Exploring Data through Nuclear Safety Indicators and Event Clocks

New Concepts in Feedback and Improvement

2010 ISM Champions Workshop

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Short Bio

Office of Health, Safety and Security

Mr. Roege assumed his current position in March 2008. He is responsible for numerous safety assistance programs including Accident Investigations, FEOSH, Human Performance Improvement (HPI), and the DOE Consolidated Audit Program. He also oversees DOE's Operating Experience Program, REMS, CAIRS, and the ORPS database system. In addition, his office produces and assesses the DOE Corporate Safety Indicators.

Mr. Roege's most recent experience was on the Secretary of Defense's staff. As a member of the Office of Program Analysis and Evaluation he worked issues associated with countering terrorism, irregular warfare, overseas basing, and capability portfolio management.

Mr. Roege is a retired Air Force officer with 22 years service. He was a long-time F-15 pilot, but also served non-flying tours in operational test & evaluation and wargaming. He was the wing Chief of Standardization and Evaluation and Chief of Safety during two of his flying tours.

Mr. Roege is a 1976 graduate of the Air Force Academy (B.S. Mathematics) and received a masters degree in Operations Research from the Massachusetts Institute of Technology in 1983. He is a distinguished graduate of the Air Command and Staff College and Australia's Joint Services Staff College.

Introduction

- Office of Corporate Safety Analysis is working to develop new capabilities to help the complex get more value-added information from the data we collect
  - New software that will enable seamless cross-database analysis
  - New indicators and methods to provide more actionable information than our traditional TRC/DART/# of ORPS events
  - Explore data to lead inquiries rather than rely on statistical probabilities
  - Inform the general risk management process
  - Provide more output by contractor rather than combining contractors into a site—this allows us to filter by a contractor cohort (e.g., construction)

Overview

- This briefing has three parts:
  - Nuclear Safety Index methodology description
  - Graphical Event Clock methodology
  - Back up slides with many other ways to think about displaying data to help make sense of our data
  - I only talk to the first two, but I do recommend reviewing the others for ideas
- Methods presented are not new
  - The index methodology tries to help guide a drill down exploratory process that hopefully ends up with a better understanding of what is going on behind the first order data
  - The event clock helps identify shifts in the underlying operating environment is a slightly different way than control charts—it can lead to much earlier inquiry into perceived trends

Nuclear Safety Index

- Focus on Nuclear Safety events
- Broken into 7 dimensions that that uses ORPS data
  - Looking for other sources, such as SBIS that can correlate non-event data with event data
  - Also want to use “positive” events such as some PISA’s in conjunction with the 7 dimensions
- Captures the highest level events separately as they swamp the index scale (by orders of magnitude) compared to the other, more numerous events—they get special attention
- Does not yet have a normalizing component (any ideas?)
- Uses the Analytical Hierarchy Process (AHP) to create an index (ratio) scale allowing comparisons across dimensions
- These indicators are on the new HSS Nuclear Safety website http://www.hss.energy.gov/beta/nsrf/ to introduce the concept (this address will change)

Analytical Hierarchy Process
(AHP)

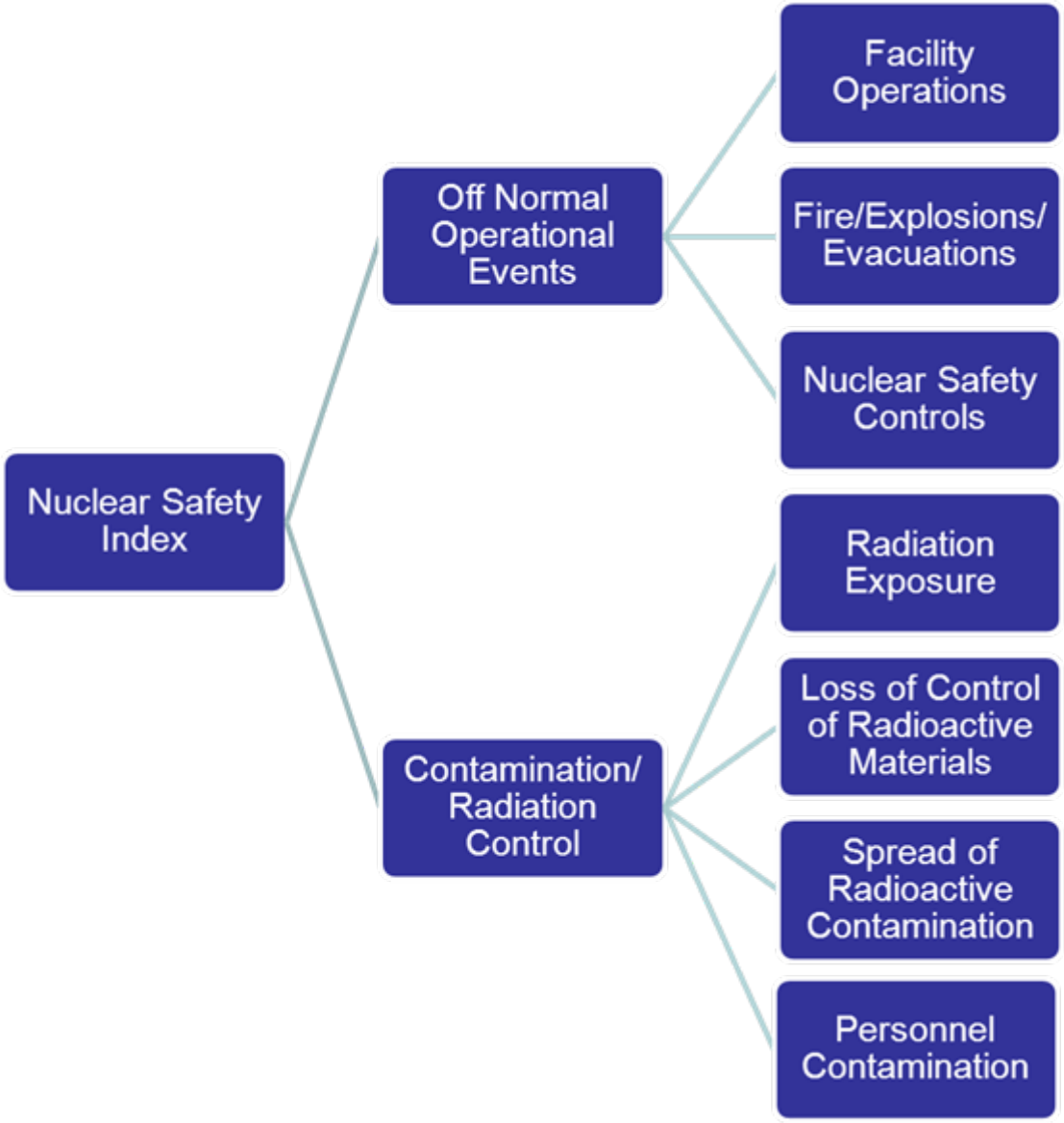
- Developed by Thomas L. Saaty in the 1970's based on research in human psychology and mathematics
- The AHP provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.
- It utilizes pair-wise comparisons to help build local and global weights for specific ORPS events to end up with a ratio scale—software is available to do the calculations
- Wikipedia has a very nice write up on the topic (http://en.wikipedia.org/wiki/Analytic_Hierarchy_Process)

AHP Pairwise Scale

The Fundamental Scale for Pairwise Comparisons		
Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6, and 8 can be used to express intermediate values. Intensities 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.		

	A	B	C
A	X	3	5
B	1/3	X	2
C	1/5	1/2	X

Nuclear Safety Index
Hierarchy



2 – 4 specific ORPS reporting categories per level 3 indicator.

Total of 20 ORPS reporting criteria.

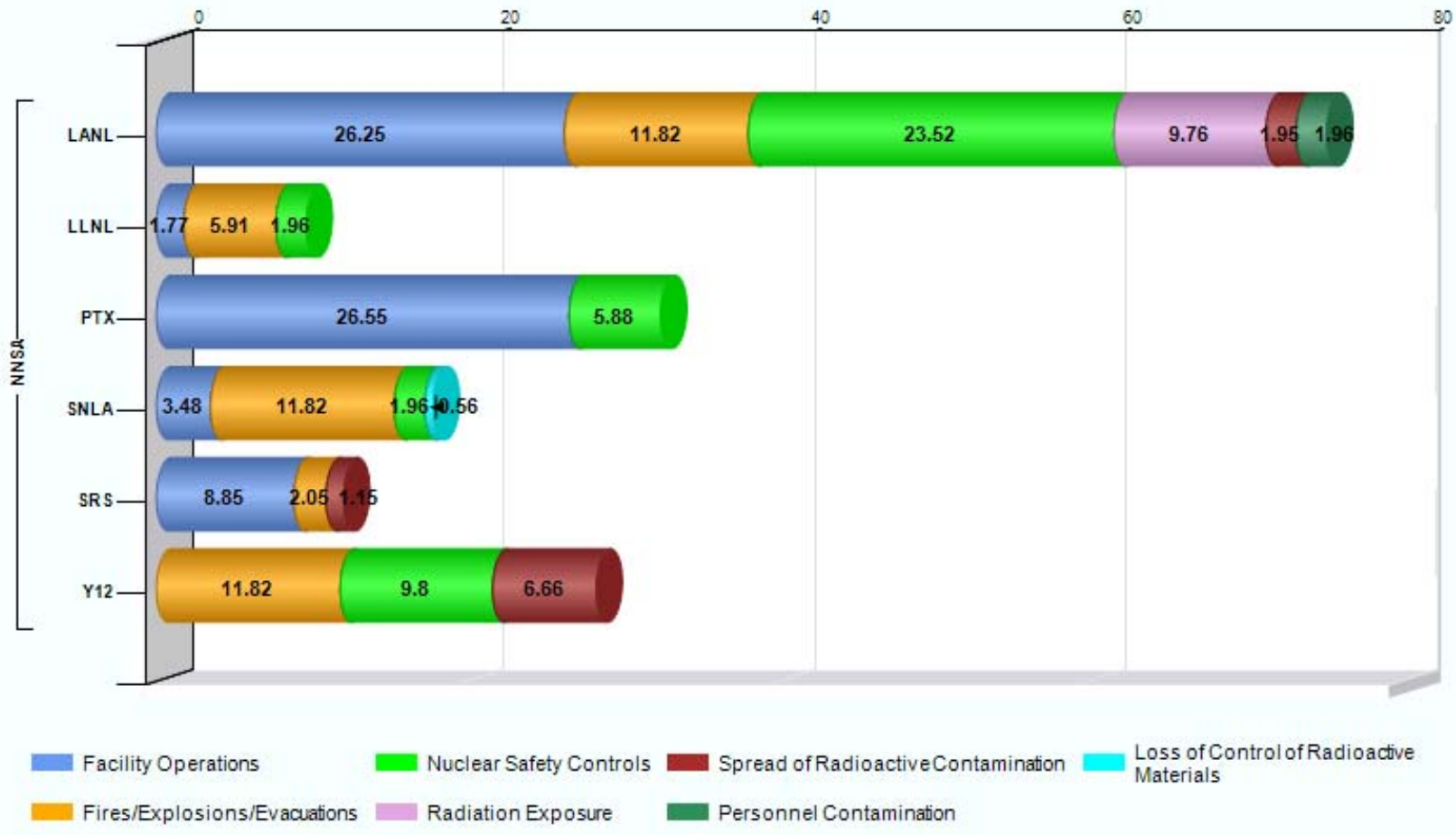
Nuclear Safety Index Using AHP

Performance Measure	ORPS Criteria	Global Weight
1.1 Facility Operations	4A(1)	1.77
	4B(1)	13.93
	4B(6)	7.49
	4B(8)	1.71
1.2 Fires / Explosions / Evacuations	2B(2)	17.04
	2B(3)	2.05
	2B(4)	5.91
1.3 Nuclear Safety Controls	3A(1)	**18.76**
	3A(2)	1.96
	3C(2)	4.28
2.1 Radiation Exposure	6C(2)	7.32
	6C(3)	2.44
2.2 Loss of Control of Radioactive Materials	6A(1)	5.04
	6A(2)	1.30
	6A(3)	0.56
2.3 Spread of Radioactive Contamination	6B(1)	3.33
	6B(2)	1.15
	6B(3)	**0.40**
2.4 Personnel Contamination	6D(2)	2.96
	6D(3)	0.49

NNSA Nuclear Safety Index View

Indicator Index

PSO Group: NNSA Year: 2009



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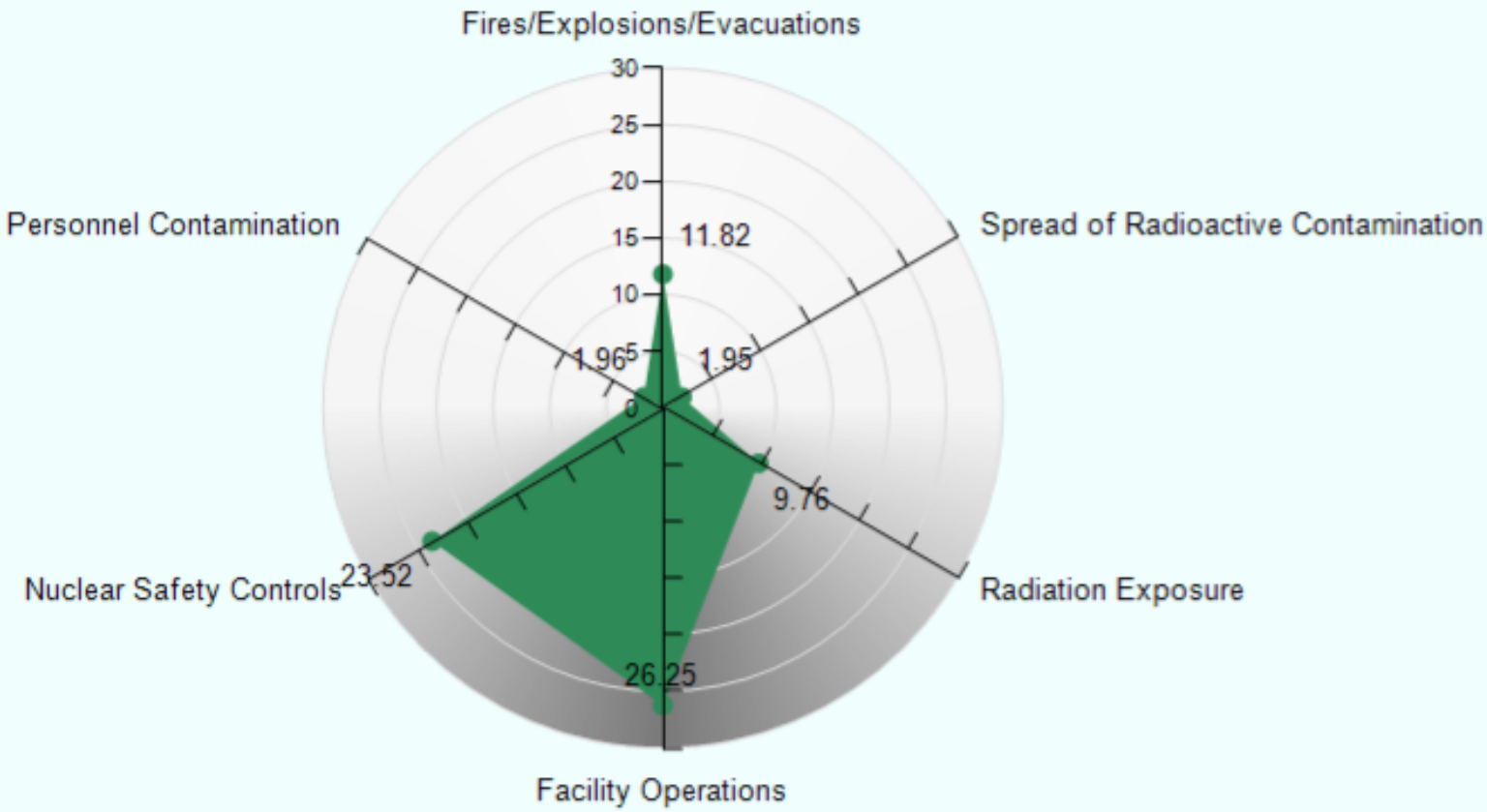
Nuclear Safety Indicator Site Detail

Data valid through: 3/29/2010

PSO Group: NNSA | Site: LANL | Contractor: LANL | Year: 2009 | Return | Back



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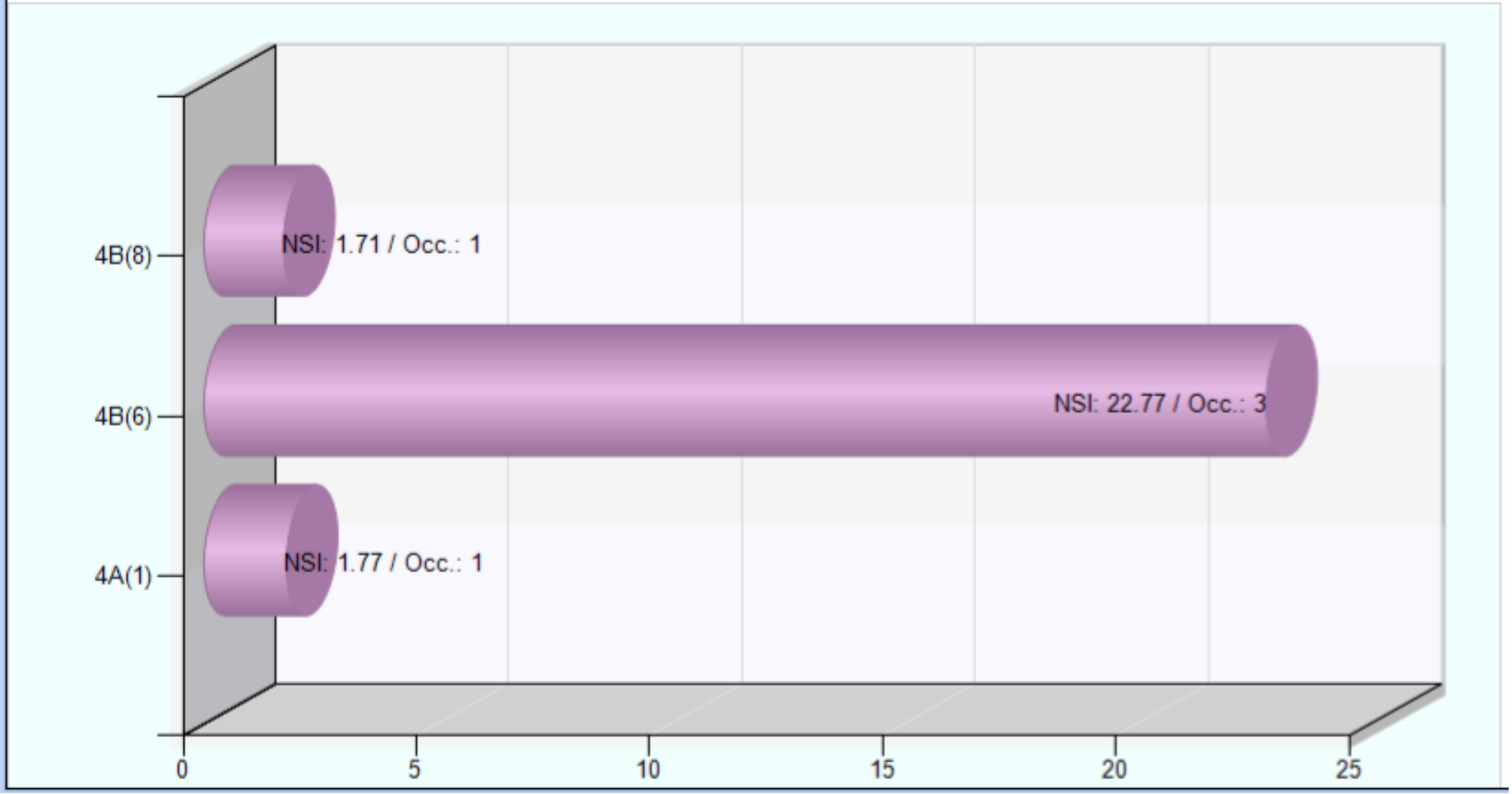
Indicator Index

Return | Back

Data valid through: 3/29/2010

PSO Group: NNSA | Site: LANL | Year: 2009 | Contractor: LANL

Indicator: Facility Operations



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ORPS Event Level

PSO Group	NNSA	Site	LANL	Indicator	Facility Operations	Return	Back

Performance Measure	4B(6)	A facility or operations shutdown (i.e., a change of operational mode or curtailment of work or processes) directed by management for safety reasons.

PSO	IDX	Contractor	ORPS Number	ORPS Title	Discovery Date	Reporting Criteria
NA	⊞ 126783	LANL	NA--LASO-LANL-ADOADMIN-2009-0006	Near Miss: Qualified Electrical Worker Receives 277V Electrical Shock	11/17/2009	4B(6)
NA	⊞ 125124	LANL	NA--LASO-LANL-HEMACHPRES-2009-0005	Unrecognized Electrical Hazard results in Shock to Employee	3/20/2009	4B(6)
NA	⊞ 126209	LANL	NA--LASO-LANL-SHOPSFAC-2009-0003	Accidental Cut of a Fire Suppression Water Line	8/14/2009	4B(6)
					Data valid through:	3/29/2010

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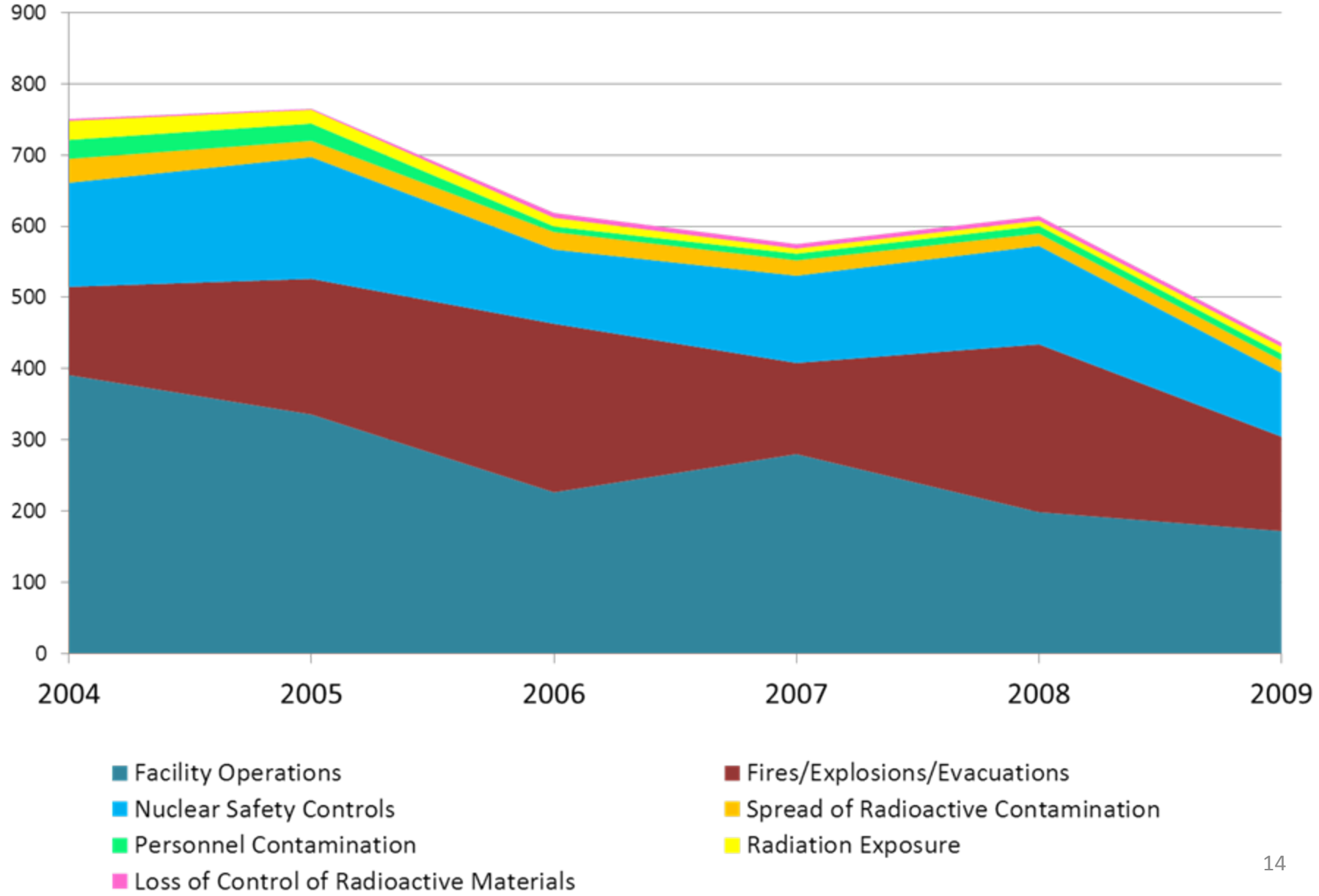
DOE Nuclear Safety Index
2004-2009



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Event Clocks

- This methodology is basically a Mean Time Between Failure (MTBF) analysis
  - INPO uses the term event clocks as a way to show the workforce how they are doing lately
- Defines a set of key events to track
  - INPO suggests displaying two metrics: *time since last event* and *average time between the last 6 events* (5 intervals)
- Instead of using the static version of this measure, we'll look at a trending graph
  - There is no normalization and therefore no need to wait for work-hour data for instance—displaying work-hours on the same graph would be beneficial though
  - One advantage is that it removes artificial variability due to calendars
- We are looking to correlate shifts in frequency to management actions (or inactions) or detect potential changes in the operating environment

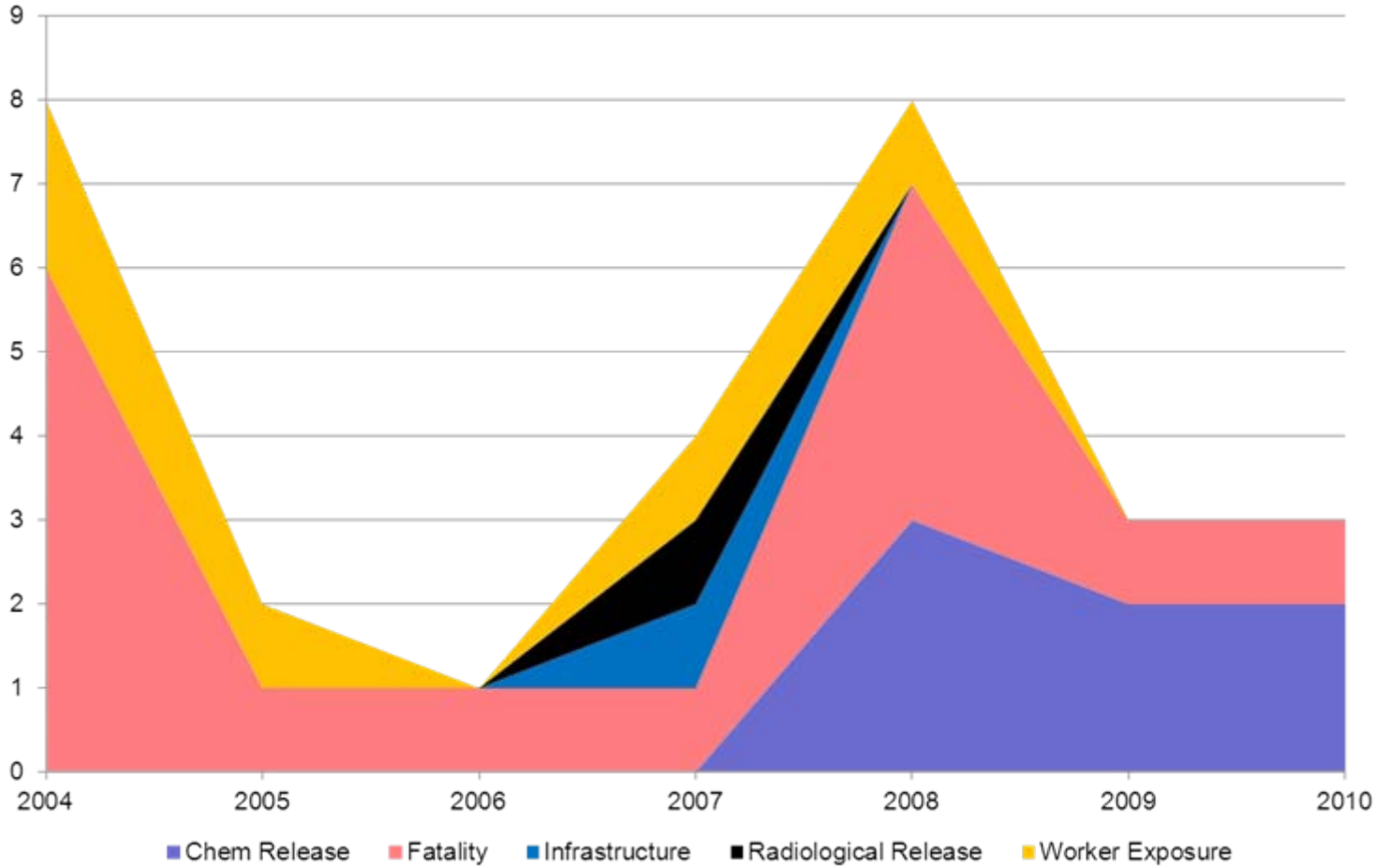
DOE ES&H Strategic Outcomes

	2004	2005	2006	2007	2008	2009	2010
Worker Safety & Health Goal 1: *No fatalities*							
Total	6	1	2	2	4	1	1
Vehicle	0	0	1	1	3	1	0
Worker Safety & Health Goal 2: *No radiological exposures > 2 rem*							
Total	2	1	0	1	1	0	0
Environmental Goal 1: *No radiological releases above regulatory limits*							
Total	0	0	0	1	0	0	0
Environmental Goal 2: *No chemical/hazardous material releases above regulatory limits*							
Total	1	2	3	2	3	2	2
Infrastructure Goal 1: *No losses > $5 million*							
Total	0	0	0	1	0	0	0

While not at zero yet, DOE generally has few significant events

Standard Annual View

Strategic Outcomes



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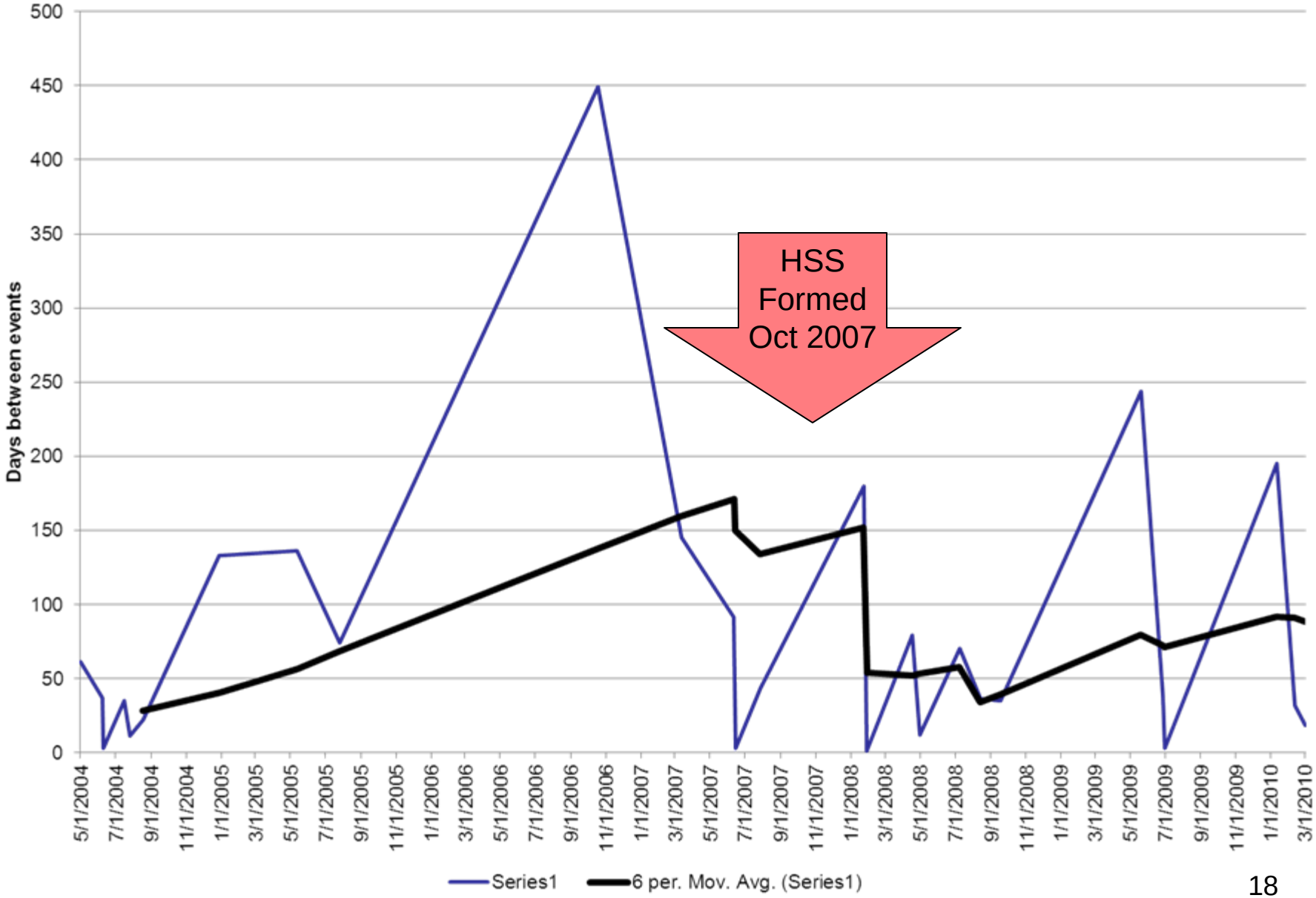
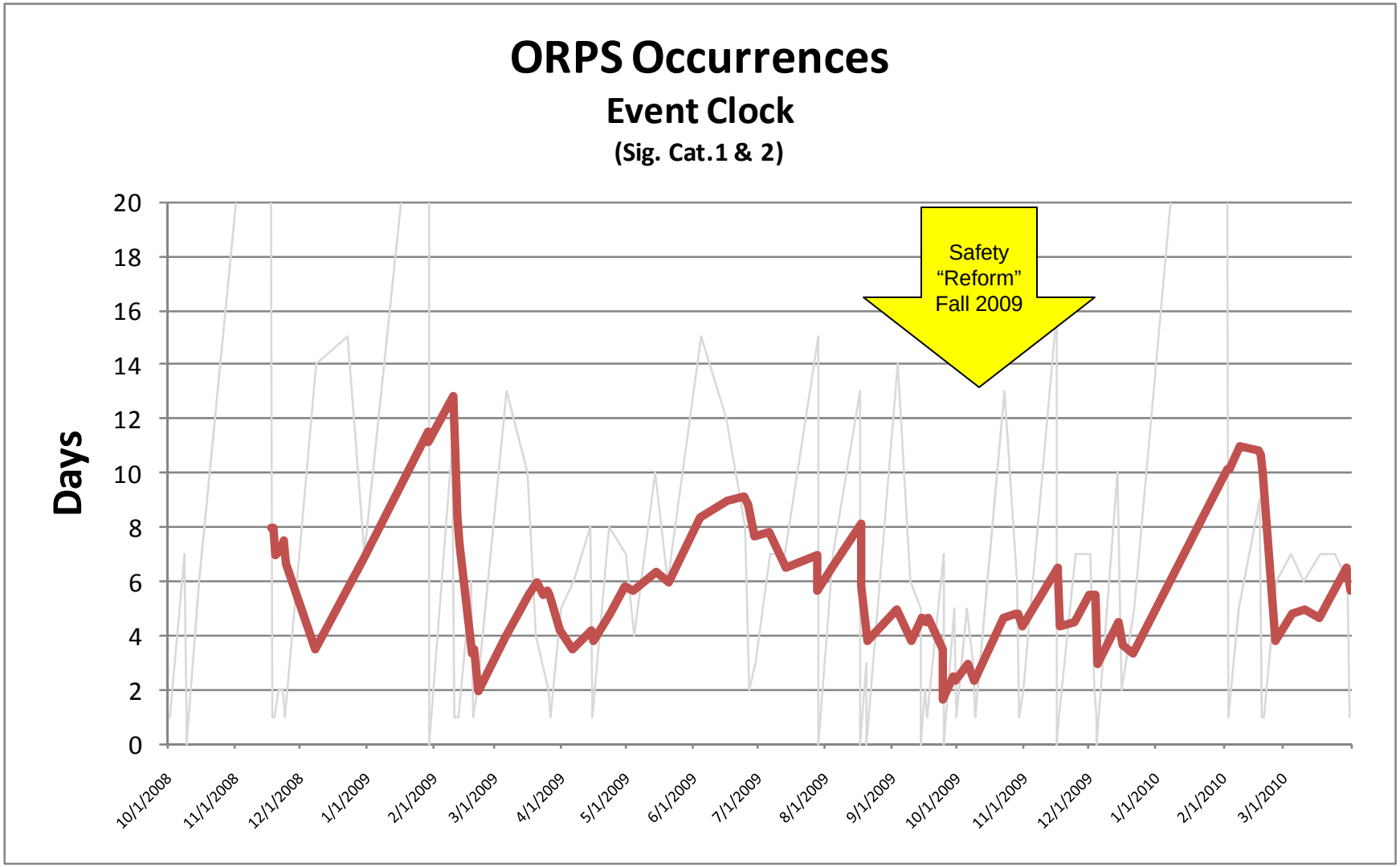
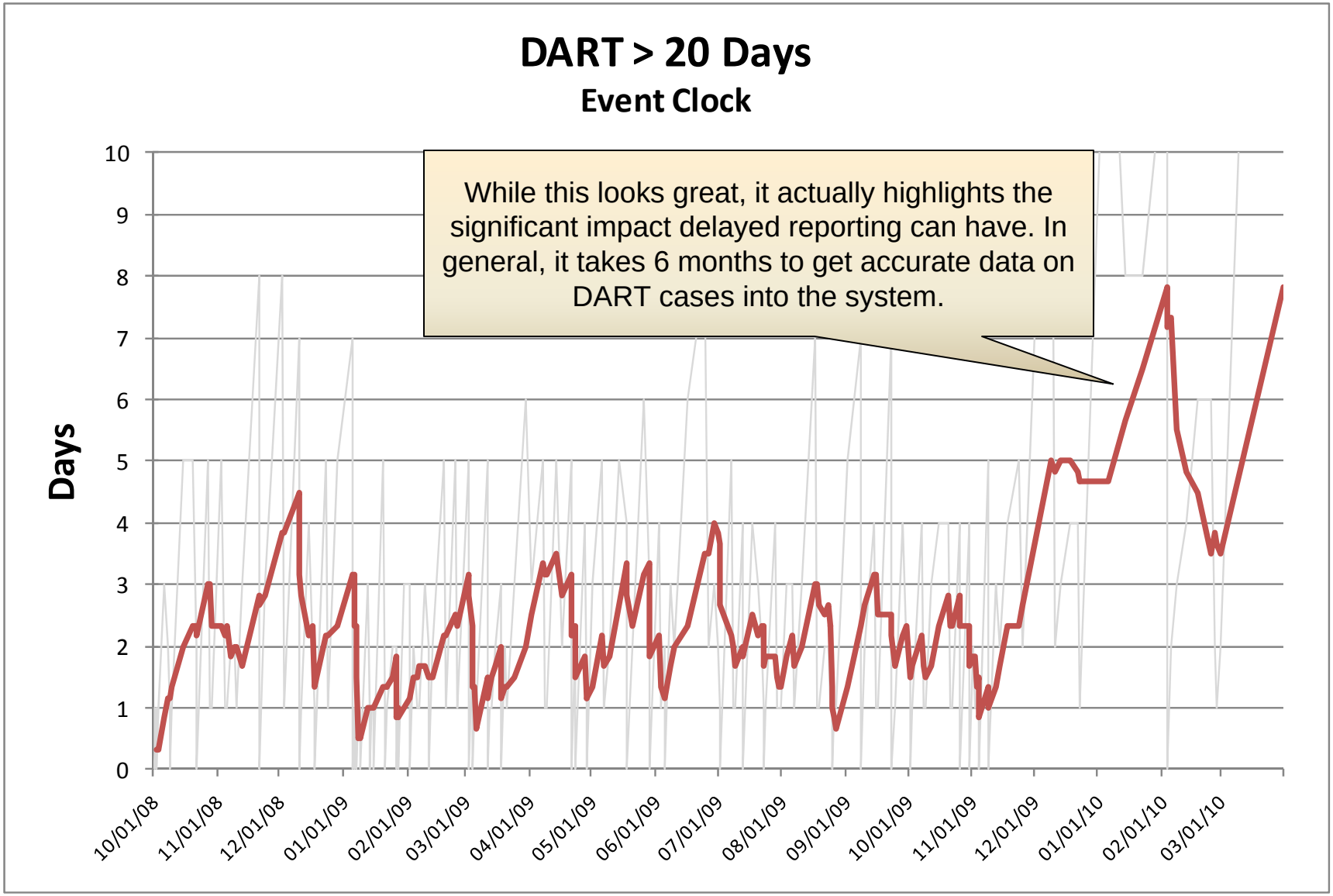
DOE Strategic Outcome Event Clock





This slide is only for the 17 national laboratories and was made in May 2010



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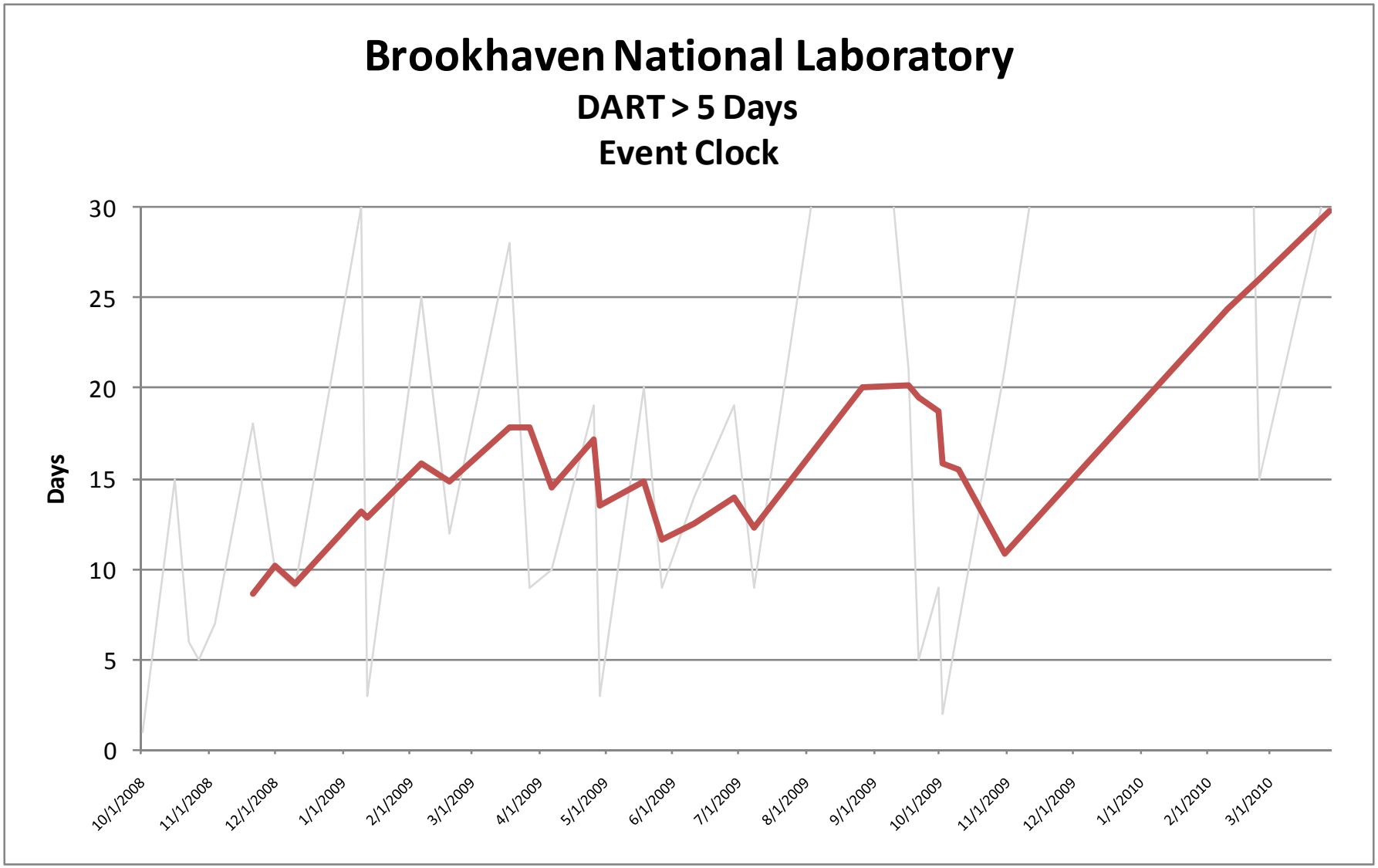


Brookhaven was chosen because they have a timely reporting history and have been taking specific management improvement actions

Conclusion

- There are many options to provide targeted, actionable data for decision-makers, we have demonstrated two methods that can be used
  - Using logical groupings helps get data organized in a way that makes more system sense
  - Using AHP and indices provides a way to compare very different elements such as apples and celery as contributors to a healthy diet ☺
- There are other methods in the back up slides, such as converting events into dollars ($) which is a great normalizing and indexing methodology

Backup Slides

Exploratory Indicator Example

Definitions for Nuclear Safety Strategic Outcomes

Event	Description	ORPS Coding Reporting Criteria
Technical Safety Requirement Violation	Any violation of a Hazard Category 1, 2, or 3 nuclear facility's Technical Safety Requirement (or Operational Safety Requirement) Safety Limit.	3A(1)
Nuclear Criticality Safety	A loss of multiple nuclear criticality process condition controls, where processes include operations, transport, and storage of fissionable materials, such that no valid controls are available to prevent a criticality accident.	3C(1)
Fires/Explosions within Containment Boundary	Any unplanned fire or explosion within primary confinement/containment boundaries for nuclear or hazardous material within a facility.	2B(1)
Radiation Overexposure	Determination of a dose that exceeds the limits specified in 10 CFR Part 835, Subpart C, Occupational Radiation Protection or DOE O 5400.5, Chapter II, Item 1	6C(1)
Personnel Contamination	Any occurrence requiring offsite medical assistance for contaminated personnel, including transporting a person to an offsite medical facility or bringing offsite medical personnel onsite to perform treatment or decontamination.	6D(1)
Nuclear Explosive Safety	Damage to a nuclear explosive that results in a credible threat to nuclear explosive safety.	7(1)

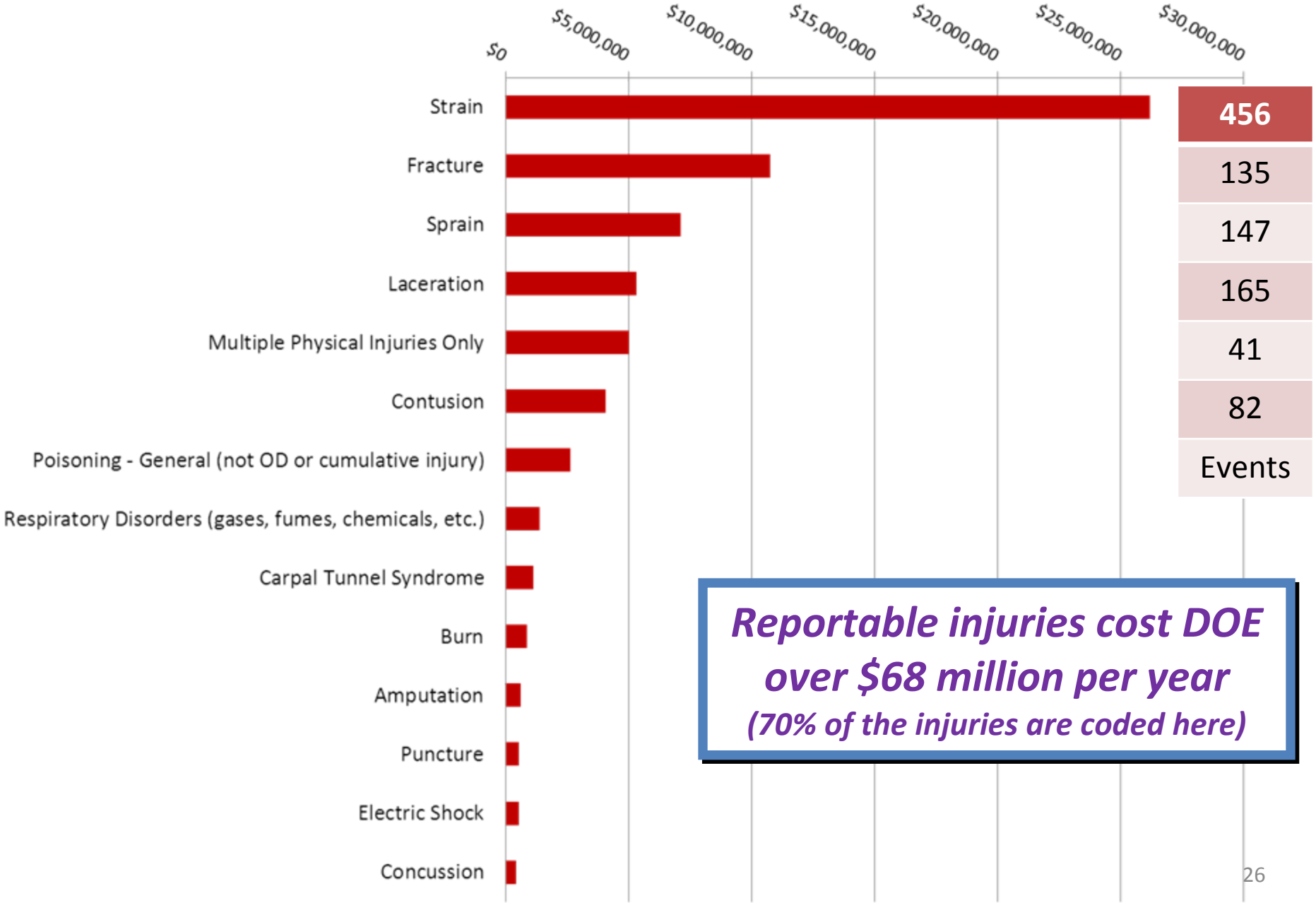
Nuclear Safety Strategic Outcomes

	2004	2005	2006	2007	2008	2009	2010
Technical Safety Requirement Violation	0	0	0	0	0	0	0
Nuclear Criticality Safety	0	0	1	0	0	0	0
Fires/Explosions within Containment Boundary	1	1	0	0	0	0	0
Radiation Overexposure	0	0	0	1	1	0	0
Personnel Contamination	0	0	0	2	0	0	0
Nuclear Explosives Safety	0	0	0	0	0	0	0
ANNUAL TOTAL	1	1	1	2*	1	0	0

- Nuclear Criticality Safety:
  - *NA--YSO-BWXT-Y12NUCLEAR-2006-0013*: Excessive Hold-up of Uranium Indicated in Induction Furnace Vacuum Filter (Oak Ridge/Y-12)
- Fires/Explosions:
  - *NA--NVSO-BN-NTS-2005-0011*: Glovebox Fire in Building (Nevada Test Site)
  - *NE-ORO--ORNL-X10NUCLEAR-2004-0004*: Two inch by four inch gauze ignites in glove box in Building 7920 (Oak Ridge/ORNL)
- Radiation Overexposure:
  - *NA--LASO-LANL-CMR-2007-0002*: Injury Sustained During Glovebox Work (LANL)
  - *NA--LASO-LANL-TA55-2008-0019*: Positive Wound Count Resulting from Injury Received While Performing Glovebox Work (LANL)
- Personnel Contamination:
  - *EM-ORO--BJC-K25ENVRES-2007-0011*: Offsite Response to Skin Contamination Event (Oak Ridge/ETTP)
  - – *NA--LASO-LANL-CMR-2007-0002*: Injury Sustained During Glovebox Work (LANL)

* Event NA-LASO-LANL-CMR-2007-0002 was reported as both a Radiation Overexposure and Personnel Contamination

2008 DOE "$afetypays" Cost by Injury Type



Reportable injuries cost DOE over $68 million per year

(70% of the injuries are coded here)

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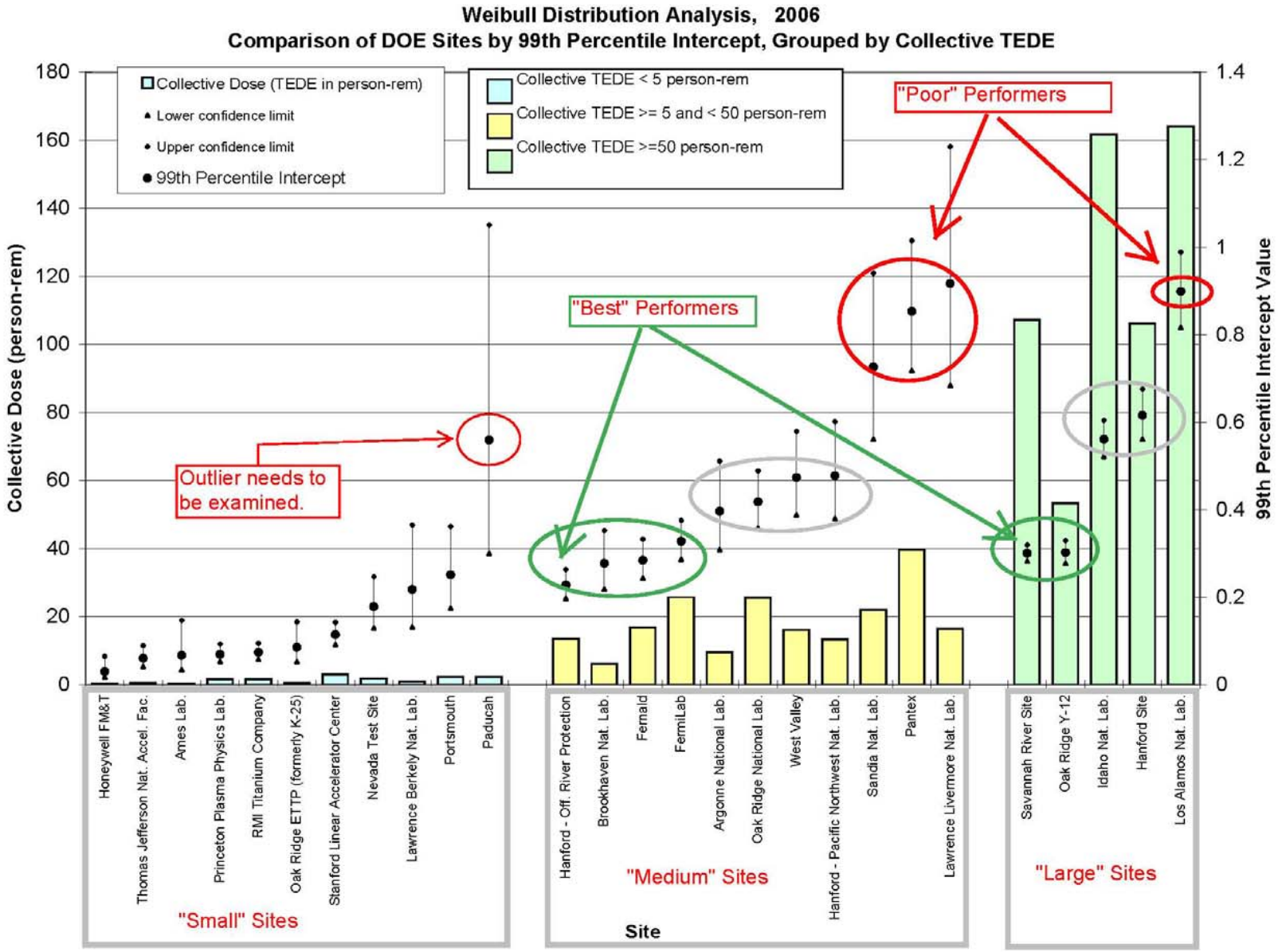
Weibull Distribution Analysis, 2006
Comparison of DOE Sites by 99th Percentile Intercept, Grouped by Collective TEDE
Collective Dose (TEDE in person-rem)
Lower confidence limit
Upper confidence limit
99th Percentile Intercept
Collective TEDE < 5 person-rem
Collective TEDE >= 5 and < 50 person-rem
Collective TEDE >=50 person-rem
"Poor" Performers
"Best" Performers
Outlier needs to be examined.
Collective Dose (person-rem)
99th Percentile Intercept Value
Honeywell FM&T
Thomas Jefferson Nat. Accel. Fac.
Ames Lab.
Princeton Plasma Physics Lab.
RMI Titanium Company
Oak Ridge ETTP (formerly K-25)
Stanford Linear Accelerator Center
Nevada Test Site
Lawrence Berkely Nat. Lab.
Portsmouth
Paducah
"Small" Sites
Hanford - Off. River Protection
Brookhaven Nat. Lab.
Fernald
FermiLab
Argonne National Lab.
Oak Ridge National Lab.
West Valley
Hanford - Pacific Northwest Nat. Lab.
Sandia Nat. Lab.
Pantex
Lawrence Livermore Nat. Lab.
"Medium" Sites
Savannah River Site
Oak Ridge Y-12
Idaho Nat. Lab.
Hanford Site
Los Alamos Nat. Lab.
"Large" Sites
Site

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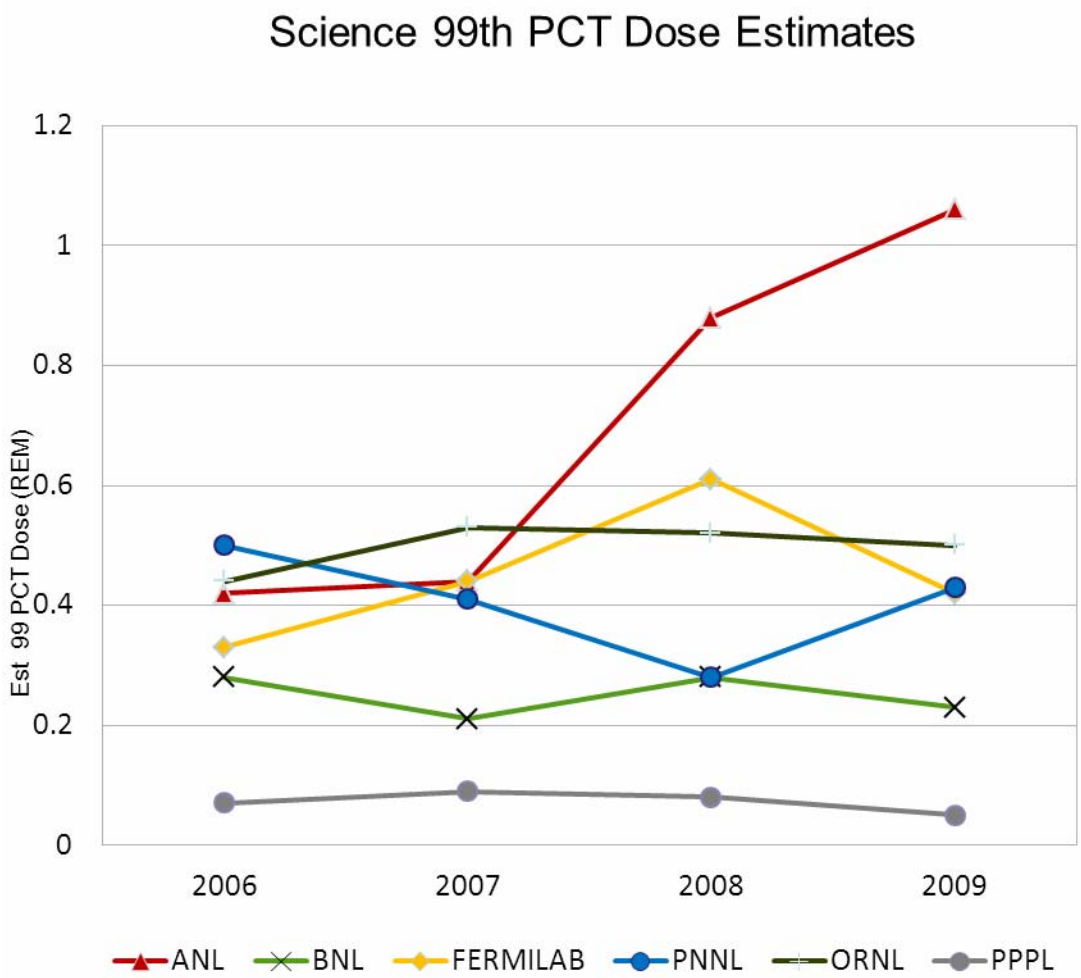
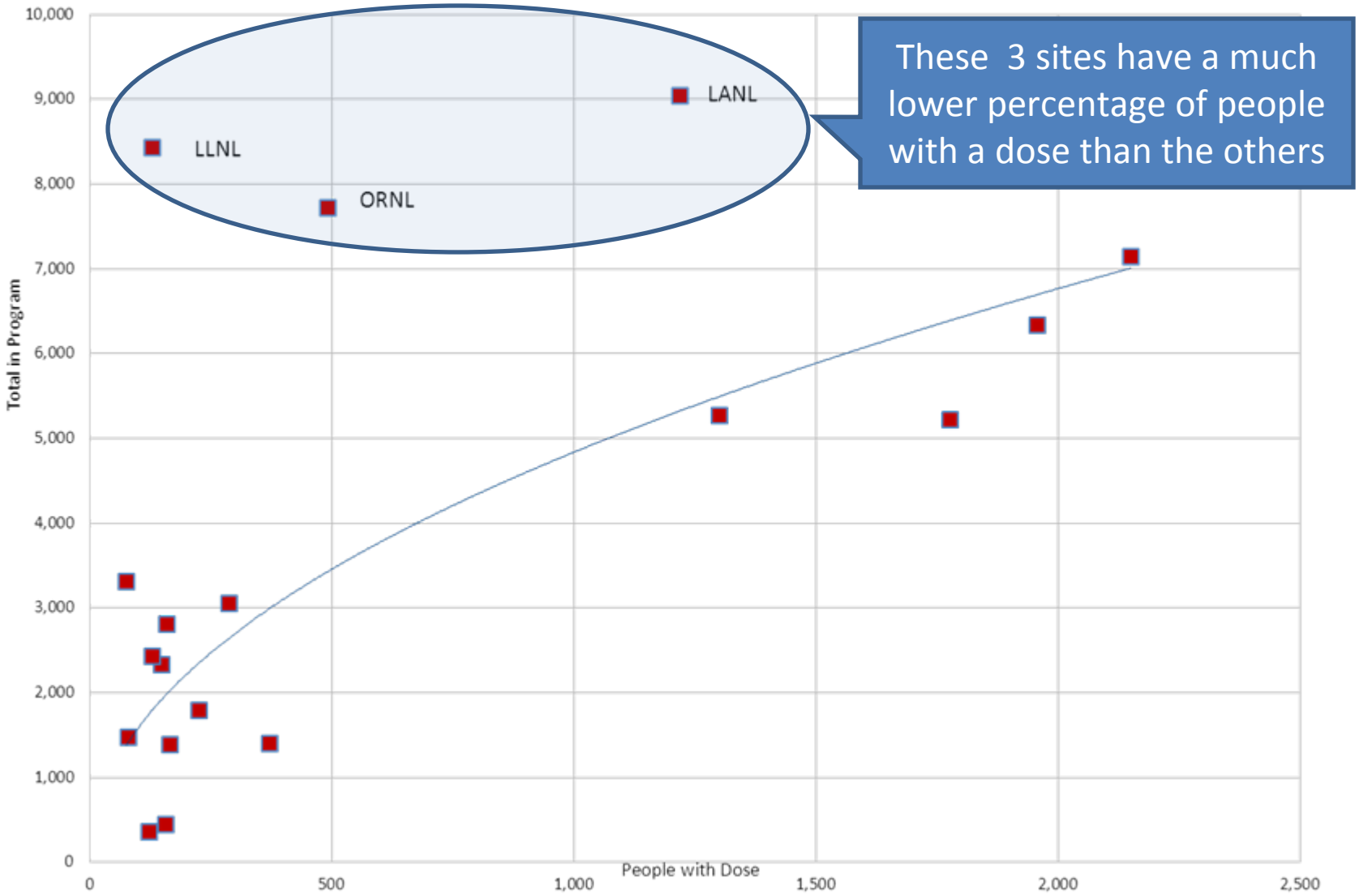
Example ALARA Assessment



- Most DOE sites manage their 99th percentile to less than 600 mrem/year
- LANL and West Valley are routinely around 1 rem/yr
- Argonne spiked in 2008 & 2009 to over 1 rem/yr, likely due to glovebox cleaning activities
- Lawrence Livermore has also spiked from about 0.8 rem/yr in 2007 to ~1.3 rem/yr in 2008 & 2009

Total in Program versus People with Dose



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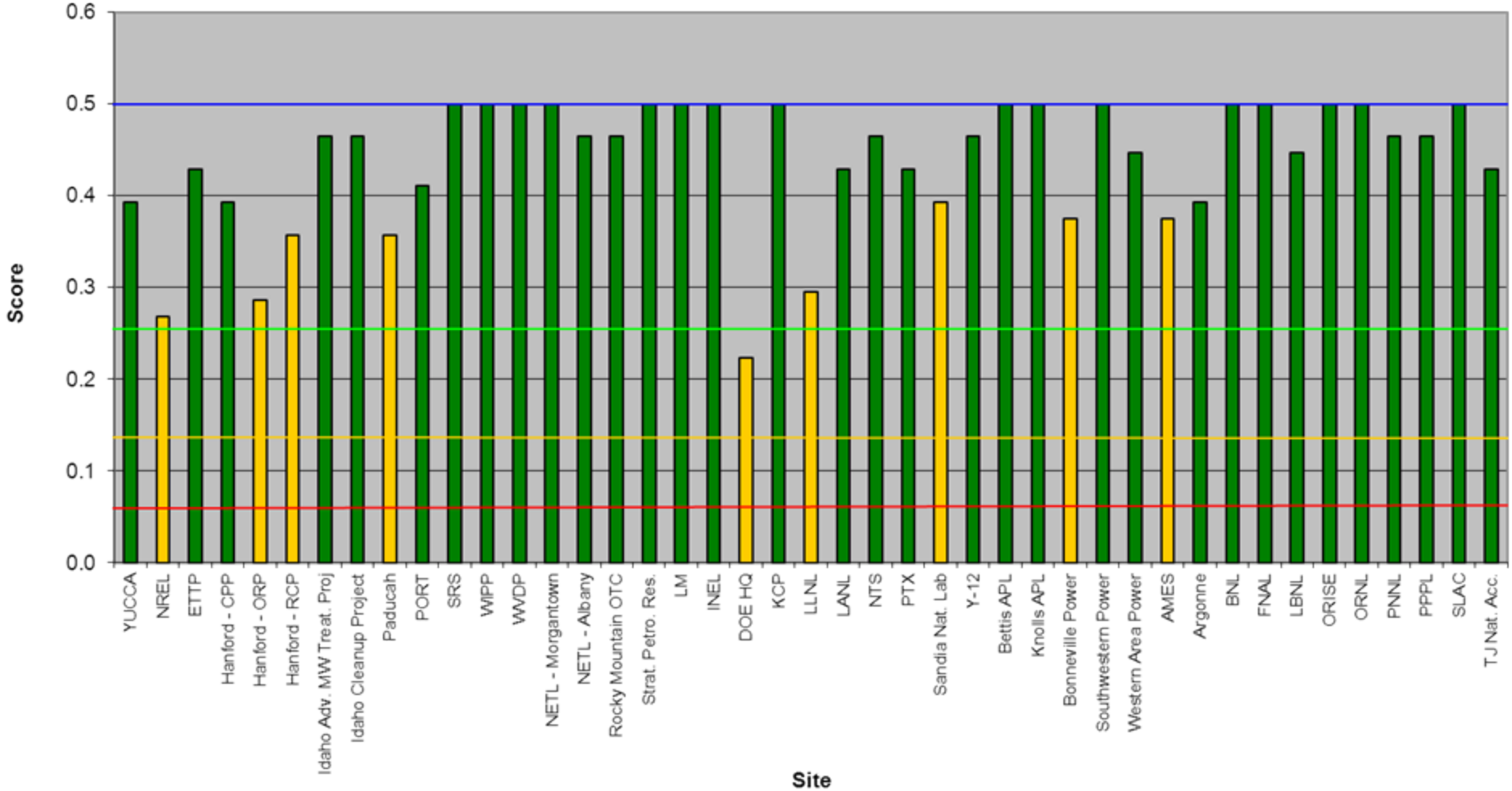
EMS Ratings Scorecard



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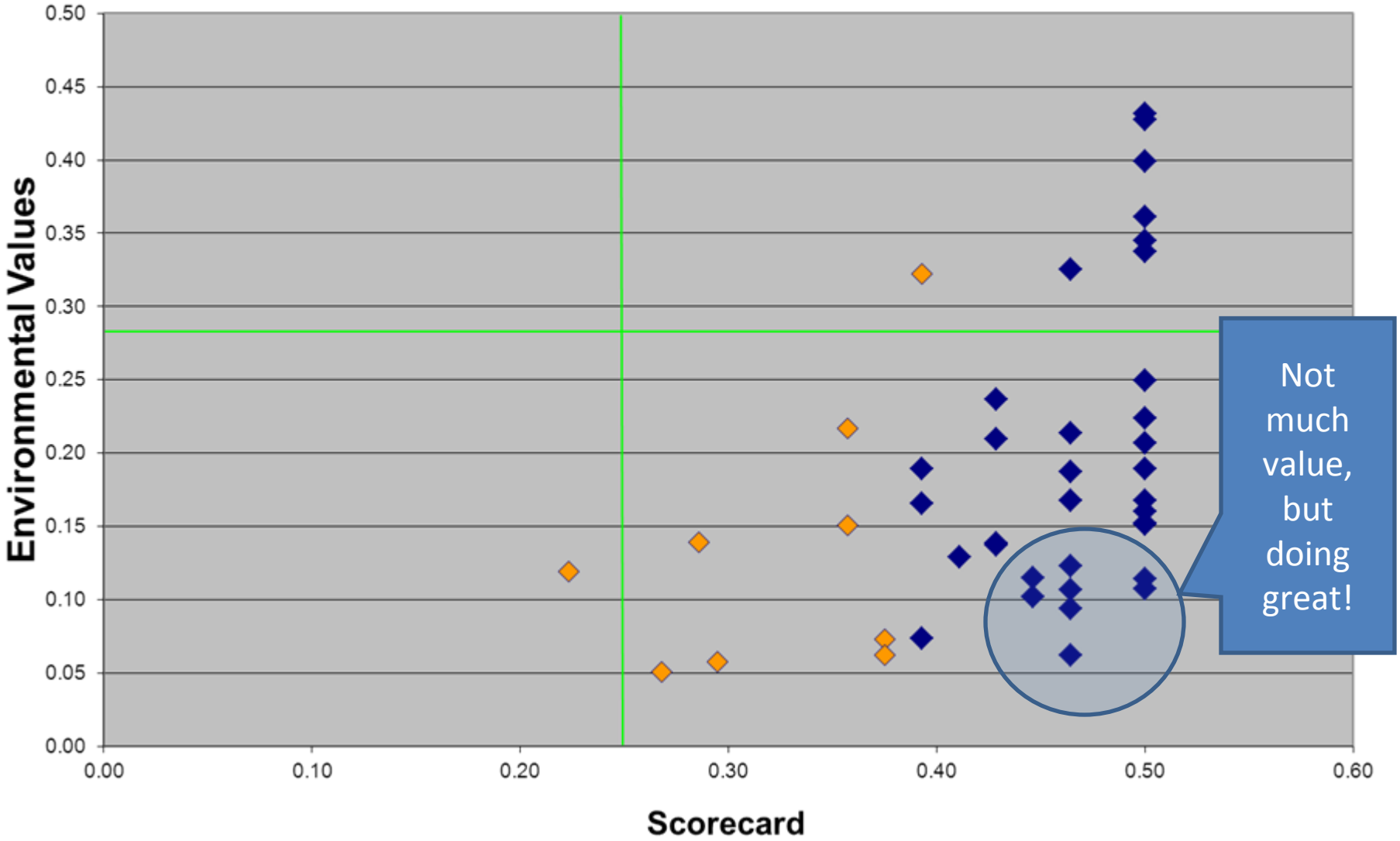
Scorecard vs Environmental Value



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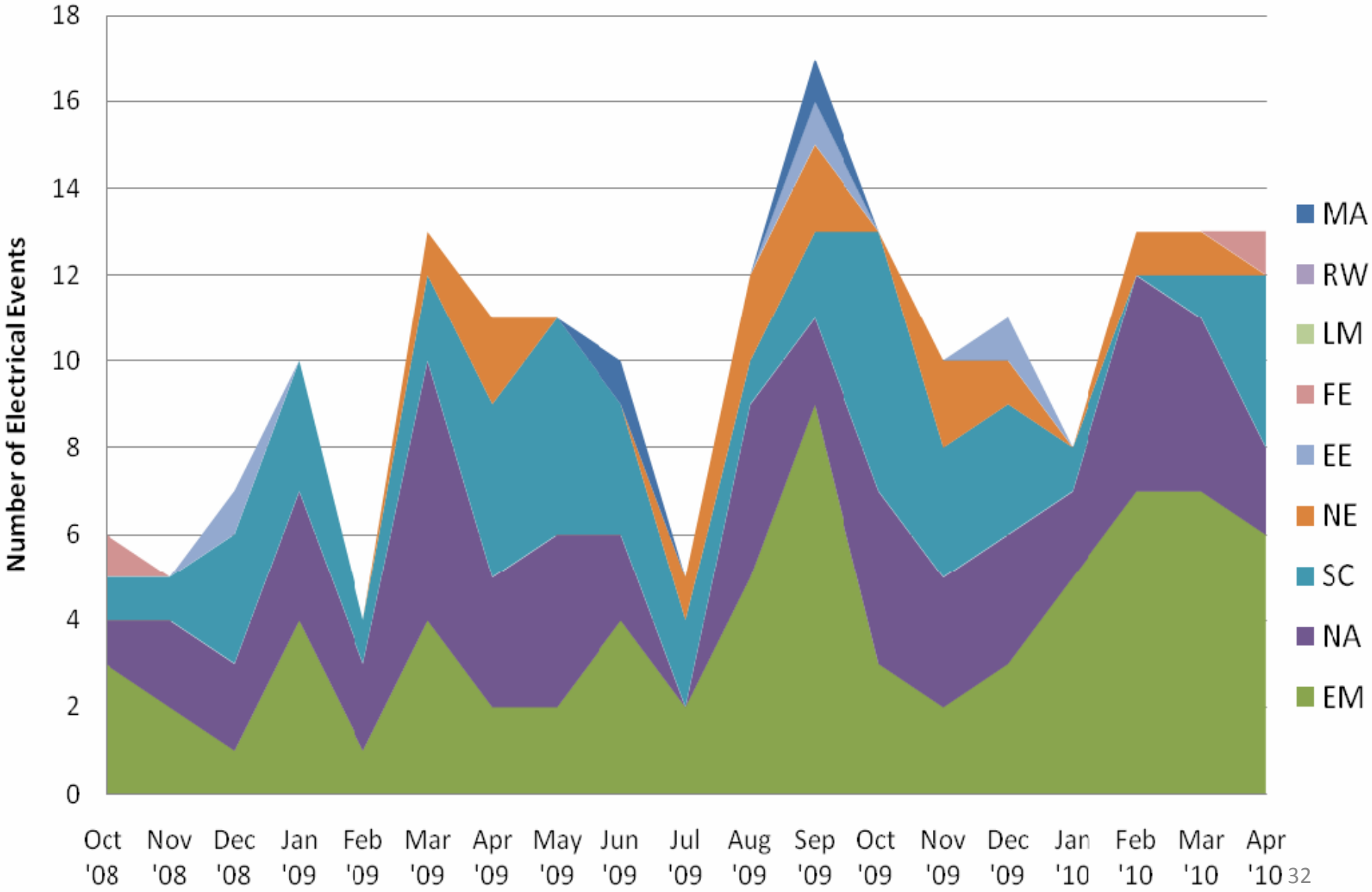
Electrical Events by Month and Secretarial Office

(Rolling 18-Month Chart)



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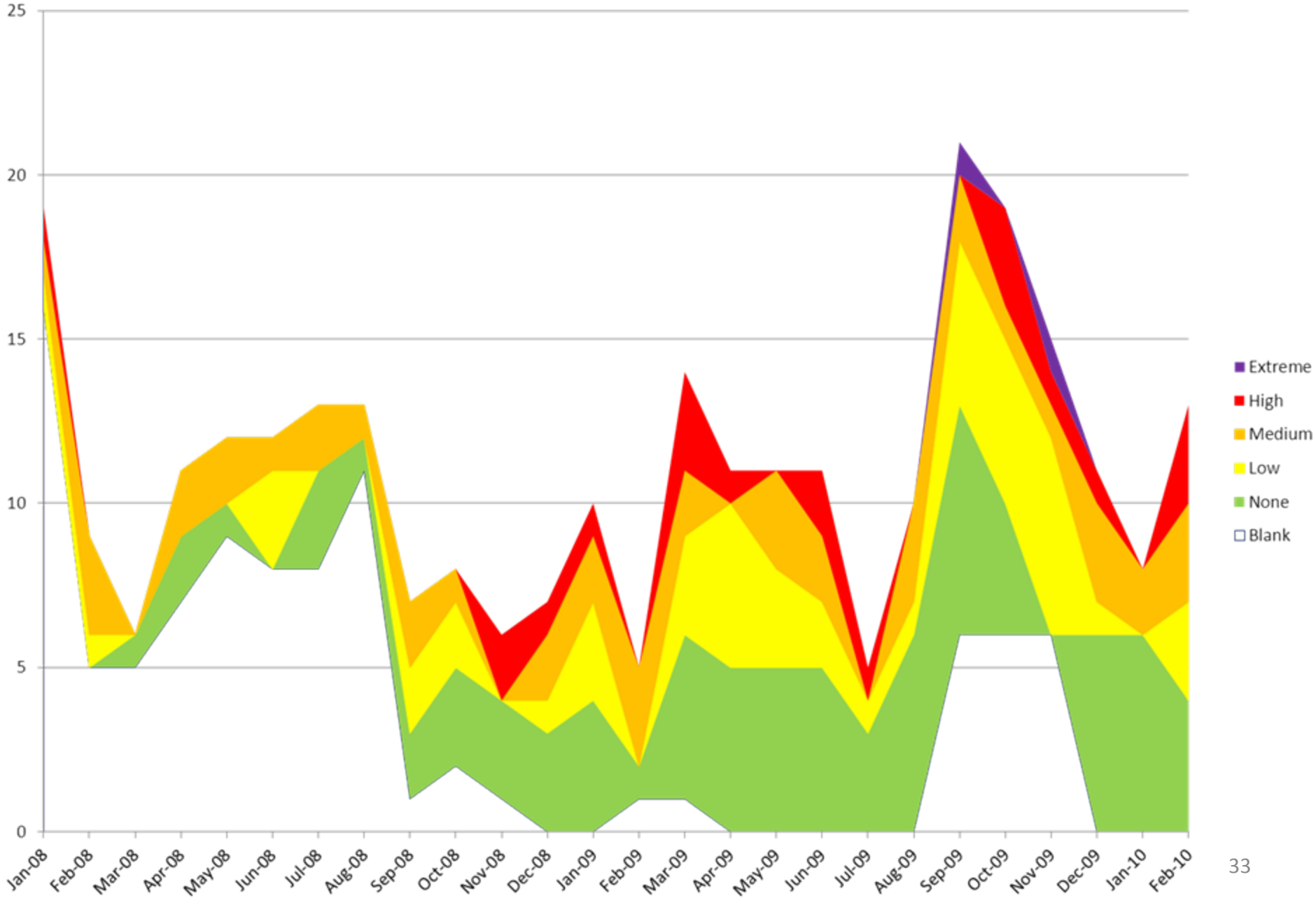
Total Electrical Events

by Severity Category



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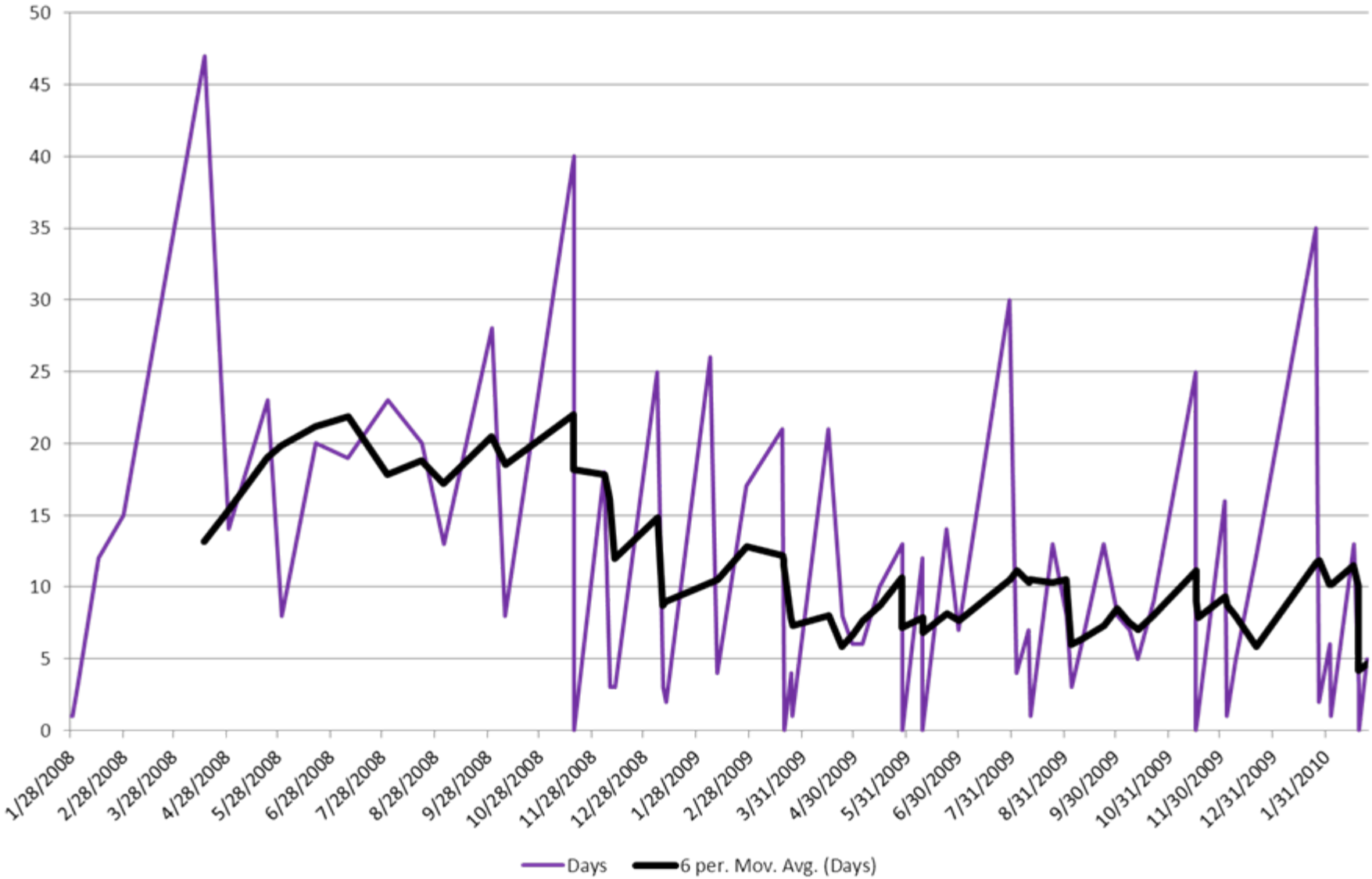
Electrical Event Clock

Medium to Extreme Severity



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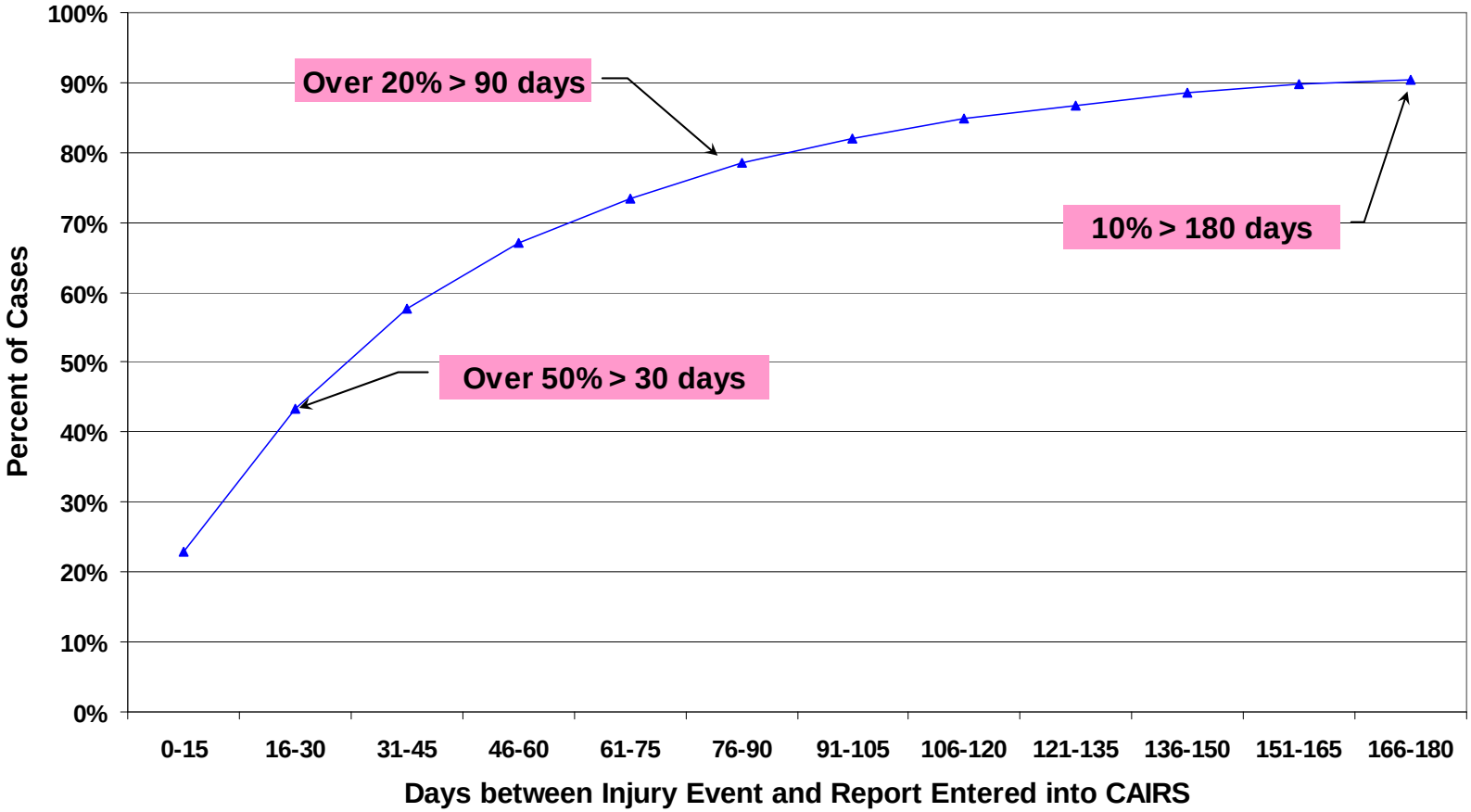
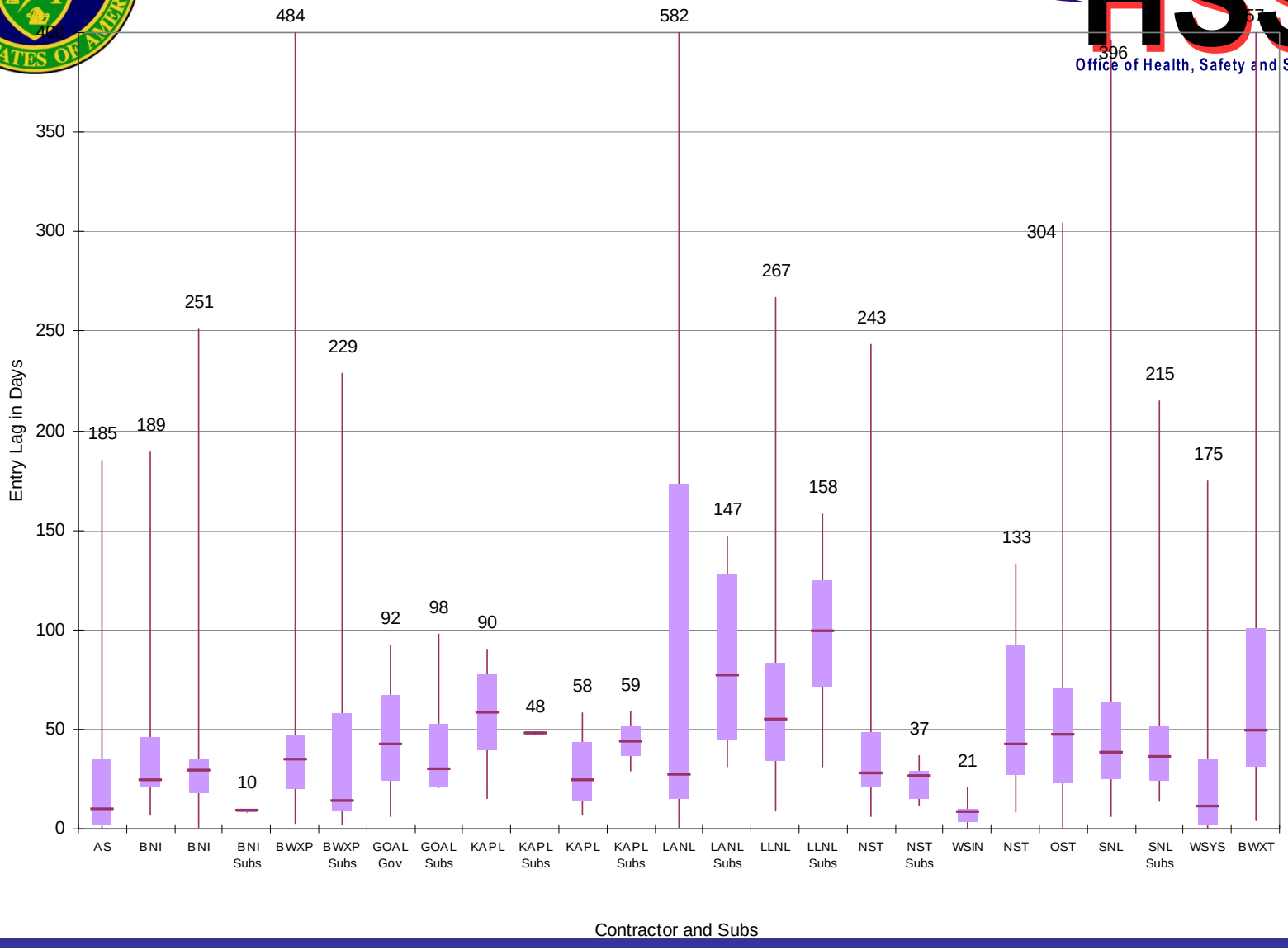
CAIRS Reporting Timeliness

2007 Data



NNSA Timeliness



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Beryllium Registry

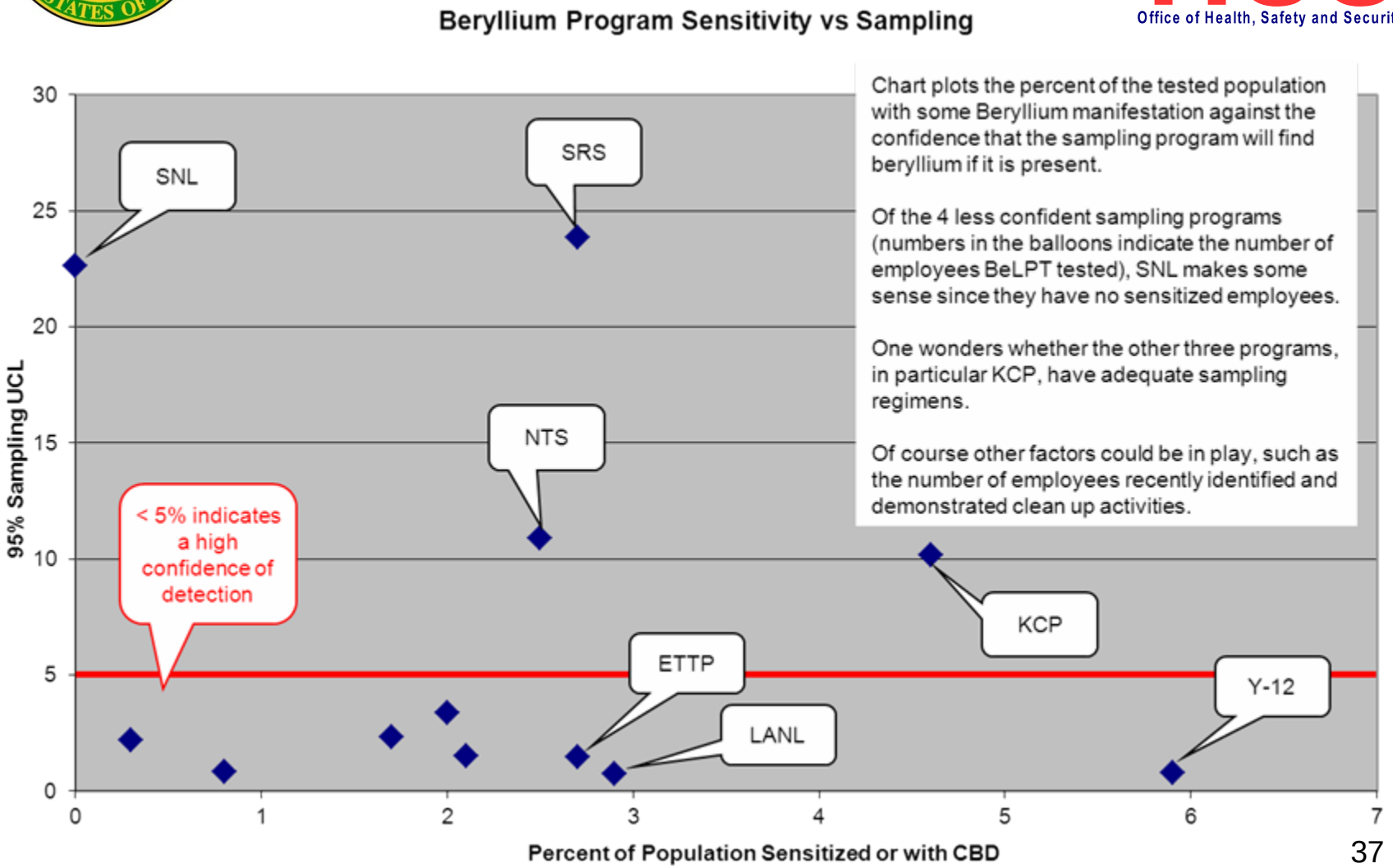

Chart plots the percent of the tested population with some Beryllium manifestation against the confidence that the sampling program will find beryllium if it is present.

Of the 4 less confident sampling programs (numbers in the balloons indicate the number of employees BeLPT tested), SNL makes some sense since they have no sensitized employees.

One wonders whether the other three programs, in particular KCP, have adequate sampling regimens.

Of course other factors could be in play, such as the number of employees recently identified and demonstrated clean up activities.

Performance Indicator Characteristics

- Performance (outcomes) are necessarily lagging indicators, but are still useful to detect long term trends and identify anomalies for further investigation
- Indicator systems should simultaneously compare many performance measures (not just ES&H) at the same time—a holistic view
- Indicators should begin at high levels then drill down as necessary
- While not technically “leading indicators,” management level measures that address broad risks and detect disruptions to normal operations are critical

Common Risk Indicators

A Few Examples

- Personnel
  - Key management turnover rate (e.g., contract changes)
  - Key position fill rate
  - Downsizing or rapid upsizing the workforce (including retirement bulge)
- Maintenance
  - Preventive maintenance backlog (days, $)
  - Maintenance rework percentage
- Training
  - Training requirement accomplishment rate
  - Key position certification rate
- Mission changes (type or scope)
- Infrastructure age and modernization investment profile (recap rate)
- Funding adequacy (may impact the other indicators)