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Addendum to the Effectiveness Monitoring Plan (EMP) for the R-Area Operable Unit (U)

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LIST OF ABBREVIATIONS AND ACRONYMS

A/AA	A-Horizon/AA-Horizon of the Upper Three Runs Aquifer
BRA	Baseline Risk Assessment
CMCOC	contaminant migration constituent of concern
CMS/FS	Corrective Measures Study/Feasibility Study
DQO	data quality objective
EMP	Effectiveness Monitoring Plan
ft	feet
ISD	in-situ decommissioning
L	liter
MCL	maximum contaminant level
MDL	method detection limit
µg	microgram
mL	milliliter
MNA	monitored natural attenuation
msl	mean sea level
NA	no action
PCB	polychlorinated biphenyl
pCi	picoCurie
PRG	preliminary remediation goal
RAOU	R-Area Operable Unit
RAGW	R-Area groundwater
RCRA	Resource Conservation and Recovery Act
RFI/RI	RCRA Facility Investigation/Remedial Investigation
SQL	Sample Quantitation limit
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site
TZ	Transmissive Zone of the Upper Three Runs Aquifer
UTM	universal transverse Mercator
VOC	volatile organic compound

1.0 INTRODUCTION

The R-Area Operable Unit (RAOU) Effectiveness Monitoring Plan (EMP) (SRNS 2011) presented the post-construction monitoring details for the following early remedial actions:

- in-situ decommissioning (ISD) of the R-Reactor Building (105-P) Complex;
- Monitoried Natural Attenuation (MNA) for the R-Area Groundwater (RAGW) subunit tritium and volatile organic compound (VOC) groundwater

The ISD remedial activities were designed to significantly reduce contaminant mobility and allow for radioactive decay of contaminants and include grouting of all below-grade areas of the building, grouting and stabilization of disassembly basin and reactor vessel contaminants, demolition associated with the disassembly basin above-ground structure and stack, and construction of a cover system over the grouted disassembly basin and reactor vessel. In addition, the 2011 RAOU EMP identified the monitoring plan for ten contaminant migration constituents of concern (CMCOCs) with the potential to exceed maximum contaminant levels (MCLs) in groundwater under a No Action (NA) scenario. These ten CMCOCs and tritium were sampled for at ten monitoring wells around the R-Reactor Building (105-P) Complex in 2012 (Figure 1 and Table 1). Because the time frame for groundwater impacts (if any) is expected to be 200 years for the most mobile constituent (iodine-129), groundwater monitoring is conducted every five years to support the remedy review analysis.

For the P-Reactor Building (105-P) Complex, the Savannah River Site (SRS) recommended in the Fifth Five-Year Remedy Review report to reduce the analytical list to those constituents that have the fastest travel times as predicted by the groundwater model (SRNS 2017). Consistent with the P-Reactor Building (105-P) Complex ISD monitoring enhancements, the R-Reactor Building (105-R) Complex ISD monitoring will be conducted for the most mobile CMCOCs to demonstrate that the ISD remedy remains effective in preventing impact to groundwater. The purpose of this Addendum to the RAOU EMP is to revise the groundwater monitoring plan to monitor only the most mobile constituents (iodine-129, carbon-14, and chlorine-36) and tritium every five years rather than all ten CMCOCs and tritium. Field parameters will also be measured as they may be early indicators of potential contamination (Table 2). The following sections provide detail specifically for the ISD monitoring optimization.

2.0 MONITORING DETAIL HISTORY

Post-construction monitoring details pertaining to the R-Reactor Building (105-P) Complex ISD early remedial action are provided in the following sections.

2.1 Monitoring of the R-Reactor Building (105-R) Complex

Results from the Tier 2 contaminant migration modeling conducted in the Resource Conservation Recovery Act (RCRA) Facility Investigation / Remedial Investigation (RFI/RI) Report with Baseline Risk Assessment (BRA) and Corrective Measures Study/Feasibility Study (CMS/FS) for the RAOU (SRNS 2009b) indicated that ten CMCOCs present in the R-Reactor Building (105-R) Complex may exceed their MCLs in groundwater in the future if NA is taken. The ten CMCOCs that are predicted to exceed their MCLs are carbon-14, chlorine-36, potassium-40, nickel-59, niobium-94, molybdenum-93, silver-108m, iodine-129, lead, and polychlorinated biphenyls (PCBs) based on an NA scenario. The R-Reactor Building (105-R) Complex R-Reactor Building (105-R) Complex ISD remedial action included grouting of all below-grade areas of the R-Reactor Building (105-R) Complex. The R-Reactor Building (105-R) Complex ISD is designed to significantly reduce contaminant mobility for a time period to allow significant radioactive decay. Fate and transport modeling under the R-Reactor Building (105-R) Complex ISD scenario indicates seven constituents may still exceed maximum contaminant levels (MCLs) in groundwater, although not for at least 200 years (SRNS 2009a).

Consistent with the P-Reactor Building (105-P) Complex ISD monitoring, the R-Reactor Building (105-R) Complex ISD monitoring targets the most mobile contaminant migration constituents of concern (CMCOCs) to demonstrate that the ISD remedy remains effective in preventing impact to groundwater. The CMCOCs that have the fastest travel times as predicted by the R-Area Operable Unit groundwater model are iodine-129, carbon-14, and chlorine-36. The model predicts iodine-129 will exceed the MCL in 200 years, carbon-14 in 3000 years, and chlorine-36 in 350 years (GeoTrans 2009). Tritium is also included in the monitoring suite due to its current presence around the R-Reactor Building (105-R) Complex and potential ability to interfere with other beta emitters (e.g., carbon-14).

Monitoring samples for the R-Reactor Building (105-R) Complex ISD were collected in March 2012 and May 2017. Ten radionuclide, PCB, lead and tritium analyses were conducted on the 2012 samples. Tritium and lead were the only analytes above their detection limits for the 2012 sample event. In 2012, the maximum tritium result was 1,650 picocuries per milliliter (pCi/mL) for the sample at well RPS004C, which is consistent for this well. In 2012, the maximum lead result was 25.4 µg/L for the sample at well RDB 1D, which was likely due to the high turbidity (49.6 NYU) as the field duplicate sample for well RDB 1D had a lead result of 14.4 µg/L. Tritium and carbon-14 were above their detection limits for the 2017 sample event. In 2017, the maximum tritium result was 1,930 pCi/mL for the sample at well RBD 3D, which is elevated for this well. In 2017, the maximum carbon-14 result was 141 pCi/L for the sample at well RDB 3D, which is below the MCL (2,000 pCi/L), but it was the first time carbon-14 has been detected in the groundwater near the R-Reactor Building (105-R) Complex. SRS recommended, and the Core Team concurred, that carbon-14 and tritium should be sampled annually at five of the monitoring wells (RDB 1D, RDB 2D, RDB 3D, RDB003DU, and RDB005C) near the R-Reactor Building (105-R) Complex (Table 1 and Figure 2). Well RDB 2D is an auxiliary ISD monitoring well for five years (2018-2022). In 2018, the maximum tritium result was 335 pCi/mL for the sample at well RBD 3D. In 2018, the maximum carbon-14 result was 95.9 pCi/L for the sample at well RDB 3D, and all other carbon-14 results were below the detection limit. Table 3 provides the maximum results for each CMCOC.

3.0 MONITORING OBJECTIVES

The R-Reactor Building (105-R) Complex ISD is discussed in Section XI of the RAOU Record of Decision (SRNS 2010a). The following data quality objective (DQO) are used for the R-Reactor Building (105-R) Complex ISD monitoring program:

<u>DQO #1:</u> Perform monitoring to verify contaminants are not released from the R-Reactor Building (105-R) Complex.

4.0 ANALYTICAL PLAN

The effectiveness of the selected ISD remedy is monitored with ten conventional groundwater wells, which are sampled and analyzed every 5 years (Table 4). Table 1, Figure 1 and Figure 2 present information on the selected wells for monitoring the R-Reactor Building (105-R) Complex ISD. Table 5 lists the specific methods and detection limits for ISD analyses and Table 6 lists hold times, preservatives, and sample containers for all analyses. The other elements of the analytical plan are the same as those described in the RAOU EMP (SRNS 2011).

5.0 FIELD IMPLEMENTATION

The R-Reactor Building (105-R) Complex ISD is monitored by ten (10) permanent monitoring wells (Figure 1). Five wells, including an auxiliary monitoring well (RDB 2D), will be analyzed for carbon-14 and tritium for 5 years (2018-2022), because carbon-14 was detected in the RDB 3D sample for 2017 ISD sample event (Figure 2 and Table 4). The other elements of the field implementation plan are the same as those described in the RAOU EMP (SRNS 2011).

6.0 REPORTING

RAOU RAGW sampling results were presented in annual reports for the past five years, which were submitted no later than six months after the final samples for the report have been collected. The first round of RAOU ISD monitoring was conducted in 2012, and the first report was submitted at the end of the second quarter (June) 2013 (Table 4), which included all the ISD monitoring data. Starting in 2018 reports will be submitted biennially with the next report due in June 2019. In 2018, RAOU ISD monitoring included sampling 5 wells annually for carbon-14 and tritium for the next 5 years (2018-2022), because carbon-14 was detected in one of the samples from the 2017 RAOU ISD sample event. The 2019 report will include all the data for the RAOU RAGW monitoring wells and all the 2017 and 2018 RAOU ISD monitoring data. The 2021 report will include the 2019 and 2020 RAOU ISD monitoring data for carbon-14 and tritium from five wells.

7.0 REFERENCES

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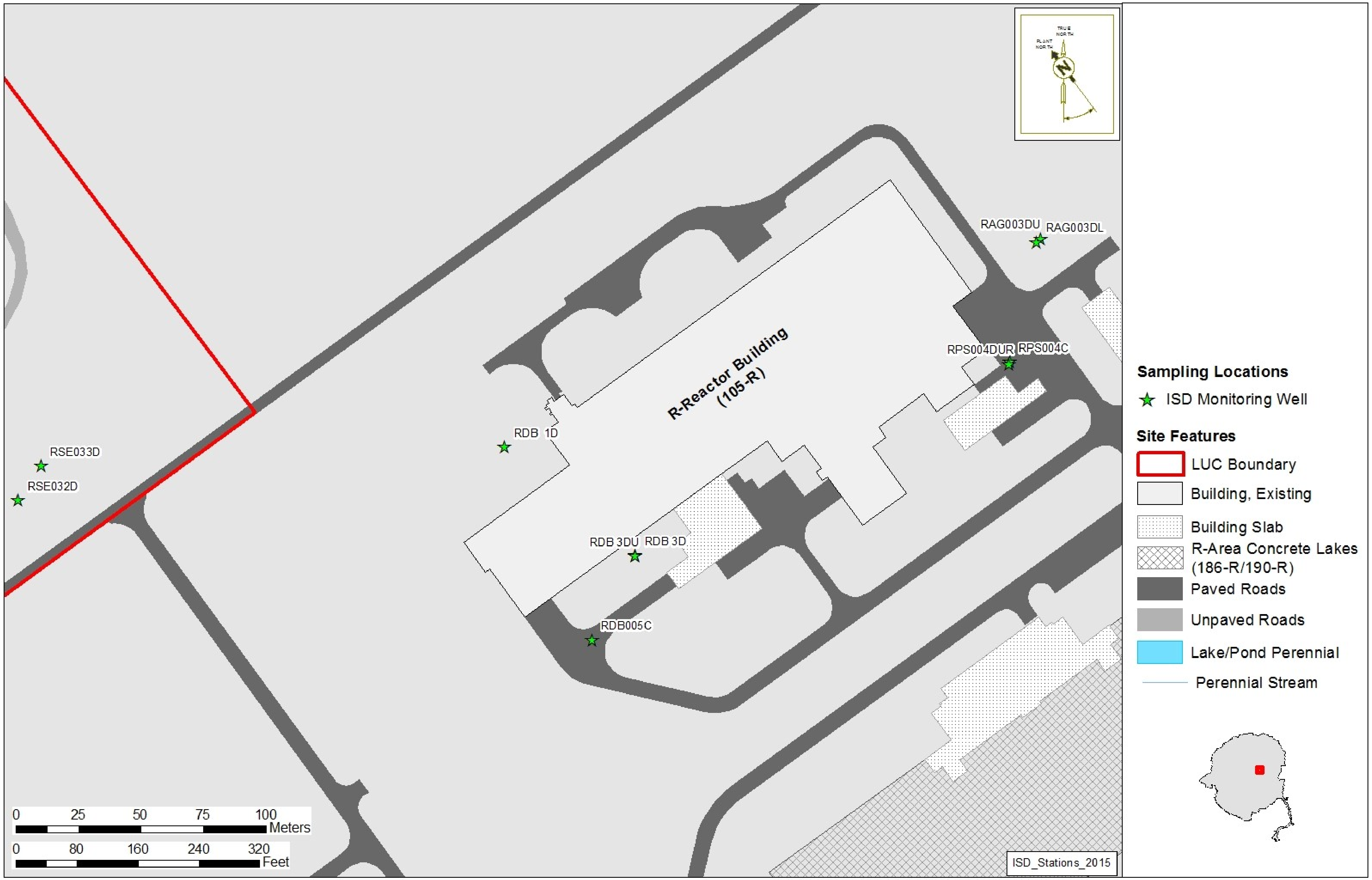

Figure 1. Monitoring Wells for the R-Reactor Building (105-R) Complex ISD

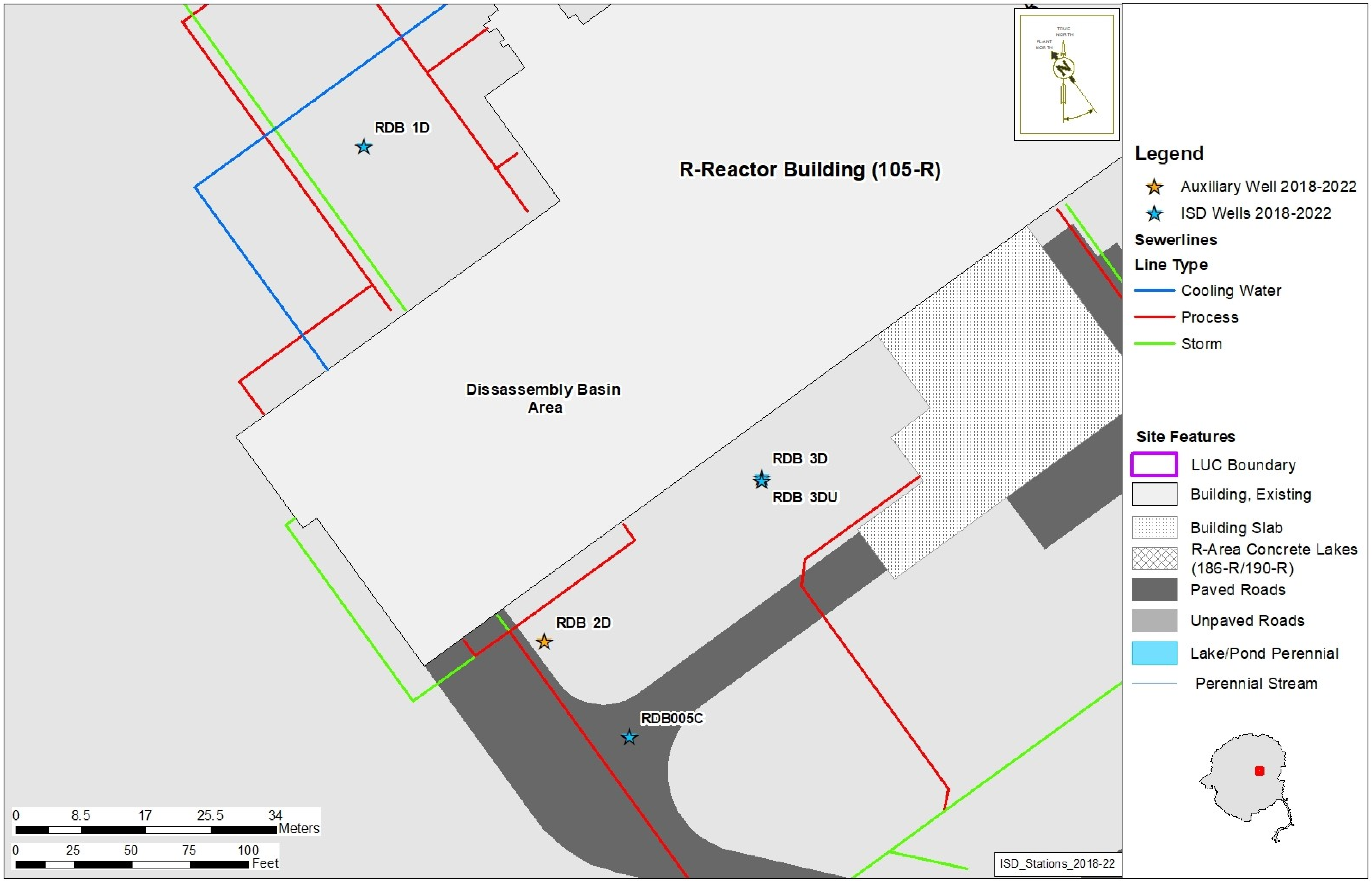

Figure 2. **Annual ISD Monitoring Wells (2018-2022)**

Table 1. Wells Monitoring the R-Reactor Building (105-R) Complex

Station ID	Aquifer Zone	Purpose	Plume	UTM[2]-N	UTM-E	Top of Casing Elevation *(ft msl[3])*	Screen Top Elevation *(ft msl)*	Screen Bottom Elevation *(ft msl)*
RDB005C	TZ[4]	Source	105-R Building Complex	3681560.48	445960.77	293.49	208.6	198.6
RDB 3D	A/AA[5]	Source	105-R Building Complex	3681594.41	445978.05	293	285.8	265.8
RDB003DU	A/AA	Source	105-R Building Complex	445949.65	445949.65	293.1	241.4	231.4
RDB 1D	A/AA	Source	105-R Building Complex	3681637.70	445925.99	292.7	285.5	265.5
RDB 2D[1]	A/AA	Auxiliary Well	105-R Building Complex	3681572.94	445949.65	292.9	285.7	265.7
RPS004C	TZ	Source	105-R Building Complex	3681671.76	446128.19	292.9	211.3	201.3
RPS004DUR	A/AA	Source	105-R Building Complex	3681676.74	446134.42	293.0	238.2	228.2
RAG003DU	A/AA	Source	105-R Building Complex	3681721.198	446140.699	292.52	237.94	227.94
RAG003DL	TZ	Source	105-R Building Complex	3681719.823	446138.794	292.67	195.88	185.88
RSE032D	A/AA	Background	105-R Building Complex	3681616.50	445731.16	301.93	264.93	254.93
RSE033D	TZ	Background	105-R Building Complex	3681630.20	445740.30	302.46	223.46	213.46

Table 1 Notes:

1) Well RDB 2D was added in 2018 as an auxiliary well monitoring carbon-14 and tritium from 2018 to 2022.
2) UTM = Universal Transverse Mercator.
3) ft-msl = feet above mean sea level.
4) TZ = Transmissive Zone of the Upper Three Runs Aquifer.
5) A/AA = A-Horizon/AA-Horizon of the Upper Three Runs Aquifer.

Table 2. Field Analyses for Groundwater

Parameter	Units	ISD Wells			
		2012	2017	2022	2027
pH	S.U.[2]	X	X	X	X
Conductivity	mS[3]	X	X	X	X
Temperature	ºC[4]	X	X	X	X
Turbidity	NTU[5]	X	X	X	X
Water Level[1]	ft bgs[6]	X	X	X	X

Table 2 Notes:
1) Water level will only be measured in groundwater and seepline wells
2) S. U. = Standard Units
3) mS = miliSiemens
4) ºC = degrees Celsius
5) NTU = Nephelometric Turbidity Units
6) ft bgs = feet below ground surface

Table 3. Maximum Monitoring Results and MCLs

Contaminant of Concern	Monitoring Well Result Observed	Maximum Detected Concentration[2]	MCL/PRG[1]	Units
Tritium	RDB 3D	1,930	20	pCi/mL
Carbon-14	RDB 3D	141	2,000	pCi/L
Chlorine-36	RDB003DU	U 139	700	pCi/L
Potassium-40	RDB 1D	U 72.3	2	pCi/L
Nickel-59	RDB005C	U 60.3	300	pCi/L
Niobium-94	RSE033D	U 4.98	6	pCi/L
Molybdenum-93	RDB 1D	U 0.92	14	pCi/L
Silver-108m	RSE033D	U 5.06	6	pCi/L
Iodine-129	RDB 1D	U 1.28	1	pCi/L
Lead[3]	RDB 1D	25.4	15	µg/L
PCBs[4]	RSE033D	U 0.10	0.5	µg/L

Notes Table 3:
1) Maximum concentration limits (MCLs) listed for carbon-14, chlorine-36, nickel-59, iodine-129, and PCBs; federal action level for lead; and preliminary remediation goals (PRGs) for potassium-40, niobium-94, molybdenum-93, and silver-108m.
2) A "U" preceding the result indicates all sample results were below the method detection limit (MDL), and the well sample with the highest MDL are entered into the table as surrogate values.
3) The RDB 1D sample had high turbidity, which likely caused the elevated lead result. A field duplicate sample was also collected at RDB 1D and the lead result was 14.4 microgram per liter (µg/L) for that sample.
4) All results for all well samples for 7 PCBs (Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor1248, Aroclor 1254 and Aroclor 1260) were all below their MDLs (0.03 µg/L) by convention the sample quantitation limit (SQL) (0.10 µg/L) is entered as a surrogate value for background well RSE033D.

Table 4. ISD Monitoring and Reporting Schedule

Year	Sample Quarter & Wells	Analytes	Report
2011			
2012	4th Quarter @ wells RDB 1D, RDB 3D, RDB003DU, RDB005C, RPS004C, RPS004DUR, RAG003DL, RAG003DU, RSE0032D AND RSE0033D.	Carbon-14, chlorine-36, iodine-129, potassium-40, nickel-59, niobium-94, molybdenum-93, lead, PCBs, tritium, and field parameters	
2013			2nd Quarter
2014			
2015			
2016			
2017	2nd Quarter @ wells RDB 1D, RDB 3D, RDB003DU, RDB005C, RPS004C, RPS004DUR, RAG003DL, RAG003DU, RSE0032D AND RSE0033D.	Carbon-14, chlorine-36, iodine-129, tritium and field parameters.	
2018[1]	4th Quarter @ wells RDB 1D, RDB 2D, RDB 3D, RDB003DU, and RDB005C	Carbon-14, tritium and field parameters.	
2019	4th Quarter @ wells RDB 1D, RDB 2D, RDB 3D, RDB003DU, and RDB005C	Carbon-14, tritium and field parameters.	2nd Quarter
2020	4th Quarter @ wells RDB 1D, RDB 2D, RDB 3D, RDB003DU, and RDB005C	Carbon-14, tritium and field parameters.	
2021	4th Quarter @ wells RDB 1D, RDB 2D, RDB 3D, RDB003DU, and RDB005C	Carbon-14, tritium and field parameters.	2nd Quarter
2022	4th Quarter @ wells RDB 1D, RDB 2D, RDB 3D, RDB003DU, RDB005C, RPS004C, RPS004DUR, RAG003DL, RAG003DU, RSE0032D AND RSE0033D.	Cabon-14, Chlorine-36, Iodine-129, tritium and field parameters.	
2023			2nd Quarter

Table 4 Notes:

1) Reporting changed to biennial in the odd years with Core Team agreement.

Table 5. Methods and Detection Limits for Surface Water and Groundwater Analysis

Analyte	Analyte ID	Preparation Method	Analysis Method	SQL[2]
Tritium	10028-17-8		EPA906.0MOD/TBD[1]	5 pCi/mL[3]
Carbon-14	14762-75-5		RADA-003	100 pCi/L
Chlorine-36	13981-43-6		RADA-033	300 pCi/L
Iodine-129	15046-84-1		RADA-006	1 pCi/L

Table 5 Notes:

1) TBD = To Be Determined.
2) SQL is the achievable sample quantitation limit (SQL) based on the 2012 and 2017 R-Reactor Building (105-R) Complex ISD monitoring results.
3) pCi/mL = picocuries per milliliter.

Table 6. Sample Hold Times, Preservatives, and Sample Containers

Analyte	Preservative	Holding Time	Containers
Tritium	None	6 months	1x 250 mL Amber Glass bottle
Carbon-14	Cold (4 +/- 2 ºC)	6 months	3 x 1 L Amber Nalgene
Chlorine-36	HNO_3 to pH <2.	6 months	2 L HDPE
Iodine-129	Cold (4 +/- 2 ºC)	6 months	3 x 1 L Amber Nalgene

Table 7. Sampling Matrix Table

Station Count	Monitoring Type	Station ID	Screen Top Elevation *(ft msl)*	Screen Bottom Elevation *(ft msl)*	Aquifer Zone	Analyses
1	ISD Monitoring	RDB005C	208.6	198.6	TZ	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.
2	ISD Monitoring	RDB 3D	285.8	265.8	A/AA	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.
3	ISD Monitoring	RDB003DU	240	230	A/AA	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.
4	ISD Monitoring	RDB 1D	285.5	265.5	A/AA	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.
5	Auxiliary Well	RDB 2D	285.7	265.9	A/AA	Field parameters, carbon-14, and tritium (2018-2022).
6	ISD Monitoring	RPS004C	211.3	201.3	TZ	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.
7	ISD Monitoring	RPS004DU	240	230	A/AA	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.
8	ISD Monitoring	RAG003DU	237.94	227.94	A/AA	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.
9	ISD Monitoring	RAG003DL	195.88	185.88	TZ	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.
10	Background ISD Monitoring	RSE032D	264.93	254.93	A/AA	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.
11	Background ISD Monitoring	RSE033D	223.46	213.46	TZ	Field parameters, carbon-14, chlorine-36, iodine-129, tritium.