



# Coastal Engineering

## Technical Note



### COMPUTER PROGRAM

### NARFET - WIND-WAVE GENERATION ON RESTRICTED FETCHES

**PURPOSE:** The purpose of this technical note is to predict significant wave height, peak period, and mean direction for narrow or restricted fetches.

**BACKGROUND:** Wind-wave generation in lakes, rivers, bays, and reservoirs is generally limited by the geometry of the water body, which is often very irregular. Most approaches to this problem consider wave generation only in the direction of the wind with fetch lengths averaged over small arcs (Shore Protection Manual (SPM) 1984) or large arcs (Saville 1954). Donelan (1980) proposed wave generation on fetch lengths in off-wind directions with reduced wind forcing (reduced by the cosine of the angle between the off-wind and wind directions) for the Great Lakes. The NARFET model (Smith 1989) is based on the Donelan concept, allowing wave generation in off-wind directions. Smith developed expressions for wave height and period as a function of fetch geometry and wind speed based on linear regressions of wave data collected on Puget Sound (Washington), Fort Peck Reservoir (Montana), Denison Reservoir (Texas), and Lake Ontario. The mean wave direction is determined by maximizing the wave period. These equations differ from those given by Donelan which were developed for the longer, more regular-shaped fetches of the Great Lakes. The NARFET model is quick and inexpensive (runs on a PC), yet considers the complexity of fetch geometry.

#### ASSUMPTIONS:

1. Waves are locally generated and fetch-limited.
2. Water depths across the fetch are deep (depth is greater than half the wave length).
3. Wind speed and direction are steady (spatially and temporally).

**INPUT:** The input to NARFET describes the fetch geometry and the wind forcing. The program accepts interactive responses to questions. Responses are either numeric or alphabetic. Alphabetic responses are shortened to one letter abbreviations shown in parentheses. Capital letters must be used. When a file name is requested, the number of characters in the name is limited to eight. The input required includes:

1. Fetch Geometry. The fetch geometry is described by radial fetch lengths measured from the shoreline to the point of interest at even angle increments. The user must specify the

angle (measured clockwise from north) of the first radial length, the total number of radials (for some locations it is not necessary to input a full 360 degree arc - unspecified lengths are set to zero), and the angle increment between radials. Then, individual radial lengths are entered interactively. The program allows the user to review radial length entries and correct errors. NARFET internally interpolates fetch lengths at 1 degree increments around the entire 360 degree arc. Then the program averages fetch lengths over 15 degree arcs centered on each one-degree increment. These fetch lengths are used to calculate wave conditions. The option is given to write this information to a file for future computer runs. A file name is requested when this option is chosen.

2. Wind Forcing. Wind forcing is represented by wind speed, direction, and duration over the water body. Wind fields are distorted by friction effects, so the measurement elevation, the boundary layer stability, and the measurement location (over land or over water) are also needed to adjust the wind speed to standard conditions. The simplified corrections to wind speed used in NARFET are based on these three factors. The correction methods are given in the SPM. Wind speeds are adjusted to the standard 10-m elevation. The air-sea temperature difference represents the boundary layer stability. If the temperature difference is unknown, the SPM recommends a correction factor of 1.1 (unstable condition). This correction factor is equivalent to an air-sea temperature difference of approximately -3 degree C. Overland wind conditions differ from overwater conditions because of increases in surface roughness over land. An additional correction is made if winds are based on overland measurements. An option is also available to correct winds for nonconstant coefficient of drag (SPM). This correction was not used in developing the model, but current Corps of Engineers guidance recommends the correction. The duration input is used to check if wave generation is limited by duration. The program does not convert very short duration wind observations (e.g. fastest mile wind speeds) to longer durations.

PROGRAM OUTPUT: The primary output of NARFET is the significant wave height, peak period, and mean direction corresponding to the input wind forcing. The program also recaps the input wind conditions and states whether the solution is fetch-limited, duration-limited, or fully-developed.

SAMPLE PROBLEM: For central Puget Sound (Figure 1), find the significant wave height, peak wave period, and mean wave direction.

Given: wind speed = 15 m/s at 10-m elevation over water  
wind direction = 200 degrees  
wind duration = 5 hours  
air-sea temperature difference unknown

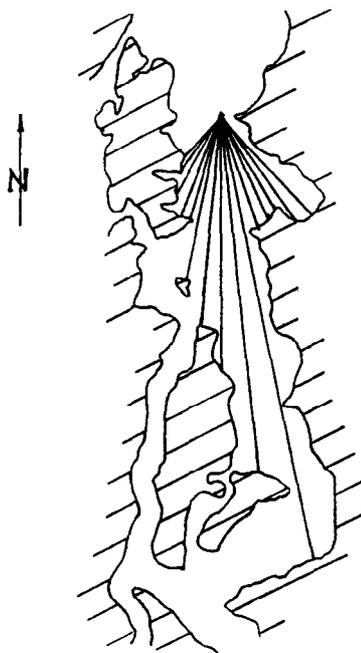


Figure 1. Southern Puget Sound Geometry.

Underlined values are user's input. Note the use of single-letter responses.

NARFET

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PROGRAM NARFET

THIS PROGRAM CALCULATES DEEPWATER WAVES FOR RESTRICTED FETCHES  
BASED ON WIND SPEED, WIND DIRECTION, AND FETCH GEOMETRY

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DO YOU WISH TO ENTER FETCH GEOMETRY (I)NTERACTIVELY  
OR FROM A (F)ILE?

I

FETCH GEOMETRY IS DETERMINED BY INPUTTING RADIAL  
LENGTHS MEASURED FROM THE POINT WHERE YOU WANT WAVE  
INFORMATION TO THE LAND BOUNDARY OF THE WATER BODY.

INPUT THE ANGLE INCREMENT BETWEEN RADIAL MEASUREMENTS (DEG)

6.

INPUT THE DIRECTION OF THE FIRST RADIAL WITH RESPECT TO  
THE LOCATION OF INTEREST (IN DEGREES MEASURED CLOCKWISE  
FROM NORTH)

138.

INPUT THE NUMBER OF RADIALS

15

INPUT UNITS OF RADIAL LENGTHS: (K)ILOMETERS, (F)EET, (M)ILES, OR  
(N)AUTICAL MILES

K

INPUT RADIAL LENGTH FOR 138.0 DEG  
10.24

INPUT RADIAL LENGTH FOR 144.0 DEG  
9.75

INPUT RADIAL LENGTH FOR 150.0 DEG  
7.88

INPUT RADIAL LENGTH FOR 156.0 DEG  
8.21

INPUT RADIAL LENGTH FOR 162.0 DEG  
8.62

INPUT RADIAL LENGTH FOR 168.0 DEG  
35.68

INPUT RADIAL LENGTH FOR 174.0 DEG  
28.24

INPUT RADIAL LENGTH FOR 180.0 DEG  
20.20

INPUT RADIAL LENGTH FOR 186.0 DEG  
16.01

INPUT RADIAL LENGTH FOR 192.0 DEG  
12.76

INPUT RADIAL LENGTH FOR 198.0 DEG  
8.21

INPUT RADIAL LENGTH FOR 204.0 DEG  
8.17

INPUT RADIAL LENGTH FOR 210.0 DEG  
7.48

INPUT RADIAL LENGTH FOR 216.0 DEG  
5.20

INPUT RADIAL LENGTH FOR 222.0 DEG  
5.08

RECAP OF INPUT ANGLES AND RADIAL LENGTHS

ANGLE = 138.0	RADIAL LENGTH =	10.24
ANGLE = 144.0	RADIAL LENGTH =	9.75
ANGLE = 150.0	RADIAL LENGTH =	7.88
ANGLE = 156.0	RADIAL LENGTH =	8.21
ANGLE = 162.0	RADIAL LENGTH =	8.62
ANGLE = 168.0	RADIAL LENGTH =	35.68
ANGLE = 174.0	RADIAL LENGTH =	28.24
ANGLE = 180.0	RADIAL LENGTH =	20.20
ANGLE = 186.0	RADIAL LENGTH =	16.01
ANGLE = 192.0	RADIAL LENGTH =	12.76
ANGLE = 198.0	RADIAL LENGTH =	8.21
ANGLE = 204.0	RADIAL LENGTH =	8.17
ANGLE = 210.0	RADIAL LENGTH =	7.48
ANGLE = 216.0	RADIAL LENGTH =	5.20
ANGLE = 222.0	RADIAL LENGTH =	5.08

HOW MANY VALUES DO YOU WISH TO CHANGE?  
(ENTER 0 FOR NONE)

0

DO YOU WISH TO SAVE FETCH GEOMETRY FOR  
FUTURE RUNS? (Y OR N)

Y

ENTER FILE NAME (MAX OF 8 CHARACTERS) TO  
SAVE FETCH GEOMETRY

PUGS.DAT

INPUT UNITS OF WIND MEASUREMENT ELEVATION: (M)ETERS OR (F)EET

M

INPUT WIND MEASUREMENT ELEVATION

10.

IS THE OBSERVATION LOCATION OVER WATER (W) OR LAND (L)?

W

INPUT UNITS OF AIR-SEA TEMPERATURE DIFFERENCE: DEGREES (C) OR (F)

C

INPUT UNITS OF WIND SPEED: (M)ETERS/SEC, (F)EET/SEC, (K)NOTS,  
OR MILES/HOUR (N)

M

INPUT AIR - SEA TEMPERATURE DIFFERENCE

-3.

INPUT WIND SPEED, WIND DIRECTION (DEG), AND DURATION (HR)

15.,200.,5.

INPUT CONDITIONS:

ADJUSTED WIND SPEED (M/S) = 22.7 ( 22.7 INPUT UNITS)  
WIND DIRECTION (DEG) = 200.0  
DURATION (HR) = 5.0  
AIR-SEA TEMP DIF (DEG C) = -3.0

SIGNIFICANT WAVE HEIGHT (M) = 1.6  
SIGNIFICANT WAVE HEIGHT (FT) = 5.3  
PEAK WAVE PERIOD (S) = 4.7  
MEAN WAVE DIRECTION (DEG) = 173.0

DURATION LIMIT (HR) = 2.9

FETCH LIMITED CONDITIONS

DO YOU WANT TO RUN ANOTHER WIND CONDITION?

N

RUN COMPLETE  
FORTRAN STOP

AVAILABILITY: A FORTRAN listing of NARFET is available from the Coastal Engineering Research Center, Coastal Oceanography Branch. The program is internally documented via comment cards, and detailed information about the development of the model is given by Smith (1989). For further information, contact Jane McKee Smith at (601) 634-2079.

REFERENCES:

Donelan, M.A. 1980. "Similarity Theory Applied to the Forecasting of Wave Heights, Periods, and Directions," Proceedings of the Canadian Coastal Conference, National Research Council, Canada, pp. 47-61.

Saville, T. 1954. "The Effect of Fetch Width on Wave Generation," Technical Memorandum No. 70, Beach Erosion Board, Washington, DC.

Shore Protection Manual. 1984. US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, US Government Printing Office, Washington, DC.

Smith, J.M. 1989 (in preparation). "Wind-Wave Generation on Restricted Fetches," US Army Waterways Experiment Station, Coastal Engineering Research Center, Vicksburg, MS.