APPENDIX B

CONTAMINATION RISK AND LABORATORY ANALYSIS

B1.0 RISK ASSOCIATED WITH CONTAMINATION

The workers, general public, and environment were never at significant risk for health and safety effects from this incident. The very small amount of contamination carried by each insect resulted in low, dispersed levels of contamination that presented no significant health risk.

Radiological contamination is radioactive material, in any chemical or physical form, that is outside the controlled containment of a capsule, tank, or other device designed to confine it. The Hanford Site contains large amounts of radioactive material left over as waste from the weapons production mission of the last five decades. The Project Hanford Management Contract (PHMC) team is stabilizing and cleaning up this waste in all its forms and placing it in secure storage. Many processes, including natural chemical and biological forces, can release the waste from containment, enabling it to enter the environment. The policies and procedures of the PHMC team have a primary goal of providing effective surveillance programs and equipment to prevent contamination spread and of detecting and immediately containing any unexpected release.

The spread of contamination by fruit flies had not been seen in the 200 East Area to this time. Fruit flies (like other animals) can pick up radioactive material in the form of a light powder or dust or a liquid that would dry into a powder or dust on their bodies if the place where the flies eat, lay their eggs, or develop as larvae is contaminated with radioactive material. When the fly lands, the contamination will come off on whatever it touches, and if the radioactive material is in the food or drink of the animal, the radioactive material will be excreted though normal body processes. The contamination is then left on the surface of a material that can be transported to another location or picked up by a person. This small amount of material can be eaten or inhaled if blown into the air, or can stick to a person's clothing or skin. If the contamination is ingested or inhaled, the radioactive material intake will expose the individual from the inside and is called internal exposure. If the contamination ends up on the skin, it will produce external exposure. These exposures are the hazards, and the risks from the radioactive contamination are proportional to the type of radiation and its exposure.

B1.1 INTERNAL CONTAMINATION EXPOSURE IMPLICATIONS OF THE INCIDENT

During the extensive bioassay monitoring performed on Site employees who worked in the vicinity of the event, no instances were identified where onsite personnel received measurable radiation exposure from this spread of contamination. Conservative bounding calculations indicate that the potential radiation exposures from this spread of contamination are not significant to either workers or members of the public.

Strontium urinalyses were performed for workers who worked in the 241-ER-152 Diversion Pit and the area behind B Plant during and preceding the time of the spread of contamination by fruit flies. Worker internal exposure was a concern initially because some of these workers spent most of their workday in facilities in this area working and even eating their lunches. In the workers tested who were most at risk for inhaling or ingesting contamination, no indication of any intake of radioactive materials has been found in cesium-detecting whole-body counts or strontium urinalysis bioassays. These bioassays are extremely sensitive, capable of detecting radioactive material with a resulting dose of far less than 1 millirem.

Elevated contamination levels were found in some fruit flies. In one extreme instance approximately 260 nanocuries of strontium-90 (^{90}Sr) were found on 9 contaminated fruit flies that were captured in the same flying-insect trap. Ingestion of all 9 fruit flies would result in a 50-year committed-effective-dose equivalent of approximately 34 millirem. By comparison, the average member of the public receives 360 millirem of background radiation exposure each year, of which 39 millirem come from naturally occurring radioactive potassium-40 (^{40}K) in the body.

An evaluation of impact was performed for recovering radioactive contamination that was transported to the City landfill as a result of this incident[1]. This evaluation concluded that the unabated offsite dose to the maximum exposed individual from removing this contamination from the City landfill and transporting it back to the Hanford Site was 3.33×10^{-3} millirem per year (0.003 millirem per year). It was postulated that if the contamination in the landfill were to spread, it would be transported as blown dust.

B1.2 EXTERNAL SKIN DOSE IMPLICATIONS OF THE INCIDENT

No case is known of fruit flies transferring any radioactive material to the skin of a person at the Hanford Site. However, a conservative scenario for such an occurrence would consist of a fly landing on a person's skin and being crushed such that all the radioactive material from the fly would be transferred to the person's skin. Based on the analysis measurements of the quantity of radioactive material on the nine trapped fruit flies mentioned above, a single fruit fly would contribute about 0.03 microcuries of radioactive material (^{90}Sr) to the skin of the person. If that material stayed on that spot on the skin for a week, the total dose to a small area of skin would not be sufficient to produce any noticeable effect to the skin (National Council on Radiation Protection (NCRP) Report No. 106, pages 10-11[2]). A more plausible scenario for contamination exposure to the skin would be for a small percentage (5 to 10 percent) to be left by the fly on a surface from which it would be spread over some area of skin, which again would not produce a noticeable effect to the skin.

Any loss of control of contamination is considered unacceptable and results in every reasonable effort to prevent and control any contamination spread.

[1] Letter, Anita J. Frankel, U.S. Environmental Protection Agency, to J. E. Rasmussen, RL, "Notification of Approval for Construction in Recovery of Radioactive Material from the Richland Landfill at the 200 Areas of the Hanford Site," WMH-9858724, dated October 8, 1998.

[2] National Council on Radiation Protection (NCRP) Report No. 106.

B2.0 DATA ANALYSIS REPORT

B2.1 INTRODUCTION

From late September through early November 1998, an approximately 2.5 hectare (6.2-acre) area at the Hanford Site's 200 East Area came under intense scrutiny to determine the source of an unexpectedly high number of radioactive contamination discoveries. The area is immediately southwest of B Plant and contains facilities and areas under the supervision of five different Hanford Site contractors or major subcontractors (Bechtel Hanford, Inc.; B&W Hanford Company; Lockheed Martin Hanford Corporation; DynCorp Tri-Cities Services, Inc.; and Waste Management Federal Services of Hanford, Inc.), four of whom, in addition to Fluor Daniel Hanford, Inc. (FDH), and the U.S. Department of Energy, Richland Operations Office, would have some involvement in the incident.

Biota-related transport of radioactive contamination had been observed and tracked in this area since at least 1982. Past monitoring records indicate that Russian thistle (*Salsola kali*), also known as tumbleweed, harvester ants (*Pogonomyrmex owyheei*), and deer mice (*Peromyscus maniculatus*) had been observed to be frequent contributors to contamination transport (i.e., vectors), often with significant loss of equipment and the need for expensive cleanup actions. The most recent (summer 1998) significant contamination spreads had been caused by deer mice at the 241-ER-151 Diversion Pit and at B Plant's K-3 Filter Pit Encapsulation Facility. Discovery of additional contamination at the nearby MO-967 Mobile Office, used as a lunchroom, was first thought to be related to these incidents.

Increased surveys found contamination in places not typical of mouse- or ant-caused contamination. The contamination was found to be associated with discarded food and food containers in places such as refuse cans, on walls, and in dumpsters. A radiological control technician (RCT) conducting a radiation survey at the lunchroom observed a speck of contamination fly away, alerting environmental monitoring personnel that a new vector for contamination spread had to be considered and new methods for survey had to be adopted. Fruit flies of the genus *Drosophila* were observed to be prevalent in the lunch trailer and throughout the area. Flying-insect traps baited with fruit were placed at each facility in the immediate area and near potential contamination sources in the 200 West Area. The traps at the southwest of B Plant in the 200 East Area quickly collected contaminated fruit flies, while those at the 200 West Area or at other 200 East Area locations did not. Only one contaminated fruit fly was discovered outside the immediate 2.5 hectare (6.2-acre) area. It was found at the U.S. Ecology site.

B2.2 PURPOSE

The Data Analysis team was formed to evaluate the radiological contamination data being collected as a result of the contamination event in and around the affected area and to determine the likely vectors for the spread of contamination and potential sources of contamination. The team also coordinated field-generated data and transmission of samples to, and reception of analytical results from the three laboratories conducting the analyses (the 100-K Spent Nuclear

Fuels Counting Facility, the 222-S Analytical Services of Waste Management Laboratories, and the 325 Radiochemical Processing Laboratory).

B2.3 BACKGROUND AND DESCRIPTION OF THE EVENT AND AFFECTED AREA

On September 28, 1998, numerous cases of low levels of radioactive contamination were found outside areas established for contamination control. The discovery, on September 28, of contamination in and around the MO-967 Mobile Office was the product of increased surveillances being performed in response to numerous discoveries of contamination in the area over the previous 60 days. These discoveries included contaminated ant mounds, a contaminated beetle, mouse droppings in a lunchroom in B Plant, a high-contamination area caused by contaminated mouse feces discovered under the hood of a government truck, and contaminated deer mice at several locations.

The affected area totaled approximately 2.5 hectares (6 acres) and is located just south of B Plant in the 200 East Area. Facilities in the area include the B Plant K-3 Filter Pit Encapsulation Facility; several offices and change and lunchroom facilities such as the MO-967 Mobile Office; the 241-ER-151 and 241-ER-152 Diversion Pits; the 2245-B Sheet Metal Shop; and the 2247-B Ironworker's Shop.

Contamination also was discovered off Site during a survey of an employee's home, where socks worn at work were discovered with very low levels of contamination. This survey was initiated after the employee's work boots were found to be contaminated during a routine exit survey.

Subsequent investigations resulted in the discovery that contaminated refuse had been delivered to the City of Richland Landfill. Preliminary investigations, based on the nature of the waste and the isotopic mix of the contamination, suggested that the contamination found in the City landfill likely originated from the 241-ER-152 Diversion Pit and was spread to foodstuff, refuse, and other locations directly by fruit flies and secondarily by cross contamination. While isotopic analyses of fruit flies found only strontium and cesium, two mice captured in the contaminated area at this time showed a 1:1 strontium-to-cesium ratio and included other radionuclides including europium, plutonium, and uranium.

B2.4 ISOTOPIC FINGERPRINT AS A TOOL TO IDENTIFY SOURCES OF CONTAMINATION

It is a reasonable practice to attempt to use isotopic fingerprints (the qualitative identification of the isotopic species in combination with their quantitative ratios) to help identify where and/or when contamination has occurred and to determine if the suspect material is from a specific event or location. In this incident the only radioactive isotopic species identified in significant-enough quantities to obtain reliable counting statistics were cesium-137 (^{137}Cs) and ^{90}Sr/yttrium-90 (^{90}Y). Some samples showed trace amounts of alpha contamination (<10 disintegrations per minute). The ratios of strontium and cesium differed widely in the affected areas (from approximately 3:1 to 184:1). Because of this broad range, the

contamination has no readily identifiable fingerprint that allows the material to be verified as being from a common source. However, because many of the samples had ratios well in excess of what is "normal" (1:1 to 1:5) for the 200 Areas, it was suspected that something unusual had occurred in the area at or around the time of discovery.

B2.5 VECTOR DESCRIPTIONS AND EXAMPLES

The team identified several vectors that could have caused the findings of radioactive contamination in and around the affected area. These include human- and work-related events and activities, deep-rooted vegetation, rodents, ants and other burrowing insects, and flying insects (fruit flies). Each of these vectors has had an effect on the contamination status of the affected area.

B2.5.1 Human- and Work-Related Events.

Operations in the area over the last 55 years clearly have affected the contamination status. Recently a contamination spread occurred as a result of ongoing work at the 241-ER-152 Diversion Pit. Contamination resulting from releases originating from the B Plant stack and filter change-outs also is well documented. These events have resulted in the direct spread of contamination in the affected area. These spreads that occurred in the last decade all are well documented and were remediated when they were first discovered.

B2.5.2 Vegetation.

The spread of contamination resulting from vegetation growing into underground contamination and raising it to the surface is well documented at the Hanford Site. Tumbleweeds and other vegetation have contributed to the contamination in the affected area. Some limited discoveries of contaminated vegetation occurred in the area, but no evidence has been found of contaminated vegetation contributing directly to contamination spreads in the immediate area in this case.

B2.5.3 Mammals.

The role of mice and other rodents as vectors of contamination spreads is well documented. The most prevalent mammals involved in spreading radioactive contamination are house mice, deer mice, and cottontail rabbits. Mammal-caused contamination spread can be in two forms. The first is the direct contamination spread via transfer of contamination from the skin surface to the surroundings if the mammal is externally contaminated from direct contact with loose contamination. The second can be the result of the animal ingesting contaminated foodstuffs and depositing contaminated excreta throughout an area.

Mammal-caused contamination spread in and around the affected area has a long history. The contamination spread at the B Plant K-3 Filter Pit Encapsulation Facility was the result of

rodents entering the filter box and ingesting contaminated materials, as well as receiving external contamination. Mice and their feces were identified as the causative agents during the heightened awareness of the affected area before the primary contamination event. It has been reported that the individuals whose boots were contaminated stated that they had to "dump" mouse feces out of their boots that had been stored in the 2247-B Ironworker's Shop. While contaminated rodents clearly have infested this area recently, no conclusive evidence has been found of current contaminated-rodent infestation in this area beyond residual contamination left by mouse feces.

B2.5.4 Ants and Other Burrowing Insects.

Another prevalent biological vector for contamination spread in and around the affected area is burrowing insects such as harvester ants. The contamination can result from the insects bringing back to their nest or consuming contaminated food materials or burrowing into contaminated soils.

The affected area has had numerous identified contamination spreads as a result of ant and burrowing-insect activities. During the time in question, this vector was evaluated and several contaminated anthills were identified in the affected area. Because of differences in isotopic ratios, it appears that the majority of the contamination was the result of ants bringing contaminated soil or mouse feces to their mounds.

B2.5.5 Fruit Flies.

The fruit fly is a new biological vector of radioactive contamination. Inspections after the incident indicated that fruit flies had access through small holes to the 241-ER-152 Diversion Pit. Fruit flies could have had access to the pit during work activities that took place on September 15. The fruit flies probably emerged and contaminated the MO-967 Mobile Office and nearby garbage dumpsters and other facilities sometime after September 25, 1998. The flies continued to be a contamination source in the area for several weeks.

B2.5.6 Human Vectors and Cross Contamination.

The human vector and subsequent cross contaminations are not an independent source of contamination, but rather a secondary contamination of items and locations that likely resulted from human contact. Examples of this include the September 29 discovery of a contaminated door on a van (G41-40356) used by ironworkers, a hard hat found contaminated in the same room with a worker's contaminated lunch bag (RSRSS249379), a contaminated boot and accompanying socks discovered on September 29, and a contaminated floor mat discovered in front of a hand and foot monitor on October 4.

B2.6 CORROBORATING AND CIRCUMSTANTIAL DATA.

Discussions with some of the RCTs who performed the surveys of the MO-967 Mobile Office and dumpsters, the affected area release survey, and surveys at the City landfill, revealed that they felt that the bulk of the contamination should be attributed to the fruit flies. They described the contamination as very spotty, small localized areas of contamination, normally associated with where foodstuffs were present or where transfer of food and juices occurred. They reiterated that other avenues for contamination were present in and around the affected area and that they had identified contaminated gloves, mouse feces, and anthills.

The boot and sock contamination incidents cannot confidently be associated with any specific contamination pathway. The owners of the boots, who leave the boots in the 2247-B Ironworker's Shop during nonworking hours, stated that they have found mouse feces in their boots. However, no recently discovered contaminated mouse feces have been identified as coming from the 2247-B Ironworker's Shop. The boots had not been worn in contaminated areas for several weeks before the event. However, the boots may have been contaminated by a fruit fly as they hung on the wall of the 2247-B Ironworker's Shop.

B2.7 CONCLUSION

Although several biotic vectors of radioactive contamination in the area southwest of B Plant have been identified (e.g., tumbleweeds, ants, beetles, mice, rabbits), both current field observations and sample analysis data indicate that fruit flies contacting contamination in the 241-ER-152 Diversion Pit were the primary vector involved in the radioactive contamination that reached the City landfill in September 1998. Even so, the historical data and the recent event indicate the need to better understand the biological vectors and to better control the spread of contamination from these sources.

B2.8 RECOMMENDATIONS

- Create an integrated program that cuts across contractor boundaries for monitoring and cleaning up contamination under the control of FDH. The goal is to prevent recontamination of areas that have been cleaned and prevent the contamination of currently clean areas.

- Integrate contaminated pest (vegetation and animal) control into a proactive program rather than responding to problems on a facility-by-facility "budget-available" basis.

- Better coordinate and use existing surveillance and monitoring resources.

- Implement communication between contractor monitoring groups and overall PHMC environmental monitoring groups.

- Create a clearinghouse for sharing existing sources (e.g., annual environmental reports, historical contamination documents) of contamination incident status to include FDH, all major subcontractors, and other Site contractors.

- Establish procedures for timely resolution of contamination spread problems.

- Develop an integrated approach to handling all environmental contamination data using standard terminology, reporting format, and expectations.

- Develop a mechanism to ensure complete and timely isotopic analysis of environmental contamination data.