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Nuclear Material Events Database

Annual Report

Fiscal Year 2014

Prepared for the U.S. Nuclear Regulatory Commission
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ENCLOSURE 1

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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, (8) Fuel Cycle Process, and (9) Other.

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ACRONYMS

ALARA	as low as reasonably achievable
ALI	annual limit on intake
AO	abnormal occurrence
CFR	Code of Federal Regulations
DDE	deep dose equivalent
DE	dose equivalent
DOT	Department of Transportation
EDE	effective dose equivalent
EQP	Equipment
EXP	Radiation Overexposure
FCP	Fuel Cycle Process
FY	fiscal year
GRMP	Georgia Radioactive Material Program
GTCC	greater than class C
HDR	high dose rate
HLW	high-level waste
IAEA	International Atomic Energy Agency
INL	Idaho National Laboratory
IROFS	item relied on for safety
ISA	integrated safety analysis
LANL	Los Alamos National Laboratory
LAS	Lost/Abandoned/Stolen Material
LKS	Leaking Sealed Source
LS	least squares
MED	Medical
MRA	moderator restricted area
NA	not applicable
NMED	Nuclear Material Events Database
NR	not recovered
NRC	Nuclear Regulatory Commission
NRCB	NRC Bulletin
ODOH	Ohio Department of Health
OTH	Other

PDEP	Pennsylvania Department of Environmental Protection
REAC/TS	Radiation Emergency Assistance Center/Training Site
RLM	Release of Licensed Material or Contamination
RSO	radiation safety officer
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
TRS	Transportation
WIPP	Waste Isolation Pilot Plant

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 2014 are summarized below. Note that a single event may be listed in more than one event type category.

Lost/Abandoned/Stolen Radioactive Sources/Material Events

Eight significant events occurred involving the loss of 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 three Category 3 sources were lost, all of which were subsequently recovered.

Five events involved the loss (and subsequent recovery) of the Category 2 sources (radiography sources contained within exposure devices). Two of the devices were left unattended at temporary jobsites, one device was lost after being left on the bumper of a truck that was driven away, one device was lost when a tornado ripped the darkroom off of a radiography truck, and one device was lost by a common carrier during shipment.

Three events involved the loss (and subsequent recovery) of the Category 3 sources. Two events involved common carriers delivering brachytherapy sources to the wrong addresses. On the remaining event, a plutonium-powered pacemaker was sent to a licensee that was not licensed to possess the device.

Medical Events

Eleven significant events occurred, all of which were classified as potential Abnormal Occurrences. Nine of the events involved doses administered to the wrong site: two during high dose rate brachytherapy, two during prostate brachytherapy, one during brachytherapy, one during gamma knife treatment, and three during Y-90 microsphere treatments. The remaining two events involved overdoses; a Y-90 dose was too large and an HDR source dwell time was too long.

A twelfth significant event classified as a potential Abnormal Occurrence occurred prior to Fiscal Year 2014, but was recently added to NMED. This was a Y-90 dose administered to the wrong site.

Radiation Overexposure Events

Four significant events occurred. Three of the events involved radiographers that were exposed by unshielded radiography sources. The fourth event involved a skin exposure to an individual who inadvertently contaminated herself while drawing a liquid source into a syringe.

Release of Licensed Material or Contamination Events

One significant event occurred. In this event, a pharmacist dropped a vial of I-131 onto the floor, contaminating the pharmacist and vicinity.

Leaking Sealed Source Events

No significant events occurred.

Equipment Failure Events

Two significant events occurred. Both of the events involved difficulties retracting radiography sources into their exposure devices.

Transportation Events

No significant events occurred.

Fuel Cycle Process Events

Four significant events occurred. Three of these events involved the inoperability of Items Relied On For Safety (IROFS) at nuclear fuel manufacturing facilities. The fourth event involved a tornado that caused some damage at a gaseous diffusion uranium enrichment facility.

A fifth significant event occurred prior to Fiscal Year 2014, but was recently added to NMED. This event involved the inoperability of an IROFS at a gaseous centrifuge uranium enrichment facility.

Other Events

One significant event occurred, which was also classified as a potential Abnormal Occurrence. This event involved a dose to an embryo/fetus that resulted from the administration of I-131 to a pregnant patient.

Nuclear Material Events Database Annual Report: Fiscal Year 2014

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 the Idaho National Laboratory (INL) and contains over 23,000 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),
- Fuel Cycle Process (FCP), 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 the 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, 2004, and September 30, 2014. The data were downloaded from the NMED on January 13, 2015. Because the 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 Federal and State Materials and Environmental Management Programs 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 the NMED. Charts are provided to display trends in annual data for the most recent 10-year period (FY05-14).

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 Total events and Agreement State-regulated events do not represent statistically significant trends (indicated by the absence of trend lines). Therefore, variations within the Total and Agreement State values represent random fluctuation around the average of the data.

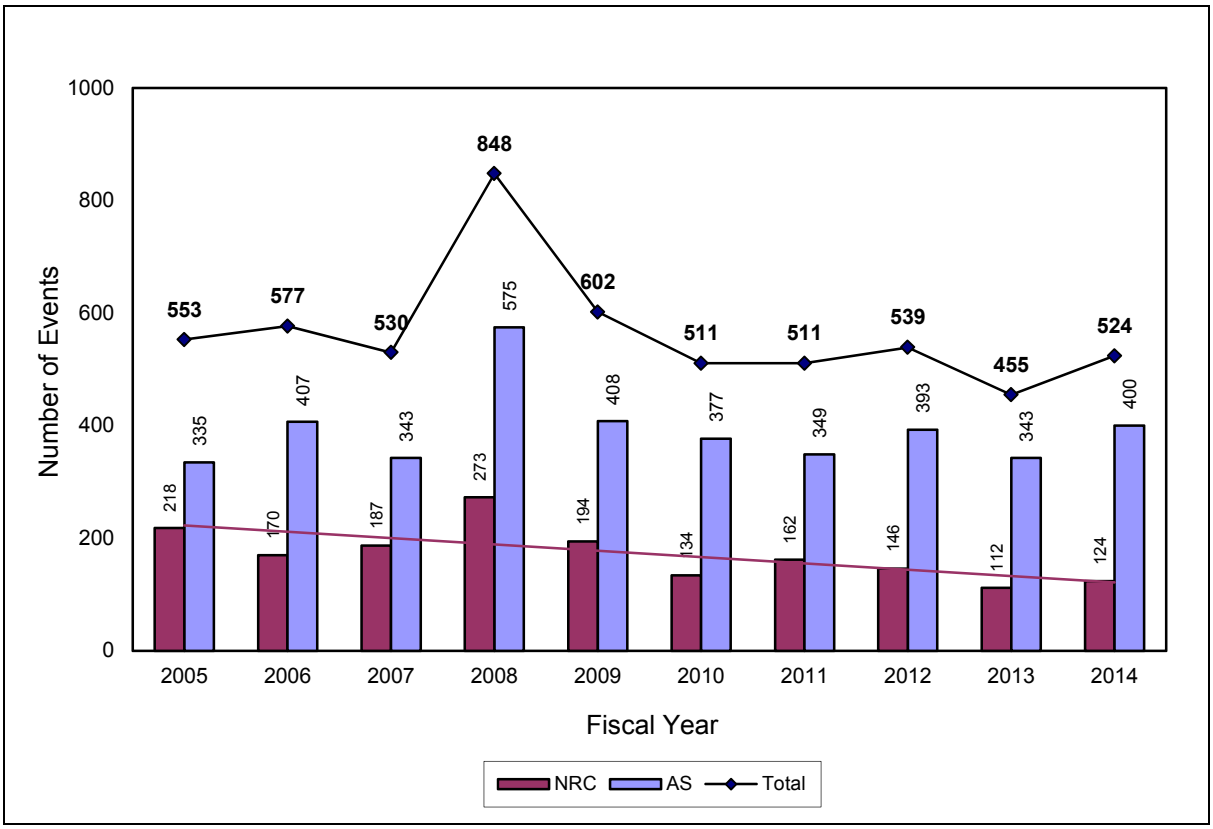

Figure 1. All NMED Events (5,650 total)

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

- In FY14, 481 occurrences accounted for 524 events; a single occurrence can be classified in different event categories.
- The FY08 and FY09 data include 272 and 65 events respectively that resulted from Wal-Mart's one-time review of their tritium exit sign inventory.
- 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
	Total	**Unique**	**Other**
Fuel Cycle Process (FCP)	-	-	-

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.
- The FCP event type differs from other types in that all FCP events are NRC-regulated. Subcategories include Unique and Other (see Section 2.9).

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 Total events and Agreement State-regulated events do not represent statistically significant trends (indicated by the absence of trend lines). Therefore, variations within the Total and Agreement State values represent random fluctuation around the average of the data.

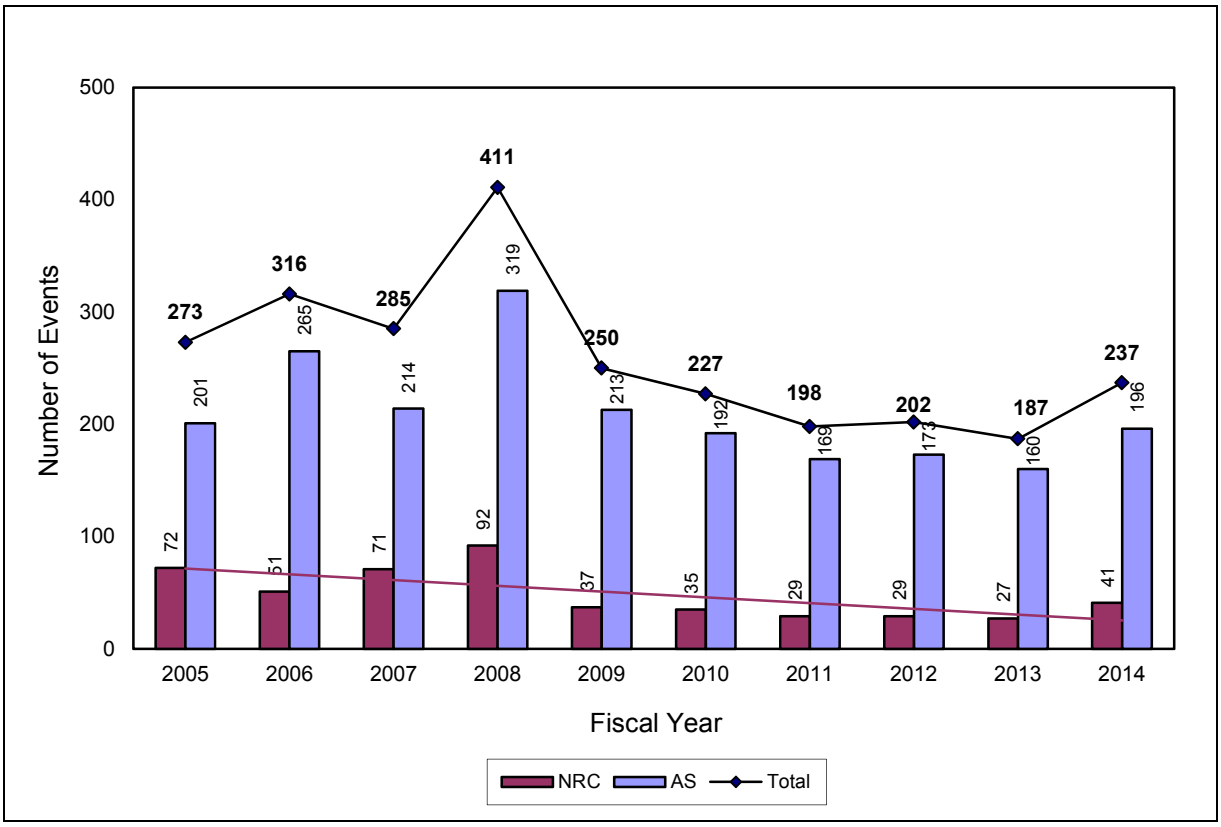

Figure 2. Lost/Abandoned/Stolen Material Events (2,586 total)

The FY08 and 09 data include 142 and 45 LAS events respectively that resulted from Wal-Mart's one-time review of their tritium exit sign inventory.

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 4,280, excluding irretrievable well-logging sources) during the 10-year period and the number that have not been recovered (approximately 2,272), grouped by IAEA category where possible. These included zero Category 1 sources, 47 Category 2

sources, and 35 Category 3 sources. All of these sources were recovered, with the exception of two Category 2 and four 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 2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
1	LAS[4]	0	0	0	0	0	0	0	0	0	0	**0**
	NR[5]	0	0	0	0	0	0	0	0	0	0	**0**
2	LAS	8	4	2	11	2	0	2	3	10	5	**47**
	NR	1	0	0	0	0	0	1	0	0	0	**2**
3	LAS	6	4	1	3	1	4	4	7	2	3	**35**
	NR	2	0	0	0	0	1	0	1	0	0	**4**
4	LAS	110	95	57	71	50	76	43	44	24	51	**621**
	NR	36	48	17	35	25	27	22	14	10	28	**262**
5	LAS	151	110	70	129	76	89	78	82	66	77	**928**
	NR	58	44	19	57	20	29	11	25	8	28	**299**
< 5	LAS	7	0	2	0	2	1	1	0	1	1	**15**
	NR	4	0	0	0	2	1	0	0	0	0	**7**
Activity Not Known[1]	LAS	3	7	3	9	5	13	12	9	8	4	**73**
	NR	0	1	0	0	0	1	0	0	0	0	**2**
Nuclide Not Known[2]	LAS	3	0	2	0	0	0	5	1	1	0	**12**
	NR	0	0	0	0	0	0	5	0	0	0	**5**
Other[3]	LAS	233	303	276	432	264	183	208	183	162	305	**2549**
	NR	146	177	146	354	161	127	139	122	81	238	**1691**
Total	**LAS**	**521**	**523**	**413**	**655**	**400**	**366**	**353**	**329**	**274**	**446**	**4280**
	NR	**247**	**270**	**182**	**446**	**208**	**186**	**178**	**162**	**99**	**294**	**2272**

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). The Category 1 through 3 source counts were corrected for the "aggregate" source events.

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 (FY05-14)

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	5	100.70	<0.01	5
Pu-238	87.7 years	1	2.50	2.44	3
Total		**6**	**103.20**	**2.44**	**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). The source counts were corrected for the "aggregate" source events.
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 1/13/2015 (data download date).

Table 4. Summary of IAEA Category 1-3 Sources Not Recovered (FY14)

Radionuclide	Half-life[1]	Number of Sources Not Recovered[2,3]	Total Activity (Ci)	Total Decayed Activity (Ci)[4]	Total Decayed Activity IAEA Category
None		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). The source counts were corrected for the "aggregate" source events.

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 1/13/2015 (data download date).

2.2.2 FY14 Data

Two hundred thirty-seven LAS events occurred in FY14, 24 of which involved irretrievable well logging sources. Excluding the irretrievable well logging sources, approximately 446 sources were lost/abandoned/stolen, 294 of which have not been recovered. Of the 446 lost sources, none were Category 1, five were Category 2, and three were Category 3 sources. All of the Category 1-3 sources were recovered.

Eight of the FY14 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 140049 - A radiography exposure device containing a 1.27 GBq (34.4 Ci) Ir-192 source was left unattended at a temporary jobsite (chemical production facility) overnight on 1/8/2014. Miscommunication between radiographers led to the incident. The radiography services company retrieved the device on the morning of 1/9/2014. The two involved radiographers were suspended pending further investigation.

Item Number 140092 - A radiography exposure device containing a 3.85 TBq (104 Ci) Ir-192 source was left unattended at a temporary jobsite (oil refinery) for approximately 2 hours on 2/9/2014. The radiographers using the device believed that there were other radiographers in the area and left the device unattended, suspended two feet from the floor, to process film. A refinery employee discovered the device and notified the radiography services company. Shortly thereafter, the company took possession of the device. Corrective actions included reprimanding personnel and providing additional training to those involved personnel. Those personnel will also be monitored and audited to assure competency and compliance with regulations and procedures.

Item Number 140095 - A radiography services company reported the loss and recovery of a radiography exposure device that contained a 1.15 TBq (31 Ci) Ir-192 source. Following operations at a refinery on 2/9/2014, a radiographer left the exposure device on the bumper of his truck. The device fell to the pavement when he drove away. Refinery personnel discovered the device in the parking lot and contacted the radiography services company. The company's RSO drove to the refinery and took possession of the device.

Item Number 140284 - A radiography services company reported the loss and recovery of a radiography exposure device that contained a 1.44 GBq (39 Ci) Ir-192 source. The radiography crew was at a refinery to perform weld testing. The crew was in their vehicle waiting out a storm when a tornado ripped the darkroom off of the vehicle. The exposure device was found within the refinery boundary and appeared to be undamaged with the source in the shielded position. Radiation surveys of the device revealed background levels. The device was transported to the manufacturer for leak testing and mechanical evaluation. Leak tests revealed negative results.

Item Number 140558 - A radiography services company reported the loss and recovery of a radiography exposure device during shipment from a job site in California to their office in Oklahoma. The device contained a 2.11 TBq (57 Ci) Ir-192 source and was picked up by a common carrier on 9/30/2014. The device was scheduled to arrive at the Oklahoma facility on 10/3/2014. However, on 10/6/2014 the device

had not arrived and was declared missing. The carrier determined that the device entered their Memphis, Tennessee, hub on 10/1/2014, but did not leave. On 10/11/2014, the radiography exposure device was found at the carrier's facility in San Jose, California. When found, both Yellow II labels had been removed from the package. The shipping document attached to the package had also been removed and replaced with an older copy. The endcap which fits over the drive cable connection fitting was not installed on the device, but was in the package (the radiography services company employee who packaged the device could not remember if the endcap was installed when the device was packaged). It appears that the device arrived in Memphis with the labels and shipping papers removed. The common carrier's staff found a sticker with a barcode on the package that had been attached when it was originally shipped from Oklahoma to California. They scanned the barcode and were able to retrieve a copy of the original (Oklahoma to California) shipping papers. These old shipping papers were attached to the package, causing it to be sent back to San Jose.

Significant Events - Category 3 Source Events

Item Number 140260 - A common carrier delivered a 402 GBq (10.86 Ci) Ir-192 source to the wrong location. The air waybill was correctly addressed and the dangerous goods certificate was properly completed, but the package was incorrectly delivered to a main hospital receiving area instead of the intended radiation oncology clinic across the street. Upon identification of the error, a hospital employee delivered the source bucket to the RSO at the correct address. The employee was questioned about the length of time in contact with the Type A package. It was estimated that the employee received a TEDE of 20 µSv (2 mrem) from 10 minutes of contact. The director of the hospital's receiving department and the involved employee were told to refuse any shipments labeled as containing radioactive material. The RSO's name will also be added to future radioactive material shipments. The shipper was contacted and they filed a formal complaint with the common carrier.

Item Number 140534 - A common carrier delivered a shipment containing approximately 370 GBq (10 Ci) of Ir-192 brachytherapy sealed sources to the wrong address on 9/8/2014. The Yellow III package was accepted by the mail room of the wrong address. The intended recipient (a medical center) was contacted on 9/8/2014 and they transferred the package to their facility less than five minutes after it arrived at the wrong address. The medical center notified the common carrier of the error. The Massachusetts Radiation Control Program performed an onsite inspection on 11/25/2014. Discussions were held with the individuals involved in the incident. The common carrier's RSO was contacted on 12/1/2014 and confirmed awareness of the incident. They will address proper deliveries during future personnel training.

Item Number 140716 - A licensee received a pacemaker containing 103.6 GBq (2.8 Ci) of Pu-238 from a medical center. The licensee did not have a license to possess Pu. The pacemaker was transported to a sister facility and will eventually be shipped to Los Alamos National Laboratory for disposal in the Off-Site Source Recovery Program.

Events of Interest

Item Number 130480 - Hospital "A" reported a potential radiation overexposure to members of the public from a deceased patient that had recently received 5.55 GBq (150 mCi) of I-131. The 35-year-old patient was administered the I-131 on 10/9/2013, approximately 10 to 14 hours prior to his death. Emergency medical technicians and coroner's office staff were called to the scene and examined the body prior to the confirmation of death, and then transported the body to Hospital "B". Hospital "A" consulted with and performed contamination surveys of all members of the public who came into contact with the body. The body was situated in a secluded portion of the morgue and lead aprons were used to reduce potential exposure. Preliminary estimates of exposure to members of the public revealed that the highest dose received was 300 µSv (30 mrem) to the driver of the vehicle that transported the body. Further calculations revealed the highest exposure to be approximately 230 µSv (23 mrem). The Colorado Department of Public Health and Environment investigated the incident. Hospital "B" isolated the body

in their morgue to allow the I-131 to decay for about three months prior to autopsy. This event was classified as an LAS and OTH event.

Item Number 130527 - An outbound trailer of scrap set off the radiation monitor alarms at a scrap metal facility on 10/31/2013. Site staff (members of the public) located the radioactive source by shoveling through the solid material and metal in the load. The radioactive source was carried by shovel approximately 150 to 200 feet. An individual then carried the source by hand to an adjoining property and placed it in a lead pipe, which was crimped. A Pennsylvania Department of Environmental Protection (PDEP) inspector was sent to the site to characterize the source. The radionuclide was determined to be Cs-137 and a measurement on the surface of the pipe was 320 mR/hour. The activity was estimated to be approximately 370 MBq (10 mCi). One member of the public was in contact with the source for approximately 2.5 hours, on and off. Scrap yard personnel used a RadEye detector, which recorded a total accumulated dose of 3.64 µSv (364 µrem). PDEP also estimated a possible extremity exposure of between 5 and 21 cGy (rad) to the individual who handled the source. The hands and feet of all parties were surveyed with negative results. The scrap yard hired a consultant health physicist to assist with the incident. PDEP identified the serial number on the source and identified the owner. The fixed gauge that originally contained the source was last accounted for in 1990. The source originally contained an activity of 1.11 GBq (30 mCi), which had decayed 0.6142 GBq (16.6 mCi) by 10/31/2013. The owner took full responsibility for the source and agreed to fully compensate disposal costs. Although doses in unrestricted areas exceeded limit of 0.02 mSv (2 mrem) in any one hour, dose estimates found that no member of the public received a whole body dose above the 1 mSv (100 mrem) limit. The extremity exposure estimate is 10 cSv (rem). Following negative leak test results, a radiological services company took possession of the source for disposal on 1/3/2014.

Item Number 140011 - A load of solid waste set off the radiation monitor alarms at a landfill on 12/6/2013. A health physics consultant responded to the landfill and identified two bare Mo-99/Tc-99m generator columns that had come from a nuclear pharmacy. A reactive inspection by the Pennsylvania Department Environmental Protection (PDEP) was initiated. The pharmacy's RSO believes that the generators had been stolen by an employee. The generators would have contained a decayed activity of approximately 18.87 GBq (510 mCi). The pharmacy concluded that the individual who disassembled the generators would have received an extremity exposure of approximately 1.127 mSv (112.7 mrem) and a whole body exposure of 1.045 mSv (104.5 mrem). They recovered the generators and held them for decay in storage. The pharmacy developed and implemented an expired generator tracking system. In addition, all facility employees will receive security awareness training. This event was classified as an EXP and LAS event.

Item Number 140043 - A university's roll-off container set off the radiation monitor alarms at a recycling/transfer station on 12/20/2013. Initial radiation surveys of the container using an ion chamber revealed the highest level at 32 mR/hour on contact, with 7.8 mR/hour at one foot, and 1.7 mR/hour at three feet. A gamma spectrum was collected using a multi-channel analyzer. The radionuclide was initially identified as Co-56. The roll-off container was stored until university staff arrived to perform additional surveys and possibly extract the radioactive material. Investigation revealed that the university's normal waste stream contained activated cyclotron foil target fragments. The university was cited for disposal of radioactive material in the normal waste stream. Investigation revealed that the highest exposed individual was the person who collected the waste and placed it into the outside waste compactor (a member of the public), who potentially received a whole body exposure of between 15 µSv and 63 µSv (1.5 and 6.3 mrem). The California Health and Human Services Agency estimated that the activity of the cyclotron target fragments was 35.52 MBq (960 µCi). The university generated new procedures for segregating and handling cyclotron clean-up material, scanning and tracking radioactive waste from the cyclotron, and provided training to cyclotron personnel. In addition, a continuously operating radiation detector was placed at the exit of the building. The university's radiation safety

committee will complete a review of the cyclotron operations to ensure a safety-first culture is implemented.

Item Number 140101 - A medical center reported the loss of an Rb-82 generator that contained a total activity of 3.7 GBq (99.9 mCi). The generator was packaged for shipment to the manufacturer for disposal. The package was left unattended and unsecured in an unrestricted area for about two hours on 2/10/2014, awaiting pickup by a common carrier. The package was sealed with radioactive material labels. The surface dose rate on contact was 19.4 mR/hour and 323 μR/hour at one meter. A surface wipe test revealed 713 dpm/100 cm^2. When the first technician arrived at the facility at six in the morning on 2/11/2014, the package was missing and no paperwork had been left by the carrier. The carrier was contacted and they had no record of a package pickup. On 2/12/2014, the RSO stated that contracted housekeeping staff had placed the package in a dumpster, which had been picked up on 2/11/2014 and sent to a landfill. Medical center personnel responded to the landfill to search for the package with negative results. Procedures were modified and personnel were trained on those updates. Updates included generators being kept in a locked hot laboratory until the common carrier picks them up, all incoming generators being placed in that locked laboratory by a facility technician upon arrival, and a new storage container on wheels being purchased to move generators in and out of the laboratory for survey prior to shipment. Ancillary staff training was also revised with emphasis on identifying labels of hazardous material and proper handling. This event was classified as an LAS and OTH event.

Item Number 140201 - A petrochemicals transportation and storage services company reported that a gauge containing a 1.13 GBq (30.47 mCi) Cs-137 source was improperly disposed of. A recycling company had burned into the gauge with a cutting torch and came to within 1 mm of the sealed source. No source leakage was identified and the sealed source was still intact. The gauge was subsequently properly disposed of. This event was classified as an EQP and LAS event.

Item Number 140216 - A semi-tractor trailer carrying radioactive material was involved in an accident on 1/5/2014. The accident was a result of inclement weather conditions and occurred on Interstate 57, near Cairo, Illinois. A fire resulted and was extinguished by local responders. The heavily damaged tractor and trailer were moved to a secure facility in Mounds, Illinois. A radiography exposure device with a 3.7 TBq (100 Ci) Ir-192 source was being transported within an approved Type B overpack. The overpack exhibited signs of external exposure to fire/heat and denting. Radiation levels were consistent with those documented on shipping papers and there was no damage to the device's integrity. When the Type B overpack was checked for removable radioactive contamination, significant activity of approximately 80,000 cpm was detected on a large area wipe. However, the contamination was from a beta emitter, rather than from Ir-192. A Type A package containing P-32 was also included in the shipment, which correlated with the contamination identified. It was determined that the Type A package contained less than 37 MBq (1 mCi) of P-32, according to shipping paperwork. The P-32 was in liquid form and was shipped in a vial in a small dense plastic shield in a card board box. The fire resulted in destruction of the box and melting of the shielded container. State of Illinois inspectors detected no elevated radiation readings at the accident site. Arrangements were made to conduct screening of equipment and personnel present at the accident site. The damaged Type B overpack containing the radiography equipment will be returned to the manufacturer. This event was classified as an LAS and TRS event.

Item Number 140238 - A gaseous diffusion plant reported the loss and recovery of one drum from a shipment of UF6 samples. On 2/6/2014, a shipment of seven drums containing a total of 659 grams of enriched UF6 in P-10 sample tubes was shipped from the plant via common carrier to a nuclear fuel manufacturer in South Carolina. Six of the drums were received by the manufacturer on 2/7/2014; one drum containing 99 grams of enriched UF6 was not delivered. On 2/11/2014, the manufacturer notified the plant that the drum was missing. An investigation determined that all seven drums made it to the carrier's South Carolina package sorting and handling facility. At some point, the shipping label separated from the missing drum. The missing drum was later found within the package sorting and handling facility. On 2/21/2014, the plant was notified of the delivery of the seventh drum to the

manufacturer. The tamper indicating device was intact. This event was classified as an FCP and LAS event.

Item Number 140239 - Unidentified radioactive material was found in a load of waste at a waste transfer station on 4/25/2014. A DOT Special Permit was issued by the Massachusetts Radiation Control Program to transport the material back to the originating transfer station. The transfer station hired a contractor to isolate the material, identify it, label it, and store it in a secure location on site. The contractor found that the radioactive material was encapsulated in a metal cylinder measuring approximately 1 inch in diameter and 2 inches long. There were no markings or labels. The radionuclide was identified as Ra-226 with an activity of 14.06 MBq (0.38 mCi). A survey revealed between 35 and 40 mR/hour on contact and approximately 3 mR/hour at one foot. Leak tests results were negative. The contractor took custody of the radioactive material.

Item Number 140340 - A truckload of scrap steel set off the radiation monitor alarms at a metal recycling facility on 6/23/2014. A damaged fixed gauge containing a 2.41 GBq (65 mCi) Cs-137 source was identified in the load. Oregon Department of Health Radiation Protection Services responded and found the gauge housing severely crushed and the shutter damaged and partially open. One side of the gauge housing was split, but compressed together. Radiation readings approximately four inches from the damaged gauge housing revealed 60 mR/hour. A recycling facility employee moved the gauge to a metal bin using a shovel and four-foot steel rod on 6/23/2014. The estimated exposure to that individual was 0.015 mSv (1.5 mrem). The gauge will be stored in a secure metal bin in a restricted and remote area pending disposal. The highest radiation reading on contact with the storage bin was 1.48 mR/hour. Wipe tests performed on the gauge housing revealed negative results. The gauge manufacturer determined who the gauge was originally sold to on 8/23/1996. Their last contact with the owner was in December 1999 for leak test services. Oregon is investigating the incident to trace the history of the gauge since 1999, as well as the location where the truck originated from. The gauge will be classified as waste and properly disposed of. The recycling facility will contact a waste broker to package and dispose of the gauge. This event was classified as an EQP and LAS event.

Item Number 140545 - A manufacturer of high voltage gas discharge products reported that a release of 4.63 GBq (125 mCi) of Kr-85 occurred on 9/26/2014. The manufacturer received the Kr-85 in a cylinder in an amount in excess of their possession limit; according to their license, they were only allowed to have 0.185 GBq (5 mCi) of Kr-85. The cylinder was connected to a vacuum furnace and a compressor was energized to create sufficient positive pressure inside of the vacuum furnace. However, sufficient positive pressure was not achieved because the pressure within the cylinder was too low. At that point, the manufacturer could only release the Kr-85 into the room or to the atmosphere through an air effluent stack. The manufacturer chose to release the Kr-85 to the atmosphere because that route was expected to result in the lowest radiation dose to an individual. Based on worst-case dose calculations, the maximum dose to a hypothetical individual standing on the building roof next to the air stack at the point of the Kr-85 release was 60 μSv (6 mrem). To prevent recurrence, the manufacturer will no longer use radioactive gas in the vacuum furnace.

2.2.3 Events Recently Added to NMED That Occurred Prior to FY14

Thirty-two 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. 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 - Category 1 Source Events
None

Significant Events - Category 2 Source Events
None

Significant Events - Category 3 Source Events
None

Events of Interest
Item Number 140327 - A metal recycling facility reported that a radiation monitor alarmed at their facility on 3/29/2013. The South Carolina Department of Health responded to the facility and identified an exposed Cs-137 source. Radiation readings revealed between 3.5 and 5 R/hour. The source was placed into a shielded area, which reduced radiation levels to between 10 and 15 mR/hour. The recycling facility hired a consultant to package, transport, and dispose of the source. The contractor arrived at the facility on 4/2/2013. The source was determined to contain an activity of 2,775 MBq (75 mCi). There were no markings on the source and the owner could not be identified. The source was packaged and transported off site and was properly disposed. Investigation revealed that no individual received greater than 0.1 mSv (10 mrem) during the incident.

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 Agreement State-regulated events represent a statistically significant increasing trend and the NRC-regulated events represent a statistically significant decreasing trend (indicated by the trend lines). However, the Total events do not represent statistically significant trends (indicated by the absence of a trend line). Therefore, variations within the Total values represent random fluctuation around the average of the data.

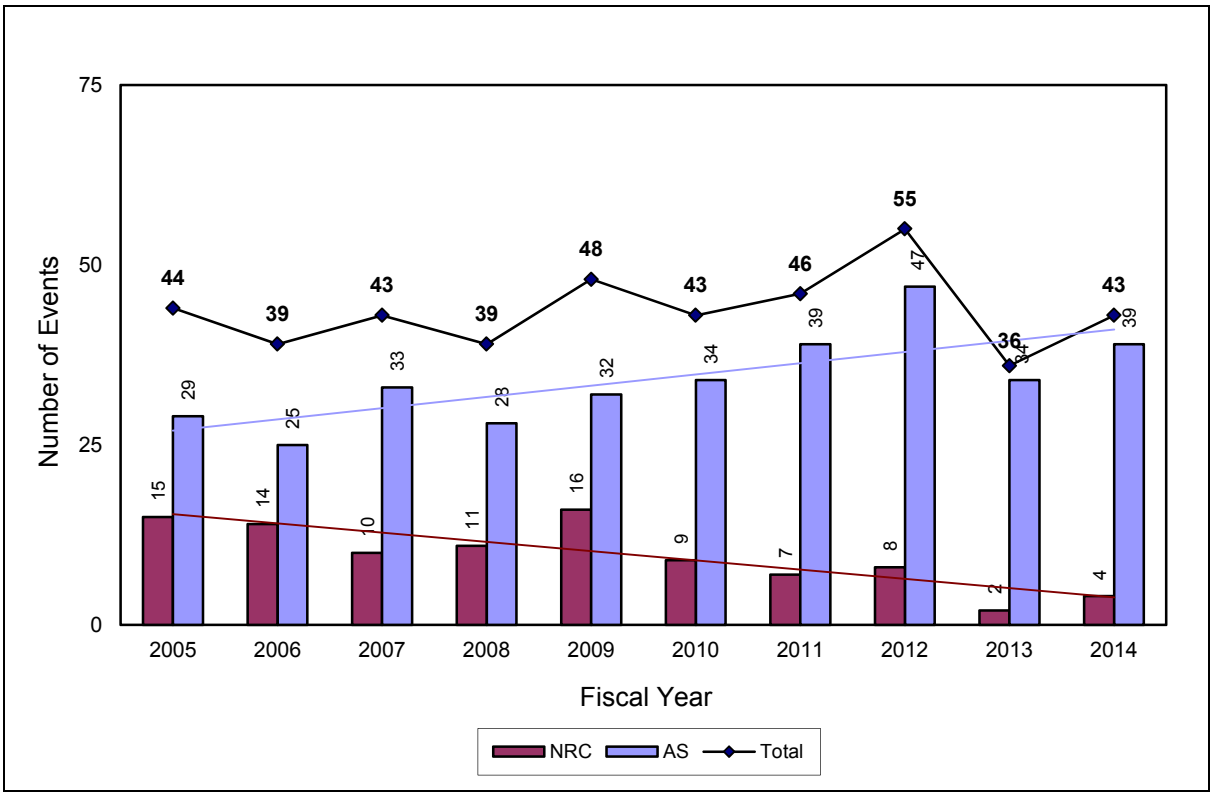

Figure 3. Medical Events (436 total)

Table 5 lists the number of MED events that were classified as Abnormal Occurrences (AOs) in NUREG-0090, *Report to Congress on Abnormal Occurrences*. Table 5 also includes 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 AO Events

	Fiscal Year										
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total[1]**
Medical	10	7	10	12	15	12	14	13	6	11	**110**
Embryo[2]	1	3	2	2	2	2	1	1	2	1	**17**
Total	**11**	**10**	**12**	**14**	**17**	**14**	**15**	**14**	**8**	**12**	**127**

Notes:

1. Events are marked as potential AOs until they complete the NRC's formal AO determination process and are reported in NUREG-0090. Potential AOs are included in this table.
2. Includes doses to an embryo/fetus or a nursing child reportable per 10 CFR 35.3047.

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 FY14 Data

Forty-three MED events occurred in FY14, 11 of which were considered significant.

Significant Events - AOs or Potential AOs

Item Number 130479 - A medical event occurred during treatment of a patient using a vaginal applicator and Cs-137 sources. Two sources contained an activity of 1.95 GBq (52.7 mCi) each and a third source contained an activity of 1.08 GBq (29.1 mCi). The applicator was found dislodged from the patient on the morning of 10/10/2013. The patient was paralyzed and would not have recognized when the applicator became dislodged. It was also noted that the patient experienced a restless night, tossing and turning. A dose of 7,000 cGy (rad) was prescribed to the mucosal surface, yielding a total implant time of 63.1 hours. The patient's inner thighs were expected to receive approximately 652 cGy (rad) during the procedure. The medical facility investigated the incident and determined that the actual implant time was at least 49.5 hours and delivered a dose of 5,491 cGy (rad) to the intended target site. A dose of up to 1,509 cGy (rad) was delivered to the surface of the patient's inner thighs. Corrective actions included modifying procedures and providing new training to personnel.

Item Number 140002 - A patient received the wrong high dose rate (HDR) treatment on 12/16/2013. The incident involved a mobile HDR unit and a 296 GBq (8 Ci) Ir-192 source. The intended site was the skin on the temporal region of the patient's head. The correct site and applicator were used. However, the physicist inadvertently selected a different patient's treatment plan and initiated the treatment. The physicist identified the error after 113.9 seconds and manually interrupted the procedure. The error caused the Ir-192 source to hit a dead-end at the first channel, due to a shorter channel length. The physicist believes the source was in that position for nearly the entire treatment time. The patient was prescribed 4,000 cGy (rad) to be delivered in eight fractions of 99.61 seconds each. For this fraction, the intended site received less than half of the intended dose, which was 500 cGy (rad). An area adjacent to the intended site received a maximum dose of 2,300 cGy (rad) to a single point and 1,000 cGy (rad) to a 1 cm radius and 4.5 mm depth. The referring physician and patient were notified of the error. The patient opted to proceed with a new treatment plan. The corrected fractions will avoid the treated area from this incident. A Georgia Department of Natural Resources inspector performed a reactive investigation on 12/18/2013. Corrective actions included requiring that a pretreatment checklist be physically signed by two independent qualified HDR operators/users.

Item Number 140047 - A medical event involving a prostate cancer treatment occurred on 12/31/2013. The patient was prescribed a D90 dose of 16,786 cGy (rad), but only received a D90 dose of 2,531 cGy (rad). The procedure involved 128 I-125 brachytherapy seeds that contained a total activity of 1.592 GBq (43.036 mCi). Six of those seeds were not implanted. Of the 122 implanted seeds, only 34 were actually implanted into the patient's prostate gland. The remaining 88 seeds were implanted outside the prostate. Estimated average doses to other organs and tissues included seminal vesicles with 1,399 cGy (rad), rectum with 4,580 cGy (rad), bladder with 389 cGy (rad), and penile bulb with 18,524 cGy (rad). The Arkansas Department of Health performed an investigation. Complications in the patient's anatomy contributed to the incident, in that the attending urologist mistook the penile bulb for the prostate gland. Corrective actions included centralizing prostate seed implant programs to fewer facilities, ensuring consistent adherence to the implant procedures and policies, evaluating implant procedures, requiring

quality assurance on ultrasound equipment, and requiring training and proficiency records for operating room staff assisting with implants.

Item Number 140094 - A patient inadvertently received 1,100 cGy (rad) to the gastric fundus during liver radioembolization using Y-90 microspheres on 1/24/2014. The procedure prescribed microspheres to the right liver lobe and was stopped when unanticipated shunting was identified. Facility staff ran contrast between vial doses to verify proper delivery of the microspheres. Patient imaging revealed the unintended 1,100 cGy (rad) dose to the gastric fundus from approximately 21.46 MBq (0.58 mCi) of Y-90 microspheres. The referring physician and patient were notified of the incident on 1/24/2014. The Ohio Department of Health performed a reactive inspection on 2/20/2014.

Item Number 140147 - A patient only received 0.81 GBq (21.8 mCi) of Y-90 microspheres to Segment IV of the left lobe of the liver instead of the prescribed 2 GBq (54.05 mCi) for an expected dose of 6,900 cGy (rad). Due to issues with hepatic arterial anatomy not previously anticipated, the medical team could not properly position the catheter. Because it was a bilateral disease that would eventually require the treatment of both lobes, they decided to move forward with the procedure. A post-delivery Bremsstrahlung scan revealed excellent coverage of Segment IV, with some minor coverage in the right lobe due to arterial anatomy. Approximately 0.81 GBq (21.8 mCi) was localized to Segment IV and 0.91 GBq (24.5 mCi) ended up in the right lobe. That resulted in doses of 2,783 and 3,128 cGy (rad), respectively. There was no significant extrahepatic activity seen. The authorized user intended to treat the right lobe next and the team reported that the treatment plan would be adjusted to take into account the diseased areas that were already treated. The patient and referring physician were notified. The event occurred due to an arterial aberration that caused the interventional radiologist to be unable to cannulate the artery. Corrective actions included requiring the authorized user to issue written directives to reflect the target organ as the entire liver versus a specific segment or lobe. They also instructed their medical team to require immediate notification of microspheres to extrahepatic organs above the acceptable levels of anticipated shunting.

Item Number 140202 - A palliative gamma knife stereotactic radiosurgery was administered to the wrong treatment site on 4/8/2014. The treatment was administered to the right side of the brain instead of the prescribed left side. The treatment was setup by a treatment planner, who took into account the patient's previous two treatments back in 2007 and 2008. Those previous treatments had been administered to the right side of the brain. The treatment planner did not realize that the pain had resolved on the right side and that the new treatment was to be administered to the left side of the brain. The incorrect treatment plan was reviewed and signed according to protocol. The treatment was started on the right side and then stopped at 1.72 minutes into the 19.14 minute procedure. That resulted in the wrong side of the brain receiving approximately 1,800 cGy (rad). The patient was informed, a correct treatment plan was created, and the treatment was administered to the left side of the brain. No detrimental effect is expected to the patient. Corrective actions included procedure modifications requiring that the doctor mark the arm of the patient on the side to be treated the day prior to treatment.

Item Number 140249 - A patient received 1.59 GBq (43 mCi) of Y-90 microspheres instead of the prescribed maximum dosage of 0.463 GBq (12.5 mCi). The event took place on 4/30/2014 during the second phase of a liver treatment. The patient received 36,300 cGy (rad) instead of the intended maximum dose of 10,200 cGy (rad). The authorized user inadvertently provided the radiopharmacist with an incorrect version of the written directive treatment form, which resulted in the radiopharmacist preparing the incorrect dosage. A delay in the arrival of the dosage, the fact that the patient was already anesthetized, and the patient's frail medical condition caused heightened stress and urgency to administer the dosage. This, combined with a vendor's inadequate implementation of a radiopharmaceutical software revision, resulted in the failure to follow all procedures and the defeat of normal checks and balances that should have identified the incorrect dosage. Both the patient and referring physician were notified. The patient has experienced no unintended side effects due to this event, but will continue to be monitored. Corrective actions included procedure changes for creating written directives and scheduling

patients, correcting the radiopharmaceutical software, and additional training for radiopharmacists and authorized users.

Item Number 140266 - A patient received high dose rate (HDR) remote afterloader treatment to the wrong location during three treatment fractions performed on 3/31, 4/7, and 4/14/2014. The patient was prescribed to receive 700 cGy (rad) per treatment using a 342.25 GBq (9.25 Ci) Ir-192 source and applicator. During the patient's follow-up visit on 5/19/2014, burns were observed to the skin on the patient's thighs and labia. Investigation revealed a source reference length of 1,223 mm was used instead of the correct 1,323 mm. Therefore, the source was 100 mm short of the intended treatment site. The estimated skin dose received by the patient was 4,200 cGy (rad). The patient and prescribing physician were informed of the event. Corrective actions included procedure modifications to incorporate a second person check of the source reference length, inserting an x-ray dummy marker in the central catheter, posting the expected reference length for applicators used, and adding a step to the HDR treatment check list to ensure the reference length.

Item Number 140462 - A medical event occurred during a prostate brachytherapy treatment. The patient was implanted with I-125 brachytherapy seeds on 6/5/2014 and a post-plan computed tomography scan was performed on 8/7/2014. The seeds contained a total activity of 949.864 MBq (25.672 mCi). During post-plan evaluation performed on 8/15/2014, it was discovered that the seeds had not been positioned in the correct target tissue. The seeds were implanted 3.5 cm inferior from the target location. The medical facility stated that approximately 29.31% of the prescribed dose was delivered to the target tissue. They determined that 16.44 cm^3 of normal tissue, inferior to the target tissue, received 14,400 cGy (rad). The facility will administer external beam radiation therapy to boost the areas that did not receive the prescribed dose. The patient will be monitored long term to track prognosis and complications. The event occurred due to inadequate ultrasound imaging of the target. Corrective actions included procedure modifications.

Item Number 140486 - A patient received approximately twice the prescribed 600 cGy (rad) during a skin treatment using a high dose rate (HDR) unit on 8/29/2014. The RSO stated that a decay corrected value for the source activity was used during data entry for the treatment plan. However, following patient treatment, it was determined that the HDR software had also corrected for decay, resulting in an exposure time that was too long. The facility informed the referring physician and held a staff meeting to discuss the incident. The facility will also review nine previously performed skin treatments to determine if additional medical events occurred.

Item Number 140502 - A Y-90 microsphere treatment on 9/14/2014 resulted in doses to a patient's liver and lungs that differed from prescribed. The revised lung shunt fraction value was used to calculate the actual radiation dose to the lungs and LT liver lobe. Results revealed that the lungs received 3,450 cGy (rad), instead of the intended 370 cGy (rad). The LT liver lobe received 6,700 cGy (rad), instead of the prescribed 11,700 cGy (rad). The administered activity to the LT liver lobe was 821.4 MBq (22.2 mCi) and the lungs were administer 689.68 MBq (18.64 mCi). The patient was prescribed to receive a total of 1,499.61 MBq (40.53 mCi). The patient's family was notified. The medical facility investigated the root cause of the incident. The Virginia Radioactive Materials Program also investigated the incident. The cause was determined to be a liver to lung shunt from the left hepatic artery. The incident involved a complicated arteriovenous shunting pathway involving two shunts. The left hepatic artery was not assayed prior to treatment. Corrective actions included procedure modifications to determine the lung shunt fractions from both the left and right hepatic arteries.

Events of Interest

Item Number 140069 - A medical facility reported that 1.11 MBq (30 mCi) of I-131 was administered to the wrong patient on 1/24/2014. The misadministration was discovered before the patient left the hospital and a blocking agent was subsequently administered. Both the patient and the doctor were informed of the incident. It was determined that the patient (non-English speaking) was not properly identified by the

registrar, who attached the wrong wrist identification band to the patient. Additionally, the authorized user did not use the patient's birth date for identification as required by written procedure. The facility performed follow-up testing on the patient and intends to monitor the patient. The thyroid dose was determined to be 728 cGy (rad) and it appears that there has been no effect on the patient. Blood tests for thyroid function revealed normal results. The facility will re-educate nuclear medicine registration staff and physicians regarding patient identification using two independent means, will conduct direct observation audits, and will educate registration staff regarding policies for using an interpreter for patient identification.

Item Number 140382 - A patient received HDR brachytherapy vaginal treatment to the wrong site on 6/19/2014. The HDR unit contained a 205.98 GBq (5.567 Ci) Ir-192 source. During the first of three fractional treatments, the vaginal cylinder was inserted into the patient and a planar digital x-ray image was taken. Unusual inferior cylinder placement was noted, but explained as special patient anatomy. Treatment proceeded without incident. However, when the patient returned for her second treatment on 6/24/2014, the cylinder insertion placement was approximately 5 cm superior to the first treatment. The facility concluded that the cylinder placement on 6/19/2014 was incorrect. The patient was prescribed to receive 1,000 cGy (rad) during each fraction. The doctor and members of the radiation oncology department investigated the incident and determined that dose to unintended tissue was 900 cGy (rad). The remaining 100 cGy (rad) was administered to the intended tissue. The doctor ordered a fourth treatment fraction for the patient to correct the error. The patient was notified and agreed to receive the additional treatment. The cause of the event was attributed to inadequate procedures. Corrective actions included procedure modifications to require pelvic scans with the cylinder inserted prior to patient treatment.

Item Number 140408 - A patient prescribed to receive a gamma knife treatment to the left side of the brain actually received a portion of another patient's treatment to the right side of the brain on 7/28/2014. The incident involved a gamma knife unit containing approximately 66.6 TBq (1,800 Ci) of Co-60. The medical facility's risk compliance officer stated that two female patients of similar size arrived for their treatments. Treatment head frames had been placed on both patients. It was decided to reschedule patient one (who had a much longer treatment time) and treat patient two first. However, the health physicist and radiation oncologist lacked communication with the nursing staff regarding the switch to treat patient two before patient one. That communication error, plus the lack of patient identification, caused the event. The Texas Department of State Health Services responded to the site and investigated the incident. The treatment time was prepared for 2.68 minutes, with a calculated total dose of 350 cGy (rad) to the center point maximum. Approximately two minutes into the treatment, a physician reviewing the procedure realized that the wrong patient was being treated and halted the treatment. The patient received 175 cGy (rad) to the wrong site. The patient and patient's physician were notified of the error. The patient was later treated using the correct treatment plan. Corrective actions included new policies and procedures incorporating better scheduling, patient identification, time-outs during the treatment process, and limiting distractions during the treatment process.

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 FY14 and was classified as a potential AO.

Item Number 140384 - An embryo/fetus received an unexpected radiation dose. A 23-year-old female patient received 3.7 GBq (100 mCi) of I-131 for thyroid ablation on 6/26/2014. The patient had blood drawn on 6/24/2014 for a pregnancy test; results received on 6/25/2014 were negative. Subsequent to the treatment, her physician requested a pregnancy re-test, which confirmed that the patient was pregnant. The estimated date of conception was 6/22 to 6/24/2014. The RSO discovered the event on 7/22/2014

and calculated that the embryo/fetus received a dose of 25 cSv (rem). As of 8/3/2014, the pregnancy was still viable.

2.3.3 Events Recently Added to NMED That Occurred Prior to FY14

Four 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. One of the MED 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 - AOs or Potential AOs

Item Number 140139 - A patient treated with Y-90 microspheres received a dose to an unintended organ on 8/15/2013. The patient was treated with 1,339.77 MBq (36.21 mCi) through the right hepatic artery. On 9/6/2013, the physician noted that the patient was experiencing intermittent abdominal pain. On 10/10/2013, the patient was administered 188.33 MBq (5.09 mCi) through the proximal left hepatic artery and 179.45 MBq (4.85 mCi) through the distal left hepatic artery. On 2/24/2014, the patient was admitted due to severe anemia and suspected gastrointestinal bleeding. On 2/27/2014, endoscopy revealed a duodenum lesion and an ulcer that had developed seemingly as a result of microspheres migrating to the stomach. A biopsy of the affected region revealed synthetic beads. It was determined that the synthetic beads were larger than normal microsphere size. The cause of the incident was determined to be the migration of microspheres through an aberrant hepatic arterial vasculature supplying the stomach. The facility is re-evaluating the microsphere procedure with the manufacturer's guidance. The Pennsylvania Bureau of Radiation Protection investigated the event.

Events of Interest

None

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 data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines). Therefore, variations within the annual values represent random fluctuation around the average of the data.

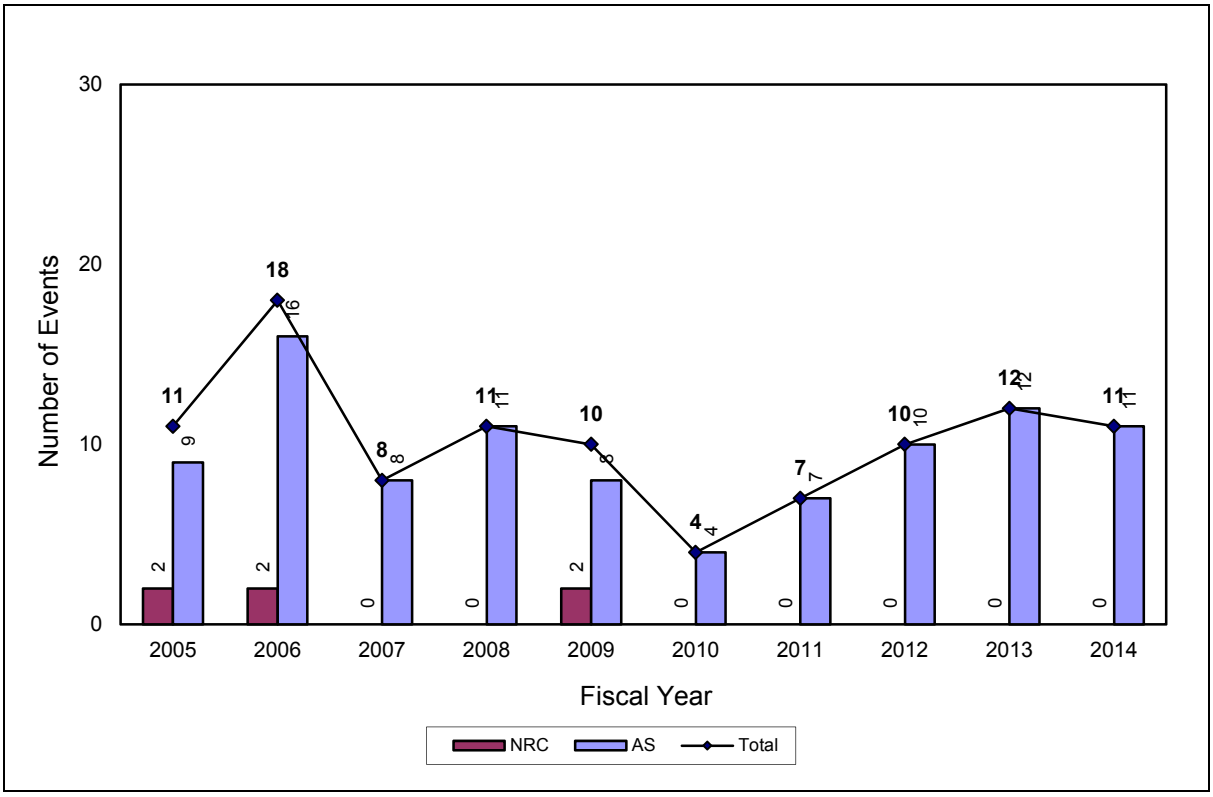

Figure 4. Radiation Overexposure Events (102 total)

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										
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Immediate	0	1	1	0	0	0	1	1	0	0	**4**
24-Hour	1	3	1	3	1	1	0	4	1	4	**19**
30-Day	10	14	6	8	9	3	6	5	11	7	**79**
Total	**11**	**18**	**8**	**11**	**10**	**4**	**7**	**10**	**12**	**11**	**102**

2.4.2 FY14 Data

Eleven EXP events occurred in FY14, four of which were considered significant.

Significant Events - Immediate Reports
None

Significant Events - Within 24-Hour Reports
Item Number 140145 - A radiographer trainee received an overexposure at a temporary job site on 3/12/2014. A radiographer and two trainees were using an exposure device and a 2.55 TBq (69 Ci) Ir-192 source to inspect welds on a tank. The two trainees were inside the tank in a man lift basket operating the exposure device. With the device hanging from the side of the tank, the trainees would position the collimator and then back away from the exposure device to the end of the control cables, approximately 35 feet. The radiographer was in a man lift outside the tank placing film. After completing an exposure, the trainees would remove the exposure device from the wall of the tank, place it in the basket, and wait to set up the next exposure. At one point, Trainee A had difficulty removing the guide tube from the exposure device. He spent 10 to 15 seconds trying to remove the guide tube. It was then determined that the source pigtail was not connected to the drive cable. The trainees stated that they were in the basket with the exposure device for as long as 15 minutes with the source not fully shielded. Trainee A was not wearing any personnel monitoring devices; he had left them in the truck. Trainee B was wearing dosimetry, but failed to turn his alarming rate meter on. The radiography company contacted the Radiation Emergency Assistance Center/Training Site (REAC/TS) for assistance. Trainee A was taken to a hospital for blood samples. Based on reenactment of the event, the company initially calculated that Trainee A received 3,680 cGy (rad) to the hand and a whole body exposure of 6 cSv (rem). However, no visual effects had been noted on his hand and he had experienced no pain. The company continued to monitor Trainee A's hand and correspond with REAC/TS. The dosimetry badge for Trainee B revealed a processed result of 3.327 cSv (rem). Upon completing their inspection, the company concluded that the source was approximately 24 inches from Trainee A for three minutes and 30 seconds. In addition, the source was approximately six inches from Trainee A's hand for about 10 seconds when he contacted the guide tube. It was concluded that Trainee A received a whole body exposure of 12 cSv (rem) and an exposure to the hand of 3.96 cSv (rem) during the incident. Those results brought his annual TEDE to 12.369 cSv (rem) and a SDE to the hand of 15.68 cGy (rad). The Texas Department of State Health Service conducted an onsite investigation and confirmed the company's conclusions. It was also determined that the radiographer that attached the drive assembly to the exposure device failed to connect the source pigtail to the drive cable prior to attaching the drive assembly. Corrective actions included suspending the involved radiographer trainer's qualifications, performing company-wide stand-downs to review the event with all personnel, removing all trainees from their duties for the remainder of 2014, and requiring the RSO to perform five unannounced audits of radiographers. As of 4/24/2014, this incident was classified as an International Nuclear Event Scale level 2 event. This event was classified as an EQP and EXP event.

Item Number 140203 - A radiographer received an overexposure at a temporary jobsite on 4/9/2014. The radiographer was using an exposure device with a 3.29 TBq (89 Ci) Ir-192 source and no collimator. Initial exposure estimates were 15 cSv (rem) whole body and between 3,000 and 5,000 cGy (rad) to the hand. The radiographer's dosimeter was sent for immediate processing and revealed results of 8.36 mSv (836 mrem). Based on investigation and exposure estimates from reenactments, the radiography company assigned the radiographer a whole body exposure of 13 cSv (rem) and an extremity dose of 6.5 cGy (rad). The Ohio Department of Health (ODOH) performed an onsite inspection on 4/10/2014. It was determined that the radiographer had not directly handled the end of the guide tube or the source. The radiographer had sat down and was chatting while waiting for an exposure to complete. When the exposure time completed, the radiographer incorrectly assumed that the assistant radiographer had retracted the source and proceeded to set up for the next procedure. The source had been elevated about chest high and was attached to a stand. The radiographer's chest was close to the source, sometimes within six inches. However, the radiographer's dosimeter was worn at the waist and was partially shielded from the source by equipment. When the radiographer noticed that the assistant radiographer was not present, he found that the source had not been retracted. ODOH determined that the radiographer's alarming rate meter had a dead battery and his survey meter was not functional and had not been checked that day. The assistant radiographer's alarming rate meter and survey instrument identified the exposed source. ODOH required additional training on applicable requirements. The radiographer will receive medical surveillance and REAC/TS will remain involved. As of 4/11/2014, this incident was classified as an International Nuclear Event Scale level 2 event.

Item Number 140528 - A radiographer received an overexposure after he failed to retract a 2.04 TBq (55 Ci) Ir-192 source into a radiography exposure device on 9/17/2014. Radiographer A (RA) was performing operations and radiographer B (RB) was developing film. RA cranked in the source but failed to fully retract it into the shielded position. RA then carried the exposure device to the tailgate of the truck and sat nearby for several minutes. The situation was discovered when RB found that all of the film was fully exposed and black. RA observed that a dose rate meter sitting on the tailgate was pegged high. RA picked up the crank assembly and turned the handle approximately one-half turn, which fully retracted the source and locked it in the shielded position. RA was not wearing any safety or monitoring equipment, except a self-reading dosimeter, which was off-scale. RB was wearing an alarming rate meter, but did not hear the alarm due to background noise. RA was near the exposure device for about 30 seconds and his whole body exposure was initially calculated to be 10.8 cSv (rem). RB was five feet from the exposure device for about 20 minutes and his whole body exposure was initially calculated to be 12.8 cSv (rem). Dosimetry for both radiographers was sent for processing. An investigation was performed and a consultant was hired. It was concluded that the exposure device and controls were working properly. It was also concluded that RB received a whole body exposure of 1.58 cSv (rem), as revealed by his properly worn dosimetry badge. Reenactments with the health physics consultant concluded that RA received a whole body exposure of 5.73 cSv (rem). REAC/TS bloodwork analysis results revealed that RA received less than 20 cSv (rem). The Texas Department of State Health Services is investigating the incident and determining the corrective actions. This event was classified as an EQP and EXP event.

Item Number 140551 - A medical imaging company reported a personnel contamination incident that occurred on 9/30/2014. An employee was drawing Ge-68 from a stock vial to manufacture line sources. She drew the required activity into a syringe and upon removing the syringe from the septum, the vial sprayed liquid onto her face. Radiation safety personnel responded and started personnel decontamination approximately 15 minutes after the incident occurred. The contaminated individual's face was washed and wet nasal swabs were used to remove radioactive contamination from her nasal passages. Following initial decontamination, radioactivity was confined to the facial areas around her nose and mouth, including inside her nasal passages. All sputum, nasal excretions, and wipes used on her skin in the affected area were collected. Urine bioassays were collected and revealed background results. Initial estimates reveal that 2.81 MBq (76 μCi) contaminated the individual's face. The most current dose

estimate revealed that the individual received a skin exposure of 240 cSv (rem). The imaging company and the Tennessee Division of Radiological Health are investigating the incident. This event was classified as an EXP and RLM event.

Events of Interest
Item Number 130614 - A member of the public received an overexposure during radiography operations on 12/10/2013. A radiography services company was performing radiography on a pressure vessel at an oil field equipment manufacturer's facility. The manufacturer's site foreman (a member of the public) was working with the radiographer. During operations, the radiographer and site foreman approached the source collimator to change the film and realized that the 2.48 TBq (67 Ci) Ir-192 source was in the exposed position and not shielded in the radiographic exposure device. The site foreman stated that he was in the area for five to eight minutes and approximately 12 to 24 inches from the source. The radiographer had touched the collimator for approximately 10 seconds. The radiography services company's RSO was informed of the incident. The site foreman and radiographer were escorted to the hospital for evaluation and released. The radiographer's initial whole body dose estimate was 40 cSv (rem). Subsequent evaluation determined that the radiographer received 9.88 cSv (rem) to the hand and 2.06 cSv (rem) to the whole body. The site foreman received a whole body dose of 5.15 mSv (515 mrem). This event was caused by the radiographer's failure to follow procedures and not using radiation detectors. Corrective actions included terminating the radiographer's employment and retraining all others on policy and procedure. The Texas Department of State Health Services investigated the incident. As of 1/22/2014, this incident was classified as an International Nuclear Event Scale level 1 event.

2.4.3 Events Recently Added to NMED That Occurred Prior to FY14

One EXP 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 - Immediate or 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). Therefore, variations within the annual values represent random fluctuation around the average of the data.

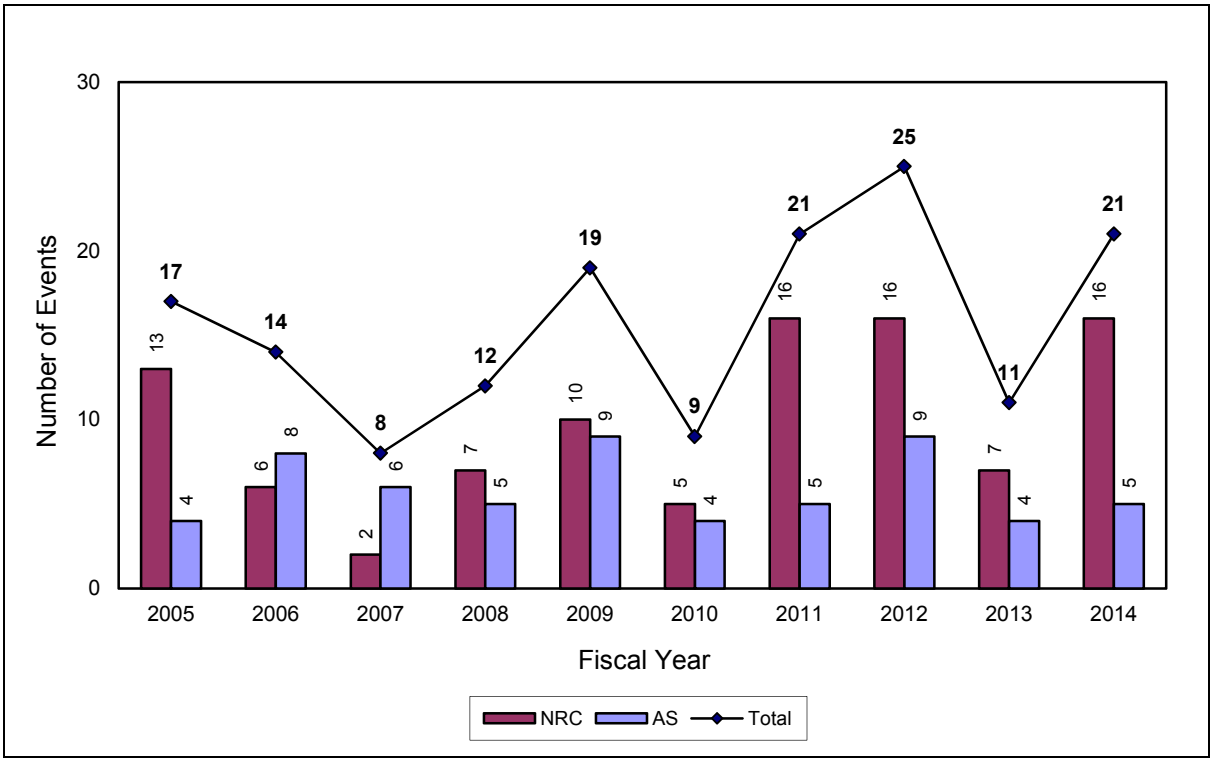

Figure 5. Release of Licensed Material or Contamination Events (157 total)

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										
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
Immediate	0	0	0	2	1	2	0	2	1	1	**9**
24-Hour	17	12	8	8	13	4	20	21	8	17	**128**
30-Day	0	2	0	2	5	3	1	2	2	3	**20**
Total	**17**	**14**	**8**	**12**	**19**	**9**	**21**	**25**	**11**	**21**	**157**

2.5.2 FY14 Data

Twenty-one RLM events occurred in FY14, one of which was considered significant.

Significant Events - Immediate Reporting

Item Number 140520 - A spill of approximately 3.7 to 4.1 GBq (100 and 110 mCi) of I-131 occurred at a nuclear pharmacy on 9/15/2014. A pharmacist dropped an I-131 glass vial onto the pharmacy floor. Most of the contamination was on the floor and shoes of the pharmacist. The RSO and pharmacist began clean-up procedures. Clothes and shoes were placed into zip lock bags. The floor was cleaned with Radiac wash and the cleaning items were also placed into zip lock bags. Activated charcoal was placed onto the floor. The three individuals involved in the incident were administered 130 mg of Lugol's solution (potassium iodine). Zip lock bags containing contaminated items were placed in the fume hood. No contamination was found on the skin of any individual. Radiation readings of 0.6 mR/hour were identified outside the closed room. The pharmacy performed bioassays at 24, 48, and 72 hours on the three involved individuals present during the spill and clean up. Those bioassay results revealed intakes to be within limits. Corrective actions included installing padded floors and additional barriers.

Events of Interest

Item Number 140551 - A medical imaging company reported a personnel contamination incident that occurred on 9/30/2014. An employee was drawing Ge-68 from a stock vial to manufacture line sources. She drew the required activity into a syringe and upon removing the syringe from the septum, the vial sprayed liquid onto her face. Radiation safety personnel responded and started personnel decontamination approximately 15 minutes after the incident occurred. The contaminated individual's face was washed and wet nasal swabs were used to remove radioactive contamination from her nasal passages. Following initial decontamination, radioactivity was confined to the facial areas around her nose and mouth, including inside her nasal passages. All sputum, nasal excretions, and wipes used on her skin in the affected area were collected. Urine bioassays were collected and have revealed background results. Initial estimates reveal that 2.81 MBq (76 μCi) contaminated the individual's face. The most current dose estimate revealed that the individual received a skin exposure of 240 cSv (rem). The imaging company and the Tennessee Division of Radiological Health are investigating the incident. This event was classified as an EXP and RLM event.

2.5.3 Events Recently Added to NMED That Occurred Prior to FY14

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 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 - Immediate Reporting

None

Events of Interest

Item Number 130177 - A radiography services company reported an unexpected radiation reading of 0.2 mSv/hour (20 mrem/hour) from a radiography exposure device on 4/15/2013. The device contained an Ir-192 source with an activity of 2,886 GBq (78 Ci). Radioactive contamination was detected on the exterior of the device, guide tube, and drive cable. High levels of radiation were detected in the right rear of the truck bed that was used to transport the exposure device. Radiography operations were being performed at a natural gas plant in Texas. The RSO was contacted and directed the radiography crew to return to the office (in Oklahoma). The RSO was able to remove the radioactive contamination from the truck bed with duct tape. Using an ND-2000 meter, the duct tape measured approximately 1 R/hour. The contaminated tape was placed in a vault. The Oklahoma Department of Environmental Quality was notified and responded on 4/16/2013. Using a microR meter, they identified radioactive contamination in the bed of the truck, where radiography equipment was assembled and disassembled. In addition, contamination was identified on the collimator, guide tube, and crank cable. No contamination was identified on the outside of the exposure device. Using a portable gamma spec, the radionuclide was identified as Ir-192. The highest level of contamination was on the collimator at 800 μR/hour. Contamination in the bed of the truck appeared to be in a discrete spot. Duct tape was used to lift the contamination and personnel reported seeing a small dark spot on the tape, believed to be a chip of Ir-192. Contaminated equipment was placed in plastic bags, placed into a large trash can, and then secured in a vault. The manufacturer of the exposure device was contacted and representatives responded to the facility on 4/17/2013. They identified contamination on the truck and on one radiographer's shirt sleeve, which was worn at the time of the incident. They also surveyed the homes and vehicles of the radiographers, with negative results. The Texas Department of State Health Services responded to the jobsite and performed radiation surveys of the various work locations. No radioactive contamination was identified. This event was classified as an EQP, LKS, and RLM event.

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 NRC-regulated events represent a statistically significant decreasing trend (indicated by the trend line). However, the Total and Agreement State-regulated events do not represent statistically significant trends (indicated by the absence of trend lines). Therefore, variations within the Total and Agreement State-regulated values represent random fluctuation around the average of the data.

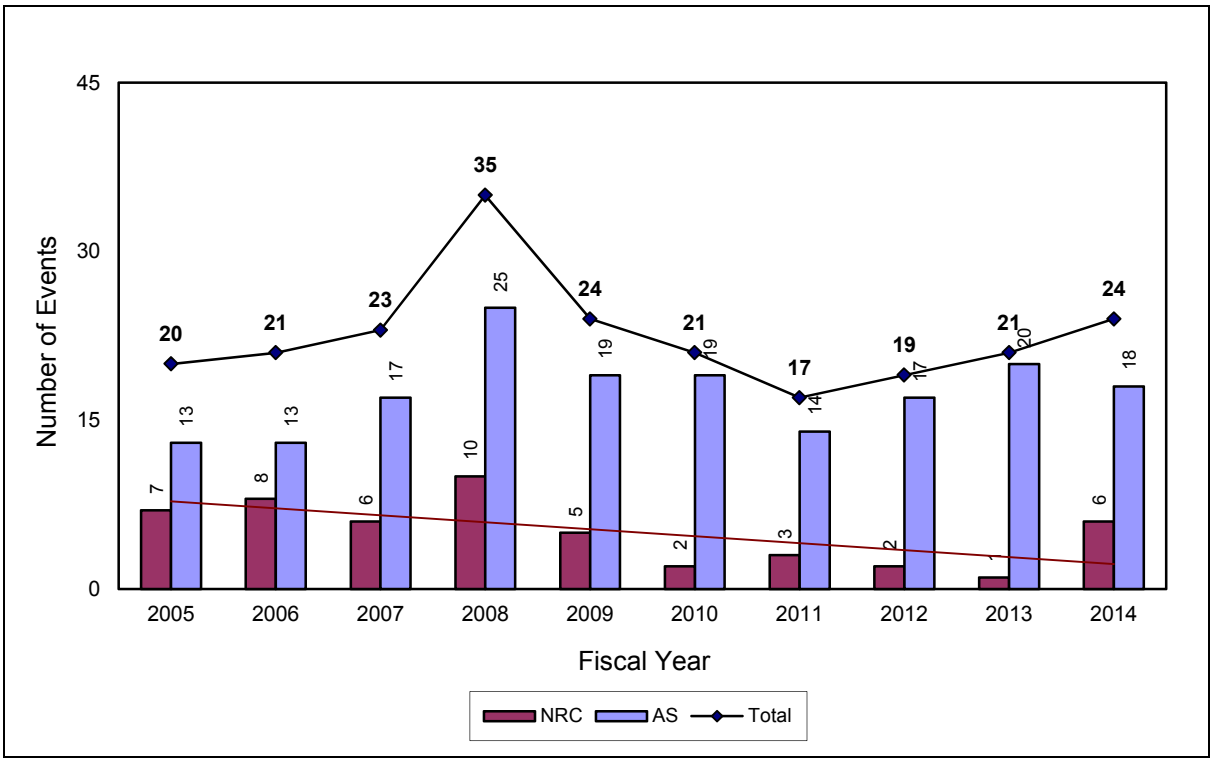

Figure 6. Leaking Sealed Source Events (225 total)

It is not possible to discern the significance of LKS events strictly from the CFR reporting requirements (as in Sections 2.4, 2.5, and 2.9). There are essentially no immediate or 24-hour reporting requirements for leaking sources. The exception is 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 FY14 Data

Twenty-four LKS events occurred in FY14, none of which were considered significant.

Significant Events
None

Events of Interest
Item Number 140191 - An 11.8 MBq (319 µCi) I-125 brachytherapy seed was broken during an implant procedure performed on 4/1/2014. The seed had jammed in the applicator during implant and the attending physician used additional force to complete the procedure. Following the implant procedure, a

radiation survey of the patient at one meter above the umbilicus revealed 1.7 mR/hour. The patient was removed from the operating room. During radiation surveys of the operating room following the operation, it was discovered that a seed had fractured. A portion of the seed was found on the sterile table. At that time, a thorough and complete area survey was performed. Radiation readings on the table, trash, and blood drain revealed 1.2 mR/hour. All contaminated items were collected for proper storage in the radiation oncology hot laboratory. All staff involved with the implant procedure were thoroughly monitored and cleared. Radiation oncology staff were monitored for thyroid uptake, which revealed background results. The patient recovery room was surveyed on 4/2/2014 and revealed background results (300 cpm). A follow-up thyroid bioassay of the patient on 4/4/2014 revealed approximately 111 kBq (3 μCi). An investigation was conducted by the State of Maryland on 4/7/2014. Corrective actions included procedure modifications requiring the removal of a seed cartridge from a jammed applicator and obtaining a second applicator to finish the implant procedure. This event was classified as an EQP and LKS event.

2.6.3 Events Recently Added to NMED That Occurred Prior to FY14

One LKS 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
Item Number 130177 - A radiography services company reported an unexpected radiation reading of 0.2 mSv/hour (20 mrem/hour) from a radiography exposure device on 4/15/2013. The device contained an Ir-192 source with an activity of 2,886 GBq (78 Ci). Radioactive contamination was detected on the exterior of the device, guide tube, and drive cable. High levels of radiation were detected in the right rear of the truck bed that was used to transport the exposure device. Radiography operations were being performed at a natural gas plant in Texas. The RSO was contacted and directed the radiography crew to return to the office (in Oklahoma). The RSO was able to remove the radioactive contamination from the truck bed with duct tape. Using an ND-2000 meter, the duct tape measured approximately 1 R/hour. The contaminated tape was placed in a vault. The Oklahoma Department of Environmental Quality was notified and responded on 4/16/2013. Using a microR meter, they identified radioactive contamination in the bed of the truck, where radiography equipment was assembled and disassembled. In addition, contamination was identified on the collimator, guide tube, and crank cable. No contamination was identified on the outside of the exposure device. Using a portable gamma spec, the radionuclide was identified as Ir-192. The highest level of contamination was on the collimator at 800 μR/hour. Contamination in the bed of the truck appeared to be in a discrete spot. Duct tape was used to lift the contamination and personnel reported seeing a small dark spot on the tape, believed to be a chip of Ir-192. Contaminated equipment was placed in plastic bags, placed into a large trash can, and then secured in a vault. The manufacturer of the exposure device was contacted and representatives responded to the facility on 4/17/2013. They identified contamination on the truck and on one radiographer's shirt sleeve, which was worn at the time of the incident. They also surveyed the homes and vehicles of the radiographers, with negative results. The Texas Department of State Health Services responded to the jobsite and performed radiation surveys of the various work locations. No radioactive contamination was identified. This event was classified as an EQP, LKS, and RLM event.

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). Therefore, variations within those annual values represent random fluctuation around the average of the data.

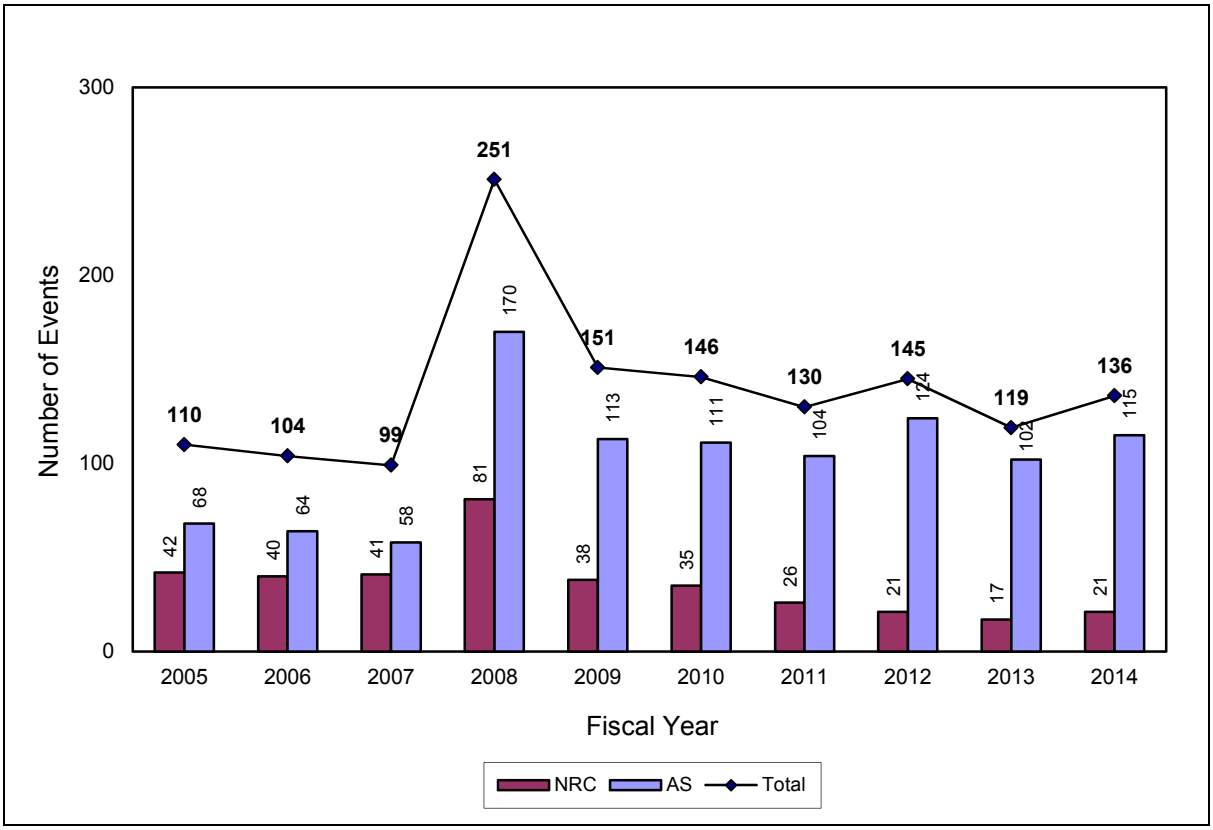

Figure 7. Equipment Events (1,391 total)

The FY08 and 09 data include 130 and 20 EQP events, respectively, which resulted from Wal-Mart's one-time review of their tritium exit sign inventory.

It is not possible to discern the significance of EQP events strictly from the CFR reporting requirements (as in Sections 2.4, 2.5, and 2.9) 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 FY14 Data

One hundred thirty-six EQP events occurred in FY14, two of which were considered significant.

Significant Events

Item Number 140145 - A radiographer trainee received an overexposure at a temporary job site on 3/12/2014. A radiographer and two trainees were using an exposure device and a 2.55 TBq (69 Ci) Ir-192 source to inspect welds on a tank. The two trainees were inside the tank in a man lift basket operating the exposure device. With the device hanging from the side of the tank, the trainees would position the

collimator and then back away from the exposure device to the end of the control cables, approximately 35 feet. The radiographer was in a man lift outside the tank placing film. After completing an exposure, the trainees would remove the exposure device from the wall of the tank, place it in the basket, and wait to set up the next exposure. At one point, Trainee A had difficulty removing the guide tube from the exposure device. He spent 10 to 15 seconds trying to remove the guide tube. It was then determined that the source pigtail was not connected to the drive cable. The trainees stated that they were in the basket with the exposure device for as long as 15 minutes with the source not fully shielded. Trainee A was not wearing any personnel monitoring devices; he had left them in the truck. Trainee B was wearing dosimetry, but failed to turn his alarming rate meter on. The radiography company contacted REAC/TS for assistance. Trainee A was taken to a hospital for blood samples. Based on reenactment of the event, the company initially calculated that Trainee A received 3,680 cGy (rad) to the hand and a whole body exposure of 6 cSv (rem). However, no visual effects had been noted on his hand and he had experienced no pain. The company continued to monitor Trainee A's hand and correspond with REAC/TS. The dosimetry badge for Trainee B revealed a processed result of 3.327 cSv (rem). Upon completing their inspection, the company concluded that the source was approximately 24 inches from Trainee A for three minutes and 30 seconds. In addition, the source was approximately six inches from Trainee A's hand for about 10 seconds when he contacted the guide tube. It was concluded that Trainee A received a whole body exposure of 12 cSv (rem) and an exposure to the hand of 3.96 cSv (rem) during the incident. Those results brought his annual TEDE to 12.369 cSv (rem) and a SDE to the hand of 15.68 cGy (rad). The Texas Department of State Health Service conducted an onsite investigation and confirmed the company's conclusions. It was also determined that the radiographer that attached the drive assembly to the exposure device failed to connect the source pigtail to the drive cable prior to attaching the drive assembly. Corrective actions included suspending the involved radiographer trainer's qualifications, performing company-wide stand-down's to review the event with all personnel, removing all trainees from their duties for the remainder of 2014, and requiring the RSO to perform five unannounced audits of radiographers. As of 4/24/2014, this incident was classified as an International Nuclear Event Scale level 2 event. This event was classified as an EQP and EXP event.

Item Number 140528 - A radiographer received an overexposure after he failed to retract a 2.04 TBq (55 Ci) Ir-192 source into a radiography exposure device on 9/17/2014. Radiographer A (RA) was performing operations and radiographer B (RB) was developing film. RA cranked in the source but failed to fully retract it into the shielded position. RA then carried the exposure device to the tailgate of the truck and sat nearby for several minutes. The situation was discovered when RB found that all of the film was fully exposed and black. RA observed that a dose rate meter sitting on the tailgate was pegged high. RA picked up the crank assembly and turned the handle approximately one-half turn, which fully retracted the source and locked it in the shielded position. RA was not wearing any safety or monitoring equipment, except a self-reading dosimeter, which was off-scale. RB was wearing an alarming rate meter, but did not hear the alarm due to background noise. RA was near the exposure device for about 30 seconds and his whole body exposure was initially calculated to be 10.8 cSv (rem). RB was five feet from the exposure device for about 20 minutes and his whole body exposure was initially calculated to be 12.8 cSv (rem). Dosimetry for both radiographers was sent for processing. An investigation was performed and a consultant was hired. It was concluded that the exposure device and controls were working properly. It was also concluded that RB received a whole body exposure of 1.58 cSv (rem), as revealed by his properly worn dosimetry badge. Reenactments with the health physics consultant concluded that RA received a whole body exposure of 5.73 cSv (rem). REAC/TS bloodwork analysis results revealed that RA received less than 20 cSv (rem). The Texas Department of State Health Services is investigating the incident and determining the corrective actions. This event was classified as an EQP and EXP event.

<u>Events of Interest</u>

Item Number 130486 - A moisture/density gauge was run over at a road construction site on 10/10/2013. The gauge contained a 1.48 GBq (40 mCi) Am-Be source and a 0.3 GBq (8 mCi) Cs-137 source. The Cs-

137 source rod separated from the gauge. The RSO responded to the site, recovered the gauge, and transported it to an Oklahoma Department of Transportation facility. Department of Environmental Quality staff inspected the gauge on 10/11/2013. The source rod had completely snapped off, but it did not appear that either of the sources had been damaged. Corrective actions included operating procedure modifications and providing additional training to gauge users.

Item Number 130508 - A fixed nuclear gauge was involved in a fire at an oil refinery on 10/23/2013. The gauge contained an 18.389 GBq (497 mCi) Cs-137 source. The source contained an original activity of 37 GBq (1 Ci) in August 1983. A consultant responded to the site to investigate. The gauge housing looked to be intact and radiation surveys at 35 feet below the gauge revealed 40 µR/hour. Contamination surveys below the vessel the gauge is mounted to revealed negative results. A perimeter was established and an Illinois Emergency Management Agency inspector was dispatched to the site and confirmed the initial findings. Arrangements were made with the manufacturer to have a field engineer travel to the site on 11/4/2013 for a more exhaustive evaluation. Radiation surveys on 11/4/2013 identified that the internal lead shielding had melted and some of it escaped from the gauge. Direct wipes of the source housing revealed no removable radioactive contamination. The source housing was removed from the vessel and placed on a shielded pallet. Maximum radiation readings were 50 mR/hour at one foot from the front of the gauge. A Type A package was prepared and the gauge was returned to the manufacturer for source recovery.

Item Number 130530 - A medical facility reported that a patient only received 53 and 66% of their prescribed dose during the first two fractions of treatment to the right breast on 10/25 and 10/28/2013. The patient was prescribed 10 fractions of 340 cGy (rad), for a total dose of 3,400 cGy (rad). The fractions were performed using a 218.3 GBq (5.9 Ci) Ir-192 source, a high dose rate unit, and a nine channel applicator. During the first fraction, channel one was treated appropriately, but channels two through eight received less than prescribed. The dose delivered during that fraction was 180.55 cGy (rad) or 53% of prescribed. The HDR manufacturer was contacted and responded to the site on 10/28/2013. The medical facility attempted the patient's second fraction on 10/28/2013, but channels two through eight again received less than prescribed. The dose delivered during the second fraction was 224.22 cGy (rad) or 66% of prescribed. The event was caused by equipment failure. Investigation revealed that as the radius of curvature of the catheter decreased, the source wire would not pass through, resulting in an HDR resistance error and procedure abortion. The medical facility revised the written directive/treatment plan and administered nine more fractions at another medical facility. The total final dose administered was 3,465 cGy (rad). The Ohio Bureau of Radiation Protection conducted an onsite investigation on 11/14/2013. Corrective actions included discontinuing treatments using this type of applicator with the HDR.

Item Number 130556 - A moisture/density gauge was damaged at a temporary jobsite on 11/14/2013 when it was run over by a road grader. The gauge contained a 1.48 GBq (40 mCi) Am-Be source and a 0.296 GBq (8 mCi) Cs-137 source. The gauge operator had left the gauge sitting on the ground and walked away to talk to an equipment operator. The grader backed over the gauge. The sources were in their shielded positions prior to the incident. During the incident, the gauge broke into two pieces and the source rod separated from the shielding block, but was still in one piece. The RSO responded to the site and verified that the sources were still intact and the gamma source was attached to the source rod. The RSO added additional shielding to the source rod to prevent the gamma source from becoming detached. He then placed the gauge and its pieces into the transport container. After the gauge was loaded into a truck and removed from the jobsite, the RSO performed radiation surveys of the area and identified no contamination. The gauge was returned to its storage location. An inspector from the State of Utah visited the company's facility on 11/15/2013. The inspector interviewed personnel involved in the incident and collected statements. Photographs were taken of the damaged gauge, wipe tests collected, and radiation surveys performed. The inspector also visited the incident site and performed

contamination surveys with negative results. The gauge was returned to the manufacturer for repair or disposal.

Item Number 130586 - The drive mechanism on a continuous pool-type irradiator failed to completely lower one of the source racks into the fully safe position at the bottom of the pool on 11/29/2013. The source rack contained 70,300 TBq (1,900,000 Ci) of Co-60 and was subsequently completely lowered into the pool by venting the source hoist air cylinder. The root cause was debris in the air system, which caused the solenoid to get stuck and prevented the source hoist piston from completely lowering the source rack. The solenoid valve spools were replaced, the source was cycled several times, and normal operations resumed.

Item Number 140017 - Two of three source racks in a panoramic irradiator failed to fully lower into their storage pool on 12/27/2013. The irradiator contained a total activity of 93,837.55 TBq (2,536,150 Ci) of Co-60. Following operations, the source racks were lowered into the pool, but racks #1 and #2 only lowered six and eight feet below the water line, respectively. That caused a travel fault. The irradiator manufacturer was notified and provided guidance to facility staff. The highest exposure rate at the surface of the pool was 18 mR/hour. Following investigation, it was determined that the pool water skimmer basket dislodged and became stuck behind rack #1, which pushed into rack #2, which pushed into rack #3. The basket was freed from the source rack using remote manipulation tools on 12/28/2013. The highest worker exposure, as recorded by pocket dosimeter, was less than 0.01 mSv (1 mrem).

Item Number 140022 - A foundry reported that the shielding of a fixed nuclear gauge, which contained a 3.7 GBq (100 mCi) Cs-137 source, was damaged due to high temperatures on 1/2/2014. The shell of a cupola had overheated; its temperature measured 990 degrees Fahrenheit (obtained remotely). The RSO was contacted, conducted a visual inspection, and noted a small puddle in front of the gauge. It was determined that lead shielding had melted out of the gauge. Using a Ludlum 3, dose rates were as high as 0.4 mR/hour approximately 21 feet from the gauge. Radiation readings obtained at the same location on 9/14/2013 during the six month inventory revealed 0.1 mR/hour. All other surveys in the vicinity of the gauge were the same or below 9/14/2013 survey results. The upper cooling water system had been taken out of service during the cupola heating process in an effort to repair a leak. While the system was down for repairs, production personnel did not check the upper shell's rising temperature as often as scheduled. By the time personnel did check, the temperature had risen to the point of damaging the lower gauge. Corrective actions included changing the mounting location of the lower gauge to reduce its exposure to high temperatures, installing custom cooling shrouds around all four gauges for protection, installing ambient temperature thermocouples to monitor temperatures around the gauges, and investigating alternate methods of level detection.

Item Number 140136 - A radiography source disconnected from an exposure device on 3/6/2014. The radiography crew was using an exposure device with a 3.41 TBq (92.2 Ci) Ir-192 source at a temporary jobsite. The radiographer stated that the locking mechanism would not trip when the drive cable was retracted. The radiographer went to the source collimator without his survey meter and picked up the collimator. When he felt the source travel down the guide tube, he dropped the guide tube. He stated that he only held the collimator for about five seconds. Exposure to the radiographer was concluded to be 15.11 cGy (rad) to the extremities and 5.09 mSv (509 mrem) to the whole body, as recorded on his dosimeter. The source was retrieved by the company. The Texas Department of State Health Services determined that the source did not disconnect, but that the radiographer failed to connect the source pigtail to the drive cable prior to connecting the drive assembly to the exposure device. Corrective actions included reprimanding involved personnel and providing additional training to personnel.

Item Number 140191 - An 11.8 MBq (319 µCi) I-125 brachytherapy seed was broken during an implant procedure performed on 4/1/2014. The seed had jammed in the applicator during implant and the attending physician used additional force to complete the procedure. Following the implant procedure, a radiation survey of the patient at one meter above the umbilicus revealed 1.7 mR/hour. The patient was

removed from the operating room. During radiation surveys of the operating room following the operation, it was discovered that a seed had fractured. A portion of the seed was found on the sterile table. At that time, a thorough and complete area survey was performed. Radiation readings on the table, trash, and blood drain revealed 1.2 mR/hour. All contaminated items were collected for proper storage in the radiation oncology hot laboratory. All staff involved with the implant procedure were thoroughly monitored and cleared. Radiation oncology staff were monitored for thyroid uptake, which revealed background results. The patient recovery room was surveyed on 4/2/2014 and revealed background results (300 cpm). A follow-up thyroid bioassay of the patient on 4/4/2014 revealed approximately 111 kBq (3 µCi). An investigation was conducted by the State of Maryland on 4/7/2014. Corrective actions included procedure modifications requiring the removal of a seed cartridge from a jammed applicator and obtaining a second applicator to finish the implant procedure. This event was classified as an EQP and LKS event.

Item Number 140201 - A petrochemicals transportation and storage services company reported that a gauge containing a 1.13 GBq (30.47 mCi) Cs-137 source was improperly disposed of. A recycling company had burned into the gauge with a cutting torch and came to within 1 mm of the sealed source. The Department of Energy exercised eminent domain and took command of the oil well next to a strategic reserve during November 2011. No source leakage was identified and the sealed source was still intact. The gauge was subsequently properly disposed of. This event was classified as an EQP and LAS event.

Item Number 140207 - A refinery reported that a fixed nuclear gauge containing a 37 GBq (1 Ci) Cs-137 source was damaged during removal on 4/10/2014. During the removal process, the gauge and rigging fell. Sharp edges on the device and source well unit created a rope failure point. The source became exposed as a result of the incident and the dose rate from the gauge was 6.4 mSv/hour (640 mrem/hour) at one foot. The damaged gauge was stuck inside the vessel tower skirt. The area was roped and barricaded. An Ohio Bureau of Radiation Protection inspector was sent to the site on the same day to observe recovery efforts. Initial efforts to return the source to its shielded position on 4/10/2014 were unsuccessful. On 4/11/2014, the source was retracted into its shielded position. Preliminary source leak tests revealed negative results. Corrective actions included providing additional training to personnel.

Item Number 140234 - An equipment failure occurred while installing a 369.26 GBq (9.98 Ci) Ir-192 source into a new remote afterloading brachytherapy unit at a medical facility on 4/24/2014. During the upload procedure, the source did not completely retract into the shielded safe and became hung-up on the in-drive. A device error stated the source was detached from the cable. The brachytherapy unit manufacturer's field service engineer entered the treatment room to investigate the issue and determined that the drive cable needed to be cut in order to remove it from the stuck drive. The engineer cut the cable and used pliers to manually insert the source into the transport container. However, he could not insert the source completely into the center of the container because the cable was cut short. The exposure rate at one meter from the container was 200 mR/hour. The medical facility's physicist and engineer ensured the treatment room door was sealed and marked, preventing entrance overnight. On the morning of 4/25/2014, temporary shielding was constructed using lead bricks on a trolley to transport the container to the facility's hot laboratory. On 4/29/2014, a Type A container arrived and the source was packaged for shipment. On 5/1/2014, the source was shipped to a storage facility for safe decay prior to being returned to the source's manufacturer. The afterloading brachytherapy unit was shipped back to the unit's manufacturer for investigation. After exhaustive and extensive analysis of the drive and the log files, the manufacturer was unable to reproduce the specific error and could not identify the root cause of the incident.

Item Number 140240 - A construction services company reported that the shutter on a moisture/density gauge was stuck open on 3/26/2014. The gauge contained a 1.85 GBq (50 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source. When the gauge was being returned to storage, an inspector noted that the gauge was overdue for a leak test. Further investigation indicated that the shutter would not close

when moved to the closed position. The gauge was sent for service on 4/1/2014. The shutter was cleaned and lubricated and a leak test performed. The shutter then worked as designed and the leak test revealed negative results. The Arizona Radiation Regulatory Agency performed an investigation. It was determined that the gauge had not been kept clean and lubricated.

Item Number 140245 - A moisture/density gauge was damaged when a motorist ran over it while in use at a temporary jobsite on 5/2/2014. The gauge contained a 1.85 GBq (50 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source. The Cs-137 source rod became detached from the gauge, but was returned to the shielded position. Radiation levels around the gauge were found to be within the normal range. The gauge was placed back into the transport container and returned to the licensee's facility. Leak tests were performed and revealed negative results. The Alabama Office of Radiation Control performed an investigation on 6/10/2014.

Item Number 140311 - A chemical plant reported that a 5.48 GBq (148 mCi) Co-60 source disconnected from a fixed nuclear gauge on 6/5/2014. The RSO stated that after retracting the source into the gauge, the source separated from the cable, and the cable fell out of the gauge. The gauge shutter closed and was locked. The gauge manufacturer was contacted and personnel responded to the facility on 6/6/2014. The manufacturer determined that the separation occurred because the wrong crimping tool had been used when the gauge was manufactured. In addition, it was determined that the manufacturer's pull test, to test the source connection, had not been performed. The manufacturer has implemented changes to their process and retrained their personnel on testing requirements for all gauges. The gauge was repaired by the manufacturer with a protective device installed and returned to the chemical plant.

Item Number 140340 - A truckload of scrap steel set off the radiation monitor alarms at a metal recycling facility on 6/23/2014. A damaged fixed gauge containing a 2.41 GBq (65 mCi) Cs-137 source was identified in the load. Oregon Department of Health Radiation Protection Services responded and found the gauge housing severely crushed and the shutter damaged and partially open. One side of the gauge housing was split, but compressed together. Radiation readings approximately four inches from the damaged gauge housing revealed 60 mR/hour. A recycling facility employee moved the gauge to a metal bin using a shovel and four-foot steel rod on 6/23/2014. The estimated exposure to that individual was 0.015 mSv (1.5 mrem). The gauge will be stored in a secure metal bin in a restricted and remote area pending disposal. The highest radiation reading on contact with the storage bin was 1.48 mR/hour. Wipe tests performed on the gauge housing revealed negative results. The gauge manufacturer determined who the gauge was originally sold to on 8/23/1996. Their last contact with the owner was in December 1999 for leak test services. Oregon is investigating the incident to trace the history of the gauge since 1999, as well as the location where the truck originated from. The gauge will be classified as waste and properly disposed of. The recycling facility will contact a waste broker to package and dispose of the gauge. This event was classified as an EQP and LAS event.

Item Number 140365 - A moisture/density gauge containing a 1.85 GBq (50 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source was run over and crushed by a bulldozer at a construction site in Kentucky on 7/11/2014. Initial radiation surveys indicated the sources were not breached, 40 mR/hour on contact with the gauge, and identified no contamination. The shattered pieces of the gauge, including the sources, were packaged into a 55-gallon drum. The drum was labeled appropriately and transported back to the licensee's facility in Tennessee. The Tennessee Division of Radiological Health responded to the facility and was there to meet the arrival of the drum. Follow-up radiation surveys and contamination smears were performed. Wipe tests and personnel dosimetry were sent for analysis. Source leak tests revealed negative results and personnel dosimetry results are pending. The Kentucky Department of Radiation Control is the regulating Agency.

Item Number 140415 - Arizona Radiation Regulatory Agency reported that during an inspection of a construction services company on 7/29/2014, it was noted that a moisture/density gauge had a shutter mechanism that was stuck in the open position, with the handle in the closed position. The gauge

contained a 1.85 GBq (50 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source. The company will have the gauge repaired.

Item Number 140529 - An oilfield services company reported that two fixed nuclear gauges stored in Type A containers at a temporary jobsite were damaged in a fire on 9/20/2014. Two other fixed gauges were involved in the event, but were not directly in the fire. The gauges each contained a 7.4 GBq (200 mCi) Cs-137 source. Radiation surveys revealed 7 R/hour on contact with one of the "in-fire" gauges, indicating that the lead shielding had been compromised. There were no elevated radiation levels on the other three gauges. All four gauges were subsequently returned to the manufacturer. The gauge with the melted shielding was damaged to the point that the source could not be removed and was disposed of. The source from the other "in-fire" gauge was removed from the irreparable housing and disposed of. The sources from the two gauges not directly in the fire were placed into new source holders and returned to the oilfield services company.

2.7.3 Events Recently Added to NMED That Occurred Prior to FY14

Eight 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 120520 - A moisture/density gauge that contained a 1.48 GBq (40 mCi) Am-Be source and a 0.3 GBq (8 mCi) Cs-137 source was stolen on the night of 9/1/2012. The gauge had been properly stored in a secure shed prior to the incident. The shed was broken into and the locked chain securing the gauge was cut. The manufacturer and local law enforcement were notified of the event. On 11/5/2012, a metal recycling facility notified the Florida Bureau of Radiation Control that the handle from a gauge was discovered at their facility. It was determined that the stolen gauge had been partially shredded. The gauge pieces were put into a shielded container and transferred to the manufacturer. Some radioactive material is likely still missing. This event is classified as an EQP and LAS event.

Item Number 130177 - A radiography services company reported an unexpected radiation reading of 0.2 mSv/hour (20 mrem/hour) from a radiography exposure device on 4/15/2013. The device contained an Ir-192 source with an activity of 2,886 GBq (78 Ci). Radioactive contamination was detected on the exterior of the device, guide tube, and drive cable. High levels of radiation were detected in the right rear of the truck bed that was used to transport the exposure device. Radiography operations were being performed at a natural gas plant in Texas. The RSO was contacted and directed the radiography crew to return to the office (in Oklahoma). The RSO was able to remove the radioactive contamination from the truck bed with duct tape. Using an ND-2000 meter, the duct tape measured approximately 1 R/hour. The contaminated tape was placed in a vault. The Oklahoma Department of Environmental Quality was notified and responded on 4/16/2013. Using a microR meter, they identified radioactive contamination in the bed of the truck, where radiography equipment was assembled and disassembled. In addition, contamination was identified on the collimator, guide tube, and crank cable. No contamination was identified on the outside of the exposure device. Using a portable gamma spec, the radionuclide was identified as Ir-192. The highest level of contamination was on the collimator at 800 μR/hour. Contamination in the bed of the truck appeared to be in a discrete spot. Duct tape was used to lift the contamination and personnel reported seeing a small dark spot on the tape, believed to be a chip of Ir-192. Contaminated equipment was placed in plastic bags, placed into a large trash can, and then secured in a vault. The manufacturer of the exposure device was contacted and representatives responded to the facility on 4/17/2013. They identified contamination on the truck and on one radiographer’s shirt sleeve,

which was worn at the time of the incident. They also surveyed the homes and vehicles of the radiographers, with negative results. The Texas Department of State Health Services responded to the jobsite and performed radiation surveys of the various work locations. No radioactive contamination was identified. This event was classified as an EQP, LKS, and RLM 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 data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines). Therefore, variations within those annual values represent random fluctuation around the average of the data.

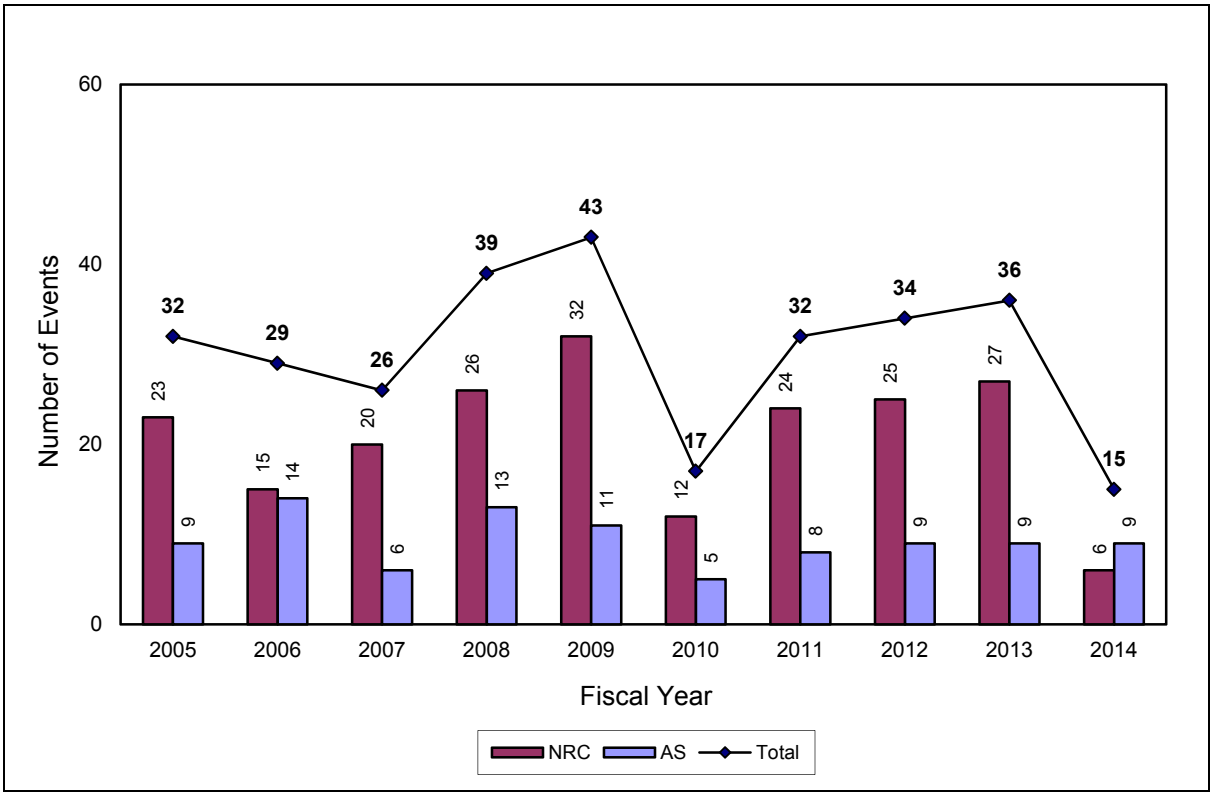

Figure 8. Transportation Events (303 total)

It is not possible to discern the significance of TRS events strictly from the CFR reporting requirements (as in Sections 2.4, 2.5, and 2.9). 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 FY14 Data

Fifteen TRS events occurred in FY14, none of which were considered significant.

Significant Events
None

Events of Interest
Item Number 140104 - A nuclear fuel manufacturer reported that conditions of approval in the Certificate of Compliance (CoC) for the MAP-12 shipping container were not followed during shipments. On 12/10/2013, during a routine refurbishment inspection of a MAP-12 container prior to use, an employee identified buckling of the outer sheet metal on a base spacer (bottom-half feet). Upon closer inspection, there was also a small crack in the side plate near a weld that attaches the base spacer to the lower body of the MAP-12 container. An examination of other MAP-12 containers found similar small cracks and

buckling in the side plates of the base spacers. As a result of this issue, all 84 MAP-12 containers were placed on hold. A visual inspection found that the 69 MAP-12 containers made by Manufacturer "A" had small cracks in some of the base spacer side plates, and 45 of the 69 had excessive buckling in some of the base spacer side plates. The 15 MAP-12 containers made by Manufacturer "B" had no visible cracks or excessive buckling and were acceptable for use. A total of 39 MAP-12 containers were needed to meet the fuel manufacturer's shipping commitments, so they were allowed to rework the 24 MAP-12 containers that only had cracks. The 45 MAP-12 containers with cracks and excessive buckling will be reworked by Manufacturer "B". The 69 affected MAP-12 containers were manufactured in the 2008-2009 timeframe and were used multiple times to make fuel shipments; it is not known when the small cracks and buckling actually began or how many shipments were made in this condition. The small cracks and buckling had minor safety impact. This event was caused by inadequate welds performed by Manufacturer "A" due to misinterpretation of the fabrication drawing; a continuous fillet weld was required on the outside joint, but intermittent fillet welds were used. This event was classified as an FCP and TRS event.

Item Number 140216 - A semi-tractor trailer carrying radioactive material was involved in an accident on 1/5/2014. The accident was a result of inclement weather conditions and occurred on Interstate 57, near Cairo, Illinois. A fire resulted and was extinguished by local responders. The heavily damaged tractor and trailer were moved to a secure facility in Mounds, Illinois. A radiography exposure device with a 3.7 TBq (100 Ci) Ir-192 source was being transported within an approved Type B overpack. The overpack exhibited signs of external exposure to fire/heat and denting. Radiation levels were consistent with those documented on shipping papers and there was no damage to the device's integrity. When the Type B overpack was checked for removable radioactive contamination, significant activity of approximately 80,000 cpm was detected on a large area wipe. However, the contamination was from a beta emitter, rather than from Ir-192. A Type A package containing P-32 was also included in the shipment, which correlated with the contamination identified. It was determined that the Type A package contained less than 37 MBq (1 mCi) of P-32, according to shipping paperwork. The P-32 was in liquid form and was shipped in a vial in a small dense plastic shield in a card board box. The fire resulted in destruction of the box and melting of the shielded container. State of Illinois inspectors detected no elevated radiation readings at the accident site. Arrangements were made to conduct screening of equipment and personnel present at the accident site. The damaged Type B overpack containing the radiography equipment will be returned to the manufacturer. This event was classified as an LAS and TRS event.

Item Number 140316 - A low-level radioactive waste processing facility reported that radiation levels on a transportation trailer exceeded 200 mR/hour. The trailer was received from a radiological services company with radiation levels on its bottom surface of approximately 350 mR/hour. A suspect package of waste was identified as a one cubic yard film box containing Ge-68 waste. The maximum radiation level on contact with the bottom of the box was 900 mR/hour. The box was classified as low specific activity; however, no markings were on the box identifying it. The Tennessee Division of Radiological Health issued a letter to the radiological services company detailing noncompliance of regulations. Corrective actions taken by the radiological services company included changes to procedures and use of a standardized checklist prior to loading waste. Permanent markings will be stenciled onto fiber containers where labels do not adhere. Standardizing the use of appropriate instrumentation and the establishment of action levels will also be implemented.

Item Number 140672 - The Florida Highway Patrol notified the Florida Bureau of Radiation Control that they performed a hazardous material traffic stop involving a vehicle owned by a cardiac imaging services company. Among other violations, a red plastic sharps container was found on a table in the cargo area with radiation levels as high as 1.224 R/hr on the surface of the container. The radionuclides included Tc-99m and Cs-137. The container is normally placed in a lead-lined vault to reduce radiation levels during transport. Once the container was properly stowed, the radiation levels were reduced to approximately 200 μR/hr.

2.8.3 Events Recently Added to NMED That Occurred Prior to FY14

Twelve TRS 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 140446 - Conditions of approval in the Certificate of Compliance (CoC) for TRUPACT-II shipping containers were not followed during shipments of transuranic waste from a Department of Energy national laboratory to a geological repository between 9/28/2012 and 5/1/2014. The Department of Energy determined that a subset of waste containers in 255 shipments have been provisionally identified to contain an unreacted oxidizer, which is in violation of the CoC. This includes up to 129 shipments comprising a total of up to 387 packages. The repository payload engineer is required to evaluate any waste process technology change associated with a given content code to ensure continued compliance with chemical composition and chemical compatibility requirements. During a review of shipments, a process change was identified that resulted in a revised chemical composition for the waste. Specifically, a procedure was changed on 8/1/2012 to authorize the use of organic absorbents to sorb free liquids; the previous practice directed the use of inorganic absorbents. This change was not submitted to the payload engineer for review and approval as required. As a result, the potential for a chemical reaction to occur within the package contents existed during transport. There were no major occurrences during transportation associated with this event and no component or system failures that contributed to the event. All shipments from the national laboratory to the repository were suspended pending completion of an investigation and implementation of corrective actions. Immediate corrective actions included procedure revision to ensure that appropriate reviews and approvals are obtained prior to implementing process changes.

2.9 Fuel Cycle Process

2.9.1 Ten-Year Data

Figure 9 displays the annual number and trend of FCP events that occurred during the 10-year period. This figure differs from those in previous sections of this report because FCP events are only associated with NRC-regulated facilities (not Agreement State-regulated). Additionally, unlike the other event types, NMED incorporates a dual use of the FCP event type; one use (Unique FCP) is for events unique to the fuel cycle process (such as a degradation of criticality controls), while the other use (Other FCP) is for any event occurring at a fuel cycle process facility (such as a lost calibration source).

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). Therefore, variations within those annual values represent random fluctuation around the average of the data.

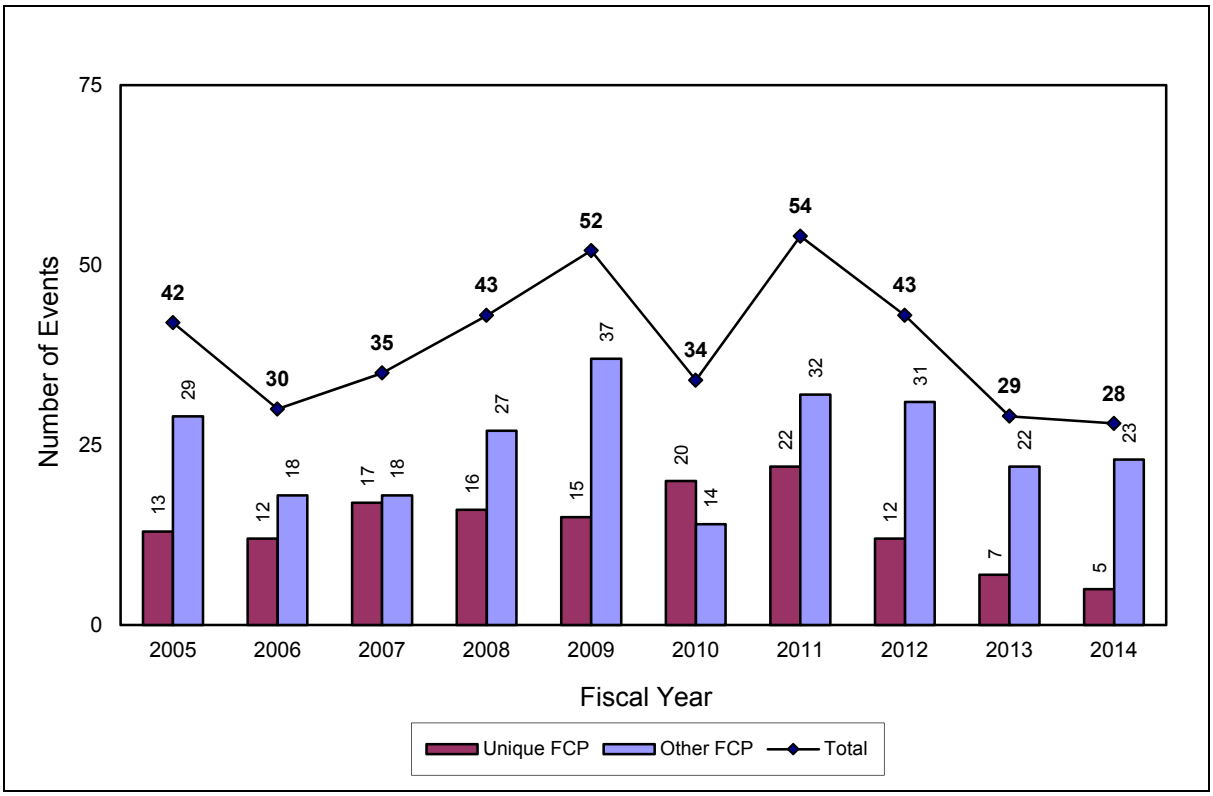

Figure 9. Fuel Cycle Process Events (390 total)

The remainder of this section will limit discussion to only those Unique FCP events (139 events).

The significance of individual FCP 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 24-hour reporting requirement. For this report, those 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 8 displays the number of events based on the different reporting requirement time categories. Note that each event is counted only once. If more than one reporting requirement applied to an event, the event is counted in only the most restrictive category.

Table 8. Unique FCP Events Classified by CFR Reporting Requirement

	Fiscal Year										
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
Immediate	3	3	5	3	3	1	1	2	2	4	**27**
24-Hour	10	9	12	13	12	19	21	10	5	1	**112**
Total	**13**	**12**	**17**	**16**	**15**	**20**	**22**	**12**	**7**	**5**	**139**

2.9.2 FY14 Data

Five Unique FCP events occurred in FY14, four of which were considered significant.

Significant Events - Immediate Reports

Item Number 130499 - A nuclear fuel manufacturer reported the failure of a vacuum breaker. The vacuum breaker is part of Item Relied On For Safety (IROFS 3526). The condition was identified on 10/27/2013 during an annual preventative maintenance check of the IROFS associated with the UO_2 steam supply system and lasted for more than eight hours. The vacuum breaker prevents backflow of uranyl nitrate solution into an unfavorable geometry supply tank and is credited in three separate integrated safety analysis (ISA) accident sequences. The vacuum breaker was determined to be blocked, preventing it from performing its safety function. The UO_2 steam boiler was down for maintenance and remained down until the vacuum breaker was replaced and tested. The other IROFS (3527) in the accident sequences remained available. A review of this event determined that is was of low safety significance. When the vacuum breaker was replaced in March 2013, the fuel manufacturer failed to follow procedures that required the use of an Engineering Change Notice. This contributed to the failure of IROFS 3526 to be available and reliable to perform its intended function. Engineering change procedures were revised.

Item Number 130531 - A gaseous diffusion uranium enrichment facility declared an alert on 11/17/2013 due to tornado that passed within their controlled access area. The tornado caused flying debris, damage to plant buildings and structures, and damage in the switchyards that resulted in a loss of power throughout sections of the site. The high pressure fire water system experienced a breach, which caused the storage tank water level to drop. The breach was isolated and the tank water level was restored. A section of perimeter fencing and lighting was damaged, resulting in security contingency measures being put in place until repairs were made. There were no injuries and no hazardous or radiological material released. Security of the site and sensitive areas was maintained throughout the event. The alert was terminated on 11/17/2013 after completion of a security check of the site perimeter and a compilation of the damages sustained by the site. Recovery team efforts were completed by 12/10/2013.

Item Number 140162 - A nuclear fuel manufacturer reported that one of the Items Relied on for Safety (IROFS) associated with the dry conversion process recycling operation was inoperable. A dew point moisture sensor that is one of the criticality controls was not operable. Although a second IROFS preventing moderation intrusion to the recycle container continued to operate within its allowable parameters, it alone was not sufficient to meet performance requirements. A pressure indicator in the same system that would have also helped prevent a criticality was later found to be in a condition that made it unreliable. The affected equipment was subsequently shutdown. At no time was an unsafe condition present. Both affected IROFS were installed in August 2012, but management measures were inadequate to ensure their reliability. Moisture condensation in the dew point sensor sufficient to impede carrier gas flow had not been previously experienced and was not anticipated. However, a small amount of moisture accumulation in the sample line and rotameter restricted flow to the sensor, causing the control to fail. The pressure indicator failed because the computer-generated operator action request had been suppressed by changing a value in the computer system. Corrective actions included restoring the

suppressed operator action request, redesigning the moisture sensor, revising the dew point probe functional test instruction, revising operating procedures, and additional training.

Item Number 140330 - A nuclear fuel manufacturer employee was observed on 6/17/2014 improperly operating two valves identified as Items Relied On For Safety (IROFS). The valves are designed to be held open simultaneously by hand while filling a column with pure ammonium hydroxide and to self-close by spring action once released. This is done to prevent the column from overflowing and causing a chemical exposure hazard to personnel. In this case, the employee propped the valves open using a box end wrench wedged into the structure of each valve, rendering them unable to perform their intended safety function. Although the operator was observing and monitoring the filling of the column, disabling the valves violated procedures. No radioactive materials were involved in this incident and no overflow occurred. Operations in the area were placed in a safe condition and an investigation was initiated. The operator was removed from operational duties and an organizational event debrief was conducted. The NRC conducted a special inspection to review this event.

Events of Interest

Item Number 140356 - A nuclear fuel manufacturer reported that one of the Items Relied on for Safety (IROFS) associated with the dry scrap recycle operation failed to meet performance requirements. On 7/12/2014, a potable water line (0.5-inch flexible plastic tubing) failed, resulting in a release of approximately 10 gallons of water into the moderator restricted area (MRA). The tubing was installed on top of a large ventilation duct passing through the MRA. The tubing was not readily visible as it was obscured by the ductwork and had a similar appearance to nearby electrical wiring. The presence of the water tubing is at variance with the MRA requirements and was not shown on system drawings. The release resulted in the failure of IROFS-900-03 for moderation restriction. Five other IROFS associated with process equipment barriers continued to perform their required safety function to limit significant moderation intrusion into the processing equipment. The affected equipment was shut down, the line was repaired to stop the leak, and the water was cleaned up and removed. At no time was an unsafe condition present. Special nuclear material was not impacted by the leak. No water escaped the area or migrated to non-contaminated areas. An investigation determined that the water line had degraded over time and ultimately failed. An extent of condition review did not identify any additional unauthorized water lines in MRAs.

2.9.3 Events Recently Added to NMED That Occurred Prior to FY14

One Unique FCP 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 (all FCP events, not just Unique FCP 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

Item Number 140103 - A gas centrifuge uranium enrichment facility identified the loss of Items Relied On For Safety (IROFS) associated with the process for decontaminating 1-S bottles in the small component decontamination train enclosure. IROFS-54a and IROFS-54b are the only IROFS credited with limiting the mass of uranium in the enclosure. Prior to placing components in the enclosure, recycling technicians use two independent measurements to verify that the mass limit is not exceeded. Both measurements involve measuring the gross weight of a 1-S bottle and subtracting the bottle's empty weight in order to obtain the mass of uranium in the bottle. However, the bottle's empty weight provided by operations personnel was actually the gross weight, so the mass of uranium was effectively cancelled from the calculation. Upon discovery, personnel recalculated the mass logs and determined that no significant uranium accumulation had occurred (processing 41 1-S bottles resulted in a mass increase of 3.1 grams of UF6, corresponding to 0.155 grams of U-235) and the administrative mass limit of 730 grams was not exceeded. Corrective actions included providing recycling technicians with access to the database where the correct empty weights are recorded. This incorrect process had been in place since

8/19/2013. This event was discovered on 9/10/2013 during a routine criticality safety walkdown. The enrichment facility did not believe that this condition was reportable. However, an NRC inspection beginning on 11/18/2013 determined that it was an apparent violation. Following discussions with the NRC, the facility reported the event to the NRC Operations Centers on 4/10/2014.

Events of Interest
None

2.10 Other

2.10.1 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.

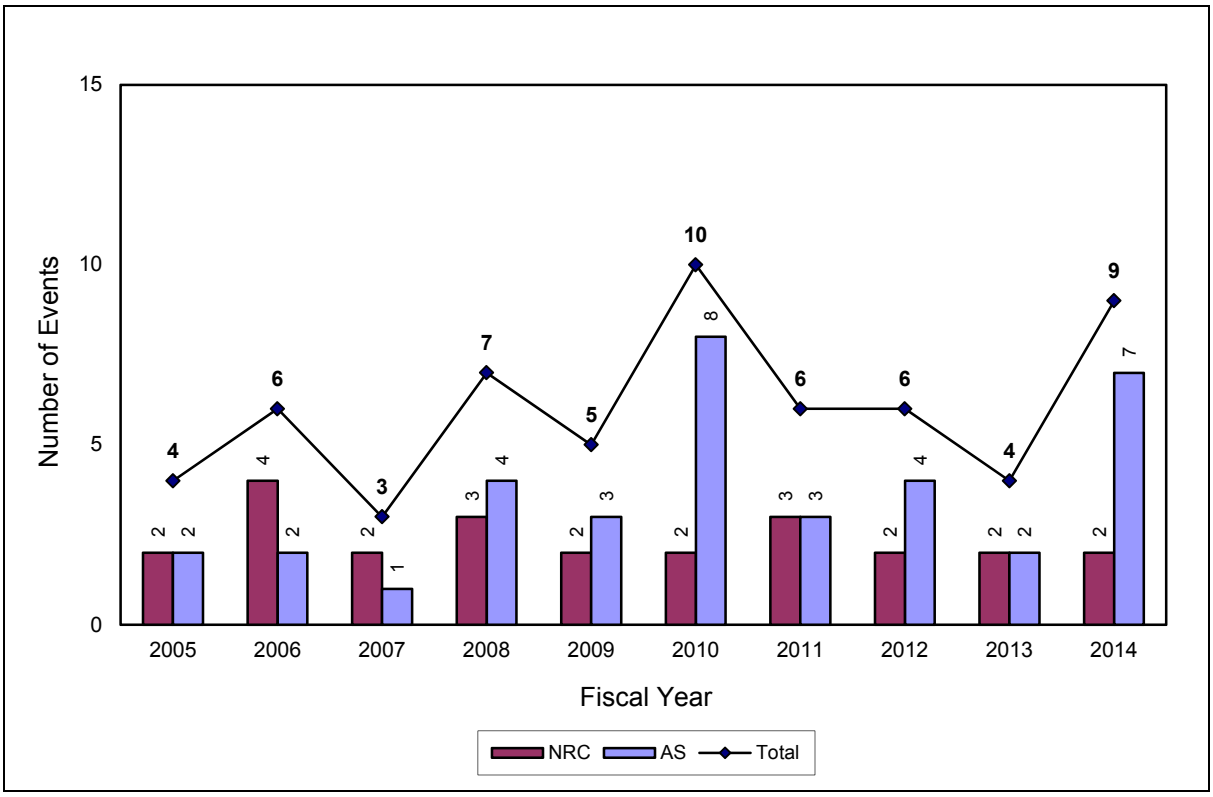

Figure 10. Other Events (60 total)

It is not possible to discern the significance of OTH events strictly from the CFR reporting requirements (as in Sections 2.4, 2.5, and 2.9). 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.

2.10.2 FY14 Data

Nine OTH events occurred in FY14, one of which was considered significant.

Significant Events

Item Number 140384 - An embryo/fetus received an unexpected radiation dose. A 23-year-old female patient received 3.7 GBq (100 mCi) of I-131 for thyroid ablation on 6/26/2014. The patient had blood drawn on 6/24/2014 for a pregnancy test; results received on 6/25/2014 were negative. Subsequent to the treatment, her physician requested a pregnancy re-test, which confirmed that the patient was pregnant. The estimated date of conception was 6/22 to 6/24/2014. The RSO discovered the event on 7/22/2014 and calculated that the embryo/fetus received a dose of 25 cSv (rem). As of 8/3/2014, the pregnancy was still viable. This event was classified as a potential AO.

Events of Interest

Item Number 130480 - Hospital "A" reported a potential radiation overexposure to members of the public from a deceased patient that had recently received 5.55 GBq (150 mCi) of I-131. The 35-year-old patient was administered the I-131 on 10/9/2013, approximately 10 to 14 hours prior to his death. Emergency medical technicians and coroner's office staff were called to the scene and examined the body prior to the confirmation of death, and then transported the body to Hospital "B". Hospital "A" consulted with and performed contamination surveys of all members of the public who came into contact with the body. The body was situated in a secluded portion of the morgue and lead aprons were used to reduce potential exposure. Preliminary estimates of exposure to members of the public revealed that the highest dose received was 300 µSv (30 mrem) to the driver of the vehicle that transported the body. Further calculations revealed the highest exposure to be approximately 230 µSv (23 mrem). The Colorado Department of Public Health and Environment investigated the incident. Hospital "B" isolated the body in their morgue to allow the I-131 to decay for about three months prior to autopsy. This event was classified as an LAS and OTH event.

Item Number 140039 - A chemical company reported that maintenance work was performed inside a vessel on 12/9/2013 while an associated fixed nuclear gauge had its shutter open. The gauge contained a 17.21 GBq (465 mCi - originally 18.5 GBq or 500 mCi) Cs-137 source. During work, a maintenance technician noticed that the lower level gauge still had its shutter open and was potentially exposing the workers inside. Work was suspended pending shutter closure. The company contacted the gauge manufacturer and the Georgia Radioactive Material Program (GRMP) for assistance. Initial radiation exposure rates inside the vessel were calculated to be a maximum of 138 mR/hour, with an average of 28 mR/hour. A few workers were inside the vessel for between 200 and 450 minutes, but most workers were in the vessel for no longer than 60 minutes. The manufacturer calculated the exposure rate at the center of the vessel along the beam centerline to be 27.2 mR/hour. The exposure rate at the side of the vessel along the beam centerline was calculated to be 11.02 mR/hour. A total of 12 workers entered the vessel. The highest estimated dose to an individual was 0.8724 mSv (87.24 mrem) and the average was approximately 0.3 mSv (30 mrem). The GRMP conducted an independent verification of the exposures. The cause was a failure to initiate the lock out/tag out work order and to manage keys used for gauge lock out/tag out. Contributing factors included nuclear gauges not being on the lockout checklists, procedural errors, the shutter was not accessible from a work platform, and the supervisor and workers failed to verify that the shutter was closed prior to entry. Corrective actions included revising vessel lock out/tag out procedures to require closing all gauge shutters on vessels requiring maintenance, modifying checklists to include radioactive sources and physical inspection of closures, modifying vessel entry permits to verify shutter closures, and better security of interlock keys.

Item Number 140101 - A medical center reported the loss of an Rb-82 generator that contained a total activity of 3.7 GBq (99.9 mCi). The generator was packaged for shipment to the manufacturer for disposal. The package was left unattended and unsecured in an unrestricted area for about two hours on 2/10/2014, awaiting pickup by a common carrier. The package was sealed with radioactive material labels. The surface dose rate on contact was 19.4 mR/hour and 323 µR/hour at one meter. A surface wipe test revealed 713 dpm/100 cm^2. When the first technician arrived at the facility at six in the morning on 2/11/2014, the package was missing and no paperwork had been left by the carrier. The carrier was contacted and they had no record of a package pickup. On 2/12/2014, the RSO stated that contracted housekeeping staff had placed the package in a dumpster, which had been picked up on 2/11/2014 and sent to a landfill. Medical center personnel responded to the landfill to search for the package with negative results. Procedures were modified and personnel were trained on those updates. Updates included generators being kept in a locked hot laboratory until the common carrier picks them up, all incoming generators being placed in that locked laboratory by a facility technician upon arrival, and a new storage container on wheels being purchased to move generators in and out of the laboratory for survey prior to shipment. Ancillary staff training was also revised with emphasis on identifying labels of hazardous material and proper handling. This event was classified as an LAS and OTH event.

Item Number 140214 - Two members of the public received whole body exposures during radiography operations at a refinery on 3/20/2014. A radiography services company was using a radiography exposure device containing a 2.86 TBq (77.4 Ci) Ir-192 source and a tungsten collimator. They performed three 25-second exposures while inspecting a 10-inch pipe. After completing the exposures, they discovered that the two individuals had been in the vicinity. Investigation revealed that the two individuals received approximately 0.18 and 0.15 mSv (18 and 15 mrem). The company was cited for conducting operations such that the dose in any unrestricted area from external sources did not exceed 0.02 mSy (2 mrem) in any one hour. The cause was determined to be human error. Corrective actions included reprimanding involved radiographers and providing them with additional training.

Item Number 140226 - While performing an unannounced inspection at a radiography services company's field station, NRC inspectors determined that radiation levels in an unrestricted area exceeded limits during radiography operations involving a 2.72 TBq (73.4 Ci) Ir-192 source. While walking around the outside of the building (an area with no boundaries or physical controls to restrict access), the inspector's survey meter read off-scale. As the inspectors retreated from the area, they measured 200 mR/hr at a distance of 40 feet from the building during the two-minute radiographic exposure. Radiographers had performed six two-minute radiographic exposures in a one-hour timeframe. The radiography services company shares the building with four other businesses. In addition to dose rates around the building exceeding limits during the six radiographic exposures, the inspectors were concerned that individuals working in a nearby office could have received doses in excess of limits over the course of a year. Radiographic operations were ceased at the field location pending a review of this event. NRC issued a confirmatory action letter, requiring that company provide the results of their investigation, dose evaluations, and a review of other jobsites. The company's analysis concluded that no member of the public received dose in excess of limits. Procedures were modified to ensure that appropriate boundaries are established and maintained, and personnel received additional training.

Item Number 140281 - A member of the public received a whole body exposure during radiography operations at a refinery. On 4/13/2014, radiography was being performed on a large storage tank constructed of 0.375-inch thick steel plate. The radiographer was in a powered personnel lift outside of the tank and operated the exposure device with a 3.15 TBq (85 Ci) Ir-192 source. The assistant radiographer was inside of the tank to place the film and access the weld locations using a crane-operated personnel lift with a qualified crane operation signal person (welder) also in the lift basket. During the setup of an exposure, the radiographer positioned the guide tube and unlocked the exposure device prior to confirming that the assistant radiographer and the welder were clear of the area. The radiographer caused the source assembly to move from the fully shielded position during his movement away from the exposure device. When the assistant radiographer's alarming rate meter and survey meter reading indicated that the source was no longer fully shielded, the crane operator was signaled to move them out of the area, which took about 15 seconds. The radiographer was notified of the situation and retracted the source back into the fully shielded position (approximately one-quarter turn). The radiographer's direct reading dosimeter read 200 μSv (20 mrem) for the day, while the assistant radiographer's direct reading dosimeter read 90 μSv (9 mrem). The estimated exposure to the welder was calculated to be 33.8 μSv (3.38 mrem). Corrective actions included terminating the radiographer's employment, additional training for the assistant radiographer, and procedure modification to require visual and verbal confirmation that personnel are out of the area prior to the exposure device being unlocked. Also, proper scaffolding will be erected to eliminate the need for a member of the public to be inside the restricted area during operations.

Item Number 140336 - A member of the public received a whole body exposure of 68 μSv (6.8 mrem) during radiography operations performed at a refinery on 3/4/2014. Radiography was being performed during the lunch hour. The radiographers were using a radiography exposure device and 2.38 TBq (64.2 Ci) Ir-192 source. The refinery made an announcement that all employees were required to leave the facility during the lunch hour while radiography was performed. However, one employee was outside the

building at the time of the announcement and did not hear it. The employee entered the building and walked to his work area, which was inside the restricted radiography area. He laid down on his toolbox and went to sleep while the radiographers performed a single three-minute exposure. The employee was approximately 27 feet from the exposed source. Following the exposure, the employee awoke and presented himself to the radiographers. At that point radiography operations were terminated and the RSO was contacted. The cause of the incident was determined to be a procedural problem.

2.10.3 Events Recently Added to NMED That Occurred Prior to FY14

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

The 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.

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.

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 category 1 quantities of material.
37.81(d)	Actual or attempted theft or diversion (or related suspicious activities) of category 2 quantities of material.
37.81(e)	Recovery of any lost or missing category 1 quantities of material.
37.81(f)	Recovery of any lost or missing category 2 quantities of material.
39.77(b)	Loss/theft of well logging sources.
40.64(c)(1)	Theft/diversion of 15 lbs (or 150 lbs 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	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)	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.
35.3045(a)(1)(ii)	Total dosage delivered differs from prescribed 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.
35.3045(a)(1)(iii)	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.
35.3045(a)(2)(i)	Administration of a wrong radioactive drug containing byproduct material 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.
35.3045(a)(2)(ii)	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)(2)(iii)	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)(2)(iv)	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)(2)(v)	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)(3)	Dose to the skin, organ, or tissue, other than the treatment site, that exceeds the prescribed dose by 0.5 Sv (50 rem) and 50% or more (excluding permanently implanted seeds that migrated from the treatment site).
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.

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.

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.
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.
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.
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)(1)	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.

Fuel Cycle Process

The FCP event type is used two ways. One usage is identical to the other event types in that it is used to code events involving FCP reporting requirements. However, it is also used to denote any type of event occurring at (or involving) a fuel cycle process facility. Therefore, reporting requirements other than those listed below can be used with the FCP event type. In this case, the event will be coded with multiple event types.

For those events involving only the FCP event type, the events are determined and coded per the 10 CFR reporting requirements, NRC Bulletin, and Safety Equipment Actuation requirement listed below.

Table A-9. FCP Reporting Requirements

FCP Reporting Requirements	Reporting Requirement Summary
70.52(a)	Inadvertent nuclear criticality.
70.App A(a)(1)	Inadvertent nuclear criticality.
70.App A(a)(2)	Acute intake by an individual of 30 mg or greater of uranium in a soluble form.
70.App A(a)(3)	Acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed material that exceeds the quantitative standards established to satisfy the requirements in 70.61(b)(4).
70.App A(a)(4)(i)	Event or condition such that no IROFSs remain available and reliable to perform the safety function in accordance with 70.61(b) and 70.61(c).
70.App A(a)(4)(ii)	Event or condition such that no IROFSs remain available and reliable to prevent a nuclear criticality accident (i.e., loss of all controls in a particular sequence).
70.App A(a)(5)	Loss of controls such that only one IROFS has been available and reliable (for longer than the past eight hours) to prevent a nuclear criticality accident.
70.App A(b)(1)	Event or condition that results in the facility being in a state not analyzed, improperly analyzed, or different from that analyzed, and results in failure to meet the performance requirements of 70.61.
70.App A(b)(2)	Loss or degradation of IROFSs that results in failure to meet the performance requirement of 70.61.
70.App A(b)(3)	Acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed materials that exceeds the quantitative standards that satisfy the requirements of 70.61(c)(4).
70.App A(b)(4)	Natural phenomenon or external event, including fires internal and external to the facility, that affected or may have affected the safety function, availability, or reliability of one or more IROFSs.
70.App A(b)(5)(i)	Occurrence of an event or process deviation that was considered in the ISA and was dismissed due to its likelihood.
70.App A(b)(5)(ii)	Occurrence of an event or process deviation that was considered in the ISA, categorized as unlikely, and whose associated unmitigated consequences would have exceeded those in 70.61(b) had the IROFSs not performed their safety function(s).
72.74(a)	Accidental criticality or any loss of special nuclear material.
76.120(a)(1)	Criticality event.
76.120(a)(4)	Emergency condition that has been declared an alert or site area emergency.

NRCB 91-01	The loss of criticality safety controls where (1) moderation is used as the primary criticality control, or (2) more than a safe mass of fissionable material is involved (regardless of the type of controls used to satisfy the double contingency principle), and that meet one or more of the following immediate reporting criteria:
Immediate reports: NRCB 91-01 – A	1. Any event that results in the violation of the double contingency principle, as defined in ANSI 8.1, and where the double contingency principle cannot be re-established within 4 hours after the initial observation of the event. 2. The occurrence of any unanticipated or unanalyzed event for which the safety significance of the event or corrective actions to re- establish the double contingency principle are not readily identifiable. 3. Any case where it is determined that a criticality safety analysis was deficient and where the necessary controlled parameters were not established or maintained. 4. Any event involving a controlled parameter previously identified by the NRC or the licensee as requiring immediate reporting to the NRC and where the double contingency principle cannot be re- established within 4 hours after the initial observation of the event.
24 hour reports: NRCB 91-01 – B	All other criticality safety events that do not meet the aforementioned criteria, but still result in a violation of the double contingency principle, such as events where the double contingency principle is violated but control is immediately re-established, should be reported to the NRC within 24 hours in accordance with the commitments in the responses to the bulletin.
S.E.A	Safety equipment actuation.

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. Exposure rates in an unrestricted area in excess of 2 mR/hr, 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. Reportable events that do not specifically fit into one of the previous event types.
4. Events not reportable to the NRC but included in the NMED program for informational purposes.

For items 1 and 2 above, OTH events are determined and coded per the 10 CFR reporting requirements listed below. Due to the nature of items 3 and 4 above, other reporting requirements may also be used.

Table A-10. OTH Reporting Requirements

OTH Reporting Requirements	Reporting Requirement Summary
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.
20.2203(a)(2)(iv)	Exposure rates in an unrestricted area in excess of 2 mR/hr, but no dose received in excess of limits.

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 the 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 the 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 TeraBequerel (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

The 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-10 below display the changes in the data published in the previous quarterly report. A positive value indicates that records were added and a negative value indicates that records were removed.

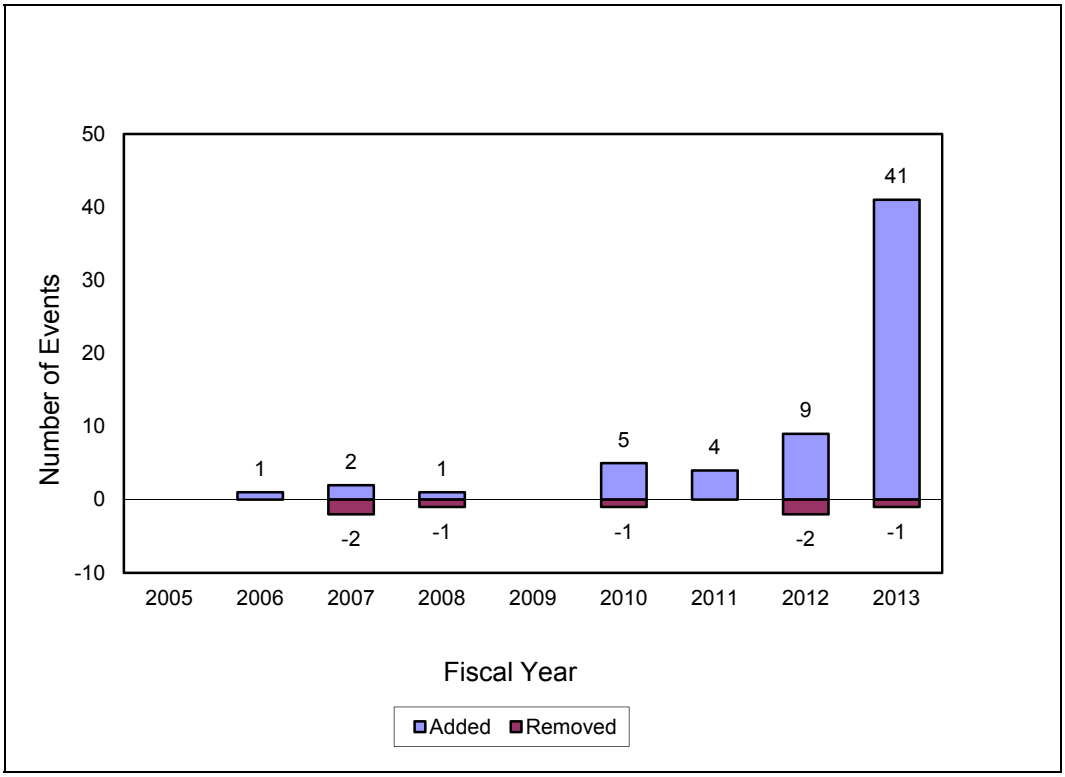

Figure D-1. Changes to All NMED Event Data

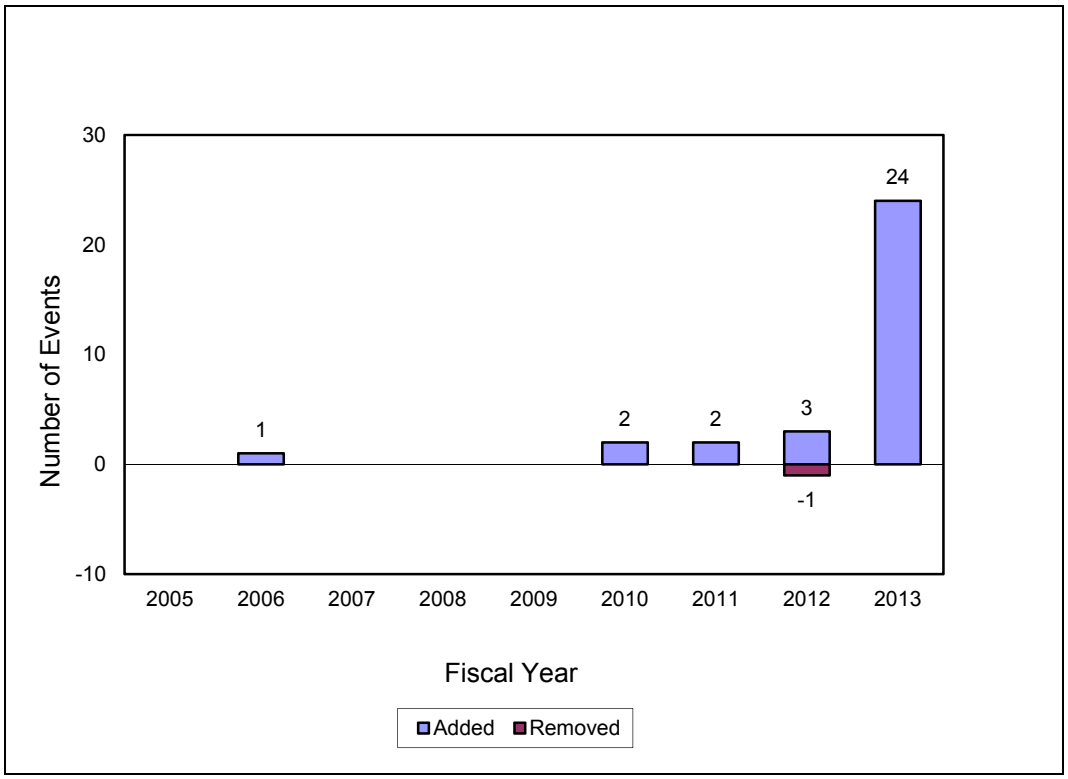

Figure D-2. Changes to LAS Data

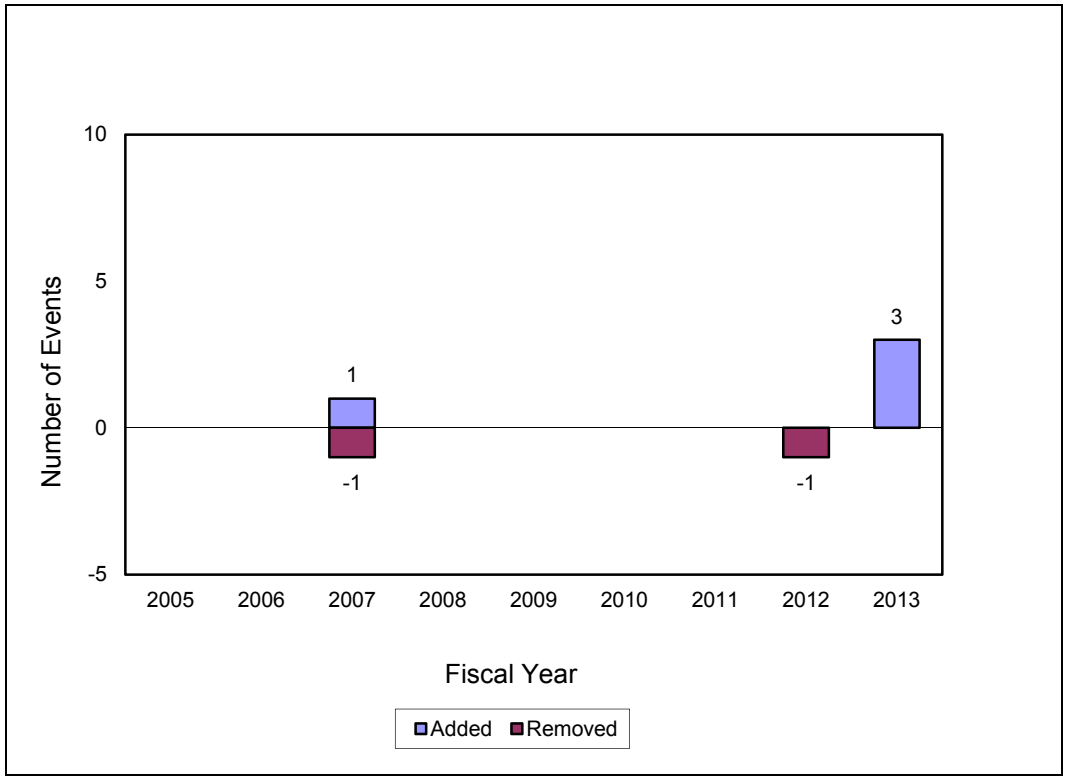

Figure D-3. Changes to MED Data

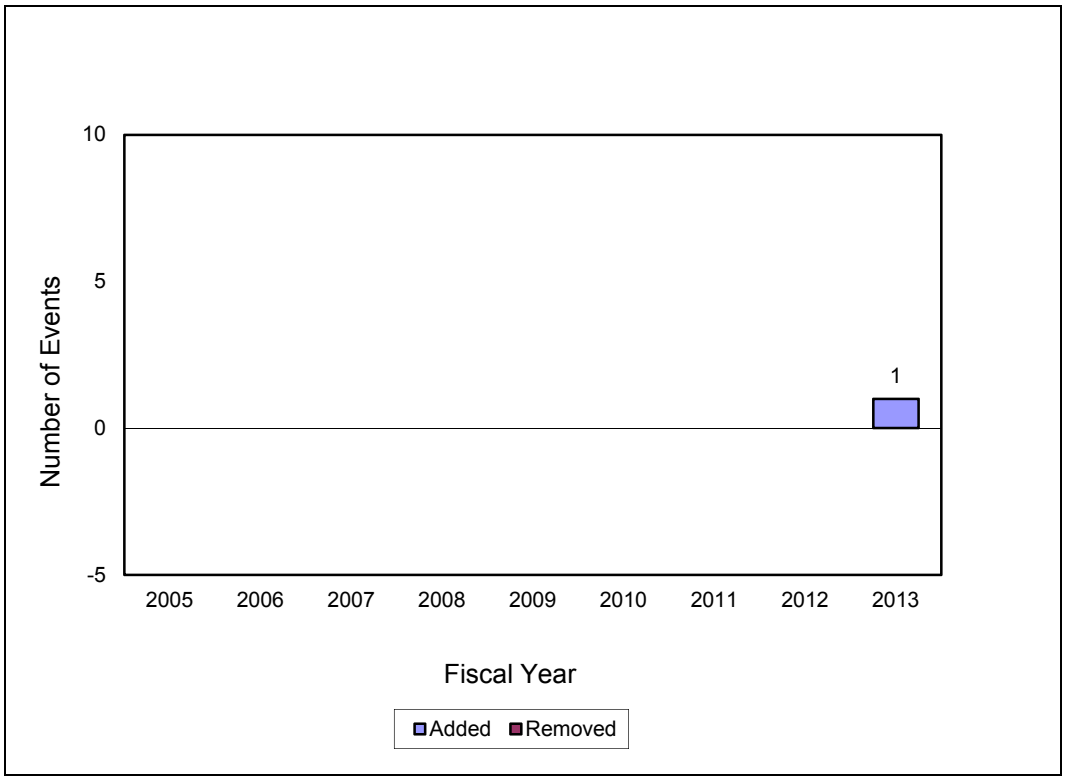

Figure D-4. Changes to EXP Data

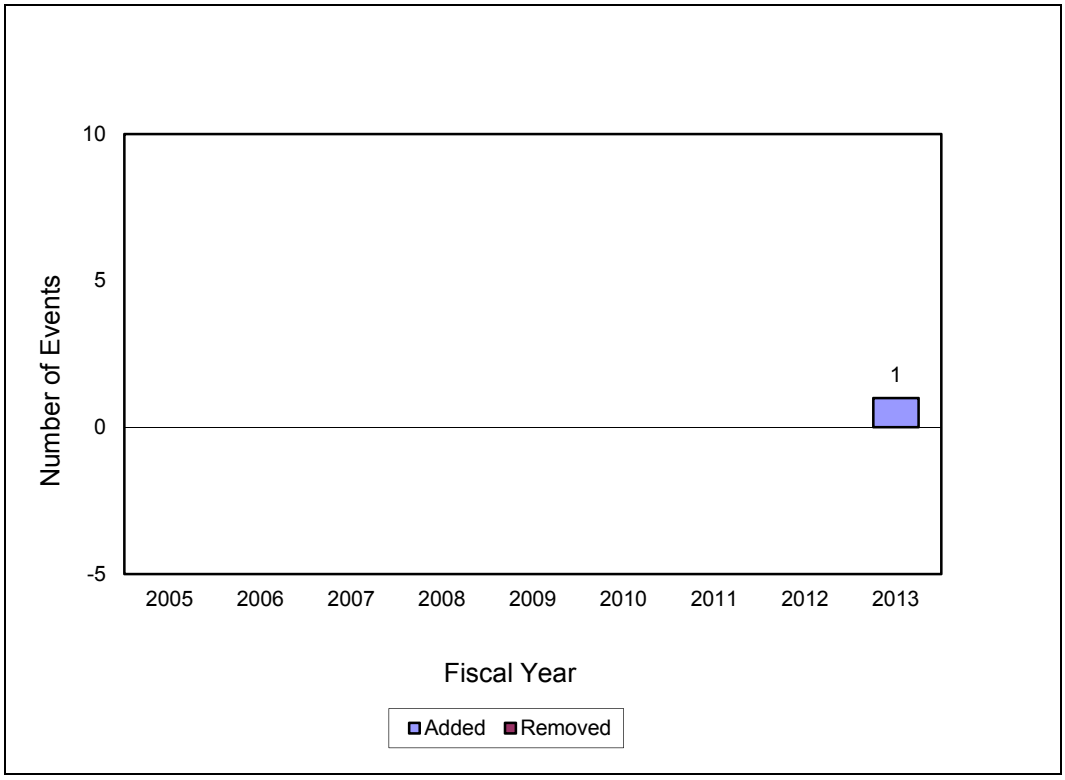

Figure D-5. Changes to RLM Data

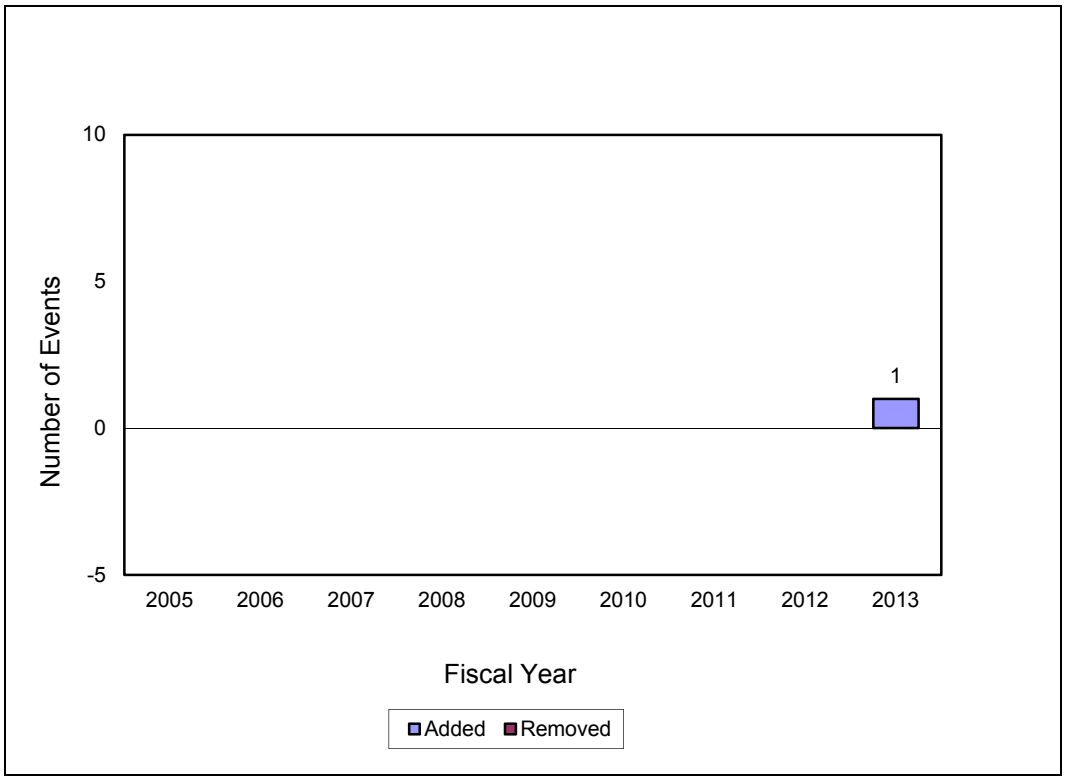

Figure D-6. Changes to LKS Data

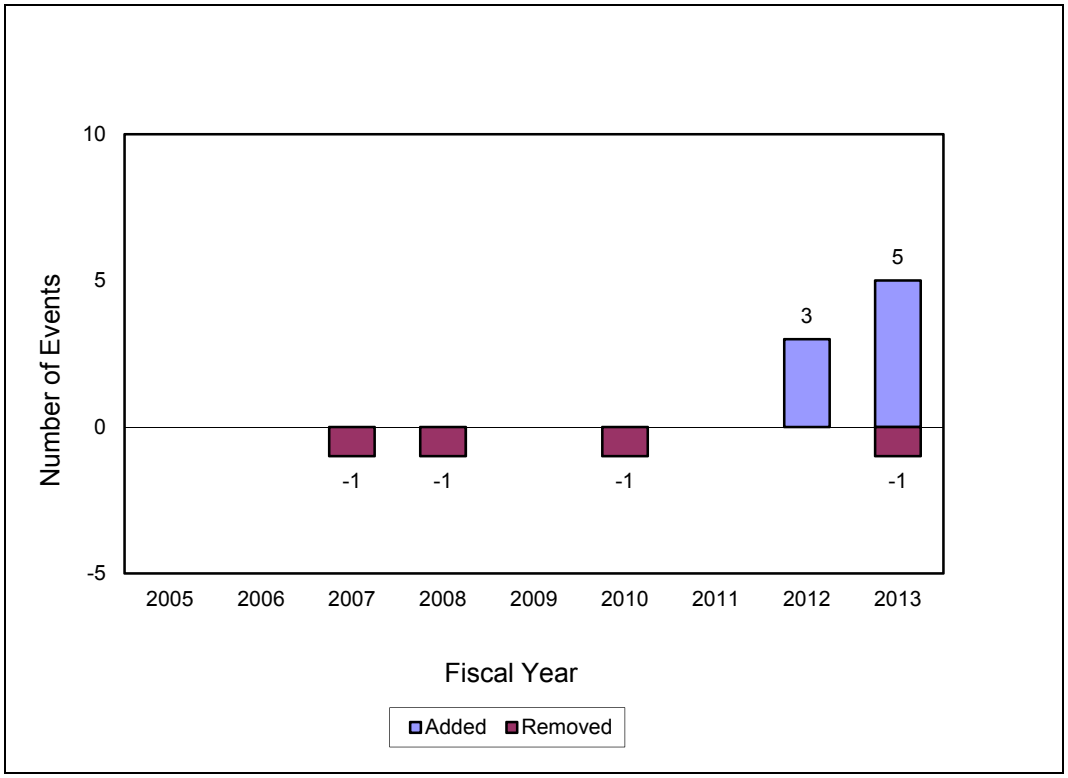

Figure D-7. Changes to EQP Data

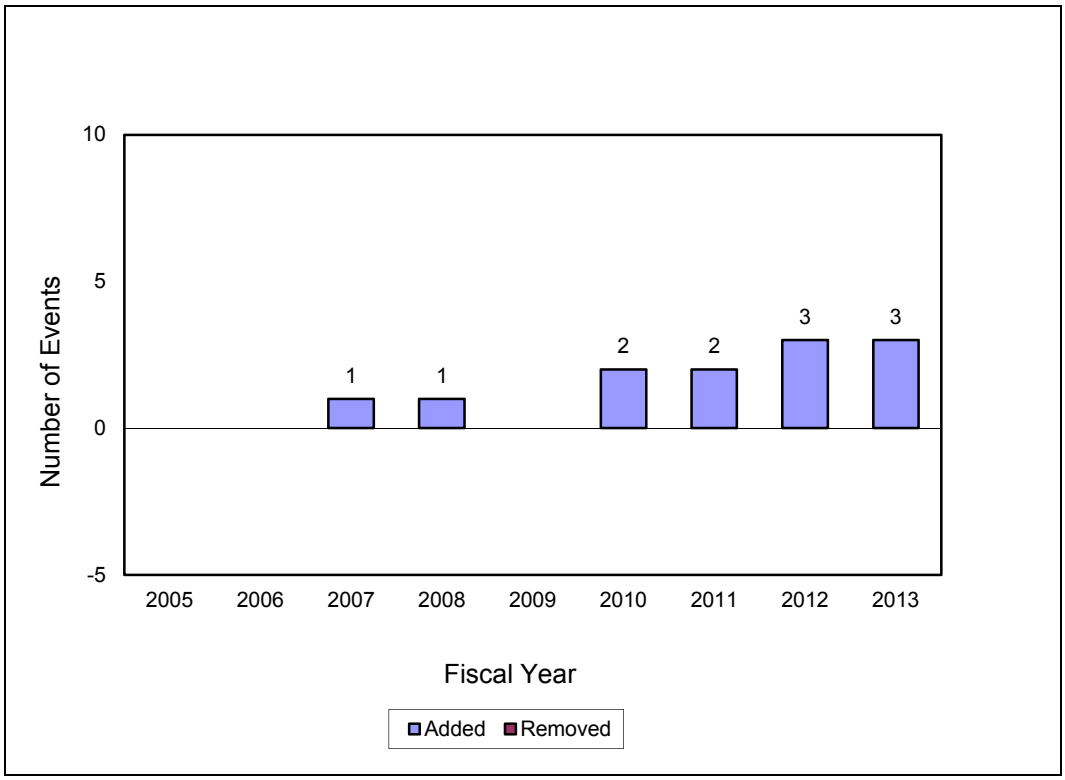

Figure D-8. Changes to TRS Data

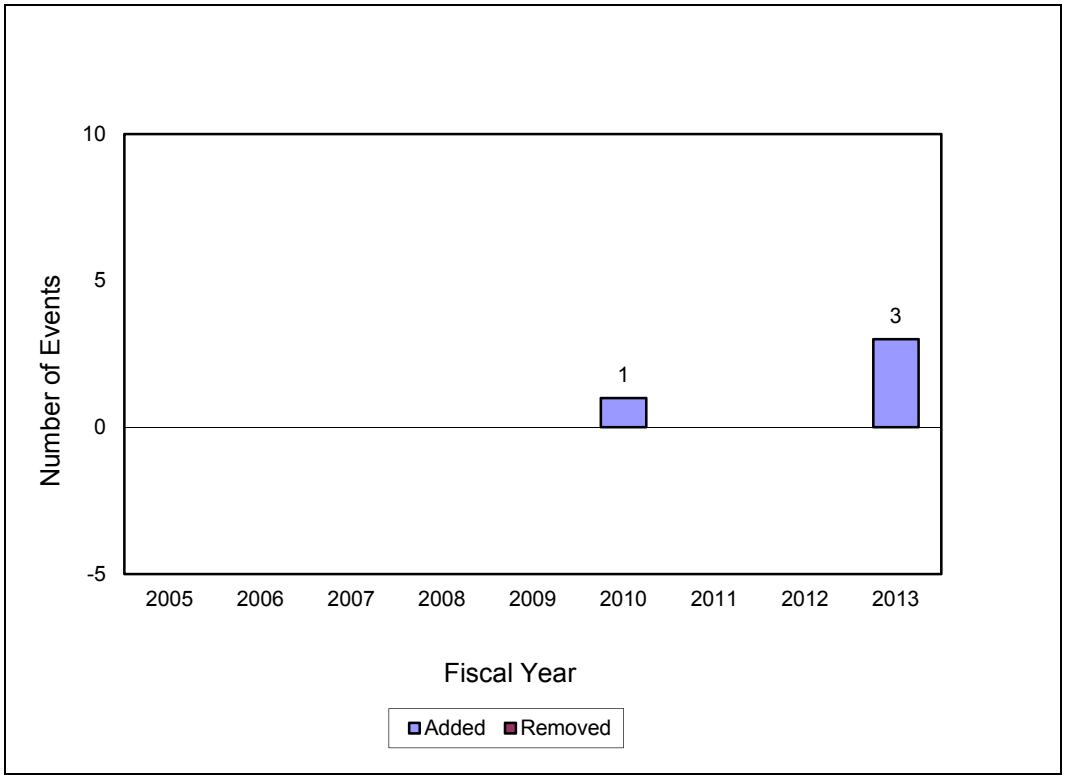

Figure D-9. Changes to FCP Data

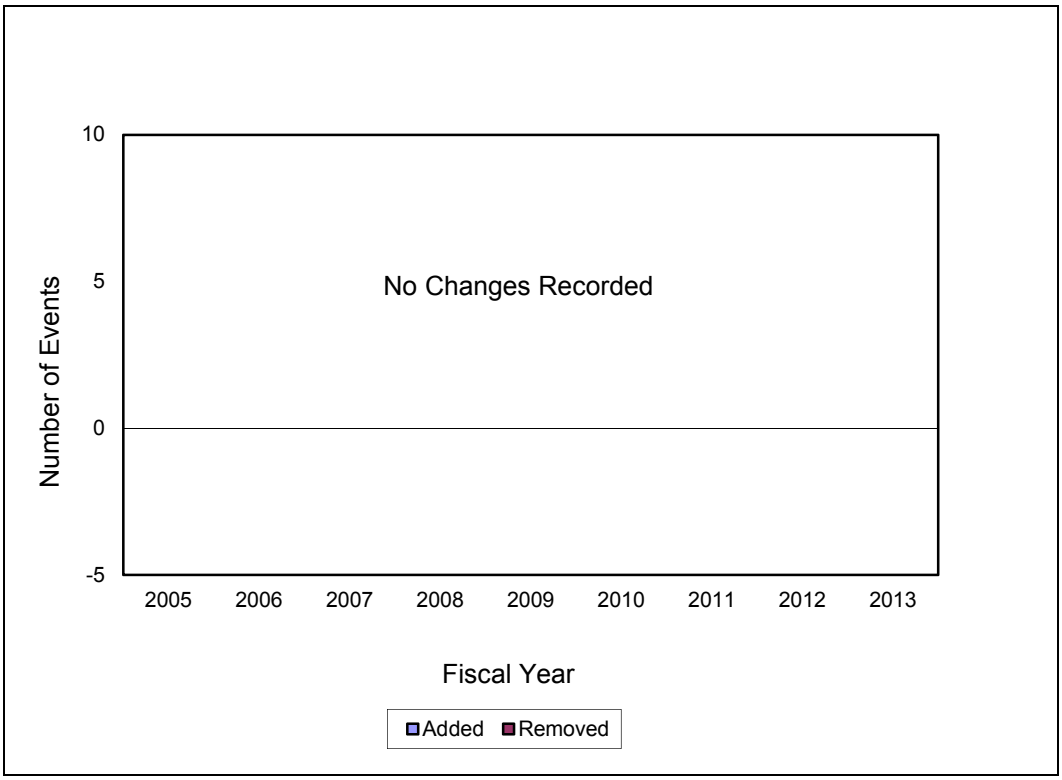

Figure D-10. Changes to OTH Data