Texas A&M University System

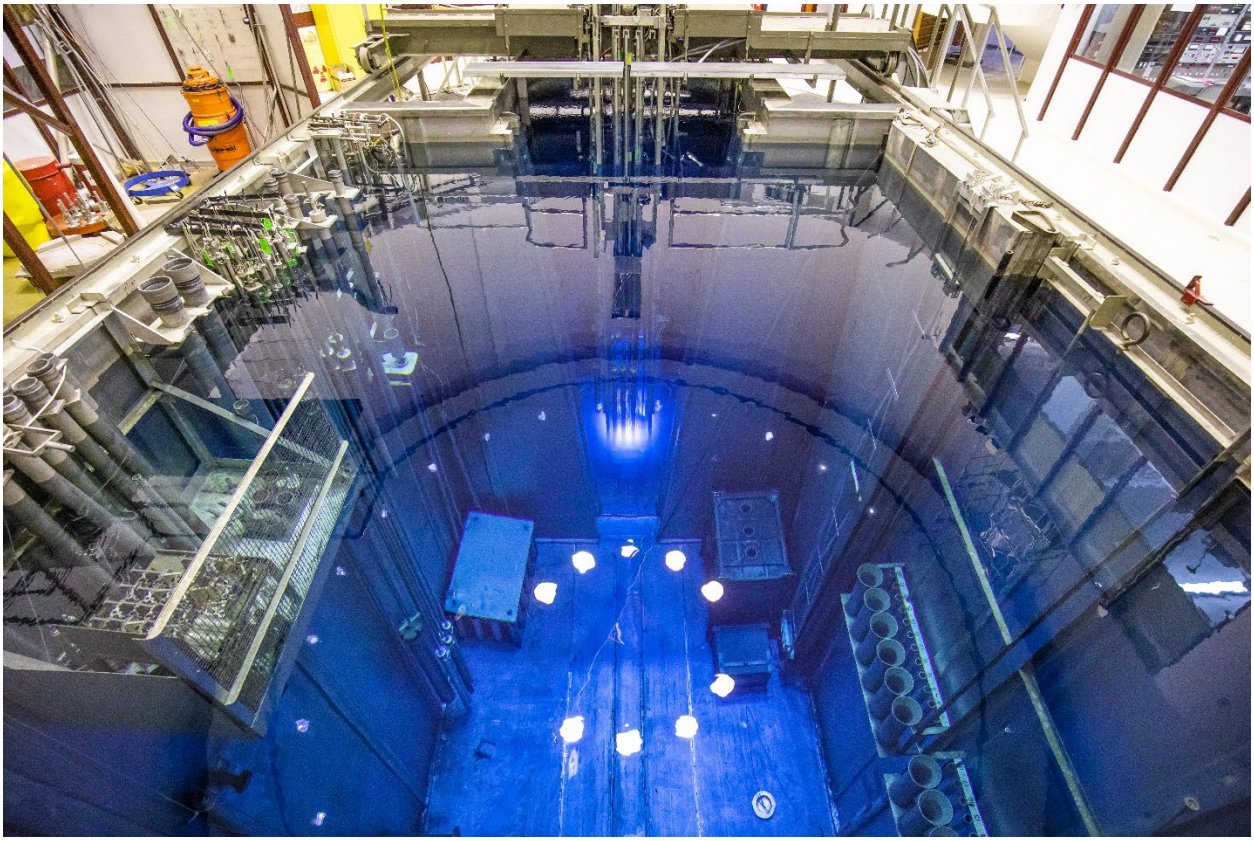
Texas A&M Engineering Experiment Station

Annual Report 2020

Nuclear Science Center Reactor

Facility Operating License R-83

Docket No. 050-00128



THE TEXAS A&M UNIVERSITY SYSTEM

TEXAS A&M ENGINEERING EXPERIMENT STATION
Nuclear Engineering & Science Center

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1 Introduction

The Texas A&M Engineering Experiment Station Nuclear Science Center (NSC) is a multi-disciplinary research and education center supporting basic and applied research in nuclear related fields of science and technology as well as providing educational opportunities for students in these fields as a service to the Texas A&M University System (TAMUS) and the state of Texas. The NSC also provides services to commercial ventures requiring radiation or isotope production services.

The NSC reactor is a 1 MW TRIGA research reactor in a large (108,000-gal.) pool. The size of the NSC reactor pool provides great flexibility in the experiments that may be conducted near the reactor. The NSC reactor facility includes five neutron beam ports, a neutron/gamma irradiation cell, hot cells with manipulator arms, and other supporting facilities.

Laboratory facilities include counting laboratories with gas flow proportional detectors and high purity germanium detectors, a pneumatics sample transfer system, and a fast neutron irradiation system.

The NSC reactor design allows for easy loading/unloading of various types of samples. The NSC actively produces a variety of radioisotopes for academic and industry users. The NSC provides neutron activation analysis (NAA) services to many research and academic institutions in the United States. The Nuclear Engineering Department on campus is a major user of the NSC reactor. The NSC is also one of the major attractions on campus. For the calendar year 2020, the NSC hosted a limited number of visitors due to the Covid restrictions placed on TAMUS facilities.

This annual report has been prepared to satisfy the reporting requirements of Technical Specification 6.6.1 of the facility operating license R-83 and of the Department of Energy University Reactor Fuel Assistance Program subcontract No. C87-101594 (DE-AC07-76ER02426).

1.1 Nuclear Science Center Staff

The staff at the Nuclear Science Center consists of three major groups: Reactor Operations, Radiation Safety, and Engineering. Personnel directly involved with the operation and maintenance of the reactor are NRC-licensed operators. The NSC is committed to its educational responsibilities and many members of the staff are part or full-time students at Texas A&M University. Appendix A shows the Nuclear Science Center Organization Chart.

The Texas A&M Engineering Experiment Station (TEES) of the Texas A&M University System operates the NSC. The Director of the NSC is responsible to the Director of the TEES for the administration and the proper and safe operation of the facility. The NSC Radiation Safety Officer is responsible to the Director of the NSC for matters relating to safety and for maintaining a proper radiation safety program. In addition to the internal structure, the Reactor Safety Board (RSB) advises the Director of the TEES and the Director of the NSC on issues or policy pertaining to reactor safety. Texas A&M Environmental Health and Safety (EHS) provides assistance when required for emergencies and for special operations as agreed. The Texas A&M University Police Department provides security support on a daily basis and is a key support group in the event of a security incident. The College Station Fire Department and Scott & White Medical Center provide offsite emergency support when required as per agreement.

There were two changes to the NSC staff in 2020. Jerry Newhouse, the Associate Director, and Cameron McDonald, the Reactor Supervisor, both left in October 2020 for other opportunities. The positions remained unfilled for the remainder of the calendar year. Duties of the Reactor Supervisor were assumed by the Manager of Operations until the position could be filled.

2 Reactor Utilization for 2020

The NSC reactor has been in operation since 1961. The reactor is a 1 MW MTR-converted TRIGA reactor. Core IX is the current core configuration and has been in use since September 2006. The NSC reactor is pulse operational and was pulsed up to $1.68 for nuclear engineering laboratories, staff training, and public tours.

The NSC reactor operated for 696.4 hours in 2020 with a total integrated power of 22.49 MW-days. There were 285 “Requests for Irradiation” processed at the NSC during the reporting period. The NSC provided services to TAMU departments, other universities, research centers, secondary schools, and industry partners in and outside the state of Texas. The cumulative total energy output since initial criticality of the LEU fuel is 1027.7 MW-days. Table 2 shows the reactor utilization summary in 2020 and Figure 2 shows the annual reactor utilization in MW-hrs of operation.

Table 2: Reactor Utilization Summary in 2020

Days of Reactor Operation	144
Integrated Power (MW-days)	22.49
Number of Hours at Steady-State	696.36
Number of Pulses	10
Number of Reactor Irradiations (RFS)	285
Unscheduled Shutdowns	8

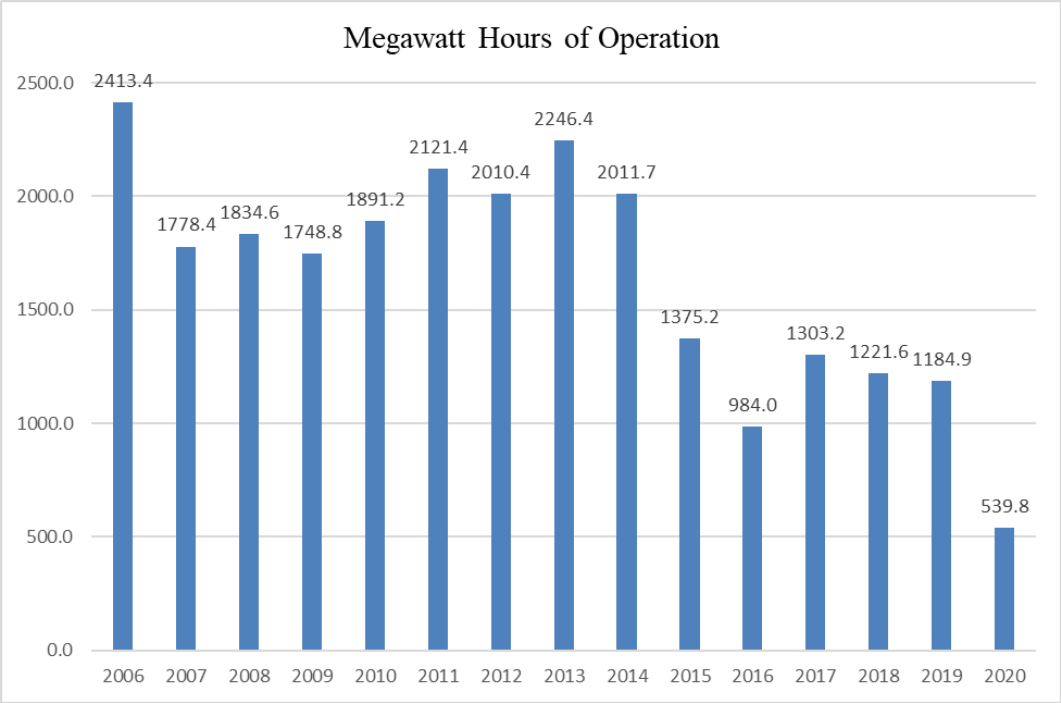

Figure 2. Annual Reactor Utilization in MW-hrs of Operation

2.1 TAMU Academic Support Program

Texas A&M University provides funding for the reactor for such academic activities as nuclear engineering laboratories. The wide range of academic users from the university reflects in the NSC's reputation as a multi-disciplinary institution.

2.2 Commercial Activity and External Research

The NSC provides services to a variety of users that provide their own funding. The majority of commercial activities focus on production of radioactive tracers for the petroleum and chemical industries. Outside research grants fund a significant amount of the NSC's research. The NSC has many years of experience producing radioisotopes and has developed several customer-specific methods for radioactive sample production and handling. The production of radioisotopes generally involves handling radioactive material with high activities. The NSC staff takes precautions to minimize the exposures during the transfer of radioactive materials to shipping shields.

3 Facility and Procedure Changes

3.1 Facility Modifications

There were no new Facility Modifications performed in 2020.

3.2 Experiment Authorization and Modification Authorization

There were no new Experiment Authorizations (EA) or Modification Authorizations (MA) in 2020.

4 Reactor Maintenance and Surveillance

4.1 Scheduled Maintenance

NSC personnel performed regular maintenance on all channels as required by the Technical Specifications. Control rod worth and scram time measurements performed in June 2020 gave the following results. The total rod worth was $15.97. The most reactive control rod was Shim Safety #4 with a worth of $4.16. The shutdown margin was $4.253 and core excess was $5.62. Scram times on all rods were less than 1.2 seconds. In addition, operators performed calorimetric calibration following each maintenance period, and fuel inspections with no abnormalities noted (as required by the Technical Specification).

4.2 Unscheduled Shutdowns

There were eight unscheduled reactor shutdowns during 2020. The cause is detailed below in Table 4-2.

Table 4-2: Unscheduled Shutdowns

01/02/20	FAM Channel was not showing correct data, Operator shut down.
01/29/20	Spurious electronic signal caused experimental scram.
02/06/20	FAM Channel was not showing correct data, Operator shut down.
06/03/20	Shim safety 1 rod dropped while operating
06/16/20	Shim safety 4 rod dropped while operating
06/20/20	Shim safety 2 rod dropped while operating
09/11/20	Linear range display stopped operating
10/15/20	Lost facility power
10/20/20	FAM computer failed

4.3 Emergency Plan and Review

The members of RSB reviewed the NSC Security and Emergency Plans.

4.4 Reactor Safety Board

The Reactor Safety Board is responsible for providing an independent review and audit of the safety aspects of the NSC reactor. The Reactor Safety Board met as required in the year 2020.

4.5 Audits

The Reactor Safety Board performed the required audits and inspections as per the Technical Specifications requirement. The results of the audit were shared with the RSB members.

4.6 NRC Inspection Results

Facility inspections were performed by the U.S. Nuclear Regulatory Commission in December 2020.

5 Health Physics Surveillance

The purpose of Health Physics surveillance is to ensure safe use of radioactive materials in the Nuclear Science Center's research and service activities and to fulfill the regulatory requirements of the U.S. Nuclear Regulatory Commission and State agencies. The NSC maintains a Health Physics group as an integral part of the organization. It is responsible for radiological as well as chemical and physical safety concerns. The radiation safety team at the TAMU Environmental Health and Safety Department provides additional support to the NSC Health Physics group upon request.

5.1 Personnel Monitoring

Personnel Monitoring was provided on a monthly basis to approximately 52 personnel. All measured doses to personnel were below the limits set forth in 10 CFR 20. The highest deep dose equivalent (DDE) recorded was 0.328R for the year. Airborne monitoring during sample handling continued to show no significant airborne activity, therefore, total effective dose equivalent will equal deep dose equivalent for 2020.

During 2020, no visitors, with the few exceptions of interested researchers, toured the Nuclear Science Center due to COVID restrictions. Minimal exposures were measured with pocket ion chambers worn by these visitors and the pocket ion chamber readings of their respective tour guides.

NSC employees who were likely to exceed 10% of their total annual dose wore whole body badges (Luxel dosimeter) and extremity badges (TLD dosimeters) that were provided by Landauer, a NVLAP accredited supplier. Landauer also provides the reports of the doses received. Employees who potentially handle more radioactive materials on a regular basis were provided two extremity badges and were exchanged on a monthly basis..

5.2 Facility Monitoring

Surveys of the Nuclear Science Center facilities were performed to assess radiological hazards to NSC workers. Radiation levels and sources of radioactive contamination were routinely monitored. All areas accessible to the general public at the NSC were surveyed for radiation and contamination levels monthly by ion chamber readings and evaluation of smear samples. Areas where contamination is expected are access/egress controlled and are evaluated on shorter intervals as needed. Building monitors and Area monitors are located strategically throughout the reactor facility, providing dose equivalent (mrem) on a monthly basis. Table 5-2 summarizes the annual accumulated dose equivalent (mrem) recorded on the area monitors for the year 2020.

Table 5-2: Total Dose Equivalent (mrem) Recorded on Area Monitors

Monitor ID	Location	Accumulated Dose Equivalent (mrem)
BLDG MNTR 1	Upper Research Level Mezzanine	525
BLDG MNTR 2	Lower Research Level Mezzanine	1322[a]
BLDG MNTR 3	Lower Research Level	20295[a]
AREA	Control Room	24
AREA	Upper Research Level	277
AREA	Room next to MHA	1194[b]

[a]Radioactive shipments were stored in the LRL area pending transport

[b]Radioactive materials were stored in the temporary locations in MHA.

5.3 Particulate Effluent Monitoring

Radioactive particulates were monitored at the base of the central exhaust stack and summarized on a monthly basis. The annual average release concentration was $1.49x10^{-18}$ µCi/cc. The total radioactivity released for 2020 was $4.42x10^{-3}$ µCi. Table 5-3 summarizes monthly particulate effluent releases during 2020. The most common isotopes noted during particulate effluent releases were Sc-46, Sb-124, and Ir-192.

Table 5-3: Particulate Effluent Releases

Quarter	Month	Particulate Activity from channel 1 (uCI)	Exhaust Volume (cc)	Additional releases (µCi)	Dilution Concentration (µCi/cc)	Total activity released (Ci)
I	January	<BG	9.96E+12	0.00E+00	<BG	<BG
	February	2.25E-03	9.32E+12	0.00E+00	1.21E-18	2.25E-09
	March	3.56E-03	9.96E+12	0.00E+00	1.79E-18	3.56E-09
	Average:	5.81E-03	2.92E+13	0.00E+00	9.94E-19	5.81E-09
II	April	<BG	9.64E+12	0.00E+00	<BG	<BG
	May	7.08E-03	9.96E+12	0.00E+00	3.55E-18	7.08E-09
	June	1.71E-03	9.64E+12	0.00E+00	8.90E-19	1.71E-09
	Average:	4.40E-03	9.74E+12	0.00E+00	2.26E-18	4.40E-09
III	July	<BG	0.00E+00	0.00E+00	<BG	<BG
	August	3.26E-03	0.00E+00	0.00E+00	1.64E-18	3.26E-09
	September	<BG	0.00E+00	0.00E+00	<BG	<BG
	Average:	3.26E-03	0.00E+00	0.00E+00	5.51E-19	3.26E-09
IV	October	2.01E-03	9.96E+12	0.00E+00	1.01E-18	2.01E-09
	November	1.75E-03	9.64E+12	0.00E+00	9.10E-19	1.75E-09
	December	8.89E-03	9.96E+12	0.00E+00	4.46E-18	8.89E-09
	Average:	4.22E-03	9.85E+12	0.00E+00	2.14E-18	4.22E-09
Summary YTD		**4.42E-03**	**1.22E+13**	**0.00E+00**	**1.49E-18**	**4.42E-09**

notes:

1. Activity released from the stack: Activity sampled from Ch 1 multiplied by volume of air going through the stack
2. Diluted Concentration equal to: Activity Released/exhaust volume * 0.005 (Technical Specification 3.5.2, dilution value for release concentration at exclusion boundary)
3. Exhaust Volume equal to: (# days/month)*(24hrs/day)*(60min/hr)*(7875 cfm)/ 3.53E-5cc)
4. Additional Release equal to: (Individual releases calculated from facility air monitoring data)
5. Total Release equal to: (Activity Released+Additional Releases)*conversion factor

5.4 Gaseous Effluent Monitoring

Argon-41 is the major gaseous effluent produced and released at the Nuclear Science Center. This effluent is monitored at the central exhaust stack. Total Argon-41 released during 2020 was approximately 1.67×10^{-4} Ci with an annual average release concentration of 2.84×10^{-14} µCi/cc. Table 5-4 summarizes monthly gaseous effluent (Ar-41) releases during 2020.

Table 5-4: Gaseous Effluent (Ar-41) Releases

Quarter	Month	Argon-41 Activity from channel 3 (µCi)	Exhaust Volume (cc)	Additional releases (mCi)	Dilution Concentration (µCi/cc)	Total activity released (Ci)
I	January	<BG	9.96E+12	0.00E+00	<BG	<BG
	February	<BG	9.32E+12	0.00E+00	<BG	<BG
	March	<BG	9.96E+12	0.00E+00	<BG	<BG
	Sum:	**0.00E+00**	**2.92E+13**	**0.00E+00**	**0.00E+00**	**0.00E+00**
II	April	<BG	9.64E+12	0.00E+00	<BG	<BG
	May	6.07E+01	9.96E+12	8.66E-13	2.46E-19	6.07E-05
	June	<BG	9.64E+12	0.00E+00	<BG	<BG
	Sum:	**6.07E+01**	**2.92E+13**	**8.66E-13**	**1.04E-14**	**6.07E-05**
III	July	<BG	9.96E+12	0.00E+00	<BG	<BG
	August	7.36E+01	9.96E+12	0.00E+00	3.70E-14	7.36E-05
	September	<BG	9.64E+12	0.00E+00	<BG	<BG
	Sum:	**7.36E+01**	**2.96E+13**	**0.00E+00**	**1.25E-14**	**7.36E-05**
IV	October	1.52E+01	9.96E+12	0.00E+00	7.64E-15	1.52E-05
	November	1.76E+01	9.64E+12	0.00E+00	9.15E-15	1.76E-05
	December	<BG	9.96E+12	0.00E+00	<BG	<BG
	Sum:	**3.28E+01**	**2.96E+13**	**0.00E+00**	**5.56E-15**	**3.28E-05**
Summary YTD		**1.67E+02**	**1.18E+14**	**8.66E-13**	**2.84E-14**	**1.67E-04**

notes:

1. Activity released from the stack: (Activity sampled from Ch 3) x (volume of air going through the stack)
2. Diluted Concentration equal to: Activity Released/exhaust volume * 0.005 (Technical Specification 3.5.2, dilution value for release concentration at exclusion boundary)
3. Exhaust Volume equal to: (# days/month)*(24hrs/day)*(60min/hr)*(7875 cfm)/ 3.53E-5cc)
4. Additional Release equal to: (Individual releases calculated from facility air monitoring data)
5. Total Release equal to: (Activity Released+Additional Releases)*conversion factor

5.5 Liquid Effluent Monitoring

Radioactive Liquid effluents are maintained in collection tanks before release from the confines of the Nuclear Science Center. Sample activity concentrations and isotope identifications were determined before each release. The concentration values for each isotope were compared with the effluent concentrations in water (10 CFR 20) and were determined to be in compliance. There were 23 releases in 2020, totaling 3.00×10^5 gallons including dilution. The total radioactivity released was 2.15 mCi with an annual average concentration of 1.90×10^{-6} μCi/cc. Summary of the release data are presented in the following Table 5-5. Radioactivity concentrations for each isotope found were below the Effluent Concentration limits specified in 10 CFR 20, Appendix B. The radionuclides identified in the waste stream were Na-22, Mn-54, Co-58, Co-60, Zn-65, and Sb-124.

Table 5-5: Liquid Effluent Releases

Quarter	Month	Number of Releases	Volume Released (cc)	Total Radioactivity (Ci)	Average Concentration (μCi/cc)
I	January	2	9.5E+07	1.37E-04	3.51E-06
	February	0	----	----	----
	March	1	5.4E+07	4.86E-05	9.01E-07
	Total	3	1.5E+08	2.15E-04	4.41E-06
II	April	0	----	----	----
	May	1	5.01E+07	4.60E-05	9.19E-07
	June	3	1.48E+08	1.34E-04	2.71E-06
	Total	4	2.0E+08	1.80E-04	3.63E-06
III	July	6	2.9E+08	6.90E-04	1.4E-05
	August	2	1.1E+08	2.63E-04	5.01E-06
	September	4	2.1E+08	4.72E-04	9.2E-06
	Total	12	6.0E+08	1.43E-03	2.86E-05
IV	October	2	9.1E+07	2.1E-04	4.7E-06
	November	1	4.9E+07	1.14E-04	2.34E-06
	December	1	4.9E+07	3.5E-06	7.2E-08
	Total	4	1.9E+08	3.28E-04	7.09E-06
Annual Summary	Total	23	1.14E+09	2.15E-03	1.90E-06

6 Environmental Monitoring

In conjunction with representatives from the Texas Department of State Health Services (TDSHS) Radiation Control, a quarterly environmental survey is conducted to ensure compliance with federal regulations. This program consists of TLD monitors located at various locations on the NSC site and two background monitors; one located at 3.84 miles NW of facility and the other at 0.25 miles SE of facility.

6.1 Site Boundary Dose Rate

The environmental survey program measures the integrated radiation exposures at the exclusion area boundaries. These measurements are made for periods of approximately 91 days using TLDs. Monthly measurements of direct gamma exposure rate in μR/h are also made at each of the TLD locations. The dosimeters were provided and processed by Texas Department of State Health Services, Environmental Monitoring, Division of Regulatory Services, Austin, Texas.

Table 6-1: Site Boundary TLD Data

Site #	Location	Quarterly Exposure rates (mrem/91 days)				TLD Dose (total)	Deep Dose=TLD dose*(1/16)
2	300 ft. W of reactor building, near fence corner	0	0	1	6	7	0.44
3	250 ft W-SW of reactor building, on SW chain link fence	2	0	2	3	6	0.38
4	200 ft NW of reactor building, on chain link fence	6	3	4	7	20	1.25
5	225 ft NE of reactor building, on fence N of driveway	0	0	1	2	3	0.19
10	190 ft SE of reactor building, near fence corner	0	0	1	4	5	0.31
11	300 ft NE of reactor building, near fence corner	0	0	3	3	6	0.38
*14	3.84 miles NW of facility	0	0	0	0	0	0
18	375 ft NE of reactor building	0	0	1	4	5	0.31
19	320 ft NE of reactor building	0	0	0	0	0	0
*23	0.25 miles SE of facility	0	0	0	4	4	0.25
24	Fence line near N wall of BLDG 1307	0	0	2	4	6	0.38

*Background TLD station

7 Radioactive Waste Shipments

In 2020, TAMU-EHS conducted a radioactive waste shipment that contained multiple old, sealed sources from the NSC. All disposal was conducted on the TAMU broad-scope state license. NRC license R-83 conducted no radioactive waste shipments.