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

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

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BACKGROUND

The Radiation Health Branch (RHB), Department for Public Health, Cabinet for Health and Family Services (Cabinet) by statutory mandate is the radiation control agency for the Commonwealth of Kentucky. The Cabinet's statutory mandate (KRS 211.842-211.852) is to establish programs to protect public health and safety, and welfare from ionizing radiation. Activities are directed toward licensing, registration, certification, inspection, waste disposal, environmental monitoring, environmental impact assessment, radiochemical analysis, dose evaluation, risk assessment, risk management, compliance, transportation of radioactive material, and emergency response relative to radioactive materials.

The RHB was the first state or federal agency to detect off-site radionuclide contamination in private drinking water wells in the vicinity of the U.S. Department of Energy's (DOE) Paducah Gaseous Diffusion Plant (PGDP) in 1988. The Cabinet funded the RHB's regular environmental sampling, monitoring, analysis, and assessment activities at PGDP from 1988 until 1991. In 1991 the RHB obtained funding under the Agreement in Principle (AIP) with DOE and the Kentucky Department of Environmental Protection, which acts as the lead agency for the AIP grant. Since 1994 the University of Kentucky has provided personnel for RHB's PGDP activities through a Program Administration Contract with the Cabinet.

The RHB is involved in sampling, monitoring, laboratory analysis, and assessment of off-site (outside DOE Property Boundary) and on-site (inside DOE Property Boundary) radionuclide contamination at PGDP. The RHB has been sampling and conducting environmental analyses at the PGDP since 1988. The RHB continues to collect and analyze surface water, sediment, groundwater, vegetation, and soil samples in order to characterize and assess impacts of the PGDP on public health.

The RHB's efforts at the PGDP have been directed toward radiological monitoring and oversight of DOE activities in order to ensure protection of public health. However, the RHB does not have regulatory authority on-site (within the DOE property boundary) at the PGDP assuming DOE has Exclusive Federal Jurisdiction. The DOE is self-regulating with regard to activities dealing with radiation

related to the uranium fuel cycle as established by the Atomic Energy Act.

The RHB collects, handles, and stores samples at the PGDP and transports the samples to the Radiation Control Laboratory (RCL) under a radioactive material license issued by the Cabinet. Samples collected for the RHB by the University of Kentucky Water Resources Research Institute (UK-KWRRI) are handled, transported, and shipped under the University of Kentucky's radioactive materials license.

The RHB collects samples and maintains monitoring equipment at the PGDP as outlined in the text and tables contained in the ***Field Sampling and Analysis Plan for the PGDP*** (FSAP, RHB, 2003). Health and safety procedures for environmental activities at the PGDP including the collection, handling, and transport of environmental samples are outlined in the ***Health and Safety Plan for the PGDP*** (HASP, RHB, 2003).

Once at the RCL, samples are analyzed for the parameters outlined in the FSAP utilizing analytical procedures defined in the ***Laboratory Procedures Manual for the RCL*** (RCL, 1996). The data is verified and validated to ensure accuracy, precision, reliability, reproducibility, comparability, and completeness of the RCL analytical results as outlined in the ***Quality Assurance Program Plan for the RCL*** (RHB, 2003).

The RCL conducts specific analyses on PGDP samples for uranium-234 (^{234}U), uranium-235 (^{235}U), uranium-238 (^{238}U), plutonium-238 (^{238}Pu), plutonium-239 (^{239}Pu), and technetium-99 (^{99}Tc). Samples are analyzed by gamma-spectroscopy to determine the presence of gamma-emitting radionuclides including thorium-234 (^{234}Th), protactinium-234m (^{234m}Pa), protactinium-233 (^{233}Pa), cesium-237 (^{137}Cs), and americium-241 (^{241}Am).

The RHB's RCL functions as a regulatory laboratory and must maintain a high standard of quality in order to ensure protection of public health from ionizing radiation. To ensure the production of high quality analytical data the RCL conducts quality control analytical analyses. Quality control samples included standards, performance evaluation samples, and background analyses. Data verification is conducted by the RCL. Data validation is conducted by an independent third party.

Analytical results are screened against a number of criteria. The following is the sequence used to evaluate data produced by the RCL. The data is evaluated to determine if: (1) each sample has a sample-specific activity for each specific analysis; (2) each sample has a sample-specific counting uncertainty; (3) each result has a sample specific minimum detectable concentration (MDC); (4) the reported activity does or does not exceed the sample-specific MDC; (5) the sample-specific counting uncertainty does or does not exceeds 50% of the sample activity; and (6) each set of data has appropriate quality control.

For this report, the RHB did not screen out data through the application of the above six (6) step approach. Therefore, all data was used to conduct the assessments presented in the report.

ISCO Automated Surface-Water Monitoring

The Cabinet's RHB maintains and operates eight (8) ISCO automated surface-water samplers in the vicinity of the PGDP. Figure 1 shows the location of the RHB's ISCO automated samplers. The RHB has automated samplers at the following locations: (1) ISCO A, at KPDES Outfall 001 weir; (2) ISCO B, at the Bayou Creek quarterly background surface-water sampling location BBCUG/R-249 upstream of the PGDP; (3) ISCO C, in Bayou Creek at sampling location BBCDG/R-151 downstream from PGDP outfalls; (4) ISCO D, at quarterly surface water sampling location LBCDG/R-248 downstream from the PGDP KPDES Outfalls to Little Bayou Creek and the North South Diversion Ditch confluence with Little Bayou Creek; (5) ISCO F, in Outfall 008 on the west side of the site; (6) ISCO G, in Little Bayou Creek at McCaw Road on the east side of the site: (7) ISCO DRUM1 (D1) in the south drain from the scrap yards outside the restricted area fence at the northwest corner of the site; and (8) ISCO DRUM2 (D2) in the north drain from the scrap yards outside the restricted area fence at the northwest corner of the site.

Each ISCO automated sampler operates continuously to automatically collect four (4) surface water samples per day at 6-hour intervals. As each of the daily water samples are collected, they are automatically combined into one (1) daily-composite sample. The sample collection cycle for the ISCO daily-composite samples averages

approximately 21 days depending on availability of RHB personnel to travel to the PGDP to collect and replace sample containers. 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 samples are analyzed for gross alpha/beta (α/β) activity, gamma (γ) activity, technetium-99 (^{99}Tc), and alpha emitting isotopes (uranium-234 (^{234}U), uranium-235 (^{235}U), uranium-238 (^{238}U), plutonium-238 (^{238}Pu), plutonium-239 (^{239}Pu).

The results of analyses for surface water samples from the ISCO sampler were assessed: (1) to ensure radionuclide discharges do not pose risks to public health; (2) to ensure the reliability of quarterly grab-sampling results; and (3) to identify temporal & spatial changes in radionuclide discharges due to past and present plant activities, hydrogeological factors, and meteorological events.

SURFACE WATER ISCOS - BAYOU CREEK, WEST DRAINAGE DITCHES AND OUTFALLS

On the west side of the Paducah Gaseous Diffusion Plant (PGDP) the Radiation Health Branch operates ISCO surface water monitors in Outfall 001, Outfall 008, the north (ISCO D2) and south (ISCO D1) drainage ditches from the scrap metal yards and SWMUs 7 and 30, upgradient of the west outfalls on Bayou Creek (ISCO B), and downgradient of the west outfalls on Bayou Creek (ISCO C)(Figure 2). Descriptive statistical parameters for key PGDP process radionuclides are provided in Table 1.

ISCO D2

ISCO D2, Figure 3, is located in the north drain of the northwest corner and receives runoff from the scrap yards and from the surface soils of SWMUs 7 and 30. The mean ^{238}U activity in surface water at ISCO D2 from 2001 to March 2005 is 18.58 picocuries per liter (pCi/l), Table 1. The mean ^{99}Tc, ^{235}U, ^{234}U, ^{238}Pu, and ^{239}Pu activity is also provided in Table 1.

Table 2 provides the annual mean activity for each of the isotopes as compared to their annual release limit as

established by ***902 KAR 100:019, Section 44(7), Table II***. Table 2 also lists the ratio of the mean activity to the established release limit.

The contaminants at location ISCO D2 do not exceed a ratio of one (1.0) and the sum of the fractions, Table 2, is less than one (1.0). This data indicates releases in the north drainage ditch from the scrap yards and SWMUs 7 and 30 falls within federal permitted releases. The regulation cited above would be an Applicable Relevant and Appropriate Requirements (ARAR) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Figure 4, provides a plot of the ^{238}U data (including counting uncertainty and detection limit) versus collection dates at ISCO D1. As see from the plot, the level of ^{238}U has been trending down during the period the sampler has been in place and ^{238}U releases now appear to be consistent with little fluctuation.

ISCO D1

ISCO D1, Figure 3, is located in the south drain of the northwest corner and receives runoff from the scrap yards and from the surface soils of SWMUs 7 and 30. The mean ^{238}U activity in surface water at ISCO D2 from 2001 to March 2005 is 255.30 pCi/l, Table 1. The mean ^{99}Tc, ^{235}U, ^{234}U, ^{238}Pu, and ^{239}Pu activity is also provided in Table 1.

Table 3 provides the annual mean activity for each of the isotopes as compared to their annual release limit as established by ***902 KAR 100:019, Section 44(7), Table II***. Table 3 also provides the ratio of the annual mean activity to the established release limit.

^{234}U and ^{238}U at location ISCO D1 exceeded a ratio of one (1.0) in 2001 but the ratio was less than one (1.0) for 2002, 2003, and 2004. ^{99}Tc, ^{235}U, ^{238}Pu, and ^{239}Pu did not exceed a ratio of one (1.0) for all years. The sum of the fractions, Table 3, is also greater than one (1.0) for 2001. This data indicates releases in the south drainage ditch from the scrap yards and SWMUs 7 and 30 are greater than federal permitted releases for 2001 but fall below release limits for 2002, 2003, and 2004. The regulation cited above would be an Applicable Relevant and Appropriate Requirements (ARAR) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Figure 5, provides a plot of the ^{238}U data (including counting uncertainty and detection limit) versus collection dates at ISCO D1. As see from the plot, the levels of ^{238}U in surface water initially trended down during the period the sampler has been in place. Subsequent to the downward trend ^{238}U releases in surface water now show little trending but fluctuation with time.

ISCO A

ISCO A, Figure 3, is located in Outfall 001 at the KPDES 001 weir. The outfall drains surface water from approximately 203 acres in the northwest part of the PGDP. Internal ditches in the Outfall 001 watershed are approximately 20,420 feet in length, unlined, and approximately 0.5 to 12 feet deep (DOE, 2004).

The mean ^{238}U activity in Outfall 001 surface water discharges measured at ISCO A from 1999 to March 2005 is 2.77 pCi/l, Table 1. The mean ^{99}Tc, ^{235}U, ^{234}U, ^{238}Pu, and ^{239}Pu activity in Outfall 001 surface water is also provided in Table 1.

Table 4 provides the annual mean activity for each of the isotopes as compared to their annual release limit as established by ***902 KAR 100:019, Section 44(7), Table II***. Table 4 provides the ratio of the annual mean activity for the isotopes to their established release limit.

The contaminants at location ISCO A do not exceed a ratio of one (1.0) and the sum of the fractions, Table 4, is less than one (1.0). This data indicates releases to Outfall 001 are less than federal permitted releases.

Figure 6, provides a plot of ^{238}U in surface water (including counting uncertainty and detection limit) versus collection dates at ISCO A. As see from the plot, the levels of ^{238}U in surface water appear to trending downward and fluctuation with time.

ISCO F

ISCO F, Figure 3, is located in Outfall 008. The Outfall 008 watershed drains 90 acres in the southwest portion of the PGDP industrial area and presently receives effluent from a number of buildings including the C-400 building. Internal ditches in the Outfall 008 watershed are

approximately 12,215 feet in length, unlined, and approximately 0.5 to 4 feet deep (DOE 2004).

The mean ^{238}U activity in surface water at ISCO F from 2002 to March 2005 is 1.42 pCi/l and the mean activity of ^{234}U is 2.83 pCi/l, Table 1. The ratio of $^{238}U/^{234}U$ activity is less than one (1.0) which is unique to Outfall 008 and indicates that discharges are impacted by plant process operations. The mean ^{99}Tc, ^{235}U, ^{234}U, ^{238}Pu, and ^{239}Pu activity at Outfall 008 is also provided in Table 1.

Table 5 provides the annual mean activity for each of the isotopes as compared to their annual release limit as established by ***902 KAR 100:019, Section 44(7), Table II***. Table 5 also provides the ratio of the mean activity to the established release limit.

The contaminants at location ISCO F do not exceed a ratio of one (1.0) and the sum of the fractions, Table 5, is less than one (1.0). This data indicates releases to Outfall 001 are less than federal permitted releases.

Figure 7, provides a plot of ^{238}U in surface water (including counting uncertainty and detection limit) versus collection dates at ISCO F. The plot indicates that the levels of ^{238}U in surface water appear to be trending downward and appears to shows temporal fluctuations.

ISCO B & C

ISCO B is located upgradient of the west side drainage ditches and Outfalls and ISCO C is located downgradient of the west drainage ditches and Outfalls, Figure 2. The mean activity of ^{238}U in surface water at ISCO B is 0.12 pCi/l and is 1.15 pCi/l at ISCO C, Table 1. The mean ^{99}Tc, ^{235}U, ^{234}U, ^{238}Pu, and ^{239}Pu activity at ISCOs B and C is also provided in Table 1.

Figure 8, provides a plot of ^{238}U in surface water (including counting uncertainty and detection limit) versus collection dates for ISCO B. The activity trend for ^{238}U in surface water appears to be relatively flat and without significant fluctuation with time as would be anticipated for a background location.

Figure 9, illustrates the trend of ^{238}U in surface water (including counting uncertainty and detection limit) versus collection dates at ISCO C. The plot demonstrates that the trend of ^{238}U activity in surface water at ISCO C is relatively flat over time with temporal fluctuations.

West Side ISCOs Radiation Dose & Risk Assessment

Radiation dose and risk assessment for ISCOs B and C in Bayou Creek was conducted using ***RESRAD BASELINE, Version 2.2, 1996, Argonne National Laboratory***. The only potential complete exposure pathway for both locations was incidental ingestion of surface water while swimming, wading, fishing, etc.

Based on the assumption that incidental ingestion of surface water is possible and using RESRAD BASELINE default input parameters (Appendix B), the potential radiation dose and risk for 2000, 2001, 2002, 2003, and 2004 for ISCOs B and C are given in Tables 6, 7, 8, 9, and 10. The hypothetical radiation dose at ISCOs B and C is less than the 25 mrem/yr radiation dose limit as established by 902 KAR 100:041, Section 2 for free release. The hypothetical radiation risk is also less than the 1×10^{-4} risk level proposed by the U.S. Environmental Protection Agency for radiation risks. The hypothetical radiation dose is also less than the negligible individual risk limit (NIRL) of 1 mrem/yr recommended by the ***"National Council on Radiation Protection and Measurements, Report Number 116 (NCRP 1993)."*** The NIRL was proposed as a level at which no further action was needed to protect health and safety.

SURFACE WATER ISCOS – LITTLE BAYOU CREEK

The RHB operates two (2) ISCO surface water monitors on the east side of the PGDP: (1) ISCO G downgradient of the east Outfalls 010, 011, 012, and 013, at Little Bayou Creek and McCaw Road; and (2) ISCO D downgradient of the intersection of the North South Diversion Ditch (NSDD) with Little Bayou Creek at Anderson Road, Figure 1. Descriptive statistical parameters for key PGDP process radionuclides are provided in Table 1 for ISCOs D and G.

ISCOs D & G

The location of ISCO G, downgradient of the east side Outfalls 010, 011, 012, and 013, and ISCO D, downgradient of the intersection of the NSDD with Little Bayou Creek at Anderson Road, are shown in Figure 10.

The mean ^{238}U activity in surface water at ISCO G is 2.53 pCi/l and at ISCO D is 1.54 pCi/l, Table 1. The mean ^{99}Tc, ^{235}U, ^{234}U, ^{238}Pu, and ^{239}Pu activity at ISCOS D and G is also provided in Table 1.

Figure 11 illustrates the trend of ^{238}U activity in surface water (including counting uncertainty and detection limit) versus collection dates at ISCO D. As seen from the plot, the ^{238}U trend at ISCO D in surface water is relatively flat and without temporal fluctuations.

Figure 12 illustrates the trend of ^{238}U activity in surface water (including counting uncertainty and detection limit) versus collection dates at ISCO G. The activity trend of ^{238}U in surface water is relatively flat but exhibits temporal fluctuations.

East Side ISCOs Radiation Dose & Risk Assessment

Radiation dose and risk assessment for ISCOs G and D in Little Bayou Creek was conducted using ***RESRAD BASELINE, Version 2.2, 1996, Argonne National Laboratory***. The only potential complete exposure pathway for both locations was incidental ingestion of surface water while swimming, wading, fishing, etc.

Based on the hypothetical assumption that incidental ingestion of surface water is possible and using RESRAD BASELINE default input parameters (Appendix B), the potential radiation dose and risk for 2000, 2001, 2002, 2003, and 2004 for ISCO D are given in Tables 6, 7, 8, 9, 10. The potential radiation dose and risk for 2002, 2003, and 2004 for ISCO G are given in Tables 8, 9, 10.

The hypothetical radiation dose at ISCOs G and D are less than the 25 mrem/yr dose limit as established by 902 KAR 100:041, Section 2 for free release. The hypothetical radiation risk is also less than the 1×10^{-4} level proposed by the U.S. Environmental Protection Agency for radiation risks. The hypothetical radiation dose is also less than

the negligible individual risk limit (NIRL) of 1 mrem/yr recommended by the *"National Council of Radiation Protection and Measurements, Report Number 116.(NRCP 1993)."* The NIRL was proposed as a level at which no further action was needed to protect health and safety.

REFERENCES

1. DOE 2004. *Sampling and Analysis Plan for Site Investigation and Risk Assessment of the Surface Water Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2137&D2, December 2004*

2. NCRP 1993. Report 116. *Limitation of Exposure to Ionizing Radiation, NCRP Publications, Bethesda, MD*

APPENDIX A – TABLES AND FIGURES

Table 1. Mean radiation activity of isotopes reported in picocuries/liter (pCi/l) in surface water from 1999 through March 2005 at Radiation Health Branch ISCO samplers. All values were included in the assessment. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated Mean, Maximum, Minimum, and Standard Deviation (STDev). All data used in the assessment was verified and validated.

Isotope		ISCO A	ISCO B	ISCO C	ISCO D	ISCO D1	ISCO D2	ISCO F	ISOC G
		pCi/l	pCi/l	pCi/l	pCi/l	pCi/l	pCi/l	pCi/l	pCi/l
Soluble Uranium-238	Mean	2.77	0.12	1.15	1.54	255.30	18.58	1.42	2.53
	Maximum	15.07	0.79	8.44	8.41	1102.00	124.50	6.24	5.77
	Minimum	0.18	-0.02	0.10	0.21	0.00	0.04	0.28	0.18
	STDev	3.02	0.13	1.05	1.22	255.02	31.13	1.47	1.31
Soluble Uranium-235	Mean	0.12	0.02	0.06	0.06	13.70	0.55	0.15	0.09
	Maximum	0.67	0.14	0.33	0.23	176.10	3.91	0.60	0.30
	Minimum	-0.05	-0.04	-0.03	-0.05	-0.22	-0.04	-0.10	0.00
	STDev	0.12	0.04	0.06	0.05	22.86	0.91	0.14	0.06
Soluble Uranium-234	Mean	1.61	0.10	0.84	0.51	146.98	7.75	2.83	0.99
	Maximum	8.01	0.23	5.41	2.68	652.50	50.93	9.95	4.61
	Minimum	0.19	0.00	0.08	0.04	-142.70	0.10	0.70	0.13
	STDev	1.53	0.05	0.70	0.45	152.86	12.65	2.16	0.94
Soluble Technetium-99	Mean	8.89	1.32	3.88	4.36	120.30	17.39	5.67	3.00
	Maximum	37.92	9.50	14.43	30.24	903.59	132.68	19.75	19.72
	Minimum	2.36	-3.60	-3.90	-1.98	3.36	-0.40	-0.81	-2.73
	STDev	5.17	2.68	3.12	4.86	150.57	25.21	3.76	4.24
Total Technetium-99	Mean	31.87	0.43	4.29	4.59	80.31	12.02	11.07	3.91
	Maximum	75.55	7.61	15.80	17.25	228.07	67.24	33.13	22.56
	Minimum	9.72	-4.66	-47.62	-2.85	6.49	2.26	3.69	-2.77
	STDev	14.95	2.22	6.66	3.93	54.60	10.23	5.55	4.71
Soluble Plutonium-239	Mean	0.02	0.03	0.00	0.03	0.13	0.06	0.01	0.02
	Maximum	0.17	0.36	0.41	0.35	2.17	2.12	0.22	0.55
	Minimum	-0.05	-0.10	-0.12	-0.10	-0.96	-0.06	-0.09	-0.11
	STDev	0.04	0.07	0.07	0.07	0.48	0.27	0.06	0.10
Soluble Plutonium-238	Mean	0.06	0.06	0.08	0.09	0.72	0.12	0.06	0.07
	Maximum	0.70	0.35	0.48	1.07	5.30	0.30	0.46	0.33
	Minimum	-0.23	-0.16	-0.16	-0.13	-1.25	0.00	-0.13	-0.14
	STDev	0.15	0.11	0.14	0.21	1.46	0.09	0.13	0.11

Table 2. ISCO D2 was installed by the Radiation Health Branch in the fall of 2000. Radiation activity of isotopes reported in picocuries/liter (pCi/l) in surface water from 2001 through 2004 for ISCO D2. All values were included in the assessment. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated annual mean activity. All data used in the assessment was verified and validated. Annual mean activity was used to calculate ratios and sum of the fractions relative to release limits.

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	
Soluble Uranium-235	1.7	300	0.006	
Soluble Uranium-234	23.6	300	0.08	
Technetium-99	46.1	60000	0.0007	0.28
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	
Soluble Uranium-235	0.7	300	0.002	
Soluble Uranium-234	11.2	300	0.04	
Technetium-99	12.4	60000	0.0002	0.13
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	
Soluble Uranium-235	0.05	300	0.0002	
Soluble Uranium-234	0.7	300	0.002	
Technetium-99	8.3	60000	0.0001	0.004
Soluble Plutonium-239	0.01	20	0.0005	
Soluble Plutonium-238	-0.01	20	-.00005	
2004				
Soluble Uranium-238	0.5	300	0.002	
Soluble Uranium-235	0.04	300	0.0001	
Soluble Uranium-234	0.5	300	0.002	
Technetium-99	8.2	60000	0.0001	0.02
Soluble Plutonium-239	0.04	20	0.002	
Soluble Plutonium-238	0.2	20	0.01	

Table 3. ISCO D1 was installed by the Radiation Health Branch in the fall of 2000. Radiation activity of isotopes reported in picocuries/liter (pCi/l) in surface water from 2001 through 2004 for ISCO D1. All values were included in the assessment. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated annual mean activity. All data used in the assessment was verified and validated. Annual mean activity was used to calculate ratios and sum of the fractions relative to release limits.

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	
Soluble Uranium-235	22.7	300	0.08	
Soluble Uranium-234	315.0	300	1.05	
Technetium-99	261.0	60000	0.004	2.98
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	
Soluble Uranium-235	6.2	300	0.02	
Soluble Uranium-234	94.0	300	0.3	
Technetium-99	74.5	60000	0.001	0.83
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	
Soluble Uranium-235	8.0	300	0.03	
Soluble Uranium-234	87.6	300	0.29	
Technetium-99	70.6	60000	0.001	0.80
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	
Soluble Uranium-235	7.1	300	0.02	
Soluble Uranium-234	81.6	300	0.27	
Technetium-99	63.0	60000	0.001	0.86
Soluble Plutonium-239	0.3	20	0.015	
Soluble Plutonium-238	1.6	20	0.08	

Table 4. ISCO A was installed by the Radiation Health Branch in the winter of 1999. Radiation activity of isotopes reported in picocuries/liter (pCi/l) in surface water from 1999 through March 2005 for ISCO A. All values were included in the assessment. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated annual mean activity. All data used in the assessment was verified and validated. Annual mean activity was used to calculate ratios and sum of the fractions relative to release limits.

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	

Table 5. ISCO F was installed by the Radiation Health Branch in the winter of 2002. Radiation activity of isotopes reported in picocuries/liter (pCi/l) in surface water from 2002 through 2004 for ISCO F. All values were included in the assessment. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated annual mean activity. All data used in the assessment was verified and validated. Annual mean activity was used to calculate ratios and sum of the fractions relative to release limits.

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	
Soluble Uranium-235	0.2	300	0.0007	
Soluble Uranium-234	3.2	300	0.0107	
Technetium-99	9.4	60000	0.0002	0.019
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	
Soluble Uranium-235	0.15	300	0.0005	
Soluble Uranium-234	2.9	300	0.0097	
Technetium-99	11.9	60000	0.0002	0.015
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	
Soluble Uranium-235	0.1	300	0.0003	
Soluble Uranium-234	2.4	300	0.0080	
Technetium-99	11.6	60000	0.0002	0.017
Soluble Plutonium-239	0.02	20	0.0010	
Soluble Plutonium-238	0.1	20	0.0050	

Table 6. Radiation Dose and Risk for 2000 at ISCOs B, C, and D. All results were included in the calculation of annual mean activity. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated annual mean activity. All data used in the assessment was verified and validated. Dose and risk values were calculated using *RESRAD BASELINE for Windows, Version 2.2, February 1996, Argonne National Laboratory*.

Location	Isotope	Mean* Activity	Dose	Risk (From Risk Dose Conversion Factors)	Risk (From Slope Factors)
		pCi/l	mrem/yr		
ISCO B	^{238}U	**0.04**	2.978E-04	6.790E-09	9.028E-10
	^{235}U	**0.03**			
	^{234}U	**0.05**			
	^{99}Tc	**-0.30**			
	^{239}Pu	**0.02**			
	^{238}Pu	**0.07**			
ISCO C	^{238}U	1.20	5.631E-04	1.284E-08	3.407E-09
	^{235}U	**0.07**			
	^{234}U	0.80			
	^{99}Tc	5.60			
	^{239}Pu	**-0.006**			
	^{238}Pu	**0.02**			
ISCO D	^{238}U	1.40	1.580E-03	3.603E-08	6.122E-09
	^{235}U	**0.04**			
	^{234}U	0.25			
	^{99}Tc	3.73			
	^{239}Pu	**-0.002**			
	^{238}Pu	**0.4**			

* 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.

Table 7. Radiation Dose and Risk for 2001 at ISCOs B, C, and D. All results were included in the calculation of annual mean activity. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated annual mean activity. All data used in the assessment was verified and validated. Dose and risk values were calculated using *RESRAD BASELINE for Windows, Version 2.2, February 1996, Argonne National Laboratory*.

Location	Isotope	Mean* Activity	Dose	Risk (From Risk Dose Conversion Factors)	Risk (From Slope Factors)
		pCi/l	mrem/yr		
ISCO B	^{238}U	**0.12**	2.832E-04	6.456E-09	1.037E-09
	^{235}U	**0.02**			
	^{234}U	**0.09**			
	^{99}Tc	**1.94**			
	^{239}Pu	**0.006**			
	^{238}Pu	**0.07**			
ISCO C	^{238}U	0.95	6.905E-04	1.574E-08	3.425E-09
	^{235}U	**0.05**			
	^{234}U	0.62			
	^{99}Tc	5.87			
	^{239}Pu	**-0.004**			
	^{238}Pu	**0.10**			
ISCO D	^{238}U	1.25	5.344E-04	1.219E-08	3.094E-09
	^{235}U	**0.05**			
	^{234}U	0.26			
	^{99}Tc	5.34			
	^{239}Pu	**0.008**			
	^{238}Pu	**0.04**			

* 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.

Table 8. Radiation Dose and Risk for 2002 at ISCOs B, C, D, and G. All results were included in the calculation of annual mean activity. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated annual mean activity. All data used in the assessment was verified and validated. Dose and risk values were calculated using *RESRAD BASELINE for Windows, Version 2.2, February 1996, Argonne National Laboratory*.

Location	Isotope	Mean* Activity	Dose	Risk (From Risk Dose Conversion Factors)	Risk (From Slope Factors)
		pCi/l	mrem/yr		
ISCO B	^{238}U	**0.14**	2.192E-04	4.998E-09	8.234E-10
	^{235}U	**0.007**			
	^{234}U	**0.13**			
	^{99}Tc	**0.39**			
	^{239}Pu	**0.04**			
	^{238}Pu	**0.007**			
ISCO C	^{238}U	0.71	5.122E-04	1.168E-08	2.571E-09
	^{235}U	**0.033**			
	^{234}U	0.56			
	^{99}Tc	4.07			
	^{239}Pu	**0.029**			
	^{238}Pu	**0.030**			
ISCO D	^{238}U	1.34	6.872E-04	1.567E-08	3.780E-09
	^{235}U	**0.05**			
	^{234}U	0.78			
	^{99}Tc	**2.97**			
	^{239}Pu	**0.008**			
	^{238}Pu	**0.04**			
ISCO G	^{238}U	3.13	1.193E-03	2.719E-08	7.382E-09
	^{235}U	**0.11**			
	^{234}U	1.62			
	^{99}Tc	**1.22**			
	^{239}Pu	**-0.015**			
	^{238}Pu	**0.01**			

* 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.

Table 9. Radiation Dose and Risk for 2003 at ISCOs B, C, D, and G. All results were included in the calculation of annual mean activity. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated annual mean activity. All data used in the assessment was verified and validated. Dose and risk values were calculated using *RESRAD BASELINE for Windows, Version 2.2, February 1996, Argonne National Laboratory*.

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**	3.148E-04	7.177E-09	1.227E-09
	^{235}U	**0.04**			
	^{234}U	**0.28**			
	^{99}Tc	**0.85**			
	^{239}Pu	**0.05**			
	^{238}Pu	**0.01**			
ISCO C	^{238}U	1.36	5.845E-04	1.333E-08	3.765E-09
	^{235}U	**0.08**			
	^{234}U	1.15			
	^{99}Tc	4.45			
	^{239}Pu	**-0.019**			
	^{238}Pu	**-0.003**			
ISCO D	^{238}U	1.19	4.909E-04	1.119E-08	3.063E-09
	^{235}U	**0.08**			
	^{234}U	0.56			
	^{99}Tc	5.01			
	^{239}Pu	**0.0005**			
	^{238}Pu	**0.01**			
ISCO G	^{238}U	2.5	1.004E-03	2.289E-08	5.997E-09
	^{235}U	**0.09**			
	^{234}U	1.07			
	^{99}Tc	2.97			
	^{239}Pu	**0.01**			
	^{238}Pu	**0.02**			

* 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.

Table 10. Radiation Dose and Risk for 2004 at ISCOs B, C, D and G. All results were included in the calculation of annual mean activity. Data were not screened out against radiation counting uncertainty or detection limit. All reported data was used to calculated annual mean activity. All data used in the assessment was verified and validated. Dose and risk values were calculated using *RESRAD BASELINE for Windows, Version 2.2, February 1996, Argonne National Laboratory*.

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.

Figure 1. Radiation Health Branch's ISCO Automatic Samplers at Paducah Gaseous Diffusion Plant. ISCOs A, B, C, and D have been in operation since 1999. ISCOs D1 and D2 have been in operation since 2001. ISCOs F and G have been in operations since 2002.

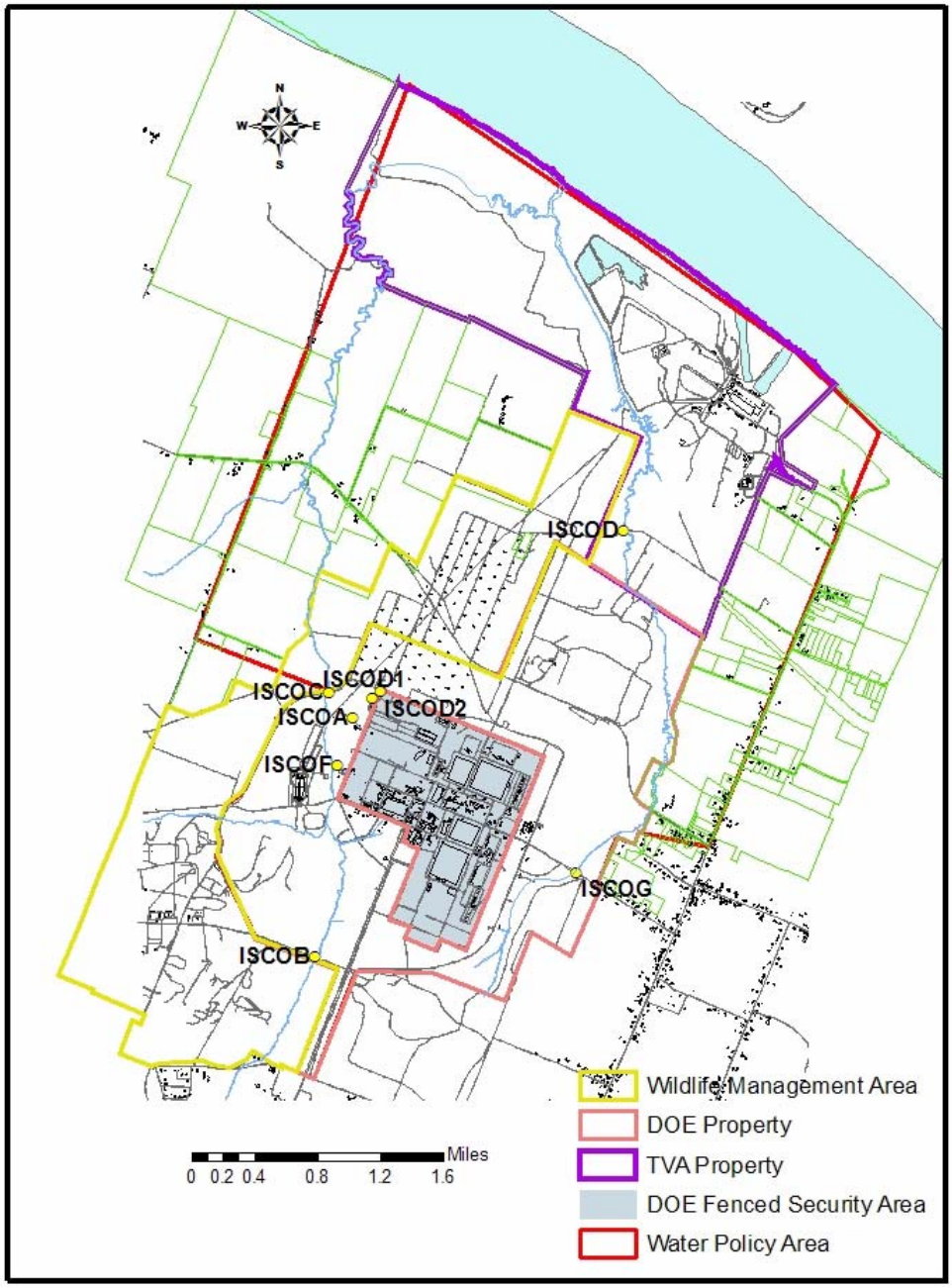


Figure 2. Radiation Health Branch's ISCO Automatic Surface Water Samplers at Paducah Gaseous Diffusion Plant. Locations of ISCOs A, B, C, D1, D2, and F on the west side of the Paducah Gaseous Diffusion.

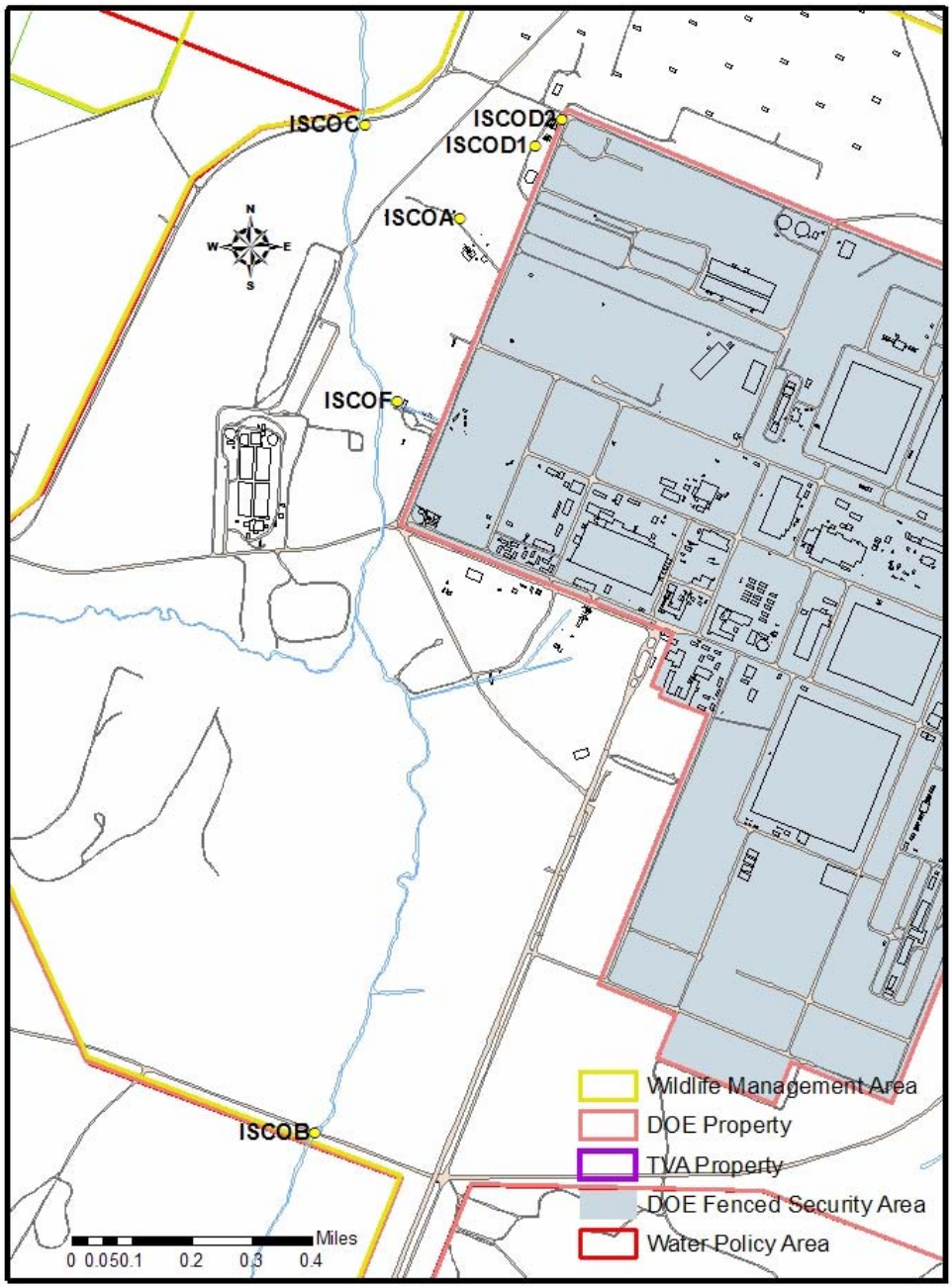


Figure 3. Radiation Health Branch's ISCO Automatic Surface Water Samplers at Paducah Gaseous Diffusion Plant. Locations of ISCOs A, D1, and D2 in the Northwest Corner Outfall and Drainage Ditches. Location of ISCO F in Outfall 008. Location of ISCO C in Bayou Creek downgradient of the west Outfalls.

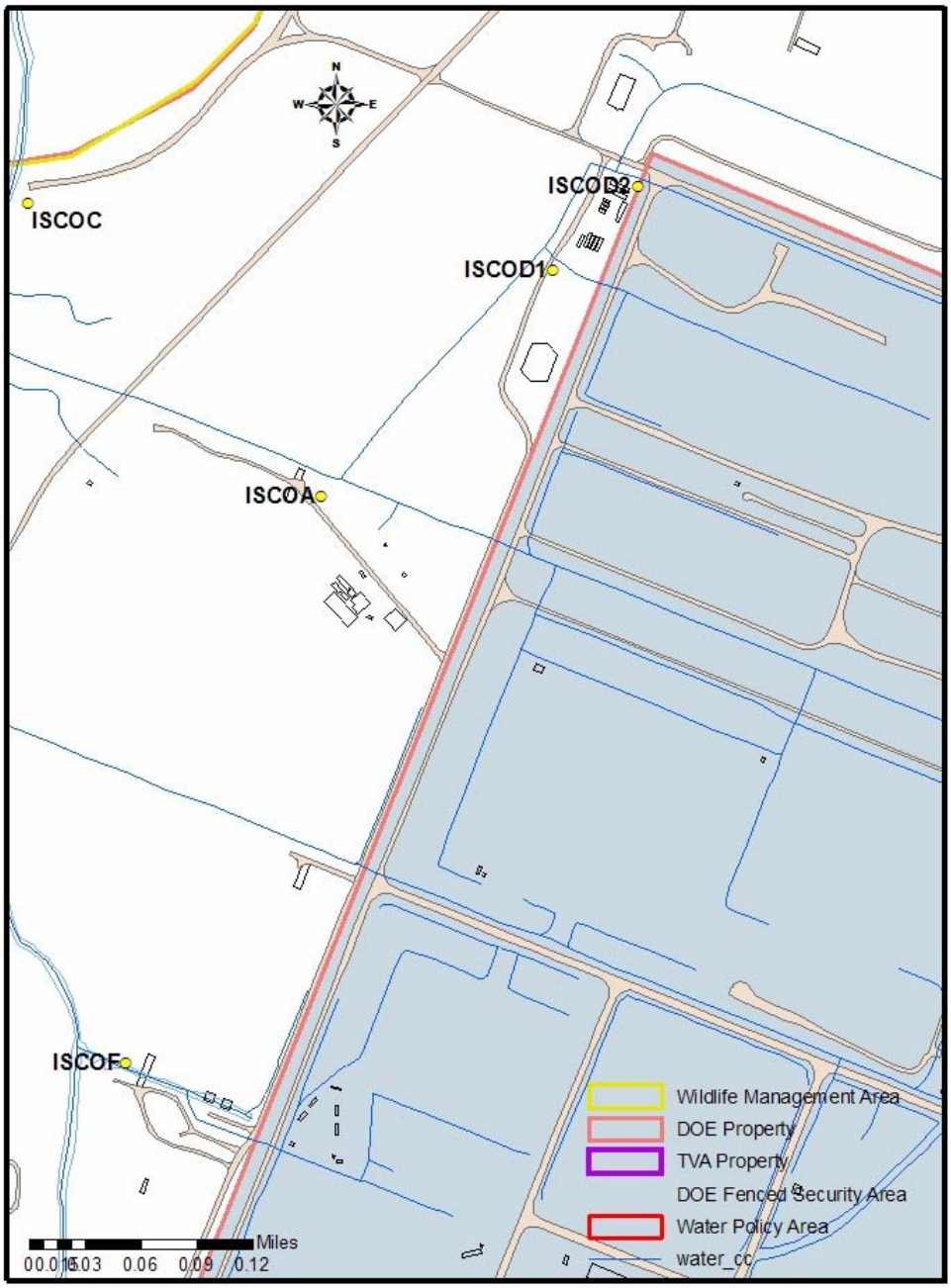


Figure 4. ISCO D2 ^{238}U activity versus collection dates in the north drain from the scrap yards outside the restricted area fence at the northwest corner of the site.

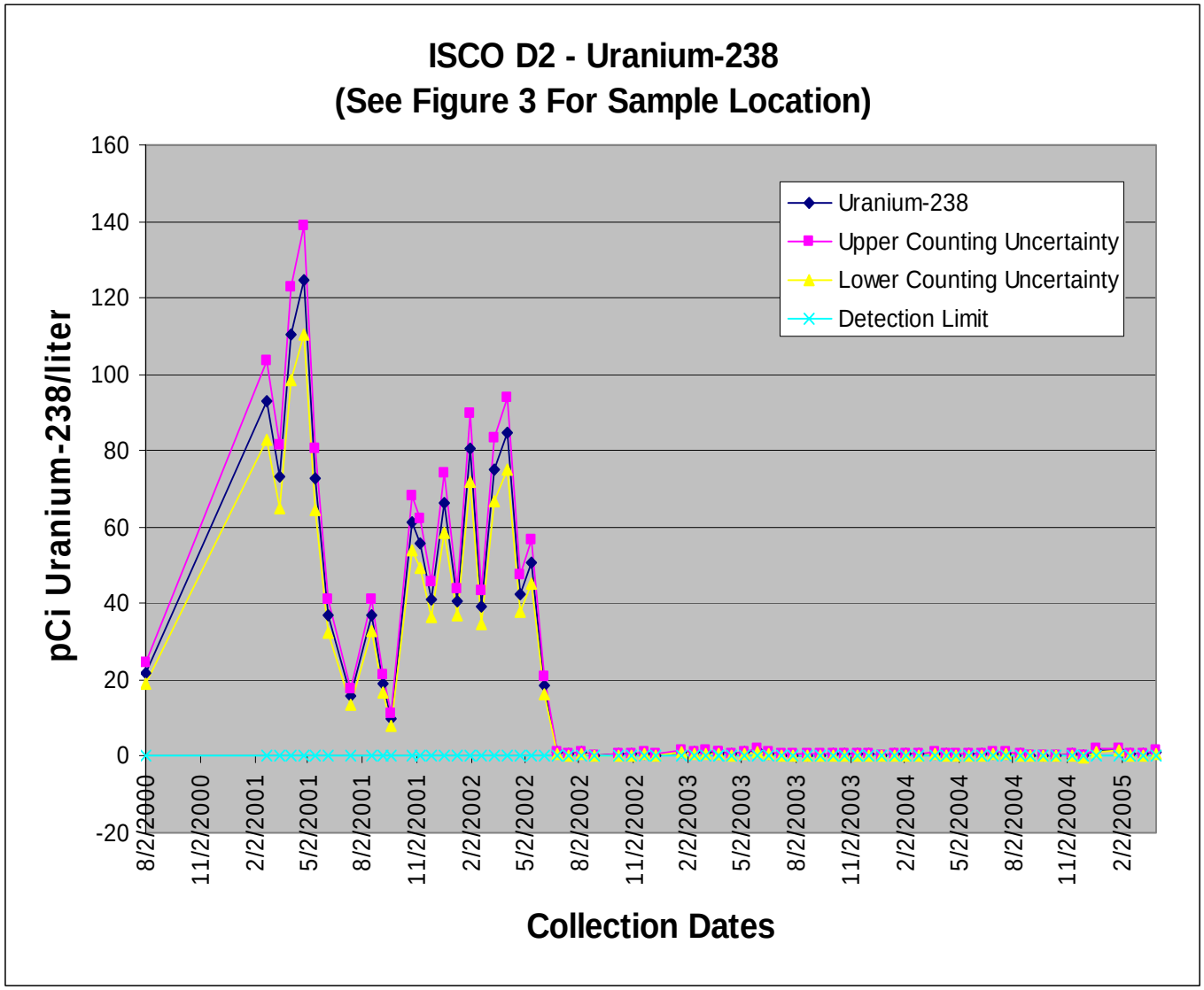


Figure 5. ISCO D1 ^{238}U activity versus collection dates in the south drain from the scrap yards outside the restricted area fence at the northwest corner of the site.

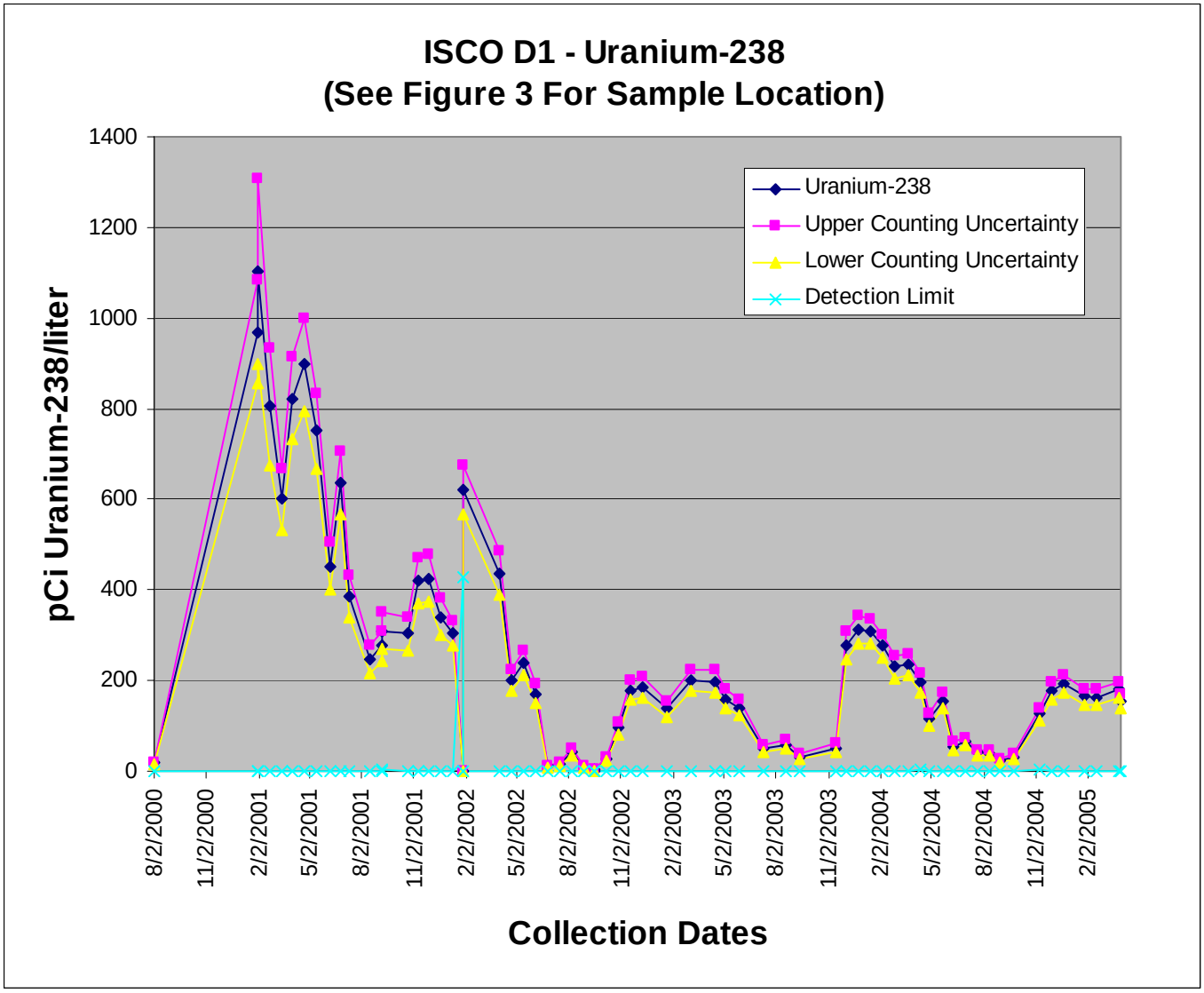


Figure 6. ISCO A ^{238}U activity versus collection dates at KPDES Outfall 001 weir outside the restricted area fence at the northwest corner of the site.

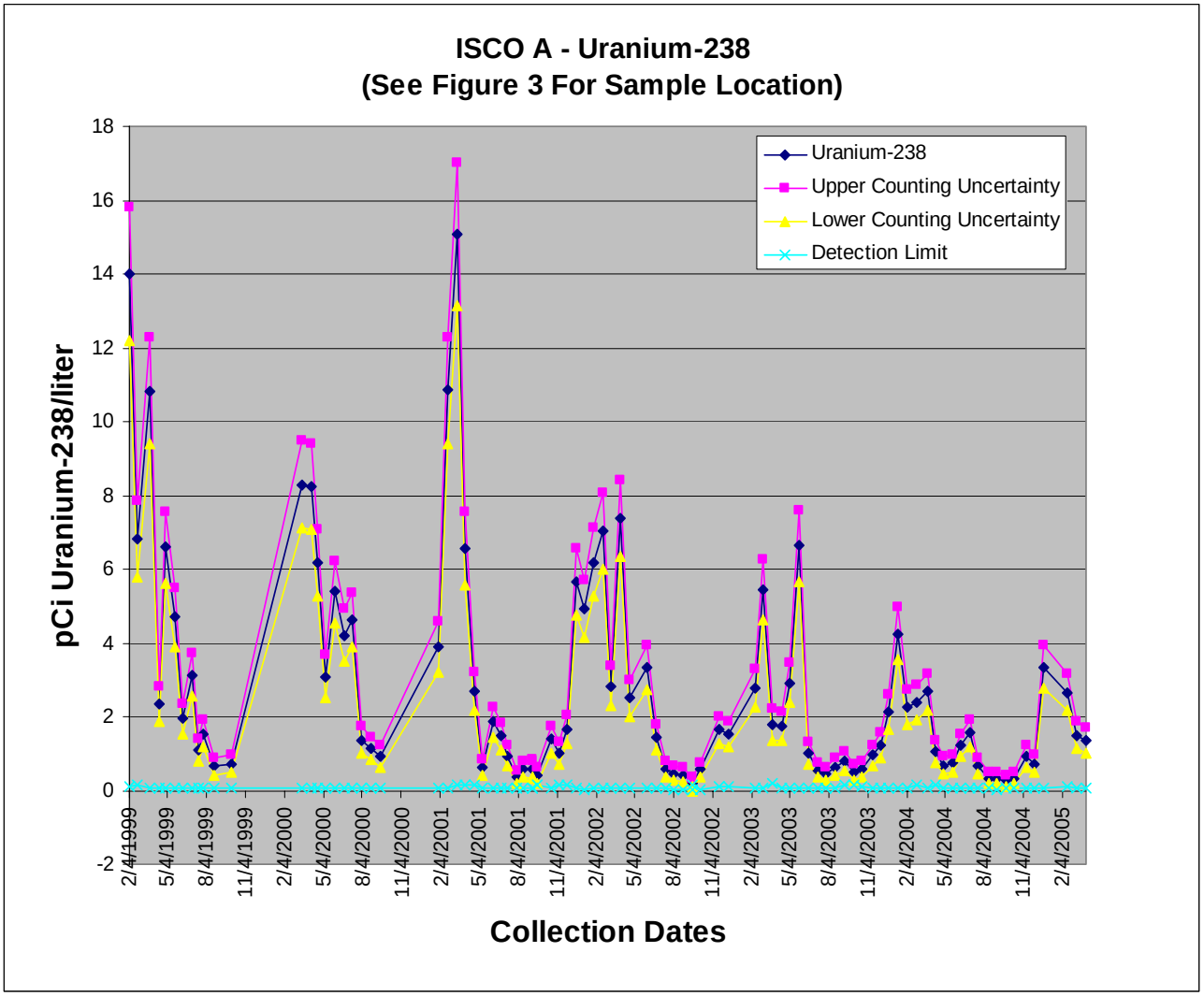


Figure 7. ISCO F ^{238}U activity versus collection dates at Outfall 008 outside the restricted area fence in the southwest corner of the site.

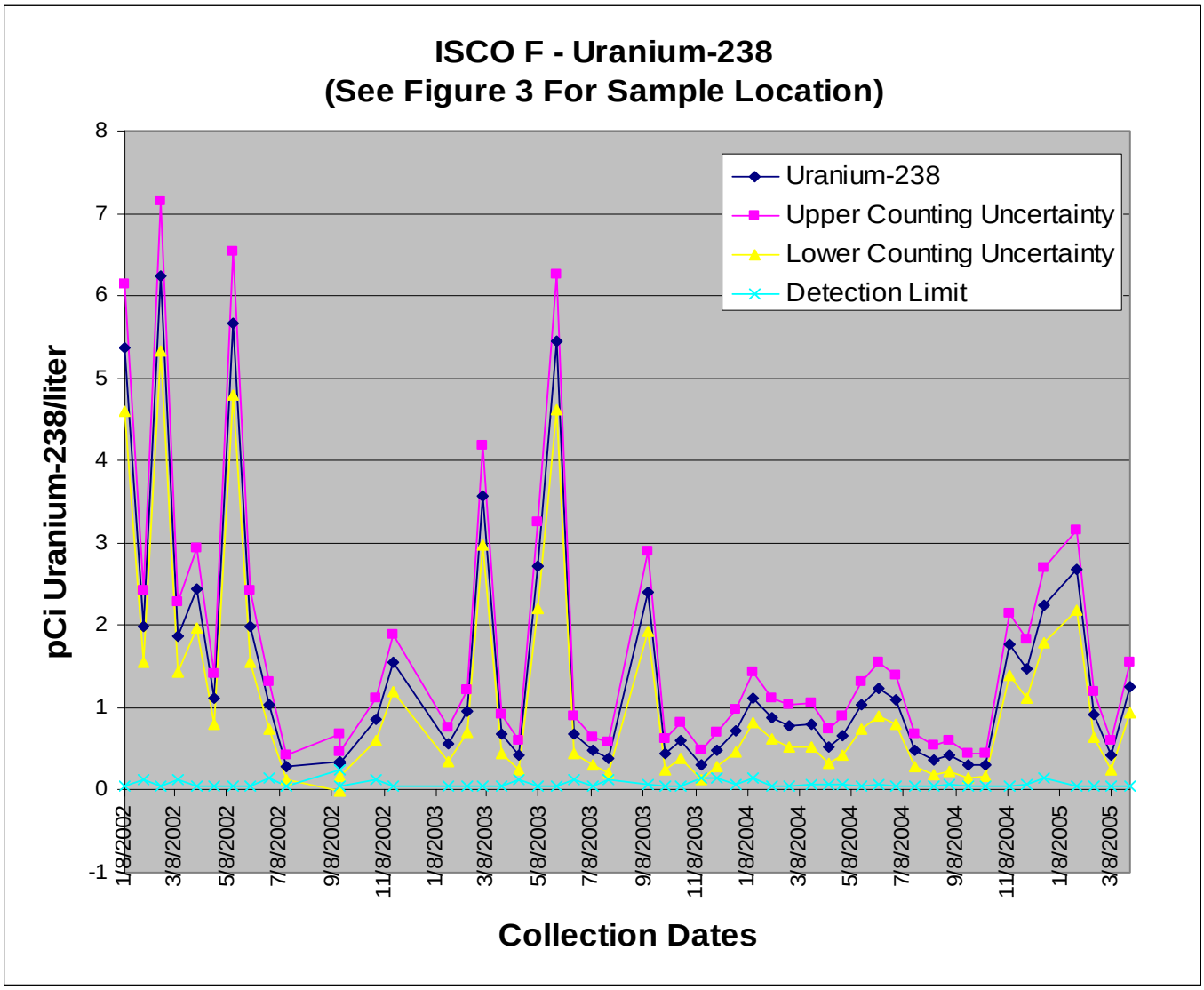


Figure 8. ISCO B ^{238}U activity versus collection dates at the Bayou Creek quarterly background surface-water sampling location BBCUG/R-249 upgradient of west side Outfalls.

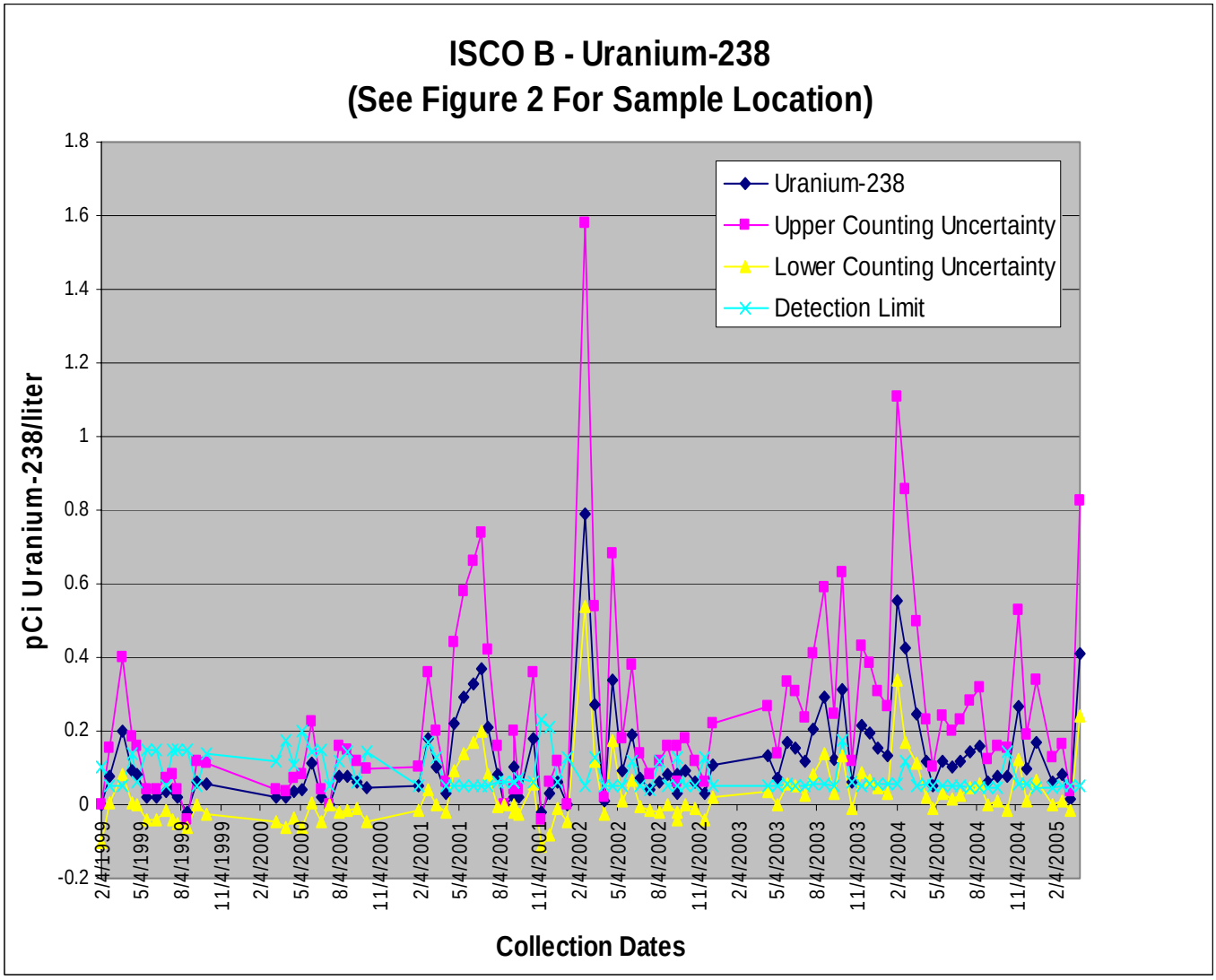


Figure 9. ISCO C ^{238}U activity versus collection dates in Bayou Creek at sampling location BBCDG/R-151 downgradient of west side Outfalls.

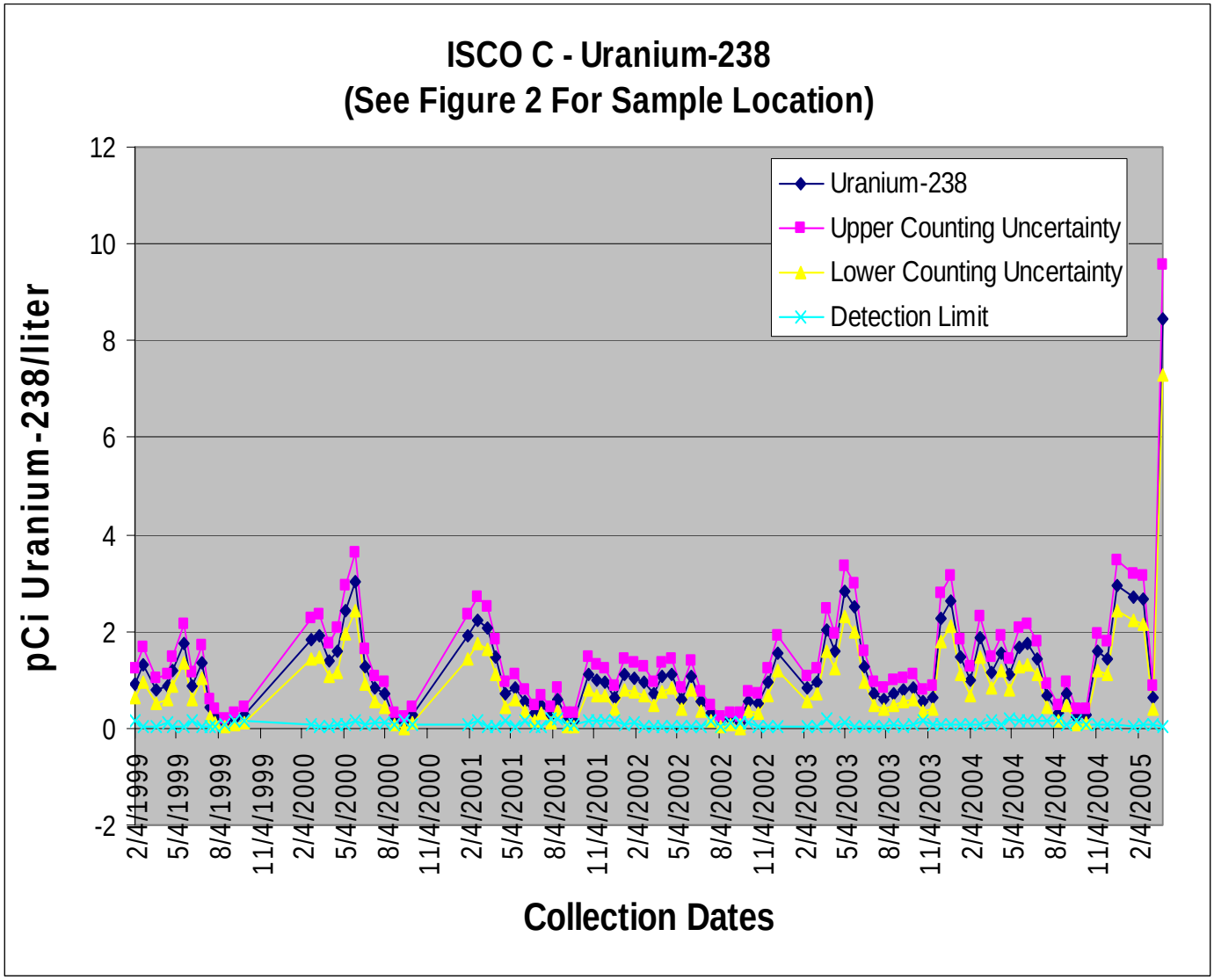


Figure 10. Radiation Health Branch's ISCO Automatic Surface Water Samplers in Little Bayou Creek at Paducah Gaseous Diffusion Plant. ISCO G is at McCaw Road and Little Bayou Creek and ISOC D is at Anderson Road and Little Bayou Creek.

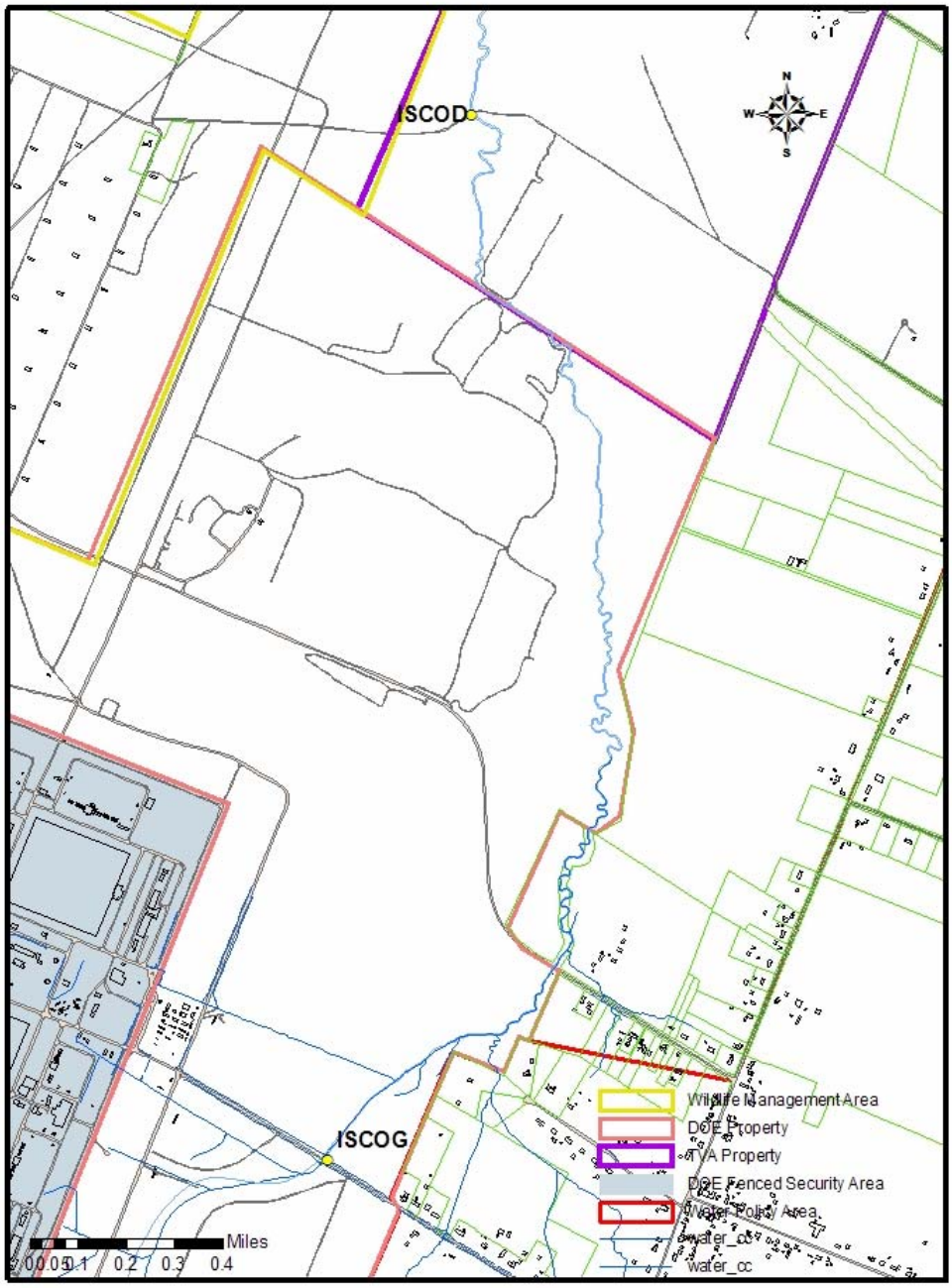


Figure 11. ISCO D ^{238}U activity versus collection dates at quarterly surface water sampling location LBCDG/R-248 downgradient of east side Outfalls to Little Bayou Creek and the North South Diversion Ditch confluence with Little Bayou Creek.

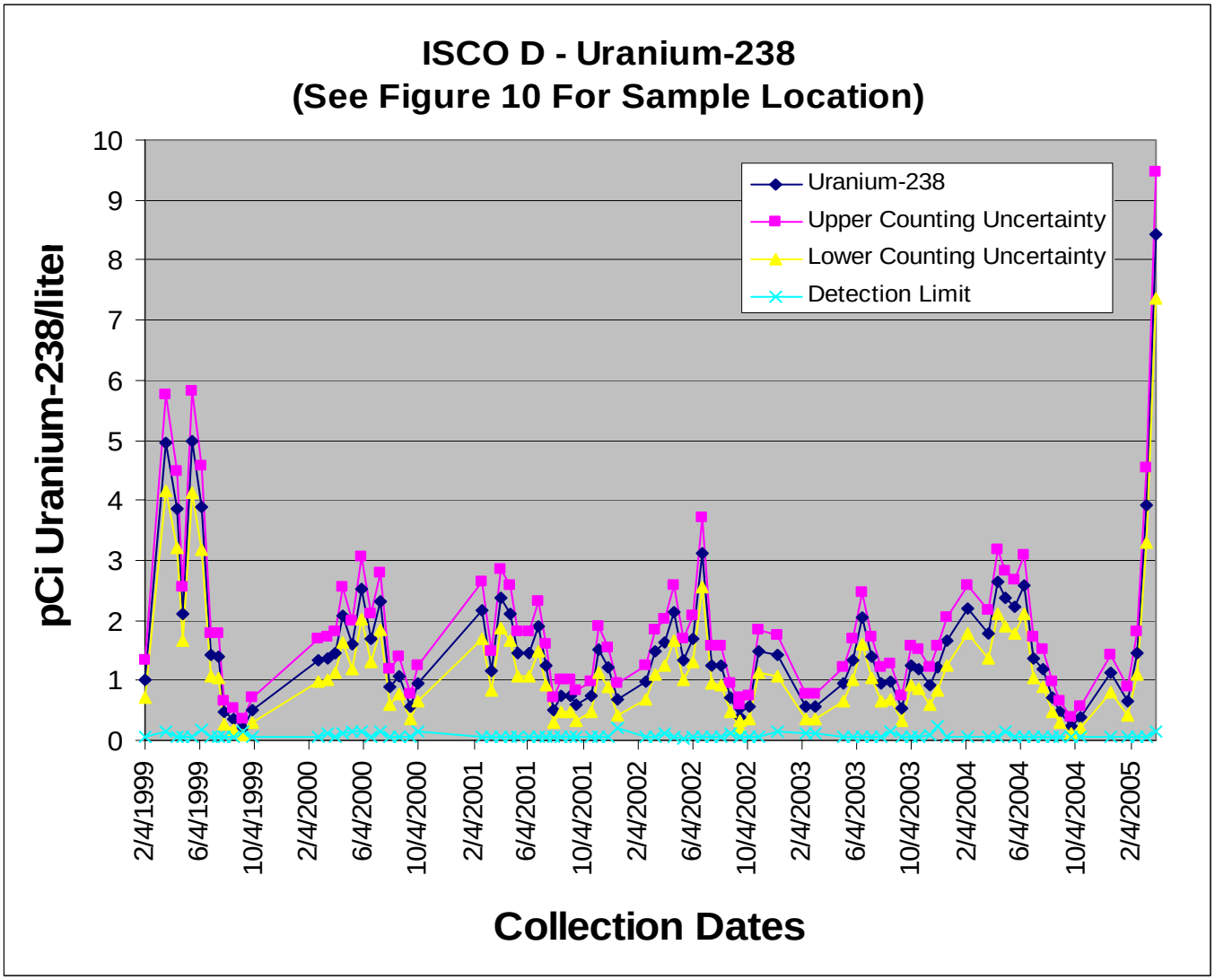
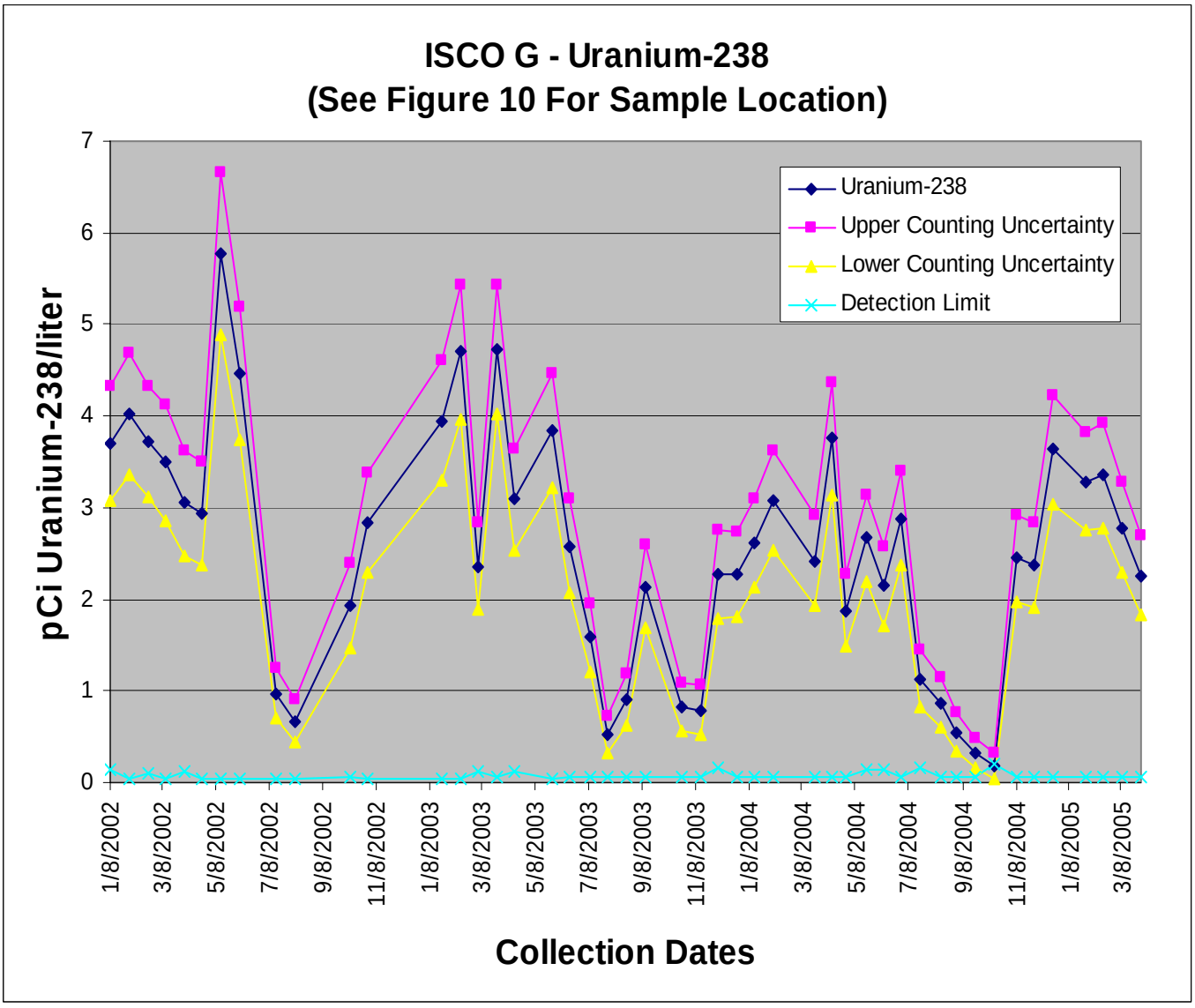


Figure 12. ISCO G ^{238}U activity versus collection dates in Little Bayou Creek at McCaw Road downgradient of east side Outfalls 010, 011, 012, and 013.



APPENDIX B – RESRAD INPUT PARAMETERS

Dose and Risk Conversion Factor (and Related) Parameter Summary

Menu	Parameter	Current Value	Default	Parameter Name	Source
	Cancer risk/dose conversion factor (risk/mrem)	7.600E-07	7.600E-07	RDCF	b
DCF1	Groundshine, surface DCF's, (mrem/yr)/(pCi/cm**2):				
DCF1	U-238+D	3.250E-02	3.250E-02	DCF1(1,1)	s
DCF1	U-235	1.940E-01	1.940E-01	DCF1(2,1)	s
DCF1	U-234	8.740E-04	8.740E-04	DCF1(3,1)	s
DCF1	Tc-99	9.110E-05	9.110E-05	DCF1(4,1)	s
DCF1	Pu-239	4.290E-04	4.290E-04	DCF1(5,1)	s
DCF1	Pu-238	9.790E-04	9.790E-04	DCF1(6,1)	s
DCF1	Groundshine, volume DCF's, (mrem/yr)/(pCi/cm**3):				
DCF1	U-238+D , soil density = 1.6 g/cm**3	1.370E-01	1.370E-01	DCF1(1,2)	s
DCF1	U-235 , soil density = 1.6 g/cm**3	7.570E-01	7.570E-01	DCF1(2,2)	s
DCF1	U-234 , soil density = 1.6 g/cm**3	4.020E-04	4.020E-04	DCF1(3,2)	s
DCF1	Tc-99 , soil density = 1.6 g/cm**3	1.260E-04	1.260E-04	DCF1(4,2)	s
DCF1	Pu-239 , soil density = 1.6 g/cm**3	2.950E-04	2.950E-04	DCF1(5,2)	s
DCF1	Pu-238 , soil density = 1.6 g/cm**3	1.510E-04	1.510E-04	DCF1(6,2)	s
DCF2	Dose conversion factors for dust inhalation, mrem/pCi:				
DCF2	U-238+D	1.180E-01	1.180E-01	DCF2(1)	s
DCF2	U-235	1.230E-01	1.230E-01	DCF2(2)	s
DCF2	U-234	1.320E-01	1.320E-01	DCF2(3)	s
DCF2	Tc-99	8.330E-06	8.330E-06	DCF2(4)	s
DCF2	Pu-239	4.290E-01	4.290E-01	DCF2(5)	s
DCF2	Pu-238	3.920E-01	3.920E-01	DCF2(6)	s
DCF3	Dose conversion factors for ingestion, mrem/pCi:				
DCF3	U-238+D	2.690E-04	2.690E-04	DCF3(1)	s
DCF3	U-235	2.670E-04	2.670E-04	DCF3(2)	s
DCF3	U-234	2.830E-04	2.830E-04	DCF3(3)	s
DCF3	Tc-99	1.460E-06	1.460E-06	DCF3(4)	s
DCF3	Pu-239	3.540E-03	3.540E-03	DCF3(5)	s
DCF3	Pu-238	3.200E-03	3.200E-03	DCF3(6)	s
DCF4	Air immersion DCF's, (mrem/yr)/(pCi/m**3):				
DCF4	U-238+D	1.460E-04	1.460E-04	DCF4(1)	s
DCF4	U-235	9.020E-04	9.020E-04	DCF4(2)	s
DCF4	U-234	8.910E-07	8.910E-07	DCF4(3)	s
DCF4	Tc-99	1.890E-07	1.890E-07	DCF4(4)	s
DCF4	Pu-239	4.950E-07	4.950E-07	DCF4(5)	s
DCF4	Pu-238	5.700E-07	5.700E-07	DCF4(6)	s
Sf-1	Groundshine, surface SF's, 1/yr per (pCi/cm**2):				
Sf-1	U-238+D	1.590E-08	1.590E-08	SLPF1(1,1)	s
Sf-1	U-235	1.160E-07	1.160E-07	SLPF1(2,1)	s
Sf-1	U-234	4.180E-10	4.180E-10	SLPF1(3,1)	s
Sf-1	Tc-99	3.620E-13	3.620E-13	SLPF1(4,1)	s
Sf-1	Pu-239	1.950E-10	1.950E-10	SLPF1(5,1)	s
Sf-1	Pu-238	4.290E-10	4.290E-10	SLPF1(6,1)	s
Sf-1	Groundshine, volume SF's, 1/yr per (pCi/g):				
Sf-1	U-238+D	5.700E-08	5.700E-08	SLPF1(1,2)	s

Dose and Risk Conversion Factor (and Related) Parameter Summary (continued)

Menu	Parameter	Current Value	Default	Parameter Name	Source
Sf-1	U-235	2.700E-07	2.700E-07	SLPF1(2,2)	s
Sf-1	U-234	2.100E-11	2.100E-11	SLPF1(3,2)	s
Sf-1	Tc-99	6.200E-13	6.200E-13	SLPF1(4,2)	s
Sf-1	Pu-239	1.300E-11	1.300E-11	SLPF1(5,2)	s
Sf-1	Pu-238	1.900E-11	1.900E-11	SLPF1(6,2)	s
Sf-2	Inhalation, slope factors, 1/(pCi):				
Sf-2	U-238+D	1.200E-08	1.200E-08	SLPF2(1)	s
Sf-2	U-235	1.300E-08	1.300E-08	SLPF2(2)	s
Sf-2	U-234	1.400E-08	1.400E-08	SLPF2(3)	s
Sf-2	Tc-99	2.900E-12	2.900E-12	SLPF2(4)	s
Sf-2	Pu-239	2.800E-08	2.800E-08	SLPF2(5)	s
Sf-2	Pu-238	2.700E-08	2.700E-08	SLPF2(6)	s
Sf-3	Ingestion, slope factors, 1/(pCi):				
Sf-3	U-238+D	6.200E-11	6.200E-11	SLPF3(1)	s
Sf-3	U-235	4.700E-11	4.700E-11	SLPF3(2)	s
Sf-3	U-234	4.400E-11	4.400E-11	SLPF3(3)	s
Sf-3	Tc-99	1.400E-12	1.400E-12	SLPF3(4)	s
Sf-3	Pu-239	3.200E-10	3.200E-10	SLPF3(5)	s
Sf-3	Pu-238	3.000E-10	3.000E-10	SLPF3(6)	s
Sf-4	Air immersion, slope factors, 1/yr per (pCi/m**3):				
Sf-4	U-238+D	7.440E-11	7.440E-11	SLPF4(1)	s
Sf-4	U-235	5.070E-10	5.070E-10	SLPF4(2)	s
Sf-4	U-234	4.180E-13	4.180E-13	SLPF4(3)	s
Sf-4	Tc-99	1.530E-15	1.530E-15	SLPF4(4)	s
Sf-4	Pu-239	2.330E-13	2.330E-13	SLPF4(5)	s
Sf-4	Pu-238	2.240E-13	2.240E-13	SLPF4(6)	s
SfRn	Radon inhalation slope factors, 1/(pCi):				
SfRn	Rn-222	1.800E-12	1.800E-12	SLPFRN(1,1)	b
SfRn	Po-218	3.700E-12	3.700E-12	SLPFRN(1,2)	s
SfRn	Pb-214	6.200E-12	6.200E-12	SLPFRN(1,3)	s
SfRn	Bi-214	1.500E-11	1.500E-11	SLPFRN(1,4)	s
SfRn	Rn-220	1.900E-13	1.900E-13	SLPFRN(2,1)	s
SfRn	Po-216	3.000E-15	3.000E-15	SLPFRN(2,2)	s
SfRn	Pb-212	3.900E-11	3.900E-11	SLPFRN(2,3)	s
SfRn	Bi-212	3.700E-11	3.700E-11	SLPFRN(2,4)	s

Note: Radionuclides are Class A human carcinogens.

(s) Dose conversion factors are taken from EPA FGR nos. 11 & 12.
Volume, inhalation and ingestion slope factors are taken from Heast (March 1994). except where noted.
Air immersion and surface slope factors are taken from EPA 402-R-93-076. except where noted.

(a) Values are calculated using DCF and risk coefficient (7.60e-4 cancer incidence risk/rem).

(b) Values taken from EPA 402-R-93-076 (June 1994).

(c) Value taken from individual radionuclides given in Heast (not from Pu-241+D).

(d) DCF value was zero, slope factor was also assumed to be zero.

(e) Slope factor from EPA report was unreasonably small, calculated from DCF and risk coefficient.

(f) DCF value increased by 50% to account for dermal absorption of H-3 in vapor form.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD-BASELINE (If different from user input)	Parameter Name
R011	Surface concentration in soil (pCi/m**2):				
R011	U-238	not used	0.000E+00	...	NUCSLS(1)
R011	U-235	not used	0.000E+00	...	NUCSLS(2)
R011	U-234	not used	0.000E+00	...	NUCSLS(3)
R011	Tc-99	not used	0.000E+00	...	NUCSLS(4)
R011	Pu-239	not used	0.000E+00	...	NUCSLS(5)
R011	Pu-238	not used	0.000E+00	...	NUCSLS(6)
R011	Volume concentration in soil (pCi/g):				
R011	U-238	not used	0.000E+00	...	NUCSLV(1)
R011	U-235	not used	0.000E+00	...	NUCSLV(2)
R011	U-234	not used	0.000E+00	...	NUCSLV(3)
R011	Tc-99	not used	0.000E+00	...	NUCSLV(4)
R011	Pu-239	not used	0.000E+00	...	NUCSLV(5)
R011	Pu-238	not used	0.000E+00	...	NUCSLV(6)
R012	Indoor air concentration (pCi/m**3):				
R012	U-238	not used	0.000E+00	...	NUCAIND(1)
R012	U-235	not used	0.000E+00	...	NUCAIND(2)
R012	U-234	not used	0.000E+00	...	NUCAIND(3)
R012	Tc-99	not used	0.000E+00	...	NUCAIND(4)
R012	Pu-239	not used	0.000E+00	...	NUCAIND(5)
R012	Pu-238	not used	0.000E+00	...	NUCAIND(6)
R012	Outdoor air concentration (pCi/m**3):				
R012	U-238	not used	0.000E+00	...	NUCAOTD(1)
R012	U-235	not used	0.000E+00	...	NUCAOTD(2)
R012	U-234	not used	0.000E+00	...	NUCAOTD(3)
R012	Tc-99	not used	0.000E+00	...	NUCAOTD(4)
R012	Pu-239	not used	0.000E+00	...	NUCAOTD(5)
R012	Pu-238	not used	0.000E+00	...	NUCAOTD(6)
R013	Concentration in plant (pCi/kg):				
R013	U-238	not used	0.000E+00	...	NUCPLT(1)
R013	U-235	not used	0.000E+00	...	NUCPLT(2)
R013	U-234	not used	0.000E+00	...	NUCPLT(3)
R013	Tc-99	not used	0.000E+00	...	NUCPLT(4)
R013	Pu-239	not used	0.000E+00	...	NUCPLT(5)
R013	Pu-238	not used	0.000E+00	...	NUCPLT(6)
R013	Concentration in meat (pCi/kg):				
R013	U-238	not used	0.000E+00	...	NUCMT(1)
R013	U-235	not used	0.000E+00	...	NUCMT(2)
R013	U-234	not used	0.000E+00	...	NUCMT(3)
R013	Tc-99	not used	0.000E+00	...	NUCMT(4)
R013	Pu-239	not used	0.000E+00	...	NUCMT(5)
R013	Pu-238	not used	0.000E+00	...	NUCMT(6)
R013	Concentration in milk (pCi/L):				
R013	U-238	not used	0.000E+00	...	NUCMK(1)
R013	U-235	not used	0.000E+00	...	NUCMK(2)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD-BASELINE (If different from user input)	Paramet Name
R013	U-234	not used	0.000E+00	...	NUCMK(3
R013	Tc-99	not used	0.000E+00	...	NUCMK(4
R013	Pu-239	not used	0.000E+00	...	NUCMK(5
R013	Pu-238	not used	0.000E+00	...	NUCMK(6
R014	Concentration in fish (pCi/kg):				
R014	U-238	not used	0.000E+00	...	NUCFSH(
R014	U-235	not used	0.000E+00	...	NUCFSH(
R014	U-234	not used	0.000E+00	...	NUCFSH(
R014	Tc-99	not used	0.000E+00	...	NUCFSH(
R014	Pu-239	not used	0.000E+00	...	NUCFSH(
R014	Pu-238	not used	0.000E+00	...	NUCFSH(
R014	Concentration in shell fish (pCi/kg):				
R014	U-238	not used	0.000E+00	...	NUCNFSH(
R014	U-235	not used	0.000E+00	...	NUCNFSH(
R014	U-234	not used	0.000E+00	...	NUCNFSH(
R014	Tc-99	not used	0.000E+00	...	NUCNFSH(
R014	Pu-239	not used	0.000E+00	...	NUCNFSH(
R014	Pu-238	not used	0.000E+00	...	NUCNFSH(
R015	Concentration in drinking water (pCi/L):				
R015	U-238	not used	0.000E+00	...	NUCDW(1
R015	U-235	not used	0.000E+00	...	NUCDW(2
R015	U-234	not used	0.000E+00	...	NUCDW(3
R015	Tc-99	not used	0.000E+00	...	NUCDW(4
R015	Pu-239	not used	0.000E+00	...	NUCDW(5
R015	Pu-238	not used	0.000E+00	...	NUCDW(6
R015	Concentration in pond water (pCi/L):				
R015	U-238	2.060E+00	0.000E+00	...	NUCPW(1
R015	U-235	7.000E-02	0.000E+00	...	NUCPW(2
R015	U-234	5.400E-01	0.000E+00	...	NUCPW(3
R015	Tc-99	6.320E+00	0.000E+00	...	NUCPW(4
R015	Pu-239	-6.100E-02	0.000E+00	...	NUCPW(5
R015	Pu-238	1.400E-01	0.000E+00	...	NUCPW(6
R016	Indoor Radon-222 concentration (pCi/m**3)	not used	0.000E+00	...	RN222(1)
R016	Outdoor Radon-222 concentration (pCi/m**3)	not used	0.000E+00	...	RN222(2)
R016	Indoor Radon-220 concentration (pCi/m**3)	not used	0.000E+00	...	RN220(1)
R016	Outdoor Radon-220 concentration (pCi/m**3)	not used	0.000E+00	...	RN220(2)
R016	Equilibrium fraction of Radon-222 daughters	not used	5.000E-01	...	EQ222
R016	Radon-222 daughter concentrations (pCi/m**3):				
R016	Po-218, indoors	not used	0.000E+00	0.000E+00	PO218(1)
R016	Po-218, outdoors	not used	0.000E+00	0.000E+00	PO218(2)
R016	Pb-214, indoors	not used	0.000E+00	0.000E+00	PB214(1)
R016	Pb-214, outdoors	not used	0.000E+00	0.000E+00	PB214(2)
R016	Bi-214, indoors	not used	0.000E+00	0.000E+00	BI214(1)
R016	Bi-214, outdoors	not used	0.000E+00	0.000E+00	BI214(2)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD-BASELINE (If different from user input)	Paramet Name
R016	Equilibrium fraction of Radon-220 daughters	not used	-1.000E+00	...	EQ220
R016	Radon-220 daughter concentrations (pCi/m**3):				
R016	Po-216, indoors	not used	0.000E+00	0.000E+00	PO216(1)
R016	Po-216, outdoors	not used	0.000E+00	0.000E+00	PO216(2)
R016	Pb-212, indoors	not used	0.000E+00	0.000E+00	PB212(1)
R016	Pb-212, outdoors	not used	0.000E+00	0.000E+00	PB212(2)
R016	Bi-212, indoors	not used	0.000E+00	0.000E+00	BI212(1)
R016	Bi-212, outdoors	not used	0.000E+00	0.000E+00	BI212(2)
B011	Density of soil (pCi/g)	not used	1.500E+00	...	DENSCZ
B011	Thickness of contaminated soil (m)	not used	1.000E+00	...	THICK
B011	Organic carbon content of soil	not used	2.000E-01	...	FOC
B012	Fruits, vegetables, and grain consumption (kg/d)	not used	5.000E-01	...	DIET3
B012	Meat and poultry consumption (kg/d)	not used	2.500E-01	...	DIET4
B012	Milk consumption (L/d)	not used	1.700E-01	...	DIET5
B012	Fish consumption (kg/d)	not used	1.500E-02	...	DIET6(1)
B012	Other seafood consumption (kg/d)	not used	2.500E-03	...	DIET6(2)
B012	Drinking water intake (L/d)	not used	1.400E+00	...	DIET7
B012	Incidental water intake (swimming) (L/d)	1.300E-01	1.300E-01	...	DIET10
B012	Soil ingestion (child) (g/d)	not used	2.000E-01	...	DIET8(1)
B012	Soil ingestion (adult) (g/d)	not used	1.000E-01	...	DIET8(2)
B013	Inhalation rate indoors (m**3/d)	not used	2.000E+01	...	INHALR(1
B013	Inhalation rate outdoors (m**3/d)	not used	2.000E+01	...	INHALR(2
B013	Time fraction outdoors	not used	3.300E-01	...	FOTD
B013	Shielding factor for groundshine	not used	7.000E-01	...	SHF1
B013	Exposure duration for child (yr)	not used	6.000E+00	...	ED(1)
B013	Total exposure duration (yr)	not used	3.000E+01	...	ED(2)
B013	Average body weight for child (kg)	not used	1.500E+01	...	BDWT(1)
B013	Average body weight for adult (kg)	not used	7.000E+01	...	BDWT(2)
B013	Average life time (yr)	not used	7.000E+01	...	AVLF
B014	Contamination fractions:				
B014	ingested plant	not used	5.000E-01	...	FRACT3
B014	ingested meat	not used	1.000E+00	...	FRACT4
B014	ingested milk	not used	1.000E+00	...	FRACT5
B014	ingested aquatic food	not used	5.000E-01	...	FRACT6
B014	ingested drinking water	not used	1.000E+00	...	FRACT7
B014	ingested soil	not used	1.000E+00	...	FRACT8
B014	incidentally(swimming) ingested water	1.000E+00	1.000E+00	...	FRACT10
B014	dermal absorption from swimming	1.000E+00	1.000E+00	...	FRACT12
B014	dermal absorption from shower water	not used	1.000E+00	...	FRACT13
B014	dermal absorption from soil contact	not used	1.000E+00	...	FRACT14
B015	Exposure frequencies (d/yr):				
B015	inhalation and external radiation	not used	3.500E+02	...	EXPF1
B015	plant ingestion	not used	3.500E+02	...	EXPF3
B015	meat ingestion	not used	3.500E+02	...	EXPF4
B015	milk ingestion	not used	3.500E+02	...	EXPF5
B015	aquatic food ingestion	not used	3.500E+02	...	EXPF6

Site-Specific Parameter Summary (continued)

Parameter	User Input	Default	Used by RESRAD-BASELINE (If different from user input)	Parameter Name
drinking water ingestion	not used	3.500E+02	...	EXPF7
soil ingestion	not used	3.500E+02	...	EXPF8
incidental(swimming) water ingestion	7.000E+00	7.000E+00	...	EXPF10
dermal absorption from swimming	7.000E+00	7.000E+00	...	EXPF12
dermal absorption from shower water	not used	3.500E+02	...	EXPF13
dermal absorption from soil contact	not used	3.500E+02	...	EXPF14
ermal absorption parameters:				
skin surface area for water contact (cm**2)	2.000E+04	2.000E+04	...	DAREAW
skin surface area for soil contact (cm**2)	not used	5.000E+03	...	DAREAS
soil to skin adherence (mg/cm**2-event)	2.000E-01	2.000E-01	...	ADHRF
duration for showering (min/event)	not used	1.000E+01	...	DURSH
duration for swimming (hr/event)	5.000E-01	5.000E-01	...	DURSM
duration for soil contact (hr/event)	not used	1.200E+01	...	DURSC

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.