A Techniques Development Laboratory
puter Program NWS TDL CP 83-2

# SIMULATION OF SPILLED OIL BEHAVIOR IN BAYS AND COASTAL WATERS

Silver Spring, Md.
October 1983

**U.S. DEPARTMENT OF COMMERCE** / National Oceanic and Atmospheric Administration / National Weather Service

## PREFACE

The Techniques Development Laboratory's (TDL's) computer program (CP) series is a subset of the Lab's technical memorandum series. The CP series documents computer programs written at TDL primarily for the Automation of Field Operations and Services (AFOS) computers.

The format for the series follows that given in the AFOS Reference Handbook, Volume 6, Bac

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# SIMULATION OF SPILLED OIL BEHAVIOR IN BAYS AND COASTAL WATERS

Kurt W. Hess

## 1. INTRODUCTION

OILSPILL is a computer program designed to forecast the behavior of floating oil in the coastal zone. The program, written in FORTRAN IV, runs on the AFOS (Automation of Field Operations and Services) Data General Eclipse S/230 computer. It can be stored on floppy disk and retrieved when it is to be run.

The program, which is run at the Alphanumeric Display Module (ADM), requires input such as oil spill location, map parameters, and wind and water current forecasts. All data entered are stored in a permanent file so the user can selectively change the data for the next model run. The output is a series of maps, printed at the Printer/Plotter Module (PPM), depicting the coastline, positions of floating oil, and positions of beached oil. The shoreline is automatically drawn from points in a geography file included with the program.

The program has been verified with data from the Amoco Cadiz, Argo Merchant, Burmah Agate, Chevron, and Torrey Canyon oil spills, all with observed winds. In any particular spill, however, errors can arise from improper selection of input values. Model output is most sensitive to changes in the wind forecast and the tidal current data.

## 2. DESCRIPTION OF THE MODEL

OILSPILL simulates a spill of oil as the continuous release of particles, each representing an arbitrary volume of oil, from a source point. These drifting particles, called drifters, move at a velocity equal to the sum of four current vectors: wind drift, tidal current, random current, and background current. Drifter position is updated several times per hour, and the position is compared to the shoreline map. During onshore winds the oil can beach, and be prevented from further motion until refloating occurs. Drifters are randomly removed to simulate continuous weathering.

### A. Oil Transport and Wind Drift

The generalized equation for steady oil transport at low concentration is expressed as follows:

$$\underset{\sim}{U} = \underset{\sim}{W}_T + \underset{\sim}{W}_B + \underset{\sim}{W}_R + \alpha \underset{\sim}{V}_\theta ,$$

where $\underset{\sim}{U}$ is the vector oil velocity, $\underset{\sim}{W}_T$ the tidal current, $\underset{\sim}{W}_B$ the background current, $\underset{\sim}{W}_R$ the random current, $\alpha$ the wind drift coefficient, and $\underset{\sim}{V}_\theta$ the 10-m wind velocity rotated anticyclonically by an angle $\theta$. The wind drift coefficient has been found to range from 2% to 5%, with 3.5% a typical value. The angle $\theta$ ranges typically from $5^\circ$ to $10^\circ$.

## B. Tidal Currents

Measurements of tidal currents along the coast and in bays show that for many locations the currents are of the rotary type. In channels where the tidal currents are described as reversing, the surface current can be thought of as a rotary current with a small or zero minimum speed. Following Sverdrup, et al. (1942), we idealize the rotary current vector in terms of a flood speed, $S_F$, the direction toward which the current floods, $\phi$, the minimum current speed (halfway between flood and ebb), $S_M$, and a time, relative to some initialization time, at which flood occurs, $\tau$. With these data, the tidal current components at any time, t, are:

$$W_E = S_F\cos[2\pi(\tau-t)/T]\sin\phi - S_M\sin[2\pi(\tau-t)/T]\cos\phi \text{ and}$$
$$W_N = S_F\cos[2\pi(\tau-t)/T]\cos\phi + S_M\sin[2\pi(\tau-t)/T]\sin\phi,$$

where $W_E$, $W_N$ are surface tidal currents to the east and north and T is the period of the tidal current.

Tidal current headings and speeds can be found from the National Ocean Survey's (NOS's) tidal current charts, and the time of flood can be found from the NOS's tidal current tables. At many coastal locations the flood and ebb currents have unequal strengths. And wherever the diurnal inequality is pronounced, successive floods and ebbs will also be quite different. OILSPILL handles these variations by modifying $S_F$ to include both diurnal and semidiurnal components.

OILSPILL will generate a spacially-varying tidal current when the user supplies data for locations other than the spill site. At each grid point a weighted mean of the data is calculated by a normalized, inverse-square weighing function to create two-dimensional distributions of the flood current. In each water grid adjacent to a land grid, the flood current direction is rectified to make it parallel to the coast. Rectification allows the tidal current to carry oil along the coast rather than into it. For the best results the user should enter data for several roughly evenly-spaced locations within the major channels or geographical areas of interest. The user may request a printout of the heading and current strength factors to insure that the procedure has been run satisfactorily. Because of storage limitations the headings are rounded off to the closest 4°, and strength factors are rounded off to the nearest 1%.

## C. Background Currents

An unchanging current, steady over the course of the simulation, is termed the background current, and is assumed here to be spacially uniform in the near field. Semi-permanent features such as the Gulf Stream and the Loop Current are examples. Steady wind conditions may also set up coastal currents which can be considered semi-permanent, since their time scale (several days) is greater than that of the tides.

## D. Random Currents

A small random current is added at each time step to simulate natural diffusion. In accordance with the random walk method (Csanady, 1973), this random current has a constant magnitude, V, but a variable direction. The diffusion coefficient, D, is related to V by

$$D = \frac{1}{2N} V^2,$$

where N is the number of walks, or steps, per unit time. Typical values of D range from 1 to 1000 $ft^2/s$, with 100 being a reasonable value. The direction is chosen by uniformly distributed random numbers.

## E. Oil Release

A continuous spill of oil is simulated by the periodic introduction of new drifting elements at the spill site. Up to 2000 drifters are permitted. The time interval, or time step, between introductions is chosen so that a drifter, moving at maximum speed, will cross no more than 98% of a grid width during any time step. The grid width is the total map width divided by the number of characters per line, which is 71. The maximum speed is the sum of the maximum values of wind drift, tidal current, background current, and ran- dom speed which are possible over the entire simulation. This limitation on the time step is essential for the calculation of oil beaching.

In cases where the wind or tidal current is large and the map represents a small area, the time step will be relatively small. The time required for computation will then be correspondingly large. The user can reduce the computation time by specifying that oil be released every N-th time step rather than every time step.

## F. Initial Oil Distribution

The user can specify an initial oil plume by entering the length of the plume and its orientation. A plume with its origin at the spill site will be constructed and will become the oil's starting position. No initial plume is created when the user enters zero for the plume length.

Up to four initial isolated oil patches of elliptical shape can also be specified. These patches are constructed when the user enters the latitude and longitude of the end points of the major axis, the width of the ellipse, and the hour of its appearance.

The latitude, longitude, and status (afloat, beached, weathered, or removed) of each drifter is stored in the data file at the end of the run. The user may employ these data as initial oil distribution at the start of the next run.

## G. Map Geography

The background map is drawn from the data stored in the auxiliary file OILSPILL.DA. Each Ocean Service Unit (OSU) has its own coastline geography file; the OSU's and the corresponding coastal area included in their files are given in Table 1. When the user enters the spill latitude, longitude, and map width and height the map boundaries are computed. The program searches through the file and draws the map.

The position of the coastline on the background map can be shifted vertically and horizontally relative to the latitude and longitude marks. This feature was added because the master geography data contain occasional distortions which are occasionally noticeable at the smallest scales.

### H. Oil Map

The output map with the oil distribution and the shoreline configuration is printed at user-specified intervals. The header block at the top of the map (Fig. 1) gives the time of the plot from the start of the simulation, the GMT valid time, and distance that each map grid length represents. There is also a symbol key, the total number of drifters, and the number of drifters in each category. The drifters in the 'weathered' category have been removed to simulate mass loss. The drifters in the 'removed' category have been eliminated because they have been advected to areas outside the map, or because truncation error caused a problem in the beaching subroutine (see Section 2.K.).

Map grid elements occupied by one or more floating oil drifters are marked by the symbols '0', '1', '2', etc. Each symbol denotes the range in which the number of drifters falls. The increment between range limits is given by the user. The presence of beached oil is marked by the symbol '@'.

On the map the position of the spill site is marked by the symbol '$'. This position can be shifted away from the map center by the user at execution time.

### I. Moving Source

Allowance has been made for motion of the source point. Two kinds of movement can be simulated: drifting and powered motion. Drifting is induced by the winds and currents. The program computes the drift velocity as the vector sum of user-supplied fractions of the wind and current velocity.

During a powered move the source point progresses at a constant velocity for a given time interval, and then may change velocity. The user supplies a starting time, and a series of speed, heading, and duration information covering the total time of the simulation.

Oil release occurs in the same manner as that for a fixed source. OILSPILL will continue to run even if the source point should move outside the map.

### J. Weathering

Petroleum and other substances in the environment are subject to weathering which includes evaporation, photo-oxidation, dispersion, dissolution, emulsification, tarball formation, and sedimentation. Describing each process separately involves a multitude of complexities, so we chose to combine them into simpler forms. Data on environmental mass changes (Jordan and Payne, 1980) show that the mass loss rate decreases with time. Recognizing this observation we postulate that weathering follows an equation of exponential decay. If we can determine the half-life, L, of the oil in the environment we can apply this weathering at the end of each hour of simulation, at which time we remove a fraction of oil mass equal to F, where

$$F = 1.0 - \exp(-\ln(0.5)/L).$$

Most spilled substances contain several constituents, each with its own half-life. In that case, each drifter is randomly assigned at the start to represent one of the constituents in the original proportions. Each constituent is then weathered at its own rate.

Table 2 contains the composition of various petroleum substances, which are assumed to be composed of five constituents. The constituent proportions are based on data given in Jordan and Payne (1980). The user selects the appropriate substance by entering the number of the substance given in the table. The inert material is not subject to weathering.

### K. Beaching

When the oil intersects the coastline, it may come up on shore, or beach, and be temporarily held motionless. In OILSPILL, beaching occurs when the drifter's position on the background map places it within a coastline grid element.

When beaching is indicated for a drifter's updated position, the new position is recalculated using wind drift plus the random current and only the components of the other water currents parallel to shore. Beaching then occurs if it is still indicated. Suppressing the current normal to the coast insures that only wind will beach the oil.

Each drifter's position is defined by its latitude and longitude coordinates. Occasionally, because of truncation error, the conversion of a floating drifter's latitude and longitude coordinates to map coordinates places the drifter within a coastline grid element. This may happen when the drifter is very close to the coastline. When this error is detected, the drifter is removed from further calculations.

Although beached drifters don't move, they continue to be weathered.

The drifters are assumed to have a finite half-life of beach residence time. That is, under offshore winds, half of all beached drifters will re-enter the water during a time period equal to the residence time half-life. At the end of each hour of simulation, a fraction of the beached drifters experiencing offshore winds are re-floated. Typical values of half-life are given in Table 3.

## 3. OPERATIONAL USE OF OILSPILL

OILSPILL is designed to run in background on the Data General Eclipse. It is too large to run directly from floppy disk, so all files must be moved to a suitable directory (e.g. DPO). The files OILSPILL.SV and OILSPILL.OL contain the program code. OILSPILL.DA contains the local geography. The auxiliary data files, which are supplied with the program, OILSPILL.D1, OILSPILL.D2, OILSPILL.D3, OILSPILL.D4, and OILSPILL.D5 contain data from specific runs. These data include the spill characteristics, the background map, the flood current speed and direction arrays, and the positions of drifters from the previous run. Data necessary to run OILSPILL are entered at the ADM with a preformatted message. At the AFOS Experimental Facility we use the name EXFMCPOIL. The product created by this preformat is named EXFOILEXF.

## A. Submitting the Program

For the initial submission of OILSPILL the user calls up the preformat (here we use EXFMCPOIL) by entering:

M:OIL

and entering the requested information (Note: OILSPILL is designed to run even if all the values entered are zeros). The data file chosen in the first line of the preformat will store the spill characteristics, map, flood currents and drifter positions. The preformatted data are stored in another product (here we use EXFOILEXF). The program is then activated by entering

RUN:OILSPILL EXFOILEXF

at the ADM. The map output will appear at the PPM.

For subsequent submissions of OILSPILL the user need only to edit the completed message by entering

E:EXFOILEXF

and changing values as required.

When OILSPILL is resubmitted with the same command as before, the program reads the contents of the data file OILSPILL.D#, where # = 1, 2, 3, 4, or 5, and then makes two decisions. The stored map will be used unless any of the following have been changed: spill latitude or longitude, map width or height, or spill site shift variables. Stored flood current directions and speed will be used unless any of the tidal current data have been changed This data file is used for two important reasons. First, time is saved when the previously-constructed arrays are used. Second, the stored map can be altered to improve the representation of coastline features (see Section 4, Item 2).

## B. The Preformat

OILSPILL uses a preformatted message for data input. A copy of the message preformat appears in Fig. 2., and a copy of the message product appears in Fig. 3. An explanation of the lines of input follows.

| LINE | REMARKS |
|---|---|
| 1 | Enter the data file number, # (use -1 for the first run of a new event). OILSPILL will read file OILSPILL.D# for data, and write all results back to the same file. Including a minus sign before the number means that the file is not read, so no initial values are taken from it. Use the same file number for all runs of one particular spill, and use other files for other spills.<br><br>Note: a datum in the brackets is right-justified, so enter it as far to the right as possible. |

2 Title (which is optional) describing the run.

3 The GMT date (e.g., 82, 11, 15, 00) for the start of the time period, which includes the spill, to be simulated. Since wind observations or forecasts generally exist for 00Z, 06Z, 12Z, and 18Z, you may choose any one of these times which preceeds the time the spill began.

4 The North latitude of the spill site in degrees, minutes, and seconds (e.g., 47, 34, 0).

5 The spill West longitude (e.g., 122, 27, 0).

6 The interval (hours) at which the map is to be printed (usually 3 or 6), the output unit number (10 for the Dasher printer, and either 12 or 14 for the PPM, depending on the installation), and the map width (degrees, minutes). The spill will be at the map center unless it is shifted away (see Line 7).

7 Enter map height, as a percent of map width on the printer. A value of 100 will produce a square map on the printer. The value entered will be adjusted (a) to be not more than (approximately) 125% and (b) to correspond to a whole number of printer lines. RISE and RIGHT are the seconds of arc the geography background may be shifted up and to the right, respectively, in relation to the latitude-longitude lines (use zero for the first run).

8 The position of the spill site, denoted by the symbol '$' on the map, may be moved to the right or down by entering non-zero (positive or negative) integer values (use zero for the first run).

9 The plot increment determines the minimum and maximum number of drifters in a grid represented by each symbol; typically the increment is in the range 1 to 10. Entering the value 1 in the second field causes the initial oil distribution to be that which was saved from the end of the previous run.

10 Spill start and stop hours relative to the starting time in Line 3. Hour 0 coincides with the start of the simulation, and hour 1, for example, means the end of the first hour. A frequency of 2 means that a drifter is released every other time step. An oil release less often than every time step will reduce computer time.

11 The wind drift fraction can be taken to be 3.5%, and the angle to be 5°.

12 Enter the index number (1 to 9) for the type of petroleum spilled (see Table 2). Normally the age (hours) will be zero. A non-zero age causes the petroleum to weather before it is released, and therefore to have a different composition; use this for oil which has been on the water for many days.

13 The horizontal diffusion coefficient has units of $ft^2/sec$. A nominal value of 100 gives reasonable results. For beached oil residence time half-lives, see Table 3. A nominal value of 50 may be used.

14 Enter the initial plume length in units of tenths of n mi. The direction is that toward which the oil is flowing (North is 000).

15 The background current (tenths of knots) is assumed constant over the simulation. The direction is that toward which it is flowing.

16 Enter the flood current maximum speed (tenths of knots), ebb current maximum speed (tenths of knots), and minimum current speed (tenths of knots). See Section 2.B. for discussion.

17 Enter the flood current heading (degrees) at the spill site.

18 Enter the time of flood after hour 0 of the simulation. We assume that the time is uniform over the field.

19 Enter speeds of second flood and ebb (tenths of knots). Use the same values as in Line 16 if current is diurnal.

20 Time at which the source begins to move. Enter zeros for a fixed source.

21 The source can drift at a given percent of the wind speed and the water current (non-wind drift) speed. Enter zeros for a fixed source.

22 The source can move under powered motion. Motion will begin at the time given in Line 20 and the source will move at the speed (kt) in the given direction (degrees) for the duration entered (h). Then the source will move as described in the next set of speed, direction, and duration values. Up to five sets of values are allowed. Note: total source motion will be the sum of powered drift, wind, and water current drift. No powered motion will occur if the first set of values contains all zeros. If the source point leaves the map area, a note will appear in the header block, and the simulation will continue.

23 Enter the wind forecast interval, and the maximum projection time (i.e., length of simulation).

24 Wind forecasts are entered here. Up to 17 values can be inserted.

25 Extra tidal current information can be entered here by giving latitude, longitude, flood direction, and speed (the time of flood at each of these locations is assumed to be the same as that at the spill site). Entering a value of 1 in the second bracket causes the printing of the two arrays (flood direction and relative speed) at the PPM.

26 Enter the number of initial elliptical oil patches, and the hour, relative to the starting date, they were sighted. The eliptical patch is defined here by two points, one at each end of the patch along the major axis, and by the width of the patch.

### C. Map Output

The output is a series of maps printed at a user-specified interval (see LINE 6, Section 3.B.). Each map (see Fig. 1) has a header block which describes the symbols used, the forecast time, the number of drifters, and the map grid element size. Latitude and longitude markers are given at the map side and bottom, respectively, and are in degrees and minutes.

### D. Data Flow

OILSPILL and its data sets reside on floppy disk and can be moved to, or linked to, DPOF when run. When all files are on DPOF, the words RUN:OILSPILL EXFOILEXF is entered at the ADM to activate the program. All messages describing the status of the program will appear at the Dasher printer. OILSPILL will read the geography data file, OILSPILL.DA, and any one of the input files, OILSPILL.D#, which contain spill coordinates and other information pertaining to a specific spill. Output maps will be printed on the PPM or other device which the user may specify. The geography array, the tidal current direction and strength arrays, and drifter postion and status arrays will be written back into the selected data file. A diagram of the data flow appears in Fig. 5.

## 4. MODEL LIMITATIONS AND CAUTIONS

The physics of oil behavior are still only partially understood. All the simple parameterizations of drift velocity, weathering, and reflcating are therefore subject to refinement from additional field observations.

The following items will alert the user to problems which may be encountered when OILSPILL is run, and they offer one or more remedies:

1. Occasionally there will be a problem reading the data file for past runs (not the geography file). You can skip reading the file by entering a negative number for the file number.

2. Because of the limited size of the geography data file, small islands and coastline features in the region of interest may be missing. There are two ways to correct this deficiency. One is to edit the data file OILSPILL.D# on the Dasher and change the array holding the coastline data. The array begins at about line 15, and is up to 40 lines long; it is easily distinguishable since it contains only 0's and 1's. Values of 1 will be graphed as coastline (.) on the oil map. The user can simply add coastline by changing 0's (or blanks) to 1's, and delete coastline by changing 1's to 0's. A copy of the data file for the map in Fig. 1 is given in Fig. 6. The second way is to use the program OILEDIT which is described elsewhere (Hess, 1983).

3. Make sure the PPM is powered on when the program OILSPILL is running. Otherwise a channel or system error will occur.

4. If the program is taking too long to execute, you can take several corrective measures. First, the oil release frequency number can be increased (see Section 3.B., Line 10). For example, doubling the frequency number will roughly halve the run time. Second, you can increase the width (minutes, seconds) of map. Finally, you can increase the rate of oil weathering to reduce the number of drifting elements. Check the value of NPERHR printed just before the first map. It should be no more that about 30; if it is, try increasing the map width.

5. When extra tidal current stations are added, you should print out the arrays of speed and direction at flood. Make sure that the values are realistic, especially in the regions near the oil. If they are not, try changing the positions of the current data, or making the values more uniform, or adding more points.

6. The wind is assumed to be uniform over the region of the spill. If there is significant spatial variation, try running OILSPILL for a short interval of time (3 to 6 hours), saving the oil position, and using the position for inital conditions at the start of the next run.

## 5. REFERENCES

Csanady, G. T., 1973: Turbulent Diffusion in the Environment. Reidel, Dordrecht, Holland, 248 pp.

Hess, K. W., 1983: Editing spilled oil behavior geography files. NOAA Techniques Development Laboratory Computer Programs, NWS TDL CP- , National Weather Service, NOAA, U.S. Department of Commerce (in preparation).

Jordan, R. E., and J. R. Payne, 1980: Fate and Weathering of Petroleum Spills in the Marine Environment. Ann Arbor Science, Ann Arbor, 174 pp.

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# 6. PROGRAM USE

## SIMULATION OF SPILLED OIL BEHAVIOR IN BAYS AND COASTAL WATERS

PART A. PROGRAM INFORMATION and INSTALLATION PROCEDURE

PROGRAM NAME: OILSPILL

AAL ID: MOHOO4
Revision No.: 03.20

FUNCTION: This program allows the user to forecast the fate of oil spilled on the sea surface. The user must enter the latitude and longitude of the winds, and the tidal current characteristics of the area. The output is a series of maps showing the position of oil and areas of beached oil.

PROGRAM INFORMATION:

| Development Programmer: | Maintenance Programmer: |
|---|---|
| Kurt W. Hess | Kurt W. Hess |
| Location: Techniques Development Laboratory | Techniques Development Laboratory |
| Phone: FTS 427-7613 | FTS 427-7613 |
| Language: Fortran IV/Rev 5.20 | Type: Overlay |

Save file creation dates:

| | | |
|---|---|---|
| Original release/Rev. 01.00 | - | September 30, 1982 |
| First revision/Rev. 02.00 | - | January 14, 1983 |
| Second revision/Rev. 03.00 | - | February 14, 1983 |
| Third revision/Rev. 03.10 | - | May 9, 1983 |
| Fourth revision/Rev. 03.20 | - | September 9, 1983 |

Run Time: 1 to 10 Minutes

Disk Space:

| | | |
|---|---|---|
| OILSPILL.SV | - | 100 RDOS blocks |
| OILSPILL.OL | - | 130 RDOS blocks |
| OILSPILL.DA | - | 40 RDOS blocks |
| OILSPILL.D1 | - | 5 RDOS blocks |
| OILSPILL.D2 | - | 5 RDOS blocks |
| OILSPILL.D3 | - | 5 RDOS blocks |
| OILSPILL.D4 | - | 5 RDOS blocks |
| OILSPILL.D5 | - | 5 RDOS blocks |

PROGRAM REQUIREMENTS:

Program Files:

| NAME | COMMENTS |
|---|---|
| OILSPILL.SV | Code To Run Model |
| OILSPILL.OL | |

Data Files:

| NAME | DP Location | READ/WRITE | COMMENTS |
|---|---|---|---|
| OILSPILL.DA | DPO | R | Geography File |
| OILSPILL.D1 | DPO | R/W | Individual Run File |
| OILSPILL.D2 | DPO | R/W | Individual Run File |
| OILSPILL.D3 | DPO | R/W | Individual Run File |
| OILSPILL.D4 | DPO | R/W | Individual Run File |
| OILSPILL.D5 | DPO | R/W | Individual Run File |

AFOS Products:

| ID | PURPOSE | COMMENTS |
|---|---|---|
| EXFMCPOIL | Holds message composition Preformat | Rename for local use |
| EXFOILEXF | Holds data for individual run | Rename for local use |

LOAD LINE

```
RLDR/P OILSPILL CSTAT DSAVE FNDEG GPERHR INPTX ISVAL OILZ MAPVAL
RECTFY [ READT AFREAD GTYPE RFOS1 RFOS2 , RFYLE RDRFT RECRE FILSV
REFORM TABLO AFREED , INIT EXTRA GEOGRY GERASE GETDAT GETLAT INITL
NEWHGT GSAVE , CFELD SMOOTH FPACK WGHT PRMAP , CURNTS CUBPOL
DRIFTR OCHECK CLOCAL MOVSOR REFLOAT WEATHR MAPOIL CHKLAT HEADER
OILINE OPATCH SETLAT SETLON TICKS ] BG.LB UTIL.LB FORT.LB
```

PROGRAM INSTALLATION:

1. Insert floppy disk into DP3.

2. Move OILSPILL.<SV OL DA D1 D2 D3 D4 D5> files to DPOF. Then create LINKS on DPO for each file (OILSPILL.SV, etc.).

3. Select a product key, cccMCPxxx, for the preformat and store EXFMCPEXF into it by entering

    STORE:DP3:EXFMCPEXF cccMCPxxx

    Select a product key, cccnnnxxx, for the OILSPILL data file and store EXFOILEXF into it by entering:

    STORE:DP3:EXFOILEXF cccnnnxxx

# SIMULATION OF SPILLED OIL BEHAVIOR IN BAYS AND COASTAL WATERS

PART B. PROGRAM EXECUTION and ERROR CONDITIONS

PROGRAM NAME: OILSPILL

AAL ID: MOHOO4
Revision No.: 03.20

## PROGRAM EXECUTION:

1. Make sure that the files for OILSPILL exist on either DPO or on DPOF with links to them on DPO, and that the OILSPILL preformat, cccMCPxxx, and the OILSPILL data product, cccnnnxxx, (see Part A) exist in the PIL.

2. Either use the preformat (cccnnnxxx), to create a new run file, or edit an old run file, so that the spill data are as desired. Data values entered in the brackets should be right-justified. Although most of the data entry is self-explanatory, refer to Section 3.B for details.

3. Run the program by entering at the ADM:

   RUN:OILSPILL cccnnnxxx

   where cccnnnxxx is the OILSPILL data file.

4. Look for output at the PPM.

## ERROR CONDITIONS:

1. Errors are most likely to occur when new files are opened. Look at the Dasher status messages to tell where in the program the problem occurs. If there is an error when reading the run data files, OILSPILL.D#, enter a negative value for the file number as per Section 3.B, Line 1, to avoid the read.

2. See Section 4 for a description of other possible errors.

Table 1. WSFO's with present or future Ocean Service Units, and the latitude and longitude limits (degrees) of the coastline geography in the data set for each WSFO. West longitudes are positive.

| WSFO | Top Latitude | Bottom Latitude | Westmost Longitude | Eastmost Longitude |
|---|---|---|---|---|
| Seattle | 49.5 | 39.0 | 129.0 | 122.0 |
| San Francisco | 45.0 | 29.0 | 127.0 | 115.0 |
| Boston | 46.0 | 38.5 | 75.0 | 60.0 |
| Washington | 42.0 | 32.0 | 87.0* | 69.0 |
| Miami | 33.0 | 24.0 | 86.5 | 79.0 |
| New Orleans | 31.0 | 23.0 | 98.5 | 83.2 |
| Honolulu | 30.0 | 15.0 | 180.0 | 150.0 |
| Cleveland | 49.0 | 41.0 | 93.0 | 75.0 |
| Anchorage | 62.0 | 53.0 | 155.0 | 130.0 |

* 79.0 for latitudes between 36.0 and 42.0.

Table 2. Common spilled petroleum substances and their compositions, in terms of percentage of total mass in each category of half-life, as used in OILSPILL.

| Number | Substance | Half-Life (h) | | | | |
|---|---|---|---|---|---|---|
| | | 3 | 10 | 30 | 100 | 300 |
| 1 | Gasoline | 50 | 50 | 0 | 0 | 0 |
| 2 | Kerosene | 33 | 34 | 33 | 0 | 0 |
| 3 | Fuel Oil #1 | 5 | 40 | 45 | 10 | 0 |
| 4 | Fuel Oil #2 | 0 | 20 | 60 | 20 | 0 |
| 5 | Residuum | 0 | 0 | 30 | 40 | 30 |
| 6 | Light Crude | 10 | 30 | 30 | 20 | 10 |
| 7 | Medium Crude | 5 | 20 | 30 | 30 | 15 |
| 8 | Heavy Crude | 0 | 10 | 35 | 30 | 25 |
| 9 | Inert Substance* | 0 | 0 | 0 | 0 | 0 |

* The inert substance has an infinite half-life.

Table 3. Typical values of beached oil residence half-Life.

| Type of shoreline | Half-Life (h) |
|---|---|
| Exposed, rocky coast | 5-10 |
| Typical coast | 20-200 |
| Fine sand | 300 |
| Coarse sand | 600 |
| Gravel | 1000 |
| Sheltered coast | 1500 |

```
+-----------------------------------------------------------------------+
HRS FROM START=  9    GMT=82020309    HOR. SPACE= 0.15 NM, VERT= 0.30 I
KEY/$=SPILL SITE/0=1- 5 DRIFTERS/1= 6-10 DRIFTERS/.=SHORE/@=BEACHED OIL
TOTAL=  42  AFLOAT=  28  BEACHED=  14  WEATHERED=   0  REMOVED=   0   I
+----------------------+----------------------+----------------------+---+
I    .                ..                         0  0       .....         I
-    .                 .                      0  0              ..47,38-
I     .                .                      0                    ..   I
I     .                ..                   0                       ..  I
I     ...              .                  0  00                      .  I
I        ......         .               0 000 0                      .  I
I              ..        .              00             .........    ..  I
-        ...    ..     +...              0   +      .         .    47,36-
I     ...    .     .....               00           ..        .   .     I
I   ..        .                                     .          ...      I
I  .           ..                    0             .           .        I
I..             .                    0             ..                   I
I              .                    00              .                   I
I              .                    0                .                  I
-              .       +            $        +        .        47,34-
I              .                                      .                 I
I              .      ........                        .                 I
I              .       .   ..                         .                 I
I              ...     ....                            @                I
I                 ..       .                           @.               I
I                   ..                                   @              I
-                     ..                     +            @    47,32-
I                      ..                                  .            I
I                       ..                                  .           I
I                       .                                    .          I
I                      .                                      .         I
I                      .        ...                           .         I
-                    . +       .   .         +                 .   47,30-
122,35              122,30    .   ..     122,25               . 122,20 I
+----------------------+----------------------+----------------------+---+
```

Figure 1. Typical PPM output from OILSPILL. This picture shows surface oil distribution after 9 hours of simulation in Puget Sound near Elliott Bay, Wash. Oil began a continuous release at 0000 GMT, at 47° 34' N, 122° 27' W. At the same time an eliptical patch was initialized near 47° 32' N, 122° 26' W. The input data are shown in Fig. 3.

```
EXFMCPOIL
WOUS00 KEX1 081200
1.TDL/OILSPILL        FILE NUMBER(1 - 5) (NEG=NO READ)   [  ]
2.                                  TITLE FOR THIS RUN   [                        ]
3.       GMT DATE FOR START OF RUN (YR, MON, DAY, HRZ)   [  ] [  ] [  ] [  ]
4.            OIL SPILL NORTH LATITUDE (DEG, MIN, SEC)   [  ] [  ] [  ]
5.            OIL SPILL WEST LONGITUDE (DEG, MIN, SEC)  [   ] [  ] [  ]
6. MAP P/O INTERVAL (H), UNIT (EG 12), WIDTH (DEG,MIN)  [   ] [  ] [  ] [  ]
7. MAP HEIGHT AS PCT OF WIDTH, RISE (SEC), RIGHT (SEC)  [   ][   ][    ]
8.   MOVE SPILL SITE RIGHT (# SPACES), DOWN (# SPACES)   [  ] [  ]
9.   OIL THICKNESS INCREMENT (EG 5), 1 TO USE PREV RUN   [  ]  [ ]
10. TIME SPILL BEGINS (H), ENDS (H) FROM 0, FREQ(EG 2)  [   ][   ] [  ]
11.      WIND DRIFT FRACTION (10THS %), DRIFT ANG (DEG)  [   ] [  ]
12.                SPILL MATERIAL INDEX (1 TO 9), AGE (H)    [ ][   ]
13.   HORIZ DIFF COEFF (EG 100), BEACHED HALF-LIFE (H) [    ][   ]
14.      INITIAL OIL PLUME LENGTH (10THS NM), DIR (DEG)  [   ][   ]
15. AVG BACKGROUND CURRENT SPEED (10THS KT), DIR (DEG)  [   ][   ]
16.TIDAL CURRENT SPEED (10THS KT) AT FLOOD, EBB, & MIN  [   ][   ][    ]
17.           FLOOD CURRENT HEADING AT SPILL SITE (DEG)  [   ]
18.                 TIME OF FLOOD AFTER 0 H (HOUR, MIN)  [   ] [  ]
19.               SPEED OF SECOND FLOOD, EBB (10THS KT)  [   ][   ]
20.    FOR MOVING SOURCE ENTER TIME OF START (HR, MIN)  [   ] [  ]
21.      SOURCE WIND DRIFT (10THS %), CURRENT DRIFT (%)  [   ][   ]          [ ]
                                                                      PAGE 01
22.SOURCE POWERED SPEED (KT), DIR (DEG), DURATION (H)  (1[  ][   ] [  ]
 (2[  ][  ] [  ](3[  ][  ] [  ](4[  ][  ] [  ](5[  ][   ] [  ]
23.WIND FCST INTERVAL (H), MAXIMUM PROJECTION TIME (H)   [  ][   ]
24.                           ENTER WIND FORECASTS (DDSS) [    ][    ][    ][    ]
 [    ][    ][    ][    ][    ][    ][    ][    ][    ][    ][    ][    ][    ]
25.  NUMBER OF EXTRA TIDAL CURRENT STATIONS, 1 FOR P/O   [  ]  [ ]
     LAT               LON               DIR   SPEED (10THS KT)
  (1[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
  (2[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
  (3[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
  (4[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
  (5[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
  (6[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
  (7[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
  (8[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
  (9[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
 (10[  ] [  ] [  ][   ] [  ] [  ][   ][   ]
26.  NUM OF INITIAL ELLIPTICAL OIL PATCHES, HOUR SITED   [  ] [ ]
     LAT OF 1      LON OF 1      LAT OF 2      LON OF 2      WIDTH(10THS NM)
  (1[ ][ ][ ][  ][ ][ ][ ][ ][ ][ ][  ][ ][ ][ ][  ]
  (2[ ][ ][ ][  ][ ][ ][ ][ ][ ][ ][  ][ ][ ][ ][  ]
  (3[ ][ ][ ][  ][ ][ ][ ][ ][ ][ ][  ][ ][ ][ ][  ]
  (4[ ][ ][ ][  ][ ][ ][ ][ ][ ][ ][  ][ ][ ][ ][  ]         [ ]
                                                                      PAGE 02
```

Figure 2. OILSPILL preformat product. A message product, produced by this preformat, appears in Figure 3.

```
WOUS00 KEX1 211400
1.TDL/OILSPILL          FILE NUMBER(1 - 5) (NEG=NO READ)      4
2.                                    TITLE FOR THIS RUN    PUGET SOUND TEST
3.         GMT DATE FOR START OF RUN (YR, MON, DAY, HRZ)    82     02     03     00
4.              OIL SPILL NORTH LATITUDE (DEG, MIN, SEC)    47     34     00
5.              OIL SPILL WEST LONGITUDE (DEG, MIN, SEC)   122     27     00
6. MAP P/O INTERVAL (H), UNIT (EG 12), WIDTH (DEG,MIN)      3     12     00     16
7. MAP HEIGHT AS PCT OF WIDTH, RISE (SEC), RIGHT (SEC)     80
8.   MOVE SPILL SITE RIGHT (# SPACES), DOWN (# SPACES)
9.   OIL THICKNESS INCREMENT (EG 5), 1 TO USE PREV RUN      5      0
10. TIME SPILL BEGINS (H), ENDS (H) FROM 0, FREQ(EG 4)            12      6
11.      WIND DRIFT FRACTION (10THS %), DRIFT ANG (DEG)    34
12.                SPILL MATERIAL INDEX (1 TO 9), AGE (H)    9
13.   HORIZ DIFF COEFF (EG 100), BEACHED HALF-LIFE (H)    100     50
14.     INITIAL OIL PLUME LENGTH (10THS NM), DIR (DEG)    10     45
15. AVG BACKGROUND CURRENT SPEED (10THS KT), DIR (DEG)
16.TIDAL CURRENT SPEED (10THS KT) AT FLOOD, EBB, & MIN      3      4      1
17.            FLOOD CURRENT HEADING AT SPILL SITE (DEG)   170
18.                  TIME OF FLOOD AFTER 0 H (HOUR, MIN)     3     10
19.               SPEED OF SECOND FLOOD, EBB (10THS KT)     4      6
20.    FOR MOVING SOURCE ENTER TIME OF START (HR, MIN)      0
21.     SOURCE WIND DRIFT (10THS %), CURRENT DRIFT (%)
22.SOURCE POWERED SPEED (KT), DIR (DEG), DURATION (H)   (1
 (2                  (3                  (4                (5
23.WIND FCST INTERVAL (H), MAXIMUM PROJECTION TIME (H)      6     12
24.                        ENTER WIND FORECASTS (DDSS)   1810   2015   1917

25.  NUMBER OF EXTRA TIDAL CURRENT STATIONS, 1 FOR P/O       1      0
     LAT                LON                DIR   SPEED (10THS KT)
  (1 47     31     00    122     25           135      5
  (2
  (3
  (4
  (5
  (6
  (7
  (8
  (9
 (10
26.  NUM OF INITIAL ELLIPTICAL OIL PATCHES, HOUR SITED      1      00
     LAT OF 1       LON OF 1          LAT OF 2       LON OF 2        WIDTH(10THS NM)
  (1 47    32    00   122    24    50    47    31    00   122    24    00   007
  (2
  (3
  (4
```

Figure 3. The product which contains the data necessary to run OILSPILL. This product was created by the preformatted message shown in Figure 2.

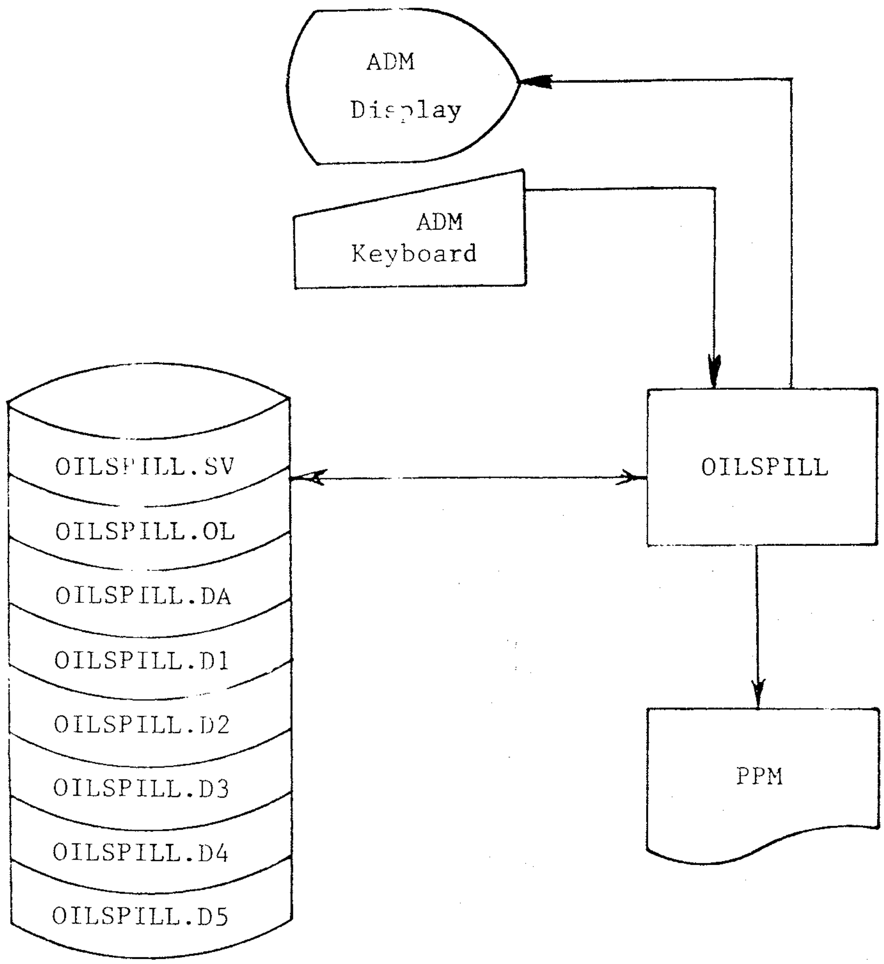
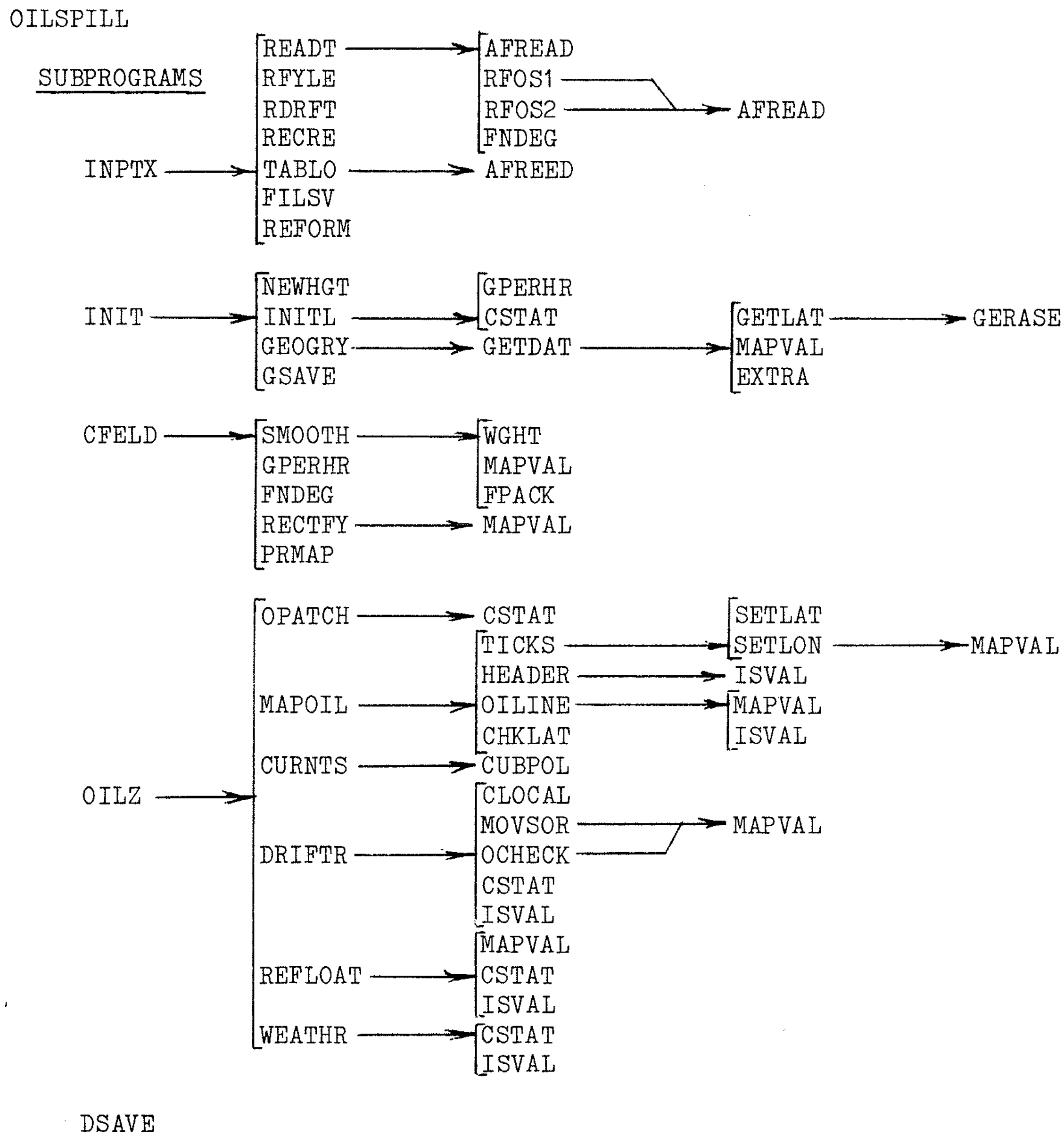



Figure 4. Data flow for the program OILSPILL.

MAIN PROGRAM




LOAD LINE

RLDR/P OILSPILL CSTAT DSAVE FNDEG GPERHR INPTX ISVAL OILZ MAPVAL
RECTFY [ READT AFREAD GTYPE RFOS1 RFOS2 , RFYLE RDRFT RECRE FILSV
REFORM TABLO AFREED , INIT EXTRA GEOGRY GERASE GETDAT GETLAT INITL
NEWHGT GSAVE , CFELD SMOOTH FPACK WGHT PRMAP , CURNTS CUBPOL
DRIFTR OCHECK CLOCAL MOVSOR REFLOAT WEATHR , MAPOIL CHKLAT HEADER
OILINE OPATCH SETLAT SETLON TICKS ] BG.LB UTIL.LB FORT.LB

Figure 5. Software structure and load line for program OILSPILL.

```
PUGET SOUND TEST
   82    2    3    0   47   34    0  122   27    0    3   12    0   16
   80    0    0    0    0    5    0   12   34    0    9    0    3   10
   30  100  300    0    0    0    0    0   50  100   10   45    0    0
    2  170    3    1    4    4    6    0    3   10    0    0    6
    1    0    6   12    3    1
   47 5333   47 5166  122 4138  122 3999    7
 1810 2015 1917
   47   31    0  122   25    0  135  166    0
  435
    010000    0    0 1100    0    0    0    0    0    0   1111100    0    0
    010000    0    0  100    0    0    0    0    0    0    0   1110000    0
    0 1000    0    0  100    0    0    0    0    0    0    0    011000    0
    0 1000    9    0  110    0    0    0    0    0    0    0    0  110    0
    0 1110    0    0   10    0    0    0    0    0    0    0    0   10    0
    0    111111    0    1    0    0    0    0    0    0    0    0   10    0
10000    0    011000    010000    0    0    0    0  1111111110000  110    0
    0    111000 1100   1110000    0    0    0    0 1000    0 1000 1100    0
    0 1110  100   1111100    0    0    0    0    011000    0 100010000    0
    110000   10    0    0    0    0    0    0    010000    0  111    0    0
   10    0    110000    0    0    0    0    0    1    0    0  100    0    0
 1100    0    010000    0    0    0    0    0    110000    0    0    0    0
10000    0    1    0    0    0    0    0    0    010000    0    0    0    0
    0    0    1    0    0    0    0    0    0    0 1000    0    0    0    0
    0    0    1    0    0    0    0    0    0    0  100    0    0    0    0
    0    0    1    0    0    0    0    0    0    0  100    0    0    0    0
    0    0    1    0 111111110    0    0    0    0  100    0    0    0    0
    0    0    1    0  100 1100    0    0    0    0  100    0    0    0    0
    0    0    111000   1111000    0    0    0    0   10    0    0    0    0
    0    0    0  110    0 1000    0    0    0    0   11    0    0    0    0
    0    0    0    110000    0    0    0    0    0    010000    0    0    0
    0    0    0    0 1100    0    0    0    0    0    0 1000    0    0    0
    0    0    0    0   11    0    0    0    0    0    0  100    0    0    0
    0    0    0    0    110000    0    0    0    0    0   10    0    0    0
    0    0    0    0   10    0    0    0    0    0    0    1    0    0    0
    0    0    0    0  100    0    0    0    0    0    0    010000    0    0
    0    0    0    0 1000    0 1110    0    0    0    0    010000    0    0
    0    0    0    010000    010001    0    0    0    0    0 1000    0    0
    0    0    0    1    0    1    011000    0    0    0    0 1000    0    0
1044
3737373737373737373737373737373737373737373737370155555555555555555555555
5555555555555555555555555555555555555555555555537373737373737373737373700
3737373745373437373737373737373737373737373437005555555555555555555555555
55555555555555555555555555555555555555555555556767672234373737343737373700
```

Figure 6. First 44 lines of the data file OILSPILL.D4 created by the Puget Sound test run. The geography array is contained in lines 11 through 40 as a series of five-digit numbers of 0's or 1's representing coast line in Fig. 1.

TDL CP 83-2
October 1983

# SIMULATION OF SPILLED OIL BEHAVIOR IN BAYS AND COASTAL WATERS

## PART A. PROGRAM INFORMATION and INSTALLATION PROCEDURE

PROGRAM NAME: OILSPILL

AAL ID: MOH004
Revision No.: 03.20

FUNCTION: This program allows the user to forecast the fate of oil spilled on the sea surface. The user must enter the latitude and longitude of the winds, and the tidal current characteristics of the area. The output is a series of maps showing the position of oil and areas of beached oil.

PROGRAM INFORMATION:

| | |
|---|---|
| Development Programmer: | Maintenance Programmer: |
| Kurt W. Hess | Kurt W. Hess |
| Location: Techniques Development Laboratory | Techniques Development Laboratory |
| Phone: FTS 427-7613 | FTS 427-7613 |
| Language: Fortran IV/Rev 5.20 | Type: Overlay |

Save file creation dates:

| | | |
|---|---|---|
| Original release/Rev. 01.00 | - | September 30, 1982 |
| First revision/Rev. 02.00 | - | January 14, 1983 |
| Second revision/Rev. 03.00 | - | February 14, 1983 |
| Third revision/Rev. 03.10 | - | May 9, 1983 |
| Fourth revision/Rev. 03.20 | - | September 9, 1983 |

Run Time: 1 to 10 Minutes

| | | | |
|---|---|---|---|
| Disk Space: | OILSPILL.SV | - | 100 RDOS blocks |
| | OILSPILL.OL | - | 130 RDOS blocks |
| | OILSPILL.DA | - | 40 RDOS blocks |
| | OILSPILL.D1 | - | 5 RDOS blocks |
| | OILSPILL.D2 | - | 5 RDOS blocks |
| | OILSPILL.D3 | - | 5 RDOS blocks |
| | OILSPILL.D4 | - | 5 RDOS blocks |
| | OILSPILL.D5 | - | 5 RDOS blocks |

PROGRAM REQUIREMENTS:

Program Files:

| NAME | COMMENTS |
|---|---|
| OILSPILL.SV | Code To Run Model |
| OILSPILL.OL | |

Data Files:

| NAME | DP Location | READ/WRITE | COMMENTS |
|---|---|---|---|
| OILSPILL.DA | DPO | R | Geography File |
| OILSPILL.D1 | DPO | R/W | Individual Run File |
| OILSPILL.D2 | DPO | R/W | Individual Run File |
| OILSPILL.D3 | DPO | R/W | Individual Run File |
| OILSPILL.D4 | DPO | R/W | Individual Run File |
| OILSPILL.D5 | DPO | R/W | Individual Run File |

AFOS Products:

| ID | PURPOSE | COMMENTS |
|---|---|---|
| EXFMCPOIL | Holds message composition Preformat | Rename for local use |
| EXFOILEXF | Holds data for individual run | Rename for local use |

LOAD LINE

```
RLDR/P OILSPILL CSTAT DSAVE FNDEG GPERHR INPTX ISVAL OILZ MAPVAL
RECTFY [ READT AFREAD GTYPE RFOS1 RFOS2 , RFYLE RDRFT RECRE FILSV
REFORM TABLO AFREED , INIT EXTRA GEOGRY GERASE GETDAT GETLAT INITL
NEWHGT GSAVE , CFELD SMOOTH FPACK WGHT PRMAP , CURNTS CUBPOL
DRIFTR OCHECK CLOCAL MOVSOR REFLOAT WEATHR MAPOIL CHKLAT HEADER
OILINE OPATCH SETLAT SETLON TICKS ] BG.LB UTIL.LB FORT.LB
```

PROGRAM INSTALLATION:

1. Insert floppy disk into DP3.

2. Move OILSPILL.<SV OL DA D1 D2 D3 D4 D5> files to DPOF. Then create LINKS on DPO for each file (OILSPILL.SV, etc.).

3. Select a product key, cccMCPxxx, for the preformat and store EXFMCPEXF into it by entering

   STORE:DP3:EXFMCPEXF cccMCPxxx

   Select a product key, cccnnnxxx, for the OILSPILL data file and store EXFOILEXF into it by entering:

   STORE:DP3:EXFOILEXF cccnnnxxx

# SIMULATION OF SPILLED OIL BEHAVIOR IN BAYS AND COASTAL WATERS

## PART B. PROGRAM EXECUTION and ERROR CONDITIONS

PROGRAM NAME: OILSPILL

AAL ID: MOH004
Revision No.: 03.20

### PROGRAM EXECUTION:

1. Make sure that the files for OILSPILL exist on either DPO or on DPOF with links to them on DPO, and that the OILSPILL preformat, cccMCPxxx, and the OILSPILL data product, cccnnnxxx, (see Part A) exist in the PIL.

2. Either use the preformat (cccnnnxxx), to create a new run file, or edit an old run file, so that the spill data are as desired. Data values entered in the brackets should be right-justified. Although most of the data entry is self-explanatory, refer to Section 3.B for details.

3. Run the program by entering at the ADM:

   RUN:OILSPILL cccnnnxxx

   where cccnnnxxx is the OILSPILL data file.

4. Look for output at the PPM.

### ERROR CONDITIONS:

1. Errors are most likely to occur when new files are opened. Look at the Dasher status messages to tell where in the program the problem occurs. If there is an error when reading the run data files, OILSPILL.D#, enter a negative value for the file number as per Section 3.B, Line 1, to avoid the read.

2. See Section 4 for a description of other possible errors.

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