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Shiprock Case Study
1986 Annual DOE
Remedial Action Programs Meeting
Oak Ridge Tennessee

by

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Uranium Mill Tailings Remedial Action Project

MASTER

United States Department of Energy

Uranium Mill Tailings
Remedial Action Program

SHIPROCK SITE

GENERAL INFORMATION

- **OPERATORS:**
 - KERR-MCGEE (1954-1963)
 - VCA-FOOTE MINERAL (1963-1968)
- **MILLFEED SOURCES:**
 - MINES ON THE COLORADO PLATEAU & NAVAJO RESERVATION
 - CONCENTRATES FROM MONUMENT VALLEY UPGRADER
- **MILL PROCESS:** ACID LEACH
- **CURRENT OWNER:** NAVAJO TRIBE
- **SITE AREA:**
 - DESIGNATED SITE: 144 ACRES
 - TAILINGS PILES: 72 ACRES
- **CONTAMINATED MATERIAL:** 1.9 MILLION CUBIC YARDS
- **VICINITY PROPERTIES:**
 - WINDBLOWN : 51 ACRES
 - DESIGNATION: 17 ACRES
 - INCLUSIONS EXPECTED: 15 ACRES

MASTER

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Remedial Action Program

SHIPROCK TAILINGS SITE MAP

200 0 200 400 600
SCALE IN FEET

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Remedial Action Program

SHIPROCK SITE

PLANNING/NEPA/DESIGN DEVELOPMENT

- **REMEDIAL ACTION: STABILIZATION-IN-PLACE**
- **NEPA DOCUMENT: ENVIRONMENTAL ASSESSMENT**
- **PRINCIPLE TECHNICAL CONCERNS:**
 - **MOVEMENT OF TAILINGS BACK FROM EDGE OF ESCARPMENT**
 - **FLOODPLAIN GROUNDWATER CONTAMINATION**
- **ACQUISITION: PROCEDURES NOT ESTABLISHED**
- **REPROCESSING: COSTS TO REPROCESS – \$115/LB OF U_3O_8**
1983 PRICE \$25/LB OF U_3O_8
- **REMEDIAL ACTION COST:**
 - **ENGINEERING \$670 K**
 - **CONSTRUCTION \$10,850 K**

United States Department of Energy

Uranium Mill Tailings
Remedial Action Program

SHIPROCK SITE KEY EVENTS

- **COOPERATIVE AGREEMENT:** OCT. 1983
- **INITIAL MEETING WITH NAVAJO
TECHNICAL STAFF:** NOV. 1983
- **INITIAL MEETING OF TASK FORCE:** NOV. 1983
- **ISSUED DRAFT EA:** DEC. 1983
- **ISSUED DRAFT REMEDIAL ACTION PLAN:** JAN. 1984
- **PUBLIC MEETINGS:** • **DRAFT EA:** JAN. & MAR. 1984
• **SHIPROCK CHAPTER:** MAR. 1984
- **MEETINGS WITH NAVAJO TECHNICAL
STAFF:** JAN., FEB. & MAY 1984
- **CHAIRMAN'S ENDORSEMENT OF
STABILIZATION-IN-PLACE:** MAY 1984
- **ISSUED EA:** JUN. 1984
- **PUBLISHED FONSI:** OCT. 1984
- **ISSUED REMEDIAL ACTION PLAN:** JUN. 1985
- **REMEDIAL ACTION:** • **PHASE I:** OCT.-DEC. 1984
• **PHASE II:** APR. 1985-NOV. 1986

NORMAL APPROACH TO PUBLIC INFORMATION AND PARTICIPATION

- **DETERMINE GOALS**
- **STRATEGIZE**
- **IMPLEMENT**

SHIPROCK GOALS

- **OVERCOME OPPOSITION TO SIP**
- **MEET TIGHT CONSTRUCTION
SCHEDULE**

SHIPROCK STRATEGY

- HOW DO WE COMMUNICATE?
- WHO'S IN CHARGE?
- HOW DO WE GET A DECISION?

COMMUNICATING

- **TRANSLATOR**
- **SUNDAY CHAPTER MEETINGS**
- **VISUAL – NOT VERBAL**

WHO'S IN CHARGE?

• TRIBAL ADMINISTRATION

- Chairman's Office**
- Tribal Council**

• CHAPTER LEVEL

- President, Council Delegate,
Vice-President, Secretary**
- IHS Health Board**
- DIN'E – The People**

REACHING A DECISION

- NEW CHAPTER RESOLUTION
REQUIRED
- TALK TALK TALK
LISTEN LISTEN LISTEN
- HEALTH BOARD COMES THROUGH
- FINAL CHAPTER MEETING

THE VOTE

86 - 1

URANTUM MILL TAILINGS RELEASES

8/22/60 RAFFINATE POND DIKE FAILURE INTO RIVER	240,000 gal 500 pCi/l Ra - 226
11/17/66 RAFFINATE LINE FAILURE SMALL QUANTITY REACHED RIVER	16,000 gal (NO ASSAY)

**WINDBLOWN CONTAMINATION ON AND ADJACENT
TO THE SHIPROCK SITE**

ISO-CONCENTRATIONS OF URANIUM, OCTOBER, 1985

ISO-CONCENTRATIONS OF TOTAL DISSOLVED SOLIDS, OCTOBER, 1985

STABILIZATION IN PLACE - FINAL CONDITION

ENVIRONMENTAL ASSESSMENT

- CONSIDERED 5 ALTERNATIVES
- CONDUCTED QUANTITATIVE RISK ASSESSMENT
- FOUND THREATENED CACTUS SPECIES
 - Consultation with USFWS, BIA, Navajo Game & Fish
 - Prepared Plan to Protect
- FOUND CONTAMINATION IN WETLANDS (33 ACRES)
 - Prepared Mitigation Plan
 - Consultation with USFWS, BIA, COE, and Navajo Game & Fish

HEALTH PHYSICS PROTECTION

- **ONSITE HIGH VOLUME SAMPLING**
- **TLD BADGING**
- **BIOASSAY**

RADIOLOGICAL CONTROLS

- **HEALTH PHYSICS PROTECTION**
- **EXCAVATION CONTROL**
- **VERIFICATION**

HEALTH PHYSICS PROTECTION ONSITE HIGH VOLUME SAMPLING

LOCATIONS: HIGHEST EXPOSURE POTENTIAL

RESULTS: LOW AVERAGE EXPOSURES

SHP OCCUPATIONAL AIR DATA (AREA)

SINGLE SAMPLES VS. ANNUAL LIMIT

DATE
— AVG = 0.064

□ 472 SAMPLES

HEALTH PHYSICS PROTECTION TLD BADGING

- **CRITERIA: RADIATION WORKERS**
- **RESULTS: LOW BUT MEASURABLE**

UMTRA PROJECT 1985 TLD RESULTS

(TLDDOSE.WR1) 4-24-86

ALL PERSONNEL

HEALTH PHYSICS PROTECTION BIOASSAY

- **METHOD: URINALYSIS**
- **RESULTS: NO SIGNIFICANT EXPOSURES**

EXCAVATION CONTROL

- **HAND HELD GAMMA**
- **DELTA SHIELD**
- **MOFLUX SYSTEM**
- **SOIL SAMPLING**

EXCAVATION CONTROL HANDHELD GAMMA

- **HIGHLY PORTABLE DETECTOR**
- **NO SHIELDING**
- **SEVERELY INFLUENCED BY PILE FLUX**

EXCAVATION CONTROL DELTA SHIELD

- **PORTABLE DETECTOR/SHIELD**
- **INTERFERENCE CORRECTED**
- **INFLUENCED BY HIGH PILE FLUX**

EXCAVATION CONTROL MOFLUX

- **WHEELED DETECTOR/SHIELD**
- **INTERFERENCE-CORRECTED SYSTEM**
- **USED IN AREAS OF HIGH PILE FLUX**

EXCAVATION CONTROL SOIL SAMPLING

- **REQUIRES SAMPLE CANNING**
- **ONSITE LABORATORY COUNTING**
- **1/2 HOUR MINIMUM TURNAROUND**
- **EXTREME FLUX**

SOIL STANDARDS VERIFICATION (SOIL SAMPLING)

**a) SITE PERIMETER AND WINDBLOWN AREAS:
5 AND 15 pCi/g**

b) CELL CONTENTS

VERIFICATION SITE PERIMETER AND WINDBLOWN SOIL

- **100 SQUARE METER: 20 ALIQUOTS**
- **RESULTS: AVERAGE RESIDUAL RA-226
LESS THAN 5 pCi/g**

ALL VERIFICATION SAMPLES AT SHIPROCK

(SHPVER1.WR1) 4-14-86

VERIFICATION FINAL CELL RA-226 CONTENTS

- **SAMPLES TAKEN FROM TOP LAYER, FINAL CELL**
- **FINAL RA-226 AND EMANATION FRACTION**

ENVIRONMENTAL MONITORING

- **PURPOSE: PROTECTION OF THE PUBLIC**
- **MONITOR RADIOACTIVE PARTICULATES**
- **MONITOR RADON IN AIR**

ENVIRONMENTAL AIR PARTICULATE MONITORING

- **LAYOUT: SAMPLERS AT SITE PERIMETER**
- **RESULTS: LITTLE INFLUENCE ON COMMUNITY**

GROSS ALPHA AND TH-230

STATION 3 SHIPROCK 1985

GROSS ALPHA AND TH-230

STATION 5 SHIPROCK 1985

GROSS ALPHA AND TH-230

STATION 8 SHIPROCK 1985

GROSS ALPHA AND TH-230

STATION 9 SHIPROCK 1985

ENVIRONMENTAL RADON MONITORING

- **LAYOUT: SAMPLERS AT PERIMETER AND
IN COMMUNITY**
- **RESULTS INDICATE LITTLE IMPACT**

ONSITE (BOUNDARY) RADON CONCENTRATION

SHIPROCK 1985

COMMUNITY RADON CONCENTRATION AVERAGE

SHIPROCK 1985

ANNUAL AVERAGE RADON CONCENTRATION

ON-SITE STATIONS - SHIPROCK 1986

ANNUAL AVERAGE RADON CONCENTRATION

OFF SITE STATIONS - SHIPROCK 1986

SHIPROCK REMEDIAL ACTION CASE STUDY¹

I. DESIGN

A. Pre-Construction Condition

Located on the Navajo Indian Reservation, the Shiprock site lies on the southwest bank of the San Juan River, on the south side of the town of Shiprock, New Mexico. The designated site [Slide 1] contains 144 acres, of which about 72 acres were covered with tailings in two adjacent piles. The upper (North) pile was up to 40 feet in height and the lower (South) pile, which covered about 46 acres, was approximately 15 feet in height. The North pile is adjacent to an escarpment, about 70 feet above the river. Except for a small shed and several surface tanks, the structures that existed on the site were in use and in conformance with the EPA standards. Although the piles had been covered with a thin layer of soil, they did not meet EPA standards. Earth dikes surrounding the piles prevented the spread of tailings by run-off water and directed other surface run-off away from the site and into arroyos draining into the San Juan River. There was some radiation contamination in surrounding soils from windblown dispersion, and contamination was present in the arroyos and the San Juan River floodplain from wind and water erosion of the tailings.

The tailings lie on a terrace deposit of dense alluvium that is underlain by nearly flat-lying beds of Mancos shale. The foundation materials below the tailings are stable, but the location of the piles adjacent to the escarpment makes the foundation potentially susceptible to failure from head-ward erosion of the gullies along the escarpment.

Ground water occurs in three zones beneath the site. Two of these occurrences are in perched systems and the third zone consists of two confined aquifers. The perched zones are discontinuous, occurring in the alluvial deposits (20 feet in thickness) and in the upper weathered Mancos shale that underlies the alluvial deposits. Because the quality of water in the perched zones is unsatisfactory for use and because there is little or no infiltration through the pile, ground-water protection was not required. The two confined aquifers, compromising the third zone, occur in the Gallup sandstone and the Dakota sandstone. The Gallup sandstone is about 400 feet below the site and the Dakota sandstone is about 2100 feet below the site. Both of these sandstone beds are separated from the tailings by nearly impermeable Mancos shale and are not expected to be subject to contamination.

B. Proposed Final Condition

The completed site will be a single embankment, covering about 76 acres, on the southeast one-half of the present site [Slides 2 and 3]. The top of the embankment will have a slope of 3.5 percent, and the sides will have a slope of 5 horizontal to 1 vertical. Based on predicted rates of erosion of the escarpment, the embankment toe will be a minimum of 300 feet from the escarpment edge. Rock-lined drainage

4005-SHP-R-01-02372-00

¹ Presented at the DOE Remedial Action Programs Conference, 1943U/44U
Oak Ridge, TN, May 6, 1986, by G. R. Thiers, Morrison-Knudsen Engineers, Inc.

ditches on the perimeter of the embankment will collect run-off from three sides of the embankment and carry the flow to an arroyo near the northern corner of the embankment, from where the run-off will flow to the San Juan River. Run-off on the fourth side (southeastern) of the embankment will flow overland into the excavated NECA borrow area over a riprap protected apron.

A security fence will enclose the embankment. The arroyos will be filled to a slope of 2 horizontal to 1 vertical. The top of the escarpment will slope away from the edge to reduce run-off over the escarpment face. The toe of the filled arroyos and the fill surfaces will be protected with select rock.

C. Major Design Elements

1. Relocation of tailings [Slide 4] involves a) cutting along the north edge of the pile to pull the toe back to 300 feet from the escarpment, b) moving the southern edge, c) bringing wind blown and water borne tailings back to the pile. Much of the cutting was in slimes, causing some equipment difficulties as discussed below under construction.

2. The largest escarpment gully, located near the eastern edge of the pile is shown in Slide 5. Filling and protecting such arroyos is covered by the cross-section shown in Slide 6.

3. Erosion protection, the handling of runoff from precipitation, is basically governed by the runoff from the probable maximum precipitation, the PMP, which is about 60 inches per hour for 2.5 minutes. At this particular site, design of a system to withstand this heavy runoff including transfer away from the pile, was particularly challenging, and afforded an opportunity for development of cost effective solutions. The final plan, shown in Slide 7, involves a) 3.5% grade on the embankment top with 3-inch rock ($D_{50} = 1.5$ inch), b) 20% slope on the sides with 8-inch rock ($D_{50} = 4$ inches), and c) ditches along the southern, western, and northern edge, the southern and western ditches being designed to contain the 1,000-year storm runoff and spill the excess from more rare storms across a riprap protected apron which reduces flow velocities to acceptable levels. The northern ditches are designed to contain the PMP and discharge into an energy dissipation area reducing velocities to acceptable levels. A discharge apron along the eastern side receives the runoff from that side of the pile and transfers it safely into the adjacent gravel borrow area. At the end of construction, the borrow area will be graded so that the flow can reach the San Juan River. The ditches and aprons will be protected by the 8-inch riprap ($D_{50} = 4$ inches) at most locations, supplemented by larger material having $D_{50} = 5.5$ inches at bends and other critical locations. The rock being used for riprap is from an existing pit just east of the pile, in the gravel terrace. Stockpiles of the materials are shown in Slide 8.

4. The radon barrier material readily available is a clayey silt located just south of the pile (Slide 9]. The deposit, which is alluvial, is about 20 feet deep and is estimated to have sufficient material for the radon barrier design thickness of 7 feet. Samples of this material were tested for radon diffusion coefficient during the first part of the construction period. At the same time, borings were made in the reconfigured tailings pile, and samples of tailings extracted at 2-foot depth intervals, to determine the average emanation fraction to use in final calculations of thickness requirements. Based on these calculations and construction progress, it was decided to leave the thickness of the radon barrier on the side slopes (Slide 10) at 7 feet and reduce the thickness on the top slope to 6.4 feet.

5. Flood plain restoration consists of stripping a one foot depth of windblown material and creation of three shallow ponds to encourage aquatic bird life.

D. Permits Required

Preparation of applications for the various permits required and follow-up to be certain the permits are granted has been a substantial piece of work at Shiprock as it is at most sites. The permits required are listed in Slide 11.

II. CONSTRUCTION

Remedial action at the Shiprock site has progressed in the following three phases. Phase I-A, surfacing of a parking area [Slide 12]; Phase I-B, preparation of the Contractor's office area west of the site and the access control area; and Phase II, the remainder of the work. Phase I-A was constructed in September 1984, and Phase I-B in January 1985. Phase II was started in July 1985 and is scheduled for completion in November 1986. The schedule for the Phase II work is shown in Slide 14.

The Navajo Engineering and Construction Authority was awarded subcontracts for all three construction phases.

One of the difficult aspects of construction has been excavation in the slimes area. Difficulties in this work were overcome by 1) using light equipment, 2) avoiding sharp turns and repeated travel over the same locations, which would "work" the tailings, and 3) mixing sands with the slimes where necessary to reduce the water content. Equipment working in the slimes area is shown in Slide 15. Water contents in this area were as high as 72%, 36% above optimum.

Slimes which are not excavated and recompacted will be a potential source of settlements, especially where loaded by significant thicknesses of other tailings, the radon barrier and erosion protection [Slide 16]. Calculations indicate that 90% of the settlement in this area will be completed within 90 days after placement of the radon

barrier and riprap bedding. To confirm this conclusion and provide a means for adding additional fill, if required, to eliminate depressions which could cause runoff concentrations, settlements will be recorded in this area after placement of the radon barrier and riprap bedding, and final grading of the riprap surface postponed until the rate of settlement is acceptable.

The current state of construction is shown in Slide 17. Completion is anticipated by November 1986. An artist's conception of the completed project is shown in Slide 18.

III. List of Slides

1. Pre-Construction Condition.
2. Proposed Final Condition - Schematic.
3. Proposed Final Condition - Drawing.
4. Relocation of Tailings - Drawing.
5. Escarpment Photo.
6. Escarpment Cross-sections - Drawing.
7. Erosion Protection - Drawing.
8. Riprap Material.
9. Borrow Area for Radon Barrier.
10. Radon Barrier - Cross-section.
11. Permits Required.
12. Construction Facilities - Drawing.
13. Decon Pad.
14. Construction Schedule.
15. Excavation and Placement of Tailings.
16. Settlement Monitoring Points.
17. Current Status.
18. Expected Final Condition (Artist's Rendition)

1

SHIPROCK TAILINGS SITE
MAY 1980 — VIEW SE

2

MAJOR WORK FEATURES

1. CONTAMINATED MATERIAL EXCAVATION
2. SITE GRADING
3. RADON BARRIER COVER
4. EROSION PROTECTION ROCK COVER

BID QUANTITIES

988,400 C.Y.
348,200 C.Y.
850,000 C.Y.
362,000 TONS

PLAN

PROPOSED FINAL CONDITION

400 0 400 800
SCALE FEET

3

3

PLAN
RELOCATION OF TAILINGS

400 0 400 800
SCALE FEET

TYPICAL ARROYO FILL SECTION

PLAN
EROSION PROTECTION
SCALE 0 400 800
FEET

51

TYPICAL COVER
DETAIL 1
NOT TO SCALE

DETAIL 2
NOT TO SCALE

SECTION A

UMTRA SHIPROCK SITE PERMITS

1. SAND AND GRAVEL PERMIT
2. RECLAMATION OF BORROW AREA AND FLOODPLAIN
3. CULTURAL RESOURCE CLEARANCES
4. APPROVAL OF WELL SEALING PROCEDURES
5. NAVAJO WATER USE PERMIT
6. CORPS OF ENGINEERS '404' PERMIT
7. NPDES (SURFACE WATER DISCHARGE) PERMIT
8. THREATENED OR ENDANGERED SPECIES CONSULTATION
9. CONTRACT FOR WATER SERVICE
10. PERMIT TO DIVERT CONTRACT WATER
11. DISCHARGE PLAN
12. AIR QUALITY CONSTRUCTION PERMITS

(11)

EQUIPMENT (EXCLUDING ROCK PRODUCTION)

3 EA. 631 SCRAPERS (18 CY FOR LOAD COUNT PRODUCTION)
 9 EA. 633 SCRAPERS (18 CY FOR LOAD COUNT PRODUCTION)
 3 EA. D-8 CATS
 3 EA. D-6 CATS
 3 EA. WATERWAGONS (2- 8,000 GAL., 1- 6,000 GAL.)
 3 EA. MOTOR GRADERS (2- 12' AND 1- 14')
 4 EA. COMPACTORS (3- 825' AND 1- SP56)

PLAN
CONSTRUCTION FACILITIES
 400 0 400 800
 SCALE FEET

12

TYPICAL DECONTAMINATION PAD SECTION

13

	1984				1985												1986											
	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
<u>SHIPROCK MILL SITE</u>	ACTUAL PROGRESS																PROJECTED											
<u>PHASE I-A CONSTRUCTION</u>	—																											
<u>PHASE I-B CONSTRUCTION</u>		—	—	—	—	—	—																					
<u>PHASE II CONSTRUCTION</u>																												
-CONTRACT AWARD 6-12-85										▲																		
-MOBILIZATION										—	—																	
-EXCAVATE CONTAMINATED MATERIAL										—	—	—	—	—	—	—	—	—	—	—	—							
-SITE GRADING											—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
-RADON BARRIER PLACEMENT												—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
-ROCK PRODUCTION													—	—	—	—												
-ROCK PLACEMENT																						—	—	—	—	—	—	—
-DEMOBILIZATION																										—	—	—

MAY 2, 1986 —

14

PLAN
SETTLEMENT MONITORING POINTS