IDAHO CALCINE HLW TECHNOLOGY PROGRAM

DIETER A. KNECHT

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Idaho Chemical Processing Plant

HLW Status

- 3,500 m^3 HLW calcine and 7,500 m^3 HLW liquid currently stored at ICPP

- Land Disposal Restriction Storage Prohibitions prohibit storage of mixed high-level waste after May 1992. Mixed waste must have a demonstrated acceptable treatment in order to be stored or the generator must obtain statutory relief in the form of a variance petition

- DOE Order 5820.2A directs that all new and readily retrievalbe HLW be processed and disposed of in a geologic repository according to the requirements of the Nuclear Waste Policy Act

IDAHO CHEMICAL PROCESSING PLANT
HLW PROGRAM JUSTIFICATION

- EM HLW Program goal in 5-YR Plan - successful deployment of HLW disposal
- Recommendation of Ahearne Advisory Committee on Nuclear Facility Safety to convert DOE HLW to form suitable for disposal
- Specifications for HLW disposal in Nuclear Waste Policy Act, Regulations of DOE, NRC and EPA, and DOE-RW Waste Acceptance Specifications
- DOE Waste Reduction Policy Statement, 40 CFR 264.75 (h) and (i) and Pollution Prevention Act of 1990 require reduced waste volume
- DOE LDR Case-by-Case Extension Application and Temporary No-Migration Petition require completion of HLW Immobilization by 2014

DOE Defense HLW Background

- Three defense HLW sites: Savannah River (SRS), Hanford, and Idaho (ICPP)

- Defense Waste Management Plan issued to comply with Public Law 97-90

  - Reference plans for disposal of defense HLW and TRU

  - Orderly transition of HLW processing by 1994 at SRS, 1999 at Hanford, and 2014 at ICPP (current estimate)

  - Increased near-term ICPP funding required to support Plan

DOE/DP-0015

The Defense Waste Management Plan

June 1983

U.S. Department of Energy
Assistant Secretary for Defense Programs
Washington, DC 20585

- PUBLIC LAW 97-90, 1982
- REFERENCE PLANS FOR DISPOSAL OF HLW AND TRU FROM ATOMIC ENERGY DEFENSE ACTIVITIES

EXECUTIVE SUMMARY

Public Law 97-90, the Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1982, states that:

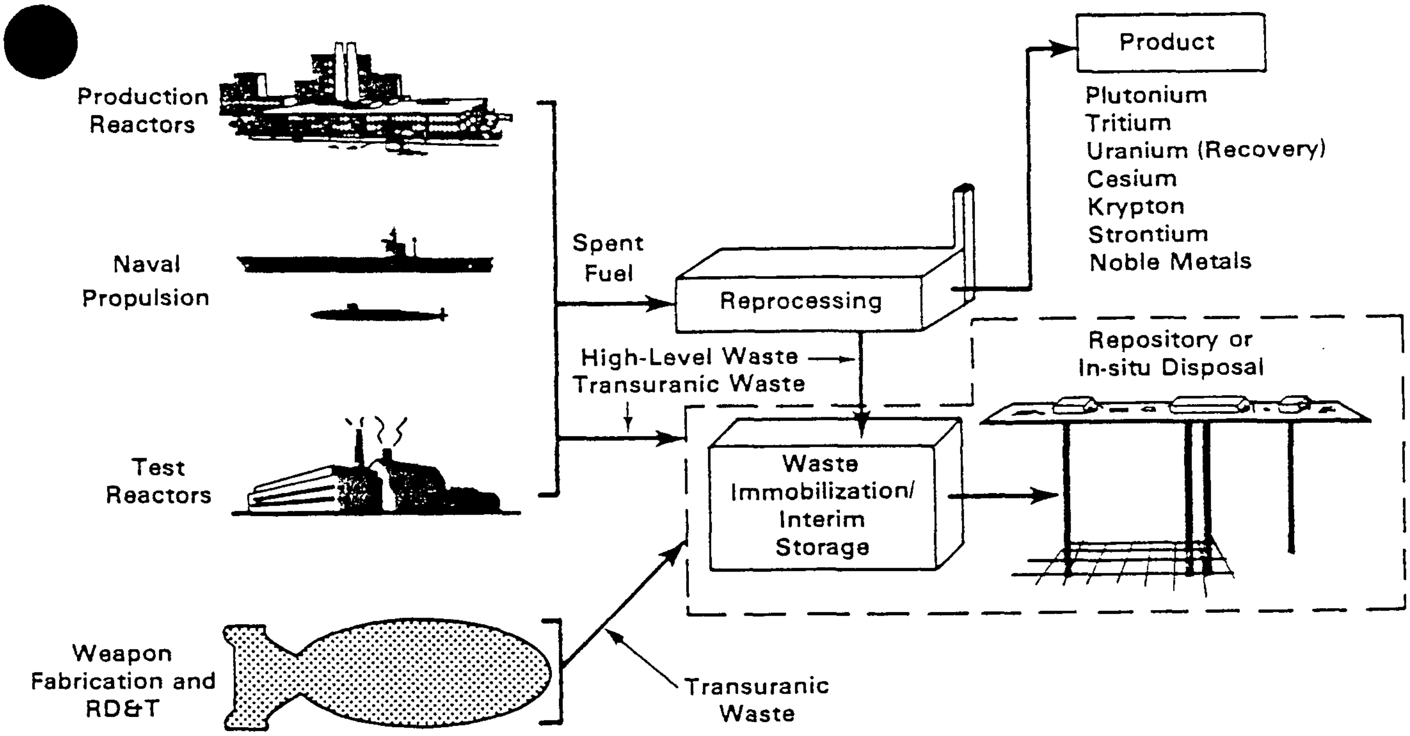
> "The President shall submit to the Committees on Armed Services of the Senate and of the House of Representatives not later than June 30, 1983, a report which sets forth his plans for the permanent disposal of high-level and transuranic wastes resulting from atomic energy defense activities".

According to the Atomic Energy Act of 1954, as amended, and the Department of Energy Organization Act, responsibility for radioactive waste and byproducts generated by DOE's nuclear activities belongs to the Secretary of the Department of Energy. The flow of materials and the resulting waste from the atomic energy defense activities addressed in P.L. 97-90 are illustrated in Figure E-1.

Defense high-level waste (HLW) and defense transuranic (TRU) waste are in interim storage at three sites, namely: at the Savannah River Plant, in South Carolina; at the Hanford Reservation, in Washington; and at the Idaho National Engineering Laboratory, in Idaho. Defense TRU waste is also in interim storage at the Oak Ridge National Laboratory, in Tennessee; at the Los Alamos National Laboratory, in New Mexico; and at the Nevada Test Site, in Nevada. (Figure E-2).

This document describes a workable approach for the permanent disposal of high-level and transuranic waste from atomic energy defense activities. The plan does not address the disposal of "suspect" waste which has been conservatively considered to be high-level or transuranic waste but which can be shown to be low-level waste. This material will be processed and disposed of in accordance with low-level waste practices.

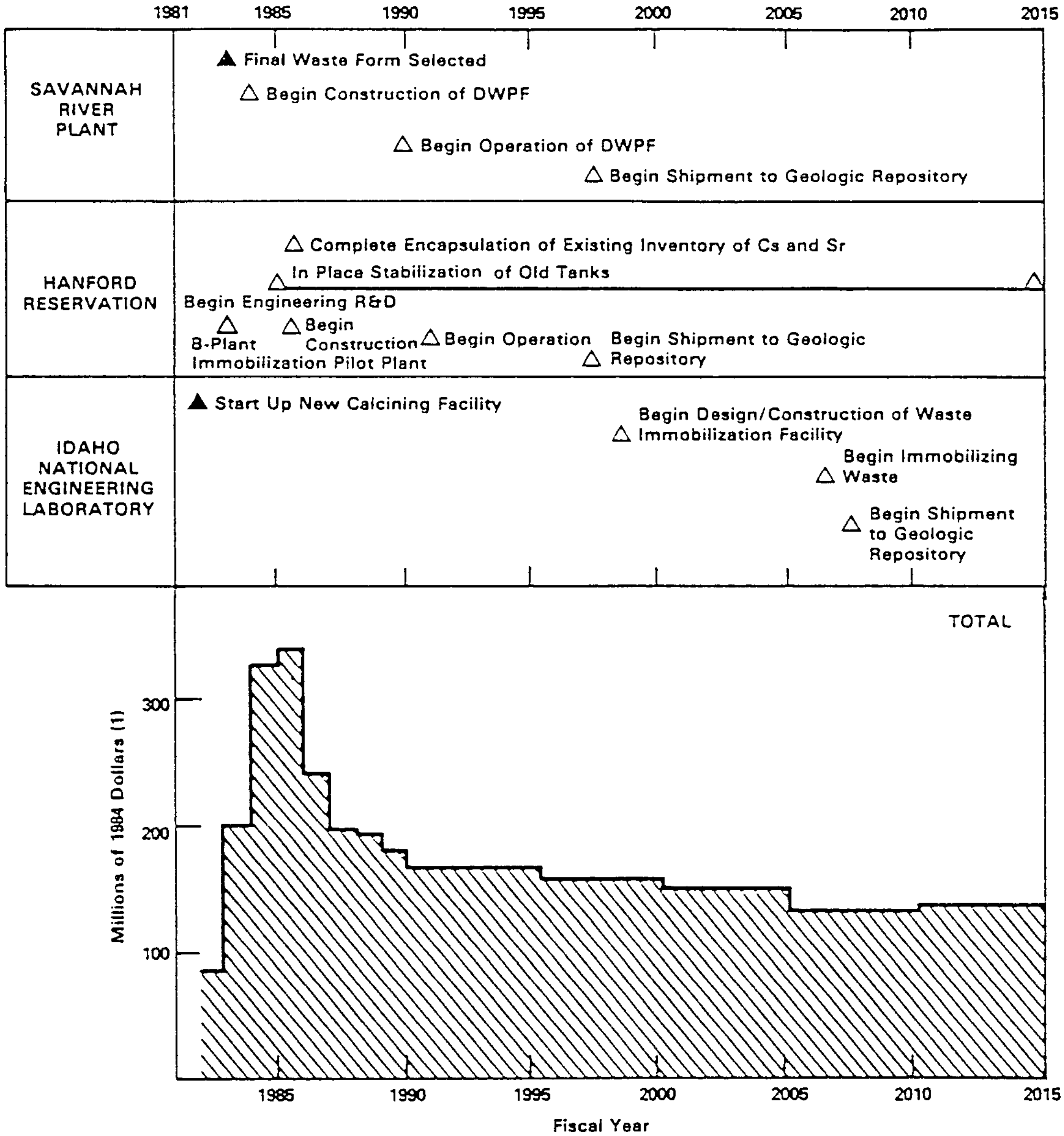
The primary goal of this program is to utilize or dispose of high-level and transuranic waste routinely, safely, and effectively. This goal will include the disposal



Note: The plan covers the outlined portion of the diagram.

FIGURE E-1

ATOMIC ENERGY DEFENSE ACTIVITIES. IRRADIATED FUELS FROM PRODUCTION, TEST AND NAVAL REACTORS ARE REPROCESSED TO SEPARATE PRODUCTS. THE WASTE FROM THESE ACTIVITIES AS WELL AS FROM WEAPON FABRICATION AND RESEARCH/DEVELOPMENT AND TESTING IS PROCESSED AND DISPOSED OF OR STORED PENDING DISPOSAL.



(1) Includes Cost for Transport to and Disposal in Geologic Repository.

△ Milestone

▲ Completed Milestones

FIGURE E-3

MAJOR MILESTONES AND COSTS FOR PERMANENT DISPOSAL OF DEFENSE HIGH-LEVEL WASTE

Savannah River Plant (SRP). High-level waste* from this site is readily retrievable and will be sent off-site for disposal in a geologic repository. Processing for disposal will begin at this site before the other two because it contains 75 percent of DOE's tanked waste radioactivity and because environmental factors are less favorable than at the other two sites. Savannah River Plant waste will be immobilized in the Defense Waste Processing Facility (DWPF) (Figure E-4) beginning in 1989.**

Hanford Reservation. Hanford's high-level waste tanks are isolated from the water table and contain much less radioactivity than tanks at the Savannah River Plant. Immobilization of new and readily retrievable high-level waste will begin about 1990 after sufficient experience is available from Savannah River's vitrification process.

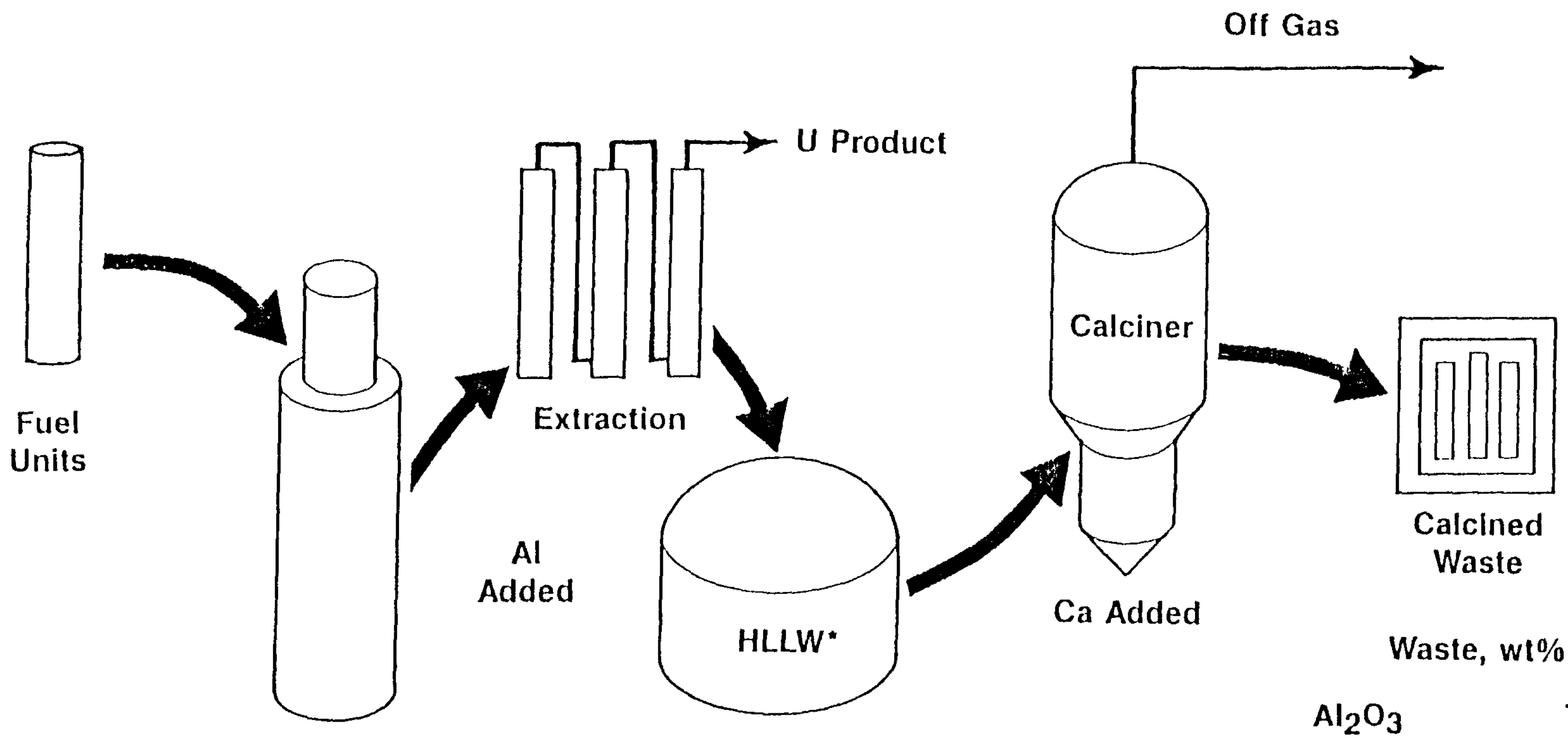
mes of stored waste and quantities of radioactive constituents
nown in Appendix B.

**All years shown in this plan are fiscal years.

High-Level Waste Characterization

- ICPP High-Level Waste is unique to the DOE reprocessing complex
  - Acidic solution, HF and HNO_3
  - Contains the spent fuel cladding material (Zr, Al) plus radionuclides
  - Contains additives to prevent criticality, Stabilize dissolver products and reduce corrosion (B, Cd, Aluminum Nitrate)
  - Routinely calcined and stored as solid
- Savannah River/Hanford/West Valley Wastes
  - Stored as liquid in basic form, $Al(OH)_3$ and NaOH
  - Consists of sludge, supernatant and salt cake

Source of Chemicals in ICPP High Level Wastes

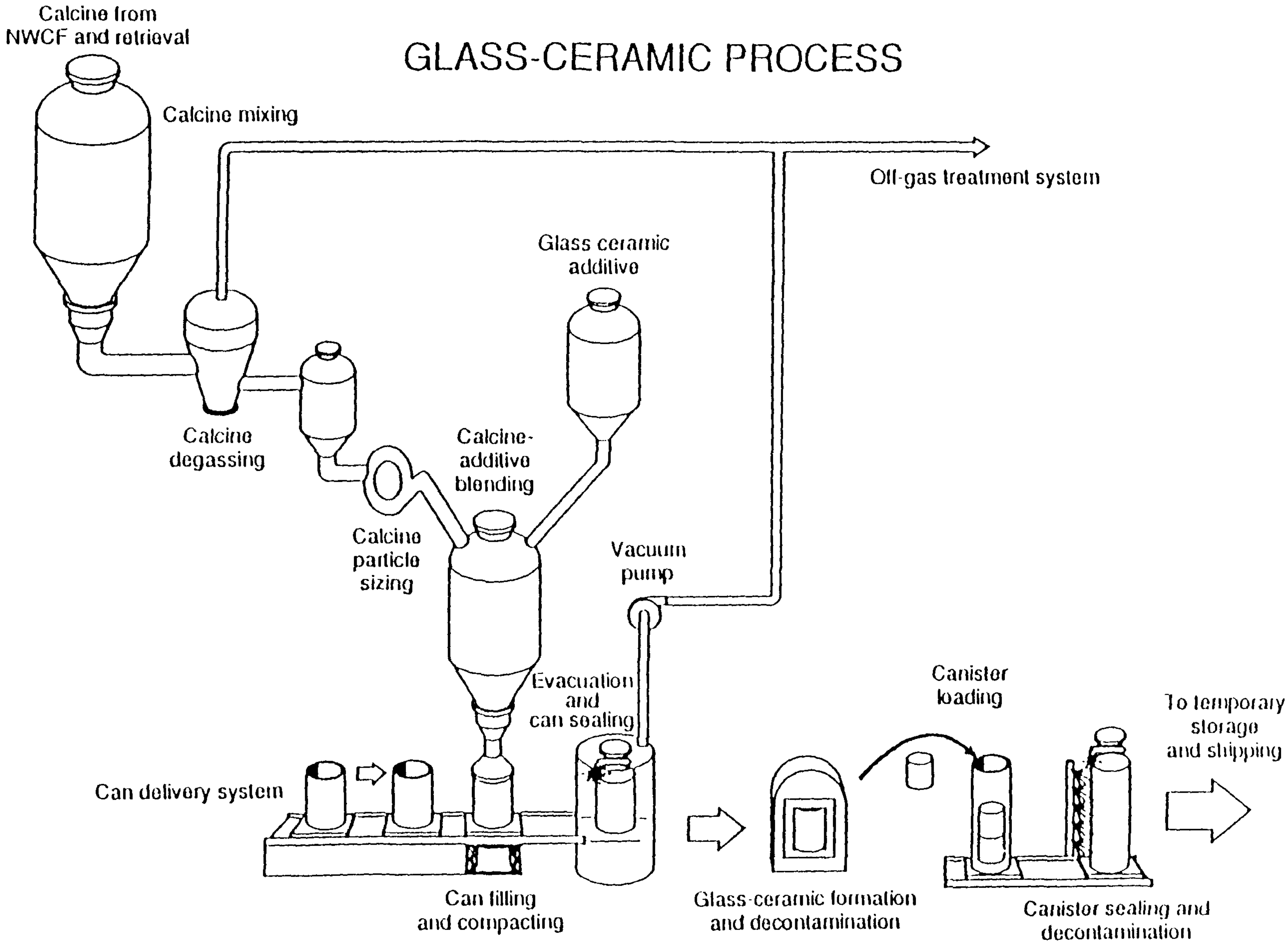


Waste, wt%	
Al_2O_3	7
ZrO_2	19
CaF_2	43
CaO	12
Cd,B Oxide	9
Na,K Oxide	6
Other	4
Total	100

* HLLW is acidic
HNO_3 and complexed HF solution

ICPP-S-11557D
(8-91)

GLASS-CERAMIC PROCESS



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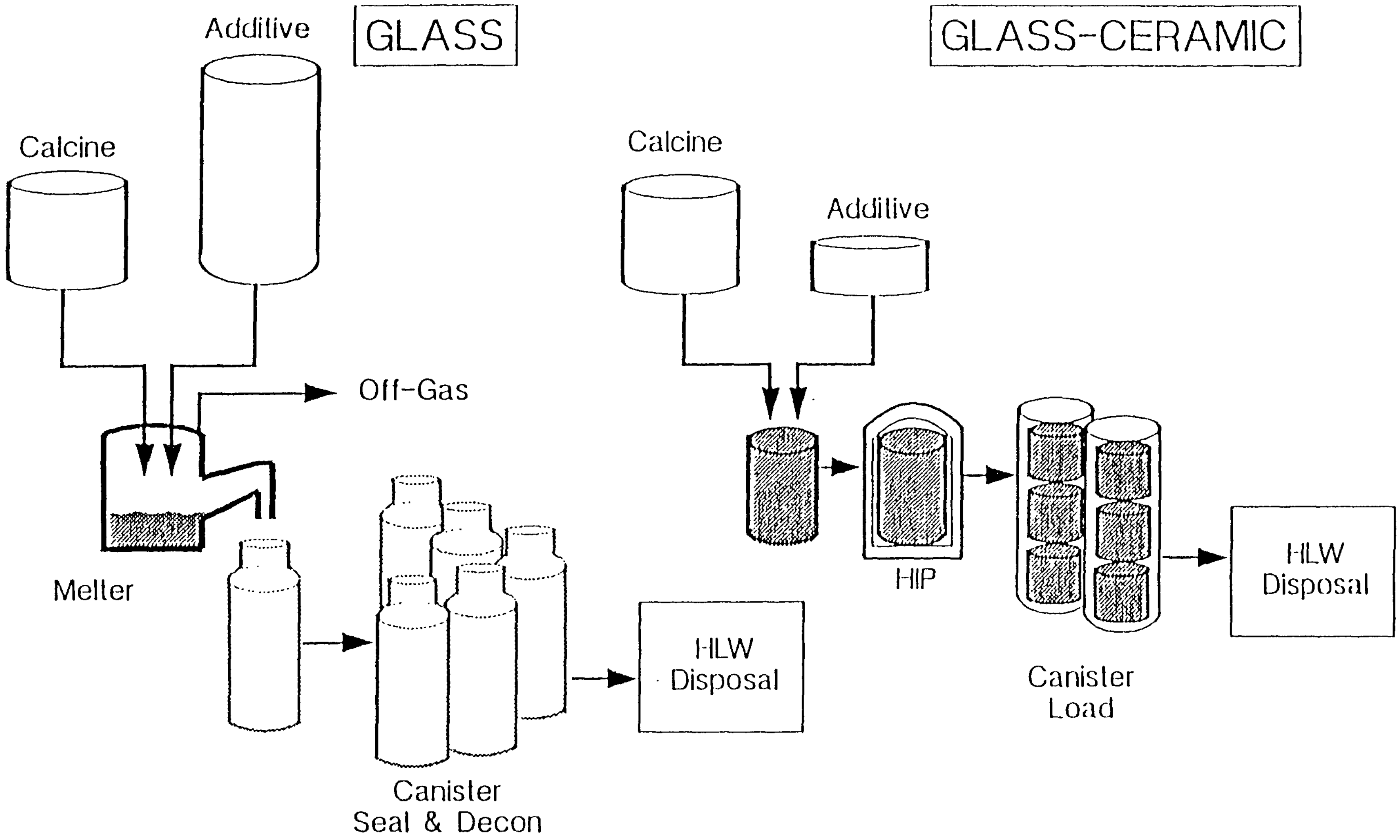
Idaho HLW Immobilization Program

Canisters of Immobilized HLW

	Existing Calcine	Existing NA-HLLW	Future NA-HLLW	Total
Glass	4970	3315	1325	9615
Glass-Ceramic / Calcine	1950	1300	520	3770
Glass / Pyrochemical	450	300	120	870
Glass / Ceramic / Pyrochemical	170	115	45	330

Conceptual ICPP HLW Immobilization Processes
Relative Volumes



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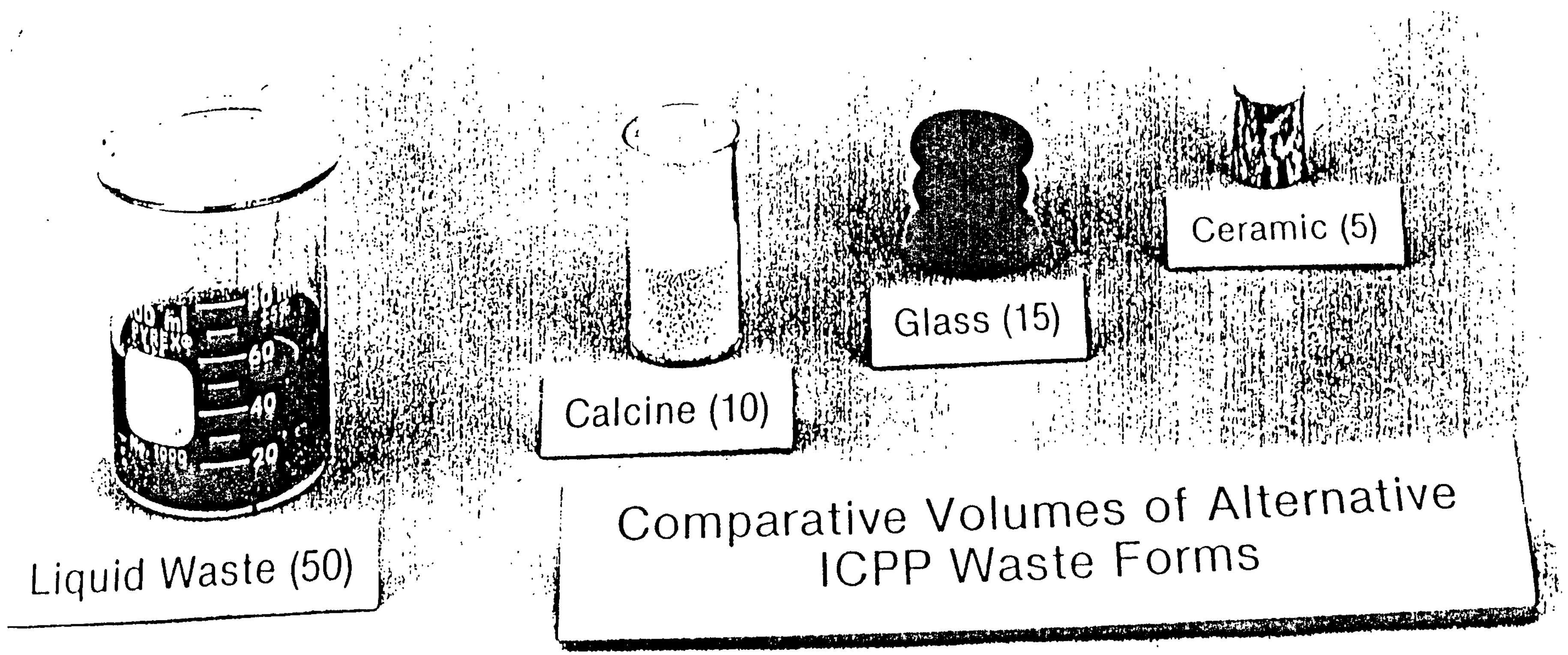
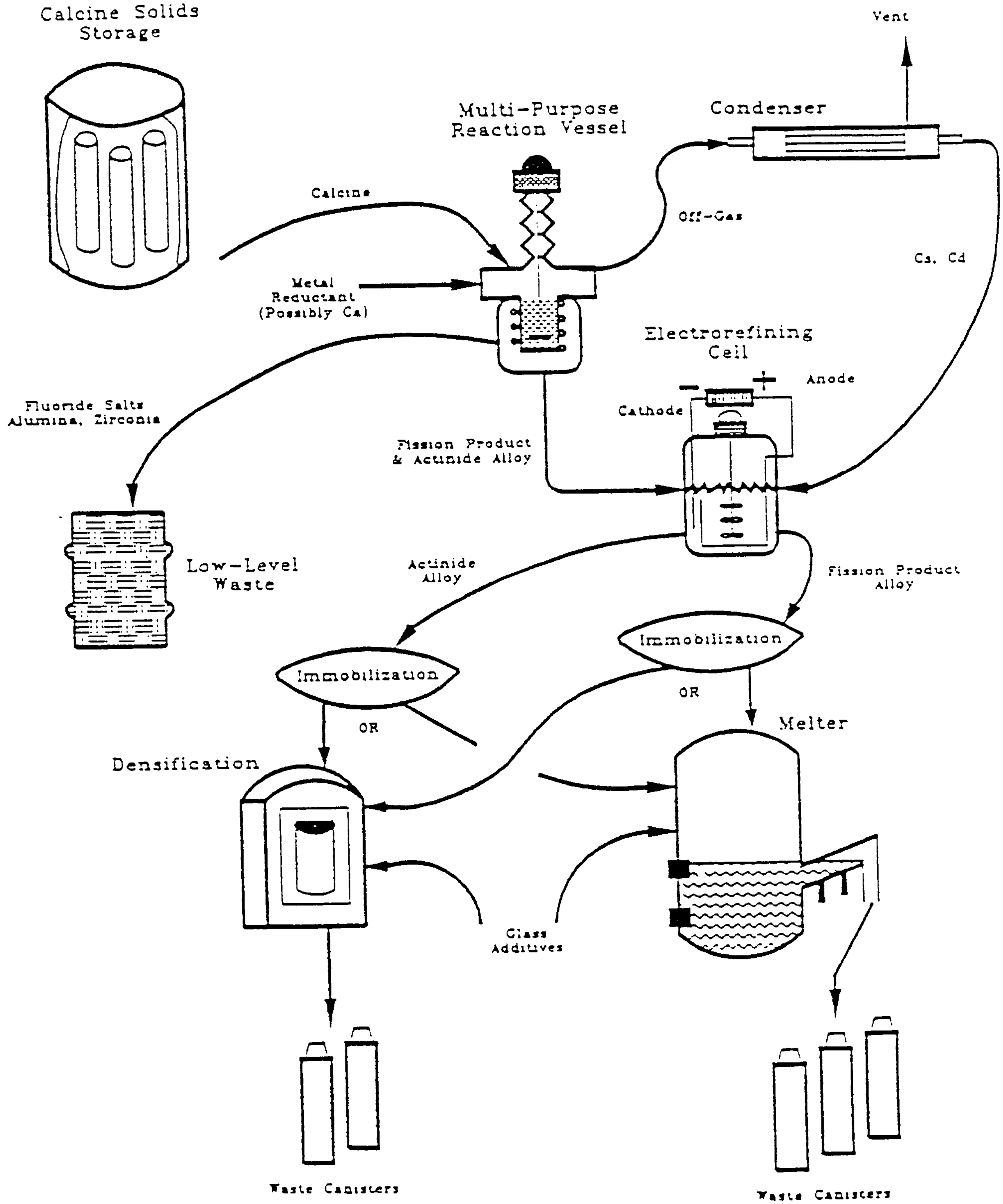

Liquid Waste (50)
Calcine (10)
Glass (15)
Ceramic (5)
Comparative Volumes of Alternative
ICPP Waste Forms

Pyrochemical Treatment of HLW Calcine



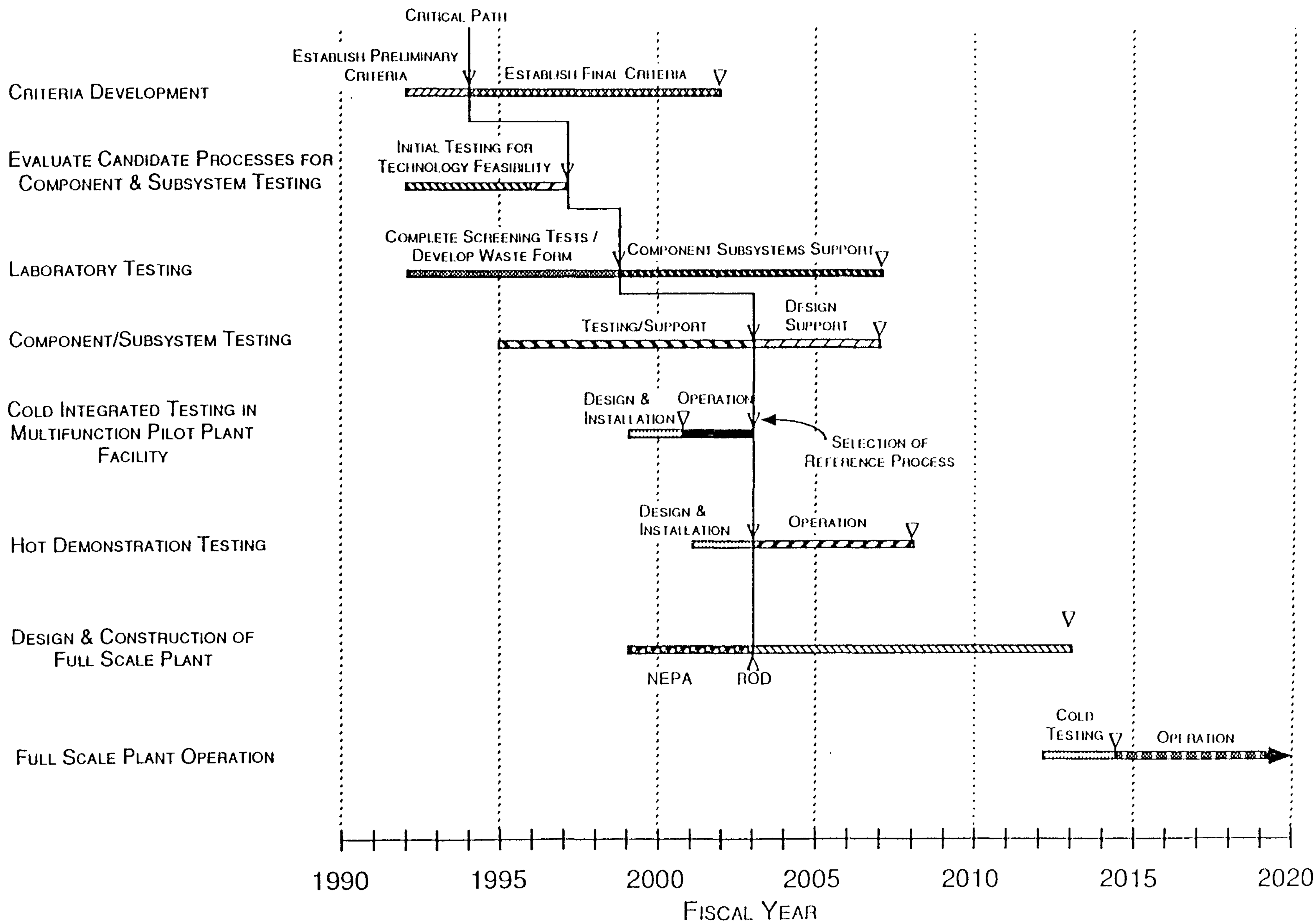
Pyroprocessing of HLW Calcine

- Heating and distillation of volatile species
- Separation of ZrO_2, Al_2O_3, CaF_2, CaO from radioactive and hazardous components.
- Reduction and electrorefining can then be performed on the remaining material.

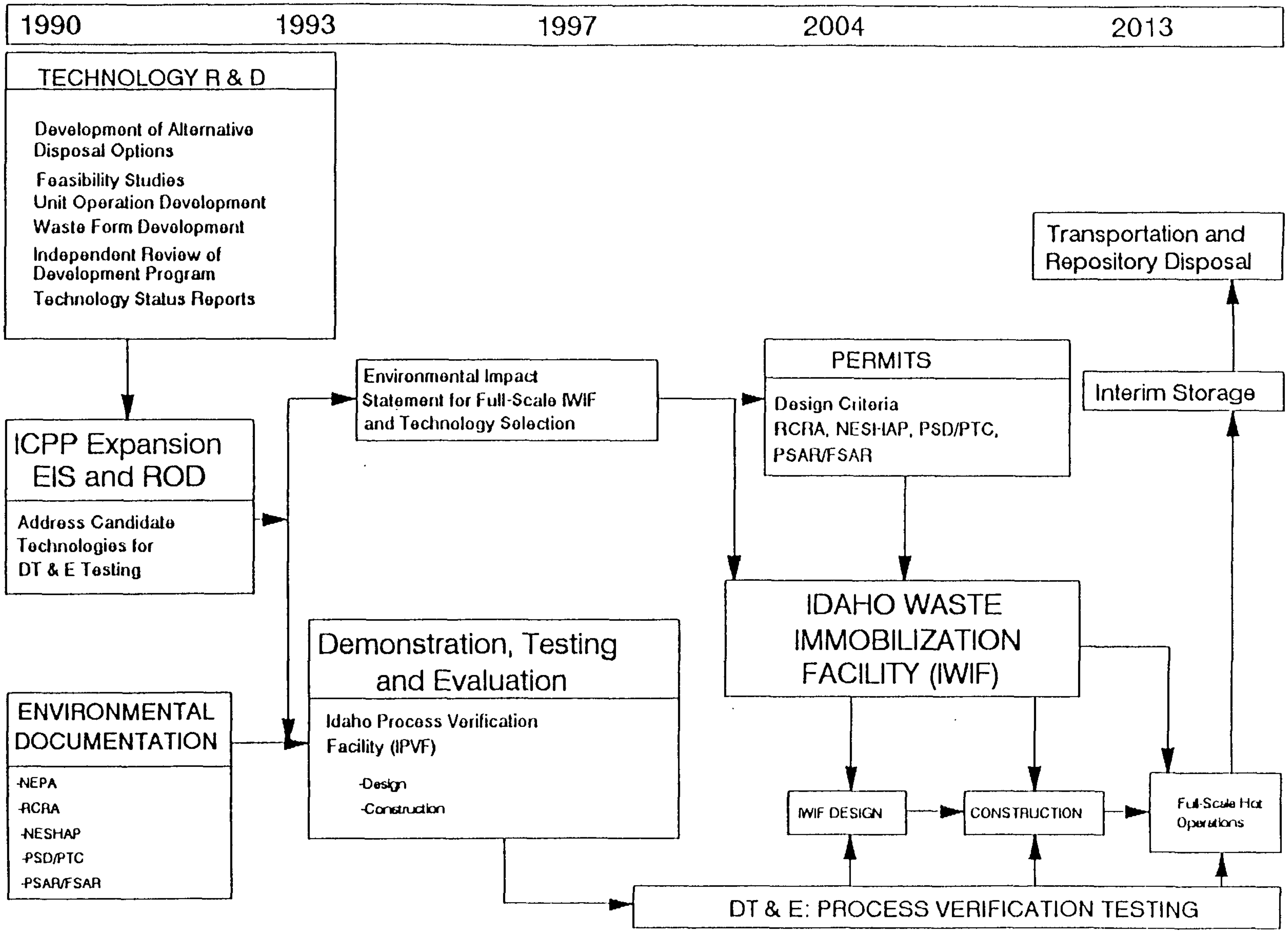
Calcine Pyroprocessing Issues

- Must demonstrate initial separation
- Not demonstrated on large scale in radioactive environment.
- May reduce HLW volume by factor of 7 for existing calcine.
- LLW volume will be about volume of original calcine.

ICPP HLW Calcine Disposal Program Plan



WASTE IMMOBILIZATION FACILITY INTEGRATION



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HLW Technical Development and Process Verification
FY-1991 Major Accomplishments

- Pilot-plant mock-up units fabricated to test feasibility of particle sizing, calcine blending, and solids flow valves
- Glass-ceramic forms prepared, leach-tested, and characterized for glass and crystalline microstructure showed leaching similar to acceptable HLW glass
- Glass prepared from neutralized HLW liquid did not have acceptable waste loadings
- Milestone reports on BDAT vitrification and glass-ceramic, including flowsheets issued:
    - Vitrification not cost effective because of large HLW volume
    - Unit operations identified for pilot-plant testing
- Proposal developed for new high-risk, large payback pyrochemical treatment of calcine

Idaho HLW Immobilization Program

Leach Rates of Candidate HLW Forms

Normalized MCC-1 Leach Rate at 90°, g/m^2-day

	Boron	Silicon	Sodium	Total Mass
Glass-Ceramic (70 wt% Calcine)	0.08	0.3	0.5	0.2
Glass (33 wt% Calcine)	0.5	0.8	0.6	0.3

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Table 2.13. Representative chemical composition of current and future HLW liquid at ICPP[a]

Component	Composition, wt %			
	Zirconium fluoride	Sodium bearing	Nonfluoride	Fluorinel
Al	1.3	0.8-1.6	1.51	0.742
B	0.15	0.005-0.01	0.003	0.241
Ca	—	0.03-0.2	0.27	—
Cl^-	—	0.06-0.1	0.023	—
Cd	—	—	1.42	—
Cr	—	—	0.036	0.0087
F^-	3.4	0.005-0.06	0.032	5.99
Fe	0.04	0.05-0.09	0.19	0.023
H^+	1.12	0.03-0.15	0.12	0.18
K	1.12	0.03-0.15	0.33	—
Mg	—	—	0.062	—
Mn	—	—	0.048	0.0004
Na	0.12	2.1-4.0	1.31	—
Ni	—	—	0.016	0.0049
NO_3^-	13.7	19.4-23.3	23.1	11.47
SO_4^{2-}	—	0.33-0.5	0.65	1.52
Zr	2.47	—	—	3.80
H_2O	76.6	76.6-69.2	70.9	76.0
	100.0	100.0	100.0	100.0
Density, g/mL	1.2	1.2-1.3	1.2	1.2

[a]Taken from U.S. Department of Energy, Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/RW-0006, Rev. 1 (December 1985).

Table 2.14. Representative chemical composition of current and future HLW calcine at ICPP[a]

Component	Composition, wt %				
	Alumina	Zirconium fluoride	Zirconium-sodium blend	Stainless steel sulfate	Fluorinel-sodium blend
Al_2O_3	82.0-85.0	13.0-17.0	10.0-16.0	4.4	6.5-7.5
$Al_2(SO_4)_3$	-	-	-	81.0	-
B_2O_3	0.5-2.0	3.0-4.0	2.0-3.0	-	3.0-3.2
CaO	-	2.0-4.0	13.0-17.0	-	3.3-3.6
CaF_2	-	50.0-56.0	33.0-39.0	-	46.0-48.0
Cd	-	-	-	-	6.0-6.5
Cr_2O_3	-	-	-	2.0	0.05
Fe_2O_3	-	-	-	7.0	0.2-0.3
Na_2O	1.3	-	6.0-8.0	-	10.0-15.0
NiO	-	-	-	0.9	0.02-0.03
NO_3^-	5.0-9.0	0.5-2.0	7.0-9.5	-	10.0-15.0
SO_4^{2-}	-	-	-	-	-
ZrO_2	-	21.0-27.0	16.0-19.0	-	10.0-20.0
Miscellaneous	0.5-1.5	0.5-1.5	0.5-1.5	4.4	-
Fission products and actinides	0.2-1.0	0.2-1.0	0.2-1.0	0.2-1.0	0.2-1.0
Density, g/mL	1.1	1.4	1.8	1.2	1.4

[a]Taken from U.S. Department of Energy, Spent Fuel And Radioactive Waste Inventories, Projections, and Characteristics, DOE/RW-0006, Rev. 1 (December 1985).

Table 2.15. Representative radionuclide composition of current HLW at ICPP[a]

Radionuclide	Liquid (10^6 Ci)	Calcine (10^6 Ci)
^{90}Sr	1.738	13.139
^{90}Y	1.738	13.139
^{106}Ru	0.024	0.010
^{106}Rh	0.024	0.010
^{134}Cs	0.107	0.192
^{137}Cs	1.901	14.512
^{137m}Ba	1.798	13.728
^{144}Ce	0.067	0.040
^{144}Pr	0.067	0.040
^{147}Pm	0.000	0.0790
^{154}Eu	0.023	0.093
Total	7.487	55.693
Specific activity, Ci/L	0.88	15.9

[a]Taken from ref. 3. Curies as of December 31, 1990. Similar values for actinide nuclides are not available.