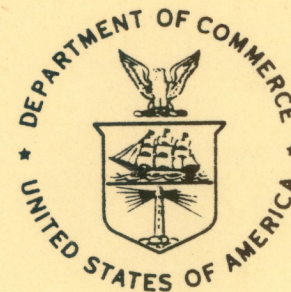


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NOAA Western Region Computer Programs and
Problems NWS WRCP - No. 26



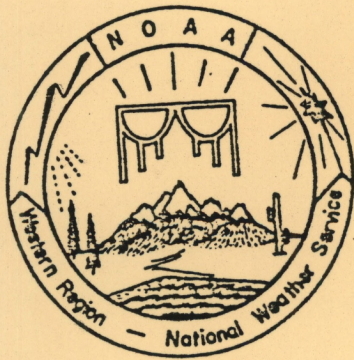
PROGRAM TO COMPUTE DOWNWIND CONCENTRATIONS FROM A TOXIC SPILL

Salt Lake City, Utah
February 1981

**U.S. DEPARTMENT OF
COMMERCE**

/ National Oceanic and
Atmospheric Administration

/ National Weather
Service



PREFACE

This Western Region publication series is considered as a subset of our Technical Memorandum series. This series will be devoted exclusively to the exchange of information on and documentation of computer programs and related subjects. This series was initiated because it did not seem appropriate to publish computer program papers as Technical Memoranda; yet, we wanted to share this type of information with all Western Region forecasters in a systematic way. Another reason was our concern that in the developing AFOS-era there will be unnecessary and wasteful duplication of effort in writing computer programs in National Weather Service (NWS). Documentation and exchange of ideas and programs envisioned in this series hopefully will reduce such duplication. We also believe that by publishing the programming work of our forecasters, we will stimulate others to use these programs or develop their own programs to take advantage of the computing capabilities AFOS makes available.

We solicit computer-oriented papers and computer programs from forecasters for us to publish in this series. Simple and short programs should not be prejudged as unsuitable.

The great potential of the AFOS-era is strongly related to local computer facilities permitting meteorologists to practice in a more scientific environment. It is our hope that this new series will help in developing this potential into reality.

NOAA Western Region Computer Programs and Problems NWS WRCP

- 1 Standard Format for Computer Series. June 1979
- 2 AFOS Crop and Soil Information Report Program. Ken Mielke, July 1979.
- 3 Decoder for Significant Level Transmissions of Raobs. John A. Jannuzzi, August 1979.
- 4 Precipitable Water Estimate. Elizabeth Morse, October 1979.
- 5 Utah Recreational Temperature Program. Kenneth M. Labas, November 1979.
- 6 Normal Maximum/Minimum Temperature Program for Montana. Kenneth Mielke, Dec. 1979.
- 7 Plotting of Ocean Wave Energy Spectral Data. John R. Zimmerman, Dec. 1979.
- 8 Raob Plot and Analysis Routines. John Jannuzzi, January 1980.
- 9 The SWAB Program. Morris S. Webb, Jr., April 1980. (PB 80-196041)
- 10 Flash-Flood Procedure. Donald P. Laurine and Ralph C. Hatch, April 1980. (PB 80-198658)
- 11 Program to Forecast Probability of Summer Stratus in Seattle Using the Durst Objective Method. John Zimmerman, May 1980.
- 12 Probability of Sequences of Wet and Dry Days. Hazen H. Bedke, June 1980. (PB80-223340)
- 13 Automated Montana Hourly Weather Roundup. Joe L. Johnston, July 1980. (PB81102576)
- 14 Lightning Activity Levels. Mark A. Mollner, July 1980. (PB81108300)
- 15 Two Fortran Applications of Wind-Driven Ekman Water Transport Theory: Upwelling Index and Storm Tide. Kent S. Short, July 1980. (PB81102568)
- 16 AFOS System Local Database Save and Rebuild Procedures or A Master Doomsday Program. Brian W. Finke, July 1980. (PB81108342)
- 17 AFOS/RDOS Translator Subroutine. Morris S. Webb, Jr., August 1980. (PB81108334)
- 18 AFOS Graphics Creation from Fortran. Alexander E. MacDonald
- 19 DATAKEYØ Repair Program. Paul D. Tolleson, August 1980. (PB81102543) (PB81-128035)
- 20 Contiguous File Transfer from the DPCM to the DCM. Paul D. Tolleson, September 1980
- 21 Freezing Level Program. Kenneth B. Mielke, September 1980. (PB81-128043)
- 22 Radar Boresighting Verification Program. Thomas E. Adler, November 1980.
- 23 Accessing the AFOS Database. Matthew Peroutka, January 1981.
- 24 AFOS Word Processor. Morris S. Webb, Jr., February 1981.
- 25 Automated Weather Log for Terminal Forecasting. John A. Jannuzzi, February 1981.

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PROGRAM TO COMPUTE DOWNWIND CONCENTRATIONS FROM A TOXIC SPILL
"

John Zimmerman

National Weather Service Forecast Office
Seattle, Washington
February 1981

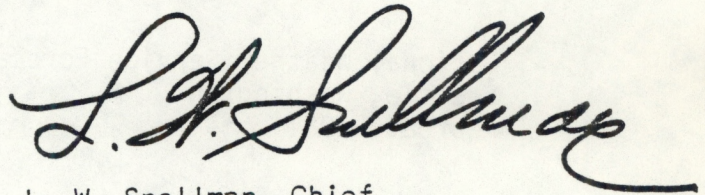
UNITED STATES
DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

National Weather
Service
Richard E. Hallgren, Director



This Technical Memorandum has been
reviewed and is approved for
publication by Scientific Services
Division, Western Region.

A handwritten signature in dark ink, appearing to read "L. W. Snellman". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

L. W. Snellman, Chief
Scientific Services Division
Western Region Headquarters
Salt Lake City, Utah

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PROGRAM TO COMPUTE DOWNWIND CONCENTRATIONS FROM A TOXIC SPILL

John Zimmerman
National Weather Service Forecast Office
Seattle, Washington

I. General Information

A. Summary:

One of the unscheduled duties of the Air Pollution Focal Point is to provide meteorological assistance in event of an accidental spill of toxic material. The immediate requirements of an on-site cleanup crew are for wind information at the location of the accident and wind forecasts for the next 12 to 24 hours. Site wind direction is obviously the most critical factor in determining what areas should be evacuated, if materials released into the atmosphere are toxic or otherwise harmful.

Making an accurate forecast of surface winds in mountain-valley terrain of the Western Region is a difficult task and must be given first priority. The Air Pollution Focal Point should, first of all, provide good weather forecasts, especially wind forecasts.

On rare occasions, however, Weather Service meteorologists may be able to render additional assistance by using "AFOS" power. Normally, estimates of downwind concentrations from a toxic spill will be provided by the EPA meteorologist when such estimates are necessary. It is conceivable, especially during nonduty hours or on weekends, that the EPA meteorologist may be difficult to contact. Therefore, the following simple computer program was developed for such occasions when it is necessary to quickly estimate toxic air concentrations and no other experts are available.

Downwind pollutant concentration is computed assuming that the plume is a continuous point source and has a Gaussian distribution, i.e.,

$$X = \frac{Q}{2\pi \sigma_y \sigma_z u} \cdot \exp -\frac{1}{2} \left(\frac{y}{\sigma_y} \right)^2 \cdot \left\{ \exp \left[-\frac{1}{2} \left(\frac{z-H}{\sigma_z} \right)^2 \right] + \exp \left[-\frac{1}{2} \left(\frac{z+H}{\sigma_z} \right)^2 \right] \right\}$$

A complete description of the Gaussian plume model and its application can be found below in C. Reference. The dispersion coefficients used, sigma y (σ_y) and sigma z (σ_z), are given in Table I.

In the program the option is allowed of either entering a value of atmospheric stability or having a value computed based on the weather conditions. Five stability values are available, i.e.,

1. very unstable
2. unstable
3. slightly unstable
4. neutral
5. stable.

The weather parameters which are used to determine atmospheric stability are given in Table II.

Output of concentration X is given in grams per-cubic meter. The units for input of wind and height of release are in the usual English units, knots, and feet as shown in the sample run of the Application section. The computer program converts these units into meters per second and meters, respectively.

The release rate Q should be input in grams per second. Information on release rate Q will be difficult to obtain when an accidental spill occurs.

If a value of 1 is input for Q, however, then relative values of air concentration are obtained; that is, concentrations normalized with respect to Q. Relative concentration (x/Q) is useful in determining the relative values of concentration at different locations. In other words, if off axis plume concentrations are measured, concentrations can be found for other locations by using the ratios of relative concentration determined by computer. It is also possible to work backwards to determine the amount of material released by considering Q the unknown and along with actual measurements of air concentration, calculate Q from computed values of relative concentration, i.e.,

$$Q = \left(\frac{X}{Q X_m} \right)^{-1}$$

where $\frac{X}{Q}$ = relative concentration
 X_m = measured concentration.

B. Environment:

This program is written in FORTRAN IV and is run on the Eclipse S/230 computer.

C. Reference:

Turner, D. B. (1969): Workbook of Atmospheric Dispersion Estimates. USDHEW PHS Environmental Health Series, Air Pollution PHS Publication No. 999-AP-26.

II. Application

A. Complete Program Description:

This computer program has been incorporated into an AFOS procedure called "SPILL". Input data are manually input into a preformat called GAS, which is shown in Figure 1. Procedure SPILL automatically calls preformat GAS to the ADM.

Table I. Dispersion Coefficients σ_y and σ_z

Stability Class	Crosswind Constant ⁽¹⁾ a	Constants for Vertical Diffusion Parameter, σ_z ⁽²⁾							
		$x \leq x_1$		x_1 (Meters)	$x_1 \leq x \leq x_2$		x_2 (Meters)	$x_2 \leq x$	
		b	q		b	q		b	q
A	0.40	0.125	1.03	250	0.00883	1.51	500	0.000226	2.10
B	0.295	0.119	0.986	1000	0.0579	1.09	10,000	0.0579	1.09
C	0.20	0.111	0.911	1000	0.111	0.911	10,000	0.111	0.911
D	0.13	0.105	0.827	1000	0.392	0.636	10,000	0.948	0.540
E	0.098	0.100	0.778	1000	0.373	0.587	10,000	2.85	0.366

(1) $\sigma_y = ax^{0.903}$, Where x is Downwind Distance from Source; σ_y and x are in Meters.

(2) $\sigma_z = bx^q$; σ_z and x are in Meters.

Table II. Weather and Stability Categories

Surface Wind Speed (at 10 m), m sec ⁻¹	Day			Night	
	Incoming Solar Radiation			Thinly Overcast or Low Cloud	
	Strong	Moderate	Slight	Cloud	Cloud
2	A	A-B	B		
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
6	C	D	D	D	D

The neutral class D, should be assumed for overcast conditions during day or night.

SEAMCPGAS
WOUS00 KSEA 221741

INPUT DATA FOR PROGRAM SPILL TO COMPUTE DOWNWIND CONCENTRATIONS.

HEIGHT OF SPILL [] FEET
RATE OF SPILL [] GRAMS/SEC
HEIGHT OF RECEPTOR [] FEET

...DOWNWIND LOCATIONS

1. [] MILES
2. [] "
3. [] "
4. [] "
5. [] "

WIND SPEED

[] KNOTS

...CROSWIND LOCATIONS

1. [] MILES
2. [] "
3. [] "
4. [] "
5. [] "

...ATMOSPHERIC STABILITY IF KNOWN ENTER VALUE...

OTHERWISE ENTER 0 []

...IF STABILITY UNKNOWN FILL IN BELOW...SKIP IF KNOWN...

SKY NOT OVERCAST=0.....SKY OVERCAST=1 []

OVERCAST THIN=0.....OVERCAST THICK=1 []

DAYTIME=0.....NIGHTTIME=1 []

SOLAR RADIATION STRONG=1 MODERATE=2 SLIGHT=3 []

[[

Figure 1. AFOS Preformat for Data Entry.

III. Procedures

A. Input/Output:

The following is an example of input data and resultant output on ADM.

```
TEMPORARY
WOUS00 KSEA 221736
.....1.....2.....3.....4.....5.....6...../
INPUT DATA FOR PROGRAM SPILL TO COMPUTE DOWNWIND CONCENTRATIONS.
  HEIGHT OF SPILL      0.      FEET
  RATE OF SPILL        3.      GRAMS/SEC
  HEIGHT OF RECEPTOR 0.      FEET

...DOWNWIND LOCATIONS      ...CROSWIND LOCATIONS
  1. .1      MILES          1. 0.      MILES
  2. .5      "              2. .25     "
  3. 1.      "              3. .5      "
  4. 3.      "              4. .75     "
  5. 15.     "              5. 1.      "
WIND SPEED                14.      KNOTS

...ATMOSPHERIC STABILITY IF KNOWN ENTER VALUE...
      OTHERWISE ENTER 0 4
...IF STABILITY UNKNOWN FILL IN BELOW...SKIP IF KNOWN...
SKY NOT OVERCAST=0....SKY OVERCAST=1
OVERCAST THIN=0.....OVERCAST THICK=1
DAYTIME=0.....NIGHTTIME=1
SOLAR RADIATION STRONG=1 MODERATE=2 SLIGHT=3
```

```
PORARY      EWOUS00 KSEA 221736
WIND SPEED = 14.KNOTS      ATMOSPHERIC STABILITY = 4
MILES
DOWNWIND      0.00      0.25      0.50      0.75      1.00
0.1      0.192E -3 0.000E 0 0.000E 0 0.000E 0 0.000E 0
0.5      0.161E -4 0.279E -16 0.000E 0 0.000E 0 0.000E 0
1.0      0.556E -5 0.240E -8 0.195E -18 0.000E 0 0.000E 0
3.0      0.102E -5 0.353E -6 0.145E -7 0.704E -10 0.407E -13
15.0     0.937E -7 0.884E -7 0.743E -7 0.555E -7 0.369E -7
```

B. Program Listing:

1. Procedure "SPILL".
2. Program Spill.

SEAPCD004
 WOUSD00 KSEA 181855

	DISPLAY (1-4)	MODE (D/M)	ACC/OV (R/A/O)	COMMAND (ANY COMMAND; LAST LINE MUST BE END OF "NAME")
01				PURGE:TEMPORARY
02				PAUSE 5
03	1	M	R	M:GAS
04				PAUSE 5
05				SAVE:TEMPORARY DP0F:TEMPORARY
06				PAUSE 5
07				RUN:@SPILLX@
08				PAUSE 20
09	1	D	R	DSP:DP0F:SPILL
10				END
11				
12				
13				
14				
15				
16				
17				
18				

Procedure "SPILL"

```

DIR DP0F
DELETE DP0F:TOXICSPIL
RENAME DP0F:TEMPORARY DP0F:TOXICSPIL
DELETE DP0F:SPILL
CRAND DP0F:SPILL
DP0F:SPILL.SV
DIR DP0
  
```

File SPILLX

TYPE SPILL.FR

PROGRAM TO COMPUTE DOWNWIND CONCENTRATIONS FROM A TOXIC SPILL

```
C
C
DIMENSION STA(5,5),SYA(5),SZA(5,3),SZB(5,3)
DIMENSION CQ(5,5),XD(5),YD(5),AA(80)
  CALL OPEN(20,"TOXICSPIL",1,IER,500)
  READ(20,50)AA
50  FORMAT(80A1)
  READ(20,5)Z,Q,H
5  FORMAT(//,3(30X,F5.0,/,/),/)
  TYPE Z,Q,H
  Z=Z/3.2808
  H=H/3.2808
  DO 6 I=1,5
6  READ(20,7)XD(I),YD(I)
7  FORMAT(15X,F5.0,20X,F5.0)
  READ(20,8)U,KK,KS,KT,KD,KR
8  FORMAT(30X,F5.0,///,40X,I1,///,3(55X,I1,/,/),60X,I1)
  CALL CLOSE(20,IER)
  TYPE XD(1),YD(1),U,KK,KS,KT,KD,KR
  U=U/1.9425
  CALL OPEN(20,"SPILL1",1,IER,500)
  DO 4 I=1,5
  READ(20,9)(STA(I,J),J=1,5)
9  FORMAT(5F5.0)
4  CONTINUE
  CALL CLOSE(20,IER)
  IF(KK.NE.0)GO TO 40
  CALL STAB(U,KK,KS,KT,KD,KR,STA)
40  TYPE "1"
  CALL OPEN(20,"SPILL2",1,IER,500)
  READ(20,15)(SYA(I),I=1,5)
15  FORMAT(5F5.0)
  CALL CLOSE(20,IER)
  CALL OPEN(20,"SPILL3",1,IER,500)
  DO 11 J=1,3
  READ(20,16)(SZA(I,J),I=1,5)
16  FORMAT(5F10.0)
11  CONTINUE
  CALL CLOSE(20,IER)
  CALL OPEN(20,"SPILL4",1,IER,500)
  DO 12 J=1,3
  READ(20,16)(SZB(I,J),I=1,5)
12  CONTINUE
  CALL CLOSE(20,IER)
  TYPE "2"
  DO 10 QI=1,5
  DO 10 J=1,5
  CALL CHI(Z,H,U,KK,Q,I,J,C,XD,YD,SYA,SZA,SZB)
  CQ(I,J)=C
```



```

10  CONTINUE
    TYPE "3"
    CALL OPEN(20,"SPILL",3,IER,500)
    WRITE(20,50)AA
    U=U*1.9425
    WRITE(20,21)U,KK
    WRITE(10,21)U,KK
21  FORMAT("    WIND SPEED =",F4.0,"KNOTS","
           WRITE(20,22)(YD(I),I=1,5)
           WRITE(10,22)(YD(I),I=1,5)
22  FORMAT("    MILES
           1" DOWNWIND    ",5F10.2)
           DO 30 I=1,5
           WRITE(20,23)XD(I),(CQ(I,J),J=1,5)
           WRITE(10,23) XD(I),(CQ(I,J),J=1,5)
23  FORMAT(F11.1,5X,5E10.3)
30  CONTINUE
    STOP
    END

```

ATMOSPHERIC STABILITY

MILES CROSSWIND",/,

R

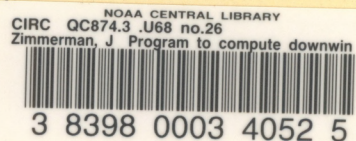
TYPE SPILL01.FR

```
      SUBROUTINE STAB(U,KK,KS,KT,KD,KR,STA)
      DIMENSION STA(5,5)
      IF(KS.NE.0)GO TO 60
      IF(U.LE.4)GO TO 11
      IF(U.LE.6)GO TO 12
      IF(U.LE.10)GO TO 13
      IF(U.LE.12)GO TO 14
      IS=5
      GO TO 20
11     IS=1
      GO TO 20
12     IS=2
      GO TO 20
13     IS=3
      GO TO 20
14     IS=4
20     CONTINUE
      IF(KD.NE.0)GO TO 30
      JS=KR
      GO TO 40
30     IF(KT.EQ.1)JS=4
      IF(KT.EQ.0)JS=5
40     CONTINUE
      KK=STA(IS,JS)
      GO TO 70
60     KK=4
70     CONTINUE
      RETURN
      END
      R
```


TYPE SPILL02.FR

```
      SUBROUTINE CHI(Z,H,U,KK,Q,I,J,C,XD,YD,SYA,SZA,SZB)
      DIMENSION XD(5),YD(5),SYA(5),SZA(5,3),SZB(5,3)
      X=XD(I)*1609
      Y=YD(J)*1609
      IF(KK.NE.1)GO TO 30
      IF(X.GT.250)GO TO 10
      IX=1
      GO TO 100
10     IF(X.GT.500)GO TO 20
      IX=2
      GO TO 100
20     IF(X.GT.1000)GO TO 40
      IX=3
      GO TO 100
30     IF(X.GT.10000)GO TO 50
      IX=2
      GO TO 100
40     IF(X.GT.100000)GO TO 50
      IX=3
      GO TO 100
50     CONTINUE
100    SY=SYA(KK)*X**2.903
      SZ=SZA(KK,IX)*X**2*SZB(KK,IX)
      A=Q/(6.2832*U*SY*SZ)
      B=.5*((Z-H)/SZ)**2+EXP(-.5*((Z+H)/SZ)**2)
      IF(B.GT.50)GO TO 200
      B=EXP(-B)
      C=.5*((Y/SY)**2)
      IF(C.GT.50)GO TO 200
      C=EXP(-C)
      C=A*B*C
      GO TO 300
200    C=0
300    RETURN
      END
```

R



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