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Report on the Emergency Response to the Event on May 14, 1997, at the Plutonium Reclamation Facility, Hanford Site, Richland, Washington

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ACRONYMS

ACES	Access Control Entry System
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	Asbestos Containing Material
AHERA	Asbestos Hazard Emergency Response Act
AMS	Alarm Monitoring Station
AMU	Aqueous Makeup Unit
AP	Associated Press
ATC	Approved Transport Container
BCSO	Benton County Sheriff's Office
BED	Building Emergency Director
BHI	Bechtel Hanford, Incorporation
BWHC	B&W Hanford Company
CA	contamination area
CAM	Continuous Air Monitor
CAPS	Criticality Alarm Panels
CAS	Central Alarm Station
CBC	complete blood count
CCl_4	carbon tetrachloride
CCX	Concentrate Column Extractant
CDR	Commander
CEDE	Committed Effective Dose Equivalent
CEIL	ceiling
CO	carbon monoxide
CPM	counts per minute
DOE	Department Of Energy
DRCM	Duty Radiological Control Manager
EAL	Emergency Action Level
EAP	Office of Environmental Assurance, Permits, and Policy (RL)
ECP	Event Command Post
EDO	Emergency Duty Officer
EMS	Emergency Management Support
EMT	Emergency Medical Technician
ENS	Emergency Notification System
EOC	Emergency Operations Center
ER	Emergency Room
ERO	Emergency Response Organization
ES&H	Environment, Safety and Health
ESH&Q	Environment, Safety, Health & Quality
FBI	Federal Bureau of Investigation
FDH	Fluor Daniel Hanford
FDNW	Fluor Daniel Northwest
FEMA	Federal Emergency Management Agency
H_2O	water
H_2SO_4	sulfuric acid
HAN	hydroxylamine nitrate
HEHF	Hanford Environmental Health Foundation
HEPA	High Efficiency Particulate Air
HFD	Hanford Fire Department
HLAN	Hanford Local Area Network
HMS	Hanford Meteorology Station
HNO_3	nitric acid

HZ	hydrazine
IC	Incident Commander
ICF	immediate care facility
ICP	Incident Commander
IDL	Internal Dose Laboratory
IH	Industrial Hygiene
IPU	Isotopic Plutonium Urinalysis
ITC	In-transit Container
JIC	Joint Information Center
Km	kilometers
KMC	Kadlec Medical Center
LAH	Level Alarm High
LCO	Limiting Conditions for Operation
LEL	Lower Explosive Limit
M	meters
MCL	Maximum Contaminant Level
MSDS	Material Safety Data Sheet
MUX	multiplexor
N_2	Nitrogen
N_2O	Nitrous Oxide
$N_2H_4O_4$	Hydroxylamine Nitrate
NaI	Sodium Iodine
NIOSH	National Institute for Occupational Safety and Health
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_3	Nitrate
NO_X	Oxides of Nitrogen
OEA	Office of External Affairs
OCF	Operations Control Facility
ONC	Occurrence Notification Center
OSHA	Occupational Safety and Health Administration
OVA	Organic Vapor Analyzer
PAR	Protective Action Recommendations
PAX	public announcement system
PDT	Pacific Daylight Time
PFP	Plutonium Finishing Plant
PRF	Plutonium Reclamation Facility
PFT	Pulmonary Function Test
POC	Patrol Operations Center
PHMC	Project Hanford Management Contractor
PTA	Patrol Training Academy
QSH	Quality, Safety and Health
RAP	Radiological Assistance Program
RCA	Radiologically Controlled Area
RCS	Radiological Control Supervisor
RCT	Radiological Control Technician
RFAR	Radio Fire Alarm Signal
RMC	Remote Mechanical C Line
ROM	Rough, Order of Magnitude
RWP	Radiological Work Permit
SAS	Safeguards and Securities
SCBA	Self Contained Breathing Apparatus
SNM	Special Nuclear Material

SOE	Shift Operating Engineer
SpG	Specific Gravity
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value
TSD	Treatment Storage and Disposal
TSI	Thermal System Insulation
UCC	Unified Command Center
UDAC	Unified Dose Assessment Center
UPI	United Press International
WBC	Whole Body Count
WDOH	Washington Department of Health
WSCF	Waste Sampling and Characterization Facility

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EXECUTIVE SUMMARY

INTRODUCTION

On the evening of May 14, 1997, a chemical explosion occurred at the Plutonium Reclamation Facility (PRF) in the 200 West Area (200-W) of the Hanford Site. This event warranted the declaration of an Alert emergency, activation of the Hanford Emergency Response Organization (ERO), and notification of offsite agencies. As a result of the emergency declaration, a subsequent evaluation was conducted to assess:

- the performance of the emergency response organization
- the occupational health response related to emergency activities
- event notifications to offsite and environmental agencies.

Additionally, the evaluation was designed to:

- document the chronology of emergency and occupational health responses and environmental notifications connected with the explosion at the facility
- assess the adequacy of the Hanford Site emergency preparedness activities; response readiness; and emergency management actions, occupational health, and environmental actions
- provide an analysis of the causes of the deficiencies and weaknesses in the preparedness and response system that have been identified in the evaluation of the response
- assign organizational responsibility to correct deficiencies and weaknesses
- improve future performance
- adjust elements of emergency implementing procedures and emergency preparedness activities.

BRIEF DESCRIPTION OF THE EVENT

On May 14, 1997, at approximately 7:53 p.m., an explosion occurred in Room 40 (Chemical Preparation Room) of the Plutonium Reclamation Facility (236-Z Building), which is located within the Plutonium Finishing Plant (PFP) complex. As a result of the over-pressurization of the tank, the stainless-steel lid of Tank A-109 in Room 40 was torn off, rupturing a fire suppression line and causing extensive damage to the room, including breaches to the roof and roof wall interface. The contents of the tank was a mixture of hydroxylamine nitrate and nitric acid. The explosion activated several security and fire-box alarms, which respectively, were received at the 200 West Central Alarm Station (CAS) and at the 200 Area Hanford Fire Station.

The Hanford Patrol initiated a security lockdown at the facility, and the PFP Building Emergency Director (BED) directed the 200 West CAS to activate the take-cover siren for the PFP facility. The BED established the Incident Command Post (ICP) in Room 104 of the 234-5Z Building Room (the main building within the PFP complex) and instructed all facility personnel to report there for personnel accountability. Eight construction workers were on a lunch break in a trailer near the 234-5Z Building when they were directed to report to Room 104. While en route to Room 104, they walked through an area located downwind from the point of the explosion and the 200-foot-high exhaust stack (291-Z-1) out of which a yellow-brown emission had been seen following the explosion.

The Incident Command Post (ICP) was established at 8:18 p.m. as a Unified Command. The ICP members included the BED, for facility matters; the Hanford Fire Department Deputy Chief (Incident Commander), for damage assessment activities and occupational health response; and the Hanford Patrol Shift Commander to coordinate security matters for the overall response. The ICP staff coordinated successive reentries into the PRF to ascertain the nature and extent of the damage and the source of the water flooding the immediate area and collecting outside the building.

After an approximate 2-hour assessment period, plant conditions were judged by the BED to warrant the declaration of an Alert emergency. As set forth in the RL Emergency Plan Implementing Procedures, the RL Emergency Operations Center (RL-EOC) was activated and assumed responsibility for additional onsite protective actions, subsequent offsite notifications, and providing logistical support to the ICP. About 4 hours into the response, the construction workers who had walked through the area downwind from the PRF explosion left PFP and reported to a local hospital for medical evaluation. Other plant personnel reported later to the hospital for evaluation. Several people who had been at the PFP complex during or after the explosion were eventually provided follow-on medical surveillance by the Hanford Site Medical Contractor (Hanford Environmental Health Foundation [HEHF]).

The PRF emergency response was the first Hanford Site activation using the reengineered Hanford ERO and the recently revised procedures for the RL-EOC. This onsite response was paralleled by the activation of offsite emergency operations centers, including the Benton and Franklin Bi-County EOC, the Grant County EOC, the Washington State EOC, and the Department of Energy Headquarters EOC. Officials from the counties and the Washington State Department of Health reported as representatives to the RL-EOC, and the Joint Information Center (JIC); an RL Representative was sent to the Bi-County EOC. The JIC notified local and other media contacts of the event and provided periodic media briefings and press conferences. The Alert emergency was terminated at 6:41 a.m. on May 15, 1997, and the RL-EOC shifted its focus to activities related to the recovery phase of the event.

RESULTS OF THE EVALUATION

The following summarizes the results of chemical dispersion modeling and associated potential health effects; radiological analysis and associated potential health effects; and major programmatic failures. While the report is designed to identify programmatic failures and areas of less-than adequate performance, several areas in which the emergency response organization did function as planned are:

- The ICP adequately performed and coordinated reentry and damage assessment activities
- Once the RL-EOC was declared operational, it assumed the responsibility for implementing additional onsite protective actions and for subsequent notifications to offsite agencies. The RL-EOC carried out these responsibilities in a timely manner.
- The JIC adequately developed and issued press releases and responded to public and media inquiries.

Other positive attributes of the emergency response to the PRF event are contained in the body of the report.

CHEMICAL HAZARDS AND POTENTIAL HEALTH EFFECTS

The major chemical constituents of Tank A-109 and their by-products from the explosive reaction have subsequently been determined to be the only credible chemical substances released from PRF that could result in worker exposure. The tank contained an aqueous solution of nitric acid and hydroxylamine nitrate. By-products from the explosion were various oxides of nitrogen. The oxides of nitrogen include nitrogen dioxide, nitric dioxide, and nitrous oxide, with nitrogen dioxide being the greatest health concern. These agents, except nitrous oxide, are primarily irritants affecting mucus membranes and the respiratory systems.

Releases of these chemical agents occurred through the main ventilation stack and small breaches in the building roof and roof-wall interface. Dispersion modeling was performed using estimated values of tank contents, chemical by-products, release points, and atmospheric conditions to calculate worker exposures. While modeling results cannot be considered to be definitive, they can establish an approximate order of magnitude estimate of exposure.

The results of the dispersion modeling indicate the concentrations of chemicals that could have traveled off the Hanford Site were negligible. The contaminant that would have been present at the highest levels is nitrogen dioxide. The maximum possible concentration of nitrogen dioxide estimated for any point of public access was about 25 ug/m3, which would have been present for only a few minutes. This level is only 25% of the annual average concentration that is permitted for the public under ambient air standards. The modeling results also indicate that worker exposures were likely brief and well below the applicable occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH) and Occupational and Safety Health Administration (OSHA). The modeling indicates that elevated levels of nitric acid vapor, nitrogen dioxide and nitrous oxide were present after the explosion. The modeled dose represents the time period of highest concentration at ground level. It does not reflect the reduction in concentration that would occur by dispersion before the individuals traversed that area. Some of the symptoms experienced by the workers are consistent with exposure to nitric acid vapors or mist. However, any physiological symptoms directly resulting from these exposures would be predicted to resolve themselves in 5-7 days without long-term health effects. It should be noted, though, that these conclusions are based on dispersion modeling results and may or may not reflect actual individual exposures resulting from the event.

RADIOLOGICAL HAZARDS AND POTENTIAL HEALTH EFFECTS

Radiological surveys performed after the explosion in Room 40 showed no change in the radiological conditions in the room. Room 40 was historically operated as a nonradioactive chemical makeup area and did not contain radiological constituents, with the exception of radiological residues from an upset condition during the mid-1980s. As a result of the severed fire-suppression sprinkler line, a small amount of low-level radioactive contamination was transported within the water through PRF. Although the water flowed into piping tunnels under PFP, no contamination from the water was detectable in PFP. The water flowed under several PRF outside doors into the surrounding exterior area. Small isolated areas of contamination have been identified in these outside areas; however, it is not possible to determine if these isolated areas of low-level contamination were due to the incident or were pre-existing.

Analysis of airborne emissions, air samples outside PRF, environmental contamination surveys, and air samples in the room where the explosion occurred showed no detectable airborne radioactivity released to the environment. A short-term increase in airborne radioactivity, however, did occur in various locations within PRF. This increase in airborne radioactivity would equate to a maximum intake of less than 1% of the annual limit for occupational workers if an individual were exposed to these concentrations. No personnel were in PRF at the time of the explosion and no personnel are known to have been exposed to airborne radioactivity. No discernable radiological changes have been detected within PFP.

Since adequate radiological contamination surveys were not conducted on the eight construction workers prior to their leaving the facility on May 14, 1997, bioassays have been offered to the workers to assist in verifying whether or not they received any internal deposition of radioactive materials.

MAJOR PROGRAMMATIC FAILURES

Major programmatic failures occurred during the emergency response. These are enumerated below along with the conditions or incidents deemed to underlie them.

1. **Failure to provide timely emergency classification and implement notifications to offsite agencies.**

- inadequate facility hazards analysis resulting in inadequate Emergency Action Levels
- inadequate procedural compliance resulting in failure to meet the 15-minute offsite notification criteria once the Alert had been declared

- failure of early notification process for non-categorized events
- notification to the Washington Department of Ecology and National Response Center was delayed.

2. **Failure to implement emergency response activities consistent with the requirements for facility take-cover and lockdown conditions.**

- inadequate process for personnel accountability during a facility take cover condition
- conflicting guidance provided to the workers resulting in exposure to chemical release
- several instances of personnel being outside sheltered areas in and around PFP during a facility take cover condition
- some of the originally exposed workers allowed to proceed outside a sheltered area to retrieve car keys and personal belongings during a facility take cover condition
- instances of site staff personnel traveling from their personal residences through as many as four security checkpoints and into the PFP protected area without being advised that a take cover condition existed at the facility
- Radiological Control Technician without proper protective equipment directed to proceed outside a sheltered area to check operability of main stack radiological monitor during a facility take cover condition
- failure to implement a consistent mechanism for personnel ingress into the PFP protected area during a security lockdown condition
- failure to properly coordinate the consistent and appropriate use of respiratory protection equipment.

3. **Failure to initiate appropriate actions in response to personnel exposure to uncharacterized hazards.**

- exposed workers not surveyed for potential radiological contamination upon reporting to the shift office or prior to release to the hospital
- no consideration given to conduct decontamination of exposed workers prior to release to the hospital
- care of exposed workers not assigned to a member of the Incident Command; workers not evaluated by on-scene EMTs; workers transported themselves to the local area hospital; 4 hours passed before workers were released from the facility so they could report to the hospital
- failure to develop clear medical criteria in existing procedures or protocols for the proper handling of workers exposed to chemical hazards
- failure to adequately prepare for and conduct proper nasal smears of exposed workers
- no written protocol existed between the Hanford medical contractor and the local area hospital for initial evaluation and treatment of occupational chemical exposures
- no established protocol in place for the Hanford medical contractor to initiate appropriate follow-up medical actions for workers exposed to chemical contaminants; approximately 35 hours elapsed between the time the affected workers were discharged from the local hospital until they were evaluated by the Hanford medical contractor.

4. **Failure to adequately prepare for emergency response to chemical hazards.**

- inadequate facility hazards analysis resulting in the lack of preparation for conducting plume tracking and environmental monitoring for chemical contaminants
- chemical monitoring equipment was not easily accessible; chemical plume monitoring did not occur
- industrial hygiene support personnel not easily accessible
- failure to effectively implement respiratory protective requirements; failure of facility respiratory protection self-assessment program; on the evening of the explosion 28 of 36 self-contained breathing apparatus (SCBA) units past due for required 2-year inspection.

GENERAL CONCLUSION

Major aspects of the responses to this emergency failed to meet the intent of DOE requirements, RL Emergency Plan Implementing Procedures, best practices for occupational health considerations, and certain environmental notification requirements. The decision to categorize the event as an Alert emergency was not made until after more than 2 hours had passed since the initiating condition. The initial notification to offsite authorities was not accomplished within the required times. The initial onsite protective actions were inadequate; initial onsite protective actions were not implemented as planned; chemical monitoring data were not obtained; actions described in the contingency plan were not completed; and the treatment of affected workers failed to meet expectations.

When the RL-EOC was declared operational, it assumed the responsibility for implementing additional onsite protective actions and for subsequent notifications to offsite agencies. The RL-EOC carried out these responsibilities in a timely manner. The consequences of the emergency did not require RL to make any Protective Action Recommendations (PAR) to offsite agencies.

The event had response actions involving facility operations, reentry and damage assessment, and security concerns. Those actions required a coordinated Unified Command structure involving the Building Emergency Director (BED), Incident Commander (IC), and Hanford Patrol Shift Commander. The RL-EOC provided support with radiological and chemical assessment modeling and with logistics, while the JIC developed and issued news releases.

In summary, the evaluation identified several significant failures associated with the responses to the declared emergency at the Plutonium Reclamation Facility. To avoid any recurrence of these problems, short-term corrective actions were implemented in the weeks since the event. Continued in-depth analysis will be done to more fully understand the major causes underlying the problems and to identify long-term corrective actions.

The issue-identification process involved a collaborative effort among the affected workers, contractors, DOE, and stakeholders. The lessons learned from these emergency responses will be shared across the Hanford Site and the entire DOE complex to enhance future emergency responses. Aggressive follow-up is essential for identified corrective actions to be effective.

Steven J. Veitenheimer, Director
Quality, Safety, and Health Programs Division
Department of Energy
Richland Operations Office

REPORT ON THE EMERGENCY RESPONSE TO THE EVENT ON MAY 14, 1997, AT THE PLUTONIUM RECLAMATION FACILITY, HANFORD SITE, RICHLAND WASHINGTON

1.0 INTRODUCTION

On May 14, 1997, at 7:53 p.m. (PDT), a chemical explosion occurred in Tank A-109 located in Room 40 on the fourth floor of the Plutonium Reclamation Facility (PRF). PRF, also known as the 236-Z Building, is an inactive plutonium processing facility, located within the Plutonium Finishing Plant (PFP) complex on the Hanford Site. PFP is located approximately 30 miles north of Richland, Washington (Figure 1) and is within a fenced protected area to provide security for the plutonium stored there.

The explosion and its aftermath were determined by facility personnel to warrant the declaration of an Alert emergency, activation of the Hanford Emergency Response Organization (ERO), and notification of offsite agencies. As a result of the emergency declaration, a subsequent evaluation was conducted to assess:

- the performance of the emergency response organization
- the occupational health responses related to emergency activities
- event notifications to offsite and environmental agencies.

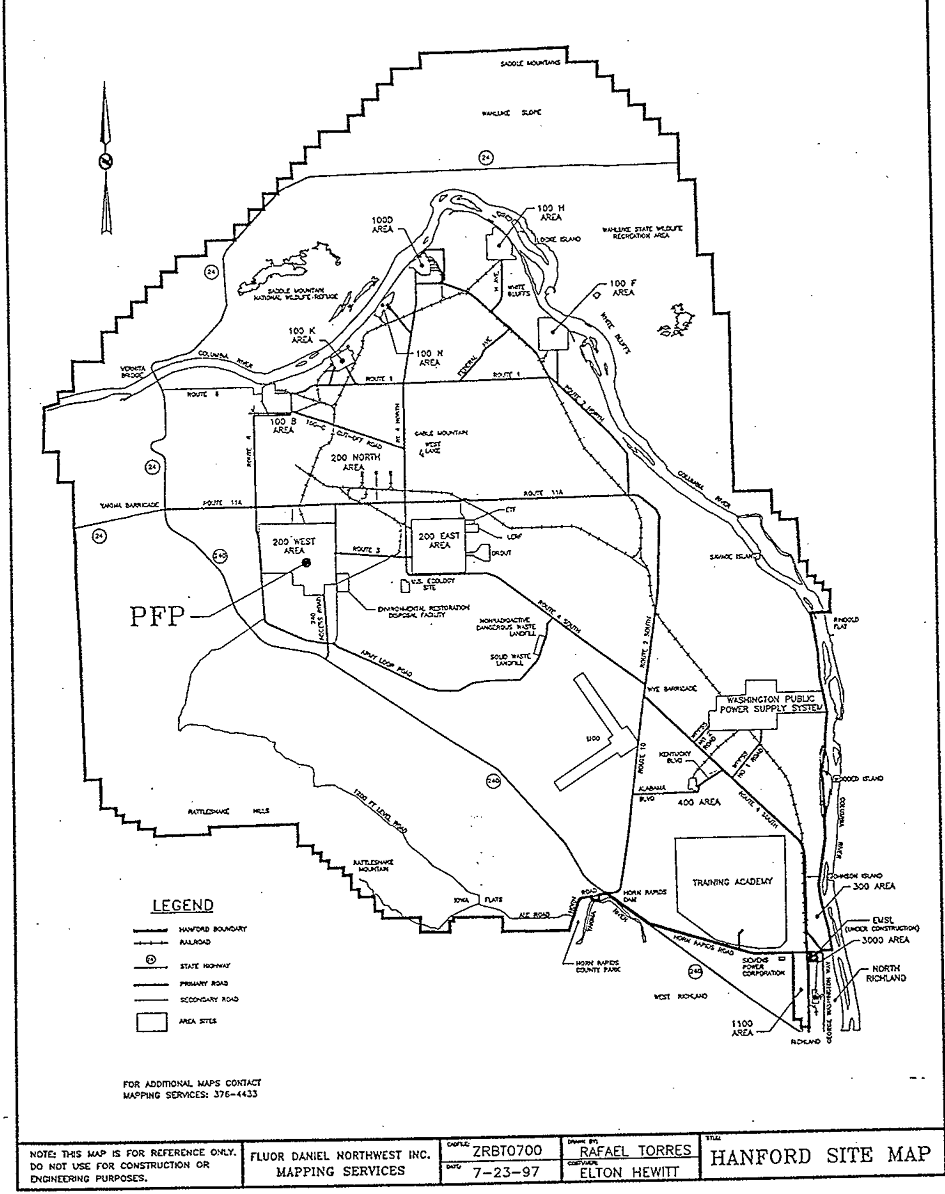
The Hanford Emergency Response Plan and the RL Emergency Plan Implementing Procedures, based on the USDOE emergency management orders and guidance, lay out in detail the activities necessary to perform critical emergency response functions, including activation, classification, notification, protective actions, resource staging, consequence assessment, monitoring, reentry, public information, termination, and recovery. The emergency response actions, beginning with the detection of the explosion, were grounded in the RL Emergency Plan Implementing Procedures and associated procedures and protocols related to security activities; environmental regulations; building and area emergency organizations; and offsite emergency management plans and procedures. The steps in the activation of the emergency response organization and the establishment of lines of communication among the various emergency operations centers generally followed the concept of operations laid out for emergency response.

Over fifty people from contractor and RL staff, both onsite and at the RL-EOC, who are trained to become part of the emergency response organization when called, worked through the night of May 14, 1997, and well into May 15, 1997, responding to the explosion. After the situation was declared an Alert emergency, the offsite counterparts to the Hanford ERO were notified and took their positions at the various county and state emergency operation centers. These centers have emergency response plans and procedures that integrate with Hanford's. The offsite emergency operation centers received status reports from the RL-EOC as the onsite response and assessment continued, and were ready to implement any protective actions for offsite populations, if necessary.

1.1 Background (1)

The DOE Richland Operations Office (RL) provides oversight of operations at the Hanford Site. Since October 1, 1996, Fluor Daniel Hanford, Inc. (FDH), under contract to RL, manages and integrates the scope of work defined in the Project Hanford Management Contract (PHMC). The B&W Hanford Company (BWHC), under subcontract to FDH, manages and operates the Plutonium Finishing Plant (PFP), which includes the Plutonium Reclamation Facility (PRF). In addition to BWHC, several other subcontractors were involved in the emergency and occupational health responses to the explosion on May 14, 1997. DynCorp Tri-Cities Services Inc., under subcontract to FDH, is responsible for operating the Hanford Fire Department and providing site-level emergency response services. B&W Protec, under subcontract to FDH, provides security for the Hanford Site. Fluor Daniel Northwest (FDNW) provides engineering and construction support to BWHC for modification work in progress at PFP at the time of the event. In addition to FDH, RL has contracts with Battelle's

FIGURE 1 - Plutonium Finishing Plant



Pacific Northwest National Laboratory (Battelle), Hanford Environmental Health Foundation (HEHF), and Bechtel Hanford Inc. (BHI), which also were involved in various aspects of responding to the event. Battelle provides dosimetry services for the site and support to RL in the emergency operations center (EOC); and has a subcontract with another laboratory that provides internal dosimetry services. HEHF provides onsite medical services to RL and the other Hanford contractors and also supports RL in the EOC. BHI provided Radiological Control Technicians (RCTs) to assist in performing radiological field monitoring during the early morning hours on May 15, 1997. Figure 2 shows RL contractors and subcontractors and their responsibilities relative to this event.

The PFP building emergency plan covers all of the PFP complex, including PRF. The shift manager, who is trained on the facility and Hanford site emergency response implementing procedures, becomes the Building Emergency Director (BED) when there is an event.

In September 1992, activities were initiated at PRF to demonstrate readiness for facility restart but stopped in December 1993 when RL directed that PRF be shut down because of mission changes. The chemical solution of hydroxylamine nitrate (HAN) in dilute nitric acid (HNO_3) was put into Tank A-109 during this period. Subsequently some of the solution was used, but following that the tank was not completely drained. Since facility shutdown in December 1993, work activities at PRF have been conducted to support and maintain the facility in long-term shutdown prior to decontamination and decommissioning activities.

On May 14, 1997, an autocatalytic (spontaneous) chemical reaction caused a chemical explosion in Tank A-109, a ventilated 400-gallon stainless-steel tank used to prepare a HAN and HNO_3 solution. Tank A-109 is located in Room 40 on the fourth floor of the PRF (Figure 3). Water within the HAN and HNO_3 solution in Tank A-109 had evaporated over a period of nearly four years. This evaporation process, which concentrated the HAN and HNO_3, and the potential presence of a catalyst (such as iron) created the conditions that led to an autocatalytic chemical reaction. The autocatalytic chemical reaction resulted in a rapid generation of gas inside Tank A-109. The gas buildup in Tank A-109 tore the lid from the tank and propelled it, and its attachments, upward with enough force to sever a 1.5-inch fire-suppression water line and to damage the ceiling and cause breaches in the roof above Room 40. Tank A-109A, a 20-liter Pyrex™ glass tank, located above Tank A-109 and previously used to add hydrazine to Tank A-109, was destroyed by the explosion. Tank A-109A was empty at the time of the explosion. The force of the Tank A-109 explosion displaced nearby Tank A-102 six inches, but did not appear to damage this empty tank or any other tanks contained in Room 40.

The pressure wave from the explosion caused an over-pressurization of Room 40 that resulted in damage to all of the internal doors leading into the room. When Room 40 was over-pressurized, there was also a temporary flow imbalance in the facility ventilation system, resulting in a positive pressure in Room 40 with respect to that outside the building. This over-pressurization was rapidly corrected as the excess gases from the explosion were exhausted via the facility ventilation system. The facility ventilation system is designed for once-through flow to allow outside air to flow from uncontaminated areas to contaminated areas, then through a high efficiency particulate air (HEPA) filter system before being exhausted by fans to the atmosphere via the PFP's main stack (Stack 291-Z-1).

Employees who were at PFP at the time of the explosion reported seeing a yellowish-brown colored plume streaming from the 291-Z-1 stack. Laboratory studies conducted after the accident revealed that this plume would likely have been a mixture of gases consisting of oxides of nitrogen, which produce a characteristic colored plume similar to that seen coming from the 291-Z-1 stack. The by-products produced from the explosion, as well as some of the original chemicals contained in Tank A-109, may have also been released through the holes in the roof above Room 40 of the PRF while the room was under positive pressure.

No personnel were in Room 40 or PRF at the time of the event; however one worker was in a change room near the entrance of the first floor of the PRF at the time of the explosion (Figure 4).

FIGURE 2
Contractor and Subcontractor Organization Chart

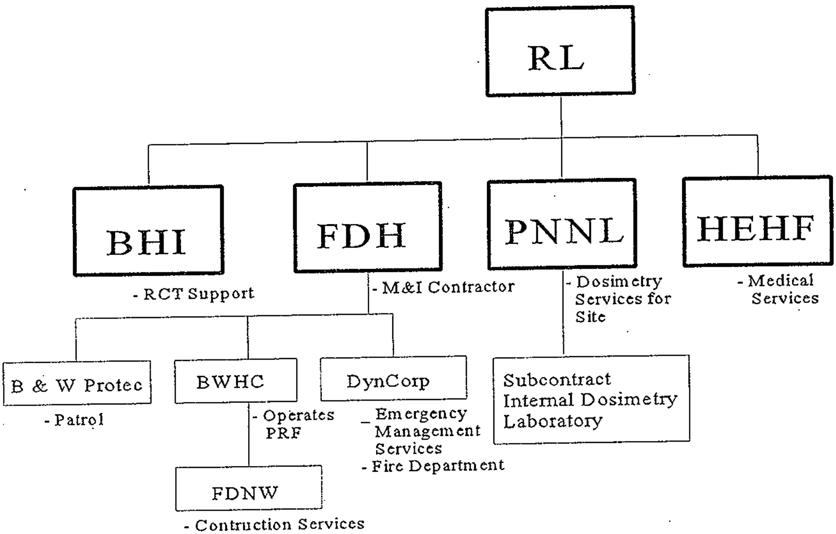
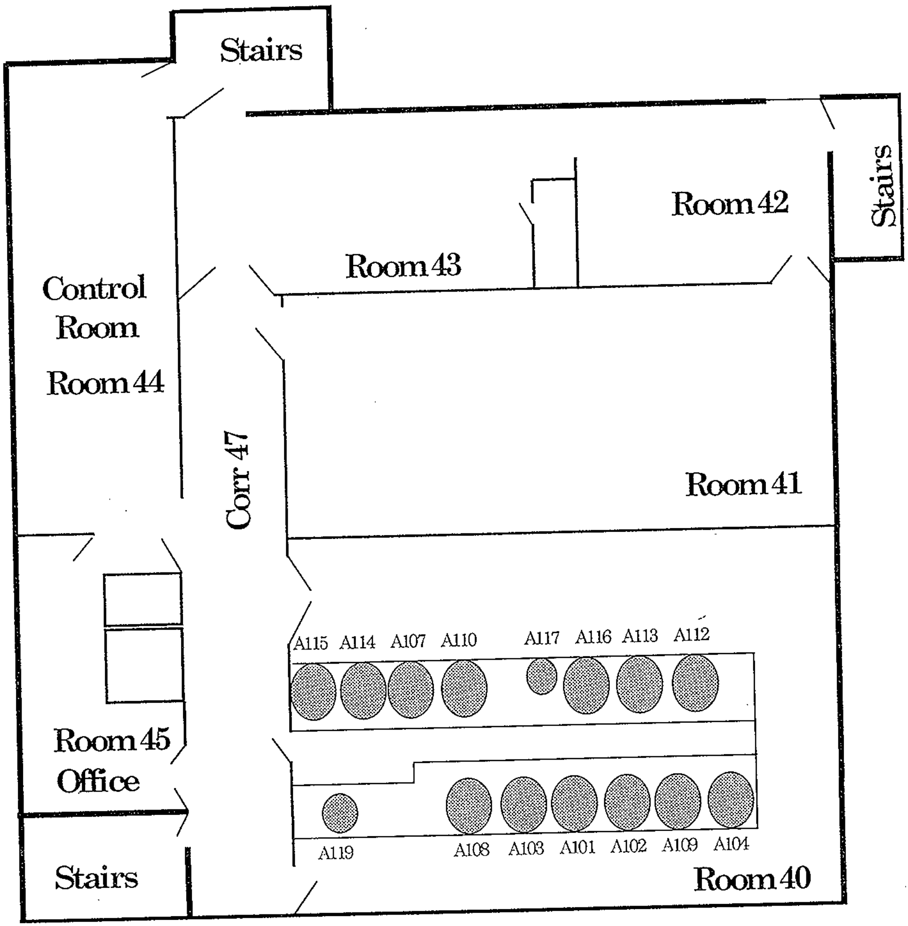


FIGURE 3
Fourth Floor of PRF



Other personnel in the general vicinity of the PRF at the time of the explosion included one security guard located on the roof of the 234-5Z facility, one security guard located southeast of the PRF, and eight construction workers located in a trailer southwest of the PRF (Figure 5). Based on the worker's locations during and after the explosion, they were potentially exposed to the emissions from the 291-Z-1 stack and from the holes in the roof of the PRF.

This report on the emergency response aspects will not re-address the physical and causal factors of the explosion, which are covered in DOE/RL-97-59, "Accident Investigation Board Report on May 14, 1997, Chemical Explosion at the Plutonium Reclamation Facility, Hanford Site, Richland, WA." This report will supplement the information provided in DOE/RL-97-59 by including appendices on the chemical and radiological hazards. These appendices, D and E, provide detailed information on the results of more intensive assessments of the chemical and radiological hazards surrounding the explosion. This information is critical for addressing worker health and safety concerns, as well as for better understanding and reducing similar workplace hazards across the Hanford Site.

1.2 Purpose of the Emergency Response Evaluation Report

The purpose of this emergency response evaluation report is to provide an assessment of the adequacy of the Hanford Site emergency preparedness activities and emergency management as demonstrated by the ERO during the May 14, 1997, declared emergency at the PRF. This report will:

- summarize the radiological and chemical hazards and their potential health effects
- present the chronology of emergency response activities, including occupational health responses and environmental notifications, resulting from the explosion at the facility
- assess the adequacy of the Hanford Site emergency preparedness activities, response readiness, and emergency management actions, including occupational health measures and environmental reporting, as demonstrated by the performance of the Emergency Response Organization
- describe and identify causes of deficiencies and weaknesses found in the preparedness and response activities
- assign organizational responsibility to correct the deficiencies and weaknesses, and actions to improve future performance, or to adjust elements of emergency implementing procedures and emergency preparedness activities

The chronology of the event is provided in both a textual form (Appendix A) and as verbatim entries from logs kept during the response and chronologies prepared immediately after the event (Appendix B). It should be noted that event logs report only the observations and personal knowledge of the individual at the time the entry was made. When all the facts are determined by the investigation team, some log entries will be in conflict with the total post-event picture. The observations or major response problems are categorized according to level of severity and labeled as deficiencies, weaknesses, or improvement items. Sections 2.0 and 3.0 present the observed problem, a description of circumstances surrounding the inadequate performance of the particular emergency response function, and present a general statement of what further analyses are needed to achieve an effective corrective action. Appendices C and F provide further detail to document the indicators related to Deficiencies 6 and 3, respectively.

The descriptions of deficiencies (Section 2.0) and weaknesses (Section 3.0) identified for this evaluation include statements of the causes apparent from the initial analysis. The causes are stated in terms of operations elements that lend themselves to being corrected, including: problems with the lack of a procedure or an error in a procedure for response; personnel error such as incorrect use of a procedure, communication problems, or inattention to detail; the lack of or failure of equipment or material necessary to the response; training deficiencies; and, problems that can be traced to managerial actions or methods such as inadequate administrative control, inadequate work planning and assignments, inadequate supervision, improper resource allocation, or the inadequate definition, dissemination, or enforcement of a policy.

FIGURE 4 - 236Z / First Floor (PRF)

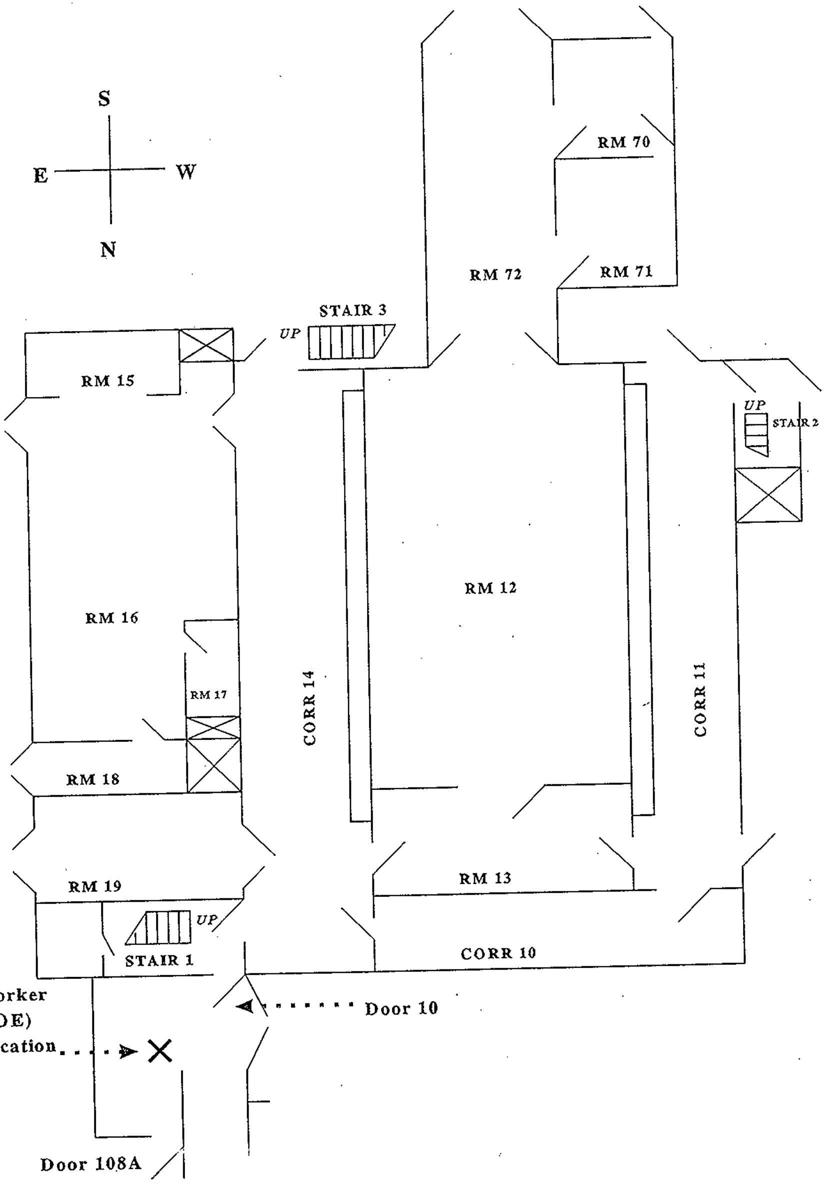
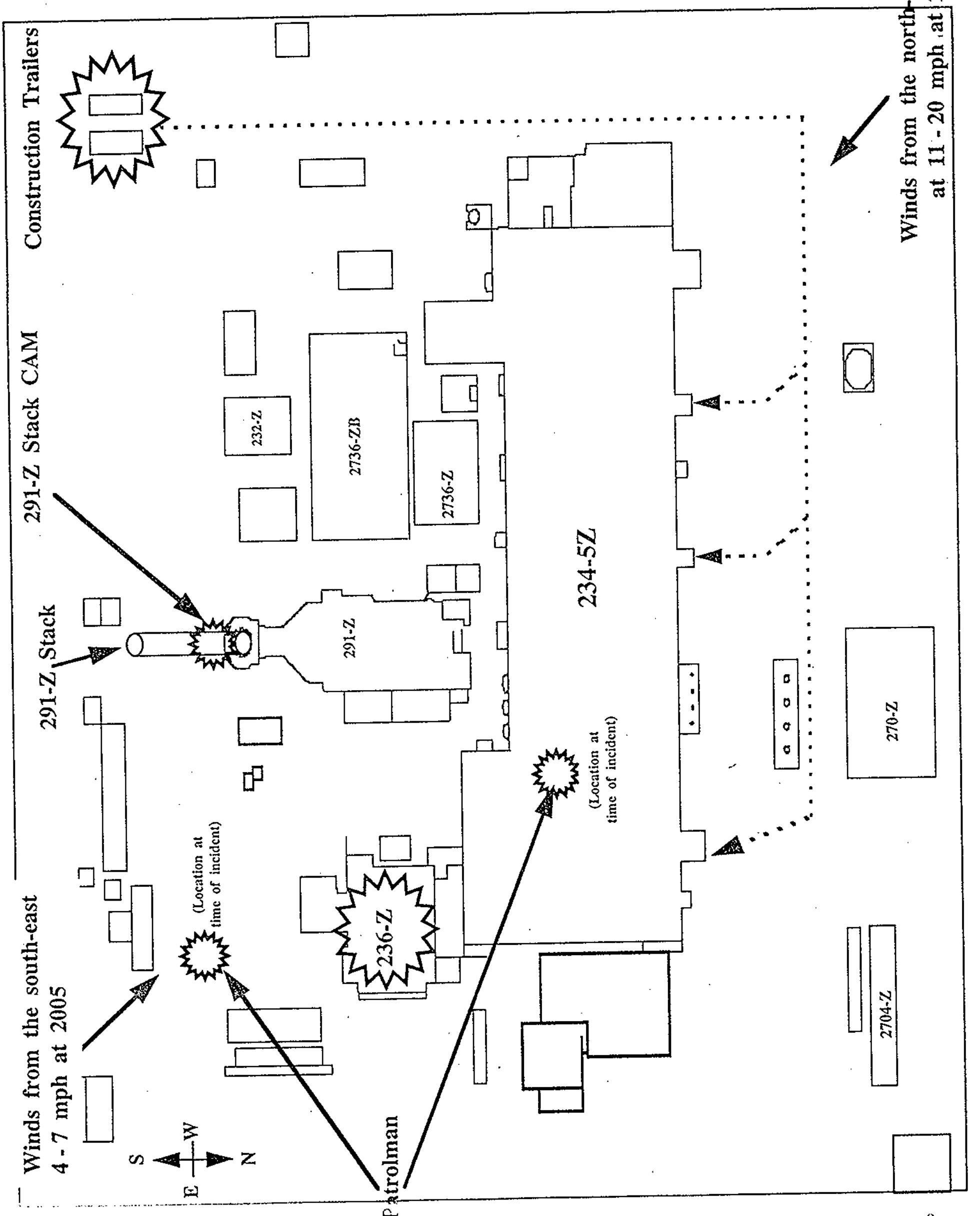


FIGURE 5 - Plutonium Finishing Plant - Aerial View



The causes serve as the focal points for needed analysis, action identification, and implementation of corrective actions. The organizational element indicated is viewed as the appropriate one to develop and implement corrective actions. The evaluation team did not attempt to provide detailed recommendations for analysis or for corrective actions, judging these to be the responsibility of the cognizant organizational element. Section 4.0 indicates improvement items, which are things of a less severe nature, but could compromise the operations of the ERO if not addressed.

1.3 Evaluation Approach

The approach for evaluating the incident at the PRF and developing this report involved the collaborative efforts of RL, HEHF, and FDH and subcontractor personnel who have overall responsibility and accountability for the performance of emergency response, occupational health, medical, and environmental functions for the Hanford site, as applicable. Additionally, the workers directly affected by the event were instrumental in providing essential input for the development of the report. Input was also provided by offsite emergency management, health, and environmental agencies.

Specific information contained in this report is a compilation of input provided from the following sources:

- interviews with the workers directly affected by the PRF event
- interviews with personnel who were present at the PRF during and after the event and who participated in the emergency response and assessment activities
- data provided by PFP personnel through Senior BWHC Management, at the request of the evaluation team
- review of the emergency response and other logbook entries, facsimile records, phone conversations, computerized messages, and monitoring records
- review of notes from post-event critique sessions, meetings with members of response units (e.g., POC, RL-EOC, including the UDAC and JIC, and the ICP), responses from personnel who participated and were asked for clarification on notes or actions, and comments on report drafts
- data collected during the development of the "Accident Investigation Report on the May 14, 1997, Chemical Explosion at the Plutonium Reclamation Facility, Hanford Site, Richland, Washington."

1.4 Summary of Emergency Response Organization Activities

The following paragraphs provide a brief description of the emergency response actions taken immediately following the explosion and continuing through the night until facility conditions were considered under control and the Alert status was terminated. The purpose of this description is to provide a general view of the chronology of the response and a general context for the deficiencies and weaknesses in the response that are described in Sections 2.0 and 3.0 which follow. Appendix A of this report gives a much more detailed chronology of the response activities, with an indication of what types of operation were occurring on simultaneously. The chronology calls out those aspects of the activities having significance for occupational health concerns and describes health follow-up initiatives conducted in the months following the explosion. Appendix B provides a comprehensive list of entries made in the various logs kept during the emergency response activities by the functional groups. These logs present the progression of the actions taken from several different locations in the ERO and provide the chronological skeleton for the information provided in Appendix A.

On May 14, 1997, at approximately 7:53 p.m., a chemical explosion occurred in Room 40 (Chemical Preparation Room) of the Plutonium Reclamation Facility (236-Z Building), located within the Plutonium Finishing Plant. The impact was felt by facility personnel and the explosion activated several security and fire box alarms, which, respectively, were received at the 200 West Central Alarm Station and at the 200 Area Hanford Fire Station. In the minutes following the explosion, several people at the facility saw a yellow-brown emission from the 200-foot-high exhaust stack (291-Z-1) at the facility.

Shortly after the explosion, the Incident Command Post was established in Room 104 as a Unified Command (UC). The UC included the Building Emergency Director (BED), for facility matters; the Hanford Fire Department Deputy Chief, in the role of Incident Commander; and the Hanford Patrol Shift Commander, to coordinate security matters for the overall response.

At 7:55 p.m. Hanford Patrol initiated a lockdown of the Plutonium Finishing Plant complex and 200 West Area, owing to an alarm that was activated by the explosion. The lockdown is a security measure that requires personnel to move to a safe place and stay there while Patrol and plant management conduct a security assessment for the protection of special nuclear material (SNM). A public address system announcement was made at 8 p.m. for all workers to report to Room 104 for accountability purposes. A yellowish-brown emission was visible from the exhaust stack and the Patrol command requested over the radio system that all patrol units stay away from the west side of the building. At approximately 8:05 p.m., the PFP Building Emergency Director (BED) directed the 200 West Central Alarm Station to activate the take cover siren for the Plutonium Finishing Plant complex. At about this time the Hanford Patrol at the facility donned respirators, which is an automatic action for them when a take cover is heard.

Just after 8 p.m., eight Fluor Daniel Northwest (FDNW) construction workers started toward Building 234-5Z in accordance with a public-address announcement ordered by the BED that all plant personnel should report to Room 104. When the workers left the construction trailer, a Hanford Patrolman instructed them to conform to the lockdown by returning to the trailer. A few minutes later the FDNW crew supervisor among the workers contacted the ICP to ask again if they were to report to Room 104; he was told they should. As the workers left the trailer a second time, the take cover siren sounded, and they were again stopped by a Hanford Patrolman. They told the Patrolman they were following the instructions of the BED, and the Patrolman permitted them to proceed, although he cautioned them about potential danger along the southeast side of the building were there to be a secondary explosion. The potential for an emission from the south canyon airlock was also discussed. The workers proceeded along the west and north sides of the PFP building and arrived at the ICP at 8:16 p.m. This route took them through the area downwind of the explosion and any emissions from the building or 200-foot exhaust stack at the facility.

After arriving at Room 104, two of the workers complained of a "metallic taste" in their mouth. They were instructed by the BED to report to the Kadlec Medical Center emergency room. They were not referred to the paramedic at the facility for any medical evaluation, although later they requested a radiological survey before leaving the facility. Several delays occurred in arranging their transportation, obtaining a radiological survey, and coordinating permission for them to leave the facility under the lockdown status .

Shortly after the alarms were received in the Patrol Operations Center (POC), it began the process of notifying the emergency response staff, which included patrol management and the Emergency Duty Officer (EDO). The EDO then contacted the PFP BED to ensure he had examined the Emergency Action Levels (EALs) for PFP, which describe the bases for determining the level of emergency response. Based on the information available to the ICP, the BED determined that no EALs for PFP had been exceeded. The EDO began notifying contractor and RL senior management of event information.

The ICP staff continued assessing the event. At 8:46 p.m. the initial Hanford Fire Department entry team reported the first tangible evidence of an explosion on the ceiling above the chemical preparation tanks in Room 40. The information available to the ICP at this time indicated the following: .the facility security was not being challenged; facility instrumentation indicated no loss of containment; stack radiological emission monitors were not alarming; and security cameras were not able to discern other facility damage. During the next 30-40 minutes the ICP staff took several actions to continue refining the initial assessment of facility conditions.

By approximately 9:20 p.m., the BED had requested a first-hand inspection of the main PFP exhaust stack radiological monitoring system and received confirmation from a radiological control technician that it was functioning properly. The BED, Incident Commander, and their support team continued to assess the magnitude of the event until approximately 10:02 p.m. when the BED declared an Alert emergency based on the potential degradation of facility safety and the need for additional resources from other onsite response organizations. According to procedures, the ICP is required to contact the POC and provide sufficient information to complete the RL Notification Form which prompts the POC to follow their checklist for declared emergencies. Following the instruction from the EDO, the POC initiated the Emergency Notification System (ENS) to activate the RL-EOC at approximately 10:05 p.m. DOE requires that emergency management notifications be made to offsite response agencies within 15 minutes of the declaration of an emergency. The POC did not receive the RL Notification Form from the ICP and did not complete all items on the appropriate checklist. Consequently, the offsite emergency management notifications were not made within the required time and other onsite protective actions for areas beyond the PFP boundary were not immediately activated.

At 10:35 p.m. the first responders arrived at the RL-EOC, and the center was declared adequately staffed at 10:55 p.m. to assume responsibility for onsite protective actions, offsite notifications, and provision of logistical support to the ICP. The declaration of an Alert prompts the activation of offsite emergency operations centers, including the Benton and Franklin Bi-County EOC, the Grant County EOC, the Washington State EOC, and the DOE Headquarters EOC. The staff earliest to arrive at the RL-EOC determined that no notifications had been made to offsite agencies, so the EOC staff initiated emergency response notifications, which were completed by 11:22 p.m. Following receipt of notification, officials from the counties and the Washington State Department of Health reported, as representatives, to the RL-EOC, and the Joint Information Center (JIC); an RL Representative was sent to the Bi-County EOC.

The JIC was declared operational at 11:08 p.m. and within approximately 40 minutes developed and disseminated the first press release. The JIC continued to provide press release information and responses to media inquiries.

The RL-EOC staff continued to monitor the status of the response and provide technical and logistical assistance to the ICP. The ICP requested that the RL-EOC send Industrial Hygiene (IH) support for on-scene evaluations and the reentry process. A significant delay occurred in locating an Industrial Hygienist to send to the facility, since no Industrial Hygienist had been assigned to on-call status for the facility and the RL-EOC did not have a list of IH resources available for emergency response. It was more than six hours before the facility Industrial Hygienist was located and sent to the ICP to assist with assessment activities.

The RL-EOC gathered and dispatched radiological field teams to begin determining whether any radioactive material could be found beyond the facility. Evaluations conducted by the ICP at the facility and the preliminary data gathered by the environmental field teams indicated no detectable ground depositions of radioactive material. Environmental air samples were collected and analyzed at the onsite analytical laboratory. By 2:30 a.m., perimeter radiological surveys of the PFP complex were completed and showed no evidence of a radiological release. Using this and other information, including that from the Industrial Hygienist, the RL-EOC terminated the take cover order in the 200 Areas shortly after 3 a.m.

A fourth reentry was conducted at approximately 4 a.m. to further evaluate the facility conditions in consideration of terminating the declared emergency, if warranted. The entry team completed a walk-through of the first, second, third, and fourth floors of the PRF facility and videotaped the facility conditions. The RL-EOC and the ICP used the video evidence as one of their bases in deciding to terminate the Alert emergency at 6:41 a.m. on May 15, 1997.

The RL-EOC activities shifted its focus to the recovery phase of the event. A recovery team was identified and a press briefing was scheduled for mid-morning to provide a status of the facility and briefly discuss the sequence of events. The transition from emergency phase to the recovery phase was performed in accordance with procedures. During the transition phase, the continuing requests from DOE-HQ, media, and others for information required that some staff remain in the RL-EOC to respond to these requests. After the recovery team was established, it was determined that the most effective manner to facilitate the recovery process was to designate a Recovery Manager who works at or near the facility, i.e., 200 West Area, and was familiar with it. In the first hours of the recovery process the position of Recovery Manager was therefore assigned to the RL Division Director responsible for the Plutonium Finishing Plant.

1.5 General Observations

Significant aspects of the response to this emergency failed to meet the intent of DOE requirements, DOE/RL-94-02 "Hanford Emergency Response Plan," the RL Emergency Plan Implementing Procedures, best practice for occupational health considerations, and certain environmental notification requirements. While this report is designed to identify programmatic failures and areas of less-than adequate performance, several areas in which the emergency response organization did function as planned are discussed below:

- When the RL-EOC was declared operational, it assumed the responsibility for implementing additional onsite protective actions and for subsequent notifications to offsite agencies. The RL-EOC carried out these responsibilities in a timely manner. The consequences of the emergency did not require RL to make any Protective Action Recommendations (PAR) to offsite agencies.

- The event had implications involving facility operations, reentry and damage assessment, and security concerns. Those response actions required a coordinated Unified Command structure involving the Building Emergency Director (BED), Incident Commander (IC), and Hanford Patrol Shift Commander. The RL-EOC provided support with radiological and chemical assessment modeling and with logistics, while the JIC developed and issued news releases

- Onsite notifications of the initial event to Patrol, Fire and the Emergency Duty Officer were completed promptly and in accordance with procedures.

- The Hanford Fire Department responded and established Incident Command within 20 minutes of the initial notification.

- Access control to Room 40, where the explosion occurred, was well maintained and controlled.

- The ICP adequately performed and coordinated reentry and damage assessment activities

- Reentry debriefings were thorough and conducted in accordance with approved procedures.

- Reentry was completed in a safe and professional manner.

- Briefings by the Incident Commander to the Site Emergency Director were precise and accurate.
- The RL-EOC effectively maintained status boards and timeline recording information.
- Once the RL-EOC was declared operational, it assumed the responsibility for implementing additional onsite protective actions and for subsequent notifications to offsite agencies. The RL-EOC carried out these responsibilities in a timely manner.
- The JIC adequately developed and issued press releases and responded to public and media inquiries.
- Public information was effectively coordinated with offsite representatives.
- Emergency termination was conducted in accordance with established procedures and a Recovery Team was appropriately assigned.

The evaluation identified nine deficiencies and fourteen weaknesses related to the emergency response. The general observations, given in more detail in Section 2.0, Deficiencies, and Section 3.0, Weaknesses are discussed below:

- The pre-planned guidance for whether this type of event at this facility needed to be categorized as an emergency was inadequately presented, which hindered the decision-making by facility operations staff. The staff at the ICP took over two hours to reach the decision to categorize the event as an Alert emergency. During that time, the process for letting offsite agencies know of the non-categorized event in progress failed.
- Subsequent to categorization, the initial notifications to offsite emergency management authorities about the Alert declaration were not accomplished within the 15-minute time frame required by DOE. The initial onsite protective actions were not coordinated in accordance with procedures by the command and control function at the ICP. Conflicting communications at the facility while personnel accountability was being conducted resulted in eight construction workers passing through the area downwind from the explosion and its emissions.
- Inadequate enforcement of the take cover order and lack of command and control to ensure proper use of personal protective equipment (PPE) resulted in many plant personnel being outside without PPE during the time when the hazards associated with the explosion were not yet completely known. Lack of adequate preparedness for being able to make a timely assessment of the chemical hazards likely to have been associated with the explosion limited the ability to make well-founded decisions about PPE, and about occupational health considerations for workers who were outside following the explosion. This also limited the ability to make appropriate and timely notifications to environmental agencies that regulate environmental hazards.
- Poor preparedness for and inadequate performance of radiation control procedures and personnel monitoring resulted in additional concerns on the part of personnel who were outside the facility on response assignments after the explosion. Delays in the exposed workers receiving follow-up occupational health evaluations resulted from inadequate policies and procedures to coordinate these activities with local medical services.

The above observations reflect the major failures and areas of concern related to the declared Alert emergency at the Plutonium Reclamation Facility on May 14, 1997. To avoid any recurrence of these problems, short-term corrective actions were implemented in the weeks since the event. Continued indepth analysis will be done to more fully understand the major causes underlying the problems and to identify long-term corrective actions. Organizational mechanisms will be developed to ensure that long-term corrective actions are implemented and enforced. RL and contractor personnel with the necessary expertise will develop these mechanisms. These individuals will be accountable for ensuring that long-term corrective actions remedy the identified problems at PFP as well as others site wide involving chemical and radiological hazards.

2.0 DEFICIENCIES

The nine deficiencies identified during this evaluation are described in detail below. A "deficiency" is a failure to meet the requirement(s) of an applicable regulation or DOE order pertaining to emergency management resulting from the following:

- Inadequate compliance, to include implementation or maintenance of a component of the emergency management system program.

The regulation or order requirement addresses a situation which had a potential for *direct adverse impact* on the health and safety of workers, public, or the environment. Deficiencies are the highest priority for the purpose of expediting corrective actions and tracking them to closure.

2.1 DEFICIENCY D01

Command and control weaknesses during the early stages of the event resulted in the failure to implement emergency response activities consistent with the requirements for facility take cover and lockdown conditions. Additionally, the command structure failed to properly coordinate the care of exposed workers and the consistent and appropriate use of respiratory protection equipment. These failures are evidenced by the following:

- Inadequate process for personnel accountability during a facility take cover and conflicting guidance provided to the workers resulting in exposure to chemical release;
- Failure to assign initial medical treatment and short term medical response actions to an appropriate member of the Incident Command; workers were not evaluated by on scene Emergency Medical Technicians (EMTs); failure to develop clear criteria in advance for the proper medical handling of workers exposed to chemical contaminants; workers transported themselves to the local area hospital; took 4 hours for workers to be released from the facility to report to the hospital;
- Several instances of personnel outside of sheltered areas in and around PFP during a facility take cover condition without personal protective equipment; instances of site staff personnel traveling from personal residence through as many as 4 security checkpoints and into the PFP protected area without being advised that a take cover condition existed at the facility; failure to implement a consistent mechanism for personnel ingress into the PFP protected area during a security lockdown condition;
- Failure to properly coordinate the consistent and appropriate use of respiratory protection equipment.

<u>Evaluation/Analysis:</u>

- Process used for personnel accountability during a facility take cover did not protect safety of workers and conflicting guidance provided to the workers resulting in exposure to the chemical release.

Subsequent to the explosion, Hanford Patrol initiated a lockdown at the facility and directed Patrol personnel to stay away from the west side of Building 234-5Z, which was downwind from the explosion site and the visible yellow-brown plume emanating from the main stack. The BED implemented a take cover for the facility and initiated a process to account for all personnel. This was problematic in that a clear policy to conduct personnel accountability during take cover conditions did not exist. Assuming all personnel were within Building 234-5Z, the BED directed a public address system (PAX) announcement be made for all plant personnel to report to Room 104. A construction worker on lunch break in a near-by construction trailer contacted the shift office by phone to determine if the PAX announcement for all "plant personnel" to report to room 104 included the eight construction workers. He was told it did and were instructed to report as directed. The eight construction workers left the trailer to proceed to Room 104 but were stopped by a Hanford Patrolman and told to return to the trailer because of lockdown and take cover conditions. The workers returned to the trailer and phoned the PFP shift office a second time for further direction. They were again instructed to report to Room 104. When the workers left the trailer the second time, they were again stopped by Hanford Patrol. The workers stated they had instructions from the shift office to report to Room 104 and were going to proceed as directed. The Hanford Patrolman accepted this explanation but advised them of concerns about a secondary explosion along the east side of the building. The Patrolman did not contact the shift office to verify the acceptability for personnel to be outside during the take cover.

After receiving information from the Hanford Patrolman relative to the potential danger on the east side of the building, the workers proceeded along the west and north sides of the main PFP facility and arrived in Room 104 at approximately 8:16 p.m. This route along the west side of the 234-5Z Building was directly downwind of the main stack emission, as well as emissions from the holes in the PRF roof.

At a later point (approximately 9:40 p.m.), and while the take cover was still in effect, two of the same workers received permission from the Incident Command Post, to return to the construction trailer to pick up personal and company vehicle keys. To do this, these two retraced their steps through the potentially affected area along the west side of Building 234-5Z to the construction trailer and back to Room 104. This action again allowed personnel to leave sheltered areas during a take cover condition. Additionally, during a subsequent effort to ensure operability of the main stack radiation monitor, a technician was directed by the shift office to proceed outside at approximately 9 p.m. without consideration for personal protective equipment. Some time later the technician exhibited symptoms of a "raspy" throat.

- **Failure to assign initial medical treatment and short term medical response actions to an appropriate member of the Incident Command; workers were not evaluated by on scene Emergency Medical Technicians (EMTs); failure to develop clear criteria for the proper medical handling of workers exposed to chemical contaminants; workers transported themselves to the local area hospital; took 4 hours for workers to be released from the facility to report to the hospital.**

Two of the eight construction workers who had been outside complained of a metallic taste in their mouth at approximately 8:16 p.m. upon arriving at Room 104. This information was not immediately passed to the Incident Command Post (ICP). When the worker's supervisor asked at approximately 9:15 p.m. that the metallic taste be reported to the ICP, the BED instructed the eight workers to report immediately to Kadlec Medical Center for evaluation. Their crew Supervisor was directed to make arrangements to ensure they arrived at the hospital. The medical treatment and handling was never appropriately assigned to a member of the ICP and, consequently, the workers were never evaluated by on scene EMTs. Additionally, there was no clear policy describing EMT actions relative to the care and handling of personnel exposed to low levels of chemical contaminants. The protocol typically followed by a paramedic or emergency medical technician at the site includes conducting a basic medical evaluation, determining the need for radiological evaluation, determining appropriate transportation, and providing pertinent information to the Kadlec Medical Center prior to any person arriving there from onsite. Information relative to potential exposures was never communicated from the on-scene EMT to the hospital.

Several hours elapsed prior to their release to the hospital. Much of the delay was attributed to conducting radiological surveys (i.e., nasal/mouth smears) and miscommunication between the BED and Hanford Patrol. Once the decision was made to send the workers to Kadlec Medical Center, the BED asked the Patrol Shift Lt. to inform Hanford Patrol that the workers would be reporting to the PFP gate to leave for the hospital. Upon the workers arriving at the gate, Hanford Patrol would not immediately allow them to leave because of the lockdown conditions. No call was made from the Patrolman to the ICP to obtain further verification. The eight workers returned to 234-5Z where they requested radiological surveying prior to leaving the facility. Two hours later, when the BED discovered the workers had not yet left the facility he once again requested that the Hanford Patrol permit the workers to leave the facility and the site. Again there was some delay until the request was successfully received by the appropriate person and the workers were permitted to leave.

- **Several instances of personnel outside of sheltered areas in and around PFP during a facility take cover condition without personal protective equipment; instances of site staff personnel traveling from personal residence through as many as 4 security checkpoints and into the PFP protected area without being advised that a take cover condition existed at the facility; failure to implement a consistent mechanism for personnel ingress into the PFP protected area during a security lockdown condition;**

The Yakima and Wye barricades on the site were closed to incoming personnel by Hanford Patrol shortly after being notified of the explosion. Access control was established at the 200 West Area main entrances due to lockdown conditions at the facility. Facility personnel responding to the event scene were allowed to proceed through these access control points without being informed a take cover or lockdown was in place for the area. As personnel arrived at PFP, approval for entry into the plant was inconsistent. Entry of some responders was authorized by the BED while others were granted access by Hanford Patrol. At times, the BED was surprised to see individuals enter the shift office who had gained access to the PFP protected area without his direct approval. There is no evidence of passport accountability at the ICP to include approvals for entry. Additionally, personnel who had arrived at PFP subsequent to the explosion were outside of sheltered areas during the take cover as they walked from the parking lot area into the plant complex.

- **Failure to properly coordinate the consistent and appropriate use of respiratory protection equipment.**

No centralized authority was identified during the emergency response phase to maintain an overview of all respiratory protection considerations. The Hanford Fire Department (HFD) Incident Commander (IC), specified and enforced use of respirators for entries into areas of the PRF where the explosion had occurred. The Incident Command Post, however, did not assume control of specifying respiratory protection requirements for areas surrounding the immediate incident area and outside the facility. This resulted in some elements of the emergency response organization conducting activities around the facility using respiratory protection equipment, while others did not.

Hanford Patrol personnel donned respirators under its own standard operating procedure in the area outside of the PFP based on the take cover order. This activity occurred only some time after the take cover was initiated and the requirement for Patrol had no bearing on other personnel conducting activities in the same vicinity. On several occasions, Radiological Control Technicians (RCTs) and other plant personnel were directed to conduct response activities outside Building 234-5Z and around the main plant ventilation stack without instructions for using respiratory protection. Additionally, some of the eight construction workers who had reported to Room 104 for accountability were later given permission to go outside Building 234-5Z without personal protective equipment.

Additionally, no consideration was afforded as to whether the respirators used by Hanford Patrol were appropriate for the existing hazards. Patrol had donned MCU/P2 respirators which are designed to protect against radiological particulates and some chemical and biological hazards. There is no evidence that the respirators would have been effective for oxides of nitrogen; the primary hazard of concern the evening of the explosion. Additionally, it should be recognized that the respirators currently in use by Hanford Patrol have not been certified by the National Institute of Occupational Safety and Health (NIOSH). The MCU/P2 respirators contain a drinking mechanism which has not been certified by NIOSH for use in radioactively contaminated airborne environments.

Causal Analysis:

- *Management Problem:* Less than adequate policy describing the methodology to initiate personnel accountability activities under all potential emergency conditions.
- *Management Problem:* Less than adequate policy describing expectations of facility personnel and emergency responders for take cover and lockdown conditions.
- *Management Problem:* Less than adequate policy describing expectations for on scene medical and command personnel to take in the event of personnel exposure to chemical contaminants.
- *Management Problem:* Less than adequate policy describing personal protective equipment expectations, including respiratory protection, for all on scene personnel during take cover conditions. Less than adequate respiratory protection in use by Hanford Patrol.
- *Inadequate Training and Hands-on Experience:* The Hanford Site BEDs and Hanford Patrol have received the initial Incident Command System training. However, there has been inadequate practice to the new system, especially with coordinating activities prior to the formal establishment of Unified Command.
- *Policy not adequately defined and communicated*: The policy and procedures addressing take cover response actions address reporting location to the BED, staying indoors, securing ventilation, and monitoring entrances to the facility. However the policy does not address the movement of sheltered personnel nor the communication of protective actions to personnel responding to the event area.

Action Taken to Date:

1. Lessons learned provided to Incident Command System personnel the week of July 14, 1997.

Judgements of Need:

1. DynCorp Emergency Preparedness and Hanford Fire Department need to identify the elements of the Incident Command training not well understood or well developed for the Hanford Site, and develop a training program for BEDs, IC's, and Patrol officers who may have responsibilities under the ICS. The training should include a practical hands-on module to adequately test the initial command functions required at the ICP.
2. FDH ESH needs to develop a policy relative to expectations during all accident scenarios, including take cover and lockdown conditions: At a minimum this policy should:
   - Provide information to non-emergency responders on take cover actions (e.g., ensure person giving instructions knows where people are in relation to hazard). Clarify required actions to conduct personnel

accountability checks.

- Provide information to emergency responders during take cover situations (e.g., access to the sheltered area, Incident Command Post, field team responders, etc).
- Provide information for coordination of take cover with security lockdowns.
- Clarify expectations for all applicable personnel responding to an emergency relative to ingress during lockdown conditions, medical response to chemical exposures, and the appropriate use of personal protective equipment.

3. RL-QSH needs to develop a policy describing expected medical response subsequent to personnel exposure to chemical contaminants.

4. FDH ESH needs to develop a policy describing the command and control of respiratory protection requirements relative to the Incident Command structure.

5. FDH ESH needs to evaluate the continued use of the MCU/P2 respirators by Hanford Patrol and implement equipment hardware changes as necessary.

6. FDH ESH and DYNCORP EP need to evaluate the offshift manning of facilities to ensure staff resource availability can fully meet all requirements and expectations in the event of an emergency condition.

2.2 DEFICIENCY D02

Offsite agencies and DOE HQ were not notified of the declared emergency within the required 15 minutes; instead all formal offsite emergency management notifications were completed over 1 hour after the initial declaration.

Evaluation/Analysis:

Offsite agencies and DOE HQ are informed of a declared emergency only after 1) the Building Emergency Director (BED) completes and approves an RL Notification Form, and 2) the BED or designee calls the Patrol Operations Center (POC) duty officer, announcing a declared emergency. If possible the RL Notification Form is faxed to the POC; otherwise the form is read to the POC duty officer and the duty officer completes a form based on the information received. The POC duty officer then makes the initial telephone notifications and faxes the completed RL Notification Form to offsite agencies and DOE HQ.

The process for completing the initial offsite notification failed during this emergency as a result of the following:

(1) the procedure for notification was not followed by the BED,
(2) the BED failed to call the POC or fax the RL Notification Form to the POC,
(3) the BED informed the Emergency Duty Officer (EDO) instead of the POC of the Alert declaration and when the EDO stated he would call the POC the BED assumed that would satisfy the notification requirement, and
(4) there is no process describing contingency actions required should the BED fail to provide verbal or written notification of an emergency declaration to the POC.

Causal Analysis:

- *Procedures not Followed*: The facility Incident Command Post (ICP) members (Building Emergency Director, ICP Communicator) did not follow DOE-0223, RLEP 3.5 "Operating the Hanford Incident Command System" procedure, which describes the actions to be followed for completing the RL Notification Form and notifying the Patrol Operations Center.

  The Building Emergency Director (BED) contacted the Emergency Duty Officer (EDO) and informed him an Alert emergency was being declared. At the request of the BED, the EDO contacted the Patrol Operations Center (POC) to request the activation of the Emergency Notification System (ENS) and implementation of onsite protective actions. The EDO informed the POC Duty Officer that the BED was directed to contact the POC with information pertaining to the RL Notification Form. The POC did not receive a call or notification fax from the BED/ICP Communicator, as required per DOE-0223, "Emergency Plan Implementing Procedures," Section 3.5 "Operating the Hanford Incident Command System," 2.7 "ICP Communicator - Checklist Duties." Additionally, the POC did not check with the PFP BED to request a fax of the RL Notification Form.

- *Inadequate Procedure*: The POC checklist for "200 Area Declared Emergencies" does not state the RL Notification Form should be sent to offsite agencies and DOE-HQ within 15 minutes nor does it provide contingency actions in the event verbal or written (fax) notification is not received from the BED.

  The POC Duty Officers use checklists to respond to various types of incidents that could occur onsite. The checklist for the "200 Area Declared Emergencies" includes steps to fax the RL Notification Form to offsite agencies, however, it does not address what to do should the form be unavailable to them. The checklist also does not emphasize the need to provide this information to offsite agencies and DOE HQ within 15 minutes of declaration.

- *Inadequate Building Emergency Director and Emergency Duty Officer Training*: The interface between the Emergency Duty Officer and the Building Emergency Director is not adequately covered in the training provided to the Building Emergency Director and Emergency Duty Officers, nor is it adequately practiced during drills and exercises.

  Upon discussions with and review of the EDO and BED logs, it appears some mis-communication between the BED and EDO occurred. The BED assumed the EDO was going to make official notification to the POC, and the EDO assumed the BED was going to make this notification. Mis-communication issues are not currently part of the BED and EDO training. During drills and exercises the EDO and BED interface is not realistically played out. For example, the EDO's activities include contacting the BED for status of non-emergency incidents where additional information is needed to determine what follow-up management notifications should be made. The EDO may call the BED several times to obtain status information, which can then be passed to senior management. During exercises, the EDO will typically make one contact with the BED and then respond to the Incident Command Post to serve as the ICP Liaison; consequently, when a real incident occurs onsite the interface between the BED and EDO is more complex than currently exercised.

- *Inadequate DOE-0223 Procedure*: Procedure RLEP 3.5, "Operating the Hanford Incident Command System," is in a format that is not useful to the Incident Command Post (ICP) responders. Consequently, the ICP responders found it cumbersome to follow.

The Incident Command Post (ICP) responders stated the information and checklists in RLEP 3.5 is vital to the successful performance of their duties. However, the procedure is large; users cannot quickly find their checklist and some of the checklists were double sided so copies would have to be made in order to use them.

Action Taken To Date:

1. Patrol Operations Center personnel and Emergency Duty Officers were provided refresher training on the need to be more proactive by following up with the BED, should notification information not be received.

Judgements of Need:

1. BWHC PRF Plant Operations needs to identify facility personnel that could be assigned an Incident Command System function (i.e, BEDs, Communicators, Logistics, Planning etc.) during emergencies at their facility and provide additional training and drills. Place emphasis on procedure usage.

2. FDH ESH needs to conduct a comprehensive review of the notification process for declared emergencies at Hanford. Process improvements identified during this review must be provided to RL for implementation site wide.

3. RL Quality Safety and Health needs to direct Hanford Site Contractors to implement process improvements, to include procedure revisions, training, and validation of the implemented improvements.

4. DynCorp Emergency Preparedness needs to:

   - Establish a means to ensure information from actual EDO responses is incorporated into refresher training packages as a lessons learned module.

   - Have all those persons assigned as EDOs discuss the bases for making judgments about the types of circumstances that would warrant ensuring the EDO responds to the facility, including prior to an event having been categorized as an emergency. Include area emergency preparedness coordinators in this discussion.

   - Revisit with the EDOs the best way to make use of the assets available to them to facilitate the taking of a more pro-active approach even prior to a condition being categorized as an emergency. These assets include others with EDO training who may be available to the on-call EDO for making notification calls or following the situation, or the area emergency preparedness coordinators.

5. FDH Environment, Safety and Health Emergency Preparedness, PNNL Emergency Preparedness, and BHI Emergency Preparedness need to ensure that the BEDs across the site, as part of their training, are made aware of the functions the EDO can fulfill when present in the ICP.

2.3 DEFICIENCY D03

Notifications to the State of Washington Department of Ecology (Ecology) and the National Response Center were delayed.

Evaluation/Analysis:

Subsequent to an event such as the PRF explosion, the BED is required to use the Emergency Response Guide (ERG) (i.e., WHC-IP-1043-PFP) which describes the actions the BED should take for response and mitigation of the emergency. Specifically, the ERG, Section 13.2 describes the steps for fires and explosion associated with hazardous materials. Within these steps, there is no reference to the Hanford Facility Contingency Plan Section 5.1.5 which indicates the "the Emergency Coordinator [BED] or his/her designee" must immediately notify Ecology. This notification is the one required by WAC 173-303-360(2)(d).

Section 13.2 of the ERG required the BED "Identify the character, exact source, amount, and extent of any released materials." Had this step been properly performed and/or planned for, the chemical release to the air may have been estimated at the time of the event. Then, if the BED would have called the Environmental Spill/Release point-of-contact as required by ERG Section 13.2.2, the Ecology notification would have been accomplished and applicability of CERCLA notification considered as long as the released materials were properly evaluated.

Note: For analysis of environmental regulations and required notifications see Appendix F.

Causal Analysis:

- *Management Problem:* Lack of integration between the environmental requirements and the emergency preparedness program has led to less than adequate direction for environmental notifications within procedures. Additionally, the expected methodology for the BED to obtain the required release data was not clear.

- *Inadequate Emergency Preparedness Documentation*: Problems with existing documents include overlap, conflicting information or direction between different sections within the same document, conflicts between requirements in different documents, essential requirements or actions not included (particularly in making internal and external notifications in a timely manner), out of date, and references are incomplete or inaccurate.

Action Taken To Date:

1. Preliminary discussions among Ecology, RL, and FDH representatives have taken place in regard to the need to fully integrate emergency plan, contingency plan, and emergency response procedures. Ecology is very supportive of the need to expedite this integration and has agreed to participate in working sessions in the near term.

2. A review of the emergency plans and procedures that should have been useable in the PRF response, against environmental requirements, has been initiated. A table is being prepared that will show where these documents are deficient. This table will serve as the basis for supporting the integration and corrective efforts.

Judgements of Need:

1. RL Environment, Safety and Health needs to determine the best approach for integrating environmental compliance notification requirements with emergency response procedures. This approach needs to be comprehensive, manageable, and usable for those expected to implement it during time critical conditions. The approach must include guidance relative to the gathering of release data for reporting.

2. RL Environment, Safety and Health needs to direct Hanford Site Contractors to develop a program to ensure that emergency plans, contingency plans, and emergency response procedures are clear, concise, consistent, and fully integrated.

2.4 DEFICIENCY D04

Industrial Hygiene planning and support for emergency conditions by the facility was inadequate, consequently, it took several hours to obtain Industrial Hygiene technical support; chemical monitoring equipment was not easily accessible; chemical monitoring outside the immediate area of the explosion did not occur. Additionally, the facility failed to effectively implement an effective chemical management program and apply an appropriate hazards analysis such that all chemical source terms were understood and evaluated.

Evaluation/Analysis:

The RL-EOC received a request from the Building Emergency Director to provide Industrial Hygiene support to the event scene. The BED provided the names of the facility Industrial Hygienists to contact. The RL-EOC attempted to contact the names provided, however, only one was available to respond to the RL-EOC. Once these resources were exhausted, the RL-EOC did not have a means to call in additional IH support. An Industrial Hygienist reported to the RL-EOC for a briefing prior to being dispatched to the event scene. There was no monitoring or protective equipment available in the RL-EOC so the Industrial Hygiene personnel were required to go to their offices to obtain the appropriate monitoring equipment prior to proceeding to PRF.

The Industrial Hygienist reported to the incident scene at approximately 2 a.m on May 15 and conducted monitoring in the immediate area; however, no means was established for chemical monitoring outside the immediate area of the explosion. The radiological field teams are highly trained and routinely practice tracking and monitoring for radiological plumes. However, they are not trained or equipped to monitor for chemical emissions. When there is a potential for a mixed release (radiological and chemical), the radiological field teams would not be able to perform their plume tracking responsibilities because of this lack of capability.

Additionally, the facility failed to adequately implement an effective chemical management system and did not adequately analyze the chemical source terms currently available for release. The chemical source terms and potential for release are the two primary factors in implementing an effective response plan for industrial hygiene environmental monitoring.

Causal Analysis:

- *Policy for response to chemical incidents not adequately defined*: There is no policy established that clearly identifies roles and responsibilities for Industrial Hygiene and radiological field team personnel in response to chemical incidents to include response actions, equipment requirements, and training requirements.
- *Inadequate Technical Representative call-in procedure:* A list of technical support representatives is contained in the DOE 0223 procedures. This list did not include Industrial Hygiene support.
- *Inadequate Call-List:* The Hanford Site on-call list does not include an Industrial Hygienist to be contacted during a situation where the facility Industrial Hygiene staff is unavailable.
- *Inadequate work organization/planning for Industrial Hygiene Response:* Monitoring and protective equipment for Industrial Hygiene personnel was not available in the RL-EOC. Consequently, response time to PFP was delayed.
- *Inadequate Chemical Management System and Hazards Analysis:* A chemical management program was not effectively implemented nor were chemical source terms, release scenarios and chemical monitoring adequately addressed.

Action Taken To Date:

1. Additional technical support representatives have been identified to support the RL-EOC.

2. It should be noted that in March 1997, RL issued a letter to Fluor Daniel Hanford directing the contractor to develop a coordinated plan to correct several deficiencies relative to emergency response and radiological control support to emergency events. In particular, RL listed deficiencies regarding inadequate radiological control technician support during emergencies; inadequate facility preparedness to respond to emergency conditions and weak drill programs for radiological control response; inadequate capability to effectively conduct radiological and chemical plume tracking and monitoring.

   In a March 31, 1997, response, Fluor Daniel Hanford informed RL the direction requested in the above referenced letter "exceeded the Contracting Officer's Representative authority"....and "that this direction does not fall within the scope of our current Prime Contract." It should be noted that RL and FDH are continuing to engage in dialogue to resolve the emergency response issues, however, to date no corrective actions have been implemented.

3. Site contractors have reviewed all chemicals in storage across Hanford to locate hydroxylamine nitrate or other potentially reactive or unstable chemicals.

4. Issued two "lessons learned" bulletins to warn all Hanford contractors and other DOE sites of potential hazards with chemical storage.

Judgements of Need:

1. FDH ESH needs to establish policy for Industrial Hygiene response for chemical incidents. It is recommended this policy address circumstances for which chemical monitoring and plume tracking is required, responsibilities for monitoring, equipment needs, equipment staging, integration with radiological field teams, and integration with Emergency Preparedness. The policy should be incorporated into the appropriate emergency plans and procedures. This action includes working with RL to correct the deficiencies identified in March 1997.

2. FDH ESH needs to:

   - Evaluate the status and availability of personal protective equipment for people who may be required to respond to an event in such a manner that may require them to enter an area of contamination at unknown concentrations. It is recommended that the lack of equipment be appropriately remedied and acquired.

   - Develop an Industrial Hygiene point of contact list and provide to FDH, Environment, Safety and Health, Emergency Preparedness for implementation. The list should identify responsibilities for IH support to the EOC and various facilities/projects.

3. FDH ESH needs to evaluate the current chemical management program and make improvements as necessary. Additionally, FDH ESH needs to ensure all applicable facilities conduct chemical source term analyses and are subsequently prepared to conduct appropriate chemical monitoring in the event of a release. FDH ESH needs to analyze "best chemical industry practices" for emergency response to benchmark proposals for Hanford in establishing policy and processes that provide industrial hygiene support and chemical monitoring/plume tracking capabilities in an emergency response.

2.5 DEFICIENCY D05

Line management personnel at the PFP failed to adequately implement the requirements of the Respiratory Protection Program and consequently, numerous emergency Self Contained Breathing Apparatus (SCBA) regulators and reducers located at PFP the evening of the explosion were past their due date for the required 2 year preventative maintenance and testing.

Evaluation/Analysis:

The Project Hanford Management Contractor (PHMC) Respiratory Protection Program requires line management to return emergency SCBA regulator systems to the Hanford Fire Department (HFD) every two years for maintenance and testing to ensure they meet manufacturer's specifications. To ensure that the requirements of the PHMC Respiratory Protection Program were being implemented effectively, RL directed Fluor Daniel Hanford Inc. to conduct a self-assessment of the respiratory protection program and its implementation at all applicable facilities/projects including the PFP. The direction was instituted as a result of a respiratory protection program assessment conducted by the RL Quality, Safety and Health Division which indicated several of the requirements of the program were not being implemented. The respiratory protection program self assessment conducted at the PFP during December 1996 identified three deficiencies associated with the implementation of the respiratory protection program. Of the deficiencies identified by PFP personnel, none of the deficiencies were associated with maintenance and testing of SCBA regulators and reducers.

In the January 1997, PFP personnel noticed several of the SCBA units were either past due or were coming due for the required 2 year preventative maintenance and testing of the regulator and reducer. To correct this deficiency and at the same time not adversely affect plant operations, PFP personnel transferred several SCBA regulators and reducers to the HFD for preventative maintenance and testing. Actions to ensure preventative maintenance and testing for the other SCBAs at the PFP was not initiated until after the May 14, 1997 explosion at the Plutonium Reclamation Facility. Consequently, at the time of the explosion, 28 of 36 SCBAs units were past due for the required preventative maintenance and testing of the regulators and reducers.

Causal Analysis:

- Policy not adequately enforced: The requirements of the Respiratory Protection Program an not effectively implemented or enforced.

- Management problem: The respiratory protection program and respiratory protection program self assessment specifically addressed the requirement for maintenance and testing of the SCBA regulators and reducers every two years, however, PFP line management failed to recognize and correct the applicable respiratory protection program weakness.

- Inadequate administrative controls: PFP lacks a defined process to ensure that SCBA regulators and reducers are routinely evaluated to determine the need for preventative maintenance and testing, and to ensure an adequate supply of appropriately tested SCBAs are available for facility use.

Actions Taken To Date:

1. The affected SCBA regulators and reducers have received the required preventative maintenance and testing.

Judgements of Need:

1. FDH Environment, Safety and Health needs to ensure respiratory protection requirements are implemented and enforced by Hanford contractors.

2. The BWHC/Plutonium Finishing Plant needs to develop the proper controls to ensure respiratory protection and other protective equipment is properly maintained and available for use when needed.

3. The BWHC/Plutonium Finishing Plant needs to take actions to ensure the self-assessment program for all applicable activities maintains the rigor necessary to identify and correct deficiencies.

2.6 DEFICIENCY D06

The Plutonium Finishing Plant failed to adequately conduct radiological surveys and nasal smears of the eight construction workers prior to their transport to the local area hospital. (Additional information regarding nasal smears and supporting information relative to the causal analysis is described in Appendix C).

Evaluation/Analysis:

Subsequent to the explosion, the eight construction workers were exposed to unknown hazards as they proceeded as directed to Building 234-5Z for accountability. Upon their arrival, none of the workers were surveyed for radiological contamination prior to entering the building. This was problematic in that the potential for radioactive contamination as a result of the explosion had not yet been fully evaluated. Upon arrival into Building 234-5Z, the potentially contaminated workers were not segregated from other non-contaminated personnel. Additionally, the conduct of radiological surveys, including nasal smears were never considered by the facility until the workers questioned PFP management and requested the surveys be completed. Despite a request by PFP management to conduct a radiological survey (i.e., whole body frisk) of the workers, no surveys were conducted. Nasal and mouth smears were collected, however, the smears were not conducted according to procedure and subsequent miscommunication between staff and management resulted in the smears not being fully evaluated until nearly a month after the event. In effect, the workers status relative to the potential for radioactive contamination was never adequately evaluated prior to their release to go to the local area hospital. Additionally, radioactive or chemical decontamination of the workers was never considered the evening of the explosion.

Causal Analysis:

- *Inadequate communication:* Lack of effective communication within the radiological control organization and between the radiological control organization and the potentially contaminated workers.
- *Inadequate equipment:* Inadequate staging of emergency response supplies and equipment. Although the necessary supplies and equipment were available in the emergency cabinet for collecting nasal smears in accordance with the applicable procedure, the availability of these materials was not readily apparent to all radiological control personnel.
- *Personnel error:* Failure to respond to the potential contamination of personnel as if the contamination was present until proven otherwise. (PFP personnel did not believe radioactive contamination was present, therefore, did not manage the situation with a conservative approach until it could be proven no contamination was present).
- *Personnel error:* Failure to understand the limitations of using a portable survey instrument to evaluate nasal smears.

Actions Taken To Date:

1. The appropriate emergency supplies have been staged at PFP.

Judgements of Need:

1. FDH ESH needs to evaluate radiological response procedures against the event circumstances to ensure the actions directed by the procedures would have provided an acceptable conservative response.
2. FDH ESH needs to evaluate responder training, to include the drill and exercise program, to ensure the responders are adequately prepared to respond to similar events. This Judgement of Need is primarily focused on how the radiological responders handled the potentially contaminated personnel (e.g., segregation of potentially contaminated personnel, conduct of surveys, etc.).
3. FDH ESH needs to evaluate the process and procedures for documenting response actions by the radiological responders to ensure the documentation is adequate to allow recreation of the actions and results.
4. FDH ESH needs to evaluate the staging of emergency equipment at all integrating contractor facilities to ensure applicable response activities are supported with appropriate supplies and equipment. Additionally, there is a need to ensure personal decontamination processes are considered for radiological as well as chemical events.

2.7 DEFICIENCY D07

Occupational medical follow-up of the affected workers by the site occupational medical contractor (Hanford Environmental Health Foundation - HEHF) did not occur until 35 hours after the event. An adequate policy between HEHF and local area hospitals describing the expected medical protocols for site personnel exposed to chemical contaminants does not exist. Additionally, there is no policy requiring Hanford Site contractors to notify HEHF in the event workers are exposed to chemical hazards regardless of suspected concentrations. Hanford Site written policies with regard to personnel exposures to low levels of chemical contaminants and radiation need significant improvement.

Evaluation/Analysis:

Workers in the vicinity of the explosion were evaluated by the site occupational medical contractor 35 hours after the event. Another affected worker was not evaluated until approximately one week after the event. Although the occupational medical staff was at the Kadlec Emergency Room the night of the event and spoke with the workers and followed up with subcontractor industrial hygiene the day after the event, HEHF medical monitoring was not initiated until almost two days post event. Neither do written medical protocols exist between the Hanford Site Medical Contractor and local area hospitals for treatment of Hanford Site personnel exposed to low levels of chemical contaminants. Additionally, communications on the evening of the explosion between HEHF and the workers relative to the types of chemicals and expected medical symptoms were inadequate. Subsequent to the event, HEHF communicated the potential chemicals of concern to Kadlec Medical Center. This information was used for medical decisions the evening of the explosion, however, this information was not adequately communicated to the affected workers.

Causal Analysis:

- *Lack of Policy/Procedure:* Adequate policies do not exist which provide expectations for:
  - contractor notification of HEHF subsequent to worker exposure to chemical contaminants during emergency situations;
  - communication between HEHF and local area hospitals describing medical protocols subsequent to chemical exposures;
  - communication between HEHF and potentially exposed workers.

Action Taken To Date:

1. The Hanford Environmental Health Foundation has initiated a procedure whereby an HEHF physician or physician's assistant will respond to the hospital emergency room in order to not only assist the emergency room physician, but to also initiate contact with the worker and the worker's management to arrange timely follow up evaluation and/or care. In addition, HEHF has undertaken a more comprehensive approach to addressing worker needs and concerns that may be associated with the event or exposure, but which may not necessarily be strictly medical in nature.

Judgements of Need:

1. RL-QSH needs to expand occupational health care strategy to include effective worker advocacy and communication to workers whose health or well being has been affected or potentially impacted by the workplace.

2. HEHF needs to establish protocols with all local hospitals that ensures HEHF will always be contacted to provide required consultation and initiate responsive follow-up treatment.

3. RL QSH needs to develop a policy outlining the expected site notification protocol subsequent to personnel exposure to chemicals.

4. HEHF needs to develop standard protocols for occupational chemical and/or radiation exposures with local hospitals.

2.8 DEFICIENCY D08

Event recognition and classification was not accomplished until over two hours after the explosion occurred. Failure to reach a timely emergency classification level was attributed to a weak facility hazards analysis resulting in less than adequate procedural Emergency Action Levels (EALs) for PFP.

Evaluation/Analysis:

Subsequent to the explosion, the facility Building Emergency Director (BED) implemented the procedural process to determine if the plant condition warranted the declaration of an emergency. Upon review of the applicable plant and site emergency procedures, the BED initially determined that the current plant conditions did not meet the stated criteria for the declaration of an emergency. The BED had no indication of a radiological release, nor was there indication that a potential sabotage event had occurred. A facility explosion was not specifically listed as a criteria for event classification, consequently, the BED did not initially declare an emergency. Subsequent to receiving information relative to the extent of facility damage and the expectation for the need to request outside resources, the BED declared an Alert level emergency over 2 hours into the event.

Additionally, the RL Emergency Procedures do not provide emergency responders with an adequate method to quickly evaluate and classify emergency conditions. Currently, there are at least two different chapters (EAL tables and generic guidelines) within the emergency procedures where responders are required to review for Emergency Action Level criteria. This methodology becomes cumbersome under emergency conditions.

Causal Analysis:

- *Inadequate Facility Hazards Analysis:* Facilities must conduct accurate hazards analysis such that technical conclusions can be reached relative to the types of events which could be expected to occur. Emergency Action Levels must then be evaluated and developed based on the expected accidents.

- *Inadequate EAL Procedure*: The Emergency Action Level procedure is not adequate to facilitate timely event recognition and classification for facility conditions.

- *Inadequate BED Training:* The BEDs are trained to use the EAL tables to perform event recognition and classification, however, the training and exercises do not focus on the use of the generic guidelines for event classification.

Action Taken To Date:

1. The PRF Emergency Action Level procedure has been revised to include a facility explosion table.

2. EALs for other site facilities have been reviewed and revised as necessary for explosions.

Judgements of Need:

1. DynCorp Emergency Preparedness needs to determine and implement process improvements for assuring the quality and usability of the Emergency Plan Implementing Procedures.

2. FDH Environment, Safety and Health (ESH) Emergency Preparedness, PNNL Emergency Preparedness, and BHI Emergency Preparedness need to revise Emergency Action Level procedures to include a table with the generic definitions for each emergency classification level.

3. FDH ESH Emergency Preparedness, PNNL Emergency Preparedness, and BHI Emergency Preparedness need to incorporate procedure revisions into Building Emergency Director training. Use of the generic definitions should be included in future drills and exercises.

4. FDH ESH needs to work with the major subcontractors to ensure all applicable facilities have conducted adequate hazards analyses and the results are factored into the Emergency Action Level criteria, as appropriate.

2.9 DEFICIENCY D09

The Plutonium Finishing Plant management system failed to correct identified deficiencies relative to the effective implementation of the emergency preparedness drill program. Additionally, the deficiencies were not appropriately tracked and closed by the cognizant RL organization.

Evaluation/Analysis:

Subsequent to an RL performed Conduct of Operations review at PFP in March 1995, it was determined that the facility emergency preparedness and operational drill programs were ineffective within the current management system. In particular, operational drills were not being conducted and emergency drills "were not sufficiently challenging to assist management in truly assessing the capabilities of the operators to protect the public." This deficiency was closed by the RL program organization in April 1996. There is no clear evidence that the drill program had improved to the point that warranted legitimate closure of the issue by RL. In addition, an RL PFP Facility Representative surveillance conducted in July 1996, concluded that "The Event Command Post (ECP) does not function effectively as a control center for an event or emergency." This issue was closed by RL in November 1996 and re-opened as a continuing deficiency subsequent to the explosion.

As a result of the extent and number of deficiencies relative to the explosion event, there is no clear indication that the drill program and ECP weaknesses have been sufficiently corrected to allow facility staff to adequately and appropriately respond to plant emergencies. Additionally, a recent RL performed readiness assessment of the fissile material handling activity has concluded that the drill program failed to adequately prepare plant personnel to respond to fissile material casualties.

Causal Analysis:

- *Inadequate corrective action management program:* There is a lack of an integrated management system and corrective action management program to effectively track and close identified deficiencies and to properly incorporate corrective actions into a manageable work scope to effect adequate closure. Inadequate facility emergency drill program. Inadequate issue verification and closure process by RL.

Short Term Actions:

N/A

Judgements of Need:

1. RL needs to ensure corrective actions taken by contractor personnel are properly evaluated and validated prior to closure.

2. B&W Hanford PFP needs to evaluate and significantly strengthen the plant corrective action management program to ensure identified deficiencies are corrected prior to closure.

3. There is a need for FDH ESH, Battelle, and BHI to evaluate the effectiveness of the emergency drill program for all contractor facilities and initiate corrective actions as applicable.

3.0 WEAKNESSES

The fourteen weaknesses identified during this evaluation are described in detail below. A "weakness" is a failure to meet the requirement(s) of an applicable regulation or DOE order pertaining to emergency management resulting from the following:

- Inadequate compliance to include implementation or maintenance of a component of the emergency management system program.

The regulation or order addresses a situation which has a potential for ***indirect adverse impact,*** or contributes to an adverse impact on the health and safety of workers, public or environment. Weaknesses must be tracked to closure.

3.1 WEAKNESS W01

The process to initiate early notifications to state and county emergency management organizations of non-categorized events occurring at Hanford facilities failed.

Evaluation/Analysis:

Representatives from local emergency management agencies expressed concern that they were not provided an informal notification of this incident prior to the official categorization. Procedures require that offsite agencies be notified of categorized events. However, it is recognized there are circumstances where an informal notification to local emergency management may be prudent, especially if there is a potential for the event to escalate or generate media interest.

The process in place on May 14, 1997 for making informal offsite notifications was contained in organization specific procedures and included the following: 1) The Emergency Duty Officer contacts the FDH On-Call Communications Representative with event information; 2) the FDH On-Call Communications Representative determines if the information should be passed to RL and if so, 3) FDH On-Call Communications Representative notifies the On-Call RL Office of External Affairs Representative; 4) RL Office of External Affairs Representative determines if the information should be passed to offsite agencies as an informal courtesy notification, and if so; 5) RL Office of External Affairs Representative initiates informal offsite notifications by 6) contacting the Occurrence Notification Center.

On May 14th, the process to make the informal notification to offsite agencies was initiated at 8:52 p.m. when the Emergency Duty Officer contacted the FDH On-Call Communications Representative. The FDH On-Call Communications Representative contacted the On-Call RL Office of External Affairs Representative, however, informal offsite notifications were not initiated by the On-Call RL Office of External Affairs Representative. The RL Office of External Affairs Representative did not recall the mention of an explosion and, consequently, did not realize the potential public interest or media significance associated with this event.

Causal Analysis:

- *Work organization and planning deficiency/Inadequate procedure:* The procedure for initiating informal notifications requires that information move through several points of contact. This is not an efficient or timely way to relay emergency information.

Action Taken To Date:

1. The Emergency Duty Officer (EDO) procedure was revised to ensure informal notifications are made to local emergency management officials for events that may be of interest to them. The revised notification process is as follows: 1) EDO determines if offsite emergency management agencies require informal notification; 2) EDO consults On-Call Sr. Management; 3) EDO initiates offsite notifications by contacting the On-Call ONC Duty Officer.

2. The EDOs have been trained on the new notification process. Fluor Daniel Hanford executives on-call and RL senior duty officers have been informed of this change as well. The new procedure has been used successfully several times.

Judgements of Need:

1. The RL Quality, Safety, and Health Programs Division needs to continually analyze the improved process by obtaining feedback from involved agencies and, if necessary, identify and direct process improvements to be implemented.

3.2 WEAKNESS W02

The Patrol Operations Center (POC) Duty Officer did not fully implement the actions described in the "200 Area Checklist for Declared Emergencies." Consequently, actions to ensure all 200 West personnel were informed of the take cover were not completed.

Evaluation/Analysis:

After receiving the Alert notification from the Emergency Duty Officer, the POC failed to implement the predetermined protective actions listed on the "200 Area Checklist for Declared Emergencies." The predetermined 200 Area protective actions for an Alert emergency are to shelter the affected 200 Area. This is accomplished by activating the 200 Area crash phones and the area sirens.

The POC did initiate the Emergency Notification System (ENS) to notify staff to report to the RL-EOC. After the POC Duty Officer activated the ENS, they were inundated with phone calls from RL-EOC emergency responders who questioned whether there was an actual emergency. These phone calls hindered the POC Duty Officer's ability to carry out other emergency response actions. Many of the RL-EOC responders stated there was no sense of urgency in the ENS message and it sounded much like the test message. Therefore, they contacted the POC for confirmation rather than respond to the RL-EOC as directed.

Causal Analysis:

- *Management problem:* ENS system failed to initiate expected response from all RL-EOC personnel.
- *Personnel error:* The RL-EOC staff contacted the POC upon receipt of the ENS message rather than report to the RL-EOC as directed. The POC Duty Officer failed to use the written instructions provided on the checklist to ensure pre-determined protective actions were implemented.

Action Taken To Date:

1. The Patrol Operations Center Duty Officer's were provided refresher training on the proper use of emergency response checklists.

Judgements of Need:

1. The Hanford Patrol Operations Center needs to establish a program for additional training and drills to ensure all Duty Officers are adequately trained to use checklists and implement checklist actions.

2. DynCorp Emergency Preparedness needs to provide retraining to the RL-EOC staff with instructions not to call the POC with questions upon receipt of an ENS message.

3. DynCorp Emergency Preparedness needs to evaluate the current ENS system to ensure the process will function as designed.

3.3 WEAKNESS W03

Onsite environmental monitoring team training requirements are not clearly defined, the quality of the equipment provided may not be adequate for their emergency response duties, and monitoring equipment is not easily accessible for off-shift response.

Evaluation/Analysis:

The onsite environmental monitoring teams are responsible for radiological plume tracking, field monitoring, and environmental sampling during emergencies. During their response to this emergency, the following concerns were identified:

- **Training requirements are not clearly defined for the field team members.**

  The field teams reported to the RL-EOC and received a briefing from the UDAC Field Team Coordinator and other staff as necessary. The briefing contained information that was available at the time and the teams were dispatched based on this information. The briefing included hazards associated with the release, time of release, protective equipment, and potential materials involved. The assumptions made about the material involved were not entirely correct, consequently, the field teams could have responded into an unknown hazard. The field teams expressed the concern they are not first responder trained, which would allow them to respond to an unknown hazard, and it has never been determined whether or not they are required to receive this training.

- **The field teams do not have the appropriate communication and monitoring equipment to efficiently track radiological plumes; specifically, high volume air samplers, portable generators, microrem meters, and cellular telephones.**

  By procedure, during plume tracking, the field teams are required to conduct radiological monitoring for two-times background using a microR meter and then take an air sample to determine plume constituents. This is done to provide UDAC data to begin quantifying the amount of materials released. The equipment available to the teams is not adequate to complete this task in a timely manner. First, the microR meters used to locate the plume edge (two-times background) are adequate for detecting beta/gamma radiation but are inadequate for detecting alpha radiation. Secondly, the volume of an air sample should be at least 30 ft^3 for beta/gamma monitoring and 100 ft^3 for alpha monitoring. The air samplers used by the field teams operate at 1 cubic foot per minute so the time to obtain an air sample would be 30 to 100 minutes depending on the nuclide involved.

  The primary source for communication with the field teams has been by radio. The radios and base stations in the RL-EOC have been unreliable at times. The teams stated during past drills and exercises the cellular telephones have been more reliable than radio communications.

- **During off-shift, by procedure, the field teams report to the RL-EOC and are briefed by the UDAC Field Team Coordinator prior to being dispatched into the field. The field teams reported to the RL-EOC as expected, however, their radiological equipment kits were not available since they are normally staged in building 2723W at 200 West Area. Fortunately, the Radiological Assistance Program (RAP) monitoring equipment and RAP vehicle were available for use by the teams and they were able to proceed to 2723W to pick up additional required equipment (i.e., generators, air samplers). Using the RAP equipment is an acceptable practice, however, the RAP equipment may not always be available for use by the teams.**

Causal Analysis:

- *Environmental field team training not adequately defined*: The existing policy does not clearly identify the environmental field team emergency response training requirements.
- *Inadequate work organization/planning*: Adequate arrangements had not been made for field team response, relative to equipment needs for an off shift emergency or for emergencies occurring in an area where the equipment is staged.

Action Taken To Date:

N/A

Judgements of Need:

1. FDH Environment, Safety and Health needs to establish a policy on how the field teams will be trained for emergency response. These policy decisions should be documented in the Hanford Emergency Plan or specific emergency procedures, as appropriate.
2. FDH Environment, Safety and Health needs to determine what type of redundancies for equipment needs or equipment staging are required.

3.4 WEAKNESS W04

The Field Team Coordinator procedure in Unified Dose Assessment Center (UDAC) does not include specific guidance on the management of radiological and chemical laboratory samples.

Evaluation/Analysis:

The Field Team Coordinator successfully made arrangements with the 222S laboratory to receive radiological samples taken by the field teams. However, the following administrative details were not included in the procedure and hindered the process for laboratory analysis.

- Chain-of-custody when using other contractor RCTs. BHI RCTs were used to obtain samples for laboratory analysis, however, samples were handed off to the DynCorp field teams because of the different chain-of-custody protocol.
- Name of individual ordering analysis and charge code. This information is required by the 222S laboratory prior to running an analysis and there was no guidance for the Field Team Coordinator in the procedures.

- Where to send the analysis. The environmental field teams pulled air samples from fixed air sampling locations, which are operated by other programs onsite. The results are essential to the environmental program as well as the emergency organization.

- Define types of sample analysis and schedule for conducting sample analysis.

Causal Analysis:

- *Inadequate Field Team Coordinator procedure:* The procedure used by the Field Team Coordinator does not address the management of laboratory samples.

Judgements of Need:

1. DynCorp Emergency Preparedness needs to revise the appropriate UDAC procedures to include information regarding laboratory analysis management.

3.5 WEAKNESS W05

The UDAC staff had difficulty obtaining the Material Safety Data Sheet for the chemical involved.

Evaluation/Analysis:

The reference materials located in UDAC did not include a listing for Hydroxylamine Nitrate. The reference materials included a listing for hydroxylamine and one for nitric acid, but not the combination. It was also noted by UDAC staff members that reference materials were incomplete (i.e., two of three reference volumes missing) at the Non-radiological Hazards Evaluator position. Emergency Preparedness maintains a list of reference materials in the UDAC and solicited comments from UDAC staff members on the quality of the materials, but there is no formal process to periodically assess the materials maintained in the center.

The computer used to obtain the MSDS information from HEHF was in constant use by the Meteorologist so the Non-Rad Hazard Evaluator was unable to access the system right away. This is the only computer in the UDAC that contains the MSDS access. When an attempt was made to access the MSDS system the User's password had expired so access was denied. The UDAC staff members were unaware there was a password for the UDAC and access could have been gained using this method. The MSDS was eventually obtained through other means, but it took longer than expected.

Causal Analysis:

- *Inadequate UDAC training*: The training materials and drills conducted for UDAC staff members do not adequately cover the resources available to the staff to obtain needed information.

- *Inadequate RL-EOC surveillance procedure*: The RL-EOC surveillance procedure does not include a process to periodically inventory reference materials.

- *Inadequate Resource Allocation*: The process to obtain MSDS was installed on one computer, which limited access during the emergency.

Action Taken To Date:

N/A

Judgements of Need:

1. DynCorp Emergency Preparedness needs to:

   - Provide additional training on the use of the HEHF MSDS system to UDAC staff members. Include training objectives to obtain reference information from computerized systems within UDAC. Routinely practice the use of the MSDS system during RL-EOC monthly activities or UDAC team building sessions.

   - Determine if MSDS access can be installed on the Non-Rad Hazard Evaluator computer. If so, ensure access capability is installed on this computer as well.

   - Revise procedures to ensure reference materials are assessed on a routine basis.

   - Assess the adequacy of reference materials in UDAC and purchase those required.

3.6 WEAKNESS W06

By its own assessment, the Joint Information Center (JIC) was adequately staffed for the demands placed on it for information about the May 14th event. However, it would have been difficult to sustain adequate staff coverage for a longer event. Consequently, if a JIC operation was required for a much longer-term event response, the JIC performance had the potential to degrade as less trained individuals staffed the JIC.

Evaluation/Analysis:

The ability of the JIC to be responsive to information needs of the media and to resolve rumors during an event is critical to maintain media cooperation and public trust. Recent cut-backs in staff for RL and other contractors have effected the Office of External Affairs (OEA) and the public information units of some of the contractors. Also, a former backup resource, the public information staff for the Supply System's WNP-2 reactor has been severely cut back. Further, an event at Hanford most typically will affect only a limited portion of the overall operations, which means that the OEA will continue to have its normal duties to contend with as well.

Causal Analysis:

- *Insufficient JIC staffing for extended events*: The resources for JIC staffing are supplied by the Hanford Site Contractors Communications staffs, which limits the number of personnel available to respond to the JIC.

Action Taken to Date:

N/A

Judgements of Need:

1. RL Office of External Affairs needs to investigate alternate means to adequately staff the JIC for long term operations. Include these means in plans and procedures as required.

3.7 WEAKNESS W07

The Occurrence Notification Center (ONC) staff failed to recognize two incomplete aspects of the emergency notification process. This failure led to one emergency management entity not receiving hard copy notification of several RL Notification Forms. Additionally, copies of paperwork important to keeping the RL-EOC informed about the notification status were not handled in accordance with emergency procedures, thereby creating the potential for a delay in information being available to the RL-EOC Policy Team about the status of the offsite notifications.

Evaluation/Analysis:

The regular hours of the ONC are 5 a.m to 7 p.m.. Also, the ONC no longer receives notification of the 911 events on the Hanford Site, which did occur when the ONC was a 24-hour operation. Thus, their routine responsibilities do not include the need for constant emergency response awareness and practice.

Additionally, the ONC staff participates in one exercise per year which allows them to practice the offsite notification process and integration with the RL-EOC. There are several smaller scale exercises conducted at Hanford, however, the offsite notification process is simulated through a control cell. Also, ONC staff members may be working one of three different shifts, and all may not be present for some drills or exercises. Consequently, the details of the notification process are not well rehearsed in relation to working as an integral part of the EOC.

Causal Analysis:

- *Inadequate training*: The training provided to the ONC staff does not address/test the complete RL-EOC emergency notification process and quality assurance for notifications for all ONC personnel.

Action Taken To Date:

1. Planning is underway to reinstate a 24-hour ONC operation.

Judgements of Need:

1. DynCorp Emergency Preparedness needs to conduct an analysis of notification processes and the procedure for emergency notifications. All ONC staff should take part in this process in order to increase the awareness and training of all staff members on the differences between routine occurrence notification activities and emergency notification duties. Documented findings from this analysis need to be used in tracking the correction of weaknesses, and for future procedure revisions and ONC training development. If the analysis indicates the need for sharpening the focus of the emergency notification procedure to call out places where the process varies somewhat from the day to day handling of notifications, revise the procedure and emphasize training on these aspects. Ensure that adequate emphasis is placed on the need for one ONC staff person to be responsible for coordination, oversight, and quality assurance of the ONC's activities during emergencies, and on providing this training to those staff members who will be expected to take on this coordination and oversight role.

3.8 WEAKNESS W08

The RL-EOC procedures do not adequately address emergency termination and recovery, relaxation of onsite protective actions, shift changes, briefings, dispatching RL Representatives to offsite locations, and facility readiness.

Evaluation/Analysis:

- **The transition from emergency termination to recovery is not adequately addressed in the termination and recovery procedures. Consequently, the remaining personnel in the RL-EOC were unable to answer technical questions asked by DOE HQ subsequent to event termination.**

The RL-EOC Operations staff underestimated the need for key individuals to remain in the RL-EOC to address questions from DOE HQ, debrief returning field teams, coordinate activities with the recovery team, and provide public information. Once the decision was made to terminate the emergency, activities in the RL-EOC began to mirror those of an exercise in that there was an immediate action to critique the emergency response rather than assign a recovery team. When the critiques were complete most of the RL-EOC staff was allowed to leave. Also, the procedures for terminating a declared emergency have several criteria for evaluation requiring definitive answers. There is no contingency approach included that would allow a relaxation of required activities if the criteria could not be resolved definitively in a reasonable time.

- **The RL-EOC procedures do not address making recommendations for the relaxation of onsite protective actions. Consequently, it took longer than necessary to arrive at the decision to lift the take cover order.**

While the RL-EOC staff was able to determine that the take cover order could be relaxed, there is no clear process for how the decision is made to relax a protective action. For example, there was some confusion about relaxing the take cover order while there was a lockdown at the facility. The appropriate individuals were consulted prior to relaxing the take cover order (i.e., UDAC, RL Emergency Manager, Security, etc.), however, this process needs to be clarified and incorporated into applicable procedures.

- **There is no direction in the RL-EOC Operations Manager's procedure to implement or consider a shift change even though it is identified as being the Operations Managers responsibility in RLEP 2.2, "General Instructions for Shift Change." Consequently, a second shift schedule was not developed and extra personnel were allowed to remain in the RL-EOC.**

There was some informal discussion in the RL-EOC regarding the need for a shift change. However, it was delayed due to the expectation the reentry activities at the command post would be completed sooner and the emergency could be terminated. Upon further discussion with RL-EOC responders, it was agreed that formal planning for a shift change should have occurred. There were extra responders in the RL-EOC upon activation who decided to remain in the RL-EOC even though their positions were adequately staffed. Had a shift change been necessary these individuals would have been unavailable for the second shift.

- **RL-EOC briefings were inconsistent and not always in accordance with established procedures. Consequently, members of the RL-EOC were not always kept informed of the most current information.**

Issues regarding the RL-EOC briefings were identified during an April 1997 exercise involving the RL-EOC staff. Corrective actions were implemented to improve the procedures containing the briefing format and protocol. During the May 14th response, the initial RL-EOC briefings were conducted in accordance with these revised procedures. However, over time the RL-EOC staff digressed from the procedures and instituted a format that seemed to work better for the key decision makers in the RL-EOC. This digression from procedures involved the RL Emergency Manager participating with the Site Emergency Director and staff in periodic discussions over the speaker phone in the Site Management Team with the Building Emergency Director. Consequently, information provided during these briefings was not communicated via the PA system to other EOC members, who later stated they did not receive adequate briefing information.

- **The appropriate RL-EOC procedure did not reflect the change in policy to send RL or Contractor Representatives to offsite emergency response facilities at an Alert declaration or higher. Consequently, a Contractor Representative was not dispatched to the Bi-County EOC until requested by County Emergency Management personnel.**

Washington State and County Emergency Management officials have the expectation that representatives will be sent to their respective EOCs to provide technical support upon declaration of an Alert emergency or higher. The Policy Team contacted the state and asked if they required an RL Representative response and were told it wasn't necessary. The county was expecting a representative to arrive in their EOC so they eventually called the RL-EOC and requested a representative to respond. Since no contractor representative was available, an RL Representative was sent to the county.

- **Old exercise data was left on the computerized Emergency Management Support (EMS) system and no one who reported to UDAC on May 14th knew how to clear the data. Consequently, the Field Team EMS Operator was unable to effectively display the pollutant sample information.**

The EMS system is routinely used during training and exercise with the UDAC staff. Several pollutant sample and field team records were developed as part of the last exercise. The EMS Operator who responded to the PFP event did not have, nor should have, the authority to delete records from the data base. The authority to clean the data base rests with the appropriate Emergency Preparedness Staff and the EMS Data Base Administrator. The Emergency Preparedness staff available on the evening of May 14th and the Data Base Administrator were not contacted to provide support.

Causal Analysis:

- *Inadequate RL-EOC procedures*: Direction is not fully provided for the transition period between termination and recovery, relaxation of onsite protective actions, planning for shift changes, RL-EOC briefings, dispatching RL Representatives to offsite locations and facility readiness.

Judgements of Need:

1. DynCorp Emergency Preparedness needs to:

    - Assess the current RL-EOC procedure for the identified weaknesses and revise the appropriate procedures as necessary.

    - Provide additional training and validate the procedure revisions through exercises or drills.

3.9 WEAKNESS W09

The checklist used by the Patrol Operations Center for declared emergencies was not current, consequently, sheltering of the 200 East Area was not implemented until the RL-EOC was operational.

Evaluation/Analysis:

DynCorp Emergency Preparedness is responsible for ensuring the appropriate POC checklists are revised to include new information contained in emergency procedures. In this instance, the POC checklist had not been revised to reflect the protective actions contained in DOE-0223 "Emergency Plan Implementing Procedures," RLEP 3.5 "Operating the Hanford Incident Command System."

Causal Analysis:

- *Inadequate administrative controls*: The DynCorp Emergency Preparedness methods used to ensure emergency procedure revisions are incorporated into other documents as required are inadequate.

Action Taken to Date:

1. The POC was provided the correct checklist.

Judgements of Need:

1. DynCorp Emergency Preparedness needs to create and implement a process to ensure Emergency Management procedure changes affecting other organizations are incorporated appropriately and adequate training is provided to applicable responders.

2. DynCorp Emergency Preparedness needs to validate the process is adequate over time.

3.10 WEAKNESS W10

Review of the Emergency Notification System (ENS) records show that several names had been inadvertently removed from the ENS listing and some phone numbers had not been updated. Consequently, not all RL-EOC staff members were notified to report to the RL-EOC.

Evaluation/Analysis:

There are two processes used to activate the RL-EOC. First, an essential staffing page is made to notify the minimum staff required to respond. Second, the Emergency Notification System is activated to call all RL-EOC responders and direct them to report to the RL-EOC. Once staff reports to the RL-EOC, the Operations Manager is responsible for determining if additional personnel are required. If these systems fail, a back-up system, which involves a manual activation of the center is initiated by the Emergency Duty Officer. Because of the way the process is designed, RL-EOC minimum staffing was achieved quickly. However, the analysis of the ENS list reveals the administrative process for maintaining this telephone listing is not functioning as intended.

Casual Analysis:

- *Inadequate administrative controls*: There are inadequate administrative controls in place to ensure the information contained on the ENS dialing list is consistent with other Emergency Response Organization staffing lists and that the phone numbers are current.

Action Taken To Date:

1. The ENS dialing list has been updated to reflect needed changes.

Judgements of Need:

1. DynCorp Emergency Preparedness needs to implement a means to perform a periodic quality assurance check by reviewing the names and phone numbers contained in HNF-IP-0541 and the ENS activation list.

3.11 WEAKNESS W11

The public information staff on the Policy Team arranged for a final news conference, which was outside the scope of their procedures. Consequently, when the media began to call the JIC to get further details on the news conference, the JIC staff could not adequately address media questions.

Evaluation/Analysis:

The process for setting up a news conference is part of the JIC procedures and should always be coordinated by the JIC staff. The procedures are designed to ensure that the JIC can be as responsive to the media as possible. Any kind of situation that leads to one part of the information team not knowing what the other part is doing creates the potential for an inadequate response. The more appropriate approach in this case would have been for the Policy Team to direct the JIC to make arrangements for a final news conferences and to inform the Policy Team of the details.

Causal Analysis:

- *Procedures not followed:* The Policy Team public information staff completed tasks that were outside the jurisdiction of established procedures and then did not adequately communicate to the JIC their decision to have a final news conference.

Action Taken To Date:

N/A

Judgements of Need:

1. DynCorp Emergency Preparedness need to provide additional training for the Policy Team and News Writers in the RL-EOC to ensure they are familiar with JIC procedures.

3.12 WEAKNESS W12

Emergency Preparedness does not have a systematic quality assurance process for compiling the record of response, nor examining this record as it is accumulated in the post-emergency stage. Consequently, the record of response pertaining to the Emergency Response Organization (ERO) activities is cumbersome to access for evaluation purposes, does not reside in one place for inspection purposes, is not well cross-referenced and may not be as comprehensive as would be desirable should future uses of it be necessary.

Evaluation/Analysis:

There is a process in place for collecting records for use in evaluation; however, this process does not adequately factor in the records management and quality assurance responsibilities for the evaluating organization.

Causal Analysis:

- *Policy not adequately defined for records management*: There is no Emergency Management policy established to provide direction for ensuring consistency and quality of records used to document emergency response.

Action Taken To Date:

N/A

Judgements of Need:

DynCorp Emergency Preparedness Management needs to:

1. Develop objectives, a framework, and internal staff guidance (consistent with RL guidance) for implementing quality assurance for response records. Consider using professional records management personnel for establishing these objectives and framework.

2. Establish a policy for what will be expected or required for those persons who participate in an actual response to provide to the record, and develop a process and time frame for implementing the policy following any activation of the ERO.

3. Train appropriate persons within the EP organization to the objectives and process for maintaining a comprehensive record of response, reinforce the training by displaying a concern for systematic documentation at the management level, and practice elements of the process during exercises.

4. Enable staff professional development along these lines by sending EP staff responsible for evaluations to courses on accident investigations and related quality assurance approaches.

3.13 WEAKNESS W13

There was no formalized approach for coordinating and integrating the efforts of RL and its contractors to respond to the myriad demands, both internal and external, for an accounting of the pre-event conditions, the event progression, and the emergency response activities. Consequently, persons involved with the event facility, response, and emergency preparedness were subjected to unnecessary duplicative requests for information.

Evaluation/Analysis:

A single point of contact responsible for coordinating the evaluation and investigation activities would have made it possible to keep track of all of the different information seeking activities related to the investigation and performance evaluations for the emergency. This would permit information sharing and reduce demands on the system. With respect to the Emergency Preparedness (EP) organization specifically, the strategy for meeting demands from various quarters was reactive in nature, even though EP could be viewed as the organization entity with the broadest view of the conditions for and performance of the event management.

Causal Analysis:

- *Policy not adequately defined*: There is no Management policy for effectively coordinating and tracking the progress of the different types of investigations or evaluations required for a declared emergency.

Action Taken To Date:

N/A

Judgements of Need:

1. RL Environment, Safety and Health needs to conduct an assessment of the stance it assumed in the overall process for RL to capture the information necessary to understand and explain the event. As part of this, the EP organization needs to be directed to address how it might have served in a more coordinated role because of its breadth of understanding of the conditions and response, and then work with RL management to develop guidance for this to be added to investigation and recovery procedures.

3.14 WEAKNESS W14

The HEHF physician assigned as the RL-EOC Medical Director has the option to obtain assistance from the HEHF on-call physician, if required. In this incident, the physician at the RL-EOC determined he would handle both roles. This divided attention contributed to an underestimation and delayed assessment of the depth of the concerns of the affected workers upon discharge from Kadlec Medical Center.

Evaluation/Analysis:

Guidance establishing the roles of the RL-EOC Medical Director and the HEHF on-call physician does not preclude the physician from performing both roles.

Causal Analysis:

- *Management Problem:* A policy was not in place prohibiting the RL-EOC Medical Director from also acting as the HEHF on-call physician to site events because a dual response had not previously been anticipated. The HEHF physician assigned to the RL-EOC Medical Director position is responsible for providing advice on the health implications of trauma and environmental contamination of an event. The on-call physician provides support to emergency personnel and assists the employer in developing follow-up treatment plans for injured or ill workers.

Action Taken To Date:

1. The practice of the option to notify the on-call physician has been changed and a medical directive issued for the RL-EOC Medical Director not to leave his/her post and to coordinate with the on-call physician in all cases.

Judgements of Need:

1. The Hanford Environmental Health Foundation (HEHF) needs to establish a policy relative to the expectations of the RL-EOC Medical response individual and the on-call physician in the event of an emergency.

4.0 IMPROVEMENT ITEMS

The ten improvement items identified during this evaluation are described below. An "improvement item" is an observation or finding citing deviations or concerns. The requirement(s) of an applicable regulation or DOE order pertaining to emergency management is met. However, the following has occurred:

- One or more of the associated emergency management system program-specific evaluation criteria are not satisfied.

Improvement items should be considered as a suggested means to improve programs. The items identified are listed here, with the name of the organization responsible for making the improvement.

1. The phone number for the field team dispatcher needs to be changed on the first responder card #2 in UDAC.

   Responsible Organization: DynCorp Emergency Preparedness

2. The first responder cards in UDAC should also include a step to fax information to the states and counties (wind field/affected area plot).

   Responsible Organization: DynCorp, Emergency Preparedness

3. The field teams should purchase hard hat lights for ease when working in the dark. The teams have equipment they need to carry, which makes it difficult to carry a flashlight.

   Responsible Organization: DynCorp Environmental Monitoring

4. Include a step in the Hazard Communicator procedure to consider staffing the position with two people, resources permitting, until two Communicators are not necessary. The UDAC Hazard Communicator position was staffed by two communicators rather than one as called for in the procedure. Consequently, the Hazard Communicator effectiveness increased, especially in the early stages of the emergency.

   Responsible Organization: DynCorp Emergency Preparedness

5. Work with States and Counties to ensure members of offsite agencies who would normally respond to the RL-EOC are provided the opportunity to participate in emergency exercises.

   The local officials who appeared in the JIC and UDAC to coordinate activities, were not necessarily those who participated in earlier exercises. Consequently, onsite responders were unfamiliar with the local officials. This may have contributed to the lack of coordination of field team information between the Washington State Representative and the UDAC Field Team Coordinator.

   Responsible Organization: RL Quality, Safety and Health

6. While the EMS system functions adequately as designed, previous issues have been identified pertaining to the EMS system. They identified the need for improved EMS training and displays. Corrective actions for displays and training have been implemented with limited success. Much of the information contained on EMS is now available on the Internet or different user areas on the HLAN. For example, the mapping information contained on HLAN is more current than the EMS data; MSDS information is available on the Battelle home page; and hazardous material inventory information is also available. Considering the cost of maintaining and the complexity of the UNIX system it may be time to look at a new emergency management information system for the RL-EOC.

   Responsible Organization: DynCorp Emergency Preparedness

7. The Federal Building lobby main entrance door was propped open to allow JIC staff and responding media access to the media support area in the Federal Building Lobby. Contract security was eventually contacted to maintain security in the lobby, however, a step should be added to the appropriate RL-EOC procedures to ensure either Hanford Patrol or the contract security be notified to maintain security of the Federal Building Lobby.

   Responsible Organization: DynCorp Emergency Preparedness

8. Since the Hanford Emergency Response Organization was recently restructured to implement the Incident Command System the responsibility for developing additional onsite protective actions recommendations was shifted from the Area Emergency Control Centers to the RL-EOC UDAC. Some members of the UDAC did not have a clear understanding of the shift in responsibility for onsite protective actions. This needs to be re-enforced in UDAC training sessions, drills and exercises.

   Responsible Organization: DynCorp Emergency Preparedness

9. A policy needs to be established for recording time worked for emergency responders not associated with the event facility. Because employees are required to complete time cards on a daily basis and their time card must reflect the activities performed, this issue arose immediately after the emergency was terminated. It is necessary to have a policy and procedure in place so in the event of an emergency these administrative details can be dealt with in a professional and timely manner. It's recognized that Hanford Site Contractors may have different procedures for how time is charged during normal operations and these procedures should be considered when establishing policy.

   Responsible Organization: RL Quality, Safety and Health

10. Procedure RLEP 3.5, "Operating the Hanford Incident Command System" needs to be revised to include information on setting up the ICP identification sign and ICP access control.

    The ability of the BED to function effectively was hampered in part by the number of people in the ICP who were asking him questions about the status of the event. Another aspect of this issue is identification of individuals who have been given authorization to be in the ICP. Several orange vests were distributed by the BED for this purpose; however, he did not have a sufficient number of vests, nor was access to the ICP denied to those not wearing vests.

    Responsible Organization: DynCorp Emergency Preparedness

APPENDIX A

CHRONOLOGY OF EVENTS

A.1 INTRODUCTION

This chronology of events begins with the explosion at approximately 7:53 p.m., on May 14, 1997, in the Plutonium Reclamation Facility (also referred to as the 236-Z Building), located at the Plutonium Finishing Plant (PFP) in the 200 West Area of the U.S. Department of Energy's Hanford Site, Richland, Washington. This chronology reflects information taken from various logs and interviews relating to the response. It is intended to indicate the sequence and timing of the activities in general and does not attempt to include every available fact or comment. Its major emphasis lies with elements of the response related to occupational health concerns. More detail on the response from all points in the overall emergency response organization is provided in the time line presented in Appendix B of this report.

This chronology is based on an array of sources of information that provide partial accounts of the emergency and occupational health responses following the explosion. These sources include: the logs kept in various control and communication centers during the event (B1-B8); activity reports provided as part of the post-event explosion investigation and emergency response evaluation; notes from post-event critiques and review sessions (A1- A6); interviews and report-review sessions with the construction workers affected by the explosion and response activities; interviews with persons holding critical positions in the emergency response organization, conducted to get their accounts and to further clarify information from other sources; reports from the Hanford Environmental Health Foundation (HEHF) staff who performed the occupational health evaluations of plant personnel and other workers who may have been affected by the explosion; and review comments on draft reports from RL, DOE-Headquarters, Hanford Site contractor management, facility and emergency response organization team members involved in the response or in emergency preparedness activities, and personnel from state and local agencies involved in the response.

Individuals involved in emergency situations may have differing perceptions and recollections of events. Attempts have been made to verify the various accounts of the events included in the chronology. This was done to present as clear and accurate a depiction of events as possible. When recollections of specific events could not be conclusively reconciled, they have been presented in the text without judgment or they have been omitted..

Because of differences in watches and clocks being used, or in log-keeping practices, times indicated for specific activities often vary a few minutes from log to log, and in some instances up to 30 minutes. All references to specific times contained in this section are intended to provide the reader with an approximation of the time frame between various activities and are not intended to denote the exact time of each activity or action.

The diagram of the PFP facility in Figure (5), provides some reference for items mentioned in the narrative. The diagram indicates: the location of the explosion (236-Z Building); the location of the 200-foot-high exhaust stack (291-Z-1) that emitted the yellowish-brown "plume" observed by some; the location of the two Hanford Patrolman who were outside and near the location of the explosion, one on the ground and one on the roof of Building 234-5Z; the location of the construction trailers; the route the workers in the construction trailer took when they responded to an announcement to report to Room 104 in the 234-5Z Building, and again when some of them returned to the trailer to collect belongings before leaving the facility; the location of the 291-Z-1 stack continuous air monitor (CAM) which a Radiological Control Technician (RCT) was sent to check about an hour after the explosion; and, at the left top of the diagram the wind speed and direction at approximately the time of the explosion and at the right bottom of the diagram the wind direction and speed just before 10 p.m., when the BED declared an Alert emergency for the facility.

A.2 CHRONOLOGY BY TIME PHASES

May 14, 1997 (7:50 to 08:59 p.m.) [1950 to 2059 Hours]

Shortly before 8 p.m., a Shift Operating Engineer (SOE) was in the change room, connected by Door 10 on the first floor of the Plutonium Reclamation Facility (PRF), preparing to don personal protective equipment before carrying out routine job functions in the facility. He was standing near Door 10, which he had already unlocked, when at 7:53 p.m. the explosion occurred in Room 40 on the fourth floor of the facility. The SOE reported that Door 10 was violently flung open by the pressure wave from the explosion, as was Door 108-A a few feet beyond him, which is an exterior door with a crash bar on it. Almost immediately (3 to 5 seconds) both doors slammed shut with considerable force. During those few seconds, the SOE was pushed back a step by the force and was pelted with dust and dirt, probably originating from the stairwell beyond Door 10 that leads to other levels of the PRF building. He did not recall any particular odor associated with the blast of air, although his ears were affected by the pressure wave. The SOE immediately headed for the access control entry system (ACES) Station where he conducted a whole body survey on himself. On his way to the ACES he encountered a Hanford Patrolman headed toward Door 10 and recommended to the Patrolman that he not enter the area. The whole body survey he conducted indicated no radiological contamination and he then went to Room 104 in the 234-5Z Building , to provide information to the PFP shift manager.

A Hanford Patrolman, positioned on the roof of the 234-5Z Building, heard the explosion and felt the building tremble. He immediately noted an odor somewhat similar to chlorine and then moved towards the edge of the building where the odor dissipated. He could also hear the fire alarm from the building and could see water coming from the PRF facility. He noted other patrolmen approaching the PRF building and then noticed what he described as "orange-brown smoke" coming from the 291-Z-1stack just before he was ordered by Patrol command to evacuate the roof. He reported that he was checked out by the Hanford Fire Department [note: presumably by a paramedic] when they arrived; he was told he had no signs of any problems [note: presumably referring to medical problems].

When the explosion occurred, the Central Alarm Station (CAS) immediately received a Door 108-A alarm, as well as several other door latch alarms, and immediately initiated a security lockdown. When the facility is in a lockdown no one may enter or leave the facility and other movement of personnel is restricted except with special permission. CAS personnel announced this lockdown status over the public announcement system (PAX) to inform all PFP personnel. Patrol command had also received information about the emission seen coming from the stack and moving in a westerly direction. Within a few minutes of the explosion they made an announcement to warn patrolmen to stay away from the west side of the building [note: it is not known if this refers to the west side of the 236-Z or the 234-5Z Building]. The Hanford Meteorological Station reports indicated at that time the wind was from the southeast to the northwest, varying between four to seven miles per hour.

The PFP shift manager, who was in the PFP Power Control Room, felt the building vibrate and heard a loud thud. A quick check of the accelerometer did not indicate any seismic activity. He noted the location of the fire alarm and also checked various monitors for other indicators of breakdown or releases from the ventilation system. The shift manager did not recall hearing the PAX announcement about the lockdown and thinks he may have been in a stairwell on his way to Room 104 when it was made. At approximately 8:00 p.m. the shift manager assumed the role of Building Emergency Director (BED), as was appropriate, and chose Room 104 to be the Incident Command Post (ICP). At approximately 8:02 p.m. he requested that a PAX announcement be made to have all plant personnel report to Room 104 for personnel accountability.

When the SOE who had been in the change room reported to the shift office, he and the BED went outside to see what other information they might be able to get. They described a "yellowish/light-brown haze" coming from the 200-foot-high 291-Z-1 exhaust stack and moving in a northwest direction. Upon reentering the facility, the BED directed an RCT to perform a radiological survey of the SOE. The SOE was again surveyed for radiological contamination by an RCT; the survey results were also negative. Following this observation, the BED requested the CAS personnel sound the take-cover alarm for the facility. When the Patrol Operations Center (POC) called to ask if they should activate a take-cover crash phone call for the entire 200 West Area, the BED directed them to make one to "close" the area, which serves the purpose of not letting more personnel enter the 200 West Area without special permission.

When the PAX announcement was made for personnel to report to Room 104, an eight-person crew of construction workers was taking a lunch break in a construction trailer located in the southwest corner of the PFP facility area. One of the eight, their supervisor, was in an office elsewhere in the trailer. While sitting outside the trailer, another member of the crew felt the concussion from the explosion. He reported seeing a burst of white steam from the vicinity of the 291-Z-1 stack, where steam related to the ventilation system is commonly seen. He also noted that he overheard a Patrolman's radio that a discharge had been seen coming from the South Canyon air lock doors.

The workers outside the trailer and in its lunch room heard the PAX alarms, both for the lockdown and for plant personnel to report to Room 104. One of the workers immediately called the Shift Manager's Office, as is normal when there is a question of any kind, to ask if the announcement concerning plant personnel to report to Room 104 included them, and received an affirmative from a plant supervisory staff person assisting the BED. At about this time the eight construction workers, including their supervisor, left the trailer to proceed to Room 104 of the 234-5Z Building. A Hanford Patrolman told them to stop because of the lockdown and to return to the trailer, which they did. The workers' supervisor called the Shift Manager's Office to reconfirm if they were to report to Room 104 and again the answer was affirmative.

The construction workers left the trailer and headed off to Room 104 via the east side of the facility. A Hanford Patrolman stopped them, mentioned the lockdown and that a take-cover action was about to be ordered. Right about then the take-cover siren sounded. [Note: the FDNW report indicates that the workers heard the take-cover siren at 8:11 p.m., as they left the trailer the second time; the PFP Operations Log indicates that the take-cover siren was at 8:04 p.m.; the earlier time is more consistent with other information.] The workers, who normally must adhere to facility-related instructions from a shift manager, told the patrolman that they were following the shift manager's instructions to report to Room 104. The Patrolman advised them that the southeast corner was the area of the explosion and they should be cautious going into that area. Conflicting recollections exist as to whether the Patrolman suggested an alternate route to them. The workers changed their course and proceeded to Room 104 via the west and north sides of the building. Given the general wind direction at that time, this inadvertently took them into the general vicinity of the path of the emission other plant personnel had seen emanating from the 291-Z-1 stack.

After arriving at Room 104, at least two of these construction workers indicated to someone that they had detected a metallic taste and odor while they were walking toward the 234-5Z Building. They were told to stand by. This information was not provided to the ICP. Between the time the eight workers arrived at Room 104 (approximately at 8:10 p.m.) and 9 p.m. several facility response activities were underway, including the following: all facility personnel were accounted for (8:15 p.m.); the BED and the Hanford Fire Department Incident Commander (IC) officially established a Unified Command at the Shift Manager's office (8:18 p.m.) which also was being used as the ICP; the Hanford Patrol Shift Commander arrived at the ICP; the Emergency Duty Officer (EDO) had been contacted about the conditions and given subsequent updates; a Hanford Fire Department team had made an entry into the affected area and reported back (8:46 p.m.) to the Incident Command Post that there was tangible evidence of an explosion in Room 40; and the BED requested (8:53 p.m.) that the electrical power to the PRF be disconnected before any further entries were made into the facility to gather information. Also at about 8:20 p.m., the supervisor with the construction workers made contact with a FDNW manager to apprise him of the situation and the workers' concerns.

May 14, 1997 (9 to 9:32 p.m.) [2100 to 2132 Hours]

Just after 9 p.m., the EDO was advised by the PHMC Executive On-Call that Hanford Patrol had been requested by the DOE Safeguards & Security Director to contact the FBI and request that the event scene be handled as a possible crime scene. Also soon after 9 p.m., the Hanford Fire Department began preparations for a second entry into the damaged area. At about the same time the information about the workers' reporting a metallic taste was provided to someone assisting the ICP team, who relayed the information to the BED. The Fire Department Incident Commander may not have been in the ICP at that moment, as he does not recall hearing this information. The BED, given that he had not received any indications of any radioactive release related to the explosion, assumed any exposure would be chemical and directed the two workers who had reported the metallic taste to report to the Kadlec Medical Center Emergency Room for evaluation. The supervisor who was with the workers requested that all of them go to the hospital, since they had all been together outside the building. At 9:15 p.m, the BED agreed . After some discussion about arrangements, the BED said that he was too busy to take care of the transportation arrangements and said that they were responsible for making arrangements to transport themselves to the hospital. Soon after that, one of the FDNW workers asked someone at the ICP whether the workers who were to go to the hospital would be able to return to the facility to retrieve their personal vehicles later in the night. They were told that they probably would not be able to get back in. A few minutes later, the construction crew supervisor requested of someone at the ICP for some of the crew to be permitted to return to the trailer to get all the workers' car keys and other items, and permission was given.

At approximately 9:09 p.m., an RCT proceeded to the 291-Z-1 stack to perform checks and reported (9:24 p.m.) that the stack CAM equipment was operable. At 9:28 p.m., the HFD Incident Commander, in one of his periodic updates to the EDO, reported that the construction workers who had been outside experienced a metallic taste and were being readied for transport to Kadlec Medical Center. The construction crew supervisor and one other worker received permission from a member of the ICP team to return to the trailer; they proceeded to the trailer along the same path they had taken earlier when walking to Room 104 from the trailer. At 9:32 p.m., the SOE completed disconnecting the electrical power to the PRF, allowing the Hanford Fire Department team to begin their second entry, which had been delayed 30 minutes after it was decided power should be disconnected. Near this time, the BED requested the Patrol Shift Lt. to call the CAS to ensure the construction workers be allowed to leave the facility in accordance with PFP lockdown protocols. During this same period, the construction crew supervisor and another crew member were at the construction trailer retrieving the workers' vehicle keys and other items. While they were at the trailer, two phone calls came in to them from two different FDNW managers, one of whom informed the supervisor that he would meet the crew at the hospital, and the other who advised them to inquire about being radiologically checked out before departing for the hospital.

May 14, 1997, (9:40 to 10 p.m.) [2140 to 2200 Hours]

When the two construction workers arrived at the lunch room in the trailer, a Hanford Patrolman was there. As the two workers were gathering up keys and clothing for the rest of the workers (9:40 p.m.), they heard a message come in to the Patrolman's radio instructing him to proceed to the 291-Z-1 stack to challenge three unidentified personnel seen there. The Patrolman responded to the message and asked if being outside still required him wearing a mask (i.e., respirator). He was given an affirmative response. The Patrolman donned his respirator and left the trailer at approximately 9:40 p.m. This raised a question in the workers' minds as to why Patrol considered respiratory protection necessary when the workers themselves had not been instructed to don respirators before they returned to the trailer. Also at this time (9:40 p.m.), the RL Safeguards and Security (SAS) Manager informed the BED and the HFD IC that the 236-Z Building be secured and treated as a potential crime scene. This brought the Hanford Patrol member at the ICP more directly into the management of activities related to assessing conditions in the affected facility. His responsibility was to ensure that important evidence was protected, which required the BED and the HFD IC to also support Hanford Patrol crime-scene procedures.

The two construction workers returned by approximately 10 p.m. to Room 104 with the vehicle keys and clothing for the others and were told by the others that they had been notified by the BED that they had been released from the facility and could proceed to Kadlec Medical Center.

At about 10 p.m., the BED decided that the continuing ambiguous conditions warranted the declaration of an Alert, he informed the EDO of this by phone (10:02 p.m.). At 10:05 p.m., the EDO instructed the POC (10:05 p.m.) to activate the Emergency Notification System, which sends a message to personnel assigned to emergency operations centers when a condition onsite meets Emergency Action Level (EAL) criteria that define the situation as an emergency. The designation of the condition as an "emergency" triggers the implementation of the RL Emergency Plan Implementing Procedures and their links to the emergency response procedures of the offsite emergency management and regulatory agencies. This carries with it an increase in the communication demands placed on the ICP and POC, as well as a broadened base of resources and assistance for managing and monitoring conditions at the facility and beyond, as necessary.

May 14, 1997 (10:05 to 11 p.m.) [2205 to 2300 Hours]

Also onsite at around 10 p.m., the eight construction workers were prepared to proceed to Kadlec Medical Center. They were intending to leave the area in four separate private vehicles and the company vehicle used routinely for transporting one of the workers who has a back injury. As they were starting to leave, the PFP ESH&Q Manager arrived at the facility (sometime around 10 p.m.). One of the construction workers approached him and requested that the workers be checked radiologically before they left the facility. The ESH&Q Manager concurred that it was appropriate and instructed a Radiological Control Technician (RCT) Duty Manager to set up to do this. After about 20 minutes the construction workers were instructed to accompany an RCT to the 270-Z Building where the surveys would be done. While the nasal smears were being taken from each of the workers, the crew supervisor called the Kadlec Medical Center (KMC) to try to contact the FDNW manager who was to meet the workers there. The manager was not located, but the worker did talk to the Emergency Room physician. This was the first indication this physician had that workers would be coming to the KMC ER because of this event at the Hanford site. The KMC physician subsequently called the RL-EOC and spoke to the RL-EOC Medical Director to obtain information on what types of materials these workers could potentially have been exposed to.

While the supervisor was talking to the KMC physician, two members of the construction crew agreed to assist B&W personnel by going out to the FDNW field office to get barrier stanchions and rope that could be used to cordon off some areas that had been dampened by water coming from the 236-Z Building after the explosion. The take-cover order was still in effect when these workers were asked to get the equipment. Shortly after 11 p.m., the construction crew again gathered and prepared to leave for the hospital.

Between 10:30 p.m. and 11 p.m., three FDNW managers representing construction operations and safety arrived at Kadlec Medical Center to be available to the construction workers coming from the facility. As early as 8:30 p.m., one of the three managers had received initial information about the event from a PFP senior manager, who then recommended that the FDNW construction team be sent to Kadlec Hospital for medical evaluation. At about 10:30 p.m., this same FDNW construction manager also had talked by phone with one of the construction workers, who told the manager that the eight of them were in the process of leaving PFP to go to Kadlec Medical Center.

Offsite, shortly after 10 p.m., personnel assigned to the RL-EOC during emergencies began to report in to the Federal Building. They had received calls from the Emergency Notification System that is activated when an emergency is declared. The RL-EOC includes a senior manager policy team, a site-support team, security support, the Occurrence Notification Center (ONC), the Joint Information Center (JIC) and media writer teams, representatives from some offsite agencies, and the Unified Dose Assessment Center (UDAC) that includes hazards assessors, meteorologists, and a field team coordination function. As the various members of the RL-EOC teams arrived between about 10:15 and 11 p.m., they were briefed about the event and began their respective activities for supporting the emergency response activities at the PFP. The formal communication links with the onsite emergency response organization, including the POC and the ICP, were established. The RL-EOC was declared formally operational at 10:55 p.m.

At about 10:45 p.m., the HEHF Physician reported to his post as the RL-EOC Medical Director and received a briefing about the explosion at the PRF facility. The UDAC informed the RL-EOC Medical Director that no radiological release was known to have occurred but that a yellowish-brown plume from the 291-Z-1 stack had been witnessed. Subsequently the UDAC obtained for the RL-EOC Medical Director an inventory list of chemicals in PRF. The RL-EOC Medical Director noted that the majority of the chemicals on the inventory list are considered to be primarily caustic in nature, which means they can cause an irritant reaction for personnel exposed to them.

Prior to the Medical Director leaving for the Kadlec Medical Center, the UDAC provided him with the information that a HFD assessment team had entered the damaged area had reported the rupture of a tank containing hydroxylamine nitrate (HAN) and nitric acid. The Medical Director inquired about other potential chemicals released. He was told that, based on the information from the entry team who had inspected the damaged area, no other storage containers appeared to be ruptured. The UDAC provided an MSDS for HAN to the RL-EOC Medical Director, who then referred to the Environmental Medical Text by CD ROM and Managing Hazardous Materials Incidents, Volume 3--Medical Management Guidelines for Acute Chemical Exposure, to review the reported medical effects of exposure to the chemicals reported to be in the tank.

May 14, 1997 (11 p.m. to 12 a.m.) [2300 to 2400 Hours]

When the first of the construction workers attempted to exit through the guard house about 11:20 p.m., after the nasal smears had been taken, they were stopped by Hanford Patrol personnel and asked to return inside the 234-5Z Building because the facility was in a lockdown. There, the construction crew's supervisor approached an RL facility representative and demanded that he do something to make it possible for them to leave. The workers who were waiting at the guard house asked why they could not leave and the guard told them they had to wait for the explosives-detection dog to check the company truck to be used as one of the vehicles for transport to the hospital. When the dog and handler returned within the next 20 minutes or so from the 200 East Area, the check was done.

In an effort to get the permission for their release, the BED was informed at about midnight the workers were at the gate. The BED had assumed they left at least 2 hours previously and insisted their release be effected immediately. They were all cleared through the gate at about 12:25 a.m.

Other activities that occurred just after 11 p.m. included: the POC faxed initial notification forms to the ONC and offsite emergency response agencies; the Joint Information Center (JIC), which is part of the RL-EOC at the Federal Building in Richland, became operational; and a Public Information Officer was dispatched to Kadlec Medical Center to assist with media inquiries associated with the construction workers, if necessary. A status briefing to the RL-EOC included the information that radiological monitoring had detected no contamination outside the affected building and that all stack readings were negative. At 11:25 p.m., a plant manager requested a perimeter survey to make further cross-checks on negative readings from the continuous air monitors (CAMs). The RadCon Supervisor arranged, probably through the UDAC, for ten RCTs to be called in to perform the surveys. He also indicated a need for Industrial Hygiene (IH) surveying support for inside PRF. Later (12 a.m.), the RadCon Supervisor faxed to UDAC personnel a hazardous materials inventory for the 236-Z Building, in response their request.

The RL-EOC Director received an inquiry from the Kadlec Medical Center Emergency Room physician about the workers reportedly coming to the KMC ER. The KMC physician requested specific information regarding any chemicals involved in the event, the extent of worker exposure, and so forth as part of preparing appropriately targeted medical examinations.

May 15, 1997 (12:05 to 1 a.m.) [0005 to 0100 Hours]

Sometime between 12:00 a.m. and 12:25 a.m. (logs differ), the eight construction workers left the facility and the 200 West Area in five separate vehicles, exited the Hanford Site through the Yakima Barricade. They arrived at the Kadlec Medical Center at 1 a.m..

At 12:50 a.m., the RCT who had been dispatched earlier in the evening to check the CAMs at the 291-Z-1 stack reported feeling bad [reports vary with respect to the symptoms, one indicating a raspy throat, another nausea]. The BED released the RCT to go to Kadlec Medical Center for a medical evaluation. The RCT, who had carpooled to the site, was driven there by a nuclear operator from the PFP. They both returned to PFP after the medical evaluation was completed by the KMC ER physician. This constituted the ninth medical evaluation performed at KMC that evening on personnel from the affected facility. The following day, the Hanford Patrolman who was on the roof at the time of the explosion, was also referred to HEHF for medical evaluation.

At about 11:30 p.m., the RL-EOC Medical Director had requested and obtained permission from the EOC Director to deliver the chemical inventory list and other relevant information to the KMC ER. After the workers arrived at KMC, the RL-EOC Medical Director went the few blocks from the RL-EOC to the KMC ER where he discussed the contents of Tank A-109, HAN, MSDS and likely by-products of the explosion with the KMC ER physician. The RL-EOC Medical Director also introduced himself to the eight workers who were sitting in a room completing the required Labor and Industries (L&I) paperwork, prior to their medical evaluations. He provided each worker with his business and home telephone number, which they were told to use should they have future concerns regarding their health. One worker accused the RL-EOC Medical Director of not knowing what he was talking about because the doctor had not been out at PFP after the explosion. The KMC ER physician indicated that he did not need additional medical support so the RL-EOC Medical Director returned to his position at the RL-EOC. The workers requested blood and urine samples be taken, but they indicate the KMC Physician insisted to them that the samples would not be of use at the time because he did not have information about what chemicals to look for. At least two of the construction workers also have commented that none of them were advised by either physician about what they may have been exposed to or what signs of exposure to watch for.

May 15, 1997 (1:05 to 7 a.m.) [0105 to 0700 Hours]

During this period, the Emergency Response Organization including both the onsite and the RL-EOC teams, continued their assessment activities. At the facility, many different activities were carried out to ascertain whether any radiological contamination had been associated with the explosion and to attempt to learn what types of chemical substances were associated with the explosion and were present either inside the affected facility or immediately outside. Some of the monitoring activities are indicated in the following summary of this six hour time frame. The comprehensive time line found in Appendix B provides a more complete list of the activities that were noted in various logs, in particular related to activities at the various emergency centers.

At the PFP, the BED and Patrol Lieutenant granted permission at 1:13 a.m. for two teams of RCTs to perform 22 static measurements downwind, southeast and southwest, to further cross-check other findings of no radiological contamination. The RadCon Supervisor contacted the 200 West CAS to ensure that the RCTs would be permitted to move about to do the surveys. These RCTs were not wearing respirators. At some point during the survey activities, the BHI RCTs were approached by a Hanford Patrolman who was wearing a respirator and asked if the Patrol could remove their respirators. The RCTs stated that they did not have the authority to make that decision, although they did not have reason to think respirators were needed. A short time later, the BHI RCTs were instructed by the UDAC field team coordinators to retrieve the filters from Patrol respirators so they could be analyzed and possibly used as another form of information about any release that might have occurred. This was reported to the Patrol Lieutenant at the ICP at 1:44 a.m.

At 2:30 a.m., the perimeter surveys of the PFP fence line were completed, showing less than detectable alpha and beta/gamma. These radiological field teams then were directed by the field team coordinator in the RL-EOC's UDAC to other locations (100-B Area and Route 4 toward the Wye barricade) based on updated meteorological data about wind shifts in the hours following the explosion. The BHI team completed the survey in the 100-B Area, showing less than detectable alpha and beta/gamma; they completed their assignment by also collecting filters from three air samplers in the 100-B Area and delivering them to the 222-S Laboratory for analysis. Both field teams reported back to the RL-EOC between 5 and 6 a.m. to leave their survey data and equipment at the UDAC.

As for the damaged area of the PRF, planning began at 1:20 a.m. in the ICP for another entry into the facility to verify current status, make further assessment of the likely cause of explosion, and to take radiological smears and air samples for chemical hazards. This entry was to be performed by a facility and security entry team, with the HFD providing standby backup to the entry team. The team made their entry at approximately 4:00 a.m. Their objectives were to inhibit criticality alarm panels (CAPS) 5 and 6; verify functionality of the 236-Z E-3 and E-4 exhaust final HEPA filters; investigate whether hazardous materials existed in the atmosphere in PRF, particularly Room 40; conduct radiological surveys and collect samples to assess radiological conditions in PRF; and collect evidence as to the cause of the explosion and assess the extent of damage to the facility. Radiological surveys made of the outer layers of their PPEs (personal protective equipment) following their exit from the damaged area indicated no detectable radiological contamination. All members of the team provided reports of their respective observations and measurements during a meeting held at 5:00 a.m.

At the RL-EOC, the RL-EOC Medical Director was contacted by the KMC ER physician at approximately 1:58 a.m. The KMC physician advised the RL-EOC Medical Director that nine workers who had been seen at the KMC ER had been evaluated and discharged. The KMC ER physician reported several of the workers had symptoms possibly linked to very low-level exposure to irritants. He stated that none of the workers had symptoms or findings that warranted treatment with medication, nor were they in acute distress requiring hospitalization. The doctor reported he told them they could call the KMC ER if their condition unexpectedly changed. At least one of the workers reports he does not recall being told this.

At 2:10 a.m. a crash phone message was issued to 200 East and 200 West Areas to the effect that the Area take-cover directives had been lifted. However, the facility take-cover was still in effect. The UDAC was asked by the PFP RadCon Supervisor to provide him with their assessment of conditions in terms of the appropriateness of lifting the take cover directives, and the removal of respiratory equipment by the Patrol. Any UDAC assessment would be based on the various results of modeling, measuring, and monitoring that are continuously compiled by the UDAC during an emergency. At approximately 2::00 a.m., the RadCon Supervisor indicated that with respect to radiological hazard, he thought Hanford Patrol could safely remove their respiratory protection. At 2:20 a.m., the PFP Industrial Hygienist reported to the BED his assessment that the take-cover directive could be lifted because there were not significant airborne chemical concentrations in evidence and the odor thresholds of the chemicals of concern were less than the Threshold Limit Value (TLV). Also, the Supply System reported at 2:53 a.m. their conclusions that previous air sampling results of 3 X 10-11 micro ci/CM3 of activity were due to radon daughters based on gamma-scan results.

At 3:11 a.m. the BED discontinued the take-cover directive for the facility and authorized removal of respiratory protection. The security lockdown was still in effect. At 3:14 a.m., the BED approved an RCT to check the 291-Z-1 Stack who reported back 6-10 CPM on the 291-Z-1 stack monitor at 3:35 a.m.. At 5:00 a.m., the reentry team reported that all HEPA filter differential pressures were acceptable and that there was no damage to the HEPA system on the second floor of the PRF. Based on videos taken within Room 40 by the entry team, it was determined at 5:03 a.m. that the affected area would no longer be treated as a potential crime scene. At 5:55 a.m., the RL SAS subsequently authorized the ICP to discontinue the facility lockdown.

At 6:41 a.m., the declared Alert emergency was formally terminated based on a review of the various entry team and other assessment reports. Turnover began at the various emergency control centers to shift into recovery phase activities.

NOTE: The remainder of the entries refer mainly to the medical follow-up provided to the workers who were evaluated at the Kadlec Medical Center in connection with the explosion. The follow-on recovery activities of RL and contractor management after termination of the emergency phase are not detailed in this appendix.

May 15, 1997 (10:30 a.m. - 4 p.m.) [1030 to 1600 Hours]

The RL-EOC Medical Director attended a press conference at 10:30 a.m. to discuss the medical aspects of the PRF event. He then proceeded to HEHF to obtain additional information from an initial plume modeling effort to revalidate the potential exposure levels of the affected workers. At 12:00 p.m., the HEHF Physician contacted the lead accident investigator for an update on the investigation to ascertain whether new findings indicated other, previously unknown, exposures may have occurred.

Although none of the workers evaluated at KMC telephoned the HEHF Physician directly to report further symptoms or request follow-up, arrangements were initiated at 4 p.m. to begin scheduling some of the workers for a debriefing and baseline medical evaluation.

May 15, 1997 (5 - 7 p.m.) [1700 to 1900 Hours]

The HEHF Physician was notified by the workers' manager that two workers had complained of skin eruptions and several workers had complained of headaches. Two workers were taken to an Immediate Care Facility (ICF) for follow-up medical evaluation. This was the first indicator to the HEHF Physician of additional medical symptoms identified by the workers. The HEHF Physician requested the construction workers' manager arrange for the workers to report to the HEHF clinic on Friday, May 16, 1997. The HEHF Physician also asked the manager to ask the workers to report any symptoms, especially respiratory, to him. The construction crew supervisor reports this message was never relayed to him by his management.

The HEHF Physician also requested the manager to ask that the ICF Physician call him with the results of his 5:00 p.m. examination of the two workers who had gone to the ICF. The HEHF Physician received a call from an ICF Physician who reported the workers had skin eruptions and subjective complaints not associated with the respiratory system. The workers have reported they asked for and but were denied blood tests at the ICF. The ICF Physician provided the two workers with an edible substance, thought to be calcium alginate. He also provided one of them with something for his skin eruptions. He then cleared the workers to return to work.

May 16, 1997 (1 - 4:45 p.m.) [1300 to 1645 Hours]

The workers reported to HEHF for an incident debriefing scheduled for 1 to 4 p.m. It was held with the original HEHF Physician, a second HEHF Physician and a Clinical Psychologist. The president of the workers' company and another manager arrived at 3:45 p.m. and stayed until the briefing ended at 4:45 p.m. The workers appeared to be anxious and were concerned about potential exposures. After the incident briefing, the workers were assigned to HEHF medical providers who began the process of broad-based medical evaluations. The examinations consisted of complete blood count (CBC); glucose and electrolyte determinations; renal and liver function tests; chest radiography; and pulmonary function studies since the respiratory tract was determined to be the target organ of concern. After the medical evaluation was completed the workers still appeared to be anxious and concerned of a potential cover-up. In response to these concerns, the workers were offered an opportunity to receive an additional medical evaluation at the University of Washington, Harborview Occupational Medical Clinic. The HEHF Physician indicated to the workers that HEHF would continue to evaluate their health status and they would be scheduled for follow-up medical examinations on a monthly basis for several months. The HEHF Physician again provided his home and work numbers, requesting the workers call him regarding any complaints.

May 17, 1997 (2 p.m.) [1400 Hours]

The HEHF physician received calls at home from two workers. One worker noted sinus irritation, the other worker had an ongoing headache.

May 19, 1997 (7:30 a.m.) [0730 Hours]

Three voice-mail messages were left during off-hours on the HEHF Physician's office phone. Two workers left messages regarding concern about exposure. One individual did not self-identify but only coughed into the telephone.

May 19, 1997 (8:30 a.m. - 4 p.m.) [0830 to 1600 Hours]

The HEHF Physician evaluated the completed laboratory work and found no evidence of abnormality that could be linked to the event. One worker who did have abnormal findings related to a pre-existing condition was referred to his private physician. One employee presented to HEHF for a follow-up EAP visit.

Preparations were begun on the referral package to be forwarded to Harborview Medical Center. The Harborview physician was contacted by the HEHF Physician and briefed on the event, the chemicals involved, and the exposure data. A list of names was given to the Harborview Clinic scheduler so workers could be contacted directly. The HEHF Physician also called the chemical exposure point of contact at the Washington State Department of Labor and Industries who informed him that Harborview performs their independent medical examinations regarding chemical exposures. This provided some assurance that the selection of this facility was acceptable. The HEHF Physician notified the workers' management of his actions and to arrange follow-up appointments with the staff psychologist for the workers.

May 20, 1997 (8 a.m.) [0800 Hours]

The HEHF Physician was notified that the Patrol manager wanted all patrolmen present at the event scene medically evaluated. Preparations were made to provide the patrolmen the same examination given to the original affected workers. It was also at this time the HEHF Physician learned of the RCT who was seen at KMC the night of the event. This worker was then enrolled into the on-going HEHF medical monitoring program.

May 21, 1997 (2:30 p.m.) [1430 Hours]

Seven workers attended a follow-up session with an HEHF Clinical Psychologist.

May 22 - June 5, 1997

HEHF continued to follow workers' concerns, discussed actions with DOE officials, resolved logistical problems with referrals to Harborview, and responded to inquiries. Based on information available, it appeared worker complaints had generally resolved as expected. Two workers complained of symptoms not typically found from this particular exposure. Both were under the care of private medical providers. The HEHF provided information to medical providers as requested and offered assistance if needed. The verbal reports from Harborview revealed no additional data related to this incident. Repeated dispersion modeling occurred June 5, with the exposure estimated at 0.5 PPM.

Two workers requested biological assay for radiological contaminants. Arrangements were made and a plutonium urinalysis was performed by the Internal Dosimetry Laboratory on June 4, 1997. HEHF continued to be available for patient concerns.

June 5, 1997 (10:30 a.m.) [1030 Hours]

The HEHF made an effort to contact the affected workers to ascertain how they were doing, notify them of their scheduled recall examinations, elicit feedback on their Harborview experience, and inquire whether they desired further discussions with the HEHF Physician prior to the next scheduled meeting. Seven workers were contacted by phone, either person-to-person or by leaving a message.

June 6, 1997

One worker was found to have a reduced pulmonary function test (PFT) at the Harborview visit. Harborview requested a repeat test be done at HEHF to verify the outcome was the result of different testing methods. A repeat PFT was completed on June 6, 1997 and found to be unchanged from the baseline of May 16, 1997, showing considerable improvement from studies conducted 1-2 years earlier.

Two workers voluntarily terminated. Termination examinations, with PFT added, were completed. Follow- up examinations for the other affected workers began to be scheduled.

June 10, 1997 (1:30 p.m.) [1330 Hours]

One worker scheduled for a follow-up consultation, including PFT.

June 13, 1997 (1:30 p.m.) [1330 Hours]

Representatives from the workers' employers, Fluor Daniel Hanford management, HEHF, Harborview Medical Center, and RL met with the workers to discuss their concerns and answer specific questions about their Harborview experience. Letters were provided to the workers offering independent medical evaluations from any university-based occupational health medical program. University programs were identified in an attachment to the letter and instructions regarding acceptance of the offer were included.

Five workers had follow-up consultations scheduled, including PFT. Heavy metal laboratory tests for five workers were ordered by HEHF.

June 16, 1997 (1:30 p.m.) [1330 Hours]

Laboratory test for heavy metals were ordered for one more worker. A total of six have been ordered by this date; with three of them as yet uncollected.

June 19, 1997 (1 - 4 p.m.) [1300 to 1600 Hours]

HEHF held a lessons-learned session for the affected workers in order to receive their feedback from a customer perspective and to identify areas the workers thought needed improvement. Agenda items focused on what the workers felt went well and what they felt did not go well with the medical care they received from HEHF. Workers expressed concerns about health effects from the incident. Several indicated continuing symptoms not consistent with the known exposure.

June 23, 1997 (1 p.m.) [1300 Hours]

Results of heavy metals laboratory tests were returned to HEHF for the first five workers. All results were below detectable limits.

June 28, 1997

One worker had been scheduled to leave this day for medical follow-up at a university-based program. As of this date, no other worker had requested this evaluation.

July 1, 1997

A summary report from Harborview Occupational Medical Clinic was returned to HEHF with conclusions summarized as potential exposure to irritant. The report recommended on-going surveillance of the workers.

July 2, 1997

Results were received from Virginia Mason Medical Clinic, where two workers elected to receive follow-up evaluation in lieu of Harborview. The results were consistent with low level irritant exposure.

July 7th through draft emergency response evaluation report phase

The workers were invited by FDH management to participate in the ongoing review of the evaluation report, and in particular, those portions relating to occupational health considerations from the night of the explosion. One worker was selected to act as a full-time representative to sit in on evaluation team meetings and to examine data. All were invited to review sessions in which a FDH staff member covered the current draft of the report with them, answered questions, and identified issues for further information collection and resolution.

APPENDIX B

COMPREHENSIVE TIMELINE

This comprehensive timeline is a compilation of several emergency response logs from the Plutonium Reclamation Facility emergency on May 14, 1997. The emergency response logs used to compile this comprehensive timeline are as follows: Hanford Emergency Duty Officer (B1), Occurrence Notification Center (B3), Hanford Patrol Operations Center (B4), Hanford Fire Department Incident Commander (B2), Plutonium Finishing Plant (PFP) Operations (B5), RL Emergency Operations Center (B6), PFP Radiological Control (B7), and Fluor Daniel Northwest Report (B8). It should be noted that event logs report the observations and personal knowledge of the individual at the time the entry was made. When all the facts are determined by the investigation team, some log entries will be in conflict with the total post-event picture.

<u>May 14, 1997</u>

0724 "B" Shift on duty. Received 2735-Z common alarm; LAH catch tank cleared; tank level indicator fluctuating, will monitor.

0930 RMC to Mode 2

0931 Per NAI operating procedure 234-A Room and Movement of Fissile Material/Waste Rev 1 in ATC/ITC by plant manager dated 4/24/97 to move fissile material by 2A-948-333 procedure and Z0-200-028 in the RMC line.

1510 RMC line returned to Mode 3 from Mode 2 and no fissile material movement allowed.

1700 Operator on surveillance noted 241-Z overflow tank alarm to tank D-7 will not clear, will be jetted because of extreme heat in 241-Z & ZA poppys will not function properly and personnel must be surveyed out by RCT.

1720 241-Z stack CAM chart drive was replaced and at this time operating properly (pkg 97-1138)

1736 "A" Shift on duty.

1739 Keys and badges accounted for

1742 Rm 104 alarm panel is functioning properly

1953 Hanford Fire Department (HFD) receives the initial automatic water flow alarm from 234-5Z, PFP/PRF, RFAR 2780, Zone 37, Room 40.

1955 Personnel felt explosion; Patrol called lockdown - door 108-A alarm - bell heard in and outside PRF. Water discharging from fire pipe outside PRF change room.

200 West Central Alarm Station (CAS) reports a Door 108 alarm along with several door latch alarms. 200 West CAS goes in to "lockdown." Unit 20 reports that he heard an explosion.

1956 Patrol Operations Center (POC) receives a fire alarm from 234-5Z.

1957 Hanford Fire Department Dispatch (HFDC) contacts the POC and advises they are sending three units.

1959 Patrolman and nuclear operators report smoke discharging from 291-Z-1 stack. Discharge is yellow/brown in color, which was visible for approximately 15 minutes.

2000 Patrol Unit 20 request that Patrol Unit 25 move from primary position and move to alternate position, due to debris coming from stack. Also request that units stay away from the west end of 234-5Z.

200 West CAS request wind direction from POC.

Public address system announcement tells workers to report to Room 104 in main 234-5Z Bldg.

2001 POC contacts weather station and request updated weather information.

2002 POC provides 200 West Area with weather information.

2002 Pax made for all facility personnel to report to OCF Rm 104.

2004 Patrol Unit 20 advises all units to "take cover." Facility take cover sirens are activated can hear them sounding in the background of radio traffic on Channel #3.

2004 Medic-92 advises other responding fire units of possible criticality.

Eight FDNW workers on lunch break located outside trailer leave; encounter Patrol Officer and are instructed to go back inside trailer.

2005 Weather station reports winds SE 4-7 mph.

POC contacts 234-5Z Plant and ascertains if they want an activation of the "Crash Phones." BED request that a "Crash Phone" message be initiated by the POC to close down 200 West Area.

2007 POC activates crash alarm system (for 234-5Z and 200W Area) personnel told to stay away from 200W area.

2009 POC contacts the Yakima and Wye Barricades and informs them to close barricades to inbound traffic.

2010 FDNW workers call the Control Room and ask for directions. Operations Engineer directs them to report to room 104.

2011 FDNW workers leave trailer and proceed along west side of 234-5Z Building.

2013 Emergency Duty Officer (EDO) received notification from Patrol Operations Center, an explosion at 234-5Z facility had occurred at 1956; multiple fire alarms, electronic security door switch failures, and water pouring out of door 108 at the Plutonium Reclamation Facility. Hanford Fire Department was in route. Name of BED provided by POC; phone number to contact BED.

2015 EDO contacted PFP BED to ascertain condition of facility and need for assistance. BED stated he did not need any assistance at the facility; asked EDO to make notifications to senior management per notification procedures; EDO agreed to make notifications. Conversation lasted about 10 to 12 minutes. EDO received general status statement. EDO asked if EALs had been reviewed and if any had been exceeded and Emergency needed to be declared. BED stated he did not have enough information to categorize at this point in time

2015 Initial accountability OK.

2016 FDNW workers arrived in Room 104 and directed to stand-by. Two workers report a metallic taste.

2018 The BED and HFD establish Unified Command in the PFP shift operations office.

POC contacts DOE-SAS Duty Officer and informs him of several door, crash phone message per BED. Also mentions Door 108-A alarm.

2019 Hanford Fire Department notifies EDO.

2021 Water discharging from DR 118, 120 PRF

2022 POC contacts Captain at the Patrol Training Academy (PTA) and requests that he respond, with other Patrol personnel to 234-5Z. POC provides briefing on event.

2025 HFDC informs POC of possible explosion and that they are making the first entry into the facility.

2025 POC contacts Deputy Chief reference the event at 234-5Z. POC informs him of multiple alarms, flooding, barricade closure, take cover ordered by BED, crash phone, debris coming from stack, and Patrol personnel on mask.

2028 BED initiates process to verify 291-Z-1 stack monitoring is still operable.

2029 Patrol Unit 10 contacts POC and requests that the explosive detection canine be placed on standby reference this event.

2030 Alarm Monitoring Station (AMS) reports water over floors in PRF - 1st flr, 3rd (dr 114) 4th Dr116, - through camera surveillance

2032 Director, B&W Protec contacts POC requesting update on event at 234-5Z.

2033 200 West CAS contacts POC and informs them that a multiplexor (MUX) has failed.

2034 222-S plant personnel directed to take cover.

2035 AMS reports water discharging out doors 118, 119, 120, 116

2037 B&W President notified.

2039 POC contacts B&W Protec Security Maintenance and advises him of MUX failure. Also mentions water line break, fire alarm, and take cover for 200 West Area.

2040 EDO received call from Incident Commander with update to conditions at plant. EDO informed IC that initial notification to Exec On Call had been completed was in process of making additional notifications. Informed by IC that doors 118, 119 and 116 had water flowing out of each; entry team preparing to make initial entry; entry team would be made up of HFD personnel. Approximate length of conversation 10 minutes. EDO asked if BED had reviewed EALs for declaration of emergency and BED stated he had not had a release of radioactive or non-radioactive material outside of the facility and did not believe he was at an Alert or higher.

2042 Requested weather station to advise of any wind change

2044 Attempting to print accountability record

2045 EDO contacts the POC and requests additional information concerning event at 234-5Z.

2046 HFD entry team CDR reports evidence of explosion on ceiling above chem prep tanks, door 953 blown outward, glass in door 954 blown outward, debris on floor, fire pipe broken.

2047 Unit 10 contacts POC and request that K-9 unit be dispatched to the scene.

2050 AMS reports camera surveillance of PRF impaired by water.

EDO contacted DynCorp Management at request of IC.

2052 AMS reports 2-3" H_2O on deck in PRF.

EDO contacted FDH Communications On Call and provided update on situation.

2053 BED directs power to be disconnected to PRF.

EDO received call from POC wanting update on what was happening; EDO provided update based on conversations with facility and IC/BED. Notified that there was a Semi-Tractor Trailer accident on Highway 240 and that HFD was responding two vehicles to assist.

2055 EDO contacted DOE Senior Management On Call; provided update.

2058 HFD reaffirms an explosion undoubtedly occurred in Rm 40.

2059 HFD reports roof of PRF is intact, visual observation of exterior reveals no breach in roof.

2059 Z5 and Z6 caps power fail alarm received

2103 AMS was asked to have field personnel visually monitor 291-Z-1 stack for any emissions

2105 EDO contacted by PHMC Executive On Call requesting update on information; EDO informed that Exec On Call had talked with RL SAS and that RL SAS was concerned about sabotage and was initiating a call to FBI and requesting that event scene be handled as a crime scene and be cordoned off for retention of evidence. Exec On Call stated he had talked with B&W Protec security staff to initiate that action. Exec On Call asked EDO to contact FDH President.

2109 RCT is proceeding to 291-Z-1 stack to perform checks.

2110 The HFD initiated the second entry into room 40.

2112 HFD requested power be disconnected to entire PRF due to possible electric shock hazard in flooded conditions.

2114 HFD further reports the electrical conduit in area of explosion is ruptured.

2115 DOE Facility Representative #1 contacts POC and requests information concerning a possible fire/explosion.

EDO contacted facility IC/BED and received update; no significant change in status, lockdown proceeding per RL SAS instructions and consideration of sabotage communicated to facility.

Decision made to have workers drive themselves to Kadlec Medical Center for treatment. BED directs FDNW Supervisor to arrange transportation of workers.

2116 DOE Facility Representative #2 contacts POC and requests information concerning reports of possible fire/explosion at 234-5Z. Request alternate number for the BED.

2119 Second entry by HFD into PRF suspended until power is disconnected

2121 Received AMU catch tank level alarm (2735-Z Area Common Alarm) due to flooding in chem prep PRF, alarm locked in, then cleared.

2122 DOE SAS contacts the POC and requests information concerning an event at 234-5Z.

2124 RCT reported 291-Z-1 stack checks are normal, all parameters are within LCO specifications.

2125 EDO contacted President FDH and provided update to situation.

2126 Shift Operating Engineer (SOE) proceeding to disconnect power to PRF.

Patrol Unit 10 provides alternate phone number to POC. Patrol Unit 10 is briefed that DOE SAS called requesting information concerning the event.

2127 Received another AMU catch tank alarm, alarm cleared

2128 EDO contacted PFP IC/BED again for update; briefing taking place at PFP relative to status of initial entry team assessment following return from entry. "Multiple doors blown open, doors blown off of hinges, blackened area in chem makeup area, glass and debris everywhere..." EDO again asked about exceeding EALs, BED stated he did not have a release of radioactive or non-radioactive material and had not exceeded EAL criteria. IC stated the ICP had conducted an update to RL SAS, stated NO FIRE, NO RELEASE, Door Alarms Functioning, Vaults OK; ~ 8 FDH employees outside experienced metallic taste and were being readied for transport to Kadlec Medical Center; 4" sprinkler system line busted and gushing water onto floor in Room 40 Aqueous Make-up; area to be secured per RL SAS request; fire engine sitting in water in parking lot and needs to be surveyed for possible contamination-approximately 6" of water in parking area on East side of building 236-Z. Conversation lasted about 15 minutes with delay for briefing in progress.

POC contact Patrolman and request that he respond to 234-5Z reference the event.

2132 Shift Operating Engineer (SOE) opened F8X608 to disconnect power to PRF
DOE Facility Representative #1 calls and requests update. POC advises him to call BED.

2133 B&W Protec Security Rep. contacts the POC requesting information concerning the event. POC informs him of multiple alarms, possible explosion, lockdown, and take cover.

2137 AMS reports camera surveillance lost in PRF

2140 Incident Commander briefs DOE SAS Manager, informed him that some type of an explosion had occurred in the PRF, that there was no fire, no radiation concerns so far, no stack alarms and that there was a RCT checking out the stack alarm for possible damage. Also that the vaults were ok. DOE SAS informed both the BED and IC that he was going to notify the FBI due to the unknown cause of this explosion. DOE SAS directed that the scene be secured. Possible security event - unified command was expanded to include the Patrol Shift Commander.

Two FDNW workers returned along same path to trailer to retrieve personal belongings.

2144 DOE SAS contacts POC and advises that the BED informed him of a possible explosion at 234-5Z in the PRF Facility..

2145 EDO contacted President B&W and provided update.

2150 Patrol Shift Commander wants to isolate 4th floor PRF as a crime scene area. The HFD offers to help Patrol accomplish this task by providing HFD personnel to assist and to show the Patrol personnel the various entrances to the facility/stairwells.
Weather reports winds 11-20 mph, from NW.

2152 POC contacts EDO and provides an update concerning the explosion, no radiological release, and no injuries.

2155 POC contacts Patrol Chief and briefs him on the event at 234-5Z.

EDO contacted PFP IC/BED for update. Received status; not much change from previous update; still did not need any assistance from EDO.

2158 HFD, first and second, entry team personnel are asked to give statements to Patrol.

2200 Radiological Control Manager arrives at the Incident Command Post.

2 FDNW workers return to Room 104 with personal belongs.

2202 EDO received call from IC/BED declaring Alert Emergency. BED stated he had not exceeded a specific EAL, but felt that the safety of the facility was in jeopardy and declared an Alert level emergency. The EDO stated he would contact the POC and have them initiate the necessary EOC activation process, and PARs for onsite affected populations. EDO stated that BED needed to complete the RL Notification form and FAX it to the POC to initiate the formal notification process.

2205 EDO contacted POC and stated that the BED had contacted him and declared an Alert at PFP and that POC needed to initiate the notification process to activate the EOC. POC asked which dialing list to use for ENS. EDO stated, not sure, use your procedures; POC agreed to look up in procedures. EDO stated facility is in process of completing the notification form and will FAX it to the POC ASAP. POC reminded to complete protective actions per procedures. POC agreed to activate ENS and do appropriate protective actions. EDO notified POC he was responding to EOC.

FDNW workers arrive at gate to leave for Kadlec Medical Center. Patrol wouldn't let them leave as long as facility was locked down. Workers return to facility.

2215 HFD took zone 37 OOS to silence bells. No FW at this time, entry is restricted to PRF. Status noted on Shift Operations Status Board by acting-Captain..

2215 EDO received ENS phone call and indicated EDO was in route to EOC.

2223 CAM in PRF (1st west - north end) heard by RCT outside door 120.

2230 FDNW workers contact Radiation Control Manager and request radiological checks.

2235 EDO arrived at EOC and began process for activation. No notification form located in EOC. First responder products began being developed.

2240 Radiological Control Manager reports CAM alarm near door 120 to BED.
Eight FDNW workers to receive nasal/mouth smears.

2242 EDO contacts the POC and requests if the Essential Staffing Page has been sent. According to POC personnel they are unable to locate the program on their computers. POC personnel find the desired program and send the page.

2243 Emergency Response Organization (ERO) communication link established with PFP. Explosion PRF (possible)--origin unknown. Door & window blown out room 40, chemical prep. No breach of containment; water leaks; water shut-off from PRF; leakage of water out exterior doors; no contamination present.

2255 The RL Emergency Operations Center declared operational. 8 workers west side of bldg. transported to Kadlec; 2 workers report metallic taste in their mouth.

2258 Third HFD entry team commencing third entry into PRF on SCBA.

2259 POC sends Notification Form to Grant County.

2300 Radiological checks, included survey and nasal smears, began on FDNW workers.

2301 POC sends Notification Form to the ONC, Grant County, DOE HQ- EOC, Oregon DOE. Grant County EOC receives second copy of the RL Notification Form.

2305 Yakima and Wye Barricades closed; 200 West Area locked down; 2 extras Patrol Officers from Patrol Training Academy dispatched to the event scene; FBI notified at 2205.

2306 Benton County Detectives, en route to command post .

2307 Mitigative actions
- All electrical power to PRF secured
- Water has been shut-off to PRF
- 200 West locked down
- No contamination levels outside bldg.
- All stack readings <291-Z-1> checked out negative

2308 Joint Information Center is fully operational. Public Information Officer dispatched to Kadlec Medical Center.

2310 Plant Manager requests perimeter survey; looking for larger particles that won't be seen on CAM.

2315 Occurrence Notification Center (ONC) Duty Officer notifies the Oregon Department of Energy Duty Officers of PRF Alert emergency.

2320 Radiological Control Manager contacts UDAC. Provides radiological data to UDAC Hazard Communicator.

2321 Occurrence Notification Center (ONC) Duty Officer initiates offsite notifications by faxing RL Notification Form. ONC notifies Washington State EOC, Bi-County EOC, Supply System, and Patrol Operations Center via DOE Crash Phone. No Crash Phone response from Grant County .

2324 POC receiving public relations/media calls.

2325 Radiological Control Manager requests 10 RCTs be called in on OT. RCT to perform perimeter surveys.

As part of the IH support need to verify yellow-brown vapor from stack, 291-Z-1. Also, for IH support this needs to be treated as a confined space. Non-rad monitoring to be considered--oxygen meter, explosimeter, OVA, and NOX monitor.

2327 Occurrence Notification Center (ONC) Duty Officer attempts to contact the Washington Department of Ecology. No response (voice-mail only).

2328 An emergency update is provided to the offsites by RL via the DOE Crash Phone System and RL Notification Form. Explosion in Room 40 of the PRF, 4" water line destroyed. Water is present on lower 4 levels of the building and is accumulating on pavement outside the building. Eight individuals outside of PRF report "metallic" taste. Are being taken to hospital to be evaluated. Fire Department on the scene, no injuries. No evidence of rad contamination. (RL Notification #2).

2330 POC contacted public relations.

2335 HFD entry team reports status of Rm 40 TK 101 is tipped outward at a northwesterly direction. Force of explosion appears centered over catwalk between TK 101 and TK 102.

2338 ONC Duty Officer provides 2nd RL Notification to the Grant County EOC.

2340 UDAC requests HAZMAT inventory for 236-Z. Radiation Control Manager faxes information by 2400 hrs.

2345 RL-EOC Protective Action Coordinator contacts the POC and requests that they activate the 200 East Area "take cover."

Exits on barricades; entry allowed for shift change

2347 200E crash phone and sirens activated for take cover.

2350 First press release issued locally and to AP & UPI; Tri-City Herald holding up printing for event story.

2353 ONC Duty initiates notification to Washington Department of Ecology. No response (voice-mail only).

2355 IH Manager contacted to provide additional IH support. (4 individuals available)

2400 No further entries this date.

<u>May 15, 1997</u>

0001 Plant status - still in response and recovery actions pertaining to explosion in PRF.

0004 ONC Duty Officer provides 2nd RL Notification to Oregon Department of Energy Duty Officer.

0005 POC check w/Kadlec Medical Center regarding 8 employees for interviews.

0010 BED clears RCT to go to 270-Z to set up mini-scaler for nasal/mouth smear.
Contacted 100N RCTs to gather PAMs and be ready to support UDAC @2351; currently getting names and

employee #s for BHI RCTs available for support.

Statement provided to Tri-City Herald reporter on status of contamination situation--"no indication of radiation release at this time. Incident occurred in chemical make-up room. Air monitors in area have not alarmed. We are continuing to survey. Initial surveys of firefighters and workers in area did not show any evidence of rad contamination".

Per POC Duty Officer, 8 employees not transported to Kadlec by HFD, drove on their own.

0015 200E tank farms have reported in as under cover and all accounted for.

No CAM alarm 291-Z-1 stack; record sampler RCT procedure no contamination and no other CAMs alarmed.

POC informed of barricade entry procedures.

0020 Crash alarm message - all facilities in 200E and 200 West in "take cover" mode because of explosion at PRF.

Per conversation w/ On-Call RL Office of External Affairs Rep., - 8 employees 30 min. out from Kadlec Medical Center.

FBI updated

Shift Sgt.. (BCSO) will dispatch deputy to hospital

0025 FDNW workers allowed to leave PFP and travel to Kadlec Medical Center.

0031 #40 to Kadlec Medical Center

0033 UDAC reports source term is comprised of acute irritators, but no acute toxins or that can be absorbed through the skin. Be prepared to wash personnel.

4 RCTs from BHI to perform 200W perimeter surveys.

0035 Following is an accountability status update for **200 West Area**
200 Area Fire Station (5)
Z-plant (32)
S Plant (8)
West Tank Farms (6)
283 Chlorinator (2)
251 Substation (1)
622R Wy Station (1)
200 East Area
2701HV (30)
B-Plant (6)
Tank Farms (12)
2751E (1)
ETF (8)
284E (2)
283E (1)
2750 (3)
242A (2)

DOE HQs briefed at 0028

0036 POC contacted re Field Teams (FAX)

0042 An emergency update is provided to the offsite agencies via the DOE Crash Phone and a RL Notification Form. The 200 East and 200 West Areas are in a take cover protective action, Hanford airspace is closed, and nasal smears taken of eight workers - results negative. Field Teams are on the scene. RL Notification #3.

0045 Patrol Shift Commander reports camcorder ready to support entry

0050 RCT reported feeling nauseous. Is being taken to Kadlec Hospital for further evaluation

0052 Patrol Lt. requests authorization to remove respirator protection.

0054 ONC Duty Officer provides 3rd RL Notification to Oregon Department of Energy Duty Officer.

0057 Per conversation w/ On-Call RL Office of External Affairs Rep., - 8 employees just arrived at Kadlec and BCSO also just arrived.

Personnel performing entry into PRF will wear 1 pair anti-c's under 1 pair of acid suit. SCBA is the respiratory protection. No RWP will be used. The DRCM will perform a pre-job with personnel performing entry.

0100 FDNW workers arrive at Kadlec Medical Center.

0100 IH Support arrives in RL-EOC and is briefed by UDAC and Site Management Team.

0105 Radiation Control Manager informs Patrol Lt. that respiratory protection removal is not authorized until UDAC clears.

0106 ONC Duty initiates notification to Washington Department of Ecology - No response (voice-mail).

0113 BED and Patrol Lt. grant permission for 2 teams of RCTs to perform 22 static measurements downwind (SE and SW). Each to ensure no contamination.

0118 POC contacted re BHI survey of Hanford Patrol Officers (barricades) w/masks

0119 Radiological Control Manager contacts 200W CAS and ensures RCTs cleared to conduct surveys.

0120 Briefing being held to plan entry into PRF. Reasons for entry are 1) inhibit CAPs 5&6, 2) verify flooding stopped, 3) bldg. ventilation D.P.s, 4) take video of Rm 40 to help evaluate cause of explosion & assess damage, 5)take radiological smears and air sample for chemical hazards.

0122 IH support en route to Event Scene.

0125 Check w/ On-Call RL Office of External Affairs Rep., - BCSO interviews in progress

0130 The HEHF on-call physician interviewed affected workers at Kadlec emergency room. Other than a metallic taste in the workers mouths, no other adverse health effects noted. At this time, not able to identify any chemical or radiological doses likely to cause adverse health effects.

0144 Patrol Lt. reports BHI RCTs have confiscated the filters from the Patrolman outside the facility. Patrolman were still wearing the respirators.

0145 IH Support arrives at ICP.

0150 >80 static measurements taken by PFP RCTs on the south side of the compound. No contamination detected. BED notified.

0155 Entry Plan
- inhibit CAP system, check for contamination
- check HEPA DP
- take air samples
- preserve crime scene/video
- rad wipes, rad air samples

0155 The JIC receives two calls - 1) alternate National Warning Center (FEMA) - Bothel, WA wanted info - press release was faxed; 2) Brig. Gen. @ Pentagon Operations Center - he heard about explosion on NBC news - press release was faxed. He offered assistance. RL-EOC Manager returned his call.

0158 ICP answers crash alarm phone - message was an update of present situation at 234-5Z

0158 Follow up from Kadlec Emergency Room - all workers have been examined and released. No significant medical problems related to this event noted.

0159 No alarms/no camera coverage in PRF facility. All other systems functional.

0200 BED held briefing, via phone, with EOC to obtain concurrence to perform entry into PRF Ref. 0120 entry.

Rad Control Supervisor contacts UDAC. Requests take-cover clear and removal of masks from Patrol.

Made 200W and 200E crash alarm informing people of event status. Eight facilities answered - total of 64 people in 200W facilities. Seven facilities answered - total of 42 in 200E facilities. No critical operations impacted.

0205 Lift take cover in 200 East and West Area. PFP personnel follow directions of BED.

0207 ICP receives call from Shift Operating Engineer at Kadlec Medical Center - reports that all Fluor Daniel construction personnel were O.K. and being released from hospital.

0210 200E and 200W crash alarm message to Lift take cover.

0212 ICP answers crash alarm phone - message give that 200 East and West Areas released from take cover condition. Does not include 234-5Z area.

0215 An emergency update is provided to the offsite agencies by RL via the DOE Crash Phone System and transmittal of the RL Notification Form. Recommending that the take cover in the 200 Areas be rescinded. UDAC Field Teams have found nothing above normal background. Site Emergency Director agreed with the recommendations. RL Notification #4

0217 Patrol Shift Commander reports no cartridges taken.

0220 Industrial Hygienist reports to BED that take-cover can be lifted. Odor thresholds for chemicals are less than TLV.

0223 RCT, mentioned on 0050 entry, released from hospital and is returning to 234-5Z.

0225 ONC Duty Officer provides 4th RL Notification to Oregon Department of Energy Duty Officer.

0227 UDAC reports that authorization to remove respirators has been given to BED. BED states not notified.

0228 Pre-job briefing for entry conducted. Power operator to check ventilation system and differential pressure on HEPAs. SOE to inhibit CAP 5 & 6. Patrol will accompany to ensure crime scene not contaminated and to video room 40 damage. RCT to perform air sample and CAW. IH to perform air sample. LEL will take prior to air sampler.

0230 Perimeter surveys of PFP fence line completed (less than detectable alpha and beta/gamma). Redirected field teams based on revised met information

- Bechtel team dispatched to 100B Area

- Team 2 dispatched to Route 4 South towards Wye barricade (taking readings every 1/4 mile).

FDNW workers discharged from Kadlec Medical Center

0236 ONC Duty Officer attempts to contact Washington State Department of Ecology - No response.

0253 Supply System reported that air sample result reported as 3X10-11 micro ci/cm3 at about 0130 was due to radon daughters based on a gamma scan.

0303 BED requesting concurrence on lifting of facility take cover. Patrol off respirators outside building?

0310 RCTs go to OCF and back with battery air samplers. BED and Patrol authorize.

0311 Take cover condition at 234-5Z has been lifted by BED, but facility remains in lockdown. PAX made informing personnel.

Removal of mask (respirators) authorized by BED.

0313 Entry Team - pre-job briefing; meet 0315; suited up to go in; ETA 0330 - 0345.

0314 BED approves RCT to check 291-Z-1 stack. Patrol contacted.

0322 Radiological Control Manager provides update to UDAC. Stressed to UDAC water in paved area outside PRF and no detectable contamination in water.

0330 Bechtel team completed ground survey in 100B Area (less than detectable alpha and beta/gamma). Collected filters from 3 air samples in 100B Area. Taking air samples to 222S lab for analysis. After sample delivery, Bechtel team is returning to 100N (terminating participation).

0335 RCT reports 6-10 cpm on 291-Z-1 stack. BED notified.

0352 BED conducts last pre-job briefing.

0355 Entry team dressed and on route to 236-Z, @ 0400 hours all 5 team members entered 236-Z. CAPS 5 & 6 inhibited - no problems w/criticality horns. Team on air for total of 9 minutes.

0400 Press release issued on 8 workers released from hospital and "take cover" order lifted.

RCT reports operator walking through a contaminated area at women's change room. RCT surveyed operator and was clean. Area being posted with rope. BED notified at 0402 hrs.

0404 Shift Operating Engineer verified no change in the AMU catch tank level.

RCTs posting PFP Director's office as a CA due to flooding.

0405 An emergency update is provided to the offsite agencies by RL via the DOE Crash Phone and the RL Notification Form. Entry team has entered the facility to survey damage caused by the explosion and check facility systems. RL Notification #5.

0406 PAX announcement made informing personnel CAPS 5 & 6 are being inhibited - do not take emergency response unless instructed otherwise

0408 ONC Duty Officer provides 5th RL Notification to Oregon Dept. of Energy Duty Officer.

0410 Reentry objectives identified

1. Set up air sampler for radiological & non-radiological release (15 minutes)
2. HEPA Filters - 3rd floor of PRF
3. Industrial Hygiene chemical air survey in room 40.
4. Complete video taping.

0410 Media availability issued to announce press conference at 1030 in Federal Building Lobby - Principals are RL acting Manager, FDH Vice President, President, B&W Hanford, Benton County Commissioner, Benton/Franklin Emergency Manager, and HEHF Physician. Reporters will be invited on an escorted bus trip to the site.

0412 Radiological Control Manager provides update to UDAC.

0415 Radio announcements started to inform all workers to report to regular duty stations onsite and be prepared to work standard shifts.

0415 PAX announcement made - CAP's 5&6 now inhibited and personnel are to take proper emergency response actions.

0417 Patrol canine officer reported, while performing checks with bomb search dog, the dog did show a response around area of Doors 118, 119 & 120. Note - this was outside the PRF facility. Also, when event happened flooding caused water to flow underneath these doors to outside of facility. It is assumed that the dog was alerted to nitrates from the explosion.

0425 Fourth entry team enters room 40.

0429 Reported that one person from PRF entry team has exited PRF. Survey indicated no contamination found on person's P.P.E.

0430 Field Team #1 is reporting back to Federal Building (approximately 0500), Field Team #2 transporting samples back to 222S Labs then will return to Federal Building (approximately 0545). At approximately 0500., new field team members will be called in and remain on standby at Federal Building.

BED/Patrol approve 3 operators/3 RCTs to set up CA's outside PRF to contain water.

0433 Reentry team has exited the PRF after 37 minutes on fresh air. The following objectives were met

1. CAPS 5 & 6 inhibited.
2. Battery powered air sampler placed outside room 40 - no rad sample due to lack of power; gross swipes negative.
3. HEPA filter bank checked
4. IH entered room 40 and took air samples
5. Video recording complete - extensive damage to 109 or 102 tank; ceiling above tanks extensive damage.
6. Results of air samples HEPA integrity will be available during debrief.
7. Volunteer bomb search team being assembled by facility.
8. Door 953 totally destroyed, door 955 received heavy damage (destroyed) and 954 is slightly damaged on hinges.
9. Tanks 109 or 102 located NW corner of room. Blast affected door 953 & 955 the worst. Blast was in a SE direction.
10. Suspect tank 109 is laying on its side; little damage to equip.

0435 Directed RCTs to post all wet/prior wet areas (based on personnel statements) outside PRF as CAS.

0438 All members of PRF entry team have exited PRF.

0443 RCTs report no contamination on outer pairs of PPE of entry team.

Late Entry

1955 5/14/97 entered LCO action statements as follows

LCO 3.1.2 CAP inoperable (Cap's 5 and 6)

B.1 Enter Mode 2 and stop fissile material movements in affected areas

LCO 3.2.1.1 Ventilation from Zone 4 areas shall pass through two operable filter stages

A.2.1 Initiate a Recovery plan and

A.2.2 Enter Mode 2 and stop all plutonium processing and handling in affected glove boxes or Zone 4 areas. Both within 48 hours

LCO 3.2.1.2 Ventilation from Zone 3 areas shall pass through one operable HEPA filter stage

B.2.1 Initiate a Recovery Plan and

B.2.2 Enter Mode 2 and stop all plutonium handling and processing in affected glove boxes or Zone 3 areas. Both within 48 hours.

48 hour time clocks start at 1955

0451 All 5 personnel on entry team surveyed. <500 dpm/100cm2 alpha upon exit of CA.

0454 UDAC contacted and provided update by Radiological Control Manager.

0459 "A" Bank and "B" Bank filters pulled. "A" Bank filter is wet. BED notified at 0500 hrs.

0500 HZ Tank - contains hydrazine, located above tank 109; very volatile material; material quantity just a heel; HZ tank no longer exists - large hole in ceiling.
All HEPA filter differential pressures (DPs) are ok; No damage to HEPA system on 2nd floor.

0503 PAX mode - meeting being held in RM 117 to discuss findings of PRF entry team.
The meeting consisted of personal reports by each team member on what they had observed and what kind of readings they had received on their instruments. The video that the Patrol escort took was viewed and it was at this time agreed that this was a facility event and should no longer be classified as a security event.

0515 All-employee message from RL Manager - sent sitewide explaining what happened and current status.

25 minutes prior to the blast, a Shift Operating Engineer conducted routine surveillance and didn't notice anything out of the ordinary. Also, a power operator was preparing to perform routine surveillance when the blast blew open door 10, located on the north side of 236-Z, 1st floor.

DOE- HQ Press Officer briefed at 0510 - press releases faxed to her. She will make sure NW congressional delegation is briefed. RL/OEA will notify local offices of congressional reps. Also state legislators and local officials.

0524 Offsite agencies updated on emergency conditions by RL via the DOE Crash Phone System. Reentry Team has exited the facility. Doors to Room 40 have received extensive damage. A number of the 15 tanks (size vary up to about 150 gallons) have received extensive damage. All HEPA filters are OK and functioning. Reentry data being analyzed. Recommendation on Alert status anticipated in 1 and ½ hours. (RL Notification #6)

0530 ONC Duty Officer provides 6th RL Notification to Oregon Dept. Of Energy Duty Officer.

0538 RCT reports all wet/prior wet areas posted as contaminated areas.

0552 BED approves Radiological Control Management to walkdown contaminated areas prior to lifting lockdown. Patrol also requests seals be placed on PRF doors. RCTs will accompany.

0555 Approval for removal of lockdown received from RL-EOC Security Director

0556 RL log review by PFP RL Facility Representative.

0558 Patrol AMS made PAX announcement informing personnel that lockdown has been lifted.

0604 The BED prepared the Emergency Termination, Reentry and Recovery sheet out of the DOE-223 Manuel. The information provided on it was conveyed via telephone to the EOC. The EOC request that it be faxed to them and upon their final review would determine the emergency terminated.

0610 Radiological Control Manager inspects contaminated areas around the PRF. Radiological tape used to mark area. Fire truck inside CA.

0619 Radiological Control Manager contacts UDAC. RCT dispatched to survey HFD truck. RCT sent to verify CA/RCA boundary.

0630 CA boundaries have been set up outside of PRF.

0640 RCT and Patrol request security boundary extension to allow easier access for Patrol to conduct ½ hour door checks. Also, RCT concerned about climbing ladder to 5th floor exterior door. BED places a hold on climb.

0641 Alert Emergency formally terminated.

0650 RCT stationed at CA boundary (with yellow rope) to ensure no personnel inadvertently cross barrier.

0652 Offsite agencies are notified of emergency termination by RL via the DOE Crash Phone and RL Notification Form. (RL Notification #7)

0654 ONC Duty Officer provides 7th RL Notification to Oregon Department of Energy Duty Officer.

0724 ONC Duty Officer provides emergency update to Washington Department of Ecology.

0800 Turnover meeting on response/recovery actions.

0818 RCT sent to front side maintenance shop for 243-Z filter change.

ONC Duty Officer provides emergency status to Washington Department of Ecology.

0930 Water line was operational as it was a fire suppression line.

0945 Recovery Lead
3 Part team at PFP in progress
1) System recovery engineering/operations
2) Water/Contamination reduction
3) Technical Investigation Eng/Labs

1000 News release to be held at 1030.

1315 1) PRF Roof sustained significant damage
- Roof flashing up
- Toe boards lifted 6-8"
- 8-10' diameter rock/gravel moved
- Concern for confinement (if electrical, HV lost)
2) unreviewed safety hazard never considered as accident.
3) reentry/recovery efforts in parallel.
- water cleanup via RLEP 3.4 approval.
- study of historical contents of tanks.

1721 Tank 109 Phase 1 Recovery Plan arrives @ EOC for review by EOC Recovery Operations Team.

1800 Tank 109 Phase 1 Recovery Plan signed off by Recovery Operations Team.

1830 Tank 109 Phase 2 Recovery Plan arrives @ EOC for review by EOC Recovery Operations Team. PRF Team requests review/sign off by 0900 on 5/16/97.

2200 EOC Recovery Operations Team suspends activities until 0700 on 5/16/97. Point of Contact during non-staffed hours is On-Call Emergency Duty Officer .

<u>May 16, 1997</u>

1130 HQ-EOC wanted an update and was informed that phase I recovery plan was completed. Phase II recovery plan has been signed off and is being implemented. At 1130 hrs, the DOE-HQ Duty Officer was informed that the RL-EOC was standing down.

APPENDIX C

CHRONOLOGY OF NASAL AND MOUTH SMEARS AND BIOASSAYS

C.1 CHRONOLOGY OF NASAL AND MOUTH SMEARS

The following describes the sequences of events associated with the collection and analysis of nasal and mouth smears from the affected workers as compiled by the investigation team.

As the eight workers were exiting the 234-5Z building (~10 p.m.) in route to the Kadlec Medical Center (KMC), the workers encountered the ESH&Q manager and Radiological Control Supervisor (RCS 1) who were just entering the facility. Based on the following facts, the workers asked the ESH&Q manager if nasal swabs should be collected from the workers.

- The workers had not received any previous radiological surveys.
- The workers had previously heard an announcement which indicated that personnel were to avoid the west side of the 234-5Z building due to plume of unknown origin emanating from the 291-Z-1 stack.
- The eight workers had arrived in building 234-5Z by proceeding along the west side of building 234-5Z and through the area of the plume.
- Two of the eight workers later left building 234-5Z (to obtain their automobile keys and personal belongings) while the facility was still in a take cover mode.
- Two of the eight workers exited 270Z to obtain barricades as requested by B&W personnel. This request reportedly did not pass through FDNW or ICP chain of command.
- While outside of Building 234-5Z, the workers observed Hanford Patrol personnel donned in respiratory protective equipment. (Note: Hanford Patrol personnel outside of Building 234-5Z were required to wear respiratory protective equipment until approximately 2 a.m. the following morning).
- While retrieving their automobile keys and personal belongings, the workers again traveled along the west side of building 234-5Z and through the general area where the plume was previously reported to have been.
- Radiological surveys were on-going in various locations within the facility (Room 40, Entry Team, 291-Z-1 stack, facility grounds, etc.) and outside of the facility (fenceline, perimeter, 200 West, etc.) to assess potential radiological contamination.
- Several alarms had been activated, some of which were believed to have been Continuous Air Monitors (CAMs).

Based on the workers inquiry, the ESH&Q manager requested the RCS 1 make arrangements to perform whole body frisks of the workers and to collect nasal and mouth (pallet) swabs from the workers. The RCS 1 subsequently requested a Radiological Control Technician (RCT 1) to collect nasal and mouth swabs from the eight workers. Based on feedback from the ESH&Q manager and RCS 1, the nasal and mouth swabs were assumed to be a precautionary measure in that no radioactive contamination had been detected in the facility or on facility recovery workers surveyed previously that night and there had been no positive indications of a radiation release from the 291-

Z-1 Stack. Conversely, a CAM alarm in the Plutonium Reclamation Facility (PRF) had been heard by a RCT and additional RCTs had been called in to support more detailed monitoring of the area outside PRF, in order to determine if "large" radioactive particles may have been released from the 291-Z-1 Stack without being detected (due to their relatively large size) by the stack CAM during this general time frame. Nasal and mouth smears are normally used as an indicator of radiation uptake, which upon positive results are followed up by bioassay which are used to assess the actual radiological dose.

The RCT 1 assigned to collect the nasal and mouth swabs, who had been trained to perform personnel decontaminations (including collection of nasal and mouth swabs or smears), was directed to the 270Z Building to take the smears from the workers. Despite direction to RCS 1 by the ESH&Q manager, no whole body frisk was provided to the affected workers.

The 270Z building is an administrative building and is not normally used for personnel decontamination (e.g., collecting nasal and mouth smears) but was used because the RCT's normal operational stations were not readily available due to the incident in the PRF. While building 270Z is used primarily as an administrative building, it does contain an emergency cabinet with supplies that are available for personnel decontamination. After evaluating the materials available in the building 270Z emergency cabinet, the RCT 1 determined many of the supplies necessary to collect the nasal and mouth smears (1] sufficient quantities of Whatman™ filter paper, 2] de-ionized water, 3] cotton tipped applicators, and 4] sample envelopes.) were not available. An inspection of the 270Z building emergency cabinet conducted on the morning of May 15, 1997 by two other RCTs, indicated that Whatman filter paper, deionized/demineralized water, and cotton tipped applicators were located in the emergency cabinet. Presumably, these supplies were in the emergency cabinet at the time of the PRF event, however, were not found by RCT 1 because the supplies were contained inside a metal holding case. Additionally, the RCT 1 was also unable to locate a copy of procedure HNF-IP-0718 (Health Physics Technical Practices and Procedures, Section 1.7, Personnel Decontamination) which describes the process for collecting nasal/mouth smears.

Approximately ten minutes (between 10:35 and 10:50 p.m.) after requesting the RCT 1 collect the nasal and mouth smears, the RCS 1 arrived at building 270Z from the 234-5Z building to assess the progress in collecting the smears. The RCT 1 informed the RCS 1 some of the necessary supplies to collect the smears were not available upon which the RCS 1 left the building in an attempt to locate the necessary supplies. The RCS 1 later returned to building 270Z with some of the needed supplies (but no Whatman filter paper) obtained from the on-scene paramedic and provided the materials to the RCT 1. Assuming that the RCT 1 now had adequate supplies to collect the nasal and mouth smears, the RCS 1 indicated another RCT 2 would be coming to the 270Z building to set up the mini-scaler which had previously been delivered to the 270Z building so the smears could be analyzed. Nasal/mouth smears are normally collected using a cotton tipped applicator with a piece of Whatman filter paper wrapped around the applicator. The Whatman filter paper is then dried (as necessary) and placed in a mini-scaler for radiological analysis. Assuming that the RCT 1 had an adequate supply of Whatman filter paper, the RCS 1 intended that a piece of Whatman filter paper would be wrapped around a rolled up gauze pad to collect the nasal and mouth smears. While collecting nasal smears directly with gauze is not in accordance with the established procedures or training, the RCT 1 felt the only option was to collect the nasal and mouth smears directly on to the gauze pads since the RCT 1 did not have enough Whatman filter paper. Accordingly, nasal and mouth smears were collected by the RCT 1 for one worker using Whatman filter paper (3 pieces of Whatman filter paper were found by RCT 1), while the smears for the other seven workers were collected using rolled up gauze pads. After collection, the smears were placed in individually marked envelopes and placed on an instrument wagon for later analysis. Approximately 20 minutes later (~12:50 a.m.), the RCT 1 complained of a scratchy throat and was told by the RCS 1 to report to KMC for evaluation. The RCT 1 also requested and was granted permission by the RCS 1 to return to the facility if no health problems were detected at KMC.

Assuming the smears had previously been counted using portable instrumentation, RCT 2 was dispatched to the 270Z building to count the smears on the mini-scaler. At approximately 4 to 4:30 a.m., the RCT 2 reported to the RCS 1 that the smears could not be counted because they were collected on gauze pads versus Whatman filter paper which is procedurally required. The RCS 1 indicated to the RCT 2 it was his understanding the smears were collected on Whatman filter paper. The RCT 2 confirmed that the smears had been collected on gauze pads. The RCS 1 indicated the RCT 2 should not count the smears at this time based on the fact that entries had been made into the PRF and there was no indication of radioactive contamination. Additionally, no other radioactive contamination had been detected at other locations throughout the facility and the surrounding area.

While at KMC, RCT 1 was told by one of the eight workers that the "nasal smears were fine." The RCT 1 assumed from this conversation that the smears had been dried and counted on the mini-scaler after RCT 1 had left the facility and the results had been negative. The RCT 1 returned to the facility around 3:30 to 4:30 a.m. and assisted in performing radiological surveys on Hanford Fire Department equipment during which time, the RCT 1 and RCS 1 did not discuss the smears or the analysis of the smears.

On the morning of May 15, 1997, various samples located in the temporary counting area of Building 270Z were placed in an "ice cream" carton by the first line RCS 2. The carton was labeled similar to "Do Not Disturb, PRF Samples, Contact RadCon Manager" and placed in the locked radiological source safe located in the 234-5Z RCT office by RCS 2. The RCS 2 indicates he does not remember if the nasal smears from the eight workers were included with the rest of the samples placed into the carton. Upon investigation, the original carton was not available and was presumed to have been discarded. On June 13, 1997, the RCT 3 who was assigned responsibility to count the smears, found the smears in a corner of the safe behind a shielded container after looking through the safe twice. The smears were reported not to be contained in an "ice cream" carton. The keys for the radiological source safe are located in the RadCon Supervisor's office and are generally available to PRF personnel. The use of the keys is not logged, however, the removal of radiological source material from the safe is logged. During the period of May 15 - June 13, 1997, the source usage log indicates that several individuals accessed the radiological source safe.

The RCT 3 indicated the envelopes found in the radiological source safe were individually labeled, and the smears appeared to be original in that the gauze smears were still rolled into a tight cone (the three Whatman filter paper smears were left flat in the bottom of the envelopes). However, the RCT 1 who originally took the smears from the eight workers did not view the smears prior to them being counted so as to verify the smears were in the same condition as they were originally left. According to the RCT 3 who counted the smears, all smears had an appearance consistent with being used for nasal or mouth smears.

After the smears were counted by RCT 3, the smears were placed into a locked cabinet located in the RadCon Supervisors office which is controlled by only two keys which are controlled by the two first line RadCon supervisors. Reportedly only one person (who was under the direction of RCS 1), other than the two supervisors entered the cabinet where the smears are currently located, during the time period of June 13 to June 29, 1997. However, there is no log for recording entries into the cabinet. The smears are currently contained in envelopes which are individually labeled with the employee's name and information for tracking purposes.

Soon (May 15 or 16, 1997) after the incident at the PRF, the ESH&Q Manager was informed by the RCS 1 the smears were collected on gauze instead of Whatman filter paper, and had not been counted on a mini-scaler. However, the RCS 1 believed as of June 13, 1997, the smears had been counted by RCT 1 on the night of the incident with a portable instrument. The ESH&Q manager met with the concerned employees (eight workers, RCT 1, and a security guard), as well as representatives from the Hanford Environmental Health Foundation (HEHF), on June 13, 1997, and informed the employees the nasal smears taken on May 14, 1997, had been counted and were negative. The concerned employees subsequently requested documentation regarding the survey results. When a request was made to the first line RadCon supervisors by the ESH&Q manager for data sheets supporting the counts, it was reported by the supervisors that analysis had not been performed. As stated previously, the first line supervisors had not requested this count be done because it was their belief, based on results of other surveys conducted of reentry personnel, facilities, and stack and building CAM results there was not a release of radiological material as a result of the incident, and therefore no further analysis was required.

The ESH&Q manager requested the smears be counted on a mini-scaler June 13, 1997. The RCT 3 responsible for the counting performed a pre-count of the smears and counting desk area with a hand held instrument. The smears were then placed in metal planchettes. The corners of the gauze had to be tucked between the planchette and the counting well. The corners tucked between the planchette and the counting well were assumed to be at the opposite end of the gauze placed in the nostril/mouth. The three Whatman filter paper smears fit into the planchettes without modification. The smears were counted on June 13, 1997 on both sides, all with negative results. Gauze, because it is more absorptive, likely would have captured more of any radioactive contamination present in the nostril/mouth than the Whatman filter paper, however because of potential self shielding of the gauze, the radiation may have been more difficult to detect. At present, the net efficiency of the collection and counting techniques using gauze has not been determined nor has additional, more sensitive analysis been performed. On June 16, 1997, a letter was sent to the concerned employees by the ESH&Q manager stating the nasal smears had been controlled under chain-of-custody since the time of the incident.(C1)

It was determined by PFP Management on, or about, June 25, 1997 after further discussion with concerned employees, the RCT 1 had not performed surveys of the smears with portable instrumentation as previously believed by the RadCon supervisors. It was also determined that while not required by HNF-IP-0718, there was no "formal" chain-of-custody. HNF-IP-0718 does not require a formal chain-of-custody since it is assumed smears will be analyzed soon after collection and the results used to determine the need for followup activities such as decontamination, bioassays, etc. A follow-up letter was sent to all concerned employees on June 25, 1997, indicating chain-of-custody had not been maintained for the smears and that the smears had not been counted with a portable instrument on May 14, 1997, as originally stated but that the smears had been counted on June 13, 1997 with a mini-scaler, and no contamination was detected.(C2)

C.2 CHRONOLOGY OF BIOASSAYS

The following describes the sequence of events associated with the collection and processing of bioassay samples from some of the workers who had been sent to Kadlec Medical Center as a result of the May 14, 1997 incident at the Plutonium Reclamation Facility (PRF).

Within the first hour of the Unified Dose Assessment Center (UDAC) activation, the UDAC Radiological Hazard Evaluator and off-duty exposure evaluator talked with the Plutonium Finishing Plant (PFP) Radcon Office, and was informed there was no contamination on nasal/mouth smears nor any worker or emergency responder radiological contamination. Other event indicators reported to UDAC at this time supported this as being a nonradiological incident. Based on this information, it was concluded that early response transuranic bioassays (i.e., chest counts, early urine, fecal samples) were not warranted.

Several days after the May 14, 1997, incident, two employees involved in the incident requested a whole body count (WBC) from the attending physician at the Hanford Environmental Health Foundation (HEHF) as part of the medical follow up to the incident. The HEHF physicians subsequently discussed the request for a WBC with personnel from the Fluor Daniel Hanford Inc. (FDH) and Battelle internal dosimetry organizations who indicated whole body counting is designed for detection of mixed fission products and was inappropriate for plutonium detection. Additionally, chest counting at this late date was not worthwhile, and urine or fecal sampling would be the most appropriate type of bioassay under the circumstances.

Bioassays are used to determine radiological dose and are normally obtained from employees who routinely work around radiologically contaminated materials or personnel found to have positive radiological surveys and/or nasal or mouth smears. The HEHF physician subsequently requested FDH internal dosimetry personnel to discuss the specifics of the bioassay with the workers, which was done. The employees agreed to participate in the bioassay and indicated they felt the bioassay was necessary as a precautionary step to which FDH and Battelle dosimetry personnel agreed.

Discussions between FDH and Battelle internal dosimetry personnel relative to the options for bioassay (e.g., fecal sampling versus urinalysis) were held and based on the fact there were no indications of a plutonium release as a result of the incident at the PRF it was concluded that urinalysis (Isotopic Plutonium Urinalysis [IPU]) was adequate as a confirmatory indication of no significant radiological intake, even though fecal sampling would be more sensitive. Employee convenience in collecting the bioassay sample was a factor in this decision, as was consistency with the routine, periodic sampling program for plutonium workers. The issue of whether or not to designate these bioassay samples as "special" samples as opposed to "contractor request" samples was also discussed. Since there were no indications of potential intake from the PRF incident, FDH internal dosimetry personnel concluded "special" incident documentation and evaluation of the samples was not necessary and asked the samples be processed as "contractor request" samples.

Bioassay Samples 1 and 2

Based on the above, on May 29, 1997 FDH internal dosimetry personnel submitted a request to the Battelle internal dosimetry laboratory (IDL) for two bioassay samples (IPU urinalysis, contractor request) to be processed on a priority basis. The bioassay samples were collected by the employees on June 3, 1997 and were received at the IDL on June 5, 1997. During the analysis of the bioassays, the alpha spectrometer were reported to have shut down in midcount and had to be restarted, resulting in a delay of 1-2 days in obtaining the results. On June 20, 1997, a report which indicated no plutonium was detected from either bioassay samples was faxed to the FDH internal dosimetry organization. This information was then reported to the employees, HEHF physician and the PFP ESH&Q Manager.

Based on concerns from two other employees involved in the PRF incident, the HEHF physician requested the FDH internal dosimetry organization process two additional bioassay requests. The PFP ESH&Q Manager also approved a request for a bioassay to be performed for a fifth individual.

Bioassay Sample 3

Records from the IDL indicate the third bioassay request for an IPU urinalysis, contractor request, to be processed on a routine basis was made on June 13, 1997. It is speculated that the actual verbal request for the bioassay indicated the sample should be processed on a priority basis rather than routine basis but IDL personnel mis-entered the processing code. The sample was collected on June 20, 1997. A report which indicated no plutonium was detected from the third bioassay samples was faxed to the FDH internal dosimetry organization on July 18, 1997. This information was then reported to the employee, HEHF physician and the PFP ESH&Q Manager.

Bioassay Sample 4

Records from the IDL indicate the fourth bioassay request for an IPU urinalysis, contractor request, to be processed on a priority basis was made on June 20, 1997, however the sample collection date was indicated as June 17, 1997. The fact the sample appears to have been collected prior to IDL personnel receiving the sample request appears to be unusual, however this may be accounted for if the bioassay sample kit was provided to the employee from a field radiological control office rather than from the IDL. IDL personnel notes regarding the sample, indicate that after the sample was collected, it was to be picked up from the 331 Internal Dosimetry office, rather than the employee's home which is the standard practice. This fact seems to indicate the sample kit was not delivered to the employees home by IDL personnel but may have been issued directly from a radiological control office with instructions to return it to the 331 Internal Dosimetry office. A hand-written log of bioassay sample kits issued and returned to the 331 Internal Dosimetry office is maintain by IDL personnel, however, there is no entry for this employee's sample and IDL personnel indicate they have no recollection of ever receiving that specific bioassay sample kit at the 331 Internal Dosimetry office. In fact, IDL personnel reported the sample request as CNO (Container Not Out) on June 30, 1997 with subsequent receipt of the sample at the IDL on July 1, 1997. This implies that IDL personnel retrieved the sample kit from the employee's home. The sampling for this employee may have been further complicated by the fact the employee was already scheduled for a periodic, IPU urinalysis for the month of June, 1997. IDL records, show this periodic sample to be a "No-Sample." A report which indicated no plutonium was detected from the fourth bioassay samples was faxed to the FDH internal dosimetry organization on July 15, 1997. This information was then reported to the employee, HEHF physician and the PFP ESH&Q Manager.

Bioassay Sample 5

Records from the IDL indicate the fifth bioassay request for an IPU urinalysis, contractor request, to be processed on a priority basis was made on June 20, 1997. FDH internal dosimetry personnel assumed the sample was being processed (e.g., sample collected and analyzed) until July 10, 1997 when the IDL was contacted to inquire about the status of the sample. At this time it was determined that the bioassay sample kit had not been delivered to the employee. The bioassay sample kit was then scheduled to be delivered to the employee on July 11, 1997 with a sample collection and pickup date of July 13 and July 14, 1997, respectively. However, it was learned that the employee was on vacation and the sample would need to be rescheduled upon the employees return to work. On July 15, 1997, personnel from the FDH internal dosimetry organization canceled the request for the IPU urinalysis for the fifth employee.

After discovering the various issues associated with the collection and processing of the original bioassay samples, FDH issued a letter on July 21, 1997 to each of the employees who were sent to Kadlec Medical Center as a result of the PRF incident. An additional letter was provided to the employee who was located on the first floor of PRF at the time of the incident, irrespective of the fact that both whole body surveys performed shortly after the incident did not detect any radiological contamination. The letter briefly described the various issues associated with the original bioassays and made available additional more sensitive bioassays.

APPENDIX D

CHEMICAL HAZARDS

D.1 Introduction

Chemical hazards associated with PRF Room 40, Tank-A109 specifically, pertinent adjacent areas, and possible reaction byproducts are discussed in this appendix to establish the plausible types and extent of chemical releases and exposures, along with their health effects.

Information was gathered and evaluated to establish the type and amount of chemical hazards involved with and potentially released by the explosion at PRF. This evaluation included verification of Tank A-109 contents, determination of reaction byproducts, and determination of other hazardous agents that could have been potentially involved from other tanks, chemicals, or materials in the area.

Once the potential chemical hazards and quantities were established, dispersion modeling was conducted to estimate chemical concentrations and exposure durations that could possibly result in the accessible or occupied areas around PRF/PFP. This information coupled with information regarding worker location and timelines for area occupancy, allows for informed conclusions regarding the potential and degree of employee exposure to the chemical agents released by this event.

D.2 Background

On May 14, 1997, at approximately 7:53 p.m., a chemical explosion occurred in Tank A-109 in Room 40 of the Plutonium Reclamation Facility (PRF) located in the 200 West Area of the Hanford Site. The inactive process facility was part of the Plutonium Finishing Plant (PFP). The multipurpose facility was designed to recover plutonium from plutonium-bearing scrap. The facility commenced full operations in 1964 and ceased active operations in 1987. In September 1992, activities were begun to prepare for and demonstrate readiness for restart of the facility, but these activities were not completed.(D1)

Nonradioactive bulk chemicals were mixed in Room 40 of PRF to support the discontinued plutonium recovery process. The solution in Tank A-109 was prepared in June 1993, as part of the demonstration of readiness for restart. The tank contained an aqueous solution of hydroxylamine nitrate (HAN) and nitric acid (HNO_3). The solution was known as complexant concentrate column extractant (CCX). The final batch of 370 gallons was prepared in Tank A-109 on June 17, 1993.(D1)

Over time, water from the solution evaporated which resulted in increasing concentrations of HAN and nitric acid. This eventually led to an unstable solution. The explosion occurred as the result of an autocatalytic chemical reaction. The reaction created a rapid evolution of gas that over-pressurized the tank beyond its design limitations.(D1)

D.2.1 Tank A-109

To determine the characteristics of the chemical release and potential for exposure as a result of the explosion, it was important to establish the chemical contents of Tank A-109. Process records, process knowledge, analytical results from both before and after the incident, and other documentation and information were provided by the facility to verify Tank A-109 contents and determine whether any evidence exists for the possible presence of other chemical agents in the tank.

The layout of tanks in Room 40 is shown in Figure D. Tank A-109 had a capacity of 400 gallons and was set on a 6,000 pound capacity industrial scale with a dial indicator. The tank was constructed of 347 stainless steel and measured 5 feet tall and 4 feet in diameter. Tank A-109 had chemical makeup lines attached for the addition of water, HAN, and nitric acid. No other chemical feed lines existed for Tank A-109. (D1)

Process records and sampling and analytical data for Tank A-109 from the Engineering, PRF Operations Control Room, and the PRF Chemical Preparations Room Log Books indicate the last chemical makeup was on June 17, 1993. Water, nitric acid, and HAN were used in the chemical makeup. Process water used for the solution likely contained corrosion products from carbon steel and stainless steel piping. At the time of makeup, the solution in the tank was analyzed for acid and HAN. The results were 0.2534 M H+ and 0.3542 M HAN. On September 27, 1994, the tank was sampled for acid and nitrate (NO_3). The results were 0.671 M and 0.638 M, respectively. Specific gravity on November 2, 1994 was measured at 0.9976.(D13)

Originally on June 17, 1993, a total of 3,400 pounds (370 gallons) of solution were prepared (at the concentrations noted above by analysis). An engineer's log on December 29, 1993 stated 2,440 pounds of the solution remained at that time, indicating that approximately 1,000 pounds of the solution had been used. The facility was last placed in weekend shutdown on December 10, 1993. Tank weight data were recorded periodically between May 23, 1994 and October 28, 1996. On May 23, 1994, 1,535 pounds of solution were present. On October 28, 1996, the solution weighed approximately 300 pounds. Regular recordings of weight data were discontinued after October 28, 1996. The last weight was noted in April 1997 as 140 pounds, in response to an RL inquiry regarding the adequacy of chemical records in Room 40.(D1)

Between December 10, 1993 and the time of the explosion, the gradual loss in solution weight can be attributed to water loss due to evaporation. Being much less volatile, it is presumed that nitric acid loss was minimal. Assuming that little if any nitric acid and HAN were lost to evaporation or reaction during this period, concentrations were probably in the range of 2-4 M nitric acid and 2.5-6 M HAN at the time of the explosion on May 14, 1997.(D2)

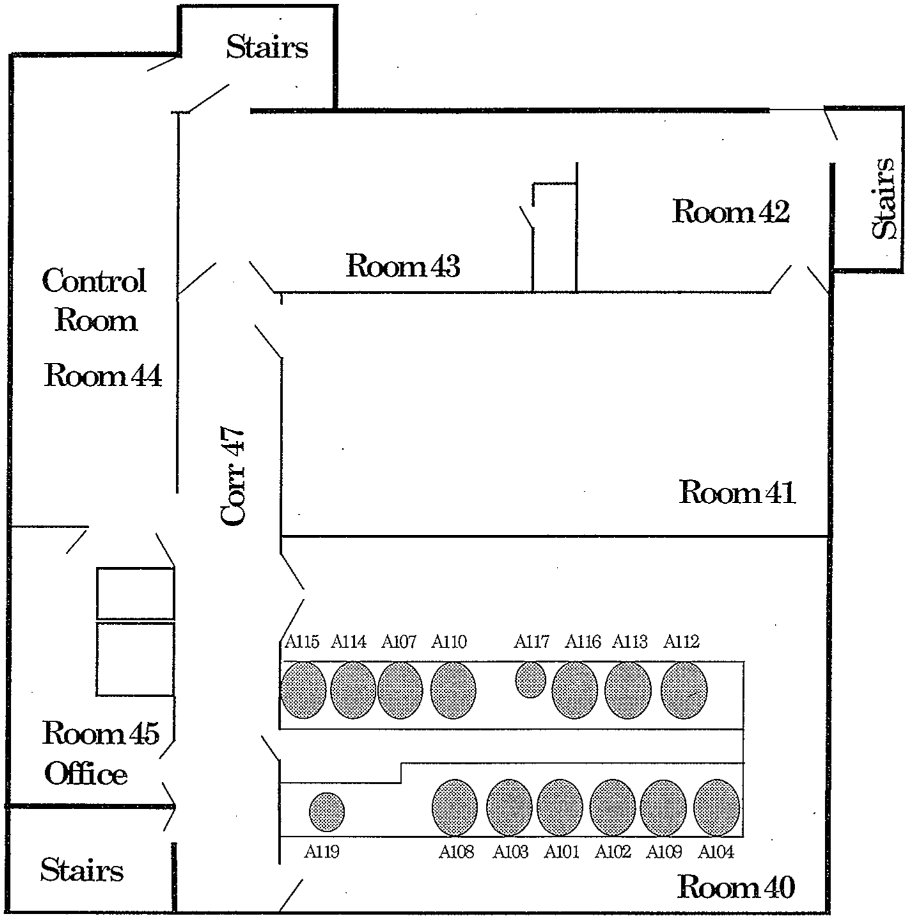
Process and analytical records, therefore, document the nature of the chemical solution as aqueous nitric acid and HAN, and do not indicate any other chemical agents as being present in or added to the tank. However, to further verify chemical content, analysis was conducted on residual tank contents after the explosion, analysis was conducted on the contents of a carboy that could be representative of Tank A-109 contents, and analysis is being planned on the contents of a line connected to Tank A-109. These items are discussed below.

D.2.1.1 <u>Residual Contents of Tank A-109</u>

Residual contents from Tank A-109 were sampled and analyzed after the explosion. In evaluating the data, it should be understood the characteristics of this residual solution would be impacted by the reaction as well as any water or other materials (e.g., debris from impacted building materials) that may have been introduced as a result of the explosion. It was stated significant debris was present in the tank after the incident, including various rubble and plaster-like material. pH was low at 0.91, indicating a highly acidic solution and supporting the presence of nitric acid. Nitrate was 46.9 grams/liter (about 4-5 wt%), supporting the presence of nitrate bearing chemicals, such as nitric acid and/or HAN. These data are consistent with the presence of an aqueous solution of nitric acid and HAN.

FIGURE D

Schematic of the Fourth Floor of the Plutonium Reclamation Facility



Various metals, anions, and cations were also determined through analysis of the residual tank solution. Iron was 5.61 grams/liter, possibly due to process water and leaching from iron-bearing piping, vessels, and debris. Calcium was 35.9 grams/liter and magnesium was 12.4 grams/liter, both of which are commonly associated with water hardness and accumulation of scale over time, and are also common in building materials such as wallboard debris. Chromium and nickel, which could be leached from stainless steel, were present at low ppm levels (less than drinking water maximum contaminant levels, MCLs).(D13)

A duplicate (split) sample of Tank A-109 residual solution was sent to a second laboratory for analysis. These results are pending review and are not included in this report.

D.2.1.2 Carboy

The origin and contents of a 5 gallon carboy previously located near Tank A-109 were investigated to determine if the carboy's contents could verify Tank A-109 contents.

- On March 14, 1997, a 5 gallon carboy located in room 40 of PRF, labeled Hydroxylamine Nitrate (HAN) was sampled for Total Alpha and Gross Beta. The purpose of the sampling was to determine the radiological status of the container to help facilitate disposition and improve housekeeping in room 40. See WSCF report 97000459. On April 10, 1997 (prior to the explosion), based on negative analytical results and no near term use identified for the material, it was declared waste and transported to PFP's non-radiological 90 Day Storage Pad.

- As a result of the May 14, 1997 event, additional analyses were requested from the original sample to help determine if the 5 gallon carboy was HAN alone or the CCX solution of nitric acid and HAN. See WSCF report 97000758 and 97000832. On June 13, 1997, Solid Waste Operations received a letter which stated that the analysis of the contents of the carboy determined the solution contained 3 wt% HAN and 0.18M nitric acid. This composition is consistent with the make-up for CCX solution as prepared for training/production runs for PRF. The letter also stated that aqueous solutions of HAN and nitric acid at these concentrations in a sealed container are known to be stable. See letter file No. 15f00-97-64.

Although the solution in the 5 gallon carboy is suspected to have originated from Tank A-109, there is no conclusive evidence to support this assumption. The liquid in the carboy was consistent with the solution which would have been in Tank A-109. However, it is not known with certainty whether the carboy was filled from Tank A-109 and, if so, when this would have happened. On June 19, 1997, the 5 gallon carboy was shipped offsite for proper disposal at a Licensed Treatment Storage and Disposal (TSD) facility.(D13)

D.2.1.3 Tank A-109/Tank 30 Line

An evaluation of the relationship between Tank A-109 and other tanks was conducted to determine whether an analysis of other in-line pipes and vessels would be representative of Tank A-109. Contents from Tank A-109 drain through a valve/filter/valve configuration then into a horizontal run on the 4th floor of PRF. After an approximately 60 ft horizontal run, the line takes a 90 degree bend and falls vertically to the 1st floor to Tank 30. During entries into Room 40, the connection was examined visually. The line appears to be intact. The line between the valve/filter and the tank is bent. All valves are closed. A work plan is being developed to sample the Tank A-109 drain line. The line will be broken on the 3rd floor, and any residual liquid in the drain line will be collected and sampled for HAN, pH, Pu, and SpG. A waste characterization analysis will also be performed.(D13)

D.2.1.4 Tank A-109 Summary

In summary, process records and sampling data for Tank A-109 prior to and after the incident indicated the tank contained an aqueous solution of hydroxylamine nitrate and nitric acid. Carboy contents were consistent with the tank contents, although it was not conclusive as to whether the carboy was filled from Tank A-109, and therefore an indication of tank contents. The Tank A-109 line leading to Tank 30 is to be sampled upon development of a work plan to further verify tank contents and/or identify any other significant constituents. At this time, however, all evidence points to HAN, nitric acid, and their reaction byproducts as the chemical agents of concern.

Future activities will include (1) evaluation of results from the second laboratory for the Tank A-109 residual sample split and (2) evaluation of the Tank A-109 line and/or Tank 30 sample(s) when collected and analyzed. Conclusions regarding Tank A-109 contents are, therefore, preliminary pending receipt and evaluation of additional data.

D.2.2 Chemicals released from Tank A-109

An explosive reaction of hydroxylamine nitrate and nitric acid can be predicted to produce water (H_2O), nitrogen (N_2), nitric oxide (NO), nitrous oxide (N_2O), nitrogen dioxide (NO_2), and nitric acid (HNO_3). Relative quantities would depend on the energy of the reaction and its degree of completion. Any nitric oxide formed would quickly oxidize to nitrogen dioxide. In addition to the reaction products, it is reasonable to assume that residual quantities of unreacted nitric acid and hydroxylamine nitrate would be released as gases or aerosols. The yellowish brown emission from 291-Z-1 Stack is consistent with nitrogen dioxide.

Laboratory studies were conducted after the incident simulating an explosion of this type of solution under various conditions. The studies verified the explosive potential of this solution and the generation of the predicted reaction products.(D2)

From an occupational health perspective, nitrogen dioxide and nitric acid are the agents of highest relative concern based on occupational exposure limits, potential relative abundance, and potential health effects. Based on starting material quantities and predicted reaction products, the chemical agents and quantities released from the explosion are estimated in the following table (Table D.1).

Table D.1 - PRF Chemicals Present Before and After Explosion

Chemical	Formula	Amount Before Explosion, kg ****	Amount After Explosion, kg (released) ****
Nitric Acid	HNO_3	14.8	1.0 (24.4)*
Hydroxylamine Nitrate	$N_2H_4O_4$	22.6	0**
Nitrous Oxide	N_2O	0	3.9
Nitrogen Dioxide	NO_2	0	17.1*
Nitric Oxide	NO	0	0***

* One prediction for reaction products would be that only small amounts of nitrogen dioxide would be formed with large amounts of nitric acid (24.4 kg). (D12) This is not in agreement with stack observations indicating an apparent nitrogen dioxide plume. Therefore, a second prediction would be that most of the nitric acid was broken down to nitrogen dioxide, and that only 1 kg of nitric acid was released. This second prediction would result in the 17.1 kg of NO_2 shown. Assuming that all but 1 kg of the 24.4 kg of nitric acid produced from the explosion reacts to form nitrogen dioxide, the amount of nitrogen dioxide produced is as follows:

One mole of HNO_3 produces one mole of NO_2.

$$\frac{23.4 \text{ kg } HNO_3}{63 \text{ kmole/kg } HNO_3} \times 46 \text{ kg/kmole } NO_2 = 17.1 \text{ kg } NO_2$$

** All of the hydroxylamine nitrate is assumed to be reacted.

*** Although a small quantity of nitric oxide is produced in the reaction, it would be quickly converted to NO_2, and is included within the NO_2 value.

**** The amounts of reaction products from Tank A-109 are calculated based on the following assumptions: (D2)(D12)

1. No nitric acid was lost from evaporation.
2. The concentrations of HNO_3 and $NH_2OH:HNO_3$ were equal at the time of the explosion.
3. All the $NH_2OH:HNO_3$ reacts.
4. Equal molar amounts of nitrogen gas and nitrous oxide were produced by the following reactions:

$$5NH_2OH:HNO_3 > 3N_2 + 8H_2O + 4HNO_3$$

And

$$4NH_2OH:HNO_3 > 3N_2O + 7H_2O + 2HNO_3$$

The initial concentration of nitric acid in the tank was 0.2534 M and the volume was about 926 L of solution initially. This means that there were 235 moles of HNO_3 present initially. After evaporation to 140 lbs (63.6 kg), the tank mixture would be:

14.8 kg HNO_3
22.6 kg $NH_2OH:HNO_3$
26.2 kg H_2O

The reaction would produce the following amounts of gases (reaction products plus vaporized water and nitric acid):

2.0 kg N_2
3.9 kg N_2O
33.3 kg H_2O
24.4 kg HNO_3

The predicted ratio between nitrogen dioxide and nitric acid could be varied relative to amounts released; however, as one would increase, the other would decrease. Values used for dispersion modeling from the stack and roof are described in Section D.2.3.2, and considered various scenarios.

D.2.3 Dispersion modeling of explosion by products from Stack 291-Z-1

D.2.3.1 Background Information

Release of chemical agents and reaction products from the explosion would have occurred from two locations; the 291-Z-1 Stack and breaches created in the PRF roof/wall above Room 40 as a result of the explosion. Various background information was assembled as the basis for predictions, estimates, and assumptions to support dispersion modeling of chemical releases from each of these sources. This information is discussed below.

The number of air changes per hour in Room 40 since the accident has not been determined. Prior to the accident, 26.3 air changes per hour existed in Room 40. It is believed little or no flow currently exists through the exhaust duct in the room due to blockages. Measured flow rates in the room prior to the accident were: 4.148 cfm supply and 5.144 cfm exhaust.

The 291-Z-1 stack is 200 feet high. Stack flow rates vary between 240,000 and 280,000 cfm.

The roof confinement above Room 40 was breached in two locations as a result of the explosion. One is about six feet in from the north wall. This breach consists of what is believed to be two, six inch diameter holes. The other breach is a narrow opening at the connection between the roof and the north wall. This opening is about seven feet in length, and the area of the openings about 0.5 square feet. Room 40 has three doors into the adjoining interior corridor. These doors were blown open. The three doors have a combined opening area of about 79.7 square feet. No windows were blown out. Room 40 has an exhaust duct that is 18 x 30 inches, or 3.75 square feet. This is the duct currently believed to be at least partially blocked.

An evaluation was conducted of the time interval estimated that room 40 was at positive pressure and whether the roof area was lifted. The roof in room 40 was affected by the over pressure of the expanding gases from Tank A-109. The peak over pressure in the room was estimated to be between 1.5 and 3 psi above room pressure by calculating the maximum pressure in the tank if it had not failed (B&W Alliance Research Center) and expanding this gas volume to the volume of room 40. This over pressure was a rapid transient above the normal pressure of the room which would have dissipated into the rest of the building, which is maintained at a negative pressure (-0.13in water gage) relative to the atmosphere. Since the ventilation for PRF ran throughout the time period of the incident, it is likely that the duration of the pressure pulse was less than 5 seconds before the room pressure had returned to a negative pressure condition (See Appendix B, [May 14, 1997, 7:50 p.m. to 08:59 p.m.]). Except for one localized area, at this point there is no direct indication that the roof "lifted", although a comprehensive study has not been completed to date. (D14) There were two identified areas where leakage from/to the room were possible. Based on these observations, it is estimated that a maximum area for in/out leakage was in the order of 0.5 to 1 square foot. This is the probable area for leakage of room air to the outside before the over pressure was relieved through the doors and ventilation system to the rest of the building.

Based on the above information, it is reasonable to assume that release sources from the facility included the 291-Z-1 stack and the breaches of the roof and roof/wall interface. The stack can be expected to be the predominant release point, since a plume of several minutes in duration was observed and since negative pressure in the room would have been reestablished within a few seconds of the explosion. The roof breaches would have been a release point for the few second period where negative pressure was lost in the room (perhaps 5 seconds). However, the small size of the breach and short period of release would make this a much more minor source, although perhaps more important, since it is in closer proximity to the area traversed by the workers than the stack.

The types and quantities of chemicals released were estimated for the purposes of dispersion modeling and are shown in Section D.2.2 and further discussed in Section D.2.3.2. These estimates were based on the available information regarding tank contents and predicted reaction products.(D2)(D12) Naturally, the relative abundance of released materials would vary depending on the completion of the reaction, energy of reaction, and other variables. The estimates utilized for the stack, however, favor the production of one of the more toxic gases, nitrogen dioxide, which was observed as a yellowish brown emission from the stack. Estimates for the roof/wall release utilized the highest predicted levels for both nitrogen dioxide and nitric acid, even though both could not exist at these high levels simultaneously (one converts to the other and vice-versa) and are therefore conservative.

For modeling purposes, it was assumed that 99% of the emissions were exhausted through the stack and that 1% were exhausted through the roof/wall breaches. This ratio seems reasonable based on the small area of the roof/wall breaches (0.5-1 square feet), short emission time from the roof/wall breaches (5 seconds before negative pressure was reestablished), and other larger pathways for dispersion (e.g., the blown open room doors of 80 square feet and the exhaust duct of 4 square feet).

The percent of total emissions released from the roof/wall breaches and the time period of the emissions are two important variables for the model. Altering these variables would impact model predictions. This is further discussed in Section D.2.3.2.

D.2.3.2 Dispersion Modeling Results

In this section an evaluation is made of the meteorological conditions present at the time of the explosion in the Plutonium Reclamation Facility (PRF) and during the next several hours when emissions from the explosion were dispersed through the atmosphere. The characteristics of the atmospheric release of contaminants through both the PFP stack and the breach in the roof of the PRF are evaluated. Information on meteorological and release conditions are used to model the atmospheric dispersion of the contaminants and to estimate ground-level concentrations.

Meteorological Conditions

Meteorological data are collected on the Hanford Site and at neighboring locations by the Hanford meteorological monitoring network. Measurements of atmospheric temperature, moisture, wind, and precipitation data (as well as other parameters) are made at the Hanford Meteorology Station and at 26 automated monitoring stations that are located across the Hanford Site and in neighboring areas (D5).

The Hanford Meteorology Station is located near the northeast corner of the 200 West Area, about 2.5 km (1.5 miles) northeast of the PFP complex. Meteorological monitoring is conducted at the station and on its 122 m (400 ft) tall instrumented tower. Wind measurements are made at seven heights on the tower, at elevations ranging from 2 m (7 ft) to 122 m (400 ft) above ground level. Air temperatures are measured at eight heights, at elevations ranging from 1.5 m (5 ft) to 122 m (400 ft) above ground level. In addition to winds and temperatures, a variety of other meteorological parameters are measured or observed at the HMS. These include measurements of atmospheric moisture, pressure, precipitation, cloud cover, and visibility (D5). Winds aloft are also measured using an acoustic sounder and twice-daily pibal ascents.

One of the Hanford meteorology monitoring network's automated stations is situated only about 300 m (1,000 ft) south of the main PFP building (234-5Z). Table D.2 presents wind directions and wind speeds measured at the PFP monitoring station from 19:45 PDT through 22:00 PDT on May 14, 1997. Wind directions and speeds represent 15-min averaged values for the period ending at the reported time. Winds are measured at about 10 m (30 ft) above ground level. Estimates of atmospheric stability and mixing depth are also presented in Table D.2. These are based on vertical temperature profile data measured by the Hanford Meteorology Station's instrumented tower and acoustic sounder.

Table D.3 presents other meteorological observations made at the Hanford Meteorology Station during this period. These include measurements of atmospheric pressure, temperature, moisture, and precipitation. Table D.4 and D.5 present hourly average values of the temperatures and winds measured at multiple levels on the station's 122-m tower.

Table D.2 Winds and Atmospheric Stability at the PFP Monitoring Stations During the Evening of May 14, 1997. Winds are measured at 10m above ground level. The wind direction is the direction from which the wind is blowing.

Time (PDT)	Wind Dir. (°)	Wind Speed (mph)	Stability Class
20:00	120	4	D
20:15	160	4	D
20:30	200	1	D
20:45	340	2	D
21:00	290	3	E
21:15	330	9	E
21:30	330	9	E
21:45	320	11	E
22:00	330	11	E

Table D.3 Surface Meteorological Observations at the Hanford Meteorology Station During the Evening of May 14, 1997.

Time (PDT)	Visibility (mles)[a]	Sea Level Pressure (mb)	Air Temp. (°F)[b]	Wet Bulb Temp. (°F)[b]	Dew Pt. Temp. (°F)[b]	Relative Humidity (%)	Sky Cover (tenths)[c]	Rainfall (1/100ths of an inch)	Sunshine (Lang-leys)
19:00	15	1008	88	63	46	22	9	0	0.28
20:00	15	1008.2	84	63	50	29	10	0	0.05
21:00	15	1008.9	78	62	52	40	10	0	0
22:00	15	1009.6	75	62	53	46	8	0	0
23:00	15	1010.5	74	60	51	44	7	0	0

[a] 15 miles is the maximum visibility that is reported by weather station staff, the actual visibility may have been considerably greater.

[b] Temperature and humidity measurements made at a heigh of 5 ft above ground level.

[c] Mostly broken middle-level clouds (altocumulus) and a thin overcast of high-level cirrus were present during the evening. Some broken cumulonimbus were present to the west at 20:00 PDT and to the north and east at 21:00 PDT. Some lightning was observed in the far distance (too far away for thunder to be heard at the station) during this time period. No rainfall was reported at any of the Hanford meteorology network's monitoring stations.

Table D.4. Temperatures Measured on the Hanford Meteorology Station's 122 m (400 ft) Instrumented Tower During the Evening of May 14, 1997. The wind direction is the direction from which the wind is blowing (e.g., a 90° wind is blowing from the east to the west).

	Temperature (°F)				
Height above Ground (ft)	**19:00 PDT**	**20:00 PDT**	**21:00 PDT**	**22:00 PDT**	**23:00 PDT**
3	87.9	83.6	78.6	75.7	73.0
30	88.0	85.8	83.9	76.9	73.8
50	86.1	84.5	82.8	75.4	72.5
100	86.7	85.5	84.3	76.3	73.7
200	86.1	85.1	84.4	76.7	73.9
250	85.9	84.9	84.3	76.7	74.0
300	86.0	85.1	84.5	77.2	74.6
400	84.8	83.8	83.3	77.3	74.1

Table D.5. Winds Measured on the Hanford Meteorology Station's 122 m (400 ft) Instrumented Tower During the Evening of May 14, 1997. The wind direction is the direction from which the wind is blowing (e.g., a 90° wind is blowing from the east to the west).

	Wind Direction (°) / Wind Speed (mph)				
Height above Ground (ft)	**19:00 PDT**	**20:00 PDT**	**21:00 PDT**	**22:00 PDT**	**23:00 PDT**
50	90° / 05	100° / 05	150° / 05	320° / 05	320° / 13
200	80° / 05	90° / 05	150° / 05	310° / 22	310° / 19
400	80° / 06	100° / 06	160° / 05	310° / 27	310° / 24

The initial transport of the contaminants released to the atmosphere from the explosion in the PRF was governed by winds at the release site. As contaminants were transported downwind from the PRF, spatial and temporal variations in the wind altered transport direction and speed. The locations of the monitoring stations used to provide wind data are presented in Figure D.1. Figures D.2 - D.16 present information (graphically and numerically) on the 15-minute averages of wind direction and wind speed at each of the Hanford meteorology monitoring network's stations from the time of the explosion until 23:30 PDT. Information is also presented on the average atmospheric stability and mixing depth present during each averaging period. Data for a given time represents the average over the previous 15-minutes (e.g., data for 20:00 PDT represents the average of observations made every few seconds from just after 19:45 to 20:00 PDT). The arrows on the wind vectors point in the direction winds are blowing toward. The size of each wind vector is proportional to the wind speed. The wind vectors are each positioned so that their midpoint (the point ½ way between their tail and arrow tip) is directly over the monitoring station's location.

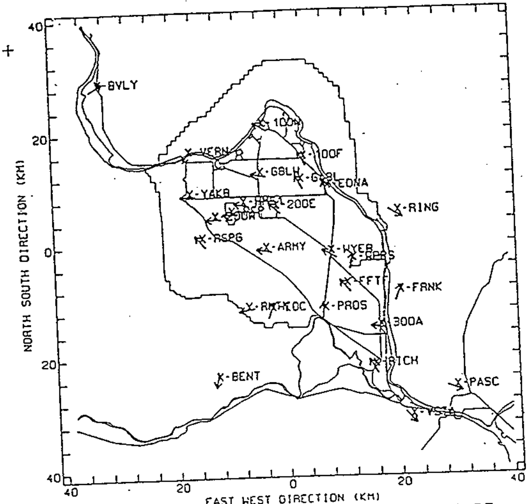
Figure D.2 shows that at the time of the explosion, the PFP and its neighboring monitoring stations (200W and HMS) were all recording winds that were blowing from the east-southeast toward the west-northwest at about 4 mph. The orientation of winds across the Site was fairly typical for the late afternoon and early evening in late spring (D6). Between 20:00 and 21:00 PDT, the wind regime began to change. At 20:00 PDT, the beginning of a downslope flow pattern is seen at the Beverly (BVLY) monitoring station (near the Columbia River, about 15 km [9 mi] northwest of the Hanford Site). At 20:15 PDT, wind speeds at Beverly increased (to 9 mph) and the winds at PFP and neighboring stations begin to slowly shift direction in a clockwise fashion. At 20:15 winds at PFP were light and blowing from the south-southeast. At 20:30, winds at PFP were very light and had shifted to blowing from the south-southwest. At 20:45, winds at PFP were still light and were blowing from the north-northwest. Also at 20:45 PDT, monitoring stations to the northwest of the PFP began to record strong winds from the northwest. By 21:00 PDT, winds at PFP and its neighboring stations were all blowing from the northwest or west-northwest). At the Vernita Bridge (VERN) station the average wind speed was 24 mph.

At 21:15 PDT, winds at the PFP and its neighboring stations were generally blowing from the northwest toward the southeast with speeds from 9 to 12 mph. All other monitoring stations in the northern and central portion of the Hanford Site were also being driven by the same flow regime. The strong flow from the northwest to the southeast was in part the result of a typical downslope drainage flow from the Cascade Mountains and its foothills. This flow regime frequently develops in the evenings during the spring and summer months and often persists until early morning hours (D6). During the evening of May 14, the normal downslope flow was strengthened by the outflow from a line of thunderstorms over the Cascade Mountains and eastern foothills. Heavy rainfall from thunderstorms was experienced in Yakima, about 70 km (45 mi) to the west of the PFP; however, the line of thunderstorms did not move eastward toward the Hanford Site.

After 21:30 PDT, the downslope flow regime continued to spread rapidly across the remainder of the Hanford Site. By 22:30 PDT, all of the monitoring stations on the Hanford Site were reporting wind with a strong northwesterly component (blowing toward the southeast). By 23:00 PDT local stations southeast of the Hanford Site (in Kennewick and Pasco) also came under the influence of this flow. The general downslope flow regime persisted across the entire Site through the following morning.

05/14/97

AT 19:30 PDT



WIND VECTORS AT 10 M ABOVE THE SURFACE

WIND VECTOR SIZE INDEPENDENT OF WIND SPEED

SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	180	5	
EOC	200	6	*
ARMY	100	4	
RSPG	140	4	
EDNA	160	3	
200E	130	3	
200W	90	5	
BVLY	240	4	
FFTF	140	4	
YAKB	90	4	
300A	100	2	
WYEB	120	3	
100N	120	4	
WPPS	190	4	
FRNK	200	2	
GABL	150	6	*
RING	300	3	
RICH	150	2	
PFP	90	5	
RMTN	80	7	*
HMS1	100	5	
PASC	290	3	
GABW	100	3	
100F	150	3	
VERN	30	2	
BENT	10	3	*
VSTA	320	3	

* : ELEVATION OF OVER 1000 FT ASL

STABILITY CLASS: A
MIXING DEPTH: 1000 M

Site Number	Site Name	Site Code
1	Prosser Barricade	PROS
2	Emergency Operations Center	EOCC
3	Army Loop Road	ARMY
4	Rattlesnake Springs	RSPG
5	Edna	EDNA
6	200 East	200E
7	200 West	200W
8	Beverly	BVLY
9	Fast Flux Test Facility	FFTF
10	Yakima Barricade	YAKB
11	300 Area	300A
12	Wye Barricade	WYEB
13	100-N	100N
14	WNP-2	WPPS
15	Franklin County	FRNK
16	Gable Mountain	GABL
17	Ringold	RING
18	Richland	RICH
19	Plutonoim Finishing Plant	PFP
20	Rattlesnake Mountain	RMTN
21	Hanford Meteorology Station	HMSS
22	Pasco	PASC
23	100-F	100F
24	Gable West	GABW
25	Vernita Bridge	VERN
26	Benton City	BENT
27	Vista Field (Kennewick)	VSTA

Figure D.1. Sample Wind Plot for the Hanford Meteorology Monitoring Network. Station positions are plotted on the map and station names and identification codes are presented above. Wind data are presented numerically and graphically.

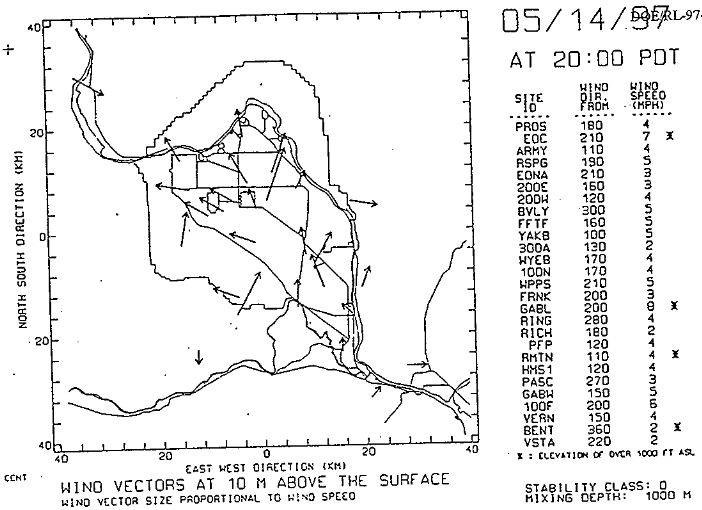


Figure D.2. Average Wind Directions and Speeds at 20:00 PDT.

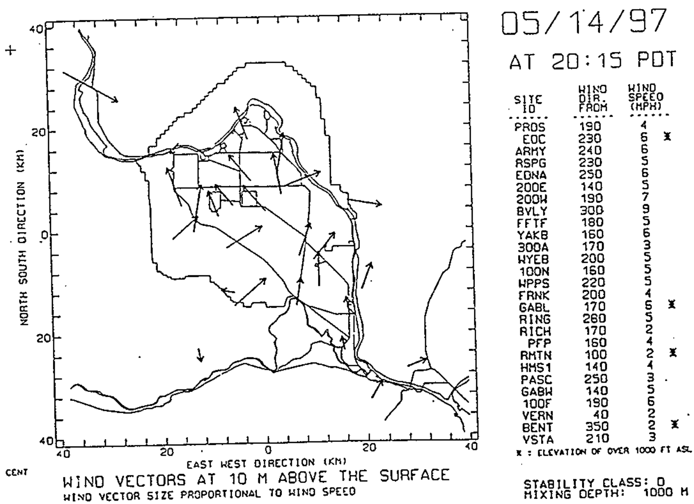
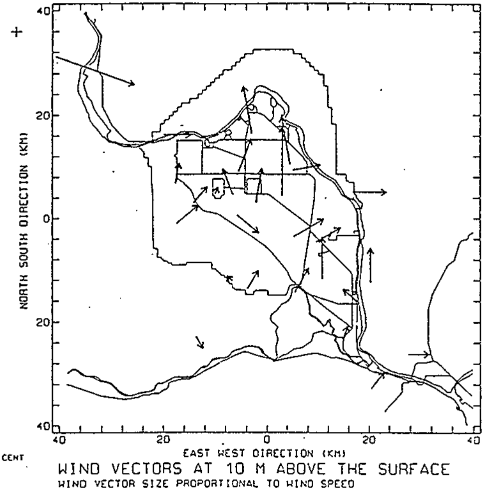


Figure D.3. Average Wind Directions and Speeds at 20:15 PDT.



05/14/97

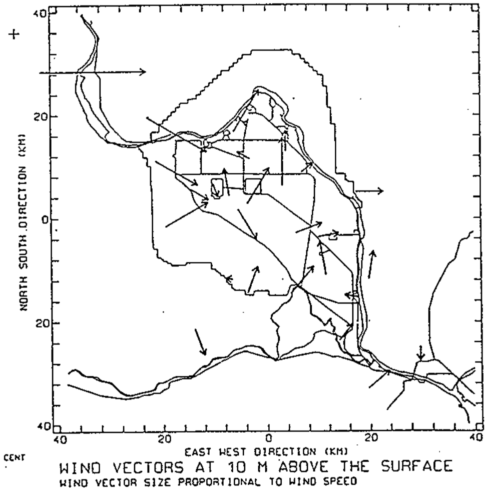
AT 20:30 PDT

SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	210	4	
EOC	210	3	*
ARMY	310	4	
RSPG	230	4	
EDNA	260	4	
200E	190	5	
200W	220	3	
BVLY	290	12	
FFTF	180	6	
YAKB	190	3	
300A	130	3	
WYEB	240	5	
100N	170	7	
WPPS	240	4	
FRNK	180	5	
GABL	180	10	*
RING	270	5	
RICH	200	2	
PFP	200	1	
RMTN	130	1	*
HMS1	160	4	
PASC	270	3	
GABW	200	5	
100F	170	7	
VERN	270	4	
BENT	330	2	*
VSTA	220	3	

* : ELEVATION OF OVER 1000 FT ASL

STABILITY CLASS: D
MIXING DEPTH: 1000 M

Figure D.4. Average Wind Directions and Speeds at 20:30 PDT.



05/14/97

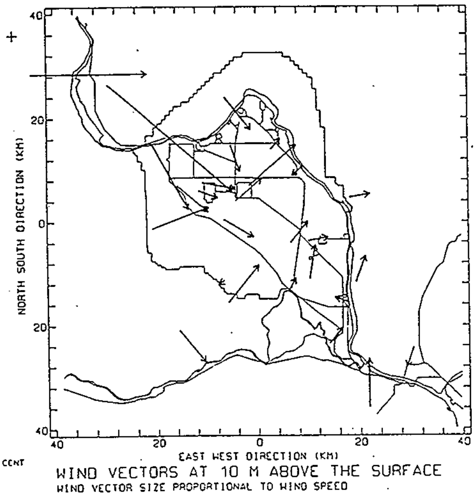
AT 20:45 PDT

SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	220	5	
EOC	200	4	*
ARMY	330	5	
RSPG	240	7	
EDNA	230	2	
200E	210	6	
200W	300	3	
BVLY	270	15	
FFTF	170	5	
YAKB	300	7	
300A	100	2	
WYEB	250	4	
100N	210	7	
WPPS	260	3	
FRNK	190	4	
GABL	180	7	*
RING	270	4	
RICH	220	3	
PFP	340	2	
RMTN	100	1	*
HMS1	170	4	
PASC	360	2	
GABW	120	2	
100F	180	3	
VERN	300	10	
BENT	340	4	*
VSTA	230	4	

* : ELEVATION OF OVER 1000 FT ASL

STABILITY CLASS: D
MIXING DEPTH: 1000 M

Figure D.5. Average Wind Directions and Speeds at 20:45 PDT.



05/14/97

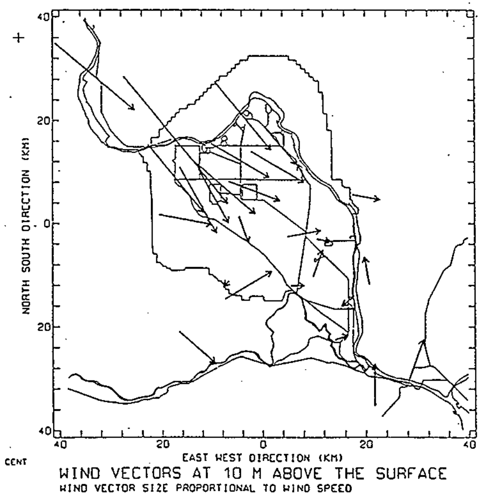
AT 21:00 PDT

SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	210	2	
EOC	220	7	*
ARMY	300	5	
RSPG	250	9	
EDNA	50	2	
200E	230	5	
200W	310	6	
BVLY	270	17	
FFTF	190	5	
YAKB	330	11	
300A	110	2	
WYEB	220	4	
100N	320	6	
WPPS	260	3	
FRNK	200	4	
GABL	230	9	*
RING	260	3	
RICH	220	3	
PFP	290	3	
RMTN	60	1	*
HMS1	280	5	
PASC	20	3	
GABW	340	4	
100F	220	2	
VERN	310	24	
BENT	320	6	*
VSTA	180	7	

* : ELEVATION OF OVER 1000 FT ASL

STABILITY CLASS: E
MIXING DEPTH: 500 M

Figure D.6. Average Wind Directions and Speeds at 21:00 PDT.



05/14/97

AT 21:15 PDT

SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	270	2	
EOC	240	8	*
ARMY	340	4	
RSPG	280	8	
EDNA	150	3	
200E	290	8	
200W	330	11	
BVLY	310	15	
FFTF	200	4	
YAKB	320	13	
300A	50	2	
WYEB	260	5	
100N	320	13	
WPPS	280	2	
FRNK	170	4	
GABL	300	9	*
RING	280	4	
RICH	250	2	
PFP	330	9	
RMTN	40	1	*
HMS1	310	12	
PASC	200	6	
GABW	300	10	
100F	320	7	
VERN	320	24	
BENT	310	7	*
VSTA	180	6	

* : ELEVATION OF OVER 1000 FT ASL

STABILITY CLASS: E
MIXING DEPTH: 500 M

Figure D.7. Average Wind Directions and Speeds at 21:15 PDT.

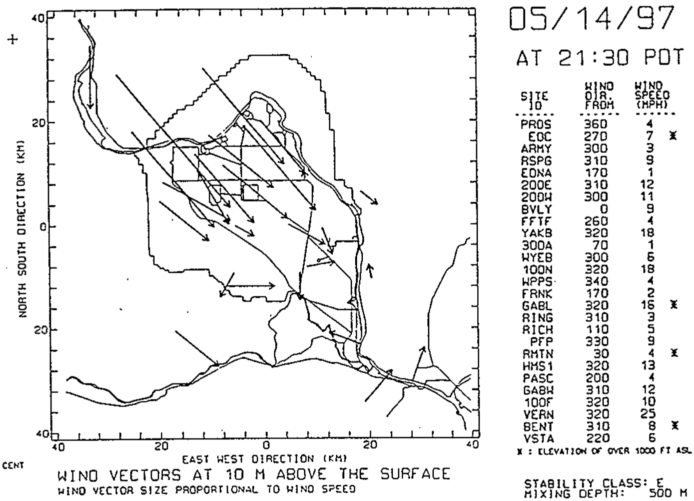


Figure D.8. Average Wind Directions and Speeds at 21:30 PDT.

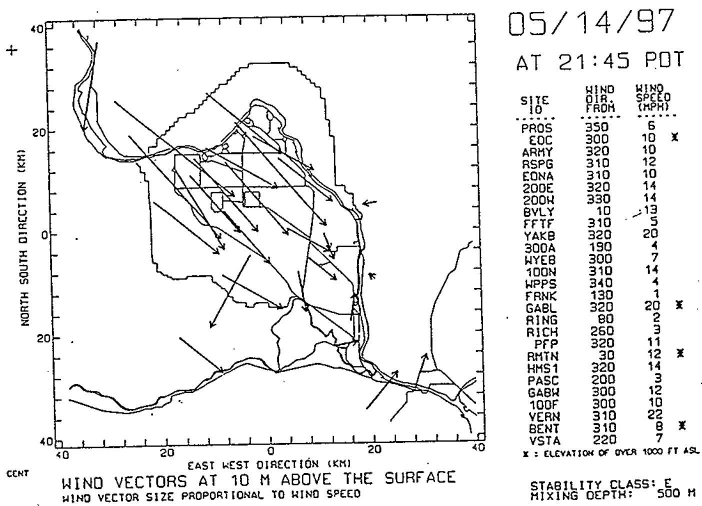


Figure D.9. Average Wind Directions and Speeds at 21:45 PDT.

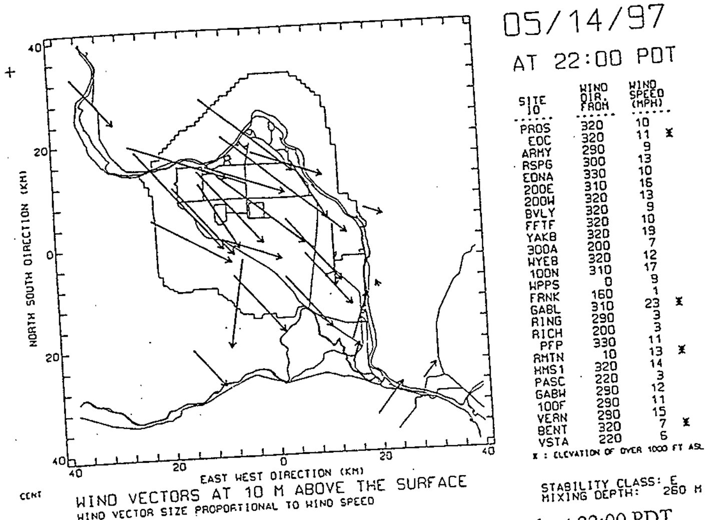


Figure D.10. Average Wind Directions and Speeds at 22:00 PDT.

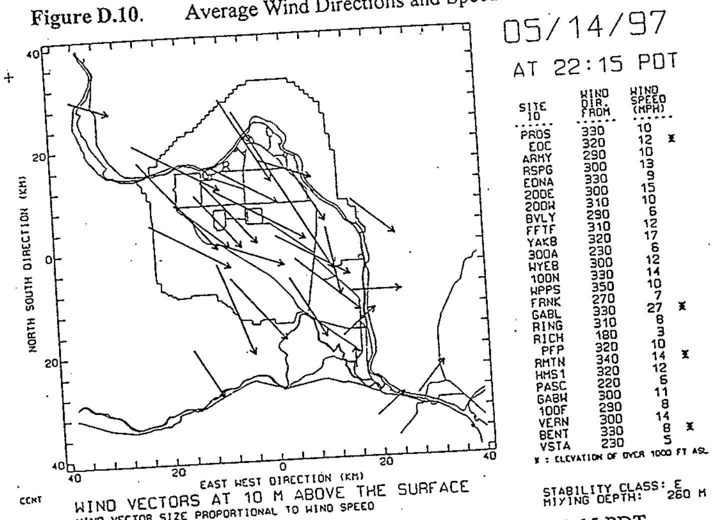
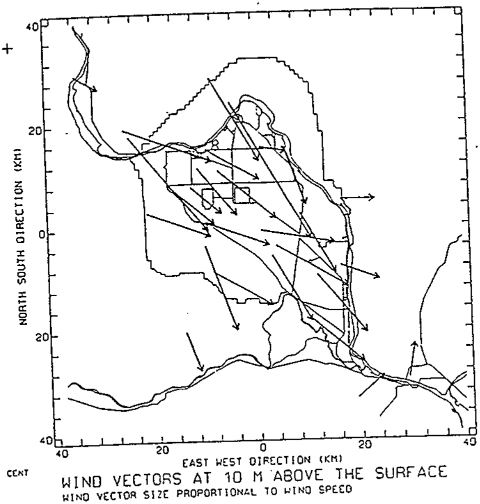


Figure D.11. Average Wind Directions and Speeds at 22:15 PDT.



05/14/97

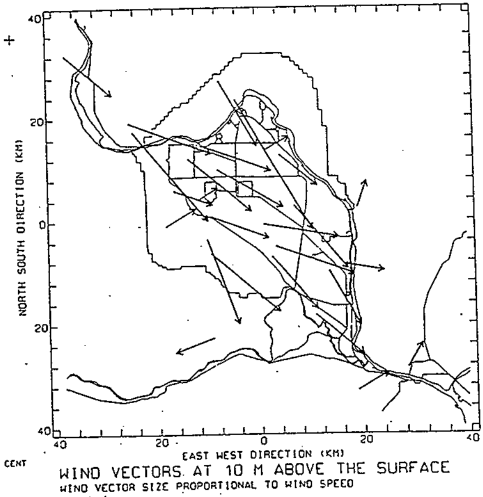
AT 22:30 PDT

SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	330	11	
EOC	300	10	*
ARMY	290	10	
RSPG	290	10	
EDNA	340	9	
200E	310	11	
200W	310	9	
BVLY	300	4	
FFTF	300	12	
YAKB	320	18	
300A	320	11	
WYEB	280	11	
100N	330	14	
WPPS	330	10	
FRNK	290	6	
GABL	330	23	*
RING	270	5	
RICH	310	10	
PFP	310	6	
RMTN	340	13	*
HMS1	320	9	
PASC	190	5	
GABW	300	9	
100F	280	4	
VERN	290	14	
BENT	340	6	*
VSTA	230	5	

* : ELEVATION OF OVER 1000 FT ASL

STABILITY CLASS: E
MIXING DEPTH: 260 M

Figure D.12. Average Wind Directions and Speeds at 22:30 PDT.



05/14/97

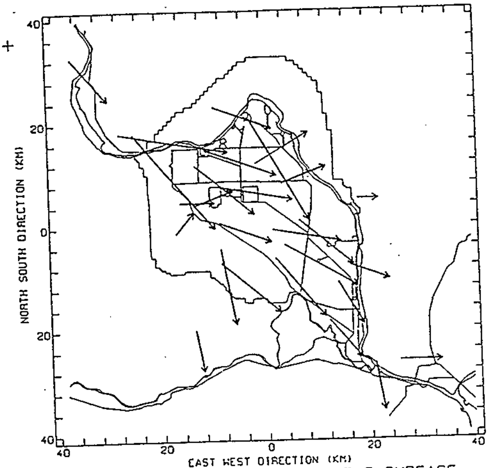
AT 22:45 PDT

SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	320	10	
EOC	310	13	*
ARMY	290	9	
RSPG	240	5	
EDNA	310	7	
200E	300	11	
200W	290	6	
BVLY	310	9	
FFTF	290	12	
YAKB	320	17	
300A	330	9	
WYEB	280	11	
100N	330	11	
WPPS	320	12	
FRNK	280	6	
GABL	330	22	*
RING	200	4	
RICH	310	9	
PFP	240	3	
RMTN	340	13	*
HMS1	310	12	
PASC	210	4	
GABW	290	11	
100F	240	4	
VERN	290	13	
BENT	70	6	*
VSTA	240	5	

* : ELEVATION OF OVER 1000 FT ASL

STABILITY CLASS: E
MIXING DEPTH: 260 M

Figure D.13. Average Wind Directions and Speeds at 22:45 PDT.



05/14/97

AT 23:00 PDT

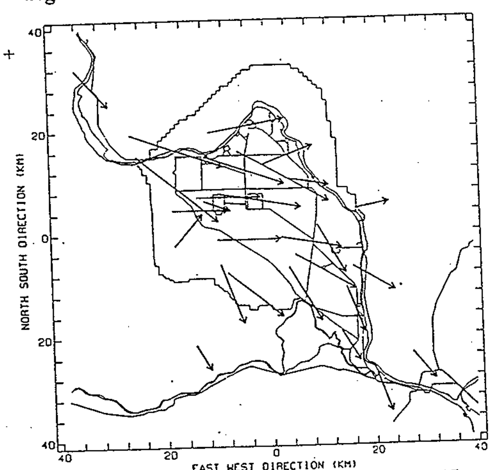
SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	320	11	
EOC	310	11	*
ARMY	290	8	
RSPG	220	4	
EDNA	250	7	
200E	280	11	
200W	270	5	
BVLY	320	8	
FFTF	300	12	
YAKB	320	18	
300A	330	7	
WYEB	280	10	
100N	290	9	
WPPS	310	10	
FRNK	250	6	
GABL	330	17	*
RING	270	3	
RICH	320	7	
PFP	250	6	
RMTN	350	11	*
HMS1	310	11	
PASC	270	6	
GABW	290	11	
100F	240	9	
VERN	280	16	
BENT	350	6	*
VSTA	350	7	

* : ELEVATION OF OVER 1000 FT ASL

WIND VECTORS AT 10 M ABOVE THE SURFACE
WIND VECTOR SIZE PROPORTIONAL TO WIND SPEED

STABILITY CLASS: E
MIXING DEPTH: 220 M

Figure D.14. Average Wind Directions and Speeds at 23:00 PDT.



05/14/97

AT 23:15 PDT

SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	330	9	
EOC	310	10	*
ARMY	270	9	
RSPG	220	6	
EDNA	280	6	
200E	280	12	
200W	270	8	
BVLY	320	7	
FFTF	300	10	
YAKB	310	15	
300A	340	7	
WYEB	280	9	
100N	260	11	
WPPS	330	8	
FRNK	300	7	
GABL	300	15	*
RING	260	5	
RICH	330	5	
PFP	290	4	
RMTN	340	9	*
HMS1	270	9	
PASC	320	5	
GABW	290	12	
100F	250	8	
VERN	290	14	
BENT	330	4	*
VSTA	340	6	

* : ELEVATION OF OVER 1000 FT ASL

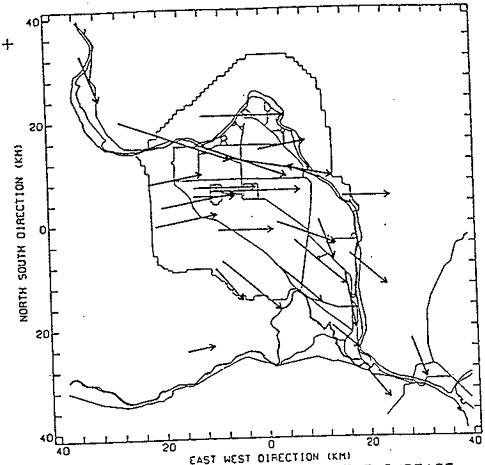
WIND VECTORS AT 10 M ABOVE THE SURFACE
WIND VECTOR SIZE PROPORTIONAL TO WIND SPEED

STABILITY CLASS: E
MIXING DEPTH: 220 M

Figure D.15. Average Wind Directions and Speeds at 23:15 PDT.

05/14/97

AT 23:30 PDT



SITE ID	WIND DIR. FROM	WIND SPEED (MPH)	
PROS	310	8	
EOC	310	11	*
ARMY	270	8	
RSPG	260	9	
EDNA	110	5	
200E	270	13	
200W	260	11	
BVLY	340	7	
FFTF	310	10	
YAKB	260	8	
300A	350	8	
WYE8	290	9	
100N	270	12	
WPPS	340	6	
FRNK	310	7	
GABL	280	16	*
RING	270	7	
RICH	310	5	
PFP	270	6	
RMTN	320	6	*
HMS1	270	9	
PASC	340	6	
GABW	290	14	
100F	260	7	
VERN	290	17	
BENT	260	4	*
VSTA	320	5	

* : ELEVATION OF OVER 1000 FT ASL

STABILITY CLASS: E
MIXING DEPTH: 220 M

Figure D.16. Average Wind Directions and Speeds at 23:30 PDT.

Atmospheric Releases

Contaminants are suspected of being released to the atmosphere by the PRF explosion via two pathways -- from a breach in the PRF roof and from the 291-Z-1 stack. The release from the stack was confirmed by observations made by Hanford Site personnel. The effluent from the stack turned a yellowish orange to brown color immediately after the explosion and visible emissions persisted for several minutes. The release from the roof occurred because the temporary over pressurization of Room 40 forced some of the contaminants from the room through a gap and holes that were created by the explosion. The gap is located between the north wall and the roof and provided a pathway to eject material laterally toward the north. A metal flashing near the gap would have acted to deflect some the emitted material downward. Two small holes are located in the ceiling above Tank A-109. Contaminants emitted through these holes would have been ejected straight up and then may have been deflected laterally by a ventilation shaft on the roof. The total area of the gap and holes in the roof of the PRF building was less than 1ft^2 (0.1m^2). The total duration of the release from the PRF roof would have been on the order of a few seconds.

Table D.6 provides a preliminary estimate of the quantities of the contaminants released from the 291-Z-1 stack and from the breach in the roof of the PRF. Based on the very small area of the breach in the roof of the PRF compared to the area of the breach between Room 40 and the interior of the PRF (i.e., blown open doors, 80 ft^2 [7 m^2]), and the continued operation of the PRF ventilation system during and after the explosion, it is assumed that only about 1% of the contaminants created in the explosion could have vented to the atmosphere through the breach in the roof.

All of the contaminants, with the possible exception of HNO_3, would have been emitted to the atmosphere as gases and would remain in that state. HNO_3 could have been present as an aerosol that might have been emitted to the atmosphere through the breach in the PRF roof. HNO_3 that instead traveled in the stream of air that was being vented through the 291-Z-1 stack would largely have reacted to form NO_2 and H_2O before being released to the environment. Aerosols that did not fully dissipate prior to encountering the stack's HEPA filter system would largely have been trapped by the HEPA filters (and HNO_3 or NO_2 re-emitted to the effluent stream as the droplets evaporated or reacted).

Table D.6 Preliminary Estimates of the Quantity of Chemical Species Released in the PRF Explosion.

Chemical Species	Maximum Stack Release, kg	Max. PRF Roof Release, kg
NO	0*	0*
N_2O	3.9	0.04
HNO_3	1.0 (24.4)**	0.24**
NO_2	17.1	0.17**
$N_2H_4O_4$	0	0***

* Nitric oxide (NO), although a by-product of the reaction, would be quickly converted to NO_2 in air, and thus the release amounts are shown as 0.

** An analysis of the PRF explosion indicates that significant amounts of HNO_3 and relatively small amounts of NO_2 are initially created. However, observations of the PFP stack effluent indicate that significant amounts of NO_2 were present by the time the explosion by-products were exhausted from the stack. To account for the presence of NO_2, HNO_3 is assumed to rapidly break down into NO_2 and H_2O. The numbers given in parenthesis indicate the original amounts of HNO_3 released in the explosion, while the numbers without parenthesis indicate the amount of HNO_3 emitted from the stack. Because the emission of contaminant from the PFP roof probably all occurred within seconds of explosion, HNO_3 is conservatively assumed to be emitted before chemical reactions can significantly deplete its concentration and NO_2 is emitted assuming that all the HNO_3 has undergone its chemical decomposition. Thus, for the roof emission, both NO_2 and HNO_3 are shown at their highest predicted levels even though both could not co-exist at these levels, because they convert to each other.

*** Although it is theorized that all or nearly all of the HAN reacted in the tank to form the contaminants listed above and there is no evidence to indicate that HAN was released to the environment; calculations were performed to estimate the air concentrations of HAN assuming that a maximum of 1 kg could have been emitted to the atmosphere through the stack and 10 g through the breach in the roof.

Release of contaminants from the PRF roof might have been complicated by building wake effects. Flow around a building produces very complex dispersion patterns (D7). As wind flows around and over buildings, mechanical turbulence is generated that increases the rate of diffusion. This enhanced turbulence, in the form of building wake downwash, can cause elevated releases to reach the ground at a more rapid rate. On the lee side of the building a cavity region is formed in which agents released into the cavity region are rapidly mixed. This rapid mixing may produce significant increases in ground-level pollutant concentrations within the cavity region. The cavity region is normally as high as the height of the building and may extend approximately three building heights or widths (which ever is larger) downwind.

The Atmospheric Dispersion of Contaminants Released From the PFP Stack

As discussed in other sections of this Appendix, it is reasonable to conclude that most of the contaminants released to the environment from the PRF explosion were emitted from the 291-Z-1 stack. The HEPA filter system for the stack exhaust stream remained in operation during and after the explosion, roof/wall breaches were of small area, and negative pressure was estimated to be re-established within five seconds.

To estimate the ground-level impact of contaminants emitted from the stack, two atmospheric dispersion models are used. To estimate maximum ground-level concentrations within a few kilometers of the stack, the EPA's SCREEN3 model was employed. SCREEN3 is used to conservatively estimate short-term air pollution concentrations, including estimates of maximum ground-level concentrations from a single source (D4). The model uses a steady-state Gaussian plume algorithm to calculate contaminant concentrations. Input requirements for SCREEN3 include source configuration information, pollutant emission parameters, and meteorological conditions. Plume rise, building wake downwash, and plume impaction on complex terrain can be computed. Key assumptions used in this modeling exercise are presented in Table D.7.

Table D.7. Key Assumptions Used by SCREEN3 in Modeling The Release from the 291-Z-1 Stack.

SOURCE TYPE	=	POINT
STACK HEIGHT (M)	=	61.
STK INSIDE DIAM (M)	=	4.1
STK EXIT VELOCITY (M/S)	=	8.9
STK GAS EXIT TEMP °C	=	23.
AMBIENT AIR TEMP °C	=	23.
WIND DIRECTION	=	120.
WIND SPEED (MPH)	=	4.
ATMOSPHERIC STABILITY	=	D - NEUTRAL
RECEPTOR HEIGHT (M)	=	0.
URBAN/RURAL OPTION	=	RURAL

The SCREEN3 model calculated a momentum-driven plume rise of 40 m (130 ft) after contaminants were released from the 61 m (200 ft) stack. The effective height of release for the effluent was therefore just over 100 m (330 ft). In the neutrally stable atmosphere into which the stack effluent was emitted, the plume slowly expanded vertically and horizontally as it is was carried downwind from the stack. Centerline pollutant concentrations at the surface for key contaminants are presented as a function of downwind distance from the stack in Table D.8.

Table D.8. PFP Stack Release - Maximum Ground-Level Concentrations of Contaminants. Results are generated using the SCREEN3 model. Values are presented for the horizontal (Sigma Y) and vertical (Sigma Z) size of the plume. Maximum contaminant-specific release rates are derived by taking the preliminary estimate of amount of each contaminant that may have been released (see Table D.6) and assuming this quantity of material is uniformly released over a 5 minute (300 s) period (although the actual period of release is most likely between 10 and 15 minutes).

			Concentration ($\mu g/m^3$)			
Distance Downwind (m)	**Sigma Y (m)**	**Sigma Z (m)**	**1 g/s generic gas release**	**13 g/s N_2O release**	**3 g/s HNO_3 or HAN release**	**60 g/s NO_2 release**
100	13	11	<1.0e-12	1.3e-11	3.0e-12	6.0e-11
200	20	15	1.0e-8	1.3e-07	3.0e-08	6.0e-07
300	26	17	3.0e-6	3.9e-05	9.0e-06	0.0002
400	32	19	2.0e-4	26	0.001	0.012
500	38	22	0.002	0.04	0.006	0.12
600	44	24	0.015	0.2	0.045	0.9
700	51	27	0.05	0.7	0.15	3
800	57	29	0.15	2.0	0.45	9
900	63	32	0.3	4.0	0.9	18
1000	69	34	0.6	7.8	1.8	36
1500	99	43	2.0	26	6	120
2000	130	52	2.5	33	7.5	150
2500	160	60	2.9	38	8.7	174
3000	190	66	3.0	39	9	180
3500	210	72	2.9	38	8.7	174
4000	240	78	2.7	35	8.1	162
5000	290	89	2.4	31	7.2	144

The SCREEN model projects the maximum ground-level pollutant concentration occurred at a distance of 3.0 km downwind from the stack. At 0.5 km from the stack, the maximum pollutant concentration at the surface is projected to have been less than 0.1% of the maximum value at 3 km. By the time contaminants traveled 0.5 km downwind of the stack, significant quantities of stack effluent had not had sufficient time to spread downward to the surface. Mechanisms that could have speeded up the spreading of the plume to the surface (such as an unstable atmosphere, building wake effects, deposition processes) were not present[1]. The extremely low concentration of contaminants at the surface is even more pronounced closer to the stack; at 0.3 km downwind of the stack the maximum pollutant concentration at the surface is projected to be about 0.1% of the maximum value at 0.5 km (or one millionth the value at 3 km).

Given the meteorological conditions during the time of the explosion, the height of the 291-Z-1 stack, the upward velocity of the effluent, and the lack of a significant and fast-acting mechanism for bringing the effluent to the surface -- no mechanism has been identified that could generate a contaminant concentration within several hundred meters of the PFP complex that was more than a small fraction of 1% of the maximum ground-level impact that occurred several kilometers from the stack. The maximum surface concentration of the key contaminants released from the 291-Z-1 stack (as reported in Table D.6) was well below levels of concern for short-term exposures.

To investigate longer range transport of the stack effluent, the MESOI model was used. MESOI is a Gaussian puff dispersion model (D8). Materials released to the atmosphere are assumed to be contained in one or more puffs. At the time a puff is released its center is assigned coordinates. The horizontal coordinates change as the puff is transported by the wind. The model allows both temporal and spatial variations in the wind field and can incorporate wind data from up to forty different locations. Vertical variations in the wind are estimated by interpolating between near-surface wind data and an upper-level wind. The MESOI adjusts puff transport to account for complex terrain features. The height of the puff's center above the ground is the height of the actual release point (e.g., the top of a stack) plus any rise due to momentum or buoyancy. The height of the puff center changes to account for variations in terrain elevation. MESOI can also account for dry deposition, wet deposition, and radioactive decay (no radioactive contaminants were emitted to the atmosphere by the PRF explosion).

MESOI computes pollutant exposures on a 41 by 41 exposure grid that covers an area of 80 km by 80 km -- producing a spacing of 2 km between adjacent receptors. Because of the space between receptors locations on the exposure grid, a puff often needs to travel several kilometers from its source until it grows to a size that would allow the model to effectively estimate maximum ground-level exposures. As a result, MESOI is often used in conjunction with a straight line plume model (like SCREEN3) to assess conditions close to the contaminant source.

The MESOI model produces estimates of the time-integrated, ground-level contaminant concentrations (exposures). Exposure estimates are a product of contaminant concentration and exposure duration. Time-integrated exposures for a 15-minute advection step can be divided by 900 seconds to provide an estimate of the average contaminant concentration during that period.

In the simulation using the MESOI model, a release of 60 kg of a generic contaminant is assumed to be emitted from the top of the 291-Z-1 stack (a release height of 61 m with plume rise not modeled) during the 15 minutes from 20:00

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[1] The rate of atmospheric mixing at the time of release was moderate to low as indicated by Hanford Meteorology Stations measurements of atmospheric stability. This assessment was confirmed by other meteorological observations (solar intensity, wind speed). Building wake effects were not present for the stack release because the stack height is so much greater than the height of any neighboring buildings. Wet deposition processes were not active (precipitation was not recorded anywhere on the Site during May 14 and relative humidities were low). Dry deposition was not a factor because contaminants were not released as particles (the exhaust stream passed through an intact HEPA filtration system) and gas-to-particle conversion would have required many tens of minutes to produce any significant level of deposition.

to 20:15 PDT[2]. The 60 kg of generic contaminant is based on the total mass of material in Tank A-109 before the explosion. Time-integrated, ground-level exposures from this simulation are presented in Figures D.17 - D.31 for each 15 minute period from 20:30 to midnight. Results for a given time period represent the exposure over the previous 15-minute period (e.g., data for 20:30 PDT represents the exposure from just after 20:15 to 20:30 PDT). To estimate exposures from specific contaminants, it is necessary to multiply model results by the best estimate of the amount of an individual contaminant (in kg) released through the stack and then divide by the 60 kg to factor out the generic release total.

At 20:15 PDT, the puff of effluent material is too small to impact any of the model's ground-level receptor locations. By 20:30 PDT, the puff has grown large enough to impact two receptors on the modeling grid. At that time the puff was located several kilometers to the northwest of the PFP. At 20:45 PDT the puff moved to the north from its prior position and continued to expand. At 21:00 PDT the puff was starting to move toward the east-southeast; its center was located about 6 km north-northwest of the PFP. Results for 20:30, 20:45, and 21:00 PDT present our best estimates of effluent position; however, maximum ground-level exposures are somewhat underestimated by the model until about 21:15 PDT (when the puff of dispersing contaminants has grown large enough to impact a number of receptors on the modeling grid).

At 21:15 PDT the center of the puff was about 4 km north of the PFP and the puff was moving rapidly to the southeast. The side edge of the puff was approaching the PFP but ground-level exposures near the PFP were six orders of magnitude (0.0001%) less than those at the surface directly beneath the center of the puff. At 21:30 PDT the center of the puff was just over 4 km (2.5 mi) to the east of PFP, near the southwestern corner of the 200 East Area. The very diffuse trailing edge of the puff was just grazing the PFP. At 21:45 PDT the center of the puff was about 9 km (6 mi) to the east-southeast of the PFP. Thirty minutes later the leading edge of the puff had crossed the Hanford Site's southern boundary near the Horn Rapids area of the Yakima River. The center of the puff was about 20 km southeast of the PFP. The puff continued its movement toward the southeast and be 22:45 PDT the center of the puff was in the vicinity of the 300 Area, just north of the city of Richland. By 23:00 PDT the center of the puff had moved across the Columbia River and into Franklin County. At 23:45 PDT, the center of the puff was almost 60 km southeast of the release location and moving out of the MESOI modeling domain.

It is interesting to note that while the winds at the PFP reversed direction between 8:00 PDT and from 08:45 PDT, the rotation of the winds observed at the PFP and neighboring stations between these times acted to move the puff toward the north and resulted in the puff center passing well to the north of the 200 West area as it traveled to the southeast. During the period prior to 21:00 PDT, no mechanism was present to expose workers in the immediate vicinity of the PFP to the main body of effluent released from the PFP stack. While the very dilute edge of the puff may have grazed the PFP from just before 21:15 to just after 21:30 PDT, contaminant exposures were exceedingly low.

[2] Emissions from the stack actually began at about 19:55 PDT and persisted for about 11 minutes. The closest fit between this information and model input restrictions was to model a release that began at 20:00 PDT and persisted for 15 minutes. This difference in release time and duration should not be significant given the time and distance scales being examined by the MESOI model.

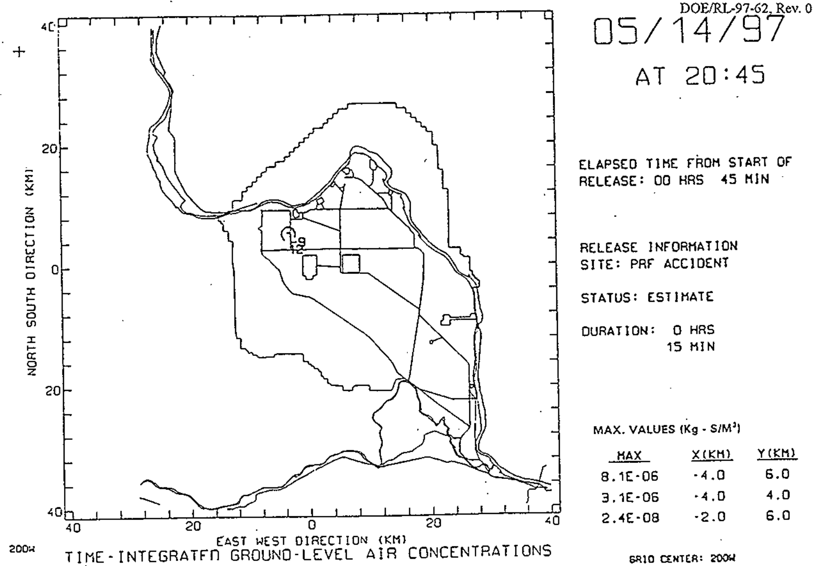

Figure D.18. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 20:45 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

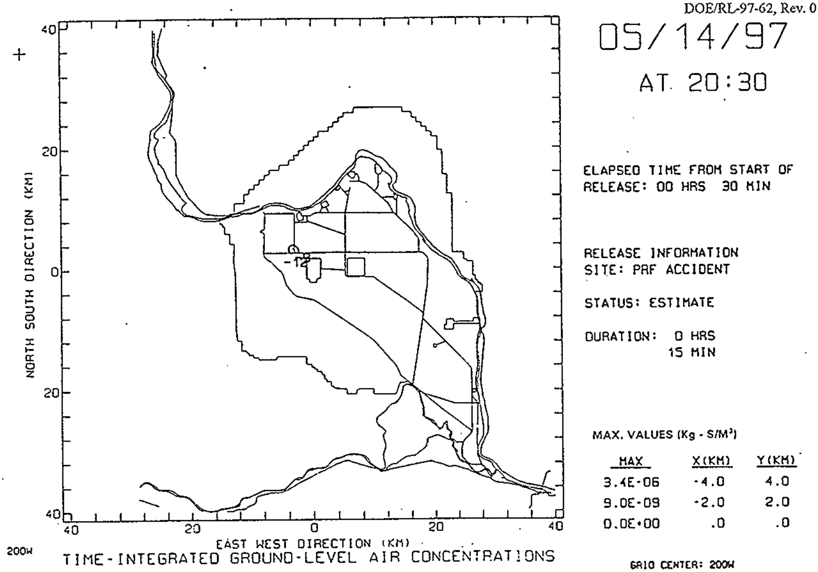

Figure D.17. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 20:30 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

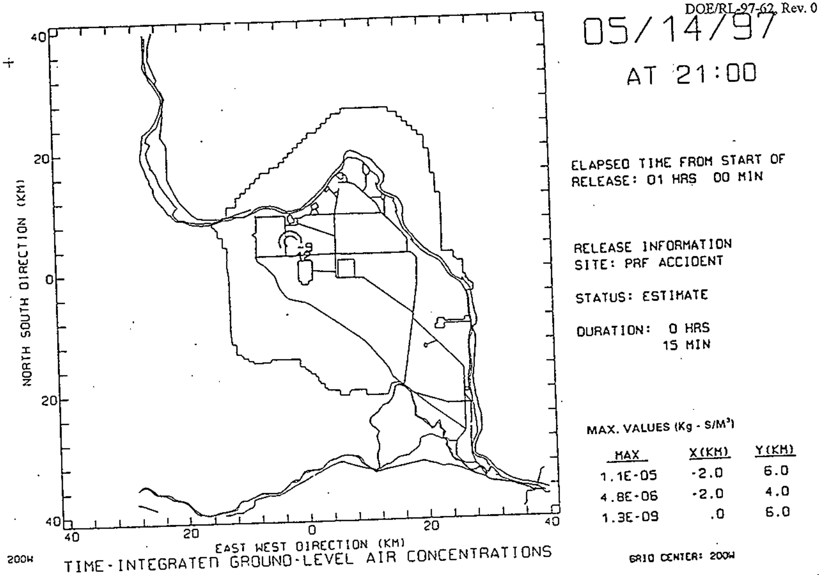

Figure D.19. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 21:00 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m^3. Contours are plotted for every three order of magnitude change in exposure (e.g., -12 = 10^{-12} kg-s/m^3, -9 = 10^{-9} kg-s/m^3).

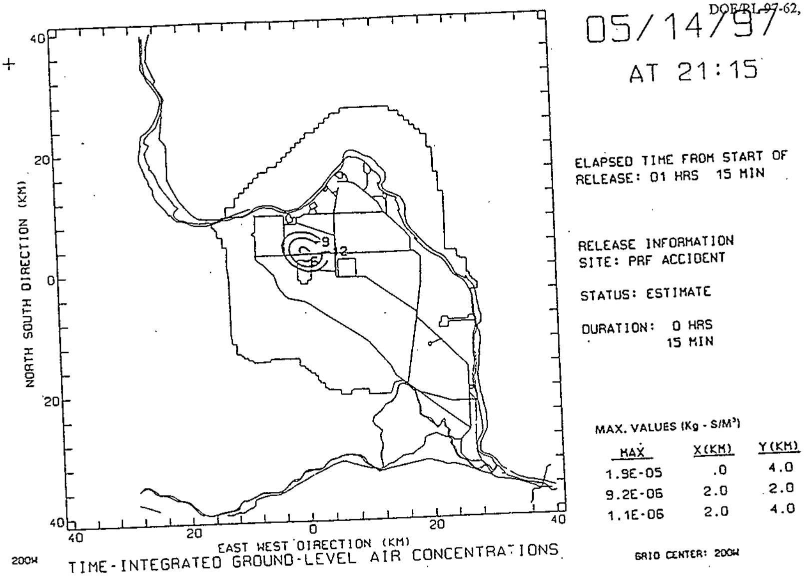

Figure D.20. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 21:15 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

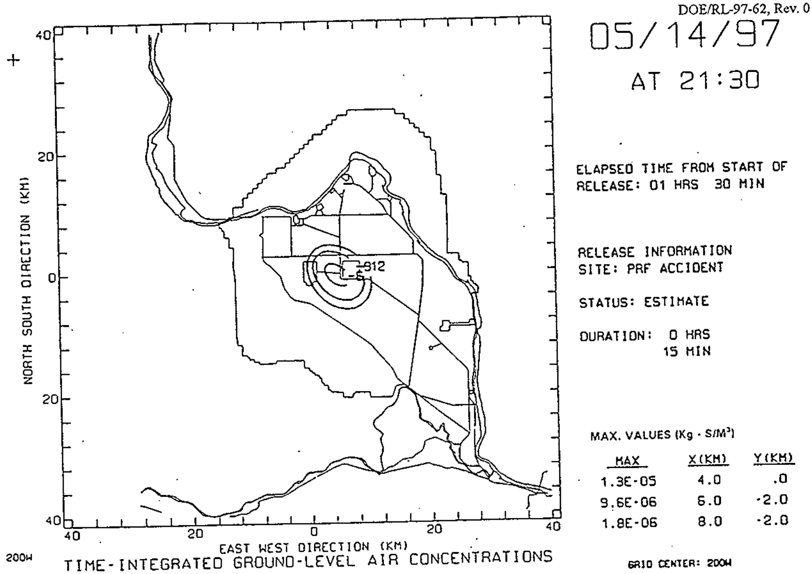

Figure D.21. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 21:30 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

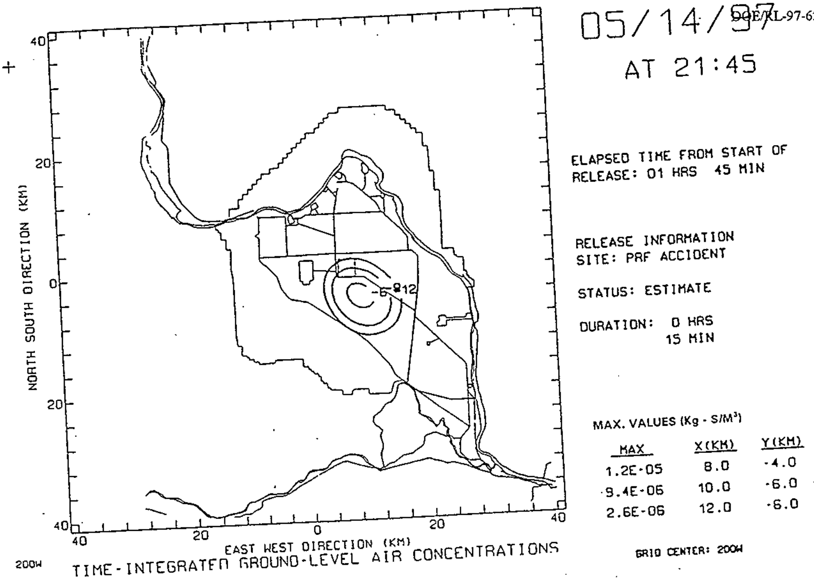

Figure D.22. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 21:45 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

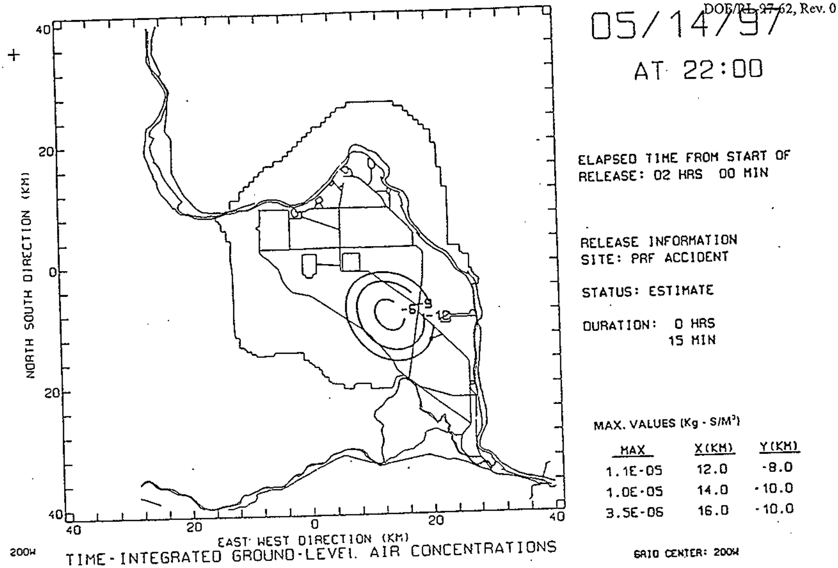

Figure D.23. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 22:00 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

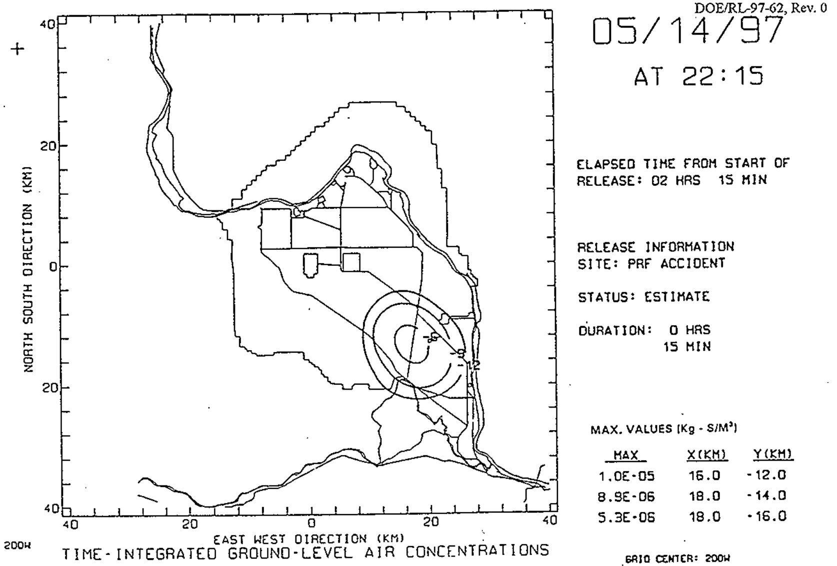

Figure D.24. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 22:15 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., -12 = 10^{-12} kg-s/m³, -9 = 10^{-9} kg-s/m³).

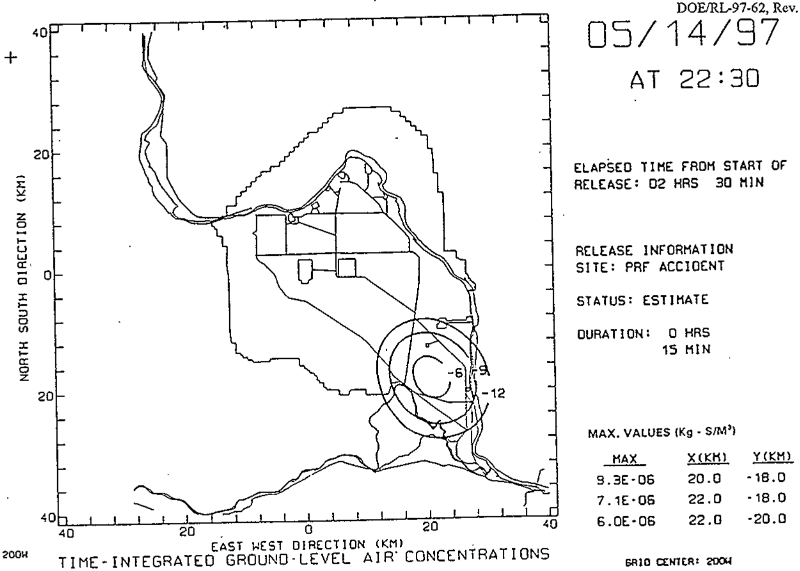

Figure D.25. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 22:30 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m^3. Contours are plotted for every three order of magnitude change in exposure (e.g., -12 = 10^{-12} kg-s/m^3, -9 = 10^{-9} kg-s/m^3).

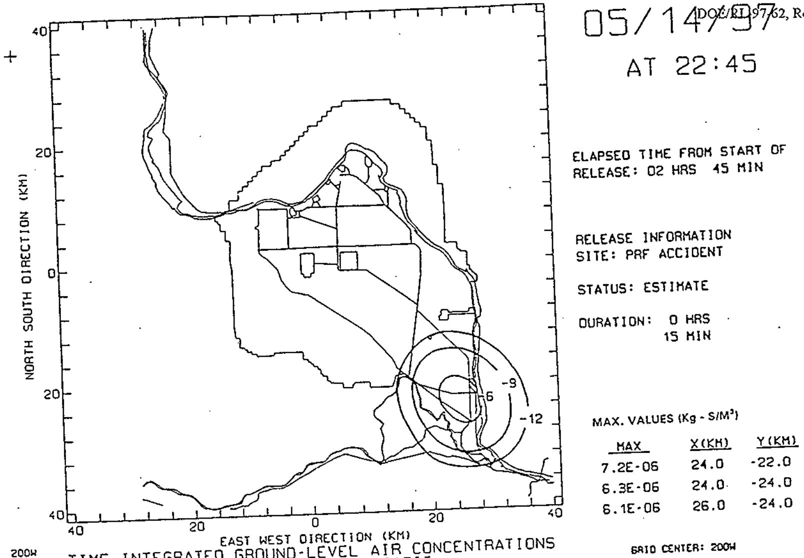

Figure D.26. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 22:45 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

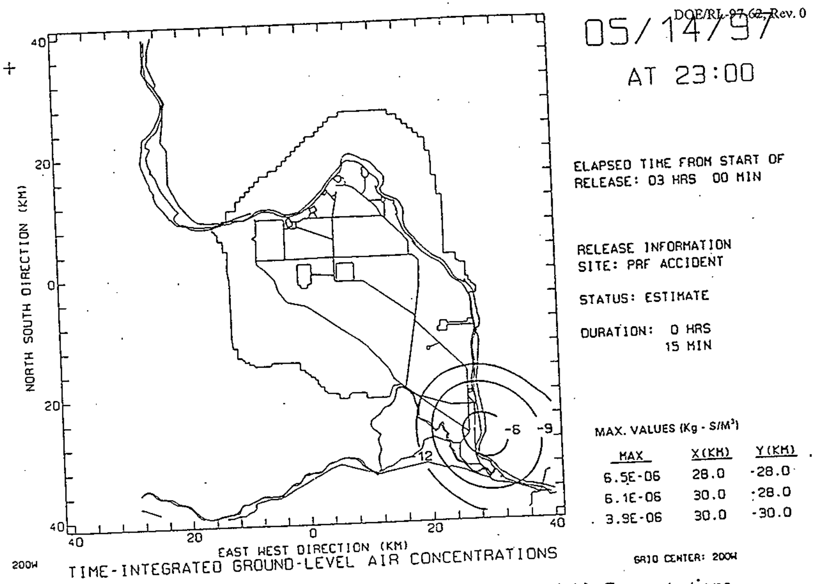

Figure D.27. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 23:00 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

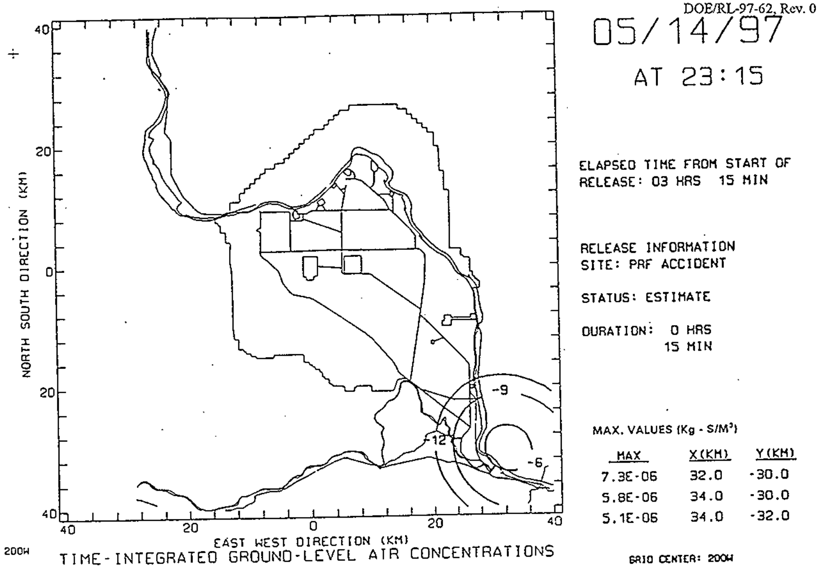

Figure D.28. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 23:15 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., -12 = 10^{-12} kg-s/m³, -9 = 10^{-9} kg-s/m³).

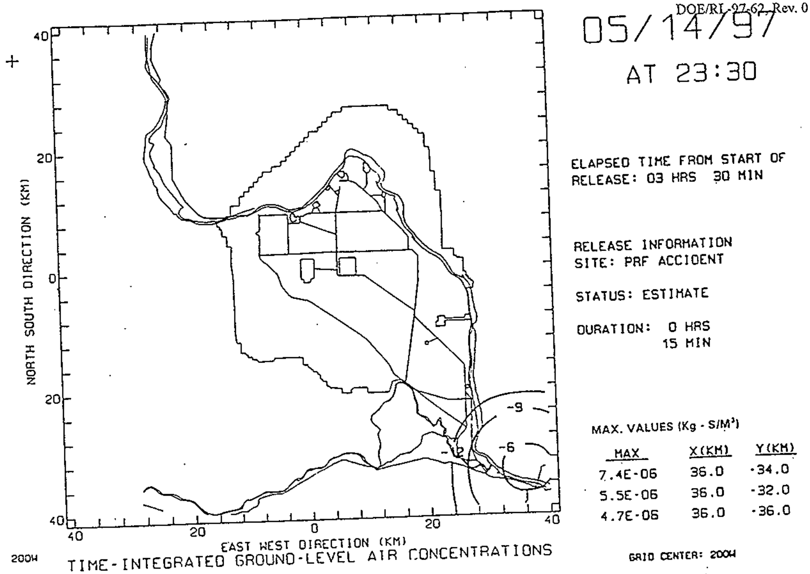

Figure D.29. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 23:30 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

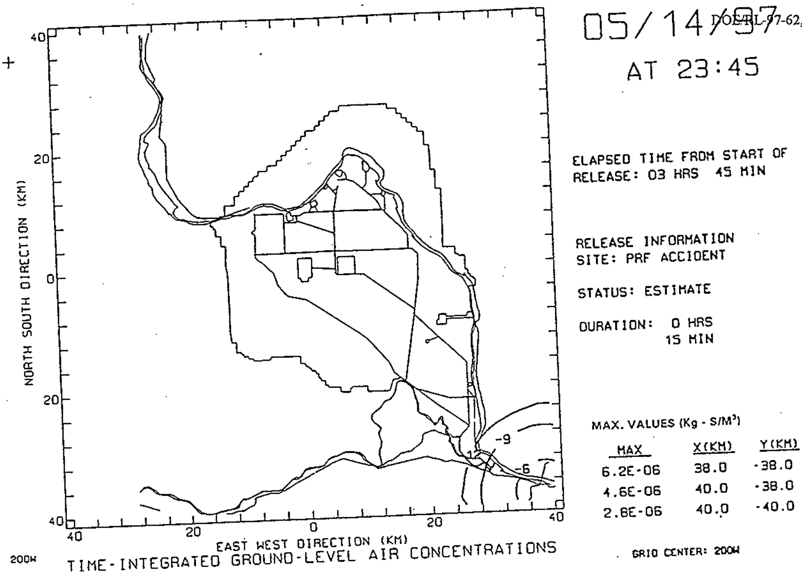

Figure D.30. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 23:45 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

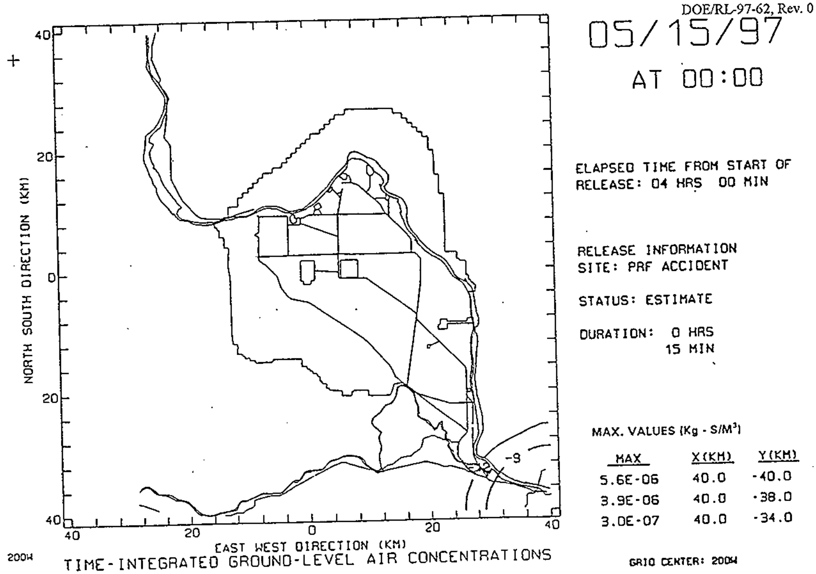

Figure D.31. PFP Stack Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at Midnight (PDT). This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas. Exposures are measured in units of kg-s/m^3. Contours are plotted for every three order of magnitude change in exposure (e.g., -12 = 10^{-12} kg-s/m^3,-9 = 10^{-9} kg-s/m^3).

The Atmospheric Dispersion of Contaminants Released From the Roof of the PRF

Unlike the emissions from the 291-Z-1 stack, the effluent material emitted from the roof of the PRF was not clearly visible to a large number of Hanford workers. However, a Patrolman on the roof of 234-5Z reported he smelled a strong chemical odor for several seconds after the explosion which he believed originated from the PRF roof. A key question about the effluent from the PRF roof is how much material was ejected laterally (so that the effluent's initial momentum carried it over the roof of the 234-5Z building) and how much was deflected downward or to the side by obstructions near the holes and gap in the roof.

Focusing on the contaminants ejected laterally from the breach in the roof and carried over the roof of the 234-5Z building, atmospheric dispersion close to the PFP can be estimated using the SCREEN3 model in conjunction with a building wake correction algorithm. Dispersion at greater distances can be estimated using the MESOI model. The algorithm used to estimate the enhanced dispersion due to building wake downwash is the Ramsdell technique (D9). This technique adjusts the dispersion coefficients used in the Gaussian plume equation to account for both low wind speed meander and building wake downwash. This approach, developed for the Nuclear Regulatory Commission, has been compared favorably with other non-Gaussian approaches (D10, D11) developed to estimate the maximum contaminant concentration in building wakes.

Key assumptions used in the SCREEN3 modeling exercise are presented in Table D.9.

Table D.9. Key Assumptions Used by SCREEN in Modeling A Release from the PRF roof.

SOURCE TYPE	=	POINT
STACK HEIGHT (M)	=	14.
WIND DIRECTION	=	120.
WIND SPEED (MPH)	=	4.
ATMOSPHERIC STABILITY	=	D - NEUTRAL
RECEPTOR HEIGHT (M)	=	0.
URBAN/RURAL OPTION	=	RURAL

Assuming all of the pollutants emitted from the PRF roof (see Table D.6) were released within 1 minute of the explosion, Table D.10 estimates the maximum centerline pollutant concentrations at the surface. Within 100 m of the source location, maximum centerline concentrations are reported on the top of the main PFP building roof (234-5Z). Model results tend to be conservative because the model does not assume an initial diffusing of the contaminants due to the energy of the release or take into account spreading along the axis of transport.

If instead it is assumed that all of the pollutants emitted from the PRF roof (see Table D.6) were released within 5 seconds of the explosion, Table D.11 conservatively estimates the maximum centerline pollutant concentrations at the surface and on the roof of the main PFP building (234-5Z). Concentrations are about an order of magnitude higher than reported for releases with a 1 minute duration (because the same quantity of material is being released into a smaller volume of air).

Because of the extremely short nature of the PRF roof release, contaminants blown over the 234-5Z roof would travel well downwind from the PRF and be clear of the PFP complex several minutes after the explosion. The peak ground level concentrations would have occurred at the 150 meters distance from PRF within about 75 seconds of the release. Concentrations at that location would have dissipated rapidly after the peak was achieved.

Focusing on contaminants that may have deflected downward by the metal flashing near the breach, initial dispersion would have been different. This sort of release scenario is very difficult to model because of the complex interactions between the effluent and the surrounding buildings. One potential pathway is for some of the effluent material to be transported northward around the east side of the 234-5Z building before escaping the building wake and moving to the west-northwest. Another potential pathway is for effluent material to rebound upwards after emission from the PRF and pass over the roof of the 234-5Z building (a similar dispersion pattern to what was modeled above using the lateral ejection scenario). A third potential pathway is for contaminants to disperse within the areas bounded by the PRF, 236Z, 2736Z, and 234-5Z buildings before being entrained in the mean flow and passing over the top of the 234-5Z building or passing around the southern edge of the 2736Z building and being transported to the west-northwest and away from the PFP complex. Under the influence of a 4 mph wind, nearly all the contaminants that might have been ejected downwards from the PRF roof should have been carried away from the PFP complex within about ten minutes of the release, although very low level concentrations could have lingered in the area.

Table D.10. PRF Roof Release - Maximum Ground-Level and PFP Roof Concentrations of Contaminants for a One Minute Duration Release. Results are generated using the SCREEN3 model and the Ramsdell building wake algorithm. Maximum contaminant-specific release rates are derived by taking the preliminary estimate of amount of each contaminant that may have been released (see Table D.6) and assuming that this quantity of material is uniformly released over a 1 minute period. Concentration are presented in mg/m^3 (to convert milligrams to micrograms multiply by 1,000).

			Concentration (mg/m^3)				
Distance Downwind (m)	**Sigma Y (m)**	**Sigma Z (m)**	**1 g/s generic gas release**	**0.7 g/s N_2O release**	**4.0 g/s HNO_3 release**	**3 g/s NO_2 release**	**0.2 g/s HAN release**
60 (on 234-5Z roof)	*5*	*3*	*10*	*7*	*40*	*30*	*2*
80 (on 234-5Z roof)	*7*	*4*	*6*	*4.2*	*24*	*18*	*1.2*
100 (on 234-5Z roof)	*8*	*5*	*4*	*2.8*	*16*	*12*	*0.8*
150*	13	16	0.5	0.35	2	1.5	0.1
200	16	18	0.4	0.28	1.6	1.2	0.08
300	23	21	0.25	0.175	1	0.75	0.05
400	30	24	0.2	0.14	0.8	0.6	0.04
500	37	26	0.13	0.091	0.52	0.39	0.026
1000	69	36	0.06	0.042	0.24	0.18	0.012
2000	130	50	0.02	0.014	0.08	0.06	0.004

* The first ground level concentration. This value represents both a horizontal and vertical drop from the 100 meters (on roof) distance.

Table D.11 PRF Roof Release - Maximum Ground-Level and PFP Roof Concentrations of Contaminants for a 5 Second Duration Release. Results are generated using the SCREEN3 model and the Ramsdell building wake algorithm. Concentration are presented in mg/m^3 (to convert milligrams to micrograms multiply by 1,000).

Distance Downwind (m)	Sigma Y (m)	Sigma Z (m)	Concentration (mg/m^3) 1 g/s generic gas release	8 g/s N_2O release	50 g/s HNO_3 release	30 g/s NO_2 release	2 g/s HAN release
60 (on 234-5Z roof)	*5*	*3*	*10*	*80*	*500*	*300*	*20*
80 (on 234-5Z roof)	*7*	*4*	*6*	*48*	*300*	*180*	*12*
100 (on 234-5Z roof)	*8*	*5*	*4*	*32*	*200*	*120*	*8*
150*	13	16	0.5	4	25	15	1
200	16	18	0.4	3.2	20	12	0.8
300	23	21	0.25	2	12.5	7.5	0.5
400	30	24	0.2	1.6	10	6	0.4
500	37	26	0.13	1	6.5	3.9	0.26
1000	69	36	0.06	0.48	3	1.8	0.12
2000	130	50	0.02	0.16	1	0.6	0.04

* The first ground level concentration. This value represents both a horizontal and vertical drop from the 100 meters (on roof) distance.

Independent of the initial dispersion of the effluent from the PRF roof breach, the MESOI model gives us estimates of the position of the puff and contaminant exposures at later times. Figures D.32 - D-35 show the puff positions and 15-min exposures at selected times during the dispersion of the contaminants. Puff positions are similar to those for a stack release, although transport speed is slightly reduced.

Potential Offsite Exposures from the PRF Event

The movement of the contaminants from the PRF from the time of first release (19:55 PDT) through the end of the release (20:10 PDT) was to the northwest about 4 mph. By 20:30 PDT, winds had shifted so that the contaminants were being transported slowly to the north. During this period, the contaminants had not moved far enough away from the PRF and had insufficient lateral spread to impact any offsite location (including State Route 240). At around 20:45 PDT, a "cool" air mass (about 4°C cooler that the air that was present over the Hanford Site) began to approach the location of the contaminant plumes (or "puffs") from the PFP stack and PRF roof releases. This cool air mass was associated with downslope flow from the Cascade Mountains and foothills and was enhanced by downdrafts from thunderstorms (the thunderstorm cells were located 70 km to the west of the Hanford Site). This downslope flow was blowing from the northwest toward the southeast with speeds in excess of 10 mph.

The interaction between the contaminant plumes and the cooler air mass was complex. The cooler, denser air mass would tend to displace the warmer (and less dense) air in its path (including the contaminant plumes) by pushing below the existing air mass and lifting it further aloft in the atmosphere. As the cooler air mass encountered the contaminant plumes, some mixing of contaminants into the cooler air mass would have occurred. While a portion of the contaminant plume would be entrained into the cooler air mass, the remainder of the contaminant plumes would have been displaced upward into the atmosphere (potentially being lifted several thousand feet above the surface). The contaminants carried aloft would only slowly mix with the cooler air below and would be transported many tens to hundreds of kilometers from the PFP before the widely dispersed remnants of the plumes could once again extend toward the surface.

As a result of this vertical displacement, the maximum concentrations of PRF contaminants at points of public access would have been associated not with the "lifted" portion of the contaminant plumes, but with the portion that initially mixed with the cooler air mass. The transport and diffusion of the contaminants in the first hour after the event and the subsequent transport and diffusion of the contaminants entrained in the cool air mass can be modeled using the MESOI model. Maximum concentrations of pollutants can be estimated using MESOI results and standard Gaussian equations.

After being entrained in the cooler air mass, the MESOI model indicated that some contaminants (at the fringes of the contaminant plume) encountered Washington State Route 240 at around 22:00 PDT (see Figures D.17 - D.31). By the time contaminants reached a point of public access, exposure to the public was dominated by PFP stack emissions. Emissions from the roof of the PRF can be ignored for this assessment because they were (1) present at much lower concentrations than emissions from the PFP stack and (2) impacted slightly different locations.

After 22:00 PDT, as the contaminant plume moved to the southeast, the fringe of the contaminant plume continued to brush highway 240. The greatest offsite concentrations of contaminants occurred when the plume passes across Horn Rapids Road and reached the southeaster boundary of the Hanford Site. After reaching this location the center of the plume (rather than its fringe) was able to directly impact points of public access.

Table D.12 provides estimates of the maximum ground-level concentrations of key contaminants directly under the plume centerline (the plume centerline is not directly over a point of public access until 23:00 PDT). Table D.13 provides estimates of the maximum ground-level concentrations of key contaminants at the maximally impacted point of public access. Concentration estimates are provided for every ½ hour from the time contaminants first reached a point of public access until the center of the contaminant plume passes beyond the Tri-Cities.

Table D.12 Maximum Ground-Level Concentrations of Key Contaminants Directly Under the Plume Centerline

Time (PDT)	Distance/Direction from PRF of Puff Center of Mass	Concentration (ug/m³)			
		Generic Gaseous Pollutant (released at a rate of 1 g/s)	N_2O (released at a rate of 13 g/s)	HNO_3 or HAN (released at a rate of 3 g/s)	NO_2 (released at a rate of 60 g/s)
22:00	14 km ESE	0.9	10	3	50
22:30	29 km SE	0.5	7	2	30
23:00	40 km SE	0.4	5	1	25
23:30	50 km SE	0.3	4	1	20

Table D.13 Maximum Ground-Level Concentrations of Key Contaminants at Maximally Impacted Points of Public Access

Time (PDT)	Distance/Direction from PRF of the Maximum Contaminant Concentration at a Point of Public Access	Concentration (ug/m³)			
		Generic Gaseous Pollutant (released at a rate of 1 g/s)	N_2O (released at a rate of 13 g/s)	HNO_3 or HAN (released at a rate of 3 g/s)	NO_2 (released at a rate of 60 g/s)
22:00	16 km SE (on SR 240)	0.007	0.09	0.02	0.4
22:30	30 km SE (near SR 240 on Horn Rapids Road)	0.02	0.3	0.06	1
23:00	40 km SE (Columbia River near North Richland)	0.4	5	1	25
23:30	50 km SE (near Pasco)	0.3	4	1	20

The estimates provided here are biased to overestimate potential concentrations. The estimates assume that all of the contaminants were entrained in the cool air mass and none were lifted aloft. In actuality, only a percentage (and probably a small percentage) of the contaminants were probably entrained into the cool air mass, most of the contaminants were probably lifted aloft by the cool air and would have reached ground-level at much lower concentrations and much further downwind from the PRF. In addition, the estimates presented here are based on a continuous release of contaminants and do not factor in diffusion along the direction of transport.

It is interesting to note that the maximum possible concentration of NO_2 estimated for any point of public access was about 25 ug/m3 (for a location near the southeastern boundary of the Site). The maximum short-term concentration is only 25% of the annual average concentration of NO_2 that is permitted for the public under ambient air concentration standards.

Summary of Dispersion Model Results and Limitations

Based on the dispersion modeling, utilizing the information and assumptions delineated in the report, results can be summarized as follows:

1. The 291-Z-1 stack emission was of no significance regarding potential for chemical exposure within the PFP complex, because the emission would not have reached ground level at that location.

2. The PRF roof/wall release could have produced concentrations of nitrogen dioxide in accessible ground level areas around PRF/234-5Z Building above the OSHA Ceiling level for brief seconds at specific locations in the pathway of the release. In addition, nitric acid could have exceeded the STEL value for brief seconds, but not the STEL itself, because the STEL is a 15 minute average concentration. These peak concentrations would have occurred within a minute or two of the release, depending on distance from the source, initial directional flow of the release, and building effects. Therefore, exposure to these peak concentrations would not have been possible for workers at ground level, because workers were not in the directional path of the release within the timeframe of peak concentrations. Exposure to the peak concentrations could have been possible for the Patrolman on the roof of 234-5Z building for a few second duration.

3. Concentrations would have dissipated rapidly and would have essentially cleared within 10 minutes. Any residual concentrations would have been at very low levels after this time.

4. Given the results of the model and its limitations as expressed below, it is possible that low level exposures could have been experienced during the timeline that workers exited the trailer and walked to 234-5Z building.

5. The maximum possible concentration of nitrogen dioxide estimated for any point of public access was about 25 ug/m3, which would have been present for only a few minutes. This level is only 25% of the <u>annual</u> average concentration that is permitted for the public under ambient air standards.

Limitations of the dispersion modeling include the following:

1. Among others, key variables for the model include (a) duration of release from the roof/wall breaches; (b) relative amounts released through the stack versus the roof/wall breaches; and © initial directional flow of the roof/wall emission. Parameters and assumptions were based on the best information available; however, significant deviations from these assumptions could impact peak concentrations and possibly timelines for peak and lower level concentrations in areas accessible by the workforce.

2. Wind direction, velocity, and consistency is also a factor. The 4 mph wind measurement used for the modeling was an average over 15 minutes, as measured by the weather stations. If wind were variable during this period, it could impact the modeling results.

3. Another unknown variable is whether significant amounts of larger-sized aerosols were released from the roof/wall breaches that could have been deposited on outside surfaces and evaporated over some period of time.

4. Nevertheless, results from the model are consistent with reports from the Patrolman on the roof of 234-5Z Building at the time of the incident. The Patrolman would have been in the pathway of the release. He reported that he noted a strong, localized chemical odor some seconds after the incident and it lasted for only a brief period.

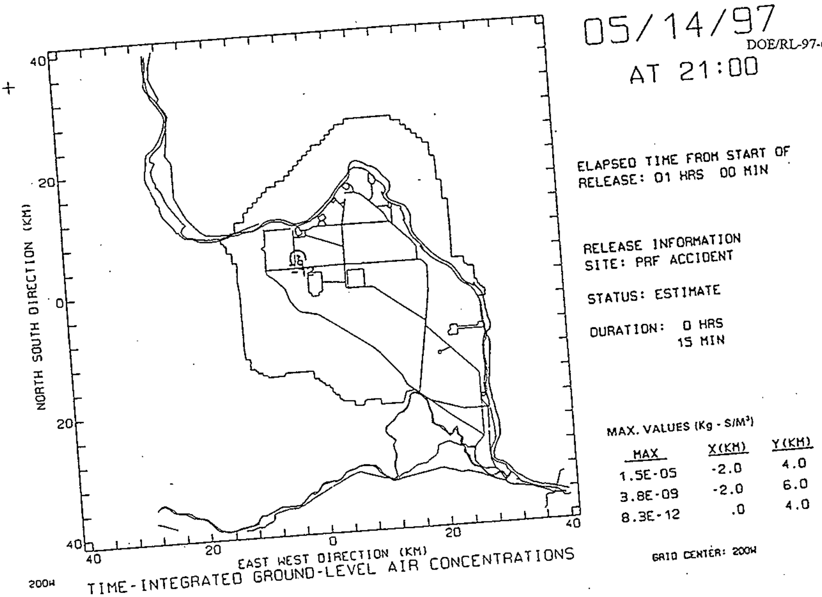

Figure D.32. PRF Roof Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 21:00 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas at 14 m above ground level. Note that the total release from the roof is currently estimated at only about 1% of what is used in this simulation. Exposure for a specific contaminant can be estimated by multiplying model results by an actual contaminant emission total (in kg) and then dividing by 60 kg. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

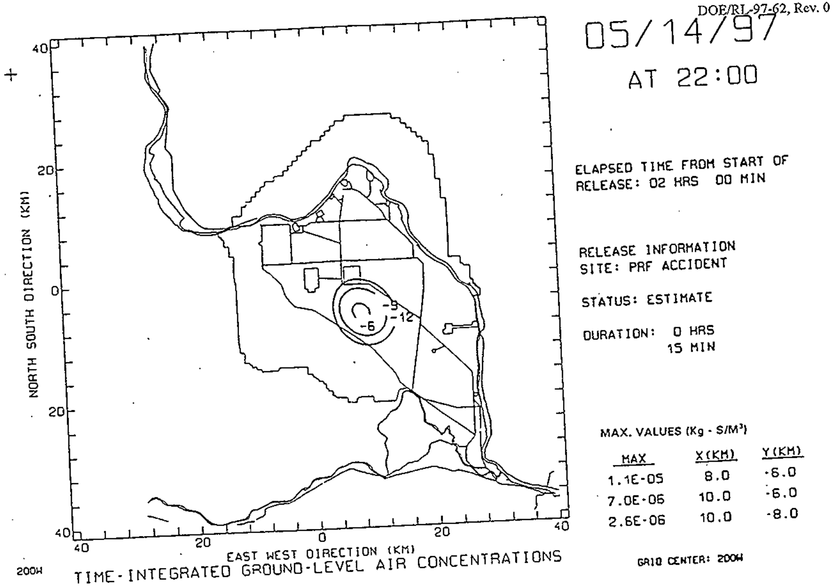

Figure D.33. PRF Roof Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 22:00 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas at 14 m above ground level. Note that the total release from the roof is currently estimated at only about 1% of what is used in this simulation. Exposure for a specific contaminant can be estimated by multiplying model results by an actual contaminant emission total (in kg) and then dividing by 60 kg. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., -12 = 10^{-12} kg-s/m³, -9 = 10^{-9} kg-s/m³).

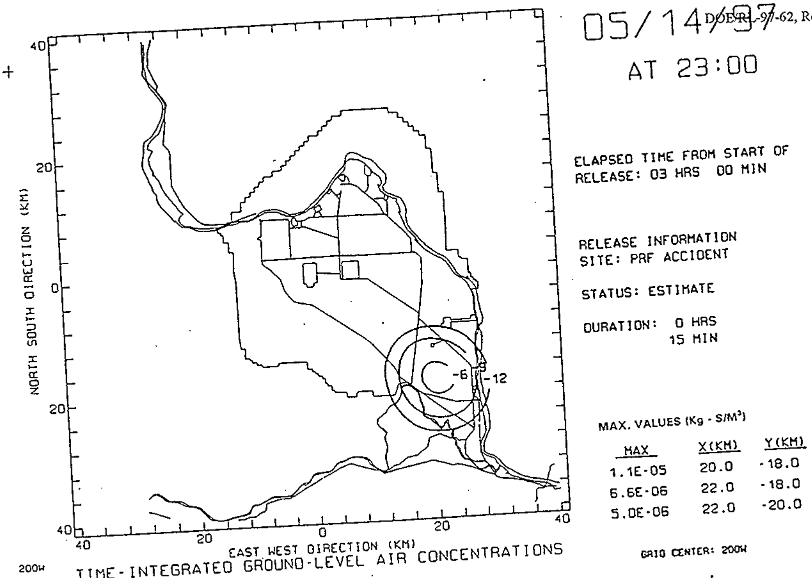

Figure D.34. PRF Roof Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at 23:00 PDT. This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas at 14 m above ground level. Note that the total release from the roof is currently estimated at only about 1% of what is used in this simulation. Exposure for a specific contaminant can be estimated by multiplying model results by an actual contaminant emission total (in kg) and then dividing by 60 kg. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., -12 = 10^{-12} kg-s/m³, -9 = 10^{-9} kg-s/m³).

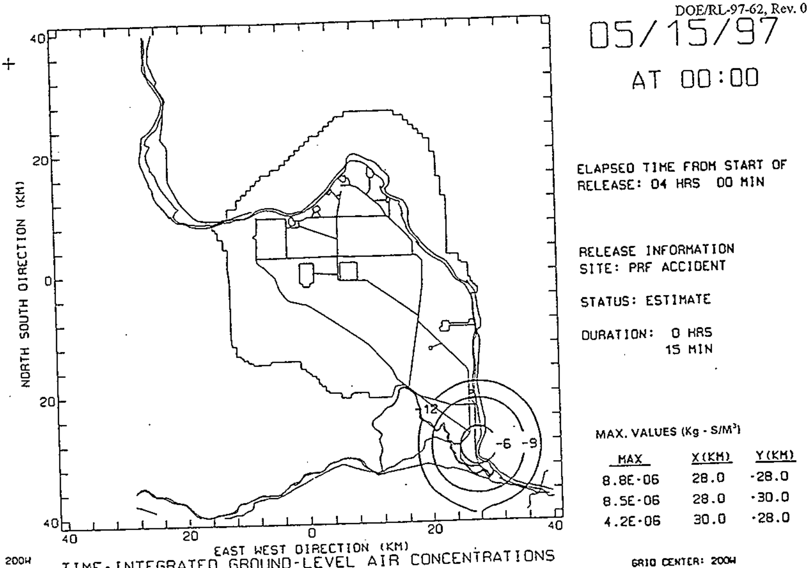

Figure D.35. PRF Roof Release: Time-Integrated Ground-Level Air Concentrations (Exposures) for the 15 Minutes Ending at Midnight (PDT). This simulation involves the release of 60 kg of a generic, non-reactive, non-depositing gas at 14 m above ground level. Note that the total release from the roof is currently estimated at only about 1% of what is used in this simulation. Exposure for a specific contaminant can be estimated by multiplying model results by an actual contaminant emission total (in kg) and then dividing by 60 kg. Exposures are measured in units of kg-s/m³. Contours are plotted for every three order of magnitude change in exposure (e.g., $-12 = 10^{-12}$ kg-s/m³, $-9 = 10^{-9}$ kg-s/m³).

D.2.4 Health effects associated with HAN, HNO_3 and explosion by products

Health effects for chemicals that were potentially involved in the PRF explosion are shown in the following table (D.14).

FORMULA	CHEMICAL NAME	WARNING PROPERTIES	EXPOSURE EFFECTS
NO_X	Oxides of nitrogen	Colorless or reddish brown gas, sweet or sharp odor	Nitrogen oxides (nitric oxide and nitrogen dioxide) are respiratory irritants with relatively low water solubility. The primary site of toxicity is the lower respiratory tract. Low concentrations initially may cause irritation, mild shortness of breath and cough. At higher concentrations, after a period of hours to days, victims may suffer temporary narrowing of the bronchi and accumulations of fluid in the lungs. Inhalation of very high concentrations can rapidly cause burns, spasms, swelling of tissues in the throat, upper airway obstruction, and death. Nitrogen oxides are skin irritants and corrosives depending on dose. Skin moisture in contact with high concentrations of nitrogen dioxide vapor can result in nitric acid formation, which may lead to second- and third-degree burns. Nitric acid may also cause yellowing of the skin. Obstruction of the bronchioles with high dose may develop days to weeks after severe exposure. Patients suffer malaise, weakness, fever, chills, progressive shortness of breath, cough, hemorrhage of the lungs or bronchioles, blue or purple coloring of the skin, and respiratory failure.
NO	Nitric Oxide	Colorless gas with a sharp, sweet odor	Nitric oxide changes to nitrogen dioxide in air. Exposure of animals to nitric oxide has caused drowsiness, unconsciousness, and death. (See oxides of nitrogen, above, for lower level exposure effects).
NO_2	Nitrogen Dioxide	Dark brown gas with a pungent, acrid odor	Exposure to high concentrations of nitrogen dioxide may cause severe breathing difficulties which are usually delayed in onset and which may cause death. (See oxides of nitrogen, above, for lower level exposure effects).
N_2O	Nitrous Oxide	Colorless, sweet-tasting gas	Exposure to very high levels of nitrous oxide can result in anesthetic effects. Exposure to pure nitrous oxide can result in death by asphyxiation.
$N_2H_4O_4$	Hydroxylamine Nitrate	Colorless, odorless	Corrosive to eyes and mucous membranes. Skin irritant. Skin may become sensitized. Soreness under fingernails. May develop skin rash.
HNO_3	Nitric Acid	Colorless to brown gas, irritant	Nitric acid vapor or mist is an irritant to the eyes, nose, throat, and skin. Liquid nitric acid or high concentrations of nitric acid vapor may cause severe burns of the eyes with permanent damage.

In summary, most of the agents are eye, skin, and respiratory tract irritants. Nitrogen dioxide dissolves slowly in water to form nitric acid, which is potentially irritating to corrosive depending on dose.

D.2.5 Exposure limits associated with HAN, HNO_3 and explosion by products

The table (D.15) below presents information for chemical releases from the explosion at the PRF facility relative to occupational exposure limits. The following abbreviations are used in this table:

- 8 hr - the average level of a chemical for an eight hour period, Time Weighted Average.
- STEL - Short Term Exposure Limit - The average level of a chemical that should not be exceeded for a 15-minute period during the workday.
- CEIL - Ceiling - Level of a chemical that should not be exceeded at any time during a workday.
- OSHA - Occupational Safety and Health Administration, Permissible Exposure Limit.
- ACGIH - American Conference of Governmental Industrial Hygienists, Threshold Limit Value.

Formula	Chemical Name	Peak Level, ppm from Modeling* (ground)	ACGIH Limits	OSHA Limits
NO_x	Oxides of Nitrogen	-----	See individual gases below	See individual gases below
NO	Nitric Oxide	0 ppm (due to oxidation to NO_2)	22 ppm (8 hr)	25 ppm (8 hr)
NO_2	Nitrogen Dioxide	7.8 ppm (15 mg/m3)	3 ppm (8 hr) 5 ppm (STEL)	5 ppm (CEIL)
N_2O	Nitrous Oxide	2.2 ppm (4.0 mg/m3)	50 ppm (8hr)	-----
$N_2H_4O_4$	Hydroxylamine Nitrate	1.0 mg/m3	-----	-----
HNO_3	Nitric Acid	9.5 ppm (25 mg/m3)	2 ppm (8 hr) 4 ppm (STEL)	2 ppm (8 hr)

* The peak values shown in this table are based on the roof release of chemicals and represent peak concentration at ground level from Table D.11. The dispersion modeling results indicated that the roof/wall release is the only significant source of exposure. These levels would have existed only for a very short time (seconds), and would have dissipated to insignificant or very low levels at the PFP facility within 10 minutes according to the modeling results.

By comparing the Peak Level column with the ACGIH and OSHA columns, the predicted maximum concentration at ground level can be compared with existing standards. It can be seen that the peak levels for nitric acid and nitrogen dioxide are above ACGIH STEL values. However, as noted in the footnote of the table, this concentration existed for only a few seconds, while the STEL averages the concentration over a 15 minute period. Thus, the STEL (and 8 hr limits) for all contaminants would not have been exceeded in areas of potential occupancy based on the modeling results. Nitrogen dioxide also exceeded the 5 ppm OSHA ceiling value, which should not be exceeded as an exposure to an employee at any time during a workday.
It should be understood, however, the peak levels would have occurred within seconds (i.e., 75 seconds) after the

explosion. Therefore, in terms of location and timeline, workers in all likelihood would not have experienced the peak exposure even briefly. Therefore, exposures above STEL and ceiling levels would not have been possible for the workers on the ground.

Also, for the roof/wall release, the highest predicted levels were used for both nitric acid and nitrogen dioxide. In reality, both could not exist at these levels simultaneously, because one would convert to the other in a relative balance.

D.2.6 Hydrazine Tank Located Above Tank A-109

A glass HZ tank was located directly above Tank A-109. This tank was shattered in the explosion. It had once contained hydrazine, but was confirmed to be empty prior to the time of the explosion. The most recent verification that it was empty was in July, 1996. The tank is believed to have been empty since the late 1970's. (D1) (D3).

D.2.7 Other Chemical Storage Tanks Located in Room 40

The concern was raised that the Tank A-109 incident may have affected the integrity of other chemical storage tanks in Room 40 which could contain hazardous chemicals. A review of the photographs taken and the video footage indicate that the force of the reaction was up and towards the entry of room 40. This is evidenced by the fact that the plastic containers of dry chemicals stored on the west wall were undisturbed while the entry doors on the east wall were buckled out.

A review of the photographs and video footage indicates that only two tanks (other than Tank A-109) appeared to be affected from the incident. First, Tank 109A (HZ tank), a glass tank located directly above Tank A-109, was shattered. The upper and lower flanges were identified in the photographs. This had once contained Hydrazine, but it was verified empty prior to the incident (see Section D.2.6). The only other tank that appears to have been affected was Tank A-104. This tank which has roughly the same dimensions as Tank A-109 was moved about 6 inches to the east as identified on the photographs. The tank is mounted to a pair of I beams that sit on a scale. The photographs show that the drain line is intact. The tank integrity does not appear to have been compromised. The tank was verified to have been empty prior to the incident.(D13)

It can be concluded, therefore, none of the other tanks appear to have been affected and that no other types of tank chemicals were released to the atmosphere.

D.2.8 Other Chemicals Stored in Room 40

A review of the presence and integrity of other chemicals stored in Room 40 was conducted. On May 15, May 16, and June 2, 1997, entries were conducted into Room 40 by a PFP Industrial Hygienist to inspect the chemical storage and tank chemical atmosphere readings. No apparent damage was noted to any chemical containers. On June 20, 1997, an assessment of the chemical risks associated with Room 40 was conducted using the last known inventory of chemicals stored in Room 40. That assessment showed that no incompatibilities existed within specific storage locations. On June 25, 1997, an entry was made into room 40 to confirm the chemical inventory and conduct an inspection of conditions. All inventories were confirmed to be correct with the exception of three intact items found in the desk (two containers of quick-n-brite cleaner and one can of light brown liquid). These containers were placed in the toxic chemical storage cabinet. All storage containers were confirmed to be in good condition with no leaks or breaks apparent.(D13)

It can be concluded, therefore, that no chemicals other than Tank A-109 contents were involved in the incident and released to the atmosphere.

D.2.9 Asbestos Containing Materials Located in Room 40

An asbestos physical inspection was conducted of PRF (building 236-Z), Room 40, on September 25, 1996. Approximately 310 lineal feet of Thermal System Insulation (TSI) which was in good condition was located on piping in the overhead. Additionally, there were 495 square feet of non-friable transite located in the room in the form of wall panels. Friable asbestos is asbestos that can easily release asbestos fibers into the air if it is disturbed; whereas, non-friable materials do not readily release fibers.(D13)

Following the explosion in Room 40, an AHERA Asbestos Inspector viewed the video tape taken during initial entries to document damage. He also held discussions with the Industrial Hygienist, Engineers, and others who had entered the space. The asbestos containing TSI covering the piping in Room 40 and corridor 30 on the third floor appeared to be intact. Transite panels in Room 40 were severely damaged, including breakage with pieces laying on the floor. However, the material is not likely to release significant amounts of asbestos fibers. Based upon his professional judgement as an asbestos inspector and worker, he determined that there was not currently a problem with friable asbestos, and initial entries did not pose a significant risk of disturbing any Asbestos Containing Material (ACM) so that it would become airborne in concentrations exceeding the OSHA 8-hour Permissible Exposure Limit of 0.1 fibers/cc.(D13)

To confirm that there was no asbestos hazard, personal air samples were taken for asbestos using lapel samplers. On April 30, 1997, a 55 minute sample showed an asbestos fiber level of 0.05 fibers/cc. Another sample, collected on June 2, 1997 for 52 minutes, indicated an asbestos fiber level of 0.08 fibers/cc. A bulk sample, collected on June 2, 1997, was analyzed using polarized light microscopy and indicated 5-10% chrysotile asbestos.(D12)

To date, all entries to Room 40 have been made while wearing Self Contained Breathing Apparatus (SCBA). Additional precautions/sampling will be undertaken once cleanup efforts are initiated.(D13)

During the explosion when the transite was damaged, it is reasonable to assume that a small amount of fibers were released to the area as a result of breaks in the material. However, the material was not pulverized, so even in a damaged state, fiber release from transite should be relatively minor. Additionally, releases from room air through the roof/wall breaches would have only occurred for about 5 seconds until negative pressure was re-established. Although the transite cleanup will be a hazard to be controlled during the recovery of PRF, it is not considered to have been a hazard outside of the PRF following the explosion incident.

D.2.10 Summary of Personal/Area Monitoring Conducted in Room 40

The following sampling results were taken using Sensidyne and Drager colorimetric detector tubes and an Industrial Scientific TMX 412. All samples were taken by a PFP Industrial Hygienist. Initial sampling on the night of the incident was based upon availability of sampling media and knowledge that chemicals of concern in Room 40, were mostly acids. Sampling conducted on June 2, 1997 was based upon a review of the chemical inventory for the room and an inspection of the chemical storage cabinets on previous entries.

On May 15, 1997 at approximately 0450, sampling was conducted for HNO_3 at the northwest corner of Room 40 between Tank A-109 and the acid cabinet. The reading was non-detectable. Limitations of this sample were due to security restrictions. The TMX was operated continuously for oxygen, Lower Explosive Limit (LEL), and Carbon Monoxide (CO). No readings other than normal (20.8% oxygen, non-detectable CO, 0.0% LEL) were encountered.

On May 16, 1997 at approximately 1530, a chemical sample was taken for HNO_3 at an arms reach in Tank A-109 using 3 pump strokes. The reading was 1.66 ppm. A second sample was pulled at an arms reach in Tank A-109 using 1 pump stroke. The reading was 2.0 ppm.

On June 2, 1997 at approximately 1120, the following samples were taken:

- Reading 1, NO sample in front of acid and toxic cabinet.
- Reading 2, NO_2 sample over Tank A-109 from catwalk.
- Reading 3, NO_2 sample over Tank A-109 from catwalk.
- Reading 4, HNO_3 sample over/in front of Tank A-109 from opposite catwalk.
- Reading 5, H_2SO_4 sample in front of acid cabinet (only Drager tube).
- Reading 6, CCl_4 sample over CCl_4 tank.
- Reading 7, CCl_4 sample at approximately 2 feet above floor in front of CCl_4 tank.

All results were non-detectable.(D13)

In summary, the samples taken within the tank approximately 1.5 days after the explosion show some residual nitric acid levels at or around the occupational exposure limit, which would be expected from an "in-tank" sample. Samples taken in the general area show no detectable residual levels of the chemical agents and reaction products. This too would be expected since these agents should have been quickly exhausted through the ventilation system.

D.3 Summary of Chemical Hazards

All evidence regarding chemical hazards points to the major chemical constituents of Tank A-109 and their by-products from the explosive reaction as the only credible substances which could have been released from PRF resulting in a possible worker exposure. No evidence was found to indicate that any other chemical agents could have been released from the explosion in quantities of significance to worker health. No other tanks that contained chemicals and no other chemical sources were found to have been disturbed to the point of releasing their contents. Any other tanks or containers that were disturbed were empty. Asbestos in the form of non-friable transite was damaged. Although this is a hazard to be controlled during the cleanup and recovery of PRF, it is not considered to have been a hazard to workers outside of PRF, and could not account for worker symptoms.

Tank A-109 contained an aqueous solution of nitric acid and hydroxylamine nitrate. Unreacted portions of these agents could have been released as aerosols or gases by the explosion. By-products from the explosive reaction would include oxides of nitrogen (released as gases) and again nitric acid. The oxides of nitrogen include nitrogen dioxide, nitric oxide, and nitrous oxide, of which nitrogen dioxide would be of greatest concern.

With the exception of nitrous oxide, all of the other agents are irritants, which would produce irritation to the eyes, nose, throat, and skin, cough, and other symptoms related to the respiratory and cardiovascular systems.

Release of these agents from PRF would have occurred through the 291-Z-1 Stack and through small breaches in the building roof and roof/wall interface. The roof and roof/wall interface breaches totaled approximately 0.5-1 square feet in area. The stack was observed to vent gases for several minutes. It is estimated that the roof/wall breaches would have released agents during only the initial few seconds (perhaps 5 seconds) after the explosion until the negative pressure of the building was restored. This is consistent with observations, as the stack was noted to vent the yellowish brown gas (nitrogen dioxide) for a period of time, while no gas was observed to be venting from the building itself.

Dispersion modeling was conducted based on known information regarding tank contents, chemical reactions, release points, atmospheric conditions, as well as various assumptions. Modeling included release points from both the PRF roof and the 291-Z-1 Stack. Results of the modeling indicated the release from the stack was of no significance regarding concentrations at PFP ground level. However, release from the roof could have produced a short-lived, maximum concentration of approximately 7.8 ppm nitrogen dioxide and 9.5 ppm nitric acid in potentially accessible areas within the PFP complex at ground level. These peak concentrations would occur within a minute or two of the explosion and would dissipate rapidly.

Based on the modeling data, had workers entered the area of maximum concentration at the exact peak time after the incident, exposure to nitrogen dioxide could have exceeded the OSHA ceiling level for a few seconds. Exposure to nitric acid could have momentarily exceeded the STEL value, but over a 15 minute period would have been well below the STEL (STEL is based on a 15 minute exposure). Peak exposures would have been possible for only a brief period (probably seconds). However, since the workers exited the trailer to go to 234-5Z Building approximately 15 minutes after the incident, the peak concentration would not have been encountered, and any residual levels would have been quite low. Therefore, the dispersion modeling shows the possibility of exposure for workers on the grounds to be at low levels, well below occupational exposure limits.

The one employee who could have experienced a very brief peak concentration at levels shown in Table D.11 was the Patrolman stationed on the 234-5Z roof at the time of the incident. The Patrolman reported a brief but strong chemical odor, very shortly after the explosion.

A low level exposure, particularly in sensitive individuals, may possibly result in symptoms reported by the toxicological and occupational medical literature as irritating to the skin, mucous membranes, or upper respiratory tract. Some of the symptoms and findings noted by some workers following the incident such as headache, cough, sore throat, skin eruptions, and eye irritation are consistent with exposure to nitric acid. Symptoms and findings that possibly could occur with such an exposure and total dosage would be predicted to resolve in 5-7 days without long term effects.

In summary, modeling indicates that nitric acid, nitrogen dioxide, and nitrous oxide were released as a result of the explosion. It is estimated that exposures at ground level resulting from this incident were brief, were well below the occupational exposure limits as an 8-hour average and 15 minute STEL. Symptoms experienced by some of the workers in the area are consistent with exposure to nitric acid.

APPENDIX E

RADIOLOGICAL HAZARDS

The following is a review of the radiological conditions surrounding the Plutonium Reclamation Facility (PRF) incident of May 14, 1997. The explosion of tank A-109 and resulting water from the rupture of the fire suppression sprinkler branch line mobilized some of the contamination in the facility resulting in minor changes in the radiological condition of the facility. This review constitutes a summary of the radiological data generated by the Plutonium Finishing Plant (PFP) radiological controls organization as well as other radiological controls organizations who supported the response to this incident. Table E.1 provides a summary of the radiological data collected as a result of the PRF incident.

E.1 Source of Potential Radiological Hazard

The PRF is a thirty-three year old facility which was designed for the primary function of producing plutonium from plutonium bearing scrap. This facility, and its supporting buildings, historically processed significant amounts of plutonium. Room 40 was used for non-radioactive chemical makeup and storage for PRF processing. Consequently, during the operational life of the facility, various systems and areas have become contaminated due to historical operational errors or upset conditions.

On January 11, 1985, a spill in the Chemical Preparation Room (40) at the PRF resulted in residual amounts of plutonium remaining on the floor surface and catch basin area after decontamination. The residual contamination was fixed in place. This low level of residual contamination contributed to the contamination of the fire protection water from the overhead pipe severed in the explosion.

The Senior Radiological Protection Technologist (RPT) who responded to the incident the morning of January 11, 1985 recalled that approximately 200 to 500 ml of highly acidic solution with 1 to 5 grams of dissolved plutonium was accidentally pumped into the catch basin area. The affected surfaces were subsequently decontaminated as much as practical and then covered with multiple coats of epoxy based, industrial paint to immobilize the remaining residual contamination. Other sources of contamination that may have contributed to the changes in the radiological conditions of the facility are multiple areas of legacy contamination deposited in normally inaccessible locations such as behind and under equipment, on overhead structures and piping, and in cracks and crevices.

E.2 Potential Radioactive Discharges

E.2.1 Room Air Sampling

Two types of room air samplers are used to routinely monitor occupational air quality for airborne radioactive material in the PRF. These two types of samplers are fixed head samplers and Continuous Air Monitors (CAM). The primary purpose of these samplers is to detect an airborne release of radioactive material. These samplers were in operation before, during, and after the incident until at least 9 p.m. on the evening of May 14, 1997.

Analysis of the PRF filter media removed from the sample heads and CAMs, as well as analysis of the strip chart recorder data, revealed there had been a short-term increase in airborne contamination in some areas of the facility separated from Room 40. At all of the 54 air sampling locations in PRF, the measured radioactivity was less than 1% of the annual limit for occupational workers and, at 42 of the 54 locations, the measured radioactivity was less than 0.1% of the annual limit. From the CAM strip chart recordings the duration of this airborne condition can be estimated at 15 minutes.

It is important to note that no one was in the PRF at the time of the event. However, if a worker had been in the facility during the time in question the workers could have received an intake ranging from 0% to 1% of the annual limit for occupational workers.

Given the possibility of dislodging legacy contamination in the adjoining PFP building from the PRF explosion, all air sampling results from the PFP's building air monitoring system were reviewed for possible increased levels of airborne contamination. All air sample results (approximately 500 samples) for this time period revealed no increased levels of airborne contamination. Additionally, radiological management at PFP has reviewed building contamination surveillances and have found no increases in contamination levels.

E.2.2 Air Filtering and Stack Sampling

The PRF air is exhausted through high efficiency particulate air (HEPA) filters before traveling to the PFP exhaust stack. The air travels through PRF exhaust ducts to the main plenum in the PFP building where it is mixed with the PFP air that has also gone through HEPA filtration. The air is then drawn by the exhaust fans through the exhaust stack facility and exhausted at a rate of approximately 240,000 cubic feet per minute (cfm) through an exhaust stack that is 200 feet tall.

The PRF building exhaust duct is monitored by a CAM downstream of the in-line HEPA filters. The day of the incident, this sample was removed and subsequently analyzed on May 16, 1997. Results of this sample analysis did not indicate any detectable radioactivity.

Additionally, the exhaust stack effluent air sample filter was removed on May 16th for analysis. The analysis of this sample did not indicate a release of radioactive airborne effluent from the stack above that which is normal. The strip chart recorder from the exhaust stack CAM also indicated no unusual variation in activity during the time period of the May 14th incident.

E.2.3 The PRF Roof Breach and Exterior Doors

As a result of the explosion, the roof above the fourth floor of the PRF was deformed and breached and an exterior door (door 108A) from the first floor change room was blown open for three to five seconds creating potential secondary pathways to the environment. The change room, the change room door, and the area outside of the change room was surveyed on May 15, 1997 and found free of contamination. The breached roof area was surveyed on May 21, 1997 for contamination by taking measurements inside the hole, on cracks in the wall, on buckled flashing, and around the perimeter of the hole. Analysis of the roof measurements indicated no detectable levels of contamination.

The explosion exhausted through the hole in the roof and the change room door for a very brief period (3 to 5 seconds). The building ventilation system is designed to maintain a negative pressure on Room 40 relative to the atmosphere. Therefore, once the explosion pulse was depleted, the ventilation system returned the room to normal air flow. The fixed head sample filter located in Room 40 was analyzed and did not indicate any airborne radioactive contaminates available for release through the roof.

On May 16, 1997, a radiological survey was performed of Room 40 to determine the extent of the changes in the radiological conditions. Smears were taken in the room on the inside of tank A-109, A-109 tank cover, A-109 tank exhaust, acid cabinet, flammable cabinet, tank 104 scale, and the walls of the room. All smears were analyzed and indicated no detectable levels of contamination. Additionally, personnel protective equipment utilized to enter and equipment used to record the condition of Room 40 was surveyed for contamination and was found to have no detectable activity.

E.2.4 Environmental Monitoring

At approximately 11 p.m. on May 14, 1997, DynCorp and Bechtel Hanford (BHI) field monitoring teams began conducting surveys in the plume path to ensure no contamination of the environment occurred. During the initial field survey, the DynCorp and BHI field monitoring teams retrieved environmental air samples at several locations outside the facility and performed contamination surveys of the ground at these sample locations. The DynCorp teams covered areas south and east of the facility all the way to the 300 area. The BHI team covered areas north and northeast of the facility and collected three additional air samples located at the 100 B/C reactor complex, which was in the path of the original plume as indicated by meteorology data recorded during and immediately after the incident. Analysis of the environmental air samples and contamination surveys indicated no detectable levels of radioactivity above background.

One environmental air sample was not retrieved the night of the event but was subsequently retrieved on May 16th during routine sample collection. This sample location was significant in that it was located approximately three kilometers downwind of the facility. Analysis of this sample showed no increase of contamination above historical values.

Surveys were also conducted by facility personnel of the security perimeter of the facility. None of the contamination surveys conducted around the perimeter of the security area indicated any detectable levels of contamination.

E.2.5 Water Discharged Outside of the PRF Facility

The water from the severed fire suppression sprinkler branch line transported contamination from the catch basin under the A-109 tank. Other areas of legacy contamination along the flow path of the water may have contributed to the contamination of the water. In order to determine the extent of the contamination, fourteen (14) water samples were taken of the spill from various locations within the PRF. The highest concentration found was 390 pCi/liter from the catch basin under tank A-109. The results of the other water samples taken from within the facility ranged from no detectable radioactivity to 47 pCi/liters. Water samples and smears were also analyzed from inside A-109 and indicated no detectable levels of contamination.

Water flowed primarily from the fourth floor of the PRF down the stairwell and elevator shaft located immediately across the corridor from Room 40. The water flowed down the corridor connected to the PFP building and into piping tunnels under the PFP building. There was no detectable contamination in the PFP building resulting from this flooding.

Water also flooded under several PRF exterior doors and into the area surrounding the building. Initially, the flooded areas (roughly 20,000 square feet) were posted as contamination areas based on the assumption the flooding had moved contamination out of the building. Ground contamination surveys which included approximately 460 Tech smears, were performed outside the building when the water had receded or evaporated. Low levels of smearable (59dpm/100cm^2) contamination was found during these post incident surveys outside door 112 along with fixed contamination (This door is the furthest from the source of water). Two other areas (outside doors 109 and 120) had indications of low levels of fixed contamination (4,800 dpm/100cm^2 maximum). None of the other survey points indicated detectable activity.

E.3 Summary of Radiological Hazards

Radiological surveys conducted in Room 40 following the explosions have shown no changes in the radiological conditions. Low levels of radioactive contamination were transported in water within the PRF due to the flooding of the facility with fire suppression water. This flooding also spread into the adjoining PFP building and to the exterior of the PRF. Measurements of areas flooded with this water outside the PRF building did not reveal any large scale contamination. Small isolated areas of contamination were identified outside the PRF, however it is not possible to determine if these isolated areas of contamination were due to the incident or were pre-existing.

A short-term transient increase in airborne radioactivity was indicated at various locations within the PRF separated from Room 40. (It is important to note that the building was not occupied at the time of the explosion.) This increase in airborne radioactivity would equate to a maximum intake of less than 1% of the annual limit for occupational workers if an individual were exposed to these concentrations. Analysis of the airborne effluent discharges, environmental air samples, environmental contamination surveys, and Room 40 air sample results all show no detectable airborne radioactivity was released to the environment.

A review of the potential secondary impact of the explosion on the radiological condition of the PFP building was evaluated. Reviews of the air monitoring and contamination surveillance programs within the facility indicated no discernable changes in the PFP's radiological condition.

Additionally, to date, results from the workers monitored by bioassay have shown no detectable internal deposition.

Table E.1 Summary of Radiological Data Gathered in Support of Radiological Conclusions

DESCRIPTION	LOCATION	DATA TYPE	POINTS	RESULTS
Contamination surveys	Grounds around PRF & PFP inside protected area	Technical smear and direct measurements	>300	Release of grounds
Contamination surveys	Flooded areas after water dissipated	Technical smears, direct measurements, large area wipes	>400	Release of areas back to Radiation Buffer Area status
Contamination surveys	Inside PRF	Technical smears, direct measurements, large area wipes	>200	Release of areas back to Radiation Buffer Area status
Water samples	Room 40, 242-Z corridor, other PRF locations	Water sample	14	Laboratory analyses confirming some very low level contamination present
Air samples	PRF	Fixed head and CAM air filter	54	Confirmed a short duration release in PRF (not from Room 40)
Air samples	PFP	Fixed head and CAM air filters	>400	Confirmed no airborne release in PFP as result of explosion
Environmental air samples	Environment around PFP protected area	Fixed head	10	Confirmed no airborne radioactive effluent release
Environmental contamination surveys	Plume path for potential release downwind of PFP	Technical smears, direct measurements, grab air samples	~30	Confirmed no airborne radioactive effluent release
Air samples	Ventilation downstream of HEPA filter	CAM and fixed head air filters	3	Confirmed no airborne radioactive effluent release
Personnel contamination surveys	Initial entry personnel and operator in change room	Direct measurements	~4	Confirmed no spread of radioactivity in PRF facility
Contamination survey	Damaged PRF roof	Technical smears and large area wipes	7	Confirmed no contamination present on externally damaged portion of PRF

APPENDIX F

ENVIRONMENTAL EVALUATION

A review of the regulatory requirements and the actions taken by facility personnel after the explosion has resulted in a determination that while the contingency plan was implemented after the explosion, notifications to regulatory agencies were delayed.

WAC 173-303-350 Contingency Plan and Emergency Procedures states, "(1) Purpose. The purpose of this section and WAC 173-303-360 is to lessen the potential impact on the public health and the environment in the event of an emergency circumstance, including a fire, explosion, or unplanned sudden or nonsudden release of dangerous waste or dangerous waste constituents to air, soil, surface water, or ground water by a facility. A contingency plan must be developed to lessen the potential impacts of such emergency circumstances, and the plan must be implemented immediately in such emergency circumstances."

- The regulation provides that the contingency plan be implemented immediately in the event of an explosion at a TSD Facility. The Hanford Site is a TSD Facility.
- Notification of the event was not made immediately in a manner consistent with the regulations and the contingency plan.
  - Attempts to notify Ecology approximately 3 ½ hours after the event were unsuccessful since Ecology does not staff a 24-hour emergency notification capability within the Nuclear Waste Program Office except via a telephone answering machine.
  - Ecology was notified as soon as possible the next morning and has been kept fully informed since that time.
  - Notifications required by WAC 173-303-360(2)(d) regulations did not immediately occur because plans/procedures were inconsistent.

Even in circumstances where the contingency plan is not implemented, but a spill or discharge of a dangerous waste or hazardous substance into the environment occurs, notification may be required by WAC 173-303-145. Under WAC 173-303-145, immediate notification to Ecology as well as to local authorities in accordance with the local emergency plan is required when there is a spill or discharge of a dangerous waste or hazardous substance into the environment such that human health or the environment is threatened. A hazardous substance (oxides of nitrogen) may have been released to the air during this incident. Ecology also requires that all spills and discharges that have to be reported under Federal law shall also be reported to Ecology as directed in their "Spills Notification Rule Amended" Focus Sheet dated August 1992. If reporting is required under CERCLA, immediate notification is to be made to Ecology as well.

Rough, order-of-magnitude (ROM) calculations were completed to estimate the amount of materials released as chemical reaction products from the explosion. These calculations were based on June 1993 information provided in the report prepared by the accident investigation team (DOE/RL-97-59) and subsequent results from experiments performed by a Hanford Site scientist predicting reaction products from the explosion. These calculations indicate that quantities of oxides of nitrogen may have exceeded the reportable quantity threshold under CERCLA.

- Observations indicate that NO_2 was present in the stack release in visible concentrations. For purposes of determining whether the explosion may have triggered CERCLA reporting, it was necessary to estimate the amount of NO_2 released. In order to estimate the amount of NO_2 that may have been released, it was assumed that almost all nitric acid was broken down to NO_2. Based on this assumption the ROM calculation indicate a total of approximately 35 pounds of NO_2 could have been released.

- This estimated amount exceeded the 10 pound reportable quantity threshold for NO_2 under CERCLA.

- While the materials originally stored in Tank A-109 did not exceed a CERCLA reportable quantity level, it is conservatively appropriate to report that the potential reaction by-product substance NO_2 may have exceeded its reportable quantity. The release of NO_2 was not immediately reported. Notification to the National Response Center concerning the release was made on July 11, 1997.

- The documents used by the facility emergency response organization do not specifically identify a need to report in this circumstance and do not contain any criteria, information, or methodology that could have been used to help determine if a reportable quantity threshold had been exceeded.

- Lack of post-event chemical monitoring data also hampered release evaluations.

An airborne release to the environment requiring reporting under WAC 246-247 occurred via a short duration airborne gaseous release with a color that is consistent with the appearance of nitrogen oxides. The transient, abnormal condition also changed the facility operations for a short period time by causing a momentary positive pressure in Room 40. Notification to the Washington Department of Health (WDOH) was required under WAC 246-247-080(5) since the conditions which occurred, if corrections had not taken place, could have resulted in a release of unfiltered airborne radiological emissions through the small holes in the roof caused by the event.

- No actual airborne release of radioactivity is known to have occurred. Even though no airborne release was confirmed, WDOH was notified of the explosion and potential release and participated in the emergency response action.

- WDOH was notified within the 24-hour time frame required by WAC 246-247 although this need is not clearly defined under the emergency preparedness documents.

APPENDIX G

DEFINITIONS

1. **Alert:** An emergency class within the Operational and Energy categories of emergency. Within the Operational Emergency category, an Alert represents events in progress or having occurred which involve an actual or potential substantial reduction for the level of facility safety and protection. Any environmental release of hazardous materials are expected to be limited to small fractions of the appropriate Protective Action Guideline (PAG) or Emergency Response Planning Guideline (ERPG) onsite. During an Energy Emergency, an Alert represents an event which has occurred or is in progress that is noteworthy; the potential impacts are not expected to be serious; and a negligible long-term, supply impact is anticipated.

2. **Consequence Assessment:** The evaluation and interpretation of radiological or other hazardous materials measurements and other information to provide a basis for decision making.

3. **Corrective Actions:** Those measures taken to terminate or mitigate the consequence of an emergency at or near the source of the emergency.

4. **Emergency:** The most serious event and consists of any unwanted operational, civil, natural-phenomenon, or security occurrence which could endanger or adversely affect people, property, or the environment.

5. **Emergency Action Level (EAL):** Specific, predetermined, observable criteria used to detect, recognize, and determine the emergency class of Operational Emergencies. An EAL can be: an instrument reading; and equipment status indicator; a measurable parameter, onsite or offsite; a discrete, observable events; results of analyses; or another observed phenomenon that indicates entry into a particular emergency class.

6. **Emergency Class:** A subset under the categories of emergency (Operational, Energy, Continuity of Government). The class further differentiates an emergency by the degree of severity, depending on the actual or potential consequence of the emergency situation. For the Operational and Energy Emergency subcategories, the classes are: Alert, Site Area, Emergency, and General Emergency. For the Continuity of Government (COG) subcategory, the three classes are: Crisis Monitoring, Emergency Response, and Recovery and Reconstitution.

7. **Emergency Operations Center (EOC):** A central facility from which management and support personnel carry out coordinated emergency response activities. The emergency operations center may be a dedicated facility or office, conference room, or other predesignated location having appropriate communications and informational materials to carry out the assigned emergency response mission and located, where possible, in a secure and protected location.

8. **Emergency Plan:** A brief, clear, and concise description of the overall emergency organization, designation of responsibilities, and procedures, including notifications, involved in coping with any or all aspects of a potential credible emergency.

9. **Emergency Planning Zone (EPZ):** A geographic area surrounding a specific DOE facility for which special planning and preparedness efforts are carried out to ensure that prompt and effective protective actions can be taken to reduce or minimize the impact to onsite personnel, public health and safety, and the environment in the vent of an Operational Emergency.

10. **Emergency Preparedness:** The training of personnel, acquisition and maintenance of resources, and exercising of the plans, procedures, personnel, and resources essential for emergency response.

11. **Emergency Response:** The implementation of planning and preparedness during an emergency involving the effective decisions, actions, and application of resources that must be accomplished to mitigate consequences and recover from an emergency.

12. **Emergency Response Organization (ERO):** The designated group(s) of personnel responsible for coping with and minimizing or mitigating the effects of an emergency.

13. **Emergency Response Planning Guidelines (ERPGs):** A hazardous material personnel exposure level or range which, when exceeded by a short term or acute exposure, will cause irreversible or other serious health effects in humans. The ERPGs are approved by a committee of the American Industrial Hygiene Association.

14. **Event:** Any real-time occurrence or significant deviation from planned or expected behavior that could endanger or adversely affect people, property, or the environment.

15. **Facility:** Any equipment, structure, system, process, or activity that fulfills a specific purpose. Examples include accelerators, storage areas, fusion research devices, nuclear reactors, production or processing plants, coal conversion plants, magnetohyrodynamics experiments, windmills, radioactive waste disposal systems and burial grounds, testing laboratories, research laboratories, transportation activities, and accommodations for analytical examinations of irradiated and unirradiated components.

16. **General Emergency:** One of the classes on emergencies in the Operational and Energy Emergency categories. Within the category of Operational Emergency, a General Emergency represents events which are in progress or have occurred that involve actual or imminent catastrophic degradation of facility protection systems, or catastrophic failure in safety or protection systems threatening the integrity of a weapon or test device which could lead to substantial offsite impacts. Any environmental release of hazardous materials can reasonably be expected to exceed the appropriate PAG or ERPG exposure levels offsite. Within the category of Energy Emergency, a General Emergency is an event which has occurred that has major energy supply impacts. Examples of such events are a major electrical energy system outage affecting consumers in more than two states or an earthquake affecting the United States or a U.S. territory that measures over 7.1 on the Richter Scale.

17. **Hazardous Materials:** Any solid, liquid, or gaseous material that is toxic, flammable, radioactive, corrosive, chemically reactive, or unstable upon prolonged storage in quantities that could pose a threat of life, property, or the environment. This definitions is applicable to DOE 5500 series Orders; it is an omnibus term used to include both "hazardous materials" as defined by the Hazardous Materials Transportation Act and "hazardous substances" as defined by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

18. **Incident Command Post:** A term describing a safe location near the event scene where emergency responders from different organizations may co-locate to coordinate emergency response actions.

19. **Joint Information Center (JIC):** A centralized facility where organizations responding to an emergency coordinate the release of accurate and timely information to the public and the media and provide a central source for all instructions. A JIC is operated cooperatively by all responding levels of Federal, state, tribal, and local governments and organizations and the involved facility.

20. **Lockdown:** A security measure whereby security forces restrict ingress and egress to the facility until the protection of classified material can be verified. Employees are directed to restrict their movement inside the facility and to proceed to the nearest building, if possible, and standby.

21. **Molar (M):** An expression, based on molecular weight, of a chemical concentration usually in one liter of aqueous solution (moles per liter of a substance in solution). For instance one mole of nitric acid weighs 63 grams (its molecular weight). Therefore, 1 M HNO_3 is equivalent to 63 grams per liter, or about 6.3% (by weight, assuming specific gravity of water).

22. **Occupational Exposure Limit (OEL):** The lower value between the PEL and TLV, which is the limit adopted by DOE.

23. **Offsite:** The area beyond the boundaries of the site.

24. **Onsite:** The facility/site area over which the Lead Federal Agency has access control authority. The onsite area includes any area that has been established as a National Defense Area or National Security Area.

25. **Patrol Operations Center (POC):** A continuously staffed communications location that serves as the Hanford Patrol's site wide command and communications center in normal and emergency situations. The POC handles all 911 calls for the Hanford Site and ensures a coordinated emergency response for fire, medical and law enforcement. In addition, the POC also conducts initial notifications to the offsite agencies during declared emergencies on the Hanford Site.

26. **Permissible Exposure Limit (PEL):** The exposure limit established by OSHA for specific chemical and physical substances. Limits as 8-Hour TWA, STEL, and Ceiling concentrations are established as PELs, defined similarly as their TLV counterparts.

27. **Protective Action:** Physical measures, such as evacuation or sheltering, taken to prevent potential health hazards resulting from a release of hazardous materials to the environment from adversely affecting employees or the offsite population.

28. **Recovery:** Actions taken after a plant has been brought to a stable or shutdown condition to return the plant to normal operation.

29. **Safety Analysis:** A documented process to systematically identify the hazards of a DOE operation; to describe and analyze the adequacy of the measures taken to eliminate, control, or mitigate identified hazards; and to analyze and evaluate potential accidents and their associated risks.

30. **Site Area Emergency:** One of the classes of Emergency in the Operational and Energy categories. Within the context of an Operational Emergency, a Site Area Emergency represents events which are in progress or have occurred involving actual or likely major failures(s) of facility safety or safeguards systems needed for the protection of onsite personnel, the public health and safety, the environment, or national security. Any environmental releases of hazardous materials are not expected to exceed the appropriate PAG or ERPG exposure levels offsite. Within the Energy Emergency category, a Site Area Emergency represents an event in which a substantial supply impact is anticipated.

31. **Source Term:** The amount of material available for release.

32. **Special Nuclear Material (SNM):** Plutonium, uranium-233, uranium enriched in isotope 233 or 235; any material artificially enriched by any of these elements; or any other material which the NRC, pursuant to the provisions of Section 51 of the Atomic Energy Act, determined to be special nuclear material, not including source material.

33. **Take Cover:** A protective action which directs Hanford employees to go inside the nearest building, close all exterior doors and windows, secure the ventilation systems, report their location, and to standby for further instructions from the emergency response organization.

34. **Threshold Limit Value (TLV):** Refers to airborne concentrations of substances and represents conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. TLVs are established by the American Conference of Governmental Industrial Hygienists (ACGIH).

35. **TLV - Ceiling (TLV-C):** The concentration that should not be exceeded during any part of the working exposure. (A limitation on this limit is the time required to monitor for the substance; if instantaneous monitoring is not possible, a 15 minute or shorter average may be required.)

36. **TLV - Short Term Exposure Limit (TLV-STEL):** The concentration to which workers can be exposed continuously for a short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, or 3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded. A STEL is defined as a 15-minute TWA exposure which should not be exceeded at any time during a workday even if the 8-hour TWA is within the TLV-TWA.

37. **TLV - Time Weighted Average (TLV-TWA):** The time weighted average concentration for a conventional 8-hour workday and 40-hour work week, to which nearly all workers may be exposed, day after day, without adverse effect.

38. **Unified Command:** A command structure used to respond to an emergency involving a hazardous facility on the Hanford Site where the Building Emergency Director (BED) and the Incident Commander (IC) share equally in the decisions made at the incident command post regarding event mitigation activities and coordination of resources. The IC and BED will discuss strategies, conduct briefings, and ensure each is informed of activities within their areas of responsibility.

APPENDIX H

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APPENDIX I

ACCIDENT INVESTIGATION AND EVALUATION TEAM*

DOE-RL	FDH	BWHC	OTHERS
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* The above lists those individuals primarily responsible for investigating the emergency response activities and developing the report associated with the May 14, 1997 event at the Plutonium Reclamation Facility. Numerous other personnel provided technical and administrative support to the development of the report.