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PWR Source Term Generation and Evaluation

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7. Document Status Designation

☒ Preliminary ☐ Final ☐ Cancelled

8. Notes/Comments

Rev.00A:

- *This document supersedes MOL.20000113.0333, which has DI# BBAC00000-01717-0210-00010, Revision 1. This revision expanded the burnup range of the PWR SNF to include 80 and 85 GWd/MTU and removed the TBV-4111.*
- *The "*.cut" files of the last revision were combined with the "*.cut" files of this calculation and stored in 5 compact disks as Attachment X. The "*.source" files generated with the DATAWRITER program are excluded in the compact disks.*

Rev.00B:

- *This revision changed the burnup value for the maximum PWR assembly from 75 to 80 GWd/MTU. Also, the "Acronyms and Abbreviation" section and Attachment XI were added, while Sections 1 and 2 (Purpose and Method) were expanded.*
- *No new computer runs were performed for this revision. The "*.cut" files of the last revision were used throughout this revision and stored in 4 compact disks as Attachment X.*
- *Added pages. The following pages from the new revision were added: 4, 30 to 32, VIII-1 to VIII-22, IX-1, IX-6 to IX-10, and XI-1.*
- *Deleted pages. The following pages from the old revision were deleted: 26 to 28, VIII-1 to VIII-18, IX-1, and IX-6 to IX-9*
- *Revised pages are identified with vertical change bars.*

Attachments	Total Number of Pages
I – Fuel Density and Composition Calculation	1
II– Burn History Calculation	2
III – Light Element Mass Calculation	12
IV – Comparison of Source Terms per MTU of 4 Average PWR Spent Fuel Assemblies	1
V – Listing of UNIX Script Files	1
VI – Calculation of Crud Source	4
VII – ^{36}Cl and ^{14}C Calculations	1
VIII – List of ".cut" Files on Compact Disks*	22
IX – Radionuclide Inventories for Performance Assessment (All Nuclides Included)	10
X – 4 Compact Disks	N/A
XI – Evolution in Time of Thermal Power and Total Radioactivity	1

RECORD OF REVISIONS

9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. QER (Print/Sign/Date)	16. Approved/Accepted (Print/Sign)	17. Date
00A	Initial Issue (see block 8)	79	IX-9	J. Tang	G. Radulescu	D. Tunney	M. Anderson	03/24/2003
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ACRONYMS AND ABBREVIATIONS

ANSI	American National Standards Institute
ASM	American Society for Metals
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
B&W	Babcock & Wilcox Company
BSC	Bechtel SAIC Company, LLC
CD	Compact Disc
CPU	Computer Processing Unit
CRWMS	Civilian Radioactive Waste Management System
DIRS	Document Input Reference System
DOE	U.S. Department of Energy
GW	Gigawatt
GWd	Gigawatt day
ID	Inner Diameter
IHML	Initial Heavy Metal Loading
MGR	Monitored Geologic Repository
MTHM	Metric Tons Heavy Metal
MTU	Metric Tons of Uranium
MW	Megawatt
MWd	Megawatt day
M&O	Management & Operating Contractor
NRC	U.S. Nuclear Regulatory Commission
NUREG	NUclear REGulatory (official publications of the NRC – NUREG series)
NA	Not Applicable
OD	Outer Diameter
ppm	parts per million
PWR	Pressurized Water Reactor
SF	Scaling Factor
SNF	Spent Nuclear Fuel
TBV	To Be Verified
wt%	weight percent

1. PURPOSE

This calculation is a revision of a previous calculation (BSC 2003 [DIRS 162471]) that bears the same title and has the Document Identifier 000-00C-MGR0-00100-000-00A. The purpose of this calculation is to revise the burnup value of the maximum pressurized water reactor (PWR) spent nuclear fuel (SNF) assembly to be consistent with *Licensing Position-009* (Williams 2003, Attachment, p. 1 [DIRS 166132]). No new computer runs were performed for this revision. The source terms for the maximum PWR assembly were taken from the results of computer runs performed for the previous revision - BSC 2003 [DIRS 162471].

The scope of work includes the following:

- Generate PWR SNF assembly source terms as a function of initial enrichment, burnup, and cooling time using an appropriate and defensible methodology.
- Provide the average and maximum PWR fuel assembly specifications.
- Calculate crud source term deposited on the surfaces of the assembly.

This calculation establishes PWR SNF assembly source terms. The results of this calculation are intended for use in evaluation of shielding requirement or other follow-on analysis. They may also be used as input for Preclosure Safety Analysis and Total System Performance Assessment analyses.

The results are provided on a per-assembly basis for the representative PWR fuel assembly used in this calculation. Limitation on the use of the results for other fuel assembly types should be evaluated on a case-by-case basis.

The source terms of the representative PWR SNF assembly are generated for the first one million years after the SNF is discharged from the reactors. These source terms provide data characterizing the neutron and gamma spectra in particles per second, the decay heat in watts, and radionuclide inventories in curies. Conservative source terms are generated for a wide range of burnups and enrichments (see Tables 8 and 12) that are representative of the waste stream, stainless steel (SS) clad, and South Texas PWR assemblies. The source term due to the activation of corrosion products deposited on the surfaces of the assembly from the coolant is also calculated.

The results of this calculation support many areas of the Monitored Geologic Repository (MGR), which include thermal evaluation, radiation dose determination, radiological safety analyses, surface and subsurface facility designs, preclosure safety analysis, and total system performance assessment. Therefore, it is subject to the requirements of the *Quality Assurance Requirements and Description* (DOE 2004 [DIRS 168669]). This includes MGR items classified as Safety Category, for example, the Commercial Waste Package (BSC 2003, p. A-3 [DIRS 165179]). Development, performance, and documentation of this calculation conform to the administrative procedure AP-3.12Q, *Design Calculation and Analyses* [DIRS 168413].

2. METHOD

The method used to evaluate the radioactive nuclides inventory and source terms at a specific time involves the simulation of the burnup and decay of fuel assemblies. For the previous revision of this calculation, the SAS2H/ORIGEN-S sequence of SCALE 4.3 computer code system was used to calculate the source terms for the selected fuel assemblies as function of assembly average burnup and cooling time. No new calculations were performed with SCALE 4.3 for this revision. Uncertainties and limitations in the computed source terms by the SAS2H/ORIGEN-S sequence are discussed in the SAS2H manual (CRWMS M&O 2000, Section S2.3 [DIRS 153872]) and in the NUREG/CR-5625 report (Hermann et al. 1994, Section 6.6.2 [DIRS 154045]).

For each time-dependent fuel composition, SAS2H performs 1D neutron transport analysis of the reactor fuel assembly using a two-part procedure with two separate lattice-models. Basically, the model represents the fuel by an infinite lattice of fuel pins (path-A model) and the cell-weighted cross sections produced with the path-A model are then applied to the fuel region of a larger unit-cell model (path B) used to represent a fuel assembly. The concept of using cell-weighted data in the 1D transport analysis of the path-B model is an approximate method for including the 2D assembly effects. The path-B model is used by SAS2H to calculate an "assembly-averaged" fuel-region flux spectrum that includes the effects of the path-A model and other components in the assembly (e.g., guide tubes, burnable poison rods, etc.). The cross sections derived from a transport analysis at each time step are used in a point-depletion computation via ORIGEN-S that produces the burnup-dependent fuel composition to be used in the next spectrum calculation. This sequence is repeated over many cycles over the power history).

Geometrically, SAS2H models the actual assembly by defining an equivalent cylindrical representation. Besides the geometric simplification, other approximations within SAS2H are:

- Axial uniformity,
- Densities within the fuel pin are considered uniform with space,
- A constant temperature is applied in each zone of the unit cell,
- A single fuel-pin unit-cell type is assumed for the entire assembly (i.e., all fuel pins are assumed to have the same enrichment), and
- Fuel loading is proportional to the fuel length.

The resulting source terms are extracted from the SAS2H output to create data files for future analyses.

Electronic management of information generated from this calculation is controlled in accordance with AP-3.13Q, *Design Control,* [DIRS 167460]. The computer input and output files generated from this calculation are stored on four compact disks (CDs), and submitted as an attachment to this document (Attachment X).

3. ASSUMPTIONS

3.1 It is assumed that various PWR assembly types can be approximated by a single assembly and the source terms generated will not be greatly affected by using this common geometry. This assumption results in the path A and B representations in SAS2H for unit cells of the South Texas and SS assemblies being identical to those of the Babcock & Wilcox (B&W) Mark B assembly used to represent the waste stream cases. Different initial heavy metal loadings (IHMLs) are accounted for by adjusting the fuel length, which is calculated from the IHML and the fuel density.

Rationale: A sensitivity study (BSC 2004, Section 6.4 [DIRS 167058]) determined that the selection of a particular assembly is not sensitive to the resulting source terms.

Usage: This assumption is used in the entire calculation.

3.2 It is assumed that the neutron activation factors for the assembly hardware regions (bottom end-fitting, plenum, and top end-fitting) are 1.5 time of the values recommended by the U.S. Nuclear Regulatory Commission (NRC) and provided in Luksic 1989, Table S.1 [DIRS 120506].

Rationale: This assumption provides 50% conservative margin for the neutron-activated sources in the hardware regions.

Usage: This assumption is used in Section 5.3.

3.3 It is assumed that the fuel rod length is 153.68 in. or 390.3472 cm (DOE 1988, p. 2A-33 [DIRS 100979]) and that the plenum region height is the difference between the fuel rod length and the fuel stack height (30.1752 cm = 390.3472 cm – 360.172 cm).

Rationale: Fuel rod data are proprietary information and. DOE 1988 [DIRS 100979] is the best available technical information.

Usage: This assumption is used in Section 5.

3.4 The hardware parts and materials of the B&W Mark B PWR assembly described in DOE 1988, p. 2A-32 and p. 2A-34 [DIRS 100979] are assumed.

Rationale: Fuel assembly data are proprietary information and the information in DOE 1988 [DIRS 100979] is the best available.

Usage: This assumption is used in Section 5.3.

3.5 It is assumed that the South Texas assembly will generate the bounding crud source term and that the physical characteristics of the South Texas assembly can be obtained from DOE 1988, p. 2A-361 and p. 2A-363 [DIRS 100979].

Rationale: Again, DOE 1988 [DIRS 100979] is the best available technical information on PWR fuel. The crud source is proportional to the surface area that is exposed to coolant; since the South Texas fuel assembly has larger surface area than the B&W Mark B assembly, it will generate a more conservative (higher) crud source that will serve as the bounding crud source for the representative PWR assembly.

Usage: This assumption is used in Section 5.3.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE APPROVED FOR QA WORK

The SAS2H/ORIGEN-S sequence of SCALE Version 4.3, modular code system (CRWMS M&O 1997, [DIRS 154059]) was used to perform source terms (decay thermal power, gamma spectrum, neutron spectrum) and radionuclide inventory calculations. The software specifications are as follows:

- Program Name: SCALE
- Version/Revision Number: 4.3 (Addendum) HP 9000 Version
- CSCI Number: 30011 V4.3 (Addendum) (CRWMS M&O 1997 [DIRS 154059])
- Computer Type: Hewlett Packard 9000 Series
- Status/Operating System: qualified[1]/HP-UX 10.20
- Computer Processing Unit Names and Civilian Radioactive Waste Management System (CRWMS) Management and Operating (M&O) Contractor Tag Number: 'Bloom,' CRWMS-M&O Tag 700887.

The SAS2H/ORIGEN-S sequence of SCALE Version 4.3 software was: (a) appropriate for source term calculations, (b) used only within the range of validation as documented in CRWMS M&O 1997. *Software Qualification Report for THE SCALE Modular Code System Version 4.3.* [DIRS 106016], and (c) obtained from Software Configuration Management in accordance with the appropriate procedure.

The "*.cut" files, which consist of the input echoes and the final ORIGEN-S outputs, are listed in Attachment VIII and their electronic versions are stored in Attachment X. The "*.cut" files are sufficient to independently repeat the calculation.

4.2 EXEMPT SOFTWARE

4.2.1 Excel

- Title: EXCEL
- Version/Revision Number: Microsoft® Excel 2000 SR-1
- This software is installed on a personal computers running Microsoft Windows 2000 with CPU Number 501661.

Standard functions of Microsoft Excel for Windows, Version 2000 SR-1, are used in this calculation to display results graphically or in tabular form and to perform simple calculations as documented in Section 5 of this calculation. The user-defined formulas, inputs, and results are documented in sufficient detail in Section 5 to allow an independent repetition of the various computations without recourse to the originator. Microsoft Excel is an exempt software product

[1] The modular code system SCALE Version 4.3 results were produced in prior revisions of this calculation. This software version has since been retired.

according to the procedure LP-SI.11Q-BSC, *Software Management*, Section 2.1.6 [DIRS 168412]. The Excel files are stored on CDs (Attachment X) and documented in Attachment VIII.

4.2.2 UNIX Script Files

- Titles: cut-script, neutrons, gammas, curies, watts
- Version/Revision Number: All are version 00
- Computer Type: Hewlett Packard 9000 Series

The UNIX script files are listed in Table 1. The "cut-script" file executes SAS2H and generates a "*.cut" file from the SAS2H output file. The other four files perform simple editorial tasks that extract lines of information from a single "*.cut" file. They are executed by typing the command "awk –f (script file) (input *.cut file name) > (output file name)". These files are intended for use only with the SAS2H/ORIGEN-S output files for the waste stream, SS clad, and South Texas assemblies stored in Attachment X. The output of the script files has been verified by visual inspection. The specific task of each script file is noted in Table 1. The script files are listed in Attachment V. This software is considered exempt from the requirements of LP-SI.11Q-BSC, *Software Management*, Section 2.1.2 [DIRS 168412].

Table 1. UNIX Script Files

File Name	Function
neutrons	Extracts the total (alpha-n plus spontaneous fission) neutron source table from a "*.cut" file
gammas	Extracts the gamma source from the light element, actinide, and fission product contributions from a "*.cut" file
watts	Extracts the total thermal output from the light element, actinide, and fission product contributions from a "*.cut" file
curies	Extracts the tables of nuclide curies from a "*.cut" file for the light element, actinide, and fission product contributions
cut-script	Generates "*.cut" file from each SAS2H output file

5. CALCULATION

5.1 REVISION HISTORY

The purpose of this revision is to update the burnup value for the maximum PWR SNF assembly to 80 GWd/MTU in conformance with the *Licensing Position-009* (Williams 2003, Attachment, p. 1 [DIRS 166132]). At the same time, based on the conclusion of BSC 2004 [DIRS 167058], the rationale of the Assumption 3.1 was modified since a sensitivity study (BSC 2004, Section 6.4 [DIRS 167058]) determined that the selection of a particular assembly is not sensitive to the resulting source terms. Also, an "Acronyms and Abbreviation" section and Attachment XI were added.

Several calculations have been performed to provide PWR SNF source terms for shielding calculations. CRWMS M&O 1997 [DIRS 136439] was the first in a series of calculations to provide source terms, but was limited to a South Texas assembly and a handful of burnups and enrichments that represented the anticipated average and maximum waste stream assemblies. In addition, the source terms represented only the first twenty-five years after discharge from the reactor. CRWMS M&O 1998 [DIRS 124815] built on this calculation to extend the source terms to 30,000 years. CRWMS M&O 1999 [DIRS 105912] extends the calculation done in CRWMS M&O 1998 [DIRS 124815] to include a wide range of burnups and enrichments, and the inclusion of a crud source. The sources were also provided out to 1 million years after discharge. CRWMS M&O 1999 [DIRS 136429] provides a complete set of conservative source terms for the SS clad, South Texas, and PWR assemblies in the expected waste stream. BSC 2003 [DIRS 162471] expands the source terms database of the representative PWR SNF in CRWMS M&O 1999 [DIRS 136429] to include burnups of 80 and 85 GWd/MTHM.

The following modifications are included in this revision:

- Figure 3, Table 14, Attachment VII and IX were updated to include the values calculated in the last revision (BSC 2003 [DIRS 162471]) for the PWR SNF assembly maximum burnup of 80 GWd/MTU. The cooling times selected to present the curies inventories correspond with those used in SAS2H calculations.
- The description of the design methodology was expanded in Section 2.
- "Acronyms and Abbreviations" section was added.
- Sections 1, 3, 5.1, 5.5, and 6 were modified.
- Attachment VIII was modified to reflect the current content of the CDs.

Since this revision retains all the results of BSC 2003 [DIRS 162471], the methodology and calculation method of the last revision and this revision are the same. The fuel densities for the PWR assemblies are kept constant, and the lengths of the assemblies are varied to reflect the heavy metal loading in the SAS2H calculations (see Section 5.4.2).

5.2 SELECTION OF CONSERVATIVE PARAMETERS

The inputs for this calculation are specifically chosen to lead to conservative source terms. This section discusses the main inputs and the reasons they are used. It covers several different

parameters. The first of these is the geometry for the South Texas, waste stream, and SS clad assemblies.

In this calculation, the geometry used to model the assemblies in SAS2H corresponds to a typical B&W Mark B PWR fuel assembly. The Mark B has a high IHML and a large amount of assembly hardware, supporting more fission product generation and hardware activation. Therefore, this assembly provides a conservative basis for the PWR waste stream. While a real Mark B assembly has an IHML of 464 kg, this is increased to 475 kg for the waste stream and the SS clad assemblies to provide slightly higher source intensities. The South Texas assembly calculations use a 550 kg IHML.

As mentioned in Section 5.1, additional heavy metal mass is accounted for by increasing the fuel length, rather than the fuel density. A longer active fuel length and a lower density rather than a shorter fuel length and a higher density decrease the fuel self-shielding. This results in a higher flux and consequently higher source intensities. In this calculation the higher IHML of the waste stream, SS clad, and South Texas assemblies is accounted for by the fuel length rather than the fuel density (see Section 5.4.2).

The fuel density also affects the source from the hardware regions of the assembly. The irradiation of the assembly hardware is calculated by inputting the desired amount of light element material into the fuel region in SAS2H. When the sources are calculated, only the light elements are included. For the South Texas assembly, since the same power is generated by a longer fuel rod than by the shorter Mark B, the result is a lower power density. This lower flux per unit height for the South Texas assembly provides a lower source for the hardware regions. For this reason, the South Texas assemblies use the hardware files for the waste stream (the SS assemblies also use waste stream files for the bottom and top assembly regions). In addition, since these hardware sources are calculated by irradiating the material in the fuel region, scaling factors (SF) are used to account for the lower flux seen in the non-fuel regions of the reactor. The SFs for the neutron flux, provided in Luksic 1989, Table S.1 [DIRS 120506], have an uncertainty of ± 50%. To generate conservative source terms for the non-fuel regions of the PWR assembly, the scaling factors used in this calculation represent 150% of those listed in Luksic 1989 [DIRS 120506].

Consideration has also been given to the material definitions. The compositions of Zircaloy-4 (ASTM B 811-90 1991 [DIRS 131753]), Stainless Steel 304, Stainless Steel 304L (ASME 2001 [DIRS 158115]), Stainless Steel 302 (ASTM A 240/A 240M-97a 1997 [DIRS 102769]), Inconel-718 (Inco Alloys International 1988 [DIRS 130835]), and Stainless Steel CF3M (ASM 1980 [DIRS 104317]) are representative of materials used in the manufacture of nuclear fuel assemblies. These compositions use the maximum amounts of cobalt given by the references and a 0.08 wt% cobalt impurity (Ludwig and Renier, p. 45 [DIRS 146398]) for the stainless steels. While none is indicated in ASME 2001 [DIRS 158115] and ASTM A 240/A 240M-97a 1997 [DIRS 102769], it is a common practice to include a cobalt impurity in stainless steels (due to nickel previously alloyed with cobalt). The balance of the remaining elements are representative of the material compositions for each material, but are biased towards the maximum amount of Sn, Ni, and Nb. Impurities are also included in the fuel itself, and are given in Table 4.

Not all the activation sources can be calculated with SAS2H. The source due to corrosion material that accumulates on the surfaces of the assembly from the flow of coolant (crud) is also calculated. A bounding crud source term is based on the South Texas assembly. This representation of the South Texas does not use Mark B dimensions. The South Texas has a greater surface area exposed to coolant, and the crud source is strongly dependent on the available surface area. This dependence comes from the source being calculated with a radioisotope activity density (Ci/cm^2). Two estimates for radioisotope densities are used, from two sources (NRC 2000 [DIRS 149756] and Jones 1992 [DIRS 146405]). This calculation is discussed in detail in Section 5.3.2.

The enrichments calculated range from 0.711 wt% (natural) to 5.5 wt% (the complete list is shown in Section 5.4.2). This is done to cover the wide range seen in the waste stream and avoid the need to extrapolate for information on assemblies currently being developed. Also, the number of time steps has been increased to 180, in order to provide more detailed information, particularly for the first 100 years the fuel is out of the reactors.

5.3 INPUT

5.3.1 Input for SAS2H Source Calculations

The general assembly description for a B&W Mark B PWR fuel assembly is provided in Table 2. Table 3 presents the PWR assembly hardware components and flux SF used to determine the masses of the light elements that are entered in SAS2H data Block 10.

The concentrations of element impurities in fresh light water reactor fuel, in parts of element per million parts of heavy metal (ppm), are listed in Table 4. These values are provided by Ludwig and Renier [DIRS 146398] and reflect measured concentrations instead of the maximum allowable concentrations given in purity specifications.

Table 5 provides the chemical compositions of the hardware materials used. Ranges are provided for some of the elements, and the values used in this calculation are provided.

Table 2. B&W Mark B PWR Fuel Assembly Description and Operating Parameters

Assembly Parameter	Value	Units	Metric	Units	Reference	
Average core exit moderator temperature	612	°F	595.4	K	Framatome Cogema 1999, p 3 [DIRS 146419] In association with BSC 2003, p. 2 [DIRS 165684]	
Average core moderator pressure	2200	Psia	-	-		
Maximum beginning of cycle boron concentration	-	-	1050	ppm		
Core thermal power	-	-	2568	MW		
Pellet average temperature (K)	1200	°F	922	K		
Fuel cladding to moderator temperature differential	50-75	°F	28-42	K		
Average core moderator temperature rise	59.4	°F	33	K		
Number of guide tubes	16	/assembly	NA	NA	Punatar 2001[b] [DIRS 155635]	Table 2-2
Number of instrument tubes	1	/assembly	NA	NA		
Clad/tube material	Zircaloy-4[a]	NA	NA	NA		
Number of assemblies	177	In core	NA	NA		
Total number of fuel rods	208	/assembly	NA	NA		
Number of rods on a lattice side	15	/side	NA	NA		
Fuel pellet outer diameter (OD)	0.3686	inches	0.93624	cm		
Fuel stack height	141.8	inches	360.172	cm		
Fuel clad OD	0.430	inches	1.0922	cm		
Clad thickness	0.0265	inches	0.06731	cm		
Fuel rod pitch	0.568	inches	1.44272	cm		
Guide tube OD	0.530	inches	1.3462	cm		
Guide tube ID	0.498	inches	1.26492	cm		
Fuel clad inner diameter (ID)	0.377	inches	0.95758	cm		
Fuel pellet fraction of theoretical density	-	-	0.95	NA		Table 2-9
Mass of U	-	-	463.63	kg		Table 3-1
Fuel assembly envelope	8.536	inches	21.6814	cm		p. 2-3
Fuel rod length	153.68	inches	390.3472	cm	Assumption 3.3	
Plenum region height	-	-	30.1752	cm		
Specific volume of steam at 2200 psi, 580°F	0.02275	ft^3/lbm	-	-	ASME 1993, p. 281 [DIRS 108050]	
Specific volume of steam at 2200 psi, 590°F	0.02235	ft^3/lbm	-	-		

NOTE: [a] Stainless steel clad calculations use SS-304 as the clad material.
[b] The sources of the fuel assembly physical data in Punatar 2001 [DIRS 155635] are from [DIRS 154999], [DIRS 155000], [DIRS 155001], and [DIRS 155002].

Table 3. Assembly Hardware and Flux Scaling Factors

Region	Flux Scaling Factors[a]	Part Name[b]	kg/Assembly[b]	Material[b]
Top end fitting	0.15	Top nozzle	7.48	Stainless Steel CF3M
		Spring retainer	0.91	Stainless Steel CF3M
		Hold down spring	1.8	Inconel-718
		Upper end plug	0.06	Stainless Steel 304
		Upper nuts	0.51	Stainless Steel 304L
Bottom end fitting	0.30	Bottom nozzle	8.16	Stainless Steel CF3M
		Spacer-bottom	1.3	Inconel-718
		Lower nuts	0.15	Stainless Steel 304[c]
Fuel/Plenum	fuel region - 1.00 plenum region - 0.30	Guide tubes	8.0	Zircaloy-4[d]
		Instrument tube	0.64	Zircaloy-4
		Spacers-incore	4.9	Inconel-718
		Grid supports	0.64	Zircaloy-4
		Spacer-plenum	1.04	Inconel-718
		Plenum spring	0.042[e]	Stainless Steel 302[e]

NOTE: [a] Assumption 3.2.
[b] Assumption 3.4.
[c] Zircaloy-4 was used instead of SS 304, but the effect on ^{60}Co activated source is negligible because of the much larger cobalt content in the bottom nozzle and bottom spacer.
[d] Stainless steel clad calculations use SS-304 as the clad material.
[e] Pounds per assembly, Assumption 3.4.

Table 4. Non-actinide Composition of UO_2

Element	Concentration (ppm)	Element	Concentration (ppm)	Element	Concentration (ppm)
Li	1.0	Mn	1.7	V	3.0
B	1.0	Fe	18.0	Cr	4.0
C	89.4	Co	1.0	Bi	0.4
N	25.0	Ni	24.0	Pb	1.0
F	10.7	Cu	1.0	Ti	1.0
Na	15.0	Zn	40.3	Ca	2.0
Mg	2.0	Mo	10.0	W	2.0
Al	16.7	Ag	0.1	Cl	5.3
Si	12.1	Cd	25.0	Sn	4.0
P	35.0	In	2.0	-	-

Source: Ludwig and Renier, Table 5.4 [DIRS 146398].

Table 5. Chemical Composition for Hardware Materials

Element	Wt% Range	Value Used
Chemical Composition for Stainless Steel 304L[a]		
C	0.03 (max)	0.03
Mn	2.00 (max)	2.00
Si	0.75 (max)	0.75
Cr	18.00-20.00	19.00
Ni	8.00-12.00	11.92
Co	-	0.08
P	0.045 (max)	0.045
S	0.03 (max)	0.03
N	0.1 (max)	0.1
Fe	Balance	66.045
Chemical Composition for Stainless Steel 304[a]		
C	0.08 (max)	0.08
Mn	2.00 (max)	2.00
Si	1.00 (max)	0.75
Cr	18.00-20.00	19.00
Ni	8.00-10.50	10.42
Co	-	0.08
P	0.045 (max)	0.045
S	0.03 (max)	0.03
N	0.1 (max)	0.1
Fe	Balance	67.495
Chemical Composition for Stainless Steel 302[e]		
C	0.15	0.15
Mn	2.00	2.00
Si	0.75	0.75
Cr	17.00-19.00	18.00
Ni	8.00-10.00	9.92
Co	-	0.08
P	0.045	0.045
S	0.03	0.03
N	0.10 (max)	0.1
Fe	Balance	68.925
Chemical Composition for Stainless Steel CF3M[b]		
C	0.03 (max)	0.03
Mn	1.50 (max)	1.50
Si	2.00 (max)	2.00
Cr	17.00-21.00	19.00
Ni	8.00-12.00	11.92
Co	-	0.08
Mo	2.00-3.00	2.50
Fe	Balance	62.97

Table 5. Chemical Composition for Hardware Materials (Continued)

Element	Wt% Range	Value Used
Chemical Composition for Inconel-718[c]		
Ni	50.00-55.00	54.00
Cr	17.00-21.00	19.00
Fe	Balance	14.934
Nb/Ta	4.75-5.50	5.5
Mo	2.80-3.30	3.05
Ti	0.65-1.15	0.90
Al	0.20-0.80	0.50
Co	1.00 (max)	1.00
Mn	0.35 (max)	0.35
Si	0.35 (max)	0.35
Cu	0.30 (max)	0.30
C	0.08 (max)	0.08
S	0.015 (max)	0.015
P	0.015 (max)	0.015
B	0.006 (max)	0.006
Chemical Composition for Zircaloy-4[d]		
O	0.09-0.16	0.12
Cr	0.07-0.13	0.10
Fe+Cr	0.28-0.37	0.20 (Fe)
Sn	1.20-1.70	1.70
Zr	Balance	97.88

NOTE: [a] ASME 2001, SEC II A SA-240, Table 1 [DIRS 158115].
[b] ASM 1980, p. 95 [DIRS 104317].
[c] Inco Alloys International 1988, p. 11 [DIRS 130835].
[d] ASTM B 811-90 1991, Table 2 [DIRS 131753].
[e] ASTM A 240/A 240M-97a 1997, Table 1 [DIRS 102769].

5.3.2 Input for Crud Calculations

In addition to the source terms for an assembly based on the irradiated assembly, it is also necessary to estimate the radiation source due to the activated corrosion products from the coolant deposited on the surfaces of the assembly (crud). These surfaces include all the areas of the assembly exposed to the flow of coolant. A bounding estimate of the PWR assembly surface area is based on a South Texas assembly (Assumption 3.5), which has a longer length, 264 fuel rods, and 25 guide or instrumentation tubes. The fuel rods for this assembly have a 0.374-inch (0.95-cm) outer diameter (OD) and a length of 176.642 inches (448.67 cm) (DOE 1988, p. 2A-363 [DIRS 100979]). Both the inner and outer surface areas of the guide and instrument tubes are included in the estimation of the surface area of the assembly. The tube OD is taken to be the pitch of the fuel pins for a conservative estimate and is 0.496 inches (1.2598 cm) (DOE 1988, p. 2A-361 [DIRS 100979]). The cladding thickness is used to determine the inside diameter and surface area and is 0.0225 inches (0.05715 cm) (DOE 1988, p. 2A-363 [DIRS 100979]). The overall assembly length is 199 inches (505.46 cm) (DOE 1988, p. 2A-361 [DIRS 100979]). In addition to the calculation of a bounding crud source based on the South Texas assembly parameters, a source for a regular B&W Mark B assembly is also calculated.

A radionuclide activity density (Ci/cm^2) is required to calculate the crud source. Two estimates for the radionuclide activity density are used in this calculation. The first estimate for the activity density is provided by the NRC NUREG-1567 (NRC 2000, Table 9.2 [DIRS 149756]), and has a value 140 μCi/cm^2, which is entirely due to ^{60}Co. The second estimate of crud activity density is provided by Jones 1992 [DIRS 146405]. This estimate has activities for eight radionuclides and is included in this calculation for information purposes only. The data from NRC 2000 [DIRS 149756] and Jones 1992 [DIRS 146405] are summarized in Table 6. Although the data in Jones 1992 [DIRS 146405] contain activities from multiple radioactive isotopes, it is recommended that the NRC value be used for crud activity. The reason is that the ^{60}Co activity from NRC is nearly three times the ^{60}Co activity from Jones 1992 [DIRS 146405]. Emitting two very energetic photons and some beta particles, ^{60}Co is the most dominant isotope for crud. Since other radionuclides in Table 6 either have shorter half-lives or emit much lower intensity radiation, they become insignificant by the time the SNF arrives the potential repository.

Table 6. Radionuclide Activity Densities Used in Crud Source Calculation

Radionuclide	Activity Density (Ci/cm^2) at Discharge	Half Life[a]	Reference
^{60}C0	1.40x10^{-4}	5.27 years	NRC 2000, Table 9.2 [DIRS 149756]
^{51}Cr	1.89x10^{-4}	27.70 days	Jones 1992, Table 1 [DIRS 146405]
^{54}Mn	7.40x10^{-5}	312.10 days	
^{55}Fe	5.90x10^{-3}	2.73 years	
^{58}Co	4.03x10^{-4}	70.88 days	
^{59}Fe	7.60x10^{-5}	44.51 days	
^{60}Co	5.10x10^{-5}	5.27 years	
^{63}Ni	2.00x10^{-6}	100.00 years	
^{95}Zr	1.90x10^{-5}	64.02 days	

NOTE: [a] Parrington et.al. 1996, pp. 24-28 [DIRS 103896].

5.4 SAS2H INPUT PARAMETER CALCULATION

This section describes the calculation of the required input for SAS2H. The SAS2H sequence calculates source terms for the four axial regions: bottom end fitting, active fuel, plenum, and top end fitting. Every calculation requires the input of assembly parameters, burnup history, decay time steps, the pin cell description (path A), and the larger unit cell description for the whole assembly (path B). The path A input is presented in Section 5.4.1. Section 5.4.2 describes the calculation of uranium isotopic composition, density, and length for the active fuel region. The calculation of the path B representation is provided in Section 5.4.3. Section 5.4.4 provides the masses of the light elements used in SAS2H source calculation of the activation products. Section 5.4.5 calculates the SAS2H input data for moderator temperature and density and boron concentration. Fuel burnup and decay calculations are provided in Section 5.4.6.

5.4.1 Input for the Path A Calculation in SAS2H

The first information in the SAS2H input files specifies the type of calculation and the cross section library to be used. The "latticecell" type of calculation and the "44groupndf5" cross section library are used. Because no dose calculation is performed in this calculation, the parameters for the shipping cask "skipcellwt" and "skipshipdata" are specified. SAS2H then uses this information to generate an infinite lattice of unit pin cells and calculate cell-weighted cross sections. These cross sections are then applied to the assembly described by the path B representation.

Figure 1 presents the path A unit pin cell representation for SAS2H and Table 7 presents the input parameters for cell calculations.

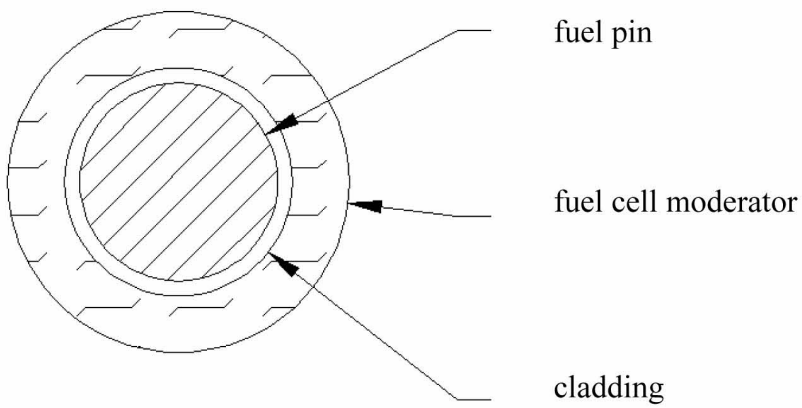

Figure 1. Unit Pin Cell Representation for Path A

Table 7. SAS2H Input for the Path A Calculation

Variable Name	Value Used
Lattice type	Square pitch
Pitch	1.44272 cm
Fuel OD	0.93624 cm
Mfuel	1
Mmod	3
Clad OD	1.0922 cm
Mclad	2
Clad ID	0.95758 cm
Mgap	0

5.4.2 Fuel Uranium Isotopic Composition, Density, and Calculated Length

The isotopic composition of uranium for commercially available enriched uranium is determined by the given initial ^{235}U enrichment and the following formulae (Bowman et.al. 1995, p. 20 [DIRS 123796]):

$$wt\%^{235}U = {}^{235}U_{enrichment_of_the_associated_fuel_batch}$$

$$wt\%^{234}U = 0.007731 * (wt\%^{235}U)^{1.0837}$$

$$wt\%^{236}U = 0.0046 * (wt\%^{235}U)$$

$$wt\%^{238}U = 100 - (wt\%^{234}U + wt\%^{235}U + wt\%^{236}U)$$

The values for initial uranium isotope composition, presented in Table 8, are calculated in Attachment I.

Table 8. Initial Uranium Isotope Composition[a]

"*.cut" Files E Code	^{235}U (wt%)	^{236}U (wt%)	^{234}U (wt%)	^{238}U (wt%)
E12	0.711	0.00327	0.00534	99.28039
E11	1.0	0.00460	0.00773	98.98767
E10	1.5	0.00690	0.01200	98.48110
E9	2.0	0.00920	0.01639	97.97441
E8	2.5	0.01150	0.02087	97.46763
E7	3.0	0.01380	0.02543	96.96077
E6	3.5	0.01610	0.03005	96.45385
E5	4.0	0.01840	0.03473	95.94687
E4	4.2	0.01932	0.03661	95.74407
E3	4.5	0.02070	0.03946	95.43984
E2	5.0	0.02300	0.04423	94.93277
E1	5.5	0.02530	0.04904	94.42566

NOTE: [a] Only enrichment 1.5 wt% through 4.0 wt% are used for the SS clad calculations.

A smeared fuel density is used in SAS2H. This is a common approach because fuel pellets expand and fill the gap during and after reactor operation. The smeared density is calculated from the following equation:

$$\rho_{smeared} = (\%\ \text{theoretical density} * \rho_{theoretical}) * \left(\frac{\text{pellet diameter}^2}{\text{clad inside diameter}^2} \right)$$

With a UO_2 density of 10.96 g/cm^3 (ORNL 1997, p. M8.2.3 [DIRS 135808]) and the pellet and clad inside diameters from Table 2, the smeared fuel density is:

$$\rho_{smeared} = (0.95) * (10.96 \frac{g}{cm^3}) * \left(\frac{0.93624^2}{0.95758^2} \right) = 9.953 \frac{g}{cm^3}$$

A smeared fuel density of 9.96 g/cm^3 is used in SAS2H. With the initial heavy metal loadings of 464 kg, 475 kg, and 550 kg respectively for the waste stream assembly, the SS clad assembly, and the South Texas assembly, the active fuel lengths of 369.699 cm, 378.463 cm, and 438.221 cm are obtained (see Attachment I).

5.4.3 Input for the Path B Calculation

The larger representation of the assembly used in the path B calculation by SAS2H is shown in Figure 2. Four regions are used in describing this larger unit cell. The four regions are concentric rings, similar to the unit pin cell representation in path A. The inner region is the moderator inside the guide tube, which is surrounded by the guide tube itself (region 2). The third region is the moderator in the guide tube cell surrounding the outside of the guide tube. The last region represents the homogenized fuel, cladding, and moderator of the assembly.

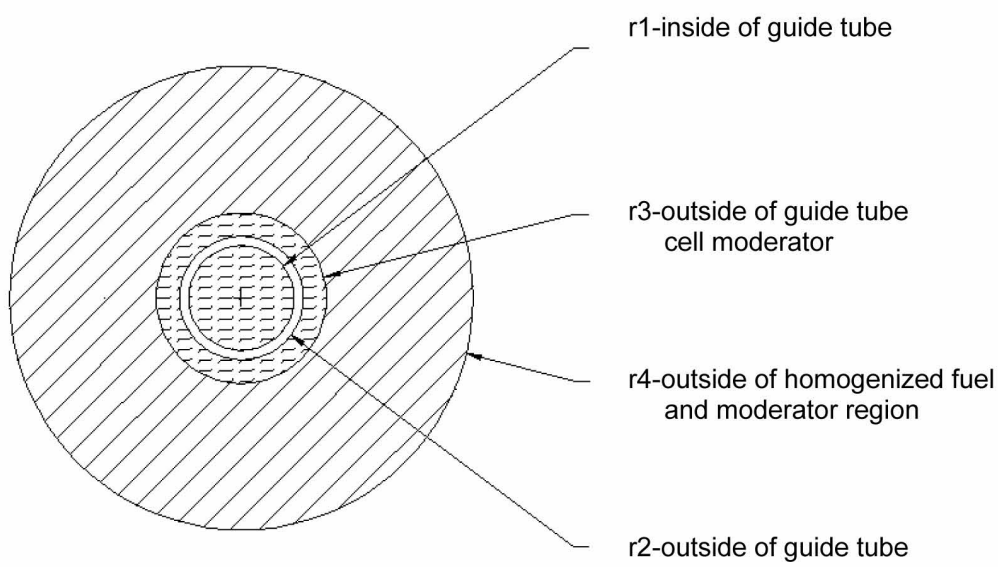

Figure 2. Larger Unit Cell Representation for Path B

The first radius, r_1, corresponds to the inner radius of the guide tube (1.26492/2 = 0.63246 cm). The second radius, r_2, corresponds to the outer radius of the guide tube (1.3462/2 = 0.6731 cm). The third radius, r_3, corresponds to an area equivalent to rod pitch squared. Thus,

$$r_3 = \sqrt{\frac{\text{pitch}^2}{\pi}} = \sqrt{\frac{1.44272^2}{\pi}} = 0.814 \text{ cm}$$

The fourth radius is calculated to preserve the guide tube-to-fuel volume ratio. The material for the fourth region is defined as mixture 500, which is the homogenized fuel, cladding and moderator determined from the path A calculation by SAS2H. Thus, the fourth radius is determined by taking a ratio of the number of available positions for fuel pins in the assembly to the number of positions used by the guide tubes and instrumentation tubes. This ratio is set equal to the ratio of the areas of the intended fuel region and the moderator (i.e., the guide tube pin cell). This allocates the number of fuel pins equally to each guide tube, and then sets the total volume of the assembly cell to be equal to the volume of the number of pin cells per guide tube. The instrument tube is taken to be equivalent to a guide tube for the path B calculation. This approach preserves the guide tube to fuel ratio and provides a unit cell that is representative of a core average composition. Therefore, the r_4 radius is derived according to the following equations:

$$\frac{N_{positions}}{N_{guide\ tubes}} = \frac{\pi r_4^2}{\pi r_3^2} = \frac{r_4^2}{r_3^2}, \text{ which can be written as } r_4^2 = r_3^2 * \frac{N_{positions}}{N_{guide\ tubes}}$$

Yielding :

$$r_4 = \sqrt{r_3^2 * \frac{N_{positions}}{N_{guide\ tubes}}} = \sqrt{0.814^2 * \frac{15 * 15}{17}} = 2.961 \text{ cm}$$

r_1 through r_4 are shown in Table 9 with the mixtures used in each radius. Table 10 lists the rest of the input for the fuel assembly required by SAS2H.

Table 9. Dimensions of the Larger Unit Cell for Path B

Variable Name	Value Used	Comment
Mixes	3	Material No. for the moderator
Radius	0.63246	cm, region 1
Mixes	2	Material No. for the Zircaloy-4
Radius	0.67310	cm, region 2
Mixes	3	Material No. for the moderator
Radius	0.814	cm, region 3
Mixes	500	Special material No. for fuel in the larger unit cell
Radius	2.961	cm, region 4

Table 10. Input for Fuel Assembly in SAS2H Calculations

Variable Name	Value Used
Npin/assm	208 pins per assembly
Fuelngth	360.172[a]
Ncycles	1 cycle
Nlib/cyc[b]	See Table 12
Lightel	33
Printlevel	5
Inplevel	2
Numholes	17
Numinstr	1
Mxtube	2
Ortube	0.6731 cm
Srtube	0.63246 cm
Asmpitch	21.6814 cm
Numztotal	4
Mxrepeats	1
Mixmod	3
Facmesh	1.0

NOTE: [a] See Section 5.4.2 for the calculation of the fuel lengths to account for the different IHMLs.
[b] Number of libraries made per cycle.

5.4.4 Light Element Mass Calculations

The masses of the light elements for each axial fuel region are calculated in Attachment III and are reported in Table 11. The light element masses are determined by multiplying the weight of the hardware by the wt%s of the elements that make up the hardware and then adjusting by scaling factors to account for hardware's location in the reactor. For the active fuel region, the impurities in the fuel are also included. SAS2H is then used to simulate the irradiation of the fuel and the light elements and to decay the radiation source.

Table 11. Light Element Masses per Assembly (kg)

Region:	Top (SF: 0.15)	Bottom (SF: 0.30)	Fuel (SF: 1)			Plenum (SF: 0.30)	
Element	**Waste Stream**	**Waste Stream**	**Waste Stream**	**South Texas**	**Steel Clad**	**Waste Stream**	**Steel Clad**
Ag	-	-	0.0000	0.0001	0.0000	-	-
Al	0.0014	0.0020	0.0324	0.0337	0.0324	0.0016	0.0016
B	0.0000	0.0000	0.0008	0.0008	0.0008	0.0000	0.0000
Bi	-	-	0.0002	0.0002	0.0002	-	-
C	0.0006	0.0010	0.0464	0.0531	0.1567	0.0003	0.0030
Ca	-	-	0.0010	0.0011	0.0010	-	-
Cd	-	-	0.0119	0.0138	0.0119	-	-
Cl	-	-	0.0025	0.0029	0.0025	-	-
Co	0.0038	0.0059	0.0495	0.0496	0.1598	0.0031	0.0059
Cr	0.3067	0.5393	1.0480	1.0764	27.1279	0.0632	0.7187
Cu	0.0008	0.0012	0.0152	0.0153	0.0152	0.0009	0.0009
F	-	-	0.0051	0.0059	0.0051	-	-
Fe	0.8894	1.5998	0.9706	1.0282	93.7937	0.0563	2.3893
In	-	-	0.0010	0.0011	0.0010	-	-
Li	-	-	0.0005	0.0006	0.0005	-	-
Mg	-	-	0.0010	0.0011	0.0010	-	-
Mn	0.0215	0.0381	0.0180	0.0181	2.7753	0.0012	0.0705
Mo	0.0397	0.0731	0.1542	0.1550	0.1542	0.0095	0.0095
N	0.0001	0.0000	0.0119	0.0138	0.1497	0.0000	0.0035
Na	-	-	0.0071	0.0083	0.0071	-	-
Nb	0.0149	0.0215	0.2695	0.2695	0.2695	0.0172	0.0172
Ni	0.3059	0.5024	2.6574	2.6592	17.0229	0.1690	0.5301
O	0.0000	0.0001	64.9109	75.1719	64.7735	0.0035	0.0000
P	0.0001	0.0001	0.0173	0.0200	0.0794	0.0000	0.0061
Pb	-	-	0.0005	0.0006	0.0005	-	-
S	0.0001	0.0001	0.0007	0.0007	0.0421	0.0000	0.0011
Si	0.0268	0.0503	0.0229	0.0238	1.0569	0.0011	0.0271
Sn	0.0000	0.0008	1.9589	2.4374	0.0128	0.0489	0.0000
Ti	0.0024	0.0035	0.0446	0.0447	0.0446	0.0028	0.0028
V	-	-	0.0014	0.0017	0.0014	-	-
W	-	-	0.0010	0.0011	0.0010	-	-
Zn	-	-	0.0191	0.0222	0.0191	-	-
Zr	0.0000	0.0440	112.6799	140.2127	0.6264	2.8164	0.0000

5.4.5 Assembly Operating Parameters

To specify the reactor moderator condition used in the pin cell calculations, the moderator temperature and density and the boron concentration are required.

The moderator temperature is determined from the average core exit temperature, 612°F, and the average moderator temperature rise across the core, 59.4°F, (see Table 2) as follows:

$$612°F - \left(\frac{59.4°F}{2}\right) = 582.3°F \cong 578.9\ K$$

The density of the moderator for this temperature is then determined from steam tables by linear interpolation. Using the values corresponding to steam temperatures of 580°F and 590°F at a steam pressure of 2200 psia, (see Table 2) the specific volume is:

$$0.02275 - \left(\frac{0.02275 - 0.02235}{590 - 580}\right) * (590 - 582.4) = 0.022446 \frac{\text{ft}^3}{\text{lbm}}$$

Converting this to density yields:

$$\frac{1}{0.022446 \frac{\text{ft}^3}{\text{lbm}}} = 44.551 \frac{\text{lbm}}{\text{ft}^3} = 0.7136 \frac{\text{g}}{\text{cm}^3}$$

If more than one library per cycle is required in SAS2H calculations, the boron concentration is automatically changed during the passes of a cycle and is assumed to vary linearly from 1.9 to 0.1 times its average (input) density during the time interval of the cycle (ORNL 1997, p. S2.2.10 [DIRS 135808]). Therefore, the required input average boron concentration is calculated by dividing the beginning of cycle value provided in Table 2 by 1.9, e.g., 1050 ppm/1.9 = 552.6 ppm.

5.4.6 Power History Input

Also required by SAS2H is the operational history of the assembly in the reactor.

Table 12 presents the values required in Block 9 of SAS2H describing the assembly's power history. Since the histories can be very complicated, this calculation uses the simple approach of one cycle and new libraries at least every 100 days. The assemblies are irradiated at a power of 14.5085 MW (2568 MWt/ 177 assemblies in a core). These parameters are calculated in Attachment II.

5.4.7 ORIGEN-S Input

The inputs for ORIGEN-S are the decay time steps shown in Table 13. Other inputs for ORIGEN-S are the specification of information tables to be printed, and how the gamma sources are generated. The gamma spectra can be calculated from the light elements, fission products and actinides of an assembly, or just from the light elements. For the hardware regions, only the light elements are used to generate the gamma source. In this calculation, the tables of curies and watts for each isotope are printed, as are the neutron and gamma spectra.

Table 12. SAS2H Input Data for Assembly Depletion/Decay ParametersX

"*.cut" Files B Code	Final Burnup (GWd/MTU)	Effective Full Power Days	U Mass (kg /assembly)	Number of Libraries per Cycle
B1	0.001	0.03274	475	1
B1	0.001	0.03791	550	1
B2	0.01	0.3274	475	1
B2	0.01	0.3791	550	1
B3	0.1	3.274	475	1
B3	0.1	3.791	550	1
B4	1	32.739	475	1
B4	1	37.909	550	1
B5	10	327.39	475	4
B5	10	379.09	550	4
B6	20	654.79	475	7
B6	20	758.18	550	8
B7	30	982.18	475	10
B7	30	1137.26	550	12
B8	40	1309.58	475	14
B8	40	1516.35	550	16
B9	48.086	1574.31	475	16
B9	48.086	1822.88	550	19
B10	50	1636.97	475	17
B10	50	1895.44	550	19
B11	60	1964.37	475	20
B11	60	2274.53	550	23
B12	70	2291.76	475	23
B12	70	2653.62	550	27
B13	75	2455.46	475	25
B13	75	2843.16	550	29
B14	80	2619.15	475	27
B15	85	2782.85	475	28

Table 13. Time Steps Used for Decay Calculation

Decay time steps (years)									
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100
110	120	130	140	150	160	170	180	190	200
250	300	350	400	450	500	550	600	650	700
750	800	850	900	950	1000	1500	2000	2500	3000
3500	4000	4500	5000	5500	6000	6500	7000	7500	8000
8500	9000	9500	$1.0x10^4$	$1.5x10^4$	$2.0x10^4$	2.5x104	$3.0x10^4$	$3.5x10^4$	$4.0x10^4$
$4.5x10^4$	$5.0x10^4$	$5.5x10^4$	$6.0x10^4$	$6.5x10^4$	$7.0x10^4$	$7.5x10^4$	$8.0x10^4$	$8.5x10^4$	$9.0x10^4$
$9.5x10^4$	$1.0x10^5$	$1.5x10^5$	$2.0x10^5$	$2.5x10^5$	$3.0x10^5$	$3.5x10^5$	$4.0x10^5$	$4.5x10^5$	$5.0x10^5$
$5.5x10^5$	$6.0x10^5$	$6.5x10^5$	$7.0x10^5$	$7.5x10^5$	$8.0x10^5$	$8.5x10^5$	$9.0x10^5$	9.50^5	$1.0x10^6$

5.5 RADIONUCLIDE INVENTORIES FOR PERFORMANCE ASSESSMENT

Several separate SAS2H/ORIGEN-S cases are provided in this calculation to determine average and maximum radionuclide inventories for specific years. The average and maximum PWR assemblies are derived from the results of CRWMS M&O 2000 [DIRS 138239] and listed below. The characteristics of the average PWR assembly are estimated based on the average PWR assembly of Case A with full inventory (83,800 MTU) in CRWMS M&O 2000, Table 5 [DIRS 138239]. For this case, the characteristics of the average PWR assembly are 3.75wt%, 41.70 GWd/MTU, and 25.3 years old with an initial uranium loading of 434 kg. A comparison study, based on the data base in DOE 1992, Appendix 1C [DIRS 102812], indicates that per initial MTU loading the average PWR assembly selected in this calculation is more conservative than any average PWR assembly for the scenarios in CRWMS M&O 2000, Table 5 [DIRS 138239] (See Attachment IV). The characteristics of the maximum PWR assembly are also derived from CRWMS M&O 2000, Attachment III, preblend files [DIRS 138239]. From these files the following maximum PWR SNF characteristics are noted: initial uranium loading of 477 kg, burnup of 69 GWd/MTU, initial uranium enrichment of 5.0 wt%, and cooling time of 5 years. It should be noted that there is no single assembly in the waste stream with these combined characteristics. Rather, these are the maximum characteristics of each parameter in the entire waste stream. Compared to these SNF characteristics, the maximum PWR assembly selected here is more conservative because the effect of the higher burnup (80 GWd/MTU versus 69 GWd/MTU) exceed that of the two kilogram (475 versus 477 kg) difference in the initial uranium loading.

To provide margin for conservatism and sufficiently cover future projected commercial high burnup fuel, the maximum burnup of 69 GWd/MTU based on the *Waste Packages and Source Terms for the Commercial 1999 Design Basis Waste Streams* (CRWMS M&O 2000, Attachment III, preblend files [DIRS 138239]) was increased to 80 GWd/MTU as the bounding burnup value. This selection is consistent with the value used in *Licensing Position-009, Waste Stream Parameters* (Williams 2003, Attachment, p. 1 [DIRS 166132]). The characteristics of the average and maximum PWR SNF assemblies used in this calculation are:

- Average PWR assembly: 4.0%, 48 GWd/MTU, 25 years cooling time
- Maximum PWR assembly: 5.0%, 80 GWd/MTU, 5 years cooling time

The radionuclide inventories (curies) for both average and maximum PWR assemblies are provided in Attachment IX for different cooling times.

5.6 CRUD SOURCE TERM

The activity of the crud on the surface of the PWR assemblies at time zero is determined by multiplying the calculated assembly surface area by the ^{60}Co or other corrosion product activity per unit area of surface. A time dependent crud activity is derived using the following equation:

$$N(t) = N(0)e^{\frac{-t \ln 2}{t_{1/2}}}$$

where $t_{½}$ is the radionuclide half-life and t is the decay time in years.

A bounding estimate of the PWR assembly surface area is 449,003 cm^2, based on a South Texas assembly. This value and the crud source term are calculated in Attachment VI.

6. RESULTS

The section presents the results of this calculation. The outputs of this calculation are reasonable compared to the inputs, and the results are suitable for the intended use. The uncertainties are taken into account by consistently using the most conservative approach; the calculations, therefore, yield a conservatively bounding set of results.

6.1 EFFECTS OF FUEL IMPURITIES

The effects of impurities in the fuel are examined using a waste stream assembly with a 4.2 wt% ^{235}U initial enrichment. Negligible differences in radiation spectra and thermal powers have been observed. However, the results for ^{36}Cl and ^{14}C are summarized in this section. Attention is given to ^{36}Cl and ^{14}C (with half-lives of 3.01×10^5 and 5715 years (Parrington et.al. 1996, p. 19 and p. 22 [DIRS 103896]), respectively) because of their very high solubility-limits in aqueous concentrations (CRWMS M&O 1995, p. 6-7 [DIRS 100198]). ^{36}Cl and ^{14}C activities at discharge as function of burnup are presented in Table 14. Two mass concentrations for the chlorine impurity have been used in these calculations: 5.3 ppm (a measured concentration from Ludwig and Renier, Table 5.4 [DIRS 146398]) and 10 ppm.

Figure 3 presents a plot of ^{36}Cl and ^{14}C activity per ppm versus burnup. This conclusion can be used to estimate the resulting radioactivity from activation of a certain chlorine impurity concentration.

Table 14. ^{36}Cl and ^{14}C Activities for the Waste Stream Assembly with 4.2 wt% ^{235}U Enrichment at Time of Discharge

Burnup (GWd/MTU)	^{36}Cl Activity (Ci/assembly)		^{36}Cl Activity (Ci/assembly)/Initial Impurity (ppm)		^{14}C Activity (Ci/assembly)	^{14}C Activity (Ci/assembly)/ Initial Impurity (ppm)
	5.3 ppm	10 ppm	5.3 ppm	10 ppm		
1	1.24×10^{-4}	2.35×10^{-4}	2.34×10^{-5}	2.35×10^{-5}	5.67×10^{-3}	6.34×10^{-5}
10	1.24×10^{-3}	2.33×10^{-3}	2.34×10^{-4}	2.33×10^{-4}	5.69×10^{-2}	6.36×10^{-4}
20	2.51×10^{-3}	4.74×10^{-3}	4.74×10^{-4}	4.74×10^{-4}	1.17×10^{-1}	1.31×10^{-3}
30	3.87×10^{-3}	7.32×10^{-3}	7.30×10^{-4}	7.32×10^{-4}	1.87×10^{-1}	2.09×10^{-3}
40	5.32×10^{-3}	1.01×10^{-2}	1.00×10^{-3}	1.01×10^{-3}	2.54×10^{-1}	2.84×10^{-3}
50	6.89×10^{-3}	1.31×10^{-2}	1.30×10^{-3}	1.31×10^{-3}	3.33×10^{-1}	3.72×10^{-3}
60	8.55×10^{-3}	1.62×10^{-2}	1.61×10^{-3}	1.62×10^{-3}	4.20×10^{-1}	4.70×10^{-3}
70	1.03×10^{-2}	1.95×10^{-2}	1.94×10^{-3}	1.95×10^{-3}	5.13×10^{-1}	5.74×10^{-3}
75	1.11×10^{-2}	2.12×10^{-2}	2.09×10^{-3}	2.12×10^{-3}	5.62×10^{-1}	6.29×10^{-3}
80	1.19×10^{-2}	-	2.25×10^{-3}	-	6.11×10^{-1}	6.83×10^{-3}

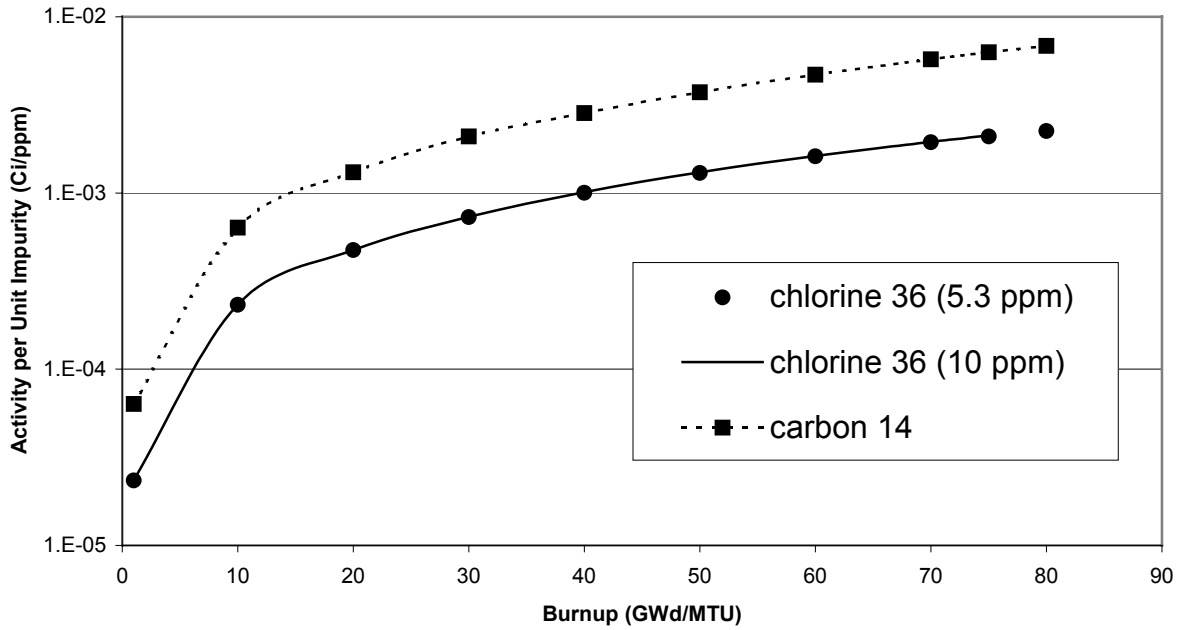

Figure 3. ^{36}Cl and ^{14}C Activity per Unit Impurity at Discharge as a Function of Burnup for a Waste Stream Assembly with 4.2 wt% ^{235}U Enrichment

6.2 WASTE STREAM, SS CLAD, AND SOUTH TEXAS SOURCE TERMS

Due to large amount of information generated by this calculation, the results are provided as electronic files on four CDs (Attachment X). However, a summary of the results are presented also in Section 6 and Attachments IV, VI, VII, and IX.

Attachment XI presents information to be used in License Application – Safety Analysis Report, Section 1.5.1.

6.3 STUDY LIMITATIONS

Data evaluated in this calculation are the assembly average source terms and it will be left to the subsequent analysis to account for any axial distribution of the radionuclide inventories and consequently radiation and heat source terms.

6.4 CONCLUSIONS

The objectives of this calculation are to generate PWR SNF assembly source terms that bound selected groupings of PWR assemblies, with regard to assembly burnup and cooling time. Bounding PWR SNF assembly source terms to be used for evaluation of shielding requirements or other follow-on analysis have been calculated in this study. The results of this calculation may also be used as input for Preclosure Safety Analysis and Total System Performance Assessment analyses.

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8. ATTACHMENTS

The ten attachments for this calculation are listed in Table 15. Attachments I to IX are included with this document. Attachment X consists of four compact discs, which content is listed in Attachment VIII. Two new worksheets "PWR.bou.2.curies" and "PWR.bou.3.curies" were added to the spreadsheet "ATTACH_IX.XLS" to include the new burnup value (80 GWd/MTU) for the maximum PWR assembly.

Table 15. Attachments

Description	Attachment Number	No. of Pages
Fuel density and composition calculations	I	1
Burn history calculations	II	2
Light element mass calculations	III	12
Comparison of source terms per MTU of 4 average PWR SNF assemblies	IV	1
Listing of UNIX script files	V	1
Calculation of crud source	VI	4
^{36}Cl and ^{14}C calculations	VII	1
List of *.cut files on compact discs	VIII	22
Radionuclide inventories for Performance Assessment (all nuclides included)	IX	10
Electronic copies versions of *.cut files	X	4 CDs
Evolution in Time of Thermal Power and Total Radioactivity	XI	1

Attachment I

Determination of fuel compositions and burn histories

Initial Heavy Metal Mass	# of pins in assembly	Pin length	pellet outer radius
464	208	360.172	0.46812
475			
550			

KG UO2/Assembly	densities (g/cc)	cross sect. area (cm^2)	volume needed (cm^3)	density (g/cc)	new fuel length (cm)
527.27	10.22	143.1949164	52939.03	9.96	**369.699**
539.77	10.47		54194.05		378.463
625	12.12		62751.00		438.221

Burn histories

Burnup,GWd/MTU	days for 464 assembly to achieve burnup	Required libraries/cycle for 100 day cycles	days for 475 assembly to achieve burnup	Required libraries/cycle for 100 day cycles	days for 550 assembly to achieve burnup	Required libraries/cycle for 100 day cycles
0.001	0.03	0.0003	0.0327	0.0003	0.0379	0.0004
0.01	0.32	0.0032	0.3274	0.0033	0.3791	0.0038
0.1	3.20	0.0320	3.2739	0.0327	3.7909	0.0379
1	31.98	0.3198	32.7394	0.3274	37.9088	0.3791
10	319.81	3.1981	327.39	3.3	379.09	3.8
20	639.63	6.4	654.79	6.5	758.18	7.6
30	959.44	9.6	982.18	9.8	1137.26	11.4
40	1279.25	12.8	1309.58	13.1	1516.35	15.2
50	1599.06	16.0	1636.97	16.4	1895.44	19.0
60	1918.88	19.2	1964.37	19.6	2274.53	22.7
70	2238.69	22.4	2291.76	22.9	2653.62	26.5
75	2398.59	24.0	2455.46	24.6	2843.16	28.4
80	2558.50	25.6	2619.15	26.2	3032.70	30.3
85	2718.41	27.2	2782.85	27.8	3222.25	32.2

235 Enrichment	236 enrichment	234 enrichment	238
0.711	0.00327	0.00534	99.28039
1	0.00460	0.00773	98.98767
1.5	0.00690	0.01200	98.48110
2	0.00920	0.01639	97.97441
2.5	0.01150	0.02087	97.46763
3	0.01380	0.02543	96.96077
3.5	0.01610	0.03005	96.45385
4	0.01840	0.03473	95.94687
4.2	0.01932	0.03661	95.74407
4.5	0.02070	0.03946	95.43984
5	0.02300	0.04423	94.93277
5.5	0.02530	0.04904	94.42566

Attachment II

PWR Source Term Generation and Evaluation

Final Burnup (GWd/MTU)	Effective Full Power Days	MW /assembly	kg /assembly	Number of libraries for 1 library every 100 days	#days covered by last library	Nlib/cycle required
0.001	0.03274	14.5085	475	0	0.03274	1
0.001	0.03791	14.5085	550	0	0.03791	1
0.01	0.3274	14.5085	475	0	0.32739	1
0.01	0.3791	14.5085	550	0	0.37909	1
0.1	3.274	14.5085	475	0	3.27394	1
0.1	3.791	14.5085	550	0	3.79088	1
1	**32.739**	14.5085	475	0	32.73943	1
1	37.909	14.5085	550	0	37.90881	1
10	319.81	14.5085	464	3	19.8	4
10	327.39	14.5085	475	3	27.4	4
10	379.09	14.5085	550	3	79.1	4
20	639.63	14.5085	464	6	39.6	7
20	654.79	14.5085	475	6	54.8	7
20	758.18	14.5085	550	7	58.2	8
30	959.44	14.5085	464	9	59.4	10
30	982.18	14.5085	475	9	82.2	10
30	1137.26	14.5085	550	11	37.3	12

Attachment II

Final Burnup (GWd/MTU)	Effective Full Power Days	MW /assembly	kg /assembly	Number of libraries for 1 library every 100 days	#days covered by last library	Nlib/cycle required
40	1279.25	14.5085	464	12	79.3	13
40	1309.58	14.5085	475	13	9.6	14
40	1516.35	14.5085	550	15	16.4	16
48.086	1537.85	14.5085	464	15	37.9	16
48.086	1574.31	14.5085	475	15	74.3	16
48.086	1822.88	14.5085	550	18	22.9	19
50	1599.06	14.5085	464	15	99.1	16
50	1636.97	14.5085	475	16	37.0	17
50	1895.44	14.5085	550	18	95.4	19
60	1918.88	14.5085	464	19	18.9	20
60	1964.37	14.5085	475	19	64.4	20
60	2274.53	14.5085	550	22	74.5	23
70	2238.69	14.5085	464	22	38.7	23
70	2291.76	14.5085	475	22	91.8	23
70	2653.62	14.5085	550	26	53.6	27
75	2398.59	14.5085	464	23	98.6	24
75	2455.46	14.5085	475	24	55.5	25
75	2843.16	14.5085	550	28	43.2	29
80	2558.50	14.5085	464	25	58.5	26
80	2619.15	14.5085	475	26	19.2	27
80	3032.70	14.5085	550	30	32.7	31
85	2718.41	14.5085	464	27	18.4	28
85	2782.85	14.5085	475	27	82.9	28
85	3222.25	14.5085	550	32	22.2	33

Attachment III - Worksheet "Data"

Babcock and Wilcox Mark B fuel assembly Hardware

Region	Part Name	kg/assembly	Material
Top	top nozzle	7.48	SS CF3M
	spring retainer	0.91	SS CF3M
	hold down spring	1.8	Inconel-718
	upper end plug	0.06	SS 304
	upper nuts	0.51	SS 304L
Bottom	bottom nozzle	8.16	SS CF3M
	bottom spacer	1.3	Inconel-718
	lower nuts	0.15	Zircaloy-4
Fuel/plenum	guide tubes	8	Zircaloy-4
Fuel/plenum	instrument tube	0.64	Zircaloy-4
Fuel/plenum	incore spacers	4.9	Zircaloy-4
Fuel	grid supports	0.64	Zircaloy-4
plenum	plenum spacers	1.04	Inconel-718
	plenum springs	0.019	SS 302
		0.042 (lbs)	

***Mass of oxygen to be added to fuel region light elements to acount for the oxygen in the fuel:

KG U	KG UO2	KG O
475	539.77	64.77
550	625	75.00
	(KG U)/0.88	(KG UO2)- (KG U)

*** Cladding mass is calculated on next worksheet
Inconel 718 used in calculation since many have this material for spacers

RAW MATERIAL DATA: **Updated 8/17**

Material:	SS 304		SS304L		Zircaloy-4	
Element	Range	Used	Range	Used	Range	Used
c	0.08 (max)	0.08	0.03 (max)	0.03	0	0
mn	2 (max)	2	2 (max)	2	0	0
p	0.045 (max)	0.045	0.045 (max)	0.045	0	0
s	0.03 (max)	0.03	0.03 (max)	0.03	0	0
si	1.0 (max)	0.75	0.75 (max)	0.75	0	0
cr	18-20	19	18-20	19	0.07-0.13	0.1
ni	8-10.5	10.42	8.0-12.0	11.92	0	0
n	0.1 (max)	0.1	0.1	0.1	0	0
fe	Balance	67.495	Balance	66.045	0.18-0.24	0.2
o	0	0	0	0	0.09-0.16	0.12
sn	0	0	0	0	1.2-1.7	1.7
zr	0	0	0	0	Balance	97.88
		99.92		99.92		100
co	-	0.08	-	0.08		
Material:		SS 304		SS304L		Zircaloy-4

Inconel-718		
Element	Range	Used
ni+co	50-55	54
cr	17-21	19
fe	bal	14.934
co (max)	1	1
mo	2.8-3.3	3.05
w	0	0
nb+ta	4.75-5.5	5.5
ti	.65-1.15	0.9
al	.2-.8	0.5
c	0.08	0.08
mn	0.35	0.35
si	0.35	0.35
b	0.006	0.006
cu	0.3	0.3
p	0.015	0.015
s	0.015	0.015
		100

SS CF3M		
Element	Range	Used
c	0.03	0.03
mn	1.5	1.5
si	2	2
cr	17-21	19
ni	8.-12	11.92
mo	2.-3	2.5
fe	balance	62.97
		99.92
co		0.08

ss302		
Element	Range	Used
c	0.15	0.15
mn	2	2
p	0.045	0.045
s	0.03	0.03
si	0.75	0.75
cr	17-19	18
ni	8.-10	9.92
mo	0	0
n	0.1	0.1
cu	0	0
fe	balance	68.925
		99.92
co		0.08

REORGANIZED DATA BY ELEMENT:

Material: / Element	SS 304	SS304L	Zircaloy-4	Inconel-718	SS CF3M	ss302
al	0	0	0	0.5	0	0
b	0	0	0	0.006	0	0
c	0.08	0.03	0	0.08	0.03	0.15
co	0.08	0.08	0	1	0.08	0.08
cr	19	19	0.1	19	19	18
cu	0	0	0	0.3	0	0
fe	67.495	66.045	0.2	14.934	62.97	68.925
mn	2	2	0	0.35	1.5	2
mo	0	0	0	3.05	2.5	0
n	0.1	0.1	0	0	0	0.1
nb+ta	0	0	0	5.5	0	0
ni	10.42	11.92	0	54	11.92	9.92
o	0	0	0.12	0	0	0
p	0.045	0.045	0	0.015	0	0.045
s	0.03	0.03	0	0.015	0	0.03
si	0.75	0.75	0	0.35	2	0.75
sn	0	0	1.7	0	0	0
ti	0	0	0	0.9	0	0
zr	0	0	97.88	0	0	0
	100	100	100	100	100	100

***Here the assumption of a 0.08wt% Cobalt impurity in the steels.

Attachment III – Worksheet "impurities.test.cases"

PWR U mass (g) **475000** **PWR mass (kg)** **539.7727273**

PWR assembly volume (cc) **54194.05**

Impurities	atomic mass (g)	PWR ppm/U	mass (kg)	at dens	
Li	6.941	1	0.000475	7.6043E-07	
B	10.811	1	0.000475	4.8822E-07	
C	12.0107	89.4	0.042465	3.9287E-05	
N	14.00674	25	0.011875	9.4208E-06	
F	18.9984032	10.7	0.0050825	2.9727E-06	
Na	22.98977	15	0.007125	3.4438E-06	
Mg	24.305	2	0.00095	4.3433E-07	
Al	26.981538	16.7	0.0079325	3.2669E-06	
Si	28.0855	12.1	0.0057475	2.2740E-06	
P	30.973761	35	0.016625	5.9643E-06	
Cl	35.4527	5.3	0.0025175	7.8906E-07	
Ca	40.078	2	0.00095	2.6339E-07	
Ti	47.867	1	0.000475	1.1027E-07	
V	50.9415	3	0.001425	3.1084E-07	
Cr	51.9961	4	0.0019	4.0604E-07	
Mn	54.938049	1.7	0.0008075	1.6333E-07	
Fe	55.845	18	0.00855	1.7013E-06	
Co	58.9332	1	0.000475	8.9562E-08	
Ni	58.6934	24	0.0114	2.1583E-06	
Cu	63.546	1	0.000475	8.3060E-08	VF
Zn	65.39	40.3	0.0191425	3.2529E-06	0.000035464
Mo	95.94	10	0.00475	5.5015E-07	
Ag	107.8682	0.1	0.0000475	4.8932E-09	
Cd	112.411	25	0.011875	1.1739E-06	
In	114.818	2	0.00095	9.1940E-08	
Sn	118.71	4	0.0019	1.7785E-07	
W	183.84	2	0.00095	5.7421E-08	
Pb	207.2	1	0.000475	2.5474E-08	
Bi	208.98038	0.4	0.00019	1.0103E-08	
Total			0.1680075		

		mass (g)	at. Dens.
cl	10	4.75	1.48879E-06

Attachment III - Worksheet "impurities.test.cases"

Light Elements (PWR)

element	From hardware mass (kg)	Add impurities mass (kg)
al	0.0245	0.0324
b	0.0003	0.0008
c	0.0039	0.0464
co	0.0490	0.0495
cr	1.0461	1.0480
cu	0.0147	0.0152
fe	0.9819	0.9904
mn	0.0172	0.0180
mo	0.1495	0.1542
n	0.0000	0.0119
nb	0.2511	0.2511
ni	2.6460	2.6574
o	0.1381	64.9081
p	0.0000	0.0166
s	0.0000	0.0000
si	0.0172	0.0229
sn	1.6117	1.6136
ti	0.0441	0.0446
zr	113.0252	113.0252
li		0.000475
f		0.0050825
na		0.007125
mg		0.00095
cl		0.0025175
ca		0.00095
v		0.001425
zn		0.0191425
ag		0.0000475
cd		0.011875
in		0.00095
w		0.00095
pb		0.000475
bi		0.00019

Zn mass (g)	**19.1425**		
	at mass (g)	**wt fr**	**at dens**
Zn-64	63.929146	0.4751	1.5808E-06
Zn-66	65.926036	0.28126	9.0748E-07
Zn-67	66.927131	0.04196	1.3336E-07
Zn-68	67.924847	0.19527	6.1150E-07
Zn-70	69.925325	0.00642	1.9529E-08
		1.00001	3.2527E-06

Ag mass (g)	**0.0475**		
	at mass (g)	**wt fr**	
Ag-107	106.90509	0.51377	2.5366E-09
Ag-109	108.904756	0.48623	2.3566E-09
		1	4.8932E-09

In mass (g)	**0.95**		
	at mass (g)	**wt fr**	
In-113	112.904062	0.04228	3.9531E-09
In-115	114.903879	0.95772	8.7987E-08
		1	9.1940E-08

Sn mass (g)	**1.9**		
	at mass (g)	**wt fr**	
Sn-112	111.90482	0.00914	1.7244E-09
Sn-114	113.902782	0.00624	1.1566E-09
Sn-115	114.903347	0.00348	6.3942E-10
Sn-116	115.901745	0.14186	2.5841E-08
Sn-117	116.902955	0.07563	1.3659E-08
Sn-118	117.901608	0.24055	4.3075E-08
Sn-119	118.903311	0.08594	1.5260E-08
Sn-120	119.902198	0.32917	5.7961E-08
Sn-122	121.903441	0.04755	8.2353E-09
Sn-124	123.905274	0.06043	1.0297E-08
		0.99999	1.7785E-07

B mass (g)	**0.475**		
	at mass (g)	**wt fr**	
b-10	10.0129371	0.18431	9.71561E-08
b-11	11.0093055	0.81569	3.91064E-07
			4.8822E-07

Li mass (g)	**0.475**		
	at mass (g)	**wt fr**	
li-6	6.015122	0.065	5.70363E-08
li-7	7.016004	0.935	7.03404E-07
			7.6044E-07

Attachment III - Worksheet "South.Texas.impurities"

South Texas impurities and number densities **539.7727273**
PWR U mass (g) **550000** **PWR mass (kg)** **625**

PWR assembly volume (cc) **62751.00402**

Impurities	atomic mass (g)	ppm/U	PWR mass (kg)	at dens	
Li	6.941	1	0.00055	7.6043E-07	
B	10.811	1	0.00055	4.8822E-07	
C	12.0107	89.4	0.04917	3.9287E-05	
N	14.00674	25	0.01375	9.4208E-06	
F	18.9984032	10.7	0.005885	2.9727E-06	
Na	22.98977	15	0.00825	3.4438E-06	
Mg	24.305	2	0.0011	4.3433E-07	
Al	26.981538	16.7	0.009185	3.2669E-06	
Si	28.0855	12.1	0.006655	2.2740E-06	
P	30.973761	35	0.01925	5.9643E-06	
Cl	35.4527	5.3	0.002915	7.8906E-07	
Ca	40.078	2	0.0011	2.6339E-07	
Ti	47.867	1	0.00055	1.1027E-07	
V	50.9415	3	0.00165	3.1084E-07	
Cr	51.9961	4	0.0022	4.0604E-07	
Mn	54.938049	1.7	0.000935	1.6333E-07	
Fe	55.845	18	0.0099	1.7013E-06	VF
Co	58.9332	1	0.00055	8.9562E-08	0.000035464
Ni	58.6934	24	0.0132	2.1583E-06	
Cu	63.546	1	0.00055	8.3061E-08	
Zn	65.39	40.3	0.022165	3.2529E-06	
Mo	95.94	10	0.0055	5.5015E-07	
Ag	107.8682	0.1	0.000055	4.8932E-09	
Cd	112.411	25	0.01375	1.1739E-06	
In	114.818	2	0.0011	9.1940E-08	
Sn	118.71	4	0.0022	1.7785E-07	
W	183.84	2	0.0011	5.7421E-08	
Pb	207.2	1	0.00055	2.5474E-08	
Bi	208.98038	0.4	0.00022	1.0103E-08	
Total			0.194535		

		mass (g)	at. Dens.
cl	10	5.5	1.72386E-06

Attachment III - Worksheet 'South.Texas.impurities'

Light Elements (PWR)

element	From hardware mass (kg)	Add impurities mass (kg)
al	0.0245	0.0337
b	0.0003	0.0008
c	0.0039	0.0531
co	0.0490	0.0496
cr	1.0461	1.0483
cu	0.0147	0.0153
fe	0.9819	0.9918
mn	0.0172	0.0181
mo	0.1495	0.1550
n	0.0000	0.0138
nb	0.2511	0.2511
ni	2.6460	2.6592
o	0.1381	64.9081
p	0.0000	0.0193
s	0.0000	0.0000
si	0.0172	0.0238
sn	1.6117	1.6139
ti	0.0441	0.0447
zr	113.0252	113.0252
li		0.000475
f		0.005885
na		0.00825
mg		0.0011
cl		0.002915
ca		0.0011
v		0.00165
zn		0.022165
ag		0.000055
cd		0.01375
in		0.0011
w		0.0011
pb		0.00055
bi		0.00022

Zn mass (g)	**22.165**		
	at mass (g)	**wt fr**	**at dens**
Zn-64	63.929146	0.4751	1.5808E-06
Zn-66	65.926036	0.28126	9.0748E-07
Zn-67	66.927131	0.04196	1.3336E-07
Zn-68	67.924847	0.19527	6.1150E-07
Zn-70	69.925325	0.00642	1.9529E-08
		1.00001	3.2527E-06

Ag mass (g)	**0.055**		
	at mass (g)	**wt fr**	
Ag-107	106.90509	0.51377	2.5366E-09
Ag-109	108.904756	0.48623	2.3566E-09
		1	4.8932E-09

In mass (g)	**1.1**		
	at mass (g)	**wt fr**	
In-113	112.904062	0.04228	3.9531E-09
In-115	114.903879	0.95772	8.7987E-08
		1	9.1940E-08

Sn mass (g)	**2.2**		
	at mass (g)	**wt fr**	
Sn-112	111.90482	0.00914	1.7244E-09
Sn-114	113.902782	0.00624	1.1566E-09
Sn-115	114.903347	0.00348	6.3942E-10
Sn-116	115.901745	0.14186	2.5841E-08
Sn-117	116.902955	0.07563	1.3659E-08
Sn-118	117.901608	0.24055	4.3075E-08
Sn-119	118.903311	0.08594	1.5260E-08
Sn-120	119.902198	0.32917	5.7961E-08
Sn-122	121.903441	0.04755	8.2353E-09
Sn-124	123.905274	0.06043	1.0297E-08
		0.99999	1.7785E-07

B mass (g)	**0.55**		
	at mass (g)	**wt fr**	
b-10	10.0129371	0.18431	9.7156E-08
b-11	11.0093055	0.81569	3.9106E-07
			4.8822E-07

Li mass (g)	**0.55**		
	at mass (g)	**wt fr**	
li-6	6.015122	0.065	5.7036E-08
li-7	7.016004	0.935	7.034E-07
			7.6044E-07

Attachment III - Worksheet 'impurities'

For volumes and weights, see Attachment I

PWR U mass (g)	**475000**	**PWR mass (kg)**	**539.7727273**
South Texas U mass (g)	**550000**	**South Texas mass (kg)**	**625**
PWR assembly volume (cc)	**54194.05**		
South Texas assembly volume (cc)	**62751**		

			PWR		**South Texas**		
Impurities	**atomic mass (g)**	**ppm/U**	**mass (kg)**	**at dens**	**mass (kg)**	**at dens**	
Li	6.941	1	0.000475	7.6043E-07	0.00055	**7.6043E-07**	
B	10.811	1	0.000475	4.8822E-07	0.00055	4.8822E-07	
C	12.0107	89.4	0.042465	3.9287E-05	0.04917	3.9287E-05	
N	14.00674	25	0.011875	9.4208E-06	0.01375	9.4208E-06	
F	18.9984032	10.7	0.005083	2.9727E-06	0.005885	2.9727E-06	
Na	22.98977	15	0.007125	3.4438E-06	0.00825	3.4438E-06	
Mg	24.305	2	0.00095	4.3433E-07	0.0011	4.3433E-07	
Al	26.981538	16.7	0.007933	3.2669E-06	0.009185	3.2669E-06	
Si	28.0855	12.1	0.005748	2.2740E-06	0.006655	2.2740E-06	
P	30.973761	35	0.016625	5.9643E-06	0.01925	5.9643E-06	
Cl	35.4527	5.3	0.002518	7.8906E-07	0.002915	7.8906E-07	
Ca	40.078	2	0.00095	2.6339E-07	0.0011	2.6339E-07	
Ti	47.867	1	0.000475	1.1027E-07	0.00055	1.1027E-07	
V	50.9415	3	0.001425	3.1084E-07	0.00165	3.1084E-07	
Cr	51.9961	4	0.0019	4.0604E-07	0.0022	4.0604E-07	
Mn	54.938049	1.7	0.000808	1.6333E-07	0.000935	1.6333E-07	
Fe	55.845	18	0.00855	1.7013E-06	0.0099	1.7013E-06	VF
Co	58.9332	1	0.000475	8.9562E-08	0.00055	8.9562E-08	3.5464E-05
Ni	58.6934	24	0.0114	2.1583E-06	0.0132	2.1583E-06	
Cu	63.546	1	0.000475	8.3060E-08	0.00055	8.3061E-08	
Zn	65.39	40.3	0.019143	3.2529E-06	0.022165	3.2529E-06	
Mo	95.94	10	0.00475	5.5015E-07	0.0055	5.5015E-07	
Ag	107.8682	0.1	4.75E-05	4.8932E-09	0.000055	4.8932E-09	
Cd	112.411	25	0.011875	1.1739E-06	0.01375	1.1739E-06	
In	114.818	2	0.00095	9.1940E-08	0.0011	9.1940E-08	
Sn	118.71	4	0.0019	1.7785E-07	0.0022	1.7785E-07	
W	183.84	2	0.00095	5.7421E-08	0.0011	5.7421E-08	
Pb	207.2	1	0.000475	2.5474E-08	0.00055	2.5474E-08	
Bi	208.98038	0.4	0.00019	1.0103E-08	0.00022	1.0103E-08	
Total			0.168008		0.194535		

Attachment III - Worksheet "tables"

element	Waste Stream Composition (kg/assembly)						
	fuel	impurities	fuel oxygen	Total	bottom	plenum	top
Ag		4.75E-05		0.000048			
Al	0.0245	0.007933		0.032433	0.0020	0.0016	0.0014
B	0.00029	0.000475		0.000769	0.0000	0.0000	0.0000
Bi		0.00019		0.000190			
C	0.00392	0.042465		0.046385	0.0010	0.0003	0.0006
Ca		0.00095		0.000950			
Cd		0.011875		0.011875			
Cl		0.002518		0.002518			
Co	0.04900	0.000475		0.049475	0.0059	0.0031	0.0038
Cr	1.04612	0.0019		1.048020	0.5393	0.0632	0.3067
Cu	0.01470	0.000475		0.015175	0.0012	0.0009	0.0008
F		0.005083		0.005083			
Fe	0.96200	0.00855		0.970550	1.5998	0.0563	0.8894
In		0.00095		0.000950			
Li		0.000475		0.000475			
Mg		0.00095		0.000950			
Mn	0.01715	0.000808		0.017958	0.0381	0.0012	0.0215
Mo	0.14945	0.00475		0.154200	0.0731	0.0095	0.0397
N	0.00000	0.011875		0.011875	0.0000	0.0000	0.0001
Na		0.007125		0.007125			
Nb	0.26950			0.269500	0.0215	0.0172	0.0149
Ni	2.64600	0.0114		2.657400	0.5024	0.1690	0.3059
O	0.13814		64.77273	64.910872	0.0001	0.0035	0.0000
P	0.00070	0.016625		0.017325	0.0001	0.0000	0.0001
Pb		0.000475		0.000475			
S	0.00070			0	0.0001	0.0000	0.0001
Si	0.01715	0.005748		0.022898	0.0503	0.0011	0.0268
Sn	1.95705	0.0019		1.958947	0.0008	0.0489	0.0000
Ti	0.04410	0.000475		0.044575	0.0035	0.0028	0.0024
V		0.001425		0.001425			
W		0.00095		0.000950			
Zn		0.019143		0.019143			
Zr	112.67989			112.679885	0.0440	2.8164	0.0000

Attachment III - Worksheet "tables"

element	South Texas Composition (kg/assembly)				Steel Clad Composition (kg/assembly)				
	fuel	fuel oxygen	impurities	Total	fuel hardware	fuel oxygen	impurities	Total	plenum
Ag			0.000055	0.00006			4.75E-05	4.75E-05	
Al	0.0245		0.009185	0.03369	0.0245		0.00793	0.03243	0.00156
B	0.0003		0.00055	0.00084	0.00029		0.00048	0.00077	0.00002
Bi			0.00022	0.00022			0.00019	0.00019	
C	0.0039		0.04917	0.05309	0.11421		0.04247	0.15668	0.00303
Ca			0.0011	0.00110			0.00095	0.00095	
Cd			0.01375	0.01375			0.01188	0.01188	
Cl			0.002915	0.00292			0.00252	0.00252	
Co	0.0490		0.00055	0.04955	0.15929		0.00048	0.15977	0.00590
Cr	1.0742		0.0022	1.07645	27.12602		0.00190	27.1279	0.71868
Cu	0.0147		0.00055	0.01525	0.01470		0.00048	0.01518	0.00094
F			0.005885	0.00589			0.00508	0.00508	
Fe	1.0183		0.0099	1.02820	93.78510		0.00855	93.7937	2.38930
In			0.0011	0.00110			0.00095	0.00095	
Li			0.00055	0.00055			0.00048	0.00048	
Mg			0.0011	0.00110			0.00095	0.00095	
Mn	0.0172		0.000935	0.01809	2.77445		0.00081	2.77526	0.07051
Mo	0.1495		0.0055	0.15495	0.14945		0.00475	0.1542	0.00952
N	0.0000		0.01375	0.01375	0.13787		0.01188	0.14974	0.00347
Na			0.00825	0.00825			0.00713	0.00713	
Nb	0.2695			0.26950	0.26950			0.2695	0.01720
Ni	2.6460		0.0132	2.65920	17.01150		0.01140	17.0229	0.53010
O	0.1719	75.00000		75.17190	0.00077	64.77273		64.7735	0.00000
P	0.0007		0.01925	0.01995	0.06280		0.01663	0.07943	0.00610
Pb			0.00055	0.00055			0.00048	0.00048	
S	0.0007			0	0.04210			0.0421	0.00110
Si	0.0172		0.006655	0.02381	1.05114		0.00575	1.05689	0.02712
Sn	2.4352		0.0022	2.43744	0.01088		0.00190	0.01278	0.00000
Ti	0.0441		0.00055	0.04465	0.04410		0.00048	0.04458	0.00281
V			0.00165	0.00165			0.00143	0.00143	
W			0.0011	0.00110			0.00095	0.00095	
Zn			0.022165	0.02217			0.01914	0.01914	
Zr	140.2127			140.21265	0.62643			0.62643	0.00000

Attachment III - Worksheet "Steel clad"

Materials and cladding mass updated 8/16	cladding volume (cm^3)	17596.28				Guide tube mass (kg)	9.634146			
	cladding mass (g)	139010.6				Instrument tube mass (kg)	0.770732			
		fuel:	92%	plenum	8%	Oxygen from fuel not included in these tables. See final worksheet 'tables'				
Region	Fuel					Plenum				
	guide tubes	instrument tube	incore spacers	cladding	grid supports	guide tubes	instrument tube	cladding	spacers	springs
	8.889393	0.711151	4.9	128.2646	0.64	0.744753	0.05958	10.74601	1.04	0.019
	SS 304	SS304	Inconel-718	SS304	Zircaloy-4	SS 304	SS 304	SS 304	Inconel-718	SS 302
al	0	0	0.5	0	0	0	0	0	0.5	0
b	0	0	0.006	0	0	0	0	0	0.006	0
c	0.08	0.08	0.08	0.08	0	0.08	0.08	0.08	0.08	0.15
co	0.08	0.08	1	0.08	0	0.08	0.08	0.08	1	0.08
cr	19	19	19	19	0.1	19	19	19	19	18
cu	0	0	0.3	0	0	0	0	0	0.3	0
fe	67.495	67.495	14.934	67.495	0.2	67.495	67.495	67.495	14.934	68.925
mn	2	2	0.35	2	0	2	2	2	0.35	2
mo	0	0	3.05	0	0	0	0	0	3.05	0
n	0.1	0.1	0	0.1	0	0.1	0.1	0.1	0	0.1
nb+ta	0	0	5.5	0	0	0	0	0	5.5	0
ni	10.42	10.42	54	10.42	0	10.42	10.42	10.42	54	9.92
o	0	0	0	0	0.12	0	0	0	0	0
p	0.045	0.045	0.015	0.045	0	0.045	0.045	0.045	0.015	0.045
s	0.03	0.03	0.015	0.03	0	0.03	0.03	0.03	0.015	0.03
si	0.75	0.75	0.35	0.75	0	0.75	0.75	0.75	0.35	0.75
sn	0	0	0	0	1.7	0	0	0	0	0
ti	0	0	0.9	0	0	0	0	0	0.9	0
zr	0	0	0	0	97.88	0	0	0	0	0

Element Mass Calculations	Fuel						Plenum					
	guide tubes	instrument tube	incore spacers	cladding	grid supports		guide tubes	instrument tube	cladding	spacers	springs	
	8.889393	0.711151	4.9	128.2646	0.64		0.744753	0.05958	10.74601	1.04	0.019	
	SS 304	SS 304	Inconel-718	SS 304	Zircaloy-4	TOTALS	SS 304	SS 304	SS 304	Inconel-718	SS 302	TOTALS
al	0.0000	0.0000	0.0245	0.0000	0.0000	0.0245	0.0000	0.0000	0.0000	0.0016	0.0000	0.0016
b	0.0000	0.0000	0.0003	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
c	0.0071	0.0006	0.0039	0.1026	0.0000	0.1142	0.0002	0.0000	0.0026	0.0002	0.0000	0.0030
co	0.0071	0.0006	0.0490	0.1026	0.0000	0.1593	0.0002	0.0000	0.0026	0.0031	0.0000	0.0059
cr	1.6890	0.1351	0.9310	24.3703	0.0006	27.1260	0.0425	0.0034	0.6125	0.0593	0.0010	0.7187
cu	0.0000	0.0000	0.0147	0.0000	0.0000	0.0147	0.0000	0.0000	0.0000	0.0009	0.0000	0.0009
fe	5.9999	0.4800	0.7318	86.5722	0.0013	93.7851	0.1508	0.0121	2.1759	0.0466	0.0039	2.3893
mn	0.1778	0.0142	0.0172	2.5653	0.0000	2.7745	0.0045	0.0004	0.0645	0.0011	0.0001	0.0705
mo	0.0000	0.0000	0.1495	0.0000	0.0000	0.1495	0.0000	0.0000	0.0000	0.0095	0.0000	0.0095
n	0.0089	0.0007	0.0000	0.1283	0.0000	0.1379	0.0002	0.0000	0.0032	0.0000	0.0000	0.0035
nb+ta	0.0000	0.0000	0.2695	0.0000	0.0000	0.2695	0.0000	0.0000	0.0000	0.0172	0.0000	0.0172
ni	0.9263	0.0741	2.6460	13.3652	0.0000	17.0115	0.0233	0.0019	0.3359	0.1685	0.0006	0.5301
o	0.0000	0.0000	0.0000	0.0000	0.0008	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
p	0.0040	0.0003	0.0007	0.0577	0.0000	0.0628	0.0001	0.0000	0.0015	0.0000	0.0000	0.0016
s	0.0027	0.0002	0.0007	0.0385	0.0000	0.0421	0.0001	0.0000	0.0010	0.0000	0.0000	0.0011
si	0.0667	0.0053	0.0172	0.9620	0.0000	1.0511	0.0017	0.0001	0.0242	0.0011	0.0000	0.0271
sn	0.0000	0.0000	0.0000	0.0000	0.0109	0.0109	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ti	0.0000	0.0000	0.0441	0.0000	0.0000	0.0441	0.0000	0.0000	0.0000	0.0028	0.0000	0.0028
zr	0.0000	0.0000	0.0000	0.0000	0.6264	0.6264	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTALS	8.889	0.711	4.900	128.265	0.640	143.405	0.223	0.018	3.224	0.312	0.006	3.783
kg*SCALING FACTOR	8.889	0.711	4.900	128.265	0.640		0.223	0.018	3.224	0.312	0.006	

Attachment III - Worksheet "South Texas"

****Oxygen from fuel not included in these tables. See final worksheet 'tables'	fuel plus plenum length	478.8452	Fractions in fuel and plenum
	cladding volume (CM^3)	21585.65305	fuel: 94% plenum 6%
	cladding mass (g)	141601.88	
	South Texas/Mark B	1.22671674	

	Part Name	guide tubes	instrument tube	incore spacers	cladding	grid supports
	kg/assembly	9.195305715	0.73562446	4.9	132.6786137	0.64
	Material	Zircaloy-4	Zircaloy-4	Inconel-718	Zircaloy-4	Zircaloy-4
Wt % of the constituent isotopes	al	0	0	0.5	0	0
	b	0	0	0.006	0	0
	c	0	0	0.08	0	0
	co	0	0	1	0	0
	cr	0.1	0.1	19	0.1	0.1
	cu	0	0	0.3	0	0
	fe	0.2	0.2	14.934	0.2	0.2
	mn	0	0	0.35	0	0
	mo	0	0	3.05	0	0
	n	0	0	0	0	0
	nb+ta	0	0	5.5	0	0
	ni	0	0	54	0	0
	o	0.12	0.12	0	0.12	0.12
	p	0	0	0.015	0	0
	s	0	0	0.015	0	0
	si	0	0	0.35	**0**	0
	sn	1.7	1.7	0	1.7	1.7
	ti	0	0	0.9	0	0
	zr	97.88	97.88	0	97.88	97.88

	Region						
	Part Name	guide tubes	instrument tube	incore spacers	cladding	grid supports	
Element Mass Calculations	kg/assembly	9.195305715	0.73562446	4.9	132.6786137	0.64	
	Material	Zircaloy-4	Inconel-718	Inconel-718	Zircaloy-4	Zircaloy-4	TOTALS
	al	0.0000	0.0000	0.0245	0.0000	0.0000	0.0245
	b	0.0000	0.0000	0.0003	0.0000	0.0000	0.0003
	c	0.0000	0.0000	0.0039	0.0000	0.0000	0.0039
	co	0.0000	0.0000	0.0490	0.0000	0.0000	0.0490
	cr	0.0092	0.0007	0.9310	0.1327	0.0006	1.0742
	cu	0.0000	0.0000	0.0147	0.0000	0.0000	0.0147
	fe	0.0184	0.0015	0.7318	0.2654	0.0013	1.0183
	mn	0.0000	0.0000	0.0172	0.0000	0.0000	0.0172
	mo	0.0000	0.0000	0.1495	0.0000	0.0000	0.1495
	n	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	nb+ta	0.0000	0.0000	0.2695	0.0000	0.0000	0.2695
	ni	0.0000	0.0000	2.6460	0.0000	0.0000	2.6460
	o	0.0110	0.0009	0.0000	0.1592	0.0008	0.1719
	p	0.0000	0.0000	0.0007	0.0000	0.0000	0.0007
	s	0.0000	0.0000	0.0007	0.0000	0.0000	0.0007
	si	0.0000	0.0000	0.0172	0.0000	0.0000	0.0172
	sn	0.1563	0.0125	0.0000	2.2555	0.0109	2.4352
	ti	0.0000	0.0000	0.0441	0.0000	0.0000	0.0441
	zr	9.0004	0.7200	0.0000	129.8658	0.6264	140.2127
	TOTALS	9.195	0.736	4.900	132.679	0.640	148.150
	kg*SCALING FACTOR	9.195	0.736	4.900	0.638	0.640	16.109

Attachment III - Worksheet "Waste Stream"

Materials and cladding mass updated 8/16	****Oxygen from fuel not included in these tables. See final worksheet 'tables'

	Region	Top					Bottom		
	Part Name	top nozzle	spring retainer	hold down spring	upper end plug	upper nuts	bottom nozzle	bottom spacer	lower nuts
	kg/assembly	7.48	0.91	1.8	0.06	0.51	8.16	1.3	0.15
	Material	SS CF3M	SS CF3M	Inconel-718	SS 304	SS 304L	SS CF3M	Inconel-718	Zircaloy-4
Wt % of the constituent isotopes	al	0	0	0.5	0	0	0	0.5	0
	b	0	0	0.006	0	0	0	0.006	0
	c	0.03	0.03	0.08	0.08	0.03	0.03	0.08	0
	co	0.08	0.08	1	0.08	0.08	0.08	1	0
	cr	19	19	19	19	19	19	19	0.1
	cu	0	0	0.3	0	0	0	0.3	0
	fe	62.97	62.97	14.934	67.495	66.045	62.97	14.934	0.2
	mn	1.5	1.5	0.35	2	2	1.5	0.35	0
	mo	2.5	2.5	3.05	0	0	2.5	3.05	0
	n	0	0	0	0.1	0.1	0	0	0
	nb+ta	0	0	5.5	0	0	0	5.5	0
	ni	11.92	11.92	54	10.42	11.92	11.92	54	0
	o	0	0	0	0	0	0	0	0.12
	p	0	0	0.015	0.045	0.045	0	0.015	0
	s	0	0	0.015	0.03	0.03	0	0.015	0
	si	2	2	0.35	0.75	0.75	2	0.35	0
	sn	0	0	0	0	0	0	0	1.7
	ti	0	0	0.9	0	0	0	0.9	0
	zr	0	0	0	0	0	0	0	97.88

Element Mass Calculations	Region	Top						Bottom			
	Part Name	top nozzle	spring retainer	hold down spring	upper end plug	upper nuts		bottom nozzle	bottom spacer	lower nuts	
	kg/assembly	7.48	0.91	1.8	0.06	0.51		8.16	1.3	0.15	
	Material	SS CF3M	SS CF3M	Inconel-718	SS 304	SS 304L	TOTALS	SS CF3M	Inconel-718	Zircaloy-4	TOTALS
	al	0.0000	0.0000	0.0014	0.0000	0.0000	0.0014	0.0000	0.0020	0.0000	0.0020
	b	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	c	0.0003	0.0000	0.0002	0.0000	0.0000	0.0006	0.0007	0.0003	0.0000	0.0010
	co	0.0009	0.0001	0.0027	0.0000	0.0001	0.0038	0.0020	0.0039	0.0000	0.0059
	cr	0.2132	0.0259	0.0513	0.0017	0.0145	0.3067	0.4651	0.0741	0.0000	0.5393
	cu	0.0000	0.0000	0.0008	0.0000	0.0000	0.0008	0.0000	0.0012	0.0000	0.0012
	fe	0.7065	0.0860	0.0403	0.0061	0.0505	0.8894	1.5415	0.0582	0.0001	1.5998
	mn	0.0168	0.0020	0.0009	0.0002	0.0015	0.0215	0.0367	0.0014	0.0000	0.0381
	mo	0.0281	0.0034	0.0082	0.0000	0.0000	0.0397	0.0612	0.0119	0.0000	0.0731
	n	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
	nb+ta	0.0000	0.0000	0.0149	0.0000	0.0000	0.0149	0.0000	0.0215	0.0000	0.0215
	ni	0.1337	0.0163	0.1458	0.0009	0.0091	0.3059	0.2918	0.2106	0.0000	0.5024
	o	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
	p	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001
	s	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001
	si	0.0224	0.0027	0.0009	0.0001	0.0006	0.0268	0.0490	0.0014	0.0000	0.0503
	sn	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0008
	ti	0.0000	0.0000	**0.0024**	0.0000	0.0000	0.0024	0.0000	0.0035	0.0000	0.0035
	zr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0440	0.0440
	TOTALS	1.122	0.137	0.270	0.009	0.077	1.614	2.448	0.390	0.045	2.883
	kg*SCALING FACTOR	1.122	0.137	0.270	0.009	0.077	1.614	2.448	0.390	0.045	2.883

Attachment III - Worksheet "Waste Stream"

	cladding volume (CM^3)	17596.28								
	cladding mass (g)	115431.61								
	Fractions in fuel and plenum			fuel:	92%	plenum	8%			
Region	FUEL					PLENUM				
	guide tubes	instrument tube	incore spacers	cladding	grid supports	guide tubes	instrument tube	cladding	spacers	springs
	7.381572	0.590526	4.9	106.50834	0.64	0.618428	0.049474	8.923266	1.04	0.019
	Zircaloy-4	Zircaloy-4	Inconel-718	Zircaloy-4	Zircaloy-4	Zircaloy-4	Zircaloy-4	Zircaloy-4	Inconel-718	SS 302
Wt % of the constituent isotopes	0	0	0.5	0	0	0	0	0	0.5	0
	0	0	0.006	0	0	0	0	0	0.006	0
	0	0	0.08	0	0	0	0	0	0.08	0.15
	0	0	1	0	0	0	0	0	1	0.08
	0.1	0.1	19	0.1	0.1	0.1	0.1	0.1	19	18
	0	0	0.3	0	0	0	0	0	0.3	0
	0.2	0.2	14.934	0.2	0.2	0.2	0.2	0.2	14.934	68.925
	0	0	0.35	0	0	0	0	0	0.35	2
	0	0	3.05	0	0	0	0	0	3.05	0
	0	0	0	0	0	0	0	0	0	0.1
	0	0	5.5	0	0	0	0	0	5.5	0
	0	0	54	0	0	0	0	0	54	9.92
	0.12	0.12	0	0.12	0.12	0.12	0.12	0.12	0	0
	0	0	0.015	0	0	0	0	0	0.015	0.045
	0	0	0.015	0	0	0	0	0	0.015	0.03
	0	0	0.35	0	0	0	0	0	0.35	0.75
	1.7	1.7	0	1.7	1.7	1.7	1.7	1.7	0	0
	0	0	0.9	0	0	0	0	0	0.9	0
	97.88	97.88	0	97.88	97.88	97.88	97.88	97.88	0	0

	FUEL						PLENUM					
Element Mass Calculations	guide tubes	instrument tube	incore spacers	cladding	grid supports		guide tubes	instrument tube	cladding	spacers	springs	
	7.381572	0.590526	4.9	106.50834	0.64		0.618428	0.049474	8.923266	1.04	0.019	
	Zircaloy-4	Zircaloy-4	Inconel-718	Zircaloy-4	Zircaloy-4	TOTALS	Zircaloy-4	Zircaloy-4	Zircaloy-4	Inconel-718	SS 302	TOTALS
	0.0000	0.0000	0.0245	0.0000	0.0000	0.0245	0.0000	0.0000	0.0000	0.0016	0.0000	0.0016
	0.0000	0.0000	0.0003	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0039	0.0000	0.0000	0.0039	0.0000	0.0000	0.0000	0.0002	0.0000	0.0003
	0.0000	0.0000	0.0490	0.0000	0.0000	0.0490	0.0000	0.0000	0.0000	0.0031	0.0000	0.0031
	0.0074	0.0006	0.9310	0.1065	0.0006	1.0461	0.0002	0.0000	0.0027	0.0593	0.0010	0.0632
	0.0000	0.0000	0.0147	0.0000	0.0000	0.0147	0.0000	0.0000	0.0000	0.0009	0.0000	0.0009
	0.0148	0.0012	0.7318	0.2130	0.0013	0.9620	0.0004	0.0000	0.0054	0.0466	0.0039	0.0563
	0.0000	0.0000	0.0172	0.0000	0.0000	0.0172	0.0000	0.0000	0.0000	0.0011	0.0001	0.0012
	0.0000	0.0000	0.1495	0.0000	0.0000	0.1495	0.0000	0.0000	0.0000	0.0095	0.0000	0.0095
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.2695	0.0000	0.0000	0.2695	0.0000	0.0000	0.0000	0.0172	0.0000	0.0172
	0.0000	0.0000	2.6460	0.0000	0.0000	2.6460	0.0000	0.0000	0.0000	0.1685	0.0006	0.1690
	0.0089	0.0007	0.0000	0.1278	0.0008	0.1381	0.0002	0.0000	0.0032	0.0000	0.0000	0.0035
	0.0000	0.0000	0.0007	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0007	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0172	0.0000	0.0000	0.0172	0.0000	0.0000	0.0000	0.0011	0.0000	0.0011
	0.1255	0.0100	0.0000	1.8106	0.0109	1.9570	0.0032	0.0003	0.0455	0.0000	0.0000	0.0489
	0.0000	0.0000	0.0441	0.0000	0.0000	0.0441	0.0000	0.0000	0.0000	0.0028	0.0000	0.0028
	7.2251	0.5780	0.0000	104.2504	0.6264	112.6799	0.1816	0.0145	2.6202	0.0000	0.0000	2.8164
TOTALS kg*SCALING FACTOR	7.382	0.591	4.900	106.508	0.640	120.020	0.186	0.015	2.677	0.312	0.006	3.195
	7.382	0.591	4.900	0.512	0.640	14.024	0.186	0.015	2.677	0.312	0.006	3.195

Attachment IV

Comparison of Source Terms per MTU of 4 Average PWR SNF Assemblies

	4%-48GWd-25y (475 MTU/Assembly)	3.75%-41.2GWD-23y (432 MTU/Assembly)	3.75%-41.7GWd-25y (434 MTU/Assembly)	3.82%-42.6GWd-22y (432 MTU/Assembly)
Curies				
Activation Products	9.6490E+02	9.7950E+02	8.6260E+02	1.0830E+03
Actinides and daughters	6.3270E+04	6.2700E+04	5.8460E+04	6.6380E+04
Fission products	2.7740E+05	2.5350E+05	2.4360E+05	2.6820E+05
Total	3.4180E+05	3.1720E+05	3.0290E+05	3.3580E+05
Watts				
Activation Products	6.4270E+00	7.4370E+00	5.8040E+00	8.6610E+00
Actinides and daughters	4.6310E+02	3.6000E+02	3.6600E+02	3.8180E+02
Fission products	7.9390E+02	7.2600E+02	6.9640E+02	7.6900E+02
Total	1.2650E+03	1.0940E+03	1.0690E+03	1.1590E+03
Grams				
Activation Products	4.4030E+05	**4.4030E+05**	4.4030E+05	4.4030E+05
Actinides and daughters	9.5050E+05	9.5740E+05	9.5690E+05	9.5590E+05
Fission products	4.9330E+04	4.2400E+04	4.2870E+04	4.3830E+04
Total	1.4400E+06	1.4400E+06	1.4400E+06	1.4400E+06
Neutrons/s				
Alpha,n	1.3490E+07	1.0420E+07	1.0580E+07	1.1070E+07
Sponteneous fission	4.2280E+08	2.7610E+08	2.6950E+08	3.1690E+08
Total neutrons	4.3650E+08	2.8650E+08	2.8030E+08	3.2810E+08
Photons/s				
Total intensity	6.7570E+15	6.1720E+15	5.9220E+15	6.5400E+15

Attachment V - Listing of UNIX Script Files

cut-script

```
batch43 INPUTFILE
csplit -f cut INPUTFILE.output "/module origens is finished/"\
 "/halt feature/"
cat cut00 cut02 > INPUTFILE.cut
rm cut0* INPUTFILE.output
```

curies

```
BEGIN {intable=0 && insas=0 }
/halt feature/ {insas=1}
/nuclide radioactivity/{if (insas) print $0; intable=1}
/initial/ {if (insas && intable) print $0}
/charge/ {if (insas && intable) print $0}
/E/ {if (insas && intable) print $0}
/total/ {intable=0}
```

gammas

```
BEGIN {insas=0 && intable=0}
/halt feature/{insas=1}
/gamma source spectrum/ {if (insas) intable=1; print $0}
/ to  / {if (insas && intable) print $0}
/totals/ {intable=0}
```

neutrons

```
BEGIN { intable=0}
/alpha-n plus/ {intable=1; print $0}
/yr/{if (intable) print $0}
/E/ {if (intable) print $0}
/ gamma sources determined / {intable=0}
```

watts

```
BEGIN {intable=0 && insas=0 }
/halt feature/ {insas=1}
/nuclide thermal power, watts/{if (insas) print $0; intable=1}
/charge/ {if (insas && intable) print $0}
/initial/ {if (insas && intable) print $0}
/E/ {if (insas && intable) print $0}
/total/ {intable=0}
```

Attachment VI - Calculation of Crud Source

South Texas information taken from 2A-361-2A-363

PWR assembly parameters to maximize surface area	Mark B	South Texas
Rod OD, cm	1.0922	0.95
Instrument tube OD	1.3462	1.25984
# of Rods	208	264
Rod Length	390.347	448.67
All dimensions in cm!		
# Guide and instrument tubes	17	25
Assembly Length	420.688	505.46
Instr. tube outside area+ inside area	3380.439626	3819.621782
PWR Assembly Surf. Area, cm^2	336057.9243	449002.7692
(Rod surface +instrument tubes inside and outside surfaces)		

Crud activities per unit area		
Co-60	1.40E-04	Ci/cm^2
NRC recommended value:	1.40E-04	Ci/cm^2
From Jones report, Table 1, p. 7		
Cr 51	1.89E-04	Ci/cm^2
Mn 54	7.40E-05	Ci/cm^2
Fe 55	5.90E-03	Ci/cm^2
Co 58	4.03E-04	Ci/cm^2
Fe 59	7.60E-05	Ci/cm^2
Co 60	5.10E-05	Ci/cm^2
Ni 63	2.00E-06	Ci/cm^2
Zn 65	0.00E+00	Ci/cm^2
Zr 95	1.90E-05	Ci/cm^2

Half Life information				
Cr 51	27.70	days	0.0758	years
Mn 54	312.10	days	0.8545	years
Fe 55	2.73	years	2.73	years
Co 58	70.88	days	0.1941	years
Fe 59	44.51	days	0.1219	years
Co 60	5.27	years	5.27	years
Ni 63	100.00	**years**	100.00	years
Zn 65	243.80	days	0.6675	years
Zr 95	64.02	days	0.1753	years

Attachment VI - Calculation of Crud Source

Fuel Age, years since reactor discharge	Crud (Ci) for regular assembly, using NRC Co 60 values	For South Texas Assembly, using NRC Co 60 values
0	47.05	62.86
5	24.38	32.57
6	21.37	28.56
7	18.74	25.04
8	16.43	21.95
9	14.41	19.25
10	12.63	16.88
11	11.07	14.80
15	6.54	8.74
20	3.39	4.53
25	1.76	2.35
30	0.91	1.22
35	0.47	0.63
40	0.24	0.33
45	0.13	0.17
50	0.07	0.09
55	0.03	0.05
60	0.02	0.02
65	0.01	0.01
70	0.00	0.01
75	0.00	0.00
80	0.00	0.00
85	0.00	0.00
90	0.00	0.00
95	0.00	0.00
100	0.00	0.00
200	0.00	0.00
300	0.00	0.00

Attachment VI - Calculation of Crud Source

Fuel Age, years since reactor discharge	Crud (Ci) for regular assembly, using Jones values								
	Cr 51	Mn 54	Fe 55	Co 58	Fe 59	Co 60	Ni 63	Zn 65	Zr 95
0	63.51	24.87	1983.41	135.43	25.54	17.14	0.67	0.00	6.39
5	0.00	0.43	557.28	0.00	0.00	8.88	0.65	0.00	0.00
6	0.00	0.19	432.32	0.00	0.00	7.79	0.64	0.00	0.00
7	0.00	0.09	335.38	0.00	0.00	6.83	0.64	0.00	0.00
8	0.00	0.04	260.18	0.00	0.00	5.99	0.64	0.00	0.00
9	0.00	0.02	201.84	0.00	0.00	5.25	0.63	0.00	0.00
10	0.00	0.01	156.58	0.00	0.00	4.60	0.63	0.00	0.00
11	0.00	0.00	121.47	0.00	0.00	4.03	0.62	0.00	0.00
15	0.00	0.00	43.99	0.00	0.00	2.38	0.61	0.00	0.00
20	0.00	0.00	12.36	0.00	0.00	1.24	0.59	0.00	0.00
25	0.00	0.00	3.47	0.00	0.00	0.64	0.57	0.00	0.00
30	0.00	0.00	0.98	0.00	0.00	0.33	0.55	0.00	0.00
35	0.00	0.00	0.27	0.00	0.00	0.17	0.53	0.00	0.00
40	0.00	0.00	0.08	0.00	0.00	0.09	0.51	0.00	0.00
45	0.00	0.00	0.02	0.00	0.00	0.05	0.49	0.00	0.00
50	0.00	0.00	0.01	0.00	0.00	0.02	0.48	0.00	0.00
55	0.00	0.00	0.00	0.00	0.00	0.01	0.46	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.01	0.44	0.00	0.00
65	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00
85	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00
95	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00
100	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00
200	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00
300	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00

Attachment VI - Calculation of Crud Source

Fuel Age, years since reactor discharge	Crud (Ci) for South Texas assembly, using Jones values								
	Cr 51	Mn 54	Fe 55	Co 58	Fe 59	Co 60	Ni 63	Zn 65	Zr 95
0	84.86	33.23	2650.01	180.95	34.12	22.90	0.90	0.00	8.53
5	0.00	0.58	744.58	0.00	0.00	11.86	0.87	0.00	0.00
6	0.00	0.26	577.62	0.00	0.00	10.40	0.86	0.00	0.00
7	0.00	0.11	448.10	0.00	0.00	9.12	0.86	0.00	0.00
8	0.00	0.05	347.62	0.00	0.00	8.00	0.85	0.00	0.00
9	0.00	0.02	269.68	0.00	0.00	7.01	0.84	0.00	0.00
10	0.00	0.01	209.21	0.00	0.00	6.15	0.84	0.00	0.00
11	0.00	0.00	162.30	0.00	0.00	5.39	0.83	0.00	0.00
15	0.00	0.00	58.78	0.00	0.00	3.19	0.81	0.00	0.00
20	0.00	0.00	16.52	0.00	0.00	1.65	0.78	0.00	0.00
25	0.00	0.00	4.64	0.00	0.00	0.86	0.76	0.00	0.00
30	0.00	0.00	1.30	0.00	0.00	0.44	0.73	0.00	0.00
35	0.00	0.00	0.37	0.00	0.00	0.23	0.70	0.00	0.00
40	0.00	0.00	0.10	0.00	0.00	0.12	0.68	0.00	0.00
45	0.00	0.00	0.03	0.00	0.00	0.06	0.66	0.00	0.00
50	0.00	0.00	0.01	0.00	0.00	0.03	0.63	0.00	0.00
55	0.00	0.00	0.00	0.00	0.00	0.02	0.61	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.01	0.59	0.00	0.00
65	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00
85	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00
95	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00
100	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00
200	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00
300	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00

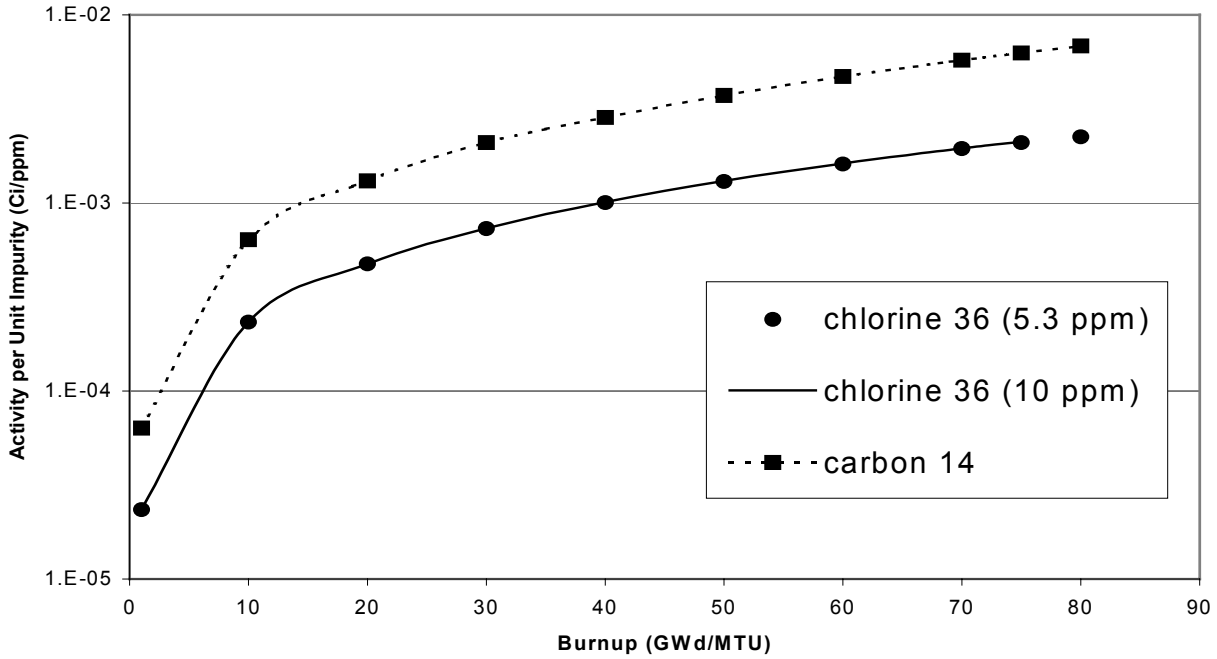
Attachment VII - ^{36}Cl and ^{14}C calculations

PWR

Burnup (GWd/MTU)	CL36 (5.3ppm)	Cl36(10ppm)	Ratio of 10 ppm to 5.3 ppm values for Cl36	curies per ppm Cl36 5.3 ppm value/5.3	Cl36 10 ppm value/10	Ratio of 10 ppm to 5.3 ppm values for Cl36 for curies per ppm
1	1.24E-04	2.35E-04	8.952E-01	2.34E-05	2.35E-05	1.0044E+00
10	1.23E-03	2.33E-03	8.943E-01	2.32E-04	2.33E-04	1.0040E+00
20	2.51E-03	4.74E-03	8.884E-01	4.74E-04	4.74E-04	1.0009E+00
30	3.87E-03	7.32E-03	8.915E-01	7.30E-04	7.32E-04	1.0025E+00
40	5.32E-03	1.01E-02	8.985E-01	1.00E-03	1.01E-03	1.0062E+00
50	6.89E-03	1.31E-02	9.013E-01	1.30E-03	1.31E-03	1.0077E+00
60	8.55E-03	1.62E-02	8.947E-01	1.61E-03	1.62E-03	1.0042E+00
70	1.03E-02	1.95E-02	8.932E-01	1.94E-03	1.95E-03	1.0034E+00
75	1.11E-02	2.12E-02	9.099E-01	2.09E-03	2.12E-03	1.0123E+00
80	1.19E-02			2.25E-03		

1.886792453

Burnup (GWd/MTU)	C-14 (Ci/assembly)	
1	5.67E-03	6.34E-05
10	5.69E-02	6.36E-04
20	1.17E-01	1.31E-03
30	1.87E-01	2.09E-03
40	2.54E-01	2.84E-03
50	3.33E-01	3.72E-03
60	4.20E-01	4.70E-03
70	5.13E-01	5.74E-03
75	5.62E-01	6.29E-03
80	6.11E-01	6.83E-03



Attachment VIII - List of Files on Compact Disks

This attachment lists the files stored on Attachment X (four CDs).

These files include:

"*.cut" files - these files are the sections of the SAS2H/ORIGEN-S output files that contain the input echoes and the final ORIGEN-S output. Other intermediate calculations and information generated by SAS2H and included in the output files have been removed. In the "*.cut" file names, the E, R, and B codes explanations are listed in Table VIII-1. The files listed as "PWR.max.2.cut", "PWR.ave.2.cut", "PWR.max.3.cut", and "PWR.min.3.cut" are used to generate radionuclide inventories for specific years (see Section 5.5). The "*.2.cut" files generate the information for cooling times up to 10000 years. The "*.3.cut" files generate the information for cooling times over 10000 years. The files listed as "pwr_imp_BU#.cut" and "pwr_cl2_BU#.cut" are the SAS2H/ORIGEN-S output files used to demonstrate the effect of fuel impurities on the source terms. The "BU#" indicates the burnup for that particular calculation, and follows the same convention as the rest of the files.

Table VIII-1. "*.cut" files Codification

"*.cut" Files E Code	Enrichment (% ^{235}U)	"*.cut" Files R Code	Light Elements Source Term Region	"*.cut" Files B Code	Burnup (MWd/MTU)
E1	5.5	R1	assembly fuel	B1	0.001
E2	5.0	R2	bottom end fitting	B2	0.01
E3	4.5	R3	plenum	B3	0.1
E4	4.2	R4	top end fitting	B4	1.
E5	4.0	-	-	B5	10.
E6	3.5	-	-	B6	20.
E7	3.0	-	-	B7	30.
E8	2.5	-	-	B8	40.
E9	2.0	-	-	B9	48.086
E10	1.5	-	-	B10	50.
E11	1.0	-	-	B11	60.
E12	0.711	-	-	B12	70.
-	-	-	-	B13	75.
-	-	-	-	B14	80.
-	-	-	-	B15	85.

UNIX script-files – these files are used to generate "*.cut" files from SAS2H/ORIGEN-S output files and to extract different parameters of interest from the "*.cut" files. They are described in Table 1.

Microsoft® EXCEL spreadsheets – these files were used to calculate and display different parameters, presented in the Attachments I, II, III, IV, VI, VII, and IX, in a tabular and/or graphical form.

Microsoft® WORD file – This file presents the UNIX script-files (Attachment V).

Attachment VIII - List of Files on Disk 1

```
 Volume in drive D is PWR ST G&E 1
 Volume Serial Number is 5F87-42C7

 Directory of D:\

05/17/2004  10:17a      <DIR>                  Attachments
05/04/2004  11:26a      <DIR>                  Oldcutfiles
05/04/2004  11:26a      <DIR>                  South Texas
05/04/2004  11:23a      <DIR>                  Steel Clad
05/04/2004  11:22a      <DIR>                  UNIX-script files
               0 File(s)              0 bytes

 Directory of D:\Attachments

05/17/2004  10:17a      <DIR>          .
05/17/2004  10:17a      <DIR>          ..
04/15/2004  12:18p              20,992         ATTACH_VII.XLS
05/17/2004  10:17a             482,816         ATTACH_XI.XLS
04/15/2004  11:35a              39,936         ATTACH_VI.XLS
04/14/2004  04:19p              35,328         ATTACH_I.XLS
04/19/2004  02:24p              22,528         ATTACH_V.doc
04/14/2004  04:29p              23,040         ATTACH_II.XLS
04/15/2004  11:06a             145,920         ATTACH_III.XLS
04/15/2004  11:06a              15,872         ATTACH_IV.XLS
04/15/2004  01:36p             458,752         ATTACH_IX.XLS
               9 File(s)      1,245,184 bytes

 Directory of D:\Oldcutfiles

05/04/2004  11:26a      <DIR>          .
05/04/2004  11:26a      <DIR>          ..
11/03/1999  09:44a             205,038         pwr_imp_BU4.cut
11/03/1999  09:44a             253,669         pwr_imp_BU8.cut
11/11/1999  03:01a             209,945         pwr_cl2_BU5.cut
11/03/1999  09:44a             231,038         pwr_imp_BU5.cut
11/11/1999  03:01a             219,052         pwr_cl2_BU6.cut
11/03/1999  09:44a             239,613         pwr_imp_BU6.cut
11/11/1999  03:01a             227,117         pwr_cl2_BU7.cut
11/03/1999  09:44a             247,667         pwr_imp_BU7.cut
11/11/1999  03:01a             187,725         pwr_cl2_BU4.cut
11/11/1999  03:01a             232,842         pwr_cl2_BU8.cut
11/03/1999  04:48p             224,366         PWR.ave.2.cut
11/03/1999  04:48p             165,193         PWR.ave.3.cut
11/03/1999  04:48p             251,313         PWR.max.2.cut
11/03/1999  04:48p             176,403         PWR.max.3.cut
11/11/1999  03:01a             237,205         pwr_cl2_BU10.cut
11/11/1999  03:01a             242,765         pwr_cl2_BU11.cut
11/11/1999  03:01a             247,649         pwr_cl2_BU12.cut
11/11/1999  03:44a             251,205         pwr_cl2_BU13.cut
11/03/1999  09:44a             258,564         pwr_imp_BU10.cut
11/03/1999  09:57a             264,789         pwr_imp_BU11.cut
11/03/1999  09:44a             269,806         pwr_imp_BU12.cut
11/03/1999  09:44a             273,715         pwr_imp_BU13.cut
              22 File(s)      5,116,679 bytes
```

Attachment VIII - List of Files on Disk 1 (Continued)

```
 Directory of D:\South Texas

05/04/2004  11:26a      <DIR>          .
05/04/2004  11:26a      <DIR>          ..
10/12/1999  09:23a           2,931,169        South.Texas.E11.R1.B10.cut
10/12/1999  09:24a           2,980,425        South.Texas.E11.R1.B13.cut
10/12/1999  09:24a           2,975,544        South.Texas.E11.R1.B12.cut
10/12/1999  09:24a           2,954,573        South.Texas.E11.R1.B11.cut
10/12/1999  09:32a           2,173,998        South.Texas.E3.R1.B1.cut
10/12/1999  09:28a           2,177,098        South.Texas.E2.R1.B1.cut
10/12/1999  09:20a           2,737,581        South.Texas.E1.R1.B5.cut
10/12/1999  09:50a           2,526,585        South.Texas.E9.R1.B4.cut
10/12/1999  09:34a           2,519,474        South.Texas.E3.R1.B4.cut
10/12/1999  09:39a           2,392,463        South.Texas.E5.R1.B3.cut
10/12/1999  09:45a           2,388,114        South.Texas.E7.R1.B3.cut
10/12/1999  09:19a           2,519,449        South.Texas.E1.R1.B4.cut
10/12/1999  09:50a           2,390,006        South.Texas.E9.R1.B3.cut
10/12/1999  09:34a           2,737,002        South.Texas.E3.R1.B5.cut
10/12/1999  09:39a           2,522,229        South.Texas.E5.R1.B4.cut
10/12/1999  09:45a           2,522,257        South.Texas.E7.R1.B4.cut
10/12/1999  09:19a           2,394,063        South.Texas.E1.R1.B3.cut
10/12/1999  09:50a           2,254,030        South.Texas.E9.R1.B2.cut
10/12/1999  09:33a           2,258,404        South.Texas.E3.R1.B2.cut
10/12/1999  09:37a           2,172,757        South.Texas.E5.R1.B1.cut
10/12/1999  09:43a           2,167,672        South.Texas.E7.R1.B1.cut
10/12/1999  09:19a           2,262,258        South.Texas.E1.R1.B2.cut
10/12/1999  09:49a           2,166,913        South.Texas.E9.R1.B1.cut
10/12/1999  09:34a           2,393,567        South.Texas.E3.R1.B3.cut
10/12/1999  09:39a           2,257,164        South.Texas.E5.R1.B2.cut
10/12/1999  09:45a           2,255,907        South.Texas.E7.R1.B2.cut
10/12/1999  09:48a           2,523,972        South.Texas.E8.R1.B4.cut
10/12/1999  09:30a           2,520,471        South.Texas.E2.R1.B4.cut
10/12/1999  09:36a           2,393,330        South.Texas.E4.R1.B3.cut
10/12/1999  09:42a           2,388,352        South.Texas.E6.R1.B3.cut
10/12/1999  09:48a           2,391,722        South.Texas.E8.R1.B3.cut
10/12/1999  09:31a           2,737,859        South.Texas.E2.R1.B5.cut
10/12/1999  09:36a           2,521,580        South.Texas.E4.R1.B4.cut
10/12/1999  09:41a           2,256,134        South.Texas.E6.R1.B2.cut
10/12/1999  09:47a           2,255,389        South.Texas.E8.R1.B2.cut
10/12/1999  09:30a           2,261,638        South.Texas.E2.R1.B2.cut
10/12/1999  09:35a           2,173,749        South.Texas.E4.R1.B1.cut
10/12/1999  09:40a           2,169,409        South.Texas.E6.R1.B1.cut
10/12/1999  09:46a           2,167,052        South.Texas.E8.R1.B1.cut
10/12/1999  09:30a           2,393,196        South.Texas.E2.R1.B3.cut
10/12/1999  09:36a           2,257,908        South.Texas.E4.R1.B2.cut
10/12/1999  09:42a           2,518,992        South.Texas.E6.R1.B4.cut
10/12/1999  09:20a           2,913,054        South.Texas.E1.R1.B9.cut
10/12/1999  09:51a           2,893,195        South.Texas.E9.R1.B8.cut
10/12/1999  09:35a           2,892,328        South.Texas.E3.R1.B8.cut
10/12/1999  09:40a           2,866,019        South.Texas.E5.R1.B7.cut
10/12/1999  09:46a           2,863,482        South.Texas.E7.R1.B7.cut
10/12/1999  09:20a           2,893,255        South.Texas.E1.R1.B8.cut
10/12/1999  09:51a           2,867,482        South.Texas.E9.R1.B7.cut
10/12/1999  09:35a           2,914,213        South.Texas.E3.R1.B9.cut
10/12/1999  09:40a           2,895,075        South.Texas.E5.R1.B8.cut
10/12/1999  09:46a           2,894,594        South.Texas.E7.R1.B8.cut
10/12/1999  09:20a           2,862,090        South.Texas.E1.R1.B7.cut
10/12/1999  09:51a           2,822,186        South.Texas.E9.R1.B6.cut
10/12/1999  09:34a           2,817,610        South.Texas.E3.R1.B6.cut
```

Attachment VIII - List of Files on Disk 1 (Continued)

10/12/1999	09:39a	2,737,183	South.Texas.E5.R1.B5.cut
10/12/1999	09:45a	2,737,103	South.Texas.E7.R1.B5.cut
10/12/1999	09:20a	2,809,763	South.Texas.E1.R1.B6.cut
10/12/1999	08:50a	2,746,326	South.Texas.E9.R1.B5.cut
10/12/1999	09:35a	2,863,350	South.Texas.E3.R1.B7.cut
10/12/1999	09:39a	2,819,514	South.Texas.E5.R1.B6.cut
10/12/1999	09:45a	2,823,765	South.Texas.E7.R1.B6.cut
10/12/1999	09:49a	2,895,413	South.Texas.E8.R1.B8.cut
10/12/1999	09:31a	2,894,133	South.Texas.E2.R1.B8.cut
10/12/1999	09:37a	2,863,520	South.Texas.E4.R1.B7.cut
10/12/1999	09:43a	2,864,465	South.Texas.E6.R1.B7.cut
10/12/1999	09:48a	2,861,024	South.Texas.E8.R1.B7.cut
10/12/1999	09:32a	2,912,917	South.Texas.E2.R1.B9.cut
10/12/1999	09:37a	2,894,950	South.Texas.E4.R1.B8.cut
10/12/1999	09:42a	2,826,677	South.Texas.E6.R1.B6.cut
10/12/1999	09:48a	2,823,593	South.Texas.E8.R1.B6.cut
10/12/1999	09:31a	2,813,508	South.Texas.E2.R1.B6.cut
10/12/1999	09:36a	2,737,936	South.Texas.E4.R1.B5.cut
10/12/1999	09:42a	2,734,699	South.Texas.E6.R1.B5.cut
10/12/1999	09:48a	2,739,202	South.Texas.E8.R1.B5.cut
10/12/1999	09:31a	2,861,356	South.Texas.E2.R1.B7.cut
10/12/1999	09:37a	2,815,378	South.Texas.E4.R1.B6.cut
10/12/1999	09:43a	2,892,031	South.Texas.E6.R1.B8.cut
10/12/1999	09:23a	2,164,309	South.Texas.E11.R1.B1.cut
10/12/1999	09:25a	2,765,051	South.Texas.E11.R1.B5.cut
10/12/1999	09:25a	2,923,758	South.Texas.E11.R1.B9.cut
10/12/1999	09:24a	2,255,529	South.Texas.E11.R1.B2.cut
10/12/1999	09:25a	2,827,331	South.Texas.E11.R1.B6.cut
10/12/1999	09:40a	2,910,865	South.Texas.E5.R1.B9.cut
10/12/1999	09:46a	2,915,291	South.Texas.E7.R1.B9.cut
10/12/1999	09:51a	2,923,795	South.Texas.E9.R1.B9.cut
10/12/1999	09:37a	2,913,115	South.Texas.E4.R1.B9.cut
10/12/1999	09:43a	2,909,507	South.Texas.E6.R1.B9.cut
10/12/1999	09:49a	2,921,159	South.Texas.E8.R1.B9.cut
10/12/1999	09:25a	2,389,038	South.Texas.E11.R1.B3.cut
10/12/1999	09:25a	2,860,217	South.Texas.E11.R1.B7.cut
10/12/1999	09:25a	2,536,573	South.Texas.E11.R1.B4.cut
10/12/1999	09:25a	2,898,153	South.Texas.E11.R1.B8.cut
10/12/1999	09:26a	2,929,225	South.Texas.E12.R1.B10.cut
10/12/1999	09:21a	2,928,190	South.Texas.E10.R1.B10.cut
10/12/1999	09:26a	2,981,226	South.Texas.E12.R1.B13.cut
10/12/1999	09:26a	2,974,855	South.Texas.E12.R1.B12.cut
10/12/1999	09:26a	2,953,370	South.Texas.E12.R1.B11.cut
10/12/1999	09:21a	2,983,300	South.Texas.E10.R1.B13.cut
10/12/1999	09:21a	2,973,932	South.Texas.E10.R1.B12.cut
10/12/1999	09:21a	2,959,548	South.Texas.E10.R1.B11.cut
10/12/1999	09:35a	2,912,992	South.Texas.E4.R1.B10.cut
10/12/1999	09:46a	2,926,453	South.Texas.E8.R1.B10.cut
10/12/1999	09:44a	2,922,542	South.Texas.E7.R1.B10.cut
10/12/1999	09:32a	2,916,483	South.Texas.E3.R1.B10.cut
10/12/1999	09:41a	2,914,564	South.Texas.E6.R1.B10.cut
10/12/1999	09:28a	2,916,149	South.Texas.E2.R1.B10.cut
10/12/1999	09:38a	2,913,002	South.Texas.E5.R1.B10.cut
10/12/1999	09:49a	2,928,300	South.Texas.E9.R1.B10.cut
10/12/1999	09:35a	2,949,311	South.Texas.E4.R1.B11.cut
10/12/1999	09:47a	2,966,133	South.Texas.E8.R1.B11.cut
10/12/1999	09:44a	2,952,287	South.Texas.E7.R1.B11.cut
10/12/1999	09:32a	2,944,829	South.Texas.E3.R1.B11.cut
10/12/1999	09:41a	2,951,112	South.Texas.E6.R1.B11.cut

Attachment VIII - List of Files on Disk 1 (Continued)

```
10/12/1999  09:29a           2,941,979         South.Texas.E2.R1.B11.cut
10/12/1999  09:38a           2,952,298         South.Texas.E5.R1.B11.cut
10/12/1999  09:49a           2,966,512         South.Texas.E9.R1.B11.cut
10/12/1999  09:36a           2,972,768         South.Texas.E4.R1.B12.cut
10/12/1999  09:47a           2,986,779         South.Texas.E8.R1.B12.cut
10/12/1999  09:44a           2,985,386         South.Texas.E7.R1.B12.cut
10/12/1999  09:33a           2,968,501         South.Texas.E3.R1.B12.cut
10/12/1999  09:41a           2,982,734         South.Texas.E6.R1.B12.cut
10/12/1999  09:29a           2,968,654         South.Texas.E2.R1.B12.cut
10/12/1999  09:38a           2,981,238         South.Texas.E5.R1.B12.cut
10/12/1999  09:49a           2,987,240         South.Texas.E9.R1.B12.cut
10/12/1999  09:36a           2,987,227         South.Texas.E4.R1.B13.cut
10/12/1999  09:47a           2,996,633         South.Texas.E8.R1.B13.cut
10/12/1999  09:45a           2,994,401         South.Texas.E7.R1.B13.cut
10/12/1999  09:33a           2,985,229         South.Texas.E3.R1.B13.cut
10/12/1999  09:41a           2,992,591         South.Texas.E6.R1.B13.cut
10/12/1999  09:30a           2,980,129         South.Texas.E2.R1.B13.cut
10/12/1999  09:39a           2,987,982         South.Texas.E5.R1.B13.cut
10/12/1999  09:50a           2,991,886         South.Texas.E9.R1.B13.cut
10/12/1999  09:19a           2,976,930         South.Texas.E1.R1.B13.cut
10/12/1999  09:21a           2,165,921         South.Texas.E10.R1.B1.cut
10/12/1999  09:22a           2,754,276         South.Texas.E10.R1.B5.cut
10/12/1999  09:23a           2,921,082         South.Texas.E10.R1.B9.cut
10/12/1999  09:26a           2,158,110         South.Texas.E12.R1.B1.cut
10/12/1999  09:27a           2,777,351         South.Texas.E12.R1.B5.cut
10/12/1999  09:28a           2,923,102         South.Texas.E12.R1.B9.cut
10/12/1999  09:21a           2,254,801         South.Texas.E10.R1.B2.cut
10/12/1999  09:22a           2,827,347         South.Texas.E10.R1.B6.cut
10/12/1999  09:27a           2,252,746         South.Texas.E12.R1.B2.cut
10/12/1999  09:27a           2,829,772         South.Texas.E12.R1.B6.cut
10/12/1999  09:22a           2,389,011         South.Texas.E10.R1.B3.cut
10/12/1999  09:23a           2,859,957         South.Texas.E10.R1.B7.cut
10/12/1999  09:27a           2,386,065         South.Texas.E12.R1.B3.cut
10/12/1999  09:28a           2,860,860         South.Texas.E12.R1.B7.cut
10/12/1999  09:22a           2,533,525         South.Texas.E10.R1.B4.cut
10/12/1999  09:23a           2,895,781         South.Texas.E10.R1.B8.cut
10/12/1999  09:27a           2,541,011         South.Texas.E12.R1.B4.cut
10/12/1999  09:28a           2,895,708         South.Texas.E12.R1.B8.cut
10/12/1999  08:17a           2,177,594         South.Texas.E1.R1.B1.cut
10/12/1999  09:18a           2,915,271         South.Texas.E1.R1.B10.cut
10/12/1999  09:18a           2,935,609         South.Texas.E1.R1.B11.cut
10/12/1999  09:18a           2,965,714         South.Texas.E1.R1.B12.cut
             156 File(s)    425,043,049 bytes

 Directory of D:\Steel Clad

05/04/2004  11:23a      <DIR>          .
05/04/2004  11:23a      <DIR>          ..
10/12/1999  09:56a           2,782,317         Steel.Clad.E11.R1.B6.cut
10/12/1999  09:56a           2,821,068         Steel.Clad.E11.R1.B7.cut
10/12/1999  09:56a           2,512,360         Steel.Clad.E11.R1.B4.cut
10/12/1999  09:56a           2,724,285         Steel.Clad.E11.R1.B5.cut
10/12/1999  09:54a           2,786,542         Steel.Clad.E10.R1.B6.cut
10/12/1999  09:54a           2,817,115         Steel.Clad.E10.R1.B7.cut
10/12/1999  09:53a           2,511,160         Steel.Clad.E10.R1.B4.cut
10/12/1999  09:54a           2,708,185         Steel.Clad.E10.R1.B5.cut
10/12/1999  09:57a           2,546,881         Steel.Clad.E11.R3.B6.cut
10/12/1999  09:57a           2,578,229         Steel.Clad.E11.R3.B7.cut
10/12/1999  09:57a           2,299,511         Steel.Clad.E11.R3.B4.cut
```

Attachment VIII - List of Files on Disk 1 (Continued)

10/12/1999	09:57a	2,494,067	Steel.Clad.E11.R3.B5.cut
10/12/1999	09:55a	2,543,340	Steel.Clad.E10.R3.B6.cut
10/12/1999	09:55a	2,575,144	Steel.Clad.E10.R3.B7.cut
10/12/1999	09:54a	2,298,950	Steel.Clad.E10.R3.B4.cut
10/12/1999	09:55a	2,482,806	Steel.Clad.E10.R3.B5.cut
10/12/1999	09:56a	2,857,583	Steel.Clad.E11.R1.B8.cut
10/12/1999	09:54a	2,852,001	Steel.Clad.E10.R1.B8.cut
10/12/1999	09:57a	2,605,337	Steel.Clad.E11.R3.B8.cut
10/12/1999	09:55a	2,604,253	Steel.Clad.E10.R3.B8.cut
10/12/1999	10:10a	2,699,294	Steel.Clad.E7.R1.B5.cut
10/12/1999	10:14a	2,706,668	Steel.Clad.E9.R1.B5.cut
10/12/1999	10:00a	2,770,507	Steel.Clad.E3.R1.B6.cut
10/12/1999	10:05a	2,777,769	Steel.Clad.E5.R1.B6.cut
10/12/1999	10:10a	2,780,927	Steel.Clad.E7.R1.B6.cut
10/12/1999	10:15a	2,783,163	Steel.Clad.E9.R1.B6.cut
10/12/1999	10:01a	2,816,024	Steel.Clad.E3.R1.B7.cut
10/12/1999	10:05a	2,814,975	Steel.Clad.E5.R1.B7.cut
10/12/1999	10:10a	2,812,901	Steel.Clad.E7.R1.B7.cut
10/12/1999	09:52a	2,855,179	Steel.Clad.E1.R1.B8.cut
10/12/1999	10:15a	2,820,032	Steel.Clad.E9.R1.B7.cut
10/12/1999	10:00a	2,494,750	Steel.Clad.E3.R1.B4.cut
10/12/1999	10:01a	2,853,614	Steel.Clad.E3.R1.B8.cut
10/12/1999	10:04a	2,491,140	Steel.Clad.E5.R1.B4.cut
10/12/1999	10:06a	2,850,059	Steel.Clad.E5.R1.B8.cut
10/12/1999	10:10a	2,499,772	Steel.Clad.E7.R1.B4.cut
10/12/1999	10:11a	2,848,021	Steel.Clad.E7.R1.B8.cut
10/12/1999	10:14a	2,505,307	Steel.Clad.E9.R1.B4.cut
10/12/1999	10:15a	2,846,783	Steel.Clad.E9.R1.B8.cut
10/12/1999	10:00a	2,697,357	Steel.Clad.E3.R1.B5.cut
10/12/1999	10:05a	2,698,354	Steel.Clad.E5.R1.B5.cut
10/12/1999	10:11a	2,471,198	Steel.Clad.E7.R3.B5.cut
10/12/1999	09:53a	2,532,504	Steel.Clad.E1.R3.B6.cut
10/12/1999	10:16a	2,478,304	Steel.Clad.E9.R3.B5.cut
10/12/1999	10:01a	2,537,302	Steel.Clad.E3.R3.B6.cut
10/12/1999	10:06a	2,544,307	Steel.Clad.E5.R3.B6.cut
10/12/1999	10:11a	2,544,573	Steel.Clad.E7.R3.B6.cut
10/12/1999	09:53a	2,570,722	Steel.Clad.E1.R3.B7.cut
10/12/1999	10:16a	2,541,190	Steel.Clad.E9.R3.B6.cut
10/12/1999	10:02a	2,576,304	Steel.Clad.E3.R3.B7.cut
10/12/1999	10:07a	2,574,986	Steel.Clad.E5.R3.B7.cut
10/12/1999	10:11a	2,572,818	Steel.Clad.E7.R3.B7.cut
10/12/1999	09:53a	2,291,651	Steel.Clad.E1.R3.B4.cut
10/12/1999	09:53a	2,608,463	Steel.Clad.E1.R3.B8.cut
10/12/1999	10:16a	2,577,978	Steel.Clad.E9.R3.B7.cut
10/12/1999	10:01a	2,288,926	Steel.Clad.E3.R3.B4.cut
10/12/1999	10:02a	2,609,810	Steel.Clad.E3.R3.B8.cut
10/12/1999	10:06a	2,285,068	Steel.Clad.E5.R3.B4.cut
10/12/1999	10:07a	2,609,617	Steel.Clad.E5.R3.B8.cut
10/12/1999	10:11a	2,288,720	Steel.Clad.E7.R3.B4.cut
10/12/1999	10:12a	2,607,569	Steel.Clad.E7.R3.B8.cut
10/12/1999	09:53a	2,468,820	Steel.Clad.E1.R3.B5.cut
10/12/1999	10:15a	2,297,335	Steel.Clad.E9.R3.B4.cut
10/12/1999	10:17a	2,600,424	Steel.Clad.E9.R3.B8.cut
10/12/1999	10:01a	2,468,879	Steel.Clad.E3.R3.B5.cut
10/12/1999	10:06a	2,469,752	Steel.Clad.E5.R3.B5.cut
10/12/1999	10:12a	2,702,613	Steel.Clad.E8.R1.B5.cut
10/12/1999	09:58a	2,765,408	Steel.Clad.E2.R1.B6.cut
10/12/1999	10:03a	2,772,984	Steel.Clad.E4.R1.B6.cut
10/12/1999	10:08a	2,777,854	Steel.Clad.E6.R1.B6.cut

Attachment VIII - List of Files on Disk 1 (Continued)

```
10/12/1999  10:12a           2,782,306         Steel.Clad.E8.R1.B6.cut
10/12/1999  09:58a           2,810,058         Steel.Clad.E2.R1.B7.cut
10/12/1999  10:03a           2,816,663         Steel.Clad.E4.R1.B7.cut
10/12/1999  10:08a           2,815,490         Steel.Clad.E6.R1.B7.cut
10/12/1999  10:13a           2,816,363         Steel.Clad.E8.R1.B7.cut
10/12/1999  09:58a           2,493,876         Steel.Clad.E2.R1.B4.cut
10/12/1999  09:58a           2,852,681         Steel.Clad.E2.R1.B8.cut
10/12/1999  10:02a           2,493,633         Steel.Clad.E4.R1.B4.cut
10/12/1999  10:03a           2,850,029         Steel.Clad.E4.R1.B8.cut
10/12/1999  10:08a           2,496,875         Steel.Clad.E6.R1.B4.cut
10/12/1999  10:08a           2,848,333         Steel.Clad.E6.R1.B8.cut
10/12/1999  10:12a           2,500,306         Steel.Clad.E8.R1.B4.cut
10/12/1999  10:13a           2,852,939         Steel.Clad.E8.R1.B8.cut
10/12/1999  09:58a           2,699,293         Steel.Clad.E2.R1.B5.cut
10/12/1999  10:02a           2,698,850         Steel.Clad.E4.R1.B5.cut
10/12/1999  10:08a           2,700,978         Steel.Clad.E6.R1.B5.cut
10/12/1999  10:13a           2,472,647         Steel.Clad.E8.R3.B5.cut
10/12/1999  09:59a           2,536,008         Steel.Clad.E2.R3.B6.cut
10/12/1999  10:04a           2,537,920         Steel.Clad.E4.R3.B6.cut
10/12/1999  10:09a           2,542,264         Steel.Clad.E6.R3.B6.cut
10/12/1999  10:13a           2,546,086         Steel.Clad.E8.R3.B6.cut
10/12/1999  09:59a           2,571,438         Steel.Clad.E2.R3.B7.cut
10/12/1999  10:04a           2,576,427         Steel.Clad.E4.R3.B7.cut
10/12/1999  10:09a           2,574,500         Steel.Clad.E6.R3.B7.cut
10/12/1999  10:14a           2,576,923         Steel.Clad.E8.R3.B7.cut
10/12/1999  09:59a           2,288,298         Steel.Clad.E2.R3.B4.cut
10/12/1999  10:00a           2,608,519         Steel.Clad.E2.R3.B8.cut
10/12/1999  10:03a           2,287,685         Steel.Clad.E4.R3.B4.cut
10/12/1999  10:04a           2,609,864         Steel.Clad.E4.R3.B8.cut
10/12/1999  10:09a           2,284,955         Steel.Clad.E6.R3.B4.cut
10/12/1999  10:09a           2,608,262         Steel.Clad.E6.R3.B8.cut
10/12/1999  10:13a           2,290,742         Steel.Clad.E8.R3.B4.cut
10/12/1999  10:14a           2,606,967         Steel.Clad.E8.R3.B8.cut
10/12/1999  09:59a           2,469,203         Steel.Clad.E2.R3.B5.cut
10/12/1999  10:03a           2,469,999         Steel.Clad.E4.R3.B5.cut
10/12/1999  10:09a           2,471,880         Steel.Clad.E6.R3.B5.cut
10/12/1999  09:51a           2,494,355         Steel.Clad.E1.R1.B4.cut
10/12/1999  09:52a           2,698,260         Steel.Clad.E1.R1.B5.cut
10/12/1999  09:52a           2,764,210         Steel.Clad.E1.R1.B6.cut
10/12/1999  09:52a           2,812,099         Steel.Clad.E1.R1.B7.cut
             110 File(s)    287,487,993 bytes

 Directory of D:\UNIX-script files

05/04/2004  11:22a      <DIR>          .
05/04/2004  11:22a      <DIR>          ..
10/12/1999  12:45p                 261         curies
02/27/2003  08:37a                 177         cut-script
10/12/1999  12:45p                 177         gammas
10/12/1999  12:45p                 158         neutrons
10/12/1999  12:47p                 268         watts
               5 File(s)          1,041 bytes

     Total Files Listed:
             302 File(s)    718,893,946 bytes
              15 Dir(s)               0 bytes free
```

Attachment VIII - List of Files on Disk 2

```
 Volume in drive D is PWR ST G&E
 Volume Serial Number is 2154-7748

 Directory of D:\

04/20/2004  11:49a      <DIR>          Waste Stream 1
               0 File(s)              0 bytes

 Directory of D:\Waste Stream 1

04/20/2004  11:49a      <DIR>          .
04/20/2004  11:49a      <DIR>          ..
10/12/1999  10:44a           2,672,362         Waste.Stream.E11.R2.B10.cut
02/21/2003  10:03a           2,727,688         Waste.Stream.E11.R2.B14.cut
10/12/1999  10:32a           2,672,723         Waste.Stream.E10.R2.B10.cut
02/21/2003  10:01a           2,725,235         Waste.Stream.E10.R2.B14.cut
10/12/1999  10:56a           2,673,941         Waste.Stream.E12.R2.B10.cut
02/21/2003  10:04a           2,726,251         Waste.Stream.E12.R2.B14.cut
10/12/1999  10:47a           2,667,944         Waste.Stream.E11.R3.B10.cut
02/21/2003  10:03a           2,730,244         Waste.Stream.E11.R3.B14.cut
10/12/1999  10:35a           2,668,171         Waste.Stream.E10.R3.B10.cut
02/21/2003  10:01a           2,727,657         Waste.Stream.E10.R3.B14.cut
10/12/1999  10:59a           2,671,765         Waste.Stream.E12.R3.B10.cut
02/21/2003  10:04a           2,728,673         Waste.Stream.E12.R3.B14.cut
10/12/1999  10:50a           2,618,552         Waste.Stream.E11.R4.B10.cut
02/21/2003  10:03a           2,676,120         Waste.Stream.E11.R4.B14.cut
10/12/1999  10:38a           2,619,037         Waste.Stream.E10.R4.B10.cut
02/21/2003  10:01a           2,674,039         Waste.Stream.E10.R4.B14.cut
10/12/1999  11:02a           2,622,373         Waste.Stream.E12.R4.B10.cut
02/21/2003  10:04a           2,674,549         Waste.Stream.E12.R4.B14.cut
10/12/1999  10:41a           2,927,839         Waste.Stream.E11.R1.B11.cut
02/21/2003  10:02a           2,966,957         Waste.Stream.E11.R1.B15.cut
10/12/1999  10:29a           2,927,543         Waste.Stream.E10.R1.B11.cut
02/21/2003  10:00a           2,966,456         Waste.Stream.E10.R1.B15.cut
10/12/1999  10:21a           2,210,392         Waste.Stream.E1.R2.B3.cut
10/12/1999  10:24a           2,195,502         Waste.Stream.E1.R3.B3.cut
10/12/1999  10:27a           2,156,972         Waste.Stream.E1.R4.B3.cut
10/12/1999  10:22a           2,615,464         Waste.Stream.E1.R2.B7.cut
10/12/1999  10:25a           2,614,106         Waste.Stream.E1.R3.B7.cut
10/12/1999  10:28a           2,569,124         Waste.Stream.E1.R4.B7.cut
10/12/1999  10:53a           2,927,141         Waste.Stream.E12.R1.B11.cut
02/21/2003  10:04a           2,963,837         Waste.Stream.E12.R1.B15.cut
10/12/1999  10:44a           2,699,067         Waste.Stream.E11.R2.B11.cut
02/21/2003  10:03a           2,730,561         Waste.Stream.E11.R2.B15.cut
10/12/1999  10:32a           2,701,013         Waste.Stream.E10.R2.B11.cut
02/21/2003  10:01a           2,732,426         Waste.Stream.E10.R2.B15.cut
10/12/1999  10:56a           2,698,199         Waste.Stream.E12.R2.B11.cut
02/21/2003  10:04a           2,729,187         Waste.Stream.E12.R2.B15.cut
10/12/1999  09:47a           2,697,129         Waste.Stream.E11.R3.B11.cut
02/21/2003  10:03a           2,732,983         Waste.Stream.E11.R3.B15.cut
10/12/1999  10:35a           2,698,703         Waste.Stream.E10.R3.B11.cut
02/21/2003  10:01a           2,734,848         Waste.Stream.E10.R3.B15.cut
10/12/1999  10:59a           2,698,503         Waste.Stream.E12.R3.B11.cut
02/21/2003  10:04a           2,731,609         Waste.Stream.E12.R3.B15.cut
10/12/1999  10:50a           2,647,499         Waste.Stream.E11.R4.B11.cut
02/21/2003  10:03a           2,678,859         Waste.Stream.E11.R4.B15.cut
10/12/1999  10:38a           2,649,569         Waste.Stream.E10.R4.B11.cut
02/21/2003  10:01a           2,680,848         Waste.Stream.E10.R4.B15.cut
10/12/1999  11:02a           2,648,997         Waste.Stream.E12.R4.B11.cut
```

Attachment VIII - List of Files on Disk 2 (Continued)

02/21/2003	10:04a	2,677,609	Waste.Stream.E12.R4.B15.cut
10/12/1999	10:41a	2,938,848	Waste.Stream.E11.R1.B12.cut
10/12/1999	10:29a	2,942,160	Waste.Stream.E10.R1.B12.cut
10/12/1999	10:21a	2,325,962	Waste.Stream.E1.R2.B4.cut
10/12/1999	10:24a	2,327,292	Waste.Stream.E1.R3.B4.cut
10/12/1999	10:27a	2,286,676	Waste.Stream.E1.R4.B4.cut
10/12/1999	10:22a	2,650,067	Waste.Stream.E1.R2.B8.cut
10/12/1999	10:25a	2,647,345	Waste.Stream.E1.R3.B8.cut
10/12/1999	10:28a	2,596,887	Waste.Stream.E1.R4.B8.cut
10/12/1999	10:54a	2,939,975	Waste.Stream.E12.R1.B12.cut
10/12/1999	10:45a	2,710,830	Waste.Stream.E11.R2.B12.cut
10/12/1999	10:32a	2,712,644	Waste.Stream.E10.R2.B12.cut
10/12/1999	10:57a	2,709,323	Waste.Stream.E12.R2.B12.cut
10/12/1999	10:48a	2,709,512	Waste.Stream.E11.R3.B12.cut
10/12/1999	10:35a	2,713,072	Waste.Stream.E10.R3.B12.cut
10/12/1999	10:59a	2,709,503	Waste.Stream.E12.R3.B12.cut
10/12/1999	10:51a	2,659,510	Waste.Stream.E11.R4.B12.cut
10/12/1999	10:38a	2,663,070	Waste.Stream.E10.R4.B12.cut
10/12/1999	11:02a	2,658,003	Waste.Stream.E12.R4.B12.cut
10/12/1999	10:42a	2,951,704	Waste.Stream.E11.R1.B13.cut
10/12/1999	10:29a	2,952,395	Waste.Stream.E10.R1.B13.cut
10/12/1999	10:20a	2,033,682	Waste.Stream.E1.R2.B1.cut
10/12/1999	10:23a	2,022,398	Waste.Stream.E1.R3.B1.cut
10/12/1999	10:26a	1,986,718	Waste.Stream.E1.R4.B1.cut
10/12/1999	10:22a	2,510,288	Waste.Stream.E1.R2.B5.cut
10/12/1999	10:25a	2,505,418	Waste.Stream.E1.R3.B5.cut
10/12/1999	10:27a	2,470,228	Waste.Stream.E1.R4.B5.cut
10/12/1999	10:23a	2,660,542	Waste.Stream.E1.R2.B9.cut
10/12/1999	10:26a	2,660,816	Waste.Stream.E1.R3.B9.cut
10/12/1999	10:28a	2,612,104	Waste.Stream.E1.R4.B9.cut
10/12/1999	10:54a	2,949,586	Waste.Stream.E12.R1.B13.cut
10/12/1999	10:45a	2,718,686	Waste.Stream.E11.R2.B13.cut
10/12/1999	10:32a	2,720,007	Waste.Stream.E10.R2.B13.cut
10/12/1999	10:57a	2,716,816	Waste.Stream.E12.R2.B13.cut
10/12/1999	10:48a	2,718,866	Waste.Stream.E11.R3.B13.cut
10/12/1999	10:35a	2,718,937	Waste.Stream.E10.R3.B13.cut
10/12/1999	11:00a	2,719,362	Waste.Stream.E12.R3.B13.cut
10/12/1999	10:51a	2,667,366	Waste.Stream.E11.R4.B13.cut
10/12/1999	10:38a	2,668,811	Waste.Stream.E10.R4.B13.cut
10/12/1999	11:03a	2,665,496	Waste.Stream.E12.R4.B13.cut
10/12/1999	10:41a	2,896,144	Waste.Stream.E11.R1.B10.cut
02/21/2003	10:01a	2,959,610	Waste.Stream.E11.R1.B14.cut
10/12/1999	10:28a	2,896,009	Waste.Stream.E10.R1.B10.cut
02/21/2003	10:00a	2,958,253	Waste.Stream.E10.R1.B14.cut
10/12/1999	10:21a	2,096,750	Waste.Stream.E1.R2.B2.cut
10/12/1999	10:24a	2,087,832	Waste.Stream.E1.R3.B2.cut
10/12/1999	10:27a	2,050,890	Waste.Stream.E1.R4.B2.cut
10/12/1999	10:22a	2,574,106	Waste.Stream.E1.R2.B6.cut
10/12/1999	10:25a	2,572,604	Waste.Stream.E1.R3.B6.cut
10/12/1999	10:28a	2,530,410	Waste.Stream.E1.R4.B6.cut
10/12/1999	10:53a	2,897,971	Waste.Stream.E12.R1.B10.cut
02/21/2003	10:04a	2,960,033	Waste.Stream.E12.R1.B14.cut
10/12/1999	10:57a	2,206,154	Waste.Stream.E12.R2.B3.cut
10/12/1999	10:32a	2,087,907	Waste.Stream.E10.R2.B2.cut
10/12/1999	10:57a	2,080,954	Waste.Stream.E12.R2.B2.cut
10/12/1999	10:33a	2,213,316	Waste.Stream.E10.R2.B3.cut
10/12/1999	10:56a	2,014,074	Waste.Stream.E12.R2.B1.cut
10/12/1999	10:31a	2,022,505	Waste.Stream.E10.R2.B1.cut

Attachment VIII - List of Files on Disk 2 (Continued)

10/12/1999	10:45a	2,086,669	Waste.Stream.E11.R2.B2.cut
10/12/1999	10:45a	2,211,617	Waste.Stream.E11.R2.B3.cut
10/12/1999	10:44a	2,020,769	Waste.Stream.E11.R2.B1.cut
10/12/1999	11:00a	2,200,986	Waste.Stream.E12.R3.B3.cut
10/12/1999	10:36a	2,079,381	Waste.Stream.E10.R3.B2.cut
10/12/1999	11:00a	2,072,820	Waste.Stream.E12.R3.B2.cut
10/12/1999	10:36a	2,201,526	Waste.Stream.E10.R3.B3.cut
10/12/1999	10:59a	2,004,650	Waste.Stream.E12.R3.B1.cut
10/12/1999	10:34a	2,008,493	Waste.Stream.E10.R3.B1.cut
10/12/1999	10:48a	2,078,535	Waste.Stream.E11.R3.B2.cut
10/12/1999	10:48a	2,202,689	Waste.Stream.E11.R3.B3.cut
10/12/1999	10:47a	2,005,765	Waste.Stream.E11.R3.B1.cut
10/12/1999	11:03a	2,165,382	Waste.Stream.E12.R4.B3.cut
10/12/1999	10:39a	2,041,913	Waste.Stream.E10.R4.B2.cut
10/12/1999	11:03a	2,033,224	Waste.Stream.E12.R4.B2.cut
10/12/1999	10:39a	2,162,320	Waste.Stream.E10.R4.B3.cut
10/12/1999	11:02a	1,967,234	Waste.Stream.E12.R4.B1.cut
10/12/1999	10:37a	1,975,665	Waste.Stream.E10.R4.B1.cut
10/12/1999	10:51a	2,038,805	Waste.Stream.E11.R4.B2.cut
10/12/1999	10:51a	2,169,521	Waste.Stream.E11.R4.B3.cut
10/12/1999	10:50a	1,974,301	Waste.Stream.E11.R4.B1.cut
10/12/1999	10:26a	2,630,797	Waste.Stream.E1.R4.B11.cut
10/12/1999	10:20a	2,672,150	Waste.Stream.E1.R2.B10.cut
10/12/1999	10:23a	2,668,426	Waste.Stream.E1.R3.B10.cut
10/12/1999	10:26a	2,619,466	Waste.Stream.E1.R4.B10.cut
10/12/1999	10:20a	2,683,853	Waste.Stream.E1.R2.B11.cut
10/12/1999	10:23a	2,683,011	Waste.Stream.E1.R3.B11.cut
10/12/1999	10:54a	2,369,702	Waste.Stream.E12.R1.B3.cut
10/12/1999	10:29a	2,242,511	Waste.Stream.E10.R1.B2.cut
10/12/1999	10:54a	2,239,729	Waste.Stream.E12.R1.B2.cut
10/12/1999	10:29a	2,375,128	Waste.Stream.E10.R1.B3.cut
10/12/1999	10:53a	2,148,686	Waste.Stream.E12.R1.B1.cut
10/12/1999	10:28a	2,155,009	Waste.Stream.E10.R1.B1.cut
10/12/1999	10:42a	2,244,135	Waste.Stream.E11.R1.B2.cut
10/12/1999	10:42a	2,374,287	Waste.Stream.E11.R1.B3.cut
10/12/1999	10:41a	2,154,885	Waste.Stream.E11.R1.B1.cut
10/12/1999	10:58a	2,618,022	Waste.Stream.E12.R2.B7.cut
10/12/1999	10:33a	2,583,981	Waste.Stream.E10.R2.B6.cut
10/12/1999	10:58a	2,585,801	Waste.Stream.E12.R2.B6.cut
10/12/1999	10:33a	2,612,294	Waste.Stream.E10.R2.B7.cut
10/12/1999	10:58a	2,536,272	Waste.Stream.E12.R2.B5.cut
10/12/1999	10:33a	2,333,159	Waste.Stream.E10.R2.B4.cut
10/12/1999	10:58a	2,345,297	Waste.Stream.E12.R2.B4.cut
10/12/1999	10:33a	2,518,820	Waste.Stream.E10.R2.B5.cut
10/12/1999	10:46a	2,585,869	Waste.Stream.E11.R2.B6.cut
10/12/1999	10:46a	2,617,985	Waste.Stream.E11.R2.B7.cut
10/12/1999	10:45a	2,336,911	Waste.Stream.E11.R2.B4.cut
10/12/1999	10:46a	2,529,863	Waste.Stream.E11.R2.B5.cut
10/12/1999	11:01a	2,617,190	Waste.Stream.E12.R3.B7.cut
10/12/1999	10:36a	2,583,263	Waste.Stream.E10.R3.B6.cut
10/12/1999	11:01a	2,587,945	Waste.Stream.E12.R3.B6.cut
10/12/1999	10:37a	2,610,336	Waste.Stream.E10.R3.B7.cut
10/12/1999	11:01a	2,534,532	Waste.Stream.E12.R3.B5.cut
10/12/1999	10:36a	2,334,653	Waste.Stream.E10.R3.B4.cut
10/12/1999	11:00a	2,343,691	Waste.Stream.E12.R3.B4.cut
10/12/1999	10:36a	2,513,722	Waste.Stream.E10.R3.B5.cut
10/12/1999	10:49a	2,587,651	Waste.Stream.E11.R3.B6.cut
10/12/1999	10:49a	2,616,389	Waste.Stream.E11.R3.B7.cut

Attachment VIII - List of Files on Disk 2 (Continued)

10/12/1999	10:48a	2,339,159	Waste.Stream.E11.R3.B4.cut
10/12/1999	10:49a	2,528,474	Waste.Stream.E11.R3.B5.cut
10/12/1999	11:04a	2,567,198	Waste.Stream.E12.R4.B7.cut
10/12/1999	10:40a	2,535,389	Waste.Stream.E10.R4.B6.cut
10/12/1999	11:03a	2,537,601	Waste.Stream.E12.R4.B6.cut
10/12/1999	10:40a	2,557,244	Waste.Stream.E10.R4.B7.cut
10/12/1999	11:03a	2,489,828	Waste.Stream.E12.R4.B5.cut
10/12/1999	10:39a	2,292,395	Waste.Stream.E10.R4.B4.cut
10/12/1999	11:03a	2,296,805	Waste.Stream.E12.R4.B4.cut
10/12/1999	10:39a	2,473,388	Waste.Stream.E10.R4.B5.cut
10/12/1999	10:52a	2,537,163	Waste.Stream.E11.R4.B6.cut
10/12/1999	10:52a	2,562,801	Waste.Stream.E11.R4.B7.cut
10/12/1999	10:51a	2,292,283	Waste.Stream.E11.R4.B4.cut
10/12/1999	10:52a	2,483,771	Waste.Stream.E11.R4.B5.cut
02/21/2003	09:32a	2,692,754	Waste.Stream.E1.R4.B15.cut
02/21/2003	09:31a	2,970,222	Waste.Stream.E1.R1.B15.cut
02/21/2003	09:31a	2,732,909	Waste.Stream.E1.R2.B14.cut
02/21/2003	09:32a	2,728,223	Waste.Stream.E1.R3.B14.cut
02/21/2003	09:32a	2,681,093	Waste.Stream.E1.R4.B14.cut
02/21/2003	09:31a	2,744,446	Waste.Stream.E1.R2.B15.cut
02/21/2003	09:32a	2,744,244	Waste.Stream.E1.R3.B15.cut
10/12/1999	10:26a	2,664,388	Waste.Stream.E1.R4.B13.cut
10/12/1999	10:18a	2,941,608	Waste.Stream.E1.R1.B13.cut
10/12/1999	10:21a	2,712,942	Waste.Stream.E1.R2.B12.cut
10/12/1999	10:24a	2,707,864	Waste.Stream.E1.R3.B12.cut
10/12/1999	10:26a	2,659,876	Waste.Stream.E1.R4.B12.cut
02/21/2003	09:31a	2,954,087	Waste.Stream.E1.R1.B14.cut
10/12/1999	10:21a	2,717,950	Waste.Stream.E1.R2.B13.cut
10/12/1999	10:24a	2,713,140	Waste.Stream.E1.R3.B13.cut
10/12/1999	10:55a	2,837,832	Waste.Stream.E12.R1.B7.cut
10/12/1999	10:30a	2,794,671	Waste.Stream.E10.R1.B6.cut
10/12/1999	10:55a	2,804,159	Waste.Stream.E12.R1.B6.cut
10/12/1999	10:31a	2,830,968	Waste.Stream.E10.R1.B7.cut
10/12/1999	10:55a	2,745,000	Waste.Stream.E12.R1.B5.cut
10/12/1999	10:30a	2,515,615	Waste.Stream.E10.R1.B4.cut
10/12/1999	10:54a	2,523,507	Waste.Stream.E12.R1.B4.cut
10/12/1999	10:30a	2,719,618	Waste.Stream.E10.R1.B5.cut
10/12/1999	10:43a	2,801,077	Waste.Stream.E11.R1.B6.cut
10/12/1999	10:43a	2,837,041	Waste.Stream.E11.R1.B7.cut
10/12/1999	10:42a	2,516,381	Waste.Stream.E11.R1.B4.cut
10/12/1999	10:42a	2,735,903	Waste.Stream.E11.R1.B5.cut
10/12/1999	10:58a	2,667,431	Waste.Stream.E12.R2.B9.cut
10/12/1999	10:34a	2,642,893	Waste.Stream.E10.R2.B8.cut
10/12/1999	10:58a	2,646,398	Waste.Stream.E12.R2.B8.cut
10/12/1999	10:34a	2,665,243	Waste.Stream.E10.R2.B9.cut
10/12/1999	10:46a	2,649,344	Waste.Stream.E11.R2.B8.cut
10/12/1999	10:47a	2,665,392	Waste.Stream.E11.R2.B9.cut
10/12/1999	11:02a	2,663,013	Waste.Stream.E12.R3.B9.cut
10/12/1999	10:37a	2,640,067	Waste.Stream.E10.R3.B8.cut
10/12/1999	11:01a	2,646,320	Waste.Stream.E12.R3.B8.cut
10/12/1999	10:37a	2,662,799	Waste.Stream.E10.R3.B9.cut
10/12/1999	10:49a	2,644,276	Waste.Stream.E11.R3.B8.cut
10/12/1999	10:50a	2,660,726	Waste.Stream.E11.R3.B9.cut
10/12/1999	11:04a	2,613,621	Waste.Stream.E12.R4.B9.cut
10/12/1999	10:40a	2,593,939	Waste.Stream.E10.R4.B8.cut
10/12/1999	11:04a	2,595,326	Waste.Stream.E12.R4.B8.cut
10/12/1999	10:40a	2,611,805	Waste.Stream.E10.R4.B9.cut
10/12/1999	10:52a	2,598,396	Waste.Stream.E11.R4.B8.cut

Attachment VIII - List of Files on Disk 2 (Continued)

```
10/12/1999  10:53a          2,611,582        Waste.Stream.E11.R4.B9.cut
10/12/1999  10:56a          2,891,213        Waste.Stream.E12.R1.B9.cut
10/12/1999  10:31a          2,860,347        Waste.Stream.E10.R1.B8.cut
10/12/1999  10:56a          2,868,608        Waste.Stream.E12.R1.B8.cut
10/12/1999  10:31a          2,885,831        Waste.Stream.E10.R1.B9.cut
10/12/1999  10:43a          2,870,934        Waste.Stream.E11.R1.B8.cut
10/12/1999  10:44a          2,889,050        Waste.Stream.E11.R1.B9.cut
10/12/1999  10:18a          2,373,785        Waste.Stream.E1.R1.B3.cut
10/12/1999  10:19a          2,827,528        Waste.Stream.E1.R1.B7.cut
10/12/1999  10:18a          2,498,066        Waste.Stream.E1.R1.B4.cut
10/12/1999  10:19a          2,868,215        Waste.Stream.E1.R1.B8.cut
10/12/1999  10:19a          2,706,428        Waste.Stream.E1.R1.B5.cut
10/12/1999  10:20a          2,877,088        Waste.Stream.E1.R1.B9.cut
10/12/1999  10:18a          2,246,240        Waste.Stream.E1.R1.B2.cut
10/12/1999  10:19a          2,774,905        Waste.Stream.E1.R1.B6.cut
10/12/1999  10:17a          2,166,186        Waste.Stream.E1.R1.B1.cut
10/12/1999  10:17a          2,884,708        Waste.Stream.E1.R1.B10.cut
10/12/1999  10:17a          2,899,303        Waste.Stream.E1.R1.B11.cut
10/12/1999  10:17a          2,935,846        Waste.Stream.E1.R1.B12.cut
             240 File(s)    616,344,248 bytes

     Total Files Listed:
             240 File(s)    616,344,248 bytes
               3 Dir(s)               0 bytes free
```

Attachment VIII - List of Files on Disk 3

```
 Volume in drive D is PWR ST G&E
 Volume Serial Number is FF5B-4533

 Directory of D:\

04/20/2004  12:06p      <DIR>          Waste Stream 2
               0 File(s)              0 bytes

 Directory of D:\Waste Stream 2

04/20/2004  12:06p      <DIR>          .
04/20/2004  12:06p      <DIR>          ..
10/12/1999  11:22a           2,093,522         Waste.Stream.E3.R2.B2.cut
10/12/1999  11:25a           2,084,604         Waste.Stream.E3.R3.B2.cut
10/12/1999  11:28a           2,047,662         Waste.Stream.E3.R4.B2.cut
10/12/1999  11:23a           2,578,534         Waste.Stream.E3.R2.B6.cut
10/12/1999  11:26a           2,577,032         Waste.Stream.E3.R3.B6.cut
10/12/1999  11:29a           2,535,086         Waste.Stream.E3.R4.B6.cut
10/12/1999  10:47a           2,089,658         Waste.Stream.E5.R2.B2.cut
10/12/1999  10:50a           2,080,750         Waste.Stream.E5.R3.B2.cut
10/12/1999  10:53a           2,043,798         Waste.Stream.E5.R4.B2.cut
10/12/1999  10:48a           2,579,133         Waste.Stream.E5.R2.B6.cut
10/12/1999  10:51a           2,577,507         Waste.Stream.E5.R3.B6.cut
10/12/1999  10:54a           2,535,437         Waste.Stream.E5.R4.B6.cut
10/12/1999  11:22a           2,208,810         Waste.Stream.E3.R2.B3.cut
10/12/1999  11:25a           2,194,054         Waste.Stream.E3.R3.B3.cut
10/12/1999  11:28a           2,155,142         Waste.Stream.E3.R4.B3.cut
10/12/1999  11:23a           2,615,426         Waste.Stream.E3.R2.B7.cut
10/12/1999  11:26a           2,614,450         Waste.Stream.E3.R3.B7.cut
10/12/1999  11:29a           2,566,730         Waste.Stream.E3.R4.B7.cut
10/12/1999  10:47a           2,205,701         Waste.Stream.E5.R2.B3.cut
10/12/1999  10:50a           2,193,187         Waste.Stream.E5.R3.B3.cut
10/12/1999  10:53a           2,152,167         Waste.Stream.E5.R4.B3.cut
10/12/1999  10:48a           2,615,502         Waste.Stream.E5.R2.B7.cut
10/12/1999  10:51a           2,614,402         Waste.Stream.E5.R3.B7.cut
10/12/1999  10:54a           2,566,806         Waste.Stream.E5.R4.B7.cut
10/12/1999  11:22a           2,323,496         Waste.Stream.E3.R2.B4.cut
10/12/1999  11:25a           2,325,074         Waste.Stream.E3.R3.B4.cut
10/12/1999  11:28a           2,284,086         Waste.Stream.E3.R4.B4.cut
10/12/1999  11:23a           2,644,965         Waste.Stream.E3.R2.B8.cut
10/12/1999  11:26a           2,644,733         Waste.Stream.E3.R3.B8.cut
10/12/1999  11:29a           2,594,161         Waste.Stream.E3.R4.B8.cut
10/12/1999  10:47a           2,323,628         Waste.Stream.E5.R2.B4.cut
10/12/1999  10:51a           2,321,590         Waste.Stream.E5.R3.B4.cut
10/12/1999  10:53a           2,280,354         Waste.Stream.E5.R4.B4.cut
10/12/1999  10:49a           2,646,508         Waste.Stream.E5.R2.B8.cut
10/12/1999  10:51a           2,646,906         Waste.Stream.E5.R3.B8.cut
10/12/1999  10:55a           2,593,958         Waste.Stream.E5.R4.B8.cut
10/12/1999  11:21a           2,031,326         Waste.Stream.E3.R2.B1.cut
10/12/1999  11:24a           2,019,918         Waste.Stream.E3.R3.B1.cut
10/12/1999  11:27a           1,984,362         Waste.Stream.E3.R4.B1.cut
10/12/1999  11:22a           2,512,092         Waste.Stream.E3.R2.B5.cut
10/12/1999  11:25a           2,504,856         Waste.Stream.E3.R3.B5.cut
10/12/1999  11:29a           2,469,790         Waste.Stream.E3.R4.B5.cut
10/12/1999  11:23a           2,666,260         Waste.Stream.E3.R2.B9.cut
10/12/1999  11:26a           2,662,288         Waste.Stream.E3.R3.B9.cut
10/12/1999  11:30a           2,613,204         Waste.Stream.E3.R4.B9.cut
```

Attachment VIII - List of Files on Disk 3 (Continued)

10/12/1999	10:45a	2,027,359	Waste.Stream.E5.R2.B1.cut
10/12/1999	10:49a	2,015,951	Waste.Stream.E5.R3.B1.cut
10/12/1999	10:52a	1,982,379	Waste.Stream.E5.R4.B1.cut
10/12/1999	10:48a	2,512,972	Waste.Stream.E5.R2.B5.cut
10/12/1999	10:51a	2,507,596	Waste.Stream.E5.R3.B5.cut
10/12/1999	10:54a	2,470,288	Waste.Stream.E5.R4.B5.cut
10/12/1999	10:49a	2,663,102	Waste.Stream.E5.R2.B9.cut
10/12/1999	10:52a	2,659,760	Waste.Stream.E5.R3.B9.cut
10/12/1999	10:55a	2,610,542	Waste.Stream.E5.R4.B9.cut
10/12/1999	11:14a	2,634,257	Waste.Stream.E2.R4.B11.cut
10/12/1999	11:05a	2,905,223	Waste.Stream.E2.R1.B11.cut
10/12/1999	11:08a	2,672,389	Waste.Stream.E2.R2.B10.cut
10/12/1999	11:11a	2,668,541	Waste.Stream.E2.R3.B10.cut
10/12/1999	11:14a	2,619,581	Waste.Stream.E2.R4.B10.cut
10/12/1999	11:06a	2,936,479	Waste.Stream.E2.R1.B12.cut
10/12/1999	11:09a	2,684,947	Waste.Stream.E2.R2.B11.cut
10/12/1999	11:11a	2,684,105	Waste.Stream.E2.R3.B11.cut
10/12/1999	11:05a	2,884,833	Waste.Stream.E2.R1.B10.cut
10/12/1999	11:39a	2,641,780	Waste.Stream.E4.R4.B11.cut
10/12/1999	11:30a	2,916,426	Waste.Stream.E4.R1.B11.cut
10/12/1999	11:33a	2,665,578	Waste.Stream.E4.R2.B10.cut
10/12/1999	11:36a	2,661,998	Waste.Stream.E4.R3.B10.cut
10/12/1999	11:39a	2,612,646	Waste.Stream.E4.R4.B10.cut
10/12/1999	11:31a	2,937,670	Waste.Stream.E4.R1.B12.cut
10/12/1999	11:34a	2,692,728	Waste.Stream.E4.R2.B11.cut
10/12/1999	11:36a	2,692,000	Waste.Stream.E4.R3.B11.cut
10/12/1999	11:30a	2,880,646	Waste.Stream.E4.R1.B10.cut
02/21/2003	09:37a	2,695,546	Waste.Stream.E2.R4.B15.cut
02/21/2003	09:35a	2,971,888	Waste.Stream.E2.R1.B15.cut
02/21/2003	09:36a	2,739,635	Waste.Stream.E2.R2.B14.cut
02/21/2003	09:36a	2,734,825	Waste.Stream.E2.R3.B14.cut
02/21/2003	09:37a	2,687,943	Waste.Stream.E2.R4.B14.cut
02/21/2003	09:36a	2,744,872	Waste.Stream.E2.R2.B15.cut
02/21/2003	09:37a	2,745,166	Waste.Stream.E2.R3.B15.cut
10/12/1999	11:15a	2,671,260	Waste.Stream.E2.R4.B13.cut
10/12/1999	11:06a	2,946,734	Waste.Stream.E2.R1.B13.cut
10/12/1999	11:09a	2,713,317	Waste.Stream.E2.R2.B12.cut
10/12/1999	11:11a	2,708,249	Waste.Stream.E2.R3.B12.cut
10/12/1999	11:15a	2,659,879	Waste.Stream.E2.R4.B12.cut
02/21/2003	09:35a	2,964,171	Waste.Stream.E2.R1.B14.cut
10/12/1999	11:09a	2,725,318	Waste.Stream.E2.R2.B13.cut
10/12/1999	11:12a	2,718,266	Waste.Stream.E2.R3.B13.cut
02/21/2003	09:42a	2,697,920	Waste.Stream.E4.R4.B15.cut
02/21/2003	09:41a	2,977,134	Waste.Stream.E4.R1.B15.cut
02/21/2003	09:42a	2,741,642	Waste.Stream.E4.R2.B14.cut
02/21/2003	09:42a	2,741,440	Waste.Stream.E4.R3.B14.cut
02/21/2003	09:42a	2,692,192	Waste.Stream.E4.R4.B14.cut
02/21/2003	09:42a	2,747,246	Waste.Stream.E4.R2.B15.cut
02/21/2003	09:42a	2,747,416	Waste.Stream.E4.R3.B15.cut
10/12/1999	11:40a	2,682,862	Waste.Stream.E4.R4.B13.cut
10/12/1999	11:31a	2,959,090	Waste.Stream.E4.R1.B13.cut
10/12/1999	11:34a	2,716,006	Waste.Stream.E4.R2.B12.cut
10/12/1999	11:36a	2,708,954	Waste.Stream.E4.R3.B12.cut
10/12/1999	11:40a	2,661,948	Waste.Stream.E4.R4.B12.cut
02/21/2003	09:41a	2,968,906	Waste.Stream.E4.R1.B14.cut
10/12/1999	11:34a	2,734,306	Waste.Stream.E4.R2.B13.cut
10/12/1999	11:37a	2,731,862	Waste.Stream.E4.R3.B13.cut
10/12/1999	11:31a	2,246,370	Waste.Stream.E4.R1.B2.cut

Attachment VIII - List of Files on Disk 3 (Continued)

10/12/1999	11:32a	2,784,956	Waste.Stream.E4.R1.B6.cut
10/12/1999	11:06a	2,372,432	Waste.Stream.E2.R1.B3.cut
10/12/1999	11:07a	2,831,234	Waste.Stream.E2.R1.B7.cut
10/12/1999	11:31a	2,374,591	Waste.Stream.E4.R1.B3.cut
10/12/1999	11:32a	2,832,380	Waste.Stream.E4.R1.B7.cut
10/12/1999	11:07a	2,494,583	Waste.Stream.E2.R1.B4.cut
10/12/1999	11:08a	2,866,618	Waste.Stream.E2.R1.B8.cut
10/12/1999	11:31a	2,498,222	Waste.Stream.E4.R1.B4.cut
10/12/1999	11:33a	2,862,692	Waste.Stream.E4.R1.B8.cut
10/12/1999	11:04a	2,163,086	Waste.Stream.E2.R1.B1.cut
10/12/1999	11:07a	2,709,321	Waste.Stream.E2.R1.B5.cut
10/12/1999	11:08a	2,877,537	Waste.Stream.E2.R1.B9.cut
10/12/1999	11:30a	2,163,335	Waste.Stream.E4.R1.B1.cut
10/12/1999	11:31a	2,708,645	Waste.Stream.E4.R1.B5.cut
10/12/1999	11:33a	2,876,021	Waste.Stream.E4.R1.B9.cut
10/12/1999	11:06a	2,244,256	Waste.Stream.E2.R1.B2.cut
10/12/1999	11:07a	2,775,360	Waste.Stream.E2.R1.B6.cut
10/12/1999	11:34a	2,092,892	Waste.Stream.E4.R2.B2.cut
10/12/1999	11:37a	2,083,984	Waste.Stream.E4.R3.B2.cut
10/12/1999	11:40a	2,047,032	Waste.Stream.E4.R4.B2.cut
10/12/1999	11:35a	2,578,762	Waste.Stream.E4.R2.B6.cut
10/12/1999	11:38a	2,577,012	Waste.Stream.E4.R3.B6.cut
10/12/1999	11:41a	2,535,066	Waste.Stream.E4.R4.B6.cut
10/12/1999	11:09a	2,207,540	Waste.Stream.E2.R2.B3.cut
10/12/1999	11:12a	2,192,784	Waste.Stream.E2.R3.B3.cut
10/12/1999	11:16a	2,153,872	Waste.Stream.E2.R4.B3.cut
10/12/1999	11:10a	2,614,176	Waste.Stream.E2.R2.B7.cut
10/12/1999	11:13a	2,612,808	Waste.Stream.E2.R3.B7.cut
10/12/1999	11:17a	2,567,454	Waste.Stream.E2.R4.B7.cut
10/12/1999	11:34a	2,208,945	Waste.Stream.E4.R2.B3.cut
10/12/1999	11:37a	2,194,189	Waste.Stream.E4.R3.B3.cut
10/12/1999	11:40a	2,155,411	Waste.Stream.E4.R4.B3.cut
10/12/1999	11:35a	2,617,440	Waste.Stream.E4.R2.B7.cut
10/12/1999	11:38a	2,616,340	Waste.Stream.E4.R3.B7.cut
10/12/1999	11:41a	2,568,744	Waste.Stream.E4.R4.B7.cut
10/12/1999	11:10a	2,322,107	Waste.Stream.E2.R2.B4.cut
10/12/1999	11:12a	2,323,685	Waste.Stream.E2.R3.B4.cut
10/12/1999	11:16a	2,282,697	Waste.Stream.E2.R4.B4.cut
10/12/1999	11:10a	2,647,518	Waste.Stream.E2.R2.B8.cut
10/12/1999	11:14a	2,647,286	Waste.Stream.E2.R3.B8.cut
10/12/1999	11:17a	2,594,338	Waste.Stream.E2.R4.B8.cut
10/12/1999	11:35a	2,324,496	Waste.Stream.E4.R2.B4.cut
10/12/1999	11:37a	2,324,700	Waste.Stream.E4.R3.B4.cut
10/12/1999	11:40a	2,283,588	Waste.Stream.E4.R4.B4.cut
10/12/1999	11:35a	2,646,136	Waste.Stream.E4.R2.B8.cut
10/12/1999	11:38a	2,646,658	Waste.Stream.E4.R3.B8.cut
10/12/1999	11:41a	2,593,710	Waste.Stream.E4.R4.B8.cut
10/12/1999	11:08a	2,030,334	Waste.Stream.E2.R2.B1.cut
10/12/1999	11:11a	2,019,050	Waste.Stream.E2.R3.B1.cut
10/12/1999	11:14a	1,983,370	Waste.Stream.E2.R4.B1.cut
10/12/1999	11:10a	2,514,401	Waste.Stream.E2.R2.B5.cut
10/12/1999	11:12a	2,507,165	Waste.Stream.E2.R3.B5.cut
10/12/1999	11:16a	2,471,851	Waste.Stream.E2.R4.B5.cut
10/12/1999	11:11a	2,666,849	Waste.Stream.E2.R2.B9.cut
10/12/1999	11:14a	2,663,125	Waste.Stream.E2.R3.B9.cut
10/12/1999	11:17a	2,614,165	Waste.Stream.E2.R4.B9.cut
10/12/1999	11:33a	2,030,583	Waste.Stream.E4.R2.B1.cut
10/12/1999	11:36a	2,019,175	Waste.Stream.E4.R3.B1.cut

Attachment VIII - List of Files on Disk 3 (Continued)

10/12/1999	11:39a	1,983,495	Waste.Stream.E4.R4.B1.cut
10/12/1999	11:35a	2,512,981	Waste.Stream.E4.R2.B5.cut
10/12/1999	11:38a	2,507,729	Waste.Stream.E4.R3.B5.cut
10/12/1999	11:41a	2,470,421	Waste.Stream.E4.R4.B5.cut
10/12/1999	11:36a	2,661,841	Waste.Stream.E4.R2.B9.cut
10/12/1999	11:38a	2,658,003	Waste.Stream.E4.R3.B9.cut
10/12/1999	11:42a	2,609,033	Waste.Stream.E4.R4.B9.cut
10/12/1999	11:09a	2,093,268	Waste.Stream.E2.R2.B2.cut
10/12/1999	11:12a	2,084,350	Waste.Stream.E2.R3.B2.cut
10/12/1999	11:15a	2,047,408	Waste.Stream.E2.R4.B2.cut
10/12/1999	11:10a	2,573,724	Waste.Stream.E2.R2.B6.cut
10/12/1999	11:13a	2,572,222	Waste.Stream.E2.R3.B6.cut
10/12/1999	11:16a	2,530,028	Waste.Stream.E2.R4.B6.cut
10/12/1999	11:27a	2,640,591	Waste.Stream.E3.R4.B11.cut
10/12/1999	11:18a	2,914,731	Waste.Stream.E3.R1.B11.cut
10/12/1999	11:21a	2,669,194	Waste.Stream.E3.R2.B10.cut
10/12/1999	11:24a	2,665,604	Waste.Stream.E3.R3.B10.cut
10/12/1999	11:27a	2,616,386	Waste.Stream.E3.R4.B10.cut
10/12/1999	11:18a	2,937,469	Waste.Stream.E3.R1.B12.cut
10/12/1999	11:21a	2,691,415	Waste.Stream.E3.R2.B11.cut
10/12/1999	11:24a	2,690,439	Waste.Stream.E3.R3.B11.cut
10/12/1999	11:18a	2,883,756	Waste.Stream.E3.R1.B10.cut
10/12/1999	10:52a	2,641,779	Waste.Stream.E5.R4.B11.cut
10/12/1999	11:42a	2,917,045	Waste.Stream.E5.R1.B11.cut
02/26/2003	10:15a	2,666,625	Waste.Stream.E5.R2.B10.cut
10/12/1999	10:49a	2,663,133	Waste.Stream.E5.R3.B10.cut
10/12/1999	10:52a	2,613,905	Waste.Stream.E5.R4.B10.cut
10/12/1999	11:43a	2,942,926	Waste.Stream.E5.R1.B12.cut
10/12/1999	10:46a	2,694,969	Waste.Stream.E5.R2.B11.cut
10/12/1999	10:49a	2,692,123	Waste.Stream.E5.R3.B11.cut
10/12/1999	11:42a	2,883,661	Waste.Stream.E5.R1.B10.cut
02/21/2003	09:40a	2,697,302	Waste.Stream.E3.R4.B15.cut
02/21/2003	09:39a	2,974,398	Waste.Stream.E3.R1.B15.cut
02/21/2003	09:40a	2,739,783	Waste.Stream.E3.R2.B14.cut
02/21/2003	09:40a	2,739,705	Waste.Stream.E3.R3.B14.cut
02/21/2003	09:40a	2,690,581	Waste.Stream.E3.R4.B14.cut
02/21/2003	09:40a	2,746,628	Waste.Stream.E3.R2.B15.cut
02/21/2003	09:40a	2,746,922	Waste.Stream.E3.R3.B15.cut
10/12/1999	11:28a	2,681,741	Waste.Stream.E3.R4.B13.cut
10/12/1999	11:19a	2,959,963	Waste.Stream.E3.R1.B13.cut
10/12/1999	11:21a	2,715,929	Waste.Stream.E3.R2.B12.cut
10/12/1999	11:24a	2,708,877	Waste.Stream.E3.R3.B12.cut
10/12/1999	11:27a	2,661,747	Waste.Stream.E3.R4.B12.cut
02/21/2003	09:39a	2,966,055	Waste.Stream.E3.R1.B14.cut
10/12/1999	11:22a	2,735,551	Waste.Stream.E3.R2.B13.cut
10/12/1999	11:25a	2,730,865	Waste.Stream.E3.R3.B13.cut
02/21/2003	09:55a	2,697,161	Waste.Stream.E5.R4.B15.cut
02/21/2003	09:43a	2,976,251	Waste.Stream.E5.R1.B15.cut
02/21/2003	09:45a	2,741,393	Waste.Stream.E5.R2.B14.cut
02/21/2003	09:55a	2,741,563	Waste.Stream.E5.R3.B14.cut
02/21/2003	09:55a	2,691,943	Waste.Stream.E5.R4.B14.cut
02/21/2003	09:55a	2,746,487	Waste.Stream.E5.R2.B15.cut
02/21/2003	09:55a	2,746,657	Waste.Stream.E5.R3.B15.cut
10/12/1999	10:53a	2,684,867	Waste.Stream.E5.R4.B13.cut
10/12/1999	11:43a	2,959,969	Waste.Stream.E5.R1.B13.cut
10/12/1999	10:47a	2,719,010	Waste.Stream.E5.R2.B12.cut
10/12/1999	10:50a	2,711,958	Waste.Stream.E5.R3.B12.cut
10/12/1999	10:53a	2,665,324	Waste.Stream.E5.R4.B12.cut

Attachment VIII - List of Files on Disk 3 (Continued)

```
02/21/2003  09:43a          2,968,667        Waste.Stream.E5.R1.B14.cut
10/12/1999  10:47a          2,734,069        Waste.Stream.E5.R2.B13.cut
10/12/1999  10:50a          2,731,625        Waste.Stream.E5.R3.B13.cut
10/12/1999  11:43a          2,243,260        Waste.Stream.E5.R1.B2.cut
10/12/1999  11:44a          2,785,451        Waste.Stream.E5.R1.B6.cut
10/12/1999  11:19a          2,374,456        Waste.Stream.E3.R1.B3.cut
10/12/1999  11:20a          2,830,490        Waste.Stream.E3.R1.B7.cut
10/12/1999  11:44a          2,371,471        Waste.Stream.E5.R1.B3.cut
10/12/1999  11:45a          2,830,814        Waste.Stream.E5.R1.B7.cut
10/12/1999  11:19a          2,496,220        Waste.Stream.E3.R1.B4.cut
10/12/1999  11:20a          2,865,573        Waste.Stream.E3.R1.B8.cut
10/12/1999  11:44a          2,497,478        Waste.Stream.E5.R1.B4.cut
10/12/1999  11:45a          2,863,188        Waste.Stream.E5.R1.B8.cut
10/12/1999  11:17a          2,164,078        Waste.Stream.E3.R1.B1.cut
10/12/1999  11:19a          2,707,642        Waste.Stream.E3.R1.B5.cut
10/12/1999  11:20a          2,878,704        Waste.Stream.E3.R1.B9.cut
10/12/1999  11:42a          2,160,111        Waste.Stream.E5.R1.B1.cut
10/12/1999  11:44a          2,708,770        Waste.Stream.E5.R1.B5.cut
10/12/1999  11:45a          2,876,919        Waste.Stream.E5.R1.B9.cut
10/12/1999  11:19a          2,244,758        Waste.Stream.E3.R1.B2.cut
10/12/1999  11:20a          2,781,916        Waste.Stream.E3.R1.B6.cut
             240 File(s)    616,284,045 bytes

     Total Files Listed:
             240 File(s)    616,284,045 bytes
               3 Dir(s)               0 bytes free
```

Attachment VIII - List of Files on Disk 4

```
 Volume in drive D is PWR ST G&E
 Volume Serial Number is DF53-540C

 Directory of D:\

04/20/2004  12:20p      <DIR>          Waste Stream 3
               0 File(s)              0 bytes

 Directory of D:\Waste Stream 3

04/20/2004  12:20p      <DIR>          .
04/20/2004  12:20p      <DIR>          ..
10/12/1999  12:11p           2,090,385        Waste.Stream.E7.R2.B2.cut
10/12/1999  12:15p           2,080,495        Waste.Stream.E7.R3.B2.cut
10/12/1999  12:18p           2,043,151        Waste.Stream.E7.R4.B2.cut
10/12/1999  12:13p           2,583,704        Waste.Stream.E7.R2.B6.cut
10/12/1999  12:16p           2,581,924        Waste.Stream.E7.R3.B6.cut
10/12/1999  12:19p           2,539,482        Waste.Stream.E7.R4.B6.cut
10/12/1999  12:37p           2,089,883        Waste.Stream.E9.R2.B2.cut
10/12/1999  12:40p           2,081,233        Waste.Stream.E9.R3.B2.cut
10/12/1999  12:43p           2,042,401        Waste.Stream.E9.R4.B2.cut
10/12/1999  12:38p           2,579,551        Waste.Stream.E9.R2.B6.cut
10/12/1999  12:41p           2,577,945        Waste.Stream.E9.R3.B6.cut
10/12/1999  12:44p           2,533,107        Waste.Stream.E9.R4.B6.cut
10/12/1999  12:12p           2,208,222        Waste.Stream.E7.R2.B3.cut
10/12/1999  12:15p           2,192,940        Waste.Stream.E7.R3.B3.cut
10/12/1999  12:18p           2,153,304        Waste.Stream.E7.R4.B3.cut
10/12/1999  12:13p           2,612,440        Waste.Stream.E7.R2.B7.cut
10/12/1999  12:16p           2,611,712        Waste.Stream.E7.R3.B7.cut
10/12/1999  12:19p           2,561,502        Waste.Stream.E7.R4.B7.cut
10/12/1999  12:37p           2,211,324        Waste.Stream.E9.R2.B3.cut
10/12/1999  12:40p           2,200,040        Waste.Stream.E9.R3.B3.cut
10/12/1999  12:43p           2,160,864        Waste.Stream.E9.R4.B3.cut
10/12/1999  12:38p           2,615,870        Waste.Stream.E9.R2.B7.cut
10/12/1999  12:41p           2,613,530        Waste.Stream.E9.R3.B7.cut
10/12/1999  12:44p           2,560,572        Waste.Stream.E9.R4.B7.cut
10/12/1999  12:12p           2,324,026        Waste.Stream.E7.R2.B4.cut
10/12/1999  12:15p           2,322,360        Waste.Stream.E7.R3.B4.cut
10/12/1999  12:18p           2,280,876        Waste.Stream.E7.R4.B4.cut
10/12/1999  12:13p           2,648,094        Waste.Stream.E7.R2.B8.cut
10/12/1999  12:16p           2,643,740        Waste.Stream.E7.R3.B8.cut
10/12/1999  12:19p           2,592,910        Waste.Stream.E7.R4.B8.cut
10/12/1999  12:37p           2,329,030        Waste.Stream.E9.R2.B4.cut
10/12/1999  12:40p           2,330,142        Waste.Stream.E9.R3.B4.cut
10/12/1999  12:43p           2,285,528        Waste.Stream.E9.R4.B4.cut
10/12/1999  12:38p           2,639,469        Waste.Stream.E9.R2.B8.cut
10/12/1999  12:41p           2,636,385        Waste.Stream.E9.R3.B8.cut
10/12/1999  12:44p           2,586,527        Waste.Stream.E9.R4.B8.cut
10/12/1999  12:10p           2,025,249        Waste.Stream.E7.R2.B1.cut
10/12/1999  12:13p           2,013,345        Waste.Stream.E7.R3.B1.cut
10/12/1999  12:17p           1,979,897        Waste.Stream.E7.R4.B1.cut
10/12/1999  12:12p           2,512,410        Waste.Stream.E7.R2.B5.cut
10/12/1999  12:16p           2,509,400        Waste.Stream.E7.R3.B5.cut
10/12/1999  12:19p           2,469,602        Waste.Stream.E7.R4.B5.cut
10/12/1999  12:13p           2,665,172        Waste.Stream.E7.R2.B9.cut
10/12/1999  12:16p           2,661,954        Waste.Stream.E7.R3.B9.cut
10/12/1999  12:20p           2,614,348        Waste.Stream.E7.R4.B9.cut
10/12/1999  12:35p           2,025,233        Waste.Stream.E9.R2.B1.cut
```

Attachment VIII - List of Files on Disk 4 (Continued)

10/12/1999	12:39p	2,011,345	Waste.Stream.E9.R3.B1.cut
10/12/1999	12:42p	1,978,393	Waste.Stream.E9.R4.B1.cut
10/12/1999	12:38p	2,515,070	Waste.Stream.E9.R2.B5.cut
10/12/1999	12:41p	2,511,802	Waste.Stream.E9.R3.B5.cut
10/12/1999	12:39p	2,672,119	Waste.Stream.E9.R2.B9.cut
10/12/1999	12:41p	2,669,541	Waste.Stream.E9.R3.B9.cut
10/12/1999	12:44p	2,620,923	Waste.Stream.E9.R4.B9.cut
10/12/1999	12:05p	2,640,976	Waste.Stream.E6.R4.B11.cut
10/12/1999	11:58a	2,668,099	Waste.Stream.E6.R2.B10.cut
10/12/1999	12:01p	2,666,751	Waste.Stream.E6.R3.B10.cut
10/12/1999	12:05p	2,615,033	Waste.Stream.E6.R4.B10.cut
10/12/1999	11:59a	2,694,910	Waste.Stream.E6.R2.B11.cut
10/12/1999	12:02p	2,689,832	Waste.Stream.E6.R3.B11.cut
10/12/1999	12:30p	2,642,497	Waste.Stream.E8.R4.B11.cut
10/12/1999	12:20p	2,920,213	Waste.Stream.E8.R1.B11.cut
10/12/1999	12:23p	2,675,982	Waste.Stream.E8.R2.B10.cut
10/12/1999	12:26p	2,675,264	Waste.Stream.E8.R3.B10.cut
10/12/1999	12:30p	2,626,904	Waste.Stream.E8.R4.B10.cut
10/12/1999	12:21p	2,955,099	Waste.Stream.E8.R1.B12.cut
10/12/1999	12:24p	2,696,059	Waste.Stream.E8.R2.B11.cut
10/12/1999	12:27p	2,691,383	Waste.Stream.E8.R3.B11.cut
10/12/1999	12:20p	2,899,556	Waste.Stream.E8.R1.B10.cut
02/21/2003	09:57a	2,696,084	Waste.Stream.E6.R4.B15.cut
02/21/2003	09:56a	2,977,416	Waste.Stream.E6.R1.B15.cut
02/21/2003	09:56a	2,742,166	Waste.Stream.E6.R2.B14.cut
02/21/2003	09:56a	2,742,212	Waste.Stream.E6.R3.B14.cut
02/21/2003	09:56a	2,692,840	Waste.Stream.E6.R4.B14.cut
02/21/2003	09:56a	2,745,658	Waste.Stream.E6.R2.B15.cut
02/21/2003	09:56a	2,745,828	Waste.Stream.E6.R3.B15.cut
10/12/1999	12:05p	2,685,896	Waste.Stream.E6.R4.B13.cut
10/12/1999	11:56a	2,962,238	Waste.Stream.E6.R1.B13.cut
10/12/1999	11:59a	2,728,084	Waste.Stream.E6.R2.B12.cut
10/12/1999	12:02p	2,725,640	Waste.Stream.E6.R3.B12.cut
10/12/1999	12:05p	2,676,640	Waste.Stream.E6.R4.B12.cut
02/21/2003	09:56a	2,971,930	Waste.Stream.E6.R1.B14.cut
10/12/1999	11:59a	2,735,222	Waste.Stream.E6.R2.B13.cut
10/12/1999	12:02p	2,735,020	Waste.Stream.E6.R3.B13.cut
02/21/2003	09:59a	2,690,768	Waste.Stream.E8.R4.B15.cut
02/21/2003	09:58a	2,974,848	Waste.Stream.E8.R1.B15.cut
02/21/2003	09:58a	2,739,424	Waste.Stream.E8.R2.B14.cut
02/21/2003	09:59a	2,739,728	Waste.Stream.E8.R3.B14.cut
02/21/2003	09:59a	2,689,850	Waste.Stream.E8.R4.B14.cut
02/21/2003	09:58a	2,740,218	Waste.Stream.E8.R2.B15.cut
02/21/2003	09:59a	2,743,012	Waste.Stream.E8.R3.B15.cut
10/12/1999	12:31p	2,686,491	Waste.Stream.E8.R4.B13.cut
10/12/1999	12:21p	2,965,705	Waste.Stream.E8.R1.B13.cut
10/12/1999	12:24p	2,728,197	Waste.Stream.E8.R2.B12.cut
10/12/1999	12:27p	2,728,253	Waste.Stream.E8.R3.B12.cut
10/12/1999	12:30p	2,678,871	Waste.Stream.E8.R4.B12.cut
02/21/2003	09:58a	2,971,430	Waste.Stream.E8.R1.B14.cut
10/12/1999	12:24p	2,735,817	Waste.Stream.E8.R2.B13.cut
10/12/1999	12:27p	2,736,121	Waste.Stream.E8.R3.B13.cut
10/12/1999	11:56a	2,244,100	Waste.Stream.E6.R1.B2.cut
10/12/1999	11:57a	2,793,875	Waste.Stream.E6.R1.B6.cut
10/12/1999	12:21p	2,243,491	Waste.Stream.E8.R1.B2.cut
10/12/1999	12:22p	2,796,177	Waste.Stream.E8.R1.B6.cut
10/12/1999	11:56a	2,371,110	Waste.Stream.E6.R1.B3.cut
10/12/1999	11:57a	2,831,138	Waste.Stream.E6.R1.B7.cut

Attachment VIII - List of Files on Disk 4 (Continued)

10/12/1999	12:21p	2,374,852	Waste.Stream.E8.R1.B3.cut
10/12/1999	12:22p	2,826,542	Waste.Stream.E8.R1.B7.cut
10/12/1999	11:57a	2,497,599	Waste.Stream.E6.R1.B4.cut
10/12/1999	11:57a	2,861,462	Waste.Stream.E6.R1.B8.cut
10/12/1999	12:22p	2,500,403	Waste.Stream.E8.R1.B4.cut
10/12/1999	12:23p	2,864,173	Waste.Stream.E8.R1.B8.cut
10/12/1999	11:55a	2,158,995	Waste.Stream.E6.R1.B1.cut
10/12/1999	11:57a	2,709,395	Waste.Stream.E6.R1.B5.cut
10/12/1999	11:58a	2,881,427	Waste.Stream.E6.R1.B9.cut
10/12/1999	12:20p	2,155,893	Waste.Stream.E8.R1.B1.cut
10/12/1999	12:22p	2,710,591	Waste.Stream.E8.R1.B5.cut
10/12/1999	12:23p	2,891,636	Waste.Stream.E8.R1.B9.cut
10/12/1999	11:59a	2,092,244	Waste.Stream.E6.R2.B2.cut
10/12/1999	12:02p	2,081,982	Waste.Stream.E6.R3.B2.cut
10/12/1999	12:06p	2,044,638	Waste.Stream.E6.R4.B2.cut
10/12/1999	12:00p	2,584,889	Waste.Stream.E6.R2.B6.cut
10/12/1999	12:03p	2,583,109	Waste.Stream.E6.R3.B6.cut
10/12/1999	12:06p	2,540,791	Waste.Stream.E6.R4.B6.cut
10/12/1999	12:24p	2,089,651	Waste.Stream.E8.R2.B2.cut
10/12/1999	12:27p	2,079,379	Waste.Stream.E8.R3.B2.cut
10/12/1999	12:31p	2,042,035	Waste.Stream.E8.R4.B2.cut
10/12/1999	12:25p	2,583,731	Waste.Stream.E8.R2.B6.cut
10/12/1999	12:28p	2,582,363	Waste.Stream.E8.R3.B6.cut
10/12/1999	12:32p	2,537,535	Waste.Stream.E8.R4.B6.cut
10/12/1999	11:59a	2,207,458	Waste.Stream.E6.R2.B3.cut
10/12/1999	12:03p	2,192,568	Waste.Stream.E6.R3.B3.cut
10/12/1999	12:06p	2,152,808	Waste.Stream.E6.R4.B3.cut
10/12/1999	12:00p	2,617,498	Waste.Stream.E6.R2.B7.cut
10/12/1999	12:04p	2,614,404	Waste.Stream.E6.R3.B7.cut
10/12/1999	12:06p	2,566,436	Waste.Stream.E6.R4.B7.cut
10/12/1999	12:24p	2,210,828	Waste.Stream.E8.R2.B3.cut
10/12/1999	12:28p	2,197,674	Waste.Stream.E8.R3.B3.cut
10/12/1999	12:31p	2,157,606	Waste.Stream.E8.R4.B3.cut
10/12/1999	12:25p	2,616,305	Waste.Stream.E8.R2.B7.cut
10/12/1999	12:29p	2,611,589	Waste.Stream.E8.R3.B7.cut
10/12/1999	12:32p	2,561,265	Waste.Stream.E8.R4.B7.cut
10/12/1999	12:00p	2,323,759	Waste.Stream.E6.R2.B4.cut
10/12/1999	12:03p	2,323,839	Waste.Stream.E6.R3.B4.cut
10/12/1999	12:06p	2,281,735	Waste.Stream.E6.R4.B4.cut
10/12/1999	12:01p	2,645,030	Waste.Stream.E6.R2.B8.cut
10/12/1999	12:04p	2,645,180	Waste.Stream.E6.R3.B8.cut
10/12/1999	12:07p	2,594,350	Waste.Stream.E6.R4.B8.cut
10/12/1999	12:25p	2,325,809	Waste.Stream.E8.R2.B4.cut
10/12/1999	12:28p	2,325,547	Waste.Stream.E8.R3.B4.cut
10/12/1999	12:31p	2,282,555	Waste.Stream.E8.R4.B4.cut
10/12/1999	12:26p	2,647,493	Waste.Stream.E8.R2.B8.cut
10/12/1999	12:29p	2,643,789	Waste.Stream.E8.R3.B8.cut
10/12/1999	12:32p	2,594,551	Waste.Stream.E8.R4.B8.cut
10/12/1999	11:58a	2,026,491	Waste.Stream.E6.R2.B1.cut
10/12/1999	12:01p	2,014,959	Waste.Stream.E6.R3.B1.cut
10/12/1999	12:04p	1,981,263	Waste.Stream.E6.R4.B1.cut
10/12/1999	12:00p	2,512,967	Waste.Stream.E6.R2.B5.cut
10/12/1999	12:03p	2,509,957	Waste.Stream.E6.R3.B5.cut
10/12/1999	12:06p	2,470,159	Waste.Stream.E6.R4.B5.cut
10/12/1999	12:01p	2,664,737	Waste.Stream.E6.R2.B9.cut
10/12/1999	12:04p	2,661,023	Waste.Stream.E6.R3.B9.cut
10/12/1999	12:07p	2,611,547	Waste.Stream.E6.R4.B9.cut
10/12/1999	12:23p	2,023,389	Waste.Stream.E8.R2.B1.cut

Attachment VIII - List of Files on Disk 4 (Continued)

10/12/1999	12:26p	2,011,485	Waste.Stream.E8.R3.B1.cut
10/12/1999	12:29p	1,978,161	Waste.Stream.E8.R4.B1.cut
10/12/1999	12:25p	2,513,047	Waste.Stream.E8.R2.B5.cut
10/12/1999	12:28p	2,510,161	Waste.Stream.E8.R3.B5.cut
10/12/1999	12:31p	2,470,363	Waste.Stream.E8.R4.B5.cut
10/12/1999	12:26p	2,671,256	Waste.Stream.E8.R2.B9.cut
10/12/1999	12:29p	2,670,414	Waste.Stream.E8.R3.B9.cut
10/12/1999	12:32p	2,622,054	Waste.Stream.E8.R4.B9.cut
10/12/1999	12:17p	2,641,378	Waste.Stream.E7.R4.B11.cut
10/12/1999	12:08p	2,916,108	Waste.Stream.E7.R1.B11.cut
10/12/1999	12:10p	2,673,547	Waste.Stream.E7.R2.B10.cut
10/12/1999	12:14p	2,672,571	Waste.Stream.E7.R3.B10.cut
10/12/1999	12:17p	2,622,599	Waste.Stream.E7.R4.B10.cut
10/12/1999	12:08p	2,955,720	Waste.Stream.E7.R1.B12.cut
10/12/1999	12:10p	2,694,940	Waste.Stream.E7.R2.B11.cut
10/12/1999	12:14p	2,688,136	Waste.Stream.E7.R3.B11.cut
10/12/1999	12:07p	2,893,555	Waste.Stream.E7.R1.B10.cut
10/12/1999	12:42p	2,655,886	Waste.Stream.E9.R4.B11.cut
10/12/1999	12:33p	2,931,742	Waste.Stream.E9.R1.B11.cut
10/12/1999	12:36p	2,676,420	Waste.Stream.E9.R2.B10.cut
10/12/1999	12:39p	2,673,842	Waste.Stream.E9.R3.B10.cut
10/12/1999	12:42p	2,625,224	Waste.Stream.E9.R4.B10.cut
10/12/1999	12:33p	2,949,791	Waste.Stream.E9.R1.B12.cut
10/12/1999	12:36p	2,707,454	Waste.Stream.E9.R2.B11.cut
10/12/1999	12:39p	2,705,020	Waste.Stream.E9.R3.B11.cut
10/12/1999	12:33p	2,898,878	Waste.Stream.E9.R1.B10.cut
02/21/2003	09:58a	2,695,645	Waste.Stream.E7.R4.B15.cut
02/21/2003	09:57a	2,979,601	Waste.Stream.E7.R1.B15.cut
02/21/2003	09:57a	2,741,606	Waste.Stream.E7.R2.B14.cut
02/21/2003	09:57a	2,741,786	Waste.Stream.E7.R3.B14.cut
02/21/2003	09:58a	2,692,032	Waste.Stream.E7.R4.B14.cut
02/21/2003	09:57a	2,745,095	Waste.Stream.E7.R2.B15.cut
02/21/2003	09:57a	2,745,523	Waste.Stream.E7.R3.B15.cut
10/12/1999	12:18p	2,688,631	Waste.Stream.E7.R4.B13.cut
10/12/1999	12:08p	2,967,597	Waste.Stream.E7.R1.B13.cut
10/12/1999	12:11p	2,729,448	Waste.Stream.E7.R2.B12.cut
10/12/1999	12:15p	2,727,262	Waste.Stream.E7.R3.B12.cut
10/12/1999	12:17p	2,680,370	Waste.Stream.E7.R4.B12.cut
02/21/2003	09:57a	2,971,246	Waste.Stream.E7.R1.B14.cut
10/12/1999	12:11p	2,737,957	Waste.Stream.E7.R2.B13.cut
10/12/1999	12:15p	2,738,261	Waste.Stream.E7.R3.B13.cut
02/21/2003	10:00a	2,678,539	Waste.Stream.E9.R4.B15.cut
02/21/2003	09:59a	2,963,135	Waste.Stream.E9.R1.B15.cut
02/21/2003	09:59a	2,727,840	Waste.Stream.E9.R2.B14.cut
02/21/2003	10:00a	2,727,018	Waste.Stream.E9.R3.B14.cut
02/21/2003	10:00a	2,676,892	Waste.Stream.E9.R4.B14.cut
02/21/2003	09:59a	2,729,983	Waste.Stream.E9.R2.B15.cut
02/21/2003	10:00a	2,731,041	Waste.Stream.E9.R3.B15.cut
10/12/1999	12:43p	2,673,672	Waste.Stream.E9.R4.B13.cut
10/12/1999	12:33p	2,952,886	Waste.Stream.E9.R1.B13.cut
10/12/1999	12:36p	2,719,407	Waste.Stream.E9.R2.B12.cut
10/12/1999	12:39p	2,719,835	Waste.Stream.E9.R3.B12.cut
10/12/1999	12:42p	2,670,081	Waste.Stream.E9.R4.B12.cut
02/21/2003	09:59a	2,960,982	Waste.Stream.E9.R1.B14.cut
10/12/1999	12:36p	2,723,370	Waste.Stream.E9.R2.B13.cut
10/12/1999	12:40p	2,723,798	Waste.Stream.E9.R3.B13.cut
10/12/1999	12:08p	2,242,241	Waste.Stream.E7.R1.B2.cut
10/12/1999	12:09p	2,797,876	Waste.Stream.E7.R1.B6.cut

Attachment VIII - List of Files on Disk 4 (Continued)

```
10/12/1999  12:34p          2,243,981        Waste.Stream.E9.R1.B2.cut
10/12/1999  12:35p          2,792,141        Waste.Stream.E9.R1.B6.cut
10/12/1999  12:08p          2,371,854        Waste.Stream.E7.R1.B3.cut
10/12/1999  12:09p          2,827,349        Waste.Stream.E7.R1.B7.cut
10/12/1999  12:34p          2,375,244        Waste.Stream.E9.R1.B3.cut
10/12/1999  12:35p          2,828,672        Waste.Stream.E9.R1.B7.cut
10/12/1999  12:09p          2,495,997        Waste.Stream.E7.R1.B4.cut
10/12/1999  12:10p          2,862,026        Waste.Stream.E7.R1.B8.cut
10/12/1999  12:34p          2,506,392        Waste.Stream.E9.R1.B4.cut
10/12/1999  12:35p          2,856,045        Waste.Stream.E9.R1.B8.cut
10/12/1999  12:07p          2,157,877        Waste.Stream.E7.R1.B1.cut
10/12/1999  12:09p          2,709,706        Waste.Stream.E7.R1.B5.cut
10/12/1999  12:10p          2,882,234        Waste.Stream.E7.R1.B9.cut
10/12/1999  12:32p          2,157,489        Waste.Stream.E9.R1.B1.cut
10/12/1999  12:34p          2,713,120        Waste.Stream.E9.R1.B5.cut
10/12/1999  12:35p          2,893,948        Waste.Stream.E9.R1.B9.cut
10/12/1999  12:44p          2,472,128        Waste.Stream.E9.R4.B5.cut
10/12/1999  11:55a          2,885,161        Waste.Stream.E6.R1.B10.cut
10/12/1999  11:55a          2,917,938        Waste.Stream.E6.R1.B11.cut
10/12/1999  11:56a          2,952,744        Waste.Stream.E6.R1.B12.cut
             240 File(s)    616,774,864 bytes

     Total Files Listed:
             240 File(s)    616,774,864 bytes
               3 Dir(s)               0 bytes free
```

Attachment IX - Radionuclide Inventories for Performance Assessment

The characteristics of the average and maximum PWR SNF assemblies are (see Section 5.5):

- Average PWR assembly- 4% ^{235}U, 48GWd/MTU, 25 years cooling time
- Maximum PWR assembly- 5% ^{235}U, 80GWd/MTU, 5 years cooling time

For the maximum case, the combination of all the maximum parameters (maximum burnup, maximum ^{235}U enrichment, and minimum cooling time – all independent of each other) were used in calculations.

Attachment IX

Average PWR Assembly Radionuclide Inventories for Short Decay Times										
Age:	**25 yr**	**125 yr**	**225 yr**	**325 yr**	**425 yr**	**525 yr**	**1025 yr**	**2025 yr**	**5025 yr**	**10025 yr**
Year:	**2033**	**2133**	**2233**	**2333**	**2433**	**2533**	**3033**	**4033**	**7033**	**12033**
ac227	1.61E-05	4.00E-05	5.59E-05	7.14E-05	8.70E-05	1.03E-04	1.85E-04	3.41E-04	8.09E-04	1.59E-03
ag108	3.85E-04	2.23E-04	1.29E-04	7.48E-05	4.34E-05	2.51E-05	1.64E-06	6.99E-09	5.41E-16	7.61E-28
ag108m	4.42E-03	2.56E-03	1.48E-03	8.60E-04	4.98E-04	2.89E-04	1.88E-05	8.03E-08	6.22E-15	8.74E-27
am241	1.98E+03	2.40E+03	2.05E+03	1.75E+03	1.49E+03	1.27E+03	5.69E+02	1.15E+02	1.15E+00	1.36E-01
am242	6.36E+00	3.89E+00	2.38E+00	1.45E+00	8.90E-01	5.44E-01	4.66E-02	3.42E-04	1.34E-10	2.84E-21
am242m	6.39E+00	3.91E+00	2.39E+00	1.46E+00	8.94E-01	5.47E-01	4.68E-02	3.43E-04	1.35E-10	2.86E-21
am243	2.20E+01	2.18E+01	2.16E+01	2.14E+01	2.12E+01	2.10E+01	2.00E+01	1.82E+01	1.37E+01	8.57E+00
ar 39	5.22E-05	4.04E-05	3.12E-05	2.41E-05	1.86E-05	1.44E-05	3.97E-06	3.02E-07	1.32E-10	3.36E-16
ba137m	3.88E+04	3.85E+03	3.82E+02	3.79E+01	3.76E+00	3.73E-01	3.58E-06	3.30E-16	0.00E+00	0.00E+00
bi211	1.61E-05	4.00E-05	5.59E-05	7.14E-05	8.70E-05	1.03E-04	1.85E-04	3.41E-04	8.09E-04	1.59E-03
bi212	2.06E-02	7.81E-03	2.89E-03	1.07E-03	3.98E-04	1.48E-04	1.91E-06	8.94E-07	9.08E-07	9.37E-07
c 14	3.32E-01	3.28E-01	3.24E-01	3.21E-01	3.17E-01	3.13E-01	2.95E-01	2.61E-01	1.82E-01	9.91E-02
ca 41	9.25E-05	9.24E-05	9.24E-05	9.23E-05	9.22E-05	9.22E-05	9.19E-05	9.12E-05	8.94E-05	8.65E-05
cd113m	7.66E+00	5.61E-02	4.12E-04	3.02E-06	2.21E-08	1.62E-10	3.43E-21	0.00E+00	0.00E+00	0.00E+00
ce142	1.86E-05	1.86E-05	1.86E-05	1.86E-05	1.86E-05	1.86E-05	1.86E-05	1.86E-05	1.86E-05	1.86E-05
ce144	1.18E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cf249	7.72E-05	6.34E-05	5.20E-05	4.27E-05	3.50E-05	2.87E-05	1.07E-05	1.48E-06	3.92E-09	1.99E-13
cf250	8.41E-05	4.20E-07	2.10E-09	1.06E-11	1.55E-13	1.03E-13	1.01E-13	9.67E-14	8.58E-14	7.03E-14
cl 36	6.80E-03	6.80E-03	6.80E-03	6.80E-03	6.79E-03	6.79E-03	6.79E-03	6.77E-03	6.72E-03	6.65E-03
cm242	5.26E+00	3.22E+00	1.97E+00	1.20E+00	7.36E-01	4.50E-01	3.85E-02	2.82E-04	1.12E-10	2.36E-21
cm243	1.03E+01	9.01E-01	7.91E-02	6.95E-03	6.10E-04	5.36E-05	2.80E-10	7.66E-21	0.00E+00	0.00E+00
cm244	1.36E+03	2.96E+01	6.42E-01	1.40E-02	3.03E-04	6.58E-06	3.18E-14	7.30E-31	0.00E+00	0.00E+00
cm245	3.07E-01	3.04E-01	3.02E-01	2.99E-01	2.97E-01	2.94E-01	2.83E-01	2.60E-01	2.04E-01	1.36E-01
cm246	1.04E-01	1.03E-01	1.01E-01	9.98E-02	9.83E-02	9.69E-02	9.01E-02	7.78E-02	5.01E-02	2.41E-02
co 60	3.13E+02	6.06E-04	1.17E-09	2.27E-15	4.40E-21	8.52E-27	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cs134	2.52E+01	6.33E-14	1.59E-28	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cs135	3.50E-01	3.50E-01	3.50E-01	3.50E-01	3.50E-01	3.50E-01	3.50E-01	3.50E-01	3.49E-01	3.49E-01
cs137	4.11E+04	4.08E+03	4.05E+02	4.01E+01	3.98E+00	3.95E-01	3.79E-06	3.49E-16	0.00E+00	0.00E+00
eu150	2.07E-05	2.99E-06	4.31E-07	6.23E-08	8.98E-09	1.30E-09	8.11E-14	3.17E-22	0.00E+00	0.00E+00
eu152	1.31E+00	7.23E-03	3.98E-05	2.20E-07	1.21E-09	6.67E-12	3.39E-23	0.00E+00	0.00E+00	0.00E+00
eu154	6.71E+02	2.10E-01	6.57E-05	2.06E-08	6.44E-12	2.01E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00
eu155	5.15E+01	1.90E-05	7.04E-12	2.60E-18	9.61E-25	3.65E-31	0.00E+00	0.00E+00	0.00E+00	0.00E+00
fe 55	3.46E+00	3.25E-11	3.04E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
h 3	1.14E+02	4.10E-01	1.48E-03	5.37E-06	1.94E-08	7.02E-11	4.35E-23	0.00E+00	0.00E+00	0.00E+00
ho166m	5.38E-04	5.08E-04	4.79E-04	4.52E-04	4.27E-04	4.03E-04	3.02E-04	1.69E-04	2.99E-05	1.67E-06
i129	2.19E-02	2.19E-02	2.19E-02	2.19E-02	2.19E-02	2.19E-02	2.19E-02	2.19E-02	2.19E-02	2.19E-02
kr 85	1.13E+03	1.76E+00	2.74E-03	4.26E-06	6.63E-09	1.03E-11	9.36E-26	0.00E+00	0.00E+00	0.00E+00
mo 93	4.14E-02	4.06E-02	3.98E-02	3.90E-02	3.83E-02	3.75E-02	3.40E-02	2.79E-02	1.54E-02	5.71E-03
nb 91	1.96E-05	1.77E-05	1.60E-05	1.44E-05	1.30E-05	1.18E-05	7.06E-06	2.55E-06	1.20E-07	7.32E-10
nb 93m	1.30E+01	1.09E+00	9.29E-01	9.27E-01	9.26E-01	9.25E-01	9.22E-01	9.16E-01	9.05E-01	8.95E-01
nb 94	8.39E-01	8.36E-01	8.33E-01	8.30E-01	8.28E-01	8.25E-01	8.11E-01	7.84E-01	7.07E-01	5.96E-01
ni 59	2.09E+00	2.09E+00	2.09E+00	2.08E+00	2.08E+00	2.08E+00	2.07E+00	2.05E+00	2.00E+00	1.90E+00
ni 63	2.52E+02	1.26E+02	6.30E+01	3.15E+01	1.58E+01	7.89E+00	2.47E-01	2.43E-04	2.31E-13	2.12E-28
np237	2.47E-01	3.26E-01	3.98E-01	4.60E-01	5.12E-01	5.57E-01	6.98E-01	7.90E-01	8.12E-01	8.11E-01
np238	2.87E-02	1.76E-02	1.08E-02	6.58E-03	4.02E-03	2.46E-03	2.11E-04	1.54E-06	6.08E-13	1.29E-23
np239	2.20E+01	2.18E+01	2.16E+01	2.14E+01	2.12E+01	2.10E+01	2.00E+01	1.82E+01	1.37E+01	8.57E+00
pa231	2.97E-05	4.53E-05	6.08E-05	7.63E-05	9.18E-05	1.07E-04	1.85E-04	3.41E-04	8.09E-04	1.59E-03
pa233	2.47E-01	3.26E-01	3.98E-01	4.60E-01	5.12E-01	5.57E-01	6.98E-01	7.90E-01	8.12E-01	8.11E-01
pa234	1.92E-04	1.92E-04	1.92E-04	1.92E-04	1.92E-04	1.92E-04	1.92E-04	1.92E-04	1.92E-04	1.92E-04
pa234m	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01
pb211	1.61E-05	4.00E-05	5.59E-05	7.14E-05	8.70E-05	1.03E-04	1.85E-04	3.41E-04	8.09E-04	1.59E-03
pb212	2.06E-02	7.81E-03	2.89E-03	1.07E-03	3.98E-04	1.48E-04	1.91E-06	8.94E-07	9.08E-07	9.37E-07
pd107	8.41E-02	8.41E-02	8.41E-02	8.41E-02	8.41E-02	8.41E-02	8.41E-02	8.41E-02	8.41E-02	8.40E-02
pm145	1.07E-03	2.13E-05	4.24E-07	8.45E-09	1.68E-10	3.35E-12	1.05E-20	0.00E+00	0.00E+00	0.00E+00
pm146	1.17E-01	4.22E-07	1.52E-12	5.45E-18	1.96E-23	7.03E-29	0.00E+00	0.00E+00	0.00E+00	0.00E+00
pm147	1.19E+02	3.99E-10	1.33E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
po212	1.32E-02	5.00E-03	1.85E-03	6.87E-04	2.55E-04	9.47E-05	1.22E-06	5.73E-07	5.81E-07	6.00E-07

Attachment IX

Average PWR Assembly Radionuclide Inventories for Short Decay Times										
Age:	**25 yr**	**125 yr**	**225 yr**	**325 yr**	**425 yr**	**525 yr**	**1025 yr**	**2025 yr**	**5025 yr**	**10025 yr**
Year:	**2033**	**2133**	**2233**	**2333**	**2433**	**2533**	**3033**	**4033**	**7033**	**12033**
po215	1.61E-05	4.00E-05	5.59E-05	7.14E-05	8.70E-05	1.03E-04	1.85E-04	3.41E-04	8.09E-04	1.59E-03
po216	2.06E-02	7.81E-03	2.89E-03	1.07E-03	3.98E-04	1.48E-04	1.91E-06	8.94E-07	9.08E-07	9.37E-07
pr144	1.18E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
pu236	1.01E-03	8.86E-07	8.85E-07	8.85E-07	8.84E-07	8.84E-07	8.81E-07	8.76E-07	8.60E-07	8.35E-07
pu238	2.29E+03	1.04E+03	4.73E+02	2.16E+02	9.83E+01	4.49E+01	9.43E-01	6.33E-04	2.97E-10	6.27E-21
pu239	1.77E+02	1.77E+02	1.77E+02	1.76E+02	1.76E+02	1.75E+02	1.73E+02	1.69E+02	1.56E+02	1.37E+02
pu240	3.18E+02	3.18E+02	3.15E+02	3.12E+02	3.09E+02	3.05E+02	2.90E+02	2.61E+02	1.90E+02	1.12E+02
pu241	2.46E+04	1.97E+02	1.87E+00	3.12E-01	2.97E-01	2.95E-01	2.83E-01	2.61E-01	2.04E-01	1.36E-01
pu242	1.64E+00	1.64E+00	1.64E+00	1.64E+00	1.64E+00	1.64E+00	1.64E+00	1.63E+00	1.62E+00	1.61E+00
ra223	1.61E-05	4.00E-05	5.59E-05	7.14E-05	8.70E-05	1.03E-04	1.85E-04	3.41E-04	8.09E-04	1.59E-03
ra224	2.06E-02	7.81E-03	2.89E-03	1.07E-03	3.98E-04	1.48E-04	1.91E-06	8.94E-07	9.08E-07	9.37E-07
rb 87	1.39E-05	1.39E-05	1.39E-05	1.39E-05	1.39E-05	1.39E-05	1.39E-05	1.39E-05	1.39E-05	1.39E-05
rh102	3.04E-03	1.26E-13	5.26E-24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
rh106	1.23E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
rn219	1.61E-05	4.00E-05	5.59E-05	7.14E-05	8.70E-05	1.03E-04	1.85E-04	3.41E-04	8.09E-04	1.59E-03
rn220	2.06E-02	7.81E-03	2.89E-03	1.07E-03	3.98E-04	1.48E-04	1.91E-06	8.94E-07	9.08E-07	9.37E-07
ru106	1.23E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
sb125	9.71E+00	9.11E-11	8.53E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
sb126	5.39E-02	5.39E-02	5.38E-02	5.38E-02	5.38E-02	5.37E-02	5.35E-02	5.32E-02	5.21E-02	5.03E-02
sb126m	3.85E-01	3.85E-01	3.85E-01	3.84E-01	3.84E-01	3.84E-01	3.82E-01	3.80E-01	3.72E-01	3.59E-01
se 79	4.57E-02	4.57E-02	4.57E-02	4.57E-02	4.57E-02	4.56E-02	4.56E-02	4.55E-02	4.52E-02	4.47E-02
sm151	2.11E+02	9.75E+01	4.51E+01	2.09E+01	9.67E+00	4.48E+00	9.52E-02	4.30E-05	3.96E-15	6.85E-32
sn121	1.24E+00	3.51E-01	9.95E-02	2.82E-02	8.00E-03	2.27E-03	4.16E-06	1.40E-11	5.36E-28	0.00E+00
sn121m	1.59E+00	4.52E-01	1.28E-01	3.64E-02	1.03E-02	2.92E-03	5.36E-06	1.81E-11	6.90E-28	0.00E+00
sn126	3.85E-01	3.85E-01	3.85E-01	3.84E-01	3.84E-01	3.84E-01	3.82E-01	3.80E-01	3.72E-01	3.59E-01
sr 90	2.72E+04	2.32E+03	1.97E+02	1.68E+01	1.43E+00	1.22E-01	5.48E-07	1.11E-17	0.00E+00	0.00E+00
tc 99	8.98E+00	8.98E+00	8.98E+00	8.98E+00	8.97E+00	8.97E+00	8.96E+00	8.93E+00	8.84E+00	8.69E+00
te125m	2.37E+00	2.23E-11	2.08E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
th227	1.59E-05	3.95E-05	5.51E-05	7.05E-05	8.58E-05	1.01E-04	1.83E-04	3.36E-04	7.98E-04	1.57E-03
th228	2.06E-02	7.81E-03	2.89E-03	1.07E-03	3.98E-04	1.48E-04	1.91E-06	8.94E-07	9.08E-07	9.37E-07
th230	1.48E-04	1.00E-03	2.14E-03	3.40E-03	4.73E-03	6.08E-03	1.29E-02	2.64E-02	6.61E-02	1.29E-01
th231	7.37E-03	7.38E-03	7.40E-03	7.42E-03	7.43E-03	7.45E-03	7.54E-03	7.71E-03	8.19E-03	8.91E-03
th234	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01
tl207	1.61E-05	3.99E-05	5.57E-05	7.12E-05	8.67E-05	1.02E-04	1.85E-04	3.40E-04	8.07E-04	1.58E-03
tl208	7.42E-03	2.81E-03	1.04E-03	3.85E-04	1.43E-04	5.32E-05	6.86E-07	3.21E-07	3.26E-07	3.37E-07
u232	2.04E-02	7.59E-03	2.81E-03	1.04E-03	3.87E-04	1.44E-04	1.87E-06	8.76E-07	8.60E-07	8.35E-07
u233	3.79E-05	1.62E-04	3.21E-04	5.08E-04	7.19E-04	9.52E-04	2.33E-03	5.61E-03	1.60E-02	3.32E-02
u234	6.77E-01	1.12E+00	1.33E+00	1.42E+00	1.46E+00	1.48E+00	1.49E+00	1.49E+00	1.48E+00	1.46E+00
u235	7.37E-03	7.38E-03	7.40E-03	7.42E-03	7.43E-03	7.45E-03	7.54E-03	7.71E-03	8.19E-03	8.91E-03
u236	1.72E-01	1.73E-01	1.74E-01	1.74E-01	1.75E-01	1.76E-01	1.81E-01	1.89E-01	2.09E-01	2.30E-01
u237	5.90E-01	4.71E-03	4.48E-05	7.46E-06	7.11E-06	7.05E-06	6.77E-06	6.24E-06	4.88E-06	3.25E-06
u238	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01
y 90	2.72E+04	2.32E+03	1.97E+02	1.68E+01	1.43E+00	1.22E-01	5.48E-07	1.11E-17	0.00E+00	0.00E+00
zr 93	8.94E-01	8.94E-01	8.94E-01	8.94E-01	8.94E-01	8.94E-01	8.94E-01	8.93E-01	8.92E-01	8.90E-01

Attachment IX

Average PWR Assembly Radionuclide Inventories for Long Decay Times						
Decay Time	**10025. yr**	**20025. yr**	**30025. yr**	**100025. yr**	**300025. yr**	**1000025 yr**
Year	**12033**	**22033**	**32033**	**102033**	**302033**	**1002033**
ac225	1.17E-02	3.63E-02	6.53E-02	2.56E-01	5.66E-01	6.26E-01
ac227	1.59E-03	3.10E-03	4.53E-03	1.09E-02	1.36E-02	1.37E-02
am241	1.36E-01	6.01E-02	2.66E-02	8.81E-05	7.64E-12	0.00E+00
am243	8.57E+00	3.35E+00	1.31E+00	1.81E-03	6.76E-07	6.56E-07
at217	1.17E-02	3.63E-02	6.53E-02	2.56E-01	5.66E-01	6.26E-01
bi210	1.02E-01	2.20E-01	3.24E-01	7.85E-01	8.53E-01	2.64E-01
bi211	1.59E-03	3.10E-03	4.53E-03	1.09E-02	1.36E-02	1.37E-02
bi213	1.17E-02	3.63E-02	6.53E-02	2.56E-01	5.66E-01	6.26E-01
bi214	1.02E-01	2.20E-01	3.24E-01	7.85E-01	8.53E-01	2.64E-01
c 14	9.91E-02	2.96E-02	8.82E-03	1.85E-06	5.72E-17	0.00E+00
ca 41	8.65E-05	8.08E-05	7.56E-05	4.72E-05	1.23E-05	1.10E-07
ce142	1.86E-05	1.86E-05	1.86E-05	1.86E-05	1.86E-05	1.86E-05
cl 36	6.65E-03	6.49E-03	6.35E-03	5.40E-03	3.41E-03	6.80E-04
cm245	1.36E-01	6.00E-02	2.65E-02	8.80E-05	7.24E-12	0.00E+00
cm246	2.41E-02	5.57E-03	1.29E-03	4.52E-08	2.59E-18	2.01E-30
cs135	3.49E-01	3.48E-01	3.47E-01	3.39E-01	3.20E-01	2.59E-01
fr221	1.17E-02	3.63E-02	6.53E-02	2.56E-01	5.66E-01	6.26E-01
fr223	2.19E-05	4.28E-05	6.25E-05	1.50E-04	1.88E-04	1.89E-04
i129	2.19E-02	2.19E-02	2.19E-02	2.18E-02	2.17E-02	2.10E-02
mo 93	5.71E-03	7.87E-04	1.09E-04	1.03E-10	6.32E-28	0.00E+00
nb 93m	8.95E-01	8.87E-01	8.82E-01	8.55E-01	7.80E-01	5.69E-01
nb 94	5.96E-01	4.24E-01	3.01E-01	2.76E-02	2.98E-05	1.24E-15
ni 59	1.90E+00	1.74E+00	1.58E+00	8.29E-01	1.31E-01	2.02E-04
np237	8.11E-01	8.09E-01	8.06E-01	7.88E-01	7.39E-01	5.89E-01
np239	8.57E+00	3.35E+00	1.31E+00	1.81E-03	6.76E-07	6.56E-07
pa231	1.59E-03	3.10E-03	4.53E-03	1.09E-02	1.36E-02	1.37E-02
pa233	8.11E-01	8.09E-01	8.06E-01	7.88E-01	7.39E-01	5.89E-01
pa234	1.92E-04	1.92E-04	1.92E-04	1.92E-04	1.92E-04	1.92E-04
pa234m	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01
pb209	1.17E-02	3.63E-02	6.53E-02	2.56E-01	5.66E-01	6.26E-01
pb210	1.02E-01	2.20E-01	3.24E-01	7.85E-01	8.53E-01	2.64E-01
pb211	1.59E-03	3.10E-03	4.53E-03	1.09E-02	1.36E-02	1.37E-02

Attachment IX

Average PWR Assembly Radionuclide Inventories for Long Decay Times						
Decay Time	**10025. yr**	**20025. yr**	**30025. yr**	**100025. yr**	**300025. yr**	**1000025 yr**
Year	**12033**	**22033**	**32033**	**102033**	**302033**	**1002033**
pb214	1.02E-01	2.20E-01	3.24E-01	7.85E-01	8.53E-01	2.64E-01
pd107	8.40E-02	8.39E-02	8.38E-02	8.32E-02	8.15E-02	7.56E-02
po210	1.02E-01	2.20E-01	3.24E-01	7.85E-01	8.53E-01	2.64E-01
po213	1.15E-02	3.55E-02	6.39E-02	2.51E-01	5.54E-01	6.13E-01
po214	1.02E-01	2.20E-01	3.24E-01	7.85E-01	8.53E-01	2.64E-01
po215	1.59E-03	3.10E-03	4.53E-03	1.09E-02	1.36E-02	1.37E-02
po218	1.02E-01	2.20E-01	3.24E-01	7.85E-01	8.53E-01	2.64E-01
pu239	1.37E+02	1.04E+02	7.84E+01	1.06E+01	3.36E-02	6.56E-07
pu240	1.12E+02	3.89E+01	1.35E+01	8.32E-03	7.17E-09	1.36E-08
pu241	1.36E-01	6.01E-02	2.66E-02	8.81E-05	7.25E-12	0.00E+00
pu242	1.61E+00	1.58E+00	1.55E+00	1.36E+00	9.40E-01	2.56E-01
ra223	1.59E-03	3.10E-03	4.53E-03	1.09E-02	1.36E-02	1.37E-02
ra225	1.17E-02	3.63E-02	6.53E-02	2.56E-01	5.66E-01	6.26E-01
ra226	1.02E-01	2.20E-01	3.24E-01	7.85E-01	8.53E-01	2.64E-01
rb 87	1.39E-05	1.39E-05	1.39E-05	1.39E-05	1.39E-05	1.39E-05
rn219	1.59E-03	3.10E-03	4.53E-03	1.09E-02	1.36E-02	1.37E-02
rn222	1.02E-01	2.20E-01	3.24E-01	7.85E-01	8.53E-01	2.64E-01
sb126	5.03E-02	4.69E-02	4.38E-02	2.70E-02	6.74E-03	5.27E-05
sb126m	3.59E-01	3.35E-01	3.13E-01	1.93E-01	4.81E-02	3.76E-04
se 79	4.47E-02	4.38E-02	4.29E-02	3.70E-02	2.43E-02	5.59E-03
sn126	3.59E-01	3.35E-01	3.13E-01	1.93E-01	4.81E-02	3.76E-04
tc 99	8.69E+00	8.41E+00	8.14E+00	6.47E+00	3.35E+00	3.37E-01
th227	1.56E-03	3.06E-03	4.47E-03	1.07E-02	1.34E-02	1.35E-02
th229	1.17E-02	3.63E-02	6.53E-02	2.56E-01	5.66E-01	6.26E-01
th230	1.30E-01	2.45E-01	3.47E-01	7.81E-01	8.50E-01	2.64E-01
th231	8.91E-03	1.01E-02	1.10E-02	1.33E-02	1.37E-02	1.37E-02
th234	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01
tl207	1.58E-03	3.10E-03	4.52E-03	1.09E-02	1.36E-02	1.36E-02
tl209	2.46E-04	7.62E-04	1.37E-03	5.38E-03	1.19E-02	1.32E-02
u233	3.47E-02	6.77E-02	9.93E-02	2.83E-01	5.60E-01	6.25E-01
u234	1.46E+00	1.42E+00	1.39E+00	1.17E+00	7.27E-01	2.28E-01
u235	8.91E-03	1.01E-02	1.10E-02	1.33E-02	1.37E-02	1.37E-02
u236	2.30E-01	2.51E-01	2.58E-01	2.61E-01	2.60E-01	2.54E-01
u238	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01
zr 93	0.8899	0.8865	0.8821	0.8552	0.7804	0.569

Attachment IX

Maximum PWR Assembly Radionuclide Inventories for Short Decay Times										
Age:	**5 yr**	**100 yr**	**200 yr**	**300 yr**	**400 yr**	**500 yr**	**1000 yr**	**2000 yr**	**5000 yr**	**10000 yr**
ac227	0.00E+00	4.48E-05	5.31E-05	6.00E-05	6.70E-05	7.39E-05	1.09E-04	1.83E-04	4.12E-04	8.26E-04
ag108	1.38E-03	8.22E-04	4.76E-04	2.76E-04	1.60E-04	9.27E-05	6.05E-06	2.58E-08	0.00E+00	0.00E+00
ag108m	1.59E-02	9.45E-03	5.48E-03	3.17E-03	1.84E-03	1.06E-03	6.95E-05	2.96E-07	0.00E+00	0.00E+00
ag109m	3.31E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ag110	4.65E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ag110m	3.42E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
am241	8.79E+02	3.08E+03	2.65E+03	2.26E+03	1.92E+03	1.64E+03	7.37E+02	1.50E+02	2.45E+00	8.25E-01
am242	1.01E+01	6.35E+00	3.89E+00	2.38E+00	1.45E+00	8.89E-01	7.61E-02	5.58E-04	0.00E+00	0.00E+00
am242m	1.02E+01	6.38E+00	3.90E+00	2.39E+00	1.46E+00	8.93E-01	7.65E-02	5.60E-04	0.00E+00	0.00E+00
am243	6.00E+01	5.95E+01	5.89E+01	5.84E+01	5.78E+01	5.73E+01	5.46E+01	4.97E+01	3.75E+01	2.34E+01
ar 39	8.39E-05	6.57E-05	5.07E-05	3.92E-05	3.03E-05	2.34E-05	6.46E-06	4.91E-07	0.00E+00	0.00E+00
ba133	2.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ba137m	9.89E+04	1.10E+04	1.09E+03	1.08E+02	1.07E+01	1.07E+00	1.02E-05	9.43E-16	0.00E+00	0.00E+00
bi211	0.00E+00	4.49E-05	5.32E-05	6.01E-05	6.70E-05	7.40E-05	1.09E-04	1.83E-04	4.12E-04	8.26E-04
bi212	4.57E-02	3.00E-02	1.11E-02	4.11E-03	1.52E-03	5.66E-04	7.00E-06	3.04E-06	0.00E+00	0.00E+00
bk249	2.56E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
c 14	5.35E-01	5.29E-01	5.22E-01	5.16E-01	5.10E-01	3.41E-03	4.73E-01	4.20E-01	2.92E-01	1.59E-01
ca 41	1.49E-04	1.49E-04	1.49E-04	1.49E-04	1.49E-04	1.49E-04	1.48E-04	1.47E-04	1.44E-04	1.39E-04
ca 45	1.15E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cd109	3.31E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cd113m	4.31E+01	4.04E-01	2.96E-03	2.17E-05	1.59E-07	1.02E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ce139	1.67E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ce142	3.02E-05	3.02E-05	3.02E-05	3.02E-05	3.02E-05	3.02E-05	3.02E-05	3.02E-05	3.02E-05	3.02E-05
ce144	5.80E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cf249	3.90E-03	3.28E-03	2.69E-03	2.21E-03	1.81E-03	1.49E-03	5.54E-04	7.66E-05	0.00E+00	0.00E+00
cf250	1.34E-02	8.70E-05	4.34E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cf251	1.96E-04	1.82E-04	1.68E-04	1.56E-04	1.44E-04	1.34E-04	9.09E-05	4.20E-05	4.14E-06	0.00E+00
cf252	2.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cl 36	1.05E-02	1.05E-02	1.05E-02	1.05E-02	1.05E-02	1.05E-02	1.05E-02	1.05E-02	1.04E-02	1.03E-02
cm242	3.56E+01	5.26E+00	3.21E+00	1.97E+00	1.20E+00	7.35E-01	6.30E-02	4.61E-04	0.00E+00	0.00E+00
cm243	4.19E+01	4.16E+00	3.65E-01	3.21E-02	2.82E-03	2.48E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cm244	1.40E+04	3.69E+02	8.02E+00	1.74E-01	3.78E-03	8.21E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cm245	1.79E+00	1.78E+00	1.76E+00	1.75E+00	1.73E+00	1.72E+00	1.65E+00	1.52E+00	1.19E+00	7.92E-01
cm246	1.21E+00	1.19E+00	1.17E+00	1.16E+00	1.14E+00	1.12E+00	1.04E+00	9.01E-01	5.80E-01	2.79E-01
cm248	1.40E-04	1.40E-04	1.40E-04	1.40E-04	1.40E-04	1.40E-04	1.40E-04	1.39E-04	1.39E-04	1.37E-04
co 58	7.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
co 60	5.99E+03	2.24E-02	4.33E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cs134	4.05E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
cs135	6.34E-01	6.34E-01	6.34E-01	6.34E-01	6.34E-01	6.34E-01	6.34E-01	6.34E-01	6.33E-01	6.32E-01
cs137	1.05E+05	1.17E+04	1.16E+03	1.15E+02	1.14E+01	1.13E+00	1.08E-05	9.98E-16	0.00E+00	0.00E+00
eu150	7.54E-05	1.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
eu152	4.54E+00	3.24E-02	1.79E-04	9.85E-07	5.43E-09	2.99E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00
eu154	6.15E+03	2.88E+00	9.02E-04	2.82E-07	8.83E-11	2.77E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
eu155	1.80E+03	1.39E-03	5.15E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
fe 55	7.27E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
gd153	1.78E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
h 3	4.95E+02	2.37E+00	8.58E-03	3.10E-05	1.12E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ho166m	3.43E-03	3.24E-03	3.06E-03	2.89E-03	2.73E-03	2.57E-03	1.93E-03	1.08E-03	1.91E-04	1.06E-05
i129	3.60E-02	3.60E-02	3.60E-02	3.60E-02	3.60E-02	3.60E-02	3.60E-02	3.60E-02	3.60E-02	3.60E-02
in113m	1.67E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
kr 85	5.79E+03	1.24E+01	1.93E-02	3.01E-05	4.68E-08	7.27E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment IX

Maximum PWR Assembly Radionuclide Inventories for Short Decay Times										
Age:	**5 yr**	**100 yr**	**200 yr**	**300 yr**	**400 yr**	**500 yr**	**1000 yr**	**2000 yr**	**5000 yr**	**10000 yr**
mn 54	8.46E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
mo 93	7.22E-02	7.07E-02	6.94E-02	6.80E-02	6.66E-02	9.39E-03	5.93E-02	4.86E-02	2.68E-02	9.94E-03
nb 91	2.93E-05	2.66E-05	2.40E-05	2.17E-05	1.96E-05	1.77E-05	1.06E-05	3.83E-06	0.00E+00	0.00E+00
nb 93m	4.87E+01	2.26E+00	1.48E+00	1.46E+00	1.46E+00	7.74E-03	1.46E+00	1.44E+00	1.42E+00	1.41E+00
nb 94	1.37E+00	1.37E+00	1.36E+00	1.35E+00	1.34E+00	6.21E-02	1.32E+00	1.27E+00	1.15E+00	9.71E-01
nb 95	3.48E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
nb 95m	1.80E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ni 59	2.96E+00	2.96E+00	2.95E+00	2.95E+00	2.94E+00	2.48E-01	2.93E+00	2.90E+00	2.82E+00	2.70E+00
ni 63	4.52E+02	2.34E+02	1.17E+02	5.86E+01	2.93E+01	1.24E+00	4.60E-01	4.52E-04	0.00E+00	0.00E+00
np235	1.73E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
np236	3.45E-05	3.45E-05	3.45E-05	3.45E-05	3.45E-05	3.44E-05	3.43E-05	3.41E-05	3.35E-05	3.25E-05
np237	4.01E-01	4.86E-01	5.79E-01	6.58E-01	7.26E-01	7.83E-01	9.66E-01	1.08E+00	1.11E+00	1.11E+00
np238	4.58E-02	2.87E-02	1.76E-02	1.07E-02	6.57E-03	4.02E-03	3.44E-04	2.52E-06	0.00E+00	0.00E+00
np239	6.00E+01	5.95E+01	5.89E+01	5.84E+01	5.78E+01	5.73E+01	5.46E+01	4.97E+01	3.75E+01	2.34E+01
pa231	4.18E-05	4.84E-05	5.53E-05	6.22E-05	6.91E-05	7.61E-05	1.11E-04	1.83E-04	4.11E-04	8.26E-04
pa233	4.01E-01	4.86E-01	5.79E-01	6.58E-01	7.26E-01	7.83E-01	9.66E-01	1.08E+00	1.11E+00	1.11E+00
pa234	1.85E-04	1.85E-04	1.85E-04	1.85E-04	1.85E-04	1.85E-04	1.85E-04	1.85E-04	1.85E-04	1.85E-04
pa234m	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01
pb211	0.00E+00	4.49E-05	5.32E-05	6.01E-05	6.70E-05	7.40E-05	1.09E-04	1.83E-04	4.12E-04	8.26E-04
pb212	4.57E-02	3.00E-02	1.11E-02	4.11E-03	1.52E-03	5.66E-04	7.00E-06	3.04E-06	0.00E+00	0.00E+00
pd107	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01
pm145	5.12E-03	1.24E-04	2.48E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
pm146	2.64E+00	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
pm147	2.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
po212	2.93E-02	1.92E-02	7.10E-03	2.63E-03	9.76E-04	3.63E-04	4.49E-06	1.95E-06	0.00E+00	0.00E+00
po215	0.00E+00	4.49E-05	5.32E-05	6.01E-05	6.70E-05	7.40E-05	1.09E-04	1.83E-04	4.12E-04	8.26E-04
po216	4.57E-02	3.00E-02	1.11E-02	4.11E-03	1.52E-03	5.66E-04	7.00E-06	3.04E-06	0.00E+00	0.00E+00
pr144	5.80E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
pr144m	8.12E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
pt193	8.74E-05	2.34E-05	5.85E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
pu236	3.46E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
pu238	6.80E+03	3.21E+03	1.46E+03	6.64E+02	3.02E+02	1.38E+02	2.77E+00	2.19E-03	0.00E+00	0.00E+00
pu239	1.83E+02	1.83E+02	1.82E+02	1.82E+02	1.82E+02	1.81E+02	1.79E+02	1.76E+02	1.65E+02	1.47E+02
pu240	4.01E+02	4.34E+02	4.30E+02	4.26E+02	4.22E+02	4.17E+02	3.96E+02	3.56E+02	2.59E+02	1.53E+02
pu241	8.00E+04	8.14E+02	8.24E+00	1.80E+00	1.74E+00	1.72E+00	1.65E+00	1.52E+00	1.19E+00	7.94E-01
pu242	3.34E+00	3.34E+00	3.34E+00	3.34E+00	3.34E+00	3.34E+00	3.33E+00	3.33E+00	3.32E+00	3.29E+00
ra223	0.00E+00	4.49E-05	5.32E-05	6.01E-05	6.70E-05	7.40E-05	1.09E-04	1.83E-04	4.12E-04	8.26E-04
ra224	4.57E-02	3.00E-02	1.11E-02	4.11E-03	1.52E-03	5.66E-04	7.00E-06	3.04E-06	0.00E+00	0.00E+00
rb 87	2.13E-05	2.13E-05	2.13E-05	2.13E-05	2.13E-05	2.13E-05	2.13E-05	2.13E-05	2.13E-05	2.13E-05
rh102	8.20E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
rh106	1.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
rn219	0.00E+00	4.49E-05	5.32E-05	6.01E-05	6.70E-05	7.40E-05	1.09E-04	1.83E-04	4.12E-04	8.26E-04
rn220	4.57E-02	3.00E-02	1.11E-02	4.11E-03	1.52E-03	5.66E-04	7.00E-06	3.04E-06	0.00E+00	0.00E+00
ru106	1.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
sb125	2.14E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
sb126	9.57E-02	9.56E-02	9.55E-02	9.55E-02	9.54E-02	9.53E-02	9.50E-02	9.44E-02	9.24E-02	8.93E-02
sb126m	6.83E-01	6.83E-01	6.82E-01	6.82E-01	6.81E-01	6.81E-01	6.79E-01	6.74E-01	6.60E-01	6.38E-01
se 79	7.35E-02	7.35E-02	7.35E-02	7.35E-02	7.35E-02	7.34E-02	7.34E-02	7.32E-02	7.28E-02	7.20E-02
sm145	2.05E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
sm151	3.19E+02	1.54E+02	7.11E+01	3.29E+01	1.52E+01	7.05E+00	1.50E-01	6.77E-05	0.00E+00	0.00E+00
sn113	1.67E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment IX

Maximum PWR Assembly Radionuclide Inventories for Short Decay Times										
Age:	**5 yr**	**100 yr**	**200 yr**	**300 yr**	**400 yr**	**500 yr**	**1000 yr**	**2000 yr**	**5000 yr**	**10000 yr**
sn119m	1.01E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
sn121	2.78E+00	8.39E-01	2.38E-01	6.75E-02	1.91E-02	3.34E-05	9.91E-06	3.33E-11	0.00E+00	0.00E+00
sn121m	3.58E+00	1.08E+00	3.07E-01	8.70E-02	2.47E-02	4.30E-05	1.28E-05	4.30E-11	0.00E+00	0.00E+00
sn123	2.53E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
sn126	6.83E-01	6.83E-01	6.82E-01	6.82E-01	6.81E-01	6.81E-01	6.79E-01	6.74E-01	6.60E-01	6.38E-01
sr 90	6.52E+04	6.29E+03	5.36E+02	4.57E+01	3.89E+00	0.00E+00	1.49E-06	3.00E-17	0.00E+00	0.00E+00
tb160	4.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
tc 98	1.57E-05	1.57E-05	1.57E-05	1.57E-05	1.57E-05	1.57E-05	1.57E-05	1.57E-05	1.57E-05	1.57E-05
tc 99	1.34E+01	1.34E+01	1.34E+01	1.34E+01	1.34E+01	2.51E-04	1.33E+01	1.33E+01	1.32E+01	1.30E+01
te123m	1.01E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
te125m	5.21E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
te127	6.27E-02	3.60E-02	3.60E-02	3.60E-02	3.60E-02	0.00E+00	3.60E-02	3.60E-02	3.60E-02	3.60E-02
te127m	6.40E-02	6.34E-01	6.34E-01	6.34E-01	6.34E-01	0.00E+00	6.34E-01	6.34E-01	6.33E-01	6.32E-01
th227	0.00E+00	4.43E-05	5.24E-05	5.92E-05	6.61E-05	7.29E-05	1.08E-04	1.81E-04	4.06E-04	8.15E-04
th228	4.56E-02	2.99E-02	1.11E-02	4.11E-03	1.52E-03	5.66E-04	7.00E-06	3.04E-06	0.00E+00	0.00E+00
th230	3.33E-05	1.12E-03	3.10E-03	5.48E-03	8.04E-03	1.07E-02	2.41E-02	5.08E-02	1.29E-01	2.53E-01
th231	3.28E-03	3.30E-03	3.32E-03	3.34E-03	3.35E-03	3.37E-03	3.46E-03	3.64E-03	4.14E-03	4.91E-03
th234	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01
tl207	0.00E+00	4.48E-05	5.30E-05	5.99E-05	6.68E-05	7.38E-05	1.09E-04	1.83E-04	4.11E-04	8.24E-04
tl208	1.64E-02	1.08E-02	3.98E-03	1.48E-03	5.48E-04	2.04E-04	2.52E-06	1.09E-06	0.00E+00	0.00E+00
tm171	4.96E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
u232	5.97E-02	2.91E-02	1.08E-02	4.00E-03	1.48E-03	5.51E-04	6.83E-06	3.01E-06	0.00E+00	0.00E+00
u233	2.42E-05	2.25E-04	4.57E-04	7.27E-04	1.03E-03	1.36E-03	3.28E-03	7.79E-03	2.21E-02	4.56E-02
u234	5.21E-01	1.80E+00	2.43E+00	2.71E+00	2.84E+00	2.90E+00	2.95E+00	2.94E+00	2.92E+00	2.88E+00
u235	3.28E-03	3.30E-03	3.32E-03	3.34E-03	3.35E-03	3.37E-03	3.46E-03	3.64E-03	4.14E-03	4.91E-03
u236	2.23E-01	2.24E-01	2.25E-01	2.27E-01	2.28E-01	2.29E-01	2.35E-01	2.46E-01	2.73E-01	3.03E-01
u237	1.91E+00	1.95E-02	1.97E-04	4.31E-05	4.15E-05	4.12E-05	3.95E-05	3.64E-05	2.85E-05	1.90E-05
u238	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01	1.42E-01
y 90	6.53E+04	6.29E+03	5.36E+02	4.57E+01	3.89E+00	0.00E+00	1.49E-06	3.00E-17	0.00E+00	0.00E+00
y 91	1.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
zn 65	4.64E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
zr 93	1.41E+00	1.41E+00	1.41E+00	1.41E+00	1.41E+00	3.87E-03	1.41E+00	1.40E+00	1.40E+00	1.40E+00
zr 95	1.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment IX

Maximum PWR Assembly Radionuclide Inventories for Long Decay Times						
Age:	**10000.0 yr**	**20000.0 yr**	**30000.0 yr**	**100000. yr**	**300000. yr**	**1000000 yr**
ac225	1.49E-02	4.82E-02	8.80E-02	3.51E-01	7.58E-01	8.63E-01
ac227	8.26E-04	1.74E-03	2.69E-03	7.69E-03	1.01E-02	1.02E-02
am241	8.25E-01	3.51E-01	1.55E-01	5.15E-04	4.24E-11	0.00E+00
am243	2.34E+01	9.15E+00	3.57E+00	4.95E-03	1.21E-05	1.18E-05
at217	1.49E-02	4.82E-02	8.80E-02	3.51E-01	7.58E-01	8.63E-01
bi210	1.97E-01	4.30E-01	6.36E-01	1.51E+00	1.64E+00	3.89E-01
bi211	8.26E-04	1.74E-03	2.69E-03	7.69E-03	1.01E-02	1.02E-02
bi213	1.49E-02	4.82E-02	8.80E-02	3.51E-01	7.58E-01	8.63E-01
bi214	1.97E-01	4.30E-01	6.36E-01	1.51E+00	1.64E+00	3.89E-01
c 14	1.59E-01	4.75E-02	1.42E-02	0.00E+00	0.00E+00	0.00E+00
ca 41	1.39E-04	1.30E-04	1.22E-04	7.60E-05	1.98E-05	0.00E+00
ce142	3.02E-05	3.02E-05	3.02E-05	3.02E-05	3.02E-05	3.02E-05
cl 36	1.03E-02	1.00E-02	9.80E-03	8.34E-03	5.26E-03	1.05E-03
cm245	7.92E-01	3.51E-01	1.55E-01	5.14E-04	4.23E-11	0.00E+00
cm246	2.79E-01	6.44E-02	1.49E-02	0.00E+00	0.00E+00	0.00E+00
cm248	1.37E-04	1.34E-04	1.32E-04	1.14E-04	7.60E-05	1.82E-05
cs135	6.32E-01	6.30E-01	6.28E-01	6.15E-01	5.79E-01	4.69E-01
fr221	1.49E-02	4.82E-02	8.80E-02	3.51E-01	7.58E-01	8.63E-01
fr223	0.00E+00	0.00E+00	0.00E+00	1.06E-04	1.40E-04	1.40E-04
i129	3.60E-02	3.60E-02	3.60E-02	3.58E-02	3.55E-02	3.44E-02
mo 93	9.94E-03	1.37E-03	1.89E-04	0.00E+00	0.00E+00	0.00E+00
nb 93m	1.41E+00	1.39E+00	1.39E+00	1.34E+00	1.23E+00	8.93E-01
nb 94	9.71E-01	6.91E-01	4.91E-01	4.50E-02	4.86E-05	0.00E+00
ni 59	2.70E+00	2.46E+00	2.24E+00	1.17E+00	1.85E-01	2.86E-04
np236	3.25E-05	3.06E-05	2.88E-05	1.89E-05	5.66E-06	0.00E+00
np237	1.11E+00	1.11E+00	1.11E+00	1.09E+00	1.02E+00	8.11E-01
np239	2.34E+01	9.15E+00	3.57E+00	4.95E-03	1.21E-05	1.18E-05
pa231	8.26E-04	1.74E-03	2.69E-03	7.69E-03	1.01E-02	1.02E-02
pa233	1.11E+00	1.11E+00	1.11E+00	1.09E+00	1.02E+00	8.11E-01
pa234	1.85E-04	1.85E-04	1.85E-04	1.85E-04	1.85E-04	1.85E-04
pa234m	1.42E-01	1.42E-01	1.42E-01	1.43E-01	1.43E-01	1.43E-01
pb209	1.49E-02	4.82E-02	8.80E-02	3.51E-01	7.58E-01	8.63E-01
pb210	1.97E-01	4.30E-01	6.36E-01	1.51E+00	1.64E+00	3.89E-01
pb211	8.26E-04	1.74E-03	2.69E-03	7.69E-03	1.01E-02	1.02E-02
pb214	1.97E-01	4.30E-01	6.36E-01	1.51E+00	1.64E+00	3.89E-01
pd107	1.60E-01	1.59E-01	1.59E-01	1.58E-01	1.55E-01	1.44E-01
po210	1.97E-01	4.30E-01	6.36E-01	1.51E+00	1.64E+00	3.89E-01
po213	1.46E-02	4.72E-02	8.61E-02	3.44E-01	7.42E-01	8.45E-01
po214	1.97E-01	4.30E-01	6.36E-01	1.51E+00	1.64E+00	3.89E-01
po215	8.26E-04	1.74E-03	2.69E-03	7.69E-03	1.01E-02	1.02E-02
po218	1.97E-01	4.30E-01	6.36E-01	1.51E+00	1.64E+00	3.90E-01
pu239	1.47E+02	1.14E+02	8.68E+01	1.18E+01	3.76E-02	1.18E-05
pu240	1.53E+02	5.32E+01	1.85E+01	1.14E-02	2.43E-07	0.00E+00
pu241	7.94E-01	3.51E-01	1.55E-01	5.15E-04	4.24E-11	0.00E+00
pu242	3.29E+00	3.23E+00	3.17E+00	2.79E+00	1.92E+00	5.25E-01

Attachment IX

Maximum PWR Assembly Radionuclide Inventories for Long Decay Times						
Age:	**10000.0 yr**	**20000.0 yr**	**30000.0 yr**	**100000. yr**	**300000. yr**	**1000000 yr**
ra223	8.26E-04	1.74E-03	2.69E-03	7.69E-03	1.01E-02	1.02E-02
ra225	1.49E-02	4.82E-02	8.80E-02	3.51E-01	7.58E-01	8.63E-01
ra226	1.97E-01	4.30E-01	6.36E-01	1.51E+00	1.64E+00	3.90E-01
rb 87	2.13E-05	2.13E-05	2.13E-05	2.13E-05	2.13E-05	2.13E-05
rn219	8.26E-04	1.74E-03	2.69E-03	7.69E-03	1.01E-02	1.02E-02
rn222	1.97E-01	4.30E-01	6.36E-01	1.51E+00	1.64E+00	3.90E-01
sb126	8.93E-02	8.33E-02	7.77E-02	4.78E-02	1.20E-02	9.34E-05
sb126m	6.38E-01	5.95E-01	5.55E-01	3.42E-01	8.54E-02	6.67E-04
se 79	7.20E-02	7.05E-02	6.90E-02	5.96E-02	3.91E-02	8.99E-03
sn126	6.38E-01	5.95E-01	5.55E-01	3.42E-01	8.54E-02	6.67E-04
tc 98	1.57E-05	1.57E-05	1.56E-05	1.55E-05	1.50E-05	1.33E-05
tc 99	1.30E+01	1.25E+01	1.21E+01	9.64E+00	5.00E+00	5.02E-01
th227	8.15E-04	1.71E-03	2.65E-03	7.58E-03	9.99E-03	1.00E-02
th229	1.49E-02	4.82E-02	8.80E-02	3.51E-01	7.58E-01	8.63E-01
th230	2.53E-01	4.81E-01	6.81E-01	1.53E+00	1.62E+00	3.84E-01
th231	4.91E-03	6.19E-03	7.17E-03	9.78E-03	1.02E-02	1.02E-02
th234	1.42E-01	1.42E-01	1.42E-01	1.43E-01	1.43E-01	1.43E-01
tl207	8.24E-04	1.73E-03	2.68E-03	7.67E-03	1.01E-02	1.01E-02
tl209	3.13E-04	1.01E-03	1.85E-03	7.37E-03	1.59E-02	1.81E-02
u233	4.56E-02	9.11E-02	1.35E-01	3.88E-01	7.71E-01	8.61E-01
u234	2.88E+00	2.80E+00	2.73E+00	2.26E+00	1.35E+00	3.10E-01
u235	4.91E-03	6.19E-03	7.17E-03	9.78E-03	1.02E-02	1.02E-02
u236	3.03E-01	3.31E-01	3.41E-01	3.45E-01	3.43E-01	3.36E-01
u237	1.90E-05	8.39E-06	3.71E-06	0.00E+00	0.00E+00	0.00E+00
u238	1.42E-01	1.42E-01	1.42E-01	1.43E-01	1.43E-01	1.43E-01
zr 93	1.40E+00	1.39E+00	1.39E+00	1.34E+00	1.23E+00	8.93E-01

Attachment XI – Evolution in Time of Thermal Power and Total Radioactivity

The following figures compare the evolution in time of the heat generated and total radioactivity of different fuel assemblies (data are presented in the Spreadsheet "ATTACH_XI.XLS"):

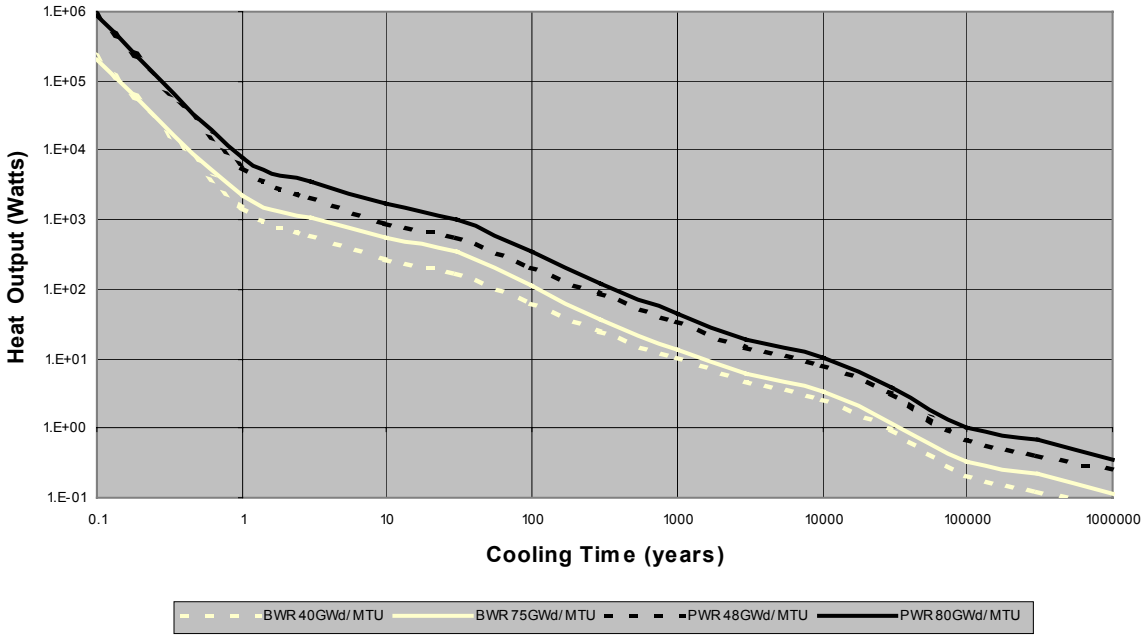


Figure XI 1. Thermal Power after Discharge – PWR / BWR Comparison

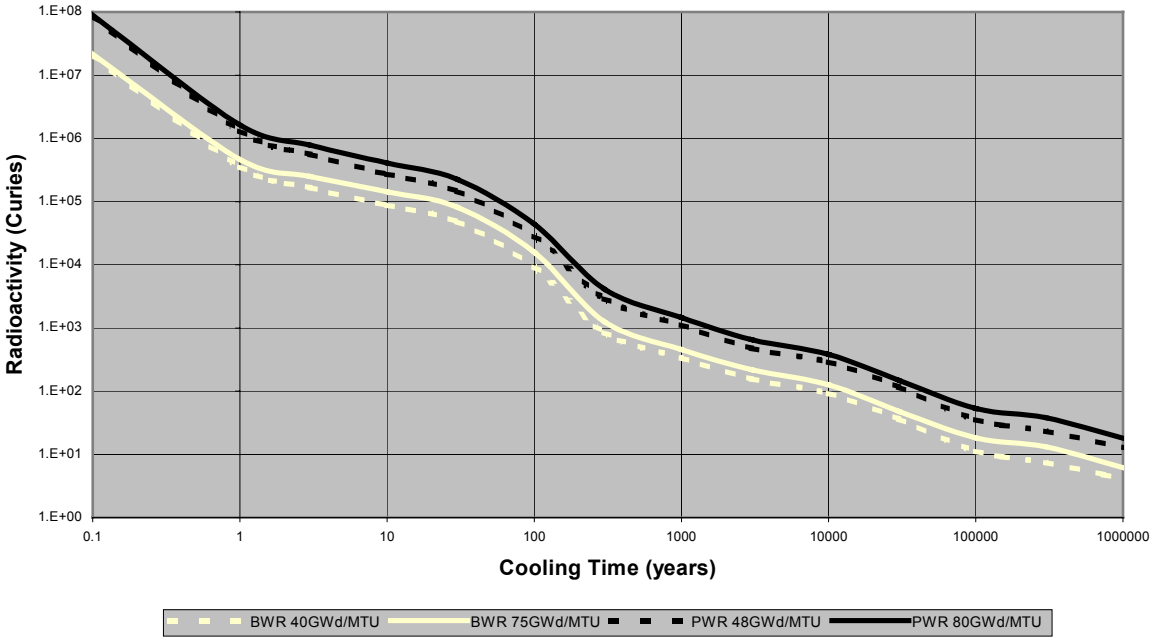


Figure XI 2. Radioactivity after Discharge – PWR / BWR Comparison

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Engineering Change Notice

Complete only applicable items.

1. QA: QA
2. Page 1 of 1

000-00C-MGR0-00100-000-00B-ECN1

3. Document Identifier:	4. Rev.:	5. Title:	6. ECN:
000-00C-MGR0-00100-000-00B	00B	PWR Source Term Generation and Evaluation	1

7. Reason for Change:

Per LP-3.12Q-BSC Design Calculations and Analyses Section 5.1 [2] c,

> "The decision of the DEM, PCSA Manager, Criticality Manager, or PCA Manager to issue calculations or analyses with a "committed" status will be based on an experienced assessment of the likelihood that the results of the calculation or analysis will change, and the degree of impact those changes will have on designs that support the regulatory submittals or procurement activities, based on the design's bounding conservatism."

the status designation of *PWR Source Term Generation and Evaluation* (000-00C-MGR0-00100-000-00B) can be changed to "Committed" as the results are not expected to change in such a manner that will affect support of regulatory submittals.

8. Supersedes Change Document: ☐ Yes If, Yes, Change Doc.: _____ ☒ No

9. Change Impact:

Inputs Changed:	☐ Yes	☒ No	Results Impacted:	☐ Yes	☒ No
Assumptions Changed:	☐ Yes	☒ No	Design Impacted:	☐ Yes	☒ No

10. Description of Change: (Address any "Yes" answers)

Add a "Committed" option in Block 7 on the cover sheet and change the "Document Status Designation" from Preliminary to "Committed". Block 7 on the cover sheet should read as follows:

7. Document Status Designation

☐ Preliminary ☒ Committed ☐ Final ☐ Canceled

11. Originator: (Print/Sign/Date) Dorin Musat	Dorin Musat	8/12/2005
Checker: (Print/Sign/Date) YuChien Yuan	YuChien Yuan	8/12/2005
Approved: (Print/Sign/Date) Dave Darling	DB Darling	8/12/05

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Engineering Change Notice

Complete only applicable items.

3. Document Identifier:	4. Rev.:	5. Title:	6. ECN:
000-00C-MGR0-00100-000-00B	00B	PWR Source Term Generation and Evaluation	2

7. Reason for Change:

This ECN removes the redundant references to delink the document to TBV-5772, TBV-5773, TBV-5774, and TBV-5775.

8. Supersedes Change Document:	☐ Yes	If, Yes, Change Doc.: _____	☒ No

9. Change Impact:

Inputs Changed:	☒ Yes	☐ No	Results Impacted:	☐ Yes	☒ No
Assumptions Changed:	☐ Yes	☒ No	Design Impacted:	☐ Yes	☒ No

10. Description of Change: (Address any "Yes" answers)

The changes to *PWR Source Term Generation and Evaluation* (DI: 000-00C-MGR0-00100-000-00B, ECN 1) include the following:

a. Removed the redundant footnote to Table 2 on page 13 (NOTE "b") as attached.

b. Removed the following redundant references from page 32 as attached and the DIRS report:

- MO0105SPACR300.002. CR3 NEMO Depl and Statepoints. Submittal date: 05/22/2001. [DIRS 154999]
- MO0105SPACR301.003. CR3 NEMO Depl and Sp. Submittal date: 05/22/2001. [DIRS 155000]
- MO0105SPACR302.004. CR3 NEMO Depletion and State Points. Submittal date: 05/22/2001. [DIRS 155001]
- MO0105SPACR303.001. CR3 NEMO Depletion and Statepoints. Submittal date: 05/22/2001. [DIRS 155002]

c. Modified the DIRS report to reflect the above changes.

11. Originator: (Print/Sign/Date) Steve Su	S. Su 8/22/2005
Checker: (Print/Sign/Date) Rick Thacker	R. Thacker 08-22-05
Approved: (Print/Sign/Date) Dave Darling	DB Darling 8/22/05

Table 2. B&W Mark B PWR Fuel Assembly Description and Operating Parameters

Assembly Parameter	Value	Units	Metric	Units	Reference	
Average core exit moderator temperature	612	°F	595.4	K	Framatome Cogema 1999, p 3 [DIRS 146419] In association with BSC 2003, p. 2 [DIRS 165684]	
Average core moderator pressure	2200	Psia	-	-		
Maximum beginning of cycle boron concentration	-	-	1050	ppm		
Core thermal power	-	-	2568	MW		
Pellet average temperature (K)	1200	°F	922	K		
Fuel cladding to moderator temperature differential	50-75	°F	28-42	K		
Average core moderator temperature rise	59.4	°F	33	K		
Number of guide tubes	16	/assembly	NA	NA	Punatar 2001 [DIRS 155635]	Table 2-2
Number of instrument tubes	1	/assembly	NA	NA		
Clad/tube material	Zircaloy-4[a]	NA	NA	NA		
Number of assemblies	177	In core	NA	NA		
Total number of fuel rods	208	/assembly	NA	NA		
Number of rods on a lattice side	15	/side	NA	NA		
Fuel pellet outer diameter (OD)	0.3686	inches	0.93624	cm		
Fuel stack height	141.8	inches	360.172	cm		
Fuel clad OD	0.430	inches	1.0922	cm		
Clad thickness	0.0265	inches	0.06731	cm		
Fuel rod pitch	0.568	inches	1.44272	cm		
Guide tube OD	0.530	inches	1.3462	cm		
Guide tube ID	0.498	inches	1.26492	cm		
Fuel clad inner diameter (ID)	0.377	inches	0.95758	cm		
Fuel pellet fraction of theoretical density	-	-	0.95	NA		Table 2-9
Mass of U	-	-	463.63	kg		Table 3-1
Fuel assembly envelope	8.536	inches	21.6814	cm		p. 2-3
Fuel rod length	153.68	inches	390.3472	cm	Assumption 3.3	
Plenum region height	-	-	30.1752	cm		
Specific volume of steam at 2200 psi, 580°F	0.02275	ft^3/lbm	-	-	ASME 1993, p. 281 [DIRS 108050]	
Specific volume of steam at 2200 psi, 590°F	0.02235	ft^3/lbm	-	-		

NOTE: [a] Stainless steel clad calculations use SS-304 as the clad material.

Hermann, O.W.; Parks, C.V.; and Renier, J.P. 1994. *Technical Support for a Proposed Decay Heat Guide Using SAS2H/ORIGEN-S Data.* NUREG/CR-5625. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 212756. [DIRS 154045]

Inco Alloys International. 1988. Product Handbook. Huntington, West Virginia: Inco Alloys International. TIC: 239397. [DIRS 130835]

Jones, R.H. 1992. *Spent Fuel Corrosion Product and Fuel Cleaning Assessment.* Los Gatos, California: Robert H. Jones, P.E., Consultant. ACC: HQX.19920825.0007. [DIRS 146405]

LP-SI.11Q-BSC, Rev. 0, ICN 0. *Software Management.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20040225.0007. [DIRS 168412]

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Luksic, A. 1989. *Activation Measurements and Comparison with Calculations for Spent Fuel Assembly Hardware.* Volume 1 of *Spent Fuel Assembly Hardware: Characterization and 10 CFR 61 Classification for Waste Disposal.* PNL-6906. Richland, Washington: Pacific Northwest Laboratory. ACC: NNA.19890926.0124. [DIRS 120506]

NRC (U.S. Nuclear Regulatory Commission) 2000. *Standard Review Plan for Spent Fuel Dry Storage Facilities.* NUREG-1567. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 247929. [DIRS 149756]

ORNL (Oak Ridge National Laboratory) 1997. *SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation.* NUREG/CR-0200, Rev. 5. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235920. [DIRS 135808]

Parrington, J.R.; Knox, H.D.; Breneman, S.L.; Baum, E.M.; and Feiner, F. 1996. *Nuclides and Isotopes, Chart of the Nuclides.* 15th Edition. San Jose, California: General Electric Company and KAPL, Inc. TIC: 233705. [DIRS 103896]

Punatar, M.K. 2001. *Summary Report of Commercial Reactor Criticality Data for Crystal River Unit 3.* TDR-UDC-NU-000001 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010702.0087. [DIRS 155635]

Williams, N.H. 2003. "Contract No. DE-AC28-01RW12101 - Licensing Position-009, Waste Stream Parameters." Letter from N.H. Williams (BSC) to J.D. Ziegler (DOE/ORD), November 13, 2003, 1105039412, with enclosure. ACC: MOL.20031215.0076. [DIRS 166132]

BSC	Calculation/Analysis Change Notice	1. QA: QA 2. Page 1 of 3

Complete only applicable items.

000-00C-MGR0-00100-000-00B-CACN001

3. Document Identifier:	4. Rev.:	5. CACN:
000-00C-MGR0-00100-000	00B	001

6. Title:
PWR Source Term Generation and Evaluation

ENG.20070905.0007

7. Reason for Change:
Phrase added to Section 1 – Purpose, as part of the corrective action for condition report 10602.

8. Supersedes Change Notice: ☐ Yes If, Yes, CACN No.: _____ ☒ No

9. Change Impact:

Inputs Changed:	☐ Yes	☒ No	Results Impacted:	☐ Yes	☒ No
Assumptions Changed:	☐ Yes	☒ No	Design Impacted:	☐ Yes	☒ No

10. Description of Change:
Added a phrase in Section 1 - Purpose, to make readers aware of the PWR Source Term Sensitivity Calculation that evaluated the gap left in the model. The phrase reads: *PWR Source Term Sensitivity Calculation* (BSC 2007 [DIRS 182853]) evaluated the fuel gap model used in this calculation. Users should consult the *PWR Source Term Sensitivity Calculation* (BSC 2007 [DIRS 182853]) when using data from this calculation.

Added the reference *PWR Source Term Sensitivity Calculation* (BSC 2007 [DIRS 182853]) to Section 7 – References.

The revised pages (5 & 31) are attached.

This CACN is in accordance with EG-PRO-3DP-G04B-00037, Rev. 9
09/05/07

11. REVIEWS AND APPROVAL

Printed Name	Signature	Date
11a. Originator: Charlotta E. Sanders		09/04/2007
11b. Checker: Dorin P. Musat		9/04/2007
11c. EGS: Kevin R. Doody		9/4/2007
11d. DEM: David B. Darling		9/5/07
11e. Design Authority: Barbara E. Rusinko		9/5/07

1. PURPOSE

This calculation is a revision of a previous calculation (BSC 2003 [DIRS 162471]) that bears the same title and has the Document Identifier 000-00C-MGR0-00100-000-00A. The purpose of this calculation is to revise the burnup value of the maximum pressurized water reactor (PWR) spent nuclear fuel (SNF) assembly to be consistent with *Licensing Position-009* (Williams 2003, Attachment, p. 1 [DIRS 166132]). No new computer runs were performed for this revision. The source terms for the maximum PWR assembly were taken from the results of computer runs performed for the previous revision - BSC 2003 [DIRS 162471].

The scope of work includes the following:

- Generate PWR SNF assembly source terms as a function of initial enrichment, burnup, and cooling time using an appropriate and defensible methodology.
- Provide the average and maximum PWR fuel assembly specifications.
- Calculate crud source term deposited on the surfaces of the assembly.

This calculation establishes PWR SNF assembly source terms. The results of this calculation are intended for use in evaluation of shielding requirement or other follow-on analysis. They may also be used as input for Preclosure Safety Analysis and Total System Performance Assessment analyses. *PWR Source Term Sensitivity Calculation* (BSC 2007 [DIRS 182853]) evaluated the fuel gap model used in this calculation. Users should consult the *PWR Source Term Sensitivity Calculation* (BSC 2007 [DIRS 182853]) when using data from this calculation.

The results are provided on a per-assembly basis for the representative PWR fuel assembly used in this calculation. Limitation on the use of the results for other fuel assembly types should be evaluated on a case-by-case basis.

The source terms of the representative PWR SNF assembly are generated for the first one million years after the SNF is discharged from the reactors. These source terms provide data characterizing the neutron and gamma spectra in particles per second, the decay heat in watts, and radionuclide inventories in curies. Conservative source terms are generated for a wide range of burnups and enrichments (see Tables 8 and 12) that are representative of the waste stream, stainless steel (SS) clad, and South Texas PWR assemblies. The source term due to the activation of corrosion products deposited on the surfaces of the assembly from the coolant is also calculated.

The results of this calculation support many areas of the Monitored Geologic Repository (MGR), which include thermal evaluation, radiation dose determination, radiological safety analyses, surface and subsurface facility designs, preclosure safety analysis, and total system performance assessment. Therefore, it is subject to the requirements of the *Quality Assurance Requirements and Description* (DOE 2004 [DIRS 168669]). This includes MGR items classified as Safety Category, for example, the Commercial Waste Package (BSC 2003, p. A-3 [DIRS 165179]). Development, performance, and documentation of this calculation conform to the administrative procedure AP-3.12Q, *Design Calculation and Analyses* [DIRS 168413].

BSC (Bechtel SAIC Company) 2004. *PWR and BWR Source Term Sensitivity Study.* 000-00C-MGR0-00300-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040114.0003. [DIRS 167058]

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CRWMS M&O 1998. *Source Term Generation and Shielding Analysis for the 21 and 12 PWR Waste Packages.* BBAC00000-01717-0210-00001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980824.0256. [DIRS 124815]

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CRWMS M&O 1999. *PWR Source Term Generation and Evaluation.* BBAC00000-01717-0210-00010 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000113.0333. [DIRS 136429]

CRWMS M&O 2000. *Users Manual for SCALE-4.4A.* 10129-UM-4.4A-00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001130.0136; MOL.20010822.0084; MOL.20010822.0085; MOL.20010822.0086; MOL.20010822.0087. [DIRS 153872]

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DOE (U.S. Department of Energy) 1992. *Characteristics of Potential Repository Wastes.* DOE/RW-0184-R1. Volume 1. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.19920827.0001. [DIRS 102812]

DOE (U.S. Department of Energy) 1988. *Characteristics of Spent Fuel, High-Level Waste, and Other Radioactive Wastes Which May Require Long-Term Isolation.* DOE/RW-0184. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. TIC: 202243. [DIRS 100979]

DOE (U.S. Department of Energy) 2004. *Quality Assurance Requirements and Description.* DOE/RW-0333P, Rev. 14. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20040331.0004. [DIRS 168669]

Framatome Cogema Fuels. 1999. *Operational Data - B&W NSS.* 51-5004349-01. Lynchburg, Virginia: Framatome Cogema Fuels. ACC: MOL.19990610.0201. [DIRS 146419]