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License No. R-76; Docket No. 50-027

Subject: 2022 Annual Report for the WSU Nuclear Science Center

The annual report for the WSU reactor facility is hereby submitted. The report covers the operating period from July 1, 2021 through June 30, 2022.

Respectfully Submitted,



C. Corey Hines  
Director

Enclosure

cc: Hillary Bennett, Reactor Supervisor, Nuclear Science Center  
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2022

# ANNUAL OPERATIONS REPORT

## **WASHINGTON STATE UNIVERSITY TRIGA REACTOR**

FACILITY LICENSE R-76 FOR THE REPORTING PERIOD  
JULY 1, 2021 TO JUNE 30, 2022

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## 1. Narrative Summary of Operation for Fiscal Year 2022

### A. Operating Experience

Core 35A has accumulated 14,297 MWH from beginning of life (BOL) through June 30, 2022. During the reporting period of July 1, 2021 to June 30, 2022, a total of 1196 samples were irradiated, for 6149 user-hours. Additionally, 9 pulses greater than \$1.00 of reactivity addition were performed during the reporting period. The quarterly operations summaries are shown in Table I.

### B. Changes in Facility Design, Performance Characteristics, and Operating Procedures Related to Reactor Safety.

No changes in facility design, performance characteristics, or operating procedures related to reactor safety were made.

### C. Results of Surveillance Tests and Requirements

surveillance tests and requirements were performed and completed within the prescribed time period.

## 2. Energy and Cumulative Output

The quarterly operations summaries are given in Table I. The cumulative energy output since the 1967 TRIGA fuel core was put into service is 1,825 megawatt days (MWD). The mixed Standard Fuel and 30/20 LEU Fuel Core 35A installed in 2008 has accumulated 595 MWD.

**Table I.** Fiscal Year 2022 Summary of Reactor Operation<sup>1</sup>

	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Totals
Hours of Operation	256	188	94	446	985
Megawatt Hours	200	133	68	361	761
Sample Irradiations	104	44	31	83	262
Samples	539	198	111	348	1196
External Irradiations	21	16	13	31	81
Pulses > \$1.00	1	2	0	6	9
User Hours	1524	1192	482	2951	6149

<sup>1</sup> Number of samples and sample irradiations do not include external client irradiations. User hours denotes the total user hours, including external client irradiations.

### 3. Emergency Shutdowns and Inadvertent Scrams

During the reporting period, there were no emergency shutdowns.

The dates and causes of the eight inadvertent scrams are listed in Table II. No scrams were due to exceeding the limiting safety system setting or safety limit.

**Table II. Inadvertent Scrams**

<b>Date</b>	<b>Description</b>
7/13/2021	Electrical Short on the bridge caused a console fuse to blow.
12/7/2021	Trainee inadvertently took mode selector switch to test.
12/23/2021	Pulse High Power SCRAM when firing the pulse rod for pulse no. 1415. The cause was traced to the J4 connector on the pulse channel being loose. Fuel temp was monitored and did not exceed the limiting safety system setting or safety limit.
3/4/2022	Manual SCRAM initiated due to miscommunication about pool water conductivity reading to the SRO. Conductivity was within technical specification limits.
3/10/2022	Linear High-Power Scram caused during power reduction, RO lowered power to ~1kW, as read on the 10kW scale of the NMP-1000 Channel. RO pressed 1kW range button, then auto range, which caused the channel reading to spike and initiated the high-power scram. TS maximum licensed power level was not exceeded, and fuel temperature was observed to stay within normal operating range as the SCRAM was caused by exceeding the 120% SCRAM setpoint of the lowest scale on the channel and not the 1MW scale.
4/12/2022	Manual scram due to RO dropping a tool in the east pool. The tool did not go near the reactor core.
4/29/2022	A trainee pulled an experiment in C8 while at 1 MW, causing a Pulse High Power SCRAM. TS maximum licensed power level was not exceeded, and fuel temperature was observed to stay within normal operating range.
6/15/2022	Pulse High Power SCRAM when firing the pulse rod for pulse no. 1421. Power levels and fuel temperature were monitored and did not exceed the tech spec values. Connections were checked and the problem could not be replicated.

### 4. Major Maintenance

Although they are not part of routine preventative maintenance, the below listed items were performed.

9/15/2021: Flow rate meter for the purification loop was not reading properly. It was replaced with one of the same make and model.

11/02/2021: The Bridge Speed controller was found to have a failing relay. It was replaced with a like-for-like part. The maximum speed was set to the required 1Ft/8Sec.

12/9/2022: The Lovejoy connector on the secondary pump for the cooling system failed and was replaced.

12/16/2022: The east gutter inlet valve was found to be inoperable and was replaced with a new 316 stainless steel ball valve. The west gutter inlet valve was also replaced.

1/17/2022: The valve on the west sump was replaced with a stainless steel ball valve and the flange on the pool return hose was replaced with the proper connecting part for the purpose.

From 1/10/2022 to 2/23/2022 the reactor pool liner was replaced according to 50.59-109-2022.

2/3/2022: An air leak was found in the line for the pulse rod air supply. The copper piping where it connected to the air hose was damaged and could not be repaired. The air hose was hooked directly into the regulator.

2/28/2022: The lower limit switch did not actuate when the pulse rod was air scrambled during the checkout but would when the rod was lowered with the drive. The connecting rod was found to be rubbing against the inside of the hold down tube and the system was realigned and lubricated.

3/28/2022: The east sump valve was replaced with a stainless-steel ball valve.

6/1/2022: The readout for control element 5 was found to be reading one inch when fully inserted. The chain driven mechanism was found to have skipped and was re-zeroed.

6/24/2022: The EGM amplifier failed and was replaced with a like for like part. The amplifier settings were set based on the previous amplifier settings and then adjusted using the method in the manual. The EGM was then calibrated as per procedure.

## **5. Changes, Tests, and Experiments Performed Under 10 CFR 50.59 Criteria**

A total of three (3) proposed changes to the facility were reviewed during the 2021-2022 year. All of the proposals were screened with the 10 CFR 50.59 requirements and found to screen out, thus allowing the changes to be made. The following changes were made to the facility under 50.59 criteria:

- 1) The east and west pool gutter valves were replaced with 316 stainless steel ball valves. The previously installed valves were not fit for the purpose, installed backwards, and the east one had failed closed.
- 2) The east and west pool sump valves as well as the flange for the return hose were replaced with 316 stainless steel replacements. This was an upgrade over previously installed parts.
- 3) The reactor pool liner was replaced with an industry standard liner: InstaCote SE FR polyurea coating system. The pool was drained one half at a time for the replacement.

## 6. Radioactive Effluent Discharges

### A. Radioactive Liquid Effluent Releases

The liquid effluent releases for the facility during the reporting period are provided in Table III.

**Table III.** Monthly Liquid Effluent Releases

Month	Volume (gallons)
July 2021	0
August	0
September	0
October	0
November	0
December	0
January 2022	280
February	0
March	4290
April	0
May	4728
June	0

Approximately 9298 gallons of liquid effluents were released from the storage tank during the reporting period. Prior to discharge, a sample of the liquid in the tank was analyzed using gamma spectroscopy and liquid scintillation counting. The January gamma spectroscopy report indicated an activity of 0.12  $\mu\text{Ci}$ . The two March gamma spectroscopy reports indicated an activity of 0.17  $\mu\text{Ci}$  and 0.76  $\mu\text{Ci}$ . The May gamma spectroscopy report indicated an activity of 0.09  $\mu\text{Ci}$ . A total of activity of 1.14  $\mu\text{Ci}$  was released as liquid effluent during the reporting period.

### B. Radioactive Gaseous Effluent Release

During the reporting period, no emission of a measurable quantity of gaseous or particulate material with a half-life greater than eight days was detected. The measured argon-41 out of the common exhaust stack did not exceed 20% of the effluent release limit. A total of 2.24 Ci of argon-41 was released, with an average argon-41 concentration of  $1.13 \times 10^{-10}$   $\mu\text{Ci/mL}$  of air, after environmental dilution. The argon-41 release and the pool water analysis is used in the 2022 Annual Report for Radioactive Air Emission License (RAEL-004), stack number 7. Per COMPLY v1.7, the reactor facility (stack 7) complies at level 4 with an effective dose equivalent of  $3.1 \times 10^{-3}$  mrem/yr. The monthly releases from Ar-41 are summarized in Table IV.

**Table IV. Monthly Argon-41 Releases<sup>2</sup>**

Month	Quantity (Ci)	Conc. After Dilution ( $\mu\text{Ci}/\text{mL}$ )	% of DAC Limit
July 2021	3.2E-01	2.0E-10	6.3E-03
August	8.2E-02	4.9E-11	1.6E-03
September	2.3E-01	1.4E-10	4.7E-03
October	2.9E-01	1.7E-10	5.8E-03
November	1.5E-01	9.2E-11	3.1E-03
December	1.6E-01	9.7E-11	3.2E-03
January 2022	1.7E-01	1.0E-10	3.4E-03
February	7.4E-02	4.7E-11	1.6E-03
March	1.0E-01	6.0E-11	2.0E-03
April	2.1E-01	1.3E-10	4.3E-03
May	2.5E-01	1.5E-10	4.9E-03
June	2.0E-01	1.2E-10	4.0E-03

### C. Radioactive Solid Waste Disposal

During the reporting period,  $1.59\text{E}+02$  mCi in 10 cubic feet of non-compacted solid waste was transferred to the WSU Radiation Safety Office for packaging and disposal.

## 7. Personnel and Visitor Radiation Doses

The quarterly doses of the WSU Nuclear Science Center reactor staff and experimenters are given in Table V. The maximum quarterly dose to a reactor staff member was 92 mrem, whole body. A total of 667 individual persons visited the Nuclear Science Center during the reporting period, of which 335 entered a controlled access area (CAA).<sup>3</sup> A total of 14 group tours, consisting of 75 individuals, visited the center during the reporting period, also entering a CAA. All but one of the doses were less than or equal to 0.2 mrem as determined by digital pocket dosimeters. The one outlier was a visitor who received a total dose of 0.5 mrem during an 8 hour period.

<sup>2</sup> Quantity released based on 4500 CFM effluent of ventilation system in AUTO mode of operation. Concentration after dilution is based on 10 CFR 20 effluent release limit of  $1.0 \times 10^{-8}$   $\mu\text{Ci}/\text{mL}$  for Ar-41 (Table 2, Col.1), and a dilution factor of  $3.4 \times 10^{-3}$  (WSU Technical Specifications 3.5.2). DAC limits are based on 10 CFR 20 derived air concentration limit of  $3.0 \times 10^{-6}$   $\mu\text{Ci}/\text{mL}$  for Ar-41 (Table 1, Col. 3) and a dilution factor of  $3.4 \times 10^{-3}$ .

<sup>3</sup> A controlled access area is an area in the building where radioactive materials are used or stored and is a part of the licensed reactor facility.



**Table V.** Quarterly Reactor and Experimenter Staff Dose<sup>4</sup> (mrem)

<b>Badge No.</b>	<b>Q3 2021</b>	<b>Q4 2021</b>	<b>Q1 2022</b>	<b>Q2 2022</b>
706	18	30	24	22
1330	--	19	25	25
1204	22	20	--	--
10921	92	28	22	55
12176	48	29	23	23
1368	--	23	24	23
1360	--	18	24	21
705	37	--	8	28
1352	--	18	23	--
1340	--	26	26	27
1222	22	--	--	--
1401	--	--	10	--
11975	62	42	40	29
1428	--	--	8	33
1335	--	19	29	28
1327	--	20	28	24
12216	30	28	24	9
3150	--	--	--	5
3151	--	--	--	5
1278	16	9	--	--
701	34	29	42	45
1160	27	25	19	22
11937	41	--	--	--
1203	21	12	--	--
12212	28	30	38	26
8141	28	28	26	23
698	63	51	18	47
1166	38	27	24	--
6145	--	--	--	5
12207	39	28	25	10
704	54	31	24	39
3135	--	--	--	12
3149	--	--	--	5
1206	21	22	--	--
703	28	25	23	9
1329	--	19	28	21
12030	75	28	--	--
1282	16	--	--	--

<sup>4</sup> "--" denotes data not available either due to departure from the facility or new personnel starting at the facility. An 'M' denotes that the dosimeter reading was less than or equal to the background radiation level for that quarter.

11965	70	49	28	--
1207	25	12	--	--
1397	--	--	11	--
1400	--	--	5	--
1399	--	--	2	--
1328	--	19	27	26

## 8. Reactor Facility Radiation and Contamination Levels

The limit of quantification (LOQ) for building removable contamination determination survey samples as measured by liquid scintillation assay is  $9.09 \times 10^{-8} \mu\text{Ci}/\text{cm}^2$ ; the survey sample data that was collected for removable contamination determination were averaged over one year. Routine building surveys showed average levels of removable activity to be less than the LOQ for all non-CAAs save for the Rm. 101 Shipping Bench, which was  $9.4 \times 10^{-8} \mu\text{Ci}/\text{cm}^2$ .

**Table VI.** Average Removable Contamination for Weekly Monitoring in CAAs and Non-CAAs<sup>5</sup>

Location	Measured Activity Above LOQ ( $\mu\text{Ci}/\text{cm}^2$ )
201B	M
201A	M
201 Reactor Bridge Steps	M
201 Sample Drop Tube	M
201 Reactor Bridge South	M
201 Reactor Bridge North	M
201 Experimenter Platform	9.6E-08
201 Laboratory Benches	M
201 Floor South	M
201-C Heat Exchanger Floor	M
201 Floor North	M
106 Ion Exchanger Pit	M
101-A Purification Pump Pit	M
<b>101 Doorway</b>	M
<b>101 Sample Preparation Bench</b>	M
<b>101 Sample Drop Hood #2</b>	M
<b>101 Hood #1</b>	M
<b>101 Hood #2</b>	M
<b>101 Hood #3</b>	M
<b>101 Hood #4</b>	M
<b>101 Shipment Bench</b>	9.4E-08
<b>RAM Storage Safe</b>	M
<b>101 Island</b>	M
<b>101 North lab Bench</b>	M
<b>B21 Panoramic Irradiator</b>	M
<b>B21 Floor</b>	M
2 South Floor	M
2 Thermal Column	M
2 Thermal Column Floor	M
2 North Floor	M
2 Cave Floor West	M
2 Cave Floor East	M

The results for the routine area radiation surveys of the building in CAAs and non-CAAs are given in Table VII. The highest average dose rate for a single location in a CAA was 24.84 mrem/hr, which occurred in Room 2 East Cave. This value is less than the limit for CAAs. The lowest average dose rate in a CAA was 0.04 mrem/hr (a

<sup>5</sup> Bolded text indicates a non-CAA. Regular text indicates a CAA. "M" indicates the value is below the LOQ value of  $9.09 \times 10^{-8} \mu\text{Ci}/\text{cm}^2$ .

level considered background), which occurred in Room 201A and Room 201C HX. The average dose rate in the radiochemistry sample hoods (a non-CAA) was 0.05 mrem/hr. The East and West cave are secured storage areas that are designed to house radioactive sources, and provide shielding. The space is posted as a high radiation area. Personnel do not typically work in this area and it is locked when not in use.

**Table VII.** Average Radiation Dose Rates for Weekly Monitoring in CAAs and Non CAAs<sup>6</sup>

<b>Location</b>	<b>Average Dose Rate (mrem/hr)</b>
Room 201 B	0.05
Room 201 A	0.04
Room 201 Bridge	0.48
Room 201 Benches	0.12
Room 201 South	0.77
Room 201 East	0.43
Room 201 C Heat Exchanger	0.04
Room 201 North	0.19
Room 106 Ion Exchanger Pit	0.98
Room 101 A Purification Pit	0.62
<b>Sample Storage</b>	0.15
<b>Room 101 Doorway</b>	0.04
<b>Room 101 Sample Prep Bench</b>	0.04
<b>Room 101 Sample Drop Hood</b>	0.05
<b>Room 101 Shipping Bench</b>	0.05
<b>Room 101 Hood 1</b>	0.05
<b>Room 101 Hood 2</b>	0.08
<b>Room 101 Hood 3</b>	0.04
<b>Room 101 Hood 4</b>	0.04
<b>Room B21 Panoramic Irradiator</b>	0.04
Room 2 South	0.18
Room 2 Thermal Column	0.05
Room 2 North	0.25
Room 2 West Cave	2.26
Room 2 East Cave	24.84

<sup>6</sup> Bolded text indicates a non-CAA. Regular text indicates a CAA. "M" indicates the value is below the LOQ value of  $9.09 \times 10^{-8}$   $\mu\text{Ci}/\text{cm}^2$ .

## 9. Environmental Monitoring Program

The environmental monitoring program is used to determine the offsite background radiation levels; thermoluminescent dosimeters (TLD's) are used to make the measurements. The offsite radiation monitoring program is required by the Technical Specifications. The TLDs that are used for offsite monitoring are designated as TLD numbers 3, 7, 9, 15 through 35, and 39 through 44. The average background radiation level is then compared to the nearest occupied dwelling.

Average quarterly dose rates for offsite locations are listed in Table VIII and are used to calculate the Technical Specification threshold of 20% above the background radiation level and compared to the limiting values which are listed in Table XI. The average environmental radiation levels for the closest offsite point of extended occupancy is listed in Table X. Table IX shows the quarterly environmental radiation levels for those TLDs located at onsite locations. The onsite locations are not required to be compared to background radiation levels.

The closest offsite points of extended occupancy are compared in Figure 1 to both the background radiation levels and the 20% above background radiation levels. The ALARA effluent release limits in Technical Specification 3.5.2(3) specify that annual radiation exposure due to reactor operation, at the closest offsite extended occupancy, shall not, on an annual basis, exceed the average offsite background radiation by more than 20%. For the reporting period, the average background radiation dose rate for off-site locations was 0.35 mrem/day, while the average radiation dose rate at the closest extended occupancy area 600 meters away was 0.32 mrem/day. This result indicates that no exposure level above normal background radiation were found, and that no dose levels exceeded Technical Specifications requirements for an offsite area of extended occupancy.

**Table VIII.** Environmental Radiation Levels at Offsite Locations<sup>7,8</sup>

Location	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Average
Fence E of NSC	0.33	0.32	0.37	0.34	0.34
Fence, N of Rad Waste Shed	0.36	0.35	0.37	0.41	0.37
Fence directly N Rad Waste Shed	0.48	0.48	0.52	0.46	0.48
S NSC, on parking lot fence	0.30	0.30	0.35	0.29	0.31
Fence S Roundtop Dr, 10 <sup>th</sup> pole W of pole C14	0.36	0.60	0.33	0.35	0.41
Telephone pole C12	0.37	0.34	0.35	0.35	0.36
Telephone pole near golf course gate	0.37	0.33	0.40	0.33	0.36
E across fairway on pine tree	0.36	0.32	0.37	0.34	0.35
Maple tree #54 along driving range	0.34	0.34	0.35	0.30	0.33
NW to fence uphill from driving range	0.36	0.33	0.36	0.34	0.35
Follow fence E to fence corner	0.37	0.34	0.37	0.37	0.36
S to lone spruce tree near water hazard	0.34	0.33	--	0.35	0.34
Roundtop hill park, NW fence corner	0.34	0.30	0.34	0.31	0.32
Deciduous tree edge of 18 <sup>th</sup> green	0.36	0.34	0.39	0.37	0.37
6ft pine tree, 3 <sup>rd</sup> W down cart path from clubhouse	0.36	0.33	0.38	0.36	0.36
3 <sup>rd</sup> to last tree after gap in same line of trees	0.35	0.29	0.32	0.30	0.31
SW to fence along path near 2 <sup>nd</sup> to last tee box at bottom hill	0.37	0.33	0.37	0.38	0.36
Follow fence partway up hill after fence turns S	0.36	0.31	0.34	0.32	0.33
Follow fence, 15 <sup>th</sup> pole E after fence turns W	0.36	0.33	0.33	0.35	0.34
Follow fence about halfway between last TLD and corner	0.39	0.34	0.36	0.36	0.36
Largest bush S of NSC	0.38	0.35	0.34	0.34	0.35
2 <sup>nd</sup> fence S NSC, W end at gate	0.33	0.31	0.33	0.30	0.32
S Fairway Rd, 1 <sup>st</sup> light post on right	0.37	0.33	0.35	0.32	0.34
S Fairway Rd, 2 <sup>nd</sup> light post on right	0.35	0.32	0.35	0.36	0.35
Ellis Way and Hog Lane sign	0.36	0.33	0.33	0.34	0.34
Bottom of radio antenna hill, fence next to shrub left of gate	0.37	0.34	0.34	0.32	0.34
3 <sup>rd</sup> fence S of NSC, SE corner, cow pasture	0.37	0.38	0.33	0.32	0.35
Airport fence W end runway at gate	0.35	0.33	0.35	0.36	0.35
Fence/entry bar E of Jewett Observatory	0.34	0.29	0.35	0.31	0.32
Railing at Terrell Mall / Library	--	--	--	0.29	0.29

<sup>7</sup> Offsite defined by the Technical Specification 1.0 and 5.1.1 as any location, which is outside the site boundary. The "--" indicates a TLD which was missing.

<sup>8</sup> Dose rate in mrem/day.

**Table IX.** Environmental Radiation Levels at Onsite Locations<sup>9,10</sup>

Location	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Average
E lower loading dock	0.33	0.31	0.34	0.34	0.33
Pool room truck door fence S end	0.48	0.39	0.47	0.48	0.45
Pool room truck door fence N end	0.52	0.39	0.53	0.63	0.52
E wall rad waste shed	0.36	0.42	0.46	0.48	0.43
N wall rad waste shed	0.44	0.45	0.67	0.55	0.53
Cooling tower fence, NE corner	0.59	0.50	0.57	0.55	0.55
Room 101 window	0.41	0.34	0.45	0.46	0.42
Railing next to upper liquid waste tank	0.39	0.31	0.36	0.33	0.35
Room 2 truck door fence	0.35	0.35	0.37	0.35	0.36
Transformer vault vent louvers	0.37	0.37	0.39	0.38	0.37
NSC main entrance, light fixture	0.42	0.42	0.44	0.36	0.41
NSC roof, pool room vent stack	0.35	0.28	0.35	0.24	0.30
NSC roof, guide wire E end of building	0.34	0.36	0.35	0.28	0.33
NSC roof, E pool room vent support leg	0.57	0.49	0.47	0.63	0.54
NSC roof, air conditioning support leg	0.34	0.26	0.36	0.29	0.31
NSC roof, W pool room vent support leg	0.63	0.46	0.50	0.69	0.57

**Table X.** Environmental Radiation Levels for the Closest Offsite Point of Extended Occupancy<sup>10</sup>

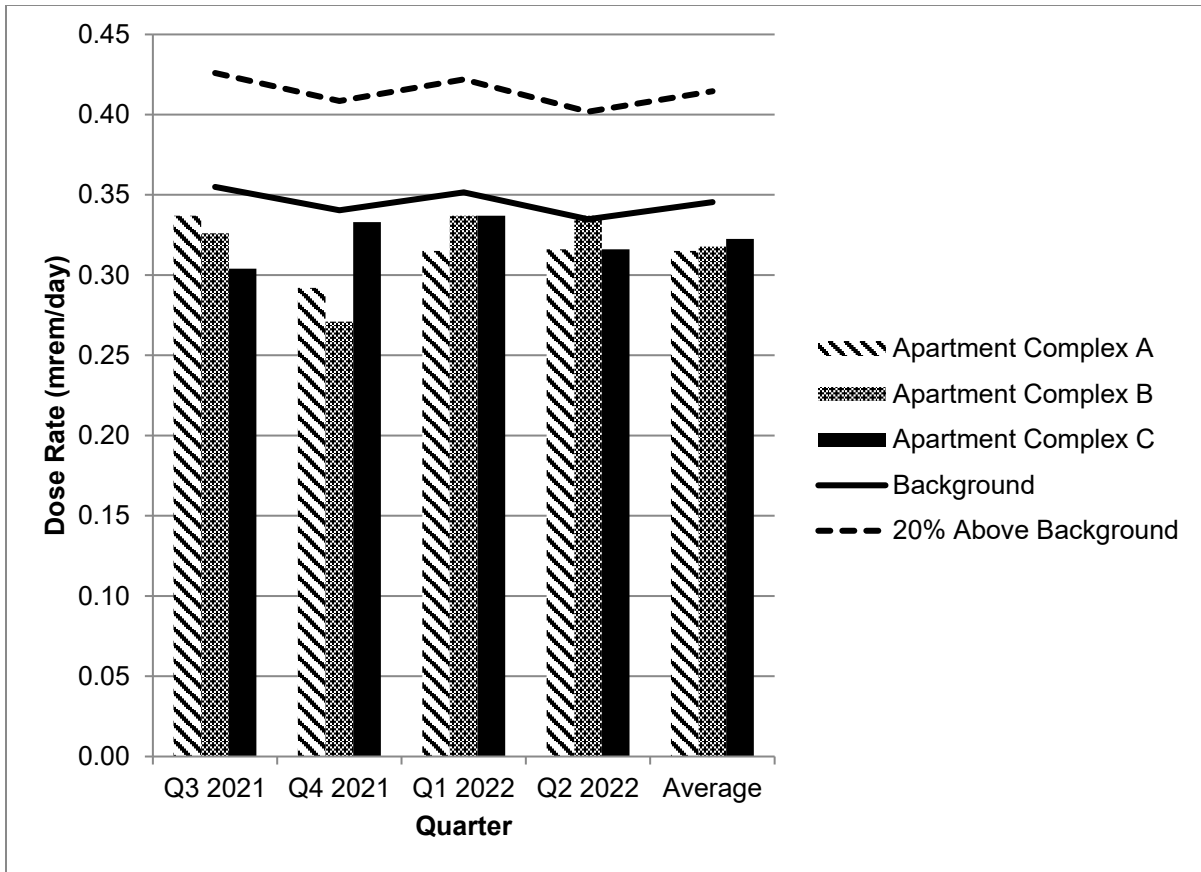
Location	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Average
Apt complex C, gas meter	0.30	0.33	0.34	0.32	0.32
Apt complex B, gas meter	0.33	0.27	0.34	0.34	0.32
1 <sup>st</sup> fence S apt complex A	0.34	0.29	0.32	0.32	0.32

**Table XI.** Background Environmental Radiation Levels<sup>10</sup>

Description	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Average
Background radiation levels	0.36	0.34	0.35	0.33	0.35
20% above background radiation levels	0.43	0.41	0.42	0.40	0.41

<sup>9</sup> Onsite defined by the Technical Specification 1.0 and 5.1.1 as any location within the site boundary. The "--" indicates a TLD which was missing.

<sup>10</sup> Dose rate in mrem/day.



**Figure I:** Environmental radiation levels for the closest offsite point of extended occupancy radiation levels as compared to background radiation levels and 20% above background radiation levels.