

**Assessment of Radiation in Surface Water at the Paducah Gaseous
Diffusion Plant**

**Radiation Health Branch
Division of Public Health Protection and Safety
Department for Public Health
Cabinet for Health and Family Services**

Objectives of Sampling Program

The results of analyses for surface water samples from the automatic samplers are assessed to:

1. Ensure radionuclide discharges do not pose risks to public health;
2. Ensure the reliability of quarterly grab-sampling results; and
3. Identify temporal & spatial changes in radionuclide discharges due to past and present plant activities, hydrogeological factors, and meteorological events.

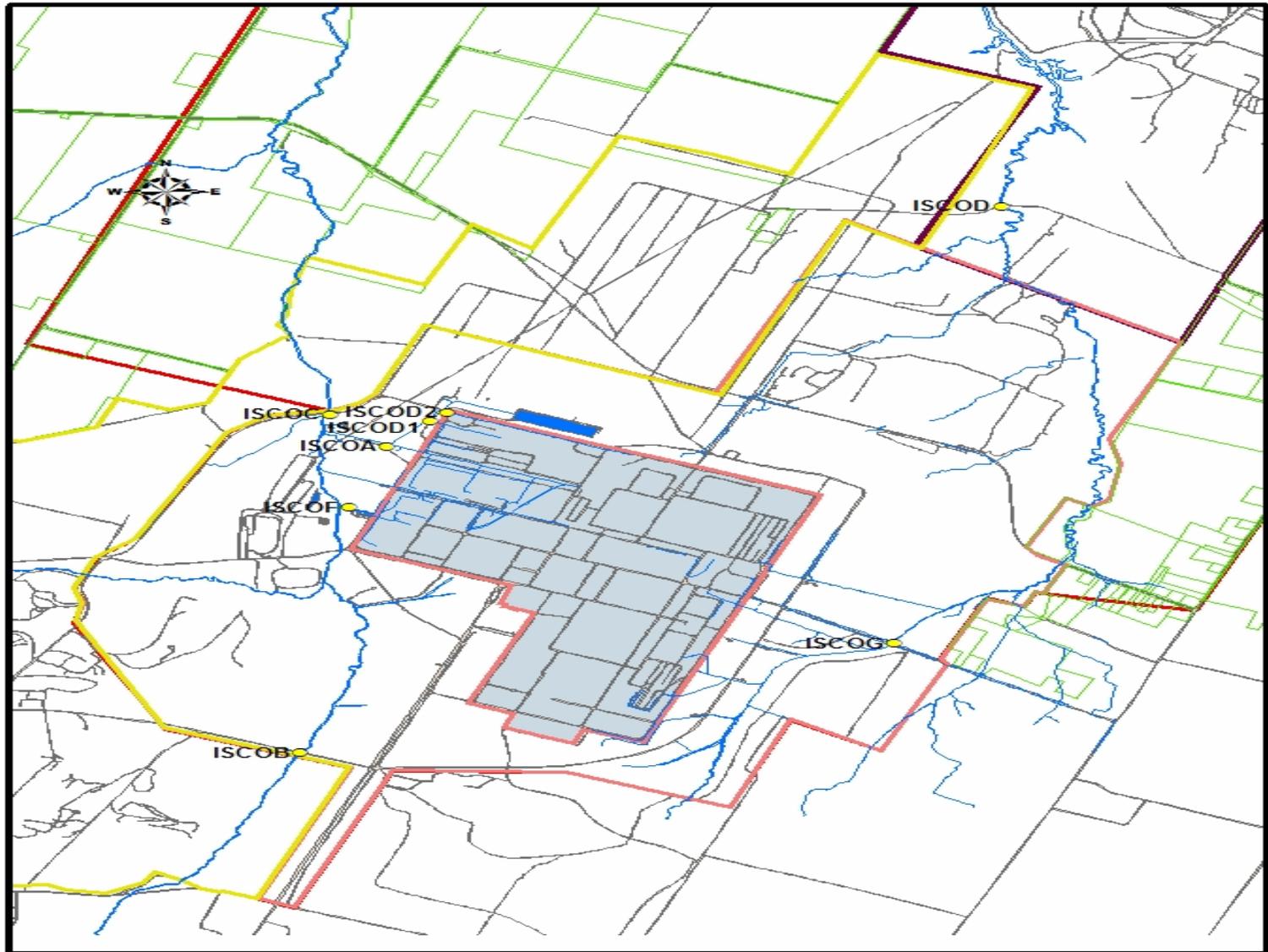
Sampling, Health and Safety, and Quality Control

- The RHB collects samples and maintains monitoring equipment at the PGDP as outlined in the:
 - ***Field Sampling and Analysis Plan for the PGDP (FSAP, RHB, 2003).***
- Health and safety procedures for activities at PGDP including the collection, handling, and transport of samples are outlined in the:
 - ***Health and Safety Plan for the PGDP (HASP, RHB, 2003).***
- Samples are analyzed as defined in the:
 - ***Laboratory Procedures Manual for the RCL (RCL, 1996).***
- The data is verified by the laboratory and validated by an independent third party to ensure accuracy, precision, reliability, reproducibility, comparability, and completeness of the analytical results as outlined in the:
 - ***Quality Assurance Program Plan for the RCL (RHB, 2003).***

Sampling and Analysis Protocol

- Each ISCO automated sampler operates continuously to automatically collect four (4) surface water samples per day at 6-hour intervals.
-
- The sample collection cycle for the ISCO daily-composite samples averages approximately 21 days.
- Sets of daily-composite samples are combined into one 21-day composite sample.
- The 21-day composite sample is filtered and the filtrate is acidified to stabilize the sample.
- The acidified filtrate is analyzed for
 - gross alpha/beta (α/β) activity,
 - gamma (γ) activity,
 - technetium-99 (^{99}Tc),
 - uranium-234 (^{234}U), uranium-235 (^{235}U), uranium-238 (^{238}U),
 - plutonium-238 (^{238}Pu), plutonium-239 (^{239}Pu).

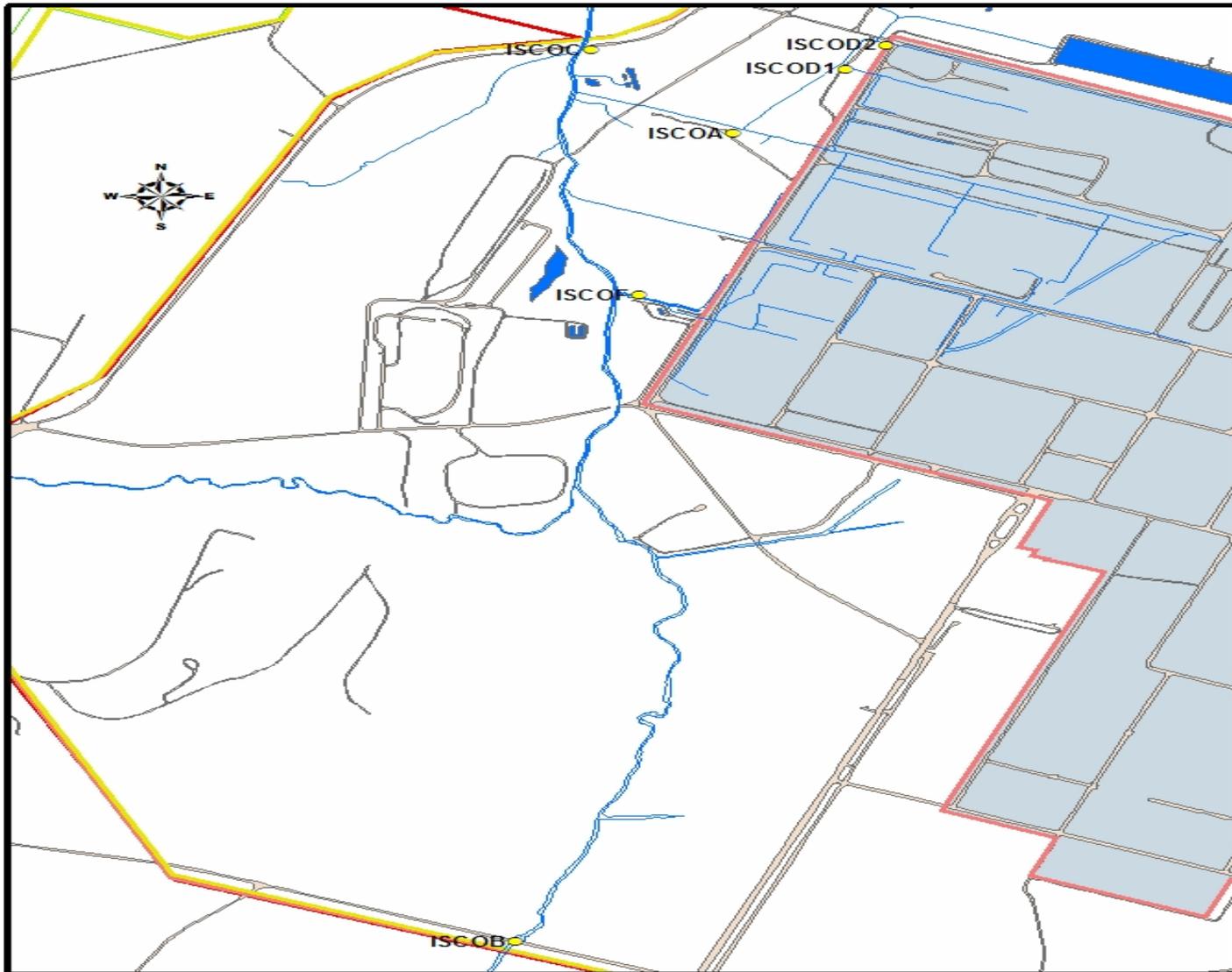
Automatic Surface Water Sampler Locations



0 0.125 0.25 0.5 0.75 1 Miles

- Residential Areas
- DOE Property
- TVA Property
- Wildlife Management Area
- DOE Fenced Security Area
- Water Policy Area

Automatic Surface Water Sampler West Side Locations



0 0.05 0.1 0.2 0.3 0.4 Miles

- Residential Areas
- DOE Property
- TVA Property
- Wildlife Management Area
- DOE Fenced Security Area
- Water Policy Area

Radiation activity of isotopes reported in surface water from 2001 through 2004 for ISCO D2

Isotope	Mean Activity ISCO D2	Release Limits 902 KAR 100:019, Section 44(7)	Ratio Mean Activity to Release Limits	Sum of the Fractions Relative to Release Limits
	pCi/l	pCi/l		
2001				
Soluble Uranium-238	58.3	300	0.19	0.28
Soluble Uranium-235	1.7	300	0.006	
Soluble Uranium-234	23.6	300	0.08	
Technetium-99	46.1	60000	0.0007	
Soluble Plutonium-239	0.01	20	0.0005	
Soluble Plutonium-238	0.1	20	0.005	
2002				
Soluble Uranium-238	27.3	300	0.09	0.13
Soluble Uranium-235	0.7	300	0.002	
Soluble Uranium-234	11.2	300	0.04	
Technetium-99	12.4	60000	0.0002	
Soluble Plutonium-239	0.04	20	0.002	
Soluble Plutonium-238	-0.001	20	-0.00006	
2003				
Soluble Uranium-238	0.7	300	0.002	0.004
Soluble Uranium-235	0.05	300	0.0002	
Soluble Uranium-234	0.7	300	0.002	
Technetium-99	8.3	60000	0.0001	
Soluble Plutonium-239	0.01	20	0.0005	
Soluble Plutonium-238	-0.01	20	-0.00005	
2004				
Soluble Uranium-238	0.5	300	0.002	0.02
Soluble Uranium-235	0.04	300	0.0001	
Soluble Uranium-234	0.5	300	0.002	
Technetium-99	8.2	60000	0.0001	
Soluble Plutonium-239	0.04	20	0.002	
Soluble Plutonium-238	0.2	20	0.01	

Radiation activity of isotopes reported in surface water from 2001 through 2004 for ISCO D1

Isotope	Mean Activity ISCO D1	Release Limits 902 KAR 100:019, Section 44(7)	Ratio Mean Activity to Release Limits	Sum of the Fractions Relative to Release Limits
	pCi/l	pCi/l		
2001				
Soluble Uranium-238	540.0	300	1.8	2.98
Soluble Uranium-235	22.7	300	0.08	
Soluble Uranium-234	315.0	300	1.05	
Technetium-99	261.0	60000	0.004	
Soluble Plutonium-239	-0.01	20	-0.0005	
Soluble Plutonium-238	0.9	20	0.045	
2002				
Soluble Uranium-238	159.0	300	0.5	0.83
Soluble Uranium-235	6.2	300	0.02	
Soluble Uranium-234	94.0	300	0.3	
Technetium-99	74.5	60000	0.001	
Soluble Plutonium-239	0.2	20	0.01	
Soluble Plutonium-238	-0.03	20	-0.0015	
2003				
Soluble Uranium-238	147.0	300	0.49	0.80
Soluble Uranium-235	8.0	300	0.03	
Soluble Uranium-234	87.6	300	0.29	
Technetium-99	70.6	60000	0.001	
Soluble Plutonium-239	0.002	20	0.0001	
Soluble Plutonium-238	-0.2	20	-0.01	
2004				
Soluble Uranium-238	142.0	300	0.47	0.86
Soluble Uranium-235	7.1	300	0.02	
Soluble Uranium-234	81.6	300	0.27	
Technetium-99	63.0	60000	0.001	
Soluble Plutonium-239	0.3	20	0.015	
Soluble Plutonium-238	1.6	20	0.08	

Radiation activity of isotopes reported in surface water from 2000 through 2004 for ISCO A

Isotope	Mean Activity ISCO A	Release Limits 902 KAR 100:019, Section 44(7)	Ratio Mean Activity to Release Limits	Sum of the Fractions Relative to Release Limits
	pCi/l	pCi/l		
2000				
Soluble Uranium-238	4.6	300	0.0153	0.028
Soluble Uranium-235	0.3	300	0.0010	
Soluble Uranium-234	2.6	300	0.0086	
Technetium-99	25.5	60000	0.0004	
Soluble Plutonium-239	-0.03	20	-0.0015	
Soluble Plutonium-238	0.09	20	0.0040	
2001				
Soluble Uranium-238	3.2	300	0.0107	0.022
Soluble Uranium-235	0.1	300	0.0003	
Soluble Uranium-234	1.8	300	0.0060	
Technetium-99	35.7	60000	0.0006	
Soluble Plutonium-239	0.002	20	0.0001	
Soluble Plutonium-238	0.08	20	0.0040	
2002				
Soluble Uranium-238	2.6	300	0.0090	0.018
Soluble Uranium-235	0.1	300	0.0003	
Soluble Uranium-234	1.5	300	0.0050	
Technetium-99	26.4	60000	0.0004	
Soluble Plutonium-239	0.03	20	0.0020	
Soluble Plutonium-238	0.04	20	0.0020	
2003				
Soluble Uranium-238	2.2	300	0.0073	0.012
Soluble Uranium-235	0.1	300	0.0003	
Soluble Uranium-234	1.5	300	0.0050	
Technetium-99	30.4	60000	0.0005	
Soluble Plutonium-239	0.008	20	0.0004	
Soluble Plutonium-238	-0.03	20	-0.0015	
2004				
Soluble Uranium-238	1.4	300	0.0047	0.015
Soluble Uranium-235	0.07	300	0.0002	
Soluble Uranium-234	1.0	300	0.0033	
Technetium-99	27.8	60000	0.0005	
Soluble Plutonium-239	0.03	20	0.0015	
Soluble Plutonium-238	0.1	20	0.0050	

Radiation activity of isotopes reported in surface water from 2002 through 2004 for ISCO F

Isotope	Mean Activity ISCO F	Release Limits 902 KAR 100:019, Section 44(7)	Ratio Mean Activity to Release Limits	Sum of the Fractions Relative to Release Limits
	pCi/l	pCi/l		
2002				
Soluble Uranium-238	2.2	300	0.0073	0.019
Soluble Uranium-235	0.2	300	0.0007	
Soluble Uranium-234	3.2	300	0.0107	
Technetium-99	9.4	60000	0.0002	
Soluble Plutonium-239	0.01	20	0.0005	
Soluble Plutonium-238	-0.003	20	-0.0002	
2003				
Soluble Uranium-238	1.4	300	0.0047	0.015
Soluble Uranium-235	0.15	300	0.0005	
Soluble Uranium-234	2.9	300	0.0097	
Technetium-99	11.9	60000	0.0002	
Soluble Plutonium-239	0.004	20	0.0002	
Soluble Plutonium-238	0.001	20	0.0001	
2004				
Soluble Uranium-238	0.9	300	0.0030	0.017
Soluble Uranium-235	0.1	300	0.0003	
Soluble Uranium-234	2.4	300	0.0080	
Technetium-99	11.6	60000	0.0002	
Soluble Plutonium-239	0.02	20	0.0010	
Soluble Plutonium-238	0.1	20	0.0050	

Radiation Dose and Risk Assessment for Surface Water

- Radiation dose and risk assessment for surface water collected by automatic samples B and C in Bayou Creek and automatic samplers D and G in Little Bayou Creek was conducted using:
 - ***RESRAD BASELINE, Version 2.2, 1996, Argonne National Laboratory.***
- Potentially complete exposure pathway for locations was incidental ingestion and dermal contact of surface water while swimming, wading, fishing, etc.

Summary of Pathway Selections

Pathway	User Selection
1 -- groundshine (R)	suppressed
2 -- inhalation (B)	suppressed
3 -- plant ingestion (B)	suppressed
4 -- meat ingestion (B)	suppressed
5 -- milk ingestion (B)	suppressed
6 -- aquatic foods ingestion (B)	suppressed
7 -- drinking water ingestion (B)	suppressed
8 -- soil ingestion (B)	suppressed
9 -- radon (R)	suppressed
10 -- incidental water ingestion (B)	active (R)
11 -- air immersion (R)	suppressed
12 -- dermal absorption from swimming (C)	active (R)
13 -- dermal absorption from shower water (C)	suppressed
14 -- dermal absorption soil contact (C)	suppressed

Note: (B), (C) and (R) under pathway denotes the applicability for both chemical and radiological, chemical, or radiological risk assessment, respectively.

(B), (C) and (R) under user selection denotes user's choice to conduct both chemical and radiological, chemical, or radiological risk assessment, respectively.

Parameters for Incidental Water Ingestion

Incidental water intake (swimming)	1.300E-01 liters per day
Average Body Weight (Child)	15 Kilograms
Average Body Weight (Adult)	70 Kilograms
Average Life Time	70 years
Contamination fraction for dermal adsorption from swimming	1
Exposure frequency for dermal adsorption from swimming	7 days per year
Skin surface area available for water contact	20000 cm ²
Duration for Swimming	0.5 hour per event

Parameters for Dermal Absorption from Swimming

Exposure duration	30 years
Average Body Weight (Child)	15 Kilograms
Average Body Weight (Adult)	70 Kilograms
Average Life Time	70 years
Contamination fraction for dermal adsorption from swimming	1
Exposure frequency for dermal adsorption from swimming	7 days per year
Skin surface area available for water contact	20000 cm ²
Duration for Swimming	0.5 hour per event

Radiation Dose and Risk for 2004 at ISCOs B, C, D, and G

Location	Isotope	Mean* Activity	Dose	Risk (From Risk Dose Conversion Factors)	Risk (From Slope Factors)
		pCi/l	mrem/yr		
ISCO B	²³⁸ U	0.17	5.538E-04	1.263E-08	1.859E-09
	²³⁵ U	0.04			
	²³⁴ U	0.19			
	⁹⁹ Tc	0.94			
	²³⁹ Pu	0.05			
	²³⁸ Pu	0.1			
ISCO C	²³⁸ U	1.24	1.016E-03	2.317E-08	4.765E-09
	²³⁵ U	0.07			
	²³⁴ U	1.05			
	⁹⁹ Tc	3.59			
	²³⁹ Pu	0.013			
	²³⁸ Pu	0.13			
ISCO D	²³⁸ U	1.48	1.001E-03	2.282E-08	4.807E-09
	²³⁵ U	0.06			
	²³⁴ U	0.49			
	⁹⁹ Tc	6.94			
	²³⁹ Pu	0.007			
	²³⁸ Pu	0.16			
ISCO G	²³⁸ U	2.06	8.799E-04	2.006E-08	5.080E-09
	²³⁵ U	0.07			
	²³⁴ U	0.54			
	⁹⁹ Tc	6.32			
	²³⁹ Pu	-0.061			
	²³⁸ Pu	0.14			

*Bold mean activity values were calculated using sample population where less than 25% of the samples analyzed had activity values that did not have results exceeding the sample specific detection limit and/or the counting uncertainty was greater than 50% of reported sample values.

ISCO D1 - Uranium-238 (See Figure 3 For Sample Location)

