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MEMORANDUM FOR: Ross A. Scarano, Chief
Low-Level Waste Licensing Branch
Division of Waste Management

FROM: Thomas E. Fleming, Project Manager
Licensing Branch 2
Uranium Recovery Field Office, Region IV

SUBJECT: MINUTES OF MEETING WITH CONTRACTORS CONCERNING LONG-TERM STABILITY OF URANIUM MILL TAILINGS TOPICAL REPORT

Place and Date: Colorado State University
Fort Collins, Colorado
December 8 and 9, 1982

Purpose: To review first draft of long-term stability report.

Participants: John D. Nelson, CSU
Stanley A. Schumn, CSU
Richard L. Volpe, Geotechnical Consultant
William Staub, ORNL
John J. Linehan, NRC
Kathleen Hamill, NRC
Thomas E. Fleming, NRC

December 8, 1982 Meeting Discussion

A copy of the first draft report was presented to the NRC staff on December 7, 1982 for review prior to the December 8, 1982 meeting. The report was found to be very preliminary and lacked detail in almost every section. Before the meeting began the contractors informed the NRC staff that they had additional material for the report with them, but because of the lack of time, they were unable to get this material into the first draft report.

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We began the meeting by discussing each failure mode section in detail. The NRC staff's specific comments on the first draft report were presented during this discussion. The major items for each failure mode section, which had been identified by the contractors in preparing the first draft, were presented on overhead transparencies. Because of the additional items that were identified during the discussion, it was decided that the report outline should be revised. It was further decided that Kathleen Hamill, John Linehan and Thomas Fleming would revise the report outline after the meeting and that we would all meet to review the revised outline the next day.

At the end of the meeting the NRC staff presented and discussed the following general comments about the report:

General Goal

The general goal of the report is to present available mitigating measures for each potential failure mode in terms of the probability that they will provide stability for 200, 500 and 1000 years.

1. The time periods such as short-long term, long-long term, etc., by which the first draft report addresses stability time periods, are too vague. Specific time periods should be referenced in order to facilitate a more precise quantification of incremental differences. Time periods of 200, 500 and 1000 years were chosen to be used in the report.

2. The report is not to address radon or radon attenuation.

3. The report should not reference any existing requirements or be restricted in any way by any regulations concerning uranium tailings long-term stability.

December 9, 1982 Meeting Discussion

All December 8, 1982 meeting participants were present during the December 9, 1982 meeting. A revised general report outline was passed out to all meeting participants and discussed. All sections from this outline were reassigned to clarify who is responsible for each report section under the new outline. A copy of this new general outline with assignments is attached. It was agreed that a detailed outline (expanded general outline referenced above) would be prepared by Thomas E. Fleming and mailed to the contractors no later than December 11, 1982. This detailed outline includes the general outline referenced above, items discussed during the December 8 and 9, 1982 meetings and material from the previous outline. A copy of this detailed outline is attached.

At the end of the meeting the following schedule was discussed and agreed to by all contractors and NRC staff.

Second Draft Report Sent to NRC	December 22, 1982
NRC Staff Comments and Meeting in Denver	January 10, 1983
Peer Review (Tentative Date)	February 24, 1983

Original signed by

Thomas E. Fleming, Project Manager
Licensing Branch 2
Uranium Recovery Field Office, Region IV

Attachment:
1. Topical Report Outline (General Outline)
2. Topical Report Outline (Detailed Outline)

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TOPICAL REPORT OUTLINE
GENERAL OUTLINE

Assessment of Long-Term Stability Techniques for Uranium Mill Tailings Impoundments

1. Introduction (JDN)
2. Differential Settlement (JDN)
3. Hydrologic and Geomorphic Failure Modes Influenced by Surrounding Environments
   - 3.1 Selection of Flood Magnitude for Evaluation (JDN)
   - 3.2 Flood Intrusion and Fluvial Mechanics (Acute Phenomena) (SAS and JDN)
   - 3.3 Gully Intrusion (Progressive Phenomena) (SAS and JDN)
4. Other Physical Failure Modes Influenced by Events Occurring Directly on the Tailings Impoundment
   - 4.1 Gully Erosion Caused by Precipitation Falling Directly On or In the Immediate Upstream Catchment Area of the Tailings Impoundment (SAS and JDN)
   - 4.2 Water Sheet Erosion (RLV)
   - 4.3 Wind Sheet Erosion (RLV)
5. Weathering and Chemical Attack (WPS)
6. Conclusions (JDN)

John D. Nelson - JDN
Rick E. Wardwell - Work With JDN
Stanley A. Schumn - SAS
Richard L. Volpe - RLV
William P. Staub - WPS

TOPICAL REPORT OUTLINE

Assessment of Long Term Stabilization Techniques for Uranium Mill Tailings Impoundments

1. Introduction

Brief description of the purpose and scope as well as a summary of the report's contents.

> The purpose of the investigation report herein is to review the potential failure modes that may cause disruption and dispersion of the tailings and to provide an assessment of the degree of confidence with which we can provide stability against potential failure by these failure modes for time periods of 200, 500 and 1,000 years.

The introduction should also include a brief paragraph on siting, emphasizing its importance in the concept of long term stability. Although siting is of major significance in minimizing and eliminating impacts of the failure modes, it is not the subject of this report. Thus, the report will be primarily cast in terms of assumptions that a site exists which is susceptible to each of the failure modes.

2. Differential Settlement

2.1 Definition

°Briefly define differential settlement and discuss what causes it. Include discussion on primary and secondary consolidation. Also include brief discussion of how differential settlement could cause failure.

°Discuss effects of self-weight and cover-weight.

°Discuss range (max-min) of differential settlement that could be expected at tailing impoundments.

2.2 Analysis Techniques/Computational Methods

°Discuss computational methods/analytical techniques to compute potential differential settlement (Lab data and example computations in appendix)

2.3 Applicable Mitigating Engineering Methods

2.3.1 Pre-loading during cover placement
2.3.2 Self-healing cover materials

°Include discussion of cover thickness needed and if more cover (thickness) will provide greater stability.

2.3.3 Regrading

All of these items (2.3.1, 2.3.2 and 2.3.3) should include a discussion of the probability that they will provide stability for 200, 500 and 1000 years.

2.4 Differential Settlement Summary

°Discuss significance of differential settlement as a long-term concern.

3. Hydrologic and Geomorphic Failure Modes Influenced by Surrounding Environments

3.1 Selection of Flood Magnitude for Evaluation

°Include brief discussion on the need for selecting the flood magnitude.

°Define 100, 200, 500, 1000 year flood and PMF. Include some perspective on the probabilities of the occurence of these floods for periods of 100, 200, 500 and 1000 years.

°Discuss the two standard deviation probability of occurence for the 100 year flood. (PMF selection rational)

°Discuss the availability of historical data in reference to a particular flood, for example 100 year flood. Discuss this with respect to the 200, 500 and 1000 year floods.

3.2 Flood Intrusion and Fluvial Mechanics (Acute Phenomena)

3.2.1 Definition

°Brief definition of what flood intrusion is and what causes it. Discuss what the differences are between flood intrusion and the other hydrologic failure modes. (Drainage area of concern.)

°Discuss range (max-min) of damage that flood intrusion could cause.

3.2.2 Analysis Techniques/Computational Methods

°Discuss analysis techniques/computational methods to estimate the magnitude of potential damage caused by flood intrusion and to determine if the cover is stable for 200, 500 and 1000 years.

3.2.3 Applicable Mitigating Engineering Methods

3.2.3.1 Type of Cover Material

°Discuss types of cover material (rock, vegetation, and others) and how these cover materials can protect against flood intrusion.

3.2.3.1.1 Rock

°Discuss size, gradation, placement and bedding.

°Discuss analysis techniques to determine rock size, depth, bedding material and placement location. Include discussion of rock cover thickness needed and if more rock cover (thickness) will provide greater stability.

°Discuss reliability of this method to provide stability for 200, 500 and 1000 years.

°Include examples.

3.2.3.1.2 Vegetation

°Discuss effects of different levels of vegetation coverages in providing stability against flood intrusion.

°Discuss vegetation bedding soil thickness and it's relationship with stability.

°Discuss analysis techniques to estimate flood intrusion damage for different levels of vegetation cover.

°Discuss reliability of using vegetation to provide stability for 200, 500 and 1000 years.

°Include examples.

3.2.3.1.3 <u>Other Cover Material</u>

3.2.3.2 <u>Diversion Structures and Rerouting</u>

°Discuss types of diversion structures.

°Discuss the reliability of using diversion structures to provide stability for 200, 500 and 1000 years.

°Discuss analysis techniques or computational methods to determine the magnitude of damage (deposition and erosion) for periods of time (200, 500 and 1000 years).

°Include samples.

3.2.4 <u>Flood Intrusion Summary</u>

3.3 <u>Gully Intrusion</u> (Progressive Phenomena)

3.3.1 <u>Definition</u>

°Brief definition of what gully intrusion is and what causes it. Discuss what the differences are between gully intrusion and the other hydrologic failure modes. Discuss range (max-min) of damage that gully intrusion could cause.

3.3.2 Analysis Techniques/Computational Methods

°Discuss analysis techniques/computation methods to estimate the magnitude of potential damage caused by gully intrusion. Derivation of methods and computations should be included in appendix.

°Identify threshold values.

3.3.3 Applicable Mitigating Engineering Methods

3.3.3.1 Type of Cover Material

°Discuss types of cover material (rock, vegetation and others) and how these cover materials can protect against gully intrusion.

3.3.3.1.1 Rock

°Discuss size, gradation, placement and bedding.

°Discuss analysis techniques to determine rock size, depth, bedding material and placement location. Include discussion of rock cover thickness needed and if more rock cover (thickness) will provide greater stability.

°Discuss the extent of the basin area that rock may have to be provided for. Will small known flow concentration areas suffice or does a major portion of the downstream basin area need rock cover?

°Discuss reliability of this method to provide stability for 200, 500 and 1000 years.

°Include examples.

3.3.3.1.2 Vegetation

°Discuss effects of different levels of vegetation coverages in providing stability against gully intrusion.

°Discuss vegetation bedding soil thickness and it's relationship with stability.

°Discuss analysis techniques to estimate gully intrusion damage for different levels of vegetation cover.

°Discuss reliability of using vegetation to provide stability for 200, 500 and 1000 years.

°Include examples.

3.3.3.1.3 Other Cover Material

3.3.3.2 Recontouring

°Can recontouring (drainage basin area or impoundment) provide stability and if so how? To what extent would this have to be done?

°Discuss analysis techniques to estimate gully intrusion damage for recontouring and to determine cover stability.

°Discuss reliability of using this method to provide stability for 200, 500 and 1000 years.

°Include examples.

3.3.4 Gully Intrusion Summary

4. Other Physical Failure Modes Influenced By Events Occurring Directly on the Tailings Impoundment

4.1 Gully Erosion Caused by Precipitation Falling Directly on or In the Immediate Upstream Catchment Area of the Tailings Impoundment

4.1.1 Definition

°Brief definition of what gully erosion is and what causes it. Discuss the differences between gully erosion and the other hydrologic failure modes. Discuss range (max-min) of damage that gully erosion could cause.

4.1.2 Analysis Techniques/Computational Methods

°Discuss analysis techniques/computational methods to estimate the magnitude of potential gully erosion damage and to determine if the cover is stable for 200, 500 and 1000 years.

°Identify threshold values.

4.1.3 Applicable Mitigating Engineering Methods

4.1.3.1 Recontouring

4.1.3.1.1 Reduce Flow Concentrations

°Discuss how recontouring can reduce flow concentrations and how reducing flow concentrations can provide stability.

°Discuss analytical techniques for determining how to reduce flow concentrations below failure thresholds.

°Identify threshold value..

°Discuss the reliability of this method to provide stability for 200, 500 and 1000 years.

°Include examples.

4.1.3.1.2 <u>Reduce Flow Velocities By Providing Gentle and/or Short Slopes</u>

°Discuss how recontouring can reduce flow velocities and how reducing flow velocities can provide stability.

°Discuss analytical techniques for determining how to reduce flow velocities below failure thresholds.

°Identify threshold values.

°Discuss the reliability of this method to provide stability for 200, 500 and 1000 years.

°Include examples.

4.1.3.2 <u>Type Cover Material</u>

°Discuss types of cover material (rock, vegetation and others) and how these cover materials can protect against gully erosion.

4.1.3.2.1 <u>Rock</u>

°Discuss size, gradation, placement and bedding.

°Discuss analysis techniques to determine rock size, depth, bedding material and placement location. Include discussion of rock cover thickness needed and if more rock cover (thickness) will provide greater stability.

°Discuss to what extent of the impoundment area the rock may have to be provided for.

°Discuss reliability of this method to provide stability for 200, 500 and 1000 years.

°Include examples.

4.1.3.2.2 Vegetation

°Discuss effects of different levels of vegetation coverages in providing stability against gully intrusion.

°Discuss vegetation bedding soil thickness and it's relationship with stability.

°Discuss analysis techniques to estimate gully intrusion damage for different levels of vegetation cover and to determine if the cover is stable.

°Discuss reliability of using vegetation to provide stability for 200, 500 and 1000 years.

°Include examples.

4.1.3.2.3 Other Cover Material

4.1.3.3 Diversion Structures and Rerouting

°Discuss types of diversion structures.

°Discuss the reliability of using diversion structures to provide stability for 200, 500 and 1000 years.

°Discuss analysis techniques or computational methods to determine the magnitude of damage (erosion fill and erosion) for periods of time (200, 500 and 1000 years) and to determine if the structure is stable for these periods.

°Include examples.

4.1.4 Gully Erosion Summary

4.2 Water Sheet Erosion

4.2.1 Definition

°Brief definition of what water sheet erosion is and what causes it. Discuss the differences between water sheet erosion and the other hydrologic failure modes. Discuss range (max-min) of damage that water sheet erosion could cause.

4.2.2 Analysis Techniques/Computational Methods

°Discuss analysis techniques/computational methods to estimate the magnitude of potential water sheet erosion damage and to determine if the cover is stable for 200, 500 and 1000 years.

°Identify threshold values.

4.2.3 Applicable Mitigating Engineering Methods

4.2.3.1 Contour Shaping (Provide Gentle Short Slopes With Gradual Transitions Between Slopes)

°Discuss how providing gentle short slopes with gradual transitions between slopes can reduce water sheet erosion and provide stability. Discuss discharge of sheet flow and its relationship to gullying.

°Discuss how to accomplish.

°Discuss analytical techniques for determining slope and slope length - Discuss threshold values.

°Discuss the reliability of this method to provide stability for 200, 500 and 1000 years.

°Include examples.

4.2.3.2 Types of Cover Material

°Discuss types of cover material (rock, vegetation and others) and how these cover materials can protect against water sheet erosion.

4.2.3.2.1 Rock

°Discuss rock size gradation, placement and bedding.

°Discuss analysis techniques to determine rock size, depth, bedding material and placement location. Include discussion of rock cover thickness needed and if more rock cover (thickness) will provide greater stability.

°Discuss to what extent of the impoundment area the rock cover may have to be provided for.

°Discuss the reliability of this method to provide stability for 200, 500 and 1000 years.

°Include examples.

4.2.3.2.2 Vegetation

°Discuss effects of different levels of vegetation coverages in providing stability against water sheet erosion.

°Discuss vegetation bedding soil thickness and its relationship with stability.

°Discuss analysis techniques to estimate water sheet erosion damage for different levels of vegetation cover and to determine if the cover is stable.

°Discuss reliability of using vegetation to provide stability for 200, 500 and 2000 years.

°Include examples.

4.2.3.2.3 Other Cover Material

4.3 Wind Erosion

4.3.1 Definition

°Brief definition of what wind erosion is and what causes it (parameters that contribute to wind erosion). Discuss the differences between wind erosion and water sheet erosion. Discuss the range (max-min) of damage that wind erosion could cause.

°Brief discussion on wind blow out.

°Discuss relationship with water sheet erosion mitigating methods and mitigating measures for wind erosion. Discuss if wind erosion protection would be needed in some cases where no other problem was required.

4.3.2 Analysis Techniques/Computational Methods

°Discuss analysis techniques/computational methods to estimate the magnitude of potential wind erosion damage and to determine if the cover is stable for 200, 500 and 1000 years.

4.3.3 Applicable Mitigating Engineering Methods

4.3.3.1 Type of Cover Material

°Discuss types of cover material (rock, vegetation and others) and how these cover materials can protect against wind erosion.

4.3.3.1.1 Rock

°See report outline for water sheet erosion section 4.2.3.2.1.

4.3.3.1.2 Vegetation

°See report outline for water sheet erosion section 4.2.3.2.2.

4.3.3.1.3 Other Cover Material

5. Weathering and Chemical Attack

5.1 Definition

°Briefly define weathering and chemical attack.

°Discuss different types of weathering and chemical attack that would effect cover material.

°Discuss what causes weathering and chemical attack and how weathering and chemical attack could cause failure.

°Discuss range (max-min) of damage that weathering and chemical attack could cause.

5.2 Analysis Techniques/Computational Methods

°Discuss analysis techniques/computational methods to estimate magnitude of failure by weathering and chemical attack.

5.3 Applicable Mitigating Engineering Methods

5.3.1 Type of Cover Material

°Discuss how the type of cover material could provide stability against weathering and chemical attack.

°Discuss analysis techniques to estimate the durability of cover materials for periods of time 200, 500 and 1000 years.

°Threshold values.

°Discuss reliability of this method to provide long-term stability for 200, 500 and 1000 years.

°Discuss cover thickness vs. breakdown. Will more cover (thickness) provide greater stability.

°Include examples.

5.4 Weathering and Chemical Attack Summary

6. Conclusions

°Summarize the significance of each failure mode in terms of long-term stability.

°Discuss interrelationship between (that is overlap or competion) the applicable mitigating engineering methods that are considered to be appropriate to mitigate the impacts of each failure mode.