REED COLLEGE

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Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555

Docket 50-288

Enclosed is Reed College Reactor's Annual Report.

Please feel free to contact me for additional information.

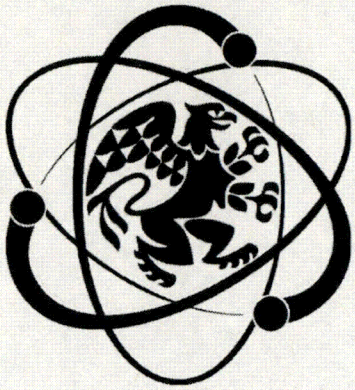
Regards,

Melinda P. Krahenbuhl
Director, Reed College Reactor

A020
NRR

REED RESEARCH REACTOR
ANNUAL REPORT

July 1, 2014 -- June 30, 2015



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OVERVIEW

This report covers the period from July 1, 2014 to June 30, 2015, 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.

We specifically wish to thank Portland General Electric and Concordia University for their financial aid.

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, especially in the field of trace-element analysis.

During the year there were 1387 visitors from schools, colleges, universities, and special groups. Specifically, 666 visitors were part of Reed College activities (prospective students, family of students, Reed classes, etc.). Seventy-two members of emergency response organizations came for training. Finally, there were 28 entries by inspectors and regulators from state and federal agencies. Including tours and research conducted at the facility, the Reed Research Reactor contributed to the educational programs of 16 colleges, universities and K-12.

During the year the reactor was taken critical 438 times on 148 days. The total energy produced was approximately 32.95 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, 1 reactor operator and 1 Senior Reactor Operator candidate passed their respective NRC exams. Results of the NRC exam administered in May (15 Reactor Operator candidates, 7 senior Reactor Operator Candidates) have not been received.

There were no radiation exposures to individuals in excess of the limit during the year. There were no releases of liquid radioactive material from the facility and airborne releases were well within regulatory limits. There was one shipment of low-level radioactive waste from the facility.

The Nuclear Regulatory Commission conducted an inspection December 8-11, 2014.

PEOPLE

Reactor Staff

Reed College eliminated the position of Assistant Director and replaced it with Reactor Operations Manager. Brian Fairchild was hired as the Reactor Operations Manager in July 2013. During the period July 1, 2013 to June 30, 2014, the staff consisted of:

Reactor Director:	Melinda Krahenbuhl	(6/11 - present)
Reactor Operations Manager:	Brian Fairchild Christina Barrett	(7/13 – 12/14) (6/14 – present)
Radiation Safety Officer:	Kathleen Fisher	(1/03 – present)
Operations Supervisor:	Christina Barrett	(5/13 – 6/14)
Training Supervisor:	Ilana Novakoski Sarah Black	(5/14 – 5/15) (5/15 – present)
Training Supervisor:	Alexandra Mariani Charlie McIntyre	(5/14 - 5/15) (5/15 – present)
Requalification Supervisor:	Wilson Horner Jowie Koh	(5/14 - 5/15) (5/15 - present)
Projects Supervisor	Hannah Choi Malcolm McCarthy	(5/14 - 5/15) (5/15 - present)

Senior Reactor Operators (SRO)			
Christina Barrett	Josh Hepworth	Simran Mahtani	Evan Peairs
Lily Ben-Avi	Wilson Horner	Charlie McIntyre	Helena Pedrotti
Hannah Choi	Melinda Krahenbuhl	Ilana Novakoski	Nathan Showell
Michael Conner	Jake Luton	Rachael Otto	Natalie Stone
Brian Fairchild	Alexandra Mariani	Alexander Pan	Reilly Villanueva
Reactor Operators (RO)			
Sarah Black	Hunter Gill	Stephan Okar	Riley Thornton
Audrey Dannar	Elisabeth Grace	Edgar Perez	
Kevin Freymiller	Jowie Koh	Grace Poetzinger	
Vincent Griffith	Malcolm McCarthy	Nicole Scherm	

The list of operators includes everyone who held a license at any time during the reporting period. Reactor Operators who upgrade their licenses to Senior Reactor Operators during the reporting period are listed under Senior Reactor Operators. For the 2014-2015 year. There are 33 licensed operators at Reed College, 16 women and 17 men.

Reactor Operations Committee (ROC)

For the 2014 – 2015, the membership of the Reactor Operation committee is listed.

Reactor Operations Committee

- Wayne Lei - (Director of Research and Development, Portland General Electric)
- Norm Dyer (OAR Services)
- Johnny Powell (Physics Faculty, Reed College)
- Robert McCollough (Neighborhood Association)
- Kathleen Fisher (Director, Reed Environmental Health and Safety)
- Dan Gerrity – (Chemistry Faculty, Reed College)
- Steve Reese (Radiation Center Director, Oregon State University)
- Nigel Nicholson (Dean of the Faculty, Reed College)
- Melinda Krahenbuhl (Director, RRR)
- Brian Fairchild (Reactor Operations Manager, RRR)
- Christina Barrett (Supervisor, RRR)

FACILITIES

Reactor Facility

In addition to the reactor, Reed College has a radiochemistry lab. The equipment available at the reactor facility includes high purity germanium gamma spectrometers, a whole body counter, ion chambers, beta counters, Geiger Muller tubes, neutron detectors, alpha detectors, and thermo luminescent dosimeter readers. These instruments are used for experiments and training in nuclear science and radiation detection. Two exit monitors are 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. Vials holding up to 17 ml (four drams) are used in this system. Samples are loaded in the specimen rack prior to the start-up of the reactor. The rack automatically rotates during irradiation to ensure each sample receives the same neutron flux. Typically, researchers use the rotating rack when long irradiation times (generally greater than five minutes) are required. The approximate thermal neutron flux in a rotating rack position at full power is 1.7×10^{12} n/cm^{2}s with a cadmium ratio of 6. The specimen rack can be used for gamma irradiations (approximately 8 Rad/min) when the reactor is shutdown.

Pneumatic Transfer System

The pneumatic transfer system ("rabbit") consists of an irradiation chamber in the outer F-ring of the core and its associated blower and piping. This allows samples to be transferred in and out of the reactor core very rapidly while the reactor is at power.

Routine use of the pneumatic transfer system involves placing samples into vials, which in turn are placed in special capsules known as "rabbits." The capsule is loaded into the system in the laboratory next to the reactor and is then transferred pneumatically into the core-irradiation position. At the end of a predetermined time the sample is transferred back to the receiving terminal, where it is removed for measurement. The transfer time from the core to the terminal is about seven seconds, making this method of irradiating samples particularly useful for experiments involving radioisotopes with short half-lives. The flux in the core terminal is approximately 5×10^{12} n/cm^{2}s when the reactor is at full power.

In-Core Facilities

The central thimble is a water-filled irradiation chamber about 3 cm in diameter. It provides the highest available neutron flux, about 1×10^{13} n/cm^{2}s. Special sample holders are used in the central thimble to provide maximum flexibility in experiment design.

A fuel replacement source holder assembly can also be used as an irradiation facility. The chamber fits into a fuel-element position within the core itself. It holds only one specially positioned irradiation container 7.5 cm in length and 2.5 cm in diameter.

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

In-Pool Facilities

Near core, in-pool irradiation facilities can be arranged for larger samples. Neutron fluxes will be lower than in the rotary specimen rack and will depend on the sample location. 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. This beam can be used to generate directional neutron flux, or for limited irradiations above the tank. Prompt gamma analysis and neutron radiography can be done. The flux above the beam exit is approximately $1x10^6$ n/cm^{2}s when the reactor is at full power.

INSPECTIONS AND AUDITS

The Nuclear Regulatory Commission conducted an inspection during December 8-11, 2014. No deficiencies were identified.

One audit was completed during this period. Scott Menn (Health Physicist -Oregon State) conducted an external audit on May 12, 2015. Recommendations are currently being evaluated.

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 continue with in-depth reactor operator training and subsequently apply for a Reactor Operator (RO) license. If successful, the individual may be hired to operate the reactor. In addition, existing ROs may take the NRC Senior Reactor Operator (SRO) exam to upgrade their licenses.

During the reporting period, 1 out of 1 RO candidates and 1 out of 1 SRO candidates passed their NRC exams. Fifteen RO candidates and 7 SRO candidates took exams in May 2015. The results from the May exams have not returned at the time of this report.

Figure 1 is a graph of the pass rate for RO and SRO since 2000.

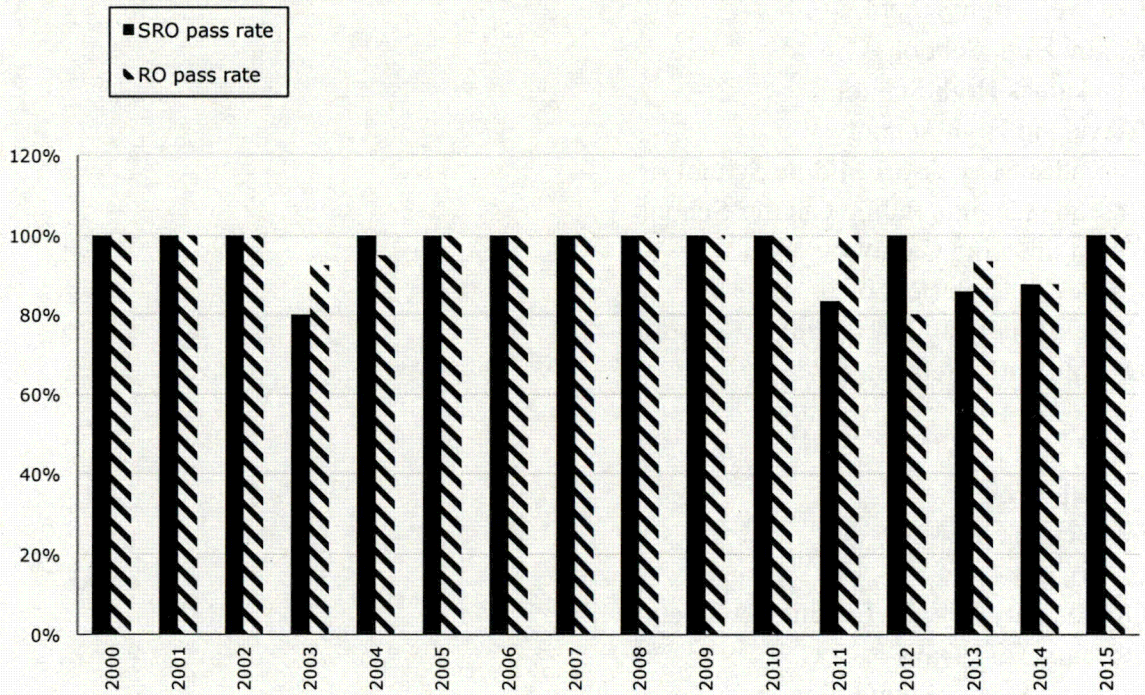

Figure 1 Reed Research Reactor License Exam Results

Outside Users

During the year there were 1387 visitors from schools, colleges, universities, and special groups. Additionally, there were 666 visitors as part of Reed College activities (prospective students, family of students, Reed classes, etc.). Seventy-two members of

emergency response organizations came for training. Finally, there were 28 entries by inspectors and regulators from state and federal agencies.

The following institutions have participated in facility tours, experiments, and research projects in the reporting period.

Colleges and Universities

Portland Community College, Rock Creek
Oregon Institute of Technology
Portland State University
Warner Pacific College
Pacific University
Concordia University

High Schools /Middle Schools/Elementary Schools

Creswell High School
Canby High School
Clackamas High School
Cleveland High School
Cascades Montessori Middle School
Cascade Heights Public Charter School
Christ the King Catholic School
Roosevelt High School
French American International School
Lincoln Park Elementary

Special Groups

Women in STEM
RSO Class
Oregon City Service Learning Academy
Obscura Tour Days
I Have a Dream Foundation
AWSEM Girls Camp
Boy Scouts Troop 113
Talented and Gifted
TRTR
iUrban Teen Tech
Lewis and Clark Science Club
Latin Forum
Cub Scouts Pack 799
Science Outreach

Figure 2 is a graph showing the history of visiting groups.

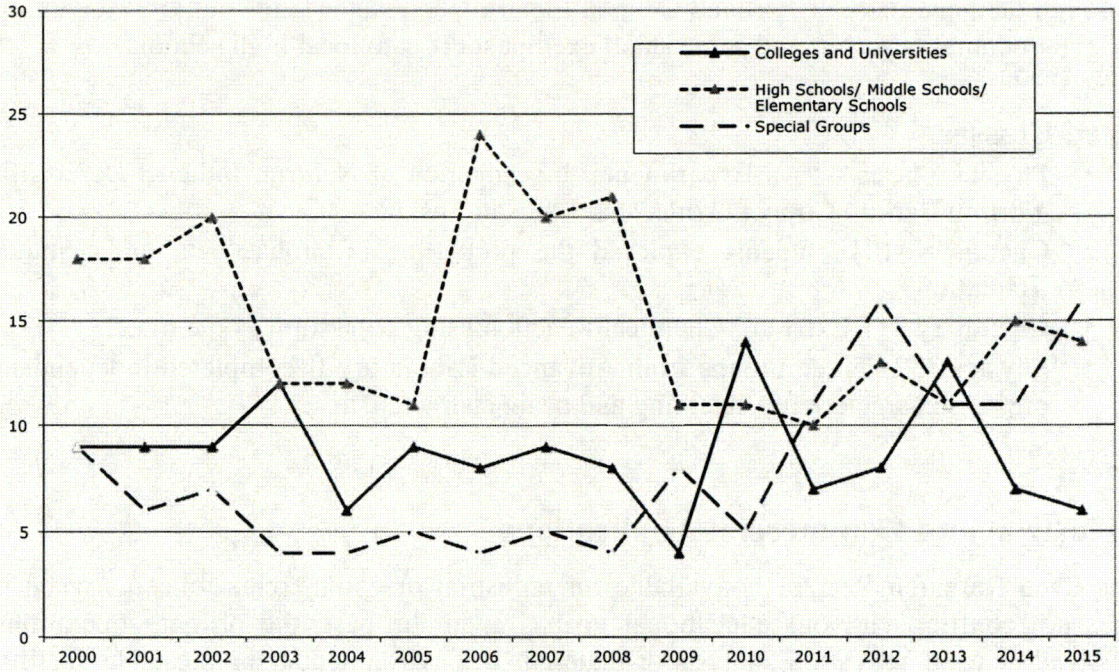

Figure 2 Visiting Groups

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 background of a Geiger Muller scaler system and then determining the half-life of a sample of radioactive material. College classes are generally more closely tailored to the individual interests and needs of the Consortium faculty member involved. Experiments include more direct use of the reactor itself by the students, more detailed analysis of materials, and emphasize the incorporation of other classroom activities as much as possible.

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. Additionally several Boy Scouts of America troops have visited the facility to complete the Nuclear Science merit badge.

High School Student Project

The Reed Research Reactor continues to be used in independent science projects initiated by students from several Oregon and Washington State high schools.

Concordia University

The reactor provides training and experiments involving radiation, radioactive material, and trace element analysis for Concordia University classes.

Scaler Kits

Through the generosity of Portland General Electric, the reactor lends out kits containing a Geiger counter, a scaler, and some small exempt sources to local high schools.

Reed Classes

- Physics Thesis – "An Experimental Investigation of Neutron Induced Defects in Yttrium Barium Copper Oxide." M. Kai Nalipinski.
- Chemistry 101 students explored the properties of alpha, beta and gamma irradiation.
- Chemistry 311 Extent of Chemical Reaction using potassium as the tracer
- Physics 332 -Three groups from Advanced Laboratory II completed independent projects characterizing shielding and beam characteristics.

Industrial and Commercial Applications

The Reed Research Reactor is available for industrial or commercial concerns when it does not conflict with our educational goals. As in the past, the primary operations involved neutron activation analysis of materials or environmental samples. The facility also provides radiation protection training to interested parties and schools in the area.

REACTOR OPERATIONS

Operations

During the year the reactor was taken critical 438 times on 148 days. The total energy produced was approximately 33 megawatt-hours. Operating history by month appears in table 1. A history of the data is shown in figure 3.

Table 1 Operating History 2014-2015

	TIMES CRITICAL	DAYS OPERATED	MW-HOURS
July 2014	11	7	1.06
August 2014	27	12	2.40
September 2014	57	17	4.19
October 2014	67	15	3.42
November 2014	59	19	2.68
December 2014	31	14	2.66
January 2015	10	6	1.72
February 2015	17	8	3.19
March 2015	41	12	3.19
April 2015	46	16	2.85
May 2015	45	13	3.14
June 2015	27	9	2.45
Total	438	148	32.95

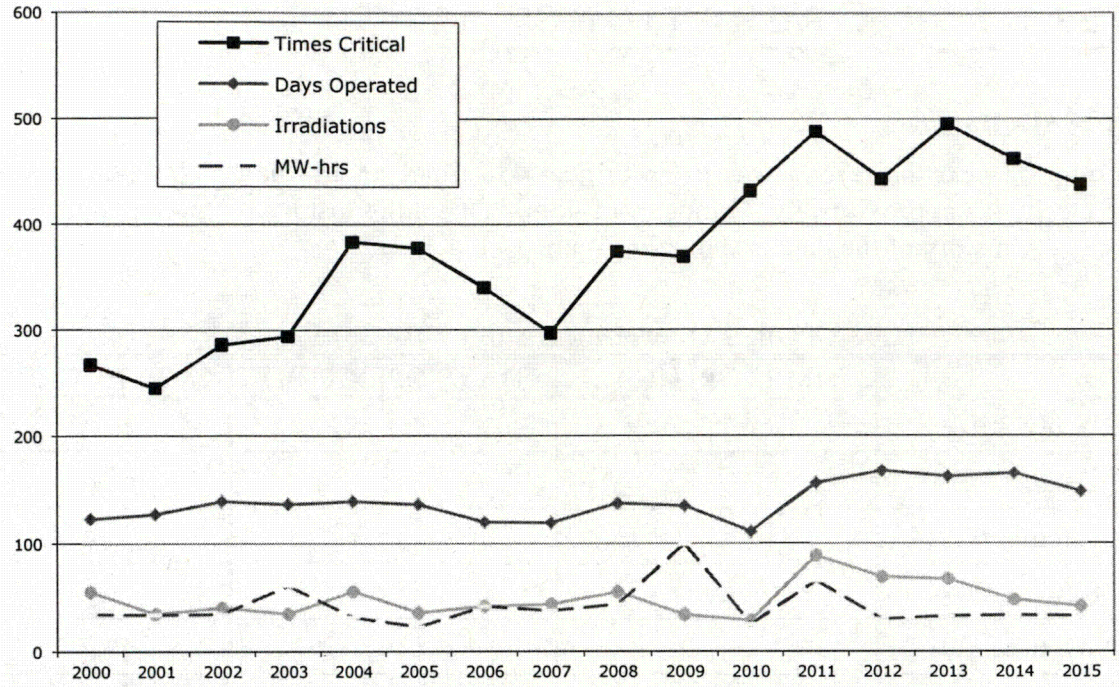

Figure 3. Operations

Unplanned Reactor Shutdowns

There were 6 inadvertent reactor shutdowns (scrams) as shown in table 2. The number of unplanned reactor shutdowns is shown in figure 4.

Table 2 Unplanned Reactor Shutdowns

DATE	SCRAM TYPE	CAUSE OF SCRAM
Oct. 11, 2014	Linear High Power	Overshot high power SCRAM set point
Nov. 7, 2014	Linear High Power	Overshot high power SCRAM set point
Nov. 15, 2014	Linear High Power	Overshot high power SCRAM set point
Nov. 20, 2014	Linear High Power	Overshot high power SCRAM set point
Mar. 26, 2015	Linear High power	Overshot high Power SCRAM set point
Apr. 24, 2014	Linear High Power	Overshot high Power SCRAM set point

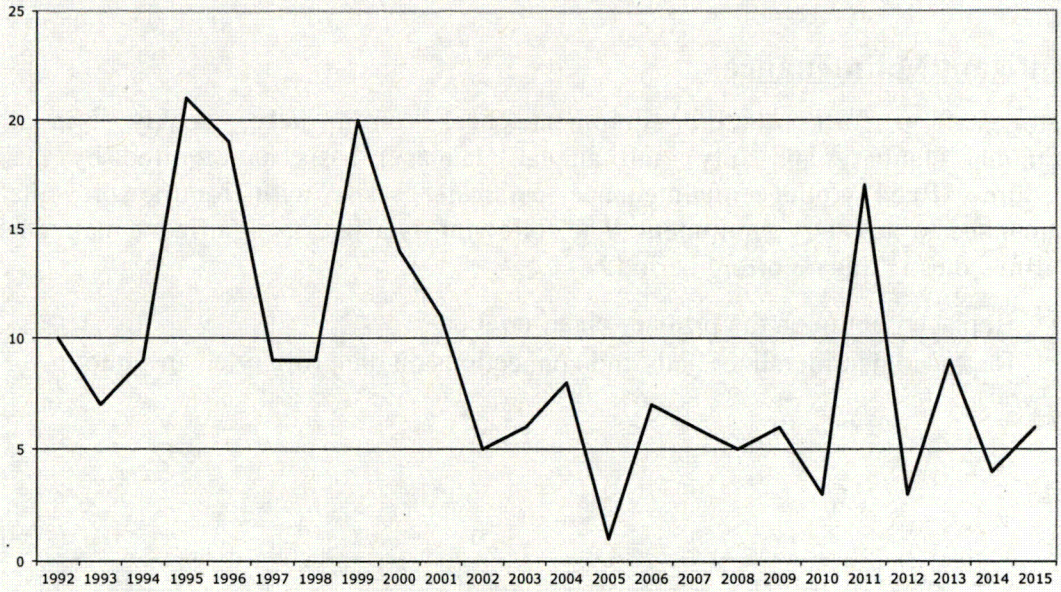

Figure 4 Unplanned Shutdowns

REACTOR MAINTENANCE

Significant Maintenance

Reactor staff performs routine equipment checks on a daily, weekly, bimonthly, semiannual (January and July) and annual (January) basis as required by facility procedures. Reed College maintenance personnel assist with routine preventative maintenance to auxiliary equipment. The following is a list of significant maintenance preformed during this reporting period.

- Replaced pump on the primary clean-up loop
- Replaced demineralizer beds and connections on the primary clean-up loop

RADIATION PROTECTION

Personnel Dosimetry

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

Two individuals received doses to their extremities. The highest recorded extremity dose was 2930 mrem for the quarter ending 6/30/2015. A single individual chest badge recoded a deep dose equivalent of 4 mrem, shallow dose equivalent of 17 for the quarter ending 6/30/2015. A root cause investigation was intiated, but has not been completed prior to the issuance of this report.

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 radiation measured by fixed dosimeters during the period July 1, 2014 to June 30, 2015 are shown in table 5. An "M" indicates less than 1 mrem during the quarter.

Table 3 Area Radiation Dosimeters
(doses are in mrem per calendar quarter)

LOCATION	HEIGHT (M)	RADIATION DETECTED	JUL 1 – SEP 30	OCT 1 - DEC 31	JAN 1 - MAR 31	APR 1 - JUN 30	TOTAL
Reactor East Wall	1.5	β, γ	0	2	3	M	5
Reactor North Wall	1.6	β, γ	7	6	6	3	22
Reactor West Wall	1.0	β, γ, n	21	6	10	10	47
Reactor South Wall	1.6	β, γ, n	3	6	4	6	19
Reactor North Wall	2.3	β, γ	2	5	7	8	22
Control Room	1.5	β, γ	3	3	1	1	8
Outside North	2.8	β, γ	M	M	M	M	M
Outside Roof	0.4	β, γ, n	M	M	M	M	M
Outside East	1.5	β, γ	M	M	M	M	M
Outside South	0.4	β, γ	M	M	M	M	M
Counting Room	1.5	β, γ	M	M	M	M	M

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 4.57×10^{-10} μCi/ml, which would deliver a dose to a member of the public of approximately 2.29 mrem, well below regulatory guidelines and constraints. Figure 5 shows the gaseous releases for each year.

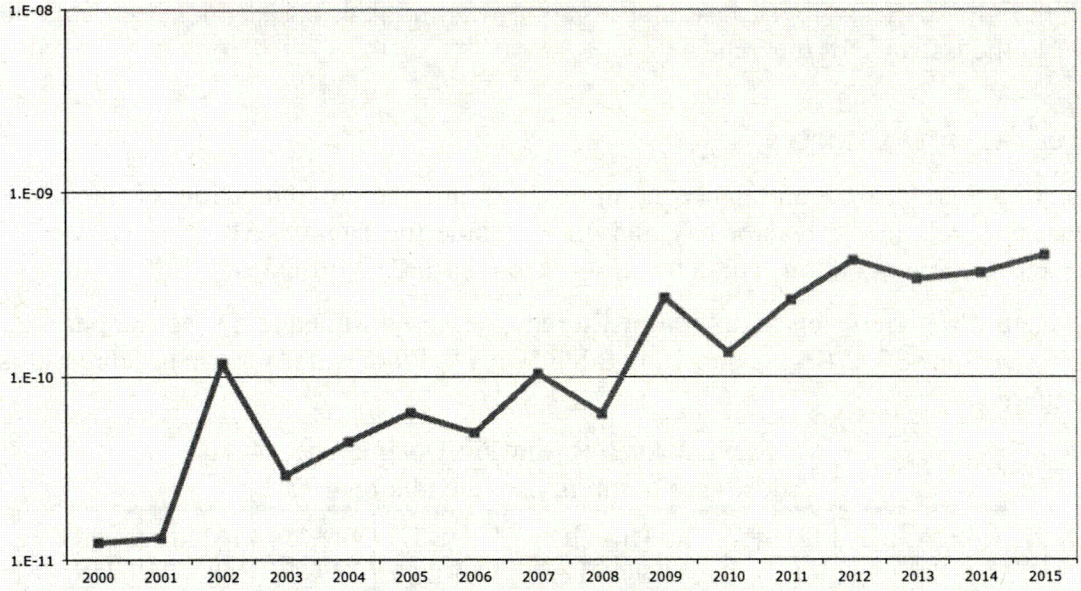

Figure 5 Gaseous Releases Activity (μCi/ml) at Site Boundary

Liquid Waste Releases

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

Solid Waste Disposal

There was 1 shipment of low-level radioactive waste from the facility during this reporting period.

Table 4 Solid Waste Disposals

Date	Activity	Nuclides
7/14/14	2.57 MBq (0.0696 mCi)	Ag110m, C14, Ce141, Co58, Co60, Cr-51, Cs134, Cs137, Eu152, Fe59, H3, K40, Mn54, Na 22, Nb95, Ru103, Sb124, Sc46, Se75, Sm153, Sr85, Ta182, Tb160, Zn65, Zr95
7/14/14	4 MBq (0.1083 mCi)	Ag 110m, Co58, Co60, Mn 54, Sr85, Zn 65

Environmental Sampling

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, but showed no activity above normal background.