

INNOVATION • DEFENSE
NONPROLIFERATION • ENVIRONMENT



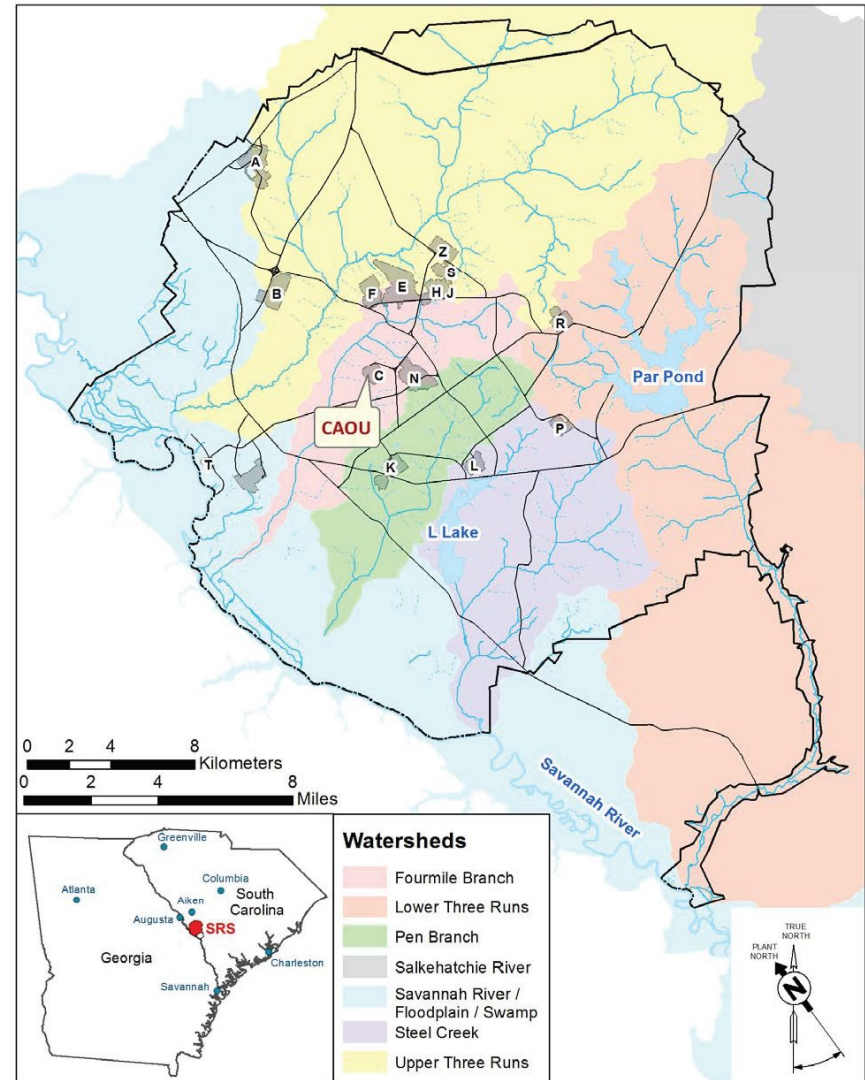
We make the world safer.

CONTAMINANT FATE AND TRANSPORT MODELING FOR C-REACTOR LEAD AND HEAVY WATER SOURCES

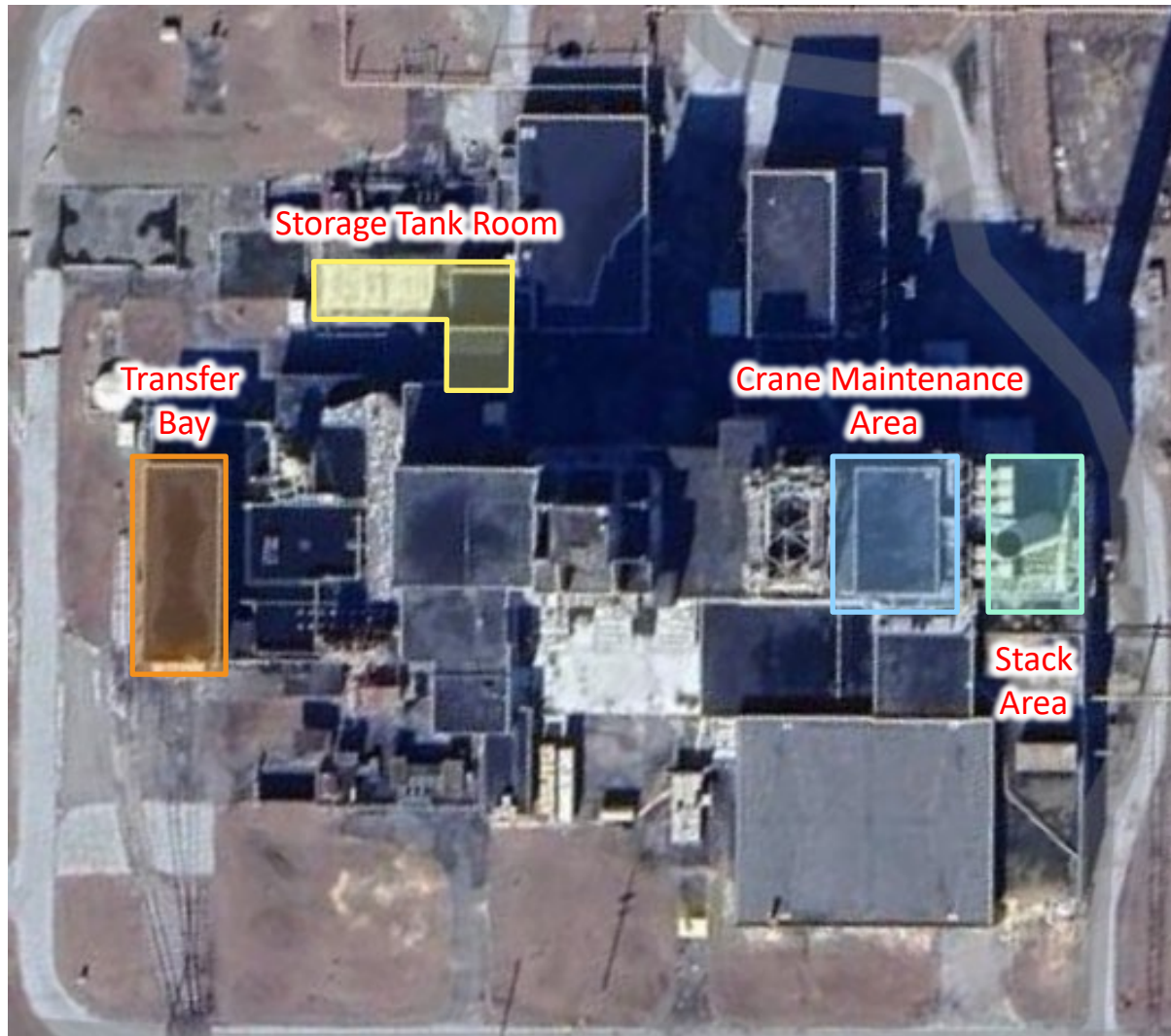
- **Presentation Objectives:**
 - Update status of C-Reactor (105-C) facility mission
 - Previous remedial decisions for C-Reactor
 - Present fate and transport modeling approach and results
 - Conclusions/Recommendations



- **C-Reactor was one of five reactors at Savannah River Site (SRS); initial mission to produce nuclear material for the national defense program**
 - C-Reactor operations began in 1955
 - Placed in cold stand-by in 1987; followed by shut down due to reduced mission need



- **In 1995, C-Reactor Decontamination (DECON) Facility mission planning began**
 - Mission to consolidate and decontaminate all tools and equipment at SRS with reuse or resale value
 - DECON Facility used the former Crane Maintenance Area (CMA), Presentation Area, Assembly Area, and Stack Area
 - Lead for DECON Facility consolidated in Crane Maintenance Area
- **DECON Facility mission cancelled; C-Reactor mission updated to cask car refurbishment and storage of lead shielding and heavy water**
 - Refurbishment of cask cars in Transfer Bay
 - Stored lead located in the CMA is considered an asset due to the potential for reuse at SRS, primarily as shielding during cask car refurbishment
 - Stored heavy water located in the Storage Tank Room has potential for reuse by Savannah River National Laboratory (SRNL) for research or for sale to off-site buyer



- CD-5 in C-Reactor Transfer Bay



- Lead material in Defense Program casks in Stack Area (left) and in B-12 containers in Crane Maintenance Area (right)



- **Miscellaneous lead in C-Reactor Process Room**



- Heavy water in C-Reactor Storage Tank Room

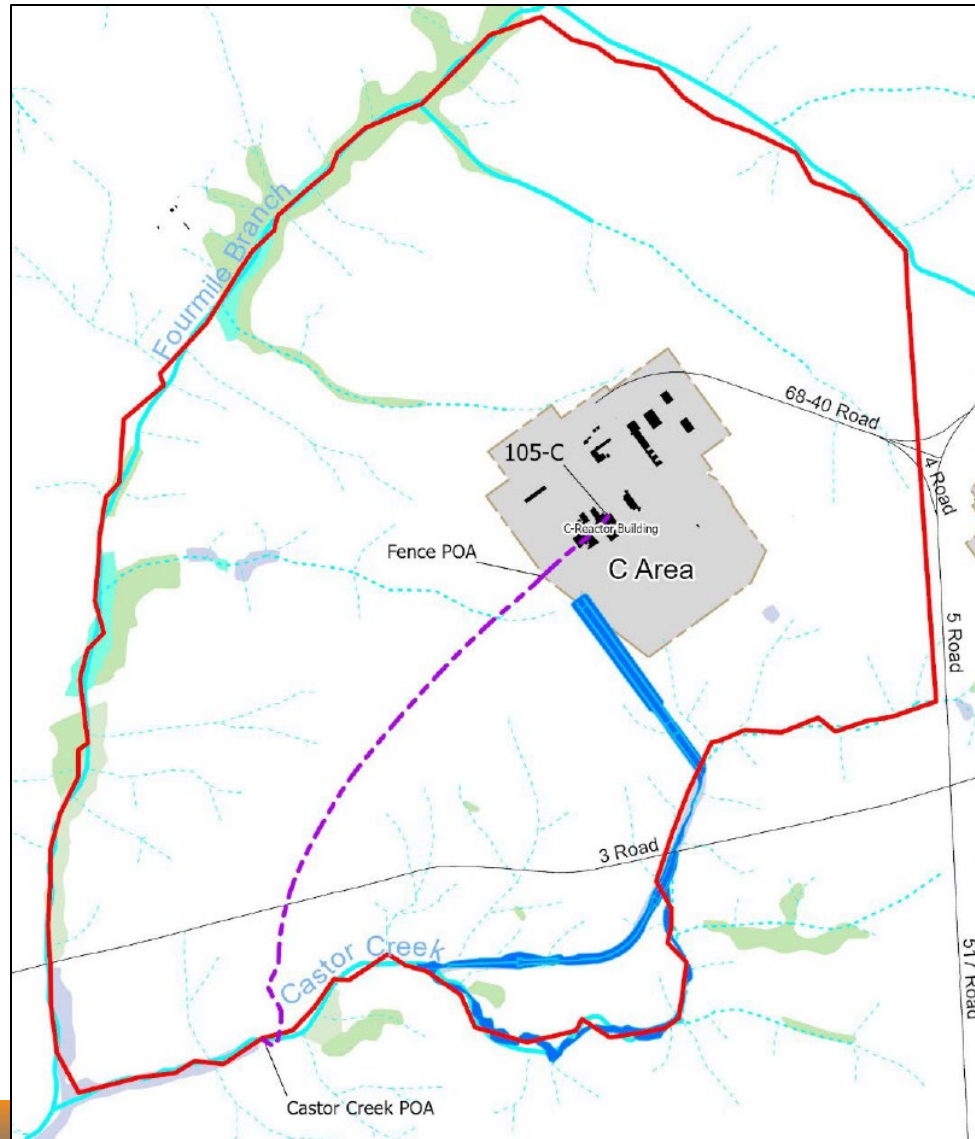


- **Potential future missions for C-Reactor**
 - Specialized testing by SRNL in conjunction with United States Department of Defense
 - Detritiation process research by SRNL using heavy water
 - *New facility would be built outside C-Reactor*

- **DOE, SCDES, and EPA signed Early Action Record of Decision (EAROD) issued to public in December 2009 established in-situ decommissioning (ISD) as the preferred end-state for the C-, K-, L-, and R-Reactor Complexes**
 - Uses ISD end-state of P-Reactor (105-P) as the basis
- **C-Area Operable Unit (CAOU) consists of C-Reactor (105-C) and all supporting facilities in C Area identified in the Federal Facility Agreement**
- **Characterization of CAOU subunits completed in September 2012**
 - In response, three non-time critical removal actions completed
 - *C-Area Reactor Area Cask Car Railroad Tracks as Abandoned*
 - *C-Area Process Sewer Lines as Abandoned*
 - *C-Reactor Disassembly Basin*
- **DOE, SCDES, and EPA signed EAROD for CAOU issued to public in September 2015 established Land Use Controls (LUCs) as preferred alternative**
 - Prevent exposure of future residents and/or industrial workers to contaminated media left in place
- **Final CAOU Record of Decision will define final ISD remedial design**

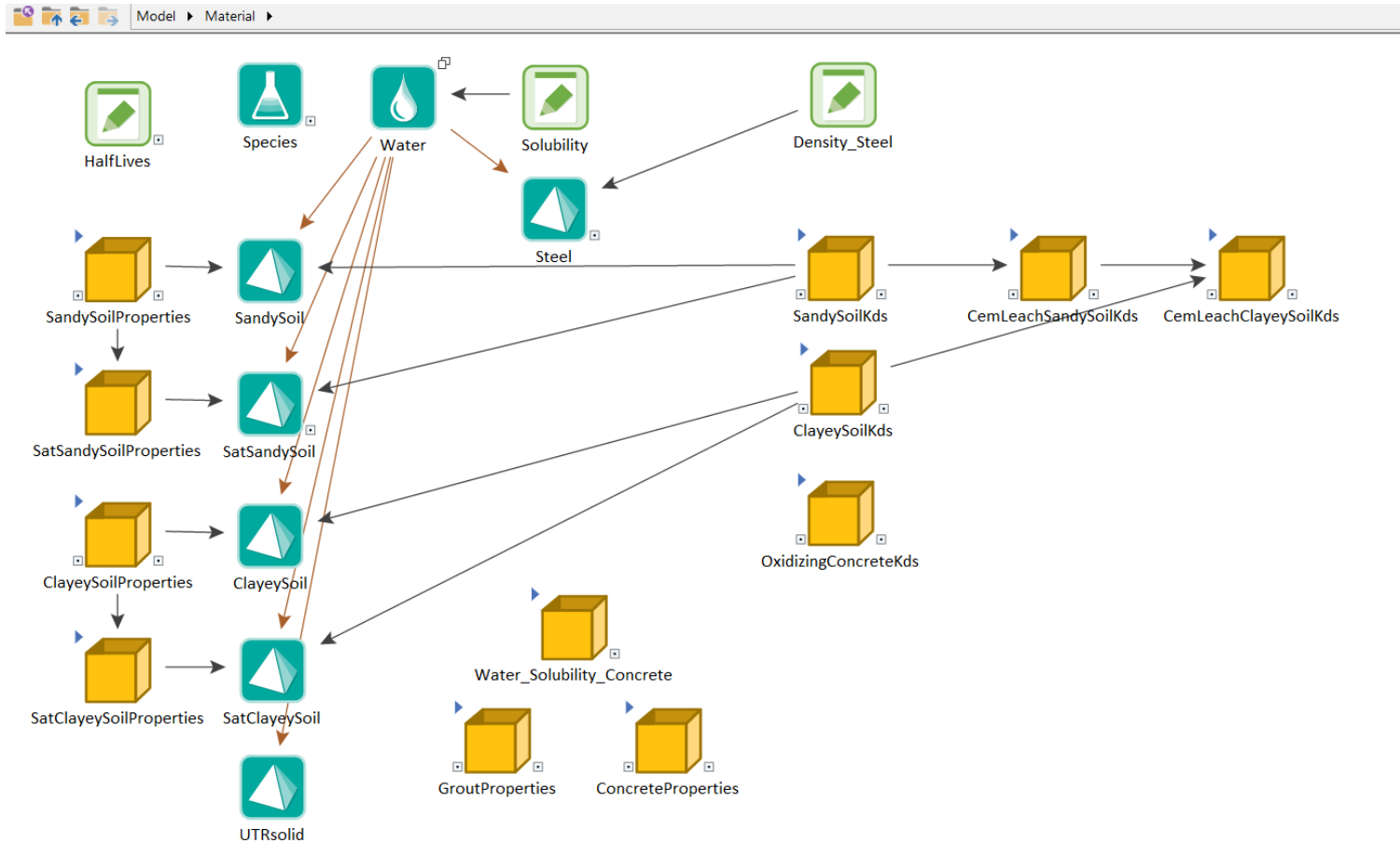
- **Three party signed EAROD established final ISD end-state with LUCs for C-Reactor**
- **ISD decision allows for consideration of ISD alternatives that are appropriate for end-state of each respective Reactor Complex**
- **ISD decision allows for consideration of consolidation of remediation waste from each Area Operable Unit inside of the respective Reactor Complex**
 - Consistent with consolidating contaminated equipment and components within C-Reactor Disassembly Basin before grouting
 - Consistent with placement of 105-R Disassembly Trailer in R-Reactor (105-R) Stack Area for final ISD end-state
- **Sources were identified in C-Reactor as candidates for inclusion in final ISD end-state**

- **Modeling of C-Reactor lead and heavy water sources completed in August 2023 using GoldSim**
- **C-Reactor contaminant sources considered in this effort include:**
 - 20-ton deionizer trailer lead source
 - 20-ton lead source in Process Area
 - 230-ton lead source in CMA
 - 43,000 gallon of heavy water in Storage Tank Room
- **C-Reactor modeling performance objectives:**
 - Points of assessment (POA): 1) 1-meter beyond the outside perimeter of C-Reactor building; 2) C-Area boundary (perimeter fence) in the direction of groundwater flow; and 3) perennial groundwater-surface water interface along the shortest travel path
 - Compliance period: 1,000 years (DOE Order 435.1-1) and 10,000 years (Nuclear Regulatory Commission guidance)
 - Compared constituent peak of the mean concentrations (mass or activity) to regulatory standards (EPA maximum contaminant levels [MCLs] or regional screening levels)

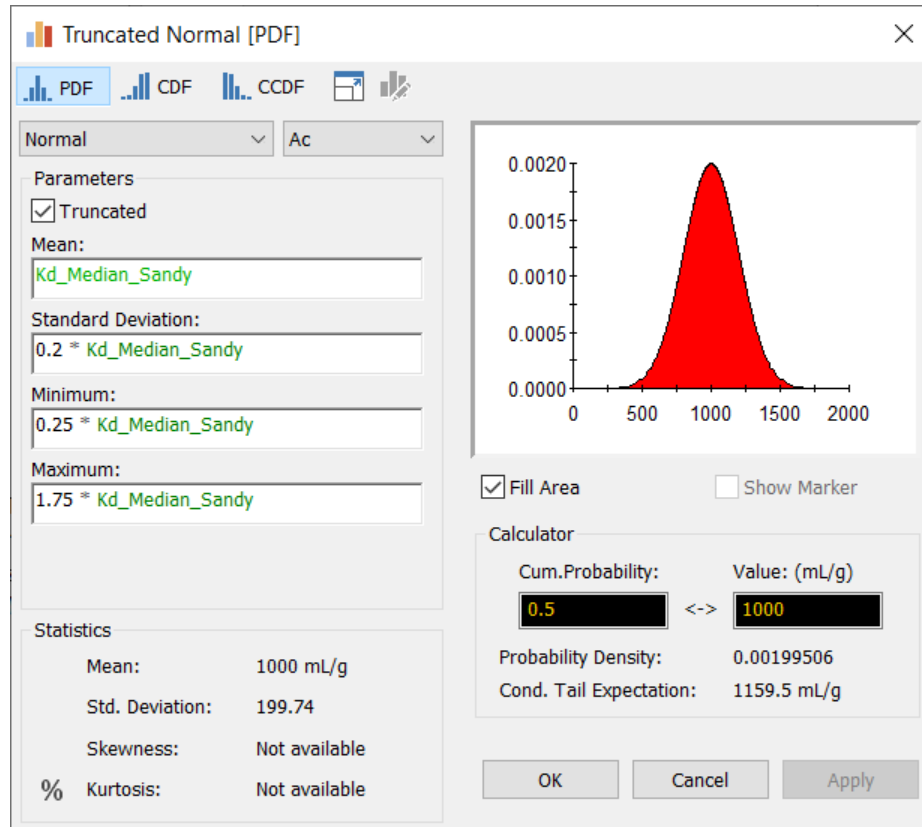


- **Building model structure**
 - Source location within C-Reactor; building geometry above and below source; vadose zone to water table
 - Saturated zone transport
 - Source containment (e.g., stainless steel tank)
 - Building properties (degradation steps for concrete, steel corrosion rate, concrete infiltration rate, etc.)
 - Transport properties (vadose zone infiltration rate, sorption coefficients, solubilities, etc.)
 - Source term constituent mass (decay corrected as appropriate)
- **Built conceptual models for each source and ISD alternative considered**

- GoldSim Model Structure



- Sandy soil-water distribution coefficient

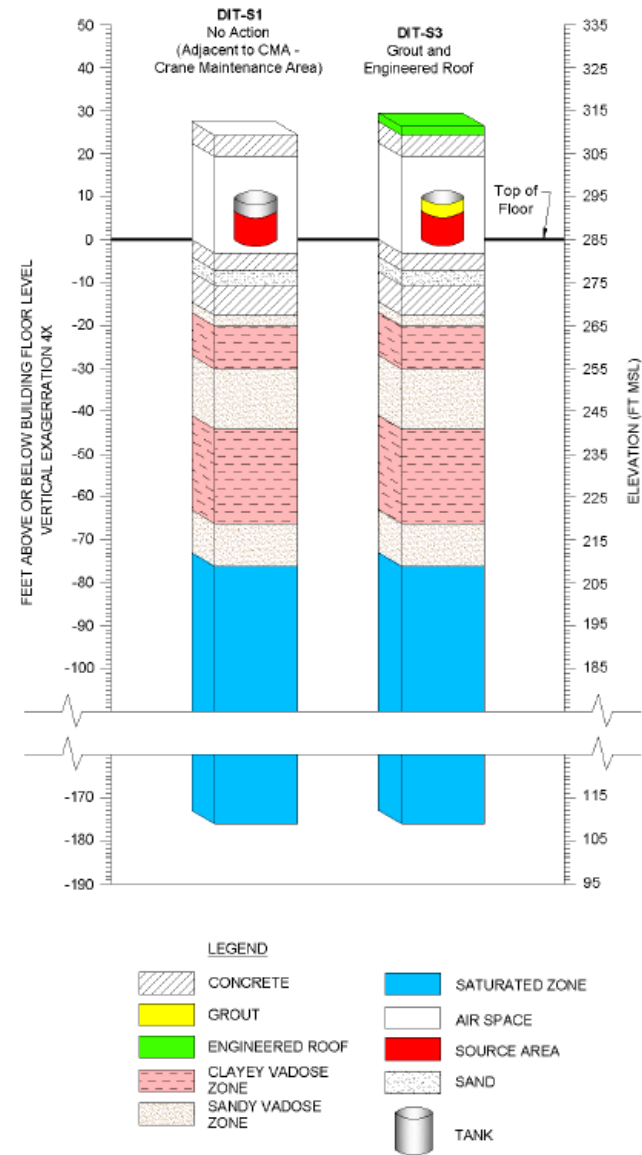


- **690-1G Deionizer Trailer used to remove radionuclides (deionize) from reactor disassembly basin water**
 - Used at C-Reactor as well as other SRS reactors
- **Currently located in N Area, adjacent to the former Ford Building (690-N)**
- **Shielded deionization vessel on trailer**
 - 20-tons of lead shielding
 - Contaminated deionization resin within vessel
 - *Characterized in 2022*



- **Simulated deionizer trailer placed in C-Reactor Stack Area**
 - Consistent with 105-R Trailer ISD within 105-R
- **Considered two ISD alternatives**
 - No Action (DIT-S1)
 - Grout vessel void and add engineered roof to Stack Area (DIT-S3)
- **Source included lead shielding and 2022 characterization data**

Constituent	Inventory (g)
Ag	0.186
Al	1251
Cd	0.145
Cr	15.58
Cs-137	5.03E-09
Fe	804.57
H-3	5.39E-11
Pu-238	4.60E-08
Sr-90	6.03E-08
Tc-99	2.02E-06
Lead	1.814E+07



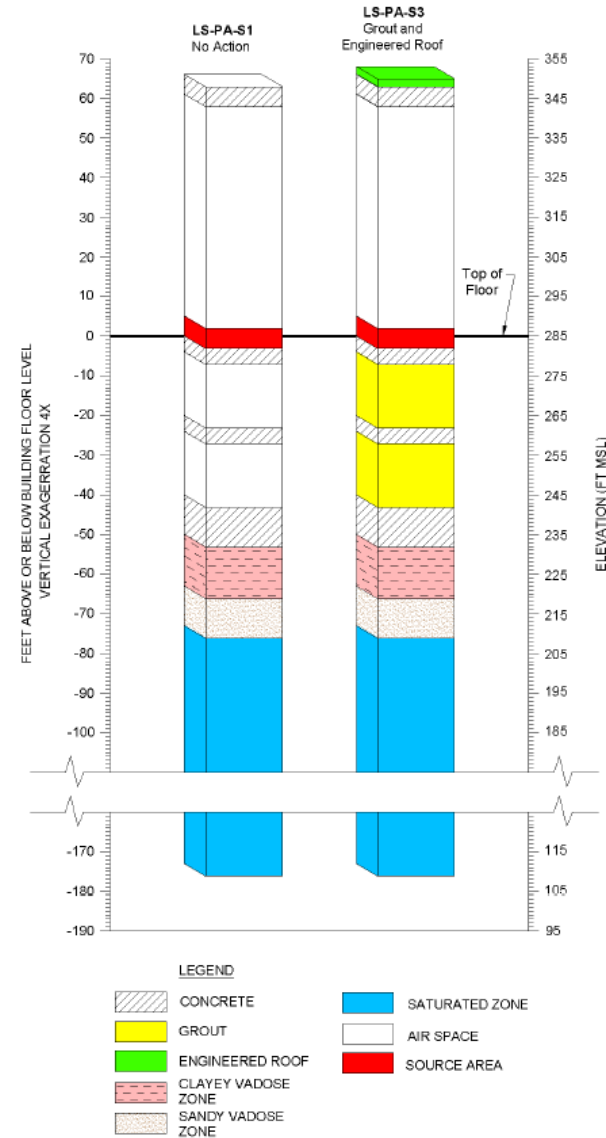
- **Simulations were run for 1,000 realizations and for 100,000 years to observe peaks past the compliance period, if applicable**
- **No modeled constituents exceed regulatory standards within 10,000 years for the No Action or the ISD alternative at any of the three POAs**
- **Model results predict there will be no impacts to groundwater within the compliance period for the deionizer trailer in the Stack Area**

- **Lead shielding left in place during tank repairs**
- **Various lead materials and configurations**
- **Inventory estimated due to access limitations considering worker exposure**
 - Estimated 20 tons of lead shielding
 - Quantity and layout estimated by observation from vantage point and existing photos



- Conservatively simulated all Process Area lead consolidated surrounding the reactor assembly
- Considered two ISD alternatives
 - No Action (LS-PA-S1)
 - Grout all below grade voids and add engineered roof above Process Area (LS-PA-S3)
- Source included 20 tons of lead shielding

Constituent	Inventory (g)
Lead	1.814E+07



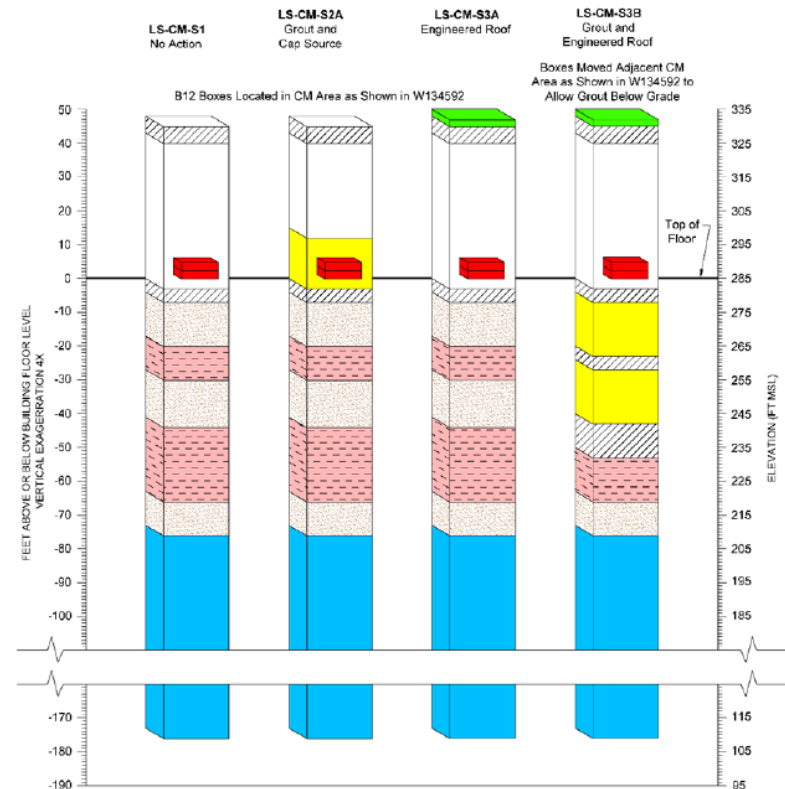
- **Simulations were run for 1,000 realizations and for 100,000 years to observe peaks past the compliance period, if applicable**
- **No modeled constituents exceed regulatory standards within 10,000 years for the No Action or the ISD alternative at any of the three POAs**
- **Model results predict there will be no impacts to groundwater within the compliance period for the Process Area lead shielding as simulated**

- **Lead material contained within 72 metal B-12 containers and 15 Defense Program casks**
 - Lead consolidated from various SRS areas (SRNL, H-Tank Farm, C-Labs, Reactors, etc.)
- **B-12 containers in C-Reactor CMA; Defense Program casks in C-Reactor Stack Area**
 - Plan to consolidate lead together for final ISD end-state
- **December 2022 lead inventory estimate of 230 tons**
 - Records of lead process/facility origins available
- **Majority of lead inventory radiologically contaminated**
 - Radiological surveys are screening level



- **First three alternatives assume consolidation in C-Reactor CMA**
 - No Action (LS-CM-S1)
 - Grout 6 ft above lead containers (LS-CM-S2A)
 - Add engineered roof to CMA (LS-CM-S3A)
- **Final alternative assumes consolidation in Crane Wash Area**
 - Add engineered roof and grout all void below grade
- **Source included 230 tons of lead inside of steel containment and estimated radiological contamination**

LEAD SOURCE (W134592, W134583, AND W134714)



Constituent	Inventory (g)
Cs-137	2.21E-04
H-3	3.55E-06
I-129	4.77E-05
Pu-241	1.77E-02
Tc-99	2.47E-02
U-234	4.17E-01
Lead	2.07E+08

LEGEND

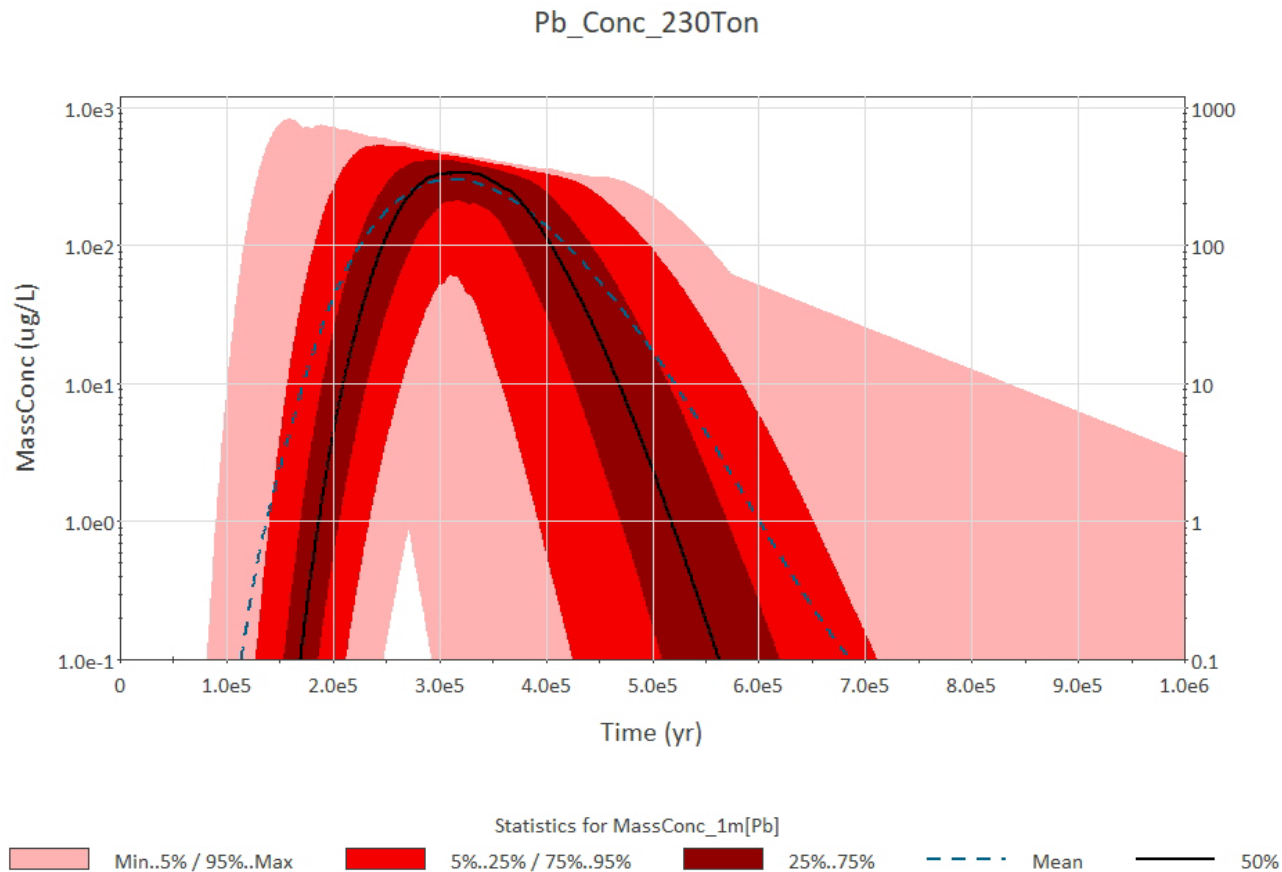
- CONCRETE
- GROUT
- ENGINEERED ROOF
- CLAYEY VADOSE ZONE
- SANDY VADOSE ZONE
- SATURATED ZONE
- AIR SPACE
- SOURCE AREA
- CONTAINERS
- CRANE MAINTENANCE AREA



- Simulations were run for 1,000 realizations and for 1,000,000 years to observe peaks past the compliance period, if applicable
- No modeled radionuclide constituents exceed regulatory standards within 10,000 years for the No Action or the three ISD alternatives at any of the three POAs
- Model results predict exceedances of lead MCL (15 µg/L) at the 1-m and facility boundary POAs for all four alternatives simulated after 300K years; no lead exceedances at the surface water POA (Castor Creek)
- Exceedances occurred after the compliance period of 10,000 years
- Peak of the mean results for lead at the 1-m and facility boundary POAs:

ISD Alternative	1-m POA		Facility Boundary POA	
	POTM [µg/L]	Travel Time [years]	POTM [µg/L]	Travel Time [years]
LS-CM-S1	3.01E+02	311,000	3.34E+01	354,000
LS-CM-S2A	3.01E+02	311,000	3.34E+01	354,000
LS-CM-S3A	3.01E+02	312,500	3.35E+01	355,000
LS-CM-S3B	3.50E+02	301,500	3.67E+01	343,500

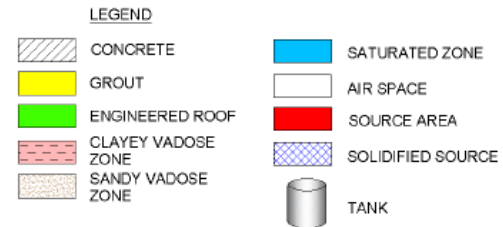
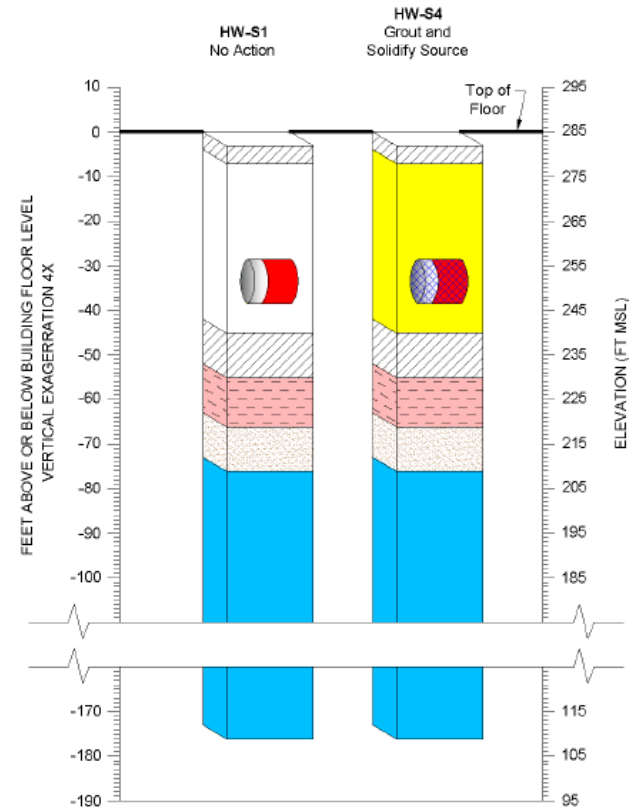
- No Action - lead results at 1-m POA for 1,000 realizations to 1,000,000 years



- **Heavy water consolidated from multiple SRS reactors, primarily C-Reactor**
 - 43,000 gallons within two tanks
 - Stored for potential reuse as moderator water, reuse for research by SRNL, or for resale to off-site buyer
- **Heavy water storage tanks located at -40 ft level; partially below C-Reactor structure**
- **Stainless steel tank construction**
- **Characterized in mid-1990s and in 2024**
 - *Primary constituent is tritium (half-life of 12.32 years) and chromium*



- Simulated heavy water remaining in Storage Tank Area
- Considered two ISD alternatives
 - No Action (HW-S1)
 - Solidify source with grout like mix and grout Storage Tank Area void to grade (HW-S4)
- Source included maximum results from 1990s data or 2024 characterization (decay corrected)



Constituent	Source Inventory	
	[g]	[Ci]
Al	3.46E+03	-
Cr	7.45E+02	-
Fe	8.70E+02	-
C-14	2.28E-04	1.03E-03
Co-60	3.44E-07	3.78E-04
Cs-137	2.39E-06	2.07E-04
H-3	2.44E+01	2.36E+05
I-129	2.33E-03	8.37E-07
Ni-63	4.10E-04	2.33E-02
Sr-90	2.12E-06	2.96E-04
Pu-238	1.54E-06	2.62E-05

- **Simulations were run for 1,000 realizations and for 100,000 years to observe peaks past the compliance period, if applicable**
- **No modeled constituents exceed regulatory standards within 10,000 years for the No Action or the ISD alternative at any of the three POAs**
 - Tritium is the primary constituent with a half-life of 12.32 years
- **Model results predict there will be no impacts to groundwater within the compliance period for the heavy water source in the Storage Tank Area**

- **Modeling of heavy water and lead sources stored at C-Reactor (105-C) completed in 2023**
 - Deionizer trailer
 - Process Area Lead
 - CMA Lead
 - Heavy Water
- **No exceedances of regulatory standards predicted within the compliance period at all POAs for all No Action scenarios**
- **Contaminant fate and transport modeling demonstrates the sources in their modeled configuration do not pose a contaminant migration risk and there are no contaminant migration problems warranting action for the sources considered**
 - Supports relocating deionizer trailer from 690-N into the Stack Area (consistent with R-Reactor)
 - Supports retaining heavy water in the Storage Tank Room
 - Supports retaining lead in the CMA and Process Area

- **Due to potential future missions of C-Reactor, the time-line for final ISD of the C-Reactor complex is uncertain; modeling results will support future ISD alternative comparative analyses, when appropriate.**
- **Clarify through letter the modeled sources under the current configuration are consistent with the ISD final remedy for C-Reactor.**
 - Include meeting minutes, modeling report reference, and presentation for documentation.
 - Relocation of the 690-1G Deionizer Trailer (used at SRS reactors) into C-Reactor; consistent with ISD final remedy for C-Reactor.

INNOVATION • DEFENSE

NONPROLIFERATION • ENVIRONMENT

SRNS

Savannah River Nuclear Solutions

We make the world safer.

