, * ) NREACH,ALLOWD2,REACH(NREACH,3),AMAND2,ACNAVD
      IF(ALLOWU2.GT.0.0.AND.ALLOWD2.GT.0.0) GO TO 660
      AMANU1=SHIP(ID,2)/2.0
      AMAND1=SHIP(ID,2)/2.0
      GO TO 750
  660 CONTINUE
      SUM=0.0
      CAP=DELT(NTIME)/TLOCK
      CONREA = NREACH
      GO TO 850
  670 CONTINUE
      AMANU1=SHIP(ID,2)/2.0
      AMAND1=SHIP(ID,2)/2.0
      GO TO 750
  680 CONTINUE
C      IS REACH 1-WAY BY SEAWAY REGULATIONS≥
      IF(REACH(NREACH,1).GT.2.0)GO TO 710
C      IS REACH DYNAMIC≥
      IF(REACH(NREACH,1).EQ.1.0) GO TO 690
      IF(REACH(NREACH,1).EQ.3.0) GO TO 690
C
      CALL STAMAN(2,1,VSHIPU,STATM)
C
      AMANU2=STATM
C
      CALL STAMAN(2,2,VSHIPD,STATM)
C
```

```
      AMAND2=STATM
      GO TO 700
  690 CONTINUE
C
      CALL DYNMAN(2,1,VSHIPU,DYNM)
C
      AMANU2=DYNM
C
      CALL DYNMAN(2,2,VSHIPD,DYNM)
C
      AMAND2=DYNM
  700 CONTINUE
      ALLOWU2 = 0.25*REACH(NREACH,3) - AMANU2 - ACNAVU
      ALLOWD2 = 0.25*REACH(NREACH,3) - AMAND2 - ACNAVD
C      CAN SHIP PROCEED 2-WAY?
C     WRITE(6, * ) NREACH,ALLOWU2,REACH(NREACH,3),AMANU2,ACNAVU
C     WRITE(6, * ) NREACH,ALLOWD2,REACH(NREACH,3),AMAND2,ACNAVD
      IF(ALLOWU2.LE.0.0) GO TO 710
      IF(ALLOWD2.LE.0.0) GO TO 710
      SUM=0.0
      CAP = DELT(NTIME)/TLOCK
      CONREA = NREACH
      GO TO 850
  710 CONTINUE
C      IS REACH DYNAMIC?
      IF(REACH(NREACH,1).EQ.1.0) GO TO 720
      IF(REACH(NREACH,1).EQ.3.0) GO TO 720
C
      CALL STAMAN(1,1,VSHIPU,STATM)
C
      AMANU1=STATM
C
      CALL STAMAN(1,2,VSHIPD,STATM)
C
      AMAND1=STATM
      GO TO 750
  720 CONTINUE
C
      CALL DYNMAN(1,1,VSHIPU,DYNM)
C
      AMANU1=DYNM
C
      CALL DYNMAN(1,2,VSHIPD,DYNM)
C
      AMAND1=DYNM
  750 CONTINUE
C
      ALLOWU = 0.5*REACH(NREACH,3) - AMANU1 - ACNAVU
      ALLOWD = 0.5*REACH(NREACH,3) - AMAND1 - ACNAVD
C     WRITE(6, * ) NREACH,ALLOWU,AMANU1,REACH(NREACH,3),ACNAVU
C     WRITE(6, * ) NREACH,ALLOWD,AMAND1,REACH(NREACH,3),ACNAVD
C      CAN SHIP PROCEED DOWNBOUND?
      IF(ALLOWD.GT.0.0)GO TO 770
C      CAN SHIP PROCEED UPBOUND?
      IF(ALLOWU.GT.0.0)GO TO 760
      CAPAC(NTIME) = 0.0
      CONSTR(NTIME) = NREACH
```

```
      GO TO 900
  760 CONTINUE
      SUM=SUM+(REACH(NREACH,6)-REACH(NREACH,5))/VSHIPU
C     WRITE(6,*) NREACH,SUM
      GO TO 800
  770 CONTINUE
C      CAN SHIP PROCEED UPBOUND≥
      IF(ALLOWU.GT.0.0)GO TO 780
      SUM=SUM+(REACH(NREACH,6)-REACH(NREACH,5))/VSHIPD
C     WRITE(6,*) NREACH,SUM
      GO TO 800
  780 CONTINUE
      SUM=SUM+(REACH(NREACH,6)-REACH(NREACH,5))/(RATIO*VSHIPU+
     ↱ (1.0-RATIO)*VSHIPD)
C     WRITE(6,*) NREACH,SUM
  800 CONTINUE
C
C      IS THE TIME TO TRANSIT SEQUENTIAL 1-WAY REACHES GREATER
C      THAN 2-WAY LOCKAGE TIME≥
C
C     WRITE(6,*) NREACH,SUM, TLOCK
      IF(SUM.GT.TLOCK)GO TO 810
      CAP = DELT(NTIME)/TLOCK
      CONREA= 54
      GO TO 850
  810 CONTINUE
      CAP = DELT(NTIME)/(TLOCK+TTRNBK)
      CONREA= 71
  850 CONTINUE
      IF(CAP.GE.CAPAC(NTIME))GO TO 860
      CAPAC(NTIME) = CAP
      CONSTR(NTIME) = CONREA
  860 CONTINUE
      IF(NREACH.NE.103) GO TO 400
  900 CONTINUE
C
      YRCAP = YRCAP + CAPAC(NTIME)
      DAYCAP = DAYCAP + CAPAC(NTIME)
C     WRITE(6,2000) NDAY,TIME       ,CAPAC(NTIME),CONSTR(NTIME),DAYCAP
 2000 FORMAT( I4,F10.3,F10.3,I10,F10.3)
  150 CONTINUE
      DAYCAP = 0.0
C
  100 CONTINUE
      WRITE(6,3000) YRCAP
 3000 FORMAT(F10.3)
      YRCAP = 0.0
  105 CONTINUE
C
C      COMPUTE AND PRINT OUTPUT
C
      STOP
      END
```

```
      SUBROUTINE STAMAN(NWAY,NSHDIR,VSHIP,STATM)
      COMMON WSP,WDIR,REACH(103,22),SHIP(2,19),NREACH,ID,IDRAFT,RHO
      COMMON/COEFCH/XYOP(7,11,2),XWPB(7),NYPB(7),XALPHA(11,3),
     *NWPB,NXALP
C
      COURSE=REACH(NREACH,2)
      WIDTH=REACH(NREACH,3)
      DEPTH=REACH(NREACH,4)
      VCUR=REACH(NREACH,9)
      CURDIR=REACH(NREACH,10)
      IF(CURDIR.EQ.0.0) CURDIR=COURSE - 180.0
      XLEN=SHIP(ID,1)
      BEAM=SHIP(ID,2)
      DRAFT=SHIP(ID,IDRAFT)
      SAIL=SHIP(ID,IDRAFT-1)
   20 CONTINUE
      YV=SHIP(ID,11)
      XNV=SHIP(ID,12)
      YDEL=SHIP(ID,13)
      XNDEL=SHIP(ID,14)
C
      UO=VSHIP*1.4667
      FAC1=0.5*RHO*XLEN*XLEN*UO
      FAC2=FAC1*XLEN
      FAC3=FAC1*UO
      FAC4=FAC3*XLEN
      YV=YV*FAC1
      XNV=XNV*FAC2
      YDEL=YDEL*FAC3
      XNDEL=XNDEL*FAC4
C
      IF(NSHDIR.EQ.2)COURSE=COURSE-180.
      YO=0.0
      IF(NWAY.EQ.2) YO=WIDTH/4.
      DEN=YV-(YDEL/XNDEL)*XNV
      IF(WDIR.GT.180.0)GO TO 30
      WDIR=WDIR+180.0
      GO TO 40
   30 CONTINUE
      WDIR=WDIR-180.0
   40 CONTINUE
      RELWND=(WDIR-COURSE)/57.29578
      RELCUR=(CURDIR-COURSE)/57.29578
      YF1=ABS(SIN(RELWND))*SIN(RELWND)*SAIL
      YFWIND=.00256*1.3*WSP*WSP*YF1
      VCURX=-VCUR*COS(RELCUR)
      VCURY=VCUR*SIN(RELCUR)
      VTOTX=UO+VCURX
      PHIW=YFWIND/(VTOTX*DEN)
      PHICUR = -VCURY/VTOTX
C
      IF(NWAY.EQ.1)PHIYO=0.0
      IF(NWAY.EQ.1)GO TO 50
      IF(NREACH.LE.20) PHIYO = 0.0
      IF(NREACH.LE.20) GO TO 50
      IF(NREACH.GT.25.AND.NREACH.LT.34)     YO =WIDTH/6.0
      CALL CHCOEF(IN,YO,UO,IOUT,YYO,XNYO)
```

```
C
      PHIYO=-YO*(YDEL*XNYO/XNDEL-YYO)/(VTOTX*DEN)
   50 CONTINUE
      IF(PHIYO.EQ.0.0) YO = 0.0
      IF(PHIYO.EQ.0.0) YYO = 0.0
      IF(PHIYO.EQ.0.0) XNYO = 0.0
      PHITOT=PHIW+PHICUR+PHIYO
      PHIM=ABS(PHITOT)
      RUDANG = (1.0/YDEL)*(YV*VTOTX*PHITOT + YV*VCURY - YYO*YO - YFWIND)
      RUDANG = RUDANG * 57.29578
      STATM=XLEN*SIN(PHIM)+BEAM*COS(PHIM)
      STATM = STATM/2.0
      IF(NREACH.GT.25.AND.NREACH.LT.34)  STATM = STATM + 0.083333*WIDTH
      IF(ABS(RUDANG).GT.35.0) STATM =1000.0
      RETURN
      END
```

```
      SUBROUTINE CHCOEF(IN,YO,UO,IOUT,YYO,XNYO)
      COMMON WSP,WDIR,REACH(103,22),SHIP(2,19),NREACH,ID,IDRAFT,RHO
      COMMON/COEFCH/XYOP(7,11,2),XWPB(7),NYPB(7),XALPHA(11,3),
     *      NWPB,NXALP
C      WRITE(6,3)
    3 FORMAT(≠ENTER CHCOEF≠)
C
      WIDTH=REACH(NREACH,3)
      BEAM=SHIP(ID,2)
      DRAFT=SHIP(ID,IDRAFT)
      WDEPTH=REACH(NREACH,4)
      WPB=WIDTH/BEAM
      HPT=WDEPTH/DRAFT
C
      IF(ABS(YO).GE.0.001)GO TO 10
      YYO=0.
      XNYO=0.
      RETURN
C
   10 CONTINUE
      DO 40 I=1,NWPB
      IF(WPB.GT.XWPB(I))GO TO 30
      IF(I.NE.1)GO TO 20
      WRITE(6,15)
   15 FORMAT(≠ WPB IS LESS THAN XWPB(1)≠)
      YYO=0.
      XNYO=0.
      RETURN
C
   20 CONTINUE
      AYOPB=ABS(YO)/BEAM
      IF(AYOPB.GT.0.0)GO TO 25
      YYO=0.
      XNYO=0.

      RETURN
   25 CONTINUE
      I1=I-1
      GO TO 45
   30 CONTINUE
      IF(I.LT.NWPB)GO TO 40
      YYO=0.
      XNYO=0.
      RETURN
   40 CONTINUE
      WRITE(6,42)
   42 FORMAT(≠ERROR IN SUBROUTINE CHCOEF AT STATEMENT 40≠)
      RETURN
   45 CONTINUE
      DO 200 II=1,2
      IF(II.EQ.1)L=I1
      IF(II.EQ.2)L=I
      MYPB=NYPB(L)
      DO 90 J=1,MYPB
      IF(AYOPB.GT.XYOP(L,J,1))GO TO 80
      IF(J.EQ.1)GO TO 50
      GO TO 70
```

```
C
   50 CONTINUE
C       AYOPB CAN NOT BE LESS THAN ZERO, VALUE OF XYOP(L,1,1)
      WRITE(6,60)AYOPB,XYOP(L,1,1)
   60 FORMAT(≠ERROR IN SUBROUTINE CHCOEF AT STATEMENT 50.≠/
     *       ≠AYOPB OF ≠,F10.2,≠ LESS THAN ≠,F10.2)
      RETURN
   70 CONTINUE
C       AYOPB BETWEEN J AND J-1
      DTAB1=XYOP(L,J,1)-XYOP(L,J-1,1)
      DTAB2=XYOP(L,J,2)-XYOP(L,J-1,2)
      DYOPB=AYOPB-XYOP(L,J-1,1)
      YOPP=XYOP(L,J-1,2)+DTAB2*DYOPB/DTAB1
      GO TO 100
C
   80 CONTINUE
      IF(J.LT.NYPB(L))GO TO 90
C       AYOPB GREATER THAN FINAL VALUE OF XYOP
      DTAB1=XYOP(L,J,1)-XYOP(L,J-1,1)
      DTAB2=XYOP(L,J,2)-XYOP(L,J-1,2)
      DYOPB=AYOPB-XYOP(L,J,1)
      YOPP=XYOP(L,J,2)+DTAB2*DYOPB/DTAB1
      GO TO 100
   90 CONTINUE
C       SHOULD NOT EXIT DO LOOP HERE
      WRITE(6,95)
   95 FORMAT(≠ERROR IS SUBROUTINE CHCOEF AT STATEMENT 90≠)
      RETURN
  100 CONTINUE
C
      IF(II.EQ.1)YOP1=YOPP
      IF(II.EQ.2)YOP2=YOPP
  200 CONTINUE
C       VALUE OF YOP BETWEEN YOP1 AND YOP2
      DWPB1=XWPB(I)-XWPB(I1)
      DWPB2=WPB-XWPB(I1)
      DYOP=YOP2-YOP1
      YOP=YOP1+DYOP*DWPB2/DWPB1
C
      DO 300 K=1,NXALP
      IF(HPT.GT.XALPHA(K,1))GO TO 180
      IF(K.NE.1)GO TO 170
C       HPT LESS THAN FIRST VALUE OF XALPHA
      DXAL1=XALPHA(2,1)-XALPHA(1,1)
      DXAL2=XALPHA(2,2)-XALPHA(1,2)
      DXAL3=XALPHA(2,3)-XALPHA(1,3)
      DHPT=XALPHA(1,1)-HPT
      XBAR=XALPHA(1,2)-DXAL2*DHPT/DXAL1
      ALPHA=XALPHA(1,3)-DXAL3*DHPT/DXAL1
      GO TO 220
C
  170 CONTINUE
C       HPT BETWEEN K-1 AND K
      DXAL1=XALPHA(K,1)-XALPHA(K-1,1)
      DXAL2=XALPHA(K,2)-XALPHA(K-1,2)
      DXAL3=XALPHA(K,3)-XALPHA(K-1,3)
      DHPT=HPT-XALPHA(K-1,1)
```

```
      XBAR=XALPHA(K-1,2)+DXAL2*DHPT/DXAL1
      ALPHA=XALPHA(K-1,3)+DXAL3*DHPT/DXAL1
      GO TO 220
C
  180 CONTINUE
      IF(K.NE.NXALP)GO TO 300
C       HPT ABOVE FINAL VALUE OF XALPHA
      DXAL1=XALPHA(K,1)-XALPHA(K-1,1)
      DXAL2=XALPHA(K,2)-XALPHA(K-1,2)
      DXAL3=XALPHA(K,3)-XALPHA(K-1,3)
      DHPT=HPT-XALPHA(K,1)
      XBAR=XALPHA(K,2)+DXAL2*DHPT/DXAL1
      ALPHA=XALPHA(K,3)+DXAL3*DHPT/DXAL1
      GO TO 220
  300 CONTINUE
C       SHOULD NOT EXIT DO LOOP HERE
      WRITE(6,205)
  205 FORMAT(*ERROR IN SUBROUTINE CHCOEF AT STATEMENT 300*)
      RETURN
C
  220 CONTINUE
      YYO=0.5*RHO*SHIP(ID,1)*DRAFT*UO*UO*YOP*ALPHA/ABS(YO)
      XNYO=XBAR*SHIP(ID,1)*YYO
C       WRITE(6,4)YO,XO,WPB,HPT,V,YYO,XNYO,YOP,YOP1,YOP2,YOPP,ALPHA,XBAR
    4 FORMAT(*EXIT CHCOEF*/5E15.4/5E15.4/5E15.4)
      RETURN
      END
```

```
'TINE MAXDIS     73/73   OPT=1                                    FTN 4.6+428

      SUBROUTINE MAXDIS(IN,DISMAX)
      COMMON WSP,WDIR,REACH(103,22),SHIP(2,19),NREACH,IO,IDRAFT,RHO
C
      IJ=IN+1
      DMAX=REACH(1,IN)
      UMAX=REACH(1,IJ)
      DO 100 I=2,103
      IF(REACH(I,IN).GT.DMAX)DMAX=REACH(I,IN)
      IF(REACH(I,IJ).GT.UMAX)UMAX=REACH(I,IJ)
  100 CONTINUE
      DISMAX=UMAX
      IF(DMAX.GT.UMAX)DISMAX=DMAX
      RETURN
      END
```

```
      SUBROUTINE SUNRS(NDAY,IYEAR,SUNRIS,SUNSET)
C       ALL ANGLES SHOULD BE IN DEGREES
      CON=3.14159/180.
      NDAYS=273
      IF(IYEAR.EQ.68)NDAYS=274
C       SUNRISE CALCULATION
      TR=NDAY+NDAYS+11.0/24.0
      IF(IYEAR.NE.68.AND.TR.GT.365.0) TR = TR-365.0
      IF(IYEAR.EQ.68.AND.TR.GT.366.0) TR = TR-366
      XMR=0.9856*TR-3.251
      XLR=XMR+1.916*SIN(CON*XMR)+0.02*SIN(CON*2.*XMR)+282.565
      IF(XLR.GT.360.0)  XLR = XLR-360.0
      NQLR=1.0+XLR/90.0
      ALPHAR=ATAN(0.91746*SIN(CON*XLR)/COS(CON*XLR))/CON
      IF(ALPHAR.GT.360.0)  ALPHAR = ALPHAR-360.0
      IF(ALPHAR.LT.0.0)ALPHAR=360.0+ALPHAR
      NQALR=1+ALPHAR/90.0
      DIFFR=NQLR-NQALR
      ALPHAR=ALPHAR+DIFFR*90.0
      YR=0.39782*SIN(CON*XLR)
      XR=SQRT(1.-YR*YR)
      DELTAR=ATAN(YR/XR)/CON
      COSHR=(-0.01454-SIN(CON*DELTAR)*0.7071)/
     *  (ABS(COS(CON*DELTAR))*0.7071)
      XH=COSHR
      YH=SQRT(1.-COSHR*COSHR)
      HR=ATAN(YH/XH)/CON
      XHR=HR
      IF(COSHR.GT.0.0)XHR=360.0-HR
      IF(COSHR.LT.0.0)  XHR = 270.0 - (90.0+HR)
      TIMER=XHR/15.0+ALPHAR/15.0-0.06571*TR-6.620
      SUNRIS=TIMER
      IF(TIMER.LT.0.0)SUNRIS=TIMER+24.0
      IF(TIMER.GE.24.0)SUNRIS=TIMER-24.0
C
C       SUNSET CALCULATION
      TS=NDAY+NDAYS+23.0/24.0
      IF(IYEAR.NE.68.AND.TS.GT.365.0) TS = TS-365.0
      IF(IYEAR.EQ.68.AND.TS.GT.366.0) TS = TS-366
      XMS=0.9856*TS-3.251
      XLS=XMS+1.916*SIN(CON*XMS)+0.02*SIN(CON*2.*XMS)+282.565
      IF(XLS.GT.360.0)  XLS = XLS-360.0
      NQLS=1.0+XLS/90.0
      ALPHAS=ATAN(0.91746*SIN(CON*XLS)/COS(CON*XLS))/CON
      IF(ALPHAS.GT.360.0)  ALPHAS = ALPHAS-360.0
      IF(ALPHAS.LT.0.0)ALPHAS=360.0+ALPHAS
      NQALS=1.0+ALPHAS/90.0
      DIFFS=NQLS-NQALS
      ALPHAS=ALPHAS+DIFFS*90.0
      YS=0.39782*SIN(CON*XLS)
      XS=SQRT(1.-YS*YS)
      DELTAS=ATAN(YS/XS)/CON
      COSHS=(-0.01454-SIN(CON*DELTAS)*0.7071)/
     *  (ABS(COS(CON*DELTAS))*0.7071)
      XHS=COSHS
      YHS=SQRT(1.0-XHS*XHS)
      HS=ATAN(YHS/XHS)/CON
```

```
      IF(COSHS.LT.0.0) HS = 180.0 + HS
      TIMES=HS/15.0+ALPHAS/15.0-0.06571*TS-6.620
      SUNSET=TIMES
      IF(TIMES.LT.0.0) SUNSET=TIMES+24.0
      IF(TIMES.GE.24.0) SUNSET=TIMES-24.0
      RETURN
      END
```

```
      SUBROUTINE DYNMAN(NWAY,NSHDIR,VSHIP,DYNM)
      COMMON WSP,WDIR,REACH(103,22),SHIP(2,19),NREACH,ID,IDRAFT,
     * RHO
      DIMENSION VW(7),VSHIP1(28),VSHIP2(35),DY44U(28),DY44D(28),
     * DY46U(28),DY46D(28),DY50U(28),DY50D(28),DY56U(35),DY56D(35)
      DIMENSION DY44LU(28),DY44LD(28),DY50LU(28),DY50LD(28)
      DIMENSION DY56LU(35),DY56LD(35)
      DIMENSION L(4),LM(4)
C
      DATA VW/45.,30.,15.,0.,-15.,-30.,-45./
      DATA VSHIP1/7*(3.,6.,9.,12.)/
      DATA VSHIP2/7*(3.,6.,9.,12.,15.)/
      DATA DY56U/229.67,228.91,228.71,224.00,220.34,
     1227.38,230.04,217.17,205.00,193.61,
     2225.71,229.17,210.06,190.00,179.02,
     3225.87,225.26,201.67,144.71,117.00,
     4225.27,226.26,197.75,142.64,115.20,
     5225.47,225.27,189.57,137.04,111.83,
     6225.03,226.88,214.39,129.02,106.75/
      DATA DY56D/300.76,225.66,225.34,172.16,130.41,
     1267.29,225.45,225.04,156.54,123.07,
     2225.46,225.36,215.88,148.88,119.34,
     3225.62,226.44,211.74,147.28,118.59,
     4225.30,226.36,204.92,144.83,117.46,
     5267.29,225.07,186.78,137.31,113.56,
     6227.33,226.09,225.78,126.09,107.35/
      DATA DY50U / 14804.23,297.82,218.33,173.45,443.64,306.95,224.92,
     1178.89,453.26,315.40,230.34,182.21,452.21,317.73,232.04,183.27,
     2463.83,321.31,233.49,183.87,489.12,331.76,238.74,187.06,3277.64,
     3351.35,248.37,192.77/
      DATA DY50D / 17260.94,3975.76,142.35,143.92,5686.79,180.07,187.38,
     1163.91,255.47,294.71,232.41,186.38,617.72,350.86,248.84,192.98,
     21070.65,402.14,262.64,198.16,5512.92,600.08,315.57,219.95,
     317079.67,3227.82,412.55,258.67/
      DATA DY46U/929.08,107.23,86.02,76.72,133.48,100.14,83.47,74.30,
     1222.98,134.59,103.00,86.96,303.78,140.49,105.49,88.26,
     2408.92,144957,107.15,89.09,161.38,113.87,92.83,80.62,
     3533977,125.93,99.36,84.82/
      DATA DY46D/ 1000.0,242.55,187.11,163.95,
     1344.44,213.33,196.83,158.31,682.19,309.14,241.66,191.39,
     2770.26,304.53,244.99,191.30,1499.26,348.97,245.89,191.81,
     3422.06,251.19,194.98,158.59,1000.0,276.92,200.74,162.31/
      DATA DY44U/35760.,751.47,332.0,256.1,5500.69,475.6,322.55,250.6,
     1824.00,462.98,316.82,248.29,819.1,464.03,316.57,249.49,
     2831.82,466.97,317.59,249.93,865.13,475.98,321.99,252.46,
     330457.31,490.90,329.67,257.08/
      DATA DY44D/35760.0,3207.51,795.46,271.24,
     13217.48,1397.76,369.35,273.99,1981.75,606.08,387.89,282.67,
     21331.40,627.47,394.74,285.74,1379.06,641.85,397.89,286.79,
     31138.14,690.23,412.91,293.18,3080.05,1220.61,443.07,304.82/
      DATA DY44LU/
     1 1000.00, 771.30, 336.63, 258.90, 1000.00, 479.10, 325.19, 252.23,
     1  825.70, 464.08, 318.28, 249.21, 819.78, 464.32, 317.64, 250.19,
     1  834.29, 467.24, 318.39, 250.48, 903.10, 478.32, 322.26, 252.57,
     1 1000.00, 496.77, 331.79, 258.32/
      DATA DY44LD/
     1 1500.00, 1000.00,811.39,273.25,1500.00,1000.00,370.41,275.27,
```

```
     1 1000.00,611.40,391.44,285.20,1334.21,635.03,399.18,288.67,
     1 1408.58,651.12,402.76,289.93,1200.84,706.74,419.77,297.34,
     1 1200.00,900.00,454.86,310.80/
      DATA DY50LU/
     1 1000.00,298.80,218.62,174.37,446.96,308.92,226.11,180.59,
     1 459.08,318.56,233.49,184.39,454.22,321.32,235.63,185.58,
     1 471.26,325.46,237.03,187.41,499.20,338.25,242.91,189.90,
     1 1000.00,374.06,253.62,196.34/
      DATA DY50LD/
     1 1000.00,800.00,146.77,140.34,1000.00,184.36,188.28,164.10,
     1 259.99,296.87,234.32,187.81,627.56,355.44,251.35,194.72,
     1 1087.10,408.29,265.88,200.11,1200.00,612.71,321.02,223.08,
     1 1200.00,1000.00,421.95,263.70/
      DATA DY56LU/
     1264.,246.,245.,264.,233.,232.,238.,314.,252.,203.,
     1231.,235.,293.,234.,187.,228.,230.,252.,213.,126.,
     1228.,230.,252.,203.,115.,261.,226.,249.,175.,112.,
     1260.,243.,253.,131.,107./
      DATA DY56LD/
     1300.,253.,237.,182.,137.,350.,236.,237.,164.,128.,
     1242.,231.,227.,155.,123.,228.,232.,217.,153.,122.,
     1249.,230.,214.,150.,121.,300.,237.,193.,141.,116.,
     1350.,258.,229.,128.,109./
      DATA L/4,7.2,2/
      DATA LM/4,7,2,2/
C
      COURSE=REACH(NREACH,2)
      IF(NSHDIR.EQ.2)COURSE=COURSE-180.0
      IF(WDIR.GT.180.0)GO TO 3
      WDIR=WDIR+180.0
      GO TO 4
    3 CONTINUE
      WDIR=WDIR-180.0
    4 CONTINUE
      RELWND=WDIR-COURSE
      VWIND=WSP*SIN(RELWND/57.29578)
      IF(NWAY.EQ.2)WRITE(6,10)
   10 FORMAT(≠REACH IS TWO-WAY, ERROR IN DATA≠)
      IF(NREACH.EQ.44)GO TO 20
      IF(NREACH.EQ.46)GO TO 30
      IF(NREACH.EQ.50)GO TO 40
      IF(NREACH.EQ.56)GO TO 50
      WRITE(6,15)NREACH
   15 FORMAT(≠RFACH ≠,I4,≠ NOT DYNAMIC≠)
      RETURN
C
   20 CONTINUE
      IF(NSHDIR.EQ.1.AND.ID.EQ.1) GO TO 21
      IF(NSHDIR.EQ.2.AND.ID.EQ.1) GO TO 22
      IF(NSHDIR.EQ.1.AND.ID.EQ.2) GO TO 23
      IF(NSHDIR.EQ.2.AND.ID.EQ.2) GO TO 24
   21 CONTINUE
      DYNM=DTAB(VSHIP1,DY44U,VW,VSHIP,VWIND,L)
      RETURN
   22 CONTINUE
      DYNM=DTAB(VSHIP1,DY44D,VW,VSHIP,VWIND,L)
      RETURN
```

```
   23 CONTINUE
      DYNM = DTAB(VSHIP1,DY44LU,VW,VSHIP,VWIND,L)
      RETURN
   24 CONTINUE
      DYNM = DTAB(VSHIP1,DY44LD,VW,VSHIP,VWIND,L)
      RETURN
C
   30 CONTINUE
      IF(NSHDIR.EQ.1) GO TO 31
      IF(NSHDIR.EQ.2) GO TO 32
   31 CONTINUE
      DYNM=DTAB(VSHIP1,DY46U,VW,VSHIP,VWIND,L)
      RETURN
   32 CONTINUE
      DYNM=DTAB(VSHIP1,DY46D,VW,VSHIP,VWIND,L)
      RETURN
C
   40 CONTINUE
      IF(NSHDIR.EQ.1.AND.ID.EQ.1) GO TO 41
      IF(NSHDIR.EQ.2.AND.ID.EQ.1) GO TO 42
      IF(NSHDIR.EQ.1.AND.ID.EQ.2) GO TO 43
      IF(NSHDIR.EQ.1.AND.ID.EQ.2) GO TO 44
   41 CONTINUE
      DYNM=DTAB(VSHIP1,DY50U,VW,VSHIP,VWIND,L)
      RETURN
   42 CONTINUE
      DYNM=DTAB(VSHIP1,DY50D,VW,VSHIP,VWIND,L)
      RETURN
C
   43 CONTINUE
      DYNM = DTAB(VSHIP1,DY50LU,VW,VSHIP,VWIND,L)
      RETURN
   44 CONTINUE
      DYNM = DTAB(VSHIP1,DY50LD,VW,VSHIP,VWIND,L)
      RETURN
   50 CONTINUE
      IF(NSHDIR.EQ.1.AND.ID.EQ.1) GO TO 51
      IF(NSHDIR.EQ.2.AND.ID.EQ.1) GO TO 52
      IF(NSHDIR.EQ.1.AND.ID.EQ.2) GO TO 53
      IF(NSHDIR.EQ.2.AND.ID.EQ.2) GO TO 54
   51 CONTINUE
      DYNM=DTAB(VSHIP2,DY56U,VW,VSHIP,VWIND,LM)
      RETURN
   52 CONTINUE
      DYNM=DTAB(VSHIP2,DY56D,VW,VSHIP,VWIND,LM)
      RETURN
   53 CONTINUE
      DYNM = DTAB(VSHIP2,DY56LU,VW,VSHIP,VWIND,LM)
      RETURN
   54 CONTINUE
      DYNM = DTAB(VSHIP2,DY56LD,VW,VSHIP,VWIND,LM)
      RETURN
      END
```

```
NCTION DTAB        73/73   OPT=1                                FTN 4.6+428

      FUNCTION DTAB(XTAB,YTAB,ZTAB,X,Z,L)
C
      DIMENSION L(4),LM(4),LL(4),DUMX(20),DUMY(20),XTAB(400),
     * YTAB(400),ZTAB(20)
C
C       L(1) = NUMBER OF PAIRS OF POINTS PER LINE
C       L(2) = NUMBER OF LINES
C       L(3) = DEGREE OF LAGRANGE INTERPOLATION ALONG LINE
C       L(4) = DEGREE OF LAGRANGE INTERPOLATION BETWEEN LINES
C       XTAB = ARRAY OF X VALUES
C       YTAB = ARRAY OF Y VALUES
C       ZTAB = ARRAY OF Z VALUES
C       X = PRIMARY INDEPENDENT VARIABLE
C       Z = SECONDARY INDEPENDENT VARIABLE
C       DTAB = DEPENDENT VARIABLE
C
      LL(1)=L(1)
      LL(2)=L(3)
C
C       CHECK TO SEE IF ONLY ONE LINE HAS BEEN INPUT
C
      IF(L(2)-1)20,10,20
   10 CONTINUE
      DTAB=TABX(XTAB,YTAB,X,LL)
C
C       ONLY ONE LINE HAS BEEN INPUT
C
      RETURN
   20 CONTINUE
C
C       MORE THAN ONE LINE HAS BEEN INPUT.  NOW CHECK TO SEE IF
C       Z LIES ON A LINE ZTAB(I).
C       IF IT DOES, THE CORRECT LINE IS INTERPOLATED.
C       IF IT DOES NOT, A DUMMY ARRAY IS GENERATED WHERE A DUMMY X
C       IS GENERATED FOR EACH LINE, AND A DUMMY Y CORRESPONDING TO
C       X FOR THE LINE.  THE RESULTANT LINE ARRAY IS THEN
C       INTERPOLATED.
C
      KK=L(2)
      DO 50 I=1,KK
      LIN=L(1)*(I-1)+1
      TEST = ABS(Z-ZTAB(I))
      IF(TEST-0.01) 30,30,40
   30 CONTINUE
      DTAB=TABX(XTAB(LIN),YTAB(LIN),X,LL)
C
C       Z LIES OF A LINE ZTAB(I)
C
      RETURN
   40 CONTINUE
      DUMX(I)=ZTAB(I)
      DUMY(I)=TABX(XTAB(LIN),YTAB(LIN),X,LL)
   50 CONTINUE
      LM(1)=L(2)
      LM(2)=L(4)
      DTAB=TABX(DUMX,DUMY,Z,LM)
      RETURN
      END
```

```
C
C
      FUNCTION TABX(XTAB,YTAB,O,L)
C
      DIMENSION L(2),A(5),B(5),Y(5),XTAB(400),YTAB(400),X(5)
C
C      L(1) = NUMBER OF PAIRS OF POINTS
C      L(2) = DEGREE OF FIT WITH A MAXIMUM OF 4
C      XTAB = ARRAY OF X VALUES
C      YTAB = ARRAY OF Y VALUES
C      O = INDEPENDENT VARIABLE
C      TABX = DEPENDENT VARIABLE
C
C
      NPTS=L(1)
      K=L(2)+1
      K=MIN0(K,NPTS)
C
C      BRANCH TO 10 IF X IS INCREASING
C      BRANCH TO 160 IF X IS DECREASING
C      ERROR IF X(1)=X(2)
C
      IF(XTAB(1)-XTAB(2))10,290,160
   10 CONTINUE
      IF(XTAB(1)-O)20,140,200
   20 CONTINUE
      DO 120 IX=2,NPTS
C
C      X ARRAY IS SEARCHED TO FIND X CLOSEST TO O
C
      IF(XTAB(IX)-XTAB(IX-1))290,290,30
   30 CONTINUE
      IF(XTAB(IX)-O)120,150,40
   40 CONTINUE
C
C      IF O LIES BETWEEN EITHER END POINT OF THE X ARRAY AND ITS
C      ADJACENT POINT, THE INTERPOLATION IS LIMITED TO NO GREATER
C      THAN A SECOND DEGREE FIT.
C
      IF(IX-2)50,50,60
   50 CONTINUE
      K=MIN0(K,3)
   60 CONTINUE
      IF(IX-NPTS)80,70,70
   70 CONTINUE
      K=MIN0(K,3)
   80 CONTINUE
      NDX=IX-(K/2)
      IF(IX-NPTS)100,90,90
   90 CONTINUE
      NDX=NPTS-(K-1)
  100 CONTINUE
      DO 110 IL=1,K
C
C      X AND CORPESPONDING Y VALUES FOR X≠S BRACKETING O ARE
C      TRANSFERED TO LAGRANGIAN EQUATION.
C
```

```
            X(IL)=XTAB(NDX)
            Y(IL)=YTAB(NDX)
            NDX=NDX+1
          110 CONTINUE
            GO TO 210
          120 CONTINUE
          130 CONTINUE
      C
      C      TO GET PAST 120, O IS LARGER THAN THE LARGEST VALUE OF X IN
      C      XTAB.  EXTRAPOLATION IS NECESSARY TO FIND TABX AT O.
      C
            TABX=((YTAB(NPTS)-YTAB(NPTS-1))/(XTAB(NPTS)-XTAB(NPTS-1)))*
           *  (O-XTAB(NPTS))+YTAB(NPTS)
            RETURN
      C
          140 CONTINUE
            IX=1
          150 CONTINUE
            TABX=YTAB(IX)
            RETURN
      C
          160 CONTINUE
            IF(O-XTAB(1))170,140,200
          170 CONTINUE
            DO 190 IX=2,NPTS
      C
      C      X ARRAY IS SEARCHED TO FIND X CLOSEST TO O
      C
            IF(XTAB(IX)-XTAB(IX-1))180,290,290
          180 CONTINUE
            IF(O-XTAB(IX))190,150,40
          190 CONTINUE
      C
      C      TO GET PAST 190, O IS SMALLER THAN THE SMALLEST VALUE OF X IN
      C      XTAB.  EXTRAPOLATION IS NECESSARY TO FIND TABX FOR O.
      C
            GO TO 130
          200 CONTINUE
            TABX=((YTAB(2)-YTAB(1))/(XTAB(2)-XTAB(1)))*
           *  (O-XTAB(1))+YTAB(1)
            RETURN
      C
          210 CONTINUE
            DO 220 LL=1,K
            A(LL)=1.
            B(LL)=1.
          220 CONTINUE
            P=O.
      C
      C      LAGRANGIAN INTERPOLATION PERFORMED WITH POINTS BRACKETING O
      C
            DO 280 N=1,K
            DO 270 J=1,K
            AA=O-X(J)
            IF(J-N)230,240,230
          230 CONTINUE
            A(N)=A(N)*AA
```

```
  240 CONTINUE
      BB=X(N)-X(J)
      IF(BB)250,260,250
  250 CONTINUE
      B(N)=B(N)*BB
  260 CONTINUE
  270 CONTINUE
      C=(A(N)/B(N))*Y(N)
      P=P+C
  280 CONTINUE
      TABX=P
      RETURN
C
  290 CONTINUE
C
C      EQUAL CONSECUTIVE OR NON-MONOTONIC VALUES OF X ENCOUNTERED
C      IN XTAB.
C
      TABX=54321.12345
      RETURN
      END
```

```
   NYO≠ AND YYO≠ DATA          INPUT FOR PROGRAM AWCAP
 NWPB NXALP
   7   11
          XWPB ARRAY
     2.00       3.00       4.00       5.00       6.00       7.00       8.00
          NYPB ARRAY
   6    6    9   11    8    9   10
YPO ARRAY, READ 6 ENTRIES PER LINE, FIRST YO/B THEN YO≠ LIN
    0.000      .100       .200       .300       .400       .520
    0.000      .005       .019       .036       .062       .102
    0.000      .200       .400       .600       .800      1.000
    0.000      .008       .019       .030       .056       .091
    0.000      .200       .400       .600       .800      1.000
    1.200     1.400      1.450
    0.000      .004       .008       .014       .022       .033
     .048      .070       .080
    0.000      .200       .400       .600       .800      1.000
    1.200     1.400      1.600      1.800      2.000
    0.000      .003       .006       .010       .013       .018
     .022      .030       .040       .050       .067
    0.000      .400       .800      1.200      1.600      2.000
    2.400     2.500
    0.000      .008       .010       .016       .022       .034
     .052      .056
    0.000      .400       .800      1.200      1.600      2.000
    2.400     2.800      3.000
    0.000      .007       .009       .012       .017       .021
     .028      .039       .045
    0.000      .400       .800      1.200      1.600      2.000
    2.400     2.800      3.200      3.500
    0.000      .006       .008       .010       .014       .016
     .018      .022       .030       .035
          XALPHA ARRAY
     H/T        XBAR      ALPHA
     1.00       -.50       1.30
     1.20       -.35       1.10
     1.40       -.28       1.00
     1.60       -.23        .92
     1.80       -.20        .86
     2.00       -.17        .80
     2.20       -.15        .76
     2.40       -.13        .70
     2.60       -.11        .67
     2.80       -.10        .62
     3.00       -.09        .59
   REACH TYPE REACH(I,1),I=1,103
  2.000    5.000    2.000    0.000    5.000    2.000    2.000    2.000    2.000    2.000
  2.000    2.000    2.000    0.000    2.000    2.000    2.000    2.000    2.000    2.000
  2.000    2.000    2.000    2.000    0.000    2.000    2.000    2.000    4.000    2.000
  2.000    4.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000
  2.000    2.000    2.000    3.000    2.000    2.000    2.000    2.000    5.000    3.000
  4.000    0.000    4.000    0.000    4.000    3.000    4.000    2.000    2.000    2.000
  2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000
  0.000    5.000    2.000    2.000    2.000    2.000    2.000    4.000    2.000    2.000
  2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000
  2.000    2.000    2.000    2.000    2.000    5.000    2.000    2.000    2.000    2.000
  2.000    2.000    2.000
  UPBOUND COURSE BEARING REACH(I,2),I=1,103
167.000 167.000 167.000 167.000 167.000 165.000 157.000 177.000 199.000 221.000
241.000 260.000 269.000 269.000 269.000 255.000 277.000 303.000 278.000 249.000
266.400 223.500 241.300 218.000 209.300 209.300 226.000 237.000 237.000 248.300
270.000 287.000 287.000 263.300 242.400 209.000 234.400 266.200 228.200 207.200
225.550 239.150 262.500 241.100 209.000 236.000 278.000 234.000 267.000 267.000
```

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267.000 272.000 261.000 260.000 257.000 257.000 257.000 233.000 248.000 262.150
233.000 255.000 220.000 237.000 255.250 237.000 227.000 248.000 242.050 206.150
209.000 209.000 209.000 227.200 237.000 221.450 238.350 238.350 220.000 238.000
223.000 231.000 220.000 232.000 236.000 222.000 217.000 194.000 218.000 209.000
225.000 218.000 214.000 219.000 235.000 235.000 231.000 239.000 228.000 246.000
263.000 193.200 234.000
  MINIMUM CHANNEL WIDTH REACH(I,3),I=1,103
200.000 200.000 225.000  80.000  80.000 280.000 280.000 280.000 280.000 280.000
280.000 280.000 280.000  80.000 250.000 250.000 250.000 250.000 225.000 250.000
500.000 650.000 750.0001400.000  80.000 590.000 590.000 590.000 180.000 590.000
590.000 180.000 590.000 500.0001160.0001160.0001160.000 480.000 450.000 450.000
450.000 460.000 480.000 650.000 460.000 700.000 460.000 460.000 600.000 700.000
700.000  80.000 442.000  80.000 442.000 442.000 442.000 610.000 730.000 730.000
730.000 730.000 730.000 600.000 630.000 610.000 600.000 600.000 580.000 400.000
 80.000  80.000 840.000 500.000 400.000 400.000 450.000 550.000 630.000 730.000
730.000 730.000 730.000 400.000 300.000 300.000 550.000 610.000 610.000 610.000
600.000 600.000 450.700 450.000 450.000 450.000 450.000 610.000 610.000 730.000
730.000 730.000 730.000
 MINIMUM CHANNEL DEPTH REACH(I,4),I=1,103
 35.000  27.000  27.000  27.000  27.000  27.000  27.000  27.000  27.000  27.000
 27.000  27.000  27.000  27.000  27.000  27.000  27.000  27.000  27.000  27.000
 28.500  28.500  32.000  42.000  27.000  27.000  27.000  27.000  27.000  27.000
 27.000  27.000  27.000  28.000  28.000  40.000  40.000  35.000  28.500  28.500
 28.500  28.500  35.700  28.500  29.000  29.000  29.000  29.000  31.000  32.000
 29.000  27.000  27.000  27.000  27.000  27.000  29.000  46.000  37.000  44.000
 48.000  37.000  36.000  29.000  27.000  29.000  56.000  48.000  29.000  29.000
 27.000  27.000  29.000  29.000  29.000  29.000  29.500  29.500  36.000  45.000
 34.000  52.000  57.000  43.000  29.000  29.000  38.000  29.000  29.000  29.000
 39.000  29.000  70.000  70.000 100.000 100.000 100.000  29.000  29.000  50.000
 48.000  29.000  84.000
  BEGINNING CHANNEL MILEAGE REACH(I,5),I=1,103
  0.000   1.300   1.300   3.000   3.250   3.250   4.000   5.250   7.850   8.500
  9.250  10.000  10.500  11.750  12.000  13.250  14.750  15.750  17.370  18.000
 20.000  22.300  27.000  30.000  31.500  32.500  36.000  38.500  38.500  39.000
 40.500  40.500  44.500  47.000  51.400  54.200  56.400  63.000  64.200  66.400
 67.800  70.300  72.500  73.600  77.100  78.000  79.000  80.000  80.000  82.000
 83.000  84.000  84.000  87.500  87.500  90.500  92.500  95.000  96.000  99.000
100.000 101.000 102.000 104.000 106.000 108.000 109.000 110.000 110.750 112.000
112.500 112.500 112.750 114.000 117.500 119.500 121.000 123.000 123.000 124.750
126.500 133.500 136.500 138.250 139.000 140.000 142.000 144.000 146.500 151.000
154.000 157.000 159.000 160.000 162.000 164.500 164.500 167.000 169.500 170.500
178.000 182.000 186.000
 ENDING CHANNEL MILEAGE REACH(I,6),I=1,103
  1.300   1.300   3.000   3.250   3.250   4.000   5.250   7.850   8.500   9.250
 10.000  10.500  11.750  12.000  13.250  14.750  15.750  17.370  18.000  20.000
 22.300  27.000  30.000  31.500  32.500  36.000  38.500  39.000  38.500  40.500
 44.500  44.500  47.000  51.400  54.200  56.400  63.000  64.200  66.400  67.800
 70.300  72.500  73.600  77.100  78.000  79.000  80.000  82.000  80.000  83.000
 84.000  84.000  87.500  87.500  90.500  92.500  95.000  96.000  99.000 100.000
101.000 102.000 104.000 106.000 108.000 109.000 110.000 110.750 112.000 112.500
112.750 112.750 114.000 117.500 119.500 121.000 123.000 123.000 124.750 126.500
133.500 136.500 138.250 139.000 140.000 142.000 144.000 146.500 151.000 154.000
157.000 159.000 160.000 162.000 164.500 164.500 167.000 169.500 170.500 178.000
182.000 186.000 190.000
 UPBOUND SPEED LIMIT REACH(I,7),I=1,103
  7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000
  7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000
 12.000  18.000  18.000  18.000   0.000  10.000  10.000  10.000  10.000  10.000
 10.000  10.000  10.000  18.000  18.000  18.000  18.000  18.000  18.000  18.000
 10.000  10.000  10.000  10.000  10.000  10.000  10.000  10.000  10.000  10.000
 10.000   0.000   7.000   0.000  13.000  13.000  13.000  15.000  15.000  15.000
 15.000  15.000  15.000  13.000  13.000  13.000  15.000  15.000  15.000  15.000
  0.000   0.000  15.000  15.000  15.000  15.000  15.000  15.000  15.000  15.000
 15.000  15.000  15.000  15.000  15.000  15.000  15.000  15.000  13.000  13.000
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13.000  10.000  10.000  10.000  10.000  10.000  10.000  10.000  10.000  15.000
15.000  15.000  15.000
DOWNBOUND SPEED LIMIT REACH(I,8),I=1,103
 7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000
 7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000   7.000
12.000  18.000  18.000  18.000   0.000  12.000  12.000  12.000  12.000  12.000
12.000  12.000  12.000  18.000  18.000  18.000  18.000  18.000  18.000  18.000
12.000  12.000  12.000  12.000  12.000  12.000  12.000  12.000  12.000  12.000
12.000   0.000   7.000   0.000  13.000  13.000  13.000  15.000  15.000  15.000
15.000  15.000  15.000  13.000  13.000  13.000  15.000  15.000  15.000  15.000
 0.000   0.000  15.000  15.000  15.000  15.000  15.000  15.000  15.000  15.000
15.000  15.000  15.000  15.000  15.000  15.000  15.000  15.000  13.000  13.000
13.000  12.000  12.000  12.000  12.000  12.000  12.000  12.000  12.000  15.000
15.000  15.000  15.000
CURRENT  SPEED REACH(I,9),I=1,103
  .500    .500    .500    .500    .500    .500    .500    .500    .500    .500
  .500    .500    .500    .500    .500    .500    .500    .500    .500    .500
 3.200   2.000   2.000   1.500   0.000   3.100   3.100   3.100   3.100   3.100
 3.100   3.100   3.100   2.400   2.400   2.400   2.350   2.350   2.350   2.920
 2.920   2.800   2.800   2.800   2.800   2.800   5.060   5.060   5.060   6.750
10.100   0.000   0.000   0.000   2.000   2.700   1.760   1.400   1.400   1.400
 1.400   1.700   1.700   3.160   3.440   3.720   3.400   3.500   3.500   3.500
 0.000   0.000   4.500   4.750   4.880   3.880   4.220   1.900   1.900   1.900
 1.100   1.100   1.400   1.400   4.900   4.900   1.400    .800    .800    .800
  .800    .800    .800   3.300   3.300   3.300   3.300    .900    .900    .900
  .400    .400    .400
 CURRENT DIRECTION REACH(I,10),I=1,103

 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
53.000   0.000   0.000  30.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000  62.000   0.000  58.000   0.000   0.000   0.000  42.000
 0.000   0.000   0.000  88.000   0.000  48.000   0.000   0.000   0.000  88.000
103.000  0.000   0.000   0.000   0.000  45.000 125.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000  32.000  32.000
 0.000   0.000  47.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000  45.000  32.000  32.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000
NAVAID DISTANCES NORMAL SEASON DAY UPBOUND
  .200    .200    .200    .200    .200    .200    .200    .200    .200    .200
  .200    .200    .200    .200    .200    .200    .200    .200    .200   1.000
 1.000    .750    .750   2.000   0.000    .750   1.250    .313   0.000   1.000
  .750   0.000   1.000   1.000   1.250   1.250   1.750   1.000   1.000    .750
 1.000    .750   1.000    .750    .625    .500    .625   1.000   0.000   1.750
 1.750   0.000    .750   0.000   1.000   1.000   1.375   1.000   1.375    .750
 1.250   1.125   1.000    .625    .625    .625   1.000    .750   1.250    .500
 0.000   0.000   1.250   1.250   1.625    .750    .625   0.000   1.000   1.000
 2.000   1.750   1.250    .750    .625    .750   1.000   1.500   1.375   1.750
 1.500   1.250    .750    .750   1.375   0.000   1.000   1.750   1.250   3.000
 2.500   1.375   1.375
NAVAID DISTANCES NORMAL SEASON DAY DOWNBOUND
  .200    .200    .200    .200    .200    .200    .200    .200    .200    .200
  .200    .200    .200    .200    .200    .200    .200    .200    .200   1.000
 1.000    .750    .750   2.000   0.000    .750   1.250    .313   0.000   1.000
  .750   0.000   1.000   1.000   1.250   1.000   1.750   1.000   1.000    .500
 1.000    .625   1.000    .625    .625    .500    .500    .750   0.000   1.750
 1.750   0.000    .750   0.000   1.000   1.000   1.500    .750   1.375   1.000
 1.000   1.000   1.000    .500    .625   1.000    .750    .625   1.000    .625
 0.000   0.000    .750   1.125    .750    .625    .625   0.000   1.000   1.125
 3.000   1.500   1.250    .750    .500   1.000   1.000   1.500   1.375   1.750
 1.500   1.125    .750   1.500   1.000   0.000   1.000   1.750   1.250   2.500
```

3.000 1.375 1.750

NAVAID DISTANCES EXTENDED SEASON DAY UPBOUND

.200	.200	.200	.200	.200	.200	.200	.200	.200	.200
.200	.200	.200	.200	.200	.200	.200	.200	.200	1.500
1.375	4.250	4.000	2.000	0.000	2.250	3.000	.750	0.000	3.000
1.750	0.000	1.125	3.000	4.000	4.000	4.000	3.000	2.000	1.000
1.750	1.625	3.750	3.000	1.375	.750	1.500	.750	0.000	1.750
1.750	0.000	.750	0.000	1.000	1.375	1.375	2.250	3.375	2.000
1.250	1.000	1.000	1.250	1.000	3.750	3.000	2.500	1.625	.750
0.000	0.000	1.375	1.750	1.250	1.125	1.125	0.000	1.750	1.125
1.000	1.000	1.125	1.625	.625	1.125	2.000	3.000	3.000	3.500
2.250	2.000	1.000	.750	1.750	0.000	1.125	3.375	1.375	5.750
3.500	2.500	2.000							

NAVAID DISTANCES EXTENDED SEASON DAY DOWNBOUND

.200	.200	.200	.200	.200	.200	.200	.200	.200	.200
.200	.200	.200	.200	.200	.200	.200	.200	.200	1.375
2.000	4.000	3.250	1.500	0.000	2.500	4.000	3.125	0.000	2.250
3.000	0.000	1.500	4.125	5.000	1.500	3.000	2.250	2.250	1.000
2.500	1.125	2.250	3.000	1.250	1.125	1.750	1.000	0.000	1.750
1.750	0.000	.750	0.000	1.000	1.375	3.000	1.125	3.000	1.375
1.125	1.000	1.250	1.750	1.000	1.500	2.000	3.000	2.250	.750
0.000	0.000	1.250	1.750	1.250	1.375	1.500	0.000	1.750	1.375
1.000	1.000	1.375	1.750	.625	1.000	1.500	3.000	2.250	2.000
1.250	1.250	.750	.625	1.375	0.000	2.000	3.250	1.375	3.750
6.500	2.500	3.000							

NAVAID DISTANCES NORMAL SEASON NIGHT, UPBOUND

.200	.200	.200	.200	.200	.200	.200	.200	.200	.200
.200	.200	.200	.200	.200	.200	.200	.200	.200	1.000
1.000	1.375	1.375	2.000	0.000	1.500	1.250	.313	0.000	1.000
.750	0.000	1.125	1.000	1.250	1.000	1.750	1.000	1.000	.750
1.000	.750	1.000	1.125	.625	.500	.625	1.000	0.000	1.750
1.750	0.000	.750	0.000	1.000	1.000	1.375	1.000	1.375	1.000
1.250	1.125	1.000	.625	.625	.625	1.000	.750	1.250	.500
0.000	0.000	1.250	1.250	1.250	.750	.625	0.000	1.000	1.000
2.000	1.750	2.000	1.000	.625	.750	1.125	1.500	1.375	1.750
1.500	.500	.750	.750	1.375	0.000	1.000	1.750	1.250	3.000
2.500	1.375	1.375							

NAVAID DISTANCES NORMAL SEASON NIGHT, DOWNBOUND

.200	.200	.200	.200	.200	.200	.200	.200	.200	.200
.200	.200	.200	.200	.200	.200	.200	.200	.200	.625
1.000	1.375	1.375	1.500	0.000	1.500	1.375	.625	0.000	1.000
.750	0.000	1.125	1.000	1.250	1.000	1.750	1.000	1.000	.500
1.000	.625	1.000	1.375	.625	.500	.500	.750	0.000	1.750
1.750	0.000	.750	0.000	1.000	1.000	1.500	.750	1.375	1.000
1.000	1.000	1.000	.500	1.000	1.000	.750	.625	1.000	.625
0.000	0.000	.750	1.125	1.000	.625	.625	0.000	1.000	1.125
3.000	1.500	2.000	.750	.500	1.000	1.000	1.500	1.375	2.000
1.500	1.125	.750	1.500	1.000	0.000	1.000	1.750	1.250	2.500
3.000	1.375	1.750							

NAVAID DISTANCES EXTENDED SEASON NIGHT, UPBOUND

.200	.200	.200	.200	.200	.200	.200	.200	.200	.200
.200	.200	.200	.200	.200	.200	.200	.200	.200	1.375
1.750	10.000	5.500	2.500	0.000	3.000	3.000	.750	0.000	3.000
2.500	0.000	2.500	6.250	4.000	4.250	6.250	2.250	2.500	1.000
1.750	2.000	5.250	4.000	1.375	2.250	1.750	.750	0.000	1.750
1.750	0.000	.750	0.000	1.000	2.000	1.375	2.250	4.000	2.000
1.250	1.000	1.000	2.000	1.000	4.000	3.375	2.500	1.625	.750
0.000	0.000	1.750	2.500	2.000	1.250	1.125	0.000	1.750	1.750
1.000	1.000	2.000	1.625	.625	1.125	2.000	2.250	4.250	5.000
2.250	2.000	1.000	.750	1.750	0.000	1.125	3.375	2.000	5.750
3.500	3.500	2.000							

NAVAID DISTANCES EXTENDED SEASON NIGHT, DOWNBOUND

.200	.200	.200	.200	.200	.200	.200	.200	.200	.200
.200	.200	.200	.200	.200	.200	.200	.200	.200	1.375

2.500	6.500	10.000	2.500	0.000	2.250	4.125	3.125	0.000	2.000
2.500	0.000	2.500	6.000	7.500	1.750	6.250	2.250	4.250	1.000
2.625	1.500	3.000	4.500	1.750	1.375	2.250	1.000	0.000	1.750
1.750	0.000	.750	0.000	1.000	1.375	3.000	1.125	3.000	1.375
1.125	1.000	1.250	2.250	1.125	1.375	2.000	3.000	4.000	.750
0.000	0.000	1.000	3.750	1.250	1.375	1.500	0.000	1.750	2.500
1.000	1.000	2.000	2.000	.625	.750	2.000	2.750	3.250	4.500
2.750	1.250	.750	.625	1.375	0.000	2.000	3.250	3.750	3.750
6.500	4.250	3.000							

ELECTRONIC NAVAID ACCURACY

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000							

VISUAL DAY NAVAID ACCURACY

15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000							

VISUAL NIGHT ACCURACY

15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
15.000	15.000	15.000							

ICE INDICATOR

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000							

SHIP LENGTH	600.0000	730.0000
SHIP BEAM	75.2000	76.0000
SAIL AREA BALLAST	16700.0000	17000.0000
BALLAST DRAFT	16.0000	18.0000
SAIL AREA LOADED	8800.0000	11250.0000
LOADED DRAFT	25.5000	26.0000
LOCKING TIME NOR UP	37.2800	39.6000

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LOCKING TIME NOR DN    38.3100    43.0000
LOCKING TIME EXT UP    41.4800    43.8000
LOCKING TIME EXT DN    42.5100    47.2000
SHIP CHARACTER.  YV     -.0106     -.0106
SHIP CHARACTER.  NV     -.0035     -.0035
              YDELTA     .0012      .0012
              NDELTA    -.0006     -.0006
              YYO       0.0000     0.0000
              NYO       0.0000     0.0000
COEFFICIENTS FOR A1    29.5600    29.5600
 VSHIP=F(VIS)    A2      .6215      .6215
                 A3     0.0000     0.0000
FLOAT. NAVAID PULL          77         77         76         75         76
ICE FORMS                   97         91         91         75         83
ICE LOCKAGE BEGINS          97         91         91         82         83
ICE LOCKAGE STOPS          176        176        184        182        176
ICE DISAPPEARS             176        183        191        189        183
FLOAT. AIDS INSTAL         194        194        201        204        208
MAX WIND SPD FOR 1-WAY TRAFFIC SO SHORE CANAL    30.0000
MAX WIND SPD FOR 2-WAY TRAFFIC SO SHORE CANAL    15.0000
TURNBACK TIME IN MIN      11.0000
ICE LOCKAGE TIME IN MIN      31.0000
UPBOUND SHIP RATIO    COEFFICIENTS      .5000     0.0000     0.0000
IS NAV SYSTEM ELECTRONIC  1-YES  0-NO     0
TYPE OF SHIP  1-SALTY   2-LAKER     1
SHIP DRAFT  4-BALLAST  6-LOADED     6
NUMBER OF DAYS IN SPECIFIC YEAR    50
SPECIFIC YEAR 1-52 2-65 3-67 4-68 5-69     1
   OCT65-SEPT66   OGDENSBURG WATER TEMPERATURE DATA
 15.500  15.500  15.000  14.400  13.900  13.300  13.300  13.300  13.300  13.300
 12.800  12.800  12.800  12.200  12.200  12.200  12.200  12.200  12.200  12.200
 12.200  12.200  12.200  12.200  12.200  11.700  11.000  10.600  10.000  10.000
 10.000  10.000   9.400   9.400   8.900   8.900   8.900   8.900   8.900   8.900
  8.300   8.300   8.300   7.800   7.800   7.200   7.200   7.200   7.200   7.200
  7.200   7.200   7.200   7.200   7.200   6.100   6.100   6.100   6.100   6.100
  5.600   5.600   5.600   5.600   5.600   5.600   5.600   5.000   5.000   4.400
  4.400   4.400   4.400   4.400   4.400   4.400   4.400   4.400   4.400   4.400
  4.400   4.400   3.900   3.300   3.900   3.900   3.300   3.300   3.300   2.800
  2.800   3.300    .500    .500    .500    .500    .500    .500    .500    .500
   .500    .500    .500    .500    .500    .500    .500    .500    .500    .500
   .500    .500    .500    .500    .500    .500    .500    .500    .500    .500
   .500    .500    .500    .500    .500    .500    .500    .500    .500    .500
   .500    .500    .500    .500    .500    .500    .500    .500    .500    .500
   .500    .500    .500    .500    .500    .500    .500    .500    .500    .500
   .500    .700    .700    .900    .700    .800    .800   1.100   1.600   1.400
  1.100   1.700   1.600   1.100   1.100   1.800   1.600   1.500   1.200   1.500
  1.800   1.900   1.800   1.800   2.000   2.200   2.100   2.500   2.400   2.000
  1.800   1.900   2.200   2.000   2.300   2.500   2.600   2.600   2.700   3.000
  3.100   3.100   3.400   3.700   4.000   3.800   3.300   3.900   4.200   4.300
  4.400   4.600   5.000   5.000   5.000   5.200   5.300   5.300   5.200   4.900
  5.100   5.600   5.600   5.500   5.800   5.700   5.800   5.800   5.600   5.800
  5.000   5.800   5.900   6.000   6.000   6.200   6.600   6.400   6.500   6.400
  7.100   7.600   7.900   8.000   8.600   8.900   9.600  10.300  10.800  11.100
 11.000  10.600  10.900  10.900  11.300  11.500  11.700  12.000  12.300  12.900
 13.100  13.000  12.900  13.100  13.600  13.900  14.000  14.100  14.100  14.400
 14.500  14.700  14.800  15.300  15.300  15.700  16.200  16.400  16.800  17.600
 18.100  18.400  18.900  19.100  19.700  20.000  20.400  20.400  20.600  20.600
 20.800  20.300  20.400  20.900  21.100  21.500  21.400  21.600  21.900  21.900
 21.600  21.400  21.200  21.000  21.200  21.400  21.400  21.200  21.500  21.600
 21.300  21.300  21.200  21.300  21.500  21.100  21.000  20.600  21.200  21.600
 21.500  21.500  21.300  21.900  21.300  21.500  21.400  21.500  21.500  21.000
 21.000  21.200  21.200  21.300  21.100  20.700  20.500  20.370  20.200  19.800
 20.000  20.200  20.300  20.400  20.400  20.500  20.500  20.400  20.100  20.000
 19.900  19.800  20.000  19.300  19.700  19.600  19.500  19.500  19.400  19.000
```

SAMPLE OUTPUT OF ANAWCAP

FOR

SALTY CLASS SHIP

$T_{ice\ lock} = 0$

$V_{ship} = V_{speed\ limit}$; under low visibility conditions

NO ELECTRONIC NAVIGATION SYSTEM

(Electronic Accuracy = 1000')

WEEKLY AND DAILY CAPACITY RESULTS

WEEK	WEEKLY CAPACITY	DAILY CAPACITY 1	2	3	4	5	6	7
1	201.443	33.807	35.955	33.808	32.265	19.052	23.815	22.741
2	182.999	23.815	23.815	33.808	23.814	28.577	15.830	33.340
3	210.543	32.267	33.340	33.849	38.103	23.814	27.503	21.667
4	236.466	27.502	30.119	38.103	33.341	33.341	38.104	35.956
5	169.317	33.341	33.340	23.815	23.815	27.504	14.288	13.214
6	196.820	27.504	35.956	33.339	28.578	33.341	19.050	19.052
7	145.970	9.526	17.978	17.978	13.215	32.265	27.504	27.504
8	187.155	24.282	29.045	13.215	22.741	33.341	26.428	38.103
9	118.465	22.741	33.340	17.978	21.666	14.288	3.689	4.763
10	141.065	22.741	9.526	8.451	18.445	25.355	18.445	38.102
11	120.611	4.762	26.428	29.512	32.734	13.588	10.191	3.396
12	101.708	16.984	15.211	10.191	3.397	23.778	16.984	15.163
13	88.139	20.382	20.380	18.542	0.000	0.000	6.794	22.041
14	100.049	8.334	10.191	23.779	20.381	16.983	6.794	13.587
15	69.485	3.397	13.558	10.191	3.397	10.190	11.768	16.984
16	88.471	21.976	11.794	3.397	0.000	3.397	25.430	22.477
17	76.412	8.473	0.000	3.397	13.588	16.985	16.984	16.985
18	54.349	6.793	3.397	3.397	6.794	16.985	0.000	16.983
19	147.288	20.380	23.777	20.380	15.610	22.981	16.985	27.175
20	103.537	13.588	10.190	9.528	13.587	23.777	16.985	15.882
21	30.149	10.191	6.793	0.000	0.000	13.165	0.000	0.000
22	118.356	0.000	3.397	26.883	16.984	16.742	27.174	27.176
23	148.313	23.777	16.392	19.823	23.779	27.176	23.778	13.588
24	88.317	13.588	16.984	16.983	3.397	20.380	16.985	0.000
25	88.282	0.000	3.397	0.000	23.742	16.983	27.176	16.984
26	122.288	0.000	3.397	16.985	27.176	23.777	27.175	23.778
27	112.433	10.545	13.588	27.175	3.397	3.397	20.910	33.421
28	233.721	34.665	32.187	28.346	34.641	34.635	34.627	34.620
29	154.707	14.025	22.466	9.713	18.759	25.056	33.500	31.188
30	248.601	34.881	33.340	37.030	34.880	38.102	38.102	32.266
31	262.425	37.028	38.102	38.103	38.103	35.956	38.103	37.030
32	243.237	38.104	31.193	34.881	35.956	31.192	35.955	35.956
33	240.537	34.882	38.103	38.103	37.028	33.726	37.029	21.666
34	244.447	23.814	35.956	38.104	37.029	38.102	33.340	38.102
35	238.578	33.340	37.029	23.814	34.882	38.104	38.102	33.307
36	256.590	37.030	37.029	34.881	38.104	38.103	38.103	33.340
37	235.393	37.029	38.103	33.808	37.030	27.504	28.578	33.341
38	227.410	38.104	30.119	24.282	38.104	38.104	27.504	31.193
39	227.873	19.052	38.103	35.956	30.119	33.807	38.102	32.734
40	216.806	31.193	35.956	32.266	34.881	34.881	23.814	23.815
41	215.870	28.577	33.340	33.339	27.503	32.267	28.577	32.267
42	261.349	38.102	38.103	33.806	38.103	37.030	38.102	38.103
43	233.243	38.103	33.340	35.956	33.808	31.193	28.577	32.266
44	258.735	38.102	32.267	38.103	38.102	37.029	38.102	37.030
45	223.716	37.030	33.340	21.666	34.881	35.956	37.029	23.814
46	233.240	33.340	33.340	32.267	33.340	38.102	32.733	38.118
47	249.680	35.954	35.955	27.504	38.104	38.103	37.030	37.030

11	120.611	4.762	26.428	29.512	32.784	18.588	10.191	8.896
12	101.708	16.984	15.211	10.191	3.397	23.778	16.984	15.163
13	88.139	20.382	20.380	18.542	0.000	0.000	6.794	22.041
14	100.049	8.334	10.191	23.779	20.381	16.983	6.794	13.587
15	69.485	3.397	13.558	10.191	3.397	10.190	11.768	16.984
16	88.471	21.976	11.794	3.397	0.000	3.397	25.430	22.477
17	76.412	8.473	0.000	3.397	13.588	16.985	16.984	16.985
18	54.349	6.793	3.397	3.397	6.794	16.985	0.000	16.983
19	147.288	20.380	23.777	20.380	15.610	22.981	16.985	27.175
20	103.537	13.588	10.190	9.528	13.587	23.777	16.985	15.882
21	30.149	10.191	6.793	0.000	0.000	13.165	0.000	0.000
22	118.356	0.000	3.397	26.883	16.984	16.742	27.174	27.176
23	148.313	23.777	16.392	19.823	23.779	27.176	23.778	13.588
24	88.317	13.588	16.984	16.983	3.397	20.380	16.985	0.000
25	88.282	0.000	3.397	0.000	23.742	16.983	27.176	16.984
26	122.288	0.000	3.397	16.985	27.176	23.777	27.175	23.778
27	112.433	10.545	13.588	27.175	3.397	3.397	20.910	33.421
28	233.721	34.665	32.187	28.346	34.641	34.635	34.627	34.620
29	154.707	14.025	22.466	9.713	18.759	25.056	33.500	31.188
30	248.601	34.881	33.340	37.030	34.880	38.102	38.102	32.266
31	262.425	37.028	38.102	38.103	38.103	35.956	38.103	37.030
32	243.237	38.104	31.193	34.881	35.956	31.192	35.955	35.956
33	240.537	34.882	38.103	38.103	37.028	33.726	37.029	21.666
34	244.447	23.814	35.956	38.104	37.029	38.102	33.340	38.102
35	238.578	33.340	37.029	23.814	34.882	38.104	38.102	33.307
36	256.590	37.030	37.029	34.881	38.104	38.103	38.103	33.340
37	235.393	37.029	38.103	33.808	37.030	27.504	28.578	33.341
38	227.410	38.104	30.119	24.282	38.104	38.104	27.504	31.193
39	227.873	19.052	38.103	35.956	30.119	33.807	38.102	32.734
40	216.806	31.193	35.956	32.266	34.881	34.881	23.814	23.815
41	215.870	28.577	33.340	33.339	27.503	32.267	28.577	32.267
42	261.349	38.102	38.103	33.806	38.103	37.030	38.102	38.103
43	233.243	38.103	33.340	35.956	33.808	31.193	28.577	32.266
44	258.735	38.102	32.267	38.103	38.102	37.029	38.102	37.030
45	223.716	37.030	33.340	21.666	34.881	35.956	37.029	23.814
46	233.240	33.340	33.340	32.267	33.340	38.102	32.733	38.118
47	249.680	35.954	35.955	27.504	38.104	38.103	37.030	37.030
48	187.622	32.266	33.341	32.266	13.215	15.830	27.971	32.733
49	168.661	38.103	23.814	27.503	37.028	23.814	9.526	8.873
50	223.247	23.814	33.340	33.339	35.955	35.956	33.341	27.502
51	164.556	32.267	27.503	19.052	14.289	23.815	23.815	23.815
52	210.184	28.577	27.655	33.340	33.340	30.119	23.814	33.339
53	34.881	34.881						

YEARLY CAPACITY = 9143.7
EXTENDED SEASON CAPACITY = 1428.5
NORMAL SEASON CAPACITY = 7715.2
YEAR = 4ELECTRONIC ACCURACY = 1000

FREQUENCY OF OCCURENCE OF RESTRAINING REACHES FOR TOTAL YEAR

	1	2	3	4	5	6	7	8	9
0	3	0	0	1377	0	0	0	0	0
10	0	0	0	205	0	0	0	0	0
20	32	241	0	50	0	0	0	0	0
30	0	0	0	0	0	0	3	0	0
40	0	120	119	35	0	0	0	38	0
50	0	257	0	331	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0
70	457	0	7	0	0	0	0	0	0
80	61	0	11	5	0	0	0	19	5
90	0	0	0	0	0	0	0	0	0
100	0	0	0						

CODE NUMBER DEFINITIONS

NUMBER	
4	Two-way traffic in South Shore Canal, normal season
14	One-way traffic in South Shore Canal, normal season
25	Traffic halts in Beauharnois Canal, normal or extended season
52	One-way traffic in South Shore Canal, extended season
54	Traffic proceeding two way in all reaches
71	Traffic proceeding one-way only in several sequential reaches
Others	Indicates reach number which caused capacity to be zero

FREQUENCY OF OCCURENCE OF RESTRAINING REACHES FOR NORMAL SEASON

	1	2	3	4	5	6	7	8	9
0	3	0	0	1377	0	0	0	0	0
10	0	0	0	205	0	0	0	0	0
20	15	28	0	50	0	0	0	0	0
30	0	0	0	0	0	0	3	0	0
40	0	65	73	13	0	0	0	0	0
50	0	63	0	331	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0
70	125	0	0	0	0	0	0	0	0
80	61	0	2	0	0	0	0	5	0
90	0	0	0	0	0	0	0	0	0
100	0	0	0						

FREQUENCY OF OCCURENCE OF RESTRAINING REACHES FOR EXTENDED SEASON

	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
20	17	213	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0
40	0	55	46	22	0	0	0	38	0
50	0	194	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0
70	332	0	7	0	0	0	0	0	0
80	0	0	9	5	0	0	0	14	5
90	0	0	0	0	0	0	0	0	0
100	0	0	0						

B.7 DEFINITION OF VARIABLES

(Variables are listed alphabetically)

Program AWCAP

ACNAVD	Downbound navigation accuracy
ACNAVU	Upbound navigation accuracy
ALLOWD	Downbound allowable clearance, 1-way traffic
ALLOWD2	Downbound allowable clearance, 2-way traffic
ALLOWU	Upbound allowable clearance, 1-way traffic
ALLOWU2	Upbound allowable clearance, 2-way traffic
AMAND1	Maneuvering width for 1-way traffic, downbound
AMAND2	Maneuvering width for 2-way traffic, downbound
AMANU1	Maneuvering width for 1-way traffic, upbound
AMANU2	Maneuvering width for 2-way traffic, upbound
ATEMPR	Air Temperature, °F
CAP	Reach capacity
CAPAC	Seaway capacity for a given time interval
CONREA	Constraining reach number
CONSTR	Constraining reach number for a given time interval
DELT	Time interval in hours
DISMAX	Maximum distance throughout Seaway which includes a sufficient number of navigational aids to fix position visually
DISMED	Maximum distance throughout Seaway which includes a sufficient number of navigational aids to fix position visually, extended season, day
DISMEN	Maximum distance throughout Seaway which includes a sufficient number of navigational aids to fix position visually, extended season, night
DISMND	Maximum distance throughout Seaway which includes a sufficient number of navigational aids to fix position visually, normal season, day
DISMNN	Maximum distance throughout Seaway which includes a sufficient number of navigational aids to fix position visually, normal season, night

Program AWCAP (Continued)

DISNAVD	Distance to fix position visually, downbound
DISNAVU	Distance to fix position visually, upbound
DTEMP	Temperature difference between water and air
DTIME	Time difference used in defining daily time intervals
DYNM	Dynamic maneuvering width
HOUR	Time in hours at beginning of time interval
I	Index
IDAY	Day of year, IDAY = 1 corresponds to October 1
IH	Time of the day of weather station observations
II	Seaway Sector Index
ITITLE	Title array
IYEAR	Year
J	Weather time interval index
JT	Index used to generate data for CHCOEF
K	Weather station index, Seaway Sector Index
L	Title index
MONTH	Month
N	Reach parameter index, N = 1,22
ND	Daily time interval index, ND = 1,10
NDAY	Day number
NDELT	Weather time interval index, NDELT = 1,8
NREACH	Reach number
NTIME	Daily time interval index, NTIME = 1,10
NTT	Index used to set time at beginning of the ten daily time intervals
NUM	Index indicating day number
NUMDAY	Number of days in a year
RATIO	Ratio of upbound traffic to total traffic
RHO	Density of water
RICE	Number of downbound transits per ice lockage
RIVSTM	Riversteam visibility in miles

Program AWCAP (Continues)

STATM	Static maneuvering width
SUM	Time to transit a 1-way reach
SUNRIS	Time of sunrise, hours
SUNSET	Time of sunset, hours
TIME	Time of the day
TINT	Weather time interval index
TLCKEX	Extended season lockage time, hours
TLCKNO	Normal season lockage time, hours
TLOCK	Lockage time
VISMIN	Minimum visibility over the entire Seaway
VISMNO	Minimum visibility observed at the 3 weather stations
VISMNR	Minimum of riversteam visibility over the entire Seaway
VISOBR	Observed visibility for a particular reach
VISRSR	Riversteam visibility for a particular reach
VISVAC	Visual accuracy, feet
VSHIP	Ship speed, mph
VSHIPD	Downbound ship speed, mph
VSHIPU	Upbound ship speed, mph
WATEM	Water temperature, °F
WDIR	Wind direction, °T
WINDCL	Beam wind speed occurring at St. Catherine lock portion of South Shore Canal
WINDLL	Beam wind speed occurring at St. Lambert lock portion of South Shore Canal
WINDMX	Maximum wind speed occurring on the Seaway
WINDSLB	Beam wind speed occurring at St. Louis Bridge in the Beauharnois Canal
WINDVFB	Beam wind speed occurring at Valley Field Bridge in the Beauharnois Canal
WSP	Wind speed, mph

Subroutine STAMAN

BEAM	Ship beam
COURSE	Upbound or downbound course bearing, °T
CURDIR	Current direction, °T
DEN	$Y_v - (Y_\delta/N_\delta)N_v$
DEPTH	Water depth, ft
DRAFT	Ship draft, ft
FAC1	Dimensional factor, 1/2(RHO)(XLEN)^{2}UO
FAC2	Dimensional factor, FAC1*XLEN
FAC3	Dimensional factor, FAC1*UO
FAC4	Dimensional factor, FAC3*XLEN
NSHDIR	Ship direction, 1 - upbound 2 - downbound
NWAY	Traffic mode, 1 - one-way traffic 2 - two-way traffic
PHICUR	Yaw angle due to current
PHIM	Absolute value of PHITOT
PHITOT	Total yaw angle of ship
PHIW	Yaw angle due to wind
PHIYO	Yaw angle due to operating off channel centerline
RELCUR	Current direction relative to ship
RELWND	Wind direction relative to ship
RHO	Density of water
RUDANG	Rudder angle, degrees
SAIL	Sail area of ship
UO	Ship speed in feet per second
VCUR	Current velocity, fps
VCURX	Longitudinal component of current with respect to the ship
VCURY	Transverse (side) component of current with respect to the ship
VTOTX	Total longitudinal flow velocity with respect to ship
WIDTH	Width of reach
XLEN	Length of ship

Subroutine STAMAN (Continued)

XNDEL	N_δ	Ship
XNV	N_v	Hydrodynamic
XNYO	N_{yo}	Coefficients
YDEL	Y_δ	
YFWIND	Beam wind force	
YFl	Projected beam area of ship	
YO	Distance off channel centerline	
YV	Y_v	Ship hydrodynamic coefficients
YYO	Y_{yo}	

Subroutine MAXDIS

DISMAX	Maximum distance which includes a sufficient number of navigational aids to fix position visually over the entire Seaway
DMAX	Maximum distance which includes a sufficient number of navigational aids to fix position visually over the entire Seaway, downbound
I	Reach number index
IJ	Reach array element description index
IN	Reach array element description index
UMAX	Maximum distance which includes a sufficient number of navigational aids to dic position visually over the entire Seaway, upbound

Subroutine SUNRS

ALPHAR	Sun's right ascension for sunrise
ALPHAS	Sun's right ascension for sunset
COSHR	Cosine of HR
COSHS	Cosine of HS
DELTAR	Sun's declination for sunrize
DELTAS	Sun's declination for sunset
DIFFR	Number of quadrants difference between the sun's true longitude and the sun's declination for sunrise
DIFFS	Number of quadrants difference between the sun's true longitude and the sun's declination for sunset
HR	Sun's local hour angle for sunrise
HS	Sun's local hour angle for sunset
IYEAR	Year
NDAY	Day of the year, NDAY = 1 corresponds to January 1
NDAYS	Beginning of fiscal year, NDAYS = 273
NQALR	Quadrant of the sun's declination for sunrise
NQALS	Quadrant of the sun's declination for sunset
NQLR	Quadrant of the sun's true longitude for sunrise
NQLS	Quadrant of the sun's true longitude for sunset
SUNRIS	Time of sunrise, local mean time
SUNSET	Time of sunset, local mean time
TIMER	Local mean time of sunrise
TIMES	Local mean time of sunset
TR	Approximate time of sunrise in days since 0 January, 0 hr. Universal time
TS	Approcimate time of sunset in days since 0 January, 0 hr. Universal time
XH	Cosine of the sun's local hour angle for sunrise
XHR	Sun's local hour angle for sunrise
XHS	Cosine of the sun's local hour angle for sunset
XLR	Sun's true longitude for sunrise
XLS	Sun's true longitude for sunset
XMR	Sun's mean anomaly for sunrise
XMS	Sun's mean anomaly for sunset

Subroutine SUNRS (Continued)

XR	Cosine of the sun's declination for sunrise
XS	Cosine of the sun's declination for sunset
YH	Sine of the sun's local hour angle for sunrise
YHS	Sine of the sun's local hour angle for sunset
YR	Sine of the sun's declination for sunrise
YS	Sine of the sun's declination for sunset

Subroutine DYNMAN

COURSE	Upbound course bearing, °T
DYNM	Dynamic maneuvering width, ft
DY44D	Dynamic maneuvering width array for reach 44, Salty class ship, downbound
DY44LD	Dynamic maneuvering width array for reach 44, Laker class ship, downbound
DY44U	Dynamic maneuvering width array for reach 44, Salty class ship, upbound
DY50D	Dynamic maneuvering width array for reach 50, Salty class ship, downbound
DY50LD	Dynamic maneuvering width array for reach 50, Laker class ship, downbound
DY50LU	Dynamic maneuvering width array for reach 50, Laker class ship, upbound
DY50U	Dynamic maneuvering width array for reach 50, Salty class ship, upbound
DY56D	Dynamic maneuvering width array for reach 56, Salty class ship, downbound
DY56LD	Dynamic maneuvering width array for reach 56, Laker calss ship, downbound
DY56LU	Dynamic maneuvering width array for reach 56, Laker class ship, upbound
DY56U	Dynamic maneuvering width array for reach 56, Salty class ship, upbound
L	Array used in Functions DTAB, TABX*
LM	Array used in Functions DTAB, TABX*
NSHDIR	Ship direction
NWAY	Traffic mode 1 - one-way traffic 2 - two-way traffic
VSHIP1	Ship speed array
VSHIP2	Ship speed array
VW	Wind speed array
VWIND	Reach wind speed, mph

* Function DTAB
Function TABX — These two functions are described fully in the program listing section of this report.

Program ANAWCAP

CAPAC	Seaway capacity for one daily time period
CONSTR	Constraining reach for one daily time period
DAILY	Daily seaway capacity
DAYCAP	Sum of daily time period capacities, DAYCAP=DAYCAP + CAPAC (NTIME)
EXTCAP	Extended season capacity
EXTSEA	Extended season events array
I	Daily time interval index
IACC	Electronic accuracy array
IBG	Reach number index used in output format
IDAY	Day number, IDAY=1 represents 1 Oct.
IEND	Reach number index used in output format
IEX	Extended season index
IFRQ	Constraining reach frequency array for the entire year
IFRQEX	Constraining reach frequency array for the extended season
IFRQN	Constraining reach frequency array for the normal season
IJ	Output format index
M	Daily time interval index
N	Reach number index, day number index
NACC	Number of accuracies to be annalized
NBEGIN	Index used to determine weekly capacity
NDAY	Day number index
NDAZE	Daily capacity index, NDAZE=IDAY
NEND	Index used to determine weekly capacity

Program ANAWCAP (Continued)

NEX1	Index indicating beginning of extended season
NEX2	Index indicating end of extended season
NREACH	Reach number
NTEN	Output format index
NTIME	Time of the day at the beginning of each daily time period
NUMAC	Number of accuracies to be analyzed
NUMDAY	Number of days in a year
NUMDW	Number of days in week number 53
NWEEK	Week number index
NYEAR	Year number
WEEKLY	Weekly seaway capacity
WEKCAP	Sum of weekly capacity results, WEKCAP=WEKCAP+ DAILY (NDAZE)
XNORCAP	Normal season seaway capacity
YEARLY	Yearly seaway capacity

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