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January 1995

US Army Corps of Engineers
Waterways Experiment Station

Wave Information Studies of US Coastlines

QTSAW (Quick Typhoon Surge and Waves)

by Barbara A. Tracy

Approved For Public Release; Distribution Is Unlimited

Prepared for Headquarters, U.S. Army Corps of Engineers

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Final report

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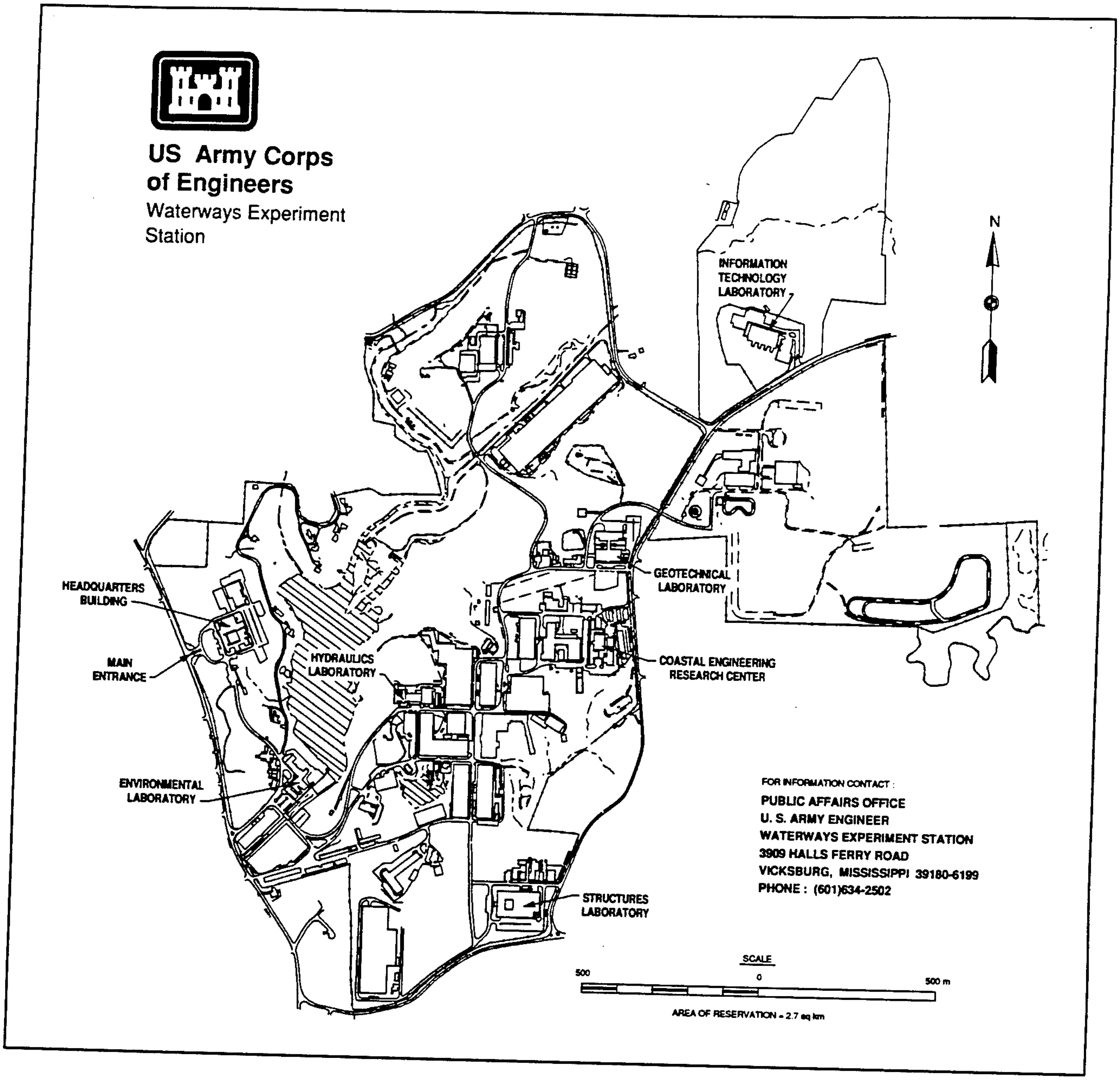

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Preface

In late 1976 a study to produce a wave climate for U.S. coastal waters was initiated at the U.S. Army Engineer Waterways Experiment Station (WES). The Wave Information Study (WIS) was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE) as part of the Coastal Field Data Collection Program, which is managed by the WES Coastal Engineering Research Center (CERC). Messrs. John H. Lockhart, Jr.; John G. Housley; James E. Crews; and Robert H. Campbell, HQUSACE, are Technical Monitors for the Coastal Field Data Collection Program; Ms. Carolyn M. Holmes is Program Manager; and Dr. Jon M. Hubertz, CERC, is WIS Project Manager.

This report, the 31st in a series, is a user's guide for a historical database of typhoon parameters (1945-1991) and computer programs called QTSAW that calculates typhoon waves and surge around the island of Guam in the western Pacific. Historical data were compiled using data files from Mr. Frank Wells at the Naval Ocean Command Center, Joint Typhoon Warning Center in Guam. This report was written by Ms. Barbara Tracy who served as principal investigator for the QTSAW system. Mr. Bill Grosskopf of Offshore and Coastal Technologies, Inc., provided the surge and wind model with user information under a purchase order. Ms. Beverly Green, contract employee, set up the typhoon database. The vector plot programs were written by Barry White, contractor, for another project. Stanley Boc, U.S. Army Engineer Division, Pacific Ocean, provided advice on the system; and Ms. Willie A. Brandon, Coastal Oceanography Branch (COB), CERC, offered suggestions for user information. Dr. Hubertz provided technical assistance.

The study was conducted under the direct supervision of Dr. Martin C. Miller, Chief, COB, and Mr. H. Lee Butler, Chief, Research Division, CERC; and under the general supervision of Dr. James R. Houston and Mr. Charles Calhoun, Jr., Director and Assistant Director, CERC, respectively.

At the time of publication of this report, Dr. Robert W. Whalin was Director of WES. COL Bruce K. Howard, EN, was Commander.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
knots	0.5144444	meters per second
nautical miles	1.852	kilometers

1 Introduction

Description of Database

QTSAW is a system of data files and programs set up on the personal computer (PC) to calculate waves and surge at points near the Guam coast for a typhoon close to the island of Guam in the Mariana Islands in the western Pacific Ocean. The foundation of this system is a database of storm data from the Joint Typhoon Warning Center.[1] These data include storm parameters from 1945 to 1991 in a boxed area around Guam. The boundaries of this box are latitude 10° by 17° North (N) and longitude 141.5° by 148.5° East (E). A specific storm can be accessed from this database by its year, month, or name; or data for a recent storm not in the database can be entered. Data from this specific storm are used to create a wind and pressure field for the Guam area. A numerical surge model uses the wind and pressure field to produce a time series of water surface elevations. The wind field can also be used as input for a numerical wave model to produce a time series of significant wave heights. This process allows a quick desktop estimate of typhoon surge and waves for the Guam area.

Installing the Database

The database and its programs have been stored on two diskettes.[2] Diskette 1 (TYDABS) contains the database files in a compressed file called FTG2892.zip. The rest of the files on this diskette are executable graphical application files and information files. Diskette 1 contains 13 files. Diskette 2 (FORT) contains the executable FORTRAN programs and the input option files for the wind, surge, and wave runs. Diskette 2 contains 10 files. This database was prepared on a 386/33MHz PC with 1 MB of RAM and a math co-processor.

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[1] Computer files received from Frank H. Wells, NOCC/JTWC.

[2] Diskettes are available from Wave Information Studies, c/o Ms. Robin Hoban, CR-O, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

Begin the installation procedure by creating a subdirectory called "TYDABS" on the PC; load the diskette in drive B on the PC; then, copy all the files from diskette 1 (TYDABS) to the subdirectory TYDABS. The procedure is shown below (underlined words are words the user types in):

```
C>mkdir tydabs
C>cd tydabs
C\TYDABS>copy b:*.*
```

This procedure assumes that the computer is set on the C drive and that diskettes are read on the B drive. The next step is to decompress the storm files in the database. The following procedure does this:

```
C\TYDABS>pkunzip ftg2892.zip
```

The unzip procedure will produce 556 files with the FTG prefix. These are the storm data files and their description follows.

Storm Data Organization

The original database has been divided into separate files for each storm, each year, and each year-month. All these files have been named with an FTG prefix. The files with an FTGU prefix contain data for a whole year or a whole month in one specific year. These FTGU files are valuable when searching for a specific storm in a whole year or a whole month of data. FTGU89 contains data on all storms that occurred in 1989. FTGU8910 contains data on storms that occurred in October 1989. This file, FTGU8910, happens to include two storms. The FTGU prefix files cannot be used as input for the programs in the QTSAW database. These files are for information only and should be used to locate the one storm of interest. The month label in the file name refers to the month shown in the first record of the storm file. If a 1989 storm began in October and continued into November, it is stored in the FTGU8910 file.

The QTSAW system has been set up to run one storm at a time, and data must be input from only one storm file. These separate storm files are indexed by the FTG prefix. To locate the file names for the storms that occurred in October 1989, type (after the C prompt):

```
C\TYDABS>dir ftg8910*
```

The above directory command would show the storm file names FTG8910A.COL and FTG8910T.FRT for October 1989. After the FTG, the year and month appear. The "A" suffix indicates the storm only reached tropical storm strength in the Guam area. The "T" suffix indicates typhoon strength. An "S" suffix indicates supertyphoon intensity. Tropical storms or depressions (A) attained a strength of 63 knots[1] or less. Supertyphoons (S) attained a strength of 130 knots or more. Typhoons (T) had maximum wind speed strengths between 64 and 129 knots. (Wells 1991, p. 2) The extension after the dot in the file name is an abbreviation of the storm's name. All of these abbreviations are indexed in a WordPerfect file named abrev.wp5. This file is printed in Appendix A and is available on the TYDABS (diskette 1) diskette. COL stands for Colleen and FRT stands for Forrest. These FTG individual storm files have been changed to formatted ASCII files that can be used with FORTRAN programs. To see the names of all the storm files for a specific year, type (after the C prompt):

C\TYDABS>dir ftg89*

This will list all the storm files for 1989, and the storm's month and intensity. The above command would produce:

ftg8901a.win
ftg8904s.and
ftg8906a.els
ftg8907a.hop
ftg8907a.jud
ftg8908a.own
ftg8909a.peg
ftg8909a.vra
ftg8909a.ang
ftg8910a.col
ftg8910t.frt
ftg8911a.hnt
ftg8911a.irm
ftg8912a.td3
ftg8912t.jac

There were 16 storms that attained supertyphoon strength in the Guam box area from 1945-1991. These file names are listed in the file "super.inf" (available on diskette 1). The file names in super.inf are:

ftg9111s.sth
ftg9111s.yur
ftg8904s.and
ftg8612s.kim
ftg7810s.rit
ftg7605s.pam
ftg7607s.thr
ftg7511s.jun
ftg7105s.amy
ftg6312s.sus

[1] A table of factors for converting non-SI units of measurement to SI units is presented on page vii.

ftg6211s.kar
ftg6109s.nan
ftg5805s.phy
ftg5711s.lol
ftg5308s.nin
ftg5212s.hes

Some storms listed as typhoons attained supertyphoon status outside the Guam box. The storm strength indicator only applies to the storm when it is in the Guam box area.

There are a total of 556 files with the FTG prefix. This includes 256 files that have the FTGU prefix. There are 300 individual storm files. There were 22 storm files from 1945 to 1949; 61 storm files from 1950 to 1959; 64 storm files from 1960 to 1969; 51 storm files from 1970 to 1979; 78 storm files from 1980 to 1989; and 24 storm files from 1990 through 1991.

2 Creating Wind and Pressure Fields

The first step in the QTSAW system is to select one FTG storm file. The FTG storm files discussed in the previous section provide the initial information to create a cyclone.dat file, the input file for the wind model. The cyclone.dat file includes the latitude and longitude of the eye of the storm, the maximum wind speed, the central pressure, the radius of maximum wind speed, the forward translation velocity, and the direction of motion. Most of these parameters are included in the original FTG file, but some have to be calculated. The radius of maximum winds is not included in the original data so this value is set to a default value of 20 nautical miles (n.m.). The program prompts the user to enter a new radius value for values other than 20.

This paragraph uses Typhoon Pamela (1976) as an example for the creation of a cyclone.dat file. First, find the applicable FTG filename for Typhoon Pamela. Use the directory command on page 3 in the previous section and list all the storms in 1976. You will notice that Pamela is a supertyphoon and her file name is ftg7605s.pam. The FORTRAN executable program, GUDAT.EXE, is set up to create a cyclone.dat file using one FTG file as input. GUDAT is also capable of creating a cyclone.dat file from new storm data that are typed in, and a discussion of creating a cyclone.dat file from new input data follows in the next paragraph. In the procedure below, the underlined text was entered and the other text was written to the screen by the program. Type the word "EXIT" to get out of the program. The following shows how to make a cyclone.dat file for Supertyphoon Pamela using a radius of maximum winds equal to 15 n.m..

C\TYDABS>gudat
Please enter the name of the file to be rewritten, enter "NEW" for a new storm, or "EXIT" to quit:ftg7605s.pam

Default radius is 20 n.m.
Type "99" for default value or enter a new radius value in n.m.15

```
CYCLONE.DAT has been written
  with  12   records
  beginning on  76   5   19
  Storm name is  PAMELA
```

Please enter the name of the file to be rewritten, enter "NEW" for a new storm, or "EXIT" to quit:exit

The cyclone.dat file contains 12 records (6-hr intervals). The beginning date is May 19, 1976, and the storm's name is Pamela. Each line of the cyclone.dat file contains information on the date/time (UTC), the latitude (N) and longitude (E) of the eye, the maximum wind velocity in knots, the central pressure in millibars, the radius of maximum winds in nautical miles, the translation velocity in knots, and the translation direction in Cartesian degrees. The last column contains a zero to indicate that no values will be blended into the wind fields. This last feature is not available in the database. Figure 1 contains the cyclone.dat file for Pamela.

76051912	10.2	147.7	130.0	898.0	15	6.4	141.3	0
76051918	10.6	147.2	130.0	898.0	15	6.4	141.3	0
76052000	11.0	146.6	130.0	898.0	15	7.2	146.3	0
76052006	11.3	146.2	125.0	914.0	15	5.0	143.1	0
76052012	11.6	145.9	125.0	914.0	15	4.2	135.0	0
76052018	12.1	145.7	120.0	914.0	15	5.4	111.8	0
76052100	12.9	145.4	120.0	914.0	15	8.5	110.6	0
76052106	13.3	144.9	120.0	914.0	15	6.4	141.3	0
76052112	13.9	144.4	120.0	914.0	15	7.8	129.8	0
76052118	14.6	144.0	120.0	914.0	15	8.1	119.7	0
76052200	15.5	143.4	120.0	914.0	15	10.8	123.7	0
76052206	16.4	142.7	120.0	914.0	15	11.4	127.9	0

Figure 1. A 6-hr cyclone.dat file for Supertyphoon Pamela in 1976

GUDAT also has the capability to produce a cyclone.dat file from new data. You may have data on a current storm that is approaching, or you may want to move a severe storm over an area of interest. Selecting the new option requires you to enter a sequence of five numbers describing the storm's location and intensity and a date. The sequence of five numbers corresponds to a month, day of the month, a latitude, a longitude, and a maximum wind speed in knots. The program assumes data are entered at consecutive 6-hr intervals. There is no need to enter the hour; the hour is set when the date changes. If less than four data entries are made on the same day, the data will begin with the 00 hour. The user will also be prompted to enter a two-digit year and a storm name (storm names must be 12 characters or less). The following example produces a cyclone.dat file for a storm in 1994 called Herman. Three entries of storm data are shown.

C\TYDABS>gudat

Please enter the name of the file to be rewritten, enter "NEW" for a new storm, or "EXIT" to quit:new

Enter two-digit year, 19--:94

Enter storm name:Herman

Type "ENTER" to enter data or "DONE" when complete:enter

Enter five numbers separated by commas; e.g., 12,07,11.7,148.0,125
to represent month,day,latitude,longitude, and max WS in
knots:12,19,11.7,148,125

Type "ENTER" to enter data or "DONE" when complete:enter

Enter five numbers separated by commas; e.g., 12,07,11.7,148.0,125
to represent month,day,latitude,longitude, and max WS in
knots:12,20,12.2,146.4,125

Type "ENTER" to enter data or "DONE" when complete:enter

Enter five numbers separated by commas; e.g., 12,07,11.7,148.0,125
to represent month,day,latitude,longitude, and max WS in
knots:12,20,12.3,146,125

Type "ENTER" to enter data or "DONE" when complete:done

Default radius value is 20 n.m.
Type "99" for default value or enter a new radius value in n.m.99

CYCLONE.DAT has been written
with three records
beginning on 94 12 19
Storm name is Herman

Please enter the name of the file to be written, enter "NEW" for a new storm, or "EXIT" to quit:exit

Installing the Database Programs

After you have produced a cyclone.dat file, you are ready to use the QTSAW programs to produce winds, waves and surge. A new subdirectory on the PC stores the FORTRAN programs and the input and output files. The programs for this new subdirectory are stored on diskette 2 which is called FORT. Return to the C drive from the TYDABS subdirectory and create a new subdirectory called FORT. Move to subdirectory FORT; put diskette 2 in drive B; and copy all the files from diskette 2 to the PC under subdirectory FORT. The procedure is listed below:

```
C\TYDABS>cd..
C>mkdir fort
C>cd fort
C\FORT>copy b:*.*
```

The FORT subdirectory now contains the wind, surge, and wave programs. The cyclone.dat file needs to be copied to the FORT subdirectory so that it can be used as input to the rest of the programs. This procedure is shown below:

```
C\FORT>cd..
C>copy \tydabs\cyclone.dat \fort\cyclone.dat
C>cd fort
```

Running Surge and Waves in One Step

A batch processing file has been set up to produce surge and wave results without any intermediate steps. This process will produce the same files and results described in detail in the next sections of this user's guide. If you are interested in moving slowly and checking each input and output step of the wind, wave, and surge runs, move on to the next section of this report and follow each step of the process. The batch processing file, QTSAW.BAT, contains all the steps and programs to produce waves and surge on a 0.1-deg spacing latitude-longitude grid. This grid has 11 rows and 11 columns and is described in the section on creating a wind field. The QTSAW.BAT file requires a 6-hr input cyclone.dat file that resides on the subdirectory TYDABS. QTSAW.BAT is resident on the FORT subdirectory. After you have chosen your storm and the 6-hr cyclone.dat file has been prepared on the TYDABS subdirectory, you can create wind, surge, and wave results just by moving to the FORT subdirectory and typing the word qtsaw. The batch file assumes you have just completed a cyclone.dat file on the TYDABS subdirectory and have moved to the FORT subdirectory. The procedure to create surge and waves for the 11 by 11 grid with 0.1-deg spacing follows:

```
C:\FORT>qtsaw
```

Figure 2 contains a listing of the QTSAW.BAT file. All of the commands will be echoed to the screen and all of the print statements in the programs will flash on the screen as the system is running. Several pauses have been built into the batch file after the major programs have completed their processing. After a pause, hit the "ENTER" key to continue the processing. Control C will interrupt the batch file and stop the processing. All the plotting programs described in this report should work on the output files and input files created with the batch file. If you have run the batch file to create surge and wave results and are interested in the maximum surge and wave results for the storm, move to the report sections titled "Creating Graphics of the Maximum

```
del cyclone
copy \tydabs\cyclone.dat cyclone
del cyclone.dat
tyint<cyclone
del cyclone
del winds.dat
del press.dat
tropwind<tropint
pause winds and pressure complete
del waves.dat
del waves.mat
waves
pause typhoon waves complete
copy winds.dat winsurg.dat
del optsurg.dat
copy optsurg.otd optsurg.dat
del htfld
del debug
del scale.out
del select.out
del restrt.out
s2
pause surge complete
```

Figure 2. The QTSAW.BAT file listing

Wave Heights" and "Creating Graphics of the Maximum Surge" (see "Contents" for page numbers). The following sections describe the separate processes for creating the winds, waves, and surge in detail. Several graphics programs are also described.

Creating an Hourly Input File

Both the wave and surge model will give better results if wind fields come in at hourly intervals. The following procedure uses the FORTRAN executable file TYINT to interpolate the 6-hr cyclone.dat file and produce a new cyclone.dat file with hourly input records. The procedure renames the cyclone.dat file cyclone. Remember that all the calculation programs reside on the FORT subdirectory. All the plotting programs are resident on the TYDABS subdirectory. The commands below first move you to the FORT subdirectory.

C\TYDABS>cd \fort
C\FORT>rename cyclone.dat cyclone
C\FORT>tyint<cyclone

This procedure has created a new cyclone.dat file. The old information is stored in the file named cyclone. The file "cyclone" can be deleted.

Creating a Plot of a Storm Path

A PASCAL plot program, TYPLOT, is available to show a graphical display of the path of the storm. If your computer contains a graphics package, the program should produce a plot on the screen. The file "egavga.bgi" on subdirectory TYDABS contains graphics information for the PC. This plot program on subdirectory TYDABS is set up to plot the data in a file called cyclone.dat that is resident on the subdirectory fort. The procedure to produce the plot (including a switch to directory TYDABS from FORT) is:

```
C\FORT>cd TYDABS
C\TYDABS>typlot
```

The plot using the hourly data for Typhoon Russ in 1990 is reproduced in Figure 3. Circles are plotted to represent each date of information in the cyclone.dat file. Beginning and ending dates are listed at the top of the plot. Guam is plotted on a grid showing the Guam box area. Depress the "ENTER" key to clear the plot from the screen.

Creating a Wind Field

The first step in evaluating surge and waves is to create the input wind field. A numerical model, TROPWIND, creates the hurricane wind field and the pressure field from the cyclone.dat file. This model is a parametric model based on Collins and Viehman (Collins and Viehman 1971) and was developed by Bill Grosskopf[1] to be used in connection with the surge model. The model creates wind fields and pressure fields on a regularly spaced latitude-longitude grid. The program prompts the user to enter the edges of the grid and the grid spacing. Longitude values are assumed to be in the Eastern Hemisphere and latitudes are north latitudes. Values should be entered in decimal degrees. Output formats for the wind and pressure fields have been set to be compatible with the surge and wave model. There is no need to change these formats before each application.

TROPWIND will operate with many different grid sizes, but a standard size has been established to use with the surge and wave program system. This grid has been set up to run on a 0.1-deg latitude-longitude spacing, has 11 rows and 11 columns, and covers the area from latitude 12.8° to 13.8° N. and longitude 144.25° to 145.25° E. TROPWIND produces two output files, winds.dat and press.dat, and will produce an error if either winds.dat or press.dat already exist. Verify that all previous winds.dat or press.dat files have been deleted before trying to run TROPWIND. TROPWIND will prompt

---

[1] Offshore and Coastal Technologies, Inc., East Coast, 510 Spencer Road, Avondale, PA 19311.

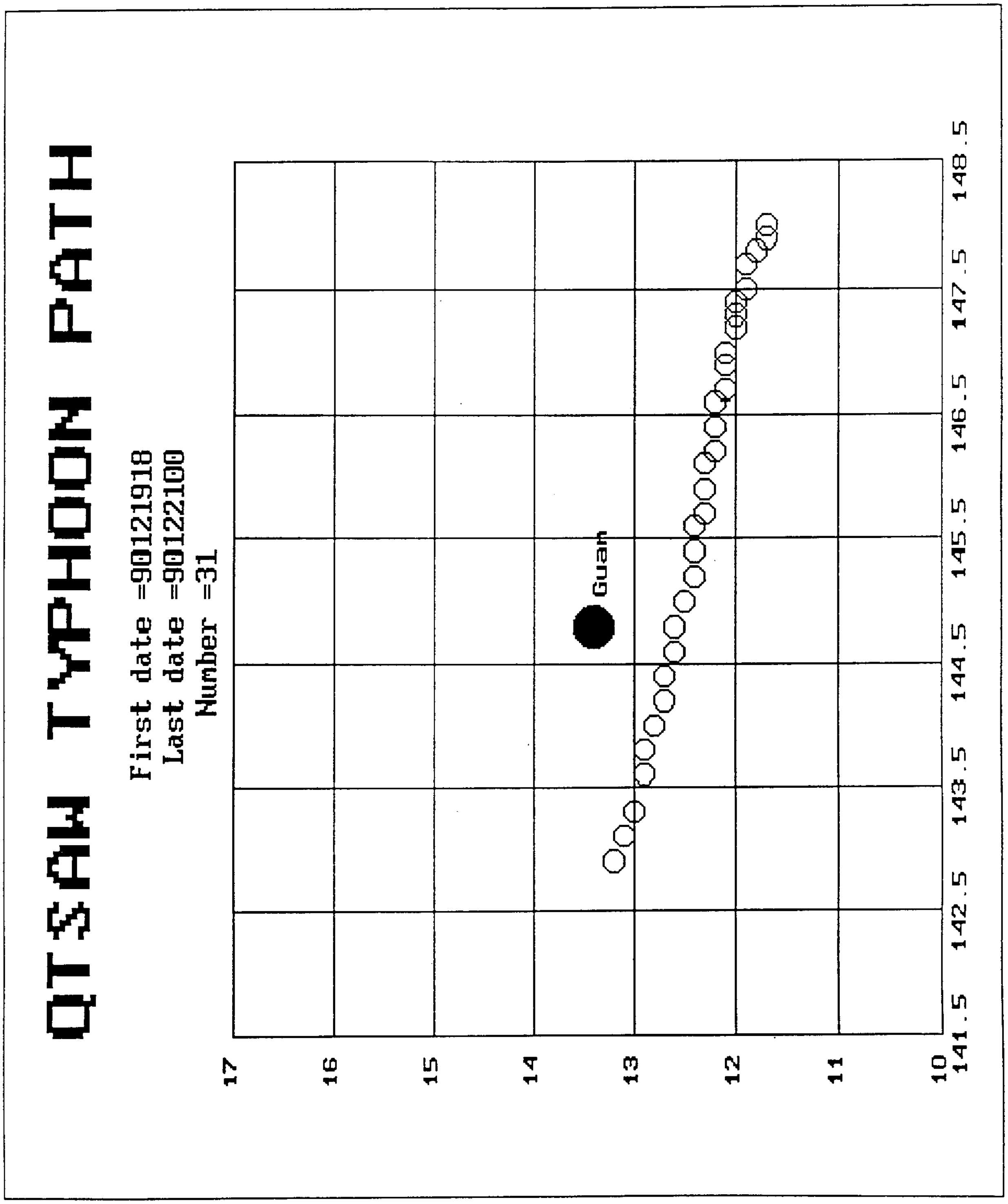

Figure 3. Plot of 1-hr positions of Typhoon Russ

the user to enter latitude and longitude values for the edges of the grid. Values for xmin and xmax refer to the longitude values, and ymin and ymax refer to the latitude values. Dinc is the grid spacing in degrees. The procedure to make a 0.1-deg wind field to fit the surge and wave option files is:

```
C\FORT>tropwind
    xmin:144.25
    xmax:145.25
    ymin:12.8
    ymax:13.8
    dinc:0.1
```

The program will start executing and will specify a grid size of 11 by 11. Screen printing will continue until the wind field is complete (only a few minutes).

Creating Wind Field Graphics

You can see a graphical display of the wind field you have created by moving back to the TYDABS subdirectory to use the STATWIND program. STATWIND prompts for the size of the grid (11 columns and 11 rows) and the file name of the wind file(\fort\winds.dat). Type "statwind" at the C prompt in the TYDABS subdirectory for a graphical display (contours with vectors superimposed) of the wind fields. Typing an "h" after the vector display appears on the screen produces a help screen that lists the various things that can be done with the displays. Each date is plotted separately. Hit the period key to advance to the next date. Enter "Q" twice to get out of the program. Figure 4 shows a print of one of the vector displays for Typhoon Russ.

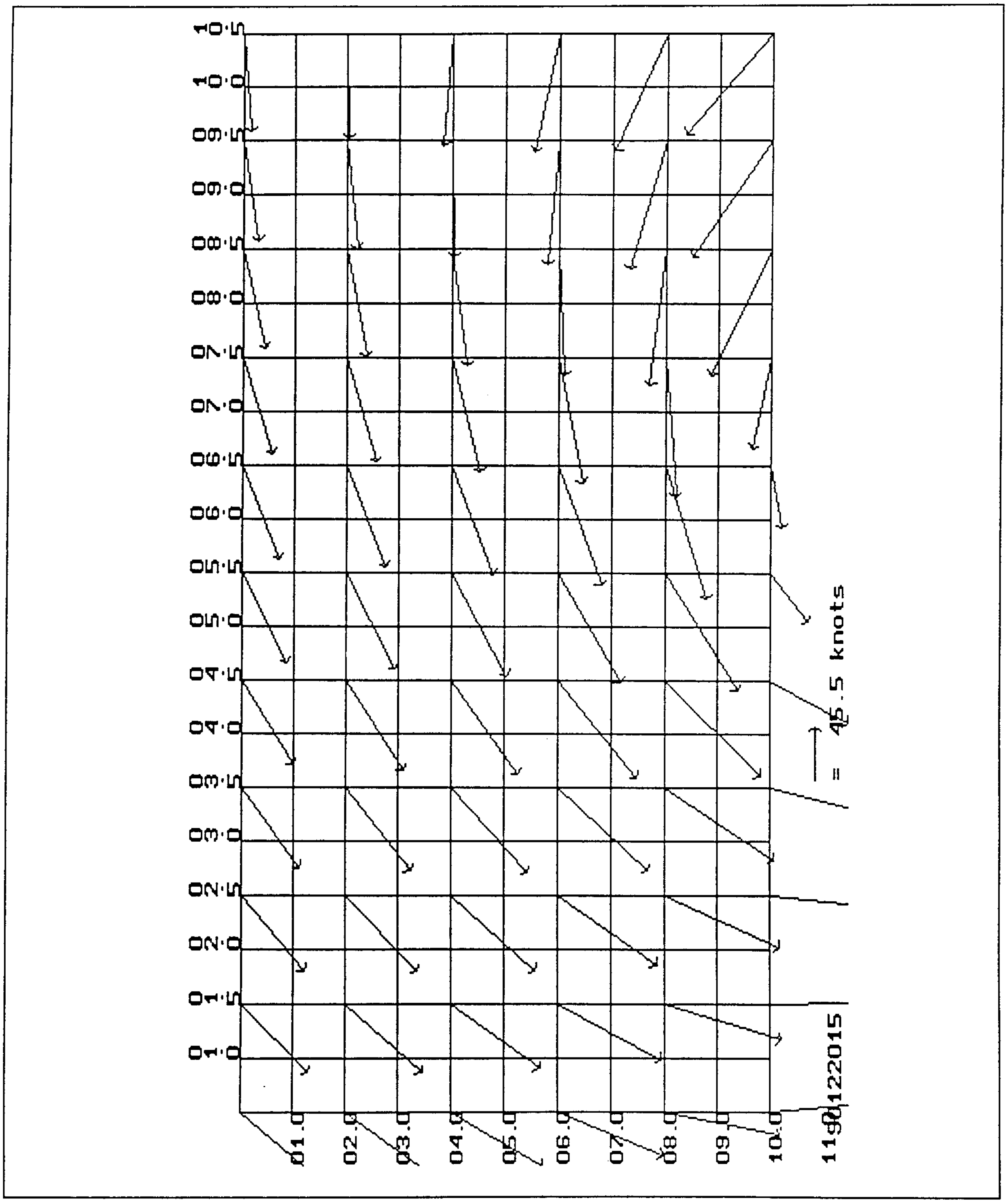

Figure 4. Vector plot of Typhoon Russ wind fields at 90122015

3 Recreating Typhoon Waves

A deepwater version of the Wave Information Study (WIS) production wave model, WISWAVE 2.0, Hubertz (1992), has been set up for the QTSAW system. This deepwater wave model is a time-dependent spectral model and has the same source functions and solution techniques as the general depth wave model. The model has been modified to use 324 KB of memory on the PC. This should be available on most PCs. A standard options.dat file, the input file for the wave model, has been prepared for the area around Guam. This area extends from latitude 12.8° to 13.8° N and longitude 144.25° to 145.25° E. The grid spacing is 0.1 deg. Guam is located in the approximate center of the wave grid. The input files for a wave run consist of the options.dat file and the input wind file, winds.dat, created by TROPWIND. The options.dat file specifies that hourly wind fields over the grid area will be in the winds.dat file. The wave output files will be waves.dat and waves.mat. Before running a job, verify that no waves.dat or waves.mat files already exist. To run waves (make sure you are on the FORT subdirectory) type:

C\FORT>waves

Screen printing will begin and will continue until the program is finished. A typical typhoon wave run takes about 10-15 min on a 386 PC (33 MHz with a math co-processor).

The waves.mat file is the most useful file to visualize the wave field around Guam. Data are output every 3 hr for the length of the storm. The output for each date includes three matrices of data. Each matrix is labelled with the date and a title. The first matrix for each date contains the significant wave height in meters at each water location (zero entries indicate land points). The second matrix contains the wave direction (toward in Cartesian degrees). The third matrix contains the peak period in seconds. Figure 5 shows an example of this file for 1 output hour of Typhoon Russ.

The information in the waves.mat file can help in estimating the extra elevation produced by the deepwater waves breaking at the edge of the reef. Check the wave direction to determine how much wave energy is headed toward the coast you are considering. The cosine of the angle made by the wave vector and the vector normal to the shore are used to determine the wave component heading toward the shore. The extra elevation is approximately

```
90122018 WV HT,m
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  7.2  7.8  8.2  8.8  8.7  7.5  6.4  5.1  3.6  0.0
0.0  9.3  8.5  7.4  6.2  4.6  0.0  6.6  5.3  3.7  0.0
0.0 10.0  9.1  7.8  6.3  4.4  0.0  6.9  5.7  4.2  0.0
0.0 10.1  8.8  7.6  5.7  0.0  0.0  7.6  6.5  4.6  0.0
0.0 10.5  9.8  8.9  7.2  0.0  9.5  8.5  6.9  4.7  0.0
0.0 12.3 12.1 11.8 11.6 11.7 10.8  9.0  7.0  4.8  0.0
0.0 14.4 14.4 14.0 12.3 11.1  9.5  9.2  7.2  5.0  0.0
0.0 14.9 13.4 11.9 10.4  8.8  8.1  7.7  7.3  5.0  0.0
0.0 11.6 11.9 10.3  8.6  7.1  6.2  5.7  5.4  5.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
90122018 WV DIR
 0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
 0. 185. 183. 181. 179. 177. 173. 165. 162. 160.   0.
 0. 189. 189. 188. 187. 186.   0. 164. 160. 158.   0.
 0. 193. 190. 186. 183. 181.   0. 159. 155. 151.   0.
 0. 195. 186. 179. 171.   0.   0. 154. 148. 147.   0.
 0. 191. 179. 169. 158.   0. 154. 149. 145. 143.   0.
 0. 187. 176. 168. 163. 156. 153. 147. 141. 140.   0.
 0. 186. 178. 171. 165. 159. 152. 148. 138. 134.   0.
 0. 189. 180. 172. 165. 156. 150. 145. 139. 129.   0.
 0. 196. 183. 175. 169. 157. 148. 143. 138. 127.   0.
 0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
90122018 Tp,sec
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  9.1  9.1 10.0 10.0 10.0  9.1  8.3  7.7  5.9  0.0
0.0 10.0 10.0  9.1  7.7  6.2  0.0  8.3  7.7  6.2  0.0
0.0 11.1 10.0  9.1  8.3  6.7  0.0  9.1  7.7  6.7  0.0
0.0 10.0  9.1  8.3  6.7  0.0  0.0  9.1  8.3  7.1  0.0
0.0 10.0 10.0 11.1 11.1  0.0 10.0 10.0  9.1  7.1  0.0
0.0 12.5 11.1 11.1 11.1 11.1 11.1 10.0  9.1  7.1  0.0
0.0 12.5 12.5 12.5 12.5 11.1 10.0 10.0  9.1  7.1  0.0
0.0 12.5 12.5 11.1 10.0  9.1  9.1  9.1  9.1  7.1  0.0
0.0 12.5 11.1  9.1 11.1  7.7  7.7  7.7  7.1  7.1  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

Figure 5. The waves.mat file showing a matrix of significant wave height in meters, wave direction in degrees, and peak period in seconds

1/10 of the deepwater significant wave height component heading toward the shore (see Chapter 3 in the *Shore Protection Manual* (1984)).

The waves.dat file provides one line of wave output information for each output hour. This information is similar to the one line output file described in Hubertz (1992). Four locations have been chosen as special output stations. Table 1 describes these stations in relation to the wave grid.

Table 1
Special Output Stations

Station No.	Column	Row (from bottom)
1	4	5
2	3	4
3	7	5
4	6	5

Each line begins with the station number followed by a date. The wave height is listed times a factor of 10. The peak period and mean period follow in seconds. The wave direction is next in Cartesian degrees. The wind speed and direction follow in knots and Cartesian degrees. There are three zeros for future data fields. The next number is the spectral energy in the discrete region in m**2 times 10**4. The next 20 numbers present a percentage of the spectral energy in each of the 20 frequency bands used in the energy calculation. The frequency bands range from .03 to .22 Hz in even increments of .01.

Creating Graphics of the Wave Field

A vector plotting package named STATWAVE will plot the wave vectors on the PC screen. A program, CONT, has been set up to prepare a new file from waves.mat to be used as an interface to STATWAVE. The CONT program produces an output file called waves.con. To create the waves.con file for input into the plotting program, type (make sure you are in the FORT subdirectory):

```
C\FORT>cont
```

For plotting, type "statwave" at the C prompt (under the TYDABS subdirectory) and answer the questions (the grid has 11 rows and 11 columns; the file name for input is \fort\waves.con). STATWAVE has the same commands as STATWIND and has a help screen available by typing "h."

Creating Graphics of the Maximum Wave Heights

A display showing numbered output locations where wave results are available around the island of Guam is available by using a Pascal program called GUOUT. GUOUT resides on the TYDABS subdirectory and plots numbered output locations for the 11 by 11 wave grid (0.1-deg spacing). Wave results are available at all the numbered locations except for location 17, which was set as a land point in the input grid for the wave model. Type GUOUT at the C prompt in the TYDABS subdirectory for a copy of this plot. Figure 6 is a copy of this graphic.

Maximum wave heights for each of the output locations displayed in Figure 6 can be displayed by a Pascal program that reads the information in the waves.mat file created by the wave model. Go to the TYDABS subdirectory and type GUMAX at the C prompt. The maximum wave height for the entire storm at each of the output locations around Guam is displayed in feet. Again, one of the points was considered as land and shows a zero result. Figure 7 shows this wave result plot for Typhoon Russ.

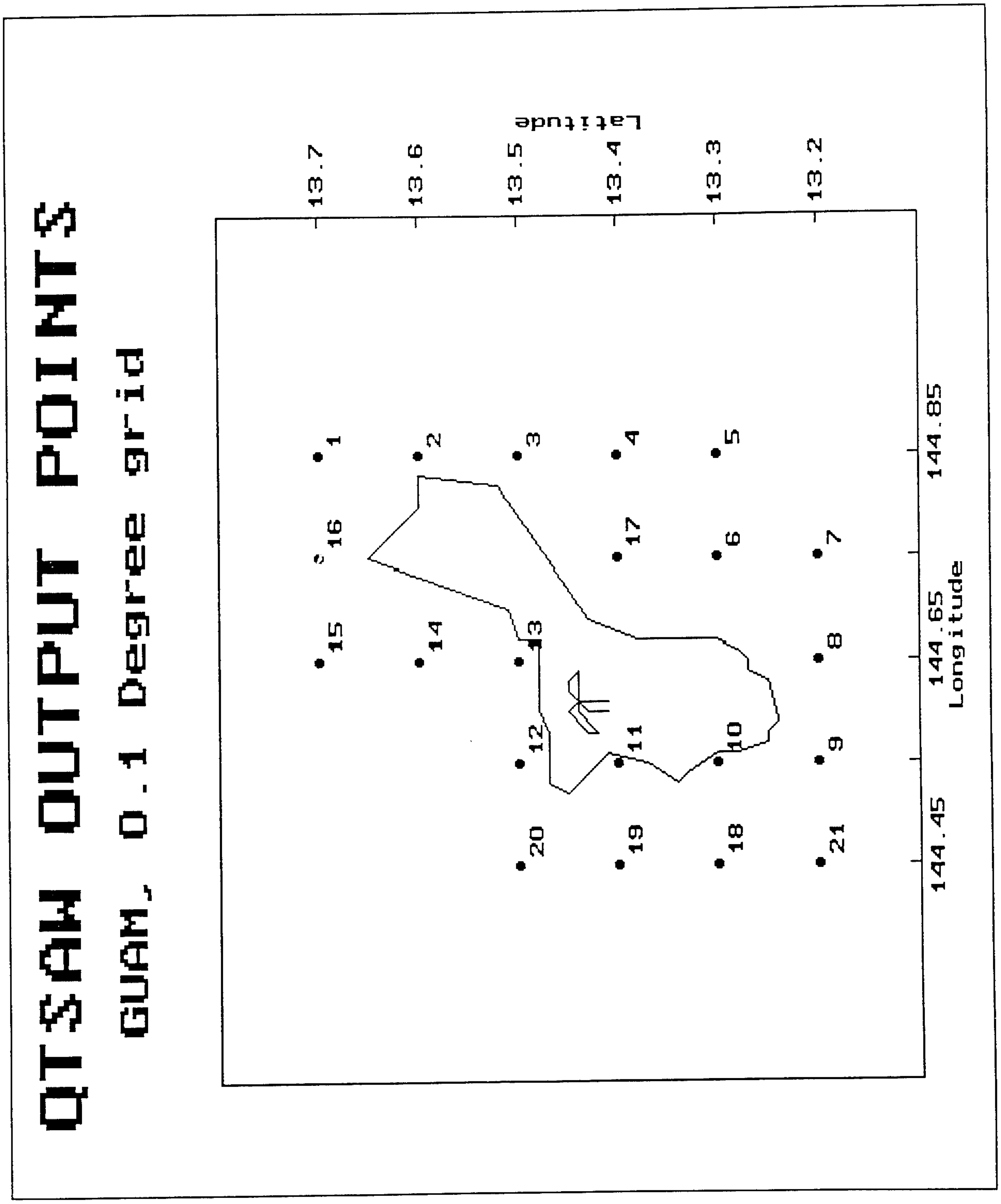

Figure 6. Graphic display of numbered output stations for Island of Guam

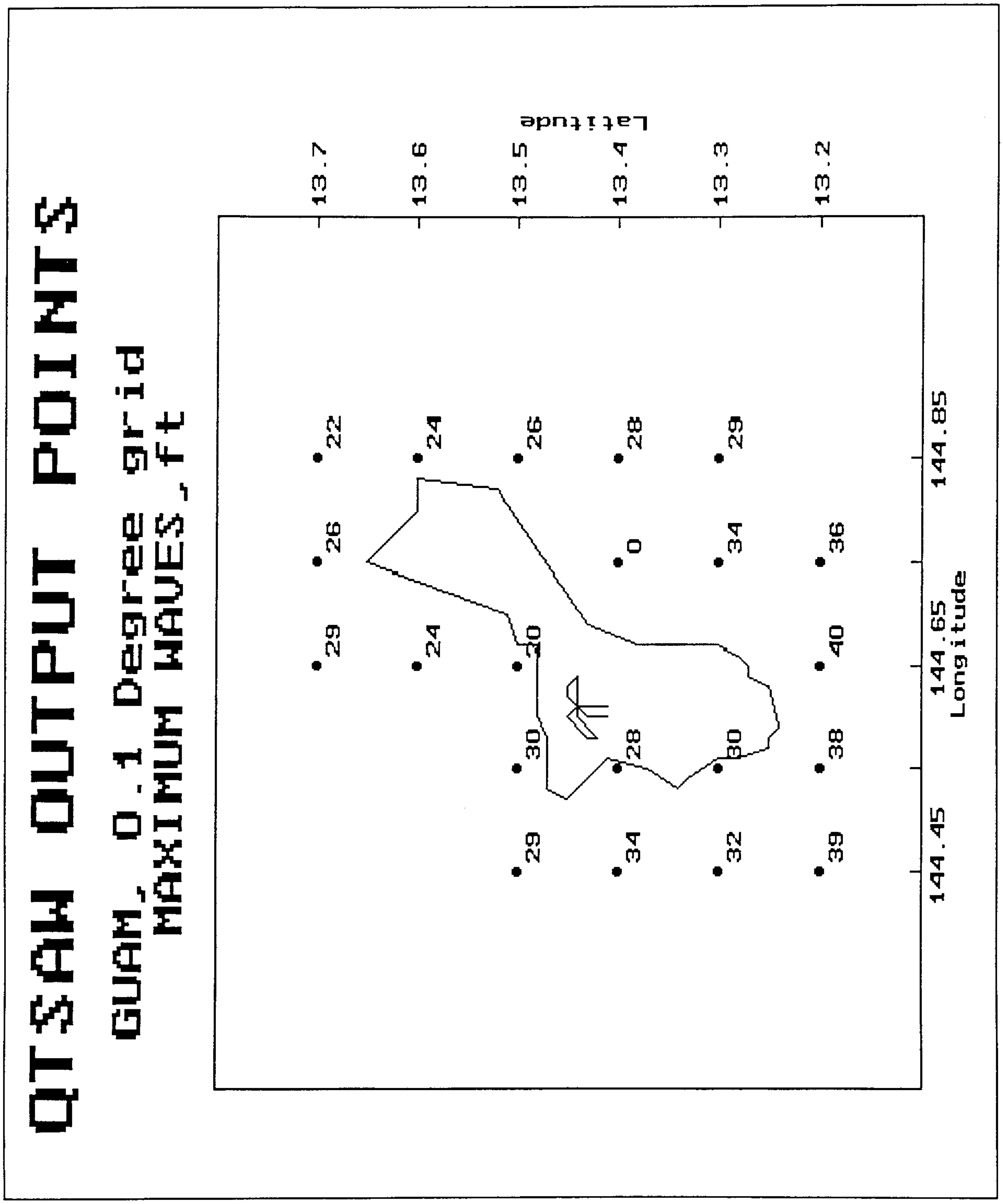

Figure 7. Maximum wave height plot for Typhoon Russ

4 Recreating Typhoon Surge

The SURGEII model developed by Reid, Vastano, and Reid (1977) has been modified and tested to produce a PC-based surge model called S2. The model was obtained under a purchase order from Bill Grosskopf.[1] This model is an open coast surge model that uses wind stress and barometric pressure drops as the main source terms to produce water level elevations. The solution technique in S2 is similar to the original SURGEII model, but the Coriolis force has been added to the system. Special coding to handle channels and barriers in the SURGEII model has been eliminated.

S2 requires a wind input file named WINSURG.DAT, a pressure input file named PRESS.DAT, and OPTSURG.DAT, which contains run options, parameters and the grid representation. S2 produces the output files: HTFLD, SCALE.OUT, DEBUG, SELECT.OUT, and RESTRT.OUT. HTFLD and SCALE.OUT are the only two files that have been incorporated into the QTSAW system. The HTFLD file includes the matrix of water elevations in feet over the entire grid for each date, a matrix of velocities in knots for each grid point, and a matrix of directions in radians for each date. Figure 8 shows an example of the HTFLD file for one output hour of Typhoon Russ. The file SCALE.OUT lists the maximums of the quantities defined in HTFLD and shows scaled matrices containing 1 through 9 for each grid point on each output date. Figure 9 shows the SCALE.OUT file. A "9" in the matrix of heights in the SCALE.OUT file indicates the maximum height is at this location; a "1" represents the minimum.

To produce a surge run on a grid corresponding to the previous wave grid (0.1-deg spacing), copy the given OPTSURG.OTD (the 0.1 deg input file available on the FORT subdirectory) to OPTSURG.DAT. S2 expects OPTSURG.DAT as input. S2 also needs an input wind file called WINSURG.DAT. Copy WINDS.DAT to WINSURG.DAT. WINDS.DAT must be 11 columns by 11 rows and include the area from latitude 12.8° to 13.8° N and the area from longitude 144.25° to 145.25° E to coordinate with the information in OPTSURG.OTD. Winds should be every hour and output

[1] Offshore & Coastal Technologies, East Coast, Engineering for the Marine Environment, 510 Spencer Road, Avondale, PA 19311.

```
TIME IN HOURS=    21
surges
  0.9  0.9  1.0  1.0  1.0  1.0  1.0  1.0  1.0  0.9  0.9
  1.0  1.1  1.2  1.4  1.3  1.4  1.3  1.4  1.2  1.4  1.0
  1.0  1.2  1.6  1.6  1.7  1.6  2.0  2.0  1.7  1.7  1.0
  1.1  1.3  1.7  1.7  1.9  1.5  0.0  2.9  2.2  2.0  1.1
  1.2  1.4  1.7  1.9  1.8  0.0  4.4  3.1  2.7  2.5  1.2
  1.3  1.6  1.9  1.9  1.7  0.0  4.9  3.7  3.0  2.8  1.3
  1.4  1.8  2.3  2.5  2.5  2.6  4.0  4.0  3.5  3.2  1.4
  1.6  2.4  2.6  3.0  3.5  3.6  3.8  4.1  3.4  3.5  1.6
  1.7  2.6  3.7  3.8  4.2  4.5  4.4  4.2  3.9  3.9  1.7
  1.8  2.8  4.1  4.8  5.5  5.7  5.5  5.0  4.2  3.9  1.8
  1.8  2.1  2.5  2.9  3.3  3.3  3.3  2.9  2.5  2.1  1.8
TIME IN HOURS=    21
velocities
 0.0 1.1 1.0 0.8 0.6 0.4 0.2 0.4 0.7 0.7 0.1
 0.3 2.4 2.2 2.1 1.9 1.8 1.8 1.8 1.7 1.8 0.5
 0.5 2.6 2.5 2.4 2.2 2.2 2.0 1.6 1.6 1.7 0.3
 0.5 2.7 2.7 2.5 2.3 0.9 0.0 1.1 1.6 1.7 0.2
 0.4 2.7 2.6 2.5 2.1 0.0 0.8 1.7 1.9 1.9 0.5
 0.4 2.6 2.5 2.3 1.9 0.0 1.7 1.8 1.9 1.9 0.4
 0.4 2.6 2.4 2.2 2.1 2.3 3.0 2.6 2.3 2.1 0.6
 0.6 2.6 2.4 2.2 2.2 2.3 2.9 2.9 2.7 2.3 0.9
 1.0 3.0 2.8 2.6 2.6 2.6 2.8 3.0 3.0 2.8 1.2
 1.2 3.2 3.0 2.8 2.6 2.5 2.5 2.6 2.8 2.7 1.1
 0.1 1.1 1.0 0.8 0.6 0.5 0.5 0.6 0.8 0.8 0.0
TIME IN HOURS=    21
angles
  4.2  4.7  4.7  4.7  4.7  4.7  4.6  4.7  4.7  4.6  3.1
  3.2  4.4  4.3  4.2  4.0  3.7  3.4  3.7  4.0  4.1  3.1
  3.2  4.3  4.3  4.1  4.0  3.7  3.2  3.7  4.2  4.3  3.1
  3.2  4.3  4.3  4.2  4.1  3.9  0.0  4.5  4.4  4.4  3.1
  3.2  4.4  4.4  4.4  4.5  0.0  4.0  4.1  4.2  4.1  3.1
  3.2  4.5  4.5  4.5  4.6  0.0  4.5  4.3  4.3  4.2  3.1
  3.2  4.4  4.4  4.3  4.0  3.3  3.8  4.0  4.1  4.1  3.1
  3.2  4.3  4.3  4.1  3.8  3.5  3.7  3.8  3.9  3.9  3.1
  3.2  4.0  4.0  3.8  3.7  3.5  3.5  3.7  3.8  3.7  3.1
  3.1  3.9  3.9  3.8  3.6  3.5  3.6  3.6  3.8  3.7  3.1
  1.6  4.7  4.7  4.7  4.7  4.7  4.7  4.7  4.7  4.7  0.0
```

Figure 8. The HTFLD file that is output from the surge model. Surges are in feet, velocities are in knots, and angles are in radians

will be printed every 3 hr. Check to make sure HTFLD, DEBUG, SCALE.OUT, SELECT.OUT, and RESTRT.OUT do not exist before making a surge run. To produce a surge run (make sure you are on the FORT subdirectory and have created an OPTSURG.DAT and WINDS.DAT file), type:

C\FORT>s2

Maximum surge values will be printed for each hour as the run proceeds.

```
SIMULATION TIME IN HOURS    18
 HTMIN =   0.00000000E-01   HTMAX =        3.47892618   ZERO =    0.00000000E-01
 location of max i,j is          10          10
11122222222
12222322222
21333343332
223344.4342
22334.44443
22333.65553
22233145663
23334445574
22455666894
22556778895
22333444556
SIMULATION TIME IN HOURS    18
 VELMAX=        2.70598483 (KNOTS)
03322112330
07765445670
08876526770
188762.6770
08887.37881
08887.67881
08877288881
08775478981
18766678992
28876667992
03322223340
 ANGLE = 45 DEGREES TIMES COUNTER
SIMULATION TIME IN HOURS    18
66666666664
46665556664
46655556660
466555.6664
46666.55654
46666.66664
66666555664
56666555554
46655555554
45555555554
26666666660
```

Figure 9. This SCALE.OUT file from the surge model scales heights and velocities using a "9" for maximum height and a "1" for minimum height. Angles are 45 deg times the counter in the angle matrix

Creating Graphics of the Maximum Surge

The maximum surge for each of the output locations shown in Figure 6 can be displayed by a Pascal program that reads the information in the HTFLD output file from the surge run. Go to the TYDABS subdirectory and type GSMAX at the C prompt. The maximum surge at each of the output locations around Guam for the entire storm is displayed in feet. Figure 10 shows a copy of this graphic for Typhoon Russ.

Creating Surge on a Smaller Grid

Another options file has been provided to produce surge on a smaller scale. A new wind file must be produced using different coordinates for TROPWIND. This grid extends over the southeastern coast of Guam and has a grid spacing of 0.5 n.m. Latitude extends from 13.15° to 13.3° N. Longitude extends from 144.7° to 144.833° E. Grid spacing is 0.00833 deg. Delete all WINDS.DAT, PRESS.DAT, and WINSURG.DAT files before going through the TROPWIND procedure to produce a new WINDS.DAT file. The 1-hr cyclone.dat file does not need to be altered if you are still interested in the same storm. Run TROPWIND to produce a new WINDS.DAT file and copy this file to WINSURG.DAT. The new options file on this smaller grid is called OPTSURG.SEC. Delete the old OPTSURG.DAT file and copy OPTSURG.SEC to the file name OPTSURG.DAT. Make sure you have deleted all previous S2 output files, and you can now run S2 using the new wind fields on the smaller grid. The surge graphics program is not set up to show graphics of the smaller grid.

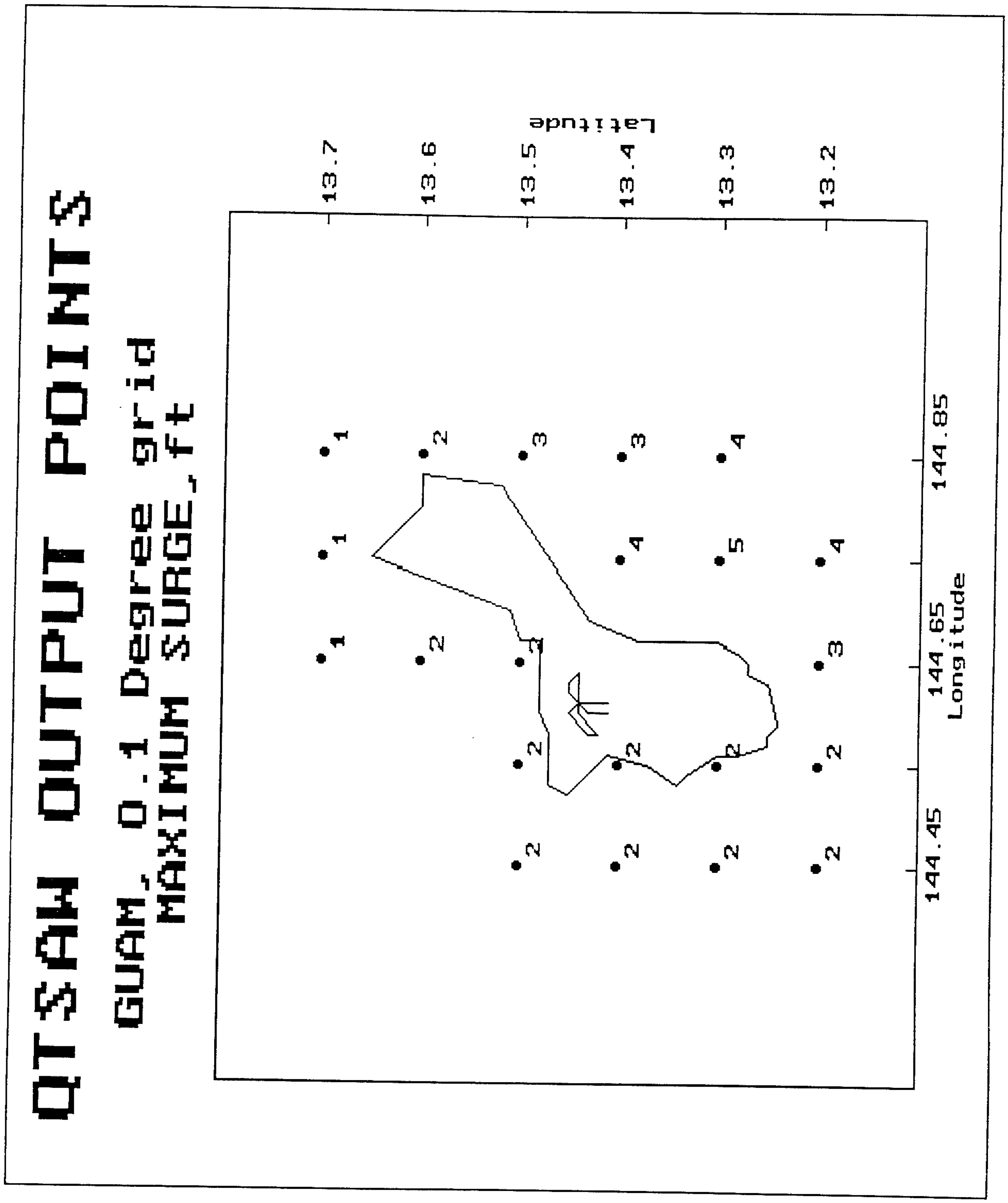

Figure 10. Graphic display of maximum surge for Typhoon Russ

5 Results

Maximum surge and wave setup results for the 0.1-deg grids are summarized in Figure 11. The figure shows a map of Guam with the maximum estimated sea inundation heights above mean high water during Typhoon Russ. This map is from NOCC/JTWC (1991). The dots in the ocean area to the right of Guam are points from the QTSAW 0.1-deg grid and represent the closest points to the coast. The maximum surge results and the calculated wave setup results are shown next to each of these dots. This is an example of the estimation that can be made with the QTSAW system for Typhoon Russ.

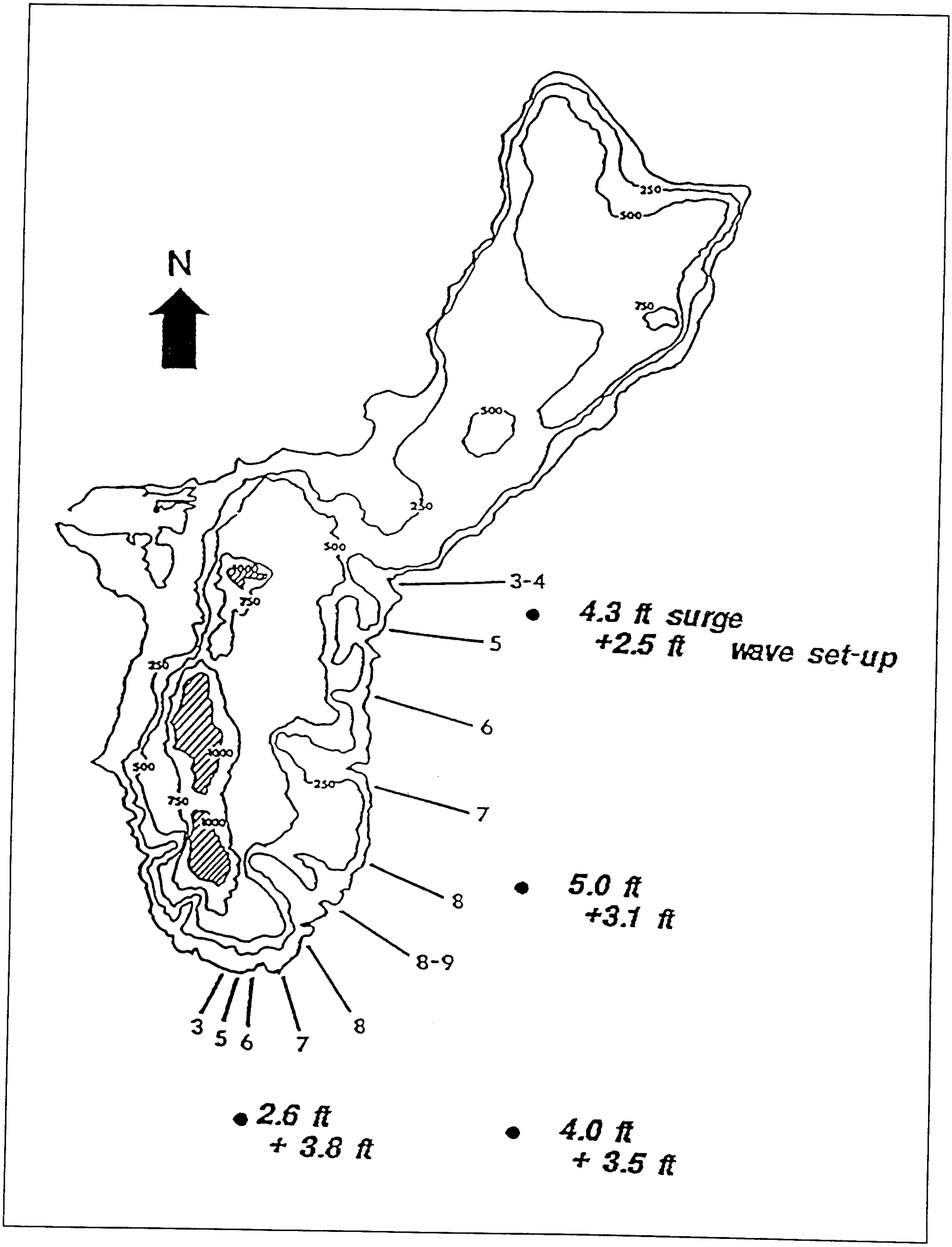

Figure 11. Maximum surge and wave set-up results for 0.1-deg grids, Typhoon Russ

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Appendix A Abbreviations for Storm Names

ABBY - ABB
ABE - ABE
AGNES - AGN
ALICE - ALI
ALLYN - ALY
AMY - AMY
AND - ANDY
ANGELA - ANG
ANN - ANN
BABA - BBE
BABS - BAB
BARBARA - BAR
BEATRIC - BEA
BERNIDA - BND
BESS - BES
BETTY - BET
BEVERLY - BEV
BILLIE - BIL
CAITLIN - CAI
CARLA - CRL
CARMEN - CAR
CHARLOT - CHL
CHAROLO - CHO
CHRIS - CHR
CLARA - CLA
COLLEEN - COL
CORA - COR
DELORES - DLR
DIANNE - DIA
DINAH - DIN
DORIS - DOR
DOT - DOT
ED - ED
ELAINE - ELN
ELLIS - ELS
EMMA - EMA
FAYE - FAY
FLO - FLO
FLOSSIE - FLS
FORREST - FRT
FRAN - FRN
FRANCIS - FRN
FREDA - FRE
GATTIE - HAT
GAY - GAY
GEORGIA - GIA
GERALD - GER
GILDA - GIL
GINNY - GIN

GLADYS - GDY
HARRIET - HAR
HAZEN - HAZ
HELEN - HEL
HELENE - HLE
HESTER - HES
HOLLY - HOL
HOPE - HOP
HUNT - HNT
IAN - IAN
IDA - IDA
IKE - IKE
INGRID - ING
IONE - ION
IRMA - IRM
IVY - IVY
JACK - JAC
JANIE - JAN
JEAN - JEN
JEANNIE - JNE
JEFF - JEF
JOAN - JOA
JOE - JOE
JUDY - JUD
JUNE - JUN
KAREN - KAR
KATE - KAT
KATHLEE - KTL
KATHY - KTY
KEZIA - KEZ
KEZIA - KEZ
KIM - KIM
KIMMA - KIN
KIT - KIT
KORYN - KOR
KYLES - KYL
LANA - LAN
LANA - LAN
LEWIS - LEW
LEX - LEX
LIBBY - LIB
LILLY - LIL
LISE - LIS
LOLA - LOL
LORNA - LOR
LOUISE - LOU
LUCY - LUC
LUKE - LUK
LYNN - LYN

MAC - MAC
MAMIE - MAM
MARGE - MAR
MARIE - MRE
MARY - MRY
MAURY - MAU
MIREILLE - MRL
NADINE - NAD
NANCY - NAN
NELSON - NSN
NINFA - NIN
NORMA - NRM
NORRIS - NOR
ODESSA - ODE
OPAL - OPL
OLGA - OLG
OLIVE - OLV
OLIVE - OLI
OPEL - OPE
OPHELIA - OPH
ORA - ORA
ORCHID - ORC
OWEN - OWN
PAGE - PAG
PAMELA -PAM
PAT - PAT
PAT - PAT
PATSY - PTY
PEARL - PRL
PEGGY - PEG
PERCY - PCY
PHYLLIS - PHY
PHYLLIS - PHY
POLLY - POL
QUERIDA - QUE
RITA - RIT
ROBYN - ROB
ROGER - ROG
ROSALIN - RSL
ROSE - ROS
ROY - ROY
RUBY - RUB
RUSS - RUS
RUTH - RUT
SALLY - SAL
SARAH - SAR
SETH - STH
SHIRLEY - SHL
SPERRY - SPE

SUSAN - SUS
TD35W - TD3
TESS - TES
THAD - THD
THELMA - THM
THERESE - THR
TILDA - TIL
TIP - TIP
TRIX - TRX
TS5452 - TS5
VAL - VAL
VANESSA - VNS
VERA - VRA
VERNE - VER
VERNON - VRN
VIOLA - VIO
VIRGINIA - VIR
WALT - WLT
WANDA - WAN
WARREN - WRN
WENDY - WEN
WILDA - WLD
WILMA - WLM
WINNIE - WIN
WINONA - WIN
WYNNE - WYN
YURI - YUR
ZOLA - ZOL

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13. ABSTRACT *(Maximum 200 words)*

This report is a user's guide for the personal-computer (PC)-based system called QTSAW (Quick Typhoon Surge and Waves). The programs and data to operate this system were developed on a 386 (33-MHz) PC and are included on two computer diskettes. The data set is the storm parameter data for all the typhoons in the Guam area (10 deg by 17 deg N latitude and 141.5 by 148.5 deg E longitude) from 1945-1991. The programs in the system create wind and pressure fields from the input storm data. These wind and pressure fields are then used as input to programs that calculate the wave and surge conditions for the Island of Guam. Several graphical display programs are available for the output results. This system was set up as part of the Wave Information Studies to help meet the needs of the Pacific Ocean Division, U.S. Army Corps of Engineers.

14. SUBJECT TERMS

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