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SRS Composite Analysis and Cover Modeling Considerations

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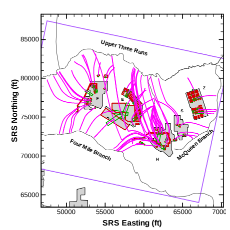
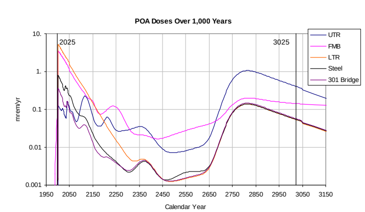




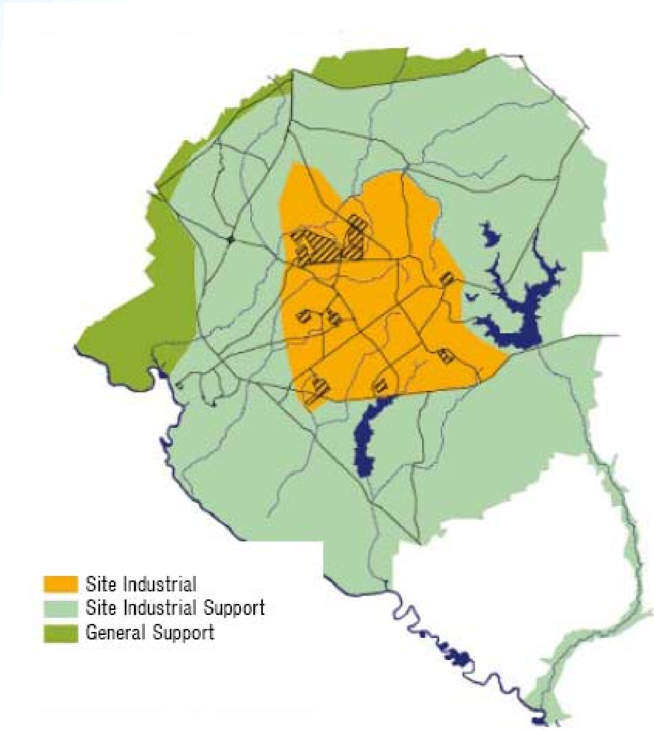
Presentation to Performance Assessment Community of Practice

SRS Composite Analysis (CA): What is it?

SRS CA is an end state, public dose projection (required by DOE 435.1):

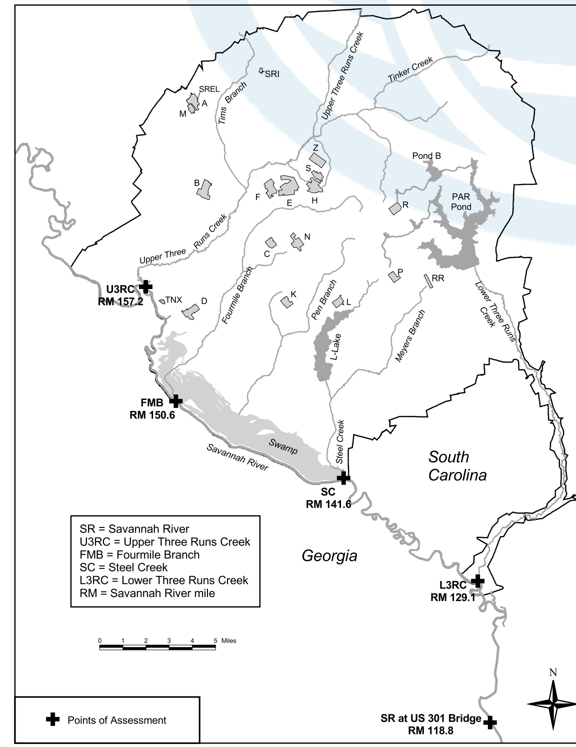
- **To provide reasonable expectation of public radiological protection resulting from all SRS radioactive sources anticipated to remain at projected end state**
- **Evaluated at site boundary points of assessment (POA) over a minimum 1,000 year assessment period (AP) from the end state**
- **Performance measures:**
  - 100 mrem/year primary dose limit
  - 30 mrem/year administrative dose constraint
- **Risk based management tool to help prioritize and select source actions relative to radiological protection of the public**

SRS Land Use Plans and SRS CA POAs



SRS Land Use Plan

(End State Vision; Comprehensive Plan / Ten Year Site Plan)



SRS CA Points of Assessment (POAs)

Primary Screening Analyses

- **Transport Pathways Screening: 50 pathways screened to 2 primary pathways: 1) Source leaching and 2) groundwater transport to surface streams**
- **Exposure Scenario Screening: Recreational and residential bound exposures, since exposure due to contact with, and use of, contaminated surface water**
- **Radionuclide Screening: 849 radionuclides considered reduced to 49 parents to be modeled**
- **D&D Facility Screening: D&Ded Facilities with radionuclide concentrations less than MCL directly beneath them screened out (31 facilities)**

Modeling Approach

- **1-D abstraction from 3-D flow models**
- **Graded approach**
- **Hybrid modeling approach using GoldSim^{TM} for both transport and dose modeling (152 sources) :**
  - Reasonably-conservative best estimate deterministic base case:
    - Generic Release Model
    - Source Release Modeling
  - Deterministic sensitivity cases and probabilistic (uncertainty) modeling to aid in the interpretation of the deterministic base case results

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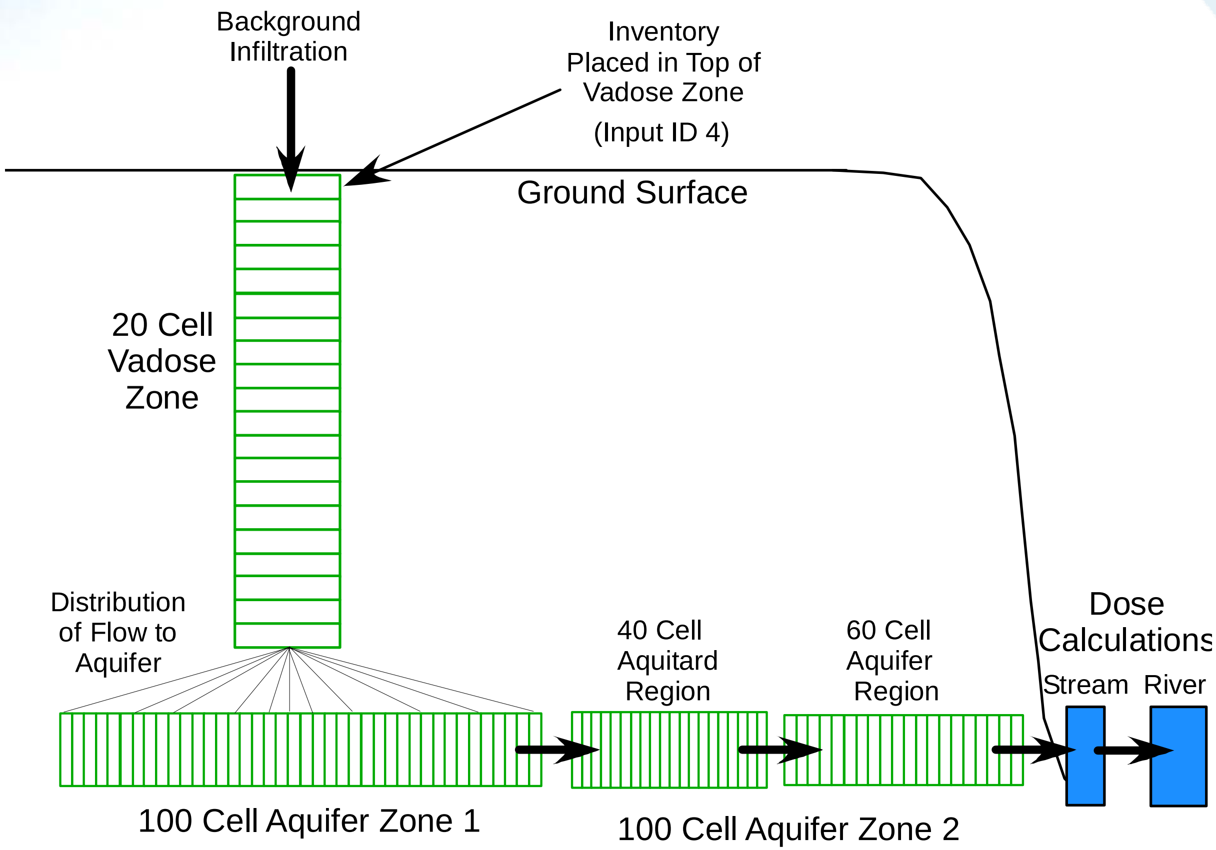
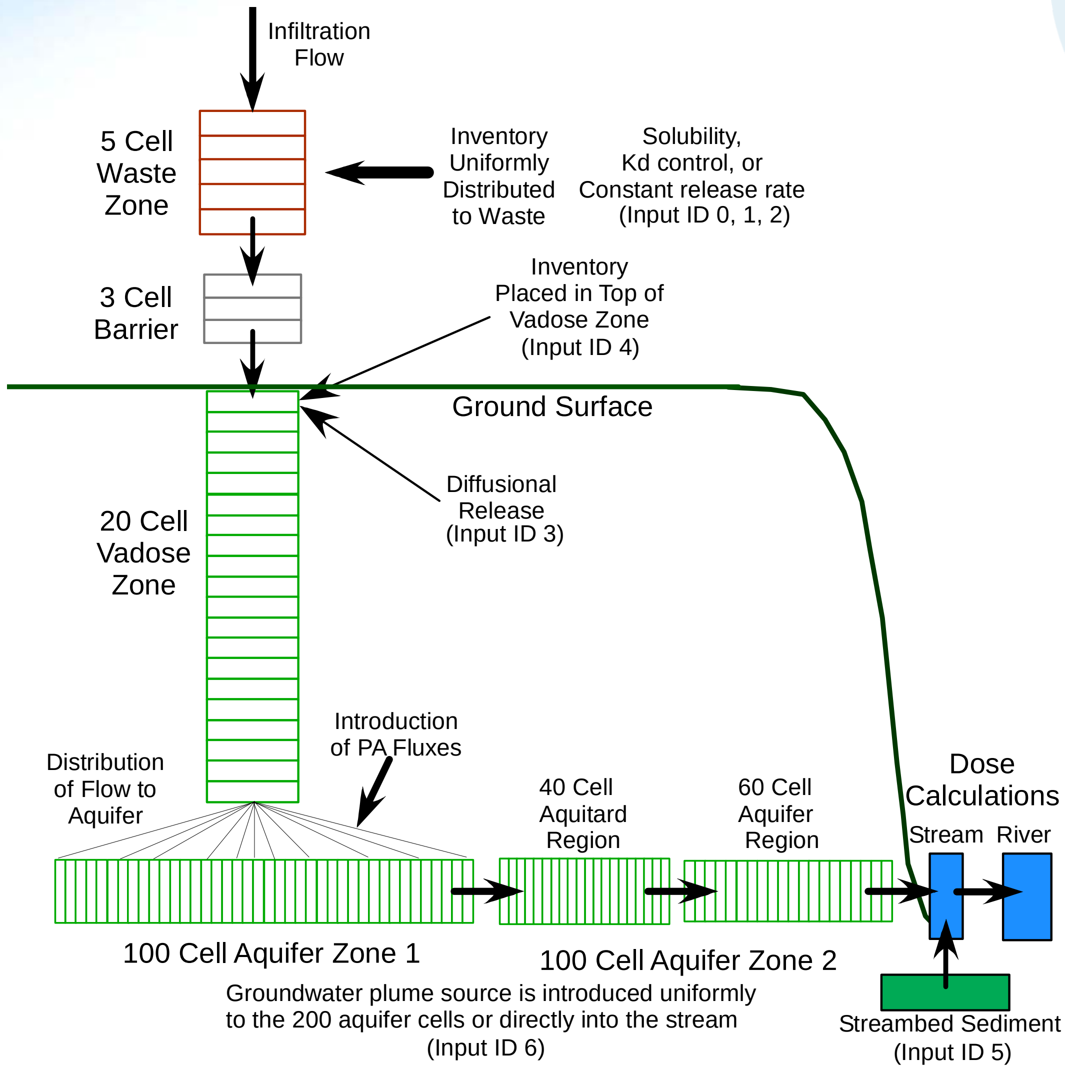
Generic Release Transport Module



- Applied to all 137 CA surface sources
- 108 sources gave maximum doses < 0.1 mrem/yr; no further modeling conducted

Source Release Transport Module



- Applied to 29 surface sources with generic release >0.1 mrem/yr
- Applied to 15 plume and stream bed sources
- More accurately accounts for radionuclide release mechanism (e.g. reactor vessel, PA flux to water table)

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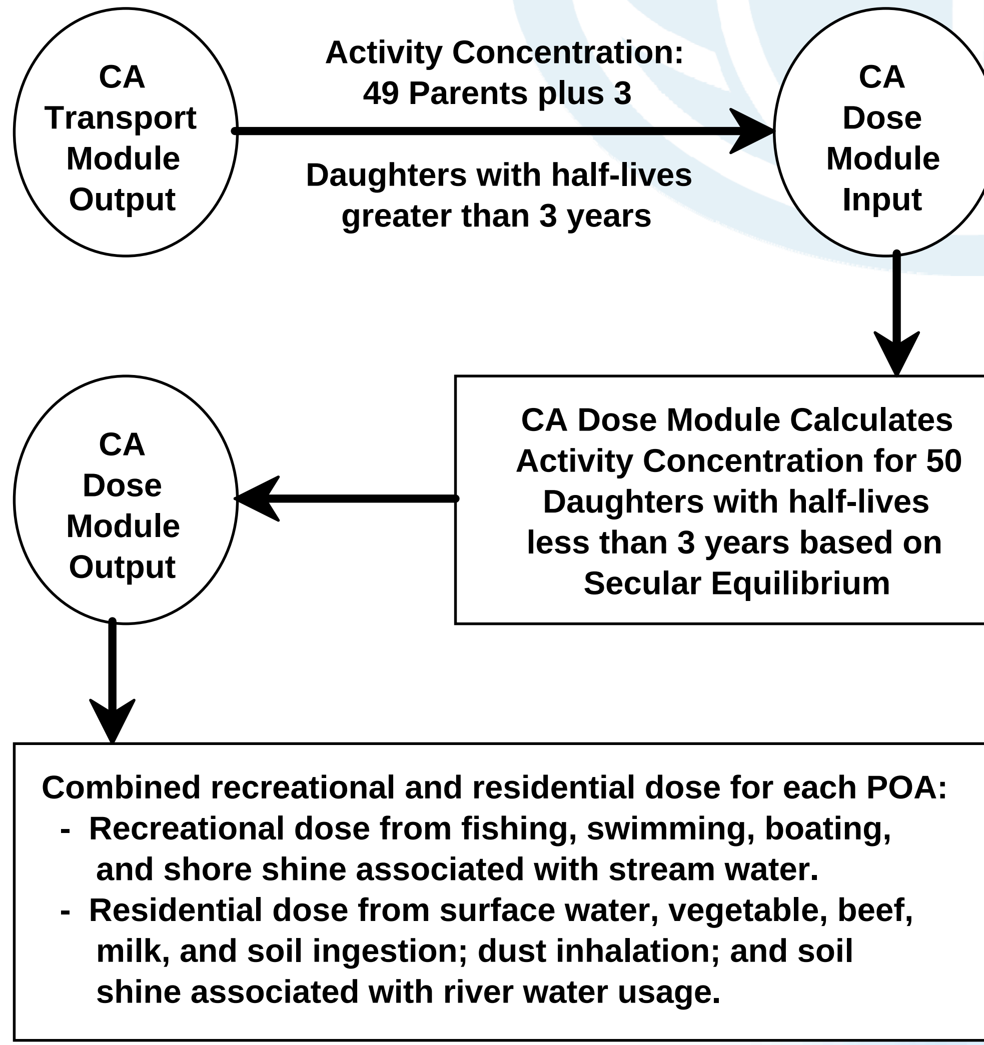
Dose Module

GoldSim™ Dose Module calculates a combined recreational and residential dose for each POA.



Input Data

- Inventories
- Infiltration and distribution
- Porosity, density, tortuosity and saturation and distribution
- K_d and distributions and CDP correction factors
- Vadose zone thickness and lithology
- Aquifer flow path length, clay length, flow velocity, and flow velocity distribution
- Average stream and river flow and distributions
- Radionuclide decay chains, branching fractions, half lives and molecular weights
- Bioaccumulation (transfer factors) and dose conversion factors
- Human exposure parameters and consumption rates and distributions

Input Data: Inventory Development

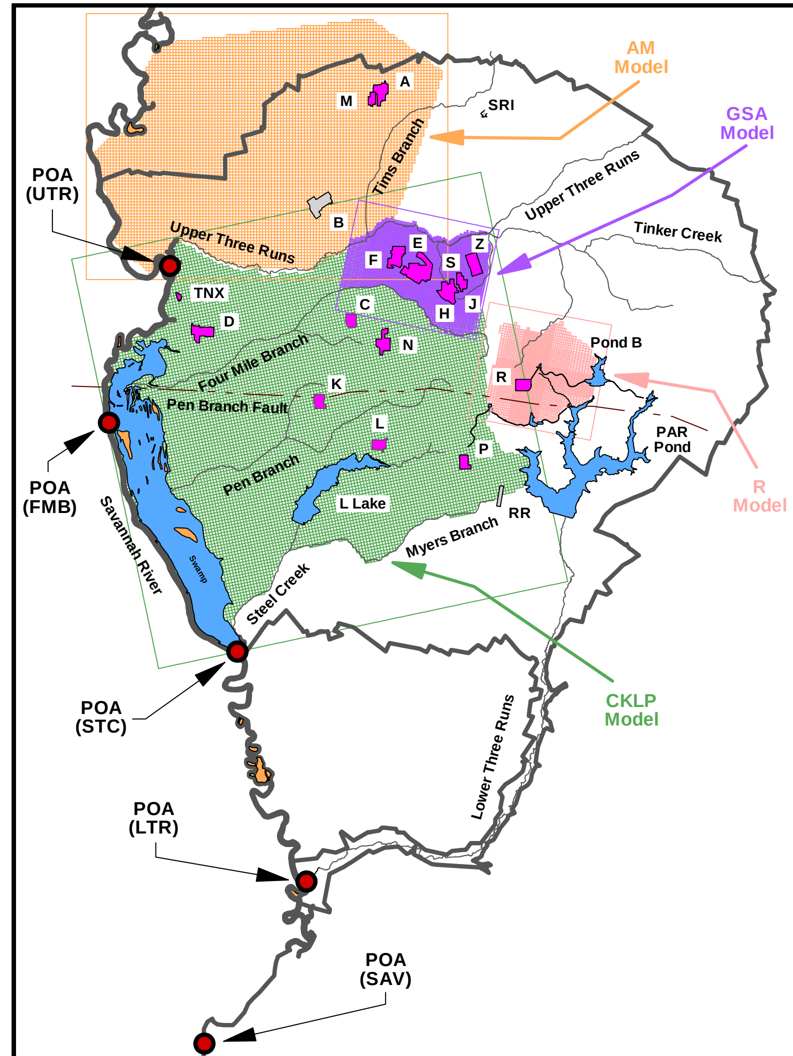
Facilities and Sites with a Projected End State Inventory:

- **PA Facilities (Tanks and LLW Facilities): Inventories developed for PAs (also used PA flux to water table as input to CA model)**
- **RCRA/CERCLA Sites: Investigations associated with RCRA/CERCLA process**
- **Facilities under D&D:**
  - MCL screening
  - Post D&D sampling and analysis
  - Modeling (e.g. reactor vessels)
- **Operating Facilities:**
  - Safety Analysis Reports (e.g. H-Canyon)
  - NEPA Documentation (MOX)

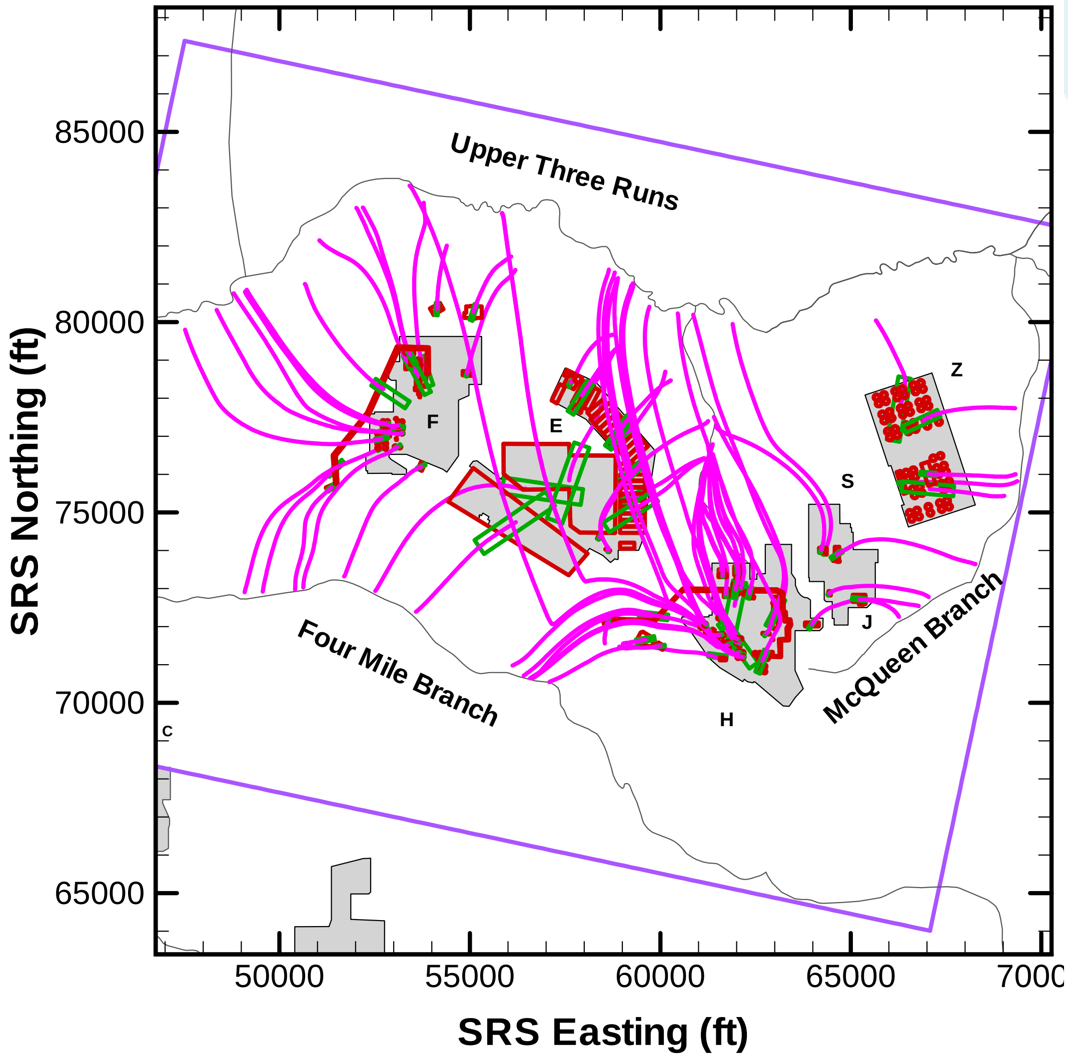
Input Data: Aquifer Flow Path Parameters

Existing 3D Flow Models Utilized

Area Flow Model	Code
AM	MODFLOW
CKLP	FACT
GSA	PORFLOW (FACT based)
R	FACT



Input Data: Aquifer Flow Path Parameters (GSA Example)

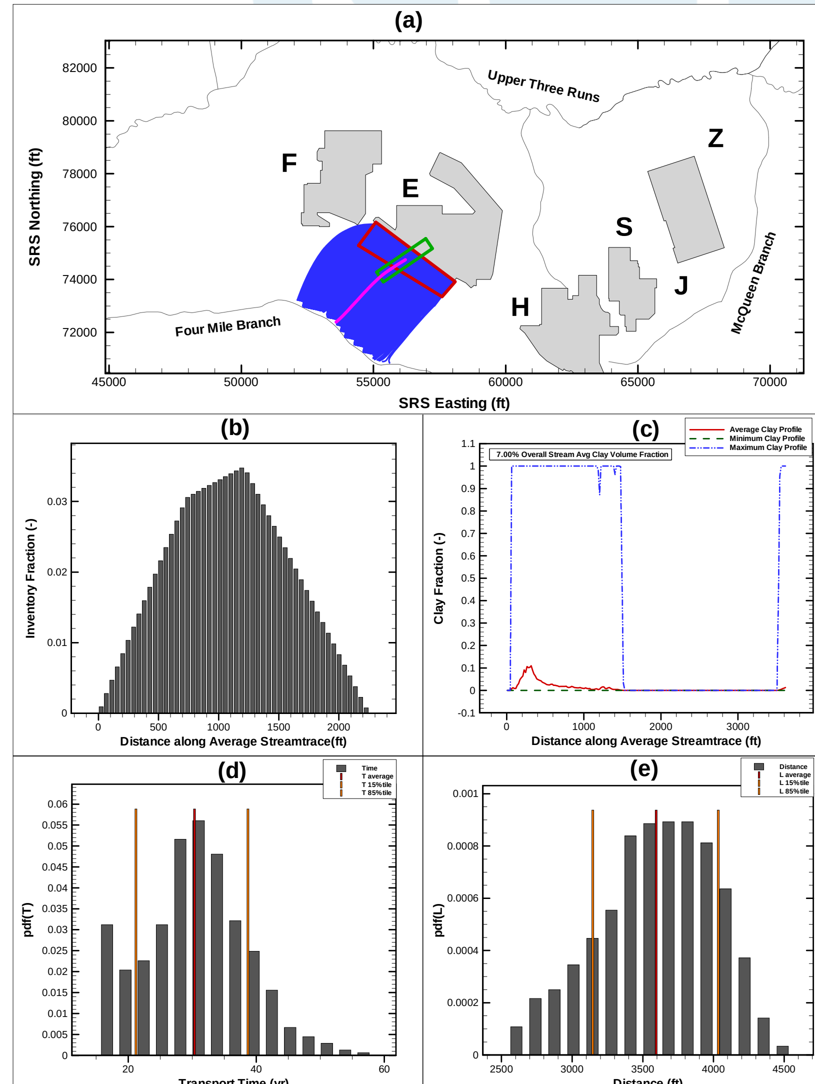


1-D abstraction from 3-D GSA PORFLOW flow model for GSA sources

Input Data: Aquifer Flow Path Parameters (ORWBG Example)

Example: Old Radioactive Waste Burial Ground (ORWBG) 1-D abstraction from 3-D GSA PORFLOW flow model:

a) Streamtrace plot (~1000)
b) Inventory distribution (area projection)
c) Clay in flow path (~27 ft)
d) Transport time (~30 years)
e) Distance (~3600 ft)



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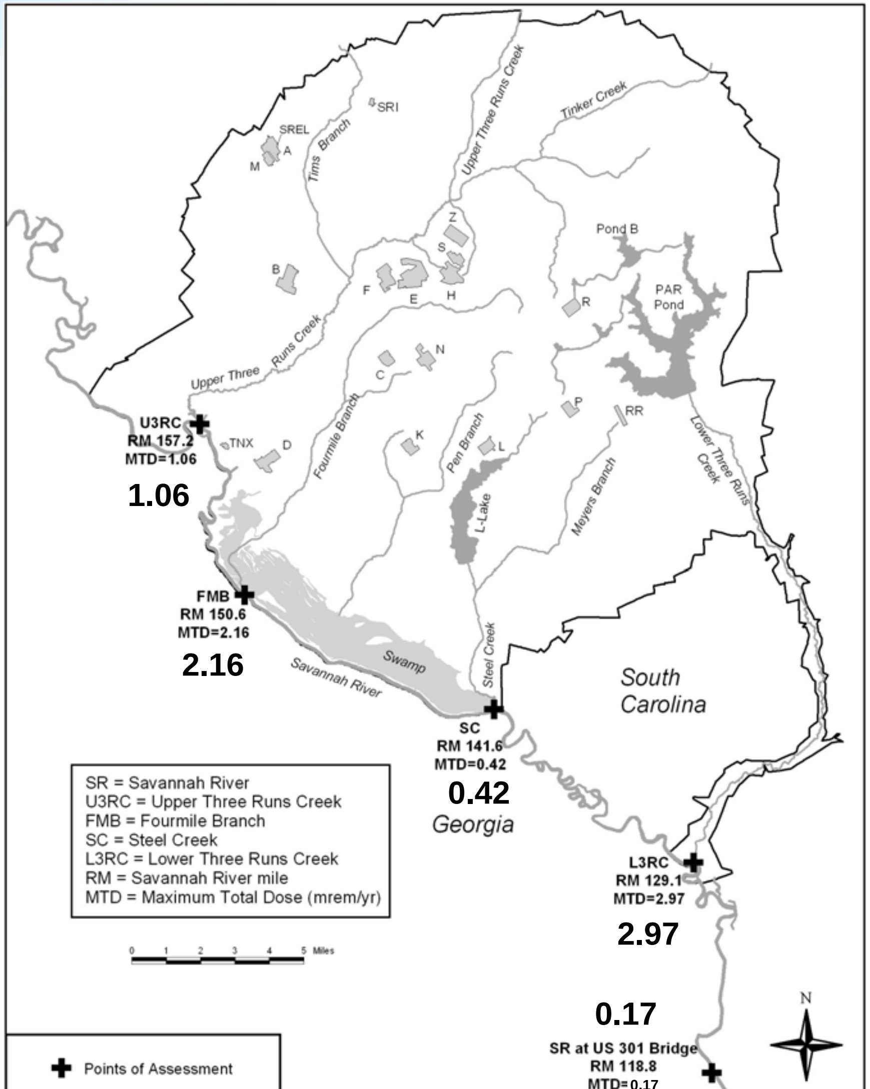
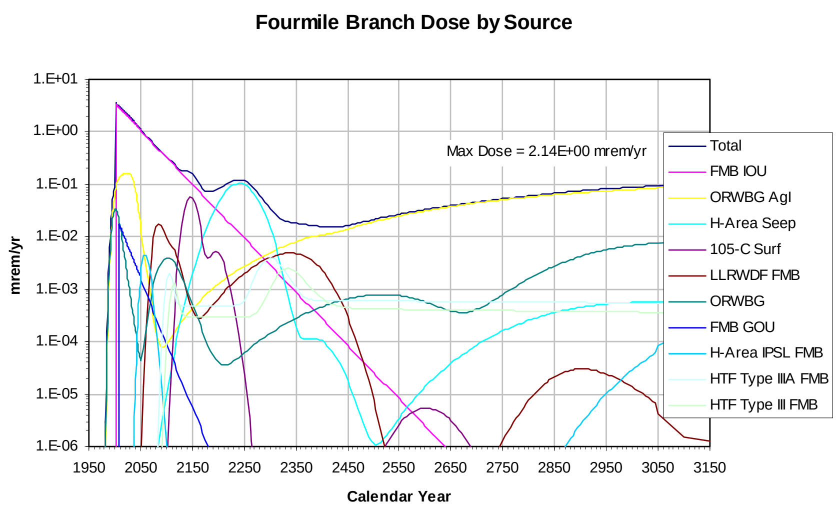
SRS CA Deterministic Base Case Results

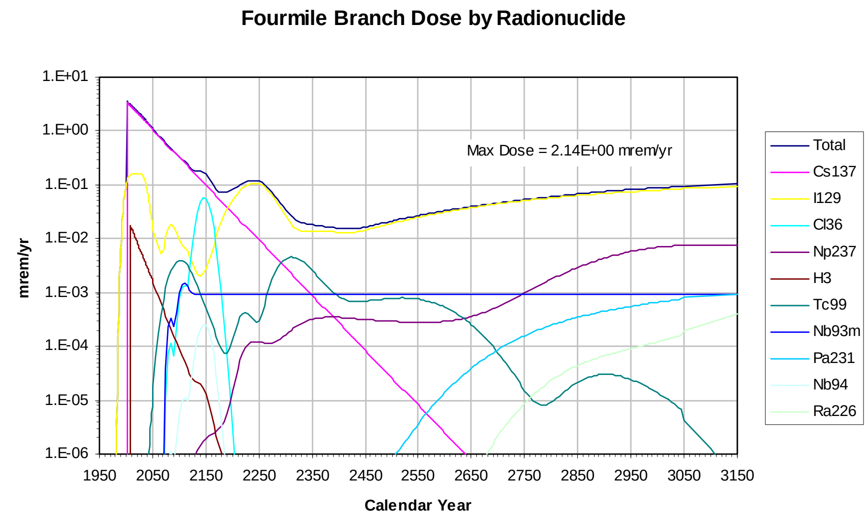


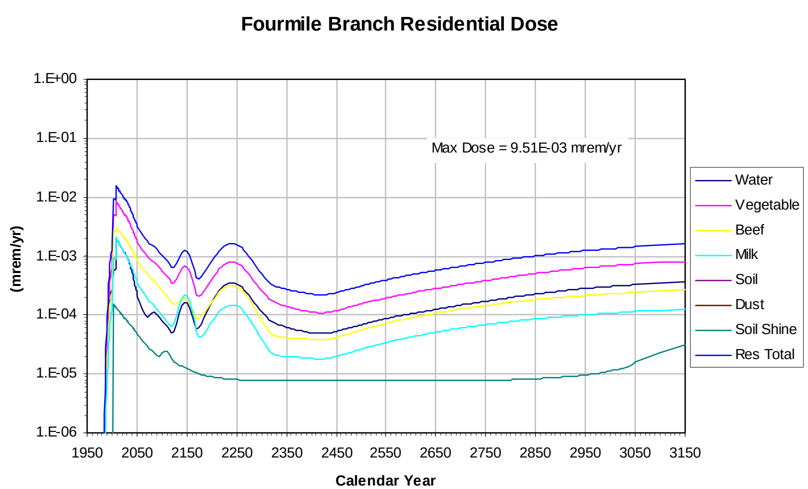
Performance measures:

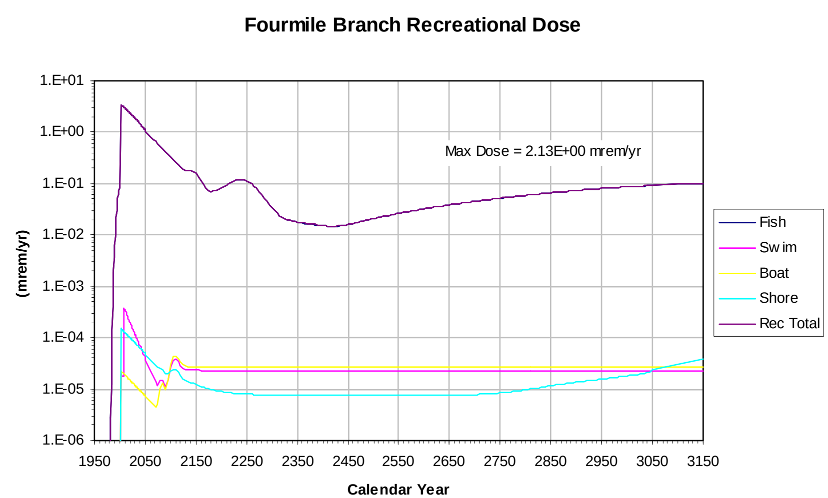
- 100 mrem/year primary dose limit
- 30 mrem/year administrative dose constraint

Deterministic Base Case Results (FMB Example)









FMB = Fourmile Branch

Sensitivity Results

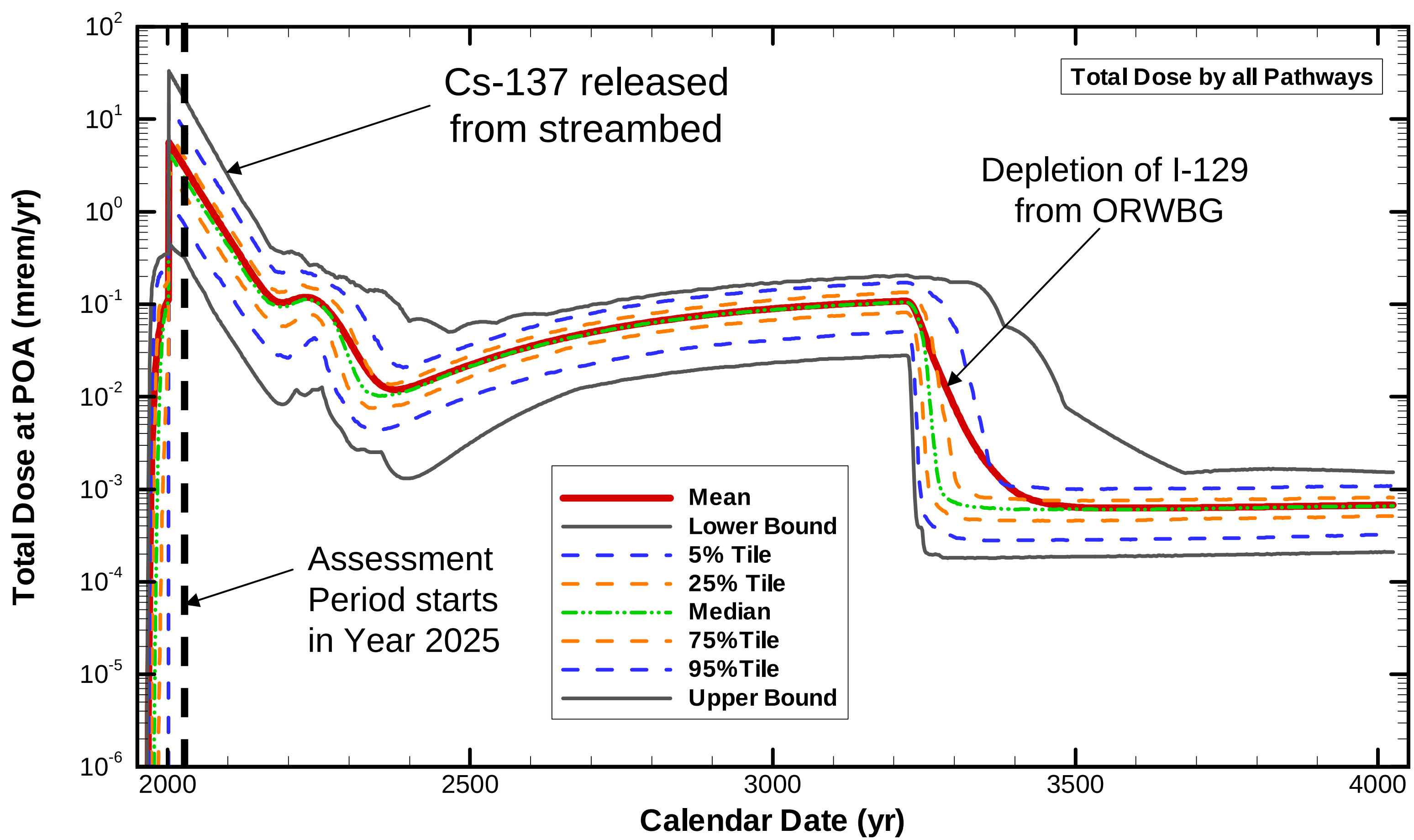
Principal Results of Sensitivity Cases

Sensitivity Case	Principal Result
Stream and River Flow	Maximum at 7Q10 (Low) Flow = 10.1 mrem/yr (LTR POA) versus 3.0 mrem/yr base case
Alternative POA	Maximum dose of 9.7 mrem/yr for Fourmile Branch POA at the edge of the SRS industrial core versus 2.2 mrem/yr base case
Source Inventory	Inventory multiplier to reach 30 mrem/yr at POAs: 10 at LTR (IOU); 14 at FMB (IOU); 28 at UTR (H-Canyon); 75 at SC/PB (IOU); and 950 in SR
Groundwater Divide	Maximum Dose Increase Factor to FMB = 42.2 (HTF dose increased from 3.3E-04 to 1.4E-02 mrem/yr with groundwater flow direction change from UTR to FMB)
Alternative End State Date	Changing the End State Date from 2025 to 2050 results in either no change or a reduction in dose at each POA
C14 Bioaccumulation Factor	Changing the C14 bioaccumulation factor from 3 L/kg to 4,500 and 50,000 L/kg had no effect on dose during 1000-yr CA assessment period
Aquifer Clay	Increase in dose without clay ranged from a factor of 0.9 to 2.8 with an average of 1.4
Maximum Dose over 100,000 years	16 significant sources have maximum doses outside the 1,000-year assessment period. The highest dose over 100,000 years is 3.6E-01 mrem/yr from the NRCDA (part 6) versus 3.7E-03 mrem/yr base case

Probabilistic Uncertainty Analysis

- **Consider sources contributing greater than 0.05 mrem/yr for each POA**
- **Use distributions of parameter values:**
  - Background and engineered barrier infiltration rates
  - Material property values (porosity, density, tortuosity, and saturation)
  - Distribution coefficients (Kds)
  - Concrete aging
  - Aquifer flow velocity
  - Stream and river flow rates
  - Human exposure parameters and consumption rates

Probabilistic (Uncertainty) Results (FMB Example)



FMB sources representing 98% of maximum base case dose

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SRS CA Model Summary

- **The same GoldSim model was used for all base case calculations and sensitivity studies**
  - Ran a single CA source at a time with model results stored in Excel workbooks
  - Base case calculations included:

    108 "generic" surface sources

    \+ 29 source release surface sources

    + 15 stream bed and plume sources

    152 CA sources
- **Runtimes of 1 to 5 minutes/CA source**
- **Developed a variation on this basic model to allow running multiple sources simultaneously for the uncertainty analysis**
  - Run times of 4 to 20 hours for 2 to 5 coupled sources and 400 realizations (scope of uncertainty was limited by computing resources)

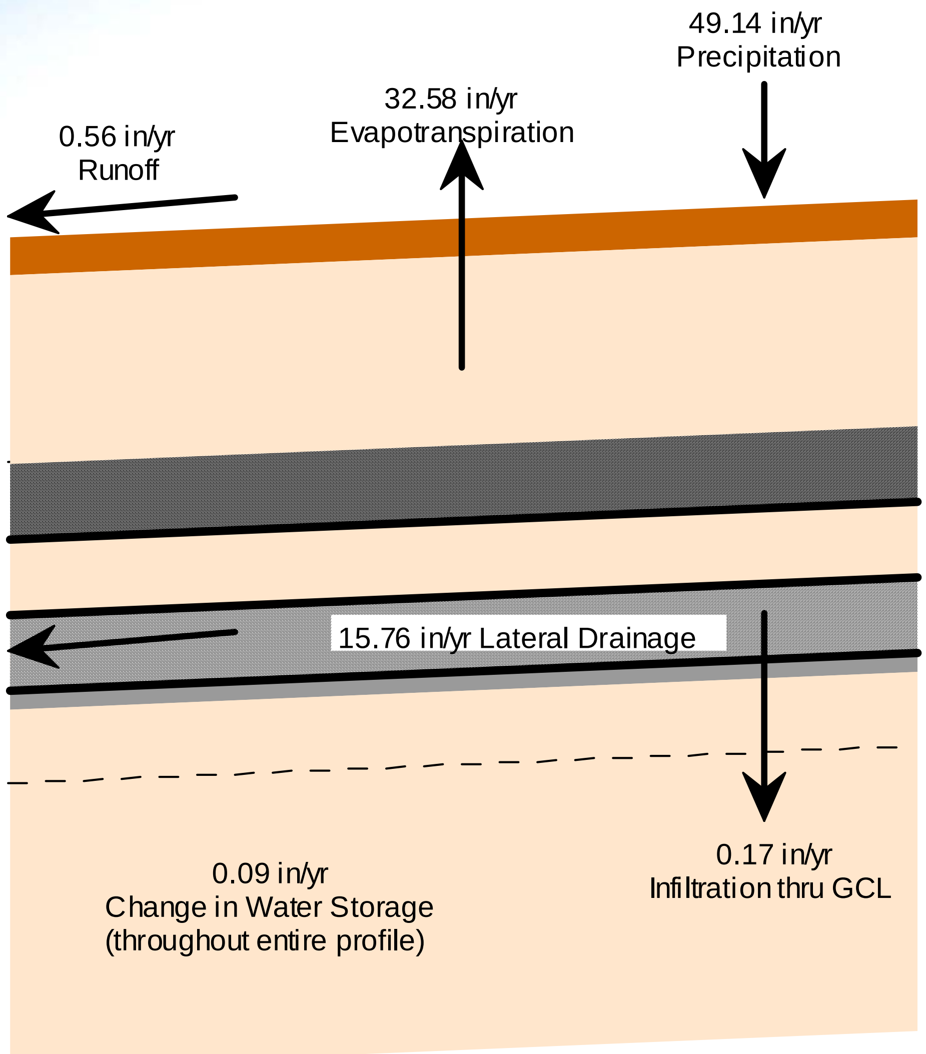
CA Conclusions

- **Maximum deterministic dose is 3 mrem/year (i.e., 10% of the 30 mrem/year dose constraint)**
- **Sensitivity and uncertainty analyses provide great confidence that dose constraint will not be exceeded**
- **The CA provides DOE management a risk based tool to help prioritize and select source actions relative to radiological protection of the public:**
  - e.g. D&D of H-Canyon should include significant removal of Np237
  - Many sources are of no significant concern relative to the public

CA Considerations for ASCEM

- **Management tool (#1 consideration):**
  - "What if" (quick turn-around may be required)
  - Dose tied back to specific source, radionuclide, and pathway
- **Site-wide approach:**
  - Sources
  - Hydrogeology (Vadose zone/groundwater/surface water)
  - May require sub-models with greater resolution
- **Graded approach:**
  - Screening (pathways, exposure scenarios, radionuclides, sources, etc.)
  - Use of existing approved models where available (e.g. PAs)
  - Data limitation consideration
  - Level of source modeling commensurate with dose/risk
  - Level of modeling commensurate with need for uncertainty analysis

Cover Modeling Considerations



Cover modeling performed to:

- **Determine infiltration to waste over time**
- **Provide upper boundary condition for flow and transport modeling**

Primary Cover Modeling Consideration

Change in material properties due to degradation as input to cover models, for example:

Layer	Degradation Mechanism
Vegetative cover	Succession
Soil above the erosion barrier	Erosion
Erosion barrier	Root penetration
Lateral drainage layer	Silting-in
	Root penetration
High density polyethylene (HDPE) geomembrane	Antioxidant depletion, thermal oxidation, & tensile stress cracking
	Root penetration
Geosynthetic clay liner (GCL)	Divalent cations (Ca^{+2}, Mg^{+2}, etc.)
	Root penetration

Examples of Potential Cover Modeling Improvement

- **R&D and model development supporting coupling HDPE geomembrane tensile strength reduction, due to antioxidant depletion and subsequent thermal oxidation, with the applied HDPE geomembrane stress field in order to predict the resulting tensile stress cracking of the HDPE geomembrane.**
- **R&D and model development supporting analysis of the impact of roots on the infiltration through composite barrier layers (e.g. HDPE geomembrane overlying a GCL)**

Backup Slides

CA Source Release Mechanism

Source Unit	Sources	Source Release Mechanism										
		Clay Cap	Concrete Cap	Geo-synthetic Cap	Metal Cask	AgI Solubility	Diffusion	Metal Corrosion	Concrete Barrier Kd	PA Flux	Tritium Plumes	Streambed Sediment
E-Area ILV	1									✓		
E-Area LAWV	1									✓		
E-Area LLRWDF	2			✓								
E-Area MWMF	1	✓										
E-Area ORWBG	2			✓		✓						
Z-Area Vault 2	3									✓		
F-Area Seepage Basin	1	✓										
H-Area Seepage Basin	1	✓										
NRCDA 7E Metal	6				✓			✓				
Reactor Vessel Stainless Steel (C, K, L, P, R)	5		✓					✓	✓			
H-Area Canyon	1		✓									
Tritium Area Buildings: 232-H, HANM, HAOM, 264-2H, TEF	5						✓					
GOUs: FMB, D-Area, K-Area, L-Area, P-Area, R-Area, T-Area	7										✓	
IOUs: FMB, LTR, PB, SR-A, SR-B, SC, UTR, SpdTbr	8											✓

Deterministic Base Case Results

Maximum Cumulative* Dose at each POA

Point of Assessment	1000-Year Maximum Cumulative Dose mrem/yr	Next 9000-Year Maximum Cumulative Dose mrem/yr	Major Contributing Source	Major Contributing Radionuclide	Major Exposure Scenario/Pathway
Upper Three Runs	1.06	0.40	H-Canyon	Np237	Recreational / Fish Ingestion
Fourmile Branch	2.16	0.14	FMB IOU	Cs137	Recreational / Fish Ingestion
Steel Creek/Pen Branch	0.42	0.05	SC IOU	Cs137	Recreational / Fish Ingestion
Lower Three Runs	2.97	0.05	LTR IOU	Cs137	Recreational / Fish Ingestion
Savannah River	0.17	0.05	LTR IOU	Cs137	Residential / Vegetable Ingestion

* Cumulative dose includes contribution from upstream sources