I. Independent Review of Selected Sections of the 2009 West Valley Decommissioning Final Environmental Impact Statement

Prepared by the
<u>Independent Expert Review Team</u>:
B. John Garrick, Chairman
Sean J. Bennett
Robert H. Fakundiny
Shlomo P. Neuman
Michael T. Ryan
Chris G. Whipple

for the
New York State Energy Research and Development Authority
November 20, 2009

II. Independent Review of the Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center

Prepared by the
<u>Independent Expert Review Team</u>:
B. John Garrick, Chairman
Jimmy T. Bell
Sean J. Bennett
Robert H. Fakundiny
Shlomo P. Neuman
Frank L. Parker
Michael T. Ryan
Peter N. Swift
Chris G. Whipple
Michael P. Wilson

for the
New York State Energy Research and Development Authority
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Independent Review of Selected Sections of the 2009 West Valley Decommissioning Final Environmental Impact Statement

Prepared for
New York State Energy Research and Development Authority
West Valley, New York
November 20, 2009

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Chris G. Whipple

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West Valley, New York
November 20, 2009

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SECTION 1

INTRODUCTION

The New York State Energy Research and Development Authority (NYSERDA) convened a West Valley Independent Expert Review Team (IERT) to review the 2009 West Valley Decommissioning Final Environmental Impact Statement (2009 FEIS). The IERT consisted of nationally and internationally distinguished scientists and engineers in the geosciences, nuclear science and engineering, health physics, and the risk and environmental sciences. Brief summaries of their qualifications are provided in Appendix A.

As background, multiple drafts of the EIS have been prepared since 1996 and have gone through extensive internal and external review. Information on these reviews and additional background on the site and events leading to this review are provided in the 2008 draft environmental impact statement (DEIS) report prepared by IERT.[1] The emphasis in this current review is to (1) identify significant changes from the 2008 DEIS and (2) consider the impact on the technical basis and defensibility of the 2009 FEIS. This review covers several EIS chapters and appendices known to consist of significant revision since the issuance of the 2008 DEIS. Included are Appendices D through H, Chapter 2, and Chapter 4. In addition, selected topics from the appropriate chapters were reviewed to determine whether the concerns identified by the IERT in 2008 were resolved. The selected topics include seismic hazard and seismic risk, engineered barriers, uncertainty analysis, and cost/benefit analysis.

[1] "Independent Review of the Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center," September 23, 2008.

SECTION 2

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The overarching finding and conclusion is that additional information has been included in the FEIS over the DEIS for a variety of topics, but the added information does not eliminate many of the concerns of the 2008 IERT review.

New information has been added in the 2009 FEIS and clarifications have been provided on some of the IERT concerns. Examples where information has been added are erosion modeling, representation of the engineered barriers in the near field groundwater flow model for the South Plateau, the one dimensional calculations, and selected engineered barriers such as a modification of the tank closure approach. Descriptions of the engineered barriers are now much clearer. The section on streambed armoring has one significant change from the 2008 report – the total armored length of streams to be armored was increased from 4,300 to 12,900 linear feet.

Several concerns remain. There continues to be issues on the quality of the models for erosion, seismic hazard and seismic risk, groundwater flow and contaminant transport, the basis of the cost benefit analysis, the treatment of uncertainty in the assessments, and the scientific basis of the radiation dose calculations. The absence of any probabilistic analysis greatly compromises any meaningful quantification of the uncertainties in the various analyses.

Summaries of the topical reviews follow.

EROSION (Reviewer: Sean J. Bennett)

Several changes have been made in the approach to erosion modeling, the most significant of which is the complete elimination of the SIBERIA model and the expanded use and discussion of the CHILD model.

The FEIS has not addressed key recommendations made on erosion in the 2008 IERT review. In particular, a stronger hydrologic and geomorphic connection has not been made between model parameterization and onsite characterization, quantitative comparison of model output with actual field data has not been made, a rigorous uncertainty analysis of model predictions has not been conducted, and the quantification of all uncertainty bounds has not been made. In addition, many of the model components, especially with regard to the gully erosion and landscape evolution are unjustifiable and unsupported by scientific evidence.

There has been a significant effort to refine and extend the use of the CHILD model. For example, in Appendix G, a surface erosion release mechanism considers two components: vertical movement of the groundwater surface and horizontal movement of the near-vertical creek banks. These mechanisms now are addressed via a specific simulation using the CHILD model, whereas the simplified gully erosion model previously presented has been eliminated from discussion.

While significant efforts are made to expand and refine the use of the CHILD model, these changes have not rendered the results any more reliable or defensible. This is because (a) a hydrologic and geomorphic disconnection still exists between model parameterization and onsite characteristics, (b) a quantitative comparison of all model output with actual field data has not been provided, and (c) a rigorous uncertainty analysis of model predictions has not been conducted. Moreover, many of the model components, especially with regard to the gully erosion and landscape evolution, are unjustifiable and unsupported by scientific evidence.

Finally, the absence of a rigorous uncertainty analysis of surface erosion model predictions and a quantification of all uncertainty bounds compromises reliable dose predictions.

No additional recommendations are made at this time.

SEISMIC HAZARD AND SEISMIC RISK (Reviewer: Robert H. Fakundiny)

Many minor changes have been made in the 2009 FEIS having to do with seismic hazards. Most of the changes are confined to the seismic hazard estimates. But even with respect to the seismic hazard evaluation, it is not supported by an adequate scientific basis in such areas as seismic zones. There has been no substantive response to the 2008 review recommendations. Thus, the 2009 FEIS results having to do with seismic events are neither more reliable nor defensible.

Neither seismic hazards nor seismic risks are considered in the long term performance assessment (LTPA) calculations. In general, the information presented is not risk-informed.

The recommendation continues that a combined probabilistic and deterministic seismic hazard analysis be coupled with a seismic risk evaluation before designs are finalized.

GROUNDWATER FLOW AND CONTAMINANT TRANSPORT (Reviewer: Shlomo P. Neuman)

Groundwater flow and contaminant transport modeling are discussed in Appendices D, E, G, and H. Appendix D: Assertions about unconfined aquifers as "not a reasonable source of domestic or irrigation water" are fundamentally wrong. Invalid reasons were given for not performing probabilistic analyses. Appendix E: No significant change in the approach to groundwater flow and contaminant transport modeling and prediction. Additional information is presented on a variety of topics, including a more accurate representation of engineered barriers in the near field groundwater flow model for the South Plateau. Appendix G: Unable to identify any notable change in the 2009 Appendix G models for the LTPA. Appendix H: DOE has not satisfied IERT's previous critique of the one-dimensional flow-tube approach. DOE's counter arguments are weak. The treatment of engineered barriers in the LTPA continues to be incomplete. The impact of groundwater flow on erosion remains unaddressed.

With one exception, the DOE has not followed the 2008 IERT recommendations. Appendix E now contains a new paragraph purporting to address the recommendation on the one dimensional calculations, which the IERT finds to be insufficient and unconvincing. There were no substantive changes in the approach to groundwater flow and contaminant transport modeling and prediction. As previously observed, probabilistic analyses, and therefore uncertainty analyses, were not used in the LTPA. Appendix G, for all practical purposes, remains unchanged.

The groundwater modeling predictions presented in the 2009 FEIS are not supported by an adequate scientific basis to quantify radiation doses to human receptors. The 2009 FEIS does not resolve adequately any of the issues noted in the 2008 IERT with respect to groundwater flow and transport modeling under uncertainty. Uncertainties have been noted but not quantified in the 2009 FEIS. Section 2.8 of Chapter 2 argues, unconvincingly, that "Uncertainty associated with analytical methods and the use of new technologies has been accommodated in this EIS by making conservative assumptions in the environmental impact analysis."

All conclusions and recommendations in Chapter 6 of the 2008 IERT report with regard to these issues remain valid.

COST BENEFIT ANALYSIS (Reviewers: Michael T. Ryan and Chris G. Whipple)

Three alternatives were evaluated with a "collective dose avoided" metric and different discount rates. The three alternatives were indexed to the No Action Alternative, but not in a transparent manner. Extensive use is made of "collective dose," a poor metric for determining risk. As a result, conclusions are not considered reasonable. The basis for the dose calculations for the case of lost institutional controls is not clear. The dose calculations as presented are not conducive to reaching conclusions based on risk.

The use of collective dose as a metric and the absence of risk insights make it clear that the recommendations made in the 2008 review were not followed. Thus, the recommendation remains on the need for evaluations that better communicate risk insights.

TREATMENT OF UNCERTAINTY IN THE LONG TERM PERFORMANCE ASSESSMENT (Reviewers: Michael T. Ryan and Chris G. Whipple)

There have been no significant changes in the approach to uncertainty analysis from the 2008 review. The models are generally void of probability based information that would be the basis for meaningful uncertainty analysis (the groundwater discussion now contains some new statistical information on hydraulic conductivities which, however, is not used in the analysis). The absence of a probability based uncertainty analysis also greatly compromises any attempt at making the assessments risk-informed or having a high level of confidence in the quality of the dose modeling. The approach to considering uncertainty is based on alleged use of conservative assumptions. No attempt was made to quantify the uncertainties.

The recommendations of the 2008 DEIS review on uncertainty in the long term performance assessment prevail.

ENGINEERED BARRIERS (Reviewer: Chris G. Whipple)

The changes between the 2008 DEIS and the 2009 FEIS in the engineered barrier assumptions appear to be minor and are not considered significant. However, there are changes. For example, it does appear that the tank closure approach has been modified to take advantage of work done on tank closures at Savannah River and Hanford. In general, the engineered barrier assumptions seem reasonable, with the exception that no evidence was provided supporting the performance of streambed armoring over a long time period. The assumptions about the lifespan of the Controlled Low Strength Material (CSLM) and strong grout in the tanks and vaults appear reasonable.

As to recommendations, the description of the engineered barriers is much clearer than the 2008 version. While it might be more realistic to do the analysis with the performance of the barriers degrading over time, such long-term performance is sufficiently uncertain that any particular set of values could not be justified. It is clear that the first two engineered barriers address general sheet erosion and large rainfall events. They do not address gullying and headcut erosion.

The section on streambed armoring has one significant change from the 2008 report – the total armored length of streams to be armored was increased from 4,300 to 12,900 linear feet. Section 2.14 (Erosion Controls Construction) of the Sitewide Close-In-Place Technical Report is essentially unchanged from the 2008 version, with the exception that the 2009 version includes the statement "In addition, several existing medium- to large-scale erosion control installations through the southwestern New York region were reviewed to gain a better understanding of the various types of structures used, the successes and failures, and the mechanisms for failure, for these structures." The capability of streambed armoring to prevent headcut erosion is critical to the proposed approach, and the statement that existing erosion control installations were reviewed is clearly an important step towards determining whether such armoring would work, how long it would work, and what sort of maintenance is required to prevent headcut erosion.

With respect to dose calculations, no engineered barrier uncertainties were considered except through the use of assumptions thought to be bounding.

DOSE CALCULATIONS (Reviewer: Chris G. Whipple)

Some scenarios were not evaluated that likely could result in significant doses. For example, in the unmitigated erosion case, no onsite receptor scenarios are analyzed that include exposures via a food or drinking water pathway. In general, the reasons for the differences in the dose estimates between 2008 and 2009 for the resident farmer are not clear. It would be helpful to know if the differences are due largely or entirely to the use of the STOMP model in place of RESRAD.

SECTION 3

COMPOSITION OF THE INDEPENDENT EXPERT REVIEW TEAM

The members of the Independent Expert Review Team are all distinguished in the disciplines important to the purpose and scope of the 2009 FEIS review. The disciplines included geoscience, nuclear science and engineering, health physics, risk assessment, and environmental science and engineering.

Dr. B. John Garrick, Chairman, U.S. Nuclear Waste Technical Review Board, and an independent consultant in the nuclear and risk sciences was named as the initial member and chairman of the IERT. Dr. Garrick assisted NYSERDA in selecting the review team and had the responsibility for integrating the reviews and leading the preparation of this final report. The full membership and their affiliations are listed below. Qualification summaries of the IERT members are presented in Appendix A.

Sean J. Bennett, Ph.D., Professor, State University of New York at Buffalo, Buffalo, New York

Robert H. Fakundiny, Ph.D., New York State Geologist Emeritus, Rensselaer, New York

B. John Garrick, Ph.D., Chairman, U.S. Nuclear Waste Technical Review Board, Arlington, Virginia, and Independent Consultant, Laguna Beach, California

Shlomo P. Neuman, Ph.D., Regents' Professor, University of Arizona, Tucson, Arizona

Michael T. Ryan, Ph.D., Principal, Michael T. Ryan and Associates LLC, Lexington, South Carolina

Chris G. Whipple, Ph.D., Principal, ENVIRON International Corporation, Emeryville, California

SECTION 4

REVIEW PROCESS

The Department of Energy provided NYSERDA with a complete draft of the Final Environmental Impact Statement on October 6, 2009. The IERT was asked by NYSERDA to review several EIS chapters and appendices known to be undergoing significant revision since the issuance of the DRAFT EIS and the "results" chapters that present, discuss, and compare this information. The IERT was asked to (1) identify any significant changes from the 2008 DEIS and (2) consider the impact of this new work on the technical basis and defensibility of the 2009 FEIS. NYSERDA provided additional guidance in the form of topic-specific review questions. The questions provided a focus for each topical area. NYSERDA also requested that the IERT identify other important issues not brought forth by answering the topic-specific questions.

The following 2009 FEIS sections were reviewed:

- Appendix D – Overview of Performance Assessment Approach
- Appendix E – Geohydrological Analysis
- Appendix F – Erosion Studies
- Appendix G – Models for Long-Term Performance Assessment
- Appendix H – Long-Term Performance Assessment Results
- Chapter 2 – Comparison of Environmental Impacts
- Chapter 4 – Environmental Consequences

The IERT also reviewed certain other sections of the 2009 FEIS to determine whether the issues and concerns identified in the 2008 IERT review remain or whether the concerns identified by the IERT in 2008 were resolved. These additional review areas include:

- Seismic Hazard and Seismic Risk
- Engineered Barriers
- Uncertainty Analysis
- Cost/Benefit Analysis

SECTION 5

FINDINGS

EROSION

1. The SIBERIA model has been eliminated. There has been a significant effort to refine and extend the use of the CHILD model.

2. The FEIS has not addressed key recommendations made on erosion in the 2008 IERT review.

3. Quantitative comparison of model output with actual field data has not been made, and a rigorous uncertainty analysis of model predictions has not been conducted.

4. A quantitative comparison of all model output with actual field data has not been provided.

SEISMIC HAZARD AND SEISMIC RISK

1. Many minor changes have been made in the 2009 FEIS primarily having to do with seismic hazard estimates.

2. The seismic hazard evaluation is not supported by an adequate scientific basis in such areas as seismic zones.

3. There has been no substantive response to the 2008 DEIS review recommendations.

4. Neither seismic hazards nor seismic risks are considered in the long term performance assessment calculations.

GROUNDWATER FLOW AND CONTAMINANT TRANSPORT

1. Additional information is presented on a variety of topics, including a more accurate representation of engineered barriers in the near field groundwater flow model for the South Plateau.

2. No significant change from the 2008 DEIS in the approach to groundwater flow and contaminant transport modeling and prediction.

3. DOE has not satisfied IERT's previous critique of the one-dimensional flow-tube approach, although more information was provided.

4. No discernible change in the 2009 Appendix G models for the LTPA.

5. Probabilistic analyses, and therefore uncertainty analyses, were not used in the LTPA.

6. The groundwater modeling predictions presented in the 2009 FEIS are not supported by an adequate scientific basis to quantify radiation doses to human receptors.

COST BENEFIT ANALYSIS

1. Extensive use is made of "collective dose." (Collective dose is considered a poor metric for determining risk.)

2. The three alternatives to remediation were indexed to the No Action Alternative, but not in a transparent manner.

3. The basis for the dose calculations for the case of lost institutional controls is not clear.

4. There was no probability analysis to support risk-informed conclusions.

5. The 2009 FEIS does not reflect consideration of the 2008 IERT recommendations.

TREATMENT OF UNCERTAINTY IN THE LONG TERM PERFORMANCE ASSESSMENT

1. There have been no significant changes in the approach to uncertainty analysis from the 2008 review.

2. The approach to considering uncertainty is based on alleged use of conservative assumptions.

3. The models are void of probability based information (the groundwater discussion now cites some hydraulic conductivity statistics which, however, are not used in the analysis) that would be the basis for meaningful uncertainty analysis. No attempt was made to quantify the uncertainties.

ENGINEERED BARRIERS

1. The changes between the 2008 DEIS and the 2009 FEIS in the engineered barrier assumptions appear to be minor and are not considered significant.

2. In general, the engineered barrier assumptions seem reasonable, with the exception that no evidence was provided supporting the performance of streambed armoring over a long time period.

3. The section on streambed armoring has one significant change from the 2008 DEIS – the total armored length of streams to be armored was increased from 4,300 to 12,900 linear feet.

4. The description of the engineered barriers in the 2009 FEIS is much clearer than the 2008 DEIS, but the substantive change is minor.

5. While the assumptions for engineered barriers are reasonable, their treatment in the LTPA continues to be incomplete.

6. Engineered barriers address general sheet erosion and large rainfall events. They do not address gullying and headcut erosion.

7. The tank closure approach has been modified to take advantage of work performed at Savannah River and Hanford.

8. No engineered barrier uncertainties were considered except through the use of bounding assumptions.

DOSE CALCULATIONS

1. No onsite receptor scenarios are analyzed that include exposures via a food or drinking water pathway.

2. The basis for the dose calculations for the case of lost institutional controls is not clear.

3. The absence of a rigorous uncertainty analysis compromises reliable dose predictions.

4. The reasons for the differences in the dose estimates between the 2008 DEIS and the 2009 FEIS for the resident farmer are not clear.

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

The overarching conclusion is that while new information has been included in the 2009 FEIS that enhances the clarity of descriptive information, changes to the analysis have failed to resolve key outstanding issues previously pointed out by the IERT. Most recommendations presented in the 2008 DEIS review by the IERT remain relevant to the 2009 FEIS.

APPENDIX A

QUALIFICATION SUMMARIES OF THE MEMBERS OF THE INDEPENDENT EXPERT REVIEW TEAM

Dr. B. John Garrick - Chairperson of the Independent Expert Review Team – Dr. Garrick has a Ph.D. in Engineering and Applied Science and an M.S. in Nuclear Engineering from the University of California, Los Angeles; graduate from the Oak Ridge School of Reactor Technology; and a B.S. in Physics from Brigham Young University. He is an executive consultant on the application of the risk sciences to complex technological systems in the space, defense, chemical, marine, transportation, and nuclear fields. He was appointed as Chairman of the U.S. Nuclear Waste Technical Review Board on September 10, 2004, by President George W. Bush. He served for 10 years (1994-2004), 4 years as chair, on the U.S. Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste. His areas of expertise include risk assessment and nuclear science and engineering. A founder of the firm PLG, Inc., Dr. Garrick retired as President, Chairman, and Chief Executive Officer in 1997. Before PLG's acquisition and integration into a new firm, it was an international engineering, applied science, and management consulting firm.

Dr. Garrick was elected to the National Academy of Engineering in 1993, President of the Society for Risk Analysis 1989-90, and recipient of that Society's most prestigious award, the Distinguished Achievement Award, in 1994. He has been a member and chair of several National Research Council committees, having served as vice chair of the Academies' Board on Radioactive Waste Management and as a member of the Commission on Geosciences, Environment, and Resources. He recently chaired the National Academy of Engineers Committee on Combating Terrorism. Among other National Academy committees he has chaired are the Committee on the Waste Isolation Pilot Plant, the Committee on Technologies for Cleanup of High-Level Waste in Tanks in the DOE Weapons Complex, and the Panel on Risk Assessment Methodologies for Marine Systems. Other Academy committee memberships included space applications, automotive safety, and chemical weapons disposal. He is a member of the first class of lifetime national associates of the National Academies.

Dr. Garrick has published more than 250 papers and reports on risk, reliability, engineering, and technology, author of the book "Quantifying and Controlling Catastrophic Risks" (September 2008), written several book chapters, and was editor of the book, *The Analysis, Communication, and Perception of Risk*.

Dr. Sean J. Bennett - Dr. Sean J. Bennett is a Professor in the Geography Department at the State University of New York at Buffalo. He holds a Ph.D., M.A., and B.S. in Geology. Dr. Bennett has extensive experience in physical and numerical modeling of gully erosion and river processes. His current research interests seek to quantify flow and sediment transport processes in watersheds and to determine the impact of these processes on soil losses, river form and function, water quality and ecology, landscape evolution, and watershed infrastructure and integrity. Prior to joining the State University of New York, he served as a Research Geologist with the U.S. Department of Agriculture, Agricultural Research Service, National Sedimentation

Laboratory in Oxford, MS, and was a Research Fellow in the School of Earth Sciences at the University of Leeds.

Dr. Bennett has served as Guest Editor for the International Journal of Sediment Research (WASER), Assistant Editor for The Professional Geographer (AAG), Associate Editor for Water Resources Research (AGU), Associate Editor for the Journal of Hydraulic Engineering (ASCE), and Co-editor for Sedimentology (IAS). Dr. Bennett has published two edited books and authored over 100 journal publications, conference proceeding papers, and technical reports.

Dr. Robert H. Fakundiny - Dr. Robert H. Fakundiny is the New York State Geologist Emeritus. He holds a Ph.D., M.A., and B.A. in Geology. He served as the New York State Geologist and Chief of the New York State Geological Survey for 26 years before his retirement in 2004. Among other honors, he is a Fellow of the Geological Society of America, the American Association for the Advancement of Science, the New York Academy of Sciences, the Geological Society of Canada, and the Geological Society (London). He is a Past President of the American Institute of Professional Geologists, Past President of the Association of American State Geologists and Past Chair of the North American Commission on Stratigraphic Nomenclature. He authored numerous scientific papers on the structure and tectonics of New York State, and is the author of highly recognized work on the Clarendon-Linden fault system.

Dr. Fakundiny was one of the principal investigators and conducted or managed extensive research on the geology, hydrology and geomorphology of the Western New York Nuclear Service Center during the 1970s and 1980s. He was a member of NYSERDA's Independent Radioactive Waste Technical Review Group during the 1990s, and he served as a member of the 2005-2006 West Valley EIS Performance Assessment Peer Review Group.

Dr. Shlomo P. Neuman - Dr. Shlomo P. Neuman is Regents Professor in the Department of Hydrology and Water Resources at the University of Arizona in Tucson. He holds a Ph.D. and a M.S. in Engineering Science, and a B.S. in Geology. Dr. Neuman's fields of specialization are subsurface hydrology and contaminant transport. He has made seminal contributions to the areas of pumping test design and analysis, flow in multilayered geologic media, finite element simulation of subsurface flow and transport, estimation of aquifer parameters, fractured rock hydrology, peat hydrology, geostatistics, hydrologic scaling and stochastic analysis of heterogeneous geologic media. He is a Member of the National Academy of Engineering, a Fellow of the American Geophysical Union, and a Fellow of the Geological Society of America. He holds honorary professorships at the University of Nanjing and the Hydraulic Research Institute in China.

Dr. Neuman has received numerous awards and citations during his career, including the 2003 Robert E. Horton Medal of the American Geophysical Union, and is a former Birdsall Distinguished Lecturer of the GSA and Langbein Lecturer of the AGU. Dr. Neuman has served on various national and international advisory panels including the Scientific Review Group for high-level nuclear waste disposal in Canada. Dr. Neuman is Associate Editor of Water Resources Research and a member of the Editorial Board of Stochastic Hydrology and Hydraulics. He is the author of over 310 publications, and has served on the 2005-2006 West Valley EIS Performance Assessment Peer Review Group.

Dr. Michael T. Ryan - Michael T. Ryan, Ph.D., C.H.P., is an independent consultant in radiological sciences and health physics. He is certified in comprehensive practice by the American Board of Health Physics. He is an adjunct faculty member at Texas A&M University and Vanderbilt University. Dr. Ryan received the Ph.D. in 1982 from the Georgia Institute of Technology, where he was inducted into the Academy of Distinguished Alumni. He graduated from Lowell Tech with a Bachelors degree in Radiological Health Physics. Dr. Ryan received a Masters degree in Radiological Sciences and Protection from the same institution that became part of the University of Massachusetts Lowell. Dr Ryan is the Editor-in-Chief of the Journal *Health Physics* and has served in this position since 2000.

He completed a nine year term as Chairman of the External Advisory Board for Radiation Protection at Sandia National Laboratories in 2007. He is a member of a similar external review board for Lawrence Livermore National Laboratory. He completed 8 years of service on the Scientific Review Group appointed by the Assistant Secretary of Energy to review the ongoing research in health effects at the former weapons complex sites in the Southern Urals. He has also served on several Committees of the National Academy of Sciences producing reports regarding radioactive waste management topics. He also served as Chairman for the Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste and Materials (ACNW and ACNW&M). Dr. Ryan served on Committee since 2002 until it was merged with the Advisory Committee on Reactor Safeguards (ACRS) in 2008. In June, 2008, Dr. Ryan became a member of the ACRS.

Dr. Ryan has been a member of the National Council on Radiation Protection and Measurements since 1992. He was elected to the Board of Directors and served from April 1998 to May 1992. He was appointed as Chairman of Scientific Committee 87 and Scientific Vice President for the Program Area of Radioactive and Mixed Waste from April 1998 to May 2002.

Dr. Ryan previously worked for Chem-Nuclear Systems, Inc., as Vice President and General Manager for the operations and compliance of the low-level radioactive waste disposal and service facilities in Barnwell, South Carolina. Previously, Dr. Ryan spent seven years in operational and environmental health physics at Oak Ridge National Laboratory.

Dr. Chris G. Whipple - Dr. Chris G. Whipple is a Principal with ENVIRON International Corporation in Emeryville, CA. He holds a Ph.D., M.S., and B.S. in Engineering Science. He is a Member of the National Academy of Engineering and is a Designated National Associate of the National Academies. He chaired and served on the National Academy of Sciences Board On Radioactive Waste Management, and he chaired the Peer Review of the Yucca Mountain Total System Performance Assessment. He has been a consultant to the U.S. Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste, to the U.S. Nuclear Waste Technical Review Board, and to the Swedish Radiation Protection Institute. He is a Member of the National Council on Radiation Protection, and a Charter Member, Fellow, and Former President of the Society for Risk Analysis.

Dr. Whipple has served on a number of national and international review boards and oversight committees, and he is the author of numerous publications on risk assessment, risk management, and risk communication. Dr. Whipple chaired the 2005-2006 West Valley EIS Performance Assessment Peer Review Group.

APPENDIX B

RESPONSES TO NYSERDA'S TOPIC-SPECIFIC REVIEW QUESTIONS

The Department of Energy provided NYSERDA with a complete draft of the Final Environmental Impact Statement on October 6, 2009. The IERT was asked by NYSERDA to review several EIS chapters and appendices known to be undergoing significant revision since the issuance of the DRAFT EIS and the "results" chapters that present, discuss, and compare this information. The IERT was asked to (1) identify any significant changes from the 2008 DEIS and (2) consider the impact of this new work on the technical basis and defensibility of the 2009 FEIS. In addition, the IERT was asked to answer Topic-Specific Review Questions provided by NYSERDA. The questions were provided by NYSERDA to guide the review with the goal of obtaining a similar focus and level of detail for each topical area. It was also requested that the IERT identify other important issues not brought forth by answering the topic-specific questions.

The following EIS sections were reviewed:

- Appendix D – Overview of Performance Assessment Approach
- Appendix E – Geohydrological Analysis
- Appendix F – Erosion Studies
- Appendix G – Models for Long-Term Performance Assessment
- Appendix H – Long-Term Performance Assessment Results
- Chapter 2 – Comparison of Environmental Impacts
- Chapter 4 – Environmental Consequences

The IERT also reviewed certain other sections of the document to determine whether the issues and concerns identified in the 2008 IERT review remain or whether the concerns identified by the IERT in 2008 were resolved. These additional review areas include:

- Seismic Hazard and Seismic Risk
- Engineered Barriers
- Uncertainty Analysis
- Cost/Benefit Analysis

The IERT's responses to NYSERDA's questions follow. A more complete review of the 2009 FEIS was performed by Dr. Bennett and is included in Appendix C.

EROSION MODELING AND PREDICTION (Dr. Sean J. Bennett)

1) *When comparing the 2009 FEIS analysis to the 2008 DEIS analysis, has there been a significant change in the approach to erosion modeling and prediction? If so, please provide a summary of the changes.*

The following list summarizes the significant changes contained in the 2009 FEIS. The most significant revisions here are the complete elimination of the SIBERIA model, and the expanded use and discussion of the CHILD model.

- F.3.1.4 Parameter Selection for CHILD Model. This section discusses the selection of parameters used in CHILD, which are summarized in Table F-8. Of note here is the use of 5 values each for 10 input parameters, which defines a design matrix, to facilitate the calibration of the model.
- F.3.1.4.2 Boundary conditions: Base-level history. This section interprets the OSL data to define a base-level history (a rate of incision or base-level lowering through the glacial sediment during this ca. 18,000-year time period).
- F.3.1.4.4 Parameters related to climate. This section revises the average storm intensity, the average fraction of time that precipitation occurs, and the average duration of a storm and inter-storm sequence as used in CHILD.
- F.3.1.4.5 Soil infiltration capacity. This section discusses the effective infiltration capacity of the site, defined as the maximum rate at which rainfall can be absorbed by the soil before generating runoff.
- F.3.1.4.6 Channel width parameters. A power function for predicting the width of river channels is presented and discussed.
- F.3.1.4.7 Parameters related to water erosion and sediment transport. Equations for the detachment capacity of cohesive sediment and the rate of bedload transport for non-cohesive sediment are presented, including the values used in the calibration procedure. The definition of the applied shear stress within the stream channels also is presented, as well as their bracketed values used in the calibration.
- F.3.1.4.9 Model-data comparison metrics. Six metrics are identified to provide a measure of model performance. These include the longitudinal profile of Buttermilk Creek, the construction of a hypsometric curve for the entire landscape, a slope-area diagram for the entire landscape, width function, a cumulative area distribution for the entire landscape, and the positions of strath terraces. The first five metrics are assigned goodness-of-fit scores from 0 (no agreement) to 1 (perfect agreement) by simply dividing the curves into 101 points and comparing these observed data points to the predicted data points.
- F.3.1.5 Testing and Calibration Results. Using the range of input parameters, 1000 computer runs are executed and the normalized goodness-of-fit measures are tabulated. The parameter datasets for these 1000 runs are randomly selected from the matrix of 10 parameters each with 5 possible values, as defined herein. Based on these results, five runs are identified that satisfy the goodness-of-fit criteria (highest values) as well as having strong "visual correspondence" to the observed topography. These five runs and their input parameters are listed in Table F-11. The run with the highest goodness-of-fit value (0.680, Run 298) then is used as the "standard case" for the forward modeling exercise, whereas the remaining four runs are used as "alternates" (Alternate 1 to 4).

Figures F-8 to F-13 compare the observed and predicted values for the "standard case" against each metric used.

- F.3.1.6.1 General approach. A total of four different forward-modeling scenarios are considered: (i) the five calibration runs for the North and South Plateaus, (ii) a "wet" condition, where the mean precipitation rate is doubled and the infiltration rate in minimized for the North and South Plateaus, (iii) a "wet + fast creep" scenario for the South Plateau, where high precipitation and runoff rates are coupled to a high soil diffusivity, and (iv) a "close-in-place" scenario, where two mounds are added to the North and South Plateaus to signify the buried waste, and where all scenarios are considered.
- F.3.1.6.2 Model resolution. Two different grid resolutions are employed. Both the North and South Plateaus are simulated at a mesh resolution of 2.8 m, whereas all other areas were simulated at a mesh resolution of 90 m.
- F.3.1.6.5 Summary of forward-run scenarios. A summary of all forward-run scenarios is provided in Table F-12, and maps depicting the relative amount of erosion and deposition for each scenario are illustrated in Figures F-15 to F-38. For each figure, the modern-day (0 years) and future (10,000 years) elevations and the difference in elevation (binned data depicting net erosion or sedimentation) are shown, and modest statements about the results are presented in the accompanying text.

2) *Does the 2009 FEIS address the recommendations provided in Section 6 (Conclusions and Recommendations) of the 2008 IERT Report relative to erosion modeling and prediction? Please explain.*

The 2008 IERT Report offered the following <u>Conclusions</u> and <u>Recommendations</u>. These statements now have response based on the revisions presented in the FEIS.

<u>Conclusion</u>: The prediction of long-term erosion processes and impacts is one of the most technically challenging issues that must be addressed in the Environmental Impact Statement (EIS). The erosion models used in the 2008 DEIS for gully erosion and landscape evolution of the West Valley site are scientifically indefensible, and predictions with regard to future radionuclide dose rates due to the surface erosion from these models cannot be accepted or ratified at this time.

<u>Recommendation</u>: Future analyses regarding erosion modeling of the North and South Plateaus should include (1) a stronger hydrologic and geomorphic connection between model parameterization and onsite characteristics; (2) quantitative comparison of all model output with actual field data; and (3) a rigorous uncertainty analysis of model predictions and the quantification of all uncertainty bounds. Resources should focus on improved and scientifically defensible models of gully erosion that accurately depict and represent the hydrologic and geomorphic characteristics of the site, that predict the formation, growth, and upstream migration of gullies in response to both surface and subsurface hydrologic events and regimes, and that quantify all uncertainty bounds of these predictions.

Response: In the FEIS, significant efforts are made to further refine and extend the use of the CHILD model. However, the revisions have not addressed the recommendations noted above and discussed below.

A stronger hydrologic and geomorphic connection has not been made between model parameterization and onsite characteristics. Although the CHILD model now uses a design matrix (5 values for 10 input parameters) for its calibration exercise, no significant efforts have been made to quantify on-site hydrologic and geomorphic parameters to better define these input parameters.

Quantitative comparison of all model output with actual field data has not been made. No demonstration has been made that the model results for the West Valley Site, using any of the equations within the CHILD model, have been verified or validated on the basis of actual data.

A rigorous uncertainty analysis of model predictions has not been conducted and the quantification of all uncertainty bounds has not been made. This request has been made during each iteration of the EIS, and it remains unanswered and unresolved.

In addition, many of the model components, especially with regard to the gully erosion and landscape evolution, are unjustifiable and unsupported by scientific evidence.

3) *Were the changes, if any, in Appendix F (Erosion Studies), incorporated into the corresponding parts of the Long-term performance assessment approach as described in Appendix G (Models for Long-Term Performance Assessment)?*

In Appendix G, a surface erosion release mechanism considers two components: vertical movement of the ground surface and horizontal movement of the near-vertical creek banks. These mechanisms now are addressed via a specific simulation using the CHILD model, whereas the simplified gully erosion model previously presented now has been eliminated from the discussion. The use of these gully erosion simulation now is part of the discussion presented in Appendix H.

4) *If changes in the approach to erosion modeling and prediction were made, do the changes make the 2009 FEIS results more reliable and defensible, less reliable and defensible, or about the same, as compared to the 2008 DEIS? Please explain.*

While significant efforts are made to expand and refine the use of the CHILD model, these changes have not rendered the results any more reliable or defensible. This is because (a) a hydrologic and geomorphic disconnection still exists between model parameterization and onsite characteristics, (b) a quantitative comparison of all model output with actual field data has not been provided, and (c) a rigorous uncertainty analysis of model predictions has not been conducted. Moreover, many of the model components, especially with regard to the gully erosion and landscape evolution, are unjustifiable and unsupported by scientific evidence.

5) *Are the erosion predictions presented in the FEIS supported by an adequate scientific basis such that they can be used to quantify radiological or other impacts to human receptors and the environment on and near the Center over long periods of time, perhaps thousands of years (e.g., see DEIS Figure H-16 and table H-67)? Please explain.*

   The erosion predictions are not supported by enough scientific evidence. This conclusion is based on (1) the lack of a strong hydrologic and geomorphic connection between model parameterization and onsite characteristics; (2) the absence of quantitative comparison of all model output with actual field data; and (3) the omission of a rigorous uncertainty analysis of model predictions and the quantification of all uncertainty bounds. Any release of radioactive material by these simulated erosion processes are without strong scientific support.

6) *Are the dose predictions, results, and comparisons of the alternatives in the 2009 FEIS presented with adequate consideration of erosion modeling uncertainties? [e.g., Section 4.1.10 of Chapter 4, Section H.2.2.4 of Appendix H, and the discussions of "uncertainties" in Section 2.8 of Chapter 2 and "incomplete and unavailable information" in Section 4.3 of Chapter 4] Please explain.*

   As a rigorous uncertainty analysis of surface erosion model predictions has not been conducted and the quantification of all uncertainty bounds has not been made, the propagation of these uncertainties into dose predictions cannot be resolved or addressed at this time.

7) *Do you have additional recommendations in regard to the information presented in the 2009 FEIS on erosion modeling and prediction?*

   Not at this time.

SEISMIC HAZARD AND SEISMIC RISK (Dr. Robert H. Fakundiny)

1) **Has there been a significant change in the approach to the seismic hazard and seismic risk analysis when comparing the 2009 FEIS to the 2008 DEIS? [See Section 3.5 of Chapter 3] If so, please provide a summary of the changes.**

Many minor changes have been made, primarily by better editing, but no substantive revisions have been made. Minor changes occur in the form of the addition or removal of various statements. Many of the concerns presented in our Draft Comment Form for Internal Review and Concurrence Draft EIS for Decommissioning and /or Long Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center, Section 3.5 "Seismology" of Chapter 3 were not addressed, particularly comments 2, 4, 6, 7, 9, 10, 25, 27, 30, 32, 33, 39, and 41 were ignored. The conclusions of each subsection of Chapter 3.5 remain the same as the 2008 DEIS.

2) **Does the 2009 FEIS address the recommendations provided in Section 6 (Conclusions and Recommendations) of the 2008 IERT Report in regard to seismic hazard and seismic risk? Please explain.**

No. The first recommendation asked for a clear documentation of the approach taken to estimating seismic risk, which they finessed by discussing only seismic-hazard estimates.

The second recommendation suggested that analyses should be informed by current technologies, and should adopt probabilistic-risk assessment approaches, which they again finessed by only discussing seismic hazard analysis. They do add a few new references later than the earlier set that are mostly pre 2004.

3) **If changes in the approach to identifying seismic hazard and seismic risk were made, do the changes make the 2009 FEIS results more reliable and defensible, less reliable and defensible, or about the same, as compared to the 2008 DEIS? Please explain.**

Substantive changes were not made; thus, the 2009 FEIS results are not more reliable nor defensible.

4) **Is the consideration of seismic hazard and seismic risk incorporated into the long-term performance assessment calculations and dose estimates (e.g. see Section D.3.1.2 of Appendix D, Appendix G Models for Long-Term Performance Assessment, Appendix H Long-Term Performance Assessment Results, Section 2.8 of Chapter 2 and Section 4.1.10 of Chapter 4 and Section 4.3)?**

Neither seismic hazards nor seismic risks are considered in the long-term performance assessment calculations. Missing are the effects of a maximum credible earthquake occurring at the site on slope stability, liquefaction of the sand and gravel layers, integrity of engineered barriers, and the caps on the NRC-Licensed Disposal Area (NDA) and the State-Licensed Disposal Area (SDA). Not addressed are the effects of seismicity occurring during the decommissioning process, such as constructing the barrier walls during the removal of the contaminated groundwater plume on the north plateau. No discussion is presented on the effect of seismicity on the buried tank farm, if the close-in-place option is used. Although these are issues for a seismic-risk analysis, they should be considered.

Appendix D, 3.1.2: The close-in-place option depends upon the integrity of the tumulus and its relation to the buried facilities. Soil-structure interaction would be useful for analyzing the possible damage to the buried tank farm, if a maximum credible earthquake struck the site.

Appendix G: Not considered is the jumbling of soil in landslides that could release radionuclides from the SDA or NDA, formation of new groundwater conduits, soil ingestion by receptors near an active landslide, or disruption of external barriers during a maximum credible earthquake.

Appendix H, Chapter 2, Chapter 4.1.10, and Chapter 4.3 do not consider seismically induced ground disruption, integrity of burial caps, or engineered barriers.

I found no sensitivity analyses in any of these sections.

ADDITIONAL QUESTIONS

5) **Are the FEIS seismic hazard and seismic risk studies presented in the FEIS supported by an adequate scientific basis such that they can be used to quantify radiological or other impacts to human receptors and the environment on and near the Center over long periods of time, perhaps thousands of years? Please explain.**

The 2009 FEIS does not present a seismic-risk analysis, and thus, the Seismology Section 3.5 does not provide decisionmakers with the information needed for decommissioning designs. The seismic-hazard evaluation in the 2009 FEIS is not supported by an adequate scientific basis where it discusses seismic-zones.

6) **Do you have additional recommendations in regard to the information presented in the 2009 FEIS on seismic hazard and seismic risk?**

I recommend that a combined probabilistic and deterministic seismic-hazard analysis be coupled with a seismic-risk evaluation before designs are finalized.

GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODELING
(Dr. Shlomo P. Neuman)

Answers to NYSERDA Questions on changes from the 2008 DEIS

1) Has there been a significant change in the approach to groundwater flow and contaminant transport modeling and prediction when comparing the 2009 analysis to the 2008 analysis? [See Appendix E Geohydrological Analysis and Appendix G Models for Long-Term Performance Assessment]. If so, please provide a summary of the changes.

Answer re Groundwater Aspects of Appendix D

On p. D-14 of the 2009 version of Appendix D the DOE states: "Site data and the three-dimensional site-wide groundwater model indicate that the Kent Recessional Sequence (KRS) is unsaturated below the North and South Plateaus, indicating that this unit is not a reasonable source of domestic or irrigation water." This is equivalent to stating that an unconfined aquifer is not a reasonable source of domestic or irrigation water; the assertion is fundamentally wrong.

The introductory paragraph of Section D.3.2.3 on p. D-21 states: "Because probability distributions of model structure (i.e., uncertainty of appropriate model structure), receptor behavior, and some model parameters are not available for both groundwater and erosion scenarios, a comprehensive probabilistic evaluation is not practical." These are not valid reasons to forego any and all probabilistic analyses of long-term performance assessment. Where statistical information is not available, it can be supplemented based on surrogate data from other sources and/or assigned subjectively, to be updated on the basis of available data using Bayesian methods.

Answer re Appendix E

There has not been a significant change in the approach to groundwater flow and contaminant transport modeling and prediction when comparing the 2009 Appendix E Geohydrological Analysis to the corresponding 2008 analysis. Some details of the analysis and presentation in Appendix E have been modified, updated and/or expanded.

The most significant changes to Appendix E have been (a) a considerable expansion of Section E.4 on Near-Field Groundwater Flow Models, (b) enlargement of the area covered by the near-field groundwater flow model for the North Plateau, (c) modification of the lateral and vertical extent of the Slack Water Sequence (SWS) within the latter model, and (so does DOE state, though the 2008 details were insufficient to verify this) (d) more accurate representation of engineered barriers in the near-field groundwater flow model for the South Plateau. Though the DOE claims to have clarified the regional model and its results, the 2009 conceptualization of site-wide groundwater flow at West Valley remains flawed.

With a few relatively minor exceptions, the site-wide groundwater flow model remains the same as that in the 2008 DEIS. Hence all my earlier comments regarding this model in Appendix 1 of the August 2008 IERT report remain relevant.

Following is a list of notable changes in the 2009 description of regional site hydrogeology and site-wide groundwater flow modeling:

Figure E-3 provides a useful new description of surface geology at the site.

Figure E-7 has been modified to include upward pointing arrows between units lying below the Kent Recessional Sequence (KRS), suggesting the possibility of upward flow through these units as proposed in my 2008 comments. Unfortunately the text, Figure E-4 and the groundwater flow model continue to reflect a flawed conceptual model according to which (see especially Section E.2.2.5) flow generally takes place downward from the KRS. Though the possibility of some upward flow beneath the KRS is conceded (see Sections E.2.2.4 - E.2.2.5) the nature of groundwater flow patterns beneath the KRS is said to be uncertain and the picture painted is confusing. As noted in my 2008 comments, this picture is contrary to well-established hydrogeologic principles of gravity driven groundwater flow. I find it incongruous that these principles are cited with reference to Prudic (1986) in the opening sentence of Section E.2.3.2 yet not adhered to consistently in either the conceptual or the numerical site-wide model.

Figure E-7 has been modified to indicate "unconfirmed" lateral discharges from the Olean Recessional Sequence (ORS), Olean Till and Bedrock to surface water; neither site hydrography or hydrogeology nor the site-wide groundwater flow model support such discharge.

Sections E.2.2.1.1 – E.2.2.1.2 provide a fairly detailed verbal and graphical description of the reinterpreted spatial distribution of sediments comprising the shallow unconfined aquifer on the North Plateau.

Section E.2.2.6 reveals that, according to Zadin (1997), hydrological connections between the bedrock aquifer and valley fill aquifer systems used by communities north of Cattaraugus Creek are not likely. Zadin's conclusion appears to contradict Section E.3.7.4 Alternative Conceptual Model – Weathered Bedrock Outlet where artificial boundary conditions are imposed on the site-wide model to generate flow through the weathered bedrock northward beneath Buttermilk Creek.

Tables E-2 and E-7 list new observed subsurface discharges into Erdman Brook and the French Drain due to Kappel and Harding.

Section E.2.3.2 states: "Considering the valley fill, two broad classes of materials coexist at the site—moderate- to high-permeability sands and gravels, and lower-permeability clay-silt tills. The alignment of groundwater flow through the low permeability materials tends to be vertical (up or down)—the materials largely serving to conduct flow from one of the more-permeable units to another. As a general rule, flow through the more-permeable units will tend to be horizontal—that material being able to sustain high flow volumes. Thus, even though the site lies in the lower hillside regime, largely vertical flow through the till unit is expected and observed." The idea that flow through low permeability sedimentary layers (aquitards or aquicludes) tends to be vertical and that through more permeable layers (aquifers) tends to be horizontal has been proposed and used successfully in situations where water is being pumped out of at least one aquifer to generate near-horizontal flow within it. The idea does not apply to a natural flow system of the kind the DOE assumes prevails at West Valley in which there are no wells to force horizontal flow through the permeable units.

Section E.2.3.2 further states: "some inflow likely occurs into the thick-bedded unit where it interfaces with weathered bedrock at the western edge of the site near Rock Springs Road. The quantity of water coming into the thick-bedded unit from the bedrock has not been well characterized." Yet the rate at which water enters this unit from the bedrock is prescribed (as if it was known precisely) in both the site-wide model and in the near-field model of the North Plateau (Section E.3.3 explains how this was done on the basis of a prescribed recharge, which is equally unknown; more on this below). This prejudices the outcome of the model and renders it suspect. A better solution would have been to prescribe head at the bedrock/thick-bedded interface based on measured groundwater levels and to treat the boundary condition probabilistically as being uncertain.

Section E.2.3.2 also states: "The Kent recessional sequence water table likely exists due to a combination of low infiltration from above through the unweathered Lavery till and a source inflow from the weathered bedrock where the Kent recessional sequence and weathered bedrock interface (Prudic 1986)—a situation analogous to that of the thick-bedded unit in the upper aquifer." As noted in my 2008 comments, this ignores likely leakage into the KRS from below (in line with the flawed conceptual framework underlying the site-wide model) with the exception of a small amount of such upward leakage near the creek outlet.

Section E.3 opens with an assertion that deterministic groundwater flow and transport models coupled with sensitivity analyses are sufficient for purposes of decision making. The assertion is unsupported and IERT 2008 comments about the need for probabilistic uncertainty assessments remain relevant. It may be worth adding that recent probabilistic Derived Concentration Guideline Level (DCGL) analyses by the DOE in the West Valley DP context have admittedly demonstrated the non-conservative (and we should add statistically biased) nature of corresponding deterministic DCGL analyses. The same may apply to the FEIS.

Section E.3 cites the Generalized Likelihood Uncertainty Estimation (GLUE) of Beven (2006) as if it was the only known method to consider jointly all sources of uncertainty in hydrologic models. It would be more correct to state that GLUE is one of several methods to accomplish this; see Neuman, S.P. and P.J. Wierenga, A Comprehensive Strategy of Hydrogeologic Modeling and Uncertainty Analysis for Nuclear Facilities and Sites, NUREG/CR-6805, prepared for U.S. Nuclear Regulatory Commission, Washington, D.C., 2003, and related work on Bayesian Model Averaging published in recent years.

Section E.3.3 states: "The averaged net infiltration for the thick-bedded unit is 27.1 centimeters per year, a value close to the 26.0 centimeters per year used by Yager (Yager 1987). The uniform infiltration into the unweathered Lavery till is 2.5 centimeters per year." It is entirely unclear how these values were obtained; there does not appear any data that would allow one (including Yager) to compute these rates independently of a groundwater flow model. Relying on Yager's calculation thus makes little sense considering that the DOE now possesses a more complete and comprehensive model of their own. Prescribing these unknown values deterministically (as if they were known) prejudices the outcome of the model, rendering it statistically biased and hence suspect. A much better approach would have been to compute recharge based on known distributions of water levels, hydraulic conductivities and seepage rates (preferably by treating these quantities probabilistically) and to assess flow rates into the Unweathered Lavery Till (ULT) as part of model calibration. It is likewise unclear how recharge was later modified as described in Section E.3.4.2; different sections of the report provide different and somewhat conflicting, as well as unclear, information, about this issue.

Section E.3.4.1 now provides statistical information about hydraulic conductivities, for example, "The 27 hydraulic conductivity data of the thick-bedded unit are lognormally distributed with a mean of 4.43×10^{-3} centimeters per second, and a median of 1.11×10^{-3} centimeters per second. The observed minimum and maximum values are 1.25×10^{-4} and 3.78×10^{-2} centimeters per second, respectively." None of these statistics, however, are utilized in a bona fide uncertainty analysis.

In Figure E-20 solid circles, previously undefined, have been replaced by well defined open circles. The corresponding text notes that "In instances where more than one hydraulic conductivity determination has been made, the arithmetic mean at that location is plotted." This is misleading because it reduces scatter.

In the same context, the 2009 version states: "The spacing of the fractures in the unweathered Lavery till could have an effect on the bulk hydraulic conductivity of the till and the appropriateness of both the laboratory- and field-determined estimates of that parameter. However, Prudic noted that, in the modeling efforts reported alongside the field results, application of these hydraulic conductivities resulted in best-fit-specific storages consistent with their experimentally determined values (Prudic 1986). This finding supports the use of Prudic's reported field and laboratory hydraulic conductivities for the unweathered Lavery till." What do we know about the sensitivity of Prudic's model to ULT hydraulic conductivities and their distribution range? I suspect not much, if anything. The DOE should therefore not rely on any but measured values of ULT conductivities in their groundwater flow and transport models.

The SWS hydraulic conductivity was increased by a factor of more than 10 relative to its 2008 values. I find it surprising that this appears not to have altered any of the model results.

To address IERT critique of how hydraulic properties have been assigned to the unsaturated zone in Table E-5, Section E.3.4.3 now states that "The establishment of this table (Pantex 2004) stems from earlier statistical characterizations by soil type as documented in the EPA RETC manual and code (EPA 1991)." Regardless of what may be documented in the cited manual and code, the IERT critique stands.

As stated in the opening sentence of Section E.3.5, the site-wide model has been calibrated both manually and using the automatic calibration code PEST. Just like in 2008, I am unclear as to why most of the results quoted in the 2009 FEIS are those corresponding to the manual and not the PEST calibration; the latter would have been more objective and would have provided statistics of parameter estimation errors; no such statistics have been listed in the 2009 FEIS. The newly expanded sub-section on Automated Calibration on p. E-48 fails to resolve the mystery. The section lists computed travel times that differ somewhat from those obtained in 2008, suggesting that some additional calibration using PEST must have been performed in the meantime. Yet most results given the 2009 FEIS appear to be those of the original manual calibration reported upon in 2008.

Figure E-21, showing the locations of calibration target wells in each layer, is a welcome new addition to the 2009 FEIS.

Analysis of site-wide groundwater flow modeling results on pp. E-60 through 64, including Figures E-31 and E-34, is largely new. The analysis reflects incorrect understanding and modeling of the regional flow system, as noted earlier.

Streamlines shown in cross-sections on Figures E-31 and E-32 are said to be planar projections of a three-dimensional pattern; why not present fence diagrams, or at least cross sections normal to those in the present figures, in order to illustrate more clearly what the three-dimensional flow pattern may look like?

Section E.4 of Near-field Groundwater Flow Models is now much more extensive than it was in 2008. The section provides considerable verbal, tabular and graphical detail about the extent of each (north and south plateau) model geometry, components, parameters and computational results. Unfortunately, no figures are included to indicate the extent and location of engineered barriers; such figures would have been extremely helpful. The area covered by the north-plateau groundwater flow model has been expanded as illustrated in Figure E-35. The following key IERT concerns remain: (a) The ULT is assigned a uniformly low hydraulic conductivity value, without considering the possibility that shallow hydraulic conductivities within it, immediately below hydraulic barrier walls, may be locally much higher; (b) the effect of pumping by resident farmers and/or erosion on groundwater flow under various future scenarios is not modeled; (c) the manner in which transport is modeled using the STOMP code is not described in sufficient detail (What source/boundary terms were applied where and why? What dispersivity values were assigned and why? Were these transient or steady state transport calculations? If transient, why is time not specified for all results? Why are results for long time frames not given? Why are values in Table E-11, associated with fixed geoprobes, said to represent center of mass?); (d) the manner in which groundwater flow modeling results would be translated into one-dimensional flow tube velocities for purposes of transport computations in Appendix G remain, despite a vague effort to explain on p. E-78, obscure and unconvincing to this reader.

As stated on p. E-67, "For the near-field flow models, the Brooks-Corey relation (Bear 1972) was used to represent the dependence of pressure and hydraulic conductivity on moisture content. Values of the bubbling pressure (h_b) and pore size distribution (λ) parameters of the relation presented in **Table E–8** were selected to match the soil textures of the units and to provide consistency with the relations used in the sitewide groundwater flow model." It is not clear why the van Genuchten model was used in the site-wide model (Section E.3.4.3) and the Brooks-Corey model in the near-field models. The IERT has raised questions about the validity of the way the DOE had estimated van Genuchten model parameters on the basis of saturated hydraulic conductivities (see earlier discussion); rendering the Brooks-Corey model parameters consistent with the former (as stated) would open them to the same criticism.

According to p. E-67, "… near-field model were developed further into three variants, the first developed for historical conditions as appropriate for the No Action Alternative, the second incorporated engineered features as appropriate for the Sitewide Close-In-Place Alternative, and the third incorporated the slurry walls present for the Phased Decisionmaking Alternative." The nature and extent of engineered features modeled in the case of each variant remain unclear. For example, since Phase 2 of the Phased Decisionmaking Alternative has not been defined, why is a slurry wall mentioned in this context, but no other engineered features? Figures showing excavations and engineered features associated with each variant would be most helpful.

<u>Answer re Appendix G</u>

I have not been able to identify any notable change in the 2009 Appendix G, Models for Long-term Performance Assessment, relative to its 2008 version.

Following is a list of a few minor modifications I found in the 2009 version (all page numbers refer to the 2009 version):

Reference to uncertainty assessment has been dropped from the bottom of p. G-3.

Section G.2.2 has been subdivided into a larger number of subsections than in the 2008 version. No new material of note has been added.

The first paragraph on p. G-11 now ends with a new sentence: "The groundwater is assumed to completely mix in the surface water."

The second paragraph on p. G-14 now speaks of three release modules; previously the text spoke mistakenly of four modules.

Figure G-4 identifies a few system components than have not been identified in the previous version of the same figure.

Paragraph just above equation G-37 no longer contains a (mistaken) reference to forward differences.

The lowermost paragraph on p. G-23 contains the following addition: "For the Close-In-Place Alternative, flow rates through the tank are low due to the presence of grout; the radial distribution of concentration of contamination may be important in determining rate of release; and flow in the horizontal direction may dominate over flow in the vertical direction. In this case, use of the cylindrical geometry, finite difference release model is appropriate." I find this newly added justification for cylindrical geometry in the presence of assumed uniform flow around the tanks unconvincing. Such assumed uniform flow is now indicated at the bottom of a revised Figure G-10.

The first paragraph of Section G.3.3 on p. G-26 contains a new sentence, "The value of groundwater velocity used in the flow tube model is derived from the three dimensional groundwater models described in Appendix E." As noted in my comments on the new Appendix E it contains an extremely brief, unclear and unconvincing explanation of a single example claimed to explain how results from Appendix E are translated into one-dimensional flow tube velocities in Appendix G.

<u>Answer re Groundwater Aspects of Appendix H</u>

The 2009 version of Appendix H appears to be an expanded version of its 2008 counterpart. The following comments are limited to aspects of Appendix H concerning groundwater flow and transport.

On p. H-21 the new Appendix H states: "The sitewide and near-field flow models used to develop this description of groundwater flow conditions are described in Appendix E. In that appendix, results of solute transport simulations with three-dimensional models indicated that plumes originating from given locations on the North Plateau followed nearly direct paths to points of discharge (Figures E–38 and E–39). In addition, one-dimensional simulation of concentration of strontium-90 in the North Plateau Groundwater Plume provided a reasonable match with the results of three-dimensional transport simulation and with measured concentrations along the centerline of the plume. On this basis, one-dimensional groundwater flow models were selected for human health impacts analysis. The value of longitudinal dispersivity is 1/10 of the distance from the source to the point at which a receptor contacts the groundwater for all sources except for the North Plateau Groundwater Plume for which the value of 5 meters determined by comparison to data (see Appendix E) is used. In addition, the one dimensional model introduces an element of conservatism by ignoring lateral dispersion that reduces downstream concentrations in the field."

This is an unsuccessful attempt on the part of the DOE to counter IERT's previous critique of the one-dimensional flow-tube approach to groundwater transport modeling in the EIS. The DOE counter argument is extremely weak:

a) Figures E-38 and E-39 of the FEIS show model cross-sections, not plume transport paths. I was not able to find any figure in the FEIS showing plume transport paths in three dimensions.
b) It is not clear what is meant by "plumes originating from given locations on the North Plateau followed nearly direct paths to points of discharge." Does "direct" mean "straight?" If so, this statement is clearly contradicted by Figure E-43 which shows the horizontal projection of a plume curving at the upper-right corner of the waste tank farm.
c) The fact that one-dimensional simulation of concentration of strontium-90 in the North Plateau Groundwater Plume provided a reasonable match with the results of three-dimensional transport simulation and with measured concentrations along the centerline of the plume is not a sufficient justification for the selection of one-dimensional groundwater flow models to analyze human health impacts. Once a three-dimensional plume transport picture is developed, one can always manipulate (calibrate) one-dimensional models to conform to some (but almost never all) aspects of this picture. It is highly unlikely that such a one-dimensional model would predict correctly three-dimensional transport under conditions other than those against which it has been so calibrated. Nowhere does the FEIS demonstrate otherwise, certainly not for the variety of scenarios analyzed in the document.
d) The DOE argument, that their one dimensional models introduce an element of conservatism by ignoring lateral dispersion that reduces downstream concentrations in the field, is not valid. Ignoring lateral dispersion ignores lateral spreading of a plume into areas not previously contaminated by this plume. Doing so requires increasing longitudinal dispersivity (not done by the DOE) which causes the plume to reach downstream points faster than it would otherwise. Neither effect is conservative.

What is the reason on p. H-23 of the revised Appendix H that "Flow control structures identified in the preliminary closure designs in the Sitewide Close-In-Place Alternative Technical Report (WSMS 2009) but not considered in this performance assessment include the upgradient barrier wall designed to redirect groundwater flow from the north plateau circumferential slurry wall, the surface drainage from the multi layered caps on the north and south plateaus, and the geomembrane layer in the multi-layered caps on the north and south plateaus?" Why have these engineered barriers not been considered in the long-term performance assessment? Have they been dropped?

What is the basis for the statement on p. H-56 of the revised Appendix H that "the various engineered features that would be put in place around and above (for example) the NDA and SDA would be little affected by the cessation of maintenance" if institutional controls fail?

On p. H-76 Appendix H addresses, in a single paragraph, the issue of integrated groundwater and erosion modeling. The revised appendix now argues that "At the present time, integrated models of groundwater releases and erosion releases are beyond the state-of-the art. This question of the effect of erosion on the performance of hydrologic barriers is addressed in sensitivity studies in the following section. However, peak annual dose impacts to offsite receptors are about 4-6 times greater in the erosion scenarios than they are in the groundwater release scenarios for the Sitewide Close-In-Place Alternative, but erosion peaks occur later. In this case, one would not expect much difference in the results of an integrated model. For the No Action Alternative, the dose to offsite receptors from the erosion scenarios ranges from about 8-14 times the groundwater release scenarios, but the peaks occur in comparable timeframes and from different waste management areas. In this particular case, one might expect an integrated model to predict doses that are additive of the two individual results."

Although it may be true that predicting the effect of groundwater flow on erosion may be beyond the current state-of-art, the reverse is not true: it should be relatively straightforward to predict the impact of known/assumed erosion (say the development of gullies) on groundwater flow. The DOE has elected to prejudge this impact rather than to predict it by modifying their groundwater flow and transport models to account for erosion. There does not appear to be any technical justification for doing so. The same comment pertains to Section H.3.4 on Erosion Damage of Groundwater Flow Barriers.

Section H.2.3 now acknowledges that "it is not possible to do a long-term performance assessment for the Preferred Alternative, because the ultimate disposition of various areas of the site is not known." This issue was not discussed explicitly in the 2008 DEIS. On p. H-77 the revised Appendix H now concludes, based on qualitative arguments, that "The Phase 1 removal actions for the Main Plant Process Building, the Vitrification Facility, and would [*sic*] result in minimal lagoons long-term impact from residual contamination in these areas. The impacts from the North Plateau Groundwater Plume will peak around the year 2045 and are not sensitive to Phase 2 decisions. Long term impacts from the Waste Tank Farm, the NDA, and the SDA depend on the Phase 2 actions and are expected to be bounded by results already calculated in the Sitewide Removal, Sitewide Close-In-Place, and the No Action Alternatives."

This argument does not sound convincing enough to resolve the question I asked in my review of the 2008 DEIS (which has been skirted in the 2008 IERT report): In what way could a long-term performance assessment that does not explicitly consider the Phased Decisionmaking Alternative contribute to its consideration in selecting among the four alternative remedial strategies?

2) Does the 2009 FEIS address the recommendations provided in Section 6 (Conclusions and Recommendations) of the 2008 IERT Report in regard to groundwater flow and contaminant transport modeling? Please explain.

Answer

The 2008 IERT report included the following conclusions and recommendations regarding **Groundwater Flow and Contaminant Transport**:

Conclusion: The general approach to groundwater flow and transport modeling described in Appendix E is acceptable but could be improved. In addition, the linkage between the 3D models in Appendix E and the 1D models used in the LTPA (as described in Appendix G) is not adequately demonstrated in the 2008 PDEIS.

Comment: This conclusion remains valid.

Recommendation: *Future modeling should evaluate uncertainties associated with, for example, alternative conceptual models for site scale flow, effects of transient changes, incomplete characterization of material properties of hydrogeologic units, and local-scale processes associated with engineered barriers. The EIS should also demonstrate that the 1D models in Appendix G are derived from and supported by the 3D models presented in Appendix E.*

Comment: The DOE has not followed any of these recommendations in their 2009 FEIS with one exception: Appendix E now contains a new paragraph purporting to address the second of the above recommendations. As explained elsewhere, the paragraph goes a very short way toward demonstrating that the 1D models in Appendix G are derived from and supported by the 3D models presented in Appendix E

Conclusion: The groundwater flow and transport models developed to support the 2008 DEIS are suitable for probabilistic analyses; this capability is important to providing insights about uncertainties, but was not used in the LTPA

Comment: This conclusion remains valid.

Recommendation: *Future analyses, for example, in support of phased decision-making, should include quantitative uncertainty analyses.*

Comment: This recommendation has not been followed.

Conclusion: Some aspects of the implementation of groundwater flow and contaminant transport modeling are inadequately justified and some appear nonconservative.

Comment: This conclusion remains valid.

Recommendation: *Future analyses should include improved documentation, additional justification of technical bases, and nonconservatisms should be identified and removed, preferably in favor of realistic treatments of uncertainty*.

Comment: This recommendation has been followed to a minimal extent: the 2009 FEIS attempts to provide, with only minimal success, some additional documentation and justification for the approach taken toward groundwater flow and transport modeling in the EIS.

The 2008 IERT report included the following conclusions and recommendations regarding **Uncertainty Analysis and Transparency**:

Conclusion: Overall, the LTPA does not provide a useful estimate of uncertainty in long-term performance associated with any of the proposed actions identified in the 2008 DEIS. The deterministic results provided from the LTPA are likely to be nonconservative and are not a suitable substitute for an uncertainty analysis.

Comment: This conclusion remains valid.

Recommendation: *Future analyses should include quantitative uncertainty analyses. The LTPA would benefit from including a full uncertainty analysis that includes reasonable and realistic ranges of values associated with the uncertainties of the following:*

- *The time-dependent physical and chemical properties of engineered barriers*
- *The rate and location of gully erosion at all locations, including on the North Plateau, and including uncertainty in extreme weather conditions*
- *Boundary conditions and material properties affecting groundwater flow*
- *Parameters used to characterize contaminant transport in ground and surface water*
- *The radionuclide inventory associated with each source term*
- *Biosphere pathway assumptions*
- *Future climate states and the impact of that uncertainty on erosion and groundwater flow.*

Comment: This recommendation has not been followed.

Conclusion: Transparency of the LTPA is poor, and it is not possible to replicate independently the analyses or to otherwise understand how the results were derived. Given these observations, quantitative results of the LTPA presented in Chapter 2, Chapter 4, and Appendix H should not be used to support decision making associated with the 2008 DEIS.

Comment: This conclusion remains valid with the exception of a few clarifications, some inadequate and unconvincing, included in the 2009 version.

Recommendation: *Future analyses should include improved documentation and transparency regarding the analytical approach and key assumptions for each alternative.*

Comment: This recommendation has been followed to a minimal extent: the 2009 FEIS attempts to justify the choice of a deterministic approach using invalid arguments. Transparency has been improved to a minimal extent.

3) Were the changes, if any, in Appendix E incorporated into the long-term performance assessment approach as described in Appendix G?

Answer:

Appendix G remains, for all practical purposes, unchanged.

4) If changes in the approach to groundwater flow and contaminant transport modeling and prediction were made, do the changes make the 2009 FEIS results more reliable and defensible, less reliable and defensible, or about the same, as compared to the 2008 DEIS? Please explain.

Answer:

There were no substantive changes in the approach to groundwater flow and contaminant transport modeling and prediction in the 2009 FEIS as compared to its 2008 version. Results of the 2009 version are not any less, nor any more, reliable and defensible, in this respect, than those of the 2008 DEIS. My answer to this question follows from those to the previous questions.

Additional Questions

Considering that the purpose of an environmental impact statement is to, among other things, 1) provide full and fair discussion of significant environmental impacts and inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment, and 2) be used by officials in conjunction with other relevant material to plan actions and make decisions:

5) Are the groundwater modeling predictions presented in the 2009 FEIS supported by an adequate scientific basis such that they can be used to quantify radiological or other impacts to human receptors on and near the Center for 100,000 years (e.g., see DEIS Figure H-14). Please explain why or why not.

Answer:

No, for all the reasons enumerated in the 2008 IERT report. The 2009 FEIS does not resolve adequately any of the issues noted in the 2008 IERT with respect to groundwater flow and transport modeling under uncertainty.

6) Are the dose predictions, other results, and comparisons of the alternatives in the 2009 FEIS presented with adequate consideration of groundwater flow and contaminant transport modeling uncertainties (e.g., Section 4.1.10 of Chapter 4, Appendix H, and the discussions of uncertainties in Section 2.8 of Chapter 2 and incomplete and unavailable information in Section 4.3 of Chapter 4)? Please explain.

Answer:

Uncertainties have been noted but not quantified in the 2009 FEIS. Section 2.8 of Chapter 2 argues, unconvincingly, that "Uncertainty associated with analytical methods and the use of new technologies has been accommodated in this EIS by making conservative assumptions in the environmental impact analysis."

7) Do you have additional recommendations or comments in regard to the information presented in the 2009 FEIS on groundwater flow and contaminant transport?

Answer:

The 2009 FEIS is an expanded version of its 2008 counterpart. As far as groundwater flow and transport under uncertainty are concerned, there are no substantive differences between the two versions. All conclusions and recommendations in Chapter 6 of the 2008 IERT report with regard to these issues remain valid.

COST BENEFIT ANALYSIS (Drs. Michael T. Ryan and Chris G. Whipple)

1) **Has there been a significant change in the approach for the EIS cost-benefit analyses when comparing the 2009 FEIS to the 2008 DEIS? [See Section 4.2 of Chapter 4, Section 2.6.3 of Chapter 2]. If so, please provide a summary of the changes.**

The comments in response to this question are primarily based on pages 2-63 through 2-75 (Chapter 2 Section 2.6.2).

FEIS Sections 2.6.2. (Long term impacts) and 2.6.3 (Cost benefit analyses) provide a summary of the four decommissioning alternatives, cumulative radiation exposures expressed in person-rem (Table 2-4) and cost estimates (Table 2.5).

The financial metric expressed in the footnote of Table 2-5 is expressed as follows:

"The cost-benefit analysis presented in this EIS is intended to increase the utility of the document to NRC. The analysis was performed for all alternatives assuming real discount rates ranging from 1 to 5 percent. The range for the Sitewide Removal Alternative also reflects two assumptions for disposal of Greater-Than-Class C (GTCC) waste – i.e., $2,300 per cubic foot and $21,000 per cubic foot. For the Phased Decisionmaking Alternative, the minimum cost effectiveness value reflects the assumption of in-place closure for Phase 2 and a discount rate of 5 percent; the maximum cost value reflects the assumption of removal for Phase 2, a discount rate of 1 percent, and a GTCC waste disposal cost of $21,000 per cubic foot. The values in the table all reflect the assumption of continued institutional controls."

This footnote indicates that different estimating assumptions are made for the different alternatives. It is not clear how one can then make comparisons across alternatives. The cases and metrics are given as:

1. *"Sitewide Removal Alternative -- The discounted cost per avoided person-rem is estimated to range from about $420,000 to $1,400,000.*

2. *Site Wide Closure in Place – The incremental discounted cost per avoided person-rem (incremental cost effectiveness) is estimated to range from about $88,000 to $1,200,000.*

3. *Phased Decision-making Alternative (phase 1 only) - - The cost effectiveness of this alternative would be driven primarily by the Phase 2 decision. If the Phase 2 decision is timely removal of the remaining Waste Management Areas (WMAs), the incremental cost-effectiveness could range up to $1,400,000. If the Phase 2 decision is timely in-place closure for the remaining WMAs, the incremental cost-effectiveness could be as small as $240,000."*

These three Alternatives are evaluated with a "collective dose avoided" metric and different discount rates. They are all indexed to the No Action Case in a way that is not transparent. The *metric of discounted cost per person rem avoided versus the No Action Alternative case is difficult to understand and does not provide useful risk insights. Collective dose is NOT a good metric for risk. It ranks trivial doses and dose rates the same as significant doses and dose rates. If you accept the metrics and numbers, it seems to imply that all three alternatives have roughly the same costs relative to the No Action Alternative as a baseline. This does not seem to be a reasonable conclusion.*

Section 2.6.4, lines 1820-1823, presents a "…comparison of the alternatives and illustrates the nature of the environmental tradeoffs between decommissioning and post-decommissioning impacts. This discussion also points out how the differences among the alternatives influence the magnitude and location of the decommissioning impacts (which would occur within 60 years) as well as the location of the post-decommissioning impacts (which would occur over thousands of years)…."

Other specific points

Lines 1796-1801 state: " If institutional controls were lost and there were intruders into the industrialized area, there could be a small to very large annual dose (less than 1 millirem to 400 rem) to intruders assumed to exhume contamination from construction activities, consume food from gardens containing contaminated soil, or use untreated water from contaminated wells. The peak dose varies depending on the intruder activities and the onsite locations where the activities may occur. Assuming unmitigated erosion, onsite residents and hikers could receive a moderate to large peak annual dose (130 millirem)".

1. *If it is 400 rem per year, this needs further explanation and discussion. Individuals receiving doses of 1 plus rem per day for a few years are likely certainly going to be debilitated. Such a dose regime is likely lethal. This same number appears In Table 4.23 Summary of Long-Term Health Consequences without comment. It would be useful to know what assumptions and parameters are driving the doses so high.*

Line 1824-1835 - The discussion of the Sitewide Removal Alternative would be enhanced by the inclusion of the range of doses estimated to workers and members of the public. The reason is ascribed to exposure during transport using truck versus rail. This difference is truck driver dose can be lowered significantly by using in cab shielding! Assuming drivers are exposed at or near the cab limit is a bad assumption. What fraction of these collective doses is accrued by workers versus members of the public should be clarified. The standards for both are different. This is just one example of a lack of clarity in the risks and the individuals or groups to whom they accrue.

Lines 1830-1831 states: "Transporting this waste is estimated to result in 10 to 15 transportation fatalities from truck and rail transportation" is based on all categories of transportation". Nuclear transportation has a much better record than that. It should be clear that this is an overestimate perhaps taken from more generic transportation accident rates.

2) **Does the 2009 FEIS address the recommendations provided in Section 6 (Conclusions and Recommendations) of the 2008 IERT Report in regard to cost-benefit analysis? Please explain.**

No for the reasons stated in response to questions 4 and 5 below. Additionally the use of collective dose does not provide insights in risk and therefore makes judging cost-benefit more difficult.

3) **Is the approach for cost benefit analyses consistent with relevant regulations and guidance?**

This is beyond my expertise to answer completely. I can say that from an impacts perspective collective dose without some summary of how these numbers were developed falls short of demonstrating compliance with radiation protection guidance in my view and falls short of assessing risks.

It would be useful to provide details on how worker doses and doses to members of the public were calculated and accumulated into collective dose numbers for all relevant scenarios. I am not satisfied that there is enough information to address this question.

<u>Additional Questions</u>

4) **Is the cost benefit analysis in the 2009 FEIS presented with adequate consideration of uncertainties in release, transport, and uptake modeling, dose prediction and cost estimating?**

No. As noted above there are many places where risk insights could have been gained but bounding assumptions were selected instead. This lack of well developed risk insights is coupled with a metric collective dose that is not capable (without a lot of supporting information) of allowing any significant insights into risks. The use of collective dose as a cost metric creates a result that is not transparent and seems to indicate that all of the alternatives to the no action case have about the same (overlapping) cost ranges using this metric a noted in Table 2.5

5) **Do you have additional recommendations or comments in regard to the information presented in the 2009 FEIS on cost benefit analysis?**

Yes, filling in the following table (particularly the far right column) with data would be a very useful way to better understand risks and benefits of each alternative in a transparent way. Table 4-23 through Table 4-28 provide a start on information that does give some risk insights that could be use to provide better risk information radiation dose.

Alternative	Dose to workers based on realistic time and motion studies	Dose to members of the public	Detailed costs for each alternative
No Action	Provide dose estimates by worker type and provide both total effective dose equivalent (TEDE) by year and collectively by work activity	Provide dose estimates (mean values and distributions) to representative members of appropriate groups of the effected public for in the near field (close to the facility) and far field (further away from the facility)	Total costs developed from a work breakdown structure at the level of major tasks as a function of time and with clear cost of money assumptions
Sitewide Removal Alternative	Provide dose estimates by worker type and provide both TEDE by year and collectively by work activity	Provide dose estimates (mean values and distributions) to representative members of appropriate groups of the effected public for in the near field (close to the facility) and far field (further away from the facility)	Total costs developed from a work breakdown structure at the level of major tasks as a function of time and with clear cost of money assumptions
Sitewide Closure in Place	Provide dose estimates by worker type and provide both TEDE by year and collectively by work activity	Provide dose estimates (mean values and distributions) to representative members of appropriate groups of the effected public for in the near field (close to the facility) and far field (further away from the facility)	Total costs developed from a work breakdown structure at the level of major tasks as a function of time and with clear cost of money assumptions
Phase Decision Making Alternative	Provide dose estimates by worker type and provide both TEDE by year and collectively by work activity	Provide dose estimates (mean values and distributions) to representative members of appropriate groups of the effected public for in the near field (close to the facility) and far field (further away from the facility)	Total costs developed from a work breakdown structure at the level of major tasks as a function of time and with clear cost of money assumptions

TREATMENT OF UNCERTAINTY IN THE LONG-TERM PERFORMANCE ASSESSMENT (Drs. Michael T. Ryan and Chris G. Whipple)

1) **Has there been a significant change in the treatment of uncertainty in the long-term performance assessment when comparing the 2009 FEIS to the 2008 DEIS? [See Section D.3.2.3 of Appendix D, Appendix H, Section 2.8 of Chapter 2, and Section 4.3 of Chapter 4]. If so, please provide a summary of the changes.**

No, there have been no significant changes.

The discussion points quoted below are the ONLY places where the word "uncertainty" appears in Appendix H, Chapter 2 Section 2.8

Appendix H

D 3.2.3 "As a second step, literature of sensitivity and uncertainty analysis was reviewed to survey the current understanding of model sensitivity and uncertainty. The next step comprised review of site-specific environmental conditions, closure designs, and models to select a set of sensitivity cases. Results of deterministic sensitivity analysis are presented in Appendix H of this EIS."

From Appendix H "Long-term Performance Assessments"

Lines 323-326. "Inventory estimates were developed for the various waste management areas. In many cases, there were multiple estimates developed reflecting the <u>uncertainty</u> in the inventory. When there were multiple estimates, one of the more conservative (i.e., larger) inventory estimates was used in the analysis. Estimates of radiological and chemical constituent inventories are presented in Appendix C."

Lines 490-494. "Monitoring and maintenance activities could slow down the erosion rate while human intrusion activities that change the ground cover or local topography could locally accelerate erosion. The development and use of such predictions for establishing estimates of long-term environmental consequences along with the disclosure of <u>unquantifiable uncertainty</u> due to unpredictable future human actions is consistent with NEPA requirements."

Lines 490-493. "Monitoring and maintenance activities could slow down the erosion rate while human intrusion activities that change the ground cover or local topography could locally accelerate erosion. The development and use of such predictions for establishing estimates of long-term environmental consequences along with the disclosure of <u>unquantifiable uncertainty</u> due to unpredictable future human actions is consistent with NEPA requirements.

Lines 494-499. "Surface Water Transport. The EIS makes the conservative assumption that there is no contaminant removal from surface waters as the contaminated water flows downstream. In reality some removal will occur depending on the chemical from of the contaminants and the minerals and plants in the stream channel. In addition, <u>the EIS assumes no dilution of</u>

Cattaraugus Creek water as it flows from its discharge into Lake Erie to the Sturgeon Point intake structure because of the uncertainty and variability of the flow between the two points".

Lines 1321-1326. "Estimation of human health impacts depends in a complex manner on geologic and environmental conditions, facility closure designs, the structure of models used to represent these conditions and features and the values of parameters used in the models to characterize the conditions and features. These conditions and features may not be well known or have variability over space and time that contributes to uncertainty in estimates of health impacts. In this section, deterministic sensitivity analysis is used to provide insight into the potential range of uncertainty in estimates of health impacts."
Chapter 2

Lines 1552-1555, "Uncertainty was addressed by performing multiple analyses (e.g., alternate disposal configurations, alternate transportation modes, institutional control continuance and loss) and using conservative assumptions that were consistently applied to all alternatives. This approach was performed in a manner intended to avoid bias in the comparison of alternatives."

Lines 1943-1949, "2.8 Uncertainties Associated with Implementation of the Various Alternatives"

"Implementing any of the project alternatives involves some amount of uncertainty. For example, there is uncertainty related to the availability of waste disposal capacity for some classes of waste expected to be generated under the different alternatives. Also, there is some uncertainty involved with the availability of technologies needed to implement the alternatives. These uncertainties are discussed in greater detail in the following sections. Uncertainty associated with analytical methods and the use of new technologies has been accommodated in this EIS by making conservative assumptions in the environmental impact analysis."

Lines 1950-1955, "2.8.1 Consequence Uncertainties- Chapter 4, Section 4.3, of this EIS presents a discussion of incomplete and unavailable information that introduces uncertainty into the consequence analyses. The areas affected include human health occupational exposure), transportation, waste management (waste quantities and disposal options), and long-term human health. The uncertainties associated with incomplete and unavailable information related to these areas are summarized in this section."

Lines 1966-1974 2.8.1.2, "Transportation Information that is incomplete or unavailable includes the following: (1) more-detailed information on the distribution of radionuclides in the packaged waste, particularly the gamma emitters; (2) the radiation dose from the waste package shipment arrays; (3) the specific transportation route; and (4) more-precise information on how the waste would be shipped (by truck, rail, or some combination of truck and rail). The uncertainty related to the lack of this information is addressed through the use of conservative assumptions related to waste package inventory and surface dose rate and the fact that no credit is taken for the decay of the gamma emitters that are expected to control the dose. Uncertainty about disposal locations was addressed by considering two different waste disposal options (DOE/Commercial and Commercial) and different disposal sites for the low-level radioactive waste."

1975-1988 2.8.1.3 "Waste Volumes- The waste management analysis has two areas of uncertainty due to incomplete or unavailable information: (1) the volumes and characteristics of waste that would be generated by each alternative and (2) the availability of disposal capacity for all waste, particularly commercial low-level radioactive waste (Class B and C), Greater-Than-Class C waste, transuranic waste, and high-level radioactive waste. The uncertainty related to the volumes and characteristics of the waste is principally related to the amount of site characterization data available. While some soil characterization data do exist, much of the soil volume assumed to be excavated for the Sitewide Removal and Phased Decisionmaking Alternatives is based on process knowledge and operational history. The actual volumes to be exhumed could be smaller or greater than the assumptions in this EIS. Based on the above and the challenge of estimating exact volumes of water that would require treatment during excavation of soils and buried wastes, there would also be uncertainty associated with the volume and characteristics of wastes resulting from water management/treatment during excavation activities. The Phased Decisionmaking Alternative allows for some uncertainty in that additional actions could be analyzed and implemented as part of Phase 2 activities."
NOTE: THIS IS AN EXAMPLE OF A REASONABLE APPROACH TO DEFINING UNCERTAINTY AND RESOLVING OVER TIME

2.8.1.5 Long-term Human Health

Lines 2031-2034, "To accommodate the uncertainty associated with this incomplete or unavailable information, ***conservative assumptions*** *are used in the analysis, as presented in Chapter 4, Section 4.3.5, of this EIS. Appendix H further addresses uncertainties associated with the long-term impact analyses."*

Lines 2016-2111, "2.8.2.6 Performance of Engineered Hydraulic Barriers and Covers"

"There is uncertainty about the long-term performance of other engineered barriers, including multi-layered covers, waste grout, and hydraulic barrier walls. Hydraulic factors, such as mounding and groundwater bypass, and other aspects, such as long-term durability could potentially impact the long-term performance of hydraulic barrier walls designed to keep subsurface contaminants from migrating off the site. Long-term performance of closure caps can be affected by erosion and differential settlement that increases the permeability of the engineered covers. ***These hydraulic factors are mitigated in the analysis by use of conservative assumptions****."*

The text in the box under Section 4.3.5 seems to sum things up well.

The NYSERDA View Indicates….

"The Revised Draft EIS does not address uncertainty in a manner that provides decision-makers with information about the critical contributors to uncertainty or the importance of uncertainty in site cleanup decisions. In particular, NYSERDA is of the opinion that assertions of conservatism in analyses and assumptions in the revised Draft EIS are not adequately supported, and that the long-term analysis is not presented in enough detail or with enough clarity to be properly understood or independently replicated."

DOE's Response….(nothing given)

Observation:

All the examples above indicated that conservative assumptions seem to be the path forward to address many uncertainties. Such compounded conservative assumptions do not do a very good job of assessing risk and can in fact mask risks. Values that are selected as a central tendency for a given parameter and then evaluated out that central tendency do a better job of provided risk insights. This approach could be considered as part of the risk analysis.

2) **Does the 2009 FEIS address the recommendations provided in Section 6 (Conclusions and Recommendations) of the 2008 IERT Report in regard to the treatment of uncertainty in the long-term performance assessment? Please explain.**

   No, the treatment of uncertainty in many cases has not been performed as noted in the examples above.

3) **If changes in the approach to the treatment of uncertainty in the long-term performance assessment were made, do the changes make the 2009 FEIS results more reliable and defensible, less reliable and defensible, or about the same, as compared to the 2008 DEIS? Please explain.**

   If the uncertainties in the predicted outcomes of costs, dose to workers dose to members of the public and time to complete various options for decommissioning were risk-informed the resulting EIS would, in my opinion, be more reliable.

<u>Additional Questions</u>

4) **Are the dose predictions, other results, and comparisons of the alternatives in the 2009 FEIS presented with adequate consideration of modeling and other uncertainties (e.g., Section 4.1.10 of Chapter 4, Appendix H, and the discussions of uncertainties in Section 2.8 of Chapter 2 and incomplete and unavailable information in Section 4.3 of Chapter 4)? Please explain.**

Section 4.1.10 Long-term Human Health

This section provides a summary table 4.23 "Summary of Long-Term Health Consequences". It, along with following tables throughout the Section, provides information on individual and collective annual doses for various critical groups and end states analyzed. It falls short in that this information does not have any uncertainty analysis associated with it. Further it does not have any information regarding the means or distributions of dose estimates for the critical groups or individuals.

Appendix H provides parametric sensitivity studies as follows:

Table H–70 Dependence of Infiltration through an Engineered Cap on Values of Hydraulic Parameters

Table H–71 Dependence of Onsite Resident Farmer Peak Annual Dose on the Value of Technetium Distribution Coefficient for Groundwater Release from Tank 8D-1

Table H–72 Summary of Flow Conditions for Waste Tank Farm Slurry Wall Sensitivity Analysis

Table H–73 Summary of Peak Annual Dose Estimates for Waste Tank Farm Slurry Wall Sensitivity Analysis

Table H–74 Predicted Conditions for the North Plateau Three-dimensional Near-field Groundwater Flow Model, Slurry Wall Sensitivity Analysis

Section H.3 "**Sensitivity Analysis"** provides information in Table that assesses deterministic impacts on various parameters Tables H-71 and 73 provide dose data. Table 71 indicated that for a change by a factor of 74 in "Distribution Coefficient of Technetium *in Grout (milliliters per gram)*" the change in the Peak Annual Dose (millirem per year) range over a factor of 10 for drinking water 27 for gardening and 8 for the combined intake from water and garden food at dose level in the range of 10 to 883 mrem per year. This is an important risk insight for technetium in the farming scenario. The larger the distribution coefficient the better and one that is 7 or greater produces doses that are in the 100 mrem/year range give that all the other parameters in the scenario are correct. This is a useful risk insight. Other tables in this section are titled.

Similarly, Table H–73 "Summary of Peak Annual Dose Estimates for Waste Tank Farm Slurry Wall Sensitivity Analysis" shows that there is little sensitivity between the cases of "No Erosion Damage to Slurry Wall" versus "Erosion Damage to Slurry Wall." Again this is a useful risk insight. These insights should be propagated collectively to develop insights for a realistic range of estimated doses and the parameters that impact the result. Probabilistic approaches rather than deterministic approaches are best suited for this task.

Table H–75 Flow Balance for the General Purpose Cell, Slurry Wall Sensitivity Analysis

It would provide useful risk insights to estimate how the variations in these parameters change estimates of individual dose to various receptors.

5) **Do you have additional recommendations in regard to the information presented in the 2009 FEIS on the treatment of uncertainty in the long-term performance assessment?**

   No.

Conclusions

1. **While improvements have been made in providing additional detailed information and improving some analyses by providing sensitivity study results, these efforts fall short of providing detailed risk insights into calculated doses to receptors in various scenarios evaluated.**

Recommendations

1. **Efforts should continue to add risk informed and uncertainty analyses that allow evaluation of alternative approaches to decommissioning in a more direct way.**

ENGINEERED BARRIER ASSUMPTIONS (Dr. Chris G. Whipple)

This review focuses mainly on Chapters 2 and 4, Appendices D, G, and H and the Sitewide Close-In-Place Technical Report.

1) **Has there been a significant change in the approach for engineered barrier assumptions when comparing the 2009 FEIS to the 2008 DEIS? [See Appendix D, Appendix E, Appendix F and Appendix H]. If so, please provide a summary of the changes.**

Most of the differences appear to be minor. For example, in Appendix D, Section 3.1.3 regarding the Residential Farmer Receptor, the 2008 report states that "presence of a 1- to 2-meter-thick (3.3- to 6.6-foot-thick) cap prevents direct contact with radioactive material." The 2009 document refers to a "3-meter-thick cap." Section D.3.1.3 includes the following:

> For this analysis, existence of the tank vault and placement of strong grout in the tank supports selection of a 500-year lifetime for the intruder barrier at the Waste Tank Farm (WSMS 2008). For other subsurface engineered barriers, including grouts, slurry walls, and tumulus drainage layers, a 100-year life is assumed. Specific engineered barrier parameters used for specific analyses are identified in Appendix H, Section H.2.2, of this EIS. Chemical properties of natural materials, such as adsorptive capacity, are, however, not expected to decrease with time, consistent with the long lifetimes observed for sand and clay formations in the environment (NRC 2000). Engineered disposal facilities include infiltration drainage layers and subsurface groundwater diversion structures that decrease productivity of wells inside the facility relative to wells located outside the facility. Because of the cap design incorporating large rock, it is reasonable to propose that wells under the Sitewide Close-In-Place Alternative be located outside the engineered barrier system for the Main Plant Process Building, the Vitrification Facility, the Waste Tank Farm (WTF), the NDA, and the SDA. The premise that properly selected, quarried, and placed rock can have long service life is supported by reference to analog sites for chemical weathering of rock and adherence to design and construction principles described in regulatory guidance (NRC 2002). The design thickness of the rock layers of the cap is approximately 1.14 meters (3.75 feet). Data from natural analogs include reported rates of weathering for the foreland boundary of a glacier of 1.6 millimeters per 1,000 years for gneiss surfaces and negligible weathering for quartz layers over approximately 9,700 years (Owen et al. 2007). The cap design is expected to consider both normal conditions and extreme events, and incorporate defense in depth of flow control and diversion structures to produce a robust design.

Tank and Vault Closure

In the 2008 DEIS, the close-in-place report and Appendices D and H were not consistent regarding what the tanks would be filled with. The description from the Close-In-Place Technical Report (below) is consistent with Appendix D. It appears that the tank closure approach has been modified to take advantage of work done on tank closures at Savannah River and Hanford. The closure plan is:

> The tanks and vaults would be filled to the height of the top of the tanks with CLSM, which contains sorbents and reducing materials to retard radionuclide migration. The CLSM mixture consists of Portland cement, fly ash, granulated blast furnace slag, phosphatic ore, and water. The blast furnace slag (reducing agent) and phosphatic ore (contains sorbent mineral, apatite) would limit the mobilization of long-lived radioactive isotopes, such as technetium, plutonium, uranium, and neptunium. The CLSM would also help to minimize subsidence, while its low compressive strength would allow future excavation, if necessary. The CLSM mixture would be placed as self-leveling slurry with a compressive strength of 50 to 200 lb/in^2 depending upon the application. Higher strength CLSM (200 lb/in2) might be used if future excavation is unlikely.
>
> The CLSM would be pumped simultaneously into the tanks and vaults, maintaining equivalent heights to prevent floatation of the tanks. Multiple pipes installed in the tank risers would be used to inject the CLSM. Tanks 8D1 and 8D2 would be filled with multiple lifts because of their size. Remote closed-circuit television (CCTV) cameras would be installed on the risers to monitor the progress of CLSM placement. Air displaced during the placement of CLSM would be routed through portable high efficiency particulate air (HEPA) ventilation units and portable gas monitors. Other miscellaneous tanks, ion-exchange columns, cooling coils, etc. in the subsurface of the WTF would be filled with CLSM using a grout pump and feed tube. The STS equipment inside of Tank 8D1 would remain in place and would be filled and encapsulated by CLSM. Spent zeolite would remain in the ion-exchange columns encapsulated by CLSM.

The report comments (Section H.3.3) "Grouts designed for stabilization of the tanks include fly ash material that is expected to reduce the valence state of technetium producing a precipitate with low solubility as well as sorbents designed to retain radionuclides by physical and chemical bonding." While no reference for this claim is provided, some success has been demonstrated in reducing the mobility of technetium by using apatite.[2] The Sitewide Close-In-Place Technical Report for 2009 indicates that apatite would be used in the mixture used to fill the tanks and vaults. Table 3-1 of the Sidewide Close-In-Place Technical Report lists the consumable materials associated with that alternative. The table indicates that 649 cubic yards of apatite would be used under the close-in-place alternative. The table in the 2008 report did not indicate that any apatite would be used.

In a study of technetium chemistry by scientists at Lawrence Berkeley Lab,[3] experiments regarding the chemical form of technetium in cementitious materials were performed. The study notes the results:

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[2] http://www.envirofacs.org/Pre-prints/Vol%2042%20No%201/General/aqueous/p129.pdf

[3] http://escholarship.org/uc/item/1px5g3ps Final Report, Research Program to Investigate the Fundamental Chemistry of Technetium, Lukens Jr., Wayne W., Fickes, Michael J., Bucher, Jerome J., Burns, Carol J., Edelstein, Norman, M.Shuh, David K., 12-23-2000.

> At the Savannah River Site, technetium is currently placed in a cementitious waste form that consists of a mixture of fly ash, blast furnace slag (BFS) and Portland cement plus the decontaminated supernate from the high level waste tanks (Langton 1988, Langton 1989). A similar waste form has been previously proposed for the Hanford site.
>
> Cementitious waste forms have a number of very attractive properties including low cost and low temperature preparation. The latter is particularly important for technetium since Tc_2O_7 is volatile. In terms of technetium chemistry, the major drawback of cementitious waste forms is their porosity. This porosity poses challenges to the immobilization of technetium because TcO_4^- is highly soluble and does not sorb to the minerals that comprise the cement waste form (Gilliam 1990). The behavior of TcO_4^- in the cementitious waste should closely parallel that of NO_3^-; that is, TcO_4^- should slowly diffuse from the waste. Since TcO_4^- is the stable form of technetium at pH > 10 or in aerobic environments at all pHs, the migration of technetium from cement waste forms could be problematic if it is present as TcO_4^-.
>
> To prevent migration of technetium from these waste forms, blast furnace slag is added to the grout (Langton 1988, Langton 1989, Gilliam 1990). Blast furnace slag reduces TcO_4^- to $TcO_2 \bullet xH_2O$ or TcS_2 (Allen 1997), which, unlike TcO_4^-, are insoluble. If the technetium is reduced to Tc(IV), it will remain immobilized in the cementitious waste; however, if the technetium is present as TcO_4^-, it will diffuse from the waste.
>
> Our interest in the behavior of technetium in waste began with the studies of the effectiveness of different reagents for reducing TcO_4^- prior to and during the preparation of cement samples. While BFS was effective at reducing the technetium to TcS_2, the technetium was oxidized back to TcO_4^- over a period of time ranging from days to months (Allen 1997).

One comment in our review of the 2008 report was that the reference to uncertainty analysis in the heading and body of Section H.3 is misleading; no *bona fide* uncertainty analysis has been performed in the EIS. This section is now titled Sensitivity Analysis.

The description of the distribution coefficients used in the analysis, as described in Appendix H, is difficult to follow. Tables H-13 and H-14, titled "RESRAD Unit Dose Factors for Water-Dependent Pathways" and "RESRAD Unit Dose Factors for Water-Independent Pathways," respectively, list K_ds for relevant radionuclides, and each table includes the following footnote: "Site-specific data for strontium and uranium (Dames and Moore 1995a, 1995b), balance of data from NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999)." The tables do not indicate which K_ds are based on the site-specific data and which are from NRC's generic guidance; text associated with Table H-25 indicates that site-specific values were available for strontium and uranium. The tables also do not indicate what type of media the K_ds apply to, e.g., sand and gravel, Lavery Till, etc.

Distribution coefficients are also listed in Table H-25, "Values of Distribution Coefficient for Long-term Impact Analysis." This table includes separate columns for K_ds in aquifer soils, concrete, and controlled low strength material. The text indicates, in reference to the aquifer soil K_ds, that "These values are applied to both the sandy units of the North Plateau and the silt-clay soils underlying both the North and South Plateaus." If this statement is correct, it is not clear how the values in Tables H-13 and H-14 were used. The values in Table H-25 Appendix H are, with the exception of the K_d for strontium, lower than the values listed in Tables H-13 and H-14.

The issue is further complicated by the fact that NUREG/CR-5512 has two tables of K_d values, Tables 6.84 and 6.86, and they do not report the same values. Table 6.84 reproduces the values from Table 6.7 in Volume 1 of this NUREG. Table 6.86 describes analyses to assign probability distributions to the K_ds, and since these distributions tend to be lognormal, log values of the K_ds are reported.

It is interesting to compare the distribution coefficients for the highly mobile radionuclides. Table H-25 indicates that the K_d for hydrogen (tritium) is 0 mL/g in the aquifer soils and 1 in concrete and controlled low strength material. Tables H-13 and H-14 indicate that the tritium K_d is 1 mL/g. This is reportedly taken from NUREG/CR-5512 Vol 3, but in that report, Table 6.84 indicates that the tritium K_d is zero, and tritium is not listed in Table 6.86. Possibly Table 6.84 was misunderstood to be reporting log K_d values.

Regarding technetium, Table H-25 reports K_ds of 0.1 mL/g in aquifer soils and 1 mL/g in concrete and controlled low strength material. Tables H-13/H-14 report a K_d value of 7.4 mL/g, which is consistent with Table 6.86 of NUREG/CR-5512 Vol 3. In contrast, Table 6.84 of this report has the technetium K_d as 0.1. Across the other radionuclides, the K_d values reported in Table 25 are similar to those of Table 6.84, and the values in tables H-13/H-14 with Table 6.86. It is not clear what values are used where. Section H.3.3 and Table H-71 describe a sensitivity analysis of the Tc-99 K_d. The peak dose rate and time to peak dose are calculated for technetium K_d values of 0.1, 1, and 7.4 mL/g. The results were highly sensitive to the assumed value, with the highest and earliest doses associated with the lowest K_d value.

Erosion Damage

As with the 2008 report, it is assumed that there is no erosion damage to north plateau caps. Section H.2.2.4 includes the statement "The modeling below considers unmitigated erosion only for the Low-Level Waste Treatment Facility on the North Plateau and the SDA and NDA on the South Plateau. The landscape evolution model predicts very little erosion in the region of the Main Plant Process Building, Vitrification Facility, and Waste Tank Farm, and also predicts that the only places where any serious erosion would be expected in the foreseeable future would be in the vicinities of the Low-Level Waste Treatment Facility, SDA or NDA." Given the primitive state of erosion modeling, it seems that concluding that the north plateau is not subject to gullying and erosion is to give the modeling too much credit.

Section H.2.2.4 addresses Loss of Institutional Controls Leading to Unmitigated Erosion. A footnote associated with exposure scenarios is "The onsite resident differs from the onsite resident farmer in that the former has no garden and does not drink contaminated water. See

Figure H–3 for the locations of these three receptors." The major exposure pathways for the onsite resident in the case of erosion is from direct radiation (shine) from the exposed gully face, incidental soil ingestion and dust inhalation. No food or water pathways are considered feasible. In the resident farmer scenario for the case without erosion, groundwater-related pathways were the largest dose contributors.

2) **Does the 2009 FEIS address the recommendations provided in Section 6 (Conclusions and Recommendations) of the 2008 IERT Report in regard to engineered barrier assumptions? Please explain.**

Section 6 of the 2008 IERT report contained the following two Conclusions and Recommendations:

Engineered Barrier Performance

Conclusion: Assumptions about barrier performance over time are (1) not well justified, and (2) not clearly communicated.

> *Recommendation: Future analyses should include improved documentation with adequate justification for assumptions about barrier performance through time.*

Conclusion: Plans for engineered control and mitigation of gullying do not appear to be adequate.

> *Recommendation: Plans should specifically address future headcut erosion, including consideration of changes in base level such as what might occur from the removal of the Springville Dam, and should address the possibility for initiation of new headcuts, including on the North Plateau.*

The details about the assumptions for barrier performance are identified in Appendix H, Section H.2.2.1 where the following discussion of engineered barrier assumptions appears:

> *Engineered and Natural Barriers.* Engineered barriers and natural materials considered in this performance assessment include ones with the ability to divert or control flow, some of which also have absorptive properties to retard the movement of hazardous constituents. The flow control structures considered for the Sitewide Close-In-Place Alternative analysis include the drainage and underlying clay layers of engineered caps, the circumferential subsurface slurry walls on the North and South Plateaus, the Controlled Low Strength Material (a form of grout) used to fill the tanks of the Waste Tank Farm, and the grout used to stabilize sediments at lagoons 1, 2, and 3 of the Low-Level Waste Treatment Facility. Flow control structures identified in the preliminary closure designs in the Sitewide Close-In-Place Alternative Technical Report (WSMS 2009) but not considered in this performance assessment include the upgradient barrier wall designed to redirect groundwater flow from the north plateau circumferential slurry wall, the surface drainage from the multi-layered caps on the north and south plateaus, and the geomembrane layer in the multi-layered caps on the north

and south plateaus. For the engineered barriers considered in the analysis, the values of hydraulic conductivity that control the functional capacities of these barriers are well defined by design at the time of installation but may degrade over time. No credit is taken for retardation of contaminants by the slurry walls included in the analysis. Because the rate of degradation would be difficult to predict, degraded values of hydraulic conductivity are conservatively assumed to apply over the entire time period of the long-term performance assessment, irrespective of whether institutional controls are maintained or fail…

Literature review of performance of clay layers identified dessication as the primary failure mechanism for this type of barrier (Rowe et al. 2004). The study also reported excellent performance when the layers were maintained in the saturated state. On this basis, a degraded valued of hydraulic conductivity of clay layers in the center of engineered caps of 5×10^{-8} centimeters per second was adopted. This value is one order of magnitude higher than the design value. Also based on these considerations, degradation of performance is assumed for slurry walls extending to the ground surface. Although the offset in hydraulic conductivity between the slurry wall and the surrounding natural material is large and would be expected to maintain near saturated conditions in a humid environment such as West Valley, a two-order of magnitude degradation in design value of hydraulic conductivity was assumed for this analysis. The value adopted for hydraulic conductivity of slurry walls was 1×10^{-6} centimeters per second. Values of hydraulic conductivity reported for intact concrete range from 1×10^{-10} to 1×10^{-8} centimeters per second (Clifton and Knab 1989). In order to account for degradation and potential effectiveness of placement, a value of 1×10^{-5} centimeters per second was used for Controlled Low Strength Material and grout in the long-term performance assessment. The above cited values of hydraulic properties are used in the near-field groundwater flow models to estimate rates of flow through waste materials. The results of these calculations for facilities on the North Plateau are presented in Tables H–22 and H–23 for the No Action and Sitewide Close-In-Place Alternatives, respectively. Differences in volumetric flow rates reported in these two tables are related to placement of engineered barriers while differences in waste volume between the No Action and Close-In-Place Alternatives are related to decontamination and closure activities. Placement of the engineered barriers for the Close-In-Place Alternative decreases the volume of flow and, in some cases, the direction of flow relative to the No Action Alternative. On the South Plateau, waste is simulated as mixed with soil in holes and trenches and groundwater velocities through the waste are those reported in Table H–19 for the geohydrologic unit in which the waste is located. Flow areas and waste volumes used in simulation of the South Plateau facilities are presented in Table H–24. These areas and volumes are the same for both the No Action and the Sitewide Close-In-Place Alternatives.

This description is much clearer than what was provided in 2008. While it might be more realistic to do the analysis with the performance of the barriers degrading over time, such long-term performance is sufficiently uncertain that any particular set of values could not be justified.

Regarding the second conclusion and recommendation, the three engineered barriers that are intended to mitigate erosion are diversion berms and ditches, water control structures, and streambed armoring. The discussion of the diversion berms and ditches indicates that "The primary purpose of installing diversion berms is to control the sheet flow of runoff on the north and south plateaus, and direct the flow to the areas that are appropriately protected against erosion." Similarly, the water control structures "The water control structures would be designed and constructed to respond to the common storm flows and the PMF flows in two different ways. The common storm flows (up to and including the 100-year rainfall runoff) would be transmitted from the plateau surface down to the creek bottom within a concrete pipe…. Storms exceeding the 100-year recurrence interval would naturally cause the inlet structure to become surcharged, and water would begin to pond…. At approximately two feet of depth, the ponded water would begin to spill over a broad-crested weir, and would flow down an armor protected overflow spillway." From these descriptions, it is clear that the first two engineered barriers address general sheet erosion and large rainfall events. They do not address gullying and headcut erosion.

The section on streambed armoring has one significant change from the 2008 report – the total armored length of streams to be armored was increased from 4,300 to 12,900 linear feet. Section 2.14 (Erosion Controls Construction) of the Sitewide Close-In-Place Technical Report is essential unchanged from the 2008 version, with the exception that the 2009 includes the statement "In addition, several existing medium- to large-scale erosion control installations through the southwestern New York region were reviewed to gain a better understanding of the various types of structures used, the successes and failures, and the mechanisms for failure, for these structures." The capability of streambed armoring to prevent headcut erosion is critical to the proposed approach, and the statement that existing erosion control installations were reviewed is clearly an important step towards determining whether such armoring would work, how long it would work, and what sort of maintenance is required to prevent headcut erosion. However, I could not find where such installations were discussed.

3) **If changes in the approach to engineered barrier assumptions were made, do the changes make the 2009 FEIS results more reliable and defensible, less reliable and defensible, or about the same, as compared to the 2008 DEIS? Please explain.**

I do not think the changes are significant.

Additional Questions

4) **Are the engineered barrier assumptions presented in the 2009 FEIS supported by an adequate scientific basis such that they can be used to quantify radiological or other impacts to human receptors on and near the Center for 100,000 years (e.g., see DEIS Figure H-14). Please explain why or why not.**

The engineered barrier assumptions seem reasonable, with the exception that no evidence was provided supporting the performance of streambed armoring over a long time period. The assumptions about the lifespan of the CSLM and strong grout in the tanks and vaults appear reasonable. The following statement from Section D.3.1.2 also appears reasonable:

> For the Sitewide Close-In-Place Alternative, the residual contamination in the Main Plant Process Building, the Vitrification Facility, the Waste Tank Farm, the NRC [U.S. Nuclear Regulatory Commission]-Licensed Disposal Area, and the State-Licensed Disposal Area would be located at depths greater than 3 meters (10 feet) below the current ground surface and under a rock and vegetation-covered tumulus with a maximum height of 9 meters (30 feet). Residual contamination at these depths is unlikely to be mobilized by human intrusion, burrowing animals, or vegetation or roots. Thus, assuming institutional control, transport by groundwater is the only mechanism for transport of contaminants from the waste form to the surrounding environment, and releases via diffusion and convective flow are the release mechanisms of concern.

5) **Are the dose predictions, other results, and comparisons of the alternatives in the 2009 FEIS presented with adequate consideration of engineered barrier assumption uncertainties (e.g., Section 4.1.10 of Chapter 4, Appendix H, and the discussions of uncertainties in Section 2.8 of Chapter 2 and incomplete and unavailable information in Section 4.3 of Chapter 4)? Please explain.**

As far as I can tell, no engineered barrier uncertainties were considered except through the use of assumptions thought to be bounding. The quote in response to the last question describes how parameter values thought to be representative of degraded barriers were used in a deterministic analysis. Also noted above is the lack of evidence for the effectiveness of streambed armoring to mitigate gullying.

While not directly related to the treatment of engineered barriers in the analysis, the scenarios analyzed seem to leave out certain cases likely to result in significant doses. For example, in the unmitigated erosion case, no onsite receptor scenarios are analyzed that include exposures via a food or drinking water pathway.

The possibility that a resident farmer scenario could occur on the south plateau is excluded. Appendix D at line 550 indicates that "Site data and the three-dimensional site-wide groundwater model indicate that the Kent Recessional Sequence is unsaturated below the North and South Plateaus, indicating that this unit is not a reasonable source of domestic or irrigation water." However, it is not clear whether this statement is consistent with Figures E-5 and E-6 showing the geologic cross-sections for the North and South Plateaus. These figures indicate that there is groundwater flow in the lower portion of this layer. If there are data on what boreholes or pump tests show for this layer, it would be helpful to describe it. The characteristics of this layer are described in Appendix E, line 335 as follows: "The upper interval of the Kent recessional sequence, particularly beneath the South Plateau, is unsaturated. However, the deeper lacustrine deposits are saturated and provide an avenue for slow northeast lateral flow to points of discharge (seeps) in the bluffs along Buttermilk Creek. The unsaturated conditions in the upper sequence are the result of very low vertical permeability in the overlying till, and thus there is a low recharge through the till to the Kent recessional sequence (Prudic 1986). As a result, the recessional sequence acts as a drain to the till and causes downward gradients in the till of 0.7 to 1.0, even beneath small valleys adjacent to the SDA (WMA 8) on the South Plateau (WVNS

1993b, WVNS and Dames and Moore 1997).” Whether the deeper parts of the Kent Recessional Sequence could support a well is not addressed.

6) **Do you have additional recommendations in regard to the information presented in the 2009 FEIS on engineered barrier assumptions?**

While not related to engineered barriers, Appendix H presents the results of the dose rate assessment for the close-in-place and no action alternatives. For either of these alternatives, the highest doses are calculated to occur to the resident farmer who uses groundwater. The results of the dose rate assessment are presented in tables and graphically. For example, Figures H-6 and H-7 show dose rates versus time for the Cattaraugus Creek receptor for the close-in-place and no action alternatives respectively. Figures H-10 and H-11 show doses rates to the Seneca Nation receptor, assuming indefinite institutional controls, for both alternatives. Additional figures show the cancer risks for these scenarios. However, the results for onsite receptions are not presented graphically with the exception of Figure H-14, which shows the dose rate versus time from the North Plateau Groundwater Plume, but not from any other source area. In contrast, Figures H-15 and H-17 show the contribution from each source area versus time for the Cattaraugus Creek and Seneca Nation receptors.

The reasons for the changes to the dose and risk assessment results from 2008 to 2009 are not clear. In Appendix H, tables H-3 through H-17 describe parameter values for the risk calculations. These values include consumption rates, physical estimates such as soil density and porosity, distribution coefficients, dose and risk factors per unit intake for various radionuclides, residence time, and other related values. Other than the movement of what was table H-15 in 2008 to H-5 in the 2009 version, the parameter values are identical.

Table H-18 lists DCGLs for surface soil screening. These are the concentrations that correspond to a 25 mrem/year dose rate for each radionuclide. The table notes that when multiple radionuclides are present, the sum of fractions rule is to be used. This table reflects an improvement over the previous report, in that in the 2008 version, table H-18 presented the DCGLs for a residential agriculture scenario: but for only water-dependent pathways. The water dependent pathways include those based on irrigation with contaminated water, but do not include direct soil ingestion or dust inhalation. The 2009 values match those in NUREG-1757, which indicates that these are generic values, not specific to the West Valley site. Text near this table indicates that project-specific DCGLs will be developed through the Decommissioning Plan preparation and review process.

Table H-25 of the 2009 report is identical to table H-20 of the 2008 version; it indicates the distribution coefficients used for transport calculations in the aquifer, in concrete and in controlled low strength material. With the exception of Americium, these K_d values are lower than those presented in tables H-13 and H-14.

The exposure scenario that results in the highest estimated doses is the resident farmer. In spite of the fact that identical parameters apparently were used in both versions, the dose estimates do not match; the 2009 report estimates are much lower than those of 2008. The following table compares the 2009 results with those from 2008.

Estimated Peak Annual Total Effective Dose Equivalent in Millirem per Year to Resident Farmer with a Garden Containing Contaminated Soil from Well Drilling or House Construction – Intrusion After 100 Years

	2009 FEIS	2008 DEIS
Waste Management Areas	***Sitewide Close-In-Place Alternative***	***Sitewide Close-In-Place Alternative***
Main Plant Process Building – WMA 1	Not applicable	Not applicable [a]
Vitrification Facility – WMA 1	Not applicable	Not applicable [a]
Low-Level Waste Treatment Facility – WMA 2	7.0 b	12
Waste Tank Farm – WMA 3	Not applicable	Not applicable [a]
NDA – WMA 7	Not applicable	Not applicable [a]
SDA – WMA 8	Not applicable	Not applicable [a]
North Plateau Groundwater Plume	0 d	530
Cesium Prong – onsite	4.4 c	4.4

The 2008 table includes a footnote for each "Not applicable" that says "NA: large irregular rocks of cap prevents digging of well and the thickness of cap is greater than ten feet." The 2009 version includes the following footnote for the lack of dose from the North Plateau Groundwater Plume "Peak impact due to well-drilling scenarios. The dose to the well driller from the North Plateau Groundwater Plume was nearly zero because of the cap." Since this table applies to the resident farmer, it is not clear why this statement regarding the well driller is relevant. Apparently in 2008, groundwater was assumed to be pumped from the North Plateau in the area of the groundwater plume, but outside the areas covered with a cap. In the 2009 version, the cap prevents installation of a well.

The rationale for deeming the resident farmer scenario "Not applicable" for the South Plateau is "The scenario is not applicable to the NDA and SDA receptor because of the low hydraulic conductivity of the unweathered Lavery till and the unsaturated conditions in the Kent Recessional Sequence." This is a major premise on which this assessment is based. It would be helpful to know whether there has ever been a producing well on the South Plateau. Given the significant radionuclide inventories that would be present on the South Plateau for the close-in-place or no action alternatives, the question of whether contaminated groundwater could be used seems an essential issue.

The table below compares the 2009 result with that from 2008 for the resident farmer. No explanation is provided regarding why the dose estimates changed for four of the six sources. It would be helpful to know if the differences are due largely or entirely to the use of the STOMP model in place of RESRAD.

Estimated Peak Total Effective Dose Equivalent in Millirem Per Year to a Resident Farmer using Contaminated Groundwater – Intrusion After 100 Years

	2009 FEIS	2008 DEIS
Waste Management Areas	***Sitewide Close-In-Place Alternative***	***Sitewide Close-In-Place Alternative***
Main Plant Process Building – WMA 1	162	366
Vitrification Facility – WMA 1	1.9	1.9
Low-Level Waste Treatment Facility – WMA 2	31.6	4.1
Waste Tank Farm – WMA 3	157	527
NDA – WMA 7	Not applicable	Not applicable
SDA – WMA 8	Not applicable	Not applicable
North Plateau Groundwater Plume [b]	72	530
Cesium Prong – onsite	4.4	4.4

APPENDIX C

COMMENTS ON APPENDIX F EROSION STUDIES
APPENDIX G MODELS FOR LONG-TERM PERFORMANCE ASSESSMENT
APPENDIX H LONG-TERM PERFORMANCE ASSESSMENT RESULTS

Sean J. Bennett

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) and its cooperators have prepared a Final Environmental Impact Statement (FEIS) for the potential decommissioning of the West Valley Demonstration Project. A key component in this statement is an assessment of current and future surface erosion processes operating at and near the site and how these processes potentially can affect the buried wastes.

For the FEIS, erosion processes, modeling and performance assessments, and dose equivalencies are presented and discussed in various locations and to various degrees. The most important aspect of the surface erosion assessment is the modeling of these processes, and the future integrity of the buried wastes at the West Valley Site. These results have been presented in detail in Appendices F, G, and H, and are the focus of this review.

DOE and its cooperators present the simulation results of various models used to predict current and future erosion at the West Valley Site, specifically rill and sheet erosion, gully erosion, and landscape evolution. While significant efforts have been made to model these various surface-erosion components, the predictions from these models cannot be accepted or ratified at this time. This opinion is based on the following four assessment criteria. First, there remains a serious disconnect between model parameterization and the hydrologic and geomorphic characteristics of the site, which has resulted in dubious, highly questionable, and physically unjustifiable assumptions in the treatment and assignment of model variables. Second, no verification or validation of any models was presented in the context of comparing model output to actual field data. Third, many of the model components, especially with regard to gully erosion and landscape evolution, are unjustifiable and unsupported by current scientific evidence. Fourth, no rigorous uncertainty analysis in any model predictions was provided. The uncertainty bounds in model predictions for the gully erosion and landscape evolution are expected to be very large considering the conceptualization, construction, parameterization, discretization, application, and interpretation of the models employed.

Most importantly, any predictions made using any gully erosion or landscape evolution model with regard to future releases of radionuclides due to the surface erosion of the West Valley Site as presented herein are scientifically indefensible based on the four criteria outlined above. It was the opinion of the 2006 and 2008 Peer Review Group that the science behind landscape evolution models is not mature enough to justify relying on these models to provide long-term predictions of erosional processes, and that the associated uncertainty bounds of these predictions should be quantified. The review, based on the revisions and refinements of these approaches, recapitulates these previous opinions.

1. INTRODUCTION

The U.S. Department of Energy commissioned the preparation of a Final Environmental Impact Statement for the potential decommissioning of the West Valley Demonstration Project. The New York State Energy Research & Development Authority (NYSERDA), as a joint lead agency on the project, assembled a peer-review group of expert scientists to review the FEIS. Two previous versions of the EIS was reviewed by a group of scientists, one in 2006 (herein referred to as Peer Review of Draft Environmental Impact Statement, PRDEIS06), and a second in 2008 (herein referred to as Peer Review of Draft Environmental Impact Statement, PRDEIS08). This current document reviews the surface erosion assessment and modeling as described in the FEIS, which represents the latest iteration of the former documents.

It is important to reiterate the primary findings of these previous reviews, given that the surface erosion results of the FEIS potentially have changed in response to these expert opinions. These findings are summarized below.

For the peer review of the DEIS conducted in 2006, the following comments and findings were presented.

1. Some of the landscape predictions generated using SIBERIA in the DEIS are unrealistic, which compounds the lack of confidence in these predictions. These include the "freezing" of stream channel headcuts in time, the obliteration of gullies over time, and the "smoothing" of the landscape over time, rather than becoming rougher due to active channel incision (PRDEIS06, pp. 26-27).
2. The counter-intuitive SIBERIA predictions may in part be artifacts of how the code has been applied in the DEIS. These artifacts may stem from the inability to switch from hillslope to channel modes, the choice of the diffusion coefficient, and the 50 by 50-m grid spacing, which is too large to accommodate small-scale erosion features such as gullies (PRDEIS06, pp. 28-29).
3. SIBERIA has predicted future landscapes for the site that are considered unrealistic and hence not credible (PRDEIS06, p. 29).
4. Little has been done to quantify the uncertainty in SIBERIA predictions quoted in the DEIS (PRDEIS06, p. 29).
5. The modeling analysis does not consider the impact of potential future climate changes on erosion (PRDEIS06, p. 30).
6. The conceptualizations of the erosion processes are considered highly dubious with respect to geomorphic evolution, gully growth and development, on-site characterization of erodibility indices, differentiating the erosion processes on the North Plateau as different from those on the South Plateau, and gully head advance and stream piracy, among others (PRDEIS06, pp. 30-38).

Of the many key findings of the PRDEIS06, the following concluding statements were offered on the erosion processes and landscape evolution models (PRDEIS06, p. 66).

> The science behind landscape evolution models such as SIBERIA is not mature enough to justify relying on these models to provide long-term predictions of

> erosional processes and rates in glaciated terrains of the northeastern United States. A less sophisticated but more credible alternative would be to judiciously extrapolate observed short and long-term patterns and rates of erosion at the site and the surrounding region into the future, considering similar such patterns and rates recorded in similar terrains elsewhere, and quantifying in a conservative manner the associated predictive uncertainty bounds. However, the PRG [peer-review group] expects the uncertainty associated with such extrapolation to be large.

Additional commentary from the PRDEIS06 focuses on the landscape evolution model SIBERIA. As discussed therein, SIBERIA does not consider commonly accepted erosion processes such as knickpoint migration. SIBERIA has predicted future landscapes for the site that the peer-review group considers unrealistic and hence not credible. Whereas it might be possible to produce more realistic future landscapes with SIBERIA, its reliability as a predictor would still remain uncertain. No attempt has been made to quantify the uncertainty in SIBERIA predictions.

For the peer review of the DEIS conducted in 2008, the following comments and findings were presented (PRDEIS08, pp.15-16).

1. A serious disconnect exists between model parameterization and the hydrologic and geomorphic characteristics of the site. This has resulted in highly questionable and physically unjustifiable assumptions in the treatment and assignment of variables within these models.
2. No verification or validation of any models was presented in the context of comparing model output with actual field data.
3. Many of the model components, especially with regard to the gully erosion and landscape evolution, are unjustifiable and unsupported by scientific evidence.
4. No uncertainty analysis of any model predictions was provided. The uncertainty in model predictions for the gully erosion and landscape evolution is expected to be very large (orders of magnitude) considering the conceptualization, construction, parameterization, discretization, application, and interpretation of the models involved.

More specific comments regarding Appendix F Erosion Studies are summarized below (PRDEIS08, pp. 16-17).

2. Short-term erosion rates determined using USLE, SEDIMOT II, CREAMS, and WEPP are not considered useful in the broad context of the present and future integrity of the West Valley site. This is because the greatest at-a-point rates of surface erosion are due to advancing gullies, which none of these models addresses.
3. The model simulation using SIBERIA from the initial post-glacial landscape to modern time has not adequately addressed, or presented in a scientifically defensible way, the long-term evolution of the West Valley Demonstration Project and nearby environs. No details have been provided as to how the initial, post-glacial landscape conditions were defined and represented within SIBERIA. It is highly unlikely that the same model will adequately represent the evolution of the landscape over the next 10,000 years.

4. The concept of channel initiation as used in SIBERIA appears to result in a stream channel network similar, if not identical, to the modern network, and a channel network system that displays no spatial variation over time.
5. No discussion exists regarding the numerical schemes used in SIBERIA or CHILD and how these schemes ultimately affect the hydrologic and geomorphic processes under consideration.
6. The only calibration scheme used for the SIBERIA and CHILD models is through a "forced-fit" approach that minimized the difference between predicted and observed longitudinal profiles of select streams in select corridors. This approach does not consider the vertical uncertainties of the Digital Elevation Model (DEM) used, which may be several meters, or the possibility of arriving at "the right answers for the wrong reasons."
7. The results from the forward modeling exercises using SIBERIA and CHILD, from modern time to 10,000 years in the future, are so briefly discussed and so poorly supported by graphical information that they have no credibility or utility in this assessment. Moreover, it seems highly unlikely that the North Plateau Waste Management Areas 1 and 3 will experience only 0.1 to 0.3 meters of erosion in the next 10,000 years.
8. All physically-based hydrologic and geomorphic models are subject to significant uncertainty, which includes uncertainties in model input, model structure, definition and inclusion of parameters (governing equations), and observational data. Future projections using the same models also include uncertainties for model linkages and input data. Any predictions made using any landscape evolution model with regard to future releases of radionuclides due to surface erosion processes are scientifically indefensible since no rigorous and comprehensive uncertainty analysis has been undertaken. Moreover, the uncertainty bounds for predicting radionuclide dose rates based on such models are likely to be very large. Any decisions on decommissioning the West Valley site should carefully consider these large uncertainty estimates.

Both Appendix G Models for Long-term Performance Assessment and Appendix H Long-term Performance Assessment Results presented and discussed gully erosion as a potential release mechanism for the buried wastes and introduced a gully erosion model. The general findings from review of this material include the following (PRDEIS08, p.17).

1. The simple gully erosion model, as constructed in Appendices G and H, is very crudely defined and not scientifically based.
2. The authors predict that the top of the NDA wastes could be breached in 490 to 910 years, and the bottom of the NDA wastes could be breached in 955 to 2,330 years (Table H-65). Even adopting the very low and constant rate for gully advance of 0.4 meters/year, a gully intersecting the top of the NDA could occur within 33 to 165 years, or about one order of magnitude quicker in time compared to the estimates presented in Table H-65. The two values reflect the two distances from Erdman Brook to the NDA (13 meters from the northeastern side and 66 meters to the northwestern side) and the gully advance rate of 0.4 meters/year.

Of the many key findings of the PRDEIS08, the following concluding statements were offered on the erosion processes and landscape evolution models (PRDEIS08, p. 15).

> The most important aspect of the surface erosion assessment is the modeling of the processes that affect the future integrity of the buried wastes at the West Valley site. It is the opinion of the IERT [peer-review group] that while significant efforts have been made to model the various surface erosion components of the West Valley site, the predictions from these models cannot be accepted or ratified at this time. Most importantly, any predictions made using a gully erosion or landscape evolution model with regard to future radionuclide doses due to the surface erosion of the West Valley site are scientifically indefensible.

The author of the current document also has additional information that is pertinent to the evaluation of the surface erosion assessment, which comes from three sources. The first source is an interagency workshop that was held on Oct. 10-11, 2007 in Rockville, MD to discuss the progress of and results from new assessment activities with regard to the West Valley Demonstration Project. The workshop was attended by representatives of the New York State Department of Environmental Conservation, NYSERDA, DOE, U.S. Nuclear Regulatory Commission, and the U.S. Environmental Protection Agency, along with invited experts and consultants. Day 1 of the workshop entailed presentations dedicated to the review of and response to the DEIS, surface erosion modeling, and engineered barriers and erosion control. Day 2 of the workshop entailed an open discussion amongst the participants regarding the presentations and results from Day 1. The same author offered scientific opinion on these surface erosion assessments (Peer Review of West Valley Erosion Workshop, October 10-11, 2007, Rockville, MD, Final Report of December 7, 2007; herein termed EPRG-1). The second source of information comes from a document prepared by DOE and its cooperators and entitled "Parameters Using the Deterministic Calibration of SIBERIA" dated February 4, 2008. The same authors above offered scientific opinion on this SIBERIA document (Peer Review of "Parameters Using the Deterministic Calibration of SIBERIA," Final Report of March 28, 2008; herein termed EPRG-2). The third source of information comes from a PowerPoint presentation prepared by DOE and its cooperators entitled "Refined Erosion Analysis for West Valley FEIS" dated July 24, 2009, which also received peer review.

This current review offers scientific opinion on the surface erosion assessments contained within the FEIS, and the structure of the review will be as follows. First, as this document is a revision of the DEIS, a brief summary of the significant or noteworthy revisions to date are provided. These comments are simply statements of fact rather than a critical assessment of the results, findings, and interpretations therein, and the section headings used below are derived from the FEIS. Second, a detailed review of the FIES is conducted on topics in the order in which they appear. As this document may repeat information presented previously, any notable or significant commentary directed toward sections during previous peer-review also is repeated. Third, comments are provided on whether the current revisions have adequately addressed the most recent recommendations offered during the peer review process. Fourth, additional critical comments on model verification and uncertainty analysis are presented, along with simplified estimation of the uncertainty of the CHILD model predictions. Fifth, a brief review of the long-term performance models and results in Appendices G and H is presented as it pertains to the surface erosion predictions. From a technical standpoint, Appendix F provides the core of the erosion assessment and modeling, while additional erosion issues are discussed in Appendices G and H.

2. COMPARISON OF APPENDIX F EROSION STUDIES IN THE DEIS AND FEIS

Three versions of "Appendix F Erosion Studies" have been submitted for review and comment to this referee: (1) a version for the Draft Environmental Impact Statement (DEIS) dated 6/13/2008, which received significant review and written commentary (PRDEIS08), (2) a revised version for the DEIS dated 9/2008, which received review and very minor written commentary, and (3) a version for the Final Environmental Impact Statement (FEIS) dated 10/5/2009, which will be reviewed below. As part of the review process for Appendix F for the FEIS, comments are provided below that summarize the significant or noteworthy revisions to date, specifically those changes made to the revised DEIS. These comments simply are statements of fact rather than a critical assessment of the results, findings, and interpretations therein, and the section headings used below are derived from the FEIS version.

Summary of notable changes to Appendix F of the FEIS.

1. **F.2.2.1 Radiocarbon and Luminescence Dating of Fluvial Deposits**. This is a new subheading, and presents the advantages and disadvantages of ^{14}C and optically stimulated luminescence (OSL) dating techniques, provides additional references, and discusses two ways to determine the age of the OSL sample (central-age and minimum-age models). The dates obtained, their geomorphic significance, and their interpretation (F.2.2.2) also are presented.

2. **F.3 Erosion Rate Prediction Methods.** Previous versions of this section presented and discussed the landscape evolution models SIBERIA and CHILD. The most significant revisions here are
    a. the complete elimination of the SIBERIA model, and
    b. the expanded use and discussion of the CHILD model.

3. **F.3.1.4 Parameter Selection for CHILD Model.** This section discusses the selection of parameters used in CHILD, which are summarized in Table F-8. Of note here is the use of 5 values each for 10 input parameters, which defines an input matrix, to facilitate the calibration of the model. Only those sections where significant revision occurs are briefly mentioned below.
    a. *F.3.1.4.1 Reconstructed postglacial topography of Buttermilk Creek*. This section presents the boundary conditions for the model simulation from the last glacial maximum (ca. 18,000 years ago) to the present time.
    b. *F.3.1.4.2 Boundary conditions: Base-level history*. This section interprets the OSL data to define a base-level history (a rate of incision or base-level lowering through the glacial sediment during this ca. 18,000-year time period).
    c. *F.3.1.4.4 Parameters related to climate*. This section revises the average storm intensity, the average fraction of time that precipitation occurs, and the average duration of a storm and inter-storm sequence as used in CHILD. This section also presents new variables as well as new values for existing variables.

d. *F.3.1.4.5 Soil infiltration capacity*. This section discusses the effective infiltration capacity of the site, defined as the maximum rate at which rainfall can be absorbed by the soil before generating runoff. The spatial variation of this parameter also is discussed.
e. *F.3.1.4.6 Channel width parameters*. A power function for predicting the width of river channels is presented and discussed.
f. *F.3.1.4.7 Parameters related to water erosion and sediment transport*. Equations for the detachment capacity of cohesive sediment and the rate of bedload transport for non-cohesive sediment are presented, and each is represented by an excess shear-stress approach. Values for the detachment coefficient, transport efficiency, and the critical shear stress for initiation of particle motion are provided, including the 5 values used in the calibration procedure. The definition of the applied shear stress within the stream channels also is presented, as well as their bracketed values used in the calibration.
g. *F.3.1.4.9 Model-data comparison metrics*. Six metrics are identified to provide a measure of model performance. These include the longitudinal profile of Buttermilk Creek, the construction of a hypsometric curve for the entire landscape (a plot of the cumulative area of land within the catchment that lies below a given elevation), a slope-area diagram for the entire landscape (gradient as a function of contributing area), width function (a frequency distribution of flow-path length within the catchment), a cumulative area distribution for the entire landscape (the drainage area as a function of the cumulative distribution of drainage area), and the positions of strath terraces (former positions of the stream channel) as deduced from the OSL data. The first five metrics are assigned goodness-of-fit scores from 0 (no agreement) to 1 (perfect agreement) by simply dividing the curves into 101 points and comparing these observed data points to the predicted data points.

4. **F.3.1.5 Testing and Calibration Results.** Using the range of input parameters, 1000 computer runs are executed and the normalized goodness-of-fit measures are tabulated. The parameter datasets for these 1000 runs are randomly selected from the matrix of 10 parameters each with 5 possible values, as defined herein. Based on these results, five runs are identified that satisfy the goodness-of-fit criteria (highest values) as well as having strong "visual correspondence" to the observed topography. These five runs and their input parameters are listed in Table F-11. The run with the highest goodness-of-fit value (0.680, Run 298) then is used as the "standard case" for the forward modeling exercise, whereas the remaining four runs are used as "alternates" (Alternate 1 to 4). Figures F-8 to F-13 compare the observed and predicted values for the "standard case" against each metric used.

5. **F.3.1.6 Forward Modeling of Erosion Patterns.** Several input parameter sets and options are used to simulate the evolution of the site from the present time to 10,000 years into the future. The most notable changes include the following.

a. *F.3.1.6.1 General approach*. A total of four different scenarios (26 runs) are considered here: (i) the five calibration runs (termed Standard and Alternates 1 to 4) for the North and South Plateaus (10 runs total), (ii) a "wet" condition, where the mean precipitation rate is doubled and the infiltration rate in minimized for the North and South Plateaus (2 runs total), (iii) a "wet + fast creep" scenario for the South Plateau, where high precipitation and runoff rates are coupled to a high soil diffusivity (1 run total; further discussed in F.3.1.6.4), and (iv) a "close-in-place" scenario, where two mounds are added to the North and South Plateaus to signify the buried waste, and where all scenarios are considered (13 runs total).

b. *F.3.1.6.2 Model resolution*. Two different grid resolutions are employed. Both the North and South Plateaus are simulated at a mesh resolution of 2.8 m, whereas all other areas were simulated at a mesh resolution of 90 m.
c. *F.3.1.6.5 Summary of forward-run scenarios*. A summary of all forward-run scenarios is provided in Table F-12, and maps depicting the relative amount of erosion and deposition for each scenario are illustrated in Figures F-15 to F-38. For each figure, the modern-day (0 years) and future (10,000 years) elevations and the difference in elevation (binned data depicting net erosion or sedimentation) are shown, and modest statements about the results are presented in the accompanying text.
d. *F.3.1.6.10 Comparison with present-day features and processes*. This section states that the simulations replicate many of the erosional processes and patterns observed in the present-day landscape, and that the propagation of gullies from the plateau rims present an important threat to the buried waste.
e. *F.3.1.6.11 Discussion of forward modeling results*. This section makes the following general statements regarding the forward modeling results.
    i. None of the forward-modeling scenarios show any large-scale exhumation of the buried wastes, but there is the potential that the "wet" scenario could cause exhumation.
    ii. All scenarios produce very little erosion on the South Plateau.
    iii. Since the "wet" scenario is consistent with the observed erosion around the Frank's Creek and Erdman Brook confluences, this scenario may be a closer representation of the on-site conditions despite the higher rates of precipitation and runoff.
    iv. The locations of the gullies are highly sensitive to small variations in parameter values and initial topography.
    v. The results should be interpreted with caution since a constant climate assumption is used and spatially homogenous parameter values are employed.

6. **F.3.2.3 Short Term Infiltration Capacity Prediction.** The SWAT model is used to simulate evapotranspiration and runoff for the Cattaraugus Creek watershed, using the Gowanda, NY stream gauge for calibration and validation. Based on these results and hydrologic balance, a regional infiltration capacity value is determined, which corroborates the value employed in the CHILD model.

7. **F.4 Conclusions.** Several notable comments are offered in this section, including the following (paraphrased).
    a. Gully erosion and mass-wasting are the greatest erosional threats to the buried wastes.
    b. It is recognized that the time span, limited data set, and imperfectly known process laws leave scope for uncertainty that must be acknowledged.
    c. Sources of uncertainty include model structure, input values, initial topographic conditions used for model calibration, topographic data used for model comparison, and spatial heterogeneity of the materials.
    d. None of the future erosion scenarios show large-scale erosional exhumation of the buried waste.

e. Large-scale erosional exhumation of the buried waste in the next 1,000 to 10,000 years should be considered *unlikely but not implausible*. [Italics used in the FEIS]

3. REVIEW OF APPENDIX F EROSION STUDIES IN THE FEIS

F.1 Magnitude of Surface Erosion Rates Based on Empirical Studies

Rates of surface erosion at the West Valley Site were compiled from empirical studies, monitoring programs, and geochronologic analyses. These rates, especially for sheet and rill erosion, are not atypical for regionally-derived values (Montgomery, 2007; Wilkinson and McElroy, 2007). Gully erosion, however, now is recognized as a significant, if not dominant, source of soil loss from agricultural areas and upland regions worldwide (Bennett et al. 2000a; Poesen et al., 2003).

Based on these findings, the greatest at-a-point surface erosion rates are due to advancing gullies, which are one to two orders of magnitude greater than all other erosion rates. It is noted here that (1) gully erosion is a discrete process in time and space, (2) gullies are rather small topographic features (decimeters to meters in scale), and (3) both down-cutting of the gully and widening of the gully would occur concomitantly during headward erosion and advance. Gordon et al. (2008) recently showed numerically that on agricultural fields ephemeral gullies up to 2 m wide and 0.275 m deep could advance up to 250 m in a single year, depending upon the severity and frequency of runoff events and the erodibility of the soil.

At present, more than 20 major and moderate-sized gullies have been identified, as shown in Figure F-5. It is obvious that gullies, with very active rates of advancement, are the principal threat to the West Valley Site.

F.2.2.1 Radiocarbon and Luminescence Dating of Fluvial Deposits

In order to conduct the long-term modeling exercise, a rate of incision (or the rate of base-level drop) is required. Stream incision rates based on a single ^{14}C dated sample range from 4.8 to 6.0 m per 1000 years (4.8 to 6.0 mm/yr). Additional samples were collected and analyzed using the quartz-based optically stimulated luminescence dating technique (sample locations are shown in Figure F-6). Two ways to determine the age of an OSL sample are presented and discussed (central-age model in Table F-3, and minimum-age model in Table F-4). Based on these dates, the stratigraphic location of the samples, and the quality of the dating results, it is concluded that Buttermilk Creek has had an average incision rate of 1 to a few meters per 1000 years (1 to a few mm per year) since 10,000 to 17,000 years ago.

F.2.3.3 Measurement of Gully Advance Rates

While more than 20 major and moderate-sized gullies have been identified at the site, few gully migration rates have been determined. Three active gullies are identified and their migration rates determined: 0.4 m/yr for the SDA gully on Erdman Brook, 0.7 m/yr for the NP-3 gully on Frank's Creek, and 0.7 m/yr for the 006 gully on Frank's Creek (Figure F-5, Table F-7). It is noted herein that other gullies have not shown sufficient visible movement of the gully heads for the calculation of migration rates (Lines 417-418), yet it is not known what data this statement is based upon. Without intervention, and assuming constant rates of advance, these gullies could intersect the SDA trench within 200 years and the Construction and Demolition Debris Landfill within 100 to 150 years.

Summary comments on *F.2 Magnitude of Surface Erosion Rates Based on Empirical Studies*:

1. More than 20 major and moderate-sized gullies have been identified at the WVDP, some in very close proximity to the buried waste. Data on rates of gully advance are very limited, but those available suggest advance rates of 0.4 to 0.7 m/yr.
2. Based on these rates, gullies could breach the SDA and Construction and Demolition debris Landfill within 100 to 200 years without intervention.
3. Actively advancing gullies, therefore, are the principal surface erosion threat to the WVDP.

F.3 Erosion Rate Prediction Methods

This section presents the Channel-Hillslope Integrated Landscape Development (CHILD) model, a numerical model capable of simulating the evolution of landscapes over relatively large time and space scales. From the literature describing the model and its components (e.g., Tucker et al., 2001a,b), the following briefly summarizes the important attributes of the model. As noted above, the landscape evolution model SIBERIA, a precursor to CHILD, was previously used in this environmental impact analysis, but its applications have been completely replaced by CHILD.

The computational grid is based on a triangulated irregular network (TIN), which can vary in arrangement and resolution. Since a TIN creates Voronoi polygons of known surface areas and slopes, all model calculations for mass continuity and flow rates are based on a finite-volume approach. The primary input parameters are rainfall, a preexisting surface topography, either an uplift or base-level lowering rate, and geomorphic laws governing transport of water and sediment across the landscape. This mass transport is subdivided into two broad categories: channels that are governed by open-channel flow relationships, and hillslope mass movement that is governed by a diffusion process.

F.3.1.4.1 Reconstructed Postglacial Topography of Buttermilk Creek.

The evolution of Buttermilk Creek watershed from the end of the last glacial maximum (ca. 18,000 years ago) to modern time was simulated using CHILD. The topography at the start of this simulation was constructed using a valley slope projection method, which connects remnant topographic features within the valley. Based on this, a mean valley slope of 0.0035 is used, and a total incision depth at the Buttermilk Creek outlet of 69 m is employed. This is equivalent to a base-level lowering rate of about 3.8 m per 1000 years, or about 4 mm/yr. A digital elevation model (DEM) then is created that uses the modern DEM or the reconstructed valley-surface DEM (remnants plus slope), whichever is higher, and this DEM is shown in Figure F-7.

As previously noted in the EPRG-1, the evolution of the Buttermilk Creek Valley landscape was very complex, and presumably included the initial deposition of alluvial fans and deltas at the periphery of the proglacial lake and their subsequent dissection by their own feeder creeks as changes in base levels occurred. The drainage pattern during deglaciation would have been complex in space and dynamic in time, since lowering of the proglacial lake levels would have exposed variable topography and relict stream channel valleys and divides. Initial erosion was affected by lake dewatering and its supposed catastrophic flow. Meanwhile, feeder creeks eroding the highland above the lakes established entrenchment in the lake bottom by flooding the exposed dewatered lake-bottom surface. Entrenchment form and pattern were influenced by the location and orientation of joints and other discontinuities within the uppermost part of the Lavery till. Headward erosion of the creeks by knickpoint migration would react differently to local stratigraphic variations within the valley's glacial deposits as local base levels were established in response to the erosion of the controlling bedrock sill near the mouth of Buttermilk Creek.

The modern landscape of the Buttermilk Creek Valley includes remnants of hanging proglacial lake deltas, highland-creek alluvial fans, and lake-beach strands of previous high-standing proglacial lakes, as noted in the PRDEIS08. Similarly, the plateau tops, which are imposed upon well-weathered Lavery till, appear to have experienced relatively minor erosion as compared with the creek sides. These relict plateau-top features attest to the lack of uniform postglacial erosion of the drainage basin. Likewise, they imply that most erosion is by headward and sideward erosion in creek beds, and not by uniform downward erosion of all surfaces.

Two important observations were made by the EPRG-1, as well as the reviewers for the PRDEIS06 and PRDEIS08, with respect the long-term simulation of the site using the SIBERIA model. First, the fluvial network system appears to become locked in space over the length of the simulations (millennia). That is, all simulated river channels' thalwegs and gully heads appear to remain at the same location over 1000s of years—frozen in time. Second, a stream channel drainage network based entirely on the modern-day stream channel network is used (i.e., the modern-day channel network was superimposed onto this 18,000 years-before-present landscape). In the FEIS, no longer are plots of the landscape as a function of time presented, and the description of the bed surface topography and at the beginning of the simulation now is conspicuously absent.

F.3.1.4.2 Boundary Conditions: Base-level History

This section interprets the OSL data to define a base-level history (a rate of incision or base-level lowering through the glacial sediment during this ca. 18,000-year time period). Given the uncertainty of the dates, and the geomorphic interpretation of the deposits, five dates are used as the starting point of base-level lowering (18,300, 17,500, 16,700, 16,000, and 15,240 years ago) and five dates are used to demarcate the confluence of Cattaraugus and Buttermilk Creeks with a discrete river terrace where Sample 7a was collected (7,050, 9,500, 12,000, 14,500, and 17,040 years ago). The difference in elevation between these respective points of reference, whether the elevation of the terrace or the elevation of the modern confluence, divided by the difference in time is defined as the rate of base-level drop within Buttermilk Creek. No explicit rates have been reported here, but these rates appear to vary from about 1 to 22 m per 1000 years based on Tables F-3 and F-4.

F.3.1.4.4 Parameters Related to Climate

The CHILD model requires an average storm intensity, an average fraction of time that precipitation occurs, and an average duration of a storm and inter-storm sequence. Data measured at the Western New York Nuclear Service Center (WNYNSC) weather station now are used to define these parameters. The mean annual precipitation rate for the 9.8 years of record is 1.02 m/yr, with an average storm duration of 2.57 hr and an average flow depth of 3.73 mm. The value of the precipitation-duration parameter is estimated to be 0.08, i.e. precipitation occurs on average 8% of the time or there are about 700 hrs of rainfall per year. This translates into an average storm intensity of 1.45 mm/hr.

These average rainfall intensities seem contrived. Storm intensities of 1.45 mm/hr for 2.57 hr appear inordinately low, and the occurrence of rain 8% of the time or 700 hr/yr seems inordinately high. Given these values, one might expect 272 days of rain per year in the WVDP region, during which time each storm would last 2.57 hr at a rate of 1.45 mm/hr. It is more likely that less frequent, higher intensity storms take place, which would generate much higher rates of runoff. For example, one could expect in the West Valley Demonstration Project (WVDP) about 30 days of thunderstorms, and probable maximum precipitation rates of about 430 mm in 6 hr (71 mm/hr) to 560 mm in 24 hr (23 mm/hr; Dingman, 2002). It is noted here that CHILD presumably draws at random a precipitation event from exponential frequency distributions. Yet it is unclear how representative these values are given the above discussion.

F.3.1.4.5 Soil Infiltration Capacity

Estimations of the rate of infiltration are presented. These range from 0.9 to 3.4 mm/hr. Based on these results, five values for the soil's effective infiltration capacity I_c are defined: 3.82, 8.29, 16.8, 19.4, and 68.7 m/yr, which are equivalent to 0.4, 1.0, 1.9, 2.2, and 7.8 mm/hr.

The likelihood of a storm event producing runoff appears to be low given these mean values. Unless there is water storage within the subsurface that modulates I_c, it appears that only the lower two rates (0.4 and 1.0 mm/hr) are less than the prescribed mean storm intensity of 1.45 mm/hr. That is, those randomly selected storm events must deviate considerably from the mean values in order to generate runoff of any significance.

F.3.1.4.6 Channel Width Parameters

Channel width W (m) at any node within the drainage network is defined as

$$W = k_w Q^\gamma \quad (1)$$

where Q is flow rate (m^3/s) and k_w and γ are empirical coefficients. Channel width can be evaluated at-a-station (width as a function of discharge at a given location) or in the downstream direction (width as a function of a given discharge frequency in the downstream direction; typically bankfull). Using regional data, the following values are used: $k_w = 4.49$ and $\gamma = 0.5$. No distinction is made between hillslope channels (rills and gullies) and stream channels. In a recent report, the USDA-NRCS (2007) developed regional curves to predict channel width in the downstream direction. For channels covered by less than 50% vegetation, $k_w = 3.31$ (2.15 to 5.08) and $\gamma = 0.5$, where the values in parentheses represent the 90% confidence interval for k_w.

The exponent γ is commonly assumed to be ~0 to 0.2 at-a-station and ~0.5 in the downstream direction (Knighton, 1998). This essentially translates into nearly rectangular cross-sections that increase in width downstream. For upland concentrated flows, this exponent in the downstream direction decreases to ~0.4 for gullies and ~0.3 for rills (Nachtergaele et al., 2002). It is noted that while the coefficients used in eq. (1) have some resemblance to published and regional values, it is disappointing that this equation has not been derived from or verified with on-site measurements or determinations.

F.3.1.4.7 Parameters Related to Water Erosion and Sediment Transport

Equations for the detachment capacity of cohesive sediment and bedrock and the rate of bedload transport for non-cohesive sediment are presented, and each is represented by an excess shear-stress approach. For detachment limited flows, the detachment capacity (m/s) is

$$D_c = K_b(\tau - \tau_{cb}) \qquad (2)$$

where K_b is the detachment coefficient (m/Pa-yr), τ is the mean boundary shear stress (Pa; defined below), and τ_{cb} is the critical shear stress for the cohesive material (Pa). Owing to the lack of data, the following bracketed values are used in the analysis: 1, 4, 16, 80, and 400 Pa for τ_{cb}, 1, 10, 100, 1000, and 10,000 m/Pa-yr for K_b of the thick till (noted herein as K_{bt}), and 0.001, 0.01, 0.1, 1, and 10 for K_b of the Paleozoic bedrock (noted herein as K_{br}).

Defining the detachment coefficient and critical shear stress for cohesive sediment and bedrock is problematic. Knapen et al. (2007) provided an exhaustive review on soil erodibility by upland, concentrated flows, focusing primarily on K_b and τ_c. In addition to a number of observations, they found the following: (1) K_b and τ_c can vary among soils by several orders of magnitude, (2) no statistically significant relationship exists between K_b and τ_c for all available data, and (3) a multitude of soil and environmental properties are responsible for the large range and temporal and spatial variation in K_b and τ_c. In contrast, Hanson and Simon (2001) used a jet-test device to determine the erodibility of a wide range of cohesive beds under natural, in situ conditions, and these data define the following relationship:

$$K_b = 0.1\tau^{0.5} \qquad (3)$$

where units for K_b are cm^3/N-s. Here is the problem. It is clear that user-defined or quantified values of K_b and τ_c would be far superior to any estimated values, given these discussions. Knappen et al. (2007), however, suggest that no systematic relationship exists between K_b and τ_c for paired samples, whereas Hanson and Simon (2001) suggest that K_b is proportional to τ_c. Bracketed values for both K_b and τ_c are adopted herein. Yet these erodibility parameters are not paired samples, as in the case of Knapen et al. (2007), nor are these functionally related, as in the case of Hanson and Simon (2001) and eq. (3). As such, the uncertainty in predicting the detachment of cohesive material and bedrock is considered very large.

For transport limited flows, the volumetric sediment transport capacity for non-cohesive sediment of a single grain size Q_c (assumed to be m^3/yr) is defined as

$$Q_c = WK_f \left(\tau^p - \tau_{cr}^p\right) \qquad (4)$$

where K_f is a lumped transport efficiency parameter (noted herein as $m^2/Pa^{2/3}$-yr), τ_{cr} is the critical shear stress for the non-cohesive (regolith) material (Pa), and p is an empirical coefficient. This equation is similar in form to Meyer-Peter and Müller's (1948) formula (as reported in Wong and Parker, 2007), and in its simplest dimensionless form is defined as

$$q_* = 8\left(\tau_*^{3/2} - \tau_{*c}^{3/2}\right) \qquad (5)$$

where q_* is dimensionless volume bedload transport rate per unit channel width, τ_* the dimensionless bed shear stress, and τ_{*c} are dimensionless critical shear stress for the particle (the variables used to non-dimensionalize these parameters are not important here). In the CHILD model, $K_f \approx 8$, but must be converted for units (reported as ~500), and $p \approx 3/2$. Since this relation is written for a single grain size, and the transport efficiency parameter can vary, the following bracketed values are used in the analysis: 20, 100, 500, 2,500, and 12,500 $m^2/Pa^{2/3}$-yr for K_f, and 4, 10, 23, 54, and 124 Pa for τ_{cr}, which results in the following equivalent grains sizes 0.005, 0.014, 0.032, 0.074, and 0.170 m using

$$\tau_{cr*} = \frac{\tau_{cr}}{\left(\sigma - \rho\right) gD} \qquad (6)$$

where $\tau_{cr*} = 0.045$ for hydraulically rough, turbulent flows, σ is sediment density (2650 kg/m^3), ρ s fluid density (1000 kg/m^3), and D is grain size (m; see Bridge and Bennett, 1992). By using these bracketed values, eq. (4) effectively includes a range of possible grain sizes and a whole host of bed states that could alter the effective shear stress responsible for sediment transport (see Bridge and Bennett, 1992).

There are a relatively large number of predictive bedload transport equations currently available (e.g., Gomez and Church, 1989; Barry et al., 2004). The accuracy of these relations, however, depends both upon the analytic strength of the formulation and the quality of the data it is being compared to (Barry et al., 2004; Bunte et al., 2004). The bedload transport relation defined in eq. (4) is no exception since (1) several studies have shown its lack of predictive ability (e.g., Gomez and Church, 1989; Barry et al., 2004), (2) potential errors may exist in its derivation (Wong and Parker, 2007), and (3) this formulation has not been compared or validated with any field data collected on-site. Because eq. (4) and its coefficients have not been verified or validated for sediment transport data from Buttermilk Creek or its local environs, the predictions can be orders of magnitude higher or lower than observed values (e.g., Barry et al., 2004). As such, the uncertainty in predicting the transport of non-cohesive sediment also is considered very large.

The CHILD model calculates a mean bed shear stress τ (Pa) using

$$\tau = \rho g^{2/3} C_f^{1/3} \left(\frac{Q}{W}\right)^{2/3} S^{2/3} \qquad (7)$$

where C_f is defined as a dimensionless friction factor, which is then related to the Manning coefficient n ($s/m^{1/3}$) by

$$C_f^{1/3} = \frac{gn^2}{H^{1/3}} \qquad (8)$$

where H is flow depth. To solve eqs. (7) and (8), it is assumed that (1) $n \approx 0.033 \text{ to } 0.06 \text{ s/m}^{1/3}$, which encompass beds covered by sand dunes to those covered by gravel to cobbles (Julien, 2002), and $H \approx 1 \text{ ft}$ (0.30 m). Using $K_t = \rho g^{2/3} C_f^{1/3}$ and the above assumptions, $K_t \approx 1150 \text{ to } 1750$. The following bracketed values then are used in the analysis: 1,000, 1,250, 1,500, 1,750, and 2,000 for K_t.

These equations are similar in form to the following standard relationships for steady, uniform flows in wide, rectangular channels (from Julien, 2002, pp. 88-93):

$$\tau = \rho g H S \tag{9}$$

$$H = \left(\frac{fq^2}{8gS}\right)^{1/3} = \left(\frac{fQ^2}{8W^2 gS}\right)^{1/3} = \left(\frac{nq}{S^{1/2}}\right)^{3/5} \tag{10}$$

$$U = \frac{H^{2/3} S^{1/2}}{n} = CH^{1/2} S^{1/2} = \sqrt{\frac{8g}{f}} H^{1/2} S^{1/2} \tag{11}$$

$$f = \frac{8\tau}{\rho U^2} = \frac{8gHS}{U^2} \tag{12}$$

$$f = \frac{8g}{C^2} = \frac{8gn^2}{H^{1/3}} \tag{13}$$

where $H \approx R$, R is hydraulic radius (m), q is unit discharge (m^2/s), f is the Darcy-Weisbach friction factor (dimensionless), U is mean flow velocity (m/s), and C is the Chezy coefficient (m$^{1/2}$/s). In the version of CHILD presented by Gasparini et al. (2004), the mean boundary shear stress τ derived explicitly by Howard (1994) is employed, defined as

$$\tau = \rho g \left(\frac{n}{k_1}\right)^{0.6} (PA)^{0.3} S^{0.7} \tag{14}$$

where k_1 is an empirical constant determined by $W = k_1 A^{0.5}$, and P is precipitation (m/yr) and A is drainage basin area (m^2), such that $Q = PA$, which is notably different from eq. (7). The relationships defined in eqs. (7) and (8) appear questionable for the following reasons: (1) it is unknown what manipulations were used to derive eqs. (7) and (8) above, given the standard expressions shown eqs. (9) to (13) (this referee was unable to derive either eq. (7) or (8)), (2) it appears that one roughness coefficient (n) is used as input to a second roughness coefficient (C_f in eq. (8)), which is circular logic, and (3) there is no justification to assume flow at bankfull stage within the entire watershed is both non-varying in space and time, and equal to 1 ft (0.30 m). Without such derivations, and given the assumptions above, the uncertainty in predicting mean bed shear stress is considered very large.

F.3.1.4.8 Parameters Related to Sediment Transport by Soil Creep and Landsliding

The hillslope regions of the WVDP are subject to mass-wasting processes. Following Roering et al. (1999), the CHILD model uses a sediment transport equation derived to simulate the combined processes of biogenic activity, rainsplash, soil creep, and solifluction on hillslopes, defined as

$$q_{sc} = \frac{-K_d \nabla z}{1 - \left(|\nabla z| / S_c\right)^2} \quad (15)$$

where q_{sc} is the vector hillslope sediment flux (m^3/m-yr), K_d is a hillslope diffusion coefficient (m^2/yr), ∇z is the topographic gradient (m/m), and S_c is a threshold slope gradient (taken here as 21°). Values of K_d for a wide range of studies are summarized in Table F-10, but no such values are available for WVDP. As such, the following bracketed values then are used in the analysis: 0.0003, 0.001, 0.003, 0.01, and 0.036 (m^2/yr) for K_d.

In its original derivation, Roering et al. (1999) note that eq. (15) does not explicitly include relatively small soil slips, but it may capture their diffusive behavior over long timescales. Moreover, eq. (15) does not address relatively larger landslides.

F.3.1.4.9 Model-data Comparison Metrics

As noted above, six metrics are identified to provide a measure of model performance. These include the longitudinal profile of Buttermilk Creek, the construction of a hypsometric curve for the entire landscape, a slope-area diagram for the entire landscape, width function, a cumulative area distribution for the entire landscape, and the positions of strath terraces. Similar metrics have been employed to compare the SIBERIA model to natural catchments (e.g., Hancock et al., 2002). Here, the first five metrics are assigned goodness-of-fit scores from 0 (no agreement) to 1 (perfect agreement) by simply dividing the curves into 101 points and comparing these observed data points to the predicted data points.

F.3.1.5 Testing and Calibration Results

To facilitate model sensitivity, and potentially address predictive uncertainty, the authors adopt a Latin Hypercube Sampling (LHS) approach (e.g., McKay, 1992). In this method, a range of probable values a for each uncertain parameter b is defined and given equal probability of occurrence. In this case, $a = 5$ and $b = 10$ (see Table F-8 and the bracketed values discussed), which defines a design matrix. Thus, the number of possible combinations is $a^b \approx 10^6$. As such, this design matrix then is sampled randomly, and the authors chose a limit of 1000 computer runs to conduct this work. This approach is widely used in risk assessment, and can be used to quantify the uncertainty ranges of the model output based on the accepted range of input parameters.

Using the range of input parameters, the 1000 computer simulations, and the model-data comparison metrics, five runs are identified that satisfy the goodness-of-fit criteria (highest values) as well as having strong "visual correspondence" to the observed topography. These five runs and their input parameters are listed in Table F-11. The run with the highest goodness-of-fit value (0.680, Run 298) then is used as the "standard case" for the forward modeling exercise, whereas the remaining four runs are used as "alternates" (Alternate 1 to 4). Figures F-8 to F-13 compare the observed and predicted values for the "standard case" against each metric used.

Several key points need to be addressed here.

1. Five runs (298, 321, 622, 891, 972) are identified as being "superior" simulations using the LHS approach and the "goodness-of-fit" indices (Table F-11). What is striking about these results is the large range in parameter values that actually result in a "superior" performance. These ranges typically are orders of magnitude. For example, the bedrock erodibility coefficient for till K_{bt} can range from 10 to 10,000, and the bedrock erodibility coefficient for bedrock K_{br} can range from 0.001 to 1. Yet model performance is deemed "superior" using these wide-ranging values if the combination of all the other parameters results in an appropriate "goodness-of-fit" value. In fact, not a single parameter shown in Table F-11 can be considered relatively constant across all acceptable calibration runs, and yet all of them are considered to be "superior" based on the metrics employed.
    a. Because the parameter ranges have not been strongly tied to the physical or hydrologic characteristics of the site, as noted previously, the results cannot be accepted. How can one confidently accept one simulation run's results over another's when the input parameters can be so markedly different? This apparent disconnect between model parameterization used by CHILD in simulating the WVDP and the hydrologic and geologic characteristics has been noted in previous reviews.
    b. Because the range of parameters can vary by orders of magnitude, it is likely that the uncertainty of the predictions also can vary by orders of magnitude. No quantification of this uncertainty is provided, yet the LHS approach used herein could provide such a measure (see McKay, 1992).
    c. This calibration procedure assumes that all parameters used to arrive at the result are appropriate for the hydrologic and geologic environment. As noted in previous reviews, one could get the right answer, in this case some reasonable fit between model predictions and stream profile elevation, for the wrong reasons (i.e., the use of model parameters that have little physical or hydrologic relation to the site-specific conditions). There remains no demonstration that model input parameters have any strong relation whatsoever to on-site characteristics.
2. It is still unknown how model construction at the start of the simulation immediately following the last glacial maximum (i.e., the initial landscape topography, the location and characteristics of the drainage network, etc.) affects the simulated landscape and network characteristics of the present day.
3. There is very little utility in comparing observed basin hypsometry (Figure F-10), slope-area distribution (Figure F-11), the catchment-width function, and fractional drainage area (Figure F-14) with model output. These approaches essentially aggregate data from disparate locations within the basin. In addition, it appears entirely likely that if the modern network is used as the starting point for the simulation, then these plots would share similar topographic signatures. The longitudinal profile of Buttermilk Creek (Figure F-9) is a more appropriate comparison of model output, yet this comparison also is fraught with uncertainty. The U.S. Geological Survey (U.S. Department of the Interior, National Mapping Division) reports that a "desirable" vertical root-mean-square error (RMSE) estimation for a 7.5-minute DEM is less than 7 m, but a maximum RMSE of 15 m is permitted.
4. The authors do not report the range of the predicted values, be these bed surface elevations or some other control point, based on these 1000 simulations. That is, the authors are, for the first time, in a position to provide a quantifiable measure of the uncertainty of the model output based on the LHS approach adopted, yet this information and results are not reported.

5. The resolution of the grid employed in these simulations appears to be 90 m (see line 1221). By design, only the largest of stream channels can be digitally represented in this mesh. Although actively advancing gullies are the principal surface erosion threat to the WVDP, gullies cannot be simulated in these model simulations.

F.3.1.6 Forward Modeling of Erosion Patterns

Based on these five "superior" calibration runs defined above, and their input parameters sets, the evolution of the WVDP from the present time to 10,000 years into the future is simulated. A total of four different scenarios (26 runs) are considered here: (i) the five calibration runs (termed Standard and Alternates 1 to 4) for the North and South Plateaus (10 runs total), (ii) a "wet" condition, where the mean precipitation rate is doubled and the infiltration rate in minimized for the North and South Plateaus (2 runs total), (iii) a "wet + fast creep" scenario for the South Plateau, where high precipitation and runoff rates are coupled to a high soil diffusivity (1 run total; further discussed in F.3.1.6.4), and (iv) a "close-in-place" scenario, where two mounds are added to the North and South Plateaus to signify the buried waste, and where all scenarios are considered (13 runs total).

In all cases, an extrinsic control is imposed on the erosion processes at the WVDP. That is, a base-level lowering rate is used by the CHILD model to geomorphically drive the evolution of the landscape.

F.3.1.6.2 Model Resolution

Two different grid resolutions are employed. Both the North and South Plateaus are simulated at a mesh resolution of 2.8 m, whereas all other areas were simulated at a mesh resolution of 90 m.

F.3.1.6.5 Summary of Forward-run Scenarios

A summary of all forward-run scenarios is provided in Table F-12, and maps depicting the relative amount of erosion and deposition for each scenario are illustrated in Figures F-15 to F-38. For each figure, the modern-day (0 years) and future (10,000 years) elevations and the difference in elevation (binned data depicting net erosion or sedimentation) are shown. The following observations are made.

1. In general, very little erosion (less than 0.25 m) takes place on the plateau regions. This presumably is because of the reduced slope S or lack of runoff Q for concentrated flow erosion, and the lack of any significant topographic gradient ∇z for mass-wasting to occur. Since S and potentially Q are small, mean bed shear stress τ using eq. (7), or something similar for overland flow, also is small. Since ∇z is small, there is no topographic gradient to drive the diffusion of material downslope, as predicted in eq. (15).
2. The deepening of the stream channels and gullies surrounding the SDA and NDA range from 5 to 27 m in 10,000 years. This rate of incision, 0.005 to 0.027 m/yr, is comparable to the imposed rate of base-level lowering adopted in CHILD, about 0.001 to 0.022 m/yr (see above). This is no surprise since it is base-level lowering that drives erosion and landscape evolution within the model.

3. Some gullies are noted to advance 100 to 200 m into the plateau regions in 10,000 years. These rates of gully advance, 0.1 to 0.2 m/yr, are comparable to the observed rates presented above (0.4 to 0.7 m/yr, Table F-7), yet these rates should be considered modest at best.
4. Those gullies identified on the North Plateau that grow headward with time appear to do so because they are pre-existing topographic phenomena. That is, these gullies exist and grow headward because they already exist on the landscape [the hollows already exist in the digital elevation model (DEM)]. The model operators recognize this phenomenon by noting that the locations of the gullies are highly sensitive to small variations in parameter values and initial topography (line 1582). This is in stark contrast to the initiation of gullies on a landscape in response to geomorphic processes, which does not appear to occur within the model. In seems highly unlikely that up to 20 m of incision occurs within the streams surrounding the North Plateau without the creation of edge-of-field gullies, which would allow this drop in local base-level to propagate upward onto the plateau and toward the buried wastes.
5. It is well accepted that the headward advance of gullies (specifically edge-of-field gullies that link the hillslopes to the streams) is the primary threat to the buried wastes at the WVDP. Yet the grid resolution employed (2.8 m for the plateau areas) still appears to be too coarse to rectify gullies that are decimeter to meter in scale.

F.3.1.6.11 Discussion of Forward Modeling Results

It is difficult to accept or ratify the results presented for the future evolution of the WVDP as depicted within the CHILD model. This opinion is based on the following four criteria: (1) a serious disconnect exists between model parameterization and the hydrologic and geomorphic characteristics of the site, (2) no verification or validation of any models is presented in the context of comparing model output with actual field data, (3) many of the model components are unjustifiable and unsupported by scientific evidence, and (4) no uncertainty analysis of any model predictions is provided.

F.3.2 Verification of Landscape Evolution Modeling Results – Short-term Modeling Studies

Short-term soil erosion rates were calculated using four commonly-used models: USLE, SEDIMOT II, CREAMS, and WEPP. The primary short-coming in the use of these models is the parameterization of the hydrology and the erodibility of the soil material. While the hydrologic parameters typically rely upon SCS-approaches (e.g., USDA-SCS, 1986), the erodibility indices must be either user-defined or calculated values. Table F-16 summarizes some of these parameters as used in WEPP, for example, where the rill and interrill erodibility coefficients and the critical shear stresses of the soils are identified. As already noted, Knapen et al. (2007) found that the erodibility coefficients and the critical shear stress can vary among soils by several orders of magnitude, that no statistically significant relation exists between the erodibility coefficient and critical shear stress for all available data, and that a multitude of soil and environmental properties are responsible for the large range and temporal and spatial variation in these erodibility indices, in addition to a number of other observations. Given the complex surface geology of the site and the variable geotechnical characteristics of the soils and tills, derived erosion rates from these models can vary by orders of magnitude just because of inadequately quantifying the soil's erodibility characteristics. That is, no on-site verification exists of the erodibility coefficients used in these models and presented in Table F-16. Derived erosion rates would have very large ranges of uncertainty because of this lack of verification.

More importantly, none of these models can explicitly address gully erosion processes on hillslopes, either as classic or ephemeral gullies. The only models currently available to field practitioners to address ephemeral gully erosion on agricultural fields or upland areas are (1) the Ephemeral Gully Erosion Model (Merkel et al., 1988; USDA-SCS, 1992; Woodward, 1999), and (2) its recent revision (Gordon et al., 2007). The results from these soil models used herein provide little useful information with regard to the present and future integrity of the West Valley Site since gullies are the principal surface erosion threat and since the models employed are incapable of predicting soil losses from these erosional features.

The SWAT model also was used to simulate the Cattaraugus Creek watershed. The results from this simulation are used to corroborate the regional infiltration capacity value employed in the CHILD model. The results shown here are similar to those in an undated report by Evans and Renschler (undated; see references).

F.4 Conclusions

A number of summary statements are offered at the end of Appendix F based primarily on the modeling results presented. Below is a selection of these statements, with line numbers, and brief comments in response.

Line 1972: "The agreement between modeled and observed topography increases confidence in the ability of the model to generate realistic future-erosion scenarios, though it is recognized that the enormous time span, limited data set, and imperfectly known process laws leave scope for uncertainty that must be acknowledged in interpreting any model results."

> Response: The results of any model simulation must be tempered by the uncertainty embedded within it. There exist a variety of techniques to quantify the uncertainty of model predictions. While previous reviews of this EIS have recognized this uncertainty, and have made specific requests for its quantification, no such discussion is presented.

Line 1989: "While some degree of gully activity was common in the modeled scenarios, the location of the fastest-growing gullies is difficult to determine because the flow paths that feed the gullies are quite sensitive to small perturbations in topography. This sensitivity makes it essentially impossible to predict the exact positions of gullies, at least in a deterministic sense."

> Response: Gully erosion is not adequately addressed within the CHILD model because: (1) gully erosion can only occur if these topographic hollows already exist in the DEM, i.e., there is no geomorphic mechanism in the CHILD model to create gullies, and (2) the grid resolution precludes the topographic expression of gullies.

Line 1995: "The model scenarios are subject to several important sources of uncertainty."

Response: It is appreciated that the sources of uncertainty are at least recognized, but the magnitude of this uncertainty remains to be determined.

Line 2029: "Given (1) the close proximity of large gullies to waste-burial areas in some model scenarios, (2) the various sources of uncertainty that influence predicted rates and patterns of erosion, and (3) the indeterminacy of gully position, it is recommended that large-scale erosional exhumation of burial areas in the next 1,000 to 10,000 years should be considered *unlikely but not implausible*."

Response: This statement is based on model simulations known to be (1) laden with unrealistic and unjustifiable assumptions, (2) hydrologically and geomorphically disconnected from the on-site characteristics, and (3) fraught with large uncertainty in its predictive ability. As such, this declarative statement has little scientific support.

Summary comments on *F.3 Erosion Rate Prediction Methods*:

1. The model simulation using CHILD from the initial post-glacial landscape to modern time used a simplified surface topography. The surface erosion processes of Buttermilk Creek Valley since this glacial maximum were very complex, yet the model simulation does not appear to capture these complexities. Therefore, it is highly unlikely that the same model will adequately represent the evolution of the landscape over the next 10,000 years.
2. In previous iterations of this modeling exercise, notably using SIBERIA, it was assumed that the surface drainage network at the beginning of the simulation (ca. 18ka) was the same as the modern drainage network (i.e., the modern-day channel network was superimposed onto this 18,000 years-before-present landscape). It also was previously suggested in the PDEIS06 and PDEIS08 that the fluvial network system became locked in space over the length of the simulations (i.e., all simulated river channels' thalwegs and gully heads appear to remain at the same location over 1000s of years—frozen in time). In the FEIS, no longer are plots of the landscape as a function of time presented, and the description of the bed surface topography and at the beginning of the simulation is conspicuously absent.
3. Samples collected within the Buttermilk Creek watershed are dated using the OSL technique. Based on these ages, rates of base-level lowering from the last glacial maximum to present day range from 1 to 22 m per 1000 years (1 to 22 mm/yr).
4. The average storm events utilized by the CHILD model seem contrived, and the likelihood of a given storm event producing runoff appears to be low.
5. Defining the detachment coefficient and critical shear stress for cohesive sediment and bedrock is problematic. It is clear that user-defined or quantified values of the detachment coefficient and the critical bed shear stress for the materials would be far superior to any estimated values. Yet the use of bracketed values for these erodibility parameters, seemingly unrelated to each other, results in a very large predictive uncertainty range in the erosion of cohesive sediments and bedrock.
6. For transport limited flows, the volumetric sediment transport capacity for non-cohesive sediment of a single grain is based on the formulation of Meyer-Peter and Müller (1948), using a wide range of values for the lumped transport efficiency parameter and critical shear stresses for particle entrainment. The accuracy of this relation is highly

questionable, since its predictive ability has not been demonstrated here and it has been criticized elsewhere in the literature. The use of bracketed values for these erosion parameters results in a very large uncertainty range in the prediction of bedload transport.

7. The relationships used to define mean bed shear stress within the CHILD model appear questionable because it is unknown what manipulations were used in their derivation, it appears that one roughness coefficient is used as input to a second roughness coefficient, and there is no justification whatsoever to assume flow at bankfull stage within the entire watershed is both non-varying in space and time, and equal to 1 ft (0.30 m). Without such derivations, and given the assumptions above, the uncertainty in predicting mean bed shear stress is considered very large.
8. Five simulations of the WVDP from the last glacial maximum to the present time are identified as being “superior” using the LHS approach and the “goodness-of-fit” indices, as presented in the calibration section. The results, however, cannot be accepted or ratified at this time. In addition, the following issues are identified.
    a. What is striking about these results is the large range in parameter values that actually result in a “superior” performance, which are typically orders of magnitude. It is difficult to accept a particular model simulation when such variability in input parameters exists.
    b. Because the range of parameters can vary by orders of magnitude, it is likely that the uncertainty of the predictions also can vary by orders of magnitude.
    c. It is still unknown how model construction at the start of the simulation immediately following the last glacial maximum conditions the simulated landscape and network characteristics of the present day.
    d. The range of the predicted values based on these 1000 simulations would provide a quantifiable measure of the uncertainty of the model output, yet this information and results are not reported.
    e. The resolution of the grid employed in these simulations negates the occurrence and propagation of gullies, which appear to be the principal surface erosion threat to the WVDP.
9. It is difficult to accept or ratify the results presented for the future evolution of the WVDP as depicted within the CHILD model. This opinion is based on the following four criteria:
    a. A serious disconnect exists between model parameterization and the hydrologic and geomorphic characteristics of the site,
    b. No verification or validation of any models is presented in the context of comparing model output with actual field data,
    c. Many of the model components are unjustifiable and unsupported by scientific evidence, and
    d. No uncertainty analysis of any model predictions is provided.
10. Short-term erosion rates determined using USLE, SEDIMOT II, CREAMS, and WEPP are not considered useful in the broad context of the present and future integrity of the West Valley Site. This is because no on-site verification or validation of the hydrologic and geomorphic input parameters used in these models was conducted, and none of these models is capable of predicting the development, growth, and upstream migration of and soil losses due to gullies.

11. The concluding statement that “large-scale erosional exhumation of burial areas in the next 1,000 to 10,000 years should be considered *unlikely but not implausible*” has little scientific support.

4. RESPONSES TO REVIEW OF PDEIS

In the review of Appendix F in the DEIS (PRDEIS08), several summary statements were offered to DOE and its cooperators regarding the surface erosion modeling components. Below these statements are repeated, and comments are offered on whether these are addressed herein (Table 1).

Table 1: The main conclusions from the Peer Review of the Draft (on left) in comparison to the revisions presented in the Final EIS (on right).

Draft EIS dated 6/13/2008	Final EIS dated 10/5/2009
A serious disconnect exists between model parameterization and the hydrologic and geomorphic characteristics of the site. This has resulted in highly questionable and physically unjustifiable assumptions in the treatment and assignment of variables within these models.	This serious disconnect still exists, as many of the input parameters remain estimations rather than based on measurements or on-site quantification.
No verification or validation of any models is presented in the context of comparing model output with actual field data.	No verification or validation of any models or their individual components is demonstrated.
Many of the model components, especially with regard to the gully erosion and landscape evolution, are unjustifiable and unsupported by scientific evidence.	Many of the model components remain unjustified and unsupported by scientific evidence and on-site verification.
No uncertainty analysis of any model predictions is provided. The uncertainty in model predictions for the gully erosion and landscape evolution is expected to be very large (orders of magnitude) considering the conceptualization, construction, parameterization, discretization, application, and interpretation of the models involved.	No uncertainty analysis of any model predictions is provided.

While the current version of the EIS dated 10/5/2009 offers some refinements over the previous version dated 6/13/2008, especially with regard to modeling the surface processes, serious deficiencies still remain.

5. ADDITIONAL COMMENTS ON MODEL VERIFICATION AND UNCERTAINTY ANALYSIS

An additional discussion of model verification and uncertainty analysis is warranted. Several of these comments appear in previous reviews, notably PRDEIS08, and summarized below.

Model Verification

All these models require the following: (1) input parameters that describe the hydrologic, geologic, and topographic characteristics of the site; (2) use of site-specific hydrologic and geologic parameters; (3) various forms of calibration or verification of model results; (4) some consideration for the numerical schemes employed; and (5) a consistent treatment of the hydrologic, geologic, and topographic characteristics of the site across models, even though these models differ considerably in their physical and theoretical basis and intended applications.

All models predict the magnitudes of selected hydrologic and geologic characteristics, and their time and space variations, on the basis of input variables and model constructions. For USLE, SWAT, and WEPP, these output data include runoff rates and soil losses for the entire watershed, subwatersheds, or individual hillslopes. For CHILD, these output data include landscape denudation by downslope soil movement, water and sediment transport rates within the drainage network, and the change in elevation over time of all hillslope and river locations.

A nearly universal approach in the assessment of model applicability is the calibration and verification of model results with actual data. Model calibration commonly involves the alteration of unknown input parameters, coefficients, equations, or treatments of processes for the sole purpose of improving the predictive capability of the model's output, in comparison with actual observations for a quantitative calculation of goodness-of-fit. Model verification commonly entails the quantitative comparison of the calibrated model output with actual data that were not previously used in the calibration procedure. Data for both selected storms or entire seasons that could be used to calibrate and verify these models include rates for surface runoff, soil erosion, water flow, and sediment transport within the drainage network, and these data could represent characteristics at-a-point in space and instantaneous in time, or aggregated over various temporal or spatial scales.

No verification comparisons of model output have been presented. That is, no demonstration has been made that the model results for the West Valley Site have been verified or validated on the basis of actual data. This issue is different from the calibration procedure used herein: the use of landscape metrics for data-model comparison (*F.3.1.4.9 Model-data Comparison Metrics*). The problem here is that even though models can be physically-based and strongly-aligned to the hydrologic and geologic characteristics of the site, the models may report erroneous or aberrant results, the nature of which remains undetected, ignored, or overlooked because of this lack of verification.

Uncertainty Analysis

The results of all physically-based hydrologic and geomorphic models are subject to significant uncertainty, which can be assessed for simulating past events and for predicting future events. At least four types of uncertainty for simulating past events exist: (1) input uncertainty, which refers to dynamic input data such as rainfall, sediment loads, and land use and land cover, among others; (2) model structure uncertainty, which includes the imperfections in the model itself, data resolution, and numerical algorithms, among others; (3) parameter uncertainty, which refers to process-parameter values, commonly quantified in the governing equations; and (4) observational uncertainty, which refers to the observational data upon which the model simulation is compared and evaluated (e.g., Beven and Binley, 1992; Liu and Gupta, 2007) . All uncertainties commonly are assumed: (1) to be mutually independent, though this is not necessarily true; (2) to be assessable individually; and (3) to be additive with respect to model results. It also is assumed that the total uncertainty of the model's prediction can be quantified by analytic or stochastic means. Two additional types of uncertainty can emerge for predicting future events: (1) linkage uncertainty, which refers to changes in the numerical relations between the driving forces and model output, such as runoff, loads, and elevations, all of which can be attributed to variations in the internal or external characteristics of the watershed, i.e. changes in land management; and (2) future input uncertainty, which refers to the uncertainty of the magnitude, frequency, duration, and character of the model driving forces such as future weather patterns, hydrologic events, etc. The generalized-likelihood-uncertainty-estimation method is widely used in hydrologic uncertainty analyses, and is based on providing acceptable fits to observational data and stochastic model simulations that use traditional goodness-of-fit measures (Beven and Binley, 1992; Beven and Freer, 2001).

Model results presented herein have not included a quantification of the uncertainty of simulations, either in the simulation of past events or in the prediction of future events, and no distinction has been made amongst the uncertainties related to the governing equations, the input parameters, or the model structure. Moreover, the use of CHILD for future predictions results in additional uncertainty considerations, including changes in the relations between the driving forces and model output and the changes in future input parameters.

An important point should be made here with regard to the uncertainty in predicting radionuclide exhumation and release due to surface erosion processes using a long-term erosion model. On the basis of the numerical construction of CHILD, the sources of input and potential verification of model parameters, and the future hydrologic, geomorphic, and land-use forecasting to be employed, the uncertainty bounds in predicting, at a given time in the future, the topography of the West Valley Demonstration Project, the location and dimensions of its stream channels and gullies, and the fluxes of water and sediment exiting the site are likely to be very large. Thus, the prediction of radionuclide dose at a given downstream location at a given time in the future, based on a long-term erosion model simulation, also would be subject to this same uncertainty range.

Estimation of Model Uncertainty

It is important to quantify uncertainty values for the simulated results, as this defines the confidence level in the predicted values. These uncertainties can arise from errors due to measurement of parameters and the propagation of these errors in subsequent calculations. Since the landscape evolution results represent hypothetical simulations, the current discussion is restricted to the uncertainties in the prediction of bed surface elevation z at a discrete point (x,y) in time t.

The governing equation the evolution of bed surface elevation z within CHILD is

$$\frac{\partial z}{\partial t} = -\nabla \boldsymbol{q}_s + B(x, y, t) \tag{16}$$

where $\boldsymbol{q_s}$ is sediment flux (volume rate per unit width) and B is a source term accounting for either rate of tectonic uplift or base-level lowering (Tucker et al., 2001b). For hillslopes governed by the diffusion of mass z_h,

$$\frac{\partial z_h}{\partial t} = -\nabla(-K_d \nabla z) = K_d \nabla^2 z \tag{17}$$

for hillslopes and channels governed by detachment-limited concentrated flows z_d,

$$\frac{\partial z_d}{\partial t} = -D_c \tag{18}$$

and for hillslopes and channels governed by transport-limited concentrated flows z_t,

$$\frac{\partial z_t}{\partial t} = -\left(\frac{1}{1-p}\right)\frac{q_s/W}{\partial x} \tag{19}$$

where p is bed porosity. In these equations, conservation of mass is addressed using a simple finite-volume approach, as afforded by the Voronoi polygons defined by the TIN. The variables in each of these equations, and their respective functions, have been presented above (see eqs. (1), (2), (4), (7), (8), and (15)). For the uncertainty estimation presented below, bed surface elevation will be examined for an arbitrary location at a discrete time.

Here a simplified approach for estimating the uncertainty of a given predictive relation is presented. Following Rabinovich (2005; see also Alonso et al., 2002), let Y be the result of a calculation involving N variables $X_1, X_2, X_3 \ldots X_N$. The relation between the uncertainty for these variables, denoted at $u_{X_1}, u_{X_2}, u_{X_3} \ldots u_{X_N}$, and the uncertainty interval of the calculated result u_Y can be expressed as:

$$u_Y = \left[\left(\frac{\partial Y}{\partial X_1} u_{X_1}\right)^2 + \left(\frac{\partial Y}{\partial X_2} u_{X_2}\right)^2 + \ldots + \left(\frac{\partial Y}{\partial X_N} u_{X_N}\right)^2\right]^{1/2} \tag{20}$$

where the partial derivatives are evaluated at the point $\overline{Y}$, $\overline{X}_1$, $\overline{X}_2 \ldots \overline{X}_N$ so that the variations of the variables are small. In general, eq. (20) can be reduced to a dimensionless form, where ε is the dimensionless uncertainty estimate for both the input parameters and the calculated result:

$$\varepsilon_Y = \left[\left(\frac{\partial Y}{\partial X_1} \varepsilon_{X_1}\right)^2 + \left(\frac{\partial Y}{\partial X_2} \varepsilon_{X_2}\right)^2 + \ldots + \left(\frac{\partial Y}{\partial X_N} \varepsilon_{X_N}\right)^2\right]^{1/2} \tag{21}$$

Equation 21 now yields the relative error of the estimate $\overline{Y}$ in terms of the propagation of relative errors in the input variables. In the case here, Y is represents bed height and variables X_1, X_2, $X_3 \ldots X_N$ represent those parameters used to predict bed height, and while error propagation is additive, the magnitude of the uncertainty is conditioned by the form of the partial derivative.

An estimation of the uncertainty for each variable equation can be determined using either published information or the bracketed values employed in the LHS design matrix. For Q, the 90% confidence interval published by USDA-NRCS (2007) will be used. For all parameters with bracketed values presented herein, the mean $\bar{x}$ and root-mean-square rms of the values are defined as:

$$\bar{x} = \sum_{i=1}^{5} x_i \tag{22}$$

$$rms = \sqrt{\frac{1}{n}\sum_{i=1}^{5} (x_i - \bar{x})^2} \tag{23}$$

where the subscript i denotes an individual value. The fractional uncertainty ε is then defined as:

$$\varepsilon = \frac{rms}{\bar{x}} \tag{24}$$

where $\varepsilon \times 100 = \pm\%$ uncertainty. The fractional uncertainties of all key parameters, and the total fractional uncertainty of all key equations, are presented in Table 2 based on the application eqs. (20) to (24). In these calculations, the following assumptions were made:

1. No error is assigned to S, and an average slope of Buttermilk Creek is taken as 0.015,
2. No error is assigned to precipitation, or the parameters used in the assignment, frequency, and intensity of the storms, and
3. Mean parameter values are used when partial derivatives require one, as defined below:
    a. using $\overline{Q} \approx Q_b =$ [illegible]0 m^3/s as reported in the DEIS, and $\overline{W} \approx 24.6$ m using Q_b and eq. (1), $\overline{Q/W} =$ [illegible].22 m^2/s,
    b. using $\overline{Q/W}$, $\overline{Q/W} = \overline{HU}$, $\bar{n} = 0.047$ s/m$^{1/3}$, and eq. (11), $\overline{H} =$ [illegible].13 m,
    c. using $\overline{C_f}$, $\overline{H}$, $\bar{n}$, $\overline{Q/W}$, and eqs. (7) and (8), $\bar{\tau} =$ [illegible].7 Pa, [It is worth noting here that this referee still finds eq. (7) questionable. For example, using $\overline{C_f}$, $\overline{H}$, $\bar{n}$, $S = 0.015$ and eq. (9), $\bar{\tau} =$ [illegible]66 Pa, which appears to be a more likely mean bed shear stress for the bankfull flow in question],
    d. for Q_c, $\overline{\tau_{cr}} \approx$ [illegible]2 Pa, which is the average value for cohesive and non-cohesive sediments as reported here, and the average of their fractional uncertainty values is used (1.27). It is noted here that $\overline{\tau_{cr}} > \bar{\tau}$. A range of flows, however, would be used in CHILD, thus H and Q/W also would in eqs. (7) and (8).

The relative uncertainties of key parameters reflect the use of the bracketed values within the design matrix. While some parameters and equations result in relatively small uncertainties, such 0.07 (±7%) for the starting age of base-level lowering, most relations result in fractional uncertainties of 1 to 2 (±100 to ±200%). Extending this to the prediction of bed height, as shown in eqs. (16) to (19), and using the same approach as shown in eqs. (20) and (21), the fractional uncertainties range from about 1.3 to 2.5 (±130% to ±250%) at a given *x*, *y*, and *t* and precipitation event. That is, any uncertainties related to precipitation, time, and space, and the propagation of these uncertainties, are not included in this estimate.

In summary, while the uncertainty estimates presented above are simply defined, they do provide reasonable values based on the equations employed and the input value ranges. Thus, one could conclude that the percent uncertainty of the model CHILD for predicting bed surface elevation at a given location (hillslope or stream channel) ranges from ±130% to ±250%, or the predicted bed surface can be height could be as much as 3.5 times larger or smaller than that reported. Additional uncertainties would arise from (1) input uncertainty of those parameters not examined here; (2) model structure uncertainty; (3) parameter uncertainty not considered here; and (4) observational uncertainty (e.g., Beven and Binely, 1992; Liu and Gupta, 2007). As noted above, temporal or spatial uncertainties and uncertainties related to the precipitation events also have not been quantified. One could image that an uncertainty range of ±130% to ±250% for predicting bed surface elevation would increase significantly if these calculations are run 10 times per year (0.1 yr global time step, see line 663) over an area of ~100 km^2 for a 10,000 year simulation. Given that additional significant uncertainties are recognized but not yet quantified, the uncertainty of the CHILD model predictions are minimally ±250%, and are likely to be considerably higher.

Table 2: Summary of equations and their uncertainties

Eq. no.	Parameter or equation	Parameter	Estimated fractional uncertainty of each parameter[1]	Total fractional uncertainty of equation[3]
	Start of base-level lowering		0.07	
	Age of river terrace		0.30	
	I_c		0.98	
(1)	$W = k_w Q^\gamma$	Q	0.44[2]	0.44
(2)	$D_c = K_b(\tau - \tau_{cb})$	K_{bt}, τ_{cb}	1.76, 1.52	2.53
		K_{br}, τ_{cb}	1.76, 1.52	
		τ	1.02	
(7)	$\tau = \rho g^{2/3} C_f^{1/3} \left(\frac{Q}{W}\right)^{2/3} S^{2/3}$	K_t ($\approx C_f$)	0.24	1.02
		W	0.44	
(4)	$Q_c = W K_f(\tau^p - \tau_{cr}^p)$	W	0.44	1.60
		K_f	1.52	
		τ	1.02	
		τ_{cr}	1.02	
		τ_{cb}	1.52	
(15)	$q_{sc} = \frac{-K_d \nabla z}{1-(\lvert\nabla z\rvert/S_c)}$	K_d	1.34	1.34

[1]based on eq. (23)
[2]based on 90% confidence intervals published by USDA-NRCS (2007)
[3]based on eq. (21), and a mean parameter value is used if the partial differential equation requires one

It should be noted that the design matrix constructed in the LHS scheme above can be used to determine an uncertainty measure. In the current application, 1000 computer runs were executed in the calibration exercise of CHILD. Based on these results, one could quantify the uncertainty of the simulated values simply by reporting the range of predictions, as is the original intention of the LHS approach (McKay, 1992). No such information has been presented.

6. COMMENTS TO APPENDIX G MODELS FOR LONG-TERM PERFORMANCE ASSESSMENT AND APPENDIX H LONG-TERM PERFORMANCE ASSESSMENT RESULTS

In Appendix G "Models for Long-term Performance Assessment" and Appendix H "Long-term Performance Assessment Results," the authors introduce a gully erosion scenario to establish an upper bound on the potential effects of unmitigated erosion under a loss of institutional control. The following sections provide critical commentary with regard to the construction and use of this gully erosion scenario.

The authors recognize that the headward advance of gullies is the primary threat to the buried wastes at the West Valley Site. To examine this threat, and to approximate the release time of these radioactive materials, the authors use one of the CHILD model simulations for the North Plateau, where the mean precipitation intensity is twice the modern value and the soil infiltration capacity is at its minimum value (called NPTwet, Table F-12, Appendix F). In this simulation, the dimensions of the gully (its width, length, and depth) over time are summarized in Table H-26 and shown graphically at two future times (100 and 4000 years) in Figures H-4 and H-5, respectively.

Current gully erosion models treat each aspect of gully incision, migration, widening, and sediment flux as discrete processes that conform to physically-based governing equations driven by rates of overland flow. Some examples of these models include the Ephemeral Gully Erosion Model (Merkel et al., 1988; USDA-SCS, 1992; Woodward, 1999) and the analytical formulations of Sidorchuk (1999) and Casali et al. (2003). The model of Gordon et al. (2007) represents the most physically-based and conceptually-appropriate gully erosion model to discuss here, and this model draws heavily upon the headcut erosion model of Alonso et al. (2002). The critical components of the gully erosion model of Gordon et al. (2007) are briefly described below.

For a given runoff event, a hydrograph can be constructed at the mouth or outlet of the field or small watershed under investigation, and flow rate at a given location within the field is proportional to the upstream drainage area, depending on the length of the gully (Gordon et al., 2007). Once the flow rate at the mouth of the field exceeds the erosion threshold of the soil (similar to eq. (2), Foster et al., 1982), incision is initiated in the form of a headcut (Bennett et al., 2000b) that migrates upstream at a rate proportional to the flow rate and conditioned by the soil's erodibility and the hydraulics of the headcut brinkpoint (Alonso et al., 2002). The depth of the gully, or the depth of headcut scour, also is proportional to the flow rate and conditioned by the soil's erodibility and the plunge pool scour hole (Alonso et al., 2002). The width of the gully downstream of the headcut (Nachtergaele et al., 2002; Torri et al., 2006) and sediment transport

(Bingner and Thereur, 2002), whether limited by sediment supply or flow capacity, also will be proportional to flow rate. The headcut migration rate, the gully width, and the rates of sediment entrainment, transport, and deposition all will vary accordingly in time and space since flow is unsteady and spatially varied.

The erosion of the landscape using CHILD does not account for gully erosion processes, especially the formation and mechanics of gully erosion, and the accelerated rates of erosion that are commonly observed. Additional comments to this approach are provided below.

1. The simulated rate of gully advance shown in Table H-26 is about 0.026 m/yr. This rate is about an order of magnitude lower that the observed rates for select gullies at the WVDP (0.4 to 0.7 m/yr, Table F-7), which are considered modest at best. Because rates of gully headcut advance should be a function of overland flow rate conditioned by the soil's erodibility and the characteristics of the scour pool (Alonso et al., 2002), gully headcut advance rates can vary widely. For example, Gordon et al. (2008) modeled ephemeral gully advance rates in Belgium, Georgia, Mississippi, and Iowa, and these simulated rates could reach as much as 200 m per year. Nachtergaele et al. (2002) reported gully advance rates in Belgium ranging from 8 to 23 m/yr. In rill erosion studies where headcuts were observed, migration rates for these features are significantly higher, ranging from about 0.1 to 2.0 mm/s depending on headcut height and flow rate (Bryan and Poesen, 1989; Bryan, 1990; Slattery and Bryan, 1992; Bennett, 1999; Bennett et al., 2000b). It would seem that the simulated gully advance rate of 0.026 m/yr is very low.
2. The simulated rate of gully widening shown in Table H-26 is about 0.008 m/yr. This rate also is lower than the observed rates for select gullies at the WVDP (Tables F-5 and F-6). In addition, gully width is a function of flow rate (Torri et al., 2006), and these dimensions should be conditioned by surface runoff.
3. The simulated rate of gully incision shown in Table H-26 is about 0.003 m/yr. This rate of incision reflects the imposed rate of base-level lowering within the CHILD model (see Tables F-3 and F-4), rather than plunge pool scour and/or cantilever mass failure as commonly observed in incising rills and gullies (Robinson et al., 2000).
4. The authors do not recognize the role of seepage (exfiltration) on gully erosion initiation and upstream migration. Evidence of surface seepage processes at the West Valley Site is pervasive, and this exfiltration process has been shown to cause, catalyze, and significantly enhance headcut erosion and gully development in cohesive materials (Huang and Laflen, 1996; Fox et al,. 2007). It is highly likely that rates of gully erosion at the West Valley Site would be greatly enhanced because of the pervasive seepage that occurs, yet such linkages have not been addressed herein.

The model CHILD cannot adequately address gully erosion processes. Current models of gully erosion treat each component of the erosion process explicitly, closely coupled to overland flow rates, the erodibility of the soil material, and the hydraulics of the scour hole. Seepage processes, know to enhance or directly cause gully erosion, also are pervasive in the WVDP. The rates of gully advance, widening, and incision as reported here are not coupled to these physical processes, and the rates appear to be grossly underestimated. As such, the estimated times for encroachment to and the breaching of the NDA, and the subsequent release of radioactive material due to gully erosion, also are underestimated.

7. CONCLUSIONS

Appendix F of this FEIS provides the core of the erosion assessment and modeling. In addition, the results of simulations using the CHILD model are considered further in Appendix H. Based on the review of this material, the following conclusions are provided.

1. More than 20 major and moderate-sized gullies have been identified at the WVDP, some in very close proximity to the buried waste. Data on rates of gully advance are very limited, but those available suggest rather modest advance rates of 0.4 to 0.7 m/yr. Based on these advance rates, gullies could breach the SDA and Construction and Demolition Debris Landfill within 100 to 200 years without intervention. Actively advancing gullies, therefore, are the principal surface erosion threat to the WVDP.
2. The model simulation using CHILD from the initial post-glacial landscape to modern time used a simplified surface topography. The surface erosion processes of Buttermilk Creek Valley since this glacial maximum were very complex, yet the model simulation does not appear to capture these complexities. Therefore, it is highly unlikely that the same model will adequately represent the evolution of the landscape over the next 10,000 years.
3. In previous iterations of this modeling exercise, notably using SIBERIA, it was assumed that the surface drainage network at the beginning of the simulation (ca. 18ka) was the same as the modern drainage network (i.e., the modern-day channel network was superimposed onto this 18,000 years-before-present landscape). It also was previously suggested in the PDEIS06 and PDEIS08 that the fluvial network system became locked in space over the length of the simulations (i.e., all simulated river channels' thalwegs and gully heads appear to remain at the same location over 1000s of years—frozen in time). In the FEIS, no longer are plots of the landscape as a function of time presented, and any description or discussion of the bed surface topography and at the beginning of the simulation is conspicuously absent.
4. Samples collected within the Buttermilk Creek watershed are dated using the OSL technique. Based on these ages, rates of base-level lowering from the last glacial maximum to present day range from 1 to 22 m per 1000 years (1 to 22 mm/yr).
5. The average storm events utilized by the CHILD model seem contrived, and the likelihood of a given storm event producing runoff appears to be low.
6. Defining the detachment coefficient and critical shear stress for cohesive sediment and bedrock is problematic. It is clear that user-defined or quantified values of the detachment coefficient and the critical bed shear stress for the materials would be far superior to any estimated values. Yet the use of bracketed values for these erodibility parameters, seemingly unrelated to each other, results in a very large predictive uncertainty in the erosion of cohesive sediments and bedrock.
7. For transport limited flows, the volumetric sediment transport capacity for non-cohesive sediment of a single grain is based on the formulation of Meyer-Peter and Müller (1948), using a wide range of values for the lumped transport efficiency parameter and critical shear stresses for particle entrainment. The accuracy of this relation is highly questionable, since its predictive ability has not been demonstrated here and it has been criticized elsewhere in the literature. The use of bracketed values for these erosion parameters results in a very large uncertainty in the prediction of bedload transport.

8. The relationships used to define mean bed shear stress within the CHILD model appear questionable because it is unknown what manipulations were used in their derivation, one roughness coefficient may be used as input to a second roughness coefficient, and there is no justification whatsoever to assume flow at bankfull stage within the entire watershed is both non-varying in space and time, and equal to 1 ft (0.30 m). Without such derivations, and given the assumptions above, the uncertainty in predicting mean bed shear stress is considered very large.
9. Five simulations of the WVDP from the last glacial maximum to the present time are identified as being "superior" using the LHS approach and the "goodness-of-fit" indices, as presented in the calibration section. The results, however, cannot be accepted or ratified at this time. In addition to the number of issues identified above regarding the input parameters used, the following issues are identified.
    a. What is striking about these results is the large range in parameter values that actually result in a "superior" performance, which are typically orders of magnitude. It is difficult to accept a particular model simulation, or have confidence in the model's prediction, when such variability in input parameters exists.
    b. Because the range of parameters can vary by orders of magnitude, it is likely that the uncertainty of the predictions also can vary by orders of magnitude.
    c. It is still unknown how model construction at the start of the simulation immediately following the last glacial maximum conditions the simulated landscape and network characteristics of the present day.
    d. The range of the predicted values based on these 1000 simulations would provide a quantifiable measure of the uncertainty of the model output, yet this information and results are not reported.
    e. The resolution of the grid employed in these simulations negates the occurrence and propagation of gullies, which appear to be the principal surface erosion threat to the WVDP.
10. It is difficult to accept or ratify the results presented for the future evolution of the WVDP as depicted within the CHILD model, given the number of deficiencies already cited.
11. Short-term erosion rates determined using USLE, SEDIMOT II, CREAMS, and WEPP are not considered useful in the broad context of the present and future integrity of the West Valley Site. This is because no on-site verification or validation of the hydrologic and geomorphic input parameters used in these models is conducted, and none of these models is capable of predicting the development, growth, and upstream migration of and soil losses due to gullies.
12. The concluding statement that "large-scale erosional exhumation of burial areas in the next 1,000 to 10,000 years should be considered *unlikely but not implausible*" has little scientific support.
13. While the current version of the EIS dated 10/5/2009 offers some refinements over the previous version dated 6/13/2008, especially with regard to modeling the surface processes, deficiencies still remain, and these include the following.
    a. A serious disconnect exists between model parameterization and the hydrologic and geomorphic characteristics of the site,

b. No verification or validation of any models is presented in the context of comparing model output with actual field data,
c. Many of the model components, especially with regard to the gully erosion and landscape evolution, are unjustifiable and unsupported by scientific evidence, and
d. No uncertainty analysis of any model predictions is provided.

14. No verification comparisons of model output have been presented. That is, no demonstration has been made that the model results for the West Valley Site have been verified or validated on the basis of actual data.
15. A simplified uncertainty analysis of the governing equations and model input parameters is presented for the CHILD model. The percent uncertainty of the model CHILD for predicting bed surface elevation at a given location ranges from ±130% to ±250% (predicted bed surface elevation could be as much as 3.5 times larger or smaller than that reported by the model). Additional uncertainties not quantified here include those related to additional input parameters, model structure, and comparison datasets, as well as those uncertainties related to time, space, and precipitation. It is envisioned that these additional uncertainties would significantly increase the model uncertainty range reported here.
16. The simulated rates of gully advance and gully widening shown in Table H-26 are significantly lower than observed rates for select gullies at the WVDP. In addition, the simulated rate of gully incision simply reflects the imposed rate of base-level lowering within the CHILD model.
17. Current models of gully erosion treat each component of the erosion process explicitly, closely coupled to overland flow rates, the erodibility of the soil material, and the hydraulics of the scour hole, and these processes are not addressed within the CHILD model.
18. The role of seepage (exfiltration) on gully erosion initiation and upstream migration is not considered, despite the pervasive evidence of surface seepage at the West Valley Site.
19. Given that CHILD model cannot adequately address gully erosion processes, and that the simulated rates of gully erosion are much less than both reported at the WVDP and within the literature, the estimated times for encroachment to and the breaching of the NDA by advancing gullies, and the subsequent release of radioactive material, also are significantly underestimated.

It was noted in the PRDEIS08 that any predictions made using any landscape evolution model with regard to future releases of radionuclides due to surface erosion processes were scientifically indefensible for the following reasons:

1. A serious disconnect exists between model parameterization and the hydrologic and geomorphic characteristics of the site,
2. No verification or validation of any models is presented in the context of comparing model output with actual field data,
3. Many of the model components, especially with regard to the gully erosion and landscape evolution, are unjustifiable and unsupported by scientific evidence, and
4. No uncertainty analysis of any model predictions is provided.

The revisions presented in the FEIS have not altered this assessment, and these statements remain valid. That is, there has been no change in either the reliability or defensibility of the

FIES results with respect to the surface erosion component as compared to its previous version. The prediction of radionuclide doses based on the surface erosion models are, by default, scientifically indefensible, and the uncertainty bounds such predictions are likely to be very large. Any decisions on decommissioning the West Valley Site should carefully consider these large uncertainty estimates.

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APPENDIX D

ACRONYMS AND ABBREVIATIONS

BFS	Blast Furnace Slag
CCTV	Closed Circuit Television
Center	Western New York Nuclear Service Center
CLSM	Controlled Low Strength Material
Codes	CHILD, CREAMS, DandD, MACCS, ORIGEN, PEST, RESRAD, RISKIND, SEDIMOT II, SIBERIA, SWAT, TRAGIS, USLE, WEPP
CPC	Chemical Process Cell
DCGL	Dervied Concentration Guideline Level
DEIS	Draft Environmental Impact Statement
DEM	Digital Elevation Model
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
FEIS	Final Environmental Impact Statement
GLUE	Generalized Likelihood Uncertainty Estimation
GTCC	Greater Than Class C
HEPA	High Efficiency Particulate Air
IERT	Independent Expert Review Team
KRS	Kent Recessional Sequence
KRU	Kent Recessional Unit
KT	Kent Till
LHS	Latin Hypercube Sampling
LTPA	Long Term Performance Assessment
NDA	NRC-Licensed Disposal Area
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
NYSERDA	New York State Energy Research and Development Authority
ORS	Olean Recessional Sequence
OLS	Optically Simulated Luminescence
PDEIS	Preliminary Draft of the West Valley Decommissioning Environmental Impact Statement
PRDEIS	Peer Review of Draft Environmental Impact Statement
PRG	Peer Review Group
RMSE	Root Mean Square Error
SDA	State-Licensed Disposal Area
SWS	Slack Water Sequence
TEDE	Total Effective Dose Equivalent
TIN	Triangulated Irregular Network
TRU	Transuranic
ULT	Unweathered Lavery Till
WMA	Waste Management Area
WNYNSC	Western New York Nuclear Service Center

WTF	Waste Tank Farm
WVDP	West Valley Demonstration Project

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FINAL DRAFT

Independent Review of the Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center

Prepared for
New York State Energy Research and Development Authority
West Valley, New York
September 3, 2008

FINAL DRAFT

Independent Review of the Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center

Prepared by the
Independent Expert Review Team

B. John Garrick, Chairman
Jimmy T. Bell
Sean J. Bennett
Robert H. Fakundiny
Shlomo P. Neuman
Frank L. Parker
Michael T. Ryan
Peter N. Swift
Chris G. Whipple
Michael P. Wilson

Prepared for
The New York State Research and Development Authority
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We also wish to acknowledge the contribution of Dr. Robert D. Waters of Sandia National Laboratories who was not a member of the IERT, but who was a major contributor to the IERT review on transportation.

CONTENTS

SECTION 1

INTRODUCTION AND SUMMARY

The New York State Energy Research and Development Authority (NYSERDA) convened a team of ten technical experts to conduct an independent review of the 2008 Preliminary Draft of the West Valley Decommissioning Environmental Impact Statement (2008 PDEIS). The Independent Expert Review Team (IERT) consisted of nationally and internationally distinguished scientists and engineers in the geosciences, nuclear science and engineering, health physics, and the risk and environmental sciences. Brief summaries of their qualifications are provided in Appendix B. The thrust of the review was to determine if the 2008 PDEIS is scientifically sound, with emphasis on the validity and defensibility of selected topics considered critical to assuring public health and safety, and environmental protection of the Western New York Nuclear Service Center (Center) and surrounding regions.

The Center is a 3,300-acre property located in southwestern New York State. It is the location of a commercial nuclear fuel reprocessing plant that was operated by Nuclear Fuel Services, Inc. (NFS), from 1966 to 1972. NYSERDA is the current owner of the facility. In 1980, the United States Congress passed the West Valley Demonstration Project (WVDP) Act. The Act directed the U.S. Department of Energy (DOE) to carry out a high level radioactive waste demonstration project of the complex in accordance with requirements prescribed by the U.S. Nuclear Regulatory Commission (NRC) with an initial goal of solidifying the liquid wastes into a form suitable for transportation and disposal. While DOE manages 179 acres of the Center, including the approximately 8-acre "NRC-Licensed Disposal Area" (NDA) for the WVDP, NYSERDA manages the 15-acre "State-Licensed Disposal Area" (SDA), a commercial radioactive waste disposal facility that operated from 1963 to 1975. NYSERDA also manages the balance of the 3,300-acre Center property. The decommissioning criteria for the WVDP are contained in the NRC's License Termination Rule (LTR) (10 CFR Part 20 Subpart E).

NYSERDA is participating with DOE in the preparation of an Environmental Impact Statement (EIS) to assess decommissioning and/or long-term stewardship at the WVDP and the Center. The NRC intends to adopt the West Valley EIS to fulfill its National Environmental Policy Act (NEPA) obligations associated with prescribing the decommissioning criteria for the WVDP through the NRC's West Valley Policy Statement. Under an agreement between DOE and NYSERDA, DOE has the responsibility for obtaining and managing the EIS contractor. NYSERDA and DOE are sharing the cost for the preparation of the EIS.

Multiple drafts of the EIS have been prepared since 1996 and have gone through extensive internal and external review. For example, the 2005 draft, which included a Long Term Performance Assessment (LTPA), was reviewed by a Peer Review Group (PRG) of nationally recognized scientists selected by NYSERDA, with the assistance of DOE. The PRG validated concerns noted previously by NYSERDA and raised a number of additional concerns.[1]

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[1] PRDEIS, Peer Review of Draft Environmental Impact Statement and/or Long-Term Stewardship at the West Valley Demonstration Project in Western New York Nuclear Service Center, by J.D. Bredehoeft, R.H. Fakundiny, S.P. Neuman, J.W. Poston, and C.G. Whipple, Final Report of April 25, 2006.

The Peer Review Report, which was completed in April 2006, concluded:

> "…doses and concentrations [in the DEIS] cannot, in our view, reliably be used to decide whether or not the various decommissioning alternatives would meet the dose limits of the License Termination Rule, or to rank the alternatives on the basis of predicted concentrations and doses."

The result is a new draft of the EIS that is the basis for the current IERT review and, as noted earlier, is identified as the 2008 PDEIS. Because of the possibility of major changes in the site properties over the chosen period for the performance assessment, the LTPA is a major focus of the IERT review, with erosion being the primary concern with respect to impacting the locations for the possible releases of radiation. Besides erosion and radiation release locations, other LTPA issues receiving careful attention from the IERT are groundwater flow and transport, engineered barriers, sources and quantities of radioactive material, and analysis transparency and uncertainties. Beyond the LTPA, the IERT has been requested by NYSERDA to review several other issues connected with the 2008 PDEIS. These include the approach to the exhumation alternative, associated transportation risks, seismic hazards, intentional destructive acts, and cost benefit analysis.

As noted previously, the guidance for the reviews focused on the scientific and technical validity and defensibility of selected topics in the 2008 PDEIS. Depending on the importance of the issue and the findings of the review, other factors were considered especially with respect to erosion and mechanisms for transporting radionuclides, of which surface water and groundwater were considered the most important. For these topics, the review questions were more detailed than most having to do with the fine structure of modeling approaches, site characterization, representation of the site dynamics, probabilistic and sensitivity analysis, transparency and realism of the results.

It should be observed that the IERT review was based on drafts of EIS sections provided by NYSERDA between May 2008 and August 2008. As such, some detailed page numbers, figures, etc., referenced in the individual IERT reviews in Appendix A of this report may not coincide exactly with more recent versions of the EIS. The findings, and conclusions and recommendations, based on the detailed unedited reviews of Appendix A, are in Sections 5 and 6, respectively. The IERT concluded from the reviews that a phased approach to decommissioning and remediation of the West Valley site should receive serious consideration. That the IERT should reach this general conclusion is not surprising as the scientific community has long advocated a deliberate, systematic and phased approach to making decisions for the long term management of radioactive wastes.[2,3]

A question of interest is whether the findings of the IERT review provide a basis for overarching conclusions and recommendations that crosscut all of the topics reviewed—conclusions and

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[2] National Research Council. 1990. Rethinking High-Level Waste, a Position Statement of the Board on Radioactive Waste Management. Washington, D.C. The National Academies Press.

[3] National Research Council. 2003. One Step at a Time: The Staged Development of Geological Repositories for High-Level Radioactive Waste. Washington, D.C. The National Academies Press.

recommendations that would facilitate decisions on a path forward for NYSERDA to consider. In that regard, the IERT recognizes five overarching conclusions from their review of the 2008 PDEIS:

1. Current monitoring and West Valley management practices provide assurance that the short-term risk (30 to 100 years) of any significant releases of radiation at locations accessible to the public is very low. The long-term risk of the site (hundreds or thousands of years) will have to be demonstrated by improved and more credible analyses than now exist in the 2008 PDEIS.

2. The existing knowledge base is capable of supporting risk assessments providing there is accountability for the uncertainties in the analyses performed. With continued monitoring and acquisition of new data as needed, especially in relation to the modeling of erosion and the formation of gullies, characterization of both the site and the waste forms will be sufficient to support effective decisionmaking.

3. Current analyses documented in the 2008 PDEIS, including the LTPA, are not adequate to support a final decision regarding disposition of the site. Principal concerns are the lack of transparency and appropriate modeling in selected analyses, the absence of a risk perspective regarding the treatment of uncertainties and risk importance, and failure to analyze the Phased Decisionmaking Alternative.

4. Given that the 2008 PDEIS is not adequate to support a final decision regarding the long-term disposition of the West Valley site, the IERT considers it prudent to postpone such a decision until an adequate environmental impact statement is completed. Consideration should be given to the pursuit of Phase 1 of the Phased Decisionmaking Alternative during this interim period.

5. The approaches to estimating remediation costs and assessing cost benefit lack transparency with respect to the procedures, computational methods, and detailed scenarios employed. Indications are that the methodology and techniques for conducting the cost estimates of specific remediation alternatives, such as the exhumation of the waste, differ from those used at other DOE sites and in some cases appear to be excessive.

Consistent with these conclusions, the IERT provides five summary level recommendations for the West Valley Demonstration Project as it moves forward.

1. Contain and mitigate existing contaminant plumes. Offsite exposures and associated risks from existing contaminant plumes are very low and their prudent management should continue to minimize this risk.

2. Improve analyses to support future steps in the decisionmaking process, focusing on uncertainties that contribute to risk. Analyses need not increase in complexity, but they should provide a realistic assessment of the impacts of significant uncertainty, and they must be clearly documented.

3. Plan and implement remediation actions consistent with updated analyses (i.e., phased decisionmaking). Realistic and implementable plans based on credible analyses must be available to inform decisionmaking.

4. Maintain strong administrative controls to provide high confidence in the continued safety of the site during the decisionmaking process.

5. Cost analyses should be transparent and based on realistic scenarios and established methods of computation used in the nuclear waste field at other DOE sites.

SECTION 2

PURPOSE AND SCOPE OF THE INDEPENDENT EXPERT REVIEW TEAM

INTRODUCTION

The purpose and scope of the IERT review of the 2008 PDEIS was an assessment of the following.

- Validity and defensibility of the performance assessment (PA), including the identification and treatment of critical processes and events, such as erosion, groundwater transport, engineered barrier performance, receptor locations, and exposure scenarios
- Validity and defensibility of the assumptions for engineered barrier performance
- Validity of the source term used for the high level waste (HLW) tanks and North Plateau plume and the approach for addressing uncertainty in the source term
- Validity of the approach for assessing and addressing uncertainty in the performance assessment
- Transparency of the analyses used in the comparison of alternatives, including uncertainties in these analyses
- Limitations of the PA and appropriate uses of PA results in decommissioning decisions
- Approach used for the transportation analysis, and the validity and defensibility of the estimate for transportation fatalities and injuries from the exhumation of the disposal areas and HLW tanks
- Manner in which the costs and benefits of the remediation alternative were analyzed
- Logic and validity of the approach for removing the HLW tanks, and the validity of the cost estimate for removing the tanks
- Logic and validity of the approach for exhuming the disposal areas, and the validity of the cost estimates for exhuming the disposal areas
- Seismic hazards and intentional destructive acts

BACKGROUND

Site Location and Responsible Agencies

The Western New York Nuclear Service Center is a 3,300-acre property located in southwestern New York State. The Center, which is commonly referred to as the West Valley site, is owned by New York State, and is the location of the only commercial nuclear fuel reprocessing plant ever to operate in the United States. The facility was operated by Nuclear Fuel Services, Inc., from 1966 to1972, and reprocessed 640 metric tons of spent fuel from commercial and defense nuclear reactors under a Part 50 license issued by the U.S. Atomic Energy Commission. NFS was licensed as operator, and the New York State Atomic and Space Development Authority (a predecessor agency of the New York State Energy Research and Development Authority) was licensed as owner. NYSERDA continues to hold title to the Center today. Approximately 600,000 gallons of liquid high-level waste were generated during fuel reprocessing operations.

West Valley Demonstration Project Act

In 1980, the United States Congress passed the West Valley Demonstration Project Act. The Act directed the U.S. Department of Energy to carry out a high level radioactive waste demonstration project (the West Valley Demonstration Project). DOE's responsibilities at the Center as part of the WVDP include solidifying the liquid high-level waste remaining from the reprocessing operation, decontaminating and decommissioning the facilities used in the solidification of the HLW, transporting the solidified HLW to a federal repository, and disposing of the low-level and transuranic waste produced from the WVDP. DOE manages 179 acres of the Center for conducting the WVDP, including the approximately 8-acre NDA that was used between 1966 and 1986 for disposal of solid radioactive waste associated with reprocessing and decontamination and decommissioning activities. NYSERDA manages the 15-acre SDA, a commercial radioactive waste disposal facility that operated from 1963 to 1975. NYSERDA also manages the balance of the 3,300-acre Center property.

West Valley Decommissioning Criteria

The WVDP Act directs DOE to decontaminate and decommission the tanks, facilities, material, and hardware used in the solidification of the HLW in accordance with requirements prescribed by the U.S. Nuclear Regulatory Commission. In 2002, NRC published *"Decommissioning Criteria for the West Valley Demonstration Project (M-32) at the West Valley Site; Final Policy Statement"* (67 FR 5003) that prescribed the NRC's License Termination Rule (10 CFR Part 20 Subpart E) as the decommissioning criteria for the WVDP. In the Policy Statement, the Commission applied the LTR to the NRC-licensed portion of the West Valley site, but recognized that "the decommissioning of the West Valley Site will present unique challenges which may require unique solutions."

While the NDA is NRC regulated and subject to such regulations as the License Termination Rule, there is no requirement to decommission the SDA under its present regulatory framework. Nevertheless, as part of the EIS process, NYSERDA will examine performance, regulatory, environmental, and policy considerations related to the management of the SDA and assess the effectiveness of the present management strategy, as well as alternatives to the present management strategy.

Decommissioning Environmental Impact Statement

NYSERDA is participating with DOE in the preparation of an Environmental Impact Statement to assess decommissioning and/or long-term stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. NYSERDA and DOE are joint lead agencies on this EIS. DOE is the lead agency with regard to its decisions under the National Environmental Policy Act, and NYSERDA is the lead agency in regard to its decisions under the State Environmental Quality Review Act. The U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency, and the New York State Department of Environmental Conservation are participating in the preparation of the EIS as Cooperating Agencies.

NRC intends to adopt the West Valley EIS to fulfill its NEPA obligations associated with prescribing the decommissioning criteria for the WVDP through the NRC's West Valley Policy Statement. In addition, NRC will use the analysis in the EIS, along with that in a Decommissioning Plan to be prepared by DOE, to determine whether DOE's preferred alternative meets the decommissioning criteria prescribed by NRC.

DOE awarded a contract for the preparation of the EIS to Science Applications International Corporation in 1993. Under an agreement between DOE and NYSERDA, DOE has responsibility for managing the EIS contractor, but NYSERDA and DOE share the cost for the preparation of the EIS. The agreement states that DOE will manage the EIS contractor with the support and advice of, and in consultation and cooperation with, NYSERDA. NYSERDA provides input to DOE on the EIS through discussions at meetings, and through written comments generated by NYSERDA's in-house technical staff. The NYSERDA staff reviews are supplemented with outside experts when additional technical expertise and resources are needed to address areas of particular interest or concern.

In early 1996, DOE and NYSERDA issued the *Draft Environmental Impact Statement for the Completion of the West Valley Demonstration Project and the Closure or Long-term Management of Facilities at the Western New York Nuclear Service Center* (1996 DEIS) for public comment. For a number of reasons, NYSERDA and DOE decided that the 1996 DEIS would be followed by a revised Draft EIS rather than proceeding immediately to a Final EIS. A scoping process was held in 2003 to solicit public input on the scope of the revised Draft EIS; EIS preparation continued.

2005 Multi-Agency Review and Peer Review of the DEIS

In September 2005, DOE produced a draft DEIS for agency review that included analyses intended to demonstrate that the site will perform adequately over long time periods (i.e., 10,000+ years) to meet the decommissioning criteria for the West Valley site. After conducting an initial review of this draft of the DEIS, NYSERDA staff concluded that the analyses, particularly the long-term erosion predictions, were not credible.

To further assess the credibility and technical basis for the LTPA, NYSERDA, with the assistance and participation of DOE, convened a Peer Review Group that was composed of nationally recognized scientists, including Dr. Chris Whipple (Chairman), Dr. Shlomo Neuman, Dr. John Bredehoeft, Dr. Robert Fakundiny, and Dr. John Poston. After a 5-month review, the PRG validated the majority of NYSERDA's concerns, and identified a number of additional concerns. The Peer Review Report, which was completed in April 2006, concluded:

> "Considering our skepticism about the manner in which erosion, groundwater flow and contaminant transport were accounted for in the DEIS, we cannot be sure that contaminant concentrations and doses predicted on the basis of these analyses in the performance assessment are either reliable or conservative. As such, these doses and concentrations cannot, in our view, reliably be used to decide whether or not the various decommissioning alternatives would meet the dose limits of the License Termination Rule, or to rank the alternatives on the basis of predicted concentrations and doses."

Long Term Performance Assessment

The EIS provides estimates of radiation doses to onsite and offsite receptors from radionuclide inventories remaining in facilities that are closed in place under various closure alternatives. These radiation doses are calculated using a long term performance assessment. Recent drafts of the EIS show calculations that are carried out for periods of up to 100,000 years. This long analytical time frame is used because the long-lived radionuclide inventory at the site, combined with engineered barriers to limit radionuclide releases, creates the potential for doses to receptors for very long periods of time. It is important to note that the primary facilities at West Valley are constructed in or on a thick sequence of unconsolidated, actively eroding, glacial sediment that is less than 38,000 years old.

SECTION 3

THE COMPOSITION OF THE INDEPENDENT EXPERT REVIEW TEAM

The members of the Independent Expert Review Team are all distinguished in the disciplines important to the purpose and scope of the 2008 PDEIS review. The disciplines included geoscience, nuclear science and engineering, health physics, risk assessment, and environmental science and engineering.

Dr. B. John Garrick, Chairman, U.S. Nuclear Waste Technical Review Board, and an independent consultant in the nuclear and risk sciences was named as the initial member and chairman of the IERT. Dr. Garrick assisted NYSERDA in selecting the review team and had the responsibility for integrating the reviews and leading the preparation of this final report. The full membership and their affiliations are listed below. Qualification summaries of the IERT members are presented in Appendix B.

Jimmy T. Bell, Ph.D., Retired, Oak Ridge National Laboratory, Oak Ridge, Tennessee

Sean J. Bennett, Ph.D., Professor, State University of New York at Buffalo, Buffalo, New York

Robert H. Fakundiny, Ph.D., New York State Geologist Emeritus, Rensselaer, New York

B. John Garrick, Ph.D., Chairman, U.S. Nuclear Waste Technical Review Board, Arlington, Virginia, and Independent Consultant, Laguna Beach, California

Shlomo P. Neuman, Ph.D., Regents' Professor, University of Arizona, Tucson, Arizona

Frank L. Parker, Ph.D., Distinguished Professor, Vanderbilt University, Nashville, Tennessee

Michael T. Ryan, Ph.D., Principal, Michael T. Ryan and Associates LLC, Lexington, South Carolina

Peter N. Swift, Ph.D., Yucca Mountain Lead Laboratory Chief Scientist, Sandia National Laboratories, Albuquerque, New Mexico

Chris G. Whipple, Ph.D., Principal, ENVIRON International Corporation, Emeryville, California

Michael P. Wilson, Ph.D., Professor, State University of New York at Fredonia, Fredonia, New York

SECTION 4

THE PROCESS FOR CONDUCTING THE REVIEWS

The overarching guidance used by IERT in their review was one of assurance that the assessments performed in the 2008 PDEIS were based on sound scientific principles and that the results were realistic and transparent. In particular, the review was from the perspective of whether IERT could conclude that the 2008 PDEIS is an adequate basis for NYSERDA and DOE to make the right decisions on how best to protect the public and the environment from harmful exposures to radiation and hazardous materials. The scope of the reviews varied, depending primarily on the importance of the issue and the findings of the review. For some reviews such as erosion and radionuclide transport mechanisms (groundwater and surface water), the reviews were very detailed in the areas of site characterization and modeling.
In general, the reviews involved the following evaluations.

1. Basic information regarding the history and current status of the Western New York Nuclear Service Center (Center)

The IERT reviewed documentation regarding the history and current status of the Center with a focus on understanding the types and quantities of radioactive materials and other contaminants located within various facilities and present in the environment. The IERT as a whole and in part toured the facilities, discussed the current status of the facilities with NYSERDA and WVDP project staff, and reviewed the current work activities underway to further manage these radioactive and hazardous materials.

2. Models of performance

The IERT evaluated models and processes having to with both environmental impacts and the long term performance of the West Valley site. Evaluations involved such disciplines and activities as groundwater flow and transport; surface water flow and erosion; sources of radioactivity and public accessibility; fate and transport of radionuclides and other contaminants; seismic hazards; methods of remediation; engineered barriers; dosimetry models and the quality of the investigations in terms of their credibility, transparency, and the representation of the uncertainties involved. The goal of these reviews is to develop insights regarding the accuracy of the predictions of impacts from individual facilities of the Center relevant to each of the closure alternatives.

3. Schemes for remediation

The alternatives for the remediation of the West Valley site range from complete removal of all radioactive materials to taking no action and simply maintaining the facility as is. The IERT evaluated the extent to which these alternatives were analyzed in the 2008 PDEIS with emphasis on the risks for workers and members of the public from routine operations and postulated accidents associated with each remediation alternative. The evaluation was compromised by the absence of relevant risk evaluations, optimistic assumptions on the indefinite availability of institutional controls, and the absence of an assessment of the Phased Decommissioning Alternative.

4. Risks for various schemes of protection over short and long time durations

The IERT evaluated the analyses presented in the 2008 PDEIS for each of the alternatives for remediation offering insights regarding risks for short and long time frames. In particular, evaluations included the composition of the inventories of radioactive materials contained in each of the major facilities at the Center, the confidence about how well they are being contained, and the accuracy with which the movement of radioactive materials in the environment is known.

Finally, the reviews follow the protocol used by the National Academies of documenting its findings, conclusions, and recommendations in a formal report.

SECTION 5

FINDINGS

This section summarizes the findings of the individual topical reviews performed on the 2008 PDEIS. The conclusions and recommendations are presented in Section 6 and the full reviews are in Appendix A. The topics reviewed are listed below. The first six topics relate to the Long Term Performance Assessment, while the remaining seven are the findings of the other individual reviews that were performed.

- Groundwater Flow and Contaminant Transport
- Erosion Modeling, Assessment, and Prediction
- Engineered Barrier Performance
- Inventory and Source Term
- Exposure Locations and Scenarios
- Uncertainty Analysis and Transparency
- Approach and Cost of NDA Exhumation
- Approach and Cost of SDA Exhumation
- Approach and Cost of HLW Tank Exhumation
- Transportation Analysis
- Seismic Hazard Analysis
- Intentional Destructive Acts
- Cost Benefit Analysis

FINDINGS REGARDING THE LONG TERM PERFORMANCE ASSESSMENT

Groundwater Flow and Contaminant Transport

- The general approach to groundwater flow and contaminant transport modeling described in Appendix E of the 2008 PDEIS is acceptable but could be improved, as we suggest in Appendix A to this report. The approach relies on a far-field simulator of three-dimensional steady state groundwater flow across the site and two separate near-field simulators of three-dimensional steady state flow under the North and South Plateaus. Each simulator accounts for both saturated and unsaturated flow and each is calibrated against some of the available hydrogeologic site data. The near-field models are constrained in part by simulation results generated by the site model. The models are deterministic. Each model is subjected to a sensitivity analysis whereby some of its calibration parameters are varied individually to generate a limited range of possible outcomes. The near-field flow models can in principle account for the effects of various anthropogenic structures, including waste forms and engineered barriers, on three-dimensional groundwater flow around, through, and under such structures. Velocity fields generated by the flow models can in principle be fed into corresponding three-dimensional contaminant transport models capable of predicting space-time variations in contaminant concentrations and mass fluxes within the groundwater system and across its boundaries. It should in our view be possible to propagate uncertainties in model inputs (such as groundwater recharge and contaminant release rates, boundary and initial conditions, future irrigation and pumping rates, erosional impacts on site topography) and parameters (such as permeabilities, advective porosities, dispersivities, retardation coefficients) through such flow and transport models by Monte Carlo methods to generate a probabilistic range of outcomes.

- The groundwater flow and transport modeling capabilities just described are not being adequately utilized in the 2008 PDEIS. Flow beneath the Kent Recessional Sequence is rendered artificially stagnant through an inadequate representation of far-field hydrogeologic boundaries. Vertical flow and contaminant transport through the overlying Unweathered Lavery Till are rendered artificially low through the imposition of lower permeability and higher advective porosity values than appears to be justified by available data. Seepage under engineered barrier and slurry walls, keyed 2 to 3 feet into this unit, is rendered artificially low (and eventually disregarded) by ignoring measurements which indicate that, at shallow depths, the Unweathered Lavery Till may be locally quite permeable. It is unclear to what extent the capability to simulate three-dimensional seepage and transport around, through, and under engineered structures has been utilized; Appendix E presents only a sketchy description of a limited number of corresponding computational examples, none developed to their full extent. The ability to account for input and parameter uncertainty by generating a probabilistic range of outcomes has not been utilized at all.

- In principle, the models described in Appendix E could be used to generate probabilistic predictions of contaminant migration, concentrations and mass fluxes by groundwater to various receptors onsite and offsite under each closure alternative. Such probabilistic predictions could be fed into a probabilistic assessment of short- and long-term risks posed by each alternative. This was not done. Instead, the LTPA was done deterministically according to Appendix G of the 2008 PDEIS by (a) defining a series of horizontal and vertical flow channels, each having a constant rectangular cross section and flow/transport characteristics, based on groundwater flow modeling in Appendix E and (b) solving an advective or advective-dispersive transport equation analytically or numerically along each one-dimensional flow channel. The 2008 PDEIS does not describe in any detail, and does not provide any example of how such flow channels are defined on the basis of groundwater flow models developed in Appendix E. Absent such descriptions and explanations, it is not possible for the IERT to verify the validity of the process by which model results from Appendix E are translated into flow channels and corresponding transport paths in Appendix G.

- One aspect of the process by which model results from Appendix E are translated into flow channels and corresponding transport paths in Appendix G, which appears to be clear but to lack justification, is the virtual disregard of horizontal seepage under engineered barriers and slurry walls through the shallow Unweathered Lavery Till. Another aspect we question is the assumption that engineered components of waste remaining in place, and surrounding barriers, maintain their original chemical properties and a somewhat degraded but still relatively low permeability for up to 100,000 years. Yet another aspect of the process that we deem physically implausible, and nonconservative, is the assumption that contaminants in a flow channel emanating from a waste form mix completely with uncontaminated waters in nearby flow channels, the nature and extent of which remains undefined. Considering the unverified nature of the process by which groundwater flow and contaminant transport are modeled for purposes of the LTPA in Appendix G, and the deterministic nature of the analysis which does not appear to justify such a simplification, the IERT questions (a) the need for a simplified flow and transport analysis of the kind presented in Appendix G, given a modeling capability in Appendix E that is more powerful and credible, and (b) the outcome of this analysis, as reported in Appendix H and elsewhere within the 2008 PDEIS.

- Nowhere does the 2008 PDEIS mention a possible impact of existing groundwater contamination at depth on onsite or offsite receptors under each alternative. That such contamination exists is evidenced by documented leakage of contaminated water into shallow and deep sediments from trenches and other excavations on the South Plateau.

- When surface soil is contaminated by irrigation with groundwater or surface water, exposure by drinking water is said to involve consumption of the primary source of groundwater or surface water rather than by consumption of water infiltrating through the contaminated soil. This does not appear conservative to us because it ignores further groundwater contamination by waters infiltrating through contaminated soils.

- A permeable treatment wall and a permeable reactive barrier are planned to mitigate further North Plateau Groundwater Plume Migration. No discussion or analysis of the design or effectiveness of such a wall and barrier are provided in the 2008 PDEIS. Given mixed results[4] with the existing passive treatment system at the site, it is not clear to us that the planned wall and barrier can be counted on to perform as assumed in the 2008 PDEIS.

Erosion Modeling, Assessment, and Prediction

Summary

The most important aspect of the surface erosion assessment is the modeling of the processes that affect the future integrity of the buried wastes at the West Valley site. It is the opinion of the IERT that while significant efforts have been made to model the various surface erosion components of the West Valley site, the predictions from these models cannot be accepted or ratified at this time. Most importantly, any predictions made using a gully erosion or landscape evolution model with regard to future radionuclide doses due to the surface erosion of the West Valley site are scientifically indefensible. This opinion is based on the following assessment criteria.

1. A serious disconnect exists between model parameterization and the hydrologic and geomorphic characteristics of the site. This has resulted in highly questionable and

[4] West Valley Nuclear Services Company, Inc., Supplemental Hydrogeologic Investigation of the North Plateau Pilot Permeable Treatment Wall: Performance Assessment and Evaluation of Potential Enhancements. Nov. 2002

physically unjustifiable assumptions in the treatment and assignment of variables within these models.

2. No verification or validation of any models was presented in the context of comparing model output with actual field data.

3. Many of the model components, especially with regard to the gully erosion and landscape evolution, are unjustifiable and unsupported by scientific evidence.

4. No uncertainty analysis of any model predictions was provided. The uncertainty in model predictions for the gully erosion and landscape evolution is expected to be very large (orders of magnitude) considering the conceptualization, construction, parameterization, discretization, application, and interpretation of the models involved.

Appendix F Findings

- Short-term erosion rates determined using USLE, SEDIMOT II, CREAMS, and WEPP are not considered useful in the broad context of the present and future integrity of the West Valley site. This is because the greatest at-a-point rates of surface erosion are due to advancing gullies, which none of these models addresses.

- The model simulation using SIBERIA from the initial post-glacial landscape to modern time has not adequately addressed, or presented in a scientifically defensible way, the long-term evolution of the West Valley Demonstration Project and nearby environs. No details have been provided as to how the initial, post-glacial landscape conditions were defined and represented within SIBERIA. It is highly unlikely that the same model will adequately represent the evolution of the landscape over the next 10,000 years.

- The concept of channel initiation as used in SIBERIA appears to result in a stream channel network similar, if not identical, to the modern network, and a channel network system that displays no spatial variation over time.

- No discussion exists regarding the numerical schemes used in SIBERIA or CHILD and how these schemes ultimately affect the hydrologic and geomorphic processes under consideration.

- The only calibration scheme used for the SIBERIA and CHILD models is through a "forced-fit" approach that minimized the difference between predicted and observed longitudinal profiles of select streams in select corridors. This approach does not consider the vertical uncertainties of the Digital Elevation Model (DEM) used, which may be several meters, or the possibility of arriving at "the right answers for the wrong reasons."

- The results from the forward modeling exercises using SIBERIA and CHILD, from modern time to 10,000 years in the future, are so briefly discussed and so poorly supported by graphical information that they have no credibility or utility in this assessment. Moreover, it seems highly unlikely that the North Plateau Waste Management Areas 1 and 3 will experience only 0.1 to 0.3 meters of erosion in the next 10,000 years.

- All physically-based hydrologic and geomorphic models are subject to significant uncertainty, which includes uncertainties in model input, model structure, definition and inclusion of parameters (governing equations), and observational data. Future projections using the same models also include uncertainties for model linkages and input data. Any predictions made using any landscape evolution model with regard to future releases of radionuclides due to surface erosion processes are scientifically indefensible since no rigorous and comprehensive uncertainty analysis has been undertaken. Moreover, the uncertainty bounds for predicting radionuclide dose rates based on such models are likely to be very large. Any decisions on decommissioning the West Valley site should carefully consider these large uncertainty estimates.

Appendix G-H Findings

- The simple gully erosion model, as constructed in Appendices G and H, is very crudely defined and not scientifically based.

- The authors predict that the top of the NDA wastes could be breached in 490 to 910 years, and the bottom of the NDA wastes could be breached in 955 to 2,330 years (Table H-65). Even adopting the very low and constant rate for gully advance of 0.4 meters/year, a gully intersecting the top of the NDA could occur within 33 to 165 years, or about one order of magnitude quicker in time compared to the estimates presented in Table H-65.

Engineered Barrier Performance

1. The barriers that would be constructed on the North Plateau in the Close-In-Place Alternative were selected to consist, first, of filling the tanks with grout and cementing or using fill in the lagoons. An engineered cap would be installed over the main process building, vitrification facility, and the tanks, and a somewhat less elaborate cap over the lagoons. Slurry walls would be installed around the North Plateau facilities covered by the cap and around lagoon 1. A permeable treatment wall would be installed near the leading edge of the North Plateau Groundwater Plume.

2. Under the Close-In-Place Alternative, South Plateau barriers would include engineered caps over the SDA and NDA of the same design used on the North Plateau for the main process building and tanks, trenches and disposal holes in the NDA and SDA would be grouted, and both areas would be surrounded by slurry walls. A leachate treatment facility would be constructed.

3. Aspects of engineered barrier performance can be evaluated by comparing the Sitewide Close-In-Place and No-Action Alternatives.

4. We are concerned that the assumptions about barrier performance over time are (1) not well justified, and (2) not clearly communicated.

    - For the Sitewide Close-In-Place Alternative, engineered barriers (e.g., grout, slurry walls) on the North Plateau are assumed to degrade at an ambiguously specified time. It appears that these barriers undergo a one-time degradation in performance at 100 years, with the possible exception of the high strength grout used to fill the tanks. The Sitewide Close-In-Place Report indicates that this grout will last for 500 years, but in response to an IERT inquiry, the EIS contractor indicated that "The 500-year strong grout at the top of the tanks is then a redundant feature whose capability is not needed in the current approach to analysis." We find this inconsistent and confusing.

    - It is assumed that barriers on the North Plateau would not experience damage due to erosion. The technical basis for this assumption is unclear and needs justification. If one thinks that no credit should be given for institutional controls, including maintenance of erosion mitigation features, beyond a few hundred years, then erosion on the North Plateau after mitigation measures fail appears likely. The assumption that the South Plateau barriers are vulnerable to erosion damage is credible. A more realistic analysis should include considerations of cases in which engineered barriers on the North Plateau are subject to both degradation and erosion.

    - The counter-intuitive result that doses from the north groundwater plume to a Buttermilk Creek receptor at 100 years are larger for the Sitewide Close-In-Place Alternative than for the No Action Alternative is not sufficiently explained.

    - Regarding doses from South Plateau facilities, there is little or no reduction in modeled offsite dose associated with the additional barriers called for in the Sitewide Close-In-Place Alternative, relative to the No Action Alternative. Intuitively, one would expect some reduction in dose rates with the addition of the engineered barriers, due to delay in transport and radioactive decay.

    - The technical basis for the distribution coefficients (K_ds) used in the transport calculation for the mobile radionuclides (technetium, iodine, and tritium) is weak or missing and the assertion that technetium solubility will be limited by fly ash in concrete is not supported. For this reason, K_ds should be conservatively assumed to be zero for these materials. The potential for high pH conditions to lead to greater than assumed mobility for other radionuclides should also be evaluated.

5. The erosion mitigation measures seem to be focused at controlling surface runoff during extreme storm events, e.g., the 100-year rainfall. However, erosion by headcuts would not be mitigated by the specified measures. Erosion by headcuts is a major problem for gully and stream stabilization in southwestern New York.

6. The 2008 PDEIS and its underlying documents do not include an analysis of performance history of erosion or slope controls in southwestern New York. Generally speaking, erosion controls are designed for only a few decades, often less. Major renovations to control

structures are often needed within a few years. Designer experience is limited to the short term. For the time scales of concern and interest on the West Valley site, and for the case in which the institutional memory necessary to maintain erosion barriers cannot be assumed, there is no basis to think that the proposed erosion mitigation measures will work.

7. Specific comments on the modeling of groundwater flow and transport through and around the engineered barriers are discussed in Appendix A of this report. As explained in Appendix A, the IERT is not convinced that keying barrier and slurry walls 2 to 3 feet into the Unweathered Lavery Till, as the 2008 PDEIS specifies, would be effective in preventing seepage of groundwater to take place into and out of the waste enclosure under these structures.

Inventory and Source Term

SDA and NDA Inventories

- The disposed inventories of radioactive materials have been the subject of extensive study.[5,6] The inventories have been evaluated using user's lists, disposal records and chemical processing plant records, characteristics of wastes by generator type, and other data discussed in the reports to estimate disposed inventories from several major waste categories. The uncertainties in these estimates have been assessed by considering uncertainties in estimation methods such as dose to curie conversion factors, radionuclide scaling factors, and various approaches to concentration averaging and assignment to various waste streams. While it is true that these factors rely on scaling "easily-measured radionuclides" to "hard-to-measure radionuclides," they are usually based on measured values for representative benchmark samples. In the URS reports the authors provide a detailed and transparent account of what they calculated and why for the inventories of the SDA and NDA disposal facilities including alternative methods of estimation. There are summary tables from the NDA and SDA reports that are listed in the detailed report in Appendix A.

- Table S-2 indicated that the NDA contains 360,924 ft^3 of waste. The total radionuclide inventory is reported in Table S-1 as 298,364 curies. Detailed inventories by radionuclides are provided in Table 2-2. Tables S-1, S-2, and 2-2 are from the report referenced in Footnote 6 below.

- The best estimate of the volume of waste buried in the SDA is 2,362,470 ft^3. The total radionuclide inventory as of January 1, 2000, is estimated to be 129,615 curies. Seven radionuclides account for more than 97% of this activity. In decreasing order of activity, these radionuclides are: ^{3}H, ^{238}Pu, ^{63}Ni, ^{137}Cs, ^{137m}Ba, ^{60}Co, and ^{241}Pu.

[5] SDA Radiological Characterization Report, URS Corporation. September 2002.
[6] Estimated Radionuclide Inventory for the NRC-Licensed Disposal Area at the West Valley Demonstration Project, URS and Dames & Moore. August 2000.

Buried HLW Tanks

- The total estimated residual activity in the Waste Tank Farm is conservatively estimated at 350,000 curies, as given in Appendix C, page C-15, of the 2008 PDEIS. The estimated radionuclide inventory includes all of the radionuclides associated with spent nuclear fuel including: source material, special nuclear material, and fission and activation product inventories, that have been determined by a combination of direct sample measurements, scaling factors, and process knowledge.

- Almost all the radioactive materials in the tanks are from ^{90}Sr and ^{137}Cs. Out of roughly 350,000 curies, the estimate reported in Appendix C is that only 1,260 curies result from radionuclides other than ^{90}Sr and ^{137}Cs. These two radionuclides have similar half-lives of about 30 years. This means that over the 60-year period of the tank farm removal, the inventory in the tanks would decay from ~350,000 curies to about 87,000 curies.

Balance of the Plant

- The estimated total activities for each of the two facilities (Main Plant and Vitrification) are given in the 2008 PDEIS, Appendix C, Tables C-1 and C-3. The total activity for the main plant (without the vitrified products) is estimated at 6,100 curies, with a ^{137}Cs and ^{90}Sr contribution of 4,420 curies. The actinide activity of americium and plutonium is 1,661 curies. The total activity for the vitrification building is estimated to be 1,860 curies of Cs and Sr and 14 curies of actinides, allowing for considerable flexibility in the remediation of these buildings.

- The low inventory level of the main plant is partially explained by the process hot cells having been cleaned before the vitrified canisters were stored. These HLW vitrified canisters will be moved to another facility before remediation begins. With the low radiation levels found here, remediation may be possible without additional containment.

- The vitrification building was not highly contaminated because it operated for only a short period of time, without having had any contaminating spills. The HLW was totally contained, with the exception of the off-gas, which was scrubbed to decontaminate it from the Cs. Therefore, the remediation of the building may be possible without additional containment.

Plume

- The North Plateau Groundwater Plume has been studied and evaluated. Data shows that inventories of ^{90}Sr and ^{137}Cs are the principal radionuclides followed by radioisotopes of uranium, plutonium, neptunium, americium, and technetium in much smaller quantities. The plume continues to be monitored. Monitoring to date has shown that ^{90}Sr is traveling northeast in the North Plateau groundwater system. The sources include pipes that have leaked in or near the Main Process Building. Some mitigation measures to date have eliminated some sources but have not been fully effective. ^{90}Sr is leaving the West Valley Demonstration Project site via discharges of the groundwater to surface water

(Erdman Brook, Franks Creek and beyond) but is diluted in the streams to very low concentrations compared to drinking water standards.

- There is some question as to whether there is a new contribution to the plume from the northeast corner of the Main Process Building. Additional mitigation measures should be considered for the leading edge of the plume. The IERT, based on a field visit and review of monitoring data, suggests that it would be prudent to further evaluate (perhaps using a line of geoprobe measurements and sampling) whether a new source is developing north of the process building that may now or potentially in the future contribute to the plume. If a new source is developing with the potential to add to the plume in a significant way, efforts should be put forth to eliminate it.

Exposure Locations and Scenarios

- The Phased Decisionmaking Alternative is not analyzed.

- The determination of the point of compliance, while defined by the regulatory authorities, is also subject to negotiation and exceptions for valid reasons. While the locations for the offsite points of compliance are stated, it is not always clear that this represents the point of highest dose as it is based on the concentration of radioactive materials. They all have different degrees of mobility, bioavailability, and impact on the body.

- While the local point of compliance is the intersection of Buttermilk and Cattaraugus Creeks and groundwater is not assumed to be a pathway in the near term, the person considered to have the highest potential dose obtains his drinking water from groundwater seepage.

- While the Seneca Nation is treated as a special case because of the possibility of higher consumption of fish than the default amount, it does not appear that the possibility that people near the site might also have a diet richer in fish than the default amount investigated.

- Some aspects of the technical bases for the scenarios, for example the decision to exclude erosion from the North Plateau, are insufficiently justified and are believed wrong.

- The scenario carried forward into Chapter 2 of the 2008 PDEIS, which assumes full institutional control and no erosion for 100,000 years, does not provide a useful representation of plausible future states of the system.

- There are inconsistencies in the way assumptions about the effectiveness of institutional controls are applied across the site. Specifically, current maintenance activities are assumed for the No-Action Alternative with institutional controls to continue in perpetuity on the North Plateau (resulting in a zero contribution to long-term dose from most North Plateau sources for this scenario), but are apparently assumed to cease on the South Plateau, allowing degradation of the currently functioning barriers at the SDA and NDA.

- There are inconsistencies in the results presented for scenarios assuming continuation of institutional controls. For example, Tables 2-B and H-54 in the 2008 PDEIS do not appear to be consistent in their presentation of collective dose values. It appears that Table H-54 contains results that do not include the assumption of perpetual maintenance of the North Plateau structures.

Uncertainty Analysis and Transparency

- The Long Term Performance Assessment documented in Appendix H of the 2008 PDEIS does not contain an uncertainty analysis. All modeling is deterministic, and results are presented as single values, without quantification of the uncertainty in performance associated with uncertainty in scenarios, models, and model inputs.

- The potential for uncertainty in the performance assessment is acknowledged, but there is very little discussion of sources of uncertainty and their possible impacts on performance. The approach taken by the authors as an alternative to an uncertainty analysis is to assert that the modeling cases considered are conservative, and to provide selected sensitivity analyses that are intended to demonstrate conservatism. This approach is not a substitute for a quantitative uncertainty analysis and cannot be used to identify those uncertainties that have the largest impacts on overall uncertainty in model results.

- Documentation provided in the 2008 PDEIS does not demonstrate that the LTPA analyses are conservative. On the contrary, numerous potential non-conservatisms can be identified or inferred from the available information, and the IERT concludes performance estimates are very likely non-conservative with respect to what more realistic scenarios and a reasonable treatment of uncertainty might show. Examples of unevaluated uncertainties and possible non-conservatisms are provided in Appendix A to this report.

- Sensitivity analyses described in Appendix H do not address a sufficient range of uncertainty to support the conclusion that the LTPA is conservative, nor are they sufficiently well documented to evaluate in detail.

- Transparency of the LTPA documentation is poor. Based on the information provided in the 2008 PDEIS, its appendices, and related documents, it is not possible to replicate independently the analyses or to otherwise understand how the results were derived. Incomplete documentation in many cases precludes understanding what was actually done in the LTPA and prevents a detailed evaluation of the analyses.

OTHER FINDINGS REGARDING SPECIFIC ISSUES

Approach and Cost of NDA Exhumation

The NDA trenches and holes include all forms of nuclear waste: transuranic (TRU), Greater Than Class C (GTCC), Class C, and lower levels. Locations of the various waste types demand both remote and contact-handled technologies. In the time frame of the proposed remediation, the NDA site will generate wastes that cannot be shipped “offsite” to any repository. The 2008 PDEIS exhumation approach for remediation should work, but it will be very expensive, primarily because of the cost of excavation and disposal of the “low-level” overburden above the trenches.

- The NDA burial ground includes NFS Deep Holes, NFS Special Holes, and the WVDP Burial Trenches. The total volume of NDA waste is 361,000 ft^3, with a total activity of 298,000 curies. Hence, the average activity of the waste is 0.83 curies per cubic foot[7]. Most of the waste is soil (121,000 ft^3) and is Class C waste. The remaining waste includes some GTCC.

- A small amount of spent nuclear fuel (12 ft^3) with a high activity (12,316 curies/ft^3) is included in the NDA. Also, 7,266 ft^3 of hardware with an activity of 196,000 curies is included. All of the other waste here (354 ft^3) has activity less than 1 curie/ft^3. These differences in activity suggest that removal of the lower volumes of wastes with high activity could reduce the NDA source term to more acceptable limits. However, the Sitewide Total Removal Alternative (STRA) proposes total removal of all NDA wastes.

- The cost for exhuming the NDA waste is given as $924 million (per the STRA Technical Report). This cost will be a significant portion of the total projected West Valley remediation cost of $9.6 billion. It is noteworthy that the pre-remediation construction cost is about $41 million, or less than 5% of the total cost. The most costly portion of the STRA would be the overburden removal and backfill, which is estimated to cost $777 million, or 84% of the total cost for this waste management alternative. It is also worth noting that the credibility of these cost estimates has not been established. There is a need to verify that the cost estimates were generated by a qualified engineering firm with experience in radionuclide operations.

- Locations of the burial holes and trenches in the NDA are not precisely mapped. There is insufficient evidence from geophysical investigations of the burial locations to define the limits of waste disposal and determine proper locations for construction of environmental enclosures and installation of shoring for trench and hole waste removal. Some trenches in both the NDA and SDA will have higher concentrations than others. The only way to determine this is in the field. Fortunately, that is possible and one need not aggregate the data but can measure the doses in the field in real time.

- The first item proposed in this approach is construction of a large building, the environmental enclosure (or secondary containment), over the waste burial holes. This 134,590 ft^2 enclosure would have 1-ft-thick reinforced concrete walls and would be equipped with a heating, ventilating, and air conditioning (HVAC) system having high efficiency particulate air (HEPA) filtration. The structure would have a 35-foot eave height, and a span of up to 165 feet, large enough to allow use of heavy equipment inside

[7] Estimated Radionuclide Inventory for the NRC-Licensed Disposal Area at the West Valley Demonstration Project, prepared by Ralph E. Wild, URS/Dames and Moore; prepared for West Valley Nuclear Services Company, Inc. August 2000.

and to allow erection of confinement structures within it. Access to the interior areas would be provided by equipment shield doors as well as numerous shielded mandoors. The building would be designed to withstand design-basis natural hazards, such as earthquake, high winds, and snow loading. It would also contain appropriate levels of fire protection, water, and electrical supply, and a closed-circuit camera security and operations system. A gantry crane with closed-circuit television capability would enable remote operations.

- It is not evident that alternative approaches were considered for the environmental enclosure. For example, how much would be saved if the NDA environmental enclosure were designed only to prevent the release of dust, but not to serve as a secondary environmental containment? Such enclosures have been successfully used in site cleanup operations, but they would not do well during winters at the site, so plans would require either summer operations only or completion of the exhumation during one operating season. A containment change could provide some cost reduction (~2 to 4%), but the margin of error on the total NDA cost estimate is probably >10%.

- In addition, a Container Management Facility (CMF) would be built for the dual purpose of preparing the removed wastes from the NDA and the SDA for transportation. A third building, a leachate treatment facility, would be constructed on the SDA site and would treat leachate materials from either or both sites.

- The NFS Deep Holes, the NFS Special Holes, and the WVDP Burial Trenches require different equipment and operations for exhuming the waste. The NFS Deep Holes contain Class C and GTCC wastes and will require that waste removal be contained. A special containment system, a modular, shielded exhumation enclosure (MSEE), is to be used over each hole. The NFS subject hole would first be prepared with sheet piling to avoid cave-in, then the MSEE would be placed over the sheet piling by the overhead crane system. Waste from the holes and the piling sheets will be placed in 55-gal drums and removed using the MSEE hoist and the remotely operated crane system. Apparently the drums are to be transferred in a remote manner to the CMF and from there to an unidentified repository. Any leachate encountered during exhumation would be pumped to the Leachate Treatment Facility. After a hole is excavated, the soil between holes is to be excavated as low-level waste and all equipment is to be moved to the next hole.

- The NFS Special Holes contain lower levels of activity than the Deep Holes, and the excavation is to be done under a HEPA-filtered, ventilated, confinement tent structure. Particular holes with GTCC waste would be exhumed using the processes used for the Deep Holes. The soil overburden (4 ft deep) would be excavated and managed as low-specific–activity waste. Excavation from these holes is somewhat described in Appendix C of the 2008 PDEIS, but the description could be better written. In essence, the waste is removed from each hole, placed in covered transfer boxes, and transferred to the CMF. There the waste is prepared for the appropriate repository destination. Any exhumed leachate is pumped to the Leachate Treatment Facility. After the excavation of each hole is completed, the temporary confinement tent is dismantled and reset over the next of these holes.

- The WVDP Burial Trenches, Trenches 1-7, will be exhumed in the same manner as the NFS Special Holes. Trenches 8-12 will be excavated in a less-robust structure, the WVDP Disposal Area Confinement Structure, located in the courtyard area of the environmental enclosure. These Trenches 8-12 will be housed in a conventional steel building with HEPA filtration. The excavation operations are contact handled, using heavy machinery. The low-level waste materials are packaged for disposal in a repository.

- The total secondary containment proposed for the NDA site will be very expensive (estimated cost of ~$50 million in the STRA Technical Report). This cost estimate is undoubtedly lower than actual costs, if the estimates used costs of concrete and rebar at $69/yard^3 and $61/ton (the values used in the Facility Description and Methodology Technical Report), rather than more realistic values of today, which would be ~$130/yard^3 for concrete and $1,200/ton for rebar. The large differences in these costs call into question the total integrity of the cost estimates.

- A major issue for the exhumation alternative is the volume and costs of the wastes generated. Much of the cost is for the overburden removal and the disposal of the portion considered low-level waste (LLW). Wastes will be generated that cannot be sent offsite at this time. The TRU waste and the GTCC waste will stay onsite until a repository is available and will accept it. This will add to the onsite storage requirements and will require additional storage facilities which are not included in the STRA cost estimates (the vitrified HLW is already onsite and also requires a new facility). The understanding is that the projected capacity of the first Yucca Mountain HLW repository is already designated, and the only space for the West Valley HLW or GTCC waste would be in a second repository if and when it becomes available. This means that West Valley would probably need to store the HLW, the TRU, and the GTCC waste onsite for as long as 100 years.

- Because of uncertainties in both the political and technological arenas, it is difficult to make accurate projections of the costs and actions over the long period of time (greater than 60 years) proposed for the remediation actions needed at West Valley. These difficulties were not discussed in the 2008 PDEIS. DOE has recognized this and has provided a phased approach of 5 years at a time to reduce the uncertainty.

- The 2008 PDEIS approach to exhumation lacks flexibility to account for lessons learned as the remediation project is implemented. During the long period over which the project will be carried out, new findings of conditions onsite, new technological advances, changes in funding availability, etc., will require changes in the sequence and scope of the work to be carried out. Volumes and cost numbers depend upon the technologies and schedules chosen. The exhumation schemes suggested seem to be based upon the most extreme conditions rather than those most likely to occur and with little attention to the impact on the risk to the workers and the public compared to the cost. In addition, the 2008 PDEIS has not considered the best options for the individual waste sites but has proposed a uniform solution for all.

- The remediation structures for the NDA are not proposed for reuse but are to be demolished at the conclusion of activities. Equipment such as the MSEE could be used for both the NDA and the SDA.

- The review team generally agrees that this approach for exhuming NDA or Waste Management Area 7 will lead to closure. The concern is whether other approaches were considered that would result in lower overall costs. The most expensive item in the Sitewide Total Removal Alternative approach is the removal and disposal of the contaminated overburden. The cost of this item can be changed significantly by retaining part of the material onsite. The approach identified for exhuming the NDA site is probably doable, but it is possible that simpler and less expensive approaches are also feasible. The methods for the NFS Special Holes are not fully defined, but if there is a failure, the MSEE technology could be used for all of these holes.

Approach and Cost of SDA Exhumation

The average radioactivity levels of the SDA are relatively low (0.05 curies/ft^3) and there are some GTCC that average ~2 curies/ft^3. The outer containment building is costly, and the requirement for it is questionable. However, the major cost driver is the material handling and disposal of contaminated overburden. The approach described in the 2008 PDEIS will work, but it will be very costly.

- The SDA burial ground includes 14 trenches. Trenches 1-7 comprise the North SDA, and contain some waste that is greater than Class A. Trenches 8-14, which also contain waste greater than Class A, make up the South SDA. The total volume of waste in the 14 trenches is ~2.4 million ft^3, with a total activity of 0.13 million curies. The average activity of this waste is, therefore, about 0.05 curies/ft^3.[8]

- The total SDA inventory has been subdivided into waste classes, and several portions of the SDA were identified as containing GTCC. However, the location of the GTCC is not identified such that the GTCC could be separately removed. The volume of the GTCC and its associated activity are given, and the average maximum activity of the GTCC is ~2 curies/ft^3 (~ 60 curies/m^3).

- The approach for exhuming each of the North and South SDA trenches is similar, except in size of the project. Environmental enclosures would be built for each of the areas. The North SDA enclosure would be 155,800 ft^2 (205 ft x 700 ft) and would be 35 feet high. The South SDA enclosure would be 244,950 ft^2 (345 ft x 710 ft) and 35 ft high. The exterior walls would be 1-ft-thick reinforced concrete. Each enclosure would have a metal roof with gutters. Each enclosure would also have an HVAC system with HEPA filtration and a gantry crane system.

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[8] SDA Radiological Characterization Report, prepared by Ralph E. Wild, URS Corporation; prepared for West Valley Nuclear Services Company, Inc. September 20, 2002.

- Cost estimates for exhuming the SDA site trenches are given in the Technical Report for the STRA. The number of large containment buildings planned for the site, including the SDA is alarming. Analysis of the estimated costs shows that the construction of two containment buildings is projected to cost $112 million, or about 6% of the total project cost. The cost information presented on these rigid buildings suggests the possibility of overpricing of the total estimate for the excavation.

- The cost driver for the $1.42 billion estimate is the removal of the overburden and backfill. This is 77% of the total cost estimate, with a contingency of $399 million (28%). The estimated costs are given with large contingencies. Their credibility is not verifiable. Were the estimates prepared with input costs given in the Facility Description and Methodology Technical Report? That report quotes the price of concrete and rebar at $69/yard^3 and $61/ton, respectively. Recent prices for these materials (telephone conversations with local providers) indicate $130/yard^3 for concrete and $1,200/ton for rebar. This leads us to question all of the material prices used in preparation of the STRA cost estimates.

- The approach described in the STRA Technical Report would work, but it is possible that simpler and less expensive approaches are also feasible. The exhumation schemes suggested seem to be based upon the most extreme conditions, rather than the most likely conditions, and with little attention to the reduction in risk to the workers, if any, compared to the cost. The wisdom of double containment for complete sites is questionable since the atmospheric releases are only 0.1 curies/year of tritium and barely 0.01 curies of other nuclides are being released to the atmosphere. In particular, the need for a secondary containment structure to prevent air emissions should be further evaluated. If other options such as watering to prevent dust releases would work, and if releases of tritiated water vapor would not produce significant worker or offsite doses, then removal costs may be less than estimated.

Approach and Cost of HLW Tank Exhumation

The two largest of the four tanks contain about 350,000 curies or about 40% of the total West Valley radioactivity inventory. As such, their containment and management should be a high priority for any of the West Valley remediation alternatives. The technologies for removing the solid wastes and the ion exchange columns from the large tanks are not well-defined in the 2008 PDEIS, and some of the waste is not included in the estimated costs. The estimated costs for the exhumation of the tanks, $834 million, may be ~75% of the actual costs.

- The approach for remediation of the tanks was described in the Sitewide Total Removal Alternative scenario of the 2008 PDEIS and in the STRA Technical Report. The review team questions the practicality of being able to perform the exhumation of the tanks in the manner presented for the $834 million estimated.

- The high-level waste tanks at West Valley are identified as 8D-1 through 8D-4. For purposes of this discussion, they will be called Tank 1 through Tank 4. Tank 1 and Tank 2 have capacities of 750,000 gallons each, while Tanks 3 and 4 have capacities of 15,000 gallons each. Tanks 1 and 2 have residual waste, with the major portions having been previously removed for vitrification. The activity of the residuals in these two tanks is 300 to 400 kilocuries. Tank 3 was used as a holding tank for about 1,500 gallons of condensate from Tank 4 and thus was slightly contaminated. Tank 4 contains about 10,000 gallons HLW from processing thorium fuel, and the activity of the HLW totals about 5 kilocuries.

- The total estimated residual activity in the Waste Tank Farm is conservatively estimated at 350,000 curies, as given in Appendix C, page C-15, of the 2008 PDEIS. The decision concerning future tank farm management need not be a function of the accuracy of the inventory data. The estimated radionuclide inventory includes all of the radionuclides associated with spent nuclear fuel including source material, special nuclear material, and fission and activation product inventories that have been determined by a combination of direct sample measurements, scaling factors, and process knowledge.

- As previously indicated, almost all the radioactive materials in the tanks are from ^{90}Sr and ^{137}Cs. The fact that the tank wastes are almost entirely 30-year half-life material suggests that a key question in remediation of these tanks is whether institutional controls could be relied on for the 300 or so years it would take for the ^{90}Sr and ^{137}Cs radionuclides to be much less of a threat, when considering remediation alternatives. Then, the focus for dose calculations becomes the remaining long lived radionuclides.

- The first step of the exhumation approach is the proposal to build a containment building over the entire tank farm area. This building would be 265 feet x 150 feet, with a height of 87 feet. The physical dimensions and structure of the building would be very similar to a reprocessing canyon. There would be a remote handling work cell (150 ft x 45 ft) and conventional auxiliary buildings of similar dimensions. This approach, using a process canyon and auxiliary buildings may be necessary for this particular scenario. The estimated cost for design, construction, and commission is given as $210 million, and as $192 million and $189 million in Table 3-18 and Table 3-19 of the Technical Report.[9] It would require several years (2 or more) for construction and set-up prior to an estimated 13-year operating period. After operations are completed, the facility would be decommissioned and removed.

- The containment canyon for HLW tank remediation may be more than is necessary. First, the average thickness of the walls need not be 4 ft. A wall thickness of 1 ft should be sufficient. Secondly, the vast containment area (37,750 ft^2) could be decreased to an area just sufficient to cover Tanks 1 and 2. The aboveground structure could be removed without an overbuilding. Third, Tanks 3 and 4 could be remediated under a flexible building. Fourth, existing buildings could be used for chemical and physical treatment of the waste. Fifth, the operations cost should be reduced. The total cost of $834 million for Waste Management Area 3 closure, as proposed for the STRA discussed in the 2008 PDEIS is likely too low, but with the changes enumerated here, it could probably be implemented at about $800 million.

[9] Kurasch, D.H., Summary Considerations for the Selective Removal of Tank 8D-3. June 2007.

- Currently the technologies for remediation of the HLW tanks have not been sufficiently identified or described. Specifically, the technologies for waste removal from the tanks should be better described, and the problems of transferring the solid-liquids waste from the tanks should be recognized and resolved. Will the tanks be washed before and after exhumation? How will the washing be done, and how will the washwater be managed? Is there a plan to try to remove the ^{90}Sr and ^{137}Cs from the tank components so that the quantity of HLW may be reduced? If so, have any studies or experiments been done to address the form and behavior of these materials?

- The position of the Supernatant Treatment System (STS) Support Building within the process canyon and the management of the ion-exchange columns are not well defined. The description of the decommissioning of the STS facility inside the process canyon is deficient. Also lacking was a strategic plan for the order of addressing the farm tanks with respect to training and experience. A time for implementation of this plan within the 60-year time frame was not presented nor discussed.

- The major driving force for costs is the item identified as "operations" at $427 million, or 51% of the total estimate. The construction cost for the containment canyon is 23% of the total estimated cost. Reducing the size of this containment facility and decreasing the wall thickness could result in major savings. Of course, such savings should include consideration of as low as is reasonably achievable (ALARA) practices and assurance that dose limits are met. (The process canyon for processing spent nuclear fuel at a capacity of 800 tons per year has a wall thickness of 5 ft.) The demolition costs for a smaller-scaled facility would also be considerably less.

Transportation Analysis

- In general, the transportation analyses are well documented with only a few exceptions and use reasonable data and analysis approaches.

- Compared to national annual average transportation fatalities, the additional risk of implementing any of the proposed alternatives is minor.

- The general conclusions of the transportation analysis in the 2008 PDEIS are reasonable and consistent with other transportation analyses. However, several technical issues were found.

- Sixty years of transportation operations (Sitewide Total Removal Alternative) assuming today's level of transportation technology and medical ability to treat cancer is not realistic. Given the rate of change in transportation and medical technologies, results may be very different if these changes could be factored in. This constancy assumption is common in these kinds of regulatory analyses because of the uncertainty of the future state of transportation and medicine.

- There were insufficient details presented to assess the realism of the high-temperature fire accident scenario (Appendix J, p. J-26; Appendix I, p. I-752 of the 2008 PDEIS) and the individual dose consequences to a maximally exposed individual 100 meters downwind. For example, such high-temperature fire conditions usually result in favorable dispersion conditions because of their energy content, but insufficient modeling details were presented to confirm this.

- Many assumptions were made in the transportation risk analyses that appear to be conservative, which compromises making comparisons between alternative remediation strategies. The impact of the assumptions on uncertainty was not quantified. The risk is that without some quantification of the uncertainties in the assumptions, the transportation risks could appear to be artificially high.

- The technical issue of greatest concern is the use of the risk metric "railcar-kilometers" for estimating rail risks because it contributes to the largest risk – number of calculated non-radiological fatalities – and because it seems to lead to erroneous results. There are two main concerns with this metric. First, the metric may overestimate the non-radiological risk associated with rail transport because each railcar of waste is assumed to represent a single rail shipment. Second, to the extent that waste is shipped by rail as part of variable-construct trains, with other cargo, the train would pose essentially the same non-radiological risk regardless of the presence of waste. Attributing this component of risk solely to the transportation of radioactive waste may be inappropriate, given that some of the trains will run regardless.

Seismic Hazard Analysis

- Section 3.5, "Seismology," of Chapter 3, "Affected Environment," of the 2008 PDEIS does not specify its goals as to whether it is attempting to provide the necessary data, analyses, and models required to perform an adequate seismic-hazard assessment at the Western New York Nuclear Service Center site for the purposes of assuring that site integrity will not be compromised during and after decommissioning.

- The final result of DOE's analysis is the arbitrary choosing of 0.10g with a return period of 2,000 years as the horizontal ground motion that would be experienced from the maximum credible earthquake affecting the site, a conclusion derived in the early 1980s with then-current technology.

- The approach to seismic analysis that the authors of this 2008 PDEIS section desire to be used is not apparent. A probabilistic seismic hazard evaluation (PSHA) may be assumed to be the goal for the use of the information provided within this section, but the information is not adequate for such an analysis.

- The section on peak horizontal-ground acceleration (PHGA) estimates, Section 3.5.3, of the 2008 PDEIS starts out by implying that it will discuss PSHAs, but then only discusses various estimates of maximum credible earthquakes and only three estimates of PHGA, which range from 0.10 to 0.07g, but at differing return periods. The section does not suggest which acceleration should be used in a PSHA. The estimates from various study groups all fail to consider the southwest branch of the Clarendon-Linden fault system (CLFS) as part of the Clarendon-Linden source structure or as part of the Clarendon-Linden source zone. The work of Tuttle, et al., proved that part of the CLFS has been active, although they found no indications of magnitudes greater than about 5.2.

- Section 3.5 of the 2008 PDEIS presents secondary and tertiary summaries of the likelihood of earthquake activity on the bases of limited data and speculative arguments, rather than a critical evaluation of the likelihood of damage to structures at the Center from seismicity. The analysis within Section 3.5 essentially presents a resulting, single PHGA for the basis of safety analyses, which was a value chosen from one of many earlier studies without compelling reasons for doing so. This opinion about PHGA is given on the basis of over-reliance on secondary- and tertiary-data sources and qualitative discussions found in consultancy reports and speculative regional tectonic models, rather than a rigorous coupled probabilistic and deterministic approach now used in the assessment of new critical structures, such as nuclear facilities.

- The authors confuse the reader on the difference between seismic risk evaluation and seismic hazard analysis. For example, in Section 3.5 it is stated that the purpose is to provide information about the "risk" to the Center posed by earthquakes. Such a risk assessment was not provided. The two types of analyses have differences that have not been resolved.

- The seismic hazard analysis, as presented, does not consider advancements in seismic engineering analyses and modeling. For example, many new approaches to seismic risk analyses are being developed for the nuclear power industry, which may be applicable to the Center closure process and the integrity of engineered barriers, remaining structures, filled holes in surficial deposits, and other facilities. A complete probabilistic and deterministic seismic hazard evaluation (PSHA and DSHA) and seismic risk evaluation, similar to those used in the design of nuclear power plants is not provided, nor are the data, assumptions, and speculations adequate to do so. Furthermore, there is an absence of the newer modeling techniques that look at such specific issues as Eastern U.S. versus Western U.S. seismic-wave attenuation, soil-structure interaction, seismic-wave incoherency, among others.

- A number of other data issues were observed. Tables 3-6 and 3-7 (Chapter 3 of the 2008 PDEIS), which provide much of the data or assumptions about the site are difficult to use because the valuable information on both, the estimates of PHGA for various magnitudes, are not apportioned in the same increments. Table 3-7 also does not provide estimates above an equivalent to MMI VII, which is below the maximum credible earthquake. Chapter 3 fails to adequately identify and reference data sources. Many of the sources referenced in this section are derivative sources that used data from previous studies. The original source references should be provided where possible. There lacks linkage information in the seismic risk analysis between the specific structures that would be affected by different seismic scenarios. The source material for establishing the seismic source zone for the Center is not compelling. The seismic source zones presented are not clear indications of the conditions at the Center.

Intentional Destructive Acts

- With noted exceptions, the conclusions appear to be reasonable, but their quantitative basis cannot be confirmed. That is, Appendices N and I are not stand alone documents in regard to containing sufficient information to evaluate the quantitative basis for their conclusions.

- The review team believes that a scenario based approach to intentional destructive acts is appropriate. However, there was difficulty in understanding the logic behind the choice of scenarios. The selection appears to have been by assumption rather than by a deliberate and systematic process. There was insufficient evidence presented to support the claim that the chosen scenarios are in fact bounding. A more credible approach would probably have been to follow the lead of the performance assessments for Yucca Mountain and the Waste Isolation Pilot Plant and consider "stylized" scenarios—an approach that attempts to reasonably represent multiple scenarios, but not necessarily claim that they are bounding, something very difficult to prove.

- The observation that "the analysis assumed no emergency response such as evacuation or sheltering" was disappointing as such actions can greatly impact the consequences. For example, emergency response and recovery have been major contributors to the low risk results of nuclear power plant probabilistic risk assessments and they are generally accepted as representative of what could really happen.

- The review team had several questions about the choices that were made of the materials at risk. For example, the basis for excluding the vitrified HLW was not technically supported. The basis given for excluding the vitrified waste was that it would not disperse into respirable fragments following an attack. This assertion while possibly true was not supported with analysis or references. The review team also questioned the inconsistency in target materials between Appendix N and Appendix I. In Appendix N Tank 8D-2 was the choice for the material at risk. In Appendix I, a composite of Tanks 8D-1 and 8D-2 was used as the material at risk for accident scenarios because components of the inventories in both tanks are combined to provide a bounding inventory. The basis for these different assumptions was not adequately presented.

- The doses presented lacked statistical information regarding their range, and were unclear about assumptions on intervention, sheltering and other protective measures especially in relation to elevated releases and demographics. Inadequate attention was given to the limitations of the dose calculations as they were performed for both small and large doses. For example, the review team questions the meaningfulness of calculating latent cancer fatalities (LCFs) for doses that are at or near the range of background doses for the exposed population. Also, with respect to larger doses for the individual worker and maximally exposed individual, LCF is not a meaningful concept.

- The review team was not able to make the connections between the computer codes that were supposedly used, MACCS and RISKIND, and the resulting calculations, because of insufficient information on the conceptual models and input parameter values.

- With regard to Section N.5.1 and Table N-5 of Appendix N in the 2008 PDEIS, the review team had difficulty resolving some of the entries. For example, what mechanisms exist to result in a 300-mile dose from a zero-energy release and why are the differences in the doses so small between the zero-energy ground-level release and the elevated plume release?

Cost Benefit Analysis

- There is a great deal of useful information in the reports that covers alternative decommissioning strategies. Each of the alternatives is described and reasonable approaches are developed for the structure used to develop the work plans and cost information. While these are at a top level of a work breakdown structure, they are detailed enough to develop an understanding of what is intended to be done under each alternative. The key facilities are described in each report (very repetitively as the same information is repeated in each report) and the specific actions under each alternative are developed in each report, respectively.

- There is no transparent treatment of uncertainties and contingencies in the development of the work plans and cost estimates. It is not clear what uncertainties or risks are inherent in these work plans and cost estimates. Decommissioning projects of this type have many uncertainties associated with them and contingencies need to be well developed to guide decisionmakers in their choices. There is also a lack of clarity in several documents of the actual cost modeling assumptions, including the issue of using present value or adjusted dollars.

- In Chapter 2, Part II of the 2008 PDEIS, the following statement is made: "*The best available information was used and conservative but reasonable assumptions were made where uncertainties exist. These conservative assumptions (identified in Chapter 4) were made to ensure that the EIS does not underestimate potential environmental impacts.*" No quantitative information and analysis were provided to back up this statement. For example, how was the best available information determined? A more rigorous risk-informed analysis is necessary to show that the 2008 PDEIS does not underestimate environmental impacts.

- The use and limitations of LCF are not well described (Section 2.6.1). Care must be taken and uncertainties must be assessed when applying a statistic such as LCF to small radiation doses to small groups of people. Additionally, it is erroneous to apply such a statistic across generations, i.e., for a period much longer than a human life span.

- At several places in the text, doses and LCFs are compared to background without being specific about the magnitude of background. The implication is that doses smaller than background are good and doses that are very much less than background are better. Making comparisons to "background" may not be as useful as possibly to "standards" as the background values are being revised. Such comparisons create more confusion since medical exposures involve relatively high doses (a few to 10's of rad) delivered at high dose rates versus very low doses (a few mrad or less) delivered at very, very low dose rates. The effects of these different exposure regimes are very different. Additionally, the average background radiation exposure in the United States is currently under consideration by the National Council on Radiation Protection (NCRP). A new report is expected soon from the NCRP with a significant revision upward of the total radiation exposure from all sources. Increases in medical exposures have been previously reported at the NCRP 2007 Annual meeting and are a major contributor to the increases in background radiation.

- It is not possible from the information given (Chapter 2, Part 2 of the 2008 PDEIS) to determine if these collective doses are trans-generational, conservative, or non-conservative from the information given. In the case of the Sitewide Total Removal Alternative it is not possible to determine if the collective dose is trans-generational based on the long time period for that option.

- Examination of Table 2-B in Section 2.6.2 shows that the only quantitative dose results brought forward from Appendix H are for the scenario in which full institutional controls remain effective indefinitely, with no erosion and no onsite intrusion. This scenario is unrealistic and should not be the primary basis used in Chapter 2 to inform decisions.

- In Table 2-C of Section 2.6.3 there is an estimate of cost avoided per person-rem for the Close-In-Place Alternative without full explanation of how and where it was determined. More information is needed on how the value in Table 2-C for this alternative was determined. If the value in Table 2-C was calculated based on doses from the results in Table 2-B, then they are not based on a realistic scenario, and that should be explained.

- The number of fatalities in shipping radioactive materials seems high. At several places in Chapter 2 (and Chapter 4) of the 2008 PDEIS very high values are reported. No basis for these high values is provided. It is possible that the transportation statistics are for all commercial transportation, in which case this is not the appropriate basis for the analysis. If the statistics are not specialized to nuclear shipments, then the risk for nuclear accident shipments are very much overestimated and in fact are not correct. Using average accident rates is not conservative, it is just wrong.

- The use of collective dose, peak dose, average dose, conservative dose, reasonably foreseeable annual increment of dose and other terms need to be carefully defined. As currently written, these terms are not well defined. These terms imply statistical significance though none has been derived or demonstrated in the text.

- Chapter 4 of the 2008 PDEIS has a lot of good summary information regarding scenarios that were considered and analyzed. The tables are a very good way of presenting the results that went into their preparation.

- Figure 4-4 of Chapter 4, "Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for Cattaraugus Creek Receptor for the Sitewide Close-In-Place Alternative with Continuation of Institutional Controls" show cancer rates over 100,000 years, a non-credible scenario.

- The tables and figures in Section 4.1.10 including Figures 4-3 through 4-5 and Tables 4-19 through 4-25 of the 2008 PDEIS are useful formats for the presentation of the information they contain. However, several important explanations are missing. There is no meaningful discussion of uncertainties regarding the data in any of the tables or figures. There is no statistical analysis to facilitate a meaningful interpretation of the results. For example, based on all the uncertainties in the parameters that went into calculations that support Figure 4.4, it is impossible to know when the plots become statistically the same. Nor is it clear how LCFs are calculated or what they mean for trans-generational time periods. And as previously noted, comparisons to background radiation exposure without stating what background is and how it varies among the populations of interest introduce unnecessary uncertainty.

- The "Methodologies and Facilities Technical Report" of the 2008 PDEIS provides a reasonably detailed summary with figures, tables, charts, maps, and sketches to give the reader a concise overview of the history, facilities, uses and surrounding properties at the West Valley Demonstration Project. In the section on "Key Assumptions and Estimating Bases," the radiological engineering guidelines are clear and reasonable. As was the case of the other documents, there is no indication of how contingencies or uncertainties are to be addressed. In this section there are assumptions that could have very significant cost implications regarding the volumes of wastes that will be generated in each category and what storage provisions will be made for orphan wastes (wastes that do not have a disposal option at present).

- It is not clear if careful attention has been given to optimizing the generation of wastes that can be easily disposed. Optimization of wastes does not necessarily mean generating small amounts of wastes. Rather it means generating wastes that can be readily transported and disposed at a facility capable of handing its constituents and characteristics. Further, it is not clear what wastes will be generated from each of the decommissioning approaches listed and what disposal paths are available and what wastes will be orphaned in each case. This was a very important issue for the case of Rocky Flats and will be important for the WVDP wastes since they include a wide range of waste types with a varying array of constituents.

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

Section 5 summarized the findings of the IERT reviews of the 2008 PDEIS. In this section conclusions and recommendations are presented based on the findings from the full reviews contained in Appendix A. The conclusions and recommendations are divided into four groups: (1) issues associated with the Long Term Performance Assessment, (2) the defensibility and rigor of the LTPA, (3) other specific issues reviewed by the IERT, and (4) overarching conclusions and recommendations.

The references appearing in some of the conclusions and recommendations are with respect to the chapters, sections, and appendices of the 2008 PDEIS, not of this report.

LONG TERM PERFORMANCE ASSESSMENT

Groundwater Flow and Contaminant Transport

Conclusion: The general approach to groundwater flow and transport modeling described in Appendix E is acceptable but could be improved. In addition, the linkage between the 3D models in Appendix E and the 1D models used in the LTPA (as described in Appendix G) is not adequately demonstrated in the 2008 PDEIS.

> *Recommendation: Future modeling should evaluate uncertainties associated with, for example, alternative conceptual models for site scale flow, effects of transient changes, incomplete characterization of material properties of hydrogeologic units, and local-scale processes associated with engineered barriers. The EIS should also demonstrate that the 1D models in Appendix G are derived from and supported by the 3D models presented in Appendix E.*

Conclusion: The groundwater flow and transport models developed to support the 2008 PDEIS are suitable for probabilistic analyses; this capability is important to providing insights about uncertainties, but was not used in the LTPA

> *Recommendation: Future analyses, for example, in support of phased decision-making, should include quantitative uncertainty analyses.*

Conclusion: Some aspects of the implementation of groundwater flow and contaminant transport modeling are inadequately justified and some appear non-conservative.

> *Recommendation: Future analyses should include improved documentation, additional justification of technical bases, and non-conservatisms should be identified and removed, preferably in favor of realistic treatments of uncertainty.*

Erosion Modeling, Assessment, and Prediction

Conclusion: The prediction of long-term erosion processes and impacts is one of the most technically challenging issues that must be addressed in the EIS. The erosion models used in the 2008 PDEIS for gully erosion and landscape evolution of the West Valley site are scientifically indefensible, and predictions with regard to future radionuclide dose rates due to the surface erosion from these models cannot be accepted or ratified at this time.

> *Recommendation: Future analyses regarding erosion modeling of the North and South Plateaus should include (1) a stronger hydrologic and geomorphic connection between model parameterization and onsite characteristics; (2) quantitative comparison of all model output with actual field data; and (3) a rigorous uncertainty analysis of model predictions and the quantification of all uncertainty bounds. Resources should focus on improved and scientifically defensible models of gully erosion that accurately depict and represent the hydrologic and geomorphic characteristics of the site, that predict the formation, growth, and upstream migration of gullies in response to both surface and subsurface hydrologic events and regimes, and that quantify all uncertainty bounds of these predictions.*

Engineered Barrier Performance

Conclusion: Assumptions about barrier performance over time are (1) not well justified, and (2) not clearly communicated.

> *Recommendation: Future analyses should include improved documentation with adequate justification for assumptions about barrier performance through time.*

Conclusion: Plans for engineered control and mitigation of gullying do not appear to be adequate.

> *Recommendation: Plans should specifically address future headcut erosion, including consideration of changes in base level such as what might occur from the removal of the Springville Dam, and should address the possibility for initiation of new headcuts, including on the North Plateau.*

Inventory and Source Term

Conclusion: There is sufficient inventory information to support initiation of activities associated with any of the proposed alternatives, including exhumation.

> *Recommendation: Acquisition of additional information regarding the inventory and source term should occur during future site management and remediation activities, including exhumation if that option is selected.*

Conclusion: The fact that the radioactivity in tank wastes is dominated by 30-year half-life material suggests that a key question in tank waste management is whether institutional controls can be relied on for the approximately 300 years it would take for this component of the waste to cease to be a major contributor to calculated dose levels.

Recommendation: Future analyses supporting decisions regarding tank waste management should evaluate uncertainty associated with the reliability of engineered barriers and institutional controls over a 300-year period.

Conclusion: Mitigation measures to date have eliminated some, but perhaps not all, sources contributing to the North Plateau Groundwater Plume. Offsite transport of radionuclides in the plume continues to occur in surface water, but at low concentrations.

Recommendation: Evaluate the possibility that a new source term is developing in the northeast corner of the main process building. Consider additional mitigation measures for the leading edge of the North Plateau Groundwater Plume.

Exposure Locations and Scenarios

Conclusion: The scenarios and exposure locations for the short-term assessment appear reasonable, consistent with maintaining institutional controls during the operational period. The short-term assessment does not address scenarios that include intrusion or failures of institutional control that might allow releases by groundwater transport or erosion.

Recommendation: Confirm that the scenarios and exposure locations for the short-term assessment meet the needs of future analyses, and modify if necessary. Include discussions of possible short-term risks associated with groundwater transport and erosion.

Conclusion: The scenarios and exposure locations selected for the LTPA could be adequate to inform the EIS decisionmaking process, providing that the technical bases for the selection and modeling of the scenarios are improved as suggested elsewhere in these conclusions and recommendations. These scenarios and exposure locations may not be appropriate for other programmatic or regulatory purposes (e.g., for a decommissioning license termination).

Recommendation: Future analyses should emphasize documentation of the bases for scenario selection and the defensibility of the models used to represent the scenarios. Confirm that the scenario and exposure locations meet programmatic and regulatory needs, and modify as necessary.

Conclusion: The scenario carried forward into Chapter 2 of the 2008 PDEIS, which assumes full institutional control and no erosion for 100,000 years, does not provide a useful representation of plausible future states of the system.

Recommendation: Greater emphasis for decisionmaking regarding long-term performance should be placed on a combination of the unmitigated erosion and intrusion with loss of institutional control scenarios.

Conclusion: The assertion that the scenarios chosen for analysis in the LTPA are conservative is not supported in the documentation.

Recommendation: The EIS should select scenarios that are either 1) conservative, or 2) provide a reasonable representation of a range of future states that could result in risk to humans. Further information on recommendations having to do with LTPA scenarios is covered in the following two topics.

Uncertainty Analysis and Transparency

Conclusion: Overall, the LTPA does not provide a useful estimate of uncertainty in long-term performance associated with any of the proposed actions identified in the 2008 PDEIS. The deterministic results provided from the LTPA are likely to be non-conservative and are not a suitable substitute for an uncertainty analysis.

Recommendation: Future analyses should include quantitative uncertainty analyses. The LTPA would benefit from including a full uncertainty analysis that includes reasonable and realistic ranges of values associated with the uncertainties of the following:

- *The time-dependent physical and chemical properties of engineered barriers*
- *The rate and location of gully erosion at all locations, including on the North Plateau, and including uncertainty in extreme weather conditions*
- *Boundary conditions and material properties affecting groundwater flow*
- *Parameters used to characterize contaminant transport in ground and surface water*
- *The radionuclide inventory associated with each source term*
- *Biosphere pathway assumptions*
- *Future climate states and the impact of that uncertainty on erosion and groundwater flow.*

Conclusion: Transparency of the LTPA is poor, and it is not possible to replicate independently the analyses or to otherwise understand how the results were derived. Given these observations, quantitative results of the LTPA presented in Chapter 2, Chapter 4, and Appendix H should not be used to support decisionmaking associated with the 2008 PDEIS.

Recommendation: Future analyses should include improved documentation and transparency regarding the analytical approach and key assumptions for each alternative.

THE DEFENSIBILITY AND RIGOR OF THE LONG TERM PERFORMANCE ASSESSMENT

Conclusion: As described in the previous sections summarizing findings relevant to specific technical focus areas within the LTPA, the IERT has identified multiple concerns that call into question the adequacy of specific components of the analysis. For example, the scenarios chosen for reporting in Chapter 2 of the 2008 PDEIS that assume institutional controls remain effective indefinitely are not credible, key assumptions and conclusions regarding erosion are unsubstantiated, and potential non-conservatisms throughout the modeling undermine the 2008 PDEIS's assertion that the LTPA provides a conservative estimate of risk. Poor documentation and a lack of transparency preclude understanding many aspects of what was actually done. Overall, the IERT concludes that the LTPA does not provide defensible estimates of potential risks of the West Valley site after the time of decommissioning. The estimates of mean annual dose presented in Chapter 2, Table 2-B, are not credible and should not be used to support the decisionmaking process.

> *Recommendation: Future analyses of long-term performance, for example to support phased decision making, should address realistic scenarios and should identify and remove non-conservatisms. Documentation should be clear and thorough, and analyses should include a quantitative evaluation of uncertainty associated with uncertainty in conceptual models and data.*

Conclusion: This conclusion notwithstanding, it should be noted that the LTPA provides estimates of the potential risks associated with only two of the four alternatives considered: the Sitewide Close-In-Place Alternative and the No-Action Alternative. As indicated in Section 2.6 of the 2008 PDEIS, the Sitewide Total Removal and the Phased Decisionmaking Alternatives are not analyzed in the LTPA. Although results of the LTPA are considered qualitatively in the comparison of the four alternatives, the LTPA is not a factor in the rationale for selecting Phased Decisionmaking as the Preferred Alternative (Section 2.6.7). Concerns expressed here by the IERT about the defensibility of the LTPA therefore may not invalidate the selection of the Phased Decisionmaking Alternative as the most reasonable path.

> *Recommendation: Shortcomings of the 2008 LTPA and the absence of the evaluation of the Phased Decisionmaking Alternative should not preclude its selection as the preferred alternative for remediation of the West Valley site.*

OTHER CONCLUSIONS AND RECOMMENDATIONS REGARDING SPECIFIC ISSUES

Approach and Cost of NDA, SDA and HLW Tank Exhumation

Conclusion: The proposed approach for exhuming the NDA, SDA, and Tanks could succeed but is very conservative, over-manages the risk, and is unnecessarily expensive. Alternative approaches could also be acceptable at potentially significantly lower overall costs.

Recommendation: Consider alternative approaches that may achieve acceptable performance at lower cost; for example, consider alternative structures for providing secondary containment, consider retaining some overburden onsite as low level waste, and use information determined in the field to inform decisions in real time regarding strategies for exhumation, shipment, and disposal of wastes.

Conclusion: Total costs for the approach presented in the STRA report (e.g., with secondary containment buildings) are underestimated.

Recommendation: Confirm and update cost estimates as appropriate.

Transportation Analysis

Conclusion: In general, the transportation analyses are clearly stated, well documented, and use reasonable data and analysis approaches. Four conclusions of the transportation analyses are (1) it is unlikely that transportation of radioactive wastes would cause an additional fatality as a result of radiation, (2) the highest calculated transportation risks to the public would be under the Sitewide Total Removal Alternative and Nevada Test Site disposal option (this alternative has an estimated duration of 60 years), (3) the lowest calculated transportation risk to the public would be under the Sitewide Close-in-Place Alternative and commercial disposal site option (this alternative has a duration of less than 10 years), and (4) the non-radiological accident risks present the greatest risks.

Conclusion: Estimates of transportation risk are overly conservative because they use general transportation data rather than specific nuclear material shipment data and, for rail shipments, include non-radiological risks that would occur regardless of the presence of waste. Conservatism in estimation of transportation risk can introduce bias into decisionmaking when comparing alternatives.

Recommendation: Future analyses should consider data specific to the shipment of nuclear materials and should avoid erroneous conservatisms introduced by using non-representative data.

Seismic Hazard Analysis

Conclusion: Transparency of the seismic hazard analysis is poor, and the approaches taken to estimating risk are not clear.

Recommendation: Future analyses should include clear documentation of the approach taken to estimating seismic risk.

Conclusion: The seismic hazard analysis is based on conclusions drawn in the early 1980s using then-current technology.

Recommendation: Future analyses should be informed by current technologies, and should adopt probabilistic risk assessment approaches commensurate with the overall risk posed by the West Valley site.

Intentional Destructive Acts

Conclusion: Conclusions regarding the risks associated with intentional destructive acts appear to be reasonable, but their quantitative basis cannot be confirmed because supporting documentation is not provided.

Recommendation: Future analyses should include supporting documentation.

Conclusion: There is insufficient evidence presented to support the claim that the chosen scenarios are bounding.

Recommendation: A preferred approach would have been to consider stylized scenarios that represent a reasonable range of possible future conditions, and avoid claims of conservatism that may be difficult to prove.

Conclusion: The assumption that there will be no emergency response such as evacuation or sheltering is an unrealistic conservatism.

Recommendation: Future analyses should consider more realistic treatment of emergency response activities.

Cost Benefit Analysis

Conclusion: The documents reviewed contain a great deal of useful material. The primary issues are the scopes of the analyses performed, consistency in the use of terms and analytical processes, and context of the results.

Recommendation: Future analyses should place more emphasis on the risks associated with different scenarios and their consequences. Measures of risk (e.g., dose, collective dose, peak dose, average dose, conservative dose, reasonably foreseeable annual increment of dose, population dose, and latent cancer fatality) should be clearly defined. Use of population dose and latent cancer fatalities should be eliminated for low-dose conditions since these latent fatal cancers have not been demonstrated to be distinguishable from the prevailing rate of fatal cancers.

Conclusion: There is no transparent treatment of uncertainties and contingencies in the development of the work plans and cost estimates.

Recommendation: Future cost benefit analyses should document the consideration of uncertainties and contingencies.

Conclusion: Cost benefit analyses supporting selection of the preferred alternative are based on the scenario in which full institutional controls remain effective indefinitely, with no erosion and no onsite intrusion.

Recommendation: Cost benefit analyses should be based on realistic scenarios.

OVERARCHING CONCLUSIONS AND RECOMMENDATIONS

A question of great interest to the IERT is whether there are overarching conclusions and recommendations that crosscut all of the topics reviewed that would facilitate decisions on a path forward for NYSERDA and their West Valley management to consider. In that regard, the IERT recognizes five overarching conclusions from their review of the 2008 PDEIS:

1. Current monitoring and West Valley management practices provide assurance that the short-term risk (30 to 100 years) of any significant releases of radiation at locations accessible to the public is very low. The long-term risk of the site (hundreds or thousands of years) will have to be demonstrated by improved and more credible analyses than now exist in the 2008 PDEIS.

2. The existing knowledge base is capable of supporting risk assessments providing there is accountability for the uncertainties in the analyses performed. With continued monitoring and acquisition of new data as needed, especially in relation to the modeling of erosion and the formation of gullies, characterization of both the site and the waste forms will be sufficient to support effective decisionmaking.

3. Current analyses documented in the 2008 PDEIS, including the LTPA, are not adequate to support a final decision regarding disposition of the site. Principal concerns are the lack of transparency and appropriate modeling in selected analyses, the absence of a risk perspective regarding the treatment of uncertainties and risk importance, and failure to analyze the Phased Decisionmaking Alternative.

4. Given that the 2008 PDEIS is not adequate to support a final decision regarding the long-term disposition of the West Valley site, the IERT considers it prudent to postpone such a decision until an adequate environmental impact statement is completed. Consideration should be given to the pursuit of Phase 1 of the Phased Decisionmaking Alternative during this interim period.

5. The approaches to estimating remediation costs and assessing cost benefit lack transparency with respect to the procedures, computational methods, and detailed scenarios employed. Indications are that the methodology and techniques for conducting the cost estimates of specific remediation alternatives, such as the exhumation of the waste, differ from those used at other DOE sites and in some cases appear to be excessive.

Consistent with these conclusions, the IERT provides five summary level recommendations for the West Valley Demonstration Project as it moves forward.

1. Contain and mitigate existing contaminant plumes. Offsite exposures and associated risks from existing contaminant plumes are very low and their prudent management should continue to minimize this risk.

2. Improve analyses to support future steps in the decisionmaking process, focusing on uncertainties that contribute to risk. Analyses need not increase in complexity, but they should provide a realistic assessment of the impacts of significant uncertainty, and they must be clearly documented.

3. Plan and implement remediation actions consistent with updated analyses (i.e., phased decisionmaking). Realistic and implementable plans based on credible analyses must be available to inform decisionmaking.

4. Maintain strong administrative controls to provide high confidence in the continued safety of the site during the decisionmaking process.

5. Cost analyses should be transparent and based on realistic scenarios and established methods of computation used in the nuclear waste field at other DOE sites.

The Independent Expert Review Team concluded from the reviews that a phased approach to decommissioning and remediation of the West Valley site should receive serious consideration. That the IERT should reach this general conclusion is not surprising as the scientific community has long advocated a deliberate, systematic and phased approach to making decisions for the long term management of radioactive wastes.[10,11]

[10] National Research Council. 1990. Rethinking High-Level Waste, a Position Statement of the Board on Radioactive Waste. Washington, D.C. The National Academies Press.
[11] National Research Council. 2003. One Step at a Time: The Staged Development of Geological Repositories for High-Level Radioactive Waste. Washington, D.C. The National Academies Press.

APPENDIX A

DETAILED IERT REVIEWS

The general approach to the Independent Expert Review Team (IERT) review is described in Section 4 of this report. As discussed in Section 2, the IERT was requested by the New York State Energy Research and Development Authority (NYSERDA) to conduct an independent expert review of the 2008 draft of the West Valley Preliminary Draft Decommissioning Environmental Impact Statement (2008 PDEIS). The general thrust of the review was to determine if the 2008 PDEIS is scientifically sound with respect to selected issues of concern to NYSERDA. Those issues were the long term performance assessment (LTPA), the approach to the exhumation site remediation alternative, associated transportation risks, seismic hazards, possible intentional destructive acts, and the cost benefit analysis for implementing the various remediation alternatives. With respect to the LTPA, the technical issues identified for review were groundwater flow and transport, surface erosion, engineered barriers, contaminant inventory and sources, contaminant pathways and exposure locations, and the transparency and uncertainty associated with the performance assessment.

The full and unedited reviews of IERT members are contained in this appendix. For each topic reviewed, the findings are summarized in Section 5 and principal conclusions and recommendations are presented in Section 6. The reviews differ considerably in terms of scope and detail. This is a result of several factors such as the impact of the issue, the outcome of the review in terms of issues of concern, the technical content of the specific analyses, and of course, the depth of the individual review, which was at the discretion of the reviewer.

It should be noted that the IERT review was based on drafts of EIS sections provided by NYSERDA between May 2008 and August 2008. As such, some detailed page numbers, figures, etc., referenced in the IERT report may not coincide exactly with more recent versions of the EIS.

GROUNDWATER FLOW AND CONTAMINANT TRANSPORT

Review Team
Shlomo P. Neuman (Lead)
Sean J. Bennett
Peter N. Swift

While this review was a team effort, there were differences in emphasis and sometimes opinions between reviewers. To preserve these differences, the team members are explicitly identified with their individual comments. Team member Sean J. Bennett is generally in agreement with the comments and with the approach to individualize them.

SOURCE MATERIAL REVIEWED[1]

- Chapter 2 – Proposed Action, Alternatives, and Summary of Environmental Impacts
- Chapter 3 – Affected Environment
- Chapter 4 – Environmental Consequences
- Appendix D – Overview of Performance Assessment Approach
- Appendix E – Geohydrological Analysis
- Appendix G – Models for Long Term Performance Assessment
- Appendix H: Long-Term Performance Assessment Results (draft of 7/7/2008)

COMMENTS BY SHLOMO P. NEUMAN

Chapter 3 – Affected Environment

Following are a few comments/questions concerning Chapter 3.

1. Top paragraph p. 3-16: Figures 3-8 and 3-9, said to show surficial geologic units in profile and plan view, actually show how these units are embedded in a model that has not been introduced.
2. Bottom paragraph, p. 3-16: The Unweathered Lavery Till (ULT) on the North Plateau is introduced here as being predominantly unweathered and unfractured; the top paragraph on p. 3-20 (last sentence) implies the same vis-à-vis the ULT on the South Plateau. This is inconsistent with the Peer Review Group (PRG) report (item b on p. 43, item 6 on p. 50, item b on p. 53, etc.) and with the discussion of Till Fractures on pp. 3-20 – 3-21.
3. Top sentence p. 3-41: I doubt that there is such a thing as overland sheet flow anywhere except in some textbooks and theoretical papers; have you ever observed such flow? I have not except perhaps on paved surfaces.
4. Section 3.62 on Groundwater quotes estimated values of water balance components (recharge rates, discharge rates) and hydraulic parameters (conductivity and porosity), sometimes citing the sources of these estimates and sometimes not.

[1] In general the source material for all of the reviews is from the 2008 PDEIS, but there are exceptions. The exceptions are references and technical reports relevant to the 2008 PDEIS.

5. Recent measurements are ascribed to WVNS and URS 2006a; can I examine this document?
6. Some of the quoted water balance estimates are taken from Yager (1987); are there no recent estimates produced for purposes of the EIS?
7. The only water level map shown (Figure 3-20) is from Yager (1987); have recent water level maps not been produced for purposes of the EIS?
8. The hydraulic conductivity values ascribed to the ULT appear to be very low (on the order of 10^{-8} cm/sec), ignoring the potential role of fractures and other high-permeability inclusions within the ULT. This is inconsistent with the PRG report and with the section on Till Fractures on pp. 3-20 – 3-21.
9. Can I examine the Yager (1987) document?
10. It is taken for granted (citing a Dames & Moore report) that groundwater leaks downward from the Kent Recessional unit (KRU) into the underlying Kent Till (KT). Considering the regional setting of the site it is, in my opinion, much more likely that water is in fact leaking upward from the Kent Till into the KRU.
11. Is there information about the rate of groundwater seepage out of the KRU where the latter crops out along the edges of each plateau? If so, that should allow one to estimate the rate at which the KRU is supplied with water through vertical leakage from the overlying ULT, and thus to estimate the effective vertical hydraulic conductivity of the ULT. Presently the report takes for granted that this conductivity is on the order of 10^{-8} cm/sec.

Appendix D - Overview of Performance Assessment Approach

The analysis is deterministic; there is no *bona fide* uncertainty analysis of any kind. Hence references to uncertainty analysis in Appendix D, and especially in Section D.3.2.3, are misleading.

Appendix D constitutes largely a brief recapitulation of material presented in greater (though generally insufficient) detail in Appendices E, G, and H. The analysis described in Appendix D thus suffers from the same deficiencies as those I have pointed out in my comments on Appendices E, G, and H. A few additional comments follow.

Lines 104 – 108, 239-243: Analysis of surface water conditions is restricted to average flows. Surely erosional processes are more sensitive to hydrologic extremes than to averages? Does this mean that erosional processes and their impacts on human health have been underestimated in the EIS?

It is not clear why site conditions arising from extreme global-climate changes are not considered (lines 214-218). Sensitivity analyses described in S1ection H.3 do not address this factor in a sufficient and convincing manner.

Chapter 2 - Proposed Action, Alternatives, and Summary of Environmental Impacts

Part 1, Lines 111-115, 607-610, 1078-1079: A permeable treatment wall and a permeable reactive barrier will be installed to mitigate further North Plateau Groundwater Plume

Migration. No discussion or analysis of the design or effectiveness of such a wall and barrier are provided in the EIS. Given mixed results with the existing passive treatment system at the site, it is not clear that the planned wall and barrier can be counted on to perform as assumed in the EIS.

Part 2, Lines 2-5: Considering that long-term impacts of the Phased Decisionmaking Alternative have not been subjected to performance assessment (PA), it is difficult to see how the results of the PA in Section 2.6 could define sharply the issues and provide a clear basis for choice among the alternatives, as stated. The Phased Decisionmaking Alternative has been preselected as the preferred alternative, rendering any such comparison mute. The rationale given in support of this preferred alternative in section 2.7 does not rely in any way on long-term PA.

The summary of environmental impacts in Chapter 2 derives from Appendices D, E, G, and H. This summary therefore suffers from the same shortcomings as those I have pointed out earlier in my assessments of these appendices.

The reference to uncertainty analysis in Section 2.8 is misleading: no *bona fide* uncertainty assessment has been included in the EIS. The assertion (lines 395-396) that uncertainty has been accommodated in the EIS by making some conservative assumptions for purposes of environmental impact analysis is unjustified on two counts: 1. Conservatism is not a substitute for uncertainty assessment and 2. There is no convincing demonstration in the document that the analysis is in fact conservative.

The long term impacts discussed in Chapter 2 (Section 2.6.2) are limited to the unrealistic case in which institutional controls remain in place indefinitely. The discussion of these impacts is therefore misleading and unhelpful.

Chapter 4 - Environmental Consequences

As far as long-term environmental consequences are concerned, Chapter 4 provides a summary of results presented in Appendix H. All my comments concerning those results, and the manner they have been obtained (Appendix E and G) apply to the summary in Chapter 4.

Appendix E - Geohydrological Analysis

Appendix E provides some background information about site hydrogeology and describes in general terms the approach used to model groundwater flow for purposes of the EIS. The approach is to develop a far-field (site) simulator of three-dimensional steady state groundwater across the site and two separate near-field (local) simulators of three-dimensional steady state flows under the North and South Plateaus. Each simulator accounts for both saturated and unsaturated flows. Each is calibrated against some of the available hydrogeologic site data, first manually and eventually automatically (though this activity has not been completed) using the inverse code PEST. Parameters varied during calibration include horizontal and vertical hydraulic conductivities of selected units and recharge values as well as spatial distribution (in the site model, but not in the local models) on the soil surface. Whereas the site model extends vertically to bedrock, the local North and South Plateau models extend down to the bottom of the ULT unit.

Both local models are constrained in part by simulation results generated by the site model and are additionally calibrated for existing conditions. The models are deterministic. Each model is subjected to a sensitivity analysis whereby some of its calibration parameters are varied, one at a time, to generate a range of possible outcomes. The stated purpose of these models (p. E-1) is to (a) establish a way of estimating the potential impact that various decommissioning actions may have on groundwater flow regimes under each plateau and (b) form the basis for projecting the impacts of these alternatives on contaminant transport. The manner in which such projections are to be accomplished is not discussed in Appendix E.

The local models applied to the Closed-In-Place Alternative include some engineered features.

The local model for the North Plateau was used to simulate the transport of Strontium-90 and the results compared with GeoProbe measurements of concentration in the corresponding plume. This model was also used to investigate the transport of a hypothetical conservative tracer from the bottom of the High Level Waste Tanks toward the northwest edge of the modeled area.

The following comments are based entirely on the text, figures and tables in Appendix E (version of 5-6-08). Further comments may be provided following review of the following cited documents and calculation packages (REF PACS):

- WVDP 2007
- NPSR 90
- WVNS 2006
- URS 2006
- Yaeger 1987
- GW calcPackREF
- Hydraulic conductivity calculation package (REF)
- Groundwater model calculation package (REF)
- REF EIDhydro
- WL calcPack REF
- Model Calibration REF
- Target REF
- SNL 2008

The idea of simulating jointly saturated and unsaturated groundwater flows in three dimensions across the site, and locally under each plateau under various decommissioning alternatives, is sound. So is the idea of superimposing the transport of contaminants, dissolved in groundwater, on such models as done in Appendix E. As pointed out later in connection with Appendix G, this same approach was not adopted for purposes of Performance Assessment.

Though in principle the approach adopted in Appendix E is sound, there is considerable room for improvement:

1. A steady state model cannot account for effects of site alterations due to closure activities, future climate changes, erosional processes and human activities at and around the site on flow and contaminant transport (a) while these changes are taking place and (b) following the occurrence of such changes before a new steady state develops (if it does). The EIS needs to address the question to what extent is a steady state groundwater flow analysis adequate in light of such temporal adjustments in the groundwater regime across the site and under each plateau.

2. To calibrate the steady state groundwater flow models, seasonal variations from well hydrographs were filtered out to establish the presence of systematic trends in water levels, and then well hydrographs exhibiting such trends were excluded from the list of calibration targets. The filtering method needs to be clarified and convincing justification given for disregarding water level records exhibiting trends.

3. The conceptual framework underlying the site model is fundamentally flawed and must be modified.

   The conceptual framework of site-wide flow is illustrated in Figure E-4, shown schematically in Figure E-8, and discussed in the text. According to this framework, groundwater flow throughout the sedimentary complex below the Kent Recessional Sequence (KRS) and above the bedrock is directed downward; the only exception is lateral seepage from the Kent Till into Buttermilk Creek (see also Figures E-6 and E-7). Flow from the bedrock is taken to take place into the KRS and the Olean Recessional Sequence (OLS).

   In the numerical model a constant head boundary condition is imposed in the bedrock with the intent of maintaining the measured water table elevation, and lateral flow, in the KRS (Figure E-15). This is based on the modelers' conviction that the overlying ULT has a permeability which is too low to allow sufficient leakage from above, through the ULT into the KRS, to maintain the water table and lateral flow within the KRS at their current levels.

   In the nominal (base case) model there is no flow out of the deep bedrock except laterally into the KRS and OLS. No flow is allowed to take place across the southern boundary of the (base case) model which, however, is not a physical barrier to flow. No flow is considered to take place below Quarry Creek on the west and below Buttermilk Creek on the east, there being in reality no physical barriers to flow under these creeks. Recharge is restricted to take place through the floor of the modeled valley area, but not from higher elevations around the valley. As a consequence, groundwater below the KRS is for all practical purposes stagnant. A similar result would have been obtained by simply eliminating all but layers 1 – 12 from the 23-layer groundwater flow model; layers 13 – 23 (as modeled) are thus entirely redundant.

In an alternative conceptual model briefly mentioned on p. E-53, the deep bedrock is allowed to discharge groundwater northward into Cattaraugus Creek. The weathered bedrock constant head used to create such discharge was varied in several runs to reveal very little impact on heads in the upper units (above and including the KRS). Based on this and the stagnant velocity fields obtained below the KRS (Figure E–25 and Figure E–26) the modelers concluded that the deeper aquifer systems in the Buttermilk Creek basin can be ignored with little consequence when modeling impacts of near-surface facilities.

Unfortunately, the finding of virtually stagnant groundwater at depth in both the nominal and the alternative models is an artifact of incorrect conceptualization. It is well known that in topographic settings similar to that of West Valley, groundwater recharged along topographic highs surrounding the valley flows downward and laterally to converge, and discharge, upward toward the valley floor. At the West Valley site such convergence and discharge are expected to take place not toward and through the valley floor but toward and through the KRS, which in turn discharges into Buttermilk Creek. The KRS is thus expected to be fed from three general directions: leakage from above through the ULT, leakage from below through the KT, and conceivably lateral seepage from the bedrock on the west.

As the site model is used to constrain the local North and South Plateau flow models, a fundamental conceptual error affecting the former may impact the validity of the latter in ways that are difficult to ascertain without first correcting the error. In particular, the question what are the relative and absolute rates at which the KRS is fed from the above three sources is important for the estimation of the role played by the ULT in conducting water, and contaminants, downward toward the KRS and Buttermilk Creek from the North and South Plateaus. The base case model in Appendix E cannot be relied upon to address this question correctly because it (a) presupposes that recharge of the KRS from above, through the ULT, is inconsequential relative to lateral recharge from the bedrock, (b) imposes an artificial head boundary at the bedrock-KRS interface to maintain such lateral recharge, (c) presupposes that water flows out of the KRS into the underlying KT rather than vice versa, as should be expected, yet (d) prevents such downward flow from taking place by rendering groundwater throughout the modeled area effectively stagnant below layer 12.

2. In the site model and the two local models developed for the North and South Plateaus, the hydraulic conductivity of the ULT has been assigned on the basis of measured values. At depths of less than 3 m below the top of the ULT on each plateau its hydraulic conductivity was assigned a uniform isotropic value of 1×10^{-6} cm/sec, and at greater depths a value of 6×10^{-8} cm/sec. This latter value is near the

upper end of laboratory measurements, reported to be in the range $2\times10^{-8} - 8\times10^{-8}$ (p. E-32).

The following considerations lead this reviewer to believe that the hydraulic conductivity value of 6×10^{-8} cm/sec, assigned to all but the uppermost 3 m of the ULT in all three models, may be too low (and thus not conservative) when applied to the shallow parts of the ULT. In particular, it may not be conservative to assume (as does the EIS) that keying slurry walls 2 – 3 feet into the shallow ULT prevents leakage under these walls:

a) The 6×10^{-8} cm/sec value is based largely on field measurements of undisturbed till shown by open circles in Figure E-19. These measurements represent relatively small (local) volumes of low-permeability till. The larger scale, effective hydraulic conductivity of the ULT is likely affected by fractures which are known to exist and heal plastically only at depths exceeding 50 ft; by pod- and lens-like inclusions of permeable coarse material; by excavations of holes and trenches to depths exceeding 3 m; and by reworking of the original sediments. The effective hydraulic conductivity of the ULT at shallow depth is therefore likely to be larger than that indicated by the open circles in Figure E-19.

b) Reworking of the original sediments is said to have yielded the higher local conductivities shown by dark circles in Figure E-19. There are 8 such values in the depth range of 0 – 20 ft as compared to 9 open circles, scattered jointly over 4.5 orders of magnitude. There are only 3 open circles in the depth range of 30 – 50 ft. It thus appears that to extract a statistically meaningful average conductivity from these data it would be best to fit a straight line to them by regression. Such a line would show a much milder decline with elevation than does the unit slope line in Figure E-19. A regression would tend, for the most part if not in its entirety, to lie above the model value of 6×10^{-8} cm/sec.

   More importantly, the regression line would be associated with a wide confidence interval and a much wider prediction interval, especially in the 20 – 50 ft depth range. This in turn would indicate that, based on these data alone, the modelers should vary their assigned ULT conductivity about the regression value at random over a wide range of statistically predicted values (rather than keeping it at the low deterministic value of 6×10^{-8} cm/sec). Even higher values should be allowed in order to take account of the remaining factors (e.g. fracturing) listed under (a).

c) Our team has examined water level records from SDA trenches 2, 3, 4, 5, 8, 9, 10N, 10S, 11, 12, 13, 14 for the years 1986 – 2008. We have analyzed the rate at which water levels in these trenches have receded from their maximum in the mid 1990s by assuming that (a) no recharge into the trenches took place during the recession period and (b) leakage out of the trenches took place vertically downward under pure gravity, i.e., under a unit hydraulic gradient. This gave estimates of vertical hydraulic conductivity of the ULT beneath the trenches ranging from 4.8×10^{-8} to 1.2×10^{-7} cm/sec with a geometric average of 7.5×10^{-8} cm/sec. Assuming that recharge into the trenches took place during the recession period would have yielded higher estimates of hydraulic conductivity, depending on recharge rate. These results might help constrain the proposed regression analysis from below.

d) Sensitivity results in Figure E-22 convey the impression that varying the vertical hydraulic conductivity of the ULT about its deterministically assigned value (of 6×10^{-8} cm/sec) would cause deterioration in model quality as measured by the SSR model fit criterion. The impression is misleading because everything but this conductivity was kept constant for purposes of the analysis. Had the model been recalibrated for each choice of ULT conductivity, it would have yielded modified values of other calibration parameters without necessarily causing deterioration in model fit (to measured heads and/or seepage rates).

3. Sensitivity analyses of the kind conducted in the EIS are useful to ascertain how changes in one parameter impact model output when all other parameters are kept fixed. Such sensitivity analyses, however, constitute neither an assessment of uncertainty nor a replacement for it. Available data indicate that there is enough uncertainty about hydrogeologic conditions to warrant a bona fide uncertainty assessment of groundwater flow and contaminant transport at the site.

   One important way to incorporate uncertainty in the modeling approach is to generate random predictions of effective ULT hydraulic conductivity based on a regression analysis of the data in Figure E-19 (as proposed earlier) and calibrate the models for each random effective value.

   A more comprehensive uncertainty analysis would include generating jointly random realizations of thick-bedded unit (TBU) conductivities and effective ULT and KRS conductivities, then calibrating the models for each realization. As conductivities of the TBU have been analyzed geostatistically, it should be straightforward to generate multiple realizations of TBU conductivity fields using established geostatistical methods. The KRS could be assigned random effective values equal to the spatial mean of any corresponding TBU realization.

   Additional elements of uncertainty that should be easy to incorporate in the modeling approach include setting calibration weights equal to inverse error variances of measured heads and seepage rates against which the calibration is performed.

   Calibrating the models using PEST following the assignment of such weights should allow one to quantify parameter estimation errors and correlations between them for each case. It would be useful to analyze statistically the calibration residuals to verify that measurement errors are normally distributed (as assumed when one adopts a least squares calibration criterion) and the parameter estimates are unbiased.

Doing so should allow one to generate multiple random simulations of groundwater flow across the site and under each plateau, and then summarize the results statistically.

Such statistical predictions of groundwater flow should, in our opinion, form the basis for the analysis of contaminant transport on each plateau under each alternative site decommissioning option.

4. Soil moisture characteristics were assigned in the model on the basis of a unit's equivalent scalar hydraulic conductivity (geometric mean of principal values) at saturation according to Table E-5. The manner in which Table E-5 was developed is unclear: this reviewer is unaware of any studies demonstrating a correlation between soil moisture characteristics and saturated hydraulic conductivity.

   Instead, there is a rich literature on pedotransfer functions relating soil unsaturated hydraulic properties to soil texture (most notably percent gravel, sand, silt, clay and soil density). Information about soil texture is available for the TBU (having been used to extend its database on saturated hydraulic conductivities) and most likely for the KRS as well as other units. Using established pedotransfer functions to estimate soil moisture characteristics for the site would have been, in this reviewer's opinion, more credible than the approach taken.

   Most pedotransfer functions allow assessing the uncertainty associated with predictions of unsaturated hydraulic properties on the basis of soil texture. No attempt to assess such uncertainties is reported in the EIS.

5. The porosity values listed in Table E-4 are likely overestimated for fractured units such as the ULT. Using them to compute advective velocities of contaminants would thus lead to underestimation of transport migration rates, possibly by orders of magnitude.

6. Only two alternatives are analyzed, No Action and Close-in-Place (p. E-55). How will this allow assessing the preferred phased alternative?

7. Boundary conditions applied in the local (near-field) models are said to be consistent with site observations and with those applied to the site-wide model (lines 27, 1168 – 1169). Yet whereas calibrated recharge along the upper boundary of the site model varies spatially (lines 837 – 840), in the local models it is uniform (lines 1176 – 1177) with calibrated values (lines 1179, 1347) that seem to differ from those obtained with the site model.

8. Appendix E provides no details about (a) how engineered structures and flow through/around them are modeled in three dimensions and (b) what three-dimensional flow patterns develop in and around them. Such detail must be provided for the following reason.

   According to Appendix C, the plan is to key future slurry and barrier walls 1 m (3 ft) into the Unweathered Lavery Till. It should be the role of Appendix E to present detailed three-dimensional analyses of how effective this would be in diverting groundwater around such enclosures.

   As pointed out earlier, the shallow ULT may be considerably more permeable than is presently assumed for purposes of groundwater modeling. Figure E-19 indicates that in its upper few meters undisturbed ULT may locally reach permeabilities in excess of 10^{-4} cm/sec. It is therefore not self evident that keying slurry and barrier walls 1 m into such material would prevent groundwater from flowing freely into and out of the enclosed areas underneath the walls. The nature and rates of such seepage must be elucidated and quantified.

Additional technical comments on Appendix E are listed below:

- The bottom of p. E-7 speaks of a recent revision in the extent of the LTS and the slack-water sequence beneath the North Plateau. It is not clear whether or not this revision is reflected in Figure E-5, dated 2005.
- It would be useful to complement the west-east cross-sections in Figures E-5 and E-6 with south-north sections to provide a more complete picture of shallow site hydrogeology at the site.
- The slack-water sequence in Figure E-7 is not shown in Figure E-5; it would be good to render the figures mutually consistent.
- Is there a difference between the two Unweathered Lavery Till boxes in the upper diagram of Figure E-7? If so, what is it?
- The top of p. E-11 speaks of coarse sediments filling a narrow northeast trending trough in the Lavery till. It would be helpful to delineate this trough on a map and in sections.
- Table E-2 lists observed seep and stream flows used in model calibration. Do any of these values reflect discharge from the KRS? For reasons explained earlier, it would be useful to quantify the discharge from the KRS.
- At the top of p. E-24 the bottom of the site model is said to be at a depth of 525 ft. Depth below what?
- The designation of boundary conditions on Figure E-14 and corresponding text on p. E-25 are unclear. What triangles does the text refer to?
- On p. E-23 the assumption of steady state groundwater flow is said to be addressed in the sensitivity analysis. This does not appear to be the case.
- There is some lack of clarity about how the weathered bedrock (WB) was incorporated in the various model layers. In particular, it is not clear how the section

in Figure E-15 relates to the model results in Figure E-24: where in the latter figure is the WB and where was head in the bedrock prescribed?

- What artificial neural network was used to extend the saturated hydraulic conductivity database of the TBU on p. E-31? Was it the Rosetta pedotransfer model?
- It would be useful to complement the kriged map in Figure E-17 with a map of corresponding kriging errors and a graph of the underlying sample variogram with the fitted spherical model and number of data pairs associated with each point.
- On p. E-31 clustered hydraulic conductivity measurements are said to have been removed from the data base. Would it not have been better to average them and use their spread to obtain a measure of uncertainty for inclusion in the kriging process?
- On p. E-32 (Figure E-17), would it not have been more consistent to interpolate and extrapolate the data across the entire TBU area by kriging rather than assigning a uniform mean conductivity to areas containing few data? This would have allowed associating kriging (estimation) errors (variances) with the entire area, as suggested earlier.
- It would help to include a legend in Figure E-19.
- What is meant by "averaged" hydraulic conductivity values in line 757 of the text? Averaged over what?
- The Unweathered Bedrock conductivity of 1.0×10^{-5} cm/sec quoted in line 825 is inconsistent with the value of 1.0×10^{-7} cm/sec listed in Table E-3.
- The 1^4 anisotropy ratio in column 4 of Table E-3 must be a typographical error.
- It is hard to agree with the statement in line 910 that the match between observed and computed seep and stream discharge rates in Table E-7 is good overall.
- How was the 20 cubic meters per day lateral recharge value into the TBU determined (line 1172)?
- Assigning a uniform recharge over the TBU for analysis of the No Action Alternative (line 1179) appears to be inconsistent with the spatially variable recharge rates allowed in the site model.
- Where can the reader verify that predictions of plume center of mass are consistent with observations (line 1194)?

Appendix G - Models for Long-Term Performance Assessment

For purposes of long term performance assessment, Appendix G analyzes contaminant transport by groundwater as if it took place along one-dimensional flow tubes having rectangular cross-section (p. *G-26*). In each flow tube, advective velocity and other transport parameters are taken to be constant. The approach is said to be appropriate because travel distances to onsite receptors are relatively short. Transport along each flow tube is simulated analytically or numerically, depending on the nature of the contaminant source. The analysis is deterministic.

For groundwater flow scenarios, the direction and rate of movement of water around and through the waste material is said to have been estimated using the near-field flow models described in Appendix E (pp. *G-1, G-3*). Neither Appendix E nor Appendix G (or any other part of the EIS) provide a single fully developed example of (a) a three-dimensional flow pattern of the kind expected to control contaminant transport at the site, be it on a far- or near-field scale or (b) a detailed explanation/illustration of how this flow pattern is translated into a network of one-dimensional flow tubes. In fact, not a single network of flow tubes is presented in any detail. Instead Figures G-2 and G-4 (and the ancillary text) indicate that in groundwater release scenarios no consideration is given to flow under barrier walls; existing or future soil contamination by contaminated irrigation water leaching back to the groundwater table through the shallow unsaturated zone, or being mobilized by a fluctuating water table; or the potential of deriving drinking water from a (possibly contaminated) well completed within the KRS; more on this below. Flow area and volumetric flow rates across an external barrier (grout, slurry wall or clay layer) are assumed to be the same as those across the wasteform (p. *G-19*), a situation that we doubt would develop in realistic three-dimensional flow scenarios. Constituent concentration in groundwater at the release point to an aquifer is calculated upon dividing the total release by the aquifer flow passing around the wasteform (p. *G-19, G-24*), which in our view brings about a much greater amount of dilution than would be either reasonable or conservative to assume. Considering further that flow is expected to converge and diverge around and under obstacles such as slurry walls and local waste forms, as well as converge toward wells, drains and seeps, it is difficult for us to understand how such flow could be represented validly using the highly schematized flow tube models discussed in Appendix G. This, and the fact that parameters are listed in Appendix H (but not in Appendix G) without any substantial explanation as to how they were obtained, causes us to question the ability of flow tube models mentioned (but described without detail) in Appendix G to produce valid results for purposes of PA.

Appendix E describes (in very little detail) two simulations of transport based on local three-dimensional flow models: a model for the North Plateau was used to simulate the transport of Strontium-90 (the results having been compared with GeoProbe measurements of concentration in the corresponding plume) and a similar model was used to investigate the transport of a hypothetical conservative tracer from the bottom of the High Level Waste Tanks toward the northwest edge of the modeled area. Yet there was apparently no attempt to compare the output of any transport model in Appendix G with these much more convincing simulations of transport in Appendix E. This erodes further our confidence in the validity of the transport models described in Appendix G.

In our view, the only possible rationale for replacing full-fledged three-dimensional transport models of the kind employed briefly in Appendix E with simplified one-dimensional flow-tube models of the kind employed in Appendix G would be to use the latter repeatedly in the context of a Monte Carlo uncertainty analysis. Considering that the analyses in Appendices E and G are deterministic, this rationale does not apply. Should a future version of the EIS include such a Monte Carlo analysis, this should be accompanied by a clear and convincing demonstration that the flow-tube models employed are equivalent, in ways that are relevant to PA, to the more general flow and transport models in Appendix E.

Appendix G states (p. *G-4*) that the deterministic integrated codes developed there were extended into uncertainty analysis versions that were then verified. We were unable to find any *bona fide* uncertainty analyses of this kind, or their verification, anywhere in the EIS; at best, deterministic sensitivity analyses or bounded calculations (e.g. p. *G-43*) are given.

Though the analysis is said to be conservative, we have been unable to find any indications within the EIS that it in fact is.

Additional Comments:

Neither Appendix E nor Appendix G considers the possible impact of erosion on groundwater flow and/or transport. We believe that such impact is likely following the loss of institutional control.

The schematic design, analysis and evaluation process in Figure G-1 calls for model rejection and/or refinement if predicted impacts do not satisfy review/regulatory criteria. There is no provision to reject and/or refine a model based on its validity as a predictor. In our view, the latter should precede the former.

The rationale for assuming that use of a well is feasible on the North Plateau but not on the South Plateau (p. *G-4*) is not clear to us. This is said to follow from a three-dimensional site model prediction that although horizontal flow occurs in the Kent Recessional Sequence, the unit is unsaturated beneath each plateau. To our knowledge, water level measurements in boreholes completed within the KRS indicate that this unit includes an unconfined saturated zone under each plateau. To the extent that the three-dimensional model suggests otherwise, the model should be suspect, not the data. Considering further that the KRS is relatively permeable, it is unclear to us why one no one would ever consider deriving water from wells completed within this unconfined aquifer.

The residual radioactive material scenario on p. G-4 is said to consider ingestion of drinking water on the North Plateau. It appears that contaminant concentrations in well water (e.g. equation G-11) are obtained using RESRAD but no details are provided. Why (and how) was RESRAD used for this purpose rather than one of the flow/transport models developed in the EIS?

Description of the finite difference scheme used to solve the one-dimensional advection-dispersion equations (p. *G-21, G-24*) is contradictory: on one hand, the scheme is said to be implicit, based on the Crank-Nicholson formulation, on the other hand it is said to be forward in time (a scheme cannot be both). To avoid oscillations in the central difference approximation adopted here, one must control Peclet and Courant numbers, but whether or not oscillations are actually avoided in the analysis is not discussed. An oscillatory solution could render concentrations negative and therefore meaningless; does this ever happen in the EIS and, if so, how is such a situation handled?

Appendix H - Long-Term Performance Assessment Results

In my comments on Appendices E and G, I discussed issues with long term performance assessment relating to groundwater flow and subsurface contaminant transport. These issues affect all results in Appendix H that are derived in part on the basis of groundwater flow and subsurface contaminant transport models. This includes the No Action Alternative and the Close-In-Place Alternative in the case of indefinite continuation of institutional controls. The latter case takes up nearly half (pp. *H-19* through *H-38*) of the results discussion (pp. *H-16* through *H-60*) in Appendix H. Cases entailing loss of institutional control (pp. *H-38* through *H-60*) result primarily in intruder scenarios that are taken to be much less dependent on groundwater flow and subsurface contaminant transport than on other factors and are, therefore, less sensitive to the manner in which these phenomena are modeled. These latter scenarios result, as a matter of course, in greater impacts on onsite receptors than does the Close-In-Place Alternative under perpetual institutional control.

Personally, I consider the case of indefinite continuation of institutional controls to be unrealistic. Nevertheless, the heavy emphasis placed on this case in Appendix H, and throughout the EIS, suggests that this case is considered realistic by the authors of the document. Hence issues associated with the way groundwater flow and subsurface contaminant transport are handled in the EIS merit corresponding weight in our assessment of the document.

Nowhere is there any reference to the impact that existing groundwater contamination at depth may have on onsite or offsite receptors under each alternative. That such contamination exists is evidenced by documented leakage of contaminated water into shallow and deep sediments from trenches and other excavations on the South Plateau. It appears to be completely ignored in the EIS.

A major conceptual issue I have with the use of PA as a means of helping one to select an alternative course of action is that no PA has been performed on the Phased Decision-making Alternative. The latter is identified in the EIS as the preferred alternative on the basis of criteria other than the outcome of the PA. What role, if any, remains for PA to play in helping one to select an alternative? Given that a preferred alternative has already been identified, and that this alternative has not been tested against other alternatives on the basis of PA, what remaining purpose is there for PA in the EIS?

Additional Comments:

The reference to uncertainty analysis in the heading and body of Section H.3 is misleading; no *bona fide* uncertainty analysis has been performed in the EIS.

When surface soil is contaminated by irrigation with groundwater or surface water, exposure by drinking water is said to involve consumption of the primary source of groundwater or surface water rather than by consumption of water infiltrating through the contaminated soil (p. *H-8*). What is the rationale behind this?

Tables H-5 through H-17 list single values for parameters used in PA. Though generic sources are often listed, the relevance of many of these parameters to the site remains unclear. It would be more meaningful to specify ranges rather than single values for these parameters and relate them to site-specific sources of data.

The results in Section H.2.2 are said to be generally conservative (p. *H-19*). The EIS does not make a convincing case in support of this statement.

The scenario of resident farmer exposed to contaminated water is said to be inapplicable to the NDA and SDA receptor because of the low hydraulic conductivity of the Unweathered Lavery Till and the unsaturated conditions in the Kent Recessional Sequence (p. *H-40*). As stated earlier, contaminated water has been documented to leak into the ULT from trenches and excavations in the South Plateau, and the KRS is known to form an unconfined aquifer that could, conceivably, be contaminated by slight leakage through the overlying till. It is therefore not out of the realm of possibility that a resident farmer would attempt to derive well water from the KRS.

It defies credibility that predicted doses and risks for the Sitewide Close-In-Place Alternative are barely changed because the various engineered features around and above (for example) the NDA and SDA would be little affected by the cessation of maintenance under the loss of institutional control scenario (p. *H-41*). Clearly gradual degradation of the integrity and efficacy of these features, coupled with enhanced (possibly catastrophic) erosion, would insure otherwise.

COMMENTS BY PETER N. SWIFT

Questions for Review

Overall IERT guidance for review: "Do the assessments provide an adequate basis for making good decisions on how best to protect the public and the environment from harmful exposures to radiation and hazardous materials."

Specific review criteria for groundwater flow and contaminant transport: "Does the groundwater analysis adequately represent how groundwater might impact the source term and the transport of contaminants to the exposure locations? Are the approaches reasonable considering the time constants involved?

Supplemental Review Questions Posed by Shlomo Neuman July 9, 2008

1. Has groundwater flow under existing conditions been rationally conceptualized and modeled, regionally and locally?
2. Has groundwater flow under conditions created by the various alternatives been rationally conceptualized and modeled, regionally and locally? Have the potential impacts of loss of institutional control, and consequent erosion, on groundwater flow been properly factored in? Have flow regimes created by changes to the site due to the removal of cover and installation of engineering barriers/caps been properly analyzed?
3. Has contaminant transport under each alternative been rationally conceptualized and modeled, in a way that is consistent with modeled groundwater flow, regionally

and locally? Are simplifications adopted for purposes of PA reasonable and convincing?
4. Have conceptual, data, model parameter and scenario uncertainties been rationally accounted for and quantified?
5. If not, are there ways in which this could/should have been done?
6. Otherwise, is the deterministic approach taken, coupled with sensitivity analyzes, sufficiently conservative to obviate the need for quantitative uncertainty assessment in flow/transport?

Peter N. Swift Comments

I have focused my review on the implementation of the groundwater flow and contaminant transport models in the long term performance assessment. My comments are organized in three parts: general observations on the overall approach, responses to the six supplemental questions, and then a conclusion that addresses the questions posed in the review guidance.

Overall Approach to Modeling Groundwater Flow and Contaminant Transport

The overall approach to groundwater flow modeling is outlined on the opening page of Appendix E, lines 25-30. Appendix E describes the development of a site-scale groundwater flow model (Section E.3) that is used to inform local-scale near-field models that are developed separately for the North and South Plateaus (Section E.4). Outputs from the near-field models are used to define direction and magnitude of water flow in the simplified models described in Section G.3 and implemented in the LTPA in Appendix H.

Given the need to assess possible release and transport from multiple locations within the site, the overall approach is reasonable. The use of simplified flow and transport models in the LTPA is good, because it has the potential to allow for rapid and flexible uncertainty analyses on key parameters such as specific discharge and retardation coefficients. Identification of the relative importance of uncertainty in flow and transport could, in turn, provide guidance on the need for further refinement of the underlying site and near-field models. The only analyses described in the draft DEIS (i.e., in Appendix H) are deterministic, and this potential advantage of the modeling approach does not appear to have been used.

Documentation in the draft DEIS appears to be insufficient to determine if the three layers of flow models have been implemented appropriately. Appendix G (Section G.3) describes the simplified models implemented in the LTPA, but does not provide a clear description of the input parameters used in the calculations described in Appendix H. Presumably water fluxes reported in tables in Section E.4 (e.g., Table E-14 and others) are used directly in the simplified LTPA models, but specific cross-referencing to Appendices G and H (and from those Appendices to Appendix E) would be helpful. This lack of clear documentation precludes evaluation of the extent to which the LTPA simplifications adequately represent the outcomes of the near-field and site models.

Appendix E is the primary source for evaluating the extent to which the site and near-field models adequately and appropriately represent groundwater flow in the regions of interest, consistent with an intended purpose of informing inputs to the LTPA models. I have a limited set of specific comments on the text of Appendix E attached as an appendix to this memorandum, and I'll defer to the other members of the review team for further comments on the conceptual and computational models documented there.

Responses to Supplemental Specific Review Questions

1. Has groundwater flow under existing conditions been rationally conceptualized and modeled, regionally and locally?

Yes, I believe the conceptual model presented in Appendix E for existing conditions is rational, although, as noted by Shlomo Neuman in his comments, some aspects of the implementation are unrealistic.

2. Has groundwater flow under conditions created by the various alternatives been rationally conceptualized and modeled, regionally and locally? Have the potential impacts of loss of institutional control, and consequent erosion, on groundwater flow been properly factored in? Have flow regimes created by changes to the site due to the removal of cover and installation of engineering barriers/caps been properly analyzed?

Answers to this question require consideration of the three basic scenarios analyzed in the LTPA in Appendix H: The first scenario evaluates 100,000 years of performance with full institutional control and no erosion. This scenario does not represent a realistic future state of the system, and results for times later than several hundred years should be interpreted only as a stylized analysis selected for programmatic purposes. The second scenario examines the 100,000-year consequences of the loss of institutional control without erosion (i.e., it includes human intrusion and onsite receptors beginning at 100 years), and the third scenario examines the consequences of gully erosion on the South Plateau, without including groundwater release pathways. A more complete assessment of the possible future state of the system conditional on the assumptions, models, and parameter values used in Appendix H could have been achieved by summing consequences of the second and third scenarios, but this was not done.

The second scenario (loss of institutional control, no erosion) addresses the consequences of stylized human intrusions in the absence of erosion. This approach is appropriate for near-future intrusions (i.e., at 100 years). Intrusions at early times may present the greatest total risk (due to reductions in the inventory at later time), but this case is not made in Appendix H. No scenarios address the impacts of erosion on releases by groundwater transport. The near-field flow models for the North and South Plateaus (Section E.4) include the impact of a limited set of engineered structures (caps, slurry wall) on groundwater flow. There is no analysis of the impact of changes in ground cover on recharge other than through engineered caps, nor is there an analysis of the degradation of engineered features other than caps. Impacts of erosion on engineered barriers are addressed only through a sensitivity analysis (Section H.3.6) that is not sufficiently documented to review.

3. Has contaminant transport under each alternative been rationally conceptualized and modeled, in a way that is consistent with modeled groundwater flow, regionally and locally? Are simplifications adopted for purposes of PA reasonable and convincing?

I believe the model simplifications for PA are conceptually reasonable, but documentation is insufficient to determine if the implementations are appropriate and consistent with the site and local models.

4. Have conceptual, data, model parameter and scenario uncertainties been rationally accounted for and quantified?

No. In general, the impacts of uncertainties are not quantified in the LTPA. As stated in the draft DEIS in Section D.3.2.3 (line 744) "Because probability distributions of model structure, receptor behavior, and some model parameters are not available for both groundwater and erosion scenarios, a comprehensive probabilistic evaluation is not practical. Thus a combination of conservative assumptions and sensitivity analyses were applied to investigate uncertainty associated with dose estimate."

The overall review of the treatment of uncertainty in the LTPA is being reviewed by another subgroup of the IERT, but it's appropriate to note here that additional documentation would be needed to substantiate the assertion that the deterministic treatment of groundwater flow and transport is conservative. The sensitivity analyses presented in Appendix H, Section H.3 are a very small subset of the potentially relevant analyses, and do not provide a comprehensive evaluation of uncertainty in groundwater flow and transport.

5. If not, are there ways in which this could/should have been done?

A preferred approach would have been to conduct multiple realizations of the site and near-field groundwater flow models to provide a distribution of flow inputs for the LTPA models. The LTPA could then have been run in a Monte Carlo mode providing a full uncertainty analysis for the main scenarios.

Alternatively, the authors could provide sufficient documentation to demonstrate that the deterministic treatment of groundwater flow is conservative.

6. Otherwise, is the deterministic approach taken, coupled with sensitivity analyzes, sufficiently conservative to obviate the need for quantitative uncertainty assessment in flow/transport?

Given that the total risk from the site in the current LTPA is dominated by the human intrusion scenario of the onsite resident farmer (e.g., Table H-41) and, somewhat later in time, by releases from gully erosion of the South Plateau (e.g., Table H-58), it is possible that the existing groundwater flow and transport models, with additional clarifying documentation and appropriate sensitivity analyses, may be adequate for the purpose of supporting DEIS decisionmaking.

Emphasis should be on providing improved documentation of the major exposure modes (intruding resident farmer and gully erosion). Deterministic and conservative sensitivity analyses could then be conducted using existing groundwater flow and transport models to determine if improved models with more realistic treatments of uncertainty have a potential to result in increased estimates of total risk.

Conclusions

Does the assessment provide an adequate basis for making good decisions on how best to protect the public and the environment from harmful exposures to radiation and hazardous materials?

As noted above in response to supplemental question 6, the LTPA results presented in Appendix H suggest that offsite groundwater flow and transport is a relatively small contributor to total peak annual dose in the two scenarios that provide the most useful insights into long-term performance. If that observation is shown to be correct, and if decisions are to be based in part on total risk from all pathways, a simplified groundwater model such as the one implemented in the LTPA may be adequate and appropriate. Additional sensitivity analyses could be designed and conducted using the LTPA models to confirm the relative contribution of groundwater transport to total risk.

"Does the groundwater analysis adequately represent how groundwater might impact the source term and the transport of contaminants to the exposure locations? Are the approaches reasonable considering the time constants involved?"

Documentation in the draft DEIS of the implementation of the simplified LTPA models is not sufficient to determine if the representation is adequate for the purpose. As noted above in my comments on the overall approach, the approaches taken in the DEIS are reasonable and could provide a useful tool for uncertainty analysis.

Swift Specific Comments Relevant to Text in Chapter 3 (1/7/08) and Appendix E (5/5/08)

Chapter 3

Section 3.4, line 619: please check the reference to "the retreat of the Wisconsinan ice sheet about 124,000 years ago…."

Appendix E

Section E-1, Introduction, lines 10-13. The introduction of the geologic units "slack-water sequence" and "Kent Recessional Sequence" would benefit from a reference to a complete discussion of geology, which presumably should be to Chapter 3.

Section E.2.1, line 102. Statement refers to the "deeply incised Franks Creek". The description may be inappropriate in the southern portion of the area.

Section E.2.1.3, line 150 and following. There is a discussion here of the "recent reinterpretation" of geology and the consequent "revision to the model" that presupposes that the reader is familiar with the previous version of the model. Was that version published? Is there a reference for it that should be added here? If it was not published, do you need to discuss the previous version at all (here and elsewhere)?

Figure E-7, line 174. The figure suggests that there is a no-flow boundary at the base of the slackwater sequence. Is this correct? (Note also that the hyphenation of slackwater is inconsistent.)

Section E.2.2.2, line 265. The paragraph here on the Lavery Till is partially redundant with preceding paragraphs, and contains a misleading statement that "the till is variably weathered and fractured to a depth of 0.9 to 4.9 meters." The preceding paragraph indicates that the fracturing extends to 8 meters, and the 4.9 meters refers only to the depth of weathering.

Section E.2.2.4, line 336. The phrase "occurs along Buttermilk Creek" would perhaps be better stated "crops out along Buttermilk Creek" or "…is exposed along…" The unit presumably occurs under larger areas than just along the creek.

Section E.3, line 531. replace "there the" with "there is the"

Section E.3.3, line 620: The statement "Some nodes along Quarry Creek and Franks creek are therefore modeled as constant head…" maybe doesn't need "therefore" in it, because it doesn't refer back to the previous sentence.

Section E.3.4.1, line 779-780. Should "mostly the South Plateau" be "mostly on the South Plateau"? There is something missing at "the scale of spatial any structure…."

Section E.3.7, line 1020. There is a statement that "…grid refinement is needed in this area. That work is currently underway." Either complete the work and provide it, or provide an explanation here of why that work is not "needed." I'm not convinced that the work is "needed" to support an EIS, but if you say it is, then it is.

Section E.3.7, line 1061. Text says “The source of this effect [partial saturation along the crest of the East Plateau] was not determined.” If you don’t know, you don’t know, but once you’ve brought it up, you should either explain it or explain why full understanding of this feature is not necessary for the purpose of this work. Simply stating that you don’t know makes it appear to be a deficiency in your analysis.

EROSION MODELING, ASSESSMENT, AND PREDICTION

Review Team
Sean J. Bennett (Lead)
Robert H. Fakundiny
Michael P. Wilson

SOURCE MATERIAL REVIEWED

- SIBERIA Calibration White Paper
- Chapter 3 – Affected Environment
- Chapter 4 Part I – Near Term Consequences
- Chapter 4 Part II – Long Term Consequences
- Appendix D – Overview of Performance Assessment Approach
- Appendix F – Erosion Modeling
- Appendix G – Models for Long Term Performance Assessment
- Appendix H – Long Term Performance Assessment Results

SUMMARY

The U.S. Department of Energy (DOE) and its cooperators have prepared a revised Preliminary Draft Environmental Impact Statement (2008 PDEIS) for the potential decommissioning of the West Valley Demonstration Project (WVDP). A key component in this statement is an assessment of current and future surface erosion processes operating at and near the site and how these processes potentially can affect the buried wastes.

For the 2008 PDEIS, erosion processes, modeling and performance assessments, and dose equivalencies are presented and discussed in various locations and to various degrees. The most important aspect of the surface erosion assessment is the modeling of these processes, and the future integrity of the buried wastes at the West Valley Site. These results have been presented in detail in Appendices F, G, and H, and are the focus of this review.

DOE and its cooperators present the simulation results of various models used to predict current and future erosion at the West Valley Site, specifically rill and sheet erosion, gully erosion, and landscape evolution. While efforts have been made to model these various surface-erosion components, the predictions from these models cannot be accepted or ratified at this time. This opinion is based on the following four assessment criteria. First, there remains a serious disconnect between model parameterization and the hydrologic and geomorphic characteristics of the site, which has resulted in dubious, highly questionable, and physically unjustifiable assumptions in the treatment and assignment of model variables. Second, no verification or validation of any models was presented in the context of comparing model output to actual field data. Third, many of the model components, especially with regard to gully erosion and landscape evolution, are unjustifiable and unsupported by current scientific evidence. Fourth, no rigorous uncertainty analysis in any

model predictions was provided. The uncertainty bounds in model predictions for the gully erosion and landscape evolution are expected to be very large (orders of magnitude) considering the conceptualization, construction, parameterization, discretization, application, and interpretation of the models employed.

Most importantly, any predictions made using any gully erosion or landscape evolution model with regard to future releases of radionuclides due to the surface erosion of the West Valley Site as presented herein are scientifically indefensible. It was the opinion of the 2006 Peer Review Group that the science behind landscape evolution models is not mature enough to justify relying on these models to provide long-term predictions of erosional processes, and that the associated uncertainty bounds of these predictions should be quantified. The current Independent Expert Review Team, based on the revisions presented, recapitulates this previous opinion.

INTRODUCTION

The U.S. Department of Energy commissioned the preparation of a Draft Environmental Impact Statement (DEIS) for the potential decommissioning of the West Valley Demonstration Project. The New York State Energy Research & Development Authority (NYSERDA), as a joint lead agency on the project, assembled a peer-review group of expert scientists to review the DEIS. The first version of the DEIS was reviewed by a group of scientists in 2006 (herein referred to as Peer Review of the Draft Environmental Impact Statement, PRDEIS, 2006). This current review document represents the collective opinion on the surface erosion assessment and modeling as described in the revised 2008 PDEIS.

In addition, the peer review of the PDEIS on behalf of NYSERDA conducted in 2006 offered commentary and opinion on the surface erosion conceptualizations and modeling components of the West Valley Site (Appendix F in the DEIS). The current Independent Expert Review Team recognizes the importance of these initial findings, and briefly summarizes the main points below.

1. Some of the landscape predictions generated using SIBERIA in the DEIS are unrealistic, which compounds the lack of confidence in these predictions. These include the “freezing” of stream channel headcuts in time, the obliteration of gullies over time, and the “smoothing” of the landscape over time, rather than becoming rougher due to active channel incision (PRDEIS, pp. 26-27).
2. The counter-intuitive SIBERIA predictions may in part be artifacts of how the code has been applied in the DEIS. These artifacts may stem from the inability to switch from hillslope to channel modes, the choice of the diffusion coefficient, and the 50 by 50-m grid spacing, which is too large to accommodate small-scale erosion features such as gullies (PRDEIS, pp. 28-29).
3. SIBERIA has predicted future landscapes for the site that are considered unrealistic and hence not credible (PRDEIS, p. 29).
4. Little has been done to quantify the uncertainty in SIBERIA predictions quoted in the DEIS (PRDEIS, p. 29).

5. The modeling analysis does not consider the impact of potential future climate changes on erosion (PRDEIS, p. 30).
6. The conceptualizations of the erosion processes are considered highly dubious with respect to geomorphic evolution, gully growth and development, onsite characterization of erodibility indices, differentiating the erosion processes on the North Plateau as different from those on the South Plateau, and gully head advance and stream piracy, among others (PRDEIS, pp. 30-38).

Of the many key findings of the PRDEIS (2006), the following concluding statements were offered on the erosion processes and landscape evolution models (PRDEIS, p. 66).

> The science behind landscape evolution models such as SIBERIA is not mature enough to justify relying on these models to provide long-term predictions of erosional processes and rates in glaciated terrains of the northeastern United States. A less sophisticated but more credible alternative would be to judiciously extrapolate observed short and long-term patterns and rates of erosion at the site and the surrounding region into the future, considering similar such patterns and rates recorded in similar terrains elsewhere, and quantifying in a conservative manner the associated predictive uncertainty bounds. However, the PRG expects the uncertainty associated with such extrapolation to be large.
>
> As presented in the DEIS, SIBERIA does not consider commonly accepted erosion processes such as knickpoint migration. SIBERIA has predicted future landscapes for the site that the PRG considers unrealistic and hence not credible. Whereas it might be possible to produce more realistic future landscapes with SIBERIA, its reliability as a predictor would still remain uncertain. No attempt has been made to quantify the uncertainty in SIBERIA predictions.

The authors of this current document also have additional information that is pertinent in the evaluation of the surface erosion assessment, which comes from two sources. The first source is an interagency workshop that was held on October 10-11, 2007, in Rockville, MD to discuss the progress of and results from new assessment activities with regard to the West Valley Demonstration Project. The workshop was attended by representatives of the New York State Department of Environmental Conservation, NYSERDA, DOE, U.S. Nuclear Regulatory Commission (NRC), and the U.S. Environmental Protection Agency (EPA), along with invited experts and consultants. Day 1 of the workshop entailed presentations dedicated to the review of and response to the DEIS, surface erosion modeling, and engineered barriers and erosion control. Day 2 of the workshop entailed an open discussion amongst the participants regarding the presentations and results from Day 1. The same authors above offered scientific opinion on these surface erosion assessments (*Peer Review of West Valley Erosion Workshop, October 10-11, 2007, Rockville, MD, Final Report of December 7, 2007*; herein termed EPRG-1). The second source of information comes from a document prepared by DOE and its cooperators and entitled *Parameters Using the Deterministic Calibration of SIBERIA* dated February 4, 2008. The same authors above offered scientific opinion on this SIBERIA document (*Peer Review of Parameters Using the Deterministic Calibration of SIBERIA, Final Report of March 28, 2008*; herein termed EPRG-2). The results from both of these documents, prepared for and distributed by NYSERDA, will also be included here, where appropriate.

Erosion processes, modeling and performance assessments, and dose equivalencies are presented and discussed in various locations in the 2008 PDEIS and to various degrees. The erosion processes can be divided into three groups, each with a number of subdivisions. The first group presents all empirical data currently available for erosion at the West Valley Site, and this group includes estimates for rates of sheet and rill erosion, stream channel erosion (down-cutting), stream valley width expansion, and gully advance. The second group presents all model applications and assessments, and this includes models results for sheet and rill erosion, stream channel erosion (down-cutting), landscape evolution modeling, and erosion within a single gully. In addition, some information is presented contextually with regard to uncertainty analysis and some quantitative results with regard to sensitivity analysis of select models used. Finally, these modeling results then are used to predict dose equivalencies as they pertain to unmitigated erosion of the West Valley Site. Table 1 summarizes these main topics, each subtopic, and the location where each is discussed within the 2008 PDEIS.

This current review summarizes the findings of the Erosion Peer-Review Team commissioned by NYSERDA to offer scientific opinion on these surface erosion assessments, both as presented within the context of the 2008 PDEIS and as a result of previous meetings and information provided by DOE and its cooperators. From a technical standpoint, Appendix F provides the core of the erosion assessment and modeling, and the remaining appendices provide additional background information. From a policy standpoint, Chapters 3 and 4 provide statements regarding the future integrity of the site and contamination and release scenarios. This IERT review will focus on Appendices F, G, and H, noting that some repetition in findings is due to the construction of the 2008 PDEIS. In addition, only those comments critical of the processes and results presented will be summarized here.

Table 1: Surface erosion topics discussed and their location in the 2008 PDEIS.

Topic	Subtopic	Location in RDEIS					
		Chap. 3	Chap. 4	App. D	App. F	App. G	App. H
Empirical data							
	Sheet and rill erosion	X			X		
	Stream channel erosion (down-cutting)	X			X		
	Stream valley widening	X			X		
	Gully advance	X			X		
	Erosion rates	X					
Model assessment							
	Sheet and rill erosion				X		
	HEC-6				X		
	Landscape evolution modeling		X	X	X		X
	Single gully		X	X		X	X
	Uncertainty analysis						X
	Sensitivity analysis						X
Dose equivalencies based on surface erosion processes			X		X		

Chap. – Chapter; App. – Appendix.

APPENDIX F – EROSION STUDIES

F.1 Magnitude of Surface Erosion Rates Based on Empirical Studies

Rates of surface erosion at the West Valley Site were compiled from empirical studies, monitoring programs, and geochronologic analyses. The ranges of erosion rates for each process are summarized in Table 2. These rates, especially for sheet and rill erosion, are not atypical for regionally-derived values (Montgomery, 2007; Wilkinson and McElroy, 2007). Gully erosion, however, now is recognized as a significant, if not dominant, source of soil loss from agricultural areas and upland regions worldwide (Bennett, et al., 2000a; Poesen, et al., 2003).

Based on these findings, the greatest at-a-point surface erosion rates are due to advancing gullies, which are one to two orders of magnitude greater than all other erosion rates. It is noted here that (1) gully erosion is a discrete process in time and space, (2) gullies are rather small topographic features (decimeters to meters in scale), thus their relative contribution to total sediment yield in this environment may be small, and (3) both down-cutting of the gully and widening of the gully would occur concomitantly during headward erosion. Gordon, et al. (2008), recently showed that on agricultural fields ephemeral gullies up to 2 m wide and 0.275 m deep could advance up to 250 m in a single year, depending upon the severity and frequency of runoff events and the erodibility of the soil.

Table 2: Summary of empirically-derived average annual surface erosion rates for a range of processes.

Surface erosion process	Range of empirically-determined erosion rate (m/yr)
Sheet and rill	0.0 to 0.001
Stream channel down-cutting	0.001 to 0.06
Stream valley widening	0.04 to 0.2 (locally up to 4.9 to 5.8)
Gully advance	0.4 to 0.7

At present, more than 20 major and moderate-sized gullies have been identified, as shown in Figure F-5. We therefore agree with the authors of the 2008 PDEIS that gullies, with very active rates of advancement, are the principal threat to the West Valley Site.

F.2 Magnitude of Surface Erosion Rates Based on Short-Term Models

Short-term soil erosion rates were calculated using four commonly-used models: USLE, SEDIMOT II, CREAMS, and WEPP. The primary short-coming in the use of these models is the parameterization of the hydrology and the erodibility of the soil material. While the hydrologic parameters typically rely upon SCS-approaches (e.g., USDA-SCS, 1986), the erodibility indices must be either user-defined or calculated values. Table F-10 of the 2008 PDEIS summarizes some of these parameters as used in WEPP, for example, where the rill and interrill erodibility coefficients and the critical shear stresses of the soils are identified. Recently, Knapen, et al. (2007), provided an exhaustive review on soil erodibility by upland, concentrated flows, focusing primarily on these indices. Knapen, et al., found the following: (1) erodibility coefficients and the critical shear stress can vary among soils by several orders of magnitude; (2) no statistically significant relation exists between the erodibility coefficient and critical shear stress for all available data; and (3) a multitude of soil and environmental properties are responsible for the large range and temporal and spatial variation in these erodibility indices, in addition to a number of other observations. Given the complex surface geology of the site and the variable geotechnical characteristics of the soils and tills, derived erosion rates from these models can vary by orders of magnitude just because of inadequately quantifying the soil's erodibility characteristics. That is, no onsite verification exists of the erodibility coefficients used in these models and presented in Table F-10. Derived erosion rates would have very large ranges of uncertainty (orders of magnitude) because of this lack of verification,

More importantly, none of these models can explicitly address gully erosion processes on hillslopes, either as classic or ephemeral gullies. The only models currently available to field practitioners to address ephemeral gully erosion on agricultural fields or upland areas are (1) the Ephemeral Gully Erosion Model (Merkel, et al., 1988; USDA-SCS, 1992; Woodward, 1999), and (2) its recent revision (Gordon, et al., 2007). The results from these soil models provide little useful information with regard to the present and future integrity of the West Valley Site since gullies are the principal surface erosion threat and since the models employed are incapable of predicting soil losses from these erosional features.

F.3 Magnitude of Surface Erosion Rates Based on Long-Term Models

F.3.1 Reconstructed Postglacial Topography of Buttermilk Creek.

The evolution of Buttermilk Creek watershed from the end of the last glacial maximum (10,000 to 17,000 years ago) to modern time was simulated using SIBERIA, which was limited to Franks Creek watershed, and CHILD, which was limited to Buttermilk Creek.

As previously noted in the EPRG-1, the evolution of the Buttermilk Creek Valley landscape was very complex, and presumably included the initial deposition of alluvial fans and deltas at the periphery of the proglacial lake and their subsequent dissection by their own feeder creeks as changes in base levels occurred. The drainage pattern during deglaciation would have been complex in space and dynamic in time, since lowering of the proglacial lake levels would have exposed variable topography and relict stream channel valleys and divides. Initial erosion was affected by lake dewatering and its supposed catastrophic flow. Meanwhile, feeder creeks eroding the highland above the lakes established entrenchment in the lake bottom by flooding the exposed dewatered lake-bottom surface. Entrenchment form and pattern were influenced by the location and orientation of joints and other discontinuities within the uppermost part of the Lavery till. Headward erosion of the creeks by knickpoint migration would react differently to local stratigraphic variations within the valley's glacial deposits as local base levels were established in response to the erosion of the controlling bedrock sill near the mouth of Buttermilk Creek.

The landscape sometime in the past, possibly 5,000 to 6,000 years ago, should have resembled in gross configuration the current landscape of neighboring Connoiserauly Creek watershed. The bedrock sill near the mouth of Connoiserauly Creek formed a prominent dam to glacial lacustrine deposits upstream, and a major temporary base level for the watershed. A similar condition existed in Buttermilk Creek, possibly several millenia ago.

The modern landscape of the Buttermilk Creek Valley includes remnants of hanging proglacial lake deltas, highland-creek alluvial fans, and lake-beach strands of previous high-standing proglacial lakes. Similarly, the plateau tops, which are imposed upon well-weathered Lavery till, appear to have experienced relatively minor erosion as compared with the creek sides. These relict plateau-top features attest to the lack of uniform postglacial erosion of the drainage basin. Likewise, they imply that most erosion is by headward and sideward erosion in creek beds, and not by uniform downward erosion of all surfaces. A landscape evolution model should take into account these same processes and resulting alterations to the landscape.

The authors note that the "likely magnitude of [post-glacial] tilt is comparable to the uncertainty in the estimates of paleo-valley gradient" [lines 812-813], as such this isostatic adjustment has not been incorporated in the model calibration. Yet the paleogradients can be measured by the change in elevation of the individual beach strands from south to north within the basin, and this change in gradient through time can be considered a change in base level.

F.3.2 Model Input Parameters

All these models require the following: (1) input parameters that describe the hydrologic, geologic, and topographic characteristics of the site; (2) use of site-specific hydrologic and geologic parameters; (3) various forms of calibration or verification of model results; (4) some consideration for the numerical schemes employed; and (5) a consistent treatment of the hydrologic, geologic, and topographic characteristics of the site across models, even though these models differ considerably in their physical and theoretical basis and intended applications.

All models predict the magnitudes of selected hydrologic and geologic characteristics, and their time and space variations, on the basis of input variables and model constructions. The USLE, SWAT, and WEPP output data include runoff rates and soil losses for the entire watershed, subwatersheds, or individual hillslopes. For SIBERIA and CHILD, these output data include landscape denudation by downslope soil movement, water and sediment transport rates within the drainage network, and the change in elevation over time of all hillslope and river locations.

A nearly universal approach in the assessment of model applicability is the calibration and verification of model results with actual data. Model calibration commonly involves the alteration of unknown input parameters, coefficients, equations, or treatments of processes for the sole purpose of improving the predictive capability of the model's output, in comparison with actual observations for a quantitative calculation of goodness-of-fit. Model verification commonly entails the quantitative comparison of the calibrated model output with actual data that were not previously used in the calibration procedure. Data for both selected storms or entire seasons that could be used to calibrate and verify these models include rates for surface runoff, soil erosion, water flow, and sediment transport within the drainage network, and these data could represent characteristics at-a-point in space and instantaneous in time, or aggregated over various temporal or spatial scales.

No calibration procedures or verification comparisons of model output have been presented. That is, no demonstration whatsoever has been made that the model results for the West Valley Site have been verified or validated on the basis of actual data. The problem here is that even though models can be physically-based and strongly-aligned to the hydrologic and geologic characteristics of the site, the models may report erroneous or aberrant results, the nature of which remains undetected, ignored, or overlooked because of this lack of calibration and verification.

All models employed here to assess the hydrologic and geologic characteristics of the West Valley Site and their time and space variations use common, if not identical, input parameters, such as values for soils, land use and land cover, topography, rainfall/runoff events, etc. The IERT suggests that all such parameters be treated, explicitly or otherwise, in a consistent manner across these different model platforms. This issue would be moot if a strong hydrologic and geologic connection exists between the models and the site, which does not appear to be the case. A consistent treatment of processes or hydrologic and physical space across models has not been demonstrated.

F.3.3 Model Parameters in SIBERIA

The concept of a dominant or effective discharge is well accepted in fluvial geomorphology. The concept as applied here is a somewhat different interpretation and extension. The authors assume that the dominant or effective discharge Q_e (m^3/yr) at a given location in the basin can be defined as:

$$Q_e = \beta_3 A^{m_3} \qquad (1)$$

where A is the contributing area to that discharge point (m^2), β is a coefficient having units $\left(m^3/yr\right)\left(m^2\right)^{3}$, and m_3 is a dimensionless coefficient (lines 821-829). The dominant discharge, as defined here, would be the indefinitely maintained flow that would produce "the same long-term average erosion or deposition rate as the natural sequence of flows."

This equation and its application raise some important questions, which are summarized below.

1. It appears that the authors, by definition, have eliminated rainfall as an input parameter, and assumed that drainage basin area is the sole determinant of flow discharge. That is, stream channel flow is decoupled from the meteorological input, its hydrologic characteristics (infiltration, runoff, etc.), and its temporal and spatial variation as these relate to climatic variations and potentially extreme events. Such an assumption may be valid where data exist to support it, such as the extensive U.S. Geological Survey's (USGS) stream gauging database, which may be ca. 100 years old. It also can be assumed that, over a 100-yr period, climate can be considered constant (notwithstanding recent discussions of global climate change) and that recent extreme events such as the 1993 Flood of the Upper Midwest (U.S.) would be accounted for in this hydrologic time-series. It seems less likely that, over millennia, such an assumption is justified, especially given the recent glacial history of the West Valley Site. The implicit assumption here is that the functional relation $Q_e \propto A^{m_3}$ is temporally invariant from the last glacial maximum until today and from today until sometime in the distant future (1000s of years). The IERT does not agree with this assumption, and this basic tenet would add a significant uncertainty range to the prediction of Q_e.
2. Using available data and engineering formulae, the authors have determined that the bankfull discharge Q_{BF} for Buttermilk Creek at the Bond Road gauging station on the basis of a 1.2-yr recurrence interval is 30 m^3/s for a drainage area of 77.7 km^2. Assuming $Q_e \approx Q_{BF}$, the authors note that for data collected in Hydrologic Region 6, bankfull discharge Q_{BF} (with units ft^3/s) can be defined empirically as:

$$Q_{BF} = 48.0 A^{0.842} \qquad (2)$$

where A has units of mi^2 and the coefficient 48.0 would have units of $\left(\mathrm{ft^3/s}\right)/\left(\mathrm{mi^2}\right)^{0.842}$ following the dimensional logic of eq. (1) above (lines 856-860). It should be noted here that no uncertainty range is defined for eq. (2). If one solves eq. (2) using $A = 77.7\ \mathrm{km^2} = 30.01\ \mathrm{mi^2}$, one calculates $Q_{BF} = 841.6\ \mathrm{ft^3/s} = 23.8\ \mathrm{m^3/s}$, which is about 21% lower than the 30 m^3/s presented above, plus or minus the uncertainty of the derived regression equation.

As this Q_{BF} is a reasonable approximation, the authors then transfer the coefficients directly in eq. (1) (see Table F-16). This substitution, however, is dimensionally incorrect. While the slope of the power function m_3 remains dimensionless, thus $m_3 \approx 0.842$ as noted in Table 1, β does have dimensions. Using the coefficient in eq. (2) as 48.0 with the units $\left(\mathrm{ft^3/s}\right)/\left(\mathrm{mi^2}\right)^{0.842}$ and making the appropriate corrections for units, β in eq. (1) should have the value of 3.98e^{-6} $\left(\mathrm{m^3/s}\right)/\left(\mathrm{m^2}\right)^{3}$ or 170.6 $\left(\mathrm{m^3/yr}\right)/\left(\mathrm{m^2}\right)^{3}$. In either case, there appears to be a significant dimensional error in the analysis and the implications of this error in the SIBERIA model runs have yet to be determined.

3. Fluvial sediment transport rate per unit width q_s (kg/m-s) is defined by the authors as

$$q_s = \beta_1 Q_t q^{m_1} S^{n_1} - QsHold \qquad (3)$$

where β_1 is a correlation coefficient for flow in channels and hillslopes (units of (kg/m-s)/(m^3/m-s)^{m_1}), Q_t is a coefficient for sediment transport on hillslopes (dimensionless), q unit discharge (m^2/s), S is slope (dimensionless), $QsHold$ is the threshold for sediment movement (presumably the same units as q_s), and m_1 and n_1 are empirical coefficients (lines 886-896). The approach taken herein is to assign constant values to q_{st}, m_1, and n_1, and allow β_1 and Q_t to be calibrated (fitted) by model output.

Deficiencies using this approach are as follows.

a. Equation (3) and its coefficients have not been verified or validated for sediment transport data from Buttermilk Creek or its local environs. Numerous bedload transport or total load transport equations are available in the literature, with varying degrees of complexity and theoretical and empirical support (e.g., Barry, et al., 2004). A common result when blindly applying such sediment transport equations is that the predictive values can be orders of magnitude higher or lower than the observed values. Yet no such verification or comparison to data has been provided. The IERT has little confidence in the use of eq. (3) for Buttermilk Creek as adopted here.
b. It has not been demonstrated that the calibrated values of β_1 and Q_t, on the basis of the model's ability to replicate the elevation of the channels and plateaus within the Buttermilk Creek watershed, are within the range of expected values. That is, eq. (3) and the calibration procedure employed might be giving the "right

answers for the wrong reasons," and this becomes especially problematic when using SIBERIA to predict the future geomorphic evolution of the basin. It would be appropriate to provide a critical evaluation of eq. (3) and the coefficients used, as supported by sediment transport data from Buttermilk Creek and its local environs, before any additional decisions are made regarding the remaining coefficients. The IERT has little confidence in the approach as adopted here.

The assumption made by the authors is that the coefficient for channel initiation (β_5; line 971) was calibrated on the basis of the configuration of the modern channel network, which is "unlikely to change much over time in this fixed-basin scenario" [lines 980-981]. The IERT offers the following comments and questions on this section, in general, and this precept, in particular.

1. The IERT is still unclear on the exact mechanism for channel initiation in SIBERIA. It would be most helpful to have a more thorough and graphical explanation for channel initiation, as well as a detailed comparison of the SIBERIA output files to USGS topographic maps.
2. An important observation made in the EPRG-1, as well as the reviewers for the 2008 PDEIS, was that the fluvial network system became locked in space over the length of the simulations (millennia). That is, all simulated river channels' thalwegs and gully heads appear to remain at the same location over 1000s of years—frozen in time. It would be most helpful to know the following information.
    a. What are the exact numerical and morphodynamic conditions that would be necessary to create new channels at the West Valley Site using SIBERIA and for these gullies to extend in a headward direction? It is the opinion of the IERT that knowing precisely where gullies are created, knowing the headward extension rate of both existing gullies and new gullies, and determining the connectivity between these gully systems would be critical in assessing the erosion potential of the West Valley Site.
    b. What is the physical scale of new channels and their type (i.e., gullies or streams)? As noted in the EPRG-1, no information has been provided in sufficient detail as to whether the grid currently used by SIBERIA is static or dynamic in time. As such, it is not known if such fluvial or gully erosional and depositional processes become "grid-locked" in space, e.g., a river channel's or gully's thalweg and head remain at the same location over millennia.
    c. Most importantly, it would seem that the "calibration" of the β_5 coefficient with the modern network system would preclude or negate an alternative network system, either in the forward modeling scenario or in the future predictions.

The numerical schemes employed for the SIBERIA model, and how these schemes ultimately affect the simulated hydrologic and geomorphic processes under consideration, have not been discussed or presented in any detail. No information has been provided on the effects of grid size and grid construction on numerical stability, the time-steps used in the simulations, and how these various time- and space-steps affect the processes being simulated, even though much focus should remain on the governing equations.

A major concern is the use of a relatively coarse grid, ca. 50 m as reported in the 2008 PDEIS, and the interpretation of long-term changes in landscape features that potentially occur at the sub–grid scale. Because the various gullies currently dissecting the West Valley Site have dimensions on the order of decimeters to meters, these critically important features are significantly smaller than the scale of the grid employed. No discussion has been provided as to how these relatively small, yet critically important, geomorphic features are represented hydrologically, topographically, or topologically within SIBERIA, and how the transition from so-called hillslope-dominated to fluvial-dominated landscapes are treated in space.

In a similar vein, no discussion or sufficient detail has been provided as to how time is treated in the long-term simulation using the SIBERIA model, which is important in consideration of how the hydrologic drivers are imposed on the system. It is not known if such time-steps are daily, monthly, yearly, etc., how the hydrologic events over these time-steps are aggregated and released, and how the fluvial erosional and depositional processes are assessed. For example, if the time-step is yearly and this annual flow first is routed through the network system (flow and sediment routing are decoupled), then there may exist situations where the amount of erosion or deposition at-a-point results in numerical instabilities or aberrant topographic characteristics such as negative bed slopes in streams or gullies.

It is noted by the authors that cross-sections traversing Buttermilk Creek using existing topographic maps were employed for comparative purposes with a one-dimensional version of SIBERIA to assess the hillslope diffusion coefficient (lines 1041-1047). Yet no details are provided regarding the scale and contour interval of these sections. In addition, the authors note that the maximum stable slope angles range from 20 to 30° when measured from digital elevation models (DEMs; lines 1048-1049). However, it has been observed by several researchers that maximum slope angles at West Valley Site are commonly ~21° when measured in the field. It would be of great importance to note the existence of 30° slopes in steady-state condition, to determine where these slopes are located, and to assess the geomorphic differences between these 30° slopes and the more common 21° slopes.

F.3.4 Model Parameters in CHILD

Nearly all of the criticisms outlined above regarding the SIBERIA model can be applied equally to the CHILD model, and these are discussed below.

A significant disconnect appears between model parameterization used by CHILD in simulating the West Valley Site and the hydrologic and geologic characteristics as observed and documented. CHILD requires detailed characterization of the hydrology including hydrometeorology, the near-surface soil conditions, land cover that would control infiltration and runoff, surface topography, surface-water connectivity, and the transport of water and sediment through the gullies and streams as well as their rates and their variations in time and space. The parameterization of this physical space also must be site-specific; all model input parameters should be, within reason, based upon published reports from the site, empirical data collected to quantify key indices, or onsite observations. Moreover, these hydrologic and geologic characteristics will most certainly vary in space and may also vary in time.

CHILD uses approximations and equations to quantify hydrometeorology (lines 1060-1075), runoff (lines 1089-1093), channel width (line 1101), sediment transport (lines 1129, 1144), boundary shear stress within the river channels (line 1169), and soil creep (line 1178). Yet no verification or comparisons of model output have been presented with actual data. That is, no demonstration whatsoever has been made that the model results for the West Valley Site for any of the above processes have been verified or validated on the basis of actual data. In each case, assumptions are made with regard to the processes, equations, and/or coefficients, without any critical evaluation as to how these pertain to the West Valley Site. The only demonstration offered by the authors is the comparison of longitudinal profiles for the major streams, which is discussed below. As noted above, even though models can be physically-based, the models may report erroneous or aberrant results, the nature of which remains undetected, ignored, or overlooked because of this lack of calibration and verification.

The parameters used to model precipitation appear oddly derived. It is stated that for modeling purposes, precipitation intensity, duration, and period between storms of 2.1 mm/hr, 5 hr, and 65 hr, respectively, are used on the basis of long-term data collected for the month of August, considered to be a conservative estimate (lines 1062-1067). While a variety of processes can initiate rill development on hillslopes, rainfall remains the dominant driving mechanism (e.g., Parsons and Wainwright, 2006). If rainfall intensities of 2.1 mm/hr (line 1064) are combined with an infiltration capacity of 1 mm/hr (line 1093) and clay-rich, till-derived soils (line 1098) with relatively low erodibility indices (Table F-10), the likelihood of any flow concentration of significant consequence, any soil loss, or any rill and gully development is extremely low. Hillslope processes and denudation, thus, are completely governed by diffusion (line 1178) rather than overland or concentrated flow. This result contradicts the existence of gullies and their recognized importance in the present and future integrity of the West Valley Site.

As reported by the authors, CHILD uses two grid node spacings (~90 m for the outer-regions of Buttermilk Creek watershed and ~22.5 m in the vicinity of the North and South Plateaus; lines 1227-1228). Through direct observation, the more than 20 major and moderate-sized gullies currently identified on the two plateaus, as shown in Figure F-5, are less than 22.5 m wide, with many significantly narrower than this width. Moreover, the gullies commonly are less than 5 m deep, and, as noted below, this is the average difference between observed and predicted elevations along the major streams. By numerical design, CHILD therefore is incapable of creating rills, gullies, and small creeks with channels less than ~22.5 m wide and less than 5 m deep. While we agree with the authors that actively eroding gullies are the principal threat to the West Valley Site, neither CHILD nor SIBERIA currently are capable of rectifying, simulating, or predicting these critically important erosional features as applied here.

F.3.5 Model Calibrations

The only calibration of the SIBERIA and CHILD models was a "goodness-of-fit" metric using the longitudinal profiles of select streams, despite the large number of physically-based relationships in both. For the SIBERIA model, the longitudinal profile from Erdman Brook through the lower portion of Franks Creek was used (lines 1199-1201). For the CHILD model, the longitudinal profile of Buttermilk Creek within its main valley was used (lines 1198-1199). Calibration or "force-fitting" of each model was restricted to varying β_1 and *QsHold* in eq. (3) for SIBERIA (Table F-19), and to varying K_b and K_f for CHILD, where these are bulk coefficients used in the detachment-limited and transport-limited sediment relations, respectively. All other terms within these sediment transport equations, in particular, and these models, in general, were assumed from the literature or assigned by the users. The results of these forced-calibrations are compared with longitudinal profiles obtained from 7.5-minute U.S. Geological Survey digital elevation models in Figure F-15 for SIBERIA and F-12 for CHILD.

The IERT offers the following comments regarding this calibration procedure and the results and discussion presented.

1. The authors inappropriately use the phrase "error estimates" (lines 1123 and 1265) instead of "goodness-of-fit." In the former, a reader might assume that a rigorous uncertainty analysis was used, rather than simply force-fitting a model to data.
2. There is no discussion of the error of the DEM used and the error of the simulated longitudinal profiles. In the former case, the U.S. Geological Survey (U.S. Department of the Interior, National Mapping Division) reports that a "desirable" vertical root-mean-square error (RMSE) estimation for a 7.5-minute DEM is less than 7 m, but a maximum RMSE of 15 m is permitted. In Figures F-12 and F-15, the average difference between the observed longitudinal profiles derived from these DEMs and the simulations is about 5 m. As such, a statement should be included that the common range of uncertainty for the simulated longitudinal profiles is, at least, 5 to 15 m.
3. This "forced" calibration assumes that all parameters used to arrive at the result are appropriate for the hydrologic and geologic environment. In short, one could get the right answer, in this case some reasonable fit between model predictions and stream profile elevation, for the wrong reasons. This is further compounded if a model is forced to fit erroneous elevation data derived from a DEM, as is done here.

F.3.6 Forward Modeling

Using the existing topography, both SIBERIA and CHILD then were used to simulate the surface topography of the West Valley Site 10,000 years into the future. While the authors briefly summarize the simulation results, these written descriptions cannot be recognized or reconciled on the supporting figures (Figures F-20 and F-21). That is, these figures are indecipherable. The IERT takes great exception to the statement that gullies have advanced headwards (lines 1384, 1385, 1443), as all preliminary results presented thus far showed no such geomorphic response. Moreover, it seems very highly unlikely that the North Plateau

Waste Management Areas 1 and 3 will experience only 0.1 to 0.3 m of erosion in the next 10,000 years.

F.3.7 Uncertainty in Long-Term Model Performance

The results of all physically-based hydrologic and geomorphic models are subject to significant uncertainty, which can be assessed for simulating past events and for predicting future events. At least four types of uncertainty for simulating past events exist: (1) input uncertainty, which refers to dynamic input data such as rainfall, sediment loads, and land use and land cover, among others; (2) model structure uncertainty, which includes the imperfections in the model itself, data resolution, and numerical algorithms, among others; (3) parameter uncertainty, which refers to process-parameter values, commonly quantified in the governing equations; and (4) observational uncertainty, which refers to the observational data upon which the model simulation is compared and evaluated (e.g., Beven and Binely, 1992; Liu and Gupta, 2007) . All uncertainties commonly are assumed: (1) to be mutually independent, though this is not necessarily true; (2) to be assessable individually; and (3) to be additive with respect to model results. It is also assumed that the total uncertainty of the model's prediction can be quantified by analytic or stochastic means. Two additional types of uncertainty can emerge for predicting future events: (1) linkage uncertainty, which refers to changes in the numerical relations between the driving forces and model output, such as runoff, loads, and elevations, all of which can be attributed to variations in the internal or external characteristics of the watershed, i.e., changes in land management; and (2) future input uncertainty, which refers to the uncertainty of the magnitude, frequency, duration, and character of the model driving forces such as future weather patterns, hydrologic events, etc. The generalized-likelihood-uncertainty-estimation (GLUE) method is widely used in hydrologic uncertainty analyses, and is based on providing acceptable fits to observational data and stochastic model simulations that use traditional goodness-of-fit measures (Beven and Binley, 1992; Beven and Freer, 2001).

Model results presented herein using USLE, SWAT, WEPP, SIBERIA, and CHILD have not included a quantification of the uncertainty of simulations, either in the simulation of past events or in the prediction of future events, and no distinction has been made amongst the uncertainties related to the governing equations, the input parameters, or the model structure. Moreover, the use of SIBERIA and CHILD for future predictions results in additional uncertainty considerations, including changes in the relations between the driving forces and model output and the changes in future input parameters.

On the basis of previous discussions with DOE, and especially after the Oct. 10-11, 2007, Erosion Workshop attended by the Erosion Review Team, the IERT was expecting that all categories of uncertainty as discussed above for all models employed at the West Valley Site would be addressed, assessed, quantified, and evaluated. The IERT further anticipated that rigorous uncertainty analyses such as GLUE would be applied and strictly enforced. It was noted in the EPRG-1 that unaddressed or inadequate estimation of the uncertainty of model simulations obviously can lead to indefensible results.

An additional important point should be made here with regard to the uncertainty in predicting radionuclide exhumation and release due to surface erosion processes using a long-term erosion model. On the basis of the numerical construction of SIBERIA and CHILD, the sources of input and potential verification of model parameters, and the future hydrologic, geomorphic, and land-use forecasting to be employed, the IERT envisioned that the uncertainty bounds in predicting, at a given time in the future, the topography of the West Valley Demonstration Project, the location and dimensions of its stream channels and gullies, and the fluxes of water and sediment exiting the site are likely to be very large (several orders of magnitude). Thus, the prediction of radionuclide dose at a given downstream location at a given time in the future, based on a long-term erosion model simulation, also would be subject to this same uncertainty range.

No such uncertainty analysis was conducted. The authors offer the following statements.

> Probabilistic erosion estimates with uncertainty bounds, based on ensembles of model runs, are feasible in principle but would require additional computation and analysis time; this was considered beyond the scope of the present study. (1365-1366)

The IERT does not accept this conclusion. DOE has been made fully aware that the results of all models, especially the landscape evolution models, should be accompanied by a rigorous uncertainty analysis (PRDEIS, 2006).

F. 4 Concluding Statement for Appendix F

An Independent Expert Review Team was commissioned by NYSERDA to offer scientific opinion on the surface erosion assessments and modeling results as presented in the 2008 PDEIS prepared for the West Valley Site. Appendix F of this 2008 PDEIS provides the core of the erosion assessment and modeling. In addition to this document, the authors of this statement have three additional documents from which to draw information: (1) the Peer Review of the 2005 DEIS (PRDEIS, 2006), (2) the Peer Review of the "West Valley Erosion Workshop" (EPRG-1), and (3) the Peer Review of "Parameters Using the Deterministic Calibration of SIBERIA" (EPRG-2).

From the information presented, we offer the following scientific opinion on the surface erosion assessments and modeling results as presented to date.

1. On the basis of all empirical data currently available, the greatest at-a-point rates of surface erosion are due to advancing gullies. These erosional features are discrete in space and time and decimeters to meters in scale. More than 20 such gullies already have been identified at the West Valley Site, and their future headward growth and subsequent intersection with the buried wastes have already been postulated.
2. Short-term erosion rates determined using USLE, SEDIMOT II, CREAMS, and WEPP are not considered useful in the broad context of the present and future integrity of the West Valley Site. This conclusion is based on the following.

   a. There exists no onsite verification or validation of the hydrologic and geomorphic input parameters used in these models. The uncertainty of these predictions, therefore, could vary by orders of magnitude.
   b. None of these models is capable of predicting the development, growth, and upstream migration of and soil losses due to gullies, which already has been identified as a critical threat to the West Valley Site. The above models, therefore, provide no useful information to predict or mitigate these important such surface erosion processes.
3. The model simulation using SIBERIA from the initial post-glacial landscape to modern time has not adequately addressed, or presented in a scientifically defensible way, the long-term evolution of the West Valley Demonstration Project and nearby environs. No details have been provided as to how the initial, post-glacial landscape conditions were defined and represented within SIBERIA. Moreover, the surface erosion processes of Buttermilk Creek Valley since this glacial maximum were very complex, yet the model simulation does not appear to capture these complexities. Therefore, it is highly unlikely that the same model will adequately represent the evolution of the landscape over the next 10,000 years.
4. The concept of dominant discharge, the flow and sediment transport equations used in SIBERIA, and the treatment of distinctly different fluvial systems are fraught with assumptions and results that do not appear to be reasonable, dimensionally correct, or physically justifiable given the time and space scales over which they are applied. This lack of justification, in fact, extends to the definitions of all critically-important parameters used in SIBERIA.
5. The concept of channel initiation as used in SIBERIA appears to result in a stream channel network similar, if not identical, to the modern network, and a channel network system that displays no spatial variation over time (as noted previously). The conditions necessary to create new streams or gullies numerically, or for existing streams and gullies to extend headward, is still unknown, yet these same geomorphic processes clearly threaten the integrity of the buried nuclear waste at the West Valley Site. Most importantly, it appears that the calibration of the SIBERIA model using the existing (or modern) drainage network system precludes, negates, or greatly suppresses the development of an alternate network system. This may, along with the grid spacing, be a reason why the fluvial network systems appear "frozen" in time and space.
6. No discussion exists regarding the numerical schemes used in SIBERIA and how these schemes ultimately affect the hydrologic and geomorphic processes under consideration. This is especially important regarding grid spacing, time-steps, excessive erosion or deposition, and numerical stability.
7. The same criticisms offered on the SIBERIA model are equally warranted with the CHILD model. These include the following.
   a. The apparent disconnect between model parameterization and onsite hydrologic and geomorphic characteristics.
   b. The complete lack of verification of model components or comparisons with onsite field data, which results in *ad hoc* assignment of equation coefficients.

c. The oddly defined precipitation indices that, when coupled with an *ad hoc* infiltration capacity, appears to negate or severely reduce the likelihood of erosion due to concentrated overland flow.
d. The relatively coarse grids used, which by design precludes the creation of rills, gullies, and small drainage channels since these geomorphic features are dimensionally smaller than the grids employed.
e. No discussion exists regarding the numerical schemes used in CHILD and how these schemes ultimately affect the hydrologic and geomorphic processes under consideration.

8. The only calibration scheme used for the SIBERIA and CHILD models is through a "forced-fit" approach that minimized the difference between predicted and observed longitudinal profiles of select streams in select corridors. This approach does not consider the vertical uncertainties of the DEM used, which may be several meters, or the possibility of arriving at "the right answers for the wrong reasons."
9. The results from the forward modeling exercises using SIBERIA and CHILD, from modern time to 10,000 years in the future, are so briefly discussed and so poorly supported by graphical information that they have no credibility or utility in this assessment. Moreover, it seems very highly unlikely that the North Plateau Waste Management Areas 1 and 3 will experience only 0.1 to 0.3 m of erosion in the next 10,000 years.
10. All physically-based hydrologic and geomorphic models are subject to significant uncertainty, which includes uncertainties in model input, model structure, definition and inclusion of parameters (governing equations), and observational data. Future projections using the same models also include uncertainties for model linkages and input data. Any predictions made using any landscape evolution model with regard to future releases of radionuclides due to surface erosion processes are scientifically indefensible since no rigorous and comprehensive uncertainty analysis has been undertaken,. Moreover, the uncertainty bounds for predicting radionuclide dose based on such models are likely to be very large. Any decisions on decommissioning the West Valley Site should carefully consider these large uncertainty estimates.

APPENDIX G MODELS FOR LONG-TERM PERFORMANCE ASSESSMENT
APPENDIX H LONG-TERM PERFORMANCE ASSESSMENT RESULTS

G-H.1 Simple Gully Erosion Model

In Appendix G "Models for Long-term Performance Assessment" and Appendix H "Long-term Performance Assessment Results," the authors have introduced and used a simple gully erosion model (lines 1371-1379, Appendix G; lines 882-885 and 1058-1989, Appendix H). This model was introduced to establish an upper bound on the potential effects of unmitigated erosion under a loss of institutional control (lines 882-885, Appendix H). The following sections provide critical commentary with regard to the construction and use of this simple gully erosion model.

The authors recognize that the headward advance of gullies is the primary threat to the buried wastes at the West Valley Site. To examine this threat and to approximate the release time of these radioactive materials, the authors construct a simple gully erosion model using the following characteristics: it is triangular in shape, and it has an initial advance rate of 0.4 m/yr, a down-cutting rate of 0.058 m/yr, and stable sideslopes of 21º. Moreover, the time-variation of advance rate is quantified using a decay function for gully length (lines 1066-1077, Appendix H), which assumes that the gully migration rate decreases asymptotically with time. This decay rate requires the definition of a rate parameter *b* (in units 1/yr), which was approximated as 0.001 yr^{-1}.

Current gully erosion models treat each aspect of gully incision, migration, widening, and sediment flux as discrete processes that conform to physically-based governing equations driven by rates of overland flow. Some examples of these models include the Ephemeral Gully Erosion Model (Merkel, et al., 1988; USDA-SCS, 1992; Woodward, 1999) and the analytical formulations of Sidorchuk (1999) and Casali, et al. (2003). The model of Gordon, et al. (2007) represents the most physically-based and conceptually-appropriate gully erosion model to discuss here, and this model draws heavily upon the headcut erosion model of Alonso, et al. (2002). The critical components of the gully erosion model of Gordon, et al. (2007) are briefly described as follows.

For a given runoff event, a hydrograph can be constructed at the mouth or outlet of the field or small watershed under investigation, and flow rate at a given location within the field will be proportional to the upstream drainage area, depending on the length of the gully (Gordon, et al., 2007). Once the flow rate at the mouth of the field exceeds the erosion threshold of the soil (Foster, et al., 1982), incision is initiated in the form of a headcut (Bennett, et al., 2000b) that migrates upstream at a rate proportional to the flow rate and conditioned by the soil's erodibility and the hydraulics of the headcut brinkpoint (Alonso, et al., 2002). The depth of the gully, or the depth of headcut scour, also is proportional to the flow rate and conditioned by the soil's erodibility and the plunge pool scour hole (Alonso, et al., 2002). The width of the gully downstream of the headcut (Nachtergaele, et al., 2002; Torri, et al., 2006) and sediment transport (Bingner and Thereur, 2002), whether limited by sediment supply or flow capacity, also will be proportional to flow rate. The headcut migration rate, the gully width, and the rates of sediment entrainment, transport, and deposition all will vary accordingly in time and space since flow is unsteady and spatially varied.

The simple gully erosion model, as constructed here in Appendices G and H, is very crudely defined and not scientifically based. These conclusions are further discussed below.

1. The authors assume an initial rate of gully advance of 0.4 m/yr. As noted above, rates of gully headcut advance should be a function of overland flow rate conditioned by the soil's erodibility and the characteristics of the scour pool (Alonso, et al., 2002). Because of this dependency, gully headcut advance rates can vary widely. For example, Gordon, et al. (2008) modeled ephemeral gully advance rates in Belgium, Georgia, Mississippi, and Iowa, and these simulated rates could reach as much as 200 m per year. Nachtergaele, et al. (2002) reported gully advance rates in Belgium ranging from 8 to 23 m/yr. In rill erosion studies where headcuts

were observed, migration rates for these features are significantly higher, ranging from about 0.1 to 2.0 mm/s (or about 10^3 to 10^4 m/yr) depending on headcut height and flow rate (Bryan and Poesen, 1989; Bryan, 1990; Slattery and Bryan, 1992; Bennett, 1999; Bennett, et al., 2000b). Further justification is required to use an initial rate of 0.4 m/yr.

2. The authors do not recognize the role of seepage (exfiltration) on gully erosion initiation and upstream migration. Evidence of surface seepage processes at the West Valley Site is pervasive, and this exfiltration process has been shown to cause, catalyze, and significantly enhance headcut erosion and gully development in cohesive materials (Huang and Laflen, 1996; Fox, et al,. 2007). It is highly likely that rates of gully erosion at the West Valley Site would be greatly enhanced because of the pervasive seepage that occurs, yet such linkages have not been addressed herein.
3. The authors assume that the gully advance rate decreases asymptotically with time following a decay function (lines 1069-1078, Appendix H). This function requires the definition of the rate parameter *b*, which the authors report as $b = 0.001$ yr^{-1}. This rate parameter results in a half-life of gully extension *T* of 693 yr using $T = \ln 2/b$ (Nachtergaele, et al., 2002). This parameter represents the amount of time it takes the gully to erode half of the remaining gully length. Using those regional studies summarized by Nachtergaele, et al. (2002), *T* ranges from 1.3 yr for gullies in Colorado (Graf, 1977) and Belgium and 1.5 yr for gullies in Australia (Rutherford, et al., 1997). Yet the authors claim here that the gullies near the West Valley Site have a half-life of more than two orders of magnitude greater than those reported elsewhere, suggesting much lower (more attenuated) rates of gully head advance.
4. The down-cutting rate in the simple gully model is reported to be 0.058 m/yr (line 1063, Appendix H; see also Table 2 above), which appears to be based on rates of stream channel down-cutting rather than rates of gully down-cutting. Again, rates of gully incision should be determined by rates of concentrated flow entering these erosional channels conditioned by the soil's erodibility rather than rates of down-cutting observed in rivers and streams where such hydrodynamic incision processes may not be equivalent or transferrable.

G-H.2 Predictions Using the Simple Gully Erosion Model

The authors use these conceptualizations to predict the time it would take for a single gully emerging from Erdman Brook to intersect the NDA, assuming a down-cutting rate of 0.018 m/yr. On the basis of these distances, rates of advance and down-cutting, the asymptotic decay rate, and the assigned decay rate parameter, the authors predict that the top of the NDA wastes could be breached in 490 to 910 years, and the bottom of the NDA wastes could be breached in 955 to 2330 years (Table H-65). The following comments are offered with regard to this analysis.

1. The distances from Erdman Brook to the NDA are as follows: ~66 m to the northwestern side, and ~13 m from the northeastern side. In addition, the distances between the NDA gully and the NDA is ~25 m. Here, Figure F-5 and the designated

border of the NDA were used to determine these distances. Even adopting the very low and constant rate for gully advance of 0.4 m/yr, a gully intersecting the top of the NDA could occur within 33 to 165 years, or about one order of magnitude quicker in time compared to the estimates presented in Table H-65.

2. It is highly likely that gully advance rates could be significantly higher (orders of magnitude higher) than the 0.4 m/yr reported here, as suggested by such studies as Nachtergaele, et al. (2002) and Gordon, et al. (2008). These higher rates of advance would significantly reduce the time required for a single gully to breach the top of the NDA.

G-H.3 Concluding Statement for Appendices G and H Regarding the Simple Gully Erosion Model

The authors construct a simple gully erosion model in an attempt to quantify the environmental risk associated with the loss of institutional control and unmitigated erosion. It has been suggested that the initial breaching of the NDA based an advancing and down-cutting gully would occur within 490 to 910 years and continue into the future as the gully incises into the buried wastes.

It is the opinion of the IERT that this model is crudely constructed and not scientifically based. Current models of gully erosion treat each component of the gully erosion process explicitly, closely coupled to overland flow rates, the erodibility of the soil material, and the hydraulics of the scour hole. The rate of gully advance, its attenuation over time, and the rate of down-cutting are not coupled to these physical processes, and the rates used herein appear to be grossly underestimated. The estimated times for encroachment to and the breaching of the NDA, therefore, are also underestimated and are not scientifically defensible.

General Conclusion to the Erosion Assessment and Modeling

The most important aspect of the surface erosion assessment is the modeling of these processes and the future integrity of the buried wastes at the West Valley Site. It is the opinion of the IERT that while significant efforts have been made to model the various surface erosion components of the West Valley Site, the predictions from these models cannot be accepted or ratified at this time. Most importantly any predictions made using any gully erosion or landscape evolution model with regard to future radionuclide dose due to the surface erosion of the West Valley Site are scientifically indefensible. This opinion is based on the following assessment criteria.

1. A serious disconnect exists between model parameterization and the hydrologic and geomorphic characteristics of the site. This has resulted in dubious, highly questionable, and physically unjustifiable assumptions in the treatment and assignment of variables within these models.
2. No verification or validation of any models was presented in the context of comparing model output with actual field data.

3. Many of the model components, especially with regard to the gully erosion and landscape evolution, are unjustifiable and unsupported by scientific evidence.
4. No uncertainty in any model predictions was provided. The uncertainty in model predictions for the gully erosion and landscape evolution is expected to be very large (orders of magnitude) considering the conceptualization, construction, parameterization, discretization, application, and interpretation of the models involved.

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ENGINEERED BARRIER PERFORMANCE

Review Team
Chris G. Whipple (Lead)
Shlomo P. Neuman
Michael T. Ryan
Peter N. Swift
Michael P. Wilson

Three basic approaches to remediation of the Western New York Nuclear Service Center (WNYNSC) are analyzed in the 2008 PDEIS: a Sitewide Removal Alternative, a Sitewide Close-In-Place Alternative, and the No Action Alternative. The Close-In-Place alternative describes a closure plan that makes extensive use of engineered barriers; the barriers associated with this alternative are the focus of this report. These barriers are described below, including a description of the analytical assumptions used in the performance assessment as currently understood by the review team and our evaluation of these assumptions.

2008 PDEIS SOURCE MATERIAL REVIEWED

- Sitewide Close-In-Place Alternative Technical Report, Washington Safety Management Solutions LLC and URS, WSMSWV080004, Revision 0, June 2008 (since it is referred to repeatedly, this will subsequently be referred to as the Sitewide report)
- Chapter 2, Proposed Action, Alternatives, and Summary of Environmental Impacts, 4-22-2008 version
- Chapter 3, Affected Environment
- Chapter 4, Environmental Consequences
- Appendix C, Descriptions of Facilities/Areas, Implementation Activities, and Description of New Construction
- Appendix D, Overview of Performance Assessment Approach
- Appendix E, Geohydrological Analysis
- Appendix G, Models for Long-Term Performance Assessment
- Appendix H, Long-Term Performance Assessment Results

QUESTIONS TO BE ADDRESSED

- Is the performance analysis of the engineered barriers technically sound?
- Are the assumptions and bases for the properties and behavior of barriers over time reasonable?

OVERVIEW OF ENGINEERED BARRIERS IN THE CLOSE-IN-PLACE ALTERNATIVE

As described below in the discussion based on the defined waste management areas (WMA), the approach to protecting onsite waste by means of engineered barriers, defined in the Sitewide report, involves:

- grouting the tanks,
- cementing lagoon sediments,
- use of French drains and barrier walls up-gradient from or around the major waste areas,
- installation of engineered covers over the main waste areas,
- use of a reactive barrier wall down-gradient of the North Plateau Groundwater Plume, and
- application of mitigation measures to control erosion.

A map of the WMAs is included as Figure 1; as noted in the caption, it is taken directly from the Sitewide report.

WMA 1 – Main Plant Process Building and Vitrification Facility

The location and features of WMA 1 are discussed in Section 2.1 and displayed in Figure 2-1 of the Sitewide Close-In-Place report. The closure plan would use grout to fill tanks 35104, 7D-13, 15D-6, and the off-gas trench. [Note: these are comparatively small tanks; the large tanks are in WMA 3.] An engineered multi-layer cap would be installed to cover the main plant process building after it has been removed down to the floor slab. This cap would also cover much of WMA 3. A North Plateau double-barrier wall system and cap would be installed as indicated in Figure 2, also from the Sitewide report. The cap and barrier wall are discussed in more detail under WMA 3 below.

WMA 2 – LLW Treatment Facility Area (including lagoons)

The plan for in-place closure of WMA 2 is described in Section 2.2 of the Sitewide Close-In-Place report and is illustrated in Figure 3, taken from that report. The plan is to cement the sediments in lagoons 1, 2, and 3, and to install clean fill in lagoons 4 and 5. A soil-bentonite barrier wall would surround lagoon 1 "to divert groundwater around the portion of the lagoon that is below the groundwater table." Piping would be grouted in place.

Backfill would be placed on the cemented lagoons to raise the surface to match the slope selected for the cap. The cap would consist of a 3-foot thick compacted clay layer and a geosynthetic liner, a 60-mil low density polyethylene membrane as the primary infiltration barrier. At the edges of the cap, an anchor trench would be constructed where the liner would terminate. A 2-foot thick gravel drainage layer would drain to landfill cap perimeter. A 3-foot thick intruder barrier made of 3-inch diameter cobbles would be installed over the drainage layer to eliminate or mitigate burrowing animals from impacting the drainage layer or liner. If deemed necessary, a filter layer may be needed between the intruder barrier and the drainage layer to provide stability between the layers. Finally, an 18-inch vegetation layer would be installed to protect against erosion of the WMA 2 cap.

WMA 3 – Waste Tank Farm Area

The layout of WMA 3 is described and illustrated in the Sitewide report in Section 2.3 and in Figure 2-12 on page 33. Under the closure plan, tanks 8D-1 through 8D-4 would be isolated, emptied, dried, then grouted in place and covered by an engineered multi-layer cap that would also cover much of WMA 1. A barrier wall would also be installed as indicated in Figure 2. Waste tank pump storage vaults and piping would be grouted in place. Pumps would be removed for offsite disposal.

A barrier wall – referred to in the Sitewide report at the circumferential wall – would be constructed to surround the stabilized facilities in WMA 1 and WMA 3 to limit groundwater infiltration. A separate up-gradient low permeability soil/bentonite barrier wall would be constructed to redirect groundwater flow and prevent mounding against the circumferential wall. The circumferential barrier wall would include an up-gradient segment that is identical to the up-gradient barrier wall. The down-gradient portion of the wall would contain a sorbent selected to retard or capture certain migrating radionuclides. This down-gradient section would also be slightly more permeable than the up-gradient barrier walls to minimize the possibility of groundwater mounding within the circumferential barrier wall. The barrier/slurry walls would be keyed 2 to 3 feet into the unweathered Lavery till with the purpose of preventing seepage below the barriers. As discussed in the Groundwater Fate and Transport report from the IERT, this may be insufficient to prevent seepage into the waste enclosure under these structures.

A multi-layer cap would be constructed that would extend beyond the subsurface barrier walls. The cap would be approximately 13 feet thick and consist of the following 13 components, from top to bottom:

- Riprap – 2.5 feet thick, to provide erosion protection and function as a bio-intrusion barrier;
- Rock Filter/Bedding – 1.25 feet thick, to function as bedding to riprap and filter to underlying layers and provide additional erosion protection;
- Coarse Sand Filter – 6 inches thick, serves as a granular filter to prevent degradation of underlying loam layer;
- Compacted Loam – 2-foot thick sandy clay soil, to provide water storage and freeze/thaw protection;
- Coarse Sand Filter – 6 inches thick, to prevent clogging of underlying drainage layer;
- Gravel Drainage Layer – 1-foot thick, to serve as the primary drain for removing water that percolates into the cap;
- Geotextile – marginal thickness, to protect the underlying geomembrane from puncture and excessive wear from drainage gravel;
- Geomembrane Liner – 40 to 60 mil, serves as infiltration barrier in the short term;

- Bentonite/Additive Mixture – 2-foot thick bentonite sand mixture, functions as a low permeability barrier layer in the long term;
- Sandy Clay Loam – 1-foot thick compacted layer, to provide structural support for bentonite layer and function as secondary water storage and freeze/thaw protection;
- Geocomposite – marginal thickness, serves as a leak detection layer in the short term;
- Geomembrane Liner – same as above, functions as secondary infiltration barrier; and
- Compacted Clay – 1.5 feet thick to provide a foundation and structural support, in addition to redundant infiltration protection.

WMA 4 – Construction and Demolition Debris Landfill, WMA 5 – Waste Storage Area, and WMA 6 – Central Project Premises Area

No engineered barriers are planned beyond backfilling and filling with rubble.

WMA 7 – NRC Licensed Disposal Area (NDA) and Associated Facilities and WMA 8 – State Licensed Disposal Area (SDA) and Associated Facilities

The NDA and SDA are described together because the approach to these areas is similar. The plan is for the trenches and disposal holes in the NDA and SDA trenches to be grouted, covered with geomembrane caps, and surrounded by slurry walls. Figures 4 and 5 illustrate the closure plan.

A facility would be constructed to treat leachate from the NDA and SDA, and it would be designed to remove organic chemicals, remove solids by filtration, and remove dissolved radionuclides by ion exchange. The "cleaned" leachate will still contain tritium, because an ion exchange process cannot remove tritium present as tritiated water. A Resource Conservation and Recovery Act (RCRA) permit may be required for operation and for disposal of the discharge from the leachate treatment facility. The conceptual design involves processing about 1,000 gallons per day.

Grout would be pumped into the trenches and holes to stabilize the waste and to prevent subsidence under the caps. This would be a considerable undertaking. The Sitewide report uses inconsistent units to describe what is needed, and indicates that for the NDA an area of 27,100 ft^2 would be grouted. In the SDA, the estimate is that 1.4 million ft^3 of grout would be required.

The closure caps placed over the NDA and SDA would be of a design identical to the cap planned for WMA 1 and WMA 3 on the North Plateau, described above.

WMA 9 – Radwaste Treatment System Drum Cell Area, **WMA 10 – Support and** Services Area, **WMA 11** – Bulk Storage Warehouse and Hydrofracture Test Well Area, **WMA 12 – Balance of Site and Cesium Prong**

No engineered barriers are planned for these areas.

NORTH PLATEAU PLUME

The Sitewide report indicates that the North Plateau Groundwater Plume will be addressed by isolating the plume source area from the down-gradient portions of the plume through the installation of the barrier walls and engineered cover for WMA 1 and WMA 3. The downstream area of the plume would be mitigated through the use of a permeable treatment wall. This system would be installed near the leading edge of the plume and a smaller seepage face permeable reactive barrier would be installed at the seepage face of the plume within the swamp ditch. The permeable treatment wall wing sections are intended to control groundwater from flowing around the ends of the primary treatment wall, which would be orientated perpendicular to the direction of groundwater flow. The wall would be approximately 250 feet in length, two to three feet thick and 25 feet deep. The permeable treatment wall would be replaced at an unspecified future time, and following such replacement it is thought that there would be no need for additional groundwater management.

EROSION CONTROLS

The conceptual long-term erosion control plan is illustrated in Figure 6. This erosion control concept includes:

- Diversion berms and ditches;
- Water control structures; and
- Streambed armoring.

The primary purpose of installing diversion berms is to control runoff on the North and South Plateaus, and direct the flow to the areas that are appropriately protected against erosion. Diversion berms are intended to mitigate the free flow of runoff over the edge of the plateaus in unprotected areas. The diversion berms running along the top of the Quarry Creek and Franks Creek banks would direct flow to Water Control Structure 1 (WCS1) and WCS2 indicated in Figure 6.

The diversion berms running along the top of the Erdman Brook banks would direct flow to either WCS3, or on the South Plateau, WCS4 and WCS5. The primary diversion berms on site would likely be constructed entirely of imported fine-grained soils to prevent infiltration, with imported stone and riprap layers to achieve long-term resistance to erosion.

The size and extent of the diversion berms are based on the extent of the probable maximum flood. To minimize long-term erosion of the berms they would be constructed using rock armoring, similar in composition to the water control structures. Beneath the armoring, the primary diversion berm would be constructed of compacted silty clay soil. The armoring would then consist of coarse sand (to serve as a filter layer to create stability between the soil and the rock layers), a layer of rock bedding, and finally a layer of riprap rock.

Water control structures would be installed at locations selected based on the current preferential flow to these areas. The general locations where water control structures would be installed are the NP1 Gully, NP2 Gully, Lagoon Creek Gully, SDA Gully, and (possibly) the NDA Gully (see Figure 6).

The water control structures would be designed and constructed to respond to common storm flows and the PMF flows in two different ways. The common storm flows (up to and including the 100-year rainfall runoff) would be transmitted from the plateau surface down to the creek bottom within a concrete pipe. Concrete fill would be poured around the piping to promote long-term durability, and the inlet structure, as well, would be constructed of cast-in-place reinforced concrete. Storms exceeding the 100-year recurrence would cause significant ponding behind the diversion berms and above the concrete inlet structure. At approximately 2 feet of depth, the ponded water would begin to spill over a broad-crested weir, and would flow down an armor protected overflow spillway. Both the spillway and the pipe discharges would be protected using discharge aprons. These structures would be reinforced with riprap rock armoring following the guidance of NUREG 1623.

EVALUATION OF ENGINEERED BARRIERS

The first question we ask regarding the engineered barriers is "Is the performance analysis of the engineered barriers technically sound?"

To answer this question requires that the details of the barrier design be clearly specified, which is not the case. The review team found it difficult to understand several aspects of how the engineered barriers would be constructed. It was also not clear how the performance of the barriers was modeled. In particular, nothing is said about the design of the permeable groundwater plume treatment wall or the basis for the assumption that, with one replacement at an unidentified future time presumably within the period of institutional control, it will be effective in remediating the strontium 90 laden groundwater.

Tables of engineered barrier properties, including hydraulic conductivity estimates for caps and slurry walls, were provided, but the time periods for which these properties were assumed to hold were unclear, as were the properties of the barriers at some future time. An email provided additional information about the assumptions regarding the hydraulic conductivity of various barriers versus time. It is our understanding, subject to correction by the project team, that the conductivity of all the barriers except the high strength grout used to fill the tanks undergoes a step increase at 100 years, but that beyond 100 years no further changes are assumed. The initial conductivity of the cap is down in the range of 10^{-13} cm/sec due to the geomembrane liner. For the caps, no credit is taken for the geomembrane after 100 years, but the low conductivity bentonite/additive layer, with an assumed conductivity of 5×10^{-9} is projected to persist indefinitely. The up-gradient wall around the North Plateau has a hydraulic conductivity of less than 10^{-8} cm/sec. The rest of the WMA 1 and WMA 3 slurry walls and the up-gradient wall for the NDA have conductivities of less than 10^{-7} cm/sec. As with the caps, the conductivity of the slurry walls increases from below 10^{-8} cm/s to 10^{-6} cm/s at 100 years. The conductivity of the grout in the tanks increases from 5 x 10-6 cm/s to 1 x 10-5 cm/s after 500 years. As noted above, the analysis of the potential efficiency of the barrier/slurry wall design (i.e., that it will be keyed 2 – 3 feet into the ULT) is not described in sufficient detail to allow review. A technical basis for statements concerning what the walls and French drains would do to groundwater flow is not provided.

A subsequent email appeared to contradict some information in the first regarding the hydraulic conductivity of the slurry walls as a function of time. The first email said:

> "For the up-gradient slurry walls, the design value of hydraulic conductivity of less than 1 x 10^{-8} cm/s is increased to 1 x 10^{-6} cm/s after 100 years and is assumed to remain at this level for the period of analysis."

However, the second email had a different answer:

> "Because the technical basis for prediction of rates of degradation of these engineered barriers is difficult to develop and subject to controversy, the DEIS estimates of human health impacts for groundwater release scenarios assumed degraded conditions for the slurry walls, caps and grout immediately after placement. Thus degraded conditions for these subsurface features are referred to time of zero years."

In addition to parameter values, the conceptual models for how radionuclides are transported from site areas protected by barriers were not clearly described. In some instances, we compared the calculated dose rates from Appendix H, and compared results for the Close-In-Place alternative with the No Action alternative to see what effect the installations of barriers had on performance. For example, a footnote in Table H-21 reads:

> The predicted peak TEDE from the North Plateau Groundwater Plume is slightly less for the No Action Alternative than for the Sitewide Close-In-Place Alternative because mitigating features in the latter case slightly reduce the rate of groundwater flow to Cattaraugus Creek, thus resulting in slightly greater predicted concentration of radionuclides.

This quote describes the results of a dose rate calculation in which institutional controls are presumed to endure indefinitely. Because the time to peak dose from the plume is 100 years for both alternatives, the assumed presence of institutional controls is reasonable. But it is not clear why higher doses are estimated under the Close-In-Place Alternative with engineered barriers than under the No Action Alternative. One possible inference we drew from this footnote was that the groundwater flow used for the North Plateau plume is based on an assumption of constant contaminant flux. Why this would be the case is not explained, and this model choice results in a calculation that installing barriers to prevent recharge of the plume source area and a down-gradient reactive barrier wall do not restrict the movement of strontium. If these assumptions are correct, it is unclear why such engineered barriers would ever be used. We do not find the assumption of constant contaminant flux, independent of the water flow, to be credible. An alternative inference was that the 100-year time step of the model lacked resolution for this source and receptor, and for the No Action (and no barrier) case, the peak dose occurred before 100 years. The dose for the Close-In-Place scenario occurred later and was therefore calculated to be higher. These interpretations are speculative but reflect the lack of clarity and transparency of the DEIS.

An assumption that needs to be examined in more detail is that the barriers on the North Plateau would not experience damage due to erosion. The technical basis for this result is unclear, and if one does not credit the maintenance of erosion mitigation features beyond a few hundred years, this assumption is not likely to be valid. The assumption that the South Plateau barriers are vulnerable to erosion damage is credible.

The erosion mitigation measures seem to be focused at controlling surface runoff during extreme storm events, e.g., the 100-year rainfall. However, erosion by headcuts would not be mitigated by the specified measures. Erosion by headcuts is a major problem for gully and stream stabilization in southwestern New York. Both ephemeral and long-lasting headcuts are apparent throughout the West Valley nuclear site itself. Plans for the future treatment of headcuts do not extend far enough downstream in the Frank's-Buttermilk system. For example, if Springville Dam on Cattaraugus Creek is removed, a 5 or 10 meter headcut can be expected to move up the system. More importantly, the convex-up longitudinal profile of Frank's Creek and other existing gullies provide energy for headcuts.

The planned approach to stabilization is basically one of water diversion, gully-wall slope grading, and use of rip-rap. Headcuts will attack all of these features, as headcuts currently do throughout the region. Use of rip rap for stream stabilization has typically failed in this region for periods of more than a few years or decades. In southwestern New York, well-placed, large rip-rap has been lifted by relatively small flows within a year of placement. The future plans for new construction do not address headcut migration into the diversion-outfalls.

Plans for the future do not adequately address initiation of new gullies. Planned diversion of surface waters should be helpful. But will diversions enhance sapping or headcuts elsewhere (a topic not addressed in the 2008-PDEIS)? There should be well designed contingencies to mitigate gully heads from the outset. What will be done?

The plans for grading gully-wall slopes are very inadequate. Plans call for grading slopes such as 3-horizontal to 1-vertical (approximately 21°) and 2-horizontal to 1-vertical and steeper. The concept of slope stability has been misunderstood; these slopes are too steep. Many drafts of the EIS (1996, 2005, 2008) or their underlying reports have referred to 21-degrees as "stable," but not as being maintained by the dynamic processes of translating tree-blocks, rotating landslides, creep, etc. These processes are in dynamic equilibrium with gully down-cutting. Slope and stream rates are mutually adjusted, but the slopes are unstable. Unwittingly, plans require design slopes at factors of safety of less than one.

Perhaps the ultimate problem is that the PDEIS-2008 and its underlying documents do not include an analysis of performance history of erosion or slope controls in southwestern New

York. Generally speaking, erosion controls are designed for only a few decades, often less.[2] Major renovations to control structures are often needed within a few years. Designer experience is limited to the short term. For the time scales of concern and interest on the West Valley site, and for the case in which the institutional memory necessary to maintain erosion barriers cannot be assumed, there is no basis to think that the proposed erosion mitigation measures will work.

An observation: for the Sitewide removal approach, most of the wastes would end up in a covered containment cell much like those planned for the Close-In-Place option, in which multi-layer covers would be the primary barrier to water that would otherwise enter the waste and transport it to receptor locations. Some of the issues above such as future institutional controls and nearby receptors will be the same at offsite waste disposal sites as at West Valley. The one significant difference in the West Valley site setting is the potential for erosion. It seems likely that erosion will be the decisive issue regarding the acceptability of a closure plan based on engineered barriers.

The second question asked of the engineered barriers groups was "Are the assumptions and bases for the properties and behavior of barriers over time reasonable?"

This question is difficult to answer in part because it is unclear how the assessment was done. For example, it is reported in the 2008 PDEIS that the high strength grout used to fill the tanks will maintain low conductivity for 500 years. Given that the waste in the tanks is initially mostly cesium and strontium, a 500-year delay would allow most the activity to decay, from several hundred thousand curies to several hundred. After 300 years, about half the activity in the tanks is from Cs-137 and Sr-90; but after 500 years these isotopes only contribute a few percent. At 500 years, the dominant radionuclides are Am-241, Pu-239, and Pu-240. These are not generally considered to be mobile in the environment; a small amount of the mobile Tc-99, about 12 curies, would also be present. But in response to an email request for clarification of what parameter values were used in the analysis, we were told, in reference to the caps that would be constructed over WMAs 1 and 3 and on the

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[2] Nunnally, Nelson, R. 1978. Stream renovation – an alternative to channelization, Environmental Management, v.2., No. 5, pp. 403-411.
Nunnally, N.R., and E.A. Keller. 1979. Use of fluvial processes to minimize adverse effects of stream channelization: Water Resources Research Institute of the University of North Carolina, Report No. 144, 115pp.
NYS Soil and Water Conservation Committee. 2005. New York State Standards and Specifications for Erosion and Sediment Control. For the NYS Dept. of Environmental Conservation, Division of Water. Previously: New York Guidelines for urban erosion and sediment control. 1991. Empire State Soil and Water Conservation Society, Syracuse, NY.
Simon, A., M. Doyle, M. Kandolf, F.D. Shields, Jr., B. Rhoads, and M. McPhillips. 2007. Critical evaluation of how the Rosgen Classification and associated "Natural Channel Design" methods fail to integrate and quantify fluvial processes and channel response: Journal of the American Water Resources Association, Vol. 43, No. 5, p. 1117-1131.
Thigpen, Janet. 2006. Stream Processes: Chemung County Soil and Water Conservation District, 851 Chemung St., Horseheads, NY 14845.
Wilson, M.P. 1983. Erosion of banks along piedmont urban streams: Water Resources Research Institute of the University of North Carolina, Report No. 189, 32pp.

South Plateau, that "The 500-year strong grout at the top of the tanks is then a redundant feature whose capability is not needed in the current approach to analysis."

Concerning the behavior of barriers over time, page D-8 includes the comment:

> Consistent with regulatory guidance (NRC 2000), hydraulic property values of barriers subject to degradation mechanisms, such as subsidence, cracking, or clogging, were assumed to degrade over time. Chemical properties, such as adsorptive capacity, were assumed to remain constant consistent with past practice (Kennedy and Strenge 1992, Yu, et al., 1993).

The comment regarding chemical properties is repeated on page D-11 but with an added qualifier:

> Chemical properties of natural materials, such as adsorptive capacity, are, however, not expected to decrease with time, consistent with the long lifetimes observed for sand and clay formations in the environment (NRC 2000).

The first quote makes no distinction between natural materials and engineered materials; the second quote does. This distinction may be important for materials such as grout that degrade with time.

A related issue is the selection of distribution coefficients (that is, K_ds) used in waste transport calculations. The values used in the analysis are reported in Table H-20 for flow through an aquifer, concrete, and controlled low strength material (CLSM). CLSM would be used under the Close-In-Place Alternative for the tank area. For technetium, the K_d value is reported as 0.1 mL/g for aquifer flow and 1 for concrete and CLSM. For iodine, a K_d of 1 mL/g is assumed for all three media. Similarly, Table H-20 reports a K_d value of 1 for hydrogen (tritium) in concrete and CLSM. Given that tritium is likely to be present as tritiated water, the basis for believing that tritium would be retarded is not explained. If it is assumed that tritium would exchange with nonradioactive hydrogen in the concrete, a reference should be provided.

The use of K_ds greater than zero for these three radionuclides, especially for concrete and CLSM, is questionable. At other DOE sites such as Yucca Mountain, technetium is usually assumed to flow without retardation in the vadose zone. A review of such parameters at the Hanford site[3] includes the following comment:

> Dissolved technetium is present in oxic environmental systems as the aqueous Tc(VII) oxyanion species TcO_4^-. Technetium(VII) is essentially

[3] Geochemical Factors Affecting the Behavior of Antimony, Cobalt, Europium, Technetium, and Uranium in Vadose Sediments, K. M. Krupka, R. J. Serne, PNNL-14126, December 2002.

> nonadsorptive (i.e., K_d values are ≈ 0 ml/g), highly soluble, and thus highly mobile under oxic conditions at neutral and basic pH values.

Given that concrete typically has a high pH, the conditions cited in this PNNL report are likely to apply. The Yucca Mountain project has avoided the use of concrete in the repository design because high pH conditions tend to increase the solubility and mobility of several radionuclides.

Table H-64 indicates the sensitivity of the estimated dose rate to an onsite resident farmer to the K_d for technetium. The table indicates that the estimated dose and the time to peak dose are highly sensitive to the K_d. For a K_d of 0.1, the estimated peak dose rate from all radionuclides is 883 mrem/yr, and this occurs 28 years after closure. For a K_d of 1 mL/g, the peak dose rate is 242 mrem/yr at 116 years after closure. A calculation is also made for a technetium K_d of 7.4; this results in a peak dose rate of 114 mrem/yr at 1,200 years. It would be interesting to know what the calculation would indicate for a technetium K_d of zero.

The text in Section H.3.4 that discusses Table H-64 (page H-62) incorrectly identifies the K_d units as millimeters per gram; it should be milliliters per gram. This section includes the comment:

> Grouts designed for stabilization of the tanks include fly ash material that is expected to reduce the valence state of technetium producing a precipitate with low solubility as well as sorbents designed to retain radionuclides by physical and chemical bonding.

No reference regarding the effect of fly ash on technetium chemistry is provided, nor is any instance cited where sorbents added to concrete have been shown to retain technetium.

This text also indicates that the basis for the K_d values in Table H-20 is a 1990 literature review of K_ds of radionuclides in four different types of soil.[4] None of these soils reflect high pH conditions likely for grout. Depending on the specific radionuclide, the K_d estimate comes either from experimental data, largely from column tests, or concentration ratios for plant-to-soil concentrations. All of the technetium estimates are based on experimental data. Table 1 of this paper is the basis for the estimates in Table H-20 of the DEIS. In the original paper, these values are described as geometric means. The data on which these estimates are based are listed in Tables A-1 through A-4 of the reference. The range of results indicates the difficulty in measuring K_ds near zero. For sandy soil, the mean of the natural log of the K_d is reported as -2. For loam, the mean of the natural log is -2.3. With some noise in the test system, the mean value estimates of 0.1 and 1 may have much to do with the lower measurement limits of the test system than with the actual K_d of technetium. And since K_ds cannot be less than zero, any variability in the measurements will lead to geometric means that are greater than zero.

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[4] Default Soil Solid/Liquid Partition Coefficients, *K_ds,* for Four Major Soil Types: A Compendium, Marsha I. Sheppard and D. H. Thibault, Health Physics, Vol. 59, No. 4 (October), pp. 471-482, 1990.

Unless more substantive support can be offered for the K_ds used for the mobile radionuclides (technetium, iodine, and tritium) and for the assertion that fly ash will limit technetium solubility in concrete, K_ds should be conservatively assumed to be zero for these materials. The potential for high pH conditions to result in greater than assumed mobility for other radionuclides should also be evaluated.

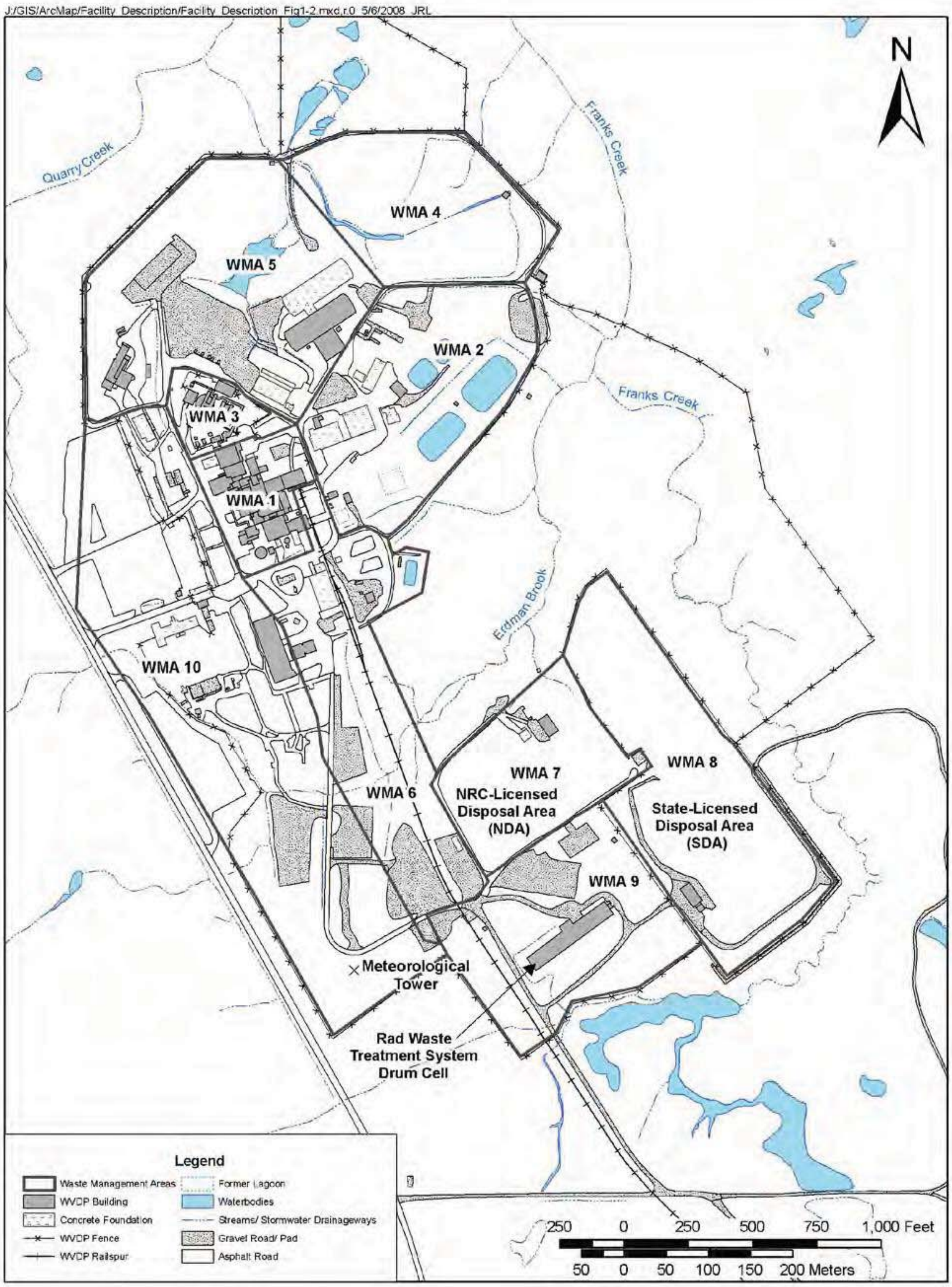

Figure 1 (Figure 1-2 in Sitewide report) Location of Waste Management Areas 1 through 10

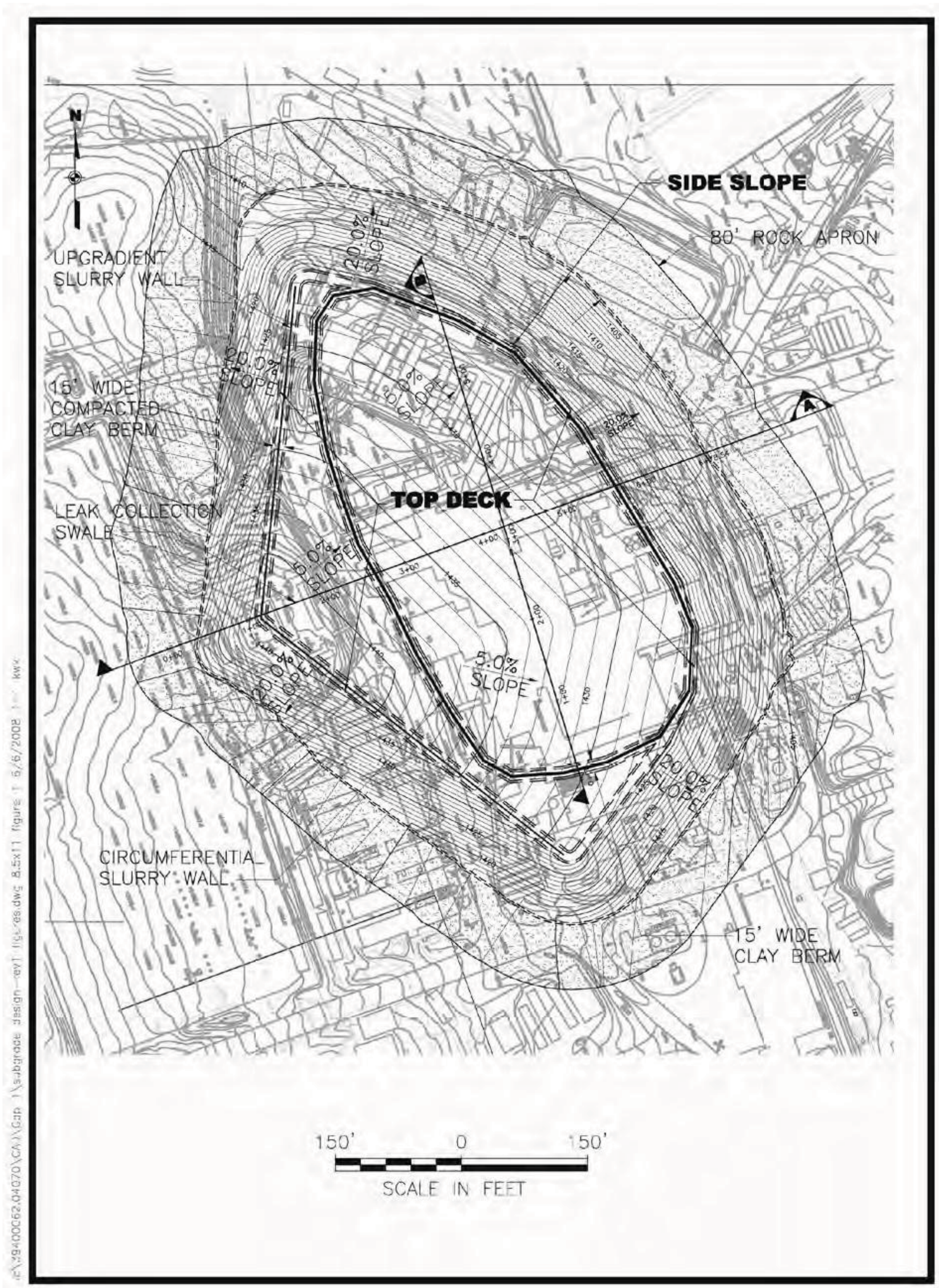

Figure 2 (Figure 2-15 in Sitewide report) North Plateau Cap and Barrier Walls

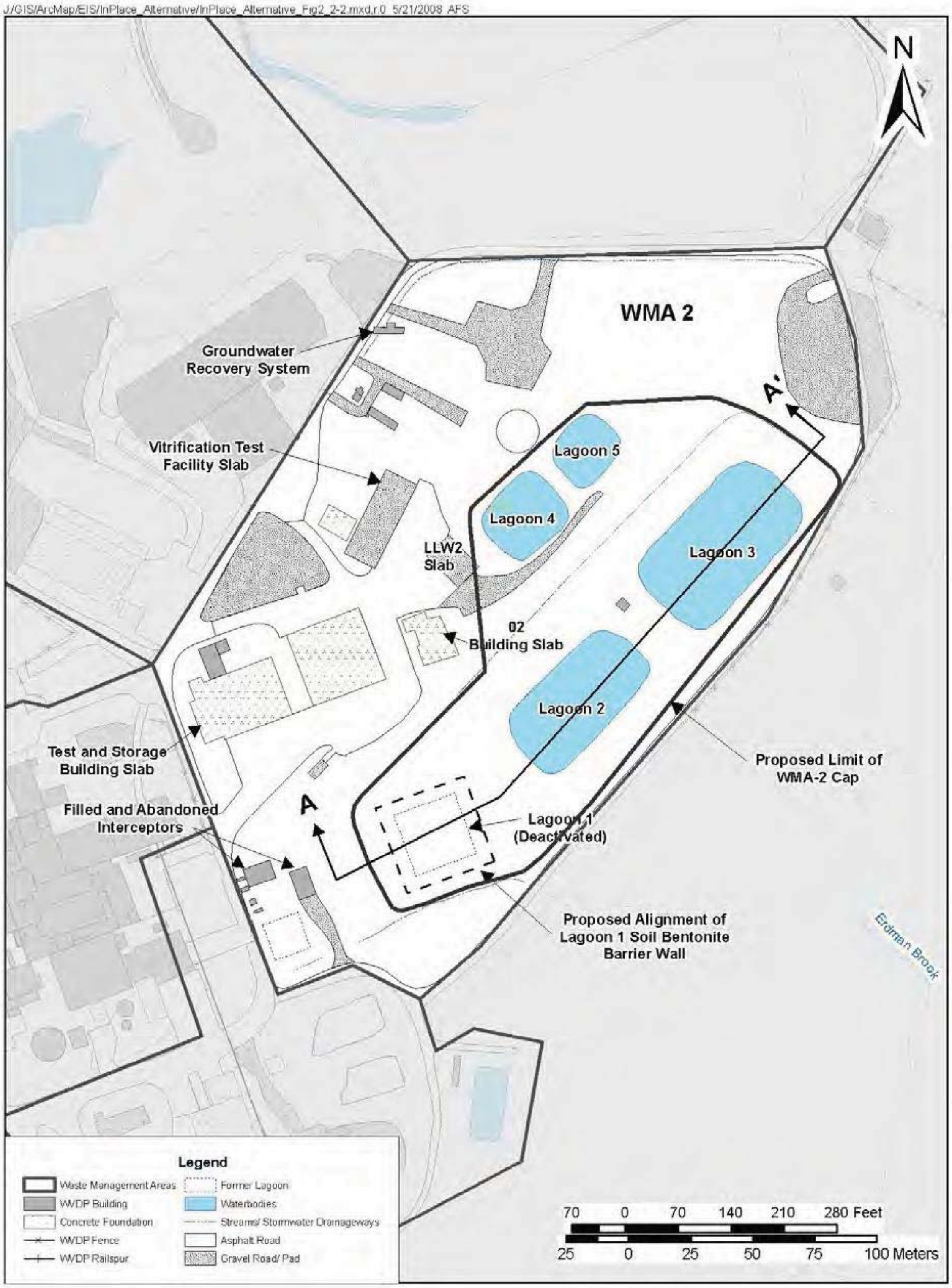

Figure 3 (Figure 2-10 in Sitewide report) WMA 2 Cap and Barrier Wall

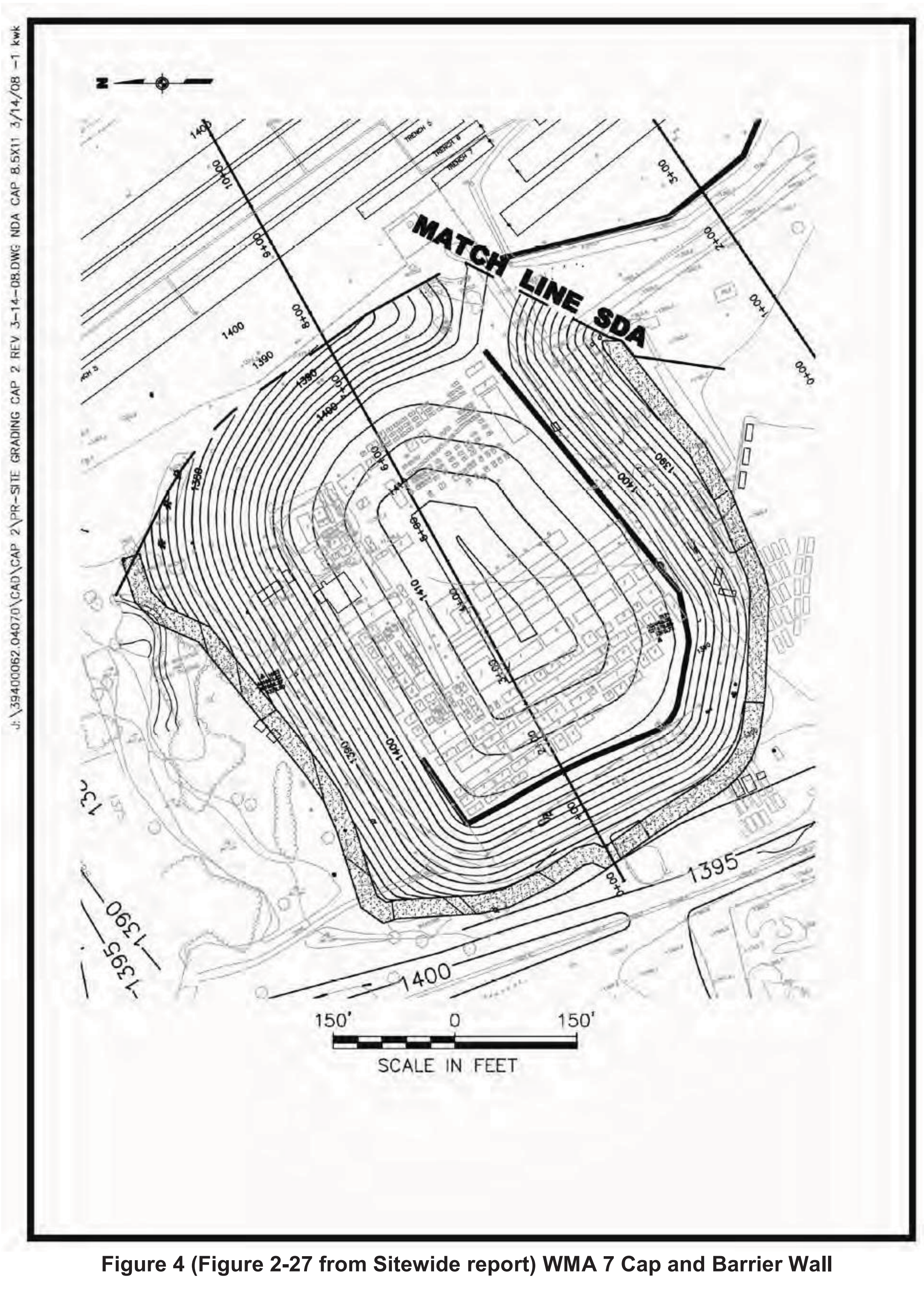

Figure 4 (Figure 2-27 from Sitewide report) WMA 7 Cap and Barrier Wall

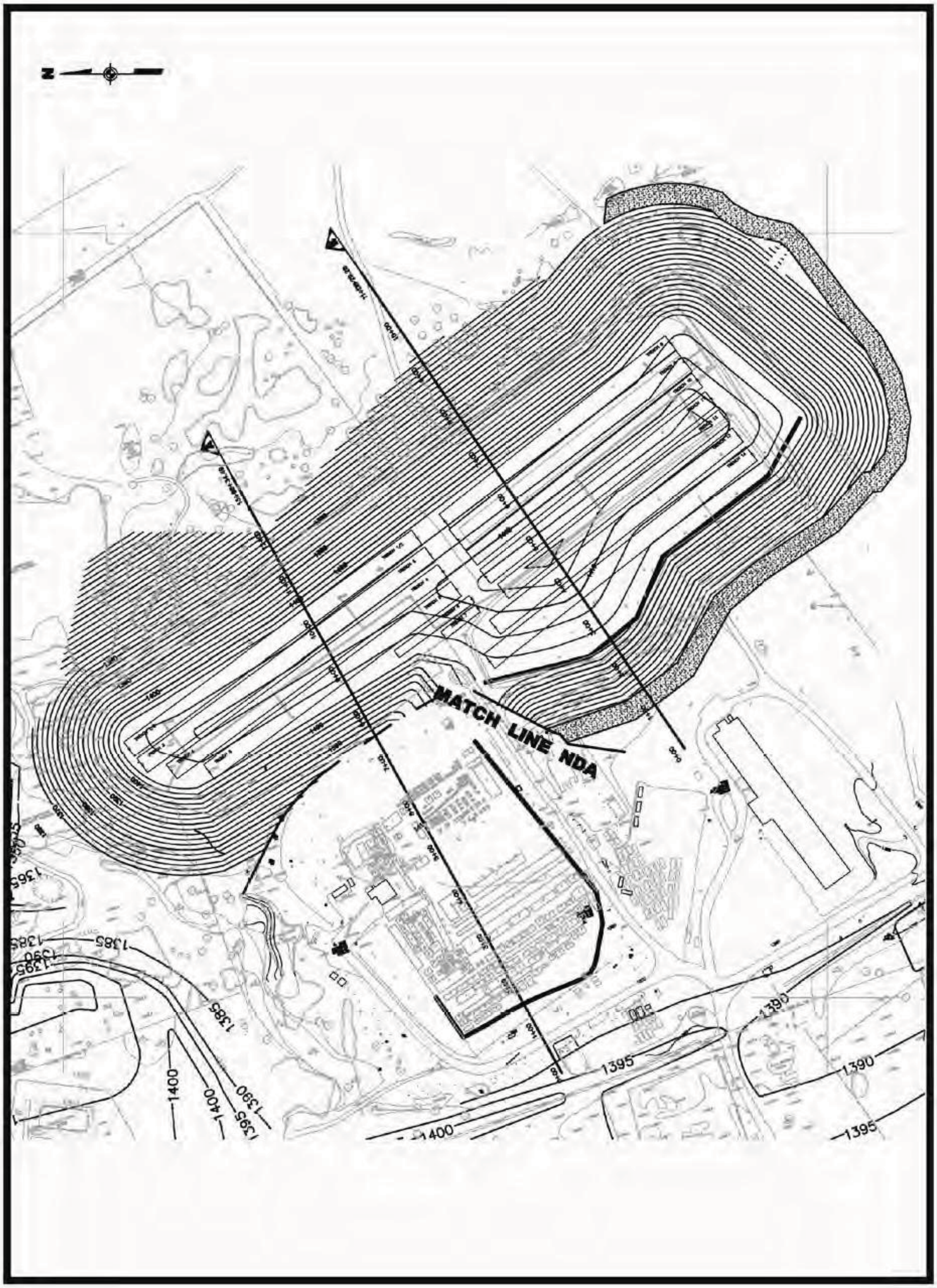

Figure 5 (Figure 2-30 from Sitewide report) WMA 8 Cap and Barrier Wall

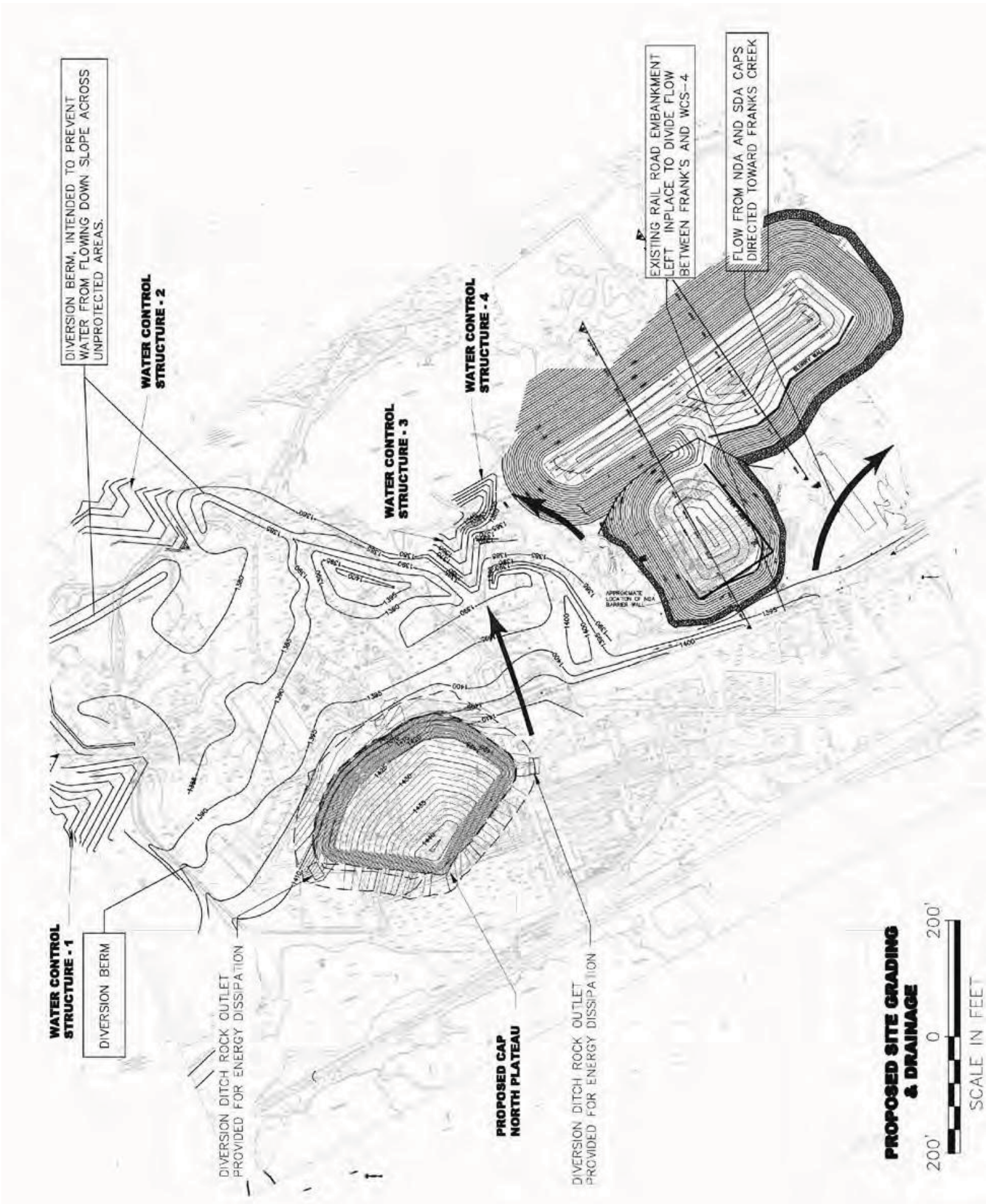

Figure 6 (Figure 2-36 from Sitewide report) Conceptual Plan for Sitewide Erosion Controls

INVENTORY AND SOURCE TERM

Review Team
Michael T. Ryan (Lead)
Jimmy T. Bell
Frank L. Parker
Chris G. Whipple

2008 PDEIS SOURCE MATERIAL REVIEWED

- Appendix C, Existing Facilities, Implementation of Decommissioning and New Construction
- Revised Inventory Estimates for the HLW Tank Farm
- Revised Inventory Estimate for the Main Plant Process Building and Vitrification Facility
- SDA Radiological Inventory Report
- SDA Hazardous Chemical Inventory Report
- NDA Radiological Inventory Report
- NDA Hazardous Chemical Inventory Report

REVIEW BY MICHAEL T. RYAN

This report addresses radioactive inventories for four main areas of the West Valley Demonstration Project (WVDP): (1) the WMA-8 area (SDA), (2) the WMA-7 area (NDA), (3) the WMA-3 area (HLW tanks), and (4) the WMA-1 area (Main plant and vitrification facilities). The radionuclide inventories for the NDA and SDA have been previously examined and are summarized below presenting information provided by Dr. Michael T. Ryan, with revisions by Dr. Frank L. Parker. The HLW tanks inventory is given in the 2008 PDEIS, Appendix C, Table C-8. Additional information and comments are given by Dr. Jimmy T. Bell and Dr. Chris G. Whipple.

The radioactive materials inventories for both the NDA and the SDA have been extensively characterized. The best summary and critical analyses of these characterizations are provided in two reports.[5,6] These two reports provide the best available summaries on these inventories by making fundamental analyses of as much raw data as is available. The section below covering the NDA and SDA provides excerpts from the SDA and NDA reports.

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[5] Estimated Radionuclide Inventory for the NRC-Licensed Disposal Area at the West Valley Demonstration Project, prepared by Ralph E. Wild, URS/Dames and Moore; prepared for West Valley Nuclear Services Company, Inc. August 2000.
[6] SDA Radiological Characterization Report, prepared by Ralph E. Wild, URS Corporation; prepared for West Valley Nuclear Services Company, Inc. September 20, 2002.

This summary provides excerpts, summaries, and key assumptions that have been made to estimate the radiological inventories, characteristics, and uncertainties of wastes disposed in both the NDA and SDA where appropriate. These insights could provide the basis for future analysis of the disposed inventory.

Summary of the NDA Report

The following summary is designed to provide information regarding the inventories of radioactive materials with an assessment of the uncertainties that exist in the source data and assumptions made in estimating these inventories.

The authors of the NDA report reported key improvements over previous estimates. The key improvements that were reported include application of the same methodology to all wastes, whether generated and disposed of by Nuclear Fuel Services or by WVDP. The report considered the radionuclide inventories and physical characteristics of fuel assemblies received for reprocessing as reported in "Characterization of Reactors Fuel Reprocessed at West Valley" (WVNS, 1992) as the basis for radionuclide distributions used to characterize Category 1 and Category 2 wastes. Dose-to-curie conversion factors were used to obtain radionuclide activities of Category 2 wastes at the time of disposal. 10 CFR 61 waste classification calculations to individual waste burials of Category 1 and Category 2 waste were also developed.

Investigation of the sensitivity of waste classification calculations to assumptions regarding radionuclide distributions was also performed. A further note in the report provides a caution regarding waste classification:

> "It is important to distinguish between the Part 61 classification of 'in place' NDA waste as estimated in this report and the classification of any materials that may be exhumed. Although radioactive decay and ingrowth has been taken into account, classification of 'in-place' waste assumes that the waste still retains its original physical form. In reality, much of the waste, especially Category 2 wastes not buried in steel containers, is likely to have begun to decompose and some of the radioactivity such waste contained has transferred to soil used as backfill in the burial holes and trenches. As a result, the volume of contaminated material exhumed could be greater that the volume of original waste. Depending on how waste might be exhumed, treated or solidified and repackaged, it is likely that the classification of exhumed materials would shift towards lower classifications once in a form suitable for transportation to and disposal at another facility." The NDA report provides two key tables in the executive summary (S-1 and S-2) that provide respectively estimates of the volume and radioactive material content for categories of waste classified using the 10 CFR 61 classification system. These tables are reproduced below.

Table S-1 Activity of "In-Place" NDA Waste by 10 CFR Part 61 Classification on January 1, 2000

	Activity (Ci)				
EIS Waste Category	A	B	C	GTCC	Total
Fuel	0	0	0	12,316	12,316
Hardware	0.065	0	0.002	196,838	196,838
Ion Exchange	9.43	3.74	84.7	10,469	10,567
Degraded Solvent	0	0	73.2	3,137	3,210
Air Filters	0.409	0	56.4	1,918	1,975
Failed Equipment	7.98	4.70	70.3	24,918	25,001
Compacted Trash	0.100	0	5.38	850	855
Non-Compacted Trash	1.50	1.14	0.692	281	284
Soil	10.1	533	42.9	0	586
General Waste	12.3	6.37	219	6,963	7,201
Combination	13.3	0	9.23	39,489	39,511
Special	7.75	0	0	0	7.75
Debris	3.57	1.28	0.058	5.62	10.5
Total	66.4	551	562	297,185	298,364

Table S-2 Volume of "In-Place" NDA Waste by 10 CFR Part 61 Classification on January 1, 2000

	Volume (ft^3)				
EIS Waste Category	A	B	C	GTCC	Total
Fuel	0	0	0	12	12
Hardware	281	0	24	7,266	7,570
Ion Exchange	16,831	529	1,198	6,240	24,798
Degraded Solvent	0	0	1,610	2,385	3,995
Air Filters	358	0	3,084	7,452	10,893
Failed Equipment	10,024	291	3,168	13,272	26,755
Compacted Trash	1,404	0	182	79	1,665
Non-Compacted Trash	14,137	57	92	226	14,513
Soil	79,562	39,757	1,102	0	120,421
General Waste	57,304	718	6,179	10,726	74,927
Combination	16,563	0	288	26,893	43,745
Special	5,700	0	0	0	5,700
Debris	25,790	108	4	27	25,929
Total	227,954	41,460	16,931	74,578	360,924

Chapter 2 of the NDA report provides the bases for assigning radionuclides and their distributions in Category 1 and Category 2 wastes. These assumptions address radionuclide material content of waste based on what process generated them. Both calculational (ORIGEN) and records' searches were integrated in making these assessments.

A key uncertainty is noted below.

> "As indicated in Table 2-4, waste characterized using surrogates accounts for a significant fraction of the volume and activity of waste disposed of by NFS and a significant fraction of the volume of waste disposed of by WVDP. Although average radionuclide concentrations for surrogate wastes were calculated without regard to who buried the waste, there are significant differences in the concentrations of surrogates required for NFS wastes and those required for WVDP wastes. The averaged radionuclide concentrations for surrogates for most NFS waste are on the order of a few Ci/ft3, while the concentrations for surrogates required for WVDP waste are two to four orders of magnitude less."

Future assessments of the performance of the NDA disposal site and the radiological impacts of any releases over time will need to include assessment of:

1. Inventories of radioactive materials (total curie content by radionuclide).

2. Performance of waste forms to contain radioactive materials.

3. Performance of waste packaging to contain radioactive materials.

4. Performance of the man-made engineering features of the disposal cells (e.g., materials of construction, water management features such as leachate collection systems, and covers).

5. Performance of the natural geohydrological system to retard and or contain the migration of radioactive materials.

All of the items take on more or less importance, based on the time in the facilities' life cycle one considers. The three periods most commonly considered are: the operational period (waste operations are ongoing), closure period (the disposal site is put into its final configuration), a post closure monitoring period (a time of active engineered feature performance and environmental monitoring typically including active maintenance), and long term monitoring (a period of reduced confirmatory monitoring with or without maintenance). Item 1 will be discussed here in order to focus on the time-dependent inventory.

Table 2.1 of the NDA report provides for Category 1 wastes:

- Disposed volumes
- Time of disposal
- Radioactive material content (gross curie totals) for NDA disposed wastes

Table 2.1 also provides for Category 2 wastes the distributions for:

- Head end wastes (Radionuclide Distribution A): Assumes 1.0% total fission product and actinide inventory to the total activation product inventory in all fuel assemblies (accounts for cutting and chopping process).

- “Waste Side” waste (Radionuclide Distribution B): Results from adding the total inventory of fission products and actinides in all fuel assemblies at the time of reprocessing [dissolution into the chemical process cell (CPC)].

- “Product Side” waste: Constructed by dividing the amount of all radionuclides in the “Waste Side” distribution, except for uranium and plutonium, by a factor of 1000.

- Distribution S: A special distribution for SDA wastes inadvertently disposed in the NDA containing a shipment of failed equipment contaminated with $^{95}Zr/^{95}Nb$. As noted, since these are short lived radionuclides, they do not contribute to the inventories on January 1, 2000.

- Distribution X: A special radionuclide distribution for hardware.

All of these items could be the basis for uncertainty analyses in the radioactive materials inventory.

The radionuclide inventory information for the NDA is contained in:

- Table 3-1 Fuel Reprocessing Campaigns at the Western New York Nuclear Service Center

- Table 3-2 Waste Categories, Waste Types, and Radionuclide Distributions Used in the NDA Integrated Database

- Table 3-3 Radionuclide Distributions for Category 1 Wastes at the time of Reprocessing by Material Processed

- Table 3-3 Radionuclide Distributions for Category 1 Wastes at the Time of Reprocessing by Material Processed

- Table 3-4 Weights of Materials in Each ORIGEN Zone by Campaign

- Table 3-5 Radionuclide Distributions for Category 1 Waste at the Time of Reprocessing by Campaign

- Table 3-6 Radionuclide Distribution A (Head End) for Category 2 Waste at the Time of Disposal

- Table 3-7 Radionuclide Distribution B (Waste Side) for Category 2 Waste at the Time of Disposal

- Table 3-8 Radionuclide Distribution C (Product Side) for Category 2 Waste at the Time of Disposal

Tables 3-6 through 3-8 are the key tables that provide the inventory of radioactive materials for performance assessments.

- Table 5-3 Radionuclide Inventory (Ci) for NFS NDA Waste on January 1, 2000, by EIS Waste Category

- Table 5-4 Radionuclide Inventory (Ci) for WVDP NDA Waste on January 1, 2000, by EIS Waste Category.

These last two tables are available in the NDA report on the website (URS_2000_rad_inv.pdf).

Summary of the SDA Report

The SDA was used primarily for a large number of commercial and government customers disposing wastes. The following summary is designed to provide information regarding the inventories of radioactive materials with an assessment of the uncertainties that exist in the source data and assumptions made in estimating these inventories.

The SDA reports of key improvements in the SDA inventory (footnote 2 above) are offered in its introduction. The report states:

"The process of revising estimated radionuclide inventory and waste classification for the SDA involved the following activities:

- Reconstruction of a single integrated database.

- Verification of the reconstructed database against all microfilmed disposal records.

- Review and revision of waste profiles and the application of add-ins.

- Estimation of waste classification for individual database records.

- Estimation of radionuclide inventory by trench section and special purpose hole."

For consistency with the revised NDA radionuclide inventory, radionuclide inventory and waste classification of SDA waste are estimated for January 1, 2000.

The main features in the development of the SDA inventory are the use of fixed concentration method and a variable concentration method. Both methods yield the same total activity in the wastes at the time of disposal. The variable concentration method uses a scaling factor. As noted in the SDA report: "The scaling factor is the ratio of total activity calculated based on volume assigned to the profile and the profile concentration to the activity reported in disposal records."

The fixed concentration method, "assigns the waste profile concentration to each database record assigned to the profile."

This technique results in a more realistic estimate of the concentration (lower) in disposed waste as reported in the report Summary and reproduced below.

Principal Radionuclides in SDA Wastes

	Method of Calculation	
Radionuclide	Fixed Concentration	Variable Concentration
H-3	31.5%	31.8%
C-14	0.2%	0.2%
Fe-55	0.1%	0.1%
Co-60	3.1%	4.1%
Ni-59	0.6%	0.6%
Ni-63	15.9%	15.9%
Sr-90	0.1%	0.1%
Y-90	0.1%	0.1%
Cs-137	11.8%	11.3%
Ba-137m	11.2%	10.7%
Th-234	0.1%	0.1%
Pa-234m	0.1%	0.1%
U-238	0.1%	0.1%
Pu-238	20.7%	20.5%
Pu-239	0.1%	0.1%
Pu-241	3.2%	3.0%
Am-241	0.3%	0.3%
Total	99.5%	99.5%

The percentages of 99.5 are based on the full numerical precision of the data. Due to round-off, the sums of the percentages show above are 99.2 and 99.1, respectively, for the fixed and variable concentration methods.

Distribution of Waste Volume by Class			
		Estimation Method for SDA	
Class	Commercial Sites 1987-1989	Fixed Concentration	Variable Concentration
A	96.9 %	74.6 %	93.8 %
B	2.3 %	1.2 %	1.0 %
C	0.8 %	20.8 %	2.1 %
GTCC	n/a	3.4 %	3.1 %

The report provides clear and concise conclusions regarding the preference for the ‘variable concentration method’ result.

The report notes:

”The variable concentration method was developed, existing waste profiles were revised and new waste profiles were added, and the database of disposal records was verified and extensively revised to address these limitations. Like the fixed concentration method, the variable concentration method assumes that each waste profile defines the average radionuclide concentrations in waste assigned to the profile. Stated another way, both methods assume that the total activity of wastes assigned to a waste profile is the product of the volume of waste assigned to the profile and the radionuclide concentrations that define the profile. The fixed concentration method assumes that each database record had the same concentration: the average concentration that defines the waste profile. The variable concentration method uses the ratio of this total activity to the total activity reported in disposal records to scale the concentrations assigned to each database record. Thus, both methods estimate the same radionuclide activities at the time of disposal but give very different estimates for waste classification and for activity in individual trenches, trench sections, and special holes.”

The report made several corrections to the inventory as noted below:

“During verification of the database, records of several shipments were found that were not included in previous work. Inclusion of these shipments increased the estimated volume of waste buried in the SDA to 2,362,470 ft^3. The total radionuclide inventory as of January 1, 2000, is estimated to be 129,615 Ci. Seven radionuclides account for more than 97% of this activity. In decreasing order of activity, these radionuclides are: H-3, Pu-238, Ni-63, Cs-137, Ba-137m, Co-60, and Pu-241.”

The inventories reported in Table 3-10 based on the variable concentration method and fixed concentration method are reproduced below

Table 3-10. Activities of Principal Radionuclides on January 1, 2000 Estimated by Disposal Trench

Nuclide	Activity (Ci) by Fixed Concentration Method Burial Trench														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
H-3	2.20E+01	5.00E+01	9.36E+02	2.00E+03	5.33E+03	3.34E+02	1.50E+00	1.04E+04	4.39E+03	5.00E+03	7.57E+03	2.27E+03	1.22E+03	8.05E+02	4.04E+04
C-14	6.74E+00	7.61E+00	1.93E+01	3.47E+01	3.86E+01	9.03E-01	4.08E-01	4.16E+01	2.98E+01	2.75E+01	4.12E+01	2.70E+01	1.41E+01	1.66E+01	3.06E+02
Fe-55	2.44E-02	1.16E-01	2.00E-01	2.01E+00	2.38E+01	1.81E+01	2.47E-03	2.99E+01	2.68E-01	1.34E-01	3.18E-01	5.68E+00	9.18E-01	1.90E+01	1.00E+02
Co-60	4.32E+00	1.76E+01	2.66E+01	1.60E+02	1.31E+03	5.07E+02	3.04E-01	1.12E+03	2.09E+01	2.14E+01	1.14E+01	1.92E+02	6.52E+01	4.48E+02	3.91E+03
Ni-59	2.59E-01	1.11E+00	1.54E+00	2.45E+01	3.89E+02	8.14E+01	1.54E-02	2.31E+02	4.75E-01	1.95E-01	2.54E-01	1.88E+01	6.54E-01	5.04E+01	8.00E+02
Ni-63	5.07E+01	6.68E+01	1.17E+02	6.87E+02	9.45E+03	2.03E+03	2.91E+00	5.75E+03	8.94E+01	4.83E+01	5.47E+01	5.21E+02	7.24E+01	1.34E+03	2.03E+04
Sr-90	4.92E+00	7.06E+00	1.07E+01	1.87E+01	1.24E+01	3.83E-02	3.24E-01	1.20E+01	1.19E+01	9.89E+00	1.96E+01	1.35E+01	2.75E+01	3.00E+01	1.78E+02
Y-90	4.93E+00	7.07E+00	1.07E+01	1.87E+01	1.24E+01	3.84E-02	3.24E-01	1.20E+01	1.19E+01	9.89E+00	1.96E+01	1.35E+01	2.75E+01	3.01E+01	1.79E+02
Cs-137	5.96E+02	1.06E+03	1.68E+03	3.52E+03	1.88E+03	1.28E-01	3.97E+01	1.11E+03	1.21E+03	5.97E+02	6.39E+02	7.72E+02	9.29E+02	1.08E+03	1.51E+04
Ba-137m	5.64E+02	1.00E+03	1.58E+03	3.33E+03	1.78E+03	1.21E-01	3.75E+01	1.05E+03	1.14E+03	5.64E+02	6.04E+02	7.31E+02	8.79E+02	1.02E+03	1.43E+04
Th-234	2.26E-02	5.43E-02	9.27E-01	4.36E+01	3.99E+01	0	1.39E-03	3.73E+01	1.12E+01	1.54E+01	1.31E+01	4.66E+00	1.27E+01	1.30E+01	1.92E+02
Pa-234m	2.26E-02	5.43E-02	9.27E-01	4.36E+01	3.99E+01	0	1.39E-03	3.73E+01	1.12E+01	1.54E+01	1.31E+01	4.66E+00	1.27E+01	1.30E+01	1.92E+02
U-238	2.26E-02	5.43E-02	9.27E-01	4.36E+01	3.99E+01	0	1.39E-03	3.73E+01	1.12E+01	1.54E+01	1.31E+01	4.66E+00	1.27E+01	1.30E+01	1.92E+02
Pu-238	1.19E+00	1.60E+00	3.34E+00	1.39E+01	1.88E+02	0	7.61E-02	4.14E+03	4.28E+03	1.23E+04	5.50E+03	4.83E+01	4.26E+01	4.14E+00	2.65E+04
Pu-239	1.09E+00	2.49E+00	1.13E+01	1.58E+01	3.43E+01	0	6.90E-02	9.72E+00	6.18E+00	3.65E+00	5.90E+00	4.92E+01	4.11E+01	3.31E+00	1.84E+02
Pu-241	8.72E+00	1.12E+01	3.47E+01	1.42E+02	5.62E+02	0	6.03E-01	1.84E+02	5.45E+01	1.15E+01	1.98E+02	1.50E+03	1.33E+03	1.01E+02	4.14E+03
Am-241	2.33E+00	2.95E+00	7.06E+00	2.69E+01	7.16E+01	0	1.45E-01	2.25E+01	1.15E+01	1.28E+01	2.72E+01	1.27E+02	1.10E+02	9.25E+00	4.31E+02
Total	1,267.08	2,232.93	4,441.20	10,119.50	21,209.77	2,975.13	83.89	24,273.58	11,281.49	18,674.08	14,733.01	6,306.13	4,799.30	5,002.58	127,399.66

Only radionuclides contributing at least 0.1 percent of the total SDA activity (128,024.48 Ci) are shown. These radionuclides account for 99.5 percent of the total SDA activity.

Nuclide	Activity (Ci) by Variable Concentration Method Burial Trench														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
H-3	8.68E+00	7.93E+01	9.07E+02	2.82E+03	3.75E+03	2.65E+03	3.73E+00	6.93E+03	3.89E+03	7.08E+03	8.64E+03	2.28E+03	1.43E+03	8.12E+02	4.13E+04
C-14	2.74E+00	3.80E+00	1.21E+01	8.63E+01	2.48E+01	6.78E+00	1.01E+00	2.08E+01	3.39E+01	4.12E+01	4.07E+01	2.11E+01	3.83E+00	6.95E+00	3.06E+02
Fe-55	1.45E-02	1.27E-01	1.76E-01	3.81E+00	7.02E+00	1.67E+02	6.81E-03	8.05E-01	3.62E-01	3.91E-02	3.83E-01	4.73E+00	2.37E-01	6.87E-01	1.86E+02
Co-60	2.62E+00	1.90E+01	2.38E+01	2.79E+02	4.00E+02	4.30E+03	8.32E-01	3.40E+01	2.76E+01	1.55E+01	2.04E+01	1.54E+02	3.59E+01	2.23E+01	5.33E+03
Ni-59	1.45E-01	1.20E+00	1.41E+00	5.09E+01	1.11E+02	6.11E+02	4.21E-02	5.64E+00	6.62E-01	3.38E-02	4.62E-01	1.56E+01	1.24E-01	1.38E+00	8.00E+02
Ni-63	1.69E+01	3.64E+01	7.98E+01	1.59E+03	2.69E+03	1.54E+04	7.27E+00	1.57E+02	1.32E+02	8.51E+00	7.41E+01	4.21E+02	1.33E+01	5.90E+01	2.07E+04
Sr-90	1.85E+00	4.08E+00	4.75E+00	5.53E+01	5.30E+00	2.95E-01	8.07E-01	5.09E+00	1.60E+01	1.36E+01	8.10E+00	2.34E+01	1.86E+01	1.78E+01	1.75E+02
Y-90	1.85E+00	4.08E+00	4.75E+00	5.53E+01	5.31E+00	2.95E-01	8.07E-01	5.09E+00	1.60E+01	1.36E+01	8.10E+00	2.34E+01	1.86E+01	1.78E+01	1.75E+02
Cs-137	2.43E+02	8.00E+02	9.58E+02	8.12E+03	1.19E+03	9.84E-01	1.01E+02	3.32E+02	1.90E+03	6.29E+01	3.55E+02	1.78E+02	1.29E+02	2.58E+02	1.46E+04
Ba-137m	2.30E+02	7.56E+02	9.06E+02	7.68E+03	1.12E+03	9.31E-01	9.53E+01	3.14E+02	1.79E+03	5.95E+01	3.36E+02	1.68E+02	1.22E+02	2.45E+02	1.38E+04
Th-234	2.07E-02	7.56E-02	5.06E-01	5.92E+01	9.37E+00	0	3.45E-03	4.04E+01	1.08E+01	1.40E+01	1.18E+01	1.14E+01	1.32E+01	2.10E+01	1.92E+02
Pa-234m	2.07E-02	7.56E-02	5.06E-01	5.92E+01	9.37E+00	0	3.45E-03	4.04E+01	1.08E+01	1.40E+01	1.18E+01	1.14E+01	1.32E+01	2.10E+01	1.92E+02
U-238	2.07E-02	7.56E-02	5.06E-01	5.92E+01	9.37E+00	0	3.45E-03	4.04E+01	1.08E+01	1.40E+01	1.18E+01	1.14E+01	1.32E+01	2.10E+01	1.92E+02
Pu-238	4.43E-01	9.18E-01	2.28E+00	3.18E+01	1.71E+02	0	1.91E-01	4.16E+03	4.34E+03	1.23E+04	5.49E+03	2.06E+01	4.20E+00	4.30E-01	2.65E+04
Pu-239	4.02E-01	1.84E+00	1.03E+01	3.11E+01	2.01E+01	0	1.73E-01	2.07E+01	5.81E+01	2.84E+00	4.80E-01	2.71E+01	1.06E+01	3.49E-01	1.84E+02
Pu-241	3.20E+00	6.01E+00	3.23E+01	3.98E+02	1.79E+02	0	1.51E+00	5.84E+02	1.89E+03	3.32E+00	8.18E+00	6.45E+02	1.29E+02	4.92E+00	3.89E+03
Am-241	8.56E-01	1.57E+00	5.44E+00	6.94E+01	2.30E+01	0	3.63E-01	6.29E+01	1.88E+02	1.12E+01	9.73E+00	5.43E+01	1.09E+01	7.87E-01	4.39E+02
Total	512.07	1,714.60	2,950.30	21,449.56	9,730.44	23,110.57	212.72	12,752.30	14,314.05	19,676.00	15,023.88	4,071.61	1,961.82	1,510.30	128,990.21

Only radionuclides contributing at least 0.1 percent of the total SDA activity (129,614.67 Ci) are shown. These radionuclides account for 99.5 percent of the total SDA activity.

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Possible North Plateau Groundwater Plume

During a recent visit of the source term review team (Drs. Michael T. Ryan, Jimmy T. Bell and Frank L. Parker) to the site, NYSERDA staff pointed out a possible plume that may be a contributor (Geoprobe Point #29) to the North Plateau Groundwater Plume.

NYSERDA reported that this location was sampled during the 1994 and 1998 Geoprobe sampling program. The Sr-90 concentrations vary with depth (e.g., at 15' below surface Sr-90 = 33,000 pCi/L, at 27' below surface Sr-90 = 540,000 pCi/L and 33' below surface Sr-90

= 300,000 pCi/L in 1994). These varying values at depth differ from the other Sr-90 contamination levels (i.e., the geoprobe points attributed to the single source are highest in Sr-90 concentration closer to ground surface).

NYSERDA staff reported that Geoprobe Point No. 29 also has highest levels of alpha contamination near or under the Main Plant Process Building (e.g., 120 pCi/L at 15' depth in 1994). The geoprobe field sheet for this location is the only one where the description of the soils is identified as "orange, rusty sand." All other locations are identified as being gray, brown or some combination of the two.

NYSERDA staff noted during the visit that there are a number of documented leaks/spills that occurred during NFS reprocessing activities. They reported that some of these leaks/spills contained slightly different concentrations of the suite of radionuclides (i.e., there were larger concentrations of the long-lived alpha radionuclides) and were much larger in volume than the leak currently identified as predominant leak. DOE does not believe that these leaks/spills are significant contributors to the North Plateau Groundwater Plume. However, sampling in the areas closest to these leaks/spills has not been performed to confirm their contributions to the plume.

The team visiting the site that day felt that it is reasonable to raise this question and it deserves serious attention. Perhaps a limited number of samples could help better characterize this as a source that is contributing to the plume or not.

COMMENTS BY JIMMY T. BELL AND CHRIS G. WHIPPLE ON THE HLW TANKS: INVENTORIES

The total estimated residual activity in the Waste Tank Farm is conservatively estimated at 350,000 Ci, as given in Appendix C, page c-15, of the 2008 PDEIS. This inventory is calculated from past operations at West Valley. The decision concerning future tank farm management need not be a function of the accuracy of the inventory data. The activity includes all of the radionuclides associated with spent nuclear fuel, and the ratios of various radionuclides are in accord with spent nuclear fuel. Hence, the total inventory of the tanks can be used to determine approaches to tank farm management.

The total estimated current waste tank inventory is given in the table below, along with the projected inventories at 60 years, 100 years, and 300 years. Almost all the activity in the tanks is from Sr-90 and Cs-137. Out of roughly 350,000 Ci, the estimate reported in Appendix C is that only 1,260 Ci results from radionuclides other than Sr-90 and Cs-137. These two radionuclides have similar half-lives of about 30 years. This means that over the 60-year period of the tank farm removal, the inventory in the tanks would decay from ~350,000 Ci to about 87,000 Ci. While this is still a large amount of activity, it does reflect a significant decrease. The fact that the tank wastes are almost entirely 30-year half-life material suggests that a key question in

Nuclide	8D-1	8D-2	8D-3	8D-4	Total	halflife, y	after 60 Years	after 100 years	after 300 years
Carbon-14	2.00E-02	5.46E-03	1.47E-05	9.99E-03	3.55E-02	1.23E+01	1.21E-03	1.27E-04	1.61E-09
Strontium-90	2.03E+03	3.02E+04	6.85E-01	4.40E+03	3.27E+04	2.86E+01	7.64E+03	2.90E+03	2.27E+01
Technetium-99	5.40E+00	5.85E+00	1.56E-02	2.40E-01	1.15E+01	2.13E+05	1.15E+01	1.15E+01	1.15E+01
Iodine-129	6.80E-03	7.68E-03	1.96E-05	3.20E-03	1.77E-02	15,700,000	1.77E-02	1.77E-02	1.77E-02
Cesium-137	2.21E+05	8.90E+04	1.74E-01	1.68E+03	3.12E+05	30.2	7.87E+04	3.14E+04	3.19E+02
Uranium-233	2.60E-01	8.73E-02	2.14E-03	4.40E-02	3.93E-01	159,200	3.93E-01	3.93E-01	3.92E-01
Uranium-234	1.00E-01	3.33E-02	7.70E-04	3.00E-03	1.37E-01	244,500	1.37E-01	1.37E-01	1.37E-01
Uranium-235	3.40E-03	1.34E-03	2.11E-05	1.40E-04	4.90E-03	703,800,000	4.90E-03	4.90E-03	4.90E-03
Uranium-238	3.10E-02	8.15E-03	2.06E-04	5.60E-05	3.94E-02	4,468,000,000	3.94E-02	3.94E-02	3.94E-02
Neptunium-237	2.30E-02	5.16E-01	2.58E-04	1.20E-02	5.51E-01	2,140,000	5.51E-01	5.51E-01	5.51E-01
Plutonium-238	5.37E+00	1.41E+02	9.97E-03	1.92E+01	1.66E+02	87.8	1.03E+02	7.54E+01	1.55E+01
Plutonium-239	1.50E+00	3.68E+01	2.67E-03	6.30E-01	3.89E+01	24,100	3.88E+01	3.88E+01	3.86E+01
Plutonium-240	1.10E+00	2.68E+01	1.92E-03	3.10E-01	2.82E+01	6,570	2.80E+01	2.79E+01	2.73E+01
Plutonium-241	3.40E+01	5.81E+02	6.98E-02	1.16E+01	6.27E+02	14.4	3.49E+01	5.09E+00	3.36E-04
Americium-241	3.77E-01	3.81E+02	1.90E-02	2.68E+00	3.84E+02	432	3.49E+02	3.27E+02	2.37E+02
	2.23E+05	1.20E+05	9.81E-01	6.11E+03	3.46E+05		8.69E+04	3.48E+04	6.73E+02
less Sr-90, Cs-37	4.82E+01	1.17E+03	1.22E-01	3.47E+01	1.26E+03		5.67E+02	4.87E+02	3.31E+02

remediation of these tanks is whether institutional controls could be relied on for the 300 or so years it would take for the activity from Sr-90 and Cs-137 to decay to very low levels, leaving only a small inventory of Sr and Cs with the long lived radionuclides in the inventory. Residual radioactivity levels for the West Valley Tank Farm at 60, 100, and 300 years are shown in the table provided on the following page.

COMMENTS BY JIMMY T. BELL AND CHRIS G. WHIPPLE ON INVENTORIES IN THE MAIN PLANT AND VITRIFICATION FACILITIES

The estimated total activities for each of the two facilities (Main Plant and Vitrification) are given in the 2008 PDEIS, Appendix C, Tables C-1 and C-3. The total activity for the Main Plant (without the vitrified products) is estimated at 6,100 Ci, with a cesium (Cs) and strontium (Sr) contribution of 4,420 Ci. The actinide activity of americium and plutonium is 1,661 Ci. The total activity for the vitrification building is estimated to be 1,860 Ci of Cs and Sr and 14 Ci of actinides. The activity levels of the two buildings suggest that the remediation of these buildings should be of a lesser priority. It also indicates that neither building could be a source for significant radioactive leakage.

The low inventory level of the Main Plant is partially explained by the process hot cells having been cleaned before the vitrified canisters were stored. These HLW vitrified canisters will be moved to another facility before remediation begins. With the low radiation levels found here, the remediation can be done without additional containment.

The vitrification building was not highly contaminated because it operated for only a short period of time, without having had any contaminating spills. The HLW was totally contained, with the exception of the off-gas, which was scrubbed to decontaminate it of Cs content. Therefore the remediation of the building can be done without further containment.

COMMENTS BY FRANK L. PARKER

General Comments

It is well known from work at Oak Ridge and the other major nuclear sites that in the early days of the projects, the main concern with waste products was the dose to individuals who processed, handled, and disposed of the wastes. The exact content was not of as great a concern, nor was there that much concern about the hazardous chemical wastes as it was believed that if one were safe with exposure to the radioactive materials, then one would be safe with the exposure to the hazardous chemical materials. Further, alpha and gamma spectrometers were not yet invented. Therefore, most of the analyses were alpha or beta-gamma counting. Therefore, one cannot expect great accuracy in establishing inventories based upon disposal records. Consequently, this will not be a critique of the methodology but only to determine if the "inventories" are sufficient for the purposes to which they will be put.

Radioactive Inventories at West Valley Demonstration Project

In determining the need for inventories, one should recognize that they will have two main uses: a) to help plan the exhumation of the materials and the risk to the operators and the local community, and b) to determine the risk to the public from the release of the materials to the environment. Since the exhumation will be carried out with field instrumentation to determine the risk to the operators, one need only to have an indication where there may be high radiation doses and dangerous atmospheric releases. Since the accuracy of the estimates for the inventory will be continuously checked in the field, a reasonable approximation should be sufficient. For the risk to members of the public where no field measurements of the risk will be available, except for the "plume of Sr-90" going off-site, the inventory should be known with a greater accuracy. However, considering the uncertainty in some of the methodology of determining the transport and modification of the material in the environment, the uptake of the material by humans and the biota and the dose to both by such uptake, a factor of 2 in the estimated inventory would be no greater than the uncertainty in the other parts of the calculation of the dose. Obviously, this means that a deterministic estimate is not reasonable but a range and the probability of each percentile should be obtained.

Waste Tanks

However, at the West Valley facility that dealt primarily with reprocessing of spent fuel and the conversion of the waste products, the radiation history of the fuel elements received is quite well known. Therefore, one can calculate with codes such as ORIGEN the initial radionuclide inventory. Then, one can subtract the material in the vitrified waste and, with known decay rates, determine what I assume would be the major portion of radioactive material on the site, though the exact location and concentration would be less well known. The table below is taken from the material on the picture of the WVDP, "Estimated Total Curies at the West Valley Demonstration Project," dated June 25, 2002. Only the larger amounts of radioactive material sites, minus waste packaged for shipping, are shown.

Facility	Curies
Radioactive Waste Storage Tanks	450,000
NDA	300,000
SDA	130,000
Original Nuclear Fuel Reprocessing Building	22,000

One can assume that except for decay and movement off-site, both relatively small considering the age of the waste material (spent fuel reprocessing ceased in 1972), the activity today is similar to what it was at that time. However, it is important to note that curies are not a good surrogate for risk as one has to consider the mobility, half-lives, bioavailability, solubility, toxicity, etc., to determine the risk. The amount of radioactive Cs-137 in the liquid and the solids in Tank 8D-1 are estimated to be 700 and 150,000 curies, respectively. No samples have been taken of the solids nor are there samples of the rings of deposits on the inside of the tanks. The Supernatant Treatment System in Tank 8D-1 contains an estimated activity of 80,000 Ci of Cs-137 on the zeolite ion exchange columns. No samples have been taken of the zeolite. Similarly, Tank 8D-2 contains 130 and 20,000 curies in the liquid and solid wastes, respectively. Direct radiation measurements were used to obtain these estimates. Samples were taken of the material in the rings in Tank 8D-2 and of the liquid "heel". (Gemini Consulting Co. Residual Radionuclide Inventory Estimate for the Waste Tank Farm-Supplemental Report, February 7, 2005; Andrea Mellon, Additional Information Related to the High-Level Waste Tank Farm, June, 2008). The values in Gemini for the conservative case compare well with the values in Appendix C, Table C-8, p. C-15, for the total estimated residual activity in the Waste Tank Farm.

It would appear from the above that there is sufficient inventory information to carry out the exhumation safely, if it is determined to do so. For the risk assessment of doses to members of the general public, one would estimate the likelihood of the material in the tank migrating offsite. Since the majority of the activity is contained, in the ion exchange columns and/or the solids in the tanks, then one would have to make assumptions about the accidents in operations and the movement of the material off-site. With proper procedures, that should not be a major problem. Since most of the other material in the tanks is tightly bound to the tank interior and components therein, it is unlikely that they will become mobile in the environment unless in the process of exhuming the contents and the tank itself, material becomes mobile.

NRC-Licensed Disposal Area (NDA)

NDA		CUBIC		
	CURIES	FEET	METERS	Ci/cu m
NSF DEEP HOLES	220,000	65,000	1,840	120
NSF SPECIAL HOLES	77,000	97,000	2,747	28
WFDP TRENCHES	1,207	200,000	5,663	0.2

The NDA disposal area contains the waste from the operation and decommissioning of the reprocessing and vitrification plants. The deep holes contain the hulls; unreprocessed, damaged spent fuel elements; and high dose materials (>500 R/h). The trenches contain low level wastes and their nuclide distribution was obtained by a variety of means including dose-to-nuclide conversions. Dose-to-nuclide conversion involves major assumptions about a fixed distribution of nuclides in all categories of waste. In addition, it is estimated that about 1 million gallons of leachate have accumulated in the NDA hole and trenches.

Again, are the inventories sufficiently accurate for exhumation purposes and for risk analyses? Because of the high dose rates in the deep holes, it is clear that special measures must be taken for their exhumation. Even an order of magnitude change in the dose rate would have no impact on the precautions that need to be taken. For the special holes, most likely the same is true. However, because of the likelihood that some of the holes might have lower levels of radioactive material, field instrumentation should be used to determine the actual doses. For the trenches with their much lower level of radioactivity, field instrumentation should be used to determine how to handle the wastes.

There appears to be no information on the nuclides and their concentration in the leachate. Obviously, that needs to be checked by sampling and precautions taken as a function of the dose levels.

For risk analyses, the contents of the deep and special holes dominate. Even though Estimated Radionuclide Inventory, Table C-10, is for the entire NDA site, one could assume that all the nuclides are from the special and deep holes. Since the wastes are from their own site and the irradiation times and the fuel content known, as well as the efficiency of the separations, then the estimated quantity in Table 2-3, p. 2-12, Activity, Volume and Concentration of In-Place NDA Waste by 10CFR61 Classification, could be used as a "conservative estimate". (Wild, URS, Estimated Radionuclide Inventory for the NRC Licensed Disposal Area at the West Valley Demonstration Project, August 2000). It should be noted that these estimates "did not include verification of the NDA data base against disposal records". (Wild, URS, SDA Radiological Characterization Report, September 2002). It is somewhat surprising that this was not done.

State-Licensed Disposal Area (SDA)

The wastes buried in the SDA come from a variety of sources including reactors, nuclear fuel cycle facilities, institutions, industries, and isotope production facilities. Therefore, the wastes are much more heterogeneous than those in the NDA and have, in general, lower contents of radioactive material. The waste, in general, is buried as received. Except for Trench 6 in North Disposal Area, the wastes in all other trenches have less than 200 millirad/hr. Trench 6, a series of special purpose holes, contains mainly irradiated reactor parts.

	SDA	CUBIC		
	CURIES	FEET	METERS	Ci/cu m
NORTH DISPOSAL AREA	60,000	932,000	26,391	2.3
SOUTH DISPOSAL AREA	70,000	1,431,000	40,522	1.7

As in the description of the NDA, are the inventories sufficiently accurate for exhumation purposes and for risk analyses? Because of the likelihood of high dose rates in Trench 6 it is clear that special measures must be taken for the exhumation of its contents. For risk analyses, it was thought that the contents of Trench 6 would dominate. However, as shown in Table 3-10, Activities of Principal Radionuclides Estimated by Disposal Trench, using the Variable Concentration Method (Wild, URS, SDA Radiological Characterization Report, September 2002, p. 109), even with estimates to 8 significant figures, Trenches 4 (21,500 Ci), 6 (23,100 Ci), and 10 (19,700 Ci) are important for exhumation as well as Trenches 5, 8, 9, and 11. It is somewhat surprising that there are no packages with dose rates greater than 200 mrad/hr. For all of these trenches as well as those with their much lower level of radioactivity, field instrumentation should be used to determine how to handle the wastes.

Further, Wild notes that ".., results based on the fixed concentration method should not be used in analyses of radiological impacts involving SDA wastes" (ibid p. ii). Wild further states, "While the variable concentration method yields results that are more realistic, it is not without its limitations. For example, disposal records contain little information about waste burial locations for Trenches 1 through 3 and are inconsistent with available information regarding the dimension of some other trenches. This limits the ability to accurately estimate activities and concentration by location." (ibid p. ii)

So, even with this Herculean effort, there is sufficient uncertainty so that a range of risk outcomes should be calculated.

EXPOSURE LOCATIONS AND SCENARIOS

Review Team
Frank L. Parker (Lead)
Robert H. Fakundiny
Peter N. Swift
Chris G. Whipple

1. STATEMENT OF PURPOSE

This review was guided by the following two questions:

> "Do we have a reasonable set of exposure locations and scenarios for radionuclides and hazardous materials and is the assessment realistic and on a sound technical basis?
>
> Are the locations and scenarios reasonable considering the time constants involved?"

For the purposes of this review, the source term is taken to be the release rate and chemical form of contaminants (radiation and hazardous materials) from the engineered barriers of the facilities. The exposure location is that location accessible to the public that could result in the highest exposures of radiation and hazardous materials.

2. 2008 PDEIS SOURCE MATERIAL REVIEWED

- Chapter 3: Affected Environment
- Appendix D: Overview of Performance Assessment Approach
- Appendix G: Models for Long-Term Performance Assessment
- Appendix H: Long-Term Performance Assessment Results
  Only Appendix H contained site specific information that will be discussed below.

3. POINT OF COMPLIANCE AND SCENARIOS

3. A. Introduction

Reviews of exposure locations (in more formal regulatory language, points of compliance) and scenarios for the West Valley site must consider potentially applicable regulatory guidance and requirements, from three federal agencies and the state of New York. The Environmental Protection Agency (EPA), Nuclear Regulatory Commission (NRC), and the Department of Energy (DOE) all deal with exposure locations (more formally as point of compliance) and scenarios in slightly different fashion. Further, Authorized States[1], including New York State, may have slightly different compliance points and scenarios. Therefore, to answer these questions technically and to meet the regulatory requirements, guidance, etc., for both the point of compliance and the content of the scenarios, we need to know what these agencies require. In addition, other sub-groups of the review team are examining topics that impinge on this work, such as Erosion, Groundwater, Engineered Barrier Performance, Inventories, and Uncertainty Analysis; all impacting the Long Term Performance Assessment. Therefore, we shall limit our critique to the legal requirements and the practice for points of compliance and adequacy of the scenarios being investigated. In other words for this report, ***Exposure Locations and Scenarios,*** we shall not go into the details of the scenarios and the meaning of their outcomes.

The following sections of this review summarize the relevant regulatory guidance and criteria as described in the 2008 PDEIS (Section 3.B), and from other potentially relevant sources Section 3.C), and summarize the current understanding of the DOE and the NRC with respect to applicability of regulatory guidance and criteria to the EIS (Section 3D).

3.B. U.S. Department of Energy, 2008 PDEIS for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center

First we look into the DOE's 2008 PDEIS for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project (WVDP) and Western New York Nuclear Service Center (WNYNSC), 2008, Chapter 5 Applicable Laws, Regulations and Other Requirements[2] to see what is said about these topics. The following paragraphs are extracted from the 2008 PDEIS.

i. "Nuclear Regulatory Commission License Termination Rule (10 CFR 20, Subpart E) p. 5-5, ll. 246-261

For unrestricted release, the License Termination Rule specifies a dose criterion of 25 millirem per year total effective dose equivalent (TEDE) to the average member of the critical group, plus as low as reasonably achievable (ALARA) considerations. For restricted release, the License Termination Rule specifies an individual dose criterion of 25 millirem per year TEDE plus ALARA considerations using legally enforceable institutional controls established after a public participation process. Even if institutional controls fail, individual doses should not exceed 100 millirem per year TEDE. If it is demonstrated that the 100 millirem per year TEDE criterion is technically not achievable or prohibitively expensive in the event of failure of institutional controls, the individual dose criterion in the event of failure of institutional controls may be as high as 500 millirem per year TEDE. However, in circumstances where restricted release is required, if the 100 millirem per year TEDE criterion is exceeded, and/or the use of alternate criteria has been determined, the area would be rechecked by a responsible government entity no less frequently than every 5 years. Resources would have to be set aside to provide for any necessary control and maintenance of the institutional controls. Finally, the License Termination Rule permits alternative individual dose criteria of up to 100 millirem per year TEDE plus ALARA considerations for restricted release, with institutional controls established after a public participation process.

ii. NRC Final Decommissioning Policy Statement P. 5-7 5-8 ll. 267-292

Under authority of the WVDP Act, NRC published its final policy statement in 2002 adopting the NRC License Termination Rule provisions as the decommissioning criteria for the Project (67 FR 5003; February 1, 2002). The criteria of the License Termination Rule applies to the decommissioning of: (1) the high level radioactive waste tanks and other facilities in which high-level radioactive waste solidified under the WVDP was stored, (2) the facilities used in the solidification of the waste, and (3) any material and hardware used in connection with the WVDP. The policy statement also provided criteria for the determination of wastes "incidental" to reprocessing, and established that the calculated dose from this incidental waste is to be integrated with all the other calculated doses from the remaining material at the entire NRC-licensed site to ensure that the NRC decommissioning criteria are met.

Although the policy statement prescribes the use of the NRC's License Termination Rule as the decommissioning criteria for the WVDP, the NRC recognizes that the health and safety and cost-benefit considerations may justify the evaluation of alternatives that do not fully comply with License Termination Rule criteria. Therefore, the NRC is prepared to provide flexibility to assure cleanup to the maximum extent technically and economically feasible (67 FR 5004). DOE may request alternative criteria and/or potential exemptions to the requirements under 10 CFR Part 20 Subpart E and Subpart N, respectively, based on site specific analysis which demonstrates the public health and safety will be adequately protected with reasonable assurance (67 FR 5004). The policy statement also provides that the criteria in the License Termination Rule will also apply to the termination of the New York State Energy Research and Development Authority's NRC license after the license is reactivated. For those portions of the site covered by the WVDP Act, it is NRC's intent that any exemptions or alternative criteria authorized for DOE to meet the provisions of the WVDP Act will also apply to NYSERDA at the time of site license termination, if license termination is possible (67 FR 5011). (See further discussion of the License Termination Rule below.)

iii. Safe Drinking Water Act of 1974, as amended (42 U.S.C. 300(f) *et seq*.) P.5-9 ll. 360-366

The Safe Drinking Water Act, as amended, establishes minimum national standards for public water supply systems in the form of maximum contaminant levels (MCLs) for pollutants, including radionuclides. Although the New York State Department of Health (NYSDOH) has primacy for the Safe Drinking Water Act in New York, the water quality standards are implemented by New York State Department of Environmental Conservation (NYSDEC), which administers the Act in the State. Groundwater is not currently used as a public water supply at the WNYNSC. The MCL for manmade beta and gamma emitters is based on a 4 millirem-per-year dose limit. This limit applies to community water systems, including any that might utilize waters from the West Valley Site.

iv. NRC and EPA Memorandum of Understanding P.5-10 ll. 412-422

The EPA also established standards for cleanup in keeping with its authority under the Comprehensive Environmental Response Compensation Liability Act (CERCLA). The NRC and the EPA signed a Memorandum of Understanding establishing a framework for their relationship in the radiological decommissioning and decontamination of NRC-licensed sites. The Memorandum of Understanding provides that EPA will defer exercise of its authority under CERCLA for facilities decommissioned under NRC authority. The Memorandum of Understanding includes provisions for NRC and EPA consultation at particular sites when, at the time of license termination: (1) groundwater contamination exceeds EPA MCLs, (2) NRC contemplates restricted release or alternate criteria for release of the site, and/or (3) residual radioactive soil concentrations exist that exceed levels defined in the Memorandum of Understanding (67 FR 65375; October 24, 2002)."

v. Applicable New York State Laws, Regulations, and Other Requirements

The applicable New York State laws, regulations, and other requirements are also given in Chapter 5 of the 2008 PDEIS. However, they do not differ from the US requirements shown here for points of location and scenarios.

3.C. Further Guidance from U.S. Environmental Protection Agency, U.S. Nuclear Regulatory Commission and the U.S. Department of Energy

It can be seen from the above, except for the dose limitations, that no details are given for the Points of Compliance and Scenarios. Therefore, to obtain more detailed guidance on these concerns, further information was sought from the Federal agencies most directly involved: EPA, NRC, and the DOE. All three agencies that have regulatory responsibility for some disposal facilities have different views on the matter.

i. U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency states for Municipal Solid Waste Landfills, "The relevant point of compliance specified by the Director of an approved State shall be no more than 150 meters from the waste management unit and shall be located on land owned by the owner of the MSWLF unit".[3] EPA further states "The downgradient monitoring system must be installed at the relevant point of compliance specified by the Director of an approved State…"[4] It should be noted that EPA has given detailed instructions on how to carry out risk assessments for Superfund sites, including exposure points and pathways (equivalent to points of compliance and scenarios).[5]

ii. U.S. Nuclear Regulatory Commission

The U.S. Nuclear Regulatory Commission has stated "For West Valley, the NRC license is currently in abeyance while DOE completes its responsibilities under the West Valley Demonstration Project Act The WVDP Act requires that NRC establish decommissioning criteria for the site. NRC published those criteria in 2002 (NRC, 2002) and included criteria for determining whether certain waste disposed of onsite is incidental waste; however, NRC does not have regulatory or enforcement authority over DOE under the WVDP Act. Although the WVDP Act does assign a monitoring role to NRC at West Valley, at this point, NRC staff has not performed a technical evaluation of a waste determination at WVDP to assess compliance with safety requirements comparable to the performance objectives in 10 CFR Part 61, Subpart C. Therefore, the West Valley site is not included in the following discussion of monitoring. Monitoring approaches and activities relating to incidental waste disposal actions for WVDP can be included in a revised and updated version of the guidance document when relevant. If the license is reinstated and responsibility for the entire site returns to the licensee (the New

York State Energy Research and Development Authority [NYSERDA]), NRC will retain the same monitoring and inspection responsibilities that it has for other licensees under the Atomic Energy Act with respect to ensuring that the site meets all applicable regulatory requirements."[6] See Appendix B of this review for NRC requirements for points of compliance for the License Termination Rule.[7]

The Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria (NUREG-1757, Vol. 2, Rev. 1)[7] "provides guidance on compliance with the radiological criteria for license termination (License Termination Rule (LTR)) in 10 CFR Part 20, Subpart E. This guidance takes a risk-informed, performance-based approach to the demonstration of compliance. The approaches to license termination described in this guidance will help to identify the information (subject matter and level of detail) needed to terminate a license by considering the specific circumstances of the wide range of NRC licensees. Licensees should use this guidance in preparing decommissioning plans, license termination plans, final status surveys, and other technical decommissioning reports for NRC submittal. NRC staff will use the guidance in reviewing these documents and related license amendment requests.

Volume 2 is applicable to all licensees subject to the LTR."

Excerpts from NUREG-1757 are given in Appendix A of this review.

3.D. Views of DOE and NRC on Point of Compliance

The position of the DOE with respect to the appropriate points of compliance and scenarios is given in the 2008 PDEIS[2] and its appendices. Although the EIS is part of the NEPA (National Environmental Protection Act) process, and is not written to demonstrate compliance with NRC regulations and guidance applicable to decommissioning and the License Termination Rule, the DOE states in the 2008 PDEIS Appendix D (lines 344-346) that it is their intent to "[i]dentify receptors based on review and interpretation of prior analysis performed by the NRC, U.S. Environmental Protection Agency, and DOE, and on principles applied in environmental and safety analyses. This intent is based on a "desire to comply with regulations and guidance of Federal agencies charged with environmental analysis and the need to conduct analysis that provides a preliminary basis for comparison with regulatory requirements (Appendix D, lines 348-350). Thus, guidance from NUREG-1757 relevant to decommissioning and license termination should be relevant to the 2008 PDEIS.

The Summary Notes from the 10 July 2007 Generic Technical Issue Discussion (between DOE and the NRC-added) on Point of Compliance[8] indicated that DOE and NRC staff agreed that deviation from the standard point of compliance at the boundary of the 100-meter buffer may be appropriate. However, information and analysis are necessary to adequately support such deviation. DOE and NRC staff agreed that appropriate points of compliance may depend on some site–specific considerations and may need to be addressed on a site-specific basis. Though they had agreed to meet again, no meetings have taken place in the last year. The NRC staff stated that "three key questions exist. (1) How does point of compliance drive cleanup levels versus the need to satisfy the Maximum Contaminant Levels (MCL) for groundwater protection? (2) What flexibility does DOE have in establishing the point of compliance? (3) What level of justification is needed to support NRC acceptance of greater reliance on institutional controls than is done for commercial low-level waste disposal facilities?" See Appendix B of this review for the full Summary Notes.

As the comments below submitted by the NRC on Appendix D indicate, the NRC does not agree that the approach taken in the 2008 PDEIS to scenarios and receptor locations is consistent with regulatory guidance:

> This discussion indicates that the approach for identifying receptors is based on review and interpretations of prior analysis performed by NRC, EPA, and DOE and on principles applied in environmental and safety analysis as well as the desire to comply with regulations and guidance of Federal agencies and that provide a preliminary basis for comparison with regulatory requirements. It could be inferred from this discussion that the 2008 PDEIS dose modeling approach is consistent with NRC's LTR. However, fundamental elements of NRC's LTR and its guidance in NUREG-1757 are not being used in the 2008 PDEIS. Instead, DOE has selected other approaches for the 2008 PDEIS such as: 1) the 100-year time for loss of institutional controls instead of immediate loss; 2) temporary loss of institutional controls instead of extended loss; 3) no receptor within the area of control when institutional controls are in place; 4) scenario selection does not appear to be consistent with the realistic scenario guidance in NUREG-1757 Table 5.1, and 5) sensitivity analysis are not included for degradation of erosion controls and engineered barriers. These differences could have an impact on the dose results and add confusion to understanding the approach and results. No explanation is given for taking a different approach.
>
> DOE should clarify the discussion of its approach for the EIS performance assessment, why it has been selected, and why it is different than NRC's regulatory approach under the LTR/West Valley Policy Statement. NRC understands that the EIS is not a compliance document, but as DOE states in line 349, one of the purposes of the EIS is to provide a preliminary basis for comparison with regulatory requirements.

4. IMPLEMENTATION OF THE POINT OF COMPLIANCE AND SCENARIO SELECTION FOR THE 2008 PDEIS

4.A. Point of Compliance and Scenario Locations for the Short-Term Performance Assessment (Section D.2)

The scenarios and point of compliance locations for the short term assessment appear reasonable, consistent with maintaining institutional controls during the operational period. The pathways considered for releases associated with site remediation are air releases and surface water runoff. Exposures in the short-term due to groundwater transport of radionuclides or hazardous chemicals are not considered likely. Because institutional controls are assumed to succeed in the short-term, no intruder or on-site resident scenarios are considered nor does erosion occur. We agree that institutional controls will both greatly reduce the likelihood of significant offsite releases due to groundwater transport or erosion and mitigate consequences should a release occur. We also concur that institutional controls will be effective in preventing intrusion. Risks associated with these pathways are unlikely to be zero, however, and additional discussion would be helpful.

4.B Point of Compliance and Scenario Locations for the Long-Term Performance Assessment

The Point of Compliance for the long-term performance assessment (LTPA) is stated to be for off-site receptor locations at: Cattaraugus Creek – Edies Road/Mill Street; confluence of Buttermilk and Cattaraugus Creeks, Cattaraugus Creek – Seneca Nation of Indians Cattaraugus Reservation; Gowanda, New York; and Lake Erie, including municipal water system intakes at Sturgeon Point near Derby, New York and in the Niagara River.[9] Onsite receptor locations are at:[10] North Plateau (Main Plant Process Building (WMA 1); Vitrification Facility (WMA 1); Low Level Waste Treatment Facility (WMA 2); Waste Tank Farm (WMA 3); North Plateau Plume and Cesium Prong) and Onsite South Plateau (NDA (WMA 7), SDA (WMA 8); Onsite Buttermilk Creek and Resident/recreational hiker located on the East bank of Franks Creek opposite the SDA; and on the West bank of Erdmann Creek opposite the NDA (additional receptor for the erosion analysis).

The scenarios selected for consideration[11] were:

- Home Construction
  inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and exposure to external radiation from the walls of an excavation for the foundation of a home.
- Well Drilling
  inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and direct exposure to external radiation from contaminated water in a cuttings pond.
- Residential Farmer-Maintaining a Home and Garden
  living in a home, maintaining a garden, harvesting fish and deer, and recreational hiking. The scenario may be initiated by existing residual contamination of surface soil, by irrigation with contaminated groundwater or surface water, by deposition of contaminated soil from the home construction excavation on the ground surface, by deposition of contaminated soil from the well drilling cuttings pond on the ground surface, or by exposure of contaminated material during erosion. For both radionuclides and hazardous chemicals, maintenance of a home and garden involves inadvertent ingestion of soil, inhalation of fugitive dust, and consumption of crops and animal products. For radionuclides, there is an additional pathway, exposure to external radiation.
- Recreational Hiker
  inadvertent ingestion of soil and inhalation of fugitive dust for both radionuclides and hazardous chemicals and exposure to direct radiation for radionuclides.

It should be noted that ingestion of contaminated groundwater is not listed nor taken into account for the short term performance assessment though one of the points of compliance actually used is residential farmer who obtains his drinking water supply from groundwater seepage.
The review focuses on exposure locations and scenarios for the LTPA, with primary emphasis therefore on the scenarios that were implemented in Appendix H[12].

Assertion of Conservatism in Scenario Selection for the LTPA

Appendix D states a governing principle for scenario selection: "In practice, a set of scenarios intended to represent the upper range of potential impacts was selected for analysis" (Appendix D, lines 12-13, also line 37).

There is not a strong case in the available documentation that this intent has been met. The intent would better be stated as "to provide a reasonable representation of a range of future states that could result in risk to humans." As discussed below, the scenarios implemented in Appendix H can be characterized as representative of a range of consequences, but it's difficult to argue that they represent the upper range of consequences. There appears to be no requirement to model the upper range of consequences, and the analysis could be more credible if it did not assert this. (Examples where scenarios did not choose the upper range include the decision to exclude erosion from the North Plateau and the decision to evaluate less favorable conditions for erosion and precipitation through sensitivity analyses only—see Sections H.2.2.2.6 and H.3. Note also the statement in Section H.2.2, that analyses are "generally conservative, except for those that include unmitigated erosion, in which case a 'best-case' estimate is presented.")

Scenarios for the Long-Term Performance Assessment (Section D.3)

Section D.3 lays out the basic methodology for scenario selection and provides some important direction for the analysis. For example, Section D.3.1 provides the basis for the decision to perform analyses that extend to the time of peak impact. Section D.3.1.1 provides the basis for the decision to exclude "extreme global-scale climatic changes" from the analysis (i.e., guidance from the Nuclear Regulatory Commission in NUREG-1573). Section D.3.1.1 also states that natural cycling of wetter and dryer conditions is addressed through sensitivity analyses. The approach of evaluating wetter and dryer conditions through a sensitivity analysis is conceptually acceptable, although it would be preferable to include a range of wetter and dryer conditions explicitly in the LTPA. In practice, the relevant analysis in Appendix H, Section H.3.2, is limited to a qualitative discussion, and it is somewhat misleading to refer to it in Section D as a sensitivity analysis.

Section D.3.1.1 defines the receptors considered for the long-term analysis. These receptors appear to be chosen reasonably. Assumptions about where to place human intrusion receptors are policy decisions, rather than technical ones, and reasonable justifications are provided.

Disruptive events considered in the scenario development (Section D.3.1.1) are reasonable, although landslide processes such as described in Chapter 3, Section 3.4.2, do not appear to have been evaluated as part of the erosion modeling. There does not seem to have been a systematic treatment of potentially relevant events and processes, but this is acceptable as long as the major events have been incorporated. Cross-references to Chapter 3 for the discussions of tornado and flood risks would be helpful.

The description of the specific scenarios is difficult to follow and would be improved by cross-referencing to the sections in Appendix H where each scenario is modeled. There should be a one-to-one mapping between Section D.3 and Appendix H, and there is not. Rather, it appears that the scenario descriptions in D.3 may not have been updated after modeling was done. For example, Table D-4 indicates that the "Residential erosion" mode was evaluated for the North Plateau. Appendix H, Section H.2.2.2.6, explicitly excludes erosion of the North Plateau from quantitative dose assessments.

Receptors and Scenarios Modeled in the Long-Term Performance Assessment (Appendix H)

Section H.1.3.1 lists the receptors and locations modeled in the LTPA. Locations are consistent with those identified conceptually in Appendix D. Locations appear appropriate, but there is insufficient specificity in the details of the on-site intruder locations. For example, simply stating "Locations …. include… Waste Tank Farm…" (Appendix H) does not provide enough information to determine where a groundwater well is placed relative to the tanks. In general, however, location of receptors (i.e., compliance points) appears to be reasonable and appropriate for all scenarios.

No justification is given in Appendix H for the locating the on-site receptor for erosion scenarios on the opposite banks of the creeks from the erosion points (Section H). Appendix D provides justification by noting that the development of steep slopes results in conditions less favorable to utilization. This may be reasonable given the stylized nature of all assumptions about human intrusion, but it is not consistent with the initial assertion that these scenarios represent the upper range of consequences.

Appendix H provides consequence analyses for three basic scenarios, evaluated at multiple receptor locations for two alternative actions: the "site-wide close in place alternative" and the "no-action alternative."

The first scenario assesses peak annual dose for 100,000 years, assuming continuation of institutional controls (Section H.2.2.1). This scenario is neither reasonable, realistic, nor on a sound technical basis, considering the time constants involved. The scenario should be reported as a stylized analysis that is conducted to provide insight into specific conditions in which human control of the site remains unchanged for 100,000 years, with full mitigation of local disruptions, but with no mitigation of off-site radiation releases. The lack of realism in this case should be noted, and it should not be used as the primary basis for decision making. Note that this is the only case considered quantitatively in Section 2.6.2 of the 2008 PDEIS, "Proposed Action, Alternatives, and Summary of Environmental Impacts" (see Table 2-B, footnote b).

Specific details of the assumptions made for the institutional control scenarios are not clear, and require explanation and justification. For example, existing maintenance activities are assumed for the no-action alternative to remain effective in perpetuity on the North Plateau, resulting in zero long-term dose from the major North Plateau source areas (e.g., Table H-21). The same assumption is not made for the NDA and SDA on the South Plateau, where existing caps are assumed to degrade after 100 years, without maintenance. Similarly, specifications of the times and amount of degradation of engineered barriers emplaced on both the North and South Plateaus for the close-in-place alternative are ambiguous.

The second scenario assesses peak annual dose for 100,000 years assuming loss of institutional control after 100 years, without erosion (Section H.2.2.2). This scenario provides a useful framework for examining consequences to intruders in the relatively near future, before erosion processes have substantially modified site topography. This is important, because intrusion at early times, while radionuclide inventories are high, has a potential to result in large doses. Placement of intruders and exposure locations appears reasonable, given the need to stylize any scenario that involves near-term loss of institutional control. The value of the scenario at later times (i.e., thousands to tens of thousands of years) is less clear, because erosion and degradation of engineered barriers may contribute to dose.

The third scenario assesses peak annual dose resulting from unmitigated erosion of the South Plateau (Section H.2.2.2.6). The time period of the simulation is not given. Groundwater pathway doses are not included, and peak doses occur relatively early, before 1,000 years. This scenario provides a useful framework for examining consequences of gully erosion. Placement of receptors is reasonable, although additional discussion should be provided for the decision not to place a resident farmer directly over the eroding waste. Additional justification should be provided for the decision to exclude erosion of the North Plateau completely from the analysis. Comparison of consequences for the second scenario (loss of institutional control, no erosion) for the resident farmer using water contaminated by the waste tank farm (Table H-41) for the Close-in-Place and No-Action Alternative suggests that the engineered barriers at the waste tank farm are a critical factor in reducing consequences. Could erosion of the North Plateau compromise those engineered barriers, resulting in larger consequences? Erosion is predicted in this scenario to reach the SDA and NDA within several hundreds of years. Comparable erosion on the North Plateau could have significant consequences, and the decision to exclude it should be justified with more information than is provided in Section H.2.2.2.6. The sensitivity analysis that addresses erosion damage to the engineered barriers at the waste tank farm (Section H.3.6) is not sufficiently well documented to answer questions about the potential importance of erosion on the North Plateau. Note that the dose estimates for intact and degraded slurry walls given in the text (188 and 6960 mrem/yr, respectively, Section H.3.6) do not agree with those given in table H-67 (145 and 149 mrem/yr, respectively).

The erosion scenario is presented (Section H.2.2.2.6) as a "bounding erosion scenario." It is difficult to see what is bounded, given the exclusion of the North Plateau and the statement, already noted, that for "unmitigated erosion … a 'best-case' estimate is presented" (H.2.2). It would be better to characterize this scenario as “a stylized representation of possible consequences following gully erosion of the South Plateau.”

Consideration of the possible interactions between the second and third scenarios is missing from Appendix H. In general, consequences of the two scenarios to downstream receptors should be additive because they address different release pathways. Results are not presented in a way that allows summing. Peak consequences from the two scenarios occur at different times, however, so summing consequences may not change conclusions.

The LTPA does not include a discussion of the probabilities associated with the three scenarios. Although determining scenario probabilities is part of the EPA and NRC’s methodology for long-term performance assessments for geologic repositories (40 CFR 191, 40 CFR 197, 10 CFR 63), the decision to present the scenario results in Appendix H without probabilities is appropriate. Unlike scenarios defined by rare disruptive events, the distinctions between these scenarios are driven by assumptions about the nature of future human actions that are essentially unknowable, i.e., the extent to which institutional controls will remain effective in the future. The first scenario, continuation of full institutional control forever, is not realistic. Neither, however, is it realistic to assume that institutional controls will cease totally after 100 years, as is assumed in parts for the second and third scenarios. The actual times at which institutional controls will fail, and the ways in which they will fail, are not something the LTPA can reasonably evaluate. It makes sense, therefore, to present decision makers with separate scenario results conditional on different stylized assumptions about the time and nature of failure. It would be helpful if text in Appendix H, Chapter 4, and Chapter 2 qualitatively addressed the reasoning behind the presentation of conditional, rather than probability-weighted, scenario results.

5. FINDINGS AND CONCLUSIONS

The IERT review has identified the following findings with respect to exposure locations and scenarios in the 2008 PDEIS.

1. The determination of the point of compliance, while defined by the regulatory authorities, is also subject to negotiation and exceptions for valid reasons. While the locations for the off-site points of compliance are stated, it is not always clear that this represents the point of highest dose as it is based on the concentration of radioactive materials. They all have different degrees of mobility, bioavailability and impact on the body.
2. While the local point of compliance is the intersection of Buttermilk and Cattaraugus Creeks and groundwater is not assumed to be a pathway in the near term, the person considered to have the highest potential dose gathers his drinking water from groundwater seepage.
3. While the Seneca Nation is treated as a special case because of the possibility of higher consumption of fish than the default amount, it does not appear that the possibility that people near the site might also have a diet richer in fish than the default amount was investigated.

4. The scenarios and receptor locations selected for the LTPA could be adequate to inform the EIS decision making process if the technical bases for the selection and modeling of the erosion and intrusion scenarios are sound. However, some aspects of the technical bases for the scenarios, for example the decision to exclude erosion from the North Plateau, are insufficiently justified and possibly wrong.
5. The scenario carried forward into Chapter 2 of the 2008 PDEIS, which assumes full institutional control and no erosion for 100,000 years, does not provide a useful representation of plausible future states of the system, and any use of this scenario should be justified on programmatic rather than technical grounds.
6. There are inconsistencies in the way assumptions about the effectiveness of institutional controls are applied across the site. Specifically, current maintenance activities are assumed for the no-action alternative with institutional controls to continue in perpetuity on the North Plateau (resulting in a zero contribution to long-term dose from most North Plateau sources for this scenario), but are apparently assumed to cease on the South Plateau, allowing degradation of the currently functioning barriers at the SDA and NDA.
7. There are inconsistencies in the results presented for scenarios assuming continuation of institutional controls. These should be rectified. *(For example, there is an apparent contradiction between Tables 2-B and H-54. These tables agree on the time-integrated population dose for the close-in-place alternative (2,100 and 36,000 person-rem at 1,000 and 10,000 years). But Table 2-B shows the collective dose for the no action alternative to be 1,800 and 37,000 person-rem at 1,000 and 10,000 years, while Table H-54 shows the collective doses to be 248,000 and 320,000 person-rem at 1,000 years and 10,000 years. Both tables indicate that their estimates are for the case where institutional controls continue. It appears that Table H-54 contains results that do not include the assumption of perpetual maintenance of the North Plateau structures that is noted in point 6 above.)*
8. Emphasis for decision-making regarding long-term performance should be placed on a combination of the unmitigated erosion and intrusion with loss of institutional control scenarios.
9. Scenarios and receptor locations used for other programmatic or regulatory purposes (e.g., for a decommissioning license termination) must meet guidance and criteria specific to those applications.

Consistent with these findings, the IERT review has identified the following conclusions with respect to exposure locations and scenarios in the 2008 PDEIS.

1. There is inadequate justification for some of the assertions in the document. Even search of the reference documents sometimes fails to find the rationale for the assertions.
2. Overall, the scenarios and receptor locations selected for the LTPA could be adequate to inform the EIS decision making process, assuming that the technical bases for the selection and modeling of the scenarios are sound. However, it is not always clear why some of the points of compliance were selected nor why some of the scenarios were rejected. Scenarios and receptor locations used for other

programmatic or regulatory purposes (e.g., for a decommissioning license termination) must meet guidance and criteria specific to those applications.

3. Some aspects of the technical bases for the scenarios, for example the decision to exclude erosion from the North Plateau, are insufficiently justified and possibly wrong.
4. There appear to be inconsistencies and contradictions in various parts of the 2008 PDEIS and supporting documents. These should be corrected so doubt is not cast on the reliability of the documents. (We understand that part of that may be due to data taken from documents that were prepared at different times.)
5. Greater emphasis for decision-making regarding long-term performance should be placed on a combination of the unmitigated erosion and intrusion with loss of institutional control scenarios.

REFERENCES

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3. U.S. EPA, Criteria for Municipal Solid Waste Landfills, 40CFR258(d)

4. U.S. EPA, Criteria for Municipal Solid Waste Landfills, 40CFR258.51(a)(ii)(2)

5. U.S. Environmental Protection Agency, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December 1989 **http://www.epa.gov/oswer/riskassessment/ragsa/index.htm**

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7. Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria (NUREG-1757, Vol. 2, Rev. 1), September 2006

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http://em.doe.gov/pdfs/07-07-10_POC_GTI_Notes_(final).pdf

9. U.S. Department of Energy, Revised Draft EIS for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center, Appendix H, Long-Term Assessment Results, 2008

10. ibid

11. ibid

12. ibid

APPENDIX A

EXCERPTS FROM CONSOLIDATED DECOMMISSIONING GUIDANCE: CHARACTERIZATION, SURVEY, AND DETERMINATION OF RADIOLOGICAL CRITERIA, NUREG-1757, VOL. 2, REV. 2

APPENDIX I

The licensee may also have to consider the impact of multiple areas of elevated concentration within a single larger area. In general, modeling two small areas independently and combining the results of the two dose assessments should result in a higher dose than if the two areas were combined and modeled as a single area. The higher dose is unrealistic in that it assumes that the receptor location relative to each contaminated area is such that the dose is maximized from each contaminated area independently. For a more reasonable estimate of potential dose, these smaller areas may be combined into a single larger area if the concentrations within the smaller areas are comparable. If this is not the case, then the licensee may model each smaller area individually and modify the scenario and critical group assumptions for each area (e.g., time spent on each area) and combine the results.

1.3 Criteria for Selecting and Modifying Scenarios, Pathways, and Critical Groups

1.3.1 Introduction

After the source term has been evaluated, the question becomes: "How could humans be exposed either directly or indirectly to residual radioactivity?" or "What is the appropriate exposure scenario?" Each exposure scenario should address the following questions:

1 . How does the residual radioactivity move through the environment?
2. Where can humans be exposed to the environmental concentrations?
3. What is the likely land use(s) in the future for these areas?
4. What are the exposure group's habits that will determine exposure? (e.g., what do they eat and where does it come from? How much? Where do they get water and how much? How much time do they spend on various activities? etc.)

The ultimate goal of dose modeling is to estimate the dose to a specific receptor. Broad generalizations of the direct or indirect interaction of the affected receptors with the residual radioactivity can be identified for ease of discussion between the licensee, regulator, public, and other interested parties. Scenarios are defined as reasonable sets of activities related to the future use of the site. Therefore, scenarios provide a description of future land uses, human activities, and behavior of the natural system. In most situations, there are numerous possible scenarios of how future human exposure groups could interact with residual radioactivity. The compliance criteria in Part 20 for decommissioning does not require an investigation of all (or many) possible scenarios; its focus is on the dose to members of the critical group. The critical group is defined (at 10 CFR 20.1003) as " ... the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances." By combining knowledge about the answers to Questions I and 2, the licensee can develop exposure pathways. Exposure pathways are the routes that residual radioactivity travels, through the environment, from its source, until it interacts with a human. They can be fairly simple (e.g., surface-soil residual radioactivity emits gamma radiation, which results in direct exposure to the individual standing on the soil) or they can be fairly involved (e.g., the residual radioactivity in the surface soil leaches through the unsaturated soil layers into the underlying aquifer and the water from the aquifer is pumped out by the exposed individual for use as drinking water, which results in the exposed individual ingesting the environmental concentrations). Exposure pathways typically fall into three principal categories, identified by the manner in which the exposed individual interacts with the environmental concentrations resulting from the residual radioactivity: ingestion, inhalation, or external (i.e., direct) exposure pathways.

As required under Subpart E, the dose from residual radioactivity is evaluated for the average member of the critical group, which is not necessarily the same as the maximally exposed individual. This is not a reduction in the level of protection provided to the public, but an attempt to emphasize the uncertainty and assumptions needed in calculating potential future doses, while limiting boundless speculation on possible future exposure scenarios. Although it is possible to actually identify with confidence the most exposed member of the public in some operational situations (through monitoring, time studies, distance from the facility, etc.), identification of the specific individual who may receive the highest dose some time (up to 1,000 years) in the future is impractical, if not impossible. Speculation on his or her habits, characteristics, age, or metabolism could be endless. The use of the "average member of the critical group" acknowledges that any hypothetical "individual" used in the performance assessment is based, in some manner, on the statistical results from data sets (e.g., the breathing rate is based on the range of possible breathing rates) gathered from groups of individuals. Although bounding assumptions could be used to select values for each of the parameters (i.e., the maximum amount of meat, milk, vegetables, possible exposure time, etc.), the result could be an extremely conservative calculation of an unrealistic scenario and may lead to excessively low allowable residual radioactivity levels, compared to the actual risk.

Calculating the dose to the critical group is intended to bound the individual dose to other possible exposure groups because the critical group is a relatively small group of individuals, because of their habits, actions, and characteristics, who could receive among the highest potential dose at some time in the future. By using the hypothetical critical group as the dose receptor, coupled with prudently conservative models, it is highly unlikely that any individual would actually receive doses in excess of that calculated for the average member of the critical group. The description of a critical group's habits, actions, and characteristics should be based on credible assumptions and the information or data ranges used to support the assumptions should be limited in scope to reduce the possibility of adding members of less exposed groups to the critical group.

ALARA analyses should use the dose based on the reasonably foreseeable land use for any cost benefit calculations performed.

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1.3.2 Issues in Selecting and Modifying Scenarios, Pathways, and Critical Groups

The definition of scenarios, identification of a critical group with its associated exposure pathways, and the dose assessment based on that definition can be generic or site specific. Licensees might:

- Use screening scenarios, screening groups, and pathway parameters as described in NUREG-1549 (NRC 1998a) and the NUREG/CR-5512 series. This can be used for either screening or site-specific analyses.
- Use the default screening scenarios as a starting point to develop more site-specific pathway analyses or critical group habits.
- Develop site-specific scenarios, critical groups, and identify associated exposure pathways from scratch.

To establish either site-specific scenarios, critical groups, and/or sets of exposure pathways, the licensee may need to provide justifications defending its selections. For some licensees, this may require minimum amounts of site-specific data to support the assumptions inherent in the existing default screening scenarios or for removing specific exposure pathways. For others, the licensee may need to thoroughly investigate and justify the appropriateness of the selected scenarios and/or critical groups, which may include evaluation of alternate scenarios and/or critical groups. If a licensee creates the exposure scenario and associated critical group based on site-specific conditions (e.g., at a site that is grossly different than the assumptions inherent in the default scenarios), the licensee should provide documentation that provides a transparent and traceable audit trail for each of the assumptions used in developing the exposure scenario and critical group [e.g., justify the inclusion (or exclusion) of a particular exposure pathway].

1.3.3 Recommended Approaches

1.3.3.1 Screening Analyses

In the case of screening, the decisions involved in identifying the appropriate scenario and critical group, with their corresponding exposure pathways, have already been made. Scenario descriptions acceptable to NRC staff for use in generic screening are developed and contained in NUREG/CR-5512, Volume 1. NUREG/CR-55 12, Volume 3, and NUREG-1549, provide the rationale for applicability of the generic scenarios, critical groups, and pathways at a site; the rationale and assumptions for scenarios and pathways included (and excluded); and the associated parameter values or ranges (only from NUREG/CR-5512, Volume 3). A summary of the scenarios is in Table 1.2. The latest version of the DandO computer code should contain the latest default data values for the critical group's habits and characteristics.

APPENDIX I

Table I.2 Pathways for Generic Scenarios

Building Occupancy Scenario

This scenario accounts for exposure to fixed and removable residual radioactivity on the walls, floor, and ceiling of a decommissioned facility. It assumes that the building may be used for commercial or light industrial activities (e.g., an office building or warehouse).

Pathways include:

- external exposure from building surfaces
- inhalation of (re)suspended removable residual radioactivity
- inadvertent ingestion of removable residual radioactivity.

Resident Farmer Scenario

This scenario accounts for exposure involving residual radioactivity that is initially in the surficial soil. A farmer moves onto the site and grows some of his or her diet and uses water tapped from the aquifer under the site.

Pathways include:

- external exposure from soil;
- inhalation to (re)suspended soil;
- ingestion of soil;
- ingestion of drinking water from aquifer;
- ingestion of plant products grown in contaminated soil and using aquifer to supply irrigation needs;
- ingestion of animal products grown onsite (using feed and water derived from potentially contaminated sources); and
- ingestion of fish from a pond filled with water from the aquifer.

I.3.3.2 Site-Specific Analyses

Site-specific analyses give licensees greater flexibility in developing the compliance scenario. The licensee should justify its selection of the compliance scenario based on reasonably foreseeable land use at the site. The compliance scenario should result in an exposure to the public, such that no other scenario, using reasonably foreseeable land use assumptions, will result in higher doses to its exposure group(s). The level of justification and analysis provided by the licensee will be depend on the how close the analysis is to the “real” dose. The more realistic the analysis, greater degrees of justification and, potentially ancillary analyses, will be required.

J.2 Scenario, Exposure Pathways, and Critical Group

To develop the exposure scenario(s) for the critical group, the analyst should to address the following questions:

- How does the residual radioactivity move through the environment?
- Where can humans be exposed to the environmental concentrations?
- What are the exposure group's habits that will determine exposure? (What do they eat and where does it come from? How much? Where do they get water and how much? How much time do they spend on various activities?)

Again, these are not in a strict order to answer and are highly interdependent. In this example, since there is no site information that could preclude the use of a residential farmer, and this is a generic situation, the members of the critical group will be assumed to be residential farmers as described in the default exposure scenarios. It may be possible, even at fairly generic sites, to modify this assumption. For more information, see Section I.3 of Appendix I and Appendix M of this volume.

A conservative analysis could just assume all of the material was spread on the surface (Figure J.2). But by considering the other two questions, two alternate exposure scenarios can be developed: (1) leaching of the radionuclides from their buried position to the ground water, which is then used by a residential farmer; and (2) inadvertent intrusion into the buried residual radioactivity by house construction for a resident farmer with the displaced soil, which includes part of the residual radioactivity, spread across the surface (Figure J.3). The second alternative exposure scenario encompasses all the exposure pathways and, although not all of the source term is in the original position, leaching will occur both from the remaining buried residual radioactivity (if there is any) and the surface soil. Unless differences in the thickness of the unsaturated zone will make a tremendous difference in travel time to the aquifer, the ground water concentrations should be similar and, therefore, will generally result in higher doses than the first alternate scenario.

APPENDIX B

SUMMARY NOTES FROM THE 10 JULY 2007 GENERIC TECHNICAL ISSUE DISCUSSION ON POINT OF COMPLIANCE

Attendees: Representatives from Department of Energy-Savannah River (DOE-SR), DOE-Headquarters (DOE-HQ), and the U.S. Nuclear Regulatory Commission (NRC), met at the NRC offices in Rockville, Maryland on 10 July 2007. Representatives from the South Carolina Department of Health and Environmental Control (SCDHEC) and State of Idaho participated in the meeting via a teleconference link.

Discussion: DOE believes that based on the position papers provided prior to the meeting, DOE and NRC staff have many areas of agreement and no significant areas of disagreement with respect to the specific point of compliance requirements articulated in the respective DOE and NRC requirements. The NRC position paper was based on NUREG-1854 and the DOE position paper was based on DOE Order 435.1 and its associated technical basis and guidance documents.

Topics: The following three specific topical areas were discussed during the meeting:

1. NRC staff perspectives on point of compliance

2. DOE perspectives on point of compliance

3. Joint perspectives on point of compliance

Summary: The following summarizes the discussion and the principal points of technical understanding identified during the meeting, unless otherwise noted.

NRC staff perspectives on point of compliance

- NRC staff noted that the statutory authorities for both the NRC and DOE arise from the Atomic Energy Act of 1954 as amended.

- NRC staff stated that time of compliance and period of institutional control are related issues and should be integrated with consideration of appropriate points of compliance.

- NRC staff noted that it has approved technical policy positions both on point of compliance and on time of compliance, and an issue paper to the Commission (a SECY paper) may be required if it is necessary to deviate from the established NRC technical policy issues.

- NRC staff noted that the requirements of the Code of Federal Regulations, Title 10, Part 61 (10 CFR 61) are based, in part, on the expectation that low-level waste disposal sites will not be released for unrestricted use. The requirements of 10

CFR 61 were developed to provide protection from low-level waste disposal facilities, (e.g., it will generally decay to levels which pose minimal risk if disturbed within 500 years) which may be different from the residue in high-level waste tanks.

- NRC staff noted that while the point of compliance is at the 100 meter buffer zone boundary, the point of compliance can be elsewhere if adequate justification is provided.

- NRC staff stated that reliance on institutional control to restrict access can be challenging and requires justification including consideration of the consequences of institutional control failure. The Love Canal incident is a prime example of unanticipated loss of land use control and the potential pitfalls of reliance on institutional control.

- The NRC staff expressed interest in the DOE concept of institutional control flexibility in DOE Manual 435.1-1 but expressed lack of understanding as to how DOE implements it. The NRC staff is interested in a description of the DOE process for invoking and justifying institutional controls and establishing the boundaries for those institutional controls.

- NRC staff stated that long-term protection of the public should rely on site and engineered features with institutional control providing secondary protection.

DOE perspectives on point of compliance

- DOE stated that their perspective on point of compliance is derived from the DOE Manual 435.1-1, which is founded principally on the Integrated Safety Management System, is supported by sound technical bases, and is implemented with comprehensive guidance.

- DOE noted that a related regulatory regime under which much DOE remediation work is performed is Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA has requirements (implemented by the Environmental Protection Agency) for detailed land use compliance plans, land use controls, periodic reviews extending into the indefinite future, notification of land use changes, and perpetual institutional control.

- DOE stated that its Section 3116 activities at SRS will be performed consistent with Federal Facility Agreement for the Savannah River Site and the associated CERCLA and the Resource Conservation and Recovery Act (RCRA) requirements (e.g., the General Separations Area at Savannah River which includes both CERCLA and RCRA actions).

- DOE noted that CERCLA allows for imposing greater protection areas and durations when necessary for effective management of hazardous materials.

- DOE noted that it uses facility performance assessments to guide facility design, construction, and operations and uses projections of interacting source projections through composite analyses to guide larger scale site remediation decisions and policies. Employing a big picture approach (like the NRC risk-informed approach) is more likely to maximize benefit from the available funding than is addressing potentially interacting facilities individually.

- DOE noted that worker risk is an important consideration in developing and optimizing remediation plans.

- DOE stated that drawing the analogy between commercial low-level waste disposal facilities and DOE closure of tanks consistent with Section 3116 is inappropriate because the DOE closures are remediation actions, not operational disposal actions. It must be recognized that 10 CFR 61 was developed in the context of problems with commercial low-level waste disposal facilities.

- DOE stated that, in considering point of compliance, is it important to take into consideration local practices so the scenarios established for analyses will be credible, but analyses must also acknowledge that local practices could change.

- DOE noted that DOE land use commitments are driven by site-specific factors. DOE further noted that some sites, although currently not the Savannah River Site, are subject to permanent land withdrawal

- DOE noted that the manner in which cumulative impacts are addressed influences the point of compliance and should be discussed, as the NRC position on cumulative impacts may present difficulty in the point of compliance determinations. Interim cumulative projections for multiple sources are problematic when some of the sources are slated for future remediation thus reducing the projected cumulative dose.

- DOE noted that grouping of facilities has implications for both establishing the disposal boundary and for forecasting cumulative impacts. DOE requirements acknowledge that inadvertent intrusion is possible, but have justified limiting the duration of such incidents to one year.

Joint perspectives on point of compliance

- DOE and NRC staff agreed that there are regulatory regimes other than the NRC (10 CFR 61) and DOE (DOE Manual 435.1-1) that also drive point of compliance determinations.

- DOE and NRC staff agreed that a key question is how considerations of institutional control can be factored into identification of an appropriate point of compliance.

- DOE and NRC staff agreed that protection of the public in the accessible environment and protection of inadvertent intruders are both important, but there are significant differences in the protection goals and approaches for achieving them.

- DOE and NRC staff agreed that the highest potential dose outside the buffer zone may be the intersection of plumes from multiple sources thus identifying an appropriate point of compliance for multiple interacting plumes from multiple sources.

- DOE and NRC staff agreed that an alternative to protection of inadvertent intruders with institutional controls is to evaluate the protection afforded by passive engineered features that discourage intrusion into the waste matrix.

- DOE questioned whether it is appropriate to include areas of contaminant plume interaction in the buffer zone.

<u>Conclusions and Actions</u>:

- Although DOE and NRC staff agreed that deviation from the standard point of compliance at the boundary of the 100-meter buffer may be appropriate, information and analysis is necessary to adequately support such deviation. DOE and NRC staff agreed that appropriate points of compliance may depend on some site–specific considerations and may need to be addressed on a site-specific basis.

- NRC staff stated that three key questions exist. (1) How does point of compliance drive cleanup levels versus the need to satisfy Maximum Concentration Limits (MCLs) for groundwater protection? (2) What flexibility does DOE have in establishing the point of compliance? (3) What level of justification is needed to support NRC acceptance of greater reliance on institutional controls than is done for commercial low-level waste disposal facilities?

- NRC staff and DOE agreed on a proposed path forward for development of compatible NRC and DOE positions on point of compliance and institutional control: DOE plans to develop a process for justification of point of compliance and time of institutional control based on the point of compliance generic technical issue discussions. NRC staff agreed to evaluate DOE's proposal in preparation for further discussions on this topic.

- DOE plans to work with the affected sites to ensure that the generic process developed is suitable for all of the sites and reflects the NRC position paper to the extent possible.

- NRC staff plans to perform a comparative analysis of the NRC position paper and the paper DOE proposes to submit on their proposed approach to address point of compliance with the goal of developing a mutually acceptable position that is fully protective of public health and safety.

UNCERTAINTY ANALYSIS AND TRANSPARENCY

Review Team
Peter N. Swift (Lead)
Shlomo P. Neuman
Michael T. Ryan
Chris G. Whipple

1.0 2008 PDEIS SOURCE MATERIAL REVIEWED

- Chapter 2 (Part 2): Proposed Action, Alternatives, and Comparison of Environmental Impacts (file dated 7/25/2008)
- Chapter 4 Part II: Long Term Consequences (draft of 7/15/08)
- Appendix D: Overview of Performance Assessment Approach (draft of 6/30/08)
- Appendix G: Models for Long-Term Performance Assessment (draft of 6/30/08)
- Appendix H: Long-Term Performance Assessment Results (draft of 7/15/2008)

2.0 INTRODUCTION

Consistent with the overall direction provided to the IERT, this review focuses on evaluating whether the assessments presented in the preliminary 2008 PDEIS provide an adequate basis for making good decisions on how best to protect the public and the environment from harmful exposures to radiation and hazardous material.

The first portion of the review evaluates the treatment of uncertainty in the long-term performance assessment (LTPA) that supports the 2008 PDEIS, and comments on the overall transparency of the LTPA. The portion of the review considers four questions specific to uncertainty analyses:

- What is the approach taken to quantify the uncertainties associated with important risk indicators?
- Is the approach based on contemporary methods of probabilistic risk assessment?
- What are considered the most important contributors to the radiation and hazardous materials risk?
- Are the approaches reasonable considering the time constants involved?

Subsequent sections of this review comment on the sensitivity analyses documented for the LTPA, identify examples of potentially significant uncertainties that have not been evaluated, provide examples of possible nonconservatisms in the LTPA, and comment on the overall transparency of the LTPA and its treatment of uncertainty.

3.0 UNCERTAINTY ANALYSES

3.1 The LTPA Approach to Uncertainty

The 2008 PDEIS approach to understanding uncertainty in the LTPA is stated in Appendix D, Section D.3.2.3, lines 743-752. The entire discussion is reproduced here.

> Evaluation of uncertainty involves consideration of contributions from model structure, model parameters, and scenario elements (Draper, Saltelli, and Tarantola 1999). Because probability distributions of model structure, receptor behavior, and some model parameters are not available for both groundwater and erosion scenarios, a comprehensive probabilistic evaluation is not practical. Thus, a combination of conservative assumptions and sensitivity analyses were applied to investigate uncertainty associated with annual dose estimates. As a first step in the process, the nature of the model was reviewed to identify fidelity to the physical system represented by the model. As a second step, literature of sensitivity and uncertainty analysis was reviewed to survey the current understanding of model sensitivity and uncertainty. The next step comprised review of site-specific environmental conditions, closure designs and models to select as set of sensitivity cases. Results of deterministic sensitivity analysis are presented in Appendix H.
>
> Draper D., A. Saltelli, and S. Tarantola, 1999, "Scenario and Parametric Sensitivity and Uncertainty Analysis in Nuclear Waste Disposal Risk Assessment: The Case of GESAMAC," in *Mathematical and Statistical Methods for Sensitivity Analysis*, Saltelli, A., K. Chan, and M. Scott (ed.), John Wiley and Sons, Inc., New York, New York.

Consistent with this approach, the LTPA documented in Appendix H does not quantify uncertainty associated with risk. All analyses are deterministic, and rely on single choices for conceptual and computational models and single values for model input parameters. The multiple sources of uncertainty inherent in this analysis (as in any other large analysis) are largely unacknowledged, and there is no systematic discussion of how uncertainty has been characterized. Impacts of uncertainties on decision making are stated to be accounted for by conservative choices in scenario selection and modeling. For example, Section 2.8, Uncertainties Associated with Implementation of the Various Alternatives" (lines 268-270) states "The dose analysis is considered to be conservative and efforts were made to keep the level of conservatism consistent across the alternatives by using the same methods and models. Similarly, the opening section of Appendix D (line 12-13) states "a set of scenarios intended to represent the upper range of potential impacts was selected for analysis."

In practice, the 2008 PDEIS documentation does not demonstrate that the deterministic LTPA is either conservative or that it has appropriately incorporated or bounded uncertainty. No discussion is provided in Appendix H supporting an assertion that the three scenarios analyzed quantitatively, which are full institutional control for 100,000 years, loss of institutional control at 100 years with human intrusion but no erosion, and loss of institutional control at 100 years followed by unmitigated erosion, represent the upper range of consequences. On the contrary, Appendix H states specifically that, for the unmitigated erosion scenario (which taken broadly represents a plausible future state), “a ‘best-case’ estimate is presented” (Section H.2.2, line 299). In most cases, no additional justification is provided to support assertions that models and parameters are conservative, and documentation is insufficient to conclude that the chosen approach of conservatism has been implemented effectively. Examples of potentially nonconservative treatments of uncertainty are summarized in this review in Section 6.

3.2 Comparison of the LTPA Approach to Contemporary Methods of Probabilistic Risk Assessment

The LTPA approach to evaluating uncertainty is not consistent with contemporary methods of probabilistic risk assessment because the LTPA is not a probabilistic analysis. The existing LTPA approach of using detailed analysis of key processes to inform a linked system of simplified models could, in principle, be well-suited for Monte Carlo simulations using sampled values for uncertain input parameters. Conditional on the adequacy of the individual model components and characterization of uncertainties, Monte Carlo simulation would have allowed an analysis that could have both quantified uncertainty in the overall risk estimates conditional on uncertainty associated with input parameters and allowed for the identification of those uncertainties in model inputs that contribute most to uncertainty in overall performance. The existing LTPA does not make use of this approach. The adequacy of the models to represent the relevant processes has not been sufficiently documented, uncertainty in models and their input parameters has not been characterized, and models have been run deterministically, precluding a quantitative uncertainty analysis.

The conservative and deterministic approach chosen for the 2008 PDEIS is in general a poor tool for comparing costs and benefits among multiple alternatives because no information is provided about the extent to which results diverge from estimates of reality. Probabilistic approaches that focus on a meaningful display of uncertainty about a reasonable estimate of mean risk provide a better basis for comparison among alternatives, and are widely used in other analogous assessments.

3.3 Identification of Important Contributors to Risk

Documentation in the 2008 PDEIS does not specifically identify important contributors to either the magnitude of risk or the uncertainty in long-term risk. In part, this may be because the deterministic approach taken does not allow statistical quantification of the relative importance of parameter uncertainty. As discussed elsewhere in this review, the LTPA is sufficiently flawed that results should not be interpreted quantitatively and should not be relied on to support decision making directly. However, setting aside the utility of the LTPA, it is somewhat surprising that there is no discussion of insights regarding the major uncertainties contributing to risk.

As shown in the following discussion, both common sense and existing LTPA results suggest that performance will be sensitive to the effectiveness and duration of institutional controls, to the effectiveness and durability of engineered barriers, and to the rate and extent of erosion. These are potentially useful insights that are absent from the 2008 PDEIS and could inform the decision-making process.

Keeping in mind the limitations of the existing LTPA, comparison of the results from the resident farmer scenario at the waste tank farm for the no-action and close-in-place alternatives (e.g., Table H-41) provides an example of how logical insights about risk contributors could have been inferred. The annual dose 100 years after decommissioning to the resident farmer consuming groundwater 100 meters downgradient of the waste tank farms is reported for the no-action alternative to be 22,630,000 mrem/yr. The same farmer is reported to receive 527 mrem/yr for the close-in-place alternative. Regardless of the accuracy of either number and without attempting to quantify an acceptable annual dose level, an important conclusion is clear. Without engineered barriers associated with the close-in-place alternative, consequences to an on-site farmer are unacceptable. Barriers must have a very high level of effectiveness and reliability to reduce annual doses to an acceptable level.

Similarly, reported annual dose estimates following unmitigated gully erosion into the South Plateau (Table H-58) are consistent with a reasonable inference that erosion has the potential to result in large consequences at relatively early times (421 mrem/yr at 725 years in the example here). The potential importance of erosion processes is further highlighted by comparison to the previously mentioned Table H-41. What would consequences be like if gully erosion breached the waste tank farm at relatively early times, rather than the NDA and SDA? By extrapolation from the results presented in Table H-41, it appears that the annual doses would be high. Gully erosion in the North Plateau is simply excluded from the LTPA by assertion in Section H.2.2.2.6, but it is a straightforward observation to conclude that had uncertainty in erosion processes been included in the analysis, it could have been a very significant contributor to overall uncertainty. Additional insight could be provided from improved analyses if the future radioactive inventory (i.e., accounting for decay and ingrowth) was provided for each waste management area, and if results in Table H-41 were presented as time histories rather than as single-time results at 100 years. Displaying results as time histories would allow conceptual evaluation of the role of radioactive decay in reducing doses from individual sources, including the North Plateau.

A comparison between the results reported in Table H-42 and those in Table H-58 indicates that, absent erosion, the analysis estimates that only very low doses would occur to the Cattaraugus Creek receptor for the close-in-place alternative. However, if erosion occurs, dose rates in excess of 400 mrem/yr are predicted for the Buttermilk Creek resident farmer. This comparison indicates the critical questions are "How likely is erosion and how much credit should be given to measures taken to mitigate erosion?" Unfortunately, the answers to these questions are not provided.

A final example of the type of insight that perhaps could have been extracted from the LTPA comes from inspection of results for the scenario that considers cases in which institutional controls continue indefinitely (Table H-21). Current operational barrier systems on the North Plateau (i.e., "drying systems and roofs"; see footnote b to Table H-

21) are assumed to be maintained in perpetuity for the no-action alternative. This condition is clearly not possible (see the discussion of scenarios elsewhere in this review). The subsequent assumption that resulting long-term doses from the major North Plateau source areas are therefore zero is unsupportable, but it highlights the importance in the LTPA of assumptions about the essentially unknowable duration of institutional controls. It is not clear why the analyses reported in Table H-21 did not apply the same assumption to the NDA and SDA facilities on the South Plateau, which have relatively small but nonzero contributions to dose in the no-action alternative. Further inspection of Table H-21 indicates that estimated annual doses are higher for the close-in-place alternative (although still small), presumably reflecting the removal of operational barriers ("drying systems and roofs") at closure and emplacement of permanent barriers that then degrade to some extent. The assumptions made for these analyses are not clear, but the small magnitude of annual doses confirms the importance in the LTPA of the assumptions regarding long-term performance of engineered barriers.

3.4 Reasonableness of the LTPA Approach to Uncertainty

As discussed above, the approach taken to evaluating uncertainty in the LTPA is not optimal, and the implementation of the approach does not support quantitative interpretation of results. These drawbacks notwithstanding, a logical analysis of the future performance of the system could have allowed insight into possible sources of long-term risk that might reasonably inform programmatic decisions for the 2008 DEIS. Chapter 2 of the 2008 DEIS, *Proposed Action, Alternatives, and Summary of Environmental Impacts*, would be the appropriate place for those insights to be brought forward for consideration in the decision making process. The opportunity has been missed. Section 2.6.2 compares long-term impacts for each of the four alternatives formally evaluated in the 2008 DEIS: Sitewide Removal; Sitewide Close-in-Place, Phased Decisionmaking (which is proposed as the "Preferred Alternative"), and No Action. Two of the four alternatives are considered to be outside the scope of the LTPA: sitewide removal is simply assumed without justification to result in an acceptably small annual dose to an offsite receptor, and phased decision making is not analyzed because possible conditions are considered to be unknown. Consequences associated with the two alternatives that have been analyzed, close-in-place and no-action, are reported in Chapter 2 only for the scenario assuming full institutional control for 100,000 years, without human intrusion or erosion (Table 2-B). As noted elsewhere in this review, this scenario is not credible (nor is it adequately documented), and choosing it as the primary quantitative basis from the LTPA to support decision making precludes any reasonable use of LTPA insights in the 2008 PDEIS.

4.0 EVALUATION OF SENSITIVITYANALYSES SUPPORTING THE LTPA

In lieu of uncertainty analyses that quantify effects of uncertainty across a full range of model inputs, the LTPA supplements its deterministic analyses with a limited set of sensitivity analyses in which selected parameters are varied individually to specified alternative values. In general, "one-off" sensitivity analyses of this type can be useful for testing specific aspects of model behavior, or for displaying the effects of well-defined changes in the system, such as might result from an alternative specification of design parameters, but they cannot provide insight into the coupled effects of uncertainty in multiple aspects of the model. They should not be considered a substitute for uncertainty analyses.

Sensitivity analyses conducted using the LTPA, or components of the LTPA, are described in Appendix H, Section H.3. Five "key conditions or parameters" are examined: changes in the amount of precipitation, degree of degradation of engineered caps, technetium-99 retention in grout, rate of gully erosion, and the impact of erosion on engineered structures.

The analysis of changes in the amount of precipitation (Section H.3.2) is limited to a qualitative evaluation that concludes that variability in precipitation (based on the historic record) will have an insignificant impact on infiltration and groundwater flow, and that therefore quantitative analysis is not needed. Given the exclusion of climate change from the LTPA, it seems unnecessary and inappropriate to highlight this as one of the key uncertainties to be evaluated through a sensitivity analysis. Unevaluated effects of climate change on long-term performance are likely to be substantially larger than the effects of historic variability in weather. Effects of fluctuations in precipitation, with or without climate change, on gully erosion are not considered.

The analysis of degradation of engineered caps (Section H.3.3) is limited to a relatively simple demonstration that varying the design values for the hydraulic conductivity of cap components (gravel drainage layers and clay flow barriers) will change the modeled rate at which water infiltrates through the caps. Justifications for the range of values considered are not given, and changes in flow are not propagated through the LTPA model to provide annual dose estimates, limiting the overall usefulness of the analysis.

The analysis of the effects of possible retention of technetium 99 (Section H.3.4) in grout demonstrates that if distribution coefficients for technetium 99 are significantly higher than those used in the LTPA, calculations will show less technetium 99 reaching the well of an onsite resident farmer downgradient from a waste tank, and peak annual doses will be reduced accordingly. This insight may provide guidance for the design of engineered barriers surrounding the waste tanks, but the analysis seems an odd choice to be identified as a key uncertainty in the LTPA.

The analysis of sensitivity to the rate of gully erosion (Section H.3.5) demonstrates that for alternative values of the initial growth rate and downcutting rate, the calculated time for a gully to reach the NDA from Erdman Brook increases by a factor of roughly 2 to 3, and the associated peak annual dose drops by a factor of almost four. The analysis may provide information about the possible sensitivity of long-term performance to the rate of erosion, but it does not demonstrate conservatism in the base-case LTPA estimates, as asserted, because evidence is not presented to support the assertion that the base-case rates are in fact conservative for the site.

The analysis of erosion damage to groundwater flow barriers (Section H.3.6) consider the effects of possible damage to the slurry wall surrounding a single waste tank, Tank 8D-1. This analysis is potentially important, because uncertainty in the performance of the engineered barriers is likely to be one of the most important unquantified contributors to uncertainty in overall long-term risk. The discussion in Section H.3.6 does not provide information about the changes in material properties assumed in the analysis for the barrier components, and documentation is insufficient to evaluate the case further. Annual dose results presented in the text for a downgradient resident farmer, 188 mrem/yr for a degraded but undamaged barrier and 6,960 mrem/yr for a damaged barrier, respectively (Appendix H line 1129-1130) do not agree with values given in Table H-67 (145 and 149 mrem/yr, respectively).

Additional sensitivity analyses specific to the calibration of the site-scale groundwater flow models are presented in Appendix E, Section E.3.6. These analyses do not have direct bearing on the interpretation of uncertainty in the LTPA, and are discussed elsewhere in the IERT review in the context of the groundwater flow and transport models.

5.0 POTENTIALLY SIGNIFICANT UNCERTAINTIES NOT EVALUATED IN THE LTPA

Observations about the potential importance of uncertainties that were not evaluated in the LTPA are unavoidably speculative. However, consistent with the speculative observations above in Section 3.3 regarding probable important contributors to uncertainty in risk, it is reasonable to note that unquantified uncertainties associated with the rate and location of gully erosion, degradation of engineered barriers, and groundwater flow and contaminant transport associated with degraded barriers may be particularly significant. In addition to these examples, all of the many uncertain inputs used in the LTPA could be treated probabilistically, and assumptions, models, and parameter values should be applied consistently across the various model domains. The LTPA would benefit from including a full uncertainty analysis that includes reasonable and realistic ranges of values associated with the uncertainties of the following:

- The time-dependent physical and chemical properties of engineered barriers
- The rate and location of gully erosion at all locations, including on the North Plateau, and including uncertainty in extreme weather conditions
- Boundary conditions and material properties affecting groundwater flow
- Parameters used to characterize contaminant transport in ground and surface water
- The radionuclide inventory associated with each source term
- Biosphere pathway assumptions
- Future climate states and the impact of that uncertainty on erosion and groundwater flow.

6.0 **EXAMPLES OF NONCONSERVATISMS IN THE LTPA**

In addition to potentially significant uncertainties that have not been evaluated in the 2008 PDEIS, some of the deterministic modeling decisions made in constructing the LTPA appear to be nonconservative. The lack of explanation for these apparent nonconservatisms undermines the assertion in the PDEIS that the LTPA represents a conservative analysis. Examples of potential nonconservatisms include:

- The exclusion of erosion on the North Plateau from the LTPA. The statement is made in Appendix H, Section H.2.2.2.6 (lines 893-896) that "the landscape evolution model predicts … that the only place where any serious erosion would be expected in the foreseeable future would be in the SDA or NDA." This is not consistent with the statement in Appendix F, Section F.3.2.6.3 (lines 1406-1407) that "the CHILD model scenarios predict that the areas most prone to erosion are the existing gullies, the east and west rims of the north plateau, and the three Creek valleys (Franks, Erdman, and Quarry)." The IERT review comments elsewhere on the adequacy of the landscape evolution modeling to support LTPA conclusions; the observation here is simply that the justification provided in Appendix H is not supported by the conclusions of Appendix F.
- Assumptions made in scenario construction regarding the duration of institutional controls. Assertions of indefinite institutional controls (and, in the case of the no-action alternative, perpetual maintenance of some, but not all, facilities) can be presented as stylized programmatic assumptions, but they cannot reasonably be called conservative. Given that these assumptions have a major impact on the results brought forward into Chapter 2 (Section 2.6.2, Table 2-B), it is misleading to refer to the LTPA as a conservative analysis.
- Assumptions regarding degraded barrier performance. Engineered barriers are assumed to degrade to their final state 500 years after decommissioning, and then to undergo no further degradation. Chemical properties of engineered barriers are assumed to remain effective permanently.
- The exclusion of landslide processes. As noted in Chapter 3, Section 3.4.2, landslides and slope failures are an ongoing process associated with incised creeks in the surrounding region, and the decision to exclude these processes without consideration may be nonconservative.
- The exclusion of fracture pathways for lateral flow and contaminant transport in the weathered Lavery Till on the South Plateau. Fractures exist in the weathered till, and the decision to model the unit as an unfractured porous medium with relatively low permeability and high advective porosity may result in an underestimate of the extent of lateral transport of radionuclides from the NDA and SDA.
- The assumption that the permeability of the unweathered Lavery Till is low enough that flow around slurry walls and other engineered barriers keyed 2 to 3 feet into the unit will be negligible. Flow that bypasses engineered barriers through higher permeability pathways could result in significantly greater radionuclide transport.

- The assumption, made in Appendix G, Section G.3, that concentrations of contaminant released from a barrier are diluted by mixing with uncontaminated groundwater from surrounding flow tubes. Concentrations in zones of incomplete mixing will remain higher than modeled.
- The exclusion of future changes in base level for erosion models. At both local and regional scales, significant changes in base level for Cattaraugus Creek can reasonably be anticipated during the 100,000-yr simulation period, and could result in an acceleration of erosion at the site.

7.0 TRANSPARENCY OF THE LTPA AND ITS TREATMENT OF UNCERTAINTY

In general, transparency of the LTPA is poor. Based on the information provided in the 2008 PDEIS, its appendices and related documents, it is not possible to replicate independently the analyses or to otherwise understand how the results were derived. Incomplete documentation in many cases precludes understanding what was actually done in the LTPA and prevents a detailed evaluation of the analyses.

Documentation of the LTPA would benefit from clear descriptions of the component conceptual models, assumptions made in constructing the models, their mathematical formulations, and identification of input parameter values for each modeling case. Existing documentation presents general methodology in Appendix D, component model descriptions variously in Appendices E, F, and G, and descriptions of simulation cases in Appendix H. Detailed cross-referencing between these appendices would improve transparency of the analyses, but additional information not currently included in any portions of the PDEIS is needed to evaluate the design and parameterization of the analyses. Transparency in the presentation of model implementation would be improved by providing full specification for each simulation case of the relevant assumptions, initial and boundary conditions, and all input parameter values, with references to source information. In general, this information is lacking throughout. Transparency in the presentation of results would be improved by displaying results of all modeling cases in the same formats; for example, 100,000-year annual dose histories for selected receptor locations could be presented for all cases so that readers could readily compare results among the scenarios.

8.0 CONCLUSIONS REGARDING UNCERTAINTY ANALYSES AND TRANSPARENCY IN THE LTPA

The LTPA does not include quantification of uncertainty in risk and is not consistent with approaches taken in probabilistic risk assessments. Available documentation suggests some potentially significant uncertainties have not been evaluated. Assertions that other uncertainties have been bounded conservatively are not justified. Transparency of the LTPA is poor, and it is not possible to replicate independently the analyses or to otherwise understand how the results were derived. Given these observations, quantitative results of the LTPA presented in Chapter 2, Chapter 4, and Appendix H should not be used to support decision making associated with the PDEIS.

APPROACH AND COST OF NDA, SDA, AND HLW EXHUMATION

Review Team
Jimmy T. Bell
Frank L. Parker
Chris G. Whipple

1. INTRODUCTION

The following portions of the 2008 Preliminary Draft Environmental Impact statement (2008 PDEIS) documentation provide the primary source material for these reviews:

- Appendix C – Existing Facilities, Implementation of Decommissioning, and New Construction
- Methodologies and Facilities Technical Report
- Site-Wide Removal Technical Report

The remainder of this review is divided into three sections. Section 2, prepared by Jimmy T. Bell and Chris G. Whipple, contains a summary of the proposed exhumation approaches, with comments for each of the three primary waste areas potentially subject to exhumation (the NDA, the SDA, and the High-Level Waste Tanks). Section 3 contains a separate review provided by Frank L. Parker; and Section 4 contains a set of findings that summarize the overall review.

2. PROPOSED APPROACHES TO EXHUMATION OF THE NDA, SDA, AND HLW TANKS

Review by Jimmy T. Bell and Chris G. Whipple

This section of the review summarizes the proposed Approach and Cost for Exhuming the NDA Site (WMA-7), the SDA (WMA-8) and the High-Level Tank (WM-3) waste. In the 2008 PDEIS, this is treated as part of the Site-Wide Total Removal Alternative (STRA); therefore this review is based on the assumption that this alternative has been selected, and we consider only that approach.

2.1 NDA EXHUMATION

This analysis uses the information from the 2008 PDEIS and, specifically, the description of the STRA. The NDA burial ground includes NFS Deep Holes, NFS Special Holes and the West Valley Demonstration Project (WVDP) Burial Trenches. The total volume of NDA waste is 361,000 cubic feet, with a total activity of 298,000 curies. Hence, the average activity of the waste is 0.83 Ci per cubic foot (per the URS report). Most of the waste is soil (121,000 cubic feet) and is Class C waste. Other waste in this area is reported to be Greater Than Class C (GTCC).

A small amount of spent nuclear fuel (12 cubic feet) with a high activity (12,316 Ci per cubic foot) is included in the NDA. Also, 7,266 cubic feet of hardware with an activity of 196,000 Ci is included. All of the other waste here (354 cubic feet) has activity less than 1 Ci per cubic foot. These differences in activity suggest that removal of the lower volumes of wastes with high activity could reduce the NDA source term to more acceptable limits. However, the STRA proposes total removal of all NDA wastes.

The cost for exhuming the NDA waste is given as $924 million (per STRA Technical Report). This cost will be a significant portion of the total projected West Valley remediation cost of $9.6 billion. It is noteworthy that the pre-remediation construction cost is about $41 million, or less than 5% of the total cost. The most costly portion of the STRA for the NDA would be the removal and disposal of the overburden and the backfill operation, which is estimated to cost $777 million, or 84% of the total NDA cost for this waste management alternative. It is also worth noting that the credibility of these cost estimates has not been established. We need to verify that the cost estimates were generated by a qualified engineering firm with experience in radionuclide operations.

The remainder of this analysis of the STRA approach and costs for remediation of the NDA will, in the following numbered paragraphs, review the operational approach and then provide comments keyed to these paragraph numbers.

(1) The first item proposed in this approach is construction of a large building, the Environmental Enclosure, over the waste burial holes. This 134,590-sq ft enclosure would have 1-ft-thick reinforced concrete walls, and would be equipped with an HVAC system having HEPA filtration. A gantry crane with a closed-circuit television capability would enable remote operations.

(2) In addition, a Container Management Facility (CMF) would be built for the dual purpose of preparing the removed wastes from the NDA and the SDA for transportation. A third building (a leachate treatment facility) would be constructed on the SDA site and would treat leachate materials from either or both sites.

(3) After construction of these buildings, the exhumation would begin. The NFS Deep Holes, the NFS Special Holes, and the WVDP Burial Trenches would require different equipment and operations and, thus, are separately considered.

(3a) **The NFS Deep Holes**: These holes contain Class C and GTCC wastes and will require that waste removal be contained. A special containment system, a modular, shielded exhumation enclosure (MSEE), is used over each hole. The subject hole would first be prepared with sheet piling to avoid cave-in, then the MSEE would be placed over the sheet piling by the overhead crane system. Waste from the holes and the piling sheets will be placed in 55-gal drums and removed using the MSEE hoist and the remotely operated crane system. Apparently the drums are to be transferred in a remote manner to the CMF and from there to an unidentified repository. Any leachate encountered during exhumation would be pumped to the Leachate Treatment Facility.

After a hole is excavated, the soil between holes is to be excavated as low-level waste and all equipment is to be moved to the next hole.

(3b) **The NFS Special Holes**: Most of these holes contain lower levels of activity than the Deep Holes, and the excavation is to be done under a HEPA-filtered, ventilated, confinement tent structure. Particular holes with GTCC waste would be exhumed using the processes used for the Deep Holes. The soil overburden (4 feet deep), would be excavated and managed as low-specific–activity waste. Excavation from these holes is somewhat described in Appendix C of the 2008 PDEIS, but the description could be better written. In essence, the waste is removed from each hole, placed in covered transfer boxes, and transferred to the CMF. There the waste is prepared for the appropriate repository destination. Any exhumed leachate is pumped to the Leachate Treatment Facility. After the excavation of each hole is completed, the temporary confinement tent is dismantled and reset over the next of these holes.

(3c) **The WVDP Burial Trenches**: Trenches 1-7 will be exhumed in the same manner as the NFS Special Holes. Trenches 8-12 will be excavated in a less-robust structure, the WVDP Disposal Area Confinement Structure, located in the courtyard area of the Environmental Enclosure. These Trenches 8-12 will be housed in a conventional steel building with HEPA filtration. The excavation operations are contact handled, using heavy machinery. The low-level waste materials are packaged for disposal in a repository.

Comments

The review team generally agrees that this approach for exhuming the NDA will lead to closure. We also agree that this is likely to be the most expensive approach to that task, and that we could offer acceptable approaches that would result in lower overall costs. The most expensive item in the STRA approach is the removal and disposal of the overburden, and the cost of this item can be changed significantly only by retaining part of the LLW onsite. In addition, this group believes that seepage from the NDA will likely cause this effort to be greater than that described in the 2008 PDEIS, and this may suggest that a pristine condition for the site cannot be achieved at the cost estimated. A more realistic estimate for returning the area to a pristine condition is probably about $1 billion. This estimate is affected only slightly by the containment costs, but is largely dependent on the removal and disposal of the overburden and the backfill operation. In brief, the approach identified for exhuming the NDA site appears appropriate, but will also be very expensive. The methods for the NFS Special Holes are not fully defined, but if there is a failure, the MSEE technology could be used for all of these holes.

A major issue in this strategy requiring the total removal for NDA closure is the volume and costs of the wastes generated. Much of the cost is for the overburden removal and disposal, since this will be considered low-level waste (LLW). While the overburden waste removal may be a necessary part of this alternative, it should not be necessary for other alternative remediation strategies. Also, if the overburden soil could be retained onsite, this would be more cost-effective than disposing of the entire overburden as LLW.

The total containment proposed for the NDA site (see paragraph 1 above) will be very expensive (estimated cost of ~$50 million in the STRA Technical Report). This cost estimate is undoubtedly lower than actual costs, if the estimates used costs of concrete and rebar at $69/cubic yard and $61/ton (the values used in the Facility Description and Methodology Technical Report), rather than more realistic values of today, which would be ~$130/cubic yard for concrete and $1,200/ton for rebar. The large differences in these costs calls into question the total integrity of the cost estimates.

The costs of construction and demolition of the buildings suggest that a less-rigid containment might be used, which could be equally effective and less expensive. This would work favorably for removal of the overburden, but would not affect the larger disposal costs. Hence, a cost reduction of 2-4% might result, but the error margin on the total NDA cost estimate is probably plus or minus 20%.

Another factor to consider is that the STRA approach to NDA closure will generate wastes that cannot be sent off-site at this time. The TRU waste and the GTCC waste will stay on-site until a repository is available and will accept it. This will add to the on-site storage requirements and will require additional storage facilities which are not included in the STRA cost estimates (the vitrified HLW is already on-site and also requires a new facility). Our understanding is that the projected capacity of the first Yucca Mountain HLW repository is already designated, and the only space for the West Valley HLW or GTC waste would be in a second repository if and when it becomes available. This means that West Valley would probably need to store the HLW, the TRU, and the GTCC waste on-site for as long as 100 years.

In summary, the costs alone for the STRA discourage the selection of this alternative. The need for future on-site storage of the generated waste from this alternative is also a discouraging factor.

2.2 SDA EXHUMATION

Description of Exhumation Approach and Cost

This section of the report reviews the Approach and Cost for Exhuming the SDA Site Waste (WMA-8) information from the 2008 PDEIS. In the 2008 PDEIS this is treated as part of the description of the STRA; therefore this report is based on the assumption that this alternative has been selected, and we consider only that approach.

The SDA burial ground includes 14 trenches. Trenches 1-7 comprise the North SDA, and contain some waste that is greater than Class A. Trenches 8-14, which also contain waste greater than Class A, make up the South SDA. The total volume of waste in the 14 trenches is ~2.4 million cubic feet, with a total activity of 0.13 million curies. The average activity of this waste is, therefore, about 0.05 curies per cubic foot.[7]

[7] SDA Radiological Characterization Report, URS Corporation. September 2002.

The total SDA inventory has been sub-divided into waste classes, and several portions of the SDA were identified as containing GTCC waste. However, the location of the GTCC is not identified such that the GTCC could be separately removed. The volume of the GTCC and its associated activity are given, and the average maximum activity of the GTCC is ~2 curies per cubic foot (~ 60 curies per cubic meter).

The approach for exhuming each of the North and South SDA trenches is similar, except in size of the project. Environmental enclosures would be built for each of the areas. The North SDA enclosure would be 155,800 square feet (205 x 700 ft) and would be 35 ft high. The South SDA enclosure would be 244,950 square feet (345 ft x 710 ft) and 35 ft high. The exterior walls would be 1-ft thick reinforced concrete. Each enclosure would have a metal roof with gutters. Each enclosure would also have an HVAC system with HEPA filtration and a gantry crane system.

The SDA Environmental Enclosures would be constructed over the North SDA and over the South SDA. The order of constructing the two enclosures is not significant, and the actual exhumation may begin when one of the environmental enclosures is completed. The implementation of the trench remediation would proceed as follows:

1. The overburden soil (about 12 feet) will be excavated, placed in appropriate containment, sampled, (for transportation purposes), and transferred to a commercial low-level rad-waste repository.
2. Sheet piling will be driven on each side of the trench to a depth of about 1ft below the base of the planned excavation. An Exhumation Enclosure is to be installed immediately over the trench, but there is no description of this enclosure or of how the gantry crane operates with it.
3. The waste is exhumed from the trench by a remotely operated gantry excavator with closed-circuit cameras. Large components will be sheared into smaller pieces for transfer.
4. All material in each trench and between the sheet pilings would be excavated and placed in appropriate containers. The filled containers would be transferred to the CMF for processing, packaging, characterization, and off-site transport. The means of transportation to the CMF is not discussed. Although the CMF is located near the trenches, some kind of truck or other machine will be required to move the SDA waste to the CMF. This will also require containment and deserves consideration.
5. The trenches have some liquid components called leachates. The 2008 PDEIS, Appendix C says the leachates will be removed from the SDA trenches and pumped to leachate treatment. The nature of the leachates is not well defined, and the pumping system from the trenches to a treatment facility is not described.
6. After the waste from a trench has been removed, the Exhumation Enclosure will be removed to another trench. The sheet piling will also be removed and later re-used.

7. After all of the 14 trenches have been treated, the Environmental Enclosure will be decontaminated and removed.

The planned approach for exhuming the SDA trenches is quite good, but will also be very expensive. Several details, as noted above, require additional consideration and definition. However, there is no reason to doubt the total effectiveness of the plan. No time frame for the SDA exhumation is given in the 2008 PDEIS.

Cost estimates for exhuming the SDA site trenches are given in the Technical Report for the STRA. The number of large containment buildings in the planned approach is alarming, and the associated costs will be equally alarming.

1. **The Containment Management Facility**. This will be a 130,000-sq ft facility that will serve both the SDA and NDA sites. So about one-half of the cost will be added to the SDA cost.
2. **The Leachate Treatment Facility**. Again, this facility supports remediation of both the SDA and the NDA sites. About half the cost of this facility would apply to the cost of remediating each site.
3. **The North Environmental Enclosure**. This is a containment canyon with an area of 155,800 square feet, and a height of 35 feet. The construction and the decontamination and decommissioning (D&D) costs are estimated to be $52 million and $110 million, respectively.
4. **The South Environmental Enclosure**. This is a containment canyon with an area of 244,950 square feet and a height of 35 feet. The total construction and D&D costs for the above proposed buildings are estimated to be $61 million and $149 million.

Estimated costs for exhuming the SDA waste are given in the Technical Report on STRA as $1.85 billion. It is, therefore, a significant portion of the total estimated West Valley remediation cost of $9.6 billion. Analysis of the estimated costs shows that the construction of two containment buildings is projected to cost $112 million, or about 6% of the total project cost. This is important because the cost of these rigid buildings leads to a question about overpricing of the total estimate for the excavation. A change to less-rigid containment could be considered, but it would only reduce the total cost by a relatively small amount, within the error range. The demolition costs of a rigid structure should also be considered, and we have assumed that the demolition costs for the rigid structure will approximate the construction and demolition costs of the suggested less-rigid structure.

Comments

A breakdown of the STRA strategy for exhuming the SDA waste clearly shows that the cost driver in these estimates is the removal and disposal of the overburden and the backfill operation ($1.42 billion). This is 77% of the total cost estimate, with a contingency of $399 million (28%). The estimated costs are given with large contingencies, and we must question the credibility of the estimates. We need to know whether these estimates were made by a qualified engineering firm with experience in radionuclide operations. Were the estimates prepared with input costs given in the Facility Description and Methodology Technical Report? That report quotes the price of concrete and rebar at $69/cubic yard and $61/ton, respectively. Recent prices for these materials (telephone conversations with local providers) indicate $130/cubic yard for concrete and $1,200/ton for rebar. This leads us to question all of the material prices used in preparation of the STRA cost estimates.

Another factor to consider is that the STRA approach to SDA or WMA-8 closure will generate wastes that cannot be sent off-site at this time. The TRU waste and the GTCC waste will stay on-site until a repository is available and will accept it. This will add to the on-site storage requirements and will require additional storage facilities. Our understanding is that the projected capacity of the first Yucca Mountain HLW repository is already designated, and the only space for the West Valley HLW or GTC waste would be in a second repository, if and when it becomes available. This means that West Valley would probably need to store the HLW, the TRU, and the GTCC waste on-site for as long as 100 years.

In summary, the costs alone for the STRA are a discouraging factor for the selection of this alternative. The need for future on-site storage of the generated waste from this alternative is also a negative consideration.

In our view, the approach described in the STRA Technical Report would work, but it is possible that simpler and less expensive approaches are also feasible. In particular, the need for a secondary containment structure to prevent air emissions should be further evaluated and less complicated methods for confining contaminants should be considered.

2.3 HLW EXHUMATION

Description of the Exhumation Approach and Cost

This section of the report reviews the Approach and Cost for Exhuming the HLW Tank Waste (WM-3), using information from the 2008 PDEIS. In the 2008 PDEIS this is treated as part of the description of the STRA; therefore this report is based on the assumption that this alternative has been selected, and we consider only that approach.

The high-level waste (HLW) tanks at West Valley are identified as 8D-1 through 8D-4. For purposes of this discussion, they will be called Tank 1 through Tank 4. Tanks 1 and 2 have capacities of 750,000 gallons each, while Tanks 3 and 4 have capacities of 15,000 gallons each. Tanks 1 and 2 have residual waste, with the major portions having been previously removed for vitrification. The activity of the residuals in these two tanks is 300 to 400 kilocuries. Tank 3 has not been contaminated, but Tank 4 contains about 10,000 gallons HLW from processing thorium fuel, and the activity of the HLW totals about 5 kilocuries. Tanks 1 and 2 may be considered the most hazardous of West Valley wastes requiring remediation; they contain about half of the total activity of the site and, are, therefore, an important subject for discussion.

The HLW tanks are numbered 1-4, with the larger tanks, 1 and 2, having greater volumes. Most of the activity is inside the tanks, with the greatest portion in Tank 2, as a result of the previous processing. The tanks are being dried to the point of zero liquid contents. The distribution of nuclide activities in Tank 2 is not given, but after all water is removed the total inventory will exist in solid phase.

The total estimated residual activity in the Waste Tank Farm (350,000 Ci) is given in Appendix C of the 2008 PDEIS. The activity includes all of the radionuclides associated with spent nuclear fuel and the ratios of various radionuclides are in accord with spent nuclear fuel. Hence, the total inventory of the tanks can be used to determine the future tank farm management. The error in the estimate of 350,000 Ci could be ~50,000 Ci. Any management decision could be the same for either 300,000 Ci or 400,000 Ci. One other important piece of information from the inventory studies is that almost all the activity in the tanks is from Sr-90 and Cs-137. Out of roughly 350,000 Ci, the estimate reported in Appendix C is that only 1260 Ci are from radionuclides other than Sr-90 and Cs-137. These two radionuclides have similar half-lives of about 30 years. This means that over the 60-year life of the tank farm removal, the inventory in the tanks would decay from 350,000 Ci to about 87,000 Ci. While this is still a large amount of activity, it also reflects a significant decrease.

The calculation of the dose to humans depends on the inventory of radionuclides, the technologies selected for their removal or fixation, the source term (release rates of radionuclides, including their physical and chemical forms), and radionuclide transport to the accessible environment. As noted in the IERT review of engineered barriers, the relatively rapid decrease in activity in the tanks suggests that a key question for alternatives that do not exhume the tanks is whether institutional controls can be relied on for the approximately 300 years required for the activity of Sr-90 and Cs-137 to decay to very low levels. There would still be the issue of the long lived radionuclides and their impact on radiation dose.

The first step of this scenario's approach is the proposal to build a containment building over the entire tank farm area. This building would be 265 feet x 150 feet, with a height of 87 feet. This would be very similar to a reprocessing canyon. There would be a RH work cell (150 ft x 45 ft) and conventional auxiliary buildings of similar dimensions. This approach, using a process canyon and auxiliary buildings may be necessary for this particular scenario. The estimated cost for design, construction, and commission is given as $210 million,[8] and as $192 million and $189 million in Table 3-18 and Table 3-19 of the STRA Technical Report. It would require several years (2 or more) for construction and set-up prior to an estimated 13-year operating period. After operations are completed, the facility would be decommissioned and removed. This would require about 2 more years and an estimated cost of ~$200 million. The total remediation time would then be about 17 years, with a total estimated cost of about $834 million; i.e., ~$49

[8] Kurasch, D.H., Summary Considerations for the Selective Removal of Tank 8D-3. June 2007.

million per year. One can assume that this $49 million is part of the total estimated $160 million per year cost for the complete scenario, and also assume that this would be performed concurrently with other remediation work.

After the containment canyon is commissioned, operations would begin and continue for an estimated 13 years, at an annual cost of $49 million. The operations inside the containment canyon are independently considered below.

1. Removal of the existing above-ground superstructure over the tanks. Appendix C indicates manned and remote-operated equipment. It does not indicate that the manned operation is limited to the removal of non-contaminated items before contaminated items are addressed. Most of this equipment will be contaminated and will require disposal. Where will this disposal be done?
2. The soil above and around the tanks will be removed and packaged for off-site disposal. This will require remote operations because the operation site will have been contaminated by the removal of the above-ground superstructure.
3. Removal of the residual waste from Tanks 1 and 2 will follow the complete removal of the vault roofs and the tank tops. This removal must be done using standard established remote operations techniques and is rather straightforward.   By the time of exhumation, the residual waste will be in solid form and is to be removed by a "Dislodging and Conveyance System." This system is not described; if it is to be developed, the development and demonstration costs will be significant. A considerable amount of tank washing will be required before destruction of the tanks. This washwater must be managed, but the washing operation is not discussed. Management of the washwater will also add to the estimated remediation expenses. Any solids-liquid separation system will work, but the immobilization of the transuranic waste must follow the criteria for the designated disposal site. It is uncertain that the grout-filled drums will meet disposal criteria for transuranic waste (Appendix C).
4. After Tanks 1 and 2 are cleaned, they are to be segmented and packaged for shipment to a repository. Further washing of the tank parts may be necessary to minimize the transuranic waste. All washing of radioactive components requires an evaporator for water removal and residue collection. Has an appropriate evaporator been identified?
5. Tank 3 is not contaminated except by association with Tank 4, which contains the process waste from thorium fuels. Tank 3 may be of use in the remediation of Tank 4, therefore Tank 4 remediation should precede Tank 3 removal. The removal of residual liquid and solids from Tank 4 cleanup would follow the routine used for Tanks 1 and 2. There should be no problem in removal of the vault and Tanks 3 and 4.   Filling the holes after removal of the tanks would use only conventional technology and requires no discussion. It might also be wise to address Tanks 4 and 3 before beginning work on the larger Tanks 1 and 2. The experience gained on remediation of the smaller tanks could be valuable for addressing the larger tanks.

Comments

Currently the technologies for remediation of the HLW tanks have not been sufficiently identified or described. Specifically, the technologies for waste removal from the tanks should be better described, and the problems of transferring the solid-liquids waste from the tanks should be recognized and resolved. Will the tanks be washed before and after exhumation? How will the washing be done, and how will the washwater be managed? Is there a plan to try to remove the Sr-90 and Cs-137 from the tank components, so that the quantity of HLW may be reduced? If so, have any studies or experiments been done to address the form and behavior of these materials?

The position of the STS Support Building within the process canyon and the management of the ion-exchange columns must be better defined. Also, decommissioning of the STS facility inside the process canyon should be more completely described. A strategic plan for the order of addressing the farm tanks should be considered, with respect to training and experience. Also, time for implementation of this plan within the 60-year time frame should be identified as priority one.

Several areas discussed above appear to indicate cost estimation deficiencies. A thorough study of the technology and management costs could lead to a significant increase in estimated costs, perhaps as much as ~$2 billion.

The canyon structure, the Waste Processing Facility (WPF), over the tank farm, having 4-ft-thick concrete walls has a construction cost estimate of $189 million, an operations estimate of $427 million and a WPF demolition cost estimate of $180 million. No cost estimates for waste disposal appear in Table 3-19 of the Technical Report except for the "Removal of Surface Structures," estimated at $12 million. Other wastes, including Class C (9,000 cubic ft) and TRU (11,000 cubic ft) are noted in the text. These wastes, at disposal costs of $700 and $2,300 per cubic ft, respectively, amounting to $6.3 million and $25.3 million, respectively, for a total of $31.6 million, are not included in Table 3-19.

The major driving force for costs is the item identified as "operations" at $427 million, or 51% of the total estimate. The construction cost for the containment canyon (WPF) is 23% of the total estimated cost. Reducing the size of this containment facility and decreasing the wall thickness, assuming such reductions were consistent with results of an As Low As Reasonably Achievable (ALARA) analysis and that applicable dose limits were met, could save perhaps $100 million. (The process canyon for processing spent nuclear fuel at a capacity of 800 tons per year has a wall thickness of 5 ft.) The demolition costs for a smaller-scaled facility would also be considerably less.

The estimated $834 million total cost for exhuming the HLW tanks is likely very low for the STRA. It appears that the waste disposal costs were not included. In addition, the management for execution of this task has not been considered. Would management be contracted to companies outside the present operations? Has a management cost been considered in the estimated total? Could the present operations management be expanded to handle this task? If so, what would be the cost of that option?

The containment canyon for HLW tank remediation may be more than is necessary. First, the average thickness of the walls need not be 4 ft. A wall thickness of 1 ft should be sufficient, although this needs to be confirmed by analysis. Secondly, the vast containment area (37,750 square feet) could be decreased to an area just sufficient to cover Tanks 1 and 2. The above-ground structure could be removed without an overbuilding. Third, Tanks 3 and 4 could be remediated under a flexible building. Fourth, existing buildings could be used for chemical and physical treatment of the waste. Fifth, the operations cost should be reduced. The total cost of $834 million for WMA-3 closure, as proposed for the STRA discussed in the 2008 PDEIS is likely too low, but with the changes enumerated here, it could probably be implemented at about $800 million.

3. EXHUMATION of TANKS, NDA AND SDA at the WEST VALLEY SITE

Review by Frank L. Parker

3.1 General Comments

A. Lack of Information on How Decisions Were Made

The Department of Energy Office of Environmental Management (DOE-EM) at West Valley is neither following its own protocols nor its own best practices in the EIS and other documents. For example, the DOE-EM documentation is unsatisfactory as it is primarily assertions without the backup to show logically how those decisions were reached. Contrast those documents with the Critical Decision-1 Document for the Integrated Facility Disposition Project at DOE Oak Ridge Office (DOE-ORO). The following excerpts are taken from its Executive Summary, May 30, 2008.

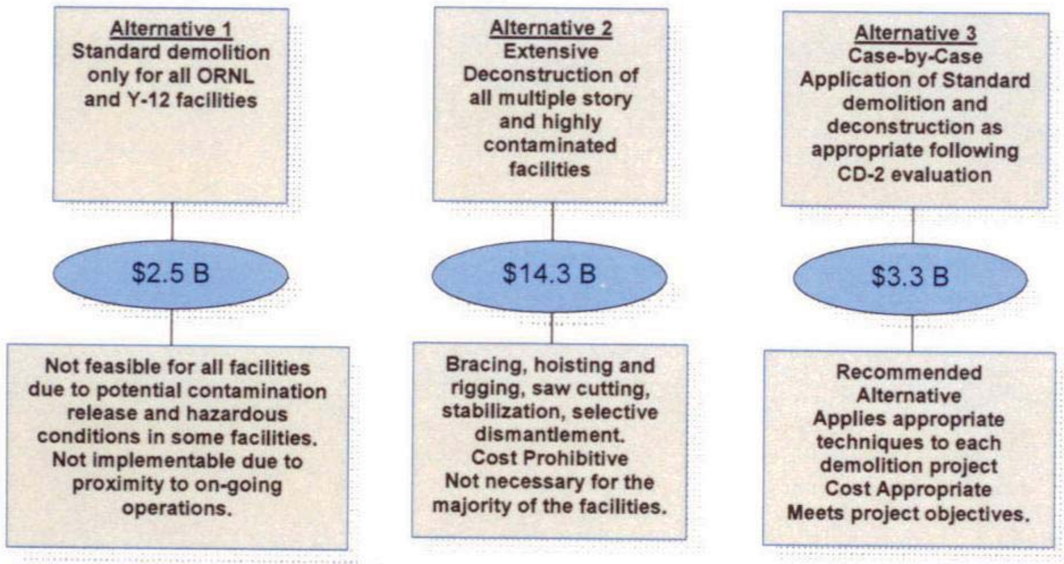

Figure 8. D&D Alternatives

Integrated Facility Disposition Project Executive Summary

Similar analyses were made for the Remedial Action Alternatives, Waste Disposal Alternatives and New/Reconfigured Alternatives with the details and rationale provided. Such material is missing from the documents furnished to NYSERDA.

B. Period of Time of Detailed Project Information

It is difficult to make accurate projections of the cost and actions over the long period of time, greater than 60 years, for some of the actions needed at West Valley. These difficulties were not discussed in the report. However, as shown below, DOE-EM has recognized this and has provided a phased approach of five years at a time to reduce the uncertainty as shown below. Note that the estimated cost **range** for the entire project must be given rather than a single deterministic cost as in the West Valley documentation. A cost estimating model was used and a probabilistic approach taken to determine the range of costs.

"In accordance with DOE-EM protocol for environmental cleanup projects spanning many years, the IFDP has adopted a phased approach which includes executing the IFDP scope in sequential five year phases. The phased approach is used to define and obtain CD-2 and CD-3 approval of the near term baseline (normally five years). For the remaining portion of the life-cycle, a reasonable cost range is determined."(PHASED CD-2/CD-3 APPROACH (ftp://ftp.p2s.com/CD-1%20Final%20Document_5-30-08/) Page 7 Executive Summary)

C. Cost Analyses

"All unit prices were determined in 2008 dollars; thus all estimated costs are in 2008 dollars." (Facility Description and Methodology Technical Report WSMS-WV-08-0001, JUNE 2008, p. 104). Therefore, the STRA Technical Report shows only unescalated costs. That is not sufficient. One should also have a present value cost and an escalated cost as they provide different perspectives on cost. I believe that it is necessary to determine a life cycle cost, recognizing that the costs are much less certain as they are further projected in the future, as otherwise it is not possible to compare the various options. As noted in the previous section, these costs should be revised at least every 5 years and the out year's costs should have a "reasonable cost range" and not a single value as shown in the STRA Technical Report. As noted in the CD-1 report, it is stated **"**The current IFDP Life-Cycle Cost Estimate was prepared for preliminary planning purposes and is considered appropriate for CD-1. The CD-1 unescalated point cost estimate for IFDP is $5.72 billion, as shown in Figure 12. The CD-1 cost range is $5.15B to $7.97 billion. The schedule duration is 26 years." (BASIS OF ESTIMATE RANGE, page 13). They also noted "Based on this direction, the IFDP CD-1 approach was to conduct the analysis and prepare the conceptual designs necessary to evaluate alternatives and establish a reasonable cost range for the entire project, then to perform detailed schedule sequencing analysis to define the specific subprojects for the first five years which will constitute the CD-2/3A deliverable. The phased approach is the underlying foundation to the IFDP execution strategy. Through this approach, the 5-year plans integrate all DOE-EM and other program requirements while maintaining an overall project life-cycle perspective as shown on Figure 4. Such methods should be followed in the work at the West Valley Site."

D. Changes in Scope as Further Information is Obtained

During the long period over which the project will be carried out, new findings of conditions on site, new technological advances, changes in funding availability, etc., will require changes in the sequence and scope of the work to be carried out. As shown below, a number of models were used for scheduling and sequencing purposes at Oak Ridge as shown in their CD-1 report.

"**SEQUENCING**

IFDP sequencing incorporates project priorities into the preliminary performance baseline and is the basis for phased execution strategy. The first priority of IFDP sequencing is risk reduction, followed by Surveillance and Maintenance cost reduction, and release of strategic real estate to ORNL and Y-12. Primavera® P6™ Project Management scheduling and risk analysis were used in the development of CD-1 to arrive at the preliminary schedule and baseline. The IFDP phasing strategy and changing conditions require the ability to analyze and respond to changes quickly. Through use of the Polestar Supermodel, IFDP will incorporate at CD-2 a sequencing that allows for quick analysis of the complex interactions that occur when a sequencing-related factor changes. Examples of key and interrelated sequencing factors are shown in Figure 13.

Sequencing Factors

- Risk
- Regulatory milestones
- Budgets
- Facility availability
- Physical locations and site limitations
- Release of strategic real estate
- Impacts on department missions
- Environmental Safety and Health
- Waste management operations
- Design and procurement lead times

The Supermodel provides the ability to group projects by area, risk, or other logical groupings, and assigns weighting to specific groups and allows for the quick adaptation while conducting different funding and D&D scenarios. Existing Record of Decision (ROD) dates are included, contract deliverables and milestones are considered, and S&M cost reduction is calculated and used to optimize the schedule."

It is not apparent that such an approach was used at West Valley. It would be wise to do so.

E. Technology Used in Exhuming Waste from Tanks, NDA, and SDA

Volumes and cost numbers depend upon the technology and schedules chosen. The exhumation schemes suggested seem to be based upon the most extreme conditions and not what is likely to occur and with little attention to the reduction in risk, if any, compared to the cost. The technologies and techniques chosen have been too affected by the prejudices of experience. Times have changed and the practices that were routine, even recently, are no longer the state of the art. In addition, they have not chosen what is the best choice for the individual waste sites rather than a uniform solution for all of the wastes.

Two examples of such extreme measures are given here to support this argument.

Table 3-16. Packaged Volume for A. Disposal at NTS and Commercial Facilities, STRA Technical Report, WSMC-WV-08-0002, June 2008 and B. Initial Inventory, Appendix C, Descriptions of Facilities/Areas, Implementation Activities, and Description of New Construction of 2008 PDEIS for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center

WMA 8 Closure A.	
Surface Structure Removal	
South SDA EE Construction	
North SDA EE Construction	
Lagoon Confinement Construction	
SDA Waste Excavation	
Lagoon Confinement Demolition	
North SDA EE Demolition	
South SDA EE Demolition	
Total (line added)	17,345,471 cubic feet

SDA	B.	
	CURIE	CUBIC FT
North	60,000	932,000
South	70,000	1,431,000
Total (line added)		2,363,000

We can see from this simple example that (17,345,471/2,363,000 =) 7.3 times as much volume will be excavated as the initial inventory! A 10-20 percent increase would be understandable but 730 percent is mind boggling. The reduction in costs is equally mind boggling. The cost of SDA Waste Excavation is estimated to be $1,417,944,800, STRA. Therefore, with a 10% increase in the volume excavated over the initial inventory, the total cost of excavation would be ($1,417,944,800/13,295,101 = ~$107/cubic foot; if 10% increase in volume in excavation, the cost would be (2,363,000 x 1.1) = 2,599,300 x $107 =) ~$ 278,000,000 or more than a billion dollars less than the present estimated costs! Equally impressive savings could be made by excavating a reasonable amount at the NDA.

The second example deals with double containment for most of the NDA and SDA.

The wisdom of double containment for complete sites is questionable since the atmospheric releases are only 0.1 curies per year of tritium and barely 0.01 of other nuclides are being released to the atmosphere. After 50 years Sr-90 spikes (no explanation is given for that figure except that it involves the removal of the North Plateau Groundwater Plume but does not say what preventive measures such as wetting the soils and noting that strontium does not volatilize) but is still less than 0.1 curies per year. (Figure 3-5 of the STRA.)

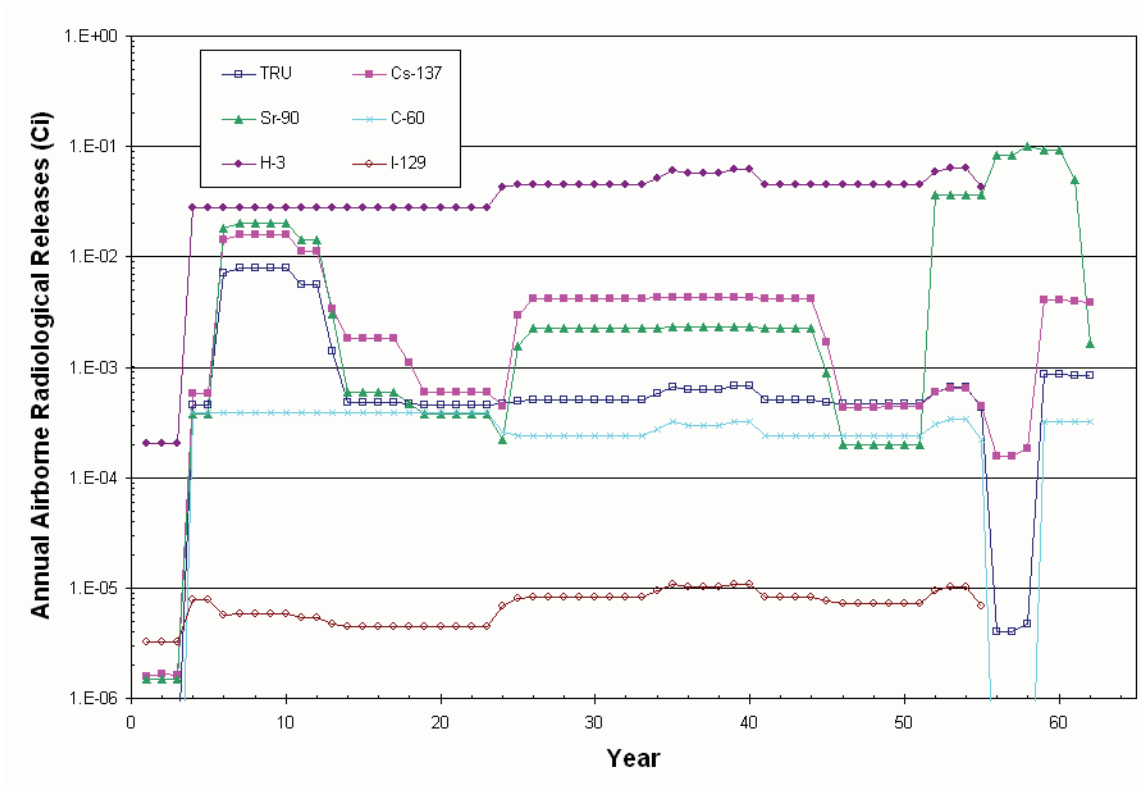

Figure 3-5. Environmental Airborne Releases by Implementation Year

3.2. Removal of Tanks and Their Contents

It is not clear why the process is so complicated as the waste tanks at ORNL, practically next door to the cafeteria, were emptied and D&Ded without incident. DOE should examine the techniques used there. Also DOE needs to look at the operations at Pits 4 and 9 at INEEL and the sliding covers at the very low level waste sites in France for much lower cost containment methods. The large containment buildings discussed here are more reminiscent of the Chernobyl cover that is needed because of the high radiation fields and poor condition of the sarcophagus. In the STRA Technical Report it is shown that the enclosure at the Tank Farm Waste Processing Facility covers everything connected with the tanks. What is the justification for this, especially since there will be Waste Tank Farm Confinement Areas? Local, modular control is much more effective and even more protective. No justification is given for the statement "However, performing the entire mission, including packaging, at the tank site is considered more cost effective and safer than separate facilities for tank removal and waste packaging." In any case, the removals should be done surgically using modern analytical equipment to monitor the alpha, beta and gamma emissions and providing the necessary shielding, breathing apparatus etc. locally rather than the large, expensive to build, maintain, operate and decommission facilities. Temporary inflatable facilities with HEPA filters and the above considerations should be sufficient to maintain healthy work environments at much reduced costs.

It is not clear that the experience obtained at the Savannah River, Idaho, and Hanford sites in emptying the tanks and removing the liquid and solid heels has been utilized.[9] Major strides have since been made in techniques to remove heels from the bottom of tanks with complicated coil inclusions.

The risers in the tanks are not shown so it is not known whether it would be more effective to remove the fluids and heels in the tanks while the covers are still in place and providing shielding while this is done. The same is true for the internals. With the soil cover and tank top in place, it should be a less hazardous operation. In this instance it is made clear that the sheet piling will be recycled whereas in the NDA and SDA there is no mention of recycling the sheet piling.

In Appendix C it is noted that "Titanium-treated zeolite would be used to sorb Cs-137 in the Tank 8D-4 liquid and trap a portion of the plutonium content." Why not do this in the other tanks? Since such a large portion of the curie content is Sr-90, Cs-17 and H-3, why not store these wastes and let decay reduce their hazard?

It is believed that the data, risk, costs, perspective (other radiological and chemical hazards remaining on site) and social concerns should play a part in determining if any of the tanks should be removed and the costs, risks, etc., of total exhumation should be compared with leaving selected portions behind.

3.3. Removal of the Contents of the NDA Site

As noted in the General Comments section, doubt is expressed for the necessity of double containment. Note from the schematic of Environmental Enclosure, shown below, that the exhumation at NDA will be divided into two parts, NFS and WVDP. So there will be uncertainty in the contents, their location and the doses that will be received when excavating. The procedures suggested provide for reduction of doses but at an inordinate cost because they provide total protection for almost all excavations. “This enclosure (NDA Environmental Enclosure-added) would be constructed over the footprint of the NFS burial area of the NDA and a portion of the WVDP burials and is intended to cover all disposal areas known to contain wastes of categories greater than Class A.” That is not justification but only an assertion and extra costs are not known because the risk reduction is not shown.

> *“Geophysical Investigation*
> Locations of the burial holes and trenches in the NDA are not precisely mapped. Thorough geophysical investigation of the burial locations, to the extent practical, would be performed to define the limits of waste disposal and determine proper locations for construction of environmental enclosures and installation of shoring for trench and hole removal.”

[9] Tank Waste Retrieval, Processing, and On-site Disposal at Three Department of Energy Sites: Final Report Committee on the Management of Certain Radioactive Waste Streams Stored in Tanks at Three Department of Energy Sites, National Research Council, 2006.

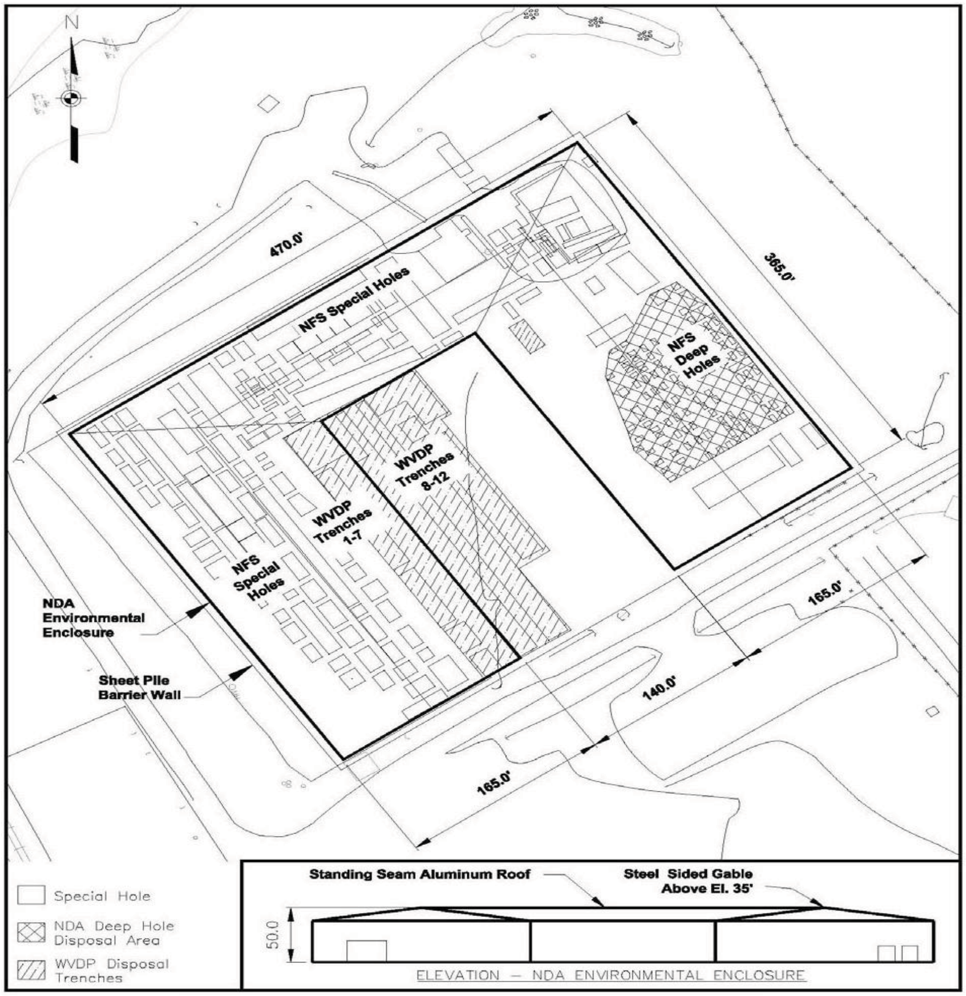

Figure 2-28. Conceptual NDA Environmental Enclosure

The exact dimensions of the Modular Shielded Environmental Enclosure are unclear as the Perspective View has no dimensions and the Wall and Panel Sections do not show all of the measurements. It is surprising that these structures will not be reused at the SDA but will be demolished at the conclusion of activities.

No further discussion is given of the size or composition of the WVDP Disposal Area Confinement Structure. There is no discussion of the disposition of the MSEE.

For the SDA "The general construction specifics of both enclosures would be essentially identical to that of the NDA Environmental Enclosure, as discussed in Section 2.7.1." and "Similar to the process employed for the NDA removal, the SDA removal would be performed within a MSEE when high radiation fields are expected." Overburden soil would be excavated within the confinement structure while the trenches would be excavated within both the confinement structure and the MSEE.

Yet we know that some trenches in both the NDA and SDA will have higher concentrations than others. The only way to determine this is in the field. Fortunately, that is possible and one need not aggregate the data but can measure the doses in the field in real time. Obviously, that would be preferable as one would be able to use the simplest and least expensive method to excavate the material, process it and ship it to the appropriate facility for disposal rather than sending almost all of the material to the most expensive disposal site.

These are not untested techniques. For example, as shown below in an excerpt from an INEEL document,[10] this is already being done.

> "**Buried Waste—**Uncertainties with regard to buried wastes is most pronounced for SDA disposals. Although some uncertainty exists regarding the inventories at the SL-1 and BORAX Burial Grounds, the locations of the wastes are well documented. Contaminant inventories for these two sites are limited to radionuclides and have been modeled based on the best available information. Within the SDA, locations of individual waste disposals are not exact, but location information is likely developed as well as is possible given the available information. Current efforts are focused on refining inventory estimates for INEEL-generated wastes and are continuing. Probes have been installed into the SDA to provide additional information on infiltration rates, disposal locations, and other factors."

Similar retrieval actions have been carried out at ORNL.[11] A movable weather enclosure that covers several trenches at once was designed and erected at the site for waste package excavation and overpacking. "Continuous monitoring of the conditions inside the excavation enclosure during cask retrieval provides the data needed for the field radiological engineer and radiation control supervisor to downgrade personal protective equipment (PPE) once base line data are established, and subsequently upgrade PPE only when conditions warrant." Therefore, in two instances with similar conditions to West Valley, it has been possible to do the removal less expensively and with greater comfort for the workers.

As the contents and locations of the wastes in the trenches are not accurately known, it is clear that cleanup should proceed on the basis of the individual items and not the average. Just a few areas are highly contaminated and their treatment should be different than the less contaminated areas. As shown above in the General Comments, the excavation of the trenches yields significantly more material than the initial inventory and would also lead to significant savings.

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[10] INEEL Subregional Conceptual Model Report Volume 3: Summary of Existing Knowledge of Natural and Anthropogenic Influences on the Release of Contaminants to the Subsurface Environment from Waste Source Terms at the INEEL, **INEEL/EXT-03-01169 Rev. 2,** September 2003, Pages 5-2 and 5-3.

[11] Retrieval of Buried Transuranic Waste at Oak Ridge National Laboratory, D.W.Turner, D.H. Boling and M.A. Johnson, Proceedings WM'06 Conference, March 2006.

Further, even if equipment such as the MSEE is required, why should it not be used for NDA and SDA rather than constructing and decontaminating two identical pieces of equipment? Since the removals are not, from a technical point of view, time critical, the simpler and faster removal advocated above would make it possible to decrease the number of times that the equipment would be used. The same rationale holds for the simplified system recommended above and then it would be possible not to work in the winter time under such difficult conditions.

These approaches should be investigated as the time and cost savings would seem to be significant. For a simple calculation of the cost savings on the equipment if they could be reused, the costs for the Environmental Enclosures construction and demolition for the NDA and WVDP are approximately $147 million. Though the time savings would seem to be substantial, it would take a greater effort to calculate them.

The peak annual dose from normal operational airborne radiological releases for sitewide removal is 0.0036 millirem at the Site boundary and 0.076 millirem at Cattaraugus Creek near the site and from liquid releases at the Cattaraugus site 0.0013 millirem. For the no action airborne releases scenario, the dose is approximately an order of magnitude less at the site boundary and twice as great at the Cattaraugus site while for the liquid release, the dose is 2 orders of magnitude greater (Tables I-10 and I-11 Appendix I of the 2008 PDEIS. These doses show that the calculated airborne doses are extremely low and also call into question the need for double containment. It should be noted that though a widely used computer code GENII was used in these analyses, there is insufficient information given here to determine if the doses were correctly calculated. The input data are not given nor the chemical speciation of the waste nor the details of the flow path including the chemical and physical interactions on route. Therefore, we don't know what values were used-whether they were the mean, median, 95% or some other value.

It should also be noted that the calculations for non-radiological pollutants are only for atmospheric releases and no justification is given for ignoring liquid releases (Appendix K). It should be noted that in Table K-5 Nonradiological Air Pollutant Concentrations by Alternative, only PM_{10} Maximum Incremental Concentration for Sitewide Close-in-Place Alternative for 24 hours atmospheric releases exceeds the permissible limit and by a small amount.

With this background, then it becomes important to see what the relative costs for each of the alternatives are. **"**Table 4–33 presents a summary of the cost to complete the decommissioning actions for each alternative, as well as the annual cost for any monitoring and maintenance that is part of the alternative. The table shows the high initial cost and zero out-year cost for the STRA and the zero initial cost, but higher annual monitoring and maintenance cost for the No Action Alternative."

Cost Element	*Sitewide Removal Alternative*	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative – Phase 1*	*No Action Alternative*
Cost to complete decommissioning actions (millions of 2008 dollars)	9,600	840	4,300	0
Effective annual cost to monitor and maintain site (millions of 2008 dollars per year)	0	0.8	not estimated	12
Present value (millions of 2008 dollars) using 3 percent annual cost escalation and 5 percent annual discount for future expenditures	5,700	800	4,000	600

Though we are not to make any judgments on which alternative to choose, it is important to have some understanding of the relative costs and to compare those to the dosages that that will be incurred and the other impacts for each of the alternatives. Unfortunately, we do not know how the costs were computed and with the previous history in DOE of cost overruns, these need to be treated with some skepticism.

3.4. Removal of the Contents of the SDA Site

Most of the comments about the SDA would be similar to those for the NDA and in the General Comments and so shall not be repeated here.

4. FINDINGS

This section summarizes the findings of the IERT exhumation review team with respect to each of the primary waste areas that are potential candidates for exhumation.

4.1 FINDINGS WITH RESPECT TO EXHUMATION OF THE NDA

The NDA trenches include all forms of nuclear waste: TRU, GTCC, Class C and lower levels. Locations of the various waste types demands both remote and contact-handled technologies. In the time-frame of the proposed remediation, the NDA site will generate wastes that cannot be shipped "off-site" to any repository. The EIS exhumation approach for remediation should work, but it will be very expensive, primarily because of cost of the excavation and disposal of the "low-level" overburden above the trenches.

- The NDA burial ground includes NFS Deep Holes, NFS Special Holes and the WVDP Burial Trenches. The total volume of NDA waste is 361,000 cubic feet, with a total activity of 298,000 curies. Hence, the average activity of the waste is 0.83 Ci per cubic foot.[12] Most of the waste is soil (121,000 cubic feet) and is Class C waste. Other waste in this area is reported to be Greater Than Class C.

[12] Estimated Radionuclide Inventory for the NRC-Licensed Disposal Area at the West Valley Demonstration Project, URS and Dames & Moore. August 2000.

- A small amount of spent nuclear fuel (12 cubic feet) with a high activity (12,316 Ci per cubic foot) is included in the NDA. Also, 7,266 cubic feet of hardware with an activity of 196,000 Ci is included. All of the other waste here (354 cubic feet) has activity less than 1 Ci per cubic foot. These differences in activity suggest that removal of the lower volumes of wastes with high activity could reduce the NDA source term to more acceptable limits. However, the "Site Removal Alternative" proposes total removal of all NDA wastes.

- The cost for exhuming the NDA waste is given as $924 million (per STRA Technical Report). This cost will be a significant portion of the total projected West Valley remediation cost of $9.6 billion. It is noteworthy that the pre-remediation construction cost is about $41 million, or less than 5% of the total cost. The most costly portion of the STRA would be the removal and disposal of the overburden and the backfill operation, which is estimated to cost $777 million, or 84% of the total cost for this waste management alternative. It is also worth noting that the credibility of these cost estimates has not been established. There is a need to verify that the cost estimates were generated by a qualified engineering firm with experience in radionuclide operations.

- Locations of the burial holes and trenches in the NDA are not precisely mapped. There is insufficient evidence of geophysical investigations of the burial locations to define the limits of waste disposal and determine proper locations for construction of environmental enclosures and installation of shoring for trench and hole waste removal. Some trenches in both the NDA and SDA with have higher concentrations than others. The only way to determine this is in the field. Fortunately, that is possible and one need not aggregate the data but can measure the doses in the field in real time. This may provide justification for the complete Environmental Enclosure.

- The first item proposed in this approach is construction of a large building, the Environmental Enclosure (or secondary containment), over the waste burial holes. This 134,590-sq ft enclosure would have 1-ft-thick reinforced concrete walls and would be equipped with an HVAC system having HEPA filtration. The structure would have a 35-ft eave height, and a span of up to 165 ft, large enough to allow use of heavy equipment inside and to allow erection of confinement structures within it. Access to the interior areas would be provided by equipment shield doors as well as numerous shielded mandoors. The building would be designed to withstand design-basis natural hazards, such as earthquake, high winds, and snow loading. It would also contain appropriate levels of fire protection, water, and electrical supply, and a closed-circuit camera security and operations system. A gantry crane with a closed-circuit television capability would enable remote operations

- It is not evident that alternative approaches were considered for environmental enclosure. For example, how much would be saved if the NDA Environmental Enclosure were designed only to prevent the release of dust, but not to serve as a secondary environmental containment? Such enclosures have been successfully used in site cleanup operations but they would not do well during winters at the site, so plans would require either summer operations only or completion of the exhumation during one operating season. A containment change could provide some cost reduction (~2-4%), but the margin of error on the total NDA cost estimate is probably >10%.

- In addition, a Container Management Facility would be built for the dual purpose of preparing the removed wastes from the NDA and the SDA for transportation. A third building, a leachate treatment facility, would be constructed on the SDA site and would treat leachate materials from either or both sites.

- The NFS Deep Holes, the NFS Special Holes, and the WVDP Burial Trenches require different equipment and operations for exhuming the waste. The NFS Deep Holes contain Class C and GTCC wastes and will require that waste removal be contained. A special containment system, a modular, shielded exhumation enclosure, is to be used over each hole. The NFS subject hole would first be prepared with sheet piling to avoid cave-in, then the MSEE would be placed over the sheet piling by the overhead crane system. Waste from the holes and the piling sheets will be placed in 55-gal drums and removed using the MSEE hoist and the remotely operated crane system. Apparently the drums are to be transferred in a remote manner to the Container Management Facility and from there to an unidentified repository. Any leachate encountered during exhumation would be pumped to the Leachate Treatment Facility. After a hole is excavated, the soil between holes is to be excavated as low-level waste and all equipment is to be moved to the next hole.

- The NFS Special Holes contain lower levels of activity than the Deep Holes, and the excavation is to be done under a HEPA-filtered, ventilated, confinement tent structure. Particular holes with GTCC waste would be exhumed using the processes used for the Deep Holes. The soil overburden (4 feet deep), would be excavated and managed as low-specific–activity waste. Excavation from these holes is somewhat described in Appendix C of the 2008 PDEIS, but the description could be better written. In essence, the waste is removed from each hole, placed in covered transfer boxes, and transferred to the CMF. There the waste is prepared for the appropriate repository destination. Any exhumed leachate is pumped to the Leachate Treatment Facility. After the excavation of each hole is completed, the temporary confinement tent is dismantled and reset over the next of these holes.

- The WVDP Burial Trenches, Trenches 1-7, will be exhumed in the same manner as the NFS Special Holes. Trenches 8-12 will be excavated in a less-robust structure, the WVDP Disposal Area Confinement Structure, located in the courtyard area of the Environmental Enclosure. These Trenches 8-12 will be housed in a conventional steel building with HEPA filtration. The excavation operations are contact handled, using heavy machinery. The low-level waste materials are packaged for disposal in a repository.

- The total secondary containment proposed for the NDA site will be very expensive (estimated cost of ~$50 million in the STRA Technical Report). This cost estimate is undoubtedly lower than actual costs, if the estimates used costs of concrete and rebar at $69/cubic yard and $61/ton (the values used in the Facility Description and Methodology Technical Report), rather than more realistic values of today, which would be ~$130/cubic yard for concrete and $1,200/ton for rebar. The large differences in these costs calls into question the total integrity of the cost estimates.

- A major issue for the exhumation alternative is the volume and costs of the wastes generated. Much of the cost is for the overburden removal and disposal, since this will be considered low-level waste (LLW). Wastes will be generated that cannot be sent off-site at this time. The TRU waste and the GTCC waste will stay on-site until a repository is available and will accept it. This will add to the on-site storage requirements and will require additional storage facilities which are not included in the STRA cost estimates (the vitrified HLW is already on-site and also requires a new facility). The understanding is that the projected capacity of the first Yucca Mountain HLW repository is already designated, and the only space for the West Valley HLW or GTCC waste would be in a second repository if and when it becomes available. This means that West Valley would probably need to store the HLW, the TRU, and the GTCC waste on-site for as long as 100 years.

- Because of uncertainties in both the political and technological arenas, it is difficult to make accurate projections of the costs and actions over the long period of time (greater than 60 years) proposed for the remediation actions needed at West Valley. These difficulties were not discussed in the 2008 PDEIS. DOE-EM has recognized this and has provided a phased approach of five years at a time to reduce the uncertainty.

- The 2008 PDEIS approach to exhumation lacks flexibility to account for lessons learned as the remediation project is implemented. During the long period over which the project will be carried out, new findings of conditions on site, new technological advances, changes in funding availability, etc., will require changes in the sequence and scope of the work to be carried out. Volumes and cost numbers depend upon the technologies and schedules chosen. The exhumation schemes suggested seem to be based upon the most extreme conditions rather than those most likely to occur and with little attention to the reduction in risk, if any, compared to the cost. In addition, the 2008 PDEIS has not considered the best options for the individual waste sites but has proposed a uniform solution for all.

- The remediation structures for the NDA are not proposed for reuse but are to be demolished at the conclusion of activities. Equipment such as the MSEE could be used for both the NDA and the SDA.

- The calculations for non-radiological pollutants are only for atmospheric releases, and no justification is given for not considering liquid pathways.

- The review team generally agrees that this approach for exhuming NDA or WMA-7 will lead to closure. The concern is whether other approaches were considered that would result in lower overall costs. The most expensive item in the STRA approach is the removal and disposal of the overburden. The cost of this item can be changed significantly by retaining part of the LLW onsite. The approach identified for exhuming the NDA site appears appropriate, but will also be very expensive. The methods for the NFS Special Holes are not fully defined, but if there is a failure, the MSEE technology could be used for all of these holes.

4.2 FINDINGS WITH RESPECT TO SDA EXHUMATION

The average radioactivity levels of the SDA are relatively low (0.05 Ci per cubic foot, and there are some GTCC that average ~2 Ci per cubic foot. The outer containment building is costly, and the requirement for it is questionable. However, the major cost driver is the disposal of the overburden. The approach described in the 2008 PDEIS will work, but it will be very costly.

- The SDA burial ground includes 14 trenches. Trenches 1-7 comprise the North SDA, and contain some waste that is greater than Class A. Trenches 8-14, which also contain waste greater than Class A, make up the South SDA. The total volume of waste in the 14 trenches is ~2.4 million cubic feet, with a total activity of 0.13 million curies. The average activity of this waste is, therefore, about 0.05 curies per cubic foot.[13]

- The total SDA inventory has been sub-divided into waste classes, and several portions of the SDA were identified as containing Greater Than Class C waste. However, the location of the GTCC is not identified such that the GTCC could be separately removed. The volume of the GTCC and its associated activity are given, and the average maximum activity of the GTCC is ~2 Curies per cubic foot (~ 60 curies per cubic meter).

- The approach for exhuming each of the North and South SDA trenches is similar, except in size of the project. Environmental enclosures would be built for each of the areas. The North SDA enclosure would be 155,800 square feet (205 X 700 ft) and would be 35 feet high. The South SDA enclosure would be 244,950 square feet (345 ft X 710 ft) and 35 ft high. The exterior walls would be 1-ft-thick reinforced concrete. Each enclosure would have a metal roof with gutters. Each

[13] SDA Radiological Characterization Report, URS Corporation. September 2002.

enclosure would also have an HVAC system with HEPA filtration and a gantry crane system.

- Cost estimates for exhuming the SDA site trenches are given in the Technical Report for the STRA. The number of large containment buildings planned for the site, including the SDA is alarming. Analysis of the estimated costs shows that the construction of two containment buildings is projected to cost $112 million, or about 6% of the total project cost. The cost information presented on these rigid buildings suggests the possibility of overpricing of the total estimate for the excavation.

- The cost driver in these estimates is the excavation/backfill costs of $1.42 billion. This is 77% of the total cost estimate, with a contingency of $399 million (28%). The estimated costs are given with large contingencies. Their credibility is not verifiable. Were the estimates prepared with input costs given in the Facility Description and Methodology Technical Report? That report quotes the price of concrete and rebar at $69/cubic yard and $61/ton, respectively. Recent prices for these materials (telephone conversations with local providers) indicate $130/cubic yard for concrete and $1,200/ton for rebar. This leads us to question all of the material prices used in preparation of the STRA cost estimates.

- The approach described in the STRA Technical Report would work, but it is possible that simpler and less expensive approaches are also feasible. The exhumation schemes suggested seem to be based upon the most extreme conditions, rather than the most likely conditions, and with little attention to the reduction in risk, if any, compared to the cost. The wisdom of double containment for complete sites is questionable since the atmospheric releases are only 0.1 curies per year of tritium and barely 0.01 of other nuclides are being released to the atmosphere. In particular, the need for a secondary containment structure to prevent air emissions should be further evaluated. If other options such as watering to prevent dust releases would work, and if releases of tritiated water vapor would not produce significant worker or offsite doses, then removal costs may be less than estimated.

4.3 FINDINGS WITH RESPECT TO HLW TANK EXHUMATION

The two largest of the four tanks contain about 350,000 Ci or about 40% of the total West Valley radioactivity inventory. As such, they should be priority one in the West Valley remediation. The technologies for removing the solid wastes and the ion exchange columns from the large tanks are not well-defined in the 2008 PDEIS, and some of the waste is not included in the estimated costs. The estimated costs for the exhumation of the tanks, $834 million, may be ~75% of the actual costs.

- The approach for remediation of the tanks was described in the STRA scenario of the 2008 PDEIS and in the STRA Technical Report. The estimated total cost for this scenario is $9.6 billion (2005 dollars), and these costs would be spread over

60 years, an estimated $160 million per year. It seems quite impractical to propose to accomplish such a significant task over a two-man-career time period, with all of the political and societal barriers which could arise. It also seems appropriate to prioritize remediation of the HLW tanks as the first objective.

- The high-level waste (HLW) tanks at West Valley are identified as 8D-1 through 8D-4. For purposes of this discussion, they will be called Tank 1 through Tank 4. Tanks 1 and 2 have capacities of 750,000 gallons each, while Tanks 3 and 4 have capacities of 15,000 gallons each. Tanks 1 and 2 have residual waste, with the major portions having been previously removed for vitrification. The activity of the residuals in these two tanks is 300 to 400 kilocuries. Tank 3 has not been contaminated, but Tank 4 contains about 10,000 gallons HLW from processing thorium fuel, and the activity of the HLW totals about 5 kilocuries. Tanks 1 and 2 may be considered the most hazardous of West Valley wastes requiring remediation; they contain about 40% of the total activity of the site and, are, therefore, an important subject for discussion.

- The total estimated residual activity in the Waste Tank Farm is conservatively estimated at 350,000 Ci, as given in Appendix C of the 2008 PDEIS. This inventory was not calculated from past operational experience and data at West Valley and is not precise. The decision concerning future tank farm management need not be a function of the accuracy of the inventory data. The estimated radionuclide inventory includes all of the radionuclides associated with spent nuclear fuel including: source material, special nuclear material, and fission and activation product inventories, that have been determined by a combination of direct sample measurements, scaling factors and process knowledge. The IERT finds that the total inventory as reported is a reasonable metric to determine the future tank farm management. It is unlikely that management decisions would be different for an inventory over the range of 200,000 to 400,000 Ci of total radionuclide inventory.

- Almost all the radioactive materials in the tanks are from ^{90}Sr and ^{137}Cs. Out of roughly 350,000 Ci, the estimate reported in Appendix C is that only 1260 Ci results from radionuclides other than ^{90}Sr and ^{137}Cs. These two radionuclides have similar half-lives of about 30 years. This means that over the 60-year period of the tank farm removal, the inventory in the tanks would decay from ~350,000 Ci to about 87,000 Ci. While this is still a large amount of total activity, it does reflect a significant decrease. The fact that the tank wastes are almost entirely 30-year half-life material suggests that the key question in remediation of these tanks is whether institutional controls could be relied on for the 300 or so years it would take for the ^{90}Sr and ^{137}Cs radionuclides to decay.

- The first step of the exhumation approach is the proposal to build a containment building over the entire tank farm area. This building would be 265 feet x 150 feet, with a height of 87 feet. This would be very similar to a reprocessing canyon. There would be a remote handling work cell (150 ft x 45 ft) and conventional auxiliary buildings of similar dimensions. This approach, using a process canyon and auxiliary buildings may be necessary for this particular scenario. The estimated cost for design, construction, and commission is given as $210 million,[14] and as $192 million and $189 million in Table 3-18 and Table 3-19 of the STRA Technical Report. It would require several years (2 or more) for construction and set-up prior to an estimated 13-year operating period. After operations are completed, the facility would be decommissioned and removed. This would require about 2 more years and an estimated cost of ~$200 million. The total remediation time would then be about 17 years, with a total estimated cost of about $834 million; i.e., ~$49 million per year. One can assume that this $49 million is part of the total estimated $160 million per year cost for the complete scenario, and also assume that this would be performed concurrently with other remediation work.

- The containment canyon for HLW tank remediation may be more than is necessary. First, the average thickness of the walls need not be 4 ft. A wall thickness of 1 ft should be sufficient. Secondly, the vast containment area (37,750 square feet) could be decreased to an area just sufficient to cover Tanks 1 and 2. The above-ground structure could be removed without an overbuilding. Third, Tanks 3 and 4 could be remediated under a flexible building. Fourth, existing buildings could be used for chemical and physical treatment of the waste. Fifth, the operations cost should be reduced. The total cost of $834 million for WMA-3 closure, as proposed for the STRA discussed in the 2008 PDEIS is likely too low, but with the changes enumerated here, it could probably be implemented at about $800 million.

- Currently the technologies for remediation of the HLW tanks have not been sufficiently identified or described. Specifically, the technologies for waste removal from the tanks should be better described, and the problems of transferring the solid-liquids waste from the tanks should be recognized and resolved. Will the tanks be washed before and after exhumation? How will the washing be done, and how will the washwater be managed? Is there a plan to try to remove the Sr-90 and Cs-137 from the tank components, so that the quantity of HLW may be reduced? If so, have any studies or experiments been done to address the form and behavior of these materials?

- The position of the STS Support Building within the process canyon and the management of the ion-exchange columns are not well defined. The description of the decommissioning of the STS facility inside the process canyon is deficient. Also lacking was a strategic plan for the order of addressing the farm tanks with respect to training and experience. A time for implementation of this plan within the 60-year time frame was not presented nor discussed.

[14] Kurasch, D.H., Summary Considerations for the Selective Removal of Tank 8D-3. June 2007.

- The major driving force for costs is the item identified as “operations” at $427 million, or 51% of the total estimate. The construction cost for the containment canyon (WPF) is 23% of the total estimated cost. Reducing the size of this containment facility and decreasing the wall thickness could result in major savings. Of course, such savings should include consideration of ALARA practices and assurance that dose limits are met. (The process canyon for processing spent nuclear fuel at a capacity of 800 tons per year has a wall thickness of 5 ft.) The demolition costs for a smaller-scaled facility would also be considerably less.

TRANSPORTATION ANALYSIS

Review Team
Robert D. Waters
Peter N. Swift

2008 PDEIS SOURCE MATERIAL REVIEWED

- Transportation-related sections of Chapter 4 Environmental Consequences (which is a summary of the analyses in Appendix J)
- Appendix J, Evaluation of Human Health Effect from Transportation

In general, the transportation analyses are clearly stated, well documented, and use reasonable data and analysis approaches. The analysis methodology is summarized in the following section followed by a summary of the results and conclusions of the analysis. A discussion of the analysis and results, where specific concerns with the analysis are raised, concludes this review.

SUMMARY OF ANALYSIS METHODOLOGY

Off-site disposal options considered in the 2008 PDEIS include Hanford (as a proxy for a commercial western U.S. disposal site for Class B/C waste), Energy Solutions, the Nevada Test Site (NTS) (including the Yucca Mountain Project (YMP)), the Waste Isolation Pilot Plant (WIPP), and Barnwell. When disposal options for a particular class of waste do not exist, or may not be available in the longer term, assumptions are made that tend to increase travel distances to hypothetical[15] facilities in the western United States. Transportation routes were determined using the TRAGIS routing computer program, which is a GIS-based transportation analysis computer program used to identify and select routes for transportation radioactive materials within the United States.

The type, volume, and radiological inventories of wastes to be shipped are based on analyses described in other parts of the 2008 PDEIS. The number of shipments was also based on the type of packaging required for each type of waste to be shipped and the number of these containers that could be carried by a truck (tractor semi-trailer) or railcar. A train consisting of one railcar was assumed to estimate number of required trips.

"Per-shipment" risk factors and total risk for the different Alternatives are calculated. Truck and rail risks are considered individually. Radiological and non-radiological impacts of transportation to the public and transportation workers resulting from accidents and incidence-free transportation are calculated.

[15] In this sense, "hypothetical facilities" include facilities that currently exist (e.g., WIPP) or those that are being considered (e.g., YMP) but do not currently have the regulatory approval to accept the type of waste considered.

Calculated radiological health risks consider collective doses to nearby populations and risks to a hypothetical maximally exposed individual (MEI). External doses are considered for incidence-free transportation. Both external doses and committed effective doses due to the airborne pathway are considered for transportation accidents. Radiological doses are converted to health risks by use of a health risk conversion factor of 0.0006 latent cancer fatalities (LCF) per person-rem of exposure. Maximum exposures to transportation crews were considered to be limited by a 2 rem per year DOE administrative control for radiation workers.

Calculated non-radiological health risks are based on transportation-related fatalities using several years of accident data. For truck transportation, the denominator of this fatality risk rate is "100 million truck kilometers," and different mean rates are used for rural, suburban and urban population zones. For rail transportation, the denominator is "100 million railcar kilometers," and a single mean rate is used for all population zones.

SUMMARY OF ANALYSIS RESULTS AND CONCLUSIONS

Two intermediate results are presented. Risk factors per shipment of radioactive wastes (Table J-6) are presented for the different classes of waste and their transport destination for incident-free and accident scenarios for crew and public for truck and rail shipments. An estimated number of shipments for each Alternative and each waste type is provided (Table J-7).

The primary analysis results for each Alternative are total lifecycle transportation risks for incident-free and accident scenarios for crew members and members of the public for truck and rail shipments. Results of two transportation options are presented: the first considers Barnwell for disposal of all Class B and C wastes (Table J-8); the second considers a western U.S. disposal site for these wastes (Table J-9). The primary difference between these transportation options is the distance travelled and population types traversed. The dominant transportation risk from each of these Alternatives is the non-radiological accident risk. Because transportation risks are a function of the number of shipments, the calculated transportation risks are greater for Alternatives with more off-site shipments than for Alternatives with fewer off-site shipments.

Estimated doses to MEIs during incident-free transportation are provided (Table J-10). Estimated doses to the populations and to an MEI during the most severe accident conditions (Table J-11) are also provided.

Four conclusions are provided as summarize here:

- It is unlikely that transportation of radioactive wastes would cause an additional fatality as a result of radiation.
- The highest calculated transportation risks to the public would be under the Sitewide Removal Alternative and NTS disposal option. This Alternative has an estimated duration of 60 years.

- The lowest calculated transportation risk to the public would be under the Sitewide Close-in-Place Alternative and commercial disposal site option. This Alternative has duration of less than 10 years.
- The non-radiological accident risks present the greatest risks.

Compared to national annual average transportation fatalities, the additional risk due to any of these Alternatives is minor.

DISCUSSION OF ANALYSIS AND RESULTS

The general conclusions of the transportation analysis in the 2008 PDEIS are reasonable and consistent with other transportation analyses.

One can take exception to several technical issues with the risk analysis. Some of these include:

- Sixty years of transportation operations (Sitewide Removal Alternative) assuming today's level of transportation technology and medical ability to treat cancer. Given the rate of change in transportation and medical technologies, results may be very different if these changes could be factored in. This constancy assumption is common in these kinds of regulatory analyses because of the uncertainty of the future state of transportation and medicine.

- Use of a high-temperature fire accident scenario (p. J-26, l. 752) for exposure to a MEI located 100 m downwind. Depending on the details of the analysis not presented, lofting of the contaminants due to this high-temperature fire could reduce the dose to this MEI.

- In general, conservatisms in the transportation risk analysis can make comparisons to other alternatives problematic by making the transportation risks appear artificially high. Several conservatisms were mentioned but none stood out so much as to be highlighted here.

The technical issue of greatest concern is the use of the risk metric "railcar-kilometers" for estimating rail risks because it contributes to the largest risk – number of calculated non-radiological fatalities – and because it seems to lead to erroneous results. There are two main concerns with this metric. First, the metric may overestimate the nonradiological risk associated with rail transport because each railcar of waste is assumed to represent a single rail shipment. Second, to the extent that waste is shipped by rail as part of variable-construct trains, with other cargo, the train would pose essentially the same nonradiological risk regardless of the presence of waste. Attributing all of this component of risk solely to the transportation of radioactive waste may be inappropriate, given that some of the trains will run regardless.

The metric "railcar-kilometers", which the authors compare to "truck-kilometers," is a measure of the cargo-carrying capability of the rail industry. (The airline equivalent is "seat-miles"). However, when used as a basis for calculating transportation risk the similarities between these metrics for truck and rail transport cease. The distance travelled, speed, road or railway conditions, and traffic are the primary contributor to transportation fatality risk. The metric "truck-kilometers" is a measure of distance travelled by a single autonomous tractor-semitrailer truck (and most semitrailer trucks are configured with a single semitrailer). However, because trains gain their efficiency by pulling multiple railcars, each railcar is not autonomous and the metric "railcar-kilometer" does not directly measure the distance the train travelled – a primary contributor to risk. The average number of railcars in a train is necessary to calculate the distance travelled (by an average size train) using the railcar-kilometer metric.

Because "railcar-kilometers" is a measure of cargo-carrying capacity, its use in risk analysis leads to some paradoxical results. The authors state several times that doubling the number of railcars in a train doubles the fatality risk for that trip, implying that the resulting reduced number of trips will not off-set or reduce the inherent transportation risks. Being a measure of cargo-carrying capacity, use of this metric results in a fixed total transportation risk as a function of total material carried rather than risk based on the number of trips taken, which does not seem appropriate for non-radiological transportation risks. This "fixed total transportation risk" outcome is appropriate for the incident-free radiological risk, where the risk is derived mainly from the number of railcars passing a fixed receptor. It also seems an appropriate metric for transportation-accident radiological risk because doubling the number of railcars doubles the potential source term and halves the number of trips, concomitantly reducing likelihood.

The "railcar-kilometer" metric implies that one or a few waste-laden railcars are part of a larger variable construct train. (See Saricks and Tompkins, 1999 p. 21 cited in Appendix J of the 2008 PDEIS for a discussion of variable-construct versus dedicated trains.) If these waste-laden railcars are a small part of a much larger train (Saricks and Tompkins estimate 68 cars in an average train), then the non-radiological risk is already inherently included in the train that would run whether the few additional waste-laden railcars were present or not. This is another difference between variable-construct train and truck risks – the truck would not travel if not for the waste cargo; the same is not true for variable-construct trains. One could argue that the incremental non-radiological rail transportation risk due to an additional waste-laden railcar is negligible.

CONCLUSIONS

In general, the transportation analyses are clearly stated, well documented, and use reasonable data and analysis approaches. The general conclusions of the transportation analysis in the 2008 PDEIS are reasonable and consistent with other transportation analyses.

While a few technical issues of concern were mentioned, one issue rose above the rest – the use of the metric "railcar-kilometer" for calculating transportation risk for the rail option. Use of this metric artificially increases the calculated non-radiological transportation risk for the presumed contribution to a variable-construct train. The transportation risks in the PDEIS are generally based on the number of additional trips made necessary by the given Alternative. The non-radiological risks for the rail option are the largest calculated transportation risks and are artificially high due to use of this metric.

SEISMIC HAZARD ANALYSIS

Review Team
Robert H. Fakundiny (Lead)
Sean J. Bennett
Michael P. Wilson

2008 PDEIS SOURCE MATERIAL REVIEWED

- Section 3.5, "Seismology, of Chapter 3 – Affected Environment

EXECUTIVE SUMMARY

Section 3.5, "Seismology," of Chapter 3, "Affected Environment." does not specify its goals as to whether it is attempting to provide the necessary data, analyses, and models required to perform an adequate seismic-hazard assessment at the Western New York Nuclear Service Center (WNYNSC) site for the purposes of assuring that site integrity will not be compromised during and after decommissioning. The final result of DOE's analysis is the arbitrary choosing of 0.10g with a return period of 2,000 years as the horizontal ground motion that would be experienced from the maximum credible earthquake affecting the site, a conclusion derived in the early 1980s with then-current technology. The seismic-hazard analysis, as presented, does not consider advancements in seismic engineering analyses and modeling and should not, therefore, be used to support any future safety decisions regarding earthquake effects at the WNYNSC site and to the future integrity of the radioactive wastes onsite.

GENERAL COMMENTS

This review examines Section 3.5 "Seismology" of Chapter 3, "Affected Environment." The section includes discussions of "Earthquake History of Western New York and Vicinity (3.5.1), Tectonic Features and Seismic Source Zones (3.5.2), Peak Horizontal Ground Acceleration Estimates (3.5.3), and Liquefaction Potential (3.5.4), plus two tables: 3.6, "The Modified Mercalli Intensity Scale of 1931, with Generalized Correlations to Magnitude, and Peak Ground Acceleration," and 3.7, "Seismic Hazard Estimates."

The West Valley 2008 PDEIS should provide the information needed by decision-makers to understand how expected seismicity will affect any structures, facilities, engineered barriers, and surficial ground inhomogeneities, such as filled pits or trenches and berms remaining at the Western New York Nuclear Service Center (WNYNSC) after decontamination and decommissioning (seismic risk). The prudent approach would be to undertake a complete probabilistic and deterministic seismic-hazard evaluation (PSHA and DSHA) and seismic-risk evaluation, similar to those used in the design of nuclear power plants. These are not presented in Section 3.5, nor are the data, assumptions, and speculations adequate to do so. The IERT reviewers question what the metric or goals are that this section attempts to satisfy. The first sentence, Line 712, states that the purpose of the section is to provide information about the risk to the WNYNSC posed by earthquakes, implying that it will be a seismic risk evaluation, which it is not. One problem with the section is the apparent confusion between the terms "hazard" and "risk," and the fact that the two are different types of analyses. The section does not present discussions of the value for including many of the newer modeling techniques that look at such issues as Eastern U.S. versus Western U.S. seismic-wave attenuation (Krinitzsky, 1998), soil-structure interaction (EPRI, 2007), seismic-wave incoherency (Abrahamson, 2007), among others (NRC, 2007).

Section 3.5 does not constitute a complete probabilistic- and deterministic-hazard assessment, nor does it constitute a seismic-risk analysis. The data and correlations of various MMI-magnitude relations presented and discussed are inadequate to do so. The section presents secondary and tertiary summaries of the likelihood of earthquake activity on the bases of limited data and speculative arguments, rather than a critical evaluation of the likelihood of damage to structures at the WNYNSC from seismicity. As such, the seismic-hazard analysis, as presented, does not consider advancements in seismic-engineering analysis and modeling and should not, therefore, be used to support any safety decisions regarding earthquake effects at the WNYNSC site, and to the future integrity of any radioactive waste remaining onsite.

The analysis within Section 3.5 essentially presents a resulting, single peak horizontal-ground acceleration (PHGA) for the basis of safety analyses, which was a value chosen from one of many earlier studies without compelling reasons for doing so. This opinion about PHGA is given on the basis of over-reliance on secondary- and tertiary-data sources and qualitative discussions found in consultancy reports and speculative regional tectonic models, rather than a rigorous coupled probabilistic and deterministic approach now used in the assessment of new critical structures, such as nuclear facilities. New approaches to seismic-risk assessment are being tested that employ both experimental research and sophisticated computer modeling, which may be applicable to the WNYNSC closure process and the future integrity of the site. Still, none of these new approaches has been adopted in this section, nor even discussed as to their applicability.

Tables 3-6 and 3-7, which provide much of the data or assumptions about the site, are difficult to use, because the valuable information on both, the estimates of PHGA for various magnitudes are not apportioned in the same increments. Table 3-7 also does not provide estimates above an equivalent to MMI VII, which is below the maximum credible earthquake (MCE).

The section on PHGA estimates, 3.5.3, starts out by implying that it will discuss PSHAs, but then only discusses various estimates of MCEs and only three estimates of PHGA, which range from .10 to .07g, but at differing return periods. The section does not suggest which acceleration should be used in a PSHA. The estimates from various study groups all fail to consider the southwest branch of the Clarendon-Linden fault system (CLFS) (Van Tyne, 1975; Fakundiny, et al., 1978) as part of the Clarendon-Linden source structure or as part of the Clarendon-Linden source zone. The work of Tuttle, et al. (2002) proved that part of the CLFS has been active, although they found no indications of magnitudes greater than about 5.2.

The section fails to identify whether sources of data are from speculative discussions, such as some of the work by Jacobi and colleagues (Jacobi, 2002; Jacobi and Fountain, 1993; 2002) and by Fakundiny and Pomeroy (2002). Many of the sources referenced in this section are derivative sources that used data from previous studies. The original source references should be provided where possible.

Seismic-risk analysis requires a description of the structures that may be affected by the hazard. Different results will be derived from different scenarios, i.e., whether the high-level tanks will be left in ground, whether the waste-tank vaults will be left in ground, and whether the voids be filled with backfill, water, or other material. These questions are relevant now for the EIS, and become critical if soil-structure interaction (SSI) studies (Ostaden, 2007; EPRI, 2007) are made for the final design of in-ground structures left at the end of the decommissioning process. These SSI studies can provide valuable information about how impinging seismic waves may disturb the integrity of below-ground features through ground collapse, collapse affecting erosion rates, groundwater flow paths, and the influence of one facility upon another, such as berms affecting the shaking within pits, among other features.

The approach to seismic analysis that the preparers of this EIS section desire to be used is not apparent. PSHA may be assumed to be the goal for the use of the information provided within this section, but the information is not adequate for such an analysis. Steps in PSHA include distribution of locations of earthquakes along presumed seismic-source structures or zones, distribution of magnitudes and rates of recurrence for source earthquakes, distribution of ground motions away from the source earthquake, and integration of the hazard by computing the probabilities of various ground-motion estimates, among others. None of the seismic source zones presented by the eight engineering teams in the referenced EPRI-SOG source-zone exercises (Risk Engineering, Inc., 2007a) includes the WNYNSC, placing it in "background" source zones. This approach is negated by the information collected since that exercise that the southwest branch of the Clarendon-Linden fault system (CLFS) (Van Tyne, 1975) trends toward, and may be near, the site (Fakundiny and Pomeroy, 2002). The EPRI-SOG exercise also estimated seismic parameters by statistical analyses of historical seismicity from areas outside the northeastern United States, calculated these area parameters, smoothed them by assumptions specified by each team, and weighted alternative seismic parameters using values that were specified by each team, all approaches that are highly arbitrary.

Some engineering geologists do not believe the probabilistic approach is appropriate to stand alone in a seismic-hazard analysis, but rather should be coupled with a deterministic approach also, especially for critical structures, such as nuclear facilities (Krinitzsky, 1998; Krinitzsky, 2002a; Krinitzsky, 2002b; Wang and others, 2003). Krinitzsky, who is one of the most respected engineering geologists in the country, does not favor several aspects of the probabilistic approach, including: (1) the b-value approach; (2) paleoseismic studies; (3) using "characteristic earthquakes" (4) logic trees;

(5) slip rates on faults, especially normal and thrust faults; and (6) using expert opinions to derive seismic source zones (the EPRI-SOG approach.) He states: "Engineering design must be done deterministically if one is to have seismic safety coupled with good engineering judgement. However, there is a need for probability…Probability is needed to obtain operating basis earthquakes, to perform risk analyses to prioritize projects, and for assigning recurrence estimates to deterministic earthquakes. The probability for these purposes is non-critical…The design for critical structures, those for which failure is intolerable, such as dams, nuclear power plants, hazardous waste repositories, etc., must be based on maximum credible earthquakes, obtained by deterministic procedures, in order to assure their seismic safety." Krinitzsky (1998) is critical of Gaussian smoothing also. Wang et al. (2003) state that the PSHA does not "…provide the intended uniform protection against seismic risk,…[it] is either over-conservative in some areas or not conservative enough in other areas…" Four of their concerns are: (1) "…there is not consensus on exactly how to select seismological parameters and assign weights in PSHA…"; (2) "…the ground motion derived from PSHA does not have a clear physical meaning and should not be compared to ground motion from any individual earthquake…"; (3) "…PSHA cannot define the worst-case ground-motion scenario…"; and (4) "…PSHA provides…infinite choices for the users and decision makers." This highlights the need for a statement of how the results are assumed to be used.

Many new approaches to seismic-risk analyses are being developed for the nuclear-power industry, which may be applicable to the WNYNSC closure process and the integrity of engineered barriers, remaining structures, filled holes in surficial deposits, and other facilities. Topics include: cumulative absolute velocity (CAV) (actually the cumulative absolute acceleration x time) (Risk Engineering, Inc., 2007b); ground-motion correlation with peak ground acceleration at various frequencies; site-response frequency spectra for MCE at rock or soil sites; de-aggregation of distance and magnitude relations for low-frequency and high-frequency parts of the design spectra (NRC, 2007), among many others.

INTENTIONAL DESTRUCTIVE ACTS

Review Team
B. John Garrick (Lead)
Michael T. Ryan
Peter N. Swift

2008 PDEIS SOURCE MATERIAL REVIEWED

- Appendix I, Radiological and Hazardous Chemical Human Health Impacts
- Appendix N, Intentional Destructive Acts

REASONABLENESS OF THE OVERALL CONCLUSIONS

With noted exceptions, the conclusions appear to be reasonable, but their quantitative basis cannot be confirmed. That is, Appendices N and I are not stand alone documents in regard to containing sufficient information to evaluate the quantitative basis for their conclusions. The review team concluded that there must be additional source material to support the appendices, but they were not referenced or cited in the available documentation.

CHOICE AND BASIS FOR DESTRUCTIVE ACT SCENARIOS

The review team believes that a scenario based approach to intentional destructive acts is appropriate. However, there was difficulty in understanding the logic behind the choice of scenarios. The selection appears to have been by assumption rather than by a deliberate and systematic process. There was insufficient evidence presented to support the claim that the chosen scenarios are in fact bounding. A more credible approach would probably have been to follow the lead of the performance assessments for Yucca Mountain and the Waste Isolation Pilot Plant and consider "stylized" scenarios—an approach that attempts to reasonably represent multiple scenarios, but not necessarily claim that they are bounding, something very difficult to prove.

A further lesson learned from past analyses of the type of Appendix N is that recovery and emergency response is an extremely important consideration if realism in the scenarios is the goal, which it should always be. The observation that "the analysis assumed no emergency response such as evacuation or sheltering" was disappointing as such actions can greatly impact the consequences. For example, emergency response and recovery have been major contributors to the low risk results of nuclear power plant probabilistic risk assessments and they are generally accepted as representative of what could really happen.

MATERIALS AT RISK

The review team had several questions about the choices that were made of the materials at risk. For example, the basis for excluding the vitrified HLW was not technically supported. The basis given for excluding the vitrified waste was that it would not disperse into respirable fragments following an attack. This assertion while possibly true was not supported with analysis or references. The review team also questioned the inconsistency in target materials between Appendix N and Appendix I. In Appendix N Tank 8D-2 was the choice for the material at risk (MAR). In Appendix I, a composite of Tanks 8D-1 and 8D-2 was used as the MAR for accident scenarios because components of the inventories in both tanks are combined to provide a bounding inventory. The basis for these different assumptions was not adequately presented.

DOSE CALCULATIONS

The review team had a number of issues with the dose calculations. One area that especially concerned the review team has to do with their use of population dose. The doses presented lacked statistical information regarding their range, and were unclear about assumptions on intervention, sheltering and other protective measures especially in relation to elevated releases and demographics. Inadequate attention was given to the limitations of the dose calculations as they were performed for both small and large doses. For example, the review team questions the meaningfulness of calculating latent fatal cancers (LCFs) for doses that are at or near the range of background doses for the exposed population. Also, with respect to larger doses for the individual worker and maximally exposed individual, LCF is not a meaningful concept.

The review team was not able to make the connections between the computer codes that were supposedly used, MACCS and RISKIND, and the resulting calculations, because of insufficient information on the conceptual models and input parameter values.

With regard to Section N.5.1 and Table N-5, the review team had difficulty resolving some of the entries. For example, what mechanisms exist to result in a 300-mile dose from a zero-energy release and why are the differences in the doses so small between the zero-energy ground-level release and the elevated plume release.

OTHER

In Appendix I, predecisional draft of 04/30/08, there is a sentence fragment: “Although most of the results presented in this EIS are for distances at least 100 meters (328 feet) downwind from a hypothesized release source.”

COST BENEFIT ANALYSIS

Review Team
Michael T. Ryan (Lead)
B. John Garrick

2008 PDEIS SOURCE MATERIAL REVIEWED

- Chapter 2, Part II (Comparison of Alternatives)
- Chapter 4, Part II (Long Term Consequences)
- Methodologies and Facilities Technical Report
- In-Place Closure Technical Report
- Site-Wide Removal Technical Report
- No Action Alternative Technical Report
- Phased Decommissioning Technical Report
- Site-Wide Removal Table

INTRODUCTION

A review was made of the above documents to assess the technical basis for the analyses made in the 2008 PDEIS relating to the costs and benefits of the various action alternatives for reducing public radiation exposure from the decommissioning and remediation of the Western New York Nuclear Service Center (WNYNSC) site. The utility function for such cost benefit analyses is generally the relationship between the dollar costs of the decommissioning or remediation action per person rem avoided; that number is usually between $20,000 and $25,000. The credibility of such cost benefit analyses is naturally dependent on the credibility of the cost analyses for each of the remediation alternatives under consideration and the quality of the dose calculations. Thus, the findings and summary of the review focus on the cost basis and the dose calculations, especially regarding assumptions, definitions, and applications.

FINDINGS

1. There is a lot of useful information in the reports that cover alternative decommissioning strategies. Each of the alternatives is described and reasonable approaches are developed for the structure used to develop the work plans and cost information. While these are at a top level of a work breakdown structure, they are detailed enough to develop an understanding of what is intended to be done under each alternative. The key facilities are described in each report (very repetitively with the same information being repeated in each report) and the specific actions under each alternative are developed in each report, respectively.

2. There is no transparent treatment of uncertainties and contingencies in the development of the work plans and cost estimates. It is not clear what uncertainties or risks are inherent in these work plans and cost estimates**.** Decommissioning

projects of this type have many uncertainties associated with them and contingencies need to be well developed to guide decision makers in their choices. There is also a lack of clarity in several documents of the actual cost modeling assumptions, including the issue of using present value or adjusted dollars.

3. In Chapter 2, Part II, the following statement is made: "*The best available information was used and conservative but reasonable assumptions were made where uncertainties exist. These conservative assumptions (identified in Chapter 4) were made to ensure that the EIS does not underestimate potential environmental impacts.*" No quantification of this statement is offered. This statement is not supported by analysis. For example, how was best available information determined? Without a more rigorous risk-informed analysis, it has not been shown that the 2008 PDEIS does not underestimate environmental impacts.

4. The use and limitations of latent cancer fatality (LCF) is not well described (Section 2.6.1). Care must be taken and uncertainties must be assessed when applying a statistic such as LCF to small radiation doses to small groups of people. Additionally, it is erroneous to apply such a statistic across generations, i.e., for a period much longer than a human life span.

5. At several places in the text, doses and LCFs are compared to background without being specific about the magnitude of background. The implication is that doses smaller than background are good and doses that are very much less than background are better. Such comparisons create more confusion since medical exposures involve relatively high doses (a few to 10s of rad) delivered at high dose rates versus very low doses (a few mrad or less) delivered at very, very low dose rates. The effects of these different exposure regimes, as we are learning from low dose radiation effects studies, are very different. Additionally, the average background radiation exposure in the United States is currently under consideration by the National Council on Radiation Protection (NCRP). A new report is expected soon from the NCRP with a significant revision upward of the total radiation exposure from all sources. Increases in medical exposures have been previously reported at the NCRP 2007 Annual meeting and are a major contributor to the increases.

6. It is not possible from the information given (see lines 137-145, page 5 of Chapter 2 [Part 2]) to determine if these collective doses are trans-generational, conservative, or non- conservative from the information given. In the case of the Sitewide Removal Alternative it is not possible to determine if the collective dose is trans-generational based on the long time period for that option.

7. Examination of Table 2-B in Section 2.6.2 shows that the only quantitative dose results brought forward from Appendix H are for the scenario in which full institutional controls remain effective indefinitely. No erosion, no on-site intrusion. This scenario is unrealistic and should not be the primary basis used in Chapter 2 to inform decisions.

8. In Table 2-C of Section 2.6.3 there is an estimate of cost avoided per person-rem for the close-in-place alternative without full explanation of how and where it was determined. More information is needed on how the value in Table 2-C for the close-in-place alternative was determined. If the value in Table 2-C was calculated based on doses from the results in Table 2-B, then they are not based on a realistic scenario, and that should be explained.

9. The number of fatalities in shipping radioactive materials seems high. At several places in Chapter 2 (and Chapter 4) very high values are reported. No basis for these high values is provided. It is possible that the transportation statistics are for all commercial transportation, in which case this is not the appropriate basis for the analysis. If the statistics are not specialized to nuclear shipments, then the risk for nuclear accident shipments are very much overestimated and in fact are not correct. Using average accident rates is not conservative it is just wrong.

10. There appears to be an error in the collective doses for the "No Action Alternative" (Section 2.6.2, Lines 186-188). In particular, how can the collective dose over 1,000 years be greater than the population dose over 10,000 years? Making comparisons to "background" may not be as useful as possibly to "standards" for the reasons stated earlier as the background values are being revised.

11. The use of collective dose, peak dose, average dose, conservative dose, reasonably foreseeable annual increment of dose and other terms need to be carefully defined. As currently written, these terms are not well defined. These terms imply statistical significance though none has been derived or demonstrated in the text.

12. Chapter 4 has a lot of good summary information regarding scenarios that were considered and analyzed. The tables are a very good way of presenting the results that went into their preparation.

13. Figure 4-4, "Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for Cattaraugus Creek Receptor for the Sitewide Close-In-Place Alternative with Continuation of Institutional Controls," shows cancer rates over 100,000 years with no discussion of uncertainty. The absence of time dependent uncertainties compromises an understanding of the radiological and chemical risks and their relationship over time. It is not possible to resolve the differences in terms of the likelihoods of the different dose scenarios.

14. The tables and figures in Section 4.1.10 including Figures 4-3 through 4-5 and Tables 4-19 through 4-25 are useful formats for the presentation of the information they contain. However, several important explanations are missing. There is no meaningful discussion of uncertainties regarding the data in any of the tables or figures. There is no statistical analysis to facilitate a meaningful interpretation of the results. For example, based on all the uncertainties in the parameters that went into calculations that support Figure 4.4, it is impossible to know when the plot becomes

statistically the same. Nor is it clear how LCFs are calculated or what they mean for trans-generational time periods. And as previously noted, comparisons to background radiation exposure without stating what background is and how it varies among the populations of interest introduce unnecessary uncertainty.

15. The "Methodologies and Facilities Technical Report" provides a reasonably detailed summary with figures, tables, charts, maps, and sketches to give the reader a concise and reasonably detailed overview of the history, facilities, uses and surrounding properties at the West Valley Demonstration Project (WVDP). In the section on "Key Assumptions and Estimating Bases," the radiological engineering guidelines are clear and reasonable. As was the case of the other documents, there is no indication of how contingencies or uncertainties are to be addressed. In this section there are assumptions that could have very significant cost implications regarding the volumes of wastes that will be generated in each category and what storage provisions will be made for orphan wastes (wastes that do not have a disposal option at present).

16. It is not clear if careful attention has been used to optimize the generation of wastes that can be easily disposed. Optimization of wastes does not necessarily mean generating small amounts of wastes. Rather it means generating wastes that can be readily transported and disposed at a facility capable of handling its constituents and characteristics. Further, it is not clear what wastes will be generated from each of the decommissioning approaches listed and what disposal paths are available and what wastes will be orphaned in each case. This was a very important issue for the case of Rocky Flats and will be important for the WVDP wastes since they include a wide range of waste types with a varying array of constituents.

SUMMARY

The documents reviewed contain a great deal of useful material. The primary issues are the scopes of the analyses performed, consistency in the use of terms and analytical processes, and context of the results.

The scope issues are primarily the lack of a risk-informed perspective that is dependent on the quantification of uncertainties and an appropriate interpretation of the results. The implication is not necessarily the need for probabilistic based risk analyses, but there is the need to adopt a risk perspective of "scenarios," "likelihoods," and "consequences." Scenarios for each decommissioning alternative need to be identified, their uncertainties at least approximated and discussed, some insights about their likelihood of occurrence, and finally the different consequences need to be distinguishable. Another scoping issue noted in the Findings is that the reviewed documents lacked the analytical details to allow the reader to understand the analyses that support the assertions that are summarized in many of the tables and figures. That is, there is text that asserts conclusions without supportive analyses or evidence.

Throughout the documents, as cited in the Findings, there were inconsistencies. For example, it was not always clear what costing models were being used, whether it was future dollars or present worth; the use of LCFs for the case of very low doses and collective doses at times was confusing and misleading as cited in several of the Findings. Definitions are needed to help the reader wade through the many interpretations of dose, e.g., collective dose, peak dose, average dose, and conservative dose.

One of the greatest challenges in presenting nuclear related information to the public is context. Answering the question, "what does it all mean" is a serious issue. Such concepts as collective dose is a prime example of big numbers that have nuclear connotations and scare the public, but in proper context most often involve imperceptible risk. When such concepts are used, they need to be explicitly clear in their meaning and they are often not in relation to the cost benefit analyses contained in the 2008 PDEIS and 2008 PDEIS related documents. A similar problem exists in calculating LCFs for the case of very small doses. Since these reports are for the public as well as the regulators, they require very skillful authorship to present their real meaning.

APPENDIX B

QUALIFICATION SUMMARIES OF THE MEMBERS OF THE INDEPENDENT EXPERT REVIEW TEAM

Dr. B. John Garrick - Chairperson of the Independent Expert Review Team – Dr. Garrick has a Ph.D. in Engineering and Applied Science and an M.S. in Nuclear Engineering from the University of California, Los Angeles; graduate from the Oak Ridge School of Reactor Technology; and a B.S. in Physics from Brigham Young University. He is an executive consultant on the application of the risk sciences to complex technological systems in the space, defense, chemical, marine, transportation, and nuclear fields. He was appointed as Chairman of the U.S. Nuclear Waste Technical Review Board on September 10, 2004, by President George W. Bush. He served for 10 years (1994-2004), 4 years as chair, on the U.S. Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste. His areas of expertise include risk assessment and nuclear science and engineering. A founder of the firm PLG, Inc., Dr. Garrick retired as President, Chairman, and Chief Executive Officer in 1997. Before PLG's acquisition and integration into a new firm, it was an international engineering, applied science, and management consulting firm.

Dr. Garrick was elected to the National Academy of Engineering in 1993, President of the Society for Risk Analysis 1989-90, and recipient of that Society's most prestigious award, the Distinguished Achievement Award, in 1994. He has been a member and chair of several National Research Council committees, having served as vice chair of the Academies' Board on Radioactive Waste Management and as a member of the Commission on Geosciences, Environment, and Resources. He recently chaired the National Academy of Engineers Committee on Combating Terrorism. Among other National Academy committees he has chaired are the Committee on the Waste Isolation Pilot Plant, the Committee on Technologies for Cleanup of High-Level Waste in Tanks in the DOE Weapons Complex, and the Panel on Risk Assessment Methodologies for Marine Systems. Other Academy committee memberships included space applications, automotive safety, and chemical weapons disposal. He is a member of the first class of lifetime national associates of the National Academies.

Dr. Garrick has published more than 250 papers and reports on risk, reliability, engineering, and technology, author of the book "Quantifying and Controlling Catastrophic Risks" (September 2008), written several book chapters, and was editor of the book, *The Analysis, Communication, and Perception of Risk*.

Dr. Jimmy T. Bell - Dr. Jimmy T. Bell is the Chief Executive Officer and Chief Consultant for Bell Consultants. He holds a B.S. in Chemistry and a Ph.D. in Physical Chemistry. He provides consulting services in areas related to actinide chemistry, nuclear waste management, and nuclear fuel reprocessing technologies. He recently served as Deputy Chair of the National Technical Advisory Group to the Tanks Focus Area, organized by DOE to study and provide recommendations for remediating the tank wastes at DOE sites.

Dr. Bell was employed at the Oak Ridge National Laboratory from 1963 until his retirement in 1995 as Head of the Chemical Development Section of the Chemical Technology Division. His work there included participation in and supervision of programmatic activities in actinide spectroscopy and separations; plutonium chemistry; molten salt oxidation treatment of mixed wastes; atomic vapor laser isotope separation (AVLIS) feed and product processing; a U.S. Nuclear Regulatory Commission-supported study of fission product release and behavior in severe light-water reactor accidents; nuclear wastes separations technologies; thermodynamics and stabilities of superconducting materials; nuclear fuel reprocessing technologies; and purification of uranium alloys. Dr. Bell holds four patents and has published more than 45 technical papers.

In addition, Dr. Bell served as a DOE reviewer for nuclear proliferation and sensitive nuclear technologies and has worked as a special investigator for the U. S. International Technology Program. He is a member of the American Chemical Society, the American Nuclear Society, and the American Institute of Chemical Engineers. For many years, he served as Co-Chairman of the International Symposium on Separation Science and Technology.

Dr. Sean J. Bennett - Dr. Sean J. Bennett is a Professor in the Geography Department at the State University of New York at Buffalo. He holds a Ph.D., M.A., and B.S. in Geology. Dr. Bennett has extensive experience in physical and numerical modeling of gully erosion and river processes. His current research interests seek to quantify flow and sediment transport processes in watersheds and to determine the impact of these processes on soil losses, river form and function, water quality and ecology, landscape evolution, and watershed infrastructure and integrity. Prior to joining the State University of New York, he served as a Research Geologist with the U.S. Department of Agriculture, Agricultural Research Service, National Sedimentation Laboratory in Oxford, MS, and was a Research Fellow in the School of Earth Sciences at the University of Leeds.

Dr. Bennett has served as Guest Editor for the International Journal of Sediment Research (WASER), Assistant Editor for The Professional Geographer (AAG), Associate Editor for Water Resources Research (AGU), Associate Editor for the Journal of Hydraulic Engineering (ASCE), and Co-editor for Sedimentology (IAS). Dr. Bennett has published two edited books and authored over 100 journal publications, conference proceeding papers, and technical reports.

Dr. Robert H. Fakundiny - Dr. Robert H. Fakundiny is the New York State Geologist Emeritus. He holds a Ph.D., M.A., and B.A. in Geology. He served as the New York State Geologist and Chief of the New York State Geological Survey for 26 years before his retirement in 2004. Among other honors, he is a Fellow of the Geological Society of America, the American Association for the Advancement of Science, the New York Academy of Sciences, the Geological Society of Canada, and the Geological Society (London). He is a Past President of the American Institute of Professional Geologists, Past President of the Association of American State Geologists and Past Chair of the North American Commission on Stratigraphic Nomenclature. He authored numerous scientific papers on the structure and tectonics of New York State, and is the author of highly recognized work on the Clarendon-Linden fault system.

Dr. Fakundiny was one of the principal investigators and conducted or managed extensive research on the geology, hydrology and geomorphology of the Western New York Nuclear Service Center during the 1970s and 1980s. He was a member of NYSERDA's Independent

Radioactive Waste Technical Review Group during the 1990s, and he served as a member of the 2005-2006 West Valley EIS Performance Assessment Peer Review Group.

Dr. Shlomo P. Neuman - Dr. Shlomo P. Neuman is Regents Professor in the Department of Hydrology and Water Resources at the University of Arizona in Tucson. He holds a Ph.D. and a M.S. in Engineering Science, and a B.S. in Geology. Dr. Neuman's fields of specialization are subsurface hydrology and contaminant transport. He has made seminal contributions to the areas of pumping test design and analysis, flow in multilayered geologic media, finite element simulation of subsurface flow and transport, estimation of aquifer parameters, fractured rock hydrology, peat hydrology, geostatistics, and stochastic analysis of heterogeneous geologic media. He is a Member of the National Academy of Engineering, a Fellow of the American Geophysical Union, and a Fellow of the Geological Society of America. He holds honorary professorships at the University of Nanjing and the Hydraulic Research Institute in China.

Dr. Neuman has received numerous awards and citations during his career, including the 2003 Robert E. Horton Medal of the American Geophysical Union, and is a former Birdsall Distinguished Lecturer of the GSA. Dr. Neuman has served on various national and international advisory panels including the Scientific Review Group for high-level nuclear waste disposal in Canada. Dr. Neuman is Associate Editor of Water Resources Research and a member of the Editorial Board of Stochastic Hydrology and Hydraulics. He is the author of over 300 publications, and he served on the 2005-2006 West Valley EIS Performance Assessment Peer Review Group.

Dr. Frank L. Parker - Dr. Frank L. Parker, Distinguished Professor of Environmental and Water Resources Engineering at Vanderbilt University and member of the National Academy of Engineering, is a pioneer in nuclear waste management and environmental protection. Over the past five decades, he has served as head of the Radioactive Waste Disposal Research Section of Oak Ridge National Laboratory, head of the Radioactive Waste Disposal Research Program at the International Atomic Energy Agency, senior research fellow of the Beijer Institute of the Royal Swedish Academy of Sciences, and senior research fellow of the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. At IIASA, he was head of the Radiation Safety of the Biosphere Program that investigated radioactive contamination in the former Soviet Union and in the People's Republic of China. Professor Parker has chaired or been a member of many national and international advisory committees, including the U.S. Department of Energy's Environmental Management Advisory Board, Scientific Advisory Board (DOD, DOE, EPA) of the Strategic Environmental Research and Development Program, the Arctic Military Environmental Cooperation program (DOD), and the National Research Council's Board on Radioactive Waste Management.

Dr. Parker also served as a consultant to international bodies and countries, including IAEA, WHO, UNSCEAR, World Bank, Belgium, France, Israel, Italy, Pakistan, Sweden and Switzerland. He joined Vanderbilt as a part-time faculty member in1963 and began teaching full time in 1967.

Dr. Michael T. Ryan - Michael T. Ryan, Ph. D., C.H.P., is an independent consultant in radiological sciences and health physics. He is certified in comprehensive practice by the

American Board of Health Physics. He is an adjunct faculty member at Texas A&M University and Vanderbilt University. Dr. Ryan received the Ph.D. in 1982 from the Georgia Institute of Technology, where he was inducted into the Academy of Distinguished Alumni. He graduated from Lowell Tech with a Bachelors degree in Radiological Health Physics. Dr. Ryan received a Masters degree in Radiological Sciences and Protection from the same institution that became part of the University of Massachusetts Lowell. Dr Ryan is the Editor-in-Chief of the Journal *Health Physics* and has served in this position since 2000.

He completed a nine year term as Chairman of the External Advisory Board for Radiation Protection at Sandia National Laboratories in 2007. He is a member of a similar external review board for Lawrence Livermore National Laboratory. He completed 8 years of service on the Scientific Review Group appointed by the Assistant Secretary of Energy to review the ongoing research in health effects at the former weapons complex sites in the Southern Urals. He has also served on several Committees of the National Academy of Sciences producing reports regarding radioactive waste management topics. He also served as Chairman for the Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste and Materials (ACNW and ACNW&M). Dr. Ryan served on Committee since 2002 until it was merged with the Advisory Committee on Reactor Safeguards (ACRS) in 2008. In June, 2008, Dr. Ryan became a member of the ACRS.

Dr. Ryan has been a member of the National Council on Radiation Protection and Measurements since 1992. He was elected to the Board of Directors and served from April 1998 to May 1992. He was appointed as Chairman of Scientific Committee 87 and Scientific Vice President for the Program Area of Radioactive and Mixed Waste from April 1998 to May 2002.

Dr. Ryan previously worked for Chem-Nuclear Systems, Inc., as Vice President and General Manager for the operations and compliance of the low-level radioactive waste disposal and service facilities in Barnwell, South Carolina. Previously, Dr. Ryan spent seven years in operational and environmental health physics at Oak Ridge National Laboratory.

Dr. Peter N. Swift - Dr. Peter N. Swift is the Chief Scientist for the Yucca Mountain Lead Laboratory and a Distinguished Member of the Technical Staff at Sandia National Laboratories. Dr. Swift has over 18 years of experience in transuranic and high-level radioactive waste disposal, including geologic disposal concepts, performance assessment, integration of technical and regulatory activities, and licensing and certification. He has extensive experience with the planning and production of performance assessment analyses for complex nuclear facilities, having served as Manager for the Yucca Mountain Total System Performance Assessment Department and, previously, as the lead for the performance assessment component of the of the Waste Isolation Pilot Plant (WIPP) Compliance Application.

Dr. Swift holds a Ph.D. in Geosciences from the University of Arizona, and is a member of the American Geophysical Union, Geological Society of America, and American Association for the Advancement of Science. He has more than 50 publications, including refereed technical papers, technical reports, and conference papers.

Dr. Chris G. Whipple - Dr. Chris G. Whipple is a Principal with ENVIRON International Corporation in Emeryville, CA. He holds a Ph.D., M.S., and B.S. in Engineering Science. He is a Member of the National Academy of Engineering and is a Designated National Associate of the National Academies. He chaired and served on the National Academy of Sciences Board On Radioactive Waste Management, and he chaired the Peer Review of the Yucca Mountain Total System Performance Assessment. He has been a consultant to the U.S. Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste, to the U.S. Nuclear Waste Technical Review Board, and to the Swedish Radiation Protection Institute. He is a Member of the National Council on Radiation Protection, and a Charter Member, Fellow, and Former President of the Society for Risk Analysis.

Dr. Whipple has served on a number of national and international review boards and oversight committees, and he is the author of numerous publications on risk assessment, risk management, and risk communication. Dr. Whipple chaired the 2005-2006 West Valley EIS Performance Assessment Peer Review Group.

Dr. Michael P. Wilson - Dr. Michael P. Wilson is a Professor of Geology at the State University of New York at Fredonia. Dr. Wilson holds an A.B. in Earth Science Education, M.S. in Geology, and a Ph.D in Geology with a minor in Geotechnical Engineering. His research interests include chemical and sediment loading in the watersheds of southwestern New York State. Dr. Wilson has prepared environmental management plans for lakes and drinking water supplies, and he manages the Chautauqua County Water Network in cooperation with the Chautauqua County Health Department. Because of the frequent problems with water turbidity in the upland reservoirs of the Southern Tier of New York, he has done significant work on erosion processes and rates, and he has investigated the effectiveness of implementing erosion controls at many locations across the Southern Tier. Previously, Dr. Wilson studied erosion, erosion controls, and landform development in Texas and North Carolina.

Dr. Wilson is the author of more than 70 technical reports and publications. He served on the Editorial Board of the Association of Engineering Geologists Bulletin, held eight offices in professional societies, and presented stream erosion research to the North Carolina Sediment Control Commission. He was appointed by the New York State Department of Health to the New York State Source Water Assessment Program and featured in a thousand-attendee teleconference, was appointed to the Chautauqua Lake Management Commission, and was North Carolina’s representative to the Southeast Conference on Groundwater Management. Dr. Wilson also wrote technical portions of the New York State Civil Service Exam in hydrology.

APPENDIX C

ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
Center	Western New York Nuclear Service Center
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLFS	Clarendon-Linden Fault System
CLSM	Controlled Low Strength Material
CMF	Container Management Facility
Codes	CHILD, CREAMS, DandO, MACCS, ORIGEN, PEST, RESRAD, RISKIND, SEDIMOT II, SIBERIA, SWAT, TRAGIS, USLE, WEPP
CPC	Chemical Process Cell
DEIS	Draft Environmental Impact Statement
DEM	Digital Elevation Model
DOE	U.S. Department of Energy
DOE-EM	Department of Energy Office of Environmental Management
DOE-ORO	DOE Oak Ridge Office
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
GLUE	Generalized Likelihood Uncertainty Estimation
GTCC	Greater Than Class C
HEPA	High Efficiency Particulate Air
HLW	High level Waste
HVAC	Heating, Ventilating, and Air Conditioning
IERT	Independent Expert Review Team
KRU	Kent Recessional Unit
KT	Kent Till
LCF	Latent Cancer Fatalities
LLW	Low Level Waste
LTPA	Long Term Performance Assessment
LTR	License Termination Rule
MAR	Material At Risk
MCE	Maximum Credible Earthquake
MCL	Maximum Contaminant Levels/Maximum Concentration Limits
MEI	Maximally Exposed Individual
MSEE	Modular, Shielded Exhumation Enclosure
NCRP	National Council on Radiation Protection
NDA	NRC-Licensed Disposal Area
NEPA	National Environmental Policy Act
NFS	Nuclear Fuel Services
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
NYSERDA	New York State Energy Research and Development Authority

OLS	Olean Recessional Sequence
PA	Performance Assessment
PDEIS	Preliminary Draft of the West Valley Decommissioning Environmental Impact Statement
PHGA	Peak Horizontal-Ground Acceleration
PRDEIS	Peer Review of Draft Environmental Impact Statement
PRG	Peer Review Group
PSHA	Probabilistic Seismic Hazard Evaluation
RCRA	Resource Conservation and Recovery Act
RMSE	Root Mean Square Error
SDA	State-Licensed Disposal Area
STRA	Sitewide Total Removal Alternative
STS	Supernatant Treatment System
TBU	Thick Bedded Unit
TEDE	Total Effective Dose Equivalent
TRU	Transuranic
ULT	Unweathered Lavery Till
WB	Weathered Bedrock
WCS	Water Control Structure
WIPP	Waste Isolation Pilot Plant
WMA	Waste Management Area
WNYNSC	Western New York Nuclear Service Center
WVDP	West Valley Demonstration Project
YMP	Yucca Mountain Project