

WM-10
PDR

AUG 06 1982

101
3104.2/SAS/82/08/02/0

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Distribution:

- ✓ WMHL file
- WMHL r/f
- WM r/f
- NMSS r/f
- JBMartin
- REBrowning
- MJBell
- SASilling & r/f
- HJMiller
- JOBunting
- PDR
- DJFehringer
- MNataraja
- CBelote

Return to
WM
623-55

101
WMHL: 3104-2

MEMORANDUM FOR: Malcolm R. Knapp
High-Level Waste Licensing
Management Branch
Division of Waste Management

FROM: Stewart A. Silling
High-Level Waste Licensing
Management Branch
Division of Waste Management

SUBJECT: INTERACTIVE BASALT MODEL

WMHT has expressed an interest in using an interactive, deterministic model for radionuclide transport at Hanford. I have implemented such a model, which is based on the NWFT method of solution. The model runs in a calculator mode, allowing the user to change parameters and immediately see the effect on discharge.

The attached document describes the model and how to use it.

ORIGINAL SIGNED BY
Stewart A. Silling
High-Level Waste Licensing
Management Branch
Division of Waste Management

Enclosure:
As stated

00025

OFC : WMHL <i>SJS</i> :	:	:	:	:	:	:
NAME : SASilling:lmc	:	:	:	:	:	:
DATE : 8/6 /82	:	:	:	:	:	:

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AN INTERACTIVE MODEL FOR TRANSPORT IN BASALT

This model is an interactive program for performing simple, deterministic calculations of radionuclide discharge at the Hanford site. It allows the user to modify the input parameters easily and immediately see the effect on discharge.

The flow model is a two-pipe network (see Figure 1). One pipe is vertical, representing flow from the repository to an aquifer. The other pipe is horizontal, representing the aquifer which transports material from the site to the accessible environment.

The transport solution used is derived from the BAND model in NWFT/DVM, which is based on an analytic solution by Lester, Jansen, and Burkholder [1]. The discharge is integrated over 10,000 years and is expressed as a fraction of the release limit allowed by the EPA Standard.

The nuclides and their initial inventories are preset. The nuclides are C14, Sr90, Tc99, I129, Sn126, Ni53, Zr93, Cs135, Cs137, Am243, Am241, Pu240, Pu239, Pu238, Np237, and U234. The initial inventories represent the composition of spent fuel.

Most of the remaining parameters in the model can be set by the user. However, each parameter has a "base case" default value which the model assumes unless it is overridden by the user.

The optional parameters are shown in Table 1.

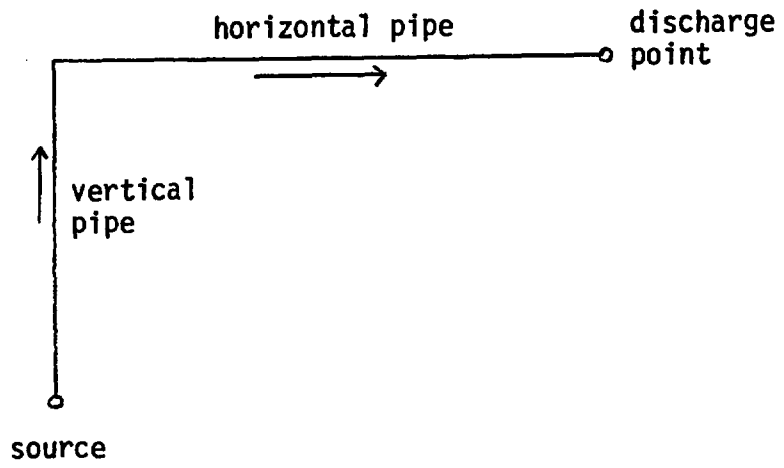


Figure 1. Two pipe network.

Table 1. Parameters

<u>Name</u>	<u>Units</u>	<u>Default</u>	<u>Meaning</u>
KDVC	ml/gm	0	Kd in vertical pipe for carbon
KDVI	ml/gm	2.05E0	Kd in vertical pipe for iodine
KDVTC	ml/gm	1.22E1	Kd in vertical pipe for technecium
KDVFP	ml/gm	3.14E2	Kd in vertical pipe for Sn, Ni, Zr, Cs, and Sr
KDVAM	ml/gm	7.07E3	Kd in vertical pipe for americium
KDVPU	ml/gm	4.84E2	Kd in vertical pipe for plutonium
KDVU	ml/gm	7.21E1	Kd in vertical pipe for uranium
KDVNP	ml/gm	2.05E2	Kd in vertical pipe for neptunium
KDHC	ml/gm	0	Kd in horizontal pipe for carbon
KDHI	ml/gm	1.00E0	Kd in horizontal pipe for iodine
KDHTC	ml/gm	3.16E0	Kd in horizontal pipe for technecium
KDHFP	ml/gm	2.24E0	Kd in horizontal pipe for Su, Ni, Zr, Cs, and Sr
KDHAM	ml/gm	3.16E1	Kd in horizontal pipe for americium
KDHPU	ml/gm	1.00E1	Kd in horizontal pipe for plutonium
KDHU	ml/gm	1.00E1	Kd in horizontal pipe for uranium
KDHNP	ml/gm	7.07E-1	Kd in horizontal pipe for neptunium
SOLC	gm/gm	infinite	Solubility of carbon
SOLI	gm/gm	infinite	Solubility of iodine
SOLTC	gm/gm	1.00E-8	Solubility of technecium
SOLFP	gm/gm	infinite	Solubility of Sn, Ni, Zr, Cs, and Sr
SOLAM	gm/gm	infinite	Solubility of americium
SOLPU	gm/gm	2.50E-10	Solubility of plutonium

(continued)

(Table 1, continued)

<u>Name</u>	<u>Units</u>	<u>Default</u>	<u>Meaning</u>
SOLU	gm/gm	2.00E-5	Solubility of uranium
SOLNP	gm/gm	2.50E-16	Solubility of neptunium
DISP	ft ²	5.00E2	Dispersivity
AREAV	ft ²	8.61E6	Cross-sectional area of vertical pipe
CONDV	ft/da	4.20E-5	Conductivity in vertical pipe
CONDH	ft/da	1.00E2	Conductivity in horizontal pipe
PORV	--	1.20E-2	Porosity in vertical pipe
PORH	--	2.00E-1	Porosity in horizontal pipe
GRADV	ft/ft	1.75E-2	Gradient in vertical pipe
GRADH	ft/ft	5.05E-3	Gradient in horizontal pipe
DISTV	ft	3.25E-3	Length of vertical pipe
DISTH	ft	5.28E3	Length of horizontal pipe
LEACH	yr	1.00E5	Leach time
CANLIFE	yr	1.00E3	Canister life

In order to help account for the fact that vertical flow in basalt is primarily through fractures, a correction proposed by Pepping, Chu, and Siegel [2] is applied to the retardation factor in the vertical pipe. This retardation factor is assumed to be

$$R = 1 + K_d \rho$$

instead of the porous medium expression

$$R = 1 + K_d \rho (1-\phi)/\phi$$

The conductivity in the vertical pipe is an equivalent value which accounts for the series of different resistances in the various layers. The assumed stratigraphy for the site is shown in Figure 2 and the estimated conductivities and porosities are shown in Table 2. The conductivity for the vertical pipe is found as follows:

$$K_{avg} = \frac{\sum_{i=1}^n L_i}{\sum_{i=1}^n \frac{L_i}{K_i}}$$

where L_i = thickness of layer i
 K_i = conductivity of layer i

The average porosity is found similarly:

$$\phi_{avg} = \frac{\sum_{i=1}^n L_i}{\sum_{i=1}^n \frac{L_i}{\phi_i}}$$

where ϕ_i = porosity of layer i

Using the numerical values shown in Table 2, the average values are found to be as follows:

$$K_{avg} = 4.2E-5 \text{ ft/da}$$
$$\phi_{avg} = 0.012$$

These average values are used as the defaults for the vertical pipe flow parameters. The default values for the horizontal leg are characteristic of the overlying aquifer, layer UA.

The default values for Kd in the vertical pipe are taken from Pepping, Chu, and Siegel [3] and represent the properties of reducing secondary minerals. The Kd values for the horizontal leg are taken from the same source and represent oxidizing sandstone or siltstone. The default solubilities are also taken from this report [4].

Use of the Program

The program operates at the Brookhaven CSCF on either of the 6600 machines, MFA and MFB. It is assumed that the user knows how to dial up and login to one of these machines.

Following the login procedure, execute the following commands:

```
ATTACH,EZHANF,ID=SAS,MR=1.  
ETL,400.  
EZHANF.
```

<u>i</u>	<u>Layer</u>	<u>Effective Thickness (ft)</u>	<u>Horizontal Hydraulic Conductivity (ft/da)</u>	<u>Vertical Hydraulic Conductivity (ft/da)</u>	<u>Effective Porosity</u>
1	UA	100	1.0E2	1.0E2	1.7E-1
2	J	850	4.5E-1	4.5E-1	1.1E-2
3	I-M	150	1.2E1	1.2E0	1.4E-1
4	H	150	1.0E-1	1.0E-1	1.1E-2
5	G	200	3.2E-2	3.2E-2	1.1E-2
6	F	690	1.0E-4	1.0E-4	1.1E-2
7	I-V	10	1.0E0	1.0E-1	1.4E-1
8	E	690	3.2E-6	3.2E-5	1.1E-2
9	D	60	1.0E-2	1.0E-2	3.5E-2
10	C	50	3.2E-6	3.2E-5	5.0E-3
11	B	150	1.0E-2	1.0E-2	3.5E-2
12	A	150	3.2E-7	3.2E-6	5.0E-3

Table 2. Flow parameters by layer

The program will type some messages and then will await a command. The commands are as follows:

- | | |
|-----------------|---|
| LIST | View the current parameters. |
| (PARAM)=(VALUE) | Set a parameter to a new numerical value. Parameters are listed in Table 1. Example: CONDV=0.1. |
| (PARAM)=DEFAULT | Set a parameter to the default value. |
| ALL=DEFAULT | Set all parameters to their defaults. |
| RELOAD | Set all parameters to what their values were the last time a GO command was entered. (This is useful in recovering from system aborts.) |
| GO | Execute the model and print results. Retain the current parameter values following completion. |
| LONG | Turn on or off the option for printing discharges for each nuclide. |
| QUIT | Leave the EZHANF program. |
| HELP | View a writeup on how to use the program. |

Error Recovery

Occasionally entry of bad data may cause a system abort, usually as a result of an internal attempt to divide by zero. When this occurs, the user will be returned to Intercom command mode, indicated by an error message and a "COMMAND" prompt. The program may then be restarted by typing the following line:

START.

The program will then load the default values for the parameters. The last set of user-defined parameters (which caused the abort) can be reloaded by typing the following line:

RELOAD

Then the erroneous value can be corrected.

Example

The following output from an interactive session illustrates all the commands. Lines typed by the user are shown in lower case letters, while lines typed by the computer are shown in upper case.

Dial up: x28380 for 300 baud

BROOKHAVEN INTERCOM 4.7
DATE 08/05/82
TIME 14.38.23.

PLEASE LOGIN

LOGIN: SILLING: 7EFG: 1349: SUP.

← Login

SUP UPDATED 08/04/82 TODAY IS 08/05/82

SEE LOGIN FOR IMPORTANT MESSAGES.

P1 NMSILLING PNO01349
COMMAND- ATTACH: EZHAF: IDSAS: MR=1.

PFM IS
EZHAF
CY= 017 SN=SHARE
COMMAND- ETL: 400.

COMMAND- EZHAF.

UPDATE CREATION RUN
:CREATING NEW PROGRAM LIBRARY
UPDATE COMPLETE.
DEFAULT PARAMETERS LOADED.
READY.

← Commands to initiate program.

← System messages - may appear in a different order. May take a few minutes.

2.153 CP SECONDS COMPILATION TIME LIST

← First user command.

KDVC	= 0.	KDVI	= 2.050000E+00
KDVT	= 1.220000E+01	KDVFP	= 3.140000E+02
KDVAM	= 7.070000E+03	KDVFU	= 4.840000E+02
KDU	= 7.210000E+01	KDVNP	= 2.050000E+02
KDHC	= 0.	KDHI	= 1.000000E+00
KDHTC	= 3.160000E+00	KDHFP	= 2.240000E+00
KDHAM	= 3.160000E+01	KDHPU	= 1.000000E+01
KDHU	= 1.000000E+01	KDHNP	= 7.070000E-01
SOLC	= 9.999900E+04	SOLI	= 9.999900E+04
SOLTC	= 1.000000E-08	SOLFP	= 9.999900E+04
SOLAM	= 9.999900E+04	SOLPU	= 2.500000E-10
SOLU	= 2.000000E-05	SOLNP	= 2.500000E-16
DISP	= 5.000000E+02	AREAV	= 8.610000E+06
CONDV	= 4.200000E-05	CONDH	= 1.000000E+02
PORV	= 1.200000E-02	PORH	= 2.000000E-01
GRADV	= 1.750000E-02	GRADH	= 5.050000E-03
DISTV	= 3.250000E+03	DISTH	= 5.280000E+03
LEACH	= 1.000000E+05	CANLIFE	= 1.000000E+03

← Default parameters.

READY.
GO

← Execute.

A G E N D A

NUCLEAR REGULATORY COMMISSION
Visit to
BASALT WASTE ISOLATION PROJECT
Richland, Washington
June 9, 10, 11, 1982
1135 Jadwin Building

PROPOSED ATTENDEES

DOE

W. W. Ballard
J. H. Anttonen
R. B. Goranson
R. Stein
H. Smedes
~~M. P. Kurich~~
A. G. Lassila
D. J. Squires

ONI

~~M. A. Glora~~
P. L. Collyer
J. O. Duguid*

NRC

H. J. Miller
J. T. Greeves
L. Chase*
P. Prestholt
E. J. Quinn*
T. Verma*

Sandia

~~J. Neal~~
S. Sinnock

NRC Consultants

David Pentz - Golder*
Dick Gates - Golder*
Roy Williams - U. of Idaho*

ONI Consultants

Frank Vanhouter*
William Bonini*
John Kelleher*
Dennis Lachel*

Rockwell

R. A. Deju
R. J. Gimera
L. R. Fitch
H. B. Dietz
D. A. Turner
S. M. Price
R. E. Geohart
K. Kim
H. Babad
R. G. Baca
J. H. Larue
M. F. Nicol
F. A. Spane

*Thursday and Friday only

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AGENDA

NUCLEAR REGULATORY COMMISSION VISIT
Richland, Washington
June 9-11, 1982

Wednesday, June 9 - 1135 Jadwin Building

9:00 - 9:30 a.m.	Welcome and Introduction	R. B. Goranson/R. A. Deju
9:30 - 9:45	SCR Outline/BWIP Approach	L. R. Fitch
9:45 - 10:45	Geology/Hydrology	
	● Overview of Data Chapters	S. M. Price/R. E. Gephart
	● Issues and Plans (Chapter 13)	S. M. Price/R. E. Gephart
10:45 - 12:00 noon	Waste Package/Geochemistry	
	● Overview of Data Chapters	H. Babad
	● Issues and Plans (Chapter 15)	W. Babad
12:00 - 1:00 p.m.	LUNCH	
1:00 - 2:00 p.m.	Performance Assessment	
	● Overview of Studies to Date (Ch. 12)	R. G. Baca
	● Issues and Plans (Chapter 16)	R. G. Baca
2:00 - 3:00	Geoengineering/Repository Design	
	● Overview of Data Chapters	D. A. Turner/K. Kim
	● Issues and Plans (Chapter 14)	
3:00 - 4:30	Open Discussions - Future Workshops and Availability of Information	

Thursday, June 10 - 1135 Jadwin Building

8:30 - 9:30 a.m.	Drilling and Testing Program	S. M. Baker
9:30 - 12:00 noon	Discussion on BWIP In Situ Testing	H. B. Dietz/R. E. Gephart/ K. Kim
12:00 - 1:30 p.m.	LUNCH	
1:30 - 3:30	Discussions with the NRC on their thoughts on in situ testing	
3:30 - 4:00	Debriefing	R. B. Goranson/ J. H. Anttonen/R. A. Deju
4:00 -	Adjourn	

Friday, June 11

This day available for tours of the Near Surface Test Facility, Waste Package Laboratories, or proposed Exploratory Shaft Site as requested.

6/7/82

TRAVEL TIME= 1.453789E+05
AL EPA RATIO= 0.
DY.
DV=.03

Results.

Change vertical conductivity.

UE IS 3.000000E-02
DY.

Execute.

TRAVEL TIME= 2.092515E+02
AL EPA RATIO= 3.264946E-01
DY.

Results. Note shorter travel time.

Request detailed output.

Execute.

TRAVEL TIME= 2.092515E+02
AL EPA RATIO= 3.264946E-01
IDS FOR EACH NUCLIDE:

14	1.963680E-01
90	0.
99	1.272668E-01
129	2.859417E-03
135	0.
137	0.
126	0.
59	0.
93	0.
243	0.
241	0.
240	0.
239	0.
238	0.
237	0.
234	4.208951E-07

Same parameters, detailed output.

ADY.
VAM=0

Change K_d for Am.

UE IS 0.
ADY.

Execute. (Still uses CONDV=.03)

GW TRAVEL TIME= 2.092515E+02
TOTAL EPA RATIO= 1.415937E+02
RATIOS FOR EACH NUCLIDE:

C 14 1.963680E-01
SR 90 0.
TC 99 1.272668E-01
I129 2.859417E-03
CS135 0.
CS137 0.
SN126 0.
NI 59 0.
ZR 93 0.
AM243 1.174406E+02 }
AM241 2.382658E+01 }
PU240 0.
PU239 0.
PU238 0.
N37 0.
U234 4.208951E-07

Still gives detailed output.
Note large Am discharge.

READY.
DISP=10

← Change dispersivity.

VALUE IS 1.000000E+01
READY.

LEACH=1E6

← Change leach time.

VALUE IS 1.000000E+06
READY.

KDVAM=DEFAULT

← Reset K_d for Am to default.

VALUE IS 7.070000E+03

READY.
LONG

← It tells you what it has been reset to.

READY.
GO

← Turn off detailed output.

GW TRAVEL TIME= 2.092515E+02
TOTAL EPA RATIO= 3.084537E-02
READY.

ALL=DEFAULT

← Reset all parameters to default.

DEFAULT PARAMETERS LOADED.
READY.

DISTV=150

← Change length of vertical pipe.

VALUE IS 1.500000E+02
READY.

Change horiz. conductivity.

CONDH=0

VALUE IS 0.
READY.
GO

ARITHMETIC ERROR MODE = 02 ADDRESS = 021155
COMMAND- START.

System abort.

Restart the program.

DEFAULT PARAMETERS LOADED.
READY.
RELOAD

Go back to parameters just run.

RELOAD COMPLETE.
READY.

LIST

KDVC	= 0.	KDVI	= 2.050000E+00
KDVTG	= 1.220000E+01	KDVFP	= 3.140000E+02
KDVAM	= 7.070000E+03	KDVPU	= 4.840000E+02
KDVU	= 7.210000E+01	KDVNP	= 2.050000E+02
KDHC	= 0.	KDHI	= 1.000000E+00
KDHTC	= 3.160000E+00	KDHFP	= 2.240000E+00
KDHAM	= 3.160000E+01	KDHPU	= 1.000000E+01
KDHU	= 1.000000E+01	KDHNP	= 7.070000E-01
SOLC	= 9.999900E+04	SOLI	= 9.999900E+04
SOLTC	= 1.000000E-08	SOLF	= 9.999900E+04
SOLAM	= 9.999900E+04	SOLPU	= 2.500000E-10
SOLU	= 2.000000E-05	SOLNP	= 2.500000E-16
DISP	= 5.000000E+02	AREAV	= 2.610000E+06
CONDV	= 4.200000E-05	CONDH	= 0.
PRV	= 1.200000E-02	PRH	= 2.000000E-01
ADV	= 1.750000E-02	GRADH	= 5.050000E-03
DISTV	= 1.500000E+02	DISTH	= 5.280000E+03
LEACH	= 1.000000E+05	CANLIFE	= 1.000000E+03

Bad value - must be changed.

READY.
CONDH=25

same as before abort

Change horiz. conductivity.

VALUE IS 2.500000E+01
READY.
GO

GW TRAVEL TIME= 6.732449E+03
TOTAL EPA RATIO= 4.454067E-02
READY.
HELP

See messages.

COMMANDS ARE AS FOLLOWS:

LIST	LIST THE CURRENT PARAMETERS
LONG	TURN ON OR OFF THE OPTION FOR DETAILED OUTPUT
RELOAD	RESTORE THE PARAMETERS THAT WERE USED WHEN THE LAST GO COMMAND WAS ENTERED OR WHEN THE LAST ERROR OCCURRED
GO	EXECUTE THE TRANSPORT MODEL FOR THE CURRENT LIST OF PARAMETERS.
(PARAM) = (VALUE)	ASSIGN PARAMETER (PARAM) THE VALUE (VALUE). (VALUE) MUST BE A NUMBER WHICH OCCUPIES NO MORE THAN 10 SPACES TO THE RIGHT OF THE =.
(PARAM) = DEFAULT	ASSIGN PARAMETER (PARAM) THE DEFAULT VALUE.
ALL = DEFAULT	ASSIGN ALL PARAMETERS THE DEFAULT VALUES.
HELP	VIEW THIS WRITEUP.

PARAMETERS ARE AS FOLLOWS: E

KDVC	KD FOR CARBON IN VERTICAL LEG (ML/GM)
KDVI	" FOR IODINE
KDVTC	" FOR TECHNECIUM
KDVAM	" FOR AMERICIUM
KDVPU	" FOR PLUTONIUM
KDVU	" FOR URANIUM
KDVNP	" FOR NEPTUNIUM
KDVFP	" FOR SR, NI, ZR, CS AND SN
KDHC	SIMILAR TO ABOVE BUT FOR HORIZONTAL LEG
KDHI	"
KDTC	"
KDHPU	"
KDHU	"
KDHNP	"
KDHFP	"
SOLC	SOLUBILITY FOR CARBON (GM/GM)

SOLI	" FOR IODINE
SOLTC	" FOR TECHNICIUM
SOLAM	" FOR AMERICIUM
SOLPU	" FOR PLUTONIUM
SOLU	" FOR URANIUM
SOLNP	" FOR NEPTUNIUM
SOLFP	" FOR SR, NI, ZR, CS, AND SN
CONDV	CONDUCTIVITY IN VERTICAL LEG (FT/DA)
CONDH	CONDUCTIVITY IN HORIZONTAL LEG (FT/DA)
PORV	POROSITY IN VERTICAL LEG
PORH	POROSITY IN HORIZONTAL LEG
DISP	DISPERSIVITY (FT)
AREAV	AREA OF VERTICAL PIPE (FT**2)
GRADV	VERTICAL GRADIENT (FT/FT)
GRADH	HORIZONTAL GRADIENT (FT/FT)
LEACH	LEACH TIME OF WASTE (YR)
CANLIFE	CANISTER LIFE (YR)
DISTV	LENGTH OF VERTICAL LEG (FT)
DISTH	LENGTH OF HORIZONTAL LEG (FT)

READY.

QUIT



Exit program.

STOP

040000 MAXIMUM EXECUTION FL.

: .843 CP SECONDS EXECUTION TIME.

COMMAND- LOGOUT.

Logout.

CPU 8.745 SEC. 8.745 ADJ.

SYS TIME 29.775

CONNECT TIME 0 HRS. 13 MIN.

08/05/82 LOGGED OUT AT 14.51.56.

<

Hang up.

References

1. D. H. Lester, G. Jansen, and H. C. Burkholder, "Migration of Radionuclide Chains Through an Adsorbing Medium," AIChE Symposium Series No. 152 - Adsorption and Ion Exchange, 71, p. 202 (1975).
2. R. E. Pepping, M. S. Y. Chu, and M. D. Siegel, "Technical Assistance for Regulatory Development: A Simplified Repository Analysis in a Reference Basalt Site," draft, pp. 9-11 (1982).
3. Ibid., p. 14.
4. Ibid., p. 15.