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DISPOSAL OF RADIOACTIVE WASTES*

MASTER

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DISPOSAL OF RADIOACTIVE WASTES*

1. Introduction — DWG 79-1661. As discussed in Lecture 2, all of the principal types of radioactive wastes are generated in fuel reprocessing plants. Success in managing those wastes should offer the key to handling the wastes from virtually all other sources. We have discussed the origin, nature and methods of treatment for these wastes. Today I would like to very briefly review the management approach, then devote the remainder of my time to a discussion of the disposal requirements options that are available.

2. Fuel Reprocessing Waste Management — DWG 70-1494.

   2.1 Gaseous waste management

   - Methods must be developed to immobilize ^{3}H, ^{85}Kr, ^{129}I, perhaps ^{14}C
   - Storage of ^{85}Kr and ^{3}H for 1 to 2 centuries; ^{129}I and ^{14}C must be isolated, or diluted and dispersed

   2.2 Liquid wastes given multistep treatment

   2.3 Solid wastes

   - TRU to repository; beta, gamma to land burial
   - Compaction, incineration, and solidification methods are under development

   2.4 All types require packaging and shipment prior to disposal.

3. Beneficial Uses of Wastes. I would like to depart briefly to address an issue that is frequently raised whenever waste management is discussed — that of the beneficial utilization of radioactive wastes. There are a wide variety of possible uses for many of the fission products and heavy-element isotopes found in the spent fuel from nuclear reactors. Many proposals have been made for using specific isotopes, the bulk solidified high-level wastes, and even the unprocessed spent fuel for heat and radiation sources. Also, some of the fission products have potential industrial value as mineral resources. From the standpoint of nuclear waste management, however, it must be kept in mind that the beneficial utilization of wastes or waste constituents does not represent an end in itself, but must be considered as only another form of interim storage. The sharpness of the separations that are achievable by present technology is insufficient to permit materially altering the disposal requirements of the waste residuals; and, after the useful potential of the separated components has been realized, the requirements for their ultimate disposal likewise remain virtually unchanged. Finally, the large-scale recovery of specific constituents from wastes, preparation into forms suitable for use, and distribution over wide sectors of the country must be carefully assessed, since they have a number of adverse impacts on waste management.

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3.1 Important considerations — DWG 79-1662.

3.2 We conclude that any large-scale use of waste or waste constituents should be based on a detailed cost-risk-benefit analysis that considers the risk of radiation exposure to man in contrast to economic value of the particular beneficial use and any additional costs to fuel reprocessing and waste management.

4. Interim Solid Storage. Required for all transuranium wastes presently because final repositories have not been demonstrated. They are also needed for storage of spent fuels.

4.1 Sealed storage cask concept — DWG 74-6122. A "fail-safe" concept for long-term ($\sim$100-year) storage.

4.2 Sealed cask storage array — DWG 74-6124. Casks placed on 25-ft centers would require 1000-1200 acres of land in year 2000.

4.3 Air-cooled vault — DWG 74-6121.

4.4 Water basin — DWG 74-6123. Method currently in use for short-term ($\leq$20 years) use.

4.5 Low- and intermediate-level TRU wastes are non-heat-generating materials and are currently being stored in various types of surface facilities at DOE sites pending resolution of a final isolation site.

5. Transportation. Radioactive materials are shipped only in solid forms, with the exception of minor quantities of ^{85}Kr and tritium. Hundreds of thousands of such shipments have taken place over the past 30 to 40 years without any serious exposures to man and this is an unparalled record in the history of transporting hazardous materials.

5.1 Low-level wastes. Shipped in unshielded or lightly-shielded drums and crates by both rail and motor freight to shallow-land burial grounds.

5.2 High-level waste cask (conceptual) — DWG 71-3841.

- 100 tons, 8 to 10 in. Pb or Fe, 4 to 6 in. H_2O
- Fins dissipate up to 40 kW

5.3 Low-level TRU waste (15 million ft^3 exists; another 10 million expected by year 2000).

- Pelletized — DWG 70-9015
- ATMX car — PHOTO 99351. Weighs 60 tons, takes a 60-ton payload

5.4 Noble-gas shipment cask (conceptual) — DWG 71-3839.

6. Disposal Methods. The only wastes currently being disposed of are low-level wastes and tritium from reactors; all the other types are being stored while final disposal options are being evaluated.

6.1 Low-level wastes are disposed of in shallow-land burial grounds or at Oak Ridge National Laboratory by hydrofracturing into a shale formation several hundred feet below the surface.

- Location of burial sites — DWG-12267. Six commercial sites, however only Barnwell, Beatty, and Richland are in operation. Others have been closed because of public concern over their operations.
- Photo of burial trench — PHOTO 97988. Over 50 million ft^3 DOE waste and 16 million ft^3 of commercial waste have been buried using about 1000 acres of land. By the year 2000, the land requirements will be more than doubled if present burial techniques are continued.
- Hydrofracturing — DWG 63-3830. In use at ORNL and can be applied to pelletized solids.

6.2 Other disposal methods in use or under development for low- and intermediate-level wastes

- Excavated caverns — PHOTO 4099-78
- Disposal in Germany — PHOTO 1192-74
- Disposal in matrix holes — PHOTO 4098-78. For LL or LL TRU wastes
- Disposal in solution-mined cavity — DWG 76-12R1. Proposed for direct disposal of low- and intermediate-level wastes by Germany

6.3 High-level and low-level TRU wastes are the greatest challenge because of their heat dissipation and their very long-term isolation requirements.

6.3.1 Possibilities for long-term storage/disposal — DWG 74-12661R1. Storage implies easy retrieval; disposal implies retrieval with difficulty, if at all. Disposal in geologic formations using conventional mining techniques is considered to be the best near-term option.

6.3.2 Locations of major geologic formations of interest.

- Salt deposits — OWI-76-25
- Argillaceous formations — DWG 74-1641
- Crystalline and volcanic rocks — DWG 75-17300

6.3.3 Advantages of salt formations for disposal — LR-DWG 61939R1

- Proposed location of Waste Isolation Pilot Plant (WIPP) in New Mexico — DWG 73-69R1
- Concept of repository — DWG 73-924
- Photo of excavations in salt — PHOTO 3274-75

7. Present U.S. RD&D Program in Waste Isolation

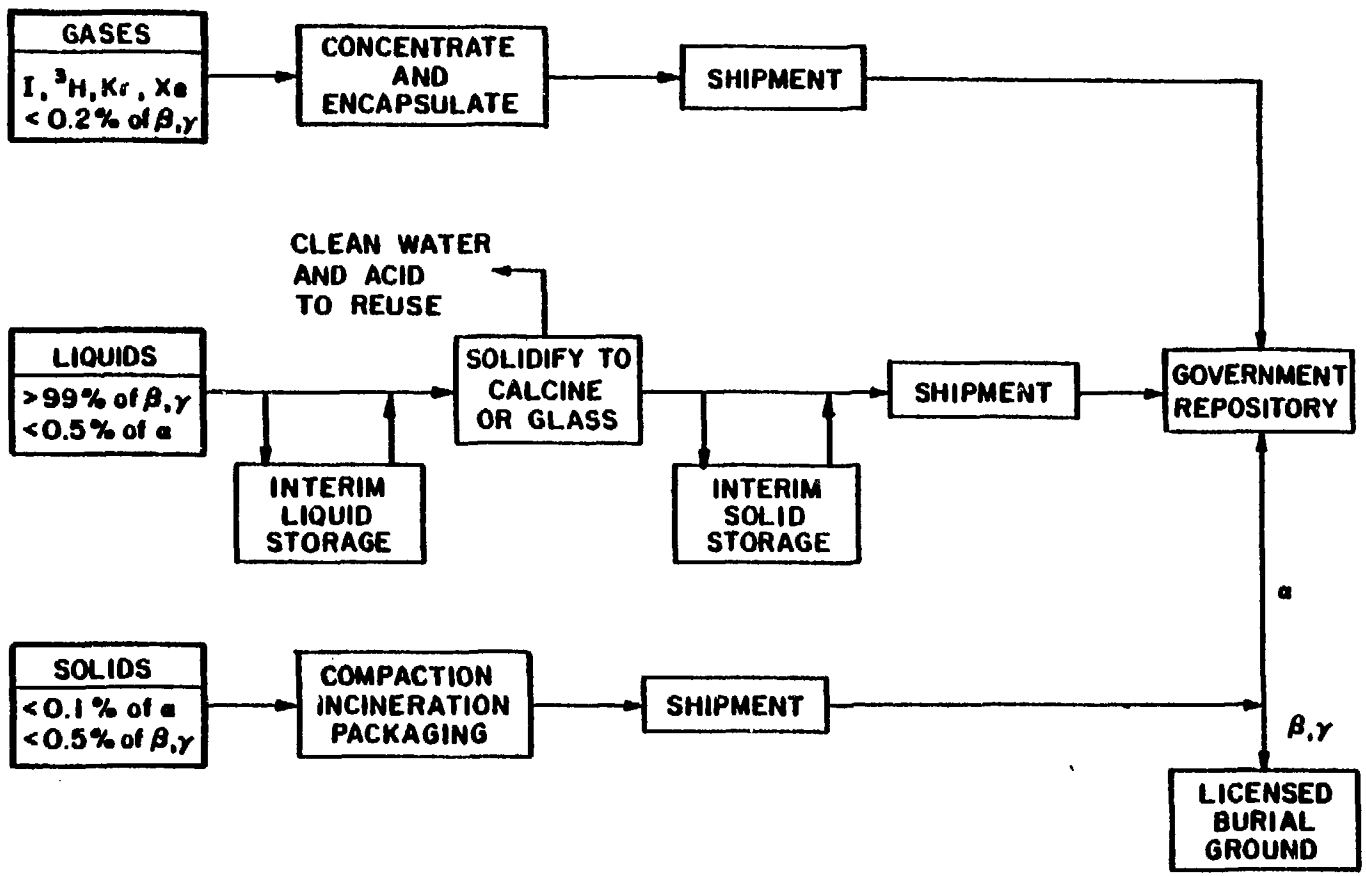
- DOE Waste Isolation Program Elements — DWG 79-627
- WIPP — DWG 79-628
- Pasco Basin Basalt — DWG 79-629
- Nevada Test Site — DWG 79-630
- ONWI Program — DWG 79-631
- Foreign Programs — DWG 79-632

ORNL-DWG 79-1661

SOURCES OF RADIOACTIVE WASTES

	FUEL PREPARATION AND FABRICATION	REACTOR OPERATION	FUEL REPROCESSING
SPENT FUEL		X	
TRANSURANIUM			
HIGH-LEVEL			X
CLADDING HULLS			X
INT.-LEVEL			X
LOW-LEVEL	X		X
NON-TRANSURANIUM			
NOBLE GASES (^{85}KR)		X	X
IODINE (^{129}I)			X
CARBON-14		X	X
TRITIUM		X	X
LOW-LEVEL		X	X

ORNL DWG 70-1494

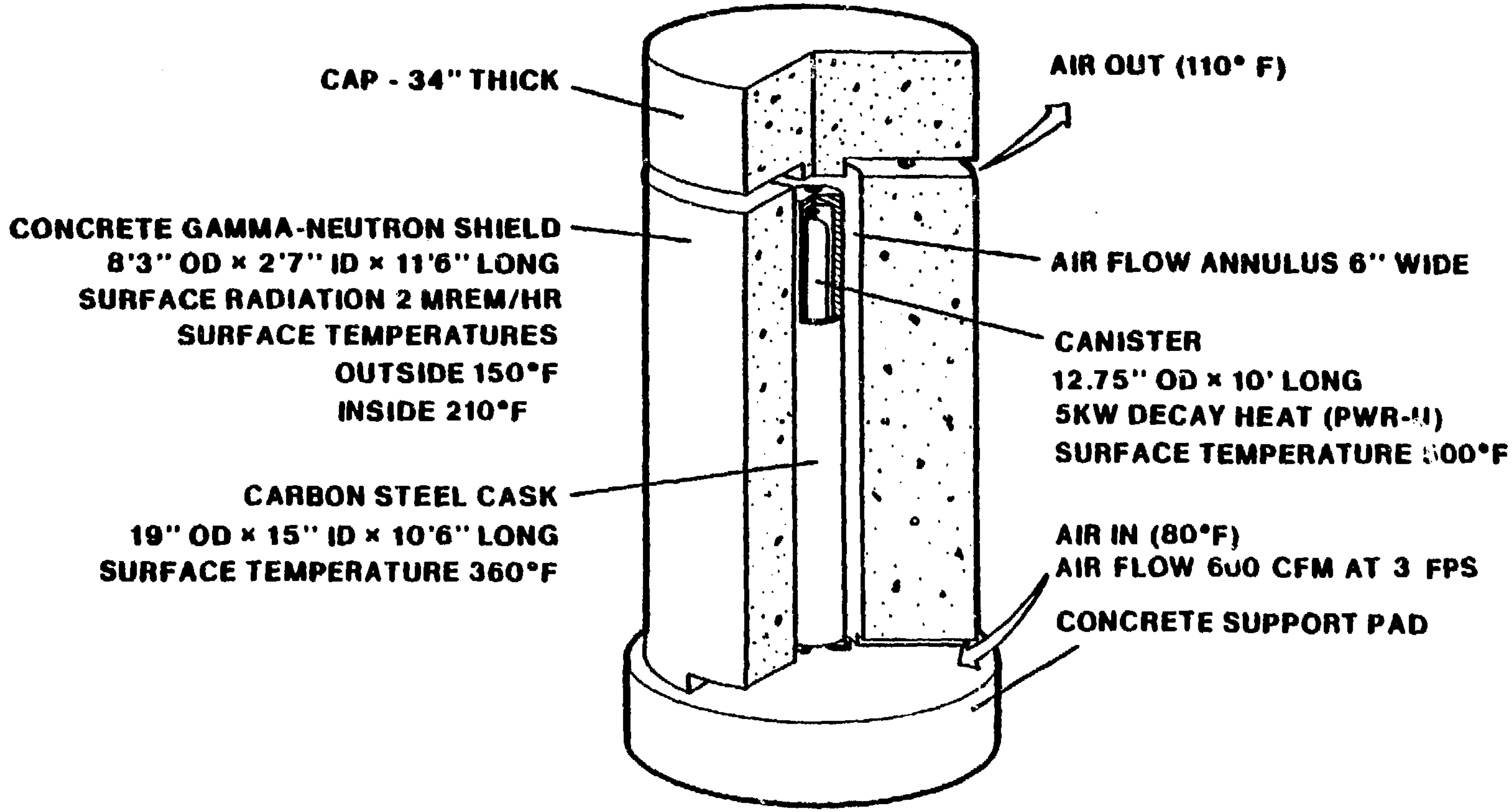


MANAGEMENT OF WASTES FROM REPROCESSING SPENT FUELS

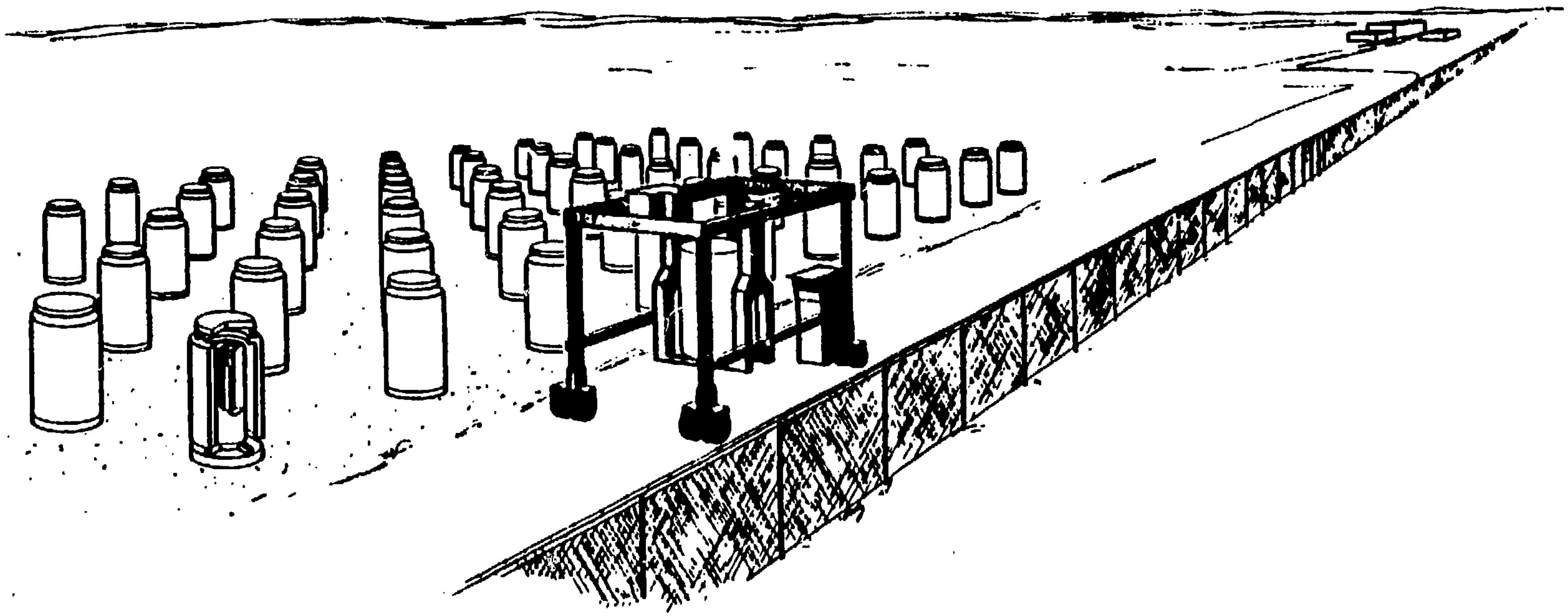
ORNL-DWG 79-1662

CONSIDERATIONS RELATIVE TO BENEFICIAL USE OF WASTE CONSTITUENTS

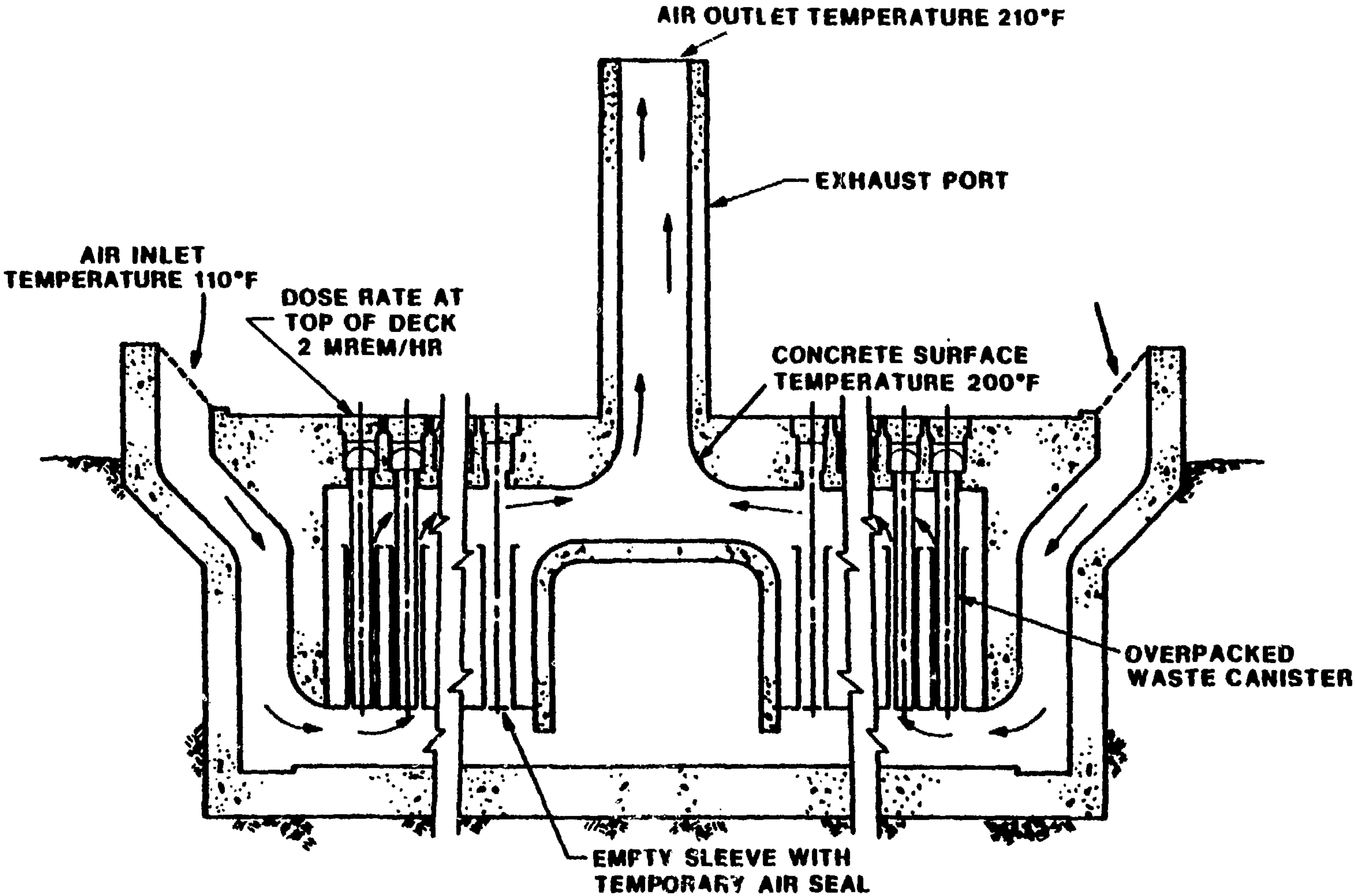
1. INCREASED GENERATION OF SECONDARY WASTES
2. INCREASED TRANSPORTATION REQUIREMENTS
3. INCREASED RISK OF RADIATION EXPOSURE
4. INCREASED ACCOUNTABILITY REQUIREMENTS
5. UNCERTAIN ECONOMICS



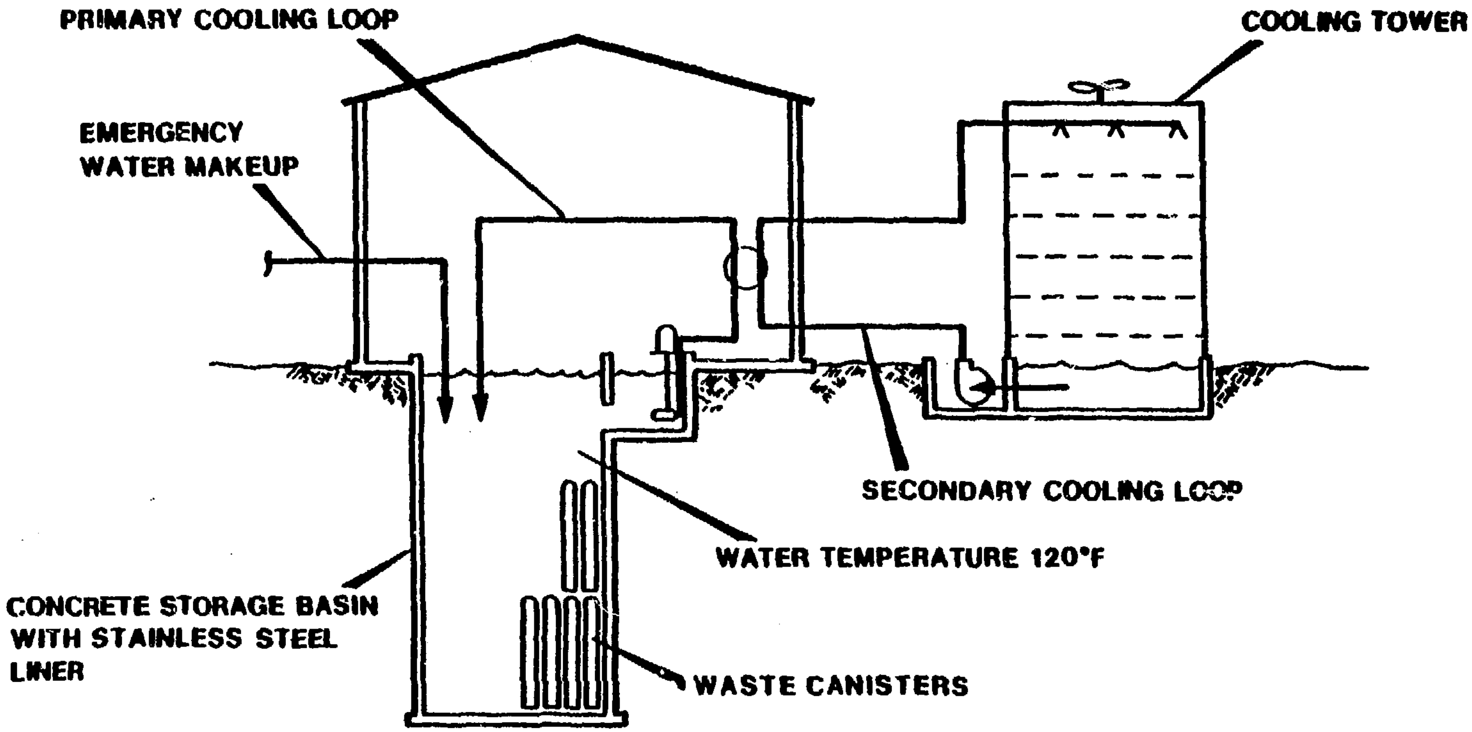
SEALED STORAGE CASK CONCEPT



SEALED CASK STORAGE ARRAY

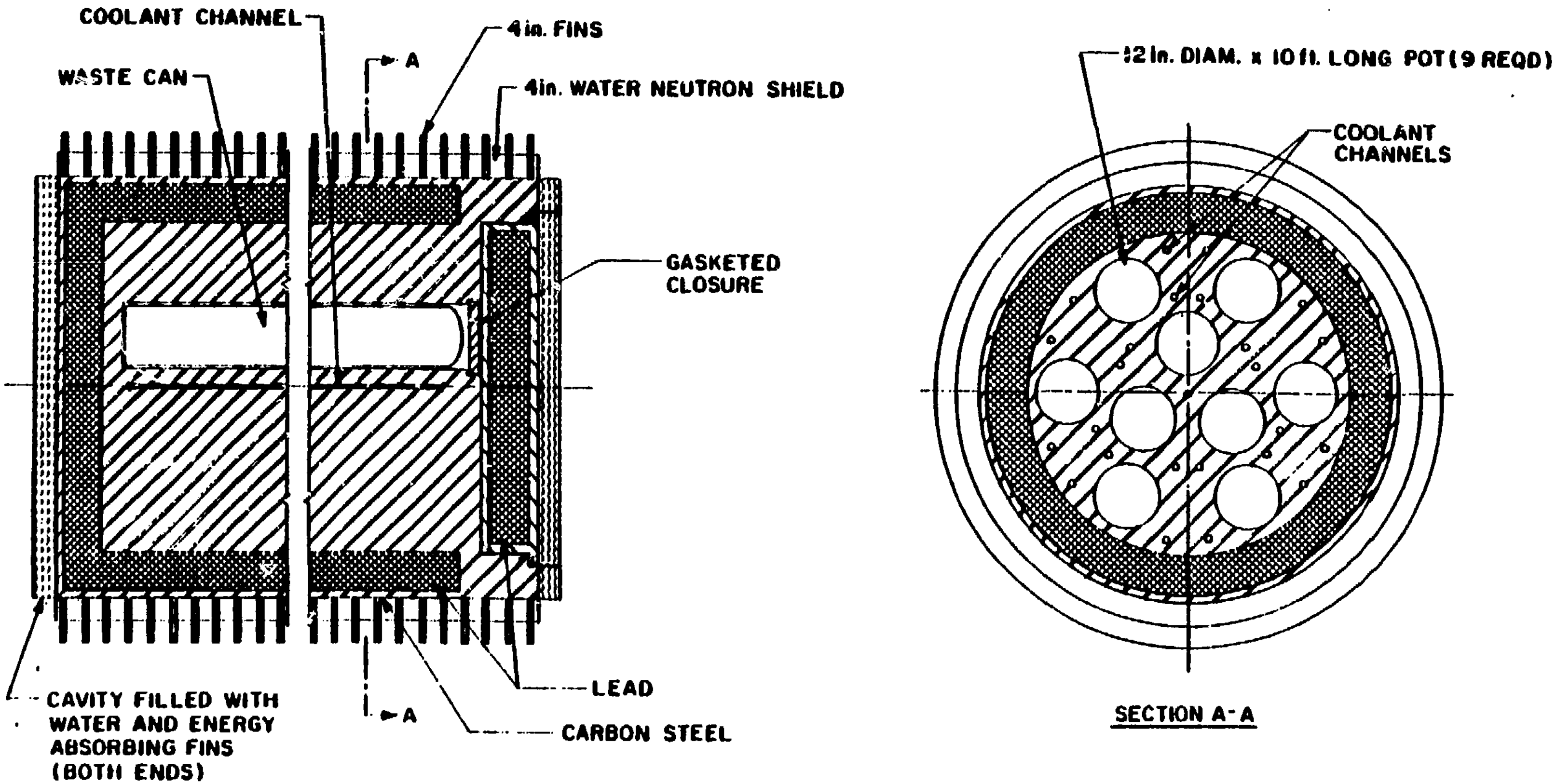


AIR-COOLED VAULT CONCEPT

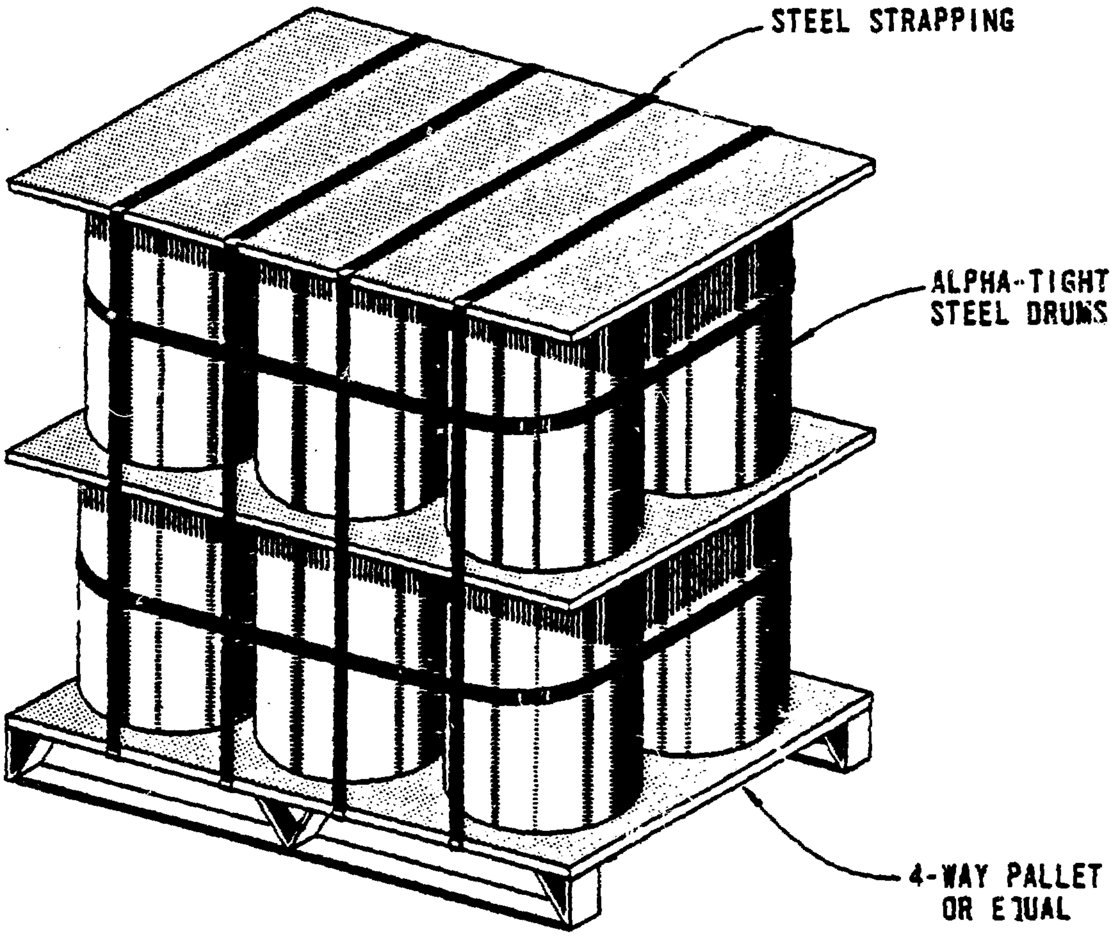


WATER BASIN CONCEPT

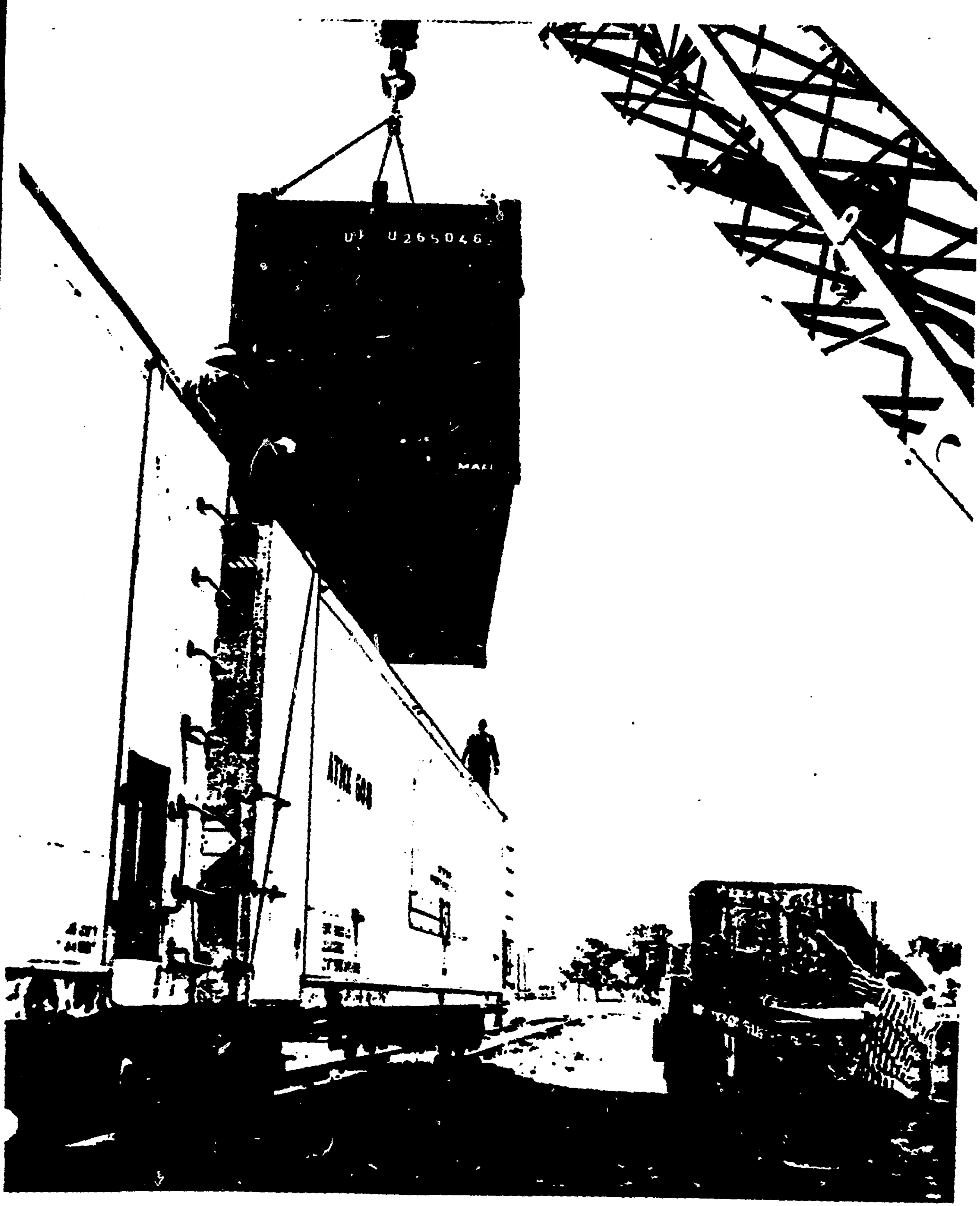
ORNL DWG 71-3841



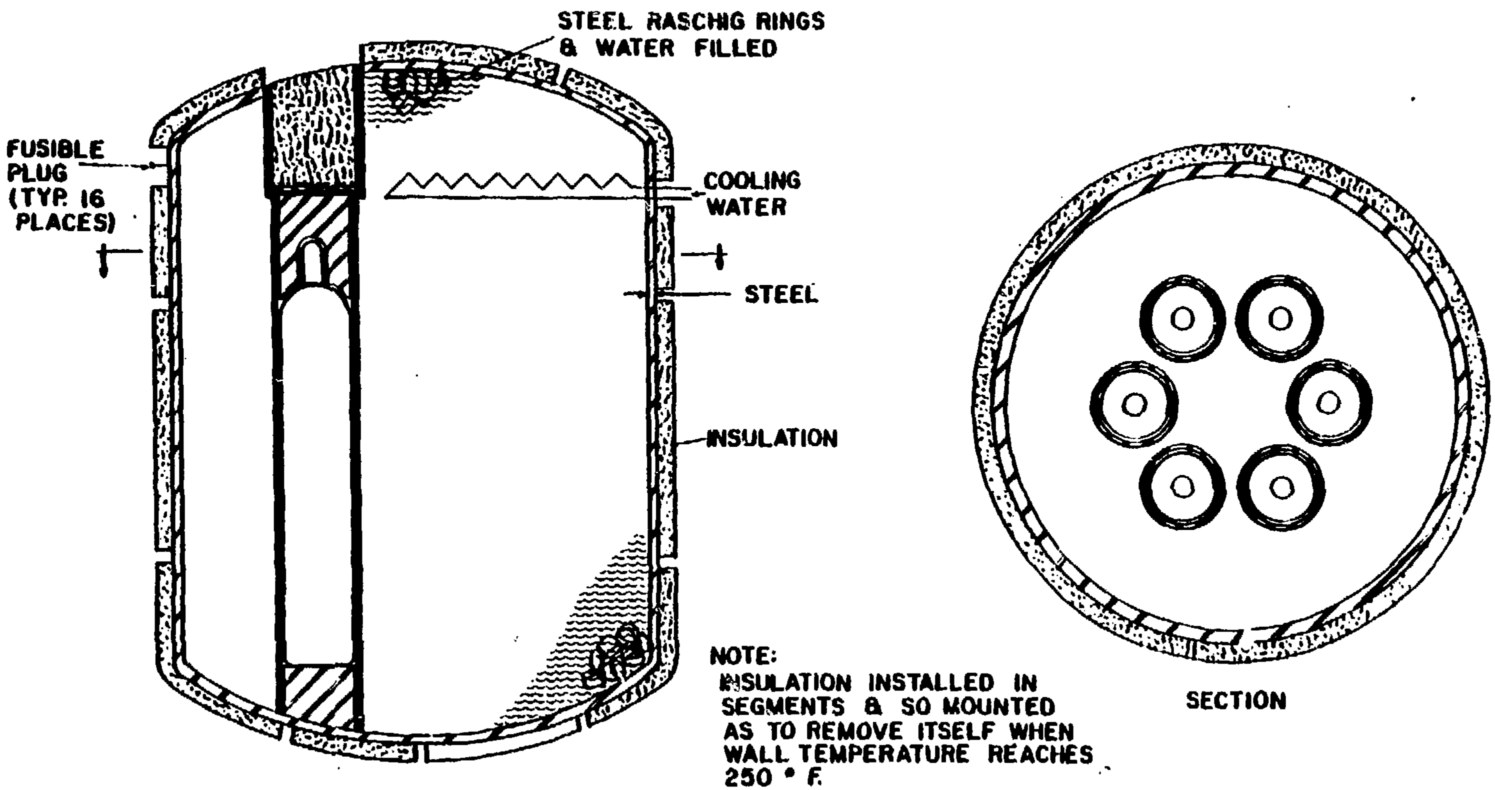
ORNL DWG 70-9015

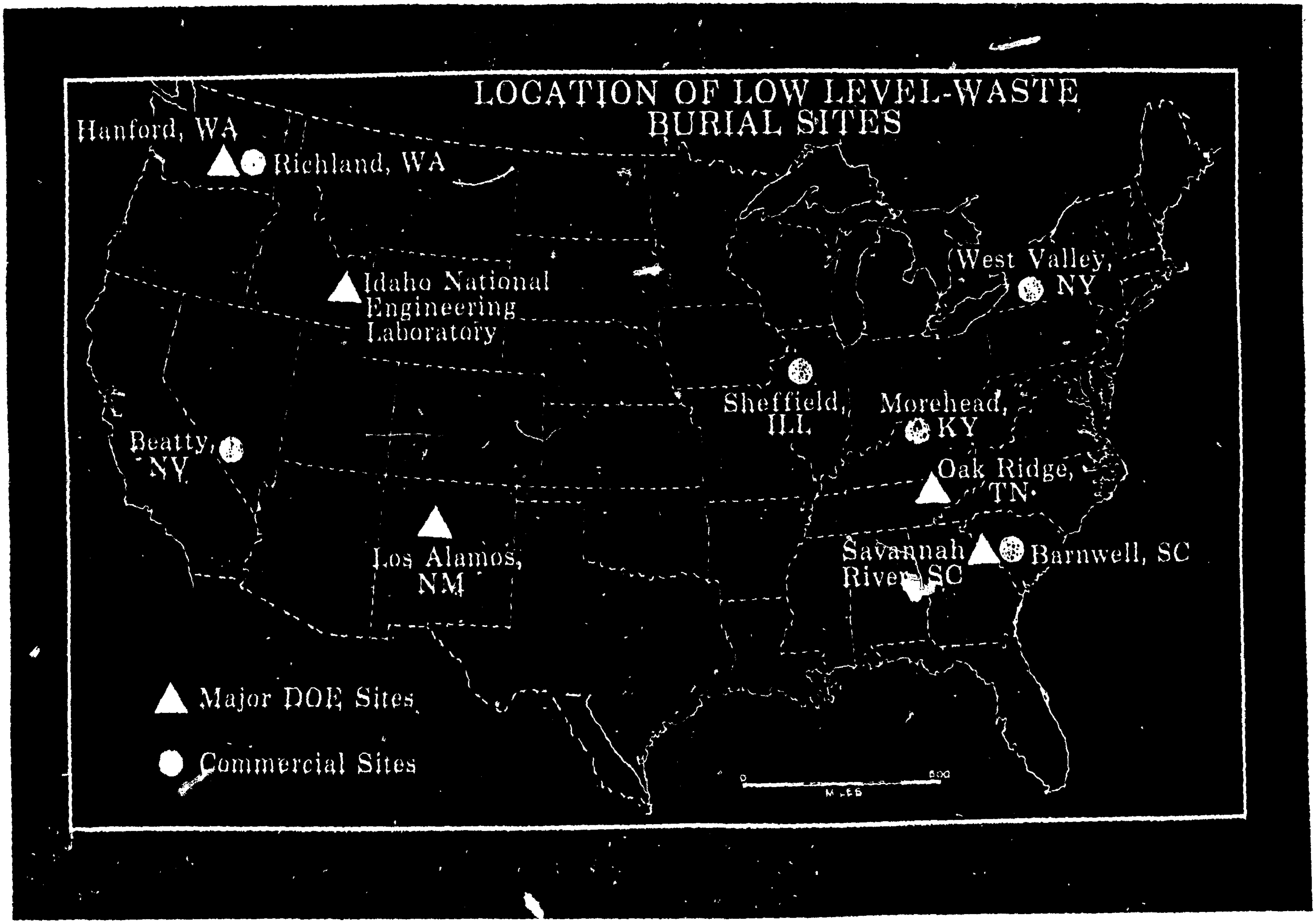


12 DRUM ALPHA BURIAL UNIT
(4 X 6 X 6 FT NOMINAL OVERALL)

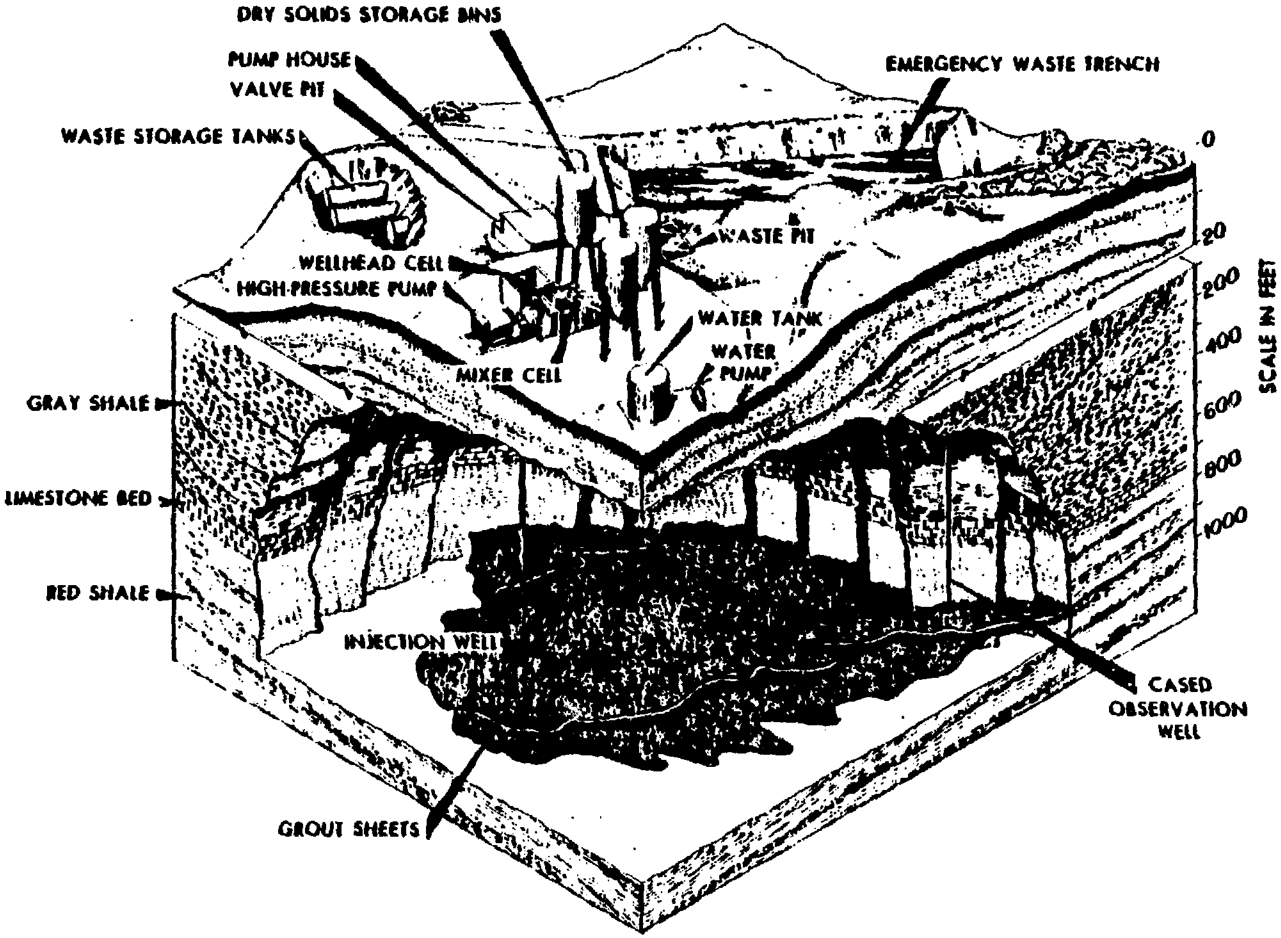


ORNL-DWG-71-3839



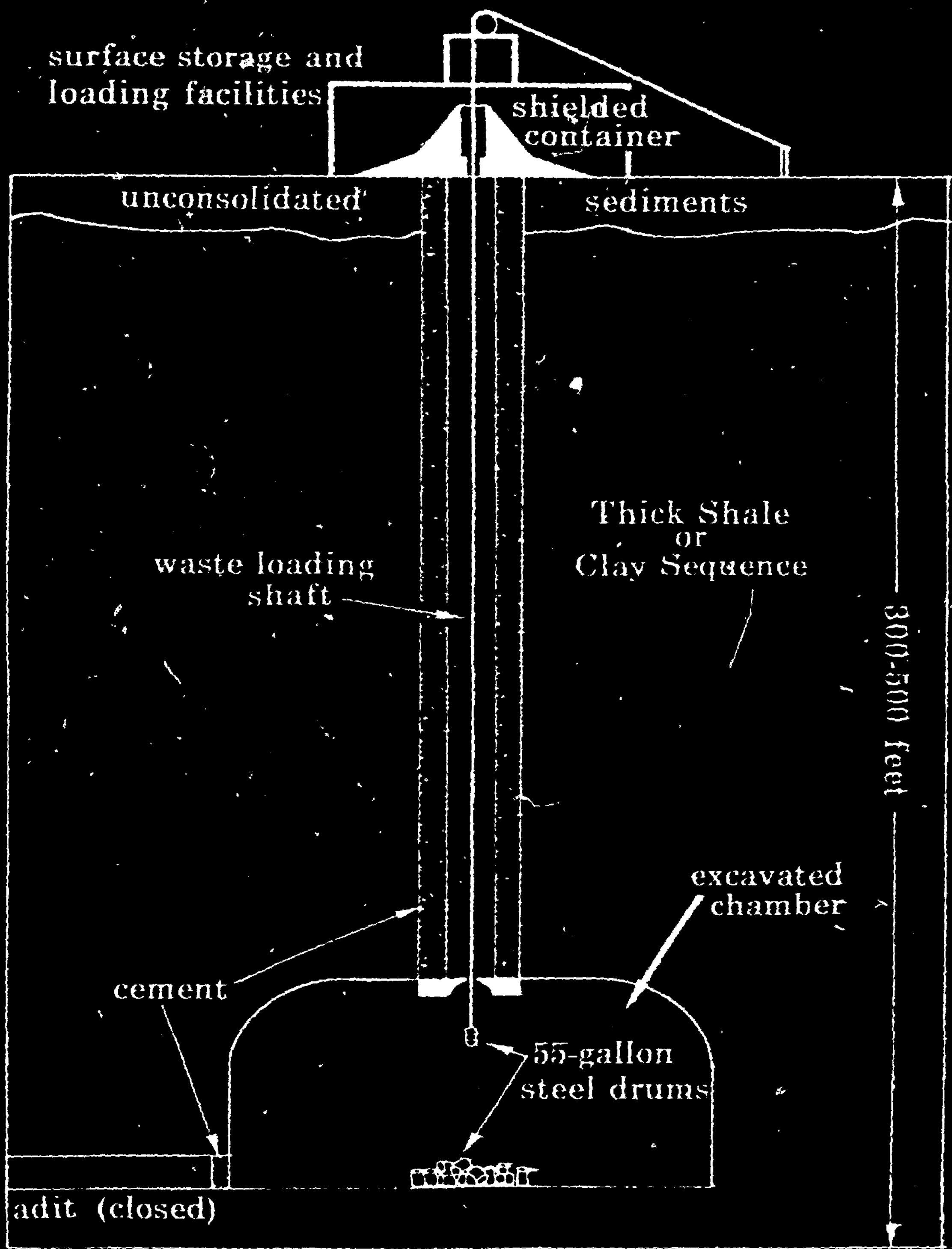

LOCATION OF LOW LEVEL-WASTE BURIAL SITES
Hanford, WA
Richland, WA
Idaho National Engineering Laboratory
West Valley, NY
Sheffield, ILL
Morehead, KY
Beatty, NY
Oak Ridge, TN
Los Alamos, NM
Savannah River, SC
Barnwell, SC
Major DOE Sites
Commercial Sites
MILES

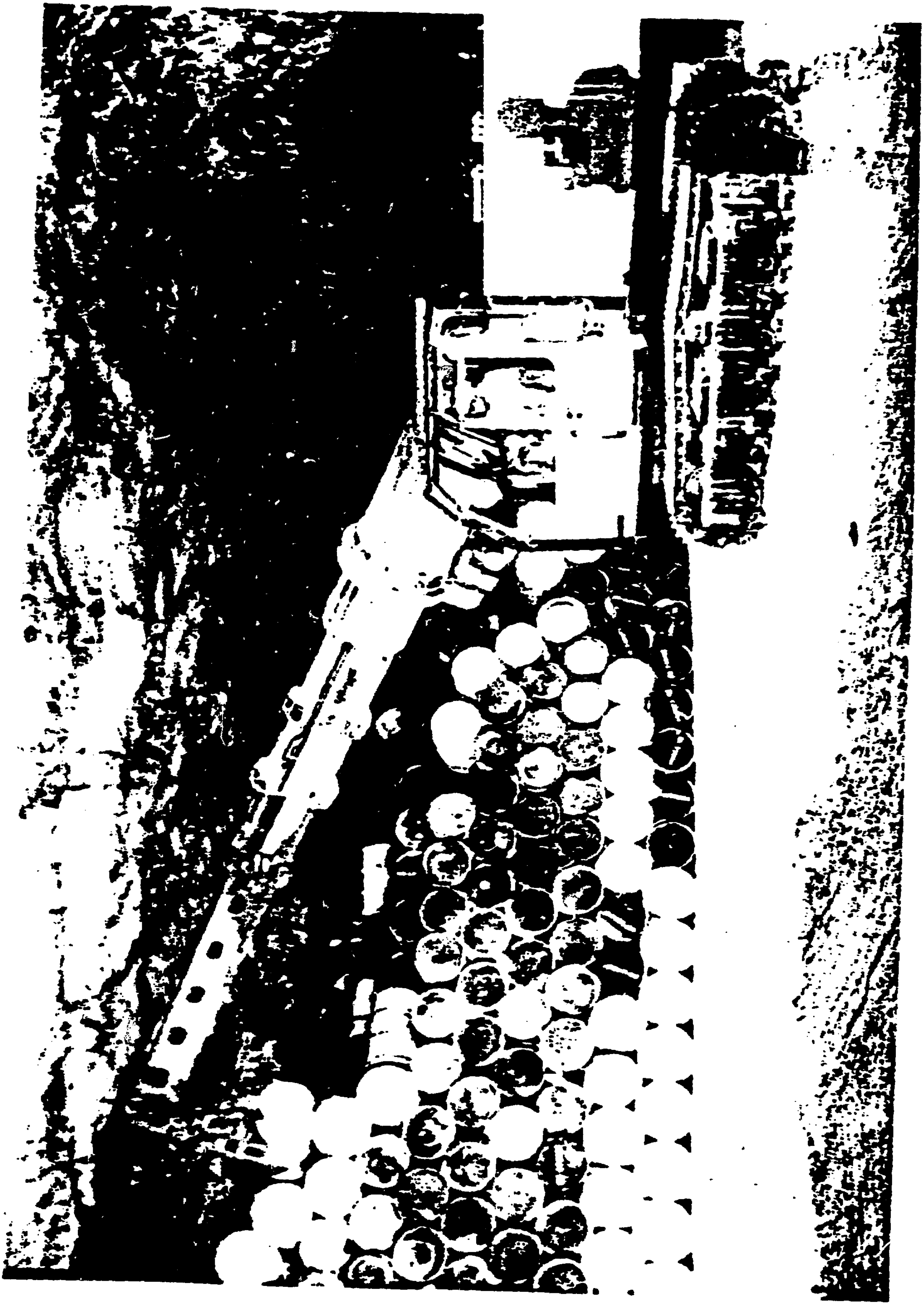
ORNL-DWG 63-3830

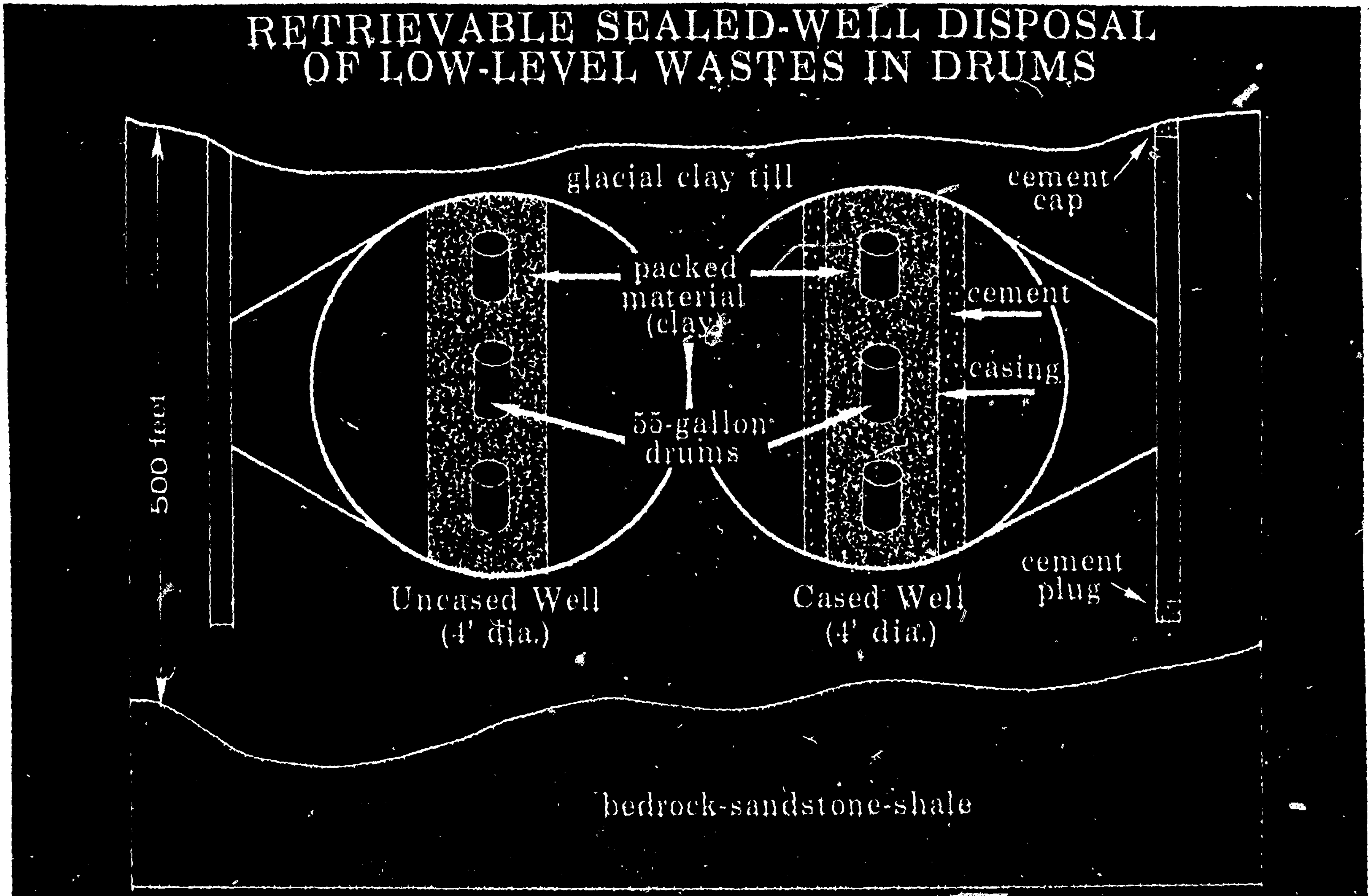


ORNL FRACTURING DISPOSAL PILOT PLANT

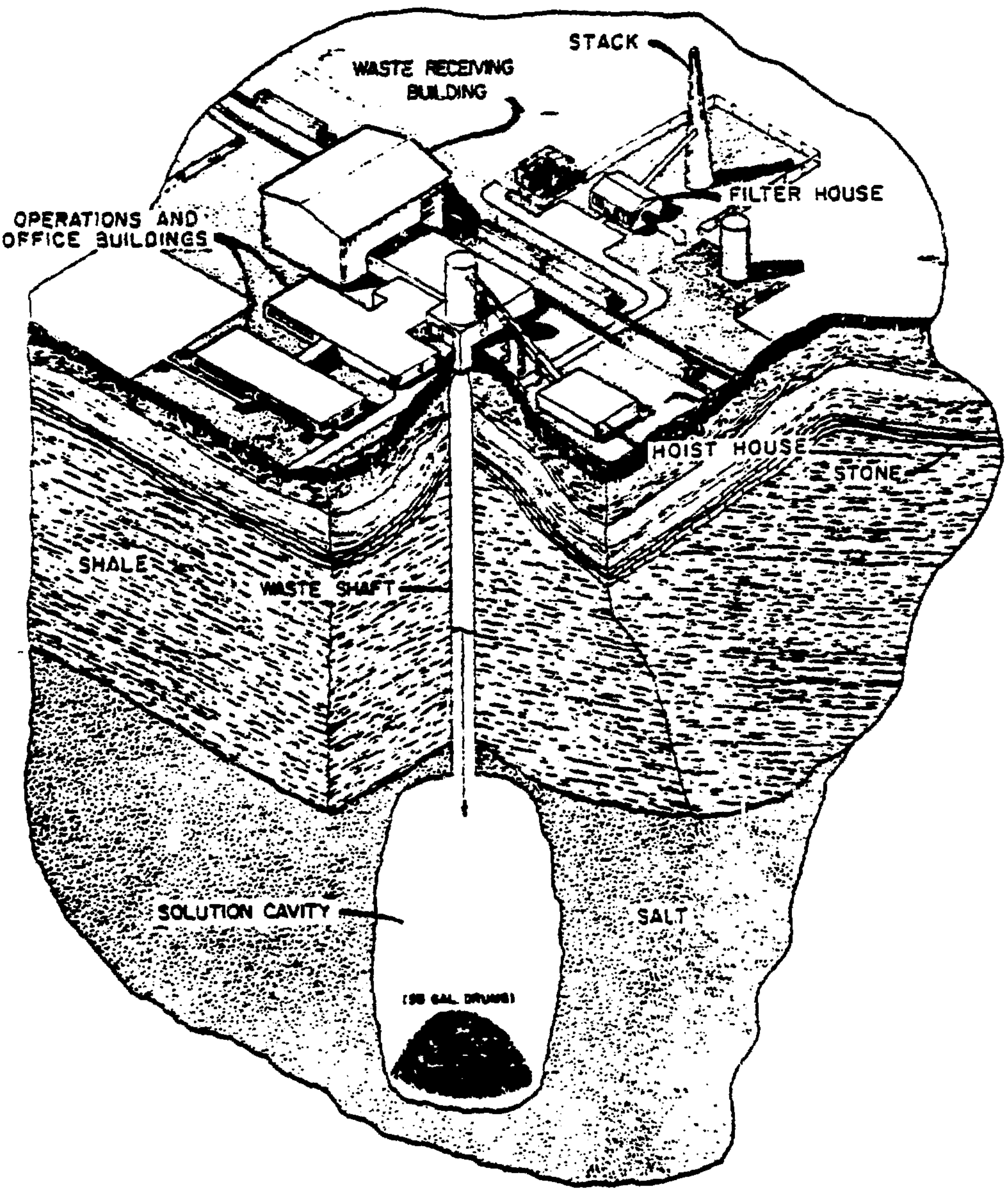
EXCAVATED-CAVERN DISPOSAL OF LOW-LEVEL WASTES IN DRUMS







RETRIEVABLE SEALED-WELL DISPOSAL
OF LOW-LEVEL WASTES IN DRUMS
glacial clay till
cement cap
packed material (clay)
cement
casing
55-gallon drums
500 feet
Uncased Well
(4' dia.)
Cased Well
(4' dia.)
cement plug
bedrock-sandstone-shale

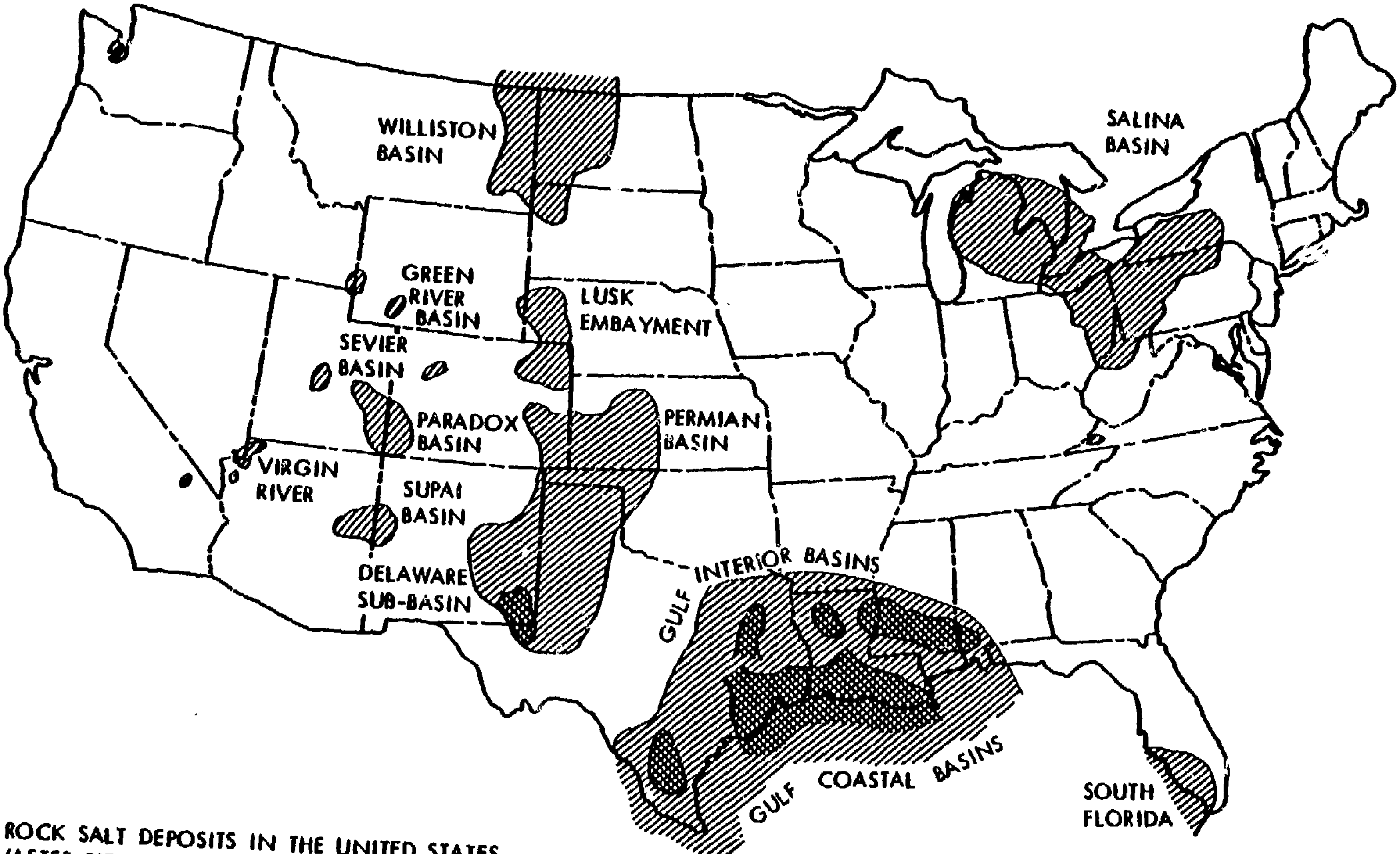


GENERALIZED CONCEPT
SOLUTION MINING FINAL STORAGE FACILITY

ORNL DWG 74-12661R1

POSSIBILITIES FOR LONG-TERM STORAGE AND DISPOSAL

1. ISOLATION ON EARTH
   - STORAGE AS LIQUIDS IN TANKS
   - STORAGE AS SOLIDS IN CONCRETE STRUCTURES
   - DISPOSAL AS SOLIDS IN CRYSTALLINE ROCKS
   - DISPOSAL AS SOLIDS IN SHALES AND CLAYSTONES
   - DISPOSAL AS SOLIDS IN SALT FORMATIONS
   - DISPOSAL AT GREAT DEPTHS UNDERGROUND
   - DISPOSAL AT SEA
   - DISPOSAL WITHIN POLAR ICE CAPS
2. TRANSMUTATION TO NONRADIOACTIVE SPECIES
3. DISPOSAL INTO OUTER SPACE

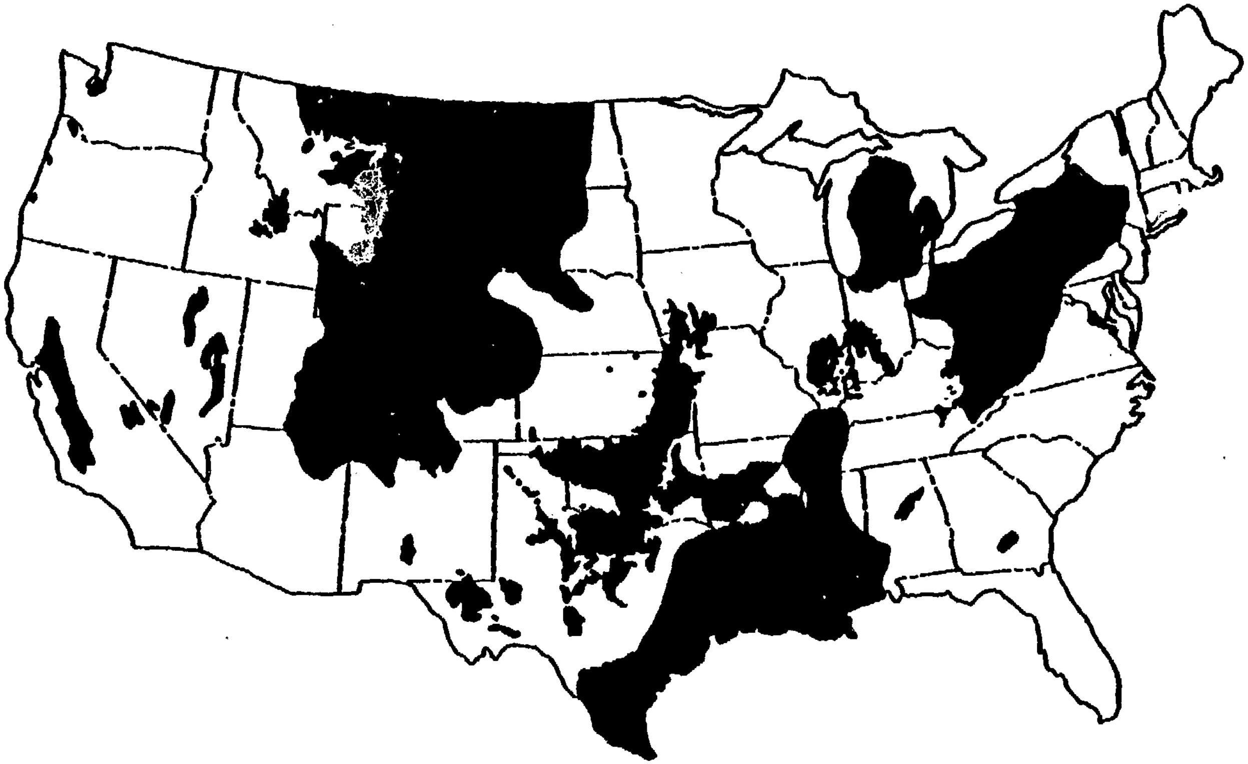


ROCK SALT DEPOSITS IN THE UNITED STATES
(AFTER PIERCE AND RICH, U.S.G.S. BULL. 1148)

Figure 5

OWI-76-25

ORNL-DWG 74-1641



Thick Bodies of Shale, Mudstone, and Claystone in the U.S.

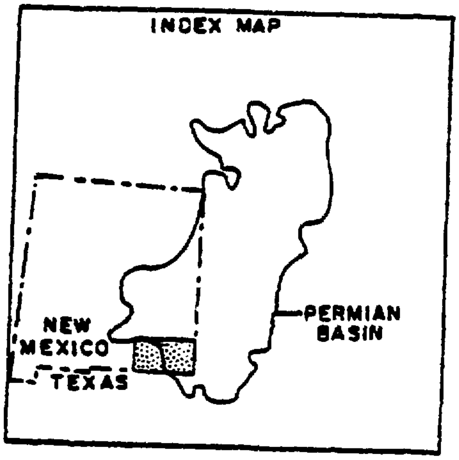
Crystalline and Volcanic Rocks in the U.S.

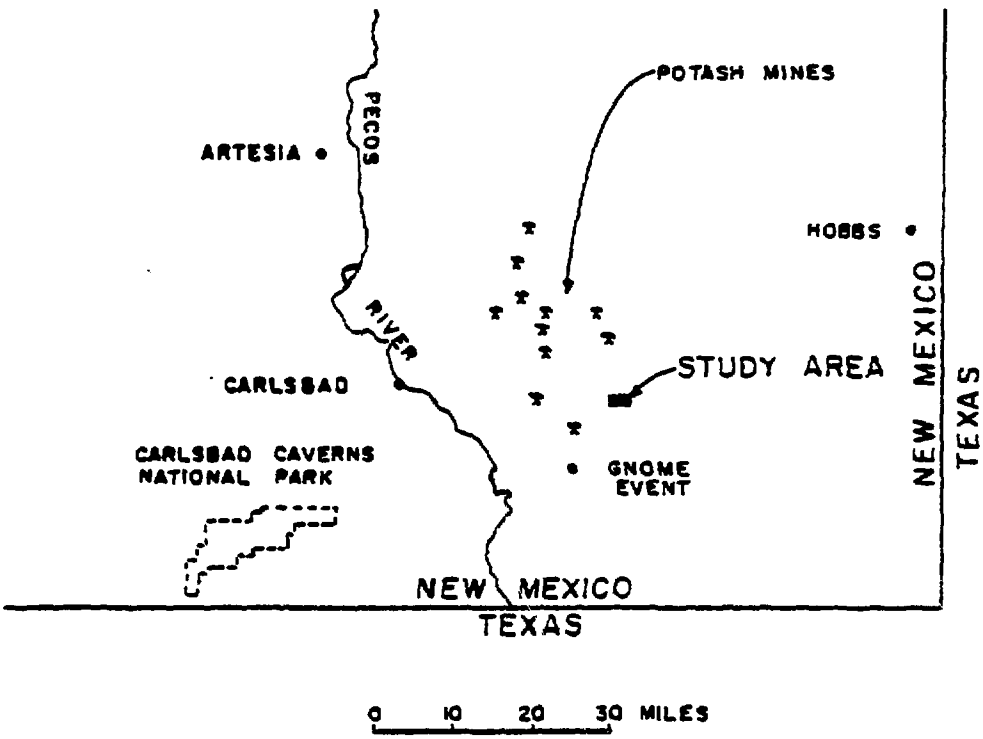
ORNL-LR-DWG 61939 R1

ADVANTAGES OF SALT FORMATIONS FOR STORAGE OF RADIOACTIVE WASTES

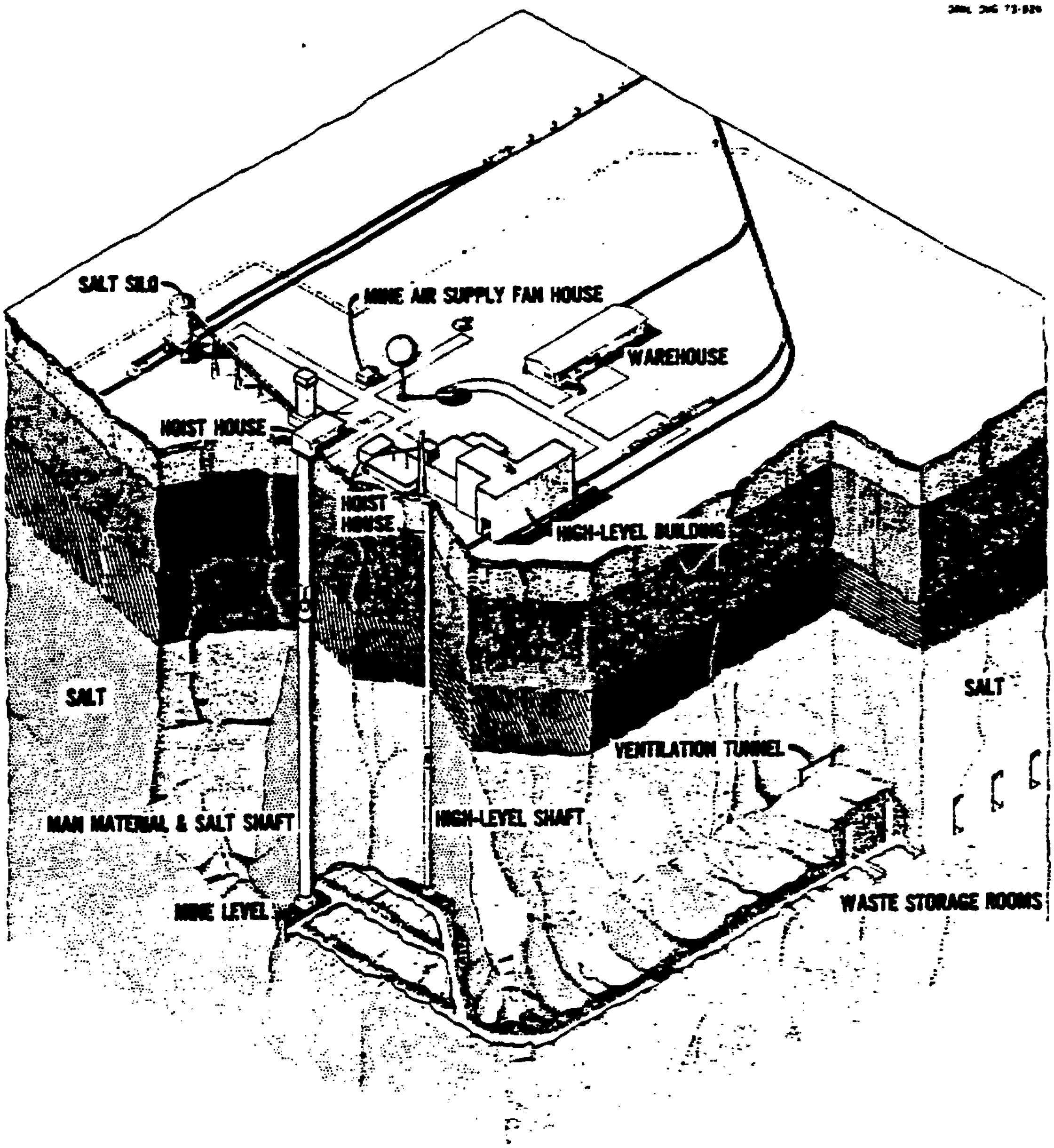
1. ESSENTIALLY IMPERMEABLE
2. WIDESPREAD AND ABUNDANT
3. HIGH STRUCTURAL STRENGTH
4. LOW COST OF DEVELOPING SPACE
5. GOOD THERMAL CONDUCTIVITY
6. LOCATED IN AREAS OF LOW SEISMICITY

ORNL DWG. 73-69 R1

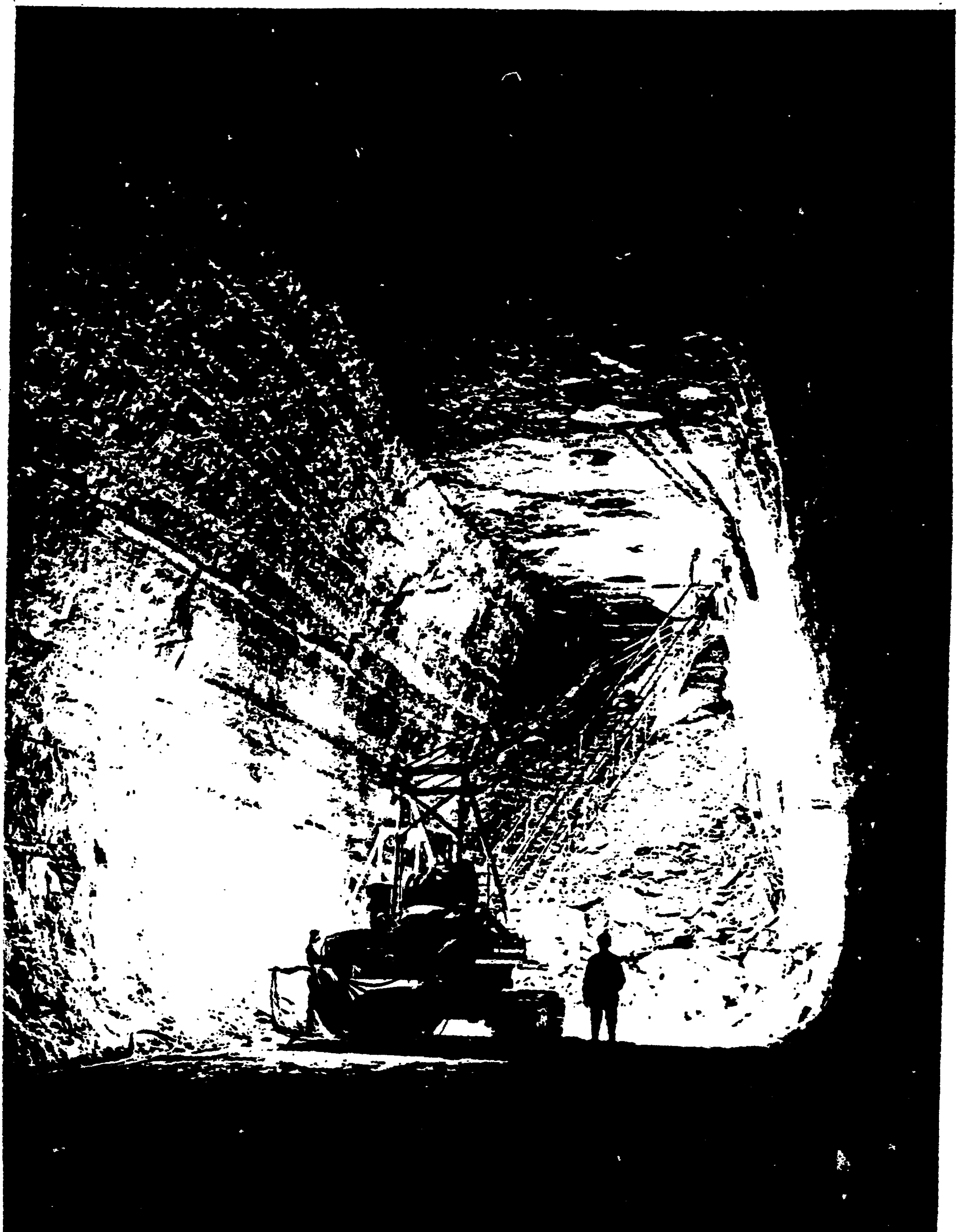




LOCATION MAP



PILOT PLANT REPOSITORY



ORNL DWG 79-627

DOE WASTE ISOLATION PROGRAM ELEMENTS

- WIPP (WASTE ISOLATION PILOT PLANT)
- PASCO BASIN BASALT
- NEVADA TEST SITE
- ONWI (OFFICE OF NUCLEAR WASTE ISOLATION)

ORNL DWG 79-628

WIPP

- RESPONSIBILITY: SANDIA, BECHTEL, WESTINGHOUSE
- MISSION: DEFENSE TRU WASTES, HLW EXPERIMENTS, PROPOSED SPENT FUEL STORAGE
- STATUS: SITE SELECTED IN BEDDED SALT 2200 FT BELOW SURFACE
- SCHEDULE: OPERATIONAL IN 1985/86

ORNL DWG 79-629

PASCO BASIN BASALT

- RESPONSIBILITY: ROCKWELL-HANFORD
- MISSION: COMMERCIAL SPENT FUEL OR HLW BUT HAS OBVIOUS APPLICABILITY FOR HANFORD DEFENSE WASTES
- STATUS: EXTENSIVE SITE INVESTIGATIONS; CONSTRUCTION UNDERWAY ON USTF (5000-FT TUNNEL SYSTEM) FOR TEMPERATURE AND MATERIALS TESTING
- SCHEDULE: OPERATIONAL IN 1990/92

ORNL DWG 79-630

NEVADA TEST SITE

- RESPONSIBILITY: SANDIA, LIVERMORE
- MISSION: COMMERCIAL SPENT FUEL AND HLW STORAGE/DISPOSAL
- STATUS: FIELD TESTS/INVESTIGATIONS OF GRANITE, ARGILLITE, TUFF, AND ALLUVIUM HAVE NOT SHOWN EXPECTED PROMISE TO-DATE
- SCHEDULE: UNCERTAIN

ORNL DWG 79-631

ONWI

- RESPONSIBILITY: BATTELLE MEMORIAL INSTITUTE
- MISSION: COMMERCIAL SPENT FUEL, HLW, TRU WASTES IN SALT, SHALE, AND GRANITE
- STATUS AND SCHEDULE
  - SITE SELECTED IN SALT DOME IN 1981
  - SITE SELECTED IN PARADOX BASIN SALT IN 1983
  - SITE SELECTED IN PERMIAN BASIN SALT IN 1983
  - SITE SELECTED IN SALINA BASIN SALT IN 1984/85
  - EFFORT INCREASING ON SHALE AND GRANITE

ORNL DWG 79-632

FOREIGN PROGRAMS

- WEST GERMANY
  - OPERATING LLW REPOSITORY IN SALT AT ASSE
  - PROPOSED LLW-HLW REPOSITORY IN SALT AT GORLEBEN
- SWEDEN - DESIGN/TESTING STUDIES OF GRANITE
- UK - HEATING TESTS IN GRANITE
- CANADA - DEVELOPMENT STUDIES IN GRANITE AND SALT
- BELGIUM - STUDIES OF CLAY DEPOSITS
- EAST GERMANY - OPERATING LLW REPOSITORY IN SALT
- USSR - APPARENTLY STUDYING SALT DEPOSITS