Hanford Secondary Waste Form Testing

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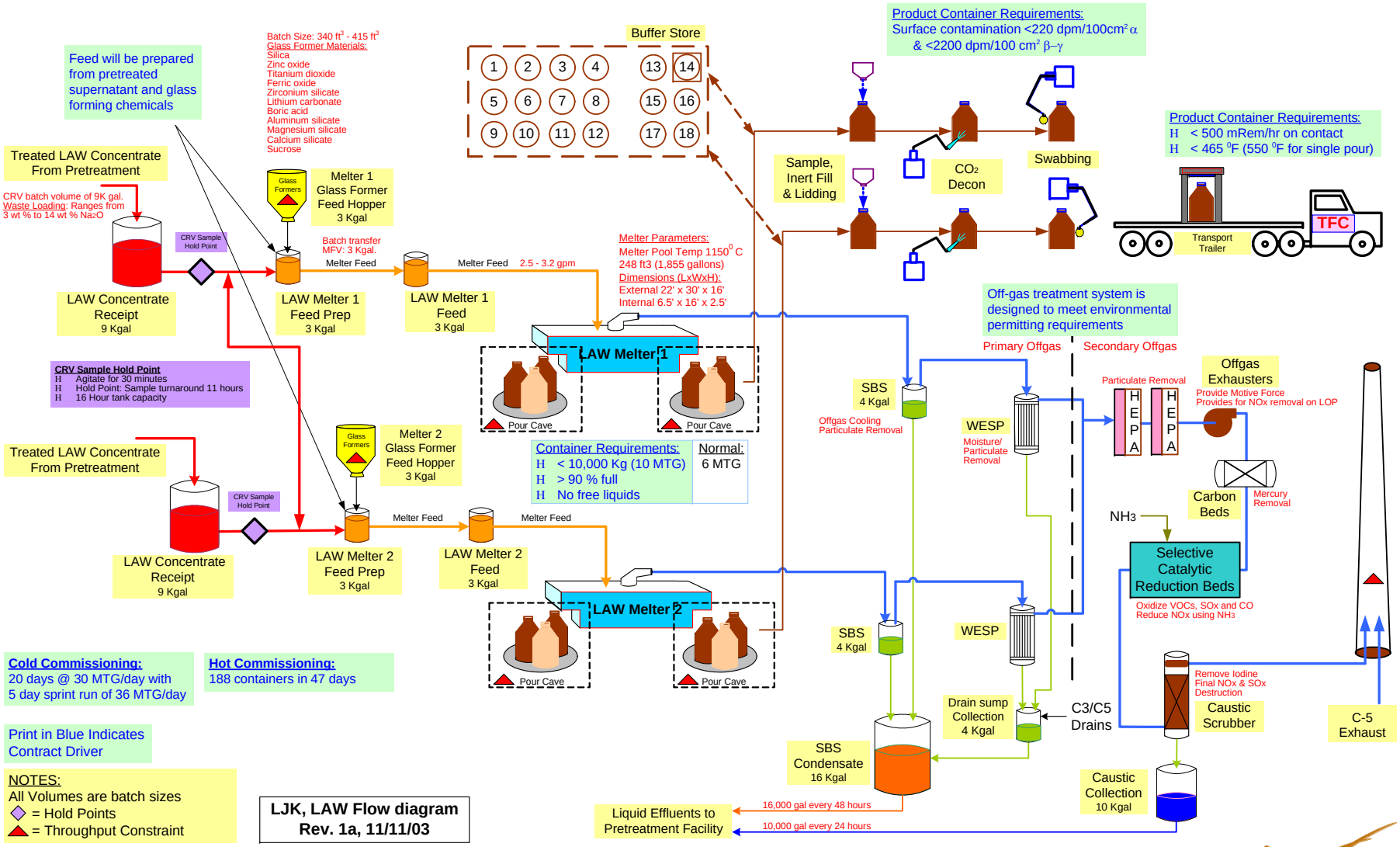
Secondary Waste Form Testing

- Purpose: Conduct a testing program to support a waste form down selection and the long-term durability evaluation of a waste form(s) for the solidification of secondary wastes from the treatment and immobilization of Hanford radioactive tank wastes.
- Client: Washington River Protection Solutions
- Phase 1: Identify and assess viability of waste form candidates
- Phase 2: Develop, optimize, and characterize waste forms to support down selection
- Phase 3: Provide data on the selected waste form to support Integrated Disposal Facility (IDF) performance assessment and Effluent Treatment Facility (ETF) facility upgrade design

What are Secondary Wastes?

- Process condensates and scrubber and/or off-gas treatment liquids from the pretreatment and ILAW melter facilities at the Hanford Tank Waste Treatment and Immobilization Plant (WTP).
- Sent from WTP to the ETF for treatment and disposal
  - Treated liquid effluents under the ETF State Wastewater Discharge Permit
  - Solidified liquid effluents under the Dangerous Waste Permit for disposal at the IDF
- Solidification Treatment Unit to be added to ETF to provide capacity for WTP secondary liquid wastes

WTP LAW Flow Diagram



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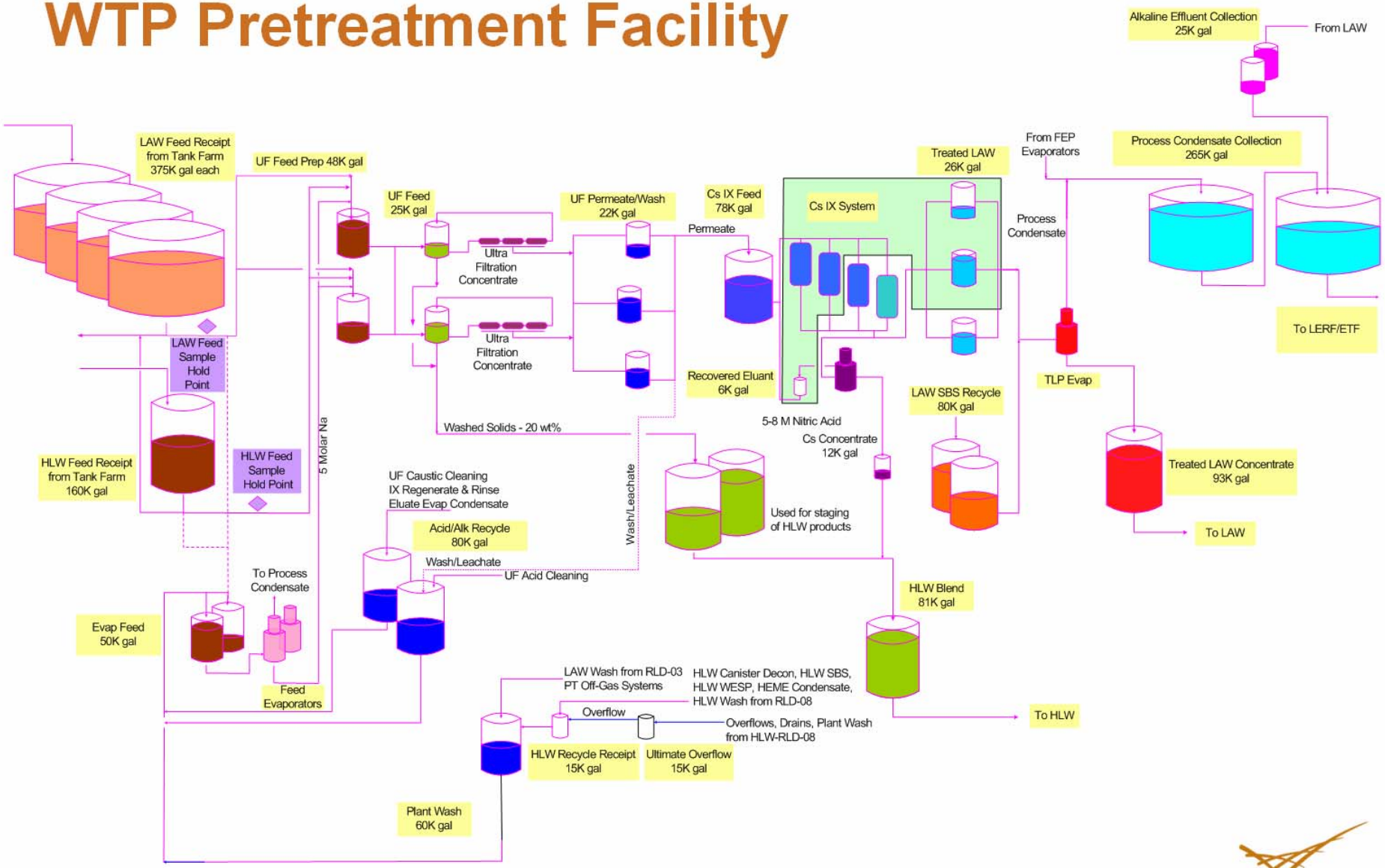
WTP Pretreatment Facility



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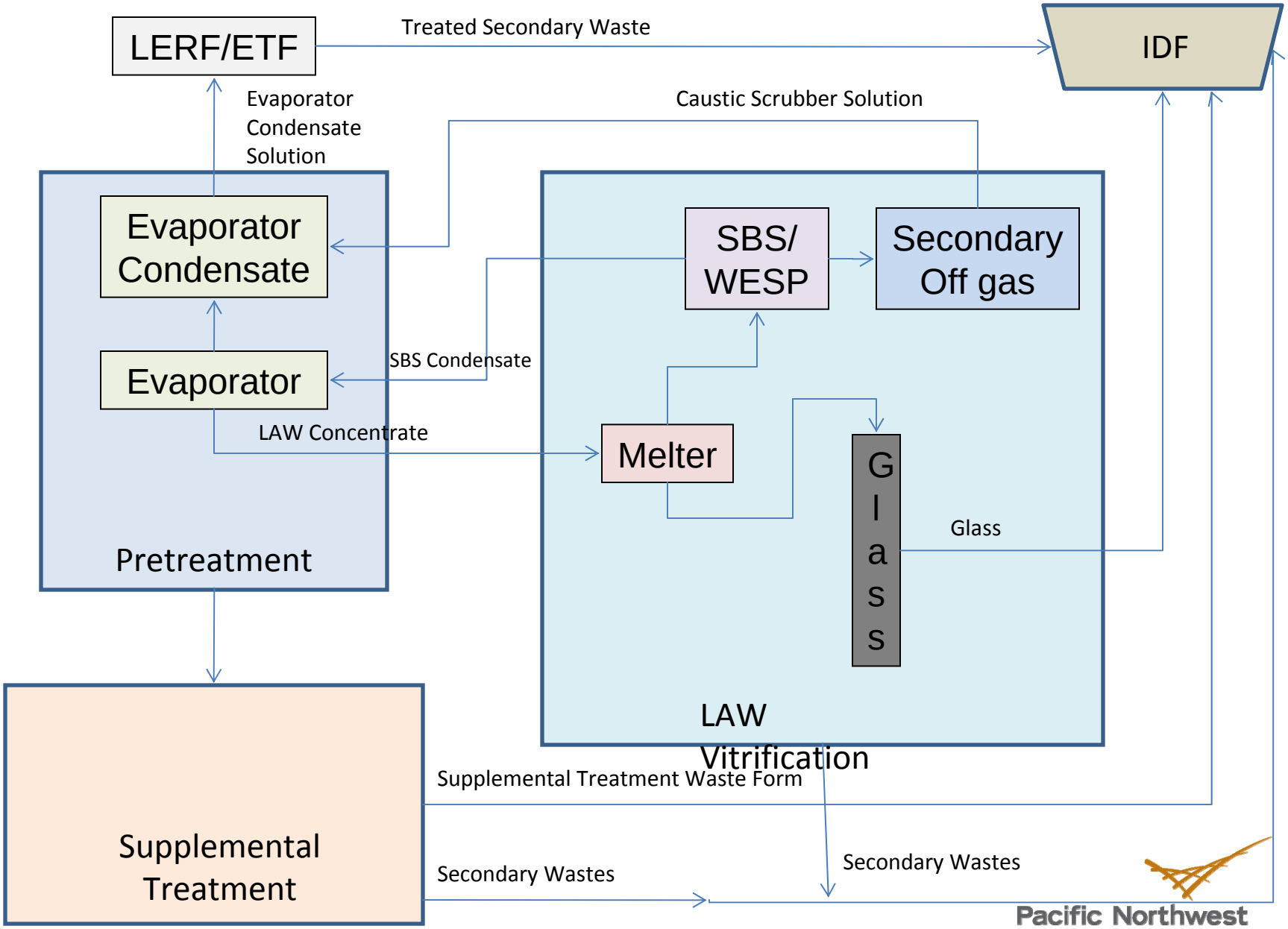

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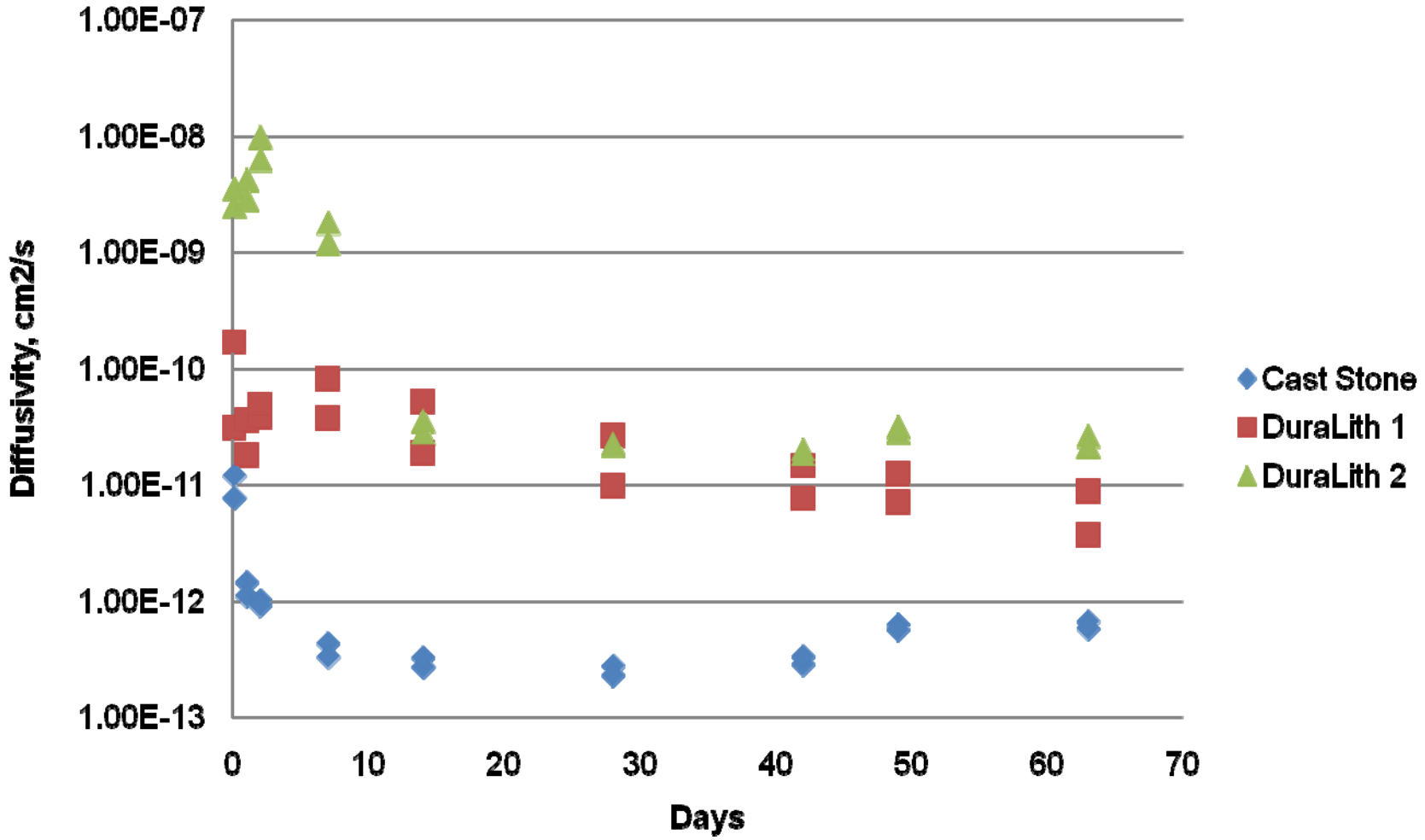
Secondary Waste Form Testing Phase 1

- Identify candidate waste forms
  - Previous secondary waste form studies
  - Literature review
  - WRPS call for expressions of interest
- Laboratory tests to assess viability of select candidate waste forms
  - Cast Stone and DuraLith geopolymer
  - Secondary waste simulant spiked with Tc
  - Draft EPA methods 1313 and 1316 for effects of pH and liquid to solid ratio
  - Draft EPA method 1315 for Tc diffusivity from monoliths
- Independent panel to review results

Immobilization Methods

- Cast Stone
- DuraLith alkali-aluminosilicate geopolymer
- Ceramicrete phosphate bonded ceramic
- Encapsulated Fluidized-Bed Steam Reformer product
- Other Waste Forms
  - Alkali-aluminosilicate hydroceramic cement
  - Goethite
  - L-TEM Technology
  - Sodalite
  - Geomelt vitrification technology
  - Tailored waste form technology based on Synroc ceramic titanate minerals
  - Nochar blend of acrylics and acrylamide co-polymers
- Getters

Tc-99 Diffusivity, cm^2/s



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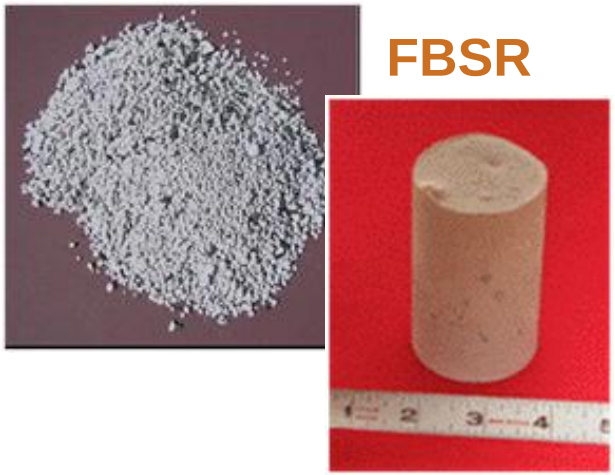
Waste Forms



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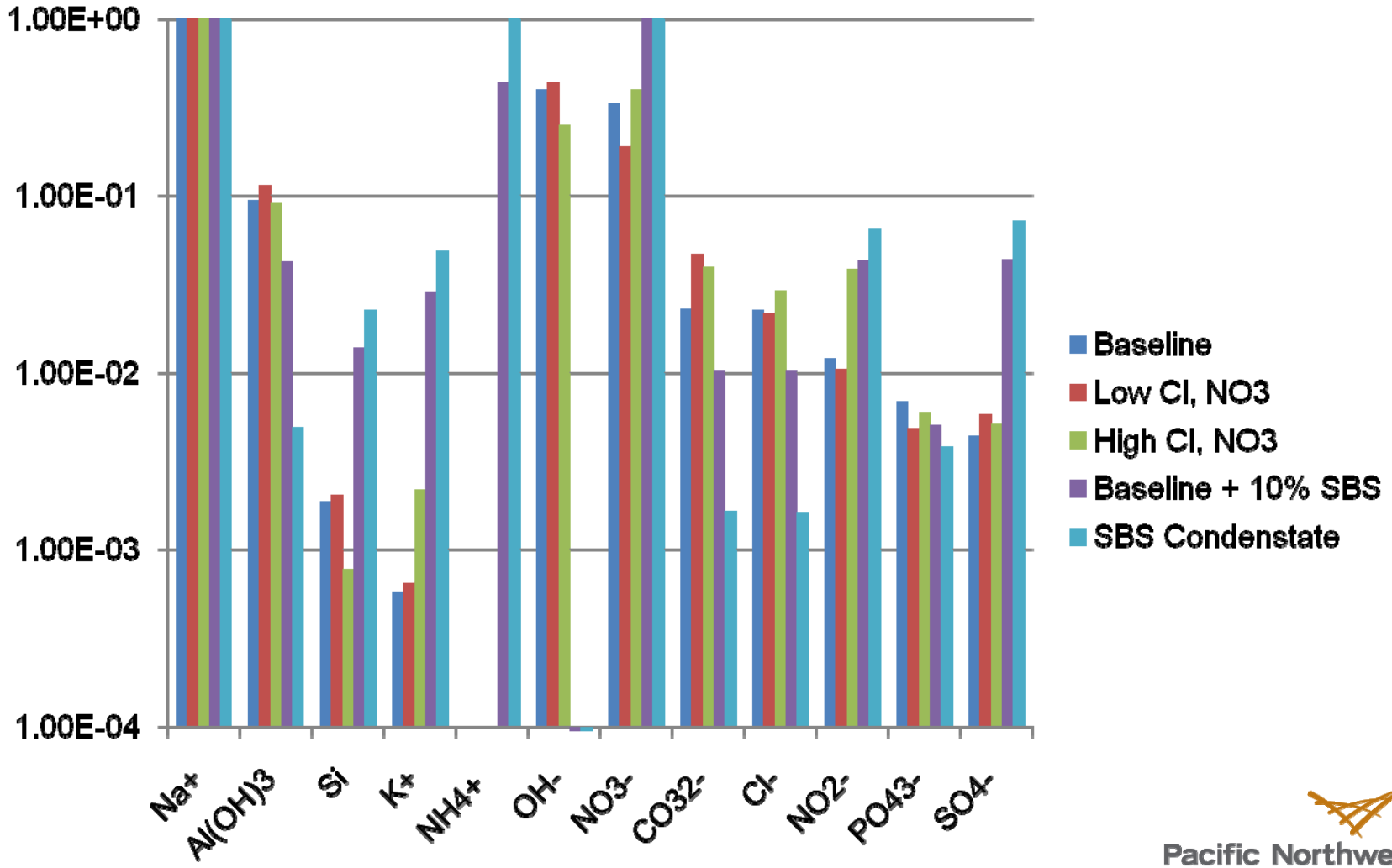
Secondary Waste Form Testing Phase 2

- Waste form development and optimization
  - Cast Stone, DuraLith, Ceramicrete
  - Optimize waste loading
  - Evaluate robustness of waste form to waste variability
- Fluidized Bed Steam Reformer product characterization
- Demonstrate compliance with waste acceptance criteria
- Engineering-scale process demonstrations
  - DuraLith, Ceramicrete
- Mechanisms of radionuclide retention to support waste form selection
  - Sequestered Tc speciation, porosity, waste form reductive capacity, EPA 1314 column leach tests

Normalized Simulant Concentrations



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Cast Stone

- CH2M Hill, Inc
- Ingredients
  - Portland Cement type I, II
  - Fly Ash Class F
  - Blast Furnace Slag
- Getters Tested
  - Bone char, bone ash, bone black, synthetic apatites, iron (Fe^0) powder, Fe- phosphate, silver (Ag)-zeolite, tin (Sn[II])-apatite
- Wastes
  - Basin 43 Waste – LERF
  - Low-Activity Waste (LAW) Simulant loading 8.2 – 24.2% wt
  - Iodine (I)-rich caustic waste - Hanford

DuraLith Alkali Alumino-silicate Geopolymer

- Catholic University of America (Vitreous State Laboratory – VSL/CUA)
- Ingredients
  - Silica and alumina source
  - Alkaline solution
- Forms amorphous or partially microcrystalline geopolymer
- Three-dimensional matrix
  - poly sialate (-Si–O–Al–O-)
  - poly sialate-siloxo (-Si–O–Al–O–Si-)
  - sialate-disiloxo (-Si–Al–Si–O–Si–O-)

TB-9R3-Samples
VSL/CUA
Duralith
HW

5 cm

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DuraLith Process Description

- Waste receipt
- Reagents addition
- Dry materials / liquid blending
- Key Equipment
  - Wet and dry chemical storage
  - Waste receipt / lag storage tank
  - Reagent addition tank
  - Ribbon-type mixer
  - Vibrator for disposal container
- Bench-scale preparation 6-inch x 12-inch cylinder

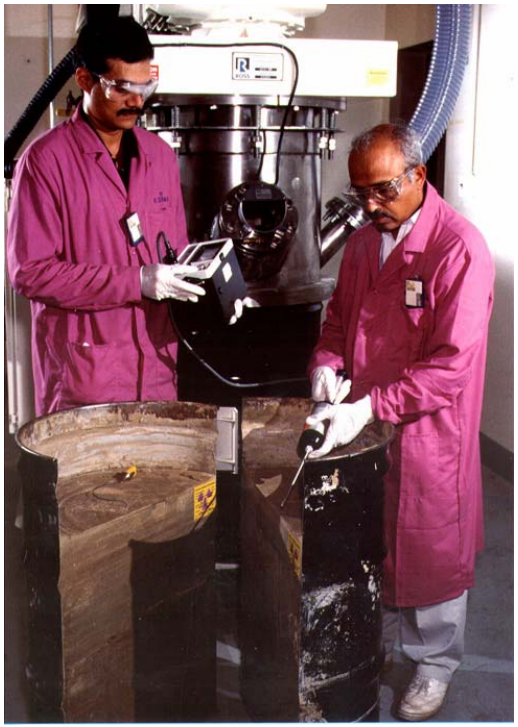
Ceramicrete Phosphate Bonded Ceramic

- CH2MHILL &
  Argonne National Laboratory (ANL)
- Ingredients:
  - Magnesium oxide
  - Potassium acid phosphate
  - Calcium silicate filler
  - Waste

- $MgO + KH_2PO_4 + 5H_2O \rightarrow MgKPO_4 \bullet 6H_2O$

Ceramicrete Process Description

- Waste receipt
- Partial neutralization
- Reagents addition
- Dry materials / liquid blending
- Key Equipment
  - Wet and dry chemical storage
  - Waste receipt / lag storage tank
  - Neutralization / reagent addition tank
  - Ribbon-type mixer
- Process demonstrated with dry wastes at drum scale with drum mixer



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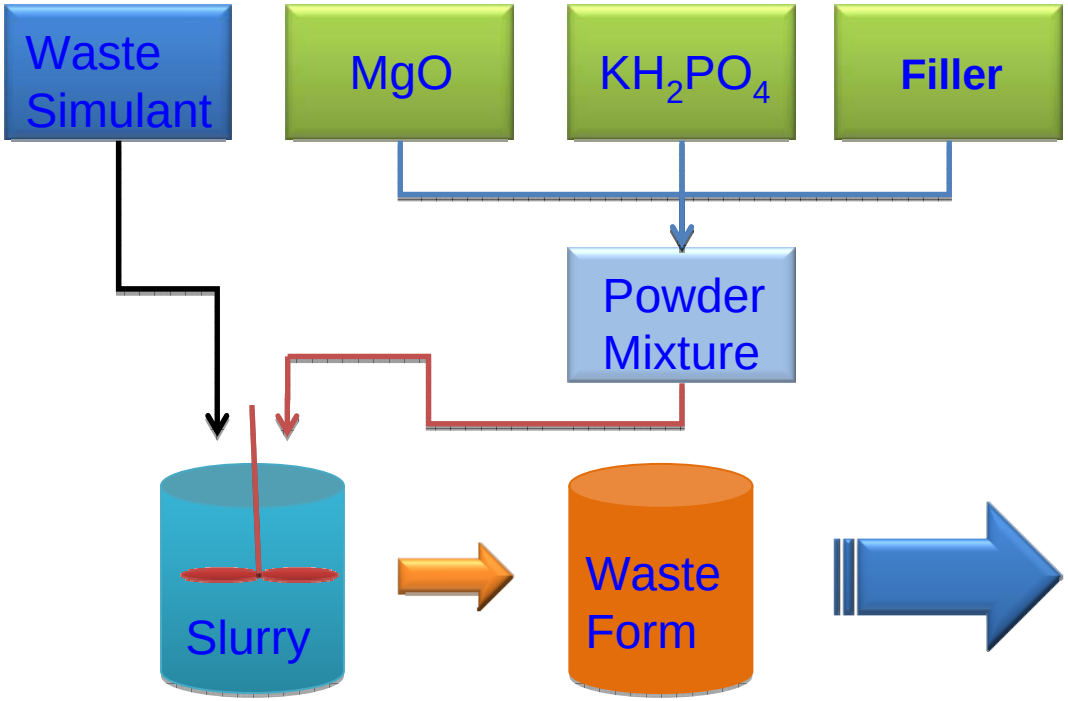
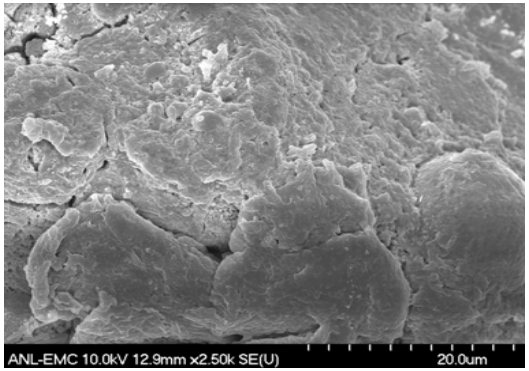
Ceramicrete Process





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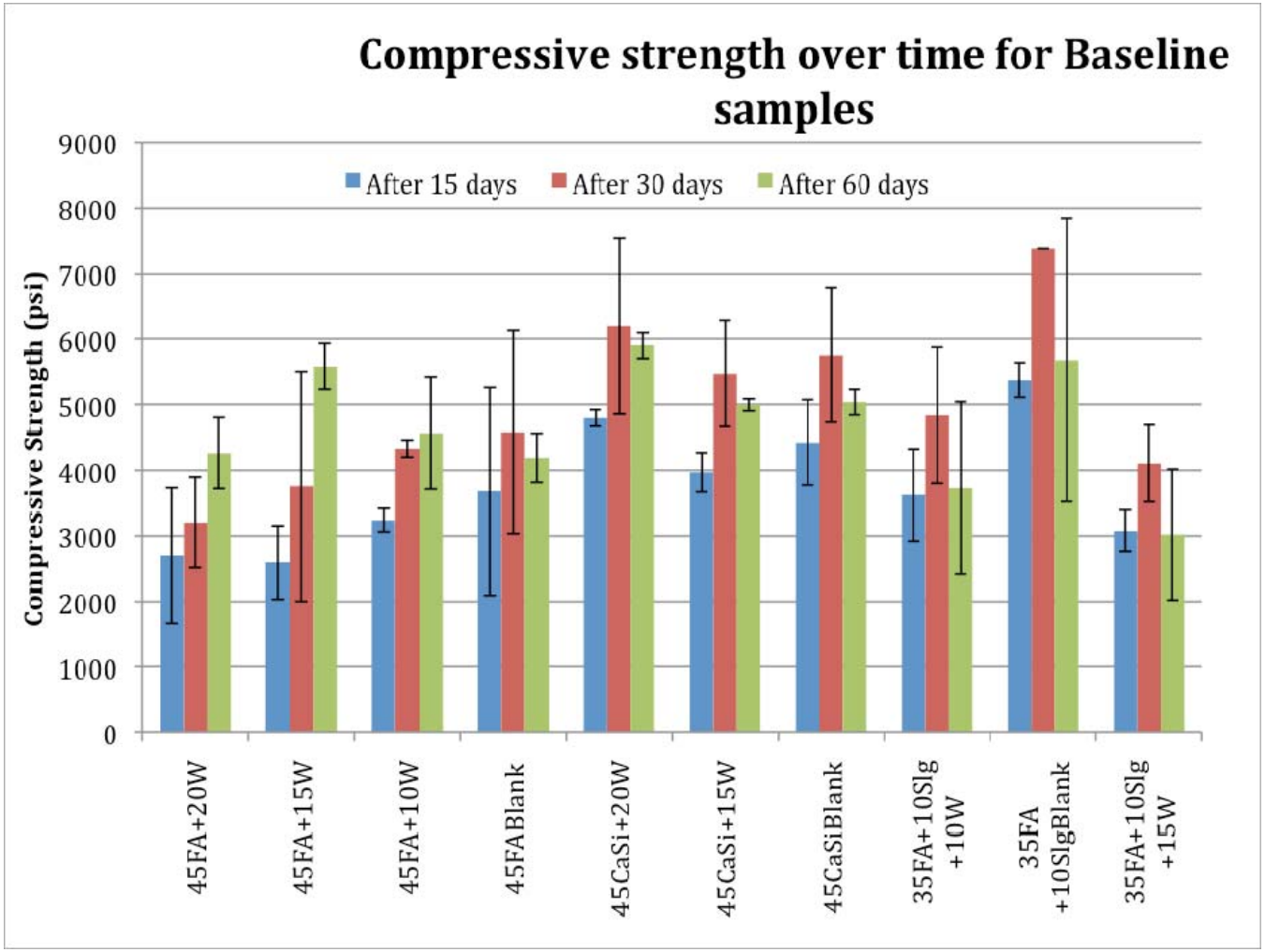
ANL Ceramicrete Compressive Strength



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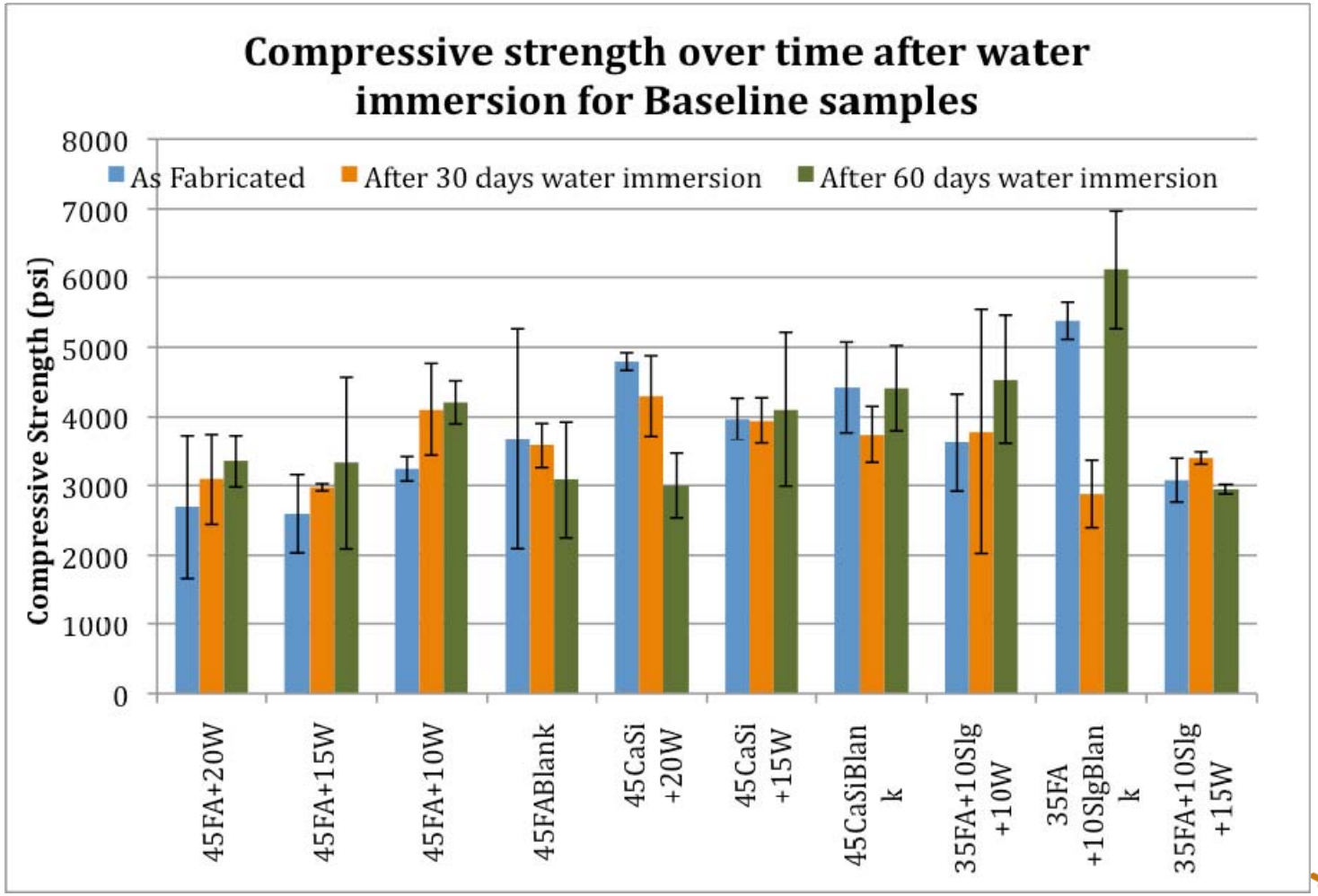
ANL Ceramicrete Compressive Strength cont'



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Fluidized Bed Steam Reforming Waste Form

- Prepared by Advanced Remediation Technologies (ART) Project
- Hanford off-gas recycle simulant spiked with Re, and RCRA metals
- Processed through Hazen Engineering Scale Technology Demonstration (ESTD) Facility
- FBSR granular product encapsulated in GEO7 geopolymer matrix at SRNL
- 2-inch x 4-inch cylinders provide to PNNL for characterization
  - Diffusivity, Leachability Index – ANSI/ANS 16.1/EPA 1315
  - Draft EPA methods 1313 and 1316 for effects of pH and liquid to solid ratio

Preliminary Waste Acceptance Criteria

- Land Disposal Restrictions – Toxicity Characteristic Leaching Procedure (TCLP)
- No free liquids
- Compressive strength – 3.45 MPa (500 psi)
- Waste form stability – ANSI/ANS 16.1 Leachability

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Toxicity Characteristic Leaching Procedure TCLP

- For RCRA Metals (Cr, Ag, Cd, Hg, Pb, As, Ba, Se)
- To address Land Disposal Restrictions

	Cast Stone	Ceramicrete	Duralith Geopolymer	FBSR / Geopolymer
Other Wastes	Pass except for Cr at highest waste loading			Pass except for Se in highly spiked waste
Secondary Waste		Pass	Pass	

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Compressive Strength
3.45 MPa (500 psi) Minimum

	Cast Stone	Ceramicrete	Duralith Geopolymer	FBSR / Geopolymer
Other Wastes	8.0 – 16.3			8.6 – 15.2
Secondary Waste	7.6 – 18.7	28.1 - 33.6	27.5 – 40.5	
Secondary Waste Irradiated		34.6	29.1	

All waste forms meet compressive strength requirement

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Leachability Index – Tc (ANSI/ANS 16.1 or EPA Draft Method 1315)

Larger LI = Lower Leaching	Cast Stone	Ceramicrete	Duralith Geopolymer	FBSR / Geopolymer
Other Wastes – Tc	9.5 – 10.4	8.5 – 14.6		
Secondary Waste – Tc	9.0–12.8		8.9 –11.4	
Secondary Waste – Re		7.2	10.4	

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Secondary Waste Form Testing Next Steps

- Complete waste form optimization – January 2011
- Engineering scale demonstrations – February 2011
- Initial waste form down selection – March / April 2011
- Final secondary waste form down selection – September 2011
- Agreement with Washington State Department of Ecology on secondary waste form selection – February 2012
- Effluent Treatment Facility Supplemental Treatment Unit Critical Decision 1 data package – February 2012
- Initiate Phase 3 to support ETF upgrade design and IDF PA – April 2011

Questions?

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