U.S. Department of Energy
Office of Environmental Management

Type B Accident Investigation Report

Radiological Contamination Event During Separations Process Research Unit Building H2 Demolition September 29, 2010

November 23, 2010

Disclaimer

This report is an independent product of the Type B Accident Investigation Board appointed by Mark A Gilbertson, Deputy Assistant Secretary for Program and Site Support, U S Department of Energy The Board was appointed to perform a Type B Accident Investigation and to prepare an investigation report in accordance with Department of Energy (DOE) Order 225 1A, *Accident Investigations*

The discussion of the facts as determined by the Board and the views expressed in the report do not assume, and are not intended to establish, the existence of any duty at law on the part of the U S Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party

This report neither determines nor implies liability

Release Authorization

On October 22, 2010, a Type B Accident Investigation Board was appointed to investigate the September 29, 2010 radiological contamination during Separations Process Research Unit Building H2 demolition. The Board's responsibilities have been completed with respect to this investigation. The analyses and the identification of the contributing causes, the root cause and the Judgments of Need resulting from this investigation were performed in accordance with DOE Order 225.1A, *Accident Investigations*

The report of the Accident Investigation Board has been accepted and the authorization to release this report for general distribution has been granted

Mark A. Gilbertson
Deputy Assistant Secretary for
Program and Site Support

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Legend

E1	Electrician
EO1	Equipment Operator – shear trackhoe operator
EO2	Equipment Operator – hammer trackhoe operator
EO3	Equipment Operator – intermodal loader
EO4	Equipment Operator – water spray operator
OM	D&D Operations Manager
RCM	Radiological Controls Manager
RCT1	Radiological Controls Technician
RCT2	Radiological Controls Technician
WS	Waste Superintendent

Acronyms

ALARA	as low as reasonably achievable
ARAR(s)	applicable or relevant and appropriate requirements
BZA	breathing zone analyzer
cm^2	Square Centimeter
COA	condition of approval
cpm	counts per minute
DAC	derived air concentration
dpm	disintegrations per minute
DOE	United States Department of Energy
DOE G	DOE Guide
DOE O	DOE Order
DOE M	DOE Manual
JHA	Job Hazard Analysis
JON	Judgment of Need
KAPL	Knolls Atomic Power Laboratory
ORPS	Occurrence Reporting and Processing System
POD	Plan of the Day
mR/hr	milliroentgen/hour
NRLFO	Office of Naval Reactors Laboratory Field Office
RC	radiological calculation
RadCon	Radiological Controls
REM	roentgen equivalent man
RWP	Radiological Work Permit
SPRU	Separations Process Research Unit
SPRU-DP	SPRU Disposition Project
WAC	Waste Acceptance Criteria
WGI	Washington Group International

Executive Summary

Introduction

On September 29, 2010, a radioactive contamination event occurred while performing open air demolition of Building H2 at the Separations Process Research Unit (SPRU) in Niskayuna, New York. Though initial indications demonstrated that low levels of contamination had been found on workers shoes and on KAPL property adjacent to the SPRU work activities, the magnitude and significance of the contamination event were not fully identified and understood by the SPRU project for several days Based on the estimated cost to remediate the accident and event circumstances, a Type B investigation was ordered. On October 22, 2010, Mark Gilbertson, Deputy Assistant Secretary for Program and Site Support, U S. Department of Energy, Office of Environmental Management (DOE-EM), formally appointed a Type B Accident Investigation Board to investigate the accident in accordance with DOE Order 225.1, *Accident Investigations* The Board began the investigation on October 28, 2010, completed the investigation on November 11, 2010, and submitted findings to the Deputy Assistant Secretary for Program and Site Support on November 12, 2010.

Accident Description

By September 29, 2010, demolition of Building H2 had progressed to the point where the roof structure, the stack, and the exterior and interior walls with the exception of the north end above the 332' building elevation had been demolished and placed in intermodal containers for disposal Demolition crews had removed an interior wall along the west half of the north end of the building the day before and were in the process of removing six evaporator system components that extended above and below the 332' elevation along the north-most outer wall Following discussion in a 0800 morning meeting on September 29, 2010, the Cleveland Wrecking work group, with Washington Group International's (WGI) concurrence, proceeded to remove the following components from the north end of building footprint: evaporator condensers 221-A and 221-B, and columns 112-A, 112-B, and 113-B, which extended from the lower elevations of the building up above ground level, and size reduced condensers 221-A, 221-B, and column 113-B prior to identifying the spread of contamination event

At approximately 1200, the demolition crew began to break for lunch. Workers exiting the area heard the frisker alarming and summoned a radiological controls technician (RCT) for assistance. The RCT discovered contaminated dust on the frisker and removed it. Personnel were directed out of the immediate area due to elevated background radiation readings in that area and conducted a frisk, finding contamination on both boots of each of the four equipment operators

In response to the boot contamination event, further radiological surveys were conducted outside the demolition area and a review of air samplers surrounding the area was performed Two perimeter air samples showed elevated readings but WGI determined these readings to be below

reportable levels Surveys were also conducted outside the demolition area. WGI and DOE-SPRU notified Knolls Atomic Power Laboratory (KAPL) of the radiological (boot contamination) event approximately at 1400 KAPL responded and started extensive surveys outside the SPRU boundary. WGI discontinued work in the area pending further investigation

During the time of the event, KAPL had workers performing asphalt milling, roadway resurfacing preparations, and various other construction/operations activities to the east of the SPRU site By the evening of September 29, 2010 KAPL's surveys had identified numerous areas of contamination on the grounds and some roofs in an area about 100 yards squared near the SPRU site. Based on survey results, KAPL performed bioassays on over 100 workers that were determined to be in the area on September 29, 2010 or workers that assisted in radiological surveys or subsequent clean up activities

The next day, September 30, 2010 and into October 1, 2010, the SPRU project experienced exceptionally heavy rains due to Tropical Storm Nicole, greater than the 100 year rain Rainfall totals were recorded at or above 7 inches.

Direct, Root, and Contributing Causes

The Board identified the open air demolition of the evaporator system components as the direct cause of the accident.

The Board identified two root causes for the accident Eliminating these would have prevented the uncontrolled spread of contamination.

- The failures by WGI to fully understand, characterize, and control the radiological hazard.
- The failure by WGI to implement a work control process that ensured facility conditions supported proceeding with the work

In addition, 20 contributing causes were identified

Conclusions and Judgments of Need

Table ES-1 summarizes the conclusions and Judgments of Need (JON) determined by the Board The conclusions are those the Board considered significant and are based on facts and pertinent analytical results. Judgments of Need are managerial controls and safety measures believed by the Board to be necessary to prevent or minimize the probability or severity of a recurrence of this type of accident. Judgments of Need are derived from the conclusions and causal factors and are intended to assist managers in developing corrective actions

Table ES-1: Conclusions and Judgments of Need

Conclusions	Judgments of Need
The Board concluded WGI placed an over-reliance on the application and effectiveness of "fixative" to control contamination during demolition and prevent the spread of contamination off-site	WGI needs to re-evaluate and justify the contamination control techniques used during demolition
The Board concluded WGI did not apply fixative to the Flash Column and Separator Columns in the west "Hot" Evaporator cell	WGI needs to ensure contamination control techniques are well defined and executed as specified in work control documents
The Board concluded the radiation protection program was ineffective in evaluating and controlling contamination sources during demolition activities The Board concluded the execution of the "Demo Prep" and "Demolition" work packages did not result in the identification and control of contaminated components The Board concluded the radiological data used did not result in appropriately characterizing and controlling the radiological hazard	WGI needs to evaluate the current Radiation Protection Program and implement improvements that demonstrate competence and rigor, specifically as applied to the characterization and control of radioactive contamination This needs to include strengthening the knowledge, skills, and abilities of the Radiological Controls Technicians
The Board concluded that the WGI process for authorizing work tasks did not ensure the work was reviewed by the appropriate Subject Matter Experts at the POD before proceeding	WGI needs to establish a work planning and authorization process that ensures review, approval, and authorization by cognizant management and subject matter experts
The Board concluded that DOE and WGI oversight programs were ineffective in the identification and correction of environment, safety and health programs deficiencies	DOE SPRU needs to strengthen their oversight process and procedures to maintain sufficient knowledge of site and contractor activities to make informed decisions about hazards and risk and evaluate contractor performance WGI needs to strengthen their Contractor Assurance System to fully comply with DOE O 226 1, *Implementation of Department of Energy Oversight Assurance Program,* with specific attention to critical self-assessments and verification of effectiveness of corrective actions
Some workers perceived schedule pressure and were reluctant to bring up issues that might slow progress	WGI management needs to cultivate an atmosphere of open communication and acceptance of employee feedback regarding work processes and safety concerns

Conclusions	Judgments of Need
The Board concluded the frequent use of terminology such as "as required," "as needed," and "as necessary," contributed to a failure to complete work steps as intended. The flexibility incorporated into work documents led to individual decision-making in determining what components in Building H2 would require additional consideration	WGI needs to strengthen the level of rigor and discipline in executing the work planning process such that work steps provide the necessary detail to ensure steps are accomplished as planned

1.0 Introduction

On September 29, 2010, a radioactive contamination event occurred while performing open air demolition of Building H2 at the Separations Process Research Unit (SPRU) in Niskayuna, New York. Though initial indications demonstrated that low levels of contamination had been found on workers shoes and on KAPL property adjacent to the SPRU work activities, the magnitude and significance of the contamination event were not fully identified and understood by the SPRU project for several days Based on the estimated cost to remediate the accident and event circumstances a Type B investigation was ordered. On October 22, 2010, Mark Gilbertson, Deputy Assistant Secretary for Program and Site Support, U.S. Department of Energy, Office of Environmental Management (DOE-EM), formally appointed a Type B Accident Investigation Board to investigate the accident in accordance with DOE Order 225 1, *Accident Investigations*. The Board began the investigation on October 28, 2010, completed the investigation on November 11, 2010, and submitted findings to the Deputy Assistant Secretary for Program and Site Support on November 12, 2010

In accordance with the appointment letter, the Board focused the investigation on the contamination event resulting from decontamination and demolition work that occurred at the SPRU H2 facility on or about September 29, 2010 Subsequent to the contamination event there were two additional events related to the hillside drain system. Although the Board did not thoroughly investigate these events, contamination control, work planning, and execution deficiencies were evaluated by the Board to be similar to those identified in this report The Board strongly recommends that DOE-SPRU and WGI corrective action plans include these events in order to prevent recurrence.

The content of this report identifies additional issues that did not result in a conclusion or a judgment of need However, the Board recommends they be considered when developing corrective action plans

1.1. Background

The Separations Process Research Unit (SPRU), located at the Knolls Atomic Power Laboratory (KAPL) near Schenectady, New York, was operated from 1950 to 1953 as a pilot plant to research the REDOX and PUREX chemical processes to extract Uranium and Plutonium from irradiated Uranium It supported operations at the Hanford Site (Washington State), and the Savannah River Site (South Carolina). The research was performed on a laboratory scale; SPRU was never a production plant

Construction on Buildings H2 and G2 began in 1948, with completion in 1949 The research operations contaminated the SPRU facilities and land areas, resulting in the need to remediate the site After 1953, KAPL continued to use Building H2 into the late 1990's for waste processing (e g processing of Radioactive Materials Laboratory reuse water and periodic cleanout of tank farm vaults).

1.2. Facility Description

SPRU, at KAPL, is located approximately 2 miles east of the city of Schenectady in the northeastern part of Schenectady County in New York State The SPRU project occupies approximately 5 acres of the approximate 200 acres of land managed by Knolls Atomic Power Laboratory

The SPRU facility consists primarily of two interconnected buildings:

- Building G2 – housed the laboratories, hot cells, separations process testing equipment, and the tunnel system beneath Building G2 Building G2 hot cells, equipment, ventilation/process piping systems, and tunnels contain residual radioactive contamination. There is low level radioactive contamination throughout the facility and systems
- Building H2 – used for liquid and solid waste processing. All areas of this building except the entryway on the 332' elevation are under radioactive controls
- H2 Tank Farm (also known as the tank vaults) – a series of underground concrete-enclosed stainless steel tanks along the eastern side of Building H2 used for storing liquid radioactive waste. The tanks have been consolidated into a single tank
- Pipe Tunnels – concrete passageways connecting the H2 Tank Farm, Building H2 to Building G2, and Building G2 to Buildings G1 and E1 The Pipe Tunnels contain residual radioactive material

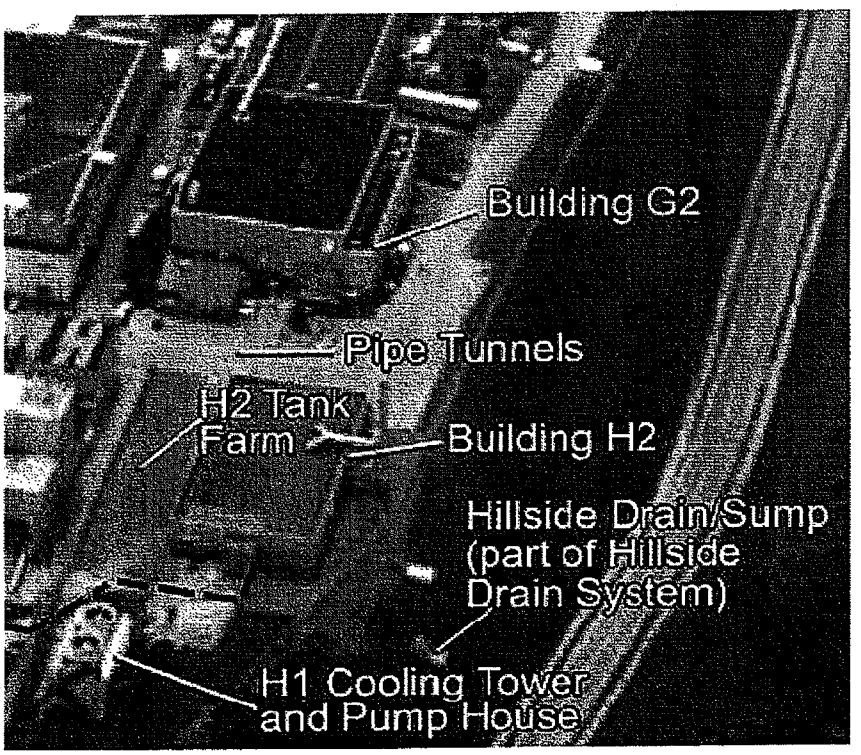


Figure 1-1: Aerial Photograph of Upper Level Looking South (Photo #A-1, 1987)

1.3. Facility Mission

The facility is currently undergoing decontamination and decommissioning activities under the purview of the Department of Energy's (DOE) Office of Environmental Management (EM). In September 1992, the Department's Office of Nuclear Energy, (current organization is Office of Naval Reactors Laboratory Field Office [NRLFO]) and EM signed a Memorandum of Agreement (MOA) on decontaminating and decommissioning the SPRU facilities. The MOA was supplemented with the SPRU Functions, Assignments, and Responsibilities Agreement (FAR) in 2000, (current Revision 2, dated February, 2009) establishing the roles and responsibilities of each Office regarding the decontamination and decommissioning of SPRU. Upon the completion of the demolition and clean-up, and sampling to ensure the clean-up levels have been met, the land will be transferred back to the NRLFO for their continued mission use.

The FAR at the Knolls Atomic Power Laboratory, Knolls Site, provides the division of responsibility and defines oversight protocols. EM is the SPRU Project owner and responsible for overall project coordination. NRLFO is the Cognizant government agency for KAPL. EM and KAPL meet periodically to discuss integration and interferences with each other's operations. The extent of NRLFO overview of DOE-SPRU and the WGI activities will be commensurate with the potential of adversely affecting KAPL's operations.

1.4. Environmental Restoration

The SPRU site process facilities and adjacent land areas include approximately five acres and are managed by the U.S. Department of Energy. The proposed action is the decommissioning and decontamination of four buildings and associated facility structures including tank farms, vaults and pipe tunnels, and removal of any contaminated soils.

In April 2006, EM completed the Nuclear Facility Historical Site Assessment (HSA) for the Separations Process Research Unit Disposition Project. The HSA documented the radiological conditions of Building H2, including a description of the east and west evaporator cells as follows:

> The 1989 survey of the west evaporator bay identified general area radiation of 0.6 to 4 milliRem per hour closed window and 0.8 to 4 milliRem per hour open window. There was a maximum reading on the sight glass isolation valve on the side of the west evaporator of 12 milliRem per hour closed window and 150 milliRem per hour open window. Loose surface contamination of floor areas indicated up to 450 picoCuries per 100 square centimeters (up to 999 disintegrations per minute) beta/gamma. Loose surface contamination on the sight glass isolation valve indicated less than 50 picoCuries per 100 square centimeters (less than 111 disintegrations per minute) alpha and 54,000 picoCuries per 100 square centimeters (119,880 disintegrations per minute) beta/gamma (C-000198, pp. 2-3). Based on this survey, the west evaporator bay is a high radiation area and a high contamination area. Further characterization is required to assess any change in radiological conditions since the 1989 survey.

1.5. Contractual Relationship

On December 13, 2007, DOE announced the award of a four-year task order to Washington Group International (WGI) to provide deactivation, demolition, and removal of the SPRU nuclear facilities (Buildings G2, H2, the Tank Enclosures, and the connecting tunnel); cleanup and environmental restoration of the underlying and surrounding contaminated soil; and the decontamination of piping tunnel connecting the SPRU facilities to other operating facilities

WGI was awarded additional funding from the American Recovery and Reinvestment Act by DOE to cover the costs associated with the current task order work scope as well as to accelerate the completion of the WGI contract scope from December 2011 to September 2011

1.6. Scope, Purpose, and Methodology

The Board began its investigation on October 28, 2010, and completed the investigation and submitted its final report to Mark A Gilbertson, Deputy Assistant Secretary for Program and Site Support, on November 12, 2010 The Board reviewed and analyzed the circumstances surrounding the accident to determine its cause including deficiencies, if any, in safety management systems and to understand lessons learned to reduce the potential for recurrence of similar accidents

In addition, the Board was requested to specifically address work planning and control, project planning, radiological controls, personnel qualifications and staffing, conduct of operations, with a particular focus on higher hazard activities, event response and the contractor assurance system.

The Board conducted its investigation using the following methodology:

- Facts relevant to the accident were gathered through interviews, document and evidence reviews, and examination of physical evidence.
- Event and causal factor charting, along with barrier analysis and change analysis techniques, were used to analyze the facts and identify the cause(s) of the accident.
- Based on the analysis of information gathered, judgments of need were developed for corrective actions to prevent recurrence.

Accident Investigation Terminology

A **causal factor** is an event or condition in the accident sequence that contributes to the unwanted result. There are three types of causal factors: direct cause(s), which is the immediate event(s) or condition(s) that caused the accident; root causes(s), which is the causal factor that, if corrected, would prevent recurrence of the accident; and the contributing causal factors, which are the causal factors that collectively with the other causes increase the likelihood of an accident, but which did not cause the accident.

Event and causal factors analysis includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the accident to occur), and the use of deductive reasoning to determine the events or conditions that contributed to the accident.

Barrier analysis reviews the hazards, the targets (people or objects) of the hazards, and the controls or barriers that management systems put in place to separate the hazards from the targets. Barriers may be physical or administrative.

Change analysis is a systematic approach that examines planned or unplanned changes in a system that caused the undesirable results related to the accident.

Figure 1-2: Accident Investigation Terminology

2.1. Event Description

Decontamination and demolition preparation activities occurred at the SPRU site for the several months preceding the accident Demolition, using heavy equipment, of Building H2 began on September 23, 2010.

Figure 2-1: Facing North of the Building H2 on the Afternoon of September 25, 2010

Prior to September 29, 2010, demolition of Building H2 had progressed to the point where the roof structure, the stack, and the exterior and interior walls with the exception of the north end above the 332' building elevation had been demolished. Some of the demolition debris had been placed in intermodal containers for disposal Demolition crews had removed an interior wall along the west half of the north end of the building the day before and were in the process of removing six evaporator system columns that extended above and below the 332' elevation along the north-most outer wall

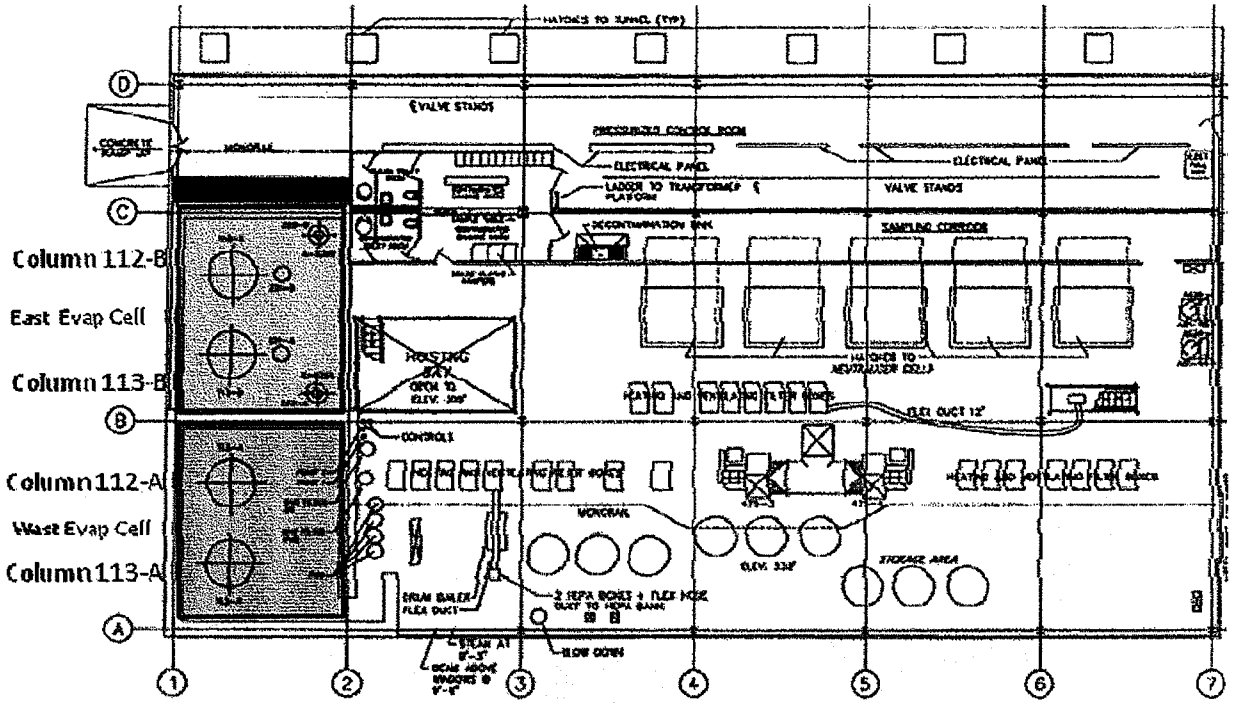


Figure 2-2: Building H2 332' Elevation

The DOE ESH&Q Manager was at the 0800 meeting on September 29, 2010, when the request was made to remove the evaporator system components that extended above the 332' elevation. He did not know if this action was appropriate and later that morning, passed the information to the DOE SPRU Facility Representative who communicated the information to the DOE SPRU Manager. Based on this discussion, though, the DOE SPRU Manager did not believe that contaminated components were being removed

Following the meeting, the Cleveland Wrecking work group, with WGI concurrence, proceeded to remove the following components from the north end of building footprint: evaporator condensers/columns 221-A and 221-B, and columns 112-A, 112-B, and 113-B, which extended from the lower elevations of the building up above ground level, and size reduced condenser/columns 221-A, 221-B, and column 113-B prior to identifying the spread of contamination event.

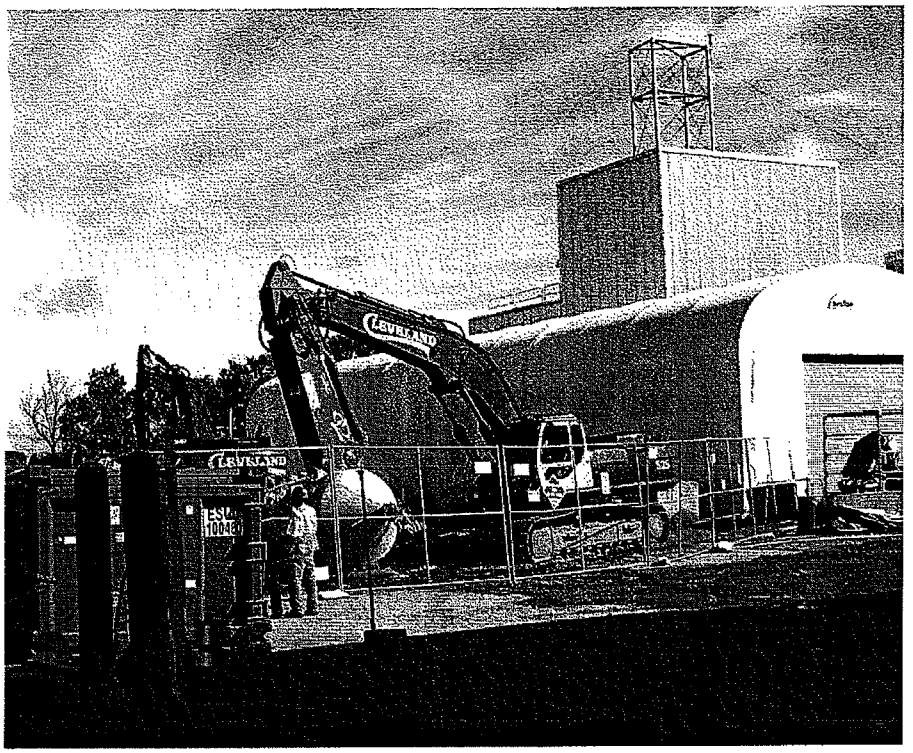


Figure 2-3: Flash Column being Size Reduced

Three wrecking crew equipment operators were working on Building H2 and a fourth worker was spraying water for dust suppression. An equipment operator (EO1) was on the east side in the process of removing two condenser/columns from the east evaporator cell while a second equipment operator (EO2) was removing the separator column (112-A) from the west evaporator cell. The third equipment operator (EO3) was loading demolition debris into intermodal containers. EO1 started size reducing the condenser/columns, and was stopped when an electrician (E1) and a radiological control technician (RCT1) noticed a white "puff" coming from one of the condenser/columns. RCT1 obtained a flammable gas meter and checked the area of the "puff" for explosive gases and then allowed the crew to resume demolition. No radiological surveys were conducted at this time. After the EO2 removed the separator column from the west evaporator cell, he repositioned his equipment to remove the flash column and separator column from the east evaporator cells. The flash and separator columns (112-B, and 113-B) were removed from the east evaporator cell and all three columns were laid down on Building H2 footprint slab. The water spray operator (EO4) noted the wind was strong enough that he needed to significantly redirect the nozzle to correct for windage.

While removing the separator column from the west evaporator cell, a bolt was ejected into the air and struck an electrical transformer outside the construction boundary. The bolt was located, surveyed, found to have fixed contamination, and the bolt was removed. RCT2 stated that he informed his management of the survey results. Demolition activities were halted and the area

surrounded by the safety fence was enlarged, further from the demolition area. The survey was not documented until approximately one week later. No documentation of the September 29th survey was provided to the Board by WGI. RCT2 who performed the survey was on vacation and provided survey results via telephone discussion with his supervisor, who subsequently documented the survey indicating fixed contamination levels less than 5,000 dpm/100 cm^2 beta/gamma. The supervisor documenting the survey recorded the wrong type of instrument which resulted in underestimation of the contamination levels. Had the appropriate instrument been recorded, the results would have been approximately 24,000 dpm/100 cm^2 beta/gamma.

At approximately 1200, the demolition crew began to break for lunch. EO4 was walking south around the south east corner of Building H2 when he heard a frisker alarming. About the same time, a worker from outside of Building H2 work area heard the frisker and summoned RCT1 for assistance. RCT1 discovered contaminated dust on the frisker and removed it. The frisker stopped alarming. RCT1 then directed the demolition crew and the worker out of the immediate area due to elevated background radiation readings in that area and conducted a frisk, finding contamination on both boots of each of the four equipment operators. The Board was informed that when the egress frisker south of Building H2 was responded to by the RCT who believed his indications; the Waste Superintendent questioned RCT1's response since he believed that the alarming condition was caused by radiation "shine".

The highest levels recorded were over 11,000 dpm beta/gamma under a 15 cm^2 probe. The contamination levels discovered on the boots of the workers were below reportable levels per DOE M 231.1-2, *Occurrence Reporting and Processing of Operations Information*. As a precaution, nasal smears were taken and found to be negative. Several days later, bioassay samples were also taken; results were not available at the time of the Board review. The Board received subsequent notification that WGI received results and no assignable dose was identified for any of the four operators.

In response to the event WGI posted the area surrounding Building H2 and between Buildings G2 and H2 as a Contamination Area and an Airborne Radioactivity Area. The demolition area of the H2 slab was surveyed by RCT1 who recorded contamination levels in the debris piles up to 500,000 dpm/100 cm^2 beta/gamma and 11,000 dpm/100 cm^2 alpha. One 16,000 dpm/100 cm^2 beta/gamma swipe was obtained on the excavator shear.

Because of the boot contamination event, further radiological surveys were conducted outside the demolition area and a review of air sampler data was performed. Two perimeter air samples showed elevated readings but WGI determined these readings to be below reportable levels. Surveys were also conducted outside the demolition area. WGI and DOE-SPRU notified KAPL of the boot contamination event approximately at 1400. KAPL responded and started extensive surveys outside the SPRU boundary. WGI discontinued work in the area pending further investigation. Based on initial surveys, WGI reduced the Contamination Area posting to an area closer to the Building H2 pad and removed the Airborne Radioactivity Area posting.

During the time of the event, KAPL had workers performing asphalt milling, roadway resurfacing preparations, and various other construction/operations activities to the east of the SPRU site By the evening of September 29, 2010 KAPL's surveys had identified numerous areas of contamination on the grounds and some roofs in an area about 100 yards squared near the SPRU site. Based on survey results, KAPL performed bioassays on over 100 workers that were determined to be in the area on September 29, 2010 or workers that assisted in radiological surveys or subsequent cleanup activities While no bioassay results were available when the Board was on site, subsequent information provided by KAPL indicates that urinalysis results have been received for the 44 people identified as the highest priority All results were below the detection level, and thus, none of these 44 individuals received a measurable dose.

The following day, September 30, 2010, in preparation for incoming Tropical Storm Nicole, a pile of debris just off the south end of the Building H2 slab was pushed back onto the slab with heavy equipment The workers sprayed fixative on the three debris piles and the evaporator separator columns on the slab of Building H2. Other preparation work was done to control storm water runoff, including the establishment of a temporary berm WGI conducted additional contamination surveys that identified additional areas of contamination and posted those areas accordingly Remaining Building H2 demolition debris was confirmed as inside Building H2 footprint.

NRLFO and KAPL with DOE-SPRU in attendance made a telephone notification of the contamination event to the New York State Department of Environmental Conservation and the New York State Department of Health

During September 30, 2010, and into October 1, 2010, the SPRU project experienced exceptionally heavy rains due to Tropical Storm Nicole, i e , greater than a 100 year rain event. Rainfall totals were recorded at or above 7 inches

2.2. Chronology of Events

The following is the Summary Event Chart and Accident Chronology as viewed by the Board.

Table 2-1: Summary Event Chart and Accident Chronology

Date/Time	Event
4/3/2009	Safety Evaluation Report for H2/G2 approved
6/12/2009	Decision to perform open air demolition was made in Decommissioning Plan
4/6/2010	Planner started work planning - first planning meeting
5/4/2010	Demolition Preparation Work Package STW-FWP-1990 issued
6/9/2010	Demo Prep Work Package STW-FWP-1990 Started
7/1/2010	ISMS Phase II review

Date/Time	Event
8/10/2010	Work Package PPP-FWP-2130 is approved for demolition
8/12/2010	SPRU-DP Final Hazard Characterization, FHC-001, was approved
9/16/2010	Radiological characterization completed for removable contamination H2
9/22/2010	"Demo Ready Checklist" signed off in STW-FWP-1990
9/23/2010	Demolition started on H2 building 332' elevation
9/24-29/2010	Elevated air sampler reading recorded by perimeter air monitors.
9/25/2010	H2 Stack was demolished
9/28/2010	POD Meeting
9/29/2010 ~ 0645	"Supervisor's" Meeting
9/29/2010 ~ 0800	0800 meeting
9/29/10 ~1000 to ~1200	EO1 removed and sized heat exchanger vessels 221-A and 221-B from east evaporator cell
	EO2 removed separator vessel 112-A from west evaporator cell
	EO2 removed separator column 113-B and flash column112-B from east cell.
	EO1 sized vessel 113-B
9/29/2010 ~1030	RCM and DPD noted vessels on the 332' level pad
9/29/2010	Uncontrolled spread of radioactive contamination during demolition of building H2
9/29/2010 ~1200	Wrecking crew broke for lunch
9/29/2010 ~1200	Operator noted frisker alarming and called RCT
9/29/2010	RCT conducted surveys and made notifications
9/29/2010	Air samples east of H2 indicated increased activity
9/29/2010	Debris pile surveyed by SPRU RCTs
9/29/2010	KAPL was notified of event
9/29/2010	KAPL deployed ~60 personnel to survey KAPL facilities
9/29/2010 ~1900	Debris pile sprayed with encapsulation material
9/29/2010 ~1900	Excavator track swiped at ~11,000 DPM
9/30/2010	Workers pushed debris back onto H2 pad

Date/Time	Event
9/30/2010 to 10/01/2010	Significant rain overflows FRAC Tank
10/4/2010	Air samples recounted and confirm increased activity
10/5-7/2010	Surveys on heavy equipment indicated varying levels of contamination including a high of 677,000 DPM and debris pile at 1 5 to 1 7 million DPM
10/7-8/2010	Covered the debris pile with tarps
10/8/2010	SPRU-DP filed occurrence report EM--WGI-G2H2-2010-0001
10/11/2010	SPRU-DP Issued "SPRU Project Improvement Corrective Action Plan"
10/12/2010	Covered the tanks with tarps
10/13-16/2010	332' elevation floor penetrations were covered
10/13/2010	STW-FWP-1990 closed out
10/22/2010	DOE declared Type B Investigation
10/22/2010	Additional heavy duty tarps added to debris piles/vessels
10/25/2010	Second "water event" occurred
10/28/2010	DOE Investigation Board arrived on site
10/28/2010	Apparent Cause Analysis issued by SPRU-DP

2.3. Event Response

On September 29, 2010, at approximately 1200, a worker found a frisker alarming that had been staged for personnel access out of the building H2 demolition area The worker notified RCT1 who knocked the dust off of the probe and attempted to clear the alarm and reset the frisker After clearing and resetting the alarm it was noticed that background levels had increased RCT1 made notifications to work area supervision and commenced response actions that included surveys of the four workers inside the work area, surveys of adjacent work areas, checks of perimeter air monitors and breathing zone air sample analysis

Additional surveys were conducted by RCTs who responded to the frisker alarm that found a few areas of contamination outside of the Building H2 footprint A bag of tools that an electrician had left at his work location were found to be contaminated. The four equipment operators who had been in the H2 demolition area were found to have contamination levels of 11,000 dpm/probe area of 15 cm^2 on the bottom of their work boots. No other contamination of personnel was identified Nasal smears of workers in the area were negative and bioassay sampling data was not available The Board received subsequent notification that WGI received results and no assignable dose was identified for any of the four operators. WGI assessed that

the perimeter air sample results from perimeter work area monitors showed elevated levels but were below Derived Air Concentration (DAC) limit values

Initial response surveys of areas surrounding the H2 demolition footprint were obtained using smears that were taken on porous surfaces such as asphalt, gravel and dirt Representative samples of gross contamination levels were not obtained using this technique. Direct frisks were not initially performed, but when performed around 1630 that afternoon, indicated elevated contamination levels at several additional locations. KAPL and NRLFO were notified of the event about two hours after the initial frisker alarm Notification phone calls were made the following day, September 30, 2010, to the New York State Department of Environmental Conservation and the New York Department of Health

WGI informed the Board that the radiologically-controlled area was immediately expanded and upgraded to an Airborne Radioactivity Area and a Contamination Area At approximately 1300 RCT1 was directed to enter the area and take a contamination survey The survey consisted of 30 smears. Approximately one half of the smears indicated contamination levels above WGI's criteria of 1000 dpm/100 cm^2 beta/gamma or 20 dpm/100 cm^2 alpha The highest readings were close to 500,000 dpm/100 cm^2 beta/gamma and over 10,000 dpm/100 cm^2 alpha Review of the Radiological Work Permit (RWP) sign-in sheet indicated that RCT1 had not signed in on the RWP prior to entering Comparison of the sign-in sheets with dates and times RCTs were in the area conducting surveys showed that, after the event, there were many entries into the area by RCTs who had not signed in on the RWP. RCT1 who entered the area the afternoon of September 29, 2010, stated that his protective equipment consisted of booties and gloves. This was in violation of the RWP which required additional protective equipment

The next morning, WGI performed additional surveys of the area to the east of Building H2 pad Gamma scans indicated contamination along the entire east side of the building However, WGI had not performed a baseline survey prior to the event; therefore the increase in the readings cannot be assessed

Shortly after the identification of the four workers with boot contamination, the perimeter air samples were collected Two samples showed elevated readings when they were counted at approximately 1345, September 29th The samples were counted again the morning of October 4, 2010 and WGI recognized that they had an uncontrolled spread of radioactive contamination

2.3.1. Reporting

DOE M 231.1-2, *Occurrence Reporting and Processing of Operations Information* details the Department's expectations for reporting specified occurrences to DOE.

On October 8, 2010, WGI submitted Occurrence Report, EM---WGI-G2H2-2010-0001 stating "The first event occurred on September 29, 2010 at approximately 1200 during demolition of H2. An equipment operator noted a frisker alarming and attempted to reset it When it continued to alarm, the operator notified RCT1 RCT1 discovered dust on the frisker head, removed the dust and reset the frisker RCT1 made notifications and response actions including surveys of workers inside the work area, surveys of adjacent work areas, checks of

environmental air monitors and breathing zone air samples were conducted Less than reportable levels of contamination were discovered on the four equipment workers boots "

The ORPS report was categorized as a management concern involving operational weaknesses after evaluation of two non-reportable events.

2.3.2. Causal Analysis

WGI performed an "Apparent Cause" analysis in accordance with the requirements of DOE G 231 1-2, *Occurrence Reporting Causal Analysis Guide*, in response to the "SPRU Project Improvement Corrective Action Plan, dated October 11, 2010 This corrective Action plan was in response to two events, the contamination event and a "water event" as it is described in the occurrence report (EM--WGI-G2H2-2010-0001)

2.4. Examination of Evidence

The Board arrived on site on October 28, 2010, 29 days after the contamination event occurred. Evidence was collected from various sources, including: WGI, DOE and NRLFO documents; WGI and DOE photographs taken between September 23, 2010 and October 7, 2010; oral interviews with WGI, DOE, and NRLFO employees; and onsite inspections by the Board

Photographs provided the Board with a chronological record of demolition of Building H2 above ground structure, demolition of the H2 ventilation system stack, removal and disposition of some evaporator system components, efforts taken in response to an approaching tropical storm, and subsequent activities taken to isolate the debris piles

Documents, combined with oral interviews, provided the Board with valuable information pertaining to work control and radiological protection concepts and practices that were in place prior to and during the accident

2.4.1. Documents Relating to the Control of Work

As part of the investigation, the team reviewed WGI/URS's work planning procedures; SPRU-ISM-002, *SPRU DP Integrated Work Control Program* and SPRU-ESH-001, *Job Hazard Analysis* Both documents contain phrases such as, as needed, as applicable, if necessary and as appropriate The work documents reviewed below also indicate that these types of phrases are widely used in the detailed work steps.

CNS-FWP-1350, Rev. 0, *Vent and Drain Piping, Equipment and Components in Building H2* (Date approved February 4, 2010, work started March 1, 2010, date completed July 1, 2010)

The scope of work was to perform radiological surveys, monitoring and set boundaries; identify and post boundaries; identify Lockout/Tagout (LOTO) points, tap and drain locations; drain piping, equipment components and sumps; and dispose of waste per SPRU-WMP-001.

The package was written and performed to remove liquid from piping, components, and sumps in Building H2 by installing hot taps where installed valves could not be used, at system high and low points per Attachment A, *H2 Low Point Drain Table*, of the work package Once the hot taps were installed, the vent and drain valves were operated and any liquid residing in that portion of the system was collected for characterization and disposal Sampling of the bulk liquids was performed in accordance with SPRU-RC-119, *Sample Collection* and SPRU-DD-007, *SPRU Disposition Project Characterization Plan*. Radiological Controls personnel were required to perform surveys for contamination control During interviews, the project radiological engineers stated that the sampling performed during the execution of this package was for the purpose of characterizing the waste liquid for disposal None of the information was intended to be utilized to assess the condition of the remaining system internals with regard to demolition

STW-FWP-1990, *H2 Demo Prep*
(Date approved May 4, 2010, work started June 9, 2010, Demo Ready Checklist completed September 22, 2010, date completed October 13, 2010 however, not yet closed out)

The scope of work was to identify locations and/or systems requiring additional characterization and/or decontamination on Attachment A, complete an inventory of legacy waste, obtain concrete samples for chemical and radiological characterization, stabilize contamination prior to work activities, decontaminate surfaces per Attachment A, lock down (i.e apply fixative to) surfaces, complete Demo Ready Checklist, document and dispose of waste, follow radiological calculation (RC)-302, OPS-008, and RC-303, CNS-FWP-1350, using hazard controls identified in Job Hazard Analysis (JHA)-104 and RWP-#35

The second note immediately following the Scope heading read as follows:

> "SPRU-302, *Conditions for Demolition Technical Basis*, with stating that "no decontamination is required prior to demolition for off-site dose considerations as long as the source term and mitigations are consistent" with the documented source term calculations
>
> The intent is to stabilize the contamination where necessary and demolish the H2 Building in open air with excavator-mounted equipment This work package provides instructions for decontaminating target areas when a source term exceeds expectations, when decontamination is needed for ALARA purposes, or when it is required by the Waste Acceptance Criteria (WAC) "

Section 5 1 covered evaluation of the 332' elevation for pre-demolition activities by reviewing the radiological survey data and that Radiological Engineering would determine whether additional radiological characterization is necessary Attachment A, *H2 Elevation 332 Demo Prep Action Items*, would be updated as necessary. Columns 112-A, 112-B, 113-A, and 113-B and evaporator condensers 221-A and 221-B extended from the 319 elevation through the 332' elevation, however, they were not identified on Attachment A None of the items listed in the attachment were considered to require decontamination or lock down. The only item encountered on the attachment was item #1, which was identified as "KAPL legacy waste, tank

sampling device " The identified action was to "Characterize boxed legacy waste and confirm it can be left in the building." No further characterization was identified on the 332' elevation as a result of this effort The section further states, "If required, obtain additional characterization data as described below: . . " Step 5 1 2(A through D) detail how to perform characterization for surface areas, piping, ducts, and materials or other equipment "as necessary "

Subsequent sections governed demo preps for elevations 319' and 309' No evaporator columns or components were identified and documented on Attachment A during execution of these sections

Other sections in the package included decontamination/removal of piping, if required and decontaminate process system components, if required. Only a single Radioactive Material Laboratory pipe was identified. Additionally, there were sections directing "lock down structural surfaces" and "lock down sumps " These sections resulted in the application of fixative as governed by RC-302. No verification of coverage or radiological survey was required following the application of the fixative. There were no surveys provided to the Board for overhead structures or component internal surfaces

The remaining sections covered the disposition of legacy waste, and demobilization The demobilization section (5 12) contained the only hold point signature that was obtained prior to approval of Attachment B, *H2 Demo Ready Checklist*. The EM-22 trip report identified that the remaining twelve hold point signatures had not been obtained during their visit on the 12th of October Subsequently, a change was made to the work package and the steps were signed off on October 12, 2010 and October 13, 2010 The signatures were obtained six weeks after approval of the *H2 Demo Ready Checklist* on September 22, 2010. None of the personnel approving the checklist identified the missing hold point signatures as a problem at the time of approval. Additionally, the checklist was approved with un-marked checkboxes in Sections 4, 5, and 7 of the checklist.

STW-FWP-2130, *G2 & H2 Buildings and G2H2 Tunnel Demolition*
(Started planning April 6, 2010, date approved August 10, 2010, work started September 23, 2010, date completed: in progress)

Scope of work regarding the demolition of Building H2 included Hot and Neutralizer cells, loading and disposing of waste per SPRU-DP-301 and 302.

PPP-FWP-2130 indicated that the H2 demolition was planned to be performed in an "open air" environment, with reliance on the application of fixative to "lock down" contamination in equipment and components during execution of STW-FWP-1990, combined with the use of misting during demolition.

Demolition of Building H2 began on September 23, 2010 A barrier, a chain-link fence, was erected around the structure Additionally, although it was not clear when, the area was posted as a Radiological Buffer Area Hoses were staged for the application of water for dust suppression.

Work was being conducted in Building G2 under section 5.4 of the work package. A HOLD POINT was signed by the WS on September 10, 2010 signifying that an anti-projectile fence is in place around the east side of Building G2, although the previous step containing a HOLD POINT had yet not been completed This step was later signed again on September 22, 2010 after the previous hold point condition had been met

Building H2 was confirmed ready for demolition by the D&D Operations Manager on September 23, 2010, as documented in step 5 5.1 H2 ventilation was secured. Demolition work progressed from the South face of the building toward the North and was documented in the Work Status Log, although two separate versions of form SPRU-209, *Work Package Status Log*, were found to be in use containing broken chronology. The work package record contains several changes over the course of the work. In accordance with the SPRU-ISM-002, the process involved inserting new pages and writing the word "superseded" across the pages to be removed. The last step found in any version of the PPP-FWP-2130 regarding the above grade demolition of Building H2 prior to October 5, 2010 was to demolish the H2 stack in step 5 5 12. The only mention of tank removal appeared in Section 5 10, *Complete Demolition of Building H2*

2.4.2. Authorization of Work

The daily operations at SPRU were planned and approved in accordance with the SPRU Disposition Project (SPRU DP) integrated work control program document SPRU-ISM-002, Rev. 11

Section 6.6 states:

> "Plan of the Day (POD) meetings are held to discuss work performed in the previous 24 hours and work to be performed during the next 24 hours On Friday, the POD meeting includes discussion of scheduled weekend activities and work scheduled for the following Monday Resource loading for activities shall be discussed, if requirements are changed as compared to those previously planned at the POD meeting. Completed activities should be identified and removed from the schedule prior to the next POD meeting.
>
> Deviations from the schedule to allow for emergent work items and other unforeseen problem areas shall be identified in the POD meeting, and the work shall be scheduled accordingly "

Section 6 7 states;

> "The SPRU DP work release process establishes multiple barriers for safe accomplishment of the work The first barrier is a POD signed by the OM that is used to authorize work for the day; the second barrier is the use of an integrated work review process that includes screening to the facility safety basis documents and the use of pre-requisite hold points; the third barrier is the authorization of each work package by a designated release authority Work may also be

authorized independently by the OM outside of the POD meeting. At the POD, planned work activities are reviewed to ensure that individual work activities do not impact other work activities."

The Board observed the wide-spread misconception of Phase I and Phase II demolition activities "Phase I," was intended for the demolition of the aboveground structure, which was primarily the portions of the facility building structure which met WGI's D&D release criteria. "Phase II" referred to the demolition of the below grade (332' elevation), contaminated portions of the facility. The Phase I/Phase II approach is discussed in; 1) the Stormwater Pollution Prevention Plan (SPPP), SPRU-ENV-002, and in the Stormwater Management Plan, dated August 5, 2010, included as Attachment H to PPP-FWP-2130, *G2 & H2 Buildings and G2H2 Tunnel Demolition*.

2.5. Post Event Anomalies

2.5.1. Overflowing FRAC Tank and Leaking Berm Events

As reported by the DOE SPRU Manager, at about 0700, on October 1, 2010, DOE SPRU discovered a FRAC tank, which was used to collect water from the H2 hillside drain sump, to be overflowing with untreated hillside drain sump water. WGI did not have operators on duty to immediately switch the flow into the other tank.

WGI obtained samples of the water, which was found to be above regulatory discharge limits. The FRAC tank had about 17,000 gallons of available capacity as of September 30, 2010. The maximum amount of water previously collected in a day had been approximately 4,000 gallons. WGI believed there was a sufficient amount of capacity in the tank to handle the anticipated rainfall but the rain from the tropical storm exceeded the 100 year storm records.

Additionally, DOE-SPRU discovered that water had also been leaking from a berm that had been constructed against the door leading from the escape tunnel of the H2 basement. The water was flowing out onto the hillside within a posted soil contamination area. Analysis of this water indicated levels of radioactivity approximately 100 times the discharge limit for the SPRU treatment system. Some contamination (about 40,000 dpm beta/gamma) was found above the discharge in the soil contamination area, but no elevated counts were found outside the soil contamination area.

2.5.2. Hillside Drain Pump Failure

At about 2140, on October 25, 2010, during a steady rain, a WGI operator performing rounds discovered that water overflowing from an overflow line to the culvert at the base of the hill below the SPRU site. The operator then discovered that the sump pumps in the hillside drain system were not working. A malfunction in the control panel caused the sump pumps to be inoperable. Additionally, although the emergency generator was not required, the failure was such that the emergency generator would not have been able to supply power to the pumps. WGI called in electricians and repairs were made within about three hours of discovery. KAPL estimated that approximately 630 gallons of water was released during the event.

2.5.3. FRAC Tank Labeling and Posting Issues

On October 28, 2010, during a familiarization tour of the area north of the H2 pad, the Board observed three FRAC tanks In response to the heavy rains and subsequent overflowing of one of the tanks, the three tanks had been piped together to provide additional capacity. The Board observed, and informed WGI of inconsistent and incorrect posting on the tanks. Specifically, one tank was labeled as empty; two tanks had radiological warning labels indicating internal contamination while the other tank had a radiological label indicating radioactive material. Not all openings had radiological warning labels attached When the Board returned the following week the labeling had not been corrected.

2.5.4. Paperwork Discrepancies

The Board reviewed numerous radiological surveys The team noticed two removable contamination surveys conducted September 10, 2010, had exact contamination count readings for the first 18 results indicating that wrong survey data was used for one of the surveys.

The Board was provided copies of RWP SPRU-DP-042, Rev 1 dated June 30, 2010, and SPRU-DP-10-042 Rev 0, dated April 30, 2010 The copies provided indicated a change to the RWP from work package 2130 to 1990. There was no documentation of who made the change and the changes were pen and ink to the copies provided to the Board.

Additionally, numerous other surveys reviewed by the Board included pen and ink changes made after the survey was signed off by the original surveyor without documentation of who made the changes or when the change was made

The Board was told that a survey of a bolt that was ejected from the demolition area was performed on September 29, 2010. The survey was not documented until approximately one week later. No documentation of the September 29th survey was provided to the Board by WGI RCT2 who performed the survey was on vacation and provided survey results via telephone discussion with his supervisor, who subsequently documented the survey indicating fixed contamination levels less than 5,000 dpm/100 cm^2 beta/gamma. The supervisor documenting the survey recorded the wrong type of instrument which resulted in underestimation of the contamination levels Had the appropriate instrument been recorded, the results would have been approximately 24,000 dpm/100 cm^2 beta/gamma

The demobilization section (5 12) of work package **STW-FWP-1990,** *H2 Demo Prep* contained the only hold point signature that was obtained prior to approval of Attachment B, *H2 Demo Ready Checklist* The EM-22 trip report identified that the remaining twelve hold point signatures had not been obtained during their visit on October 12, 2010 Subsequently, a change was made to the work package and the steps were signed off on October 12, 2010 and October 13, 2010 The signatures were obtained six weeks after approval of the *H2 Demo Ready Checklist* on September 22, 2010.

2.6. Current Status of Building H2 Footprint

Building H2 debris was stabilized by moving all of the waste into a pile within the footprint with heavy equipment. Fixative was liberally applied to the pile several times. After Tropical Storm Nicole passed, openings in process system columns were covered. Several days later the sharp edges were mitigated by placing pallets and hay bales where potential problems were identified prior to covering the debris pile with tarps. Layers of tarps were then placed over the pile and secured with sandbags. A John Deere excavator was surveyed and released from the area to the south end of the building. Building H2 footprint remains posted as a Contamination Area. D&D operations remain suspended, pending completion of a comprehensive corrective action plan.

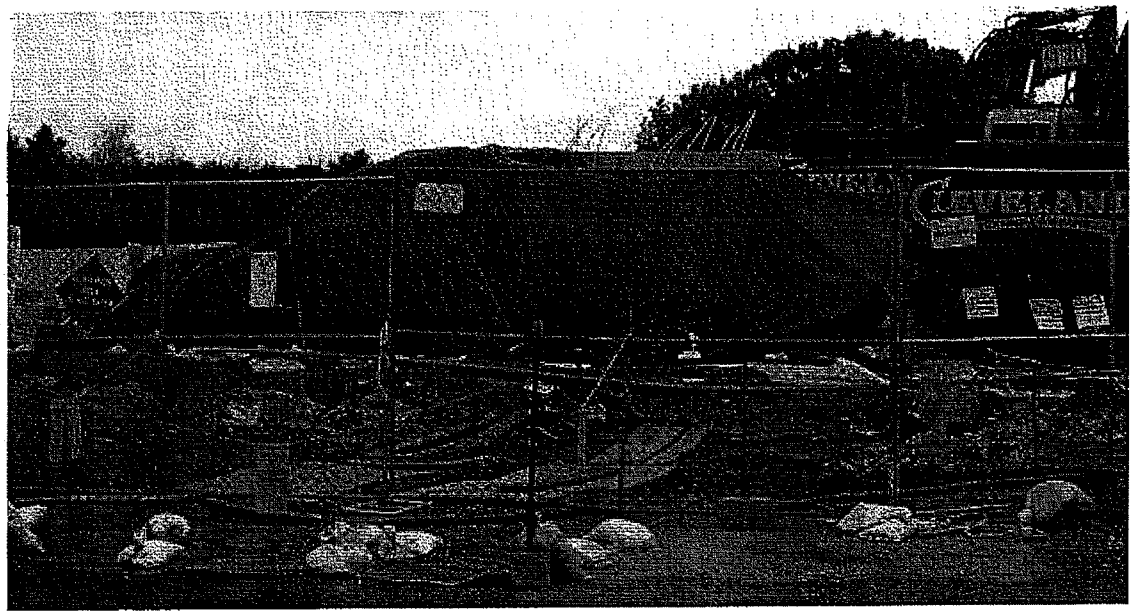


Figure 2-4: Building Footprint Taken Afternoon of October 23, 2010

2.6.1. Contamination Levels

Radiological surveys taken on October 5 and October 6, 2010 recorded on-site contamination levels, on the Building H2 slab, following attempts to lock-down the contamination after the event, of close to 1,700,000 dpm/100 cm^2 (4 mrad/hr) removable beta/gamma and over 11,000 dpm/100 cm^2 removable alpha.

An NRLFO representative stated that contamination was found over an area of approximately 104,000 square feet on the KAPL site as a result of the incident. Review of KAPL post September 29, 2010, survey results shows that there were numerous small areas spread over approximately one half of the 104,000 square feet that had average readings of 20,000 to 40,000 dpm/100 cm^2 beta/gamma. There was one small area with an elevated reading of approximately 150,000 dpm/100 cm^2 beta/gamma.

The NRLFO representative stated that the majority of these areas have been decontaminated to KAPL contamination limits They also stated that air monitoring samples taken down hill at the discharge area to the Mohawk River, although below any limits, indicated some low level of elevated radioactivity Additional monitoring of this area may be needed to help quantify the extent of the contamination event

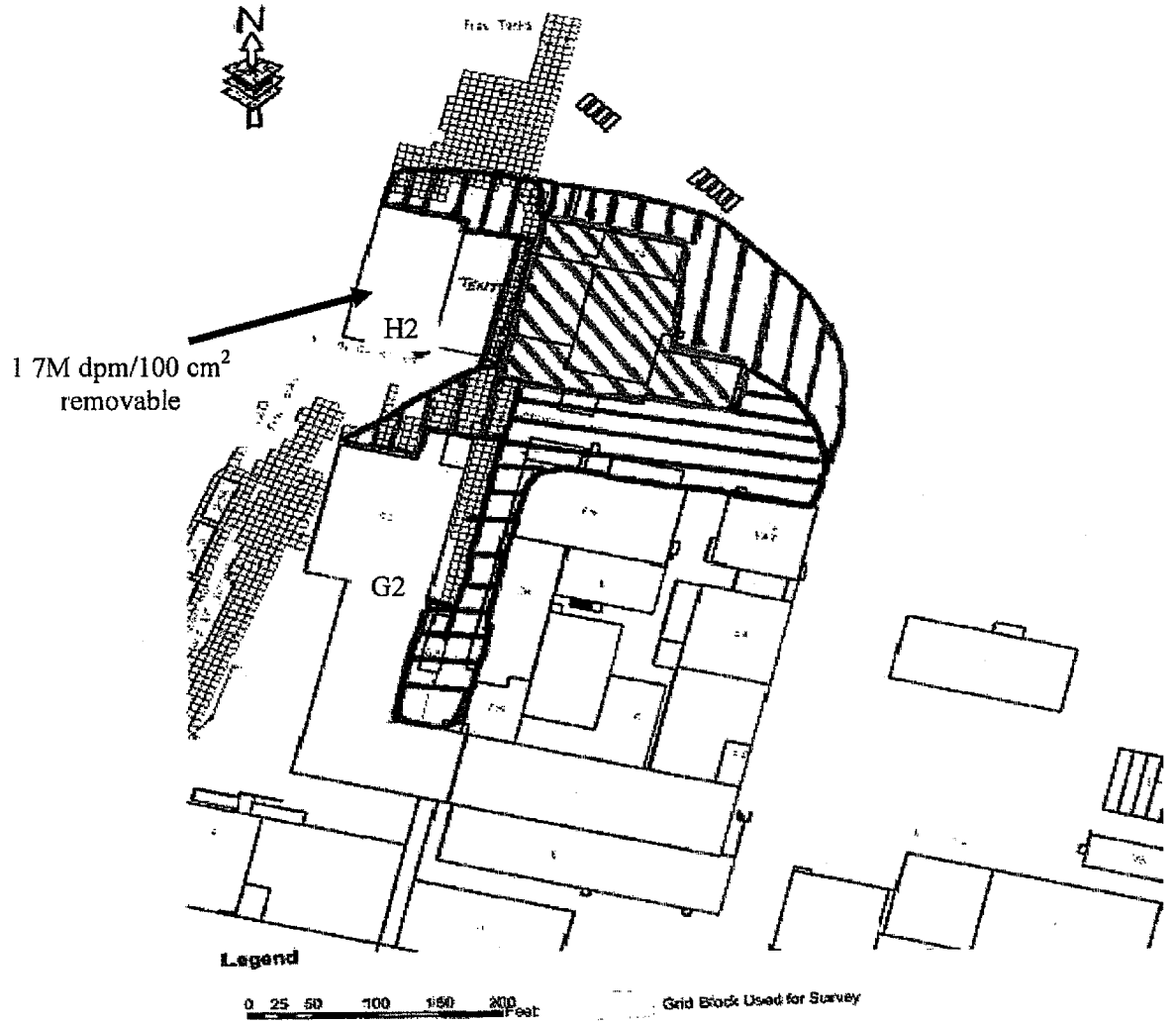


Figure 2-5: Approximate Area of Contamination

Note: KAPL provided the Board with data that there were some spots of contamination (spots less than 12,000 DPM) on the roofs of Buildings E4/E5 that are not shown on the above map KAPL stated that workers decontaminated these spots.

2.7. Investigative Readiness and Scene Preservation

Several factors impacted the ability of the Board to make an appropriate assessment of WGI's investigative readiness On September 30, 2010, actions were taken to control storm water runoff from incoming Tropical Storm Nicole. Those preparations and the subsequent record rainfall exacerbated both the contamination event and the ability to identify contamination locations The magnitude of the event was not identified for five more days, following the storm. WGI had a procedure for event reporting and investigation, SPRU-EESH-005, Rev 4, *Event Investigation and Reporting Manual*. That procedure provided sufficient information and direction that, if followed, would result in proper categorization, notification, reporting, and follow-up for this event

DOE appointed a Type B Accident Investigation team on October 22, 2010 The accident scene was not preserved

3.0 Analysis of Facts

3.1. Authorization of Work

Sections 6 6 and 6 7 of SPRU-ISM-002, Rev. 11, *SPRU-DP Integrated Work Control Program* are conflicting The Section, 6.6, states that emergent work shall be identified in the POD meeting and scheduled accordingly, while Section, 6.7 states that the OM can independently authorize work outside of the POD meeting See Section 2 4 2: Authorization of Work.

The work planning, approval and execution process for work conducted on the day of the event, September 29, 2010, consisted of a POD meeting at 1530 on September 28, 2010, that provided an updated status of work in progress and planning for the work to be conducted the following day A document referred to as the POD showed work package approval status and expected work package start and finish dates The POD document was updated after this meeting and a revised POD was issued around 1900 that evening that included the current scheduled work updates On September 29, 2010, at 0645, a supervisor's meeting occurred in preparation for a 0700 meeting with the work crew. At 0800, WGI management held a work status meeting.

Prior to the 0645 meeting on the morning of the event, the WS mentioned to the Operations Manager (OM) that the evaporator columns protruding on the 332' elevation of building H2 needed to be removed The OM was unsure whether the columns should be removed during the current phase of the project so he discussed the feasibility of removing the columns at the 0800 production meeting At the 0800 managers meeting, the OM received no objection to tank removal from attendees at this meeting. The OM then left the 0800 meeting and discussed removal of the columns with the ESH&Q/Radiation Control Manager (RCM) to get additional verification that removing the columns would not pose a hazard The RCM indicated to the OM that he did not see any reason why the columns should not be removed The removal of the columns, however, was never added to the POD, nor was it required to be added to the POD The decision to remove the columns was passed down to the Cleveland Wrecking Supervisor who directed removal of the columns. Execution of work occurred without the knowledge of several key members of WGI management, including the Deputy Project Director, the Work Planner who wrote the package, and the SEC Manager/Rad Protection Superintendent

This sequence of operations on the day of the event demonstrate a failure in the planning and work execution process described in SPRU-ISM-002, Rev 11, Section 6 6, *Work Coordination*, since the removal of the columns was not discussed at the POD the day before the event In addition, the barriers for safe conduct of work discussed in Section 6.7, *Work Release*, were not effective because the work was not planned on the POD as required by the first barrier. The second barrier, use of an integrated work review process that includes screening to the facility safety basis documents and the use of pre-requisite hold points, was also not in place, since further characterization of the facility, specified in the safety basis documents, does not appear to the Board to have been performed Characterization of removable contamination levels within the process piping and columns associated with the evaporation process may have resulted in

hold points in the work package requiring careful review of the work package to ensure compliance with not only hold points but also work package scope prior to the event. Finally, the work package was written for the entire H2, G2 and H2/G2 tunnel demolition. Because of the broad work package scope, there was little opportunity for barrier three to be effective since specific work release by a designated work release authority for Building H2 demolition was already performed 19 days earlier. Releasing work this far in advance with no subsequent discussion at the POD meeting of specific work to be conducted the next day does not provide the rigor needed to control execution of hazardous work activities

The Board reviewed the Stormwater Pollution Prevention Plan (SPPP), SPRU-ENV-002, and the Stormwater Management Plan dated August 5, 2010. The Board determined that in accordance with the storm water plans, "Phase II" demolition actually commenced when either building G2 or H2 roof were breeched, and a means to collect and control runoff were required. When the radioactive contamination event occurred, the entire roof and all walls of the H2 build had been demolished

3.2. Radiological Controls

3.2.1. Radiological Work Permits

The demolition of Building H2 was conducted under Radiological Work Permit (RWP) SPRU-DP-10-059, Rev 0, *Prep and Demolish and Stage for Disposal the H2 Building and All Associated Waste,* dated September 23, 2010. The Board reviewed the RWP and associated surveys and discussed the requirements of the RWP with the workers who were in the area, the RCT1 providing job coverage and the individual who wrote the RWP. Review of a September 16, 2010, contamination survey showed that the 332' elevation working areas had removable contamination levels below 10 CFR 835 Appendix D values. Lower elevations had selected areas with contamination levels over 900,000 dpm/100 cm^2 beta/gamma on the floor. Associated pipes and components also had elevated levels of contamination. Accordingly, it was essential for personnel working in Building H2 to have a very clear understanding of restrictions from removing components for lower elevations. The Board identified the following weaknesses in the RWP and associated work control documents:

The RWP did not adequately describe the scope of work. The concept of a Phase I (H2 superstructure demolition) and Phase II (Subsurface removal of equipment) was not adequately understood or described.

- Review of a September 16, 2010, contamination survey showed that evaporator components being removed and downsized on September 29, 2010 came from an area with contamination levels over 900,000 dpm beta/gamma ^{2} on the floor.
- The RWP did not require RCT coverage for removal of the columns. Opening of processing equipment which held radioactive materials typically would require RCT surveying upon breaching a system
- There was an over reliance that the fixative was going to be extremely effective in preventing the spread of contamination. The interior of the flash column which was being size reduced

at the time of the event, contained inaccessible voids and baffles inside the column. It was extremely unlikely that fixative could have been applied to all surfaces. (See Figure 3-1and Figure 3-2.) Also pre-demolition contamination surveys were not performed in elevated areas within the building.

- The radiological contamination limiting conditions, 50 times the expected beta/gamma work area contamination levels did not reflect expected conditions
- Radiological surveys conducted after the fixative was applied focused on removable contamination levels. The Board believed that demolition activities involving components with very high levels of fixed contamination would require different radiological monitoring than those involving low levels of fixed contamination. Radiological surveys also were not performed to evaluate the demolition activities effect on disrupting the fixative
- Radiological smear surveys were not taken in upper elevations and in the interior of components.
- Contamination surveys to ensure compliance with Contamination and High Contamination Area posting and access control requirements were not required.
- Air monitoring to ensure compliance with Airborne Radioactivity Area posting and access control requirements were not required. Perimeter air monitoring indicated elevated airborne radioactivity levels of over ½ DAC. However, these samples were average values over 2 ½ and 4 ½ hour time periods. Integrated airborne contamination levels indicated levels well above 1 DAC-hour. Accordingly, monitoring data is not available to demonstrate that the DAC values were never exceeded. The Board noted that the breathing zone air sampler for a demolition worker on September 29, 2010 indicated airborne radioactivity levels in their work area which were well below levels requiring posting or other controls.
- The RWP required breathing zone analyzers (BZAs) for all equipment operators; only one of the three individuals requiring BZAs was issued one on September 29, 2010.
- The radiological limiting condition of 0.3 DAC was exceeded; however, this was never evaluated in subsequent reviews and critiques.
- On September 1, 2009, a dose rate survey was conducted on the 319 foot elevation of the west evaporator room. Contact dose rates of up to 45 mR/hr were documented on duct work. Despite this indicator of high internal radioactive contamination, workers were allowed to breach the systems without adequate contamination controls.
- The RCT1 providing intermittent job coverage did not perform periodic surveys and therefore did not keep work crews updated on radiological conditions as work progressed as required by the RWP. Even after noticing a mist or smoke rising from some equipment being size reduced, no radiological contamination survey was conducted. The RCT1 stated that for industrial safety concerns, they were instructed not to enter the work area.
- The work was not conducted under an engineered mister as specified in the technical basis document. A fire hose was used for part of the activity but its use was discontinued to wash the mud off a truck during the work evolution.

- The RWP did not require use of a Dust Boss to provide a mist during demolition of contaminated structures
- The requirement to notify the RCT of areas to be entered was not included on the RWP
- Comparison of the sign-in sheets with dates and times RCTs were in the area conducting surveys showed that, after the event, there were many entries into the area by RCTs who had not signed in on the RWP

Radiation protection personnel stated that prior to demolition work on Building H2, radiological postings were removed with the intent that anyone entering the building would notify the RCT of areas to be entered. Survey data demonstrated that Contamination Areas still existed in the building and would require posting per 10 CFR 835. The requirement to notify the RCT of areas to be entered was not specified on the RWP

3.2.2. Release Surveys

The Board reviewed release surveys for items and equipment releases from the area after the event. While the survey of an electrician's equipment bag was thorough in terms of levels of removable contamination, it failed to record results of direct scanning

The Board also reviewed a survey performed for the release of one of the excavators from the H2 area conducted October 14, 2010. The Board found the release survey to be inadequate for the following reasons:

- The survey consisted only of smear data points
- There were no friskings or direct measurements for total contamination
- There was no evaluation of potential contamination of inaccessible areas
- The WGI used a release value of 1000 dpm/100 cm^2 beta/gamma which was non-conservative given the isotopic concentrations discovered.

The survey was not performed in accordance with SPRU-RC-109, Rev 5, *Performing Radiation and Contamination Survey*, dated September 23, 2010 which states:

- 5 1 2 A - Incorporate techniques with contamination surveys to detect both removable and fixed contamination. Both types of survey measurements are required except in Fixed Contamination Areas or areas in which the background radiation levels do not permit a direct reading that is capable of detecting SPRU-RC-001, Table 2-2 values
- 5 1.2.C - Take smears of 100 cm^2 and count using a proportional counter for alpha and beta/gamma activity. The smears were not counted using a proportional counter It was common practice to count smears with types of instruments other than that specified in the procedure

In addition the survey was not performed in accordance with SPRU-RC-108, Rev 3, *Performing Surface Radioactivity Measurements*, dated March 10, 2010, of which Attachment A provides a description of methods used to decontaminate and release large equipment and materials from

radiological controls. This attachment was not completed prior to the release. WGI personnel stated that a more detailed survey specified in SRPU-RC-108 would be done prior to unrestricted release The Board noted that there was an annotation on the survey, at some unspecified time after the survey was written, stating that the survey was "conditional from H2 Demo" However, there is nothing in WGI procedures that describe "conditional" releases and which would require any additional surveys. WGI's position was that there are two levels of survey, demonstrated by post survey annotating survey documentation, was inconsistent with the scope of SPRU-RC-108 which clearly stated "This procedure applies to all types of surface radioactivity measurements performed by Radiological Control Technicians at the SPRU including unrestricted release surveys, and the documentation of the information and data."

SPRU- RC-108 is inconsistent with SPRU-RC-109 because it states in Section 4 1 1:

> "The complete assessment of a surface shall include direct measurements for radioactivity and measurements for removable radioactivity (smears) from representative portions of the surface.
>
> A In some instances, only one type of assay method may be needed for evaluation purposes (e g , removable activity levels) "

This step conflicts with Step 5 1 2A of SPRU-RC-109 as stated above.

In addition, as a job aid, the survey sheets should include a block indicating the survey time, which is required by the procedure Some surveys reviewed failed to include the time

3.2.3. Other Surveys

When RCT2 surveyed the bolt which was ejected from the work area during demolition, he found elevated fixed contamination readings and stated he notified his supervisor This indication of uncontrolled spread of radioactive material prompted no corrective action from SPRU

When RCT1 frisked out the demolition workers, on September 29, 2010, he had to relocate the friskers because of an increase in background radiation levels This change in background readings was not adequately evaluated.

On the afternoon of September 29, 2010, WGI evaluated two perimeter air samples showing elevated readings when they were counted at approximately 1345. A follow up assessment of these samples was a gamma spectroscopy scan looking for Cesium-137 Subsequent analysis showed that the predominant isotope was not Cesium-137 (it was Strontium). Had WGI done adequate radiological characterization before the event, a more appropriate analysis may have been performed.

When RCT2 performed additional surveys of the area to the east of Building H2 on September 30th, he could not assess whether there was an increase in the counts due to the lack of a baseline survey prior to the event. The survey technique employed was based on an assumption that

radioactive contamination would be primarily Cesium-137. However, subsequent analysis indicated that Cesium-137 was not the predominant isotope (it was Strontium). Had WGI completed adequate radiological characterization before the event, a more appropriate evaluation may have been performed

3.2.4. Air Monitoring Results

Prior to initiating open air demolishing of the Building H2, on September 23, 2010, WGI began monitoring the perimeter of the Building H2 area with 10 air samplers. Following the identification of the four equipment operators with personnel contamination exiting the Building H2 work area, WGI analyzed the perimeter air samplers by counting them on a proportional counter both for alpha and beta/gamma contamination. The alpha readings are used to evaluate Plutonium-239 and Americium-241 airborne radioactivity levels and the beta/gamma readings are used to evaluate Strontium-90 and Cesium-137 levels. The highest readings were noted on the air samplers along the east side of the Building H2, adjacent to the property line fence for KAPL. The results indicated airborne radioactivity levels had reached between 70 to 90% of the 10 CFR 835 DAC values

Use of occupational DAC values for evaluation of perimeter air monitoring results is very non-conservative for worker protection consideration. The perimeter air monitoring samples did not represent the breathing zone of the workers. The 10 CFR 835 DAC values are based on air concentration values which, if a worker were exposed to, would result in an occupational dose at the regulatory limit for workers, which is 5 Rem Total Effective Dose or 50 Rem Total Equivalent Dose to any organ. The dose limits for offsite doses are significantly lower.

Subsequent, to the event, WGI sent the air samples to an offsite laboratory for isotopic analysis. On October 18th the offsite laboratory provided the sample analysis results. As indicated in the following table the isotopic analysis was consistent with the earlier evaluation of the air sample results

Table 3-1: Isotopic Analysis of East Side Perimeter Air Samples

Isotope	Sample 1- Percent DAC	Sample 2 - Percent DAC
Sr-90	0.5%	0.5%
Pu-239	57%	74%
Am-241	Not detected	Not detected
Cs-137	Less than 0.1%	Less than 0.1%
Total	57%	74%

WGI determined that they had not exceeded one DAC at the perimeter. However, since the above samples are average values for time periods up to 4 ½ hours, WGI's monitoring was inadequate to demonstrate that this criteria was not exceeded

In addition, the Board reviewed the Building H2 perimeter air sampling results for the time period leading up to the event (September 23 to September 28, 2010). Although the results were significantly less than those discussed above, the Board noted that several (eight) of the perimeter air sample results showed positive signs of airborne radioactive material. Since the results were below the RWP Limiting Condition of 0 3 derived air concentration (DAC) there was no follow-up to identify the source. These results may have been an indication that the lock down of activity within the Building H2 was not 100% effective or that contaminated systems were being breached

3.2.5. Critique of Contamination Event

A critique of the incident was conducted on October 5, 2010. The Board reviewed the critique and noted the following:

- The critique stated that on September 29, 2010 perimeter air monitoring results were well below alpha and beta DAC action values. The critique used an incorrect DAC action level of 1 DAC. The RWP limiting condition was 0.3 DAC As noted above, the DAC values on two of the perimeter air samplers exceeded the RWP limiting condition and site air monitoring was inadequate to demonstrate that DAC values were not exceeded
- Also, both the critique and the Occurrence Reporting and Processing System (ORPS) Report stated that BZA samples were counted and were negative Review of WGI documentation shows that only one of the three equipment operators had been provided a BZA as required by the RWP. This was not addressed in the critique.
- The critique contained incorrect information on the results of contamination monitoring
- The WGI critique discussed the contamination levels in terms of cpm. Not converting the values to dpm makes it impossible to assess magnitude of the contamination level. The Board found this discrepancy on other critiques

3.2.6. Reporting of Contamination Event

On October 8th, WGI submitted: OPRS, EM---WGI-G2H2-2010-0001 This was reported as a management concern involving operational weaknesses after evaluation of two non-reportable events.

The Board does not agree with the assessment that the event of September 29, 2010 was non-reportable. The Board believes that the following two reporting criteria apply:

- **Group 6 - Contamination/Radiation Control**
  Subgroup B Spread of Radioactive Contamination

(1) Identification of radioactive contamination offsite due to DOE operations/activities that exceeds applicable DOE-approved authorized limits (See DOE 5400 5 or, if there are none, the values found in 10 CFR Part 835, Appendix D)

[Note: All releases of property containing or potentially containing residual radioactivity are subject to requirements in DOE 5400.5 Compliance with 10 CFR Part 835, Appendix D values does not necessarily satisfy the requirements in DOE 5400 5]

(2) Identification of onsite radioactive contamination greater than 100 times the total contamination values (see 10 CFR 835 Appendix D) and that is found outside of the following locations: Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, Radiological Buffer Areas, and certain areas that are controlled [defined in 10 CFR 835 1102(c)]

WGI personnel stated that after the September 29, 2010 contamination event, they posted the area as a Contamination Area and accordingly, any subsequent contamination found was in a posted Contamination Area. The Board disagrees with this position: it appeared likely that before the area was posted the contamination levels existed.

In addition, the Board observed that the area around Building H2 pad was posted as a Contamination Area Review of October 5 and October 6, 2010 survey data shows that a more appropriate posting would be a High Contamination Area On the pad after attempting to lockdown the contamination after the event, surveys in the debris pile of close to 1,700,000 dpm/100 cm^2 (4 mRAD per hour) removable beta/gamma and over 11,000 dpm/100 cm^2 removable alpha was identified. WGI stated that because the area was under a tarp it did not require additional posting The Board disagrees; the use of a tarp does not make the area inaccessible.

WGI personnel also stated that KAPL was considered part of their site. However, KAPL's operations are not under the WGI's Radiation Protection Program or other controls The Board bases this determination on review of radiological survey reports and maps which were developed post the September 29, 2010 event. These surveys show KAPL site contamination levels in the range of 20,000 to 40,000 dpm/100 cm^2 beta/gamma over several thousand square feet

The Board reviewed the WGI Apparent Cause Analysis dated October 28, 2010. The Board noted that while the occurrence report was filed as a Significance Category 2, the resulting monetary and other impacts drove this event to be investigated as a Type B Accident Investigation. That corrective action plan stated a "rigorous causal analysis" would be completed, however, the Apparent Cause Analysis methodology may not lead to identification and correction of root causes identified using more rigorous cause methodologies.

3.3. Previous Events and Lessons Learned

The following three events and their corrective actions highlight weaknesses in both work planning and control and the radiological protection program.

3.3.1. Arc Flash Event

On September 18, 2009, while performing utility isolations in building G2 panel 1-2, in order to achieve a "cold and dark" condition for the established work area, an arc flash was generated upon cutting a 480 volt electrical line There were no injuries due to this event. The primary causes of the event were ineffective execution of the work control process for making and obtaining approval for changes, coupled with improper accomplishment of zero energy checks

3.3.2. Unanticipated Airborne Radioactivity

On January 25, 2010, five days following the exit of five individuals from Room 103 in G2, an air sample taken by RCT1 covering the entry was counted and indicated 6 9 DAC alpha and 0 3 DAC beta/gamma The area was subsequently posted as an Airborne Radioactivity Area. Corrective actions focused on obtaining bio-assay samples for the individuals involved and ensuring future samples are representative of the breathing zone Lessons learned focused on sampling location as well.

3.3.3. Personnel Skin Contamination Following Entry into Cell #1 of Building G2

On February 26, 2010, an RCT received skin contamination and an asbestos worker alarmed a PCM upon exiting from Cell #1 of Building G2. The event identified poor posting of anti-C doffing instructions, failure to establish communication and provide for backup personnel upon exit, and weak task instruction and procedure compliance

3.4. Conduct of Operations

The SPRU -DP Conduct of Operations Program is implemented by SPRU-COO-001, *Conduct of Operations Program*. SPRU-COO-001, Rev. 0, including a compliance matrix, was conditionally approved by the DOE Contracting Officer Representative by letter SPRU-IN-0010 on May 15, 2008, pending incorporation of nine DOE comments DOE Comment No 9 relating to Chapter 16, Requirement C.7, stated:

> "Needs to state or provide the exception that procedures and work packages will be followed step by step manner unless otherwise specified "

The SPRU Disposition Project Manager responded to the DOE Contracting Officer Representative by letter DE-AM09-05SR22414-08-052, on June 11, 2008, that included SPRU-COO-001, Rev 1

The document currently in effect is SPRU-COO-001, Rev. 3, dated May 12, 2010 Deviations, Exceptions, and Clarifications associated with individual requirements have changed significantly after Revision 1, but it is not evident that DOE has been involved in approving those changes Revision 1 included two Deviations, six Exceptions, and 22 Clarifications, while Revision 3 includes 27 Deviations, 36 Exceptions, and 14 Clarifications.

Contractor management was not aware of feedback from the workgroups that fixative application did not ensure 100% coverage for some components. (EM-22 SPRU Trip Report)

The EM-22 evaluation of conduct of operations as was documented in the SPRU Trip Report identified the following areas of deficiency:

- Several hold point signatures were not completed during the performance of Building H2
- Demolition Prep work package (STW-FWP-1990), however work continued and the absence of the signatures was not noted until EM-22 requested a copy of the package.
- Misting was utilized during the building demolition for dust and airborne radioactivity suppression Two individuals indicated, however, that on the day of the contamination event, September 29, 2010, the misting hose was directed away from demolition activities to wash the tires on a truck leaving an adjacent area.
- Deficiencies were noted with the work package sign-off process. On Building H2 demolition work package (PPP-FWP-2130) and associated checklists, one individual signed off as the Decontamination and decommissioning (D&D) Supervisor, the Radiological Control Supervisor, and the Radiological Engineer (signing off for both the D&D group and the RP group represents a conflict of interest). It was also noted an alternate to the Operations Supervisor signed and authorized work under work package PPP-FWP-2130; however, interview of this alternate identified they were not familiar with building demolition activities.
- Forms used to document pre-job briefings were generic and provided no details on what was discussed in the briefing.

The EM-22 SPRU Trip Report also documented that communications were ineffective between the participating organizations and workgroups. The "Phase I/Phase II" approach for demolition was not understood by the work planners

The Board validated the issues identified in the EM-22 SPRU Trip Report, with the exception that the activity referred to as "misting" in the report was actually wetting of the construction area with an inch and one-half fire hose rather than using a "Dust Boss" that is associated with misting. The Board also identified similar and additional examples of the EM-22 identified issues, which are included in the work control section of this report

3.4.1. Paperwork Discrepancies

The Board reviewed numerous radiological surveys. The team noticed two removable contamination surveys conducted September 10, 2010, had exact contamination count readings for the first 18 results indicating that wrong survey data was used for one of the surveys.

The Board was provided copies of RWP SPRU-DP-042, Rev 1 dated June 30, 2010, and SPRU-DP-10-042 Rev 0, dated April 30, 2010. The copies provided indicated a change to the RWP from 2130 to 1990 There was no documentation of who made the change and the changes were pen and ink to the copies provided to the Board.

Additionally, numerous other surveys reviewed by the Board included pen and ink changes made after the survey was signed off by the original surveyor without documentation of who made the changes or when the change was made

The Board was told that a survey of a bolt that was ejected from the demolition area was performed on September 29, 2010 The survey was not documented until approximately one week later. No documentation of the September 29th survey was provided to the Board by WGI RCT2 who performed the survey was on vacation and provided survey results via telephone discussion with his supervisor, who subsequently documented the survey indicating fixed contamination levels less than 5,000 dpm/100 cm^2 beta/gamma The supervisor documenting the survey recorded the wrong type of instrument which resulted in underestimation of the contamination levels Had the appropriate instrument been recorded, the results would have been approximately 24,000 dpm/100 cm^2 beta/gamma

The demobilization section (5 12) of work package **STW-FWP-1990**, *H2 Demo Prep* contained the only hold point signature that was obtained prior to approval of Attachment B, *H2 Demo Ready Checklist* The EM-22 trip report identified that the remaining twelve hold point signatures had not been obtained during their visit on the 12th of October Subsequently, a change was made to the work package and the steps were signed off on October 12, 2010 and October 13, 2010. The signatures were obtained six weeks after approval of the *H2 Demo Ready Checklist* on September 22, 2010

The Board was concerned with the numerous instances of questionable documentation practices.

3.5. Integrated Safety Management

WGI utilizes SPRU-ISM-002, *SPRU DP Integrated Work Control Program* to prepare, authorize and conduct work Although lacking detail in some areas such as the categorization of work, approval and change control process, the board determined that overall, the work planning procedure provided sufficient guidance to produce an adequate work document This is also supported by the EM-22 Trip Report conclusion regarding work planning and control

3.5.1. Define the Scope of Work

The Board determined that the majority of documents reviewed contained detailed scope of work sections that provided sufficient detail to the planning group to prepare the work package. However, the detailed work steps developed from the scope lacked the necessary level of rigor and detail to ensure that the scope of work would be executed as described in the project plans and technical basis documents. One specific example that was a key decision point related to the event was step 5 1 1 of STW-WP-1990. The step stated:

> "Review existing conditions for H2 Elevation 332 by performing the following:
>
> A. Review the radiological survey data. Radiological Engineering shall determine whether additional radiological characterization is necessary. Update Attachment A, H2 Building Elevation 332 Demo Prep Action Items as necessary."

The step did not provide radiological criteria for making the determination as to what qualified as needing further characterization. This was left up to the opinion of the Radiological Engineering.

During interviews, the project radiological engineers stated that the sampling performed during the execution of the vent and drain work package was for the purpose of characterizing the waste liquid for disposal. None of the information was intended to be utilized to assess the condition of the remaining system internals with regard to demolition. The Board identified this as a missed opportunity to further understand the contamination that would be encountered when disassembling system components.

3.5.2. Analyze the Hazard

Table 3-2: Comparison of Original and Current SPRU DP Radiological Inventory[1]

Nuclide	Inventory Description/Location			
	Surface Contamination within G2 and H2 Facilities [2010 Facility Estimate] (Ci)[2]	Surface Contamination within Tank Farm Tanks [2010 Facility Estimate] (Ci)	Residual Contamination within Tank Farm Tanks [2010 Facility Estimate] (Ci)	Total SPRU DP Activity [2010 Facility Estimate] (Ci)
Sr-90	1 00/[2 00]	2 81/[2 81]	39 00/[26 51]	42 81/[31 32]
Cs-137	2 40/[13 50]	6 45/[6 45]	24 01/[39 63]	32 86/[59 58]
Pu-239	0 24/[1 58]	0 90/[0 90]	8 91/[8 64]	10 05/[11 12]
Am-241	0 03/[0 22]	0 10/[0 10]	1 16/[1 06]	1 29/[1 38]
Totals	3 67/[17 3]	10 26/[10 26]	73 08/[75 8]	87 01/[103 4]

Information included in SPRU-FHC-001, Revision 1, *SPRU Disposition Project Final Hazard Categorization*, dated August 12, 2010, included an increase in radiological inventory in the G2 and Building H2 facilities Surface contamination activity values for Pu-239 within the G2 and Buildings increased from 0.24 Ci to 1.58 Ci The amount of Pu-239 necessary to exceed the 10 CFR 835 limit of 50 Rem committed effective dose (CED) to the bone surface is about 12 nanoCi (12 x 10^{-9} Ci)

The proposed method of demolition was open air with the use of fixatives to control the spread of radioactive contamination Based on the relatively large amount (1.58 Ci) of Pu-239 estimated to be contained in surface contamination, release of a very small fraction could result in an unacceptable dose.

3 5 2 1. Technical Basis for Open Air Demolition

On September 29, 2010, D&D work continued at Building H2 The work was evaluated in SPRU-RC-302, *SPRU DP Facility – Conditions for Demolition Technical Basis Document*, dated March 16, 2010. This document states "The demolition of the G2/H2 facility and

[1] Source: SPRU-FHC-001, Rev 1

[2] Ci data outside brackets were included in DOE-SER-001, Revision 0, dated March 31, 2009, and Ci data inside brackets were included in SPRU Disposition Project Final Hazard Categorization SPRU-FHC-001, Revision 1, dated August 12, 2010

associated tank farm is constrained by offsite dose considerations to a maximally exposed offsite individual (MEOSI) for airborne releases. The EPA has established an offsite dose limit of 10 mrem per calendar year that the Project must satisfy. This paper reports the result of dose calculations using an approved pathways computer code (CAP88-PC) to demonstrate compliance with airborne release limits."

This technical basis document applies an inventory estimate developed by William Duggan (private correspondence) based on the 1989 measurements that were reported in 1992:

> "Characterization work to evaluate the inventory in the different parts of SPRU was carried out in several investigations detailed in the Preliminary Evaluation of the Status of the Separation."

The technical basis document describes the demolition as:

> "The proposed method for preparation prior to demolition of the buildings includes applying fixative to the accessible surfaces of the walls, floors, ceiling and equipment in the process cells and support corridors. The columns will be emptied, if required, under HEPA ventilation, and then fogged. Piping will be left attached to the columns. A Dust Boss will provide a mist during demolition of contaminated structures. A surfactant or tacking agent may be added to the water to improve dust suppression during load out operations. The buildings will be demolished in open air. The building debris will be size reduced as required and loaded into radioactive waste shipping containers for transportation and disposal in open air."

The technical basis also states:

> "A Dust Boss will provide a mist during demolition of contaminated structures." Use of a Dust Boss results in an offsite dose reduction factor of 0.30.

The technical basis concludes:

> "The G2/H2 facilities can be removed in open air in compliance with EPA and DOE regulations for offsite dose to the extent that the source term herein is validated by sample analysis and assumed mitigation methods are effective as indicated."

The Board found that the source term was not validated by sample analysis and the mitigation methods were not effectively implemented and their effectiveness was not assessed.

The technical basis assumes an isotopic composition with Cesium-137 contributing over 60% of the activity and Strontium-90 contributing approximately 25%. Air sample data obtained after the September 29th event indicated that this assumption was incorrect, the Strontium-90 contributed to the majority of the activity. NR personnel stated that their analysis of the contamination from the September 29, 2010 event indicated that Strontium-90 was the major

component of the activity (60 times greater than the Cesium-137 activity) The Board reviewed several radioactive waste profile records for various Building H2 waste streams Sample data from the spring and summer of 2010 indicated several waste streams where Strontium-90 activity predominated over the Cesium-137 activity. For example, a resin sample from March 2010 showed a Strontium to Cesium ratio of 3 to 1 This information was never used to revise or validate assumptions in the technical basis. It appeared that additional radiological characterization is warranted for Building H2 activities

3.5.2.2. Strontium Contamination Values

Appendix D to 10 CFR 835 lists surface contamination values One row states:

> "This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched "

DOE provides guidance on meeting this requirement in DOE G 441.1-1C *Radiation Protection Programs Guide for Use with Title 10 CFR 835, Occupational Radiation Protection*, dated 05-19-08

Section 11 5.0 states:

> The following application of Footnote 5 in Appendix D of 10 CFR 835 to Sr-90 combined with mixed fission products is considered an acceptable approach for compliance with 10 CFR 835:
>
> - Where the Sr-90 fraction is 50 percent or less, the mixed fission products surface activity values apply.
> - Where Sr-90 fraction is between 50 percent and 90 percent of the total activity, surface radioactivity values should be 3000 dpm/100 cm^2 or less.
> - Where the Sr-90 fraction exceeds 90 percent the total activity, Sr-90 surface radioactivity values should be applied to the material

SPRU-RC-302, *SPRU DP Facility – Conditions for Demolition, Technical Basis Document*, dated March 16, 2010, indicates that Building columns have more than half of their source inventory was from Sr-90. In addition, the Board review of isotopic air sample results indicated that the isotopic mixture consisted of close to 90% of the activity being from Sr-90. As stated above, NR and waste profile data indicate that more conservative Strontium values may be appropriate.

However, review of WGI's contamination surveys indicated that WGI was using the mixed fission products surface contamination values of 1000 dpm/100 cm^2 beta/gamma for removable and 5000 dpm/100 cm^2 beta/gamma for total for assessing Building H2 surface radioactivity values Discussions with WGI's radiation protection management indicated that WGI was initiating use of the lower Sr-90 removable value of 200 dpm/100 cm^2 beta/gamma; however,

this has not been reflected in WGI's procedures and the rationale for continued use of 5000 dpm/100 cm^2 beta/gamma for total surface radioactivity has not been developed.

3 5 2 3. Pre-Demolition Survey

The Board reviewed several of the surveys conducted prior to demolition activities. The surveys evaluated removable contamination levels. Discussion with survey personnel and review of documentation indicated that overhead elevations were not surveyed. The surveys were conducted to demonstrate that areas surveyed met demolition criteria from RC-302 as specified below:

> "Average contamination greater than 100 dpm alpha on a 100 cm^2 smear or greater than 5,000 dpm beta/gamma on a 100 cm^2 smear:
>
> - Suitable fixative shall be applied to accessible surfaces;
> - Apply fogging to inaccessible surfaces, as necessary (e.g. complicated geometry, columns)
> - Average contamination greater than 20 dpm alpha up to 100 alpha on a 100 cm^2 smear or 1000 dpm beta up to 5,000 dpm beta on a 100 cm^2 smear
> - Latex fixative or fogging may be provided/performed as applicable
> - Legacy covered or labeled contamination
> - Apply fixative in accessible locations to distinguish contamination during demolition and load out
> - Otherwise do not stabilize."

The Board noted that fogging was never applied as described above. Also post lock down surveys did not include surveying overhead structures and the interior of components.

The Board requested but did not receive radiological surveys results when the man-ways were removed to spray fixative inside the columns.

The Board review of the data indicated that the assumptions in RC-302 placed unreasonable expectations on the effectiveness of placing fixative on contaminated surfaces.

SPRU-FHC-001, Revision 0, *DOE Safety Evaluation Report for Separations Process Research Unit Disposition Project Final Hazard Categorization*, dated March 31, 2009, contained the following condition of approval (COA):

> "Condition of Approval #1, state, "URS/WD shall develop and implement a radiological inventory monitoring and evaluation process and periodically reviews new facility characterization data to ensure that the assumptions in the SPRU DP FHC remain representative and bounding (within the margins established in COA #2 below) The radiological inventory monitoring and evaluation process should work in conjunction with the change control process required by COA ."

DOE SPRU specified completion of COA #1 was due within 60 days of receipt of the DOE approval of the SPRU DP FHC (March 31, 2009)

DOE Safety Evaluation Report Addendum A For Revision 1 Of The Separations Process Research Unit Disposition Project Final Hazard Categorization (SPRU-PHC-001, Revision 1), Revision 0, dated August 11, 2010, accepted all COAs, including COA #1, in the original Safety Evaluation Report as having been adequately addressed The Board concluded that characterization of the facility was not adequate to support open air demolition of radioactive components in the Building facility

3.5.3. Mitigate the Hazards

The demolition of Building H2 was conducted under Radiological Work Permit (RWP) SPRU-DP-10-059, Rev 0, *Prep and Demolish and Stage for Disposal the H2 Building and All Associated Waste,* dated September 23, 2010 See Section 3 2 1 for a description of how this document was ineffectively implemented

The spraying of "fixative" appears to have been associated with a belief that doing so would preclude the possibility of any spread of radioactive contamination, so much so, that the term "locked down" was frequently and generally used by management, staff, and workers to describe how the fixative was used for contamination control; a clear over-reliance on the application methodology The Board noted that Figure 2-3, Figure 3-1 and Figure 3-2 illustrate that fixative was not applied to several surfaces of the evaporator system components.

JHA Number 104, Rev 0 was included as part of work package STW-FWP-1990. The JHA identified the work package as a Type 1 and associated RWP SPRU-DP-10-035 with the JHA The JHA for work tasks with radiological conditions included: "Adhere to RWP SPRU-DP-10-035 " However, work was documented in areas under radiological control from June 9, 2010 through August 18, 2010 The RWP start date and authorization to work signatures were August 25, 2010

Figure 3-1: Incomplete Application of Fixative to Separator Columns September 29, 2010

Figure 3-2: September 29, 2010 Post Column 113-A Removal

3.5.4. Perform Work within Controls

DOE-SPRU personnel were present at the 0800 meeting when the request to remove the evaporator system components out was made The information was shared with other DOE-SPRU personnel. Based on this discussion, though, the DOE SPRU Manager did not believe that contaminated components were being removed The Board noted that there was no apparent DOE follow-up to ensure that WGI was within the bounds of the approved work document

Work activities as recorded in the *Work Package Status Log* covered the period from June 9, 2010, through August 18, 2010. On October 10, 2010, a change to the work package was issued to remove steps 5.1.4, 5.2.4, and 5.3.4 from the work package. All three steps contained the following wording:

> "Radiological Engineering, Environmental, Industrial Hygiene and Waste Acceptance Criteria (WAC) representatives shall review the H2 Elevation [three elevations listed] Data Sheet, survey results, and characterization results, if any, to determine whether decontamination or lock-down is necessary or if the area can be left as is for open air demolition
>
> Is decontamination necessary Yes □ No □
>
> Is lock-down necessary? Yes □ No □"

Each of these steps also included hold points signifying that the data collected had been reviewed by signature and Attachment A, *H2 Building Source Reduction Data Sheet* was updated by the Radiological Engineering, Environmental, Industrial Hygiene and WAC representatives. This change was documented on the last page of the ***Work Package Status Log*** with the comment:

> ". this confirmation of necessary and completed actions is captured by the full set of signatures on the Demo Ready Checklist."

The Demo Ready Checklist does not make the same affirmation that the data has been updated and has three areas for which no "yes" or "no" check box is checked to indicate the specific items have been completed.

In addition to the 12 out of 13 hold points not signed prior to the work, the Board also noted that numerous hold points were removed from the work package after the event The removal of these hold points was not explained and not adequately documented by issuing the work package as a new revision.

The Radiological Engineer hold points addressed that radiological characterization results are consistent with the actions specified to be authorized. Radiological data, such as posted lock-down contamination and radiation survey results were not reviewed when these hold points were signed on October 13, 2010

3.5.5. Provide for Feedback and Improvement

Type 1 work packages are required by procedure to complete "lessons learned" as soon after the work package completion as possible. The Board reviewed the only available Separations Process Research Unit Disposition Project SPRU-DP Feedback Checklist associated with CNS-FWP-1350, and found the document to be adequate. The discovery of an unexpected energy source and recommendations for improving the task were included in the checklist. The Board also reviewed critique minutes for several events and found the feedback section to generally be adequate. However, it is not evident that lessons learned identified during performance of work and event critiques were incorporated into future activities.

3.5.5.1 Contractor Assurance System

WGI has established elements of a Contractor Assurance System (CAS). *Integrated Safety Management System Description*, SPRU-2008-ISM-001, Revision 5, dated September 28, 2010, lists DOE O 226.1, *Performance Assurance* [Incorrect title], as the reference, and indicates that the Assurance Plan per DOE O 226.1 [The current document is DOE O 226.1A] is integrated throughout the feedback mechanisms in the ISMS which is primarily implemented through the Project Quality Assurance Plan. *Project Specific Quality Assurance Plan*, SPRU-QAP-001, Revision 5, dated May 26, 2010, contains Attachment A, SPRU DP *Contractor Assurance System*. It was noted that *Management Assessments*, SPRU-PQP-019, Revision 1, March 26, 2009, does not reference DOE O 226.1A. The Board did not request, and did not review, the DOE document that approved the WGI CAS program description.

The Board confirmed the deficiencies identified in the EM-22 Trip Report that the majority of issues related to work-planning and contamination control had been identified by DOE, rather than by the contractor, and that a review of the issue tracking system identified prior issues similar to performance issues noted during the accident, which indicated the existence of potential recurrent problem areas.

Two weeks prior to the accident WGI completed an assessment of the WGI Radiation Protection Program relating to radiological monitoring compliance with DOE-STD-1098-2008, Article 134 was completed as part of a corrective action for a previously DOE identified issue. The assessment was conducted over a seven week period, and identified no issues. The Board noted that several assessment criteria that were determined to be fully compliant during the assessment were demonstrated weaknesses during the accident.

3.5.6. Integrated Safety Management Guiding Principles

During the interviews conducted by the Board, several personnel provided information about perceived production pressure. It is not clear to the Board what caused this production pressure, but appears to have been driven by project supervision and management personnel. Of specific mention were the Deputy Project Director and the Waste Superintendent. It was perceived that these two were brought into the project with the purpose of improving production and in one interview it was mentioned that they had been successful in performing this function. The management style used by these two individuals appears to the Board to have created an

atmosphere of fear among the workforce to speak up about issues of concern. During a POD meeting, attended by two of the board members, on Thursday, November 4, 2010, a strong production push was perceived for the accomplishment of scheduled work with little to no allowance for discussion from the workforce about any problems encountered in performing the work. The work planning staff reported that extreme schedule pressure existed when writing the package that would cover the Cleveland Wrecking work, since Cleveland Wrecking was on site and needed to start work. The conceptual drive for production is commended by the Board, however, open discussion between the work force and management about the work should be encouraged so that a questioning attitude is developed within the workforce. Concerns or questions about the work planned should be resolved before work is allowed to proceed. It should be clear to all workers on the project that there will be no retribution if they execute their stop work authority.

On the day of the event, there were workers at the site who felt unsure about whether the tanks should be removed but were afraid to express their concern to members of management controlling the work. RCTs were not allowed into the Building demolition area because of a concern for their safety. The Board questions whether the decision to remove radiological controls technician oversight from the demolition activity was made with production as the focus rather than focusing on the worker's radiological protection. When a concern was expressed to an RCT due to an abnormal noise heard by an electrician during size reducing of one of the condensers, the RCT stopped work to perform explosive gas samples. Once these samples were completed, however, the Board was informed that the Waste Superintendent admonished the RCT for stopping work indicating that the noise was to be expected during the material shearing process. It was also reported that a few hours later, when the egress frisker south of Building H2 was responded to by the RCT who believed his indications; the Waste Superintendent questioned RCT1's response since he believed that the alarming condition was caused by radiation "shine".

WGI supervision and management should employ management techniques that will improve communication between managers and workers. Questions should be encouraged during pre-job briefings. Work should not be commenced and should be stopped, if in progress, if there are unanswered questions from workers. A production driven environment should not exist such that unsafe work practices are allowed or perceived to exist by the workforce.

3.6. Event and Causal Factors Chart

After performing the barrier and change analyses, the Board assigned results from each analysis to events on the chronology of events. This involved assigning the analyses results as conditions that were related or caused the events on the chronology. Assigning these conditions with events resulted in the events and causal factors (ECF) chart as seen in Appendix D. Once conditions were assigned, the Board examined the chart to determine which events were significant (meaning which events played a role in causing the accident). The Board then assessed the significant events (and the conditions of each) to determine the causal factors of the accident.

3.7. Barrier Analysis

After a basic chronology of events was developed, the Board performed a Barrier Analysis of the accident. To start the Barrier Analysis, the Board chose a target (the person or item to be protected) and the hazard (what the person or item is to be protected from). The Barrier Analysis is presented in Appendix B

3.8. Change Analysis

To further support the development of causal factors, the Board performed a Change Analysis of the accident. The Board examined the planned and unplanned changes that caused the undesired results or outcomes related to the event. The Change Analysis is presented in Appendix C

4.0 Conclusions and Judgments of Need

JONs are the managerial controls and safety measures determined by the Board to be necessary to prevent or minimize the probability or severity of a recurrence These JONs are linked directly to the casual factors which are derived from the facts and analysis They form the basis for corrective action plans which must be developed by line management The Board's conclusions and JONs are listed below in Table 4-1

The Board concluded this accident was preventable.

The direct cause of the accident was the open air demolition of the evaporator system components

The root causes of the accident were:

- The failures by WGI to fully understand, characterize, and control the radiological hazard
- The failure by WGI to implement a work control process that ensured facility conditions supported proceeding with the work

It is anticipated that SPRU will review the Incident Analysis reports when finalized and inform EM if any additional actions are required.

Table 4-1: Conclusions and Judgments of Need

Conclusions	Judgments of Need
The Board concluded WGI placed an over-reliance on the application and effectiveness of "fixative" to control contamination during demolition and prevent the spread of contamination off-site	WGI needs to re-evaluate and justify the contamination control techniques used during demolition
The Board concluded WGI did not apply fixative to the Flash Column and Separator Columns in the west "Hot" Evaporator cell	WGI needs to ensure contamination control techniques are well defined and executed as specified in work control documents
The Board concluded the radiation protection program was ineffective in evaluating and controlling contamination sources during demolition activities The Board concluded the execution of the "Demo Prep" and "Demolition" work packages did not result in the identification and control of contaminated components The Board concluded the radiological data used did not result in appropriately characterizing and controlling the radiological hazard	WGI needs to evaluate the current Radiation Protection Program and implement improvements that demonstrate competence and rigor, specifically as applied to the characterization and control of radioactive contamination This needs to include strengthening the knowledge, skills, and abilities of the Radiological Controls Technicians

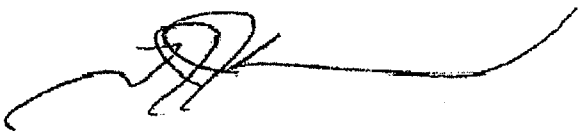
Conclusions	Judgments of Need
The Board concluded that the WGI process for authorizing work tasks did not ensure the work was reviewed by the appropriate Subject Matter Experts at the POD before proceeding	WGI needs to establish a work planning and authorization process that ensures review, approval, and authorization by cognizant management and subject matter experts
The Board concluded that DOE and WGI oversight programs were ineffective in the identification and correction of environment, safety and health programs deficiencies	DOE SPRU needs to strengthen their oversight process and procedures to maintain sufficient knowledge of site and contractor activities to make informed decisions about hazards and risk and evaluate contractor performance WGI needs to strengthen their Contractor Assurance System to fully comply with DOE O 226 1, *Implementation of Department of Energy Oversight Assurance Program,* with specific attention to critical self-assessments and verification of effectiveness of corrective actions
Some workers perceived schedule pressure and were reluctant to bring up issues that might slow progress	WGI management needs to cultivate an atmosphere of open communication and acceptance of employee feedback regarding work processes and safety concerns
The Board concluded the frequent use of terminology such as "as required," "as needed," and "as necessary," contributed to a failure to complete work steps as intended. The flexibility incorporated into work documents led to individual decision-making in determining what components in the Building H2 would require additional consideration	WGI needs to strengthen the level of rigor and discipline in executing the work planning process such that work steps provide the necessary detail to ensure steps are accomplished as planned

The Board identified the following contributing causes to the accident:

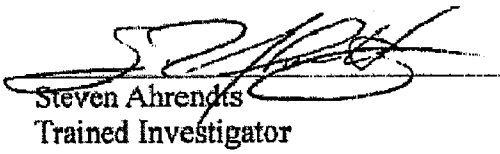
- There was no plan for application of fixative. The interior construction of the vessel(s) was not known to the workers applying fixative.
- There was no verification of the coverage or effectiveness of the fixative.
- There was overconfidence in the effectiveness of the fixative to "lockdown" contamination.
- It was not specific to how fixative was to be used when removing vessels, tanks, or other components having internal configurations.
- Decontamination was not used during removal of the evaporator system vessels.
- The work package did not integrate the hazard controls identified in the JHA and specifically RC302, Rev 1.

- The work package execution did not assure all process vessels in Building H2 were identified and characterized
- RWPs were written in generic terms and not specific to the task being performed
- Steps in work packages relating to identifying hazards were not completed
- The responsible SMEs approved working level documents without fully ensuring the hazard controls were identified
- PPP-FWP-2130, G2/H2, RC302, RWP & work plan for doing radioactive work were not adequate to implement appropriate radiological controls for the work being performed.
- PPP-FWP-2130 addresses the use of water for dust control vs contamination control
- The use of the "Dust Boss" for contamination control identified in RC-302 was not included in the work package
- No criteria was established and approved to color code vessels for special handling
- The Project did not recognize the importance of understanding historical process and system knowledge
- Requirement to fully characterize SPRU for D&D was not completed
- Lack of rigor in executing the characterization plan
- Procedure allows work to be conducted outside of the POD review and discussion process
- Programmatic deficiencies were not identified and corrected.
- DOE SPRU Oversight did not assure programmatic deficiencies were identified and corrected

5.0 Board Signatures



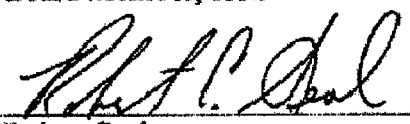
T. J. Jackson,
Trained Board Chair / Investigator
Board Chair, EMCBC



Steven Ahrendts
Trained Investigator
Board Member, DOE-ID

Roger Claycomb
Trained Investigator
Board Member, DOE-ID

Peter O'Connell
Trained Investigator
Board Member, HSS



Robert Seal
Trained Board Chair / Investigator
Board Member, DOE-ID

6.0 Board Members, Advisors, Consultants

Board Members

Chairperson	T J Jackson, Chair, EMCBC
Member	Steven Ahrendts, Board Member, DOE-ID
Member	Roger Claycomb, Board Member, DOE-ID
Member	Peter O'Connell, Board Investigator, HS-11
Member	Robert Seal, Board Member, DOE-ID

Advisor/Board Coordinator

Technical Advisor	William McQuiston, MAS Consultants

Administrative Coordinator

Consultant	Susan Keffer, Project Enhancement Corporation

Appendix A:
Appointment of Type B Accident Investigation Board

Department of Energy
Washington, DC 20585

October 22, 2010

MEMORANDUM FOR T. J. JACKSON
ASSISTANT DIRECTOR
OFFICE OF LOGISTICS MANAGEMENT
CONSOLIDATED BUSINESS CENTER

FROM: MARK A GILBERTSON
DEPUTY ASSISTANT SECRETARY FOR
PROGRAM AND SITE SUPPORT

SUBJECT: Type B Investigation of Radiological Contamination during Separations Process Research Unit H2 Demolition

A Type B investigation into the radiological contamination event resulting from decontamination and demolition (D&D) work that occurred at the Separations Process Research Unit (SPRU) H2 facility on or about September 29, 2010, was requested to be conducted by Mr John Rampe, SPRU. The request is based on the event meeting the Department of Energy (DOE) Order 225 1A, *Accident Investigations*, categorization threshold of an estimated loss greater than $1,000,000, as well as being deemed warranted by the event circumstances

I hereby establish a Type B Accident Investigation Board (Board) to investigate the subject radiological contamination event You are appointed as the Board chairperson The Board will be composed of the following members:

T J Jackson	Accident Investigation Board Chair
Peter O'Connell	Accident Investigator/Health Physics/Radiological Control
Roger Claycomb	Work Planning/Personnel Qualifications and Training
Bob Seal	D&D/Conduct of Operations/Contractor Assurance
Steven Arendts	Operations/Waste Management/Event Response

The Office of Corporate Safety Programs (HS-31) is providing Mr William McQuiston and Ms Sue Keffer to provide accident investigation technical support and administrative support, respectively, to the Board.

The scope of the Board's investigation is to include, but not be limited to, identifying all relevant facts, determining direct, contributing, and root causes of the contamination event, developing conclusions, and determining the Judgments of Need to prevent recurrence.

Based on an evaluation already conducted by the Office of Safety Operations Assurance, the Board's investigation should address the following areas: work planning and control,

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project planning, radiological controls, personnel qualifications and staffing, conduct of operations, with a particular focus on higher hazard activities; also event response and the contractor assurance system should be evaluated The scope of the investigation is to include DOE direction and oversight activities

The Board is expected to provide my office with periodic reports on the status of the investigation Please submit draft copies of the factual portion of the investigation report to my office, the Office of Safety and Security Program, the SPRU Project Office, and the affected contractor for factual accuracy review prior to finalization The final report should be provided to me within 30 days of the date of this memorandum. Discussion of the investigation and copies of the draft report will be controlled until I authorize release of the final report.

If you have any further questions, please contact me at (202) 586-5042

cc: I. Triay, EM-1
D. Chung, EM-2
F Marcinowski, EM-3 (Acting)
C. Anderson, EM-3 1
S Krahn, EM-20
K. Picha, EM-20 (Acting)
T. Krietz, EM-21
R. Goldsmith, EM-22
R. Schassburger, EM-52
J Rampe, SPRU
P O'Connell, HS-11
C Lewis, HS-31
D. Pegram, HS-31
B. McArthur, HS-10
R. Claycomb, ID
B. Seal, ID
S Ahrendts, ID
D Macias, Project Manager, WGI

Appendix B: Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all tasks. A barrier is any means used to control, prevent, or impede a hazard from reaching a target, thereby reducing the severity of the resultant accident or adverse consequence. A hazard is the potential for an unwanted condition to result in an accident or other adverse consequence. A target is a person or object that a hazard may damage, injure, or fatally harm. Barrier analysis determines how a hazard overcomes the barriers, comes into contact with a target (e.g., from the barriers or controls not being in place, not being used properly, or failing), and leads to an accident or adverse consequence. The results of the barrier analysis are used to support the development of causal factors.

Table B-1: Barrier Analysis

Hazard: Radiological contamination		Target: Workers and environment	
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?**
Application of "fixative" to contaminated surfaces	As applied to the vessel(s) in question, the fixative was ineffective to control contamination spread.	There was no plan for application. The interior construction of the vessel(s) was not known to the workers. There was no verification of the coverage or effectiveness of the fixative. There was overconfidence in the effectiveness of the fixative to "lockdown" contamination.	Failure to properly and fully apply fixative to the vessel(s) internals increased the probability of the spread of contamination. **B1**
Work Package PPP-FWP-2130 for the D&D activities	Failed	The work package did not integrate the hazard controls identified in the JHA and specifically RC302, Rev 1. It was not specific to how fixative was to be used when removing vessels, tanks, or other components having internal configurations.	The work package was not specific in identifying the components being removed. **B2**

Hazard: Radiological contamination		Target: Workers and environment	
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?**
Work Package STW-FWP-1990, H2 Demo Prep	Failed	Steps relating to identifying hazards were not completed.	Ready for Demo Checklist was signed as complete giving a false sense of safety. **B3**
Use of subject matter expertise to identify and control the hazards	Failed	The responsible SME's approved work level documents without fully ensuring the hazard controls were identified.	Potential radiological hazards were not controlled. **B4**
Radiological Work Permits special instructions used to control/limit spread of contamination.	Failed	RWPs were written in generic terms and not specific to the task being performed.	Failed to establish on-site radiological monitoring during building demolition. **B5**
Confinement structure [tent] (prevents spread)	Not used	Not used	Use of a confinement structure could have prevented the spread of contamination beyond the immediate work area. **B6**
Radiological Control Practices	Failed to prevent the spread of contamination	PPP-FWP-2130, G2/H2, RC302, RWP & work plan for doing radioactive work were not adequate to implement appropriate radiological controls for the work being performed.	Failure to implement the proper controls contributed to the spread of contamination. **B7**

Hazard: Radiological contamination		Target: Workers and environment	
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?**
Misting for contamination control	The Dust Boss identified in RC-302 was not used. Use of a fire hose for dust control was used intermittently.	PPP-FWP-2130 addresses the use of water for dust control. The use of the "Dust Boss" for contamination control identified in RC-302 was not included in the work package.	Spread of radioactive contamination was not controlled as discussed in RC302. **B8**
Hold Points are used to verify completion of work steps prior to continuing work.	Hold points in work package STW-FWP-1990 were bypassed and subsequently removed by revision after the last work steps were recorded in the work package status log.	Management did not enforce the requirements in the work control program regarding the execution of hold points.	H2 Demo Prep work package was completed without the initially required sources being identified. **B9**
STW-FWP-1990 - preparation of Building H2 for demolition	Failed	The work package execution did not assure all process vessels in H2 were identified and characterized.	Failure to identify the evaporator process vessels as a potential contamination source, lead to a loss of control of radiological contamination. **B10**
Characterization of radiological hazards	Failed to identify the process components in H2 as radiological hazards requiring special controls.	Lack of rigor in executing the characterization plan.	Failure to identify the process components that ultimately resulted in the radiological event. **B11**
Color coding of special components	Vessels were not identified and marked.	No criteria was established and approved to color code vessels for special handling.	Demolition of the evaporator vessels was not controlled resulting in spread of radioactive contamination. **B12**

Hazard: Radiological contamination		Target: Workers and environment	
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?**
Process knowledge	Workers and SMEs were not familiar with the operation and potential impacts of the evaporator systems.	The Project did not recognize the importance of understanding historical process and system knowledge.	Project did not recognize the potential sources for spread of contaminated material. **B13**
Decontaminate components prior to sizing	Not used.	Decontamination was not used during removal of the evaporator system vessels.	Components were not decontaminated. **B14**
SPRU-DP Decommissioning Plan (SPRU-DD-004)	Failed	Requirement to fully characterize SPRU for D&D was not completed.	Lack of characterization data resulted in a failure to identify radiological hazard during removal of the vessels. **B15**
Contractor Assurance (Oversight)	Failed	Programmatic deficiencies were not identified and corrected.	Failed to identify and correct weaknesses in the radiological protection and work controls programs **B16**
Work is controlled by POD approval	Failed	Procedure allows work to be conducted outside of the POD review and discussion process	Lost opportunity to have the work reviewed by SMEs **B17**
DOE Oversight	Less than adequate	Programmatic deficiencies were not identified and corrected.	Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. **B18**

Appendix C: Change Analysis

Change is anything that disturbs the "balance" of a system from operating as planned. Change is often the source of deviations in system operations. Change can be planned, anticipated, and desired, or it can be unintentional and unwanted. Change analysis examines the planned or unplanned disturbances or deviations that caused the undesired results or outcomes related to the accident. This process analyzes the difference between what is normal (or "ideal") and what actually occurred. The results of the change analysis are used to support the development of causal factors.

Table C-1: Change Analysis

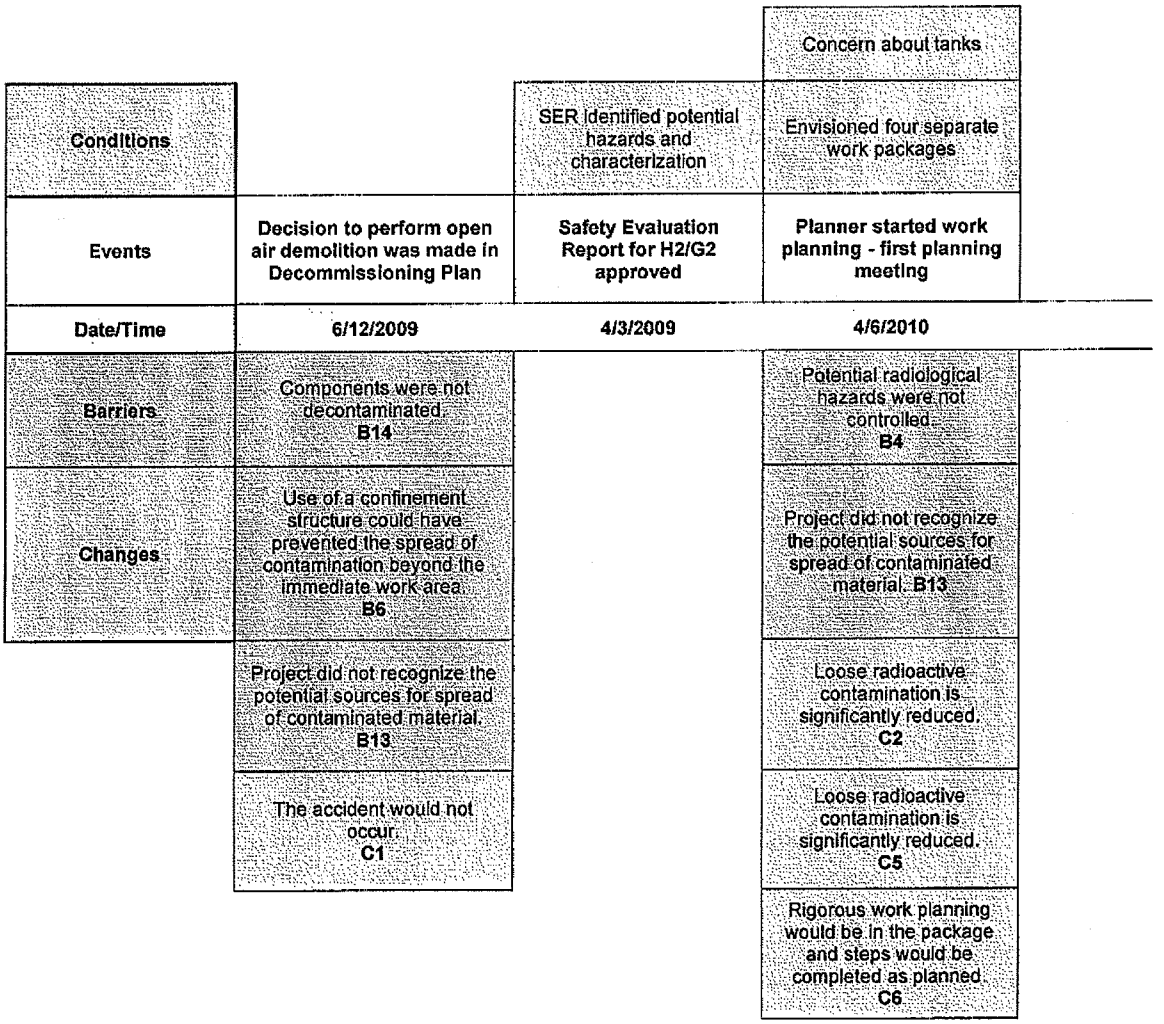
Accident Situation	Accident Free, Prior or Ideal Situation	Difference	Evaluation of the Effect on the Accident
Demolition was performed in open air	Demolition is performed in tent/cover or other confinement.	Radioactive contamination when performing demolition would not be spread outside the demolition area.	The accident would not occur. **C1**
Fixative was not applied to the west cell evaporator vessel exteriors	Fixative is applied to all vessel exteriors and interior surfaces	Loose radioactive contamination is available for dispersal in open air.	Loose radioactive contamination is significantly reduced. **C2**
Characterization of Building H2 did not identify the location and concentration of radioactive contamination hold up in process piping and vessels.	Characterization of Building H2 documented the location and concentration of radioactive contamination in piping and vessels internals.	Work planners and SMEs would be aware of the location and quantities of radioactive contamination and develop effective mitigation.	Mitigation against uncontrolled spread of radioactive materials is tailored to the specific tasks. **C3**
Removal of the evaporator cell vessels was not discussed at the POD meeting	All work planned to be accomplished is authorized at the POD meeting and discussed	Appropriate SMEs were not available to review and/or discuss the work to be accomplished.	Lost opportunity for the SMEs to review the work to be done and the work package and review hazards. **C4**
Use of fixatives replaced decontamination as the primary method of contamination control.	Decontamination to prescribed levels of activity would establish a known and controllable level of radioactive contamination.	Contamination levels would be known after decontamination and the level of radiological hazard would be better defined.	Loose radioactive contamination is significantly reduced. **C5**

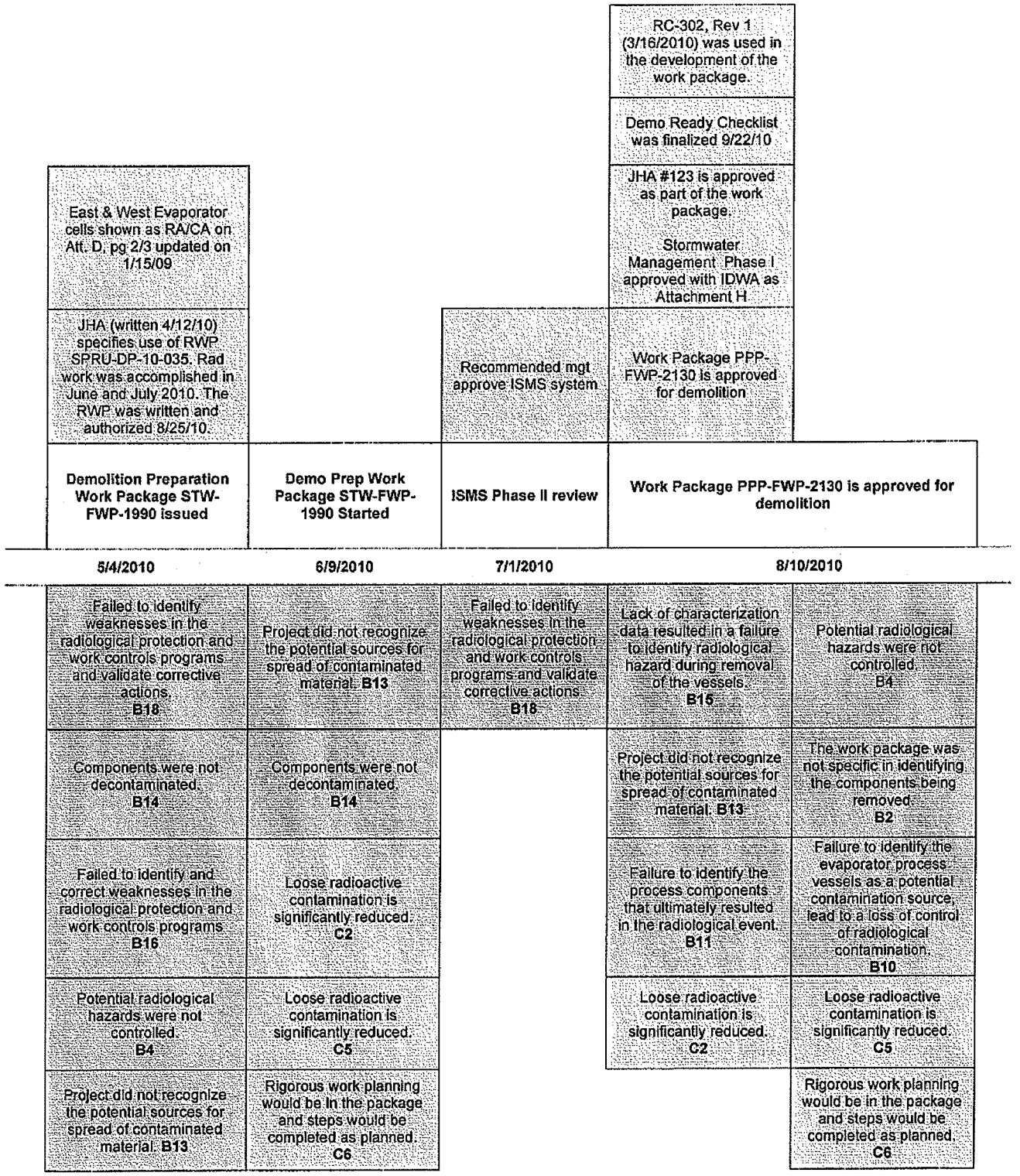
Accident Situation	Accident Free, Prior or Ideal Situation	Difference	Evaluation of the Effect on the Accident
Work package is overly flexible and left the final decision points to the discretion of the worker.	Adequate detail is provided to perform the work as planned. If work cannot be performed as expected, worker stops until problems are resolved.	Work package is clear and does not use statements as "as applicable," "when necessary, and "if required."	Rigorous work planning would be in the package and steps would be completed as planned **C6**

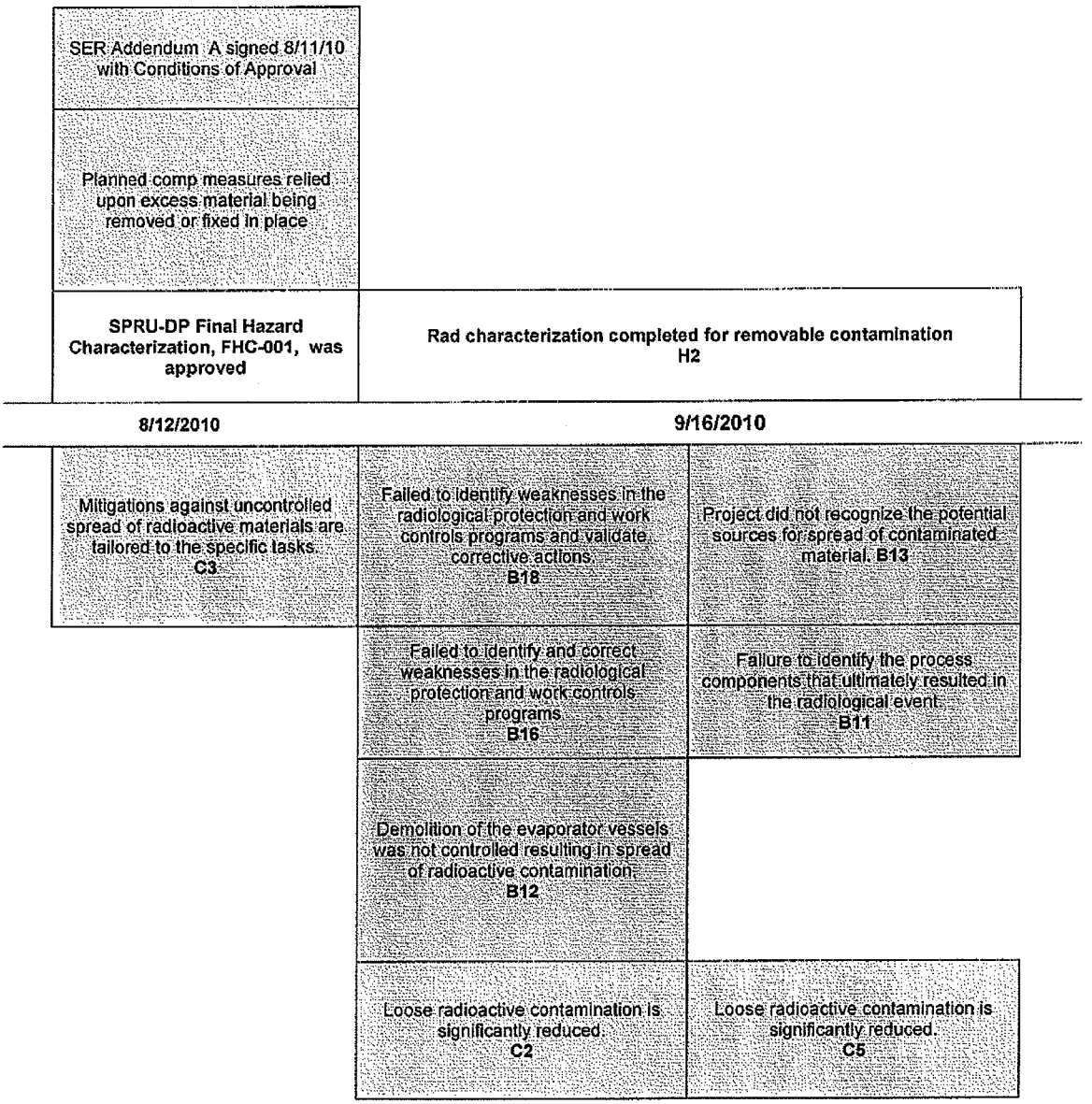
Appendix D: Events and Causal Factor Analysis

An events and causal factors analysis was performed in accordance with the DOE Workbook *Conducting Accident Investigations* The events and causal factors analysis requires deductive reasoning to determine those events and/or conditions that contributed to the accident Causal factors are the events or conditions that produced or contributed to the accident, and they consist of direct, contributing, and root causes The direct cause is the immediate event(s) or condition(s) that caused the accident The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the accident, but which did not solely cause the accident. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar accidents The causal factors are identified in Figure D-1: Events and Causal Factors Analysis on pages D-1 through D-8

Figure D-1: Events and Causal Factors Analysis




RC-302, Rev 1 (3/16/2010) was used in the development of the work package.
Demo Ready Checklist was finalized 9/22/10
JHA #123 is approved as part of the work package.
Stormwater Management Phase I approved with IDWA as Attachment H
East & West Evaporator cells shown as RA/CA on Att. D, pg 2/3 updated on 1/15/09
JHA (written 4/12/10) specifies use of RWP SPRU-DP-10-035. Rad work was accomplished in June and July 2010. The RWP was written and authorized 8/25/10.
Recommended mgt approve ISMS system
Work Package PPP-FWP-2130 is approved for demolition
Demolition Preparation Work Package STW-FWP-1990 issued
Demo Prep Work Package STW-FWP-1990 Started
ISMS Phase II review
Work Package PPP-FWP-2130 is approved for demolition
5/4/2010
6/9/2010
7/1/2010
8/10/2010
Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. B18
Project did not recognize the potential sources for spread of contaminated material. B13
Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. B18
Lack of characterization data resulted in a failure to identify radiological hazard during removal of the vessels. B15
Potential radiological hazards were not controlled. B4
Components were not decontaminated. B14
Components were not decontaminated. B14
Project did not recognize the potential sources for spread of contaminated material. B13
The work package was not specific in identifying the components being removed. B2
Failed to identify and correct weaknesses in the radiological protection and work controls programs B16
Loose radioactive contamination is significantly reduced. C2
Failure to identify the process components that ultimately resulted in the radiological event. B11
Failure to identify the evaporator process vessels as a potential contamination source, lead to a loss of control of radiological contamination. B10
Potential radiological hazards were not controlled. B4
Loose radioactive contamination is significantly reduced. C5
Loose radioactive contamination is significantly reduced. C2
Loose radioactive contamination is significantly reduced. C5
Project did not recognize the potential sources for spread of contaminated material. B13
Rigorous work planning would be in the package and steps would be completed as planned. C6
Rigorous work planning would be in the package and steps would be completed as planned. C6


SER Addendum A signed 8/11/10 with Conditions of Approval
Planned comp measures relied upon excess material being removed or fixed in place
SPRU-DP Final Hazard Characterization, FHC-001, was approved
Rad characterization completed for removable contamination H2
8/12/2010
9/16/2010
Mitigations against uncontrolled spread of radioactive materials are tailored to the specific tasks. C3
Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. B18
Project did not recognize the potential sources for spread of contaminated material. B13
Failed to identify and correct weaknesses in the radiological protection and work controls programs. B16
Failure to identify the process components that ultimately resulted in the radiological event. B11
Demolition of the evaporator vessels was not controlled resulting in spread of radioactive contamination. B12
Loose radioactive contamination is significantly reduced. C2
Loose radioactive contamination is significantly reduced. C5

H2 Demo Ready Checklist complete		
"Demo Ready Checklist" signed off in STW-FWP-1990		
9/22/2010		
Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. **B18**	H2 Demo Prep work package was completed without the initially required sources being identified. **B9**	Failure to properly and fully apply fixative to the component(s) internals increased the probability of the spread of contamination. **B1**
Lack of characterization data resulted in a failure to identify radiological hazard during removal of the evaporator system components. **B15**	Demolition of the evaporator vessels was not controlled resulting in spread of radioactive contamination. **B12**	Ready for Demo Checklist was signed as complete giving a false sense of safety. **B3**
Failure to identify the process components that ultimately resulted in the radiological event. **B11**	Project did not recognize the potential sources for spread of contaminated material. **B13**	Components were not decontaminated. **B14**
Failure to identify the evaporator system components as a potential contamination source, lead to a loss of control of radiological contamination. **B10**	Potential radiological hazards were not controlled. **B4**	Failed to identify and correct weaknesses in the radiological protection and work controls programs **B16**
Rigorous work planning would be in the package and steps would be completed as planned. **C6**		

		No communication of readings
Wrecking crew used water stream to control fugitive dust		No evidence of any actions taken in response to elevated readings
Demolition started on H2 building 332' elevation		**Elevated air sampler reading recorded by perimeter air monitors**
9/23/2010		**9/24-29/2010**
Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. **B18**	Spread of radioactive contamination was not controlled as discussed in RC302. **B8**	Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. **B18**
Lack of characterization data resulted in a failure to identify radiological hazard during removal of the evaporator system components. **B15**	Use of a confinement structure could have prevented the spread of contamination beyond the immediate work area. **B6**	Failed to identify and correct weaknesses in the radiological protection and work controls programs **B16**
Project did not recognize the potential sources for spread of contaminated material. **B13**	Failed to establish on-site radiological monitoring during building demolition. **B5**	Use of a confinement structure could have prevented the spread of contamination beyond the immediate work area. **B6**
Failure to identify the process components that ultimately resulted in the radiological event. **B11**	Failure to implement the proper controls contributed to the spread of contamination. **B7**	Project did not recognize the potential sources for spread of contaminated material. **B13**
Failure to identify the evaporator system components as a potential contamination source, lead to a loss of control of radiological contamination. **B10**	Components were not decontaminated. **B14**	Spread of radioactive contamination was not controlled as discussed in RC302. **B8**
Demolition of the evaporator components was not controlled resulting in spread of radioactive contamination. **B12**	Failed to identify and correct weaknesses in the radiological protection and work controls programs **B16**	Components were not decontaminated. **B14**
Loose radioactive contamination is significantly reduced. **C2**	Loose radioactive contamination is significantly reduced. **C5**	

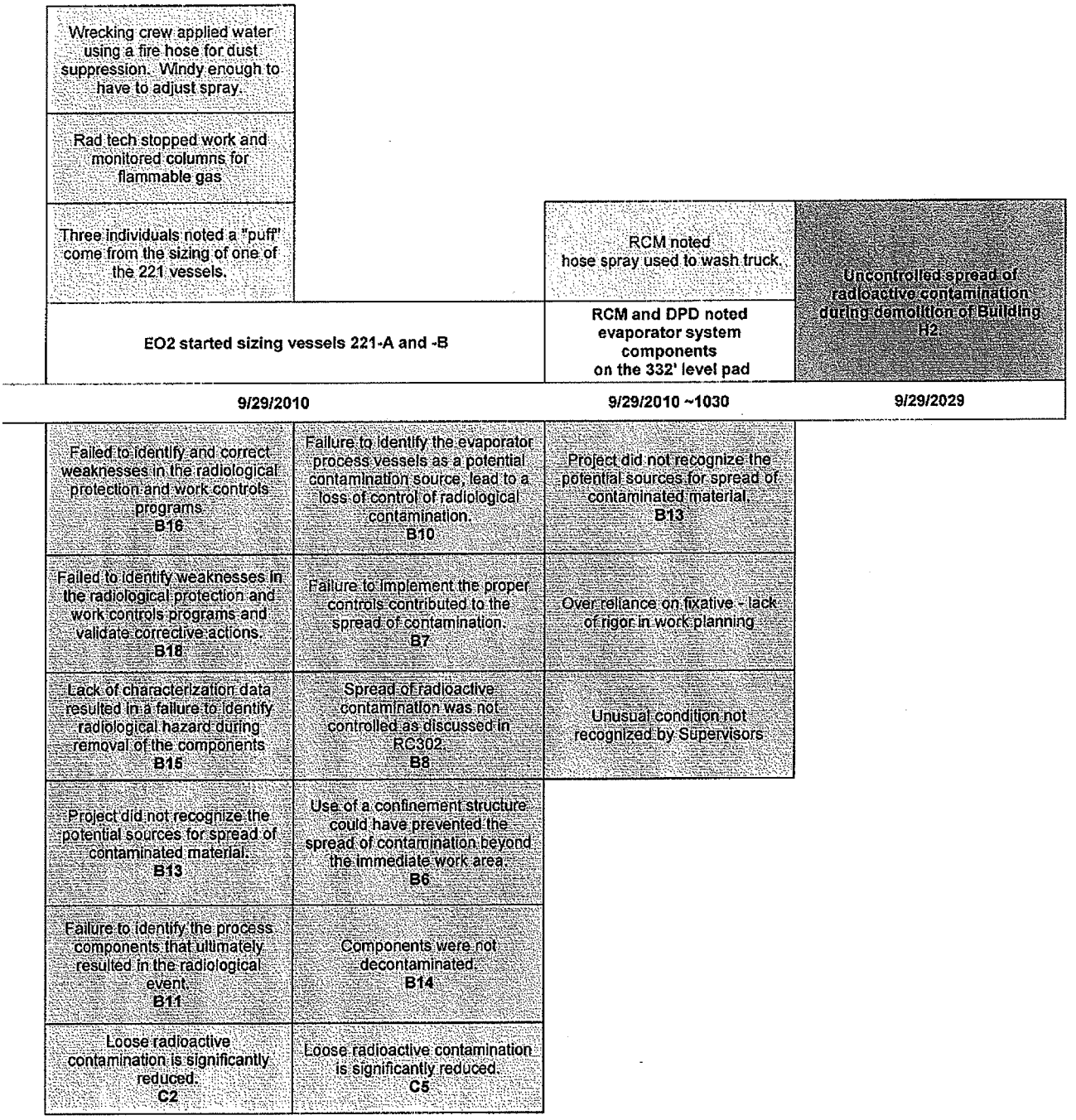
Authorized outside the POD meeting by the OM		Vessel removal authorized outside the POD meeting by the OM
Removal of the evaporator system components was not discussed	Waste Superintendent asked D&D OM about removing the components.	D&D OM asked RCM after meeting about removing components. RCM said it was OK
POD Meeting	**"Supervisor's" Meeting**	**0800 meeting**
9/28/2010	**9/29/2010 0645**	**9/29/2010 0800**
Lost opportunity to have the work reviewed by SMEs **B17**	Project did not recognize the potential sources for spread of contaminated material. **B13**	Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. **B18**
Lost opportunity for the SMEs to review the to-be done and work package and review hazards. **C4**	Demolition of the evaporator system components was not controlled resulting in spread of radioactive contamination. **B12**	Project did not recognize the potential sources for spread of contaminated material. **B13**
	The work package was not specific in identifying the components being removed. **B2**	Demolition of the evaporator system components was not controlled resulting in spread of radioactive contamination. **B12**
	Lost opportunity for the SMEs to review the to-be done and work package and review hazards. **C4**	The work package was not specific in identifying the components being removed. **B2**
		Lost opportunity for the SMEs to review the to-be done and work package and review hazards. **C4**

A bolt was "thrown" outside the footprint when removing one of the columns
Evaporator system components extend above the 332' floor elevation and down to the 319' elevation floor.
Components were "violently" pulled up from the 319' elevation and laid down on the 323' floor elevation.

EO2 removed heat exchanger vessels 221-A and 221-B from east evaporator cell
EO1 removed separator vessel 112-A from west evaporator cell

9/29/10 ~1000 to ~1200

Failed to identify and correct weaknesses in the radiological protection and work controls programs **B16**	Components were not decontaminated. **B14**	Spread of radioactive contamination was not controlled as discussed in RC302. **B8**
Lost opportunity to have the work reviewed by SMEs **B17**	Project did not recognize the potential sources for spread of contaminated material. **B13**	Failure to implement the proper controls contributed to the spread of contamination. **B7**
Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. **B18**	Demolition of the evaporator vessels was not controlled resulting in spread of radioactive contamination. **B12**	Use of a confinement structure could have prevented the spread of contamination beyond the immediate work area. **B6**
Lack of characterization data resulted in a failure to identify radiological hazard during removal of the components. **B15**	Failure to identify the process components that ultimately resulted in the radiological event. **B11**	Loose radioactive contamination is significantly reduced. **C2**
Failed to establish on-site radiological monitoring during building demolition. **B5**	Failure to identify the evaporator process vessels as a potential contamination source, lead to a loss of control of radiological contamination. **B10**	


Wrecking crew applied water using a fire hose for dust suppression. Windy enough to have to adjust spray.
Rad tech stopped work and monitored columns for flammable gas
Three individuals noted a "puff" come from the sizing of one of the 221 vessels.
RCM noted hose spray used to wash truck.
Uncontrolled spread of radioactive contamination during demolition of Building H2
EO2 started sizing vessels 221-A and -B
RCM and DPD noted evaporator system components on the 332' level pad
9/29/2010
9/29/2010 ~1030
9/29/2029
Failed to identify and correct weaknesses in the radiological protection and work controls programs. B16
Failure to identify the evaporator process vessels as a potential contamination source, lead to a loss of control of radiological contamination. B10
Project did not recognize the potential sources for spread of contaminated material. B13
Failed to identify weaknesses in the radiological protection and work controls programs and validate corrective actions. B18
Failure to implement the proper controls contributed to the spread of contamination. B7
Over reliance on fixative - lack of rigor in work planning
Lack of characterization data resulted in a failure to identify radiological hazard during removal of the components B15
Spread of radioactive contamination was not controlled as discussed in RC302. B8
Unusual condition not recognized by Supervisors
Project did not recognize the potential sources for spread of contaminated material. B13
Use of a confinement structure could have prevented the spread of contamination beyond the immediate work area. B6
Failure to identify the process components that ultimately resulted in the radiological event. B11
Components were not decontaminated. B14
Loose radioactive contamination is significantly reduced. C2
Loose radioactive contamination is significantly reduced. C5