January 2023

Nuclear Material Events Database

Annual Report

Fiscal Year 2022

Prepared for the U.S. Nuclear Regulatory Commission
by Idaho National Laboratory (INL/RPT-22-70577)

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ABSTRACT

This report presents information on trending and analysis of incidents/accidents (events) reported to the Nuclear Regulatory Commission (NRC) that involve radioactive material. The events are reported by NRC licensees, Agreement States, and non-licensees, and are recorded in the NRC's Nuclear Material Events Database. The reported events are classified into categories based on event reporting requirements defined in Title 10 of the Code of Federal Regulations. The categories in this report are (1) Lost/Abandoned/Stolen Material, (2) Medical, (3) Radiation Overexposure, (4) Release of Licensed Material or Contamination, (5) Leaking Sealed Source, (6) Equipment, (7) Transportation, and (8) Other.

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ACRONYMS

ADOH	Arkansas Department of Health
ALARA	as low as reasonably achievable
ALI	annual limit on intake
AO	abnormal occurrence
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
CT	computed tomography
DDE	deep dose equivalent
DE	dose equivalent
DOT	Department of Transportation
EDE	effective dose equivalent
EQP	Equipment
EXP	Radiation Overexposure
FBI	Federal Bureau of Investigation
FBRC	Florida Bureau of Radiation Control
GTCC	greater than class C
HAZMAT	hazardous material
HDR	high dose rate
HLW	high level waste
IAEA	International Atomic Energy Agency
IEMA	Illinois Emergency Management Agency
INL	Idaho National Laboratory
KDHE	Kansas Department of Health & Environment
LAS	Lost/Abandoned/Stolen Material
LDE	lens dose equivalent
LKS	Leaking Sealed Source
LS	least squares
MED	Medical
NA	not applicable
NASA	National Aeronautics and Space Administration
NMED	Nuclear Material Events Database
NR	not recovered
NRC	Nuclear Regulatory Commission

OTH	Other
PET	positron emission tomography
REAC/TS	Radiation Emergency Assistance Center/Training Site
RLM	Release of Licensed Material or Contamination
RSO	radiation safety officer
SBRT	stereotactic body radiation therapy
SDE	shallow dose equivalent
SNM	special nuclear material
SSE	error sum of squares
SSR	regression sum of squares
SST	total sum of squares
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
TRS	Transportation

EXECUTIVE SUMMARY

The Nuclear Regulatory Commission's (NRC) Nuclear Material Events Database (NMED) contains records of events involving nuclear material reported to the NRC by NRC licensees, Agreement States, and non-licensees. The reported events are classified based on reporting requirements defined by Title 10 of the Code of Federal Regulations. The event reports are evaluated to identify statistically significant trends and events of higher significance (referred to as significant events in this report).

The significant events that occurred in Fiscal Year 2022 are summarized below. Some of these events are considered potential Abnormal Occurrences (AOs) until they complete NRC's formal AO determination process and are reported in NUREG-0090, *Report to Congress on Abnormal Occurrences*. Note that a single event may be listed in more than one event type category.

Lost/Abandoned/Stolen Radioactive Sources/Material Events

Ten significant events occurred involving the loss of 12 Category 1-3 sources as defined by the International Atomic Energy Agency's *Code of Conduct on the Safety and Security of Radioactive Sources (2004)*. No Category 1 sources, five Category 2 sources, and seven Category 3 sources were lost; all of which were recovered.

Regarding the ten significant events:

- Four of the events involved the loss of Category 2 sources (five total). All of the sources were lost during shipping and subsequently recovered. Two of the events involved sources lost by a common carrier. In the other two events, a common carrier delivered the source to the wrong location.
- Six of the events involved the loss of Category 3 sources (seven total). All of the sources were lost during shipping and subsequently recovered. Three of the events involved sources lost by a common carrier. In the other three events, a common carrier delivered the source to the wrong location.

In addition to the 10 events above, one other significant event occurred prior to FY22 that was recently added to NMED. In this event, a source was lost by a common carrier during shipping and subsequently recovered.

Medical Events

Five significant events occurred, all of which were classified as potential Abnormal Occurrences. In three events, patients received more dose than prescribed during Y-90 microsphere treatments. The other two events involved doses delivered to unintended sites, one during gamma knife treatment and one during Y-90 microsphere treatment.

Radiation Overexposure Events

Two significant events occurred. In the first event, a radiographer received an overexposure while handling radiography equipment with the source in an unshielded position. In the second event, an employee of a radiopharmaceutical manufacturer received an extremity overexposure while synthesizing F-18 fluorodeoxyglucose.

In addition to the two events above, one other significant event occurred prior to FY22 that was recently added to NMED. In this event, an employee of an industrial radioactive tracer manufacturer received an overexposure after becoming contaminated while drilling into a container of Ir-192 tracer beads.

Release of Licensed Material or Contamination Events

One significant event occurred. A hospital's hot laboratory became contaminated when a vial of liquid I-131 sodium iodide broke.

In addition to the event above, one other significant event occurred prior to FY22 that was recently added to NMED. In this event, an industrial radioactive tracer manufacturing employee received an overexposure after becoming contaminated while drilling into a container of Ir-192 tracer beads.

Leaking Sealed Source Events

No significant events occurred.

Equipment Events

One significant event occurred. A radiographer received an overexposure while handling radiography equipment with the source in an unshielded position.

Transportation Events

Two significant events occurred. Both of these events involved the receipt of packages with high external radiation levels due to unshielded sources that were shipped from international customers.

Other Events

One significant event occurred, which was also classified as a potential Abnormal Occurrence. In this event, an embryo/fetus received a radiation dose when a patient who was unknowingly pregnant received an I-131 treatment.

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1. INTRODUCTION

1.1 Overview and Objectives

Nuclear material event reports are evaluated to identify statistically significant trends and significant events. The reported information aids in understanding why the events occurred and in identifying any actions necessary to improve the effectiveness of the nuclear material regulatory program.

A database for tracking nuclear material events was developed by the Nuclear Regulatory Commission (NRC) in 1981. In 1993, using existing material events databases, the NRC developed a new and more comprehensive database for tracking material events. This database, designated the Nuclear Material Events Database (NMED), contains records of events involving nuclear material reported to the NRC by NRC licensees, Agreement States, and non-licensees. The database is maintained by Idaho National Laboratory (INL) and contains approximately 28,000 records of material events submitted to the NRC from January 1990 to present.

The events in this report are classified into the following categories based on event reporting requirements defined by Title 10 of the Code of Federal Regulations (CFR):

- Lost/Abandoned/Stolen Material (LAS),
- Medical (MED),
- Radiation Overexposure (EXP),
- Release of Licensed Material or Contamination (RLM),
- Leaking Sealed Source (LKS),
- Equipment (EQP),
- Transportation (TRS), and
- Other (OTH).

A description of categories addressed in this report and associated screening criteria are presented in Appendix A.

1.2 NMED Data

A single occurrence report may be captured in more than one NMED event category. For example, a report may describe a loss of licensed material that also resulted in a radiation overexposure. In such a case, both event categories are recorded in NMED and identified by the same report number (referred to as an item number in the database).

The data presented in this report are limited to reportable events that occurred between October 1, 2012, and September 30, 2022. The data were downloaded from NMED on December 12, 2022. Because NMED is a dynamic database that is updated daily, variations in data may be encountered over time. Furthermore, even though many events were reported and entered in the database for operational experience purposes, only those events required to be reported by 10 CFR are addressed in this report.

This report displays annual trend data for each of the event categories for a 10-year period. A trend analysis was performed on each event category to identify the existence or absence of a statistically significant trend. If a statistically significant trend exists, the display indicates the direction and

approximate rate of change with a trend line. For the purposes of this report, a statistically significant trend exists if the analysis indicates that the computed fit and slope of a least squares linear model is valid at a 95% confidence level. A primer on the statistical methods employed in the trend analysis is presented in Appendix B.

Note that the trending methodology is not normalized; the trend only considers the number of reported events and does not directly account for external issues such as changes to regulatory requirements or changes in the number of licensees. For example, an increasing trend in the number of medical events could be caused by an increase in the number of medical procedures being performed. Likewise, an event type showing a decreasing trend for NRC licensees and an increasing trend for Agreement State licensees could be caused by States becoming Agreement States (resulting in fewer NRC licensees and more Agreement State licensees).

Reporting guidance for Agreement States is provided in the *Handbook on Nuclear Material Event Reporting in the Agreement States*. The handbook is an appendix to the NRC Office of Nuclear Material Safety and Safeguards procedure SA-300, *Reporting Material Events*. Access to NMED is available to the staff of NRC, Agreement State, and Federal agencies at http://nmed.inl.gov.

For assistance on searches or other questions, contact Robert Sun (nmednrc@nrc.gov, 301-415-3421).

2. ANALYSIS OF NMED DATA

Event reports submitted to the NRC involving nuclear material are reviewed, categorized, and entered into NMED. Charts are provided to display trends in annual data for the most recent 10-year period (FY13-22).

2.1 All NMED Events

Figure 1 displays the annual number and trend of NMED events that occurred during the 10-year period. The trend analysis determined that the NRC-regulated events represent a statistically significant decreasing trend (indicated by the trend line). However, the Agreement State-regulated and Total events do not represent statistically significant trends (indicated by the absence of trend lines).

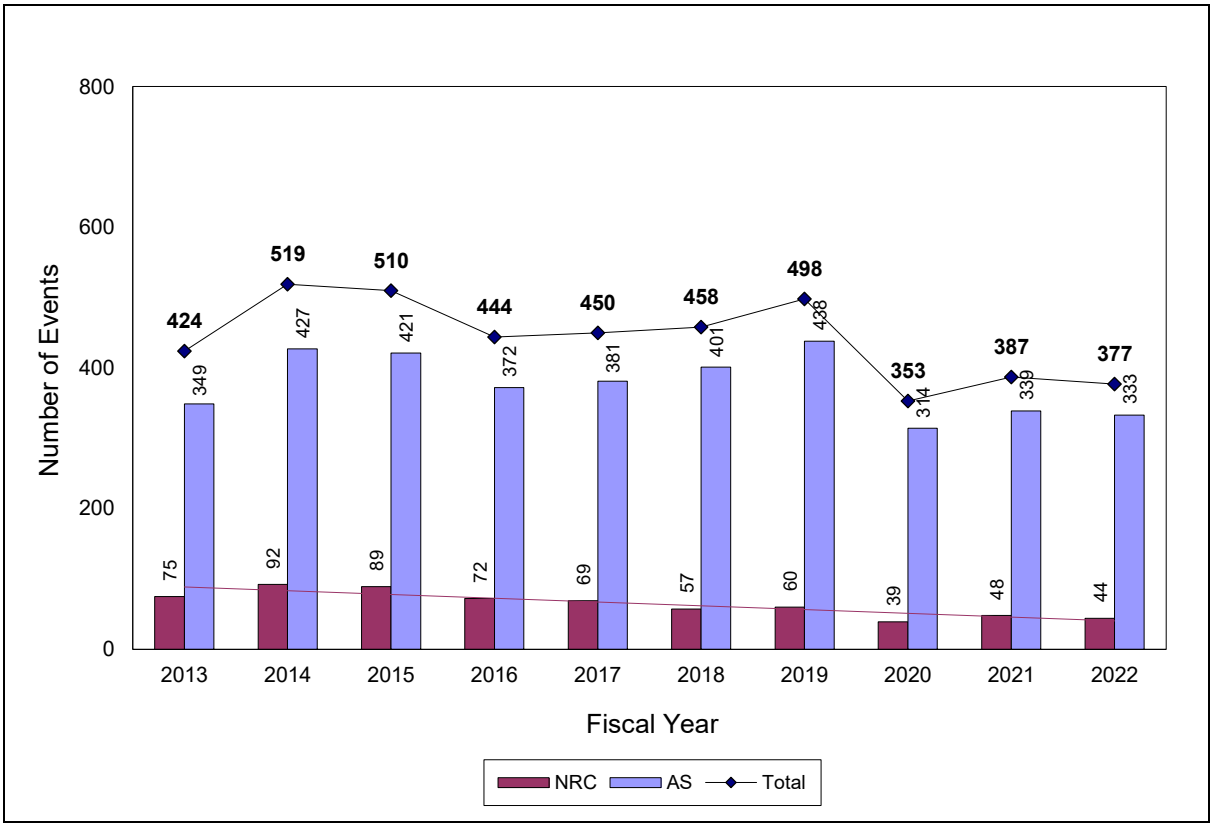

Figure 1. All NMED Events (4,420 total)

The following observations are made regarding the data in Figure 1.

- In FY22, 358 occurrences accounted for 377 events; a single occurrence can be classified in different event categories.
- The COVID-19 pandemic likely contributed to the decrease in events beginning in 2020.
- The most recent year's data are typically many records less than their final value when subsequent updates and late reports are received (see Appendix D, Figure D-1).
- The transition of states from NRC to Agreement State jurisdiction could result in increasing trends in Agreement State data and decreasing trends in NRC data.

Table 1 displays a summary of the trending analysis for all NMED event types included in this report. A more detailed discussion of the trending analysis results can be found in the section of this report devoted to each event type.

Table 1. Summary of Trending Analysis

Event Type	Total	NRC	Agreement State
All NMED Events	-	↘	-
Lost/Abandoned/Stolen Material (LAS)	-	↘	-
Medical (MED)	-	-	-
Radiation Overexposure (EXP)	↘	-	↘
Release of Licensed Material or Contamination (RLM)	-	-	-
Leaking Sealed Source (LKS)	-	-	-
Equipment (EQP)	-	-	-
Transportation (TRS)	↘	↘	↘
Other (OTH)	NA	NA	NA

Notes:

- ↗ indicates a statistically significant increasing trend.
- ↘ indicates a statistically significant decreasing trend.
- - indicates no statically significant trend.
- NA indicates that the data does not support trending analysis.

2.2 Lost/Abandoned/Stolen Material

2.2.1 Ten-Year Data

Figure 2 displays the annual number and trend of LAS events that occurred during the 10-year period. The trend analysis determined that the NRC-regulated events represent a statistically significant decreasing trend (indicated by the trend line). However, the Agreement State-regulated and Total events do not represent statistically significant trends (indicated by the absence of trend lines).

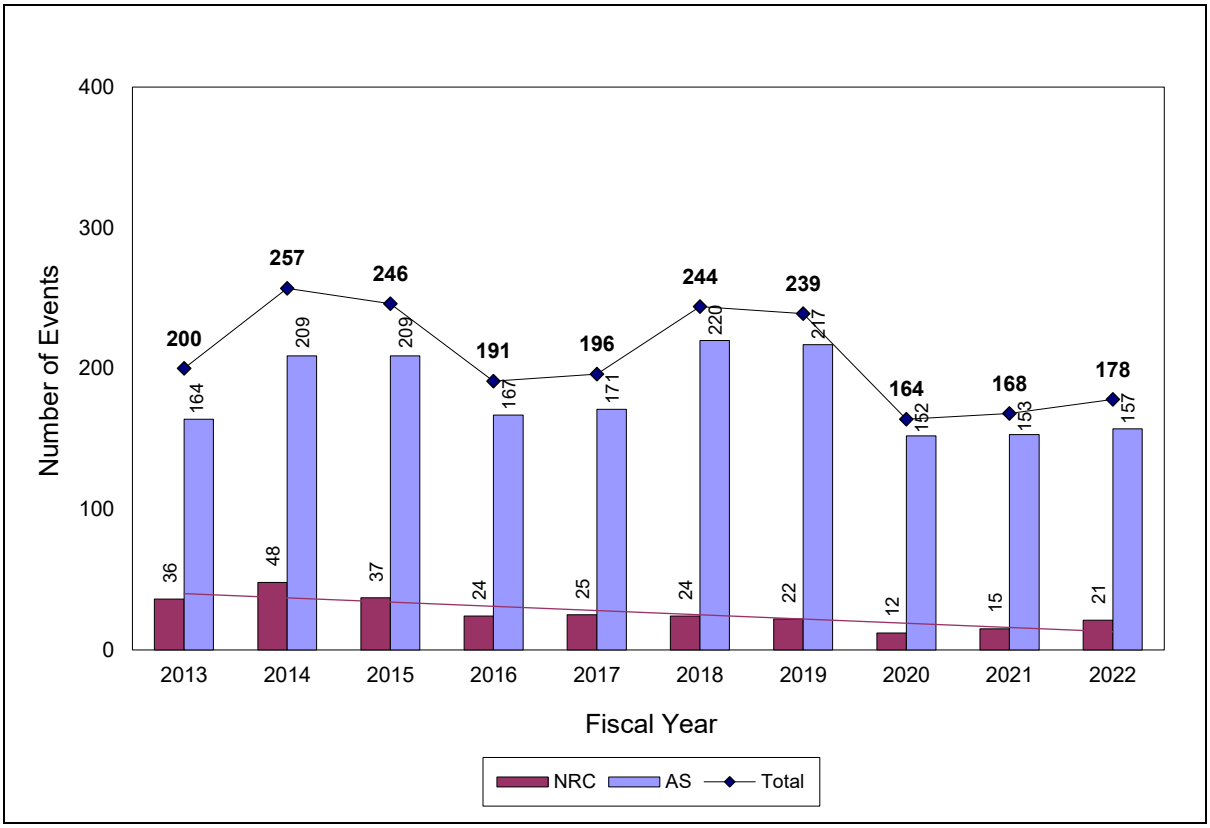

Figure 2. Lost/Abandoned/Stolen Material Events (2,083 total)

Appendix C contains a list of radionuclides derived from the International Atomic Energy Agency's (IAEA) *Code of Conduct on the Safety and Security of Radioactive Sources (2004)*. These radionuclides are grouped by the amount of radioactivity into five categories that correspond to the relative hazard, with Category 1 being the most hazardous.

For this report, IAEA Category 1 through 3 source events (excluding irretrievable well-logging source events) are considered significant. Regardless of IAEA category, events involving irretrievable well-logging sources are not considered significant. Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

Table 2 displays the number of sources lost (approximately 3,880 excluding irretrievable well-logging sources) during the 10-year period and the number that have not been recovered (approximately 2,314), grouped by IAEA category where possible. These included three Category 1 sources, 76 Category 2 sources, and 41 Category 3 sources; all of which were recovered, with the exception of one Category 2 and six Category 3 sources.

Table 2. Number of Sources Lost/Abandoned/Stolen (LAS) and Sources Not Recovered (NR) - Excluding Irretrievable Well Logging Sources

Category		Fiscal Year 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
1	LAS[4]	0	0	2	0	0	0	0	1	0	0	**3**
	NR[5]	0	0	0	0	0	0	0	0	0	0	**0**
2	LAS	10	5	9	8	7	3	9	4	16	5	**76**
	NR	0	0	0	0	1	0	0	0	0	0	**1**
3	LAS	3	4	4	5	1	4	5	3	5	7	**41**
	NR	0	0	1	0	0	0	2	2	1	0	**6**
4	LAS	24	53	45	43	36	39	51	57	62	62	**472**
	NR	8	25	19	17	10	17	22	25	35	33	**211**
5	LAS	72	88	88	83	55	76	67	59	70	68	**726**
	NR	9	32	33	46	15	28	24	17	36	35	**275**
< 5	LAS	1	1	2	1	10	4	2	2	0	1	**24**
	NR	0	0	2	1	1	4	1	2	0	1	**12**
Activity Not Known[1]	LAS	7	3	3	1	1	3	4	17	0	7	**46**
	NR	0	0	1	0	0	0	1	0	0	4	**6**
Nuclide Not Known[2]	LAS	1	0	1	0	1	0	0	0	1	0	**4**
	NR	0	0	0	0	0	0	0	0	0	0	**0**
Other[3]	LAS	174	330	201	252	165	281	499	263	163	160	**2488**
	NR	92	257	110	187	75	173	394	234	148	133	**1803**
Total	**LAS**	**292**	**484**	**355**	**393**	**276**	**410**	**637**	**406**	**317**	**310**	**3880**
	NR	**109**	**314**	**166**	**251**	**102**	**222**	**444**	**280**	**220**	**206**	**2314**

Notes:

1. The "Activity Not Known" category includes sources containing radionuclides listed in Appendix C for which the activity was not reported. Therefore, the sources were not included in Categories 1 through 5.
2. The "Nuclide Not Known" category includes those sources for which the radionuclide was not reported. Thus, the sources were not included in Categories 1 through 5 or Other.
3. The "Other" category includes sources containing radionuclides not included in Appendix C.
4. Events involving a larger number of sources are sometimes entered as a single source with an aggregate activity (for example, the loss of a container of brachytherapy seeds may be entered as a single source with a total combined activity).

5. Events involving the loss/theft of multiple sources may involve the recovery of only some of the sources and are entered as being partially recovered (rather than marking each source individually). The Category 1 through 3 "not recovered" source counts were corrected for the "partially recovered" source events.

Tables 3 and 4 provide more detail regarding the 10-year and current year "not-recovered" data highlighted in Table 2 in yellow and green, respectively. Table 3 displays radionuclide data pertaining to the IAEA Category 1 through 3 sources lost during the 10-year period that have not yet been recovered. The Decayed Activity values are conservative estimates in that the values are typically decayed from the loss date instead of the manufacturer's assay date. As a result, the actual decayed activities (based on the manufacturer's assay date) are likely less than the estimates. Table 4 is similar to Table 3 but limited to the current year.

Table 3. Summary of IAEA Category 1-3 Sources Not Recovered (FY13-22)

Radionuclide	Half-life[1]	Number of Sources Not Recovered[2,3]	Total Activity (Ci)	Total Decayed Activity (Ci)[4]	Total Decayed Activity IAEA Category
Ir-192	73.83 days	6	92.2	0.0	5
Pu-238	87.7 years	1	2.8	2.6	3
Total		**7**	**95.0**	**2.6**	**3**

Notes:

1. Half-life values from the Chart of the Nuclides, 16th Edition.
2. Events involving a larger number of sources are sometimes entered as a single source with an aggregate activity (for example, the loss of a container of brachytherapy seeds may be entered as a single source with a total combined activity).
3. Events involving the loss/theft of multiple sources may involve the recovery of only some of the sources and are entered as being partially recovered (rather than marking each source individually). The source counts were corrected for the "partially recovered" source events.
4. The source activities were decayed from the event date to 12/12/2022 (data download date).

Table 4. Summary of IAEA Category 1-3 Sources Not Recovered (FY22)

Radionuclide	Half-life[1]	Number of Sources Not Recovered[2,3]	Total Activity (Ci)	Total Decayed Activity (Ci)[4]	Total Decayed Activity IAEA Category
		0			
Total		**0**			

Notes:

1. Half-life values from the Chart of the Nuclides, 16th Edition.
2. Events involving a larger number of sources are sometimes entered as a single source with an aggregate activity (for example, the loss of a container of brachytherapy seeds may be entered as a single source with a total combined activity).
3. Events involving the loss/theft of multiple sources may involve the recovery of only some of the sources and are entered as being partially recovered (rather than marking each source individually). The source counts were corrected for the "partially recovered" source events.

4. The source activities were decayed from the event date to 12/12/2022 (data download date).

2.2.2 FY22 Data

One hundred seventy-eight LAS events occurred in FY22, six of which involved irretrievable well logging sources. Excluding the irretrievable well logging sources, approximately 310 sources were lost/abandoned/stolen, 206 of which have not been recovered. Of the 310 lost sources, none were Category 1, five were Category 2, and seven were Category 3 sources; all of which were recovered.

Ten of the FY22 LAS events were considered significant (involved Category 1-3 sources). Note that regardless of IAEA category, events involving irretrievable well logging sources are not considered significant.

Significant Events - Category 1 Source Events
None

Significant Events - Category 2 Source Events
Item Number 210463 - A radiography equipment manufacturer reported that a radiography exposure device containing a 3.89 TBq (105 Ci) Ir-192 source was lost during shipping to a customer. The common carrier stated that the package was delivered on 10/26/2021. However, the customer's RSO said the package had not been delivered. It was subsequently discovered that the package had been delivered to the wrong address. On 10/27/2021, the common carrier picked up the exposure device from the wrong address and delivered it to the correct address.

Item Number 220258 - A NASA Operations and Maintenance contractor reported that a 3.7 TBq (100 Ci) Ir-192 source was temporarily unsecured. The contractor ordered the source on 3/24/2022. The source manufacturer sent an advanced shipping notice email to the contractor's RSO after hours on 5/26/2022. However, the RSO was on vacation until 5/31/2022. The source was delivered to the contractor's shipping/receiving dock at 1000 on 5/27/2022. This was not in accordance with the standard practice for the source to be delivered directly to the building where licensed sources are secured. The contractor employee that signed for receipt was not radiation safety qualified. The source remained in the shipping/receiving building, which is locked when personnel are not on site, until 5/31/2022. When the RSO arrived at work at 0600 on 5/31/2022, he read the manufacturer's advanced shipping notice email and identified that the source had been delivered. The RSO retrieved the source and brought it to the secure vault. An investigation determined that no employee was exposed to an unallowable amount of radiation. The root cause was that the source manufacturer failed to verify that the NASA contractor was prepared to receive the source prior to shipping it. Corrective actions were implemented to improve shipping coordination and communication with the source manufacturer and prevent the unauthorized receipt of radioactive material by the NASA contractor's receiving personnel. These included adding additional personnel contacts for delivery coordination, updating shipping/receiving procedures, training staff that only radiation qualified personnel may take possession of radioactive material, and adding signage to the receiving dock.

Item Number 220346 - A radiography equipment manufacturer reported that two packages containing 12 Ir-192 sealed sources with a total activity of 47.34 TBq (1,279.4 Ci) were missing. Package 1 was shipped on 7/19/2022 in two pieces. One piece of that package contained four Ir-192 sources with a total activity of 15.92 TBq (430.2 Ci). Package 2 was shipped on 7/20/2022 and contained eight Ir-192 sources with a total activity of 31.42 TBq (849.2 Ci). Both packages were intended for export to Mexico. Package 1 was last scanned at the common carrier's hub in Memphis, Tennessee, on 7/28/2022. Package 2 was last scanned at the same hub on 7/22/2022. The manufacturer reported on 8/4/2022 that the common carrier confirmed that all packages had been located and delivered to their intended destination in Mexico.

Item Number 220352 - A radiography equipment manufacturer reported on 8/4/2022 that a shipment from Australia, containing 32 Ir-192 sealed sources totaling 4.96 TBq (134 Ci) and two Se-75 sealed sources totaling 0.31 TBq (8.38 Ci), was missing in transit. The shipment included six packages: five packages

containing Ir-192 sources and one package containing Se-75 sources. The shipment departed from Sydney, Australia, on about 7/1/2022. The shipment arrived at Chicago O'Hare International Airport on 7/20/2022. The manufacturer was informed on 8/4/2022 that the shipment was missing. The shipment was subsequently discovered on the loading dock of a ground transportation company in Boston, Massachusetts, on 8/4/2022. The transportation company had picked up the shipment at O'Hare on 7/21/2022. The manufacturer received the shipment on 8/5/2022 and confirmed that all six package seals were intact.

Significant Events - Category 3 Source Events

Item Number 210536 - A hospital reported that a common carrier delivered a radioactive source package to the wrong location and left it unattended. The package contained a 370 GBq (10 Ci) Ir-192 source. A secretary discovered the package when exiting the medical oncology suite at approximately 1420 on 12/1/2021. She noticed the radiation label, picked up the package, and took it to the radiation oncology suite (down the hallway). Radiation oncology staff notified the chief therapist and physicist, who promptly brought the source into the designated area, performed a radiation survey and inspection to ensure no break in seals or radiation leakage, and documented receipt of the package. Radiation levels on the package were 4.2 mR/hour on contact and 0.6 mR/hour at one meter. The common carrier's tracking indicated that the package was delivered at 1404 on 12/1/2021. The package was not delivered to the radiation therapy department as indicated by the shipper's declaration for dangerous goods and no receipt signature/confirmation was obtained. The common carrier was notified that the failure to follow established delivery protocol was unacceptable. Radiation exposure and potential risk to staff from the shielded source was negligible. The radiation oncology team had an in-service/training to review the incident and procedures for receipt of radioactive material packages.

Item Number 220142 - A radiography equipment manufacturer reported a missing package containing a source changer and a 244.2 GBq (6.6 Ci) Ir-192 source. The package was shipped from a radiography services company in Edmonton, Canada, on 2/15/2022. The package was scanned on 3/3/2022 at the common carrier's hub in Memphis, Tennessee. The radiography services company contacted the manufacturer on 3/9/2022 to inform them that the common carrier could not locate the package. The carrier subsequently located the package on 3/22/2022 at their Memphis hub.

Item Number 220159 - A hospital reported the loss and recovery of a 370 GBq (10 Ci) Ir-192 high dose rate (HDR) source. On 3/22/2022, a common carrier delivered the source/package to the wrong floor and clinic at the hospital. Instead of being delivered to radiation oncology on the 1st floor of the hospital, the source was delivered to a 4th floor clinic. The person that received the package did not have radiation safety or transportation training and signed for the package without understanding what it was. That person placed the package on the floor of an access-controlled staff working area. The hospital received an email from the HDR manufacturer on 3/28/2022 to schedule a date/time for installation of the new source. It was at that time that the hospital realized that the source had not arrived at the intended location. An investigation was initiated and the package was located in the 4th floor clinic. The package was surveyed and observed to be intact with no evidence of tampering. The package was taken to the correct location and secured in locked storage. The hospital evaluated the radiation exposure received by clinic staff working in proximity to the package. The maximum exposure received by an individual sitting in a chair two feet from the source for five hours/day for five days was calculated to be 0.1 mSv (10 mrem). The Oregon Department of Health investigated the incident. The hospital updated their process to closely monitor replacement source shipments while in transit using the shipper's supplied tracking number. If shipment tracking indicates delivery without being physically received, the hospital has a follow-up procedure in place to respond. Additionally, to ensure that other departments identify and understand the markings on radioactive material shipments, the hospital RSO and Clinical Education Department developed training for staff who potentially receive packages.

Item Number 220254 - A radiography equipment manufacturer reported that a package containing nine sealed Cs-137 sources with a total activity of 513.93 GBq (13.89 Ci) was lost during shipping. The

package was shipped on 4/15/2022 to an oil field services company in Houston, Texas. The common carrier notified the manufacturer on 5/27/2022 that they could not locate the package. The last known location was the common carrier's facility in Memphis, Tennessee. The package was found on 6/2/2022 at the common carrier's facility in Houston, Texas. The package was delivered to the oil field services company on 6/2/2022.

Item Number 220297 - A radiography services company reported the loss of a shipment containing a source changer and a 166.5 GBq (4.5 Ci) Ir-192 source. The shipment was sent to a radiography equipment manufacturer on 6/16/2022. The manufacturer notified the radiography services company on 6/20/2022 that only two of three shipments had arrived. The common carrier's tracking system indicated that package arrived at their hub in Memphis, Tennessee, on 6/17/2022. The common carrier could not locate the package and it was officially declared as lost on 6/29/2022. The common carrier subsequently located the missing package in their Memphis hub on 7/5/2022. The package was delivered to radiography equipment manufacturer on 7/5/2022.

Item Number 220305 - A hospital received a 374 GBq (10.11 Ci) Ir-192 HDR brachytherapy source at an unauthorized location and without proper controls. The State of Louisiana reported this event to NRC Region I on 12/21/2021. A radioactive source manufacturer notified the hospital on 10/26/2021 that the source was expected to be delivered on 11/8/2021. Due to a labor strike at the hospital that began on 11/3/2021, some delivery drivers refused to cross the strike line to make deliveries. Therefore, the hospital's senior management arranged with a local organization to receive shipments during the strike (the hospital's RSO was not informed of this arrangement). This alternative delivery location was not an authorized location in the hospital's NRC license. The local organization was to palletize the deliveries, which the hospital would retrieve in a box truck. The shipper delivered the source to the local organization on 11/8/2021, leaving the package unattended on the exterior dock. The local organization found the package about one hour after delivery, recognized that radioactive material was involved, and contacted the hospital to immediately retrieve the package. A member of the local organization's staff (a member of the public) stayed with the package at a distance of approximately 1 meter for about 30 minutes until the hospital retrieved the package. DOT regulations were not followed while transporting the source from the local organization's facility to the hospital. The package was secured at the hospital until 12/10/2021, when a service provider arrived to perform an HDR source exchange. The service provider noted that the security tab on the package was missing, but it did not appear that any tampering of the source occurred. The source remained locked within the interior shield of the shipping container during transit and storage (the key needed to access the source was not shipped with the source; the key was at the hospital). Corrective actions included personnel training and procedure modification.

Events of Interest

Item Number 210447 - A steel manufacturer reported finding a fixed nuclear gauge containing a 33.3 MBq (900 µCi) Cs-137 source in an incoming load of scrap. The gauge was manufactured in 2008 and did not appear to be designed to have a source shutter. Radiation surveys revealed 33 mR/hour on contact with the open side and 1 mR/hour at three feet from the closed side. They contacted the manufacturer, who told them that the gauge was originally sold in 2008 as a generally licensed device to be used for level detection on a dredge. The Texas Department of State Health Services performed an onsite investigation at the original owner's facility on 11/1/2021. The owner stated that they sold the dredge and gauge to a company in Oklahoma. The Oklahoma Department of Environmental Quality contacted the second owner who confirmed that they purchased a dredge and gauge, but it was not the gauge found at the steel manufacturer. The original owner recovered the gauge from steel manufacturer on 11/10/2021. The gauge was picked up for disposal by the manufacturer on 2/16/2022. The original owner indicated that they were unable to determine how the gauge ended up at steel manufacturer.

Item Number 210498 - A metal recycling facility reported finding a radioactive source. A radiation monitor alarmed on their metal shredder on 11/19/2021. Two members of the Kansas Department of Health & Environment (KDHE) responded to the site on 11/19/2021. Radiation surveys revealed that the

highest exposure rate on a large pile of shredded metal was 26.2 mR/hour. The radionuclide was identified as Ra-226. KDHE performed radiation surveys of the machinery that shreds the metal and did not identify any elevated exposure rates. It was suspected that the radioactive source was not punctured and there was no residual contamination of the scrap yard or machinery. A licensed contractor removed the material on the evening of 11/19/2021. The contractor measured 150 mR/hr on contact with the source and calculated an activity of 74 MBq (2 mCi). KDHE was not able to identify who was responsible for inappropriately disposing of the radioactive material. The source was disposed of as waste.

Item Number 210522 - The RSO of a manufacturer of self-luminous gun sights and optics was contacted by the FBI on 12/2/2021 regarding scrap bags containing H-3 that were discovered in a raid. The bags belonged to the manufacturer who believed they contained 3.7 TBq (100 Ci) of H-3. The dates on the scrap bags ranged from 2012 to 2017. The RSO was unsure how long the scrap bags had been missing.

Item Number 220078 - A construction materials testing company reported that they were informed by their portable gauge service company that the 159.1 MBq (4.3 mCi) Cs-137 source had broken off a moisture/density gauge and was missing. The gauge was last used on 11/6/2021 at a temporary job site. A technician satisfactorily completed one test on road base material. When he attempted a second test, the gauge readings were not normal. The testing company RSO stated that as soon as the testing had been completed on the road base material, nine inches of concrete was poured over the base, and then topped with four inches of asphalt. The gauge was returned to the testing company facility and then sent to the gauge service company. The RSO and service company performed radiation surveys of the two areas of the street where testing had been performed back on 11/6/2021. They were unable to locate the source with hand-held detectors. The Texas Department of State Health Services performed radiation surveys of the street on 12/16/2021 and identified the source's location. Exposure rates at the surface of the asphalt were between 13 to 15 µR/hour and measurements at one meter were equal to background at 4 µR/hour. The source was recovered on 3/1/2022 by a company that was licensed for sealed source recovery. The source holder, with the source inside, was found approximately four inches down the testing hole in the compacted base material (under the cement and asphalt). A field leak test was negative, as was the field measurement of soil for potential radioactive contamination. The source recovery company transported the source to its facility where the leak test was repeated. Soil samples were analyzed by a third-party laboratory. The source leak test and soil sample analyses were negative for radioactive contamination. The source, source holder, and gauge were all transferred to the manufacturer for evaluation. The NRC Registry of Radioactive Sealed Sources and Devices indicates that this device also contains an Am-Be source with a maximum activity of 1.85 GBq (50 mCi). This event was classified as an EQP and LAS event.

Item Number 220140 - A radioactive gauge was found in scrap metal at recycling facility on 3/2/2022. The facility was unable to identify the customer from whom the scrap metal was purchased. Intact labeling provided general licensee information of a fixed nuclear thickness gauge containing a 5.55 GBq (150 mCi) Am-241 source. The manufacturer was contacted and identified the original gauge owner. The Arkansas Department of Health (ADOH) responded to recycling facility on the morning of 3/3/2022. A metal drum, clearly labeled as containing radioactive material, was closed and in good condition. ADOH personnel surveyed the drum; the top measured 185 µR/hour and the bottom 85 µR/hour. The gauge shutter appeared to be missing. The recycling facility contacted ADOH again on 3/17/2022 to report the discovery of a second gauge that also contained a 5.55 GBq (150 mCi) Am-241 source. That gauge was once registered to the same gauge owner. Both gauges were found in the remnants of the original load of scrap metal. The second gauge was placed into a radioactive material labeled drum and secured in a remote storage building where the first gauge was being stored. The shutter on the second gauge appeared to be attached but not closed. There were no known individual radiation exposures. The two gauges were transferred back to the manufacturer. The cause of the event was the original owner's lack of effective procedures, failure to appoint and support an individual responsible for regulations/requirements, and lack of personnel training. The owner appointed a responsible individual and backup, trained those two

individuals, provided awareness training for all employees working around nuclear gauges, conducted an inventory of all gauges, and placed additional radiation labels on all gauges.

Item Number 220201 - A construction materials testing company reported that a moisture/density gauge was lost and damaged when it fell from the back of a truck in transit on 4/27/2022. The gauge contained a 1.48 GBq (40 mCi) Am-Be source and a 0.3 GBq (8 mCi) Cs-137 source. Pieces of the gauge were on Interstate Highway I-25 as a result of vehicles running over the gauge. The locations of the sources were initially undetermined. The company contacted the police to help cordon off the affected area to support retrieval of gauge pieces and conduct surveys. Colorado Department of Public Health & Environment staff arrived on site at 1350 hours on 4/27/2022. HAZMAT and fire department personnel were already on site. I-25 was shut down for roughly 0.5 miles. The sources were located and packaged by onsite HAZMAT teams. The gauge base with the Am-Be source was secured in an overpack. The Cs-137 source capsule was extracted from a crack in the pavement by HAZMAT and placed into a shielded box. The highest radiation level on contact with the box containing the Cs-137 source was 0.2 mSv/hour (20 mrem/hour). The highest radiation level on contact with the overpack containing the Am-Be source was 4 µSv/hour (400 µrem/hour). Both containers were labeled and secured for transport per DOT specifications. A gauge service provider assisted with leak testing and ultimate disposal of the damaged gauge and sources. Corrective actions included terminating the employment of personnel involved and providing additional training to all gauge users. This event was classified as an EQP and LAS event.

Item Number 220260 - A phosphate mining company reported the failure of a fixed density gauge on a pipeline on 6/3/2022. The 185 MBq (5 mCi) Cs-137 source separated from the gauge. An employee found the source on the ground, picked it up, held it in their hand for anywhere from 30 to 60 seconds before realizing what it was, then dropped it and reported to management. The source was placed in an empty bucket and transported to a shelf in the onsite radioactive material storage cabinet. The Florida Bureau of Radiation Control (FBRC) was contacted and an inspector responded to the site. FBRC calculated an extremity dose of 1.42 cSv (rem). The Radiation Emergency Assistance Center/Training Site (REAC/TS) confirmed that dose and calculated a dose of 2.24 cSv (rem) with no decay correction. It was determined that there was very little to no medical concern and the company should just continue to observe the employee’s hand. This event was classified as an EQP and LAS event.

Item Number 220262 - A fixed nuclear gauge at a limestone mine was out of service and scheduled for replacement when it was inappropriately removed from a belt line by a maintenance worker and thrown in a scrap metal hopper on 5/13/2022 for recycling. The gauge contained a 592 MBq (16 mCi) Cs-137 source. Mine personnel conducted a scheduled six-month physical inventory on 6/1/2022 and discovered that the gauge was missing from the belt line. They searched the premises and found the gauge in the scrap metal hopper under additional scrap metal and approximately 10 inches of gravel. They removed the gauge and conducted radiation surveys, which revealed approximately 30 mR/hour on contact. The gauge was placed in a metal cabinet for storage with exposure rates of less than 1 mR/hour on the exterior. All work was performed without notification or consultation with the Kentucky Division of Public Health and Safety. The company stated that the metal cabinet was located in a warehouse on the premises, but made no mention of security, access control, postings, relationship to occupied spaces, etc. They also stated that the gauge was rusted and that the shutter was not reliable. No mention was made of lock out/tag out, position of shutter mechanism, condition of labels, presence of postings, training of the worker that performed removal work, etc. A reactive inspection was planned for 6/8/2022.

2.2.3 Events Recently Added to NMED That Occurred Prior to FY22

Twenty-three LAS events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. One of these events was considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events - Category 1 Source Events
None

Significant Events - Category 2 Source Events
None

Significant Events - Category 3 Source Events
Item Number 220055 - A medical equipment manufacturer reported at 0945 on 10/27/2021 that several shipments containing Ir-192 high dose rate sources were missing. There were seven separate shipments from various licensees. The equipment manufacturer had removed and packaged the sources, which were then shipped by the licensees to a radioactive source manufacturer. The shipments were picked up by a common carrier at the licensees' facilities between July 2020 and January 2021. Each package (Type A) held an Ir-192 source. Package 1 held a 0.518 GBq (14 mCi) source, Package 2 held a 1.3 GBq (35 mCi) source, Package 3 held a 9.84 GBq (266 mCi) source, Package 4 held a 41.63 GBq (1.125 Ci) source, Package 5 held a 67.34 GBq (1.82 Ci) source, Package 6 held a 27.16 GBq (734 mCi) source, and Package 7 held a 112.85 GBq (3.05 Ci) source. The medical equipment manufacturer reported at 1500 on 10/27/2021 that five of the seven packages were successfully received by the radioactive source manufacturer. Packages 2 and 3 were still missing. Months later, the common carrier located the remaining two packages in their hub in Memphis, Tennessee. The medical equipment manufacturer sent an engineer to relabel and reship the packages to the radioactive source manufacturer.

Events of Interest
Item Number 220119 - A radioactive gauge service company reported the loss of a 1.42 GBq (38.49 mCi) Am-Be source from a customer's moisture/density gauge. After the customer experienced low readings from the gauge, the service company used their own company van to pick up the gauge on 6/29/2021. After months of troubleshooting efforts, the service company discovered on 3/8/2022 that the Am-Be source cap was loose and the source was missing (the Cs-137 source was still present). The service company searched for the source by surveying their calibration facility, the unloading/loading area, and the van that picked up the gauge. They could not locate the source and believed it was not in the gauge or its transportation case when picked up from the customer. The service company updated their calibration/repair/servicing procedures to include checking the Am/Be source cap to ensure that the cap is tight and there is evidence of thread locker around the source cap. Technicians will add thread locker to the source caps and tighten them if they encounter a loose source cap. The technicians will also notify their RSO so they can forward the information to the gauge manufacturer. The service company notified their two Agreement State facilities along with the technicians that drive their mobile calibration laboratories to check for loose source caps. This event was classified as an EQP and LAS event.

2.3 Medical

2.3.1 Ten-Year Data

Figure 3 displays the annual number and trend of MED events that occurred during the 10-year period. The trend analysis determined that the data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines).

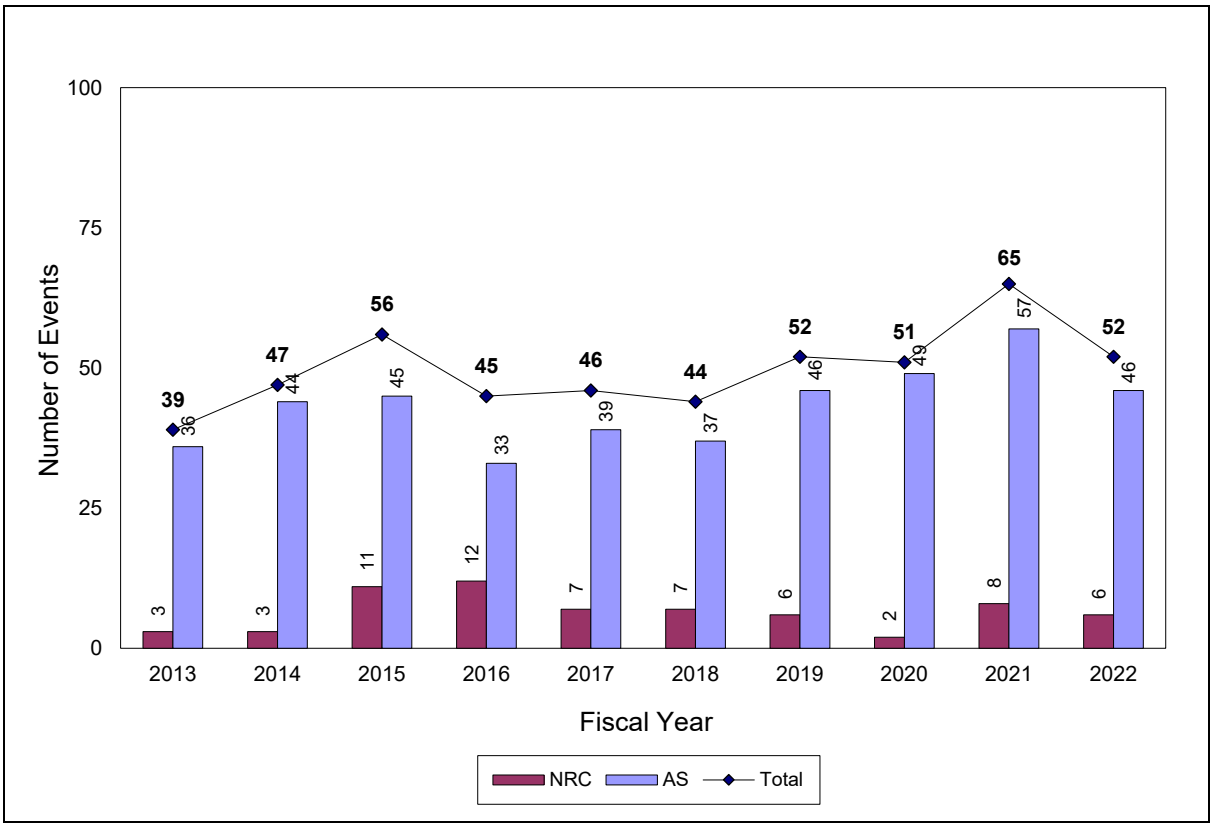

Figure 3. Medical Events (497 total)

Table 5 lists the number of MED events that were classified as Abnormal Occurrences (AOs) in NUREG-0090, *Report to Congress on Abnormal Occurrences*. Note that recent events are considered potential AOs until they complete NRC's formal AO determination process and are reported in NUREG-0090. Potential AO events are included in Table 5. Also included are events involving doses to an embryo/fetus or a nursing child (reportable per 10 CFR 35.3047). By definition, these events are not medical events (reportable per 10 CFR 35.3045) and are captured in NMED as an "Other" event. However, they are included here for reference.

Table 5. Medical and Embryo/Fetus or Nursing Child - AOs or Potential AOs

	Fiscal Year										
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Medical	7	11	14	7	10	8	7	8	7	5	**84**
Embryo	2	1	1	1	0	0	0	1	0	1	**7**
Total	**9**	**12**	**15**	**8**	**10**	**8**	**7**	**9**	**7**	**6**	**91**

For this report, events classified as AOs (or potential AOs) are considered significant. Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.3.2 FY22 Data

Fifty-two MED events occurred in FY22, five of which were considered significant and classified as potential AOs.

Significant Events - AOs or Potential AOs

Item Number 210494 - A patient received more dose than prescribed during a Y-90 microsphere treatment on 11/19/2021. The patient was prescribed two administrations to different segments of the liver of 12,600 cGy (rad) using an activity of 1 GBq (27 mCi) and 13,800 cGy (rad) using an activity of 2.72 GBq (73.4 mCi). However, the medical center estimated that the administered doses were 25,600 cGy (rad) using 2.18 GBq (59 mCi) and 29,400 cGy (rad) using 4.4 GBq (119 mCi), which were 103% and 113% greater than prescribed, respectively. The administered doses had been ordered with an incorrect calibration date of 11/22/2021. A full dose projection was initiated by the vendor. The patient was notified of the incident on 11/19/2021. The Wisconsin Department of Health Services initiated a reactive inspection and was on site 11/30/2021 and 12/6/2021. An interview with the microsphere manufacturer occurred on 12/14/2021. The inspection was completed on 6/1/2022. The medical center instituted corrective actions, including updating their Y-90 case worksheet to add new verification of the dose-in-hand versus the written directive, as well as updating the dose ordering process to require a written document with a second person to sign-off. Personnel were trained on the updates. The patient received additional laboratory work in late November 2021 and February 2022, with no adverse effects noted or expected.

Item Number 220173 - A patient received more dose than prescribed during a Y-90 microsphere treatment on 4/5/2022. The patient was prescribed to receive treatment to liver segments 2 and 3, and then treatment to liver segments 6 and 7. Two patients were scheduled for microsphere treatments that day. Two tailored dose vials for Patient A and three tailored dose vials for Patient B were stored in the hot laboratory. A certified nuclear medicine technologist mistakenly selected one of Patient B's vials for Patient A's treatment to liver segments 2 and 3. The incorrectly selected vial contained an activity of 2.17 GBq (58.6 mCi) at the time of administration. If the proper vial had been selected, the administration activity would have been 0.355 GBq (9.6 mCi). The other correct vial selected contained 1.3 GBq (35.2 mCi). The two vials (one of Patient A's and one of Patient B's) were taken to the therapy suite, where they were approved and administered to Patient A. The written directive prescribed a dose of 12,000 cGy (rad) to segments 2 and 3 of Patient A's liver. However, the error resulted in a dose of 73,660 cGy (rad) to segments 2 and 3. That dose was to only a small portion of the liver and not to the whole liver. The lung dose was calculated to be approximately 585 cGy (rad). The standard dosimetry for segmental Y-90 administrations is to aim for no less than 40,000 cGy (rad). The dose to Patient A was considered clinically acceptable and no negative effects to the patient were anticipated. Patient B's treatment was canceled as the correct microsphere dose was no longer available. An immediate corrective action was instituted that required the signed verification of dose vial activity by two technologists, with a temporary requirement that one of those verifications be completed by a supervisor or manager. A second immediate corrective action was instituted that required that all dose vials be re-verified in the event of a hand-off between certified nuclear medicine technologists. The Y-90 microsphere standard operating procedure was revised. Nuclear medicine staff and authorized users were trained on the updated Y-90 microsphere standard operating procedure. For 90 days, a supervisor checked the cart, documentation, and calibration information for accuracy prior to transport to the interventional radiology suite. The Office of Radiation Safety performed monthly audits of Y-90 administration documentation for 90 days to assess the documentation for effectiveness of the corrective actions. The Office of Radiation Safety then continued with quarterly audits.

Item Number 220241 - A patient received dose to an unintended site during a gamma knife treatment on 5/18/2022. The patient underwent treatment of four lesions in the brain using Co-60. The patient had MRIs and CT scans. Those images were fused by the neurosurgeon and radiation oncologist. Upon completion of treatment, they discovered that although the targets were moved with the second image fusion, the shots and contours were not. That resulted in the treatment being 0.5 cm off for all four targets. The prescribed dose was between 2,000 and 2,100 cGy (rad), but the delivered dose to target tissue was between 800 and 1,500 cGy (rad). Maximum dose to healthy tissue was estimated to range between 2,182 and 2,709 cGy (rad). The patient and referring physician were informed. The Pennsylvania Department of Environmental Protection will perform a reactive inspection.

Item Number 220280 - A patient received more dose than prescribed during a Y-90 microsphere treatment on 6/14/2022. Microspheres are ordered in a few stock quantities, from which hospitals withdraw the prescribed doses. The hospital ordered a unit vial of 5.6 GBq (151 mCi) from the pharmacy and received 5.14 GBq (139 mCi). Nuclear medicine compared the received dose with the ordered dose and labeled the vial with the received dose. Rather than withdrawing the prescribed dose, the entire stock quantity was taken to interventional radiology for administration. The dose was administered to the patient without verifying the activity in the Nalgene jar or seeing the activity listed on the label. The patient was prescribed 2.2 GBq (59.46 mCi) for a dose of 15,000 cGy (rad) to the right lobe of the liver but was administered 5.07 GBq (137 mCi) for a dose of 34,000 cGy (rad). The authorized user signed the written directive after the procedure with 5.14 GBq (139 mCi) prescribed and 5.07 GBq (137 mCi) delivered. The prescribing physician (interventional radiologist) realized the error the next day when reading the post report. The cause of the event was human error. Corrective actions included implementing a new procedure.

Item Number 220296 - A patient received dose to an unintended site during a Y-90 microsphere treatment on 6/24/2022. The patient was prescribed an activity of 1.45 GBq (39.2 mCi) to the right lobe of the liver with an estimated size of 474 grams for a dose of 14,800 cGy (rad). However, post-administration imaging indicated that the activity was delivered to the left lobe of the liver with an estimated size of 283 grams for an estimated dose of 24,000 cGy (rad). The preliminary cause was based on the patient's anatomy; the left hepatic branch was close to the intended treatment site. The physician's office notified the patient on 6/29/2022. The patient was amenable to going back to treat the right lobe of the liver. The Colorado Department of Public Health & Environment is investigating the incident.

Events of Interest

Item Number 210537 - A patient received dose to an unintended site during a high dose rate (HDR) brachytherapy treatment for vaginal cancer on 10/28/2021. The patient was prescribed a total dose of 2,100 cGy (rad) to be delivered in three fractions of 700 cGy (rad) each using a 277 GBq (7.485 Ci) Ir-192 source. The first fraction was delivered on 10/28/2021. At some point later, the patient began experiencing complications from a hysterectomy and ended up going to a different hospital. The patient did not return to the original hospital to complete the HDR treatment. At the second hospital, a radiation oncologist discovered that the treatment on 10/28/2021 was 3 cm off and the colon/bowel received some fraction of the first treatment dose. On 12/9/2021, it was discovered that the HDR brachytherapy apparatus had passed beyond the apex of the vagina and the patient required re-suturing of the cervix. The original hospital's medical physicist determined that 9.6 cm^3 of the small bowel and 0.7 cm^3 of the sigmoid colon received 700 cGy (rad). The referring physician and patient were informed of this event on 12/10/2021. The Pennsylvania Department of Environmental Protection performed a reactive inspection on 12/17/2021. Corrective actions included procedure modification to require CT imaging/review after insertion of HDR brachytherapy applicators.

Item Number 220085 - A patient received dose to an unintended site during a treatment on 2/11/2022. The patient received 600 cGy (rad) to the lower third nasal dorsum using a remote afterloader containing a 237.58 GBq (6.421 Ci) Ir-192 source and a skin applicator. However, the prescribing physician

specified the right nasal sidewall. The patient and prescribing physician were notified on 2/14/2022. The patient was monitored and no adverse effects were evident.

Item Number 220261 - A patient received dose to an unintended site during a high dose rate brachytherapy treatment. The patient was diagnosed with basal carcinoma of the skin of the left scalp. The patient was administered a total of 3,600 cGy (rad) over six weeks; 600 cGy (rad) per week. On 6/3/2022, the physician/authorized user determined that he had misidentified the treatment site.

Item Number 220275 - A patient received dose to an unintended site during a high dose rate (HDR) brachytherapy treatment on 6/7/2022. The patient was prescribed two different treatments, one each for two different lesions located on the patient's lower right leg. The first lesion was prescribed 5,100 cGy (rad) with 17 fractions at 300 cGy (rad) each, using stereotactic body radiation therapy (SBRT). This treatment was completed in February 2022 without incident. The second lesion was prescribed 4,000 cGy (rad) with eight fractions of 500 cGy (rad) each, using an HDR unit with a 177.6 GBq (4.8 Ci) Ir-192 source. The first fraction of the second lesion's treatment was delivered on 6/7/2022. During set-up for the second fraction on 6/10/2022 and after drawing a circle on the patient's leg to help align the second lesion and monitor positioning during treatment, the patient informed the physicist that the circle during the first fraction had been drawn and the dose had been delivered to the first lesion (that was already treated in February). Treatment staff immediately alerted the patient's physician. Images from the patient's first HDR fraction were compared to the February SBRT treatment and found to be at the same location. The patient's written directive was updated to reflect an additional fraction to the second lesion. Both lesions were within 1.5 inches of each other. The physician stated there was no adverse effect to the patient since the dose went to the site of the first lesion and that the 500 cGy (rad) dose was likely to benefit the patient. The incident occurred due to human error. The oncology center had failed to note the change in patient positioning from supine to prone while using photos of the treatment areas. They also failed to confirm the written directive's treatment site. A contributing factor was the proximity of the two lesions and that the second lesion was not present during the February SBRT treatment. Corrective actions included adding a pretreatment step for multiple lesions in close proximity, asking the patient to point to the site to be treated, and including more images of the body and lesions to better identify the site and orient treatment personnel.

Embryo/Fetus or Nursing Child Dose Events - AOs or Potential AOs

Doses to an embryo/fetus or nursing child are reportable per 10 CFR 35.3047. By definition, these events are not medical events (reportable per 10 CFR 35.3045) and are captured in NMED as "Other" events. However, it is appropriate to also discuss these events in this section. One of these events occurred in FY22.

Item Number 220256 - An embryo/fetus received a radiation dose when a patient who was unknowingly pregnant was administered 3.7 GBq (100 mCi) of I-131 on 3/2/2022. A pregnancy test was performed in advance of the administration and indicated that the patient was not pregnant. The RSO received a call on 4/13/2022 notifying him that the patient was seven days pregnant when the administration occurred. The patient was informed and returned to the hospital to do a whole-body count to estimate biological half-life. The hospital calculated that upwards of 740 kBq (20 µCi) of I-131 was retained by week 11 of the pregnancy and 75% was taken up by the embryo/fetus. Dose prior to 11 weeks was reportedly estimated as that to the maternal uterus. The hospital estimated the dose to the embryo/fetus through 12 weeks of development as 26.6 cGy (rad). The Illinois Emergency Management Agency performed a reactive inspection on 6/2/2022. The cause of the event was determined to be the ineffectiveness of the pregnancy testing policy to account for very early-stage pregnancies that standard pregnancy tests cannot detect. The hospital revised its pregnancy testing policy to include patient instruction to abstain from intercourse for at least 10 days prior to administration of I-131.

2.3.3 Events Recently Added to NMED That Occurred Prior to FY22

Eight MED events and no embryo/fetal dose events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. None of the MED events were considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events - AOs or Potential AOs
None

Events of Interest
Item Number 210259 - A patient received dose to an unintended site during a high dose rate (HDR) treatment on 6/11/2021. The patient was receiving fraction two of three using an HDR treatment unit, vaginal cylinder, and a 312.84 GBq (8.455 Ci) Ir-192 source. The cylinder position was verified before treatment. After the fraction was completed, the treatment team noted that the vaginal cylinder had been displaced approximately 6 cm, a shift of approximately 5 cm. It was not known when the cylinder shifted during treatment. The intended treatment site/volume was prescribed to receive a dose of 700 cGy (rad). The hospital estimated that the administered dose was 142 cGy (rad). The unintended treatment site/volume was prescribed to receive no dose but received approximately 700 cGy (rad). Corrective actions included removing the involved HDR part from clinical use. The patient was informed of the incident on 6/11/2021. The hospital stated that the patient was examined on 5/9/2022 and had not exhibited nor reported any complications resulting from the incident.

Embryo/Fetus or Nursing Child Dose Events - AOs or Potential AOs
None

2.4 Radiation Overexposure

2.4.1 Ten-Year Data

Figure 4 displays the annual number and trend of EXP events that occurred during the 10-year period. The trend analysis determined that the Agreement State-regulated and Total events represent statistically significant decreasing trends (indicated by the trend lines). However, the NRC-regulated events do not represent a statistically significant trend (indicated by the absence of a trend line).

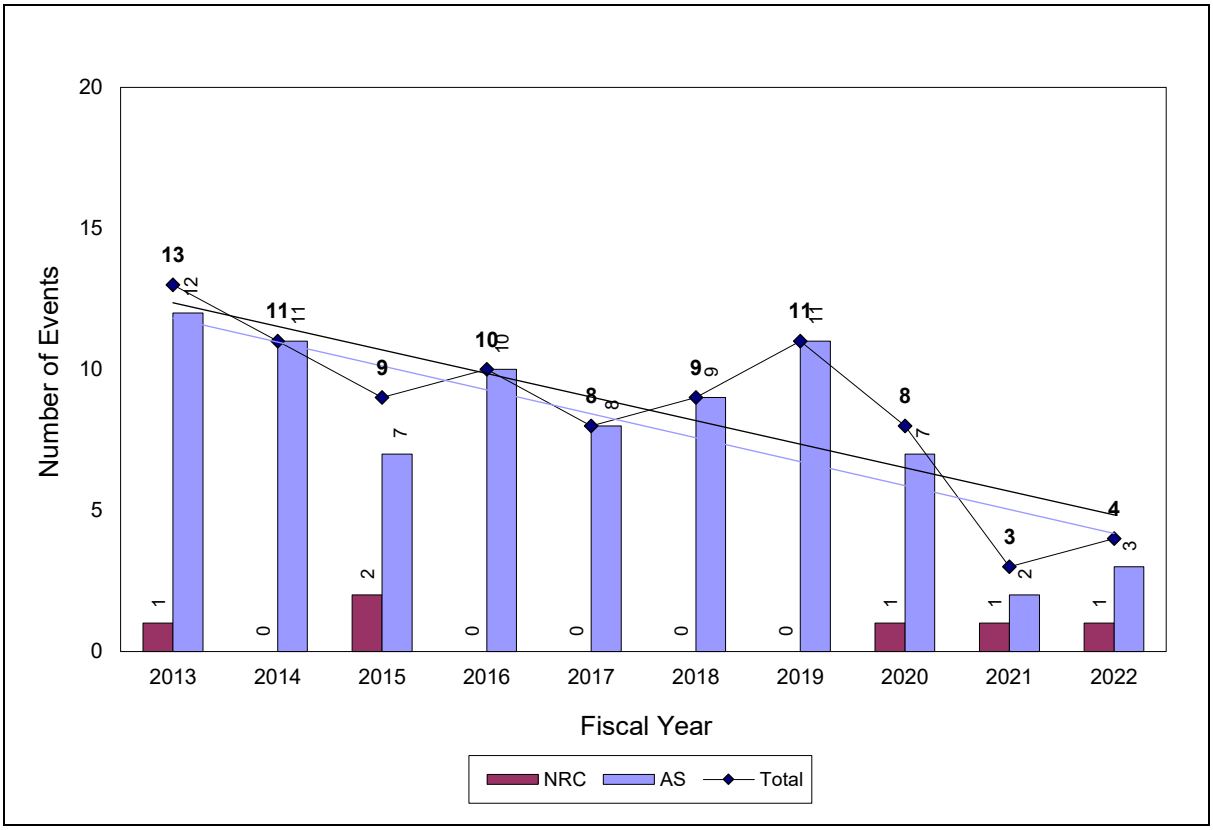

Figure 4. Radiation Overexposure Events (86 total)

The significance of individual EXP events may be determined by the CFR reporting requirement applicable to the event. For example, an event that is required to be immediately reported is typically more significant than an event with a 30-day reporting requirement. For this report, events requiring immediate or 24-hour reporting are considered significant. Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

Table 6 displays the number of events based on the different reporting requirement time categories. Note that each event is counted only once. If an event involved exposures that were reportable in more than one category, the event is counted in only the most restrictive category.

Table 6. EXP Events Classified by CFR Reporting Requirement

	Fiscal Year										
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Immediate	0	0	0	1	0	1	0	1	0	0	**3**
24-Hour	1	3	4	1	2	3	4	0	0	2	**20**
30-Day	12	8	5	8	6	5	7	7	3	2	**63**
Total	**13**	**11**	**9**	**10**	**8**	**9**	**11**	**8**	**3**	**4**	**86**

2.4.2 FY22 Data

Four EXP events occurred in FY22, two of which were considered significant.

Significant Events - Immediate Reporting
None

Significant Events - Within 24-Hour Reporting
Item Number 210436 - A radiographer received an overexposure on 10/6/2021. When he tried to retract a 3.37 TBq (91 Ci) Ir-192 source into a radiography exposure device, the locking mechanism slide would not lock. The radiographer approached the exposure device with a radiation survey meter and noticed that the readings were high, so he retreated. The area was roped off and placed under surveillance. The radiographer's direct reading dosimeter was off scale, so he remained outside the boundary. The radiographer's company dispatched an RSO with source retrieval authorization to recover the source. The source was secured later that same morning. The RSO received 0.6 mSv (60 mrem) and his assistant received 0.2 mSv (20 mrem). Emergency processing of the radiographer's and assistant radiographer's TLDs showed that they received approximately 9.3 cSv (rem) and 2 cSv (rem), respectively. The radiographer's hands were monitored for erythema, as it was determined that he handled the guide tube and collimator with the source in an unshielded position. Both workers were placed on mandatory leave and the company committed to retraining employees. The Pennsylvania Department of Environmental Protection performed a reactive inspection on 10/12/2021. Dose reconstruction and event re-enactments were performed to determine how the source disconnect occurred; a bent pin on the control cable seemed to be the cause of the event. As of 10/19/2021, this incident had a final International Nuclear Event Scale rating level of 2. This event was classified as an EQP and EXP event.

Item Number 220015 – An employee of a radiopharmaceutical manufacturer received an extremity overexposure. The employee was synthesizing F-18 fluorodeoxyglucose in a mini cell on 11/26/2021. The employee opened the door to the mini cell after hearing a sound indicating that the conical reservoir cap blew off during synthesis. He contaminated his gloves, laboratory coat, and pants, which he removed and replaced. He did not contaminate his skin. Radiation surveys showed that the floor was not contaminated as a result of the event. The RSO sent the employee's finger ring and TLD for processing. For the period of 11/15 to 11/28/2021, the employee received a total of 2.08 mSv (208 mrem) DDE to the chest, 58.330 cSv (rem) to the left hand, and 6.442 cSv (rem) to the right hand. The employee was removed from radiation related work. Corrective actions included providing additional training to personnel.

Events of Interest
None

2.4.3 Events Recently Added to NMED That Occurred Prior to FY22

Three EXP events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. One of these events was considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added

and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events - Immediate Reporting

Item Number 220010 - An employee of an industrial radioactive tracer manufacturer received an overexposure following a contamination event on 10/22/2019. The employee was manually drilling a container with 39.96 GBq (1.08 Ci) of Ir-192 ceramic tracer beads. The employee was not wearing eye or face shields and a puff of dust from the drilling struck the employee's face and eyes. The Radioactive Processing Laboratory has a dedicated ventilation system and is separate from the rest of the facility. This type of work would normally be performed in a lead-lined hot laboratory with a manipulator arm, but the manipulator arm was out of service. Areas of the building were contaminated by the incident. The areas were decontaminated and radiation surveys performed on 10/23/2019 were below background. Immediately after the incident, the employee repeatedly washed their face and eyes. On the next day, a radiation survey of the employee's face and eyes revealed 200 mR/hour. Subsequent radiation surveys over the next 103 days showed steadily decreasing rates, down to 10 mR/hour on day 103. The New Mexico Radiation Control Program reached out to NRC on 6/23/2020 seeking assistance in determining the employee's dose. NRC provided options on how to proceed, including encouraging the employee to submit to a full body count. A whole body bioassay was performed on 7/17/2020, which was 272 days after the exposure. The results of the first count revealed 152.44 Bq (4.12 nCi) and the result of the second count revealed 160.58 Bq (4.34 nCi). A dose assessment indicted that the employee received a CEDE of 0.0148 mSv (1.48 mrem), a SDE of 663 cSv (rem), a LDE of 11.5 cSv (rem), and an EDE of 0.036 mSv (3.6 mrem). As of 12/21/2021, this incident had a provisional International Nuclear Event Scale rating level of 2. This event was classified as an EXP and RLM event and as a potential Abnormal Occurrence.

Significant Events - Within 24-Hour Reporting

None

Events of Interest

None

2.5 Release of Licensed Material or Contamination

2.5.1 Ten-Year Data

Figure 5 displays the annual number and trend of RLM events that occurred during the 10-year period. The trend analysis determined that the data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines).

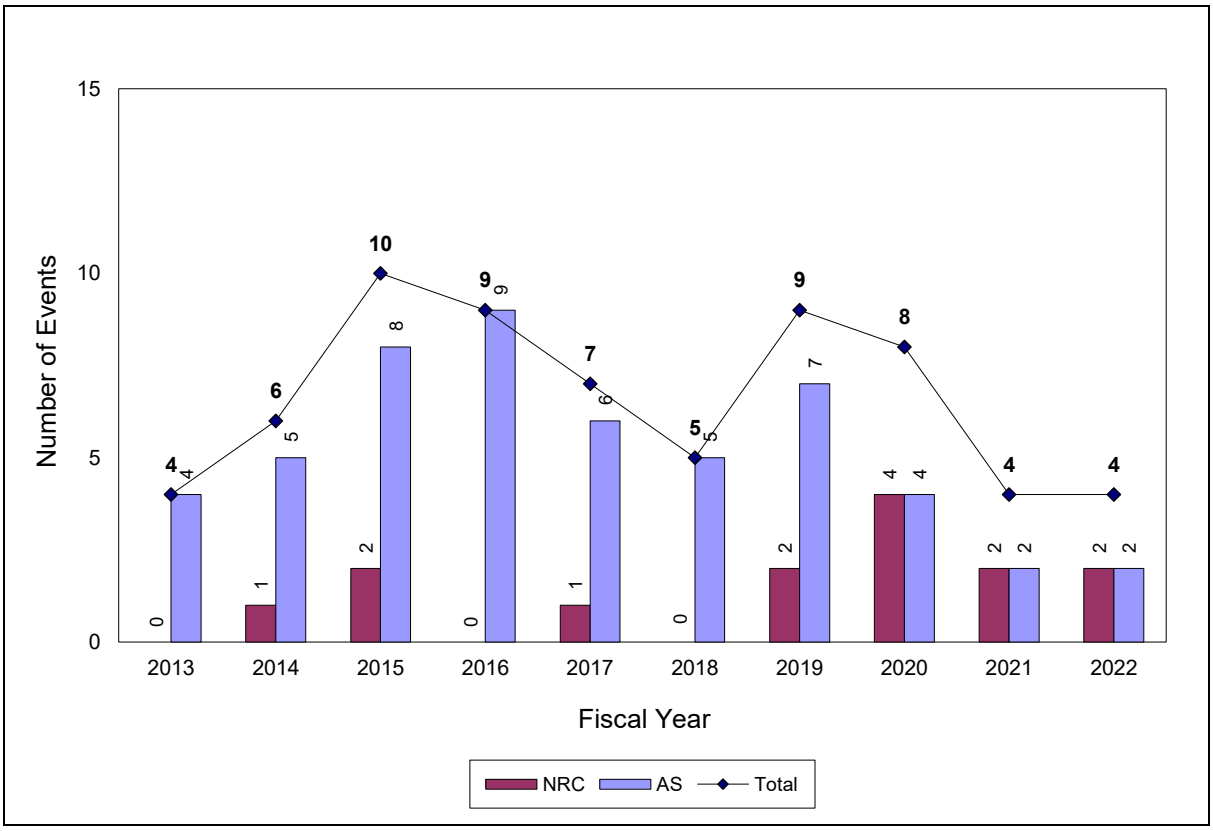

Figure 5. Release of Licensed Material or Contamination Events (66 total)

The significance of individual RLM events may be determined by the CFR reporting requirement applicable to the event. For example, an event that is required to be immediately reported is typically more significant than an event with a 30-day reporting requirement. For this report, events requiring immediate reporting are considered significant. Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

Table 7 displays the number of events based on the different reporting requirement time categories. Note that each event is counted only once. If an event involved exposures that were reportable in more than one category, the event is counted in only the most restrictive category.

Table 7. RLM Events Classified by CFR Reporting Requirement

	Fiscal Year										
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Immediate	1	1	1	1	3	1	1	2	0	1	**12**
24-Hour	2	3	9	8	3	4	6	5	3	3	**46**
30-Day	1	2	0	0	1	0	2	1	1	0	**8**
Total	**4**	**6**	**10**	**9**	**7**	**5**	**9**	**8**	**4**	**4**	**66**

2.5.2 FY22 Data

Four RLM events occurred in FY22, one of which was considered significant.

Significant Events - Immediate Reporting
Item Number 220292 - A hospital reported that a contamination event occurred early in the afternoon of 6/22/2022 while preparing an assay of a 5.55 GBq (150 mCi) liquid I-131 sodium iodide. The vial cracked (the vial head and septum separated from the main body) while a certified Nuclear Medicine technician was attempting to remove excess packing material with forceps. A spill occurred that contaminated the Nuclear Medicine hot laboratory. The area was immediately controlled, additional contamination controls were put in place, and cleanup efforts were initiated. No significant personal skin contamination occurred. Preliminary assessments on 6/22/2022 did not indicate gross I-131 uptake in any affected staff. The 24-hour thyroid bioassay results were negative for detected I-131 uptake in the thyroid for staff present during the spill but will be repeated at 48 hours. Decontamination efforts are ongoing.

Events of Interest
None

2.5.3 Events Recently Added to NMED That Occurred Prior to FY22

One RLM event was recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. This event was considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events - Immediate Reporting
Item Number 220010 - An employee of an industrial radioactive tracer manufacturer received an overexposure following a contamination event on 10/22/2019. The employee was manually drilling a container with 39.96 GBq (1.08 Ci) of Ir-192 ceramic tracer beads. The employee was not wearing eye or face shields and a puff of dust from the drilling struck the employee's face and eyes. The Radioactive Processing Laboratory has a dedicated ventilation system and is separate from the rest of the facility. This type of work would normally be performed in a lead-lined hot laboratory with a manipulator arm, but the manipulator arm was out of service. Areas of the building were contaminated by the incident. The areas were decontaminated and radiation surveys performed on 10/23/2019 were below background. Immediately after the incident, the employee repeatedly washed their face and eyes. On the next day, a radiation survey of the employee's face and eyes revealed 200 mR/hour. Subsequent radiation surveys over the next 103 days showed steadily decreasing rates, down to 10 mR/hour on day 103. The New Mexico Radiation Control Program reached out to NRC on 6/23/2020 seeking assistance in determining the employee's dose. NRC provided options on how to proceed, including encouraging the employee to submit to a full body count. A whole body bioassay was performed on 7/17/2020, which was 272 days after the exposure. The results of the first count revealed 152.44 Bq (4.12 nCi) and the result of the second count revealed 160.58 Bq (4.34 nCi). A dose assessment indicted that the employee received a

CEDE of 0.0148 mSv (1.48 mrem), a SDE of 663 cSv (rem), a LDE of 11.5 cSv (rem), and an EDE of 0.036 mSv (3.6 mrem). As of 12/21/2021, this incident had a provisional International Nuclear Event Scale rating level of 2. This event was classified as an EXP and RLM event and as a potential Abnormal Occurrence.

Events of Interest
None

2.6 Leaking Sealed Sources

2.6.1 Ten-Year Data

Figure 6 displays the annual number and trend of LKS events that occurred during the 10-year period. The trend analysis determined that the data do not represent statistically significant trends (indicated by the absence of trend lines).

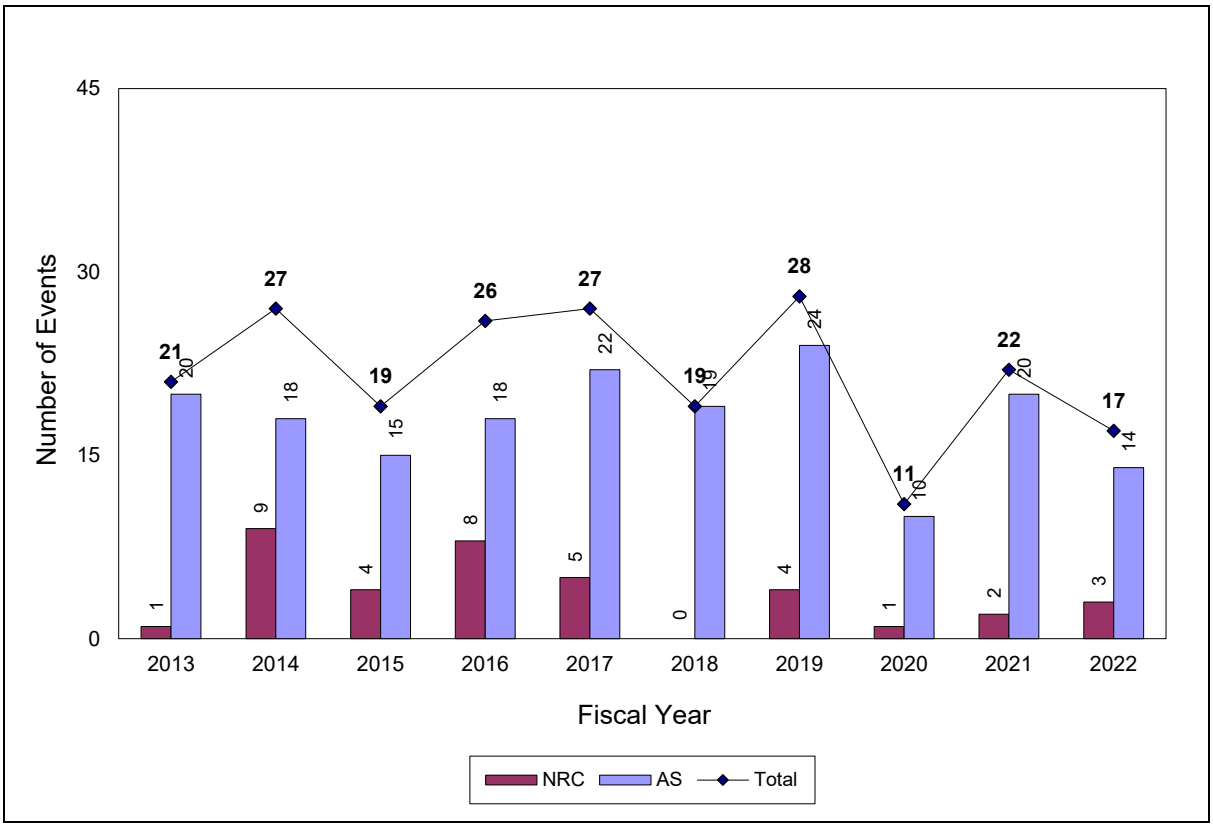

Figure 6. Leaking Sealed Source Events (217 total)

It is not possible to discern the significance of LKS events strictly from the CFR reporting requirements (as in Sections 2.4 and 2.5). There are essentially no immediate or 24-hour reporting requirements for leaking sources. The exception is 10 CFR 39.77(a), which is an immediate report to the NRC Regional office of a ruptured well logging source. Therefore, event significance will be determined on an event-by-event basis based on the severity of the event (e.g., significant exposure to workers, members of the public, and/or the environment). Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.6.2 FY22 Data

Seventeen LKS events occurred in FY22, none of which were considered significant.

Significant Events
None

Events of Interest
None

2.6.3 Events Recently Added to NMED That Occurred Prior to FY22

Three LKS events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. None of these events were considered significant. Note that

this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events
None

Events of Interest
None

2.7 Equipment

2.7.1 Ten-Year Data

Figure 7 displays the annual number and trend of EQP events that occurred during the 10-year period. The trend analysis determined that the data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines).

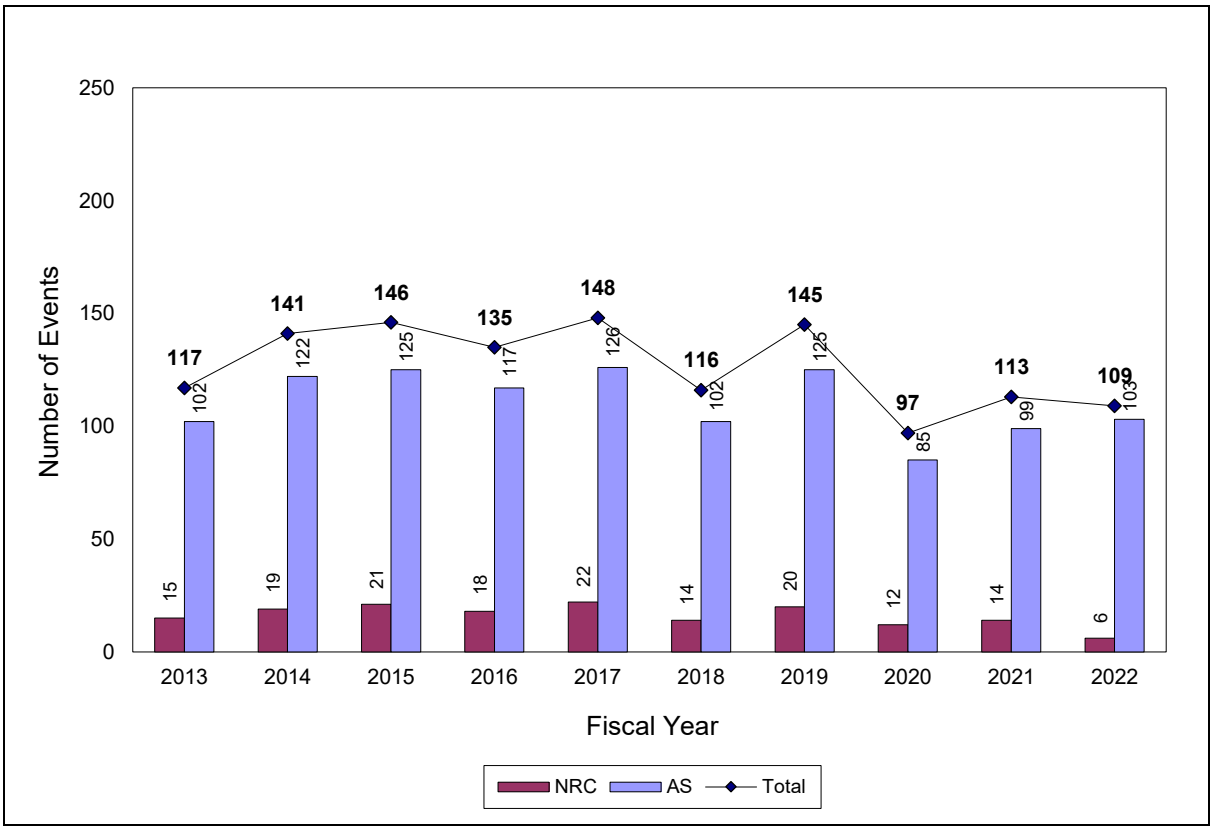

Figure 7. Equipment Events (1,267 total)

It is not possible to discern the significance of EQP events strictly from the CFR reporting requirements (as in Sections 2.4 and 2.5) because essentially all of the CFRs associated with EQP events require reporting within 24-hours. Therefore, event significance will be determined on an event-by-event basis based on the severity of the event (e.g., significant exposure to workers, members of the public, and/or the environment). Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.7.2 FY22 Data

One hundred nine EQP events occurred in FY22, one of which was considered significant.

Significant Events

Item Number 210436 - A radiographer received an overexposure on 10/6/2021. When he tried to retract a 3.37 TBq (91 Ci) Ir-192 source into a radiography exposure device, the locking mechanism slide would not lock. The radiographer approached the exposure device with a radiation survey meter and noticed that the readings were high, so he retreated. The area was roped off and placed under surveillance. The radiographer's direct reading dosimeter was off scale, so he remained outside the boundary. The radiographer's company dispatched an RSO with source retrieval authorization to recover the source. The source was secured later that same morning. The RSO received 0.6 mSv (60 mrem) and his assistant received 0.2 mSv (20 mrem). Emergency processing of the radiographer's and assistant radiographer's

TLDs showed that they received approximately 9.3 cSv (rem) and 2 cSv (rem), respectively. The radiographer's hands were monitored for erythema, as it was determined that he handled the guide tube and collimator with the source in an unshielded position. Both workers were placed on mandatory leave and the company committed to retraining employees. The Pennsylvania Department of Environmental Protection performed a reactive inspection on 10/12/2021. Dose reconstruction and event re-enactments were performed to determine how the source disconnect occurred; a bent pin on the control cable seemed to be the cause of the event. As of 10/19/2021, this incident had a final International Nuclear Event Scale rating level of 2. This event was classified as an EQP and EXP event.

Events of Interest

Item Number 210482 - A patient received less dose than prescribed when an HDR afterloader unit malfunctioned on 11/12/2021. The afterloader contained a 277.5 GBq (7.5 Ci) Ir-192 source. During patient treatment, the error message "8C.2 - Dummy park switch or drive failure" was displayed after the first 15 channels were delivered. The field service engineer was called and suggested to power down the HDR afterloader unit and reboot it, which did not resolve the problem. To avoid leaving the patient under general anesthesia any longer, the authorized user decided to stop the treatment and left the remaining four channels untreated. The prescribed dose was 1,400 cGy (rad) and the estimated dose given was 1,020 cGy (rad). This event was classified as an EQP and MED event.

Item Number 210512 - A patient received less dose than prescribed during a high dose rate (HDR) brachytherapy prostate treatment on 11/24/2021. The HDR unit contained a 221.26 GBq (5.98 Ci) Ir-192 source. The patient was treated without issue through the first channel. At the start of the second channel, an error was received indicating that the source position slipped while at the 0.0 cm mark. The procedure was paused with no treatment to the patient through the second channel. A dummy wire test was run, with no errors indicated. A second attempt at treatment with the Ir-192 source through the second channel was made and the same position error was indicated. The treatment was cancelled at that point. The total prescribed dose was 1,500 cGy (rad), but the patient only received 50 cGy (rad), or 3.3%. The source was verified to be in the HDR unit and no additional radiation exposure to the patient or staff was received from the event. The hospital contacted the HDR manufacturer. A field service engineer determined that the fault was a hardware issue with the active source encoder, which serves as a second check mechanism for how much the source is moving compared against its internal motor calculations for positioning. The engineer replaced the encoder. This event was classified as an EQP and MED event.

Item Number 220023 - A construction materials testing company reported that a technician was unable to retract a 0.37 GBq (10 mCi) Cs-137 source to its fully shielded position within a moisture/density gauge. The gauge also contained a 1.48 GBq (40 mCi) Am-Be source. The failure occurred at the end of the fourth sample taken on the morning of 12/29/2021. The technician placed the gauge into its transport container and returned it to the shop. The RSO performed a radiation survey of the gauge and found the highest reading one meter from the gauge at 4 µSv/hour (0.4 mrem/hour). The RSO stated that the transport index for the gauge that morning was 0.2. The source rod was stuck about two inches from being fully shielded. They used a hammer and anchor bolt to drive the source back into the shielded position. The RSO stated that they noticed wet clay material oozing out of the area between the source shaft and the gauge case. The RSO believed that the clay was preventing the source from fully retracting. The RSO was instructed to isolate the hammer and anchor bolt used to drive the source into the shielded position. The Texas Department of State Health Services responded to the facility and performed fixed and removable contamination surveys on the hammer and anchor bolt with negative results. The RSO's hands and clothing were surveyed for contamination; no contamination was detected. A leak test of the Cs-137 source was performed and no leakage was identified. A gauge repair company stated that the source rod was not bent, but the bearing assembly of the source rod was severely impacted by soil. A likely cause was the technician pushing the gauge into the soil, which forced soil into the opening around the source rod. Technicians were retrained to be careful not to push gauges into the soil. The gauge was cleaned, repaired, and returned to service. The RSO performed visual inspection of all gauges to make

sure there were none with impacted soil that might prevent source rod movement. The construction materials testing company will add a lubrication and visual inspection of the interior of the sliding block areas and source rod base to the maintenance schedule. Technicians were also retrained on what to do if the source will not retract.

Item Number 220041 - A construction materials testing company reported that a moisture/density gauge was damaged at a temporary jobsite in Humble, Texas, on 1/14/2022. The gauge contained a 1.48 GBq (40 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source. The technician had put the gauge down and moved about three feet away to prepare for another measurement. The gauge was run over by a small bulldozer, which damaged the gauge body and separated the source rod and handle from the base of the gauge. The Cs-137 source was in the shielded position at the time of the impact. The Cs-137 source was determined to be intact and still attached to the source rod. The technician secured the area and contacted the RSO. The RSO responded to the site and was able to loosely put the gauge back together and return the gauge to its transportation case. The RSO then confirmed that the radiation profile had not changed from the manufacturer's specifications. The area where the gauge was being used was surveyed with no radiation readings above background. The gauge was returned to the company's facility pending shipment to the manufacturer for assessment. Both sources passed their leak tests on 2/22/2022. The root cause of the incident was lack of vigilance by the technician and not communicating with the bulldozer driver. No individual received significant radiation exposure due to this event. A meeting was held with all technicians to remind them to be vigilant, to communicate with personnel operating vehicles, and to maintain control of their gauges.

Item Number 220078 - A construction materials testing company reported that they were informed by their portable gauge service company that the 159.1 MBq (4.3 mCi) Cs-137 source had broken off a moisture/density gauge and was missing. The gauge was last used on 11/6/2021 at a temporary job site. A technician satisfactorily completed one test on road base material. When he attempted a second test, the gauge readings were not normal. The testing company RSO stated that as soon as the testing had been completed on the road base material, nine inches of concrete was poured over the base, and then topped with four inches of asphalt. The gauge was returned to the testing company facility and then sent to the gauge service company. The RSO and service company performed radiation surveys of the two areas of the street where testing had been performed back on 11/6/2021. They were unable to locate the source with hand-held detectors. The Texas Department of State Health Services performed radiation surveys of the street on 12/16/2021 and identified the source's location. Exposure rates at the surface of the asphalt were between 13 to 15 µR/hour and measurements at one meter were equal to background at 4 µR/hour. The source was recovered on 3/1/2022 by a company that was licensed for sealed source recovery. The source holder, with the source inside, was found approximately four inches down the testing hole in the compacted base material (under the cement and asphalt). A field leak test was negative, as was the field measurement of soil for potential radioactive contamination. The source recovery company transported the source to its facility where the leak test was repeated. Soil samples were analyzed by a third-party laboratory. The source, source holder, and gauge were all transferred to the manufacturer for evaluation. The source leak test and soil sample analyses were negative for radioactive contamination. The NRC Registry of Radioactive Sealed Sources and Devices indicates that this device also contains an Am-Be source with a maximum activity of 1.85 GBq (50 mCi). This event was classified as an EQP and LAS event.

Item Number 220151 - A paper company reported that a fixed nuclear gauge was damaged in a fire on 3/27/2022. The gauge contained a 7.4 GBq (200 mCi) Cs-137 source. Radiation readings revealed 3 mR/hour on the surface at the bottom of the gauge and 250 mR/hour on the surface at the top of the gauge. A radiation reading on the walkway three feet above the gauge was 300 µR/hour. A radiation reading at the bottom of the ladder was 100 µR/hour. The company barricaded/roped off areas on the walkway and at the bottom of the ladder. The gauge was located approximately 12 feet off the floor and was not readily accessible by employees. A gauge service provider removed and properly secured the

damaged gauge on the evening of 3/27/2022. The gauge was prepared for shipment. Radiation readings around the shipping container revealed one elevated reading of 30 mR/hour on the outside of the drum.

Item Number 220179 - A panoramic irradiator facility reported a failure of the electronic brake on the irradiator vault entrance door. The irradiator contained Co-60 sources with a total activity of 133,000 TBq (3,600,000 Ci). The failure was discovered at 1200 on 4/11/2022. Operations were discontinued at that time. Following troubleshooting and diagnosis of the issue, the failure was reported to the corporate RSO at 1830. Operations were reinitiated after implementing temporary remedial access control measures and training staff on the revised procedures. However, it was subsequently identified that the implemented remedial access control procedure was in conflict with certain regulatory requirements, so operations were again discontinued until the equipment was repaired or another option explored. Illinois Emergency Management Agency (IEMA) inspectors were dispatched on 4/12/2022 to perform a reactive inspection. The brake was repaired after receiving and installing a replacement part on 4/13/2022. Safety checks were successfully performed with no issues and irradiation operations resumed. No personnel injuries or radiation exposures occurred and no adverse effects on the security system were reported.

Item Number 220201 - A construction materials testing company reported that a moisture/density gauge was lost and damaged when it fell from the back of a truck in transit on 4/27/2022. The gauge contained a 1.48 GBq (40 mCi) Am-Be source and a 0.3 GBq (8 mCi) Cs-137 source. Pieces of the gauge were on Interstate Highway I-25 as a result of vehicles running over the gauge. The locations of the sources were initially undetermined. The company contacted the police to help cordon off the affected area to support retrieval of gauge pieces and conduct surveys. Colorado Department of Public Health & Environment staff arrived on site at 1350 hours on 4/27/2022. CSP HAZMAT, Castle Rock HAZMAT, and fire department personnel were already on site. I-25 was shut down for roughly 0.5 miles. The sources were located and packaged by onsite HAZMAT teams. The gauge base with the Am-Be source was secured in an overpack. The Cs-137 source capsule was extracted from a crack in the pavement by HAZMAT and placed into a shielded box. The highest radiation level on contact with the box containing the Cs-137 source was 0.2 mSv/hour (20 mrem/hour). The highest radiation level on contact with the overpack containing the Am-Be source was 4 µSv/hour (400 µrem/hour). Both containers were labeled and secured for transport per DOT specifications. A gauge service provider assisted with leak testing and ultimate disposal of the damaged gauge and sources. Corrective actions included terminating the employment of personnel involved and providing additional training to all gauge users. This event was classified as an EQP and LAS event.

Item Number 220244 - A biodiesel refinery reported that a fire occurred at approximately 1900 on 5/22/2022. The fire impacted two fixed nuclear gauges, each containing a 370 MBq (10 mCi) Cs-137 source. Illinois Emergency Management Agency (IEMA) staff were dispatched to determine the status of shielding, potential contamination, and source security. Gauge 1 did not appear to have its integrity compromised. However, Gauge 2 exhibited radiation exposure rates of approximately 350 to 400 mR/hour near contact. Large area wipes showed no indication of radioactive contamination. An exclusion zone was established at approximately four feet in diameter and six feet above the damaged gauge. In order to prevent public radiation exposures, both gauges were isolated. Both gauges remained mounted to their pipes, pending removal to a secure location. The gauges were bagged to prevent the spread of contamination. The damaged gauge was inverted to direct the unshielded source radiation into the ground. A licensed service provider was on site on 5/31/2022 to properly remove and package the damaged gauge for disposal. IEMA staff was on site to oversee operations. IEMA verified that leak tests on both gauges revealed no radioactive contamination, the area of the fire was able to be released for unrestricted use, and the gauges were properly stored/secured. The refinery was informed of the need for proper disposal within two years.

Item Number 220260 - A phosphate mining company reported the failure of a fixed density gauge on a pipeline on 6/3/2022. The 185 MBq (5 mCi) Cs-137 source separated from the gauge. An employee found the source on the ground, picked it up, held it in their hand for anywhere from 30 to 60 seconds

before realizing what it was, then dropped it and reported it to management. The source was placed in an empty bucket and transported to a shelf in the onsite radioactive material storage cabinet. The Florida Bureau of Radiation Control (FBRC) was contacted and an inspector responded to the site. FBRC calculated an extremity dose of 1.42 cSv (rem). The Radiation Emergency Assistance Center/Training Site (REAC/TS) confirmed that dose and calculated a dose of 2.24 cSv (rem) with no decay correction. It was determined that there was very little to no medical concern and the company should just continue to observe the employee's hand. This event was classified as an EQP and LAS event.

Item Number 220321 - A construction materials testing company reported that a moisture/density gauge containing a 1.63 GBq (44 mCi) Am-Be source and a 0.333 GBq (9 mCi) Cs-137 source was severely damaged on 7/15/2022. The gauge had been unsecured in an open bed of a truck with the tailgate down. While leaving a worksite, the gauge fell from the truck and was run over by a semi-trailer truck. The licensee proceeded to pick up the debris, including the source rod and bottom plate. The debris was secured in the bed of the truck and a 55-gallon steel drum was placed over the debris. A 15-foot caution zone was extended around the truck until the fire department arrived to scan the area for contamination. No radioactive contamination was detected on the road and radiation readings were the same as background. A Kentucky Division of Public Health & Safety inspector arrived at the site at about 1630 on 7/15/2022 and conducted independent scans and contamination swipes; no leakage of either source was identified. The shielding around the Cs-137 source remained intact and radiation readings were as expected from the shielded source. The tungsten shielding block was placed at the exposed source rod end and taped in place to further reduce possible radiation exposure. The Am-Be source remained attached to the bottom housing and scans showed the radiation readings to be nominal and no removable contamination was detected. The gauge debris was transferred to a plastic bucket, secured in the 55-gallon steel drum, and transported to the licensee facility. The gauge was stored in a room with appropriate signage isolated from the gauge storage area. Radiation readings were checked outside the room to ensure that exposure rates were at a minimum. A reactive inspection is planned.

Item Number 220357 - A steel manufacturer reported a damaged fixed nuclear gauge that contained a 1.72 GBq (46.5 mCi) Co-60 source. A mold failed during casting on 8/7/2022, resulting in molten steel overflowing onto the gauge. The top of the source holder was sheared off and the shutter was stuck open. Operators were routinely more than six feet away at the time of casting and were further away during the accident, in a large part due to the heat. Radiation exposure rates were recorded at a maximum of 20 mR/hour directly above the source holder on the mold. Six inches above the mold, the exposure rate dropped to 2 mR/hour. The area was blocked off and boundaries were surveyed at 0.1 mR/hour. A service provider responded on 8/8/2022, performed a satisfactory leak test, and repaired the shutter. Corrective actions also included procedure modifications and providing additional training to personnel. The Illinois Emergency Management Agency performed a reactive inspection on 8/8/2022 to verify that conditions did not result in any public or worker radiation exposures and that the damage to the source did not result in contamination.

Item Number 220382 - An oilfield services company reported that some of the lead shielding on the source shutter of a fixed nuclear gauge was missing. The gauge was approximately 8.5 years old and contained a 7.4 GBq (200 mCi) Cs-137 source. On 8/23/2022, they were preparing to service an engine to which the gauge was indirectly attached. They noticed that there was only one lead block remaining on the shutter. Normally there would be four to seven lead blocks. The gauge was removed from the assembly and placed in storage with a lead blanket on top. Surveys found no elevated radiation levels. There were no overexposures to workers. A service company replaced the shutter and several individuals were brought in to evaluate the loss of lead shielding. All concurred that it was likely caused by vibrations as the gauge was attached to an assembly with two engines and multiple moving parts. It was also noted that a metal plate that should be on the outside of the lead shields was missing. It was hypothesized that the loss or lack of metal plate may have accelerated the deterioration and loss of the lead shields. The

company updated their inspection procedure to look for other instances of this problem. The Texas Department of State Health Services investigated the incident.

Item Number 220415 - A construction materials testing company reported that a moisture/density gauge was damaged by a bulldozer at a temporary jobsite on 9/14/2022. The gauge contained a 1.48 GBq (40 mCi) Am-Be source and a 0.3 GBq (8 mCi) Cs-137 source. The gauge was in use when the operator of the bulldozer stopped within 8 to 10 feet of the gauge. After a brief pause and despite attempts by the authorized user to stop the driver, the bulldozer proceeded forward and impacted the gauge. The notched index rod was broken and the entire Cs-137 source rod was displaced from the gauge. The area was cordoned off in a 100-foot diameter circle and the RSO was contacted. The source rod was successfully reinserted into the gauge and radiation readings confirmed that no residual radioactivity remained after removal of the gauge from the site. The condition of the Am-Be source was not determined, but the gauge housing did not suffer significant damage. No radiation overexposures are expected from the incident, but dosimetry for personnel involved was requested. The damaged gauge will be transported to the testing company's headquarters for leak testing and final disposition. A follow-up inspection is planned by the Kentucky Division of Public Health and Safety.

2.7.3 Events Recently Added to NMED That Occurred Prior to FY22

Six EQP events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. None of these events were considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events
None

Events of Interest
Item Number 220119 - A radioactive gauge service company reported the loss of a 1.42 GBq (38.49 mCi) Am-Be source from a customer's moisture/density gauge. After the customer experienced low readings from the gauge, the service company used their own company van to pick up the gauge on 6/29/2021. After months of troubleshooting efforts, the service company discovered on 3/8/2022 that the Am-Be source cap was loose and the source was missing (the Cs-137 source was still present). The service company searched for the source by surveying their calibration facility, the unloading/loading area, and the van that picked up the gauge. They could not locate the source and believed it was not in the gauge or its transportation case when picked up from the customer. The service company updated their calibration/repair/servicing procedures to include checking the Am/Be source cap to ensure that the cap is tight and there is evidence of thread locker around the source cap. Technicians will add thread locker to the source caps and tighten them if they encounter a loose source cap. The technicians will also notify their RSO so they can forward the information to the gauge manufacturer. The service company notified their two Agreement State facilities along with the technicians that drive their mobile calibration laboratories to check for loose source caps. This event was classified as an EQP and LAS event.

2.8 Transportation

2.8.1 Ten-Year Data

Figure 8 displays the annual number and trend of TRS events that occurred during the 10-year period. The trend analysis determined that the NRC-regulated, Agreement State-regulated, and Total events represent statistically significant decreasing trends (indicated by the trend lines).

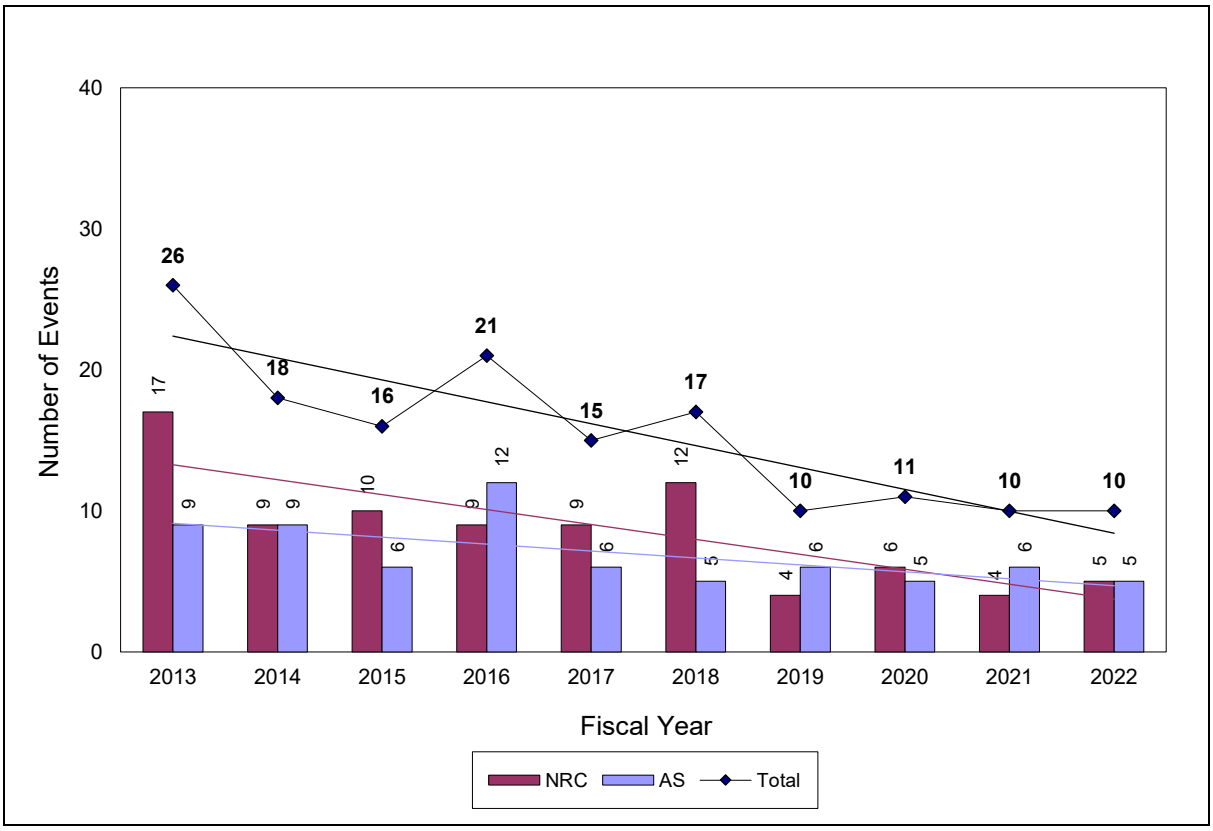

Figure 8. Transportation Events (154 total)

It is not possible to discern the significance of TRS events strictly from the CFR reporting requirements (as in Sections 2.4 and 2.5). Therefore, event significance will be determined on an event-by-event basis based on the severity of the event (e.g., significant exposure to workers, members of the public, and/or the environment). Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.8.2 FY22 Data

Ten TRS events occurred in FY22, two of which were considered significant.

Significant Events

Item Number 210477 - A radiography equipment manufacturer received an unshielded 2.59 GBq (69.87 mCi) Ir-192 source in a type B container on 11/5/2021. An oilfield services company in Nigeria had shipped three Ir-192 sources for exchange, in separate drums. When received, two of the drums contained radiography exposure devices, but the third drum contained just the unshielded source. The radiation reading on the side of the drum was 300 mR/hour and the reading from the top of the drum with the lid off was between 40 and 50 mR/hour. The radiography equipment manufacturer retrieved the source and placed it in a shield. They stated that they will hold onto the devices and terminate their relationship with the Nigerian company.

Item Number 220302 - A radioactive source disposal facility received a package of sources for disposal from Costa Rica. The package had a surface radiation reading of 5 mSv/hour (500 mrem/hour). The shipment contained two drums, which had two sources inside each drum. The shielding in one drum had moved during shipment. This drum contained two 37 GBq (1 Ci) Am-241 sources.

Events of Interest

Item Number 210458 - A radiopharmaceutical manufacturing company received a package on 10/25/2021 with high levels of removable contamination. The package contained 2.14 GBq (57.81 mCi) of Zr-89 when packaged on 10/22/2021. The bottom of the package revealed 217,410 cpm in a background of 1,510 cpm. The package was opened and the top of the lead pig, which held the vial of approximately 200 ml of liquid Zr-89, was found detached from the bottom of the lead pig. Pieces of the vial were observed outside of the lead pig, indicating that the vial was broken. The package was resealed and placed into the cyclotron vault for safety and containment purposes. The package was stored 50 feet away from personnel at the facility. The Zr-89 manufacturer and common carrier were notified of the situation. The radiopharmaceutical manufacturing company determined that the vial had been broken prior to their receipt. Contamination on the outside of the package was likely caused by the person opening the package, since the fluid was likely initially only on the interior.

Item Number 220327 - A PET production facility shipped a package containing F-18 fluorodeoxyglucose to a hospital. Receipt surveys of the package showed radiation levels of 110 mR/hr on contact and removable contamination levels of 1,050,000 dpm/cm^2 (17.5 kBq/cm^2 or 0.473 μCi/ cm^2). Pre-shipment surveys of the package showed radiation levels of 3 mR/hr on contact and removable contamination levels of 210 dpm/ cm^2 (3.5 Bq/cm^2 or 0.095 nCi/ cm^2). The transportation company was notified. Surveys of the PET production facility and transport vehicle identified no contamination. An inspection was conducted on 8/25/2022. Individuals responsible for packaging and surveying the doses did not follow company procedures. They were reprimanded and retrained.

2.8.3 Events Recently Added to NMED That Occurred Prior to FY22

One TRS event was recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. This event was not considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events

None

Events of Interest

None

2.9 Other

2.9.1 Ten-Year Data

Figure 10 displays the annual number of OTH events that occurred during the 10-year period. Because OTH events do not fit a defined criterion that ensures consistency within the data, trending analysis is not performed on this data.

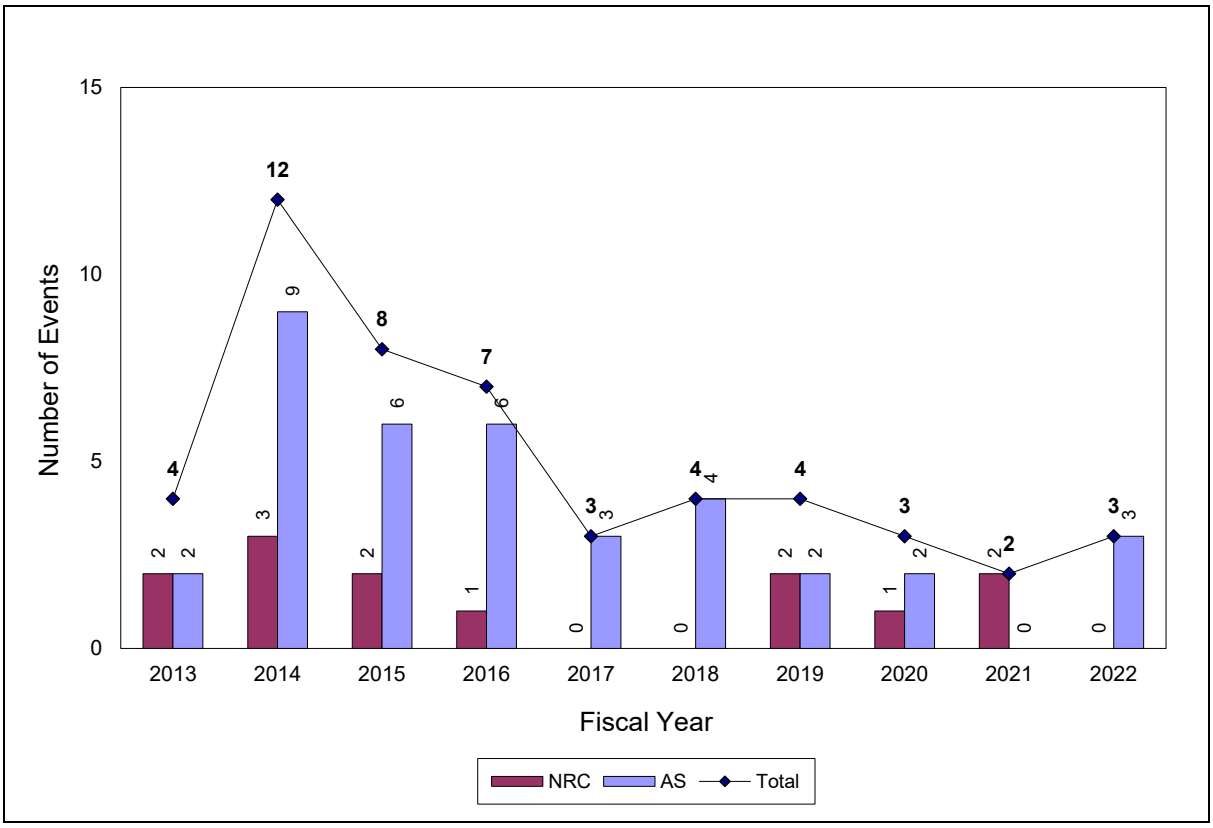

Figure 9. Other Events (50 total)

It is not possible to discern the significance of OTH events strictly from the CFR reporting requirements (as in Sections 2.4 and 2.5). Therefore, event significance will be determined on an event-by-event basis based on the severity of the event (e.g., significant exposure to workers, members of the public, and/or the environment). Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.9.2 FY22 Data

Three OTH events occurred in FY22, one of which was considered significant.

Significant Events

Item Number 220256 - An embryo/fetus received a radiation dose when a patient who was unknowingly pregnant was administered 3.7 GBq (100 mCi) of I-131 on 3/2/2022. A pregnancy test was performed in advance of the administration and indicated that the patient was not pregnant. The RSO received a call on 4/13/2022 notifying him that the patient was seven days pregnant when the administration occurred. The patient was informed and returned to the hospital to do a whole-body count to estimate biological half-life. The hospital calculated that upwards of 740 kBq (20 µCi) of I-131 was retained by week 11 of the pregnancy and 75% was taken up by the embryo/fetus. Dose prior to 11 weeks was reportedly estimated as that to the maternal uterus. The hospital estimated the dose to the embryo/fetus through 12 weeks of development as 26.6 cGy (rad). The Illinois Emergency Management Agency performed a reactive

inspection on 6/2/2022. The cause of the event was determined to be the ineffectiveness of the pregnancy testing policy to account for very early-stage pregnancies that standard pregnancy tests cannot detect. The hospital revised its pregnancy testing policy to include patient instruction to abstain from intercourse for at least 10 days prior to administration of I-131. This event was classified as a potential Abnormal Occurrence.

Events of Interest
Item Number 220270 - A radiography services company reported that two armed individuals broke into their Commerce City, Colorado, location on 6/11/2022. The company described the incident as part of a chain of local break-ins. The two individuals were able to access the vault that contained the radiography exposure devices but were unsuccessful in accessing the devices stored within a secure container in the vault. It appeared that no radioactive materials were accessed or removed from the storage area. Denver police responded to the facility. According to the National Source Tracking System, as of 6/11/2022 the company was in possession of six I-192 sources, ranging from 3.63 to 0.888 TBq (98 to 24 Ci). The Colorado Department of Public Health & Environment is investigated the incident.

2.9.3 Events Recently Added to NMED That Occurred Prior to FY22

No OTH events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events
None

Events of Interest
None

Appendix A

Event Type Descriptions and Criteria

Appendix A
Event Type Descriptions and Criteria

NMED events covered by this report are divided into the following categories based on the event reporting requirements defined in 10 CFR. Note that the tables in this appendix do not contain the full text of the applicable CFRs.

Lost/Abandoned/Stolen Material (LAS)

The LAS event category includes those events where licensed radioactive material is lost or found, abandoned or discovered, and stolen or recovered. The radioactive material involved can be sealed or unsealed material, specifically or generally licensed, exempt or non-exempt quantities, involve a licensee or a non-licensee, and can be found anywhere. Abandoned well logging sources are included in this category.

NMED LAS reportable events are those that meet the reporting requirements of 10 CFR Part 20.2201. Events that do not meet the 20.2201 reporting requirement thresholds are captured as not-reportable LAS events. Additionally, LAS events involving non-Atomic Energy Act material are entered into NMED as not-reportable events.

All reportable LAS events will be coded as one of the following reporting requirements. For events involving more than one source, the decision of 10 × or 1,000 × the 10 CFR Part 20 Appendix C quantity is based on the aggregate quantity of licensed material.

Table A-1. Primary LAS Reporting Requirements

Primary LAS Reporting Requirements	Reporting Requirement Summary
20.2201(a)(1)(i)	Aggregate activity ≥ 1,000 × 10 CFR Part 20 Appendix C quantity
20.2201(a)(1)(ii)	Aggregate activity > 10 and < 1,000 × 10 CFR Part 20 Appendix C quantity
39.77(d)	Irretrievable well logging source

The following additional (secondary) CFRs will be added as applicable. This should occur infrequently. For the 10 CFR 37 requirements, the event will instead be coded as OTH if there was no actual theft, sabotage, or diversion of Category 1 or 2 quantities of radioactive material.

Table A-2. Secondary LAS Reporting Requirements

Secondary LAS Reporting Requirements	Reporting Requirement Summary
30.55(c)	Theft/diversion of 10 Ci (or 100 Ci per year) of H 3 (not generally licensed).
37.57(a)	Unauthorized entry resulted in actual ~~or attempted~~ theft, sabotage, or diversion of a category 1 or category 2 quantity of material.
37.57(b)	Suspicious activity related to possible theft, sabotage, or diversion of a category 1 or category 2 quantity of material
37.81(a)	A shipment of category 1 quantities of material is lost or missing.
37.81(b)	A shipment of category 2 quantities of material is lost or missing.
37.81(c)	Actual ~~or attempted~~ theft or diversion (or related suspicious activities) of a shipment of category 1 quantities of material.
37.81(d)	Actual ~~or attempted~~ theft or diversion (or related suspicious activities) of a shipment of category 2 quantities of material.
37.81(e)	Recovery of any lost or missing shipment of category 1 quantities of material.
37.81(f)	Recovery of any lost or missing shipment of category 2 quantities of material.

39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.
40.64(c)(1)	Theft/diversion of 15 lb (or 150 lb per year) of source material (uranium or thorium).
73.71(a)(1)	Lost shipment of any SNM.
73.App G(I)(a)(1)	Actual or attempted theft or unlawful diversion of SNM.
74.11(a)	Loss, theft or unlawful diversion (actual or attempted) of SNM or the unauthorized production of enriched uranium.
76.120(a)(2)	Loss, other than normal operating loss, of special nuclear material.
76.120(a)(3)	Actual or attempted theft or unlawful diversion of special nuclear material.
150.16(b)(1)	Actual or attempted theft or unlawful diversion of SNM.
150.17(c)(1)	Attempted theft or unlawful diversion of more than 6.8 kg (15 lb) of Uranium or Thorium at any one time or more than 68 kg (150 lb) in any one calendar year.
150.19(c)	Theft/diversion of 10 Ci (or 100 Ci per year) of H-3 (not generally licensed). Note: This requirement is just like 30.55(c) but applies to Agreement States and offshore waters.

Medical (MED)

MED events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-3. MED Reporting Requirements

MED Reporting Requirements	Reporting Requirement Summary
35.3045(a)(1)(i)(A)	Total dose delivered that differs from the prescribed dose by 20% or more; and differs from the prescribed dose by more than 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(i)(B)	Total dosage delivered that differs from the prescribed dosage by 20% or more or falls outside the prescribed range; and results in a dose that differs from prescribed by more than 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(i)(C)	Fractionated dose delivered that differs from the prescribed dose for a single fraction by 50% or more; and differs from the prescribed dose by more than 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(A)	Administration of a wrong radioactive drug containing byproduct material or the wrong radionuclide for a brachytherapy procedure that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(B)	Administration of a radioactive drug containing byproduct material by the wrong route of administration that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(C)	Administration of a dose or dosage to the wrong individual or human research subject that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(D)	Administration of a dose or dosage delivered by the wrong mode of treatment that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(E)	Leaking sealed source that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(iii)	Dose to the skin, organ, or tissue, other than the treatment site, that exceeds by 0.5 Sv (50 rem) or more and 50% or more the expected dose to that site from the procedure if the administration had been given in accordance with the written directive prepared or revised before administration.
35.3045(a)(2)(i)	For permanent implant brachytherapy, the total source strength administered differs by 20% or more from the total source strength documented in the post-implant portion of the written directive, excluding sources that were implanted in the correct site but migrated outside of the treatment site.
35.3045(a)(2)(ii)	For permanent implant brachytherapy, the total source strength administered outside of the treatment site exceeds 20% of the total source strength documented in the post-implant portion of the written directive, excluding sources that were implanted in the correct site but migrated outside of the treatment site.
35.3045(a)(2)(iii)(A)	For permanent implant brachytherapy, an administration that includes the wrong radionuclide.
35.3045(a)(2)(iii)(B)	– For permanent implant brachytherapy, an administration that includes the wrong individual or research subject.
35.3045(a)(2)(iii)(C)	For permanent implant brachytherapy, an administration that includes sealed sources implanted directly into a location discontiguous from the treatment site, as documented in the post-implant portion of the written directive.
35.3045(a)(2)(iii)(D)	For permanent implant brachytherapy, an administration that includes a leaking sealed source resulting in a dose that exceeds 0.5 Sv (50 rem) to an organ or tissue.

35.3045(b)	Event resulting from patient intervention in which the administration of byproduct material or radiation from byproduct material results in unintended permanent functional damage to an organ or a physiological system, as determined by a physician.

Events are not considered MED events if they involve:

- Only a linear accelerator,
- Doses administered in accordance with a written directive (even if the directive is in error), or
- Patient intervention, unless the event results in unintended permanent functional damage to an organ or physiological system.

Events are considered MED events if, for example, a linear accelerator is used for therapy by mistake instead of a teletherapy unit or a teletherapy unit instead of a linear accelerator.

For purposes of determining whether to categorize an event as MED or EXP, MED events occur to patients only (i.e., those being administered a medical procedure). For example, if a patient receives too much dose during a procedure, the event would be categorized as MED rather than EXP. However, radiation exposure received from a cause other than the patient's medical procedure may be categorized as EXP.

Radiation Overexposure (EXP)

EXP events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-4. EXP Reporting Requirements

EXP Reporting Requirements	Reporting Requirement Summary
20.2202(a)(1)(i)	An individual received a total effective dose equivalent of 25 rem (0.25 Sv) or more.
20.2202(a)(1)(ii)	An individual received a lens dose equivalent of 75 rem (0.75 Sv) or more.
20.2202(a)(1)(iii)	An individual received a shallow-dose equivalent to the skin or extremities of 250 rad (2.5 Gy) or more.
20.2202(b)(1)(i)	Loss of control of material causing or threatening to cause an individual to receive a total effective dose equivalent exceeding 5 rem (0.05 Sv) in a period of 24 hours.
20.2202(b)(1)(ii)	Loss of control of material causing or threatening to cause an individual to receive an eye dose equivalent exceeding 15 rem (0.15 Sv) in a period of 24 hours.
20.2202(b)(1)(iii)	Loss of control of material causing or threatening to cause an individual to receive a shallow-dose equivalent to the skin or extremities exceeding 50 rem (0.5 Sv) in a period of 24 hours.
20.2203(a)(2)(i)	Doses in excess of the occupational dose limits for adults in 20.1201.
20.2203(a)(2)(ii)	Doses in excess of the occupational dose limits for a minor in 20.1207.
20.2203(a)(2)(iii)	Doses in excess of the limits for an embryo/fetus of a declared pregnant woman in 20.1208.
20.2203(a)(2)(iv)	Doses in excess of the limits for an individual member of the public in 20.1301.
20.2203(a)(2)(v)	Doses in excess of any applicable limit in the license.
39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.

The EXP event category includes all regulatory overexposures of radiation workers or exposures of members of the public to radiation. The overexposure can be external or internal and can be whole body, extremity, skin, lens of the eye, or internal dose. When the overexposure involves multiple individuals or an individual with multiple overexposure types (such as whole body and extremity), the different types of overexposures are entered separately. Note that dosimeters record exposure if improperly stored near a radiation source and, depending on the type of dosimeter, may react as though they are in a radiation field when exposed to heat or humidity.

It is NRC policy to classify only those events that positively involve a personnel overexposure, and not just a dosimeter exposure, as reportable EXP events. For example, either the licensee does not contest the personnel overexposure, or in cases where the licensee does contest the overexposure, the State or NRC determines the event to be personnel overexposure.

EXP limits do not apply to patients receiving medical procedures.

Release of Licensed Material or Contamination (RLM)

RLM events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-5. RLM Reporting Requirements

RLM Reporting Requirements	Reporting Requirement Summary
20.2202(a)(2)	Release of radioactive material, inside or outside of a restricted area, so that had an individual been present for 24 hours, the individual could have received an intake 5 times the ALI.
20.2202(b)(2)	Release of material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake in excess of 1 ALI.
20.2203(a)(2)(vi)	Doses in excess of the ALARA constraints for air emissions established under 20.1101(d).
20.2203(a)(3)(i)	Radiation or concentrations of radioactive material in a restricted area in excess of any applicable limit in the license.
20.2203(a)(3)(ii)	Radiation or concentrations of radioactive material in an unrestricted area in excess of 10 times any applicable limit set forth in Part 20 or in the license.
20.2203(a)(4)	Levels of radiation or releases of radioactive material in excess of the standards in 40 CFR Part 190, or of license conditions related to those standards.
30.50(a) 40.60(a) 70.50(a) 76.120(b)	Event that prevents immediate protective actions necessary to avoid exposures to radiation or radioactive materials that could exceed regulatory limits or releases of material that could exceed regulatory limits.
30.50(b)(1) 40.60(b)(1) 70.50(b)(1) 76.120(c)(1)	Unplanned contamination event that requires access to be restricted for > 24 hours, involves > 5 times the lowest ALI, and has access restricted for a reason other than to allow isotopes with a half-life of < 24 hours to decay.
30.50(b)(3) 40.60(b)(3) 70.50(b)(3) 76.120(c)(3)	Event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on the individual's clothing or body.
39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.
50.72(b)(3)(xii) 72.75(c)(3)	Event requiring the transport of a radioactively contaminated person to an offsite medical facility for treatment.

The RLM event category includes two types of events. The first type is a radioactive release to air or water exceeding the 10 CFR Part 20 Appendix B annual limit on intake (ALI). The second type of RLM event involves contamination events such as a radioactive spill outside of work areas, removable contamination found on equipment, or material tracked around a laboratory such that additional radiological control measures had to be implemented. This category does not include spills inside of laboratory hoods, radiopharmaceutical dose preparation areas, or hot cells where radioactive work routinely requires cleanup or changing of absorbent paper after the performance of a task. Should there be multiple release types (e.g., surface, air, water, or person) or areas of contamination associated with the release, this information is entered individually.

Leaking Sealed Source (LKS)

LKS events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-6. LKS Reporting Requirements

LKS Reporting Requirements	Type of Source
31.5(c)(5)	Generally licensed
34.27(d)	Radiography
35.67(e)	Medical
39.35(d)(1)	Well logging (leaking)
39.77(a)	Well logging (ruptured)
30.50(b)(2)	All other sources

The NRC requires that most sealed sources be periodically leak tested to verify that the material is still sealed and that the source is still considered safe to use without contamination controls, including protective clothing or gloves. Sources are generally exempt from leak testing under the following conditions [see 10 CFR Part 31.5(c)(2), 34.27(c), 35.67(f), and 39.35(e)]:

- Sources containing only gaseous radioactive material (like H-3, Kr-85, etc.),
- Sources containing licensed material with a half-life of 30 days or less,
- Sources containing <= 100 μCi of other beta and/or gamma emitting material,
- Sources containing <= 10 μCi of alpha emitting material,
- Sources held in storage in the original shipping container prior to initial installation,
- Seeds of Ir-192 encased in nylon ribbon, or
- Sources in storage and not in use (must be leak tested prior to use or transfer).

A source is considered leaking if a leak test can detect greater than 0.005 μCi of removable radioactive material. The leaking source is then removed from service, disposed of or returned to the manufacturer for repair, and a report is sent to the NRC or Agreement State with the details of the leaking source.

For regulatory reporting purposes, a leaking source is generally considered a failed device under 10 CFR Part 30. Therefore, in most cases an LKS event is also coded as an EQP event. An exception is the Ni-63 foil source, which is coded as only an LKS event.

Equipment (EQP)

EQP events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-7. EQP Reporting Requirements

EQP Reporting Requirements	Reporting Requirement Summary
21.21(d)(1)(i)	A failure to comply or a defect affecting the construction or operation of a facility or an activity that is subject to licensing requirements.
21.21(d)(1)(ii)	A failure to comply or a defect affecting a basic component that is supplied for a facility or an activity that is subject to licensing requirements.
30.50(a) 40.60(a) 70.50(a) 76.120(b)	Event that prevents immediate protective actions necessary to avoid exposures to radiation or radioactive materials that could exceed regulatory limits or releases of material that could exceed regulatory limits.
30.50(b)(2) 40.60(b)(2) 70.50(b)(2) 72.75(d)(1) 76.120(c)(2)	Equipment is disabled or fails to function as designed.
30.50(b)(4) 40.60(b)(4) 70.50(b)(4) 76.120(c)(4)	Unplanned fire or explosion that damages any licensed material or any device, container, or equipment containing licensed material.
31.5(c)(5)	Actual or indicated failure to shielding, the on-off mechanism or indicator, or upon the detection 0.005 uCi or more of removable radioactive material.
34.101(a)(1)	Unintentional disconnection of the radiographic source assembly from the control cable.
34.101(a)(2)	Inability to retract and secure the radiographic source assembly to its fully shielded position.
34.101(a)(3)	Failure of any radiographic component (critical to the safe operation of the device) to properly perform its intended function.
35.3204	Eluate exceeding the permissible concentration of Mo-99, Sr-82, and Sr-85, as listed in 35.204(a), at the time of generator elution; more than 0.15 kBq Mo-99 per MBq Tc-99m, more than 0.02 kBq Sr-82 per MBq Rb-82 chloride, or more than 0.2 kBq Sr-85 per MBq Rb-82 chloride.
36.83(a)(1)	An irradiator source stuck in an unshielded position.
36.83(a)(2)	Fire or explosion in an irradiator radiation room.
36.83(a)(3)	Damage to the irradiator source racks.
36.83(a)(4)	Failure of the irradiator cable or drive mechanism used to move the source racks.
36.83(a)(5)	Inoperability of the irradiator access control system.
36.83(a)(6)	Detection of irradiator source by the product exit monitor.
36.83(a)(7)	Detection of irradiator radioactive contamination attributable to licensed radioactive material.
36.83(a)(8)	Structural damage to the irradiator pool liner or walls.
36.83(a)(9)	Abnormal water loss or leakage from the irradiator source storage pool.
36.83(a)(10)	Irradiator pool water conductivity exceeding 100 microsiemens per centimeter.
39.77(a)	Ruptured well logging sealed source.
39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.

72.75(c)(1)	Defect in any spent fuel, HLW, or reactor-related GTCC waste storage structure, system, or component that is important to safety.
72.75(c)(2)	Significant reduction in the effectiveness of any spent fuel, HLW, or reactor-related GTCC waste storage confinement system during use.
72.242(d)	Design or fabrication deficiency for any spent fuel storage cask delivered to a licensee which affects the ability of components important to safety to perform their safety function.

The EQP event category includes all types of radiological equipment problems, including generally licensed device problems covered in 10 CFR Part 31; radiography equipment problems covered in 10 CFR Part 34; irradiator problems covered in 10 CFR Part 36; well logging problems covered in 10 CFR Part 39, and other types of equipment covered in 10 CFR Part 30, 40, 70, and 76. EQP events are defined as the failure of, or a defect in, any piece of equipment that either contains licensed radioactive materials as an integral part, or whose function is to interact with such materials.

Transportation (TRS)

TRS events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-8. TRS Reporting Requirements

TRS Reporting Requirements	Reporting Requirement Summary
20.1906(d)(1)	Transported package exceeds removable surface contamination limits.
20.1906(d)(2)	Transported package exceeds external radiation limits.
71.5	Transportation of licensed material.
71.95(a)(1)	Significant reduction in the effectiveness of any NRC-approved Type B or Type AF packaging during use.
71.95(a)(2)	Defects with safety significance in any NRC-approved Type B or fissile material packaging, after first use.
71.95(a)(3)	Conditions of approval in the Certificate of Compliance were not observed in making a shipment.
71.95(b)	Conditions in the Certificate of Compliance were not followed during a shipment.

Other (OTH)

The OTH event category includes the following types of events:

1. Doses to an embryo/fetus or nursing child reportable per 10 CFR Part 35.3047. Note that these events are not MED events (reportable per 10 CFR Part 35.3045).
2. Dose in an unrestricted area in excess of 2 mrem in an hour, but no individual received a dose in excess of limits (if a dose in excess of limits is received, the event is an EXP event).
3. 10 CFR 37 events that do not result in the actual theft, sabotage, or diversion of Category 1 or 2 quantities of radioactive material. Otherwise, the event is as an LAS event.
4. Reportable events that do not specifically fit into one of the previous event types.

For items 1-3 above, OTH events are determined and coded per the 10 CFR reporting requirements listed below. Due to the nature of item 4 above, other reporting requirements may also be used.

Table A-9. OTH Reporting Requirements

OTH Reporting Requirements	Reporting Requirement Summary
20.2203(a)(2)(iv)	Dose in an unrestricted area in excess of 2 mrem in an hour, but no dose received in excess of limits.
35.3047(a)	Dose to an embryo/fetus greater than 50 mSv (5 rem) DE from administration of byproduct material or radiation from byproduct material to a pregnant individual unless specifically approved, in advance, by the authorized user.
35.3047(b)(1)	Dose to a nursing child greater than 50 mSv (5 rem) TEDE resulting from an administration of byproduct material to a breast-feeding individual.
35.3047(b)(2)	Dose to a nursing child resulting in unintended permanent functional damage to an organ or physiological system, as determined by a physician, resulting from an administration of byproduct material to a breast-feeding individual.
37.57(a)	Unauthorized entry resulted in ~~actual or~~ attempted theft, sabotage, or diversion of a category 1 or category 2 quantity of material.
37.57(b)	Suspicious activity related to possible theft, sabotage, or diversion of a category 1 or category 2 quantity of material
37.81(c)	~~Actual or~~ attempted theft or diversion (or related suspicious activities) of a shipment of category 1 quantities of material.
37.81(d)	~~Actual or~~ attempted theft or diversion (or related suspicious activities) of a shipment of category 2 quantities of material.
39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.

Appendix B

Statistical Trending Methodology

Appendix B
Statistical Trending Methodology

General

The following is a general discussion of statistical trending techniques.

A common approach to the statistical analysis of trend is based on regression methods. In particular, it is often the case that a relationship exists between the values assumed by a pair of variables. For example, if x is time (in years), and y is the rate of events per year, then we could use regression methods to study whether there is a relationship between time and event rate.

Regardless of the application, it is standard practice to refer to x as the independent variable and y as the dependent variable. Another common term for the dependent variable is "response variable," and the terms covariant and explanatory variable are sometimes used for the independent variable. Also, it is typical with regression modeling that the independent variable can be measured with little or no error, but the dependent variable involves a random error. Consequently, even if there is a deterministic functional relationship between the two variables, when data pairs (x_1, y_1), (x_2, y_2),..., (x_n, y_n) are plotted, the points will not coincide exactly with the function, but instead will tend to be scattered. Such a plot is called a scatter diagram and shows the variation in the data. The plots in this report are bar charts containing the same information.

Fitting a Straight Line to Data

Consider a linear function

$$f(x) = \alpha + \beta x \tag{B-1}$$

where α and β are unknown parameters. A common model is that y is the sum of a linear function of the form (1) and a random error term, e. Standard results on estimation and inference about the parameters of the model assume that e is a normally distributed random variable with mean 0 and constant (but unknown) variance, σ^2. These assumptions mean that:

- Each yi is an observed value of a random quantity that is normally distributed [with mean f(xi)], and
- All the observations yi are of variables with a common variance, σ2.

The y_i are also assumed to be observations of random quantities that are independent of each other.

Under these conditions, the usual approach to estimating the unknown parameters α and β is the method of least squares (LS). In this method, α and β are selected so that the sum of the squares of the vertical distances between the data points and the fitted line is as small as possible. The LS method leads to the estimates

$$\hat{\beta} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})y_i}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \text{ and} \tag{B-2}$$

$$\hat{\alpha} = \bar{y} - \hat{\beta}\bar{x}\,, \tag{B-3}$$

where $\bar{x}$ and $\bar{y}$ are arithmetic averages. The estimated LS regression line is then

$$\hat{y} = \hat{\alpha} - \hat{\beta}x\,, \tag{B-4}$$

and an estimate of σ is

$$s = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{n-2}} \,. \tag{B-5}$$

Testing for Trend

A trend exists whenever the true slope, β, is not zero. We start the analysis with the idea that β is zero, and then ask whether the data tell us otherwise. Two quantities computed from the data are used in this assessment. The first, the *error sum of squares* (SSE), appears in the numerator of s. It is defined as

$$SSE = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \,. \tag{B-6}$$

This quantity is the number that is minimized in order to find the estimates of α and β. The differences being squared in SSE represent random variations that remain after the linear fitting process. The second quantity is the *regression sum of squares* (SSR), defined by the following equation

$$SSR = \sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2 \,. \tag{B-7}$$

Note that SSR looks at deviations between the fitted line and the default notion that the data are constant and have no slope.

One can show by algebra that

$$SSE + SSR = SST \,, \tag{B-8}$$

where the *total sum of the squares* (SST), is defined as

$$SST = \sum_{i=1}^{n} (y_i - \bar{y})^2 \,. \tag{B-9}$$

SST measures the overall variation in the data. It is the numerator that would be used to estimate the variance in a sample from a normally-distributed random variable, where all the data in the sample have the same distribution (and thus no trend). This variance measures "random variation" in such a sample.

In the framework of the linear function (1), the regression's effectiveness is measured by the *SSR* term defined above. When it is small, the fitted curve will not differ very much from the horizontal line $y = \bar{y}$. *SSE* will be approximately equal to *SST*, and, from the data, both *SSE* and *SST* will be estimates of mere random variation. In this case, the data does not provide evidence that β is different from zero.

On the other hand, if the y values tend to vary linearly with respect to the independent variable, x, then some of the variation in the y values can be attributed to this dependence on x. Since *SSR* assesses the difference between the least squares predictions of the y values and the arithmetic mean, $\bar{y}$, it is a measure of the variation which is "explained" by the linear relationship. When the slope of the fitted line is large, more of these differences will tend to be large, resulting in a large value of *SSR*.

In the equation, $SST = SSE + SSR$, the total variation is partitioned into two parts, the variation due to random error and the variation due to the linear relationship. The fraction of the total variation that is due to the linear relationship is called the coefficient of determination, or r^2, and is defined by:

$$r^2 = \frac{SSR}{SST} \,. \tag{B-10}$$

r^2 is a fraction that varies from 0 to 1. It will be near 0 if most of the variation is due to randomness, and it will be near 1 if most of the variation is due to the linear relationship.

The closeness to 1 needed for the data to show that the slope is not zero depends on the number of data points. If the dependent data are independent, normally-distributed at each x, with constant variance, and no trend, then the quantity, F, defined by

$$F = \frac{(n-2)\,r^2}{1-r^2} \tag{B-11}$$

can be shown to have an F distribution with degrees of freedom 1 and $n - 2$, where n is the number of data points. When the data satisfy the assumptions except that there is a significant trend, r^2 will be closer to 1 and the computed F statistic will be much larger. Specifically, if the computed F exceeds the upper fifth percentile of the F distribution with 1 and $n - 2$ degrees of freedom, we infer that the data contain evidence that β is not zero, at the 5% level of significance. In this case, we reject the null hypothesis that $\beta = 0$ and conclude that a statistically significant trend exists, with 95% confidence.

As an example, for an assumed set of data fit to the linear model, assume the $r^2 = 0.9369$ and that n is 13. Then the calculated F is 163.3. The upper 95th percentile of the $F(1,11)$ distribution is 4.84. Since 163.3 far exceeds the upper 95th F percentile, the linear model is statistically significant. In this example, the data show that it would be very unlikely for a trend not to exist. The linear model explains too much of the variation in the data for a trend not to exist.

Applying the Model to NMED Data

The method described above was applied for each category of NMED event data, for the overall NMED data, and for additional subgroups of data when trends were found in the overall data. When the calculated F exceeded the 95th percentile, the trend line was shown on the graph and identified as being statistically significant.

In future reports, methods slightly different than that explained above could be employed because NMED data in many cases does not follow the assumptions listed above. In particular, three considerations apply.

- The data are counts, and thus are discrete rather than being normally distributed. This problem is most pronounced when the counts are relatively low or sparse. Also, normally-distributed data in general can be negative, but the counts are always greater than or equal to zero.
- Variations in counts tend to increase as the counts increase. If the events occur at random, with a constant occurrence rate in a particular year or quarter, then the variance of the count for that year or quarter is equal to the mean or average for that year or quarter. Thus, the assumption of a constant variance for the data in each year may not apply.
- Finally, more than one count can be associated with a single reported incident in a single event category. This situation would occur, for example, if several pieces of equipment fail in an event or if several types of overexposure occur. In these cases, the data are not independent.

One way to address the first two concerns is to identify the number of licensees in various NMED categories and study the event occurrence rates rather than the counts. The rates are more likely to come from a continuum and might have a more constant variance.

Taking logarithms of the counts and then applying the LS method avoids the problem of possible negative trend lines. The resulting models can be converted back to the scale of the counts after the regression line is identified. In the scale of the counts, the resulting trend, if any, has a slight curvature.

Weighted regression is a method similar to the LS method described above, but it compensates explicitly for the effect of the different variances from year to year.

Another approach that deals with the first two concerns is to apply regression methods that have been designed specifically for counts. Poisson regression, for example, is based on the idea that the data in each

time period are counts observed from a Poisson distribution, with an occurrence rate that is described by the model. Given occurrence rates in each time period, and independent counts, the probability of seeing the observed data is easily computed by multiplying the occurrence probabilities for the individual time periods. The slope and intercept parameter estimates are selected so that the model maximizes the resulting "likelihood function."

The third issue may have little effect on the results of a trend analysis, as long as there are many counts with relatively few occurring in clumps, no trends in the occurrence of clumps, and no large clumps of counts coming from a single occurrence report. The best way to address the dependence issue is to identify and remove the duplicate counts prior to the trend analysis.

Appendix C

IAEA Radionuclide Categorization

Appendix C
IAEA Radionuclide Categorization

Table C-1 lists the radionuclides that this report uses to determine the significance for events involving the loss, abandonment, or theft of radioactive sources. This list is derived from the IAEA *Code of Conduct on the Safety and Security of Radioactive Sources (2004)* and from IAEA Safety Guide RS-G-1.9, *Categorization of Radioactive Sources*. Based on the amount of radioactivity involved, the radionuclides are grouped into five categories, with Category 1 being the most hazardous. These categories may be summarized as follows (derived from IAEA Safety Guide RS-G-1.9, *Categorization of Radioactive Sources*):

Category 1: **Extremely dangerous.** These sources could cause permanent injury within a few minutes if handled. Doses could be fatal to someone in close proximity to an unshielded source for periods ranging from a few minutes to an hour.

Category 2: **Very dangerous.** These sources could cause permanent injury within minutes to hours if handled. Doses could be fatal to someone in close proximity to an unshielded source for periods ranging from hours to days.

Category 3: **Dangerous.** These sources could cause permanent injury within hours if handled. Doses could possibly (but unlikely) be fatal to someone in close proximity to an unshielded source for periods ranging from days to weeks.

Category 4: **Unlikely to be dangerous.** These sources would not cause permanent injury, although delayed health effects are possible. Doses could possibly (but unlikely) cause temporary injury to someone in close proximity to an unshielded source for a period of many weeks.

Category 5: **Most unlikely to be dangerous.** These sources would not cause permanent injury.

Table C-1. IAEA Code of Conduct Category 1 through 5 Radionuclide Activity Thresholds

Radionuclide	Category 1		Category 2		Category 3		Category 4		Category 5	
	TBq	Ci [1]	TBq	Ci [1]	TBq	Ci [1]	TBq	Ci [1]	TBq	Ci [1]
Am-241	60	1,622	0.6	16.2	0.06	1.62	0.0006	0.0162	1.0e-08	2.7e-07
Am-241/Be	60	1,622	0.6	16.2	0.06	1.62	0.0006	0.0162	1.0e-08	2.7e-07
Cf-252	20	541	0.2	5.4	0.02	0.54	0.0002	0.0054	1.0e-08	2.7e-07
Cm-244	50	1,352	0.5	13.5	0.05	1.35	0.0005	0.0135	1.0e-08	2.7e-07
Co-60	30	811	0.3	8.1	0.03	0.81	0.0003	0.0081	1.0e-07	2.7e-06
Cs-137	100	2,703	1.0	27.0	0.10	2.70	0.001	0.0270	1.0e-08	2.7e-07
Gd-153	1,000	27,030	10.0	270.3	1.00	27.03	0.01	0.2703	1.0e-05	2.7e-04
Ir-192	80	2,162	0.8	21.6	0.08	2.16	0.0008	0.0216	1.0e-08	2.7e-07
Pm-147	40,000	1,081,200	400.0	10,812.0	40.00	1,081.20	0.4	10.8120	1.0e-05	2.7e-04
Pu-238	60	1,622	0.6	16.2	0.06	1.62	0.0006	0.0162	1.0e-08	2.7e-07
Pu-239/Be	60	1,622	0.6	16.2	0.06	1.62	0.0006	0.0162	1.0e-08	2.7e-07
Ra-226	40	1,081	0.4	10.8	0.04	1.08	0.0004	0.0108	1.0e-08	2.7e-07
Se-75	200	5,406	2.0	54.1	0.20	5.41	0.002	0.0541	1.0e-06	2.7e-05
Sr-90 (Y-90)	1,000	27,030	10.0	270.3	1.00	27.03	0.01	0.2703	1.0e-08	2.7e-07
Tm-170	20,000	540,600	200.0	5,406.0	20.00	540.60	0.2	5.4060	1.0e-06	2.7e-05
Yb-169	300	8,109	3.0	81.1	0.30	8.11	0.003	0.0811	1.0e-05	2.7e-04

Notes

1. The primary values are given in terabecquerel (TBq). Curie (Ci) values are provided for practical usefulness only and are rounded after conversion.

Appendix D

Revision of Data

Appendix D
Revision of Data

NMED is a dynamic database with new reports and revisions to previous reports being added on a continuing basis. This activity can result in additions or subtractions to data that was published in previous issues of this report. Numerical changes in NMED numbers can result from several different types of technical changes to coded data. The most common types of changes to database records are:

- Record additions due to late reporting
- Record additions or subtractions due to changes in event type
- Changes between fiscal years due to event date changes on individual events
- Record additions or subtractions due to changes in event reportability
- Record additions or subtractions due to reclassifying a single combined event as multiple individual events (or vice versa)
- Record deletions due to duplicated records or NRC direction

Figures D-1 through D-9 below display the changes in the data published in the previous annual report. A positive value indicates that records were added and a negative value indicates that records were removed.

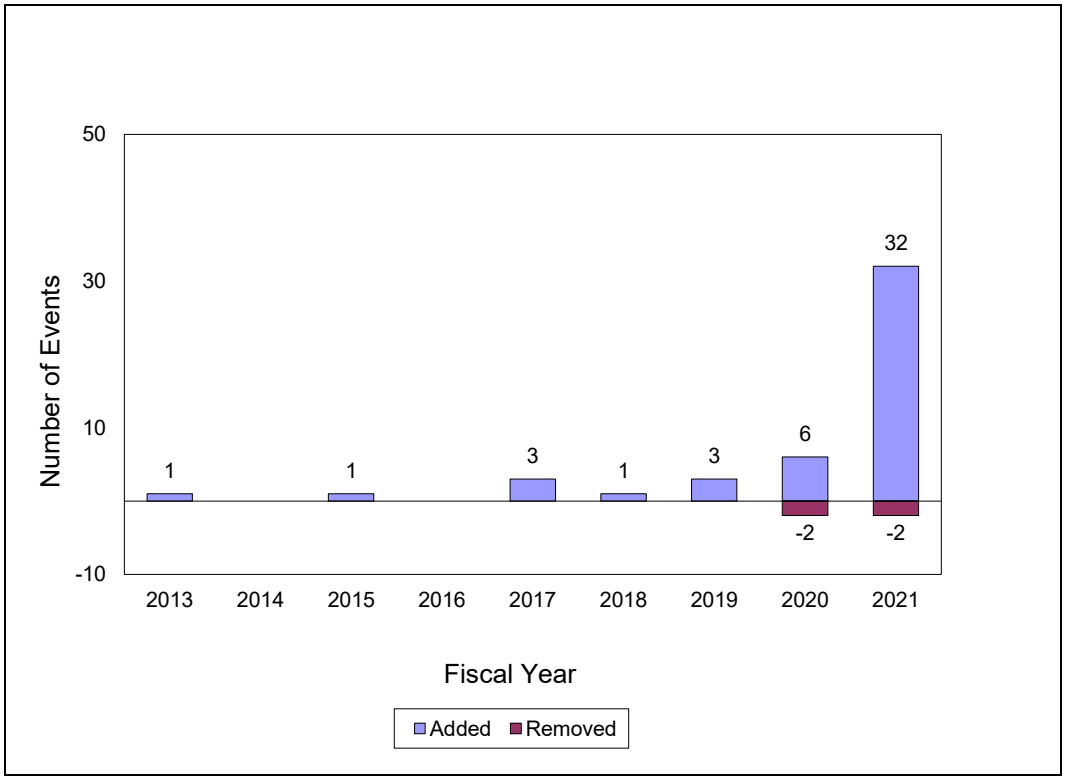

Figure D-1. Changes to All NMED Event Data

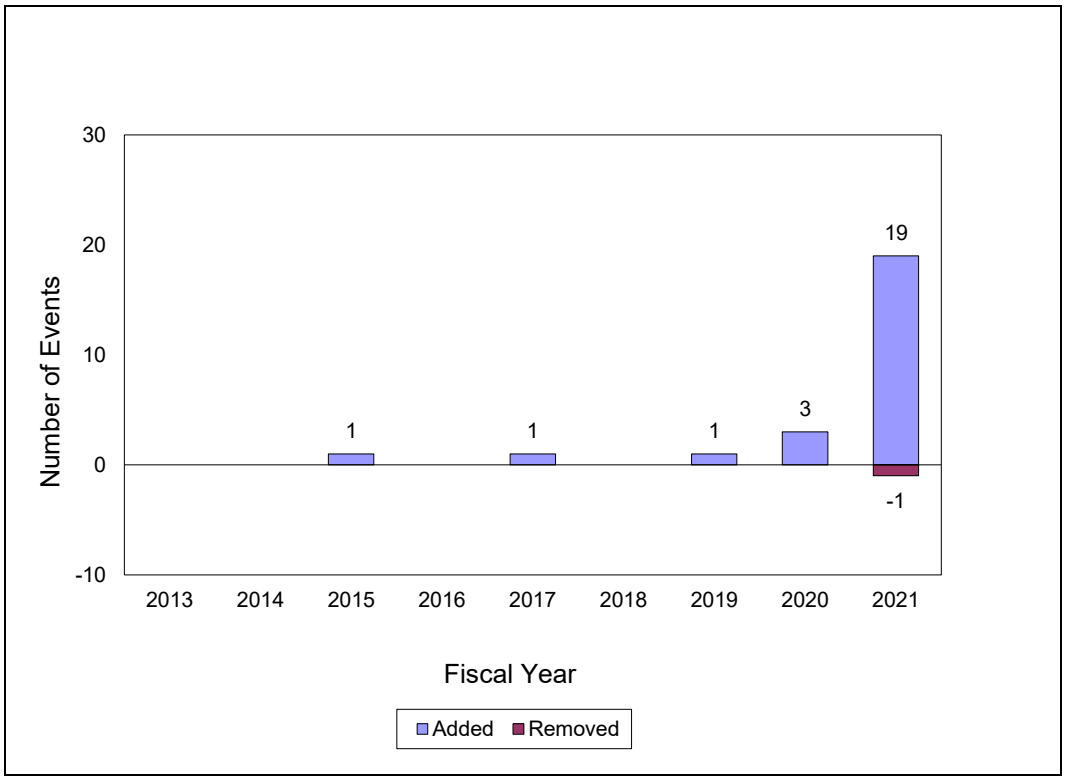

Figure D-2. Changes to LAS Data

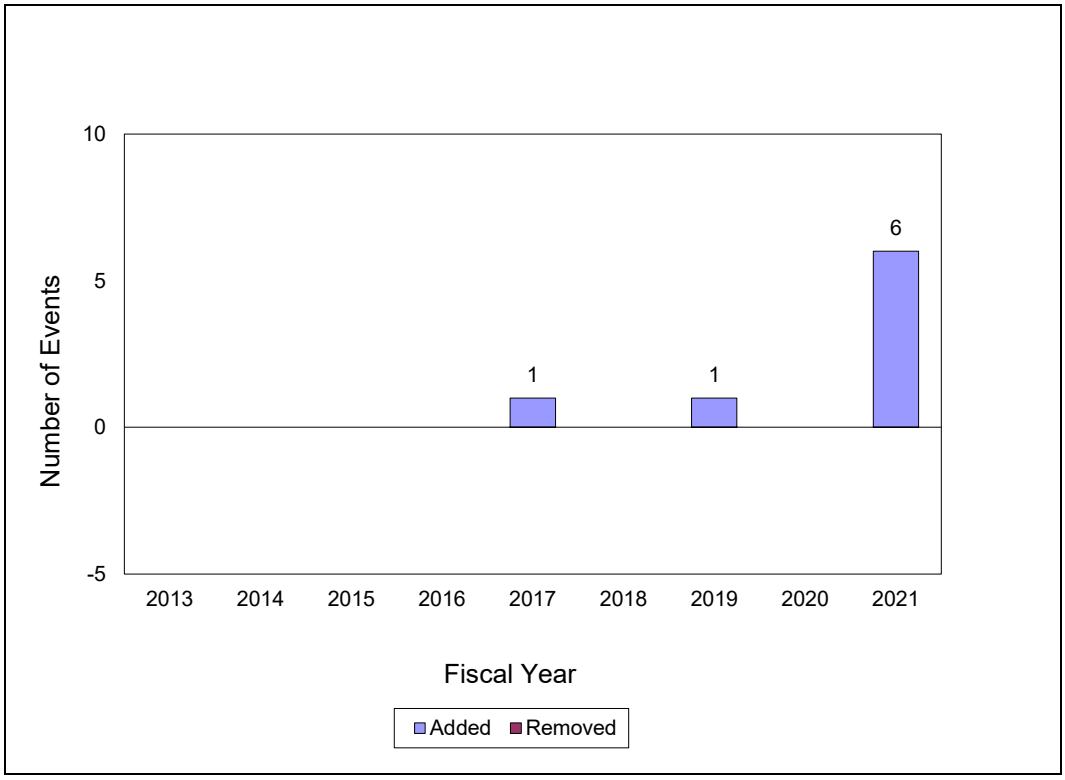

Figure D-3. Changes to MED Data

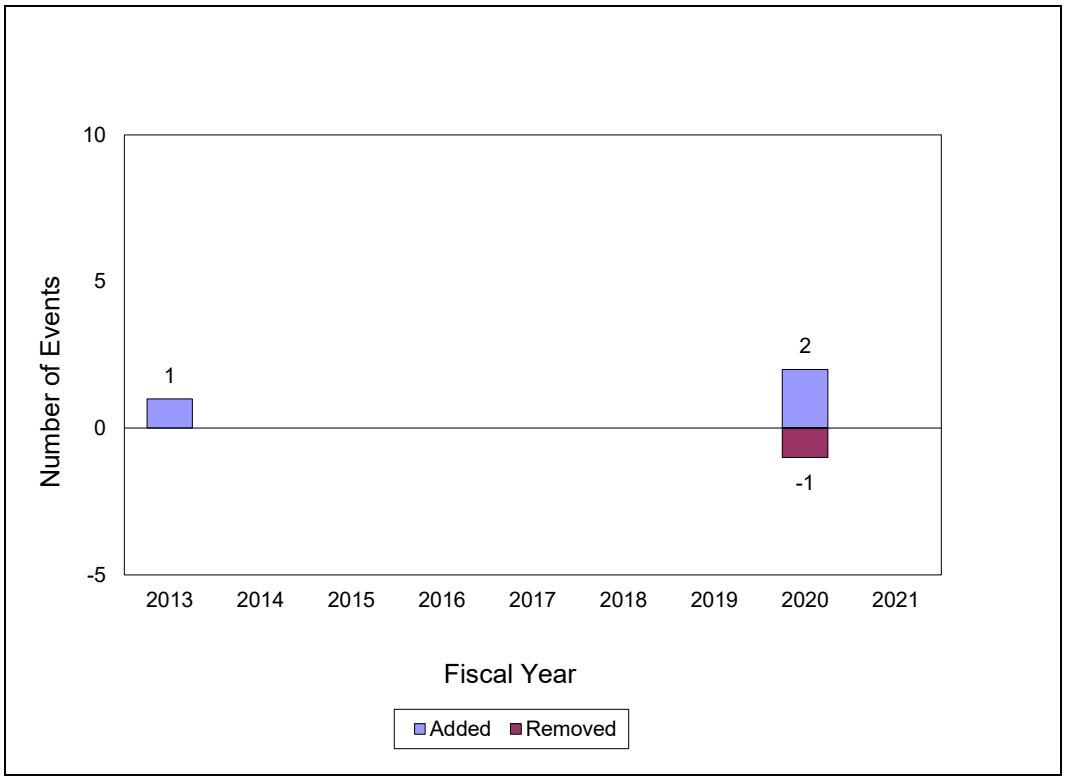

Figure D-4. Changes to EXP Data

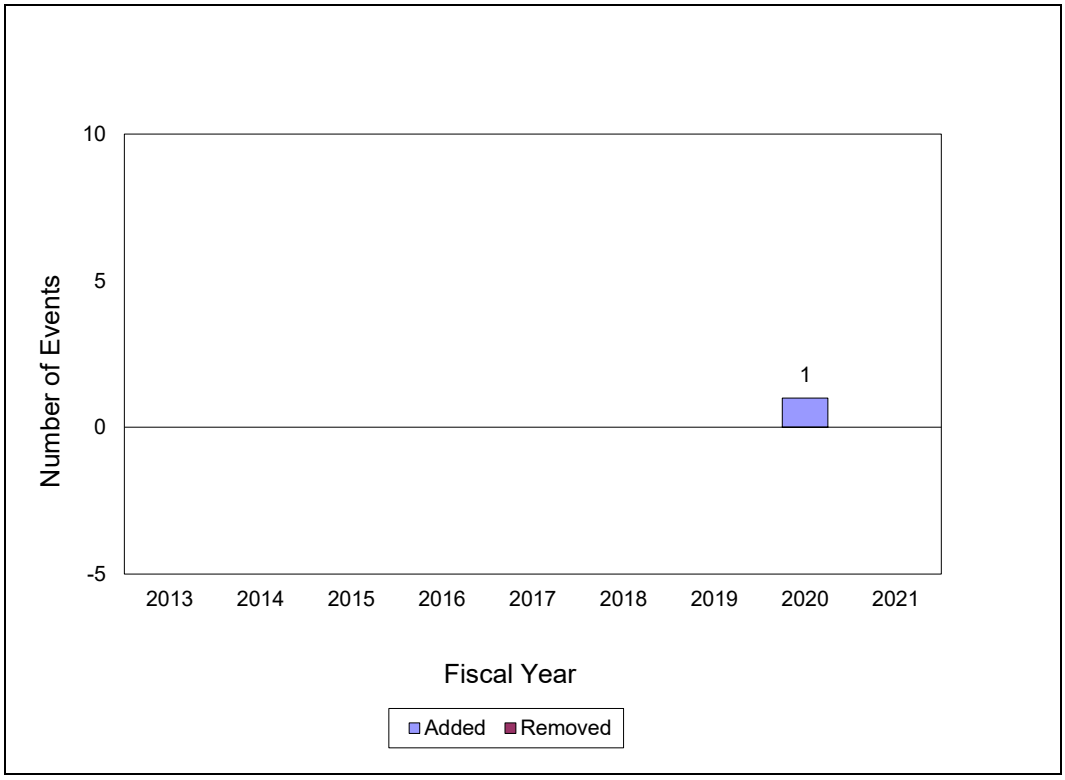

Figure D-5. Changes to RLM Data

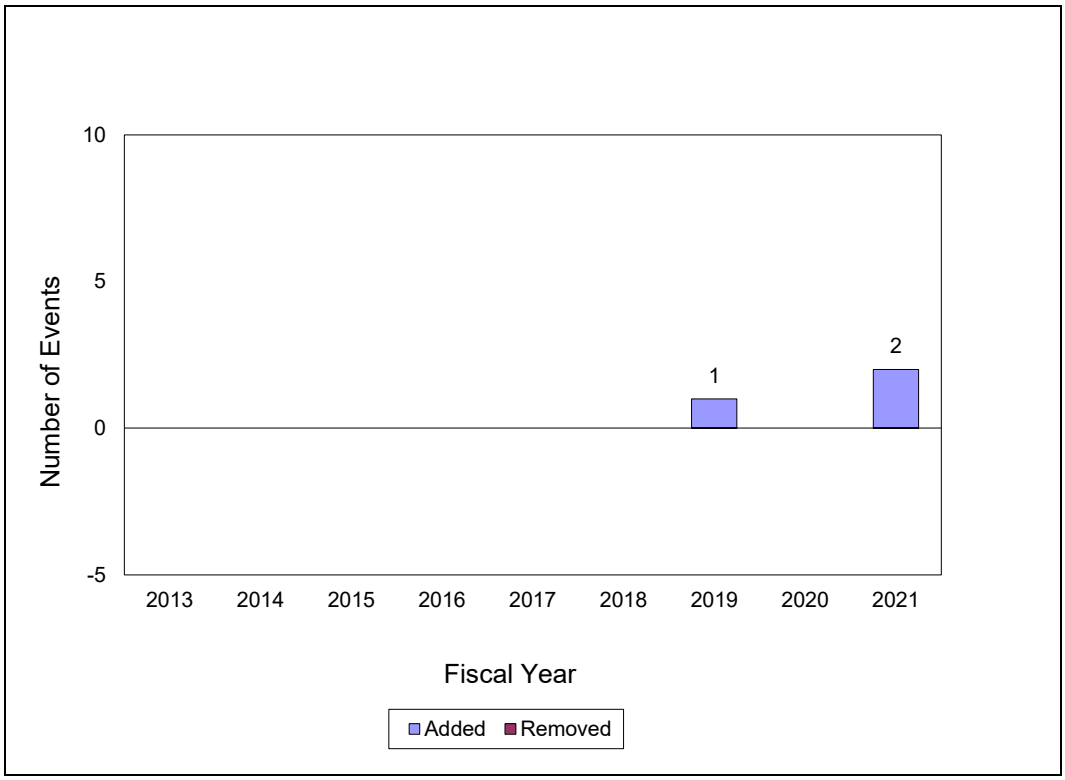

Figure D-6. Changes to LKS Data

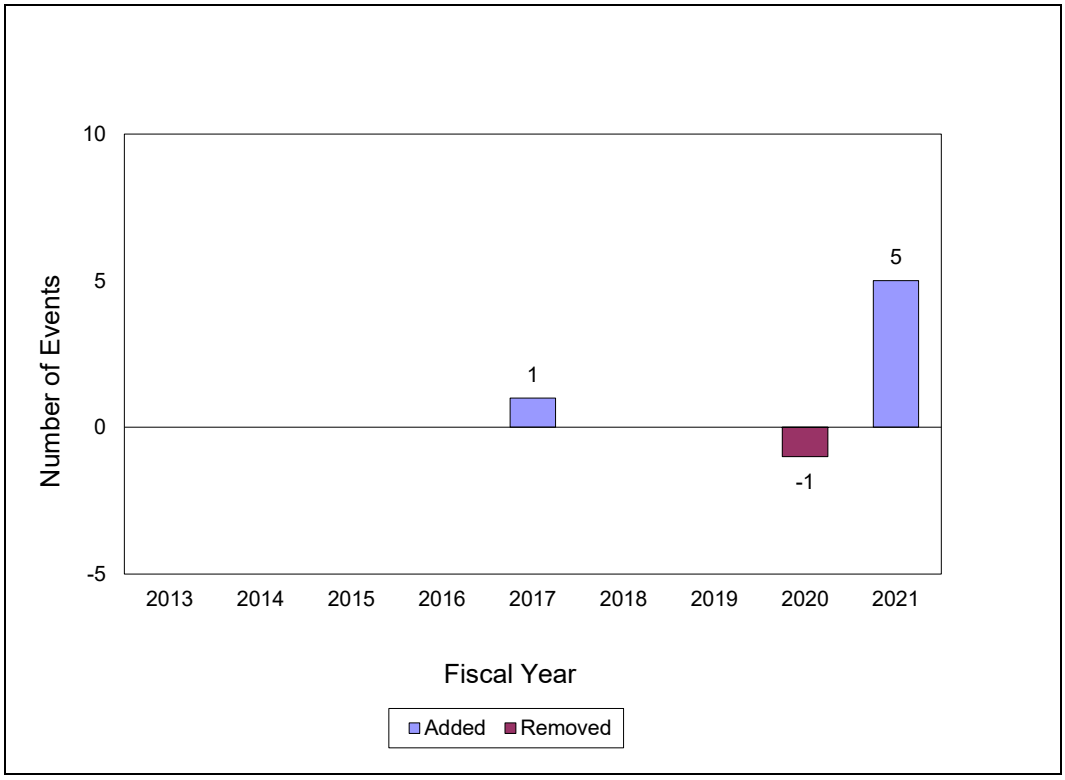

Figure D-7. Changes to EQP Data

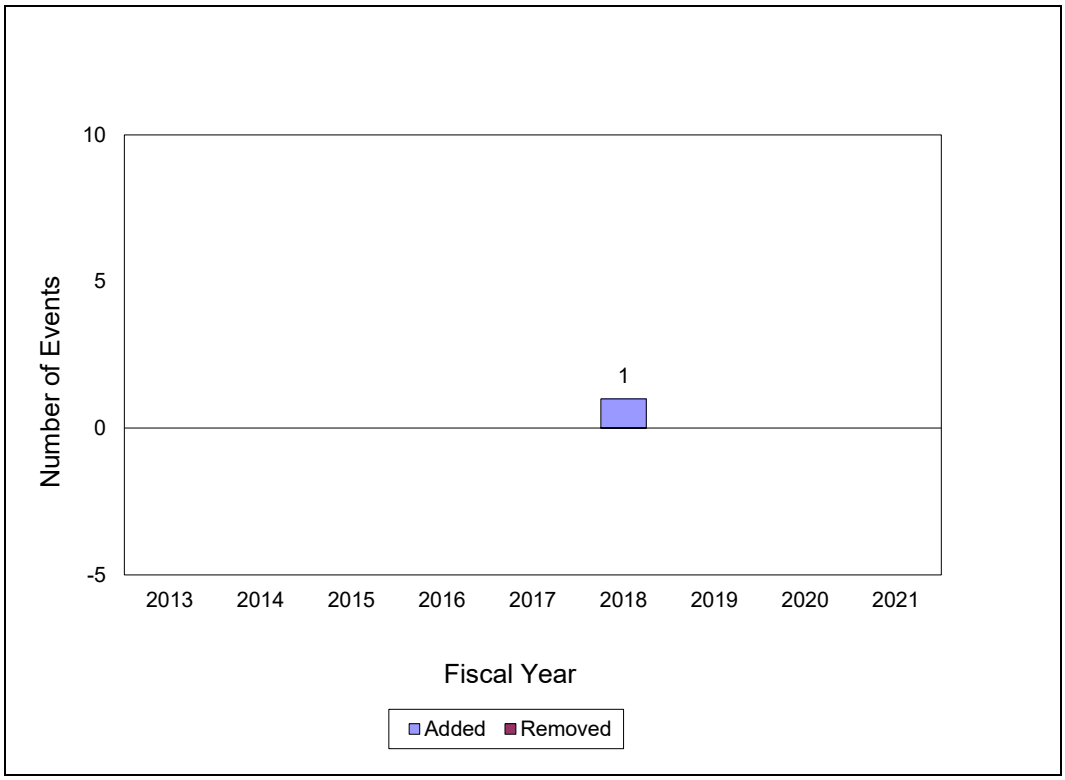

Figure D-8. Changes to TRS Data

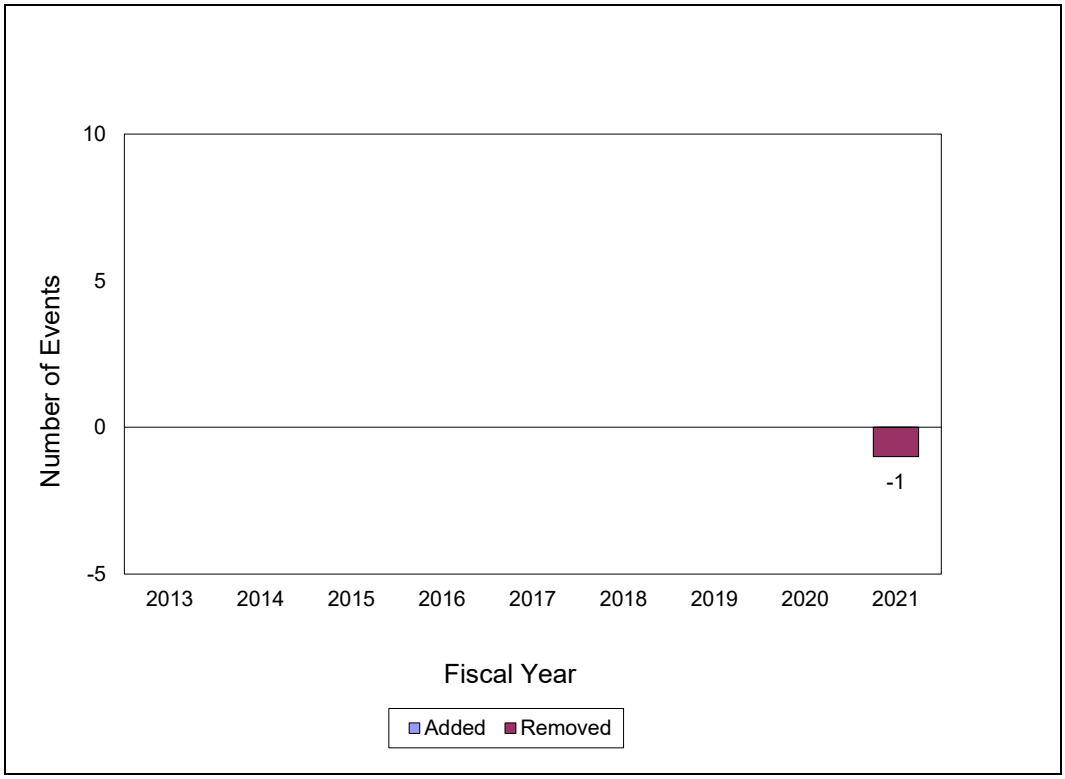

Figure D-9. Changes to OTH Data