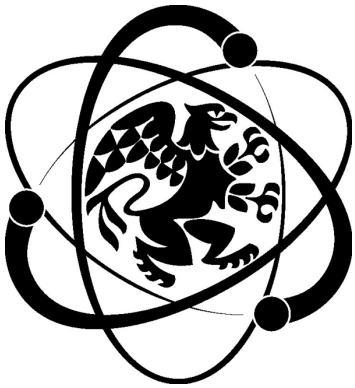
REED RESEARCH REACTOR ANNUAL REPORT

July 1, 2019 -- June 30, 2020 *(rev. 1)*



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OVERVIEW

This report covers the period from July 1, 2019 to June 30, 2020, and is intended to fulfill the reporting requirements of the U.S. Nuclear Regulatory Commission License No. R-112, Docket 50-288, the U.S. Department of Energy, and the Oregon Department of Energy Rule No. 345-030-010.

Reed College operates a 250 kW TRIGA® Mark I reactor. The Reed College Research Reactor has been a resource for research and educational projects in the Portland area since 1968. The main uses of the Reed Research Reactor are instruction and research.

During the year there were 451 visitors from schools, colleges, universities, and special groups. An additional 509 visitors came as part of a Reed sponsored activity (prospective students, family of students, Reed classes, etc.). Twelve members of emergency response organizations came for training. Including tours and research conducted at the facility, the Reed Research Reactor contributed to the educational programs of 45 institutions.

During the year the reactor was taken critical 279 times on 109 days. The total energy produced was 14.50 megawatt-hours.

The reactor staff consists of a Director, a Reactor Operations Manager, and Reed College undergraduate students who are licensed by the Nuclear Regulatory Commission as reactor operators or senior reactor operators. During the reporting period, one RO candidate received an NRC license after passing the NRC exam administered in October 2019.

In March 2020 the Director took a leave of absence, which became permanent in June. An Interim Director was hired in March 2020. We hope to have a permanent replacement in place by September 2020.

There were no radiation exposures to individuals in excess of any limits during the year. There were no releases of liquid radioactive material from the facility. Airborne releases were well within regulatory limits. There were no shipments of low-level radioactive waste from the facility.

The Nuclear Regulatory Commission did not conduct an inspection during this reporting period due to the pandemic. One external audit was performed in March 2020.

This reporting year is unique in that the nation is experiencing a pandemic. In March 2020 the college decided not to operate reactor except as necessary. We hope to resume operations for Reed students in Fall 2020.

On March 16, 2020 the NRC issued a Confirmatory Order to the reactor. It is discussed in this report under Inspections and Audits.

PEOPLE

Reactor Staff

During the reporting period the staff consisted of the following:

Table 1 Supervisory Staff

Reactor Director	Stephen Frantz (Interim) Melinda Krahenbuhl	3/20 - present 6/11 - 3/20
Reactor Operations Manager	Toria Ellis	6/19 - present
Radiation Safety Officer	April Sams	5/16 - present
Operations Supervisor	Val Lim	5/19 - 6/20
Training Supervisor	Thomas Malthouse Elena McKnight	5/19 - 6/20 5/18 - 6/20
Requalification Supervisor	Sophie Bender	5/19 - 6/20
Projects Supervisor	Addison Gyunn	5/19 - 6/20

Table 2 Staff

Senior Reactor Operators (SRO)			
Beatrice Barrar	Addison Gyunn	Yilian Liu	Shawn Owens
Sophie Bender	Melinda Krahenbuhl	Elena McKnight	Matt Parson
Bri Dobson	Jonathan Li	Thomas Malthouse	
Toria Ellis	Val Lim	Claire Mashlan Milander	
Reactor Operators (RO)			
Abur-Rauf Ahmed	Gavin Dury	Jillian James	Ethan Shek
M Benesch	Marie Faulkner	Pratik Kafle	Nemo Shen
Kees Benkendorfer	Yu Fu	Kaitlyn Li	Kaiyan Shi
Ryen Burris	Segovia Garcia	Natalie Murphy	Avantika Vivek
Dorothy Cheng	Stephaine Gee	Patrick Park	Rebecca Xie
Ashlee Cook	Emanuel Gordis	Gio Ramirez	
Ismayn Ditter	Megan Hilton	Tenzin Sangpo	
Riyaz Ditter	Matt Hwang	Henry Scheffer	
Reactor Technicians			
Laura Estridge	Samantha Hordyk	Gianmatteo Martinez	Laura Yosida

The list of operators includes everyone who held a license at any time during the reporting period. Reactor Operators who upgraded their licenses to Senior Reactor Operators during the reporting period are listed under Senior Reactor Operators. On June 30, 2020 there were 25 licensed operators at Reed College.

Reactor Operations Committee (ROC)

The membership of the Reactor Operation committee during the reporting period is listed.

Reactor Operations Committee

- Lucas Illing, ROC Chair (Physics Faculty, Reed College)
- Steve Reese (Radiation Center Director, Oregon State University)
- Wayne Lei (Portland General Electric-retired)
- Norm Dyer (OAR Services-retired)
- Nigel Nicholson (Dean of the Faculty, Reed College)
- April Sams (Director, Reed Environmental Health and Safety)
- Jerry Shurman (Math Faculty, Reed College)
- Melinda Krahenbuhl (Director, RRR)
- Stephen Frantz (Interim Director, RRR)
- Toria Ellis (Reactor Operations Manager, RRR)
- Val Lim (Supervisor, RRR)

FACILITIES

Reactor Facility

In addition to the reactor, Reed College has a radiochemistry lab. The equipment includes high purity germanium gamma spectrometers, ion chambers, beta counters, Geiger Muller tubes, and alpha detectors. These instruments are used for experiments and training in nuclear science and radiation detection. One exit monitor is in the control room. A liquid scintillation detector serves both the reactor and broad scope license users. The reactor facility has several systems for performing irradiations, described below.

Rotating Specimen Rack Facility

The rotating specimen rack is located in a well on top of the graphite reflector surrounding the core. The rack consists of a circular array of 40 tubular receptacles, each of which can accommodate two irradiation tubes. The rack automatically rotates during irradiation to ensure each sample receives the same neutron flux. The thermal neutron flux in a rotating rack position at full power is approximately 1.7 $x10^{12}$ n/cm^2s with a cadmium ratio of 6.

Pneumatic Transfer System

The pneumatic transfer system ("rabbit") consists of an irradiation chamber in the outermost F-ring of the core and its associated glovebox, blower and piping. This allows samples to be transferred in and out of the reactor core very rapidly while the reactor is at power. The flux in the core terminal at full power is approximately $5x10^{12}$ n/cm^2s.

In-Core Facilities

The central thimble is a water-filled irradiation chamber about 3 cm in diameter. It provides the highest available neutron flux at full power, approximately $1x10^{13}$ n/cm^2s.

Foil-insertion holes, 0.8 cm in diameter, are drilled at various positions through the grid plates. These holes allow the insertion of special holders containing flux wires into the core to obtain three-dimensional neutron flux maps of the core.

In-Pool Facilities

Near core, in-pool irradiation facilities can accommodate larger samples. Neutron fluxes are lower than in the rotary specimen rack. An iridium gamma irradiator is also in the reactor pool for gamma-only irradiations.

Beam Facilities

The central thimble can be evacuated with gas, producing a vertical neutron beam. The flux above the beam exit at full power is approximately $1x10^6$ n/cm^2s.

INSPECTIONS AND AUDITS

Due to the pandemic, the Nuclear Regulatory Commission did not conduct any inspections during this reporting period. Note the NRC did conduct inspections in June 2019 and in July 2020, but they fall outside of this reporting period.

Dr. Cameron Goodwin, Director of the Rhode Island Nuclear Science Center (RINSC), conducted an external audit on March 16, 2020. The audit discovered no significant concerns and provided several helpful suggestions.

Confirmatory Order

On March 16, 2020 the NRC issued a Confirmatory Order (EA-19-071) to the Reed Research Reactor. The Confirmatory Order was issued due to a failure of the Director to disclose to the NRC potentially disqualifying medical information about two license applicants in 2015. In addition, the Director gave a Controlled Access Area key to an unauthorized individual.

The NRC concluded through its investigations that the Director had willfully failed to provide the NRC with required information, and the Director had willfully violated the Reed's Security Plan. As a result of the investigation the NRC suspended the Director's license for three years.

Reed College has agreed with the Confirmatory Order but disagreed that the Director's apparent violations were willful. Reed completed the actions required by the Confirmatory Order on June 10, 2020. Many requirements of the Confirmatory Order will remain binding on the reactor in the future.

USERS

Reactor Operations Seminar

The Reed Research Reactor conducts an annual seminar series. This non-credit course serves as an introduction to nuclear reactor theory, health physics, and reactor operation. Some of the students are hired and continue with in-depth reactor operator training. Most subsequently apply for a Reactor Operator (RO) license. If successful, the individual is hired to operate the reactor. Current ROs may take the NRC Senior Reactor Operator (SRO) exam to upgrade their licenses.

Due to the pandemic, the NRC only administered one exam during the reporting period. One student was issued a Reactor Operator license after the successful completion of a make-up exam administered in October 2019.

Figure 1 shows the pass rate for RO and SRO since 2000. Figure 2 shows the number of RO and SRO license candidates since 2000.

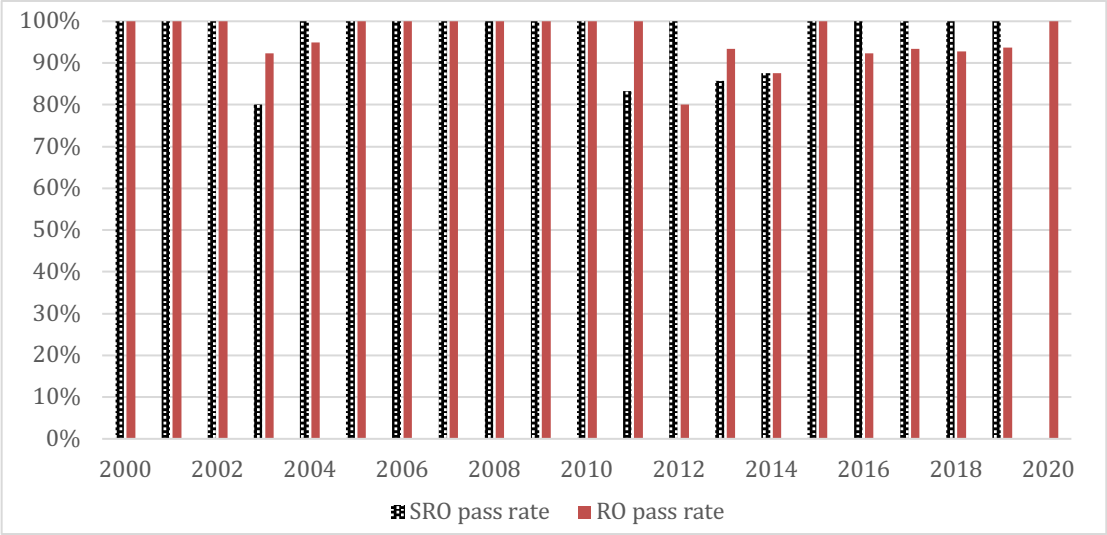

Figure 1 NRC License Exam Results

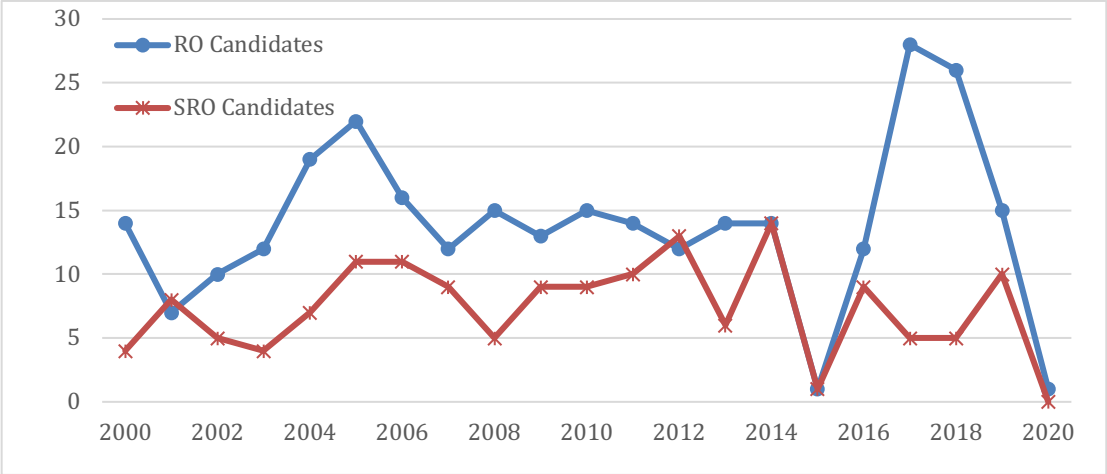

Figure 2 NRC License Candidates

Outside Users

During the reporting period there were 451 visitors from schools, colleges, universities, and special groups. Additionally, 509 individuals visited as part of Reed College activities (prospective students, family of students, Reed classes, etc.). Twelve members of emergency response organizations came for training.

Figure 3 is a graph showing the history of visiting groups since 2000.

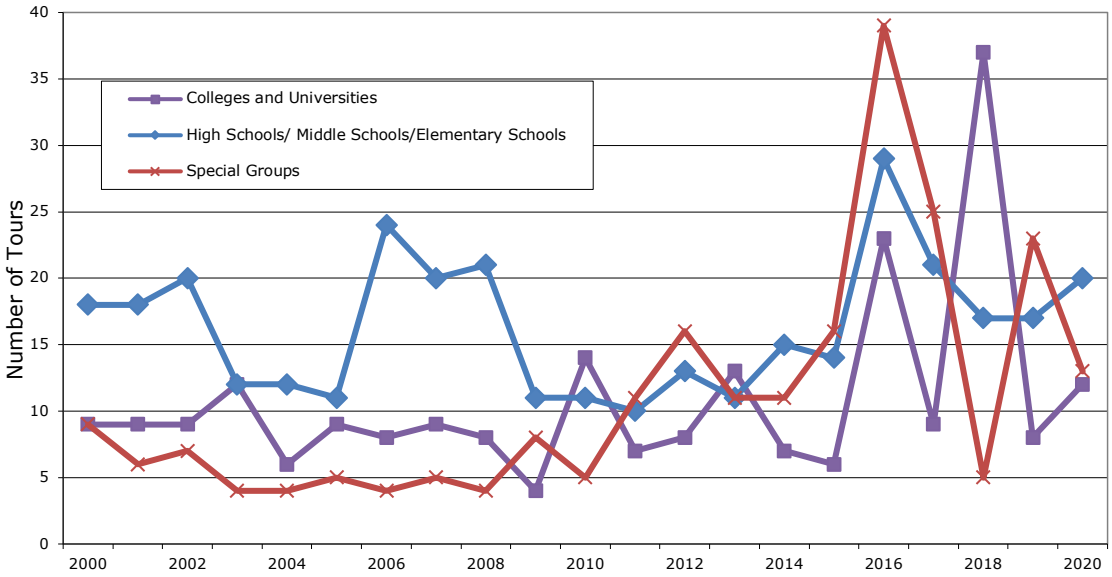

Figure 3 Visiting Groups

Many reactor tours include hands-on use of facility equipment to conduct experiments in radiation science, health physics, and nuclear physics. A typical lab involves determining the half-life of a sample of radioactive material.

Several special programs for gifted children use the reactor for projects. These are designed to enrich their educational program and prepare them for college. Some of the groups who use the reactor target minority and disadvantaged youth who are historically under-represented in science professions.

High School Student Projects

The reactor continues to be used in independent science projects initiated by students from several Oregon and Washington State high schools. This year's projects included:

- Silver self-shielding irradiation in the reactor
- Plant mutation study with a gamma source

Reed Classes

The Fall 2019 Nuclear Literatures class toured the facility.

Theses:

- A biology major used the gamma source.
- A physics major had planned on irradiating superconductor samples for his thesis but was unable to complete the project due to the pandemic.

Industrial and Commercial Applications

The Reed Research Reactor is available for industrial or commercial concerns when it does not conflict with our educational goals. The facility also provides radiation protection training to interested parties and schools in the area, including an annual Radiation Safety Officer (RSO) class. We also provide radiation meter calibration if requested.

REACTOR OPERATIONS

Operations

During the reporting period the reactor was taken critical 279 times on 109 days. The total energy produced was approximately 14.50 megawatt-hours. Operating history by month appears in Table 3. A history of the data is shown in Figure 4.

Table 3 Operating

	Times Critical	Days Operated	MW-Hours
July 2019	25	12	1.21
August 2019	26	13	1.92
September 2019	40	19	1.75
October 2019	30	13	1.90
November 2019	60	15	2.73
December 2019	17	8	0.44
January 2020	10	10	0.87
February 2020	39	9	1.79
March 2020	22	6	0.92
April 2020	0	0	0.00
May 2020	0	0	0.00
June 2020	10	4	0.97
Total	**279**	**109**	**14.50**

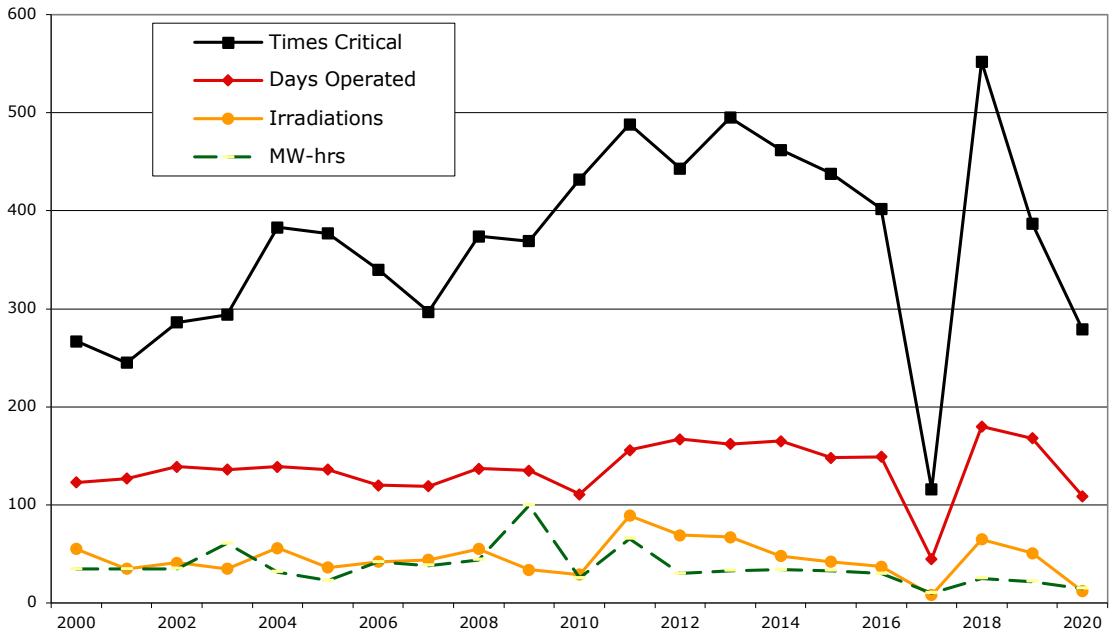

Figure 4 Operating History

Unplanned Reactor Shutdowns

There were 7 inadvertent reactor shutdowns (scrams) during the reporting period as shown in Table 4. The number of unplanned reactor shutdowns since 2000 is shown in Figure 5.

Table 4 Unplanned Shutdowns

Date	Scram Channel	Cause of Scram
Jul 15, 2019	Percent	RO was watching at Linear Channel.
Aug 26, 2019	Linear	RO switched to auto rod and power increased quickly.
Aug 28, 2019	Linear	Auto range was turned off.
Oct 5, 2019	Linear	RO overshot target power of 230kW.
Jan 17, 2020	Linear	RO was calibrating auto demand.
Jan 25, 2020	Linear	RO went up in power too quickly.
Feb 27, 2020	Linear	RO not paying close attention to someone operating under direction while they went up in power.

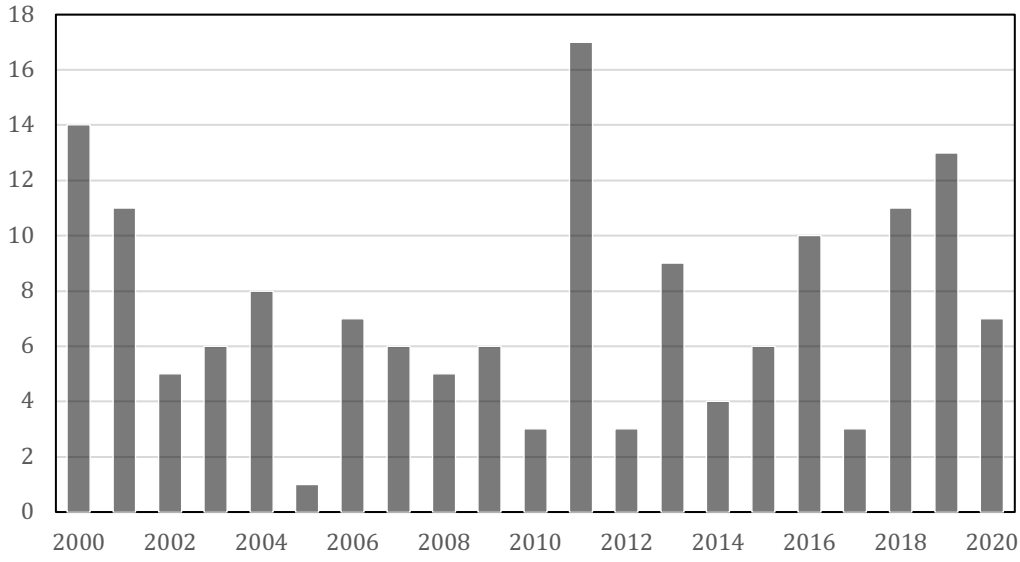

Figure 5 Unplanned Shutdowns

REACTOR MAINTENANCE

Significant Maintenance

Most maintenance items do not require a 50.59 Safety Review because they are screened out by our procedures. There were no 50.59 Safety Reviews required during the reporting period. Reactor staff performed routine equipment checks on a daily, biweekly, bimonthly, semiannual (January and July) and annual (January) basis as required by facility procedures. Reed College maintenance personnel assisted with routine preventative maintenance to auxiliary equipment. The following significant maintenance items were competed during the reporting period.

- Replaced the pool level detector with new model.
- Replaced the CAM vacuum pump.
- Adjusted the GSM low flow alarm weighting factor.
- Replaced a bearing on ventilation supply fan.

RADIATION PROTECTION

Personnel Dosimetry

Dosimeters are changed on a calendar quarter schedule. Individuals are issued beta-gamma sensitive ring badges and whole-body badges.

The highest individual doses received were 7 mrem/quarter Deep Dose Equivalent (DDE) and 35 mrem/quarter Shallow Dose Equivalent (SDE). These doses are well below occupational dose limits and no further action was required.

Fixed Area Dosimetry

Radiation levels are continually monitored to provide an indication of the average radiation levels in the reactor bay and dose outside the facility. All dosimeters monitor beta and gamma radiation. Three locations also measure neutron dose.

The Deep Dose Equivalent (DDE) radiation measured by fixed dosimeters during the period April 1, 2019 to March 31, 2020 are shown in Table 5. The dosimeters from April 1, 2020 to June 30, 2020 are currently being processed. An "M" indicates less than 1 mrem above background during the quarter.

Table 5 Area Radiation Dosimeters
(doses are in mrem per calendar quarter)

Location	Height (m)	Radiation Detected	Apr 1 - Jun 30	Jul 1 - Sep 30	Oct 1 - Dec 31	Jan 1 - Mar 31	Total
Reactor East Wall	1.5	β, γ	8	10	4	1	**23**
Reactor North Wall	1.6	β, γ	8	10	3	2	**23**
Reactor West Wall	1.0	β, γ, n	13	10	2	7	**32**
Reactor South Wall	1.6	β, γ, n	12	10	4	3	**29**
Reactor North Wall - High	2.3	β, γ	12	11	2	1	**26**
Control Room	1.5	β, γ	11	12	5	3	**31**
Outside North	2.8	β, γ	7	5	M	M	**12**
Outside Roof	0.4	β, γ, n	35	6	M	M	**41**
Outside East	1.5	β, γ	4	2	M	M	**6**
Outside South	0.4	β, γ	4	4	M	M	**8**
Counting Room	1.5	β, γ	3	4	M	M	**7**

Gaseous Releases

The only routine release of gaseous radioactivity is from ^{41}Ar (1.83-hour half-life) and ^{16}N (7.13-second half-life). These come from activation of pool water and air in the pool water and in the irradiation facilities. For the reporting period, the average gaseous activity at the site boundary was 1.18×10^{-10} μCi/ml, which would deliver a dose to a member of the public of approximately 0.6 mrem, well below regulatory guidelines and constraints. Figure 6 shows the gaseous releases for each year since 2000.

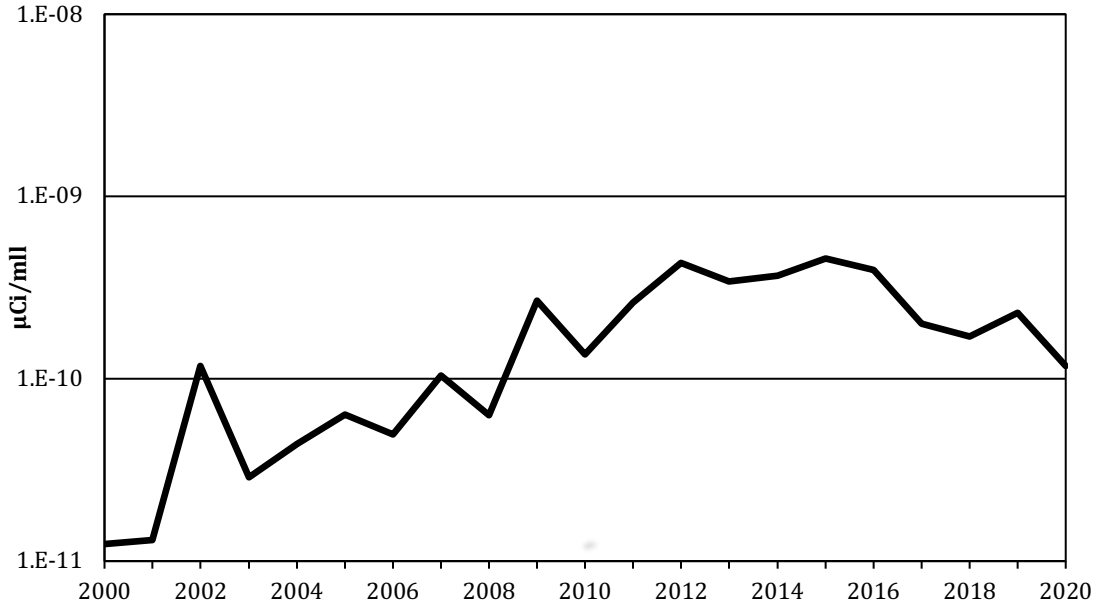

Figure 6 Gaseous Release Activity (μCi/ml) at Site Boundary

Liquid Waste Releases

No liquid radioactive waste was released from the Reed Research Reactor during this reporting period.

Solid Waste Disposal

There were no shipments of low-level radioactive waste from the facility during this reporting period.

Environmental Sampling

All environmental samples were counted in a high purity gamma spectroscopy system. Soil samples taken from the area surrounding the facility showed no activity above background. Water from the facility's secondary cooling system and the nearby canyon were sampled for activation products and tritium; the water samples showed no activity above background.