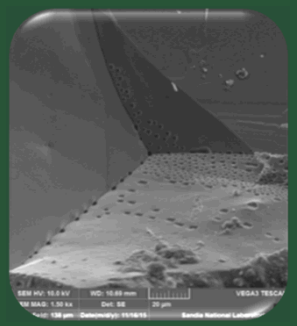
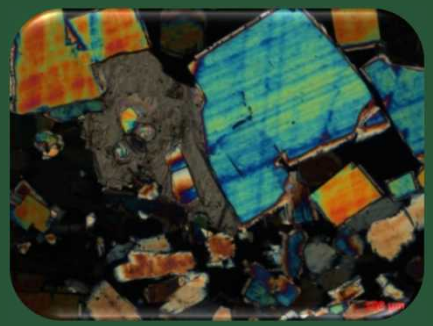

7th US/German Workshop on Salt Repository Research, Design, and Operation

Nature of the WIPP Safety Case Carlsbad, New Mexico, USA

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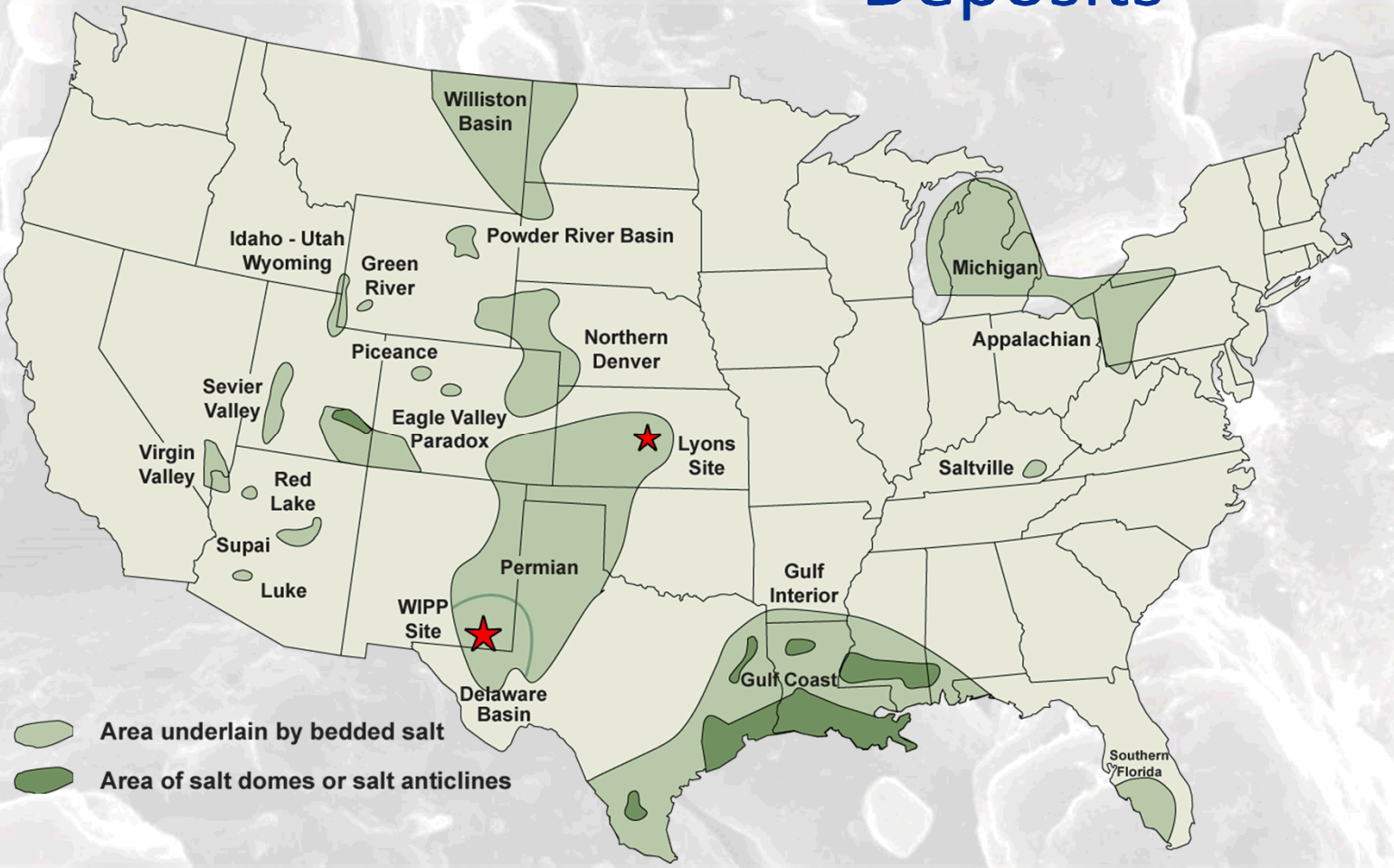
WIPP Background – Why Salt?

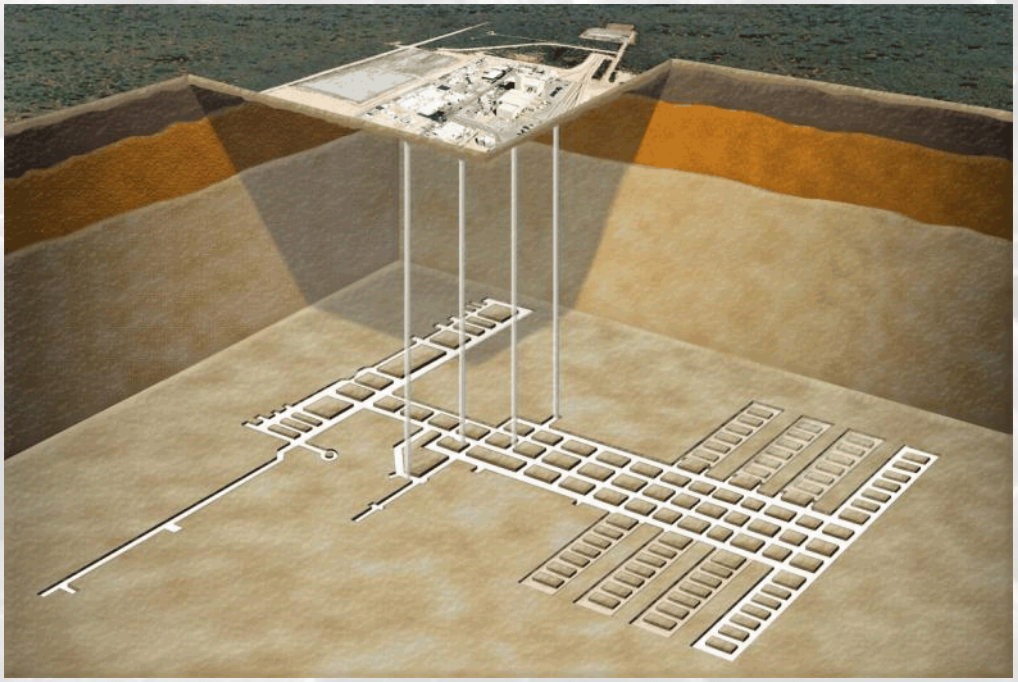
Bedded Salt, Chosen Purposefully, for the Siting of the US Defense Nuclear Wastes

- Salt can be mined easily
- Salt is known to close under the pressure of overlying beds, and therefore will consolidate around the waste and isolate it in place
- Salt is essentially impermeable
- Fractures in salt are self healing
- Salt that has existed underground for millions of years will almost certainly remain stable for millions of years into the future
- Salt has a relatively high thermal conductivity
- Wide geographic distribution (many potential sites)

WIPP Background – US Salt Deposits



WIPP Background – Repository Layout



- 2,150 feet deep
- Eight disposal panels
- Four vertical shafts
- Filtered ventilation
- North Experimental Area
- Meant for the permanent disposal of defense-related transuranic radioactive waste

Long-Term Regulatory Requirements

- 40 CFR Part 191
  - Generally applicable to permanent geologic repositories for the disposal of radioactive waste
    - Not WIPP-specific, included HLW, SNF, & TRU
- 40 CFR Part 194
  - WIPP-specific certification criteria

The Regulations: Limits Long-Term Releases

40 CFR 191 Subpart B

- Conservative
- Uses defense-in-depth approach
- Primarily a *release* standard, but releases are based on estimated doses caused by a hypothetical in-situ uranium ore body
  - *Quite unique, and quite clever* – basing maximum allowable disposal risks on those posed by unmined nuclear raw material

The Regulations: Limits Long-Term Releases

40 CFR 191.13

(a)Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, based upon performance assessments, that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall:

- Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A); and
- Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (Appendix A).

(b) Performance assessments need not provide complete assurance that the requirements of § 191.13(a) will be met. Because of the long time period involved and the nature of the events and processes of interest, there will inevitably be substantial uncertainties in projecting disposal system performance. Proof of the future performance of a disposal system is not to be had in the ordinary sense of the word in situations that deal with much shorter time frames. Instead, what is required is a reasonable expectation, on the basis of the record before the implementing agency, that compliance with § 191.13(a) will be achieved.

NOTE: In developing the standard, EPA did its own modeling of a hypothetical geologic repository using a standard source term (waste expected from 100,000 metric tons of reactor fuel). The releases from that generic repository were predicted to cause roughly the same health risks (premature cancer deaths) as an unmined uranium ore body, needed to produce the same 100,000 metric tons of reactor fuel. The values in Table A, Appendix 1, are a way to normalize releases to this standard source term, taking into account that not all radionuclides are created equal, in terms of their ability to negatively impact human health.

The Regulations:
Redundant Elements of Safety

40 CFR Part 191.14

" § 191.14 To provide the confidence needed for long-term compliance with the requirements of 191.13,…"

six qualitative *"assurance requirements"* were included to provide *additional confidence* that the containment requirements would be met, given the substantial uncertainties inherent in predictions of repository performance over 10,000 years

1. Active Institutional Controls
2. Monitoring
3. Passive Institutional Controls
4. Engineered Barriers
5. Consideration of the Presence of Resources
6. Removal of Waste

The Regulations: Conservative Aspects/Assumptions

40 CFR Part 191

- Assumes inadvertent human intrusion *will happen,* and these releases must be included, even though deep drilling is hardly considered an "inadvertent" endeavor; additionally, even though passive institutional controls (long-term markers) will be employed, they are assumed to be ineffective.*

* WIPP certification criteria allow for credit to be taken for PIC effectiveness, but EPA has allowed credit only during active controls (100 years after closure)

The Regulations: Other Key Features

40 CFR Part 191

- 10,000 year performance period
  - A period of 10,000 years was considered long enough to distinguish geologic repositories with relatively good capabilities to isolate wastes from those with relatively poor capabilities. This period was considered short enough so that major geologic changes would be unlikely and repository performance might be reasonably projected.
- Demonstration of compliance based on a probabilistic assessment of risk
- Demonstration of a "reasonable expectation" that compliance with the release limits will be achieved
  - Due to long time-period of evaluation, redundant safety considerations, and inherent uncertainties in such predictions, only a "reasonable expectation" is required

The WIPP Safety Case

- Features, Events, and Processes (FEPs) were identified using all available resources and databases
- Scenario development process was done iteratively and reviewed broadly before finalization
- Performance Assessment (PA) parameters were scrutinized and based on either experimental data, expert judgment, or expert elicitation. These processes were all governed by a thorough and documented Quality Assurance Program.
- Final conceptual models were Peer Reviewed by Independent Peer Panel and documented as part of the Compliance Certification Application (CCA 1996)

The WIPP Safety Case

- As with our governing regulation, the WIPP safety case is conservative
- Conservatism is employed as a means to deal with uncertainty, especially over the 10,000 year regulatory period of interest
  - 10,000 years is short compared to a 1 million year regulatory framework, but
  - It's still a long time (twice the time that has elapsed from the founding of Troy to today)
- Conceptual models containing conservatisms are used to demonstrate WIPP's compliance with containment requirements; these conceptual models have been judged to be adequate

The WIPP Safety Case

- Undisturbed (base case)

- Disturbed Scenarios
  - An accidental deep borehole intercepts the repository and a deeper hypothetical zone of pressurized brine beneath the repository (results in releases of cuttings, cavings, and spallings, but also may serve to saturate the repository hundreds or thousands of years later) (E1 Scenario)
  - An accidental deep borehole intercepts only the repository (results in releases of cuttings, cavings, and spallings) (E2 Scenario)
  - An accidental deep borehole intercepts the repository that was previously intercepted by a borehole that also intercepted a zone of pressurized brine (results in cuttings, cavings, spallings, and direct brine release [DBR]) (E1E2 Scenario)
  - Mining occurs in potash-bearing units above the repository resulting in subsidence, disruption, and increased transmissivity of saturated zones

The WIPP Safety Case

Human Intrusion Scenario Conservatism Example

- Assumes that current drilling rate in area persists into the future for 10,000 years
  - Ignores inevitable depletion and resulting reduction in drilling rate
  - Provides for multiple and compound intrusion scenarios
  - Ignores the high probability of “rediscovering” the existence of the repository and updating human knowledge base of the repository’s existence

The WIPP Safety Case

- Formal PA calculations have demonstrated compliance for each certification and recertification submittal
  - Compliance Certification Application – 1996
  - Compliance Recertification Application – 2004
  - Compliance Recertification Application – 2009
  - Compliance Recertification Application – 2014

- Parameter input changes have been made with each regulatory cycle, but performance predictions remain fairly consistent

- Results have repeatedly shown that cumulative releases from WIPP over the next 10,000 years will fall below the applicable regulatory limits

The WIPP Safety Case

Future Treatment of Conservatisms

- Perhaps some conservatisms could be reduced in order to be more “realistic,” however . . .
  - What some consider “realistic” others may not, especially when those “realisms” are extended over 10,000 years
  - Pursuit of “realism” may not be worth the effort from either a regulatory or a stakeholder communication perspective, if injecting “realism” into a given conceptual model has no appreciable effect on the projected performance of the repository

Conclusion

- WIPP's steadfast compliance position is due in equal parts to:
  - A thoughtful and protective regulatory standard
  - A rigorous and robust Safety Case
  - An excellent host site

- Looking toward the future, it may be that one or more of the conceptual models foundational to the WIPP safety case will be modified in order to reduce uncertainty
  - These modifications will be undertaken at appropriate times within the regulatory cycle
  - They will be tested through rigorous peer review before being implemented

Back-Up Slides

PA Methodology

Regulatory Context

System Description

- Site Characteristics
- Facility Characteristics
- Waste Characteristics

FEPs Identification And Screening

Scenario Development

Scenario Probabilities

Consequence Analysis

Regulatory Standard for Radioactive Releases (40 CFR 191)

Uncertainty Analysis, CCDF Construction, and Performance Results

Notes/Backup

EPA Development of the Release Standard (1985)

The EPA modeled the performance of potential repositories for SNF and HLW in several geologic media. Radionuclide releases over 10,000 years were projected. Very general models of environmental transport and a linear, non-threshold dose-effect relationship were used to relate these releases to the incidence of premature cancer deaths they might cause. For the various geologic media, these assessments indicated that disposal of the wastes from 100,000 metric tons of reactor fuel would cause a population risk ranging from no more than about ten to a little more than one hundred premature deaths during 10,000 years, assuming that the then-existing provisions of 10 CFR Part 60 regarding engineered barriers were met.

The EPA also evaluated the health risks from the unmined uranium ore needed to produce 100,000 metric tons of reactor fuel. Population risks ranging between 10 and 100,000 premature cancer deaths over 10,000 years were associated with this quantity of in-situ uranium ore, depending upon analytical assumptions used in the evaluation.

Limiting radionuclide releases to levels associated with no more than 1,000 premature cancer deaths over 10,000 years from disposal of the wastes from 100,000 metric tons of reactor fuel satisfied two important objectives. First, it provided a level of protection that appeared reasonably achievable by applying the various options being considered within the national program for commercial wastes. Second, such a limitation would keep risks to future populations at acceptably small levels, because it appeared to limit risks to no more than the midpoint of the range of estimated *risks that future generations would have been exposed to if the uranium ore had never been mined.*

Notes/Backup

EPA Deliberations on "Reasonable Expectation" - 1985

The containment requirements call for a *reasonable expectation* that the various quantitative tests be met. This phrase reflects the fact that unequivocal numerical proof of compliance is neither necessary nor likely to be obtained. A similar qualitative test, *reasonable assurance*, is used with NRC regulations. Although the EPA's intent is similar, the NRC phrase was not used in 40 CFR Part 191 because *reasonable assurance* is associated with a level of confidence that may not be appropriate for the very long-term projections that are called for by 40 CFR 191.13.