Alpha Event and Follow up

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Candu Industry Philosophy

- Ratio of beta to alpha the determining factor for protection;
- If ratios high:
  - Precautions for beta will provide adequate protection from alpha
  - Whole Body Counting (WBC) – dosimetry for beta adequate
- If ratios low:
  - Specific monitoring for alpha becomes necessary to verify control and becomes a significant factor for dosimetry
- In operating CANDU plants, ratios were expected in the order of 10,000:1
  - Focus on Alpha was limited to characterization in fuel handling areas in the operating plant
  - Individual knowledge limited

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Alpha Dosimetry in Canada

- Regulatory approved Alpha dosimetry laboratory required:
  - AECL Chalk River is only accredited facility
  - Large-volume, very low threshold alpha bioassay analysis capability (TIMs), but throughput is limited and results not quickly available – was also not commercially available service
  - No Canadian NPPs, including Bruce Power, are currently approved for alpha dosimetry

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Bruce Power Reactors

- Two of Bruce Power's reactors have been under major refurbishment for five years
- Lay-up of the reactors was in place for many years before this (approximately ten years total)
- Significant decontamination efforts had been conducted prior to refurbishment to improve conditions for working
  - H-3 source term had been reduced
  - Beta gamma contamination levels were low
  - Much work was conducted without respiratory protection
- As contamination ages ratios decrease and the alpha proportion becomes more significant dosimetrically

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Refurbishment Work

- Refurbishment included cutting, magnetite removal and machining of feeders
- Feeder preparation prior to welding conducted in 2009
- ALARA Plan prepared
- Engineered controls to prevent the spread of contamination
- HEPA vacuum system
- Specially designed tools used to contain and collect contamination during work
- PPE controls included the wearing of Plastics Suits

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Refurbishment Work

- U2 feeder work completed successfully in fall 2009
  - No detection of any beta airborne activity
  - Low beta contamination levels
- Unit 1 commenced at the end of November 2009
  - Same controls used in Unit 2 were used in Unit 1
  - Airborne beta activity detected early
  - Additional controls were placed on work
  - Work tented to enclose activity
  - Further monitoring added
  - Detected alpha contamination

Initial Response

- All work was suspended in Unit 1
- Canadian regulator notified of event
- Root cause investigation was initiated
- Initial group of most exposed workers removed from work
- Obtained approval to use AECL dosimetry lab for our employees
- Alpha surveys conducted in U1 and U2
- Extensive cleaning of Unit 1 conducted
- Further work suspended – PHT work in U2
- Purchase of new and deployment of existing alpha monitoring equipment – friskers, air samplers, personnel monitors

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Dose Assessments

- Difficult to assess dose based on limited information
- Prioritized assessment process developed
- Dose estimates based on:
  - Vault access logs that documents all entries for all personnel
  - Air sample results (beta and alpha)
  - Conservative models to determine the hazard levels during work evolution
- All workers in vault assessed for possible exposures:
  - Before building tents for feeder work
  - After tents until the end of feeder work

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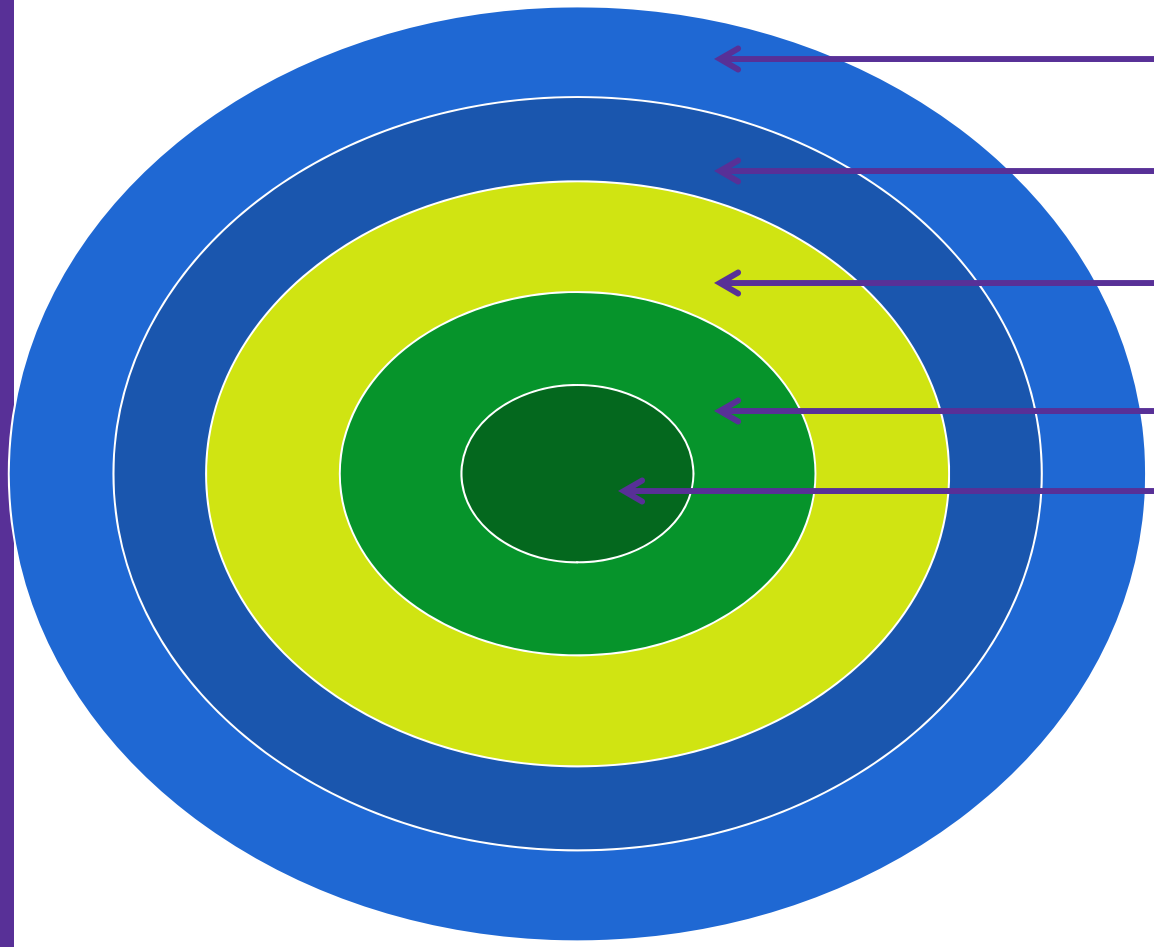
Further Response



Infrequently – General Vault Area (358)

Frequently – General Vault Area (176)

Areas near Feeder Work (13)

Spurious WBC (6)

Directly involved

Prioritize assessment based on work group activity and time spent in vault

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Significant Challenges

- Lack of familiarity with alpha - not an issue in operating plants so individual knowledge limited
- Large number of people to reach out to
- No CNSC approved laboratories in Canada for alpha dosimetry:
  - Large-volume Alpha bioassay analysis available in Canada but limited and results not quickly available
  - Alpha bioassay analysis process is complicated, therefore dose results not quickly available
  - New suppliers required for fecal analysis
- Alpha related work restrictions necessary to ensure sample purity
- Complicated issue to explain and lack of trust
- Several stakeholders

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Interim actions

- Alpha monitoring controls were added to U1 and U2 vault for general access:
  - Personal alpha contamination monitors
  - Routine air sample counting for alpha
- Back to Work
  - Staged return to work process developed (all work was suspended for 2 months)
  - Return to work criteria and plan for work in both vaults were established – additional alpha contamination and airborne monitoring and controls included
  - Comprehensive alpha characterisation of systems and areas
- Protocols/procedures developed
  - Work planning criteria and work controls for alpha
  - Alpha monitoring and air sampling protocols
  - Alpha free release standards and protocols
  - Verification waste streams to consider alpha
  - Incident response for alpha, including dosimetry requirements

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Summary of Improvements Made

- Improvements initially focused on restart, but now extended to all operating units and fuel handling:
  - New standards for alpha control
  - New RPPE
  - New procedures
  - New training
  - New alpha instrumentation
  - Enhanced air sampling program
  - New alpha dosimetry processes
  - Permits revised for alpha controls
  - Engaged external experts

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Communications

- Extensive communications have been conducted
  - Workers
  - Management
  - Industry
  - Joint Health and Safety Committees
  - Joint Committee on Radiation Protection

- Communications continue on improvements and changes in operating units and with dosimetry practices and results

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Contributors

1. Material Condition
2. Rad work planning procedure
3. Source Term Procedure
4. Performance testing of tool
5. Technical Knowledge
6. Tent Installation
7. Rad Workplace Monitoring
8. EPRI
9. REPS
10. Loose contamination
11. Group think
12. Analysis
13. Bruce Power Oversight

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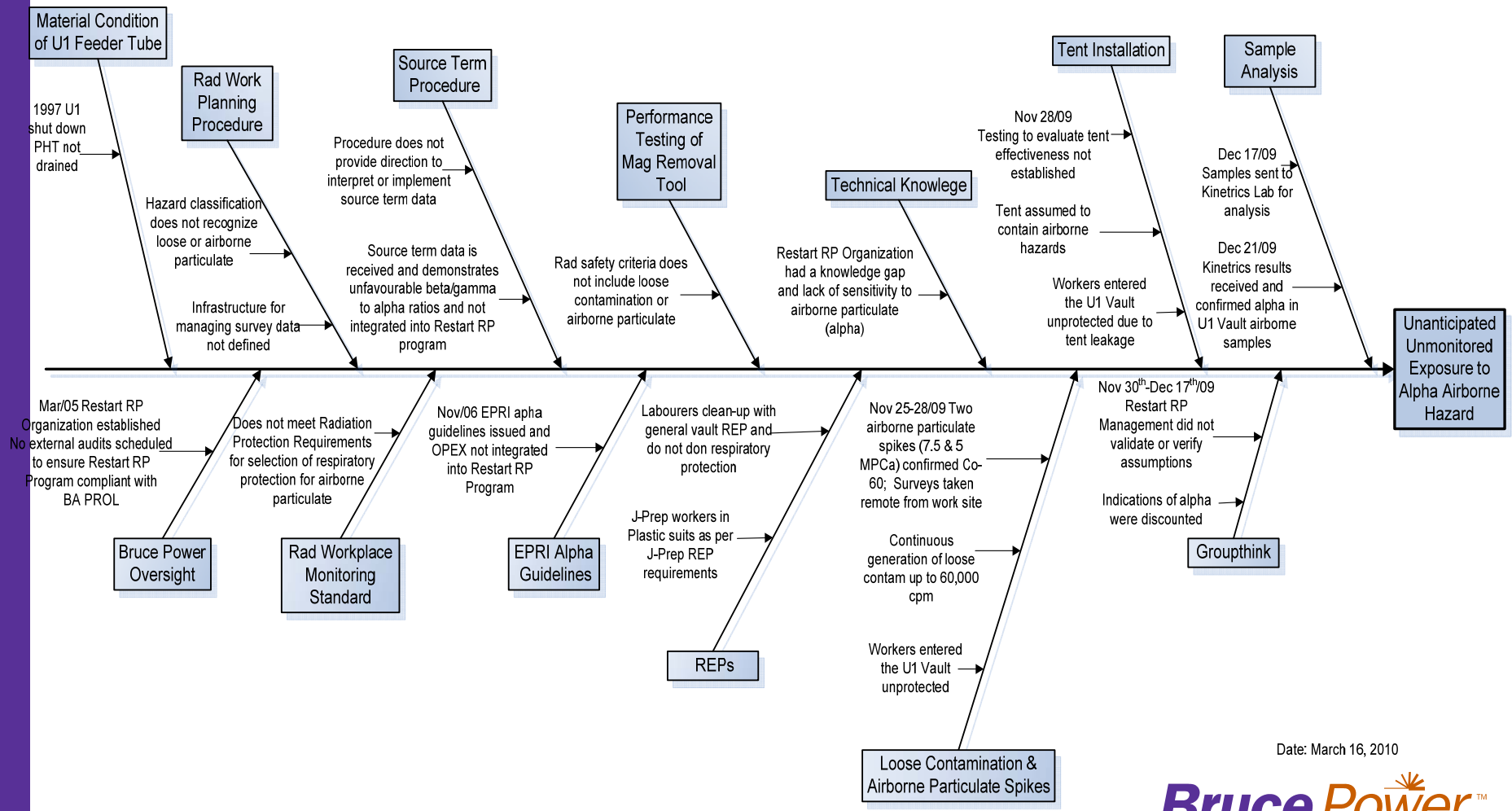
Bruce Unit 1 Restart Alpha Event



Date: March 16, 2010

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Bioassay sampling statistics

- 556 people were in the vault during the work period in question
  - Initial estimates indicated up to 193 could require further bioassay testing
- 552 personnel were tested - at least one sample
  - 33 individuals provided multiple samples (average 4 each)
  - 9 individuals remain on ongoing sampling
  - Total of 177 urine and 1086 fecal samples taken in 2009
  - Process of dosimetry has taken 12 months to complete
- Final results confirm initial estimates

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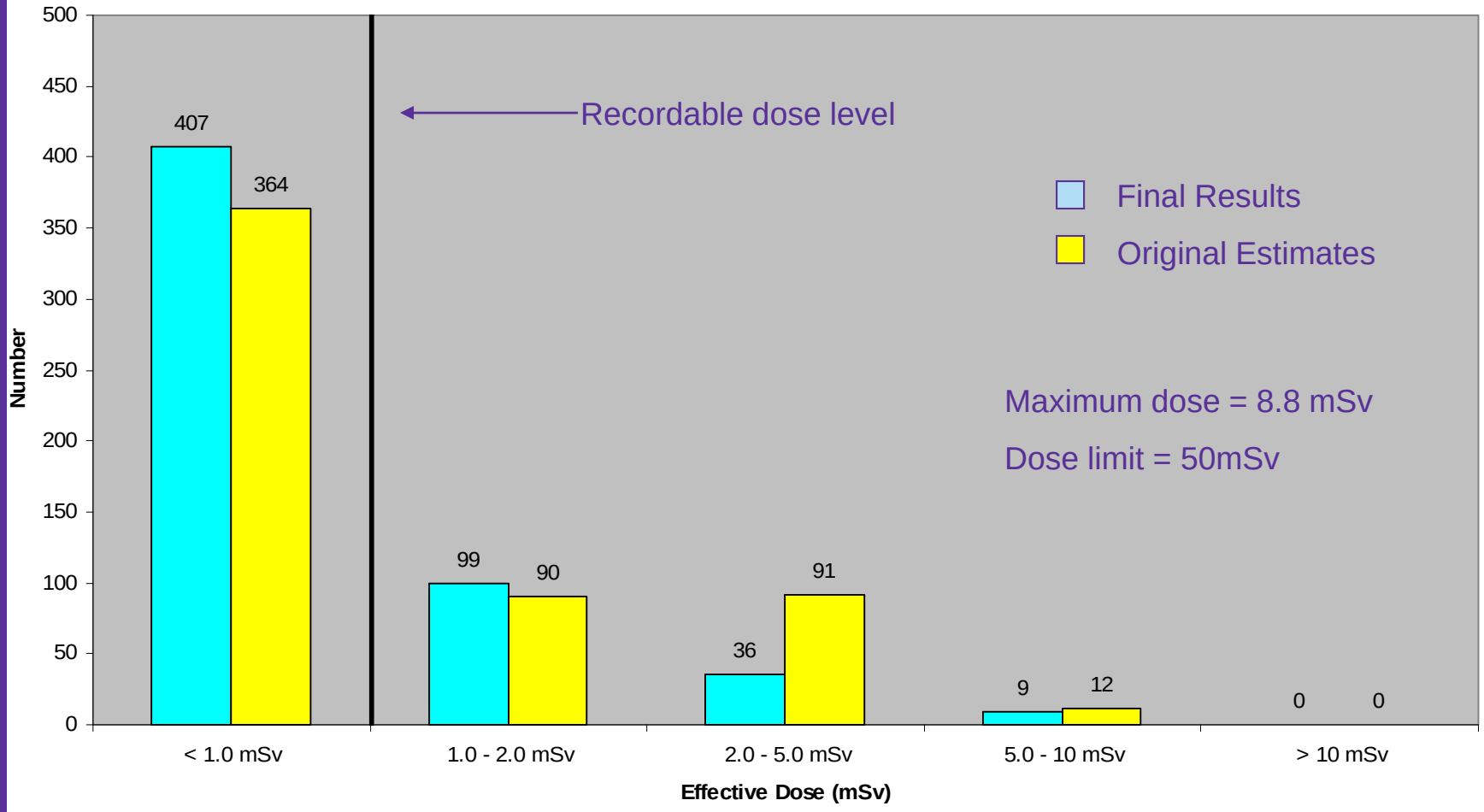
Alpha Contamination Event Dose Histogram
(Updated to 29 November, 2010)



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Future Activities

- Extent of condition work expanded to identify any historical doses
  - Workers in restart from previous work
  - Workers in fuel handling
  - Workers from other facilities
- 1008 individuals will be sampled
  - To date 700 samples complete
- Work is ongoing to assess doses to all personnel
  - Approximately ten percent of those sampled indicated potential intakes
  - Challenge is sensitivity of fecal historically, lack of lower threshold urinalysis capability and volume of personnel
  - Working with industry to create new bioassay laboratory
  - Ongoing, routine dosimetry practices to be defined

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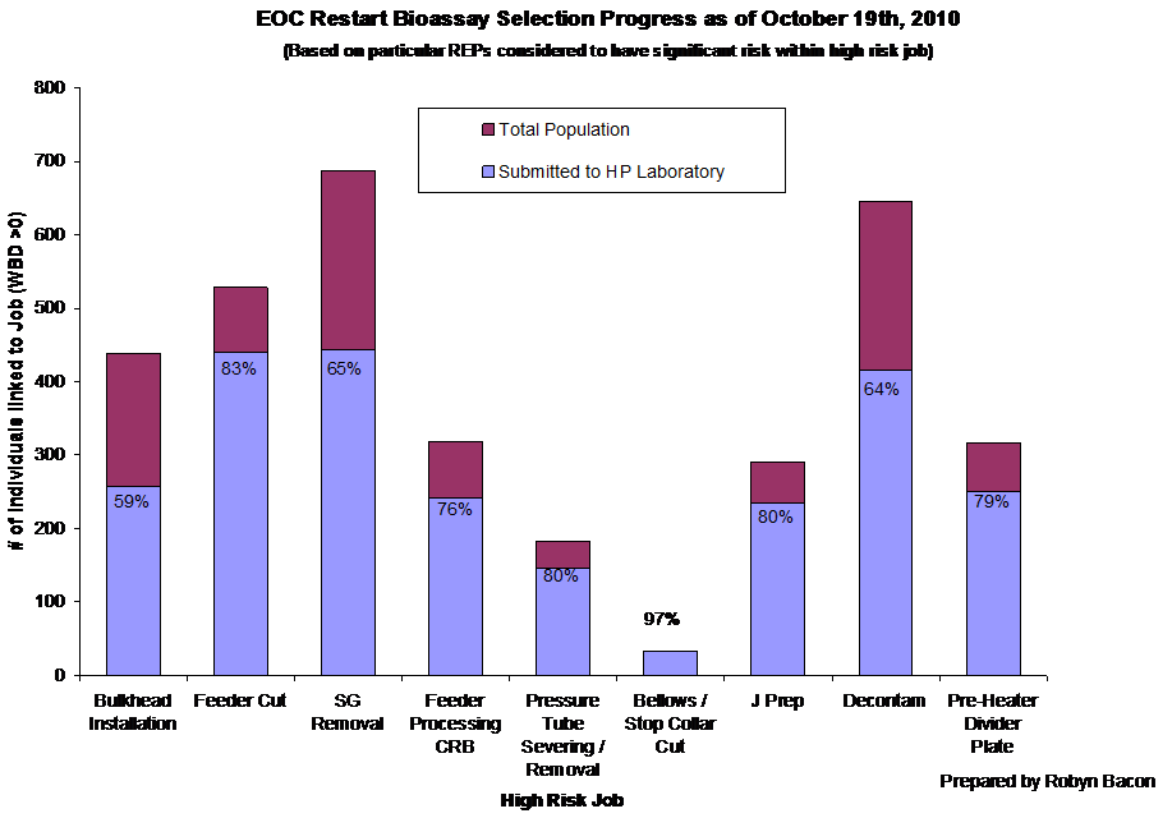
Range of Restart Activities



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Summary

- Significant radiological event with large number of workers exposed to alpha and large consequences for company
- Ongoing work to assess historical impact of alpha and continue to identify any other issues
- Major contributors were lack of understanding of characterization implications and reliance on old assumptions
- Extremely vital to have accurate technical basis, believe instruments when indicating an abnormal condition and challenge assumptions

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