Review of Sandia National Laboratories' Mixed Waste Landfill Corrective Measure Implementation Plan and Fate and Transport Model:

Comments and Recommendations

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INTRODUCTION

These Comments and Recommendations address portions of the Sandia National Laboratories' (SNL) Mixed Waste Landfill (MWL) Corrective Measure Implementation Plan (CMIP) and Fate and Transport Models (FTM) posted on the New Mexico Environment Department (NMED) Website. NMED required SNL to provide these documents as part of the Permit Modification issues to SNL regarding the MWL in May, 2005.

The Corrective Measure Implementation Plan ("CMIP") is posted at http://www.nmenv.state.nm.us/hwb/SNL/MWL/SNL_Mixed_Waste_Landfill_CMI_Work_Plan_(11-2005).pdf. The Fate and Transport Model ("FTM"), titled "Probabilistic Performance-Assessment Modeling of the Mixed Waste Landfill at Sandia National Laboratories" Document Number SAND 2005-6888 is posted at http://www.nmenv.state.nm.us/hwb/SNL/MWL/Fate_and_Transport_(Probabilistic_Performance-Assessment_Modeling_of_the_MWL;%2011-2005).pdf).

The Permit Modification issued by New Mexico Environment Department for the Mixed Waste Landfill (posted at http://www.nmenv.state.nm.us/hwb/SNL/MWL/Final_Decision/Permit_Language_for_the_Mixed_Waste_Landfill.pdf) requires that Sandia/DOE submit a CMIP that "shall, at a minimum, include:

a. A description of the selected remedy;
b. A description of the remediation system objectives;
c. An identification and description of the qualifications of key persons, consultants, and contractors that will be implementing the remedy;
d. Detailed engineering design drawings and systems specifications for all elements of the remedy;
e. A construction and construction quality assurance work plan;
f. An operation and maintenance plan;
g. The results of any remedy pilot tests, such as landfill cover test plots;
h. A schedule for submission to the Administrative Authority of periodic progress reports;
i. A schedule for implementation of the remedy;
j. A health and safety plan;
k. A comprehensive fate and transport model that studies and predicts future movement of contaminants in the landfill and whether they will eventually move further down the vadose zone and/or to groundwater;
l. Triggers for future actions that identify and detail specific monitoring results that will require additional testing or the implementation of an additional or different

remedy."

In response to comments identified during review of the FTM and CMIP, recommendations regarding specific revisions to the FTM and CMIP are identified. The recommendations include revising the CMIP to reflect modifications proposed for the FTM.

Due to the technical nature of the FTM, the reliance of NMED on a contractor to conduct a technical review of the FTM, and the numerous areas of deficiency in the FTM noted in these comments it is also strongly recommended that NMED convene a "technical discussion group" to serve as a public meeting to provide for an exchange among interested stakeholders regarding the adequacy of the FTM and CMIP. It is recommended that such a technical discussion group include representatives of the permittee, the NMED and members of the public who have expressed an interest in the studies conducted by SNL and/or submitted comments to the NMED on the CMIP and/or FTM. It is recommended that this technical discussion group be convened prior to the determinate that the FTM and CMIP are either "comprehensive" or "complete" with respect to the technical requirements applicable to the wastes at the MWL.

I. Fate and Transport Model Comments and Recommendations

A. General Comments: The document submitted to comply with the FTM requirements in the Permit Modification is not comprehensive with respect to:

1. **The volume of each individual waste product and physical state of containers for the full range of contaminants at the Mixed Waste Landfill;**
2. **Potential for releases including vadose zone and groundwater contamination due to transport not considered in the FTM including mechanisms such as biological transport of contaminants through the ground surface, human intrusion, and movement of contaminants by wind/air;**
3. **Modeling for the complete suite of radionuclides and daughter products, metals, and volatile and semi-volatile organic compounds in the known inventory of the MWL.**

RECOMMENDATION: The FTM should be revised to provide the "comprehensive" model required by the Permit Modification and the CMIP should be modified to reflect the findings of the revised FTM following its acceptance as technically complete and comprehensive by NMED.

B. Areas not addressed in the FTM:

1. **The FTM fails to address biological transport of contaminants resulting from plant and animal uptake of contaminants and subsequent dispersion of soil, plant and animal material by wind, including vertebrate and invertebrate animals entering the landfill and plants**

transporting contaminants taken up through their root systems. Data presented at the December 2004 MWL Public Hearing by SNL demonstrate that deer mice and vegetation at the MWL show contamination with low levels of tritium and radon.

2. **The FTM fails to address transport of contaminants resulting from human intrusion associated with accidental events and the eventual failure of the land use restriction portions of the institutional controls proposed by SNL for the MWL. Accidental or unforeseen events that could be included in FTM model assumptions should be understood to include discharges of large volumes of water at the site on the order of disposal of more than 270,000 gallons of reactor cooling water at the site or the pooling of snow melt and rain water above trenches, circumstances that occurred at the MWL while it was an active disposal site.**
3. **The FTM fails to provide a comprehensive fate and transport analysis as it does not include calibrated model "realizations" for the full range of radioactive and hazardous constituents identified at the MWL including: a wide range of radionuclides, a wide range of metals and inorganic compounds including beryllium, nickel, chromium, sodium, lithium, and the range of volatile organic compounds already demonstrated to have been escaped from the MWL. A comprehensive list of radionuclides, metals and volatile organic compounds can be found in what is identified in the CMIP at p. 4-2 as "[a] detailed MWL waste inventory, by pit and trench, … provided in the Environmental Restoration Project "Responses to NMED Technical Comments on the Report of the Mixed Waste Landfill Phase 2 RCRA Facility Investigation Dated September 1996" (SNL 1998)."**
4. **The FTM fails to identify or address fate and transport dynamics associated with the potential for formation of mobile, potential hazardous compounds by radiolysis - the process by which radionuclides can mix with non-radioactive constituents and form new compounds – to occur among waste constituents of the MWL.**
5. **The "triggers" identified in the FTM fail to include monitoring mechanisms to reflect either human intrusion, biological transport, or the waste constituents identified at the MWL, but not considered in the FTM.**
6. **The FTM fails to identify means to monitor, model and assure the effectiveness of institutional controls or the consequences of the failure of such passive site protection measures.**
7. **The FTM fails to provide a risk assessment/performance assessment analysis in its evaluation of the potential for release of contaminants from the MWL.**

RECOMMENDATION: In order for the FTM to be fully "comprehensive," NMED should require that the FTM be revised and expanded to address each of the areas of incompleteness identified above.

C. Areas addressed inadequately in the FTM:

1. **The FTM relies on data regarding releases of radionuclides, heavy metals and VOCs ("volatile organic compound") from the Phase 1 and Phase 2 RCRA Feasibility Investigation (RFI) gathered 1993 – 1995. FTM at 14. No new data gathering was conducted. No new data gathering is proposed to calibrate or verify the modeling conducted**.

RECOMMENDATION: The NMED should require that SNL conduct a monitoring program to verify the accuracy of the model parameters and model results identified in the FTM. This program should include sampling of the vadose zone at and beneath the MWL to determine if the FTM's predictions and assumptions accurately reflect conditions at the MWL.

2. **The FTM appears to have failed to identify or consider either the mechanisms for deterioration of waste containers or the consequences of the deterioration of waste containers in any manner during development of the input parameters and assumptions for its VOC, heavy metal and radionuclide models, with the single exception of the radon model runs in which radium-226 containers were determined to deteriorate in 1,000 years**.

The failure to address container deterioration systematically in the FTM results in the model using inappropriate, non-conservative assumptions about the "source terms" of waste constituents. The MWL waste containers, or the MWL waste containers SNL is aware of, include 55-gallon drums, plastic bags and other short-lived containers with an identifiable lifespan that is very short, a few decades in the case of 55-gallon drums, compared to the extremely long-lived hazards associated with the MWL contents other than tritium and cobalt-60.

The failure to address the limits on the durability containers due to deterioration mechanisms and resulting contaminant releases ignores a primary critique of SNL's data presented at the December 2004 MWL Public Hearing, as identified by the Hearing Officer, that SNL studies and models to date have failed to address the inevitable deterioration of waste containers.

RECOMMENDATION: To reflect the intent of the Hearing Officer as stated in her Final Report and Proposed Final Order, the FTM should be revised to identify and address fate and transport dynamics that would occur as a result of the deterioration of all VOC, heavy metal and radionuclide containers at the MWL.

Also, the FTM's analysis of potential radon movement should be revised to both identify mechanisms that would result in deterioration of the radium-226 containers and conduct model realizations for container deterioration faster than the 1000-year period reported such as deterioration within 100-years of disposal.

3. **The FTM concludes that PCE, the one organic compound modeled in the FTM, would reach groundwater for all 100 model runs ("realizations") with the majority of the model runs showing PCE reaching groundwater within 50 years**.

The FTM states:

"Figure 22 [on p. 55] shows the simulated PCE concentrations in the groundwater as a function of time for all 100 realizations. **The majority of the realizations show the aquifer concentrations peaking before 50 years**. **Depending on the time of disposal, this corresponds to peak concentrations occurring by 2010 – 2040.** [emphasis added]. To date, no detectable amounts of PCE have been found in the groundwater at the MWL. This is still consistent with the simulations which show a large amount of variability in the simulated concentrations resulting from uncertainty included in the input parameters." FTM at pp. 54-55. Figure 22 is attached these comments as APPENDIX A.

Thus, the FTM confirms that a volatile organic compound already shown to have escaped from the MWL, tetrachloroethylene (PCE), is likely to reach the groundwater aquifer within 50 years in most model runs. This finding should serve as a basis for NMED to focus a substantially higher degree of attention on the need for a corrective measure at the MWL that can be demonstrated to effectively control releases of VOCs.

Figure 23 in the FTM shows the concentration of PCE anticipated in the groundwater by the model realizations. This figure shows that the vast majority of the realizations – about 80% - show PCE levels in the groundwater in the range of 1 – 5 micrograms per liter, equivalent to parts per billion. Prediction of those concentrations of PCE reaching the groundwater represent a prediction of significant contamination as PCE is not naturally occurring and therefore **zero** PCE would be predicted to have reached groundwater if no PCE were already shown to have escaped from the MWL. Figure 23 is attached to these comments in APPENDIX A.

The FTM shows that PCE reaches groundwater based on data from previously detected releases of VOCs at the MWL as, the FTM notes:

"Although no quantitative estimates of the volumes of these contaminants disposed of in the MWL exist, soil samples provide an estimate of the extent and concentration of the region contaminated with VOCs at the MWL." FTM at p. 52.

The lack of information about this highly mobile contaminant in the MWL inventory, or the form and condition of containers used for disposal of PCE and other VOCs and SVOCs, prevents SNL from conducting analyses based on accurate estimates of the amount of VOCs and SVOCs in the MWL. The lack of recent or current VOC and SVOC monitoring data since the 1993 Phase 2 RFI prevents SNL from accurately reflecting the current extent of VOC and SVOC releases from the MWL in the FTM.

As SNL has no information available about the VOC waste volume and disposal practices the FTM used the:

"[M]aximum measured gas concentration (5,900 ppb) … as a minimum value in a uniform distribution increasing to ten times this value to develop a range of equilibrium aqueous concentrations." FTM at p. 52. In other words, since the MWL permittee acknowledges that it has no information on the amount or form of the PCE (and other VOCs and SVOCs) in the landfill or how the containers they were disposed in have aged, the model used the amount of VOCs and SVOCs more than a decade ago that had already leaked from the landfill for the "source term."

This method of identifying the "source term" for the PCE FTM does not account for the likelihood that the amount of PCE, and other VOCs, leaking from waste containers may have increased significantly since 1993 when the VOC releases used to develop the FTM were detected.

The FTM only modeled one organic compound, PCE, though a dozen VOCs and SVOCs were demonstrated to have been released from the landfill by 1995. In spite of the demonstration that PCE would reach groundwater within 50 years in all model realizations, the FTM failed expand its modeling study to address the fate and transport of other organics detected in the Phase 2 RFI monitoring data.

Similarly the FTM fails to identify or present model realizations for the decay products of PCE and the other VOCs and SVOCs demonstrated to have escaped the MWL in 1993. This is particularly problematic as at least one decay product of PCE, vinyl chloride, has a maximum contaminant level (MCL) established by EPA of 2 ppb, less than the proposed trigger level of 2.5 ppb proposed for PCE in the FTM at p. 62. See EPA "National Primary Drinking Water Regulations" at http://www.epa.gov/safewater/contaminants/dw_contamfs/vinylchl.html.

As no information is presented in the FTM regarding fate and transport model realization data for any PCE decay product, no information is presented regarding concentrations of any decay products in groundwater that may have been predicted by the FTM model realizations.

The FTM should be revised to correct inconsistencies in data presented regarding PCE releases from the MWL. The FTM states that the maximum PCE detected in 1993 was 5,900 ppb at p. 52, but lists the maximum concentration of PCE in 1993 as 5,200 ppb on Figure 21 at p. 53.

RECOMMENDATION: Because PCE was shown to reach groundwater in all model realizations within approximately 50 years, the FTM should be revised to include model realizations reflecting future movement of all VOCs and SVOCs found to have been released from the landfill in 1993. These additional models and model realizations should be revised to include consideration of the decay products of PCE and the other VOC s and SVOCs that were shown to have escaped the MWL by 1993. Decay products modeled should include any decay products, such as vinyl chloride, that may have MCLs as low or lower than that established for PCE.

The FTM should be revised to reflect the potential for container deterioration to have resulted in significant additional VOC and SVOC releases from the MWL at rates well beyond the "ten times" indicated in the FTM at p. 52. As substantial additional deterioration of VOC and SVOC containers is likely to have occurred since 1993, it is reasonable for the FTM to be revised to include consideration of VOC and SVOC source terms 100x and 1000x the maximum values detected in the vadose zone in 1993 for all VOCs and SVOCs detected at the landfill. Model realizations considering source terms 100 – 1000 times concentrations detected in 1993 will allow the FTM to address the potential for additional releases since 1993 or releases not detected in 1993.

The FTM should be revised to include evaluation of the vapor phase transport mechanism attributed to the VOCs that reached the groundwater at the Chemical Waste Landfill at SNL. This revision should be included to ensure that the assumptions regarding PCE movement used in the FTM reflect real world conditions at as demonstrated at other landfills at SNL.

The FTM should be revised to include a VOC and SVOC detection and monitoring system to provide real world data to verify results of model realizations.

The NMED should request a revision of the FTM that corrects any inconsistencies in data used and presented in the FTM. The indication that the FTM authors may have understated the maximum PCE gas concentrations in 1993 by more than 10% (the difference between 5,900 and 5,200) in one of its models (as reflected in Figure 21) should serve as a basis for the NMED to require verification that the appropriate, higher value was used in the FTM. In addition, the NMED should require that SNL verify that model realizations were indeed conducted with using values "ten times" the 1993 maximum gas concentration of PCE as neither Figure 21 or any other portion of the FTM discussion of VOC model realizations appear to reflect the use of values "ten times" 1993 maximum gas concentrations asserted by the FTM at p. 52.

The NMED should consider requiring improvements in the Corrective Measure proposed for the MWL to prevent future releases of VOCs and SVOCs from the MWL as the FTM (and a 1995 Argonne National Laboratory study cited in the FTM, as discussed below) demonstrates the high probability of VOCs reaching groundwater beneath the MWL at values at or near applicable maximum contaminant level standards.

4. **The FTM identifies a 1995 Argonne National Laboratory [cited as Johnson 1995 in the FTM] report at p. 16 that showed that VOCs released from the MWL could reach the water approximately 250 years from the time of disposal. This study was not provided to NMED as part of either the Corrective Measures Study (CMS), Corrective Measure Implementation Plan (CMIP) or the references for either of those reports**.

The FTM at p. 16 states:

"**The [Argonne National Laboratory study report as Johnson, 1995] study also included screening calculations for aqueous-phase transport of PCE and TCE, and predicted that these VOCs could reach the water table approximately 250 years**

from time of disposal. No calculations were conducted for vapor-phase transport, which has proven to be the most significant transport mechanism for organic compounds in the vadose zone at nearby ER sites, including the Chemical Waste Landfill."

This 1995 study is cited as:

"Johnson, R., D. Blunt, D. Tomasko, H. Hartmann, and A. Chan, 1995, A Human Health Risk Assessment for the Mixed Waste Landfill, Sandia National Laboratories, Albuquerque, New Mexico, Argonne National Laboratory, Argonne, IL."

Though the FTM asserts that the Argonne Study used a "worst case scenario" approach, the failure of the 1995 Study to consider vapor-phase transport mechanisms, which has been shown to have resulted in VOCs escaping the Chemical Waste Landfill at SNL reaching the groundwater aquifer, appears to contradict that assertion.

The combination of the 1995 Argonne study with the FTM demonstrates that the high mobility of VOCs is not controlled by the proposed Corrective Measure at the MWL and the likelihood that VOCs will reach the groundwater aquifer beneath the MWL even if the currently approved Corrective Measure is installed at the MWL.

RECOMMENDATION: The NMED should require SNL to provide the agency with copies of the 1995 Argonne Study, review the Study, and consider its relevance regarding the adequacy of the Corrective Measure identified in the Permit Modification since SNL failed to present the Study to NMED or the public or consider it during the development of the Corrective Measure Study.

The NMED should review the Corrective Measure approved in the Permit Modification as the conclusions of the 1995 Argonne Report are contrary to the conclusions presented in the CMS and MWL hearing by SNL that contaminants such as VOCs *could not* reach groundwater at the MWL site. See statement "Contaminants are unlikely to reach groundwater …" CMS at 29.

5. **The "trigger levels" identified in the FTM fail to provide for early detection and early response to releases prior to the exceedence of health–based standards. The proposed trigger levels fail to provide either early detection or early response as they are set at values at or near regulatory standards rather than at levels that would demonstrate the "edge of the plume," which is the purpose of trigger levels as identified by the MWL Hearing Officer's Final Report at pp. 35 – 40.**

The trigger levels identified in the FTM are values that are well above background concentrations for the constituents identified and fail to identify levels that would demonstrate that the "edge of a plume" has reached a location of concern or that statistically significant increases in the concentration of contaminants have been detected by monitoring activities.

Exceedences of the proposed trigger levels identified in the FTM would demonstrate that significant and extensive contamination has already occurred, not conditions at the "edge

of the plume," and would result in subsurface contamination that would be much more expensive to remedy than contamination detected at trigger levels set at concentrations exceeding background by a statistically significant value, such as 25% or 50%, above locally appropriate background values.

Though neither the Permit Modification or the Secretary's Final Order provide a specific definition for "trigger levels," several sources can be identified that demonstrate that the appropriate understanding of "trigger level" as identified in the MWL Hearing Officer's Final Report is a concentration of a constituent designated to "detect contamination" or the "edge of a plume," rather than an exceedence of a regulatory standard.

In her Final Report, the Hearing Officer identified an example of trigger levels as: "one trigger could be that if contaminants moved a specific distance deeper under the landfill, then this might result in NMED ordering future excavation" at p. 40.

At the MWL Public Hearing in December 2004, NMED's technical witness Willam Moats stated, "…triggers themselves would be designed around detection of contamination in the vadose zone and the groundwater." MWL Hearing Transcript at p. 1141.

RECOMMENDATION: To insure that trigger levels identify the "edge of a plume" and "detect contamination," rather than the exceedence of regulatory standards, the trigger levels applied to the monitoring systems at the MWL should be set at concentrations that reflect a significant increase above background values rather than at a concentrations that approach regulatory standards and are many times higher than background conditions. The location of the monitoring systems at which the trigger levels would apply should be beneath the landfill, but well above the groundwater level for the trigger levels to serve as an "early warning system" rather than confirmation of groundwater contamination by applying proposed trigger levels at an elevation at which groundwater is found as proposed in the FTM.

To provide "detection of contamination," trigger levels should be established at a level 25 – 50% above initial concentrations for contaminants of concern. Verification of contaminant concentrations when detected will provide assurance that values that exceed background concentrations by a significant amount are not anomalous or indicative of analytic error.

6. **The trigger levels proposed in the FTM fail to identify trigger levels for waste constituents that apply at the edge of the MWL or in the vadose zone below the site but above the water table**.

The FTM lists recommended "trigger levels" in Section 4.2.1 at pp. 61 – 62. The list fails to include vadose zone trigger levels for contaminants identified in the MWL and only lists vadose zone trigger level for "infiltration" as measured by moisture content increase.

RECOMMENDATION: The FTM should be revised to provide for a vadose zone monitoring program that includes analysis of all of the constituents identified on pp. 61 – 62 and other constituents that may be identified based on these comments or other recommendation provided to the NMED to insure that all transport mechanisms, both anticipated and unanticipated, are addressed by the trigger levels implemented at the MWL.

7. **The FTM discussion of "Trigger Levels"' does not address the degree to which monitoring for moisture content changes would reflect vapor phase movement of VOCs**.

Vapor phase movement of VOCs is noted as the mechanism for VOC transport to groundwater at the Chemical Waste Landfill at SNL. See quote from Johnson 1995, FTM at p. 16.

RECOMMENDATION: The FTM should identify effective technologies for detection of vapor phase movement of VOCs into the vadose zone beneath the MWL. These technologies should be included in an expanded monitoring system to provide for detection of VOC and SVOC releases from the MWL.

8. **A broad range of sources of uncertainty in the FTM were identified by the FTM lead author Dr. Clifford Ho in a powerpoint presentation at a DOE-sponsored public meeting on the FTM in January 2006. The "uncertainty variables" identified by Dr. Ho included: waste inventory and size; thickness of cover and vadose zone; and transport parameters including: infiltration, adsorption coefficient, saturated conductivity, moisture content; tortuosity coefficients, and boundary-layer thickness.**

The FTM Report posted at on the NMED site does not identify the "uncertainty variables" in as clear and succinct a manner as the presentation by Dr. Ho and does not identify the range of values use for each of the "uncertainty variables" parameters used in model realizations to account for those sources of uncertainty for each of the contaminants modeled.

RECOMMENDATION: The FTM should be revised to identify the full range of uncertainty variables associated with each of the constituents addressed in the FTM.

The FTM should be revised to identify the range of values used in model realizations to account for the uncertainty associated with each variable.

II. Corrective Measures Implementation Plan Comments and Recommendations

A. **The CMIP fails to effectively incorporate the content and findings of the FTM in either the evaluation or design of the Corrective Measure proposed for the MWL**.

While the CMIP includes the full text of the FTM as Appendix E in the CMIP as posted by NMED, the body of the CMIP does not appear to refer to or incorporate any of the information identified in the FTM in the substance of the CMIP.

Neither the "Regulatory Basis" (Section 3), "MWL Characteristics" (Section 4), "Technical Basis" (Section 5), "Vadose Zone Moisture Monitoring" (Section 7), "Conclusions" (Section 8) nor "References" (Section 9.0) sections of the CMIP identify or refer to the FTM or the data it contains.

RECOMMENDATION: The CMIP should be revised to incorporate the analyses and findings in the FTM - when it is determined to be comprehensive and meet the requirements of the Permit Modification and associated guidelines and regulations by NMED - in the design, operation and monitoring and maintenance plans proposed by the permittee for the MWL.

B. **The CMIP fails to provide a comprehensive or detailed long-term operation and maintenance plan for public comment or review**.

While the MWL Permit Modification requires the permittee to provide an operation and maintenance plan, the CMIP only provides information about vadose zone instrumentation and defers the presentation of information on the duration and frequency of the operation and maintenance plan until the conclusion of an unspecified consultation process with NMED. That approach is identified as the process for development of a MWL long-term monitoring and maintenance plan. No aspects of a MWL monitoring program other than vadose zone monitoring are identified or addressed in the CMIP. See CMIP p. 7-1.

RECOMMENDATION: The CMIP should be revised to include a comprehensive long-term monitoring and maintenance program for public review and comment. The proposed long-term monitoring and maintenance program should include: all parameters to be monitored, all media – including air, soil, vadose zone, groundwater and biota (plants and animals); recommended limits of detection for analytic equipment to be use; frequency of sampling and analysis; quality control and quality assurance measures; monitoring and maintenance cost estimates; MWL cover inspections and maintenance activities; and measures to verify that all institutional control aspects of the proposed corrective measure are in place and enforced for the full closure and post-closure period at the MWL.

C. The CMIP proposes only three vadose zone monitoring sites – boreholes - and does not provide a demonstration that such an arbitrary and limited number of instruments will provide comprehensive vadose zone monitoring.

The CMIP at p. 7-1 describes a vadose zone monitoring program that includes three access holes based on the "simplicity, low cost and long-term viability" of the approach. Unfortunately, the permittee did not consider it appropriate to provide a vadose zone

monitoring program that is comprehensive enough to comply with the MWL Permit Modification or capable of monitoring the vadose zone beneath all of the MWL. This shortcoming in the CMIP is particularly significant in light of the FTM demonstrations that groundwater contamination due to VOC releases is inevitable as it occurs in all model realizations.

In its analysis, the CMIP fails to identify locations where contaminants from the MWL have been shown to have migrated from their point of disposal into the vadose zone in the Phase 2 RFI investigation nor does it correlate those locations with the three vadose zone monitoring sites in the CMIP. These locations are identified in the record of the MWL public hearing and include data from the "RFI Phase 2" conducted in the early 1990s.

No information is available on the extent of the migration of contaminants since the RFI Phase 2 investigations as such an investigation has not been required by NMED or attained and reported by SNL.

RECOMMENDATION: The CMIP should be revised to incorporate data from an investigation of the current extent of migration of contaminants into the vadose zone. The NMED should require SNL to conduct investigations using technologies such as ground penetrating radar and other geophysical methods to detect moisture distribution in addition to soil borings and other methods to insure that the vadose zone monitoring program can be demonstrated to be comprehensive and addresses the full extent of vadose zone contamination beneath and adjacent to the MWL.

The CMIP should be revised to include additional vadose zone monitoring that is capable of providing a comprehensive capacity to detect contaminants released from the MWL.

In the alternative, the CMIP should be revised to demonstrate that the proposed vadose zone monitoring system is configured in a manner that can detect all potential routes of migration of contaminants, including volatile and semi-volatile organic compounds, identified beneath or adjacent to the MWL in the RFI Phase 2 investigation.

D. **The CMIP fails to address the technical literature related to bio-intrusion barriers or identify monitoring systems appropriate for detect of release associated with bio-intrusion into the MWL**.

An extensive body of technical literature has been developed on bio-intrusion barriers as well as releases of contaminants through vertebrates, invertebrates and plants that have been shown to have penetrated bio-intrusion barriers. This data was summarized in a report by a leading international expert on bio-intrusion barrier design and function prepared for Citizen Action New Mexico and presented to the NMED as part of its comments on SNL's proposed corrective measure at the MWL. This report, "Review of Sandia National Laboratories/New Mexico Evapotranspiration Cap Closure Plans for the Mixed Waste Landfill," by Tom Hakonson, Ph.D., Environmental Evaluation Services, LLC, is available at http://www.radfreenm.org/pages/hakonson_full.htm.

In his report, Dr. Hakonson's asserted that assumption that "tritium is now present in vegetation and animals that now occupy the MWL" was correct. He also cited investigations in which Sr- 90, Cs-137 and Pu - all contaminants found at the MWL - have been discovered in animals occupying similar landfills containing mixed wastes and further states that biological transport of radioactive contaminants is likely to occur over time and increase over the long-term.

Information presented at the Mixed Waste Landfill Public Hearing in December 2004 by SNL confirms Dr. Hakonson's assertion regarding deer mice and vegetation at the MWL which show contamination with low levels of tritium and radon. See MWL Hearing Record Transcript at pp. 102 - 104 as noted in Hearing Officer Final Report at pp. 7 and 35.

Regarding biological transport of contaminants, Dr. Hakonson's report states:

"Both plants and animals have the potential to transport buried waste to the ground surface. Plants do so via roots that can penetrate several meters into the landfill. Furthermore, most plant species have the capability to penetrate the relatively thin cover soil layer proposed for the MWL. This means that the term, "shallow rooted" as used by the SNL/NM ET cap designers is inappropriate given that the grass species that they propose to use to revegetate the ET cover all have the capability to send roots several meters into the soil. If soil moisture penetrates beyond the existing rhizosphere, plant root distribution will extend downward to capture moisture at the deeper depths.

"Roots in contact with waste can incorporate soluble constituents and transport them to the ground surface. This uptake process is analogous to a one-way valve in that contaminants are pumped upward to above ground vegetation that eventually senesces and deposits associated contaminants on the ground surface. Burrowing by animals and insects also has the potential to access buried waste several meters below the ground surface. This can lead not only to chemical and radiation exposures to the organisms but also to physical transport of the waste upward in the soil profile and to the ground surface.

"This leads to what I believe is one of the more important deficiencies in the proposed MWL closure, namely the assumption that vertical and horizontal transport of site contaminants resulting from biological processes is not an important contributor to exposure pathways. My review suggests that relevant data from the MWL on contaminants in vegetation, animals, and soil cast to the surface by burrowing animals apparently do not exist. The reason biointrusion may be important is that it represents the major mechanism leading to vertical transport of contaminants to the ground surface and through the drying effect of plant transpiration on cover soils, plays a major role in the evolution of volatile contaminants from the ground surface. While vertical transport by biota may be small on a short time scale, over many decades these processes may become dominant in mobilizing buried waste.

"<u>It is my opinion that the soil sampling done by SNL/NM in 1990 as a part of the Phase 2 RFI provides little information that can be used to answer questions about the effects of biointrusion in transporting MWL contaminants to the soil surface. The RFI soil sampling grid resulted in evenly spaced samples (i. e., that were non-randomly distributed), that provided coarse spatial resolution of contaminant concentrations, and that involved sampling locations that were recently disturbed such as Trench F where</u>

backfill was added just months before the soil samples were taken. Furthermore, those samples that were taken in 1990 represent a single snap shot in time and depending on the degree of past mechanical disturbances that occurred within the MWL boundaries, they may represent a snap shot with little elapsed time between soil surface disturbance and when the soil samples were taken.[emphasis added]."

RECOMMENDATION: The CMIP should be revised to include a thorough investigation and re-sampling of the soil at the MWL to identify bio-intrusion mechanisms and biological transport of contaminants, and consider the relationship of these findings of such investigations to the Corrective Measure for the MWL. The NMED should consider revisions to the Corrective Measure permitted for the MWL based on information concerning biological transport in Dr. Hakonson's report and sampling data collected from the flora and fauna at the MWL by SNL since biological transport of contaminants has occurred - and continues to occur - at the dump.

The implementation of a comprehensive sampling program designed to detect levels of radioactive contamination in plants and animals living at the MLW is strongly recommended as a part of the CMIP with appropriate trigger levels to be used to determine future corrective actions at the MWL.

APPENDIX A

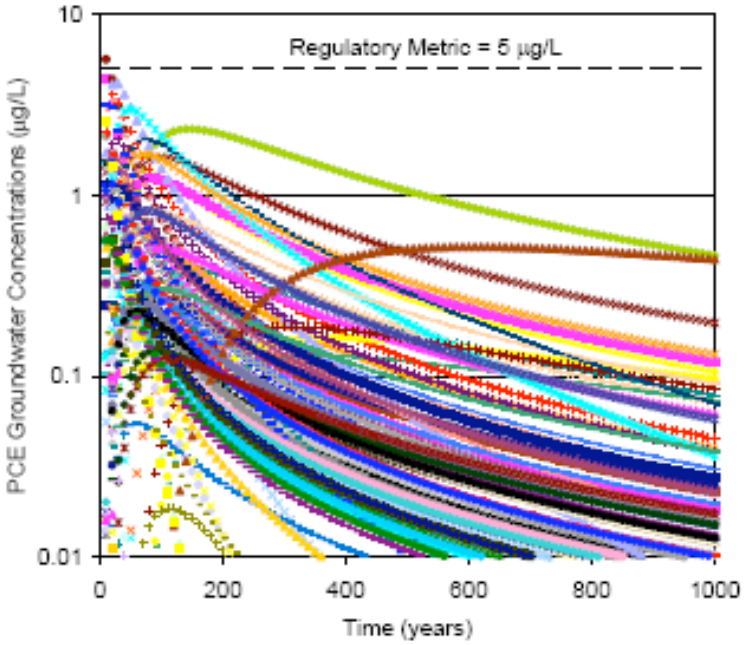

Figure 22. Simulated PCE groundwater concentrations for 100 realizations.

"Figure 22 shows the simulated PCE concentrations in the groundwater as a function of time for all 100 realizations. The majority of the realizations show the aquifer concentrations peaking before 50 years. Depending on the time of disposal, this corresponds to peak concentrations occurring by 2010 – 2040. So far, no detectable amounts of PCE have been found in the groundwater at the MWL. This is still consistent with the simulations, which show a large amount of variability in the simulated concentrations resulting from uncertainty included in the input parameters (see next section)." FTM at 54 –55.

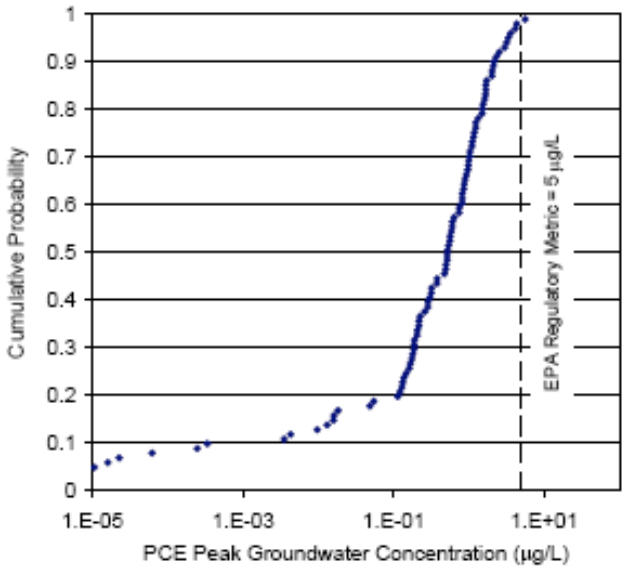

Figure 23. Cumulative probability for simulated PCE peak groundwater concentrations for 100 realizations.