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SOFTWARE RELEASE NOTICE

1. SRN Number: PA-SRN-213

2. Project Title: TSPA & Technical Integration Code

Project No. 20-01402-762

3. SRN Title: TPA Version 3.3

4. Originator/Requestor: Bruce Mabrito

Date: 11/29/99

5. Summary of Actions

- ☐ Release of new software
- ■ Release of modified software:
  - ■ Enhancements made
  - ■ Corrections made
- ☐ Change of access software
- ☑ Software Retirement GW 1/28/2003

6. Persons Authorized Access

Name	Read Only/Read-Write	Addition/Change/Delete
Sitakanta Mohanty	RW	
Ron Janetzke	RW	
Tim McCartin (NRC)	RW	
M. Rose Byrne (NRC)	RW	

7. Element Manager Approval: Gordon Wittmeyer Date: 11/29/99

8. Remarks:

An 8mm tape containing FORTRAN source code for the TPA Version 3.3 code, and 3 data CDs containing binary executable files for the PC/Windows platform were sent to NRC.

CNWRA Form TOP-6 (05/98)

SOFTWARE SUMMARY FORM

01. Summary Date: 11/24/99

02. Summary prepared by (Name and phone):
Sitakanta Mohanty (210) 522-5185

03. Summary Action:
Modified

04. Software Date: 11/24/99

05. Short Title: TPA Version 3.3

06. Software Title: TPA - System Performance Assessment Computer Code, Version 3.3

07. Internal Software ID:
None

08. Software Type:

☐ Automated Data System

☒ Computer Program

☐ Subroutine/Module

09. Processing Mode:

☐ Interactive

☒ Batch

☐ Combination

10. Application Area:

a. General:
☐ Scientific/Engineering ☐ Auxiliary Analyses
☒ Total System PA
☐ Subsystem PA ☐ Other

b. Specific:

11. Submitting Organization and Address:

CNWRA/SwRI
6220 Culebra Road
San Antonio, TX 78228

12. Technical Contact(s) and Phone:

Sitakanta Mohanty (210) 522-5185

13. Software Application: The TPA Code consists of the following modules: UZFLOW, NFENV, EBSREL, UZFT, SZFT, DCAGW, FAULTO, SEISMO, VOLCANO, ASHPLUMO, ASHRMVO, DCAGS, LHS, EXEC.

14. Computer Platform:
SUN Workstation
PC

15. Computer Operating System: UNIX
Windows NT

16. Programming Language(s): FORTRAN

17. Number of Source Program Statements: Approx. 42,000 lines w/o stand alone codes

18. Computer Memory Requirements: 72 Mb

19. Tape Drives: None

20. Disk Units: N/A

21. Graphics: N/A

22. Other Operational Requirements:

Uses system environment variables: TPA_TEST and TPA_DATA.

23. Software Availability:
☒ Available ☐ Limited ☐ In-House ONLY

24. Documentation Availability:
☐ Available ☐ Preliminary ☒ In-House ONLY

25.
Software Developer:
Date: 11/24/99

CNWRA Form TOP-4-1 (05/98)

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES
QUALITY ASSURANCE
SURVEILLANCE REPORT

PROJECT NO.: 20.01402.159 | **REPORT NO.:** 2000-13 | **PAGE** 1 **OF** 2

SURVEILLANCE SCOPE: Review of CNWRA Developed Scientific and Engineering Software to determine whether the documentation present in the CNWRA Software Working Records Folders is adequate.

REFERENCE DOCUMENTS: Technical Operating Procedure-018, Development and Control of Scientific and Engineering (S&E) Software; QAP-004, Surveillance Control; Nonconformance Report 2000-03.

STARTING DATE: 3/7/2000 **ENDING DATE:** 6/9/2000

QA REPRESENTATIVE: B. Mabrito

PERSONS CONDUCTING TEST/EXAM/ACTIVITY: Various CNWRA staff working on Developed S&E software.

SATISFACTORY FINDINGS: During the course of this surveillance, CNWRA Developed S&E software and documentation was checked and contact made with CNWRA staff who worked with the software. In each case, the particular S&E software folder was reviewed for completeness and where no Design Verification Report (DVR) was located, the objective evidence in the folder was compared to the DVR form questions and discussions were held with cognizant CNWRA staff. The list of Developed S&E software reviewed is included in Attachment A.

In each case, key elements of the DVR were compared against that which was included in each software folder in the QA working records. Also, the previous version of the software code documentation was checked to ensure that the earlier DVR had been properly completed. The later version of the software documentation showed the specific changes made through the Software Change Reports. Based on this review, it is clear that although in a few cases no DVR was accomplished, product quality did not suffer. The minor enhancements and "bug" fixes made to TPA Version 3.2.3 and 3DStress Version 1.3.1 and 1.3.2 software were clearly identified and controlled so that the CNWRA product being delivered met the client's requirements.

UNSATISFACTORY FINDINGS: None.

NONCONFORMANCE REPORT NO.: None.

ATTACHMENTS: Attachment A.

RECOMMENDATIONS/ACTIONS: N/A.

APPROVED: ______________________
CENTER DIRECTOR OF QUALITY ASSURANCE

DATE: 6/12/2000

DISTRIBUTION:
ORIGINAL - CENTER QA DIRECTOR QA Records
ORIGINATOR
PRINCIPAL INVESTIGATORS OF EACH CODE
ELEMENT MANAGERS
B. Sagar, H. Garcia

CNWRA FORM QAP-8 (4/93)

ATTACHMENT A

NAME OF S&E SOFTWARE	DESIGN VERIFICATION REPORT		NOTES
3DStress Version 1.2	Present	Dated 5/8/97	
3DStress Version 1.3	Present	Dated 8/7/98	
3DStress Version 1.3.1	Not Present		Software Release Notice Dated 7/15/99
3DStress Version 1.3.2	Not Present		Software Release Notice Dated 9/16/99
ASHPLUME Version 1.0	Present	Dated 6/23/97	
BREATH Version 1.1	Not Present		Software Release Notice Dated 9/21/95
BREATH Version 1.2	Present	Dated 9/17/97	
EBSPAC Version 1.0	Present	Dated 5/15/97	
EBSPAC Version 1.1	Present	Dated 6/17/97	
FAULTING Version 1.0	Not Present		Software Release Notice Dated 1/21/98 Module put under TPA Code and controlled in that manner.
GEOINVRT Version 1.0	Software Code Not Finished		Software Requirements Description only.
HAZINFO Version 1.0	Software Code Not Finished		Software Requirements Description only.
MULTIFLO Version 1.2	Present	Dated 3/2/2000	
MULTIFLO Version 2.0	Software Code Not Finished		Software Requirements Description only.
PVHA Version 1.0	Present	Dated 2/15/2000	
SUFLAT Version 1.0	Not Present		Element Manager (EM) determined that this software has not been used for regulatory reviews and will not be used for such work. EM requested the folder be archived in QA Records to reflect previous efforts on code.
TECTRAN Version 1.0	Software Code Not Finished		Software Requirements Description only.
TPA Version 3.2	Present	Dated 7/17/98	
TPA Version 3.2 (PP) Beta	Present	Dated 11/25/98	
TPA Version 3.2.3	Not Present		Software Release Notice Dated 7/14/99
TPA Version 3.3	Present	Dated 11/24/99	
TPA Version 4.0	Present	Dated 3/31/2000	

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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

DESIGN VERIFICATION REPORT FOR CNWRA SOFTWARE: TPA Version 3.3

1 of 4 pages

November 24, 1999

Total-System Performance Assessment (Scientific and Engineering Software) Version 3.3

NOTE: This version of the TPA Software contains changes from the previous version released. Software Change Reports (SCRs) have been utilized as the change documentation method and they are being retained in the TPA Version 3.3 folder.

1. **This Design Verification Report is prepared by:** Bruce Mabrito in conjunction with the Software Development Team, including S. Mohanty and R. Janetzke.

Full Title of CNWRA scientific and engineering software: Total-System Performance Assessment (TPA) Version 3.3.

Demonstration work station: SPARC20 in conjunction with the SCRATCHY1 server.

Operating System: SunOS 5.5.1

2. **Software Requirements Description and any changes thereto approved by Element Manager?**

[✓ YES] NO N/A

Note: The SRD is for the TPA code in general, not for this specific version.

3. **Software Development Plan (SDP) and any changes have been approved by the Element Manager?**

YES [✓ NO] N/A

Note: The Software Change Requests were used to document and control the changes for this Version 3.3 of the TPA code. There are 15 Software Change Reports were utilized for TPA Version 3.3.

4. **Design and Development**
Module-level testing is documented in either scientific notebooks or in Software Change Reports?

[✓ YES] NO N/A

Note: Testing is documented in Software Change Reports Numbers 272 to 278, and 280 to 287.

5. **Is the CNWRA scientific and engineering software developed in accordance with the conventions described in the SDP?**

[✓ YES] NO N/A

Note: The conventions described in the SDP dated 5/29/98 for TPA V. 3.2 were followed.

6. **Is the CNWRA software documented internally?**

[✓ YES] NO N/A

Does the primary program header contain the following information:

A. **Program title, Developed for (Customer), Office/Division/Date/Customer Contact/Telephone number, Software Developer, Telephone number, titles of Associated Documentation/Designator, and the Disclaimer Notice?**

[✓ YES] NO N/A

B. **Source code module header information provides Program Name, Client Name, Contract Reference, Revision number?**

[✓ YES] NO N/A

Note: An NRC Contract number is present and accurate for previous years. The new NRC Contract number will appear on TPA Version 4.0.

7. **Software designed so that individual runs are uniquely identified by Date, Time, Name of software and version?** [✓ YES] NO N/A

8. **The physical labeling on the software or the referenced list has Program Name/Title, Module/Name/Title, Module Revision, File Type (i.e. ASCII, OBJ, EXE), Recording Date and Operating System of the Supporting Hardware?**

[✓ YES] NO N/A

9. **Users' Manual**

Is there a Users' Manual for the software?

YES [✓ NO] N/A

If no, explain: Per NRC instructions/schedule and the CNWRA HLW Operations Plans, the TPA Version 4.0 Users' Manual will be delivered to the NRC later. See the High-Level Waste Ops Plan for FY2000.

Are there basic instructions for the use of the software?

[✓ YES] NO N/A

Note: The TPA Version 3.2 Users' Manual is applicable to this TPA Version 3.3..

10. Acceptance Testing

Does the acceptance testing demonstrate whether or not requirements in the ~~SDP~~ SRD 1/14/00 have been fulfilled?

YES NO [✓ N/A]

Note: CNWRA Software Change Reports were extensively used in generation of TPA Version 3.3.

Has acceptance testing been conducted for each intended computer platform and operating system?

[✓ YES] NO N/A

Note: The acceptance testing for TPA Version 3.3 was conducted by R. Rice (consultant), M. Muller (SwRI Div. 15) and M. Menchaca (SwRI Div. 15).

Have installation tests been performed on the target platform?

[✓ YES] NO N/A

Note: Installation testing was performed on the SCRATCHY1 work station.

11. Configuration Control

Is the Software Summary Form completed and signed?

[✓ YES] NO N/A

If no, explain:

12. Is a software technical description prepared, documenting the essential mathematical and numerical basis?

YES [✓ NO] N/A

If no, explain: The 15 Software Change Reports describe the technical details of TPA Version 3.3.

13. Is the source code available (or, is the executable code available in the case of commercial codes)?

[✓ YES] NO N/A

14. Have all the script/make files and executable files been submitted to the Software Custodian?

[✓ YES] NO N/A

Note about dates: On the evening of 11/24/99, the Software Custodian (B. Mabrito) performed the actions needed to complete the Design Verification Report with R. Janetzke in Bldg. 189 on the SwRI grounds. The Software Summary Form was dated 11/24/99 and the TPA Version 3.3 tape and CDs were dated 11/24/99. The Element Manager will review the Software Release Notice on 11/29/99 prior to the deliverable being sent out to the NRC. The dates on the documents will essentially agree.

Ron Janetzke **11/24/99**

Ron Janetzke Date
CNWRA TPA Software Developer

Bruce Mabrito **11/24/99**

Bruce Mabrito Date
CNWRA Software Custodian

Attachments/

Original to: Software Folder
cc: CNWRA Software Developer
Cognizant EM

8/34

Date: 11/23/99
Sender: "rfolck" <rfolck@gateway.net>
To: "Bruce Mabrito" <bmabrito@swri.edu>
cc: <rjanetzke@swri.edu>
bcc: Bruce Mabrito
Priority: Normal
Subject: TPA, Version 3.3

Bruce,

I spent some time with Ron Janetzke concerning the release for TPA, Version 3.3. The version incorporates SCRs 272-278, 280-287. Testing is primarily "back-to-back" (comparison to a baseline) testing and includes functional testing when necessary, i.e., functionality change. Some weak spots need to be assessed/verified when you do the Code Custodian Design Verification Report:

1.. Some testing had yet to be completed. Verify that testing is complete and that there are test results to support each SCR. This includes locating test results for SCR 272 that was completed some time ago and documented in a Scientific Notebook.

2.. Some tests did fail (termed unexpected results) under SCRs 273 and 275. Re-testing was conducted but it was difficult to relate the re-test results to the original test failures. Ron is going to ensure that this traceability is clear.

3.. Some unexpected results can be explained. Ron is going to ensure that the rationale is clearly documented.

Ron and I also discussed how to manage the dates on documents, CDs, etc. Everything does not have to be dated the same day but their is a linear sequence to the dates. For example:

a.. The Software Release Form (signed by the EM), labels on the CDs, labels on tapes, and release letter to the NRC need to have the same date, the release date.

b.. The date on the Design Verification Report completed by the Software Custodian must be <= the date on the Software Release Notice.

c.. The date on the Software Summary Form completed by the developer should be <= the date of the Design Verification Report.

d.. The completion date for SCRs should be <= the date on the Software Summary Form.

Give me a call if you have any questions.

Randy

Randolph W. Folck
Process Innovation, Inc.
6434 Club Oaks
San Antonio, Texas 78249
(210) 558-4236
rfolck@gateway.net

RFC822.TXT FileItem.txt

Earlier Design Verification
Verification discussions
from R. Folck, CNWRA
Consultant of Software and
QA matters.

Objective evidence

```
c Program Name:           TPA - Total-System Performance Assessment Code
c File Name:              exec.f
c File Date:              11/24/99
c Release Version:        3.3
c
c Client Name:            USNRC
c                         U. S. Nuclear Regulatory Commission
c                         NRC Office of Nuclear Material Safety and Safeguards
c                         Division of Waste Management
c Contract Number:        NRC 02-93-005
c
c NRC Contact             Tim McCartin (301) 415-6681
c
c CNWRA Contact:          Sitakanta Mohanty (210) 522-5185
c                         Center for Nuclear Waste Regulatory Analyses
c                         San Antonio, Texas 78238-5166
c                         smohanty@swri.edu
c
c Revisions:
c                         3.1.1     includes SPCRs 101 through 205
c                         3.1.2     includes SPCRs 206 through 224
c                         3.1.3     includes SPCRs 225 through 227
c                         3.1.4     includes SPCRs 228 through 231
c                         3.2       includes SPCRs 232 through 252
c                         3.2.1     3.2PCbeta port of 3.2 to PC running NT4
c                         3.2.2     3.2PVMbeta mod of 3.2.1 to enable PVM
c                         3.2.3     includes SCRs  260 through 271
c                         3.3       includes SCRs  272 through 278
c                            and    includes SCRs  280 through 287
c
c Documentation:          Predecisional "Total-System Performance Assessment
c                         (TPA) Version 3.2 Code: Module Description and
c                         User's Guide", Center for Nuclear Waste Regulatory
c                         Analyses
c NUREG-Series Designator: N/A
ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c
c
c = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = =
c
c                                 D I S C L A I M E R
c
c = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = =
c
c     "This computer code/material was prepared as an account of work
c performed by the Center for Nuclear Waste Regulatory Analyses (CNWRA)
c for the Division of Waste Management of the Nuclear Regulatory
c Commission (NRC), an independent agency of the United States
c Government.  Neither the developer(s) of the code nor any of their
c sponsors make any warranty, expressed or implied, or assume any legal
c liability or responsibility for the accuracy, completeness, or
c usefulness of any information, apparatus, product or process
c disclosed, or represent that its use would not infringe on privately-
c owned rights."
c
c     "In no event unless required by applicable law will the sponsors
c or those who have written or modified this code, be liable for
c damages, including any lost profits, lost monies, or other special,
c incidental or consequential damages arising out of the use or
c inability to use the program (including but not limited to loss of
c data or data being rendered inaccurate or losses sustained by third
c parties or a failure of the program to operate with other programs),
c even if you have been advised of the possibility of such damages or
c for any claim by any other party."
c
```

```
c = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = =
c
c by S. Mohanty, R. Janetzke, R. Rice, A. Lozano
c    R. Manteufel (initial version)
c
c=======================================================================
       program exec
c=======================================================================
c Executive for TPA Version 3.2.3
c Contact Person: : S. Mohanty
c
cc       1         2         3         4         5         6         7
cc34567890123456789012345678901234567890123456789012345678901234567890
c
      implicit double precision (a-h,o-z)
      implicit integer (i-n)

cc rwj 7-2-99 importance analysis
      include 'ia.i'

      include 'maxntime.i'
      include 'maxnsuba.i'
      include 'maxnnucl.i'
cc rwr 9/3/97 modified to remove for_study messages
cc      include 'setfiles.i'
      include 'execa.i'
      include 'execb.i'

      include 'inventb.i'
cc rwr insertcasl  6/9/97  Added for spfilter.e
      include 'path.i'

cc rwr 6/7/97 modifications for output

      include 'samplerv.i'
      include 'samplerb.i'
      include 'samplerd.i'

cc rwr end of modifications
```

```
=======================================================================
         exec: Welcome to TPA Version 3.3 PVM capable
       Job started: Wed Nov 24 19:49:16 1999
=======================================================================
 Specified Global Parameters:

               Compliance Period =  10000.0 (yr)
         Maximum Simulation Time =  10000.0 (yr)
          Number Of Realizations =      1
              Number Of Subareas =      7
              Volcanism scenario =      1 (yes=1, no=0)
               Faulting scenario =      1 (yes=1, no=0)
                Seismic scenario =      1 (yes=1, no=0)
      Distance to Receptor Group =     20.0 (km)


 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


 ***>>> NOTE: When running with volcanism, verify that   <<<***
 ***>>> the maximum value of the PDF for parameter       <<<***
 ***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
 ***>>> equal to the parameter MaximumTime[yr].          <<<***


 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C*
*
-----------------------------------------------------------------------
     subarea   1 of   7           realization    1 of    1
-----------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
      *** No Corrosion WP Failure ***
 exec: calling seismo
 exec: calling faulto
 exec: calling volcano
 exec: failed WPs from INITIAL   event =     16 at time =      0.0 yr
  *** failed WPs:   16  out of   1663 ***
 exec: calling ebsrel
                    Highest release rates from Sub Area  1
            Tc99    1.6936E-02 [Ci/yr/SA] at  2.198E+03 yr
            Ni59    3.5837E-03 [Ci/yr/SA] at  3.076E+03 yr
            C14     1.8156E-03 [Ci/yr/SA] at  3.076E+03 yr
            Cs135   6.5995E-04 [Ci/yr/SA] at  4.191E+03 yr
            Se79    6.4718E-04 [Ci/yr/SA] at  2.198E+03 yr
            I129    5.1619E-05 [Ci/yr/SA] at  2.251E+03 yr
 exec: calling uzft
                    Highest release rates from UZ
            Tc99    1.6791E-02 [Ci/yr/SA] at  2.251E+03 yr
            Ni59    3.5555E-03 [Ci/yr/SA] at  3.384E+03 yr
            Cs135   6.5933E-04 [Ci/yr/SA] at  4.191E+03 yr
            Se79    6.4038E-04 [Ci/yr/SA] at  2.251E+03 yr
            I129    5.1098E-05 [Ci/yr/SA] at  2.307E+03 yr
            Cl36    2.0831E-05 [Ci/yr/SA] at  2.251E+03 yr
 exec: calling szft
                    Highest release rates from SZ
            I129    4.3106E-05 [Ci/yr/SA] at  8.897E+03 yr
            Cl36    1.7282E-05 [Ci/yr/SA] at  8.101E+03 yr
```

```
      The remaining   18  nuclide(s) have zero release
 ----------------------------------------------------------------------
      subarea   2 of   7           realization    1 of    1
 ----------------------------------------------------------------------
  exec: calling uzflow
  exec: calling nfenv
  exec: calling ebsfail
       *** No Corrosion WP Failure ***
  exec: failed WPs from INITIAL   event =     17 at time =      0.0 yr
  exec: failed WPs from VOLCANIC  event =     20 at time =   3996.8 yr (includes
 ejected WPs)
  exec: failed WPs from FAULTING  event =    168 at time =   9543.3 yr
   *** failed WPs:   205  out of   1767 ***
   *** ejected WPs:   3
  exec: calling ebsrel
                  Highest release rates from Sub Area  2
             Tc99    1.0528E-01 [Ci/yr/SA] at  9.543E+03 yr
             Ni59    2.2301E-02 [Ci/yr/SA] at  1.000E+04 yr
             C14     4.4627E-03 [Ci/yr/SA] at  1.000E+04 yr
             Se79    3.4886E-03 [Ci/yr/SA] at  9.543E+03 yr
             Cs135   4.4172E-04 [Ci/yr/SA] at  7.205E+03 yr
             I129    2.9872E-04 [Ci/yr/SA] at  9.323E+03 yr
  exec: calling uzft
                     Highest release rates from UZ
             Tc99    1.0525E-01 [Ci/yr/SA] at  9.543E+03 yr
             Ni59    2.1553E-02 [Ci/yr/SA] at  1.000E+04 yr
             Se79    3.4876E-03 [Ci/yr/SA] at  9.543E+03 yr
             Cs135   4.3530E-04 [Ci/yr/SA] at  7.205E+03 yr
             I129    2.9770E-04 [Ci/yr/SA] at  9.543E+03 yr
             Cl36    1.1164E-04 [Ci/yr/SA] at  9.543E+03 yr
  exec: calling szft
                     Highest release rates from SZ
             Cl36    8.9489E-07 [Ci/yr/SA] at  1.000E+04 yr
             I129    4.3584E-08 [Ci/yr/SA] at  1.000E+04 yr
      The remaining   18  nuclide(s) have zero release
 ----------------------------------------------------------------------
      subarea   3 of   7           realization    1 of    1
 ----------------------------------------------------------------------
  exec: calling uzflow
  exec: calling nfenv
  exec: calling ebsfail
       *** No Corrosion WP Failure ***
  exec: failed WPs from INITIAL   event =      8 at time =      0.0 yr
  exec: failed WPs from VOLCANIC  event =      6 at time =   3996.8 yr
  exec: failed WPs from FAULTING  event =     55 at time =   9543.3 yr
   *** failed WPs:    69  out of    855 ***
  exec: calling ebsrel
                  Highest release rates from Sub Area  3
             Tc99    2.6088E-02 [Ci/yr/SA] at  5.696E+03 yr
             Ni59    5.4977E-03 [Ci/yr/SA] at  6.407E+03 yr
             C14     2.0349E-03 [Ci/yr/SA] at  6.113E+03 yr
             Cs135   1.0743E-03 [Ci/yr/SA] at  7.038E+03 yr
             Se79    9.7622E-04 [Ci/yr/SA] at  5.564E+03 yr
             I129    8.0075E-05 [Ci/yr/SA] at  5.434E+03 yr
  exec: calling uzft
                     Highest release rates from UZ
             Tc99    2.6071E-02 [Ci/yr/SA] at  5.696E+03 yr
             Ni59    5.4930E-03 [Ci/yr/SA] at  6.407E+03 yr
             Cs135   1.0738E-03 [Ci/yr/SA] at  7.038E+03 yr
             Se79    9.7557E-04 [Ci/yr/SA] at  5.564E+03 yr
             I129    8.0030E-05 [Ci/yr/SA] at  5.696E+03 yr
             Cl36    3.2949E-05 [Ci/yr/SA] at  5.564E+03 yr
  exec: calling szft
                     Highest release rates from SZ
             I129    7.4481E-05 [Ci/yr/SA] at  8.691E+03 yr
```

```
           Cl36    3.0075E-05 [Ci/yr/SA] at  8.293E+03 yr
     The remaining   18  nuclide(s) have zero release
 -----------------------------------------------------------------------
     subarea   4 of   7           realization    1 of    1
 -----------------------------------------------------------------------
  exec: calling uzflow
  exec: calling nfenv
  exec: calling ebsfail
      *** No Corrosion WP Failure ***
  exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
  exec: failed WPs from VOLCANIC  event =      1 at time =   3996.8 yr
  exec: failed WPs from FAULTING  event =     15 at time =   9543.3 yr
   *** failed WPs:   21  out of   472 ***
  exec: calling ebsrel
                  Highest release rates from Sub Area  4
           Tc99    1.5742E-02 [Ci/yr/SA] at  1.682E+03 yr
           Ni59    2.8057E-03 [Ci/yr/SA] at  2.540E+03 yr
           C14     1.6477E-03 [Ci/yr/SA] at  2.540E+03 yr
           Se79    6.3400E-04 [Ci/yr/SA] at  1.682E+03 yr
           Cs135   4.5771E-04 [Ci/yr/SA] at  3.384E+03 yr
           I129    4.9578E-05 [Ci/yr/SA] at  1.766E+03 yr
  exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant
 ground water travel time. ***
                      Highest release rates from UZ
           Tc99    1.5742E-02 [Ci/yr/SA] at  1.682E+03 yr
           Ni59    2.8057E-03 [Ci/yr/SA] at  2.540E+03 yr
           Se79    6.3400E-04 [Ci/yr/SA] at  1.682E+03 yr
           Cs135   4.5771E-04 [Ci/yr/SA] at  3.384E+03 yr
           I129    4.9578E-05 [Ci/yr/SA] at  1.766E+03 yr
           Cl36    2.1351E-05 [Ci/yr/SA] at  1.682E+03 yr
  exec: calling szft
                      Highest release rates from SZ
           I129    1.4815E-05 [Ci/yr/SA] at  4.499E+03 yr
           Cl36    6.4100E-06 [Ci/yr/SA] at  4.191E+03 yr
     The remaining   18  nuclide(s) have zero release
 -----------------------------------------------------------------------
     subarea   5 of   7           realization    1 of    1
 -----------------------------------------------------------------------
  exec: calling uzflow
  exec: calling nfenv
  exec: calling ebsfail
      *** No Corrosion WP Failure ***
  exec: failed WPs from INITIAL   event =      6 at time =      0.0 yr
  exec: failed WPs from VOLCANIC  event =     11 at time =   3996.8 yr
  exec: failed WPs from FAULTING  event =     25 at time =   9543.3 yr
   *** failed WPs:   42  out of   654 ***
  exec: calling ebsrel
                  Highest release rates from Sub Area  5
           Tc99    3.3205E-02 [Ci/yr/SA] at  9.543E+03 yr
           Ni59    6.9539E-03 [Ci/yr/SA] at  1.000E+04 yr
           C14     1.4807E-03 [Ci/yr/SA] at  1.000E+04 yr
           Se79    1.1375E-03 [Ci/yr/SA] at  9.543E+03 yr
           Cs135   2.7485E-04 [Ci/yr/SA] at  6.875E+03 yr
           I129    9.7385E-05 [Ci/yr/SA] at  9.323E+03 yr
  exec: calling uzft
                      Highest release rates from UZ
           Tc99    1.5307E-02 [Ci/yr/SA] at  1.000E+04 yr
           Ni59    3.7473E-04 [Ci/yr/SA] at  8.897E+03 yr
           I129    3.6068E-05 [Ci/yr/SA] at  1.000E+04 yr
           Cl36    1.7298E-05 [Ci/yr/SA] at  1.000E+04 yr
     The remaining   16  nuclide(s) have zero release
  exec: calling szft
                      Highest release rates from SZ
           I129    1.5966E-05 [Ci/yr/SA] at  9.543E+03 yr
```

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```
            Cl36     9.1717E-06 [Ci/yr/SA] at  9.107E+03 yr
     The remaining   18  nuclide(s) have zero release
---------------------------------------------------------------------
    subarea   6 of   7           realization    1 of    1
---------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
     *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      7 at time =      0.0 yr
  *** failed WPs:    7  out of   738 ***
 exec: calling ebsrel
                  Highest release rates from Sub Area  6
            Tc99     4.6398E-02 [Ci/yr/SA] at  1.000E+04 yr
            Se79     1.5449E-03 [Ci/yr/SA] at  1.000E+04 yr
            I129     1.3425E-04 [Ci/yr/SA] at  1.000E+04 yr
            Cl36     5.0027E-05 [Ci/yr/SA] at  1.000E+04 yr
     The remaining   16 nuclide(s) have zero release
 exec: calling uzft
                         There is no UZ release
 exec: calling szft
                         There is no SZ release
---------------------------------------------------------------------
    subarea   7 of   7           realization    1 of    1
---------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
     *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      3 at time =      0.0 yr
  *** failed WPs:    3  out of   278 ***
 exec: calling ebsrel
                  Highest release rates from Sub Area  7
            Tc99     2.2598E-03 [Ci/yr/SA] at  2.602E+03 yr
            Ni59     4.6204E-04 [Ci/yr/SA] at  3.466E+03 yr
            C14      2.7685E-04 [Ci/yr/SA] at  3.384E+03 yr
            Cs135    9.9690E-05 [Ci/yr/SA] at  4.291E+03 yr
            Se79     9.6763E-05 [Ci/yr/SA] at  2.602E+03 yr
            I129     7.6982E-06 [Ci/yr/SA] at  2.665E+03 yr
 exec: calling uzft
      *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                     Highest release rates from UZ
            Tc99     2.2598E-03 [Ci/yr/SA] at  2.602E+03 yr
            Ni59     4.6204E-04 [Ci/yr/SA] at  3.466E+03 yr
            Cs135    9.9690E-05 [Ci/yr/SA] at  4.291E+03 yr
            Se79     9.6763E-05 [Ci/yr/SA] at  2.602E+03 yr
            I129     7.6982E-06 [Ci/yr/SA] at  2.665E+03 yr
            Cl36     3.4439E-06 [Ci/yr/SA] at  2.602E+03 yr
 exec: calling szft
                     Highest release rates from SZ
            I129     6.8351E-06 [Ci/yr/SA] at  5.832E+03 yr
            Cl36     3.0076E-06 [Ci/yr/SA] at  5.564E+03 yr
     The remaining   18  nuclide(s) have zero release
 exec: calling dcagw
                     Highest annual dose GW pathway
            I129     9.5843E-03 [mrem/yr]  at  9.107E+03 yr
            Cl36     1.4746E-04 [mrem/yr]  at  8.691E+03 yr
     The remaining   18  nuclide(s) have zero release
           At end of TPI, annual dose GW pathway
            I129     8.6252E-03 [mrem/yr]
            Cl36     1.2095E-04 [mrem/yr]
               sum   8.7462E-03 [mrem/yr]
     The remaining   18  nuclide(s) have zero release
 exec: calling ashplumo
```

```
exec: calling ashrmovo
exec: calling dcags
                    Highest annual dose from GS
             Pu240  2.4766E+01 [mrem/yr] at  3.997E+03 yr
             Pu239  2.0924E+01 [mrem/yr] at  3.997E+03 yr
             Am243  1.4490E+00 [mrem/yr] at  3.997E+03 yr
             Am241  6.4136E-01 [mrem/yr] at  3.997E+03 yr
             Pu242  1.5592E-01 [mrem/yr] at  3.997E+03 yr
             Np237  1.5566E-01 [mrem/yr] at  3.997E+03 yr
exec: end realizations

exec:  Run Successfully Completed
```

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File:
TPA Version 3.3
Software
Folder

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U.S. Nuclear Regulatory Commission
ATTN: Mr. James Firth
Office of Nuclear Materials Safety and Safeguards
Division of Waste Management
Performance Assessment and HLW Integration Branch
Mail Stop 7C-18
Washington, DC 20555

Subject: Transmittal of the TPA Version 3.3 Code

Dear Mr. Firth:

Attached herewith is an 8mm tape containing FORTRAN source code for the TPA Version 3.3 code, which can be compiled on both the SUN workstation and the PC (NT 4.0 operating system). In addition, 3 copies of binary executable files for the PC/Windows platform are contained on CDs. This version of the code contains approximately 66,400 lines of code and will execute the delivered *tpa.inp* file in 6 minutes on a SparcStation 20. The following modifications were implemented in the TPA Version 3.3 code:

(i) Many TPA intermediate or auxiliary parameters are averaged over subareas or realizations. The TPA code was changed where appropriate to weight the output by the number of subareas and realizations actually analyzed in an abbreviated run, rather than always using 7 for the number of subareas and the number of realizations returned by LHS for the realization count.

(ii) The importance analysis functionality of the TPA-IA version, based on TPA Version 3.1.4, was added.

(iii) The *tpanames.dbs* file that contains the abbreviations used for the sensitivity analysis will now be updated automatically at the beginning of a run even when new input parameters are added to the primary input file (i.e. *tpa.inp*).

(iv) Users can now define plume capture and dilution parameters in the *tpa.inp* file.

(v) A lower limit is imposed on the average flux for release calculations based on the matrix permeability of the invert. This change was implemented to avoid the divide by zero error that appears in several realizations for some combinations of input parameters.

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TPA Version 3.3

Testing Results For TPA Version 3.3

SCRs 273 - 277

To: R. Janetzke
From: R. Rice
15 pages
11/23/99

testing performed by

Robert Rice

report submitted

November 19,1999

10/26/99 - 11/5/99

11/23/99

Testing began to the Test Plans for SCRs 273 - 277. A directory structure described in the test plans was created on the "c:\" partition in the subdirectory "testing_3.2.3e".
The tests will be conducted in the same order provided in the test plans with the first being for SCR 273.

TESTING FOR SCR273

Note: (1) the file comparisons [filecomp.bat and filecomp.out] are located in the v3.2.3 subdirectories for all tests unless otherwise noted).

(2) contrary to the information stated on the test plans, the v3.2.3 and v3.2.3e source codes were delivered on a single CD prepared by R. Janetzke on 9/24/99.

SCR273\flag1\test1\10k - Expected Results: The filecomp.out file shows no differences in the output files when compared to the results in the SCR273\flag1\test1\10k\v3.2.3 subdirectory(*.res, *.tpa [except spquery.tpa, see below], *.rlt, *.ech, and *.cum), except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision) and the time, date ad header of the run. A comparison between the v3.2.3 and v3.2.3e cp.tpa files performed using an EXCEL spreadsheet indicates no differences except those attributable to precision. It is also noted that the 15 new flags for the importance analysis are present in the cp.tpa file from v3.2.3e. Additionally, there are a handful (10 or so) parameter names that are queried for a value one more time in version 3.2.3e than in version 3.2.3. The reasons for these differences are identified below for the 100k-yr run.

SCR273\flag1\test1\100k - Unexpected Results: The filecomp.out file in the v3.2.3 subdirectory shows many differences in the output files when compared to the results in the SCR273\flag1\test1\100k\v3.2.3 subdirectory in addition to the expected differences noted in the test plan for the cp.tpa file (single vs. double precision) and the time, date, and header of the run. As mentioned earlier, there are a handful (10 or so) parameter names that are queried for a value one more time in version 3.2.3e than in version 3.2.3. The reasons for this difference are attributable to a different methodology used to determine the WP_Stiffness in the two versions. In version 3.2.3e, the following approach is used (from seismo.f):

```
cc rwj 7-2-99 importance analysis
cc        Calculate package stiffness.
cc        (Page 4-41 of 3.1.4 User's Guide)
cc        3.14159d0 is pi

          WPWall = OuterWPThickness + AInnerWPThickness
          Rave = WPDiameter - WPWall/2.0d0
          Package_Stiffness = 48.d0 * Package_Modulus * 3.14159d0 *
     &                      Rave**3 * WPWall /  WPLength**3
```

and the screen print shows the following:

(v3.2.3):
```
xec: calling seismo
xec: failed WPs from INITIAL   event =     16 at time =      0.0 yr
xec: failed WPs from CORROSION event =   1647 at time =  20525.6 yr
```

(v3.2.3):
```
xec: calling seismo
xec: failed WPs from INITIAL   event =     16 at time =      0.0 yr
```

```
xec: failed WPs from SEISMIC    event =     4 at time =   4169.3 yr
xec: failed WPs from CORROSION event =  1643 at time =  20525.6 yr
```

The results, as documented in filecomp.out, before the execution of SEISMO are the same for both versions, however after SEISMO the results are inconsistent.

To verify that the additional code in SEISMO was causing this difference, TPA runs were performed with the SEISMO flag OFF in "test" subdirectories located below the v3.2.3 and v3.2.3e subdirectories. A comparison of the output from these two runs verifies that the differences in the output were caused by the additional code in SEISMO. All other results were expected and consistent between the v3.2.3 and v.3.2.3e runs. Furthermore, the increased number of times certain parameters were queried for a value (as identified in the 10k-yr analysis) is solely attributable to the additional code in SEISMO.

SCR273\flag1\test2\10k - Expected Results: The filecomp.out file in the SCR273\flag1\test2\10k\v3.2.3e subdirectory shows no differences in the output files when compared to the results in the SCR273\flag1\test1\10k\v3.2.3 subdirectory(*.res, *.tpa, *.rlt, *.ech, and *.cum), except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. Based on the previous testing, there are no unexpected results.

SCR273\flag1\test2\100k - Expected Results: The filecomp.out file in the SCR273\flag1\test2\100k\v3.2.3e subdirectory shows no differences in the output files when compared to the results in the SCR273\flag1\test1\100k\v3.2.3 subdirectory(*.res, *.tpa, *.rlt, *.ech, and *.cum), except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date, and header of the run, and differences described and explained earlier in this report. To remove the differences in results attributable to modifications in the SEISMO methodology that was identified in test1 at 100 kyr, the "test" subdirectory below the SCR273\flag1\test2\100k\v3.2.3e subdirectory contains a TPA run performed without SEISMO. The TPA results in this subdirectory (specifically, refer to the filecomp.out file) verify that the output from v3.2.3 and v3.2.3e are consistent. Thus, based on the previous testing, there are no unexpected results.

SCR273\flag1\test3\10k - Expected Results: The filecomp.out file in the SCR273\flag1\test3\10k\v3.2.3e subdirectory shows no differences in the output files when compared to the results in the SCR273\flag1\test1\10k\v3.2.3 subdirectory(*.res, *.tpa, *.rlt, *.ech, and *.cum), except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. Based on the previous testing, there are no unexpected results.

SCR273\flag1\test3\100k - Expected Results: The filecomp.out file in the SCR273\flag1\test3\100k\v3.2.3e subdirectory shows no differences in the output files when compared to the results in the SCR273\flag1\test1\100k\v3.2.3 subdirectory (*.res, *.tpa, *.rlt, *.ech, and *.cum), except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date, and header of the run, and differences described and explained earlier in this report. To remove the differences in results attributable to modifications in the SEISMO methodology that was identified in test1 at 100 kyr, the "test" subdirectory below the SCR273\flag1\test2\100k\v3.2.3e subdirectory contains a TPA run performed without SEISMO. The TPA results in this subdirectory (specifically, refer to the filecomp.out file) verify that the output from v3.2.3 and v3.2.3e are consistent. Thus, based on the previous testing, there are no unexpected results.

SCR273\flag1\test4\10k and SCR273\flag1\test4\100k: The v3.2.3e subdirectories in the SCR273\flag1\test4\10k and SCR273\flag1\test4\100k directories contain the preliminary output from these runs. Final testing for SCR273\flag1\test4\10k and SCR273\flag1\test4\100k will be conducted after the changes identified in this report are addressed to verify that all flags can be activated and the results are reasonable. The testing performed for this SCR indicated that all flags could be activated and that the 10-kyr and 100-kyr results are reasonable (i.e., all WPs fail at t=0; EBS, UZ, and SZ releases are equal; and peak doses and doses at the end of the simulation time are high). These results are reasonable because with all flags activated the groundwater dose directly arises from EBS release rates.

SCR273\flag2\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag2\test1\10k\v3.2.3_modified subdirectory shows no differences in the output files (*.res, *.tpa, *.rlt, *.ech, and *.cum) compared to the v3.2.3e subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. Based on the previous testing, there are no unexpected results.

SCR273\flag2\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag2\test1\100k\v3.2.3_modified subdirectory shows no differences in the output files (*.res, *.tpa, *.rlt, *.ech, and *.cum) compared to the v3.2.3e subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. Based on the previous testing, there are no unexpected results.

SCR273\flag3\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag3\test1\10k\v3.2.3_modified subdirectory shows no differences in the output files (*.res, *.tpa, *.rlt, *.ech, and *.cum) compared to the v3.2.3e subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. Based on the previous testing, there are no unexpected results.

SCR273\flag3\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag3\test1\100k\v3.2.3_modified subdirectory shows no differences in the output files (*.res, *.tpa, *.rlt, *.ech, and *.cum) compared to the v3.2.3e subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. Based on the previous testing, there are no unexpected results.

SCR273\flag4\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag4\test1\10k\v3.2.3e subdirectory shows no differences in the output files when compared to the results in the SCR273\flag1\test1\10k\v3.2.3 subdirectory(*.res, *.tpa, *.rlt, *.ech, and *.cum), except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. Based on the previous testing, there are no unexpected results.

SCR273\flag4\test1\100k - Expected Results: The filecomp.out file in the

SCR273\flag4\test1\100k\v3.2.3e subdirectory shows no differences in the output files when compared to the results in the SCR273\flag1\test1\100k\v3.2.3 subdirectory (*.res, *.tpa, *.rlt, *.ech, and *.cum), except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date, and header of the run, and differences described and explained earlier in this report. To remove the differences in results attributable to modifications in the SEISMO methodology that was identified in test1 at 100 kyr, the "test" subdirectory below the SCR273\flag4\test1\100k\v3.2.3e subdirectory contains a TPA run performed without SEISMO. The TPA results in this subdirectory (specifically, refer to the filecomp.out file) verify that the output from v3.2.3 and v3.2.3e are consistent. Thus, based on the previous testing, there are no unexpected results.

SCR273\flag5\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag5\test1\10k\v3.2.3e subdirectory shows many expected differences in the output files when compared to the results in the SCR273\flag1\test1\10k\v3.2.3 subdirectory(*.res, *.tpa, *.rlt, *.ech, and *.cum), including the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report.

SCR273\flag5\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag5\test1\100k\v3.2.3e subdirectory shows many expected differences in the output files when compared to the results in the SCR273\flag1\test1\100k\v3.2.3 subdirectory(*.res, *.tpa, *.rlt, *.ech, and *.cum), including the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report.

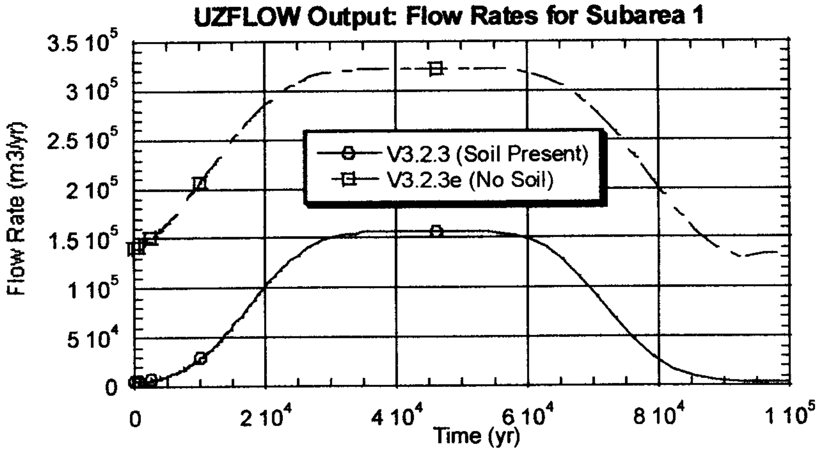
For flag5 testing, to explain the results and understand whether the behavior is reasonable the following hand calculations were conducted and plots prepared.

To compute the area of subarea 1, the following EXCEL was used (note that the area of subarea 1 is 791,564 m^2) using the methodology in subarea.f.

Subarea 1			
x	y	d1 625.8528	
547472	4079324	d2 1338.817	
548069.2	4079137	d3 114641.5	area1 415011.4
547847.3	4077816		
547318.4	4077934	d1 541.8598	
		d2 1398.163	
		d3 82467.62	area2 376553.2
			total area 791564.6

From the dcagw.ech file, the AAP (average annual precipitation) at a representative time (i.e., t = 0) is 6.4094 in/yr [or 0.1628 m/yr]. Since subarea has an area of about 792,000 m^2, the volumetric flow rate of year in subarea 1 is 129,000 m^3/yr. This value is reasonable when compared to the volumetric flow rate in uzflow.rlt, which is 141,320 m^3/yr. The differences appear to be attributable to subarea dependencies and the differences are reasonable.

The following plot shows the difference between v3.2.3 and v3.2.3e flow rates if the soil is removed. As expected, when the soil is removed, the flow rate shows a large increase.



To further explore these results and whether the flow rates are reasonable, additional TPA runs for 100 kyr were performed with the SEISMO flag OFF using v3.2.3e and v3.2.3 (see the SCR273\flag5\test1\100k\v3.2.3e\test and SCR273\flag5\test1\100k\v3.2.3_modified subdirectories). The v3.2.3 code was run using modified soil depth data in soildem.dat with all the soil thicknesses set equal to zero. Using the filecomp.bat file, the results in these two directories were found to be the same. Thus, based on this run and the plot and hand calculation presented previously, the flag in v3.2.3e is correctly setting the soil thicknesses to zero.

SCR273\flag6\test1\10k and SCR273\flag6\test1\100k - Unexpected Results: The filecomp.out file in the SCR273\flag6\test1\10k\v3.2.3e and SCR273\flag6\test1\100k\v3.2.3e subdirectories shows many differences in the output files when compared to the results in the SCR273\flag1\test1\10k\v3.2.3 and SCR273\flag1\test1\100k\v3.2.3 subdirectories and the SCR273\flag6\test1\10k\v3.2.3_modified and SCR273\flag6\test1\100k\v3.2.3_modified subdirectories (*.res, *.tpa, *.rlt, *.ech, and *.cum). The results from these runs are quite different because of what appears to be a inconsistency in the implementation of the UUL presence flag. The other changes (i.e., factors affecting the repository temperature, FOW, FMULT, removal of near-field reflux and losses, and the subarea wet fraction) appear to be correctly implemented. The inconsistency is related to setting the chloride concentration equal to zero. The following example shows that the screen message has a different WP corrosion time for the v3.2.3 and v3.2.3e simulations. This difference are most likely attributed to the chloride concentrations (note the expected results of an later failure time for v3.2.3, with [Cl] = 0, than for v3.2.3e, which has a nonzero [Cl]):

v3.2.3:
```
-----------------------------------------------------------------------
--
      subarea    1 of    7             realization     1 of     1
-----------------------------------------------------------------------
```

```
--
xec: calling uzflow
xec: calling nfenv
xec: calling ebsfail
     ebsfail: time of WP failure =    26840.6  yr
xec: calling seismo
xec: failed WPs from INITIAL   event =     16 at time =      0.0 yr
xec: failed WPs from CORROSION event =   1647 at time =  26840.6 yr
```

```
v3.2.3e   ------------------------------------------------------------
          --------
     subarea   1 of   7          realization    1 of    1
---------------------------------------------------------------------
--
xec: calling uzflow
xec: calling nfenv
xec: calling ebsfail
     ebsfail: time of WP failure =    19756.2  yr
xec: calling seismo
xec: failed WPs from INITIAL   event =     16 at time =      0.0 yr
xec: failed WPs from SEISMIC   event =      4 at time =   4169.3 yr
xec: failed WPs from CORROSION event =   1643 at time =  19756.2 yr
 *** failed WPs: all WPs failed ***
xec: calling ebsrel
```

Note: For the following tests (flags 7 to 14) which remove hydrostratigraphic units from the UZ or SZ, the test procedure was streamlined from that described in the Test Plan, in that for v3.2.3e, the flag was activated, while for v3.2.3 the hydrostratigraphic unit thickness was set equal to zero in tpa.inp (i.e., instead of forcing the hydrostratigraphic unit to be considered, the unit was removed using the flag in v3.2.3e and the thicknesses were set equal to zero in v3.2.3; thus, the results should be the same). For these tests, the filecomp.out file should be the same, whereas filecom2.out, (comparison between v3.2.3e runs with the different hydrostratigraphic units removed and the base case runs of v3.2.3 in SCR273\flag1\test1 for 10 kyr and 100 kyr) should be different.

SCR273\flag7\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag7\test1\10k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag7\test1\10k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. As expected, filecom2.out file (comparison between SCR273\flag7\test1\10k\v3.2.3e and SCR273\flag1\test1\10k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag7\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag7\test1\100k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag7\test1\100k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. (Note that for the 100-kyr simulations the SEISMO flag was not activated, because of reasons described previously.) As expected, filecom2.out file (comparison between SCR273\flag7\test1\100k\v3.2.3e and SCR273\flag1\test1\100k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag8\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag8\test1\10k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag8\test1\10k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. As expected, filecom2.out file (comparison between SCR273\flag8\test1\10k\v3.2.3e and SCR273\flag1\test1\10k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag8\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag8\test1\100k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag8\test1\100k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. (Note that for the 100-kyr simulations the SEISMO flag was not activated, because of reasons described previously.) As expected, filecom2.out file (comparison between SCR273\flag8\test1\100k\v3.2.3e and SCR273\flag1\test1\100k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag9\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag9\test1\10k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag9\test1\10k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. As expected, filecom2.out file (comparison between SCR273\flag9\test1\10k\v3.2.3e and SCR273\flag1\test1\10k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag9\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag9\test1\100k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag9\test1\100k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. (Note that for the 100-kyr simulations the SEISMO flag was not activated, because of reasons described previously.) As expected, filecom2.out file (comparison between SCR273\flag9\test1\100k\v3.2.3e and SCR273\flag1\test1\100k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag10\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag10\test1\10k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag10\test1\10k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. As expected, filecom2.out file (comparison between SCR273\flag10\test1\10k\v3.2.3e and SCR273\flag1\test1\10k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag10\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag10\test1\100k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag10\test1\100k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. (Note that for the 100-kyr simulations the SEISMO flag was not activated, because of reasons described previously.) As expected, filecom2.out file (comparison between SCR273\flag10\test1\100k\v3.2.3e and SCR273\flag1\test1\100k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag11\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag11\test1\10k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag11\test1\10k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. As expected, filecom2.out file (comparison between SCR273\flag11\test1\10k\v3.2.3e and SCR273\flag1\test1\10k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag11\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag11\test1\100k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag11\test1\100k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. (Note that for the 100-kyr simulations the SEISMO flag was not activated, because of reasons described previously.) As expected, filecom2.out file (comparison between SCR273\flag11\test1\100k\v3.2.3e and SCR273\flag1\test1\100k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag12\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag12\test1\10k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag12\test1\10k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. As expected, filecom2.out file (comparison between SCR273\flag12\test1\10k\v3.2.3e and SCR273\flag1\test1\10k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag12\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag12\test1\100k\v3.2.3e subdirectory shows no differences in the output files compared to the SCR273\flag12\test1\100k\v3.2.3_modified subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. (Note that for the 100-kyr simulations the SEISMO flag was not activated, because of reasons described previously.) As expected, filecom2.out file (comparison between SCR273\flag12\test1\100k\v3.2.3e and SCR273\flag1\test1\100k\v3.2.3 results) shows differences in the results, which indicates the unit was removed from the calculations.

SCR273\flag13\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag13\test1\10k\v3.2.3e subdirectory shows no differences through the UZ release rates in the output files compared to the SCR273\flag1\test1\10k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. The differences in the results begin after the SZ computation when the STFF layer is removed. The following information shows that the STFF layer was removed from nefiisz.inp and that the GWTT was affected. Moreover, the SZ release rates with STFF removed began at 2,800 yr, whereas these releases began at 3,200 yr with the STFF layer present. It was not possible to readily modified the data to generate v3.2.3 results that matched v3.2.3e results with the STFF layer removed.

SCR273\flag13\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag13\test1\100k\v3.2.3e subdirectory shows no differences through the UZ release rates in the output files compared to the SCR273\flag1\test1\100k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. The differences in the results begin after the SZ computation when the STFF layer is removed. The following information shows that the STFF layer was removed from nefiisz.inp. Moreover, the SZ release rates with STFF removed began at 2,800 yr, whereas these releases began at 3,200 yr with the STFF layer present. It was not possible to readily modified the data to generate v3.2.3 results that matched v3.2.3e results with the STFF layer removed. (Note that for the 100-kyr simulations the SEISMO flag was not activated, because of reasons described previously.)

```
***** nefiisz.inp
 1      1      2     187.2        0.0         0.0        0.0
 2      2      3    8039.0        0.0         0.0        0.0
                    MIGRATION PATH PROPERTIES ARRAY
***** C:\TESTING_3.2.3E\SCR273\FLAG1\TEST1\10K\V3.2.3\NEFIISZ.INP
 1      1      2     187.2        0.0         0.0        0.0
 2      2      3   14294.9        0.0         0.0        0.0
 3      3      4    8039.0        0.0         0.0        0.0
                    MIGRATION PATH PROPERTIES ARRAY
*****

***** gwttuzsz.res
         1          2.8018E+01        2.6307E+01        2.9378E+01        2.5479E+01
   1.7330E+03       1.9684E+03        2.4106E+01
   5.4781E+02       4.8541E+03        4.8541E+03        2.1640E+03        2.1640E+03
   2.2151E+03       2.2151E+03        2.2151E+03
   2.9545E+03       4.8821E+03        4.8804E+03        2.1933E+03        2.1894E+03
   3.9481E+03       4.1835E+03        2.2392E+03
   3.5023E+03
***** C:\TESTING_3.2.3E\SCR273\FLAG1\TEST1\10K\V3.2.3\GWTTUZSZ.RES
         1          2.8018E+01        2.6307E+01        2.9378E+01        2.5479E+01
   1.7330E+03       1.9684E+03        2.4106E+01
   5.4781E+02       5.0860E+03        5.0794E+03        2.3381E+03        2.3349E+03
   2.3794E+03       2.3758E+03        2.3743E+03
   3.1383E+03       5.1140E+03        5.1057E+03        2.3675E+03        2.3604E+03
   4.1124E+03       4.3442E+03        2.3984E+03
   3.6861E+03
```

SCR273\flag14\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag14\test1\10k\v3.2.3e subdirectory shows no differences through the UZ release rates in the output files compared to the SCR273\flag1\test1\10k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. The differences in the results begin after the SZ computation when the SAV layer is removed. The following information shows that the SAV layer was removed from nefiisz.inp and that the GWTT was affected. Moreover, the SZ release rates with SAV removed began at 1,700 yr, whereas these releases began at 3,200 yr with the STFF layer present. It was possible to readily modified the data to generate v3.2.3 results that matched v3.2.3e results with the SAV layer removed (refer to the filecom2.out file in SCR273\flag14\test1\10k\v3.2.3e which compares results in this run with those in SCR273\flag14\test1\10k\v3.2.3_modified). The results are consistent, as expected.

SCR273\flag14\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag14\test1\100k\v3.2.3e subdirectory shows no differences through the UZ release rates in the output files compared to the SCR273\flag1\test1\100k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. The differences in the results begin after the SZ computation when the SAV layer is removed. The following information shows that the SAV layer was removed from nefiisz.inp. Moreover, the SZ release rates with SAV removed began at 2,800 yr, whereas these releases began at 3,200 yr with the SAV layer present.(Note that for the 100-kyr simulations the SEISMO flag was not activated, because of reasons described previously.) It was possible to readily modified the data to generate v3.2.3 results that matched v3.2.3e results with the SAV layer removed (refer to the filecom2.out file in SCR273\flag14\test1\100k\v3.2.3e which compares results in this run with those in SCR273\flag14\test1\100k\v3.2.3_modified). The results are consistent, as expected.

```
***** nefiisz.inp
 2      2      3   14294.9       0.0       0.0       0.0
                    MIGRATION PATH PROPERTIES ARRAY
***** C:\TESTING_3.2.3E\SCR273\FLAG1\TEST1\10K\V3.2.3\NEFIISZ.INP
 2      2      3   14294.9       0.0       0.0       0.0
 3      3      4    8039.0       0.0       0.0       0.0
                    MIGRATION PATH PROPERTIES ARRAY
*****
```

```
***** gwttuzsz.res
         1         2.8018E+01      2.6307E+01      2.9378E+01      2.5479E+01
1.7330E+03      1.9684E+03      2.4106E+01
   5.4781E+02      2.3196E+02      2.2538E+02      1.7412E+02      1.7093E+02
1.6429E+02      1.6072E+02      1.5917E+02
   1.8380E+02      2.5997E+02      2.5169E+02      2.0350E+02      1.9641E+02
1.8973E+03      2.1291E+03      1.8327E+02
   7.3160E+02
***** C:\TESTING_3.2.3E\SCR273\FLAG1\TEST1\10K\V3.2.3\GWTTUZSZ.RES
         1         2.8018E+01      2.6307E+01      2.9378E+01      2.5479E+01
1.7330E+03      1.9684E+03      2.4106E+01
   5.4781E+02      5.0860E+03      5.0794E+03      2.3381E+03      2.3349E+03
2.3794E+03      2.3758E+03      2.3743E+03
   3.1383E+03      5.1140E+03      5.1057E+03      2.3675E+03      2.3604E+03
4.1124E+03      4.3442E+03      2.3984E+03
   3.6861E+03
*****
```

SCR273\flag15\test1\10k - Expected Results: The filecomp.out file in the SCR273\flag15\test1\10k\v3.2.3e subdirectory shows no differences through the SZ release rates in the output files compared to the SCR273\flag1\test1\10k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. The differences in the results begin after the computation of dose which uses the pumping rate in v3.2.3 and the streamtube flow rate in v3.2.3e for the dilution volume. See the file totdose.res for the dilution volume. The pumping rate is 1.0902e+07 m3/yr (sampled parameter) in v3.2.3. This value is replaced in the v3.2.3e simulation for flag15 with

3.7452e+05 m3/yr in v3.2.3e, which is the sum of the SZ streamtube flow rates (562+585+523+377 m3/yr/m) times the mixing zone thickness (182.9616 m). In the v3.2.3e runs, a smaller dilution volume is used and the doses are higher by this ratio (e.g., the dose at 10 kyr is 1.6624E-01 mrem/yr (v3.2.3e) compared to 5.7110E-03 mrem/yr (v3.2.3). Note that the ratio of these doses is the same ratio as the dilution volume ratio (29.1). Thus, the results are reasonable and expected. Also, an additional run was performed in the SCR273\flag15\test1\10k\v3.2.3_modified subdirectory in which the pumping volume was made very small that caused the next largest dilution volume to be used in the computations. These results exactly matched those in SCR273\flag15\test1\10k\v3.2.3e (see SCR273\flag15\test1\10k\v3.2.3e\filecom2.out).

SCR273\flag15\test1\100k - Expected Results: The filecomp.out file in the SCR273\flag15\test1\100k\v3.2.3e subdirectory shows no differences through the SZ release rates in the output files compared to the SCR273\flag1\test1\100k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. The differences in the results begin after the computation of dose which uses the pumping rate in v3.2.3 and the streamtube flow rate in v3.2.3e for the dilution volume. See the file totdose.res for the dilution volume. The pumping rate is 1.0902e+07 m3/yr (sampled parameter) in v3.2.3. This value is replaced in the v3.2.3e simulation for flag15 with 3.7452e+05 m3/yr in v3.2.3e, which is the sum of the SZ streamtube flow rates (562+585+523+377 m3/yr/m) times the mixing zone thickness (182.9616 m). In the v3.2.3e runs, a smaller dilution volume is used and the doses are higher by this ratio (e.g., the dose at 100 kyr is 9.2359E+00 mrem/yr (v3.2.3e) compared to 3.1716E-01 mrem/yr (v3.2.3). Note that the ratio of these doses is the same ratio as the dilution volume ratio (29.1). Thus, the results are reasonable and expected. Also, an additional run was performed in the SCR273\flag15\test1\100k\v3.2.3_modified subdirectory in which the pumping volume was made very small that caused the next largest dilution volume to be used in the computations. These results exactly matched those in SCR273\flag15\test1\100k\v3.2.3e (see SCR273\flag15\test1\100k\v3.2.3e\filecom2.out).

TESTING FOR SCR274

SCR274\test1\10k - Expected Results: See the description above of SCR273 for flag1\test1\10k. The results are in the v3.2.3 and v3.2.3e subdirectories of SCR273 for flag1\test1\10k and are consistent with the expected results.

SCR274\test1\100k - Expected Results: See the description above of SCR273 for flag1\test1\100k. The results are in the v3.2.3 and v3.2.3e subdirectories of SCR273 for flag1\test1\100k and are consistent with the expected results. The output below from the information printed to the screen during a TPA simulation (see tpa.inp) illustrates that the early peak releases are not being treated as no releases in v3.2.3e. Note that only Tc99 was analyzed in this test for illustrative purposes because it exhibits source depletion using SF dissolution rate model 1and has no ingrowth.

```
v3.2.3e---------------------------------------------------------------
       subarea    1 of    7          realization    1 of    1
   -------------------------------------------------------------------

   xec: calling uzflow
   xec: calling nfenv
   xec: calling ebsfail
        ebsfail: time of WP failure =    20525.6  yr
   xec: failed WPs from INITIAL   event =     16 at time =      0.0 yr
```

```
xec: failed WPs from CORROSION event =   1647 at time =  20525.6 yr
 *** failed WPs: all WPs failed ***
xec: calling ebsrel
                     Highest release rates from Sub Area          1
              Tc99    2.5854E+01 [Ci/yr/SA] at  2.216E+04 yr
xec: calling uzft
      *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                        Highest release rates from UZ
              Tc99    2.5854E+01 [Ci/yr/SA] at  2.216E+04 yr
xec: calling szft
                        Highest release rates from SZ
              Tc99    1.0061E+01 [Ci/yr/SA] at  5.375E+04 yr
```

```
v3.2.3 -----------------------------------------------------------------------
     subarea   1 of   7          realization    1 of    1
-----------------------------------------------------------------------
xec: calling uzflow
xec: calling nfenv
xec: calling ebsfail
     ebsfail: time of WP failure =    20525.6  yr
xec: failed WPs from INITIAL   event =      16 at time =      0.0 yr
xec: failed WPs from CORROSION event =   1647 at time =  20525.6 yr
 *** failed WPs: all WPs failed ***
xec: calling ebsrel
                     Highest release rates from Sub Area          1
              Tc99    2.5854E+01 [Ci/yr/SA] at  2.216E+04 yr
xec: calling uzft
                           There is no UZ release
xec: calling szft
                           There is no SZ release
```

TESTING FOR SCR275

SCR275\test1\10k - Expected Results: See the description above of SCR273 for flag1\test1\10k. The results are in the v3.2.3 and v3.2.3e subdirectories of SCR273 for flag1\test1\10k and are consistent with the expected results.

SCR275\test1\100k - Expected Results: See the description above of SCR273 for flag1\test1\100k. The results are in the v3.2.3 and v3.2.3e subdirectories of SCR273 for flag1\test1\100k and are consistent with the expected results.

SCR275\test2\10k and SCR275\test2\100k - Expected Results: The filecomp.out file in the SCR275\test2\10k\v3.2.3e and SCR275\test2\100k\v3.2.3e subdirectories shows the time and date are included in the ASHPLUME output file.

TESTING FOR SCR276

SCR276\test1\10k - Expected Results: See the description above of SCR273 for flag1\test1\10k. The results are in the v3.2.3 and v3.2.3e subdirectories of SCR273 for flag1\test1\10k and are consistent with the expected results (i.e., the constant parameters in cp.tpa are written to this v3.2.3e file in double precision, instead of single precision as in v3.2.3).

SCR276\test1\100k - Expected Results: See the description above of SCR273 for flag1\test1\100k. The results are in the v3.2.3 and v3.2.3e subdirectories of SCR273 for flag1\test1\100k and are consistent with the expected results (i.e., the constant parameters in cp.tpa are written to this v3.2.3e file in double precision, instead of single precision as in v3.2.3).

TESTING FOR SCR277

SCR277\test1\10k - Expected Results: See the description above of SCR273 for flag1\test1\10k. The results are in the v3.2.3 and v3.2.3e subdirectories of SCR273 for flag1\test1\10k and are consistent with the expected results.

SCR277\test1\100k - Expected Results: See the description above of SCR273 for flag1\test1\100k. The results are in the v3.2.3 and v3.2.3e subdirectories of SCR273 for flag1\test1\100k and are consistent with the expected results.

SCR277\test2\10k and SCR277\test2\100k - Expected Results: The filecomp.out files in the SCR277\test2\10k\v3.2.3e and SCR277\test2\100k\v3.2.3e subdirectories show many differences in the results compared to the SCR273\flag1\test1\10k\v3.2.3 and SCR273\flag1\test1\100k\v3.2.3 subdirectories, including the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. The v3.2.3_modified subdirectories contains output from simulations that stopped execution because the TPA v3.2.3 code did not have the capability to accept a tpa.inp parameter names that wasn't previously defined in the tpanames.dbs file. The differences in the v3.2.3 and v3.2.3e results arise from the addition of new sampled parameters in the tpa.inp file, which causes a different set of output values from the LHS sampling. Most significant to this test is that not only were the 10 new sampled parameters and two flags added to the sp.tpa, cp.tpa, spquery.tpa files, but also the 10 new parameters were added to the tpanames.dbs file was shown below:

```
new1parameter                                          1
new2parameter                                          2
new3parameter                                          3
new4parameter                                          4
new5parameter                                          5
new6parameter                                          6
new7parameter                                          7
new8parameter                                          8
new9parameter                                          9
new12parameter                                         10
```

Additionally, in the samplpar.hdr file, the new parameter names are not listed with a name or abbreviation (see below):

```
Input file tpa.inp as supplied with TPA Version 3.2.4b Code.

 8-27-99

 TPA 3.2.3.e PVM capable, Job started: Sat Nov 06 09:21:44 1999
 Names for Sampled Parameters (Nonconstant)

 Specified in "tpa.inp" - Values for Each Vector


     1
```

```
 2
 3
 4
 5
 6
 7
 8
 9
10
11  AAMAI@S    ArealAverageMeanAnnualInfiltrationAtStart[mm/yr]
12  MAPM@GM    MeanAveragePrecipitationMultiplierAtGlacialMaximum
13  MATI@GM    MeanAverageTemperatureIncreaseAtGlacialMaximum[degC]
14  FOC-R      FractionOfCondensateRemoved[1/yr]
```

It would be reasonable to write either a dummy abbreviation or a number with the parameter name in this file.

SCR277\test3\10k and SCR277\test3\100k - Expected Results: The filecomp.out files in the SCR277\test3\10k\v3.2.3e and SCR277\test3\100k\v3.2.3e subdirectories show many differences in the results compared to the SCR273\flag1\test1\10k\v3.2.3 and SCR273\flag1\test1\100k\v3.2.3 subdirectories, including the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. The differences in the results arise from the addition of new sampled parameters in the tpa.inp file, which causes a different set of output values from the LHS sampling. Most significant to this test is that not only was the new sampled parameter added to the sp.tpa, cp.tpa, spquery.tpa files, but also the new parameter was added to the tpanames.dbs file was shown below:

```
BeginningOfSEISMOWPFailureInterval3[yr]                  SeisInt3
BeginningOfSEISMOWPFailureInterval4[yr]                  SeisInt4
FOCTR                                               FOCTR1
```

(note that parameter name matched an abbreviation in tpanames.dbs and that the abbreviation was changed appropriately)

SCR277\test4\10k and SCR277\test4\100k - Expected Results: The filecomp.out files in the SCR277\test4\10k\v3.2.3e and SCR277\test4\100k\v3.2.3e subdirectories show many differences in the results compared to the SCR273\flag1\test1\10k\v3.2.3 and SCR273\flag1\test1\100k\v3.2.3 subdirectories, including the expected differences noted in the test plan for the cp.tpa file (single vs. double precision), the time, date and header of the run, and differences described and explained earlier in this report. The differences in the results arise from the addition of two new sampled parameters in the tpa.inp file, which causes a different set of output values from the LHS sampling. Most significant to this test is that not only were the two new sampled parameter added to the sp.tpa, cp.tpa, spquery.tpa files, but also the new parameter was added to the tpanames.dbs file was shown below:

```
BeginningOfSEISMOWPFailureInterval3[yr]                  SeisInt3
BeginningOfSEISMOWPFailureInterval4[yr]                  SeisInt4
AbCdEfGhIjKlMnOpQrStUvWxYz                               ACEGIKMO
AaCcEeGgIiKkMmOoQqSsUuWwYy                               ACEGIKM1
```

(note that the upper case letters were the same in the two parameter names and that the abbreviation was changed appropriately)

11/23/99

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Follow-up Testing for SCRs 273 - 277

TPA Version 3.3

To: R. Janetzke
From: R. Rice
11/23/99
3 pages

testing performed by

Robert Rice

report submitted

November 23,1999

11/23/99

Follow-up testing for SCRs 273 to 277 was performed and the results summarized below. This write-up will be extracted and used for the test report.

Note: In the follow-up test results provided in this report, the v3.2.3 and v3.2.3n output is different not only because of the reasons identified in the test plan (i.e., differences of single versus double precision in the cp.tpa file and the time and date of the run) but also because of changes introduced in the versions from 3.2.3e to 3.2.3n. Specifically, the releaset.f values are somewhat different because of a modification in the interpolation algorithm that allowed for variable time steps. Also, determination of the SEISMO magnitude of events was changed from the method in v3.2.3 and v3.2.3e to the method in v3.2.3n. Consequently, comparison of the results as described in the follow-up test plan may need to be altered slightly. Any differences will be highlighted in the following discussion of results.

follow_up\test1\10k - Expected Results: This test is establishes a baseline between the version 3.2.3 and 3.2.3n results for 10,000 yr and is a follow-up to SCR273\flag1\test1\10k. The filecomp.out file in follow_up\test1\10k\v3.2.3n shows reasonable results and no unexpected differences in the output files when compared to the results in the follow_up\test1\10k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision); the time, date and header of the run; and the differences in the release rates from releaset.f and the magnitude of the seismic events, which were expected as described at the beginning of this test report.

follow_up\test1\100k - Expected Results: This test is establishes a baseline between the version 3.2.3 and 3.2.3n results for 100,000 yr and is a follow-up to SCR273\flag1\test1\100k. The filecomp.out file in follow_up\test1\100k\v3.2.3n shows reasonable results and no unexpected differences in the output files when compared to the results in the follow_up\test1\100k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision); the time, date and header of the run; and the differences in the release rates from releaset.f and the magnitude of the seismic events, which were expected as described at the beginning of this test report.

follow_up\test2\10k - Expected Results: This test is a follow-up to SCR273\flag6\test1\10k. The filecomp.out file in follow_up\test2\10k\v3.2.3n shows reasonable results and no unexpected differences in the output files when compared to the results in the follow_up\test2\10k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision); the time, date and header of the run; and the differences in the release rates from releaset.f and the magnitude of the seismic events, which were expected as described at the beginning of this test report. Specifically, this test verifies that the chloride concentration is zeroed out in the chlrdmf.dat file for v3.2.3n when the UUL is removed.

follow_up\test2\100k - Expected Results: This test is a follow-up to SCR273\flag6\test1\100k. The filecomp.out file in follow_up\test2\100k\v3.2.3n shows reasonable results and no unexpected differences in the output files when compared to the results in the follow_up\test2\100k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision); the time, date and header of the run; and the differences in the release rates from releaset.f and the magnitude of the seismic events, which were expected as described at the beginning of this test report. Specifically, this test verifies that the chloride concentration is zeroed out in the chlrdmf.dat file for v3.2.3n when the UUL is removed.

follow_up\test3\10k and follow_up\test3\100k - Expected Results: This test is a follow-up to the SCR273\flag1\test1\10k and SCR273\flag1\test1\100k testing which identified a difference in the implementation of the WP stiffness (i.e., a tpa.inp parameter in v3.2.3 and a computed value in v3.2.3n). The filecomp.out file in follow_up\test3\10k\v3.2.3n shows reasonable results and no unexpected differences in the output files when compared to the results in the follow_up\test3\10k\v3.2.3 subdirectory, except for the expected differences noted in the test plan for the cp.tpa file (single vs. double precision); the time, date and header of the run; and the differences in the release rates from releaset.f and the magnitude of the seismic events, which were expected as described at the beginning of this test report. Because of the change in the methodology used to determine the magnitude of the seismic event and that there were no seismic events in both v3.2.3 and v3.2.3n output, it was not possible to directly match outputs. However, a hand calculation using an equation in the v3.2.3n seismo.f and the values specified in tpa.inp that were used to compute the WP stiffness in v3.2.3n was consistent with the constant value for the WP stiffness specified in v3.2.3 tpa.inp. The hand calculation and source code in v3.2.3n seismo.f are shown below:

```
      WPWall = OuterWPThickness + AInnerWPThickness
      Rave = WPDiameter - WPWall/2.0d0
      Package_Stiffness = 48.d0 * Package_Modulus * 3.14159d0 *
     &                    Rave**3 * WPWall /  WPLength**3
```

with the following values (these values are specified in tpa.inp):

OuterWPThickness = 0.1 m
AInnerWPThickness = 0.02 m
WPDiameter = 1.802 m
Package_Modulus = 2.07 x 10^{11} Pa
WPLength = 5.682 m

Using these values, Package_Stiffness = 1.2146 x 10^{10} Pa-m. A value of 1.21 x 10^{10} Pa-m was specified in v3.2.3 tpa.inp. Thus the values are consistent.

11/23/99

SOFTWARE CHANGE REPORT

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-288

Software Title and Version: TPA 3.3

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):

This SCR does not address a specific module, but rather is a vehicle for the documentation of the reasonableness test specified in the SDP.

Change Requested by:
S. Mohanty
Date: 3-15-00

Change Authorized by (*Software Developer*):
R. Janetzke
Date: 3-15-00 R. Janetzke

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

This reasonableness test compares output of TPA4.0 to TPA3.2.3.

Implemented by:
N/A

Date:

Description of Acceptance Tests:

See attached.

Tested by: S. Mayer
S. Mayer Stefan Mayer

Date:
3-31-00

CNWRA Form TOP-5 (01/99)

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TPA Reasonableness Test Plan - SCR 288

Test name: TPA4.0beta - Reasonableness Test - SCR288

Anticipated start date: 03-15-00

Anticipated completion date: 03-31-00

Amount of your time available to perform this test: 90%

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): 0/100
[*Process level testing tests the subroutine in standalone mode outside of the TPA code, usually with the aid of a special purpose driver of trivial construction. System level testing tests the subroutine in a fully integrated environment with the TPA code.*]

Output files to be checked: infilper.res, nearfld.res, uzst.rlt, szst.rlt, totdose.res, gwttuzsz.res

Input files to be checked for proper data transfer to the program:
tpa.inp, strmtube.dat

Disposition of documentation (storage medium, physical location, and access method):
[*Documentation should include test driver source code, and input, intermediate and output files. Also include any plot files or plot hard copies that are used to display the results.*]
Test work performed on vulcan
Results stored on attached floppy
Some results and discussion stored in Scientific Notebook #170

Initial comparison test:
Major changes of base case mean value simulations in output totdose.res will be identified.

Functional test:
The parameter values and/or code changes that significantly influence prediction changes will be identified.

Reasonableness test:
The reasonableness of cause and effect will be discussed.

Final Checklist (completed during testing):
- Did the modification substantially change the results?
- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?
- Which nuclides were monitored to determine reasonableness of results in term of dose?

TPA Test Results - SCR 288

Details of the test and test results can be read in the appropriate section of scientific notebook #170. Some details of the notebook entry are printed and attached.
The input files, code generated output files, and code performance testing files that were used for this test are documented in attached floppy disk.

Initial comparison test:	All main changes documented and discussed.	DONE
Functional test:	See attached notebook excerpt.	DONE
Reasonableness test:	See attached notebook excerpt.	PASSED

Final Checklist (completed during testing):

- Did the modification substantially change the results?	YES
- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?	YES
- Which nuclides were monitored to determine reasonableness of results in term of dose?	Tc99, I129, Cl36, Se79, Np237

Excerpt of Scientific Notebook # 170

4. DISCUSS REASONABLENESS OF BASE CASE COMPARISON

4.1 Repeat final reasonableness test

Based on the preliminary findings, and given the rapid succession of code in parameter input changes in parallel to the preliminary work, a series of core reasonableness tests have been repeated.

They focus on the prediction of TEDE obtained from versions 3.2.3 and 4.0. To describe the influence and evaluate reasonableness of the main parameters and changes introduced in version 4.0, following scenarios were simulated and compared to each other:

1) Base case 3.2.3
2) As 1), with all WPs forced to fail at 16000 [yr] (to have comparison case independent of corrosion)
3) As 2), using only single subarea model (for easier comparison of relative average SZ travel times)
4) Base case 4.0
5) As 4), with DripShieldFailureTime set to 0 (simulate no drip shield presence)
6) As 5), with all WPs forced to fail at 16000 [yr] (to have comparison independent of corrosion)
7) As 6), using only single subarea (for easier comparison of relative average SZ travel times)
8) As 7), with DistanceFromTuffToAlluviumInterface reset to 5.0 [km] (approximate 3.2.3 input)
9) As 8), with total waste reduced to 62728 [MTU] (to approximate #WPs used in 3.2.3)
10) As 9), with 8 SAs
11) As 5), with distance and total waste approximated to 3.2.3, and mean corrosion rates modified by setting AA_1_1 to 39000 (value chosen so that WP failure is ~ 17000, similar to 3.2.3 base case)
12) As 11), with DripShielFailureTime back to 7422 [yr]
13) As 11), with DistanceFromTuffToAlluviumInterface reset to original base case value of 12.5 [km]

4.2 Discuss results

The influence of the dripshield as predicted with TPA version 4.0 is to delay initial radionuclide arrival time. It has no predicted influence on TEDE resulting from intermediate time releases (in this case, resulting from the corrosion of most WP at ~ 17000 [yr]). The comparisons were done for version 4.0, both for the base case and for the case in which WP corrosion was forced. For each case, the influence of the dripshield, by either setting DripShieldFailureTime to 0.0 [yr] or to 7422 [yr], was considered.

Figure 4.1.1 shows the simualted results. It also shows that the DripShield has no influence of the intermediate time arrival of radionuclides, since both "corrosion" curves overlap for the influence of corrosion related release. This is reasonable, since the dripshield is supposed to prevent radionuclides to be transported from the repository, even if WP have failed early on. It is also reasonable that, if the dripshield fails before WP corrode, that the release from corroded WP yields a TEDE which is not affected by the dripshield.

Note that the base case 4.0 does not predict corrosion failure over the first 50000 [yr] with the given set of mean input parameters. Here is not the place to evaluate whether model and/or parameter assumptions related to WP corrosion are appropriate or not. What is observed is that, these models and/or parameters given as they are, it is reasonable that the TEDE prediction lacks the second peak in comparison to results from version 3.2.3. The increase in TEDE predicted towards the end of the 50000 [yr] period considered is likely due to the delayed arrival of radionuclides that were released with initial WP failure.

To make a direct comparison of the influence of corrosion possible, an *ad hoc* change was done in the input parameter set in tpa.inp. Corrosion was simulated by modifying the input parameter AA_1_1, which governs the average, even corrosion of the outer overpack. A value was chosen to assure that corrosion failures occur at about the same time as in version 3.2.3. Figure 4.1.1 shows that with corrosion simulated in this manner, version 4.0 also predicts a second peak TEDE, and values at intermediate times which are two orders of magnitude higher than without corrosion.

In Figure 4.1.2, the 3.2.3 base case is compared to 4.0 base case and to modifications of the latter, where 1) the dripshield was set to fail at 0.0 [yr], 2) the WP corrosion rate was input to approximate 3.2.3 corrosion failure times, 3) the number of WP was reduced to equal the 3.2.3 base case, and 4) the distance to tuff-alluvium interface was either set to 5.0 [km] to approximate the 3.2.3 case, or left at the default 4.0 mean input value of 12.5 [km].

Clearly, the main differences in TEDE predictions from versions 3.2.3 and 4.0 base cases are due to the introduction of the drip shield, and to the modified corrosion properties. By comparison, the two modified simulations predict TEDE that are closer to the old version 3.2.3 base case.

However, these TEDE curves still have some unexplained differences. Mainly, the modified base case 4.0 version simulations predict early and intermediate breakthrough peaks that are roughly a factor of four greater than predicted by version 3.2.3. Further, the time of these peaks are shifted by several millenia.

A first hypothesis to explain these remaining differences called upon the modified dose conversion factors for the new version. However, the only radionuclides that appeared in GW by the end of 50000 [yr] to any significant concentration were Tc99, I129, Cl36, Se79, and Np237. The average conversion factors used in the different versions were compared to each other and no significant update changes were found for these specific radionuclides.

A second hypothesis to explain the differences was based on the modified transport behavior. Especially, the simulations of transport through the SZ rely upon significantly altered input data.

A preliminary comparison of average GW travel times through the UZ an SZ in the different subareas indicates that there have been a number of substantial changes to the code estimates. For example, UZ and SZ travel times now average 594 [yr] and 767 [yr], respectively. They fluctuate between 401 [yr] and 1317 [yr] for all SA in the UZ (except in SA8 with 17 [yr]), and are similar for all SA in the SZ. The resulting combined UZSZ GW travel times fluctuate between 797 [yr] and 2155 [yr], with an average of 1361 [yr]. By comparison with version 3.2.3, the averages for UZ, SZ, and combined UZSZ were 264 [yr], 3650 [yr], and 3914 [yr], respectively. Fluctuations were significantly higher, being 20 [yr] for most SA in UZ, except 823 [yr] in SA5 and 926 [yr] in SA6, and ranging from 2697 [yr] to 5951 [yr] for SZ.

Unfortunately, an overall change in transport parameter (setting the distance from Tuff to Alluvium to 5.0 [km] from 12.5 [km]) cannot explain the changes in TEDE since version 3.2.3. As far as peak times in the curves are concerned, the 5.0 [km] case yields an intermediate peak time similar to that of 3.2.3, while the 12.5 [km] case yields an early peak time similar to 3.2.3.

To gain greater insight, a detailed look at all involved radionuclides contributing to TEDE is offered. Only those radionuclides are shown that have significant breakthrough (i.e., if the release rate was 10^{-7} [Ci/yr] or less by 50000 [yr], they are not shown): I129, Cl36, Tc99 for both versions, and Se79 and Np237 for version 4.0. Figures 4.1.3, 4.1.4. and 4.1.5 show the release rates for the three simulations considered for each of the 7, respectively 8 subareas.

Five main points are observed:

- Np237 and Se79 have breakthrough by 50000 [yr] in version 4.0 only
- The release rate estimates for the three most important radionuclides Tc99, I129, and Cl36 are roughly equal in magnitude for all simulations
- There is a significant time shift of the Tc99 predicted release rates relative to the I129 and Cl36 release rates when the Tuff to Alluvium interface distance is modified
- There is an overall time shift of BTCs due to the change of said distance
- All subareas yield similar BTCs for the three main radionuclides in version 4.0 simulations, while SA1 and SA2 yield a BTC delayed by more than 5000 [yr] in version 3.2.3

A comparison of results suggests the following:

- The strong increase (2 orders of magnitude) of Tc99 release rates from all subareas near 40000 [yr] (version 4.0, distance 5.0 [km]), when other release rates are slightly declining, is paralleled by only a minor increase in the TEDE curve. Thus Tc99 has only a minor contribution to todal dose when compared to I129 and Cl36.
- The time shift of BTCs from different subareas simulated in version 3.2.3, due to different transport properties input to the simulation, causes relatively lower peak TEDE than obtained with version 4.0, where all SA BTCs contribute peak release rates at similar times
- The significant time shift of I129 intermediate time peak in version 3.2.3 simulation correlates with the dual peak of the corresponding TEDE curve

- The higher TEDE estimate at 50000 [yr] from version 4.0 is correlated with overall higher release rates at that time, and the possible contribution of the Se79 and Np237

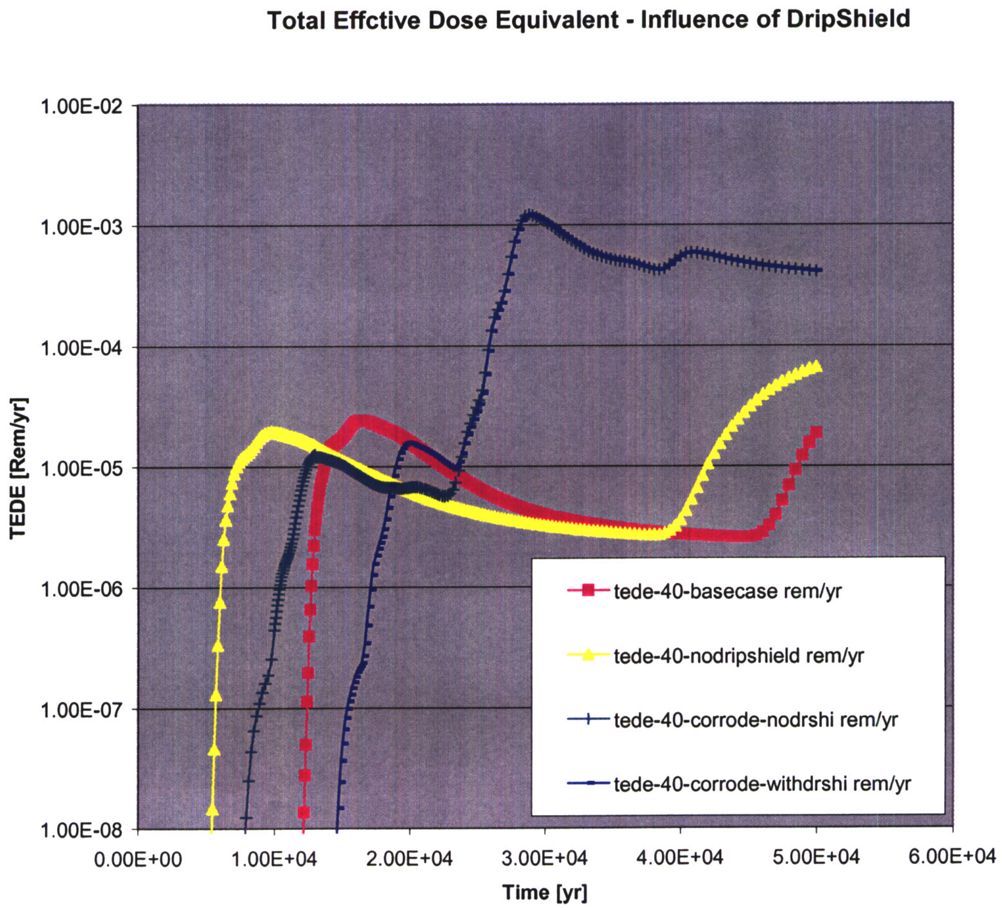

Figure 4.1.1: Influence of DripShield

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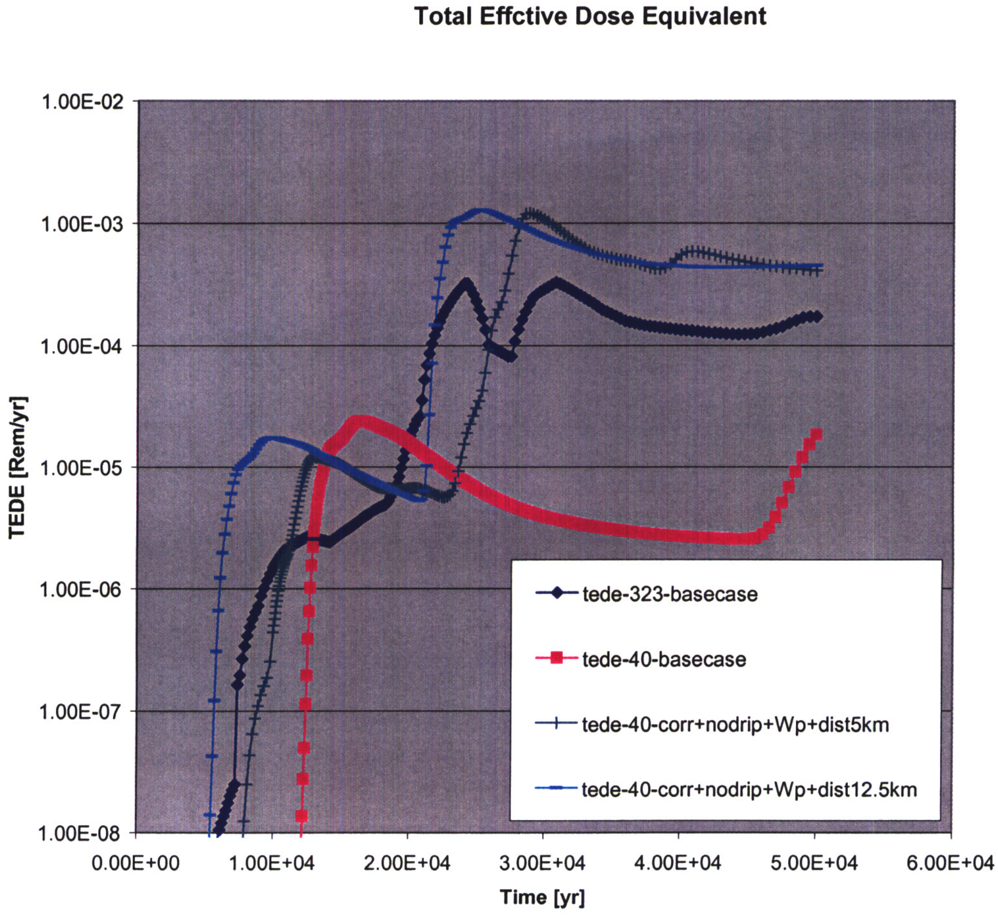
Figure 4.1.2: Comparison of versions 3.2.3 and 4.0 base case, and 4.0 modified to simulate comparable corrosion failure, comparable number of WP in the repository, and two SZ hydrogeologic travel



scenarios

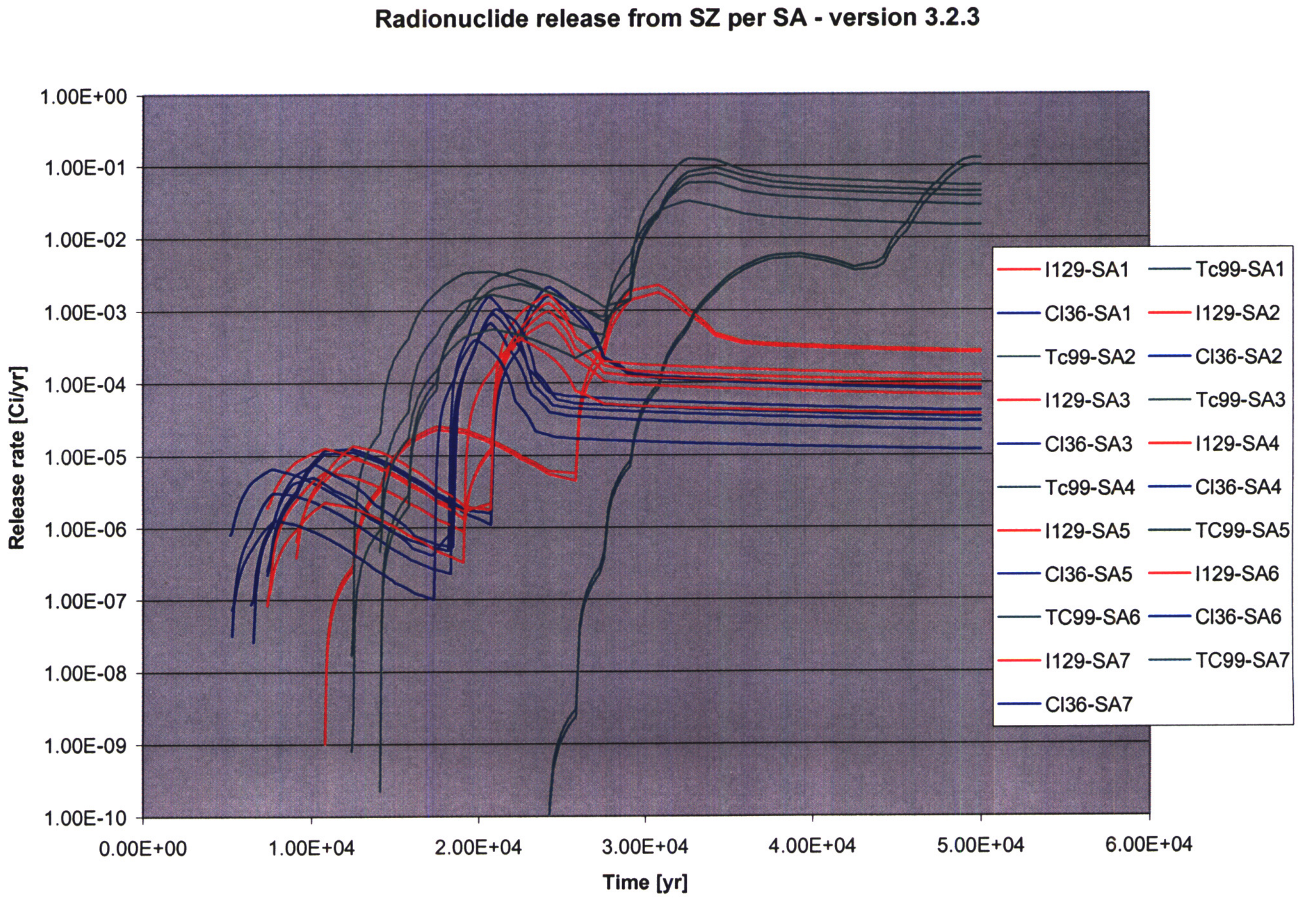


Figure 4.1.3: Radionuclide release rates of the three only significant contributors for version 3.2.3

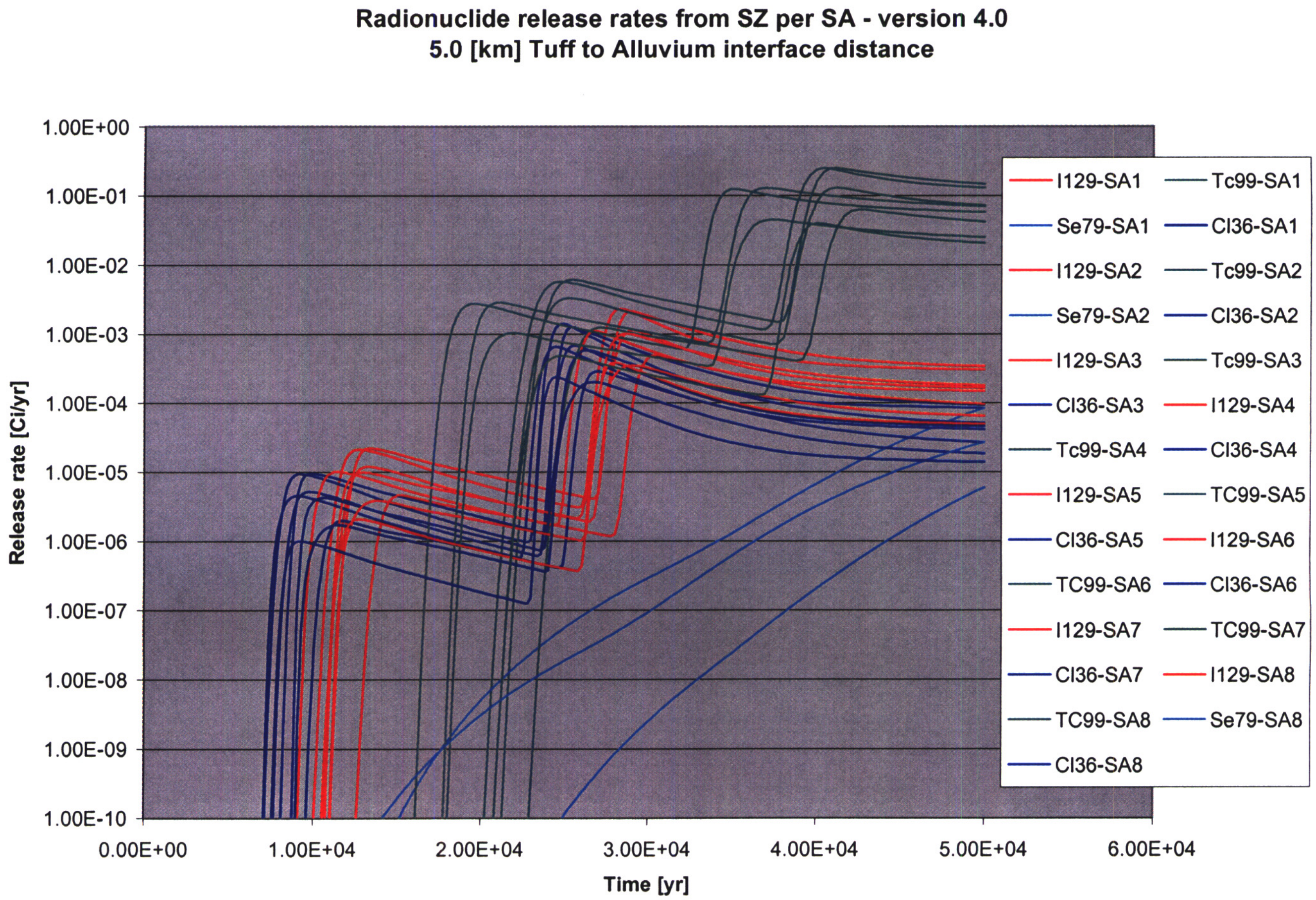
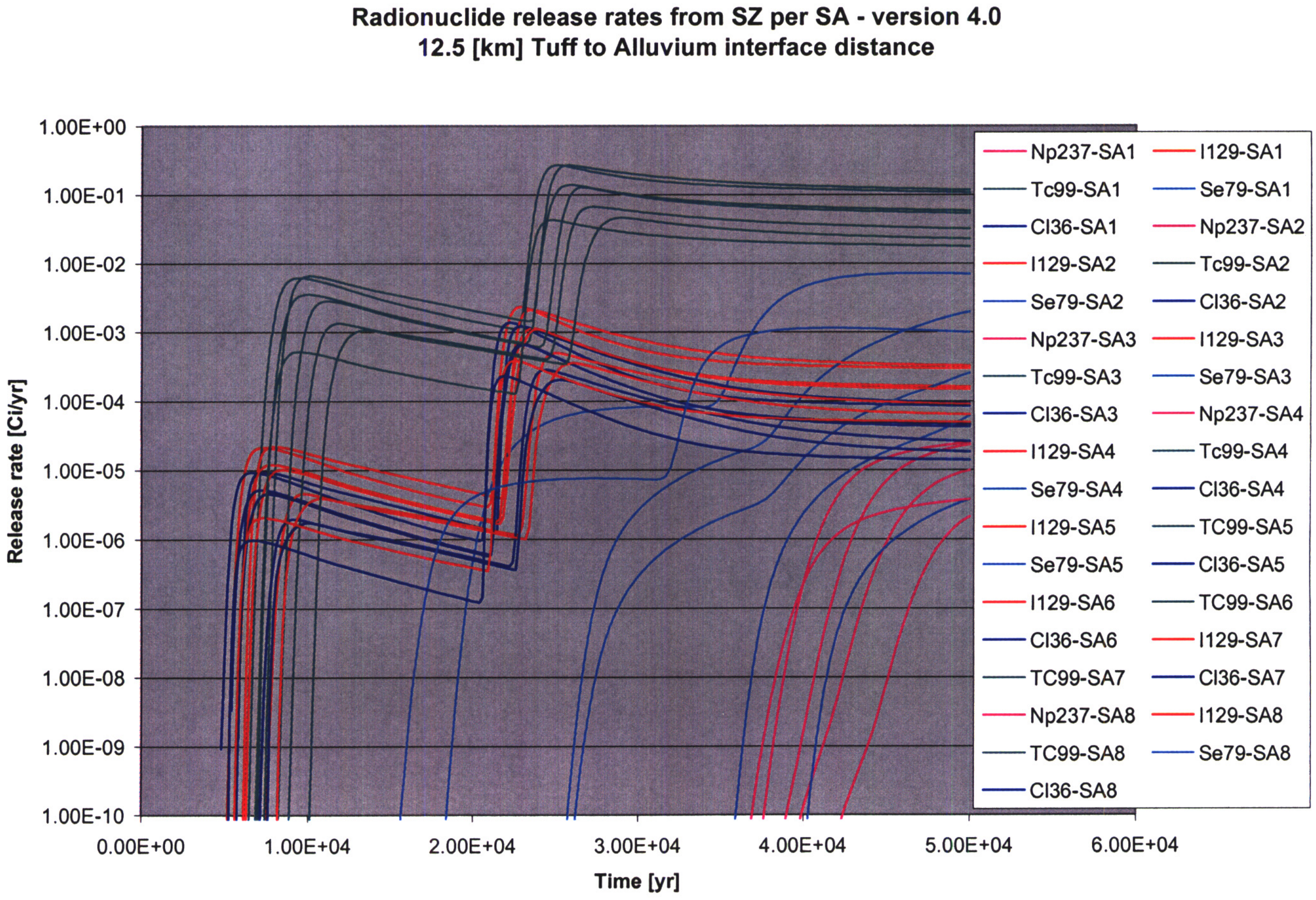


Figure 4.1.4: Radionuclide release rates of the four only significant contributors for version 4.0 for a short Tuff to Alluvium interface comparable to version 3.2.3 simulations

Figure 4.1.5: Radionuclide release rates of the five only significant contributors for version 4.0 using the default Tuff to Alluvium interface



5. CONCLUSION

In summary, the differences of TEDE predicted by the mean value base cases of versions 3.2.3 and 4.0 are mainly influenced by a few parameters and/or code changes.

The introduced dripshield delays early radionuclide breakthrough times, which seems reasonable.

The modified material property models and parameter values do not predict WP corrosion for 50000 [yr]. As a consequence, a significantly reduced TEDE estimate at intermediate times is obtained. This seems reasonable. Note that it does not affect predictions for compliance period, since corrosion failure estimated in version 3.2.3 is also beyond that period.

With otherwise similar simulation conditions, the modified transport properties explain the remaining core differences of the TEDE estimates. Mainly, the more uniform arrival times of peak radionuclide release rates are responsible for higher TEDE estimated in version 4.0. The different assumptions (streamtube data input and tuff to alluvium interface) of SZ transport may explain the time differences in peak TEDE values.

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-289	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

subarea.f

The qlhitsa routine does not correctly handle a segment with the first point outside the subarea and the last point inside the subarea.

Change Requested by: R. Janetzke Date: 1-19-00	**Change Authorized by** (*Software Developer*): R. Janetzke R. Janetzke Date: 1-19-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

A new test was added to determine if only the last point of a segment is inside the subarea. If this is true then the sense of the intersection coefficient for routine linehitline is properly reversed.

Implemented by: Ron Janetzke Ron Janetzke	**Date:** 1-19-00

Description of Acceptance Tests:

A test driver program was developed using the SUBAREA utility module to check whether qlhitsa subroutine correctly computed the length of intersection of a line segment with a subarea (quadrilateral) for six scenarios. A complete description of the test is included on the following pages.

Tested by: Rob Rice	**Date:** 3/17/00

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3/17/00

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	# of pages ▸ 10
To Ron Janetzke	From Rice
SCRs 289, 293, 304	Co.
Dept.	Phone # 915-581-0853
Fax # 210-522-5155	Fax # 915-581-2853

SCR-289: Modify qlhitsa to handle starting point outside and ending point inside quadrilateral

3/16/00 through 3/17/00

The test plan for SCR-289 is listed below:

TPA Test Plan SCR-289

Tester: Rob Rice

Test name: Modify qlhitsa to handle starting point outside and ending point inside quadrilateral

Anticipated start date: March 16, 2000

Anticipated completion date: March 17, 2000

Amount of your time available to perform this test: 16 hours

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50):
100% of the time will be spent developing a test driver program and the associated test to exercise the qlhitsa subroutine in the SUBAREA utility module. Thus, there is no process-level or system-level testing associated with this testing.

Output files to be checked: screen print from the test driver program

Input files to be checked for proper data transfer to the program: source code for the test driver program

Disposition of documentation (storage medium, physical location, and access method):
All tests will be archived on a CD-ROM and described in a scientific notebook that will be submitted to the TPA code custodian, Ron Janetzke, upon completion of the testing. On the CD-ROM, the \testing_4.0\ subdirectory will contain the test driver program (*test.f*) and the output from this driver (*test.out*). This test is associated with SCR-304 (line source instead of area source for the drift temperature calculation). Thus, the impact of this modification on the TPA results can examined in the SCR-304 testing results.

Functional Test Descriptions:

Test 1: The *subarea.f* file will be modified to call the qlhitsa subroutine and test six different sets of scenarios of interest for a line segment intersecting a quadriliateral. That is, line segment endpoints (1) both on the quadrilateral; (2) not intersecting the quadrilateral; (3) starting point outside and ending point inside the quadrilateral; (4) starting point inside and ending point outside the quadrilateral; (5) both points inside the quadrilateral; and (6) both points outside the quadrilateral. The \testing_4.0\ subdirectory contains the test driver program (*test.f*) and the output from this driver (*test.out*).

- Hand calculations: Hand calculations for this testing are limited to verification that the length of intersection of the line segment with the subarea is correctly computed. Because simplified geometry was used to specify the coordinates of the line segments and subarea in the six test sets, the correctness of the computations will be evident by inspection of the output from the *test.f* driver program in the *test.out* file that is available in the \testing_4.0\ subdirectory.

- Process level: N/A

- **System level:** N/A

Reasonableness Test Description: Based on the hand calculations described above, the correctness of the length of intersection of the line segment with the subarea will be evaluated.

Final Checklist (completed during testing):

- **Did the modification substantially change the results?** N/A (see SCR-304 test results)

- **Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in *tpa.inp*?** N/A (see SCR-304 test results)

- **Which nuclides were monitored to determine reasonableness of results in term of dose?** N/A (see SCR-304 test results)

Discussion of test results for SCR-289:

Test 1 Results: The listing for the test driver program (*test.f*) in the \testing_4.0 directory is provided below. Note that the test driver program echos the input data and also supplies the expected\correct output.

(file: *test.f* - driver program only)

```
program test_qlhitsa

implicit double precision (a-h,o-z)

INCLUDE 'maxnsuba.i'
INCLUDE 'subareaa.i'
INCLUDE 'subareab.i'
INCLUDE 'subareag.i'

dimension xyp1(2)
dimension xyp2(2)

nsastore = 7
ikey = 88923

xystore(1,1,1) = 0.0d0
xystore(2,1,1) = 0.0d0
xystore(1,2,1) = 1.0d1
xystore(2,2,1) = 0.0d0
xystore(1,3,1) = 1.0d1
```

```
xystore(2,3,1) = 1.0d1
xystore(1,4,1) = 0.0d0
xystore(2,4,1) = 1.0d1

isa = 1

xyp1(1) = 0.0d0
xyp1(2) = 5.0d0
xyp2(1) = 1.0d1
xyp2(2) = 5.0d0

call qlhitsa(xyp1,xyp2,isa,iflag,alengthinsa)

print *,' '
print *,' '
print *,'**************************'
print *,'TEST 1: BOTH POINTS ON SUABREA'
print *,'xyp1=',xyp1(1),xyp1(2)
print *,'xyp2=',xyp2(1),xyp2(2)
print *,' '
print *,'iflag=(1=hit,0=miss)',iflag
print *,'alengthinsa=',alengthinsa
print *,'(alengthinsa should be 10.0)'
print *,'**************************'
print *,' '
print *,' '

xyp1(1) = -0.1d0
xyp1(2) = 5.0d0
xyp2(1) = 9.9d0
xyp2(2) = 5.0d0

call qlhitsa(xyp1,xyp2,isa,iflag,alengthinsa)

print *,' '
print *,' '
print *,'**************************'
print *,'TEST 2: LEFT OUT AND RIGHT IN SUBAREA'
print *,'xyp1=',xyp1(1),xyp1(2)
print *,'xyp2=',xyp2(1),xyp2(2)
print *,' '
print *,'iflag=(1=hit,0=miss)',iflag
print *,'alengthinsa=',alengthinsa
print *,'(alengthinsa should be 9.9)'
print *,'**************************'
print *,' '
print *,' '

xyp1(1) = 0.1d0
xyp1(2) = 5.0d0
xyp2(1) = 1.1d1
xyp2(2) = 5.0d0

call qlhitsa(xyp1,xyp2,isa,iflag,alengthinsa)

print *,' '
```

```
print *,' '
print *,'***************************'
print *,'TEST 3: LEFT IN AND RIGHT OUT SUBAREA'
print *,'xyp1=',xyp1(1),xyp1(2)
print *,'xyp2=',xyp2(1),xyp2(2)
print *,' '
print *,'iflag=(1=hit,0=miss)',iflag
print *,'alengthinsa=',alengthinsa
print *,'(alengthinsa should be 9.9)'
print *,'***************************'
print *,' '
print *,' '

xyp1(1) = 0.1d0
xyp1(2) = 5.0d0
xyp2(1) = 9.9d0
xyp2(2) = 5.0d0

call qlhitsa(xyp1,xyp2,isa,iflag,alengthinsa)

print *,' '
print *,' '
print *,'***************************'
print *,'TEST 4: LEFT IN AND RIGHT IN SUBAREA'
print *,'xyp1=',xyp1(1),xyp1(2)
print *,'xyp2=',xyp2(1),xyp2(2)
print *,' '
print *,'iflag=(1=hit,0=miss)',iflag
print *,'alengthinsa=',alengthinsa
print *,'(alengthinsa should be 9.8)'
print *,'***************************'
print *,' '
print *,' '

xyp1(1) = -0.1d0
xyp1(2) = 5.0d0
xyp2(1) = 1.1d1
xyp2(2) = 5.0d0

call qlhitsa(xyp1,xyp2,isa,iflag,alengthinsa)

print *,' '
print *,' '
print *,'***************************'
print *,'TEST 5: LEFT OUT AND RIGHT OUT SUBAREA'
print *,'xyp1=',xyp1(1),xyp1(2)
print *,'xyp2=',xyp2(1),xyp2(2)
print *,' '
print *,'iflag=(1=hit,0=miss)',iflag
print *,'alengthinsa=',alengthinsa
print *,'(alengthinsa should be 10.0)'
print *,'***************************'
print *,' '
print *,' '

xyp1(1) = -0.1d0
```

```
      xyp1(2) = 5.0d1
      xyp2(1) = 1.1d1
      xyp2(2) = 5.0d1

      call qihitsa(xyp1,xyp2,isa,iflag,alengthinsa)

      print *,' '
      print *,' '
      print *,'**************************'
      print *,'TEST 6: NO INTERSECTION WITH SUBAREA'
      print *,'xyp1=',xyp1(1),xyp1(2)
      print *,'xyp2=',xyp2(1),xyp2(2)
      print *,' '
      print *,'iflag=(1=hit,0=miss)',iflag
      print *,'alengthinsa=',alengthinsa
      print *,'(alengthinsa should be 0.0)'
      print *,'**************************'
      print *,' '
      print *,' '

      stop
      end
```

The *test.f* program was compiled to generate the *test.exe* file The output from this executable is available in \testing_4.0\test.out and is lsted below.

(file: *test.out*)

```
**************************
TEST 1: BOTH POINTS ON SUABREA
xyp1=   0.00000000000000        5.00000000000000
xyp2=   10.0000000000000        5.00000000000000

iflag=(1=hit,0=miss)           1
alengthinsa=   10.0000000000000
(alengthinsa should be 10.0)
**************************

**************************
TEST 2: LEFT OUT AND RIGHT IN SUBAREA
xyp1=  -0.100000000000000        5.00000000000000
xyp2=   9.90000000000000        5.00000000000000

iflag=(1=hit,0=miss)           1
alengthinsa=   9.90000000000000
(alengthinsa should be 9.9)
**************************

**************************
TEST 3: LEFT IN AND RIGHT OUT SUBAREA
xyp1=   0.100000000000000        5.00000000000000
xyp2=   11.0000000000000        5.00000000000000

iflag=(1=hit,0=miss)           1
```

```
alengthinsa=   9.90000000000000
(alengthinsa should be 9.9)
*************************

*************************
TEST 4: LEFT IN AND RIGHT IN SUBAREA
xyp1=  0.100000000000000         5.00000000000000
xyp2=   9.90000000000000         5.00000000000000

iflag=(1=hit,0=miss)           1
alengthinsa=   9.80000000000000
(alengthinsa should be 9.8)
*************************

*************************
TEST 5: LEFT OUT AND RIGHT OUT SUBAREA
xyp1=  -0.100000000000000        5.00000000000000
xyp2=    11.0000000000000        5.00000000000000

iflag=(1=hit,0=miss)           1
alengthinsa=   10.0000000000000
(alengthinsa should be 10.0)
*************************

*************************
TEST 6: NO INTERSECTION WITH SUBAREA
xyp1=  -0.100000000000000        50.0000000000000
xyp2=    11.0000000000000        50.0000000000000

iflag=(1=hit,0=miss)           0
alengthinsa=   0.00000000000000
(alengthinsa should be 0.0)
*************************
```

Note that the expected and calculated output (i.e., alengthinsa) are the same for all tests. Thus, the testing results for SCR-289 reported above and archived in the \tesing_4.0 directory indicates the TPA Version 4.0 code **PASSES** the test.

TESTING TPA VERSION 4.0 CODE

SCRs 304, 293, and 289

Testing Performed by

Robert W. Rice

March 23, 2000

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TESTING TPA VERSION 4.0 CODE

Three SCRs were identified in the following table for testing by R. Rice (SCRs 304, 293, and 289). The testing for these three SCRs is described in the following pages. See the \testing_4.0 subdirectory on the CD accompanying the test results (submitted to R. Janetzke on 3/24/00) for the source code, executables, data, and output files. The test plans, the test results, and the scientific notebook are available in the \testing_4.0\testplan subdirectory.

The TPA Version 4.0beta code was received from R. Janetzke on a CD dated 2/18/00. Installation tests were conducted in the \testing_4.0\install_test subdirectory on an NT PC and the results compared to the results included on the CD. The output of the installation test was entirely consistent with the output files included on the CD (except for the expected differences in the time and date of the run).

The results from the TPA Version 4.0beta code were compared to the results from the TPA Version 3.3 code, which was available from R. Janetzke on a CD dated 11/29/99. The TPA Version 3.3 code files are located in the \tpa33 subdirectory.

The following pages provide the test plans and results of testing conducted for SCRs 304, 293, and 289.

TPA 4.0 Development Task List

Change #	Effort Level	Description	Implementer	Module	Work Outline	Area of Change	Tester	Status	SCR #	Rationale
0	M	Different corrosion rate for welds	Pensado/ Mohanty	failt.f	Weld corrosion built into overall corrosion calculation	code	Brossia	testing	294	Potential early failure mechanism
				ebsfail.f	Convert 6 hardwired values to input parameters.	code				
1	H	Flexibility in defining the exposure pathways	Muller	gentoo.f	Incorporate stand-alone GENII into TPA	code	LaPlante	testing	301	Capability to address concern of stakeholders
			LaPlante							
2	H	Stochastic biosphere and receptor group	Muller	gentoo.f	Incorporate stand-alone GENII into TPA, incorporate parameter for pluvial transition.	code	Weldy	testing		Capability to address concern of stakeholders
			Smith/ Janetzke/ LaPlante/ Mohanty							
4	H	Include drip shield	Pensado/ Mohanty	ebsrel.f, failt.f	New factor DRIP failure time given by CLST KTI.	code	Codell	testing	294	EDA-II Design
				tpa.inp	Add 2 new parameters.	data				
			Codell	releaset.f	Pre-exponential term.	code	Mohanty	testing		
19	L	Time-dependent mass loading (resuspension ash)	Weldy/ Esh	dcags.f	modify distribution (make time-dependent)	code	Smith	testing	292	Reduce excess conservatism
6	M	Alluvium length variation,	Menchaca/ Janetzke	szft.f	Modify hardwired minimum Tuff length	code	Menchaca	testing	300	Remove feature inconsistent with stochastic PA
			Winterle	strmtube.dat		data		testing		
		Clarify diffusion parameter	McCartin	szft.f	Add penetration distance and fractures per meter parameters.	code	Esh	testing	290	
11	L	# packages entrained in conduit and expelled to surface.	Janetzke	volcano.f	remove geometric consideration in volcano.f. Add/modify # packages distribution	code	Weldy	testing	293	Address possible non-conservatism
12	L	Number of magma induced mechanical failures remaining in drift.	Janetzke	volcano.f	Accommodate new sampled parameter.	code	Rice	testing		Improved information.
				tpa.inp	Add new sampled parameter.	data				

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TPA 4.0 Development Task List

Change #	Effort Level	Description	Implementer	Module	Work Outline	Area of Change	Tester	Status	SCR #	Rationale
27	M	Temporal variability of flow rate.	Rice/ Esh	ebsrel.f	FMULT, FOW	code	Mohanty	testing	303	Improve dynamic features of code
				ebsrel.def						
			Codell	releaset.f		code				
30	H	WP Temperature	Mohanty	nfenv.f	Modify existing model based on EDA-II design	code	McCartin	testing	304	EDA-II Design
43	M	Repository layout	Janetzke	exec.f	Reflect EDA-II design	code	Rice	testing		EDA-II Design
40	M	SEISMO generate seismic events in a repeatable manner	Muller/ Janetzke	seismo.f	system -level code change	code	Janetzke	testing	298	improve interpretation.
42	M	Enable logbeta and iuniform sampled parameter distributions	Codell	snllhs.f	Add logbeta and iuniform distributions to snllhs.f.	code	Janetzke	testing	299	With these additional features the original internal Monte Carlo sampling scheme can be fully replaced with the LHS method.
8	M	Failure type dependent water contact model	Rice	ebsrel.f	Bathtub or flowthru based on failure type.	code	Pensado	testing	296	Remove potential code inconsistency
				ebsrel.def	Add new controls for failure types	data				
				tpa.inp	Add 8 flags to map failure type to model	data				
			Codell	releaset.f	Accommodate new ebsrel.inp file.	code	Mohanty	testing		
32	L	Radiolysis effects via H2O2.	Pensado/ Mohanty	failt.f ebsfail.f	New range of values for models 1 and 2 parameters.	code	Codell	testing	294	Improved information.
38		Variable times steps for reflux models 2 & 3.	Esh	nfenv.f	Use larger time steps after 10k years	code	Mayer	testing	305	Improve code execution.
35	L	Update mean infiltration.	Stohoff	uzflow.f	Move some of the precipitation and temperature modelling to a preprocessor .	code	Fedor	testing	291	Incorporate new theory and data, and reduce TPA run times.
45	I	Use data files for invent.f information	Rice	invent.f	Move bwr & pwr time histories and percentages to a data file.	code	Menchaca	testing	295	Improve flexibility of code.

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Change #	Effort Level	Description	Implementer	Module	Work Outline	Area of Change	Tester	Status	SCR #	Rationale
Bug Fix		Modify qlhitsa to handle starting point outside and ending point inside quadrilateral	Janetzke	subarea.f		code	Rice	testing	289	
Bug Fix		The equation for 'average radius' in seismo was mistyped.	McCartin/ Janetzke	seismo.f	As a minimum rerun the importance analysis run that revealed the inconsistency.	Code	Pensado	testing	302	

END OF TESTING FOR SCRS 304, 293, AND 289. AS PRESENTED ABOVE, THE TPA VERSION 4.0 CODE PASSES ALL OF THE TESTS DESCRIBED IN THE TEST PLANS FOR THESE SCRS.

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-290	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

szft.f, tpanames.dbs

The input parameters for tuff diffusion could be made more user freindly by performing a small calculation in the code.

Change Requested by: T. McCartin Date: 1-19-00	**Change Authorized by** ~~(*Software*~~ *Developer*): R. Janetzke R Janetzke Date: 1-19-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

The porosity of the tuff layer was adjusted by a new PenetrationFraction parameter with a constant value of 0.8.

A new code variable PenetrationDistance is calculated with a new input parameter called FracturesPerMeter with a constant value of 10.0, and the PenetrationFraction.

The final diffusion rate was changed to be a function of porosity, input diffusion rate, and penetration distance.

Implemented by: Tim McCartin Tim McCartin	**Date:** 3/14/2000 1-24-00

Description of Acceptance Tests: (see attached test plan)

1) Spreadsheet calculation of the diffusion rate to verify the equations were coded properly. **The code passed the acceptance test.**

2) Verification that the new input in TPA40 results in the appropriate diffusion rate used by NEFTRAN. **The code passed the acceptance test.**

Tested by: David Esh	**Date:** 3-14-00 3/14/2000

CNWRA Form TOP-5 (01/99)

RECEIVED
MAR 14 2000

TPA Test Plan

Test name: Matrix Diffusion parameter calculation

Anticipated start date: 3-8-00

Anticipated completion date: 3-14-00

Amount of your time available to perform this test: 20%

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50):

Because the code change was simply a new presentation of data that is used to calculate a previous TPA 3.3 input parameter (DiffusionRate_STFF) a simplified driver for process testing was not constructed. The code was tested by running various mean value problems at the system-level.

system-level testing = 100%

Output files to be checked: nefiisz.inp

Input files to be checked for proper data transfer to the program: tpa.inp

Disposition of documentation (storage medium, physical location, and access method):
files and documentation provided via e-mail message to R. Janetzke on 3-14-00.
Files and documentation to reside permanently on C:\TPA_OUT\SZTest2, including:

MatDiff_test_plan_TPA40.wpd	This document
scr_290_Esh.wpd	SCR for this code change
MatDiffTest.xls	Spreadsheet calculations for the code change
tpa.sztest.001	tpa.inp file with DiffusionRate_STFF=0.0
tpa.sztest.002	tpa.inp file with DiffusionRate_STFF=1.0E-14
tpa.sztest.003	tpa.inp file with DiffusionRate_STFF=1.0E-1
nefiisz.inp.001	Created NEFTRAN input file resulting from tpa.sztest.001
nefiisz.inp.002	Created NEFTRAN input file resulting from tpa.sztest.002
nefiisz.inp.003	Created NEFTRAN input file resulting from tpa.sztest.003

Functional Test Descriptions:

- Hand Calculations: The code delivers the same result as the equations given below:

The spreadsheet MatDiffTest.xls was created to perform calculation of the diffusion rate parameter (DiffusionRate_STFF = rold) using the new input parameters (FracturesPerMeter_STFF = z, ImmobilePorosityPenetrationFraction_STFF = n) and the old input parameters (TPA40 DiffusionRate_STFF = rnew, ImmobilePorosity_STFF = q).

Penetration distance = x = n/(2 * z)

Immobile porosity = y = q * n

DiffusionRate_STFF = rold = (y * rnew)/(0.28 * x^2)

The spreadsheet calculations, for similar input, resulted in identical values to those created in nefiisz.inp. **Therefore the code passes the acceptance test.**

- Process-level tests: not applicable

- System-level tests: The code properly reads input from the tpa.inp file and generates nefiisz.inp file.

Three input files were generated to test three different diffusion rate values (tpa.sztest.001, tpa.sztest.002, tpa.sztest.003) and the generated NEFTRAN output files were examined to verify the correct transfer of data (nefiisz.001, nefiisz.002, nefiisz.003). The values in the input files generated for use by NEFTRAN were correct.

Therefore the code passes the acceptance test.

Reasonableness Test Description: not applicable or covered above

Final Checklist (completed during testing):

- Did the modification substantially change the results? No, no performance metric needed for this code change.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp? No, no performance metric needed for this code change.

- Which nuclides were monitored to determine reasonableness of results in term of dose? Not applicable

MatDiff Test.xls

Parameters		
Fracturespermeter	10	B3
Penetration Fraction	0.8	B4
ImmobilePorosity_STFF	0.01	B5
Matirx Porosity		
DiffusionRate_STFF	1.00E-14	B7
Penetration distance	0.04	B9
Immobile porosity	0.008	B10
Diffusion rate	1.786E-13	

Equations Used
(B4/(2*B3)
(B5*B4)
(B10*B7)/(0.28*(B9)^2)

Calculation of old Diffusion rate

File	code value	calculated value	Result
tpa.sztest.001	0	0	exact to round-off
tpa.sztest.002	1.79E-13	1.78571E-13	exact to round-off
tpa.sztest.003	1.79E+00	1.78571E+00	exact to round-off

code values taken from the nefiisz.inp file

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-291	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

array.f, uz_flowi.i, uz_flowr.i, uz_parms.i, uzflow.f

preuzflow.f	version of preprocessor that mimics uzflow
testuzflow.f	test driver and simulated TPA routines
uzflow.f	revised uzflow
array.f	revised array.f

include files similar to or identical to released version
path.i, uz_climi.i, uz_climr.i, uz_climz.i, uz_flowi.i, uz_flowr.i, uz_flowz.i, uz_parms.i

new include files

preuzf.i	all definitions for preprocessor
testuzf.i	some stuff for the simulated TPA routines in testuzflow.f

new data file (other data files are unchanged)

maiDTBL.dat	output from the preprocessor and read by uzflow
preuzflow.dat	input to the preprocessor

Change Requested by: S. Mohanty Date: 1-19-00	**Change Authorized by** (*Software Developer*): R. Janetzke R Janetzke Date: 1-19-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

array.f was modified to include 3 new routines, initr, initi, and initchar, which initialize a vector with an input value. also an error print statement in zeroi was corrected.

Implemented by: S. Stothoff	**Date:** 1-26-00

Description of Acceptance Tests: NoTe: Testing for SCR 291 is superceded by the modifications and Testing for SCR 312. Ron Janetzke

Tested by:	**Date:**

CNWRA Form TOP-5 (01/99) → See SCR PA-SCR-312 for objective Evidence. QA 3/31/2000

SOFTWARE CHANGE REPORT (SCR)

SCR No. PA-SCR-291	**Software Title and Version:** TPA 4.0beta	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

TPA 3.2 UZFLOW module directly implemented the bare-soil regression equation for shallow infiltration. The TPA 4.0 UZFLOW module instead reads in a table of infiltration estimates prepared by the ITYM preprocessor. Preprocessor ITYM only had TPA 3.2 regression equation for shallow infiltration implemented, thus necessitating this software change report. Regression equations for filled fractures for different bedrock types and the inclusion of vegetation model needed to be added.

The primary effect of this change is on the UZFLOW module. The attached testing plan tests both the UZFLOW and the ITYM preprocessor.

Change Requested by: R. Fedors Date: 3-8-00	**Change Authorized by** (*Software Developer*): R. Janetzke R Janetzke Date: 3-8-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

See attached description of ITYM preprocessor. A more complete description is included in the TPA 4.0 documentation Appendix H.

Implemented by: R. Janetzke Janetzke/Stothoff/Fedors	**Date:** March 17, 2000

Description of Acceptance Tests:

See attached test plan.

Tested by: R Fedors R. Fedors	**Date:** March 28, 2000

CNWRA Form TOP-5 (01/99)

TPA Test Plan

Test name: Randy Fedors

Anticipated start date: March 17, 2000

Anticipated completion date: March 27, 2000

Amount of your time available to perform this test: 20 hrs

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50):

> [*Process level testing tests the subroutine in standalone mode outside of the TPA code, usually with the aid of a special purpose driver of trivial construction. System level testing tests the subroutine in a fully integrated environment with the TPA code.*]

For checking the itym preprocessor and the linkage to UZFLOW, a 50:50 split was done; note that itym runs as a separate program and does not need a special purpose driver. Tests will also be performed to make sure that the output from ITYM is correctly handled by the UZFLOW module.

Only a system level check is needed for the comment lines being added to the top of the external input file *maidtbl.dat*. UZFLOW was modified to properly read in the comment lines at the top *maidtbl.dat.*

Output files to be checked:

screen output
maidtbl.dat
uzflow.rlt
infilt.res

Input files to be checked for proper data transfer to the program:

itym.inp
maidtbl.dat

Disposition of documentation (storage medium, physical location, and access method):

> [*Documentation should include test driver source code, and input, intermediate and output files. Also include any plot files or plot hard copies that are used to display the results.*]

Scientific notebook #277 contains the entries and the zip diskette with the test files.

Functional Test Descriptions:

A driver will be coded that produces *maidtbl.dat* tables that will enable the easy evaluation of two items below: (i) a hand calculation of a check on the interpolation between climates in UZFLOW, and (ii) a check on the subarea averaging done in UZFLOW. Other tests will be run using the ITYM preprocessor to create *maidtbl.dat* files and using the TPA 4.0 executable to make sure the *maidtbl.dat* file lead to acceptable TPA 4.0 results.

Hand Calculations:

1. Using hand calculations, check the interpolation between climates scheme in UZFLOW module.

Process-level tests:

2. Check the input options in the *itym.dat* file to make sure that available options produce *maidtbl.dat* files

that can be properly read by the UZFLOW module. Specifically, test the aggregation number for pixels, the input range for precipitation and temperature, and the number of DEMs.

3. Evaluate the subarea averaging in UZFLOW by setting all values of infiltration in *maidtbl.dat* to the same value except for values in one subarea, which will have a different value.

System-level tests:

4. Check to make sure that the UZFLOW module can now read *maidtbl.dat* file with comment lines. This is a simple check to ensure that multiple comment lines are handled. This test will also check to make sure that UZFLOW stops if there are an unexpected number of records in the *maidtbl.dat* file, something that could happen if the comment lines are not properly handled or if the *maidtbl.dat* file is modified by hand.

Reasonableness Test Description:

5. Check the output of ITYM preprocessor to make sure that it is reasonable in terms of magnitude and in terms of distribution across the *maidtbl.dat* output domain. This will be done by tabulating the expected mean values of the entire modeling domain and by plotting the distribution within specific climatic conditions.

6. Compare TPA 3.2 output for subarea averages with TPA 4.0 subarea average when the flag in itym.inp is set to either TPA3 or TPA4. The TPA3 flag option in the ITYM preprocessor uses the same regression as was implemented directly in UZFLOW of TPA 3.2.

Final Checklist (completed during testing):

- Did the modification substantially change the results?

Infiltration estimates for future climates were reduced magnitude in TPA 4.0 over that of TPA 3.2.3 as expected. Percolation values for present-day remained unchanged because there are *tpa.inp* parameters to constrain the present-day infiltration values. This change in the UZFLOW module does, however, add higher quality estimates of both the magnitude and spatial distribution of both present-day and future infiltration.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?

Yes, comparison was reasonable given the changes in subarea delineation.

- Which nuclides were monitored to determine reasonableness of results in term of dose?

N/A

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TEST RESULTS

PA-SCR-312 and PA-SCR-291

All entries were made in Scientific Notebook #227 and were referenced to each specific Test listed below. The scientific notebook contains the directory paths for each component of each Test.

Test 1

Interpolation between climate states was done with spatially uniform infiltration but temporally varying between 1 and 2 and between 1 and 20 mm/yr. The *tpa.inp* file parameters for UZFLOW were set to constant values to control the output. Hand calculations eventually confirmed that UZFLOW was properly calculating the interpolated values. The average infiltration over time reported in *infilper.res* was confirmed by the hand calculations. The interpolation is done in log10 space in UZFLOW, not in standard linear space as initially suspected by the tester.

This series of tests successfully passed.

Test 2

Available options in the input file *itym.dat* for ITYM were checked to make sure that they produced *maidtbl.dat* files that could be properly read by UZFLOW. The num_pixel_merge option produced maidtble.dat files of the expected size and structure for values of 1, 4, and 8; all resulting maidtble.dat files were successfully read by UZFLOW. The input values for the range of precipitation and temperature were adjusted to something smaller than what the TPA simulation was expecting from the climate parameters in the *tpa.inp* file; UZFLOW properly rejected the *maidtbl.dat* file and stopped. The number of DEMSs for different temperatures (num_MAT_table) was changed from 4 to 2 to 1. ITYM produced the proper *maidtbl.dat* file and UZFLOW successfully read in the DEMs for num_MAT_table values of 4 and 2; ITYM did not produce a table with num_MAT_table set to 1. A *maidtbl.dat* file was created with *maid.f* with only one temperature; UZLOW properly rejected that *maidtbl.dat* (tpa.e stopped) when num_MAT_table was set to 1 (we do not presently allow for UZFLOW to interpolate between 1 value for temperature or 1 value for precipitation since this does not make sense).

This series of tests successfully passed.

Test 3

A *maidtbl.dat* file was created that only had non-zero values of infiltration in one subarea (subarea 8) using the fortran code *maidSA8.f*. Initially, UZFLOW did not properly read in the *maidtble.dat*, and hence, it did not calculate the expected subarea averages. This was corrected during testing; a new version of uzflow.f with 4 corrections (presented in Scientific Notebook #227) successfully corrected this problem. When UZFLOW calculates subarea averages, it stops after calculating subarea averages when the average equals zero and prints messages to the screen. The captured screen output was inspected to make sure that only subarea 8 had a non-zero average.

This test successfully passed.

Test 4

Tests were made using manipulated *maidtbl.dat* files that contained unusual or garbage information to check UZFLOW ability to bomb-out when passed bad information. As part of this check, it was shown that the comment lines added to the top of *maidtbl.dat* were properly read in by UZFLOW. Some values of zero as infiltration are okay (some pixels may have evaporation equal to or greater than precipitation), however, subarea averages of zero infiltration are not likely. TPA 4.0 properly ran to completion when some entries were zero, and it properly bombed when a subarea average was zero for at least one climate state DEM. Screen capture of the simulation were checked to determine when the code bombed (stopped before completing a simulation). The TPA 4.0 code also stopped when gibberish entries (non-numeric entries for infiltration) and keyword errors (CELLSIZE) were manually put into the *maidtbl.dat* file. This part of the check was done in case someone manually alters the *maidtbl.dat* file instead of using ITYM to create it.

This test successfully passed.

Test 5

The ITYM software output was evaluated for reasonableness by tracking averages for each climate state and by plotting particular climate states. The averages were tabulated for climate states for values of precipitation of 100, 200, and 800 and temperatures of 0, 14.7, and 22 degrees celcius. Both precipitation increases and temperature decreases led to increased infiltration, just as expected by our background in hydrology. The plots of separate climate states (precipitation = 200 mm/yr and temperature of 0 degrees celcius, and precipitation = 200 mm/yr and temperature = 14.67 degrees celcius) properly reflect our knowledge of the spatial variation of shallow infiltration across Yucca Mountain.

This test successfully passed.

Test 6

Output were compared from *infilper.res* and *uzflow.rlt* files for simulations using (i) TPA 3.2.3, (ii) TPA 4.0 (TPA3 option), and (iii) TPA 4.0 (TPA4 option). The standard deviations in *itym.dat* were set to zero when creating the *maidtbl.dat* file to get consistency in this test. A reasonableness check indicated that certain subareas had higher averages than other subareas, when it should have been reversed. Once the corrections noted in Test 3 were implemented into UZFLOW, the subareas over the crest of Yucca Mountain had the expected higher averages than subareas further east.

This test successfully passed.

ITYM PREPROCESSOR

Prepared by:
Stuart Stothoff and Randall Fedors
March 9, 2000

1. Software Function

The Infiltration Tabulator for Yucca Mountain (ITYM) preprocessor software is intended to estimate expected mean annual infiltration (EMAI) for each grid block ("pixel") of a Digital Elevation Model (DEM) for a set of climate states. EMAI will be estimated for several values of expected mean annual precipitation (EMAP) and expected mean annual temperature (EMAT), providing as output a table of EMAI as a function of EMAP and EMAT. The table can be at the native scale of the DEM, or blocks of pixels can be aggregated to reduce the size of the output table.

The output table will be used as input to the TPA 4.0 code (Mohanty et al., 1999) to estimate EMAI as a function of climate change for each of the subareas in the repository. The TPA 4.0 code has been modified to accept a table of EMAI as a function of EMAP and EMAT, rather than calculating EMAI during each realization. The UZFLOW routines used in TPA 3.2 (Mohanty and McCartin, 1998) to estimate EMAI are placed in the ITYM preprocessor software, providing the option of reproducing the mean annual infiltration (MAI) estimates used in TPA 3.2.

The primary option of the ITYM preprocessor incorporates an enhanced description of the bedrock and soil properties relative to TPA 3.2 (Mohanty and McCartin, 1998). The abstraction used in TPA 3.2 is based on simulations describing MAI through shallow soil on bedrock with open fractures. Two additional abstractions have been developed describing MAI through shallow soils over bedrock with carbonate and soil filled fractures. At its base level, ITYM is a Fortran implementation of a set of Matlab routines developed over the last few years to estimate the spatial distribution of MAI in the vicinity of the repository. The ITYM preprocessor, in addition, enhances the algorithms used in the Matlab routines by adding the capability of explicitly accounting for uncertainty and decade scale temporal variability.

A future modification to the ITYM preprocessor software is considered crucial, and thus worth noting in this SRD. The modification could not be implemented in this version of ITYM. The standard deviation of simulated MAI could be calculated concurrently with the calculation of the mean of MAI during the Monte Carlo simulations in ITYM. The standard deviation could be passed to the UZFLOW module so that it could be used along with the calculated expected mean to define a distribution for TPA sampling to account for uncertainty in hydraulic parameters during future climates. Currently, the uncertainty in hydraulic properties (e.g., soil texture, soil thickness, fracture filling) during future climates is lumped with the uncertainty in future climate conditions in the TPA 3.2 and 4.0 codes.

2. Technical Basis

The ITYM code is based on abstracted equations (Stothoff, 1999) relating mean annual infiltration (MAI) to climatic parameters on a decadal scale, soil and bedrock hydraulic properties, and soil thickness. The abstractions are based on numerous one-dimensional (1D) bare-soil simulations of heat and mass flow with various combinations of climatic and hydraulic parameters. These abstracted equations appropriate for bare soil are modified to account for vegetation using a heuristic relationship.

The DEM structure will be used to independently estimate each of the parameters for each pixel. Hydraulic properties will be assigned according to bedrock maps (Day et al., 1998) and soil cover maps (TRW, 1997) obtained from the DOE as ArcInfo coverages and mapped to the DEM pixels. Climatic properties will be estimated for each pixel according to the local elevation, slope, and aspect. Soil thickness will be provided for each pixel of the DEM as an input file.

Each soil unit is assumed to consist of a soil matrix with some proportion of rock fragments. The rock fragments reduce the permeability and porosity of the soil matrix. The hydraulic properties of the soil and the proportion of rock fragments are uncertain and variable.

Each bedrock unit is assumed to consist of several pathways for water to infiltrate, including a bedrock pathway and various fracture pathways. The fracture pathways are user-defined, but typically would include soil-filled, carbonate-filled, and unfilled fractures. The permeability and porosity of each pathway are multiplied by the volume fraction of the pathway to account for the reduced area for flow. The volume fraction of each pathway is uncertain and variable, as are all bedrock hydraulic properties. The user decides if the pathways are summed to provide MAI or whether just the largest is used (the pathways compete for water, which is not accounted for in the abstracted equations).

The effects of vegetative transpiration, which extracts water through a larger portion of the soil column than evaporation, are incorporated using a simple heuristic relationship. For this relationship, enhanced water extraction to account for transpiration is constrained to soil columns of intermediate thickness and the amount transpired is calibrated so that the site-wide average shallow infiltration estimate is brought in line with current estimates based on other approaches. Noting that the root-mass distribution of a plant in deep soil tends to be approximately exponentially decreasing with depth, a simple model for plant scavenging is

$$f_{scav} = E_0 + [1 - \exp(-\alpha B)](E_1 - E_0)$$

where f_{scav} is the fraction of MAI scavenged, B is the soil moisture capacity, α is an uptake decay factor with soil moisture capacity, and E_0 and E_1 are the efficiencies with zero and infinite soil capacity. The efficiencies and uptake decay factors are dependent on the vegetation type and density, which in turn is dependent on the climate. The three parameters are assumed to be of the form

$$E_0(\mathrm{MAI}) = E_{00} + G_0 \log_{10}(\mathrm{MAI})$$
$$E_1(\mathrm{MAI}) = E_{10} + G_1 \log_{10}(\mathrm{MAI})$$
$$\alpha(\mathrm{MAI}) = \alpha_0 + G_\alpha \log_{10}(\mathrm{MAI})$$

For calculation of present-day infiltration, the parameters could be set so that simulated MAI matches current estimates based on other approaches. The parameters are consider uncertain in ITYM, thus are sampled. As a replacement for the heuristic approach, an alternative approach for root-water extraction can readily be incorporated at some later time.

Each of the parameters used to estimate MAI is either spatially or temporally variable, and the variability descriptions are themselves uncertain. Each of the parameters is sampled from a distribution to account for variability. Uncertainty in the statistical distribution is accounted for by sampling the parameters describing the statistical distribution. Correlation between the various hydraulic properties for a soil or bedrock unit is allowed, as is correlation between the various climatic inputs.

3. Computational Approach

3.1 Data Flow and the User Interface

Primary input to ITYM is through a command file with keyword commands that supply control parameters, descriptions of the sampled parameters, and descriptions of the soil and bedrock units. Several additional files are used to provide the DEMs of elevation, soil thickness, bedrock unit, soil unit, and mean annual wind speed. An additional file is used to provide a table of mean annual solar radiation as a function of ground orientation.

The program structure is straightforward.

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- Read the command file to obtain parameters
- Read the DEM files and tables
- Loop over the output climatic states to estimate EMAI as a function of EMAP and EMAT. For each climatic state, loop over the number of realizations
  - A. For each realization
    - 1. Sample all properties
    - 2. Estimate all properties for each pixel of the DEM
    - 3. Calculate MAI for each pixel of the DEM
    - 4. Keep a running tally of MAI for each pixel
  - B. Calculate mean of MAI over all realizations for each pixel
  - C. Output the DEM for mean MAI as part of the output table of EMAI

The parameters sampled during the Monte Carlo process are listed in table 1 along with the sampled parameters in TPA 4.0 (Mohanty et al., 1999). The basis for the sampling distributions for the parameters in ITYM will be presented in the user's guide and program documentation. The simulations of MAI use a 10 year record from the Desert Rock meteorologic station (Stothoff, 1999) that is scaled for the different climatic conditions. The ITYM considers uncertainty in the scaling of the 10 year Desert Rock record, hence addresses uncertainty on the decadal scale. The TPA 4.0 samples climatic factors relevant to uncertainty on a larger time scale. Table 1 does not include the TPA 4.0 parameters sampled for perturbations of climate on a century scale since this capability of the code is not currently used.

3.2 Hardware and Software Requirements

The software is to be written in standard FORTRAN 77/90. The software is to be used in conjunction with the TPA code, thus must run on the platforms and operating systems that the TPA code runs on. The code will link to the modules in the TPA code that handle system-dependent calls to maintain portability.

3.3 Graphics Requirements

The program does not use graphics.

3.4 Pre- and Post-Processors

The command file may be generated using a Matlab preprocessor or may be created using an ascii editor. The six external files (5 DEMs and 1 table) are static and have been created as follows:

- The elevation DEM with 30-m pixels is generated by the USGS.
- The soil thickness DEM is created using a preprocessor code, as is the wind speed distribution.
- The bedrock-unit map and the soil-unit map are both converted from the ArcInfo coverages into DEMs using a preprocessor code.
- The table of mean annual solar radiation as a function of ground-surface orientation is created using a preprocessor code.

No post-processing is necessary for the code to be used for the TPA code. Visual verification of the predicted results may require a post-processor to plot the results.

Table 1. Parameters sampled in the ITYM and the TPA 4.0 codes. The parameters for the unsaturated zone constitutive relations are described in van Genuchten (1980).

	Sampled in ITYM	Sampled in TPA 4.0
permeability (for each soil and bedrock type)	X	
van Genuchten α (for each soil and bedrock type)	X	
van Genuchten m (for each soil and bedrock type)	X	
porosity (for each soil and bedrock type)	X	
soil thickness multiplier	X	
decadal precipitation multiplier	X	
decadal temperature increase	X	
decadal vapor density	X	
decadal cloud cover	X	
decadal wind speed	X	
efficiency parameter E_{00} (vegetation)	X	
efficiency parameter E_{10} (vegetation)	X	
efficiency parameter α_0 (vegetation)	X	
efficiency parameter G_0 (vegetation)	X	
efficiency parameter G_1 (vegetation)	X	
efficiency parameter G_α (vegetation)	X	
ArealAverageMeanAnnualInfiltrationAtStart		X
MeanAveragePrecipitationMultiplierAtGlacialMaximum		X
MeanAverageTemperatureIncreaseAtGlacialMaximum		X

4 References

Day, W., C. Potter, D. Sweetkind, and C. San Juan. 1998. Bedrock Geologic Map of the Central Block Area, Yucca Mountain, Nye County, Nevada. USGS Miscellaneous Investigations Series I-2601, Denver, CO: U.S. Geological Survey.

Mohanty, S. and T.J. McCartin. 1998. Total-System Performance Assessment (TPA) Version 3.2: Module Descriptions and User's Guide. CNWRA Predecisional Report, San Antonio, TX: Center for Nuclear Waste Regulatory Analyses.

Mohanty, S., R.W. Janetzke, and R.W. Rice. 1999. Software Requirements Description for Total-System Performance Code Version 4.0. CNWRA Report, San Antonio, TX: Center for Nuclear Waste Regulatory Analyses.

Stothoff, S. 1999. Infiltration Abstractions for Shallow Soil over Fractured Bedrock in a Semiarid Climate. CNWRA Letter Report, San Antonio, TX: Center for Nuclear Waste Regulatory Analyses.

TRW. 1997. Site Atlas 1997, Part 1, Yucca Mountain, Nye County, Nevada. Yucca Mountain Site Characterization Project, Las Vegas, NV: TRW Environmental Safety Systems Technical Data Management. (pages 1.6 to 1.11).

van Genuchten, M.Th. 1980. A Closed-Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils. Soil Science Society of America Journal, Volume 44, p. 892-898.

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⋊⋊⋊ TRANSMISSION REPORT ⋊⋊⋊

MAR-27-00 10:55 ID:2105225155 CTR NUC WASTE REG ANA

START TIME	MAR-27-00 10:54
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RESOLUTION	STD
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FROM: Ron Janetzke

TELEPHONE NO.:

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SOFTWARE CHANGE REPORT (SCR)

SCR No. PA-SCR-312	**Software Title and Version:** TPA 4.0beta	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

The primary effect of this change is on the UZFLOW module. The TPA 3.2 UZFLOW module did not have the capability of reading the *maidtbl.dat* external file because it did not allow for comment lines at the top of the file. The comment lines included a date stamp and described the contents of the *maidtbl.dat* file. The revisions to the preprocessor ITYM that creates the *maidtbl.dat* file are described in Performance Assessment Software Change Report (PA-SCR) #291. Because of the linkage between PA-SCR #291 and PA-SCR #312, they are being put through the system as one package.

Change Requested by: R. Fedors Date: 3-8-00	**Change Authorized by** (*Software Developer*): R. Janetzke R Janetzke Date: 3-8-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

The UZFLOW module was modified so that comment lines at the top of the external file *maidtbl.dat* would be ignored when UZFLOW was reading in the file.

Implemented by: R Janetzke Janetzke/Stothoff	**Date:** March 17, 2000

Description of Acceptance Tests:

See attached test plan for PA-SCR-291 where testing was done to establish that the file could be read in properly.

Tested by: R Fedors R. Fedors	**Date:** March 28, 2000

CNWRA Form TOP-5 (01/99)

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-292	**Software Title and Version:** TPA 3.3	**Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s): 1) DCAGS does not currently account for the reduction in the mass loading factor after deposition of the ash blanket. This yields excessively high estimations of dose at long times after the volcanic event.

Change Requested by: J. Weldy Date: 2/4/00	**Change Authorized by** (*Software Developer*): R. Janetzke R Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*): 1) Implement a model that calculates the mass load as an exponentially decreasing function of time. 2) Add two new parameter values - one that represents the mass load at long times after the event and a second that represents the rate of reduction of the mass load parameter.

Implemented by: J. Weldy	**Date:** 2/14/00

Description of Acceptance Tests:

1. Set the rate of reduction of the mass loading factor to 0 and the airborne mass load above fresh ash blanket to the same value as was set in TPA 3.3 (loguniform 1e-4, 1e-2). The results should match the results in TPA 3.3.

2. Run a single realization with very small time steps (a few years at most) and a relatively large initial mass load (~1e-2) with the base rate of reduction of the mass loading factor (0.0693). The dose should fall only very slightly faster than the formula $D=D_0\exp(-0.0693t)$ would predict over time frames of 10-20 years.

Tested by: MICHAEL A. SMITH	**Date:** 3-27-00

Attachment 1 PA-SCR-292 TPA Test Plan

DCAGS Test 1: Perform hand calculations to confirm code calculation of time dependent mass loading factor (tmassload).
Anticipated start date: 3/15/00
Anticipated completion date: 3/24/00
Amount of your time available to perform this test: 4 h
Percent of your time to be spent in process level testing and system level testing: 100/0
Output files to be checked: dcagstest,dat
Input files to be checked for proper data transfer to the program: tpa.inp
Disposition of documentation (storage medium, physical location, and access method): 250 Mb zip disk #mas1, stored with scientific notebook # 377, with files stored in /testtpa40beta/testdcags/test1.
Functional Test Descriptions:

- **-Hand Calculations:** postprocessing in dcagsrlt_test1.xls
- **-Process-level tests:** Write dcags.f parameter values to new file called dcagstest.dat to confirm values are processed correctly. These stored values are also used to confirm calculations by hand. Stored parameters are: it, itoe, massload, soilmassload, reductionrate, tmassload, dmassload, tim(it), and tim(itoe). Repeat test using minimum and maximum values for DCAGS parameters.
- **-System-level tests:** none

Reasonableness Test Description: none
Final Checklist (completed during testing):

- **-Did the modification substantially change the results?** No
- **-Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?** No, this function is not available in TPA 3.3.
- **-Which nuclides were monitored to determine reasonableness of results in terms of dose?** Not applicable, testing calculation of time-dependent mass loading factor.

DCAGS Test 2: Compare results between TPA 3.3 and TPA 4.0betak for reasonableness.
Anticipated start date: 3/15/00
Anticipated completion date: 3/24/00
Amount of your time available to perform this test: 4 h
Percent of your time to be spent in process level testing and system level testing: 100/0
Output files to be checked: dcags.rlt
Input files to be checked for proper data transfer to the program: tpa.inp
Disposition of documentation (storage medium, physical location, and access method): 250 Mb zip disk #mas1, stored with scientific notebook # 377, with files stored in /testtpa40beta/testpluvial/test2.
Functional Test Descriptions:

- **-Hand Calculations:** none
- **-Process-level tests:** none
- **-System-level tests:** Using as similar as possible parameter values for both tpa.inp files, run TPA 3.3 and TPA 4.0betak codes to compare results produced in dcags.rlt for reasonableness.

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Reasonableness Test Description: Results in dcags.rlt were compared to results from TPA 3.3

Final Checklist (completed during testing):

- **Did the modification substantially change the results?** No
- **Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?** Yes
- **Which nuclides were monitored to determine reasonableness of results in terms of dose?** All base case radionuclides.

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-293

Software Title and Version: TPA 3.3

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):

volcano.f

The current volcano module calculates the amount of waste entrained by the magma and the number of failed canisters remaining in the drift, by using the geometry of the repository and the volcanic event. It is desired to provide a mechanism to invoke a second volcano model that would permit the user to specify directly the number of canisters in each category, with no consideration for geometry.

Change Requested by:
B. Hill
Date: 1-4-00

Change Authorized by (*Software Developer*):
R. Janetzke R. Janetzke
Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

Four new input parameters were created to accommodate the desired changes. VolcanoModel(1=Geometric,2=Distribution), SubareaOfVolcanicEvent[], NumberOfWPsEntrainedByEjecta[], and NumberOfMagmaInducedMechanicalFailuresRemainingInDrift[]. The old geometric model was not removed and may be selected by the user.

Implemented by:
R. Janetzke R. Janetzke

Date:
1-11-00

Description of Acceptance Tests:

The TPA code was tested to verify that the number of WPs ejected and failed within the dike associated with an igneous event for the specified subarea was correctly transferred from the VOLCANO module to the EBSREL and ASHPLUMO modules and to the screen print and system-level files (i.e., *wpsfail.res).* A complete description of the test is included on the following pages.

Tested by:
Rob Rice

Date:
3/15/00

CNWRA Form TOP-5 (01/99)

3/15/00

SCR-293: Number of magma induced mechanical failures remaining in drift

3/13/00 through 3/15/00

The test plan for SCR-293 is listed below:

TPA Test Plan SCR-293

Tester: Rob Rice

Test name: Number of magma induced mechanical failures remaining in drift

Anticipated start date: March 13, 2000

Anticipated completion date: March 15, 2000

Amount of your time available to perform this test: 24 hours

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50):
50% system-level and 50% process-level testing will be performed. The TPA code reads information from the *tpa.inp* file, which is sampled and written to *sp.tpa*, and uses these values to determine the number of WPs ejected and the number of WPs failed from magma within the drift during an igneous event. These values are written to the screen and to *wpsfail.res*. However, the fraction of WPs failed by an igneous event is also contained in the *volcano.rlt* file and the number of WPs failed from igneous activity are contained in the *ebsrel.ech* file and the *ebsrel.inp* file. Thus, in this testing, which will be sufficient to evaluate the correct application of this change, both system level and process level testing will be performed.

Output files to be checked: screen print, *sp.tpa*, *wpsfail.res*, *ebsrel.ech*, and *volcano.rlt*

Input files to be checked for proper data transfer to the program: *tpa.inp*

Disposition of documentation (storage medium, physical location, and access method):
All tests will be archived on a CD-ROM and described in a scientific notebook that will be submitted to the TPA code custodian, Ron Janetzke, upon completion of the testing. On the CD-ROM, the \testing_4.0\volcano subdirectory will contain all testing output files.

<u>Functional Test</u> Descriptions:

Test 1: The values specified in *tpa.inp* that are sampled and written to *sp.tpa* for the number of WPs failed by the dike and ejected from the volcano will be checked against the values in the screen print, *wpsfail.res*, *ebsrel.ech*, and *ebsrel.inp* files, and the fraction of failed WPs in *volcano.rlt* file. The values examined should be consistent. These results are archived in the \testing_4.0\volcano\basecase subdirectory.

Test 2: Test 1 will be repeated, except for the activation of the direct release only flag in the *tpa.inp* file. These results for ground surface releases and doses in *tpa.out* and *dcags.rlt* should be the same as the Test 1 results. These results are archived in the \testing_4.0\volcano\directreleaseonly subdirectory.

- Hand calculations: Hand calculations for this testing are limited to verification that the total number of WPs failed in an igneous event is consistent with the sum of the WPs ejected and the WPs failed within the dike. These values can be checked in the screen print and the *sp.tpa*, *wpsfail.res*, and *ebsrel.ech* files. Also, the fraction of WPs failed in an igneous events will be checked to ensure the total number of failed WPs is correctly computed. These values are available in the *volcano.rlt* file.

- Process level: The process-level checks will be performed by examining the *ebsrel.inp*, *ebsrel.ech*, and *volcano.rlt* files as described in the "Hand calculations" section above.

- System level: The system-level checks will be performed by examining the screen print and the *sp.tpa* and *wpsfail.res* files as described in the "Hand calculations" section above.

Reasonableness Test Description: Based on the hand calculations and checks described above, the reasonableness of the determination of WPs ejected and failed within the dike will be verified and evident in the results for Tests 1 and 2.

Final Checklist (completed during testing):

- Did the modification substantially change the results? No. Because only the number of WPs ejected and failed within the dike are changed, but are within the range of WPs failures used in the previous version of the TPA code, the ground surface doses from DCAGS did not change significantly with this modification (see the *tpa.out* files in the following sampled and mean value directories). These results are archived in the \testing_4.0bkk\volcano\basecase and \testing_4.0bkk\volcano_meanvalue subdirectories and the \tpa33\volcano and \tpa33\volcano_meanvalue subdirectories.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in *tpa.inp*? Yes. The results for versions 3.3 and 4.0 were not significantly different. Refer to the previous question.

- Which nuclides were monitored to determine reasonableness of results in term of dose? The radionuclides with the highest dose rates in version 3.3 (i.e., I-129 and Cl-36) were monitored for purposes of evaluating the reasonableness of the results in terms of dose. This two radionuclides also appear in the version 4.0 results together with Tc-99. Again, the differences in the version 3.3 and 4.0 doses were reasonable. These results are also archived in the \testing_4.0bkk\basecase_meanvalue and \tpa33\basecase_meanvalue subdirectories.

Discussion of test results for SCR-293:

Test 1 Results: The following values were specified in the tpa.inp file for Test 1. For the files in Test1, refer to the \testing_4.0\volcano subdirectory.

(file: *tpa.inp*)

```
**
```

```
**        ***>>> Disruptive Scenario flags <<<***
**
iflag
VolcanismDisruptiveScenarioFlag(yes=1,no=0)
1
**
. . .

**
**
**        ***>>> VOLCANO <<<***
**
iconstant
VolcanoModel(1=Geometric,2=Distribution)
2
**

. . .

** For Distribution model only.
iconstant
SubareaOfVolcanicEvent[]
2
**
uniform
NumberOfWPsEntrainedByEjecta[]
1.0, 10.
**
uniform
NumberOfMagmaInducedMechanicalFailuresRemainingInDrift[]
1.0, 150.0
**
```

All of the other *tpa.inp* file parameters were not changed.

Using the above parameters, the following error message from the TPA code was written to *tpa.out.*

```
exec: calling dcags
              Highest annual dose from GS
          Pu239  2.0785E+03 [mrem/yr] at  6.407E+03 yr
          Pu240  2.0336E+03 [mrem/yr] at  6.407E+03 yr
          Am243  1.2088E+02 [mrem/yr] at  6.407E+03 yr
          Pu242  1.6480E+01 [mrem/yr] at  6.407E+03 yr
          Np237  1.4925E+01 [mrem/yr] at  6.407E+03 yr
           U234  5.3939E+00 [mrem/yr] at  6.407E+03 yr
exec: end realizations
 ***>>> Error in igetunitnumber <<<***
  iopen .gt. maxunit
  iopen =        128
  maxunit =        127
  need to increase size of maxunit
```

As a result of this error message, Test 1 testing was stopped. To address this error, it was recommended that the number of file units in fu2.i (i.e., parameter (maxunit = 127)) should be increased from 127 to a larger value (e.g., 150).

Test 2 Results: For Test 2, the same parameters as shown in the *tpa.inp* file for Test 1 were used and additionally, the direct release only flag was activitated (see below).

(file: *tpa.inp*)

```
**
iflag
DirectReleaseOnlyFlag(yes=1,no=0)
1
**
```

With these parameters in the *tpa.inp* file, the following screen print was written to the *tpa.out* file.

```
-----------------------------------------------------------
   subarea  1 of  8        realization   1 of   1
-----------------------------------------------------------
exec: calling volcano
-----------------------------------------------------------
   subarea  2 of  8        realization   1 of   1
-----------------------------------------------------------
-----------------------------------------------------------
   subarea  3 of  8        realization   1 of   1
-----------------------------------------------------------
-----------------------------------------------------------
   subarea  4 of  8        realization   1 of   1
-----------------------------------------------------------
-----------------------------------------------------------
   subarea  5 of  8        realization   1 of   1
-----------------------------------------------------------
-----------------------------------------------------------
   subarea  6 of  8        realization   1 of   1
-----------------------------------------------------------
-----------------------------------------------------------
   subarea  7 of  8        realization   1 of   1
-----------------------------------------------------------
-----------------------------------------------------------
   subarea  8 of  8        realization   1 of   1
-----------------------------------------------------------
File specified STATUS= "OLD" doesn't exist (see "Input/Output" in the Lahey
 Fortran 90 Language Reference), FILE=ebsflo.dat, UNIT
```

The above error occurred because during the direct release calculations the *ebsflo.dat* file was not written, although the EXEC was expecting the file to exist.

The two problems (number of file units in Test 1 and no *ebsflo.dat* in Test 2) were communicated to the TPA code custodian, Ron Janetzke, who made the modifications and sent an email attachment with the modified files. Tests 1 and 2 were then conducted again using these files (see the \testing_4.0bkk [version k] subdirectory for these repeated tests - note that the second k was added to the subdirectory name because of a bug in the NT system which doesn't allow for 16 characters in the path designation [i.e., set TPA_DATA = c:\testing_4.0bk and set TPA_TEST = c:\testing_4.0bk both have 16 characters]).

Test 1 Results (repeated - see the \testing_4.0bkk\basecase subdirectory):

Using the same parameters shown above for the original Test 1, the following output files were generated. These files are intended to show the correct implementation of specifying the number of WPs in the dike and the subarea for the igneous activity, instead of using geometric considerations.

(file: *sp.tpa*) - shows the sampled values used in the calculations (note: ejected WPs range from 1 to 10 and dike failed WPs range from 1 to 150 - see previous Test 1)

. . .

NumberOfWPsEntrainedByEjecta[]
NumberOfMagmaInducedMechanicalFailuresRemainingInDrift[]
WindSpeed[cm/s]
VolcanicEventDuration[s]
VolcanicEventPower[W]
AshMeanParticleLogDiameter[d_in_cm]
AirborneMassLoadAboveFreshAshBlanket[g/m3]

. . .

0.7844329E+01
0.6950236E+02
0.1026452E+04
0.3789644E+06
0.1729527E+12
0.3606378E+00
0.7010928E-02

Using the above values, the number of WPs ejected and failed within the dike should be 8 and 69, respectively, from subarea 2.

From the screen print in *tpa.out,* the number of WPs failed within each subarea are listed below.

```
-----------------------------------------------------------
   subarea   1 of   8         realization    1 of    1
-----------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling ebsfail
   *** No Corrosion WP Failure ***
exec: calling seismo
exec: calling volcano
exec: failed WPs from INITIAL  event =      11 at time =      0.0 yr
 *** failed WPs:           11  out of        1394 ***

. . .

-----------------------------------------------------------
   subarea   2 of   8         realization    1 of    1
```

```
------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling ebsfail
    *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL  event =     12 at time =      0.0 yr
exec: failed WPs from VOLCANIC  event =     77 at time =  6407.3 yr (includes ejected WPs)
 *** failed WPs:          89  out of       1542 ***
 *** ejected WPs:           8

. . .

------------------------------------------------------------
   subarea  3 of  8        realization   1 of   1
------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling ebsfail
    *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL  event =     6 at time =     0.0 yr
 *** failed WPs:           6  out of       802 ***

. . .

------------------------------------------------------------
   subarea  4 of  8        realization   1 of   1
------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling ebsfail
    *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL  event =     3 at time =     0.0 yr
 *** failed WPs:           3  out of       400 ***

. . .

------------------------------------------------------------
   subarea  5 of  8        realization   1 of   1
------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling ebsfail
    *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL  event =     6 at time =     0.0 yr
 *** failed WPs:           6  out of       776 ***

. . .

------------------------------------------------------------
   subarea  6 of  8        realization   1 of   1
------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling ebsfail
    *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL  event =     7 at time =     0.0 yr
```

```
 *** failed WPs:          7  out of        866 ***

 . . .

 ------------------------------------------------------------
    subarea  7 of  8         realization   1 of   1
 ------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
    *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL  event =      3 at time =      0.0 yr
  *** failed WPs:          3  out of        336 ***
 . . .

 ------------------------------------------------------------
    subarea  8 of  8         realization   1 of   1
 ------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
    *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL  event =      7 at time =      0.0 yr
  *** failed WPs:          7  out of        855 ***
```

Note that from the above results, only subarea 2 exhibited WP failure from VOLCANO with 77 total WPs (7 ejected and the remaining WPs within the dike). These results are expected given the sampled values in *sp.tpa* given above.

To verify the correct assignment of failed WPs from igneous activity, the *wpsfail.res* file is provided below (note that there are 77 WPs failing from igneous activity).

```
 Input file tpa.inp as supplied with TPA Version 4.0beta Code.
 Base case
 TPA 4.0beta, Job started: Mon Mar 20 12:10:40 2000
 Number of Failed WPs by Type of Disruptive Event

 Including Time of Event - Values for Each Vector


    vector       time       #corrode      #seismic       #fault       #igact
   unitless       yr        unitless      unitless      unitless     unitless
        1     6.4073E+03   0.0000E+00    0.0000E+00    0.0000E+00    7.7000E+01
```

To further verify the correct data transfer of failed WPs from igneous activity to the EBSREL module, the values in the *ebsrel.ech* are given below.

```
 Input file tpa.inp as supplied with TPA Version 4.0beta Code.
 Base case
 TPA 4.0beta, Job started: Mon Mar 20 12:10:40 2000
 Echo of EBSREL Input Values
        with the output mode specified in "tpa.inp"
```

```
REALIZATION   1

SUBAREA   1

type of event    number wps failed   time of event
  INITIAL         1.1000E+01      0.0000E+00
  FAULTING          0.0000E+00       0.0000E+00
  VOLCANO           0.0000E+00       0.0000E+00
  SEISMO 1         0.0000E+00      9.9639E+02
  SEISMO 2         0.0000E+00      3.4659E+03
  SEISMO 3         0.0000E+00      7.3763E+03
  SEISMO 4         0.0000E+00      1.0000E+04
  CORROSION          0.0000E+00       1.0000E+04
  EXTRUSIVE         8.0000E+00      0.0000E+00

. . .

SUBAREA   2

type of event    number wps failed   time of event
  INITIAL         1.2000E+01      0.0000E+00
  FAULTING          0.0000E+00       0.0000E+00
  VOLCANO           6.9000E+01       6.4073E+03
  SEISMO 1         0.0000E+00      9.9639E+02
  SEISMO 2         0.0000E+00      3.4659E+03
  SEISMO 3         0.0000E+00      7.3763E+03
  SEISMO 4         0.0000E+00      1.0000E+04
  CORROSION          0.0000E+00       1.0000E+04
  EXTRUSIVE         8.0000E+00      6.4073E+03

. . .

SUBAREA   3

type of event    number wps failed   time of event
  INITIAL         6.0000E+00      0.0000E+00
  FAULTING          0.0000E+00       0.0000E+00
  VOLCANO           0.0000E+00       0.0000E+00
  SEISMO 1         0.0000E+00      9.9639E+02
  SEISMO 2         0.0000E+00      3.4659E+03
  SEISMO 3         0.0000E+00      7.3763E+03
  SEISMO 4         0.0000E+00      1.0000E+04
  CORROSION          0.0000E+00       1.0000E+04
  EXTRUSIVE         8.0000E+00      0.0000E+00

. . .

SUBAREA   4

type of event    number wps failed   time of event
  INITIAL         3.0000E+00      0.0000E+00
  FAULTING          0.0000E+00       0.0000E+00
  VOLCANO           0.0000E+00       0.0000E+00
  SEISMO 1         0.0000E+00      9.9639E+02
```

```
   SEISMO 2        0.0000E+00       3.4659E+03
   SEISMO 3        0.0000E+00       7.3763E+03
   SEISMO 4        0.0000E+00       1.0000E+04
   CORROSION         0.0000E+00       1.0000E+04
   EXTRUSIVE       8.0000E+00       0.0000E+00

 . . .

 SUBAREA    5

 type of event    number wps failed    time of event
   INITIAL        6.0000E+00        0.0000E+00
   FAULTING           0.0000E+00        0.0000E+00
   VOLCANO            0.0000E+00        0.0000E+00
   SEISMO 1         0.0000E+00       9.9639E+02
   SEISMO 2         0.0000E+00       3.4659E+03
   SEISMO 3         0.0000E+00       7.3763E+03
   SEISMO 4         0.0000E+00       1.0000E+04
   CORROSION          0.0000E+00        1.0000E+04
   EXTRUSIVE        8.0000E+00        0.0000E+00

 . . .

 SUBAREA    6

 type of event    number wps failed    time of event
   INITIAL        7.0000E+00        0.0000E+00
   FAULTING           0.0000E+00        0.0000E+00
   VOLCANO            0.0000E+00        0.0000E+00
   SEISMO 1         0.0000E+00       9.9639E+02
   SEISMO 2         0.0000E+00       3.4659E+03
   SEISMO 3         0.0000E+00       7.3763E+03
   SEISMO 4         0.0000E+00       1.0000E+04
   CORROSION          0.0000E+00        1.0000E+04
   EXTRUSIVE        8.0000E+00        0.0000E+00

 . . .

 SUBAREA    7

 type of event    number wps failed    time of event
   INITIAL        3.0000E+00        0.0000E+00
   FAULTING           0.0000E+00        0.0000E+00
   VOLCANO            0.0000E+00        0.0000E+00
   SEISMO 1         0.0000E+00       9.9639E+02
   SEISMO 2         0.0000E+00       3.4659E+03
   SEISMO 3         0.0000E+00       7.3763E+03
   SEISMO 4         0.0000E+00       1.0000E+04
   CORROSION          0.0000E+00        1.0000E+04
   EXTRUSIVE        8.0000E+00        0.0000E+00

 . . .

 SUBAREA    8

 type of event    number wps failed    time of event
```

```
INITIAL       7.0000E+00      0.0000E+00
FAULTING        0.0000E+00      0.0000E+00
VOLCANO         0.0000E+00      0.0000E+00
SEISMO 1        0.0000E+00      9.5669E+02
SEISMO 2        0.0000E+00      3.4659E+03
SEISMO 3        0.0000E+00      7.3763E+03
SEISMO 4        0.0000E+00      1.0000E+04
CORROSION         0.0000E+00      1.0000E+04
EXTRUSIVE         8.0000E+00      0.0000E+00
```

Note in the above values from *ebsrel.ech*, the extrusive failures are reported as 8 WPs for each subarea and only subarea 2 show VOLCANO failures (69) at the time (6.4073E+03 yr) which corresponds to the time for the volcanic event (see the screen print from *tpa.out* above).

To verify that the correct fraction of WPs failed by the volcanic event is correctly transferred out of the VOLCANO module, the *volcano.rlt* is provided below.

```
 Input file tpa.inp as supplied with TPA Version 4.0beta Code.
 Base case
 TPA 4.0beta, Job started: Mon Mar 20 12:10:40 2000
 VOLCANO Results

 with the output mode specified in "tpa.inp"


REALIZATION    1


ALL SUBAREAS

amtuejected =   7.6561E+01

subarea  volcanicamtufailed
    1       0.0000E+00
    2       6.7834E+02
    3       0.0000E+00
    4       0.0000E+00
    5       0.0000E+00
    6       0.0000E+00
    7       0.0000E+00
    8       0.0000E+00

Fraction of Waste Packages Failed by Volcanism

     time       subarea1   subarea2   subarea3   subarea4   subarea5
   1 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
   2 2.3102E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

. . .

 179  5.9709E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 180  6.1130E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 181  6.2584E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 182  6.4073E+03  0.0000E+00  5.0160E-02  0.0000E+00  0.0000E+00  0.0000E+00
 183  6.5596E+03  0.0000E+00  5.0160E-02  0.0000E+00  0.0000E+00  0.0000E+00
```

```
184 6.7154E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
185 6.8750E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
186 7.0382E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
187 7.2053E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
188 7.3763E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
189 7.5513E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
190 7.7304E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
191 7.9137E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
192 8.1013E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
193 8.2933E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
194 8.4897E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
195 8.6908E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
196 8.8966E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
197 9.1072E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
198 9.3227E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
199 9.5433E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
200 9.7690E+03 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00
201 1.0000E+04 0.0000E+00 5.0160E-02 0.0000E+00 0.0000E+00 0.0000E+00

     time      subarea6   subarea7   subarea8
  1 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  2 2.3102E+00 0.0000E+00 0.0000E+00 0.0000E+00

. . .

179 5.9709E+03 0.0000E+00 0.0000E+00 0.0000E+00
180 6.1130E+03 0.0000E+00 0.0000E+00 0.0000E+00
181 6.2584E+03 0.0000E+00 0.0000E+00 0.0000E+00
182 6.4073E+03 0.0000E+00 0.0000E+00 0.0000E+00
183 6.5596E+03 0.0000E+00 0.0000E+00 0.0000E+00
184 6.7154E+03 0.0000E+00 0.0000E+00 0.0000E+00
185 6.8750E+03 0.0000E+00 0.0000E+00 0.0000E+00
186 7.0382E+03 0.0000E+00 0.0000E+00 0.0000E+00
187 7.2053E+03 0.0000E+00 0.0000E+00 0.0000E+00
188 7.3763E+03 0.0000E+00 0.0000E+00 0.0000E+00
189 7.5513E+03 0.0000E+00 0.0000E+00 0.0000E+00
190 7.7304E+03 0.0000E+00 0.0000E+00 0.0000E+00
191 7.9137E+03 0.0000E+00 0.0000E+00 0.0000E+00
192 8.1013E+03 0.0000E+00 0.0000E+00 0.0000E+00
193 8.2933E+03 0.0000E+00 0.0000E+00 0.0000E+00
194 8.4897E+03 0.0000E+00 0.0000E+00 0.0000E+00
195 8.6908E+03 0.0000E+00 0.0000E+00 0.0000E+00
196 8.8966E+03 0.0000E+00 0.0000E+00 0.0000E+00
197 9.1072E+03 0.0000E+00 0.0000E+00 0.0000E+00
198 9.3227E+03 0.0000E+00 0.0000E+00 0.0000E+00
199 9.5433E+03 0.0000E+00 0.0000E+00 0.0000E+00
200 9.7690E+03 0.0000E+00 0.0000E+00 0.0000E+00
201 1.0000E+04 0.0000E+00 0.0000E+00 0.0000E+00
```

Note that only subarea 2 shows WP failure from the igneous activity. Also note that amtuejected = 7.6561E+01, using 9.76 MTUs/WP, this corresponds to 7.8 (or 8) WPs. Additionally, amtuejected in subarea 2 = 6.7834E+02, and using 9.76 MTUs/WP, this corresponds to 69.5 (or 69) WPs. These values are consistent with the values reported above.

Moreover, the fraction of Wps failed by the igneous activity above (5.0160E-02) for subarea 2, which has 1542 WPs, corresponds to a total of 77 WPs (i.e., 69 + 8 by dike and ejected, respectively).

Thus, based on the above results for Test 1, using the \testing_4.0bkk files, the input data is correctly transferred within the TPA code and the modifications were implemented correctly.

Test 2 Results (repeated - see the \testing_4.0bkk\directreleaesonly subdirectory):

The above description of the *tpa.inp* file parameters for Test 2 in the \testing_4.0\directreleaseonly subdirectory was repeated in the \testing_4.0bkk\directreleaseonly subdirectory. The tpa.out files were compared to verify the results were consistent when all calculations (groundwater and ground surface in Test 1) are performed and when only direct release (ground surface in this test) calculations are performed.

(file: *tpa.out* from Test 1 [groundwater and ground surface])

```
exec: calling ashplumo
exec: calling ashrmovo
exec: calling dcags
           Highest annual dose from GS
      Pu239  5.6412E+02 [mrem/yr] at  7.730E+03 yr
      Pu240  4.9782E+02 [mrem/yr] at  7.730E+03 yr
      Am243  3.3735E+01 [mrem/yr] at  7.730E+03 yr
      Np237  8.2473E+00 [mrem/yr] at  7.730E+03 yr
       Tc99  7.6886E+00 [mrem/yr] at  7.730E+03 yr
       Nb94  6.5254E+00 [mrem/yr] at  7.730E+03 yr
exec: end realizations
```

(file: *tpa.out* from Test 2 [ground surface only]

```
exec: calling ashplumo
exec: calling ashrmovo
exec: calling dcags
           Highest annual dose from GS
      Pu239  5.6412E+02 [mrem/yr] at  7.730E+03 yr
      Pu240  4.9782E+02 [mrem/yr] at  7.730E+03 yr
      Am243  3.3735E+01 [mrem/yr] at  7.730E+03 yr
      Np237  8.2473E+00 [mrem/yr] at  7.730E+03 yr
       Tc99  7.6886E+00 [mrem/yr] at  7.730E+03 yr
       Nb94  6.5254E+00 [mrem/yr] at  7.730E+03 yr
exec: end realizations
```

Note that the above results for the ground surface doses are consistent, which indicate that the modifications tested in SCR-293 were correctly implemented. Thus, the TPA Version 4.0 code **PASSES** the testing for SCR-293.

As an extra check on the TPA code results, the *ashout.res* values were checked for Tests 1 and 2. As a result of this comparison, it was discovered that when the direct release only flag was activiated, the time for the volcanic event was set equal to zero, instead of the actual time of the volcanic event (refer to the *ashout.res* files in the \testing_4.0bkk\volcano\basecase and

\testing_4.0bkk\volcano\directreleaseonly subdirectories). The code custodian, Ron Janetzke, was contacted concerning this problem, modifications were accomplished to correct this problem in *exec.f*, and a new *exec.f* was tested in the \testing_4.0bkk2 subdirectory. The test results (which are actually the same tests as Tests 1 and 2) are archived in the \testing_4.0bkk2\volcano\basecase and \testing_4.0bkk2\volcano\directreleaseonly subdirectories and show the same files (and time for the volcanic event) in each file.

****

Testing Notes and Recommendations

Other testing was conducted to examine the robustness of the implemented changes that were not a part of the SCR-293 test plan. These tests examined acceptable ranges for the number of WPs ejected and failed within the dike. Through testing, it was discovered that when more WPs failures than the number of WPs in the subarea was specified, the TPA correctly provided an error message and code execution stopped. However, there was no similar check on specifying the number of failed or ejected WPs at less than zero or on specifying a non-existent subarea for the location of the volcanic event. It is recommended that simple error checks be introduced into the TPA code to check for ranges of failed WPs (i.e., greater than zero and less than the number of WPs in the subarea) and whether the subarea exists (i.e., if 8 subareas are specified in the *tpa.inp* file, the volcanic event can not occur in subarea 0 or 9).

Furthermore, it could be useful to easily allow certain users the capability to eject or fail all WPs in the repository by introducing a flag in the *tpa.inp* file, for example.

****

TESTING TPA VERSION 4.0 CODE

SCRs 304, 293, and 289

Testing Performed by

Robert W. Rice

March 23, 2000

TESTING TPA VERSION 4.0 CODE

Three SCRs were identified in the following table for testing by R. Rice (SCRs 304, 293, and 289). The testing for these three SCRs is described in the following pages. See the \testing_4.0 subdirectory on the CD accompanying the test results (submitted to R. Janetzke on 3/24/00) for the source code, executables, data, and output files. The test plans, the test results, and the scientific notebook are available in the \testing_4.0\testplan subdirectory.

The TPA Version 4.0beta code was received from R. Janetzke on a CD dated 2/18/00. Installation tests were conducted in the \testing_4.0\install_test subdirectory on an NT PC and the results compared to the results included on the CD. The output of the installation test was entirely consistent with the output files included on the CD (except for the expected differences in the time and date of the run).

The results from the TPA Version 4.0beta code were compared to the results from the TPA Version 3.3 code, which was available from R. Janetzke on a CD dated 11/29/99. The TPA Version 3.3 code files are located in the \tpa33 subdirectory.

The following pages provide the test plans and results of testing conducted for SCRs 304, 293, and 289.

TPA 4.0 Development Task List

Change #	Effort Level	Description	Implementer	Module	Work Outline	Area of Change	Tester	Status	SCR #	Rationale
0	M	Different corrosion rate for welds	Pensado/ Mohanty	failt.f	Weld corrosion built into overall corrosion calculation	code	Brossia	testing	294	Potential early failure mechanism
				ebsfail.f	Convert 6 hardwired values to input parameters.	code				
1	H	Flexibility in defining the exposure pathways	Muller	gentoo.f	Incorporate stand-alone GENII into TPA	code	LaPlante	testing	301	Capability to address concern of stakeholders
			LaPlante							
2	H	Stochastic biosphere and receptor group	Muller	gentoo.f	Incorporate stand-alone GENII into TPA, incorporate parameter for pluvial transition.	code	Weldy	testing		Capability to address concern of stakeholders
			Smith/ Janetzke/ LaPlante/ Mohanty							
4	H	Include drip shield	Pensado/ Mohanty	ebsrel.f, failt.f	New factor DRIP failure time given by CLST KTI.	code	Codell	testing	294	EDA-II Design
				tpa.inp	Add 2 new parameters.	data				
			Codell	releaset.f	Pre-exponential term.	code	Mohanty	testing		
19	L	Time-dependent mass loading (resuspension ash)	Weldy/ Esh	dcags.f	modify distribution (make time-dependent)	code	Smith	testing	292	Reduce excess conservatism
6	M	Alluvium length variation,	Menchaca/ Janetzke	szft.f	Modify hardwired minimum Tuff length	code	Menchaca	testing	300	Remove feature inconsistent with stochastic PA
			Winterle	strmtube.dat		data		testing		
		Clarify diffusion parameter	McCartin	szft.f	Add penetration distance and fractures per meter parameters.	code	Esh	testing	290	
11	L	# packages entrained in conduit and expelled to surface.	Janetzke	volcano.f	remove geometric consideration in volcano.f. Add/modify # packages distribution	code	Weldy	testing	293	Address possible non-conservatism
12	L	Number of magma induced mechanical failures remaining in drift.	Janetzke	volcano.f	Accommodate new sampled parameter.	code	Rice	testing		Improved information.
				tpa.inp	Add new sampled parameter.	data				

TPA 4.0 Development Task List

Change #	Effort Level	Description	Implementer	Module	Work Outline	Area of Change	Tester	Status	SCR #	Rationale
27	M	Temporal variability of flow rate.	Rice/ Esh	ebsrel.f	FMULT, FOW	code	Mohanty	testing	303	Improve dynamic features of code
				ebsrel.def						
			Codell	releaset.f		code				
30	H	WP Temperature	Mohanty	nfenv.f	Modify existing model based on EDA-II design	code	McCartin	testing	304	EDA-II Design
43	M	Repository layout	Janetzke	exec.f	Reflect EDA-II design	code	Rice	testing		EDA-II Design
40	M	SEISMO generate seismic events in a repeatable manner	Muller/ Janetzke	seismo.f	system -level code change	code	Janetzke	testing	298	improve interpretation.
42	M	Enable logbeta and iuniform sampled parameter distributions	Codell	snllhs.f	Add logbeta and iuniform distributions to snllhs.f.	code	Janetzke	testing	299	With these additional features the original internal Monte Carlo sampling scheme can be fully replaced with the LHS method.
8	M	Failure type dependent water contact model	Rice	ebsrel.f	Bathtub or flowthru based on failure type.	code	Pensado	testing	296	Remove potential code inconsistency
				ebsrel.def	Add new controls for failure types	data				
				tpa.inp	Add 8 flags to map failure type to model	data				
			Codell	releaset.f	Accommodate new ebsrel.inp file.	code	Mohanty	testing		
32	L	Radiolysis effects via H2O2.	Pensado/ Mohanty	failt.f ebsfail.f	New range of values for models 1 and 2 parameters.	code	Codell	testing	294	Improved infromation.
38		Variable times steps for reflux models 2 & 3.	Esh	nfenv.f	Use larger time steps after 10k years	code	Mayer	testing	305	Improve code execution.
35	L	Update mean infiltration.	Stohoff	uzflow.f	Move some of the precipitation and temperature modelling to a preprocessor .	code	Fedor	testing	291	Incorporate new theory and data, and reduce TPA run times.
45	I	Use data files for invent.f information	Rice	invent.f	Move bwr & pwr time histories and percentages to a data file.	code	Menchaca	testing	295	Improve flexibility of code.

Change #	Effort Level	Description	Implementer	Module	Work Outline	Area of Change	Tester	Status	SCR #	Rationale
Bug Fix		Modify qlhitsa to handle starting point outside and ending point inside quadrilateral	Janetzke	subarea.f		code	Rice	testing	289	
Bug Fix		The equation for 'average radius' in seismo was mistyped.	McCartin/ Janetzke	seismo.f	As a minimum rerun the importance analysis run that revealed the inconsistency.	Code	Pensado	testing	302	

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END OF TESTING FOR SCRS 304, 293, AND 289. AS PRESENTED ABOVE, THE TPA VERSION 4.0 CODE PASSES ALL OF THE TESTS DESCRIBED IN THE TEST PLANS FOR THESE SCRS.

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-293	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

volcano.f

The current volcano module calculates the amount of waste entrained by the magma and the number of failed canisters remaining in the drift, by using the geometry of the repository and the volcanic event. It is desired to provide a mechanism to invoke a second volcano model that would permit the user to specify directly the number of canisters in each category, with no consideration for geometry.

Change Requested by: B. Hill Date: 1-4-00	**Change Authorized by** (*Software Developer*): R. Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

Four new input parameters were created to accommodate the desired changes. VolcanoModel(1=Geometric,2=Distribution), SubareaOfVolcanicEvent[], NumberOfWPsEntrainedByEjecta[], and NumberOfMagmaInducedMechanicalFailuresRemainingInDrift[]. The old geometric model was not removed and may be selected by the user.

Implemented by: R. Janetzke	**Date:** 1-11-00

Description of Acceptance Tests:
See attached Software Test Plan

Tested by: James Weldy James R. Weldy	**Date:** 3-7-00

TPA Test Plan

Tester: James Weldy

Test name: Test of implementation of the user specified number of waste packages extruded by an igneous event and number of waste packages failed by an igneous event.

Anticipated start date: 3/7/00

Anticipated completion date: 3/7/00

Amount of your time available to perform this test: 6 hours

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): Testing will consist of 100% system level testing, utilizing the intermediate output files produced by the TPA code to ensure that the changes are functioning properly.

Output files to be checked: rgssa.tpa, uzft.ech, screen output

Input files to be checked for proper data transfer to the program: tpa.inp

Disposition of documentation (storage medium, physical location, and access method): All tests will be archived on a floppy disk and described in a scientific notebook that will be submitted to the TPA code custodian, Ron Janetzke, upon completion of the testing. On the floppy disks, the tests will be contained in the folders test 1 through test 4.

<u>Functional Test</u> Descriptions:
- System-level tests:

Test 1: This test will make sure that the switch that was put in the volcano module properly switches between a geometric method to calculate the number of WPs ejected by a volcano based on the diameter of the cone and a user specified distribution of WPs ejected. Two single realizations were run for this test. For both realizations, the number of WPs ejected based on the geometric method is very small (1) and the number of WPs ejected based on the user input method is higher (75) to tell the difference between the two.

The screen output will be examined to ensure that the proper number of WPs are reported as having been ejected by the volcanic event. Additionally, the rgssa.tpa files generated will be compared to each other to ensure that the realization with the higher number of WPs ejected has an appropriately higher dose associated with it.

Files needed for testing include tpa.inp, rgssa.tpa, and screen.out (a capture of the screen output) for each realization. Files associated with the geometric model will be labeled with a 1 while files associated with the user input method will be labeled with a 2.

Test 2: This test will make sure that the code properly uses the input values for number of WPs failed and ejected by a volcanic event when user specified parameters are used. One single realization was run for this test. For the realization, the number of WPs ejected is 10 and the number of WPs failed is 30. The screen output will be examined to ensure that the proper number of WPs are reported as having been failed and ejected by the volcanic event. Files needed for testing include tpa.inp and screen.out (a capture of the screen output) for the realization.

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Test 3: This test will make sure that the code puts the volcanic event in the correct subarea as specified in the input file when user specified parameters are used. Two single realizations were run for this test. For the first realization, the number of WPs ejected is 10 and the number of WPs failed is 30. The subarea in which the event occurs is changed from the base value of 2 to the test value of 3. The second realization is the same as the first, but the switch is returned to the geometric value to ensure that the code does not place the volcano in subarea 3 using this model. The screen output will be examined to ensure that the WPs are failed in the proper subarea. Additionally, the file uzft.ech will be examined to ensure that the release of radionuclides to subarea 3 is larger than the other subareas, since more WPs have failed in that subarea. Files needed for testing include tpa.inp and screen.out (a capture of the screen output) for the realization.

Test 4: This test is to ensure that the code returns an error if more WPs are released from a subarea than the total number of WPs in the subarea. This will be checked by setting the number of WPs ejected in subarea 2 to 2000 and then setting the number of WPs failed by magma in subarea 2 to 2000. Since there are only ~1500 WPs in subarea 2, this should result in an error. The screen output will be checked for this test.

Reasonableness Test Description:

Test 5: This test is to compare the magnitude of the doses between a mean values run with TPA 3.3 and TPA 4.0 for the direct release only run. Both cases were run for a single realization with all parameters at their mean values. The results in rgssa.tpa were then compared to ensure that the change in dose was reasonable.

Final Checklist (completed during testing):

- Did the modification substantially change the results? The modification to the code did not substantially change the results of the calculation. Using the same input data as the data used in TPA 3.3 results in the same dose being calculated in TPA 4.0 as was calculated in TPA 3.3. However, the new input parameters increased the dose calculated by almost an order of magnitude in the first year following the eruption.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp? Yes. Using the new input data in TPA 4.0beta led to an increase in dose by almost an order of magnitude in the first year following the eruption. This is primarily due to the increase in the number of waste packages failed due to the eruption.

- Which nuclides were monitored to determine reasonableness of results in term of dose? The total dose as calculated in rgssa.tpa was monitored, which is dominated (at 5000 years postclosure) by Pu-239 and Pu-240.

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-~~4~~ 294

Software Title and Version: TPA 3.3

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s): ebsfail.f

Changes are necessary to include ten new input variables to the failt.f module associated to drip shield, radiolysis, and Enhanced Design Alternative (EDA) II.

Change Requested by:
R. Janetzke
Date: 1-4-00

Change Authorized by (*Software Developer*):
R. Janetzke Ron Janetzke
Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

Changes to the ebsfail.inp module were implemented to incorporate the ten new input variables to the failt.f module, provided that these variables are defined in the tpa.inp file. The names selected for these variables are

tpa.inp name	*tpanames.dbs name*
CoefForLocCorrOfInnerOverpack	IO-CofLC
ExponentForLocCorrOfInnerOverpack	IO-ExpLC
ChlorideMultFactorIntactDripShield	ChloriDS
DripShieldFailureTime[yr]	DSFailTi
DensityOuterOverpack[kg/m^3]	OO-Densy
DensityInnerOverpack[kg/m^3]	IO-Densy
EquivalentWeightOuterOverpack[kg/mol]	OO-EqWei
EquivalentWeightInnerOverpack[kg/mol]	IO-EqWei
DeltaPotentialDueToRadiolysis[V]	DelPRadi
DecayingConstantRadiolysis[1/yr]	DecCRadi

The variable LocalizedCorrRateOfInnerOverpack[m/yr] has been deleted because its information is redundant with CoefForLocCorrOfInnerOverpack.

Related changes were also required in the template file ebsfail.def, and the file defining the short names tpanames.dbs. The tpa.inp require the inclusion of the above variables.

Implemented by: OP
Osvaldo Pensado

Date:
1-19-00

Description of Acceptance Tests:

see attached

Test for the Preexponent of dissolution model2 parameter

Tested by: Osvaldo Pensado
SEAN BROSSIA

Date: 1-21-00
3/22/00

3/30/2000

CST

Richard Codell 3/24/00

CNWRA Form TOP-3 (01/99)

S. Mohanty

The code was also tested by changing several values in columms 3 and 4 of the wpflow.def file while keeping all other values were made same. The code interpolated the values correctly while mapping data from the wpflow.def time steps to the TPA time steps.

Based on the above tests the code appears to be using the newly implemented time dependent fmult and fow correctly.

3/30/2000

Testing SCR # 294 incorporation of the pre-exponential coefficient in the release model 2.

Files tpa.inp, EBSREL, releaset.f, ebsflo.dat. Ebsnef.dat should be tested to ensure that the change is implemented correctly.

The EBSREL file appears to be getting the Preexponential_SFdissolutionModel2 correctly. This was checked in ebsrel.inp. The following is the output file ebsflo.dat created by EBSREL.f. Note that the flow factor is 1. Also, the drip-shield failure time was specified at time = 0. Therefore the second column is not zero at the beginning.

```
      1.0          ! flowfactr: flow factor
      201          ! number of rows of data to follow
 0.00000E+00  1.01418E+01  4.47210E-02  1.73205E-01    ! t(yr),drip/wp(m^3/yr),fmult,fow
 2.31016E+01  1.01418E+01  4.47210E-02  1.73205E-01
 4.67440E+01  1.01418E+01  4.47210E-02  1.73205E-01
 7.09399E+01  1.01418E+01  4.47210E-02  1.73205E-01
 9.57023E+01  1.01418E+01  4.47210E-02  1.73205E-01
 1.21044E+02  1.01418E+01  4.47210E-02  1.73205E-01
 1.46980E+02  1.01418E+01  4.47210E-02  1.73205E-01
 1.73522E+02  1.01418E+01  4.47210E-02  1.73205E-01
 2.00686E+02  1.01418E+01  4.47210E-02  1.73205E-01
 2.28486E+02  1.01418E+01  4.47210E-02  1.73205E-01
 2.56937E+02  1.01418E+01  4.47210E-02  1.73205E-01
 2.86054E+02  1.01418E+01  4.47210E-02  1.73205E-01
 3.15852E+02  1.01418E+01  4.47210E-02  1.73205E-01
 3.46349E+02  1.01418E+01  4.47210E-02  1.73205E-01
 3.77559E+02  1.01418E+01  4.47210E-02  1.73205E-01
 4.09499E+02  1.01418E+01  4.47210E-02  1.73205E-01
 4.42188E+02  1.01418E+01  4.47210E-02  1.73205E-01
 4.75642E+02  1.01418E+01  4.47210E-02  1.73205E-01
 5.09879E+02  1.01418E+01  4.47210E-02  1.73205E-01
 5.44917E+02  1.01418E+01  4.47210E-02  1.73205E-01
 5.80776E+02  1.01418E+01  4.47210E-02  1.73205E-01
 6.17474E+02  1.01418E+01  4.47210E-02  1.73205E-01
```

6.55032E+02	1.01418E+01	4.47210E-02	1.73205E-01
6.93469E+02	1.01418E+01	4.47210E-02	1.73205E-01
7.32805E+02	1.01418E+01	4.47210E-02	1.73205E-01
7.73063E+02	1.01418E+01	4.47210E-02	1.73205E-01
8.14263E+02	1.01418E+01	4.47210E-02	1.73205E-01
8.56428E+02	1.01418E+01	4.47210E-02	1.73205E-01
8.99579E+02	1.01418E+01	4.47210E-02	1.73205E-01
9.43741E+02	1.01418E+01	4.47210E-02	1.73205E-01
9.88937E+02	1.01418E+01	4.47210E-02	1.73205E-01
1.03519E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.08253E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.13097E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.18055E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.23129E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.28322E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.33636E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.39075E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.44641E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.50338E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.56167E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.62134E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.68240E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.74489E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.80884E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.87429E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.94127E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.00982E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.07997E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.15177E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.22524E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.30044E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.37740E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.45616E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.53676E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.61926E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.70368E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.79008E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.87850E+03	1.01418E+01	4.47210E-02	1.73205E-01
2.96899E+03	1.01418E+01	4.47210E-02	1.73205E-01
3.06160E+03	1.01418E+01	4.47210E-02	1.73205E-01
3.15638E+03	1.01418E+01	4.47210E-02	1.73205E-01
3.25337E+03	1.01418E+01	4.47210E-02	1.73205E-01
3.35264E+03	1.01418E+01	4.47210E-02	1.73205E-01
3.45423E+03	1.01418E+01	4.47210E-02	1.73205E-01
3.55820E+03	1.01418E+01	4.47210E-02	1.73205E-01

3.66461E+03	1.01418E+01	4.47210E-02	1.73205E-01
3.77350E+03	1.01418E+01	4.47210E-02	1.73205E-01
3.88495E+03	1.01418E+01	4.47210E-02	1.73205E-01
3.99900E+03	1.01418E+01	4.47210E-02	1.73205E-01
4.11572E+03	1.01418E+01	4.47210E-02	1.73205E-01
4.23518E+03	1.01418E+01	4.47210E-02	1.73205E-01
4.35743E+03	1.01418E+01	4.47210E-02	1.73205E-01
4.48255E+03	1.01418E+01	4.47210E-02	1.73205E-01
4.61059E+03	1.01418E+01	4.47210E-02	1.73205E-01
4.74163E+03	1.01418E+01	4.47210E-02	1.73205E-01
4.87574E+03	1.01418E+01	4.47210E-02	1.73205E-01
5.01299E+03	1.01418E+01	4.47210E-02	1.73205E-01
5.15346E+03	1.01418E+01	4.47210E-02	1.73205E-01
5.29721E+03	1.01418E+01	4.47210E-02	1.73205E-01
5.44432E+03	1.01418E+01	4.47210E-02	1.73205E-01
5.59488E+03	1.01418E+01	4.47210E-02	1.73205E-01
5.74897E+03	1.01418E+01	4.47210E-02	1.73205E-01
5.90666E+03	1.01418E+01	4.47210E-02	1.73205E-01
6.06805E+03	1.01418E+01	4.47210E-02	1.73205E-01
6.23321E+03	1.01418E+01	4.47210E-02	1.73205E-01
6.40224E+03	1.01418E+01	4.47210E-02	1.73205E-01
6.57523E+03	1.01418E+01	4.47210E-02	1.73205E-01
6.75226E+03	1.01418E+01	4.47210E-02	1.73205E-01
6.93345E+03	1.01418E+01	4.47210E-02	1.73205E-01
7.11887E+03	1.01418E+01	4.47210E-02	1.73205E-01
7.30863E+03	1.01418E+01	4.47210E-02	1.73205E-01
7.50284E+03	1.01418E+01	4.47210E-02	1.73205E-01
7.70159E+03	1.01418E+01	4.47210E-02	1.73205E-01
7.90500E+03	1.01418E+01	4.47210E-02	1.73205E-01
8.11317E+03	1.01418E+01	4.47210E-02	1.73205E-01
8.32621E+03	1.01418E+01	4.47210E-02	1.73205E-01
8.54424E+03	1.01418E+01	4.47210E-02	1.73205E-01
8.76738E+03	1.01418E+01	4.47210E-02	1.73205E-01
8.99573E+03	1.01418E+01	4.47210E-02	1.73205E-01
9.22944E+03	1.01418E+01	4.47210E-02	1.73205E-01
9.46861E+03	1.01418E+01	4.47210E-02	1.73205E-01
9.71339E+03	1.01418E+01	4.47210E-02	1.73205E-01
9.96390E+03	1.01418E+01	4.47210E-02	1.73205E-01
1.02203E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.04826E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.07512E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.10260E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.13072E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.15950E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.18896E+04	1.01418E+01	4.47210E-02	1.73205E-01

1.21910E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.24995E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.28153E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.31384E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.34691E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.38075E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.41539E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.45083E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.48711E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.52423E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.56223E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.60111E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.64091E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.68163E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.72331E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.76597E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.80962E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.85430E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.90002E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.94681E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.99470E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.04371E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.09387E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.14520E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.19773E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.25149E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.30651E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.36282E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.42045E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.47942E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.53978E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.60155E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.66477E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.72946E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.79567E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.86343E+04	1.01418E+01	4.47210E-02	1.73205E-01
2.93278E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.00375E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.07638E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.15072E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.22679E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.30464E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.38432E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.46586E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.54931E+04	1.01418E+01	4.47210E-02	1.73205E-01

3.63472E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.72212E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.81157E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.90311E+04	1.01418E+01	4.47210E-02	1.73205E-01
3.99680E+04	1.01418E+01	4.47210E-02	1.73205E-01
4.09268E+04	1.01418E+01	4.47210E-02	1.73205E-01
4.19081E+04	1.01418E+01	4.47210E-02	1.73205E-01
4.29123E+04	1.01418E+01	4.47210E-02	1.73205E-01
4.39401E+04	1.01418E+01	4.47210E-02	1.73205E-01
4.49919E+04	1.01418E+01	4.47210E-02	1.73205E-01
4.60683E+04	1.01418E+01	4.47210E-02	1.73205E-01
4.71699E+04	1.01418E+01	4.47210E-02	1.73205E-01
4.82973E+04	1.01418E+01	4.47210E-02	1.73205E-01
4.94511E+04	1.01418E+01	4.47210E-02	1.73205E-01
5.06319E+04	1.01418E+01	4.47210E-02	1.73205E-01
5.18404E+04	1.01418E+01	4.47210E-02	1.73205E-01
5.30772E+04	1.01418E+01	4.47210E-02	1.73205E-01
5.43429E+04	1.01418E+01	4.47210E-02	1.73205E-01
5.56382E+04	1.01418E+01	4.47210E-02	1.73205E-01
5.69639E+04	1.01418E+01	4.47210E-02	1.73205E-01
5.83206E+04	1.01418E+01	4.47210E-02	1.73205E-01
5.97091E+04	1.01418E+01	4.47210E-02	1.73205E-01
6.11301E+04	1.01418E+01	4.47210E-02	1.73205E-01
6.25843E+04	1.01418E+01	4.47210E-02	1.73205E-01
6.40726E+04	1.01418E+01	4.47210E-02	1.73205E-01
6.55957E+04	1.01418E+01	4.47210E-02	1.73205E-01
6.71545E+04	1.01418E+01	4.47210E-02	1.73205E-01
6.87498E+04	1.01418E+01	4.47210E-02	1.73205E-01
7.03824E+04	1.01418E+01	4.47210E-02	1.73205E-01
7.20533E+04	1.01418E+01	4.47210E-02	1.73205E-01
7.37632E+04	1.01418E+01	4.47210E-02	1.73205E-01
7.55132E+04	1.01418E+01	4.47210E-02	1.73205E-01
7.73042E+04	1.01418E+01	4.47210E-02	1.73205E-01
7.91371E+04	1.01418E+01	4.47210E-02	1.73205E-01
8.10129E+04	1.01418E+01	4.47210E-02	1.73205E-01
8.29327E+04	1.01418E+01	4.47210E-02	1.73205E-01
8.48973E+04	1.01418E+01	4.47210E-02	1.73205E-01
8.69080E+04	1.01418E+01	4.47210E-02	1.73205E-01
8.89657E+04	1.01418E+01	4.47210E-02	1.73205E-01
9.10716E+04	1.01418E+01	4.47210E-02	1.73205E-01
9.32269E+04	1.01418E+01	4.47210E-02	1.73205E-01
9.54325E+04	1.01418E+01	4.47210E-02	1.73205E-01
9.76898E+04	1.01418E+01	4.47210E-02	1.73205E-01
1.00000E+05	1.01418E+01	4.47210E-02	1.73205E-01

The following is the output file ebsnef.dat from ebsrel. The value for I-129 is highlighted. The value presented below are for a pre-exponential coefficient in model 2 of 1.0.

```
I129
  2.3102E+01  0.0000E+00
  4.6744E+01  3.9650E-04
  7.0940E+01  3.1061E-06
  9.5702E+01  2.9750E-08
  1.2104E+02  7.0513E-09
  1.4698E+02  6.1460E-09
  1.7352E+02  5.5529E-09
  2.0069E+02  5.0757E-09
  2.2849E+02  4.6888E-09
  2.5694E+02  4.3691E-09
  2.8605E+02  4.0997E-09
  3.1585E+02  3.8682E-09
  3.4635E+02  3.6662E-09
  3.7756E+02  3.4875E-09
  4.0950E+02  3.3275E-09
  4.4219E+02  3.1828E-09
  4.7564E+02  3.0509E-09
  5.0988E+02  2.9298E-09
  5.4492E+02  2.8178E-09
  5.8078E+02  2.7137E-09
  6.1747E+02  2.6165E-09
  6.5503E+02  2.5254E-09
  6.9347E+02  2.4395E-09
  7.3281E+02  2.3583E-09
  7.7306E+02  2.2813E-09
  8.1426E+02  2.2079E-09
  8.5643E+02  2.1380E-09
  8.9958E+02  2.0710E-09
  9.4374E+02  2.0067E-09
  9.8894E+02  1.9449E-09
  1.0352E+03  1.8853E-09
  1.0825E+03  1.8277E-09
  1.1310E+03  1.7720E-09
  1.1806E+03  1.7181E-09
  1.2313E+03  1.6700E-09
  1.2832E+03  1.6192E-09
  1.3364E+03  1.5700E-09
  1.3908E+03  1.5221E-09
  1.4464E+03  1.4754E-09
  1.5034E+03  1.4300E-09
  1.5617E+03  1.3858E-09
  1.6213E+03  1.3427E-09
  1.6824E+03  1.3008E-09
  1.7449E+03  1.2599E-09
```

1.8088E+03	1.2201E-09
1.8743E+03	1.1813E-09
1.9413E+03	1.1435E-09
2.0098E+03	1.1066E-09
2.0800E+03	1.0706E-09
2.1518E+03	1.0391E-09
2.2252E+03	1.0045E-09
2.3004E+03	9.7091E-10
2.3774E+03	9.3913E-10
2.4562E+03	9.0837E-10
2.5368E+03	8.7855E-10
2.6193E+03	8.4965E-10
2.7037E+03	8.2171E-10
2.7901E+03	7.9470E-10
2.8785E+03	7.6856E-10
2.9690E+03	7.4375E-10
3.0616E+03	7.1924E-10
3.1564E+03	6.9602E-10
3.2534E+03	6.7911E-10
3.3526E+03	6.5035E-10
3.4542E+03	6.3406E-10
3.5582E+03	6.1358E-10
3.6646E+03	5.9339E-10
3.7735E+03	5.7064E-10
3.8849E+03	5.5077E-10
3.9990E+03	5.3408E-10
4.1157E+03	5.1675E-10
4.2352E+03	4.9747E-10
4.3574E+03	4.8151E-10
4.4825E+03	4.6453E-10
4.6106E+03	4.4950E-10
4.7416E+03	4.3548E-10
4.8757E+03	4.2185E-10
5.0130E+03	4.0873E-10
5.1535E+03	3.9608E-10
5.2972E+03	3.8382E-10
5.4443E+03	3.7258E-10
5.5949E+03	3.6134E-10
5.7490E+03	3.5061E-10
5.9067E+03	3.4023E-10
6.0680E+03	3.3021E-10
6.2332E+03	3.2043E-10
6.4022E+03	3.1125E-10
6.5752E+03	3.0468E-10
6.7523E+03	2.9626E-10
6.9334E+03	2.8760E-10
7.1189E+03	2.7771E-10
7.3086E+03	2.6989E-10
7.5028E+03	2.6275E-10

7.7016E+03	2.5780E-10
7.9050E+03	2.4814E-10
8.1132E+03	2.4157E-10
8.3262E+03	2.3644E-10
8.5442E+03	2.3035E-10
8.7674E+03	2.2344E-10
8.9957E+03	2.1786E-10
9.2294E+03	2.1261E-10
9.4686E+03	2.0743E-10
9.7134E+03	2.0407E-10
9.9639E+03	1.9924E-10
1.0220E+04	1.9290E-10
1.0483E+04	1.8921E-10
1.0751E+04	1.8488E-10
1.1026E+04	1.7982E-10
1.1307E+04	1.7745E-10
1.1595E+04	1.7170E-10
1.1890E+04	1.6983E-10
1.2191E+04	1.6571E-10
1.2500E+04	1.6235E-10
1.2815E+04	1.5759E-10
1.3138E+04	1.5432E-10
1.3469E+04	1.5136E-10
1.3808E+04	1.4855E-10
1.4154E+04	1.4564E-10
1.4508E+04	1.4381E-10
1.4871E+04	1.3972E-10
1.5242E+04	1.3735E-10
1.5622E+04	1.3614E-10
1.6011E+04	1.3224E-10
1.6409E+04	1.2984E-10
1.6816E+04	1.2913E-10
1.7233E+04	1.2563E-10
1.7660E+04	1.2429E-10
1.8096E+04	1.2247E-10
1.8543E+04	1.2023E-10
1.9000E+04	1.1831E-10
1.9468E+04	1.1576E-10
1.9947E+04	1.1363E-10
2.0437E+04	1.1281E-10
2.0939E+04	1.1032E-10
2.1452E+04	1.0942E-10
2.1977E+04	1.0724E-10
2.2515E+04	1.0524E-10
2.3065E+04	1.0382E-10
2.3628E+04	1.0228E-10
2.4204E+04	1.0117E-10
2.4794E+04	1.0037E-10
2.5398E+04	9.8380E-11

2.6015E+04	9.7105E-11
2.6648E+04	9.5835E-11
2.7295E+04	9.4623E-11
2.7957E+04	9.3457E-11
2.8634E+04	9.3435E-11
2.9328E+04	9.1979E-11
3.0038E+04	9.0793E-11
3.0764E+04	8.8942E-11
3.1507E+04	8.8801E-11
3.2268E+04	8.7299E-11
3.3046E+04	8.6168E-11
3.3843E+04	8.4995E-11
3.4659E+04	8.4298E-11
3.5493E+04	8.4165E-11
3.6347E+04	8.3276E-11
3.7221E+04	8.2378E-11
3.8116E+04	8.0840E-11
3.9031E+04	7.9975E-11
3.9968E+04	7.9307E-11
4.0927E+04	7.8666E-11
4.1908E+04	7.7722E-11
4.2912E+04	7.6938E-11
4.3940E+04	7.6417E-11
4.4992E+04	7.5614E-11
4.6068E+04	7.4896E-11
4.7170E+04	7.4561E-11
4.8297E+04	7.3714E-11
4.9451E+04	7.3756E-11
5.0632E+04	7.2581E-11
5.1840E+04	7.2107E-11
5.3077E+04	7.2102E-11
5.4343E+04	7.0744E-11
5.5638E+04	7.0260E-11
5.6964E+04	6.9920E-11
5.8321E+04	6.9363E-11
5.9709E+04	6.8922E-11
6.1130E+04	6.8238E-11
6.2584E+04	6.7950E-11
6.4073E+04	6.7941E-11
6.5596E+04	6.7546E-11
6.7154E+04	6.7034E-11
6.8750E+04	6.6128E-11
7.0382E+04	6.6177E-11
7.2053E+04	6.5850E-11
7.3763E+04	6.4799E-11
7.5513E+04	6.4464E-11
7.7304E+04	6.4025E-11
7.9137E+04	6.3677E-11
8.1013E+04	6.3345E-11

8.2933E+04	6.2919E-11
8.4897E+04	6.2576E-11
8.6908E+04	6.2676E-11
8.8966E+04	6.1736E-11
9.1072E+04	6.1581E-11
9.3227E+04	6.1227E-11
9.5433E+04	6.0793E-11
9.7690E+04	6.1096E-11
1.0000E+05	6.0079E-11

When the value was changes to 1000, the activity released from the WP (i.e., ebsnef.dat file) changed as shown below for I-129.

I129

2.3102E+01	0.0000E+00
4.6744E+01	9.2828E-04
7.0940E+01	7.3221E-06
9.5702E+01	7.1810E-06
1.2104E+02	6.8633E-06
1.4698E+02	6.1440E-06
1.7352E+02	5.5530E-06
2.0069E+02	5.0758E-06
2.2849E+02	4.6889E-06
2.5694E+02	4.3692E-06
2.8605E+02	4.0997E-06
3.1585E+02	3.8683E-06
3.4635E+02	3.6663E-06
3.7756E+02	3.4876E-06
4.0950E+02	3.3276E-06
4.4219E+02	3.1829E-06
4.7564E+02	3.0510E-06
5.0988E+02	2.9299E-06
5.4492E+02	2.8179E-06
5.8078E+02	2.7138E-06
6.1747E+02	2.6166E-06
6.5503E+02	2.5254E-06
6.9347E+02	2.4396E-06
7.3281E+02	2.3584E-06
7.7306E+02	2.2813E-06
8.1426E+02	2.2080E-06
8.5643E+02	2.1380E-06
8.9958E+02	2.0710E-06
9.4374E+02	2.0068E-06
9.8894E+02	1.9449E-06
1.0352E+03	1.8853E-06
1.0825E+03	1.8278E-06

1.1310E+03	1.7721E-06
1.1806E+03	1.7182E-06
1.2313E+03	1.6711E-06
1.2832E+03	1.6201E-06
1.3364E+03	1.5708E-06
1.3908E+03	1.5228E-06
1.4464E+03	1.4761E-06
1.5034E+03	1.4307E-06
1.5617E+03	1.3864E-06
1.6213E+03	1.3433E-06
1.6824E+03	1.3012E-06
1.7449E+03	1.2603E-06
1.8088E+03	1.2205E-06
1.8743E+03	1.1816E-06
1.9413E+03	1.1438E-06
2.0098E+03	1.1069E-06
2.0800E+03	1.0710E-06
2.1518E+03	1.0359E-06
2.2252E+03	1.0066E-06
2.3004E+03	9.7281E-07
2.3774E+03	9.3754E-07
2.4562E+03	9.0955E-07
2.5368E+03	8.7962E-07
2.6193E+03	8.5055E-07
2.7037E+03	8.2240E-07
2.7901E+03	7.9221E-07
2.8785E+03	7.6346E-07
2.9690E+03	7.3793E-07
3.0616E+03	7.1523E-07
3.1564E+03	6.9709E-07
3.2534E+03	6.7083E-07
3.3526E+03	6.5169E-07
3.4542E+03	6.2445E-07
3.5582E+03	6.0292E-07
3.6646E+03	5.8309E-07
3.7735E+03	5.6427E-07
3.8849E+03	5.4580E-07
3.9990E+03	5.2796E-07
4.1157E+03	5.1080E-07
4.2352E+03	4.9378E-07
4.3574E+03	4.7787E-07
4.4825E+03	4.6279E-07
4.6106E+03	4.4781E-07
4.7416E+03	4.3385E-07
4.8757E+03	4.2020E-07

5.0130E+03	4.0678E-07
5.1535E+03	3.9424E-07
5.2972E+03	3.8200E-07
5.4443E+03	3.7040E-07
5.5949E+03	3.5908E-07
5.7490E+03	3.4827E-07
5.9067E+03	3.3788E-07
6.0680E+03	3.2790E-07
6.2332E+03	3.1829E-07
6.4022E+03	3.0904E-07
6.5752E+03	3.0016E-07
6.7523E+03	2.9162E-07
6.9334E+03	2.8340E-07
7.1189E+03	2.7550E-07
7.3086E+03	2.6791E-07
7.5028E+03	2.6060E-07
7.7016E+03	2.5357E-07
7.9050E+03	2.4681E-07
8.1132E+03	2.4030E-07
8.3262E+03	2.3404E-07
8.5442E+03	2.2802E-07
8.7674E+03	2.2222E-07
8.9957E+03	2.1664E-07
9.2294E+03	2.1127E-07
9.4686E+03	2.0609E-07
9.7134E+03	2.0111E-07
9.9639E+03	1.9631E-07
1.0220E+04	1.9169E-07
1.0483E+04	1.8723E-07
1.0751E+04	1.8294E-07
1.1026E+04	1.7880E-07
1.1307E+04	1.7481E-07
1.1595E+04	1.7097E-07
1.1890E+04	1.6726E-07
1.2191E+04	1.6368E-07
1.2500E+04	1.6023E-07
1.2815E+04	1.5690E-07
1.3138E+04	1.5369E-07
1.3469E+04	1.5058E-07
1.3808E+04	1.4759E-07
1.4154E+04	1.4470E-07
1.4508E+04	1.4191E-07
1.4871E+04	1.3921E-07
1.5242E+04	1.3660E-07
1.5622E+04	1.3408E-07

1.6011E+04	1.3165E-07
1.6409E+04	1.2930E-07
1.6816E+04	1.2702E-07
1.7233E+04	1.2482E-07
1.7660E+04	1.2269E-07
1.8096E+04	1.2063E-07
1.8543E+04	1.1864E-07
1.9000E+04	1.1671E-07
1.9468E+04	1.1485E-07
1.9947E+04	1.1304E-07
2.0437E+04	1.1129E-07
2.0939E+04	1.0959E-07
2.1452E+04	1.0795E-07
2.1977E+04	1.0636E-07
2.2515E+04	1.0482E-07
2.3065E+04	1.0332E-07
2.3628E+04	1.0188E-07
2.4204E+04	1.0047E-07
2.4794E+04	9.9109E-08
2.5398E+04	9.7788E-08
2.6015E+04	9.6506E-08
2.6648E+04	9.5263E-08
2.7295E+04	9.4055E-08
2.7957E+04	9.2884E-08
2.8634E+04	9.1746E-08
2.9328E+04	9.0642E-08
3.0038E+04	8.9569E-08
3.0764E+04	8.8527E-08
3.1507E+04	8.7515E-08
3.2268E+04	8.6531E-08
3.3046E+04	8.5575E-08
3.3843E+04	8.4645E-08
3.4659E+04	8.3742E-08
3.5493E+04	8.2863E-08
3.6347E+04	8.2009E-08
3.7221E+04	8.1178E-08
3.8116E+04	8.0369E-08
3.9031E+04	7.9582E-08
3.9968E+04	7.8815E-08
4.0927E+04	7.8070E-08
4.1908E+04	7.7344E-08
4.2912E+04	7.6637E-08
4.3940E+04	7.5948E-08
4.4992E+04	7.5277E-08
4.6068E+04	7.4623E-08

4.7170E+04	7.3986E-08
4.8297E+04	7.3365E-08
4.9451E+04	7.2760E-08
5.0632E+04	7.2169E-08
5.1840E+04	7.1594E-08
5.3077E+04	7.1032E-08
5.4343E+04	7.0484E-08
5.5638E+04	6.9949E-08
5.6964E+04	6.9428E-08
5.8321E+04	6.8919E-08
5.9709E+04	6.8421E-08
6.1130E+04	6.7936E-08
6.2584E+04	6.7462E-08
6.4073E+04	6.6999E-08
6.5596E+04	6.6546E-08
6.7154E+04	6.6104E-08
6.8750E+04	6.5673E-08
7.0382E+04	6.5250E-08
7.2053E+04	6.4838E-08
7.3763E+04	6.4435E-08
7.5513E+04	6.4040E-08
7.7304E+04	6.3654E-08
7.9137E+04	6.3277E-08
8.1013E+04	6.2908E-08
8.2933E+04	6.2547E-08
8.4897E+04	6.2194E-08
8.6908E+04	6.1849E-08
8.8966E+04	6.1511E-08
9.1072E+04	6.1180E-08
9.3227E+04	6.0856E-08
9.5433E+04	6.0539E-08
9.7690E+04	6.0228E-08
1.0000E+05	5.9925E-08

Note that the values are different for these two cases.

I had also tried to print from inside the releaset.f code. It indicated that the value got passed on correctly from tpa.inp file to ebsrel.inp and finally to model 2 inside the code.

Note that the parameter aaa on releaset.f was assigned the value of pre-exponential coefficient read from the tpa.inp file. This parameter was originally specified as approximately 3.54. But a factor of 1E4 was multiplied in the equation to assign proper unit. This resulted in an improper attribution of unit to this parameter. Therefore, the value of 1E4 was brought to the TPA code to specify the parameter. Therefore, now the parameter is specified as 3.54E4 (for example) instead of 3.54.

85/397

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

FAXED FROM
THE
DIVISION OF WASTE MANAGEMENT
(DWM/NMSS)

FAX NUMBER: (301) 415-5399

VERIFICATION: (301) 415-7208

LOCAL: ____

LONG DISTANCE: ____

* * * * * * * * * * * *

1. Ron Janetzke **FAX #:** ____
   LOCATION: ____ **VERIFY:** ____

2. ____ **FAX #:** ____
   LOCATION: ____ **VERIFY:** ____

3. ____ **FAX #:** ____
   LOCATION: ____ VERIFY: ____

Radiolysis test.

RECEIVED
MAR 24 2000

NUMBER OF PAGES 4 **PLUS COVER SHEET**

FROM: Richard Codell

PHONE: ____

MAIL STOP: ____

86/357

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-~~45~~ 294	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s): ebsfail.f

Changes are necessary to include ten new input variables to the failt.f module associated to drip shield, radiolysis, and Enhanced Design Alternative (EDA) II. Changes also necessary to the dissolution model (Model 2) to introduce a distribution function for the preexponential coefficient. SM

Change Requested by: R. Janetzke Date: 1-4-00	**Change Authorized by** (*Software Developer*): R. Janetzke Ron Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

Changes to the ebsfail.inp module were implemented to incorporate the ten new input variables to the failt.f module, provided that these variables are defined in the tpa.inp file. The names selected for these variables are

tpa.inp name	*tpanames.dbs name*
CoefForLocCorrOfInnerOverpack	IO-CofLC
ExponentForLocCorrOfInnerOverpack	IO-ExpLC
ChlorideMultFactorIntactDripShield	ChloriDS
DripShieldFailureTime[yr]	DSFailTi
DensityOuterOverpack[kg/m^3]	OO-Densy
DensityInnerOverpack[kg/m^3]	IO-Densy
EquivalentWeightOuterOverpack[kg/mol]	OO-EqWei
EquivalentWeightInnerOverpack[kg/mol]	IO-EqWei
DeltaPotentialDueToRadiolysis[V]	DelPRadi
DecayingConstantRadiolysis[1/yr]	DecCRadi

The variable LocalizedCorrRateOfInnerOverpack[m/yr] has been deleted because its information is redundant with CoefForLocCorrOfInnerOverpack.

Related changes were also required in the template file ebsfail.def, and the file defining the short names tpanames.dbs. The tpa.inp require the inclusion of the above variables.

Implemented by: Osvaldo Pensado	**Date:** 1-19-00

Description of Acceptance Tests:

see attached

Tested by: Osvaldo Pensado SEAN BROSSIA CSB	**Date:** 1-21-00 3/22/00

Richard Codell 3/24/00

CNWRA Form TOP-5 (01/99)

Preexponential SF Dissolution Model 2 has been introduced ~~to~~ in the tpa.inp file, EBSREL, and releasect.f.

37/357

TPA Test Plan

Test Name: Effects of radiolysis on waste package failure

Anticipated Completion Date: March 24, 2000

Amount of time available to perform this test: as needed in week of March 20-24, 2000

Percent of testing time to be spent in process level and system level testing:

100% system level

Output files to be checked:

corrode.out
wpsfail.res

Input files to be checked for proper data transfer to the program:

tpa.inp

Disposition of documentation

Scientific notebook 3/2000 pages 9 and 10 from Richard Codell, and directory /home/nmss2/rbc/tpa40betaF/radio

Functional Test Description:

1. Set up the tpa.inp file for the mean-value data set, but change the values of the parameters:

   CritChlorideConcForSecondLayer = 10^{-5} mol/L.
   DeltaPotentialDueToRadiolysis[V] = 0.1 to 5.0 volts

Examine file wpsfail.res to determine if failure time of waste packages is sensitive to the imposed radiolysis voltage, characterized by the parameters

2. Set up a mean value run to determine when waste packages fail by corrosion by inspecting the file corrode.out. Use the default value of DeltaPotentialDueToRadiolysis[V] E_0, of zero volts. Then repeat run, setting 5 volts, and CritChlorideConcForSecondLayer to low value of 10^{-5} moles/liter. Inspect the new failure time and the output in file corrode.out to see if the corrosion potential listed has changed in the correct direction.

Reasonableness Test Description:

See above.

Final Checklist:

- Did the modification substantially change the result?

No. Under anticipated conditions, radiolysis is not expected to make any difference in corrosion of the waste packages. The functional testing forced a set of unreasonable conditions in terms of artificially low critical chloride concentration for the inner barrier, and high radiolysis potential to demonstrate that the mechanism was working.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?

Not applicable. There was no similar radiolysis effect included in TPA 3.3.

- Which nuclides were monitored to determine reaonable ness of results in terms of dose?

No radionuclides were checked. I determined that the only check necessary was the response of the waste package failure time to the changes in the parameters.

Results of test

1. Under expected conditions, the potential added by radiolysis, as determined by the parameter DeltaPotentialDueToRadiolysis[V] is not expected to exceed 1 volt. The decay constant is expected to be not critical. I artificially boosted DeltaPotentialDueToRadiolysis[V] up to 10 volts, and finally 1000 volts, both of which were unreasonably large, but saw no effect on the corrosion failure time. After consulting with Osvaldo Pensado, I reduced the parameter CritChlorideConcForSecondLayer, to an unreasonably low10^{-5}. This allowed a demonstration of the effect of radiolysis. Figure 1 shows a plot of corrosion time in subarea 1 to E_0. There is a step decrease in lifetime at about $E_0 = 1.0$ volts. The decay parameter is not sensitive. The input file tpa.inp and all of the .res files are stored in the directory /home/nmss2/rbc/tpa40betaF/radio.

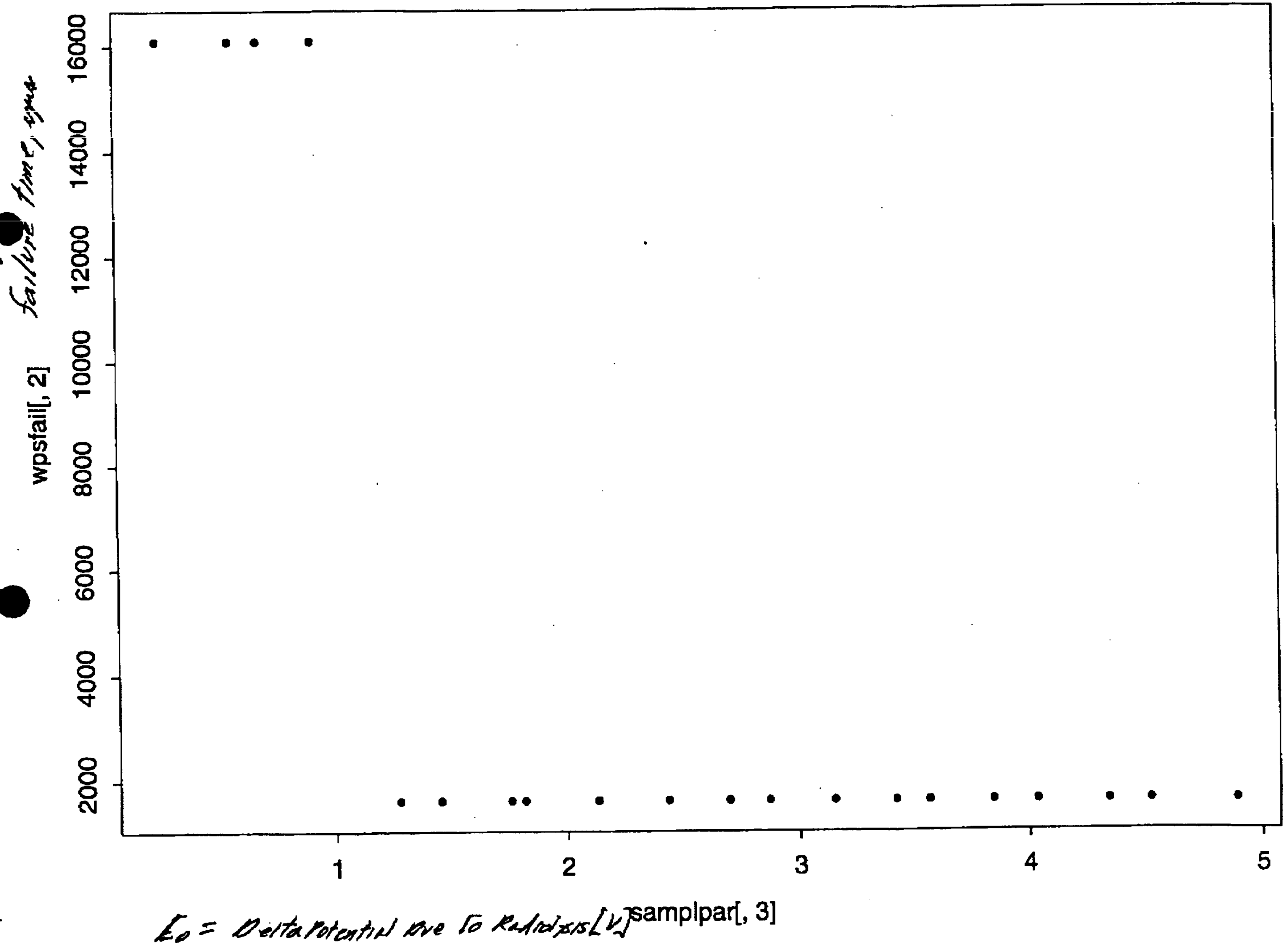
2. Using the mean-value case, but setting the radiolysis potential to either 5 volts and the critical chloride concentration for the second layer to 10^{-5} molar, the code clearly led to early corrosion failure. The changes had the effect of drastically changing the value of Ecorr in file corrode.out by about 4.5 volts. These results are stored in files corrode.out.base and corrode.out.5volts in directory /home/nmss2/rbc/tpa40betaF/radio.

On the basis of these tests, I conclude that the radiolysis sections of the tpa.40 Beta F version are working correctly.

Richard Codell 3/24/00

54/357

correlation between E0 potential and failure time RBC 3/24/00



90/357

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

FAXED FROM
THE
DIVISION OF WASTE MANAGEMENT
(DWM/NMSS)

FAX NUMBER: (301) 415-5399 **VERIFICATION:** (301) 415-7208

LOCAL: ____ **LONG DISTANCE:** ____

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1. Ron Janetzke **FAX #:** ____
   LOCATION: ____ **VERIF:** ____

2. ____ **FAX #:** ____
   LOCATION: ____ **VERIF:** ____

3. ____ **FAX #:** ____
   LOCATION: ____ **VERIF:** ____

Partial results for Assign #4, "[illegible] Drip Shield". I discovered an error in the functional test and need to rerun it this morning. I'll FTP the files for this part in /pub/incoming/testdrip. I need the SCR for this.

NUMBER OF PAGES 2 **PLUS COVER SHEET**

FROM: Dick Codell

PHONE: ____ **MAIL STOP:** ____

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MAR 28 2000

Change #4, Include Drip Shield

TPA Test Plan

Test Name: Effects of drip shield failure time on waste package failure time and peak dose

Anticipated Completion Date: March 27, 2000

Amount of time available to perform this test: as needed March 20-27, 2000

Percent of testing time to be spent in process level and system level testing:

100% system level

Output files to be checked:

gwpkdos.res
wpsfail.res

Input files to be checked for proper data transfer to the program:

tpa.inp

Disposition of documentation

Scientific notebook and directory /home/nmss2/rbc/tpa40betaF/testdrip for the reasonableness test and and /home/nmss2/rbc/tpa40betaF/dripmc for the functional test.

Functional Test Description:

Set up the tpa.inp file for the full Monte-Carlo data set, but change the values of the parameters:

Examine file gwpkdos.res and gwpkds_c.res to determine if the drip shield is having an effect on the peak doses.

Reasonableness Test Description:

Make a single run with the mean value data set with subarea 1 only for 100,000 years, setting the drip shield failure time to either 1000 or 9000 years. There are no waste package corrosion failures prior to 10,000 years, so only the initial juvenile failures will contribute dose. If the drip shield is working, there will be no doses for 10,000 years, and reduced doses at the 100,000 years time period of interest.

Final Checklist:

- Did the modification substantially change the result?

Yes. There was no drip shield in tpa 3.3. Drip shield appears to reduced doses in the tests.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?

Not applicable. There was no drip shield model in TPA 3.3.

- Which nuclides were monitored to determine reasonableness of results in terms of dose?

No individual radionuclides were checked, but the overall dose response was checked.

Results of test

Functional Test

Not yet completed. Anticipated 3/29/00.

Reasonableness test

Peak doses for the 10,000 and 100,000 year time periods of interest (tpi), with 1000 and 9000 year drip shield lifetime are presented in the table below. As expected, the drip shield lifetime of 9000 years eliminated dose for the 10,000 year tpi and slightly reduces the dose for the 100,000 year tpi.

	Peak Dose, rem 10,000 yr time period of interest	Peak Dose, rem 100,000 yr time period of interest
1000-yr Drip Shield Lifetime	1.08E-6	1.0932E-3
9000-yr Drip Shield Lifetime	0	1.0931E-3

Files for the reasonableness test are stored in the directory datax/home/nmss2/rbc/tpa40betaF/testdrip. The input files are tpa.inp.meanbase and tpa.inp.meanDS for the 1000 and 9000 year drip shield lifetime, respectively. The output files examined are gwpkdos.res and gwpkds_c.res for the 100,000 and 10,000 year time periods of interest respectively. Appended to these files are the suffix meanbase and meanDS for the 1000 year and 9000 year lifetimes, respectively.

Richard Codell 3/28/00

93/357

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-~~4~~ 294	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s): ebsfail.f

Changes are necessary to include ten new input variables to the failt.f module associated to drip shield, radiolysis, and Enhanced Design Alternative (EDA) II.

Change Requested by: R. Janetzke Date: 1-4-00	**Change Authorized by** (*Software Developer*): R. Janetzke Ron Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

Changes to the ebsfail.inp module were implemented to incorporate the ten new input variables to the failt.f module, provided that these variables are defined in the tpa.inp file. The names selected for these variables are

tpa.inp name	*tpanames.dbs name*
CoefForLocCorrOfInnerOverpack	IO-CofLC
ExponentForLocCorrOfInnerOverpack	IO-ExpLC
ChlorideMultFactorIntactDripShield	ChloriDS
DripShieldFailureTime[yr]	DSFailTi
DensityOuterOverpack[kg/m^3]	OO-Densy
DensityInnerOverpack[kg/m^3]	IO-Densy
EquivalentWeightOuterOverpack[kg/mol]	OO-EqWei
EquivalentWeightInnerOverpack[kg/mol]	IO-EqWei
DeltaPotentialDueToRadiolysis[V]	DelPRadi
DecayingConstantRadiolysis[1/yr]	DecCRadi

The variable LocalizedCorrRateOfInnerOverpack[m/yr] has been deleted because its information is redundant with CoefForLocCorrOfInnerOverpack.

Related changes were also required in the template file ebsfail.def, and the file defining the short names tpanames.dbs. The tpa.inp require the inclusion of the above variables.

Implemented by: Osvaldo Pensado	**Date:** 1-19-00

Description of Acceptance Tests:

Tested by: Osvaldo Pensado SEAN BROSSIA	**Date:** 1-21-00 3/22/00

CNWRA Form TOP-5 (01/99)

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-#294	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s): failt.f
Changes are necessary to incorporate the presence of the drip shield, and to allow the user to incorporate the new materials considered in the Enhanced Design Alternative (EDA) II. The computation of the corrosion potential must be modified to account for the presence of radiolysis.

Change Requested by: R. Janetzke Date:1-4-00	**Change Authorized by** (*Software Developer*): R. Janetzke Ron Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

With respect to the drip shield (DS), a failure time is defined in the input file that affects the selection of the chloride concentration factor. Two different chloride multiplication factors are used depending on whether the DS is intact or has failed. Two new input parameters are associated with this change.

With respect to the EDA II, old "hard-wired" parameters used to convert current densities into corrosion rates (alloy densities and equivalent molecular weights) are now defined by the user. A single equation for localized corrosion is used in the description of the degradation of the inner and outer layer (before, the penetration rate of the inner layer was defined as constant). Each layer may have associated its own localized-corrosion parameters. The new approach is more general and allows for the reproduction of prior results. In total, six new input parameters are associated with the EDA II change. A variable in failt has been deleted (crate2) since it provides redundant information with one of the new variables.

With respect to the radiolysis, the computed corrosion potential is increased by a term described by a decreasing-in-time exponential function. Two user-defined parameters describe this exponential function.

Thus, a total of ten new input parameters have been introduced.

Implemented by: Osvaldo Pensado	**Date:** 1-19-00

95/397

Description of Acceptance Tests:

The testing phase is thoroughly documented in the Scientific Notebook # 170, in the failt part maintained by Osvaldo Pensado. Similar testing documentation (without plots) can be found in Vulcan, at the directory /home/opensado/tpa4/testfailt/ in the readme files. Here we summarize the main results.

DS tests: testing of whether the appropriate chloride multiplication factor is selected as function of the DS failure time. The file corrode.out contains a flag (named chloride flag), that equals one when the chloride concentration is above a critical concentration during wet conditions, and zero otherwise. The chloride flag can be forced to be zero or one at a given time by changing the chloride multiplication factors and the failure time of the drip shield. The value of this chloride flag versus time has been compared with our expectations, and complete agreement was found. See the Scientific Notebook # 170 for visual display of the comparisons.

Radiolysis tests: verifying that the corrosion potential is increased by the exponential function, and that the corrosion potential controls the degradation mode under aqueous conditions. A reference run was selected that did not include the presence of radiolysis. A second run with consideration of radiolysis and the corrosion potential was compared to the corrosion potential of the reference run. The difference in these corrosion potentials versus time was compared to an exponential function generated with the mathematical software Matlab. One hundred percent agreement was found. It was also verified that the corrosion potential controls the corrosion mode, and that localized corrosion can be enforced by a big artificial increment in the corrosion potential.

EDA II tests: verifying that the conversion factor between current density and corrosion rate is well implemented within the failt module, and verify that the equation for localized corrosion is also well implemented. A reference run was selected for comparison purposes. In alternative runs, the densities and equivalent molecular weights were modified in such a manner that the same corrosion rate of the reference run would be produced. A consistent implementation would imply equivalent results (i.e., same corrode.out output files) for these runs, and we found this to be the case.

With respect to the formula for localized corrosion, since it is a simple mathematical formula, the expected result was plotted using Matlab, and the expected result was compared to the computed result by the failt module. Consistent results were produced after further minor adjustments to the failt module.

Tested by: Osvaldo Pensado	**Date:**1-21-00

CNWRA Form TOP-5 (01/99)

96/377

TPA Test Plan and Results for SCR 294

Test name: Evaluation of New WP Corrosion Parameters and Overall Performance of TPA 4.0 on WP Corrosion

Anticipated start date: March 13, 2000

Anticipated completion date: March 21, 2000

Amount of your time available to perform this test: 20 hrs

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): 25/75

Output files to be checked: corrode.out/wpsfail.res

Input files to be checked for proper data transfer to the program: ebsfail.inp/tpa.inp

Disposition of documentation (storage medium, physical location, and access method):

Documentation contained in Scientific Notebook #298 in addition to zip disk electronic file storage in notebook.

Functional Test Descriptions:

Parameters Examined:

tpa.inp name	tpanames.dbs name	name in this analysis
CoefForLocCorrOfInnerOverpack	IO-CofLC	A_{C22}
ExponentForLocCorrOfInnerOverpack	IO-ExpLC	n_{C22}
DensityOuterOverpack	OO-Densy	316 density
DensityInnerOverpack	IO-Densy	C22 density
EquivalentWeightOuterOverpack	OO-EqWei	EW_{316}
EquivalentWeightInnerOverpack	IO-EqWei	EW_{C22}
AA_2_1	AA_2_1	C22 passive current density
CoefForLocCorrOfOuterOverpack	OO-CofLC	A_{316}
ExponentForLocCorrOfOuterOverpack	OO-ExpLC	n_{316}

- **Hand Calculations:** Hand calculations using an Excel spreadsheet were performed to analyze the output from process level modeling of failt.e. The parameters examined were the EW and density for both 316 stainless steel (SS) and alloy C22. The predicted time to failure and remaining thickness at 100,000 yr (if no failure had occurred) were calculated. Several assumptions were made in these calculations: (1) the initial humid-air corrosion/dry period was neglected for simplicity, (2) the corrosion rate current density (i) in Equation 1 (EW is Equivalent Weight, F is Faraday's constant, and ρ is density), was determined based on the calculating the corrosion rate from the basecase time

$$CR = \frac{iEW}{F\rho} \qquad (1)$$

to failure and using the basecase parameters and was assumed to be constant for all simulations. This second assumption also allowed for a check of the Excel spreadsheet to ensure that it was performing properly.

- **Process-level tests:** The parameters examined were the EW and density for both 316SS and alloy C22. Each parameter was examined at 5 different levels: basecase, and 1/10, 1/2, 2x, and 10x of the basecase value. The predicted time to failure and remaining thickness at 100,000 yr (if no failure had occurred) were determined. For these simulations, only the corresponding material was analyzed. That is, for analysis of 316SS the thickness of the alloy C22 barrier was set to zero. Similarly the thickness of the 316SS was set to zero for the alloy C22 analyses.

- **System-level tests:** The analyses performed were aimed at examining the new corrosion parameters inserted into TPA 4.0 (EW and density for 316SS and alloy C22), parameters associated with localized corrosion (A and n from Equation 2, where D is the pit depth, A is a multiplication factor and t is time) which were already present but applied to carbon steel, and to gage the performance of TPA 4.0 as compared to TPA 3.2 from a WP corrosion perspective. For the analysis of A and n for alloy C22, the localized corrosion parameters associated with calculation of E_{rp} as

$$D = At^{n} \qquad (2)$$

well as the critical chloride concentration were assigned the values observed for alloy 625 to ensure that localized corrosion of alloy C22 would take place. In addition, given the long WP lifetimes expected with alloy C22, the simulations were run out to 100,000 y and each simulation consisted of 100 vectors.

Reasonableness Test Description: The results from the simulations were compared to hand calculations as well as to the direction of expected change (increasing or decreasing time to WP corrosion failures) to determine reasonableness.

Final Checklist (completed during testing):
- Did the modification substantially change the results?
No. There did not appear to be a significant change in the results from the modifications.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?
No, but TPA 3.2 and TPA 4.0beta were compared using identical parameters. No significant differences observed.

- Which nuclides were monitored to determine reasonableness of results in term of dose?
No radionuclides were monitored, only WP corrosion was examined in this test.

Results of Test Plan:

System-level tests:
Overall the modifications to the TPA 4.0 code as compared to TPA 3.2 were implemented correctly without significant effects on the functionality of the code. All the system level results are shown in the accompanying figures in the form of the probability of a WP corrosion failure as a function of time. As can be seen, there was no significant difference between the results obtained for the TPA 4.0 and TPA 3.2 basecase. When the EW for 316SS was increased, a decrease in time to corrosion failure would have been expected. No change was observed and was attributed to the likelihood that corrosion failure of 316 was dominated by localized corrosion rather than passive dissolution (where EW would influence the results). Similar results were found for changes in the density of 316SS. Changes in the localized corrosion propagation parameters for 316SS did result in noticeable changes in predicted performance and the changes were in accordance with what was expected (i.e., increasing A resulted in a decrease in time to WP corrosion failure and increasing n resulted in delaying WP corrosion failure).

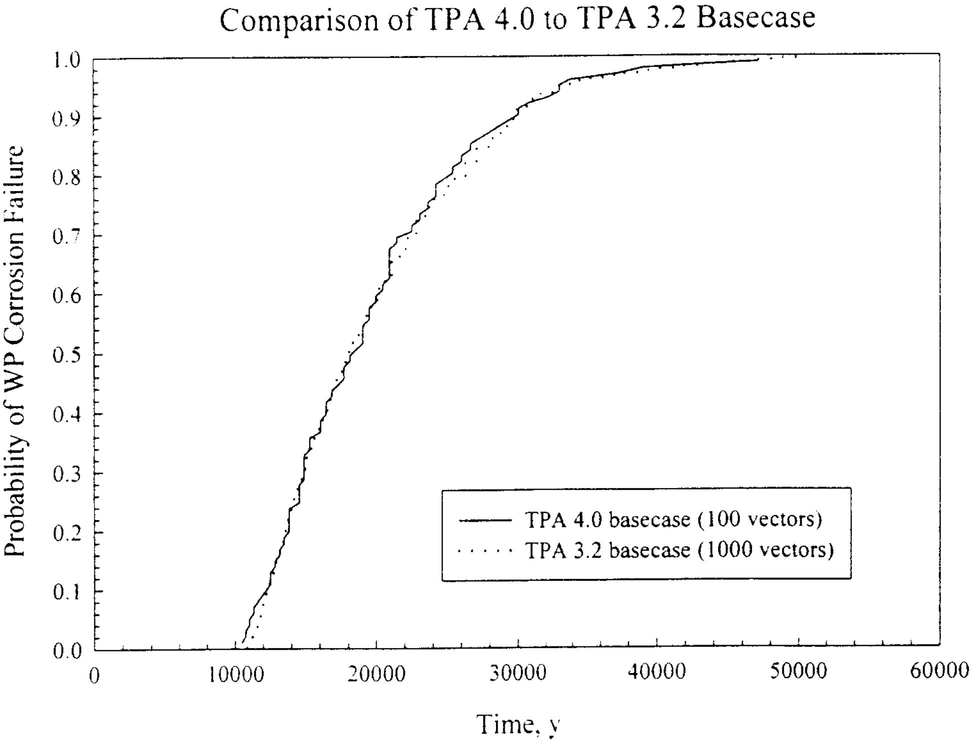
Examination of the corrosion parameters for alloy C22 yielded similar results. For further comparison of TPA 4.0 to TPA 3.2, the passive dissolution rate was modified to reflect the values measured in CNWRA experimental work (lower than that used in the TPA basecase). Only a slight deviation was noticed in comparing the two versions. This deviation is likely caused by the observation that the values used in the TPA 4.0 basecase for EW of 316SS and alloy C22 were reversed. That is, the value for EW for alloy C22 was lower than it should have been as the EW was assumed to be that of 316 and vise-versa. The net effect is that the EW for alloy C22 used in TPA 4.0 would cause an increase in the time to WP corrosion failure as was observed. This was further confirmed when EW was examined in which an increase in EW resulted in a decrease in the time to WP corrosion failure. Decreasing the density of alloy C22 by a factor of 10 also resulted in a significant decrease in time to first WP corrosion failure. When the localized corrosion parameters associated with Erp and the critical chloride concentration for alloy C22 were assigned the values used for alloy 625, a significant change in predicted performance was observed (similar to what has been seen with TPA 3.2). When the localized corrosion propagation terms (A and n) where then varied, the expected results were observed.

Summary of Observations from System-level tests:
Given the simplifying assumptions that went into these analyses and the observation that the changes made to various parameters had the appropriate effect on the end result of predicted WP corrosion performance, it appears that the modifications made to TPA 4.0 are satisfactory and have been correctly implemented.

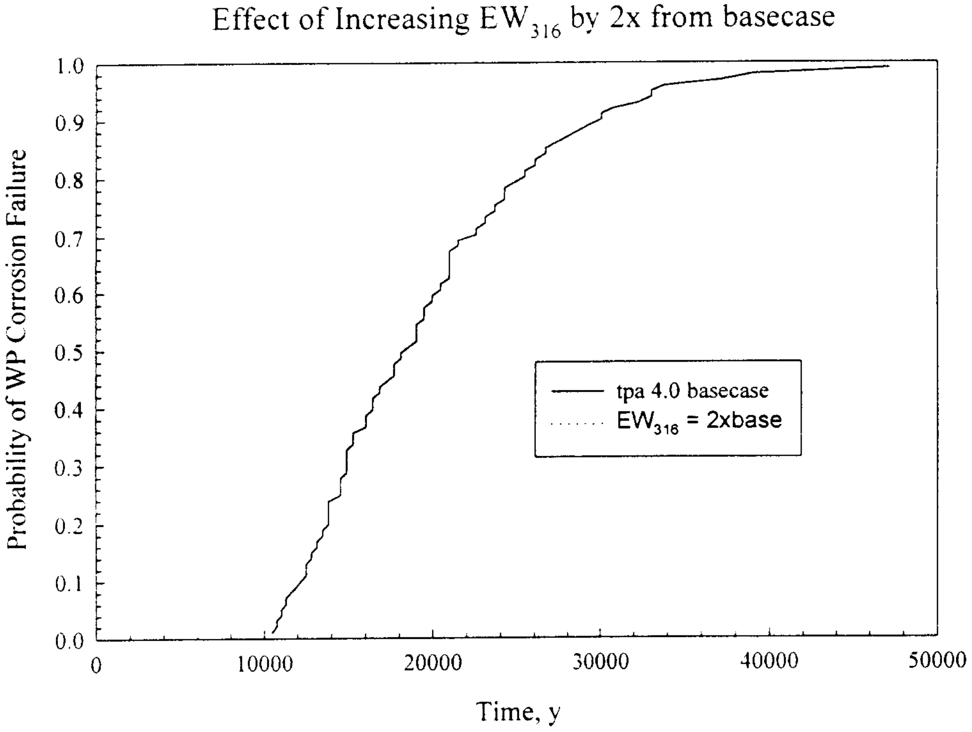
Process-level tests:
Lastly, to examine the failt.e module, a series of simulations were run to calculate the corrosion rate and thus the effective time to failure for each of the WP barrier component materials considering the new EW and density parameters. When examining 316SS, the alloy C22 thickness was set to zero and the corrosion rates/time to failure from the code were compared to those determined through a simple hand calculation (see tables below). Based on the simplifying assumptions as outlined above, the hand calculations and the simulations agreed well (< 6% difference). The only exception to this were cases in which the time to failure was very short in which case the initial humid air corrosion/dry period would play a more significant role in determining the time to failure which was not considered in the hand calculations.

Similar results were observed when examining alloy C22 with the 316SS thickness set to zero. In this case, however, the time to failure was not always used as in some simulations it was > 100,000 y (the end of the simulation). In these instances, the remaining thickness determined from the simulation and the hand calculation were compared. Again there was some deviation between the results, with the calculated thickness always being larger than the thickness determined from the simulation. At most the differences between these was 21 %.

Summary of Observations from Process-level tests:
Given the simplifying assumptions that went into these analyses and calculations and the observation that the changes made to various parameters had the appropriate effect on the end result of predicted WP corrosion performance, it appears that the modifications made to failt.e are satisfactory and have been correctly implemented.



Comparison of TPA 4.0 to TPA 3.2 Basecase



Effect of Increasing EW_{316} by 2x from basecase

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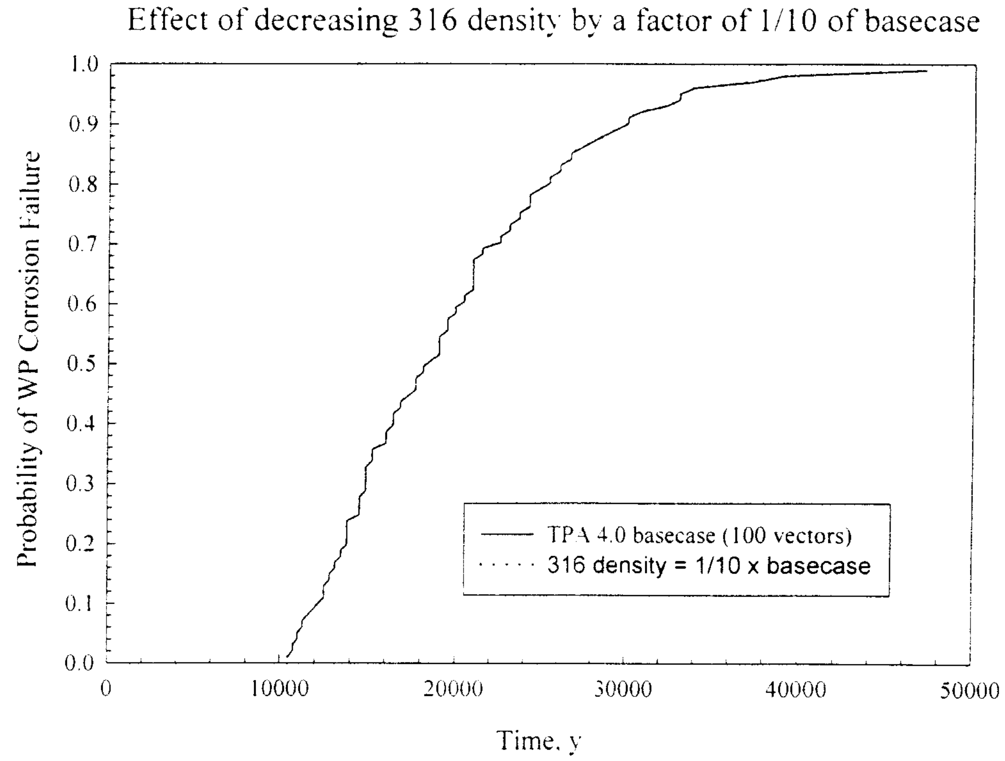
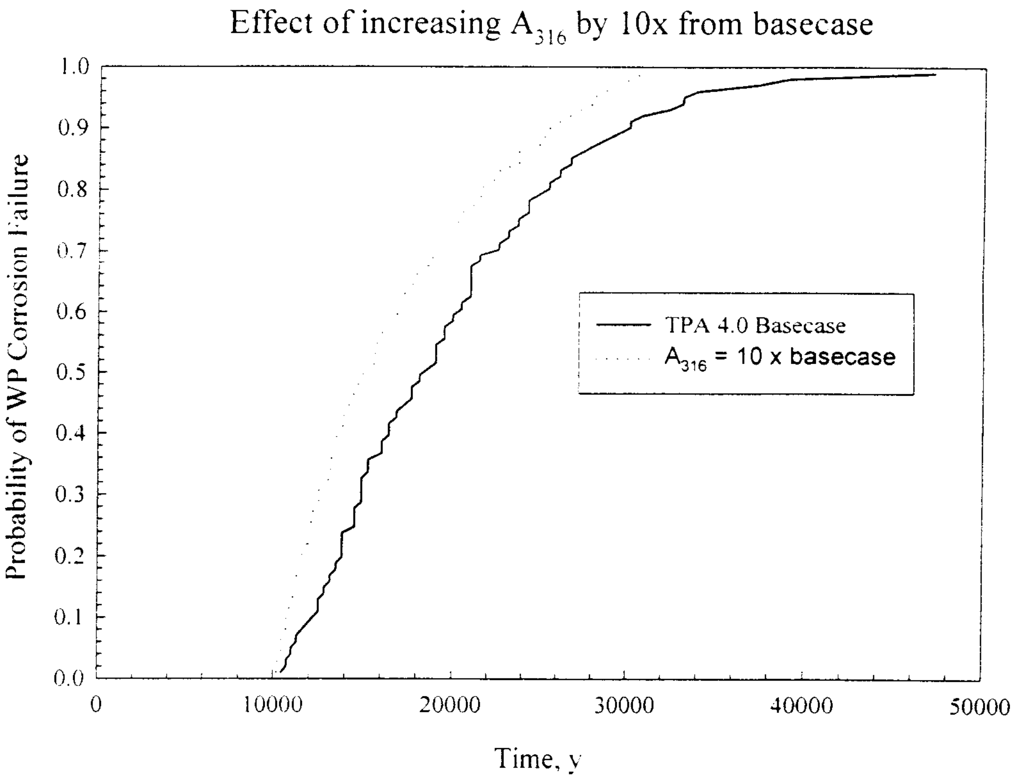
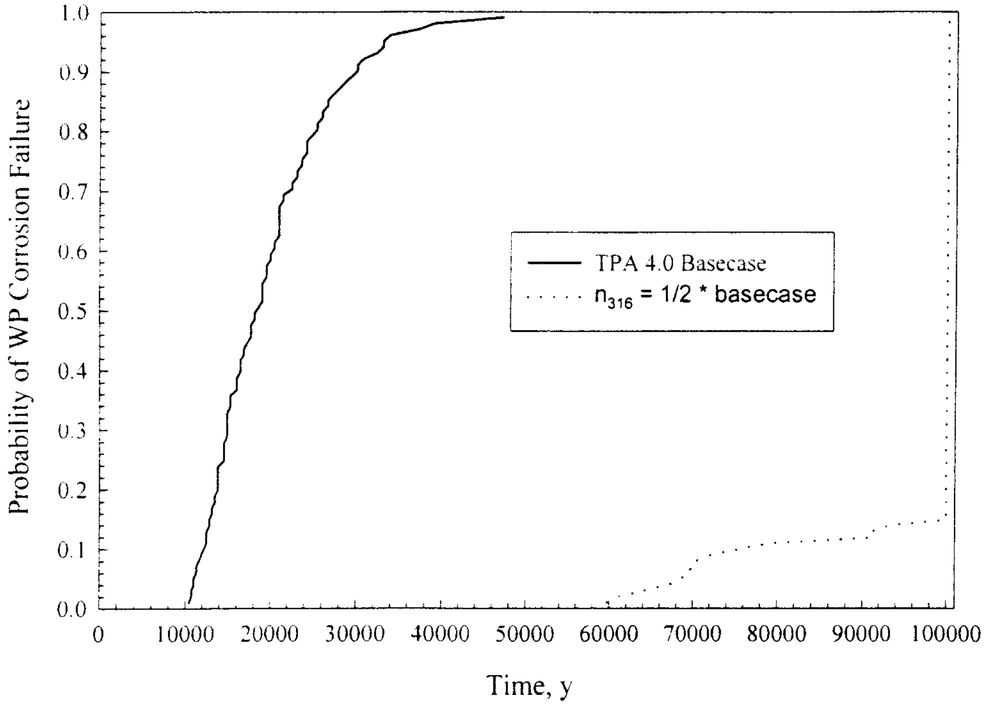
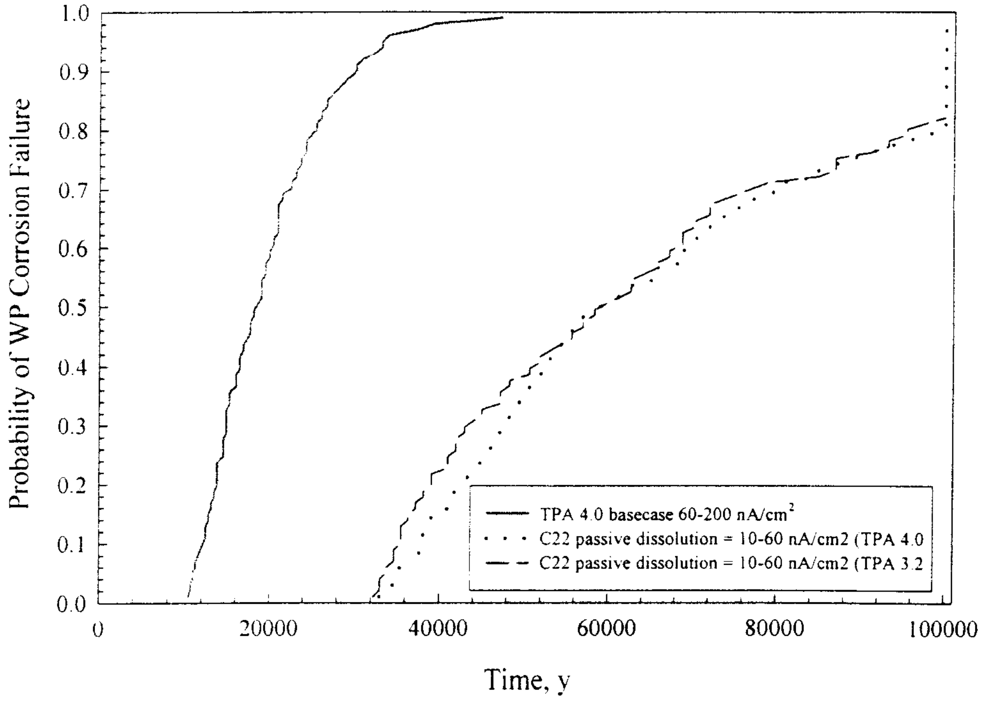

Effect of decreasing 316 density by a factor of 1/10 of basecase
Probability of WP Corrosion Failure
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10000
20000
30000
40000
50000
Time, y
TPA 4.0 basecase (100 vectors)
316 density = 1/10 x basecase

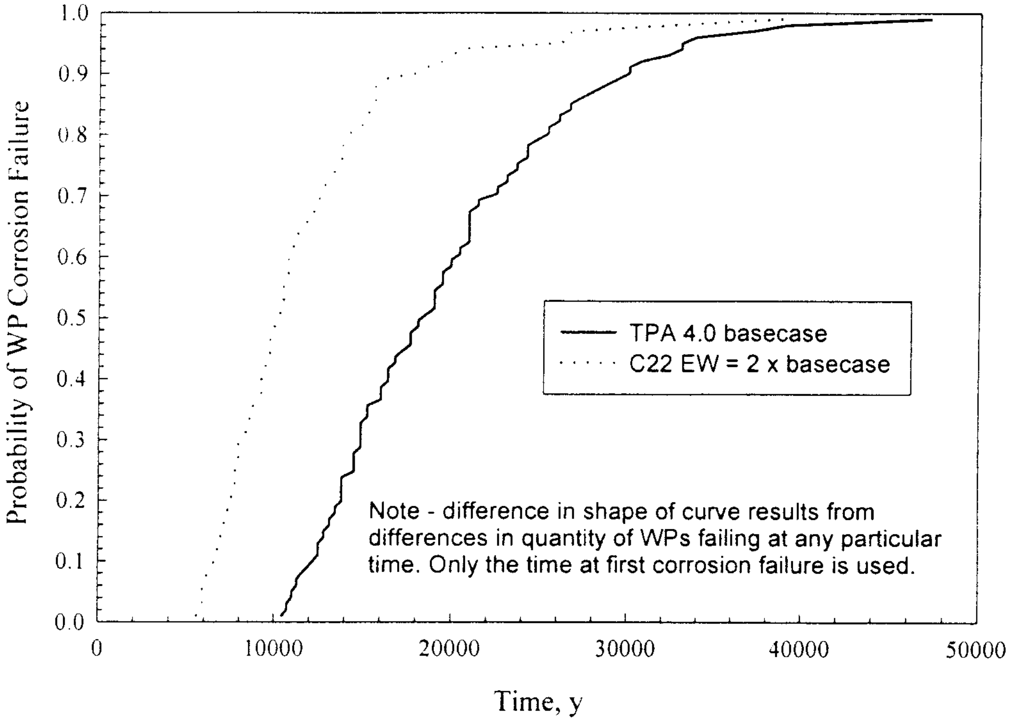

Effect of increasing A_{316} by 10x from basecase
Probability of WP Corrosion Failure
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10000
20000
30000
40000
50000
Time, y
TPA 4.0 Basecase
A_{316} = 10 x basecase

Effect of decreasing n_{316} by 1/2 compared to basecase



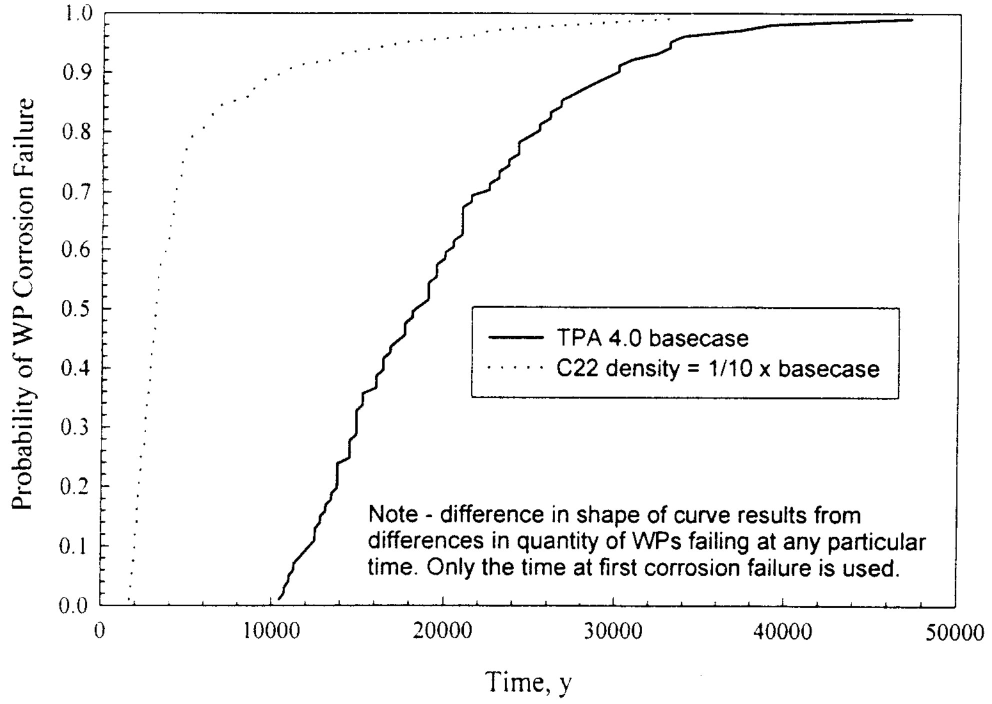
Effect of changing passive dissolution rate of C22 in TPA 4.0 compared to TPA 4.0 basecase and similar change in TPA 3.2





Effect of increasing EW_{C22} by 2x compared to basecase

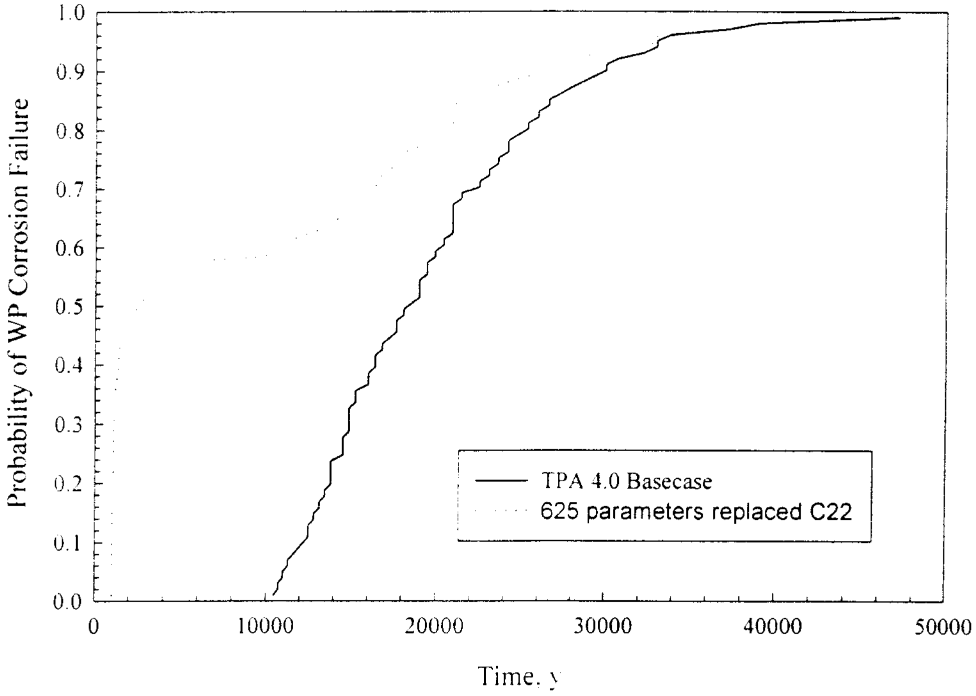
Note - difference in shape of curve results from differences in quantity of WPs failing at any particular time. Only the time at first corrosion failure is used.



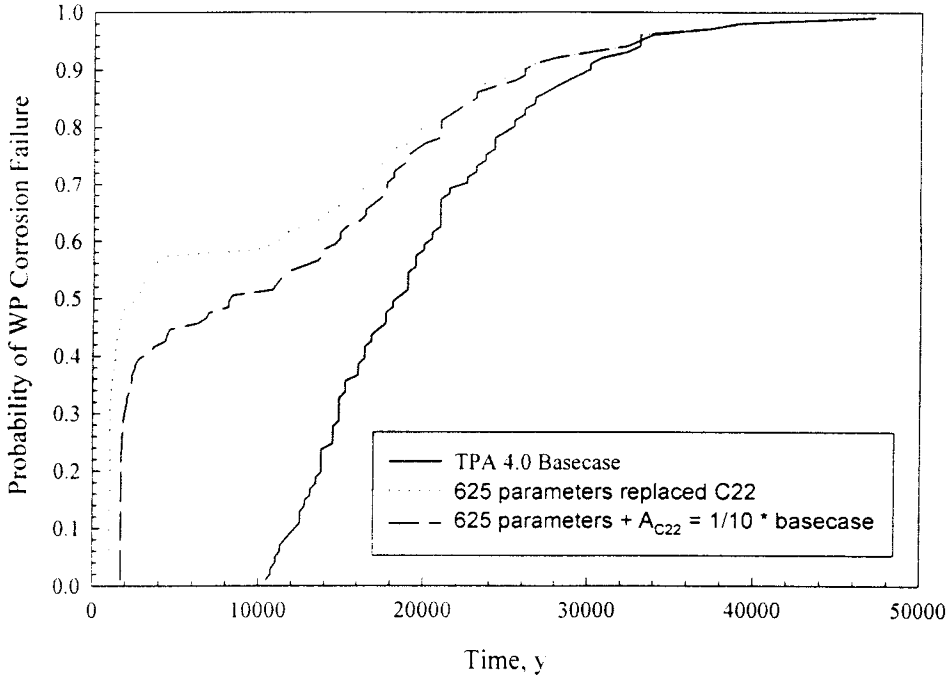
Effect of decreasing C22 density by 10x compared to basecase

Note - difference in shape of curve results from differences in quantity of WPs failing at any particular time. Only the time at first corrosion failure is used.

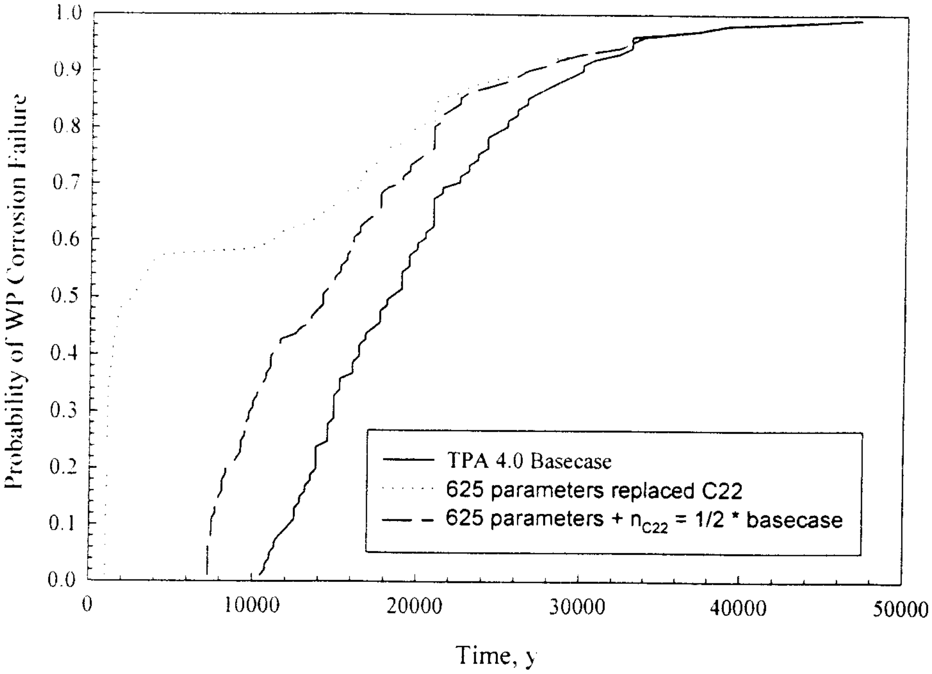
Replacement of 625 parameters for C22:
E_{rp} (including slope, temperature dependence, intercepts)
critical chloride concentration



Effect of decreasing A_{C22} by 10x using 625 parameters



Effect of decreasing n_{C22} by 2x using 625 parameters



316 Analysis

Case	EW	density	I	CR	time to failure (0.1m) yrs	failt.e time to failure yrs	% difference
EW1	2.79E-02	7.86E+03	9.57E-03	3.52E-13	8995.73	8995.73	0.000
EW2	2.79E-03	7.86E+03	9.57E-03	3.52E-14	89957.3	84897.32	-5.960
EW3	1.40E-02	7.86E+03	9.57E-03	1.76E-13	17991.46	17659.68	-1.879
EW4	5.59E-02	7.86E+03	9.57E-03	7.05E-13	4497.865	4741.63	5.141
EW5	2.79E-01	7.86E+03	9.57E-03	3.52E-12	899.573	1390.75	35.317
p1	2.79E-02	7.86E+03	9.57E-03	3.52E-13	8995.73	8995.73	0.000
p2	2.79E-02	7.86E+02	9.57E-03	3.52E-12	899.573	1390.75	35.317
p3	2.79E-02	3.93E+03	9.57E-03	7.05E-13	4497.865	4741.63	5.141
p4	2.79E-02	1.57E+04	9.57E-03	1.76E-13	17991.46	17659.68	-1.879
p5	2.79E-02	7.86E+04	9.57E-03	3.52E-14	89957.3	84897.32	-5.960

note: assumed the same value for all runs based on basecase; also cannot account for initial dry/humid corrosion period in calculation

C22 Analysis 0.2 m

Case	EW	density	i (A/m^2)	CR (m/s)	time to failure (yr)	failt.e ttf (yr)	% diff	thickness at 100kyr (m)	failt.e thickness at 100kyr (m)	%diff
EW1	2.55E-02	8.14E+03	2.84E-04	9.22E-15	68749.77999	68749.78	0.00	-0.0091	0.0000	#DIV/0!
EW2	2.55E-03	8.14E+03	2.84E-04	9.22E-16	687497.7999	100000	-588	0.0171	0.0151	-13.18
EW3	1.28E-02	8.14E+03	2.84E-04	4.61E-15	137499.56	100000	-37.50	0.0055	0.0045	-21.05
EW4	5.11E-02	8.14E+03	2.84E-04	1.84E-14	34374.89	34658.61	0.82	-0.0382	0.0000	#DIV/0!
EW5	2.54E-01	8.14E+03	2.84E-04	9.18E-14	6907.484189	7308.63	5.49	-0.2695	0.0000	#DIV/0!
p1	2.55E-02	8.14E+03	2.84E-04	9.22E-15	68749.77999	68749.78	0.00	-0.0091	0.0000	#DIV/0!
p2	2.55E-02	8.14E+02	2.84E-04	9.22E-14	6874.977999	7308.63	5.93	-0.2709	0.0000	#DIV/0!
p3	2.55E-02	4.07E+03	2.84E-04	1.84E-14	34374.89	34658.61	0.82	-0.0382	0.0000	#DIV/0!
p4	2.55E-02	1.63E+04	2.84E-04	4.61E-15	137499.56	100000	-37.50	0.0055	0.0045	-21.05
p5	2.55E-02	8.14E+04	2.84E-04	9.22E-16	687497.7999	100000	-588	0.0171	0.0151	-13.18

note: assumed the same value for all runs based on basecase; also cannot account for initial dry/humid corrosion period in calculation

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SOFTWARE CHANGE REPORT (SCR)

An SCR must be filled up for reporting any problems found in a developed code or any necessary modifications that must be brought into the code. A revised Software Requirement Document (SRD) is needed if extensive modifications to the code are expected. If one SCR description of a group of small changes, it will be considered acceptable if specific changes are clearly identified with the modified modules.

SCR No. (*Software Developer Assigns*): PA-SCR-295	**Software Title and Version:** TPA ~~4.0~~ 3.3 RJ	**Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

invent.f (modified)

invento.i (new include file)

burnup.dat (new data file)

Change Requested by: R. Janetzke Date: 1/27/00	**Change Authorized by** (*Software Developer*): R. Janetzke Date: 1-27-00

Description of Implemented Change(s) (*If changes not implemented, please justify*):

the data for the SF burnup were removed from invent.f & placed into a data file.

Implemented by: R. Rice	**Completed Date:** 1/27/00

CNWRA TOP-5 Form

TPA Version 4.0 Test Plan: PA-SCR-295

Task Description: Test the invent.f module, the invento.i, include file and new burnup.dat, input file.

Reason for Change: The burnup.dat file provides burnup rate data. This data used to reside in the invent.f module but has now been extracted into its own file.

Analyst: R. Janetzke, R. Fedors **Date:** 02/07/00

Controlled Version: Version 3.3
Modified Version: Version 4.0beta

Anticipated Completion:

Time available for testing:

Percent of Hours for process-level testing:

Output files to be checked:

tpa.out (with modified output lines)

Input files to be checked for correct data transfer:

burnup.dat

Mode of documentation

Functional Testing

Process-level testing:

Test 1 Testing for correct burnup data transfer.

The burnup data used to be embedded in data statements in the invent.f module. The burnup data is now in a separate file named burnup.dat and resides in the data subdirectory. The first test is to see that no changes in output occurred because of the transfer of data to an external file.

One of the recent tpa versions that first began to use an external burnup.dat file was tpa3.3l.

A new subdirectory named tpa3.3lWithOldInvent was created and all the necessary files were copied over to it from tpa3.3l. Additionally a tpa3.3a invent.f file (that still had the burnup data embedded within the code) was substituted for the tpa3.3l invent.f module. After compiling and running the code, a comparison was made with the normal output of an identical tpa3.3l run (i.e. an identical tpa.inp file was used). The only differences between the two runs was the time stamp in the header information of each output file.

PASSED.

Test 2 Testing for proper reading of current burnup.dat file.

The burnup.dat file has changed since the burnup data embedded in the invent module was first extracted to an external file. A test needs to be executed to assure that the data is being properly read in.

Using a current version of the tpa code, the invent.f module is slightly modified to print the burnup.dat data to the screen as it is being read in from the file. The screen output was then redirected to an output file named tpa.out. A comparison of the tpa.out output file and the burnup.dat shows that the data is being read in properly.

Below is portion of the screen output showing the burnup.dat data as read in and below that is the contents of the burnup.dat file.

File: tpa.out

```
=======================================================================
     exec: Welcome to TPA Version 4.0beta
    Job started: Sat Mar 25 10:29:34 2000
=======================================================================
bwrblend =   0.35000000000000
 pwrblend =   0.65000000000000
 time =    1.0010005000000 bwr =    4429.2460000000 pwr =    9036.7690000000
 time =    1.0100501670000 bwr =    4402.9990000000 pwr =    8982.4220000000
 time =    1.1051709180000 bwr =    4148.9270000000 pwr =    8456.6060000000
 time =    2.7182818280000 bwr =    2289.8580000000 pwr =    4626.1820000000
 time =    7.3890560990000 bwr =    1183.0430000000 pwr =    2366.6890000000
 time =    20.085536920000 bwr =    611.21270000000 pwr =    1210.7640000000
 time =    54.598150030000 bwr =    315.77980000000 pwr =    619.40990000000
 time =    148.41315910000 bwr =    163.14590000000 pwr =    316.88130000000
 time =    403.42879350000 bwr =    84.288470000000 pwr =    162.11200000000
 time =    1096.6331580000 bwr =    43.547190000000 pwr =    82.934180000000
 time =    2980.9579870000 bwr =    22.498420000000 pwr =    42.427940000000
 time =    8103.0839280000 bwr =    11.623690000000 pwr =    21.705530000000
 time =    22026.465790000 bwr =    6.0053160000000 pwr =    11.104240000000
 time =    59874.141720000 bwr =    3.1026140000000 pwr =    5.6807720000000
 time =    162754.79140000 bwr =    1.6029490000000 pwr =    2.9062020000000
 time =    442413.39200000 bwr =   0.82815500000000 pwr =    1.4867720000000
```

```
time =   1202604.2840000 bwr =  0.42786200000000 pwr =  0.76061100000000
REPOSITORY DESIGN INFORMATION
Subarea  Area     Waste  Number of WP
  #    [m^2]    [MTU]
  1   723591.3   14200.8      1455
  2   784763.0   15303.7      1568
          .
          .
          .
```

```
File:   burnup.dat
TITLE: New data introduced for TPA Version 4.0 (rwr 2/24/00)
0.35                    ! bwr blend
0.65                    ! pwr blend
   times (yr)      bwr (W/MTU)      pwr (W/MTU)
    1.0010005       4429.246        9036.769
   1.010050167       4402.999        8982.422
   1.105170918       4148.927        8456.606
   2.718281828       2289.858        4626.182
   7.389056099       1183.043        2366.689
   20.08553692       611.2127        1210.764
   54.59815003       315.7798        619.4099
   148.4131591       163.1459        316.8813
   403.4287935       84.28847        162.112
   1096.633158       43.54719        82.93418
   2980.957987       22.49842        42.42794
   8103.083928       11.62369        21.70553
   22026.46579       6.005316        11.10424
   59874.14172       3.102614        5.680772
   162754.7914       1.602949        2.906202
   442413.3920       0.828155        1.486772
   1202604.284       0.427862        0.760611
```

PASSED.

Hand calculations:

System-level testing:

Reasonableness testing:

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Final checklist:

- **Did the modification substantially change the results?**

There was absolutely no "data" difference in any of the output files when the old invent.f file was substituted into a new tpa that used the burnup.dat. The only differences were related to the time stamp header information.

- **Were TPA 3.3 and 4.0beta compared using corresponding mean values in tpa.inp? (If NO, please state reason).**

-

- **Which nuclides were monitored to determine reasonableness of results in terms of dose.**

Jose Menchaca

Jose M

3/27/00

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-~~4xx~~ 296 Rg

Software Title and Version: TPA 3.3

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s): (ebsrel.f, ebsrel.def, and tpa.inp)
Enhance tpa code capabilities to model failure type dependent water contact modes (bathtub or flowthru)

Change Requested by:
Date: Codell/Esh

Change Authorized by (*Software Developer*):
R. Janetzke R Janetzke
Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*): To model failure type dependent water contact modes (either bathtub or flowthru), 8 new parameters (one for each of the 8 failure types) were added to tpa.inp and ebsrel.f was modified to write these new values to the releaset.f input file, ebsrel.inp. The ebsrel.inp template, ebsrel.def, was also modified.

Implemented by: Robert W. Rice

Date: 1/13/00

Description of Acceptance Tests:
See attached test.

Tested by: Osvaldo Pensado OP

Date: 3/16/00

CNWRA Form TOP-5 (01/99)

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TPA Test Plan

Osvaldo Pensado 3/2/00

Test name: Test of changes described in PA-SCR-296 to the releaset module.
Code version to test: TPA 4.0beta

Anticipated start date: 3/2/00

Anticipated completion date: 3/6/00

Amount of your time available to perform this test: 20 hr

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): 80/20

Output files to be checked: trelease.out, ebsnef.dat, relcum.out, relfrac.out, maxrel.dat, inv1000.out

Input files to be checked for proper data transfer to the program: ebsrel.inp

Disposition of documentation (storage medium, physical location, and access method):
Electronic files are located in vulcan, at
/home/opensado/tpa4/testreleaset/ } Also located on attached disks.
/home/opensado/tpa4/tparel
Multiple *readme* files are included therein for the easy reading of the computations.

Functional Test Descriptions:

Process-level tests:

The radionuclide release is only function of the number of waste packages failed, the wet fraction, and the failure time. It is not function of the failure type. It is also function of the water contact mode. With that in mind, several runs having the same number of waste packages failed, the same wet fraction, and the same failure time, must have the same output files.

System-level tests:

The TPA code will be run to determine that the flags defining the water contact mode for each failure type are appropriately mapped into the file ebsrel.inp. The output files trelease.out, ebsnef.dat, relcum.out, relfrac.out, maxrel.dat, and inv1000.out produced by a TPA run must coincide with runs of the isolated module releaset.f

Reasonableness Test Description:

Runs of the releaset.f module for TPA 3.3 and TPA 4.0beta having the same numbers in the ebsrel.inp files (with the exception of the new flags), must produce identical output files, if all of the water contact flags are adequately selected.

Test Results

Osvaldo Pensado 3/15/00

Several runs of the releaset module were completed. The runs were selected in such a manner that the same number of WP failed, the same spent fuel wet fraction, and the same failure time were chosen. The only output data file used by the tpa system is ebsnef.dat. This file displayed always identical (and, therefore, consistent) results for all of the realizations. The same output file is generated with the releaset module for tpa 3.3, when the input data in ebsrel.inp is adequately selected.

Other output files did not display consistent data, such as relfrac.out, maxrel.dat, inv1000.out (these files are not used by the tpa system), specially when the WP are failed due to corrosion. I found that the releaset.e module for TPA 3.3 had that same problem. Thus, this problem was not generated by the addition of the flags by R. Rice. This problem needs to be addressed.

With respect to the system level testing, no problem was found. The flags in tpa.inp are well mapped into ebsrel.inp. Results of a single module realization are identical to the results of the TPA run.

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-~~4XX~~ 296	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s): (ebsrel.f, ebsrel.def, and tpa.inp)
Enhance tpa code capabilities to model failure type dependent water contact modes (bathtub or flowthru)

Change Requested by: Date: Codell/Esh	**Change Authorized by** (*Software Developer*): R. Janetzke R Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*): To model failure type dependent water contact modes (either bathtub or flowthru), 8 new parameters (one for each of the 8 failure types) were added to tpa.inp and ebsrel.f was modified to write these new values to the releaset.f input file, ebsrel.inp. The ebsrel.inp template, ebsrel.def, was also modified.

Implemented by: Robert W. Rice	**Date:** 1/13/00

Description of Acceptance Tests:
Please see attached.

Tested by: S. Mohanty	**Date:** 3/30/2000.

CNWRA Form TOP-5 (01/99)

SCR # 296:

Failure-type dependent water contact model:

For the test, tpa.inp, EBSREL, releaset.f, ebsnef.dat, ebsrel.inp files should be verified to ensure that the bathtub vs. flow-through choices are transmitted properly to these files from the tpa.inp.

The test was conducted by specifying tpa.inp parameters at 1 as shown below.

```
**
**
**        ***>>> EBSREL <<<***
**
** rwr 1/12/00 modified to allow for failure type-specific
**          water contact modes (added a flag for each of
**          the 8 failure types)
**  ** rwr 7/8/98 modify flow model flag
** iflag
** FlowModelFlag(0=BathTub,1=FlowThrough)
** 0
iflag
WaterContactMode_Initial(0=BathTub,1=FlowThrough)
1
**
iflag
WaterContactMode_Faulting(0=BathTub,1=FlowThrough)
1
**
iflag
WaterContactMode_Volcanic(0=BathTub,1=FlowThrough)
1
**
iflag
WaterContactMode_SeismicInterval1(0=BathTub,1=FlowThrough)
1
**
iflag
WaterContactMode_SeismicInterval2(0=BathTub,1=FlowThrough)
1
**
iflag
WaterContactMode_SeismicInterval3(0=BathTub,1=FlowThrough)
1
**
iflag
```

```
WaterContactMode_SeismicInterval4(0=BathTub,1=FlowThrough)
1
**
iflag
WaterContactMode_Corrosion(0=BathTub,1=FlowThrough)
1
**
```

Below is the ebsrel.inp file that shows that all parameters have been transferred properly from tpa.inp through EBSREL to the ebsrel.inp file for use by the releaset.f program.

```
\input data file for ebspac release code in tpa: releaset.f
|
\Cell information
  1.45500E+03    5.59224E-01     ! xcon: # of WP; sawetfrac: wetted subarea
 0.00000E+00 7.00000E+00         ! defect,idefect:  initially defective time [yr] & WPs affected
 0.00000E+00 0.00000E+00         ! sftimef,isconf:  faulting fail time [yr] & WPs affected
 0.00000E+00 0.00000E+00         ! sftimev,isconv:  volcano fail time [yr] & WPs affected
 9.88937E+02 0.00000E+00         ! seismt1,seismp1: first  seismic failure time [yr] & WP affected

 3.45423E+03 0.00000E+00        ! seismt2,seismp2: second seismic failure time [yr] & WP affected

 7.30863E+03 0.00000E+00         ! seismt3,seismp3: third  seismic failure time [yr] & WP affected

 5.43429E+04 0.00000E+00         ! seismt4,seismp4: fourth seismic failure time [yr] & WP affected

|
\WP information
  1.57900E+00,    5.27500E+00  ! dintl: wp ID, xintl: internal length [m]
  4.83000E+00                 ! xvol: wp internal vol[m3]
|
\Thermal data
'ebstrh.dat'               ! temfil: temp. file (output from ebspac_fail.f)
  9.99000E+02                 ! ctemp: BP of water at atm. condition [C]
|
\Flow parameters
'ebsflo.dat'               ! hydfil: flow parameters file
|
\SF  materials
\
  0.97600E+04                 ! amassc: SF mass per WP [kg]
  1.06000E+04,       1         ! fueden,ileach (1:particle,2:grain)
\
\Fuel leaching model paramters and water contact mode (bathtub=0, flowthru=1)
 8.08114E-01   1       ! wetfrac(1),iwatcont(1): init def ht fract of wet SF and water contact
 7.34925E-01   1       ! wetfrac(2),iwatcont(2): fau fail ht fract of wet SF and water contact
```

```
3.85743E-01  1       ! wetfrac(3),iwatcont(3): vol fail ht fract of wet SF and water contact
1.02991E-01  1       ! wetfrac(4),iwatcont(4): seim1 fail ht fract of wet SF and water contact
2.44644E-01  1       ! wetfrac(5),iwatcont(5): seim2 fail ht fract of wet SF and water contact
2.17325E-01  1       ! wetfrac(6),iwatcont(6): seim3 fail ht fract of wet SF and water contact
6.93125E-01  1       ! wetfrac(7),iwatcont(7): seim4 fail ht fract of wet SF and water contact
8.81843E-01  1       ! wetfrac(8),iwatcont(8): cor fail ht fract of wet SF and water contact
2                    ! imodel: leaching model
9.000E+00  2.100E-01  3.710E+00 ! phvalue,oxgnovpr [atm]; cco3 [mol/L]: used if imodel=1

  2.500E-06              ! usrlrate:[kg/yr/m2]: used if imodel=3
  1.000E+03              ! preexpo: preexponential term for imodel=2
|
\ Radionuclide inventory
'ebspac.nuc'             ! elefil: nuclide names, halflife,inventory
|
\C-14 generation
  2.02438E-03              ! r0z: initial radius of SF particle [m]
  1.25000E-05              ! radu: radius of the SF grain [m]
  1.05014E-06              ! radsg: subgrain fragment radius after trans. frac. [m]
  1.00000E+00              ! claddingcorfact: cladding correction factor
  6.10000E-04              ! thclad: thickness of cladding [m]
  7.20000E-04              ! cfuel: C-14 [ci] /kg SF
  4.89000E-04              ! czmetal: C-14 [ci] /kg SF in Zyr. clad & other metals
  2.48000E-05              ! czoxide: C-14/kg SF in initial Zry oxide & crud
  6.20000E-06              ! cgap: C-14/kg SF in grain and gap
|
\NUMERICAL
\
\Grids
10, 10                   ! imax,jmax: # of grid nodes in i,j directions
\X-COOR of grid nodes
.1, .5, 1.0, 2.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0
\Y-COOR of grid nodes
.1, .5, 1.0, 2.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0
\ Note: zones apply to the above grid, zones are the same for all cell
\ZONES
4                        ! nzones: no. of zones for material types
1   1 1   1 1              ! iz,ib,jb,ie,je: for zone 1
2   2 1   2 1              ! iz,ib,jb,ie,je: for zone 2
3   3 1   3 1              ! iz,ib,jb,ie,je: for zone 3
4   4 1   10 1             ! iz,ib,jb,ie,je: for zone 4
|
\Rock parameters
0.14, 0.14, 0.14, 0.14       ! rpor(1..nzones): rock porosity
|
```

```
\Radionuclide transport
5.6e-5, 5.6e-5, 5.6e-5, 5.6e-5  ! rdiff(1..nzones):diffusion coef. [m2/yr]
  5.50000E+00               ! driftdia [m]
|
\Solution algorithm control parameters (Runge-Kutta)
25., 0.0, 10.               ! dtinit [yr], dtmin [yr], dtmax [yr]
1.0e-2, 1.0e-10               ! eps, tiny
|
\output parameters
200                         ! nbt: number of time intervals for output
|
\END
```

A value of 1 assigned to the water contact mode parameter makes the code use flow-through model which implies that as soon as water contact the failed WP, the nuclides will immediately come out of the WP. This is evident in the following ebsnef.dat file. This file was created by specifying drip-shield failure time at 0.

```
*lognormal
constant
DripShieldFailureTime[yr]
000.0
**3700.0, 27300.0
```

That means, for initially defective failure, the nuclides will be released from the WP instranteneously.

```
elease rate [ci/yr]
      20       200  ! num nucs, ntemp
CM246
  2.3102E+01  0.0000E+00
  4.6744E+01  2.2344E-05
  7.0940E+01  1.9568E-05
  9.5702E+01  3.5373E-05
  1.2104E+02  3.3836E-05
  1.4698E+02  3.0131E-05
  1.7352E+02  2.7129E-05
  2.0069E+02  2.4700E-05
  2.2849E+02  2.2725E-05
  2.5694E+02  2.1088E-05
  2.8605E+02  1.9704E-05
  3.1585E+02  1.8512E-05
  3.4635E+02  1.7468E-05
  3.7756E+02  1.6542E-05
  4.0950E+02  1.5710E-05
  4.4219E+02  1.4957E-05
  4.7564E+02  1.4268E-05
  5.0988E+02  1.3634E-05
  5.4492E+02  1.3047E-05
```

5.8078E+02	1.2500E-05
6.1747E+02	1.1989E-05
6.5503E+02	1.1509E-05
6.9347E+02	1.1057E-05
7.3281E+02	1.0628E-05
7.7306E+02	1.0222E-05
8.1426E+02	9.8353E-06
8.5643E+02	9.4662E-06
8.9958E+02	9.1131E-06
9.4374E+02	8.7746E-06
9.8894E+02	8.4494E-06
1.0352E+03	8.1365E-06
1.0825E+03	7.8349E-06
1.1310E+03	7.5439E-06
1.1806E+03	7.2628E-06
1.2313E+03	6.9910E-06
1.2832E+03	6.7274E-06
1.3364E+03	6.4733E-06
1.3908E+03	6.2268E-06
1.4464E+03	5.9879E-06
1.5034E+03	5.7563E-06
1.5617E+03	5.5317E-06
1.6213E+03	5.3140E-06
1.6824E+03	5.1030E-06
1.7449E+03	4.8985E-06
1.8088E+03	4.7004E-06
1.8743E+03	4.5085E-06
1.9413E+03	4.3226E-06
2.0098E+03	4.1426E-06
2.0800E+03	3.9682E-06
2.1518E+03	3.7993E-06
2.2252E+03	3.6434E-06
2.3004E+03	3.4827E-06
2.3774E+03	3.3201E-06
2.4562E+03	3.1842E-06
2.5368E+03	3.0442E-06
2.6193E+03	2.9090E-06
2.7037E+03	2.7790E-06
2.7901E+03	2.6446E-06
2.8785E+03	2.5123E-06
2.9690E+03	2.3991E-06
3.0616E+03	2.2906E-06
3.1564E+03	2.2018E-06
3.2534E+03	2.0900E-06
3.3526E+03	2.0014E-06

3.4542E+03	1.8909E-06
3.5582E+03	1.7949E-06
3.6646E+03	1.7094E-06
3.7735E+03	1.6281E-06
3.8849E+03	1.5499E-06
3.9990E+03	1.4749E-06
4.1157E+03	1.4034E-06
4.2352E+03	1.3311E-06
4.3574E+03	1.2658E-06
4.4825E+03	1.2033E-06
4.6106E+03	1.1439E-06
4.7416E+03	1.0870E-06
4.8757E+03	1.0328E-06
5.0130E+03	9.7887E-07
5.1535E+03	9.2902E-07
5.2972E+03	8.8256E-07
5.4443E+03	8.3723E-07
5.5949E+03	7.9284E-07
5.7490E+03	7.5220E-07
5.9067E+03	7.1341E-07
6.0680E+03	6.7641E-07
6.2332E+03	6.4128E-07
6.4022E+03	6.0644E-07
6.5752E+03	5.7449E-07
6.7523E+03	5.4421E-07
6.9334E+03	5.1541E-07
7.1189E+03	4.8688E-07
7.3086E+03	4.6057E-07
7.5028E+03	4.3574E-07
7.7016E+03	4.1114E-07
7.9050E+03	3.8895E-07
8.1132E+03	3.6726E-07
8.3262E+03	3.4701E-07
8.5442E+03	3.2695E-07
8.7674E+03	3.0873E-07
8.9957E+03	2.9101E-07
9.2294E+03	2.7401E-07
9.4686E+03	2.5831E-07
9.7134E+03	2.4326E-07
9.9639E+03	2.2857E-07
1.0220E+04	2.1531E-07
1.0483E+04	2.0243E-07
1.0751E+04	1.9000E-07
1.1026E+04	1.7843E-07
1.1307E+04	1.6718E-07

1.1595E+04	1.5697E-07
1.1890E+04	1.4709E-07
1.2191E+04	1.3763E-07
1.2500E+04	1.2890E-07
1.2815E+04	1.2034E-07
1.3138E+04	1.1258E-07
1.3469E+04	1.0491E-07
1.3808E+04	9.8061E-08
1.4154E+04	9.1265E-08
1.4508E+04	8.5023E-08
1.4871E+04	7.9165E-08
1.5242E+04	7.3396E-08
1.5622E+04	6.8206E-08
1.6011E+04	6.3318E-08
1.6409E+04	5.8594E-08
1.6816E+04	5.4327E-08
1.7233E+04	5.0182E-08
1.7660E+04	4.6379E-08
1.8096E+04	4.2775E-08
1.8543E+04	3.9356E-08
1.9000E+04	3.6249E-08
1.9468E+04	3.3290E-08
1.9947E+04	3.0524E-08
2.0437E+04	2.8007E-08
2.0939E+04	2.5626E-08
2.1452E+04	2.3397E-08
2.1977E+04	2.1357E-08
2.2515E+04	1.9421E-08
2.3065E+04	1.7694E-08
2.3628E+04	1.6052E-08
2.4204E+04	1.4536E-08
2.4794E+04	1.3152E-08
2.5398E+04	1.1873E-08
2.6015E+04	1.0705E-08
2.6648E+04	9.6527E-09
2.7295E+04	8.6561E-09
2.7957E+04	7.7585E-09
2.8634E+04	6.9422E-09
2.9328E+04	6.1949E-09
3.0038E+04	5.5215E-09
3.0764E+04	4.9043E-09
3.1507E+04	4.3478E-09
3.2268E+04	3.8465E-09
3.3046E+04	3.3945E-09
3.3843E+04	2.9888E-09

3.4659E+04	2.6204E-09
3.5493E+04	2.2946E-09
3.6347E+04	2.0048E-09
3.7221E+04	1.7469E-09
3.8116E+04	1.5180E-09
3.9031E+04	1.3133E-09
3.9968E+04	1.1337E-09
4.0927E+04	9.7707E-10
4.1908E+04	8.3756E-10
4.2912E+04	7.1660E-10
4.3940E+04	6.0999E-10
4.4992E+04	5.1929E-10
4.6068E+04	4.3923E-10
4.7170E+04	3.7082E-10
4.8297E+04	3.1155E-10
4.9451E+04	2.6074E-10
5.0632E+04	2.1788E-10
5.1840E+04	1.8091E-10
5.3077E+04	1.5002E-10
5.4343E+04	1.2344E-10
5.5638E+04	1.0144E-10
5.6964E+04	8.2896E-11
5.8321E+04	6.7404E-11
5.9709E+04	5.4623E-11
6.1130E+04	4.4067E-11
6.2584E+04	3.5340E-11
6.4073E+04	2.8230E-11
6.5596E+04	2.2408E-11
6.7154E+04	1.7754E-11
6.8750E+04	1.3949E-11
7.0382E+04	1.0912E-11
7.2053E+04	8.4954E-12
7.3763E+04	6.5643E-12
7.5513E+04	5.0550E-12
7.7304E+04	3.8595E-12
7.9137E+04	2.9323E-12
8.1013E+04	2.2177E-12
8.2933E+04	1.6634E-12
8.4897E+04	1.2419E-12
8.6908E+04	9.1846E-13
8.8966E+04	6.7699E-13
9.1072E+04	4.9451E-13
9.3227E+04	3.5868E-13
9.5433E+04	2.5833E-13
9.7690E+04	1.8433E-13

```
  1.0000E+05  1.3074E-13
U238
  2.3102E+01  0.0000E+00
  4.6744E+
```

It should be verified why the first row gives zero. It could be an artifact of the interpolation.

When the flow mode was changes from flow-through to bathtub, for all cases: the following results in ebsnef.dat clearly indicates that the release takes place at a later time compared to the bathtub model.

```
release rate [ci/yr]
      20       200  ! num nucs, ntemp
CM246
  2.3102E+01  0.0000E+00
  4.6744E+01  0.0000E+00
  7.0940E+01  0.0000E+00
  9.5702E+01  2.5738E-05
  1.2104E+02  2.9261E-05
  1.4698E+02  2.9503E-05
  1.7352E+02  2.8521E-05
  2.0069E+02  2.6970E-05
  2.2849E+02  2.5235E-05
  2.5694E+02  2.3519E-05
  2.8605E+02  2.1918E-05
  3.1585E+02  2.0467E-05
  3.4635E+02  1.9170E-05
  3.7756E+02  1.8017E-05
  4.0950E+02  1.6990E-05
  4.4219E+02  1.6071E-05
  4.7564E+02  1.5245E-05
  5.0988E+02  1.4497E-05
  5.4492E+02  1.3814E-05
  5.8078E+02  1.3188E-05
  6.1747E+02  1.2609E-05
  6.5503E+02  1.2071E-05
  6.9347E+02  1.1569E-05
  7.3281E+02  1.1098E-05
  7.7306E+02  1.0654E-05
  8.1426E+02  1.0235E-05
  8.5643E+02  9.8369E-06
  8.9958E+02  9.4582E-06
  9.4374E+02  9.0968E-06
  9.8894E+02  8.7511E-06
  1.0352E+03  8.4198E-06
  1.0825E+03  8.1015E-06
  1.1310E+03  7.7953E-06
```

1.1806E+03	7.5003E-06
1.2313E+03	7.2157E-06
1.2832E+03	6.9408E-06
1.3364E+03	6.6751E-06
1.3908E+03	6.4182E-06
1.4464E+03	6.1695E-06
1.5034E+03	5.9288E-06
1.5617E+03	5.6957E-06
1.6213E+03	5.4700E-06
1.6824E+03	5.2514E-06
1.7449E+03	5.0398E-06
1.8088E+03	4.8349E-06
1.8743E+03	4.6366E-06
1.9413E+03	4.4448E-06
2.0098E+03	4.2593E-06
2.0800E+03	4.0800E-06
2.1518E+03	3.9067E-06
2.2252E+03	3.7393E-06
2.3004E+03	3.5778E-06
2.3774E+03	3.4220E-06
2.4562E+03	3.2717E-06
2.5368E+03	3.1269E-06
2.6193E+03	2.9875E-06
2.7037E+03	2.8533E-06
2.7901E+03	2.7242E-06
2.8785E+03	2.6000E-06
2.9690E+03	2.4807E-06
3.0616E+03	2.3662E-06
3.1564E+03	2.2562E-06
3.2534E+03	2.1507E-06
3.3526E+03	2.0495E-06
3.4542E+03	1.9526E-06
3.5582E+03	1.8597E-06
3.6646E+03	1.7707E-06
3.7735E+03	1.6856E-06
3.8849E+03	1.6041E-06
3.9990E+03	1.5262E-06
4.1157E+03	1.4518E-06
4.2352E+03	1.3806E-06
4.3574E+03	1.3126E-06
4.4825E+03	1.2477E-06
4.6106E+03	1.1857E-06
4.7416E+03	1.1265E-06
4.8757E+03	1.0700E-06
5.0130E+03	1.0162E-06

5.1535E+03	9.6479E-07
5.2972E+03	8.8824E-07
5.4443E+03	8.3833E-07
5.5949E+03	8.0093E-07
5.7490E+03	7.5417E-07
5.9067E+03	7.1966E-07
6.0680E+03	6.7829E-07
6.2332E+03	6.4628E-07
6.4022E+03	6.0941E-07
6.5752E+03	5.7955E-07
6.7523E+03	5.4691E-07
6.9334E+03	5.1925E-07
7.1189E+03	4.9025E-07
7.3086E+03	4.6466E-07
7.5028E+03	4.3906E-07
7.7016E+03	4.1529E-07
7.9050E+03	3.9278E-07
8.1132E+03	3.7184E-07
8.3262E+03	3.4795E-07
8.5442E+03	3.3127E-07
8.7674E+03	3.0982E-07
8.9957E+03	2.9224E-07
9.2294E+03	2.7784E-07
9.4686E+03	2.6024E-07
9.7134E+03	2.4443E-07
9.9639E+03	2.2943E-07
1.0220E+04	2.1678E-07
1.0483E+04	2.0321E-07
1.0751E+04	1.9132E-07
1.1026E+04	1.7961E-07
1.1307E+04	1.6877E-07
1.1595E+04	1.5862E-07
1.1890E+04	1.4734E-07
1.2191E+04	1.3793E-07
1.2500E+04	1.2902E-07
1.2815E+04	1.2090E-07
1.3138E+04	1.1266E-07
1.3469E+04	1.0581E-07
1.3808E+04	9.8553E-08
1.4154E+04	9.1715E-08
1.4508E+04	8.5762E-08
1.4871E+04	7.9952E-08
1.5242E+04	7.3594E-08
1.5622E+04	6.8434E-08
1.6011E+04	6.3471E-08

1.6409E+04	5.8885E-08
1.6816E+04	5.4512E-08
1.7233E+04	5.0455E-08
1.7660E+04	4.6641E-08
1.8096E+04	4.3115E-08
1.8543E+04	3.9489E-08
1.9000E+04	3.6297E-08
1.9468E+04	3.3375E-08
1.9947E+04	3.0648E-08
2.0437E+04	2.8110E-08
2.0939E+04	2.5769E-08
2.1452E+04	2.3579E-08
2.1977E+04	2.1384E-08
2.2515E+04	1.9478E-08
2.3065E+04	1.7746E-08
2.3628E+04	1.6080E-08
2.4204E+04	1.4541E-08
2.4794E+04	1.3181E-08
2.5398E+04	1.1907E-08
2.6015E+04	1.0759E-08
2.6648E+04	9.6771E-09
2.7295E+04	8.7159E-09
2.7957E+04	7.8288E-09
2.8634E+04	6.9598E-09
2.9328E+04	6.2181E-09
3.0038E+04	5.5561E-09
3.0764E+04	4.9389E-09
3.1507E+04	4.3896E-09
3.2268E+04	3.8622E-09
3.3046E+04	3.4077E-09
3.3843E+04	3.0050E-09
3.4659E+04	2.6437E-09
3.5493E+04	2.3022E-09
3.6347E+04	2.0158E-09
3.7221E+04	1.7573E-09
3.8116E+04	1.5309E-09
3.9031E+04	1.3219E-09
3.9968E+04	1.1380E-09
4.0927E+04	9.8483E-10
4.1908E+04	8.4135E-10
4.2912E+04	7.1852E-10
4.3940E+04	6.1520E-10
4.4992E+04	5.1939E-10
4.6068E+04	4.4190E-10
4.7170E+04	3.7312E-10

4.8297E+04	3.1440E-10
4.9451E+04	2.6291E-10
5.0632E+04	2.1986E-10
5.1840E+04	1.8206E-10
5.3077E+04	1.5036E-10
5.4343E+04	1.2459E-10
5.5638E+04	1.0191E-10
5.6964E+04	8.3440E-11
5.8321E+04	6.7558E-11
5.9709E+04	5.5034E-11
6.1130E+04	4.4035E-11
6.2584E+04	3.5636E-11
6.4073E+04	2.8476E-11
6.5596E+04	2.2550E-11
6.7154E+04	1.7876E-11
6.8750E+04	1.3989E-11
7.0382E+04	1.1008E-11
7.2053E+04	8.5361E-12
7.3763E+04	6.6189E-12
7.5513E+04	5.0765E-12
7.7304E+04	3.8594E-12
7.9137E+04	2.9597E-12
8.1013E+04	2.2216E-12
8.2933E+04	1.6766E-12
8.4897E+04	1.2431E-12
8.6908E+04	9.2802E-13
8.8966E+04	6.8204E-13
9.1072E+04	4.9585E-13
9.3227E+04	3.6114E-13
9.5433E+04	2.5926E-13
9.7690E+04	1.8443E-13
1.0000E+05	1.3108E-13

The code appears to be correctly using the bathtub vs. flow through model depending on how they are selected.

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-297	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

nfenv.f, reader.f, tpa.inp, repdes.dat (new), subarea.f, and volcano.f

Use new repository layout consistent with DOE's EDA-II design basis.

Change Requested by: S. Mohanty Date: 1-4-00	**Change Authorized by** (*Software Developer*): R. Janetzke R. Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

New intermediate file drifts.dat.

- New repository coordinates were introduced.
- New subareas (subarea 8, 9, and 10) were created)
- New algorithm was introduced to determine drift lengths ~~based~~ intersected by a subarea
- Although the design of the algorithm ~~was~~ is general, the TPA 4.0 will use only a fixed repository layout to avoid complications associated with intersection between lines

Implemented by: R. Janetzke ~~M. Muller~~ R. Janetzke	**Date:** 1-20-00

Description of Acceptance Tests:

The Testing for This SCR has been superceded by SCR-304. See test plan + test report for SCR-304.

R. Janetzke
3-27-00

Tested by:	**Date:**

CNWRA Form TOP-5 (01/99)

representing drift and pentagonal subareas.

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-298

Software Title and Version: TPA 3.3

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):

SEISMO samplehazzardcurve uses random number which is also used by other modules. This causes uncontrolled series of numbers depending on run parameters. make a separate seed and random call just for seismo.
changes to modudes: ran.f, reader.f, sampler.f, tpainp, tpanames.dbs

Change Requested by:
R. Janetzke
Date: 1-19-00

Change Authorized by (*Software Developer*):
R. Janetzke R Janetzke
Date: 1-19-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

SEISMO is given own seed and random calls following current code processes:
seed is set once in reader.f as is current tpa seed, then calls to new routines:
setranseis, ranlseis, and raneseis are make as is currently done with old routines

ran.f setran, ranl, rane copied to setranseis, ranlseis, raneseis and common block changed
reader.f SeedForRandomNumberForSEISMO read in and saved by call to setranseis (seed)
sampler.f samplehazzardcurve() changed to call ranlseis and raneseis
tpa.inp added SeedForRandomNumberForSEISMO as a constant
tpanames.dbs added " with its abbreviation

Implemented by:
Michael Muller

Date:
Jan 11, 2000

Description of Acceptance Tests:
Test Plan + Results Attached

Tested by: Ron Janetzke

Date: 3-6-00

CNWRA Form TOP-5 (01/99)

Test Plan for SCR #298

Test name: Repeatable seismic events

Anticipated start date: 3-6-00

Anticipated completion date: 3-7-00

Amount of time available to perform this test: 1 day

Percent of time to be spent in process and system level testing: 50/50

Output files to be checked: screen output captured in tpa.out, wpsfail.res, seismo.ech.

Input files to be checked for proper data transfer to the program: None, all input comes from argument lists.

Disposition of documentation: Hard copy attached.

Functional tests descriptions:

Hand calculations: None

Process-level test 1: Check output of setranseis() routine with test driver against setran(). Output should be the same for both routines if both seeds are the same. This routine is only called once and produces only one output value in common block aseedseis. Routine setran uses common block aseed.

PASSED

Process-level test 2: Check output of ran1seis() function with test driver. The output of ran1seis() should match the output of ran1() when started with the same seed. Only the first few values of a random sequence need to be checked.

PASSED

Process-level test 3: Check output of raneseis() function with test driver. The output from raneseis() should be the same as rane() when both are started with the same seed. Checks are be made for zero value, negative and positive arguments.

PASSED

Process-level test 4: Check output of samplehazardcurve routine with test driver. Runs with longer time periods of interest should produce more events. Output plots show number of events vs. time period of interest, type of events vs. time period of interest, and type of events vs. time of events.

PASSED

System-level test 5: Check TPA output files for two vectors for several time periods of interest. The first 10,000 years of each run for the second vector should be the same.

PASSED

Reasonableness test description: Do the seismic events appear in the time range specified in tpa.inp?

YES

Did the modification substantially change the results?

NO

Was TPA 4.0beta output compared to TPA3.3 output?

NO, proper behavior is determined from TPA 4.0beta output alone.

Which nuclides were monitored to determine reasonableness of results in terms of dose?

I129 and Cl36.

```
c       Test driver 1 for testing SCR #298
        implicit double precision (a-h,o-z)
      common / aseedseis / aseedseis
      common / aseed / aseed
  100 continue
        print *, ' '
        print *, 'Begin test 298_1, enter seed'
        read (5,*) rseed
        print *, 'rseed = ', rseed
        call setranseis (rseed)
        print *, 'After call setranseis rseed = ', rseed
        call setran (rseed)
        print *, 'After call setran rseed     = ', rseed
        print *, 'After both calls aseedseis  = ', aseedseis
        print *, 'After both calls aseed      = ', aseed
        if (aseedseis .eq. aseed) then
          print *, ' '
          print *, 'aseedseis equals aseed'
          print *, 'Test 298_1 result: PASSED'
        else
          print *, ' '
          print *, 'aseedseis does not equal aseed'
          print *, 'Test 298_1 result: FAILED'
        end if
        go to 100
        stop
        end
c=========================================================================
      subroutine setran( aseed1 )
c=========================================================================
c set seed for random number generator
c
c aseed1 = input, double precision, seed value
c          recommend value for aseed be between 1.0d8 and 1.0d9 when
c          working in double precision.
c          if changed to single precision, recommend 1.e3 to 1.e5
c
      implicit double precision (a-h,o-z)

      common / iset  / iset
      common / aseed / aseed

      if( (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9) ) then
        print *, ' ***>>> Error in setran <<<*** '
        print *, ' (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9)'
        print *, ' aseed1 = ', aseed1
        STOP
      endif

      aseed =  aseed1
      iset = 99233

      return
      end
c=========================================================================
      function ran1( )
c=========================================================================
c random number generator.
c based on congruential generator described in "Stochastic Simulation"
c by Brian D. Ripley, 1987, John Wiley & Sons
c see page 20, equation (1) and Table 2-4 on pg 39.  Used 4th alogorithm
c in table.
c
c ran1 = output, double precision, random number between 0.0 and 1.0
c
```

```
      implicit double precision (a-h,o-z)
      common / iset  / iset
      common / aseed / aseed

cc a = 7^5
      data a / 16807.d0      /
cc m = 2**31 - 1
cc      data m / 2147483647      /
cc am = dble( m )
      data am / 2.147483647d9      /

      if( iset .ne. 99233 ) then
         iset = 99233
         aseed = 5.05187067d8
      endif

      aseed = dmod( aseed * a, am )
      ran1 = aseed/am

      return
      end
c========================================================================
c
cc mam 01/14/00 Copied setran, ran1 and rane and renamed them to
cc              setranseis, ran1seis, and raneseis. Changed name of
cc              common block to hold new seed. Deleted a few unused lines.
cc              Now random numbers are based on seed from tpa which is
cc              only modified here and only called by samplehazardcurve.
c
c               setranseis, ran1seis, raneseis are for use in setting
c               hazzard curve time and magnitude/type of events based
c               one seed in tpa.inp.
c
c
c========================================================================
      subroutine setranseis( aseed1 )
c========================================================================
c set seed for random number generator
c
c aseed1 = input, double precision, seed value
c          recommend value for aseed be between 1.0d8 and 1.0d9 when
c          working in double precision.
c          if changed to single precision, recommend 1.e3 to 1.e5
c
      implicit double precision (a-h,o-z)

      common / aseedseis / aseed

      if( (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9) ) then
        print *, ' ***>>> Error in setranseis <<<*** '
        print *, ' (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9)'
        print *, ' aseed1 = ', aseed1
        STOP
      endif

      aseed =  aseed1

      return
      end
c========================================================================
      function ran1seis( )
c========================================================================
c random number generator.
c based on congruential generator described in "Stochastic Simulation"
c by Brian D. Ripley, 1987, John Wiley & Sons
```

```
c see page 20, equation (1) and Table 2-4 on pg 39.  Used 4th alogorithm
c in table.
c
c ran1seis = output, double precision, random number between 0.0 and 1.0
c
      implicit double precision (a-h,o-z)
      common / aseedseis / aseed

cc a = 7^5
      data a / 16807.d0       /
cc m = 2**31 - 1
cc       data m / 2147483647       /
cc am = dble( m )
      data am / 2.147483647d9       /

      aseed    = dmod( aseed * a, am )
      ran1seis = aseed/am

      return
      end
c==========================================================================
      function raneseis(alam)
c==========================================================================
c random sample from exponential
c  pdf = alam* EXP( - alam * t )
c
c alam     = input,  double precision, input parameter for exponential pdf
c raneseis = output, double precision, sampled parameter from exponential pdf
c                    Note:   0.0 < raneseis < Infinity
c
      implicit double precision (a-h,o-z)
      external ran1seis
      if( alam .le. 0.0d0 ) then
         print *, ' '
         print *, ' ***>>> Error in raneseis <<<*** '
         print *, ' alam .le. 0.0d0 '
         print *, ' alam = ', alam
         STOP
      endif
      raneseis = - dlog( 1.0d0 - ran1seis() ) / alam
      return
      end
c==========================================================================
c==========================================================================
      function rane(alam)
c==========================================================================
c random sample from exponential
c  pdf = alam* EXP( - alam * t )
c
c alam = input, double precision, input parameter for exponential pdf
c rane = output, double precision, sampled parameter from exponential pdf
c                Note:   0.0 < rane < Infinity
c
      implicit double precision (a-h,o-z)
      external ran1
      if( alam .le. 0.0d0 ) then
         print *, ' '
         print *, ' ***>>> Error in rane <<<*** '
         print *, ' alam .le. 0.0d0 '
         print *, ' alam = ', alam
         STOP
      endif
      rane = - dlog( 1.0d0 - ran1() ) / alam
      return
      end
```

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```
Begin test 298_1, enter seed
rseed =     123456789.00000
After call setranseis rseed =     123456789.00000
After call setran rseed     =     123456789.00000
After both calls aseedseis  =     123456789.00000
After both calls aseed      =     123456789.00000

aseedseis equals aseed
Test 298_1 result: PASSED

Begin test 298_1, enter seed
rseed =     987654321.00000
After call setranseis rseed =     987654321.00000
After call setran rseed     =     987654321.00000
After both calls aseedseis  =     987654321.00000
After both calls aseed      =     987654321.00000

aseedseis equals aseed
Test 298_1 result: PASSED

Begin test 298_1, enter seed
rseed =   0.
 ***>>> Error in setranseis <<<***
 (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9)
 aseed1 =   0.
```

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```
Begin test 298_1, enter seed
rseed =     -199999999.00000
 ***>>> Error in setranseis <<<***
 (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9)
 aseed1 =    -199999999.00000
```

```
Begin test 298_1, enter seed
rseed =      9999999999.0000
 ***>>> Error in setranseis <<<***
 (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9)
 aseed1 =     9999999999.0000
```

```
c       Test driver 2 for testing SCR #298
        implicit double precision (a-h,o-z)
      common / aseedseis / aseedseis
      common / aseed / aseed
        print *, ' '
        print *, 'Begin test 298_2, enter seed'
        read (5,*) rseed
        print *, 'rseed = ', rseed
        call setranseis (rseed)
        call setran (rseed)
        do i = 1,10
          s = ran1seis()
          print *, 'After call #',i,' s = ', s
          a = ran1()
          print *, 'After call #',i,' a = ', a
          if (a.eq. s) then
            print *, ' '
            print *, 'a equals s'
            print *, 'Test 298_2 result: PASSED'
            print *, ' '
            print *, ' '
          else
            print *, ' '
            print *, 'a does not equal s'
            print *, 'Test 298_2 result: FAILED'
            print *, ' '
            print *, ' '
          end if
        end do
        end
c=========================================================================
      subroutine setran( aseed1 )
c=========================================================================
c set seed for random number generator
c
c aseed1 = input, double precision, seed value
c          recommend value for aseed be between 1.0d8 and 1.0d9 when
c          working in double precision.
c          if changed to single precision, recommend 1.e3 to 1.e5
c
      implicit double precision (a-h,o-z)

      common / iset  / iset
      common / aseed / aseed

      if( (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9) ) then
        print *, ' ***>>> Error in setran <<<*** '
        print *, ' (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9)'
        print *, ' aseed1 = ', aseed1
        STOP
      endif

      aseed =  aseed1
      iset = 99233

      return
      end
c=========================================================================
      function ran1( )
c=========================================================================
c random number generator.
c based on congruential generator described in "Stochastic Simulation"
c by Brian D. Ripley, 1987, John Wiley & Sons
c see page 20, equation (1) and Table 2-4 on pg 39.  Used 4th alogorithm
c in table.
```

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```
c
c ran1 = output, double precision, random number between 0.0 and 1.0
c
      implicit double precision (a-h,o-z)
      common / iset  / iset
      common / aseed / aseed

cc a = 7^5
      data a / 16807.d0      /
cc m = 2**31 - 1
cc      data m / 2147483647      /
cc am = dble( m )
      data am / 2.147483647d9      /

      if( iset .ne. 99233 ) then
         iset = 99233
         aseed = 5.05187067d8
      endif

      aseed = dmod( aseed * a, am )
      ran1 = aseed/am

      return
      end
c========================================================================
c
cc mam 01/14/00 Copied setran, ran1 and rane and renamed them to
cc              setranseis, ran1seis, and raneseis. Changed name of
cc              common block to hold new seed. Deleted a few unused lines.
cc              Now random numbers are based on seed from tpa which is
cc              only modified here and only called by samplehazardcurve.
c
c               setranseis, ran1seis, raneseis are for use in setting
c               hazzard curve time and magnitude/type of events based
c               one seed in tpa.inp.
c
c
c========================================================================
      subroutine setranseis( aseed1 )
c========================================================================
c set seed for random number generator
c
c aseed1 = input, double precision, seed value
c          recommend value for aseed be between 1.0d8 and 1.0d9 when
c          working in double precision.
c          if changed to single precision, recommend 1.e3 to 1.e5
c
      implicit double precision (a-h,o-z)

      common / aseedseis / aseed

      if( (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9) ) then
        print *, ' ***>>> Error in setranseis <<<*** '
        print *, ' (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9)'
        print *, ' aseed1 = ', aseed1
        STOP
      endif

      aseed =  aseed1

      return
      end
c========================================================================
      function ran1seis( )
c========================================================================
```

```
c random number generator.
c based on congruential generator described in "Stochastic Simulation"
c by Brian D. Ripley, 1987, John Wiley & Sons
c see page 20, equation (1) and Table 2-4 on pg 39.  Used 4th alogorithm
c in table.
c
c ran1seis = output, double precision, random number between 0.0 and 1.0
c
      implicit double precision (a-h,o-z)
      common / aseedseis / aseed

cc a = 7^5
      data a / 16807.d0      /
cc m = 2**31 - 1
cc       data m / 2147483647      /
cc am = dble( m )
      data am / 2.147483647d9      /

      aseed    = dmod( aseed * a, am )
      ran1seis = aseed/am

      return
      end
c=======================================================================
      function raneseis(alam)
c=======================================================================
c random sample from exponential
c  pdf = alam* EXP( - alam * t )
c
c alam     = input,  double precision, input parameter for exponential pdf
c raneseis = output, double precision, sampled parameter from exponential pdf
c                    Note:   0.0 < raneseis < Infinity
c
      implicit double precision (a-h,o-z)
      external ran1seis
      if( alam .le. 0.0d0 ) then
         print *, ' '
         print *, ' ***>>> Error in raneseis <<<*** '
         print *, ' alam .le. 0.0d0 '
         print *, ' alam = ', alam
         STOP
      endif
      raneseis = - dlog( 1.0d0 - ran1seis() ) / alam
      return
      end
c=======================================================================
c=======================================================================
      function rane(alam)
c=======================================================================
c random sample from exponential
c  pdf = alam* EXP( - alam * t )
c
c alam = input, double precision, input parameter for exponential pdf
c rane = output, double precision, sampled parameter from exponential pdf
c                Note:   0.0 < rane < Infinity
c
      implicit double precision (a-h,o-z)
      external ran1
      if( alam .le. 0.0d0 ) then
         print *, ' '
         print *, ' ***>>> Error in rane <<<*** '
         print *, ' alam .le. 0.0d0 '
         print *, ' alam = ', alam
         STOP
      endif
```

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```
      rane = - dlog( 1.0d0 - ran1() ) / alam
      return
      end
```

```
Begin test 298_2, enter seed
rseed =     123456789.00000
After call #   1 s =    0.21841829699390
After call #   1 a =    0.21841829699390

a equals s
Test 298_2 result: PASSED


After call #   2 s =    0.95631757655941
After call #   2 a =    0.95631757655941

a equals s
Test 298_2 result: PASSED


After call #   3 s =    0.82950923397649
After call #   3 a =    0.82950923397649

a equals s
Test 298_2 result: PASSED


After call #   4 s =    0.56169544279654
After call #   4 a =    0.56169544279654

a equals s
Test 298_2 result: PASSED


After call #   5 s =    0.41530708149788
After call #   5 a =    0.41530708149788

a equals s
Test 298_2 result: PASSED


After call #   6 s =     6.6118734919521D-02
After call #   6 a =     6.6118734919521D-02

a equals s
Test 298_2 result: PASSED


After call #   7 s =    0.25757779239564
After call #   7 a =    0.25757779239564

a equals s
Test 298_2 result: PASSED


After call #   8 s =    0.10995679353827
After call #   8 a =    0.10995679353827

a equals s
Test 298_2 result: PASSED


After call #   9 s =     4.3828997781421D-02
After call #   9 a =     4.3828997781421D-02

a equals s
Test 298_2 result: PASSED
```

```
After call #  10 s =     0.63396571233588
After call #  10 a =     0.63396571233588

a equals s
Test 298_2 result: PASSED
```

```
c       Test driver 3 for testing SCR #298
        implicit double precision (a-h,o-z)
      common / aseedseis / aseedseis
      common / aseed / aseed
        print *, ' '
        print *, 'Begin test 298_3, enter seed'
        read (5,*) rseed
        print *, 'rseed = ', rseed
        call setranseis (rseed)
        call setran (rseed)
        print *, ' '
        print *, 'Enter lambda'
        read (5,*) alam
        print *, 'alam = ', alam
        do i = 10,-1,-1
          s = raneseis(alam)
          print *, 'After call #',i,' s = ', s
          a = rane(alam)
          print *, 'After call #',i,' a = ', a
          if (a .eq. s) then
            print *, ' '
            print *, 'a equals s'
            print *, 'Test 298_3 result: PASSED'
            print *, ' '
            print *, ' '
          else
            print *, ' '
            print *, 'a does not equal s'
            print *, 'Test 298_3 result: FAILED'
            print *, ' '
            print *, ' '
          end if
          alam = dble(i)
          print *, 'alam = ', alam
        end do
        end
c=========================================================================
      subroutine setran( aseed1 )
c=========================================================================
c set seed for random number generator
c
c aseed1 = input, double precision, seed value
c          recommend value for aseed be between 1.0d8 and 1.0d9 when
c          working in double precision.
c          if changed to single precision, recommend 1.e3 to 1.e5
c
      implicit double precision (a-h,o-z)

      common / iset  / iset
      common / aseed / aseed

      if( (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9) ) then
        print *, ' ***>>> Error in setran <<<*** '
        print *, ' (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9)'
        print *, ' aseed1 = ', aseed1
        STOP
      endif

      aseed =  aseed1
      iset = 99233

      return
      end
c=========================================================================
      function ranl( )
```

```
c=======================================================================
c random number generator.
c based on congruential generator described in "Stochastic Simulation"
c by Brian D. Ripley, 1987, John Wiley & Sons
c see page 20, equation (1) and Table 2-4 on pg 39.  Used 4th alogorithm
c in table.
c
c ran1 = output, double precision, random number between 0.0 and 1.0
c
      implicit double precision (a-h,o-z)
      common / iset  / iset
      common / aseed / aseed

cc a = 7^5
      data a / 16807.d0      /
cc m = 2**31 - 1
cc      data m / 2147483647      /
cc am = dble( m )
      data am / 2.147483647d9      /

      if( iset .ne. 99233 ) then
         iset = 99233
         aseed = 5.05187067d8
      endif

      aseed = dmod( aseed * a, am )
      ran1 = aseed/am

      return
      end
c=======================================================================
c
cc mam 01/14/00 Copied setran, ran1 and rane and renamed them to
cc              setranseis, ran1seis, and raneseis. Changed name of
cc              common block to hold new seed. Deleted a few unused lines.
cc              Now random numbers are based on seed from tpa which is
cc              only modified here and only called by samplehazardcurve.
c
c               setranseis, ran1seis, raneseis are for use in setting
c               hazzard curve time and magnitude/type of events based
c               one seed in tpa.inp.
c
c
c=======================================================================
      subroutine setranseis( aseed1 )
c=======================================================================
c set seed for random number generator
c
c aseed1 = input, double precision, seed value
c          recommend value for aseed be between 1.0d8 and 1.0d9 when
c          working in double precision.
c          if changed to single precision, recommend 1.e3 to 1.e5
c
      implicit double precision (a-h,o-z)

      common / aseedseis / aseed

      if( (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9) ) then
        print *, ' ***>>> Error in setranseis <<<*** '
        print *, ' (aseed1 .lt. 1.0d8) .or. (aseed1 .gt. 1.0d9)'
        print *, ' aseed1 = ', aseed1
        STOP
      endif

      aseed =  aseed1
```

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```
      return
      end
c========================================================================
      function ran1seis( )
c========================================================================
c random number generator.
c based on congruential generator described in "Stochastic Simulation"
c by Brian D. Ripley, 1987, John Wiley & Sons
c see page 20, equation (1) and Table 2-4 on pg 39.  Used 4th alogorithm
c in table.
c
c ran1seis = output, double precision, random number between 0.0 and 1.0
c
      implicit double precision (a-h,o-z)
      common / aseedseis / aseed

cc a = 7^5
      data a / 16807.d0      /
cc m = 2**31 - 1
cc      data m / 2147483647      /
cc am = dble( m )
      data am / 2.147483647d9      /

      aseed    = dmod( aseed * a, am )
      ran1seis = aseed/am

      return
      end
c========================================================================
      function raneseis(alam)
c========================================================================
c random sample from exponential
c  pdf = alam* EXP( - alam * t )
c
c alam     = input,  double precision, input parameter for exponential pdf
c raneseis = output, double precision, sampled parameter from exponential pdf
c                    Note:   0.0 < raneseis < Infinity
c
      implicit double precision (a-h,o-z)
      external ran1seis
      if( alam .le. 0.0d0 ) then
         print *, ' '
         print *, ' ***>>> Error in raneseis <<<*** '
         print *, ' alam .le. 0.0d0 '
         print *, ' alam = ', alam
         STOP
      endif
      raneseis = - dlog( 1.0d0 - ran1seis() ) / alam
      return
      end
c========================================================================
c========================================================================
      function rane(alam)
c========================================================================
c random sample from exponential
c  pdf = alam* EXP( - alam * t )
c
c alam = input, double precision, input parameter for exponential pdf
c rane = output, double precision, sampled parameter from exponential pdf
c                Note:   0.0 < rane < Infinity
c
      implicit double precision (a-h,o-z)
      external ran1
      if( alam .le. 0.0d0 ) then
```

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```
         print *, ' '
         print *, ' ***>>> Error in rane <<<*** '
         print *, ' alam .le. 0.0d0 '
         print *, ' alam = ', alam
         STOP
      endif
      rane = - dlog( 1.0d0 - ran1() ) / alam
      return
      end
```

```
Begin test 298_3, enter seed
rseed =     987654321.00000

Enter lambda
alam =     111111111.00000
After call #  10 s =     1.2384131701701D-08
After call #  10 a =     1.2384131701701D-08

a equals s
Test 298_3 result: PASSED


alam =    10.0000000000000
After call #  9 s =    0.17980635327295
After call #  9 a =    0.17980635327295

a equals s
Test 298_3 result: PASSED


alam =     9.0000000000000
After call #  8 s =     6.3736286952249D-02
After call #  8 a =     6.3736286952249D-02

a equals s
Test 298_3 result: PASSED


alam =     8.0000000000000
After call #  7 s =    0.12141424332814
After call #  7 a =    0.12141424332814

a equals s
Test 298_3 result: PASSED


alam =     7.0000000000000
After call #  6 s =     1.7834269865396D-02
After call #  6 a =     1.7834269865396D-02

a equals s
Test 298_3 result: PASSED


alam =     6.0000000000000
After call #  5 s =    0.11538544025042
After call #  5 a =    0.11538544025042

a equals s
Test 298_3 result: PASSED


alam =     5.0000000000000
After call #  4 s =    0.13233896070334
After call #  4 a =    0.13233896070334

a equals s
Test 298_3 result: PASSED


alam =     4.0000000000000
After call #  3 s =     1.1375947569417
After call #  3 a =     1.1375947569417
```

```
a equals s
Test 298_3 result: PASSED


alam =     3.0000000000000
After call #  2 s =    0.20806009811164
After call #  2 a =    0.20806009811164

a equals s
Test 298_3 result: PASSED


alam =     2.0000000000000
After call #  1 s =    0.33078720594717
After call #  1 a =    0.33078720594717

a equals s
Test 298_3 result: PASSED


alam =     1.0000000000000
After call #  0 s =     2.9065596164068
After call #  0 a =     2.9065596164068

a equals s
Test 298_3 result: PASSED


alam =   0.

 ***>>> Error in raneseis <<<***
 alam .le. 0.0d0
 alam =   0.
```

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```
Begin test 298_3, enter seed
rseed =      987654321.00000

Enter lambda
alam =    -1.0000000000000

 ***>>> Error in raneseis <<<***
 alam .le. 0.0d0
 alam =    -1.0000000000000
```

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```
constant
DripShieldFailureTime[yr]
1000.0
**ENDOPR
constant
ReferencepH
9.0
**
constant
WPsurfaceScaleThickness[m]
0.0
**
constant
TortuosityOfScaleonWP
1.0
**
constant
PorosityOfScaleonWP
1.0
**
constant
YieldStrength[MPa]
205.0
**

          actor

**
consta
Fract      ou   ss[MPa-m**0.
250.0
**
**OPR
constant
DensityOuterOverpack[kg/m^3]
7860.0
**
constant
DensityInnerOverpack[kg/m^3]
8140.0
**
constant
EquivalentWeightOuterOverpack[kg/mol]
0.027925
**
constant
EquivalentWeightInnerOverpack[kg/mol]
0.02554222222222222222
**
constant
DeltaPotentialDueToRadiolysis[V]
0.0
**
constant
DecayingConstantRadiolysis[1/yr]
7.0e-5
**ENDOPR
**
**
**            ***>>> SEISMO  <<<***
** mam 01/14/00 Seed only for random numbers used by samplehazardcurve().
**              It should be constant as it is used only once.
constant
SeedForRandomNumberForSEISMO
505187067.0
```

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```
**
hazardcurve
SeismicHazardCurveforSEISMO
10
1.00 180.0
2.00 500.0
3.00 1200.0
4.00 2400.0
5.00 4400.0
6.00 7800.0
7.00 11000.0
8.00 20000.0
9.00 30000.0
10.00 44000.0
**
constant
WeightPercentageOfRockFallThatHitsWPforSEISMO
1.0
**
constant
WeightOfWPforSEISMO[N]
1.27D05
**
constant
WPModulusOfElasticityforSEISMO[Pa]
2.07D11
**
  mal
    odulusOfElasticityforSEISM  a]
2         4.14D10
**
constant
WPPoissonRatioforSEISMO[]
0.2D0
**
normal
RockPoissonRatioforSEISMO[]
0.15, 0.25
**
constant
RockFallingDistanceforSEISMO[m]
2.0D0
**
constant
WPFallingDistanceforSEISMO[m]
0.3D0
**
iconstant
WPNumberofSupportPairforSEISMO
2
**
constant
WPSupportStiffnessforSEISMO[pa*m]
5.5D09
**
constant
DistributionJointSpacing1forSEISMO
5.0D-03
**
constant
DistributionJointSpacing2forSEISMO
5.0D-03
**
constant
DistributionJointSpacing3forSEISMO
```

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```
5.0D-03
**
constant
DistributionJointSpacing4forSEISMO
0.629D0
**
constant
DistributionJointSpacing5forSEISMO
0.356D0
**
normal
SEISMOJointSpacing1[m]
0.466, 0.600
**
normal
SEISMOJointSpacing2[m]
0.333 0.466
**
normal
SEISMOJointSpacing3[m]
0.20, 0.333
**
normal
SEISMOJointSpacing4[m]
0.06, 0.20
**
normal
SEISMOJointSpacing5[m]
0.03, 0.06
**
**  5/28/1998 tpa3.2 new value (smh)
**
constant
WPUltimateStrength[N/m^2]
4.5D08
**
constant
GrainDensityforTSw2SEISMO[]
2.55
**
**  5/28/1998 tpa3.2 new values next 60 parameters(replacing seismo.dat)
**
constant
FractionAreaForGroundMotion1
0.05
**
constant
FractionAreaForGroundMotion2
0.12
**
constant
FractionAreaForGroundMotion3
0.17
**
constant
FractionAreaForGroundMotion4
0.23
**
constant
FractionAreaForGroundMotion5
0.28
**
constant
FractionAreaForGroundMotion6
0.34
```

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```
**
constant
FractionAreaForGroundMotion7
0.4
**
constant
FractionAreaForGroundMotion8
0.46
**
constant
FractionAreaForGroundMotion9
0.5
**
constant
FractionAreaForGroundMotion10
0.54
**
** rwr 7/8/98 modify the VerticalExtentOfRockFall names by adding "_"
constant
VerticalExtentOfRockFall1_1[m]
0.0
**
constant
VerticalExtentOfRockFall1_2[m]
0.0
**
constant
VerticalExtentOfRockFall1_3[m]
0.0
**
constant
VerticalExtentOfRockFall1_4[m]
0.0
**
constant
VerticalExtentOfRockFall1_5[m]
0.0
**
constant
VerticalExtentOfRockFall1_6[m]
0.0
**
constant
VerticalExtentOfRockFall1_7[m]
0.0
**
constant
VerticalExtentOfRockFall1_8[m]
0.0
constant
VerticalExtentOfRockFall1_9[m]
0.0
**
constant
VerticalExtentOfRockFall1_10[m]
0.0
**
uniform
VerticalExtentOfRockFall2_1[m]
0.5 0.6
**
uniform
VerticalExtentOfRockFall2_2[m]
0.5 1.0
**
```

```
uniform
VerticalExtentOfRockFall2_3[m]
0.5 1.1
**
uniform
VerticalExtentOfRockFall2_4[m]
0.5 1.2
**
uniform
VerticalExtentOfRockFall2_5[m]
0.5 1.3
**
uniform
VerticalExtentOfRockFall2_6[m]
0.5 1.4
**
uniform
VerticalExtentOfRockFall2_7[m]
0.5 1.45
**
uniform
VerticalExtentOfRockFall2_8[m]
0.5 1.5
**
uniform
VerticalExtentOfRockFall2_9[m]
0.5 1.65
**
uniform
VerticalExtentOfRockFall2_10[m]
0.5 1.8
**
uniform
VerticalExtentOfRockFall3_1[m]
0.5 1.0
**
uniform
VerticalExtentOfRockFall3_2[m]
0.5 2.0
**
uniform
VerticalExtentOfRockFall3_3[m]
0.5 2.5
**
uniform
VerticalExtentOfRockFall3_4[m]
0.5 3.0
**
uniform
VerticalExtentOfRockFall3_5[m]
0.5 3.5
**
uniform
VerticalExtentOfRockFall3_6[m]
0.5 4.0
**
uniform
VerticalExtentOfRockFall3_7[m]
0.5 4.5
**
uniform
VerticalExtentOfRockFall3_8[m]
0.5 5.0
**
uniform
```

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```
VerticalExtentOfRockFall3_9[m]
0.5 5.7
**
uniform
VerticalExtentOfRockFall3_10[m]
0.5 6.5
**
uniform
VerticalExtentOfRockFall4_1[m]
0.5 2.7
**
uniform
VerticalExtentOfRockFall4_2[m]
0.5 5.5
**
uniform
VerticalExtentOfRockFall4_3[m]
0.5 6.0
**
uniform
VerticalExtentOfRockFall4_4[m]
0.5 6.5
**
uniform
VerticalExtentOfRockFall4_5[m]
0.5 7.0
**
uniform
VerticalExtentOfRockFall4_6[m]
0.5 7.5
**
uniform
VerticalExtentOfRockFall4_7[m]
[illegible].0

uniform
VerticalExtentOfRockFall4_8[m]
0.5 8.5
**
uniform
VerticalExtentOfRockFall4_9[m]
0.5 9.3
**
uniform
VerticalExtentOfRockFall4_10[m]
0.5 10.0
**
uniform
VerticalExtentOfRockFall5_1[m]
0.5 4.7
**
uniform
VerticalExtentOfRockFall5_2[m]
0.5 9.33
**
uniform
VerticalExtentOfRockFall5_3[m]
0.5 9.7
**
uniform
VerticalExtentOfRockFall5_4[m]
0.5 10.0
**
uniform
VerticalExtentOfRockFall5_5[m]
```

```
0.5 10.7
**
uniform
VerticalExtentOfRockFall5_6[m]
0.5 11.33
**
uniform
VerticalExtentOfRockFall5_7[m]
0.5 12.0
**
uniform
VerticalExtentOfRockFall5_8[m]
0.5 12.66
**
uniform
VerticalExtentOfRockFall5_9[m]
0.5 13.3
**
uniform
VerticalExtentOfRockFall5_10[m]
0.5 14.0
**
**  5/28/1998 tpa3.2 two new parameters introduced
**
constant
WPYieldPoint[]
0.002
**
constant
WPPlasticElongation[]
0.02
**
**
**
**          ***>>>  EBSREL  <<<***
** rwr 1/12/00 modified to allow for failure type-specific
**             water contact modes (added a flag for each of
**             the 8 failure types)
**  ** rwr 7/8/98 modify flow model flag
** iflag
** FlowModelFlag(0=BathTub,1=FlowThrough)
** 0
iflag
WaterContactMode_Initial(0=BathTub,1=FlowThrough)
0
**
iflag
WaterContactMode_Faulting(0=BathTub,1=FlowThrough)
1
**
iflag
WaterContactMode_Volcanic(0=BathTub,1=FlowThrough)
1
**
iflag
WaterContactMode_SeismicInterval1(0=BathTub,1=FlowThrough)
0
**
iflag
WaterContactMode_SeismicInterval2(0=BathTub,1=FlowThrough)
0
**
iflag
WaterContactMode_SeismicInterval3(0=BathTub,1=FlowThrough)
0
```

```
=========================================================================
          exec: Welcome to TPA Version 4.0beta
        Job started: Thu Mar  2 17:06:18 2000
=========================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea    Area        Waste    Number of WP
    #      [m^2]       [MTU]
    1    723591.3     14200.8        1455
    2    784763.0     15303.7        1568
    3    390372.0      7564.0         775
    4    207581.3      4157.8         426
    5    378972.8      7417.6         760
    6    424872.5      8305.8         851
    7    163938.3      3152.5         323
    8    393468.9      7944.6         814

 Total Area [acre]          =     856.82238463061
 Total Buried Waste [MTU]   =     68046.720000000
 Repository AML [MTU/acre] =     79.417532992367

 Specified Global Parameters:

               Compliance Period =  10000.0 (yr)
         Maximum Simulation Time =  10000.0 (yr)
          Number Of Realizations =      1
              Number Of Subareas =      8
              Volcanism scenario =      1 (yes=1, no=0)
               Faulting scenario =      1 (yes=1, no=0)
                Seismic scenario =      1 (yes=1, no=0)
       Distance to Receptor Group =     20.0 (km)


 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


 ***>>> NOTE: When running with volcanism, verify that   <<<***
 ***>>> the maximum value of the PDF for parameter       <<<***
 ***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
 ***>>> equal to the parameter MaximumTime[yr].          <<<***


 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C*
*

 Begin test 298_4
 timemax =     10000.0000000000
 numberofseismicevents =    53
 time of event,     type of event
     272.97832275400    3.0000000000000
     362.45800399540    1.0000000000000
     498.09373914336    1.0000000000000
     965.71605478642    1.0000000000000
     977.22673617891    1.0000000000000
    1003.08068657299    2.0000000000000
     1210.1794339875    2.0000000000000
     1251.3587029011    1.0000000000000
     1645.8106397230    1.0000000000000
     1832.7753093646    1.0000000000000
     2059.0448563356    2.0000000000000
```

```
     2205.5132215353    5.0000000000000
     2920.2966930581    1.0000000000000
     2942.7691542551    1.0000000000000
     3110.0422874438    2.0000000000000
     3121.2418605975    1.0000000000000
     3476.2235306517    1.0000000000000
     3497.8539453465    2.0000000000000
     3506.4742071487    1.0000000000000
     3969.6745230919    1.0000000000000
     4508.8213236165    1.0000000000000
     4561.3336461503    1.0000000000000
     4801.2962062834    1.0000000000000
     5092.1774433065    5.0000000000000
     5260.9926106975    1.0000000000000
     5458.7351798655    2.0000000000000
     5559.5338707518    1.0000000000000
     5733.4348662364    2.0000000000000
     6319.4024203679    1.0000000000000
     6623.5794207524    1.0000000000000
     6710.8127184080    1.0000000000000
     6738.3487347777    1.0000000000000
     6756.2312284267    4.0000000000000
     6869.3422126669    2.0000000000000
     6945.6440455501    1.0000000000000
     7736.7108489231    1.0000000000000
     7893.8014272904    2.0000000000000
     8230.3626344728    2.0000000000000
     8246.4099730172    2.0000000000000
     8380.6207929396    4.0000000000000
     8390.1234786947    1.0000000000000
     8447.3947587895    1.0000000000000
     8512.8487937838    1.0000000000000
     8719.5645594142    3.0000000000000
     9094.9721925817    1.0000000000000
     9098.4504295357    1.0000000000000
     9288.9515003996    1.0000000000000
     9392.9972727062    1.0000000000000
     9445.0841218737    1.0000000000000
     9449.8669910619    1.0000000000000
     9670.2708083417    1.0000000000000
     9704.9955634218    1.0000000000000
     9960.2343120756    4.0000000000000
=======================================================================
         exec: Welcome to TPA Version 4.0beta
       Job started: Thu Mar  2 17:07:14 2000
=======================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea   Area       Waste   Number of WP
    #      [m^2]      [MTU]
    1     723591.3   14200.8        1455
    2     784763.0   15303.7        1568
    3     390372.0    7564.0         775
    4     207581.3    4157.8         426
    5     378972.8    7417.6         760
    6     424872.5    8305.8         851
    7     163938.3    3152.5         323
    8     393468.9    7944.6         814

 Total Area [acre]          =     856.82238463061
 Total Buried Waste [MTU]   =     68046.720000000
 Repository AML [MTU/acre]  =     79.417532992367

 Specified Global Parameters:

               Compliance Period =  10000.0 (yr)
```

```
          Maximum Simulation Time =  20000.0 (yr)
           Number Of Realizations =      1
               Number Of Subareas =      8
               Volcanism scenario =      1 (yes=1, no=0)
                Faulting scenario =      1 (yes=1, no=0)
                 Seismic scenario =      1 (yes=1, no=0)
       Distance to Receptor Group =     20.0 (km)


 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


 ***>>> NOTE: When running with volcanism, verify that   <<<***
 ***>>> the maximum value of the PDF for parameter       <<<***
 ***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
 ***>>> equal to the parameter MaximumTime[yr].          <<<***


 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C*
*

 Begin test 298_4
 timemax =      20000.000000000
 numberofseismicevents =   102
 time of event,     type of event
     272.97832275400    3.0000000000000
     362.45800399540    1.0000000000000
     498.09373914336    1.0000000000000
     965.71605478642    1.0000000000000
     977.22673617891    1.0000000000000
    1003.08068657299    2.0000000000000
     1210.1794339875    2.0000000000000
     1251.3587029011    1.0000000000000
     1645.8106397230    1.0000000000000
     1832.7753093646    1.0000000000000
     2059.0448563356    2.0000000000000
     2205.5132215353    5.0000000000000
     2920.2966930581    1.0000000000000
     2942.7691542551    1.0000000000000
     3110.0422874438    2.0000000000000
     3121.2418605975    1.0000000000000
     3476.2235306517    1.0000000000000
     3497.8539453465    2.0000000000000
     3506.4742071487    1.0000000000000
     3969.6745230919    1.0000000000000
     4508.8213236165    1.0000000000000
     4561.3336461503    1.0000000000000
     4801.2962062834    1.0000000000000
     5092.1774433065    5.0000000000000
     5260.9926106975    1.0000000000000
     5458.7351798655    2.0000000000000
     5559.5338707518    1.0000000000000
     5733.4348662364    2.0000000000000
     6319.4024203679    1.0000000000000
     6623.5794207524    1.0000000000000
     6710.8127184080    1.0000000000000
     6738.3487347777    1.0000000000000
     6756.2312284267    4.0000000000000
     6869.3422126669    2.0000000000000
```

```
  6945.6440455501     1.0000000000000
  7736.7108489231     1.0000000000000
  7893.8014272904     2.0000000000000
  8230.3626344728     2.0000000000000
  8246.4099730172     2.0000000000000
  8380.6207929396     4.0000000000000
  8390.1234786947     1.0000000000000
  8447.3947587895     1.0000000000000
  8512.8487937838     1.0000000000000
  8719.5645594142     3.0000000000000
  9094.9721925817     1.0000000000000
  9098.4504295357     1.0000000000000
  9288.9515003996     1.0000000000000
  9392.9972727062     1.0000000000000
  9445.0841218737     1.0000000000000
  9449.8669910619     1.0000000000000
  9670.2708083417     1.0000000000000
  9704.9955634218     1.0000000000000
  9960.2343120756     4.0000000000000
 10038.0839700093     1.0000000000000
 10071.9593835673     1.0000000000000
 10114.9093561105     3.0000000000000
 10378.2531034265     1.0000000000000
 10533.5408916117     1.0000000000000
  10565.369746256     1.0000000000000
  11747.434371838     1.0000000000000
  11830.547045304     2.0000000000000
  11931.762617686     1.0000000000000
  12248.897842403     1.0000000000000
  12559.656707622     1.0000000000000
  12808.480084429     1.0000000000000
  12998.936815836     1.0000000000000
  12999.312532375     1.0000000000000
  13007.581710428     2.0000000000000
  13193.830171520     2.0000000000000
  13193.922764902     1.0000000000000
  13379.541473932     1.0000000000000
  13392.633182236     3.0000000000000
  13393.829024841     1.0000000000000
  13455.071089581     1.0000000000000
  13468.417300285     3.0000000000000
  13484.891972432     1.0000000000000
  14189.579287419     1.0000000000000
  14514.538826096     1.0000000000000
  14675.912483313     1.0000000000000
  15278.787405602     3.0000000000000
  15750.829297722    10.0000000000000
  15843.523182201     4.0000000000000
  15956.554363771     6.0000000000000
  16039.641423227     1.0000000000000
  16500.731884403     2.0000000000000
  16824.099079180     2.0000000000000
  16830.974435082     1.0000000000000
  17186.755536702     1.0000000000000
  17303.723880599     2.0000000000000
  17405.992041175     7.0000000000000
  17608.420931993     1.0000000000000
  17703.390404059     1.0000000000000
  17880.621501628     1.0000000000000
  17921.667985543     1.0000000000000
  17925.588267543     3.0000000000000
  17942.190457179     3.0000000000000
  18273.663006019     1.0000000000000
  18558.150441573     1.0000000000000
  18909.127140987     1.0000000000000
```

```
     19030.372730702     2.0000000000000
     19156.785127639     2.0000000000000
     19997.477746333     4.0000000000000
=======================================================================
          exec: Welcome to TPA Version 4.0beta
        Job started: Thu Mar  2 17:08:05 2000
=======================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea   Area       Waste   Number of WP
    #      [m^2]      [MTU]
    1     723591.3    14200.8         1455
    2     784763.0    15303.7         1568
    3     390372.0     7564.0          775
    4     207581.3     4157.8          426
    5     378972.8     7417.6          760
    6     424872.5     8305.8          851
    7     163938.3     3152.5          323
    8     393468.9     7944.6          814

 Total Area [acre]          =     856.82238463061
 Total Buried Waste [MTU]   =     68046.720000000
 Repository AML [MTU/acre]  =     79.417532992367

 Specified Global Parameters:

               Compliance Period =  10000.0 (yr)
         Maximum Simulation Time =  40000.0 (yr)
          Number Of Realizations =      1
              Number Of Subareas =      8
              Volcanism scenario =      1 (yes=1, no=0)
               Faulting scenario =      1 (yes=1, no=0)
                Seismic scenario =      1 (yes=1, no=0)
      Distance to Receptor Group =     20.0 (km)


 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


 ***>>> NOTE: When running with volcanism, verify that   <<<***
 ***>>> the maximum value of the PDF for parameter       <<<***
 ***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
 ***>>> equal to the parameter MaximumTime[yr].          <<<***


 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C*
*

 Begin test 298_4
 timemax =     40000.000000000
 numberofseismicevents =    217
 time of event,    type of event
     272.97832275400    3.0000000000000
     362.45800399540    1.0000000000000
     498.09373914336    1.0000000000000
     965.71605478642    1.0000000000000
     977.22673617891    1.0000000000000
    1003.08068657299    2.0000000000000
     1210.1794339875    2.0000000000000
     1251.3587029011    1.0000000000000
```

```
   1645.8106397230     1.0000000000000
   1832.7753093646     1.0000000000000
   2059.0448563356     2.0000000000000
   2205.5132215353     5.0000000000000
   2920.2966930581     1.0000000000000
   2942.7691542551     1.0000000000000
   3110.0422874438     2.0000000000000
   3121.2418605975     1.0000000000000
   3476.2235306517     1.0000000000000
   3497.8539453465     2.0000000000000
   3506.4742071487     1.0000000000000
   3969.6745230919     1.0000000000000
   4508.8213236165     1.0000000000000
   4561.3336461503     1.0000000000000
   4801.2962062834     1.0000000000000
   5092.1774433065     5.0000000000000
   5260.9926106975     1.0000000000000
   5458.7351798655     2.0000000000000
   5559.5338707518     1.0000000000000
   5733.4348662364     2.0000000000000
   6319.4024203679     1.0000000000000
   6623.5794207524     1.0000000000000
   6710.8127184080     1.0000000000000
   6738.3487347777     1.0000000000000
   6756.2312284267     4.0000000000000
   6869.3422126669     2.0000000000000
   6945.6440455501     1.0000000000000
   7736.7108489231     1.0000000000000
   7893.8014272904     2.0000000000000
   8230.3626344728     2.0000000000000
   8246.4099730172     2.0000000000000
   8380.6207929396     4.0000000000000
   8390.1234786947     1.0000000000000
   8447.3947587895     1.0000000000000
   8512.8487937838     1.0000000000000
   8719.5645594142     3.0000000000000
   9094.9721925817     1.0000000000000
   9098.4504295357     1.0000000000000
   9288.9515003996     1.0000000000000
   9392.9972727062     1.0000000000000
   9445.0841218737     1.0000000000000
   9449.8669910619     1.0000000000000
   9670.2708083417     1.0000000000000
   9704.9955634218     1.0000000000000
   9960.2343120756     4.0000000000000
  10038.0839700093     1.0000000000000
  10071.9593835673     1.0000000000000
  10114.9093561105     3.0000000000000
  10378.2531034265     1.0000000000000
  10533.5408916117     1.0000000000000
   10565.369746256     1.0000000000000
   11747.434371838     1.0000000000000
   11830.547045304     2.0000000000000
   11931.762617686     1.0000000000000
   12248.897842403     1.0000000000000
   12559.656707622     1.0000000000000
   12808.480084429     1.0000000000000
   12998.936815836     1.0000000000000
   12999.312532375     1.0000000000000
   13007.581710428     2.0000000000000
   13193.830171520     2.0000000000000
   13193.922764902     1.0000000000000
   13379.541473932     1.0000000000000
   13392.633182236     3.0000000000000
   13393.829024841     1.0000000000000
```

```
13455.071089581     1.0000000000000
13468.417300285     3.0000000000000
13484.891972432     1.0000000000000
14189.579287419     1.0000000000000
14514.538826096     1.0000000000000
14675.912483313     1.0000000000000
15278.787405602     3.0000000000000
15750.829297722    10.0000000000000
15843.523182201     4.0000000000000
15956.554363771     6.0000000000000
16039.641423227     1.0000000000000
16500.731884403     2.0000000000000
16824.099079180     2.0000000000000
16830.974435082     1.0000000000000
17186.755536702     1.0000000000000
17303.723880599     2.0000000000000
17405.992041175     7.0000000000000
17608.420931993     1.0000000000000
17703.390404059     1.0000000000000
17880.621501628     1.0000000000000
17921.667985543     1.0000000000000
17925.588267543     3.0000000000000
17942.190457179     3.0000000000000
18273.663006019     1.0000000000000
18558.150441573     1.0000000000000
18909.127140987     1.0000000000000
19030.372730702     2.0000000000000
19156.785127639     2.0000000000000
19997.477746333     4.0000000000000
20145.785506184     2.0000000000000
20371.109040860     1.0000000000000
20451.770731438     1.0000000000000
20497.157208918     1.0000000000000
20760.994248007     1.0000000000000
20807.541220307     1.0000000000000
21028.204733707     2.0000000000000
21091.706111548     2.0000000000000
21143.772146482     3.0000000000000
21296.103462087     1.0000000000000
21513.597692592     1.0000000000000
21717.264144356     1.0000000000000
22017.070098507     3.0000000000000
22045.006233886     1.0000000000000
22067.893890786     1.0000000000000
22343.227470293     1.0000000000000
22418.532186233     2.0000000000000
22805.628653739     1.0000000000000
22869.752220660     1.0000000000000
22870.800643252     1.0000000000000
23039.832016080     1.0000000000000
23189.507432405     6.0000000000000
23323.361216116     1.0000000000000
23367.882325927     1.0000000000000
23681.374160940     1.0000000000000
23978.006028840     1.0000000000000
24147.052675623     1.0000000000000
24170.516301882     1.0000000000000
24182.781427895     2.0000000000000
24196.991588917     2.0000000000000
24497.888275908     1.0000000000000
24573.269356308     1.0000000000000
24727.385996645     1.0000000000000
25085.108824224     1.0000000000000
25196.518990564     1.0000000000000
25243.013757026     2.0000000000000
```

```
25755.925030897     2.0000000000000
25828.324633371     2.0000000000000
26270.090312603     1.0000000000000
26578.744871481     3.0000000000000
26737.517370866     1.0000000000000
26767.894552853     1.0000000000000
27357.006504444     1.0000000000000
27364.389039957     1.0000000000000
27450.159166000     1.0000000000000
27639.871584176     1.0000000000000
27956.853387504     1.0000000000000
28037.473973738     1.0000000000000
28302.616403646     1.0000000000000
28359.284402162     4.0000000000000
28412.888571859     1.0000000000000
28605.874278123     2.0000000000000
28696.572261488     1.0000000000000
28818.351670868     2.0000000000000
29201.738933273     1.0000000000000
29349.621652918     1.0000000000000
29409.414271779     1.0000000000000
29494.192064442     3.0000000000000
30062.052188191     1.0000000000000
30106.226818583     1.0000000000000
30245.181318294     1.0000000000000
30352.860306781     1.0000000000000
30546.157532280     2.0000000000000
30621.776518389     1.0000000000000
30657.241972090     1.0000000000000
30855.274829212     1.0000000000000
30965.135562367     1.0000000000000
31694.907985741     1.0000000000000
31797.997093813     1.0000000000000
31799.068782464     2.0000000000000
32062.559755975     2.0000000000000
32319.115916529     2.0000000000000
32325.575258263     3.0000000000000
32426.686595311     1.0000000000000
32485.840239341     2.0000000000000
32610.688909091     4.0000000000000
32684.302070650     2.0000000000000
32790.774525350     1.0000000000000
32920.127215301     1.0000000000000
33347.810078637     1.0000000000000
33410.178734075     1.0000000000000
33622.709183970     1.0000000000000
33688.891590496     2.0000000000000
34047.984807566     1.0000000000000
34532.852232807     1.0000000000000
34609.699328872     2.0000000000000
34663.634848798     2.0000000000000
34831.818576171     1.0000000000000
34973.885784955     1.0000000000000
35139.369265051     3.0000000000000
35391.291392619     1.0000000000000
35580.982109675     1.0000000000000
35604.363676961     1.0000000000000
35678.808264553     1.0000000000000
36096.266334045     5.0000000000000
36098.617216517     1.0000000000000
36113.608085373     1.0000000000000
36118.919723991     1.0000000000000
36343.792478830     1.0000000000000
36410.236117239     2.0000000000000
36652.101415918     1.0000000000000
```

```
      36742.790457036     4.0000000000000
      37526.631882676     1.0000000000000
      37542.989426298     5.0000000000000
      38576.804793533     1.0000000000000
      38606.862377777     1.0000000000000
      38844.054316736     1.0000000000000
      38856.568323120    10.0000000000000
      39120.098073723     1.0000000000000
      39283.736054082     2.0000000000000
      39490.634717115     2.0000000000000
      39552.013959204     1.0000000000000
      39588.308872263     3.0000000000000
      39611.095473936     2.0000000000000
      39726.035213143     2.0000000000000
=========================================================================
           exec: Welcome to TPA Version 4.0beta
         Job started: Thu Mar  2 17:08:25 2000
=========================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea   Area      Waste   Number of WP
    #     [m^2]      [MTU]
    1    723591.3   14200.8        1455
    2    784763.0   15303.7        1568
    3    390372.0    7564.0         775
    4    207581.3    4157.8         426
    5    378972.8    7417.6         760
    6    424872.5    8305.8         851
    7    163938.3    3152.5         323
    8    393468.9    7944.6         814

 Total Area [acre]          =     856.82238463061
 Total Buried Waste [MTU]   =     68046.720000000
 Repository AML [MTU/acre]  =     79.417532992367

 Specified Global Parameters:

               Compliance Period =  10000.0 (yr)
         Maximum Simulation Time =  70000.0 (yr)
          Number Of Realizations =      1
              Number Of Subareas =      8
              Volcanism scenario =      1 (yes=1, no=0)
               Faulting scenario =      1 (yes=1, no=0)
                Seismic scenario =      1 (yes=1, no=0)
       Distance to Receptor Group =     20.0 (km)


 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


 ***>>> NOTE: When running with volcanism, verify that   <<<***
 ***>>> the maximum value of the PDF for parameter       <<<***
 ***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
 ***>>> equal to the parameter MaximumTime[yr].          <<<***


 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C*
*

 Begin test 298_4
```

```
timemax =      70000.000000000
numberofseismicevents =    381
time of event,     type of event
    272.97832275400     3.0000000000000
    362.45800399540     1.0000000000000
    498.09373914336     1.0000000000000
    965.71605478642     1.0000000000000
    977.22673617891     1.0000000000000
   1003.08068657299     2.0000000000000
    1210.1794339875     2.0000000000000
    1251.3587029011     1.0000000000000
    1645.8106397230     1.0000000000000
    1832.7753093646     1.0000000000000
    2059.0448563356     2.0000000000000
    2205.5132215353     5.0000000000000
    2920.2966930581     1.0000000000000
    2942.7691542551     1.0000000000000
    3110.0422874438     2.0000000000000
    3121.2418605975     1.0000000000000
    3476.2235306517     1.0000000000000
    3497.8539453465     2.0000000000000
    3506.4742071487     1.0000000000000
    3969.6745230919     1.0000000000000
    4508.8213236165     1.0000000000000
    4561.3336461503     1.0000000000000
    4801.2962062834     1.0000000000000
    5092.1774433065     5.0000000000000
    5260.9926106975     1.0000000000000
    5458.7351798655     2.0000000000000
    5559.5338707518     1.0000000000000
    5733.4348662364     2.0000000000000
    6319.4024203679     1.0000000000000
    6623.5794207524     1.0000000000000
    6710.8127184080     1.0000000000000
    6738.3487347777     1.0000000000000
    6756.2312284267     4.0000000000000
    6869.3422126669     2.0000000000000
    6945.6440455501     1.0000000000000
    7736.7108489231     1.0000000000000
    7893.8014272904     2.0000000000000
    8230.3626344728     2.0000000000000
    8246.4099730172     2.0000000000000
    8380.6207929396     4.0000000000000
    8390.1234786947     1.0000000000000
    8447.3947587895     1.0000000000000
    8512.8487937838     1.0000000000000
    8719.5645594142     3.0000000000000
    9094.9721925817     1.0000000000000
    9098.4504295357     1.0000000000000
    9288.9515003996     1.0000000000000
    9392.9972727062     1.0000000000000
    9445.0841218737     1.0000000000000
    9449.8669910619     1.0000000000000
    9670.2708083417     1.0000000000000
    9704.9955634218     1.0000000000000
    9960.2343120756     4.0000000000000
   10038.0839700093     1.0000000000000
   10071.9593835673     1.0000000000000
   10114.9093561105     3.0000000000000
   10378.2531034265     1.0000000000000
   10533.5408916117     1.0000000000000
    10565.369746256     1.0000000000000
    11747.434371838     1.0000000000000
    11830.547045304     2.0000000000000
    11931.762617686     1.0000000000000
```

```
    12248.897842403     1.0000000000000
    12559.656707622     1.0000000000000
    12808.480084429     1.0000000000000
    12998.936815836     1.0000000000000
    12999.312532375     1.0000000000000
    13007.581710428     2.0000000000000
    13193.830171520     2.0000000000000
    13193.922764902     1.0000000000000
    13379.541473932     1.0000000000000
    13392.633182236     3.0000000000000
    13393.829024841     1.0000000000000
    13455.071089581     1.0000000000000
    13468.417300285     3.0000000000000
    13484.891972432     1.0000000000000
    14189.579287419     1.0000000000000
    14514.538826096     1.0000000000000
    14675.912483313     1.0000000000000
    15278.787405602     3.0000000000000
    15750.829297722    10.0000000000000
    15843.523182201     4.0000000000000
    15956.554363771     6.0000000000000
    16039.641423227     1.0000000000000
    16500.731884403     2.0000000000000
    16824.099079180     2.0000000000000
    16830.974435082     1.0000000000000
    17186.755536702     1.0000000000000
    17303.723880599     2.0000000000000
    17405.992041175     7.0000000000000
    17608.420931993     1.0000000000000
    17703.390404059     1.0000000000000
    17880.621501628     1.0000000000000
    17921.667985543     1.0000000000000
    17925.588267543     3.0000000000000
    17942.190457179     3.0000000000000
    18273.663006019     1.0000000000000
    18558.150441573     1.0000000000000
    18909.127140987     1.0000000000000
    19030.372730702     2.0000000000000
    19156.785127639     2.0000000000000
    19997.477746333     4.0000000000000
    20145.785506184     2.0000000000000
    20371.109040860     1.0000000000000
    20451.770731438     1.0000000000000
    20497.157208918     1.0000000000000
    20760.994248007     1.0000000000000
    20807.541220307     1.0000000000000
    21028.204733707     2.0000000000000
    21091.706111548     2.0000000000000
    21143.772146482     3.0000000000000
    21296.103462087     1.0000000000000
    21513.597692592     1.0000000000000
    21717.264144356     1.0000000000000
    22017.070098507     3.0000000000000
    22045.006233886     1.0000000000000
    22067.893890786     1.0000000000000
    22343.227470293     1.0000000000000
    22418.532186233     2.0000000000000
    22805.628653739     1.0000000000000
    22869.752220660     1.0000000000000
    22870.800643252     1.0000000000000
    23039.832016080     1.0000000000000
    23189.507432405     6.0000000000000
    23323.361216116     1.0000000000000
    23367.882325927     1.0000000000000
    23681.374160940     1.0000000000000
```

```
23978.006028840     1.0000000000000
24147.052675623     1.0000000000000
24170.516301882     1.0000000000000
24182.781427895     2.0000000000000
24196.991588917     2.0000000000000
24497.888275908     1.0000000000000
24573.269356308     1.0000000000000
24727.385996645     1.0000000000000
25085.108824224     1.0000000000000
25196.518990564     1.0000000000000
25243.013757026     2.0000000000000
25755.925030897     2.0000000000000
25828.324633371     2.0000000000000
26270.090312603     1.0000000000000
26578.744871481     3.0000000000000
26737.517370866     1.0000000000000
26767.894552853     1.0000000000000
27357.006504444     1.0000000000000
27364.389039957     1.0000000000000
27450.159166000     1.0000000000000
27639.871584176     1.0000000000000
27956.853387504     1.0000000000000
28037.473973738     1.0000000000000
28302.616403646     1.0000000000000
28359.284402162     4.0000000000000
28412.888571859     1.0000000000000
28605.874278123     2.0000000000000
28696.572261488     1.0000000000000
28818.351670868     2.0000000000000
29201.738933273     1.0000000000000
29349.621652918     1.0000000000000
29409.414271779     1.0000000000000
29494.192064442     3.0000000000000
30062.052188191     1.0000000000000
30106.226818583     1.0000000000000
30245.181318294     1.0000000000000
30352.860306781     1.0000000000000
30546.157532280     2.0000000000000
30621.776518389     1.0000000000000
30657.241972090     1.0000000000000
30855.274829212     1.0000000000000
30965.135562367     1.0000000000000
31694.907985741     1.0000000000000
31797.997093813     1.0000000000000
31799.068782464     2.0000000000000
32062.559755975     2.0000000000000
32319.115916529     2.0000000000000
32325.575258263     3.0000000000000
32426.686595311     1.0000000000000
32485.840239341     2.0000000000000
32610.688909091     4.0000000000000
32684.302070650     2.0000000000000
32790.774525350     1.0000000000000
32920.127215301     1.0000000000000
33347.810078637     1.0000000000000
33410.178734075     1.0000000000000
33622.709183970     1.0000000000000
33688.891590496     2.0000000000000
34047.984807566     1.0000000000000
34532.852232807     1.0000000000000
34609.699328872     2.0000000000000
34663.634848798     2.0000000000000
34831.818576171     1.0000000000000
34973.885784955     1.0000000000000
35139.369265051     3.0000000000000
```

```
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  36118.919723991     1.0000000000000
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  36652.101415918     1.0000000000000
  36742.790457036     4.0000000000000
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  41144.340185401     1.0000000000000
  41177.908692378     4.0000000000000
  41285.998062378     1.0000000000000
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  41667.481795737     2.0000000000000
  41858.938723429     1.0000000000000
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  42015.506255705     1.0000000000000
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  42924.613342218     1.0000000000000
  42979.576208349     8.0000000000000
  43102.042192112     1.0000000000000
  43196.690003374     1.0000000000000
  43593.952159207     1.0000000000000
  43839.094761058     1.0000000000000
  43965.656485633     1.0000000000000
  44372.782165557     2.0000000000000
  44450.815422835     1.0000000000000
  44512.408517256     2.0000000000000
  44596.310217205     5.0000000000000
  44850.539543899     1.0000000000000
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  45182.116288754     5.0000000000000
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  45705.441887295     1.0000000000000
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  46059.811687894     4.0000000000000
  46335.690071477     1.0000000000000
  46411.674931063     1.0000000000000
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48213.668758122     3.0000000000000
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59492.230018681     1.0000000000000
59753.496979484     1.0000000000000
```

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 60038.863288037    1.0000000000000
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 60505.499949589    1.0000000000000
 60632.029418181    2.0000000000000
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 60853.553527868    2.0000000000000
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 62405.333875728    1.0000000000000
 62573.127830340    1.0000000000000
 62620.957722428    1.0000000000000
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 63167.379464683    1.0000000000000
 63174.053151838    3.0000000000000
 63407.562664300    3.0000000000000
 63418.651730315    1.0000000000000
 63450.464981391    1.0000000000000
 63721.164433885    3.0000000000000
 63811.805657421    1.0000000000000
 63873.221588152    1.0000000000000
 64046.557835563    1.0000000000000
 64403.593336938    1.0000000000000
 64591.873292556    1.0000000000000
 64595.889595548    2.0000000000000
 64947.625867328    1.0000000000000
 65095.674596012    2.0000000000000
 65113.792563608    1.0000000000000
 65194.388924016    1.0000000000000
 65265.216223738    3.0000000000000
 65327.604665974    4.0000000000000
 66658.223805364    1.0000000000000
 66845.941536231    2.0000000000000
 66989.355039547    1.0000000000000
 67107.613729049    1.0000000000000
 67129.990027629    1.0000000000000
 67333.950896896    1.0000000000000
 67533.977635743    3.0000000000000
 67548.064752741    4.0000000000000
 67586.363003015    1.0000000000000
 67619.692075372    1.0000000000000
 68010.878449956    1.0000000000000
 68064.584550875    1.0000000000000
 68295.020293615    3.0000000000000
 68852.877407896    1.0000000000000
 68906.297263692    1.0000000000000
 69278.851259359    1.0000000000000
 69469.609190003    2.0000000000000
 69723.603738666    2.0000000000000
 69745.881857773    1.0000000000000
 69902.094050183    4.0000000000000
=================================================================
          exec: Welcome to TPA Version 4.0beta
        Job started: Thu Mar  2 17:08:50 2000
=================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea    Area      Waste    Number of WP
```

```
   #     [m^2]       [MTU]
   1    723591.3    14200.8        1455
   2    784763.0    15303.7        1568
   3    390372.0     7564.0         775
   4    207581.3     4157.8         426
   5    378972.8     7417.6         760
   6    424872.5     8305.8         851
   7    163938.3     3152.5         323
   8    393468.9     7944.6         814

Total Area [acre]          =     856.82238463061
Total Buried Waste [MTU]   =     68046.720000000
Repository AML [MTU/acre]  =     79.417532992367

Specified Global Parameters:

               Compliance Period =  10000.0 (yr)
         Maximum Simulation Time = 100000.0 (yr)
          Number Of Realizations =      1
              Number Of Subareas =      8
              Volcanism scenario =      1 (yes=1, no=0)
               Faulting scenario =      1 (yes=1, no=0)
                Seismic scenario =      1 (yes=1, no=0)
      Distance to Receptor Group =     20.0 (km)


**>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
**>>> You may not be using the standard chains specified   <<<**
**>>> in the invent module.                                <<<**
**>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


***>>> NOTE: When running with volcanism, verify that   <<<***
***>>> the maximum value of the PDF for parameter       <<<***
***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
***>>> equal to the parameter MaximumTime[yr].          <<<***


The specified path for data  = $TPA_DATA/
The specified path for codes = $TPA_TEST/

**To modify global parameters or the path, stop code execution using control-C*
*

Begin test 298_4
timemax =     100000.000000000
numberofseismicevents =    557
time of event,     type of event
    272.97832275400    3.0000000000000
    362.45800399540    1.0000000000000
    498.09373914336    1.0000000000000
    965.71605478642    1.0000000000000
    977.22673617891    1.0000000000000
   1003.08068657299    2.0000000000000
    1210.1794339875    2.0000000000000
    1251.3587029011    1.0000000000000
    1645.8106397230    1.0000000000000
    1832.7753093646    1.0000000000000
    2059.0448563356    2.0000000000000
    2205.5132215353    5.0000000000000
    2920.2966930581    1.0000000000000
    2942.7691542551    1.0000000000000
    3110.0422874438    2.0000000000000
    3121.2418605975    1.0000000000000
    3476.2235306517    1.0000000000000
```

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 3497.8539453465    2.0000000000000
 3506.4742071487    1.0000000000000
 3969.6745230919    1.0000000000000
 4508.8213236165    1.0000000000000
 4561.3336461503    1.0000000000000
 4801.2962062834    1.0000000000000
 5092.1774433065    5.0000000000000
 5260.9926106975    1.0000000000000
 5458.7351798655    2.0000000000000
 5559.5338707518    1.0000000000000
 5733.4348662364    2.0000000000000
 6319.4024203679    1.0000000000000
 6623.5794207524    1.0000000000000
 6710.8127184080    1.0000000000000
 6738.3487347777    1.0000000000000
 6756.2312284267    4.0000000000000
 6869.3422126669    2.0000000000000
 6945.6440455501    1.0000000000000
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 7893.8014272904    2.0000000000000
 8230.3626344728    2.0000000000000
 8246.4099730172    2.0000000000000
 8380.6207929396    4.0000000000000
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 8447.3947587895    1.0000000000000
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 9392.9972727062    1.0000000000000
 9445.0841218737    1.0000000000000
 9449.8669910619    1.0000000000000
 9670.2708083417    1.0000000000000
 9704.9955634218    1.0000000000000
 9960.2343120756    4.0000000000000
10038.0839700093    1.0000000000000
10071.9593835673    1.0000000000000
10114.9093561105    3.0000000000000
10378.2531034265    1.0000000000000
10533.5408916117    1.0000000000000
 10565.369746256    1.0000000000000
 11747.434371838    1.0000000000000
 11830.547045304    2.0000000000000
 11931.762617686    1.0000000000000
 12248.897842403    1.0000000000000
 12559.656707622    1.0000000000000
 12808.480084429    1.0000000000000
 12998.936815836    1.0000000000000
 12999.312532375    1.0000000000000
 13007.581710428    2.0000000000000
 13193.830171520    2.0000000000000
 13193.922764902    1.0000000000000
 13379.541473932    1.0000000000000
 13392.633182236    3.0000000000000
 13393.829024841    1.0000000000000
 13455.071089581    1.0000000000000
 13468.417300285    3.0000000000000
 13484.891972432    1.0000000000000
 14189.579287419    1.0000000000000
 14514.538826096    1.0000000000000
 14675.912483313    1.0000000000000
 15278.787405602    3.0000000000000
 15750.829297722   10.0000000000000
 15843.523182201    4.0000000000000
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16830.974435082     1.0000000000000
17186.755536702     1.0000000000000
17303.723880599     2.0000000000000
17405.992041175     7.0000000000000
17608.420931993     1.0000000000000
17703.390404059     1.0000000000000
17880.621501628     1.0000000000000
17921.667985543     1.0000000000000
17925.588267543     3.0000000000000
17942.190457179     3.0000000000000
18273.663006019     1.0000000000000
18558.150441573     1.0000000000000
18909.127140987     1.0000000000000
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19156.785127639     2.0000000000000
19997.477746333     4.0000000000000
20145.785506184     2.0000000000000
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27364.389039957     1.0000000000000
27450.159166000     1.0000000000000
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     28359.284402162       4.0000000000000
     28412.888571859       1.0000000000000
     28605.874278123       2.0000000000000
     28696.572261488       1.0000000000000
     28818.351670868       2.0000000000000
     29201.738933273       1.0000000000000
     29349.621652918       1.0000000000000
     29409.414271779       1.0000000000000
     29494.192064442       3.0000000000000
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     32062.559755975       2.0000000000000
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```

```
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   60505.499949589     1.0000000000000
   60632.029418181     2.0000000000000
   60725.406470970     2.0000000000000
   60853.553527868     2.0000000000000
   61198.166783443     1.0000000000000
   61300.023361179     1.0000000000000
   61676.980587037     1.0000000000000
   62125.196887954     2.0000000000000
   62318.526701774     1.0000000000000
   62405.333875728     1.0000000000000
   62573.127830340     1.0000000000000
   62620.957722428     1.0000000000000
   62989.805365712     1.0000000000000
```

```
63122.044421111     1.0000000000000
63167.379464683     1.0000000000000
63174.053151838     3.0000000000000
63407.562664300     3.0000000000000
63418.651730315     1.0000000000000
63450.464981391     1.0000000000000
63721.164433885     3.0000000000000
63811.805657421     1.0000000000000
63873.221588152     1.0000000000000
64046.557835563     1.0000000000000
64403.593336938     1.0000000000000
64591.873292556     1.0000000000000
64595.889595548     2.0000000000000
64947.625867328     1.0000000000000
65095.674596012     2.0000000000000
65113.792563608     1.0000000000000
65194.388924016     1.0000000000000
65265.216223738     3.0000000000000
65327.604665974     4.0000000000000
66658.223805364     1.0000000000000
66845.941536231     2.0000000000000
66989.355039547     1.0000000000000
67107.613729049     1.0000000000000
67129.990027629     1.0000000000000
67333.950896896     1.0000000000000
67533.977635743     3.0000000000000
67548.064752741     4.0000000000000
67586.363003015     1.0000000000000
67619.692075372     1.0000000000000
68010.878449956     1.0000000000000
68064.584550875     1.0000000000000
68295.020293615     3.0000000000000
68852.877407896     1.0000000000000
68906.297263692     1.0000000000000
69278.851259359     1.0000000000000
69469.609190003     2.0000000000000
69723.603738666     2.0000000000000
69745.881857773     1.0000000000000
69902.094050183     4.0000000000000
70024.902391656     1.0000000000000
70182.119490131     3.0000000000000
70454.586555059     1.0000000000000
70869.030505667     1.0000000000000
70888.092994324     2.0000000000000
71301.201410658     3.0000000000000
71458.402435146     1.0000000000000
71488.343689411     1.0000000000000
71627.242030680     1.0000000000000
71632.119712333     1.0000000000000
71702.742108581     1.0000000000000
71787.913380543     1.0000000000000
72158.272530282     3.0000000000000
72336.407386636     1.0000000000000
72525.370228965     4.0000000000000
72612.003596360     1.0000000000000
72769.059100285     2.0000000000000
72885.863560779     1.0000000000000
72990.218340007     1.0000000000000
73089.440377368     2.0000000000000
73120.514885687     2.0000000000000
73468.754970207     1.0000000000000
73814.125796641     1.0000000000000
74141.342107498     1.0000000000000
74145.400312185     1.0000000000000
74352.753944720     2.0000000000000
```

```
74588.919463774     1.0000000000000
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74716.159192225     1.0000000000000
74729.905109912     1.0000000000000
74948.681173181     1.0000000000000
75013.304199157     1.0000000000000
75187.277748475     3.0000000000000
75326.665658710     1.0000000000000
75351.379985542     1.0000000000000
75395.852341666     1.0000000000000
75452.389256115     2.0000000000000
75521.908380152     1.0000000000000
75677.961473335     1.0000000000000
75730.860635174     1.0000000000000
75940.421329009     3.0000000000000
76050.327319253     2.0000000000000
76108.873190116     2.0000000000000
76263.743961355     1.0000000000000
76486.944475398     4.0000000000000
76559.929655662     1.0000000000000
76659.309155106     1.0000000000000
76836.844077305     1.0000000000000
77120.382656299     1.0000000000000
77272.157554409     1.0000000000000
77357.704103559     1.0000000000000
77563.064712991     1.0000000000000
77726.078719106     1.0000000000000
77759.514783320     1.0000000000000
77796.375294993     1.0000000000000
77840.758730509     1.0000000000000
78115.610922354     1.0000000000000
78277.135437655     1.0000000000000
78499.560991818     1.0000000000000
78576.685587346     2.0000000000000
78606.557782596     1.0000000000000
78620.911505945     1.0000000000000
78659.801730584     2.0000000000000
78929.095652921     1.0000000000000
78950.471467355     1.0000000000000
79493.377662148     3.0000000000000
79672.525710137     1.0000000000000
79899.457775091     1.0000000000000
79923.141547137     2.0000000000000
79941.737500513     1.0000000000000
80138.256336033     5.0000000000000
80180.646224607     3.0000000000000
80308.832874736     1.0000000000000
80506.466104716     7.0000000000000
80510.936094229     1.0000000000000
80558.712581034     1.0000000000000
80567.495466080     1.0000000000000
80656.948584823     1.0000000000000
80660.679821051     4.0000000000000
80957.442389455     1.0000000000000
81522.666651511     1.0000000000000
81708.606419417     2.0000000000000
81958.120754561     1.0000000000000
82261.495709681     2.0000000000000
82398.566549287     1.0000000000000
82646.833631144     5.0000000000000
82809.885295162     2.0000000000000
82970.779700649     1.0000000000000
83177.938894938     1.0000000000000
84012.873762582     1.0000000000000
84118.471171983     4.0000000000000
```

```
84154.129136815     2.0000000000000
84252.152527630     1.0000000000000
84359.945857607     2.0000000000000
84494.400649373     1.0000000000000
84838.280299764     1.0000000000000
84906.116322385     1.0000000000000
84963.456077657     1.0000000000000
85522.535352864     1.0000000000000
85609.827284702     1.0000000000000
85739.473572977     1.0000000000000
85793.265734639     1.0000000000000
86000.230224092     2.0000000000000
86048.646601990     3.0000000000000
86326.052204176     3.0000000000000
86327.873446786     1.0000000000000
86367.155444840     1.0000000000000
86411.112368332     5.0000000000000
86587.291570772     1.0000000000000
86680.464049065     1.0000000000000
86706.046198272     1.0000000000000
86913.281714331     2.0000000000000
86963.705134057     1.0000000000000
87002.807914210     1.0000000000000
87257.377906768     1.0000000000000
87297.376244218     2.0000000000000
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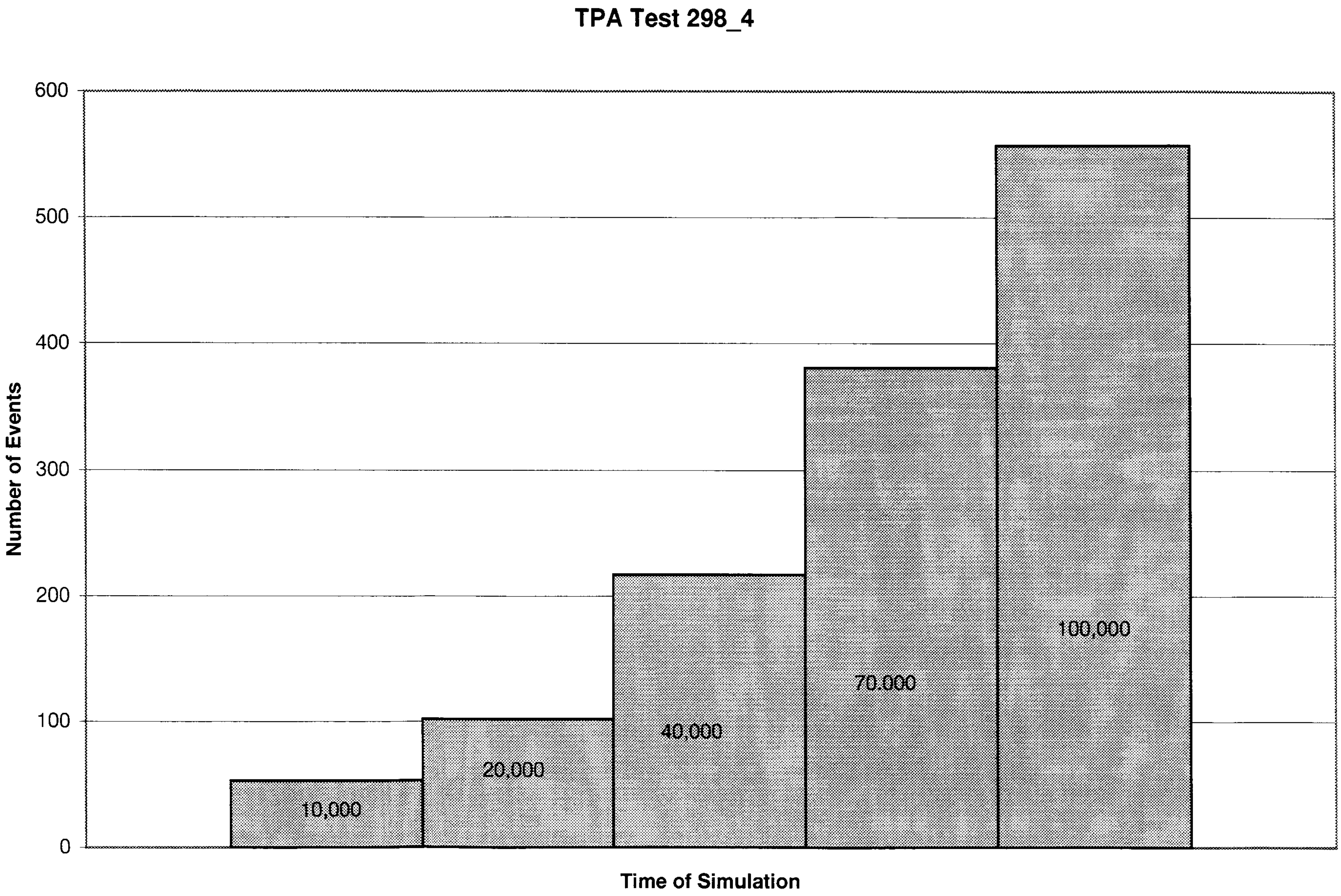
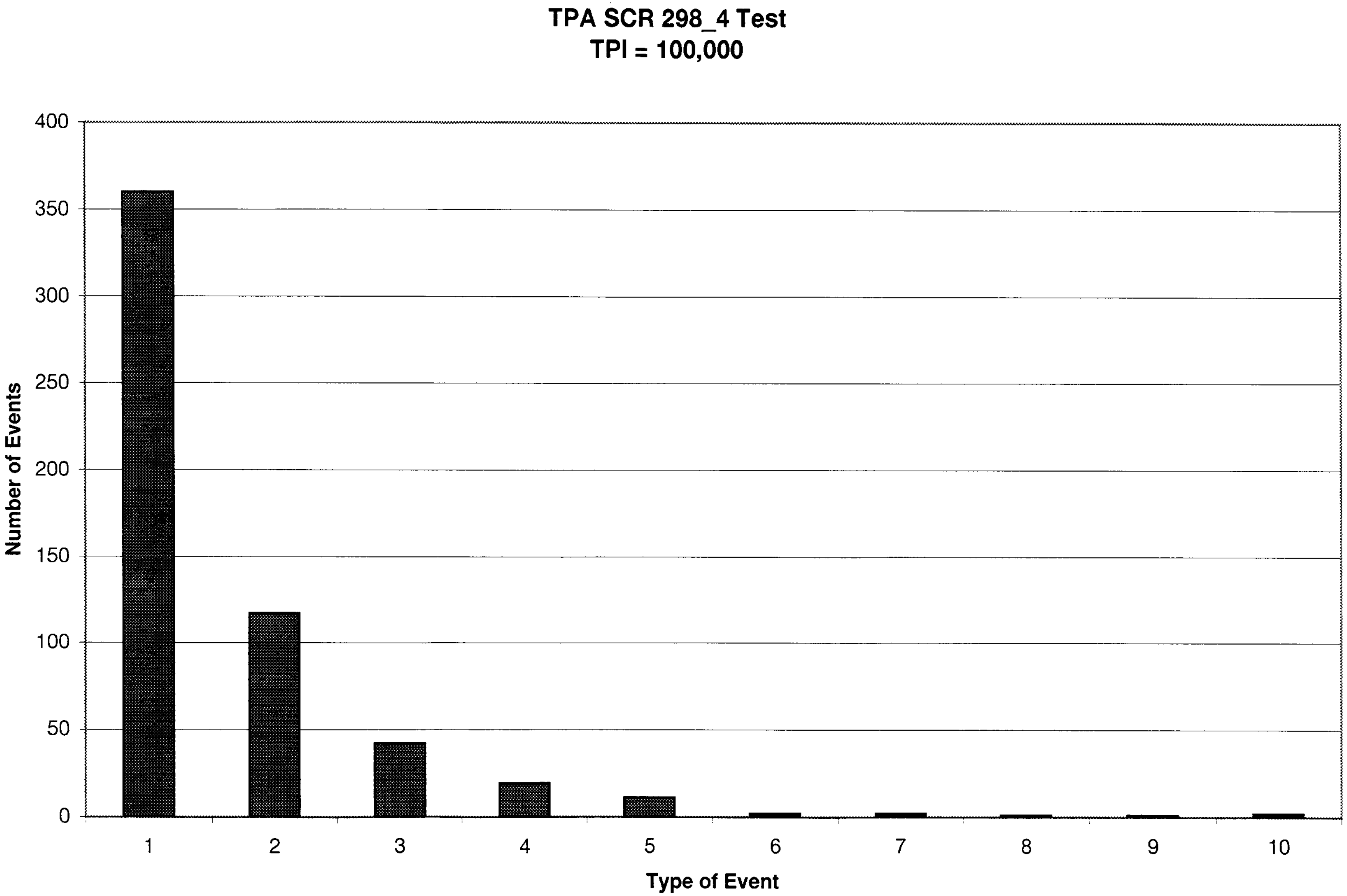
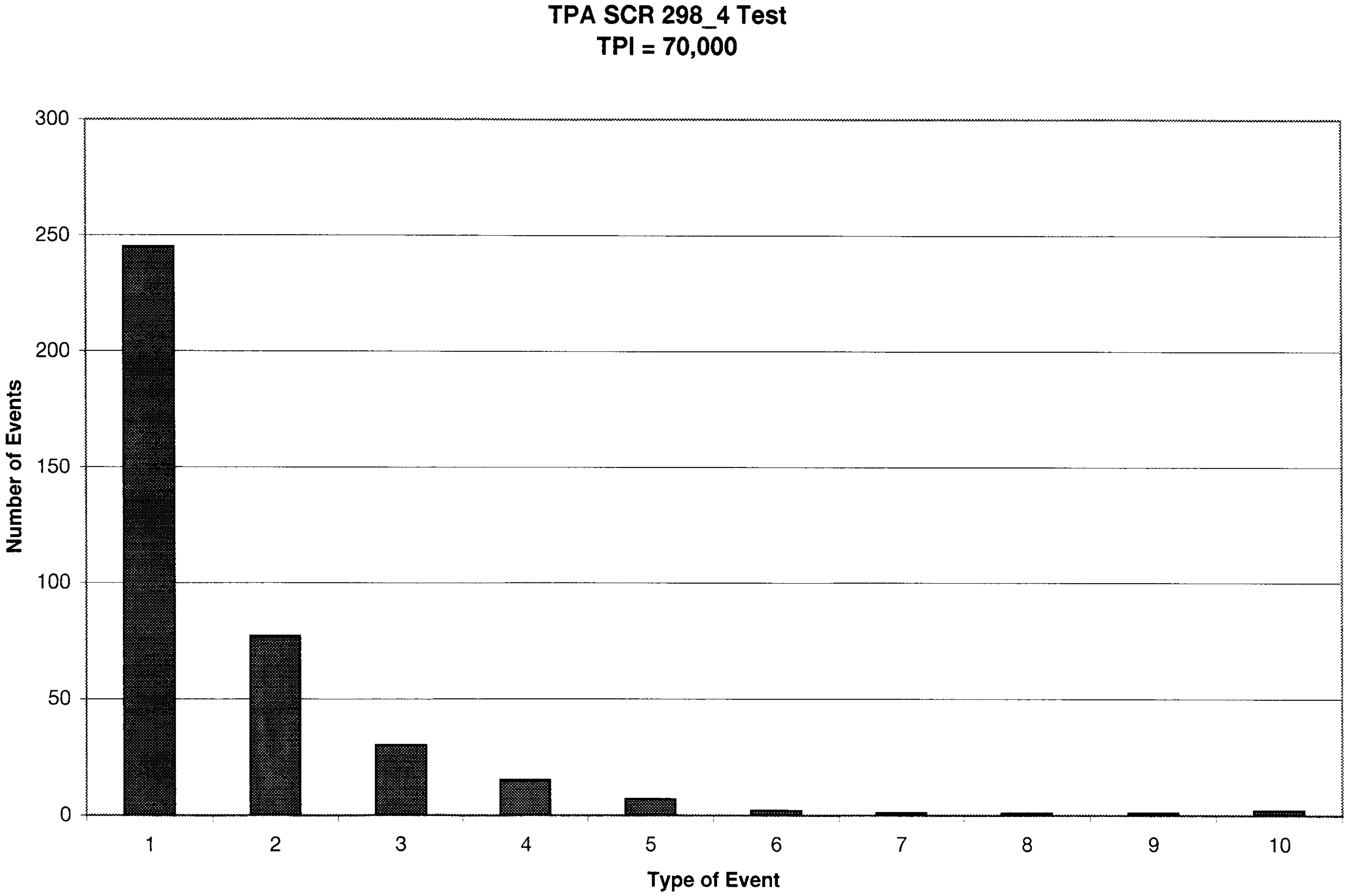
87827.198030521     2.0000000000000
88018.448568645     5.0000000000000
88219.974496505     1.0000000000000
88792.246974542     2.0000000000000
88946.079841717     1.0000000000000
89110.603231576     1.0000000000000
89542.266340767     1.0000000000000
89648.911167029     3.0000000000000
89745.897797563     2.0000000000000
89771.643326818     1.0000000000000
90208.799772022     1.0000000000000
90289.562802919     2.0000000000000
90345.225357734     1.0000000000000
90485.264795857     1.0000000000000
90508.641588725     1.0000000000000
91038.145962122     1.0000000000000
91818.095742136     1.0000000000000
91900.675475706     1.0000000000000
91905.114511621     3.0000000000000
92001.178070689     1.0000000000000
92228.976441138     1.0000000000000
93215.282226505     1.0000000000000
93611.593764043     1.0000000000000
94156.968352031     2.0000000000000
94491.875180517     2.0000000000000
94523.783719336     2.0000000000000
94571.207598179     1.0000000000000
94839.130756879     2.0000000000000
94911.639947002     1.0000000000000
95165.391353012     1.0000000000000
95319.806475016     1.0000000000000
95531.477091249     2.0000000000000
95694.982330734     1.0000000000000
95904.545645509     1.0000000000000
96041.741978294     1.0000000000000
96086.005644088     1.0000000000000
96093.457546890     1.0000000000000
96255.955850948     2.0000000000000
96457.899827195     2.0000000000000
```

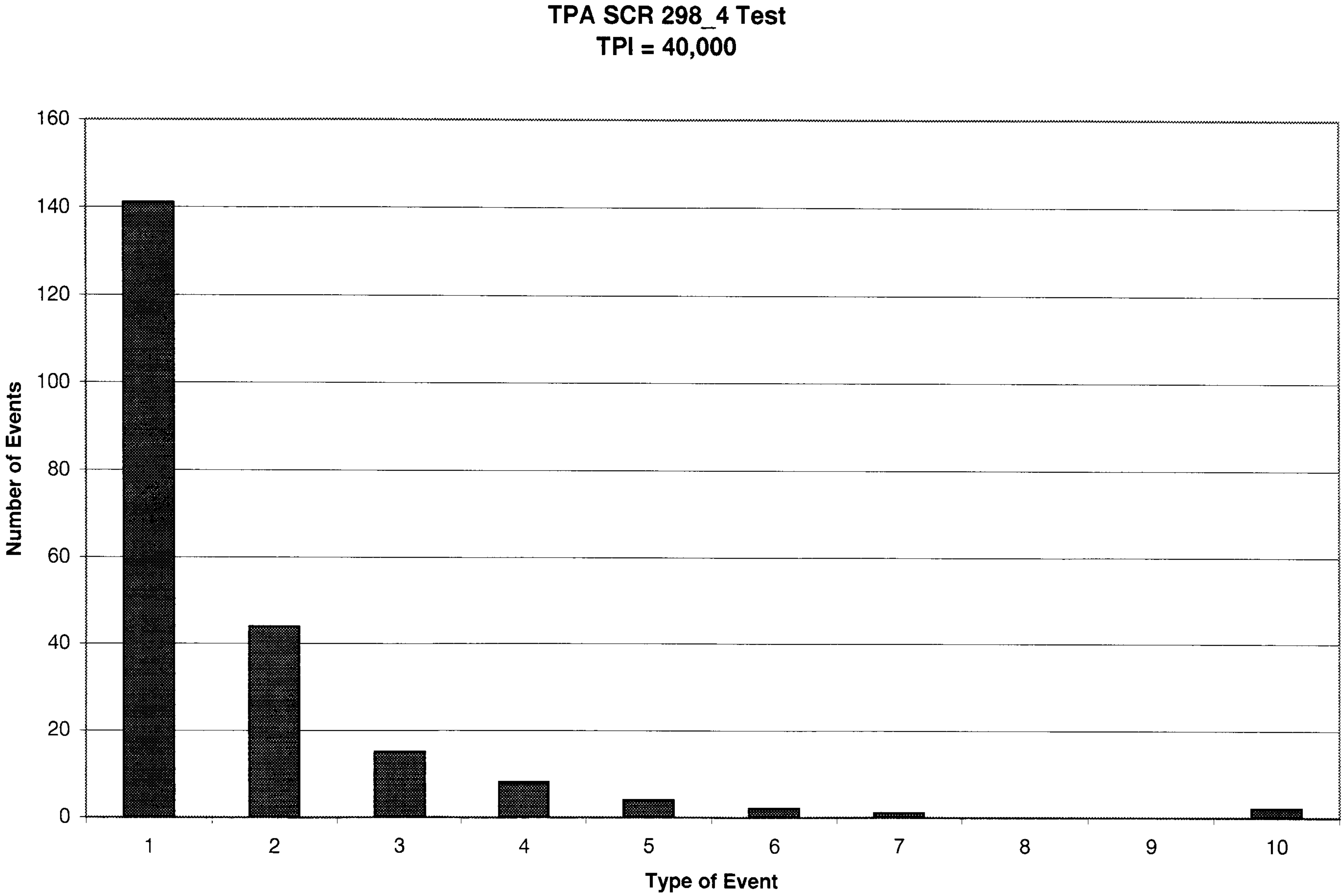
```
96665.765890515    1.0000000000000
96984.238805632    2.0000000000000
97022.510729934    1.0000000000000
97058.645821090    1.0000000000000
97503.710084431    2.0000000000000
97511.855669798    2.0000000000000
97685.510891860    1.0000000000000
97730.757880691    1.0000000000000
97916.436291866    2.0000000000000
97927.104684347    1.0000000000000
97964.234356099    2.0000000000000
98170.174254800    2.0000000000000
98513.299700959    1.0000000000000
98878.696121260    1.0000000000000
99043.627308201    1.0000000000000
99074.421095191    1.0000000000000
99349.233086917    2.0000000000000
99619.341172723    1.0000000000000
99638.826672845    2.0000000000000
99726.631911713    2.0000000000000
```

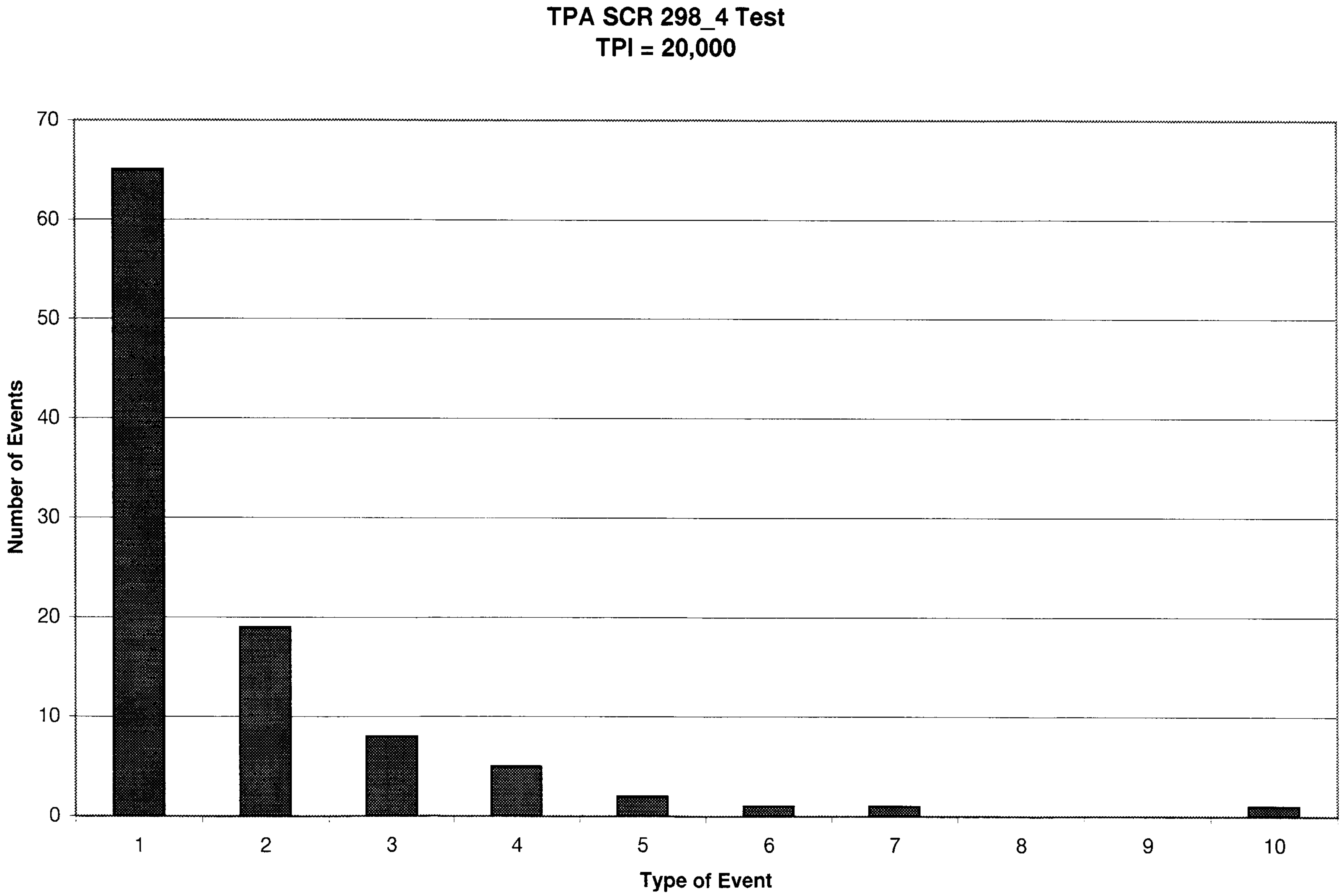

TPA Test 298_4
Number of Events
600
500
400
300
200
100
0
10,000
20,000
40,000
70,000
100,000
Time of Simulation


TPA SCR 298_4 Test
TPI = 100,000
Number of Events
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
Type of Event

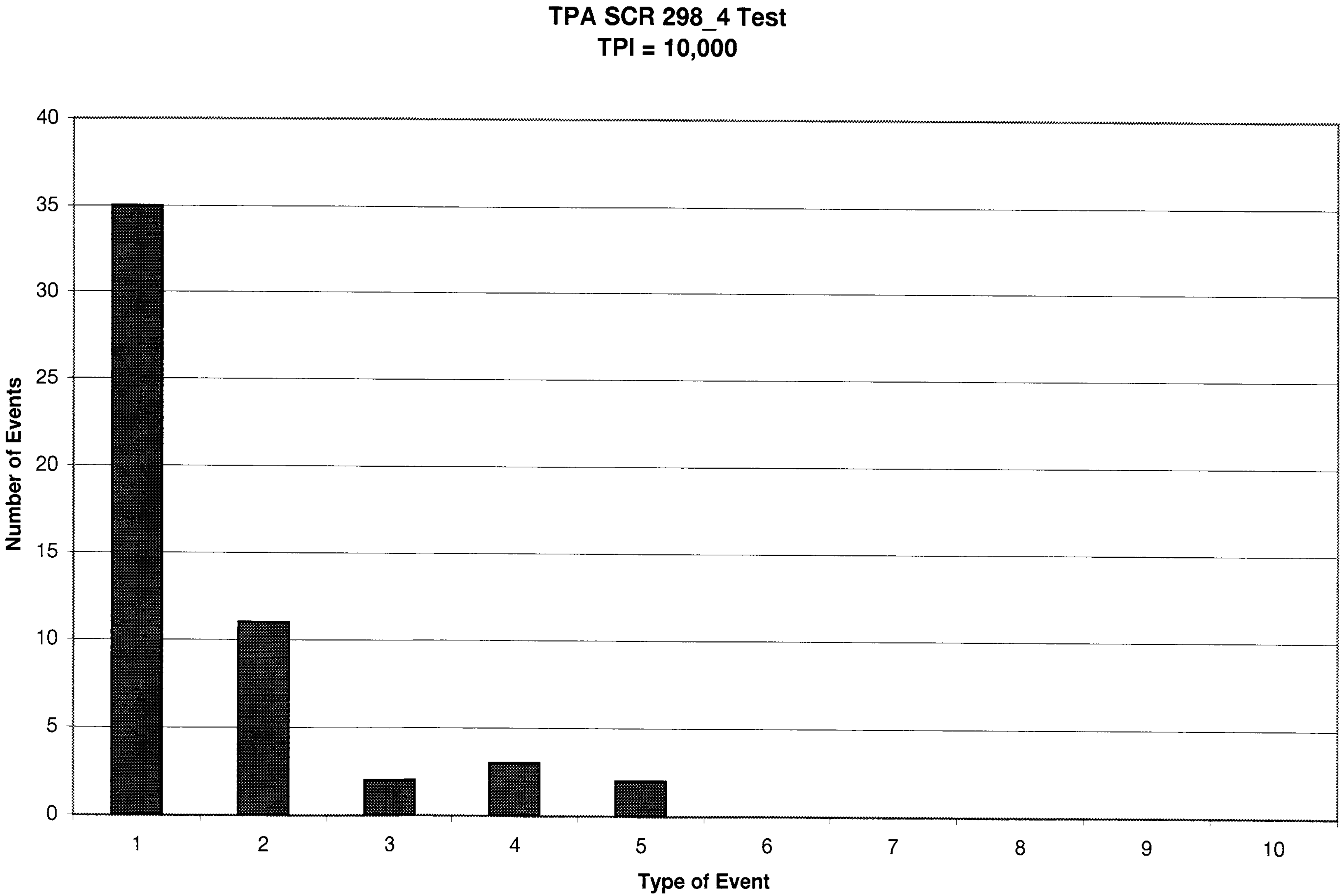

TPA SCR 298_4 Test
TPI = 70,000
Number of Events
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
Type of Event

186/397


TPA SCR 298_4 Test
TPI = 40,000
Number of Events
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
Type of Event

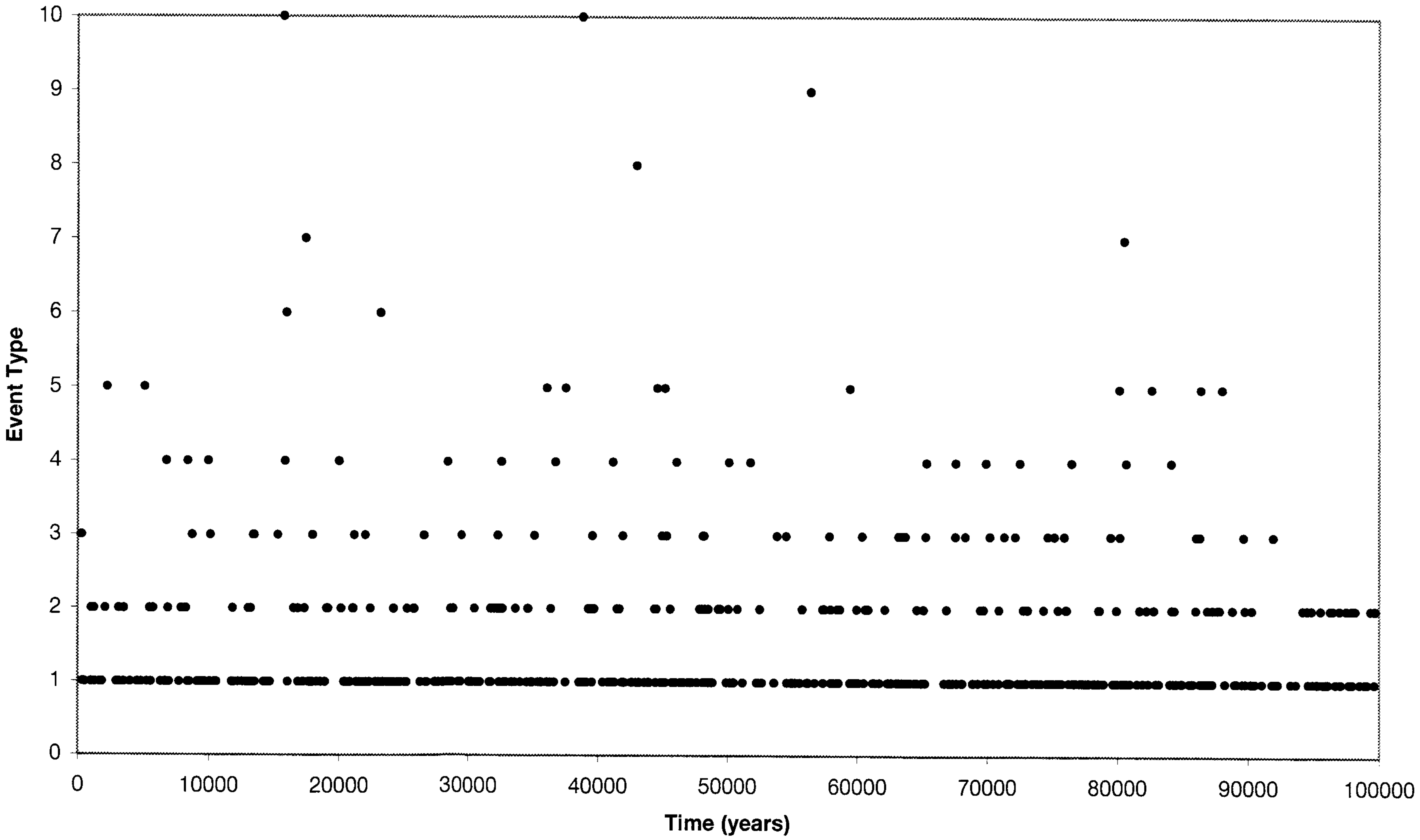


TPA SCR 298_4 Test
TPI = 20,000

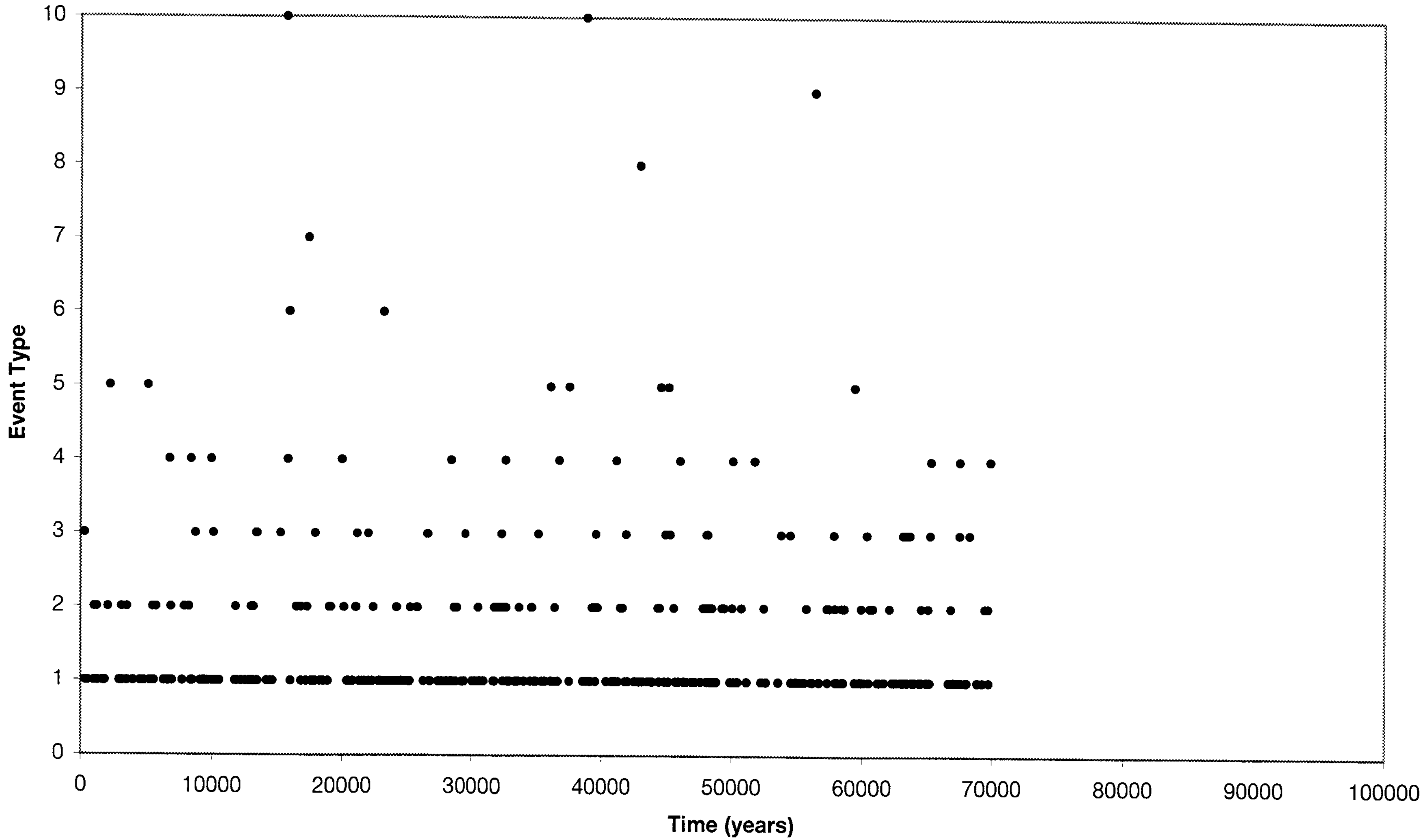

TPA SCR 298_4 Test
TPI = 10,000
Number of Events
0
5
10
15
20
25
30
35
40
Type of Event
1
2
3
4
5
6
7
8
9
10

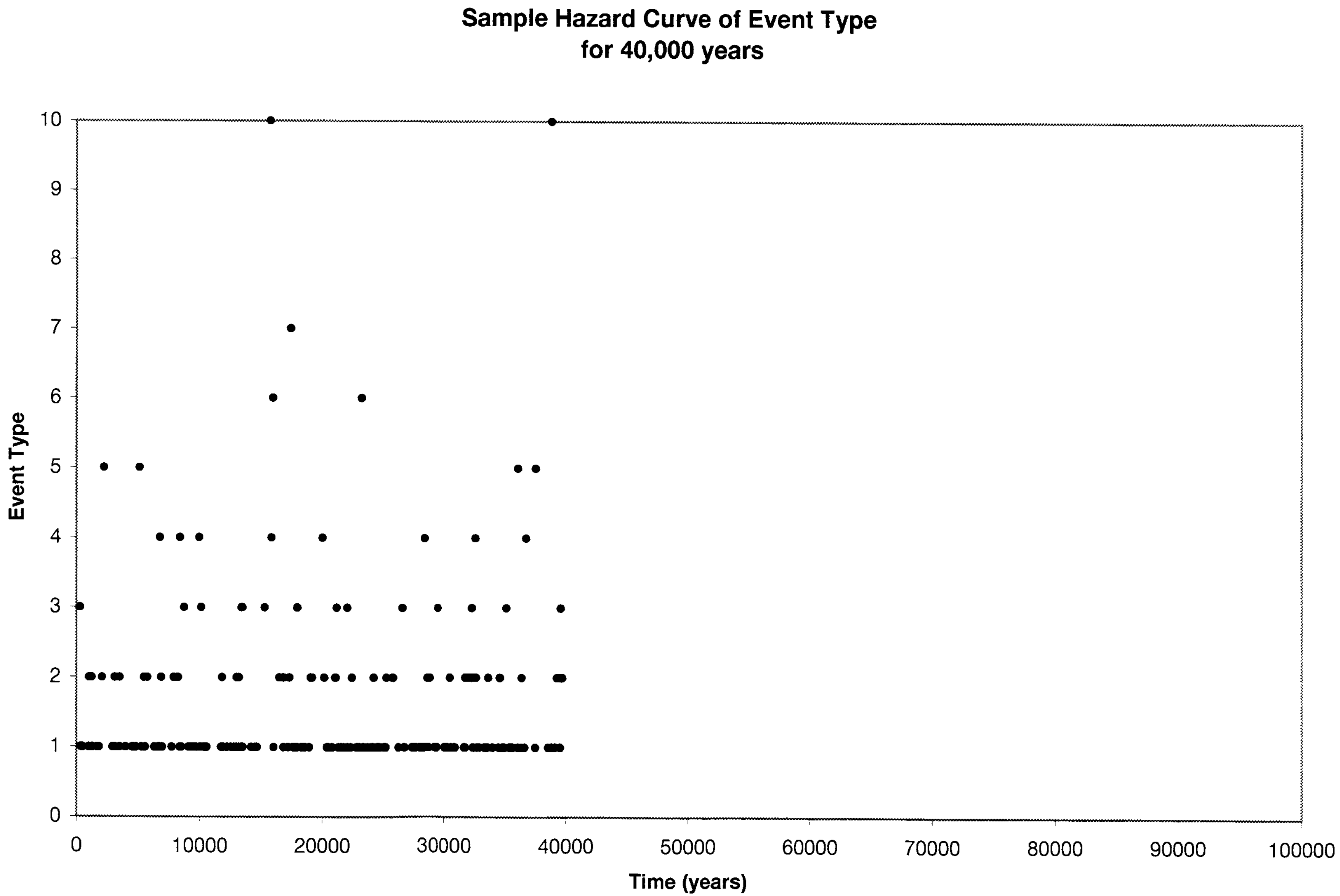
189/357

Sample Hazard Curve of Event Type for 100,000 years

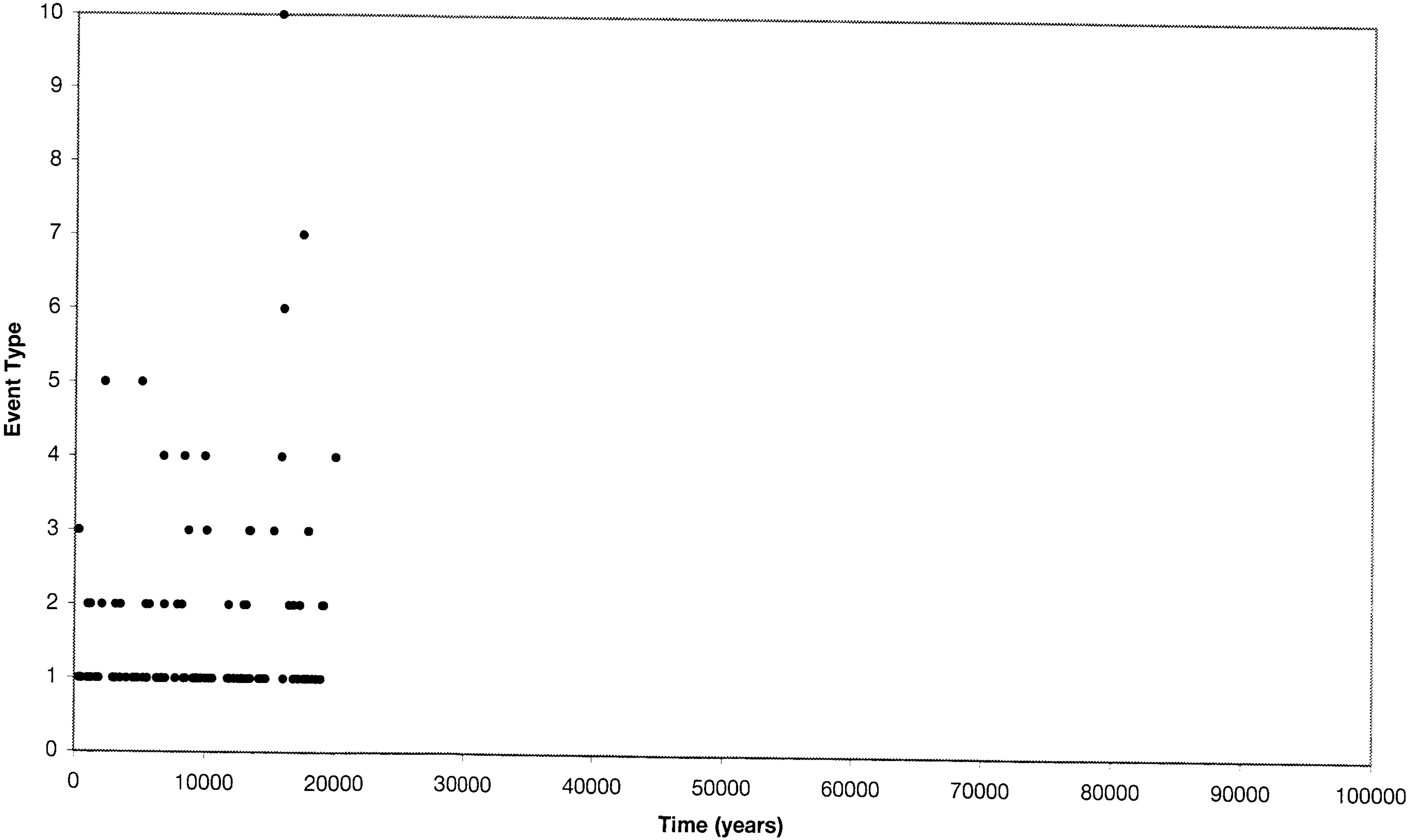


Sample Hazard Curve of Event Type
for 70,000 years



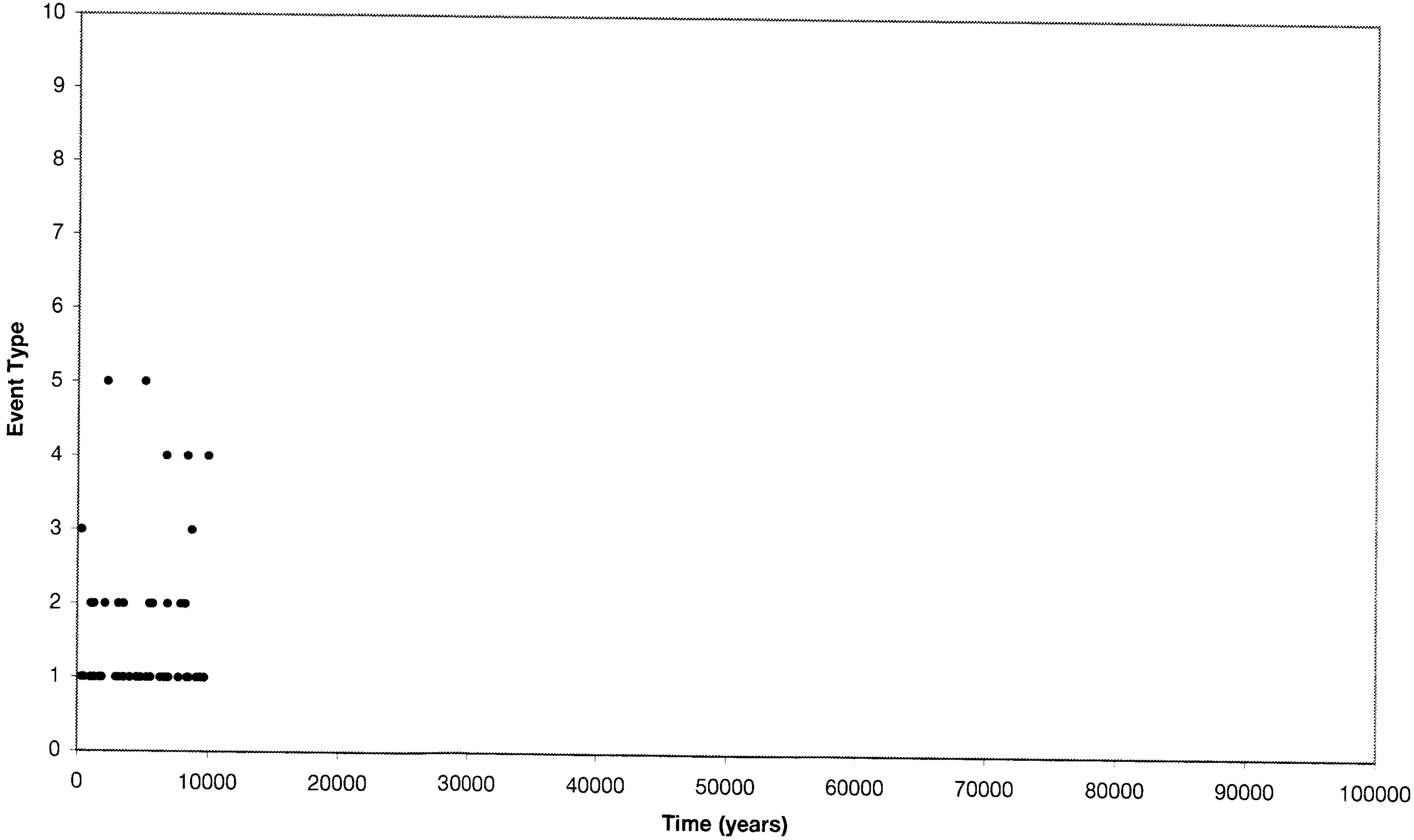


Sample Hazard Curve of Event Type
for 40,000 years



Sample Hazard Curve of Event Type for 20,000 years

Sample Hazard Curve of Event Type
for 10,000 years



```
========================================================================
          exec: Welcome to TPA Version 4.0beta
        Job started: Fri Mar  3 11:09:16 2000
========================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea    Area       Waste   Number of WP
    #       [m^2]      [MTU]
    1     723591.3    14200.8       1455
    2     784763.0    15303.7       1568
    3     390372.0     7564.0        775
    4     207581.3     4157.8        426
    5     378972.8     7417.6        760
    6     424872.5     8305.8        851
    7     163938.3     3152.5        323
    8     393468.9     7944.6        814

 Total Area [acre]          =     856.82238463061
 Total Buried Waste [MTU]   =     68046.720000000
 Repository AML [MTU/acre] =     79.417532992367

 Specified Global Parameters:

               Compliance Period =  10000.0 (yr)
         Maximum Simulation Time =  10000.0 (yr)
          Number Of Realizations =      2
              Number Of Subareas =      8
              Volcanism scenario =      1 (yes=1, no=0)
               Faulting scenario =      1 (yes=1, no=0)
                Seismic scenario =      1 (yes=1, no=0)
       Distance to Receptor Group =     20.0 (km)


 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


 ***>>> NOTE: When running with volcanism, verify that   <<<***
 ***>>> the maximum value of the PDF for parameter       <<<***
 ***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
 ***>>> equal to the parameter MaximumTime[yr].          <<<***


 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C*
*

   ***>>> WARNING: THE APPEND OPTION IS SELECTED <<<***
 (see "OutputMode(0=None,1=All,2=UserDefined)" in tpa.inp)
 For "SelectAppendFiles", a value of 4 (seismo.ech and seismo.rlt only) was set
in tpa.inp.
 By selecting this option, files are written which may require    1 meg of disk
space.
 (more disk space could be needed)

------------------------------------------------------------------------
     subarea    1 of    8           realization    1 of    2
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
      *** No Corrosion WP Failure ***
```

```
 exec: calling seismo
 exec: calling faulto
 exec: calling volcano
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
  *** failed WPs:   4  out of   1455 ***
 exec: calling ebsrel
                 Highest release rates from Sub Area  1
             Tc99    2.2429E-02 [Ci/yr/SA] at  3.384E+03 yr
             Ni59    4.7014E-03 [Ci/yr/SA] at  3.384E+03 yr
             C14     2.7528E-03 [Ci/yr/SA] at  3.384E+03 yr
             Cs135   1.0090E-03 [Ci/yr/SA] at  3.384E+03 yr
             Se79    9.3571E-04 [Ci/yr/SA] at  3.384E+03 yr
             Am243   2.9810E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling uzft
    *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                   Highest release rates from UZ
             Tc99    2.2429E-02 [Ci/yr/SA] at  3.384E+03 yr
             Ni59    4.7014E-03 [Ci/yr/SA] at  3.384E+03 yr
             Cs135   1.0090E-03 [Ci/yr/SA] at  3.384E+03 yr
             Se79    9.3571E-04 [Ci/yr/SA] at  3.384E+03 yr
             Am243   2.9810E-04 [Ci/yr/SA] at  1.000E+04 yr
             Cm245   2.8595E-04 [Ci/yr/SA] at  6.875E+03 yr
 exec: calling szft
                   Highest release rates from SZ
             I129    5.8922E-05 [Ci/yr/SA] at  1.000E+04 yr
             Cl36    2.7146E-05 [Ci/yr/SA] at  6.407E+03 yr
      The remaining   18  nuclide(s) have zero release
 exec: calling dcagw
                   Highest annual dose GW pathway
             I129    1.1364E-02 [mrem/yr]  at  1.000E+04 yr
             Cl36    1.8226E-04 [mrem/yr]  at  6.407E+03 yr
      The remaining   18  nuclide(s) have zero release
           At end of TPI, annual dose GW pathway
             I129    1.1364E-02 [mrem/yr]
             Cl36    6.9994E-05 [mrem/yr]
               sum   1.1434E-02 [mrem/yr]
      The remaining   18  nuclide(s) have zero release
 exec: calling ashplumo
 exec: calling ashrmovo
 exec: calling dcags
                   Highest annual dose from GS
              Pu240  8.4854E+02 [mrem/yr] at  1.682E+03 yr
              Am241  6.7192E+02 [mrem/yr] at  1.682E+03 yr
              Pu239  5.9676E+02 [mrem/yr] at  1.682E+03 yr
              Am243  4.7546E+01 [mrem/yr] at  1.682E+03 yr
              Pu242  4.2009E+00 [mrem/yr] at  1.682E+03 yr
              Np237  3.5436E+00 [mrem/yr] at  1.682E+03 yr
-----------------------------------------------------------------------
    subarea   1 of   8          realization    2 of    2
-----------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
      *** No Corrosion WP Failure ***
 exec: calling seismo
 exec: calling faulto
 exec: calling volcano
 exec: failed WPs from INITIAL   event =     11 at time =      0.0 yr
 exec: failed WPs from SEISMIC   event =      4 at time =   6258.4 yr
  *** failed WPs:  15  out of   1455 ***
 exec: calling ebsrel
                 Highest release rates from Sub Area  1
             Tc99    2.3224E-03 [Ci/yr/SA] at  4.607E+03 yr
             Ni59    4.8168E-04 [Ci/yr/SA] at  4.607E+03 yr
```

```
                C14      2.5210E-04 [Ci/yr/SA] at  4.607E+03 yr
                Cs135    1.0630E-04 [Ci/yr/SA] at  4.607E+03 yr
                Se79     9.7338E-05 [Ci/yr/SA] at  4.607E+03 yr
                Cm245    3.5547E-05 [Ci/yr/SA] at  8.293E+03 yr
 exec: calling uzft
          *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                         Highest release rates from UZ
                Tc99     2.3224E-03 [Ci/yr/SA] at  4.607E+03 yr
                Ni59     4.8168E-04 [Ci/yr/SA] at  4.607E+03 yr
                Cs135    1.0630E-04 [Ci/yr/SA] at  4.607E+03 yr
                Se79     9.7338E-05 [Ci/yr/SA] at  4.607E+03 yr
                Cm245    3.5547E-05 [Ci/yr/SA] at  8.293E+03 yr
                Np237    1.9814E-05 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
                         Highest release rates from SZ
                Tc99     2.2748E-03 [Ci/yr/SA] at  5.696E+03 yr
                Ni59     1.9838E-05 [Ci/yr/SA] at  1.000E+04 yr
                I129     7.6979E-06 [Ci/yr/SA] at  5.696E+03 yr
                Cl36     3.3962E-06 [Ci/yr/SA] at  5.564E+03 yr
                Np237    1.7716E-09 [Ci/yr/SA] at  1.000E+04 yr
                Se79     1.5446E-20 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling dcagw
                         Highest annual dose GW pathway
                I129     1.1150E-03 [mrem/yr]  at  5.696E+03 yr
                Tc99     3.5386E-04 [mrem/yr]  at  5.696E+03 yr
                Cl36     1.6958E-05 [mrem/yr]  at  5.564E+03 yr
                Ni59     3.0015E-06 [mrem/yr]  at  1.000E+04 yr
                Np237    6.2871E-07 [mrem/yr]  at  1.000E+04 yr
                Se79     3.4609E-20 [mrem/yr]  at  1.000E+04 yr
             At end of TPI, annual dose GW pathway
                I129     7.3930E-04 [mrem/yr]
                Tc99     2.4739E-04 [mrem/yr]
                Cl36     1.0166E-05 [mrem/yr]
                Ni59     3.0015E-06 [mrem/yr]
                Np237    6.2871E-07 [mrem/yr]
                Se79     3.4609E-20 [mrem/yr]
                   sum   1.0005E-03 [mrem/yr]
 exec: calling ashplumo
 exec: calling ashrmovo
 exec: calling dcags
                         Highest annual dose from GS
                 Pu239   7.0818E+03 [mrem/yr] at  8.101E+03 yr
                 Pu240   6.0633E+03 [mrem/yr] at  8.101E+03 yr
                 Am243   3.6760E+02 [mrem/yr] at  8.101E+03 yr
                 Pu242   5.8635E+01 [mrem/yr] at  8.101E+03 yr
                 Np237   5.2928E+01 [mrem/yr] at  8.101E+03 yr
                  U234   1.9235E+01 [mrem/yr] at  8.101E+03 yr
 exec: end realizations

 exec:  Run Successfully Completed
```

```
Input file tpa.inp as supplied with TPA Version 4.0beta Code.
Test 298_5 TPI=10,000.
TPA 4.0beta, Job started: Fri Mar  3 13:48:13 2000
Number of Failed WPs by Type of Disruptive Event

Including Time of Event - Values for Each Vector


      vector             time          #corrode         #seismic          #fault
      #igact
     unitless             yr           unitless         unitless         unitless
     unitless
         1           1.0000E+04       0.0000E+00       0.0000E+00       0.0000E+00
   0.0000E+00
         2           6.2584E+03       0.0000E+00       4.0000E+00       0.0000E+00
   0.0000E+00
```

199/35

```
 Input file tpa.inp as supplied with TPA Version 4.0beta Code.
 Test 298_5 TPI=10,000.
 TPA 4.0beta, Job started: Fri Mar  3 13:48:13 2000
 Echo of SEISMO Input Values

 with the output mode specified in "tpa.inp"


REALIZATION    1


ALL SUBAREAS

(same values and times for all subareas and vectors)

   ntim
    201

       time
   1  0.0000E+00
   2  2.3102E+00
   3  4.6744E+00
   4  7.0940E+00
   5  9.5702E+00
   6  1.2104E+01
   7  1.4698E+01
   8  1.7352E+01
   9  2.0069E+01
  10  2.2849E+01
  11  2.5694E+01
  12  2.8605E+01
  13  3.1585E+01
  14  3.4635E+01
  15  3.7756E+01
  16  4.0950E+01
  17  4.4219E+01
  18  4.7564E+01
  19  5.0988E+01
  20  5.4492E+01
  21  5.8078E+01
  22  6.1747E+01
  23  6.5503E+01
  24  6.9347E+01
  25  7.3281E+01
  26  7.7306E+01
  27  8.1426E+01
  28  8.5643E+01
  29  8.9958E+01
  30  9.4374E+01
  31  9.8894E+01
  32  1.0352E+02
  33  1.0825E+02
  34  1.1310E+02
  35  1.1806E+02
  36  1.2313E+02
  37  1.2832E+02
  38  1.3364E+02
  39  1.3908E+02
  40  1.4464E+02
  41  1.5034E+02
  42  1.5617E+02
  43  1.6213E+02
  44  1.6824E+02
  45  1.7449E+02
  46  1.8088E+02
```

```
 47   1.8743E+02
 48   1.9413E+02
 49   2.0098E+02
 50   2.0800E+02
 51   2.1518E+02
 52   2.2252E+02
 53   2.3004E+02
 54   2.3774E+02
 55   2.4562E+02
 56   2.5368E+02
 57   2.6193E+02
 58   2.7037E+02
 59   2.7901E+02
 60   2.8785E+02
 61   2.9690E+02
 62   3.0616E+02
 63   3.1564E+02
 64   3.2534E+02
 65   3.3526E+02
 66   3.4542E+02
 67   3.5582E+02
 68   3.6646E+02
 69   3.7735E+02
 70   3.8849E+02
 71   3.9990E+02
 72   4.1157E+02
 73   4.2352E+02
 74   4.3574E+02
 75   4.4825E+02
 76   4.6106E+02
 77   4.7416E+02
 78   4.8757E+02
 79   5.0130E+02
 80   5.1535E+02
 81   5.2972E+02
 82   5.4443E+02
 83   5.5949E+02
 84   5.7490E+02
 85   5.9067E+02
 86   6.0680E+02
 87   6.2332E+02
 88   6.4022E+02
 89   6.5752E+02
 90   6.7523E+02
 91   6.9334E+02
 92   7.1189E+02
 93   7.3086E+02
 94   7.5028E+02
 95   7.7016E+02
 96   7.9050E+02
 97   8.1132E+02
 98   8.3262E+02
 99   8.5442E+02
100   8.7674E+02
101   8.9957E+02
102   9.2294E+02
103   9.4686E+02
104   9.7134E+02
105   9.9639E+02
106   1.0220E+03
107   1.0483E+03
108   1.0751E+03
109   1.1026E+03
110   1.1307E+03
111   1.1595E+03
```

```
 112  1.1890E+03
 113  1.2191E+03
 114  1.2500E+03
 115  1.2815E+03
 116  1.3138E+03
 117  1.3469E+03
 118  1.3808E+03
 119  1.4154E+03
 120  1.4508E+03
 121  1.4871E+03
 122  1.5242E+03
 123  1.5622E+03
 124  1.6011E+03
 125  1.6409E+03
 126  1.6816E+03
 127  1.7233E+03
 128  1.7660E+03
 129  1.8096E+03
 130  1.8543E+03
 131  1.9000E+03
 132  1.9468E+03
 133  1.9947E+03
 134  2.0437E+03
 135  2.0939E+03
 136  2.1452E+03
 137  2.1977E+03
 138  2.2515E+03
 139  2.3065E+03
 140  2.3628E+03
 141  2.4204E+03
 142  2.4794E+03
 143  2.5398E+03
 144  2.6015E+03
 145  2.6648E+03
 146  2.7295E+03
 147  2.7957E+03
 148  2.8634E+03
 149  2.9328E+03
 150  3.0038E+03
 151  3.0764E+03
 152  3.1507E+03
 153  3.2268E+03
 154  3.3046E+03
 155  3.3843E+03
 156  3.4659E+03
 157  3.5493E+03
 158  3.6347E+03
 159  3.7221E+03
 160  3.8116E+03
 161  3.9031E+03
 162  3.9968E+03
 163  4.0927E+03
 164  4.1908E+03
 165  4.2912E+03
 166  4.3940E+03
 167  4.4992E+03
 168  4.6068E+03
 169  4.7170E+03
 170  4.8297E+03
 171  4.9451E+03
 172  5.0632E+03
 173  5.1840E+03
 174  5.3077E+03
 175  5.4343E+03
 176  5.5638E+03
```

```
  177   5.6964E+03
  178   5.8321E+03
  179   5.9709E+03
  180   6.1130E+03
  181   6.2584E+03
  182   6.4073E+03
  183   6.5596E+03
  184   6.7154E+03
  185   6.8750E+03
  186   7.0382E+03
  187   7.2053E+03
  188   7.3763E+03
  189   7.5513E+03
  190   7.7304E+03
  191   7.9137E+03
  192   8.1013E+03
  193   8.2933E+03
  194   8.4897E+03
  195   8.6908E+03
  196   8.8966E+03
  197   9.1072E+03
  198   9.3227E+03
  199   9.5433E+03
  200   9.7690E+03
  201   1.0000E+04

(the following values are for each vector)


numberofevents =      53
event  timeofseismicevents   typeofseismicevents
   1        2.7298E+02          1.5000E-01
   2        3.6246E+02          5.0000E-02
   3        4.9809E+02          5.0000E-02
   4        9.6572E+02          5.0000E-02
   5        9.7723E+02          5.0000E-02
   6        1.0031E+03          1.0000E-01
   7        1.2102E+03          1.0000E-01
   8        1.2514E+03          5.0000E-02
   9        1.6458E+03          5.0000E-02
  10        1.8328E+03          5.0000E-02
  11        2.0590E+03          1.0000E-01
  12        2.2055E+03          2.5000E-01
  13        2.9203E+03          5.0000E-02
  14        2.9428E+03          5.0000E-02
  15        3.1100E+03          1.0000E-01
  16        3.1212E+03          5.0000E-02
  17        3.4762E+03          5.0000E-02
  18        3.4979E+03          1.0000E-01
  19        3.5065E+03          5.0000E-02
  20        3.9697E+03          5.0000E-02
  21        4.5088E+03          5.0000E-02
  22        4.5613E+03          5.0000E-02
  23        4.8013E+03          5.0000E-02
  24        5.0922E+03          2.5000E-01
  25        5.2610E+03          5.0000E-02
  26        5.4587E+03          1.0000E-01
  27        5.5595E+03          5.0000E-02
  28        5.7334E+03          1.0000E-01
  29        6.3194E+03          5.0000E-02
  30        6.6236E+03          5.0000E-02
  31        6.7108E+03          5.0000E-02
  32        6.7383E+03          5.0000E-02
  33        6.7562E+03          2.0000E-01
```

```
   34         6.8693E+03          1.0000E-01
   35         6.9456E+03          5.0000E-02
   36         7.7367E+03          5.0000E-02
   37         7.8938E+03          1.0000E-01
   38         8.2304E+03          1.0000E-01
   39         8.2464E+03          1.0000E-01
   40         8.3806E+03          2.0000E-01
   41         8.3901E+03          5.0000E-02
   42         8.4474E+03          5.0000E-02
   43         8.5128E+03          5.0000E-02
   44         8.7196E+03          1.5000E-01
   45         9.0950E+03          5.0000E-02
   46         9.0985E+03          5.0000E-02
   47         9.2890E+03          5.0000E-02
   48         9.3930E+03          5.0000E-02
   49         9.4451E+03          5.0000E-02
   50         9.4499E+03          5.0000E-02
   51         9.6703E+03          5.0000E-02
   52         9.7050E+03          5.0000E-02
   53         9.9602E+03          2.0000E-01

REALIZATION    2


ALL SUBAREAS


numberofevents =      67
event  timeofseismicevents   typeofseismicevents
   1          1.2527E+01          5.0000E-02
   2          3.9924E+02          5.0000E-02
   3          4.1373E+02          5.0000E-02
   4          4.6255E+02          5.0000E-02
   5          7.3680E+02          1.5000E-01
   6          8.1708E+02          5.0000E-02
   7          8.2961E+02          5.0000E-02
   8          9.6140E+02          5.0000E-02
   9          1.0032E+03          5.0000E-02
  10          1.1745E+03          5.0000E-02
  11          1.3062E+03          5.0000E-02
  12          1.3894E+03          5.0000E-02
  13          1.4566E+03          1.0000E-01
  14          1.5558E+03          1.5000E-01
  15          1.5909E+03          5.0000E-02
  16          1.7819E+03          1.0000E-01
  17          2.4110E+03          5.0000E-02
  18          2.4258E+03          5.0000E-02
  19          2.6411E+03          5.0000E-02
  20          2.6501E+03          1.0000E-01
  21          2.9539E+03          1.0000E-01
  22          3.3314E+03          5.0000E-02
  23          3.6335E+03          5.0000E-02
  24          3.6865E+03          5.0000E-02
  25          3.7051E+03          3.0000E-01
  26          3.9448E+03          1.0000E-01
  27          3.9595E+03          5.0000E-02
  28          4.0632E+03          3.0000E-01
  29          4.1099E+03          1.0000E-01
  30          4.3373E+03          1.0000E-01
  31          4.5935E+03          1.5000E-01
  32          4.6667E+03          5.0000E-02
  33          4.9332E+03          5.0000E-02
  34          5.1303E+03          5.0000E-02
  35          5.2975E+03          1.0000E-01
  36          5.4241E+03          5.0000E-02
```

```
 37          5.5428E+03          1.5000E-01
 38          5.8311E+03          5.0000E-02
 39          6.0744E+03          1.0000E-01
 40          6.1510E+03          5.0000E-02
 41          6.3262E+03          4.5000E-01
 42          6.6136E+03          5.0000E-02
 43          6.6610E+03          5.0000E-02
 44          6.7401E+03          5.0000E-02
 45          6.8756E+03          2.5000E-01
 46          6.9212E+03          5.0000E-02
 47          7.1608E+03          5.0000E-02
 48          7.2093E+03          5.0000E-02
 49          7.3820E+03          5.0000E-02
 50          7.4428E+03          1.5000E-01
 51          7.4735E+03          5.0000E-02
 52          7.6353E+03          5.0000E-02
 53          7.8756E+03          5.0000E-02
 54          7.9252E+03          5.0000E-02
 55          7.9709E+03          5.0000E-02
 56          8.0213E+03          2.0000E-01
 57          8.0659E+03          5.0000E-02
 58          8.2442E+03          1.0000E-01
 59          8.4413E+03          5.0000E-02
 60          8.4479E+03          5.0000E-02
 61          8.6398E+03          1.0000E-01
 62          9.1217E+03          5.0000E-02
 63          9.1770E+03          5.0000E-02
 64          9.2414E+03          1.0000E-01
 65          9.2961E+03          5.0000E-02
 66          9.3155E+03          1.0000E-01
 67          9.7329E+03          1.0000E-01
```

```
==========================================================================
          exec: Welcome to TPA Version 4.0beta
        Job started: Fri Mar  3 11:14:36 2000
==========================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea    Area       Waste    Number of WP
    #      [m^2]       [MTU]
    1    723591.3    14200.8        1455
    2    784763.0    15303.7        1568
    3    390372.0     7564.0         775
    4    207581.3     4157.8         426
    5    378972.8     7417.6         760
    6    424872.5     8305.8         851
    7    163938.3     3152.5         323
    8    393468.9     7944.6         814

 Total Area [acre]          =     856.82238463061
 Total Buried Waste [MTU]   =     68046.720000000
 Repository AML [MTU/acre]  =     79.417532992367

 Specified Global Parameters:

               Compliance Period =  10000.0 (yr)
         Maximum Simulation Time =  20000.0 (yr)
          Number Of Realizations =      2
              Number Of Subareas =      8
              Volcanism scenario =      1 (yes=1, no=0)
               Faulting scenario =      1 (yes=1, no=0)
                Seismic scenario =      1 (yes=1, no=0)
      Distance to Receptor Group =     20.0 (km)


 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


 ***>>> NOTE: When running with volcanism, verify that   <<<***
 ***>>> the maximum value of the PDF for parameter       <<<***
 ***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
 ***>>> equal to the parameter MaximumTime[yr].          <<<***


 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C*
*

   ***>>> WARNING: THE APPEND OPTION IS SELECTED <<<***
 (see "OutputMode(0=None,1=All,2=UserDefined)" in tpa.inp)
 For "SelectAppendFiles", a value of 4 (seismo.ech and seismo.rlt only) was set
in tpa.inp.
 By selecting this option, files are written which may require    1 meg of disk
space.
 (more disk space could be needed)

--------------------------------------------------------------------------
     subarea    1 of    8           realization    1 of    2
--------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
      *** No Corrosion WP Failure ***
```

```
 exec: calling seismo
 exec: calling faulto
 exec: calling volcano
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
  *** failed WPs:   4  out of   1455 ***
 exec: calling ebsrel
                  Highest release rates from Sub Area  1
              Tc99    2.2429E-02 [Ci/yr/SA] at  3.384E+03 yr
              Ni59    4.7014E-03 [Ci/yr/SA] at  3.384E+03 yr
              C14     2.7528E-03 [Ci/yr/SA] at  3.384E+03 yr
              Cs135   1.0090E-03 [Ci/yr/SA] at  3.384E+03 yr
              Se79    9.3571E-04 [Ci/yr/SA] at  3.384E+03 yr
              Am243   5.6580E-04 [Ci/yr/SA] at  2.000E+04 yr
 exec: calling uzft
      *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                      Highest release rates from UZ
              Tc99    2.2429E-02 [Ci/yr/SA] at  3.384E+03 yr
              Ni59    4.7014E-03 [Ci/yr/SA] at  3.384E+03 yr
              Cs135   1.0090E-03 [Ci/yr/SA] at  3.384E+03 yr
              Se79    9.3571E-04 [Ci/yr/SA] at  3.384E+03 yr
              Am243   5.6580E-04 [Ci/yr/SA] at  2.000E+04 yr
              Cm245   2.8595E-04 [Ci/yr/SA] at  6.875E+03 yr
 exec: calling szft
                      Highest release rates from SZ
              I129    5.3303E-05 [Ci/yr/SA] at  9.769E+03 yr
              Cl36    2.4264E-05 [Ci/yr/SA] at  6.875E+03 yr
              U234    2.4027E-08 [Ci/yr/SA] at  2.000E+04 yr
              U238    5.6910E-09 [Ci/yr/SA] at  2.000E+04 yr
              Se79    1.6658E-12 [Ci/yr/SA] at  2.000E+04 yr
              Th230   2.0065E-13 [Ci/yr/SA] at  2.000E+04 yr
 exec: calling dcagw
                      Highest annual dose GW pathway
              I129    1.0280E-02 [mrem/yr]  at  9.769E+03 yr
              Cl36    1.6291E-04 [mrem/yr]  at  6.875E+03 yr
              U234    1.2523E-06 [mrem/yr]  at  2.000E+04 yr
              U238    2.6898E-07 [mrem/yr]  at  2.000E+04 yr
              Pb210   6.8647E-11 [mrem/yr]  at  2.000E+04 yr
              Th230   1.8244E-11 [mrem/yr]  at  2.000E+04 yr
             At end of TPI, annual dose GW pathway
              I129    1.2205E-03 [mrem/yr]
              Cl36    1.0491E-05 [mrem/yr]
              U234    1.2523E-06 [mrem/yr]
              U238    2.6898E-07 [mrem/yr]
              Pb210   6.8647E-11 [mrem/yr]
              Th230   1.8244E-11 [mrem/yr]
                sum   1.2325E-03 [mrem/yr]
 exec: calling ashplumo
 exec: calling ashrmovo
 exec: calling dcags
                      Highest annual dose from GS
               Pu240  8.4854E+02 [mrem/yr] at  1.682E+03 yr
               Am241  6.7192E+02 [mrem/yr] at  1.682E+03 yr
               Pu239  5.9676E+02 [mrem/yr] at  1.682E+03 yr
               Am243  4.7546E+01 [mrem/yr] at  1.682E+03 yr
               Pu242  4.2009E+00 [mrem/yr] at  1.682E+03 yr
               Np237  3.5436E+00 [mrem/yr] at  1.682E+03 yr
-----------------------------------------------------------------------
     subarea    1 of    8           realization    2 of    2
-----------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
     ebsfail: time of WP failure =    14191.9  yr
 exec: calling seismo
```

```
 exec: calling faulto
 exec: calling volcano
 exec: failed WPs from INITIAL   event =     11 at time =      0.0 yr
 exec: failed WPs from SEISMIC   event =      4 at time =   6258.4 yr
 exec: failed WPs from CORROSION event =   1441 at time =  14191.9 yr
  *** failed WPs: all WPs failed (  1455) ***
  Total WPs may not equal sum of event WPs due to roundoff.
 exec: calling ebsrel
                  Highest release rates from Sub Area  1
              Tc99    2.3224E-03 [Ci/yr/SA] at  4.607E+03 yr
              Ni59    4.8168E-04 [Ci/yr/SA] at  4.607E+03 yr
              C14     2.5210E-04 [Ci/yr/SA] at  4.607E+03 yr
              Cs135   1.0630E-04 [Ci/yr/SA] at  4.607E+03 yr
              Se79    9.7338E-05 [Ci/yr/SA] at  4.607E+03 yr
              Np237   6.3970E-05 [Ci/yr/SA] at  2.000E+04 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                      Highest release rates from UZ
              Tc99    2.3224E-03 [Ci/yr/SA] at  4.607E+03 yr
              Ni59    4.8168E-04 [Ci/yr/SA] at  4.607E+03 yr
              Cs135   1.0630E-04 [Ci/yr/SA] at  4.607E+03 yr
              Se79    9.7338E-05 [Ci/yr/SA] at  4.607E+03 yr
              Np237   6.3970E-05 [Ci/yr/SA] at  2.000E+04 yr
              Ra226   5.2280E-05 [Ci/yr/SA] at  2.000E+04 yr
 exec: calling szft
                      Highest release rates from SZ
              Tc99    2.2748E-03 [Ci/yr/SA] at  5.696E+03 yr
              Ni59    4.2627E-04 [Ci/yr/SA] at  1.218E+04 yr
              Se79    7.9328E-05 [Ci/yr/SA] at  1.419E+04 yr
              Np237   3.2281E-05 [Ci/yr/SA] at  2.000E+04 yr
              I129    7.6979E-06 [Ci/yr/SA] at  5.696E+03 yr
              Cl36    3.3962E-06 [Ci/yr/SA] at  5.564E+03 yr
 exec: calling dcagw
                      Highest annual dose GW pathway
              Np237   1.1456E-02 [mrem/yr]  at  2.000E+04 yr
              I129    1.1150E-03 [mrem/yr]  at  5.696E+03 yr
              Tc99    3.5386E-04 [mrem/yr]  at  5.696E+03 yr
              Se79    1.7775E-04 [mrem/yr]  at  1.419E+04 yr
              Ni59    6.4495E-05 [mrem/yr]  at  1.218E+04 yr
              Cl36    1.6958E-05 [mrem/yr]  at  5.564E+03 yr
            At end of TPI, annual dose GW pathway
              Np237   1.1456E-02 [mrem/yr]
              I129    4.2280E-04 [mrem/yr]
              Tc99    1.2532E-04 [mrem/yr]
              Se79    7.7743E-05 [mrem/yr]
              Ni59    3.1708E-05 [mrem/yr]
              Cl36    6.0493E-06 [mrem/yr]
                 sum  1.2120E-02 [mrem/yr]
 exec: calling ashplumo
 exec: calling ashrmovo
 exec: calling dcags
                      Highest annual dose from GS
               Pu239  7.0818E+03 [mrem/yr] at  8.101E+03 yr
               Pu240  6.0633E+03 [mrem/yr] at  8.101E+03 yr
               Am243  3.6760E+02 [mrem/yr] at  8.101E+03 yr
               Pu242  5.8635E+01 [mrem/yr] at  8.101E+03 yr
               Np237  5.2928E+01 [mrem/yr] at  8.101E+03 yr
                U234  1.9235E+01 [mrem/yr] at  8.101E+03 yr
 exec: end realizations

 exec:  Run Successfully Completed
```

```
Input file tpa.inp as supplied with TPA Version 4.0beta Code.
Test 298_5 TPI=20,000.
TPA 4.0beta, Job started: Fri Mar  3 13:52:22 2000
Number of Failed WPs by Type of Disruptive Event

Including Time of Event - Values for Each Vector


    vector         time          #corrode       #seismic        #fault
    #igact
   unitless         yr           unitless       unitless       unitless
   unitless
       1        2.0000E+04      0.0000E+00     0.0000E+00     0.0000E+00
  0.0000E+00
       2        6.2584E+03      0.0000E+00     4.0000E+00     0.0000E+00
  0.0000E+00
       2        1.4192E+04      1.4410E+03     0.0000E+00     0.0000E+00
  0.0000E+00
```

```
 Input file tpa.inp as supplied with TPA Version 4.0beta Code.
 Test 298_5 TPI=20,000.
 TPA 4.0beta, Job started: Fri Mar  3 13:52:22 2000
 Echo of SEISMO Input Values

 with the output mode specified in "tpa.inp"


REALIZATION    1


ALL SUBAREAS

(same values and times for all subareas and vectors)

   ntim
    211

        time
   1  0.0000E+00
   2  2.3102E+00
   3  4.6744E+00
   4  7.0940E+00
   5  9.5702E+00
   6  1.2104E+01
   7  1.4698E+01
   8  1.7352E+01
   9  2.0069E+01
  10  2.2849E+01
  11  2.5694E+01
  12  2.8605E+01
  13  3.1585E+01
  14  3.4635E+01
  15  3.7756E+01
  16  4.0950E+01
  17  4.4219E+01
  18  4.7564E+01
  19  5.0988E+01
  20  5.4492E+01
  21  5.8078E+01
  22  6.1747E+01
  23  6.5503E+01
  24  6.9347E+01
  25  7.3281E+01
  26  7.7306E+01
  27  8.1426E+01
  28  8.5643E+01
  29  8.9958E+01
  30  9.4374E+01
  31  9.8894E+01
  32  1.0352E+02
  33  1.0825E+02
  34  1.1310E+02
  35  1.1806E+02
  36  1.2313E+02
  37  1.2832E+02
  38  1.3364E+02
  39  1.3908E+02
  40  1.4464E+02
  41  1.5034E+02
  42  1.5617E+02
  43  1.6213E+02
  44  1.6824E+02
  45  1.7449E+02
  46  1.8088E+02
```

```
 47  1.8743E+02
 48  1.9413E+02
 49  2.0098E+02
 50  2.0800E+02
 51  2.1518E+02
 52  2.2252E+02
 53  2.3004E+02
 54  2.3774E+02
 55  2.4562E+02
 56  2.5368E+02
 57  2.6193E+02
 58  2.7037E+02
 59  2.7901E+02
 60  2.8785E+02
 61  2.9690E+02
 62  3.0616E+02
 63  3.1564E+02
 64  3.2534E+02
 65  3.3526E+02
 66  3.4542E+02
 67  3.5582E+02
 68  3.6646E+02
 69  3.7735E+02
 70  3.8849E+02
 71  3.9990E+02
 72  4.1157E+02
 73  4.2352E+02
 74  4.3574E+02
 75  4.4825E+02
 76  4.6106E+02
 77  4.7416E+02
 78  4.8757E+02
 79  5.0130E+02
 80  5.1535E+02
 81  5.2972E+02
 82  5.4443E+02
 83  5.5949E+02
 84  5.7490E+02
 85  5.9067E+02
 86  6.0680E+02
 87  6.2332E+02
 88  6.4022E+02
 89  6.5752E+02
 90  6.7523E+02
 91  6.9334E+02
 92  7.1189E+02
 93  7.3086E+02
 94  7.5028E+02
 95  7.7016E+02
 96  7.9050E+02
 97  8.1132E+02
 98  8.3262E+02
 99  8.5442E+02
100  8.7674E+02
101  8.9957E+02
102  9.2294E+02
103  9.4686E+02
104  9.7134E+02
105  9.9639E+02
106  1.0220E+03
107  1.0483E+03
108  1.0751E+03
109  1.1026E+03
110  1.1307E+03
111  1.1595E+03
```

```
 112  1.1890E+03
 113  1.2191E+03
 114  1.2500E+03
 115  1.2815E+03
 116  1.3138E+03
 117  1.3469E+03
 118  1.3808E+03
 119  1.4154E+03
 120  1.4508E+03
 121  1.4871E+03
 122  1.5242E+03
 123  1.5622E+03
 124  1.6011E+03
 125  1.6409E+03
 126  1.6816E+03
 127  1.7233E+03
 128  1.7660E+03
 129  1.8096E+03
 130  1.8543E+03
 131  1.9000E+03
 132  1.9468E+03
 133  1.9947E+03
 134  2.0437E+03
 135  2.0939E+03
 136  2.1452E+03
 137  2.1977E+03
 138  2.2515E+03
 139  2.3065E+03
 140  2.3628E+03
 141  2.4204E+03
 142  2.4794E+03
 143  2.5398E+03
 144  2.6015E+03
 145  2.6648E+03
 146  2.7295E+03
 147  2.7957E+03
 148  2.8634E+03
 149  2.9328E+03
 150  3.0038E+03
 151  3.0764E+03
 152  3.1507E+03
 153  3.2268E+03
 154  3.3046E+03
 155  3.3843E+03
 156  3.4659E+03
 157  3.5493E+03
 158  3.6347E+03
 159  3.7221E+03
 160  3.8116E+03
 161  3.9031E+03
 162  3.9968E+03
 163  4.0927E+03
 164  4.1908E+03
 165  4.2912E+03
 166  4.3940E+03
 167  4.4992E+03
 168  4.6068E+03
 169  4.7170E+03
 170  4.8297E+03
 171  4.9451E+03
 172  5.0632E+03
 173  5.1840E+03
 174  5.3077E+03
 175  5.4343E+03
 176  5.5638E+03
```

```
  177   5.6964E+03
  178   5.8321E+03
  179   5.9709E+03
  180   6.1130E+03
  181   6.2584E+03
  182   6.4073E+03
  183   6.5596E+03
  184   6.7154E+03
  185   6.8750E+03
  186   7.0382E+03
  187   7.2053E+03
  188   7.3763E+03
  189   7.5513E+03
  190   7.7304E+03
  191   7.9137E+03
  192   8.1013E+03
  193   8.2933E+03
  194   8.4897E+03
  195   8.6908E+03
  196   8.8966E+03
  197   9.1072E+03
  198   9.3227E+03
  199   9.5433E+03
  200   9.7690E+03
  201   1.0000E+04
  202   1.0245E+04
  203   1.0561E+04
  204   1.0969E+04
  205   1.1496E+04
  206   1.2177E+04
  207   1.3056E+04
  208   1.4192E+04
  209   1.5659E+04
  210   1.7553E+04
  211   2.0000E+04


 (the following values are for each vector)


numberofevents =     102
event  timeofseismicevents   typeofseismicevents
   1         2.7298E+02        1.5000E-01
   2         3.6246E+02        5.0000E-02
   3         4.9809E+02        5.0000E-02
   4         9.6572E+02        5.0000E-02
   5         9.7723E+02        5.0000E-02
   6         1.0031E+03        1.0000E-01
   7         1.2102E+03        1.0000E-01
   8         1.2514E+03        5.0000E-02
   9         1.6458E+03        5.0000E-02
  10         1.8328E+03        5.0000E-02
  11         2.0590E+03        1.0000E-01
  12         2.2055E+03        2.5000E-01
  13         2.9203E+03        5.0000E-02
  14         2.9428E+03        5.0000E-02
  15         3.1100E+03        1.0000E-01
  16         3.1212E+03        5.0000E-02
  17         3.4762E+03        5.0000E-02
  18         3.4979E+03        1.0000E-01
  19         3.5065E+03        5.0000E-02
  20         3.9697E+03        5.0000E-02
  21         4.5088E+03        5.0000E-02
  22         4.5613E+03        5.0000E-02
  23         4.8013E+03        5.0000E-02
```

```
  24          5.0922E+03          2.5000E-01
  25          5.2610E+03          5.0000E-02
  26          5.4587E+03          1.0000E-01
  27          5.5595E+03          5.0000E-02
  28          5.7334E+03          1.0000E-01
  29          6.3194E+03          5.0000E-02
  30          6.6236E+03          5.0000E-02
  31          6.7108E+03          5.0000E-02
  32          6.7383E+03          5.0000E-02
  33          6.7562E+03          2.0000E-01
  34          6.8693E+03          1.0000E-01
  35          6.9456E+03          5.0000E-02
  36          7.7367E+03          5.0000E-02
  37          7.8938E+03          1.0000E-01
  38          8.2304E+03          1.0000E-01
  39          8.2464E+03          1.0000E-01
  40          8.3806E+03          2.0000E-01
  41          8.3901E+03          5.0000E-02
  42          8.4474E+03          5.0000E-02
  43          8.5128E+03          5.0000E-02
  44          8.7196E+03          1.5000E-01
  45          9.0950E+03          5.0000E-02
  46          9.0985E+03          5.0000E-02
  47          9.2890E+03          5.0000E-02
  48          9.3930E+03          5.0000E-02
  49          9.4451E+03          5.0000E-02
  50          9.4499E+03          5.0000E-02
  51          9.6703E+03          5.0000E-02
  52          9.7050E+03          5.0000E-02
  53          9.9602E+03          2.0000E-01
  54          1.0038E+04          5.0000E-02
  55          1.0072E+04          5.0000E-02
  56          1.0115E+04          1.5000E-01
  57          1.0378E+04          5.0000E-02
  58          1.0534E+04          5.0000E-02
  59          1.0565E+04          5.0000E-02
  60          1.1747E+04          5.0000E-02
  61          1.1831E+04          1.0000E-01
  62          1.1932E+04          5.0000E-02
  63          1.2249E+04          5.0000E-02
  64          1.2560E+04          5.0000E-02
  65          1.2808E+04          5.0000E-02
  66          1.2999E+04          5.0000E-02
  67          1.2999E+04          5.0000E-02
  68          1.3008E+04          1.0000E-01
  69          1.3194E+04          1.0000E-01
  70          1.3194E+04          5.0000E-02
  71          1.3380E+04          5.0000E-02
  72          1.3393E+04          1.5000E-01
  73          1.3394E+04          5.0000E-02
  74          1.3455E+04          5.0000E-02
  75          1.3468E+04          1.5000E-01
  76          1.3485E+04          5.0000E-02
  77          1.4190E+04          5.0000E-02
  78          1.4515E+04          5.0000E-02
  79          1.4676E+04          5.0000E-02
  80          1.5279E+04          1.5000E-01
  81          1.5751E+04          5.0000E-01
  82          1.5844E+04          2.0000E-01
  83          1.5957E+04          3.0000E-01
  84          1.6040E+04          5.0000E-02
  85          1.6501E+04          1.0000E-01
  86          1.6824E+04          1.0000E-01
  87          1.6831E+04          5.0000E-02
  88          1.7187E+04          5.0000E-02
```

```
   89         1.7304E+04          1.0000E-01
   90         1.7406E+04          3.5000E-01
   91         1.7608E+04          5.0000E-02
   92         1.7703E+04          5.0000E-02
   93         1.7881E+04          5.0000E-02
   94         1.7922E+04          5.0000E-02
   95         1.7926E+04          1.5000E-01
   96         1.7942E+04          1.5000E-01
   97         1.8274E+04          5.0000E-02
   98         1.8558E+04          5.0000E-02
   99         1.8909E+04          5.0000E-02
  100         1.9030E+04          1.0000E-01
  101         1.9157E+04          1.0000E-01
  102         1.9997E+04          2.0000E-01

REALIZATION    2


ALL SUBAREAS



numberofevents =     120
event  timeofseismicevents   typeofseismicevents
    1         1.2527E+01          5.0000E-02
    2         3.9924E+02          5.0000E-02
    3         4.1373E+02          5.0000E-02
    4         4.6255E+02          5.0000E-02
    5         7.3680E+02          1.5000E-01
    6         8.1708E+02          5.0000E-02
    7         8.2961E+02          5.0000E-02
    8         9.6140E+02          5.0000E-02
    9         1.0032E+03          5.0000E-02
   10         1.1745E+03          5.0000E-02
   11         1.3062E+03          5.0000E-02
   12         1.3894E+03          5.0000E-02
   13         1.4566E+03          1.0000E-01
   14         1.5558E+03          1.5000E-01
   15         1.5909E+03          5.0000E-02
   16         1.7819E+03          1.0000E-01
   17         2.4110E+03          5.0000E-02
   18         2.4258E+03          5.0000E-02
   19         2.6411E+03          5.0000E-02
   20         2.6501E+03          1.0000E-01
   21         2.9539E+03          1.0000E-01
   22         3.3314E+03          5.0000E-02
   23         3.6335E+03          5.0000E-02
   24         3.6865E+03          5.0000E-02
   25         3.7051E+03          3.0000E-01
   26         3.9448E+03          1.0000E-01
   27         3.9595E+03          5.0000E-02
   28         4.0632E+03          3.0000E-01
   29         4.1099E+03          1.0000E-01
   30         4.3373E+03          1.0000E-01
   31         4.5935E+03          1.5000E-01
   32         4.6667E+03          5.0000E-02
   33         4.9332E+03          5.0000E-02
   34         5.1303E+03          5.0000E-02
   35         5.2975E+03          1.0000E-01
   36         5.4241E+03          5.0000E-02
   37         5.5428E+03          1.5000E-01
   38         5.8311E+03          5.0000E-02
   39         6.0744E+03          1.0000E-01
   40         6.1510E+03          5.0000E-02
   41         6.3262E+03          4.5000E-01
   42         6.6136E+03          5.0000E-02
```

```
    43          6.6610E+03          5.0000E-02
    44          6.7401E+03          5.0000E-02
    45          6.8756E+03          2.5000E-01
    46          6.9212E+03          5.0000E-02
    47          7.1608E+03          5.0000E-02
    48          7.2093E+03          5.0000E-02
    49          7.3820E+03          5.0000E-02
    50          7.4428E+03          1.5000E-01
    51          7.4735E+03          5.0000E-02
    52          7.6353E+03          5.0000E-02
    53          7.8756E+03          5.0000E-02
    54          7.9252E+03          5.0000E-02
    55          7.9709E+03          5.0000E-02
    56          8.0213E+03          2.0000E-01
    57          8.0659E+03          5.0000E-02
    58          8.2442E+03          1.0000E-01
    59          8.4413E+03          5.0000E-02
    60          8.4479E+03          5.0000E-02
    61          8.6398E+03          1.0000E-01
    62          9.1217E+03          5.0000E-02
    63          9.1770E+03          5.0000E-02
    64          9.2414E+03          1.0000E-01
    65          9.2961E+03          5.0000E-02
    66          9.3155E+03          1.0000E-01
    67          9.7329E+03          1.0000E-01
    68          1.0267E+04          1.0000E-01
    69          1.0486E+04          1.0000E-01
    70          1.0840E+04          5.0000E-02
    71          1.0964E+04          2.0000E-01
    72          1.1392E+04          2.5000E-01
    73          1.1543E+04          1.0000E-01
    74          1.1678E+04          1.5000E-01
    75          1.2014E+04          5.0000E-02
    76          1.2060E+04          5.0000E-02
    77          1.2432E+04          1.0000E-01
    78          1.2510E+04          5.0000E-02
    79          1.2568E+04          1.5000E-01
    80          1.2759E+04          1.0000E-01
    81          1.2843E+04          1.0000E-01
    82          1.3269E+04          5.0000E-02
    83          1.3377E+04          5.0000E-02
    84          1.3526E+04          1.0000E-01
    85          1.3545E+04          5.0000E-02
    86          1.3558E+04          1.0000E-01
    87          1.3840E+04          1.0000E-01
    88          1.4116E+04          5.0000E-02
    89          1.4142E+04          5.0000E-02
    90          1.4333E+04          5.0000E-02
    91          1.4375E+04          5.0000E-02
    92          1.4489E+04          5.0000E-02
    93          1.4901E+04          1.5000E-01
    94          1.5097E+04          2.5000E-01
    95          1.5264E+04          5.0000E-02
    96          1.5436E+04          5.0000E-02
    97          1.5738E+04          1.0000E-01
    98          1.5783E+04          5.0000E-02
    99          1.5902E+04          5.0000E-02
   100          1.5930E+04          5.0000E-02
   101          1.6516E+04          1.0000E-01
   102          1.6721E+04          5.0000E-02
   103          1.6800E+04          1.0000E-01
   104          1.6996E+04          2.0000E-01
   105          1.7294E+04          5.0000E-02
   106          1.7410E+04          5.0000E-02
   107          1.7584E+04          5.0000E-02
```

```
  108         1.7637E+04          5.0000E-02
  109         1.8229E+04          5.0000E-02
  110         1.8516E+04          5.0000E-02
  111         1.8545E+04          5.0000E-02
  112         1.8755E+04          5.0000E-02
  113         1.9105E+04          5.0000E-02
  114         1.9319E+04          1.0000E-01
  115         1.9371E+04          1.5000E-01
  116         1.9496E+04          5.0000E-02
  117         1.9699E+04          5.0000E-02
  118         1.9738E+04          1.0000E-01
  119         1.9768E+04          5.0000E-02
  120         1.9785E+04          5.0000E-02
```

```
========================================================================
          exec: Welcome to TPA Version 4.0beta
        Job started: Fri Mar  3 13:16:28 2000
========================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea   Area      Waste   Number of WP
    #     [m^2]      [MTU]
    1    723591.3    14200.8        1455
    2    784763.0    15303.7        1568
    3    390372.0     7564.0         775
    4    207581.3     4157.8         426
    5    378972.8     7417.6         760
    6    424872.5     8305.8         851
    7    163938.3     3152.5         323
    8    393468.9     7944.6         814

 Total Area [acre]          =     856.82238463061
 Total Buried Waste [MTU]   =     68046.720000000
 Repository AML [MTU/acre]  =     79.417532992367

 Specified Global Parameters:

                Compliance Period =  10000.0 (yr)
          Maximum Simulation Time =  40000.0 (yr)
           Number Of Realizations =      2
               Number Of Subareas =      8
               Volcanism scenario =      1 (yes=1, no=0)
                Faulting scenario =      1 (yes=1, no=0)
                 Seismic scenario =      1 (yes=1, no=0)
       Distance to Receptor Group =     20.0 (km)


 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


 ***>>> NOTE: When running with volcanism, verify that   <<<***
 ***>>> the maximum value of the PDF for parameter       <<<***
 ***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
 ***>>> equal to the parameter MaximumTime[yr].          <<<***


 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C*
*

   ***>>> WARNING: THE APPEND OPTION IS SELECTED <<<***
 (see "OutputMode(0=None,1=All,2=UserDefined)" in tpa.inp)
 For "SelectAppendFiles", a value of 4 (seismo.ech and seismo.rlt only) was set
in tpa.inp.
 By selecting this option, files are written which may require    1 meg of disk
space.
 (more disk space could be needed)

------------------------------------------------------------------------
     subarea    1 of    8           realization    1 of    2
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
      ebsfail: time of WP failure =    26976.1  yr
```

```
 exec: calling seismo
 exec: calling faulto
 exec: calling volcano
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
 exec: failed WPs from CORROSION event =   1451 at time =  26976.1 yr
  *** failed WPs: all WPs failed (  1455) ***
  Total WPs may not equal sum of event WPs due to roundoff.
 exec: calling ebsrel
                  Highest release rates from Sub Area  1
              Tc99    8.6460E-02 [Ci/yr/SA] at  3.266E+04 yr
              Ni59    1.6764E-02 [Ci/yr/SA] at  3.266E+04 yr
              Am243   9.3187E-03 [Ci/yr/SA] at  3.266E+04 yr
              Np237   7.4597E-03 [Ci/yr/SA] at  3.266E+04 yr
              Pu239   5.9839E-03 [Ci/yr/SA] at  4.000E+04 yr
              Th230   3.3643E-03 [Ci/yr/SA] at  4.000E+04 yr
 exec: calling uzft
      *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                      Highest release rates from UZ
              Tc99    8.6460E-02 [Ci/yr/SA] at  3.266E+04 yr
              Ni59    1.6764E-02 [Ci/yr/SA] at  3.266E+04 yr
              Am243   9.3187E-03 [Ci/yr/SA] at  3.266E+04 yr
              Np237   7.4597E-03 [Ci/yr/SA] at  3.266E+04 yr
              Pu239   5.9839E-03 [Ci/yr/SA] at  4.000E+04 yr
              Th230   3.3643E-03 [Ci/yr/SA] at  4.000E+04 yr
 exec: calling szft
                      Highest release rates from SZ
              Tc99    9.9170E-03 [Ci/yr/SA] at  3.266E+04 yr
              Se79    2.5765E-04 [Ci/yr/SA] at  3.266E+04 yr
              I129    2.1895E-04 [Ci/yr/SA] at  4.000E+04 yr
              Cl36    6.3493E-05 [Ci/yr/SA] at  4.000E+04 yr
              U234    2.6122E-07 [Ci/yr/SA] at  4.000E+04 yr
              U238    6.5447E-08 [Ci/yr/SA] at  4.000E+04 yr
 exec: calling dcagw
                      Highest annual dose GW pathway
              I129    4.2227E-02 [mrem/yr]  at  4.000E+04 yr
              Tc99    3.1281E-03 [mrem/yr]  at  3.266E+04 yr
              Se79    8.5232E-04 [mrem/yr]  at  3.266E+04 yr
              Cl36    4.2629E-04 [mrem/yr]  at  4.000E+04 yr
              U234    1.3614E-05 [mrem/yr]  at  4.000E+04 yr
              U238    3.0933E-06 [mrem/yr]  at  4.000E+04 yr
            At end of TPI, annual dose GW pathway
              I129    4.2227E-02 [mrem/yr]
              Tc99    1.0423E-03 [mrem/yr]
              Cl36    4.2629E-04 [mrem/yr]
              Se79    2.0356E-04 [mrem/yr]
              U234    1.3614E-05 [mrem/yr]
              U238    3.0933E-06 [mrem/yr]
                 sum  4.3915E-02 [mrem/yr]
 exec: calling ashplumo
 exec: calling ashrmovo
 exec: calling dcags
                      Highest annual dose from GS
              Pu240   8.4854E+02 [mrem/yr] at  1.682E+03 yr
              Am241   6.7192E+02 [mrem/yr] at  1.682E+03 yr
              Pu239   5.9676E+02 [mrem/yr] at  1.682E+03 yr
              Am243   4.7546E+01 [mrem/yr] at  1.682E+03 yr
              Pu242   4.2009E+00 [mrem/yr] at  1.682E+03 yr
              Np237   3.5436E+00 [mrem/yr] at  1.682E+03 yr
------------------------------------------------------------------------
     subarea    1 of    8           realization    2 of    2
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
```

```
      ebsfail: time of WP failure =    14488.0  yr
 exec: calling seismo
 exec: calling faulto
 exec: calling volcano
 exec: failed WPs from INITIAL   event =     11 at time =      0.0 yr
 exec: failed WPs from SEISMIC   event =      4 at time =   6258.4 yr
 exec: failed WPs from CORROSION event =   1441 at time =  14488.0 yr
  *** failed WPs: all WPs failed (  1455) ***
  Total WPs may not equal sum of event WPs due to roundoff.
 exec: calling ebsrel
                     Highest release rates from Sub Area  1
              Tc99    3.7482E-01 [Ci/yr/SA] at  2.258E+04 yr
              Ni59    5.5232E-02 [Ci/yr/SA] at  2.258E+04 yr
              Cs135   3.1499E-02 [Ci/yr/SA] at  2.258E+04 yr
              Se79    2.3933E-02 [Ci/yr/SA] at  2.258E+04 yr
              Pb210   1.4049E-02 [Ci/yr/SA] at  4.000E+04 yr
              Ra226   1.2515E-02 [Ci/yr/SA] at  4.000E+04 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                      Highest release rates from UZ
              Tc99    3.7482E-01 [Ci/yr/SA] at  2.258E+04 yr
              Ni59    5.5232E-02 [Ci/yr/SA] at  2.258E+04 yr
              Cs135   3.1499E-02 [Ci/yr/SA] at  2.258E+04 yr
              Se79    2.3933E-02 [Ci/yr/SA] at  2.258E+04 yr
              Pb210   1.4049E-02 [Ci/yr/SA] at  4.000E+04 yr
              Ra226   1.2515E-02 [Ci/yr/SA] at  4.000E+04 yr
 exec: calling szft
                      Highest release rates from SZ
              Tc99    3.0656E-01 [Ci/yr/SA] at  2.258E+04 yr
              Ni59    4.5029E-02 [Ci/yr/SA] at  3.266E+04 yr
              Se79    1.7484E-02 [Ci/yr/SA] at  3.266E+04 yr
              Np237   9.4481E-03 [Ci/yr/SA] at  4.000E+04 yr
              I129    1.9242E-03 [Ci/yr/SA] at  2.258E+04 yr
              Cl36    1.0827E-03 [Ci/yr/SA] at  2.258E+04 yr
 exec: calling dcagw
                      Highest annual dose GW pathway
              Np237   3.3530E+00 [mrem/yr]  at  4.000E+04 yr
              I129    2.7872E-01 [mrem/yr]  at  2.258E+04 yr
              Tc99    4.7686E-02 [mrem/yr]  at  2.258E+04 yr
              Se79    3.9175E-02 [mrem/yr]  at  3.266E+04 yr
              Ni59    6.8129E-03 [mrem/yr]  at  3.266E+04 yr
              Cl36    5.4060E-03 [mrem/yr]  at  2.258E+04 yr
             At end of TPI, annual dose GW pathway
              Np237   3.3530E+00 [mrem/yr]
              I129    7.1146E-02 [mrem/yr]
              Tc99    2.5514E-02 [mrem/yr]
              Se79    1.7127E-02 [mrem/yr]
              Ni59    5.1855E-03 [mrem/yr]
              Cl36    8.1764E-04 [mrem/yr]
                 sum  3.4728E+00 [mrem/yr]
 exec: calling ashplumo
 exec: calling ashrmovo
 exec: calling dcags
                      Highest annual dose from GS
              Pu239   7.0818E+03 [mrem/yr] at  8.101E+03 yr
              Pu240   6.0633E+03 [mrem/yr] at  8.101E+03 yr
              Am243   3.6760E+02 [mrem/yr] at  8.101E+03 yr
              Pu242   5.8635E+01 [mrem/yr] at  8.101E+03 yr
              Np237   5.2928E+01 [mrem/yr] at  8.101E+03 yr
               U234   1.9235E+01 [mrem/yr] at  8.101E+03 yr
 exec: end realizations

 exec:  Run Successfully Completed
```

```
Input file tpa.inp as supplied with TPA Version 4.0beta Code.
Test 298_5 TPI=40,000.
TPA 4.0beta, Job started: Fri Mar  3 13:56:25 2000
Number of Failed WPs by Type of Disruptive Event

Including Time of Event - Values for Each Vector


      vector           time        #corrode      #seismic       #fault
      #igact
     unitless           yr         unitless      unitless      unitless
     unitless
         1         2.6976E+04    1.4510E+03    0.0000E+00    0.0000E+00
  0.0000E+00
         2         6.2584E+03    0.0000E+00    4.0000E+00    0.0000E+00
  0.0000E+00
         2         1.4488E+04    1.4410E+03    0.0000E+00    0.0000E+00
  0.0000E+00
```

```
 Input file tpa.inp as supplied with TPA Version 4.0beta Code.
 Test 298_5 TPI=40,000.
 TPA 4.0beta, Job started: Fri Mar  3 13:56:25 2000
 Echo of SEISMO Input Values

 with the output mode specified in "tpa.inp"


REALIZATION    1


ALL SUBAREAS

(same values and times for all subareas and vectors)

   ntim
    211

        time
   1  0.0000E+00
   2  2.3102E+00
   3  4.6744E+00
   4  7.0940E+00
   5  9.5702E+00
   6  1.2104E+01
   7  1.4698E+01
   8  1.7352E+01
   9  2.0069E+01
  10  2.2849E+01
  11  2.5694E+01
  12  2.8605E+01
  13  3.1585E+01
  14  3.4635E+01
  15  3.7756E+01
  16  4.0950E+01
  17  4.4219E+01
  18  4.7564E+01
  19  5.0988E+01
  20  5.4492E+01
  21  5.8078E+01
  22  6.1747E+01
  23  6.5503E+01
  24  6.9347E+01
  25  7.3281E+01
  26  7.7306E+01
  27  8.1426E+01
  28  8.5643E+01
  29  8.9958E+01
  30  9.4374E+01
  31  9.8894E+01
  32  1.0352E+02
  33  1.0825E+02
  34  1.1310E+02
  35  1.1806E+02
  36  1.2313E+02
  37  1.2832E+02
  38  1.3364E+02
  39  1.3908E+02
  40  1.4464E+02
  41  1.5034E+02
  42  1.5617E+02
  43  1.6213E+02
  44  1.6824E+02
  45  1.7449E+02
  46  1.8088E+02
```

```
 47  1.8743E+02
 48  1.9413E+02
 49  2.0098E+02
 50  2.0800E+02
 51  2.1518E+02
 52  2.2252E+02
 53  2.3004E+02
 54  2.3774E+02
 55  2.4562E+02
 56  2.5368E+02
 57  2.6193E+02
 58  2.7037E+02
 59  2.7901E+02
 60  2.8785E+02
 61  2.9690E+02
 62  3.0616E+02
 63  3.1564E+02
 64  3.2534E+02
 65  3.3526E+02
 66  3.4542E+02
 67  3.5582E+02
 68  3.6646E+02
 69  3.7735E+02
 70  3.8849E+02
 71  3.9990E+02
 72  4.1157E+02
 73  4.2352E+02
 74  4.3574E+02
 75  4.4825E+02
 76  4.6106E+02
 77  4.7416E+02
 78  4.8757E+02
 79  5.0130E+02
 80  5.1535E+02
 81  5.2972E+02
 82  5.4443E+02
 83  5.5949E+02
 84  5.7490E+02
 85  5.9067E+02
 86  6.0680E+02
 87  6.2332E+02
 88  6.4022E+02
 89  6.5752E+02
 90  6.7523E+02
 91  6.9334E+02
 92  7.1189E+02
 93  7.3086E+02
 94  7.5028E+02
 95  7.7016E+02
 96  7.9050E+02
 97  8.1132E+02
 98  8.3262E+02
 99  8.5442E+02
100  8.7674E+02
101  8.9957E+02
102  9.2294E+02
103  9.4686E+02
104  9.7134E+02
105  9.9639E+02
106  1.0220E+03
107  1.0483E+03
108  1.0751E+03
109  1.1026E+03
110  1.1307E+03
111  1.1595E+03
```

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112  1.1890E+03
113  1.2191E+03
114  1.2500E+03
115  1.2815E+03
116  1.3138E+03
117  1.3469E+03
118  1.3808E+03
119  1.4154E+03
120  1.4508E+03
121  1.4871E+03
122  1.5242E+03
123  1.5622E+03
124  1.6011E+03
125  1.6409E+03
126  1.6816E+03
127  1.7233E+03
128  1.7660E+03
129  1.8096E+03
130  1.8543E+03
131  1.9000E+03
132  1.9468E+03
133  1.9947E+03
134  2.0437E+03
135  2.0939E+03
136  2.1452E+03
137  2.1977E+03
138  2.2515E+03
139  2.3065E+03
140  2.3628E+03
141  2.4204E+03
142  2.4794E+03
143  2.5398E+03
144  2.6015E+03
145  2.6648E+03
146  2.7295E+03
147  2.7957E+03
148  2.8634E+03
149  2.9328E+03
150  3.0038E+03
151  3.0764E+03
152  3.1507E+03
153  3.2268E+03
154  3.3046E+03
155  3.3843E+03
156  3.4659E+03
157  3.5493E+03
158  3.6347E+03
159  3.7221E+03
160  3.8116E+03
161  3.9031E+03
162  3.9968E+03
163  4.0927E+03
164  4.1908E+03
165  4.2912E+03
166  4.3940E+03
167  4.4992E+03
168  4.6068E+03
169  4.7170E+03
170  4.8297E+03
171  4.9451E+03
172  5.0632E+03
173  5.1840E+03
174  5.3077E+03
175  5.4343E+03
176  5.5638E+03
```

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 177  5.6964E+03
 178  5.8321E+03
 179  5.9709E+03
 180  6.1130E+03
 181  6.2584E+03
 182  6.4073E+03
 183  6.5596E+03
 184  6.7154E+03
 185  6.8750E+03
 186  7.0382E+03
 187  7.2053E+03
 188  7.3763E+03
 189  7.5513E+03
 190  7.7304E+03
 191  7.9137E+03
 192  8.1013E+03
 193  8.2933E+03
 194  8.4897E+03
 195  8.6908E+03
 196  8.8966E+03
 197  9.1072E+03
 198  9.3227E+03
 199  9.5433E+03
 200  9.7690E+03
 201  1.0000E+04
 202  1.0734E+04
 203  1.1682E+04
 204  1.2907E+04
 205  1.4488E+04
 206  1.6531E+04
 207  1.9169E+04
 208  2.2576E+04
 209  2.6976E+04
 210  3.2660E+04
 211  4.0000E+04

(the following values are for each vector)


numberofevents =     217
event  timeofseismicevents   typeofseismicevents
   1         2.7298E+02         1.5000E-01
   2         3.6246E+02         5.0000E-02
   3         4.9809E+02         5.0000E-02
   4         9.6572E+02         5.0000E-02
   5         9.7723E+02         5.0000E-02
   6         1.0031E+03         1.0000E-01
   7         1.2102E+03         1.0000E-01
   8         1.2514E+03         5.0000E-02
   9         1.6458E+03         5.0000E-02
  10         1.8328E+03         5.0000E-02
  11         2.0590E+03         1.0000E-01
  12         2.2055E+03         2.5000E-01
  13         2.9203E+03         5.0000E-02
  14         2.9428E+03         5.0000E-02
  15         3.1100E+03         1.0000E-01
  16         3.1212E+03         5.0000E-02
  17         3.4762E+03         5.0000E-02
  18         3.4979E+03         1.0000E-01
  19         3.5065E+03         5.0000E-02
  20         3.9697E+03         5.0000E-02
  21         4.5088E+03         5.0000E-02
  22         4.5613E+03         5.0000E-02
  23         4.8013E+03         5.0000E-02
```

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 24          5.0922E+03          2.5000E-01
 25          5.2610E+03          5.0000E-02
 26          5.4587E+03          1.0000E-01
 27          5.5595E+03          5.0000E-02
 28          5.7334E+03          1.0000E-01
 29          6.3194E+03          5.0000E-02
 30          6.6236E+03          5.0000E-02
 31          6.7108E+03          5.0000E-02
 32          6.7383E+03          5.0000E-02
 33          6.7562E+03          2.0000E-01
 34          6.8693E+03          1.0000E-01
 35          6.9456E+03          5.0000E-02
 36          7.7367E+03          5.0000E-02
 37          7.8938E+03          1.0000E-01
 38          8.2304E+03          1.0000E-01
 39          8.2464E+03          1.0000E-01
 40          8.3806E+03          2.0000E-01
 41          8.3901E+03          5.0000E-02
 42          8.4474E+03          5.0000E-02
 43          8.5128E+03          5.0000E-02
 44          8.7196E+03          1.5000E-01
 45          9.0950E+03          5.0000E-02
 46          9.0985E+03          5.0000E-02
 47          9.2890E+03          5.0000E-02
 48          9.3930E+03          5.0000E-02
 49          9.4451E+03          5.0000E-02
 50          9.4499E+03          5.0000E-02
 51          9.6703E+03          5.0000E-02
 52          9.7050E+03          5.0000E-02
 53          9.9602E+03          2.0000E-01
 54          1.0038E+04          5.0000E-02
 55          1.0072E+04          5.0000E-02
 56          1.0115E+04          1.5000E-01
 57          1.0378E+04          5.0000E-02
 58          1.0534E+04          5.0000E-02
 59          1.0565E+04          5.0000E-02
 60          1.1747E+04          5.0000E-02
 61          1.1831E+04          1.0000E-01
 62          1.1932E+04          5.0000E-02
 63          1.2249E+04          5.0000E-02
 64          1.2560E+04          5.0000E-02
 65          1.2808E+04          5.0000E-02
 66          1.2999E+04          5.0000E-02
 67          1.2999E+04          5.0000E-02
 68          1.3008E+04          1.0000E-01
 69          1.3194E+04          1.0000E-01
 70          1.3194E+04          5.0000E-02
 71          1.3380E+04          5.0000E-02
 72          1.3393E+04          1.5000E-01
 73          1.3394E+04          5.0000E-02
 74          1.3455E+04          5.0000E-02
 75          1.3468E+04          1.5000E-01
 76          1.3485E+04          5.0000E-02
 77          1.4190E+04          5.0000E-02
 78          1.4515E+04          5.0000E-02
 79          1.4676E+04          5.0000E-02
 80          1.5279E+04          1.5000E-01
 81          1.5751E+04          5.0000E-01
 82          1.5844E+04          2.0000E-01
 83          1.5957E+04          3.0000E-01
 84          1.6040E+04          5.0000E-02
 85          1.6501E+04          1.0000E-01
 86          1.6824E+04          1.0000E-01
 87          1.6831E+04          5.0000E-02
 88          1.7187E+04          5.0000E-02
```

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  89        1.7304E+04        1.0000E-01
  90        1.7406E+04        3.5000E-01
  91        1.7608E+04        5.0000E-02
  92        1.7703E+04        5.0000E-02
  93        1.7881E+04        5.0000E-02
  94        1.7922E+04        5.0000E-02
  95        1.7926E+04        1.5000E-01
  96        1.7942E+04        1.5000E-01
  97        1.8274E+04        5.0000E-02
  98        1.8558E+04        5.0000E-02
  99        1.8909E+04        5.0000E-02
 100        1.9030E+04        1.0000E-01
 101        1.9157E+04        1.0000E-01
 102        1.9997E+04        2.0000E-01
 103        2.0146E+04        1.0000E-01
 104        2.0371E+04        5.0000E-02
 105        2.0452E+04        5.0000E-02
 106        2.0497E+04        5.0000E-02
 107        2.0761E+04        5.0000E-02
 108        2.0808E+04        5.0000E-02
 109        2.1028E+04        1.0000E-01
 110        2.1092E+04        1.0000E-01
 111        2.1144E+04        1.5000E-01
 112        2.1296E+04        5.0000E-02
 113        2.1514E+04        5.0000E-02
 114        2.1717E+04        5.0000E-02
 115        2.2017E+04        1.5000E-01
 116        2.2045E+04        5.0000E-02
 117        2.2068E+04        5.0000E-02
 118        2.2343E+04        5.0000E-02
 119        2.2419E+04        1.0000E-01
 120        2.2806E+04        5.0000E-02
 121        2.2870E+04        5.0000E-02
 122        2.2871E+04        5.0000E-02
 123        2.3040E+04        5.0000E-02
 124        2.3190E+04        3.0000E-01
 125        2.3323E+04        5.0000E-02
 126        2.3368E+04        5.0000E-02
 127        2.3681E+04        5.0000E-02
 128        2.3978E+04        5.0000E-02
 129        2.4147E+04        5.0000E-02
 130        2.4171E+04        5.0000E-02
 131        2.4183E+04        1.0000E-01
 132        2.4197E+04        1.0000E-01
 133        2.4498E+04        5.0000E-02
 134        2.4573E+04        5.0000E-02
 135        2.4727E+04        5.0000E-02
 136        2.5085E+04        5.0000E-02
 137        2.5197E+04        5.0000E-02
 138        2.5243E+04        1.0000E-01
 139        2.5756E+04        1.0000E-01
 140        2.5828E+04        1.0000E-01
 141        2.6270E+04        5.0000E-02
 142        2.6579E+04        1.5000E-01
 143        2.6738E+04        5.0000E-02
 144        2.6768E+04        5.0000E-02
 145        2.7357E+04        5.0000E-02
 146        2.7364E+04        5.0000E-02
 147        2.7450E+04        5.0000E-02
 148        2.7640E+04        5.0000E-02
 149        2.7957E+04        5.0000E-02
 150        2.8037E+04        5.0000E-02
 151        2.8303E+04        5.0000E-02
 152        2.8359E+04        2.0000E-01
 153        2.8413E+04        5.0000E-02
```

```
  154         2.8606E+04         1.0000E-01
  155         2.8697E+04         5.0000E-02
  156         2.8818E+04         1.0000E-01
  157         2.9202E+04         5.0000E-02
  158         2.9350E+04         5.0000E-02
  159         2.9409E+04         5.0000E-02
  160         2.9494E+04         1.5000E-01
  161         3.0062E+04         5.0000E-02
  162         3.0106E+04         5.0000E-02
  163         3.0245E+04         5.0000E-02
  164         3.0353E+04         5.0000E-02
  165         3.0546E+04         1.0000E-01
  166         3.0622E+04         5.0000E-02
  167         3.0657E+04         5.0000E-02
  168         3.0855E+04         5.0000E-02
  169         3.0965E+04         5.0000E-02
  170         3.1695E+04         5.0000E-02
  171         3.1798E+04         5.0000E-02
  172         3.1799E+04         1.0000E-01
  173         3.2063E+04         1.0000E-01
  174         3.2319E+04         1.0000E-01
  175         3.2326E+04         1.5000E-01
  176         3.2427E+04         5.0000E-02
  177         3.2486E+04         1.0000E-01
  178         3.2611E+04         2.0000E-01
  179         3.2684E+04         1.0000E-01
  180         3.2791E+04         5.0000E-02
  181         3.2920E+04         5.0000E-02
  182         3.3348E+04         5.0000E-02
  183         3.3410E+04         5.0000E-02
  184         3.3623E+04         5.0000E-02
  185         3.3689E+04         1.0000E-01
  186         3.4048E+04         5.0000E-02
  187         3.4533E+04         5.0000E-02
  188         3.4610E+04         1.0000E-01
  189         3.4664E+04         1.0000E-01
  190         3.4832E+04         5.0000E-02
  191         3.4974E+04         5.0000E-02
  192         3.5139E+04         1.5000E-01
  193         3.5391E+04         5.0000E-02
  194         3.5581E+04         5.0000E-02
  195         3.5604E+04         5.0000E-02
  196         3.5679E+04         5.0000E-02
  197         3.6096E+04         2.5000E-01
  198         3.6099E+04         5.0000E-02
  199         3.6114E+04         5.0000E-02
  200         3.6119E+04         5.0000E-02
  201         3.6344E+04         5.0000E-02
  202         3.6410E+04         1.0000E-01
  203         3.6652E+04         5.0000E-02
  204         3.6743E+04         2.0000E-01
  205         3.7527E+04         5.0000E-02
  206         3.7543E+04         2.5000E-01
  207         3.8577E+04         5.0000E-02
  208         3.8607E+04         5.0000E-02
  209         3.8844E+04         5.0000E-02
  210         3.8857E+04         5.0000E-01
  211         3.9120E+04         5.0000E-02
  212         3.9284E+04         1.0000E-01
  213         3.9491E+04         1.0000E-01
  214         3.9552E+04         5.0000E-02
  215         3.9588E+04         1.5000E-01
  216         3.9611E+04         1.0000E-01
  217         3.9726E+04         1.0000E-01
```

```
REALIZATION    2


ALL SUBAREAS


numberofevents =    238
event  timeofseismicevents   typeofseismicevents
   1        1.2527E+01        5.0000E-02
   2        3.9924E+02        5.0000E-02
   3        4.1373E+02        5.0000E-02
   4        4.6255E+02        5.0000E-02
   5        7.3680E+02        1.5000E-01
   6        8.1708E+02        5.0000E-02
   7        8.2961E+02        5.0000E-02
   8        9.6140E+02        5.0000E-02
   9        1.0032E+03        5.0000E-02
  10        1.1745E+03        5.0000E-02
  11        1.3062E+03        5.0000E-02
  12        1.3894E+03        5.0000E-02
  13        1.4566E+03        1.0000E-01
  14        1.5558E+03        1.5000E-01
  15        1.5909E+03        5.0000E-02
  16        1.7819E+03        1.0000E-01
  17        2.4110E+03        5.0000E-02
  18        2.4258E+03        5.0000E-02
  19        2.6411E+03        5.0000E-02
  20        2.6501E+03        1.0000E-01
  21        2.9539E+03        1.0000E-01
  22        3.3314E+03        5.0000E-02
  23        3.6335E+03        5.0000E-02
  24        3.6865E+03        5.0000E-02
  25        3.7051E+03        3.0000E-01
  26        3.9448E+03        1.0000E-01
  27        3.9595E+03        5.0000E-02
  28        4.0632E+03        3.0000E-01
  29        4.1099E+03        1.0000E-01
  30        4.3373E+03        1.0000E-01
  31        4.5935E+03        1.5000E-01
  32        4.6667E+03        5.0000E-02
  33        4.9332E+03        5.0000E-02
  34        5.1303E+03        5.0000E-02
  35        5.2975E+03        1.0000E-01
  36        5.4241E+03        5.0000E-02
  37        5.5428E+03        1.5000E-01
  38        5.8311E+03        5.0000E-02
  39        6.0744E+03        1.0000E-01
  40        6.1510E+03        5.0000E-02
  41        6.3262E+03        4.5000E-01
  42        6.6136E+03        5.0000E-02
  43        6.6610E+03        5.0000E-02
  44        6.7401E+03        5.0000E-02
  45        6.8756E+03        2.5000E-01
  46        6.9212E+03        5.0000E-02
  47        7.1608E+03        5.0000E-02
  48        7.2093E+03        5.0000E-02
  49        7.3820E+03        5.0000E-02
  50        7.4428E+03        1.5000E-01
  51        7.4735E+03        5.0000E-02
  52        7.6353E+03        5.0000E-02
  53        7.8756E+03        5.0000E-02
  54        7.9252E+03        5.0000E-02
  55        7.9709E+03        5.0000E-02
  56        8.0213E+03        2.0000E-01
  57        8.0659E+03        5.0000E-02
```

```
  58        8.2442E+03        1.0000E-01
  59        8.4413E+03        5.0000E-02
  60        8.4479E+03        5.0000E-02
  61        8.6398E+03        1.0000E-01
  62        9.1217E+03        5.0000E-02
  63        9.1770E+03        5.0000E-02
  64        9.2414E+03        1.0000E-01
  65        9.2961E+03        5.0000E-02
  66        9.3155E+03        1.0000E-01
  67        9.7329E+03        1.0000E-01
  68        1.0267E+04        1.0000E-01
  69        1.0486E+04        1.0000E-01
  70        1.0840E+04        5.0000E-02
  71        1.0964E+04        2.0000E-01
  72        1.1392E+04        2.5000E-01
  73        1.1543E+04        1.0000E-01
  74        1.1678E+04        1.5000E-01
  75        1.2014E+04        5.0000E-02
  76        1.2060E+04        5.0000E-02
  77        1.2432E+04        1.0000E-01
  78        1.2510E+04        5.0000E-02
  79        1.2568E+04        1.5000E-01
  80        1.2759E+04        1.0000E-01
  81        1.2843E+04        1.0000E-01
  82        1.3269E+04        5.0000E-02
  83        1.3377E+04        5.0000E-02
  84        1.3526E+04        1.0000E-01
  85        1.3545E+04        5.0000E-02
  86        1.3558E+04        1.0000E-01
  87        1.3840E+04        1.0000E-01
  88        1.4116E+04        5.0000E-02
  89        1.4142E+04        5.0000E-02
  90        1.4333E+04        5.0000E-02
  91        1.4375E+04        5.0000E-02
  92        1.4489E+04        5.0000E-02
  93        1.4901E+04        1.5000E-01
  94        1.5097E+04        2.5000E-01
  95        1.5264E+04        5.0000E-02
  96        1.5436E+04        5.0000E-02
  97        1.5738E+04        1.0000E-01
  98        1.5783E+04        5.0000E-02
  99        1.5902E+04        5.0000E-02
 100        1.5930E+04        5.0000E-02
 101        1.6516E+04        1.0000E-01
 102        1.6721E+04        5.0000E-02
 103        1.6800E+04        1.0000E-01
 104        1.6996E+04        2.0000E-01
 105        1.7294E+04        5.0000E-02
 106        1.7410E+04        5.0000E-02
 107        1.7584E+04        5.0000E-02
 108        1.7637E+04        5.0000E-02
 109        1.8229E+04        5.0000E-02
 110        1.8516E+04        5.0000E-02
 111        1.8545E+04        5.0000E-02
 112        1.8755E+04        5.0000E-02
 113        1.9105E+04        5.0000E-02
 114        1.9319E+04        1.0000E-01
 115        1.9371E+04        1.5000E-01
 116        1.9496E+04        5.0000E-02
 117        1.9699E+04        5.0000E-02
 118        1.9738E+04        1.0000E-01
 119        1.9768E+04        5.0000E-02
 120        1.9785E+04        5.0000E-02
 121        2.0044E+04        1.5000E-01
 122        2.0097E+04        1.0000E-01
```

```
   123        2.0755E+04        1.0000E-01
   124        2.0978E+04        5.0000E-02
   125        2.0994E+04        5.0000E-02
   126        2.1018E+04        5.0000E-02
   127        2.1220E+04        5.0000E-02
   128        2.1287E+04        5.0000E-02
   129        2.1417E+04        5.0000E-02
   130        2.1509E+04        5.0000E-02
   131        2.1565E+04        1.0000E-01
   132        2.1711E+04        1.0000E-01
   133        2.1809E+04        5.0000E-02
   134        2.1825E+04        5.0000E-02
   135        2.2191E+04        1.0000E-01
   136        2.2278E+04        1.0000E-01
   137        2.2314E+04        5.0000E-02
   138        2.2518E+04        5.0000E-02
   139        2.2714E+04        1.0000E-01
   140        2.2781E+04        1.5000E-01
   141        2.2884E+04        5.0000E-02
   142        2.3499E+04        1.5000E-01
   143        2.4294E+04        5.0000E-02
   144        2.4477E+04        1.0000E-01
   145        2.4528E+04        5.0000E-02
   146        2.4606E+04        1.5000E-01
   147        2.4606E+04        5.0000E-02
   148        2.4695E+04        1.0000E-01
   149        2.4788E+04        1.0000E-01
   150        2.5333E+04        1.5000E-01
   151        2.5348E+04        1.0000E-01
   152        2.5358E+04        5.0000E-02
   153        2.5400E+04        1.0000E-01
   154        2.5718E+04        5.0000E-02
   155        2.5982E+04        1.5000E-01
   156        2.6200E+04        5.0000E-02
   157        2.6200E+04        1.0000E-01
   158        2.6609E+04        5.0000E-02
   159        2.6764E+04        2.5000E-01
   160        2.6916E+04        1.0000E-01
   161        2.6925E+04        5.0000E-02
   162        2.7066E+04        5.0000E-02
   163        2.7382E+04        5.0000E-02
   164        2.8268E+04        1.0000E-01
   165        2.8370E+04        5.0000E-02
   166        2.8392E+04        5.0000E-02
   167        2.8606E+04        1.0000E-01
   168        2.8648E+04        5.0000E-02
   169        2.8677E+04        5.0000E-02
   170        2.9052E+04        5.0000E-02
   171        2.9173E+04        5.0000E-02
   172        2.9242E+04        2.0000E-01
   173        2.9431E+04        1.0000E-01
   174        2.9784E+04        5.0000E-02
   175        3.0277E+04        1.5000E-01
   176        3.0495E+04        1.0000E-01
   177        3.0564E+04        5.0000E-02
   178        3.0578E+04        5.0000E-02
   179        3.0810E+04        5.0000E-02
   180        3.0818E+04        5.0000E-02
   181        3.1343E+04        5.0000E-02
   182        3.1768E+04        5.0000E-02
   183        3.1880E+04        2.0000E-01
   184        3.1990E+04        5.0000E-02
   185        3.1991E+04        5.0000E-02
   186        3.2085E+04        5.0000E-02
   187        3.2106E+04        2.0000E-01
```

```
  188          3.2157E+04          1.5000E-01
  189          3.2229E+04          1.0000E-01
  190          3.2251E+04          5.0000E-02
  191          3.2300E+04          1.5000E-01
  192          3.2325E+04          5.0000E-02
  193          3.2720E+04          5.0000E-02
  194          3.2792E+04          1.5000E-01
  195          3.2820E+04          1.0000E-01
  196          3.2889E+04          5.0000E-02
  197          3.3010E+04          2.0000E-01
  198          3.3129E+04          5.0000E-02
  199          3.3374E+04          5.0000E-02
  200          3.3443E+04          1.0000E-01
  201          3.3770E+04          5.0000E-02
  202          3.3778E+04          5.0000E-02
  203          3.3836E+04          5.0000E-02
  204          3.3990E+04          5.0000E-02
  205          3.4093E+04          5.0000E-02
  206          3.4223E+04          1.5000E-01
  207          3.4275E+04          1.0000E-01
  208          3.4624E+04          3.5000E-01
  209          3.4764E+04          5.0000E-02
  210          3.4822E+04          5.0000E-02
  211          3.4841E+04          1.0000E-01
  212          3.5037E+04          5.0000E-02
  213          3.5101E+04          5.0000E-02
  214          3.5171E+04          2.0000E-01
  215          3.5214E+04          5.0000E-02
  216          3.5266E+04          1.0000E-01
  217          3.5535E+04          5.0000E-02
  218          3.5559E+04          5.0000E-02
  219          3.5683E+04          1.0000E-01
  220          3.5695E+04          1.0000E-01
  221          3.6137E+04          2.5000E-01
  222          3.6185E+04          5.0000E-02
  223          3.6333E+04          1.5000E-01
  224          3.6517E+04          5.0000E-02
  225          3.6622E+04          5.0000E-02
  226          3.6634E+04          2.0000E-01
  227          3.7347E+04          1.0000E-01
  228          3.7440E+04          5.0000E-02
  229          3.7579E+04          5.0000E-02
  230          3.8282E+04          5.0000E-02
  231          3.8564E+04          3.5000E-01
  232          3.8686E+04          5.0000E-02
  233          3.8918E+04          5.0000E-02
  234          3.9107E+04          5.0000E-02
  235          3.9149E+04          3.5000E-01
  236          3.9445E+04          5.0000E-02
  237          3.9470E+04          5.0000E-02
  238          3.9760E+04          5.0000E-02
```

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```
=========================================================================
         exec: Welcome to TPA Version 4.0beta
       Job started: Fri Mar  3 10:59:38 2000
=========================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea    Area       Waste   Number of WP
    #      [m^2]       [MTU]
    1    723591.3    14200.8        1455
    2    784763.0    15303.7        1568
    3    390372.0     7564.0         775
    4    207581.3     4157.8         426
    5    378972.8     7417.6         760
    6    424872.5     8305.8         851
    7    163938.3     3152.5         323
    8    393468.9     7944.6         814

 Total Area [acre]           =      856.82238463061
 Total Buried Waste [MTU]    =      68046.720000000
 Repository AML [MTU/acre]   =      79.417532992367

 Specified Global Parameters:

               Compliance Period =  10000.0 (yr)
         Maximum Simulation Time = 100000.0 (yr)
          Number Of Realizations =       2
              Number Of Subareas =       8
              Volcanism scenario =       1 (yes=1, no=0)
               Faulting scenario =       1 (yes=1, no=0)
                Seismic scenario =       1 (yes=1, no=0)
      Distance to Receptor Group =     20.0 (km)


 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**


 ***>>> NOTE: When running with volcanism, verify that   <<<***
 ***>>> the maximum value of the PDF for parameter       <<<***
 ***>>> TimeOfNextVolcanicEventinRegionOfInterest[yr] is <<<***
 ***>>> equal to the parameter MaximumTime[yr].          <<<***


 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C*
*

   ***>>> WARNING: THE APPEND OPTION IS SELECTED <<<***
 (see "OutputMode(0=None,1=All,2=UserDefined)" in tpa.inp)
 For "SelectAppendFiles", a value of 4 (seismo.ech and seismo.rlt only) was set
in tpa.inp.
 By selecting this option, files are written which may require    1 meg of disk
space.
 (more disk space could be needed)

-------------------------------------------------------------------------
     subarea    1 of    8           realization    1 of    2
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
      ebsfail: time of WP failure =    23464.0  yr
```

```
 exec: calling seismo
 exec: calling faulto
 exec: calling volcano
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
 exec: failed WPs from CORROSION event =   1451 at time =  23464.0 yr
  *** failed WPs: all WPs failed (  1455) ***
  Total WPs may not equal sum of event WPs due to roundoff.
 exec: calling ebsrel
                   Highest release rates from Sub Area  1
          Tc99    9.2530E-02 [Ci/yr/SA] at  2.959E+04 yr
          Ni59    1.8244E-02 [Ci/yr/SA] at  2.959E+04 yr
          Am243   1.2853E-02 [Ci/yr/SA] at  2.959E+04 yr
          Np237   7.8961E-03 [Ci/yr/SA] at  2.959E+04 yr
          Th230   7.1906E-03 [Ci/yr/SA] at  1.000E+05 yr
          Pu239   6.0218E-03 [Ci/yr/SA] at  4.773E+04 yr
 exec: calling uzft
      *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                       Highest release rates from UZ
          Tc99    9.2530E-02 [Ci/yr/SA] at  2.959E+04 yr
          Ni59    1.8244E-02 [Ci/yr/SA] at  2.959E+04 yr
          Am243   1.2853E-02 [Ci/yr/SA] at  2.959E+04 yr
          Np237   7.8961E-03 [Ci/yr/SA] at  2.959E+04 yr
          Th230   7.1906E-03 [Ci/yr/SA] at  1.000E+05 yr
          Pu239   6.0218E-03 [Ci/yr/SA] at  4.773E+04 yr
 exec: calling szft
                       Highest release rates from SZ
          Tc99    7.5643E-02 [Ci/yr/SA] at  6.093E+04 yr
          Se79    1.4790E-03 [Ci/yr/SA] at  6.093E+04 yr
          I129    2.2579E-04 [Ci/yr/SA] at  3.751E+04 yr
          U234    9.7808E-05 [Ci/yr/SA] at  6.093E+04 yr
          Cl36    6.5573E-05 [Ci/yr/SA] at  3.751E+04 yr
          U238    2.6022E-05 [Ci/yr/SA] at  6.093E+04 yr
 exec: calling dcagw
                       Highest annual dose GW pathway
          I129    4.3545E-02 [mrem/yr]  at  3.751E+04 yr
          Tc99    2.3860E-02 [mrem/yr]  at  6.093E+04 yr
          U234    5.0976E-03 [mrem/yr]  at  6.093E+04 yr
          Se79    4.8926E-03 [mrem/yr]  at  6.093E+04 yr
          U238    1.2299E-03 [mrem/yr]  at  6.093E+04 yr
          Cl36    4.4026E-04 [mrem/yr]  at  3.751E+04 yr
        At end of TPI, annual dose GW pathway
          I129    3.2462E-02 [mrem/yr]
          Tc99    2.3368E-02 [mrem/yr]
          Se79    2.8984E-03 [mrem/yr]
          U234    1.5150E-03 [mrem/yr]
          U238    4.0841E-04 [mrem/yr]
          Cl36    2.7373E-04 [mrem/yr]
            sum   6.0952E-02 [mrem/yr]
 exec: calling ashplumo
 exec: calling ashrmovo
 exec: calling dcags
                       Highest annual dose from GS
          Pu240   8.4854E+02 [mrem/yr] at  1.682E+03 yr
          Am241   6.7192E+02 [mrem/yr] at  1.682E+03 yr
          Pu239   5.9676E+02 [mrem/yr] at  1.682E+03 yr
          Am243   4.7546E+01 [mrem/yr] at  1.682E+03 yr
          Pu242   4.2009E+00 [mrem/yr] at  1.682E+03 yr
          Np237   3.5436E+00 [mrem/yr] at  1.682E+03 yr
-----------------------------------------------------------------------------
    subarea    1 of    8          realization    2 of    2
-----------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling ebsfail
```

```
      ebsfail: time of WP failure =    15046.3  yr
 exec: calling seismo
 exec: calling faulto
 exec: calling volcano
 exec: failed WPs from INITIAL   event =     11 at time =      0.0 yr
 exec: failed WPs from SEISMIC   event =      4 at time =   6258.4 yr
 exec: failed WPs from CORROSION event =   1441 at time =  15046.3 yr
  *** failed WPs: all WPs failed (  1455) ***
  Total WPs may not equal sum of event WPs due to roundoff.
 exec: calling ebsrel
                    Highest release rates from Sub Area  1
              Tc99    3.5539E-01 [Ci/yr/SA] at  2.346E+04 yr
              Ni59    5.2978E-02 [Ci/yr/SA] at  2.346E+04 yr
              Pb210   3.1128E-02 [Ci/yr/SA] at  6.093E+04 yr
              Cs135   2.9196E-02 [Ci/yr/SA] at  2.346E+04 yr
              Se79    2.1998E-02 [Ci/yr/SA] at  2.346E+04 yr
              Ra226   1.2496E-02 [Ci/yr/SA] at  4.773E+04 yr
 exec: calling uzft
        *** NEFTRAN is skipped for this UZ path since no layers have significant
ground water travel time. ***
                        Highest release rates from UZ
              Tc99    3.5539E-01 [Ci/yr/SA] at  2.346E+04 yr
              Ni59    5.2978E-02 [Ci/yr/SA] at  2.346E+04 yr
              Pb210   3.1128E-02 [Ci/yr/SA] at  6.093E+04 yr
              Cs135   2.9196E-02 [Ci/yr/SA] at  2.346E+04 yr
              Se79    2.1998E-02 [Ci/yr/SA] at  2.346E+04 yr
              Ra226   1.2496E-02 [Ci/yr/SA] at  4.773E+04 yr
 exec: calling szft
                        Highest release rates from SZ
              Tc99    3.0874E-01 [Ci/yr/SA] at  2.346E+04 yr
              Ni59    4.3481E-02 [Ci/yr/SA] at  2.959E+04 yr
              Se79    1.1809E-02 [Ci/yr/SA] at  2.959E+04 yr
              Np237   9.4299E-03 [Ci/yr/SA] at  4.773E+04 yr
              I129    1.8961E-03 [Ci/yr/SA] at  2.346E+04 yr
              Cl36    1.0471E-03 [Ci/yr/SA] at  2.346E+04 yr
 exec: calling dcagw
                        Highest annual dose GW pathway
              Np237   3.3465E+00 [mrem/yr]  at  4.773E+04 yr
              I129    2.7464E-01 [mrem/yr]  at  2.346E+04 yr
              Tc99    4.8025E-02 [mrem/yr]  at  2.346E+04 yr
              Se79    2.6461E-02 [mrem/yr]  at  2.959E+04 yr
              Ni59    6.5787E-03 [mrem/yr]  at  2.959E+04 yr
              Cl36    5.2285E-03 [mrem/yr]  at  2.346E+04 yr
             At end of TPI, annual dose GW pathway
              Np237   7.4423E-01 [mrem/yr]
              I129    3.2116E-02 [mrem/yr]
              Tc99    1.4318E-02 [mrem/yr]
              Se79    1.9327E-03 [mrem/yr]
              Ni59    1.0762E-03 [mrem/yr]
              Cl36    2.7349E-04 [mrem/yr]
                sum   7.9395E-01 [mrem/yr]
 exec: calling ashplumo
 exec: calling ashrmovo
 exec: calling dcags
                        Highest annual dose from GS
               Pu239  7.0818E+03 [mrem/yr] at  8.101E+03 yr
               Pu240  6.0633E+03 [mrem/yr] at  8.101E+03 yr
               Am243  3.6760E+02 [mrem/yr] at  8.101E+03 yr
               Pu242  5.8635E+01 [mrem/yr] at  8.101E+03 yr
               Np237  5.2928E+01 [mrem/yr] at  8.101E+03 yr
                U234  1.9235E+01 [mrem/yr] at  8.101E+03 yr
 exec: end realizations

 exec:  Run Successfully Completed
```

```
Input file tpa.inp as supplied with TPA Version 4.0beta Code.
Test 298_5 TPI=100,000.
TPA 4.0beta, Job started: Fri Mar  3 10:59:38 2000
Number of Failed WPs by Type of Disruptive Event

Including Time of Event - Values for Each Vector


    vector          time          #corrode        #seismic         #fault
    #igact
   unitless          yr           unitless        unitless        unitless
   unitless
        1        2.3464E+04      1.4510E+03      0.0000E+00      0.0000E+00
  0.0000E+00
        2        6.2584E+03      0.0000E+00      4.0000E+00      0.0000E+00
  0.0000E+00
        2        1.5046E+04      1.4410E+03      0.0000E+00      0.0000E+00
  0.0000E+00
        2        4.7727E+04      0.0000E+00      0.0000E+00      0.0000E+00
  0.0000E+00
        2        6.0928E+04      0.0000E+00      0.0000E+00      0.0000E+00
  0.0000E+00
```

```
 Input file tpa.inp as supplied with TPA Version 4.0beta Code.
 Test 298_5 TPI=100,000.
 TPA 4.0beta, Job started: Fri Mar  3 10:59:38 2000
 Echo of SEISMO Input Values

 with the output mode specified in "tpa.inp"


REALIZATION    1


ALL SUBAREAS

(same values and times for all subareas and vectors)

   ntim
    211

        time
   1  0.0000E+00
   2  2.3102E+00
   3  4.6744E+00
   4  7.0940E+00
   5  9.5702E+00
   6  1.2104E+01
   7  1.4698E+01
   8  1.7352E+01
   9  2.0069E+01
  10  2.2849E+01
  11  2.5694E+01
  12  2.8605E+01
  13  3.1585E+01
  14  3.4635E+01
  15  3.7756E+01
  16  4.0950E+01
  17  4.4219E+01
  18  4.7564E+01
  19  5.0988E+01
  20  5.4492E+01
  21  5.8078E+01
  22  6.1747E+01
  23  6.5503E+01
  24  6.9347E+01
  25  7.3281E+01
  26  7.7306E+01
  27  8.1426E+01
  28  8.5643E+01
  29  8.9958E+01
  30  9.4374E+01
  31  9.8894E+01
  32  1.0352E+02
  33  1.0825E+02
  34  1.1310E+02
  35  1.1806E+02
  36  1.2313E+02
  37  1.2832E+02
  38  1.3364E+02
  39  1.3908E+02
  40  1.4464E+02
  41  1.5034E+02
  42  1.5617E+02
  43  1.6213E+02
  44  1.6824E+02
  45  1.7449E+02
  46  1.8088E+02
```

```
 47  1.8743E+02
 48  1.9413E+02
 49  2.0098E+02
 50  2.0800E+02
 51  2.1518E+02
 52  2.2252E+02
 53  2.3004E+02
 54  2.3774E+02
 55  2.4562E+02
 56  2.5368E+02
 57  2.6193E+02
 58  2.7037E+02
 59  2.7901E+02
 60  2.8785E+02
 61  2.9690E+02
 62  3.0616E+02
 63  3.1564E+02
 64  3.2534E+02
 65  3.3526E+02
 66  3.4542E+02
 67  3.5582E+02
 68  3.6646E+02
 69  3.7735E+02
 70  3.8849E+02
 71  3.9990E+02
 72  4.1157E+02
 73  4.2352E+02
 74  4.3574E+02
 75  4.4825E+02
 76  4.6106E+02
 77  4.7416E+02
 78  4.8757E+02
 79  5.0130E+02
 80  5.1535E+02
 81  5.2972E+02
 82  5.4443E+02
 83  5.5949E+02
 84  5.7490E+02
 85  5.9067E+02
 86  6.0680E+02
 87  6.2332E+02
 88  6.4022E+02
 89  6.5752E+02
 90  6.7523E+02
 91  6.9334E+02
 92  7.1189E+02
 93  7.3086E+02
 94  7.5028E+02
 95  7.7016E+02
 96  7.9050E+02
 97  8.1132E+02
 98  8.3262E+02
 99  8.5442E+02
100  8.7674E+02
101  8.9957E+02
102  9.2294E+02
103  9.4686E+02
104  9.7134E+02
105  9.9639E+02
106  1.0220E+03
107  1.0483E+03
108  1.0751E+03
109  1.1026E+03
110  1.1307E+03
111  1.1595E+03
```

```
 112  1.1890E+03
 113  1.2191E+03
 114  1.2500E+03
 115  1.2815E+03
 116  1.3138E+03
 117  1.3469E+03
 118  1.3808E+03
 119  1.4154E+03
 120  1.4508E+03
 121  1.4871E+03
 122  1.5242E+03
 123  1.5622E+03
 124  1.6011E+03
 125  1.6409E+03
 126  1.6816E+03
 127  1.7233E+03
 128  1.7660E+03
 129  1.8096E+03
 130  1.8543E+03
 131  1.9000E+03
 132  1.9468E+03
 133  1.9947E+03
 134  2.0437E+03
 135  2.0939E+03
 136  2.1452E+03
 137  2.1977E+03
 138  2.2515E+03
 139  2.3065E+03
 140  2.3628E+03
 141  2.4204E+03
 142  2.4794E+03
 143  2.5398E+03
 144  2.6015E+03
 145  2.6648E+03
 146  2.7295E+03
 147  2.7957E+03
 148  2.8634E+03
 149  2.9328E+03
 150  3.0038E+03
 151  3.0764E+03
 152  3.1507E+03
 153  3.2268E+03
 154  3.3046E+03
 155  3.3843E+03
 156  3.4659E+03
 157  3.5493E+03
 158  3.6347E+03
 159  3.7221E+03
 160  3.8116E+03
 161  3.9031E+03
 162  3.9968E+03
 163  4.0927E+03
 164  4.1908E+03
 165  4.2912E+03
 166  4.3940E+03
 167  4.4992E+03
 168  4.6068E+03
 169  4.7170E+03
 170  4.8297E+03
 171  4.9451E+03
 172  5.0632E+03
 173  5.1840E+03
 174  5.3077E+03
 175  5.4343E+03
 176  5.5638E+03
```

```
 177  5.6964E+03
 178  5.8321E+03
 179  5.9709E+03
 180  6.1130E+03
 181  6.2584E+03
 182  6.4073E+03
 183  6.5596E+03
 184  6.7154E+03
 185  6.8750E+03
 186  7.0382E+03
 187  7.2053E+03
 188  7.3763E+03
 189  7.5513E+03
 190  7.7304E+03
 191  7.9137E+03
 192  8.1013E+03
 193  8.2933E+03
 194  8.4897E+03
 195  8.6908E+03
 196  8.8966E+03
 197  9.1072E+03
 198  9.3227E+03
 199  9.5433E+03
 200  9.7690E+03
 201  1.0000E+04
 202  1.2202E+04
 203  1.5046E+04
 204  1.8720E+04
 205  2.3464E+04
 206  2.9592E+04
 207  3.7506E+04
 208  4.7727E+04
 209  6.0928E+04
 210  7.7979E+04
 211  1.0000E+05


(the following values are for each vector)


numberofevents =     557
event  timeofseismicevents   typeofseismicevents
   1        2.7298E+02        1.5000E-01
   2        3.6246E+02        5.0000E-02
   3        4.9809E+02        5.0000E-02
   4        9.6572E+02        5.0000E-02
   5        9.7723E+02        5.0000E-02
   6        1.0031E+03        1.0000E-01
   7        1.2102E+03        1.0000E-01
   8        1.2514E+03        5.0000E-02
   9        1.6458E+03        5.0000E-02
  10        1.8328E+03        5.0000E-02
  11        2.0590E+03        1.0000E-01
  12        2.2055E+03        2.5000E-01
  13        2.9203E+03        5.0000E-02
  14        2.9428E+03        5.0000E-02
  15        3.1100E+03        1.0000E-01
  16        3.1212E+03        5.0000E-02
  17        3.4762E+03        5.0000E-02
  18        3.4979E+03        1.0000E-01
  19        3.5065E+03        5.0000E-02
  20        3.9697E+03        5.0000E-02
  21        4.5088E+03        5.0000E-02
  22        4.5613E+03        5.0000E-02
  23        4.8013E+03        5.0000E-02
```

```
 24        5.0922E+03        2.5000E-01
 25        5.2610E+03        5.0000E-02
 26        5.4587E+03        1.0000E-01
 27        5.5595E+03        5.0000E-02
 28        5.7334E+03        1.0000E-01
 29        6.3194E+03        5.0000E-02
 30        6.6236E+03        5.0000E-02
 31        6.7108E+03        5.0000E-02
 32        6.7383E+03        5.0000E-02
 33        6.7562E+03        2.0000E-01
 34        6.8693E+03        1.0000E-01
 35        6.9456E+03        5.0000E-02
 36        7.7367E+03        5.0000E-02
 37        7.8938E+03        1.0000E-01
 38        8.2304E+03        1.0000E-01
 39        8.2464E+03        1.0000E-01
 40        8.3806E+03        2.0000E-01
 41        8.3901E+03        5.0000E-02
 42        8.4474E+03        5.0000E-02
 43        8.5128E+03        5.0000E-02
 44        8.7196E+03        1.5000E-01
 45        9.0950E+03        5.0000E-02
 46        9.0985E+03        5.0000E-02
 47        9.2890E+03        5.0000E-02
 48        9.3930E+03        5.0000E-02
 49        9.4451E+03        5.0000E-02
 50        9.4499E+03        5.0000E-02
 51        9.6703E+03        5.0000E-02
 52        9.7050E+03        5.0000E-02
 53        9.9602E+03        2.0000E-01
 54        1.0038E+04        5.0000E-02
 55        1.0072E+04        5.0000E-02
 56        1.0115E+04        1.5000E-01
 57        1.0378E+04        5.0000E-02
 58        1.0534E+04        5.0000E-02
 59        1.0565E+04        5.0000E-02
 60        1.1747E+04        5.0000E-02
 61        1.1831E+04        1.0000E-01
 62        1.1932E+04        5.0000E-02
 63        1.2249E+04        5.0000E-02
 64        1.2560E+04        5.0000E-02
 65        1.2808E+04        5.0000E-02
 66        1.2999E+04        5.0000E-02
 67        1.2999E+04        5.0000E-02
 68        1.3008E+04        1.0000E-01
 69        1.3194E+04        1.0000E-01
 70        1.3194E+04        5.0000E-02
 71        1.3380E+04        5.0000E-02
 72        1.3393E+04        1.5000E-01
 73        1.3394E+04        5.0000E-02
 74        1.3455E+04        5.0000E-02
 75        1.3468E+04        1.5000E-01
 76        1.3485E+04        5.0000E-02
 77        1.4190E+04        5.0000E-02
 78        1.4515E+04        5.0000E-02
 79        1.4676E+04        5.0000E-02
 80        1.5279E+04        1.5000E-01
 81        1.5751E+04        5.0000E-01
 82        1.5844E+04        2.0000E-01
 83        1.5957E+04        3.0000E-01
 84        1.6040E+04        5.0000E-02
 85        1.6501E+04        1.0000E-01
 86        1.6824E+04        1.0000E-01
 87        1.6831E+04        5.0000E-02
 88        1.7187E+04        5.0000E-02
```

```
   89        1.7304E+04        1.0000E-01
   90        1.7406E+04        3.5000E-01
   91        1.7608E+04        5.0000E-02
   92        1.7703E+04        5.0000E-02
   93        1.7881E+04        5.0000E-02
   94        1.7922E+04        5.0000E-02
   95        1.7926E+04        1.5000E-01
   96        1.7942E+04        1.5000E-01
   97        1.8274E+04        5.0000E-02
   98        1.8558E+04        5.0000E-02
   99        1.8909E+04        5.0000E-02
  100        1.9030E+04        1.0000E-01
  101        1.9157E+04        1.0000E-01
  102        1.9997E+04        2.0000E-01
  103        2.0146E+04        1.0000E-01
  104        2.0371E+04        5.0000E-02
  105        2.0452E+04        5.0000E-02
  106        2.0497E+04        5.0000E-02
  107        2.0761E+04        5.0000E-02
  108        2.0808E+04        5.0000E-02
  109        2.1028E+04        1.0000E-01
  110        2.1092E+04        1.0000E-01
  111        2.1144E+04        1.5000E-01
  112        2.1296E+04        5.0000E-02
  113        2.1514E+04        5.0000E-02
  114        2.1717E+04        5.0000E-02
  115        2.2017E+04        1.5000E-01
  116        2.2045E+04        5.0000E-02
  117        2.2068E+04        5.0000E-02
  118        2.2343E+04        5.0000E-02
  119        2.2419E+04        1.0000E-01
  120        2.2806E+04        5.0000E-02
  121        2.2870E+04        5.0000E-02
  122        2.2871E+04        5.0000E-02
  123        2.3040E+04        5.0000E-02
  124        2.3190E+04        3.0000E-01
  125        2.3323E+04        5.0000E-02
  126        2.3368E+04        5.0000E-02
  127        2.3681E+04        5.0000E-02
  128        2.3978E+04        5.0000E-02
  129        2.4147E+04        5.0000E-02
  130        2.4171E+04        5.0000E-02
  131        2.4183E+04        1.0000E-01
  132        2.4197E+04        1.0000E-01
  133        2.4498E+04        5.0000E-02
  134        2.4573E+04        5.0000E-02
  135        2.4727E+04        5.0000E-02
  136        2.5085E+04        5.0000E-02
  137        2.5197E+04        5.0000E-02
  138        2.5243E+04        1.0000E-01
  139        2.5756E+04        1.0000E-01
  140        2.5828E+04        1.0000E-01
  141        2.6270E+04        5.0000E-02
  142        2.6579E+04        1.5000E-01
  143        2.6738E+04        5.0000E-02
  144        2.6768E+04        5.0000E-02
  145        2.7357E+04        5.0000E-02
  146        2.7364E+04        5.0000E-02
  147        2.7450E+04        5.0000E-02
  148        2.7640E+04        5.0000E-02
  149        2.7957E+04        5.0000E-02
  150        2.8037E+04        5.0000E-02
  151        2.8303E+04        5.0000E-02
  152        2.8359E+04        2.0000E-01
  153        2.8413E+04        5.0000E-02
```

```
  154          2.8606E+04          1.0000E-01
  155          2.8697E+04          5.0000E-02
  156          2.8818E+04          1.0000E-01
  157          2.9202E+04          5.0000E-02
  158          2.9350E+04          5.0000E-02
  159          2.9409E+04          5.0000E-02
  160          2.9494E+04          1.5000E-01
  161          3.0062E+04          5.0000E-02
  162          3.0106E+04          5.0000E-02
  163          3.0245E+04          5.0000E-02
  164          3.0353E+04          5.0000E-02
  165          3.0546E+04          1.0000E-01
  166          3.0622E+04          5.0000E-02
  167          3.0657E+04          5.0000E-02
  168          3.0855E+04          5.0000E-02
  169          3.0965E+04          5.0000E-02
  170          3.1695E+04          5.0000E-02
  171          3.1798E+04          5.0000E-02
  172          3.1799E+04          1.0000E-01
  173          3.2063E+04          1.0000E-01
  174          3.2319E+04          1.0000E-01
  175          3.2326E+04          1.5000E-01
  176          3.2427E+04          5.0000E-02
  177          3.2486E+04          1.0000E-01
  178          3.2611E+04          2.0000E-01
  179          3.2684E+04          1.0000E-01
  180          3.2791E+04          5.0000E-02
  181          3.2920E+04          5.0000E-02
  182          3.3348E+04          5.0000E-02
  183          3.3410E+04          5.0000E-02
  184          3.3623E+04          5.0000E-02
  185          3.3689E+04          1.0000E-01
  186          3.4048E+04          5.0000E-02
  187          3.4533E+04          5.0000E-02
  188          3.4610E+04          1.0000E-01
  189          3.4664E+04          1.0000E-01
  190          3.4832E+04          5.0000E-02
  191          3.4974E+04          5.0000E-02
  192          3.5139E+04          1.5000E-01
  193          3.5391E+04          5.0000E-02
  194          3.5581E+04          5.0000E-02
  195          3.5604E+04          5.0000E-02
  196          3.5679E+04          5.0000E-02
  197          3.6096E+04          2.5000E-01
  198          3.6099E+04          5.0000E-02
  199          3.6114E+04          5.0000E-02
  200          3.6119E+04          5.0000E-02
  201          3.6344E+04          5.0000E-02
  202          3.6410E+04          1.0000E-01
  203          3.6652E+04          5.0000E-02
  204          3.6743E+04          2.0000E-01
  205          3.7527E+04          5.0000E-02
  206          3.7543E+04          2.5000E-01
  207          3.8577E+04          5.0000E-02
  208          3.8607E+04          5.0000E-02
  209          3.8844E+04          5.0000E-02
  210          3.8857E+04          5.0000E-01
  211          3.9120E+04          5.0000E-02
  212          3.9284E+04          1.0000E-01
  213          3.9491E+04          1.0000E-01
  214          3.9552E+04          5.0000E-02
  215          3.9588E+04          1.5000E-01
  216          3.9611E+04          1.0000E-01
  217          3.9726E+04          1.0000E-01
  218          4.0377E+04          5.0000E-02
```

```
   219          4.0790E+04          5.0000E-02
   220          4.0912E+04          5.0000E-02
   221          4.1000E+04          5.0000E-02
   222          4.1144E+04          5.0000E-02
   223          4.1178E+04          2.0000E-01
   224          4.1286E+04          5.0000E-02
   225          4.1504E+04          1.0000E-01
   226          4.1667E+04          1.0000E-01
   227          4.1859E+04          5.0000E-02
   228          4.1931E+04          1.5000E-01
   229          4.2016E+04          5.0000E-02
   230          4.2058E+04          5.0000E-02
   231          4.2571E+04          5.0000E-02
   232          4.2643E+04          5.0000E-02
   233          4.2925E+04          5.0000E-02
   234          4.2980E+04          4.0000E-01
   235          4.3102E+04          5.0000E-02
   236          4.3197E+04          5.0000E-02
   237          4.3594E+04          5.0000E-02
   238          4.3839E+04          5.0000E-02
   239          4.3966E+04          5.0000E-02
   240          4.4373E+04          1.0000E-01
   241          4.4451E+04          5.0000E-02
   242          4.4512E+04          1.0000E-01
   243          4.4596E+04          2.5000E-01
   244          4.4851E+04          5.0000E-02
   245          4.4961E+04          1.5000E-01
   246          4.5174E+04          5.0000E-02
   247          4.5182E+04          2.5000E-01
   248          4.5313E+04          1.5000E-01
   249          4.5597E+04          1.0000E-01
   250          4.5705E+04          5.0000E-02
   251          4.5967E+04          5.0000E-02
   252          4.6060E+04          2.0000E-01
   253          4.6336E+04          5.0000E-02
   254          4.6412E+04          5.0000E-02
   255          4.6577E+04          5.0000E-02
   256          4.6966E+04          5.0000E-02
   257          4.7074E+04          5.0000E-02
   258          4.7203E+04          5.0000E-02
   259          4.7245E+04          5.0000E-02
   260          4.7628E+04          5.0000E-02
   261          4.7662E+04          5.0000E-02
   262          4.7855E+04          1.0000E-01
   263          4.8040E+04          1.0000E-01
   264          4.8096E+04          5.0000E-02
   265          4.8112E+04          1.5000E-01
   266          4.8214E+04          1.5000E-01
   267          4.8280E+04          1.0000E-01
   268          4.8359E+04          5.0000E-02
   269          4.8494E+04          5.0000E-02
   270          4.8522E+04          1.0000E-01
   271          4.8550E+04          5.0000E-02
   272          4.8723E+04          5.0000E-02
   273          4.8854E+04          5.0000E-02
   274          4.9287E+04          1.0000E-01
   275          4.9418E+04          1.0000E-01
   276          4.9467E+04          1.0000E-01
   277          4.9908E+04          5.0000E-02
   278          5.0081E+04          1.0000E-01
   279          5.0126E+04          2.0000E-01
   280          5.0173E+04          5.0000E-02
   281          5.0392E+04          5.0000E-02
   282          5.0492E+04          5.0000E-02
   283          5.0796E+04          1.0000E-01
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 284        5.1176E+04        5.0000E-02
 285        5.1202E+04        5.0000E-02
 286        5.1796E+04        2.0000E-01
 287        5.2269E+04        5.0000E-02
 288        5.2351E+04        5.0000E-02
 289        5.2496E+04        1.0000E-01
 290        5.2667E+04        5.0000E-02
 291        5.3582E+04        5.0000E-02
 292        5.3589E+04        5.0000E-02
 293        5.3807E+04        1.5000E-01
 294        5.4539E+04        1.5000E-01
 295        5.4576E+04        5.0000E-02
 296        5.4914E+04        5.0000E-02
 297        5.5013E+04        5.0000E-02
 298        5.5220E+04        5.0000E-02
 299        5.5579E+04        5.0000E-02
 300        5.5763E+04        1.0000E-01
 301        5.5780E+04        1.0000E-01
 302        5.6121E+04        5.0000E-02
 303        5.6220E+04        5.0000E-02
 304        5.6424E+04        4.5000E-01
 305        5.6721E+04        5.0000E-02
 306        5.7329E+04        1.0000E-01
 307        5.7346E+04        5.0000E-02
 308        5.7432E+04        1.0000E-01
 309        5.7483E+04        1.0000E-01
 310        5.7858E+04        1.5000E-01
 311        5.7946E+04        1.0000E-01
 312        5.7952E+04        5.0000E-02
 313        5.7984E+04        5.0000E-02
 314        5.8130E+04        5.0000E-02
 315        5.8450E+04        5.0000E-02
 316        5.8472E+04        1.0000E-01
 317        5.8575E+04        5.0000E-02
 318        5.8692E+04        1.0000E-01
 319        5.9439E+04        5.0000E-02
 320        5.9460E+04        2.5000E-01
 321        5.9492E+04        5.0000E-02
 322        5.9753E+04        5.0000E-02
 323        5.9852E+04        5.0000E-02
 324        5.9918E+04        5.0000E-02
 325        5.9935E+04        5.0000E-02
 326        5.9983E+04        1.0000E-01
 327        6.0039E+04        5.0000E-02
 328        6.0101E+04        5.0000E-02
 329        6.0400E+04        1.5000E-01
 330        6.0505E+04        5.0000E-02
 331        6.0632E+04        1.0000E-01
 332        6.0725E+04        1.0000E-01
 333        6.0854E+04        1.0000E-01
 334        6.1198E+04        5.0000E-02
 335        6.1300E+04        5.0000E-02
 336        6.1677E+04        5.0000E-02
 337        6.2125E+04        1.0000E-01
 338        6.2319E+04        5.0000E-02
 339        6.2405E+04        5.0000E-02
 340        6.2573E+04        5.0000E-02
 341        6.2621E+04        5.0000E-02
 342        6.2990E+04        5.0000E-02
 343        6.3122E+04        5.0000E-02
 344        6.3167E+04        5.0000E-02
 345        6.3174E+04        1.5000E-01
 346        6.3408E+04        1.5000E-01
 347        6.3419E+04        5.0000E-02
 348        6.3450E+04        5.0000E-02
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 349        6.3721E+04        1.5000E-01
 350        6.3812E+04        5.0000E-02
 351        6.3873E+04        5.0000E-02
 352        6.4047E+04        5.0000E-02
 353        6.4404E+04        5.0000E-02
 354        6.4592E+04        5.0000E-02
 355        6.4596E+04        1.0000E-01
 356        6.4948E+04        5.0000E-02
 357        6.5096E+04        1.0000E-01
 358        6.5114E+04        5.0000E-02
 359        6.5194E+04        5.0000E-02
 360        6.5265E+04        1.5000E-01
 361        6.5328E+04        2.0000E-01
 362        6.6658E+04        5.0000E-02
 363        6.6846E+04        1.0000E-01
 364        6.6989E+04        5.0000E-02
 365        6.7108E+04        5.0000E-02
 366        6.7130E+04        5.0000E-02
 367        6.7334E+04        5.0000E-02
 368        6.7534E+04        1.5000E-01
 369        6.7548E+04        2.0000E-01
 370        6.7586E+04        5.0000E-02
 371        6.7620E+04        5.0000E-02
 372        6.8011E+04        5.0000E-02
 373        6.8065E+04        5.0000E-02
 374        6.8295E+04        1.5000E-01
 375        6.8853E+04        5.0000E-02
 376        6.8906E+04        5.0000E-02
 377        6.9279E+04        5.0000E-02
 378        6.9470E+04        1.0000E-01
 379        6.9724E+04        1.0000E-01
 380        6.9746E+04        5.0000E-02
 381        6.9902E+04        2.0000E-01
 382        7.0025E+04        5.0000E-02
 383        7.0182E+04        1.5000E-01
 384        7.0455E+04        5.0000E-02
 385        7.0869E+04        5.0000E-02
 386        7.0888E+04        1.0000E-01
 387        7.1301E+04        1.5000E-01
 388        7.1458E+04        5.0000E-02
 389        7.1488E+04        5.0000E-02
 390        7.1627E+04        5.0000E-02
 391        7.1632E+04        5.0000E-02
 392        7.1703E+04        5.0000E-02
 393        7.1788E+04        5.0000E-02
 394        7.2158E+04        1.5000E-01
 395        7.2336E+04        5.0000E-02
 396        7.2525E+04        2.0000E-01
 397        7.2612E+04        5.0000E-02
 398        7.2769E+04        1.0000E-01
 399        7.2886E+04        5.0000E-02
 400        7.2990E+04        5.0000E-02
 401        7.3089E+04        1.0000E-01
 402        7.3121E+04        1.0000E-01
 403        7.3469E+04        5.0000E-02
 404        7.3814E+04        5.0000E-02
 405        7.4141E+04        5.0000E-02
 406        7.4145E+04        5.0000E-02
 407        7.4353E+04        1.0000E-01
 408        7.4589E+04        5.0000E-02
 409        7.4662E+04        1.5000E-01
 410        7.4716E+04        5.0000E-02
 411        7.4730E+04        5.0000E-02
 412        7.4949E+04        5.0000E-02
 413        7.5013E+04        5.0000E-02
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 414       7.5187E+04        1.5000E-01
 415       7.5327E+04        5.0000E-02
 416       7.5351E+04        5.0000E-02
 417       7.5396E+04        5.0000E-02
 418       7.5452E+04        1.0000E-01
 419       7.5522E+04        5.0000E-02
 420       7.5678E+04        5.0000E-02
 421       7.5731E+04        5.0000E-02
 422       7.5940E+04        1.5000E-01
 423       7.6050E+04        1.0000E-01
 424       7.6109E+04        1.0000E-01
 425       7.6264E+04        5.0000E-02
 426       7.6487E+04        2.0000E-01
 427       7.6560E+04        5.0000E-02
 428       7.6659E+04        5.0000E-02
 429       7.6837E+04        5.0000E-02
 430       7.7120E+04        5.0000E-02
 431       7.7272E+04        5.0000E-02
 432       7.7358E+04        5.0000E-02
 433       7.7563E+04        5.0000E-02
 434       7.7726E+04        5.0000E-02
 435       7.7760E+04        5.0000E-02
 436       7.7796E+04        5.0000E-02
 437       7.7841E+04        5.0000E-02
 438       7.8116E+04        5.0000E-02
 439       7.8277E+04        5.0000E-02
 440       7.8500E+04        5.0000E-02
 441       7.8577E+04        1.0000E-01
 442       7.8607E+04        5.0000E-02
 443       7.8621E+04        5.0000E-02
 444       7.8660E+04        1.0000E-01
 445       7.8929E+04        5.0000E-02
 446       7.8950E+04        5.0000E-02
 447       7.9493E+04        1.5000E-01
 448       7.9673E+04        5.0000E-02
 449       7.9899E+04        5.0000E-02
 450       7.9923E+04        1.0000E-01
 451       7.9942E+04        5.0000E-02
 452       8.0138E+04        2.5000E-01
 453       8.0181E+04        1.5000E-01
 454       8.0309E+04        5.0000E-02
 455       8.0506E+04        3.5000E-01
 456       8.0511E+04        5.0000E-02
 457       8.0559E+04        5.0000E-02
 458       8.0567E+04        5.0000E-02
 459       8.0657E+04        5.0000E-02
 460       8.0661E+04        2.0000E-01
 461       8.0957E+04        5.0000E-02
 462       8.1523E+04        5.0000E-02
 463       8.1709E+04        1.0000E-01
 464       8.1958E+04        5.0000E-02
 465       8.2261E+04        1.0000E-01
 466       8.2399E+04        5.0000E-02
 467       8.2647E+04        2.5000E-01
 468       8.2810E+04        1.0000E-01
 469       8.2971E+04        5.0000E-02
 470       8.3178E+04        5.0000E-02
 471       8.4013E+04        5.0000E-02
 472       8.4118E+04        2.0000E-01
 473       8.4154E+04        1.0000E-01
 474       8.4252E+04        5.0000E-02
 475       8.4360E+04        1.0000E-01
 476       8.4494E+04        5.0000E-02
 477       8.4838E+04        5.0000E-02
 478       8.4906E+04        5.0000E-02
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  479          8.4963E+04          5.0000E-02
  480          8.5523E+04          5.0000E-02
  481          8.5610E+04          5.0000E-02
  482          8.5739E+04          5.0000E-02
  483          8.5793E+04          5.0000E-02
  484          8.6000E+04          1.0000E-01
  485          8.6049E+04          1.5000E-01
  486          8.6326E+04          1.5000E-01
  487          8.6328E+04          5.0000E-02
  488          8.6367E+04          5.0000E-02
  489          8.6411E+04          2.5000E-01
  490          8.6587E+04          5.0000E-02
  491          8.6680E+04          5.0000E-02
  492          8.6706E+04          5.0000E-02
  493          8.6913E+04          1.0000E-01
  494          8.6964E+04          5.0000E-02
  495          8.7003E+04          5.0000E-02
  496          8.7257E+04          5.0000E-02
  497          8.7297E+04          1.0000E-01
  498          8.7682E+04          1.0000E-01
  499          8.7827E+04          1.0000E-01
  500          8.8018E+04          2.5000E-01
  501          8.8220E+04          5.0000E-02
  502          8.8792E+04          1.0000E-01
  503          8.8946E+04          5.0000E-02
  504          8.9111E+04          5.0000E-02
  505          8.9542E+04          5.0000E-02
  506          8.9649E+04          1.5000E-01
  507          8.9746E+04          1.0000E-01
  508          8.9772E+04          5.0000E-02
  509          9.0209E+04          5.0000E-02
  510          9.0290E+04          1.0000E-01
  511          9.0345E+04          5.0000E-02
  512          9.0485E+04          5.0000E-02
  513          9.0509E+04          5.0000E-02
  514          9.1038E+04          5.0000E-02
  515          9.1818E+04          5.0000E-02
  516          9.1901E+04          5.0000E-02
  517          9.1905E+04          1.5000E-01
  518          9.2001E+04          5.0000E-02
  519          9.2229E+04          5.0000E-02
  520          9.3215E+04          5.0000E-02
  521          9.3612E+04          5.0000E-02
  522          9.4157E+04          1.0000E-01
  523          9.4492E+04          1.0000E-01
  524          9.4524E+04          1.0000E-01
  525          9.4571E+04          5.0000E-02
  526          9.4839E+04          1.0000E-01
  527          9.4912E+04          5.0000E-02
  528          9.5165E+04          5.0000E-02
  529          9.5320E+04          5.0000E-02
  530          9.5531E+04          1.0000E-01
  531          9.5695E+04          5.0000E-02
  532          9.5905E+04          5.0000E-02
  533          9.6042E+04          5.0000E-02
  534          9.6086E+04          5.0000E-02
  535          9.6093E+04          5.0000E-02
  536          9.6256E+04          1.0000E-01
  537          9.6458E+04          1.0000E-01
  538          9.6666E+04          5.0000E-02
  539          9.6984E+04          1.0000E-01
  540          9.7023E+04          5.0000E-02
  541          9.7059E+04          5.0000E-02
  542          9.7504E+04          1.0000E-01
  543          9.7512E+04          1.0000E-01
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   544          9.7686E+04          5.0000E-02
   545          9.7731E+04          5.0000E-02
   546          9.7916E+04          1.0000E-01
   547          9.7927E+04          5.0000E-02
   548          9.7964E+04          1.0000E-01
   549          9.8170E+04          1.0000E-01
   550          9.8513E+04          5.0000E-02
   551          9.8879E+04          5.0000E-02
   552          9.9044E+04          5.0000E-02
   553          9.9074E+04          5.0000E-02
   554          9.9349E+04          1.0000E-01
   555          9.9619E+04          5.0000E-02
   556          9.9639E+04          1.0000E-01
   557          9.9727E+04          1.0000E-01

REALIZATION     2


ALL SUBAREAS


numberofevents =     545
event  timeofseismicevents   typeofseismicevents
    1          1.2527E+01          5.0000E-02
    2          3.9924E+02          5.0000E-02
    3          4.1373E+02          5.0000E-02
    4          4.6255E+02          5.0000E-02
    5          7.3680E+02          1.5000E-01
    6          8.1708E+02          5.0000E-02
    7          8.2961E+02          5.0000E-02
    8          9.6140E+02          5.0000E-02
    9          1.0032E+03          5.0000E-02
   10          1.1745E+03          5.0000E-02
   11          1.3062E+03          5.0000E-02
   12          1.3894E+03          5.0000E-02
   13          1.4566E+03          1.0000E-01
   14          1.5558E+03          1.5000E-01
   15          1.5909E+03          5.0000E-02
   16          1.7819E+03          1.0000E-01
   17          2.4110E+03          5.0000E-02
   18          2.4258E+03          5.0000E-02
   19          2.6411E+03          5.0000E-02
   20          2.6501E+03          1.0000E-01
   21          2.9539E+03          1.0000E-01
   22          3.3314E+03          5.0000E-02
   23          3.6335E+03          5.0000E-02
   24          3.6865E+03          5.0000E-02
   25          3.7051E+03          3.0000E-01
   26          3.9448E+03          1.0000E-01
   27          3.9595E+03          5.0000E-02
   28          4.0632E+03          3.0000E-01
   29          4.1099E+03          1.0000E-01
   30          4.3373E+03          1.0000E-01
   31          4.5935E+03          1.5000E-01
   32          4.6667E+03          5.0000E-02
   33          4.9332E+03          5.0000E-02
   34          5.1303E+03          5.0000E-02
   35          5.2975E+03          1.0000E-01
   36          5.4241E+03          5.0000E-02
   37          5.5428E+03          1.5000E-01
   38          5.8311E+03          5.0000E-02
   39          6.0744E+03          1.0000E-01
   40          6.1510E+03          5.0000E-02
   41          6.3262E+03          4.5000E-01
   42          6.6136E+03          5.0000E-02
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  43        6.6610E+03        5.0000E-02
  44        6.7401E+03        5.0000E-02
  45        6.8756E+03        2.5000E-01
  46        6.9212E+03        5.0000E-02
  47        7.1608E+03        5.0000E-02
  48        7.2093E+03        5.0000E-02
  49        7.3820E+03        5.0000E-02
  50        7.4428E+03        1.5000E-01
  51        7.4735E+03        5.0000E-02
  52        7.6353E+03        5.0000E-02
  53        7.8756E+03        5.0000E-02
  54        7.9252E+03        5.0000E-02
  55        7.9709E+03        5.0000E-02
  56        8.0213E+03        2.0000E-01
  57        8.0659E+03        5.0000E-02
  58        8.2442E+03        1.0000E-01
  59        8.4413E+03        5.0000E-02
  60        8.4479E+03        5.0000E-02
  61        8.6398E+03        1.0000E-01
  62        9.1217E+03        5.0000E-02
  63        9.1770E+03        5.0000E-02
  64        9.2414E+03        1.0000E-01
  65        9.2961E+03        5.0000E-02
  66        9.3155E+03        1.0000E-01
  67        9.7329E+03        1.0000E-01
  68        1.0267E+04        1.0000E-01
  69        1.0486E+04        1.0000E-01
  70        1.0840E+04        5.0000E-02
  71        1.0964E+04        2.0000E-01
  72        1.1392E+04        2.5000E-01
  73        1.1543E+04        1.0000E-01
  74        1.1678E+04        1.5000E-01
  75        1.2014E+04        5.0000E-02
  76        1.2060E+04        5.0000E-02
  77        1.2432E+04        1.0000E-01
  78        1.2510E+04        5.0000E-02
  79        1.2568E+04        1.5000E-01
  80        1.2759E+04        1.0000E-01
  81        1.2843E+04        1.0000E-01
  82        1.3269E+04        5.0000E-02
  83        1.3377E+04        5.0000E-02
  84        1.3526E+04        1.0000E-01
  85        1.3545E+04        5.0000E-02
  86        1.3558E+04        1.0000E-01
  87        1.3840E+04        1.0000E-01
  88        1.4116E+04        5.0000E-02
  89        1.4142E+04        5.0000E-02
  90        1.4333E+04        5.0000E-02
  91        1.4375E+04        5.0000E-02
  92        1.4489E+04        5.0000E-02
  93        1.4901E+04        1.5000E-01
  94        1.5097E+04        2.5000E-01
  95        1.5264E+04        5.0000E-02
  96        1.5436E+04        5.0000E-02
  97        1.5738E+04        1.0000E-01
  98        1.5783E+04        5.0000E-02
  99        1.5902E+04        5.0000E-02
 100        1.5930E+04        5.0000E-02
 101        1.6516E+04        1.0000E-01
 102        1.6721E+04        5.0000E-02
 103        1.6800E+04        1.0000E-01
 104        1.6996E+04        2.0000E-01
 105        1.7294E+04        5.0000E-02
 106        1.7410E+04        5.0000E-02
 107        1.7584E+04        5.0000E-02
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   108         1.7637E+04         5.0000E-02
   109         1.8229E+04         5.0000E-02
   110         1.8516E+04         5.0000E-02
   111         1.8545E+04         5.0000E-02
   112         1.8755E+04         5.0000E-02
   113         1.9105E+04         5.0000E-02
   114         1.9319E+04         1.0000E-01
   115         1.9371E+04         1.5000E-01
   116         1.9496E+04         5.0000E-02
   117         1.9699E+04         5.0000E-02
   118         1.9738E+04         1.0000E-01
   119         1.9768E+04         5.0000E-02
   120         1.9785E+04         5.0000E-02
   121         2.0044E+04         1.5000E-01
   122         2.0097E+04         1.0000E-01
   123         2.0755E+04         1.0000E-01
   124         2.0978E+04         5.0000E-02
   125         2.0994E+04         5.0000E-02
   126         2.1018E+04         5.0000E-02
   127         2.1220E+04         5.0000E-02
   128         2.1287E+04         5.0000E-02
   129         2.1417E+04         5.0000E-02
   130         2.1509E+04         5.0000E-02
   131         2.1565E+04         1.0000E-01
   132         2.1711E+04         1.0000E-01
   133         2.1809E+04         5.0000E-02
   134         2.1825E+04         5.0000E-02
   135         2.2191E+04         1.0000E-01
   136         2.2278E+04         1.0000E-01
   137         2.2314E+04         5.0000E-02
   138         2.2518E+04         5.0000E-02
   139         2.2714E+04         1.0000E-01
   140         2.2781E+04         1.5000E-01
   141         2.2884E+04         5.0000E-02
   142         2.3499E+04         1.5000E-01
   143         2.4294E+04         5.0000E-02
   144         2.4477E+04         1.0000E-01
   145         2.4528E+04         5.0000E-02
   146         2.4606E+04         1.5000E-01
   147         2.4606E+04         5.0000E-02
   148         2.4695E+04         1.0000E-01
   149         2.4788E+04         1.0000E-01
   150         2.5333E+04         1.5000E-01
   151         2.5348E+04         1.0000E-01
   152         2.5358E+04         5.0000E-02
   153         2.5400E+04         1.0000E-01
   154         2.5718E+04         5.0000E-02
   155         2.5982E+04         1.5000E-01
   156         2.6200E+04         5.0000E-02
   157         2.6200E+04         1.0000E-01
   158         2.6609E+04         5.0000E-02
   159         2.6764E+04         2.5000E-01
   160         2.6916E+04         1.0000E-01
   161         2.6925E+04         5.0000E-02
   162         2.7066E+04         5.0000E-02
   163         2.7382E+04         5.0000E-02
   164         2.8268E+04         1.0000E-01
   165         2.8370E+04         5.0000E-02
   166         2.8392E+04         5.0000E-02
   167         2.8606E+04         1.0000E-01
   168         2.8648E+04         5.0000E-02
   169         2.8677E+04         5.0000E-02
   170         2.9052E+04         5.0000E-02
   171         2.9173E+04         5.0000E-02
   172         2.9242E+04         2.0000E-01
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 173          2.9431E+04          1.0000E-01
 174          2.9784E+04          5.0000E-02
 175          3.0277E+04          1.5000E-01
 176          3.0495E+04          1.0000E-01
 177          3.0564E+04          5.0000E-02
 178          3.0578E+04          5.0000E-02
 179          3.0810E+04          5.0000E-02
 180          3.0818E+04          5.0000E-02
 181          3.1343E+04          5.0000E-02
 182          3.1768E+04          5.0000E-02
 183          3.1880E+04          2.0000E-01
 184          3.1990E+04          5.0000E-02
 185          3.1991E+04          5.0000E-02
 186          3.2085E+04          5.0000E-02
 187          3.2106E+04          2.0000E-01
 188          3.2157E+04          1.5000E-01
 189          3.2229E+04          1.0000E-01
 190          3.2251E+04          5.0000E-02
 191          3.2300E+04          1.5000E-01
 192          3.2325E+04          5.0000E-02
 193          3.2720E+04          5.0000E-02
 194          3.2792E+04          1.5000E-01
 195          3.2820E+04          1.0000E-01
 196          3.2889E+04          5.0000E-02
 197          3.3010E+04          2.0000E-01
 198          3.3129E+04          5.0000E-02
 199          3.3374E+04          5.0000E-02
 200          3.3443E+04          1.0000E-01
 201          3.3770E+04          5.0000E-02
 202          3.3778E+04          5.0000E-02
 203          3.3836E+04          5.0000E-02
 204          3.3990E+04          5.0000E-02
 205          3.4093E+04          5.0000E-02
 206          3.4223E+04          1.5000E-01
 207          3.4275E+04          1.0000E-01
 208          3.4624E+04          3.5000E-01
 209          3.4764E+04          5.0000E-02
 210          3.4822E+04          5.0000E-02
 211          3.4841E+04          1.0000E-01
 212          3.5037E+04          5.0000E-02
 213          3.5101E+04          5.0000E-02
 214          3.5171E+04          2.0000E-01
 215          3.5214E+04          5.0000E-02
 216          3.5266E+04          1.0000E-01
 217          3.5535E+04          5.0000E-02
 218          3.5559E+04          5.0000E-02
 219          3.5683E+04          1.0000E-01
 220          3.5695E+04          1.0000E-01
 221          3.6137E+04          2.5000E-01
 222          3.6185E+04          5.0000E-02
 223          3.6333E+04          1.5000E-01
 224          3.6517E+04          5.0000E-02
 225          3.6622E+04          5.0000E-02
 226          3.6634E+04          2.0000E-01
 227          3.7347E+04          1.0000E-01
 228          3.7440E+04          5.0000E-02
 229          3.7579E+04          5.0000E-02
 230          3.8282E+04          5.0000E-02
 231          3.8564E+04          3.5000E-01
 232          3.8686E+04          5.0000E-02
 233          3.8918E+04          5.0000E-02
 234          3.9107E+04          5.0000E-02
 235          3.9149E+04          3.5000E-01
 236          3.9445E+04          5.0000E-02
 237          3.9470E+04          5.0000E-02
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 238        3.9760E+04        5.0000E-02
 239        4.0091E+04        5.0000E-02
 240        4.0093E+04        5.0000E-02
 241        4.0188E+04        5.0000E-02
 242        4.0194E+04        1.5000E-01
 243        4.0698E+04        1.0000E-01
 244        4.0871E+04        5.0000E-02
 245        4.1147E+04        1.0000E-01
 246        4.1169E+04        5.0000E-02
 247        4.1244E+04        1.0000E-01
 248        4.1345E+04        5.0000E-02
 249        4.1395E+04        5.0000E-02
 250        4.1811E+04        5.0000E-02
 251        4.1815E+04        5.0000E-02
 252        4.1960E+04        1.0000E-01
 253        4.1988E+04        1.0000E-01
 254        4.2184E+04        1.0000E-01
 255        4.2198E+04        5.0000E-02
 256        4.2460E+04        5.0000E-02
 257        4.2532E+04        2.0000E-01
 258        4.2936E+04        5.0000E-02
 259        4.3081E+04        1.0000E-01
 260        4.3356E+04        5.0000E-02
 261        4.3618E+04        5.0000E-02
 262        4.3871E+04        5.0000E-02
 263        4.3911E+04        5.0000E-02
 264        4.4144E+04        5.0000E-02
 265        4.4239E+04        1.5000E-01
 266        4.4292E+04        5.0000E-02
 267        4.4423E+04        5.0000E-02
 268        4.4536E+04        5.0000E-02
 269        4.4639E+04        5.0000E-02
 270        4.5007E+04        5.0000E-02
 271        4.5273E+04        5.0000E-02
 272        4.5275E+04        1.0000E-01
 273        4.5763E+04        1.5000E-01
 274        4.6068E+04        5.0000E-02
 275        4.6752E+04        5.0000E-02
 276        4.6804E+04        5.0000E-02
 277        4.7070E+04        5.0000E-02
 278        4.7182E+04        5.0000E-02
 279        4.7305E+04        5.0000E-02
 280        4.7437E+04        5.0000E-02
 281        4.8174E+04        5.0000E-02
 282        4.8185E+04        5.0000E-02
 283        4.8456E+04        1.5000E-01
 284        4.8463E+04        5.0000E-02
 285        4.8682E+04        5.0000E-02
 286        4.8713E+04        5.0000E-02
 287        4.8784E+04        1.0000E-01
 288        4.9449E+04        5.0000E-02
 289        4.9470E+04        5.0000E-02
 290        4.9770E+04        5.0000E-02
 291        5.0042E+04        5.0000E-02
 292        5.0066E+04        1.0000E-01
 293        5.0441E+04        5.0000E-02
 294        5.0594E+04        5.0000E-02
 295        5.0659E+04        1.0000E-01
 296        5.1030E+04        5.0000E-02
 297        5.1170E+04        5.0000E-02
 298        5.1365E+04        5.0000E-02
 299        5.1928E+04        5.0000E-02
 300        5.2083E+04        5.0000E-02
 301        5.2290E+04        5.0000E-02
 302        5.2405E+04        5.0000E-02
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   303          5.2553E+04          5.0000E-02
   304          5.2710E+04          1.0000E-01
   305          5.2802E+04          5.0000E-02
   306          5.2845E+04          1.0000E-01
   307          5.3120E+04          5.0000E-02
   308          5.3168E+04          5.0000E-02
   309          5.3273E+04          1.0000E-01
   310          5.3377E+04          4.0000E-01
   311          5.3428E+04          1.0000E-01
   312          5.3535E+04          5.0000E-02
   313          5.3954E+04          5.0000E-02
   314          5.4030E+04          5.0000E-02
   315          5.4591E+04          5.0000E-02
   316          5.5402E+04          5.0000E-02
   317          5.5714E+04          5.0000E-02
   318          5.5928E+04          5.0000E-02
   319          5.5958E+04          1.0000E-01
   320          5.5978E+04          2.0000E-01
   321          5.6012E+04          1.0000E-01
   322          5.6029E+04          1.0000E-01
   323          5.6236E+04          5.0000E-02
   324          5.6447E+04          1.5000E-01
   325          5.6645E+04          1.0000E-01
   326          5.7098E+04          5.0000E-02
   327          5.7532E+04          5.0000E-02
   328          5.7816E+04          5.0000E-02
   329          5.7820E+04          1.0000E-01
   330          5.8089E+04          5.0000E-02
   331          5.8109E+04          5.0000E-02
   332          5.8175E+04          5.0000E-02
   333          5.8209E+04          5.0000E-02
   334          5.8253E+04          1.0000E-01
   335          5.8562E+04          5.0000E-02
   336          5.8953E+04          5.0000E-02
   337          5.8989E+04          5.0000E-02
   338          5.9202E+04          1.5000E-01
   339          5.9281E+04          5.0000E-02
   340          5.9903E+04          5.0000E-02
   341          5.9945E+04          1.0000E-01
   342          6.0159E+04          2.0000E-01
   343          6.0318E+04          5.0000E-02
   344          6.0429E+04          5.0000E-02
   345          6.0539E+04          1.0000E-01
   346          6.0838E+04          1.0000E-01
   347          6.1185E+04          5.0000E-02
   348          6.1290E+04          2.5000E-01
   349          6.1303E+04          5.0000E-02
   350          6.1493E+04          5.0000E-02
   351          6.1659E+04          1.0000E-01
   352          6.2439E+04          1.0000E-01
   353          6.2593E+04          5.0000E-02
   354          6.2714E+04          5.0000E-02
   355          6.3182E+04          1.0000E-01
   356          6.3221E+04          5.0000E-02
   357          6.3278E+04          5.0000E-02
   358          6.3649E+04          1.0000E-01
   359          6.3667E+04          5.0000E-02
   360          6.3758E+04          5.0000E-02
   361          6.3776E+04          1.0000E-01
   362          6.3976E+04          1.0000E-01
   363          6.4033E+04          5.0000E-02
   364          6.4231E+04          5.0000E-02
   365          6.4553E+04          5.0000E-02
   366          6.5035E+04          5.0000E-02
   367          6.5946E+04          1.0000E-01
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 368        6.5950E+04        5.0000E-02
 369        6.6300E+04        5.0000E-02
 370        6.6412E+04        1.0000E-01
 371        6.6516E+04        1.0000E-01
 372        6.6529E+04        2.0000E-01
 373        6.7043E+04        2.5000E-01
 374        6.7253E+04        5.0000E-02
 375        6.7469E+04        5.0000E-02
 376        6.7481E+04        5.0000E-02
 377        6.8523E+04        5.0000E-02
 378        6.8667E+04        5.0000E-02
 379        6.8708E+04        3.0000E-01
 380        6.8708E+04        5.0000E-02
 381        6.8979E+04        5.0000E-02
 382        6.9046E+04        5.0000E-02
 383        6.9215E+04        1.0000E-01
 384        6.9296E+04        5.0000E-02
 385        6.9518E+04        1.0000E-01
 386        6.9922E+04        3.5000E-01
 387        7.0142E+04        5.0000E-02
 388        7.0250E+04        1.0000E-01
 389        7.0408E+04        5.0000E-02
 390        7.0812E+04        5.0000E-02
 391        7.0944E+04        5.0000E-02
 392        7.1058E+04        5.0000E-02
 393        7.1121E+04        1.5000E-01
 394        7.1211E+04        5.0000E-02
 395        7.1218E+04        1.0000E-01
 396        7.1382E+04        5.0000E-02
 397        7.1603E+04        5.0000E-02
 398        7.1846E+04        5.0000E-02
 399        7.1974E+04        5.0000E-02
 400        7.2146E+04        5.0000E-02
 401        7.2194E+04        4.5000E-01
 402        7.2417E+04        3.0000E-01
 403        7.2822E+04        5.0000E-02
 404        7.2994E+04        1.0000E-01
 405        7.3435E+04        5.0000E-02
 406        7.3526E+04        1.0000E-01
 407        7.3998E+04        1.5000E-01
 408        7.4172E+04        5.0000E-02
 409        7.4194E+04        5.0000E-02
 410        7.4214E+04        1.0000E-01
 411        7.4225E+04        5.0000E-02
 412        7.4274E+04        5.0000E-02
 413        7.4439E+04        5.0000E-02
 414        7.4975E+04        1.0000E-01
 415        7.4985E+04        5.0000E-02
 416        7.4986E+04        5.0000E-02
 417        7.5022E+04        1.0000E-01
 418        7.5202E+04        5.0000E-02
 419        7.5219E+04        5.0000E-02
 420        7.5465E+04        5.0000E-02
 421        7.5618E+04        1.0000E-01
 422        7.5731E+04        5.0000E-02
 423        7.5737E+04        5.0000E-02
 424        7.5739E+04        5.0000E-02
 425        7.5984E+04        5.0000E-02
 426        7.6051E+04        5.0000E-02
 427        7.6239E+04        1.5000E-01
 428        7.6338E+04        5.0000E-02
 429        7.6685E+04        5.0000E-02
 430        7.7016E+04        5.0000E-02
 431        7.7185E+04        1.0000E-01
 432        7.7208E+04        5.0000E-02
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   434        7.7866E+04        5.0000E-01
   435        7.7904E+04        1.0000E-01
   436        7.8003E+04        5.0000E-02
   437        7.8029E+04        5.0000E-02
   438        7.8495E+04        1.5000E-01
   439        7.8665E+04        1.0000E-01
   440        7.8865E+04        5.0000E-02
   441        7.9015E+04        2.0000E-01
   442        7.9120E+04        1.0000E-01
   443        7.9392E+04        5.0000E-02
   444        7.9395E+04        5.0000E-02
   445        7.9503E+04        1.0000E-01
   446        7.9865E+04        5.0000E-02
   447        8.0231E+04        1.0000E-01
   448        8.0470E+04        2.0000E-01
   449        8.0747E+04        5.0000E-02
   450        8.1332E+04        1.5000E-01
   451        8.1591E+04        5.0000E-02
   452        8.1593E+04        5.0000E-02
   453        8.1665E+04        1.0000E-01
   454        8.1694E+04        5.0000E-02
   455        8.1761E+04        1.0000E-01
   456        8.1779E+04        5.0000E-02
   457        8.1849E+04        5.0000E-02
   458        8.1931E+04        1.0000E-01
   459        8.1952E+04        1.0000E-01
   460        8.2150E+04        5.0000E-02
   461        8.2309E+04        5.0000E-02
   462        8.2515E+04        1.0000E-01
   463        8.2730E+04        5.0000E-02
   464        8.2908E+04        1.0000E-01
   465        8.3007E+04        1.0000E-01
   466        8.3271E+04        1.0000E-01
   467        8.3451E+04        1.0000E-01
   468        8.3669E+04        1.5000E-01
   469        8.3721E+04        2.0000E-01
   470        8.4021E+04        5.0000E-02
   471        8.4673E+04        1.0000E-01
   472        8.5096E+04        1.0000E-01
   473        8.5101E+04        1.0000E-01
   474        8.5144E+04        5.0000E-02
   475        8.5394E+04        1.0000E-01
   476        8.5402E+04        2.0000E-01
   477        8.5706E+04        5.0000E-02
   478        8.6152E+04        5.0000E-02
   479        8.6207E+04        1.0000E-01
   480        8.6225E+04        2.5000E-01
   481        8.6639E+04        5.0000E-02
   482        8.7538E+04        5.0000E-02
   483        8.7546E+04        2.0000E-01
   484        8.7794E+04        5.0000E-02
   485        8.8098E+04        5.0000E-02
   486        8.8159E+04        5.0000E-02
   487        8.8229E+04        5.0000E-02
   488        8.8291E+04        1.5000E-01
   489        8.8502E+04        5.0000E-02
   490        8.8571E+04        5.0000E-02
   491        8.8788E+04        1.5000E-01
   492        8.9018E+04        5.0000E-02
   493        8.9114E+04        1.5000E-01
   494        8.9590E+04        5.0000E-02
   495        8.9655E+04        5.0000E-02
   496        9.0111E+04        5.0000E-01
   497        9.0245E+04        1.0000E-01
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498        9.0263E+04        5.0000E-02
499        9.0434E+04        5.0000E-02
500        9.0517E+04        2.0000E-01
501        9.0838E+04        1.0000E-01
502        9.1315E+04        5.0000E-02
503        9.1321E+04        5.0000E-02
504        9.1572E+04        2.0000E-01
505        9.1936E+04        5.0000E-02
506        9.1967E+04        5.0000E-02
507        9.2293E+04        5.0000E-02
508        9.2373E+04        5.0000E-02
509        9.2805E+04        1.0000E-01
510        9.2970E+04        1.0000E-01
511        9.3572E+04        5.0000E-02
512        9.3880E+04        1.5000E-01
513        9.4161E+04        1.0000E-01
514        9.4249E+04        5.0000E-02
515        9.4425E+04        5.0000E-02
516        9.4683E+04        5.0000E-02
517        9.4752E+04        5.0000E-02
518        9.4828E+04        1.0000E-01
519        9.4897E+04        1.0000E-01
520        9.4939E+04        5.0000E-02
521        9.5023E+04        1.5000E-01
522        9.5052E+04        5.0000E-02
523        9.5077E+04        5.0000E-02
524        9.5993E+04        5.0000E-02
525        9.6026E+04        5.0000E-02
526        9.6162E+04        5.0000E-02
527        9.6289E+04        5.0000E-02
528        9.6376E+04        2.0000E-01
529        9.6784E+04        1.5000E-01
530        9.7024E+04        5.0000E-02
531        9.7247E+04        5.0000E-02
532        9.7554E+04        2.5000E-01
533        9.7730E+04        1.0000E-01
534        9.7942E+04        5.0000E-02
535        9.8038E+04        1.0000E-01
536        9.8053E+04        1.0000E-01
537        9.8114E+04        1.0000E-01
538        9.8361E+04        5.0000E-02
539        9.8479E+04        5.0000E-02
540        9.8519E+04        1.0000E-01
541        9.8739E+04        5.0000E-02
542        9.8901E+04        5.0000E-02
543        9.8907E+04        1.5000E-01
544        9.9178E+04        5.0000E-02
545        9.9741E+04        5.0000E-02
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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-299

Software Title and Version: TPA 3.3

Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):

snllhs.f,
It is desired that the LHS module be able to duplicate the functionality of the internal MonteCarlo sampler in the TPA code. Two distributions will need to be added: iuniform and logbeta.

Change Requested by:
S. Mohanty
Date: 1-4-00

Change Authorized by (*Software Developer*):
R. Janetzke Ron Janetzke
Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

New pdfs, logbeta, iuniform..
Logbeta and iuniform were implemented following the example of other distributions already included in the snllhs.f file.

Implemented by:
R. Codell Richard Codell

Date:
1-20-00

Description of Acceptance Tests: See Attached.

Tested by: Ron Janetzke
Ron Janetzke

Date: 3-17-00

CNWRA Form TOP-5 (01/99)

Test Plan for SCR #299

Test name: Logbeta and iuniform PDFs for SNLLHS

Anticipated start date: 3-14-00

Anticipated completion date: 3-16-00

Amount of time available to perform this test: 2 days

Percent of time to be spent in process and system level testing: 60/40

Output files to be checked: lhs.out, lhse.out

Input files to be checked for proper data transfer to the program: lhs.inp.

Disposition of documentation: Hard copy and Windows/NT floppy disk attached (all files are Unix files except *.xls).

Functional tests descriptions:
Hand calculations: None

Process-level test 1: Test the logbeta distribution with 1000 realizations using the snllhs.f standalone code. A single parameter input for lhs.inp is sufficient and may make post processing for generating plots simpler. Plots can be compared with Figure 3-6 in the users guide.

Process-level test 2: Test the iuniform distribution with 1000 realizations using the snllhs.f standalone code. A single parameter input for lhs.inp is sufficient and may make post processing for generating plots simpler. Plots can be compared with Figure 3-6 in the users guide.

System-level test 3: Test the TPA codes ability to accept the logbeta and iuniform keywords in the tpa.inp file, and create a properly formatted lhs.inp file.

Reasonableness test description: None required since no TPA input parameters use these distributions at this time.

Did the modification substantially change the results?

NO

Was TPA 4.0beta output compared to TPA3.3 output?

NO, proper behavior is determined from TPA 4.0beta output alone.

Which nuclides were monitored to determine reasonableness of results in terms of dose?
None

Test Results for SCR #299

Process-level test 1: Plot of the frequency distribution compare favorably with Figure 3-6 of the user's guide.

PASSED

Process-level test 2: Plot of the frequency distribution compare favorably with Figure 3-6 of the user's guide.

PASSED

System-level test 3: Properly formatted lhs.inp was created, see \systemlevel\lhs.inp on floppy, and produced expected output,, see \systemlevel\lhs.out on floppy.

PASSED

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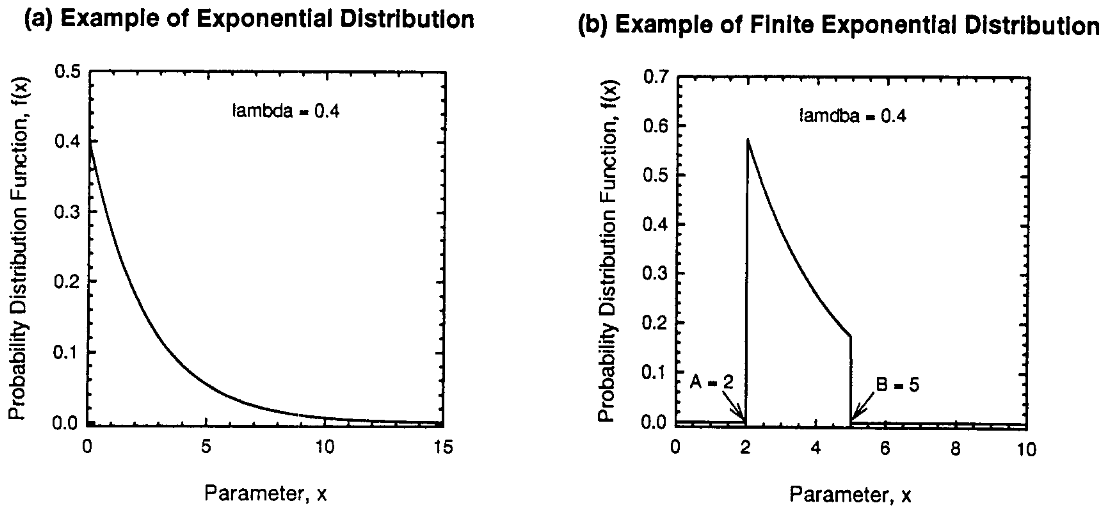
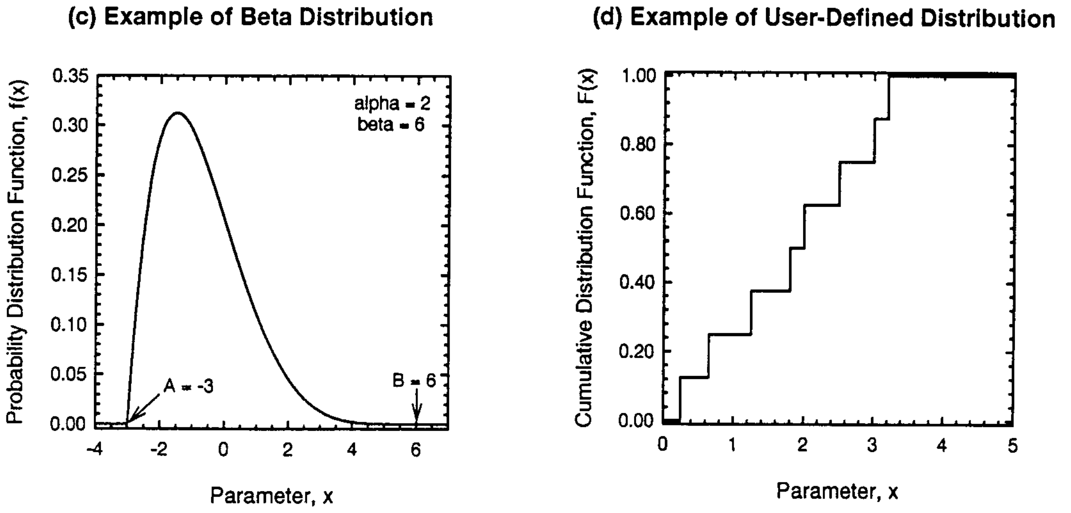
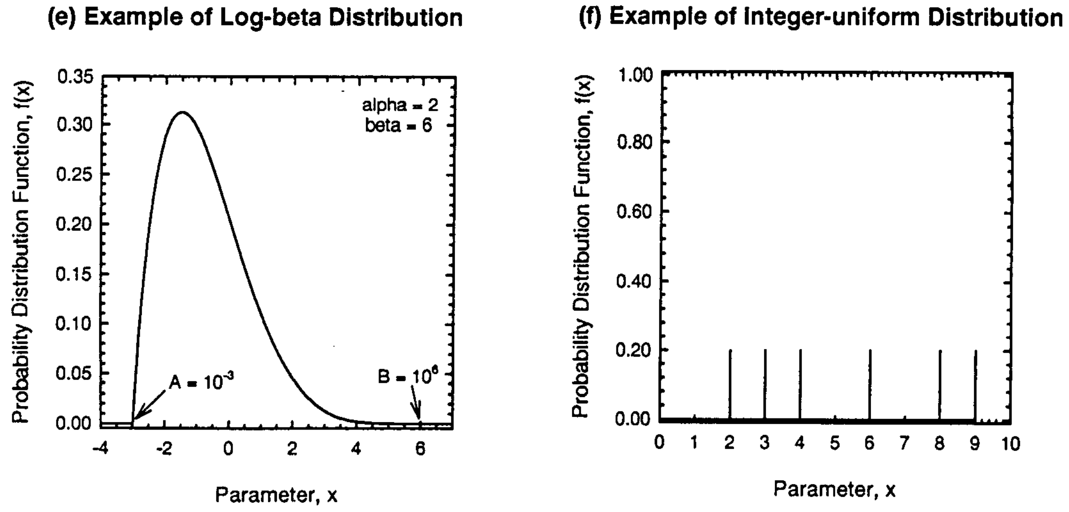

(a) Example of Exponential Distribution

(b) Example of Finite Exponential Distribution

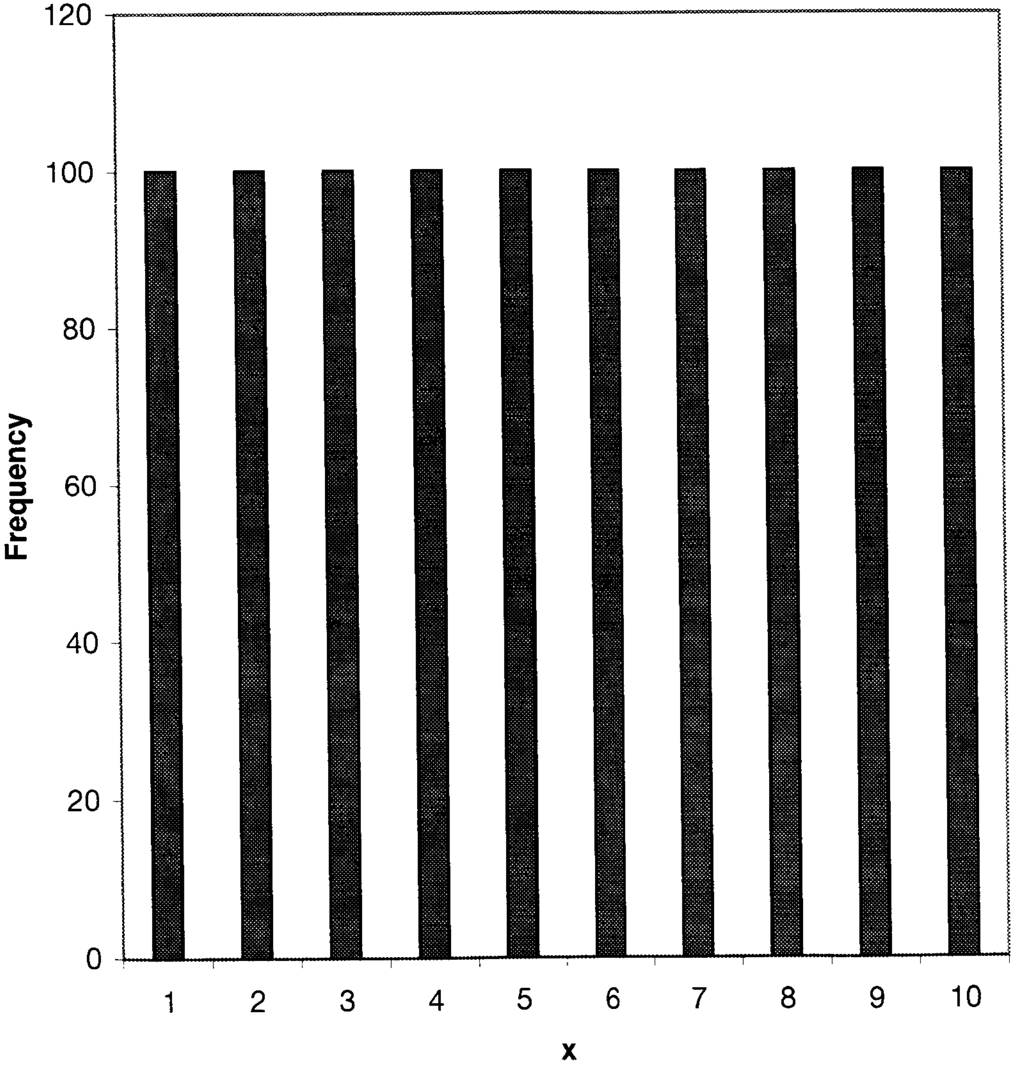

(c) Example of Beta Distribution

(d) Example of User-Defined Distribution

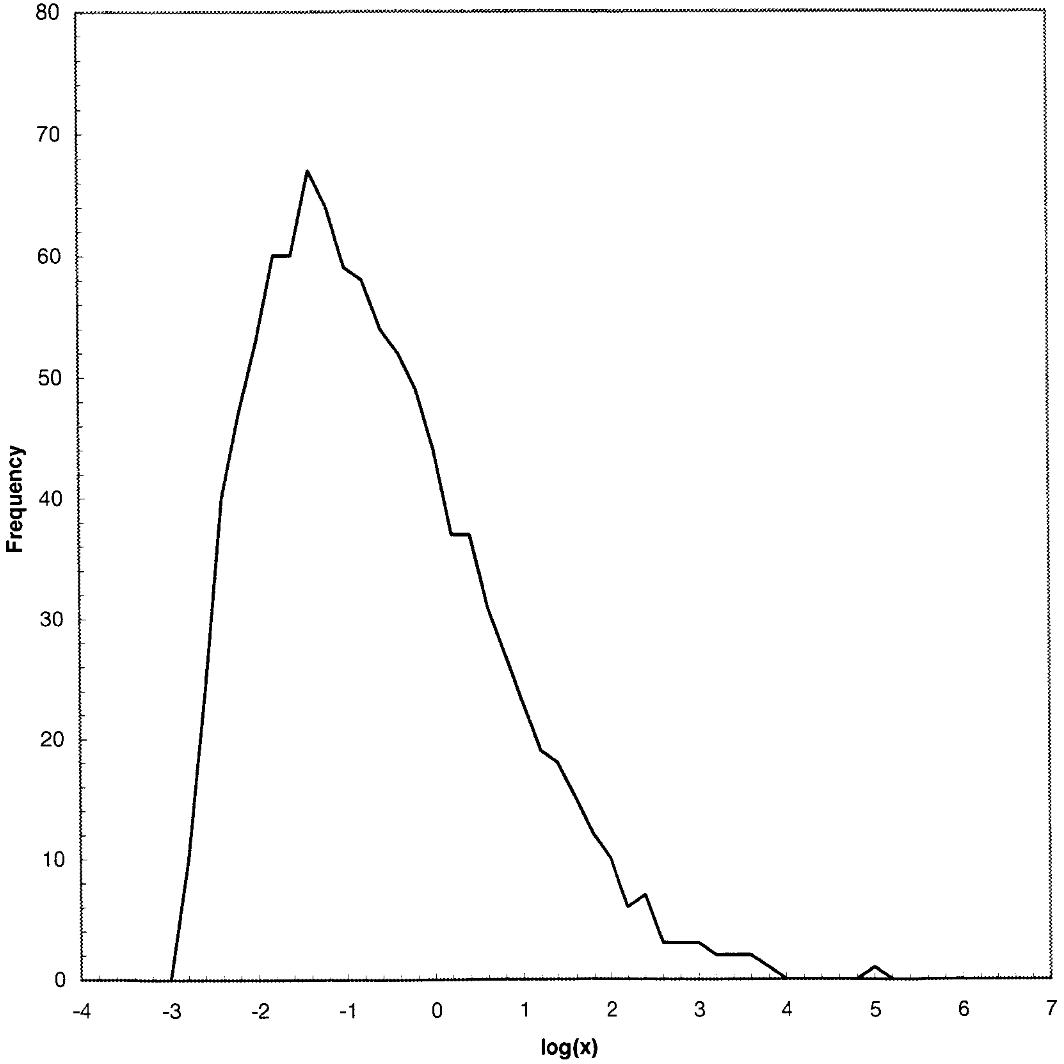

(e) Example of Log-beta Distribution

(f) Example of Integer-uniform Distribution

Fig. 3-6



SNLLHS Iuniform Distribution [0 - 10]
(1000 samples)



SNLLHS Log-beta Distribution [alpha=2, beta=6]
(1000 samples)

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-300	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

szft.f, strmtube.dat, dcagw.f, tpa.inp, szft.i, and tpanames.dbs

In TPA 3.3 the tuff/alluvium interface was fixed at about 5km. It is desired to proved this as a sampled parameter through tpa.inp.

Change Requested by: T. McCartin Date: 1-4-00	**Change Authorized by** (*Software Developer*): R. Janetzke Ron Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

A new strmtube.dat file was created to indicate the stream tube widths and lengths at equidistant contours from the repository boundary in 1km increments starting at 2km and going to 20km. The new parameter would be sampled from 5 to 20 with widths and lengths being interpolated from the strmtube.dat table. The near field stream tube centerline points are now assumed to be within the repository boundary, and the far field points begin at the repository boundary and continue to 20km.

Implemented by: M. Muller	**Date:** 1-20-00

Description of Acceptance Tests: see attached Test Plan and report

Tested by: Jose Menchaca	**Date:** 3/27/00

CNWRA Form TOP-5 (01/99)

TPA Version 3.3 Test Plan: PA-SCR-300

Task Description: Test the dcagw.f and szft.f modules and strmtube.dat input file to accommodate new stream tube parameters.

Reason for Change: The strmtube.dat file provides streamtube information for generating nefmks.f input files. The strmtube.dat file contains information about each stream tube including its flow rate, its x and y centerline coordinates in UTM units for the length of stream tube that is under the repository (i.e. the subareas) and stream tube lengths and widths for points up to 20 km beyond the repository in 1 km increments.

Analyst: R. Janetzke, R. Fedors **Date:** 02/07/00

Controlled Version: **Version 3.3**
Modified Version: **Version 4.0beta**

Anticipated Completion:

Time available for testing:

Percent of Hours for process-level testing:

Output files to be checked:

Test 1:
screen.out (for Test 1)

Test 2:
tpa.out
cumulative_nefii.inp
nefiisz.inp

Input files to be checked for correct data transfer:
strmtube.dat

Mode of documentation

Functional Testing

Process-level testing:

265/397

Test 1 Testing of new interpolate subroutine.

A new interpolation subroutine was introduced because of changes made to the strmtube.dat file and the addition of a new sampled parameter determining the distance to the tuff alluvium interface (DTTAI1). To define each stream tube length and width, the new strmtube.dat file has a table with 3 columns of data consisting of Tuff to Alluvium Interface Distance, Stream Tube Width and Stream Tube Length. When the Latin hypercube sampler selects a DTTAI1 value, the length and width of the stream tube is determined by interpolating the value of the width and length based upon where the DTTAI1 parameter falls within the Tuff to Alluvium Interface Distance index within the table. An interpolation routine was developed to return the interpolated tuff/alluvium width and length when passed the following seven parameters:

sampled tuff/alluvium distance
low distance value of table
high distance value of table
low width value of table
high width value of table
low length value of table
high length value of table

The six high and low values listed under the sampled distance are from the table data read from the strmtube.dat file.

To test this new subroutine, a standalone program, called interpolate, was created that reads the strmtube.dat file table data and requests the user to input a distance to be used. Using this information as input, the interpolate routine is invoked and the results printed to the screen for each streamtube. The user can then check his/her hand calculated results with those printed out on the screen. A sample of the output is given in screen.out

PASSED.

Test 2 Testing of strmtube.dat and stream tube calculations

Most of the changes made to the strmtube.dat file affect the szft.f module. The data values of the strmtube.dat file are read in by a subroutine of szft.f called getszunits. The input parameters to the subroutine are the subarea (isa) and the distance to critical group (disttocg). The returned parameters are the subarea mixing zone length (samixlength), the subarea mixing zone width (widthmix), the mixing zone unit abbreviation (mixsalayernam), the zone of origin for mixing zone layer name (czone), flow rate in the stream tube (flowrate), the number of units returned (numsalayers), an array of unit abbreviations (szsalayernam), an array of lengths for each unit (salength), and an array of stream tube widths for each unit (sawidth). Some of these parameters are available for viewing in some of the output files, but many are not. In order to verify that the strmtube.dat file is being read properly and that the parameters in getszunits are being properly calculated, it is necessary to output these values for the users inspection. In the getszunits module of szft.f, write statements were added right before the return statement of getszunits subroutine to display the parameters listed above.

Because the nefii.inp file is replaced for each subarea, a mechanism for saving the results of nefii.inp for each subarea is needed. Before the nefii.inp file is replaced, it will be appended to a cumulative file named cumulative_nefii.inp. In the "main" area of szft.f, i.e. before the subroutines, the few lines of code shown below were added after the 'cp nefii.inp nefiisz.inp' shell script to append the contents of the nefii.inp file to the cumulative_nefii.inp file.. This allows comparison between the lines just added to the tpa.out file in the paragraph above and the cumulative_nefii.inp files.

```
inquire( file='nefii.inp', EXIST=lexist)
if (lexist) then
   istatus = zportsh( 'cat nefii.inp >> cumulative_nefii.inp')
else
   istatus = zportsh( 'cat nefii.inp > cumulative_nefii.inp')
endif
```

Please note that in order for this to work properly the lexist parameter must be declared as logical in the declaration area before any lines of code are executed..

Hand calculations:

Several hand calculation and/or ballpark checks may be made with the assistance of write statements of pertinent parameters interspersed in the szft.f code and with a map of the current subareas and stream tubes.

A write statement displaying the centroid of a subarea allows for a ballpark estimate of which streamtube should be selected by the subroutine. Knowing the centroid location allows the user to draw a line on the current map through the centroid of the specified subarea that is parallel to the streamtube chosen allowing him/her to estimate the length of the subarea mix length. The subarea mix length should indeed be proportional to the cross-section of the subarea. Large subareas such as 1, 2, and 8 should have large subarea mix lengths while subareas such as subarea 7 should have small mix lengths.

Each salength listed as making up the alluvium zone may be calculated by taking the difference between its own length listed and the length of the previous salength.

PASS

System-level testing:

Write statements strategically spaced throughout the code will provide system level analysis of the reading of the input file, strmtube.dat.

Reasonableness testing:

Given a base case run with only the DistanceToTuffAlluviumInterface parameter allowed to vary, the pktede in the output file totaldos.res should increase as the distance to tuff alluvium interface increase. As the alluvium length decreases, flow retardation decreases allowing a greater percentage of the nuclides to reach the critical group.

PASS

Final checklist:

- **Did the modification substantially change the results?**

Because of significant changes to the strmtube.dat file, the modifications are expected to be very different than the previous version of the tpa code.

- **Were TPA 3.3 and 4.0beta compared using corresponding mean values in tpa.inp? (If NO, please state reason).**

- No. Instead of mean value run comparisons, multiple runs using different ranges of the DistanceToTuffAlluviumInterface value were used to assess the reasonableness of the output.

- **Which nuclides were monitored to determine reasonableness of results in terms of dose.**

268/357

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-301	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s): The DCAGW module of TPA 3.3 was modified with four code changes related to incorporating GENII v.1.485 into TPA 3.3.

The first change (I), 'flexibility in defining the exposure scenario,' allows TPA 4.0 users to modify biosphere characteristics and create automated biosphere-dependent dose-conversion-factor (DCF) files. Previously, the biosphere characteristics were fixed and then used externally by GENII-S to create a set of fixed DCF files (gw_cb_ad.dat, gw_cb_ci.dat, gw_pb_ad.dat, and gw_pb_ci.dat) for later use by TPA.

The second change (II), 'stochastic biosphere and receptor group,' allows TPA 4.0 users to stochastically sample up to 113 biosphere- and age-dependent parameters that will be used by GENII and TPA 4.0 to create DCF files.

The third change (III), 'build-up of radionuclides in soil from irrigation,' allows TPA 4.0 users to select a time period, prior to exposure, during which irrigation of soil occurred.

The fourth change (IV), 'age-specific doses,' allows TPA 4.0 users to select one of 6 available age groups for analysis.

Change Requested by: P. LaPlante, M. Smith Date:1-4-00	**Change Authorized by** (*Software Developer*): R. Janetzke SEE SIGNATURE ON NEXT ORIGINAL PAGE. 3/31/2000 Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

(See Attachment 1)

Implemented by: M. Smith, P. LaPlante, M. Muller	**Date:** 2-11-00

Description of Acceptance Tests: (See Attachments 2 and 3)

Roland R. Benke

Tested by: R. Benke, P.LaPlante, J. Weldy James R. Weldy	**Date: 3/27/00**

CNWRA Form TOP-5 (01/99)

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-301	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

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Change Requested by: P. LaPlante, M. Smith Date:1-4-00	**Change Authorized by** (*Software Developer*): R. Janetzke R Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

(See Attachment 1)

Implemented by: M. Smith, P. LaPlante, M. Muller	**Date:** 2-11-00

Description of Acceptance Tests:

Tested by:	**Date:**

ATTACHMENT 1: GENII-Related Modifications to TPA 3.3
SCR No. PA-SCR-301

page 1 of 2

Description of Change(s) or Problem Resolution (If changes not implemented, please justify):

Code change I was made by (i) invoking GENII v1.485 modules genvin.e and genv.e (formerly called envin.e and env.e) from dcagw.f, and (ii) adding a new section to dcagw.f, called 'gentodcf,' to calculate dose-conversion factors (DCF). For part (i), genvin.e and genv.e were modified only to allow them to be run on the UNIX platform, since the original versions were only PC compatible. Genvin.e and genv.e are called twice from dcagw.f to calculate exposure rates for non-pluvial and pluvial conditions. The exposure rates are saved in a file called genv.out (formerly env.out). For part (ii), gentodcf is used twice: to calculate non-pluvial DCFs (gw_cb_ad.dat and gw_cb_ci.dat) and pluvial DCFs (gw_pb_ad.dat and gw_pb_ci.dat). A new column was added to the DCF output files gw_cb_ad.dat and gw_pb.ad.dat to store milk-pathway DCF values. Previously, these files contained DCFs for the following 5 pathways: direct exposure, inhalation, animal product ingestion, crop and soil ingestion, and drinking water ingestion. Changes were made to the summation of DCFs done in dcagw.f to account for the new milk-pathway DCF. Additionally, the following GENII data files were modified: filename.dat, ggamen.dat, grmdlib.dat, ggrdf.dat, gnewdf.dat, gftrans.dat, gdefault.dat (formerly called filename.dat, gamen.dat, rmdlib.dat, grdf.dat, ftrans.dat, default.dat). Filename.dat was modified to tell GENII the locations and names of modified files. Ggamen.dat, grmdlib.dat, ggrdf.dat, and gnewdf.dat were modified (1/26/00, MAS) to permit exposure calculations for ^{108m}Ag. Ggrdf.dat was also modified to use Federal Guidance Report No. 12 values for air-submersion exposure and ground-surface dose coefficients (6/28/97, SJM/PAL; 1/28/00, MAS). Gftrans.dat was modified (3/19/95, SJM) to use IAEA food transfer factors. Gdefault.dat was modified (7/16/97, PAL) to use Yucca Mountain biosphere characteristics.

Code change II was made by adding 113 biosphere-related parameters to tpa.inp that are used to modify the GENII input files: ggenii.inp, gdefault.inp, and gftrans.dat (formerly called genii.in, default.in, and ftrans.dat). These parameters include the following 2 soil-related parameters written to gdefault.inp: InterceptionFraction/Irrigate, DepthOfSurfaceSoil[cm]; 1 soil-related parameter written to ggenii.inp: MassLoadingFactor[g/m3]; 36 climate-dependent parameters written to ggenii.inp: LeafyVegetableIrrigationRatePB[in/yr], OtherVegetableIrrigationRateCB[in/yr], FruitIrrigationRatePB[in/yr], GrainIrrigationRatePB[in/yr], HomeIrrigationRatePB[in/yr], PoultryFeedIrrigationRatePB[in/yr], HenFeedIrrigationRatePB[in/yr], LeafyVegetableIrrigationTimePB[mo/yr], OtherVegetableIrrigationTimePB[mo/yr], FruitIrrigationTimePB[mo/yr], GrainIrrigationTimePB[mo/yr], HomeIrrigationTimePB[mo/yr], PoultryFeedIrrigationTimePB[mo/yr], HenFeedIrrigationTimePB[mo/yr], LeafyVegetableIrrigationRateCB[in/yr], OtherVegetableIrrigationRateCB[in/yr], FruitIrrigationRateCB[in/yr], GrainIrrigationRateCB[in/yr], HomeIrrigationRateCB[in/yr], PoultryFeedIrrigationRateCB[in/yr], HenFeedIrrigationRateCB[in/yr], LeafyVegetableIrrigationTimeCB[mo/yr], OtherVegetableIrrigationTimeCB[mo/yr], FruitIrrigationTimeCB[mo/yr], GrainIrrigationTimeCB[mo/yr], HomeIrrigationTimeCB[mo/yr], PoultryFeedIrrigationTimeCB[mo/yr], HenFeedIrrigationTimeCB[mo/yr], BeefFreshForageIrrigationRatePB[in/yr], MilkFreshForageIrrigationRatePB[in/yr], BeefFreshForageIrrigationTimePB[mo/yr], MilkFreshForageIrrigationTimePB[mo/yr], BeefFreshForageIrrigationRateCB[mo/yr], MilkFreshForageIrrigationRateCB[in/yr], BeefFreshForageIrrigationTimeCB[mo/yr], and MilkFreshForageIrrigationTimeCB[mo/yr]; 6 biosphere-related parameters written to ggenii.inp: PoultryFeedGrowTime[day], HenFeedGrowTime[day], BeefFreshForageDietFraction, MilkFreshForageDietFraction, BeefFreshForageGrowTime[day], and MilkFreshForageGrowTime[day]; 66 age-dependent parameters written to ggenii.inp:

DrinkingWaterConsumptionRate1[L/yr], LeafyVegetableConsumptionRate1[kg/yr], OtherVegetableConsumptionRate1[kg/yr], FruitConsumptionRate1[kg/yr], GrainConsumptionRate1[kg/yr], BeefConsumptionRate1[kg/yr], PoultryConsumptionRate1[kg/yr], MilkConsumptionRate1[kg/yr], EggConsumptionRate1[kg/yr], InhalationExposureTime1[hr], SoilContaminationExposureTime1[hr], DrinkingWaterConsumptionRate2[L/yr], LeafyVegetableConsumptionRate2[kg/yr], OtherVegetableConsumptionRate2[kg/yr], FruitConsumptionRate2[kg/yr], GrainConsumptionRate2[kg/yr], BeefConsumptionRate2[kg/yr], PoultryConsumptionRate2[kg/yr], MilkConsumptionRate2[kg/yr], EggConsumptionRate2[kg/yr], InhalationExposureTime2[hr], SoilContaminationExposureTime2[hr], DrinkingWaterConsumptionRate3[L/yr], LeafyVegetableConsumptionRate3[kg/yr], OtherVegetableConsumptionRate3[kg/yr], FruitConsumptionRate3[kg/yr], GrainConsumptionRate3[kg/yr], BeefConsumptionRate3[kg/yr], PoultryConsumptionRate3[kg/yr], MilkConsumptionRate3[kg/yr], EggConsumptionRate3[kg/yr], InhalationExposureTime3[hr], SoilContaminationExposureTime3[hr], DrinkingWaterConsumptionRate4[L/yr], LeafyVegetableConsumptionRate4[kg/yr], OtherVegetableConsumptionRate4[kg/yr], FruitConsumptionRate4[kg/yr], GrainConsumptionRate4[kg/yr], BeefConsumptionRate4[kg/yr], PoultryConsumptionRate4[kg/yr], MilkConsumptionRate4[kg/yr], EggConsumptionRate4[kg/yr], InhalationExposureTime4[hr], SoilContaminationExposureTime4[hr], DrinkingWaterConsumptionRate5[L/yr], LeafyVegetableConsumptionRate5[kg/yr], OtherVegetableConsumptionRate5[kg/yr], FruitConsumptionRate5[kg/yr], GrainConsumptionRate5[kg/yr], BeefConsumptionRate5[kg/yr], PoultryConsumptionRate5[kg/yr], MilkConsumptionRate5[kg/yr], EggConsumptionRate5[kg/yr], InhalationExposureTime5[hr], SoilContaminationExposureTime5[hr], DrinkingWaterConsumptionRate6[L/yr], LeafyVegetableConsumptionRate6[kg/yr], OtherVegetableConsumptionRate6[kg/yr], FruitConsumptionRate6[kg/yr], GrainConsumptionRate6[kg/yr], BeefConsumptionRate6[kg/yr], PoultryConsumptionRate6[kg/yr], MilkConsumptionRate6[kg/yr], EggConsumptionRate6[kg/yr], InhalationExposureTime6[hr], SoilContaminationExposureTime6[hr]; and 2 scaling factors used to scale the plant- and animal-related columns of gftrans.dat: PlantUptakeScaleFactor and AnimalUptakeScaleFactor.

Code change III was made by adding 1 parameter to tpa.inp, to be written to the GENII input file: ggenii.inp. Radionuclide build-up in soil due to irrigation is already a function of GENII, and this change just allows the TPA 4.0 user to set or sample for this parameter value called YearsOfIrrigationPriorToIntakePeriod[yr].

Code change IV was made by (i) modifying the GENII data file: dosinc.dat (now called gnewdf.dat) and (ii) adding a parameter to tpa.inp called ReceptorAgeGroup(1=Nfnt,2Tod,3PTeen,4Teen,5Adlt,6AdltFGR11). As supplied, GENII does not calculate age-specific doses. For part (i), a new data file called gnewdf.dat was created (1/24/00 PAL) to replace dosinc.dat that contains inhalation and ingestion dose coefficients for 6 age groups and 74 radionuclides. The data for age groups 1 to 5 (infant, toddler, preteen, teen, and adult) are based on ICRP 72 values and the data for age group 6 (adult) are based on Federal Guidance Report No. 11 values. For part (ii), the ReceptorAgeGroup parameter was added to tpa.inp. The TPA user can choose one of six age groups for analysis and the choice is used in dcagw.f to read the corresponding age group data from gnewdf.dat.

Southwest Research Institute, Div. 20

TWINBROOK METRO PLAZA, #210
12300 TWINBROOK PARKWAY
ROCKVILLE, MD 20852-1606

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DATE: 3/27/00

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COMPANY:

FROM: P. LaPlante

COMPANY: SOUTHWEST RESEARCH INSTITUTE, DIVISION 20

MESSAGE:

Signed SCR –

I sent you the attachment via e-mail –
Notebook done this afternoon.
Call if you have further Q's.

Pat

RECEIVED
MAR 27 2000

Description of Change(s) or Problem Resolution (If changes not implemented, please justify):

Code change I was made by (i) invoking GENII v1.485 modules genvin.e and genv.e (formerly called envin.e and env.e) from dcagw.f, and (ii) adding a new section to dcagw.f, called 'gentodcf,' to calculate dose-conversion factors (DCF). For part (i), genvin.e and genv.e were modified only to allow them to be run on the UNIX platform, since the original versions were only PC compatible. Genvin.e and genv.e are called twice from dcagw.f to calculate exposure rates for non-pluvial and pluvial conditions. The exposure rates are saved in a file called genv.out (formerly env.out). For part (ii), gentodcf is used twice: to calculate non-pluvial DCFs (gw_cb_ad.dat and gw_cb_ci.dat) and pluvial DCFs (gw_pb_ad.dat and gw_pb_ci.dat). A new column was added to the DCF output files gw_cb_ad.dat and gw_pb.ad.dat to store milk-pathway DCF values. Previously, these files contained DCFs for the following 5 pathways: direct exposure, inhalation, animal product ingestion, crop and soil ingestion, and drinking water ingestion. Changes were made to the summation of DCFs done in dcagw.f to account for the new milk-pathway DCF. Additionally, the following GENII data files were modified: filename.dat, ggamen.dat, grmdlib.dat, ggrdf.dat, gnewdf.dat, gftrans.dat, gdefault.dat (formerly called filename.dat, gamen.dat, rmdlib.dat, grdf.dat, ftrans.dat, default.dat). Filename.dat was modified to tell GENII the locations and names of modified files. Ggamen.dat, grmdlib.dat, ggrdf.dat, and gnewdf.dat were modified (1/26/00, MAS) to permit exposure calculations for ^{108m}Ag. Ggrdf.dat was also modified to use Federal Guidance Report No. 12 values for air-submersion exposure and ground-surface dose coefficients (6/28/97, SJM/PAL; 1/28/00, MAS). Gftrans.dat was modified (3/19/95, SJM) to use IAEA food transfer factors. Gdefault.dat was modified (7/16/97, PAL) to use Yucca Mountain biosphere characteristics.

Code change II was made by adding 113 biosphere-related parameters to tpa.inp that are used to modify the GENII input files: ggenii.inp, gdefault.inp, and gftrans.dat (formerly called genii.in, default.in, and ftrans.dat). These parameters include the following 2 soil-related parameters written to gdefault.inp: InterceptionFraction/Irrigate, DepthOfSurfaceSoil[cm]; 1 soil-related parameter written to ggenii.inp: MassLoadingFactor[g/m3]; 36 climate-dependent parameters written to ggenii.inp: LeafyVegetableIrrigationRatePB[in/yr], OtherVegetableIrrigationRateCB[in/yr], FruitIrrigationRatePB[in/yr], GrainIrrigationRatePB[in/yr], HomeIrrigationRatePB[in/yr], PoultryFeedIrrigationRatePB[in/yr], HenFeedIrrigationRatePB[in/yr], LeafyVegetableIrrigationTimePB[mo/yr], OtherVegetableIrrigationTimePB[mo/yr], FruitIrrigationTimePB[mo/yr], GrainIrrigationTimePB[mo/yr], HomeIrrigationTimePB[mo/yr], PoultryFeedIrrigationTimePB[mo/yr], HenFeedIrrigationTimePB[mo/yr], LeafyVegetableIrrigationRateCB[in/yr], OtherVegetableIrrigationRateCB[in/yr], FruitIrrigationRateCB[in/yr], GrainIrrigationRateCB[in/yr], HomeIrrigationRateCB[in/yr], PoultryFeedIrrigationRateCB[in/yr], HenFeedIrrigationRateCB[in/yr], LeafyVegetableIrrigationTimeCB[mo/yr], OtherVegetableIrrigationTimeCB[mo/yr], FruitIrrigationTimeCB[mo/yr], GrainIrrigationTimeCB[mo/yr], HomeIrrigationTimeCB[mo/yr], PoultryFeedIrrigationTimeCB[mo/yr], HenFeedIrrigationTimeCB[mo/yr], BeefFreshForageIrrigationRatePB[in/yr], MilkFreshForageIrrigationRatePB[in/yr], BeefFreshForageIrrigationTimePB[mo/yr], MilkFreshForageIrrigationTimePB[mo/yr], BeefFreshForageIrrigationRateCB[mo/yr], MilkFreshForageIrrigationRateCB[in/yr], BeefFreshForageIrrigationTimeCB[mo/yr], and MilkFreshForageIrrigationTimeCB[mo/yr]; 6 biosphere-related parameters written to ggenii.inp: PoultryFeedGrowTime[day], HenFeedGrowTime[day], BeefFreshForageDietFraction, MilkFreshForageDietFraction, BeefFreshForageGrowTime[day], and MilkFreshForageGrowTime[day]; 66 age-dependent parameters written to ggenii.inp:

DrinkingWaterConsumptionRate1[L/yr], LeafyVegetableConsumptionRate1[kg/yr], OtherVegetableConsumptionRate1[kg/yr], FruitConsumptionRate1[kg/yr], GrainConsumptionRate1[kg/yr], BeefConsumptionRate1[kg/yr], PoultryConsumptionRate1[kg/yr], MilkConsumptionRate1[kg/yr], EggConsumptionRate1[kg/yr], InhalationExposureTime1[hr], SoilContaminationExposureTime1[hr], DrinkingWaterConsumptionRate2[L/yr], LeafyVegetableConsumptionRate2[kg/yr], OtherVegetableConsumptionRate2[kg/yr], FruitConsumptionRate2[kg/yr], GrainConsumptionRate2[kg/yr], BeefConsumptionRate2[kg/yr], PoultryConsumptionRate2[kg/yr], MilkConsumptionRate2[kg/yr], EggConsumptionRate2[kg/yr], InhalationExposureTime2[hr], SoilContaminationExposureTime2[hr], DrinkingWaterConsumptionRate3[L/yr], LeafyVegetableConsumptionRate3[kg/yr], OtherVegetableConsumptionRate3[kg/yr], FruitConsumptionRate3[kg/yr], GrainConsumptionRate3[kg/yr], BeefConsumptionRate3[kg/yr], PoultryConsumptionRate3[kg/yr], MilkConsumptionRate3[kg/yr], EggConsumptionRate3[kg/yr], InhalationExposureTime3[hr], SoilContaminationExposureTime3[hr], DrinkingWaterConsumptionRate4[L/yr], LeafyVegetableConsumptionRate4[kg/yr], OtherVegetableConsumptionRate4[kg/yr], FruitConsumptionRate4[kg/yr], GrainConsumptionRate4[kg/yr], BeefConsumptionRate4[kg/yr], PoultryConsumptionRate4[kg/yr], MilkConsumptionRate4[kg/yr], EggConsumptionRate4[kg/yr], InhalationExposureTime4[hr], SoilContaminationExposureTime4[hr], DrinkingWaterConsumptionRate5[L/yr], LeafyVegetableConsumptionRate5[kg/yr], OtherVegetableConsumptionRate5[kg/yr], FruitConsumptionRate5[kg/yr], GrainConsumptionRate5[kg/yr], BeefConsumptionRate5[kg/yr], PoultryConsumptionRate5[kg/yr], MilkConsumptionRate5[kg/yr], EggConsumptionRate5[kg/yr], InhalationExposureTime5[hr], SoilContaminationExposureTime5[hr], DrinkingWaterConsumptionRate6[L/yr], LeafyVegetableConsumptionRate6[kg/yr], OtherVegetableConsumptionRate6[kg/yr], FruitConsumptionRate6[kg/yr], GrainConsumptionRate6[kg/yr], BeefConsumptionRate6[kg/yr], PoultryConsumptionRate6[kg/yr], MilkConsumptionRate6[kg/yr], EggConsumptionRate6[kg/yr], InhalationExposureTime6[hr], SoilContaminationExposureTime6[hr]; and 2 scaling factors used to scale the plant- and animal-related columns of gftrans.dat: PlantUptakeScaleFactor and AnimalUptakeScaleFactor.

Code change III was made by adding 1 parameter to tpa.inp, to be written to the GENII input file: ggenii.inp. Radionuclide build-up in soil due to irrigation is already a function of GENII, and this change just allows the TPA 4.0 user to set or sample for this parameter value called YearsOfIrrigationPriorToIntakePeriod[yr].

Code change IV was made by (i) modifying the GENII data file: dosinc.dat (now called gnewdf.dat) and (ii) adding a parameter to tpa.inp called ReceptorAgeGroup(1=Nfnt,2Tod,3PTeen,4Teen,5Adlt,6AdltFGR11). As supplied, GENII does not calculate age-specific doses. For part (i), a new data file called gnewdf.dat was created (1/24/00 PAL) to replace dosinc.dat that contains inhalation and ingestion dose coefficients for 6 age groups and 74 radionuclides. The data for age groups 1 to 5 (infant, toddler, preteen, teen, and adult) are based on ICRP 72 values and the data for age group 6 (adult) are based on Federal Guidance Report No. 11 values. For part (ii), the ReceptorAgeGroup parameter was added to tpa.inp. The TPA user can choose one of six age groups for analysis and the choice is used in dcagw.f to read the corresponding age group data from gnewdf.dat.

Attachment 2

TPA Test Plan

Tester: James Weldy

Test name: Test of implementation of GENII in the TPA code - stochastic receptor group, age-dependent doses, pluvial changes

Anticipated start date: 2/24/00

Anticipated completion date: 3/27/00

Amount of your time available to perform this test: 32 hours

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): Testing will consist of 100% system level testing, utilizing the intermediate output files produced by the TPA code to ensure that the changes are functioning properly.

Output files to be checked: gw_cb_ad.dat, gw_pb_ad.dat, rgwna.tpa, sp.tpa

Input files to be checked for proper data transfer to the program: gdefault.def, gftrans.inp, gdefault.inp, ggenii.inp

Disposition of documentation (storage medium, physical location, and access method): All tests will be archived on two floppy disks and described in a scientific notebook that will be submitted to the TPA code custodian, Ron Janetzke, upon completion of the testing. On the floppy disks, the tests will be contained in the folders test 1 through test 5.

Functional Test Descriptions:

- System-level tests:

Test 2: This test is for whether the DCFs are properly switching to the pluvial DCFs at the proper time. The test will consist of running a case of adult dose for 100,000 years (so that the pluvial DCFs will kick in and return to current conditions). Then an Excel spreadsheet will be used to multiply the releases from SZFT (in dcagw.ech) by the DCF (in gw_cb_ad.dat and gw_pb_ad.dat) and divide by the proper pumping rate (from tpa.inp) to check that both are switching at the pluvial time.

Test 3: This test is to ensure that the parameters in tpa.inp for the GENII code are being sampled properly. This test will consist of running a series of 100 realizations of the TPA code and checking to see that the distribution of values generated by the sampling routine is appropriate for the distribution sampled. The tpa.inp file will be used to set up the distributions of the parameters that are sampled and the sp.tpa file will be checked to ensure that the values are sampled properly.

Test 4: This test is to ensure that the appropriate GENII files are updated between realizations based on new values that are sampled for the GENII code. This test will consist of running a single realization run and a two realization run. For both runs, it will be confirmed that the values written to ggenii.inp and gftrans.inp are correctly being transferred from the sampled value contained in sp.tpa to these GENII input files.

Reasonableness Test Description:

Test1: This test is for whether the age-specific DCFs are implemented properly in the TPA code. The test will consist of running a base case of adult DCFs which will be compared to the DCFs for the other age groups. The results will be compared to age-specific dose calculations performed earlier using an Excel spreadsheet by Weldy. This spreadsheet only indicates the changes to pathway specific dose, not overall dose.

Test 5: This test is to ensure that the pluvial DCFs calculated in the current implementation of the TPA code match the DCFs calculated for TPA 3.3 when the same input data is used. This test will consist of setting all the gentpa values in tpa.inp to constant values that match the values used in Laplante, et al. (1997) and ensure that the pluvial DCFs match those in the same reference. Files used in the test include tpa.inp, for the input data, and gw_pb_ad.dat to check the DCF.

Final Checklist (completed during testing):

- Did the modification substantially change the results? The modification to the code did not substantially change the results of the calculation. Using the same input data as the data used in TPA 3.3 results in the same dose conversion factors as were developed for TPA 3.3.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp? The pluvial DCFs were recalculated using the mean values used to calculate the pluvial DCFs for TPA 3.3 and were shown to not change.

- Which nuclides were monitored to determine reasonableness of results in term of dose? The DCFs of all 43 nuclides were monitored to ensure that results were reasonable.

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ATTACHMENT 3: Description of Acceptance Tests for GENII-Related Modifications to TPA 3.3
SCR No. PA-SCR-301

Test Plan for SCR #301

Test name: GENTPA Setup Test

Anticipated start date: 3/9/00

Anticipated completion date: 3/10/00

Amount of your time available to perform this test: 2 hours

Percent of testing time to be spent in process level testing and system level testing: This test is primarily a process level test, however, execution of GENTPA occur by executing TPA.

Output files to be checked:

ggenii.out

Input files to be checked for proper data transfer to program:

ggamen.dat
grmdlib.dat
ggrdf.dat
gdefault.def/inp
gftrans.def/inp
gnewdf.dat
ggenii.def/inp
tpa.inp

Disposition of documentation (storage medium, physical location, and access method):

-TPA input and output files used for the test will be archived on zip disks and referenced in the scientific notebook (#194)

-data file comparisons will be documented on marked printouts that will be included in the scientific notebook (#194)

Functional test descriptions:

-Hand calculations: none

-Process-level tests:

Note: Tests involving parameters and data that are radionuclide or element specific should include checking values for the following radionuclides and elements that have been shown in TPA sensitivity analyses to be important to dose: ^{245}Cm, ^{241}Am, ^{237}Np, ^{239}Pu, ^{234}U, ^{230}Th, ^{129}I, ^{99}Tc, ^{14}C, ^{79}Se, and ^{36}Cl.

Setup Test #1: Confirm data input to files is correct by checking all values in ggamen.dat, grmdlib.dat, ggrdf.dat, gdefault.def, gftrans.def, and gnewdf.dat. Correct values for these files are available from GENII-S data files used for TPA 3.3 DCFs. The proper comparison data for dose coefficients in gnewdf.dat and ggrdf.dat are Federal Guidance Report #11 (U.S. Environmental Protection Agency, 1988), and Federal Guidance Report #12 (U.S. Environmental Protection Agency, 1993), respectively. Also, confirm all adult parameter values in ggenii.def and tpa.inp are same as those listed in appendix B of CNWRA 97-009.

Setup Test #2: Test the routines that create the input file for GENTPA (ggenii.def/inp) and write to GENTPA data files to ensure correct transfer of information

- are parameters in tpa.inp being correctly written to ggenii.inp?
- are fixed parameters in ggenii.def transferred correctly to ggenii.inp?
- does GENTPA input echo in ggenii.out confirm parameters transferred correctly?
- check gdefault.inp and tpa.inp after TPA run to confirm values from tpa.inp have been passed correctly to gdefault.inp
- check gftrans.inp after TPA run to ensure values are same as gftrans.def

-System-level tests:

TPA runs used to execute GENTPA for aforementioned tests will be done for the total system. This will provide some assurance that GENTPA setup and input parameter and data transfers are operating as intended when TPA is executed.

Reasonableness Test Description: None for this test (emphasis is on checking data transfer)

Final checklist (completed during testing):

Setup Test #1:

a) confirm that all parameter and data files contain the correct information?
b) ggamen.dat, grmdlib.dat contain the same data used for DCF calculations for TPA 3.3 (consistent with gamen.dat, and grmdlib.dat from GENII-S except ^{108}Ag added)
c) ggrdf.dat contains external dose coefficients from Federal Guidance 12 (U.S. Environmental Protection Agency, 1993) (ground surface and air submersion exposure values have been correctly entered into column1 and 3 in ggrdf.dat)
d) gdefault.def contains the same data used for DCF calculations for TPA 3.3 (consistent with the default.ip3 file used for GENII-S runs for TPA 3.3)
e) gftrans.def contains the same food transfer factors use for TPA 3.3 DCFs (documented in CNWRA 97-009 and provided in ftrans.ip3)
f) gnewdf.dat contains internal dose coefficients for adult receptor consistent with values used for TPA 3.3 DCFs reported in Federal Guidance 11 (U.S. Environmental Protection Agency, 1988).
g) ggenii.def contains fixed input parameter values for GENTPA consistent with values used for TPA 3.3 DCFs (documented in CNWRA 97-009, Appendix B)
h) tpa.inp contains the same values used for TPA 3.3 DCF calculations (consistent with values reported in CNWRA 97-009, Appendix B)

Setup Test #2:

a) confirm that all parameters and data transfers are operating as intended
b) parameters in tpa.inp being correctly written to ggenii.inp
c) fixed parameters in ggenii.def transferred correctly to ggenii.inp

d) the GENTPA input echo in ggenii.out confirms parameters transferred correctly
e) gdefault.inp contains the parameter values from tpa.inp after TPA was run
f) gftrans.inp contains the correct parameter values from gftrans.def after TPA run

Did the modification substantially change results?

-not applicable to this set of tests that are focussed on confirming data and input operations (see Verification Tests for DCF Calculations plan and results described below).

Was TPA4.0beta output compared to TPA 3.3 output?

-not in this round of tests (see Verification Tests for DCF Calculations plan and results described below).

Which radionuclides were monitored to determine reasonableness of results in terms of dose?

- input data for all radionuclides checked

Test Results for GENTPA Setup Test

Setup Test #1 Results:

a) confirm that all parameter and data files contain the correct information

PASSED

b) ggamen.dat, grmdlib.dat contain the same data used for DCF calculations for TPA 3.3 (consistent with gamen.dat, and grmdlib.dat from GENII-S except ^{108}Ag added)

PASSED

c) ggrdf.dat contains external dose coefficients from Federal Guidance 12 (U.S. Environmental Protection Agency, 1993)(ground surface and air submersion exposure values have been correctly entered into column1 and 3 in ggrdf.dat)

PASSED

d) gdefault.def contains the same data used for DCF calculations for TPA 3.3 (consistent with the default.ip3 file used for GENII-S runs for TPA 3.3)

PASSED

e) gftrans.def contains the same food transfer factors use for TPA 3.3 DCFs (documented in CNWRA 97-009 and provided in ftrans.ip3)

PASSED

f) gnewdf.dat contains internal dose coefficients for adult receptor consistent with values used for TPA 3.3 DCFs reported in Federal Guidance 11 (U.S. Environmental Protection Agency, 1988).

PASSED (the inhalation dose coefficient for Ag-108m was corrected)

g) ggenii.def contains fixed input parameter values for GENTPA consistent with values used for TPA 3.3 DCFs (documented in CNWRA 97-009, Appendix B)

PASSED

h) tpa.inp contains the same values used for TPA 3.3 DCF calculations (consistent with values reported in CNWRA 97-009, Appendix B)

PASSED (constant soil Kd values for Cl and Se were changed from 0 and 150 to 0.25 and 55 to be consistent with source data for GENTPA tests. These soil Kds were subsequently formally changed to correct values specified in Appendix A of the user manual.

Setup Test #2 Results:

a) confirm that all parameters and data transfers are operating as intended

PASSED

b) parameters in tpa.inp being correctly written to ggenii.inp

PASSED

c) fixed parameters in ggenii.def transferred correctly to ggenii.inp

PASSED

d) the GENTPA input echo in ggenii.out confirms parameters transferred correctly

PASSED

e) gdefault.inp contains the parameter values from tpa.inp after TPA was run

PASSED

f) gftrans.inp contains the correct parameter values from gftrans.def after TPA run

PASSED

Test Plan for SCR #301

Test name: GENTPA Execution Test

Anticipated start date: 3/9/00

Anticipated completion date: 3/10/00

Amount of your time available to perform this test: 4 hours

Percent of testing time to be spent in process level testing and system level testing: This test is primarily a process level test, however, execution of GENTPA occurs by executing TPA.

Output files to be checked:

env.out (from GENII)
genv.out
ggenii.out
genv.cum
ggenii.cum
dcf.cum

Input files to be checked for proper data transfer to program: The GENTPA execution test (of intake calculations) requires that the following data files in TPA and GENII v1.485 need to be synchronized prior to running the test (this will be done by copying the verified TPA data data files from the GENTPA setup test to the GENII code directory):

ggamen.dat (TPA) should have the same data as gamen.dat (GENII)
grmdlib.dat (TPA) should have the same data as rmdlib.dat (GENII)
ggrdf.dat (TPA) should have the same data as grdf.dat (GENII)
gdefault.def (TPA) should have the same data as default.dat (GENII)
gftrans.def (TPA) should have the same data as gftrans.dat (GENII)
ggenii.def (TPA) should have the same data as genii.inp (GENII)
tpa.inp (TPA) should have the same data as genii.inp (GENII)

Disposition of documentation (storage medium, physical location, and access method):

-TPA and GENII input and output files used for the test will be archived on zip disks and referenced in the scientific notebook (#194)

Functional test descriptions:

-Hand calculations: the reasonableness test of the drinking water intakes (discussed below).

-Process-level tests:

Execution Test #1: Test that GENTPA provides intake results in genv.out that are consistent with intakes calculated from GENII v1.485 using the same set of input parameters

- run GENII v1.485 with same parameter set as GENTPA and compare output in env.out and genv.out. Must ensure data files such as ggrdf.dat, ggenii.def, gdefault.def, gftrans.def for TPA are used for input data in GENII runs (e.g. grdf.dat, genii.dat, default.dat) to ensure consistency.

Execution Test #2: Confirm GENTPA uses the correct data files for running envin.exe and env.exe (check the data file echo in ggenii.out after a TPA run has been completed to see if it lists the correct versions of data files (i.e., ggrdf.dat, ggamen.dat, grmdlib.dat, gdefault.inp, gftrans.inp, gbioac1.dat)

Execution Test #3: Check that the *.cum files contain the same values for all TPA realizations when fixed values are used in GENTPA and a stochastic TPA code run is executed

-System-level tests: TPA runs used to execute GENTPA for aforementioned tests will be done for the total system. This will provide some assurance that GENTPA setup and input parameter and data transfers are operating as intended when TPA is executed.

Reasonableness Test Description: If GENTPA calculates intakes that are the same as the GENII code, then they are expected to be reasonable. Drinking water intakes will be checked to ensure they are the product of groundwater concentration and consumption rate.

Final checklist (completed during testing):

Execution Test #1:

-GENTPA provides intake results in genv.out that are consistent with intakes calculated from GENII v1.485 using the same set of input parameters

Execution Test #2:

-the ggenii.out file indicates that GENTPA uses the correct data files for running envin.exe and env.exe to generate intakes for the TPA code?

Execution Test #3:

-the files genv.cum, ggenii.cum, dcf.cum contain the same values for all TPA realizations when fixed values are used in GENTPA and a stochastic TPA code run is executed

Did the modification substantially change results?

Test results indicate the code modification will allow reproduction of DCF calculations consistent with prior DCF calculations in TPA 3.2 and 3.3 if the same data are used. One exception is that the modification has implemented the leaching factor calculation (leaching factor in gftrans.inp) in a manner that does not allow calculation of leaching factors based on pluvial conditions. Previous DCF calculations for TPA 3.2 and 3.3 used leach factors in pluvial DCF calculations that were based on pluvial conditions (wetter). Thus, pluvial DCFs calculated in TPA 4.0 are slightly higher than the same for prior TPA versions, however, the difference is not considered to be significant in relation to the uncertainty of the PA calculations. The difference is in the conservative direction (elevating dose). Also, the subset of Kds that is provided in tpa.inp allows for user input to modify the calculation of leach factors, however, the remaining leach factors cannot be modified by the user unless calculated by hand and input to the gftrans.def file. Because the subset of the Kd's provided in tpa.inp are variable and the leach factors are calculated during tpa execution, this variation propagated to the leach factors calculated by TPA4.0 can lead to DCF variations from the constant DCF's used in TPA 3.2 and 3.3. However, this variation is not expected to be significant when compared with the total variation provided by other GENTPA sampled parameters and important sampled parameters from other modules.

Was TPA4.0beta output compared to TPA 3.3 output?

No. This test compared intermediate outputs from TPA4.0beta (radionuclide intakes) with similar intakes calculated with the GENII v1.485 code (code similar to the code used for TPA 3.3 DCF calculations).

Which radionuclides were monitored to determine reasonableness of results in terms of dose?

All radionuclides in the code were checked during the tests

Test Results for GENTPA Execution Test

Execution Test #1:

-GENTPA provides intake results in genv.out that are consistent with intakes calculated from GENII v1.485 using the same set of input parameters

PASSED

Execution Test #2:

-the ggenii.out file indicates that GENTPA uses the correct data files for running envin.exe and env.exe to generate intakes for the TPA code?

PASSED

Execution Test #3:

-the files genv.cum, ggenii.cum, dcf.cum contain the same values for all TPA realizations when fixed values are used in GENTPA and a stochastic TPA code run is executed

PASSED

Test Plan for SCR #301

Test name: Verification Tests for DCF Calculations

Anticipated start date: 3/10/00

Anticipated completion date: 3/13/00

Amount of your time available to perform this test: 8 hours

Percent of testing time to be spent in process level testing and system level testing: 50/50

Output files to be checked:

genv.out

gw_cb_ad.dat
gw_cb_ci.dat
rgwnr.tpa
rgwna.tpa
rgwsr.tpa

Input files to be checked for proper data transfer to program:

The TPA results from the GENTPA execution test will be used, therefore the input data will already have been confirmed from that test.

The system level tests involving the TPA 3.3 mean data set will utilize the same data files for GENTPA that were checked (and confirmed to have the appropriate TPA 3.3 data) in the GENTPA setup test. Other system level tests involve either the TPA 4.0beta tpa.inp files that was checked in the GENTPA setup test, versions of that file that contain known modifications necessary for the test, or data files that have been previously checked (e.g., mean value tpa.inp files from TPA 3.2.3 and 3.3).

Disposition of documentation (storage medium, physical location, and access method):

-TPA input and output files, and excel spreadsheet files for DCF calculations used for the tests will be archived on floppy or zip disks and referenced in the scientific notebook (#194)

Functional test descriptions:

-Hand calculations:

The DCF calculation test (discussed under 'process level tests' below) will involve using a spreadsheet program to calculate the DCFs for comparison with TPA generated DCFs

-Process-level tests:

DCF Verification Test #1: Confirm TPA DCF calculations by hand (spreadsheet) using intakes (genv.out) and dose coefficients (ggrdf.dat for external dose and gnewdf.dat for internal) from TPA intermediate and data files. Confirm daughter product DCFs are summed correctly prior to writing DCF tables gw_cb_ad.dat, gw_cb_ci.dat.

DCF Verification Test #2: Run a mean value tpa.inp file for TPA4.0beta and compare DCF outputs (gw_cb_ad.dat) with the same from a mean value TPA3.2.3 run. Given the prior testing has shown the TPA4.0beta can reproduce intakes (and thereby DCFs) calculated with models used for TPA 3.2.3 DCFs when comparable data are used as inputs, this test should identify any differences in DCFs due to data changes from TPA3.2.3 to 4.0beta.

-System-level tests:

DCF Verification System Test #1: Run a single realization of TPA 4.0 with TPA 3.3 mean value parameters and data file inputs and compare radionuclide specific dose curves over 10,000 and 100,000 yrs (from rgwnr.tpa) with TPA 3.3 results using the same data. Consider the following radionuclides for comparison of results: ^{245}Cm, ^{241}Am, ^{237}Np, ^{239}Pu, ^{234}U, ^{230}Th, ^{129}I, ^{99}Tc, ^{14}C,

^{79}Se, and ^{36}Cl (radionuclides important to dose from TPA 3.2 sensitivity analyses). Both sets of runs (TPA 3.3 and 4.0) should use the mean value data set from TPA 3.3 and the 4.0 runs should additionally use DCAGW parameter values consistent with those confirmed in the GENTPA setup testing to be the same used for DCFs in TPA 3.3. Dose coefficients from TPA 3.3 DCF calculations in GENII-S will be added to gnewdf.dat to ensure consistency in the TPA4.0 DCF calculations. This comparison could provide insight into any changes that have occurred to results due to 4.0 code changes in DCF calculations (note that module changes unrelated to DCAGW in 4.0 may change overall results in 4.0 when compared with 3.3, however, the test is still expected to be informative because there is general interest in identifying system changes and large deviations from past results can be indications of areas that need more focussed testing).

DCF Verification System Test #2: Run TPA 4.0 stochastically (100 realizations) using the most current tpa.inp with TPA 4.0 user manual (Appendix A) variable parameters for GENTPA and compare results with a TPA 3.2.3 base case run (3.2.3 used constant DCF tables). This is a general system test that may provide insight to potential problems with DCF calculations when executed stochastically along with the rest of the modules. (Note that module changes unrelated to DCAGW in 4.0 may change overall results in 4.0 when compared with 3.2.3, however, the test is still expected to be informative because there is general interest in identifying system changes and large deviations from past results can be indications of areas that need more focussed testing). An additional run of TPA4.0beta stochastically for 100 realizations with the constant GENTPA parameter set will allow presentation of differences in expected dose results (from TPA4.0beta) from the introduction of GENTPA parameter ranges and stochastic DCF calculations.

Reasonableness Test Description: If conclusions from the process level testing indicate that TPA 4.0 results based on TPA 3.3 parameters and data are similar to TPA 3.3 results, then the DCAGW calculations are considered reasonable. If differences noted the results of system tests are attributable to parameter or model changes in other modules, then GENTPA can still be considered to be producing reasonable results (DCFs).

Final checklist (completed during testing):

DCF Verification Test #1:

-confirm spreadsheet DCF calculations using intakes (genv.out) and dose coefficients (ggrdf.dat for external dose and gnewdf.dat for internal) from TPA are the same as DCFs calculated by DCAGW (in gw_cb_ad.dat, gw_cb_ci.dat) from the same information.

-confirm daughter product DCFs are summed correctly prior to writing DCF tables gw_cb_ad.dat, gw_cb_ci.dat

DCF Verification Test #2:

-verify that model changes related to DCF calculations are not contributing to significant changes to DCF results in TPA4.0beta. Verify that data changes relevant to DCF calculations in TPA4.0beta explain any significant differences in DCF results when TPA4.0 beta and TPA 3.2.3 DCFs are compared.

DCF Verification System Test #1:

-deterministic system level testing using TPA 3.3 data in TPA 4.0 runs confirmed DCF calculations in DCAGW are producing similar results to TPA 3.3 when the same input parameters and data are used in the calculations

DCF Verification System Test #2:

-stochastic system level testing comparing TPA 3.2.3 and TPA 4.0beta 100 realization runs confirm the GENTPA modifications to DCAGW TPA 4.0 (coding and data modifications) are producing similar results to TPA 3.2.3 or different results that can be explained by intentional changes. The tests added confidence that stochastic calculations in TPA 4.0 are not adversely affecting implementation of DCF calculations in DCAGW.

Did the modification substantially change results?

No. The tested calculation of DCFs (from the intakes) was shown to be implemented in a manner that does not change the results from prior TPA 3.2 DCF calculation methods. The system level tests show expected dose results can increase by about an order of magnitude in the early (first 5000 yr) period when the expected dose is more unstable and subject to influence by sampled extremes (when variable biosphere parameters are introduced). The effect of such extremes is expected to diminish when a larger number of realizations is run causing greater convergence of results to the expected value. Beyond the 5000 yr period, the use of variable biosphere parameters does not significantly change the magnitude of the expected dose.

System level results showed significant differences between TPA 4.0beta and 3.3 and 3.2.3 regarding the time of radionuclide release/transport and the quantity/type of contaminants reaching the biosphere. These aspects of the code are not related to DCAGW modifications associated with SCR #301 and are being investigated under the relevant SCRs for release and transport models.

Was TPA4.0beta output compared to TPA 3.3 output?

Yes. See the answer to the previous question. For comparison purposes, the DCFs used for 3.2.3 were the same as 3.3, therefore both can be used as a point of comparison with TPA 4.0beta.

Which radionuclides were monitored to determine reasonableness of results in terms of dose?

All radionuclide-specific tests emphasized those radionuclides that were found to be important in TPA 3.2 sensitivity analyses (Mohanty et al., 1999). These include: ^{245}Cm, ^{241}Am, ^{237}Np, ^{239}Pu, ^{234}U, ^{230}Th, ^{129}I, ^{99}Tc, ^{14}C, ^{79}Se, and ^{36}Cl. For 10,000 yr system level tests, the only radionuclides that break through the SZ are ^{129}I, ^{99}Tc, and ^{36}Cl. The DCF calculation test also considered additional radionuclides (those with daughter chains) to confirm products were being summed in DCFs correctly.

Results of Verification Tests for DCF Calculations

DCF Verification Test #1:

-confirm spreadsheet DCF calculations using intakes (genv.out) and dose coefficients (ggrdf.dat for external dose and gnewdf.dat for internal) from TPA are the same as DCFs calculated by DCAGW (in gw_cb_ad.dat, gw_cb_ci.dat) from the same information.

PASSED

-confirm daughter product DCFs are summed correctly prior to writing DCF tables gw_cb_ad.dat, gw_cb_ci.dat

PASSED

DCF Verification Test #2:

-verify that model changes related to DCF calculations are not contributing to significant changes to DCF results in TPA4.0beta. Verify that data changes relevant to DCF calculations in TPA4.0beta explain any significant differences in DCF results when TPA4.0 beta and TPA 3.2.3 DCFs are compared.

PASSED

DCF Verification System Test #1:

-deterministic system level testing using TPA 3.3 data in TPA 4.0 runs confirmed DCF calculations in DCAGW are producing similar results to TPA 3.3 when the same input parameters and data are used in the calculations

PASSED (see **Did the modification substantially change results?** above)

DCF Verification System Test #2:

-stochastic system level testing comparing TPA 3.2.3 and TPA 4.0beta 100 realization runs confirm the GENTPA modifications to DCAGW TPA 4.0 (coding and data modifications) are either producing similar results to TPA 3.2.3 or different results that can be explained by intentional changes. The tests added confidence that stochastic calculations in TPA 4.0 are not adversely affecting implementation of DCF calculations in DCAGW.

PASSED (see **Did the modification substantially change results?** above). The test results are interpreted in light of the other test results that coding modifications to DCAGW do not explain differences in results between TPA4.0beta and TPA 3.2.3 or 3.3. The data modifications to GENTPA parameters in TPA4.0 are shown to contribute to changes in results, however, the changes are the result of intended parameter and data changes (i.e., improvements).

References:

Mohanty, S., R. Codell, R. Rice, J. Weldy, Y. Lu, R.M. Byrne, T.J. McCartin, M.S. Jarzemba, and G.W. Wittmeyer. *System-Level Repository Sensitivity Analysis Using TPA Version 3.2 Code.* CNWRA 99-002. San Antonio, TX: Center for Nuclear Waste Regulatory Analyses. 1999.

U.S. Environmental Protection Agency. 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion.* Federal Guidance Report No. 11.Washington DC: U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. 1993. *External Exposure to Radionuclides in Air, Water, and Soil: Exposure-to-Dose Coefficients for General Application, Based on the 1987 Federal Radiation Protection Guidance*. Federal Guidance Report No. 12. Washington DC: U.S. Environmental Protection Agency.

TPA 4.0 Beta Testing Ideas for DCAGW (flexibility of exposure scenarios)

Constraints:

- limited to adult dose calculations (other tests cover age-dependent calculations)
- test deterministic capabilities of GENTPA (other tests cover stochastic capabilities)
- climate change not tested here (other tests cover climate change)

Test GENTPA setup:

- confirm data input to files is correct by spot checking 10% of values in ggamen.dat, grmdlib.dat, ggrdf.dat, gdefault.def, gftrans.def, and gnewdf.dat. Correct values for these files are available from GENII-S data files used for TPA 3.3 DCFs. Also, confirm 100% of values in ggenii.def are same as those listed in Appendix B of CNWRA 97-009. Confirm 100% of tpa.inp DCAGW parameters are same as Appendix A of TPA4.0 user manual.

- test the routine that creates the primary input file for GENTPA (ggenii.def/inp)
  - – are parameters in tpa.inp being correctly written to ggenii.inp?
  - – are fixed parameters in ggenii.def transferred correctly to ggenii.inp?
  - – does the GENTPA input echo in ggenii.out confirm parameters transferred correctly?

- test the routine that writes parameters from tpa.inp to GENTPA data files other than ggenii.def/inp (i.e., gdefault.def/inp, gftrans.def/inp)
  - – check gdefault.inp and tpa.inp after TPA run to confirm values from tpa.inp have been passed correctly to gdefault.inp
  - – check gftrans.inp after TPA run to ensure values are same as gftrans.def

Test GENTPA execution:

- test that GENTPA provides intake results in genv.out that are consistent with GENII intakes calculated from the same set of input parameters
  - – run GENII with same parameter set as GENTPA and compare output in env.out and genv.out. Must ensure data files such as ggrdf.dat, ggenii.def, gdefault.def, gftrans.def, newdf.dat for TPA and grdf.dat, genii.dat, default.dat, and dosinc.dat for GENII have same values prior to executing runs.

- confirm GENTPA uses the correct data files for running envin.exe and env.exe (check the data file echo in ggenii.out after a run has been completed to see if it lists the correct versions of data files, i.e., ggrdf.dat, ggamen.dat, grmdlib.dat, gdefault.inp, gftrans.inp, gbioac1.dat)

- check that *.cum files contain the same values for all TPA realizations when fixed values are used in GENTPA

Test Creation of DCF Tables following GENTPA execution:

- confirm DCF calculations by hand using intakes (genv.out) and dose coefficients (ggrdf.dat for external dose and gnewdf.dat for internal). Confirm daughter product DCFs are summed prior to writing DCF tables gw_cb_ad.dat, gw_cb_ci.dat

System Level Tests:

- Run TPA 4.0 with 3.3 parameters and data file inputs and compare radionuclide specific dose curves over 10,000 and 100,000 yrs. (note that module changes unrelated to DCAGW in 4.0 may change overall results in 4.0 when compared with 3.2)

TPA Test Plan

Test name: GENTPA Execution Test

Anticipated start date: 3/9/00

Anticipated completion date: 3/10/00

Amount of your time available to perform this test: 4 hours

Percent of testing time to be spent in process level testing and system level testing: This test is primarily a process level test, however, execution of GENTPA occurs by executing TPA.

Output files to be checked:

env.out (from GENII)
genv.out
ggenii.out
genv.cum
ggenii.cum
dcf.cum

Input files to be checked for proper data transfer to program: The GENTPA execution test (of intake calculations) requires that the following data files in TPA and GENII v1.485 need to be synchronized prior to running the test:

ggamen.dat (TPA) should have the same data as gamen.dat (GENII)
grmdlib.dat (TPA) should have the same data as rmdlib.dat (GENII)
ggrdf.dat (TPA) should have the same data as grdf.dat (GENII)
gdefault.def (TPA) should have the same data as default.dat (GENII)
gftrans.def (TPA) should have the same data as gftrans.dat (GENII)
gnewdf.dat (TPA) should have the same data as dosinc.dat (GENII)
ggenii.def (TPA) should have the same data as genii.inp (GENII)
tpa.inp (TPA) should have the same data as genii.inp (GENII)

Disposition of documentation (storage medium, physical location, and access method):

-TPA and GENII input and output files used for the test will be archived on zip disks and referenced in the scientific notebook (#194)

-data file comparisons will be documented on marked printouts that will be included in the scientific notebook (#194)

Functional test descriptions:

-Hand calculations: the reasonableness test of the drinking water intakes (discussed below).

-Process-level tests:

Test that GENTPA provides intake results in genv.out that are consistent with intakes calculated from GENII v1.485 using the same set of input parameters

- run GENII v1.485 with same parameter set as GENTPA and compare output in env.out and genv.out. Must ensure data files such as ggrdf.dat, ggenii.def, gdefault.def, gftrans.def, newdf.dat for TPA have the same parameter values as the corresponding input files in GENII (e.g. grdf.dat, genii.dat, default.dat, and dosinc.dat) prior to executing runs. Because the internal dose factors used for GENII (in dosinc.dat) cannot be modified by the user, the values used in dosinc.dat (as reported in the code documentation package provided by RSICC) will be input to newdf.dat for this test.

Confirm GENTPA uses the correct data files for running envin.exe and env.exe (check the data file echo in ggenii.out after a TPA run has been completed to see if it lists the correct versions of data files (i.e., ggrdf.dat, ggamen.dat, grmdlib.dat, gdefault.inp, gftrans.inp, gbioac1.dat)

Check that the *.cum files contain the same values for all TPA realizations when fixed values are used in GENTPA and a stochastic TPA code run is executed

-System-level tests: TPA runs used to execute GENTPA for aforementioned tests will be done for the total system. This will provide some assurance that GENTPA setup and input parameter and data transfers are operating as intended when TPA is executed.

Reasonableness Test Description: If GENTPA calculates intakes that are the same as the GENII code, then they are expected to be reasonable. Drinking water intakes will be checked to ensure they are the product of groundwater concentration and consumption rate.

Final checklist (completed during testing):

- Does GENTPA provide intake results in genv.out that are consistent with intakes calculated from GENII v1.485 using the same set of input parameters?
- Does the ggenii.out file indicate that GENTPA uses the correct data files for running envin.exe and env.exe to generate intakes for the TPA code?
- Do the files genv.cum, ggenii.cum, dcf.cum contain the same values for all TPA realizations when fixed values are used in GENTPA and a stochastic TPA code run is executed?
- Which radionuclides were monitored to determine reasonableness of results in terms of dose?

TPA Test Plan

Test name: GENTPA Setup Test

Anticipated start date: 3/9/00

Anticipated completion date: 3/10/00

Amount of your time available to perform this test: 2 hours

Percent of testing time to be spent in process level testing and system level testing: This test is primarily a process level test, however, execution of GENTPA occur by executing TPA.

Output files to be checked:

ggenii.out

Input files to be checked for proper data transfer to program:

ggamen.dat
grmdlib.dat
ggrdf.dat
gdefault.def/inp
gftrans.def/inp
gnewdf.dat
ggenii.def/inp
tpa.inp

Disposition of documentation (storage medium, physical location, and access method):

-TPA input and output files used for the test will be archived on zip disks and referenced in the scientific notebook (#194)

-data file comparisons will be documented on marked printouts that will be included in the scientific notebook (#194)

Functional test descriptions:

-**Hand calculations:** none

-**Process-level tests:**

Note: Tests involving parameters and data that are radionuclide or element specific should include checking values for the following radionuclides and elements that have been shown in TPA sensitivity analyses to be important to dose: ^{245}Cm, ^{241}Am, ^{237}Np, ^{239}Pu, ^{234}U, ^{230}Th, ^{129}I, ^{99}Tc, ^{14}C, ^{79}Se, and ^{36}Cl.

Confirm data input to files is correct by spot checking 10% of values in ggamen.dat, grmdlib.dat, ggrdf.dat, gdefault.def, gftrans.def, and gnewdf.dat. Correct values for these files are available from GENII-S data files used for TPA 3.3 DCFs. Also, confirm 100% of values in ggenii.def are same as those listed in Appendix B of CNWRA 97-009. Confirm 100% of tpa.inp DCAGW parameters are same as Appendix A of TPA4.0 user manual.

Test the routine that creates the primary input file for GENTPA (ggenii.def/inp)
- are parameters in tpa.inp being correctly written to ggenii.inp?
- are fixed parameters in ggenii.def transferred correctly to ggenii.inp?
- does GENTPA input echo in ggenii.out confirm parameters transferred correctly?

Test the routine that writes parameters from tpa.inp to GENTPA data files other than ggenii.def/inp (i.e., gdefault.def/inp, gftrans.def/inp)
- check gdefault.inp and tpa.inp after TPA run to confirm values from tpa.inp have been passed correctly to gdefault.inp
- check gftrans.inp after TPA run to ensure values are same as gftrans.def

-System-level tests: TPA runs used to execute GENTPA for aforementioned tests will be done for the total system. This will provide some assurance that GENTPA setup and input parameter and data transfers are operating as intended when TPA is executed.

Reasonableness Test Description: None for this test (emphasis is on checking data transfer)

Final checklist (completed during testing):
- did the tests confirm that all parameter and data files contain the correct information?
  - -ggamen.dat, grmdlib.dat contain the same data used for DCF calculations for TPA 3.3 (consistent with gamen.dat, and grmdlib.dat from GENII-S except ^{108}Ag added)
  - -ggrdf.dat contains external dose coefficients from Federal Guidance 12 (ground surface and air submersion exposure values have been correctly entered into column1 and 3 in ggrdf.dat)
  - -gdefault.def contains the same data used for DCF calculations for TPA 3.3 (consistent with the default.ip3 file used for GENII-S runs for TPA 3.3)
  - -gftrans.def contains the same food transfer factors use for TPA 3.3 DCFs (documented in CNWRA 97-009 and provided in ftrans.ip3)
  - gnewdf.dat contains internal dose coefficients for adult receptor consistent with values used for TPA 3.3 DCFs (reported in Federal Guidance 11)
  - ggenii.def contains fixed input parameter values for GENTPA consistent with values used for TPA 3.3 DCFs (documented in CNWRA 97-009, Appendix B)
  - tpa.inp contains the same values used for TPA 3.3 DCF calculations (consistent with values reported in CNWRA 97-009, Appendix B)

- did the tests confirm that all parameters and data transfers are operating as intended?
  - are parameters in tpa.inp being correctly written to ggenii.inp?
  - are fixed parameters in ggenii.def transferred correctly to ggenii.inp?
  - did the GENTPA input echo in ggenii.out confirm parameters transferred correctly?
  - did gdefault.inp contain the parameter values from tpa.inp after TPA was run?
  - did gftrans.inp contain the correct parameter values from gftrans.def after TPA run?

- Which radionuclides were monitored to determine reasonableness of results in terms of dose?

TPA Test Plan

Test name: Verification Tests for DCF Calculations

Anticipated start date: 3/10/00

Anticipated completion date: 3/13/00

Amount of your time available to perform this test: 8 hours

Percent of testing time to be spent in process level testing and system level testing:
50/50

Output files to be checked:

genv.out
gw_cb_ad.dat
gw_cb_ci.dat
rgwnr.tpa
rgwna.tpa

Input files to be checked for proper data transfer to program:

The TPA results from the GENTPA execution test will be used, therefore the input data will already have been confirmed from that test.

The system level tests involving the TPA 3.3 mean data set will utilize the same data files for GENTPA that were checked (and confirmed to have the appropriate TPA 3.3 data) in the GENTPA setup test. A similar test will be conducted with the *base case* TPA 3.3 data set and the GENTPA setup test files (fixed values for the intake calculations that match the parameters used for calculating DCFs for TPA 3.3)

Disposition of documentation (storage medium, physical location, and access method):

-TPA input and output files, and excel spreadsheet files for DCF calculations used for the tests will be archived on floppy or zip disks and referenced in the scientific notebook (#194)

Functional test descriptions:

-Hand calculations:

The DCF calculation test (discussed under 'process level tests' below) will involve using a spreadsheet program to calculate the DCFs for comparison with TPA generated DCFs

-Process-level tests:

Confirm TPA DCF calculations by hand (spreadsheet) using intakes (genv.out) and dose coefficients (ggrdf.dat for external dose and gnewdf.dat for internal) from TPA intermediate and data files. Confirm daughter product DCFs are summed correctly prior to writing DCF tables gw_cb_ad.dat, gw_cb_ci.dat

-System-level tests:

Run a single realization of TPA 4.0 with TPA 3.3 mean value parameters and data file inputs and compare radionuclide specific dose curves over 10,000 and 100,000 yrs (from rgwnr.tpa) with TPA 3.3 results using the same data. Consider the following radionuclides for comparison of results: ^{245}Cm, ^{241}Am, ^{237}Np, ^{239}Pu, ^{234}U, ^{230}Th, ^{129}I, ^{99}Tc, ^{14}C, ^{79}Se, and ^{36}Cl (radionuclides important to dose from TPA 3.2 sensitivity analyses). Both sets of runs (TPA 3.3 and 4.0) should use the mean value data set from TPA 3.3 and the 4.0 runs should additionally use DCAGW parameter values consistent with those confirmed in the GENTPA setup testing to be the same used for DCFs in TPA 3.3. This comparison should provide insight into any changes that have occurred to results due to 4.0 code changes (note that module changes unrelated to DCAGW in 4.0 may change overall results in 4.0 when compared with 3.2, however, the test is still expected to be informative because major changes in results are not expected and potential problems could be detected if major changes are noted).

Run TPA 4.0 stochastically using TPA 3.3 data for all parameters and compare with TPA 3.3 results using the same data (and constant DCF tables). DCAGW will be run with the data files that contain the same constant parameter values used for TPA 3.3 DCF calculations. Results presented in grwna.tpa (time history of dose by nuclide averaged over all vectors) for both sets of runs should be compared graphically for ^{245}Cm, ^{241}Am, ^{237}Np, ^{239}Pu, ^{234}U, ^{230}Th, ^{129}I, ^{99}Tc, ^{14}C, ^{79}Se, and ^{36}Cl (radionuclides important to dose). The comparisons will test if stochastic operation of TPA (for modules other than DCAGW) introduces any problems with DCAGW execution and calculation results. Because the models used to calculate DCFs have not been changed since TPA 3.3, results of running TPA 4.0 with the same data are expected to produce similar results. However, results may also change due to other TPA 4.0 module updates unrelated to DCAGW, nonetheless, the test is expected to be informative.

Reasonableness Test Description: If conclusions from the process level testing indicate that TPA 4.0 results based on TPA 3.3 parameters and data are similar to TPA 3.3 results, then the DCAGW calculations are considered reasonable.

Final checklist (completed during testing):

-Did the testing confirm spreadsheet DCF calculations using intakes (genv.out) and dose coefficients (ggrdf.dat for external dose and gnewdf.dat for internal) from TPA are the same as DCFs calculated by DCAGW (in gw_cb_ad.dat, gw_cb_ci.dat) from the same information.

-Did the testing confirm daughter product DCFs are summed correctly prior to writing DCF tables gw_cb_ad.dat, gw_cb_ci.dat

-Did the deterministic system level testing using TPA 3.3 data in TPA 4.0 runs confirm DCF calculations in DCAGW are producing similar results to TPA 3.3 when the same input parameters and data are used in the calculations?

-Did the stochastic system level testing using TPA 3.3 data in TPA 4.0 runs confirm DCF calculations in DCAGW are producing similar results to TPA 3.3 when the same input parameters and data are used in the calculations? Did the tests add confidence that stochastic calculations in TPA 4.0 are not adversely affecting implementation of DCF calculations in DCAGW?

-Which radionuclides were monitored to determine reasonableness of results in terms of dose?

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-302

Software Title and Version: TPA 3.3

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):

seismo.f

Importance analysis runs by O.Pensado show fewer failures with no over pack on vector 14 of a 50 realization run. This pointed to an error in the 'average radius' equation, discovered by T. McCartin.

Change Requested by:
T. McCartin
Date: 2-8-00

Change Authorized by (*Software Developer*):
R. Janetzke R Janetzke
Date: 2-8-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

The correct form verified by S. Hsiung :

```
Rave = (WPDiameter - WPWall)/2.0d0
```

was originally implemented without the parenthesis.

Implemented by:
R. Janetzke R Janetzke

Date:
2-9-00

Description of Acceptance Tests:
See attached tests

Tested by: Osvaldo Pensado OP

Date: 3/16/00

CNWRA Form TOP-5 (01/99)

255/357

From: Timothy McCartin
To: David Esh, Gordon Wittmeyer, James Firth, Rich...
Subject: Update on seismo

A couple of interesting items:

1) The importance calculation that removes the outer container leaves an inner container, however, the WP diameter remains the same thus the inner container now has the diameter of the WP.

2) A calculation of Package_Stiffnesss (based on WP radius, wall thickness and are all affected by the assumptions in 1 above) is performed and the base case package is about 5 time larger than the value for the WP without the outer container - this translates into a larger impact load for the base case WP versus the importance WP.

300/397

From: Timothy McCartin
To: David Esh, Gordon Wittmeyer, James Firth, Rich...
Date: Mon, Feb 7, 2000 7:50 AM
Subject: Update on Importance Analysis Bug

Fellow PAers:

I have narrowed the importance analysis bug that Osvaldo was experiencing (please pass this note on to him - he is not on our email menu). In the 50 vector run, realization #14 is an espicially good vector to examine (with no outer container the peak dose is about 20 times smaller than the base case with the outer container). How can this happen? The sampled variables for both realizations are EXACTLY the same - it seems it's our old friend seismicity at it again! The base case has THOUSANDS of WPs failed due to seicmicity (around 3,000 failed WPs) while when the outer conatiner is removed for importance analysis this number drops to 26 failed WPs. Why - as of yet I have not started to look at it but I believe this isolates the source of the problem. I believe it would be more efficient if whoever did the original work on removing the outer container take a quick look at it - let me know if this is possible. This also raises the issue of testing for the Importance Analysis in the code - we probably need to add this to our planning and budgeting on testing if this options remains in the code.

Thanks, Tim

301/337

Test Plan

Osvaldo Pensado 3/6/00

Test name: Test of changes described in PA-SCR-302 to the seismo module.
Code version to test: TPA 4.0beta

Anticipated start date: 3/6/00

Anticipated completion date: 3/11/00

Amount of your time available to perform this test: 20 hr

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): 0/100

Output files to be checked: wpsfail.res

Input files to be checked for proper data transfer to the program: tpa.inp

Disposition of documentation (storage medium, physical location, and access method):
Electronic files are located in vulcan, at
/home/opensado/tpa4/testseismo/
Multiple *readme* files are included therein for the easy reading of the computations.

Functional Test Descriptions:

Process-level tests: N/A

System-level tests:

Equations (4-43) and (4-47) in the TPA manual for version 3.2 can be made invariant for several choices of the WPDiameter. The average radius, R_{ave}, is function of the WP diameter. If the average radius is well computed, the output of several realizations having identical values of P_{dyn} and p, as defined by Equations (4-43) and (4-47), must be identical, provided that the only failure mode is seismicity. Another restriction is that the WPModulusOfElasticityforSEISMO is kept constant. The failure criterion for the WP in the SEISMO mudule is that if the impact energy exceeds a constant, then failure of the WP is produced. The impact energy is function of the impact stress, p, and the WP Young modulus, E_{wp} Therefore, if several runs have the same value of p and E_{wp}, the number of WPs failed for these runs must be identical.

Reasonableness Test Description:

A run TPA 3.3 code having exactly the same SEISMO parameters as a run of the TPA 4.0beta code must produce similar results. The results are not necessarily identical because of the different way in which the average radius is computed, and because the subarea geometry and number of WPs is different. However, the results are not expected to display significant differences.

Test Results

Osvaldo Pensado, 3/15/00

The results were consistent with the expectations. Several runs were completed with different values of the WP diameter, Poisson ratio, support stiffness, and rock fall height distance, selected in such a manner that the impact energy was the same for all of the runs. The number of WPs failed due to seismicity for these runs was the same, as expected. This indicates that the implementation of the SEISMO equations is adequate, in particular the equation for the computation of the average radius.

A comparison with a run of tpa 3.3 revealed similar results. The results cannot be identical because of the different way in which the average radius is computed, and because the subarea geometry and number of WPs is different.

303/397

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-~~xxx~~ 303 RJ	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s): ebsrel.f, tpa.inp, new data file (~~topfile~~ wpflow.dat), tpanames.dbs, ebsrel.def (add to the data subdirectory)

Change Requested by: D. Esh Date:	**Change Authorized by** (*Software Developer*): R. Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*): Modify the source code + data files to allow for temporal variability in the FOW + FMULT parameters. Also allow for a WP Flow Multiplication Factor.

Implemented by: K. Rice	**Date:** 1/17/00

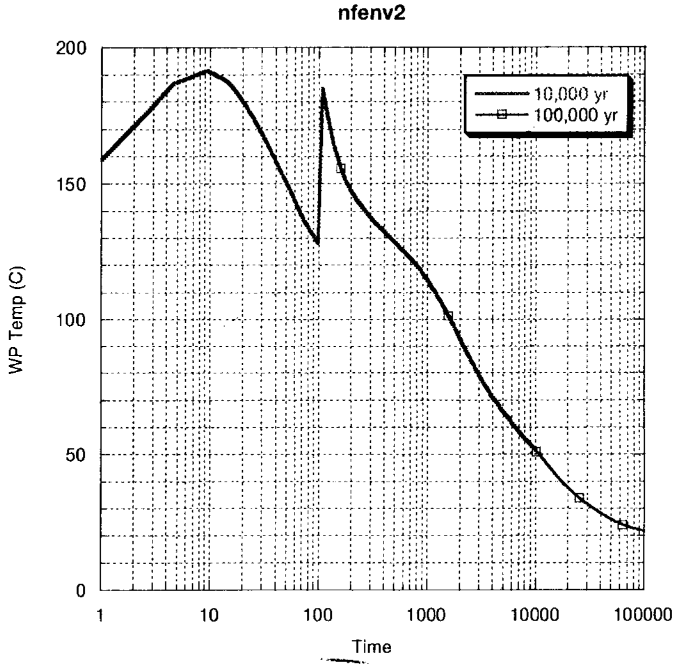
Description of Acceptance Tests: [illegible]

Tested by: Sitakanta Mohanty	**Date:** 3/20/2000

CNWRA Form TOP-5 (01/99)

[illegible]

```
1.0
**
constant
ElevationOfRepositoryHorizon[
m]
1072.0
**
constant
ElevationOfGroundSurface[m]
1400.0
**
**
```



3/20/2000

TESTS TO SUPPORT SCR # 303.

Default file that is read for the Flult and Fow factors. Note that only two rows of data are given. and both rows have same fmult and fow values. This should reflect in the output file infilper.res.

data/wpflw.def file:

```
Time history of the factors for flow diversion (Fmult) and flow contacting waste packages (Fow) used
in releaset (rwr 1/17/00)
    time (yr)     Fmult       Fow
     0.0000       1.      1.
 100000.0000      1.      1.
```

Parameters changes in the tpa.inp file to obtain flow rates constant with time:

```
**
**        ***>>> UZFLOW  <<<***
**
**uniform
constant
ArealAverageMeanAnnualInfiltrationAtStart[mm/yr]
```

```
1.0, 10.0
**
**uniform
constant
MeanAveragePrecipitationMultiplierAtGlacialMaximum
1.0                 1.5, 2.5
**
**uniform
constant
MeanAverageTemperatureIncreaseAtGlacialMaximum[degC]
0.0                   -10, -5
**
constant
TimeStepForClimate[yr]
500.0
**
constant
StandardDeviationOfMAPAboutMeanInOneTimePeriod[mm/yr]
0.0
**
constant
StandardDeviationOfMATAboutMeanInOneTimePeriod[degC]
0.0
**
constant
CorrelationBetweenMAPAndMAT
-0.8
**
iconstant
ClimatePerturbationSet
1
**
**
**       ***>>> NFENV  <<<***
*
```

Additionally, REFLUX effects were suppressed to emulate constant flow condition. This was achieved by sqitching to reflux 1 model and specifying the length of reflux zone as zero as shown below.

```
**
iconstant
SelectRefluxModel(1,2,3)
1
**3
```

```
**
constant
LengthOfRefluxZone[m]
0
**20
**
constant
MaximumFluxInRefluxZone[m/s]
1.0e-9
**
constant
PerchedBucketVolumePerSAarea[m3/m2]
0.0
**
```

Output file infilper.res file:

```
Input file tpa.inp as supplied with TPA Version 4.0betaJ Code.
 Base case
 TPA 4.0betaJ, Job started: Fri Mar 17 17:47:37 2000
 Subarea Averaged Infiltration/Deep Percolation Including

 After Reflux and Diversion - Values for Each Vector


  vector       time       avinfil      avreflux      avdivert
 unitless       yr        mm/yr        mm/yr         mm/yr
     1    0.0000E+00   9.7327E-01   9.7327E-01   9.7327E-01
     1    2.5694E+02   9.7327E-01   9.7327E-01   9.7327E-01
     1    5.8078E+02   9.7327E-01   9.7327E-01   9.7327E-01
     1    9.8894E+02   9.7327E-01   9.7327E-01   9.7327E-01
     1    1.5034E+03   9.7327E-01   9.7327E-01   9.7327E-01
     1    2.1518E+03   9.7327E-01   9.7327E-01   9.7327E-01
     1    2.9690E+03   9.7327E-01   9.7327E-01   9.7327E-01
     1    3.9990E+03   9.7327E-01   9.7327E-01   9.7327E-01
     1    5.2972E+03   9.7327E-01   9.7327E-01   9.7327E-01
     1    6.9334E+03   9.7327E-01   9.7327E-01   9.7327E-01
     1    8.9957E+03   9.7327E-01   9.7327E-01   9.7327E-01
     1    1.1595E+04   9.7327E-01   9.7327E-01   9.7327E-01
     1    1.4871E+04   9.7327E-01   9.7327E-01   9.7327E-01
     1    1.9000E+04   9.7327E-01   9.7327E-01   9.7327E-01
     1    2.4204E+04   9.7327E-01   9.7327E-01   9.7327E-01
```

```
 1    3.0764E+04   9.7327E-01   9.7327E-01   9.7327E-01
 1    3.9031E+04   9.7327E-01   9.7327E-01   9.7327E-01
 1    4.9451E+04   9.7327E-01   9.7327E-01   9.7327E-01
 1    6.2584E+04   9.7327E-01   9.7327E-01   9.7327E-01
 1    7.9137E+04   9.7327E-01   9.7327E-01   9.7327E-01
 1    1.0000E+05   9.7327E-01   9.7327E-01   9.7327E-01
```

Based on the wpflow.def and the tpa.inp file, the last two colums were expected to be 1.0 and the second colums was expected to be 9.7327E-01. because the three terms (flow rate, fmult, fow are multiplied with eachother.

ebsflo.dat:

```
      1.0           ! flowfactr: flow factor
      201           ! number of rows of data to follow
 0.00000E+00  9.96532E-03  1.00000E+00  1.00000E+00      ! t(yr),drip/wp(m^3/yr),fmult,fow
 2.31016E+01  9.96532E-03  1.00000E+00  1.00000E+00
 4.67440E+01  9.96532E-03  1.00000E+00  1.00000E+00
 7.09399E+01  9.96532E-03  1.00000E+00  1.00000E+00
 9.57023E+01  9.96532E-03  1.00000E+00  1.00000E+00
 1.21044E+02  9.96532E-03  1.00000E+00  1.00000E+00
 1.46980E+02  9.96532E-03  1.00000E+00  1.00000E+00
 1.73522E+02  9.96532E-03  1.00000E+00  1.00000E+00
 2.00686E+02  9.96532E-03  1.00000E+00  1.00000E+00
 2.28486E+02  9.96532E-03  1.00000E+00  1.00000E+00
 2.56937E+02  9.96532E-03  1.00000E+00  1.00000E+00
 2.86054E+02  9.96532E-03  1.00000E+00  1.00000E+00
 3.15852E+02  9.96532E-03  1.00000E+00  1.00000E+00
 3.46349E+02  9.96532E-03  1.00000E+00  1.00000E+00
 3.77559E+02  9.96532E-03  1.00000E+00  1.00000E+00
 4.09499E+02  9.96532E-03  1.00000E+00  1.00000E+00
 4.42188E+02  9.96532E-03  1.00000E+00  1.00000E+00
 4.75642E+02  9.96532E-03  1.00000E+00  1.00000E+00
 5.09879E+02  9.96532E-03  1.00000E+00  1.00000E+00
 5.44917E+02  9.96532E-03  1.00000E+00  1.00000E+00
 5.80776E+02  9.96532E-03  1.00000E+00  1.00000E+00
 6.17474E+02  9.96532E-03  1.00000E+00  1.00000E+00
 6.55032E+02  9.96532E-03  1.00000E+00  1.00000E+00
 6.93469E+02  9.96532E-03  1.00000E+00  1.00000E+00
 7.32805E+02  9.96532E-03  1.00000E+00  1.00000E+00
 7.73063E+02  9.96532E-03  1.00000E+00  1.00000E+00
 8.14263E+02  9.96532E-03  1.00000E+00  1.00000E+00
 8.56428E+02  9.96532E-03  1.00000E+00  1.00000E+00
```

8.99579E+02	9.96532E-03	1.00000E+00	1.00000E+00
9.43741E+02	9.96532E-03	1.00000E+00	1.00000E+00
9.88937E+02	9.96532E-03	1.00000E+00	1.00000E+00
1.03519E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.08253E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.13097E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.18055E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.23129E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.28322E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.33636E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.39075E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.44641E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.50338E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.56167E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.62134E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.68240E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.74489E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.80884E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.87429E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.94127E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.00982E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.07997E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.15177E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.22524E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.30044E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.37740E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.45616E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.53676E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.61926E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.70368E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.79008E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.87850E+03	9.96532E-03	1.00000E+00	1.00000E+00
2.96899E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.06160E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.15638E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.25337E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.35264E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.45423E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.55820E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.66461E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.77350E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.88495E+03	9.96532E-03	1.00000E+00	1.00000E+00
3.99900E+03	9.96532E-03	1.00000E+00	1.00000E+00
4.11572E+03	9.96532E-03	1.00000E+00	1.00000E+00
4.23518E+03	9.96532E-03	1.00000E+00	1.00000E+00

4.35743E+03	9.96532E-03	1.00000E+00	1.00000E+00
4.48255E+03	9.96532E-03	1.00000E+00	1.00000E+00
4.61059E+03	9.96532E-03	1.00000E+00	1.00000E+00
4.74163E+03	9.96532E-03	1.00000E+00	1.00000E+00
4.87574E+03	9.96532E-03	1.00000E+00	1.00000E+00
5.01299E+03	9.96532E-03	1.00000E+00	1.00000E+00
5.15346E+03	9.96532E-03	1.00000E+00	1.00000E+00
5.29721E+03	9.96532E-03	1.00000E+00	1.00000E+00
5.44432E+03	9.96532E-03	1.00000E+00	1.00000E+00
5.59488E+03	9.96532E-03	1.00000E+00	1.00000E+00
5.74897E+03	9.96532E-03	1.00000E+00	1.00000E+00
5.90666E+03	9.96532E-03	1.00000E+00	1.00000E+00
6.06805E+03	9.96532E-03	1.00000E+00	1.00000E+00
6.23321E+03	9.96532E-03	1.00000E+00	1.00000E+00
6.40224E+03	9.96532E-03	1.00000E+00	1.00000E+00
6.57523E+03	9.96532E-03	1.00000E+00	1.00000E+00
6.75226E+03	9.96532E-03	1.00000E+00	1.00000E+00
6.93345E+03	9.96532E-03	1.00000E+00	1.00000E+00
7.11887E+03	9.96532E-03	1.00000E+00	1.00000E+00
7.30863E+03	9.96532E-03	1.00000E+00	1.00000E+00
7.50284E+03	9.96532E-03	1.00000E+00	1.00000E+00
7.70159E+03	9.96532E-03	1.00000E+00	1.00000E+00
7.90500E+03	9.96532E-03	1.00000E+00	1.00000E+00
8.11317E+03	9.96532E-03	1.00000E+00	1.00000E+00
8.32621E+03	9.96532E-03	1.00000E+00	1.00000E+00
8.54424E+03	9.96532E-03	1.00000E+00	1.00000E+00
8.76738E+03	9.96532E-03	1.00000E+00	1.00000E+00
8.99573E+03	9.96532E-03	1.00000E+00	1.00000E+00
9.22944E+03	9.96532E-03	1.00000E+00	1.00000E+00
9.46861E+03	9.96532E-03	1.00000E+00	1.00000E+00
9.71339E+03	9.96532E-03	1.00000E+00	1.00000E+00
9.96390E+03	9.96532E-03	1.00000E+00	1.00000E+00
1.02203E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.04826E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.07512E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.10260E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.13072E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.15950E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.18896E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.21910E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.24995E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.28153E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.31384E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.34691E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.38075E+04	9.96532E-03	1.00000E+00	1.00000E+00

1.41539E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.45083E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.48711E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.52423E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.56223E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.60111E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.64091E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.68163E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.72331E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.76597E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.80962E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.85430E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.90002E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.94681E+04	9.96532E-03	1.00000E+00	1.00000E+00
1.99470E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.04371E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.09387E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.14520E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.19773E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.25149E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.30651E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.36282E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.42045E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.47942E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.53978E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.60155E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.66477E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.72946E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.79567E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.86343E+04	9.96532E-03	1.00000E+00	1.00000E+00
2.93278E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.00375E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.07638E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.15072E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.22679E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.30464E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.38432E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.46586E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.54931E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.63472E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.72212E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.81157E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.90311E+04	9.96532E-03	1.00000E+00	1.00000E+00
3.99680E+04	9.96532E-03	1.00000E+00	1.00000E+00
4.09268E+04	9.96532E-03	1.00000E+00	1.00000E+00

```
4.19081E+04  9.96532E-03  1.00000E+00  1.00000E+00
4.29123E+04  9.96532E-03  1.00000E+00  1.00000E+00
4.39401E+04  9.96532E-03  1.00000E+00  1.00000E+00
4.49919E+04  9.96532E-03  1.00000E+00  1.00000E+00
4.60683E+04  9.96532E-03  1.00000E+00  1.00000E+00
4.71699E+04  9.96532E-03  1.00000E+00  1.00000E+00
4.82973E+04  9.96532E-03  1.00000E+00  1.00000E+00
4.94511E+04  9.96532E-03  1.00000E+00  1.00000E+00
5.06319E+04  9.96532E-03  1.00000E+00  1.00000E+00
5.18404E+04  9.96532E-03  1.00000E+00  1.00000E+00
5.30772E+04  9.96532E-03  1.00000E+00  1.00000E+00
5.43429E+04  9.96532E-03  1.00000E+00  1.00000E+00
5.56382E+04  9.96532E-03  1.00000E+00  1.00000E+00
5.69639E+04  9.96532E-03  1.00000E+00  1.00000E+00
5.83206E+04  9.96532E-03  1.00000E+00  1.00000E+00
5.97091E+04  9.96532E-03  1.00000E+00  1.00000E+00
6.11301E+04  9.96532E-03  1.00000E+00  1.00000E+00
6.25843E+04  9.96532E-03  1.00000E+00  1.00000E+00
6.40726E+04  9.96532E-03  1.00000E+00  1.00000E+00
6.55957E+04  9.96532E-03  1.00000E+00  1.00000E+00
6.71545E+04  9.96532E-03  1.00000E+00  1.00000E+00
6.87498E+04  9.96532E-03  1.00000E+00  1.00000E+00
7.03824E+04  9.96532E-03  1.00000E+00  1.00000E+00
7.20533E+04  9.96532E-03  1.00000E+00  1.00000E+00
7.37632E+04  9.96532E-03  1.00000E+00  1.00000E+00
7.55132E+04  9.96532E-03  1.00000E+00  1.00000E+00
7.73042E+04  9.96532E-03  1.00000E+00  1.00000E+00
7.91371E+04  9.96532E-03  1.00000E+00  1.00000E+00
8.10129E+04  9.96532E-03  1.00000E+00  1.00000E+00
8.29327E+04  9.96532E-03  1.00000E+00  1.00000E+00
8.48973E+04  9.96532E-03  1.00000E+00  1.00000E+00
8.69080E+04  9.96532E-03  1.00000E+00  1.00000E+00
8.89657E+04  9.96532E-03  1.00000E+00  1.00000E+00
9.10716E+04  9.96532E-03  1.00000E+00  1.00000E+00
9.32269E+04  9.96532E-03  1.00000E+00  1.00000E+00
9.54325E+04  9.96532E-03  1.00000E+00  1.00000E+00
9.76898E+04  9.96532E-03  1.00000E+00  1.00000E+00
1.00000E+05  9.96532E-03  1.00000E+00  1.00000E+00
```

The interpolation of the file wpflow.def data is correct. If the TPA time goes to 100,000 yr and if data in the wpflow.def file is provided only up to 50,000 yr, then the code will use the last value from 50,000 to 100,000 yr.

The code was also tested by changing several values in columms 3 and 4 of the wpflow.def file while keeping all other values were made same. The code interpolated the values correctly while mapping data from the wpflow.def time steps to the TPA time steps.

Based on the above tests the code appears to be using the newly implemented time dependent fmult and fow correctly.

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-304	**Software Title and Version:** TPA 3.3	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

Temperature calculations were modified to be consistent with the EDA II design requirements.

Change Requested by: Sitakanta Mohanty Date: 2/15/2000	**Change Authorized by** (*Software Developer*): R. Janetzke R Janetzke Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

① The rectangular homogeneous thermal sources were replaced ~~by~~ with line sources representing drifts.

② WP spacing and drift spacing were recalculated

③ Code was modified to address ventillation prior to backfilling

④ Modifications were made to accommodate drip-shield and new WP design

Implemented by: Sitakanta Mohanty	**Date:** 2/15/2000

Description of Acceptance Tests:

For calculations related to determining the drift coordinates and the number of WPs in each drift and in each subarea, tests were conducted to use tpa.inp data (including repdes.dat) and tester-supplied data. The correctness of these computations was verified. A complete description of the test is included on the following pages.

Tested by: Rob Rice	**Date:** 3/10/00

CNWRA Form TOP-5 (01/99)

3/10/00

****

SCR-304: Repository Layout

3/6/00 through 3/10/00

The test plan for SCR-304 is listed below:

TPA Test Plan SCR-304

Tester: Rob Rice

Test name: Repository Layout

Anticipated start date: March 6, 2000

Anticipated completion date: March 10, 2000

Amount of your time available to perform this test: 32 hours

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50):
90% system-level and 10% process-level testing will be performed. The TPA code reads information from the *tpa.inp* file and also uses the data in *repdes.dat* to compute the number of WPs in each drift. These values are written to the screen and to *drifts.dat.* Thus, the major effort in this testing, which will be sufficient to evaluate the correct application of this change, will be at the system level.

Output files to be checked: screen print and *drifts.dat*

Input files to be checked for proper data transfer to the program: *tpa.inp* and *repdes.dat*

Disposition of documentation (storage medium, physical location, and access method):
All tests will be archived on a CD-ROM and described in a scientific notebook that will be submitted to the TPA code custodian, Ron Janetzke, upon completion of the testing. On the CD-ROM, the \testing_4.0\ subdirectory will contain all testing output files.

<u>Functional Test</u> Descriptions:

Test 1: Using the repository area and the WP and drift spacing in the *tpa.inp* file and the coordinates in *repdes.dat,* hand calculations (EXCEL spreadsheet) will verify the correct determination of the drift location, the number drifts, and the number of WPs in each drift, in addition to the correct assignment of WPs to each subarea, which are available in the screen print and *drifts.dat..* Plots will show the location of the drifts relative to the repository outline as specified in *repdes.dat* and the subarea coordinates specified in the *tpa.inp* file. These results are archived in the \testing_4.0\basecase subdirectory. Plots and EXCEL spreadsheets are archived in the \testing_4.0\data_plots subdirectory.

Test 2: Hand calculations similar to those in Test 1 will be performed using modified (tester-supplied) data for 1 subarea at 0 degrees using a 0 degree angle for the drifts. Because of the simplified geometry, the correct implementation of the changes in the TPA code will be evident by inspection of the results or by straight-forward calculations. These results are archived in the \testing_4.0\tester subdirectory.

Test 3: Hand calculations similar to those in Test 1 will be performed using modified (tester-supplied) data for 2 subareas at 0 degrees using a 0 degree angle for the drifts. Because of the simplified geometry, the correct implementation of the changes in the TPA code will be evident by inspection of the results or by straight-forward calculations. These results are archived in the \testing_4.0\tester2 subdirectory.

Test 4: Hand calculations similar to those in Test 1 will be performed using modified (tester-supplied) data for 1 subarea at -45 degrees using a -45 degree angle for the drifts. Because of the simplified geometry, the correct implementation of the changes in the TPA code will be evident by inspection of the results or by straight-forward calculations. These results are archived in the \testing_4.0\tester3 subdirectory.

Test 5: Hand calculations similar to those in Test 1 will be performed using modified (tester-supplied) data for 1 subarea at -45 degrees using a 0 degree angle for the drifts. Because of the simplified geometry, the correct implementation of the changes in the TPA code will be evident by inspection of the results or by straight-forward calculations. These results are archived in the \testing_4.0\tester4 subdirectory.

- Hand calculations: Hand calculations verify whether the computations are correct for determining the number of WPs in each subarea and each drift using an EXCEL spreadsheet or by inspection.

- Process-level: Process-level values written to the *drifts.dat* file in READER will be documented in the Tests 1 through 5 results and these values for the orientation, length, and number of WPs in each drift will be checked using the hand calculations described previously.

- System-level: Tests 1 through 5, as described above, will be performed using the TPA Version 4.0beta code. System-level results in the screen print and *wpsfail.res* file will be examined and analyzed using hand calculations to verify the WPs were correctly assigned to each subarea.

Reasonableness Test Description: Based on Tests 1 through 5 described above using TPA Version 4.0beta data and tester-supplied data, the reasonableness of the WP calculations will be verified and will be evident in the results for Tests 1 through 5.

Final Checklist (completed during testing):

- Did the modification substantially change the results? No. Because one subarea was added and the coordinates of the original seven subareas were modified slightly, there are a different number of WPs in the repository (6,920 compared to 6,427 in v3.3). This difference is attributable to the increased spent fuel emplaced in the repository (68,030 MTUs compared to about 63,000 MTUs in v3.3). These results are available in the *tpa.out* files in the \testing_4.0bkk\basecase and \tpa33\basecase subdirectories.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in *tpa.inp*? Yes. A comparison in the EBS releases (*cumrel.res*) shows that the results are consistent for the mean value parameters for versions 3.3 and 4.0. These are differences can be attributed to changes introduced into version 4.0 (e.g., different number of WPs for each subarea. These results are archived in the \testing_4.0bkk\basecase_meanvalue and \tpa33\basecase_meanvalue subdirectories.

- Which nuclides were monitored to determine reasonableness of results in term of dose?
The radionuclides with the highest dose rates in version 3.3 (i.e., I-129 and Cl-36) were monitored for purposes of evaluating the reasonableness of the results in terms of dose. This two radionuclides also appear in the version 4.0 results together with Tc-99. Again, the differences in the version 3.3 and 4.0 doses were reasonable. These results are also archived in the \testing_4.0bkk\basecase_meanvalue and \tpa33\basecase_meanvalue subdirectories.

Discussion of test results for SCR-304:

Test 1 Results:

The TPA Version 4.0beta code was run in the \testing_4.0\basecase subdirectory using the basecase *tpa.inp* file, except the append option was activated to generate the intermediate data transfer files (i.e., the **.rlt*, **.ech*, and **.cum* files) which are useful for process-level testing.

The following information provides the 8 subarea coordinates in the *tpa.inp* file:

```
subarea
8
edaii 1-cw
547514.88,4079310.61
548069.2,4079136.5
547847.3,4077816.2
547370.95,4077922.04
547514.88,4079310.61
edaii 2-cw
548069.2,4079136.5
548569.32,4078981.
548504.06,4077664.24
547847.3,4077816.2
548069.2,4079136.5
edaii 3-cw
547370.95,4077922.04
547847.3,4077816.2
548322.7,4077192.2
547474.7,4077281.6
547370.95,4077922.04
edaii 4-cw
547847.3,4077816.2
548504.06,4077664.24
548479.71,4077173.06
548322.7,4077192.2
547847.3,4077816.2
edaii 5-cw
547474.7,4077282.6
547887.3,4077238.1
547897.79,4076045.46
547655.97,4076123.07
547474.7,4077282.6
edaii 6-c
```

```
547887.3,4077238.1
548322.7,4077192.2
548155.7,4075962.63
547897.79,4076045.46
547887.3,4077238.1
edaii 7-cw
548322.7,4077192.2
548479.71,4077173.06
548455,4076674.51
548155.7,4075962.63
548322.7,4077192.2
edaii 8-cw
547645.27,4079656.06
548588.98,4079377.55
548569.32,4078981
547514.88,4079310.61
547645.27,4079656.06
```

The TPA code uses these coordinates and the repository outline coordinates (including the emplacement block coordinates) in *repdes.dat* to compute the drift beginning and ending points and the number of WPs in each drift, which are available in the *drifts.dat* file. A listing of these files from the \testing_4.0\basecase subdirectory is given below:

Listing of *repdes.dat*:

```
TITLE:  test file for rep design.
**
** angle - radians
**
-.304d0
**
** rep outline vertices.
**
13
547645.27,4079656.06
548588.98,4079377.55
548569.32,4078981.
548504.06,4077664.24
548479.71,4077173.06
548455,4076674.51
548155.7,4075962.63
547897.79,4076045.46
547655.97,4076123.07
547474.7,4077282.6
547370.95,4077922.04
547514.88,4079310.61
547645.27,4079656.06
**
** emplacement blocks
**
2
547504.18,   4079276.1, 548155.70,   4075962.6
547504.18,   4079276.1, 547732.82,   4081208.1
```

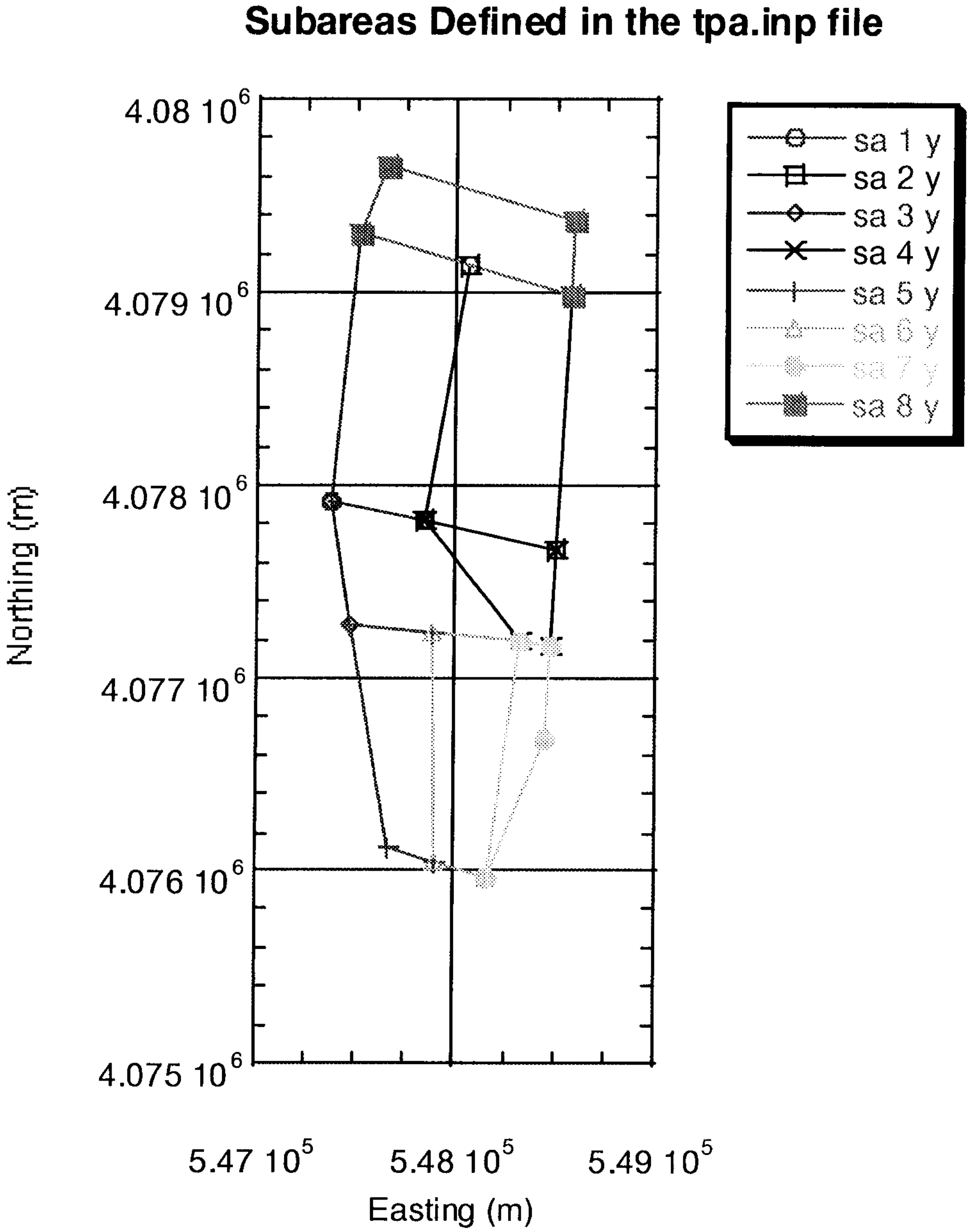
Listing of *drifts.dat*:

```
TITLE:
**
**
Emplacement Block
        1
** Drift Endpoints
**  x1          y1          x2          y2        numWP
 5.48565342E+05 4.07890074E+06 5.47506817E+05 4.07923283E+06  180
 5.48561199E+05 4.07881715E+06 5.47498295E+05 4.07915061E+06  181
 5.48557056E+05 4.07873356E+06 5.47489773E+05 4.07906839E+06  182
 5.48552913E+05 4.07864996E+06 5.47481251E+05 4.07898617E+06  182
 5.48548770E+05 4.07856637E+06 5.47472728E+05 4.07890395E+06  183
 5.48544628E+05 4.07848278E+06 5.47464206E+05 4.07882173E+06  184
 5.48540485E+05 4.07839918E+06 5.47455684E+05 4.07873951E+06  185
 5.48536342E+05 4.07831559E+06 5.47447162E+05 4.07865729E+06  185
 5.48532199E+05 4.07823200E+06 5.47438639E+05 4.07857507E+06  186
 5.48528056E+05 4.07814841E+06 5.47430117E+05 4.07849286E+06  187
 5.48523913E+05 4.07806481E+06 5.47421595E+05 4.07841064E+06  188
 5.48519770E+05 4.07798122E+06 5.47413072E+05 4.07832842E+06  188
 5.48515627E+05 4.07789763E+06 5.47404550E+05 4.07824620E+06  189
 5.48511484E+05 4.07781403E+06 5.47396028E+05 4.07816398E+06  190
 5.48507341E+05 4.07773044E+06 5.47387506E+05 4.07808176E+06  191
 5.48503198E+05 4.07764685E+06 5.47378983E+05 4.07799954E+06  191
 5.48499054E+05 4.07756326E+06 5.47371783E+05 4.07791691E+06  192
 5.48494910E+05 4.07747966E+06 5.47386295E+05 4.07782746E+06  189
 5.48490766E+05 4.07739607E+06 5.47400808E+05 4.07773802E+06  186
 5.48486622E+05 4.07731248E+06 5.47415321E+05 4.07764857E+06  182
 5.48482478E+05 4.07722889E+06 5.47429833E+05 4.07755913E+06  179
 5.48478334E+05 4.07714529E+06 5.47444346E+05 4.07746968E+06  176
 5.48474191E+05 4.07706170E+06 5.47458859E+05 4.07738023E+06  173
 5.48470047E+05 4.07697811E+06 5.47473371E+05 4.07729079E+06  170
 5.48465904E+05 4.07689451E+06 5.47487378E+05 4.07720150E+06  167
 5.48461761E+05 4.07681092E+06 5.47501334E+05 4.07711223E+06  163
 5.48457618E+05 4.07672733E+06 5.47515290E+05 4.07702296E+06  160
 5.48443392E+05 4.07664690E+06 5.47529245E+05 4.07693369E+06  156
 5.48411859E+05 4.07657190E+06 5.47543201E+05 4.07684442E+06  148
 5.48380326E+05 4.07649690E+06 5.47557157E+05 4.07675515E+06  140
 5.48348794E+05 4.07642190E+06 5.47571113E+05 4.07666588E+06  132
 5.48317261E+05 4.07634690E+06 5.47585068E+05 4.07657661E+06  124
 5.48285728E+05 4.07627190E+06 5.47599024E+05 4.07648734E+06  117
 5.48254195E+05 4.07619690E+06 5.47612980E+05 4.07639806E+06  109
 5.48222663E+05 4.07612190E+06 5.47626936E+05 4.07630879E+06  101
 5.48191130E+05 4.07604690E+06 5.47640891E+05 4.07621952E+06   93
 5.48159597E+05 4.07597190E+06 5.47654847E+05 4.07613025E+06   86
**
Emplacement Block
        2
** Drift Endpoints
**  x1          y1          x2          y2        numWP
 5.48569485E+05 4.07898433E+06 5.47516426E+05 4.07931470E+06  179
 5.48573630E+05 4.07906793E+06 5.47545076E+05 4.07939061E+06  175
 5.48577774E+05 4.07915152E+06 5.47573726E+05 4.07946651E+06  171
 5.48581918E+05 4.07923511E+06 5.47602376E+05 4.07954242E+06  167
 5.48586063E+05 4.07931870E+06 5.47631026E+05 4.07961832E+06  163
```

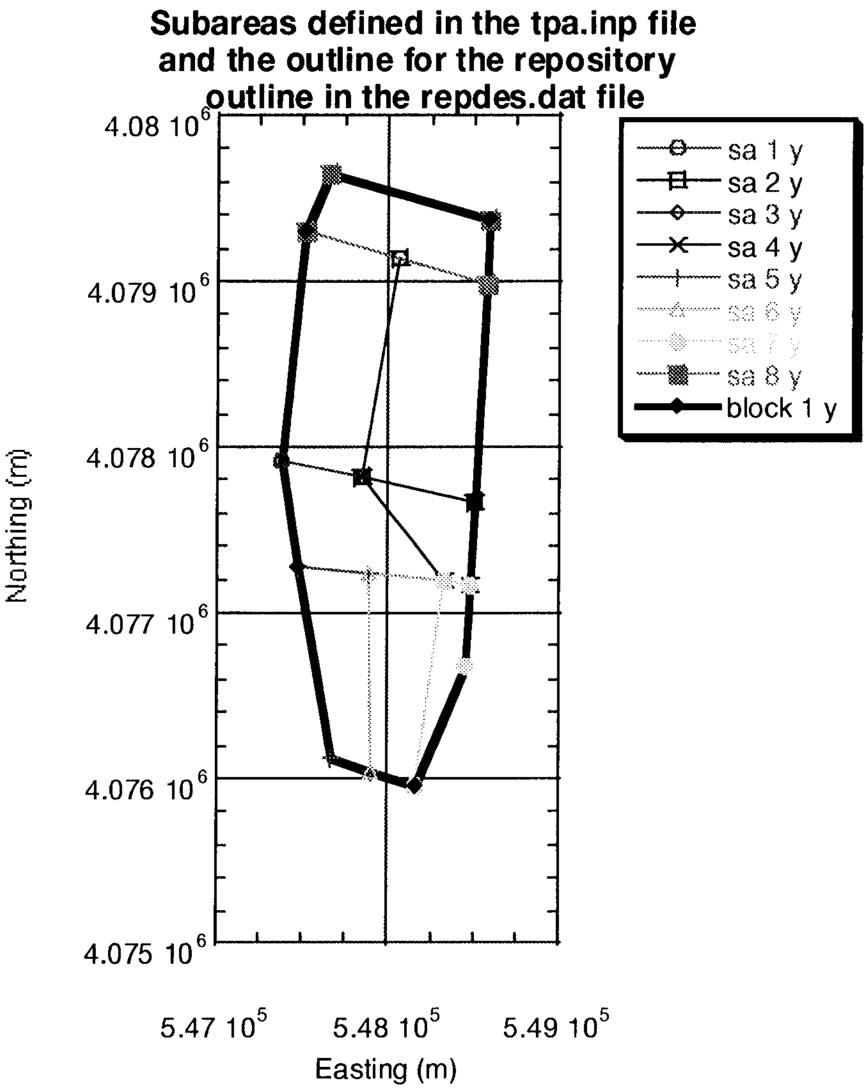
315/357

To verify that the subarea coordinates in the *tpa.inp* file are consistent with the coordinates for both the repository outline in *repdes.dat* and the drift end points in *drifts.dat*, several plots using these coordinates were generated. These plots are present below. The plots were created using Kaleidagraph and are available in the \testing_4.0\data_plots subdirectory.

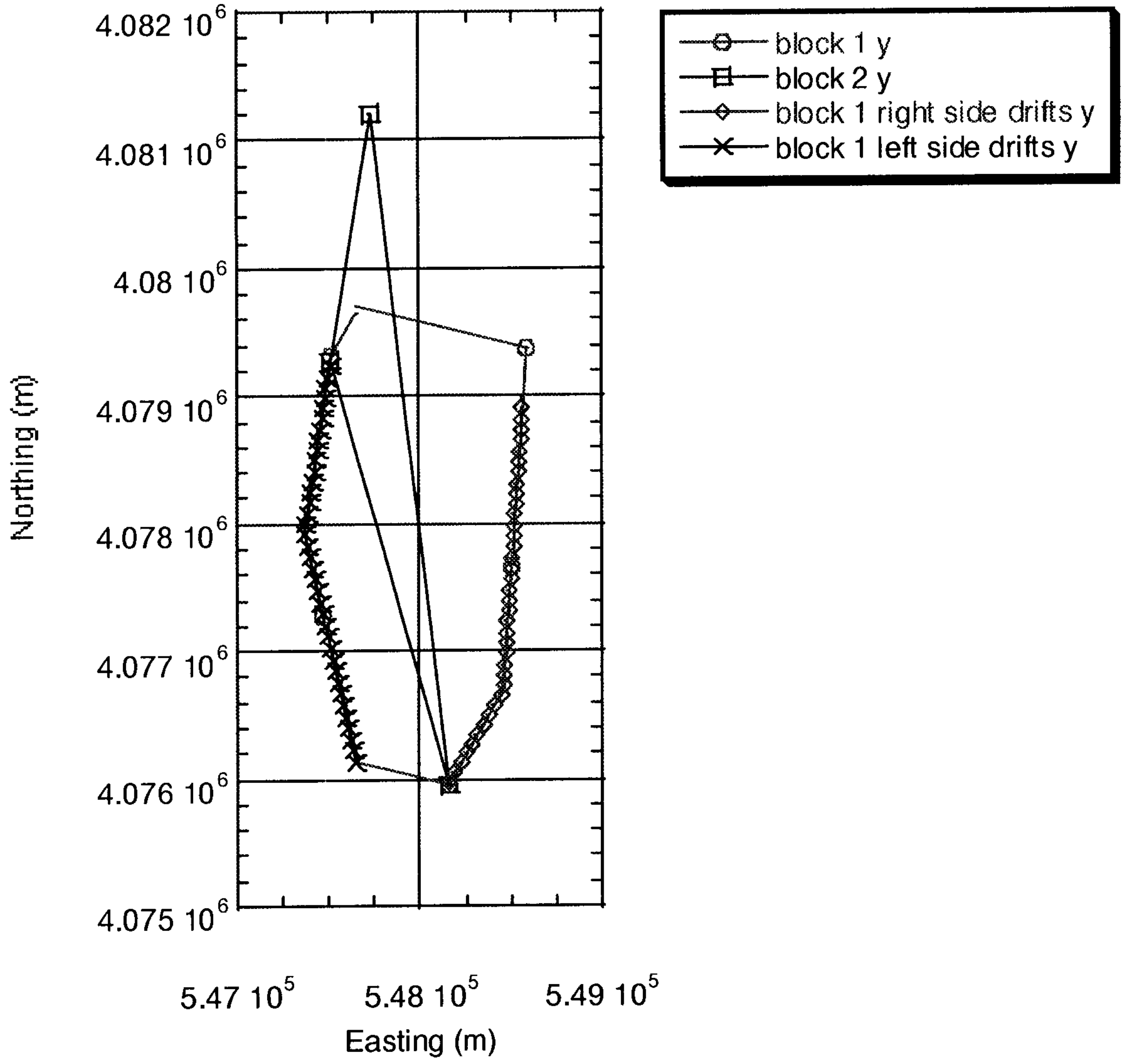
(file: tpa_inp_coord.qpc)



(file: block1.qpc)


Subareas defined in the tpa.inp file and the outline for the repository outline in the repdes.dat file

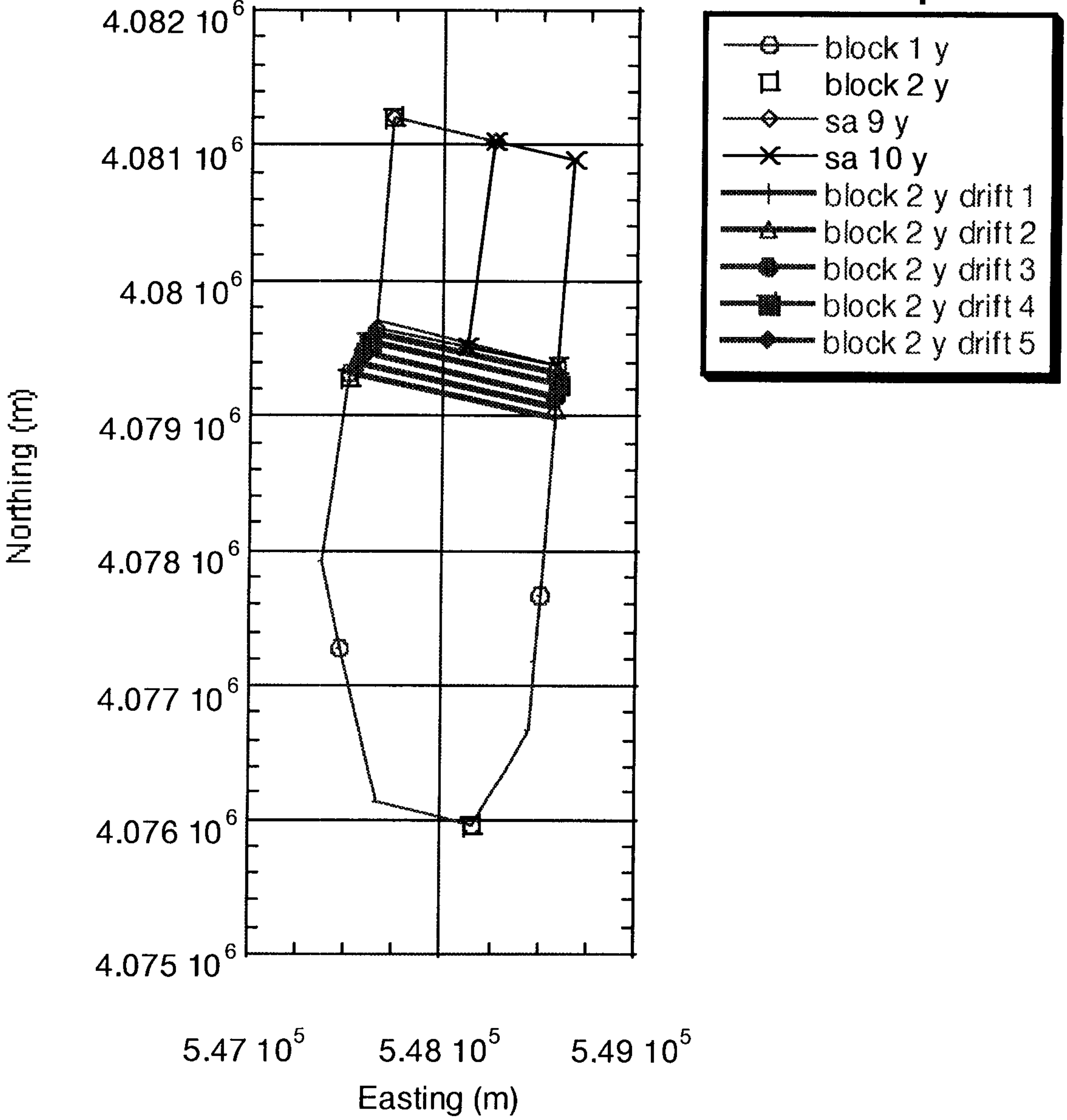
(file: block1_drifts.qpc)



Emplacement block 1 and 2 coordinates from repdes.dat and coordinates of the left and right side of the drift from drifts.dat

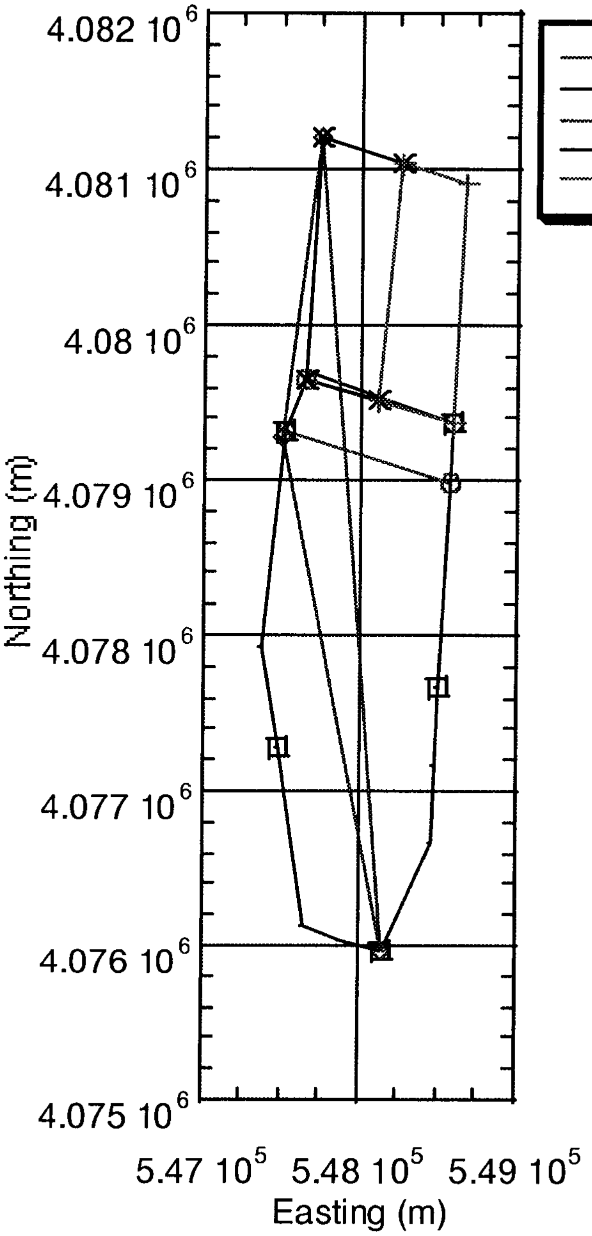
(file: block2_drifts.qpc)

Repository outline from repdes.dat (subareas 1 to 8) , subareas 9 and 10 (not used) from tpa.inp, and the five drifts in subarea 8 from drifts.dat in block 2 repdes.dat



(file: sa8910_blk12.qpc)

Repository outline for blocks 1 and 2 from repdes.dat and subareas 8,9, and 10 from tpa.inp



The titles for each of these graphs describe the plotted coordinates. The coordinates for the subareas from *tpa.inp* are consistent with the coordinates for the repository outline in *repdes.dat* and the drift end points in *drifts.dat.* Additionally, emplacement block 1 and 2 coordinates are at the upper left hand corner of subarea 1 and subarea 8, respectively. (note that the coordinates plotted in the lower right part of subarea 7 are only place holders and are not used in calculations)

To verify the number of WPs in each drift (*drifts.dat*) is consistent with the total number of WPs in the repository, the number of WPs in *drifts.dat* was summed (6970) and compared to the sum of the number of WPs listed for each subarea in the screen print (6921). These results are consistent, even though there is a difference of 1 WP, with the difference being attributed to rounding. Moreover, the fraction of the total repository area occupied by one subarea (which was used in TPA Version 3.3 to determine the number of WPs in each subarea) roughly corresponds to the number of WPs computed using the drift coordinates (see below and \testing_4.0\data_plots\tpaout.xls) and the number of WPs based on fraction of the total area correspond (see below). This verifies that reasonableness of the assignment of WPs to each subarea.

Subarea #	Area [m^2]	Waste [MTU]	Number of WP	fract of area	fract of total wps	#WPs based on fract area
1	723591.3	13605.4	1394	0.20867448	0.19997131	1454.67
2	784763	15049.9	1542	0.226315616	0.221202123	1577.646
3	390372	7827.5	802	0.112578294	0.115048056	784.7833
4	207581.3	3904	400	0.059863793	0.057380577	417.3105
5	378972.8	7573.8	776	0.10929091	0.111318319	761.8669
6	424872.5	8452.2	866	0.122527797	0.124228949	854.1413
7	163938.3	3279.4	336	0.04727771	0.048199684	329.5729
8	393468.9	8344.8	855	0.1134714	0.122650983	791.0091
total area	**3467560**	**total wps**	**6971**			

To verify that the angle (-0.304 radians) and the drift and WP spacing (81 m and 6.1392 m, respectively, as specified in the tpa.inp file) computed in READER and written to the *drifts.dat* file were correctly used to determine the drift endpoints and the number of WPs in each drift, EXCEL spreadsheet analysis was performed. The file *data.xls* in the \testing_4.0\data_plots subdirectory contains the analysis. This analysis verifies that the WPs spacing was 6.1392 m, the drift spacing was 81 m and the drift angle was -0.304 radians.

Furthermore, the total MTUs emplacement in the repository (specified in tha *tpa.inp* file as 68,030 MTUs using 9.76 MTU/WP) was consistent with the repository MTUs in tpa.out (see the \testing_4.0\basecase subdirectory).

Thus, from the Test 1 results, the modifications are correctly implemented and are reasonable.

Test 2 through Test 5 Results:

Test 2 through Test 5 utilize tester-supplied data to check the correct implementation of determining drift locations, number of WPs in each drift, and the assignment of WPs to subareas. In these tests, data were modified, including the subarea coordinates in *tpa.inp* and the repository outline, drift angle, and emplacement block coordinates in *repdes.dat*. For each of the four tests, the following data and output files will be provided: *tpa.inp* subarea coordinates, *repdes.dat*, *drifts.dat*, and the screen print from *tpa.out* showing the number of WPs in each subarea. The following list summarizes the tests and location of the input\output files from these tests.

Test	**Test Description**	**Location of Test Files**
Test 2	1 horizontal subarea and horizontal drifts	\testing_4.0\tester
Test 3	2 horizontal subareas and horizontal drifts	\testing_4.0\tester2
Test 4	1 subarea and drifts at -45 degrees	\testing_4.0\tester3
Test 5	1 subarea at -45 degrees and horizontal drifts	\testing_4.0\tester4

Test 2

(file: *tpa.inp*)

```
subarea
1
*
   0.0        0.0
   0.0     2000.0
2000.0      2000.0
2000.0         0.0
   0.0        0.0
```

(file: *repdes.dat*)

```
TITLE:  test file for rep design.
**
** angle - radians
**
0.0d0
**
** rep outline vertices.
**
5
0.0, 0.0
0.0, 2000.0
2000.0, 2000.0
2000.0, 0.0
0.0, 0.0
**
** emplacement blocks
**
2
```

```
0.0, 1000.0, 2000.0, 0.0
0.0, 1000.0, 0.0, 4000.0
```

(file: *drifts.dat*)

```
TITLE:
**
**
Emplacement Block
         1
** Drift Endpoints
**  x1           y1            x2            y2         numWP
 1.21430643E-16 9.59500000E+02 2.00000000E+03 9.59500000E+02  325
 1.21430643E-16 8.78500000E+02 2.00000000E+03 8.78500000E+02  325
 1.21430643E-16 7.97500000E+02 2.00000000E+03 7.97500000E+02  325
 1.21430643E-16 7.16500000E+02 2.00000000E+03 7.16500000E+02  325
 1.21430643E-16 6.35500000E+02 2.00000000E+03 6.35500000E+02  325
 1.21430643E-16 5.54500000E+02 2.00000000E+03 5.54500000E+02  325
 1.21430643E-16 4.73500000E+02 2.00000000E+03 4.73500000E+02  325
 1.21430643E-16 3.92500000E+02 2.00000000E+03 3.92500000E+02  325
 1.21430643E-16 3.11500000E+02 2.00000000E+03 3.11500000E+02  325
 1.21430643E-16 2.30500000E+02 2.00000000E+03 2.30500000E+02  325
 1.21430643E-16 1.49500000E+02 2.00000000E+03 1.49500000E+02  325
 1.21430643E-16 6.85000000E+01 2.00000000E+03 6.85000000E+01  325
**
Emplacement Block
         2
** Drift Endpoints
**  x1           y1            x2            y2         numWP
 1.21430643E-16 1.04050000E+03 2.00000000E+03 1.04050000E+03  325
 1.21430643E-16 1.12150000E+03 2.00000000E+03 1.12150000E+03  325
 1.21430643E-16 1.20250000E+03 2.00000000E+03 1.20250000E+03  325
 1.21430643E-16 1.28350000E+03 2.00000000E+03 1.28350000E+03  325
 1.21430643E-16 1.36450000E+03 2.00000000E+03 1.36450000E+03  325
 1.21430643E-16 1.44550000E+03 2.00000000E+03 1.44550000E+03  325
 1.21430643E-16 1.52650000E+03 2.00000000E+03 1.52650000E+03  325
 1.21430643E-16 1.60750000E+03 2.00000000E+03 1.60750000E+03  325
 1.21430643E-16 1.68850000E+03 2.00000000E+03 1.68850000E+03  325
 1.21430643E-16 1.76950000E+03 2.00000000E+03 1.76950000E+03  145
```

(file: *tpa.out*)

```
Subarea   Area     Waste   Number of WP
  #    [m^2]     [MTU]
  1   4000000.0   68027.2       6970
```

Test 3

(file: *tpa.inp*)

```
subarea
```

```
2
*
  0.0         0.0
  0.0      2000.0
 1000.0     2000.0
 1000.0       0.0
  0.0         0.0
*
 1000.0       0.0
 1000.0    2000.0
 2000.0    2000.0
 2000.0       0.0
 1000.0       0.0
```

(file: *repdes.dat*)

```
TITLE:  test file for rep design.
**
** angle - radians
**
0.0d0
**
** rep outline vertices.
**
5
0.0, 0.0
0.0, 2000.0
2000.0, 2000.0
2000.0, 0.0
0.0, 0.0
**
** emplacement blocks
**
2
0.0, 1000.0, 2000.0, 0.0
0.0, 1000.0, 0.0, 4000.0
```

(file: *drifts.dat*)

```
TITLE:
**
**
Emplacement Block
         1
**  Drift Endpoints
**   x1            y1            x2            y2         numWP
 1.21430643E-16 9.59500000E+02 2.00000000E+03 9.59500000E+02   325
 1.21430643E-16 8.78500000E+02 2.00000000E+03 8.78500000E+02   325
 1.21430643E-16 7.97500000E+02 2.00000000E+03 7.97500000E+02   325
 1.21430643E-16 7.16500000E+02 2.00000000E+03 7.16500000E+02   325
 1.21430643E-16 6.35500000E+02 2.00000000E+03 6.35500000E+02   325
 1.21430643E-16 5.54500000E+02 2.00000000E+03 5.54500000E+02   325
 1.21430643E-16 4.73500000E+02 2.00000000E+03 4.73500000E+02   325
```

```
 1.21430643E-16 3.92500000E+02 2.00000000E+03 3.92500000E+02  325
 1.21430643E-16 3.11500000E+02 2.00000000E+03 3.11500000E+02  325
 1.21430643E-16 2.30500000E+02 2.00000000E+03 2.30500000E+02  325
 1.21430643E-16 1.49500000E+02 2.00000000E+03 1.49500000E+02  325
 1.21430643E-16 6.85000000E+01 2.00000000E+03 6.85000000E+01  325
**
Emplacement Block
       2
** Drift Endpoints
**  x1          y1          x2          y2       numWP
 1.21430643E-16 1.04050000E+03 2.00000000E+03 1.04050000E+03  325
 1.21430643E-16 1.12150000E+03 2.00000000E+03 1.12150000E+03  325
 1.21430643E-16 1.20250000E+03 2.00000000E+03 1.20250000E+03  325
 1.21430643E-16 1.28350000E+03 2.00000000E+03 1.28350000E+03  325
 1.21430643E-16 1.36450000E+03 2.00000000E+03 1.36450000E+03  325
 1.21430643E-16 1.44550000E+03 2.00000000E+03 1.44550000E+03  325
 1.21430643E-16 1.52650000E+03 2.00000000E+03 1.52650000E+03  325
 1.21430643E-16 1.60750000E+03 2.00000000E+03 1.60750000E+03  325
 1.21430643E-16 1.68850000E+03 2.00000000E+03 1.68850000E+03  325
 1.21430643E-16 1.76950000E+03 2.00000000E+03 1.76950000E+03  145
```

(file: *tpa.out*)

```
Subarea  Area      Waste   Number of WP
  #     [m^2]     [MTU]
  1  2000000.0  34013.6       3485
  2  2000000.0  34013.6       3485
```

Test 4

(file: *tpa.inp*)

```
subarea
1
*
  0.0        0.0
1414.2      1414.2
  0.0       2828.4
-1414.2     1414.2
  0.0        0.0
```

(file: *repdes.dat*)

```
TITLE:  test file for rep design.
**
** angle - radians
**
-.7853982d0
**0.0d0
**
** rep outline vertices.
```

```
**
5
0.0, 0.0
-1414.2, 1414.2
0.0, 2828.427
1414.2, 1414.2
0.0, 0.0
**
** emplacement blocks
**
2
-1414.2, 1414.2, -2828.4, 2828.4
-1414.2, 1414.2, -5656.8, 5656.8
```

(file: *drifts.dat*)

```
TITLE:
**
**
Emplacement Block
         1
**  Drift Endpoints
**   x1            y1            x2            y2         numWP
-1.38556245E+03 1.44283810E+03 2.86377729E+01 2.86377729E+01   325
-1.32828735E+03 1.50011429E+03 8.59134222E+01 8.59134222E+01   325
-1.27101224E+03 1.55739049E+03 1.43189071E+02 1.43189071E+02   325
-1.21373714E+03 1.61466669E+03 2.00464721E+02 2.00464721E+02   325
-1.15646204E+03 1.67194288E+03 2.57740370E+02 2.57740370E+02   325
-1.09918694E+03 1.72921908E+03 3.15016019E+02 3.15016019E+02   325
-1.04191183E+03 1.78649527E+03 3.72291669E+02 3.72291669E+02   325
-9.84636731E+02 1.84377147E+03 4.29567318E+02 4.29567318E+02   325
-9.27361629E+02 1.90104767E+03 4.86842967E+02 4.86842967E+02   325
-8.70086526E+02 1.95832386E+03 5.44118616E+02 5.44118616E+02   325
-8.12811423E+02 2.01560006E+03 6.01394266E+02 6.01394266E+02   325
-7.55536321E+02 2.07287625E+03 6.58669915E+02 6.58669915E+02   325
-6.98261218E+02 2.13015245E+03 7.15945564E+02 7.15945564E+02   325
-6.40986116E+02 2.18742865E+03 7.73221213E+02 7.73221213E+02   325
-5.83711013E+02 2.24470484E+03 8.30496863E+02 8.30496863E+02   325
-5.26435911E+02 2.30198104E+03 8.87772512E+02 8.87772512E+02   325
-4.69160808E+02 2.35925723E+03 9.45048161E+02 9.45048161E+02   325
-4.11885706E+02 2.41653343E+03 1.00232381E+03 1.00232381E+03   325
-3.54610603E+02 2.47380963E+03 1.05959946E+03 1.05959946E+03   325
-2.97335501E+02 2.53108582E+03 1.11687511E+03 1.11687511E+03   325
-2.40060398E+02 2.58836202E+03 1.17415076E+03 1.17415076E+03   325
-1.82785296E+02 2.64563821E+03 1.23142641E+03 1.23142641E+03   145
```

(file: *tpa.out*)

```
Subarea   Area      Waste    Number of WP
  #     [m^2]      [MTU]
  1   3999923.3   68027.2        6970
```

Test 5

(file: *ipa.inp*)

```
subarea
1
*
   0.0          0.0
 1414.2       1414.2
   0.0        2828.4
-1414.2       1414.2
   0.0          0.0
```

(file: *repdes.dat*)

```
TITLE:  test file for rep design.
**
** angle - radians
**
**-.7853982d0
0.0d0
**
** rep outline vertices.
**
5
0.0, 0.0
-1414.2, 1414.2
0.0, 2828.427
1414.2, 1414.2
0.0, 0.0
**
** emplacement blocks
**
2
-1414.2, 1414.2, -2828.4, 2828.4
-1414.2, 1414.2, -5656.8, 5656.8
```

(file: *drifts.dat*)

```
TITLE:
**
**
Emplacement Block
        1
**  Drift Endpoints
**  x1             y1             x2             y2          numWP
-1.37370077E+03 1.45470000E+03 1.37370077E+03 1.45470000E+03   447
-1.29270232E+03 1.53570000E+03 1.29270232E+03 1.53570000E+03   421
-1.21170387E+03 1.61670000E+03 1.21170387E+03 1.61670000E+03   394
-1.13070541E+03 1.69770000E+03 1.13070541E+03 1.69770000E+03   368
-1.04970696E+03 1.77870000E+03 1.04970696E+03 1.77870000E+03   341
```

```
-9.68708505E+02 1.85970000E+03 9.68708505E+02 1.85970000E+03  315
-8.87710052E+02 1.94070000E+03 8.87710052E+02 1.94070000E+03  289
-8.06711598E+02 2.02170000E+03 8.06711598E+02 2.02170000E+03  262
-7.25713145E+02 2.10270000E+03 7.25713145E+02 2.10270000E+03  236
-6.44714691E+02 2.18370000E+03 6.44714691E+02 2.18370000E+03  210
-5.63716237E+02 2.26470000E+03 5.63716237E+02 2.26470000E+03  183
-4.82717784E+02 2.34570000E+03 4.82717784E+02 2.34570000E+03  157
-4.01719330E+02 2.42670000E+03 4.01719330E+02 2.42670000E+03  130
-3.20720877E+02 2.50770000E+03 3.20720877E+02 2.50770000E+03  104
-2.39722423E+02 2.58870000E+03 2.39722423E+02 2.58870000E+03   78
-1.58723970E+02 2.66970000E+03 1.58723970E+02 2.66970000E+03   51
-7.77255161E+01 2.75070000E+03 7.77255161E+01 2.75070000E+03   25
**
Emplacement Block
      2
** Drift Endpoints
**  x1          y1          x2          y2        numWP
-1.37370077E+03 1.45470000E+03 1.37370077E+03 1.45470000E+03  447
-1.29270232E+03 1.53570000E+03 1.29270232E+03 1.53570000E+03  421
-1.21170387E+03 1.61670000E+03 1.21170387E+03 1.61670000E+03  394
-1.13070541E+03 1.69770000E+03 1.13070541E+03 1.69770000E+03  368
-1.04970696E+03 1.77870000E+03 1.04970696E+03 1.77870000E+03  341
-9.68708505E+02 1.85970000E+03 9.68708505E+02 1.85970000E+03  315
-8.87710052E+02 1.94070000E+03 8.87710052E+02 1.94070000E+03  289
-8.06711598E+02 2.02170000E+03 8.06711598E+02 2.02170000E+03  262
-7.25713145E+02 2.10270000E+03 7.25713145E+02 2.10270000E+03  122
```

(file: *tpa.out*)

```
Subarea  Area     Waste   Number of WP
  #    [m^2]     [MTU]
  1  3999923.3  68027.2      6970
```

Note that from this testing, all of the results are reasonable and correct for the number of WPs in each drift and the allocation of WPs to subareas (Test 3). These results are consistent for the different angles (0 and -45 degrees) in *repdes.dat*. Also note the expected symmetry in the number of WPs in each drift (*drifts.dat*) for Test 5 for horizontal drifts and a subarea at -45 degrees.

In summary, the results from Test 1 through Test 5 suggest that the modifications for the repository layout in SCR-304 were implemented correctly in the TPA Version 4.0 code. Thus, the code **PASSES** the tests outlined in the TSCR-304 test plan.

****

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TESTING TPA VERSION 4.0 CODE

SCRs 304, 293, and 289

Testing Performed by

Robert W. Rice

March 23, 2000

TESTING TPA VERSION 4.0 CODE

Three SCRs were identified in the following table for testing by R. Rice (SCRs 304, 293, and 289). The testing for these three SCRs is described in the following pages. See the \testing_4.0 subdirectory on the CD accompanying the test results (submitted to R. Janetzke on 3/24/00) for the source code, executables, data, and output files. The test plans, the test results, and the scientific notebook are available in the \testing_4.0\testplan subdirectory.

The TPA Version 4.0beta code was received from R. Janetzke on a CD dated 2/18/00. Installation tests were conducted in the \testing_4.0\install_test subdirectory on an NT PC and the results compared to the results included on the CD. The output of the installation test was entirely consistent with the output files included on the CD (except for the expected differences in the time and date of the run).

The results from the TPA Version 4.0beta code were compared to the results from the TPA Version 3.3 code, which was available from R. Janetzke on a CD dated 11/29/99. The TPA Version 3.3 code files are located in the \tpa33 subdirectory.

The following pages provide the test plans and results of testing conducted for SCRs 304, 293, and 289.

TPA 4.0 Development Task List

Change #	Effort Level	Description	Implementer	Module	Work Outline	Area of Change	Tester	Status	SCR #	Rationale
0	M	Different corrosion rate for welds	Pensado/ Mohanty	failt.f	Weld corrosion built into overall corrosion calculation	code	Brossia	testing	294	Potential early failure mechanism
				ebsfail.f	Convert 6 hardwired values to input parameters.	code				
1	H	Flexibility in defining the exposure pathways	Muller	gentoo.f	Incorporate stand-alone GENII into TPA	code	LaPlante	testing	301	Capability to address concern of stakeholders
			LaPlante							
2	H	Stochastic biosphere and receptor group	Muller	gentoo.f	Incorporate stand-alone GENII into TPA, incorporate parameter for pluvial transition.	code	Weldy	testing		Capability to address concern of stakeholders
			Smith/ Janetzke/ LaPlante/ Mohanty							
4	H	Include drip shield	Pensado/ Mohanty	ebsrel.f, failt.f	New factor DRIP failure time given by CLST KTI.	code	Codell	testing	294	EDA-II Design
				tpa.inp	Add 2 new parameters.	data				
			Codell	releaset.f	Pre-exponential term.	code	Mohanty	testing		
19	L	Time-dependent mass loading (resuspension ash)	Weldy/ Esh	dcags.f	modify distribution (make time-dependent)	code	Smith	testing	292	Reduce excess conservatism
6	M	Alluvium length variation,	Menchaca/ Janetzke	szft.f	Modify hardwired minimum Tuff length	code	Menchaca	testing	300	Remove feature inconsistent with stochastic PA
			Winterle	strmtube.dat		data		testing		
		Clarify diffusion parameter	McCartin	szft.f	Add penetration distance and fractures per meter parameters.	code	Esh	testing	290	
11	L	# packages entrained in conduit and expelled to surface.	Janetzke	volcano.f	remove geometric consideration in volcano.f. Add/modify # packages distribution	code	Weldy	testing	293	Address possible non-conservatism
12	L	Number of magma induced mechanical failures remaining in drift.	Janetzke	volcano.f	Accommodate new sampled parameter.	code	Rice	testing		Improved information.
				tpa.inp	Add new sampled parameter.	data				

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TPA 4.0 Development Task List

Change #	Effort Level	Description	Implementer	Module	Work Outline	Area of Change	Tester	Status	SCR #	Rationale
27	M	Temporal variability of flow rate.	Rice/ Esh	ebsrel.f	FMULT, FOW	code	Mohanty	testing	303	Improve dynamic features of code
				ebsrel.def						
			Codell	releaset.f		code				
30	H	WP Temperature	Mohanty	nfenv.f	Modify existing model based on EDA-II design	code	McCartin	testing	304	EDA-II Design
43	M	Repository layout	Janetzke	exec.f	Reflect EDA-II design	code	Rice	testing		EDA-II Design
40	M	SEISMO generate seismic events in a repeatable manner	Muller/ Janetzke	seismo.f	system -level code change	code	Janetzke	testing	298	improve interpretation.
42	M	Enable logbeta and iuniform sampled parameter distributions	Codell	snllhs.f	Add logbeta and iuniform distributions to snllhs.f.	code	Janetzke	testing	299	With these additional features the original internal Monte Carlo sampling scheme can be fully replaced with the LHS method.
8	M	Failure type dependent water contact model	Rice	ebsrel.f	Bathtub or flowthru based on failure type.	code	Pensado	testing	296	Remove potential code inconsistency
				ebsrel.def	Add new controls for failure types	data				
				tpa.inp	Add 8 flags to map failure type to model	data				
			Codell	releaset.f	Accommodate new ebsrel.inp file.	code	Mohanty	testing		
32	L	Radiolysis effects via H2O2.	Pensado/ Mohanty	failt.f ebsfail.f	New range of values for models 1 and 2 parameters.	code	Codell	testing	294	Improved infromation.
38		Variable times steps for reflux models 2 & 3.	Esh	nfenv.f	Use larger time steps after 10k years	code	Mayer	testing	305	Improve code execution.
35	L	Update mean infiltration.	Stohoff	uzflow.f	Move some of the precipitation and temperature modelling to a preprocessor .	code	Fedor	testing	291	Incorporate new theory and data, and reduce TPA run times.
45	I	Use data files for invent.f information	Rice	invent.f	Move bwr & pwr time histories and percentages to a data file.	code	Menchaca	testing	295	Improve flexibility of code.

Change #	Effort Level	Description	Implementer	Module	Work Outline	Area of Change	Tester	Status	SCR #	Rationale
Bug Fix		Modify qlhitsa to handle starting point outside and ending point inside quadrilateral	Janetzke	subarea.f		code	Rice	testing	289	
Bug Fix		The equation for 'average radius' in seismo was mistyped.	McCartin/ Janetzke	seismo.f	As a minimum rerun the importance analysis run that revealed the inconsistency.	Code	Pensado	testing	302	

END OF TESTING FOR SCRS 304, 293, AND 289. AS PRESENTED ABOVE, THE TPA VERSION 4.0 CODE PASSES ALL OF THE TESTS DESCRIBED IN THE TEST PLANS FOR THESE SCRS.

****

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-304

Software Title and Version: TPA 3.3

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):
Temperature calculations were modified to be consistent with the EDA II design requirements.

Change Requested by: Sitakanta Mohanty
Date: 2/15/2000

Change Authorized by (*Software Developer*): R. Janetzke R. Janetzke
Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):
① The rectangular homogeneous thermal sources were replaced by with line sources representing drifts.
② WP spacing and drift spacing were recalculated
③ Code was modified to address ventillation prior to backfilling
④ Modifications were made to accommodate drip-shield and new WP design

Implemented by: Sitakanta Mohanty
Date: 2/15/2000

Description of Acceptance Tests:
See attached

Tested by: Richard Codell
Date: 3/27/00

CNWRA Form TOP-5 (01/99)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

FAXED FROM
THE
DIVISION OF WASTE MANAGEMENT
(DWM/NMSS)

FAX NUMBER: (301) 415-5399 **VERIFICATION:** (301) 415-7208

LOCAL: ____ **LONG DISTANCE:** ____

* * * * * * * * * * * * *

1. Ron Janetzke **FAX #:** 2105225155
   LOCATION: ____ **VERIFY:** ____

2. ____ **FAX #:** ____
   LOCATION: ____ **VERIFY:** ____

3. ____ **FAX #:** ____
   LOCATION: ____ **VERIFY:** ____

Revised Text for drip shield.
Sent down dripmc.tar.Z.
Dick

RECEIVED
MAR 28 2000

NUMBER OF PAGES 6 **PLUS COVER SHEET**

FROM: Richard Codell

PHONE: ____ **MAIL STOP:** ____

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TPA Test Plan

Test Name: Effects of drip shield failure time on waste package failure time and peak dose

Anticipated Completion Date: March 27, 2000

Amount of time available to perform this test: as needed March 20-27, 2000

Percent of testing time to be spent in process level and system level testing:

100% system level

Output files to be checked:

gwpkdos.res
wpsfail.res

Input files to be checked for proper data transfer to the program:

tpa.inp

Disposition of documentation

Scientific notebook and directory /home/nmss2/rbc/tpa40betaF/testdrip for the reasonableness test and and /home/nmss2/rbc/tpa40betaF/dripmc for the functional test.

Functional Test Description:

Set up the tpa.inp file for the full Monte-Carlo data set, but change the values of the parameters from the base case to ones that will artificially cause the waste package failure by corrosion to much shorter times. Since failure times due to corrosion are normally greater than 10,000 years, there would normally be no failures for the 10,000 year time period of interest. These changes will better show the effect of the drip shield in offering protection. Drip shield failure times are taken to be uniformly distributed between 1000 and 9000 years. There are 300 vectors in the Monte Carlo run. Changes in the input are contained in the input file tpa.inp stored in the tar file dripmc.tar.Z, which was sent to CNWRA.

Examine file gwpkds_c.res to determine if the drip shield failure time is having an effect on the peak doses.

Reasonableness Test Description:

Make a single run with the mean value data set with subarea 1 only for 100,000 years, setting the drip shield failure time to either 1000 or 9000 years. There are no waste package corrosion failures prior to 10,000 years, so only the initial juvenile failures will contribute dose. If the drip shield is working, there will be no doses for 10,000 years, and reduced doses at the 100,000 years time period of interest.

Final Checklist:

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- Did the modification substantially change the result?

Yes. There was no drip shield in tpa 3.3. Drip shield appears to reduced doses in the tests.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?

Not applicable. There was no drip shield model in TPA 3.3.

- Which nuclides were monitored to determine reasonableness of results in terms of dose?

No individual radionuclides were checked, but the overall dose response was checked.

Results of tests

Functional Test

Figure 1 shows a scatter plot of peak dose for the 10,000 year time period of interest versus the drip shield failure time. There is a weak negative correlation, but nothing dramatic. However, Tim McCartin, Dave Esh and I (Richard Codell) reasoned that only the non-retarded radionuclides are important for 10,000 years, and that there travel times are short relative to 10,000 years. Therefore, only drip shield failure times close to 10,000 years are more likely to have any effect on doses. Figure 2 is a histogram of the 100 out of 300 drip shield failure times that lead to the 100 lowest peak doses(most of which were zero). This histogram shows that the highest drip shield failure times have a pronounced effect on peak doses. Figure 3 is a Kolmogorov-Smirnov plot showing the cumulative distribution of the original drip shield failure distribution (heavy line) and the cumulative distribution of the 100 drip shield failure times leading to the lowest doses. I did not perform the K-S statistical test formally, but this figure clearly shows that the drip shield failure time is significant with respect to peak doses.

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Reasonableness test

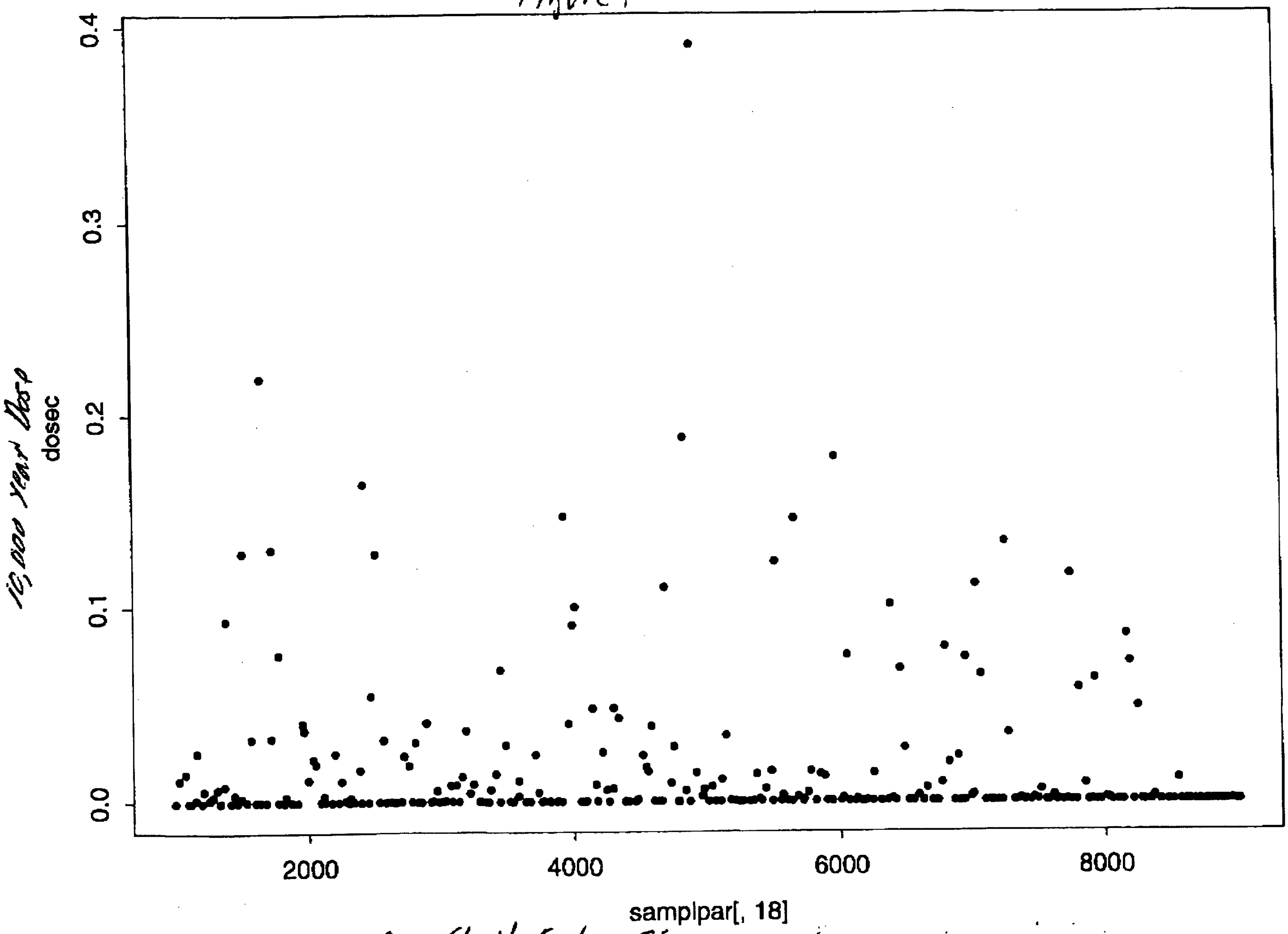
Peak doses for the 10,000 and 100,000 year time periods of interest (tpi), with 1000 and 9000 year drip shield lifetime are presented in the table below. As expected, the drip shield lifetime of 9000 years eliminated dose for the 10,000 year tpi and slightly reduces the dose for the 100,000 year tpi.

	Peak Dose, rem 10,000 yr time period of interest	Peak Dose, rem 100,000 yr time period of interest
1000-yr Drip Shield Lifetime	1.08E-6	1.0932E-3
9000-yr Drip Shield Lifetime	0	1.0931E-3

Files for the reasonableness test are stored in the directory datax/home/nmss2/rbc/tpa40betaF/testdrip. The input files are tpa.inp.meanbase and tpa.inp.meanDS for the 1000 and 9000 year drip shield lifetime, respectively. The output files examined are gwpkdos.res and gwpkds_c.res for the 100,000 and 10,000 year time periods of interest respectively. Appended to these files are the suffix meanbase and meanDS for the 1000 year and 9000 year lifetimes, respectively.

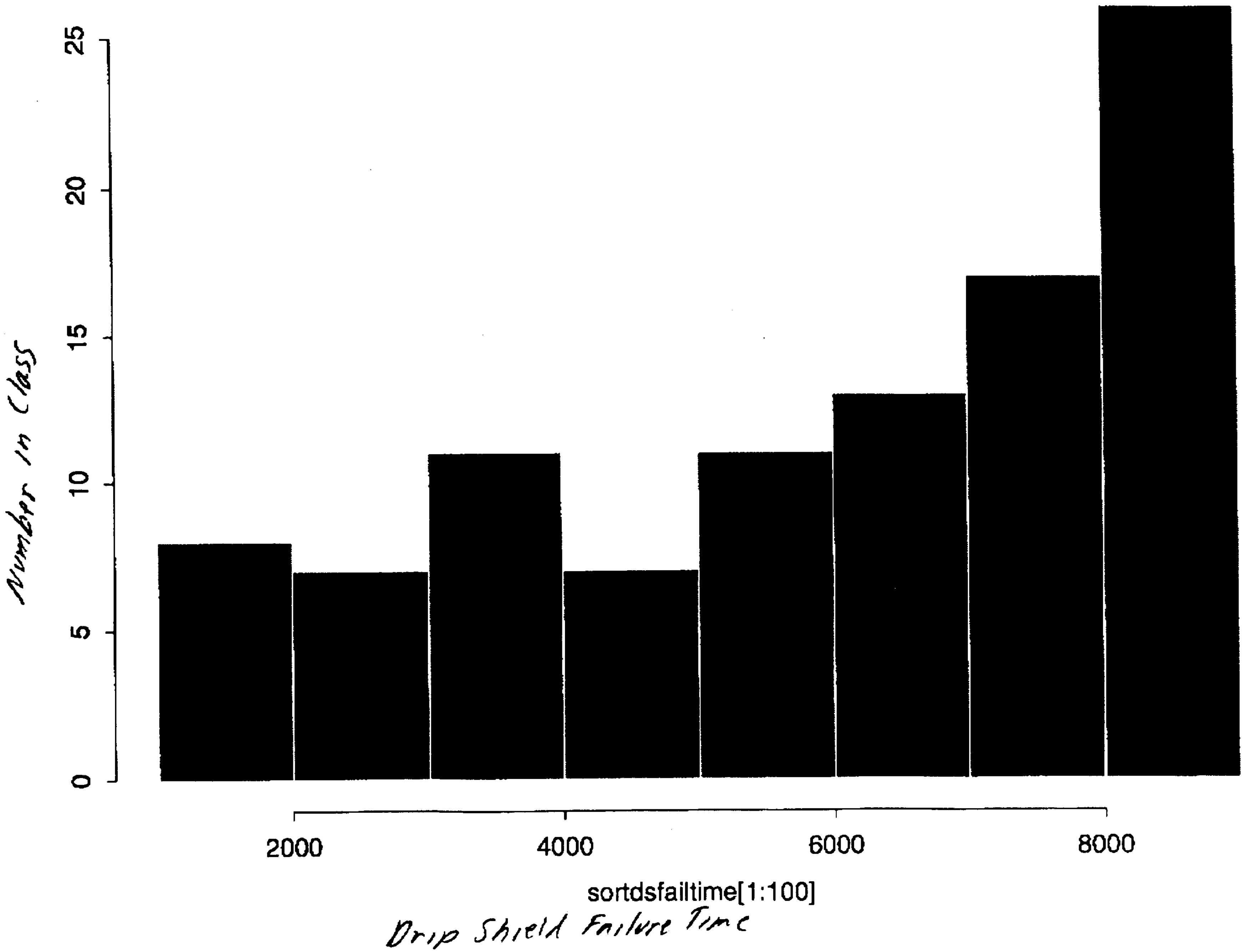
Richard Codell 3/28/00

Figure 1

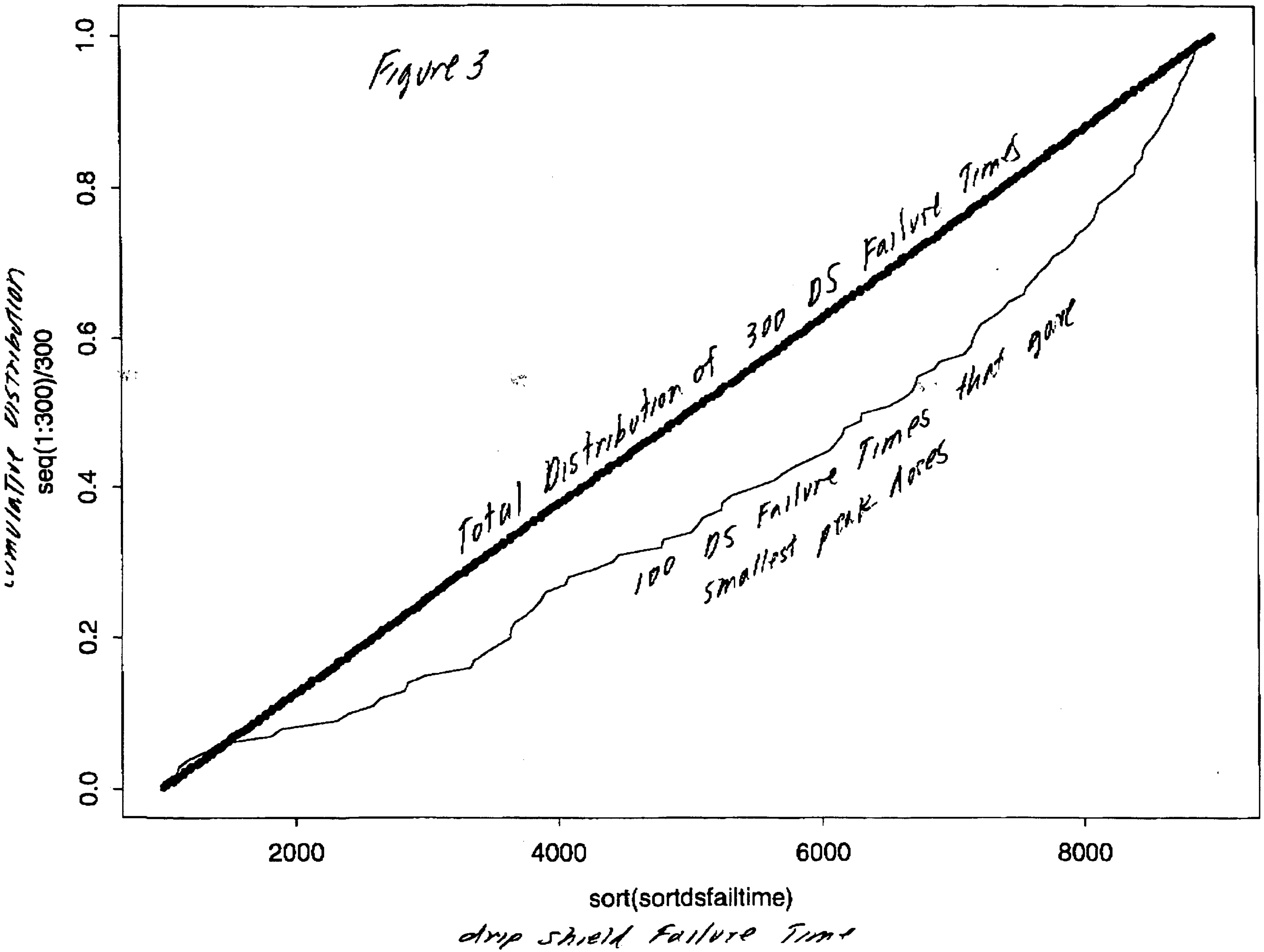


Drip Shield Failure Time

Figure 2


Number in Class
0
5
10
15
20
25
2000
4000
6000
8000
sortdsfailtime[1:100]
Drip Shield Failure Time

Drip shield failure time and 100 fail times leading to lowest dose RBC 3/28/00



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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

FAXED FROM
THE
DIVISION OF WASTE MANAGEMENT
(DWM/NMSS)

FAX NUMBER: (301) 415-5399 **VERIFICATION:** (301) 415-7208

LOCAL: ____ **LONG DISTANCE:** ____

* * * * * * * * * * * *

1. Ron Janetski **FAX #:** ____
LOCATION: ____ **VERIFY:** ____

2. ____ **FAX #:** ____
LOCATION: ____ **VERIFY:** ____

3. ____ FAX #: ____
LOCATION: ____ VERIFY: ____

Revised SCR 304

Dick

NUMBER OF PAGES 5 **PLUS COVER SHEET**

FROM: Richard Codell

PHONE: ____ **MAIL STOP:** ____

RECEIVED
MAR 28 2000

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-304

Software Title and Version: TPA 3.3

Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):
Temperature calculations were modified to be consistent with the EDA II design requirements.

Change Requested by: Sitakanta Mohanty
Date: 2/15/2000

Change Authorized by (*Software Developer*): R. Janetzke
Date: 1-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):
① The rectangular homogeneous thermal sources were replaced ~~by~~ with line sources representing drifts.
② WP spacing and drift spacing were recalculated
③ Code was modified to address ventillation prior to backfilling
④ Modifications were made to accommodate drip-shield and new WP design

Implemented by: Sitakanta Mohanty
Date: 2/15/2000

Description of Acceptance Tests:
See attached

Tested by: Richard Codell
Date: 3/27/00

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Richard Codell
3/27/00

TPA Test Plan

Test Name: Changes to thermal module for EDA-II

Anticipated Completion Date: March 27, 2000

Amount of time available to perform this test: as needed March 20-27, 2000

Percent of testing time to be spent in process level and system level testing:

70% system level
30% module debugging with DBX

Output files to be checked:

gwpkdos.res
nfenv.rch

Input files to be checked for proper data transfer to the program:

tpa.inp

Disposition of documentation

Scientific notebook 3/2000 and directory /home/nmss2/rbc/tpa40betaF/temperature which contains the input files tpa.inp.dripshield1,tpa.inp.dripshield2, tpa.inp.dripshielde, tpa.inp.noventloss and output files nfenv.rlt.dripshield1, nfenv.rlt.dripshield2, nfenv.rlt.dripshielde, and nfenv.rlt.noventloss. Also, plots of output files to show effects of changes to parameters.

Functional Test Description:

1. Set up the tpa.inp file to perform a single run with only subarea 1. Run a base run to generate the temperature of the rock and the waste package contained in file nfenv.rlt. Change the parameters that deal with the heat transfer from the drip shield so that their effects on waste package temperature can be demonstrated:

   a. Effect of thermal conductivity of drip shield
   b. Effect of emissivity of drip shield
   c. Effect of ventilation heat removal

Reasonableness Test Description:

2. Set up a single run with only subarea 1. Increase the heat loading by 10% by increasing the total waste emplaced in the repository by 10% and the waste package payload by 10%. Temperature of rock and waste package should increase about 10%. Small differences might be expected because of radiative heat transfer.

3. Set up a single run with only subarea 1. Temperature of subarea is normally determined at the center of the subarea because this is expected to maximize temperature. Using the system debugger DBX on the Sun workstation, go into the code nfenv and alter the position of the two variables that express the location of the approximate center of the subarea, xyisa(1) and xyisa(2), by adding 200 meters to each. Temperature at the new point should be suboptimal for temperature and therefore lower.

Final Checklist:

- Did the modification substantially change the result?

Yes.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?

No.

- Which nuclides were monitored to determine reaonableness of results in terms of dose?

Analysis checked only temperature responses, not radionuclide release.

Results of tests

1.a Effect of thermal conductivity of drip shield:

Made two runs. Input files saved as tpa.inp.dripshield1 and tpa.inp.dripshield2, stored in /home/nmss2/rbc/tpa40betaF/temperature. The files were identical except the values of the thermal conductivity of the drip shield was 0.00015 w/m-C in the former and 15 w//m-C in the latter. Output files nfenv.rlt for these two runs was saved in same directory and called nfenv.rlt.dripshield1 and nfenv.rlt.dripshield2. Attached figure shows results of two runs in terms of temperature of the waste package in subarea 1 for the first realization. As expected, the case with the higher thermal conductivity has a lower temperature after backfill emplacement at 200 years.

1.b Effect of Ventilation loss.

Another run was made that was the same as tpa.inp.dripshield1, but the ventilation heat removal was 30% in the original and zero removal in the new run. The input file is saved in the same directory as above, and called tpa.inp.noventloss. The output file is called nfenv.rlt.noventloss. As expected, the run with no ventilation removal produces higher temperature. This is also plotted in the above figure.

1.c Effect of emissivity of the drip shield

Another run was made, increasing the emissivity of the drip shield from 0.1 to 0.9. The input file for this run is stored in the above directory as tpa.inp.dripshielde. The output file is stored in

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the same directory as nfenv.rlt.dripshielde. As expected, the run with higher emissivity gives lower waste package temperature. This is also plotted in the above-mentioned figure.

2. Effect of increase in heat load

The heat load was increased 10%. Output from the debugging session was recorded in the file rbcqa2.txt and also Scientific Notebook 3/2000 page 4. As expected, temperature of the rock and waste package increased about 10% from the 20 degrees C initial temperature. Results are presented in the table below.

Time, yr	Base Case T, Deg C	New T', Deg C	(T'-20)/(T-20)
0	70.123	75.156	1.1
25.69	180.17	195.19	1.094
399.9	120.48	130.31	1.098
1159.5	97.978	105.68	1.099
4945.1	61.132	65.226	1.1
10000	45.607	48.161	1.1

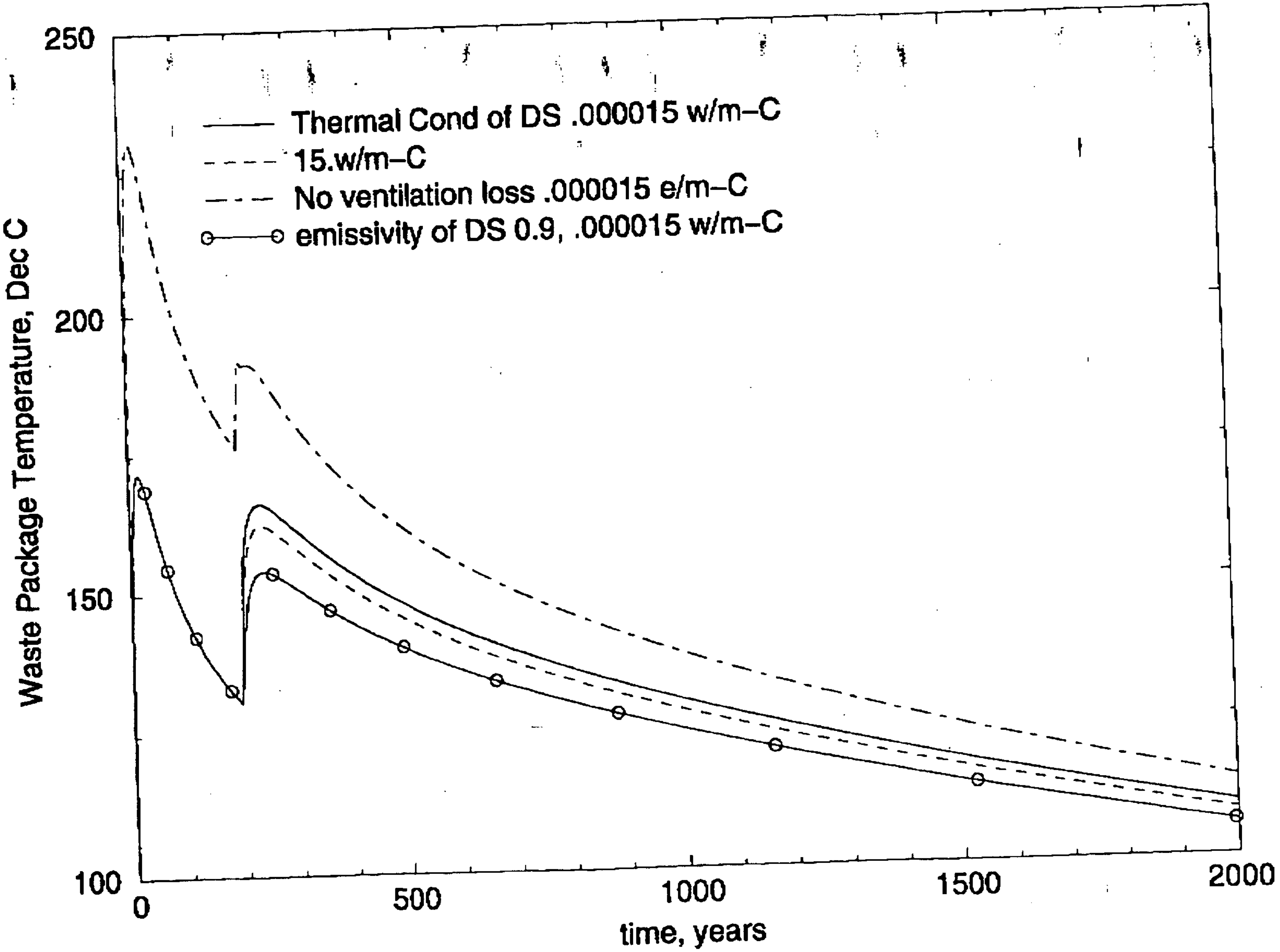
3. Effect of non-optimal location for maximum temperature

Using the DBX debugger, the variables xyisa(1) and xyisa(2) were modified by adding 200 meters to each. As expected, the temperature for the modified run was lower than for the original run. The output for the debugging session was stored in file rbcqa1.txt and also in Scientific Notebook 3/2000 page 5. The table below shows the comparison of the original and modified run.

Timestep	Temperature of repository rock, °C - Original run	Temperature of repository rock, °C - modified run
2	119.82	119.82
5	157.68	157.68
10	164.95	164.86
20	153.58	152.23
50	122.51	112.60
100	92.77	75.19
150	62.039	49.14
201	29.66	29.40
peak	165.086	165.038

Test thermal conductivity of dripshield

R. Codell 3/27/00



Richard Codell
3/27/00

TPA Test Plan

Test Name: Changes to thermal module for EDA-II

Anticipated Completion Date: March 27, 2000

Amount of time available to perform this test: as needed March 20-27, 2000

Percent of testing time to be spent in process level and system level testing:

70% system level
30% module debugging with DBX

Output files to be checked:

gwpkdos.res
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Input files to be checked for proper data transfer to the program:

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Disposition of documentation

Scientific notebook 3/2000 and directory /home/nmss2/rbc/tpa40betaF/temperature which contains the input files tpa.inp.dripshield1,tpa.inp.dripshield2, tpa.inp.dripshielde, tpa.inp.noventloss and output files nfenv.rlt.dripshield1, nfenv.rlt.dripshield2, nfenv.rlt.dripshielde, and nfenv.rlt.noventloss. Also, plots of output files to show effects of changes to parameters.

Functional Test Description:

1. Set up the tpa.inp file to perform a single run with only subarea 1. Run a base run to generate the temperature of the rock and the waste package contained in file nfenv.rlt. Change the parameters that deal with the heat transfer from the drip shield so that their effects on waste package temperature can be demonstrated:

   a. Effect of thermal conductivity of drip shield
   b. Effect of emissivity of drip shield
   c. Effect of ventilation heat removal

Reasonableness Test Description:

2. Set up a single run with only subarea 1. Increase the heat loading by 10% by increasing the total waste emplaced in the repository by 10% and the waste package payload by 10%. Temperature of rock and waste package should increase about 10%. Small differences might be expected because of radiative heat transfer.

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3. Set up a single run with only subarea 1. Temperature of subarea is normally determined at the center of the subarea because this is expected to maximize temperature. Using the system debugger DBX on the Sun workstation, go into the code nfenv and alter the position of the two variables that express the location of the approximate center of the subarea, xyisa(1) and xyisa(2), by adding 200 meters to each. Temperature at the new point should be suboptimal for temperature and therefore lower.

Final Checklist:

- Did the modification substantially change the result?

Yes.

- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?

No.

- Which nuclides were monitored to determine reaonableness of results in terms of dose?

Analysis checked only temperature responses, not radionuclide release.

Results of tests

1.a Effect of thermal conductivity of drip shield:

Made two runs. Input files saved as tpa.inp.dripshield1 and tpa.inp.dripshield2, stored in /home/nmss2/rbc/tpa40betaF/temperature. The files were identical except the values of the thermal conductivity of the drip shield was 0.00015 w/m-C in the former and 15 w//m-C in the latter. Output files nfenv.rlt for these two runs was saved in same directory and called nfenv.rlt.dripshield1 and nfenv.rlt.dripshield2. Attached figure shows results of two runs in terms of temperature of the waste package in subarea 1 for the first realization. As expected, the case with the higher thermal conductivity has a lower temperature after backfill emplacement at 200 years.

1.b Effect of Ventilation loss.

Another run was made that was the same as tpa.inp.dripshield1, but the ventilation heat removal was 30% in the original and zero removal in the new run. The input file is saved in the same directory as above, and called tpa.inp.dripshelde. The output file is called nfenv.rlt.dripshielde. As expected, the run with no ventilation removal produces higher temperature. This is also plotted in the above figure.

1.c Effect of emissivity of the drip shield

Another run was made, increasing the emissivity of the drip shield from 0.1 to 0.9. The input file for this run is stored in the above directory as tpa.inp.emmissivity. The output file is stored in the same directory as nfenv.rlt.emmisivity. As expected, the run with higher emissivity gives lower waste package temperature. This is also plotted in the above-mentioned figure.

2. Effect of increase in heat load

The heat load was increased 10%. Output from the debugging session was recorded in the file rbcqa2.txt and also Scientific Notebook 3/2000 page 4. As expected, temperature of the rock and waste package increased about 10% from the 20 degrees C initial temperature. Results are presented in the table below.

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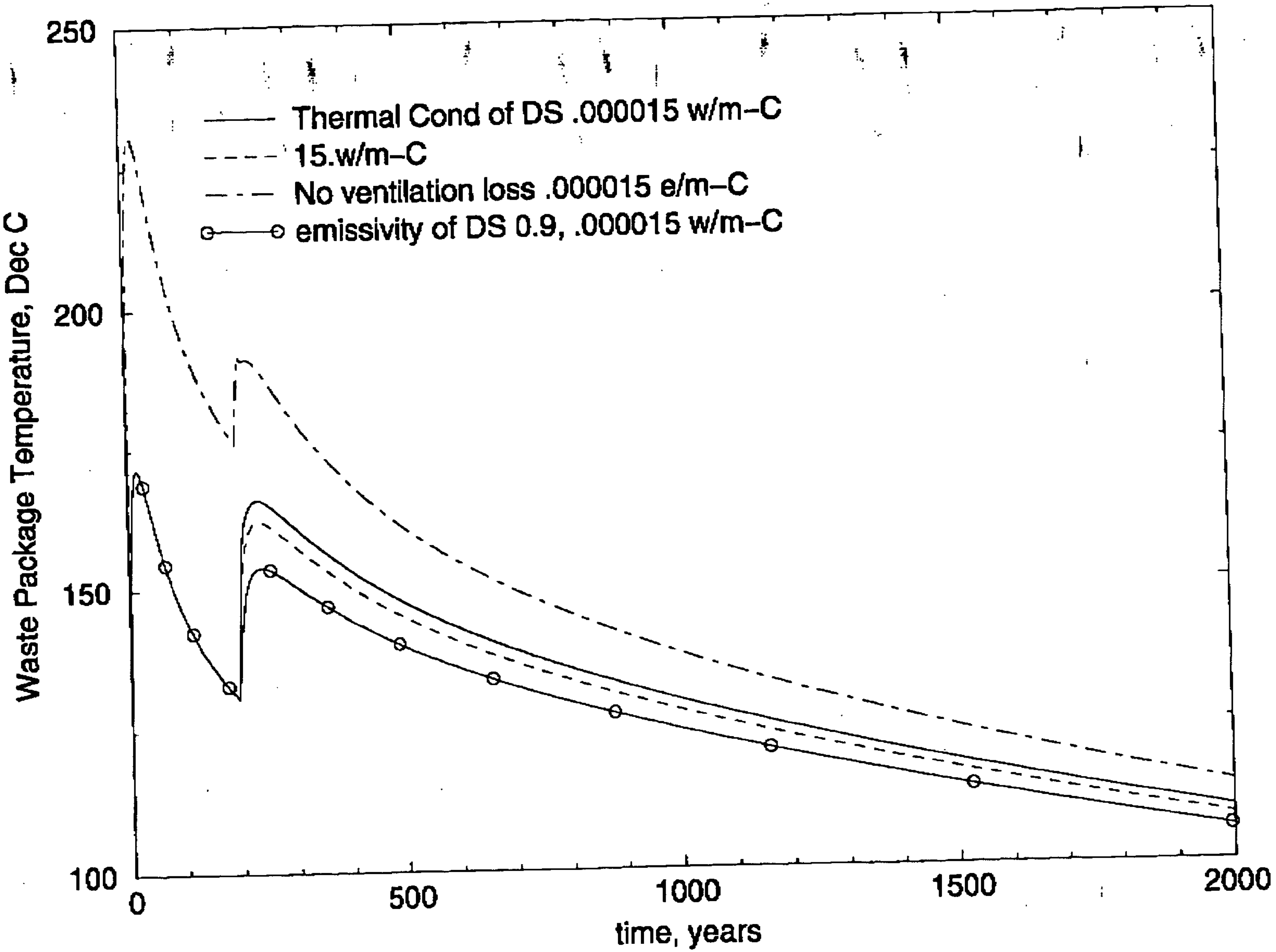
201	29.66	29.40
peak	165.086	165.038

Test thermal conductivity of dripshield

R. Codell 3/27/00



356/357

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

FAXED FROM
THE
DIVISION OF WASTE MANAGEMENT
(DWM/NMSS)

FAX NUMBER: (301) 415-5399

VERIFICATION: (301) 415-7208

LOCAL: ____

LONG DISTANCE: ____

* * * * * * * * * * * *

1. Ron Janetzke **FAX #:** ~~301-4~~ 210 522 5155

LOCATION: ____ **VERIFY:** ____

2. ____ **FAX #:** ____

LOCATION: ____ **VERIFY:** ____

3. ____ FAX #: ____

LOCATION: ____ VERIFY: ____

Signed SCR 299, and result of SCR 304

Dick

NUMBER OF PAGES 6 **PLUS COVER SHEET**

FROM: Richard Codell

PHONE: ____

MAIL STOP: ____

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-305

Software Title and Version: TPA 3.3

Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s): nfenv.f
the Reflux2 and Reflux3 subroutines used 40yr time steps to the maximum simulation time, creating excess computational burden.

Change Requested by: D. Esh
Date: 1-4-00

Change Authorized by (*Software Developer*): R. Janetzke
Date: 1-4-00 Ron Janetzke

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*): Stop reflux calculation for t > refluxend where refluxend is currently set to 10,000 yr.

1) Provided logic to calculate the # of time steps in the first 10,000 years.
2) Changed associated subroutines to only perform calculations (new # of time steps) to 10,000 yrs.
3) After 10,000 yrs the flow is not modified from the ambient percolation

Implemented by: D. Esh

Date: 2/1/00 David W. Esh

Description of Acceptance Tests:

1) Run 10,000 yr and 50,000 yr simulations for both Reflux2 + Reflux3.
2) Compare flow-rates.
3) Compare ambient flow-rate output to Reflux2 + Reflux3 flow-rate output to verify that values are the same for T > 10,000 years.

See attached Test Plan (SJR, 3/13/00)

Tested by: S. Rogers

Date:

CNWRA Form TOP-3 (01/99)

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-305

Software Title and Version: TPA 3.3

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s): nfenv.f
Reflux2 and Reflux3 subroutines used 1.0 yr time steps to the maximum simulation time, creating excess computational burden.

Change Requested by: D. Esh
Date: 1-4-00

Change Authorized by (*Software Developer*): R. Janetzke
Date: 1-4-00 Ron Janetzke

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*): Stop reflux calculation for t>refluxend where refluxend is currently set to 10,000 yr.

1) Provided logic to calculate the # of time steps in the first 10,000 years.
2) Changed associated subroutines to only perform calculations (new # of time steps) to 10,000 yrs.
3) After 10,000 yrs the flow is not modified from the ambient percolation

Implemented by: D. Esh

Date: 2/1/00

Description of Acceptance Tests:

1) Run 10,000 yr and 50,000 yr simulations for both Reflux 2 + Reflux 3.
2) Compare flow-rates.
3) Compare ambient flow-rate output to Reflux 2 + Reflux 3 flow-rate output to verify that values are the same for T > 10,000 years.

See attached Test Plan (SJM, 3/13/00)

Tested by: S. R

Date: 3/13/00

CNWRA Form TOP-5 (01/99)

TPA Test Plan

Test name: TPA4.0beta - nfenv.f software change test (refer to SCR #305)

Anticipated start date: 03-06-00

Anticipated completion date: 03-10-00

Amount of your time available to perform this test: 33%

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): 0/100
[*Process level testing tests the subroutine in standalone mode outside of the TPA code, usually with the aid of a special purpose driver of trivial construction. System level testing tests the subroutine in a fully integrated environment with the TPA code.*]

Output files to be checked: infilper.res, nearfld.res, nfenv.ech, nfenv.rlt

Input files to be checked for proper data transfer to the program:
tpa.inp, driftsa.i, maxntime.i, ia.i, path.i, reflux2.i
Rectedge.dat, drifts.dat, multiflo.dat, drythick.dat, tefkti.inp

Disposition of documentation (storage medium, physical location, and access method):
[*Documentation should include test driver source code, and input, intermediate and output files. Also include any plot files or plot hard copies that are used to display the results.*]
Test work performed on vulcan
Results stored on attached floppy

Detailed change documentation:
A line by line comparison of nfenv.f in TPA 3.3 and in TPA 4.0beta will be performed to establish the effective changes in code.

Consistency test:
Modified parameter names will be checked for consistency among nfenv.f and tpa.inp files.

Change objective achievement test:
The original motivation to perform software change will be compared to the actual influence of the software change.

Reasonableness test:
Actual modifications in code logic (beyond name changes) will be checked.

Functional test:
System-level tests:

The outputs of flow rates of test runs of version 4.0beta are compared to each other. The major changes are based on the assumption that flow rates can be estimated directly for times greater then 10000 years. This assumption will be checked. Test runs for the different Reflux models over a compliance time of 50000 years will be performed.

Final Checklist (completed during testing):
- Did the modification substantially change the results?
- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?
- Which nuclides were monitored to determine reasonableness of results in term of dose?

TPA Test Results

Details of the test and test results can be read in the attached copy of a scientific notebook #392. The input files, code generated output files, and code performance testing files that were used for this test are documented in attached floppy disk.

Detailed change documentation was performed using standard code performance analysis tools as described in scientific notebook # 392. DONE

Consistency test was performed within nfenv.f and tpa.inp. All modifications, additions and removals were found to be consistent. PASSED

Change objective achievement test was performed using the code performance test utility prof. The major objective, to increase numerical efficiency, was achieved. PASSED

Reasonableness test was performed. Changes were checked and revealed no inconsistencies. Modified code is logically structured and appropriate for the task. PASSED

Functional test was performed. 50000 year simulations for reflux1, reflux2 and reflux3 were generated using version 3.3, new version 4.0beta, and a comparison case to test assumptions for version 4.0beta.

A comparison between qualitative results obtained for infiltrating and reflux flow rates for version 3.3 and 4.0beta shows that both codes generate similar relative flow rate distributions. However, changes between versions 3.3 and 4.0 modify the computed infiltrating flow rates, which are input into module nfenv.f. Therefore, these results could not be quantified.

For this purpose of quantifying the comparison, a simple comparison case is generated. It is identical to version 4.0beta, except that the parameter refluxend in reflux2 and reflux3 is set to the duration of compliance (in this case 50000 years). Comparison of results show that flow rate values agree to within 1/10th of a percent, which is deemed sufficient accuracy. PASSED

Did the modification substantially change the results?
Changes specific to nfenv.f did not substantially change results of relative flow rate distributions.

Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?
No. However, both codes were compared with comparable tpa.inp (i.e., where all parameters present in both versions of the code were assigned the same values).

Which nuclides were monitored to determine reasonableness of results in term of dose?
None.

[Stefan Mayer, March 14, 2000]

Copy from Scientific Notebook # 392

INITIAL ENTRIES

Scientific Note Book: # 392

Issued to: Stefan Mayer

Issue Date: March 1, 2000

Printing Period:

Project Title: Test of software change in module nfenv.f for TPA 4.0beta version

Project Staff: Stefan Mayer

By agreement with the CNWRA QA, this notebook is to be printed at approximate semi-annual intervals. This computerized Scientific Notebook is intended to address the criteria of CNWRA QAP-001.

[Stefan Mayer, March 1, 2000]

Objectives

The objective of this project is to test the software changes performed during the upgrade from TPA 3.3 version to TPA 4.0beta version. The focus of this test is limited to the subroutine nfenv.f and all subroutines and functions called from within nfenv.f. It is assumed that TPA 3.3 version was tested and accepted. Where appropriate, results of the TPA 4.0beta version will therefore be compared to results obtained with TPA 3.3 version.
Specific objectives are:
1) Test that the original objectives motivating the software change were achieved (see PA-SCR-305 for objectives: reduce excess computational burden, improve code execution).
2) Perform acceptance tests as outlined in PA-SCR-305.
3 Establish the actual text modifications (additions, changes, removals) done in file nfenv.f, with the exception of all modified (added, changed, or removed) comment lines.
4) Test that all parameter and variable name changes (additions, removals, modifications) as well as changes of types (integer, real, etc) are consistent within the nfenv.f subroutine, as well as consistent with input, output, and common shared parameters throughout TPA4.0beta version.
5) Test that changed (added, removed, modified) code is consistent, reasonable, and technically sound.
6) Test that measures were taken to protect code against run time errors (underflow, overflow, out of bounds, etc.).
7) Test that the input of parameters and variables ranging within accepted bounds yields output of parameters and variables within accepted bounds.8) Test that proper measures are taken to protect code against unreasonable input, resulting either from user defined input or from intermediate results obtained from other modules, which might generate unreasonable output (GIGO).
[Stefan Mayer, March 1, 2000]

Computers, Computer Codes, and Data Files

The original computer codes to be tested TPA 4.0beta version as well as the benchmark comparion code TPA 3.3 version were located on the SUN workstation "vulcan" in directories /home/janetzke/tpa40beta and /home/janetzke/tpa33, respectively. These directories were copied with all their contents to /home/smayer/tpa40test/tpa40beta and /home/smayer/tpa40test/tpa33, respectively. Using Exceed to run an Xwindow session, "vulcan" is accessed remotely from the PC "lemur". All tests are preformed on "vulcan", in /home/smayer/tpa40test. Where useful, SUN programs and utilities (found on "vulcan" in /solapps/SUNWspro/ bin) are used to assist the testing procedure. In particular, the SUN f77 compiler and the software development cycle tool workshop are used for file comparison, compiling, debugging, etc.

NOTE: All files saved to support the test process are currently stored on vulcan in /home/smayer/TPA40test/Testresults. If these files will be stored in a different location or on a different medium at the end of the test, a further note here and at the end to this notebook will document their location. [SJM, March 10, 2000]

Table 1-1. Computer, operating system, and compiler used in the tests.

Machine NameMachine TypeOperating SystemCompilerLocationvulcanSUNW, Ultra-Enterprise; sparc; sun4uSUNOS 5.6f77 (SUN); 'Build' in 'workshop'Building 189
[Stefan Mayer, March 1, 2000]

2. PRELIMINARY CHECKS

2.1 References to nfenv.f as found in predecisional manual TPA version 3.2 code: Module descriptions and user's guide, September 1998

The purpose is to become acquainted with the overall TPA code as it relates to the module nfenv.f. The manual TPA version 3.2 code: Module descriptions and user's guide, September 1998 (referred from now on as "the manual") was written for a previous version of the code. Therefore, information will only be used as a guideline during the tests performed on parts of TPA version 4.0beta code.

Section 2.2.2 of the manual (pp 2-6 to 2-7) offers a general description of the purpose of the module nfenv.f, which is to model the influence of the near-field environment on the degradation of WPs. A detailed description of the module is referenced to section 4.2 of the manual. Associated entries to an input file are referenced to Appendix A of the manual.

In section 3.1 of the manual, the consequence module NFENV is placed within the flow diagram of the overall TPA code (Figure 3-1). The call to NFENV is preceded by a call to UZFLOW and followed by a call to EBSFAIL. The executive module EXEC assembles all parameters and data files needed for execution (page 3-4 of manual) and then proceeds to execute the consequence modules in sequence. Table 3-1 shows that NFENV implementation can be either in a table look-up or in a subroutine style, the details of which are described in Figure 3-6.

In section 3.2.2 of the manual (p. 3-9), it is stated that the primary input to NFENV is the time-dependent flow rate per WP, as computed by UZFLOW and EXEC. "The NFENV module provides values for WP temperature, RH, chloride concentration, and the time-varying flow rate of water contacting the WP". The entire NFENV output is the principal input to EBSFAIL.

Section 4.2 of the manual provides a detailed description of NFENV. This includes information flow (4.2.1), intermediate results (4.2.2), conceptual model (4.2.3) and a discussion on assumptions and conservatism (4.2.4).

[Stefan Mayer, March 2, 2000]

2.2 Interaction of module nfenv.f with TPA 4.0beta version code

Upon closer scrutiny, it becomes apparent that consequence module nfenv.f interacts with numerous other subroutines and files. In light of this, the original process level test idea and task to isolate nfenv.f as a stand-alone program is abandoned. This would require the development of an appropriate driver and links to needed data files and to called subroutines, which now appears beyond the scope of a simple function test.

It is decided to carry out process level tests in a different manner. After line-by-line comparison of the actual programming changes, related changes of input and output parameters are examined by including 'print' statements in the code. If deemed necessary, these values are changed, and the behavior of the code is noted.

[Stefan Mayer, March 3, 2000]

2.3 Detailed comparison of the changes performed in nfenv.fThe two versions of nfenv.f were compared to each other using the SUN utility "workshop". This utility is stored on "vulcan" in /solapps/SUNWspro/bin. The option "filemerge" was used to assist a detailed, line-by-line comparison between versions 3.3 and 4.0beta.

The following is a list of changed, added, or removed variables, subroutines, or code lines in nfenv.f:

- Added parameter names:
iemissds, ifracinv, icondds, ihloss_fact
plus some names in common block nfenv14

- Added include file:
driftsa.i

-Added dimension statements for:
drxy1, drxy2, drxy1sa, drxy2sa, numWP

-Added subroutine or functions:
nearestpointonline, enormsq0-2d, enorm0-2d

-Added parameter names read in from file:
RepositoryDriftAngle[radians], FactorForVentilationHeatlosses[], ThermalConductivityOfDripShield[W/m-C], EmissivityOfDripShield[-], EmplacementBackfillThickness[m], DripShieldThickness [m], DripShieldEqvIntDia [m],

CircumferentialFractionNotCoveredByFloor [], NumberOfWeightsForGaussLegendreIntegration [], DriftArealMassLoading [MTU/acre], EmplacementDriftSpacing [m], NumberOfDriftsInRepository []

- Added parameters during subroutine calls:
cond3dxyzt(...,timeofbackfill,hloss_fact,npoints,...)
reflux (...,timeofbackfill,hloss_fact,...)
interpolate (newtim,...)
convertuz (...,newtim,...)
use of newtim in reflux2

-Added lines of code:
(from) idrifts = igetunitnumber('exec ') (... 45 lines ...) (to) close(idrifts)
(lines 265 to lines 319 of code; SJM, 3/6/00)
amld=valueconsmv(ijunk)
iamtuwp=iwppayload
(from) dist2linmin=1.d29 (... 16 lines ...) (to) driftdia=valuesp(idriftdia)
(lines 605 to 622 of code; SJM 3/7/00)
(from) call distancebetween2points() (...) (to) yc(i) = ...
(lines 630 to 638 of code; SJM 3/7/00)
hloss_fact = valuesp(ihloss_fact)npoints = ivaluesp(inpoints)
emissds = valuesp(iemissds)
bfthick = valuesp(ibfthick)
dsthick = valuesp(idsthick)
ds_idia = valuesp(idsidia)
(from) shieldarea = pi*ds_idia (... 6 lines ...) (to) endif
frac_inv = valuesp(ifracinv)
gconv_post = conde_n * ...
condds = valuesp(icondds)
gcond_post = 2.0 * pi * condbf * ...
grad_pre = 4.0d0 * sbolt * ...
(from) qwp = ...*wppayload*(1.d0-hloss...) (... 7 lines ...) (to) gtot = frac_inv * ...
(lines 790 to 802 in code; SJM 3/7/00)
(from) if (tim(it1)...) (to) endif (lines 1156 to 1162, ,SJM, 3/6/00; in subroutine reflux1, SJM 3/7/00)
(In subroutine reflux2) (from) integer iter, newtim (... 20 lines ...)
(lines 1441 to 1469, SJM 3/6/00)
(In subroutine reflux3) (from) integer igetunitnumber, iter, newtim (... 20 lines ...)
(lines 1763 to 1789, SJM 3/6/00)

- Modified parameter names:
iconde_n, icondbf (from iconde, icondb in version 3.3)
gconv_pre, conde_n, condbf, grad_post

- Modified function names:
imvquery (from: iquery)
valueconsmv (from: value)

- Modified parameter dimension:

aLs(300), aBs(300), xc(300), yc(300) (from aLs(12), aBs(12), xc(12), yc(12))

-Modified parameter origin:
AML = valueconsmv(ijunk) (from: AML=..., AML has now become a module variable) - Modified parameter names read in from file:
Cond_EqvForNaturalConvection [W/m-C], ThermalConductivityOfBackfill (from EffectiveThermalConductivityOfBackfill), ThermalConductivityOfInnerOverpack [W/m-C] (from ThermalConductivityOfInnerStainlessSteelWall), ThermalConductivityOfOuterOverpack [W/m-C] (from ThermalConductivityOfOuterCarbonSteelWall)

-Modified lines of code:ijunk = imvquery(name) (from: iquery(name))
aml=valueconsmv(ijunk) (from: value(ijunk))
aL and aB now computed from dist and driftdia instead of assigning aL = aLs(i), aB = aBs(i)

-Removed parameter names originally read in from file:
WastePackagePayload [MTU], EffectiveThermalConductivityOfUnbackfilledDrift [W/m-C]
See correction of 3/6/00 below

- Removed lines of code:
(from) angle=-0.308d0 (...18 lines ...) (to) enddo
(from) if (aml.gt.80.0d0) then (...) (to) endif
(from) if (iover.eq.88334) then (...5 lines ...) (to) endif
driftdia = valuesp(idriftdia)
(from) driftspace = (... 10 lines ...) (to) endif; NOTE: driftspace now obtained using valuesp(idriftspace)
gbf = ...
(in subroutine fill) dimension tim(ntim)
(in subroutine fill) nreflux = int(tim(ntim))

[Stefan Mayer, March 3, 2000]

Note that the comparison case, which was stored in directory .../tpa33, is related to release version 3.2PCbeta and dated to 7/16/99.

Correction to entry of 3/3/00:
The read in parameter WastePackagePayload is still in the file. It has not been removed.

[Stefan Mayer, March 6, 2000]

2.4 Compare list of read in parameters to nfenv.f to related section in tpa.inp

All parameters read in using 'ispquery' were found in tpa.inp, although not in the same order as read in.

Note that 'imvquery' is not defined as an external to the nfenv.f module.

Note that the header comment lines for exec.f still reads "Executive for TPA version 3.3".

[Stefan Mayer, March 6, 2000]

3. TEST ACHIEVEMENT OF ORIGINAL SOFTWARE CHANGE OBJECTIVES

SCR No. PA-SCR-305 lists improved computational efficiency as main reason for modifying nfenv.f.
A direct comparison of sample runs on both versions of TPA code will be used to check if this objective was achieved. Files of data supporting this are currently stored on vulcan in /home/smayer/TPA40test/Testresults (SJM 3/7/00).

It is noted that the Makefile for TPA 3.3 version includes an optimization flag. For a meaningful efficiency comparison, the same flag (-O4) is added to the Makefile of TPA 4.0beta.

In addition to the differences in the tpa.inp file versions due to code modifications, a numerical difference was found for the parameter ArealAverageMeanAnnualInfiltrationAtStart [mm/yr]. The version 3.3 entry was updated to values 2.0, 10.0 as found in version 4.0beta.

Another difference: version 3.3 supported a maximum of 7 subareas, while version 4.0beta allows 8 (SJM, 3/7/00).

Comparison tests are carried out for different time intervals, and parameters MaximumTime, DurationOfCompliancePeriod, NumberOfTimeStepsInCompliancePeriod, and NumberOfTimeStepsAfterCompliancePeriod may need to be modified in tpa.inp. The parameter maxntime in file maxntime.i may also need to be modified.

[Stefan Mayer, March 6, 2000]

3.1 Reflux model 3

The choice flag in tpa.inp is set to "SelectRefluxModel = 3".

[Stefan Mayer, March 6, 2000]

3.1.1 Compare performance of test runs for 10000yr simulations and maxntime=401

Test case 1:
MaximumTime = 10000 years
DurationOfCompliancePeriod = 10000 years
maxntime = 401
NumberOfTimeStepsInCompliancePeriod = 201
NumberOfTimeStepsAfterCompliancePeriod = 0

Results of the preformance test for both versions are stored in /home/smayer/TPA40test/Testresults.
Intermediate results of files infilper.res and nearfld.res are also stored in that directory.
The files start with tpa33* and tpa40* and end in *1.dat.

The results suggest that for this case, nfenv excutes slower in the new version if only a 10000 year period is considered.

[Stefan Mayer, March 6, 2000]3.1.2 Compare performance of test runs for 50000yr simulations and maxntime=401

[Skip to Note below Test case 3; SJM 3/8/00]

Test case 2:
MaximumTime=50000 years
DurationOfCompliancePeriod=10000 years
maxntime = 401
NumberOfTimeStepsInCompliancePeriod = 201
NumberOfTimeStepsAfterCompliancePeriod = 200

As documented in tpa33timer2.dat and tpa40timer2.dat, the reflux3 subroutine in TPA 40 version executes faster than 3.3 version.

Test case 3:
An additional change is performed: the flag OutputMode in tpa.inp is set to 2, and the flag SelectAppend is set to 2 in tpa.inp, each for both versions. Both versions test runs are repeated. This time, no time difference between the two reflux3 subroutines is measured by the observation tool "prof".

MaximumTime=50000 years
DurationOfCompliancePeriod=10000 years
maxntime = 401
NumberOfTimeStepsInCompliancePeriod = 201
NumberOfTimeStepsAfterCompliancePeriod = 200

The code is run again for both versions. Again, the subroutine reflux3 executes too fast for time differences to be recorded. Version 4.0beta of nfenv.f is faster than the old one. For comparisons, see tpa33timer3.dat and tpa40timer3.dat.

[Stefan Mayer, March 7, 2000]

NOTE: A parameter error was discovered in file tpa.inp for the TPA 3.3 version, related to test cases 2 and 3. These are repeated now, with the MaximumTime parameter set to 50000 years.
[Stefan Mayer, March 8, 2000]

Repeat Test case 2:
MaximumTime=50000 years
DurationOfCompliancePeriod=10000 years
maxntime = 401
NumberOfTimeStepsInCompliancePeriod = 201
NumberOfTimeStepsAfterCompliancePeriod = 200
The simulation was repeated for version 3.3 and results compared to the equivalent simulation for version 4.0beta. Subroutine reflux3 executes several times faster in the new modified version. Timing results are currently stored on vulcan, in /home/smayer/TPA40test/Testresults/tpa33timer2.dat.

Note that with the given time step and duration settings in tpa.inp, execution time is negligible compared to overall code time.

Repeat Test case 3:
An additional change is performed: the flag OutputMode in tpa.inp is set to 2, and the flag SelectAppend is set to 2 in tpa.inp, each for both versions. The version 3.3 test run is repeated over MaximumTime = 50000 yr.

The subroutine reflux3 executes several times faster in the new version.

3.2 Reflux model 2

The analog to Test case 3 is repeated here, using the option of subroutine reflux2 in nfenv.f for both versions of the code.

Test case 4:
MaximumTime=50000 years
DurationOfCompliancePeriod=10000 years
maxntime = 401
NumberOfTimeStepsInCompliancePeriod = 201
NumberOfTimeStepsAfterCompliancePeriod = 200
SelectRefluxModel = 2

The subroutine reflux2 executes more than 3 times faster in the new version. Results of the time comparison are stored on vulcan, in /home/smayer/TPA40test/Testresults as files tpa33timer4.dat and tpa40timer4.dat.

3.3 Conclusion

The objectives for the code changes were achieved. For long simulation time periods (example: 50000 years), both the subroutines reflux2 and reflux3 in nfenv.f execute several times faster in the new version as compared to the old version.
It is noted however that either case, these subroutines only take a few percent, respectively a fraction of a percent, of the overall code execution time.

[Stefan Mayer, 8 March 2000]
Insert: Note that this omitted the calling of functions from within reflux2 and reflux3. A better test comparison study is described in section 6. below. [SJM, 3/13/2000]

4. Test that changes of parameter names are consistent within nfenv.f and with their input/output location

Visual inspection of the changes as indicated by the workshop tool “merge”, combined with a search through the nfenv.f data file and through tpa.inp, did not reveal inconsistencies in parameter names.

[Stefan Mayer, 8 March 2000]

All include files, as well as all open statements in nfenv.f were searched for and considered to obtain a list of related external parameter files.
The module reads in parameters from the files tpa.inp, driftsa.i, maxntime.i, ia.i, path.i, reflux2.i,Rectedge.dat, drifts.dat, multiflo.dat, drythick.dat and tefkti.inp. Variables are also passed to nfenv.f from exec.f.

The variables that are passed to nfenv.f from the subroutine call were not modified since version 3.3.

The parameters obtained from include files ia.i, path.i, maxntime.i and reflux2.i were not modified between the versions, nor was a change of their use in the code noted during detailed comparison.

The parameters in the new include file “driftsa.i”, maxnumdrifts and maxnumempblks, appear to be used consistently throughout nfenv.f. Both are used to dimension the new arrays drxy1 etc., and maxnumdrifts is further used to serve as an upped bound for the possible number of drifts.

File tpa.inp was searched for all new or renamed parameters in nfenv.f. All changes were found consistent between the code and the tpa.inp file.

The input files rectedge.dat, multiflo.dat, drythick.dat and tefkti.dat have not been changed for the sample runs considered for versions 3.3 and 4.0beta.

The input file drifts.dat is a new addition to version 4.0beta. It includes location coordinates for drift endpoints. New lines of code (lines 265 to 319) are included in nfenv.f to read in the content of this file. The read-in commands and the values stored in the file appear consistent upon inspection.

[Stefan Mayer, 9 March 2000]

5. Test that all code changes are reasonable

The major changes (additions) of lines of code are inspected. These lines were copied from nfenv.f to file tpa40majorchanges.dat.

5.1 Modifications on lines 265 to 319

This part of code was added to nfenv.f to read in coordinates and locators related to drift locations. Line by line inspection of code shows that all parameters are read in consistently with the format of file drifts.dat. Further, proper precautions against read in errors, respectively errors in the file format, are included.

A few tests were carried out by modifying the content of drifts.dat.

5.1.1 The Title was omitted in drifts.dat

Executed a sample run. Compared output of infilper.res and nearfld.res (renamed as tpa40infilper511.dat and tpa40nearfld511.dat and saved in default location) to equivalent output for Test case 4. Outputs were identical.

5.1.2 The order of Emplacement Blocks was modified

At first, the first Emplacement number was labeled ‘0' instead of ‘1'. The code executed and outputs of infilper.res and nearfld.res were not affected.

5.1.3 The file drifts.dat appears to be generated in a different location of the code

Upon inspection, it is noted that the modified entry in drifts.dat was not read in the code.
The file drifts.dat is removed before execution of tpa.e. Execution is not affected by this.
Tests in 5.1 are obsolete, as drifts.dat is generated in the appropriate format during each run.

5.1.4 Conclusion

Could not detect any possible source of error coming from this change in the code.

5.2 Modifications on lines 605 to 622

Note: The call to gsaxym on line 601 lists xysa(1). This may result in compilation problems with some compilers.

These lines of code compute which drift is closest to the centroid and then which point of that closest drift should be representative of the entire subarea. Code appears reasonable.

5.3 Modifications on lines 630 to 638

For each drift, the half length and center coordinates are computed. Code appears reasonable.

5.4 Modifications on lines 790 to 802

Some intermediate variables are computed here, which are used to compute the time dependent temperatures of the Wps and the SF. Code appears reasonable. Changes with respect to version 3.3 include more detailed differentiation between before and after backfill time.

5.5 Modifications on lines 1156 to 1162

Height of isotherm is now computed. New code appears reasonable.

5.6 Modifications on lines 1441 to 1469 and 1763 to 1789

These are identical changes (new lines of code) included in reflux2 and reflux 3, respectively. These changes effectively split the time stepping in two domains. The first one ranges from initial time until 10000 years (currently hard coded number). During this period, the code executes identical to version 3.3. The second domain includes all (if any) simulation times greater than 10000 years. Some computation is skipped for that period, and the time dependent flux parameter qm3peryrinsaatrep is set equal to the influx rate qm3peryrinsa in reflux2.f, respectively in reflux3.f.. This assumes that all water that infiltrates per WP also hits or enters the WP.

[Stefan Mayer, 10 March 2000]

6. Compare flow rate outputs for versions 3.3 and 4.0beta

12 possible test cases are considered, based on 2x3x2 possible combinations of running a) 10000yr or 50000yr simulations, b) using the reflux1, reflux2 or reflux3 model, and c) comparing results from code version 3.3 to 4.0beta.
For the present testing purposes, this can readily be reduced to 6 test cases, since the time steps up to 10000 years are included in the 50000 year simulations.

The test cases 3 and 4 described in section 3. above describe the 4 combinations for a 50000 yr time period. However, not all detailed output of simulated flow rates were stored. Therefore, the simulations are repeated now.

NOTE1: The TPA code underwent substantial changes since version 3.3. Comparing results between the two versions is therefore not easy, as possible differences may originate in a number of sources. In particular, preliminary checks showed that the average flow infiltration as computed in uzflow.f changes between version 3.3 and 4.0.

The best possible comparison can be obtained if the main input files tpa.inp are as similar as possible for each version. The required data in tpa.inp have also been modified, mainly through new additions, and in a few cases by replacing old parameter entries by a set of new entries. Except for those cases where the changes require the paramtere file to have additional input, the files are kept identical for the comparison simulations. The only pure parameter value change that was noted is the reduction of the drift diameter from 5.0 m to 5.5 m.NOTE2: The tpa.inp files containing the major input and the output files nfenv.ech, nfenv.rlt, infilper.res, nearfld.res are saved and stored on vulcan in /home/smayer/TPA40test/Testresults/Testflowrates.

6.1 Compare 4.0 version flow rate outputs for the different reflux models over 50000 years

6.1.1 Model Reflux1

MaximumTime=50000 years
DurationOfCompliancePeriod=10000 years
maxntime = 401
NumberOfTimeStepsInCompliancePeriod = 201
NumberOfTimeStepsAfterCompliancePeriod = 200
SelectRefluxModel = 1

6.1.2 Model Reflux2

MaximumTime=50000 years
DurationOfCompliancePeriod=10000 years
maxntime = 401
NumberOfTimeStepsInCompliancePeriod = 201
NumberOfTimeStepsAfterCompliancePeriod = 200
SelectRefluxModel = 2

6.1.3 Model Reflux3

MaximumTime=50000 years
DurationOfCompliancePeriod=10000 years
maxntime = 401
NumberOfTimeStepsInCompliancePeriod = 201
NumberOfTimeStepsAfterCompliancePeriod = 200
SelectRefluxModel = 3

6.1.3 Comparison

Comparisons between test cases are performed with the help of the merge utility of Workshop, a SUN performance analysis tools. Files are not modified using this tool, but any content differences are highlighted and easy to spot on parallel displays.

The computed flow rate distributions per WP infiltrating through the vadose zone are identical for all three simulations. Direct comparisons of all three input echo files (stored in tpa40nfenvech61x.dat) reveal no differences.Direct comparisons of the detailed output files (stored in tpa40nfenvrlt61x.dat) show that for time periods up to 10000 years, the computed flow rates that hit each WP depend on the reflux model used. They are identical for all three models beyond 10000 years.

Further, direct comparisons of the summary output files infilper.res (stored in tpa40infilper61x.res) show that the average reflux is computed equal to the average infiltration per year for times greater then 10000 years. This is consistent with the assumption underlying the major changes in nfenv.f, which stopped detailed calculation of the reflux rates for times greater than 10000 years, and set this reflux rate equal to the infiltration rate.

The question remains whether this assumption is reasonable.

Inspection of the time period before 10000 years reveals that for all three cases, the reflux rate asymptotically approaches the infiltration rate for times prior to 10000 years. This suggests that the assumption is reasonable.

However, a more precise evaluation of this core assumption is desired. For this purpose, the source code is slightly modified.

6.2 Generate a comparison case: set refluxend to 50000 years

The source code nfenv.f version 4.0beta is modified to give a comparison case (copy of modified source file in tpa40nfenv62.f). Simply, the value of refluxend was changed to 5.0E04 (from 1.0E04) on lines 1451 and 1776 in this now modified version. This will set the detailed computation time for the reflux flow rates to 5.0E04. This will also effectively annul the code changes included in version 4.0beta.
A comparison of the now computed reflux flow rates with the assigned rates beyond year 10000 as obtained in 6.1.1, 6.1.2, and 6.1.3 will show if the assumption (setting reflux rate equal to infiltration rate) is reasonable.

6.2.1 Model Reflux1

This setting of tpa.inp was rerun. Results were identical with those of 6.1.1. This was to be expected, as the change in nfenv.f did not influence this subroutine.

6.2.2 Model Reflux2

Rerunning the test case of 6.1.2, but with refluxend = 50000 years, and comparing the outputs of nfenv.rlt (stored in tpa40nfenvrlt612.dat and tpa40nfenvrlt622.dat) shows that the assumption is appropriate. Differences in computed flow rates, if any, are negligible (on the order or less than 1/10th of a percent). Same is observed for the summary outputs in infilper.res.

6.2.3 Model Reflux3

Rerunning the test case of 6.1.3, but with refluxend = 50000 years, and comparing the output of infilper.res (stored in tpa40infilper613.res and tpa40infilper623.res) shows that the assumption is reasonable. Differences in the computed flow rate values, if any, are on the order of a 1/10th of a percent. Same is true for outputs in nfenv.rlt.

6.2.4 Conclusions

The test cases described in 6.1 and 6.2 provide evidence that the modifications regarding flow rate computations performed for reflux2 and reflux3 are reasonable and appropriate. Even if computed separately (as was done in the test cases in 6.2), the flow rates are nearly identical to the infiltration rates for times greater than 10000.

6.3 Comparison to version 3.3 results

Comparable results to test cases 6.1.2 and 6.1.3 were generated previously for version 3.3 (test case 4 and repeat test case 2 of section 3., respectively). The outputs of infilper.res (tpa33infilper612.res and tpa33infilper613.res) are compared to the ones obtained in 6.1.2 and 6.1.3. Qualitatively, the infiltration and reflux flow rates have a similar relation to each other as computed for both versions of the code. Due to different input results from uzflow, no detailed quantitative comparison can be made between versions.

6.4 CPU use of different codes

A direct comparison of the execution times between test cases in 6.1 and 6.2 (using the prof utility of the workstation) shows that assigning the flow rates for times greater than 10000 years offers a significant improvement in performance of the code. The main gain in performance is through the reduced number of calls to functions from within reflux2, respectively reflux3. Mainly, the function ainterl which is in array.f has reduced execution time by a factor of 5 .3 (case reflux3), respectively 5.8 (case reflux2), when flow rates are assigned (test cases in 6.1) rather then computed (test cases in 6.2) beyond 10000 years.

Overall, the execution time could be reduced from 25 seconds to 20 seconds CPU time for an entire sample run.
[Stefan Mayer, March 13, 2000]

7 Conclusions

In summary, the code changes appear consistent and reasonable. Line by line inspection described all changes with respect to version 3.3 in detail. Coding and logic are appropriate. Assumptions underlying the changes in reflux2 and reflux3 are reasonable and were tested against a comparison test case. The overall distribution of infiltrating and reflux flow rates is similar as obtained for versions 3.3 and 4.0beta. Reflux flow rates in version 4.0beta do converge or are identical to infiltration rates.
Overall, changes passed test, are consistent and achieved improvement in code performance.
[Stefan Mayer, March 13, 2000]

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-306	**Software Title and Version:** TPA 4.0beta	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

exec.f

TPA code aborts with 'file not found' error for ebsflo.dat for runs using the DirectReleaseOnly flag.

Change Requested by: J. Weldy Date: 2-18-00	**Change Authorized by** (*Software Developer*): R. Janetzke Date: 2-26-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

An 'if'' block was introduced in the section that writes infilper.res to inhibit accessing the ebsflo.dat file for DirectReleaseOnly runs.

Implemented by: R. Janaetzke	**Date:** 2-26-00

Description of Acceptance Tests:

The TPA code was run with the Direct Release Only flag set to 1 (on). The screen output and the file rg55a.tpa were examined to ensure that the code completed execution without error. The input (tpa.inp), output (rg55a.tpa), and screen output will be submitted to the TPA code custodian on floppy disk in a directory \test1\.

Results: The code ran without error. The bug has been fixed.

Tested by: James R. Weldy	**Date:** 3-27-00

James Weldy

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-307

Software Title and Version: TPA 4.0beta

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):

uzflow.f

uzflow.f gets and out-of-bound error when the sampled AreaIAverageMeanAnnualInfiltrationAtStart value is 1.3.

Change Requested by:
S. Stothoff
Date: 2-18-00

Change Authorized by (*Software Developer*):
R. Janetzke R Janetzke
Date: 2-26-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

The constant fudge_min was changed from -0.65 to -1.65.

Implemented by:
R. Janetzke R Janetzke

Date:
2-28-00

Description of Acceptance Tests:

See test plan related to SCR # 307

Tested by: S. Mayer
S. Mayer

Date: 3/17/00

CNWRA Form TOP-5 (01/99)

TPA Test Plan - SCR # 307

Test name: TPA4.0beta - uzflow.f software change test (refer to SCR #307)

Anticipated start date: 03-15-00

Anticipated completion date: 03-15-00

Amount of your time available to perform this test: 100%

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): 0/100
[*Process level testing tests the subroutine in standalone mode outside of the TPA code, usually with the aid of a special purpose driver of trivial construction. System level testing tests the subroutine in a fully integrated environment with the TPA code.*]

Output files to be checked: None

Input files to be checked for proper data transfer to the program: tpa.inp

Disposition of documentation (storage medium, physical location, and access method):
[*Documentation should include test driver source code, and input, intermediate and output files. Also include any plot files or plot hard copies that are used to display the results.*]
Test work performed on vulcan
Results attached as hard copy

Test change by inspection:
Verify that stated change was performed as stated in SCR #307.

Test stated motivation for change:
Check that stated error occurs, and has been fixed, based on comparison of pre-change and post-change code execution (see SCR #307). Write intermediate variables to file if necessary for documentation.

Test influence of change on code:
Track the influence of change on affected variables and overall code performance.

Final Checklist (completed during testing):
- Did the modification substantially change the results?
- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?
- Which nuclides were monitored to determine reasonableness of results in term of dose?

TPA Test Results - SCR # 307

The test is very brief and documentation is provided herein.

Test change by inspection:

By inspection, it is confirmed that the value of fudge_min was modified from -0.65 to -1.65 in line 1488 of uzflow.f. PASSED

Test stated motivation for change:

The parameter fudge_min on line 1487 in uzflow.f was reset to its pre-change value of -0.65. The parameter ArealAverageMeanAnnualInfiltrationAtStart on line 399 in tpa.inp was set to 1.3, and preceded by a “constant” statement in the line above. The code TPA version 4.0betaF was executed and produced an error and abort in module uzflow.

Resetting fudge_min to its corrected value of -1.65 allowed the code to execute without error. Alternatively, replacing “constant” by “uniform” in tpa.inp on line 398 also allowed for correct execution. PASSED

Test influence of change on code:

The ArealAverageMeanAnnualInfiltrationAtStart value on line 399 in tpa.inp was kept at 1.3, and preceded by a “uniform” statement on line 398.

The code was executed twice, first with fudge_min set to -0.65 in uzflow.f, second with the same value set to -1.65. Recompiling tpa was necessary for the change to take effect in the executable tpa.e.

The outputs of infilper.res and uzflow.rlt were compared to each other for both cases. The outputs were identical, suggesting that the change in parameter value has no influence on computed data of interest. PASSED

Did the modification substantially change the results?

No

Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?

No

Which nuclides were monitored to determine reasonableness of results in term of dose?

None

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SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-308

Software Title and Version: TPA 4.0beta

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):

ebsrel.f

Lahey gives a warning message of wrong argument type for the DMAX1 function.

Change Requested by:
R. Janetzke
Date: 2-28-00

Change Authorized by (*Software Developer*):
R. Janetzke Ron Janetzke
Date: 2-28-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

The constants for the DMAX1 function when finding the avgflux were changed to double precision.

Implemented by:
R. Janaetzke Ron Janetzke

Date:
2-28-00

Description of Acceptance Tests:

See attached Test Plan and Results.

Passed Acceptance Tests.

Tested by: S. Mayer
S. Mayer

Date: 3/15/2000

CNWRA Form TOP-5 (01/99)

TPA Test Plan - SCR # 308

Test name: TPA4.0beta - ebsrel.f software change test (refer to SCR #308)

Anticipated start date: 03-15-00

Anticipated completion date: 03-15-00

Amount of your time available to perform this test: 100%

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): 0/100

[Process level testing tests the subroutine in standalone mode outside of the TPA code, usually with the aid of a special purpose driver of trivial construction. System level testing tests the subroutine in a fully integrated environment with the TPA code.]

Output files to be checked: None

Input files to be checked for proper data transfer to the program: None

Disposition of documentation (storage medium, physical location, and access method):
[Documentation should include test driver source code, and input, intermediate and output files. Also include any plot files or plot hard copies that are used to display the results.]

Test work performed on vulcan
Results attached as hard copy

Test change by inspection:

Verify that stated change was performed as stated in SCR #308.

Test influence of change on code:

Track the influence of change on affected variables and overall code performance. Compare immediate parameter values before and after change.

Final Checklist (completed during testing):

- Did the modification substantially change the results?
- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?
- Which nuclides were monitored to determine reasonableness of results in term of dose?

TPA Test Results - SCR # 308

Tests were performed on vulcan and all code and testing utilities (if any) were stored on that machine.
The version of the TPA 4.0beta code tested here was obtained from /home/janetzke/tpa40betaF.
Where needed, comparisons were made to the version TPA 4.0beta obtained from /home/janetzke/tpa40beta (version just prior to changes tested here) and to version TPA 3.3 obtained from /home/janetzke/tpa33.
Change is minor and all documentation is written here.

Test change by inspection:
A minor change was performed on line 1072 of ebsrel.f. The constant values were changed from single to double prescision. This is consistent withSCR#308 report. PASSED

Test stated motivation for change:
The motivation could not be checked, as it is compiler dependent (Lahey warning message). It is assumed appropriate, since the change has no adverse influence. ACCEPTED

Test influence of change on code:
The only parameter value affected by the change is avgflux on line 1072. Print statements were inserted to compare the values of this parameter for both code versions (before and after the change). The values are identical. PASSED

Did the modification substantially change the results?
No

Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?
No

Which nuclides were monitored to determine reasonableness of results in term of dose?
None

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-309	**Software Title and Version:** TPA 4.0beta	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s):

nfenv.f, tpa.inp

There is an inconsistency in the tpa.inp file and nfenv.f that use two different parameters to specify the same physical quantity.

Change Requested by: S. Mohanty Date: 2-24-00	**Change Authorized by** (*Software Developer*): R. Janetzke Ron Janetzke Date: 2-28-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

All references to WPUnitCellWidth[m] were changed to EmplacementDriftSpacing[m] in nfenv.f. WPUnitCellWidth[m] was removed from tpa.inp.

Implemented by: R. Janaetzke Ron Janetzke	**Date:** 3-1-00

Description of Acceptance Tests:

See attached Test Plan and Results.

Passed acceptance Tests.

Tested by: S. Mayer S. Mayer	**Date:** 3/15/00

CNWRA Form TOP-5 (01/99)

TPA Test Plan - SCR # 309

Test name: TPA4.0beta - nfenv.f software change test (refer to SCR #309)

Anticipated start date: 03-15-00

Anticipated completion date: 03-15-00

Amount of your time available to perform this test: 100%

Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): 0/100
[*Process level testing tests the subroutine in standalone mode outside of the TPA code, usually with the aid of a special purpose driver of trivial construction. System level testing tests the subroutine in a fully integrated environment with the TPA code.*]

Output files to be checked: None

Input files to be checked for proper data transfer to the program: tpa.inp

Disposition of documentation (storage medium, physical location, and access method):
[*Documentation should include test driver source code, and input, intermediate and output files. Also include any plot files or plot hard copies that are used to display the results.*]
Test work performed on vulcan
Results attached as hard copy

Test change by inspection:
Verify that stated change was performed as stated in SCR #309.

Test stated motivation for change:
Check that stated error occurs, and has been fixed, based on comparison of pre-change and post-change code execution (see SCR #309). Write intermediate variables to file if necessary for documentation.

Test influence of change on code:
Track the influence of change on affected variables and overall code performance.

Final Checklist (completed during testing):
- Did the modification substantially change the results?
- Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?
- Which nuclides were monitored to determine reasonableness of results in term of dose?

TPA Test Results - SCR # 309

Tests were performed on vulcan and all code and testing utilities (if any) were stored on that machine.
The version of the TPA 4.0beta code tested here was obtained from /home/janetzke/tpa40betaF.
Where needed, comparisons were made to the version TPA 4.0beta obtained from /home/janetzke/tpa40beta (version just prior to changes tested here) and to version TPA 3.3 obtained from /home/janetzke/tpa33.
Change is minor and all documentation is written here.

Test change by Inspection:

Before the change, the value of WPUnitCellWidth was read in from tpa.inp to nfenv.f as iwpcellwidth, type transformed and passed on to subroutine reflux3 as parameter wpcellwidth. The value of EmpladementDriftSpacing was read in as idriftspacing, type transformed, and not used.

After the change, value EmplacementDriftSpacing is read in from tpa.inp to nfenv.f, type transformed and renamed and passed on to subroutine reflux3 as parameter wpcellwidth. The read in command for WPUnitCellWidth is commented out.

This is consistent withSCR#309 report. PASSED

Test stated motivation for change:

Only one of the two parameter values was used originally. It is appropriate to discard the other. PASSED

Test Influence of change on code:

Before and after the change, the only parameter value used for further computation is wpcellwidth. A print statement is inserted after the value of wpcellwidth is assigned. It is observed that this value was modified during the code change. The value WPUnitCellWidth in tpa.inp for version TPA 4.0beta was 22.5 [m]. The value EmplacementDriftSpacing in tpa.inp for version TPA 4.0betaF is 81.0 [m]. The computed reflux rates stored in output infilper.res are different for both versions.

This test however is only concerned with changes due to code changes, not input value changes. The decision of which cell width to use was done separately and reflects a changed design. The simulation is repeated for the old version by changing the value of WPUnitCellWidth to 81.0 [m]. Now old and new version outputs to infilper.res are identical. Thus for comparable input, the results are identical and the computed values of the code are not modified. PASSED

Note: A second influence on code overall is that now the value idriftspacing is read in, type transformed, and assigned to parameter wpcellwidth. This idriftspacing is in common block nfenv14. The previsouly read in parameter iwpcellwidth was not stored in a common block. This does not influence the code results right now and is not considered a concern. However, this should be considered for future code developments.

Did the modification substantially change the results?
No

Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?
No

Which nuclides were monitored to determine reasonableness of results in term of dose?
None

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-310	**Software Title and Version:** TPA 4.0beta	**/Project No:** 20-1402-762

Affected Software Module(s), Description of Problem(s): The following modules/files of TPA 4.0beta were modified to make three code changes related to incorporating GENII v.1.485 into TPA 4.0: *exec.f*, *ebsrel.f*, *ebsfail.f*, *dcagw.f*, *ashplumo.f*, *uzft.f*, *tpanames.dbs*, and *tpa.inp*.

Change I: The DCAGW module of TPA 4.0beta does not account for age-dependent inhalation rates when creating the age-specific DCF files (*gw_cb_ad.dat*, *gw_cb_ci.dat*, *gw_pb_ad.dat*, and *gw_pb_ci.dat*). Correcting this problem will allow TPA 4.0 users to properly account for age-dependent inhalation rates when DCAGW module creates age-dependent DCF files.

Change II: TPA 4.0beta does not create an append file for *gw_cb_ad.dat* and *gw_pb_ad.dat*. This was not needed previously, since these files were fixed in TPA 3.3. Correcting this problem will aid debugging efforts during testing and permits more detailed health-physics related sensitivity analysis.

Change III: Update header information in *gw_cb_ad.dat*, *gw_cb_ci.dat*, *gw_pb_ad.dat*, and *gw_pb_ci.dat*, to come in line with current methodology.

Change Requested by: P. LaPlante, M. Smith Date: 2-25-00	**Change Authorized by** (*Software Developer*): R. Janetzke Date:

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

Change I: This code change was made by adding 6 age-specific inhalation rate parameters to *tpa.inp* that are used to modify the GENTPA v1.0 input file *gdefault.inp* (RINH, Chronic breathing (cm3/sec)). These new parameters are called InhalationRate1[cm3/s], InhalationRate2[cm3/s], InhalationRate3[cm3/s], InhalationRate4[cm3/s], InhalationRate5[cm3/s], and InhalationRate6[cm3/s]. Stochastic sampling of these parameters is possible, but default values in *tpa.inp* will be set to the constant values listed in Table 11-1 of the TPA 4.0 user manual.

Change II: This code change was made by creating a new append file called *dcf.cum* that is created in dcagw.f. The routine appends the contents of *gw_cb_ad.dat* and *gw_pb_ad.dat* for each realization to *dcf.cum*.

Change III: This code change was made by modifying write statements in dcagw.f to update the header description for the *gw_cb_ad.dat*, *gw_cb_ci.dat*, *gw_pb_ud.dat*, and *gw_pb_ci.dat* files.

Implemented by: M. Smith	**Date:** 3-2-00

Description of Acceptance Tests:
See attached document

Tested by: Osvaldo Pensado	**Date:** 3/23/00

CNWRA Form TOP-5 (01/99)

Test Plan

Osvaldo Pensado 3/22/00

Test name: Test of changes described in PA-SCR-310 to the gentpa module.
Anticipated start date: 3/21/00
Anticipated completion date: 3/22/00
Amount of your time available to perform this test: 16 hr
Percent of testing time to be spent in process level testing and system level testing (e.g. 50/50): 20/80
Output files to be checked: genv.out, gmedia.out, gw_cb_ad.dat, gw_cb_ci.dat, gw_pb_ad.dat, gw_pb_ci.dat, dcf.cum
Input files to be checked for proper data transfer to the program: tpa.inp, gdefault.inp

Disposition of documentation (storage medium, physical location, and access method):
Electronic files are located in Vulcan, at
/home/opensado/tpa4/test310/
/home/opensado/tpa4/tpa4betaKRun/
Multiple *readme* files are included therein for the easy reading of the computations.

A floppy disk containing the relevant data in the above directories is attached, including also a copy of the scientific notebook documenting the test.

Summary of changes described in PA-SCR-310

Change I: Introduction of six inhalation rate parameters in tpa.inp [InhalationRate(1-6)]
    The value of this inhalation rate is mapped into gdefault.inp as the RINH parameter. The value selected is defined by the selection of the age group (ReceptorAgeGroup in tpa.inp).

Change II: Creation of a new append file dcf.cum containing the data in gw_cb_ad.dat and gw_pb_ad.dat

Change III: Update of the header in gw_cb_ad.dat, gw_cb_ci.dat, gw_pb_ad.dat, gw_pb_ci.dat

Functional Test Descriptions:

Process-level tests:

Run the stand alone codes envin.e and env.e to generate the output files genv.out and gmedia.out. The input file to these stand alone codes defined by the variables in tpa.inp is gdefault.inp. If gdefault.inp is the same for several runs, then these tpa runs must have the same genv.out and gmedia.out files.

System-level tests:

Track the mapping of each of the six InhalationRate parameters defined in tpa.inp into gdefault.inp. Verify that the output files by the tpa code genv.out and gmedia.out coincide with the output files generated by the stand-alone codes envin.e and env.e.

Verify that data in dcf.cum indeed contain single realization data contained in gw_cb_ad.dat, gw_pb_ad.dat.

Verify that the new header in gw_cb_ad.dat, gw_cb_ci.dat, gw_pb_ad.dat, gw_pb_ci.dat does not affect the numerical data.

Reasonableness Test Description:

Comparable output files genv.out and gmedia.out must be produced by TPA 4 beta and TPA 4 beta K. The results cannot be identical since data files defining exposition pathways have been updated after the release of TPA 4 beta. The results must be comparable.

Similarly, data in gw_cb_ad.dat, gw_cb_ci.dat, gw_pb_ad.dat, gw_pb_ci.dat must be comparable.

Test Results

Osvaldo Pensado, 3/22/00

The three changes reported in PA-SCR-310 have been tested. The code tested is TPA 4.0 betaK. The new InhalationRate(1–6) are well mapped from tpa.inp into gdefault.inp. The output files genv.out and gmedia.out are influenced by the selection of this parameter. These files contain comparable data as those generated with TPA 4.0 beta. Differences are due to the update in the data files between beta and beta K versions. These differences have been addressed by Pat LaPlante and are reported elsewhere.

New headers have been added to the files gw_cb_ad.dat, gw_cb_ci.dat, gw_pb_ad.dat, gw_pb_ci.dat. The headers do not influence the correctness of the data. The data in these files is comparable to the data in these files generated with TPA 4.0 beta. Differences are due to the update in the data files between beta and beta K versions. These differences have been addressed by Pat LaPlante and are reported elsewhere.

Data are appropriately appended to dcf.cum. Single realization data were compared to data in this file with a 100 % agreement, thus indicating that the data in dcf.cum is adequate. The validity of these data rely on the validity of the data in gw_cb_ad.dat and gw_pb_ad.dat.

In summary, the changes reported in PA-SCR-310 are well implemented.

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-311

Software Title and Version: TPA 4.0beta

/Project No: 20-1402-762

Affected Software Module(s), Description of Problem(s):

exec.f

Exhumed WPs are hardwired to subarea 2 and ignore the user's selection in the tpa.inp file.

Change Requested by:
J. Weldy
Date: 3-7-00

Change Authorized by (*Software Developer*):
R. Janetzke
Date: 3-7-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*):

Exec.f was modified to honor the user's selection of volcanic model in tpa.inp. Exhymed WPs now appear in the subarea specified by the user.

Implemented by:
R. Janaetzke

Date:
3-9-00

Description of Acceptance Tests:
See attached

Tested by:
Michael Muller

Date:
Mar 28, 2000

CNWRA Form TOP-5 (01/99)

TPA Version 4.0beta Test Plan for PA-SCR-311 Mar. 27, 2000

Task Description: Ejected Wps are improperly counted and displayed as belonging to subarea 2.

Analyst: Michael Muller

Controlled Version: TPA Version 4.0beta, Feb 15, 2000.
vulcan:/home/janetzke/tpa40beta.

TPA4.0versionO: directory: vulcan:/net/scratchy1/export/home/janetzke/tpa/dev

Tests:

Run Beta and O with
VolcanismDisruptiveScenarioFlag(yes=1,no=0) = 1
VolcanoModel(1=Geometric,2=Distribution) = 2
SubareaOfVolcanicEvent[] = 1,2, and 8 **(CASE 1,2,3)**

Results:

Version Beta:

Ejected WPs are only shown for subarea 2 for all cases. wpsfail.res correct. ebsrel.inp incorrect.

Version O:

Ejected WPs are shown in selected subarea for each case. wpsfail.res correct. ebsrel.inp correct. **PASS** for all cases. See data outputs from screen_tpa.out, wpsfail.res, and ebsrel.inp below:

Version Beta:

screen_tpa.out exec: Welcome to TPA Version 4.0beta

tpa, SubareaOfVolcano[] = 1 **CASE 1**

```
---------------------------------------------------------------------
   subarea  1 of  8        realization   1 of   1
---------------------------------------------------------------------
exec: calling volcano
exec: failed WPs from INITIAL  event =    11 at time =    0.0 yr
exec: failed WPs from VOLCANIC  event =    77 at time =  6407.3 yr
 *** failed WPs:  88  out of  1394 ***
---------------------------------------------------------------------
   subarea  2 of  8        realization   1 of   1
```

```
------------------------------------------------------------------
exec: failed WPs from INITIAL   event =     12 at time =      0.0 yr
 *** failed WPs:  12  out of   1542 ***
 *** ejected WPs:   8
------------------------------------------------------------------
   subarea   8 of   8         realization   1 of   1
------------------------------------------------------------------
exec: failed WPs from INITIAL   event =      7 at time =      0.0 yr
 *** failed WPs:   7  out of   855 ***
```

tpa, SubareaOfVolcano[] = 2 **CASE 2**

```
------------------------------------------------------------------
   subarea   1 of   8         realization   1 of   1
------------------------------------------------------------------
exec: calling volcano
exec: failed WPs from INITIAL   event =     11 at time =      0.0 yr
 *** failed WPs:  11  out of   1394 ***
------------------------------------------------------------------
   subarea   2 of   8         realization   1 of   1
------------------------------------------------------------------
exec: failed WPs from INITIAL   event =     12 at time =      0.0 yr
exec: failed WPs from VOLCANIC  event =     77 at time =   6407.3 yr (includes ejected WPs)
 *** failed WPs:  89  out of   1542 ***
 *** ejected WPs:   8
------------------------------------------------------------------
   subarea   8 of   8         realization   1 of   1
------------------------------------------------------------------
exec: failed WPs from INITIAL   event =      7 at time =      0.0 yr
 *** failed WPs:   7  out of   855 ***
```

tpa, SubareaOfVolcano[] = 8 **CASE 3**

```
------------------------------------------------------------------
   subarea   1 of   8         realization   1 of   1
------------------------------------------------------------------
exec: calling volcano
exec: failed WPs from INITIAL   event =     11 at time =      0.0 yr
 *** failed WPs:  11  out of   1394 ***
------------------------------------------------------------------
   subarea   2 of   8         realization   1 of   1
------------------------------------------------------------------
exec: failed WPs from INITIAL   event =     12 at time =      0.0 yr
 *** failed WPs:  12  out of   1542 ***
 *** ejected WPs:   8
```

```
-------------------------------------------------------------------
   subarea   8 of   8         realization    1 of    1
-------------------------------------------------------------------
 exec: failed WPs from INITIAL   event =      7 at time =      0.0 yr
 exec: failed WPs from VOLCANIC  event =     77 at time =   6407.3 yr
  *** failed WPs:   84  out of   855 ***
```

wpsfail.res

```
 Number of Failed WPs by Type of Disruptive Event

 Including Time of Event - Values for Each Vector


   vector        time         #corrode       #seismic        #fault                    #igact
  unitless        yr          unitless       unitless       unitless                   unitless
       1       6.4073E+03    0.0000E+00    0.0000E+00    0.0000E+00   7.7000E+01
```

ebsrel.inp, subarea8 selected

```
 6.40726E+03 7.70000E+01        ! sftimev,isconv:  volcano fail time [yr] & WPs affected
~
```

Version O:

screen_tpa.out   exec: Welcome to TPA Version 4.0betaO

tpa, SubareaOfVolcano[] = 1 **CASE 1**

```
-------------------------------------------------------------------
   subarea   1 of   8         realization    1 of    1
-------------------------------------------------------------------
 exec: calling volcano
 exec: failed WPs from INITIAL   event =      9 at time =      0.0 yr
  *** failed WPs:   45  out of   1455 ***
  *** ejected WPs:   2
-------------------------------------------------------------------
   subarea   2 of   8         realization    1 of    1
-------------------------------------------------------------------
 exec: failed WPs from INITIAL   event =      9 at time =      0.0 yr
  *** failed WPs:   9  out of    1568 ***
-------------------------------------------------------------------
   subarea   8 of   8         realization    1 of    1
-------------------------------------------------------------------
```

```
exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
 *** failed WPs:  5  out of  814 ***
```

tpa, SubareaOfVolcano[] = 2 **CASE 2**

```
-------------------------------------------------------------------
   subarea   1 of   8          realization    1 of    1
-------------------------------------------------------------------
exec: calling volcano
exec: failed WPs from INITIAL   event =      9 at time =      0.0 yr
 *** failed WPs:  9  out of  1455 ***
-------------------------------------------------------------------
   subarea   2 of   8          realization    1 of    1
-------------------------------------------------------------------
exec: failed WPs from INITIAL   event =      9 at time =      0.0 yr
 *** failed WPs:  45  out of  1568 ***
 *** ejected WPs:  2
-------------------------------------------------------------------
   subarea   8 of   8          realization    1 of    1
-------------------------------------------------------------------
exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
 *** failed WPs:  5  out of  814 ***
```

tpa, SubareaOfVolcano[] = 8 **CASE 3**

```
-------------------------------------------------------------------
   subarea   1 of   8          realization    1 of    1
-------------------------------------------------------------------
exec: calling volcano
exec: failed WPs from INITIAL   event =      9 at time =      0.0 yr
 *** failed WPs:  9  out of  1455 ***
-------------------------------------------------------------------
   subarea   2 of   8          realization    1 of    1
-------------------------------------------------------------------
exec: failed WPs from INITIAL   event =      9 at time =      0.0 yr
 *** failed WPs:  9  out of  1568 ***
-------------------------------------------------------------------
   subarea   8 of   8          realization    1 of    1
-------------------------------------------------------------------
exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
 *** failed WPs:  41  out of  814 ***
 *** ejected WPs:  2
```

wpsfail.res

```
         Number of Failed WPs by Type of Disruptive Event

   Including Time of Event - Values for Each Vector


    vector       time      #corrode     #seismic      #fault              #igact
   unitless       yr       unitless     unitless     unitless            unitless
      1      3.6347E+03   0.0000E+00   0.0000E+00   0.0000E+00  3.6000E+01
~

ebsrel.inp, subarea8 selected

 3.63472E+03 3.40000E+01        ! sftimev,isconv:  volcano fail time [yr] & WPs affected
```

394/357

SOFTWARE CHANGE REPORT (SCR)

SCR No. (*Software Developer Assigns*): PA-SCR-313	**Software Title and Version:** TPA 4.0beta	**/Project No:** 20-1402-762

dcagw.f

Affected Software Module(s), Description of Problem(s): 1) DCAGW currently accounts fo pluvial conditions by making changes to the calculated DCFs, but does not account for the corresponding changes to the well pumping rate. 2) The switch to pluvial conditions occurs much too early, when the climate definition changes from semi-arid to arid (less than 5000 years), whereas the pluvial DCFs are based on the glacial maximum conditions which don't occur until about 40000 years. 3) The current implementation of the GENII code in DCAGW does not allow the user to modify the leach rates from the soil.

Change Requested by: J. Weldy Date: 2/4/00	**Change Authorized by** (*Software Developer*): R. Janetzke R Janetzke Date: 2-4-00

Description of Change(s) or Problem Resolution (*If changes not implemented, please justify*): 1) Implement a pluvial well pumping rate for the 20 km receptor group which is used at the same time that the pluvial DCFs are used. 2) Add a user input parameter to specify the time at which pluvial DCFs and pumping rates are used. 3) Add user input parameters of Kds and soil properties so that the leach rate can be calculated from these parameters and the precipitation rate, irrigation rate, and evapotranspiration rate.

Implemented by: J. Weldy James R. Weldy	**Date:** 2/4/00

Description of Acceptance Tests:

1. Set the time to switch to pluvial DCFs at a time beyond the calculation time to ensure that th same results are achieved as before the change was implemented.
2. Use a very small pluvial dilution volume and ensure that the dose becomes significantly larger in the year that the switch to pluvial conditions occurs, and then drops back down when the return to current conditions occurs.
3. Use the default data and confirm there are no significant changes between the files gftrans.de and gftrans.inp. Note that there is a factor of two difference between the leach factors for Cl-36 due to differences in sources of data between the old calculation and the new calculation.
4. Change the Kds in Soil for all of the RNs in the tpa.inp file. Ensure that they are all different in the gftrans.inp file.

Tested by: MICHAEL A. SMITH	**Date:** 3-27-00

CNWRA Form TOP-5 (01/99)

Attachment 1 PA-SCR-313 TPA Test Plan

Pluvial Test 1: Set the time to switch to pluvial DCFs at a time beyond the calculation time to ensure that the same results are achieved as before the change was implemented.
Anticipated start date: 3/15/00
Anticipated completion date: 3/24/00
Amount of your time available to perform this test: 2 h
Percent of your time to be spent in process level testing and system level testing: 0/100
Output files to be checked: rgwsr.tpa
Input files to be checked for proper data transfer to the program: tpa.inp
Disposition of documentation (storage medium, physical location, and access method): 250 Mb zip disk #mas1, stored with scientific notebook # 377, with files stored in /testtpa40beta/testpluvial/test1.
Functional Test Descriptions:

-**Hand Calculations:** postprocessing in rgwsr_test1.xls

-**Process-level tests:** none

-**System-level tests:** Compared rgwsr.tpa results from TPA 4.0betaf and TPA 4.0beta to determine if the addition of the PluvialTimeSwitch parameter affects results when not invoked. The PluvialTimeSwitch was set at 13,000 yr for a 10,000 yr run in TPA 4.0betaf and results were compared with results from a 10,000 yr run in TPA 4.0beta.
Reasonableness Test Description: none
Final Checklist (completed during testing):

-**Did the modification substantially change the results?** No

-**Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?** Yes

-**Which nuclides were monitored to determine reasonableness of results in terms of dose?** Summed dose from all radionuclides (rgwsr.tpa).

Pluvial Test 2: Use a very small pluvial dilution volume and ensure that the dose becomes significantly larger in the year that the switch to pluvial conditions occurs, and then drops back down when the return to current conditions occurs.
Anticipated start date: 3/15/00
Anticipated completion date: 3/24/00
Amount of your time available to perform this test: 2 h
Percent of your time to be spent in process level testing and system level testing: 0/100
Output files to be checked: rgwsr.tpa
Input files to be checked for proper data transfer to the program: tpa.inp
Disposition of documentation (storage medium, physical location, and access method): 250 Mb zip disk #mas1, stored with scientific notebook # 377, with files stored in /testtpa40beta/testpluvial/test2.
Functional Test Descriptions:

-**Hand Calculations:** postprocessing in rgwsr_test2.xls

-**Process-level tests:** none

-**System-level tests:** Set PluvialPumpingRateAtReceptorGroup20km to a very low value (6.215) so that when the model switched to pluvial conditions the dilution rate would decrease by about 10^6 times that of the default value (6.215e6). Decreasing dilution volume acts to increase dose, so it would be clearly evident by viewing the TPA 4.0betaf output exactly when the switch to pluvial conditions occurred. The PluvialSwitchTime was set to 40,000 yr.

Reasonableness Test Description: none

Final Checklist (completed during testing):

- **Did the modification substantially change the results?** No
- **Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?** No, this function is not available in TPA 3.3.
- **Which nuclides were monitored to determine reasonableness of results in terms of dose?** Summed dose from all radionuclides (rgwsr.tpa).

__Pluvial Test 3:__ Use the default data and confirm there are no significant changes between the files gftrans.def and gftrans.inp. Note that there is a factor of two difference between the leach factors for ^{36}Cl due to differences in sources of data between the old calculation and the new calculation.

Anticipated start date: 3/15/00

Anticipated completion date: 3/24/00

Amount of your time available to perform this test: 2 h

Percent of your time to be spent in process level testing and system level testing: 0/100

Output files to be checked: gftrans.inp

Input files to be checked for proper data transfer to the program: gftrans.def

Disposition of documentation (storage medium, physical location, and access method): 250 Mb zip disk #mas1, stored with scientific notebook # 377, with files stored in /testtpa40beta/testpluvial/test3.

Functional Test Descriptions:

- **Hand Calculations:** postprocessing in gftrans_test3.xls
- **Process-level tests:** none
- **System-level tests:** Run TPA 4.0betaf and compare gftrans.def and gftrans.inp for significant changes. All leaching factor values changed < 10%, except for Cl (~90%), which was expected to have a greater change due to a new calculation methodology.

Reasonableness Test Description: none

Final Checklist (completed during testing):

- **Did the modification substantially change the results?** No
- **Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?** Yes
- **Which nuclides were monitored to determine reasonableness of results in terms of dose?** All radionuclides reported in gftrans.inp.

__Pluvial Test 4:__ Change the Kds in soil for all of the radionuclides in the tpa.inp file. Ensure that they are all different in the gftrans.inp file.

Anticipated start date: 3/15/00

Anticipated completion date: 3/24/00

Amount of your time available to perform this test: 2 h

Percent of your time to be spent in process level testing and system level testing: 0/100

Output files to be checked: gftrans.inp
Input files to be checked for proper data transfer to the program: gftrans.def
Disposition of documentation (storage medium, physical location, and access method): 250 Mb zip disk #mas1, stored with scientific notebook # 377, with files stored in /testtpa40beta/testpluvial/test4.
Functional Test Descriptions:

- **Hand Calculations:** postprocessing in gftrans_test4.xls
- **Process-level tests:** none
- **System-level tests:** Change all KD_Soil_... parameter values in tpa.inp and determine if these changes are noted in gftrans.inp.

Reasonableness Test Description: none
Final Checklist (completed during testing):

- **Did the modification substantially change the results?** No
- **Were TPA 3.3 and TPA 4.0beta compared using corresponding mean values in tpa.inp?** No, this function is not available in TPA 3.3.
- **Which nuclides were monitored to determine reasonableness of results in terms of dose?** All radionuclides reported in gftrans.inp.