	Scientific Analysis/Calculation Error Resolution Document *Complete only applicable items.*	QA: QA Page 1 of 25

1. Document Number:	2. Revision/Addendum:	3. ERD:
ANL-WIS-MD-000027	00	05

4. Title:	5. No. of Pages Attached:
Features, Events, and Processes for the Total System Performance Assessment: Analyses	24

6. Description of and Justification for Change (Identify affected pages, applicable CRs and TBVs):

This Error Resolution Document (ERD) addresses deficiencies in the documentation of qualification of external source data used as direct input, as identified in condition report (CR) 10788. During the extent of condition evaluation, a review of ANL-WIS-MD-000027 REV 00 revealed that most of the information required for the qualification of external data was presented in the document, but some of the documentation requirements of SCI-PRO-001, *Qualification of Unqualified Data*, were omitted or needed clarification. The quality of the data is not in question, only the documentation required by SCI-PRO-001 is insufficient. Therefore, there is no impact on the conclusions of this document and no impacts on the SAR, the LA, or any other documents. This ERD provides the additional documentation necessary to address the deficiencies.

Table 1 of this ERD provides a list of the inputs classified as "Direct Input" in the DIRS that were identified as having incomplete or missing documentation for qualification for intended use. Table 1 also contains the resolutions for each input and the location within this ERD where the detailed changes to implement the resolution are described. Table 2 contains a list of the changes to the inputs and the DIRS report. This ERD used only commercial off-the-shelf word-processing software. Tables 3, 4, and 5 of this ERD contain changes to Tables D-4, J-2, and D-5 from *Features, Events, and Processes for the Total System Performance Assessment: Analyses*, which are impacted by the updated qualification documentation. Sections 1 through 15 contain the text changes to the report. New text is marked as blue underlined text (example) and deleted text is indicated by red strikethrough text (~~example~~).

	Printed Name	Signature	Date
7. Checker	Steve Hommel	Steve Hommel	4/13/09
8. QCS/QA Reviewer	Peter Persoff	Peter Persoff	04/13/2009
9. Originator	Susan LeStrange	Susan LeStrange	4/13/2009
10. Responsible Manager	Jerry McNeish	Jerry A McNeish	4/13/09.

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Table 1. Resolution to Inadequate Documentation for Qualification

Source and Description of Input	Resolution to Inadequate Documentation	Section or Table in ERD Describing Detailed Changes
Wronkiewicz et al. 1996 [DIRS 102047] Fraction of uranium released as colloids	Qualified in Section J24.3, but the discussion of technical adequacy of equipment and procedures is expanded.	Section 1
National Research Council 1992 [DIRS 105162] Water table rise and crustal extension rates due to tectonic activity	Qualified in Section J32, but discussion of corroborating data is added as qualification attribute.	Section 2
Wuschke et al. 1995 [DIRS 129326] Cratering rate probability	Qualified in Section D6.1.7, but discussion of corroborating data is added as qualification attribute. Other inputs that were marked as direct inputs are changed to indirect inputs.	Section 3, Table 2
Grieve 1987 [DIRS 135254] Cratering rate distribution and threshold size for onset of complex cratering (4 km)	Qualified in Section D6.1.2, but discussion of corroborating data is added as qualification attribute.	Section 4
Grieve et al. 1995 [DIRS 135260] Cratering rate distribution and threshold size for onset of complex cratering (4 km)	Qualified in Section D6.1.6, but discussion of corroborating data is added as qualification attribute.	Section 5, Table 2
Grieve 1998 [DIRS 163385] Exhumation depth to crater diameter ratio (0.28)	Qualified in Section D6.1.4, but discussion of corroborating data is added as qualification attribute.	Section 6, Table 2
Grieve and Robertson 1984 [DIRS 185030] Exhumation depth to crater diameter ratio (0.14) and ratio of fractured zone beneath crater to crater diameter (0.76)	Qualified in Section D6.1.3, but discussion of prior use of data is added as qualification attribute.	Section 7, Table 2
Hills and Goda 1993 [DIRS 135281] Relationship between crater radius and earthquake magnitude	Qualified in Section D6.1.5, but discussion of corroborating data is added as qualification attribute.	Section 8
Smyth and Caporuscio 1981 [DIRS 174060] Volume reduction during heating of tuff.	Qualified in Section J39.1, but discussion of corroborating data is added as qualification attribute.	Section 9
Valentine and Krogh 2006 [DIRS 177282] Thickness of impacted tuff around a dike (~20 to 100 cm)	Qualified in Section J5.2, but discussion of corroborating data is added as qualification attribute.	Section 10
Rogers et al. 1988 [DIRS 184108] Diffusion coefficient of oxygen in titanium	Qualified in Section J22, but discussion of corroborating data is added as qualification attribute.	Section 11
Wachs 2004 [184624] Volume of free water in 15-foot long DOE SNF canister	Qualified in Section J19.3, but additional discussion is added to support the attributes regarding the measurement control program and the QA program.	Section 12
Plys and Duncan 1999 [DIRS 184687] Maximum temperature and pressure for a hydrogen fire in an MCO	Qualified in Section J31.1, but discussion of prior use of data is added as qualification attribute.	Section 13
Sexton 2007 [DIRS 184742] Quantity of free and bound water in an MCO	Qualified in Section J31.4, but discussion of prior use of data is added as qualification attribute.	Section 14
Doorenbos and Pruitt 1977 [DIRS 103062] Salinity tolerance for crops	Reference is established fact because it is a source that scientists would use in their standard work practices; therefore DIRS is changed. Section J36 is deleted because qualification is not needed.	Section 15, Table 2

Table 2. Changes to Inputs and the DIRS Report

Source	Input Description	Changes Required
Barosh 1969 [DIRS 186185], p. 48	Relationship between energy released and earthquake magnitude	Add as new reference to DIRS as "Indirect Input"
Carrigan et al. 1991 [DIRS 100967]	Numerical simulation results of seismic impacts on water table elevation	Add "Section J32.2" to "Used in" column for all three DIRS entries
Chung 2007 [DIRS 185939]	QA audit of Hanford SNF program	Add as new reference to DIRS as "Indirect Input"
Dence et al. 1977 [DIRS 135253], Figure 12	Relationship of crater-diameter versus energy released	Add as new reference to DIRS as "Indirect Input"
Doorenbos and Pruitt 1977 [DIRS 103062]	Salinity tolerance for crops	Change from "Data" to "Established Fact"
Gauthier et al. 1996 [DIRS 100447], pp. 163-164	Description of maximum water-level rise associated with seismic event	Add "Section J32.2" to "Used in" column
Golan 2004 [DIRS 182752]	QA audit report for DOE Idaho Operations Office SNF program	Add as new reference to DIRS as "Indirect Input"
Grieve et al. 1995 [DIRS 135260], p. 196	Crater rate distribution based on observed earth cratering	Change from "Indirect Input" to "Direct Input"; add "Section D6" to "Used in" column
Grieve and Robertson 1984 [DIRS 185030], Eq 3 (p. 241), Eq. 9 (p. 243)	Ratio of exhumation depth to crater diameter ratios; ratio of depth of fracture zone beneath a crater to crater diameter	Add as new entry to DIRS for Grieve and Robertson (1984 [DIRS 185030]) as "Direct Input"
Grieve and Robertson 1984 [DIRS 185030], Abstract	Power law for distribution for terrestrial craters	Change from "Direct Input" to "Indirect Input", since an equation is not direct input
Grieve 1987 [DIRS 135254], pp. 248 and 257, Figure 8	Cratering rate distribution and threshold size for onset of complex cratering (4 km)	Add "Section D6" to "Used in" column
Grieve et al. 1989 [DIRS 186135], Table 3	Range of exhumation depth to crater diameter ratios	Add as new reference to DIRS as "Indirect Input"
Hills and Goda 1993 [DIRS 135281]	Meteors that result in crater diameters of 60 m could trigger earthquakes with Richter magnitudes ranging from Magnitude 6 to slightly less than Magnitude 7	Replace DIRS entry with the following: "Meteors that result in crater diameters of 60 m could trigger earthquakes with Richter magnitudes ranging from Magnitude 3.5 to about Magnitude 7"; add "Figure 17" to "Used from" column
Keating et al. 2002 [DIRS 174077]	Alterations in host rock due to igneous intrusion	Add as new reference to DIRS as "Indirect Input"
Kranz et al. 1989 [DIRS 183167]	Volume increase of zeolitized-tuff core due to hydration following vacuum drying	Add "Section J39.1.2" to "Used in" column for entry described as "Zeolitized-tuff core subjected to vacuum…" Revise description.
Liu and Welsch 1988 [DIRS 186105]	Diffusion coefficient of oxygen in titanium	Add as new reference to DIRS as "Indirect Input"
Neukum and Ivanov 1994 [DIRS 121510]	Cratering Rate Distribution is based on lunar cratering data	Add "Section D6" to "Used in" column
Parrington et al. 1996 [DIRS 103896], p. 58	Conversion from Joules to ton (nuclear equivalent of TNT)	Add new entry in DIRS as "Direct Input" and "Established Fact"
Roberson 2004 [DIRS 182751]	QA audit report for DOE Idaho Operations Office SNF program	Add as new reference to DIRS as "Indirect Input"

Table 2. Changes to Inputs and the DIRS Report (Continued)

Source	Input Description	Changes Required
Scott 1990 [DIRS 106751]	Description of geologic setting at Yucca Mountain	Add “Section J32.2” to “Used in” column and change “Input Description” column to read “Definition and description of geologic setting of Yucca Mountain”
Triay 2006 [DIRS 185938]	QA audit of Hanford SNF program	Add as new reference to DIRS as “Indirect Input”
Wernicke et al. 1988 [DIRS 149959]	Extension rates and trends in extension rates	Add as new reference to DIRS as “Indirect Input”
Wuschke et al. 1995 [DIRS 129326], Entire	Range of exhumation depth to crater diameter ratios	Change “Section D4.3.4.1” to “Section D6”
Wuschke et al. 1995 [DIRS 129326], Entire	Conservative value of increased fracturing depth…	Add “Section D6” to “Used in” column
Wuschke et al. 1995 [DIRS 129326], p. 3	Low probability of large crater diameters being associated with complex cratering	Change from “Direct Input” to “Indirect Input”
Wuschke et al. 1995 [DIRS 129326], p. 3	Spatial relationships of crater diameter to extents and depth of fracturing and exhumation	Change from “Direct Input” to “Indirect Input”
Wuschke et al. 1995 [DIRS 129326], Figure 1	Spatial extent of fracturing is assumed to be spherical	Change from “Direct Input” to “Indirect Input”

Table 3. Changes to Table D-4 (Only Rows with Changes Shown)

Item	Source	Description of Direct Input	Summary of Source
1	Grieve and Robertson 1984 [DIRS 185030]	~~Power law for distribution for terrestrial craters~~ ~~Abstract, p. 231~~ Ratio of depth of redistributed zone to diameter of crater (0.14) Equation 3, p. 241 Ratio of depth of fractured zone to diameter of crater (0.76) Equation 9, p. 243	~~Introduction of a size-frequency power law relationship for analyzing terrestrial and lunar crater diameters. This power law was further improved and used in later publications concerning crater impacts.~~ This report uses observations to estimate crater dimensions from meteorite impacts. For simple craters, the source gives a value of 0.14 for the ratio of the redistributed depth (second zone within a crater) to the diameter of an impact crater. In addition, the source provides a value of 0.76 for the ratio of the depth of the fractured zone beneath the crater to the diameter of the crater.
3	Grieve et al. 1995 [DIRS 135260]	Crater rate distribution based on observed earth cratering and the threshold size for onset of complex cratering (4 km). pp. 194 to 196	This is an update to the 1987 paper by the primary author. It provides updated cratering information, defines the constants, and addresses the limits for simple and complex cratering. This paper was taken from a technical journal. Acknowledgments are given to peer-reviewers on an earlier version of the document. This paper provides a listing of observed cratering impact structures and their diameters and ages, allowing independent confirmation of the developed distribution. A thorough reference list is also provided.
5	Hills and Goda 1993 [DIRS 135281]	Earthquake magnitudes due to a meteoroid impact range from magnitude ~~5 to slightly less than~~ 3.5 to about magnitude 7 on the Richter scale. Figures 17 and 18	This paper focuses on evaluating effects of small asteroids impacting the Earth. Figure 17 of the paper provides a relationship between crater radius and initial meteor radius. Figure 18 of the paper provides a relationship of initial meteor radius and earthquake energy. ~~This paper provides a relationship between crater diameters and earthquake energy.~~ This paper was taken from a peer-reviewed journal. Los Alamos National Laboratory prepared the work, and the development of the models is well documented and supporting equations are provided. No information is provided on quality control or development procedures
6	Wuschke et al. 1995 [DIRS 129326]	~~Spatial relationships of crater diameter to extents and depth of fracturing and exhumation.~~ ~~p. 3~~ ~~Spatial extent of fracturing is assumed to be spherical.~~ ~~Figure 1~~ Cratering rate data for the Canadian shield and application to a hypothetical Canadian repository. pp. 4 and 26	This paper is directly applicable as it presents a well-documented evaluation equivalent to the evaluation needed for the YMP. The paper provides a detailed analysis of the hazard and risk associated with meteorite impact above an underground repository. Assumptions, spatial relationships, mathematical formulations, and uncertainty analysis are all documented within the report. This paper was prepared by AECL Research to evaluate risk from meteorite impact on a hypothetical underground repository. The paper reports results of a specific technical analysis. Citations are provided for all sources and uncertainty analyses are provided.

Table 4. Changes to Table J-2 (Only Rows with Changes Shown)

Input	Source	Description	FEP	Project or External	Method[1] (Rationale)[2]	Attribute[3]
~~Doorenbos and Pruitt 1977. *Crop Water Requirements*. [DIRS 103062]~~	~~Table 36, p. 78~~	~~The data from this reference that are being used as direct input are the salinity tolerances for crop~~	~~2.2.08.07.0C~~	~~E~~	~~5 (d)~~	~~1, 3~~
Grieve and Robertson 1984. "The Potential for the Disturbance of a Buried Nuclear Waste Vault by a Large-Scale Meteorite Impact." [DIRS 185030]	~~p. 231~~Equation 3, p. 241	~~Power law for distribution for terrestrial craters~~ Ratio of depth of redistributed zone to diameter of crater (0.14)	1.5.01.01.0A	E	5 (h)	1, 3, 10
	Equation 9, p. 243	Ratio of depth of fractured zone to diameter of crater (0.76)	1.5.01.01.0A	E	5 (h)	1, 3, 10
Grieve 1987. "Terrestrial Impact Structures." [DIRS 135254]	pp. 248 and 257, Figure 8	Use of a power law for cratering rate distribution based on observed earth cratering and threshold size for onset of complex cratering	1.5.01.01.0A	E	5 (h)	1, 3, 10
Grieve et al. 1995. "The Record of Terrestrial Impact Cratering." [DIRS 135260]	pp. 194 to 196	Crater rate distribution based on observed earth cratering and the threshold size for onset of complex cratering	1.5.01.01.0A	E	5 (h)	1, 3, 10
Grieve 1998. "Extraterrestrial Impacts on Earth: The Evidence and the Consequences." [DIRS 163385]	p. 113, Figure 8	Crater diameter to depth of effect relationships. Depth of exhumation is approximately 0.28 times the crater diameter	1.5.01.01.0A	E	5 (h)	1, 3, 10
Hills and Goda 1993. "Fragmentation of Small Asteroids in the Atmosphere." [DIRS 135281]	Figures 17 and 18	Earthquake magnitudes due to a meteoroid impact range from Magnitude ~~5 to slightly less than~~3.5 to about Magnitude 7 on the Richter scale	1.5.01.01.0A	E	5 (h)	1, 3, 10
National Research Council 1992. Ground Water at Yucca Mountain, How High Can It Rise? Final Report of the Panel on Coupled Hydrologic/Tectonic/Hydrothermal Systems at Yucca Mountain. [DIRS 105162]	Chapter 2, p. 24	Extension rates declined to 5 to 10 mm/yr at 5 Ma; extension rates are still in a declining state	2.2.06.01.0A 2.2.06.02.0A	E	5 (b)	1, 3, 10
~~National Research Council 1992. Ground Water at Yucca Mountain, How High Can It Rise? Final Report of the Panel on Coupled Hydrologic/Tectonic/Hydrothermal Systems at Yucca Mountain. [DIRS 105162] (continued)~~	Chapter 5, p. 116	Results from the regional stress model approach indicated a maximum water table rise of 50 m	1.2.10.01.0A	E	5 (b)	1, 3, 10

Table 4. Changes to Table J-2 (Only Rows with Changes Shown) (Continued)

Input	Source	Description	FEP	Project or External	Method[1] (Rationale)[2]	Attribute[3]
	Chapter 5, p. 116	Predicted seismic events within the Yucca Mountain region over the next 10,000 years will not alter the large and globally extensive stresses imposed in the rock and in effect over the past 10 to 15 million years	2.2.06.01.0A 2.2.06.02.0A	E	5 (b)	1, 3, 10
	Chapter 2, p. 22	Plate tectonic activity has imparted crustal extension stresses within the Basin and Range Province (which includes the Yucca Mountain region) during the past 12 million years. Extension rates between 10 and 12 million years ago ranged between 10 and 30 mm/yr	2.2.06.01.0A 2.2.06.02.0A	E	5 (b)	1, 3, 10
Plys and Duncan 1999. *FAI/99-14, Rev. 1, Hydrogen Combustion in an MCO During Interim Storage*. [DIRS 184687]	Figure 5-1, pp. 6 and 7	The maximum achievable temperatures and pressures (11 times the initial pressure) for a hydrogen fire in a mixture of oxygen (21%) and helium (79%) inside an MCO	2.1.13.01.0A	E	5 (c)	1, 3, 7, 11
Rogers et al. 1988. "Low Temperature Diffusion of Oxygen in Titanium and Titanium Oxide Films." [DIRS 184108]	Table 1 and p. 146	The value of the oxygen diffusion coefficient in titanium at 300°C	2.1.06.06.0B	E	5 (b)	1, 3, 10
Sexton 2007. *Particulate and Water in Multi-Canister Overpacks* (OCRWM). [DIRS 184742]	Table 2-1	Maximum amount of free and bound water in an MCO is 4.3 kg	2.1.13.01.0A	E	5 (f)	2, 6, 7
	Table 2-1	The average value of free and bound water in an MCO is 1.03 kg	2.1.13.01.0A	E	5 (f)	2, 6, 7

Table 4. Changes to Table J-2 (Only Rows with Changes Shown) (Continued)

Input	Source	Description	FEP	Project or External	Method[1] (Rationale)[2]	Attribute[3]
Smyth and Caporuscio 1981. *Review of the Thermal Stability and Cation Exchange Properties of the Zeolite Minerals Clinoptilolite, Mordenite, and Analcime: Applications to Radioactive Waste Isolation in Silicic Tuff*. [DIRS 174060]	Tables A-1 and B-1, sample YM-40	Volume and weight changes observed upon heating were recorded for a rock sample from the zeolitized Calico Hills Formation. The tuff was soaked in water at 91°C for 48 hours and then kept at approximately 95°C in a drying oven. The core was weighed and measured at the beginning of the experiment and periodically throughout the 32-hour dry-heating period. The amount of water lost between the highest measured volume (hour 1) and the next measurement (hour 2), relative to the total water lost during heating, was 70.6 wt % calculated as 100 × (19.77033 g – 18.5134 g)/ (19.7703 g – 17.9906 g)	2.2.10.14.0A	P	5 (b)	1, 3
	Table A-1, sample YM-38	The selected upper bounding value for volume reduction of initially saturated zeolitic tuff heated in air at 95°C was 0.76 vol %	2.2.10.14.0A	P	5 (b)	1, 3, 10
Valentine and Krogh 2006. "Emplacement of Shallow Dikes and Sills Beneath a Small Basaltic Volcanic Center – The Role of Pre-Existing Structure (Paiute Ridge, Southern Nevada, USA)." [DIRS 177282]	p. 221	In places the tuff is densely welded and forms black vitrophyre that grades rapidly away from the contact, over a distance of ~20 to 100 cm, into nonwelded tuff that is apparently unaffected by the dike	1.2.05.00.0A	E	5 (b)	1, 3, 8, 10
Wuschke et al. 1995. Assessment of the Long-Term Risk of a Meteorite Impact on a Hypothetical Canadian Nuclear Fuel Waste Disposal Vault Deep in Plutonic Rock. [DIRS 129326]	~~p. 3~~	~~Spatial relationships of crater diameter to extents and depth of fracturing and exhumation~~	~~1.5.01.01.0A~~	~~E~~	~~5 (h)~~	~~1, 3~~
	~~Figure 1~~	~~Spatial extent of fracturing is assumed to be spherical~~	~~1.5.01.01.0A~~	~~E~~	~~5 (h)~~	~~1, 3~~
	pp. 4 and 26	Cratering rate data for the Canadian shield and application to a hypothetical Canadian repository	1.5.01.01.0A	E	5 (h)	1, 3, 10

Table 5. Changes to Table D-5 (Only Rows with Changes Shown)

Input	Source	Description
Grieve 1998. "Extraterrestrial Impacts on Earth: The Evidence and the Consequences." [DIRS 163385]	p. 113, Figure 8	Range of exhumation depth to crater diameter ratios ~~justified for use as direct input~~
Grieve et al. 1995. "The Record of Terrestrial Impact Cratering." [DIRS 135260]	pp. 194 to 196	Crater rate distribution based on observed earth cratering and the threshold size for onset of complex cratering (4 km)
Hills and Goda 1993. "Fragmentation of Small Asteroids in the Atmosphere." [DIRS 135281]	Figures 17 and 18	Richter scale magnitude of the earthquake produced by impact or debris hitting the ground as a function of initial meteoroid radius and the crater diameter as a function of the initial meteoroid radius
Wuschke et al. 1995. "Assessment of the Long-Term Risk of a Meteorite Impact on a Hypothetical Canadian Nuclear Fuel Waste Disposal Vault Deep in Plutonic Rock." [DIRS 129326]	~~p. 3 and Figure 1~~ pp. 4 and 26	~~Crater diameter to depth of effect relationships and ratio of crater diameter-to-fracture depth and the ratio are used as direct input~~ Cratering rate data for the Canadian shield and application to a hypothetical Canadian repository
Grieve and Robertson 1984. "*The Potential for the Disturbance of a Buried Nuclear Waste Vault by a Large-Scale Meteorite Impact. Proceedings of a Workshop on Transitional Processes*." [DIRS 185030]	~~Abstract, p. 231~~ Equation 3, p. 241 Equation 9, p. 243	~~Power law for distribution for terrestrial craters~~ Ratio of depth of redistributed zone to diameter of crater (0.14) Ratio of depth of fractured zone to diameter of crater (0.76)

1. Resolution to Wronkiewicz et al. 1996 [DIRS 102047]

This source is qualified in Section J24.3 of the report, but additional documentation is required. Therefore, additional justification for the equipment and procedures is added. See changes to document listed below:

Revise the first paragraph of Section J24.3.2 as follows:

> **Technical Adequacy of Equipment and Procedures Used**—The experimental apparatus and materials, summarized within the article, are adequate and appropriate for the data collected. Additional documentation of the equipment, methods, and procedures used can be found in sources referenced by Wronkiewicz et al. (1991 [DIRS 176891]) and published by Wronkiewicz et al. (1992 [DIRS 100493]). The experimental method, Unsaturated Test Method (UTM), was specifically designed to investigate the reaction between water and simulated waste forms under potential repository conditions (Wronkiewicz et al. 1992 [DIRS 100493]). The method involves periodically dripping small amounts of water on samples that are maintained in temperature-regulated stainless steel test vessels. After contacting the sample, the injected water is allowed to migrate down the sides of the sample, drip from the bottom, and collect in the test vessel. The UTM thus simulates an environment where the waste container develops breaches along its top and bottom, allowing free flow of water through the container and limited contact time with the waste form. The waste form investigated, UO_2, was an appropriate surrogate for spent fuel since

commercial spent fuel is composed of ≥ 95 % UO_2 (Wronkiewicz et al. 1992 [DIRS 100493]). The leachate for the experiments was chosen specifically for the application—groundwater from the J-13 well located near Yucca Mountain, equilibrated with crushed tuff.

2. Resolution to National Research Council 1992 [DIRS 105162]

This source is qualified in Section J32 of the report, but additional documentation is required. Therefore, corroborating information is added as a qualification attribute. See changes to document listed below:

Revise the second sentence of Section J10.2 as follows:

> …The data were qualified for intended use using the Technical Assessment method (SCI-PRO-001, Attachment 3, Method 5) with the consideration of the qualifications of personnel or organizations generating the data, the extent to which the data demonstrate the properties of interest, and the extent of corroborating data.

Add a third bullet to Section J32.1 as follows:

> …Attributes specifically applicable to these data are:
>
> - Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science (#1).
> - The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geological, mechanical) (#3).
> - Extent and quality of corroborating data or confirmatory testing results (#10).

Add the following paragraphs to the end of Section J32.2

> **Corroborating Data**— Two other modeling studies corroborate the maximum water table rise of 50 m from the National Research Council by presenting water table rise estimates of less than or equal to 50 m. Gauthier et al. (1996 [DIRS 100447], pp. 163 to 164) analyzed the potential effects of seismic activity as a result of three different types of fault displacements (normal, listric, and strike-slip faulting) on contaminant transport in the saturated zone due to changes in water table elevation. Their simulations indicated a maximum rise of 50 m within an hour of a simulated strike-slip seismic event, with a smaller rise for the other types of events. Numerical simulations by Carrigan et al. (1991 [DIRS 100967]) of seismic pumping involving earthquakes typical of the Basin and Range province (approximately 1-m fault slip) produced 2- to 3-m excursions of a water table 500 m below the ground surface. Extrapolation to an event of about 4-m slip would result in a transient rise of 17 m near the fault (Carrigan et al. 1991 [DIRS 100967], p. 1,159). Carrigan et al. (1991 [DIRS 100967]) modeled a 100-m-wide fracture zone centered on a vertical fault, with vertical permeability increased by a factor of 1,000.

For a fault-fracture zone with 1-m slip, transient excursions of about 12 m were modeled by Carrigan et al. (1991 [DIRS 100967]).

In corroboration with the extension rates and the trend in extension rates (decreasing) presented by National Research Council (1992 [DIRS 105162], Chapter 2, p. 22 and 24 and Chapter 5, p. 116), two references provide supporting information. Wernicke et al. (1988 [DIRS 149959], p. 1738) of Harvard University, Department of Earth and Planetary Sciences, found that the extension of the Basin and Range province, which includes Yucca Mountain, occurred at a rate of 20-30 mm/yr in the interval 15 to 10 Ma, but was no greater than 10 mm/yr over the past 5 million years. In addition, Figure 12 of Wernicke et al. (1988 [DIRS 149959], p. 1753] shows a plot of decreasing extension rates from about 12 Ma to the present. Scott (1990 [DIRS 106751], pp. 251 and 279) of the U.S. Geological Survey found that the extension deformation at Yucca Mountain reached a peak between 13 and 11.5 Ma and decreased afterward by a factor ranging from 2.5 to 20 times, depending on the location.

Add the following reference to Section 8.1 and the DIRS:

149959 Wernicke, B.; Axen, G.J.; and Snow, J.K. 1988. "Basin and Range Extensional Tectonics at the Latitude of Las Vegas, Nevada." *Geological Society of America Bulletin, 100,* (11), 1738-1757. Boulder, Colorado: Geological Society of America. TIC: 233007.

3. Resolution to Wuschke et al. 1995 [DIRS 129326]

This reference is qualified for intended use within Appendix D, however the qualification attributes are expanded to include corroboration of data. Some of the direct inputs are reclassified as "indirect inputs". Additional editorial fixes are also included at the end of the section. See changes to document listed below:

Revise the second and third paragraph of Section D6.1.7 (pp. D-27 to D-28) as follows:

The following criteria were used to assess the external data from *Assessment of the Long-Term Risk of a Meteorite Impact on a Hypothetical Canadian Nuclear Fuel Waste Disposal Vault Deep in Plutonic Rock* (Wuschke et al. 1995 [DIRS 129326]):

1. Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science.
2. The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geologic, mechanical).
3. Extent and quality of corroborating data or confirmatory testing results.

Justification for the appropriate use of data from *Assessment of the Long-Term Risk of a Meteorite Impact on a Hypothetical Canadian Nuclear Fuel Waste Disposal Vault Deep in Plutonic Rock* (Wuschke et al. 1995 [DIRS 129326], pp. 4 and 26):

> D.M. Wuschke, S.H. Whitaker, B.W. Goodwin, and L.R. Rasmussen have been staff members of Atomic Energy of Canada, Limited (AECL). These associations demonstrate an appropriate technical level of competence for qualification of publications authored by Wuschke et al. for their intended use in this appendix.
>
> This paper is directly applicable as it presents a well-documented evaluation equivalent to the evaluation needed for YMP. The paper provides a detailed analysis of the hazard and risk associated with meteorite impact above an underground repository. Assumptions, spatial relationships, mathematical formulations, and uncertainty analysis are all documented within the report.
>
> The cratering rate data for the Canadian shield are discussed in Section D4.2.2 and are corroborated in Figure D-5 by comparison to Neukum and Ivanov 1994 [DIRS 121510].

Remove Wuschke et al 1995 [DIRS 129326] from the list of direct inputs in Table 1.5.01.01.0A-1 (last row) on page 6-291.

Add Wuschke et al 1995 [DIRS 129326] to the list of indirect inputs in Table 1.5.01.01.0A-2 (last row) on page 6-291.

Revise the contents of Section D4.3.4.1 on page D-16, to correct the value presented and to more accurately reflect the source of information, as follows:

> A range of exhumation depth-to-crater diameter ratios of 0.10 to 0.33 is assumed in this appendix, and a value of ~~0.32 based on Wuschke et al. (1995 [DIRS 129326], Figure 1)~~0.14 based on Grieve and Robertson (1984 [DIRS 185030], Eq. 3, page 241) and 0.28 from Grieve (1998 [DIRS 163385], p. 113).

Revise the contents of Section D4.3.5.1 on page D-17, to correct the value presented and to more accurately reflect the source of information, as follows:

> The fracturing depth-to-crater diameter ratios assumed in this appendix ranges from 0.33 to 0.76 based on a value~~s~~ of ~~0.75~~ 0.76 (Grieve and Robertson 1984 [DIRS 185030], Eq. 9, page 243; Wuschke et al. 1995 [DIRS 129326], Section 2.2 and Figure 1). ~~Because the intended use is for the FEP screening, the conservative value of increased fracturing depth to 0.76 of the crater diameter, as indicated by Wuschke et al. (1995 [DIRS 129326]), is used to ensure that the range of uncertainty in this relationship is covered.~~

See changes in Tables 3, 4, and 5 of this ERD.

4. Resolution to Grieve 1987 [DIRS 135254]

This reference is qualified for intended use within Appendix D, however the qualification attributes are expanded to include corroboration of data. See changes to document listed below:

Revise the second and third paragraph of Section D6.1.2 (p. D-23) as follows:

> The following criteria were used to assess the external data from "Terrestrial Impact Structures" (Grieve 1987 [DIRS 135254]):
>
> 1. Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science.
> 2. The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geologic, mechanical).
> 3. Extent and quality of corroborating data or confirmatory testing results.
>
> Justification for the appropriate use of data from "Terrestrial Impact Structures" (Grieve 1987 [DIRS 135254]):
>
> R.A.F. Grieve has been on the faculty for the Department of Geological Sciences at Brown University and a member of the Geophysics Division for the Geological Survey of Canada. These associations demonstrate an appropriate technical level of competence for qualification of publications authored by Grieve for their intended use in this appendix.
>
> The report is a seminal work in the area of impact cratering and lists observed craters, crater characteristics, and cratering rates. The paper builds on earlier relationships of crater diameter to crater depth and provides a cratering rate estimate for large-diameter craters that are generally used in hazard estimates. This paper was taken from a peer-reviewed journal. The documentation is somewhat limited, but is generally accepted as reliable and has been updated on a periodic basis.
>
> The cratering rate distribution based on observed earth cratering are discussed in Section D4.2.1 and are corroborated in Figure D-5 by comparison to Neukum and Ivanov 1994 [DIRS 121510], Wuschke et al. 1995 [DIRS 129326], and Grieve et al. 1995 [DIRS 135260]. The threshold size for onset of complex cratering (4 km) is corroborated by Grieve et al. (1995 [DIRS 135260], p. 194)

See changes in Table 4 of this ERD.

5. Resolution to Grieve et al. 1995 [DIRS 135260]

This reference is qualified for intended use within Appendix D, however the qualification attributes are expanded to include corroboration of data. Additional editorial fixes are also included at the end of the section. See changes to document listed below:

Revise the second and third paragraph of Section D6.1.6 (pp. D-26 to D-27) as follows:

> The following criteria were used to assess the external data from "The Record of Terrestrial Impact Cratering" (Grieve et al. 1995 [DIRS 135260]):
>
> 1. Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science.
> 2. The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geologic, mechanical).
> 3. Extent and quality of corroborating data or confirmatory testing results.
>
> Justification for the appropriate use of data from "The Record of Terrestrial Impact Cratering" (Grieve et al. 1995 [DIRS 135260]):
>
> R.A.F. Grieve has been on the faculty for the Department of Geological Sciences at Brown University and a member of the Geophysics Division for the Geological Survey of Canada. These associations demonstrate an appropriate technical level of competence for qualification of publications authored by Grieve for their intended use in this appendix.
>
> This report is an update and summary of previous papers and summarizes the results of studies to date, and provides a distinction of the cratering effect data based on craters in sedimentary and crystalline materials. This paper is focused on updating the "state of knowledge" regarding the number of craters, cratering mechanics, shock metamorphism, and effect of impacts on biological evolution. This paper was taken from a peer-reviewed journal. The documentation is somewhat limited, but is generally accepted as reliable and has been updated on a periodic basis.
>
> The cratering rate distribution based on observed earth cratering are discussed in Section D4.2.1 and are corroborated in Figure D-5 by comparison to Neukum and Ivanov 1994 [DIRS 121510], Wuschke et al. 1995 [DIRS 129326], and Grieve 1987 [DIRS 135254]. The threshold size for onset of complex cratering (4 km) is corroborated by Grieve (1987 [DIRS 135254], p. 248).

See changes in Tables 3, 4, and 5 of this ERD.

6. Resolution to Grieve 1998 [DIRS 163385]

This reference is qualified for intended use within Appendix D, however the qualification attributes are expanded to include corroboration of data. A reference is added for corroboration of data. See changes to document listed below:

Revise the second and third paragraph of Section D6.1.4 (pp. D-24 to D-25) as follows:

> The following criteria were used to assess the external data from "Extraterrestrial Impacts on Earth: The Evidence and Consequences" (Grieve 1998 [DIRS 163385]):
>
> 1. Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science.
> 2. The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geologic, mechanical).
> 3. Extent and quality of corroborating data or confirmatory testing results.
>
> Justification for the appropriate use of data from "Extraterrestrial Impacts on Earth: The Evidence and Consequences" (Grieve 1998 [DIRS 163385]):
>
> R.A.F. Grieve has been on the faculty for the Department of Geological Sciences at Brown University and a member of the Geophysics Division for the Geological Survey of Canada. These associations demonstrate an appropriate technical level of competence for qualification of publications authored by Grieve for their intended use in this appendix.
>
> This report is an update and summary of previous papers and summarizes the results of studies to date, and provides a distinction of the cratering effect data based on craters in sedimentary and crystalline materials. This paper is focused on updating the "state of knowledge" regarding the number of craters, cratering mechanics, shock metamorphism, and effect of impacts on biological evolution.
>
> The ratio of the exhumation depth to crater diameter of 0.28 provided by Grieve (1998 [DIRS 163385], Figure 8) is corroborated by Grieve et al. (1989 [DIRS 186135], Table 3), which gives values for d_t (true depth of final crater) and D_r (rim crest diameter of final crater) for various craters. Calculating the ratio of d_t / D_r with values from Grieve et al. 1989 ([DIRS 186135], Table 3) gives values ranging from 0.26 to 0.34.

Add the following reference to Section 8.1 and the DIRS:

> 186135 Grieve, R.A.F.; Garvin, J.B.; Coderre, J.M., and Rupert, J. 1989. "Test of a geometric model for the modification stage of simple impact crater development." *Meteoritics, 24,* 83-88. Tucson, Arizona: Meteoritical Society. TIC: 260322.

See changes in Tables 4 and 5 of this ERD.

7. Resolution to Grieve and Robertson 1984 [DIRS 185030]

This reference is qualified for intended use within Appendix D, however the qualification attributes are expanded to include prior use of data. Additional changes to Tables D-4 and D-5 are also included at the end of the section. See changes to document listed below:

Revise the second and third paragraph of Section D6.1.3 (p. D-24) as follows:

> The following criteria were used to assess the external data from "The Potential for the Disturbance of a Buried Nuclear Waste Vault by a Large-Scale Meteorite Impact" (Grieve and Robertson 1984 [DIRS 185030]):
>
> 1. Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science.
> 2. The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geologic, mechanical).
> 3. Prior uses of the data and associated verification processes.
>
> Justification for the appropriate use of data from "The Potential for the Disturbance of a Buried Nuclear Waste Vault by a Large-Scale Meteorite Impact" (Grieve and Robertson 1984 [DIRS 185030]):
>
> R.A.F. Grieve has been on the faculty for the Department of Geological Sciences at Brown University and a member of the Geophysics Division for the Geological Survey of Canada. P. B. Robertson has been a member of the Earth Sciences Branch of The Department of Energy, Mines and Resources for Ontario Canada. These associations demonstrate an appropriate technical level of competence for qualification of publications authored by Grieve and Robertson for their intended use in this appendix.
>
> This report uses observations on the moon and earth to estimate terrestrial cratering rates and crater dimensions from meteorite impacts. For simple craters, the source gives a value of 0.14 for the ratio of the redistributed depth (second zone within a crater) to the diameter of an impact crater (Grieve and Robertson 1984 [DIRS 185030], Equation 3, p. 241). In addition, the source provides a value of 0.76 for the ratio of the depth of the fractured zone beneath the crater to the diameter of the crater (Grieve and Robertson 1984 [DIRS 185030], Equation 9, p. 243). The report uses the data in an analysis to determine the potential for a meteorite impact to disturb buried nuclear waste.
>
> The ratios of depth to diameter of 0.14 and 0.76, described in the preceding paragraph, provided by Grieve and Robertson (1984 [DIRS 185030], Equations 3 and 9, pp. 241 and 243), are used by Wuschke et al. (1995 [DIRS 129326], p.3) in

very similar calculations to determine the long-term risk of a meteorite impact on a hypothetical nuclear waste disposal site in Canada.

See changes in Tables 3, 4, and 5 of this ERD.

8. Resolution to Hills and Goda 1993 [DIRS 135281]

This reference is qualified for intended use within Appendix D, however the qualification attributes are expanded to include corroboration of data. Additional editorial fixes are also included at the end of the section. See changes to document listed below:

Revise the second and third paragraph of Section D6.1.5 (pp. D-25 to D-26) as follows:

The following criteria were used to assess the external data from "Fragmentation of Small Asteroids in the Atmosphere" (Hills and Goda 1993 [DIRS 135281]):

1. Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science.
2. The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geologic, mechanical).
3. Extent and quality of corroborating data or confirmatory testing results.

Justification for the appropriate use of data from "Fragmentation of Small Asteroids in the Atmosphere" (Hills and Goda 1993 [DIRS 135281]):

J. G. Hills and M.P. Goda have been members of the Theoretical Astrophysics Group at Los Alamos National Laboratory. These associations demonstrate an appropriate technical level of competence for qualification of publications authored by Hills and Goda for their intended use in this appendix.

The report relates the earthquake energy level from a meteoroid impact as determined from the Richter scale to the impact crater diameter, thus providing a link to the repository seismic analyses.

The magnitude of earthquake (M) on the Richter scale that could be triggered as a result of a meteor forming a 60-m diameter crater (3.5 to 7 M) is corroborated using the relationship of crater-diameter versus energy released given by Dence (1977 [DIRS 135253], Figure 12) and the relationship between energy released and earthquake magnitude given by Barosh (1969 [DIRS 186185], p. 48). A crater with a diameter of 60 m is caused by an energy release of 1×10^{13} Joules or less (Dence 1977 [DIRS 135253], Figure 12). This energy is equivalent to 2.39 kilotons (converted using: 1 ton = 4.184×10^{9} J, Parrington et al. 1996 [DIRS 103896], p. 58). An energy release (or yield (Y)) of 2.39 kilotons results in an earthquake magnitude of 4.2 M, based on the relationship M=3.9 + 0.7logY (Barosh 1969 [DIRS 186185], p. 48). Therefore the range of earthquake

magnitudes given by Hills and Goda 1993 [DIRS 135281] of 3.5 to 7 M is corroborated by the information contained in Dence 1977 [DIRS 135253] and Barosh 1969 [DIRS 186185].

Revise page 6-290, second full paragraph, first sentence, as follows:

Meteors that result in crater diameters of 60 m (corresponding to the threshold annual probability of 10^{-8}) could trigger earthquakes with Richter magnitudes ranging from magnitude 3.5 to about magnitude 7 (Hills and Goda 1993 [DIRS 135281], Figures 17 and 18). This range applies to iron or stony meteors at an average velocity of 15 km/sec (Appendix D).

Revise page D-20, second full paragraph, first sentence, as follows:

Meteors that result in crater diameters of 60 m (corresponding to the threshold annual probability of 10^{-8}) could trigger earthquakes with Richter magnitudes ranging from magnitude 3.5 to about magnitude 7 (Hills and Goda 1993 [DIRS 135281], Figures 17 and 18). This range applies to iron or stony meteors at an average velocity of 15 km/sec (Appendix D).

Add the following references to Section 8.1 and the DIRS:

135253 Dence, M.R.; Grieve, R.A.F.; and Robertson, P.B. 1977. "Terrestrial Impact Structures: Principal Characteristics and Energy Considerations." *Impact and Explosion Cratering, Planetary and Terrestrial Implications, Proceedings of the Symposium on Planetary Cratering Mechanics, Flagstaff, Arizona, September 13-17, 1976.* Roddy, D.J.; Pepin, R.O.; and Merrill, R.B., eds. Pages 247-275. New York, New York: Pergamon Press. TIC: 247237.

186185 Barosh, P.J. 1969. "Relation Between Earthquake Magnitude and Nuclear Explosion Energy Release." *Use of Seismic Intensity Data to Predict the Effects of Earthquakes and Underground Nuclear Explosions in Various Geologic Settings.* Geological Survey Bulletin 1279. Washington, D.C.: U.S. Government Printing Office. ACC: LLR.20090302.0081.

See changes in Tables 3, 4, and 5 of this ERD.

9. Resolution to Smyth and Caporuscio 1981 [DIRS 174060]

This source is qualified in Section J39.1 of the report, but additional documentation is required. Therefore, corroborating information is added as a qualification attribute. See changes to document listed below:

Add a third bullet to Section J39.1.1 as follows:

…Attributes specifically applicable to these data are:

- Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science (#1).

- The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geological, mechanical) (#3).

- Extent and quality of corroborating data or confirmatory testing results (#10).

Add the following paragraph to the end of Section J39.1.2

Corroborating Data— The upper bounding value of volume reduction (0.76 vol%) due to heating and dehydrating of tuff samples, experimentally determined by Smyth and Caporuscio (1981 [DIRS 174060], Table A-1), is corroborated by experiments described in the discussion for FEP: 2.2.10.14.0A. Experimental results from Kranz et al. 1989 [DIRS 183167] showed a volume increase of 0.6 vol% for tuff samples that were initially dehydrated, then rehydrated.

In the first paragraph of Section J39.1, change the DIRS number from "184454" to the correct DIRS number "174060".

10. Resolution to Valentine and Krogh 2006 [DIRS 177282]

This source is qualified in Section J5.2 of the report, but additional documentation is required. Therefore, corroborating information is added as a qualification attribute. See changes to document listed below:

Add a fourth bullet to Section J5.2.1 as follows:

…Attributes specifically applicable to these data are:

- Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science (#1).

- The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geological, mechanical) (#3).

- Prior peer or other professional reviews (#8).

- Extent and quality of corroborating data or confirmatory testing results (#10).

Add the following paragraph to the end of Section J5.2.2

Corroborating Data—The thickness of tuff impacted by a dike intrusion (~20 to 100 cm) from Valentine and Krogh (2006 [DIRS 177282], p. 221) is corroborated by Keating et al. (2002 [DIRS 174077]), who studied the Paiute Ridge intrusive complex located in the Nevada Test Site. Keating et al. (2002 [DIRS 174077], pp. 430 and 432) found that most alterations due to igneous intrusions occur within 0.5 to 1 m of the contact between the intrusion and the host rock and the alterations decrease back to the original state within 3 m of the contact.

Add the following reference to Section 8.1 and the DIRS:

174077 Keating, G.N.; Geissman, J.W.; and Zyvoloski, G.A. 2002. "Multiphase Modeling of Contact Metamorphic Systems and Application to Transitional Geomagnetic Fields." *Earth and Planetary Science Letters, 198,* 429-448. [New York, New York]: Elsevier. TIC: 257642.

11. Resolution to Rogers et al. 1988 [DIRS 184108]

This source is qualified in Section J22 of the report, but additional documentation is required. Therefore, corroborating information is added as a qualification attribute. See changes to document listed below:

Add a third bullet to Section J22.1 as follows:

…Attributes specifically applicable to these data are:

- Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP license application process or postclosure science (#1).
- The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geological, mechanical) (#3).
- Extent and quality of corroborating data or confirmatory testing results (#10).

Add the following paragraph to the end of Section J22.2

The oxygen diffusion coefficient in titanium metal at 300°C (8.8×10^{-18} cm^2 s^{-1}) from Rogers et al. (1988 [DIRS 184108]) is corroborated by Liu and Welsch (1988 [DIRS 186105]). Liu and Welsch (1988 [DIRS 186105]) present a literature survey on diffusion coefficients of oxygen and other elements in titanium. Most of the measured diffusion coefficients presented by Liu and Welsch (1988 [DIRS 186105], Figure 1) are at temperatures above 400°C. The diffusion coefficients at 400°C and 500°C from Rogers et al. (1988 [DIRS 184108], Table 1) compare favorably with the other literature values plotted in Figure 1 of Liu and Welsch (1988 [DIRS 186105]). The favorable comparison of diffusion coefficients at higher temperatures gives confidence that the diffusion at 300°C from Rogers et al. (1988 [DIRS 184108]) is also a reliable value.

Add the following reference to Section 8.1 and the DIRS:

186105 Liu, Z. and Welsch, G. 1988. "Literature Survey on Diffusivities of Oxygen, Aluminum, and Vanadium in Alpha Titanium, Beta Titanium, and in Rutile." *Metallurgical Transactions A, 19A*, 1121-1125. [Metals Park, Ohio: American Society for Metals]. TIC: 260321.

12. Resolution to Wachs 2004 [DIRS 184624]

This source is qualified in Section J19.3 of the report, but additional documentation is required. See changes to document listed below:

Add additional text to first bullet in Section J19.3.1 as follows:

Attributes specifically applicable to these data are:

- Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP License Application process or post closure science (#1).

Replace Section J19.3.2 with the following:

Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under an approved program that supports the YMP License Application process or post closure science—This report originates from the National Spent Nuclear Fuel Program (NSNFP) with the specific purpose to calculate the minimum amount of free water and physically adsorbed water that if completely dissociated could approach the pressure limits within a DOE SNF Standardized canister. This program works under NSNFP Quality Assurance, which implements *Quality Assurance Requirements and Description* (Wachs 2004 [DIRS 184624], p. 9, Quality Assurance). An external reviewer approving the document (Wachs 2004 [DIRS 184624], p. 1), added confidence that the data are reliable.

Extent to Which the Data Demonstrate the Properties of Interest—The volume of free water is used to estimate the pressure of water vapor in a codisposal waste package at its peak temperature of 191.0°C, shortly after repository closure. Considering the dimensions of a waste package are much larger than the dimensions of a MCO or SNF Standard canister, the relative amount of free water per canister is relatively small compared to the void volume of the waste package. Additionally, high-level waste such as that under consideration for the intended use of this data should not contain sufficient amounts of water to appreciably add to the water contained in the waste package (Wachs 2004 [DIRS 184624], p. 5).

The source document *Calculation of amount of free water required to overpressurize DOE SNF Standardized Canister and RW Waste Package* (Wachs 2004 [DIRS 184624]) was prepared for the National Spent Nuclear Fuel Project similar to the needs of YMP.

The quality and reliability of the measurement control program under which the data were generated—The report was prepared and checked by NSNFP. Roberson (2004) [DIRS 182751]) summarizes the 2004 audit of NSNFP on March 29 through April 1, 2004 and states that the NSNFP was satisfactorily implementing the QARD at that time. Golan (2004 [DIRS 182752]) reports an additional audit conducted from June 21-24, 2004, which focused on specific aspects of the NSNFP. Though the last audit found one significant condition adverse to quality, it was determined that as a whole, the specific audited programs were effectively implementing the QARD.

The extent to which conditions under which the data were generated may partially meet the QA program that supports the YMP license application process or Postclosure science—The reference was prepared under NSNFP Quality Assurance, which implements the QARD as evidenced by Roberson (2004) [DIRS 182751]) and Golan (2004 [DIRS 182752]), mentioned above, which conducted audits of the NSNFP QA program.

Add the following references to Section 8.1 and the DIRS:

182752 Golan, P.M. 2004. "Issuance of Audit Report No. 04-DOE-AU-004 for the Department of Energy Idaho Operations Office Spent Nuclear Fuel Program." Memorandum from P.M. Golan (DOE) to E.D. Sellers (DOE/ID), September 23, 2004, with attachment. ACC: MOL.20041214.0129; MOL.20041214.0130.

182751 Roberson, J.H. 2004. "Issuance of Audit Report No. 04-DOE-AU-001 for the Department of Energy Idaho Operations Office National Spent Nuclear Fuel Program." Memorandum from J.H. Roberson (DOE) to E. Sellers (DOE/ID), May 21, 2004, with attachment. ACC: HQO.20040630.0014; HQO.20040630.0015.

13. Resolution to Plys and Duncan 1999 [DIRS 184687]

This source is qualified in Section J31.1 of the report, but additional documentation is required. Therefore, prior use of data is added as a qualification attribute. See changes to document listed below:

Add a bullet to Section J31.1.1 as follows:

…Qualification process attributes used in the qualification were selected from the list provided in Attachment 4 of SCI-PRO-001. Attributes specifically applicable to these data are:

- Qualifications of personnel or organizations generating the data (#1).
- The extent to which the data demonstrate the properties of interest (#3).
- Prior uses of the data and associated verification processes (#7)

- The degree to which independent audits of the process that generated the data were conducted (#11).

Add the following paragraph to the end of Section J31.1.2, before the paragraph titled "Document Reviews":

Prior uses of the data and associated verification processes—The purpose of the source document was to analyze potential conditions that could develop during interim storage of MCOs filled with spent nuclear fuel at Hanford. The report was finalized after a preliminary version of the report was reviewed by Hanford Spent Nuclear Fuel Project. The source document includes an engineering data transmittal form that shows approval of the document by several people, including a QA representative (Plys and Duncan 1999 [DIRS 184687], p. 1). The conditions analyzed are applicable to the current use because the MCOs studied in the source document are the same containers planned for the Yucca Mountain repository.

14. Resolution to Sexton 2007 [DIRS 184742]

This source is qualified in Section J31.4 of the report, but additional documentation is required. Therefore, prior use of data is added as a qualification attribute. Additional editorial fixes are also included at the end of the section. See changes to document listed below:

Add a bullet to Section J31.4.1 as follows:

…Attributes specifically applicable to these data are:

- The technical adequacy of equipment and procedures used to collect and analyze the data (#2).
- The extent to which conditions under which the data were generated may partially meet the QA program that supports the YMP license application process or Postclosure science (#6).
- Prior uses of the data and associated verification processes (#7)

Revise the end of Section J31.4.1 as follows:

Quality Assurance Program—Although the report does not clearly identify the quality assurance program under which the report was originated, personal communication with NSNFP Manager indicated that the report was generated under the NSNFP QA program. Upon reviewing the NSNFP QA procedure (NSNFP 3.04 Rev. 6) it is permissible not to specify a QA section within certain reports. The report was peer reviewed and approved by NSNFP QA for formal public release as indicated on the engineering document change form (Sexton 2007 [DIRS 184742]). QA audits of the DOE Richland Operations Office Hanford SNF program in 2006 (Triay 2006 [DIRS 185938]) and 2007 (Chung 2007 [DIRS 185939]) found the QA program to be satisfactorily and effectively implementing the QARD, with the exception of five deficiencies found in 2006, which

were corrected by the next audit in 2007. Additional deficiencies were identified in the audit in 2007; however the NSNFP and YMP LA-related activities were not included in the 2007 audit.

Prior uses of the data and associated verification processes—The purpose of the source document was to calculate bounding estimates of characteristics of spent fuel that is packaged in MCOs, dried, and placed in interim storage at Hanford. The report was peer reviewed and approved by NSNFP QA for formal public release as indicated on the engineering document change form (Sexton 2007 [DIRS 184742]). The conditions analyzed are applicable to the current use because the MCOs studied in the source document are the same containers planned for the Yucca Mountain repository.

Revise the following reference in Section 8.1:

184742 Sexton, R.A. 2007. *Particulate and Water in Multi-Canister Overpacks (OCRWM), including EDC*. KBC-33403, Rev. 0 and HNF-EDC-07-34345. Richland, Washington: Fluor Hanford. ACC: LLR.20080116.0003; LLR.20080116.0002.

Add the following references to Section 8.1 and the DIRS:

185938 Triay, I.R. 2006. "Issuance of Audit Report Number 06-DOE-AU-006 for the Department of Energy Richland Operations Office Hanford Spent Nuclear Fuel Program." Memorandom from I.R. Triay (DOE) to K. Klein (DOE/RL), November 1, 2006, with attachment. ACC: MOL.20070112.0003; MOL.20070112.0004.

185939 Chung, D.Y. 2007. "Issuance of Audit Report No. 07-DOE-AU-006 for the Department of Energy Richland Operations Office Hanford Spent Nuclear Fuel Program." Memorandum from D.Y. Chung (DOE) to D. Brockman (DOE/RL), November 30, 2007, with attachment. ACC: MOL.20080108.0006; MOL.20080108.0007.

15. Resolution to Doorenbos and Pruitt 1977 [DIRS 103062]

This source is established fact, so qualification is not needed. Therefore, delete Section J36 of the report.