December 22, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001-HLW
	)	
(High-Level Waste Repository)	)	ASLBP No. 09-892-HLW-CAB04
	)	

NRC STAFF RESPONSE TO BOARD QUESTIONS

INTRODUCTION

On December 9, 2009, Construction Authorization Board-04 ("the Board") issued a Memorandum and Order addressing six contentions filed after the original intervention petitions. *U.S. Dep't of Energy* (High-Level Waste Repository), LBP-09-29, 70 NRC __ (Dec. 9, 2009). With respect to NEV-SAFETY-203, a petition for a rule waiver pursuant to 10 C.F.R. § 2.335, the Board directed the NRC staff ("Staff") to answer certain questions about the waiver petition filings. *Id.* at 13. The Staff answers to these questions are set forth below.

DISCUSSION

A. Question 1

> The authors of the NRC Staff's affidavit assert that the information underlying the Stuewe model has "been available" for many years. Yet the affiants do not state that the Commission was aware of that information or actually considered the Stuewe model when it conducted the rulemaking. What information, if any, in the rulemaking record before the Commission demonstrates that the Commission considered the Stuewe model or the data underlying that model? Where is any such information located?

LBP-09-29 at 13 (citation omitted).

During the rulemaking for the Implementation of a Dose Standard After 10,000 Years, 74 Fed. Reg. 10,811 (Mar. 13, 2009) ("Final 10,000 Years Rule"), the Commission considered

the same types of data and information underlying the Stüwe model, but the Commission did not consider the Stüwe model itself. Attachment 1, Affidavit of Timothy McCartin and Philip Justus, dated December 22, 2009 ("McCartin and Justus Affidavit"), at ¶¶ 6, 24. Based on the published version, the Staff understands the data and information underlying the Stüwe model to be of two types: 1) geologic information regarding topography in the basin and range in which Yucca Mountain is located, including the angle of tilting for fault blocks used to specify the topographic gradient for estimating stream power, and 2) information related to erosion processes, erosion near Yucca Mountain, climate, and floods. *Id.* at ¶ 7 (citing Stüwe et al. 2009 at 200-01, 207). The Stüwe model and its assumptions, which are not supported by a technical basis, however, were not considered during the rulemaking. *See* McCartin and Justus Affidavit at ¶ 21.

Section 801 of the Energy Policy Act of 1992 mandates that EPA and NRC radiation protection standards for Yucca Mountain be consistent with the findings and recommendations of the National Academy of Sciences (NAS). 42 U.S.C. § 10141 note; *see also* Implementation of a Dose Standard After 10,000 Years, 74 Fed. Reg. 10,811, 10,811 (Mar. 13, 2009). NAS issued these findings and recommendations in a report entitled, "Technical Bases for Yucca Mountain Standards," National Research Council, Washington, D.C., 1995 (LSN # NEV000004270). *See* 74 Fed. Reg. at 10,811. The NAS found that "an increase in erosion to the extent necessary to expose the repository (even over a million-year time scale) is extremely unlikely." McCartin and Justus Affidavit at ¶ 22 (citing, "Technical Bases for Yucca Mountain Standards," National Research Council, Washington, D.C., 1995 (LSN # NEV000004270) at 91). Accordingly, in its rulemaking, the Commission did not discuss erosion rates so great that Yucca Mountain would be denuded and the repository would be exposed.

However, in its rulemaking, the Commission did consider a broad range of information related to erosion, including the types of information underlying the Stüwe model. McCartin and

Justus Affidavit at ¶¶ 9-18, 24. The details of the consideration of erosion and its potential effects can be found in five reports referenced in the Statement of Consideration accompanying the Final 10,000 Years Rule. *Id.* at ¶ 8 (citations omitted). These reports were based on a wide range of references, including some of the references listed in the Stüwe paper. *Id.* at ¶ 19. The Stüwe paper and the Commission both considered structural information for the Yucca Mountain region, erosion processes, and washes. *Id.* at ¶ 9. The Commission used the report, "Technical Assessment of Structural Deformation and Seismicity at Yucca Mountain, Nevada," which extensively discusses structural information of the Yucca Mountain region, such as it being comprised of tilted fault blocks, to support bedrock permeability values used in specifying deep percolation values. *Id.* at ¶ 10 (citing 74 Fed. Reg. at 10,823). The Stüwe paper uses the same structural information but for a different purpose, i.e., to specify the geometry of a simplified model used to estimate erosion rates. *Id.* (citing Stüwe et al. 2009 at 202, Fig. 2).

With respect to erosion processes, the NRC used a systematic approach to evaluate a number of aspects of erosion that could affect infiltration and developed its own model. *Id.* at ¶ 11. The Statement of Consideration identifies both the report documenting the technical basis for this model, "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation," S. Stothoff, San Antonio, TX: Center for Nuclear Waste Regulatory Analyses, 2008 (LSN #s: NRC000029713, NRC000029696, NRC000029726, NRC000029710, and NRC000029695), *see, e.g.,* 74 Fed. Reg. at 10,823, and the report discussing analyses using the model, "Long-Term-Average Infiltration at Yucca Mountain, Nevada: Million-Year Estimates," Stothoff and Walter, San Antonio, TX: Center for Nuclear Waste Regulatory Analyses, 2008 (LSN # NRC000029364), *see, e.g.,* 74 Fed. Reg. at 10,820. McCartin and Justus Affidavit at ¶ 11. During the development of the Infiltration Tabulator for Yucca Mountain, the NRC considered hillslope processes, depositional processes, and the potential for debris flows, such as the 1984 event mentioned in the Stüwe paper (Stüwe et al. 2009 at 207). McCartin and Justus Affidavit

at ¶¶ 11-14 (citations omitted). The Commission has also considered climate cycles, which can affect the duration and intensity of storm events and, therefore, erosion and net infiltration. *Id.* at ¶15 (citing 74 Fed. Reg. at 10,820-21). In considering climate, the NRC used the same Forester et al. (1999) reference that the Stuwe paper references. *Id.* at ¶ 16 (citations omitted).

Finally, the Stüwe paper considered and the Commission considered, as demonstrated by the citation of reports in the Statement of Consideration, washes or gullies near Yucca Mountain. McCartin and Justus Affidavit at ¶ 18. However, the NRC considered hillslope processes, whereas the Stüwe paper did not. *Id.*

In sum, the Commission considered a broad range of information relating to erosion in order to specify the deep percolation rates in its final rule. *Id.* ¶¶ 9-18, 24. This information includes the types of general information identified in the Stüwe paper and underlying the Stüwe model. *Id.* The Commission's consideration of this information is documented in the rulemaking record through the reports cited in the Statement of Consideration accompanying the final rule. However, in its rulemaking, the Commission did not discuss the unsupported assumptions in the Stüwe paper used to estimate extreme erosion rates.

B. Question 2

> The NRC Staff affiants point to statements in the published version of the Stuewe study that "undermine the presumed reliability of this model in determining erosion rates on Yucca Mountain itself." By raising questions about the model's applicability, do these statements of limitation defeat Nevada's *prima facie* showing under section 2.335(d)? Or, rather, do they raise a factual dispute between Nevada and the NRC Staff that cannot be reconciled on the basis of the waiver petition filings?

LBP-09-29 at 14 (citation omitted).

The limitations stated in the Stüwe study itself defeat a *prima facie* showing under 10 C.F.R. § 2.335(d). The published version of the study, which was available prior to the filing of Nevada's rule waiver petition (State of Nevada's New Contentions Based on Final NRC Rule, filed May 12, 2009) contains limitations which address whether the study can be used as the

basis for the *prima facie* showing that special circumstances exist such that the rule would not serve the purposes for which it was adopted. *See* 10 C.F.R. § 2.335(b),(c). Nevada's rule waiver petition does not satisfy the standards of 10 C.F.R. § 2.335 because the Stüwe study questions its own model's reliability for use with smaller catchments and smaller gullies, which are the features at Yucca Mountain. NRC Staff Answer to Final Rule Contentions, Attachment 2, Affidavit of Brittain Hill, Philip Justus, and Timothy McCartin at ¶ 15 (citing Stüwe, K., Robi, J. and Matthai, S., 2009, Erosional Decay of the Yucca Mountain Crest, *Geomorphology*, vol. 108, p 200-208, 207. doi: 10.1016/j.geomorph.2009.01.008 ("Stüwe et al. 2009")).

A *prima facie* showing "is one that is 'legally sufficient to establish a fact or case unless disproved.'" *Public Service Co. of New Hampshire* (Seabrook Station Units 1 & 2), ALAB-895, 28 NRC 7, 22 (1988) (citing *Pacific Gas & Electric Co.* (Diablo Canyon Nuclear Power Plant, Units 1 & 2), ALAB-653, 16 NRC 55, 72 (1981)). Merely raising an issue does not constitute a *prima facie* showing. *See, e.g., Amergen Energy Co., LLC* (Oyster Creek Nuclear Generating Station), CLI-09-7, 69 NRC 235, 270 (2009) (The intervenor's showing that deterioration of trough capturing water occurred in the past did not constitute a *prima facie* case that deterioration will occur in the future.). The Staff is not raising a factual dispute with the statements of limitation in the article; the Staff is simply highlighting for the Board the authors' own statements, which postdate the draft version relied upon by Nevada, regarding qualifications and limitations of the model that Nevada relies upon to challenge the application of the rule. The Board should determine whether a *prima facie* showing has been made by looking at the information presented by Nevada, as well as the responses of the Staff and DOE. For example, even at the contention admissibility stage, where the merits of a petitioner's claim are not examined, a board determines whether the sources the petitioner relies upon actually state what the petitioner claims they do. *See Yankee Atomic Electric Co.* (Yankee Nuclear Power Station), LBP-96-2, 43 NRC 61, 90 & n.30 (1996); *rev'd in part on other grounds*, CLI-96-

7, 43 NRC 235 (1996) ("A document put forth by an intervenor as the basis for a contention is subject to scrutiny both for what it does and does not show." When a report is the central support for a contention's basis, the contents of that report are before the Board and, as such, are subject to Board scrutiny.). If a contention depends on a reference, but the Board determines the reference does not actually support the petitioner's claim, then the contention is not admissible. *See id.* It follows then that the Board should consider whether the information Nevada relies on as support for its petition, the Stüwe article, actually supports Nevada's assertion that 10 C.F.R. § 63.342(c) does not serve the purpose for which it was adopted.

Not only should the Board look at the words of the article itself, as it would for even a contention admissibility decision, but the Board should also consider the Staff's affidavit on the matter. Section 2.335(b) allows the Staff to file a counter affidavit, and 10 C.F.R. § 2.335(c) and (d) direct the presiding offer to consider such affidavit in determining whether to certify a petition to the Commission. In *Seabrook*, the Appeal Board[1] described what is required for a *prima facie* showing and also observed that, although the Attorney General filed several affidavits and numerous other documents to support its petition, neither the applicants nor the Staff filed any counter affidavits or other exhibits to rebut the Attorney General's documentary filings. *Id.* at 20-21. This statement suggests that the Appeal Board would have considered any such rebuttal evidence in reaching a decision on whether a *prima facie* showing had been made to warrant certification of the rule waiver petition to the Commission. *See also Public Service Co. of New Hampshire* (Seabrook Station Units 1 & 2), CLI-88-10, 28 NRC 573, 597 (1988) ("The

[1] The Attorney General's petition for rule waiver was filed directly with the Appeal Board. *See Seabrook*, ALAB-895, 28 NRC at 20.

Commission also believes that a rule waiver petition under § 2.758[2] ought not to be certified unless the petition *and other allowed papers* indicate that a waiver is necessary to address, on the merits, a significant safety problem related to the rule sought to be waived.") (emphasis added).

Nevada's response to the Staff's Answer did not address why it relied on the draft version of the Stüwe study when the published version was available when Nevada filed its rule waiver petition on May 12, 2009. Stüwe et al. 2009 at 200 ("[a]vailable online 13 February 2009"); Reply of the State of Nevada to NRC Staff's Answer to NEV-SAFETY-202 and 203, dated July 3, 2009 ("Nevada Reply"). In addition, Nevada did not address the differences between the draft version and the published version of the study. Even if statements in Nevada's reply could be interpreted as addressing the study's limitations, *but see* Staff Answer to Question 3 below, the assertions of counsel are not evidence. *See Oyster Creek*, CLI-09-7, 69 NRC at 291 ("Expert affidavits must be presented by competent individuals with knowledge of the facts alleged or by experts in the appropriate disciplines and the evidence contained in an affidavit must meet our admissibility standards."); *Northeast Nuclear Energy Co.* (Millstone Nuclear Power Station, Unit 3), CLI-01-03, 53 NRC 22, 27 (2001) ("Factual allegations must be supported by experts or documents to demonstrate that an evidentiary hearing is warranted."). Therefore, the statement in Nevada's reply that the model "addresses erosion degrading the landscape by sub-horizontal eating back into the ridge and not a simple downward lowering" should not be considered evidence because Nevada's counsel is not competent to make such claims. *See* Nevada Reply at 17. Accordingly, Nevada fails to make a *prima facie* showing.

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[2] 10 C.F.R. § 2.758 was redesignated as 10 C.F.R. § 2.335 without substantive change. *See* Changes to Adjudicatory Process, Final Rule, 69 Fed. Reg. 2182, 2219, Table 2 (Jan. 14, 2004).

The requirement in 10 C.F.R. § 2.335(b) that the petition be accompanied by an affidavit underscores the Commission's intent that petitioners must have evidence (i.e., sworn statements) to support claims of special circumstances—not simply arguments of counsel. Nevada cannot rely on the affidavits filed in support of its initial intervention petition to bolster the assertions of counsel. *See* State of Nevada's Petition to Intervene as a Full Party, filed December 19, 2008, Attachment 3, Affidavit of Michael C. Thorne; Attachment 20, Affidavit of Steven A. Frishman; Attachment 21, Affidavit of Stephan K. Matthäi. Those affidavits were signed in December 2008, *see id*., before the published version of the study was available, and the intervention petition, specifically NEV-SAFETY-41, did not reference the published version of the paper, *see id.* at 238-242.

The Board should determine that Nevada has not met its burden of demonstrating a *prima facie* showing that the application of 10 C.F.R. § 63.342(c) would not serve the purposes for which the rule was adopted. In so doing, it is appropriate for the Board to consider Nevada's support for the waiver petition, the Stüwe study, as well as the Staff affidavit submitted in response.

C. Question 3

> Even accepting the express limitations of the published Stuewe study, does not Nevada adequately respond to those limitations when it points out that the Stuewe model "addresses erosion degrading the landscape by sub-horizontal eating back into the ridge and not a simple downward lowering?"

LBP-09-29 at 14 (citations omitted).

The statement of Nevada's counsel in its reply that the Stüwe model "addresses erosion degrading the landscape by sub-horizontal eating back into the ridge and not a simple downward lowering," Nevada Reply at 17, does not adequately respond to the express limitations of the published Stüwe study. The study acknowledges that it has limitations with respect to its ability to represent smaller gullies. Attachment 2, Affidavit of Brittain Hill, dated

December 22, 2009 ("Hill Affidavit"), at ¶ 4 (citing Stüwe et al. 2009 at 207). However, the statement by Nevada's counsel does not address the ability of the model to represent these gullies. *See id.* at ¶ 7. Rather, Nevada's assertion goes to how erosion is modeled—sub-horizontal eating back into the ridge or downward lowering. *See* Nevada Reply at 17. In addition to not addressing the stated limitation of the study, Nevada's assertion misrepresents the study. *See* Hill Affidavit at ¶¶ 4-6. The authors do not discuss "sub-horizontal eating back into the ridge," nor any related phenomenon such as horizontal or lateral erosion. *Id.* at ¶ 5. The results of the authors' model do show that the vertical incision of gullies leads to the conclusion that incision could reach potential repository depths in the future. *Id.* at ¶ 4. The "net effect of vertical incision in the model is, in fact, downward lowering of the level of the drainages over the proposed repository site." *Id*. The figures in the Stüwe study also demonstrate that the authors' emphasis is on vertical incision. *See id.* at ¶ 6. Because the statement by Nevada's counsel is not responsive to the express limitations of the study and because it does not accurately represent the study, it is not an adequate response to the Stüwe model's limitations.

CONCLUSION

As set forth above, 1) there is information referenced in the rulemaking record to demonstrate that data and information underlying the Stüwe model were considered during the rulemaking; 2) the statements of limitation in the Stüwe model defeat the *prima facie* showing required by 10 C.F.R. § 2.335; and 3) Nevada does not adequately respond to the express limitations of the model because its response does not actually address the limitations of the study and it does not accurately represent the study. Accordingly, Nevada has failed to make

prima facie showing that special circumstances exist such that the rule would not serve the purposes for which it was adopted. Therefore, Nevada's rule waiver petition should not be certified to the Commission.

Respectfully submitted,

/Signed (electronically) by/

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Dated in Rockville, MD
this 22nd day of December, 2009

ATTACHMENT 1

AFFIDAVIT OF TIMOTHY MCCARTIN AND PHILIP JUSTUS

December 22, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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(High-Level Waste Repository)	)	ASLBP No. 09-892-HLW-CAB04
	)	

AFFIDAVIT OF TIMOTHY MCCARTIN AND PHILIP JUSTUS, Ph.D., L.G.
CONCERNING NRC STAFF'S RESPONSE TO BOARD QUESTIONS

We, Timothy McCartin and Philip Justus, do hereby state as follows:

1. (McCartin) I am employed as a Senior Level Advisor for Performance Assessment in the Division of High Level Waste Repository Safety in the Office of Nuclear Materials Safety and Safeguards, U.S. Nuclear Regulatory Commission. I was the technical lead in the development of 10 C.F.R. Part 63, the regulatory criteria that govern a U.S. Department of Energy license application for a high-level waste repository at Yucca Mountain. I was also the technical lead for NRC regulations governing high-level waste disposal at Yucca Mountain for the period after 10,000 years, including the final regulations published at 74 Fed. Reg. 10,811 (Mar. 13, 2009).

2. (McCartin) My professional experience and qualifications are stated in the affidavit submitted in support of the NRC Staff Answer to State of Nevada's New Contentions Based on Final NRC Rule, dated June 11, 2009, Attachment 2, Affidavit of Brittain Hill, Philip Justus, and Timothy McCartin, at ¶¶ 7-9 and Attachment D.

3. (Justus) I am employed as a Senior Geologist in the Division of High-Level Waste Repository Safety in the Office of Nuclear Material Safety and Safeguards at the U.S. Nuclear Regulatory Commission. In this capacity, I am responsible for the Staff's review of

Yucca Mountain site characteristics, and alternative conceptual models of geologic, tectonic, hydrologic and environmental processes and conditions.

4. (Justus) My professional experience and qualifications are stated in the affidavit submitted in support of the NRC Staff Answer to State of Nevada's New Contentions Based on Final NRC Rule, dated June 11, 2009, Attachment 2, Affidavit of Brittain Hill, Philip Justus, and Timothy McCartin, at ¶¶ 4-6 and Attachments B and C.

5. The purpose of this affidavit is to respond to the Board's Question 1 in *U.S. Dep't of Energy* (High-Level Waste Repository), LBP-09-29, 70 NRC __ (Dec. 9, 2009):

> The authors of the NRC Staff's affidavit assert that the information underlying the Stuewe model has "been available" for many years. Yet the affiants do not state that the Commission was aware of that information or actually considered the Stuewe model when it conducted the rulemaking. What information, if any, in the rulemaking record before the Commission demonstrates that the Commission considered the Stuewe model or the data underlying that model? Where is any such information located?

Id. at 13 (citation omitted).

6. As described below, the same types of data and information underlying the Stüwe model were considered by the Commission during the rulemaking. However, the Commission did not consider the Stüwe model itself.

7. Based on the published paper, the Staff understands the data and information underlying the Stüwe paper and model to be:

- Geologic information regarding topography in the basin and range, including Yucca Mountain (e.g., the presence of tilted fault blocks including the angle of the tilting for certain blocks that are used to specify the topographic gradient for estimating stream power). Stüwe et al. 2009 at 200–01.

- Information related to erosion processes (Stüwe et al. 2009 at 207), the presence of erosion near Yucca Mountain (e.g., the presence of washes or gullies (Stüwe et al. 2009 at 201)), climate (Stüwe et al. 2009 at 207), and "occasional floods" (i.e., July 1984 event reported in Coe et al. 1997 (Stüwe et al. 2009 at 207).

8. In finalizing its regulations for the period after 10,000 years the Commission specified a rate for deep percolation that was based on a broad range of information including

the types of general and specific information underlying the Stüwe model as identified above. The details of the consideration of erosion and its potential effects are provided in the references contained in the *Federal Register* notice accompanying the final rule. *See* Implementation of a Dose Standard After 10,000 Years, 74 Fed. Reg. 10,811 (Mar. 13, 2009). The references cited in the *Federal Register* notice that address erosion are:

1) "Technical Assessment of Structural Deformation and Seismicity at Yucca Mountain, Nevada," Waiting et al., San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; September 2001) (LSN # NRC000017443). *See* 74 Fed. Reg. at 10,823.

2) "The Nature of Flow in the Faulted and Fractured Paintbrush Nonwelded Hydrologic Unit," Manepally, C. et al., San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; April 2007) (LSN #: NRC000029300). *See* 74 Fed. Reg. at 10,820.

3) "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation" San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; August 2008 (LSN #s: NRC000029713, NRC000029696, NRC000029726, NRC000029710, and NRC000029695[1]). *See* 74 Fed. Reg. at 10,823.

4) "Long-Term-Average Infiltration at Yucca Mountain, Nevada: Million-Year Estimates," Stothoff and Walter, San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; August 2007 (LSN # NRC000029364). *See, e.g.,* 74 Fed. Reg. at 10,820

5) "Literature Review and Analysis: Climate and Infiltration," Stothoff and Musgrove, San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; November 2006 (LSN # NRC000028589). *See* 74 Fed. Reg. at 10,821.

9. The consideration of erosion in the rulemaking record is related to the development of the deep percolation rate and not with respect to erosion rates assumed in the Stüwe paper. The Commission considered general information similar to the information mentioned in the Stüwe paper, such as structural information for the Yucca Mountain region, erosion processes, and consideration of washes. For example:

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[1] The single report is broken up into five sections on the LSN.

10. Structural Information

The Stüwe paper uses structural information (e.g., the Yucca Mountain region is comprised of tilted fault blocks that provide information on topography). *See* Stüwe et al 2009 at 201, Fig. 1. In promulgating the rule, the Commission cited a report discussing extensive structural information of the Yucca Mountain region, "Technical Assessment of Structural Deformation and Seismicity at Yucca Mountain, Nevada," Waiting, et al., San Antonio, TX: Center for Nuclear Waste Regulatory Analyses, 2001 (LSN # NRC000017443). 74 Fed. Reg. at 10,823. This technical assessment contains over 300 references. Notably, this report has the following statement regarding low erosion rates in the Yucca Mountain region:

> The principal tool for the evaluation of prehistoric earthquakes is the study of paleoseismology. Paleoseismologists combined geologic skills of tectonic geomorphology and Quaternary geochronology to reconstruct the record of large earthquakes (e.g., McCalpin, 1996). The methodology is especially suited for the arid climate of southern Nevada, because erosion rates are sufficiently slow to allow prehistoric earthquake landforms to be preserved.

"Technical Assessment of Structural Deformation and Seismicity at Yucca Mountain, Nevada," 2001 at 3-4.

The structural information from this report was used to support bedrock permeability values used in specifying deep percolation values rather than erosion rates. Although the NRC used structural information for a different purpose than used by Stüwe (i.e., the Stüwe paper uses structural information for specifying the geometry of topographic surfaces of a simplified model, *see* Stüwe et al. 2009 at 202, Fig. 2), the Stüwe paper identifies no significant structural data or information that were not considered in the reports referenced in the *Federal Register* notice.

11. Erosion Processes

The NRC developed a model to assist its understanding of processes that could affect infiltration, including erosion. The rulemaking record identifies both the report documenting the technical basis for this model, "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation," S. Stothoff, San Antonio, TX: Center for Nuclear Waste Regulatory Analyses,

2008 (LSN #s: NRC000029713, NRC000029696, NRC000029726, NRC000029710, and NRC000029695), *see* 74 Fed. Reg. at 10,823, and the report that discusses analyses using the model, "Long-Term-Average Infiltration at Yucca Mountain, Nevada: Million-Year Estimates," Stothoff and Walter, San Antonio, TX: Center for Nuclear Waste Regulatory Analyses, 2008 (LSN # NRC000029364), *see, e.g.,* 74 Fed. Reg. at 10,820. A systematic approach was used to evaluate a number of aspects of erosion in the near surface, in particular an equilibrium soil thickness model considered the effects of dust deposition, soil creep, overland sediment transport, and bedrock erosion using three coupled mass balance equations. *See* "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation," 2008, at section 7. Section 7 in the "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation" describes the soil-balance model of Stothoff, which generally follows the approach presented by Beaumont, et al. (1992). Stüwe cites Kooi and Beaumont (1994) as an alternative erosion model that considers hillslope processes. *See* Stüwe et al. 2009 at 207. The Kooi and Beaumont (1994) paper uses the Beaumont et al. (1992) numerical model.

12. The bedrock erosion model described in the Stüwe paper considers removal processes but does not consider depositional processes. The soil-balance model of Stothoff does consider both removal and depositional processes. *See* section 7 in "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation," 2008. The presence of soil, especially thick soil layers, is expected to have an effect on erosion of the underlying bedrock. Stothoff identified that alluvium (i.e., soil) exists up to 132.6 meters deep in well J13 at the Yucca Mountain site and at least 69 boreholes at the site have greater than 5 meters of soil (Fig 7.6 in "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation," 2008) in the area considered for Figure 5 in the Stüwe paper (Stüwe et al. 2009 at 204).

13. The potential for debris flow (i.e., the 1984 event mentioned in Stüwe et al. 2009 at 207) was also considered during the development of the Infiltration Tabulator for Yucca

Mountain, which is referenced in the rulemaking record. *See* 74 Fed. Reg. at 10,823. The report documenting the technical bases for the model states:

> Gravity has a tendency to move soil masses downslope through creep and slump. Creep is slow bulk movement of the soil profile through accumulated small movements, while slump is sudden failure of the soil mass resulting in fast bulk movement. Creep is facilitated through processes that rearrange soil particles, such as freeze–thaw cycles or seismic events, and is dependent on soil texture. Creep may occur through the entire soil profile; surficial processes such as rainsplash enhance downhill movement near the ground surface. Slump also depends on soil texture, but generally occurs when the soil column is extremely moist or as a consequence of large seismic events. Slump rarely occurs under present-day conditions at Yucca Mountain, although in 1984 a slow-moving, localized, intense summer rainstorm stripped 7,040 m^3 [5.7 acre-ft] of soil from Jake Ridge, about 6 km [3.7 mi] east of Yucca Crest (TRW Environmental Safety Systems, Inc., 1998). TRW Environmental Safety Systems, Inc. (1998) estimates that the recurrence rate of such incidences is at least 500 years based on the thickness of existing soil profiles. Although a less dramatic form of mass wasting, creep often occurs in the same environments and mediates the refilling of slump reservoirs (Sidle, et al., 1985).

"Infiltration Tabulator for Yucca Mountain: Bases and Confirmation," at 7-5.

14. A key aspect of such events is the estimated infrequent nature of an event (i.e., recurrence rate of at least 500 years) and the random, localized (small affected area) nature of the event. An important focus of the rulemaking record was to document the basis for the deep percolation values to be used for Yucca Mountain; however, in considering information on debris flow, the Commission did not alter its view that the repository would remain buried. The Stüwe paper makes no mention of the potential recurrence rate for the 1984 event or the random, localized nature of such events.

15. Estimates of future climate and its cycles are important in estimating net infiltration. Climate cycles in the future can affect the duration and intensity of storms, which can also affect erosion and net infiltration. As the Commission noted in promulgating the rule:

> NRC has conducted detailed climate analyses that considered time-varying values of historic, inferred prehistoric, and potential future precipitation rates to support the range of long-term-average future deep percolation rates adopted in the final regulations. These time-varying precipitation rates were also used to estimate the range and bounds of 1-million-year-average annual precipitation. NRC used two approaches, which are described by Stothoff and Walter, ''Long-

> Term Average Infiltration at Yucca Mountain, Nevada: Million-Year Estimates,'' San Antonio, TX: Center for Nuclear Waste Regulatory Analyses (2007), to estimate time-varying sequences of mean annual precipitation that vary over glacial cycles. Both approaches estimate precipitation for glacial stages, with the sequence of glacial stages determined using well-known orbital dynamics relationships. The first approach is based on the climate reconstruction by Sharpe, ''Future Climate Analysis: 10,000 Years to 1,000,000 Years After Present,'' Reno, NV: Desert Research Institute (2003), with present-day and monsoon climatic conditions adjusted to reflect historical precipitation measurements in the vicinity of Yucca Mountain based on meteorological data in Bechtel SAIC Company (BSC), ''Simulation of Net Infiltration for Present-Day and Potential Future Climates,'' Las Vegas, NV: Bechtel SAIC Company, LLC (2004).

74 Fed. Reg. at 10,820-21.

16. As explained the in the Stothoff and Walter report ("Long-Term-Average Infiltration at Yucca Mountain, Nevada: Million-Year Estimates," August 2007, page 2-1), that portion of the NRC's approach based on climate reconstruction by Sharpe is built on the extensive work by Forester (Forester, R.M., J.P. Bradbury, C. Carter, A.B. Elvidge-Tuma, M.L. Hemphill, S.C. Lundstrom, S.A. Mahan, B.D. Marshall, L.A. Neymark, J.B. Paces, S.E. Sharpe, J.F. Whelan, and P.E. Wigand. "The Climatic and Hydrologic History of Southern Nevada During the Late Quarternary." U.S. Geological Survey Open-File Report 98-635. 1999). The Stüwe paper mentions the same Forester et al. 1999 reference with respect to Nevada climate (Stüwe et al. 2009 at 207).

17. Additionally, Section 7.4 of the "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation," 2008 contained a sensitivity study of soil depth and distributions based on storm characteristics (e.g., stream flow duration, rainfall rate) in Split Wash, a gully type feature that was discussed in the Stüwe paper. *See* Stüwe et al. 2009 at 201.

18. Consideration of Washes

The Stüwe paper mentions washes or gullies with respect to the topography of the Yucca Mountain area such as Split Wash. Stüwe et al. 2009 at 201. The "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation" (2008) considered a watershed model for the Upper Split Wash to quantify the excess infiltration (infiltration during a storm minus

precipitation). Surficial geology and topography were considered as part of this model. *See* Section 4.6 in "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation," 2008. The report also considered the effects of hillslope erosion processes on soil depths in Split Wash. Section 7.4 in "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation," 2008. This sensitivity study strongly suggests that soil creep is a dominant component of the soil depth distribution. This is a hillslope process that also accounts for deposition, which is not in the Stüwe model. *See* Stüwe et al. 2009 at 207.

19. The rulemaking documents identified in paragraph 6 were based on a wide range of references, including some of the references listed in the Stüwe paper. *See* Stüwe et al. 2009 at 207-08. The shared references are:

- Day, W.C., R.P. Dickerson, C.J. Potter, D.S. Sweetkind, C.A. San Juan, R.M. Drake, II, and C.J. Fridrich. "Geologic Map of the Yucca Mountain Area, Nye County, Nevada." U.S. Geological Survey Geological Investigations Series, Map 1-2627. Scale 1:24,000. 1998a.

  See "Technical Assessment of Structural Deformation and Seismicity at Yucca Mountain, Nevada," Waiting et al., San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; September 2001) (LSN # NRC000017443) at 6-8; "The Nature of Flow in the Faulted and Fractured Paintbrush Nonwelded Hydrologic Unit," Manepally, C. et al., San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; April 2007) (LSN #: NRC000029300) at 3-25.

- Fleck, R.J., B.D. Turrin, D.A. Sawyer, R.G. Warren, D.E. Champion, M.R. Hudson, and S.A. Minor. "Age and Character of Basaltic Rocks of the Yucca Mountain Region, Southern Nevada." Journal of Geophysical Research. Vol. 101. pp. 8,205-8,227. 1996.

  See "Technical Assessment of Structural Deformation and Seismicity at Yucca Mountain, Nevada," Waiting et al., San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; September 2001) (LSN # NRC000017443) at 6-12.

- Forester, R.M., J.P. Bradbury, C. Carter, A.B. Elvidge-Tuma, M.L. Hemphill, S.C. Lundstrom, S.A. Mahan, B.D. Marshall, L.A. Neymark, J.B. Paces, S.E. Sharpe, J.F. Whelan, and P.E. Wigand. "The Climatic and Hydrologic History of Southern Nevada During the Late Quarternary." U.S. Geological Survey Open-File Report 98-635. 1999.

  See "Long-Term-Average Infiltration at Yucca Mountain, Nevada: Million-Year Estimates," Stothoff and Walter, San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; August 2007 (LSN # NRC000029364) at 6-2.

- Potter, C.J., W.C. Day, D.S. Sweetkind, and R.P. Dickerson. "Structural Geology of the Proposed Site Area for a High-Level Radioactive Waste Repository, Yucca Mountain, Nevada." Geological Society of America Bulletin. Vol. 116, No. 7/8. pp. 858-879. 2004.

  See "The Nature of Flow in the Faulted and Fractured Paintbrush Nonwelded Hydrologic Unit," Manepally, C. et al., San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; April 2007) (LSN #: NRC000029300) at 3-28.

- Potter, C.J.; R.P. Dickerson; D.S. Sweetkind; R.M. Drake, II; E.M. Taylor; C.J. Fridrich; C.A. San Juan; and W.C. Day. "Geologic Map of the Yucca Mountain Region, Nye County, Nevada." U.S. Geological Survey Investigations Series Map, 1-2755. Scale 1:50,000. 2002.

  See "The Nature of Flow in the Faulted and Fractured Paintbrush Nonwelded Hydrologic Unit," Manepally, C. et al., San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; April 2007) (LSN #: NRC000029300) at 3-28.

- Sawyer, D.R., R.J. Fleck, M.A. Lanphere, R.G. Warren, D.E. Broxton, and M.R. Hudson. "Episodic Caldera Volcanism in the Miocene Southwestern Nevada Volcanic Field: Revised Stratigraphic Framework, 40Ar/39Ar Geochronology, and Implications for Magmatism and Extension." Geological Society of America Bulletin. Vol. 106. pp. 1,304-1,318. 1994.

  See "Technical Assessment of Structural Deformation and Seismicity at Yucca Mountain, Nevada," Waiting et al., San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; September 2001) (LSN # NRC000017443) at 6-25.

- Scott, R.B. "Tectonic Setting of Yucca Mountain, Southwest Nevada." Basin and Range Extensional Tectonics Near the Latitude of Las Vegas, Nevada. B.P. Wernicke, ed. Geological Society of America Memoir 176. Boulder, Colorado: Geological Society of America. pp. 251-282. 1990.

  See "The Nature of Flow in the Faulted and Fractured Paintbrush Nonwelded Hydrologic Unit," Manepally, C. et al., San Antonio, TX; Center for Nuclear Waste Regulatory Analyses; April 2007) (LSN #: NRC000029300) at 3-29.

20. The erosion rates used in the Stüwe paper to produce a modeling result that denudes Yucca Mountain crest in short time frames, on a geological time scale (i.e., 1 mm/year (Stüwe et al. 2009 at 203) and ten times larger (*id.* at 204)), are not supported by data and information. As discussed in the Staff's Affidavit of June 11, 2009, the erosion rates in the Stüwe paper are based on an assumption that is not supported by a technical basis. *See* NRC Staff Answer to State of Nevada's New Contentions Based on Final NRC Rule, dated June 11,

2009, Attachment 2, Affidavit of Brittain Hill, Philip Justus, and Timothy McCartin at ¶ 15. To overcome the lack of information to constrain the relationship between stream power and erosion rate, "the authors simply assume that erosion rate is proportional to the square of stream power." *Id.* Thus, "the Stuewe et al. (2008) model relies on unsupportable assumptions that are inconsistent with current scientific understanding of erosion processes at Yucca Mountain, such as factors of 40 to 400 increase in observed erosion rates." *Id.* at ¶ 16.

21. In its rulemaking, the Commission did not consider the Stüwe model and its accompanying unsupported assumptions because it is inconsistent with current scientific understanding of erosion processes at Yucca Mountain. As explained in the *Federal Register* notice publishing the final rule, the Commission's view is that the repository at Yucca Mountain would remain buried and, therefore, climate fluctuations would be dampened by the overlying rock. 74 Fed. Reg. at 10,820. This view was also held by the National Academy of Sciences. *See* "Technical Bases for Yucca Mountain Standards," 1995, at 91. The Commission stated:

> The technical bases for the deep percolation range subsume time-variant climate conditions, whose future periodicity and magnitude are based on and calibrated to the range of conditions preserved in the geologic record, which includes geomorphic changes. In addition, the hydrogeologic properties of the PTn unit overlying the repository horizon, where present, dampen the magnitude of short term fluctuations in deep percolation that might be associated with future climate change or variability in precipitation (Manepally, C., *et al.*, ''The Nature of Flow in the Faulted and Fractured Paintbrush Nonwelded Hydrogeologic Unit,'' San Antonio, TX: Center for Nuclear Waste Regulatory Analyses, April 2007). NAS acknowledges the phenomenon by indicating that ''(t)he subsurface location of the repository would provide a temporal filter for climate change affects on hydrologic responses. For this reason, climate changes lasting on the order of hundreds of years would have little, if any, effect on repository performance.''

74 Fed. Reg. at 10,820.

22. The erosion rates contained in the Stüwe paper are not supported by information that would call into question the Commission's view that waste will remained buried over the compliance period recommended by the National Academy of Sciences. Further, none of the information provided in the Stüwe paper would alter a fundamental premise set forth by the

National Academy of Sciences in recommending standards for Yucca Mountain—that it is extremely unlikely for erosion to expose the repository in the next million years:

> Several gradual and episodic natural processes or events have the potential to modify the properties of the reservoirs and the processes by which radionuclides are transported among them. We conclude that the probabilities and consequences of modifications generated by climate change, seismic activity, and volcanic eruptions at Yucca Mountain are sufficiently boundable so that these factors can be included in performance assessments that extend over periods on the order of about 10^6 years….
>
> **Climate change**
>
> At present the earth is in an interglacial phase. Our knowledge of past climate transitions indicates that a transition to a glacial climate during the next few hundred years is highly unlikely but not impossible. Such a transition during the next 10,000 years is probable, but not assured. Over a million-year time scale, however, the global climate regime is virtually certain to pass through several glacial-interglacial cycles, with the majority of the time probably spent in the glacial state. Given that a deep geologic repository is relatively shielded from the large changes in surface conditions, there are three main potential effects of climate change on repository performance. The first of these is that increases in erosion might significantly decrease the burial depth of the repository. Site specific studies of erosion rates at Yucca Mountain (DOE 1993b) indicate that an increase in erosion to the extent necessary to expose the repository (even over a million-year time scale) is extremely unlikely.

"Technical Bases for Yucca Mountain Standards," National Research Council, Washington, D.C., 1995 at 91 (LSN # NEV000004270).

23. Since the publication of the "Technical Bases for Yucca Mountain Standards" in 1995, the NRC staff is not aware of the emergence of any significant data or information that would fundamentally alter the scientific understanding of erosion processes for the Yucca Mountain region.

24. Although the Commission was aware of and considered a wide range of information in setting the deep percolation rates in its final rule, including the types of general information identified in the Stüwe paper, the Commission did not consider the unsupported assumptions in the Stüwe paper used to estimate erosion rates. The Commission's consideration of information and data underlying the Stüwe paper is documented in the rulemaking record through the above-mentioned Center for Nuclear Waste Regulatory Analyses

reports and National Academy of Sciences study cited in the *Federal Register* notice accompanying the final rule.

25. We declare under penalty of perjury that the foregoing is true and correct to the best of our knowledge, information, and belief.

/RA/

_____

Timothy McCartin

Executed in Rockville, MD
this 22nd day of December, 2009

/RA/

_____

Philip Justus, Ph.D., L.G.

Executed in Rockville, MD
this 22nd day of December, 2009

ATTACHMENT 2

AFFIDAVIT OF BRITTAIN HILL

December 22, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001-HLW
	)	
(High-Level Waste Repository)	)	ASLBP No. 09-892-HLW-CAB04
	)	

AFFIDAVIT OF BRITTAIN HILL, Ph.D
CONCERNING NRC STAFF'S RESPONSE TO BOARD QUESTIONS

I, Brittain Hill, do hereby state as follows:

1. I am employed as a Senior Advisor for Repository Science in the Division of High-Level Waste Repository Safety, Office of Nuclear Materials Safety and Safeguards at the U.S. Nuclear Regulatory Commission.

2. My professional experience and qualifications were stated in the affidavit submitted in support of the NRC Staff Answer to State of Nevada's New Contentions Based on Final NRC Rule, dated June 11, 2009, Attachment 2, Affidavit of Brittain Hill, Philip Justus, and Timothy McCartin at ¶¶ 1-3 and Attachment A.

3. The purpose of this affidavit is to respond to the Board's Question 3 in *U.S. Dep't of Energy* (High-Level Waste Repository), LBP-09-29, 70 NRC __ (Dec. 9, 2009):

> Even accepting the express limitations of the published Stuewe study, does not Nevada adequately respond to those limitations when it points out that the Stuewe model "addresses erosion degrading the landscape by sub-horizontal eating back into the ridge and not a simple downward lowering?"

Id. at 14 (citations omitted).

4. Nevada's response does not adequately respond to the express limitations in the Stüwe model for its ability to represent smaller gullies (Stüwe, K., Robi, J. and Matthai, S., 2009, Erosional Decay of the Yucca Mountain Crest, *Geomorphology*, vol. 108, p 200-208, 207. doi: 10.1016/j.geomorph.2009.01.008. Nevada claims that the Stüwe model does not address erosion as "a simple downward lowering." Nevada Reply at 17. However, information presented in Stüwe et al.

(2009) shows that the modeling of vertical incision of gullies, and not sub-horizontal "eating back" of ridges, leads these authors to conclude that incision could reach potential repository depths at some time in the future. Thus, the net effect of vertical incision in the model is, in fact, downward lowering of the level of the drainages over the proposed repository site.

5. Nevada does not cite any source for its assertion that "Thus, the model addresses erosion degrading the landscape by sub-horizontal eating back into the ridge and not a simple downward lowering." Nevada Reply at 17. Stüwe et al. (2009) do not discuss "sub-horizontal" erosion or similar processes such as horizontal or lateral erosion, or "eating back" into ridges. Instead, Stüwe et al. clearly state "In particular, we study the time that individual gullies may take to penetrate to the depth of the proposed waste deposit site." Stüwe et al. 2009 at 200.

6. Examination of Figure 6 in Stüwe et al. shows that the modeled horizontal location of the primary, north-trending crest of Yucca Mountain remains essentially unchanged as the surrounding drainages incise into the bedrock during the next presumed 4 to 8 Myr. Stüwe et al. 2009 at 205. The locations of primary ridges also do not move horizontally as the modeled blocks erode downward, as shown in Figures 2 and 3. Stüwe et al. 2009 at 202-03. In Figure 7 and supporting text, the authors emphasize that vertical incision of drainages results in modeled erosion to the level of the proposed repository. Stüwe et al. 2009 at 205-06. Thus, there is no mention of sub-horizontal eating back of ridges.

7. In sum, Nevada's assertion that the Stüwe et al. model "addresses erosion degrading the landscape by sub-horizontal eating back into the ridge and not a simple downward lowering" is not supported by discernable statements in the paper or in the results of the model. Nevada has not responded to statements made by Stüwe et al. regarding the questionable ability of their model to describe the erosive features that overlie the proposed repository, i.e. smaller gullies with drainage basins (or catchments) less than 5 km^2. Stüwe et al. 2009 at 207. Information presented in Stüwe et al. shows that Staff's comparison of vertical erosion rates, both at Yucca Mountain and at the Grand Canyon, appropriately identifies significant limitations in the Stüwe et al. model results. Nevada Reply at 16-17.

8. I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge, information, and belief.

/RA/

_____

Brittain Hill, Ph.D

Executed in New Market, MD
this 22nd day of December, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001-HLW
	)	
(High-Level Waste Repository)	)	ASLBP No. 09-892-HLW-CAB04

CERTIFICATE OF SERVICE

I hereby certify that copies of the "NRC STAFF RESPONSE TO BOARD QUESTIONS" in the above-captioned proceeding have been served on the following persons this 22nd day of December, 2009, by Electronic Information Exchange.

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