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H-Tank Farm NDAA Section 3116 Draft Basis Document Public Presentation (HTF Performance Assessment)

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HTF PA Revision Overview

- This new revision to HTF PA [SRR-CWDA-2010-00128] is based on Revision 0 issued in March 2011.
- The purpose of the revision is to take advantage of lessons learned from the Ronald W. Reagan National Defense Authorization Act of Fiscal Year 2005, Section 3116 consultation process for the F-Tank Farm (FTF) 3116 Basis Document and associated FTF PA with the Nuclear Regulatory Commission.
- In addition, this revision will reflect new information that has been obtained since Revision 0 was issued in March 2011 as well as comments received on Revision 0 from the South Carolina Department of Health and Environmental Control (SCDHEC) and the U.S. Environmental Protection Agency (EPA).
- In general, the philosophy for selection of key assumptions will transition from "most likely" value to the "most probable and defensible" value.

PA Contents Overview

- Eleven chapters
- Appendices A-U containing modeling outputs
- Over 400 figures and tables of information in the body of the PA
- Over 5000 total pages between the PA body (850 pages) and appendices
- Over 300 references utilized in development of PA

Timeline of HTF PA

- PA development began – October 2009
- Public scoping meeting was held April 20-22, 2010 with NRC, SCDHEC and EPA to discuss primarily approaches and inputs that were different from the FTF PA
- Revision 0 of the HTF PA issued March 2011
- Revision 1 of the HTF PA incorporates new information and comments received

Comments Incorporated into HTF PA Revision 1

- The HTF PA, Rev 0 text was clarified to reflect information provided to the NRC in response to the FTF Requests for Additional Information (RAIs) and resolution of issues raised in the NRC FTF Technical Evaluation Report (TER).
- The HTF PA, Rev 0 text also has been revised to reflect resolution of secondary issues from the (Low-Level Waste Disposal Facility Federal Review Group) LFRG review of Revision 0 of the HTF PA.
- Initial HTF PA, Rev 0 comments received from SCDHEC and EPA HTF PA have been addressed in HTF PA, Rev 1.

HTF PA Revision 1 Major Enhancements

- An update of the HTF inventory to reflect a revised HTF waste tank inventory document that is informed from the recent FTF work.
- A revised waste release model using thermodynamic data associated with the Nuclear Energy Agency Thermochemical Database and expanded speciation information.
- An update of the HTF Base Case model to incorporate the new waste release model, new soil K_d values, and other PA lessons learned.
- New flow variability analysis (72 flow cases modeled).

HTF PA Revision 1 Major Enhancements (cont)

- New HTF probabilistic modeling utilizing flow studies and reflecting changes to the Base Case and probabilistic input parameters.
- Additional sensitivity and barrier analyses based on PA lessons learned.
- Reference to a new report assessing the potential impact of Calcareous Zones on the HTF integrated conceptual model.
- Reference to a new report describing the Features, Events and Processes (FEPs) evaluation that was done for the HTF PA, Revision 1.

Input Parameters

Grout / Concrete Properties

- Utilized information for initial properties from testing done for FTF
- Evaluated degradation rates for tanks located in the water table
- Utilized changing moisture retention curves as material degraded versus a single curve
- Used updated grout formulation in modeling

Grout / Concrete Properties

- Cementitious material degradation estimated and used to vary the properties over time

Cementitious Material Stages	Type I	Type II	Type III	Type IIIA	Type IV
HTF Fill Grout (Initial Properties)	0 – 2,700	0 – 5,100	0 – 5,100	0 – 5,000	0 - 800
Degrading HTF Fill Grout	2,700 – 13,200	5,100 – 16,700	5,100 – 19,200	5,000 – 19,100	800 – 64,400
Fully Degraded HTF Fill Grout	13,200	16,700	19,200	19,100	64,400
HTF Concrete (Initial Properties)	0 – 1,350	0 – 2,550	0 – 2,550	0 – 2,500	0 - 400
Degrading HTF Aged Concrete	1,350 – 2,700	2,550 – 5,100	2,550 – 5,100	2,500 – 5,000	400 - 800
Fully Degraded HTF Aged Concrete	2,700	5,100	5,100	5,000	800

Hydrogeology Comparisons

FTF

- All tanks above water table – although Type IVs within 5 feet
- Flow initially to the west with a few tanks influenced by a flow divide
- General plume spread

HTF

- 4 tanks fully submerged and 4 tanks partially submerged in the water table
- Flow in multiple directions and many influenced by a flow divide
- Significant plume spread due to flow divide

Type I Tanks - Water Table

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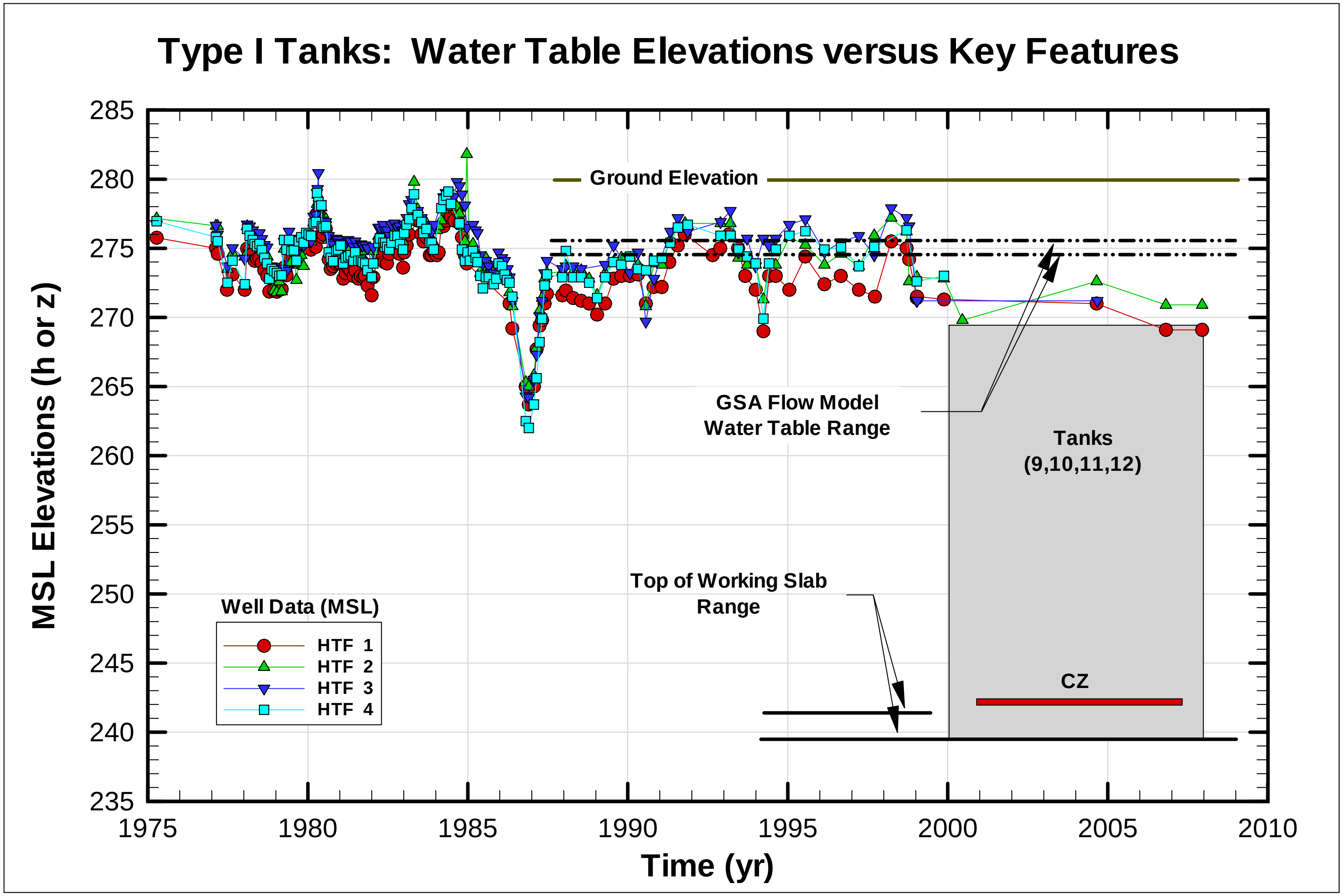

Type II Tanks - Water Table

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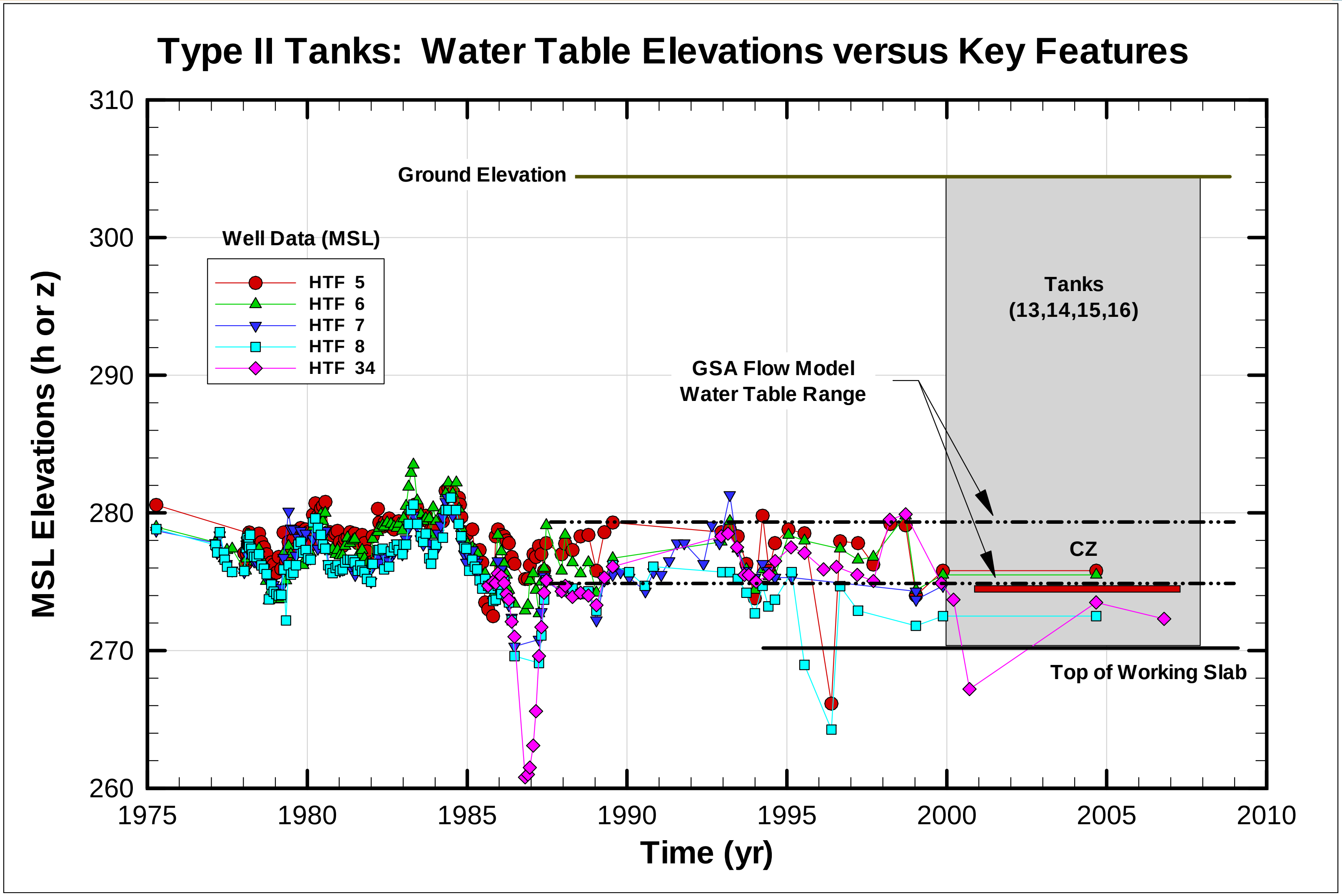


Inventory Approach Part 1

- Inventory estimates utilize current tank concentrations with adjustments for tank groupings, chemical cleaning, older vs. newer tank designs, detection limits, 1.0 curie
- All H-Area tanks were assumed to have a residual heel of 4,000 gallons in the primary tank with the exception of Tank 16. Tank 16 is assumed to have a residual heel of 1,000 gallons in the primary tank. Any residual radioactivity contained in corrosion products or as contamination on the walls and coiling coils is assumed to be accounted for in the heel on the floor; no separate calculation or assignment of source term is included in the model for the primary tanks.

Inventory Approach Part 2

- All the H-Area Type I and II tanks have a history of leak sites but the quantity of waste that has leaked to the annuli and remains today varies from tank to tank. In addition, the Tank 16 waste in its annulus is unique due to addition of sand during testing and will be the most difficult to remove. It is assumed that Tank 16 will contain 3,300 gallons in its annulus. Tanks 9 and 14 annuli contain a significant volume of waste at this time and will also be assumed to contain a residual inventory of 3,300 gallons. The annuli in Tanks 10, 11, 12, 13, and 15 contain relatively insignificant inventories at this time and will all be assumed to be closed with a residual heel of 100 gallons.

Inventory Approach Part 3

- The Type II tanks contain sand pads between the primary tank and the annular pan. In Tanks 14 and 16, it is assumed that the interstitial spaces in the pad were saturated with liquid waste. The sand pads associated with Tanks 13 and 15 are assumed to contain 100 gallons of salt waste evenly distributed within the pad.

Inventory Approach Part 4

- Assignment of constituent concentrations will utilize tank-specific information from the Waste Characterization System. We will continue to use tank grouping instead of surrogate tanks to estimate individual constituents that are missing inventories in the Waste Characterization System database. The groups are: 1) Tanks 9-12 (Type I tanks); 2) Tanks 13-15 (Type II tanks except Tank 16); 3) Tank 16; 4) Tanks 21-24 (Type IV tanks) and 5) Tanks 29-32, 35-43, and 48-51 (Type III and IIIA tanks). We will continue to use the maximum concentration for the individual constituent within the tank grouping to account for the uncertainty around the tank cleaning order.

Inventory Approach Part 5

- Concentrations associated with Cs-137, Sr-90 and Tc-99 have been adjusted lower based on results from tank cleaning efforts to date. Note: the one exception for the Type III and IIIA tanks grouping is assignment of the Pu-238 concentration based on classification as a "salt" or a "sludge" tank. Tanks 32, 35, 39, 40, 43, and 51 used a higher Pu-238 concentration consistent with sludge waste. The remaining tanks, Tanks 29, 30, 31, 36, 37, 38, 41, 42, 48, 49, and 50, used a lower Pu-238 concentration more consistent with the anticipated heel associated with a salt tank. The Pu-238 concentration drives the concentration of the Ra-226 and its daughter products, a key contributor to dose over extended time periods.

Inventory Approach Part 6

- The assumed concentrations for some individual radionuclides that may be present in trace quantities were increased based on improved understanding of their impacts to system dose. The additional conservatism in these assignments could have the added benefit of supporting increased required detection limits for final characterization sample analyses.
- The HTF non-radiological (chemical) inventory was estimated using the same methodology. Nine additional contaminants (Al, B, Cl, Co, I, Mo, PO_4, SO_4, and Sr) will be added to the non-radiological inventory of concern list and modeled in the HTF PA, based on input from SCDHEC and the EPA during the development of the Liquid Waste Tank Residuals Sampling and Analysis Program Plan.

Waste Release Model

- Waste release via solubility limits with pore volume in grout fill used for timing of transitions (reducing to oxidizing, pH transition).
- Waste Release Model Report [SRNL-STI-2012-00404] updated, including new solubility data based on FTF lessons learned. The waste release model was revised using thermodynamic data associated with the Nuclear Energy Agency Thermochemical Database and expanded speciation information.

HTF Waste Release Model

Selected Solubilities (moles/L) for HTF PA
(HTF PA Revision 1 assumes iron coprecipitation only for Tc-99)

Element	Reduced Region II	Oxidized Region II	Oxidized Region III	Condition C	Condition D
Am	1E-09	1E-09	6E-08	4E-09	4E-09
Cs	Instantaneous Release	Instantaneous Release	Instantaneous Release	Instantaneous Release	Instantaneous Release
Np	1E-09	3E-07	2E-06	1E-09	2E-05
Pu	3E-11	3E-11	3E-11	3E-11	3E-11
Ra	3E-05	3E-05	1E-05	7E-06	2E-05
Tc	1E-14	1E-13	2E-15	Instantaneous Release	Instantaneous Release
U	5E-09	5E-05	4E-06	4E-09	2E-06

Waste Chemical Transition Timing

- Utilizes same FTF approach with HTF chemistry and information for submerged tanks.

Tank Position	Eh/pH Transition	Pore Volumes
Non-Submerged	Reduced Region II to Oxidized Region II	371
	Oxidized Region II to Oxidized Region III	2,131
Submerged	Condition C to Condition D	1,414
	Condition D to Oxidized Region III	2,383

Liner Failure Times

- Steel liner degradation utilizes FTF approach with updates for submerged tanks

Waste Tank Type	Liner Failure Year for Modeling
Type I	11,397
Type II	12,687
Type III/IIIA	12,751
Type IV	3,638

- Tanks 12, 14, 15, and 16 are conservatively modeled as having initially failed waste tank liners due to observed conditions of the specific tanks (i.e., leak sites).

Distribution Coefficients

- The HTF PA Revision 1 distribution coefficients reflect the most current data available
- HTF PA uses cement-leachate impacted soil Kds for unsaturated zone tied to transition of grout

Dose Calculations

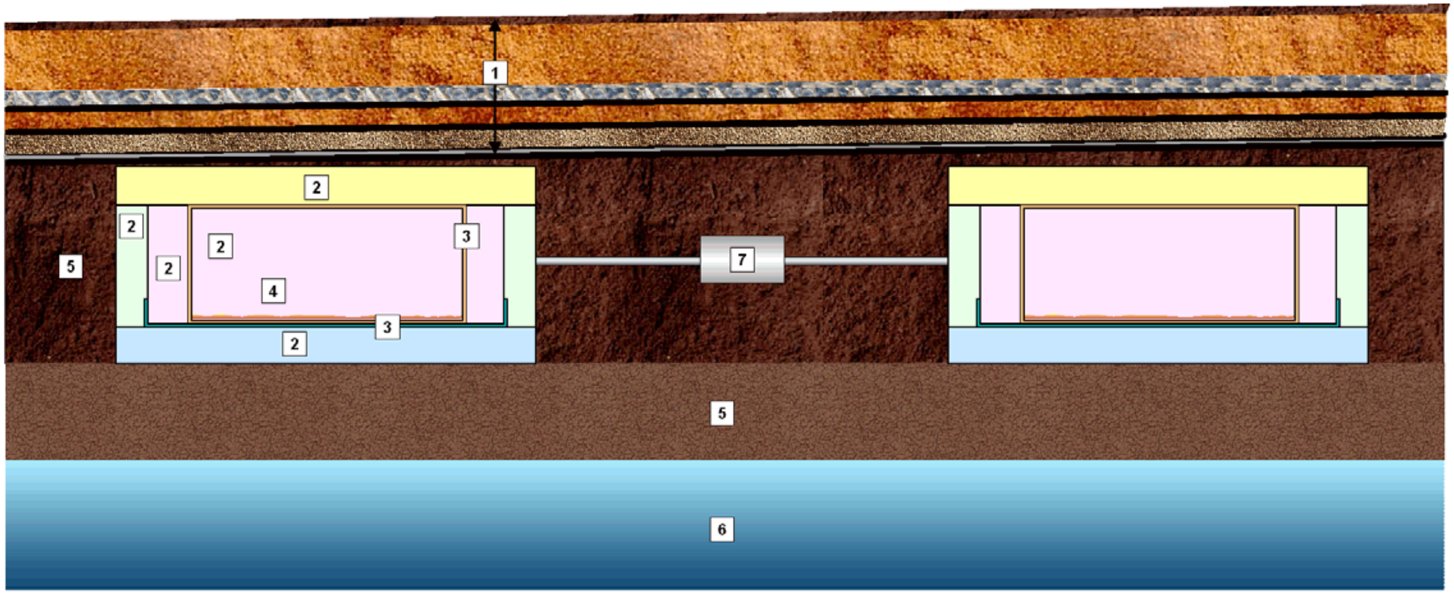
- Bioaccumulation factors updated to include IAEA-472 data
- Consumption rates updated to new SRS evaluation
- No change to DCFs from FTF except that radon dose calculation changed based on SDF RAI.
- Dose pathways not changed from FTF except that chicken and egg pathways added based on SDF RAI

Modeling

Hybrid Modeling Approach

- Modeling is a hybrid approach with the deterministic results (PORFLOW) as the baseline and the sensitivity/uncertainty analyses performed with a probabilistic code (GoldSim) to evaluate all parameters at once
- GoldSim used to better quantify uncertainty and to identify which parameters the model results are the most sensitive to.

HTF PA Conceptual Model



1 **Closure Cap -** Provides water flux to the top of tank from infiltrating rainwater.

2 **Vault Concrete and Tank Fill Grout** - Provides degradation description of the concrete and grout based materials in the tank system.

3 **Carbon Steel Tank Liner (Primary and Secondary)** - Provides degradation description of the carbon steel liners in the tank system.

4 **Contamination Leaching** - Provides waste contamination release rates of residual waste heel based on solubility and sorption rates per nuclide.

5 **Vadose Zone and Backfill** - Provides hydraulic related values for the unsaturated undisturbed soil beneath the tanks and the backfill soil surrounding the tanks.

6 **Hydrogeology** - Provides hydraulic related values for the saturated soil beneath the tanks.

7 **Ancillary Equipment -** Provides waste contamination release rates of residual waste associated with ancillary equipment.

Modeled Tank Configurations

Case	Assumed Fast Flow Paths	Degradation of Cementitious Materials	Liner Failure Time	CZ/Chemical Transition Driver
A	None	Degradation curve based on Table 4.2-30	Later failure date (based on grouted *D* of 1.0E-06 CO_2) in Table 4.2-32	Full Reducing Grout Capacity
B	Channel with no flow impedance through reducing grout	Degradation assumed to be a step change at year 501	Early failure date (based on grouted *D* of 1.0E-04 CO_2) in Table 4.2-32	Full Reducing Grout Capacity
C	Channel with no flow impedance through reducing grout	Degradation curve based on Table 4.2-30	Early failure date (based on grouted *D* of 1.0E-04 CO_2) in Table 4.2-32	CZ Reducing Capacity
D	Channel with no flow impedance through reducing grout and basemat	Degradation assumed to be a step change at year 501	Early failure date (based on grouted *D* of 1.0E-04 CO_2) in Table 4.2-32	Full Reducing Grout Capacity
E	Channel with no flow impedance through reducing grout and basemat	Degradation curve based on Table 4.2-30	Early failure date (based on grouted *D* of 1.0E-04 CO_2) in Table 4.2-32	CZ Reducing Capacity

Tank Configurations vs. Base Case

		Alternate Cases					
		B	C	D	E	No Closure Cap	Synergistic
Barriers	Closure Cap	NC	NC	NC	NC	No Closure Cap	NC
	Waste Tank Top	Tank Top Fast Flow	Tank Top Fast Flow	Tank Top Fast Flow	Tank Top Fast Flow	NC	Tank Top Fast Flow
	Waste Tank Liner	Early liner degradation	Early liner degradation	Early liner degradation	Early liner degradation	NC	Early liner degradation
	Waste Tank Grout	Early grout degradation	NC	Early grout degradation	NC	NC	NC
	Contamination Zone Reducing Capacity	NC	Grout monolith reducing capacity impact minimized	NC	Grout monolith reducing capacity impact minimized	NC	Grout monolith reducing capacity impact minimized
	Contamination Zone Solubility Limits	NC	NC	NC	NC	NC	Solubility Limits higher for Dose Drivers
	Waste Tank Basemat	NC	NC	Basemat Fast Flow	Basemat Fast Flow	NC	NC
	Vadose Zone Beneath Waste Tanks	NC	NC	NC	NC	NC	NC

PORFLOW Model Improvements

- HTF PORFLOW model based on FTF model, with modifications made to reflect physical differences.
- Lessons learned from FTF incorporated and described in PORFLOW report (SRNL-STI-2012-00465)
  - Updated characteristic curves
  - Revised longitudinal dispersivity
    - 3.2 meters is specified in HTF PA modeling as a more conservative assumption in response to concerns about excessive plume spreading (FTF PA used 10 meters).

Flow Parametric Study

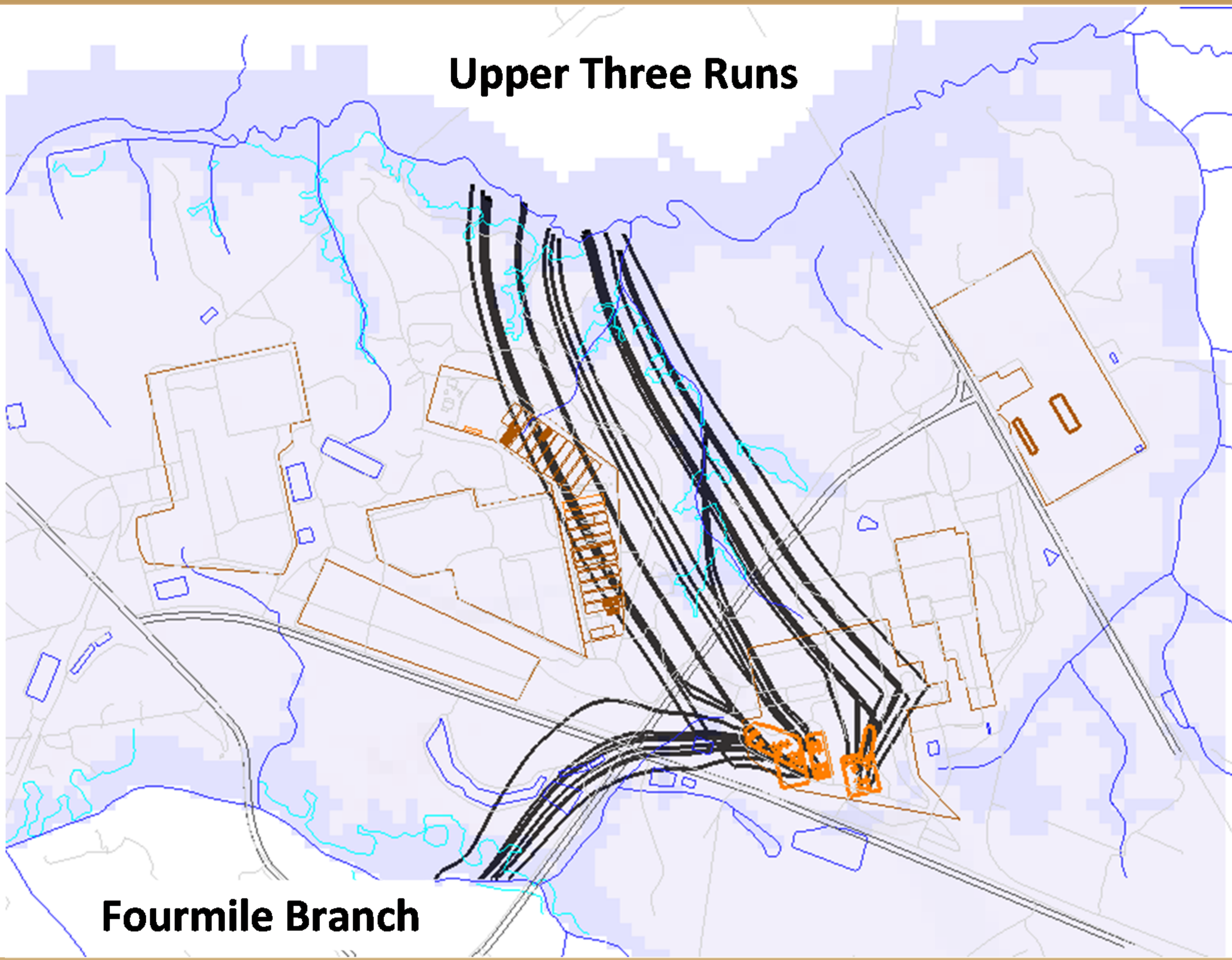
- A flow parametric study was conducted for the HTF based on the Case-A scenario.
- Flow rates and associated parameters generated during the study were output in a form that the HTF GoldSim model could utilize in stochastic fate and transport simulations
- The study included running 72 parametric cases with varying flow field cases for each of four waste tank types.

Flow Study Attributes

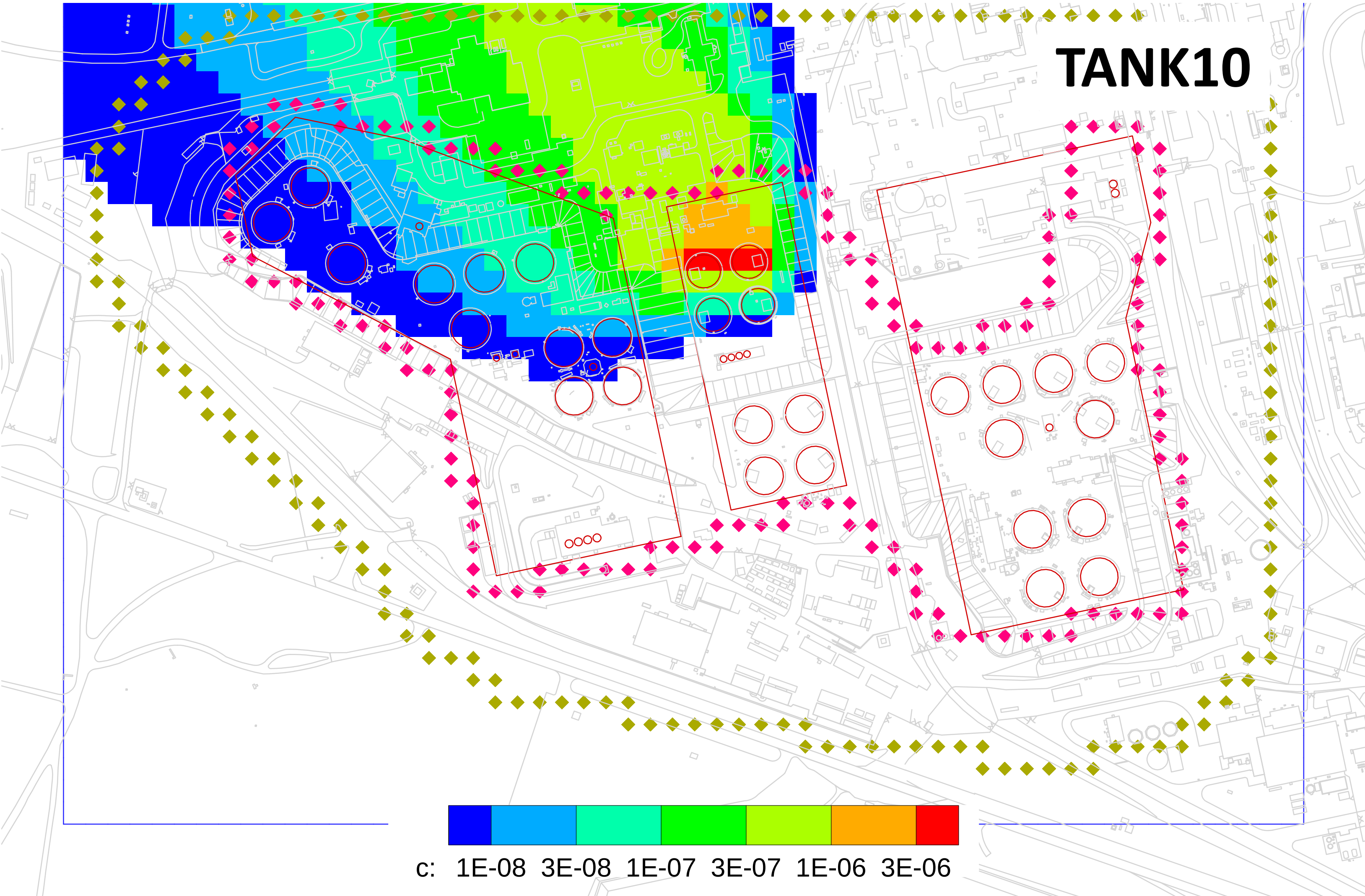
- The following attributes were varied in the study:
  - 3 fast flow cases (none, partial, full)
  - 4 liner failure times (time zero, early, moderate, late)
  - 3 cementitious material degradation rates (fast, nominal, slow)
  - 2 infiltration cases (nominal, no-cap)
- 72 total parametric cases for the 4 tank types (Type I, II, IIIA, and IV tanks)

Stream Traces from HTF

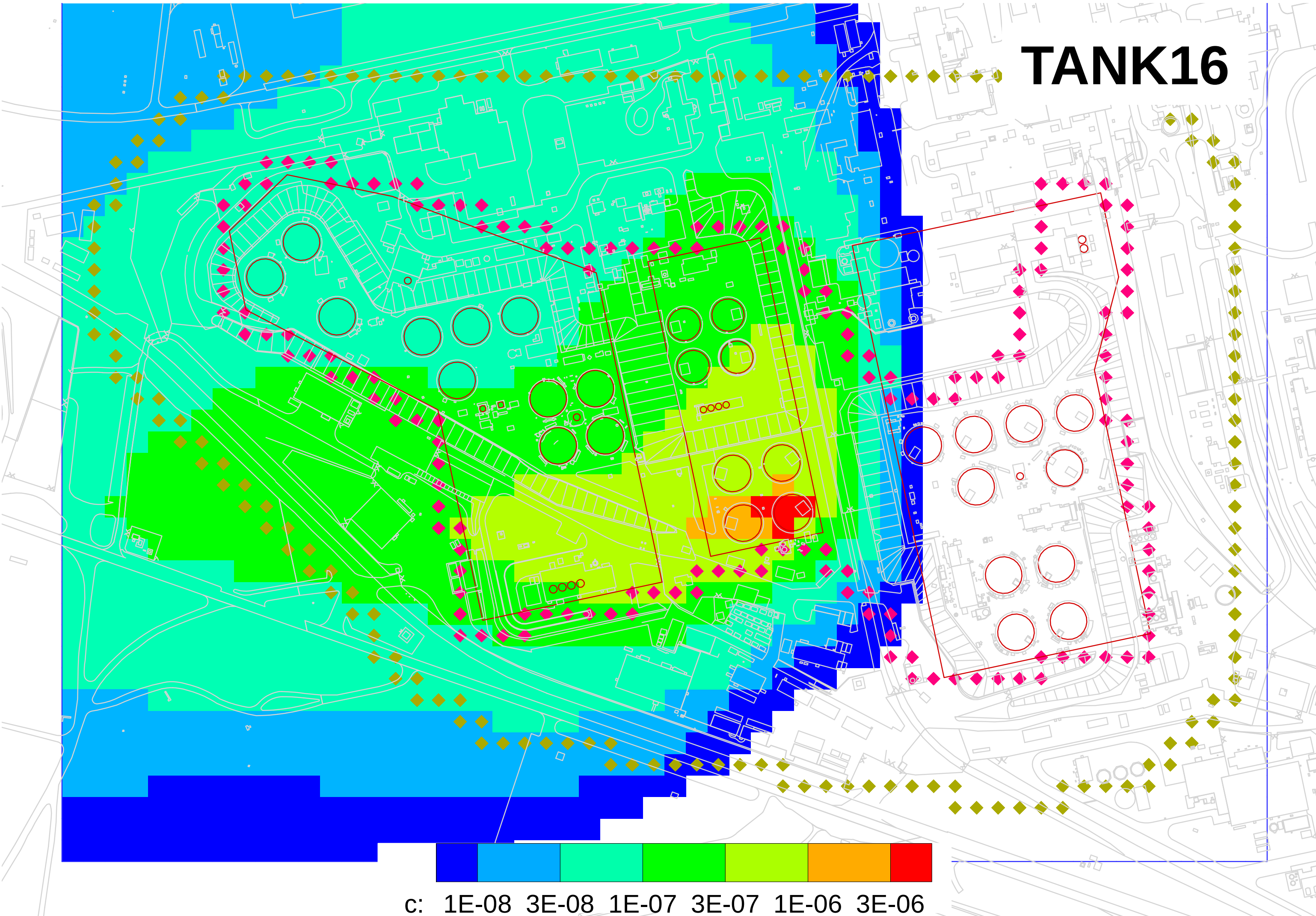
Tank Aquifer Stream Traces



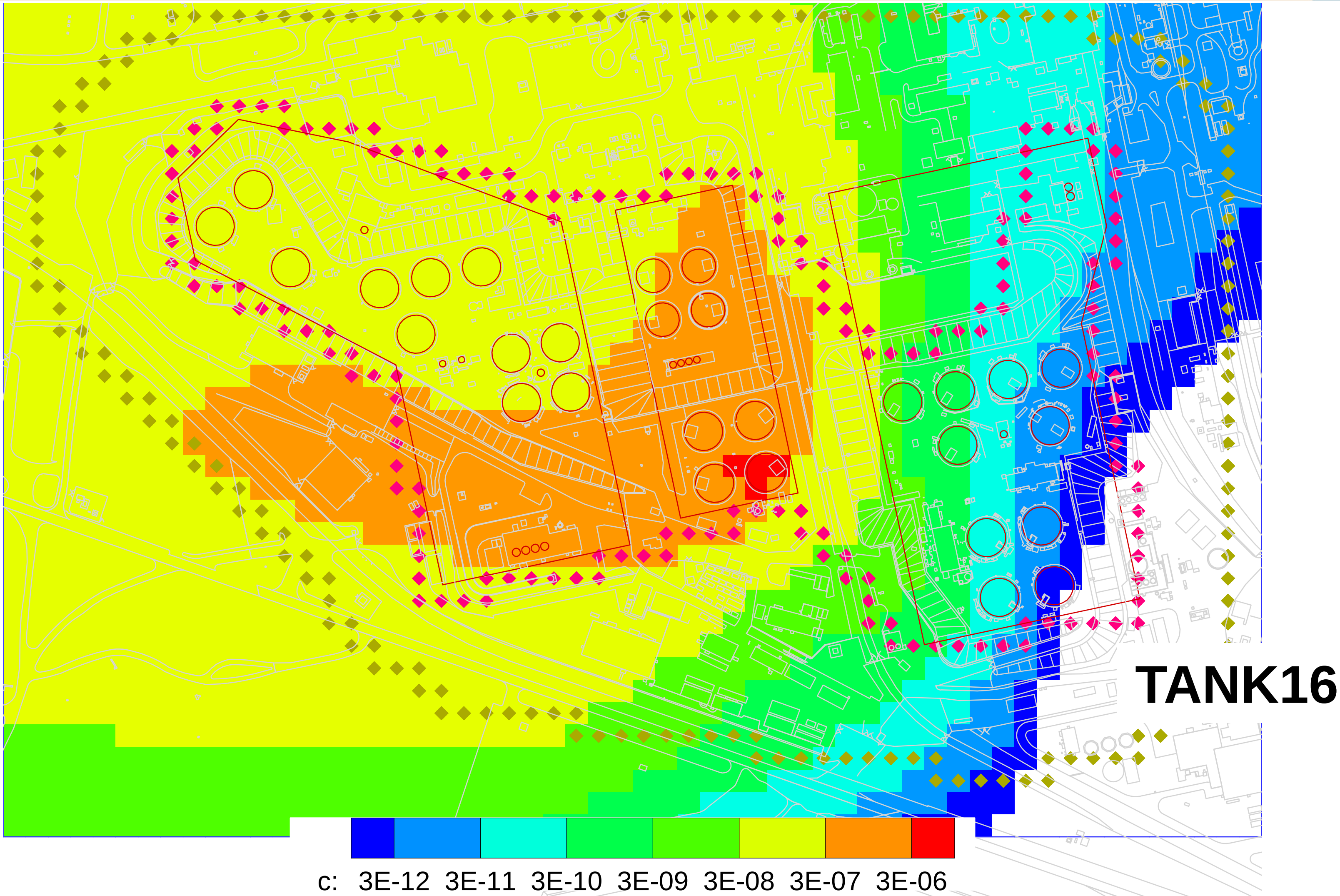
Plume Dispersion



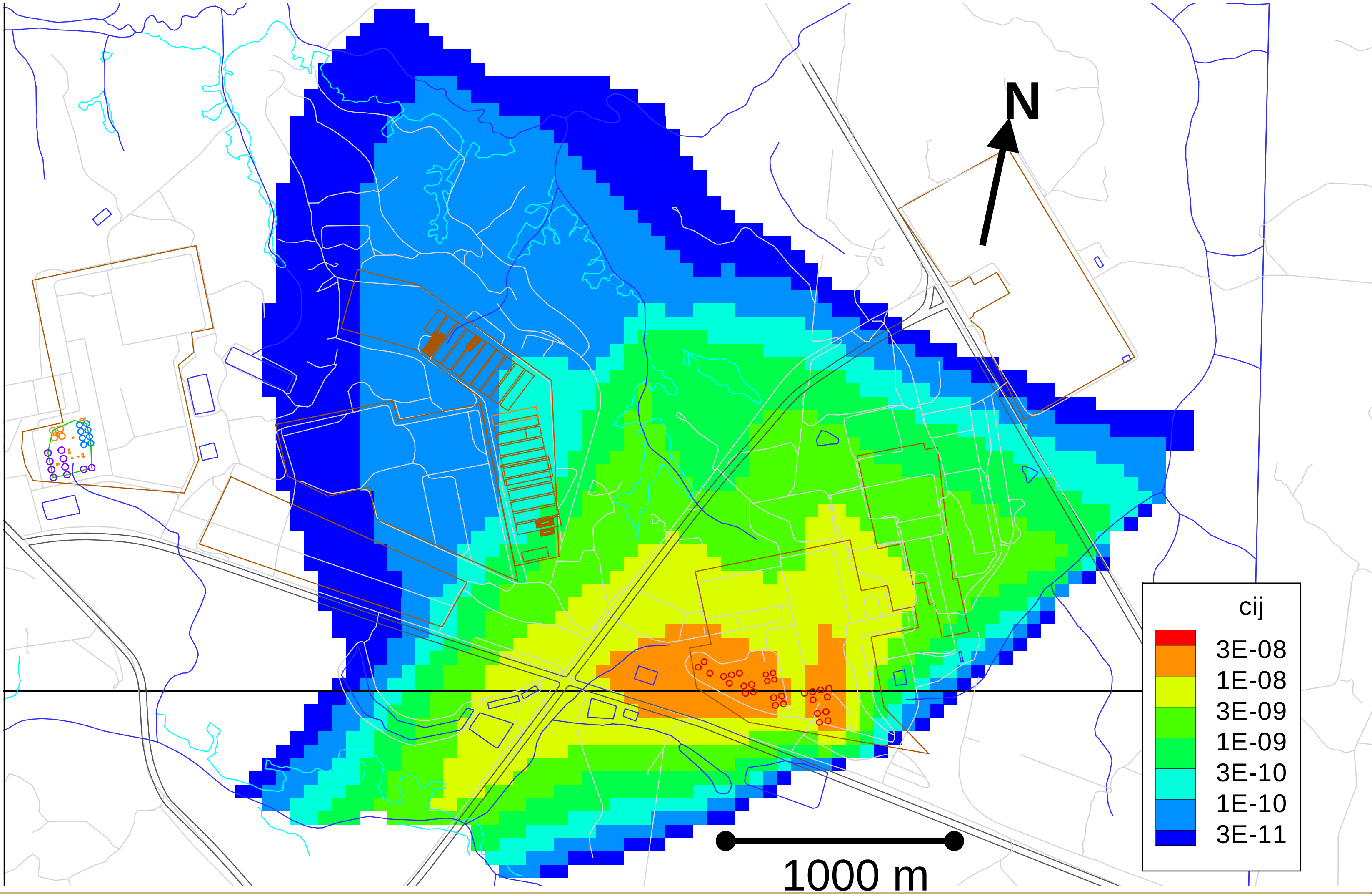
Plume Dispersion



Plume Dispersion



Plume Dispersion



GoldSim Model Dashboard

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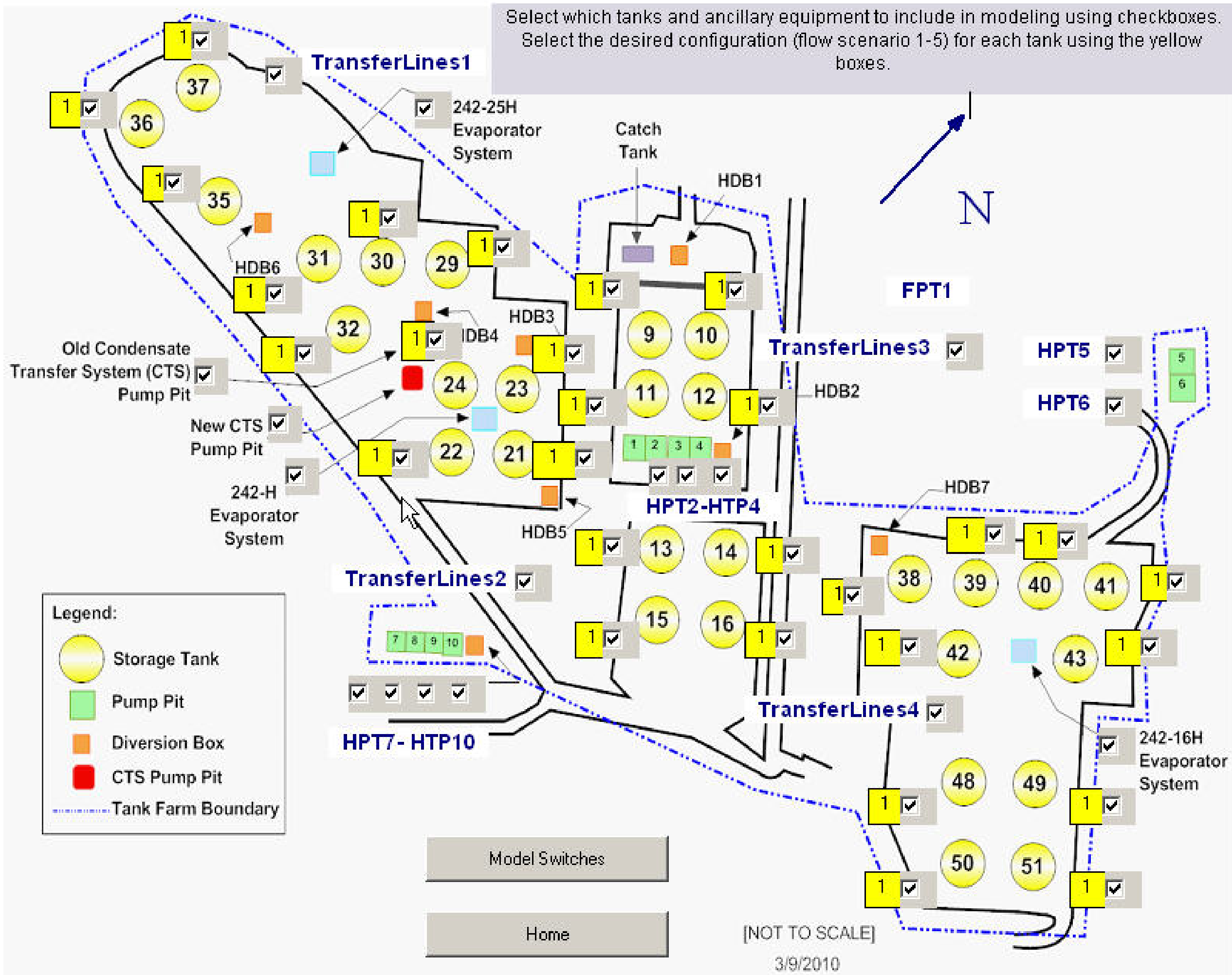
Tank and Ancillary Equipment Selector Dashboard



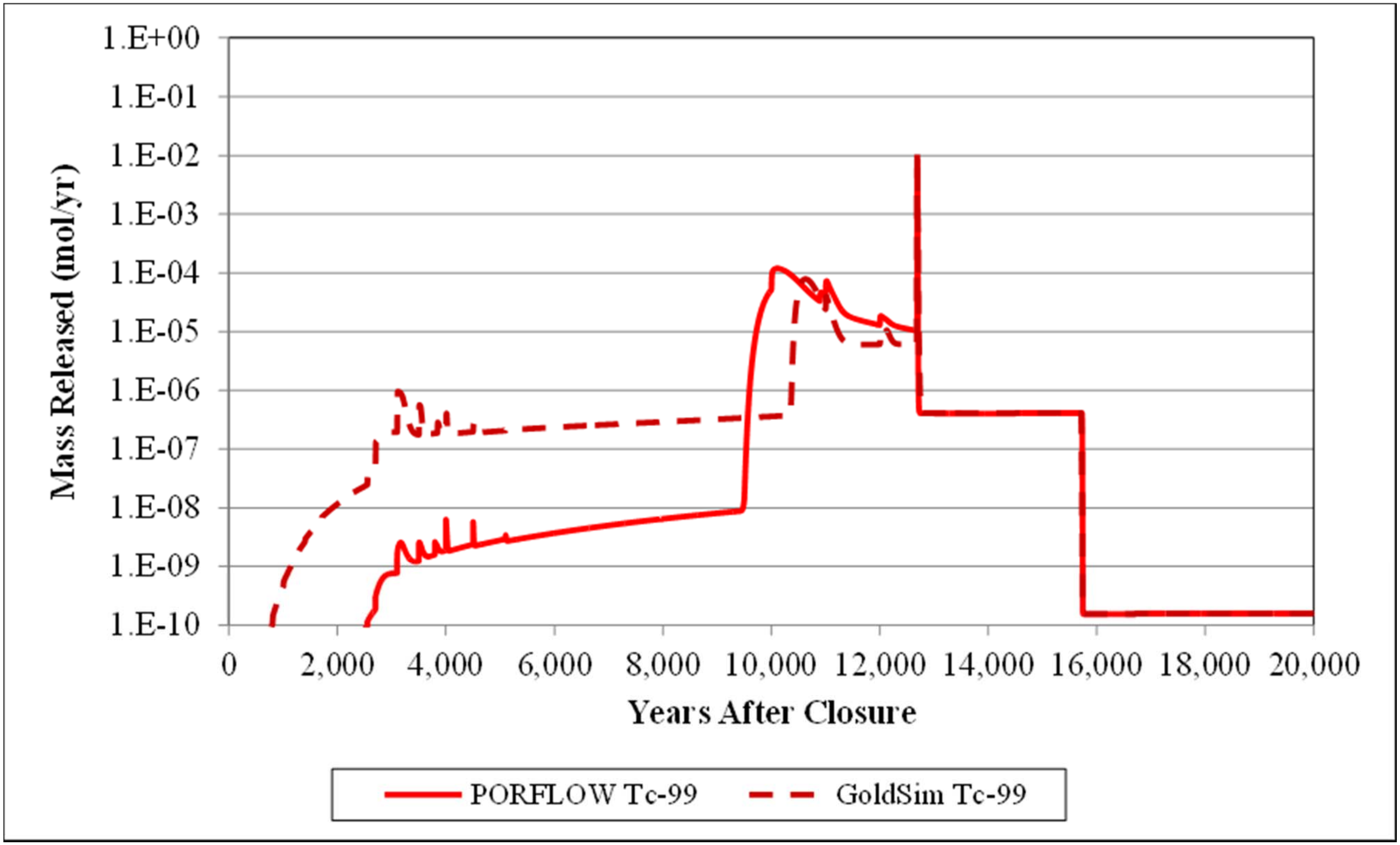
GoldSim Modeling

- HTF Goldsim model based on FTF model but with significant changes and/or enhancements
  - Modified to reflect physical differences
  - The GoldSim distributions updated with new data.
  - Uses wider array of flow fields than FTF Goldsim model
  - Better Benchmarking approach
- Uncertainty Analysis performed for an all cases stochastic and for individual cases A and D
- Examined peak realizations for Cases A, D & All Cases

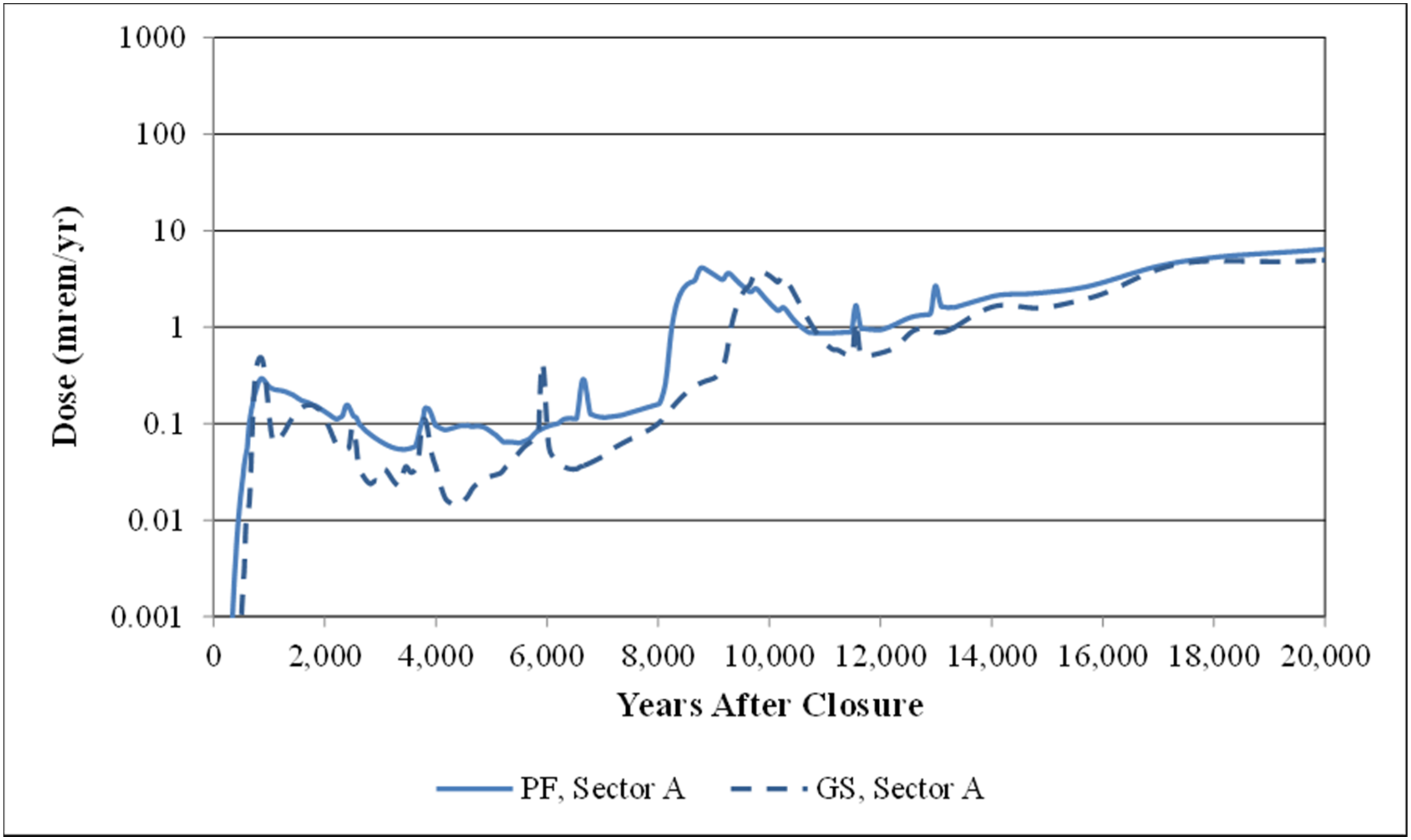
GoldSim Benchmarking

- Use of GoldSim for sensitivity / uncertainty analyses is supported by benchmarking results of 1-D GoldSim to 3-D PORFLOW results
- Benchmarked mass release from individual inventory locations, concentrations at 100m locations and total dose at 100m locations
- Benchmarked multiple tank types and conditions and five PORFLOW sectors
- Five radionuclides chosen (Ra-226, Tc-99, I-129, Np-237 and Cs-135) because of their dose significance and/or transport properties

Tank 13 Mass Release



Base Case Dose Comparison



HTF PA Results

PORFLOW Model Sectors

Sensitivity Run Radionuclides

Sensitivity Run Radionuclides for the 100m Boundary							
Radionuclide	20,000 Peak Dose (mrem/yr)						Basis
	Sector A	Sector B	Sector C	Sector D	Sector E	Sector F	
Am-241	0.00	0.00	0.00	0.00	0.00	0.00	**Np-237 parent**
I-129	1.25	8.52	5.44	0.29	5.62	5.52	**Dose > 0.25**
Ni-59	0.73	0.16	0.15	0.01	0.01	0.01	**Dose > 0.25**
Np-237	0.83	0.18	0.17	0.01	0.03	0.03	**Dose > 0.25**
Pa-231	0.80	0.52	0.50	0.02	0.40	0.39	**Dose > 0.25**
Pb-210	0.33	0.49	0.50	0.03	0.29	0.29	**Dose > 0.25**
Pu-238	0.00	0.00	0.00	0.00	0.00	0.00	**Ra-226 parent**
Pu-239	0.00	0.00	0.00	0.00	0.00	0.00	**Pa-231 parent**
Ra-226	3.90	5.77	4.70	0.30	3.35	3.42	**Dose > 0.25**
Tc-99	3.83	0.48	0.27	0.04	0.14	0.14	**Dose > 0.25**
Th-230	0.00	0.00	0.00	0.00	0.00	0.00	**Ra-226 parent**
U-234	0.00	0.00	0.00	0.00	0.00	0.00	**Ra-226 parent**
U-235	0.00	0.00	0.00	0.00	0.00	0.00	**Pa-231 parent**

PA Results – 100m (Water)

Sector[a]	Peak Dose in 1,000 Years	Peak Dose in 10,000 Years	Peak Dose in 100,000 Years
A	0.3 mrem/yr (year 860) Principal Radionuclide: Tc-99 (96 %) Principal Pathways: Water Ingestion (57 %) Vegetable Ingestion (35 %)	4.0 mrem/yr (year 8,790) Principal Radionuclide: Tc-99 (96 %) Principal Pathways: Water Ingestion (58 %) Vegetable Ingestion (35 %)	120 mrem/yr (year 90,800) Principal Radionuclide: Ra-226 (85 %) Principal Pathways: Water Ingestion (85 %) Vegetable Ingestion (14 %)
B	0.2 mrem/yr (year 730) Principal Radionuclide: Tc-99 (99 %) Principal Pathways: Water Ingestion (56 %) Vegetable Ingestion (36 %)	1.5 mrem/yr (year 8,860) Principal Radionuclides: Tc-99 (31 %) Ra-226 (31 %) Pa-231 (23 %) Principal Pathways: Water Ingestion (76 %) Vegetable Ingestion (20 %)	73 mrem/yr (year 70,380) Principal Radionuclide: Ra-226 (79 %) Principal Pathways: Water Ingestion (85 %) Vegetable Ingestion (14 %)
C	0.3 mrem/yr (year 700) Principal Radionuclide: Tc-99 (88 %) Principal Pathways: Water Ingestion (60 %) Vegetable Ingestion (33 %)	2.2 mrem/yr (year 10,000) Principal Radionuclides: Ra-226 (58 %) Pa-231 (19 %) Principal Pathways: Water Ingestion (85 %) Vegetable Ingestion (14 %)	69 mrem/yr (year 68,500) Principal Radionuclide: Ra-226 (78 %) Principal Pathways: Water Ingestion (85 %) Vegetable Ingestion (14 %)
D	0.04 mrem/yr (year 880) Principal Radionuclide: Tc-99 (96 %) Principal Pathways: Water Ingestion (55 %) Vegetable Ingestion (34 %)	0.1 mrem/yr (year 10,000) Principal Radionuclide: Ra-226 (79 %) Principal Pathways: Water Ingestion (83 %) Vegetable Ingestion (14 %)	7.1 mrem/yr (year 83,440) Principal Radionuclide: Ra-226 (85 %) Principal Pathways: Water Ingestion (85 %) Vegetable Ingestion (14 %)
E	0.1 mrem/yr (year 870) Principal Radionuclide: Tc-99 (98 %) Principal Pathways: Water Ingestion (56 %) Vegetable Ingestion (35 %)	0.1 mrem/yr (year 870) Principal Radionuclide: Tc-99 (98 %) Principal Pathways: Water Ingestion (56 %) Vegetable Ingestion (35 %)	91 mrem/yr (year 89,560) Principal Radionuclide: Ra-226 (85 %) Principal Pathways: Water Ingestion (85 %) Vegetable Ingestion (14 %)
F	0.2 mrem/yr (year 870) Principal Radionuclide: Tc-99 (93 %) Principal Pathways: Water Ingestion (58 %) Vegetable Ingestion (34 %)	0.2 mrem/yr (year 870) Principal Radionuclide: Tc-99 (93 %) Principal Pathways: Water Ingestion (58 %) Vegetable Ingestion (34 %)	99 mrem/yr (year 87,080) Principal Radionuclide: Ra-226 (85 %) Principal Pathways: Water Ingestion (85 %) Vegetable Ingestion (14 %)

PA Results – 100m (Water)

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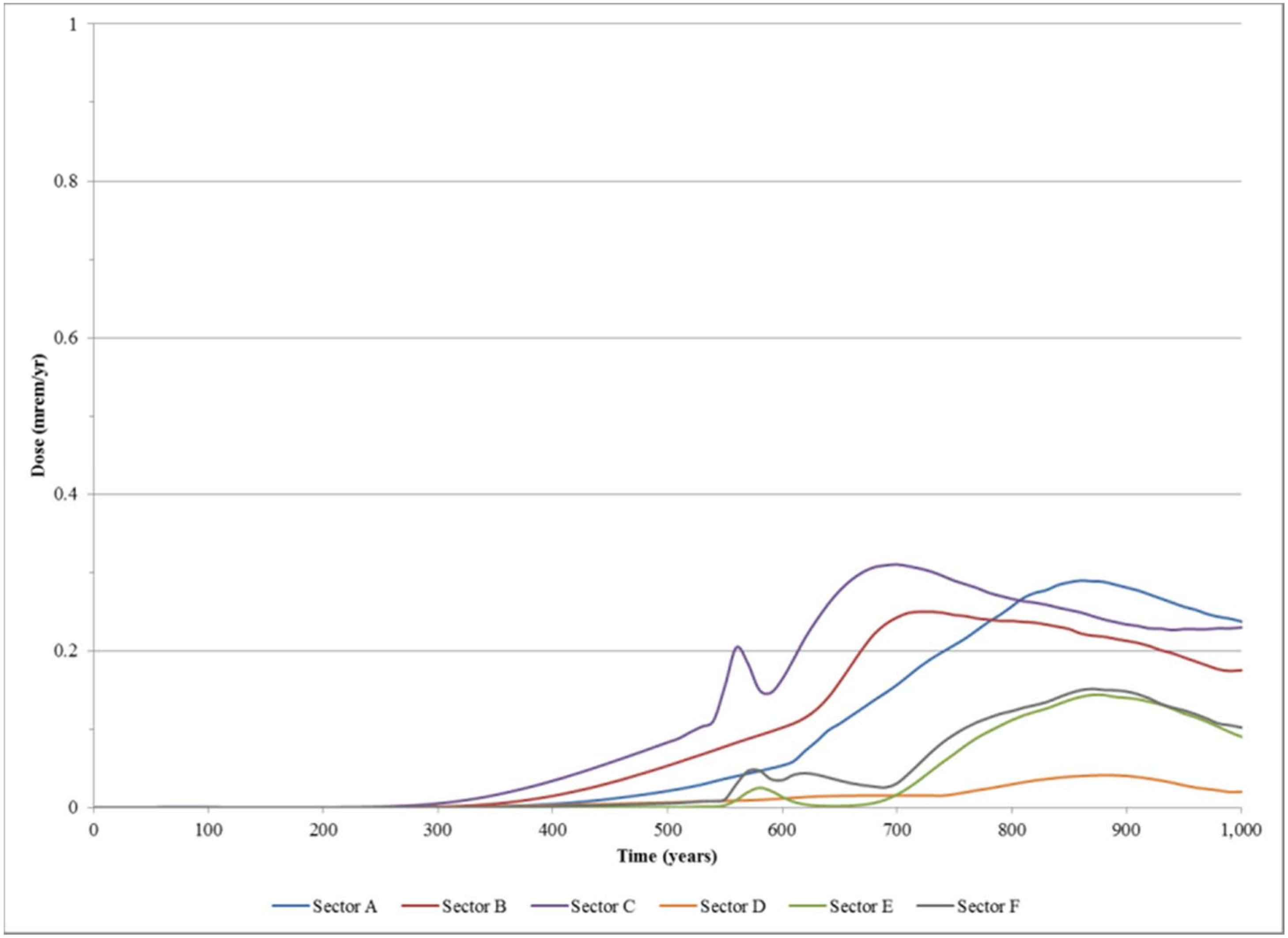
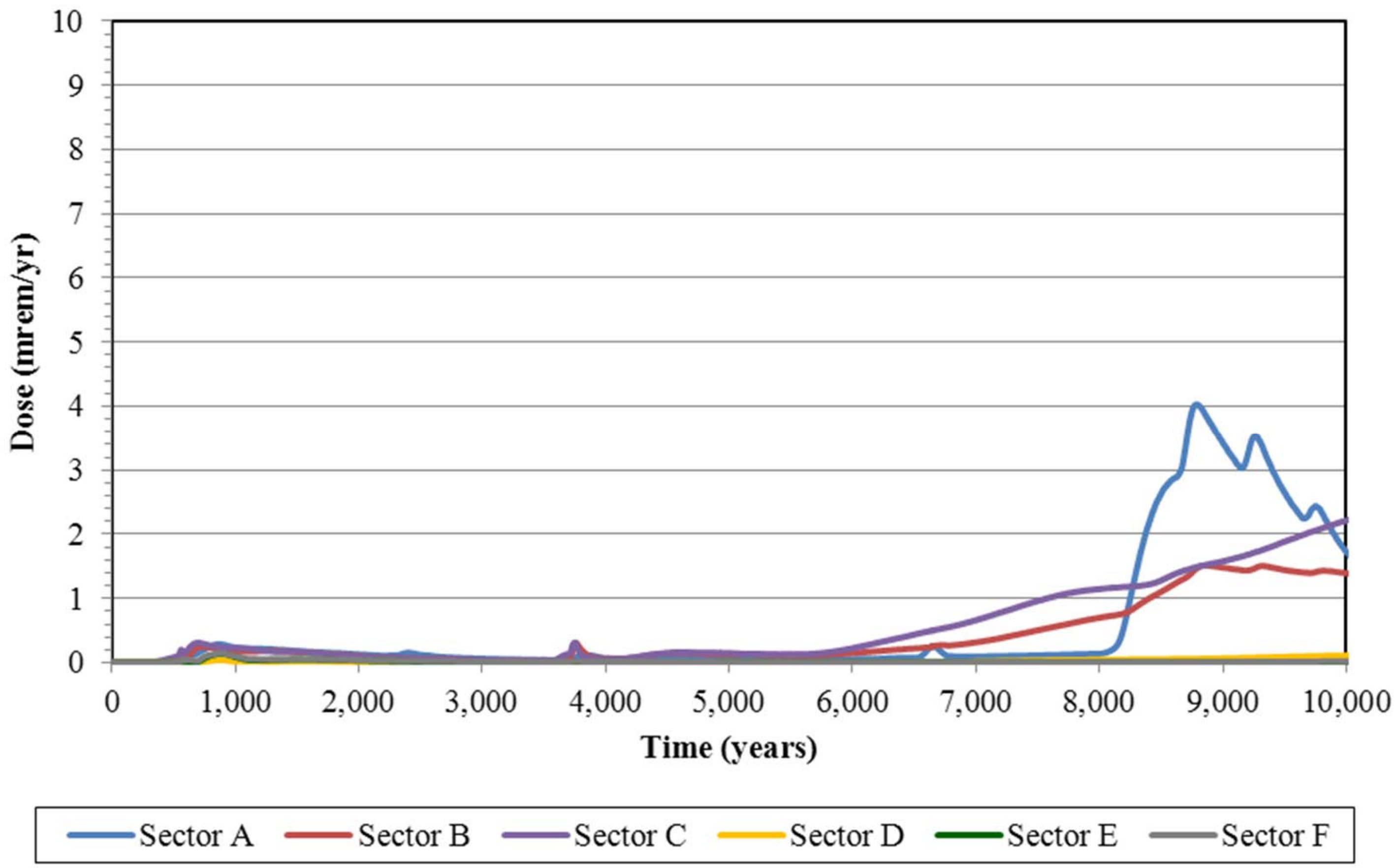
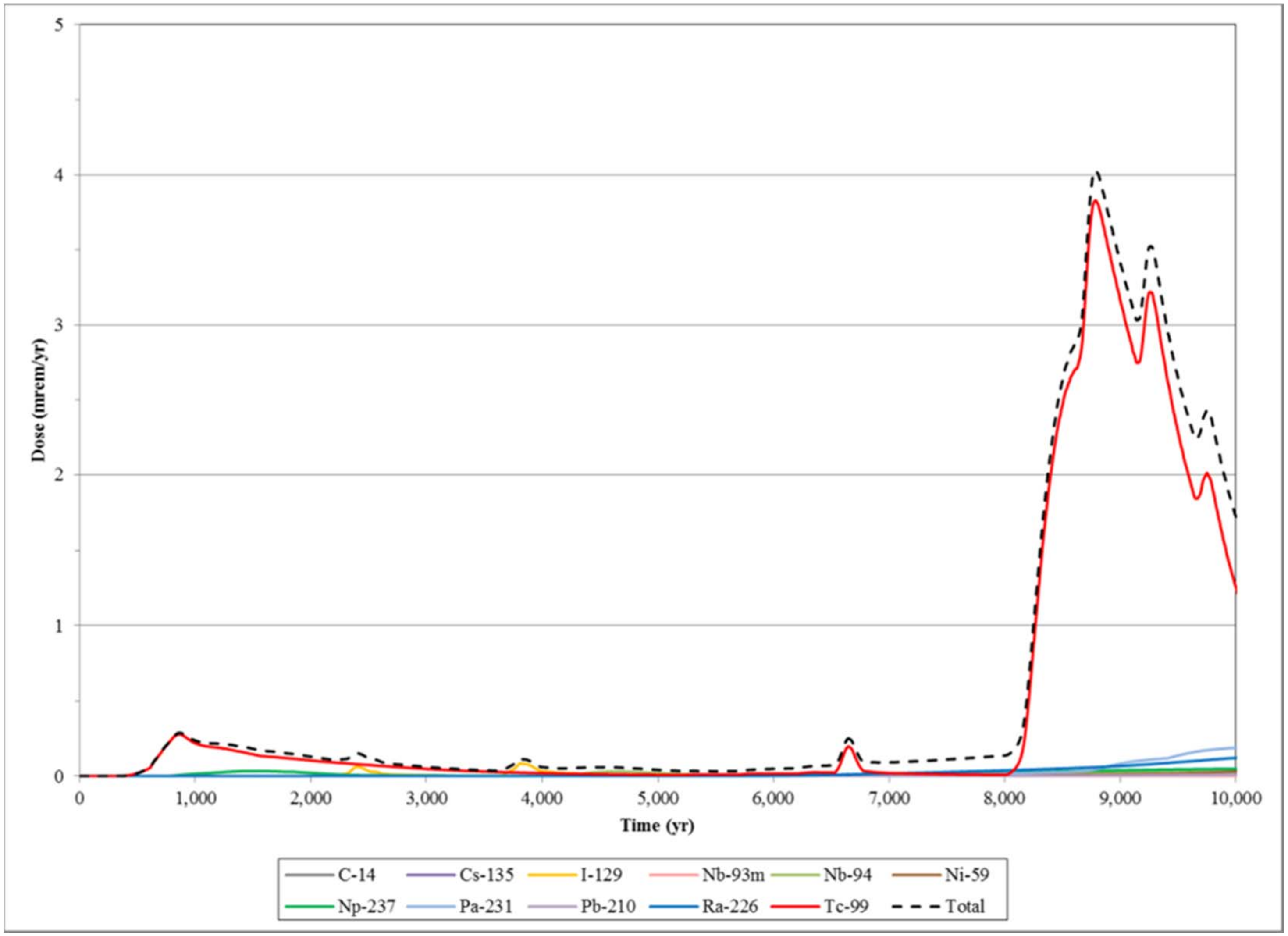


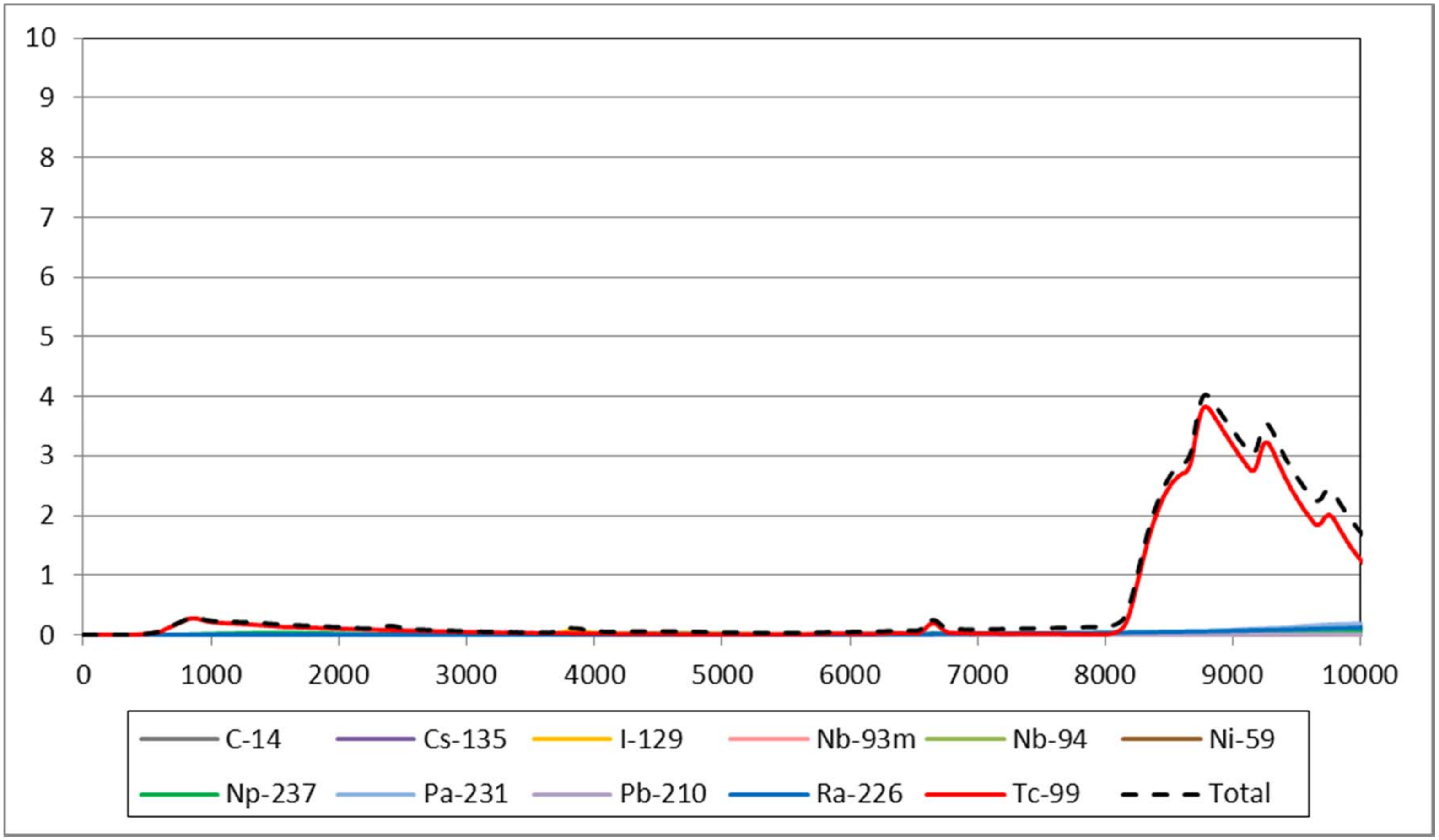
Base Case 100m Peak Groundwater Pathway Dose Results by Sector



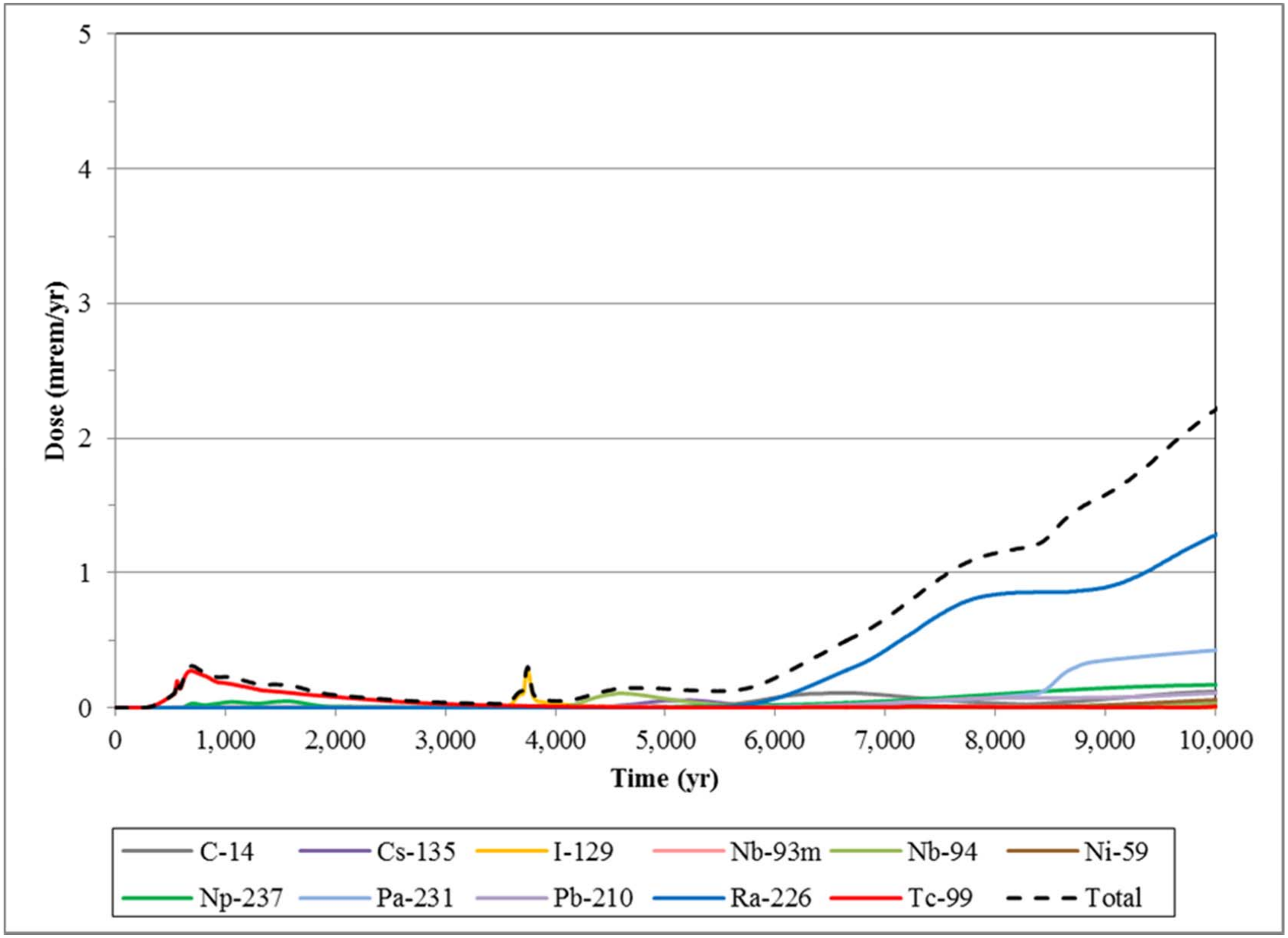
PA Results – Sector A



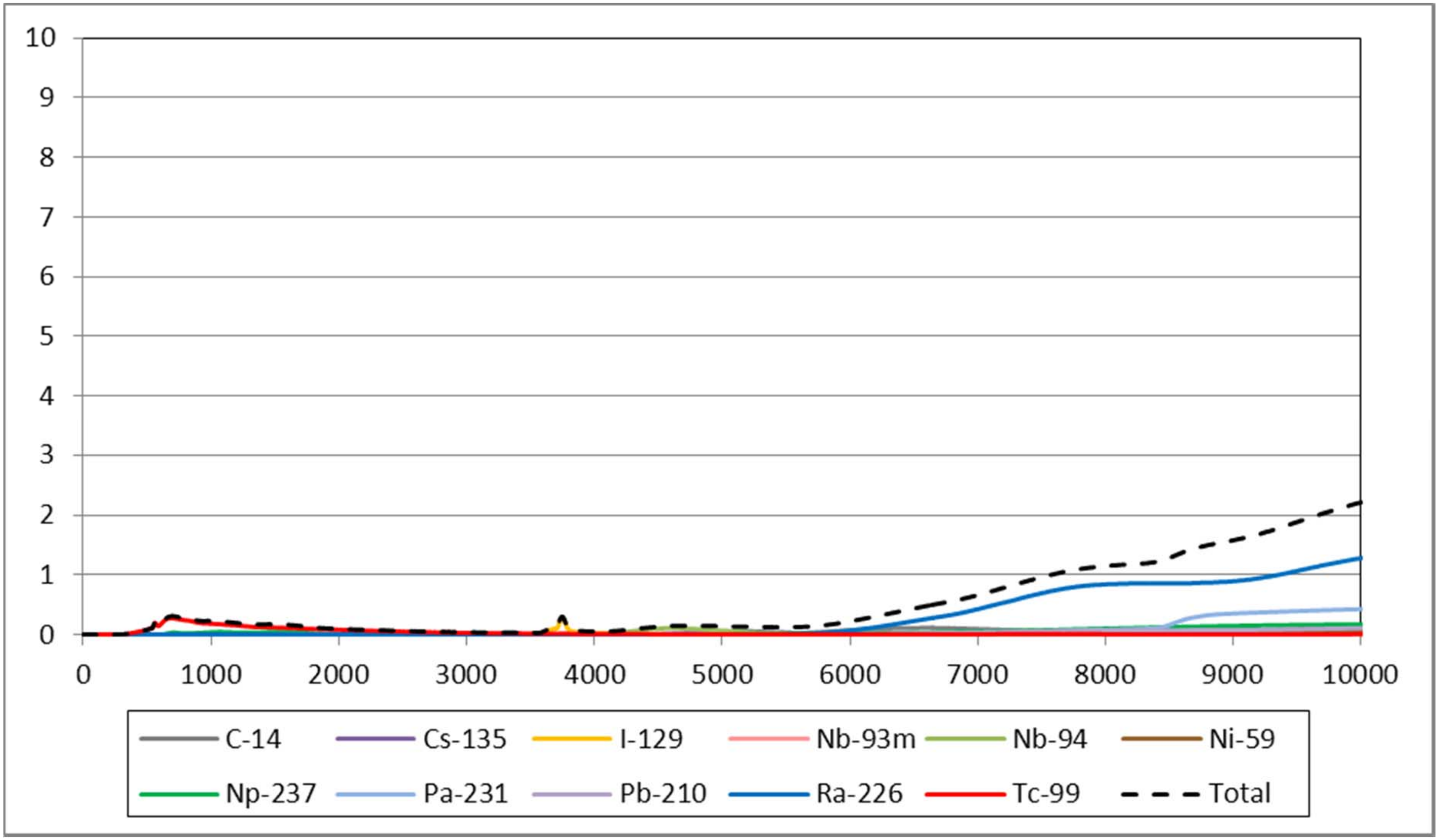
Individual Rad Contributors to the Sector A 100m Peak Groundwater Pathway Dose



PA Results – Sector C



Individual Rad Contributors to the Sector C 100m Peak Groundwater Pathway Dose



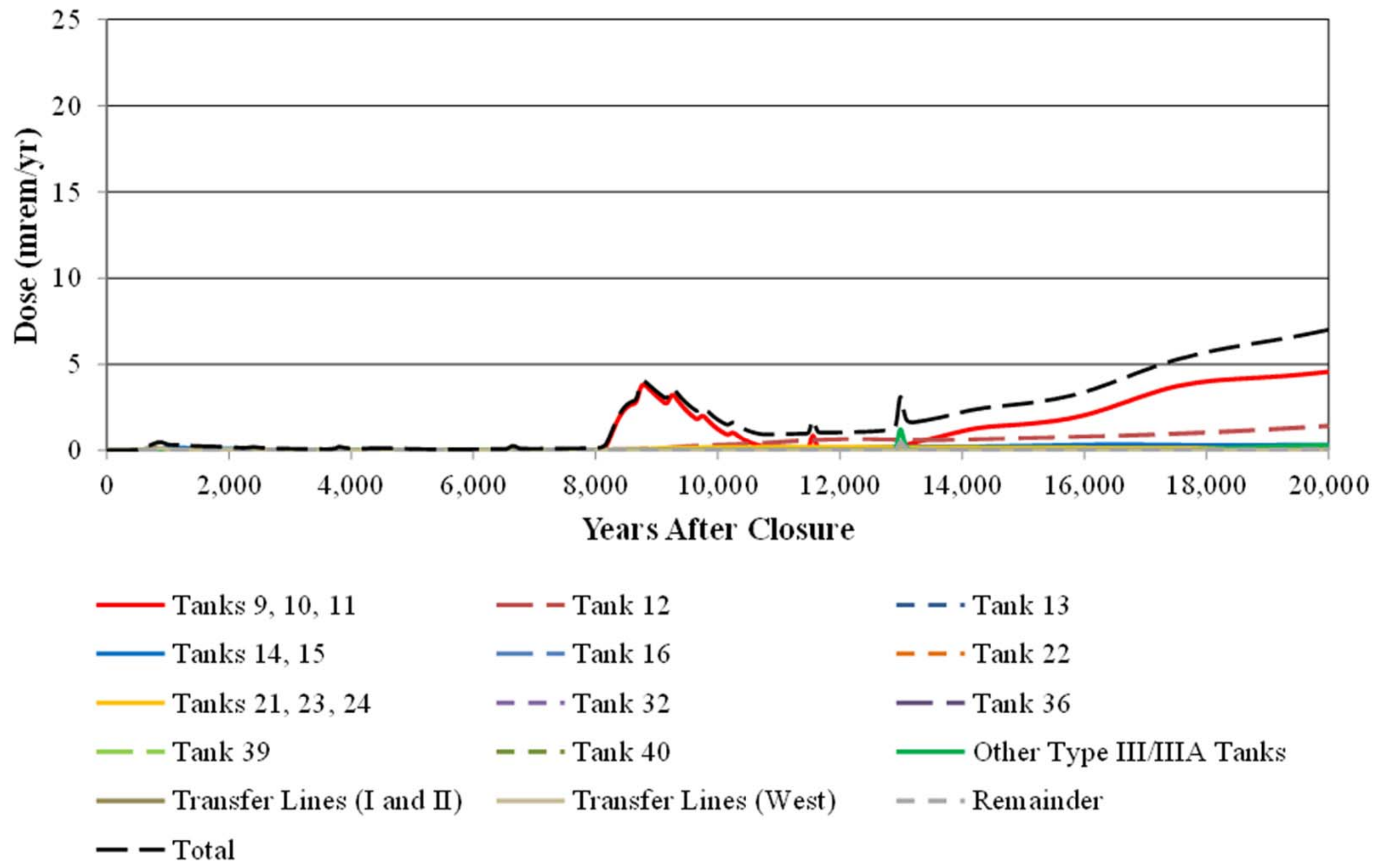
Radiological Contributors

Radionuclide	Contribution to Sector C Peak dose at year 700 (mrem/yr)	Percentage of Total Peak Dose	Contribution to Sector A Peak dose at year 8,790 (mrem/yr)	Percentage of Total Peak Dose
I-129	< 0.01	< 0.5 %	< 0.01	< 0.5 %
Nb-93m	0.01	1.7 %	< 0.01	< 0.5 %
Nb-94	< 0.01	< 0.5 %	0.02	0.6 %
Np-237	0.03	10 %	0.04	0.9 %
Pa-231	< 0.01	< 0.5 %	0.05	1.2 %
Pu-239	< 0.01	< 0.5 %	< 0.01	< 0.5 %
Ra-226	< 0.01	< 0.5 %	0.06	1.5 %
Tc-99	0.27	88 %	3.8	96 %
Others	< 0.01	< 0.5 %	< 0.01	< 0.5 %
TOTAL	0.31	100 %	4.0	100 %

Inventory Contributors

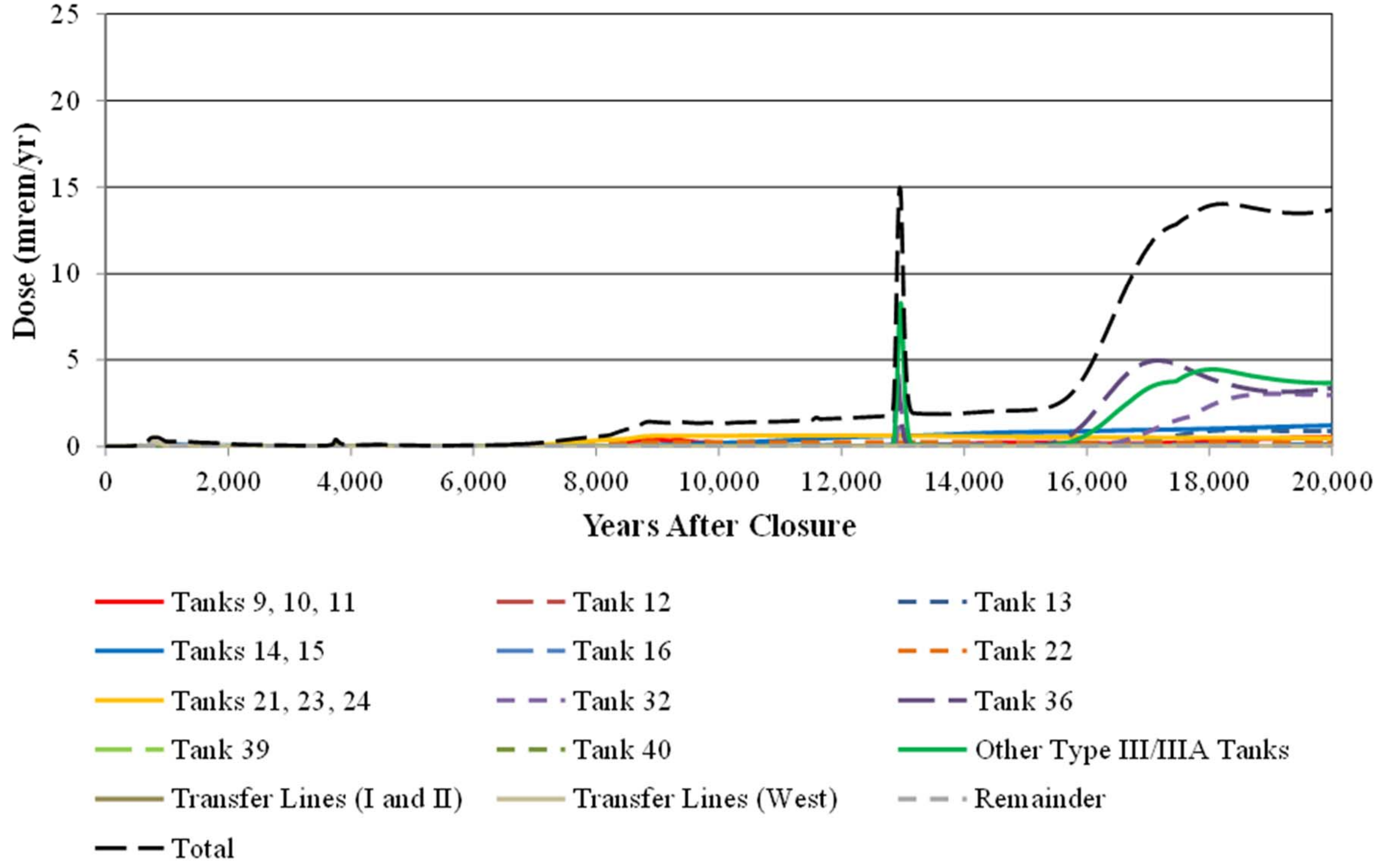
Waste Source [a]	Contribution to Sector C Peak Dose at year 700 (mrem/yr)	Percentage of Total Peak Dose	Contribution to Sector A Peak Dose at year 8,790 (mrem/yr)	Percentage of Total Peak Dose
Tanks 9, 10, and 11	< 0.01	< 0.5 %	3.8	95 %
Tank 12	< 0.01	< 0.5 %	0.08	2.0 %
Tank 13	< 0.01	< 0.5 %	< 0.01	< 0.5 %
Tanks 14 and 15	0.05	10 %	0.01	< 0.5 %
Tank 16	0.13	28 %	< 0.01	< 0.5 %
Tank 22	< 0.01	< 0.5 %	0.01	< 0.5 %
Tanks 21, 23, and 24	< 0.01	< 0.5 %	0.07	1.9 %
Transfer Line, Group 2 (Type I and Type II)	0.09	18 %	< 0.01	< 0.5 %
Transfer Line, Group 3 (West Hill)	< 0.01	< 0.5 %	< 0.01	< 0.5 %
All Other Sources	0.19	40 %	< 0.01	< 0.5 %
TOTAL	0.47	100 %	4.0	100 %

Individual Source Contributors to Base Case Doses in Sector A

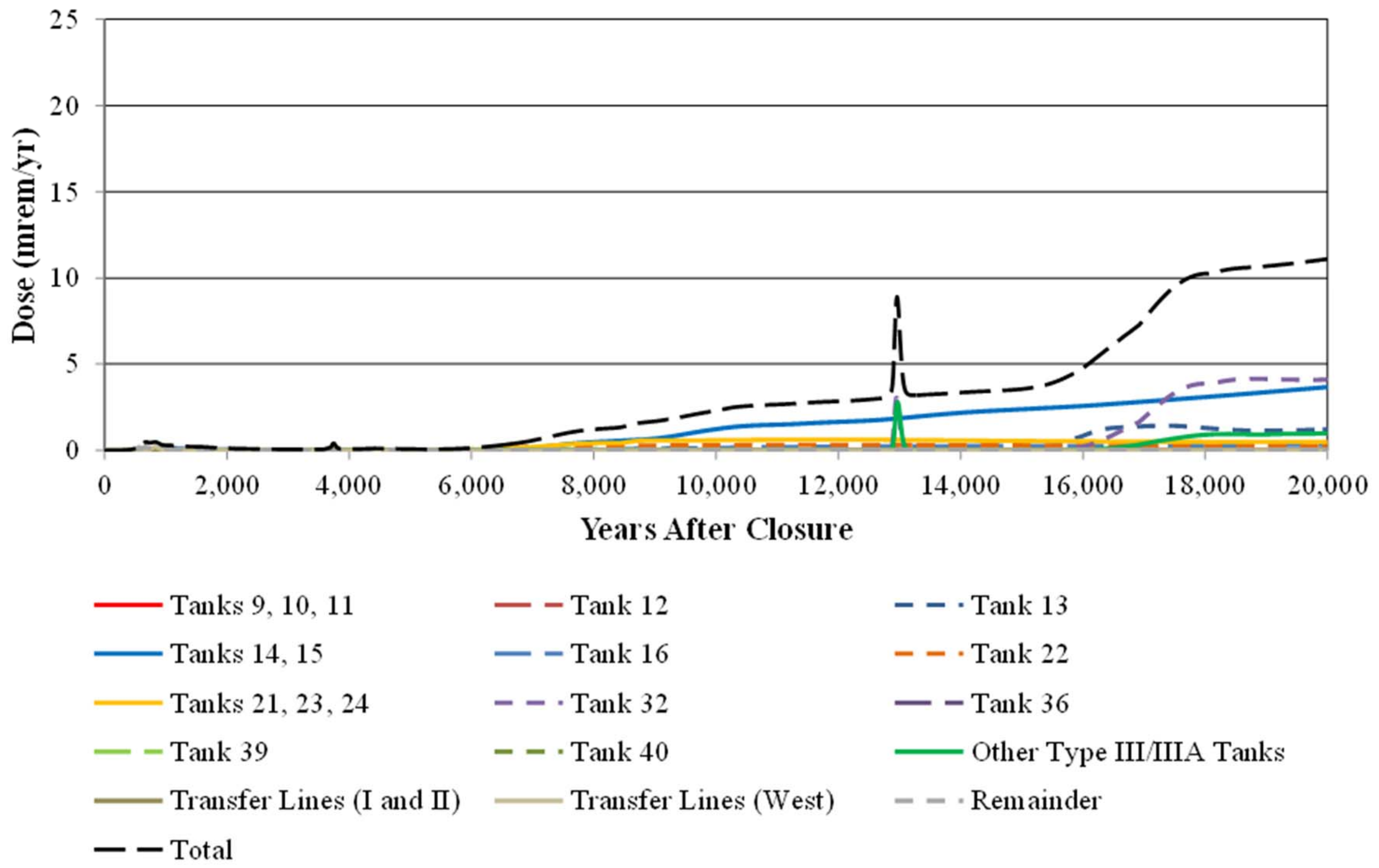


Individual Source Contributors to Base Case Doses in Sector B

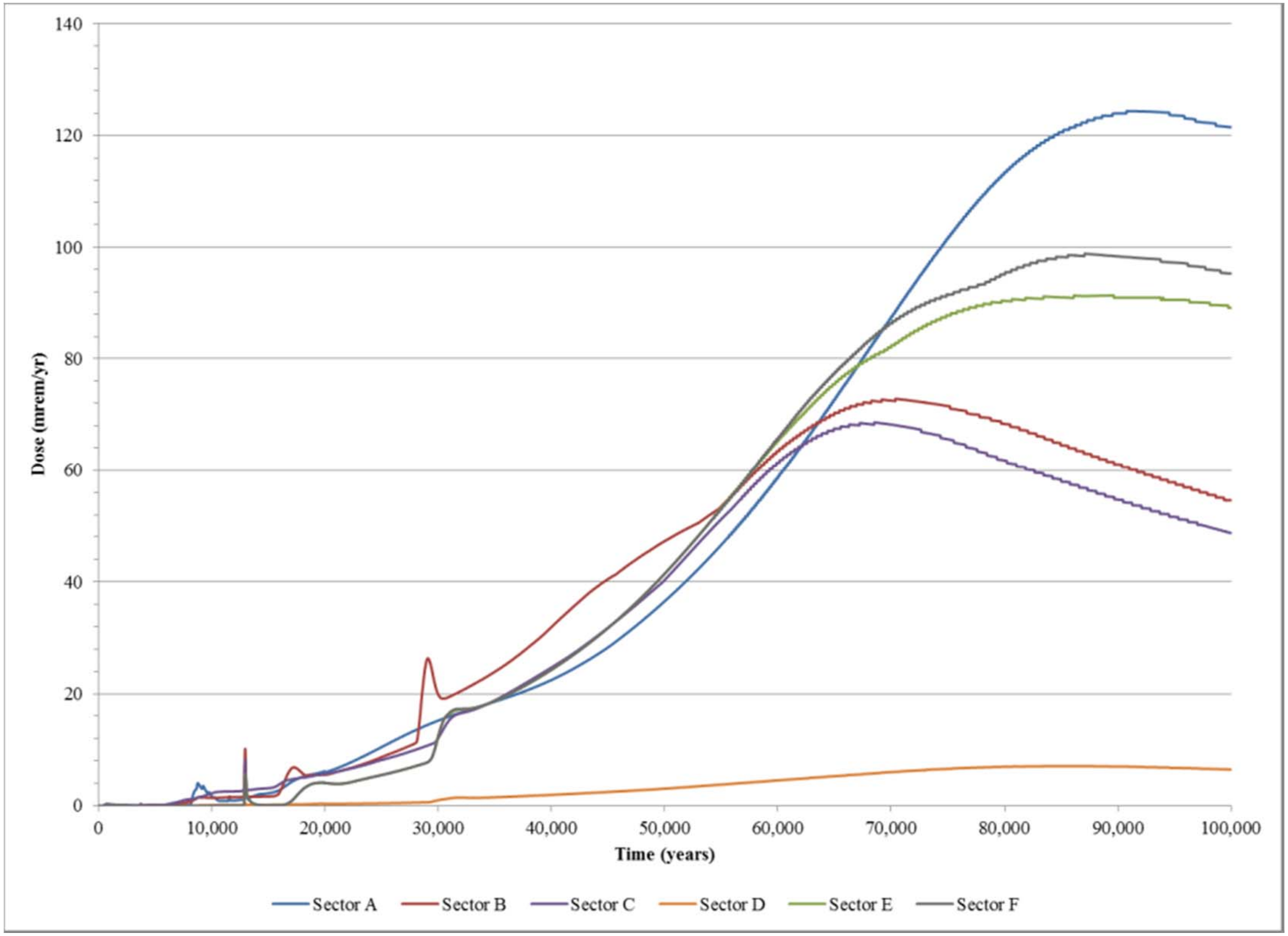
We do the right thing.



Individual Source Contributors to Base Case Doses in Sector C



Results to 100,000 Years



Uncertainty Analysis Results

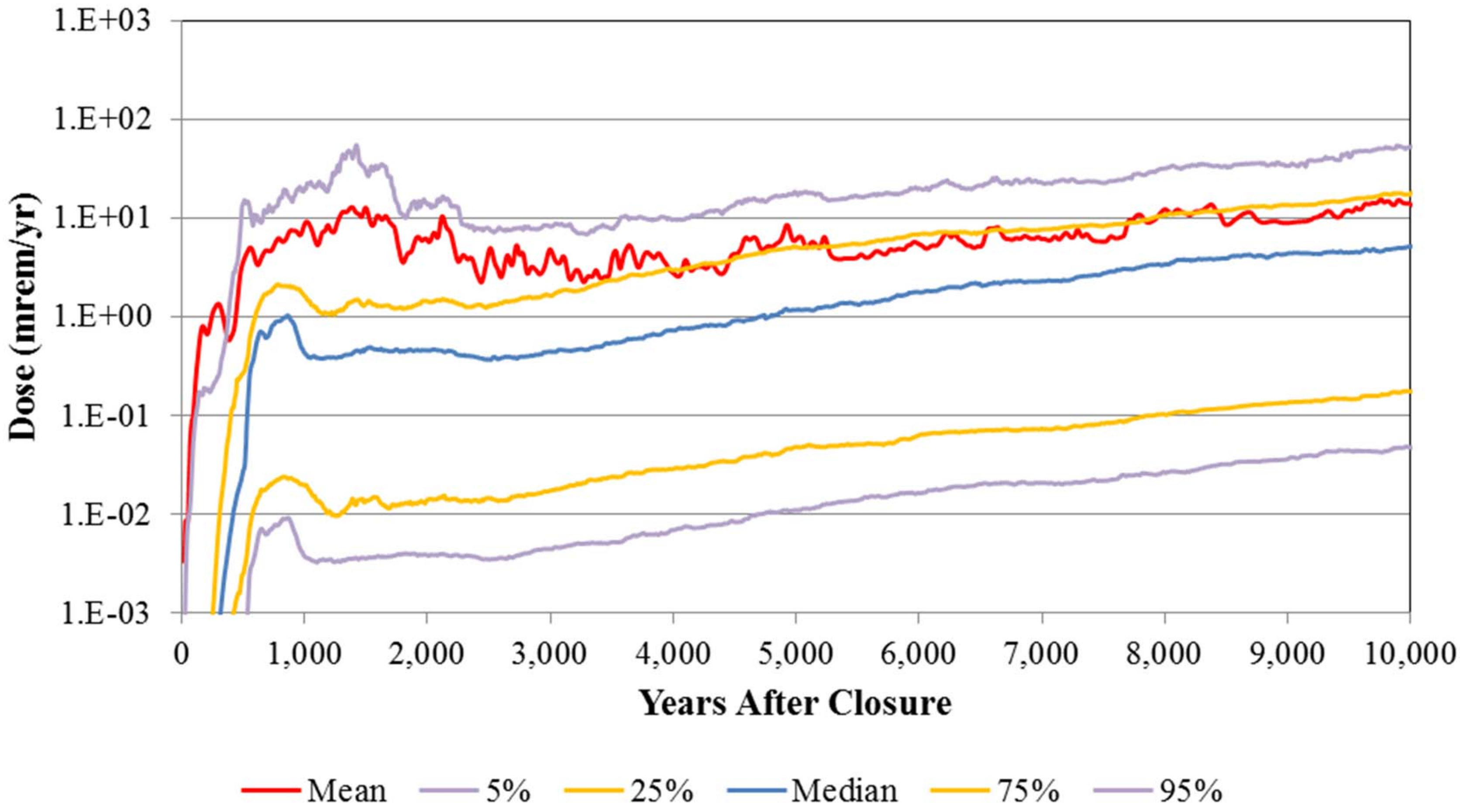
Mean of the Peaks

Endpoint Evaluated	Number of Realizations	Mean of the Peaks (mrem/yr)	Median of the Peaks (50th Percentile) (mrem/yr)	95th Percentile of the Peaks (mrem/yr)
MOP dose from Case A within 10,000 years	3,000	85	9	520
MOP dose from Case D within 10,000 years	3,000	210	31	980
MOP dose from All Cases within 10,000 years	5,000	220	28	1,000
MOP Dose from All Cases within 100,000 years	1,000	530	310	1,900

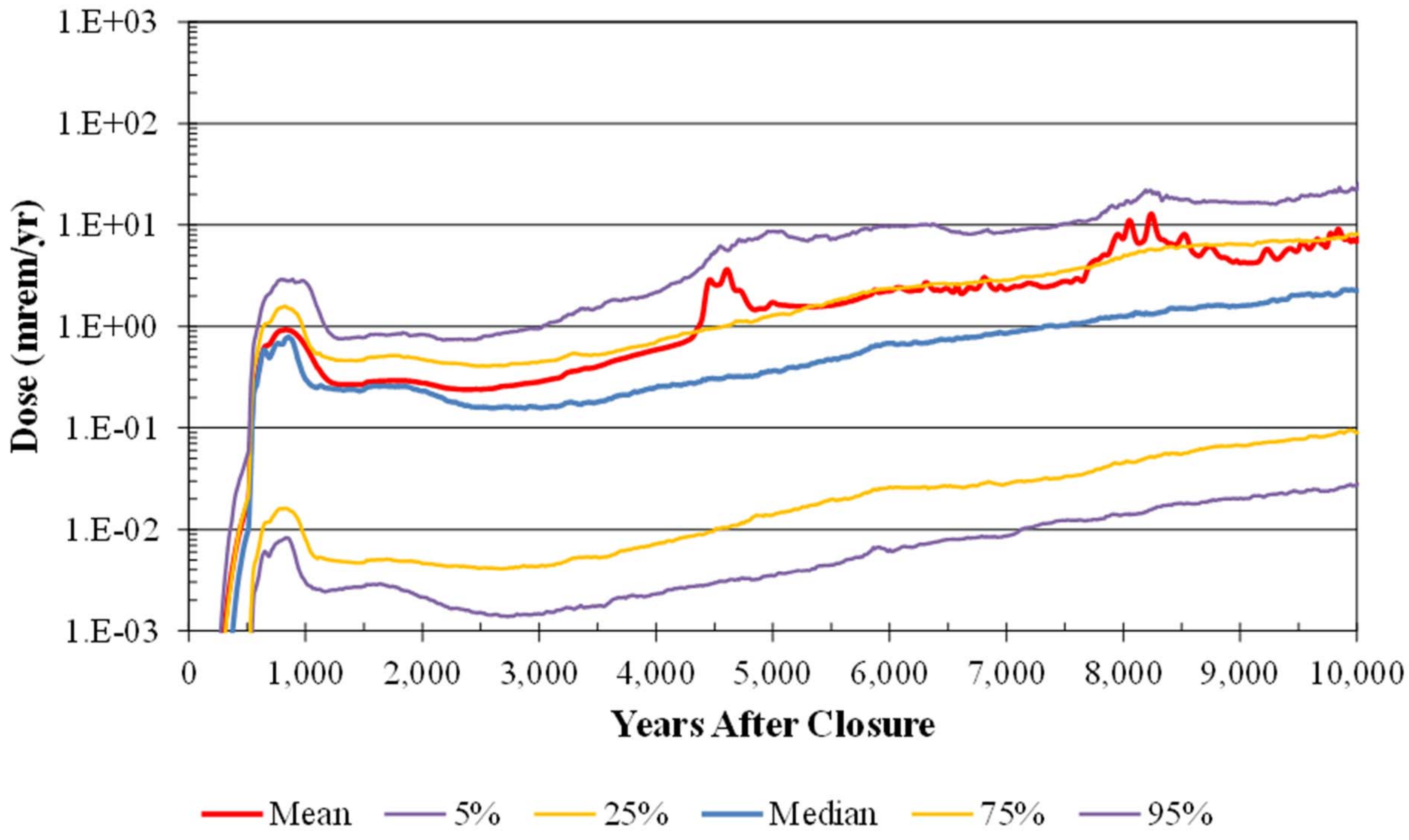
Peak of the Means

Endpoint Evaluated	Peak of the Means (mrem/yr)	Peak of the Medians (50th Percentile) (mrem/yr)	Peak of the 95th Percentiles (mrem/yr)
MOP dose from Case A within 10,000 years	13 (at time step = 8,240 years)	2.3 (at time step = 9,950 years)	24 (at time step = 9,850 years)
MOP dose from Case D within 10,000 years	35 (at time step = 9,620 years)	12 (at time step = 9,990 years)	112 (at time step = 9,960 years)
MOP dose from All Cases within 10,000 years	15 (at time step = 9,750 years)	5.6 (at time step = 9,990 years)	58 (at time step = 1,470 years)
MOP dose from All Cases within 100,000 years	205 (at time step = 67,300 years)	168 (at time step = 55,800 years)	684 (at time step = 77,100 years)

UA Results – All Cases



UA Results – Case A



Probabilistic Sensitivity

- GoldSim probabilistic Sensitivity Analysis conducted for multiple model endpoints including:
  - 100m dose
  - chronic intruder dose
  - specific radionuclide 100m concentrations
- Conducted for Cases A, D and All Cases

Deterministic Sensitivities

- Performed multiple deterministic sensitivity analyses using PORFLOW:
  - Barrier analyses
  - Cases B thru E
  - No closure cap
  - Synergistic Case

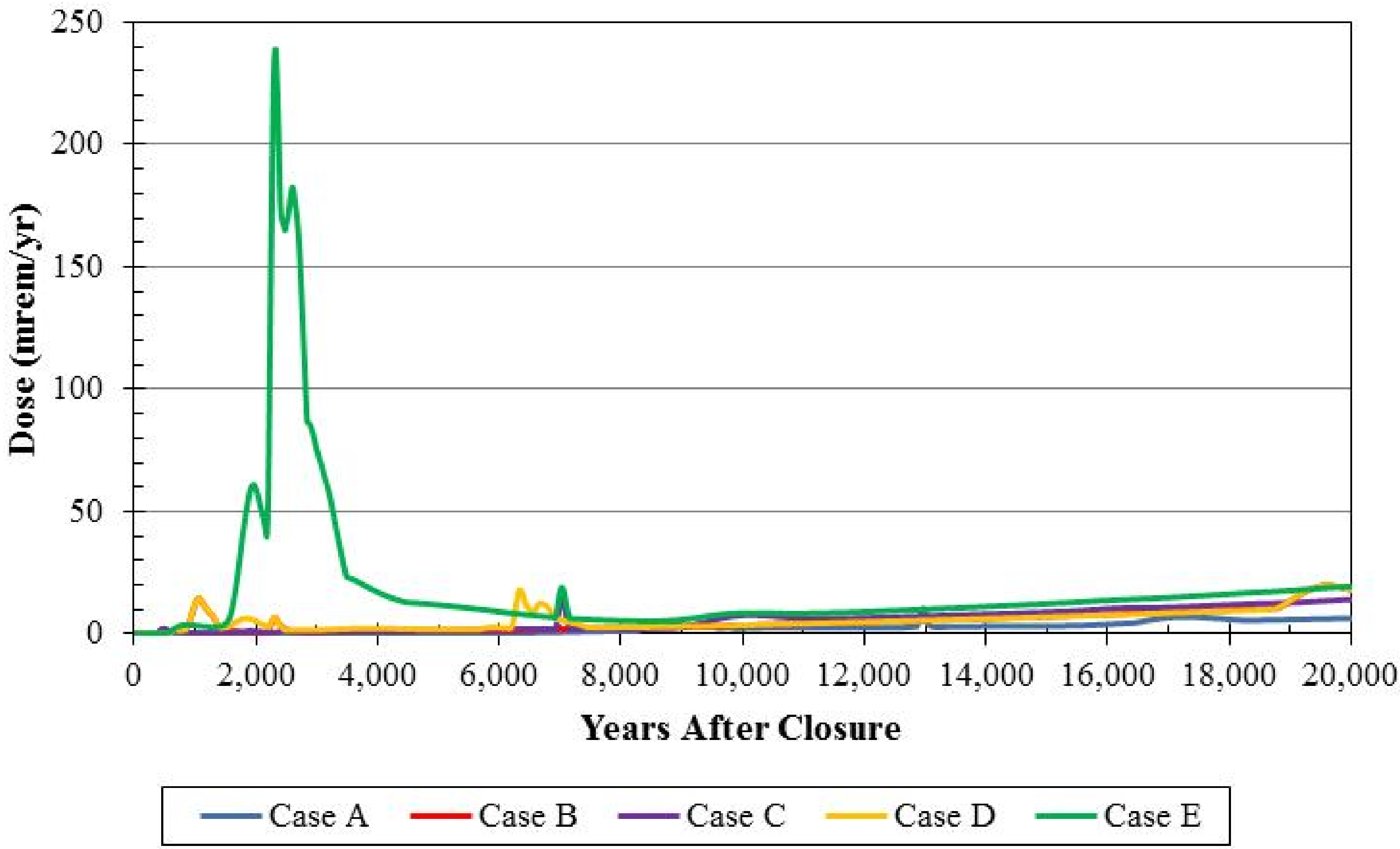
Deterministic Sensitivities

- Performed multiple deterministic sensitivity analyses using PORFLOW:
  - Grout Transition Time
  - Solubility Value Analysis
  - Calcareous Zone Analysis
  - Kd Variability Analysis
  - Liner Failure Time Analysis
  - Cementitious Degradation Analysis
  - Water Ingestion Analysis

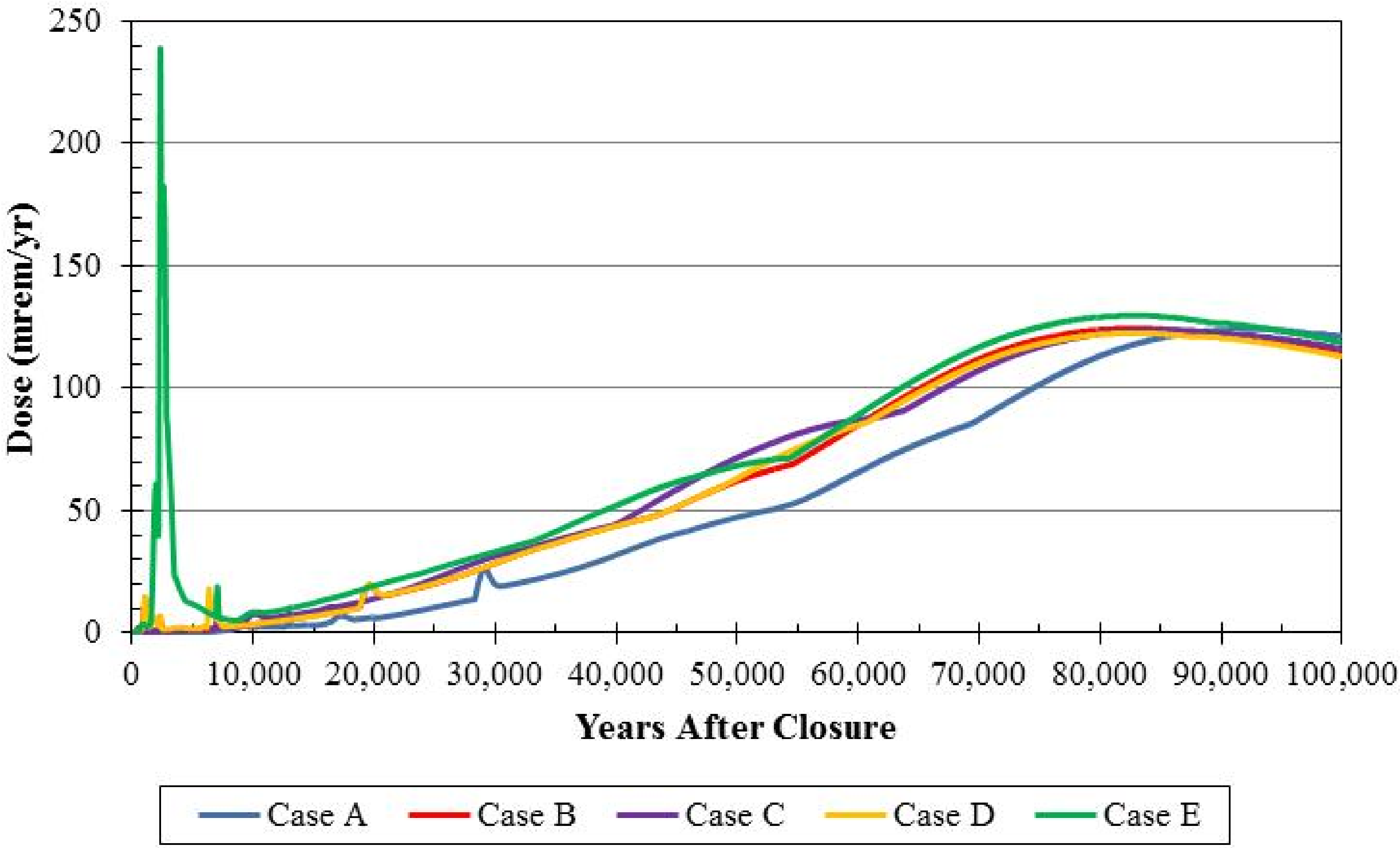
Barrier Analyses

Material Zone	Nominal	Partially Degraded	F (Failed/Fully Degraded)
Closure Cap	Infiltration profile per Base Case (Table 4.2-23)	NA	Infiltration constant at 16.45 in/yr [WSRC-STI-2007-00184]
Grout (K_d controlled)	Hydraulic properties (e.g., failure date) and chemical properties unchanged per Base Case	NA	Hydraulic properties of failed grout at time 0 – chemical properties unchanged. High flow throughout grout causes grout to impart reducing capacity onto CZ.
CZ (Solubility controlled)	CZ initial solubility limits are those associated with Base Case	NA	Solubility controls are removed for Tc-99 and Ra-226, and set to very high levels for remaining radionuclides.
Liner	Later liner failure (based on grouted CO_2 diffusion coefficient of 1E-06)	Early liner failure (based on grouted CO_2 diffusion coefficient of 1E-04)	No Liner at time 0
Tank Concrete (Basemat, Wall, Roof) (K_d controlled)	Hydraulic properties (e.g., failure date) and chemical properties unchanged per Base Case.	NA	Hydraulic properties of failed concrete – initial chemical properties unchanged. Chemical transitions are a function of the "failed" flow fields.
Natural Barrier (K_d controlled)	Native soil K_d values are set equal to Base Case values	N/A	Native soil K_d values are as defined in Table 5.6-35.

Cases A Thru E



Case A – E 100K Results

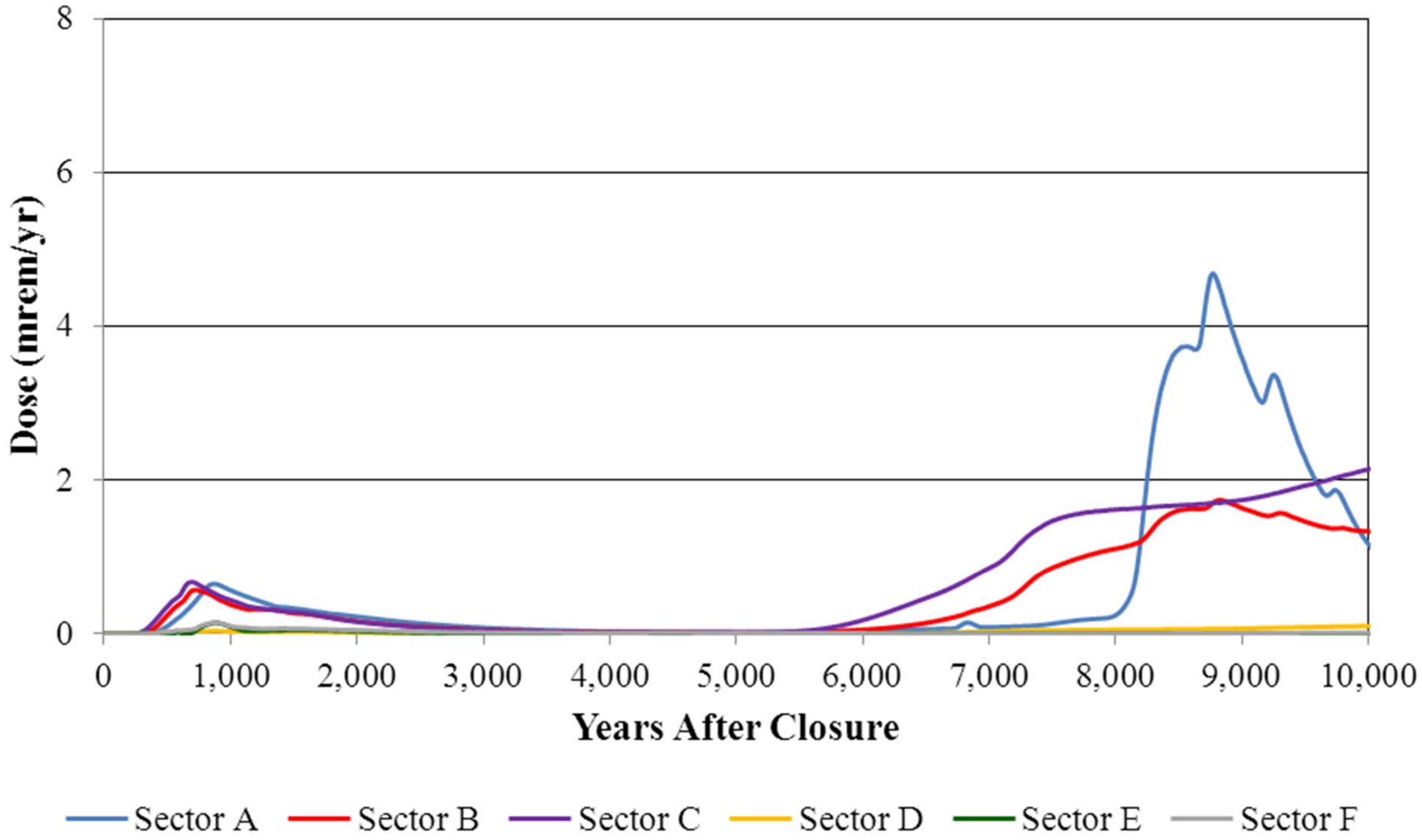


Savannah River Remediation

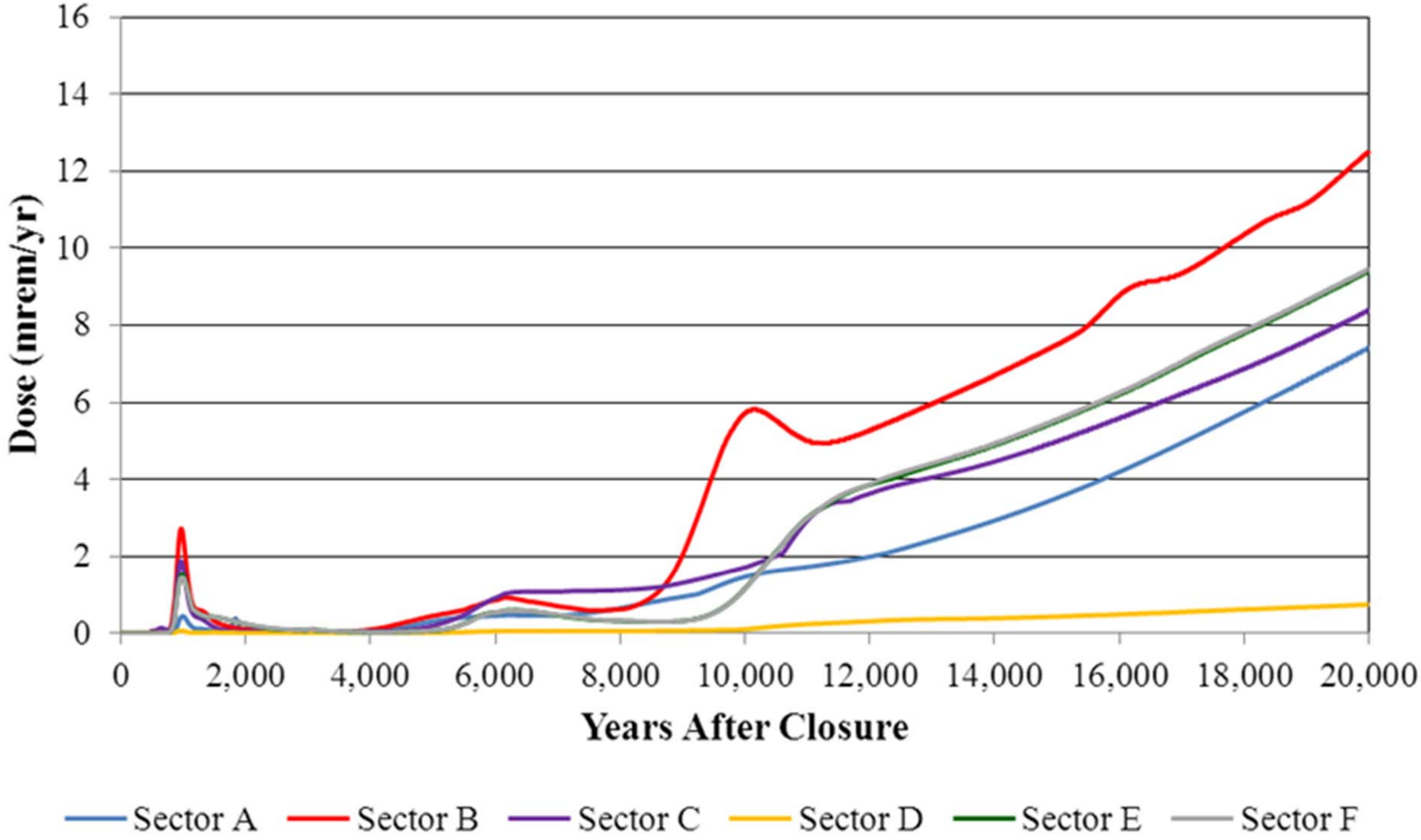
A URS COMPANY TEAMED WITH BECHTEL | CH2M HILL | B&W | AREVA

Case A With No Closure Cap

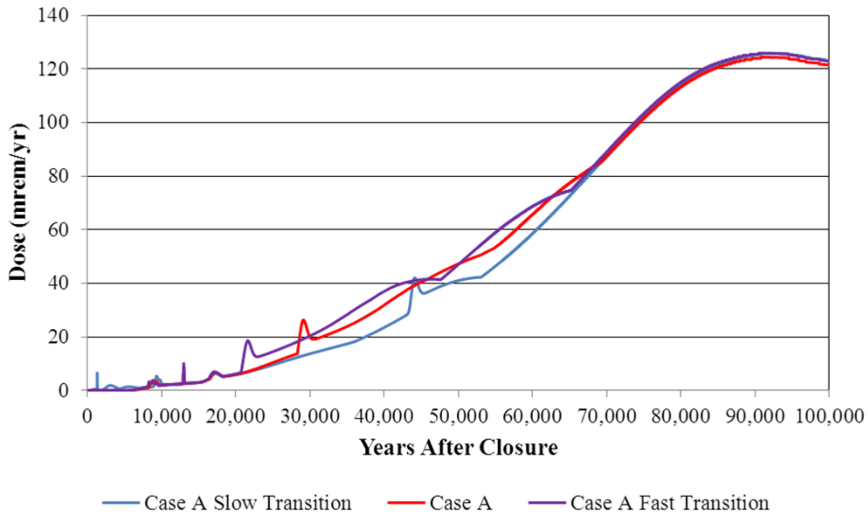
We do the right thing.



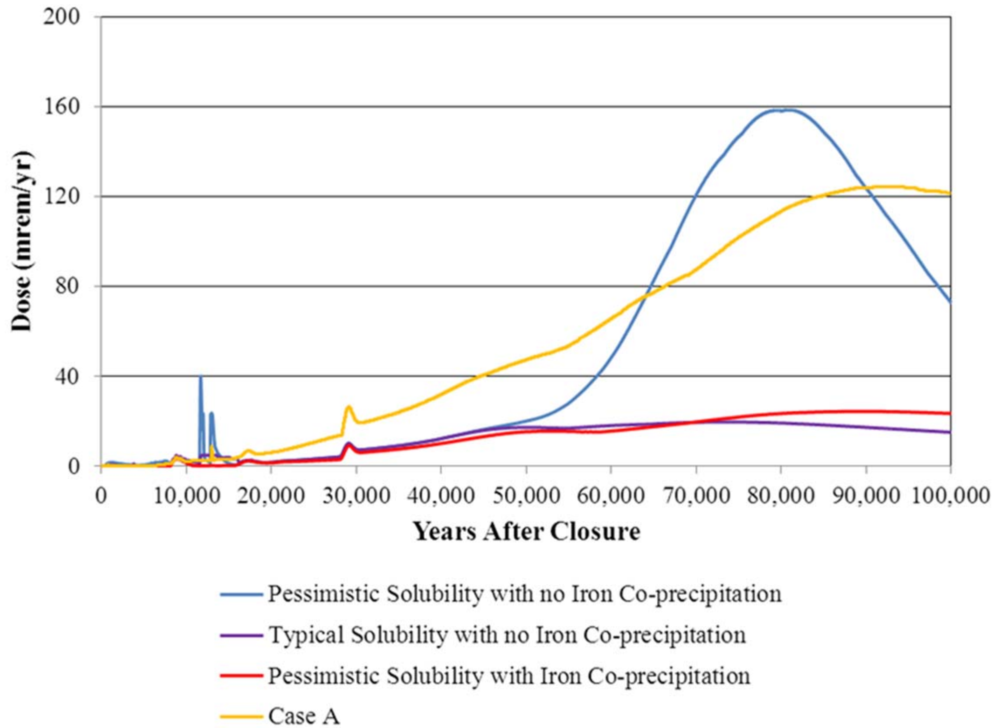
Synergistic Case



Grout Transition Time Study



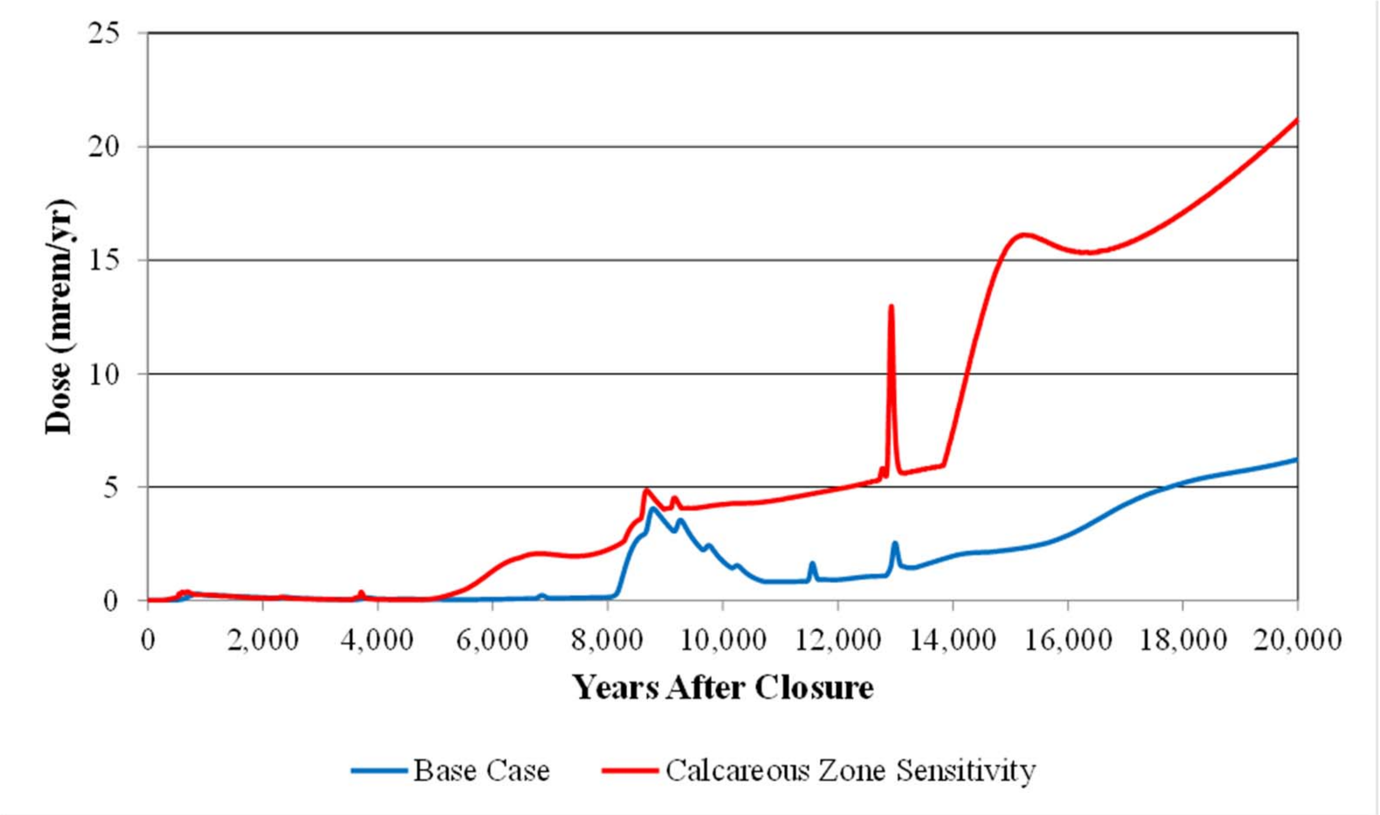
Solubility Value Analysis



Radionuclide	Study 1 - Pessimistic Solubility Values - No Fe Co-precipitation	Study 2 - Typical Solubility Values - No Fe Co-precipitation	Study 3 - Pessimistic Solubility Values - Fe Co-precipitation Assumed
Pu-239	1.1E-07	1.6E-11	1.6E-10
Tc-99	Instantaneous release	1.1E-08	1.3E-12
Np-237	1.0E-04	3.4E-05	3.0E-13
U-234	3.4E-04	4.3E-06	1.8E-10

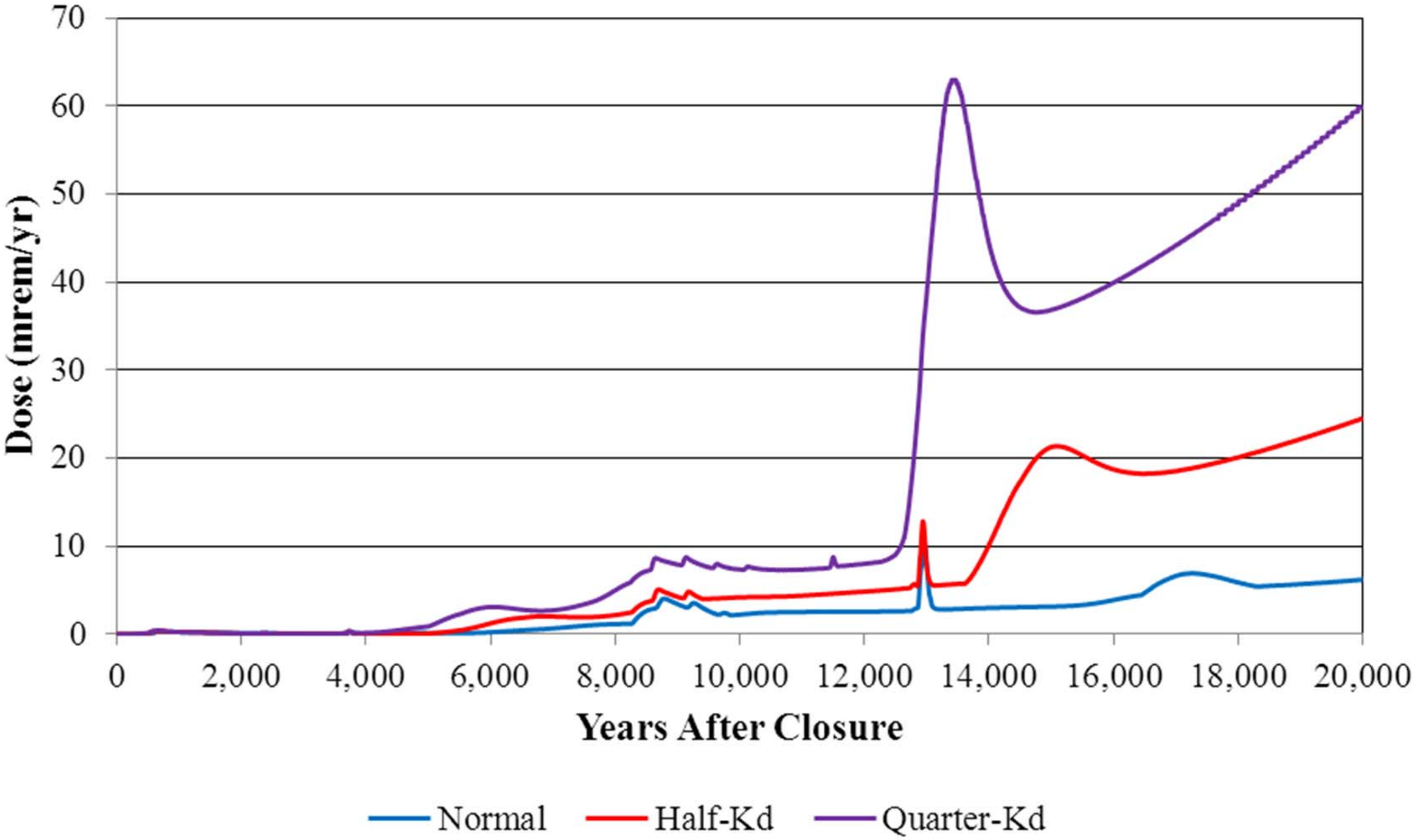
Calcareous Zone Analysis

PORFLOW soil properties were modified so that the effective porosity of the soil was 12.5 %, vs. 25 % used in the Base Case



Kd Variability Zone Analysis

PORFLOW far field soil properties were modified so that the soil had different K_d values than were used in the Base Case



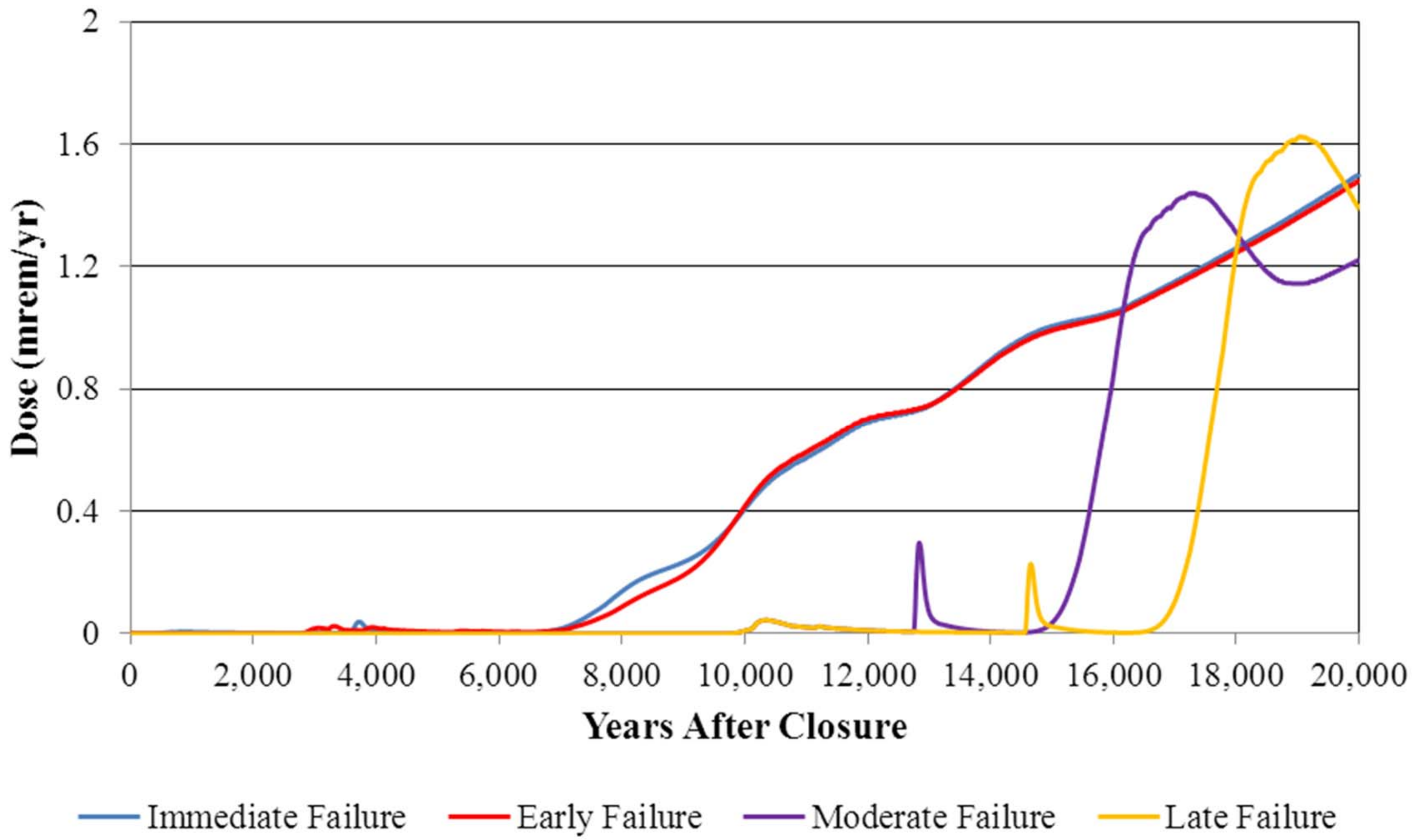
Liner Failure Time Analysis

To capture the impact of the time of liner failure on dose, twelve different flow fields reflecting different liner failure times were utilized

	Failure Time (Year) for No Fast Flow Path (Base Case)				Failure Time (Year) for Partial Flow Path (Cases B and C) and Full Fast Flow Path (Cases D and E)			
Label	Type I Liner	Type II Liner	Type III/IIIA Liner	Type IV Liner	Type I Liner	Type II Liner	Type III/IIIA Liner	Type IV Liner
Immediate	0	0	0	0	0	0	0	0
Early	2,100	2,506	3,100	500	100	100	100	75
Moderate	11,397	12,687	12,751	3,638	1,142	2,506	2,077	1,000
Late	15,000	14,500	14,500	8,000	11,000	12,000	12,000	3,638

Liner Failure Time Analysis

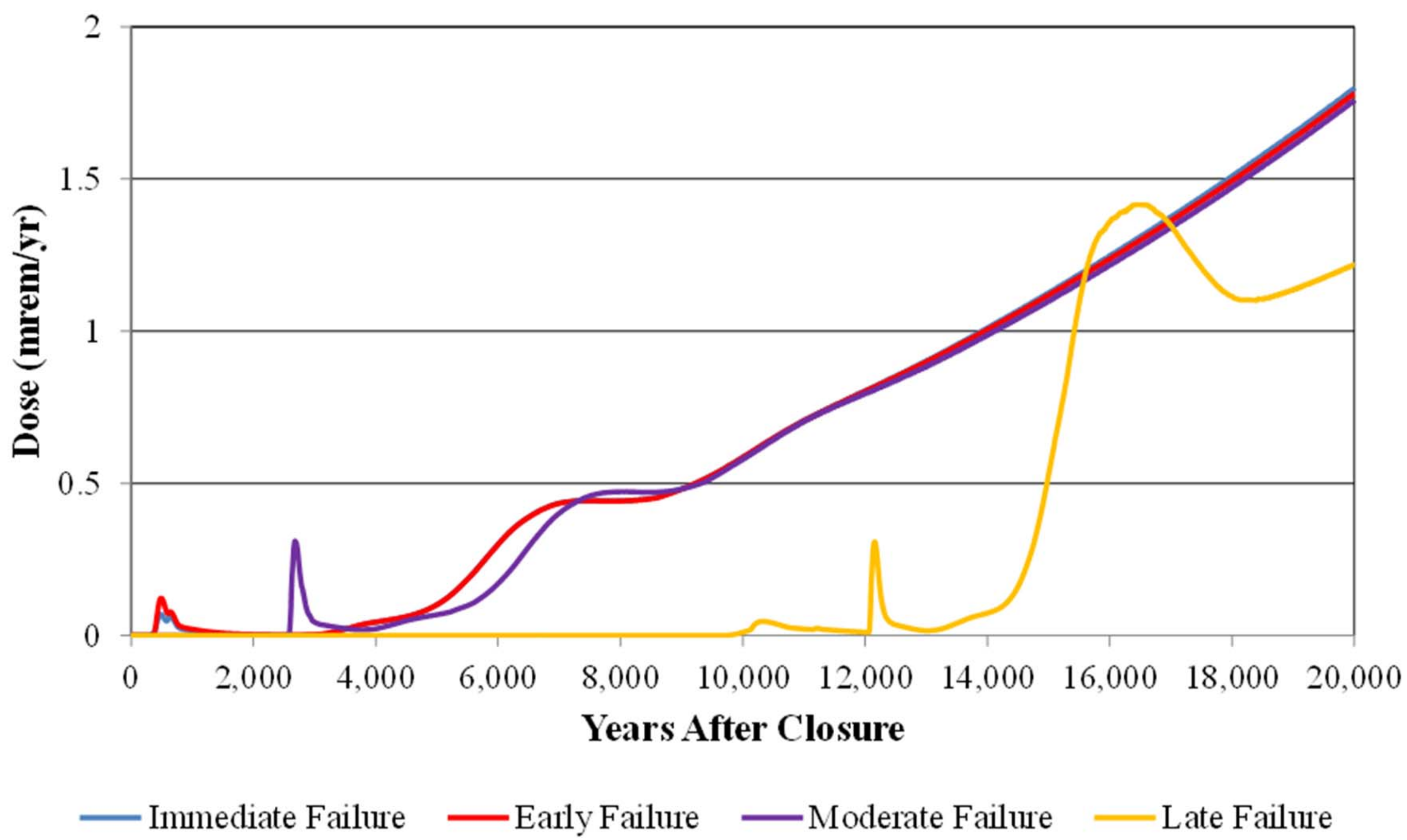
No Fast Flow Path Type II Tank MOP Dose (Base Case)



Liner Failure Time Analysis

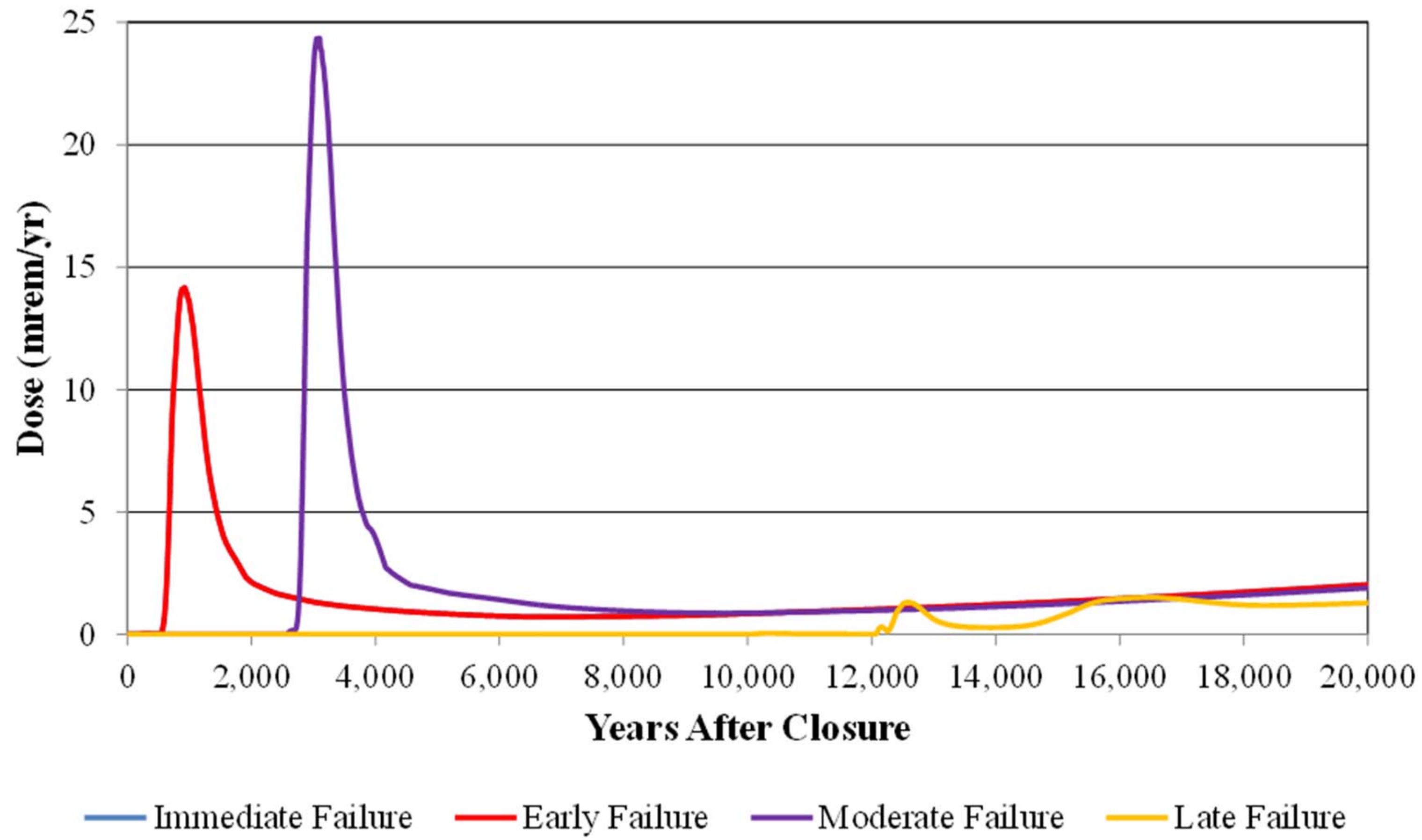
We do the right thing.

Partial Fast Flow Path Type II Tank MOP Dose (Cases B and C)



Liner Failure Time Analysis

Full Fast Flow Path Type II Tank MOP Dose (Cases D and E)

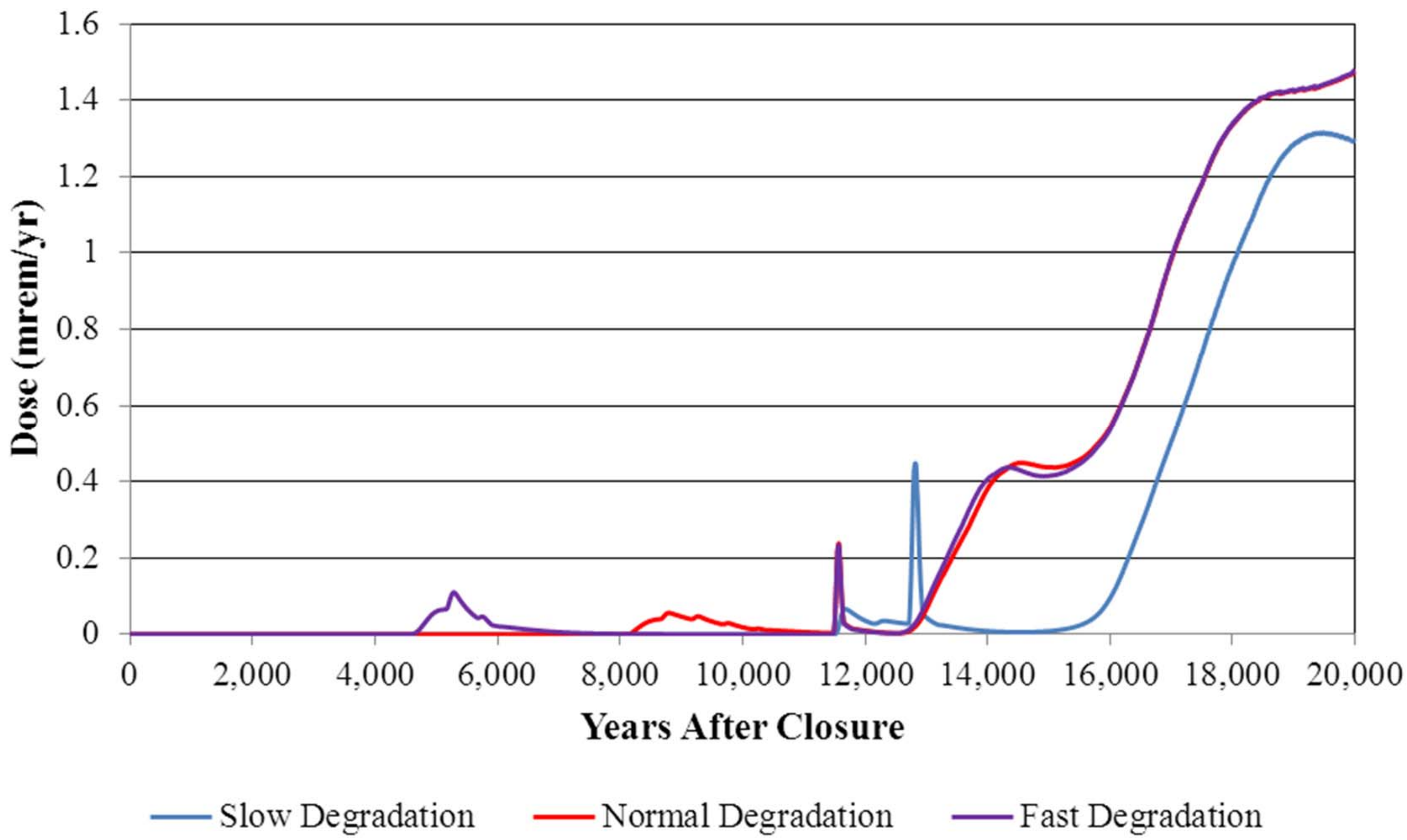


Cementitious Degradation Analysis

To capture the impact of cementitious degradation timing on flow, three different flow fields reflecting different concrete and grout degradation rates were utilized

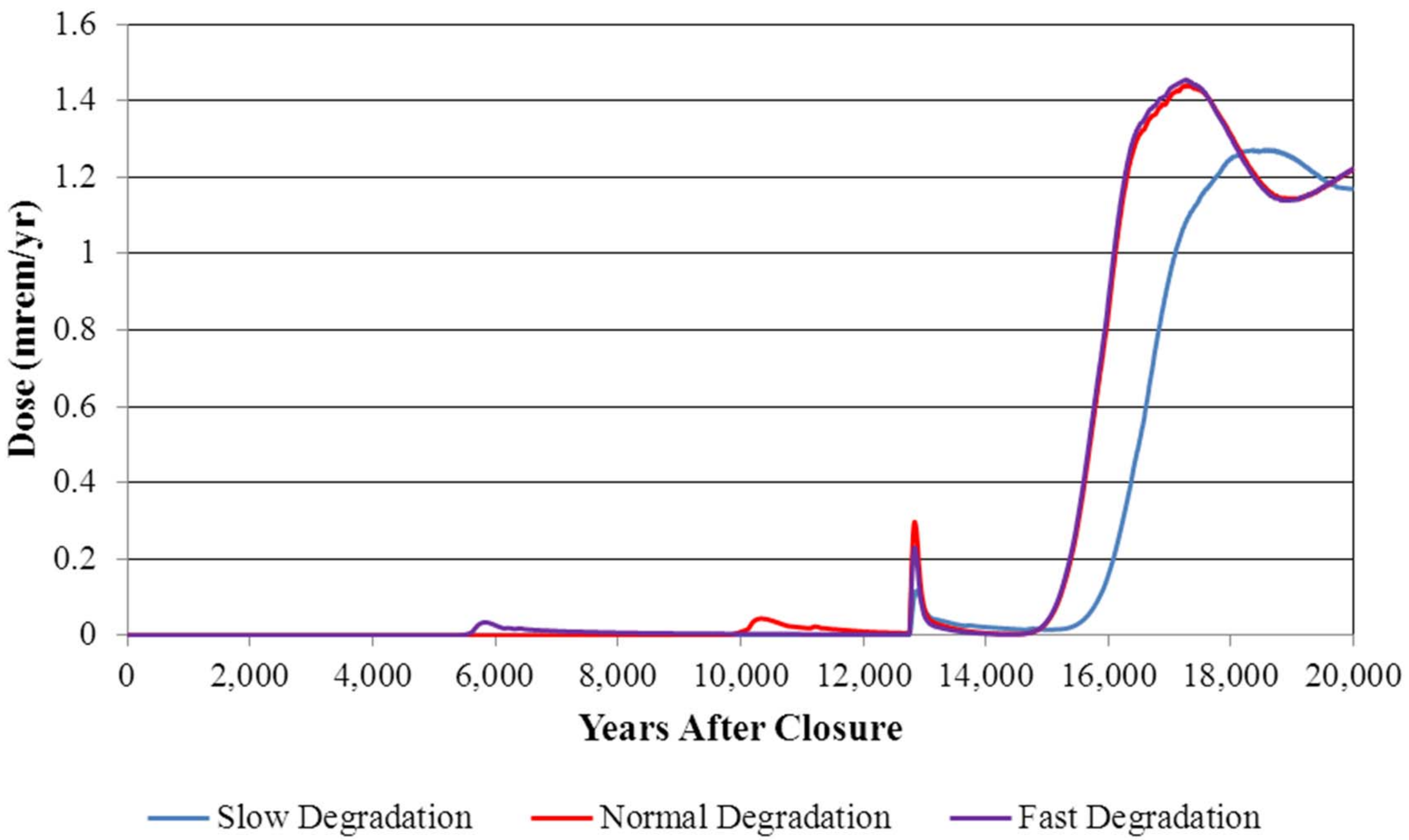
Cementitious Degradation Analysis

Cementitious Degradation Timing Type I Tank MOP Dose



Cementitious Degradation Analysis

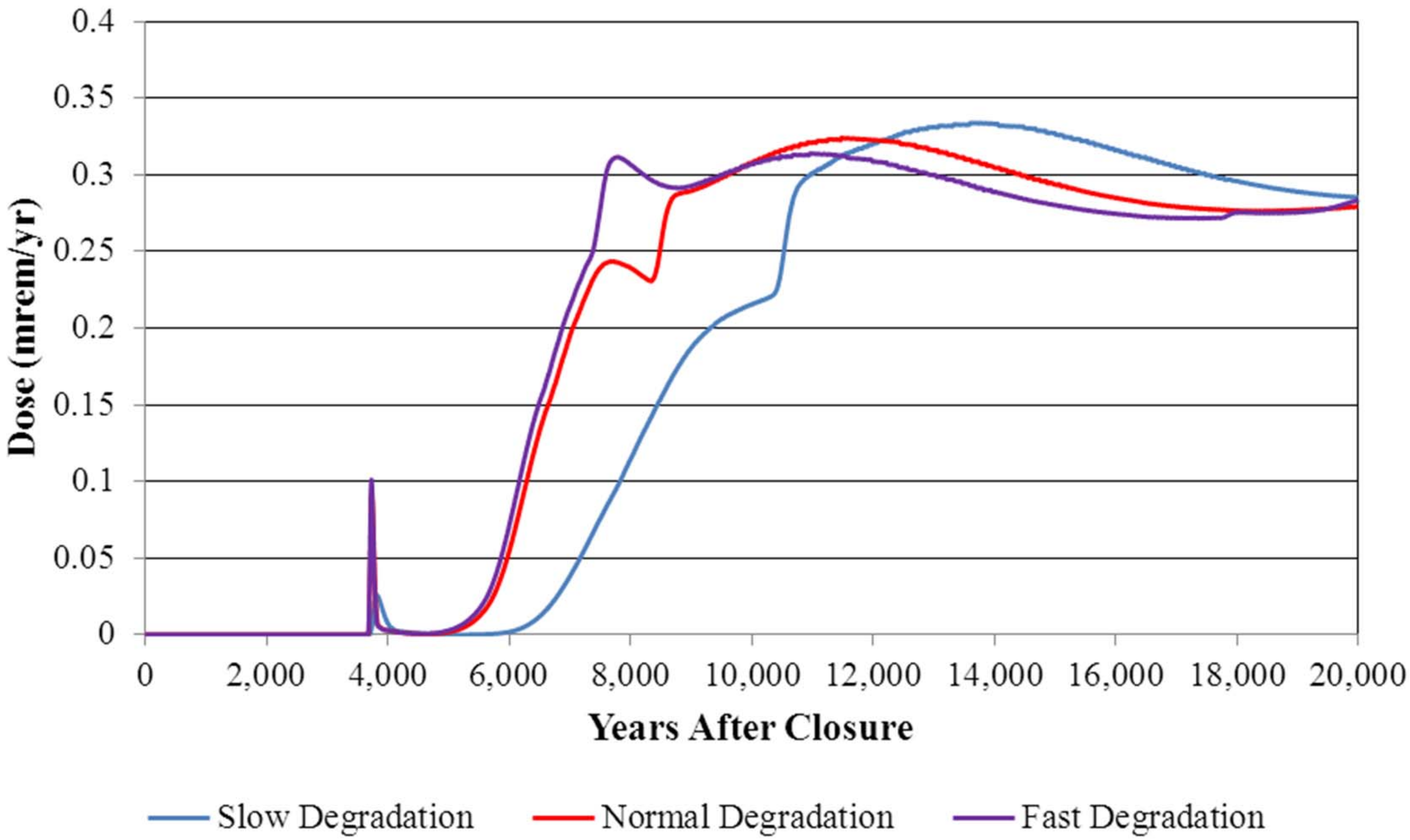
Cementitious Degradation Timing Type II Tank MOP Dose



Cementitious Degradation Analysis

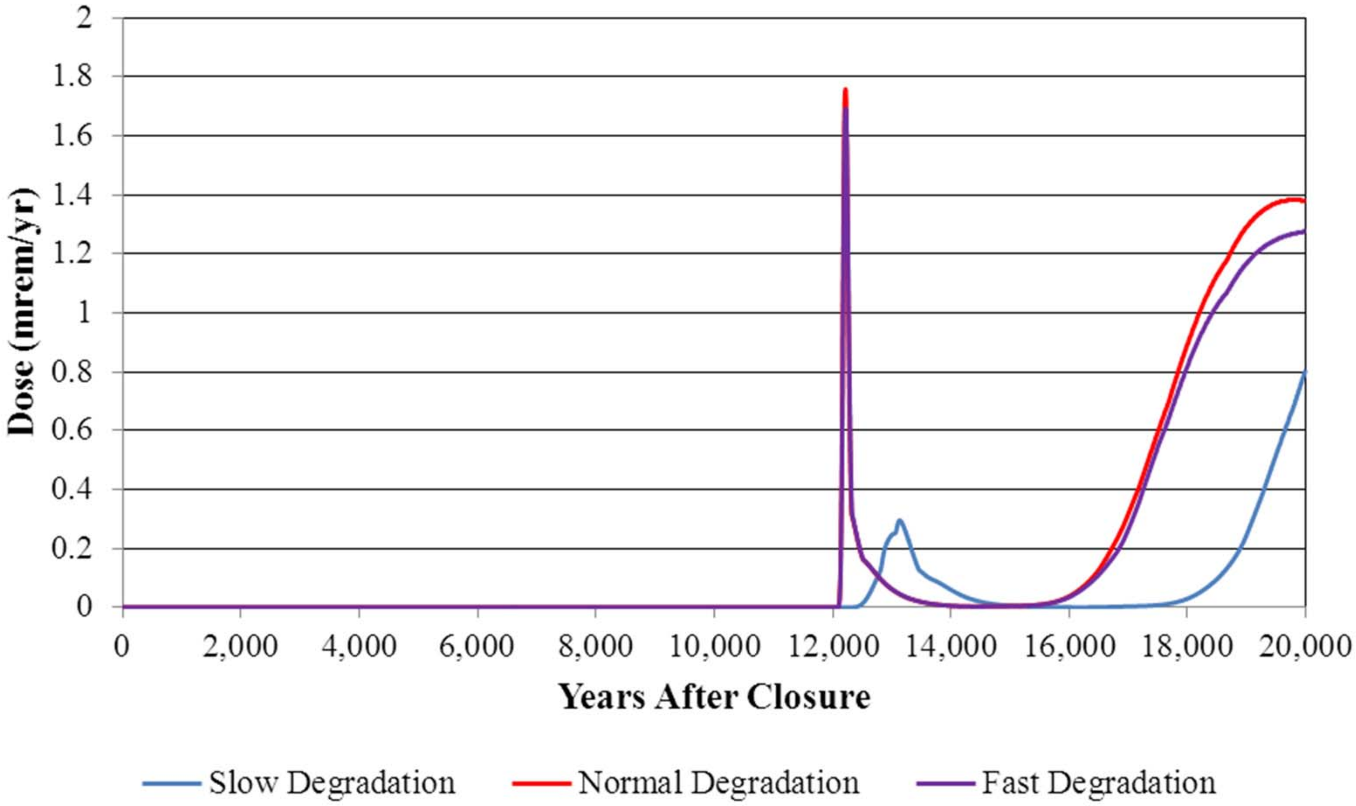
We do the right thing.

Cementitious Degradation Timing Type IV Tank MOP Dose

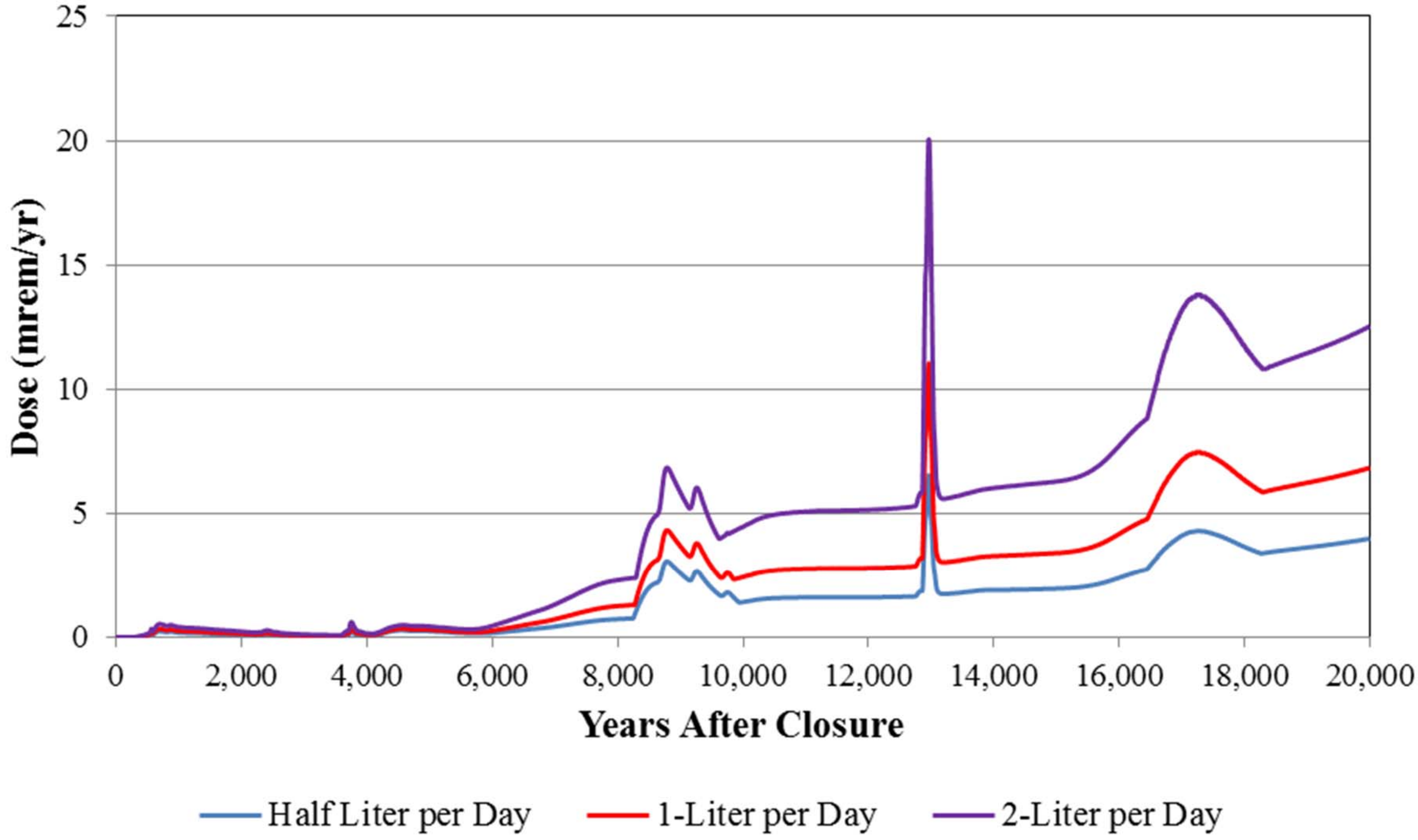


Cementitious Degradation Analysis

Cementitious Degradation Timing Type III/IIIA Tank MOP Dose



Water Ingestion Rate Variability

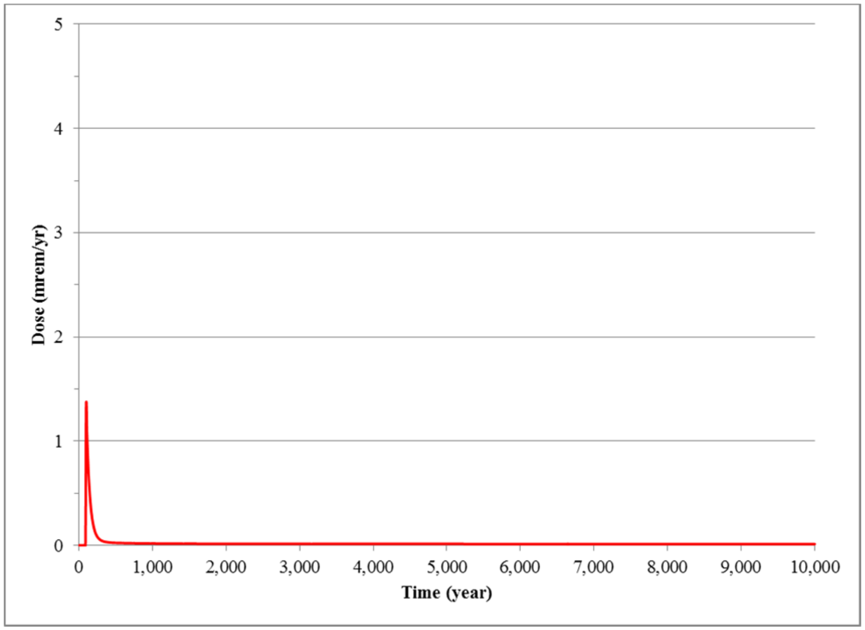


Inadvertent Intruder

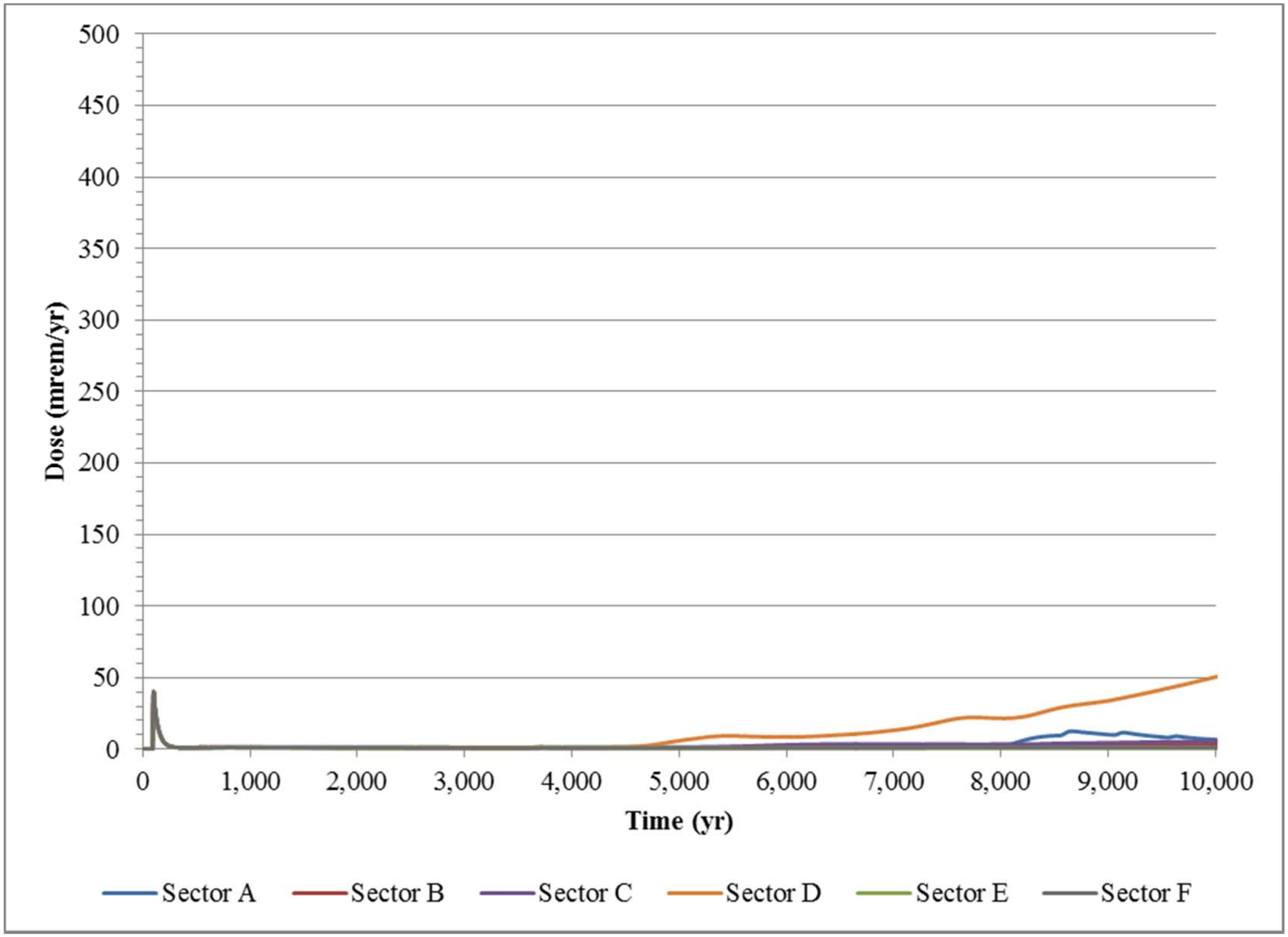
- Evaluated acute and chronic inadvertent intruder scenarios
- Utilized 1m water concentrations and drill cuttings from drilling thru a 3” diameter transfer line
- Performed probabilistic sensitivity analysis on chronic scenario
- Performed deterministic sensitivity analyses on larger transfer line, drilling into a tank and locations 1m from tanks vs. 1m from facility boundary

Acute Intruder Results

Acute Intruder Pathway Contributors	Peak Contribution (mrem)	Principal Radionuclide Pathway Dose (%)
Drill Cuttings Direct Exposure	1.3 (95%)	Cs-137/Ba-137m (96%) Sr-90/Y-90 (3%)
Drill Cuttings Ingestion	0.022 (1.6%)	Pu-238 (51%) Sr-90/Y-90 (31%)
Drill Cuttings Inhalation	0.044 (3.3%)	Pu-238 (76%) Am-241 (18%)
Total	**1.3 (100%)**	



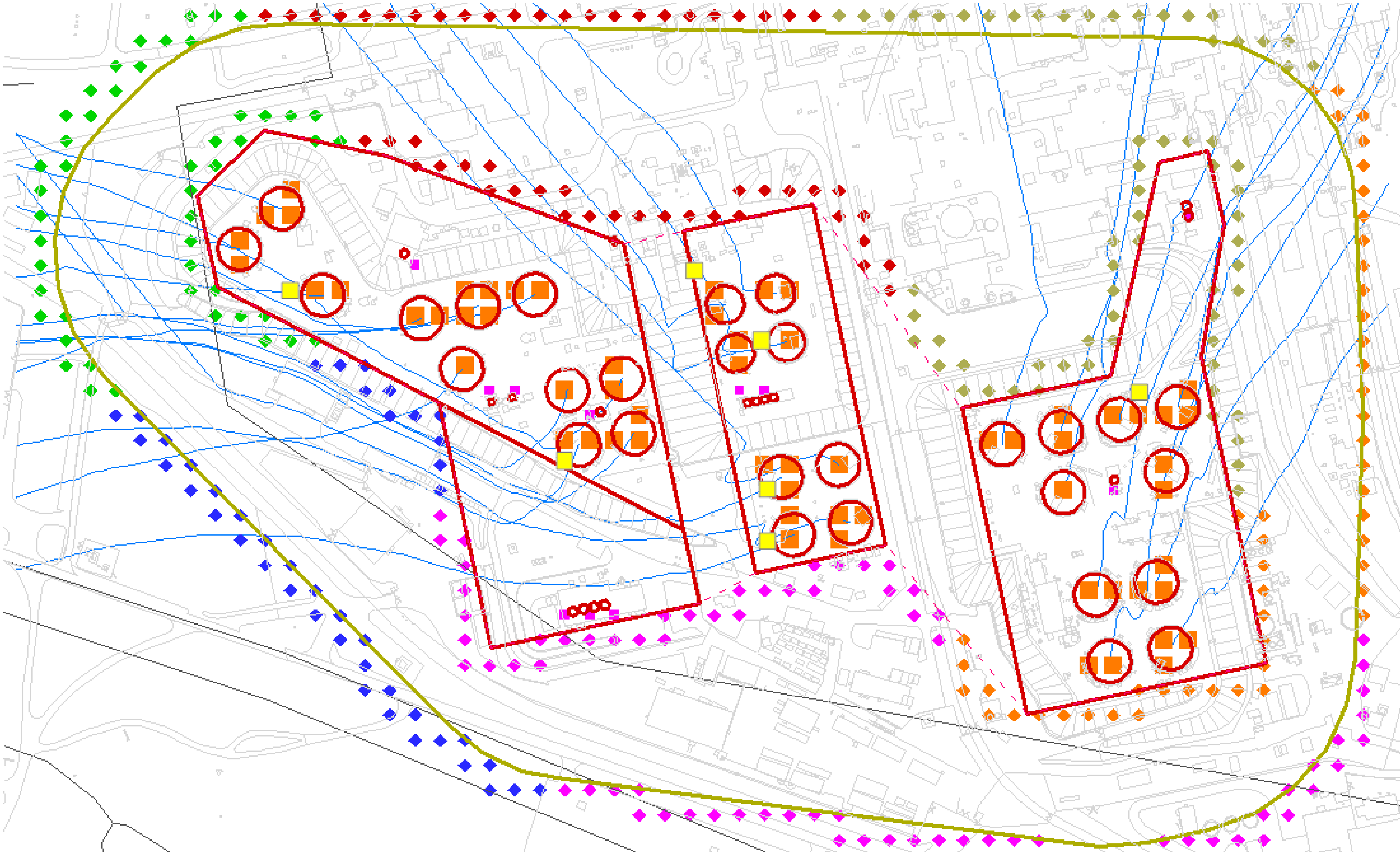
Chronic Intruder Results



Chronic Intruder Results

Chronic Intruder Pathway Contributors	Contribution to Peak (mrem/yr)	Principal Radionuclide Pathway Dose (%)
Water Ingestion	38 (74%)	Ra-226 (31 %) U-234 (29 %) U-233 (11 %)
Vegetable Ingestion	12 (23 %)	Ra-226 (28 %) U-234 (28 %) U-233 (11 %)
All others	1.1 (2.3 %)	N/A
TOTAL	50	

Select 1-meter Locations



Select 1-meter Dose Results