Challenges to Cleanup – K Basin Sludge

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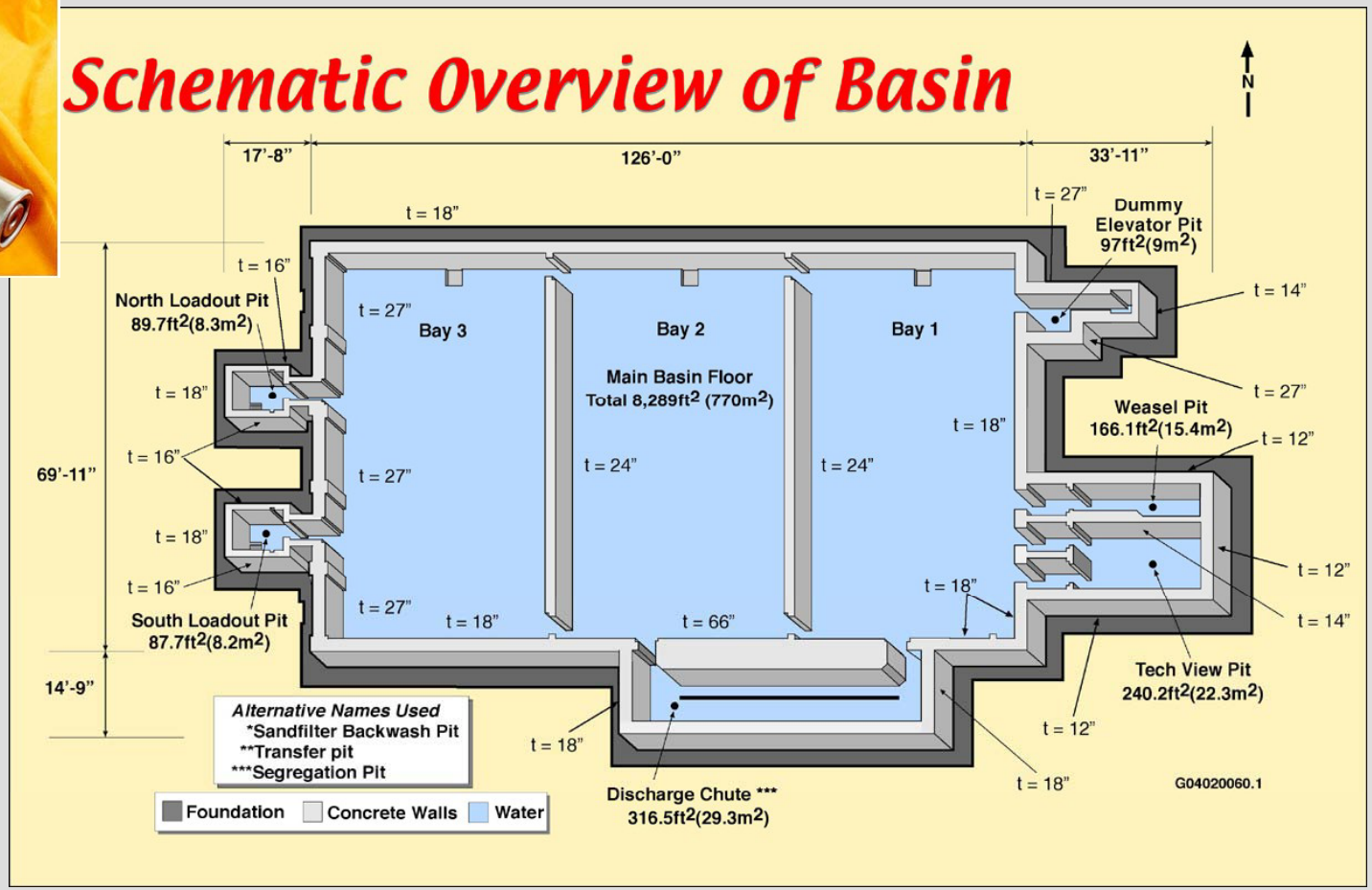
Prepared for National Academies Review
In Support of Cleanup Technology Roadmap
October 31, 2007

PNNL-SA-57802

Outline

- Background on sludge
  - What is sludge?
  - Where is sludge now?
- Why is handling and treatment a challenge?
- Evolving path-forward and PNNL technical role
- Current disposition path-forward
- Current challenges

Sludge Origin – N Reactor Spent Fuel Storage



What is Sludge? – Particulate <¼ inch

Sludge Source

- N Reactor fuel
- Corroded components
- Hanford soils
- Basin operations

Sludge Component

- U metal particles
- Iron, aluminum, and uranium (hydr)oxides
- Silica, basalt, and clay
- Sand (sand filter), ion exchange materials, spalled concrete, PCBs

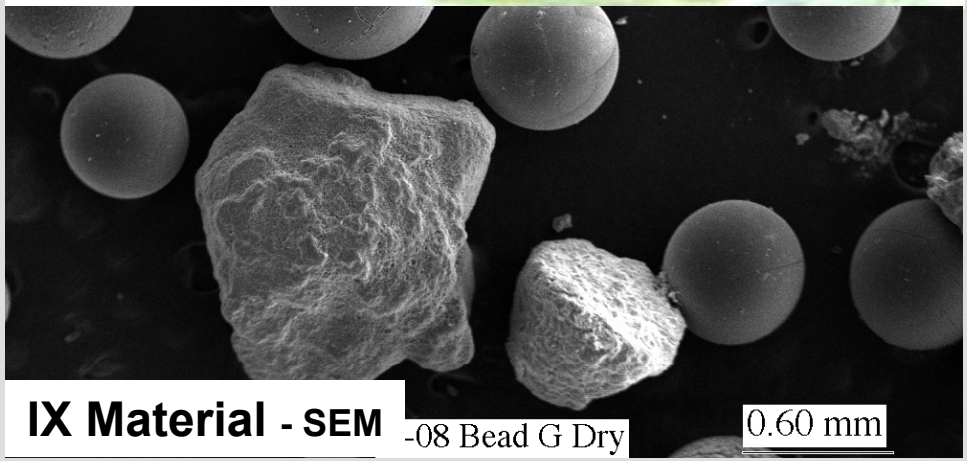
Uranium Metal-Bearing K Basin Sludges Generated Hydrogen Gas In Hot Cell

KE Canister Sludge 96-06

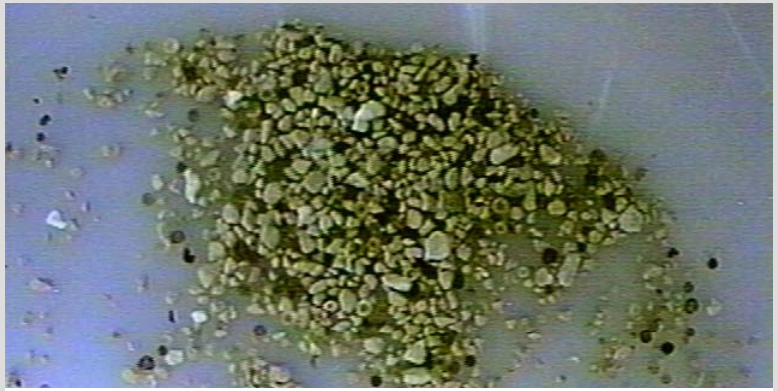
KW Canister Sludge 96-17

K Basin Sludges Also Contain Oxidized Uranium Compounds and IX Materials

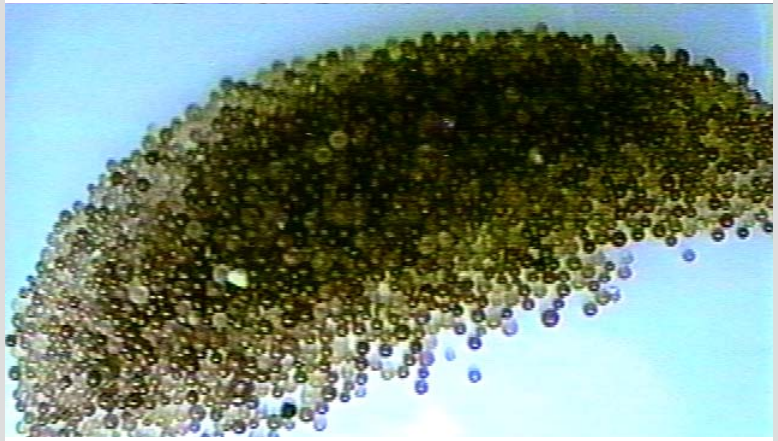
KE Floor Sludge



IX Material - SEM



Mordenite - $(Ca,Na_2,K_2)Al_2Si_{10}\cdot 7H_2O$



Strong Acid/Base IX - NRW-37

Where is Sludge Currently Stored?

Sludge has been consolidated into three locations in KW

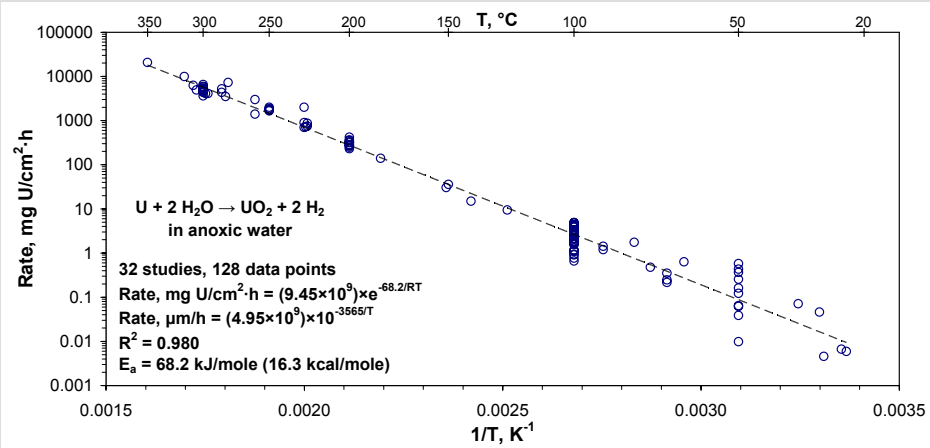
- **Container sludge**
  - 45 m^3 in 5 Engineered Containers
  - Source: floors, pits, KE canister sludge
- **Settler sludge**
  - 5.4 m^3 in 10 horizontal tubes
  - Particulate, <600/500 µm, from fuel & canister washing.
- **KOP sludge**
  - 0.26 m^3 in ~30 containers
  - Particulate, 500 µm to ¼ in. (6350 µm), from fuel & canister washing.

Sludge Stream Descriptions

Stream	Container	Settler	KOP/Strainer
Volume, m^3	45	5.4	0.26
Al, dry wt%	~8	~2	~1
Fe, dry wt%	~20	~1	~1
Si, dry wt%	~3	<1	~1
U, dry wt%	~17	~81	~91
U metal, dry wt%	~1.2	~2.7	~86
H_2O, wt% (settled sludge)	~52	~22	~8
Particle size	<6350 µm	<600 µm	>600, <6350 µm
Primary phases	$Al(OH)_3$, $Fe(OH)_3$, SiO_2, $UO_3 \cdot 2H_2O$, UO_2, OIER	$Al(OH)_3$, $Fe(OH)_3$, UO_2, $UO_3 \cdot 2H_2O$	U, UO_2, Grafoil, $Al(OH)_3$

Why Is Sludge Handling/ Treatment a Challenge?

- **High Activity** – Remote handling; sludge among highest dose radioactive material on Hanford Site.
- **Contains Uranium Metal** – <0.5 wt% to >20 wt%. U metal is pyrophoric and reacts with water to generate H_2; disposal must address this hazard.
- **No Quick/Direct Analytical Method for U Metal** – Current technique is to react with water in sealed vessel and measure hydrogen and fission product gases (rate at 100°C = 1.4 μm/h; 14 weeks for ¼-inch particle).



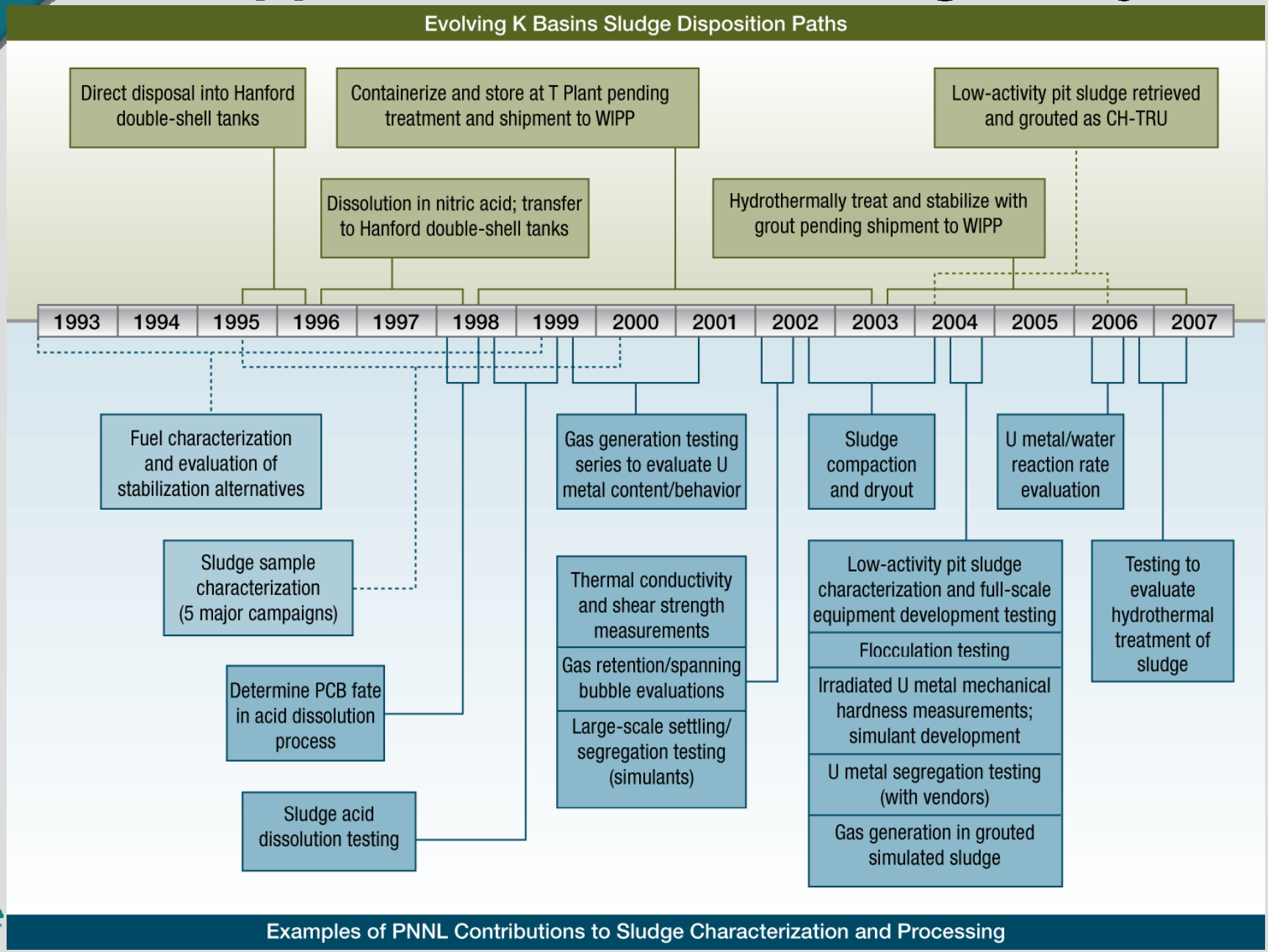
Why Is Sludge Handling/ Treatment a Challenge?

- **Difficult to Handle** – Sludge is heterogeneous, consisting primarily of particles <250 µm, but also containing up to ¼-in. U metal fragments. Particle densities range from near 1 g/cm^3 (ion exchange resin) to 19 g/cm^3 U (U metal). Much is highly dispersible (dose; airborne contamination in Basin).
- **Widely Variable Composition** – Three sludge types exist with large variations in physical form and chemical and radiological composition.

Evolving Pathforward for Disposition

Sludge Disposition Path	Reason for Change
Direct disposal into Hanford double-shell tanks – 1995-6	Tanks could not accept sludge w/o treatment
Dissolution in nitric acid; transfer to Hanford double-shell tanks – 1996-8	High treatment costs; disposal of TRU heel
Containerize & store at T Plant pending treatment & ship to WIPP – 1998-2003	Cost to continue T Plant ops. deemed excessive
Hydrothermally treat; stabilize with grout pending shipment to WIPP – 2003-7	Inadequate technical maturity
Direct grout Container; sample & char. Settler & KOP to det'n. if OK for WIPP – 2007→	Current path

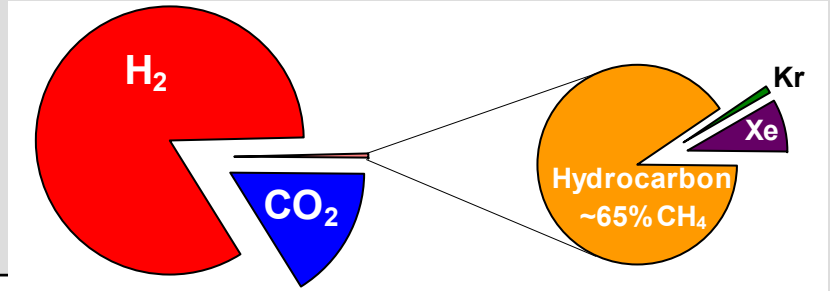
PNNL Support to K Basins Sludge Project

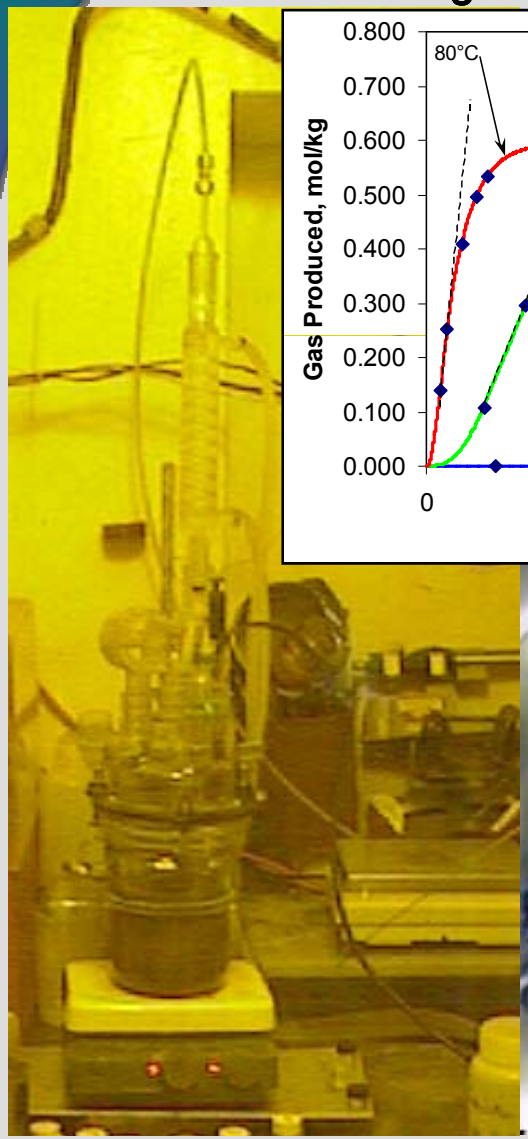


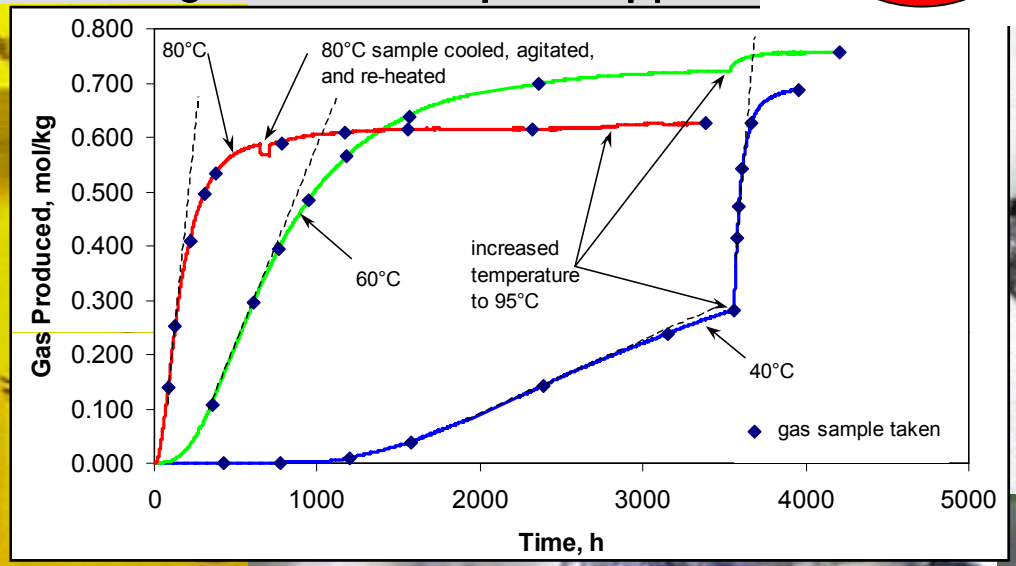
Battelle

PNNL Contributions

Sludge characterization; process testing; sludge archival; expert support







Current Disposition Pathforward

Containerized Sludge

- Direct grout (no treatment) pending shipment to WIPP
- Complete Conceptual Design (CD-1) by 9/30/08

Settler Tank and KOP Sludge

- Sample and characterize to allow validation of appropriateness for disposal to WIPP

Technical Challenges to Dispose Sludge to WIPP

- U metal in grout affects ability to ship to WIPP due to H_2 generation.
- U metal content distribution likely has changed since original measurements.
  - Need fast/reliable method to quantify U metal in sludge matrix
    - H_2 gas generation and fission product release in water (slow)
    - Eddy current techniques (immature)
    - Selective uranium phase dissolution in acid (?; under dev.)

Technical Challenges to Dispose Sludge to WIPP

- WIPP shipment protocols focus on radiolytic flammable gas generation.
- May need to measure H_2 generation rate for all sludge packages (drums).

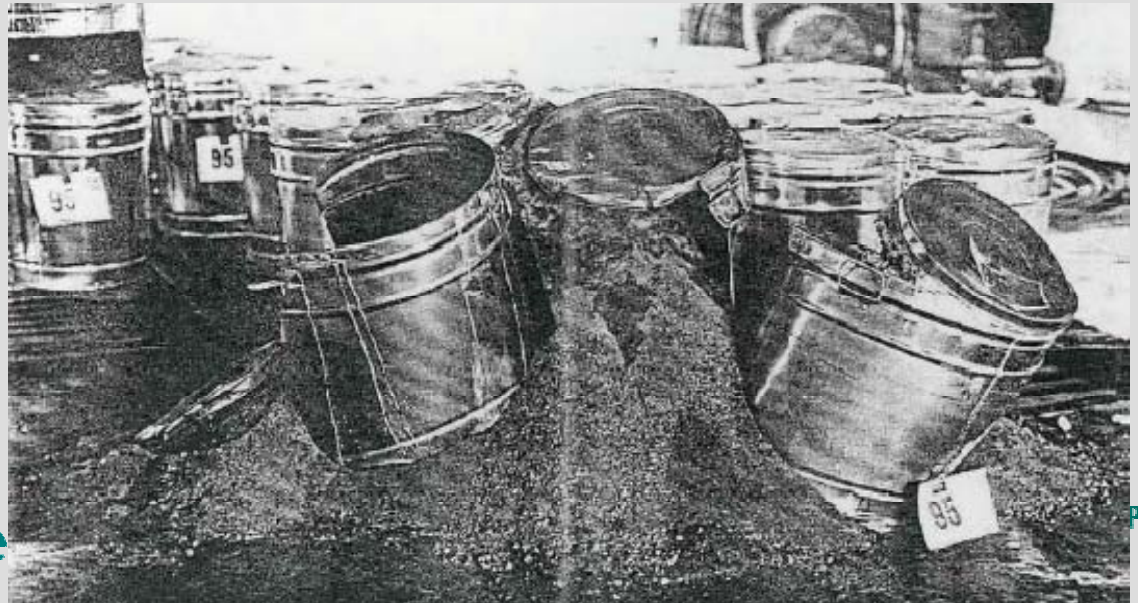
Challenge: Devise reliable test protocol to address the potential onset delay for H_2 generation due to induction period and presence of O_2.

Technical Challenges to Dispose Sludge to WIPP

- Develop approach to mitigate U metal water reaction or capture H_2.
  - Grout matrix has only small impact on reaction rate.
  - Limited testing and modeling (ESP) shows that H_2 is consumed in reduction of U(VI) to U(IV) in sludge matrix. Further work necessary to demonstrate predictability of this approach.
  - Oxygen poisoning can delay onset of more rapid anoxic (H_2-producing) corrosion.

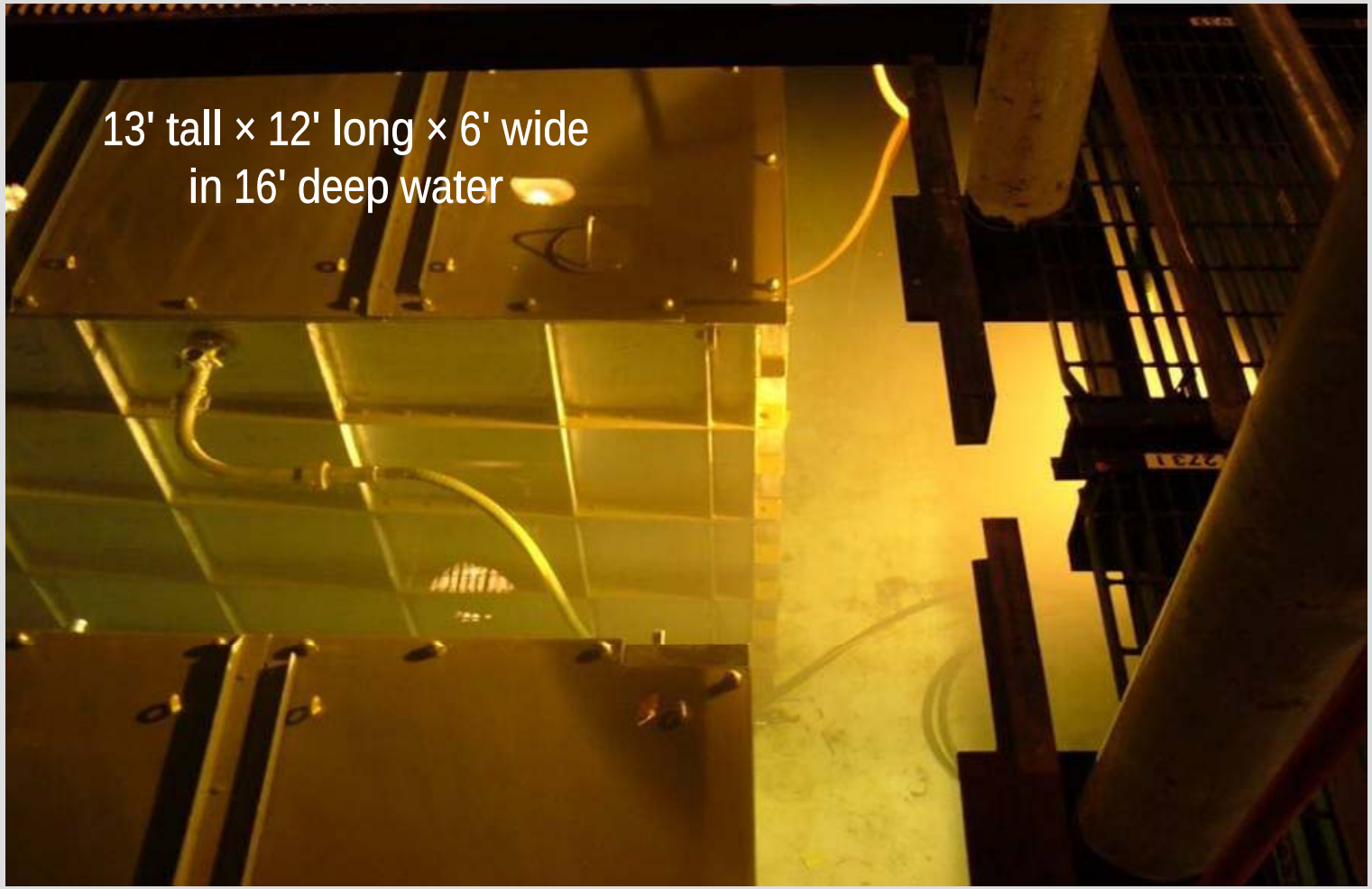
Key Challenges for Disposition of KOP

- Designation as TRU may be challenged.
- Treatment (U metal oxidation) likely to be necessary to meet WIPP RH TRAMPAC due to expected high U metal concentrations.
- Many alternatives have been evaluated, but oxidative treatment (e.g., hydrothermal, HNO_3, NaOCl, H_2O_2/CO_3^{2-}) approach is not yet defined.



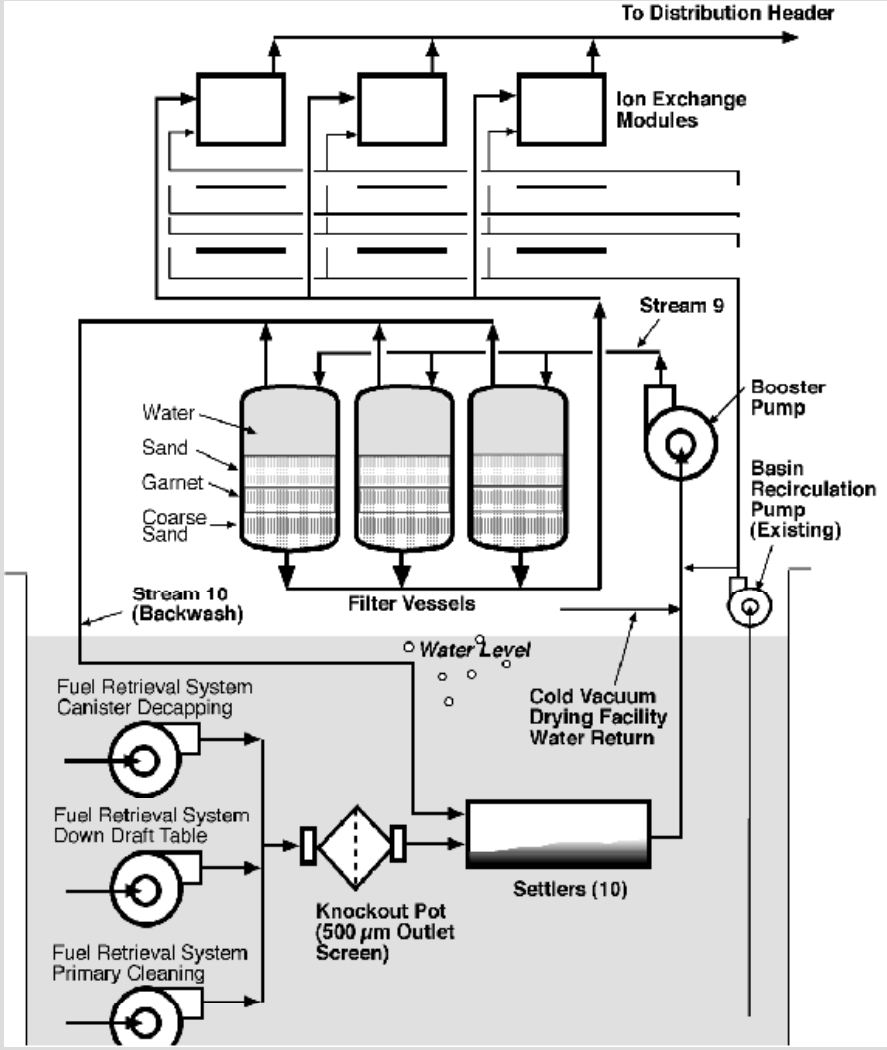
Aftermath of direct-grouting U metal fuel fabrication turnings.
Hanford – 1980.

K West Center Bay – Sludge Containers



Integrated Water Treatment System

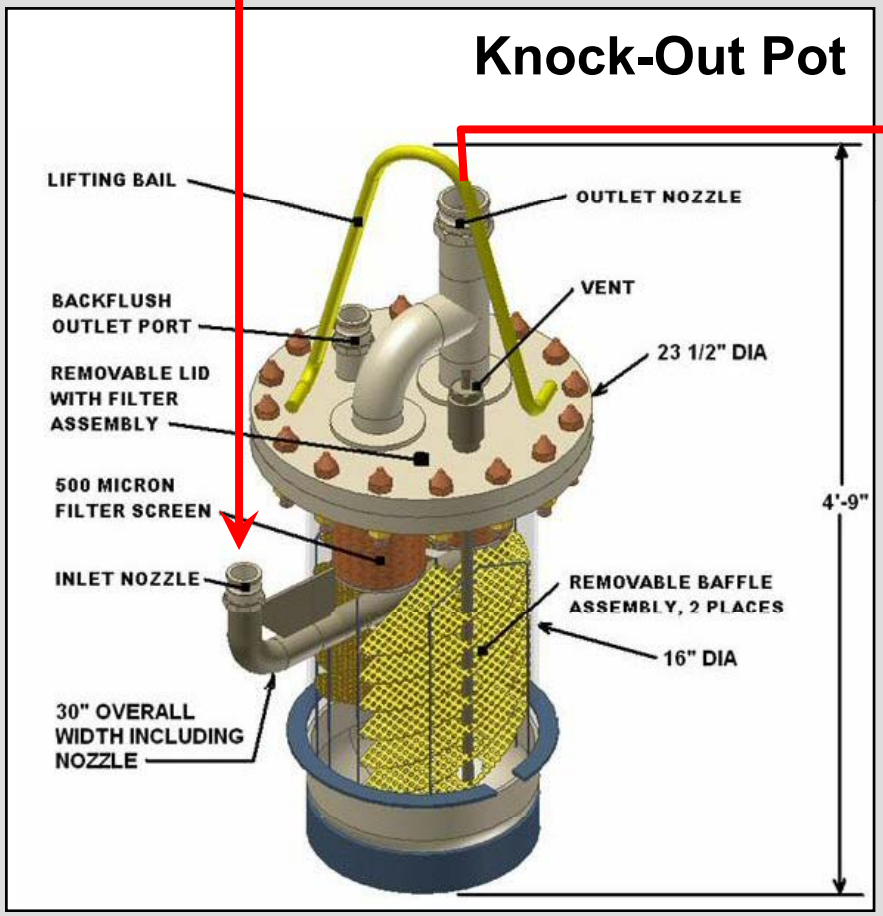
- The IWTS maintained KW Basin water clarity during the fuel washing process.
- Dislodged canister sludge and fuel surface coatings <1/4 in. and >500 μm (0.02 in.) were captured in a knockout pot (KOP).
- Sludge/coating particles between about 500 μm down to a few μm were deposited in the Settler Tanks.

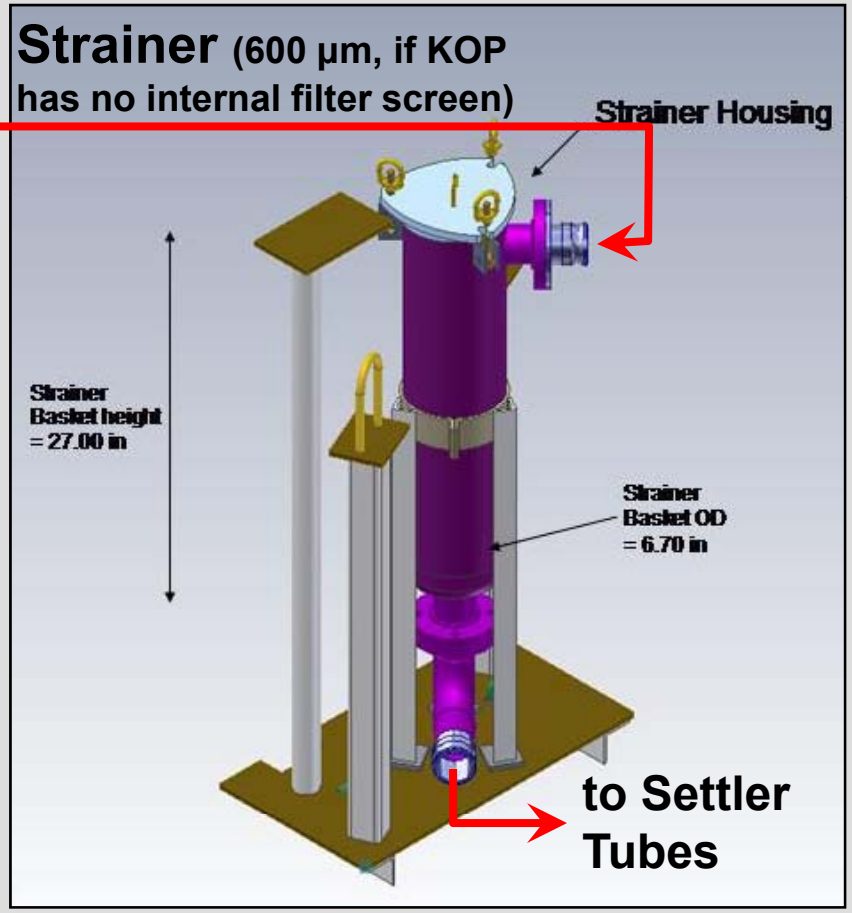
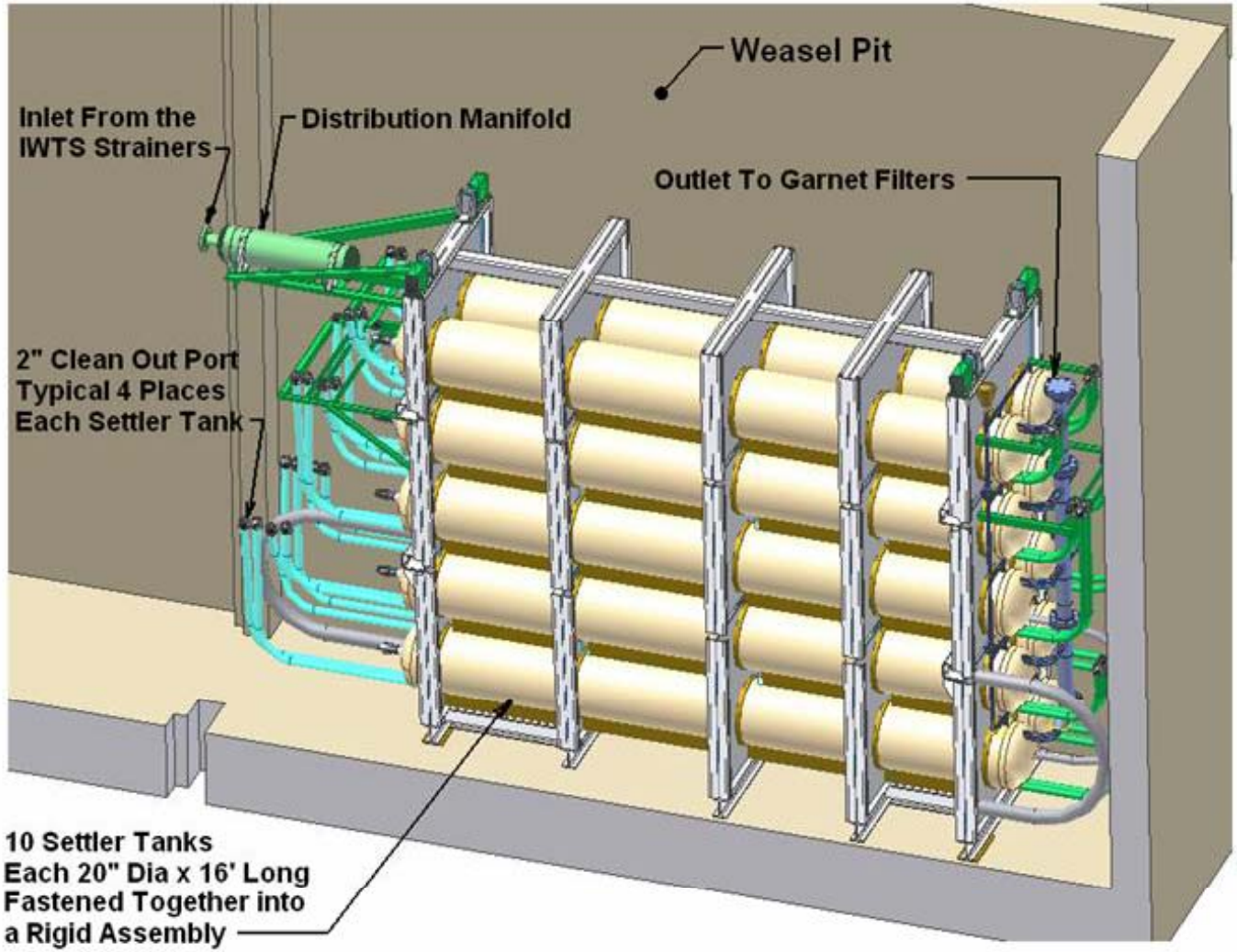


Knock-out Pot with Strainer

Strainer (>¼-inch)

Primary Cleaning (fuel washing) Machine, canister cleaning, scrap sorting





IWTS Settler Tanks