August 11, 1998

Attn: Dr. Robert S. (Stu) Dinwiddie  
Hazardous and Radioactive Materials Bureau  
New Mexico Environment Department  
P.O. Box 26110  
Santa Fe, NM 87502

RE: LEGAL NOTICE No. 98-02

Dear Dr. Dinwiddie:

Pursuant to the New Mexico Environment Department (NMED) Notice of Intent to Permit a Hazardous Waste Storage and Disposal Facility Waste Isolation Pilot Plant EPA No. NM4890139088 of May 15, 1998, Southwest Research and Information Center (SRIC) submits the following requests and comments.

SRIC is a private, nonprofit organization, incorporated in the State of New Mexico, that provides timely, accurate information to the public on matters that affect the environment, human health, and communities in order to protect natural resources, promote citizen participation, and ensure environmental and social justice now and for future generations. For more than 20 years, one element of SRIC's work has been to provide information to the general public and to represent the interests of its supporters, board of directors, and staff regarding the Waste Isolation Pilot Plant (WIPP).

As such, SRIC has long maintained that WIPP cannot be constructed or operated until the State of New Mexico issues a hazardous waste permit, pursuant to the New Mexico Hazardous Waste Act (HWA) and the Resource Conservation and Recovery Act (RCRA). SRIC will be a party, pursuant to 20 NMAC 1.4.107.A.16, in any public hearing related to a HWA permit for WIPP.

REQUESTS
1. **Extend the public comment period.** SRIC requests that the public comment period on the draft permit be extended to allow for adequate public comment on the draft sampling and analysis plan (SAP) submitted to NMED by the Department of Energy (DOE) on July 27, 1998. Such a SAP was not included in DOE's permit application nor in the draft permit, and as such is a significant change to the application. SRIC and other members of the public should be provided with an adequate time to:
(a) review and comment on the SAP, prior to NMED making any determination that the SAP is adequate or that it could be used to determine that waste stream TA-55-43 is adequately characterized; 
(b) participate in any meetings between NMED and DOE regarding the SAP; and 
(c) comment on the implications of the SAP to the application and draft permit.

SRIC has previously informed NMED in its letter of June 25, 1998 to then-Secretary Mark Weidler (attachment 1) that NMED cannot determine whether or not wastes are adequately characterized until it issues a final HWA permit. In that same letter SRIC requested that any future meetings with DOE on waste characterization be open to the public.

SRIC also informed DOE as an applicant for the permit in a letter of July 13, 1998 (attachment 2) that SRIC requested substantial public involvement in the SAP and that the SAP was a significant revision to the permit application.

Thus, SRIC requests and expects that the public comment period on the draft permit will be extended so that the public is able to review and comment on the SAP, participate in any future meetings between NMED and DOE on the SAP and the draft permit, and fully comment on the effect of the SAP on the permit application and the draft permit.

2. Public hearings must be held on any HWA permit for WIPP.
Public hearings must be held prior to the issuance of a HWA permit for WIPP, because of the extraordinary public interest in the facility and its safety, and pursuant to 20 NMAC 1.4. SRIC requests such a public hearing, although it believes that no such hearing should yet be scheduled because of the unresolved issues related to the permit application and the draft permit, as outlined in #1 above.

3. Opportunity to identify other issues. SRIC requests an opportunity to further identify issues that it will raise in any public hearing on the draft permit. The Legal Notice requests that commentors "state the nature of the issues proposed to be raised in a hearing," and SRIC is identifying several such issues herein. However, given the fact that, as previously stated, the application is being changed and an adequate time to review the SAP in relation to the application and draft permit has not been given, SRIC will not state that it is herein stating the nature of all issues that would be raised in a hearing. Moreover, pursuant to NMED Permit Procedures (20 NMAC 1.4.301 and 302), since a hearing has not been noticed, entries of appearance and written statements have not been scheduled, NMED cannot require that all issues that would be raised in a hearing be identified at this time, nor can issues now be excluded from the hearing.
COMMENTS ON THE SAMPLING AND ANALYSIS PLAN (SAP)

Although SRIC requests and requires additional time to review and comment on the SAP for itself and the public, SRIC provides the following initial comments.

1. The sampling and analysis plan is inadequate in that adequate waste characterization cannot be carried out until a permit is issued. A Waste Analysis Plan is an essential element of the WIPP HWA application and any final permit. Thus, the final permit will provide the requirements for waste characterization of all wastes that could come to WIPP. In the absence of such a final permit, the applicants cannot adequately characterize any wastes, nor can NMED determine whether any characterization is adequate. Thus, until it issues a final permit, NMED should inform DOE that it cannot determine that the SAP would provide for adequate characterization. Further, NMED should inform DOE that any further efforts to analyze waste stream TA-55-43 only delays NMED's issuance of a permit, as such analysis diverts its attention from proceeding with the draft permit and hearings thereon.

2. The sampling and analysis plan is inadequate because it seeks to "confirm" that waste stream TA-55-43 is non-hazardous, when available evidence indicates that the wastes are hazardous. NMED has twice determined that waste stream TA-55-43 has not been adequately characterized (NMED letters of June 11 and July 10). Additional technical review by the Institute for Energy and Environmental Research (IEER) has determined that there are severe problems with the acceptable knowledge documentation regarding the 36 drums identified by DOE as composing that waste stream and that part of the waste would be considered hazardous because it exhibits characteristics of corrosivity, toxicity, and reactivity (Attachment 3). Additional IEER analysis has identified further documentation problems with other materials submitted to NMED by DOE and provided further evidence that the wastes are hazardous in that they exhibit characteristics of corrosivity, toxicity, reactivity, and ignitability (Attachment 4). In light of the analysis and conclusions of NMED and IEER of the hazardous nature of the wastes, no "confirmation" of that waste stream as non-hazardous is possible.

3. The sampling and analysis plan is inadequate because it does not include full chemical analysis of all wastes in all drums. By definition, waste stream TA-55-43 is heterogeneous debris waste. Such a heterogeneous waste stream cannot be characterized by "representative sampling" because each drum is different and each bag or container inside each drum is unique. Even DOE states in its letter of July 27 that "it is extremely difficult, if not impossible, to obtain truly representative samples of a waste stream as heterogenous as TA-55-43" (at 1). Thus, DOE itself does
not maintain that the SAP provides representative sampling. Chemical analysis of a few drums would not demonstrate adequate characterization of any other drums, only full chemical analysis of contents of all drums could provide such a demonstration.

4. The partial analysis of some waste in five drums is not adequate analysis of even those five drums. The SAP indicates that portions of five of the 36 "parent drums" would be sampled (Table 2). All of the wastes in those five drums will not be fully tested to determine their corrosivity, toxicity, reactivity, and ignitability. Such a complete testing regime is necessary to determine that the wastes in those drums are non-hazardous, given the deficiencies in the acceptable knowledge documentation and the evidence that wastes in the drums exhibit those characteristics.

COMMENTS ON THE DRAFT PERMIT
SRIC is interested in all aspects of the permit. At this time, issues of concern include, but are not limited to, the following.

1. Prohibit use of and require closure of Panel 1. In the draft permit, NMED proposes to permit "Panel 1," even though the seven rooms in that panel were constructed ten years or longer ago and cannot be considered to be safe waste disposal units. In its permit application, DOE did not include information available regarding instability in the waste rooms (see, for example, Environmental Evaluation Group report, Stability Evaluation of the E140 Drift and Panel 1 Rooms at WIPP, August 1996, EEG-63). In July 1998, EEG published another relevant report, Mine Stability Evaluation of Panel 1 During Waste Emplacement Operations at WIPP, EEG-71. On June 9, 1998, in State of New Mexico v. Peña, Civ. 91-2527 and 91-2929), D.C. District Court, additional information was presented as to the likelihood of failures within those rooms (Affidavit of Lokesh Chaturvedi and Affidavit of Ian W. Farmer) (Attachments 5 and 6). SRIC advocates that Panel 1 be excluded from any permit. Further, NMED should order closure of that panel.

2. Prohibit remote-handled (RH) wastes and construction or modification of the RH Bay. The draft permit prohibits receipt or disposal of remote-handled wastes at WIPP (B-2). SRIC agrees with that prohibition because the RH wastes cannot be adequately characterized and pose significant risks to workers and the public and increase the likelihood of releases from storage and disposal of any wastes at WIPP. However, the draft permit does not prohibit activities, including construction or modification of the RH Bay, which is shown in Figure M1-1. SRIC believes that there are various problems with the RH Bay, which should prohibit its use or modification.

3. Waste characterization. The draft permit has made significant changes to the Waste Analysis Plan (WAP) contained in the permit
application. All aspects of the WAP for both retrievably stored and newly generated wastes should be fully justified and intensively reviewed in the permit hearing process. At this point, the following issues are of special importance to SRIC.

(a) sampling and analytical methods. Headspace-gas sampling must assure that innermost confinement layers are sampled. At least three samples must be required, as specified by the draft permit. Container equilibrium requirements and quality control measures are especially important. Methods must ensure that the effects of radiolysis are accounted for in the sampling and analysis. An upper confidence level of 95 percent must be used, and an adequate number of samples must be required.

(b) acceptable knowledge. Because of historic problems of managing and storing wastes and lack of accurate documentation at DOE sites, acceptable knowledge is generally unreliable. Thus, each site should fully document acceptable knowledge for each waste stream, specify any discrepancies in records, and uncertainties or assumptions must be documented and available on a drum-by-drum, box-by-box basis.

(c) radiography and visual inspection. SRIC believes that both radiography and visual inspection should be required on all drums and boxes because of the inherent deficiencies of radiography and the further deficiencies that can result from lack of adequate training and oversight. Neither acceptable knowledge, nor radiography, will identify all hazardous constituents in waste drums, so visual examination is necessary to compensate for those deficiencies.

(d) quality assurance. All aspects of quality assurance (QA) are important. Audits, deficiencies, and nonconformance reports must be readily available to identify specific weaknesses in any site's QA program or its implementation.

4. Permit modification for each generator site. Section II.C.1 prohibits storage, disposal, or other management of TRU mixed wastes until the applicants submit and the Secretary approves a permit modification for a particular generator/storage site. SRIC supports that condition. Because of the great discrepancies among sites in terms of kinds of wastes, how they were generated, managed, and stored, what kind of acceptable knowledge exists, among other issues, such a modification process is necessary to protect public health and the environment. However, what kind of modification would be required is not clearly specified in the draft permit. The Fact Sheet states that permit modification for 'any management activity described in a document that is not reflected in the permit shall not be allowed unless NMED approves a Permit modification (at 2). SRIC believes that submission to modify the permit to approve a particular generator/storage site
would be a major modification, requiring public notice and public
hearings.

5. Waste containers. Many plywood boxes and 55-gallon drums used
at generator/storage sites are currently at or past their design
life and cannot be expected to provide full containment for the
operational life of WIPP. Thus, SRIC supports requirements to
repackage wastes into containers with at least 20-year design life
at the generator/storage site and stringent requirements on
condition of containers received at WIPP.

6. Waste acceptance criteria. Ignitible, corrosive, or reactive
waste should be prohibited. SRIC supports a "no free liquid"
requirement, including requiring repackaging of containers with
free liquids. All tentatively identified compounds must be
reported and full sampling and analysis should be required to
ensure that such compounds are properly identified and measured.

7. Surface container storage units. SRIC is concerned about
inadequacies in the air monitoring equipment and personnel
training. Maintenance of all components of the units are of great
concern, given the proposed operational life of 35-year or more
and the fact that the waste handling building is already more than
a decade old and in some respects uses obsolete technology.

8. Underground container storage units. In addition to the need
to prohibit use of panel 1, discussed above, requirements for how
and when any additional panels could be mined, design
modifications in such panels and rooms, and prohibitions on mining
during waste emplacement should be incorporated into any permit.
Room-based volatile organic compounds limits must fully protect
human health. Backfill type and emplacement methods must be
specified and verified. Ventilation, air monitoring equipment,
and personnel training requirements must be specified and
strengthened. Room deformation and creep must be continuously
monitored and adequate room maintenance, before and after waste
emplacement is necessary.

9. Releases during WIPP operations. In addition to various
accident possibilities included in the permit application and
draft permit, SRIC is concerned about possible "human intrusion"
events. Of special concern is the possibility of breaches of the
underground storage area by fluids traveling through marker beds
138 and 139 and into the storage area. Fluid injection outside of
the WIPP land withdrawal area could result in significant fluid
flow into the underground storage area. This issue has not be
addressed in either the permit application or the draft permit,
but SRIC believes it is a significant risk that must be fully
considered and the draft permit must be changed to reflect this
possible scenario.
10. Manifest system/WIPP Waste Information System database. Specific testing and reliability requirements of the systems are essential.

11. Corrective action/closure. Corrective action measures, contingency planning closure requirements, and post-closure care plans are of specific concern.

12. Groundwater monitoring. Location, sampling parameters, and frequency of monitoring will be examined.

13. Financial assurance/liability requirements. These matters are important for both applicants, especially as they relate to Westinghouse Waste Isolation Division.

Thank you for your careful consideration.

Sincerely,

[Signature]

Don Hancock
June 25, 1998

Secretary Mark Weidler
New Mexico Environment Department
P.O. Drawer 26110
Santa Fe, NM 87502-0110

Dear Secretary Weidler:

Southwest Research and Information Center (SRIC) has been actively interested and involved in the New Mexico Environment Department (NMED) permitting process for the Waste Isolation Pilot Plant (WIPP) for several years. And we have been actively involved in legal action since 1991 to protect NMED's permitting authority over WIPP.

This letter is to express concerns about NMED's current "agreement" with the Department of Energy (DOE), as stated in a letter from Mary Anne Sullivan of DOE to Susan McMichael of NMED, dated June 19, 1998. In brief, SRIC believes that NMED is without authority to enter into or enforce that "agreement," given that DOE and Westinghouse do not have a RCRA permit for WIPP, nor does WIPP have interim status. Thus, NMED may provide "advice" to DOE and Westinghouse regarding their waste characterization at Los Alamos National Laboratory (LANL). But NMED may not make a determination about whether wastes are adequately characterized until it has issued a final RCRA permit.

The issue of whether WIPP can operate without a RCRA permit is a determination being made by the U.S. District Court for the District of Columbia in State of New Mexico v. Peña, Civil Action Nos. 91-2527 and 91-2929. SRIC is a party to that case. SRIC and other parties in that proceeding have consistently argued that WIPP does not have interim status and, therefore, it cannot operate and cannot receive any wastes (nor have construction) in the absence of a RCRA permit, issued by NMED under the provisions of the New Mexico Hazardous Waste Act. NMED should publicly recognize that the court, not NMED, will make the determination as to whether WIPP has interim status and whether the facility can receive any waste without a RCRA permit.

In the absence of a permit and a Waste Analysis Plan approved by NMED, DOE cannot adequately characterize its wastes, and NMED cannot determine whether or not the wastes are adequately characterized. NMED has taken a public position in its draft permit that different waste characterization is required than what
was included in DOE's Waste Analysis Plan. But NMED cannot make a determination that any waste stream has been adequately characterized, because it has no legal basis to do so in absence of a final permit. Without a final permit, a determination from NMED that does approve the characterization of any waste stream for disposal at WIPP would subject you and NMED to civil enforcement action, including injunctive and other relief.

SRIC does not object to NMED agreeing to conduct a "review" of information from DOE and to provide "advice" to DOE, although we believe that such a process should be open to the public. SRIC would appreciate being notified about future meetings with DOE regarding characterization of wastes at LANL or other facilities planning to send wastes to WIPP.

We look forward to your response and to participating actively in the NMED permitting process for WIPP.

Sincerely,

Don Hancock

cc: Ed Kelley
    Susan McMichael
July 13, 1998

W. John Arthur, III  Mike McFadden
Assistant Manager, ALO  Acting Manager, CAO
PO Box 5400  PO Box 3090
Albuquerque, NM 87185  Carlsbad, NM 88221

VIA US MAIL and FAX

Dear Mr. Arthur and Mr. McFadden:

Southwest Research and Information Center (SRIC) is extremely concerned about the activities underway between the Department of Energy (DOE) and the New Mexico Environment Department (NMED), which appear to be a non-public and illegal process. Such activities undermine the entire Part B permitting for WIPP under the Resource Conservation and Recovery Act (RCRA) and the New Mexico Hazardous Waste Act (HWA). Those activities have been initiated by DOE and could substantially delay or even invalidate the permitting process.

SRIC, therefore, requests that DOE allow substantial public involvement in its current process to gain NMED approval for its waste characterization efforts at the Los Alamos National Laboratory (LANL). SRIC also requests that DOE provide a clear explanation of how its current activities with NMED relate to its Part B application under RCRA and the HWA and to its previous promises to not open WIPP without a RCRA permit.

LANL waste characterization

On June 17, Mr. Arthur requested that NMED review additional documentation on LANL waste characterization. On July 10, NMED Secretary Weidler informed DOE that the information and data were not sufficient. But he stated, apparently in response to another request from you, that NMED would review a new waste "sampling and analysis plan" to be submitted by DOE.

Does DOE now agree with NMED that its characterization of waste stream TA-55-43, Lot No. 1 was inadequate? If not, why is DOE developing a new sampling and analysis plan for that waste stream? Will the sampling and analysis plan be used for other LANL waste streams? Will the sampling and analysis plan be used for waste streams at other DOE sites?
Review of documents relating to the proposed shipments of LANL TA-55-43 Wastes to the Waste Isolation Pilot Plant

Bernd Franke and Hisham Zerrifi

June 5, 1998
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Attachments
1 Introduction

Los Alamos National Laboratory proposes to ship waste from the TA-55 facility to the Waste Isolation Pilot Plant prior to WIPP receiving a Resource Conservation and Recovery Act (RCRA) permit. According to LANL, this waste consists of retrievably stored debris waste designated as waste stream TA-55-43 and is not regulated under RCRA. This claim is made what LANL calls using “Acceptable Knowledge” of the waste generation process.

The purpose of this report is to provide an analysis of whether this waste may actually be subject to RCRA regulation. There are two issues that will be examined. First, we will show that the waste may actually fall under RCRA regulation because it exhibits the characteristics of hazardous waste. Second, we will show that flaws in the documentation of the waste LANL proposes to ship are substantial enough to invalidate LANL’s claim that it has "Acceptable Knowledge" that the wastes are not hazardous.

2 Review of Characteristics for Hazardous Waste

The “Acceptable Knowledge Summary Report”\(^1\) claims that, based on process knowledge, TA-55 waste contains no listed hazardous wastes. It further claims that, based on process knowledge, the waste does not exhibit the characteristics of hazardous waste as defined in 40CFR261, Subpart C of ignitability, reactivity, corrosivity, and toxicity. The report also states a crucial limitation of the process knowledge approach:

“Compounds formed through radiolytic decomposition would not be noted in the process knowledge for the waste generation process.” (p.19)

In order to determine whether or not the waste is in fact subject to RCRA it is therefore essential to review the potential for radiolytic decomposition of the waste and the extent that it may change the characteristics of the waste. The following sections include an analysis of the TA-55 waste in this regard.

2.1 Corrosivity

40CFR261.22 (Characteristic of corrosivity)\(^2\) states:

(a) A solid waste exhibits the characteristic of corrosivity if a representative sample of the waste has either of the following properties:

(1) It is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5, as determined by a pH meter using Method 9040 in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Publication SW-846, as incorporated by reference in § 260.11 of this chapter.

\(^1\) Los Alamos National Laboratory Transuranic Waste Characterization/Certification Program. Acceptable Knowledge Summary Report for Combustible/Noncombustible, Metallic, and HEPA Filter Waste Resulting from \(^{238}\)Pu Fabrication Activities, TWCP-1042, p. 19

(2) It is a liquid and corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55°C (130°F) as determined by the test method specified in NACE (National Association of Corrosion Engineers) Standard TM-01-69 as standardized in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Publication SW-846, as incorporated by reference in § 260.11 of this chapter.

(b) A solid waste that exhibits the characteristic of corrosivity has the EPA Hazardous Waste Number of D002.

The Acceptable Knowledge Summary Report for the TA-55 waste appears imply that non-aqueous wastes do not have to be tested for corrosivity by pH and that LANL's definition of "aqueous" means presence of "dampness" or free liquids. If true, this would mean that wastes without free liquids could never be corrosive. Apparently, pH was only measured for one container (BFB-234) which contained one can of wet material with a pH of 3.5. (This waste container is apparently not part of the waste stream designated by DOE as non-RCRA.)

The presence of free liquids, however, is not an essential characteristic of corrosivity of a waste. Were that the case, a waste producer could circumvent the corrosivity determination by simply allowing the waste to dry to the extent that no free liquids are present. It is the pH of the waste that is a crucial characteristic in regard to corrosivity.

The need to test waste for pH even if it does not have free liquids is acknowledged in the testing procedures for TA-55 wastes for "damp" rags which came into contact with nitric and hydrofluoric acid. No definition of "damp" is provided. The pH of "damp" rags is first checked by squirting a few drops of Methyl Orange indicator solution in several locations on the rag. If the Methyl Orange test indicates the presence of acids, further analysis is done with pH paper. The procedures specifies: "If the rags are not damp enough to wet the paper, dampen the paper with distilled water".

The above-mentioned procedure was not followed in the determination of corrosivity of the rags contained in TA-55 waste. The Acceptable Knowledge Report (TWCP-1042) notes on page 7 that "damp rags presented for disposal have inadequate liquid to allow testing for pH and therefore cannot exhibit the corrosive characteristic." However, LANL could have determined the pH by dampening the pH paper with distilled water. According to TWCP-1042, LANL failed to follow this procedure. This strongly suggests that an evaluation of the corrosivity of the rags was not conducted.

In addition to the rags which came into contact with nitric and hydrofluoric acid, other components of the waste have potentially corrosive characteristics. The plastic material

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4 It should be noted that WIPP Waste Acceptance Criteria allow up to 2 liters of liquid in a drum.
7 ibid. p.17
in the waste is a mixture of various materials including polyvinylchloride (PVC). In a 1986 publication, Arakawa et al., point out: "It is known that hydrogen chloride (HCl) is the major product from poly(vinyl)chloride from irradiation. The evolved HCl is so corrosive that the metals around a nuclear reactor would be damaged." In addition, other chlorine-containing plastic materials present in TA-55 waste have the potential to produce HCl during radiolysis. Specifically, chloroprene rubber (Neoprene) and chlorosulfonated polyethylene (Hypalon) are commonly used in nuclear facilities. From the documents provided, we were unable to determine the precise composition of plastic materials. However, it is evident that TA-55 TRU waste has the potential to generate HCl and thus H⁺ ions if the waste is mixed with water. This would lower the pH of the materials in the package.

It is scientifically indefensible not to test waste without free liquids for corrosivity. The RCRA philosophy of waste characterization for toxicity and reactivity presumes the presence of water. It is for this reason that test methods require the use of water. If water were to be added, the leachate of dry corrosive waste will be corrosive - just as the leachate of dry toxic waste would similarly be toxic.

The "EPA RCRA PERMIT POLICY COMPREHENDIUM DOCUMENT RETRIEVAL AND SEARCH SYSTEM" provides further guidance on the issue of which wastes need to be tested for corrosivity:

"Although there is no regulatory definition of the term "aqueous," for purposes of the corrosivity characteristic an aqueous waste is defined as a waste for which pH is measurable. (...) This working definition of aqueous means that aqueous wastes can be in nonliquid form. Suspensions, soils, or gels for which pH is measurable are examples of aqueous nonliquids."

The essence of this guidance is clear: even dry waste should be tested for corrosivity if the pH can be measured. Even though the TA-55 TRU waste stream does not appear to have free liquids, its pH can be determined using EPA Method 9045C. The EPA Method 9045C is specifically designed to allow the determination of pH in waste materials without free liquids. The method requires the mixing 20 g of waste with 20 mL of water. The pH is determined in the supernatant.

EPA Method 9045C has been selected in determining the corrosivity characteristic of wastes in a recently published proposed compliance ruling in which the EPA proposes to grant a petition submitted by Occidental Chemical Corporation to exclude (that is, to delist) certain solid wastes from the list of hazardous wastes. In order to do so, it must

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The introduction to the compendium states "The Compendium includes documents that set forth policies and interpretations relevant to the RCRA permit program. (...) Only those documents providing a clear interpretation of Agency policy or procedures have been compiled."


10 Federal Register: May 11, 1998 (Volume 63, Number 90), Proposed Rules, page 25797-25811 (Attachment 3)
be demonstrated that the waste does not exhibit any of the hazardous waste characteristics. In support of their petition, Occidental Chemical determined the corrosivity of the wastes using SW-846 Method 9045 which is only applicable to wastes without sufficient liquids. EPA Method 9045 (identified in the current version of SW-846 as Method 9045C) is thus an accepted method for compliance determination of the corrosivity criterion. It should be applied to determine corrosivity characteristic for the TA-55 waste stream as well.

We reviewed the potential that TA-55 waste could exhibit the corrosivity characteristic, that is, a pH of less than 2. A pH of 2 equals 0.01 mol of H⁺ ions in 1 liter of an aqueous liquid. Using EPA Method 9045C, a solid waste would likely have a pH of less than 2 if one kg of the waste contains 0.01 mol of H⁺ since the H⁺ ions would be present in the water and not in the plastic waste material.

Arakawa et al.¹¹ determined the production of HCl resulting from irradiation of some plastic materials. Their results are summarized in Table 1. It is interesting to note that HCl production is markedly decreased in formulated plastics (due to addition of plasticizers, vulcanizers and stabilizers). The documented amount of Pu-238 in the drums ranges from 0.21 to 3.4 g with an average of ~1.6 g. The amount of plastic materials ranges from 0 to ~26 kg with an average of ~10.7 kg. The amount of rubber materials ranges from 0 to ~26 kg with an average of ~4.7 kg. The average specific concentration of Pu-238, ~0.18 g/kg of plastic material. In the subsequent calculations, a rounded value of 0.2 g/kg is used. The energy of Pu-238 decay is ~5.6 MeV. After one year of irradiation of 1 kg of waste material contaminated with 0.2 g Pu-238, the absorbed dose is ~2.2*10¹⁶ MeV/g or ~360 Mrad.¹²

Table 1  Production of HCl after irradiation of plastic materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Mol of HCl per gram of material at 1 Mrad</th>
<th>Mol of H⁺ per kg after 1 year at 300 Mrad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure PVC</td>
<td>1.9 * 10⁻⁵</td>
<td>6.8</td>
</tr>
<tr>
<td>PVC (model formulated)</td>
<td>2.7 * 10⁻⁵</td>
<td>0.97</td>
</tr>
<tr>
<td>PVC (special formula A)</td>
<td>2.3 * 10⁻⁷</td>
<td>0.08</td>
</tr>
<tr>
<td>PVC (special formula B)</td>
<td>1.9 * 10⁻⁷</td>
<td>0.07</td>
</tr>
<tr>
<td>Chloroprene rubber (pure)</td>
<td>3.1 * 10⁻⁶</td>
<td>1.1</td>
</tr>
<tr>
<td>Chloroprene rubber (model formulated)</td>
<td>5.0 * 10⁻⁵</td>
<td>0.02</td>
</tr>
<tr>
<td>Chloroprene rubber (special formulated)</td>
<td>7.0 * 10⁻⁵</td>
<td>0.02</td>
</tr>
<tr>
<td>Chlorosulfonated polyethylene (pure)</td>
<td>3.1 * 10⁻⁶</td>
<td>1.1</td>
</tr>
<tr>
<td>Chlorosulfonated polyethylene (model formulated)</td>
<td>5.0 * 10⁻⁶</td>
<td>0.02</td>
</tr>
<tr>
<td>Chlorosulfonated polyethylene (special formulated)</td>
<td>7.0 * 10⁻⁶</td>
<td>0.02</td>
</tr>
</tbody>
</table>


¹² Due to lack of data provided, self absorption of alpha particles could not be quantified. It could potentially reduce the dose absorbed by the plastic material by 50% or more. Our calculations are based on one year of irradiation. Thus, at a rate of 50% self-absorption, the results would reflect the HCl production after 2 years of irradiation.
For the specific contamination in the documented waste from TA-55 (median 0.2 g Pu-238 per kg of waste material), we calculated the H⁺ production after one year of irradiation, as shown in the last column of Table 1. After just one year of irradiation, all types of plastic materials have ≥0.01 mol of H⁺ per kg, equivalent to a pH of ≤2. It is therefore likely that chlorinated plastic material in TA-55 waste will release enough hydrogen chloride so that it exhibits the corrosivity characteristic. Further, the production of HCl increases over time – the longer the material is irradiated, the more corrosive it becomes.

The available documents do not allow us to quantify the type and the amount of chlorinated plastic materials in the TA-55 waste stream and the specific contamination of chlorinated plastic materials that contain Pu-238. Even if only a part of the plastic waste is chlorinated, there is sufficient potential for HCl production to render the entire waste corrosive within a relatively short period after generation, and well before it is sent to WIPP. Moreover, due to the relatively long half-life of Pu-238 (about 87 years), HCl will continue to be generated at annual rates comparable to those cited above for decades.

In our opinion, it is more likely than not that part of the documented TA-55 waste stream would be determined to be hazardous waste because it fulfills the RCRA criterion of corrosivity. Thus, knowledge of the process of radiolytic decomposition leads directly to the presumption that, in the absence of testing, the waste must be assumed to be hazardous.
2.2 Toxicity

40CFR261.24 (Characteristic of toxicity) states:

(a) A solid waste exhibits the characteristic of toxicity if, using the Toxicity Characteristic Leaching Procedure (TCLP) the extract from a representative sample of the waste contains any of the contaminants listed in table 1 at the concentrations equal or greater than the respective value given in that table.

The TA-55 waste stream has a significant potential of toxicity according to 40CFR261.24 for two constituents in table 1: vinyl chloride and benzene.

2.2.1 Vinyl Chloride

Vinyl chloride is the monomer compound used in the production of PVC. It is contained in PVC in varying amounts depending on the production methods used. Radiolysis or other external factors may enhance the release of vinyl chloride from the PVC.

The most recent Toxicological Profile for Vinyl Chloride by the Agency for Toxic Substances and Disease Registry states that "vinyl chloride has been detected in various foods and bottled drinking water as a result of migration from PVC food wrappings and containers". Vinyl chloride has been found in vinegar at levels up to 98,000 µg/L, in edible oils at 300-1,800 µg/L, and in alcoholic beverages at up to 8,400 µg/L when these foods were packaged and stored in PVC containers. By comparison, the toxicity criterion using the Toxicity Characteristic Leaching Procedure (TCLP) is 200 µg/L. The TCLP is the promulgated procedure for testing. Thus, some of the concentrations found in food significantly exceed this limit. It should be noted that at present, FDA regulates the use of PVC polymers in food packaging materials as well as the amount of the residual monomer, so that levels noted above apply to past packaging materials.

As an alternative to the TCLP, the toxicity of the material can be determined by total analysis of the waste under the conservative assumption that all toxic waste material ends up in the leachate. Since the TCLP requires using one unit of waste with 20 units of reagent, a TCLP limit of 200 µg/L corresponds to a maximum concentration in waste of 4 mg/kg.

The available documentation about the TA-55 TRU waste stream does not contain precise data on the amount of PVC or the residual monomer concentration. The waste stream may contain significant amounts of vinyl chloride the release of which may be enhanced by radiolysis to render it hazardous under the toxicity criterion based on the values found in liquids which were packaged in PVC.

14 U.S. Department of Health and Human Services, Agency of Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Vinyl Chloride (Update), September 1997 (Attachment 5)
2.2.2 Benzene

Radiolytic decomposition of plastic waste results in a variety of volatile organic compounds, among them benzene. The generation of gases from radiolytic decomposition is usually expressed with "G" values (gas molecules formed for each 100eV of absorbed energy).

Reed and Molecke\(^\text{15}\) published the G value for H\(_2\) and CO\(_2\), but not for benzene, as the result of radiolytic decomposition of WIPP plastic and rubber material. Benzene is a liquid at room temperature and only a fraction of benzene will be present in air. The data in Reed and Molecke's article allow calculation of the G value (for gaseous benzene only) based on the relative volume of hydrogen and benzene in the gas phase after 60 days of irradiation. The G value for hydrogen production from radiolysis of polyethylene in nitrogen atmosphere is reported to be 3.0 molecules of H\(_2\) per 100 eV; the H\(_2\) concentration in the corresponding gas phase after 60 days is 0.53 mole-%. Using the ratio

\[
\frac{\text{G value for H}_2 \text{ (molecules per 100 eV)}}{\text{H}_2 \text{ concentration after 60 days (mole-%)}}
\]

the G value for benzene can be inferred from measurements of benzene in the gas phase after 60 days. Reed and Molecke report the benzene concentration after 60 days of irradiation of PVC in air to be 1.1 ppmV (=0.00011 mole-%). The G-factor for gaseous benzene at the temperature in the experiment (about 30 °C) can thus be calculated to be ~0.00062 (molecules of gaseous benzene per 100 eV).\(^\text{16}\)

The energy release of the TA-55-43 contaminated plastic material over one year is ~\(2.2 \times 10^{16}\) MeV/g. For the PVC fraction, the G factor of 0.00062 molecules of benzene per 100 eV translates into \(1.2 \times 10^{17}\) molecules of benzene produced per g of PVC waste during one year of irradiation with the assumed typical amount of Pu-238 contamination. The mass of \(1.4 \times 10^{17}\) benzene molecules is ~18 µg. Thus, the specific production of gaseous benzene in PVC waste with a contamination of 0.2 g of Pu-238 concentration per kg of waste is ~18 µg per g (= 18 mg per kg) of waste. The amount of liquid benzene in waste could not be determined based on this data. It is likely to be larger than the benzene in gaseous form, given the complex multiple layers of waste packaging and because it is a liquid at room temperature. We note that it is a liquid at room temperature. Its boiling point is 80.1 °C.

The RCRA TCLP criterion for benzene is 0.5 mg/L. As an alternative to the TCLP, the toxicity of the material can be determined by total analysis of the waste, under the conservative assumption that all toxic waste material ends up in the leachate. Since the TCLP requires using one unit of waste with 20 units of reagent, a TCLP limit of 0.5 mg/L corresponds to a maximum concentration in waste of 10 mg of benzene per kilogram of waste.


\(^{16}\) Due to lack of data provided, self-absorption of alpha particles could not be quantified. It could potentially reduce the dose absorbed by the plastic material by 50% or more. Our calculations are based on one year of irradiation. Thus, at a rate of 50% self-absorption, the results would reflect the benzene production after 2 years of irradiation.
waste (mg/kg). The calculations presented above indicate that radiolysis of typical PVC waste over one year will produce 18 mg/kg. Since the cumulative benzene produced increases over time, PVC wastes that have been subject to radiolysis over many years are likely to have specific benzene concentrations in excess of the toxicity criterion of 10 mg/kg.

Consequently, if a drum with an amount of say, 5 kg of plastic material contains more than 50 mg of benzene, it would fulfill the toxicity criterion. Headspace analysis of the TA-55-43 waste drums indicate the presence of benzene (above the minimum detection limit of 1.25 ppmv) in 7 out of 36 drums for which data was supplied. The concentrations found in the headspace range from 2 to 5 ppmv. (At standard temperature and pressure, 1 ppmv of benzene is equal to 3.24 mg/m$^3$). The free volume of drums is in the order of 90%. A 55 gallon drum thus has ~0.19 m$^3$ of free volume. At a benzene concentration of 5 ppmv, the free volume would contain ~3 mg of benzene. Given the multiple types of packaging (many sealed with tape), it is reasonable to assume that only a fraction of the benzene generated by radiolysis would actually make its way into the headspace. Only a total waste analysis can provide a conclusive answer. On this basis, it is unscientific and incorrect to conclude that one can declare the waste to be non-hazardous based on “Acceptable Knowledge.” In fact, knowledge of the process of radiolysis would lead to the contrary conclusion in the absence of definitive test results.

2.3 Reactivity

40CFR261.23 (Characteristic of reactivity)$^{17}$ states:

(a) A solid waste exhibits the characteristic of reactivity if a representative sample of the waste has any of the following properties:

(...)

(4) When mixed with water, it generates toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.

The reactivity characteristic can be met because of the presence of benzene and vinyl chloride in the wastes. Both substances are highly toxic and would constitute a hazard to human health. If the waste drums were to be filled with water, these gases would be driven out of the waste drums, contaminating the surrounding air.

This section reviews the data packages on the drums that Los Alamos intends to ship to the Waste Isolation Pilot Plant. These drums are supposed to contain waste categorized as the TA-55-43 waste stream (Combustible/Non-combustible waste). The drums from this waste stream have been identified by the Department of Energy as the first shipment of waste to the Waste Isolation Pilot Plant.\(^\text{18}\) We have not been provided with an official list of all drums associated with this waste stream and therefore cannot determine if we are in possession of documentation for all drums. We have been provided a total of 36 data packages, one for each drum. Our only indication that these 36 data packages comprise the entire list is that the drums for which we have data packages match those on the list of drums for which we have real-time radiography data.\(^\text{19}\) However, they do not match any of the drum numbers for the non-destructive analysis (FRAM) data we were provided.\(^\text{20}\)

It should be noted that five drums reviewed here do not appear to belong to waste stream TA-55-43. According to the Acceptable Knowledge Summary report provided by LANL, these five drums contain HEPA filters. HEPA filters are in waste stream TA-55-47, not TA-55-43.\(^\text{21}\) It is not known why these drums were included in the 36 data packages we have received. Since these drums were also included in the radiography data batch report, it would appear that DOE intends to ship these drums as well. Despite the fact that these drums are not part of the TA-55-43 waste stream, they are included in our analysis.

Since Los Alamos National Laboratory has based their RCRA determination on Acceptable Knowledge, we have undertaken a review of their documentation. The purpose of our review was to determine whether there were problems in the documentation indicative either of potential flaws in LANL Acceptable Knowledge or of Quality Assurance problems.

According to NMT-7 Procedure document "Inspecting and Packaging Combustible and Noncombustible Transuranic Waste for WIPP" (TRUVM-TA-55-DP-01-R01) the following documents must be completed and included in the data package for each drum:

- **TRU Waste Storage Record (TWSR).** From the data packages reviewed it appears there are two versions of this form. The first is a two-page written form with information on Special Nuclear Material (SNM) isotopic composition; health physics data, signatures for inspections, etc. The second is a printed version.\(^\text{22}\)
- **Discardable Waste Log Sheet (DWLS).** From the data packages reviewed it appears there are two versions of this form. The original is a written DWLS

\(^{18}\) Letter by M.A. Sullivan (DOE) to Tom Udall (Attorney General, NM), May 18, 1998.
\(^{19}\) TWCP-1109 and TWCP-1110, RTR Batch Data reports.
\(^{20}\) TWCP-1180.
\(^{21}\) These drums are LA55605, 55695, 55696, 55938, 56053.
\(^{22}\) The printed version contains a subset of this information, as well as information that does not appear on the written version. On earlier drums this printed version was part of the waste drum report which also included information from the DWLS (see below). On later drums the name on the printout is changed to TWSR. This printed sheet appears to act as a cover sheet for the drum packages.
and the second appears to be a computer generated printout of portions of the DWLS. On some earlier drums this information was contained in a form called the Waste Drum Report.

- Waste Origination Disposition Form (WODF) for each package in the drum. This form includes information on the weight of the waste package, its SNM content, the presence of organics, etc.
- Nonconformance report (NC) and/or corrective action reports (CAR), as necessary.

In addition, the data packages include various other supporting memos, spreadsheets, shipping manifests, etc. One form present in almost all data packages is the Waste Profile Form (or in some cases a printout of the information from the Waste Profile System). This form is important as it provides documentation of Acceptable Knowledge (the form applies to a particular area and waste stream for TA-55 and has a barcode sticker with the drum number attached).

There are three categories of documentation problems found with the data packages corresponding to the drums Los Alamos National Laboratory plans to ship to the Waste Isolation Pilot Plant. These categories are 1) Missing documentation; 2) Incomplete Documentation; 3) Documents with conflicting information. These are discussed, with examples, below. Appendix A is a list of problems for each drum.

3.1 Missing Documentation

There are two types of missing documentation. The first is when a data package is missing a form in its entirety. For example, Drum LA55666 is missing the Waste Origination and Disposition Form for one of the waste packages in the drum. Forms that are missing from at least one data package include the following:

- Waste Origination and Disposition Form
- Transuranic Waste Storage Record
- Waste Profile Form
- Memo NMT-7-WM/EC-95-269 (Lower Detection Limit of assay instruments): Some drums report zero SNM for certain waste packages. According to this memo, the procedure in these cases requires use of the lower detection limit of the assay instrument (as provided in the memo).
- Written Discardable Waste Log Sheet. Computer print-out of DWLS should not act as a substitute as it does not provide the required information as per TRUWM-TA-55-DP01-R01 pp. 21-24 (e.g. printed DWLS does not include the required signatures)
- Waste Drum Report/Printed TWSR. Some information (such as confirmatory assays) are only presented on these forms and do not appear on their written counterparts. In cases where these cover sheets were missing it was impossible to determine if there was agreement between estimates of the amount of Special Nuclear Material in the drum (see below).

The second type of missing documentation is when a portion of a form is missing. A number of drum data packages are missing the second page of the Transuranic Waste Storage Record and/or the Waste Profile Form. In the case of the TWSR this appear to indicate that there is no record that the waste drums were shipped to TA-54 (the TRU
waste storage site) and properly inspected at the storage site. In the case of the Waste Profile Form, an important part of the Acceptable Knowledge procedure, significant information is missing when the second page is missing (including the presence of RCRA materials and the necessary signatures).

3.2 Incomplete Documentation

Incomplete documentation consists of sections of forms being incomplete, missing signatures, or missing data entries. One example of incomplete forms is the second page of the Transuranic Waste Storage Record. It is blank for all drums (except those in which the second page is completely missing). It is not clear at this time why this page is always either blank or missing. Again, this shows a lack of documentation on the storage of TA-55-43 waste at the TA-55 storage area. Signatures are missing from a number of Document Traveler forms, as well as TRU Waste Manifest forms and one DWLS.

The following are examples of missing data entries:

- Presence of Organics: Some versions of the WODF contain two boxes to check for the presence of organics (one for yes and one for no). In a number of WODF, these boxes are blank.
- Volume of organics: This information was not provided on some WODF. In some cases the WODF did not contain a space to fill in this information, in others it was left blank and in others N/A was entered. See below for cases where incorrect numbers were entered.
- The weight measurements of individual packages are not always complete. In many cases the gross weight was either not measured and/or not recorded. Furthermore, blank entries are assumed to be zero in adding the gross weights and therefore the total of the gross weight is in error in these cases. In at least one case the gross weight was measured and recorded on the WODF but not on the DWLS printout.

3.3 Conflicting/Improper Documentation

In some cases there are conflicts between information presented either on the same form or different forms or there is information which is not reported in a proper manner.

- Conflicting Amounts of Special Nuclear Materials: There are generally two different figures that report the total amount of SNM. The first is the SNM in each waste package and the second is from a confirmatory assay. The totals should match (within the uncertainty limits). In some cases there is also a memo about the differences between the amounts on the MASS computer program and from initial assays. This number should also match the above two figures. However, there are cases in which these numbers do not match. In a few cases the confirmatory assay is zero, though an uncertainty is presented.
- Zero SNM: In some cases the amount of Special Nuclear Materials for a data package is reported as zero. The proper procedure in this case is to use the Lower Detection Limit for the particular assay instrument used. In some
cases where a zero is reported the data package includes a memo on the LDL (without actually changing the zeros on the documentation or in the addition of SNM). In other cases this memo is not attached.

- **FRAM Data:** Los Alamos provided non-destructive assay data on six drums. However, these drums did not match any of the drum numbers for which we were provided data packages or the drums for which RTR was done. It is not known if the drums in the FRAM report are supposed to be part of this proposed shipment. We are also still missing NDA on the 36 drums.

- **Presence of Organics:** Some WODF indicate that there are no Organics and then present an amount in the Volume % and/or the Weight boxes.

- **Vol%/Weight Organics:** On some WODF the Volume % of Organics and the weight of Organics is the same number. It appears that this number corresponds to the weight of the Organics.

- **TRUCON Codes:** There appears to be conflicting and incomplete information about the shipping codes DOE assigns (see below).

In addition to the problems noted above, we would like to highlight two other important issues: Drum Repackaging and Shipping Codes.

**Drum Repackaging:** There are 5 drums which appear to have been repackaged. The original drum number has been scratched off the WODF and DWLS and a new drum number entered. The time between original packaging (as determined from the WODF) and the repackaging (as determined from the Waste Profile Form and Transuranic Waste Storage Record) is from 2-6 years (there is no documentation as to the reason for repackaging). For these repackaged drums, the documentation from the original drum is not included (except for the WODF for each package and the DWLS). New Waste Profile Forms and TWSR were created. It is particularly problematic that the original Waste Profile Form is not included since this is the basis of the Acceptable Knowledge approach that the waste is not hazardous under RCRA.

**Shipping Codes:** There is an inconsistency in the documentation of the shipping codes LANL uses for this waste. All TRU waste to be shipped to WIPP is assigned a three-digit TRUCON code according to the waste stream.\(^{23}\) This code begins with a one (1) for newly generated waste and a two (2) for retrievably-stored waste.

LANL has assigned the TA-55-43 waste stream the TRUCON code LA-116.\(^{24}\) However, this code is valid only for newly generated debris waste since it begins with a one (1). LANL has stated that it intends to ship retrievably stored legacy waste (this is the only

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\(^{23}\) See "TRUPACT-II Content Codes (TRUCON)" DOE/WIPP 89-004 Rev. 10, December 1996 for the listing of TRUCON codes for all sites. As far as we have been able to determine Rev. 10 is the most recent revision and was the revision provided by LANL. For TRUCON codes for Los Alamos (including TA-55) see "Los Alamos National Laboratory Transuranic Waste Certification Plan" TWCP-PLAN-0.2.4-001.R.1, Section 4, pp. 30-34.

\(^{24}\) It should be noted that the HEPA filter drums are assigned the LA119 TRUCON code. A similar argument about this TRUCON code can be made. We are also ignoring the fact that there are subcategories to the TRUCON codes designated by a, b, c, etc. (e.g. LA116c). We have not been able to find documentation on the differences between these subcategories, but it appears to have something to do with the packaging of the waste. However, in at least one case there is a discrepancy between the subcategory assigned to the waste by the Waste Profile Form and the subcategory assigned to the waste on the TWSR.
waste that WIPP has certified LANL to ship). Therefore, one would expect the TRUCON code to be LA-216 rather than the 116 code recorded in the drum data packages.

However, LA-216 is not a code that appears in the TRUCON list written by DOE/WIPP and provided to us by LANL. The LANL guidelines on inspecting and packaging waste from TA-55 for shipment to WIPP does list a LA-216 code, but not for the waste stream TA-55-43. In fact, the TA-55-43 waste stream is not listed at all in LANL guidelines for inspecting and packaging waste from TA-55 for shipment to WIPP and therefore does not appear to have an associated code. In conclusion, as far as we have been able to determine, documentation of a valid TRUCON shipping code for this waste stream has not been provided. Despite the fact that LANL has assigned the 216 code to other waste streams (even though it does not appear in the TRUCON list) LANL has not used it for the TA-55-43 waste stream. Instead LANL is using the shipping code that would apply if the waste were categorized as newly-generated waste. LANL’s certification from the Carlsbad Area Office explicitly excludes newly-generated waste. EPA’s certification decision also explicitly states that it covers legacy debris at LANL and does not apply to other waste streams from LANL (including newly-generated waste) or to waste streams from other facilities.

In conclusion, there are a number of documentation problems with the data provided by LANL. These documentation issues make LANL use of Acceptable Knowledge problematic.
## Appendix A: Documentation Problems by Drum

<table>
<thead>
<tr>
<th>Drum ID Number</th>
<th>Comments</th>
</tr>
</thead>
</table>
-Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference Memo attached)  
-TRU Waste Storage Record Page 2: Missing.  
-WODF: No Organics checkboxes  
-Discardable Waste Log Sheet: No signature |
| LA55400        | NOTE: This is a repackaged drum. Waste Generated in 1991, Summary Forms (including Waste Profile Form) not created until 1994.  
-WODF: Same signature for both Operator and Supervisor.  
-Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference Memo not attached)  
-TRU Waste Storage Record Page 2: Missing.  
-Waste Profile Form Page 2: Missing.  
-One WODF missing.  
-WODF: Organics checkboxes not filled in.  
-Document Traveler missing dates and initials. |
| LA55401        | NOTE: This is a repackaged drum. -Waste Generated in 1991, Summary Forms (including Waste Profile Form) not created until 1994.  
-WODF: Same signature for both Operator and Supervisor.  
-TRU Waste Storage Record Page 2: Not filled in, No signatures.  
-WODF: Organics checkboxes not filled in.  
-Document Traveler missing dates and initials. |
| LA55403        | NOTE: This is a repackaged drum. Waste Generated in 1991, Summary Forms (including Waste Profile Form) not created until 1994.  
-TRU Waste Storage Record Page 2: Not filled in, No signatures.  
-Reports Zero SNM for one waste Package instead of Lower Detection Limit (LDL Reference Memo not attached)  
-Document Traveler missing dates and initials.  
-Waste Origination and Disposition Form: Same signature for both operator and supervisor. |
| LA55406        | NOTE: This is a repackaged drum. Waste Generated in 1992, Summary Forms (including Waste Profile Form) not created until 1994.  
-TRU Waste Storage Record Page 2: Not filled in, No signatures.  
-Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference Memo not attached)  
-WODF: Nine of eleven Organics checkboxes not filled in.  
-Document Traveler missing dates and initials. |
| LA55431 | -Confirm Assay shows zero uncertainty.  
-TRU Waste Storage Record Page 2: Missing  
-Waste Profile Form Page 2: Missing  
-WOOF: One Organics checkbox not filled in, four with no checkboxes.  
-Document Traveler missing dates and initials. |
| LA55437 | -SNM Contents from Various Forms do not match. SNM for some packages in Printed Discardable Waste Log Sheet are different than entry in written Log Sheet. Results of decay (MASS memo) match written log sheet as does total from isotopic composition on TWSR. Confirm Assay does not match any of the other numbers.  
-Printed Log Sheet has blanks in Gross Weight Column.  
-TRU Waste Storage Record Page 2: Missing  
-Waste Profile Form Page 2: Missing  
-WOOF: No Organics checkboxes  
-Document Traveler missing dates and initials. |
| LA55439 | -TRU Waste Storage Record Page 2: Not filled in, No signatures.  
-WOOF: Three forms with no Organics checkboxes, three others not filled in.  
-Document Traveler missing dates and initials. |
| LA55451 | -Confirm Assay does not match SNM from log sheets or MASS memo.  
-Printed Log Sheet has blanks in both Net Weight and Gross Weight Columns.  
-TRU Waste Storage Record Page 2: Missing  
-Waste Profile Form Page 2: Missing  
-WOOF Organics Checkboxes: Six (of eight) not filled in.  
-Document Traveler missing dates and initials. |
| LA55452 | -TRUCON shipping code from Waste Profile Form (LA116B) does not match TRUCON code on the Transuranic Waste Storage Record (LA116C)  
-TRU Waste Storage Record Page 2: Missing  
-Waste Profile Form Page 2: Missing  
-Document Traveler missing dates and initials. |
| LA55476 | -Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference memo not attached)  
-Blank entries in both Net and Gross weight columns of printed DWLS.  
-TRU Waste Storage Record Page 2: Not Filled in  
-WOOF Organics Checkboxes: Not filled in |
| LA55558 | -Printed Log Sheet missing from Waste Storage Record  
-TRU Waste Storage Record Page 2: Not filled in, No signatures.  
-WOOF Organics Checkboxes: One no box, One not filled in. |
| LA55605 | **NOTE:** This drum is filled with HEPA filters and should be in waste stream TA-55-47 rather than TA-55-43.  
- Uncertainties in SNM measurements are 6-11 times the measurements themselves making it difficult to determine if there is consistency in the measurements.  
- Gross weight measurements are missing from waste log.  
- Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference Memo not attached)  
- TRU Waste Storage Record Page 2: Missing  
- Waste Profile Form Page 2: Missing  
- On one WODF the same person signed as both Operator and Supervisor.  
- WODF Organics Checkboxes: no box  
- Document Traveler missing dates and initials. |
| LA55614 | - Gross weight entries missing on printed Waste Log Sheet  
- TRU Waste Storage Record Page 2: Not Filled in  
- WODF Organics Checkboxes: No box  
- Document Traveler missing dates and initials. |
| LA55615 | - Gross Weights scratched out on printed Discardable Waste Log Sheet.  
- TRU Waste Storage Record Page 2: Not Filled in  
- WODF Organics Checkboxes: no box  
- Document Traveler missing dates and initials. |
| LA55625 | - Gross Weights scratched out on printed Discardable Waste Log Sheet.  
- TRU Waste Storage Record Page 2: Not Filled in  
- WODF Organics Checkboxes: no box  
- Document Traveler missing dates and initials. |
| LA55631 | - Gross weight entries on printed DWLS include zeros.  
- TRU Waste Storage Record Page 2: Missing  
- WODF Organics Checkboxes: no box |
| LA55663 | - Confirm Assay does not match SNM amounts from other forms.  
- Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference Memo not attached)  
- WODF Organics Checkboxes: five (of six) no box  
- TRU Waste Storage Record Page 2: Not Filled in |
| LA55666 | - Missing the WODF for one of the waste packages  
- Confirm Assay does not match SNM amounts from other forms.  
- TRU Waste Storage Record Page 2: Not Filled in  
- WODF Organics Checkboxes: Three no box, One not filled in |
| LA55668 | - Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference memo not attached)  
- Blank entries in Gross weight column of printed DWLS.  
- TRU Waste Storage Record Page 2: Missing  
- Waste Profile Form Page 2: Missing  
- WODF Organics Checkboxes: no box |
<table>
<thead>
<tr>
<th>Document ID</th>
<th>Observations and Notes</th>
</tr>
</thead>
</table>
| LA55683     | - Blank entries in Gross weight column of printed DWLS.  
- Printed DWLS missing one waste package PLS-202 (this is noted in writing on DWLS). This causes slight discrepancy between SNM counts.  
- TRU Waste Storage Record Page 2: Missing  
- Waste Profile Form Page 2: Missing  
- WODF Organics Checkboxes: no box |
| LA55695     | NOTE: This drum is filled with HEPA filters and should be in waste stream TA-55-47 rather than TA-55-43.  
- Blank entries in Gross weight column of printed DWLS.  
- TRU Waste Storage Record Page 2: Missing  
- Waste Profile Form Page 2: Missing  
- WODF Organics Checkboxes: no box |
| LA55696     | NOTE: This drum is filled with HEPA filters and should be in waste stream TA-55-47 rather than TA-55-43.  
- Zeros in Gross weight column of printed DWLS.  
- Confirm Assay is Zero.  
- TRU Waste Storage Record Page 2: Missing  
- Waste Profile Form Page 2: Missing  
- WODF Organics Checkboxes: no box  
- Document Traveler missing dates and initials. |
| LA55836     | - TRU Waste Storage Record Page 2: Not Filled in  
- Document Traveler missing dates and initials.  
- WODF Organics Checkboxes: no box |
| LA55922     | - Confirm Assay does not match other forms.  
- Blank entries in Gross weight column of printed DWLS.  
- Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference memo not attached)  
- TRU Waste Storage Record Page 2: Not Filled in  
- No Waste Profile Form (was it replaced by waste profile system? But waste profile system doc. Refers to a WPF)  
- One WODF has same signature for both operator and supervisor.  
- WODF Organics Checkboxes: no box  
- Document Traveler missing dates and initials. |
| LA55938     | NOTE: This drum is filled with HEPA filters and should be in waste stream TA-55-47 rather than TA-55-43.  
- Confirm Assay is zero.  
- One WODF (for HEPA-43 package) is missing.  
- Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference memo not attached)  
- Blank entries in Gross weight column of printed DWLS.  
- TRU Waste Storage Record Page 2: Missing  
- WODF Organics Checkboxes: six no box  
- No Waste Profile Form (was it replaced by waste profile system? But waste profile system doc. Refers to a WPF) |
| LA56000 | -TRU Waste Storage Record Page 2: Missing  
-Blank entries in Gross weight column of printed DWLS.  
-Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference Memo attached)  
-Spreadsheet of Isotopic Values is missing. Only uncertainties are presented.  
-Printed DWLS: Package weight of one package is off by two decimal places. 244 kg entered instead of 2.44 kg (as confirmed by checking with WODF).  
-WODF Organics Checkboxes: no box  
-Document Traveler missing dates and initials.  
-TRU Waste Manifest missing signatures. |
| LA56019 | NOTE: THIS is a repackaged drum. Waste Generated in 1990, Summary Forms (including Waste Profile Form) not created until 1996.  
-Confirm Assay does not match SNM from other forms.  
-Blank entries in Gross weight column of printed DWLS.  
-TRU Waste Storage Record Page 2: Not Filled in  
-WODF have same signature for both operator and supervisor.  
-WODF Organics Checkboxes: no box  
-Document Traveler missing dates and initials.  
-TRU Waste Manifest missing signatures. |
| LA56053 | NOTE: This drum is filled with HEPA filters and should be in waste stream TA-55-47 rather than TA-55-43.  
-Blank entries in Gross weight column of printed DWLS.  
-TRU Waste Storage Record Page 2: Not Filled in  
-WODF Organics Checkboxes: no box  
-Document Traveler missing dates and initials.  
-TRU Waste Manifest missing signatures. |
| LA56090 | -Blank entries in Gross weight column of printed DWLS.  
-WODF indicate no Organics but provide Weight of Organics  
-WODF: Volume of Organics not given. Weight of Organics is entered in both volume and weight boxes.  
-Document Traveler missing dates and initials.  
-TRU Waste Manifest missing signatures. |
| LA56091 | -Cover sheet missing.  
-Written DWLS missing  
-Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Reference Memo attached)  
-TRU Waste Storage Record Page 2: Missing  
-WODF indicate no Organics but provide Weight of Organics  
-WODF: Volume of Organics not given. Weight of Organics is entered in both volume and weight boxes.  
-Document Traveler missing dates and initials.  
-TRU Waste Manifest missing signatures. |
<table>
<thead>
<tr>
<th>Document ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA56142</td>
<td>Reports Zero SNM for waste Packages instead of Lower Detection Limit (Find Reference Memo which states to use LDL)</td>
</tr>
<tr>
<td></td>
<td>- Blank entries in Gross weight column of printed DWLS.</td>
</tr>
<tr>
<td></td>
<td>- TRU Waste Storage Record Page 2: Not Filled in</td>
</tr>
<tr>
<td></td>
<td>- WODF indicate no Organics but provide Weight of Organics</td>
</tr>
<tr>
<td></td>
<td>- WODF: Volume of Organics not given. Weight of Organics is entered in both volume and weight boxes.</td>
</tr>
<tr>
<td></td>
<td>- Document Traveler missing dates and initials.</td>
</tr>
<tr>
<td></td>
<td>- TRU Waste Manifest missing signatures.</td>
</tr>
<tr>
<td>LA56225</td>
<td>WODF: Volume of Organics not given. Weight of Organics is entered in both volume and weight boxes.</td>
</tr>
<tr>
<td></td>
<td>- Cover sheet missing.</td>
</tr>
<tr>
<td></td>
<td>- Written DWLS missing</td>
</tr>
<tr>
<td></td>
<td>- TRU Waste Storage Record Page 2: Missing</td>
</tr>
<tr>
<td></td>
<td>- Document Traveler missing dates and initials.</td>
</tr>
<tr>
<td></td>
<td>- TRU Waste Manifest missing signatures.</td>
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<tr>
<td>LA56283</td>
<td>Cover sheet missing.</td>
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<tr>
<td></td>
<td>- Written DWLS missing</td>
</tr>
<tr>
<td></td>
<td>- TRU Waste Storage Record Page 2: Missing</td>
</tr>
<tr>
<td></td>
<td>- WODF: Volume of Organics not given. Weight of Organics is entered in both volume and weight boxes.</td>
</tr>
<tr>
<td></td>
<td>- Reports Zero SNM for waste Packages instead of Lower Detection Limit (LDL Memo referenced but not attached)</td>
</tr>
<tr>
<td></td>
<td>- WODF Organics Checkboxes: no box</td>
</tr>
<tr>
<td></td>
<td>- Document Traveler missing dates and initials.</td>
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<tr>
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<td>- TRU Waste Manifest missing signatures.</td>
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<td>LA56397</td>
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<td>- Written DWLS missing</td>
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<tr>
<td></td>
<td>- TRU Waste Storage Record Page 2: Missing</td>
</tr>
<tr>
<td></td>
<td>- WODF: Volume of Organics not given. Weight of Organics is entered in both volume and weight boxes.</td>
</tr>
<tr>
<td></td>
<td>- WODF Organics Checkboxes: no box</td>
</tr>
<tr>
<td></td>
<td>- Document Traveler missing dates and initials.</td>
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<tr>
<td>LA56638</td>
<td>Cover sheet missing.</td>
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<td>- Written DWLS missing</td>
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<td>- TRU Waste Storage Record Missing</td>
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<td>- Waste Profile Form Missing</td>
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<td></td>
<td>- WODF: Organics Volume Box Blank</td>
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<tr>
<td></td>
<td>- WODF Organics Checkboxes: no checkboxes</td>
</tr>
<tr>
<td></td>
<td>- Document Traveler missing dates and initials.</td>
</tr>
<tr>
<td></td>
<td>- TRU Waste Manifest missing signatures.</td>
</tr>
</tbody>
</table>
July 7, 1998

Review of Documents Relating to the Proposed Shipments of LANL TA-55-43 Wastes to the Waste Isolation Pilot Plant

Dear Mr. Fettus:

On June 5, I provided you with the above referenced report, which I co-authored with Hisham Zarriff, as well as with my declaration in this matter. Over the last few weeks, we received more documents that you obtained from the Department of Energy (DOE). I have also received the initial review of the New Mexico Department of the Environment (NMED) that appears to have been based on the same set of data that was made available to IEER during the preparation of our report.

In a June 17, 1998 letter by NMED Secretary Mark E. Welder to Governor Johnson, NMED concerns were summarized as follows:

"NMED staff concluded that the LANL waste stream was inadequately characterized on numerous grounds including the following:
(1) the "process" for characterization was incomplete and substantially deviated from AK requirements;
(2) there was no validation of acceptable knowledge, a minimal requirement for use of the AK process; and
(3) there was no chemical analysis of any constituents."

I note that the NMED's determination concurs with our finding that the waste stream labeled for shipment to WIPP is insufficiently characterized to allow it to be treated as non-hazardous under RCRA. Our analysis showed that it is more likely than not that part of the waste would be considered hazardous under RCRA regulation because it exhibits the following characteristic of hazardous waste: corrosivity, toxicity and
reactivity. In addition, we found flaws in the documentation of the waste Los Alamos National Laboratory (LANL) proposes to ship that are substantial enough to invalidate LANL's claim that it has "Acceptable Knowledge" that the wastes are not hazardous. Our report pointed out that only a chemical analysis could provide conclusive data that allows evaluation of the corrosivity, toxicity and reactivity of the waste stream.

You asked us to review our determination in light of the additional information received. Assisted by Hisham Zarriffi, I have conducted such a review. We have organized our comments according to the Flow Chart entitled "Process for Characterization and Certification of Waste Stream TA-55-43, Lot No. 01". Our comments are attached.

We conclude that the additional documents do not contain information that would change our original conclusions. We actually found further flaws in the documentation of the waste LANL proposes to ship as well as further evidence that it is more likely than not that part of the waste would be considered hazardous under RCRA regulation because it exhibits the following characteristics of hazardous waste: corrosivity, toxicity, reactivity and ignitability. In addition, the new documents suggest the following:

- Based on calculations by Kosiewicz (TWCP-1211), the waste stream is likely to fulfill the RCRA criterion for ignitability because the acetone concentration in void volume, at least in part of the waste, could exceed the lower flammability limit of 2.5%.
- TWCP-1211 also contains a review of data on radiolysis that is in general agreement of IEER's use of the data; thus indirectly corroborating the findings on radiolysis expressed in our June 5, 1998 report.
- The visual inspection of several drums resulted in a finding of corrosion (interior of drum #55683, inner cans in drum #55431 rusted through, unknown rust colored powder found in drum #55478), supporting our finding in our June 5, 1998 report.
- Given the number of differences between the Visual Examination (VE) and the Real-Time Radiography (RTR) as evidenced by the number of Nonconformance Reports (NCRs) issued, it would seem prudent for LANL to conduct further VE of other drums. This is especially important since the visual examination conducted during repackaging of drums indicated numerous significant problems including the presence of sealed containers that are greater than four liters (which are not accepted under the WIPP WAC). For example, drum #55403 contained sealed six liter containers.
- We find the documentation still incomplete. Updated waste drum packages with complete information have not been provided to address our concern over missing documents and incomplete information. As noted in our original report, in addition to improper documentation, the procedure for testing pH of rags was not followed.

You will find further details of our review in the enclosed attachment. Please do not hesitate to contact me if you have any questions or comments.

Sincerely,

[Signature]

Bernd Franke
Executive Director

End.
Comments on Documents for Process for Characterization and Certification of Waste Stream TA-55-43, Lot No.01

By Bernd Franke and Hisham Zarrifi

Pu-238 Analysis at SRS (TWCP-1044): We have no comment on the determination of the Pu-238 initial feedlot as being non-RCRA.

Pu-238 re-Analysis at LANL (TWCP-1025, 26,30): We have no comment on the determination of the Pu-238 initial feedlot as being non-RCRA.

Separation of Pu-238 processing (TWCP-1042, 934): We have no comment on the assertion that Pu-238 processing was kept separate from other TA-55 activities even though this may have been difficult at times.

LANL Waste Profile Form (WPF) approval to generate waste: The WPF is supposed to be in the generator's drum package. As noted in our previous report a number of WPFs were missing the second page. The recent documents provided by LANL do not appear to address the missing information. Furthermore, the original waste profile forms for repackaged drums have not been provided by LANL.

Pu-238 waste generated and packaged according to TA-55 procedures (TWCP-700 and other waste management procedures referenced therein): Many of the documentation problems outlined in our original report indicate that procedures were not followed completely. Examples include missing documentation and improperly completed forms (e.g. many of the Waste Origination and Disposition Forms). Updated waste drum packages with complete information have not been provided. As noted in our original report, in addition to improper documentation, the procedure for testing pH of rags was not followed.

Pu-238 waste stored in Area G and retrieved for further characterization: No comment at this time.


TA-55-43 Lot No.1 selected for certification and shipment to WIPP (TWCP-597): This lot supposedly contains 36 drums. As noted in our previous report, five of these drums are filled with filters and should thus not be not included in the TA-55-43 waste stream. They are, by LANL's definition in their Acceptable Knowledge Summary Report (TWCP-1042) part of the TA-55-47 waste stream. This issue continues to remain unaddressed.
RTR performed on every drum to confirm material content of drum (LA98-3.2.1-014 and 015, TWCP-1109 and 1110): According to the Process flow diagram the RTR confirmed the absence of lead and other prohibited items. It should be noted that the RTR actually resulted in a number of NCRs being issued. For example, TWCP 1110 covers the RTR for eighteen drums (plus a second RTR on each of two drums). Ten NCRs were issued as part of TWCP-1110, nine of which were for the presence of sealed containers greater than four liters. The RTR did not detect these prohibited items. As a result a CAO Corrective Action Report was issued and the RTR operators were re-trained. See below for more discussion on the issue of sealed containers and the WIPP Waste Acceptance Criteria.

Reconciliation of RTR results with AK information (TWCP-1217): RTR results were not corroborated by visual examination (see below). Thus, even if RTR results were reconciled with AK information, this would be of little merit.

Visual Examination (VE) performed for QA of RTR Activities for five drums (LA98-3.4.1-001, TWCP-1205): Various discrepancies were discovered by LANL between the Visual Examination and the RTR. For example, only two of the five drums were assigned the same Waste Matrix Parameters (Sheet 5, p.1). A second example is assignment of TRUCON sub-codes. A comparison of TRUCON sub-codes assigned by Visual Examination, RTR and AK showed none of the five drums were assigned the same code by all three methods. The RTR assigned code never matched the AK and the VE assigned code only matched the AK on two of the five drums. Another problem identified was poor agreement on the volume. This was apparently due to the voltage settings during RTR.

Another issue discovered by the VE is that sealed containers greater than 4 liters were being identified in the RTR as ≤ 4 L (see NCR 98-077). The WIPP Waste Acceptance Criteria do not allow these containers. According to the Nonconformance Report, a temporary measure of removing the tape from the cans was undertaken since no guidance on how to deal with this issue was given from CAO or WIPP to the TWCP and then to the generator. It should be noted that we have not been given the opportunity to review the videotapes of the VE. These videos would be useful in assessing the effectiveness of the VE procedure (despite the fact that a number of problems exist with the videotapes; such as being off subject and the taping over of some videotapes by subsequent Visual Examinations).

Given the number of differences between the VE and the RTR as evidenced by the number of NCRs issued, it would seem prudent for LANL to conduct further VE of other drums. This is especially important since the visual examination conducted during repackaging of drums indicated numerous significant problems, including the presence of sealed containers that are greater than four liters (which are not accepted under the WIPP WAC). For example, drum 55403 contained sealed six liter containers. There is therefore direct evidence that drums not included in the VE for purposes of RTR comparison might not meet the WIPP WAC.¹

¹ It should be noted that the original logbook (#VE-197) for both the VE and the repackaging is the same and the work appears to have been conducted by the same personnel. The information gained from repackaging, however, was not used in comparing VE with RTR.

Institute for Energy and Environmental Research, July 7, 1998, page 2
The VE data also shows evidence found of corrosion on both individual metal cans and on the drum interior:

- Drum #55431: "Some inner cans rusted through with small pits" (VE 197, p. 31)
- Drum #55683: "Light corrosion all over" noted for the interior of drum (VE 197, p. 34)
- Drum #65476: Item #8: "Unknown rust colored powder -30cc looks like rust or sand (very fine like silt)" (VE 197, p. 55)

Head Space Gas analysis performed on each of the 36 drums (TWCP 1108 and TWCP-1211):

TWCP-1211 is a nine-page document entitled "Analysis of Literature Review on Radiolytically Generated Volatile Organic Compounds" by Stanley T. Kosiewicz, dated June 8, 1998. It is the only document in the entire new set of documents that specifically addresses the question of radiolysis that IEER reviewed in detail. The document by Kosiewicz reviews, among others, two publications that IEER relied on in its numerical determination of the amount of radiolytical degradation products:


Kosiewicz stresses the particular importance of the paper by Reed and Molecke "because it focused on the potential for alpha radiolysis to generate VOCs." On page 3 of his report, Kosiewicz correctly points out that:

"calculations were not done to estimate the mass balance between gaseous phase and solid materials. In addition, the test chambers were not checked for surface adsorption of evolved VOCs. Since this artifact would reduce the concentration of VOCs in the gas phase, it is speculated that the concentration of VOCs measured in these experiments are probably lower than what was really generated."

The limitation of the Reed and Molecke data to gaseous VOCs, thus neglecting solid phase VOCs was also observed on page 7 of IEER's analysis of their paper. IEER estimated the G value for benzene (number of benzene molecules per 100 eV of absorbed radiation) to be -0.00052. We did this on the basis of reported G values for hydrogen and the relative concentrations of hydrogen and benzene in the gas phase. In preparation of the report, Bernd Franke had an e-mail exchange with Drs. Reed and Molecke in which some background information about the paper was requested. Taking hydrogen formation from polyethylene in N₂ as an example, the discrepancy by the reported hydrogen concentration (0.005 mg) and the one calculated using the G-value (0.14 mg), had to be resolved - a factor of 28 difference. The question, posed to the authors, was whether the volume in the experimental vessel of gas was diluted before analysis. In his reply on June 1, 1998, Reed promised to look into this matter but has
Kosiewicz did not provide a quantitative analysis of the amount of benzene produced by radiolysis even though this could be easily done using the data from Reed and Molecke’s paper. Using the assumptions in Kosiewicz’s scenario and a G value for benzene of −0.0006, the amount of benzene in a TRU waste drum in 6 years is calculated to be ~43 mg per kg of waste. This concentration exceeds the RCRA TCLP criterion for benzene of 10 mg/kg of waste material.

Kosiewicz focused on the calculation of the amount of acetone produced and concluded that an acetone concentration in a waste drum after 6 years is estimated to be in the range of 12,000 ppmv (1.2%) to 620,000 ppmv (62%). The lower and upper flammability limits of acetone at atmospheric pressure and room temperature are 2.5% and 12.5%, respectively. It therefore appears likely that at least part of the waste would exhibit the RCRA characteristic of the Ignitability which is defined as follows in 40CFR261.21:

(a) A solid waste exhibits the characteristic of ignitability if a representative sample of the waste has any of the following properties:

(…)

(2) It is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes and, when ignited, burns so vigorously and persistently that it creates a hazard.

Headspace analysis of the TA-55-43 waste drums indicates the presence of acetone (above the minimum detection limit of 21 ppmv) in 25 out of 36 drums for which data was supplied. The concentrations found in the headspace range from 26 to 150 ppmv. The maximum concentration found of 150 ppmv (0.015%) is below the lower flammability limit. Given the multiple types of packaging (many sealed with tape), it is reasonable to assume that only a fraction of the acetone generated by radiolysis would actually make its way into the headspace. On the basis of the calculations provided by Kosiewicz, it is likely that the acetone concentration in at least part of the waste is in the flammability range. It is therefore likely that at least part of the waste exhibits the
characteristic of ignitability. Only a careful, complete waste analysis can provide a conclusive answer.

Koslewicz also reviewed the paper by Arakawa et al. (1986) that IEER used to infer the amount of HCl produced by radiolysis. Koslewicz did not use the data provided by Arakawa et al. to perform a quantitative analysis of the amount of HCl formed.

Comparison of Gas Analysis with PRQL and reconciliation with AK information (TWCP-1108): The AK does not provide numerical estimates on radiolytic degradation products such as benzene, acetone, and HCl. Gas analysis demonstrates the presence of acetone and benzene.

Repackage Drums in TA-55-43 Lot No. 1 to meet thermal limits (LA98-RPK-001, TWCP-1215): LANL has provided new information about the repackaging of drums from the TA-55-43 waste stream. These documents concern the repackaging of drums in order to meet the thermal limits in the WIPP Waste Acceptance Criteria. However, the documentation does not address the concerns raised in our report of June 8, which concerned a different repackaging operation, so far as we can determine. Table 1 shows the repackaging of drums as determined from the waste drum data packages used to prepare our original report.

Table 1

<table>
<thead>
<tr>
<th>Original Drum Number</th>
<th>Re-packaged Drum Number</th>
<th>Drum data packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA24007</td>
<td>LA55400</td>
<td></td>
</tr>
<tr>
<td>LA24077</td>
<td>LA55401</td>
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</tr>
<tr>
<td>LA24297</td>
<td>LA55403</td>
<td></td>
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<tr>
<td>LA24536</td>
<td>LA55408</td>
<td></td>
</tr>
<tr>
<td>LA25738</td>
<td>LA56018</td>
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</tr>
</tbody>
</table>

Table 2 is reprinted from LANL repackaging report of either 5/28/98 or 6/10/98 (both dates are on the document) and are the drums recently repackaged to meet the WIPP WAC and which have been packed in Standard Waste Boxes (SWB).

Table 2

<table>
<thead>
<tr>
<th>Repackaged SWB Number</th>
<th>Repackaged Drum Number</th>
<th>Original Drum Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>57033</td>
<td>57032</td>
<td>55403</td>
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</tr>
<tr>
<td></td>
<td>57031</td>
<td>56053</td>
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</tbody>
</table>

Comparing these two tables it is easy to see that the questions about repackaging operations we raised in our report have not been resolved. Table 2 concerns a different repackaging and renumbering operation. Note however that Drum 24297 was repackaged as drum 55403, which was then split into three separate drums (57032, 57033, and 57035).

Assign new TRUCON codes based on repackaging and confirm other information (TWCP-1218): The repackaged drums have been assigned TRUCON code LA-125A which corresponds to the TA-54 Size Reduction Facility. No documentation has been provided concerning the TRUCON code issues discussed in our original report. These issues remain to be resolved for those drums not being repackaged.

However, it is not clear that LA-125A is the appropriate TRUCON code for this waste. The LA-125A TRUCON code is associated with metal waste (and associated combustibles) from the TA-54 Size Reduction Facility (SRF) which dismantles and packages "mostly gloveboxes, process equipment, and ductwork from decommissioning operations." There is no indication that this TRUCON code can be used simply because drums may have been repackaged at the SRF.7

The issue of TRUCON codes appears even more confused than before. The use of the TRUCON code LA-125A appears to be inconsistent with its definition. It is not clear that the TRUCON code assigned to waste should be changed for repackaging. LA-125A appears to be intended for the creation of waste during dismantlement operations.

7 It is unclear at the moment that the drums were even repackaged at the SRF. Documentation in the repackaging data report (TWCP-1215) indicates that the repackaging was done in TA-50 Building 69.

Furthermore, LA-125A is defined for a very specific LANL facility that may not have been used for repackaging operations.

Radio assay of each repackaged drum to determine Pu-239 content (LA95-PAN-001, TWCP-1213): No specific comments at this time.

Reconciliation of Gamma Spectroscopy and PAN data with AK information and calculation of Cr content in each repackaged drum (TWCP-1218): No specific comments at this time.

Drums loaded into standard waste boxes to meet TRUCON code LA125A: No specific comments at this time.

$SWB$ characterization and certification information entered into WWIS for approval by DOE/CAO (TWCP-1214): No specific comments at this time. The waste characterization is incomplete with regard to RCRA characteristics of corrosivity, toxicity, reactivity and ignitability.
AFFIDAVIT OF LOKESH CHATURVEI, Ph.D.

Lokesh Chaturvedi, being duly sworn, deposes and says:

1. My name is Lokesh Chaturvedi, and I reside in the City of Albuquerque, County of Bernalillo, State of New Mexico.

2. I am employed as the Deputy Director of the Environmental Evaluation Group ("EEG") and have been so employed since March 1988. From June 1982 to March 1988 I was employed by EEG as Senior Engineering Geologist.

3. My resume is attached. My background is as follows. I received a Ph.D. in Geological Sciences from Cornell University in 1969, a M.S. in Civil Engineering from Purdue University in 1965, a M.Sc. in Applied Geology from University of Roorkee in Roorkee, India, in 1963 and a B.Sc. in Geology, Physics, and Mathematics from Maharaja's College in Jaipur, India, in 1960. I have taught courses in Introductory Geology, Physical Geology, Geology for Engineers, Introduction to Geological Engineering, Site Investigation, Engineering Geology, Subsurface Exploration, Environmental Geology, Hydrogeology, Soil Mechanics, Rock Mechanics, Geomorphology, and Geological Oceanography at both undergraduate and graduate levels. I have published since 1968 eighty research papers, as author or co-author, on subjects of Radioactive Waste Disposal, Remote sensing, Geothermal Hydrology, and Mechanical Properties of Rocks. I have performed funded research projects in site evaluation for radioactive waste disposal, geothermal hydrology and multispectral remote sensing, and I have performed several professional consulting projects in the areas of
hydrogeology, subsurface exploration, engineering materials, and nuclear waste disposal
site investigation.

4. EEG was established in 1978 to conduct independent technical evaluation of the
Waste Isolation Pilot Plant ("WIPP") project to ensure protection of public health and
safety and the environment. The funding for EEG is provided 100% through
appropriations to the Department of Energy ("DOE"). EEG has offices in Albuquerque
and Carlsbad. EEG performs independent technical evaluation of the WIPP project as
well as independent environmental monitoring of air, water, and soil at the WIPP site and
in nearby communities. EEG has published seventy EEG reports and numerous other
papers addressing scientific and technical aspects of WIPP. I have visited the WIPP site
on about 60 occasions, including approximately 50 underground visits.

5. I have prepared this affidavit at the request of the Attorney General of New
Mexico to address the condition of the underground panel 1 rooms, in which DOE now
plans to emplace radioactive waste. I understand that DOE has asserted that, should
waste be emplaced in those rooms by DOE, and should the Court later determine that
such waste should be retrieved, it would not be difficult to retrieve the waste for storage
elsewhere. In my judgment, however, retrieval of the waste after any significant time is
likely to present severe practical problems, because of the age and deteriorating conditions
of the panel 1 rooms.

6. WIPP, as the Court is aware, is located in southeastern New Mexico about 26
miles to the east of Carlsbad. The WIPP site is a four mile by four mile square. The
underground waste disposal area, called the repository, is excavated in salt beds of the
Salado Formation 2150 feet below the surface. There are four vertical shafts connecting
the repository to the surface. The repository, when completed, will consist of 56 underground rooms and connecting tunnels, called drifts. Each room is planned to be 300 feet long, 33 feet wide, and 13 feet high (as initially excavated). Contact-handled transuranic ("CH-TRU") waste is planned to be emplaced in 55-gallon drums, stacked three high in rooms and drifts. Some of the waste will also be contained in Standard Waste Boxes ("SWB's"), also stacked three high. Magnesium oxide (MgO) backfill is planned to be emplaced along with the CH-TRU waste. The MgO will be contained in plastic sacks of various sizes; some of these, called "supersacks," are planned to be placed on top of the stacks of waste drums and boxes. In addition, remote-handled transuranic ("RH-TRU") waste is planned to be emplaced in cylindrical containers about ten feet long and two feet in diameter, inserted into horizontal holes drilled in the walls of the rooms and drifts.

7. The stability and longevity of the underground rooms has been a matter of concern at WIPP since at least the early 1990's. It has long been understood that the salt beds at WIPP would converge around the waste, close, and ultimately encase the waste; indeed, such is the purpose of selecting salt beds for disposal. However, after the initial excavations it was found that the behavior of the beds differs somewhat from expectations. First, the rate of convergence of roof and floor was approximately three times the expected rate. The model of geomechanical behavior used by DOE has had to be significantly modified to reproduce this behavior. Second, due to the presence of layers of brittle rock in the salt beds, the WIPP repository has shown an unexpected amount of brittle fracture behavior, as distinguished from the plastic deformation expected by DOE. Brittle behavior is marked by more sudden and abrupt movements than plastic behavior,
and it is more complex to model and predict. These observations, in particular the enhanced closure rate, indicate that the projected life of the rooms will be less than originally expected.

8. Significant attention has been addressed to stability problems as a result of large-scale fracture behavior in disposal rooms. Four Site and Preliminary Design Validation ("SPDV") rooms were excavated in 1983 to study geomechanical behavior. Within three years signs of deterioration appeared. Fractures occurred in the roof, walls, and floors of SPDV rooms 1 and 2. In April 1989 extensive fracturing was observed in SPDV room 1 by personnel drilling holes for roof bolts. Specifically, dust emerged from previously drilled holes in the roof as holes were drilled up to 60 feet away. Apparently, dust was carried in fractures behind the roof surface.

9. Rock falls were observed thereafter. On February 4, 1991, a slab of rock, estimated by DOE to weigh 700 tons, broke loose from the roof of room 1 and fell to the floor. This event occurred in less than eight years after the room was excavated. Another roof fall occurred in SPDV room 2 on June 12, 1994.

10. The first of the planned eight panels of the repository was excavated in two stages. The panel entry in S 1950 drift, room 1, and the parts of rooms 2 and 3 were excavated in May 1986 - March 1987. Mining restarted in January 1988, and the panel was completed in June 1988. These rooms were planned for an "operational demonstration," starting in October 1988. They were fitted with 10 ft long anchor bolts at 4 ft spacing in the roof, with the intention of keeping the rooms open for up to seven years. Plans changed, and by 1990, the plan was to use only one room for the "Bin Tests," which required continuous access by scientific and maintenance personnel. DOE
assembled a group of 11 geotechnical experts (including one Sandia National Laboratory and two Westinghouse employees) in April 1991 for advice on the stability and life span of the panel 1 rooms. I attended the deliberations of this group of experts. The group concluded:

“If no additional remedial measures are taken, the rooms in the panel are likely to have a total life from seven to eleven years from the time of excavation using the currently installed roof support system, consisting of rockbolts. They indicated that the rockbolt had some beneficial effects, but agreed that it was not possible to measure their effectiveness. Estimates made by individual panel members of room life extension due to the bolting varied from a few months to several years. In conclusion, the panel believed that modifications, enhancements, and regular maintenance would be required for the rooms in panel 1 to perform satisfactorily over the assumed nine year test period starting July 1991.” (Exhibit 1).

In other words, the rooms in panel 1 could remain stable without additional support for a period of 2 to 6 years from April 1991, i.e. until 1993 with high confidence and until 1997 with decreasing confidence. Obviously, these projections of room life without additional remedial measures have expired.

11. Thereafter an elaborate “supplementary roof support system” was installed in room 1 of panel 1, when bin tests were planned. The purpose of this system was to “extend the life of room 1 to allow completion of the experiments, for an additional period of up to seven years (from July 1991).” (Exhibit 2). The system consists of additional roofbolts, steel channel beams, lacing cables and wire meshing. Each of the 286 roofbolts was fitted with a load cell for continuously monitoring the performance of the roofbolts. The system is not designed to prevent the creep of rock into the room, but to contain and support the detaching roof slab while allowing it to be lowered. Most of the load is carried by the rockbolts. The bolts are to be periodically detensioned when the load
reaches 20,000 pounds. For several years the frequency of detensioning has been about once every five weeks.

12. All the rooms of panel 1 were fitted with 10 ft long pattern bolts in the roof in 1988-89. Supplementary support system (a variation of the room 1 system) was installed in room 2 in 1991. Thus, rooms 1 and 2 have the yielding supplementary roof support system, but rooms 3 through 6 have only the original and some additional roofbolts and wire meshing. Room 7 was rebolted in 1993-94 with pattern bolts, weld mesh and slings, and a tertiary system of roof bolts and wire meshing has been installed in this room in April, 1998 to prepare the room for receipt of waste. In addition to the roof stability problems, all the rooms also face problems due to floor heave and spalling of the walls in the rooms, for which periodic maintenance is required.

13. DOE presented its “Panel 1 Utilization Plan” at a meeting of “WIPP Stakeholders” on May 19, 1994. The plan, briefly, is to continue using panel 1 rooms for waste disposal. DOE maintained that it would not be wise to excavate panel 2 until the DOE is certain that it would be used for waste disposal. DOE estimated that it would take three years to excavate a new panel, causing an unacceptable delay between getting all the approvals and starting waste emplacement. I pointed out at this meeting that the four SPDV rooms were excavated in six weeks, between March 9, 1983, and April 25, 1983, and the panel 1 was excavated in a total of 15 months even with an interruption of nine months between the two phases of excavation. In fact, according to DOE, “Rooms 4 through 7 were completed, in 1988, within approximately one month after the start of excavation.” (Exhibit 3).
14. What is the safe life of the rooms with a supplementary roof support system? The design report for the system stated the goal was to "extend the life of Room 1 to allow completion of the experiments, for an additional period of up to seven years (from July 1991)" (Exhibit 2). DOE has claimed that the room 1 support system was installed to minimize the need for ground control (i.e., maintenance) activities during experiments; otherwise DOE asserts, the rooms can be kept stable by ground control activities. Since the process of waste emplacement would not allow maintenance of the roof, floor, or walls where waste has been emplaced, it was obvious in 1991 that supplementary roof support systems would have to be installed if these rooms were to be used. The system installed in 1998 in room 7 is different and less elaborate than the one used in room 1. Also, room 7 in 1998 is 7 years older, as indeed all the rooms are, compared to room 1 in 1991. Furthermore, the room 1 system has also required periodic maintenance in the form of detensioning of the roof bolts. Therefore, any prediction of the life of the room 7 tertiary support system, in the absence of maintenance, is speculative.

15. Excavated areas require periodic maintenance. In areas without roof support, it consists of removing the unstable parts of the roof. In areas with roof bolts, broken bolts have to be replaced, and some areas are bolstered with additional bolts. The system as presently installed in room 1 requires periodic detensioning of various roofbolts, currently about once every five weeks. Periodic stabilization of the drummy areas of the walls will be necessary and the floor also has to be periodically milled and the cracks filled using crushed salt. The DOE position on the panel 1 safety is as follows:

"Panel 1 is safe and can be maintained in a safe condition indefinitely as long as maintenance can be performed." (Exhibit 4).
Since it will not be possible to conduct the required maintenance activities such as monthly detensioning of the roof bolts in room 1 and replacement of broken roof bolts of the tertiary system in room 7, the basis of the DOE's confidence, i.e., the opportunity to perform maintenance, will not exist after waste is emplaced.

16. EEG in 1996 requested Dr. Hamid Maleki of Maleki Technologies, Inc. to assess the stability of the panel 1 and the E 140 drift during the first seven years of waste emplacement operations. For this analysis, we assumed the DOE projection of April 1998 to be the starting date for waste emplacement, but made a more realistic assumption of seven years to fill panel 1, rather than the 2.5 years projected by the DOE. The capacity of panel 1 is 81,000 CH-TRU drum-equivalents, plus RH-TRU that the DOE expects to have available for disposal in 2002. Dr. Maleki recommended that DOE abandon panel 1 and mine a new panel after the decision has been made to use WIPP as a repository.

17. The WIPP facility was excavated much earlier than its intended use and requires continuous maintenance to be ready for operation until all other requirements for starting the operations have been satisfied. Judging from the past experience, a new repository panel can be excavated in about six months. EEG likewise recommended abandoning panel 1 and excavating a new panel for waste emplacement, once all the necessary certifications and permits have been received.

18. I visited the underground with Dr. Maleki and Dr. Ian Farmer, EEG consultants, on June 3, 1998 and observed conditions in the panel 1 rooms. In my opinion the overall condition of the panel 1 rooms is very poor. Convergence rates of the panel 1 rooms have continued as observed in earlier years. Visible fracturing in the roofs of all of the rooms is more pronounced than two years ago. Maintenance is required on an
ongoing basis in all of the rooms. The rooms which are supported by rock bolts are all beyond the end of their useful life, as projected by the DOE’s 1991 geotechnical panel. In my opinion, it would be unwise from a safety standpoint to emplace waste in any of the panel 1 rooms at this time. If waste is emplaced, the result is likely to be that room 7 will be partially filled during the first year of operations. In this situation the converging roof would descend onto the waste stack, but in the unfilled part of the room may fall abruptly, as in the roof collapse of SPDV room 1. Such a situation could cause a breach of containment and escape of radioactivity.

19. It must be kept in mind that, if waste is emplaced in any room at this time, maintenance must cease, at least in the waste-filled area. In estimating the feasibility of retrieval of waste, one must assume that retrieval, if needed, may commence at some future time, such as perhaps six months from now, and that such retrieval may require a similar period of time to complete. Further, one must assume that the rooms would not have been maintained since they were filled. In my opinion such retrieval would be difficult and risky. I so conclude because none of the roof bolting methods has been shown to reduce the rate of room convergence at WIPP. Moreover, how long one of these aging rooms will last with maintenance suspended is extremely dubious. Without maintenance and replacement of broken bolts, the bolt failure rate is expected to increase in a domino effect and increase the potential of roof collapse.

20. DOE now plans to emplace waste initially in room 7, a room which has been equipped with a tertiary support system consisting mainly of rock bolts. The stable and useful life of that room, as estimated by DOE’s geotechnical panel, ended in 1997. With maintenance suspended, it is not possible to have a high degree of confidence in the roof
stability of that room. I recommend that none of the panel 1 rooms be used for disposal, and I emphatically recommend that such rooms not be put to use with the expectation of having access and retrieving waste at some uncertain future time, because the useful life of such rooms, and the time during which there will be access for retrieval purposes, cannot be predicted with any assurance.

LOKESH CHATURVEDI, Ph.D.

Dated: June 5, 1998

SUBSCRIBED AND SWORN TO before me by Lokesh Chaturvedi, Ph.D., on this 5th day of June, 1998.

Notary Public

My commission expires: 7/5/2000
PRESENT POSITION
Deputy Director
Environmental Evaluation Group
New Mexico Institute of Mining & Technology
7007 Wyoming Blvd. N.E., Suite F-2
Albuquerque, New Mexico 87109

Responsible for an independent technical evaluation of the Waste Isolation Pilot Plant, the first planned deep geological repository for radioactive waste in the USA, as part of an interdisciplinary team of scientists and engineers.

SUMMARY OF PROFESSIONAL EXPERIENCE
Teaching: Have taught courses in Introductory Geology, Physical Geology, Geology for Engineers, Introduction to Geological Engineering, Site Investigation, Engineering Geology, Subsurface Exploration, Environmental Geology, Hydrogeology, Soil Mechanics, Rock Mechanics, Geomorphology and Geological Oceanography at both undergraduate and graduate levels.

Research: Have published research papers in Radioactive Waste Disposal, Remote Sensing, Geothermal Hydrology and Mechanical Properties of Rocks. Have performed several funded research projects in site evaluation for radioactive waste disposal, geothermal hydrology and multispectral remote sensing.

Consulting: Have performed several professional consulting projects in the areas of hydrogeology, subsurface exploration, engineering materials and nuclear waste disposal site investigation.

EDUCATION
Ph.D., Geological Sciences, 1969, Cornell University, Ithaca, NY.
M.S., Civil Engineering, 1965, Purdue University, Lafayette, IN.
M.Sc., Applied Geology, 1963, University of Roorkee, Roorkee, India.
B.Sc., Geology, Physics, Mathematics, 1960, Maharaja's College, Jaipur, India.

Short Course in Occupational and Environmental Radiation Protection, Harvard University, March, 1990.

PROFESSIONAL EXPERIENCE
Deputy Director, Environmental Evaluation Group, New Mexico Institute of Mining & Technology, Albuquerque, NM, March 1988 to present.


Associate Professor in Geological Engineering, Departments of Earth Sciences and Civil Engineering, New Mexico State University, Las Cruces, NM, September 1976 - May 1982.

Assistant Professor in Geology, City University of New York, Hunter College, New York, NY, September 1974 - June 1976.

Senior Lecturer in Engineering Geology, Department of Civil Engineering, Indian Institute of Technology, New Delhi, India, September 1969 - June 1974.

Visiting Assistant Professor in Geological Engineering, Michigan Technological University, Houghton, MI, January 1969 - June 1969.
PROFESSIONAL SOCIETY AFFILIATIONS
Geological Society of America (Fellow)
American Geophysical Union
American Society of Civil Engineers
Association of Engineering Geologists
Assoc. of Groundwater Scientists and Engineers
New Mexico Geological Society

COMMITTEES, SYMPOSIA, WORKSHOPS


Panel Member, National Research Council Committee to Evaluate the Science, Engineering, and Health Basis of the DOE’s Environmental Management Program: Workshop on Evaluation of Regulatory Measures, June 1995

Co-Chairman, Session on Waste Isolation Pilot Plant, International High-Level Radioactive Waste Management Conference (Sponsored by American Nuclear Society and American Society for Civil Engineers), Las Vegas, NV, USA, April 1996.

Co-Convener and Chairman, Special Symposium B-1, Prediction of Geological Hazards, EnvironmentalPrediction, Strategy of Disaster Reduction, and Evaluation of Economic Losses, 30th International Geological Congress, Beijing, China, 4-14 August, 1996.

Corresponding Member, Committee on Groundwater, American Society of Civil Engineers, 1982 - 1994.


Member, Program Committee, International Conference on High-Level Radioactive Waste Management


PRESENTATIONS
Several invited presentations at Universities, National Academy of Sciences WIPP Panel, Hearings of the U.S. Congressional Committees, New Mexico State Executive and Legislative Committees, and various other public forums.

PUBLICATIONS


PUBLICATIONS (Cont.)


PUBLICATIONS (Cont.)


PUBLICATIONS (Cont.)


Ex. 1
Report of the Geotechnical Panel on the Effective Life of Rooms in Panel 1

June 1991

Waste Isolation Pilot Plant
# REPORT OF THE GEOTECHNICAL PANEL ON THE EFFECTIVE LIFE OF ROOMS IN PANEL 1

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EXECUTIVE SUMMARY

An evaluation of the effective life of underground rooms in Panel 1 of the waste storage area of the Waste Isolation Pilot Plant (WIPP) was performed during April 1991 by a panel of geotechnical experts. The evaluation addressed concerns regarding WIPP's ability to complete a test program proposed for Panel 1. This program currently requires bins containing controlled quantities of contact-handled (CH) transuranic (TRU) radioactive waste to be placed in rooms in the panel. The bins will be monitored to obtain data on the potential generation of gases from the degradation of wastes emplaced in the WIPP underground facility. The purpose of the evaluation was (1) to provide an estimate of the life expectancy of the rooms in Panel 1; and (2) if necessary, to recommend additional remedial actions that would improve the longevity of Panel 1 rooms to allow the testing to be successfully completed.

Panel 1, the first panel to be mined in the waste storage area, was developed to receive waste for a demonstration phase that was scheduled to start in October 1988. Mining of the panel began during the second half of 1986 and was completed to final dimensions in June 1988. The original plan was to store drums of CH TRU waste in rooms for a period of 5 years. The demonstration phase was changed to an experimental program that will use CH TRU waste in bin scale tests which will be located in Panel 1. For the purposes of this report, a nine-year test period beginning July, 1991, was assumed to be necessary to complete these bin scale tests.

The panel members were able to reach positions that were reasonably consistent. They agreed on the qualitative mechanisms identified as the principal causes of the failures found in the roof of excavations in the WIPP underground test areas and established that similar fracture development could be expected in other WIPP underground areas. They concluded that if no additional remedial measures are taken, the rooms in the panel are likely to have a total life from seven to eleven years from the time of excavation using the currently installed roof support system, consisting of rockbolts. They indicated that the rockbolts had some beneficial effects, but agreed that it was not possible to measure their effectiveness. Estimates made by individual panel members of room life extension due to the bolting varied from a few months to several years. In conclusion, the panel believed that modifications, enhancements, and regular maintenance would be required for the rooms in Panel 1 to perform satisfactorily over the assumed nine-year test period starting July 1991.

The panel indicated that techniques were available that would extend the life of the rooms to varying degrees. They indicated that the rooms were currently stable but added that continuous access into the rooms would probably require remedial measures of some kind during the test period, and these measures should be undertaken. Techniques currently used in mining that would improve conditions were suggested by the panel members and included the following:

- The use of full column resin or resin anchored bolts.
- Grout anchored cables with loops, lace, and mesh covering the roof to contain and control roof rock failure.
- Relief of the lateral stresses to prevent roof and floor failures by slotting and/or relief entries.
Waste Isolation Pilot Plant
Supplementary Roof Support System
Underground Storage Area
Panel 1, Room 1

October 1991

Waste Isolation Pilot Plant
# Waste Isolation Pilot Plant
## Supplementary Roof Support System
### Underground Storage Area
#### Panel 1, Room 1

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In order to extend the life of Room 1, Panel 1, a ground support system needs to consider the past history of Room 1, the on-going deformations in the room, and the potential roof failure mode. Also, the support system must be designed to accommodate the bins and test equipment, including forklift access for bin installation and subsequent monitoring activities.

To be acceptable, the ground support system must:

- Be capable of fully supporting the anticipated roof wedge such as that produced in SPDV Room 1.
- Be capable of yielding in a manner which would accommodate the future closure and deformation of the roof rock.
- Accommodate the bin scale equipment, including forklifts and ancillary equipment.
- Extend the life of Room 1 to allow completion of the experiments, for an additional period of up to seven years (from July 1991).

The initial roof support concept developed for Room 1 of Panel 1 involved timber "crib sets" with interconnected steel beams. After further analysis, timber crib supports were abandoned in favor of yieldable roof supports which would provide more uniform roof support. These supports consisted of resin anchored steel rock bolts and steel cross beams, with yielding steel columns as commonly used in the coal mining industry. More importantly, the rock bolts could be continuously monitored using load cells and adjusted to accommodate further room creep.

As the design process proceeded, it became clear that the majority of the load would be carried by the rock bolts. The yielding columns were therefore eliminated. The steel beam was modified from an initial I beam configuration to an inverted channel, thus eliminating the complex attachment plate structure needed for the I beam.

The final roof support design contained in this document consists of 8.23m (27 feet) long 15 x 40 steel channel support sets installed laterally across Room 1 on 2.44m (8 feet) to 3.05m (10 foot) centers. Each channel set is divided into three nine foot long segments which are bolted together in-place using connecting plates. Each support set is secured by eleven 3.96m (13 feet) long Dywidag steel tendons (anchor bolts) that are resin anchored in relatively stable ground above the Anhydrite "b" clay horizon. The channel support anchor bolts are designed so that their loads can be monitored and adjusted to accommodate continuing roof deformation. To allow for differential lateral deformations, each tendon is located in an oversized .076m (3 inch) diameter hole which extends from the hole collar to the Anhydrite "b" clay horizon.

The area between the channel support sets is covered by a network of steel wire lacing cables underneath a mat of steel welded wire mesh and expanded metal. This mat is held in place by the channel support sections. Its function is to contain loose rock in between the channel support sets.
Geotechnical Field Data
And
Analysis Report
Volume I
March 1991

Waste Isolation Pilot Plant
GEOTECHNICAL FIELD DATA AND ANALYSIS REPORT
DOE/WIPP 91-012

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separation between them. Development of these fractures may be caused by shear due to bending of the thick beam or tension induced by differential movements caused by creep effects or temperature variations. This type of fracturing can develop immediately after excavation but is more likely to develop as the opening ages.

6. Shear fracturing can develop diagonally from the ribs within the immediate roof beam. As the strata shifts laterally under the action of compressive horizontal stresses the fractures become visible within the roof beam with as much as several inches of vertical separation.

7. Bed separations typically occur at the anhydrite/salt interface about 6.5 feet above the roof. Separations sometimes containing rubblized material can be as great as 5 inches.

8. Vertical tensile fractures can develop in the roof due to roof bolt support installed across previously-developed shear fractures. As differential movement occurs across the fracture plane, the restraint applied by the rock bolt can cause tensile fractures to develop from bolt hole to bolt hole or parallel to a line of bolts.

9. Low-angle lateral fractures, which run across the roof of the opening, develop at a later stage of deterioration. The mechanism explaining these fractures may relate to the development of horizontal stresses in the longitudinal direction of the room.

2.4 PERFORMANCE OF WASTE STORAGE ROOMS

Excavation of the waste storage area began in May 1986 with the mining of the Panel 1 entries. Generally the storage rooms and drifts were developed as undersized pilot drifts that were later trimmed in 1988, to their final design dimensions. These were 13 feet high, 33 feet wide, and 300 feet long and included a -0,+1 foot tolerance. Room 1 was excavated to near full dimensions in 1986, and pilot drifts for storage rooms 2 and 3 were excavated in 1987. Rooms 4 through 7 were completed, in 1988, within approximately one month after the start of excavation. The performance of Panel 1 is based on data from the SPDV Test Rooms.
1994
Panel 1 Utilization Plan

Prepared by:
Westinghouse Electric Corporation
Waste Isolation Division
Waste Isolation Pilot Plan
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MEETING MINUTES, PANEL 1 UTILIZATION PLAN
MAY 19, 1994
MEETING MINUTES

Item Number | Discussions
---|---

Extensive discussions for nearly three hours took place during and after the presentations. Highlights of the discussions are summarized below:

- Wendell Weart (SNL) initiated a discussion regarding waste retrievability issues. It was stated that there was a need for retrievability during the test phase. However, a lot of requirements have changed since the test phase and retrievability is a policy issue that will be discussed with the EPA, NAS, and others. The DOE/CAO position is that wastes for disposal would be recoverable under the provisions of 40 CFR 191 without any changes to the planned mode of disposal operations.

- Ground support in Panel 1 was discussed and it was concluded that:
  - Panel 1 is safe and can be maintained in a safe condition indefinitely as long as maintenance can be performed.
  - Roof support has no effect on roof expansion.
  - Panel 1 can be maintained just as safe as a new panel from a ground support standpoint.
  - The Panel 1 Utilization Plan has the necessary flexibility to accommodate various programmatic changes that may occur.
  - Maintenance is not required in a room after it has been filled.
  - All of the WIPP underground, including Panel 1, is inspected daily. The underground is subject to quarterly inspections by MSHA, and the USBM does an annual ground stability/safety evaluation. It was noted that several of the last MSHA inspections resulted in zero Compliance Assistance Visits (CAVs).
  - The underground is extensively instrumented and monitored. This summer the installation of a USBM real time monitoring system will be complete.
  - Should the suitability of Panel 1 diminish for any reason, including extended time for disposal, Panel 2 could be mined over an 18 to 30 month time frame.
STATE OF NEW MEXICO  )
COUNTY OF SANTA FE  ) ss.:

AFFIDAVIT OF IAN W. FARMER

Ian W. Farmer, being duly sworn, deposes and says:

1. My name is Ian W. Farmer, and I reside in the city of Newcastle upon Tyne, England.

2. I am the chairman of Ian Farmer Associates, Ltd., a geotechnical consulting firm. I have held this position since 1983.

3. My educational and professional background is as follows:

   B.Sc., Mining Engineering, University of Nottingham
   Ph.D., Civil Engineering, University of Sheffield
   D. Eng., University of Sheffield
   Fellow, Institution of Civil Engineers
   Fellow, Institution of Mining & Metallurgy
   Member, American Society of Civil Engineers
   Chartered Engineer, England
   Professional Engineer, Arizona

4. In 1968 through 1972 I was employed as a geotechnical engineer with the Cementation Company. In 1972 through 1976 I was a Lecturer in Engineering Geology at the University of Durham. In 1976 through 1984 I held the position of Reader in Geotechnical and Mining Engineering at the University of Newcastle upon Tyne. In 1984 through 1991 I was a professor of Mining Engineering at the University of Arizona; in 1987 through 1990 I was also acting head of the Mining and Geological Engineering Department at the University of Arizona. In 1983 I founded my own company, now
known as Ian Farmer Associates, Ltd. I am also an Adjunct Professor at the University of Arizona and a Visiting Professor at the University of Leeds.

5. I am the author of several books on rock mechanics and engineering geology, including Engineering Behavior of Rocks, Principles of Engineering Geology (with P.B. Attewell), Coal Mine Structures, and Fluid Flow in Discontinuous Rocks (with C.H. Lee). I have published more than 100 technical papers in the fields of geotechnical and mining engineering. I have carried out research projects related to the time dependent constitutive relationships for salt rocks, the mechanical performance of full column resin anchored rock bolts, field instrumentation, and roof support systems.

6. In connection with the Waste Isolation Pilot Plant ("WIPP"), I was a member of the Geotechnical Panel on the Effective Life of Rooms in Panel 1, convened by the U.S. Department of Energy ("DOE") in April 1991 to assess the time span over which the panel 1 rooms would be usable for proposed underground tests. At that time it was my estimate that the roof support rock bolts in the rooms in panel 1 would begin to fail at the five year point. A copy of my report is attached (ex. 1; see p. 9).

7. I visited the WIPP underground on June 3, 1998 and studied the rooms in panel 1. I was able to observe roof fracturing that was considerably more extensive than in 1991. Four of the rooms, rooms 4, 5, 6, and 7, were quite badly fractured, although adequately supported. The roof-to-floor convergence rate remains substantial at approximately 3 inches per year.

8. Room 7 is the first room in which waste is planned to be emplaced, I am told. Recently, within the last two or three months, a new series of rock bolts has been installed in the roof of room 7. There are three rows of resin anchored bolts installed in
the center of the room and two rows of mechanically anchored bolts anchored along the side walls of the room.

9. As I understand the emplacement process, DOE plans to put drums or boxes of waste three-high in the rooms and to stop maintaining the roof above the area of waste emplacement. Roof performance will continue to be monitored by remotely read instrumentation. Further, I have been told that the delivery schedule for waste is quite uncertain. If retrieval is called for, the timing of that requirement is also unknown. It should also be noted that I have seen no plans for retrieval of waste. I do not know what storage location would be used to accommodate the retrieved waste. The apparent lack of a plan, storage location, and other logistical elements is important, because it means that the process is likely to take a considerable amount of time, and during that time the conditions in the room would deteriorate. When it is retrieved, hypothetically, the most recently emplaced waste would be retrieved first, and the earliest emplaced waste would be retrieved last. Thus, the earliest emplaced waste would remain in an area without maintenance for the duration of the process of emplacement and retrieval.

10. In my view, if waste is emplaced in room 7, there will be a window of approximately two years from now during which waste may be placed in and removed from the room. After that time the level of certainty with which I can foresee retrieval is reduced. When the support system begins to fail, the signs of basic instability will become apparent. Bolts will begin to break in shear and in tension, and the rock salt will begin to break around the bolts. At that point segments of the roof will begin to fall into the mesh that is hung from the roof. Without further maintenance, the room will then be too unsafe and unpredictable in its behavior to enter.
11. Based on my understanding that emplacement of waste in room 7 may take approximately one year, it may be assumed that retrieval will consume approximately twice that amount of time, or two years. To be certain of retrievability without additional support and maintenance the first-emplaced waste would need to be retrieved two years after its emplacement. Assuming the process takes longer than two years, retrieval will become increasingly difficult, as roof conditions deteriorate, until retrievability becomes impossible.

IAN W. FARMER, Ph.D., P.Eng.

Dated: 5 June 1998

SUBSCRIBED AND SWORN TO before me by Ian W. Farmer, Ph.D., on the 5th day of June, 1998.

Margaret Allen
Notary Public

My commission expires: 7/6/2008
Ex. 1
REPORT SUBMITTED

BY

DR. I.W. FARMER
The summary report contains:

- An accurate record of the meetings of the Geotechnical Panel on Panel 1 Stability.

- A copy of the report provided to Westinghouse by this panel member.

- An accurate presentation of the consensus agreed to by the panel members at the meetings on the 23rd and 24th of April 1991.

[Signature]
Panel Member
Date: 5-28-9[1]
COMMENTS ON WASTE ROOM STABILITY AND RESPONSE TO STATEMENTS
by Ian Farmer

(1) BASIS OF DESIGN

The basis of design of both the SPDV Test Rooms and No 1 Waste Storage Panel appears to have been the requirement that the storage rooms be 33x11 ft. in section and 300 ft. long and have a tolerance of -0 +1 ft. An allowance of 24 inches vertical closure during a 5 year panel life was validated by calculations based on empirical creep equations and measurements during the first 3 years life of the Test Rooms.

In both design and analysis, deformation was assumed to result mainly from creep processes. In practice, observations have shown that this is not the case and that additional mechanisms involving strain softening, fracture and movement along discontinuities - albeit time related - are involved in a complex deformation process. This may also include effective stress effects from brine and gas.

The emphasis on creep processes results from the historic emphasis on time related deformation of most laboratory test work on rock salt. This usually involves long term loading of specimens in compression at relatively high unconfined or deviatoric stresses. The results are usually expressed as power law creep equations with secondary data on modulus of elasticity, Poisson's ratio and uniaxial compressive strength. These types of test while producing useful data, sometimes have limited relevance to the performance of underground excavations - particularly of the rock near the exposed surface of the roof, sides and floor - where deformation results from stress relief after excavation (an active expansive process) rather than specimen loading (a passive compressive process).

Baar (1977) showed that under these conditions creep limits for rock salt in-situ are extremely low and that constant rate plastic flow can occur at a yield stress difference as low as 150 psi at room temperatures. At
(a) The high deviatoric stresses at the corners of the excavation (modified by any curvature) will be relieved at an early stage by formation of a shear fracture, following the edge of the highly stressed zone into the roof and floor and probably the sides of the excavation. The existence of this fracture in a similar size of excavation is illustrated by Scormont's (1990) permeability measurements, and by numerous observations of fractures.

(b) Most of the surface deformation around the excavation will be caused by a combination of induced tensile and shear fractures modified by creep. This is illustrated in Figure 3. The tensile fractures will tend to follow the contours of major principal stress and deviatoric stress. Dilation normal to the fracture direction will cause horizontal or vertical convergence into the sides, roof and floor and modification of stress and fracture orientation. But the overall pattern agrees very well with Borns and Scormont's (1988) permeability observations (a direct result of dilation) and with their modification of Gramberg and Roest's (1984) estimates of fracture zones in rock salt.

(c) Continuing dilation will result in bed separation at partings at the much stronger (estimated 4 times) and stiffer roof and floor anhydrite layers. This is a well known phenomenon in layered rocks and in layered rock salt and is described by Baar (1977) and others. As a result the floor and roof beams may become partly detached, the former exacerbating floor heave and the latter ultimately resulting in roof failure similar to the cutter roof failure in coal mines.

(3) **SPDV Test Room Failure**

It is important to see if this postulated failure regime agrees with observations at SPDV Test Rooms 1 and 2, where the best deformation information from closure measurements, borehole anchor extensometers and inclinometers is available. The data over 6 years is plotted in Figures 4 and 5. This includes the initial nonlinear convergence at Test Room 1 in Figure 4.
resulting in an additional 3 inches of lowering of the center and lower roof below the anhydrite parting; otherwise the data is essentially the same. Data during and immediately following construction when relief of construction stresses occurred is missing.

The general deformation pattern does, however, agree with the postulated pattern in Figure 3, particularly:

(a) Deformations at the corners are not extreme, indicating that high deviatoric stresses have been relieved by formations of a shear fracture.

(b) Horizontal movements in the solid rock are largely confined to the zone above the sidewall edge and close to the shear fracture and in a direction normal to the proposed tensile fractures extending into the roof.

(c) Vertical movements are largely confined to the roof and floor and are largest below the roof parting, particularly at the center, and above the floor anhydrite layer - again particularly at the center.

It can be argued, therefore, that the general pattern of movement is essentially that postulated by Stormont (1990) for the specific WIPP case and by Baar (1977) for the general case of evaporites and involves both creep and fracture, but principally fracture, albeit over a prolonged period.

It can also be argued that Waste Panel 1 Room 1, although there is less information, is deforming in a very similar manner to the SPDV Test Rooms. The basic questions, therefore, which must be asked in assessing the long term stability of Waste Panel 1 are whether the roof will behave in a similar manner to SPDV Test Room 1 and whether the current support is adequate or can be made adequate.

(4) **ROOF SUPPORT**

The roof of SPDV Test Room 1 appears to have collapsed as a single large block, probably trapezoidal in shape, breaking up on contact with the floor. It is bounded by shear planes - apparently steep on the West side and shallow on the East side and by the clay/anhydrite parting 7 ft. into
the roof. The clay/anhydrite parting may be exposed in up to 1/3 of the roof span. Calculations by Cook (1991) indicate that the North and South ends of the roof beam fractured in tension due to the weight of the detached span.

If the unit weight of rock salt is assumed 150 lbs/cu.ft., the maximum weight of the roof beam is approximately 35,000 lbs/ft. In Test Room 1, this was unsupported. In Waste Panel Room 1, it is supported by approximately 1.7 x 10 ft. long x 5/8 or 3/4 in. roof bolts per foot, with respective average pullout loads of 19,500 and 15,000 lbs. and with design loads of 13,500 and 11,900 lbs. The bolt pattern concentrates support in the center of the room.

The rockbolts have been designed to support the dead weight of the roof layer; to accommodate creep movements and to avoid fracturing of the deforming roof surface. For the latter, it was assumed that the anchorage would yield and this was tested short term. The bolts were located 2 1/2 ft. above the anhydrite layer, where vertical downward movement is approximately 1 - 1 1/2 ins./year and horizontal movement is probably relatively small.

The purpose of rockbolting in the current geology and excavation geometry is essentially to prevent movement across discontinuities/bedding lanes and particularly the anhydrite layer. It is similar to cutter roof failure in coal mines, which is also time related and difficult to control with conventional roof bolts, however long. In these circumstances roof trusses or center cribs have been successfully used and these represent an alternative, respectively long term and short term, in the present case.

The roof at WIPP is, however, different to coal mines in that only two partings are known to exist and the rock is not laminated but apparently quite massive. In this case, it may be possible to obtain a degree of medium term control with rock bolts installed in the traditional way.
(5) RESPONSE TO STATEMENTS

STATEMENT 1: An estimate can be established for the period of time that Panel 1, in particular Room 1, remains accessible on a daily basis beyond July 1991.

1. Available information on Waste Panel 1 appears to be limited to horizontal extensometers installed in the E and W rib at the mid point in December 1983 and convergence meters installed at the midpoint and North and South ends at various dates between 1986 and 1990. Many of these are no longer functional, but a summary of data is available indicating 19 ins. of roof to floor convergence over a 5 year period to April 1991. As far as can be seen, the deformation over this period is similar to that of SPDV Test Rooms 1-4 over a similar period. Combined with a knowledge of deformation mechanisms, this gives a basis for discussion of the statement.

2. To estimate the life of Room 1, it is necessary to make some assumptions about its performance compared with SPDV Test rooms. Convergence of SPDV Test Room 1 up to 5 years reached a steady state of 3 ins/year. After 5 years, this increased as bed separations in the roof gradually led to detachment of the roof beam and ultimate collapse after about 8 years. Creep in rock salt should be a constant rate phenomenon and the constant creep rate, representing a roof or floor bay strain rate of about 0.5% per year, is moderate and almost certainly indicates a quasi-stable situation.

Provided the deformation of the roof and floor in Room 1 can be maintained at the present rate and bed separations at the anhydrite/clay roof layer prevented, there is a good prospect of medium term stability. The integrity of the roof block, based on SPDV Test Room 1 observations appears high and there is no reason why an additional 10 years life, bringing the total roof to floor convergence to about 50 ins., when the room would show considerable distortion, should not be expected.
3. A lower bound estimate of a total of 8 years (an additional 3 years) assuming the same failure mechanism as SPDV Test Room 1 is reasonable. More rapid failure is unlikely. With the proviso in paragraph 2 and good support and repair an upper limit of considerable length - say up to 20 additional years is feasible, provided the deformation can be tolerated.

4/5. Levels of uncertainty depend on the level of confidence in the assumptions made to reach an estimate. In this case, there is probably insufficient data to determine confidence levels beyond subjective terms such as high, medium or low. The most important basis for estimates is that the steady state roof and floor bay strains are moderate and in this case, in a homogeneous rock salt, it would be possible to postulate stability with a high level of confidence. The potential instability in the present case arises from the potential detachment of the roof block from the anhydrite layer and to a lesser extent buckling of the floor layer. If roof block detachment can be resisted by the support system, there will be a high level of confidence in the estimate.

6. There is limited deformation data available in the Waste Storage Panels. At the least, center line roof extensometers at the mid and quarter points are needed. These will monitor bay strains and parting separations.

7. Maintenance should be directed at maintaining roof integrity. Roof lowering at the current constant rate will lead to some extensions of shear fractures, which will require limited maintenance. The only situation which would require movement of bins would be nonlinear roof lowering. In this case either replacement of bolts or installation of cribs would be needed to maintain roof stability.

STATEMENT 2. The rockbolt system as currently configured is sufficiently effective to ensure that the test program in Panel 1, particularly Room 1 can be completed.
1. The rock bolt system is required to support the roof block for 10 years to 2000 A.D. in Room 1, Panel 1. As currently configured, the roof bolts are anchored in rock salt above the anhydrite layers which is deforming at an approximate rate of 0.5 ins/year vertically at the center and 0.25 ins/year vertically and 0.2 ins/year horizontally at the sides. The bolt collars are located at the surface which is deforming mainly vertically at a rate of 1.5 ins/year in the center, less at the sides.

The resultant bolt strain of 0.8% per year may be tolerable for up to 5 years with anchor and collar deformation (3% bolt strain is usually considered a maximum). Beyond this, there can be no certainty of continuing support, without replacement or redesign.

2. The trapezoid at roof block configuration is not a conservative assumption. Typical failures of this type often have steep break lines and a better assumption would be rectangular block. This would also lead to a better distribution of support in the critical zone close to the shear fractures at the corners. There are good reasons for arguing that these shear fractures are not typically inclined at a low angle to the horizontal.

3. The current design of roof support does not appear conservative. If a unit rock weight of 150 lbs/cu.ft. is assumed then the weight of a rectangular 33 x 7 ft. roof block is 35,000 lbs/ft. and that of the design trapezoid is 23,000 lbs/ft. For 5/8 in. bolts, the design load is 11,900 lbs. and for 3/4 in. bolts (say) 13,500 lbs. These are barely adequate for the current trapezoid, which is itself a conservative assumption.

4. The salt above the anhydrite b layer is creeping at a rate of 0.25 ins/year - a low rate, which is unlikely to result in fracture. Horizontal deformations are equally low.
5. Slippage of anchors is not a reliable method of rock bolt/roof control over an extended period of time and beyond an anchor strain of 3-4%. In the current case, beyond 5 years, anchor or collar failure would be expected.

6. Fully grouted bolts, probably with double set resins to give enhanced anchorage load are more reliable. Recent experiments by Signer and Jones (1990) have shown that high restraint can be maintained, even when part of the grouted bolt has yielded (see Figure 7). The possibility of using fully grouted 3/4 inch bolts (say) 12 ft. long with a 3 ft. quick set resin anchor tensioned to 30% of design load should be considered.

In coal mines for similar roof configurations, where cutter roof failure is likely, truss bolts are extremely effective and these should be considered for other panels, where major redesign is possible.

STATEMENT 3. The level of confidence, which can be placed in the estimates of the life for Panel provided in the response to Statement 1 is in accordance with accepted mining practice.

1. Probability is used extensively in mining, particularly for slopes; to a lesser extent for pillars. The major requirement is that there exists an accurate and accepted analytical framework for design, and sufficient information on variability of parameters, usually expressed as variograms. In the case of Panel 1, the nature of roof failure is complex, involving several different mechanisms and geomechanical data is limited.

2. Geological information is not necessarily qualitative. Certainly at WIPP, it would be possible to build up an accurate database of rock salt mineralogy and structure which would show limited variability. Most rock discontinuities, beds, grain sizes can be expressed in terms of variograms and are often the best and "hardest" information available.
Probability levels of 1 in $10^6$ are not feasible. The variations inherent in most geotechnical and geometric parameters means a probability of 1 in 10 is the best that can be obtained. Design in rock probably has the same type of probability levels as weather forecasting.

The WIPP data base is heavily orientated towards deformation measurement - since the design is based on creep. There is virtually none of the geotechnical information - particularly shear and tensile strength, which would be needed to accurately assess the performance of the openings - say by using finite element analysis with a combined creep - fracture constitutive model of the type developed by Desai and used by Stormont (1990) in his analysis.

STATEMENT 4. Modifications to the support system in Panel 1 can be implemented to ensure that access is maintained to the rooms on a daily basis until the test are completed.

1. The support system should be modified to perform in a roof where strain over the anchor length over a ten year period is likely to be 8%, equivalent to a differential displacement of 10 ins. Conventional mechanical anchors are likely to fail if subjected to this type of deformation. Roof to floor convergence over the same period is likely to be 30 ins. and roof lowering 15 ins. In addition, the current support system does not appear to have sufficient capacity to support the full roof block. The support system should be capable of generating a restraint of 35,000 lbs/ft. of room length and should provide better support for the edges of the block.

Four types of support system may be suggested:

(a) Fully grouted resin anchored bolts, 3/4 in. 12 ft. long with a 3 ft. long fast set anchorage; tensioned to 1/3 of working load. These should be set with an adjustable collar plate, and in a uniform pattern. The outer bolts should be angled towards the rib.
(b) Cable bolted trusses angled over the rib to just above the anhydrite/clay parting. The trusses should include an element of flexibility so that they can be lengthened to accommodate roof movement.

(c) Cable anchors - possibly combined with slings-installed centrally and incorporating a tensioning device which can be modified to accommodate roof lowering.

(d) Cribs installed centrally in the room including one or two elements of soft wood to allow for squeeze.

2. Some veld mesh should be installed, particularly at the pillar edges to catch loose rocks. Minimum maintenance activity should be planned - the support system should be designed to maintain roof integrity with a degree of flexibility to accommodate roof movement.

3. Once the experiment has started, installation of cribs is probably the only feasible additional support system. This should not - if planned for - require removal of cables.

STATEMENT 5. The geomechanical monitoring program and the routine observations in Panel 1 can provide sufficient warning to allow the timely retrieval of the waste from the panel.

1. The plot of rate of convergence against time from SPDV Test Room 1 provides a powerful and classic type of illustration of prescriptive roof movements leading to failure and also provides sufficiently early warning of deteriorating conditions to allow remedial action. Similarly, careful monitoring of SPDV Test Rooms 1 to 4 and other large span openings will provide additional ongoing prescriptive information - in the case of Test Room 4 for a roof including traditional rock bolts.

This is a limited data base, but the information is precise and directly relevant.
2. The geotechnical information from Room 1 is just adequate. The convergence data can be directly compared with Test Room 1.

3. Additional convergence stations and particularly roof extensometers designed to detect dilation of the parting are needed.

4. A increase in roof convergence, associated with parting dilation, which is not controlled or reduced quickly by installation of cribs or additional roof supports.

REFERENCES


$\sigma_x = \sigma_y = 2150 \text{ psi}$

Fig. 4. *Approximate contours of major and minor principal stress (psi) around a 33.7 ft x 33.7 ft.*

Approximate stress trajectories.
Fig 2. APPROXIMATE
CONTOURS OF DEVIATORIC
STRESS, $\sigma_1 - \sigma_3$ psi
AROUND A 35 ft x 13 ft
EXCAVATION.
Fig. 4 SPDV Test Room 2.
Mid Point
Mid '83 to Mid '89 (6 years)
Measured and Extrapolated
Deformations
Looking North
Fig. 6. WASTE PANEL 1 ROOM 1
W.D. POINT
JAN '86 - JAN '91 (5 YEARS)
MEASURED AND
EXTRAPOLATED DEFORMATIONS
LOOKING N.
Figure 7  Circumferential load transfer and yield of resin grouted anchors (after Pigneur and Towner, 1976)