NUREG-1028

Ruptured Cesium-137 Well-Logging Source at Shelwell Services, Inc., Hebron, Ohio

U.S. Nuclear Regulatory Commission

Region III

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U.S. Nuclear Regulatory Commission
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ABSTRACT

This U.S. Nuclear Regulatory Commission (NRC) report documents the circumstances surrounding the September 13, 1983, cesium-137 sealed source rupture incident at the Shelwell Services, Inc., facility in Hebron, Ohio. It focuses on the period from approximately 4:00 p.m. (EDT) on September 13, 1983, when the source ruptured, to October 5, 1983, when the radiological emergency response aspects of the event were concluded. Information outside these periods is recounted as necessary. The incident resulted in radiation doses to two licensee employees that exceeded the regulatory limits for whole-body and extremity exposures, and contamination of the licensee's facility, private residences, public buildings, and the personal effects of the licensee's employees, families, and friends. The emergency response required the combined efforts of NRC, U. S. Department of Energy, and state personnel. The report describes the factual information and significant findings associated with the event and, thereby, provides a data base for subsequent detailed analyses and recommendations by various NRC offices.

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C WIPE TEST RESULTS FROM A HIGHLY CONTAMINATED HOME

D SOURCE/SOURCE HOLDER DIMENSIONS AND EXTREMITY EXPOSURE CALCULATIONS

E SIEMENS FILM BADGE RESULTS

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G NRC LETTER DATED OCTOBER 25, 1983, CONCERNING DECONTAMINATION OF DRAIN TILE

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ABBREVIATIONS

AHP	Applied Health Physics, Inc.
ALARA	as low as reasonably achievable
AP	Associated Press
ARMS	Aerial Radioactive Monitoring Survey
CFR	Code of Federal Regulations
DOE	Department of Energy
dpm	disintegrations per minute
EG&G	EG&G, Inc., Energy Measurement Group
FEMA	Federal Emergency Management Agency
G-M	Geiger-Müller
HP	health physics
IRC	Incident Response Center
MPBB	maximum permissible body burden
NES	National Energy Services, Inc.
NMSS	Office of Nuclear Materials Safety and Safeguards (NRC)
NRC	Nuclear Regulatory Commission
ODSA	Ohio Disaster Service Agency
OSHA	Occupational Safety and Health Administration
PAO	public affairs officer
PIO	public information officer
PN	Preliminary Notification
RAP	radiological assistance program
RAT	radiological assistance team
RSO	radiation safety officer
SSI	Shelwell Services, Inc.
UPI	United Press International

1 INTRODUCTION

1.1 Purpose and Objective

This report documents the circumstances surrounding the September 13, 1983, cesium-137 sealed source rupture incident at the Shelwell Services, Inc. (SSI), facility in Hebron, Ohio. It focuses on the period from approximately 4:00 p.m. (EDT) on September 13, 1983, when the source ruptured, to October 5, 1983, when radiological emergency response efforts were concluded. The report provides the details of the source rupture event including cause, effect, licensee actions, and institutional (offsite agencies) response with resultant findings and conclusions. The primary objective of this report is to stress the potential deleterious and financial consequences of such an event and to convey the importance for well-logging licensees to establish safe techniques for handling licensed material and sound health physics practices. This report also identifies apparent generic problems associated with well-logging operations and provides a data base for subsequent detailed analyses.

1.2 Background

This report is the product of an NRC task force composed primarily of representatives from the Region III office. The task force received assistance from U.S. Department of Energy (DOE) Radiological Assistance Teams (Battelle Columbus Laboratory and Monsanto's Mound Laboratory), the Ohio Disaster Services Agency, and NRC and licensee contractors. The information documented in this report was developed through observations, measurements, interviews, and record reviews. The licensee (SSI) was not provided an opportunity to review or recommend changes to the report, but cooperated fully and provided data as requested.

1.3 Scope and Limitations

This report focuses on the September 13, 1983, source rupture incident at SSI in Hebron, Ohio, and subsequent institutional emergency response efforts. Emergency response efforts were those limited primarily to offsite radiation safety concerns, and include actions of the federal, state, and local agencies, and the licensee and his contractors. Emergency response efforts from initial identification of radiation safety problems and associated remedial actions through offsite contractor decontamination activities and confirmatory surveys are included. This report also includes the onsite safety concerns and partially covers the ongoing survey and decontamination efforts. It does not cover, in detail, licensee events that occurred before the source ruptured or after the emergency response efforts were completed and site decontamination efforts commenced. Appendices A through H amplify this report.

1.4 Licensed Activities and Inspection History

NRC Byproduct Material License No. 34-10445-01 was originally issued to SSI on October 27, 1964, and was last renewed in its entirety via Amendment No. 21 on June 24, 1982. The license initially authorized possession of millicurie

quantities of iodine-131 and scandium-46, in any form, for tracer studies in oil and gas wells at temporary job sites throughout the State of Ohio. Curie quantities of sealed sources were originally authorized for well-logging purposes via Amendment No. 2 on May 3, 1965, (an americium-beryllium neutron source) and via Amendment No. 8 on April 23, 1968 (cesium-137 gamma sources). The license currently authorizes up to 3 curies per americium-beryllium sealed source and up to 2 curies per cesium-137 sealed source. There is no limitation on the number of sealed sources the licensee may possess. Additionally, up to 25 millicuries of various radioisotopes, in any form, is currently authorized for oil and gas well tracer studies.

Over the last 19 years, the NRC had inspected the licensee seven times. Routine inspections performed in 1967, 1970, and 1973 resulted in two, one, and seven items of noncompliance, respectively. An unannounced inspection was attempted in 1976 but no licensee personnel were available. A concurrent investigation and inspection was conducted in February 1978 as a result of a reported lost source. This resulted in nine items of noncompliance and a $1,000 civil penalty for failure to secure licensed material stored in an unrestricted area. Routine inspections performed in 1979 and 1983 resulted in two and three items of non-compliance, respectively.

Licensed activities are performed at temporary field sites primarily in Ohio and Illinois and at the licensee's permanent facility east of Hebron, Ohio, on State Route 40. The licensee's Hebron, Ohio, facility consists of two large garage-type buildings (Buildings 1 and 2) and a trailer utilized as an office. Building 1 is the truck building, which served as the permanent storage facility for all licensed material and also housed the well-logging vehicles when not at field sites. The building contains a lockable pit located in its northwest section used for storage of radioactive material. Building 2 is the maintenance building where various machine and repair operations take place. See Figures 1 through 5. As shown in Figures 6 and 7, a residential trailer park is located northwest of the facility, approximately 150 yards from Building 2. (See also Figure 8, an aerial photo of the SSI facility and adjacent areas.)

Each building has a concrete slab foundation. The frames are wood and metal with corrugated metal roof and siding. Building 2 (the building in which the incident occurred) has no windows, two garage-type doors, two standard entrance doors, and two roof ventilators. At the entrance to SSI's access road is a frame building, leased from the State of Ohio Highway Administration, which SSI used for storage of nonradioactive materials (see Figures 1 and 9).

SSI employs approximately 40 individuals full time. At the time of the incident, 28 employees were in Ohio and 12 employees were in Illinois.

During the first 6 months of 1983, a total of 720 jobs was performed, including 300 well-logging jobs and 225 other jobs related to well-logging. The remainder (195 jobs) involved well-perforating activities. Well-logging jobs or those related to well-logging made up 73% of the total workload for the first 6 months of 1983. In 1982, a total of 1,824 jobs was performed; 1,222 were directly related to well-logging. Well-logging and related jobs made up 67% of the total work load for 1982.[1]

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[1]Information obtained from the licensee's response to the NRC Order dated October 17, 1983.

Figure 1. Shelwell Services, Inc.

Figure 2. Shelwell Building 2.

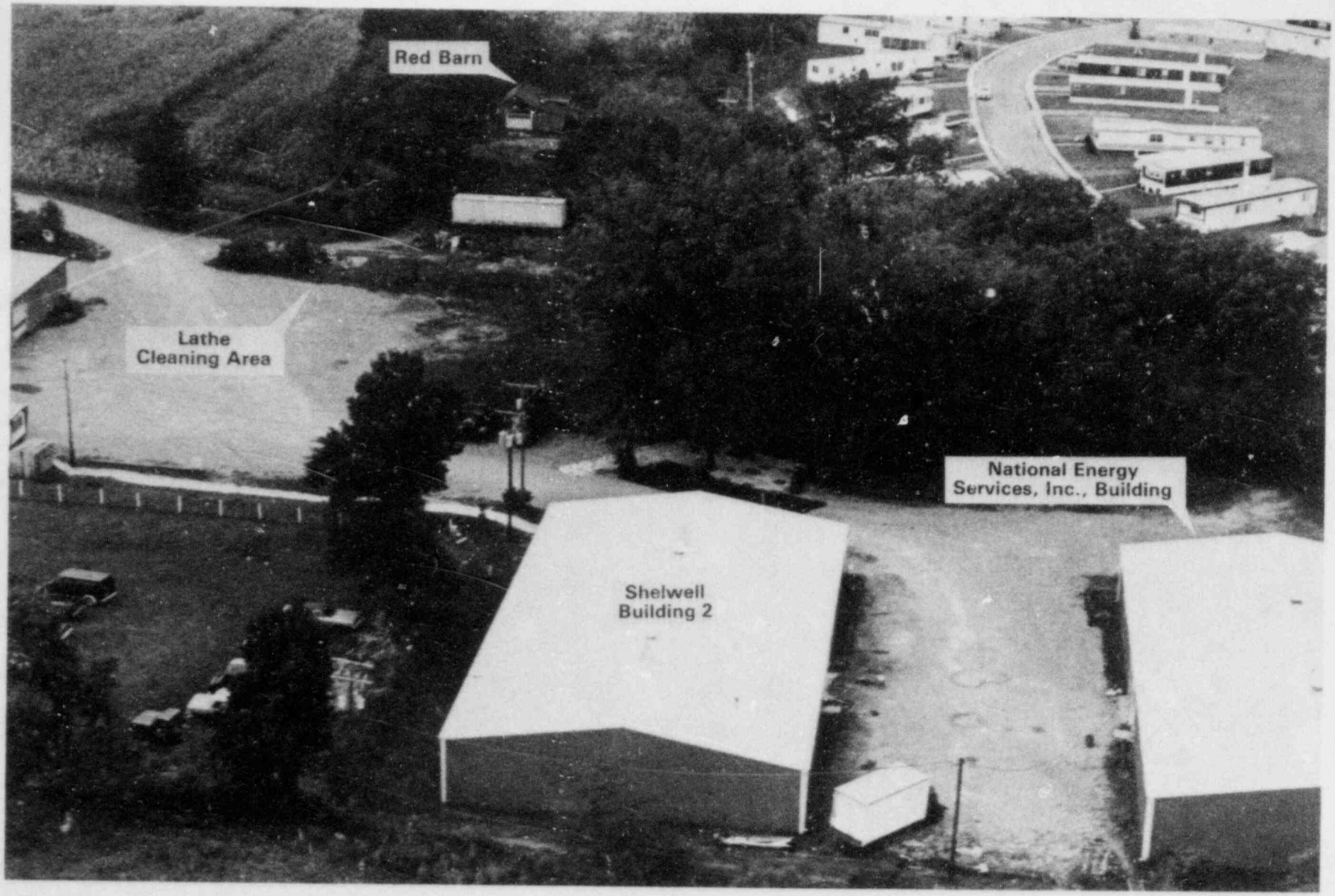


Figure 3. Shelwell Building 2, including the semi-trailer and barn.

Figure 4. Shelwell Building 1 and office trailer.

Figure 5. Shelwell Building 2

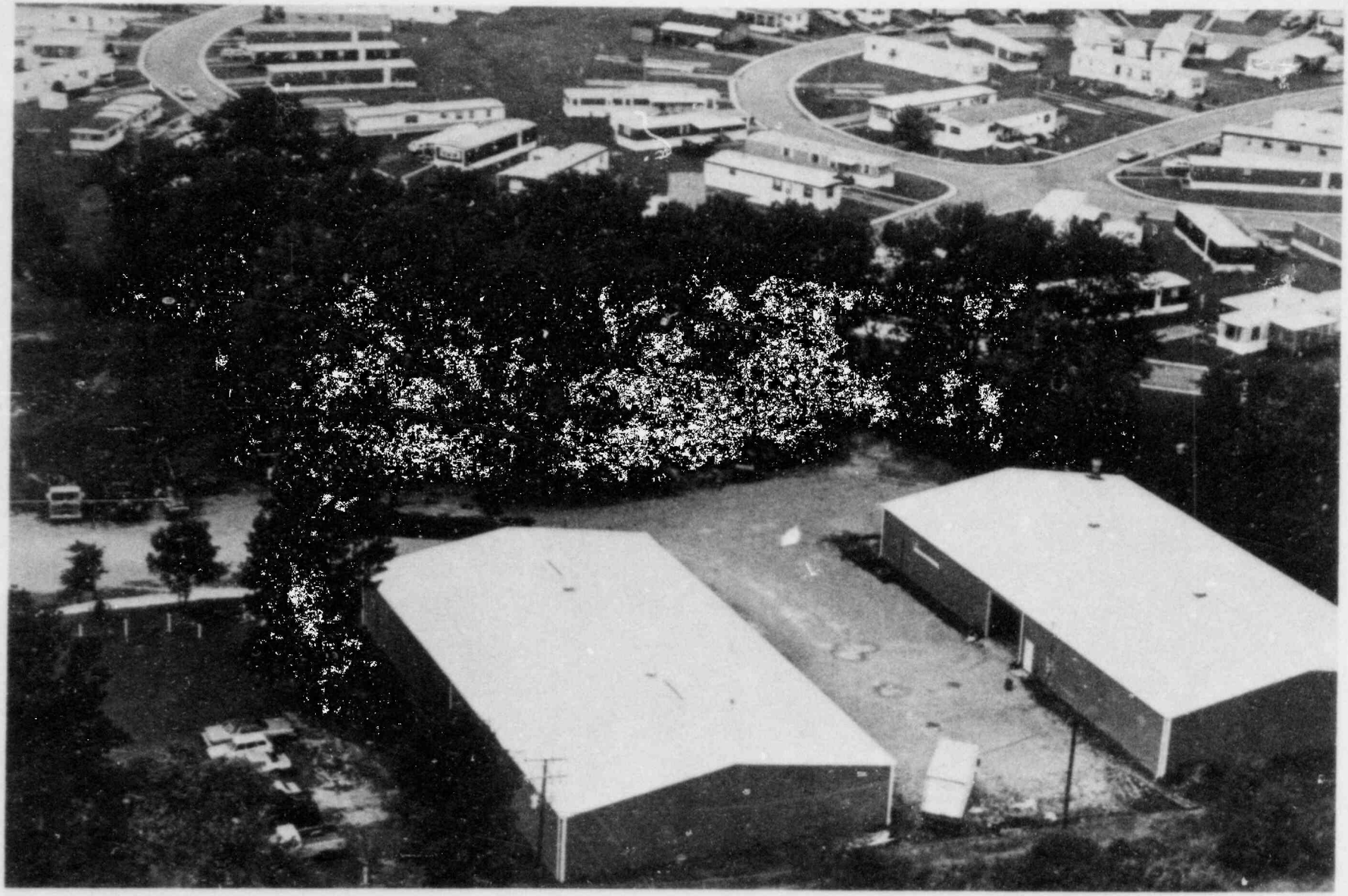


Figure 6. Trailer park adjacent to the Shelwell facility.

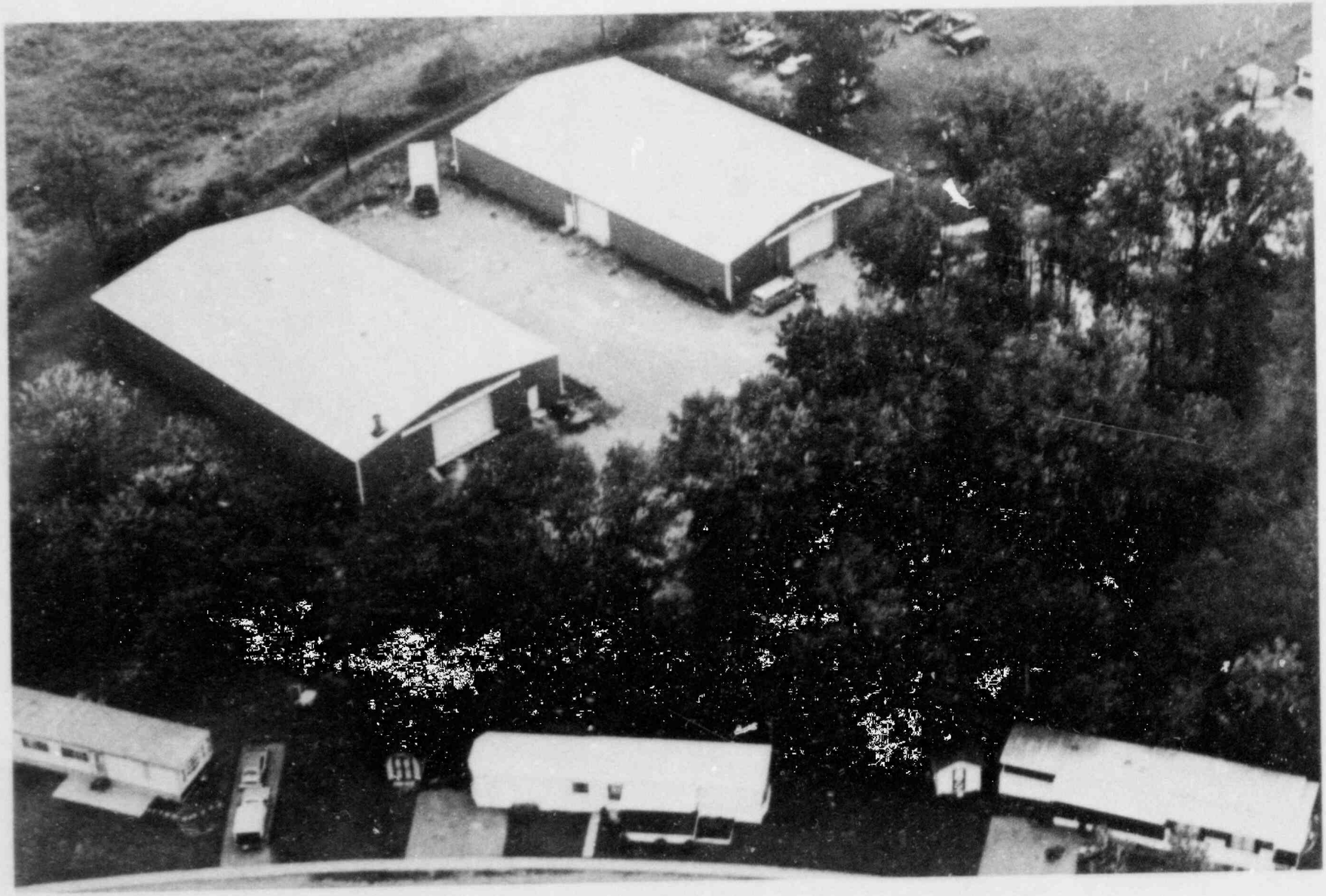


Figure 7. National Energy Services, Incorporated, Building, Shelwell Building 2, and trailer park.

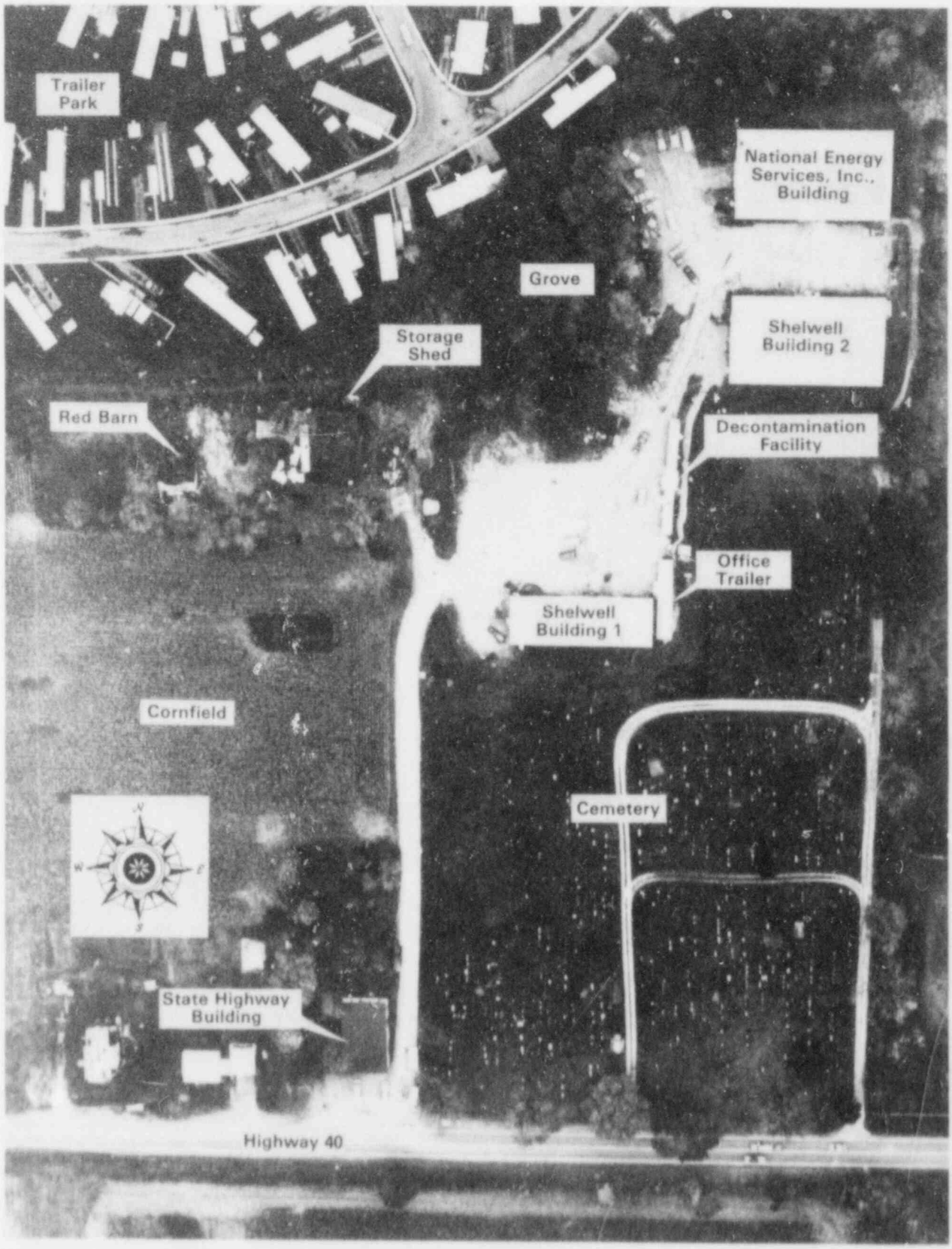


Figure 8. Aerial photograph of Shelwell Services, Inc., and adjacent areas.

Figure 9. Highway Building.

1.5 Well-Logging

Using a portable laboratory and truck-mounted rig, the well-loggers lower devices called logging tools to the bottom of a well on a wireline. As the tools are slowly reeled in the hole, they are able to measure (log) the properties of the formations they pass. A radiation log normally consists of two recorded curves: a gamma-ray curve and a neutron curve. Both indicate the types of rocks in the formation and the types of fluids contained in the rocks.

The gamma-logging tool portion consists of a detector with its associated electronics and a sealed radioactive source. The sealed source is mounted in a cylindrical holder whose dimensions vary, depending on the manufacturer. For the most part, source holders are not interchangeable from one logging tool to another. The gamma sealed sources used in well-logging are chosen to have a long radioactive half-life and to emit a high energy spectrum. Their activity ranges from a tenth to several curies (Ref. 1).

1.6 Executive Summary

1.6.1 Event Chronology

The licensee was attempting to remove a cesium-137 sealed source capsule from its holder and transfer it to another holder. The original source holder was a stainless steel cylinder approximately 2-1/2 inches long and 1-5/8 inches in diameter, housing a nominal 2-curie cesium-137 sealed source capsule in a form believed to be cesium chloride powder. Subsequently, the source remains were examined by Argonne National Laboratory and determined to contain a powdered

cesium-aluminum-silicate composition. The source holder was to be used in a well-logging density tool. The transfer was needed because the original source holder did not fit the logging tool SSI wanted to use.

Initial attempts to remove the source capsule occurred on Monday, September 12, 1983, at the licensee's facility in Hebron, Ohio; two of the licensee's employees injected penetrating oil into the cavity of the source holder, waited for the oil to take effect, and tapped the holder repeatedly against a hard surface. The licensee had successfully removed other source capsules from their holders on previous occasions using similar methods. These efforts continued unsuccessfully until they were abandoned on Tuesday afternoon, September 13. A new plan was developed and put into effect at about 4:00 p.m. (EDT) that Tuesday. Three employees were involved -- the president of SSI, a sales representative, and a machinist. The operation was performed in the licensee's machine shop (Building 2), which is a large metal-sided garage-type structure. It consisted of the following procedure:

(1) The source holder was mounted onto a lathe, the brass plug on the holder's cavity was removed, and the open end was placed in the lathe chuck (Figure 10).

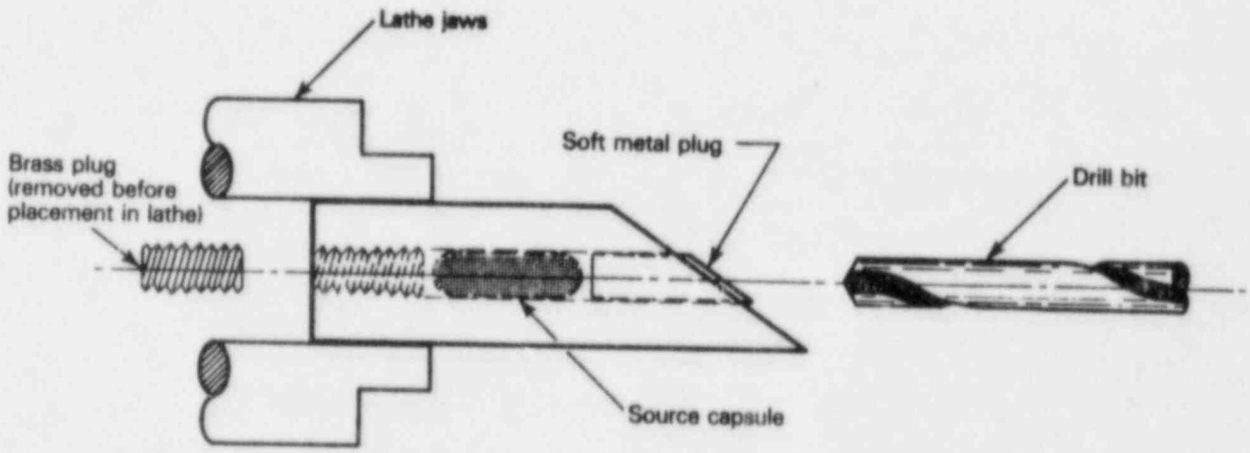


Figure 10. Source holder as placed in lathe.

(2) With the lathe turning the holder, a drill bit was worked into the holder along the axis of rotation removing a soft metal which was plugging the bottom of the source holder cavity.

(3) The drill bit was to work through the soft metal plug until it reached the source capsule. Then, based on the assumption that the source was doubly encapsulated in very hard stainless steel, the drill bit would not penetrate the capsule but would just push it free.

The work progressed as planned until the machinist guessed that the drill bit had broken into the source capsule. When the holder was removed from the lathe, the source capsule dropped out and was caught in a rag. The individuals noticed a hole in the source capsule and a brownish material escaping from the source capsule.

1.6.2 Licensee Actions - Post-Event

Source capsule remnants and drill scraps were placed into a large shielded container, bagged, and taken to the radioactive storage pit. Initially, the licensee performed radiation surveys of the lathe area. The survey instrument indicated full-scale meter deflections (i.e., radiation levels greater than 50 mR/hr). Another radiation survey of this area was performed using a different instrument of the same type, and it also pegged off scale. The licensee interpreted these observations as instrument malfunction and disregarded the readings. No personnel surveys were performed at this time. The licensee attempted to contact its health physics consultant for advice but was unsuccessful. All licensee personnel working in the area, a total of nine including the three individuals working with the source, left the site at their usual quitting time unaware of the seriousness of the incident. This resulted in significant spread of contamination to numerous private residences, vehicles, and business establishments, in addition to significant personnel contamination.

At about 9:00 a.m. (EDT), Wednesday, September 14, the licensee contacted its radiation safety officer (RSO), who was working at a field site in Illinois. Shortly thereafter the licensee also contacted its health physics consultant. The consultant instructed the licensee to:

(1) Seal off the area.

(2) Use dry paper towels as swipes and smear the floor of the building starting at the outer edge of the area and working in. Take radiation surveys of the swipes and record the readings and locations on a map.

(3) Get a wet/dry shop-vacuum cleaner and vacuum the area. After vacuuming, resmear and resurvey the area.

(4) For any areas yielding greater than 0.35 mR/hr on the swipes, make a slurry of detergent and water, wet scrub the floor using brushes, and then vacuum up the water.

(5) Repeat this process (steps 2, 3, and 4) until all areas were cleaned to $\leq$ 3 times background levels. (This was interpreted by the licensee as $\leq$ 0.35 mR/hr measured on a smear using portable survey meters.)

(6) Collect 24-hour urine samples of all employees involved.

(7) Collect employee clothing.

(8) Notify the NRC.

The president of SSI instructed his RSO to wait until more survey results were available before notifying the NRC. The licensee's consultant was asked to come to the site that morning but was unable to because of prior commitments.

The licensee initiated the cleanup procedure, detailed above, about 11:00 a.m. (EDT), September 14, and it continued through the morning of September 15. Fourteen employees were involved in the cleanup effort.

Dry wipes of the lathe itself were reported to show radiation levels of 3 R/hr. The lathe chuck was removed, wet cleaned in a bucket, then sandblasted in the licensee's parking lot. To keep the floor accessible, the lathe and other objects on the floor were moved either outside into the licensee's parking lot or to another building. These operations were performed with little regard for limiting the spread of contamination and overall radiation safety. It should be noted here that the licensee was unqualified and untrained to perform any of these decontamination activities. Some personnel involved in the cleanup considered areas whose swipes were reading $\leq$ 0.35 mR/hr as acceptable; others considered 1 mR/hr direct as acceptable.

The licensee and its consultant were aware of the 24-hour NRC reporting requirement. At approximately one-half hour before the time expired, the RSO notified NRC Region III of the incident. This was about 4:30 p.m.(EDT), Wednesday, September 14. The licensee reported to the NRC that a ruptured source caused contamination of about a 10-square-foot area within the facility, measuring 26 mR/hr initially with 0.35 mR/hr remaining in three small locations after the first cleanup, and with no resultant personnel or offsite contamination. This information was later found to be grossly in error.

1.6.3 Human Factors/Training

Two of the three individuals involved in the source rupture had previous experience in handling radioactive materials used in well-logging. One individual was the former RSO for this program from 1964 to 1979. The other individual was a former well-logger who had been with the licensee for 3.5 years. The licensee did not realize, initially, that the rupture occurred even though a hole was visible in the source capsule. Radiation surveys performed by the licensee were either done incorrectly or misinterpreted, or both. Realization of the problem and the implementation of basic health physics practices shortly after the incident could have prevented offsite contamination and limited personnel exposure. Instead, all employees working in the area left the site at their usual quitting time; most of the employees were not informed of the incident. Those who knew of the incident apparently were not aware they were radioactively contaminated, nor were they aware of the potential seriousness of the incident.

Although the licensee's health physics consultant was familiar with the facility, its equipment and its personnel, remedial actions outlined by the consultant focused on area cleanup rather than personnel protection and control of the spread of contamination. Apparently the consultant was not informed about any personnel contamination but in our view should have assumed as much since contamination of floors and equipment was evident. The licensee's attempts at cleanup were not physically supervised by individual(s) sufficiently knowledgeable in radiation safety as they should have been. Some employees involved in the cleanup had no previous training or experience in handling radioactive materials. These employees carried out the consultant's cleanup plan essentially as outlined, but with little or no regard for radiation safety. This lack of regard was not judged to be willful but resulted from inadequate knowledge and training. Licensee management did not stress limiting the spread of contamination and overall radiation safety.

1.6.4 Institutional Response

The licensee notified NRC Region III of the incident late in the afternoon on Wednesday, September 14. The information given did not reflect the seriousness of the incident, and, in fact, gave the opposite impression. By early afternoon on September 15, an NRC Region III inspector and a representative from the Ohio Disaster Services Agency (ODSA) were on site. The NRC inspector's evaluation of the situation showed that a major radiation safety problem existed and a drastic increase in the response effort was needed.

Four NRC Region III and one Department of Energy (DOE) representative from Argonne, Illinois, were dispatched to the site by private aircraft and arrived at approximately 11:00 p.m.(EDT), Thursday, September 15. Representatives of other nearby agencies arrived between approximately 5:00 and 9:00 p.m.(EDT) of the same day. Agencies that responded to the event were:

(1) NRC
(2) DOE Chicago Operations Office (Argonne Laboratory, Argonne, Illinois)
(3) DOE Radiological Assistance Team (Battelle Laboratory, Columbus, Ohio)
(4) DOE Radiological Assistance Team (Monsanto Mound Laboratory, Miamisburg, Ohio)
(5) ODSA

Preliminary surveys of the homes of the three workers directly involved in the source rupture were performed that night and indicated extensive contamination. Numerous spots were detected primarily on floors, yielding surface radiation levels of up to 10 millirems/hr. Most of the homes showed radiation levels in the microrem-per-hour range.

On September 16, response personnel surveyed various onsite and offsite locations in addition to personnel and vehicles. Residences and/or business establishments suspected of being contaminated were surveyed first (Section 6.6.1 provides a summary). The three employees involved in the rupture were sent to an NRC medical consultant for in vivo evaluation and decontamination. A command post was initially established in the licensee's office trailer, even though it was found to be contaminated with low levels of radioactivity. No other shelter was available at the time. However, operations were relocated later that day to the Newark, Ohio, National Guard Armory. Response personnel continued to survey and perform temporary decontamination efforts throughout the next few days.

A consultant firm, hired by the licensee, arrived at the scene on September 17 and began full offsite decontamination activities that day. Response agencies prioritized offsite decontamination activities and the consultant firm performed the decontamination. Media interest was very heavy and was handled both by the NRC's regional public affairs officer (PAO) onsite, by the NRC's region-based public affair officer in Glen Ellyn, Illinois, and by the State of Ohio's PAO.

1.6.4.1 NRC Order

It was determined that continued conduct of licensed activities could pose a potential threat to the health and safety of the public, including the licensee's employees. Therefore, on September 20, 1983, the NRC issued an

"Order To Show Cause and Order Temporarily Suspending License" to SSI, effective immediately. Lifting of the order was primarily contingent on the licensee performing the following:

(1) Immediate decontamination of all offsite areas that were contaminated as a result of the incident.

(2) Submission of a proposed decontamination plan for its facility, which required NRC approval before implementation.

(3) Show cause why the license should not be revoked.

1.6.5 Radiological Consequences

The NRC task force evaluated the radiological impact of the event on individuals onsite during and after the incident (employees and nonemployees) members of the general public in the surrounding areas, and the environment.

An NRC medical consultant clinically evaluated individuals who could possibly have received significant radiation exposures, either internally or externally. As a result, five of the licensee's employees were found to have some internal deposition, none of which exceeded the maximum permissible body burdens (MPBB) adopted by the NRC (Ref. 2). The maximum internal deposition, 3 days after the incident, was 51% of the MPBB. Three of the licensee's employees were determined to have received external radiation exposures exceeding the limits specified in Part 20 of Title 10 of the Code of Federal Regulations (10 CFR) (Ref. 3). The maximum external whole-body exposure received by one individual was approximately 13.5 rems as determined by his film badge. NRC calculations indicated the maximum extremity (i.e., hands) dose received was 125 rems. No other individuals were determined to have received exposures approaching NRC regulatory limits.

Radioactive material was released to the sewage system. The NRC sampled and analyzed the sewage effluents. The samples showed levels to be 6% of 10 CFR 20.303 limits for soluble cesium-137 release to unrestricted areas and 12% of the limits for insoluble.

1.6.6 Survey and Decontamination Activities

1.6.6.1 Survey Activities

During the emergency response portion of this event, radiation surveys were performed by the NRC, ODSA, and DOE teams. Offsite surveys received top priority and were performed on private residences, business establishments, vehicles, miscellaneous public places, and personnel and their effects. These surveys were performed from September 15 to October 27, 1983. Onsite surveys were performed primarily on September 14-16. The purpose of all surveys was to identify and quantify contaminated areas/items and take immediate actions to limit the spread of contamination and maintain exposures as low as reasonably achievable (ALARA). An aerial radiological measurement overflight was also performed by EG&G, Inc., Emergency Measurement Group (EG&G) of Washington, D.C. from October 17th through the 26th to identify possible contamination of any additional offsite areas. Lastly, NRC representatives performed surveys of their rental vehicles, motel rooms, and temporary operation centers to ensure they left no contamination behind.

A total of 41 private residences was surveyed. Five were found to be highly contaminated, eleven were contaminated, eleven had detectable but insignificant levels of contamination, and fourteen were found clean. (See Section 4.3, "Contamination Levels.") A total of 16 public places were surveyed. One was found to be highly contaminated, five had detectable contamination, and ten were clean. Thirty-two vehicles were surveyed; results ranged from highly contaminated to clean.

1.6.6.2 Decontamination Activities

Expedient field decontamination efforts were performed by the various response agencies on all offsite areas found to be contaminated. Areas and large items were taped and covered with plastic to reduce the spread of contamination. Smaller portable items were either bagged and set aside or confiscated. Three of the highly contaminated homes were evacuated until they would be completely decontaminated and confirmed as such by the NRC. Those residing in homes contaminated to a lesser extent were instructed to stay out of contaminated areas. Six contaminated vehicles were confiscated and left onsite. They were not returned to the owner until they had been decontaminated.

As previously noted the licensee hired a consultant firm to perform all decontaminations. Full offsite decontamination activities began on September 17 and concluded on November 16, 1983. In most cases decontamination involved vacuuming or scrubbing, cutting away contaminated portions, or confiscation. The licensee was required by the NRC Order to adhere to the NRC "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material" (NRC, Division of Fuel Cycle and Material Safety, July 1982) (Ref 4).

Onsite decontamination activities did not begin until all contaminated areas identified offsite had been decontaminated and confirmed as such by the NRC. Additionally, the licensee was required to submit a proposed decontamination plan, requiring NRC approval, before any onsite cleanup was performed. The licensee's proposed decontamination plan was conditionally approved on October 25, and onsite decontamination activities started soon after. Preliminary estimates indicated a completion date sometime in early 1984.

The onsite decontamination was reported by the licensee as completed on February 27, 1984. NRC confirmatory measurements made on February 28, 1984, showed no areas or equipment which exceeded the values in the "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material" dated July 1982, by the NRC Division of Fuel Cycle and Material Safety.

1.6.7 Findings and Conclusions

1.6.7.1 Findings

The overall cause of this event was the licensee's performance of a non-routine operation for which no procedures were established and resulted in the radioactive source puncture -- a specific license condition prohibits opening of sealed sources. Once the puncture occurred, contamination was not initially

recognized and its extent was not adequately quantified by the licensee. Information relayed in telephone communications between licensee personnel and their contract health physics consultant was not complete.

The licensee's lack of knowledge of radiation theory, practice, and safety aggravated the consequences of the incident. The licensee's decontamination efforts were not physically supervised by anyone sufficiently knowledgeable about radiation safety. This coupled with the fact that inexperienced individuals were involved in decontamination activities further escalated the incident's consequences. The licensee lacked adequate training in the following areas:

(1) Basic radiation theory
(2) Handling of sealed and unsealed sources
(3) Instrumentation usage and interpretation of results
(4) Basic radiation safety practices, including personnel protection

The licensee did not have adequate equipment to safely handle curie quantities of sealed sources (e.g. remote manipulators, tongs, etc.) or to deal with unsealed radioactive materials for tracer studies (e.g. gloves, decon materials). Also, the adequacy of the licensee's survey instrumentation was questionable.

1.6.7.2 Conclusions

The licensee did not have detailed procedures that prescribe and limit source handling under routine and emergency conditions. No procedures prohibited any operation that could damage the source.

The licensee did not have a detailed training program for its logging engineers and ancillary personnel. Their training program was deficient in (1) providing individuals with an adequate understanding of radiation theory and safety practices and (2) information required to safely perform decontamination.

Although not a major problem in this incident, the NRC staff is concerned that other licensees may not be financially able, either through company resources or insurance, to adequately handle potential incidents related to their licensed operations.

The licensee did not have a preventive maintenance program for its sealed sources used in well-logging and their related tools. Such a program may have reduced the probability of a stuck source.

Improved health physics (HP) instrumentation, to monitor routine and emergency conditions, capable of measuring high-range (10 R/hr upper) gamma, neutron radiation and low-range personnel contamination would have permitted a better assessment of the contamination.

Because of the prompt identification of contamination and remedial actions implemented by federal and state response personnel, it is believed that no individual received a significant radiation exposure as a result of offsite contamination.

Onsite contamination was significant and posed a radiological hazard if not controlled. However, these concerns were alleviated once highly contaminated items were placed in a controlled secure area and other contaminated areas were identified, secured, and covered with plastic to reduce spread.

2 SHELWELL EVENT CHRONOLOGY

2.1 Pre-Event (Before Source Rupture)

The licensee wanted to transfer a nominal 2-curie cesium-137 sealed source from one source holder to another because the original source holder did not fit the well-logging tool currently in use. The transfer was complicated by the discovery that the source was stuck in its holder. The first extraordinary attempts to free the source occurred on Monday, September 12, 1983, when penetrating oil was placed into the cavity of the source holder. After waiting for the oil to take effect, the the employees struck the holder repeatedly against a hard surface, attempting to dislodge the source. These efforts continued without success until they were abandoned on Tuesday afternoon, September 13, 1983. A new plan was developed which involved pushing the source out with a drill bit on a lathe (as detailed in Section 1.6.1).

The plan was put into effect in Building 2 of the licensee's facility at about 4:00 p.m. (EDT) that Tuesday by the SSI president, a sales representative (former logging engineer), and a machinist. The work progressed until the machinist guessed that the drill bit had pierced the source capsule.

2.2 Post-Event (After Source Rupture)

2.2.1 Tuesday, September 13, 1983

The machinist drilled into the source holder and soft gray metal spilled out. He then stopped to check the depth of the hole, drilled more, stopped again to check the progress of the hole, and resumed drilling. The drill bit was hand cranked into the source holder and the machinist tried to anticipate a strong resistance when the bit met the stainless steel encapsulated source. Instead he noticed a brown powder which he momentarily thought was rust but quickly realized was the contents of the source capsule. The source holder was removed from the lathe chuck with a wipe rag (~12 inches by 12 inches) and the source capsule fell out onto the rag. The machinist noticed a hole in the end of the capsule (the drilled hole). He asked the SSI president if the capsule was supposed to have a hole and remembered him responding, "I don't know." With the capsule lying on the wipe rag on a table, the machinist then took a metal file and ran it across the end of the capsule to test the hardness. He found the material to be very hard but very thin. The sales representative then picked up the four corners of the rag, folded them over, and placed the rag with the remnants of the source capsule into a shielded container. The container was later described as being made by SSI of lead, about 6 inches to 7 inches in diameter and 8 inches to 9 inches high and weighing 150 to 200 pounds. The sales representative then went from Building 2 to the licensee's office trailer for a survey instrument. The first survey of the lathe area showed a full-scale meter deflection on the licensee's CDV-700 meter, which was interpreted as an instrument malfunction. He returned to the trailer and informed the assistant radiation safety officer (ARSO) of what had occurred. The ARSO took another similar instrument to Building 2 and found high readings, the exact values could not be recalled. The machinist was not notified of the survey results but

washed his hands in the machine building as was his normal habit and went home. The time was about 5:00 p.m.(EDT). The ARSO accompanied the sales representative as he carried the source, holder, rags, and scraps in the shielded container to Building 1 to a vehicle grease pit, converted for storage of radioactive material. The sales representative believes he placed a cover on the top of the shielded container before leaving Building 1 and the ARSO helped place the shielded container in several plastic bags. A survey by the ARSO of the source holder and remaining contents showed 2 mR/hr on contact as opposed to the normal 6 to 8 mR/hr at 6 to 12 inches. It was at this time that the ARSO became aware that much of the source was lost. The licensee failed in its attempts to reach SSI's HP consultant, and obtain advice. The ARSO, president, and sales representative left work at about 5:30 p.m.(EDT) without any real awareness that they were radioactively contaminated to various degrees.

2.2.2 Wednesday, September 14, 1983

At approximately 8:00 a.m.(EDT), the ARSO arrived at work and noticed the door to Building 2 was open. He told employees to stay away from the area. He then called the RSO who was in Mt. Sterling, Illinois, performing routine calibrations of radiation survey instruments. The ARSO gave him a brief description of what had happened, but did not indicate there was any personal contamination. The ARSO surveyed the sales representative and found him to have 3 mR/hr personal contamination that would not wash off. At about 9:00 a.m.(EDT), the RSO reached the HP consultant for the first time, who informed him that the NRC should be notified. About a half hour later, the ARSO reached the consultant and, with the president on the line, the consultant told them how to survey and decontaminate the area, to collect urine samples and clothing from the employees and to notify the NRC (Section 1.6.2 contains a full list of his instructions).

The president asked his consultant to come to the site that morning. The president told the RSO to wait until more survey results were available before notifying the NRC.

As a result of this discussion with the consultant, the ARSO said he was aware that "people were contaminated." (Note: Earlier he had found the sales representative to be contaminated.)

Cleanup of the area was started by 11:00 a.m.(EDT) and the lathe was vacuumed. At 12:00 (EDT) noon dry wipes of the lathe and floor showed 3 R/hr, measured using the licensee's survey meters. Two of the licensee's electricians disconnected the lathe and other personnel wet-cleaned it several times. The lathe was moved by forklift into the adjoining parking lot after the machinist removed the chuck. The chuck was wet-cleaned in a 5-gallon bucket, then taken outside Building 1 and sandblasted. Small objects lying on the floor were moved by trailer from Building 2 to the State of Ohio Highway Department Building and to areas of the parking lot west of Building 2. This was done to facilitate the floor scrub. The lathe was moved to an area near the drainage ditch (see Figure 3) and sprayed with diesel fuel. A holding tank in the lathe bed collected the draining diesel fuel. After the oil spray, the lathe was moved back into Building 2, with the chuck in a square metal pan (~2-gallon size) along with the 5-gallon bucket which still contained the highly contaminated wash water. Some material used in the decontamination effort (water in open containers, rags, and trash, reading 10 to 100 mR/hr) was moved outside

about 30 yards west of Building 2 under a grove of trees. This was done to reduce the radiation background for the surveys still in progress and to keep the floor accessible for decontamination.

The president, RSO, ARSO, and HP consultant were involved in a series of phone conversations. At about 3:00 p.m.(EDT) the ARSO told the RSO that the lathe read 3 R/hr and that the area up to 10 feet from the lathe was contaminated. The RSO did not understand that this represented a reading of a swipe rather than a direct reading, which would have been much higher. The same problem existed with most surveys; the SSI surveyors were considering areas whose swipes were reading less than 0.35 mR/hr as acceptable, others considered 1 mR/hr (direct) as acceptable. The sales representative and president knew of the 24-hour reporting requirement to the NRC, and half an hour before the time expired the RSO was told to notify the NRC of the incident. This he did at about 4:30 p.m.(EDT). The radiation survey information conveyed in that telephone call was that the damaged source caused contamination of about 10 square feet measuring 26 millirems per hour initially with 0.35 millirem per hour remaining in three small locations after cleanup and that no individuals were contaminated. This information was grossly in error. The NRC inspectors feel the errors were due to several factors:

(1) The persons on site in Hebron, Ohio, were poorly trained, did not know how to survey, and thus were considering smear readings of 0.35 mR/hr or direct surveys of 1 mR/hr as "clean."

(2) The information was being relayed from personnel in Ohio to the RSO in Illinois and then from the RSO to the NRC, Region III. Facts were probably distorted by the time they reached the NRC.

(3) The licensee had no concept of the seriousness of the situation; visual concept of radioactive contamination as stated by one of the principals was that it was similar to a spill of sand or salt except that it was invisible. You could just vacuum it up and then wipe up the little that remained after vacuuming. This lack of knowledge was evident in many of the licensee's practices such as:

    (a) When told to scrub their shoes before leaving work some of the people used the same brushes they had used to decontaminate floors and equipment to clean their shoes.

    (b) No consideration was given that vacuuming and sandblasting contributed to the radioactive material becoming airborne and thus inhaled.

    (c) The licensee thought that a light misting of oil would decontaminate the lathe.

    (d) Little consideration was given to the fact that the waste sand from sandblasting the lathe chuck would contaminate other areas.

The cleaning efforts continued that evening until about 6:00 p.m.(EDT). The workers' precautions before leaving work varied: some did nothing, some washed, some changed their clothing.

The HP consultant had told the ARSO to have the principally involved workers bag their clothes worn on Tuesday and bring them to work the next day.

2.2.3 Thursday, September 15, 1983

On Thursday, cleanup attempts resumed, similar to those of Wednesday. The same persons vacuumed, scrubbed, and surveyed until the NRC and ODSA inspectors arrived at about 1:00 p.m.(EDT). The inspectors first went to the administration trailer and interviewed the ARSO. They then proceeded to Building 2 to survey the area and found high levels of contamination in the building and on items between the building and grove of trees west of the building. Then they returned to the trailer, resumed the interview with the ARSO, and, for the first time, interviewed the machinist and the sales representative. It was at this time that the inspectors became concerned that the homes of the principal parties may have been contaminated. The inspectors surveyed the bagged work clothing brought in earlier in the day and some personal vehicles. Finding them contaminated, the inspectors realized the incident was much more serious than first reported and beyond the licensee's resources to evaluate fully.

The NRC inspector made several calls to the NRC Region III office starting at 2:20 p.m.(EDT) to inform personnel there of the escalated situation and to ask for assistance. Chapter 5 gives the details of how the ODSA and NRC Region III and DOE radiological assistance teams (RAT) responded to provide this assistance. The president of SSI arrived on site soon after these calls started, and the NRC inspector noted that he did not appear to be aware that a serious situation was at hand. His manner and comments were representative of those associated with a routine inspection.

Concurrent with these phone calls and before any assistance arrived, the two inspectors performed radiation surveys of the three principals, two other Shelwell employees identified as being in Building 2 when the source was breached, and portions of the administrative trailer. These surveys all showed varying degrees of contamination. On the basis of these results the following actions were taken:

(1) Film badges were retrieved for emergency processing.

(2) Arrangements were made for an NRC medical consultant to make measurements to determine the radiation dose to the three principal persons.

(3) Highly contaminated items that had been moved out of Building 2 and were in the parking area were returned to Building 2. The door was locked after ensuring that no one was present in the building.

(4) Additional personnel and equipment were requested from NRC, ODSA, and DOE.

(5) The contaminated area in the grove of trees near Building 2 was roped off to prevent entry.

The first assistance to arrive at the Shelwell site was the ODSA team at approximately 5:00 p.m.(EDT), soon followed by the DOE radiological assistance teams from Battelle Columbus and Mound National Laboratories. Members of these units and the original two inspectors formed three teams, one each to survey

the homes of the principals. The last unit to arrive was the NRC team accompanied by the DOE RAT leader at approximately 11:00 p.m.(EDT). A meeting was held by the response leaders of NRC, DOE RAT, and ODSA to determine the status of activities already in progress, to provide a brief description of the incident to the response teams, to evaluate the range of the problem, and to establish a plan of action. The remainder of the evening at the site was spent debriefing the three survey teams on their return from the private residences, gathering further information from the Shelwell personnel, performing some radiation surveys of the site, and briefing NRC Region III management personnel at the Incident Response Center. Initial survey results showed a definite spread of contamination to the private residences; however, because of the variety of survey techniques and instruments used, there was difficulty in collating the results. Because of the time of day, approximately 1:00 a.m. (EDT) (September 16, 1983), field survey operations were terminated. The site was secured by placing a barrier across the access road. The team leaders met at a hotel room and planned the next day's activities.

2.2.4 Friday, September 16, 1983

At 6:30 a.m.(EDT), the three SSI personnel who were directly involved in the incident left for the University of Cincinnati to be examined by the NRC medical consultant. One NRC representative and one ODSA representative accompanied them. All response teams assembled at the incident site at 7:30 a.m. (EDT). They were briefed on the survey techniques to be used and data recording requirements. SSI employees were briefed and directed to provide an itinerary of their activities since 4:00 p.m.(EDT), Tuesday, September 13, 1983.

Personnel, vehicle, and site surveys were started. It should be noted that it rained heavily throughout the morning. As a result of the early site surveys, it became obvious that the contamination had been tracked throughout the site. Although the contamination levels were low, it became evident that surveys of personnel and vehicles would have to be done at a controlled area where no cross-contamination would occur after the surveys. It was decided that the entire site would be established as a controlled area, and an access and egress station was established near the entrance to the site.

At this time, all personnel started a controlled relocation to the established control point where all personnel and their vehicles were surveyed. All surveys of the site were halted, since the site would no longer be occupied. Arrangements were made to establish a new emergency control center at the Ohio National Guard Armory in Newark, Ohio.

Before the personnel left the site, the remaining material resulting from the licensee's decontamination efforts was transferred to Building 2, where the source rupture had occurred.

Several other concerns that were resolved before the personnel left the site involved ensuring that the ventilation system of Building 2 was secured and that the sump pump for the facility's sanitary drains was secured to prevent any further spread of contamination. The last concern involved the private facility on the site that was operated by National Energy Service Company (NES). This facility was directly adjacent to the building where the incident occurred. It should be noted that NES also leased, for storage purposes, the back end of Building 2. Employees gained access to NES by way of the SSI site.

Therefore, controlling access to the site would restrict activities of the NES employees. Agreement was reached that all NES personnel, at the end of the workday, would be surveyed when they left the site. NES also agreed to not operate over the weekend.

A schedule and arrangements were made to start surveying the residences of the SSI employees involved in the attempted cleanup. One team remained at the site to survey licensee employees, their cars, and bagged work clothing as the employees presented themselves throughout the day. As teams completed their assigned surveys, they reported to the emergency control center at the Armory where they were debriefed by the NRC, DOE, and ODSA team leaders.

Concurrent with these efforts other arrangements were made. The licensee had contracted with Applied Health Physics, Inc. (AHP) of Bethel Park, Pennsylvania, to perform the decontamination of offsite and onsite areas. Urine specimens were collected from all persons directly involved in the incident and cleanup. The specimens were picked up by Battelle Columbus Laboratory for analysis. Results from the emergency processing of film badges of the three principals were obtained and showed whole-body external radiation exposures ranging from 0.11 to 13.48 rems. The residences of the three principals were evacuated until AHP could decontaminate them. These efforts continued until 2:00 a.m. (EDT), Saturday (September 17) when the president of AHP arrived in Newark, Ohio, and was briefed on the situation. Then operations stopped until later in the morning.

2.2.5 Saturday, September 17, 1983

Work resumed at 8:00 a.m.(EDT) when all response personnel including AHP were briefed and survey assignments of additional residences were given to five federal and state teams. Home surveys continued throughout the day. The teams were finding varying degrees of contamination in almost every home, reaching a maximum of 10 mR/hr at contact on some home furnishings. Chapter 4 has details of the surveys.

Late in the day the president of SSI told the NRC that his original statement that he had gone directly home after the source rupture on Tuesday, September 13, was in error. Instead he recalled, after prompting from his wife, that he went directly to his daughter's home that evening. This new information was not unique as followup interviews of the three principals and nine employees involved in the attempted cleanup was revealing many more locations requiring surveys. These included restaurants, a health club, grocery stores, homes of relatives and friends, schools, and areas bordering the licensee's site. There also were visitors to the site such as salesmen, law enforcement patrols, a food vendor, and a uniform rental serviceman. There were cars, clothing, and furniture loaned by Shelwell employees to other employees and friends, which all required radiation surveys.

2.2.6 Sunday, September 18, 1983

Surveys of public places and private residences continued throughout the day until almost all known possibly contaminated locations were visited. The few exceptions were several facilities where arrangements were still being made with the owners for access, and they would be surveyed by NRC/ODSA teams. The

DOE radiological assistance teams were released: Battelle Columbus representatives at 1:00 a.m.(EDT) and those from Mound Laboratory at 12:00 noon. The release was based on the evaluation of the situation as (1) the locations requiring decontamination were identified, (2) the locations with high contamination were evacuated and thus posed no immediate risk, (3) the locations with less contamination had the items removed and held for AHP's later attention or the contamination was covered with tape or plastic and thus "fixed" until AHP could decontaminate, and (4) the remaining NRC/ODSA teams were available to provide surveys.

By the end of the day AHP finished decontamination of the first home in the group of highly contaminated locations. A procedure was established of having a daily briefing involving Shelwell management, AHP, NRC, and ODSA to determine progress and distribute work assignments.

2.2.7 Monday, September 19 - Wednesday, October 5, 1983

The initial survey results had shown that contamination was widespread, and even though the levels were quite low (with the exception of five homes), there was a need to expand the surveys to ensure that all contamination exceeding NRC guidelines was detected. Therefore, all licensee employees who had been onsite since September 13 were instructed to report to the road leading to the SSI control point so they could be interviewed and their personal cars and work clothing could be surveyed. On the basis of the results of the interviews and surveys, their homes were scheduled, by priority, for survey. The prompted interviews also revealed much more detail than the original statements. A second factor for the greater detail appeared to have been the greater concern and awareness by the employees of the seriousness of the situation after learning by word of mouth how widespread the contamination was. The interviews revealed visits by salespersons and vendors to the site, visitors to homes identified as contaminated, visits by persons identified as wearing contaminated clothing to schools, restaurants, and private homes, and items loaned such as cars, clothing, and furniture. All these persons, items, and locations had to be scheduled for followup surveys.

Information was received from the NRC's medical consultant concerning the internal deposition by the three principals, and verification that the contaminant was in fact cesium-137.

Interviews of the owner, RSO, and ARSO, coupled with a record review of the SSI inspection and licensing files as maintained by the NRC, failed to identify the source exactly but some information was obtained to indicate the source was cesium chloride, and thus readily soluble. This was supported by the success or failure of the various decontamination techniques attempted.

An up-to-date briefing was provided to the Chief of Police and members of the City Council at 9:00 p.m.(EDT) on September 20, 1983. The Mayor and Chief of Police had been first notified of the incident and about federal and state involvement in the early hours of September 16, 1983.

Samples were taken of the sewer water from the SSI sump. Results show values of 1.5×10^{-6} μCi/ml for soluble cesium-137 and 4.7×10^{-9} μCi/ml for insoluble cesium-137, which are below 10 CFR 20, Appendix B, release limits for an unrestricted area. Appendix B limits are 2×10^{-5} μCi/ml for soluble cesium-137,

and 4×10^{-5} μCi/ml for insoluble cesium-137. The decision was made, on the basis of this information, to restore power to the sump pump which permitted NES to resume use of its water system. An alternate route was also established (through the cemetery) whereby NES personnel could gain access to their facility without using the common road through the SSI grounds.

To prevent windblown vegetation from leaving and to reduce the significance should someone accidentally walk on the highly contaminated ground in the grove of trees west of Building 2, the entire area was covered with plastic tarpaulins. On the same day, September 22, 1983, ODSA made arrangements with the State Police helicopter to have aerial photos made of the site.

On Friday, September 23, 1983, a licensee's truck arrived at the Hebron site with all remaining licensed material not already onsite. The sources were placed in storage to comply with the NRC Order to suspend all licensed activity.

In addition to monitoring AHP decontamination of offsite facilities, there were:

(1) Interviews of licensee representatives to determine the causes and effects of the incident

(2) Followup of dose assessments by way of urine bioassay and whole-body counting

(3) Review of the site security, improving the posting and condition of the rope barrier (see Figure 11 showing perimeter)

(4) Interviews given to the press, radio, and TV

(5) Arrangements for an ARMS overflight

By October 5, 1983, all private homes and public places identified as contaminated during the emergency phase had been decontaminated by AHP or, in minor instances, by the NRC/DOE/ODSA survey teams, and confirmatory radiation measurements had been made by NRC/ODSA to monitor the cleanup results. The offsite emergency phase of the incident was considered "over." Attention then focused on the onsite problems. There were still some offsite efforts, since the licensee's intent was to follow ALARA (as low as reasonably achievable) concepts concerning decontamination and considered the "limits for unrestricted release" to be the limiting criteria. The efforts to clean everything to as low as reasonably achievable resulted in some additional work beyond October 6, 1983.

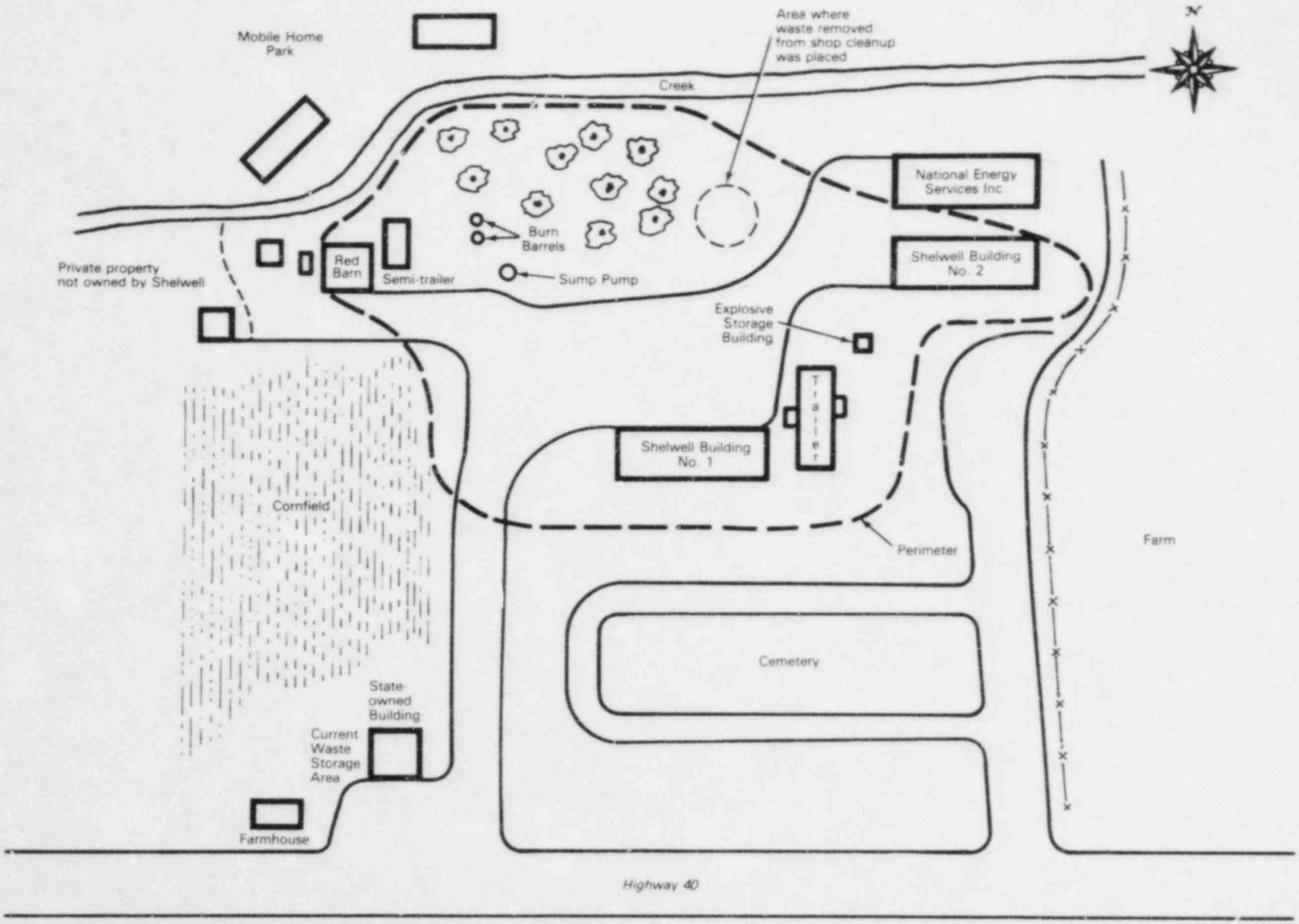


Figure 11. Sketch of Shelwell Services, Inc., faciiity.

3 RADIOLOGICAL CONSEQUENCES

This chapter evaluates the radiological impact of the SSI source rupture event to individuals onsite during and subsequent to the incident, both employees and nonemployees; to members of the general public in the Newark-Heath-Hebron areas; and to the environment. This evaluation is focused on those SSI employees involved in the source rupture and cleanup attempts; other employees nearby when the rupture occurred; individuals in the private sector who visited the Shelwell facility shortly after the rupture; offsite agency personnel responding to the event; and other individuals, including relatives and friends of employees, whose residences or places of business were found to be contaminated.

3.1 Meteorological Conditions

The source rupture occurred within a large windowless facility, the northwest corner of SSI's Building 2. This building is equipped with ceiling exhaust fans which were not in operation during or subsequent to the rupture event. The garage-type door was open at the time of the incident but the open door is believed to have had a minimal, if any, effect on the spread of contamination. Therefore, most of the contamination released as a result of the rupture remained within the confines of Building 2. The remainder of the contamination activity was spread outside this building primarily by transfer from equipment, footwear, hands, and clothing. Prevailing winds had little effect on the spread of contamination.

The ruptured cesium-137 source was believed to be composed of cesium chloride, in powder form, readily soluble in water. Heavy rains throughout the morning of September 16, 1983, some 60 hours after the source rupture, washed some of the tracked contamination into the rocks and soil of the licensee's access drive. This was the first of four rains that occurred during the emergency response phase of the operation. Areas of the licensee's access drive having the highest levels of contamination were covered with plastic to reduce migration through the soil. This included a walkway leading from Building 2 to the office trailer and an area west of the incident building where contaminated items, generated during the licensee's initial cleanup attempts, had been placed (see Figure 12).

3.2 Shelwell Services, Inc., Employees

3.2.1 Employees Involved in Source Rupture

In evaluating radiological consequences to personnel, two methods of radiation exposure must be considered. (1) Direct external exposure from the sealed cesium-137 source. This includes direct beta-gamma radiation from physically handling and being in close proximity to the source before its rupture and from personnel and clothing contamination after the rupture. (2) Internal exposure from ingestion or inhalation, of cesium-137 from the source rupture and the subsequent cleanup.

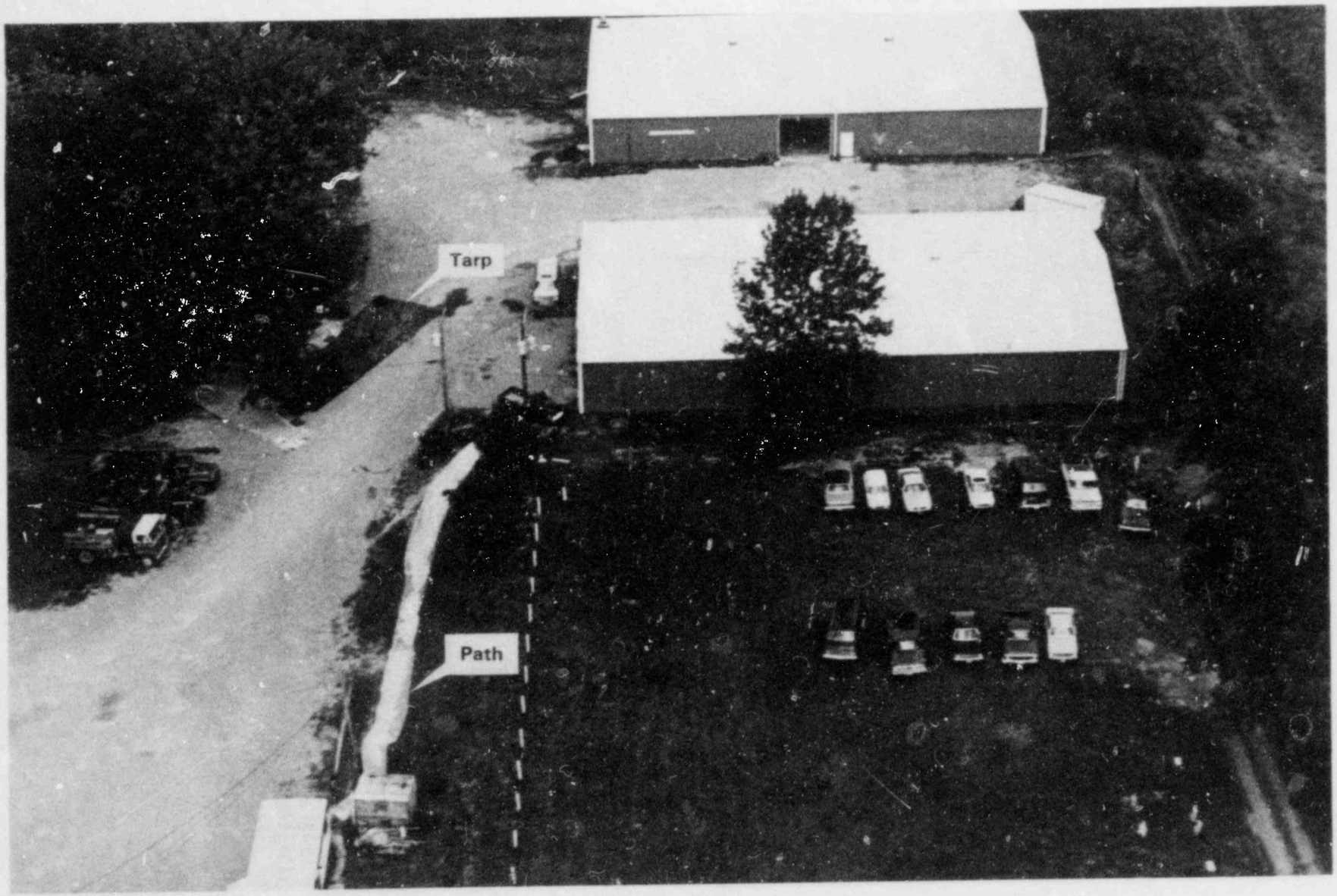
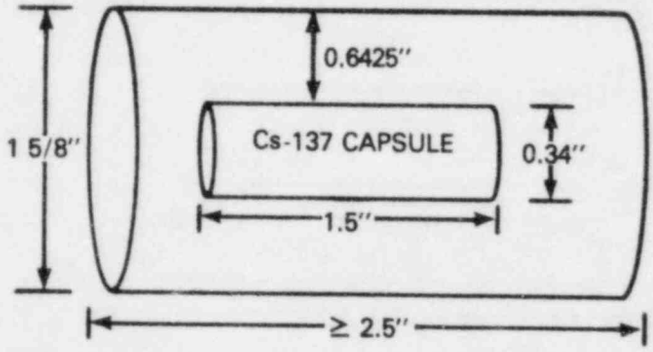


Figure 12. Plastic covers over contaminated areas.

3.2.1.1 Extremity (Hand) Exposures

Before Source Rupture: Three individuals handled the source holder, that housed the cesium-137 source, while attempting to remove the source capsule. These individuals did not know exactly how long the source holder was held in their hands but provided estimates as noted below. The president and sales representative handled the source holder for approximately 1.0 and 5.0 minutes, respectively, while attempting to free the source capsule using penetrating oil on September 12 and 13. The machinist handled the source holder for less than 30 seconds while mounting it to the lathe and performing the drill operations on September 13. On the basis of these time estimates and the radiation profiles calculated in Appendix D, hand or finger exposures are expected to be approximately 24.7 rems, 123.4 rems, and 12 rems for the president, sales representative, and machinist, respectively, during this initial phase. These exposures assume the source/source holder is as sketched in Figure 13. Further analyses of the source and source tube holder are being conducted by Argonne National Laboratory. These approximate extremity exposures will be reevaluated, if new or different information indicates the need.



0.6425" = 1.63 cm stainless steel between outside diameter of source capsule and surface of holder.

Figure 13. Sketch of source/source holder model used for exposure calculations.

After Source Rupture: Conflicting statements made this portion of the evaluation difficult. However, those interviewed did concur that two individuals handled the ruptured cesium-137 source capsule. The sales representative caught the the ruptured source capsule using a rag, placed it on a table, and later placed the remains of the source capsule in a leaded container. This individual held the bare source for approximately 30 seconds during these operations. The machinist briefly held down the ruptured source capsule with his hand or fingers while filing the capsule. This operation is estimated to have taken only a few seconds.

Since the source was ruptured, the activity of the remaining contents in the capsule could not be estimated, and, therefore, an accurate external dose could not be calculated. Additionally, the individuals involved in the rupture and in the cleanup operation on the following days had contamination on themselves and their clothing, especially on their hands. This contamination also contributed to the total extremity dose received. The machinist was partially involved in the lathe cleanup, and the sales representative in the floor cleanup.

The president had minimal involvement in the actual cleanup efforts. It is, therefore, believed that the sales representative received the highest external dose to the extremities, estimated to be approximately 2 to 3 rems during this second phase with a cumulative total of about 125 rems during the entire event. See Table 1 for the range of calculated radiation levels and the value chosen as most probable (Appendix D contains details).

Table 1. Calculated radiation levels

Unshielded Radiation Level (R/hr)	Shield Thickness Iron (cm)	Dose Buildup Factor	Shielded Radiation Level (R/hr)
19,800	0.5	1.3	19,396
4,950	1.0	1.6	4,497
2,200	1.5	1.9	1,788
1,863*	1.63	2.0	1,481
1,237	2.0	2.2	877
792	2.5	2.55	491

*1863 R/hr was selected as the most probable value based on shield thickness.
NOTES:
(1) All radiation levels assume a 1.5 curie cesium-137 isotropic point source.
(2) Calculations and their derivations are outlined in Appendix D.

The machinist received a somewhat smaller extremity dose during this second phase, and the president received the least dose of the three men involved in the source rupture. The NRC medical consultant's preliminary findings showed no evidence of any clinical effect to the principals' hands.

3.2.1.2 External Whole-Body Exposures

The external whole-body radiation exposure of employees was monitored with film badges supplied by Siemens Gammasonics, Inc. All personnel employed by SSI were provided with whole-body beta-gamma-neutron badges, which were exchanged monthly. The sales representative and machinist indicated they wore their film badges on their upper left breast pockets at all times while at work. The president was not certain if he wore monitoring equipment at any time during the event. On September 15, 1983, the NRC inspector first on the scene noted that the three principals were wearing their film badges on either their left trouser pocket or upper left shirt pocket. NRC surveys using an NRC Eberline E-520 with a thin end-window probe showed contamination of 0.2 to 1.0 mR/hr on the individuals' film badges. These three film badges were sent to the licensee's vendor, for emergency processing, on September 16, 1983. The vendor evaluated the film badges, which showed exposures of 13.48 rems for the machinist, 2.71 rems for the sales representative, and 0.110 rems for the president for the period August 25, 1983, through September 15, 1983, after correction for contamination of the holders. A radiation exposure report from the vendor is given in Appendix E. Film badge exposures for the machinist and sales representative were believed to be accurate representations of their whole-body exposures. Because the president was not certain if he had worn his film badge during the incident and because of his description of his activities, it is believed his whole-body exposure was greater than 0.110 rem but less than 2.71 rems.

3.2.1.3 Internal Exposures

Immediately After Source Rupture: At the time of the rupture some portion of the cesium contained in the capsule was dispersed into the atmosphere inside Building 2 of the SSI facility. The radioactive effluent levels within this building were not known because the licensee does not perform air sampling. Also, calculations to estimate effluent concentrations would not be meaningful for the following reasons:

(1) The amount of activity released is not known.

(2) Air volumes in the building are large and the release was not evenly distributed throughout this volume.

The three individuals involved in the source rupture would presumably have received the greatest internal deposition through inhalation. Other employees involved in the cleanup operations may also have received internal exposure through inhalation and ingestion, but to a lesser extent. External personnel surveys of the employees present in the building at the time of the rupture, showed the three individuals involved in the rupture had the highest levels of contamination on their persons. Gut surveys of the three persons showed they also had the highest levels of ingestion. On September 16, 1983, the individuals were sent to an NRC medical consultant for in vivo evaluation and decontamination. This evaluation, among other things, consisted of whole-body counting, urinalysis, and chromosome and blood studies. Preliminary results of whole-body counting showed some internal deposition, none of which exceeded regulatory limits. Three days after the incident, the maximum internal deposition in one of these individuals was found to be 15.5 microcuries. This is 51% of the maximum permissible body burden of 30 microcuries. Final results of the whole-body counting and other in vivo procedures performed by the NRC medical consultant are not available at this time, but give indications of internal depositions even lower than those of the early findings.

During Cleanup Activities: The greatest potential for internal deposition, via inhalation, during cleanup activities occurred in the dry vacuum and sandblasting phases. Two individuals were primarily involved in these operations: one dry vacuumed, another did the sandblasting.

Also, internal deposition may have occurred through ingestion, since some individuals ate lunch (probably with contaminated hands), drank coffee, etc., onsite. The machinist and sales representative involved in the rupture were also involved in these cleanup activities. As a precaution, the two individuals involved in dry vacuuming and sandblasting activities were sent, on September 30, to the NRC medical consultant for in vivo evaluation. As expected, preliminary findings showed these two individuals did exhibit some internal deposition but considerably less than the three principals.

3.2.2 Other Employees in Incident Building During Rupture and/or Involved in Cleanup Activities

A total of nine SSI employees were in Building 2 when the source ruptured on September 13 -- the three who were involved in the rupture and six others who were at various locations within the building, typically some 15 to 25 feet from the ruptured source. A total of 14 SSI employees were involved in cleanup

efforts on September 14 and 15. Eight of these fourteen had been present during the rupture. The maximally exposed individuals, three involved in the rupture and two others involved in the cleanup, were discussed in previous sections of this chapter. All other employees are expected to have considerably less personal internal exposure, if any. Since the maximally exposed employees showed no body burdens that approached regulatory limits, it was not deemed necessary to have other employees examined by the medical consultant. All other personnel did, however, submit urine samples that were analyzed by Battelle Columbus Laboratory for gross beta-gamma deposition. Results of this urinalysis, outlined in Tables 2 and 3, showed no levels that would indicate exposures in excess of the regulatory limits.

Table 2. Cs-137 analysis of urine

Employee	pCi/l	Total vol.(ml)
#1	<50	1,655
#2	370 ± 50	475
#3	<60	775
#4	<50	3,335
#5	500 ± 50	1,140
#6	<60	1,925
#7	<50	500
#8	<50	1,540
#9	<60	2,470
#10	<50	2,030
#11	<50	975
#12	<60	1,125
#13	<50	1,730
#14	<60	1,200
#15	<50	1,240
#16	<60	1,000
#17	<60	1,430

Table 3. Repeat CS-137 analysis of urine

Employee	pCi/l	Date Collected
#2	200 ± 40	NA
#5	280 ± 40	10/26-27/83
#8	<55	NA
#17	<45	NA

NOTE: NA = not available

3.2.3 All Other SSI Employees

All other employees who visited the incident site, regardless of their involvement, submitted urine samples for analysis by Battelle Columbus Laboratory. These results are also given in Table 2 and show no significant internal depositions. External whole-body exposures, as evidenced on employee film badges, showed a maximum exposure of 280 millirems with an average of 90 millirems, for the period August 25-September 15.

3.2.4 Conclusion - SSI Employees

On the basis of the film badge reports, two individuals received whole-body exposures in excess of the quarterly limits. It is also likely that a third individual received a whole-body exposure (estimated dose) in excess of the quarterly limits. With the exception of these three employees, the film badge results covering the period from August 25, 1983, to just after the incident indicated no dose in excess of the regulatory limits.

On the basis of the NRC's calculations and the licensee's estimate of the source and the source holder dimensions, it is likely that two of the three individuals handling the source and source holder received extremity exposures (estimated dose) in excess of the quarterly limit.

Analyses of the urine samples for the employees showed no levels that would indicate exposures in excess of the regulatory limits.

3.3 General Public

3.3.1 Facility Visitors

Six individuals visited the SSI facility after the rupture incident between September 13 and September 15. After the source rupture two of the six entered the building where the incident occurred. One came in shortly after the incident on September 13 for a maximum of about 30 minutes, the other entered on the morning of September 14 for only a few minutes. All six individuals and their vehicles were later surveyed by response agency personnel. One of these individuals also had his home and office areas surveyed.

Individuals who visited the facility and their associated survey results are given in Appendix A. These were individuals nos. 4, 31, 34, 52, 56 and 63.

Those areas/items found to be contaminated were immediately decontaminated or confiscated as necessary to meet the criteria set forth in Chapter 4 of this report. The data in Appendix A show that areas/items found to be contaminated were only marginally so and therefore posed no significant health or safety problem. No radiation exposure evaluations were made of these individuals, since any exposure they may have received would be less than the minimally exposed SSI employees who were present in Building 2 when the source ruptured. It is believed that no member of the private sector who visited the SSI facility received any significant internal exposure or an external exposure approaching 10 CFR 20.105 (A) limits for radiation workers.

3.3.2 Families and Acquaintances of SSI Employees

Individuals considered in this section are those who came in contact with SSI employees or their possessions (e.g., vehicles, clothing, footwear). Each SSI employee at the Hebron facility was interviewed and surveyed. Those employees who frequented the building where the incident occurred and/or were found to be contaminated were questioned about their activities during nonworking hours. As a result of their statements, 41 private residences were surveyed for possible contamination. Of these 41, a total of 16 residences was found to have some contamination exceeding the NRC decontamination criteria (i.e., required some type of decontamination) set forth in Chapter 4 of this report. Most of the contaminated areas identified were $\leq$0.2 mR/hr direct gamma, but several isolated spots were measured up to 2 to 10 mR/hr. Homes found to be highly contaminated were those of the three individuals intimately involved in the source rupture, the home of the ARSO, and the home of a relative of one of these employees. Four of the residences required extensive decontamination involving confiscation of furniture, carpeting, and other items. Two other employees' residences also required removal of carpeting and other items, but to a lesser extent. Individuals residing in these homes, other than the SSI employees themselves, were surveyed and found to be free of personal contamination.

Removable contamination was fixed by covering with plastic and tape. Portable items found to be contaminated were confiscated or immediately cleaned by emergency response personnel using improvised methods. Areas exhibiting external radiation levels $\geq$100 µR/hr gamma or contact were considered contaminated, and identified as such to those residing in the homes so access could be restricted to these areas. Three of the five residences ultimately found to be highly contaminated were evacuated by September 16. Contamination in the fourth home was located primarily in the basement, and this area was maintained as a restricted area. The fifth home contained only a highly contaminated clothes dryer, which was removed by AHP. As a result of the radiation levels found and the observation of ALARA concepts, no individual residing in the homes of SSI employees is expected to have received an exposure exceeding 10 CFR 20.105 (A) limits.

3.3.3 All Other

Individuals considered in this section are those in the private sector who frequented business establishments that were found to have detectable activity and those institutional agency personnel who responded to this incident. A total of 16 business establishments was surveyed. Of the 16, 6 were found to be contaminated. Areas typically found contaminated were entrance and lobby carpets, all of which were either immediately cleaned or confiscated to maintain any exposures ALARA. In all cases, radiation levels from floor surfaces were very low as shown in Appendix A, "Survey Results." Therefore, it is concluded that no individual who worked in or frequented these establishments received an exposure of any significance.

Institutional response personnel (NRC, state, local, and federal government agencies) who assisted in onsite emergency aspects of this event were all monitored for external exposure by use of whole-body film badges or other suitable devices. Film badge results are not available at this time. No internal deposition is expected. As a precaution, all NRC personnel who responded to this

incident submitted 12-hour urine samples. NRC Region III Laboratory analyzed these samples for gross beta-gamma deposition and found no evidence of internal deposition.

3.4 Environment

3.4.1 Vegetation

No contamination was found on any vegetation other than that on the SSI property, and even there it was limited to some small areas of ground contamination. The vegetation and soil were removed by AHP with shovels and placed in 55-gallon steel drums, sealed, and held for eventual disposal as radioactive waste.

3.4.2 Water

This section discusses the pathways for liquid release of radionuclides to the environment. Liquid releases occurred as a result of the licensee's clean-up attempts on September 14 and 15. During these activities, a water and detergent slurry was used to clean the floor of Building 2. Attempts were made to limit liquid releases down the floor's drain by collecting contaminated wash water using a wet vacuum. However, some radioactively contaminated liquid was inevitably washed down the drain.

Liquids are drained from the SSI facility by a sump pump located on the southwestern portion of the property. The sump pump drains into the town's sanitary sewage system, which leads to a wet well located at the intersection of Water and Pearl Streets in Hebron, Ohio. A pumping station then sends the sewage to the Hebron Treatment Plant located north of town. Treated water is ultimately released into Beaver Creek, which empties into the Licking River.

The licensee's sump pump was in operation during the source rupture through the morning of September 16. The sump discharge rate varies based on back pressure. The maximum discharge rate is 40 gpm with an average rate of 24 gpm. NRC inspectors collected a sump water sample on the morning of September 16, which was analyzed for cesium-137 activity by the NRC Region III Laboratory. This sample showed a cesium-137 concentration of 1.5×10^{-6} μCi/ml (soluble) and 4.7×10^{-6} μCi/ml (insoluble), which is less than the 10 CFR 20.303 limit of 2×10^{-5} μCi/ml (soluble) and 4×10^{-5} μCi/ml (insoluble). On September 20, inspectors collected a water sample from the wet well at Pearl and Water Streets. This sample also showed a cesium-137 level well below the regulatory limit.

3.4.3 Air

The majority of activity released to the atmosphere occurred within the confines of SSI's Building 2 and then settled to the floor and equipment in this building. No ventilation system was in operation during or after this incident, nor are there any windows which could have allowed an effluent release to the outside atmosphere. On the basis of these facts, the NRC believes no radiological hazard existed in the outside atmosphere as a result of this event.

3.5 Animals

3.5.1 Pets

A cat that usually lives in SSI's Building 2 was present during the rupture incident and subsequent cleanup activities. This animal was locked in Building 2 and not allowed to escape. On October 1, 1983, the cat was partially surveyed and showed an approximate surface radiation level of 50 mrad/hr. It is likely this animal had considerable internal deposition as well as external contamination. Repeated attempts to capture the cat were unsuccessful. As a result, SSI management granted authorization to kill the cat on October 13. AHP did so and will dispose of the radioactively contaminated remains by an authorized means.

While surveying the machinist's home, it was determined that his two dogs were slightly contaminated as a result of the tracking of radioactivity into the house. The levels of surface contamination were such that only a dog bath was required.

3.5.2 Wildlife

No wildlife were reported to have frequented the SSI facility grounds during the emergency aspects of this event.

4 SURVEYS AND DECONTAMINATION ACTIVITIES

Surveys were performed by the licensee, the State of Ohio Disaster Services Agency, the NRC, and DOE RATs. The survey results in this report covered the period from September 13, 1983, to October 27, 1983.

4.1 Partial List of Instruments Used

4.1.1 NRC

(1) Eberline Model E-520
Serial 2187
With Ludlum Probe
Model 44-40
Serial 1344PR

(2) Eberline Model E-520
Serial 2123
With Eberline Probe
Model HP 210

(3) Ludlum Model 14-C
Serial 28250
With Ludlum Probe
Model 44-40
Serial 13242

(4) Eberline Model PRM-7
Serial 350
NRC 010285

(5) Ludlum Model 19
Serial 21567

(6) Ludlum Model 14-C
Serial 28236

(7) Eberline Model E-520
NRC Serial 009570

4.1.2 Ohio State Disaster Services

(1) Rascal PRS-1
Serial 283

(2) PRM-7
Serial 238

(3) PRM-7
Serial 231

(4) Rascal PRS-1
Serial 321

(5) Eberline PRM-7
Serial 642

4.1.3 Department of Energy

Data are not available, but observations showed that DOE instrumentation was similar to that used by NRC and state personnel.

4.1.4 Summary

The list of instruments described above is a representative sample of the instruments used during the emergency. Numerous thin window detectors were broken during the emergency response phase. Many different probes and instruments were switched and some instruments were "cannibalized" during field repair to provide functioning instruments for the survey teams. The thin window detectors were used merely as "go"/"no go" gauges to locate radioactivity. Gamma radiation level measurements were performed using the μR and ionization-type meters.

4.2 Survey Methods and Criteria

4.2.1 Methods

Contamination was located using a Geiger-Müller (G-M) meter with a "pancake" probe or other thin window-type probe. After location of a contaminated area (beta-gamma measurement), radiation levels were measured at the surface and at 3 feet (waist high) using a μR meter to determine gamma radiation levels. A dry smear of the contaminated area was performed to determine if the contamination could be removed. Contaminated areas were covered with plastic or tape to identify the spot and to prevent its spread until full decontamination could be performed.

4.2.2 NRC Criteria for Acceptable Levels of Contamination

The NRC criteria for acceptable levels of contamination were based on the guidelines for decontamination of facilities and equipment (Ref. 4).

Items and areas were put into two categories:

(1) Personal: Items or areas that could be in contact with an individual for approximately 8 hours per day (e.g., shoes, clothing, glasses, keys, mattress).

(2) Non-personal: Items or areas that typically are not in contact with an individual for 8 hours or for a significant period of time (e.g., chairs, sofa, carpet).

A personal item or area was considered contaminated if the survey results indicated the following:

Surface radiation levels greater than 20 μR/hr
or
Removable activity greater than 1,000 dpm/100cm^2 beta-gamma

Personal items or areas with less than 20 μR/hr and less than 1,000 dpm/100cm^2 beta-gamma but which exhibited some detectable levels were not considered contaminated, but were classified as items or areas with detectable activity.

Non-personal items or areas were considered contaminated if the survey results indicated the following:

Surface radiation levels greater than 100 μR/hr
or
Removable activity greater than 1,000 dpm/100 cm^2 beta-gamma

Non-personal items or areas with less than 100 μR/hr and less than 1,000 dpm/100 cm^2 beta-gamma but which exhibited some detectable levels were not considered contaminated, but were classified as areas or items with detectable activity. Justification for these levels is given in Appendix B.

4.3 Contamination Levels

The NRC categorized contamination into the following levels:

(1) Any areas/items with surface radiation levels exceeding 1 mR/hr were considered highly contaminated.

(2) Non-personal areas/items with surface radiation levels exceeding 100 μR/hr and personal areas/items exceeding 20 μR/hr were considered contaminated.

(3) Non-personal areas/items with surface radiation levels less than 100 μR/hr and personal areas/items less than 20 μR/hr but which exhibited some detectable level were considered as having detectable activity.

(4) Areas/items with no detectable surface activity were considered clean.

Figures 14 through 19 are examples of the locations and quantities of radioactive material found in a highly contaminated home.

4.4 Survey Summary of Offsite Locations

A total of 41 home surveys were performed. Home surveys indicated the following:

Five homes were highly contaminated.

Eleven homes were contaminated.

Eleven homes had detectable activity.

Fourteen homes were clean.

CONTAMINATION SURVEY RESIDENCE #46

Bagged Items: (1) Boots; (2) Eyeglassos;
(3) Digital Watch;
(4) Papers; (5) Pillow

TEAM 1 -- Surveyors: (Battelle) 9/15/83 9:15 p.m. to 11:30 p.m.

Instrumentation:
Eberline Pac 4G
Battelle x 32560 BG 500 cpm

Eberline Rascal PRS-T
HP210T
Pancake Probe BG-15 μR

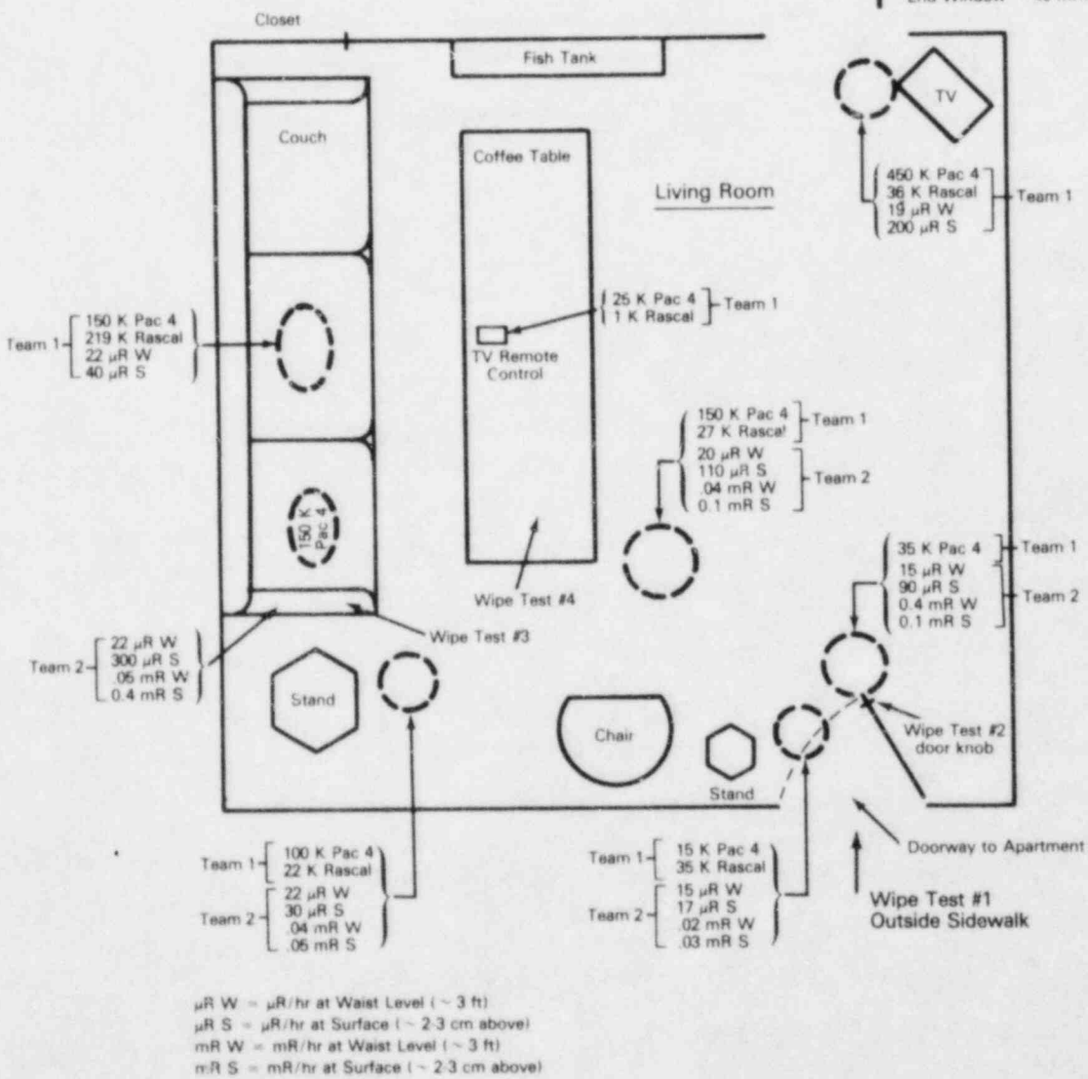
Eberline μR Meter, S/N 632
BG 190 cpm
100 cpm

TEAM 2 -- Surveyors: (NRC) 9/17/83 2:00 p.m. to 5:00 p.m.

Instrumentation:
Ludlum Md/Na 14C, S/N 28119
Checked Cs^{137} With 1μCi Source
30 K Front 2.7 K Back

Eberline Model PRM-7, S/N 632
Cs^{137}, 1μCi
Ranges: x5000 → 500 μR/hr
x500 → 425 μR/hr

Eberline Model E-520, S/N 2123
NRC 009573
Scale 0.1 → 1μCi Cs^{137}
Side → 0.4 mR/hr
End Window → 0.8 mR/hr
Scale 1.0 → 8μCi Cs^{137}
Side → 6.5 mR/hr
End Window → 40 mR/hr



μR W = μR/hr at Waist Level (~ 3 ft)
μR S = μR/hr at Surface (~ 2-3 cm above)
mR W = mR/hr at Waist Level (~ 3 ft)
mR S = mR/hr at Surface (~ 2-3 cm above)

Figure 14. Sketch of a contaminated living room.

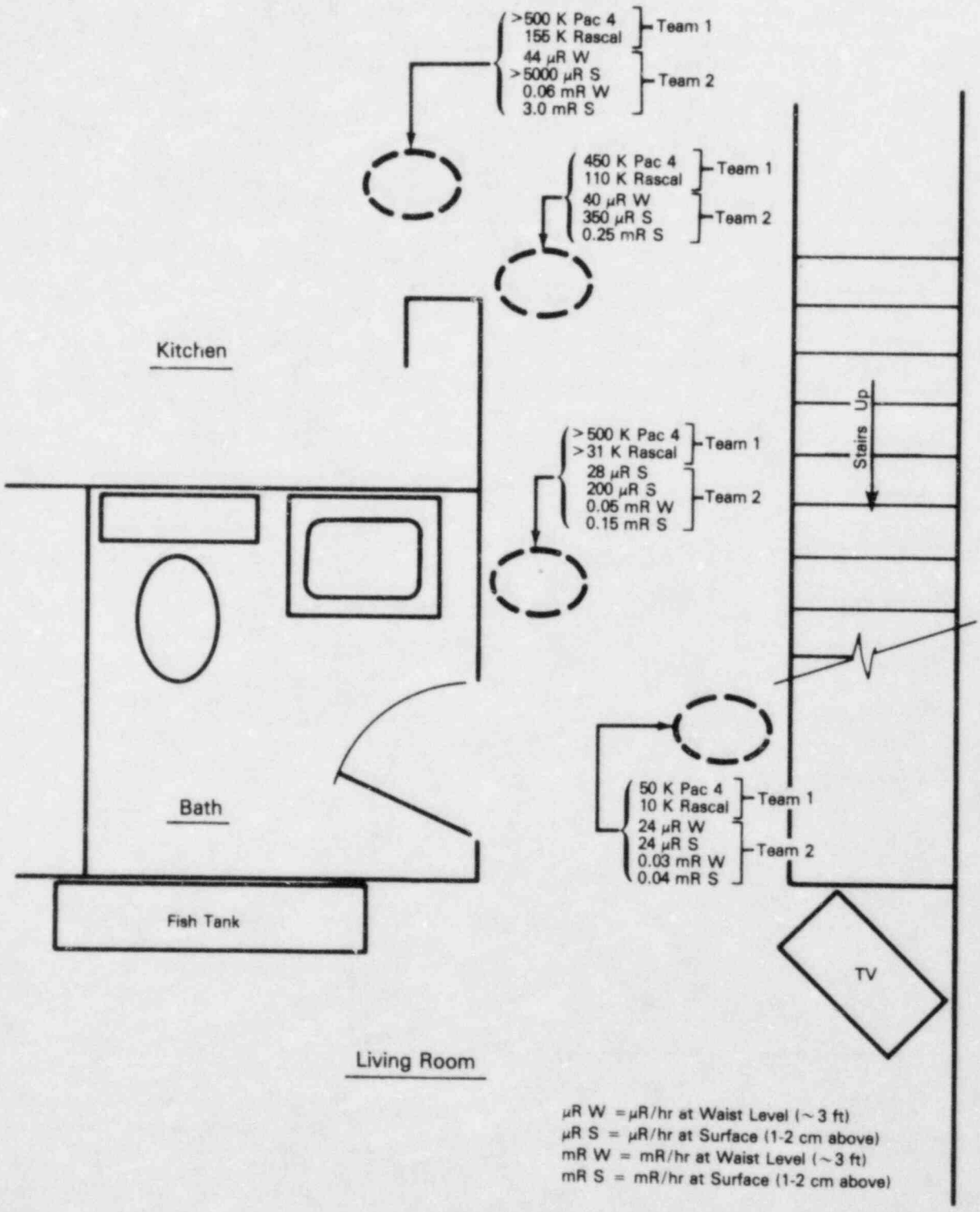


Figure 15. Sketch of a contaminated hallway.

SURVEY OF RESIDENCE #46
September 15 - 17, 1983

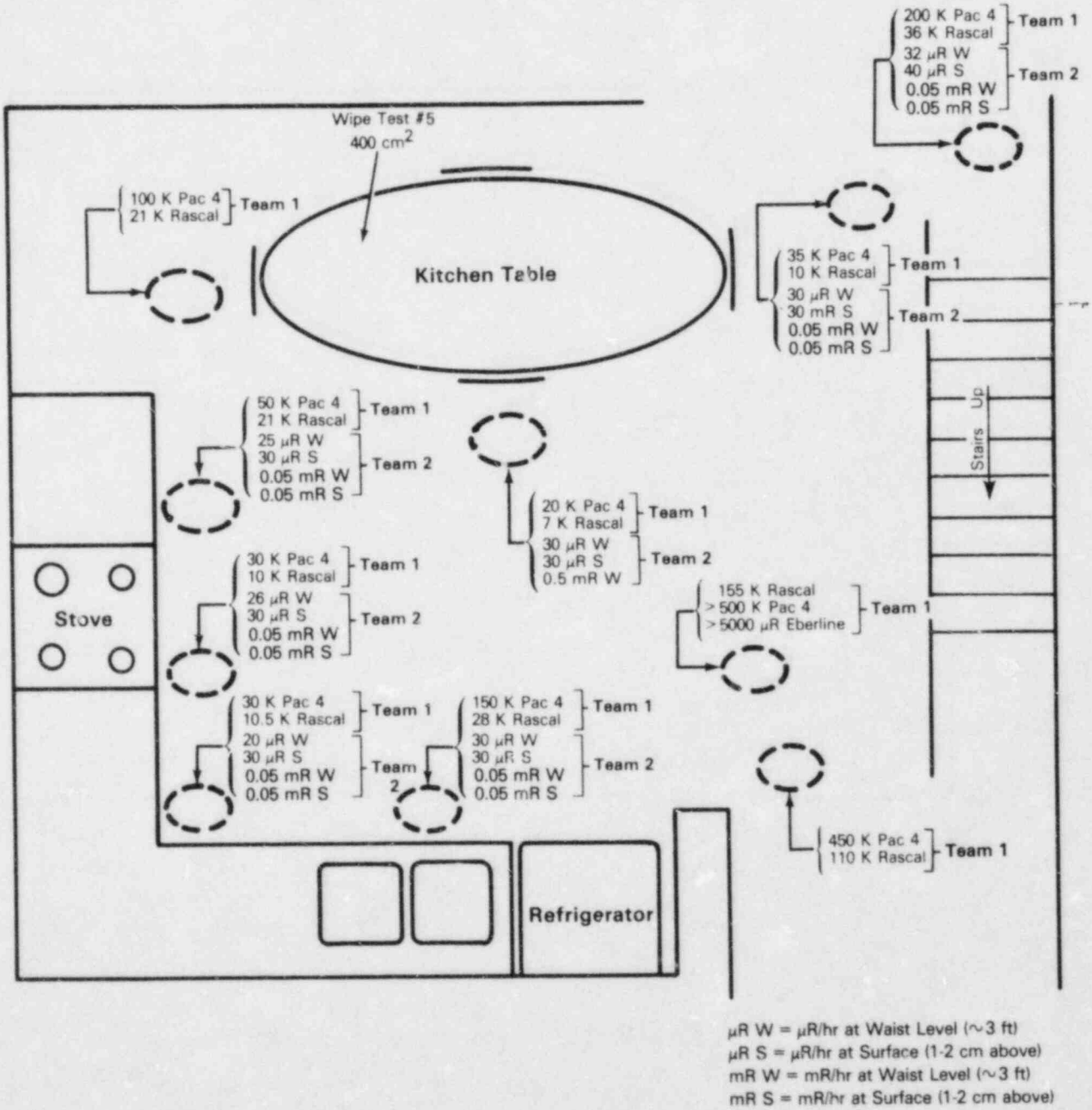
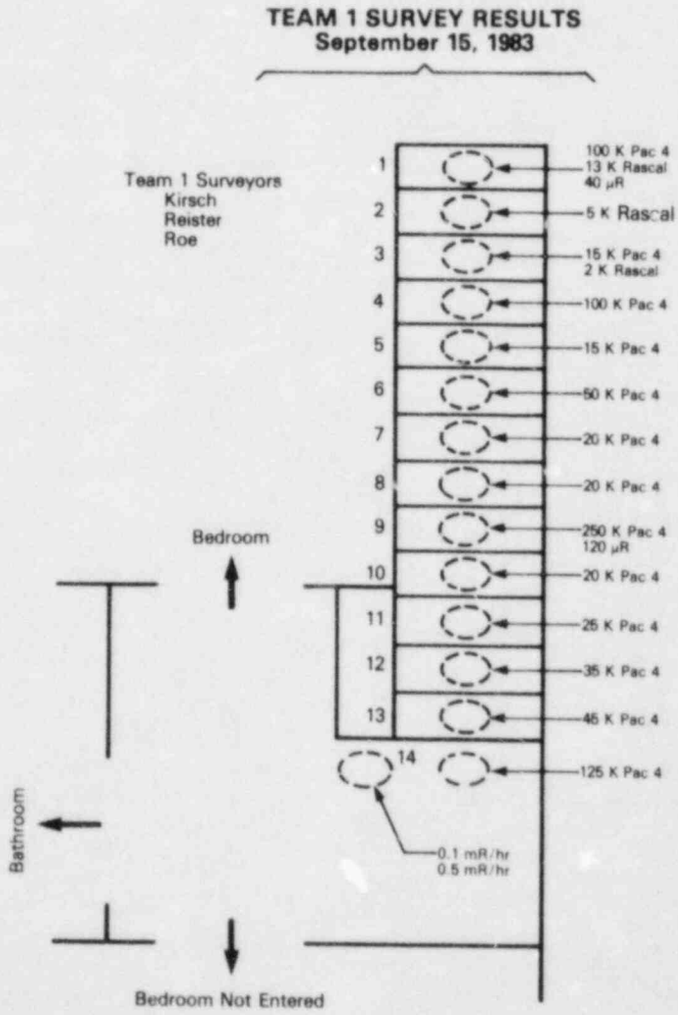


Figure 16. Sketch of a contaminated kitchen.

STAIRWAY SURVEY
RESIDENCE #46



TEAM 2 SURVEY RESULTS
September 17, 1983

mR/hr	μR/hr	Step
0.05 W 0.07 S	32 W 40 S	1
0.05 W 0.04 S	34 W 40 S	2
0.03 W 0.05 S	34 W 49 S	3
0.03 W 0.04 S	32 W 40 S	4
0.05 W 0.05 S	32 W 40 S	5
0.05 W 0.07 S	29 W 40 S	6
0.05 W 0.05 S	29 W 35 S	7
0.03 W 0.07 S	29 W 30 S	8
0.03 W 0.1 S	29 W 200 S	9
0.03 W 0.03 S	25 W 25 S	10
0.05 W 0.05 S	25 W 25 S	11
0.05 W 0.05 S	25 W 30 S	12
0.05 W 0.05 S	24 W 200 S	13
0		14

W = Waist Level
S = Surface

Figure 17. Sketch of a contaminated stairway.

UPSTAIRS BATHROOM BATH SURVEY
RESIDENCE #46
September 17, 1983
(Team 1 Results Only)

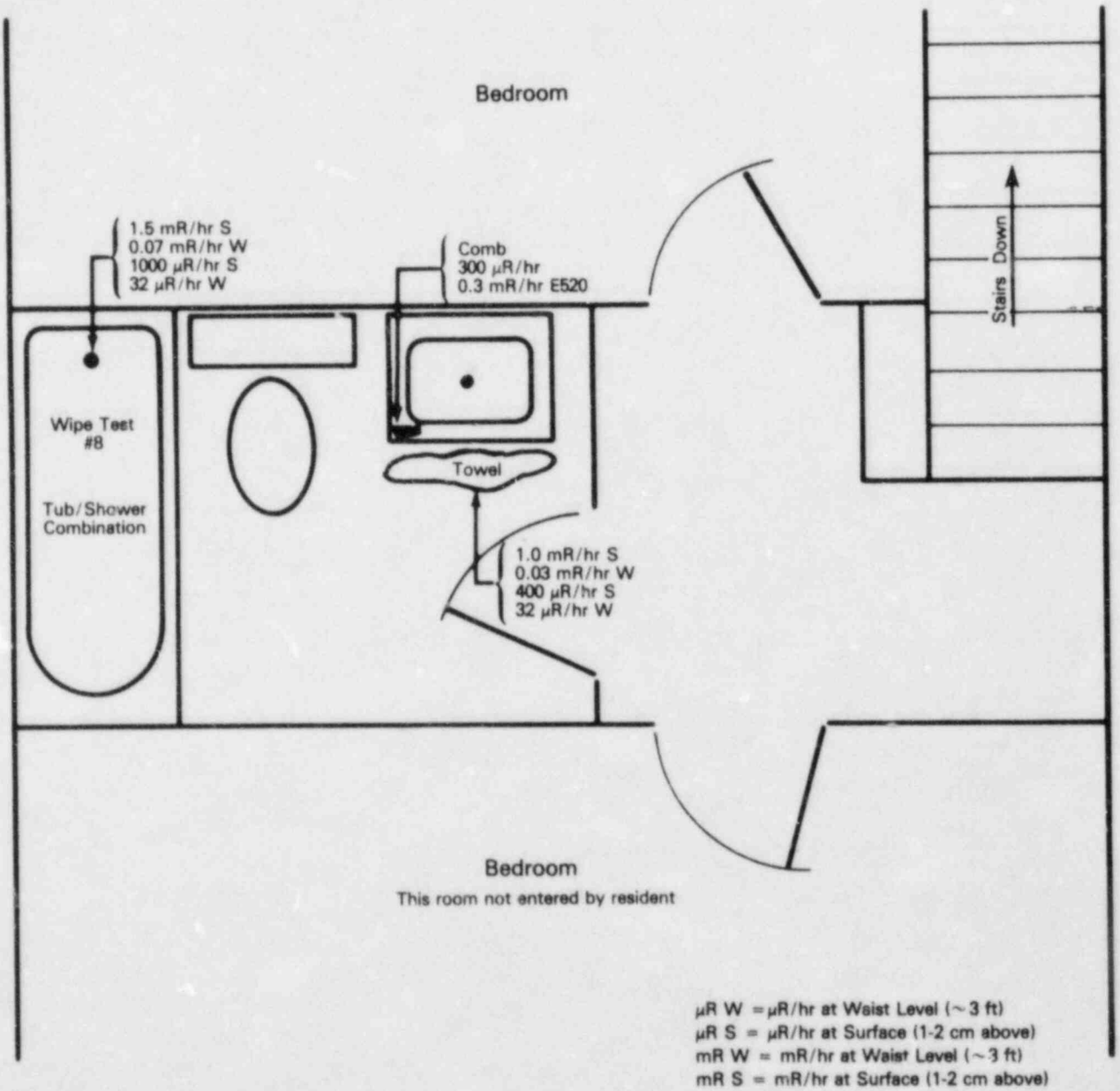
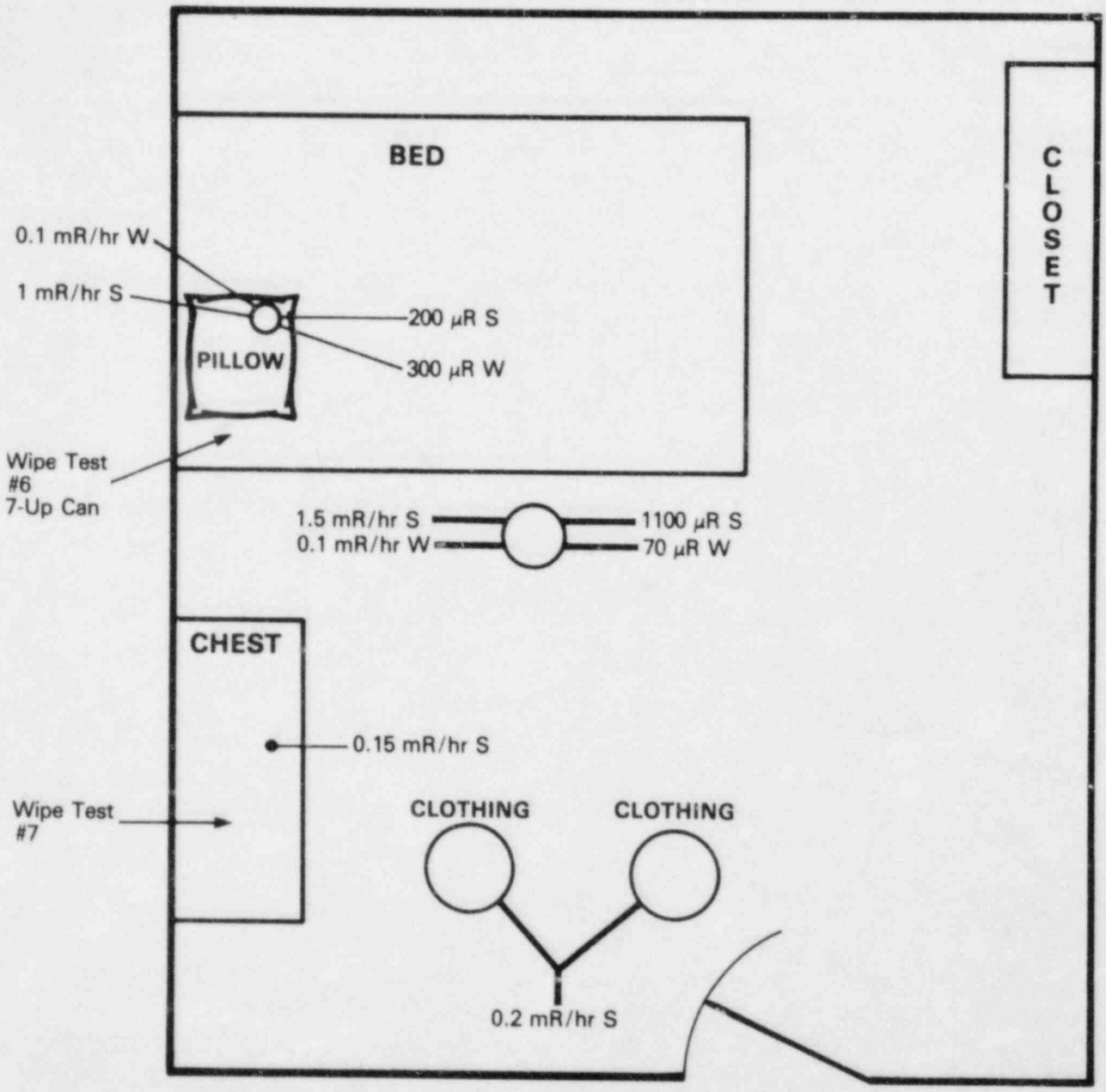


Figure 18. Sketch of a contaminated bathroom

MAIN BEDROOM SURVEY
RESIDENCE #46
September 17, 1983



S indicates Surface
W indicates Waist Level

Results in mR/hr were obtained using the Eberline Model E-520.
Results in μR were obtained using the Eberline Model PRM-7.

Middle Room Waist High Surveys - 0.1 mR/hr
Middle Room Waist High Surveys - 110 μR

Figure 19. Sketch of a contaminated bedroom

A total of 16 public facilities were surveyed. Public facility surveys indicated the following:

One public facility was highly contaminated.

Five public facilities had detectable activity.

Ten public facilities were clean.

Thirty-two vehicles were surveyed. Survey results ranged from highly contaminated to clean. Six SSI employee vehicles were confiscated and kept onsite until they were decontaminated.

4.5 Other Offsite Surveys

Surveys were performed of the rental vehicles, motel rooms, and temporary operations centers. Survey results were not always documented. The available survey records showed that there was no radiation found which exceeded the NRC acceptable surface contamination levels.

4.6 Source Evaluation

Arrangements had been made with Argonne National Laboratory in Argonne, Illinois, for the remains of the ruptured cesium-137 source capsule and its holder to be examined and subsequently disposed of. The purpose of the examination is threefold:

(1) Identify source and source holder (manufacturer, model number, etc.).

(2) Identify/quantify contents of source (form, activity remaining).

(3) Evaluate structural integrity of source capsule to determine possible generic concerns.

This examination is scheduled for January 1984. The source will ultimately be disposed of by an authorized disposal firm.

4.7 ARMS Overflight

A formal request for an ARMS (Aerial Radioactive Monitoring Survey) was made on October 4, 1983. The purpose of the overflight was to identify contamination of any additional offsite areas, since some employees were unable to remember where they went shortly after the incident.

The overflight was performed by EG&G, Inc., between October 17 and 26, 1983.

The results of the survey indicated that detectable quantities of cesium-137 were limited to the SSI facility. No contamination was detected in offsite areas. See Appendix F for specific survey results.

4.8 Decontamination Activities

During the emergency phases of the incident, most of the effort was expended identifying contaminated areas. The federal/state response teams were not

equipped to perform full decontamination. Any decontamination performed was done with the materials that were immediately available applying field expedient methods. Decontamination was performed in homes, private businesses, public places, and vehicles. Waste from the limited decontamination efforts was collected and presented to the licensee for storage and ultimate disposal.

4.8.1 Offsite Criteria

NRC required decontamination of an item or area if it met the criteria for contaminated personal items and contaminated nonpersonal items described in Sections 4.2 and 4.3 of this chapter. The licensee's goal was to try to decontaminate items to as low as reasonably achievable.

4.8.2 Methods

The field expedient decontamination efforts were a limited success. The most successful and immediate method of decontamination was to remove the contaminated item. The success of the other methods of decontamination depended on numerous variables. Some factors influencing the success of decontamination were:

(1) The type of material contaminated; for example, wood, metal, cloth, foam rubber, and leather. Nonporous items could usually be decontaminated by simply lifting off the contamination with tape or with a vacuum. Conventional cleaning methods were also useful.

(2) The length of time the contamination was on the material. This affected absorption into porous materials.

(3) The physical form of the contaminant; for example, cesium-137 was sometimes in solution, sometimes in a solid form.

4.8.2.1 Tape Method of Decontamination

Only limited success was obtained using tape to decontaminate items (e.g., lift off any contamination, in solid form, using the adhesive). Usually, the contamination was picked up after the first application of tape. Rarely was repeated taping of a contaminated area successful in removing contamination that remained after the first application of tape.

4.8.2.2 Water and Absorbent Material Method of Decontamination

Only limited success was obtained using water and absorbent materials as a method of decontamination for porous material. However, some nonporous items were decontaminated successfully using this method.

4.8.2.3 Detergent Solution and Absorbent Material Method of Decontamination

Using a detergent solution and absorbent material to decontaminate items gave similar decontamination results as using water and absorbent materials. Occasionally, detergent and scrubbing action would lift the contaminant out of certain porous materials.

4.8.2.4 Decontamination by Removing the Contaminated Item

Removing the contaminated item was the most successful method of decontamination. Confiscating the contaminated item removed the radiation hazard from the area immediately. We do not yet know if the confiscated items can be decontaminated and returned to use. AHP will either decontaminate these items or dispose of them as radioactive waste, on the basis of a cost study.

4.8.3 Onsite Decontamination Plan

The licensee's proposed decontamination plan was approved by NRC Region III on October 25, 1983.

Shelwell's onsite decontamination plan had nine major areas.

(1) Decontaminate the road and the soil, but first cover exposed surfaces or contaminated surfaces with plastic to keep racioactivity from spreading.

(2) Decontaminate the State of Ohio Highway Building.

(3) Decontaminate Shelwell's trailer and establish a control center in the trailer.

(4) Decontaminate the NES portion of Building 2 and any of their equipment in this area.

(5) Decontaminate the Shelwell portion of Building 2.

(6) Decontaminate Building 1.

(7) Decontaminate personal property (an ongoing process) as soon as the decontamination trailer is set up.

(8) Argonne National Laboratories would analyze the source capsule for defects. AHP would properly package and ship the source to Argonne before Building 1 is decontaminated.

(9) No decontamination procedures were submitted for the drain tile leading from the building where the incident occurred because the contamination has not yet been evaluated. A plan will be proposed after AHP evaluates the drain line contamination.

4.8.3.1 Methods/Implementation of Plan

The decontamination plan was approved on October 25, 1983. AHP was to perform the decontamination activities. SSI employees were not to be involved in any of the decontamination activities.

Roads, soil, and other exposed surfaces would be decontaminated first. Until the exposed surfaces could be decontaminated, they would be covered with heavy plastic to prevent the spread and further penetration of the radioactivity into the soil.

Road and parking lot decontamination was started in November 1983. It was estimated that about 200 barrels of radioactive waste would be removed from these areas.

The State of Ohio Highway Building would be the first building decontaminated. The Highway Building is an old wooden (frame) building surrounded on three sides by tall weeds. The Highway Building had a highly contaminated floor and some highly contaminated items stored in it. This building was chosen as one of the first to be decontaminated because of the high potential for fire.

Shelwell's office trailer would be the next building decontaminated to obtain a "clean" facility to be used as a decontamination control center. There were no highly contaminated items or areas in the trailer. Items in the trailer would be decontaminated in place or removed and placed in a storage trailer for decontamination at a later time.

Next, the NES portion of Building 2 would be decontaminated. Survey results indicated 40 to 60 μR/hr in this storage area. All NES gas meters would be decontaminated before removal as well as any of their other equipment and then would be released to NES. Decontamination would then continue with Shelwell's portion of Building 2. The highest radiation levels (100 to 150 mR/hr) were near the lathe and the trash barrels (see Figure 20).

The ruptured source would be removed from Building 1 before decontamination of this building starts. AHP would package and ship the ruptured source remains and its holder to Argonne National Laboratories.

Decontamination of items would start as soon as the storage trailer and the temporary decontamination facility were set up on site. The temporary decontamination facility would consist of two trailers "back to back." One trailer would be designated the storage area and would house the contaminated items. The other trailer would become the decontamination facility. An airlock would be set up between the two trailers to allow entry from the outside and into the trailers. Item and building structure decontamination would be peformed concurrently. Item decontamination includes onsite and offsite items.

AHP's goal for decontamination was to have no detectable activity above background levels, as determined by their most sensitive detection instrument. If background levels of contamination are not reached, contamination would be as low as achievable. In any event contamination would not exceed the levels in the NRC guidelines.

The levels of contamination of the drain tile had not been determined. As referenced in the letter dated October 25, 1983 (see Appendix G), from Mr. J. G. Keppler, Regional Administrator, to Mr. Clyde Shelton, President of Shelwell, decontamination of the drain tile will be delayed until more information about the extent of the contamination is obtained. NRC will approve plans to decontaminate the drain tile before any actions are taken.

All waste would be properly packaged and transported to Richland, Washington, for burial at the licensed burial site operated by U.S. Ecology, Inc.

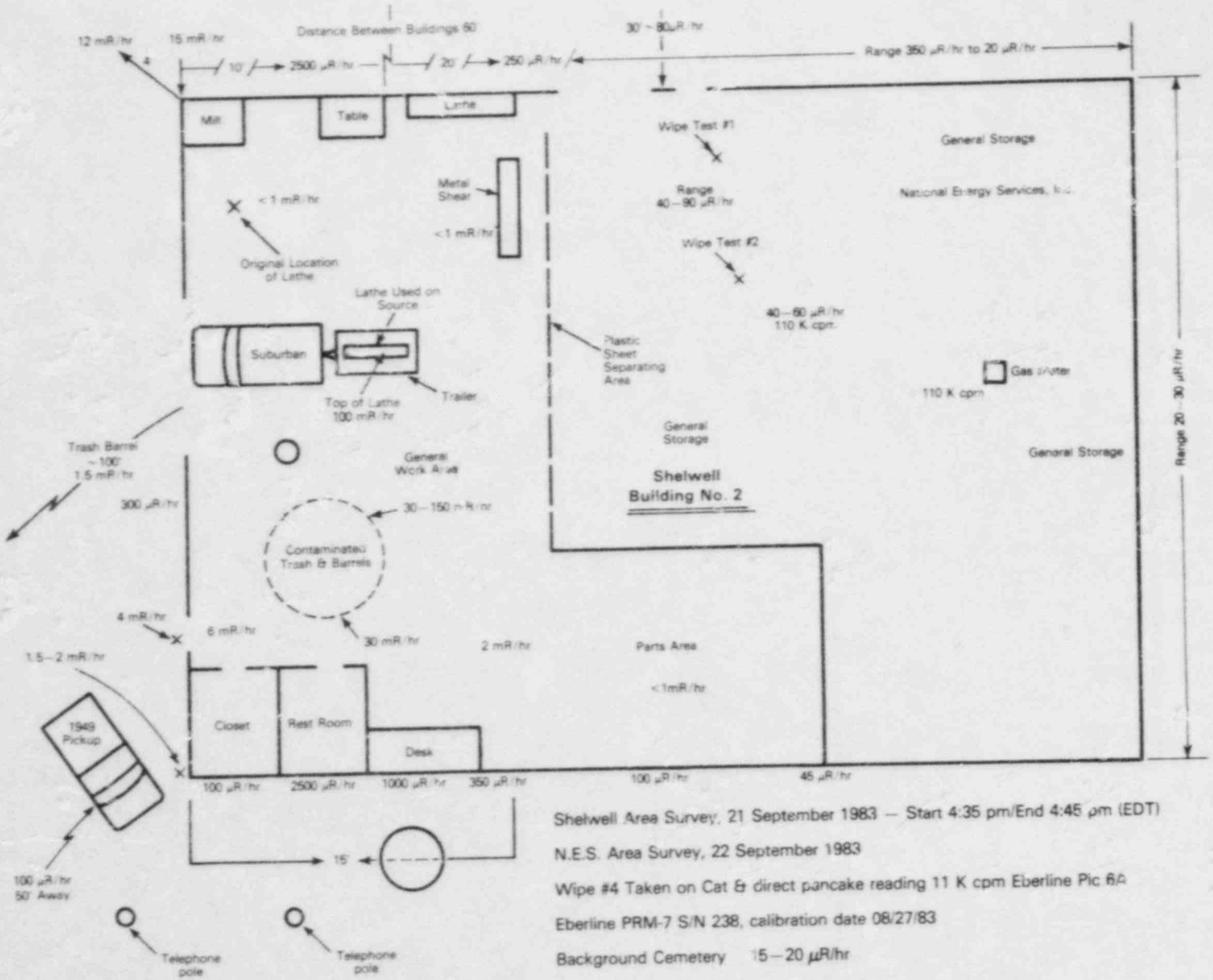


Figure 20. Sketch of Shelwell Building 2, including survey results.

5 RESPONSE ORGANIZATIONS

This chapter assesses the organizational responses to events at the SSI Hebron facility from September 13 to October 5, 1983.

5.1 Licensee Response

At about 4:30 p.m.(EDT) on Tuesday, September 13, soon after the source was ruptured, the president of SSI tried to call his health physics consultant but could not reach him. Other attempts later that evening also failed. The next morning at approximately 8:00 a.m.(EDT), the ARSO called the RSO who was in Mt. Sterling, Illinois, on company business, to notify him about the source rupture. These attempts were not dictated by any procedure, the licensee did not have an emergency plan covering such an event. Finally at about 9:30 a.m. (EDT) on Wednesday, the ARSO reached the HP consultant. The consultant discussed the requirement to notify the NRC within 24 hours with the president, the RSO, and the ARSO. The ARSO and the president decided to delay the notification until they could get some radiation readings. At about 3:30 p.m.(EDT), the ARSO called the RSO with additional survey information. At 4:00 p.m., the RSO relayed the information to the chief of NRC Region III Radiation Protection Section II and made the required notification. The information given did not reflect the seriousness of the incident, and in fact gave just the opposite impression (Section 2.2.2 of the report discusses this point in greater detail). By early afternoon on Thursday, September 15, an inspector from the NRC Region III and one from ODSA were on site. Their evaluation of the situation showed an immediate need for a drastic increase in the response effort. The licensee, at the instruction of the NRC inspector, assisted in returning some highly contaminated items from the parking area to inside Building 2 and securing the building to prevent entry. The licensee took no further steps of its own initiative to respond to the incident except at the direction of the NRC and ODSA inspectors. This situation persisted even after SSI's HP consultant arrived at about 7:00 p.m.(EDT). It became clear at this time that the NRC had to manage this emergency to ensure public health and safety and the safety of the SSI workers.

5.2 State and Local Government Response

5.2.1 State Response

The State of Ohio was notified on September 14 that SSI had a source rupture and that Region III intended to send a radiation specialist to investigate. ODSA requested to have their representative accompany the NRC inspector, and Region III concurred with the request.

ODSA and NRC inspectors arrived at the licensee's facility on September 15 at approximately 12:45 p.m.(EDT) and quickly determined assistance was needed.

The NRC inspector phoned Region III to inform personnel there of the situation and the NRC inspector requested the ODSA inspector for his agency's assistance. The OSDA concurred and by 6:00 p.m.(EDT) the OSDA Nuclear Operations Officer arrived onsite with three additional inspectors. The ODSA contingent remained until September 30, 1983. Their staffing varied throughout this period. Staffing included communications personnel, secretaries, a public affairs officer, and onsite visits by their Chief of Staff, and Deputy Director. ODSA expended a total of 736 hours (92 person days) onsite.

In addition to the public affairs, communications, radiation monitoring, and secretarial support, ODSA also arranged to have the Ohio State Police take aerial photographs of the site and for an Emergency Operations Center to be set up at the Ohio National Guard Armory.

5.2.2 Local Response

The Hebron police dispatcher was informed of the incident and of the federal and state involvement at 12:25 a.m.(EDT) on September 16, 1983, by the NRC's site team leader and the NRC public affairs officer. The Chief of Police agreed to include the site in his shift patrols and to inform the site team leader of any unusual events. He also assisted in arranging a September 20, 1983, briefing of the City Council members by the response team members.

The Hebron Fire Department was informed of the incident and fire fighting procedures were reviewed to ensure they were appropriate.

5.2.3 Communications

An emergency communications system was the primary link between the licensee's decontamination team, NRC/DOE/ODSA survey team, and the Emergency Operations Center. The system was provided by ODSA and consisted of telephones, mobile radios, and a communication van equipped with a repeater, receiver/transmitter, and telescoping long range antenna. The system had the ability to receive a hand-held radio transmission, amplify it, and retransmit it to the Columbus, Ohio, radio operator where it could enter the commercial telephone system. The state radio system provided an outstanding communications system for all points involved in this incident.

5.2.4 Public Affairs

The ODSA public information officers provided press releases both from the site and from the Columbus office. Information for the releases and press briefing were obtained from state officials.

5.3 Federal Agency Response

NRC and DOE had the primary federal response roles at the scene of the incident.

5.3.1 Department of Energy

On September 16, 1983, at 2:59 p.m.(CDT), the DOE Chicago Operations Office received a call from the chief of NRC Region III Materials Radiation Protection Section 2 requesting a radiological assistance program (RAP) callout and informed them of the incident. At 3:15 p.m.(CDT) the Dayton Area Office-Mound

Team (six men) was contacted and at 3:25 p.m.(CDT) the Battelle Columbus Team (three men) was notified. The DOE/RAP team leader accompanied the NRC Region III team on a charter flight and arrived at the site at about 11:00 p.m.(EDT), September 15.

The teams performed radiation surveys of homes, public places, persons, cars, personal effects, roads, licensee facilities, etc., until the principal contaminated sites were identified, the areas of highest contamination were evacuated, and the areas of lesser contamination had been covered with tape or plastic. When AHP started its decontamination efforts and the radiation survey program changed to one of confirming cleanup results, the DOE/RAP teams were released. The Battelle Columbus Team was released at 1:00 a.m.(EDT) on September 18, and the Mound Laboratory Team at 12:00 noon. The DOE/RAP team leader terminated DOE's on-scene involvement with his departure on the following day. The DOE involvement is estimated at ten person weeks of effort plus the time needed for report writing.

5.4 Regional NRC Response

The Region III Incident Response Center (IRC) was activated at approximately 3:30 p.m.(CDT) on September 15, 1983. Assistance was requested from the Department of Energy and the dispatched nine persons to the site. The Executive Director's Office was contacted and briefed on the events at Shewell. At approximately 5:30 p.m.(CDT), four NRC representatives and one DOE representative from Argonne left Region III for Shelwell. Between 6:00 p.m. and 10:00 p.m.(CDT) NRC efforts were expended contacting the State of Ohio (ODSA) and federal agencies (Occupational Safety and Health Administration, Federal Emergency Management Agency) to brief them on the incident. (Figures 21 through 30 show contaminated areas.)

Arrangements were made with the NRC medical consultant to schedule whole-body counting of the contaminated workers on September 16th. A press release on the incident was prepared and issued to the Columbus offices of United Press International (UPI) and the Associated Press (AP). A regional PAO officer was dispatched to the site.

The president of Shelwell was contacted and agreed that all licensed activities would stop until additional surveys could be completed.

The Region III Deputy Director and the Headquarters Duty Officer were briefed on the incident and the current events.

The IRC was deactivated at approximately 10:30 p.m.(CDT).

Figure 21. Contaminated driveway.

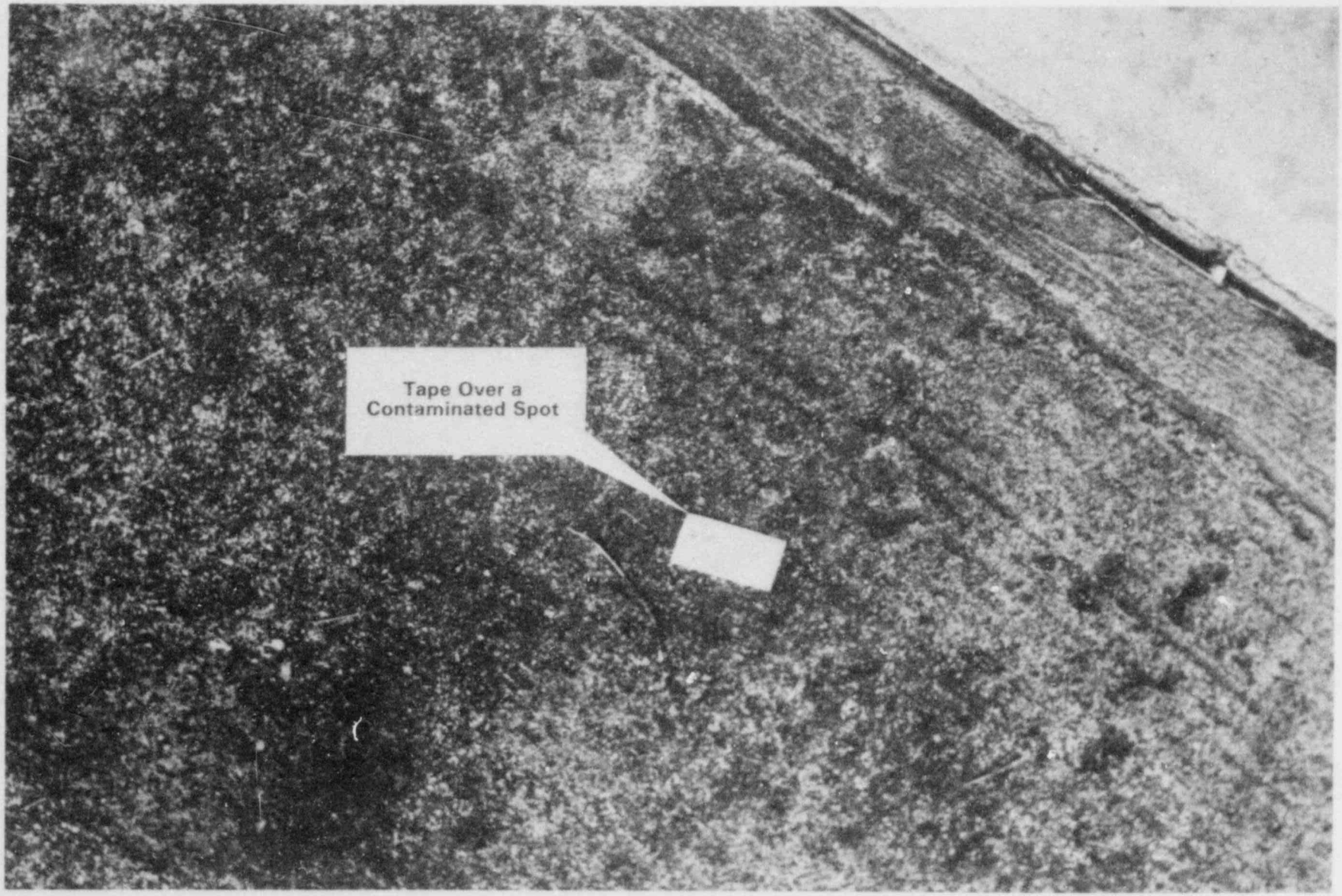


Figure 22. Contaminated driveway (closeup).

Figure 23. Contaminated carport.

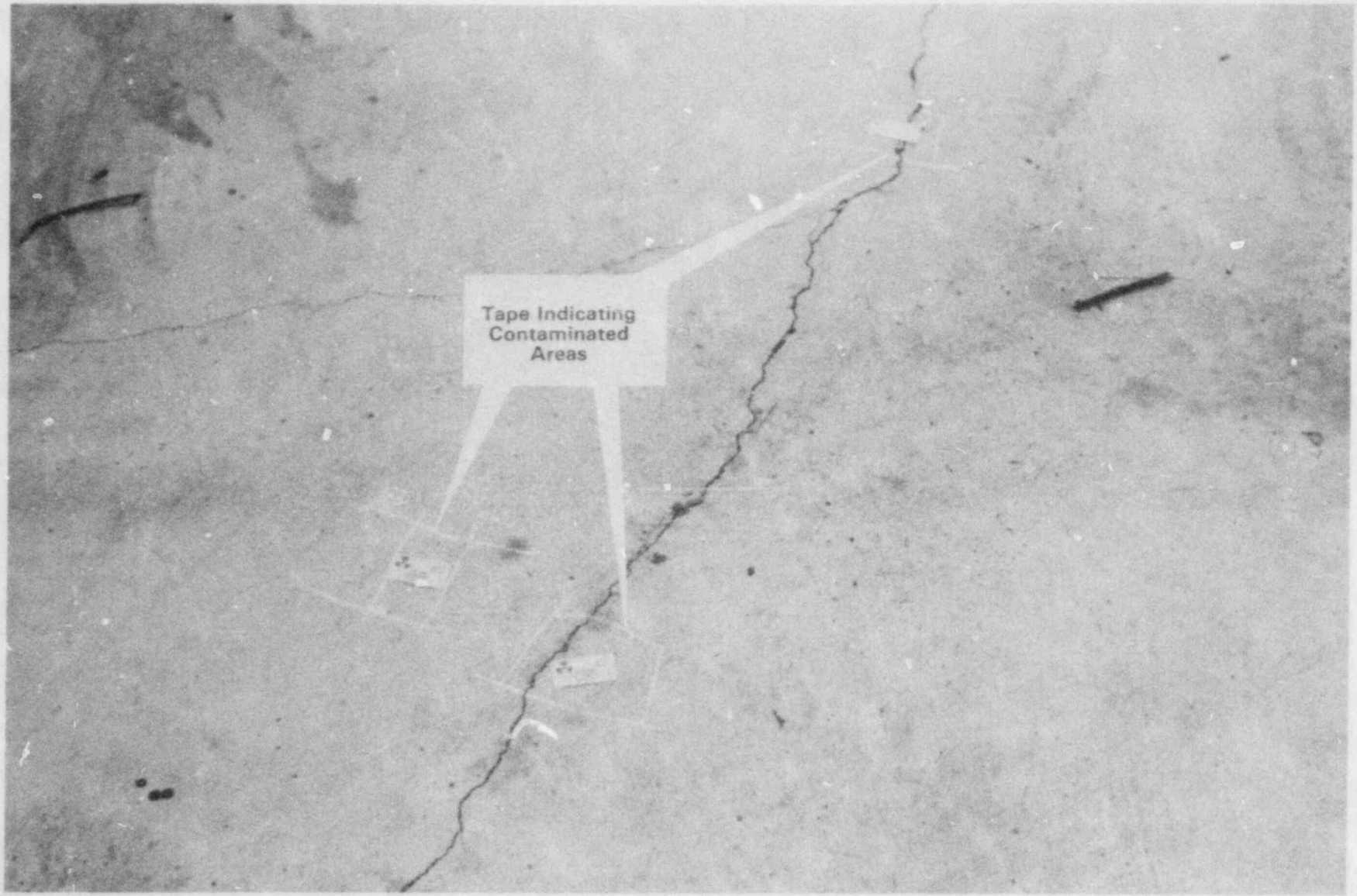


Figure 24. Contaminated carport (closeup).

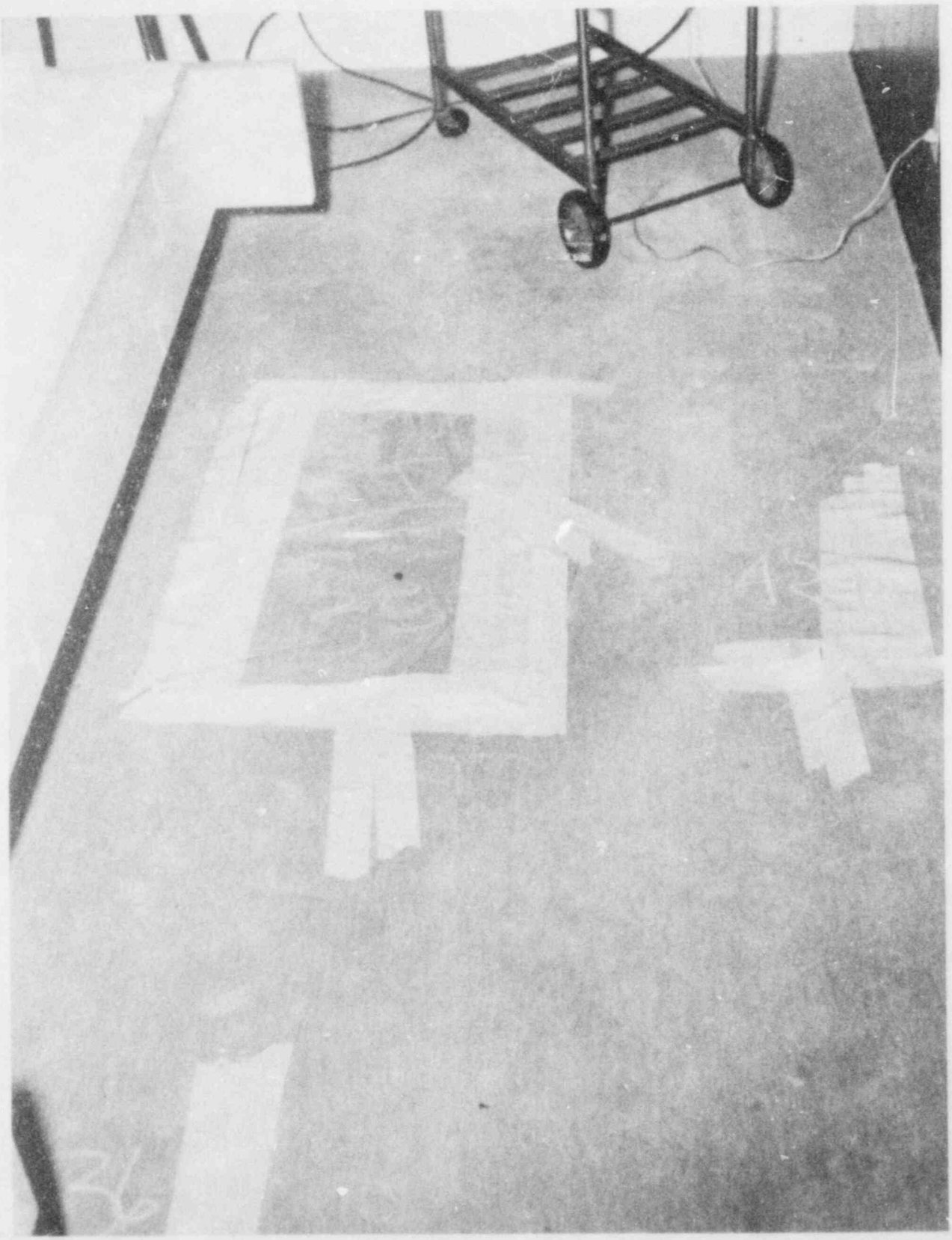


Figure 25. Contaminated bedroom.

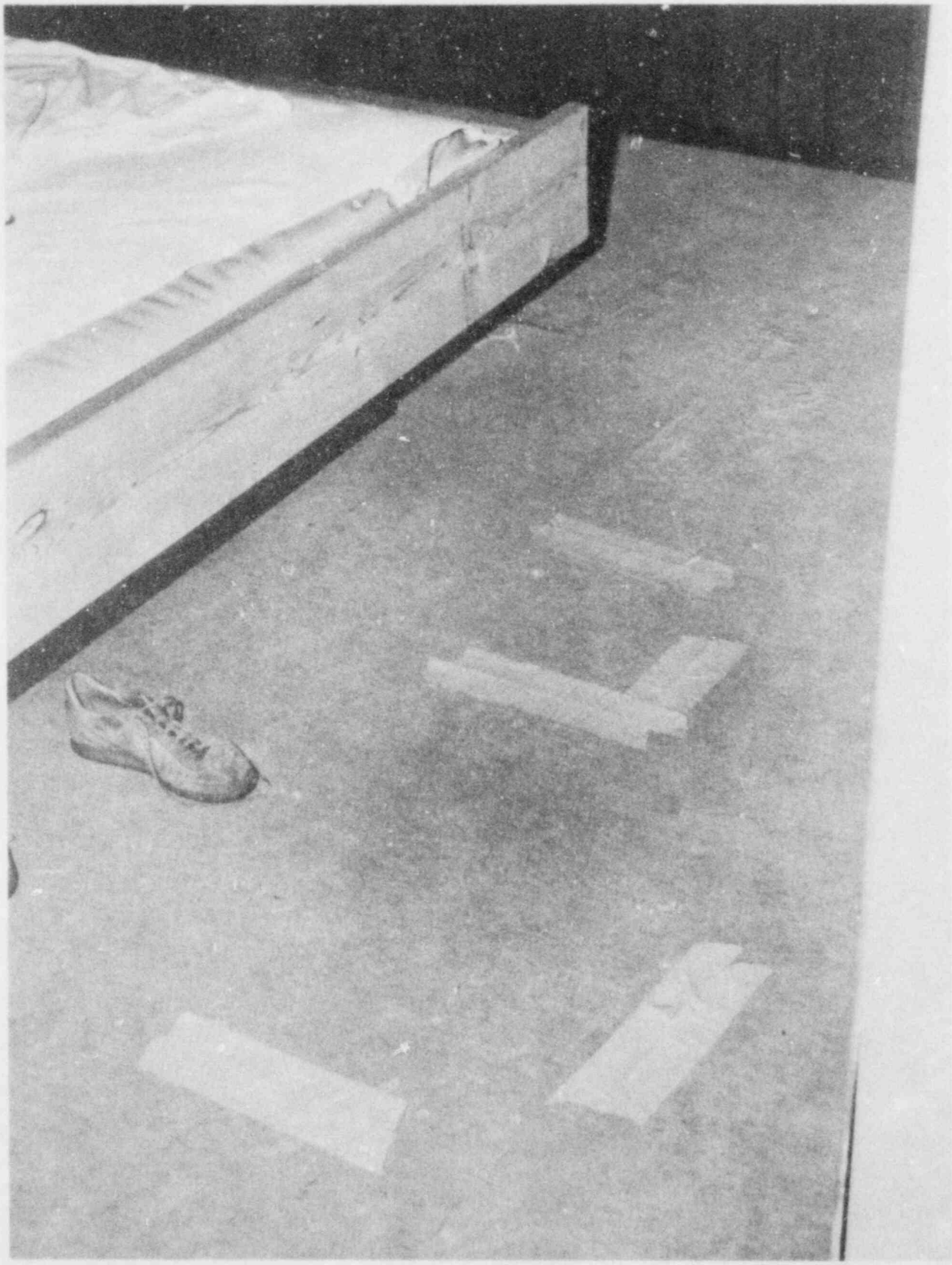
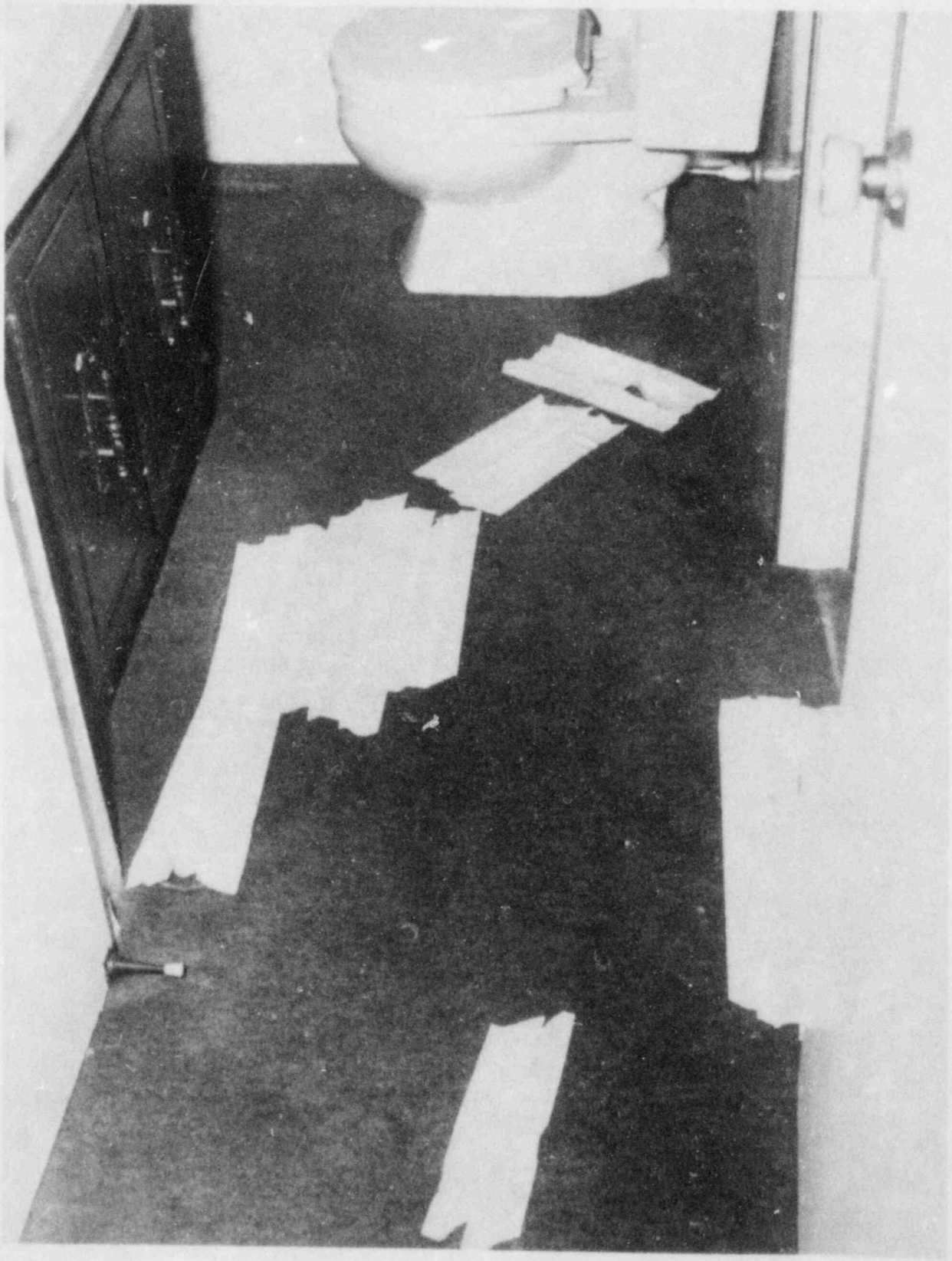


Figure 26. Contaminated bedroom.

Figure 27. Contaminated family room.



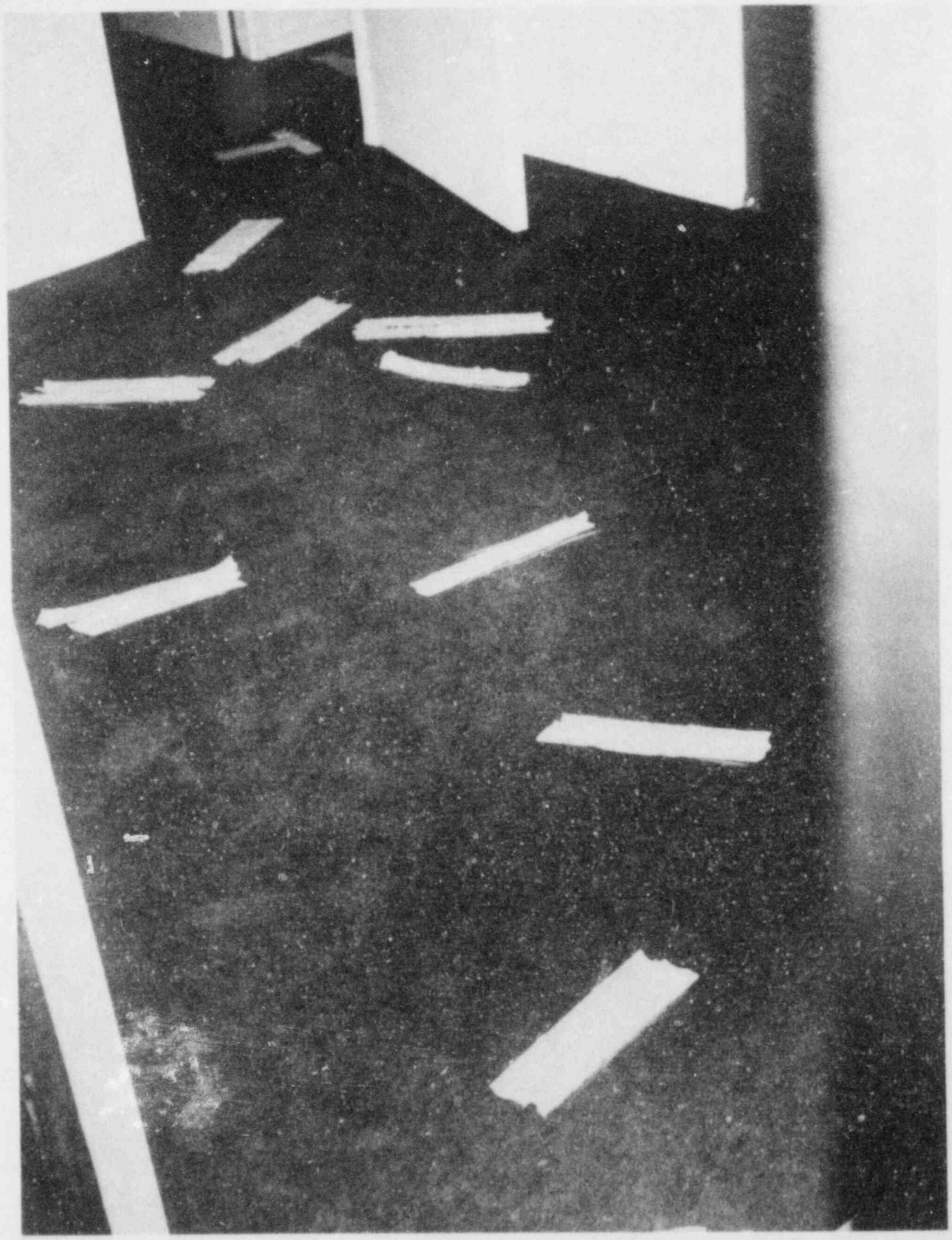


Figure 29. Contaminated bedroom.

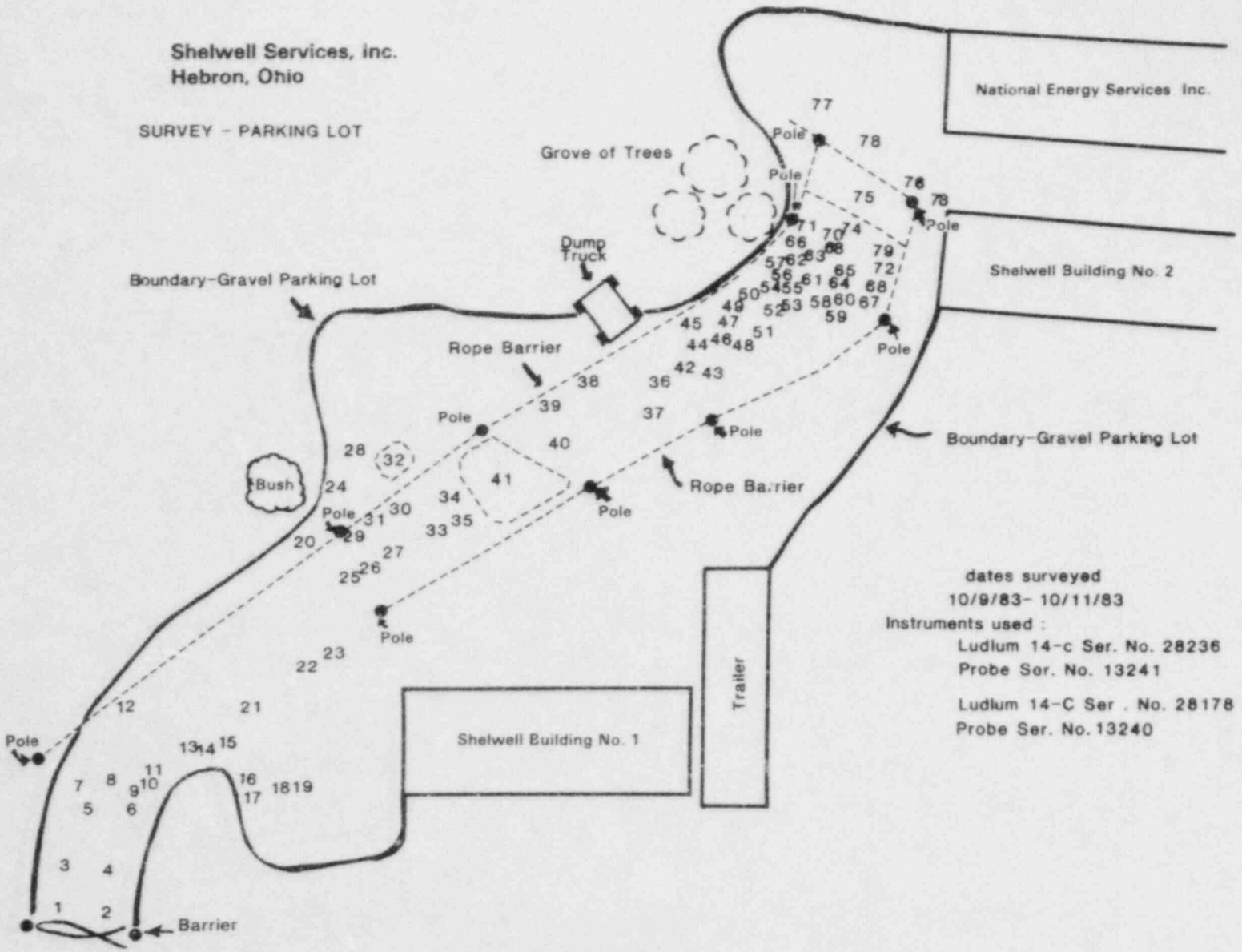


Figure 30. Sketch of contaminated roadway, with survey results.

Key to Survey Results in Figure 30

Shelwell Services, Inc., Hebron, Ohio
Dates Surveyed: October 9, 1983, and October 11, 1983

Area No.	Measurement (cpm)
1	10,000
2	8,000
3	2,000
4	1,500
5	4,000
6	1,200
7	1,200
8	3,500
9	20,000
10	1,500
11	1,200
12	10,700
13	3,000
14	1,500
15	22,000
16	20,000
17	15,000
18	12,000
19	25,000
20	20,000
21	1,500
22	18,000
23	1,500
24	1,200
25	3,000
26	3,000
27	2,000
28	90,000
29	1,500
30	2,000
31	2,000-5,000 (Several spots around puddle)
32	10,000 avg. (3 ft.^{2} area)
33	2,000-5,000 (8-10 areas around puddle)
34	10,000
35	110,000
36	18,000
37	7,000
38	10,000
39	9,000
40	2,200
41	Area ~30 spots, 3,000-5,000 avg. Max. up to 22,000
42	2,800
43	5,000

Area No.	Measurement (cpm)
44	2,600
45	80,000
46	8,000
47	3,000
48	8,000
49	3,000
50	7,000
51	2,800
52	3,000
53	6,000
54	8,000
55	2,400
56	11,000
57	30,000
58	6,000
59	12,000
60	6,000
61	3,000
62	12,000
63	3,000
64	10,000
65	8,000
66	5,000
67	12,000
68	4,000
69	5,000
70	12,000
71	3,000
72	14,000
73	12,000
74	8,000
75	2,000-300,000 (28 spots) 2,000-80,000 (25 spots) 1 spot oil = 6,000
76	8,000 (puddle)
77	140,000
78	40,000
79	20,000 (paper towel)

6 SIGNIFICANT FINDINGS AND CONCLUSIONS

This section provides significant findings and conclusions resulting from the cesium source rupture event at SSI on September 13, 1983. The findings focus on factors that may have caused the event and those that contributed to the escalation of the incident. Also discussed are radiological findings dealing primarily with personnel and area contamination and its spread, both on and off site. The information was obtained through interviews of personnel, review of the SSI Byproduct Material License, and observations and measurements made by NRC representatives.

6.1 Licensee Actions

6.1.1 Human Factors Considerations

Two of the three individuals involved in the source rupture incident had previous experience in handling radioactive materials. The president of SSI was the former radiation safety officer for this program from its inception in October 1964 through May 1979. The sales representative was a former well-logging engineer with the licensee for approximately 3-1/2 years. The third individual, a machinist, had no previous experience in handling radioactive materials.

The inspectors learned that interchanging of sealed source capsules in source holders was an occasional practice with the licensee and with many well-logging programs. However, the licensee had no formal procedure for removing source capsules from their holders. The licensee had successfully removed other source capsules from their holders on previous occasions using the penetrating oil and tapping method. The plan to push the source from its holder using a drill bit and lathe mount was formulated by the president of SSI. He assumed that the source capsule was doubly encapsulated in very hard stainless steel and would not be penetrated by the drill.

The licensee did not realize, initially, that the rupture occurred, even though a hole was visible in the source capsule. One of the principals involved stated, "I don't know," when questioned if the source capsule normally had a hole in it. The initial radiation survey of the lathe area showed full-scale deflection on the licensee's survey meter, which on this particular meter meant greater than 50 mR/hr. This reading was interpreted as an instrument malfunction. A second survey performed using a different survey meter of the same type, by another employee, showed similar results and was also interpreted as an instrument malfunction.

The remains of the source capsule were folded into a rag, put into a shielded container, and taken to the licensee's storage pit in Building 1. A survey of this container and its contents indicated, at least to one licensee individual, that much of the contents of the capsule were probably released during the rupture. No personnel surveys were performed on September 13. Initial attempts to contact the licensee's HP consultant were unsuccessful. His active onsite participation right after the source rupture could possibly have prevented

offsite contamination. Other employees working in the area were not informed of what had occurred. All individuals working in Building 2 left the site at their usual quitting time without any real awareness they were radioactively contaminated and of the potential seriousness of the incident.

One of the individuals involved in the rupture was surveyed by the licensee's ARSO on September 14, 1983, and found to have about 3 mR/hr personal contamination. It is not known which survey meter was used for this survey. SSI's HP consultant was contacted about 9:00 a.m.(EDT) on September 14, 1983, and informed about the incident. Remedial actions outlined by the licensee's consultant focused on area decontamination rather than personnel protection. Apparently the consultant was not informed of any personal contamination. Initial decontamination efforts were not physically supervised by anyone sufficiently knowledgeable about radiation safety. Individuals carried out the consultant's cleanup plan as outlined over the telephone, but with little regard for radiation safety.

One licensee representative indicated that personnel were very casual in their efforts, without much concern for personal radiation safety. Licensee management did not stress limiting the spread of contamination and overall personal radiation safety. It appears that this attitude resulted from a lack of knowledge rather than from a conscious effort to defer radiation safety in favor of facility cleanup. The first inspector on site on September 15 noticed individuals at the site had little concept about radioactive contamination; this was evidenced by many of the licensee's actions.

6.1.1.1 Conclusion - Human Factors

The overall cause of this event and its escalation was due primarily to human error, which directly relates to the licensee's lack of knowledge about radiation theory and safety.

6.1.2 Training

The current SSI NRC Byproduct Material License, Condition 12, lists 12 individuals authorized to use, or supervise the use of, licensed materials. The licensee's training program, as required by its current (expires July 31, 1984) NRC Materials License, consists of the following:

(1) A 5-hour classroom-type seminar, given by the licensee's consultant, followed by a 30-minute audio tape entitled "Radioactive Material at Shelwell."

(2) Company president and/or current RSO to evaluate each individual before designating job assignments and areas of responsibility.

No exams, periodic retraining, or other training are required.

As of August 1983, there were nine individuals, not specifically listed on the license, who handled licensed material and related logging tools under the supervision of an authorized user. Of these nine, four were interviewed during the last routine NRC inspection on August 2, 1983, and two of the four were found to not have completed the licensee's training outlined above.

The president and the current RSO at SSI have 20 and 10 years of experience, respectively, in handling the radioactive materials used in well logging.[2] However, all others involved in the rupture and decontamination activities, at least four of which are listed as authorized users in SSI's license, exhibited little knowledge about radiation safety and basic health physics practices. Licensee actions during the event further illustrated the need for additional radiation safety training. Some of these actions were:

(1) Source holders and bare sealed sources, containing curie quantities of gamma emitters, were handled manually.

(2) No personal surveys or attempts were made to limit spread of contamination.

(3) Area smear readings of 0.35 mR/hr using CDV-700 meters, were considered clean.

(4) Personal footwear were scrubbed (i.e., cleaned) with the same brushes used to decontaminate floors.

(5) No consideration given to potential airborne radioactive material during decontamination activities (e.g., vacuuming and lathe sandblasting).

(6) Survey meters were improperly used and their readings were improperly interpreted.

6.1.2.1 Conclusions - Training

The licensee's training program did not provide the information required to safely perform decontamination efforts resulting from a major rupture of a well-logging source. Also, many of the licensee's practices noted above and previously outlined in Section 2.2.2 indicate that the training program did not provide individuals with a basic understanding of radiation theory and safety practices.

6.2 Offsite Contamination

This section describes the radioactive contamination of facilities and items in all locations except those on or adjacent to the licensee's facility.

6.2.1 Homes (Includes Houses, Trailers, and Apartments)

Radioactive contamination was primarily found in the homes of SSI employees. It was also found in some homes of individuals who visited or were visited by SSI employees (e.g., relatives, friends, and neighbors). For example, the home of the relatives of one SSI employee showed radiation levels of 10 millirems/hr and had approximately 31 contaminated areas. Most of the homes showed radiation levels in the microrem-per-hour range. Contaminated areas ranged from 2 to 3 spots to 60 or more spots (see Figures 14 through 19 for a highly contaminated SSI employee's home).

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[2]SSI license application dated September 26, 1978.

Personal contamination (primarily on hands and clothing) caused contamination of items that came in contact with or were handled by these individuals. Additional contamination was also caused by cesium-137 in perspiration, since the cesium chemically acted as a salt. For example, bed sheets, a mattress, clothing, door knobs, and electrical wall switches became contaminated with low levels of radioactivity after contact with individuals who had internal depositions of cesium-137 with no skin contamination.

Radioactivity was detected in 27 homes. Seventeen homes were occupied by SSI employees. Seven homes were occupied by neighbors of SSI employees. Three homes were occupied by relatives of SSI employees. Radioactivity detected in one home came from the tile on the floor (possibly thorium on the tile). Radioactive contamination was primarily detected on rugs, floors, and seat cushions on furniture.

6.2.2 Vehicles (Includes Passenger Cars, Trucks, Vans, and Public Service Vehicles)

A total of 32 vehicles were surveyed. Survey results indicated 23 vehicles had detectable amounts of radioactivity, and 9 vehicles had no detectable amounts of radioactivity above background radiation.

Radioactive contamination was detected in 18 vehicles used by SSI employees, 2 delivery vehicles, 2 vehicles used by visiting sale representatives, and 1 vehicle used by a friend of an SSI employee. Radioactive contamination was detected primarily on the floors, floor mats, and seat cushions.

Foam rubber vehicle seats contributed to recontamination of individual's clothing. It appears that pressure by a sitting individual applied to the foam rubber seats caused migration of the radioactivity to the surface of the seat, thus recontaminating the individual occupying the seat.

Vehicles surveyed usually showed radiation levels in the microrem-per-hour range; however, some were in the millirem-per-hour range. In most of the vehicles only two or three spots of contamination were detected; however, a few vehicles were highly contaminated and required extensive decontamination involving cutting or complete removal of seats, floor rugs, and other items. Six vehicles were confiscated and kept at the licensee's facility until they were decontaminated.

6.2.3 Public Facilities (Includes Restaurants, Grocery Stores, Taverns, Schools, a Health Club, and Other Business Establishments)

Sixteen public facilities were surveyed. Survey results indicated no detectable radiation levels above background at 10 public facilities. Five public facilities had detectable amounts of radioactive contamination. One facility had a highly contaminated floor mat. Radioactive contamination was primarily found on floors and rugs and, in one case, on the seat cushions of a couch.

Surveys of public facilities showed radiation levels from the microrem-per-hour range to the millirem-per-hour range. Most of the survey results indicated no detectable radiation levels above background. Only one facility showed survey results in the millirem-per-hour range. The survey results indicated that public facilities had not been extensively contaminated. The one exception of

a public facility listed as highly contaminated was due to the activity found on one floor mat. Once the mat was removed, all other contamination was less than 1 mR/hr. This reduced the classification from "highly contaminated" to "contaminated."

6.2.4 Conclusion - Offsite Contamination

Radioactive material was spread to a total of 33 offsite locations. Six locations were highly contaminated. Eleven locations were contaminated. Sixteen locations had detectable activity. The radiation survey results in offsite locations ranged from no detectable radiation above background to levels of 5 to 10 millirems/hr.

Because of the prompt identification of contamination and remedial actions implemented by federal and state response personnel, it is believed that no individual received a significant radiation exposure as a result of offsite contamination.

6.3 Onsite Contamination

This section describes the radioactive contamination found at the licensee's site near Hebron, Ohio. This includes all property owned by or leased to SSI, in addition to nearby property owned by other individuals or businesses.

6.3.1 SSI Property

6.3.1.1 Building 2

Building 2 is the one in which the incident occurred and is also referred to as the machine shop. The eastern portion of this building is leased to NES.

Contamination was caused directly by the source rupture itself, which occurred in the northwest section of this building. Licensee surveys, consisting of floor smears, peformed on September 14 before the cleanup attempts showed contamination to be primarily in the immediate area of the incident and also in the south and southeast portions of the building. The southeast portion is an area where most of the other SSI employees were working at the time of the rupture. Licensee surveys also showed contamination, to a lesser extent, in the northeast section of the building, which is leased to NES.

The contamination in this building has not been fully evaluated because the area was evacuated and secured when the NRC inspector arrived at the site on September 15. However, preliminary licensee and NRC surveys indicated extensive removable contamination throughout the building. Licensee surveys, before cleanup attempts, showed loose contamination on floors yielding radiation levels averaging about 5 to 10 mR/hr with spots showing up to 50 mR/hr. One of the licensee's representatives stated that a wipe test of the lathe yielded a radiation level of 3 R/hr. The licensee's wipe tests after the initial floor cleaning showed radiation levels of approximately 0.5 to 3.5 mR/hr. Spot surveys performed by the first NRC inspector onsite confirmed these results. The highest direct radiation levels found inside this building during initial NRC spot surveys were found on equipment and tools. For example, the shop vacuum showed approximately 600 mR/hr and a tool chest showed 15 to 25 mR/hr.

Floor surveys performed by AHP on October 5, 1983, showed direct radiation levels ranging from about 0.25 to 25 mR/hr at the surface and from 0.25 to 13 mR/hr at waist height.

6.3.1.2 Building 1

Building 1 is the logging truck storage and maintenance building. It is also used for storage of radioactive materials (i.e., converted vehicle grease pit).

Contamination in this building was caused by personnel tracking. The three primary tracking methods were:

(1) Tracking off personnel shoes and clothing. Contamination was light and spotty in all normally occupied areas such as the truck bays and office areas.

(2) Spillover or leakage that may have occurred when the container housing the remains of the ruptured source was brought to this building and placed in storage. The storage area is located in the northwest section of this building, partially segregated from other areas.

(3) Contamination from the sandblasting equipment, stored in this building, that was used to clean the contaminated lathe. This equipment is maintained in the southwest portion of Building 1 in a low-traffic area.

Surveys performed by AHP on October 5, 1983, showed direct radiation levels in spots ranging from 0.5 mR/hr off floor surfaces to 12 mR/hr in the area of the radioactive storage pit. Again, this was a spot survey to quickly evaluate the extent of the contamination.

6.3.1.3 Office Trailer

Contamination in the trailer was caused exclusively by tracking off shoes, clothing, and equipment. Preliminary surveys performed by NRC and Battelle Columbus Laboratory representatives on September 16, 1983, showed low level spotty contamination in several areas of the trailer.

6.3.1.4 Parking Lot and Access Drive

Contamination was caused in four ways:

(1) Directly as a result of the rupture. This was limited to the apron and access drive immediately outside the garage door on the west side of Building 2.

(2) From items/equipment that were cleared from the building where the incident occurred to facilitate the licensee's initial decontamination attempts. Items were placed primarily in the parking lot and access drive west of the building in which the incident occurred.

(3) During lathe sandblasting that took place in the access drive immediately west of Building 1.

(4) From tracking off shoes and clothing in numerous spots of the parking lot and access drive.

NRC surveys of the access drive and portions of the parking lot on October 9 and 11 showed low level contamination in several areas. This was after four rains had washed away some portion of the contamination resulting from the incident. The highest levels of contamination were found in the area west of Building 2 where pieces of equipment had been placed during the licensee's early cleanup efforts. Surveys of the rock and gravel access drive and parking lot consisted of direct beta-gamma surface measurements. Direct gamma waist-height measurements were not taken because high area background levels from Building 2 interfered with obtaining accurate readings. Areas exhibiting the highest levels of contamination are shown in Figure 30.

AHP took soil samples, some of which were analyzed by NRC. NRC samples were analyzed in the Region III Laboratory. AHP samples were analyzed at the AHP facility in Bethel Park, Pennsylvania. The NRC results are listed in Table 4.

Table 4. NRC access drive and parking lot soil samples

Sample No.	NRC result µCi/gm (dry)
1	1.57×10^{-6}
2	2.0×10^{-7}
3	1.33×10^{-4}
4	2.37×10^{-3}
5	1.16×10^{-5}

6.3.2 Other Adjacent Property

6.3.2.1 NES Building

The NES building is located at the northern boundary of the Shelwell site. AHP surveyed this building on September 16. No contamination was found; the building is considered clean.

6.3.2.2 Cornfield

The cornfield borders the southwestern boundary of the Shelwell site. A small area (approximately 100 feet square) of topsoil adjacent to the cornfield was found to contain low levels of contamination. This contamination was caused by tracking from personnel and equipment. No areas of the field itself were frequented by personnel and, therefore, were not expected to be contaminated. The contaminated soil from the area adjacent to the field was removed by shovel and placed in barrels awaiting eventual disposal.

6.3.2.3 Cemetery

The cemetery borders the south end of the southeastern boundary of the Shelwell site. Contamination could only be present here if tracked by personnel. Because personnel did not frequent this area, no contamination was expected. To confirm this, AHP surveyed the area on October 21, 24, and 28. No contamination was found.

6.3.2.4 Tree Grove

The tree grove is located at the northwestern boundary of the Shelwell site. Contamination was found at the eastern outskirts of the grove and was limited to a small area of the ground where the licensee collects trash. No contamination was found in other areas of this grove. Contamination came here by two methods:

(1) From tracking of personnel during the licensee's decontamination attempts

(2) From contaminated items and equipment (e.g., brushes used to scrub floors and contaminated water slurry) placed in this area during the licensee's decontamination attempts on September 14 and 15

Contaminated tools and equipment (e.g., scrub brushes, liquid from shop vacuum, and rags) used in the licensee's cleanup attempts had been placed near the tree grove in the licensee's trash collection area. These items exhibited direct radiation levels ranging from a few mR/hr to 200 to 300 mR/hr, and a pail of wash water showed 1.5 R/hr. The tree grove area was roped off and covered with plastic to restrict access and limit migration of contamination into the soil. The contaminated items were returned to Building 2. The soil was removed by shovel and placed into drums until it could be disposed of as radioactive waste.

6.3.2.5 State Highway Building (Near Route 40)

The State Highway Building was contaminated by personnel tracking and by items removed from the building where the incident occurred and placed here during the licensee's cleanup attempts. The building was also used as a temporary storage area for radioactive wastes collected by AHP during onsite and offsite decontamination.

Surveys performed by NRC representatives on September 20, 1983, showed removable contamination in many areas of this building. Direct surface radiation levels were typically 50 μR/hr on floors with certain isolated items reading up to 15 mR/hr.

6.3.3 Conclusions - Onsite Contamination

Contamination was significant in the incident building and posed a radiological hazard if not controlled. Contaminated items placed near the tree grove were also an area of concern. These concerns were alleviated once these items were returned to the building where the incident occurred and the grove area was covered with plastic. The storage pit in Building 1 was an extremely low traffic area and, once contamination was controlled, posed no significant concerns. Uncontrolled areas onsite that exhibited contamination were not considered hazards because the contamination was light and spotty. No onsite areas adjacent to SSI property were found to have significant contamination; therefore, no deleterious effects are anticipated.

7 MEDIA INTEREST

Region III learned late in the afternoon of September 14, 1983, that the source damage incident occurred on September 13 at the Shelwell Services, Inc., facility in Hebron, Ohio. An NRC inspector, dispatched to the site on September 15, found significant contamination to company personnel and the facility. The likelihood was also great that the workers' homes had become contaminated.

A Region III public affairs officer (PAO), who was visiting the Perry construction site near Cleveland, Ohio, was dispatched to the Hebron area to meet a team of four Region III inspectors who were sent to the site by chartered aircraft. He arrived by car on September 15 at about 8:00 p.m.(EDT). The Region III site team arrived about 10:00 p.m.(EDT) at Columbus Airport, about 35 miles from the Shelwell site.

Meanwhile, the Region III Incident Response Center was activated on September 15 and the senior public affairs officer prepared a response-to-inquiry statement, which was also provided to the Ohio Disaster Services Agency (ODSA) for its use.

Once the site PAO was in the vicinity, Region III issued a news announcement on the source rupture incident and planned home surveys. The announcement was coordinated with ODSA and provided to the Associated Press (AP) and United Press International (UPI) bureaus in Columbus, Ohio. ODSA had a public information officer on duty in Columbus through the evening.

The site PAO accompanied one of the NRC inspectors to the Shelwell site and joined the rest of the Region III team there about 11:00 p.m.(EDT). Also at the site were personnel from the Department of Energy Radiological Assistance Team and ODSA. All response personnel were briefed on the event and its status. Preliminary surveys of the homes of the three workers directly involved in the source rupture incident indicated extensive contamination.

The onsite PAO learned that village officials in Hebron (population 2200) had not been informed about the incident. He telephoned Mayor Henry Porter of Hebron at 12:30 a.m., Friday, September 16, informing him about the incident and the federal and state response. At Mayor Porter's request, Hebron Police Chief Harry Clark was notified the following morning.

Both the mayor and Police Chief Clark were told they would be briefed periodically on NRC/ODSA findings and decontamination plans. The police chief subsequently spent at least 1 hour on each of the next 2 days with the Region III site PAO. The police chief was, therefore, able to allay the fears of local residents who contacted him with questions about their safety.

News media inquiries were handled both by the Region III and the site PAO. Reporters were referred to the site PAO by the ODSA public information officer. Preliminary Notifications were prepared by the Region III PAO with copies provided by telecopy to the ODSA for use in responding to inquiries.

During the day of September 16, the site PAO was interviewed by newspaper, radio, and TV reporters. The television interviews led off the 7:00 p.m. newscasts at all three Columbus TV stations, but not the 11:00 p.m. broadcasts.

Throughout the incident, the NRC team leader kept the site PAO fully informed about all developments so that the PAO was able to respond quickly and accurately to all media inquiries.

Because of the amount of contamination on the Shelwell site, the NRC/ODSA team leaders moved their command post on September 16 to an Ohio National Guard Armory in Newark, Ohio, about 5 miles from Shelwell. The site PAO continued taking telephone calls from the media at this new location, and gave one television interview.

Media inquiries trailed off dramatically on Saturday, September 17. Highly contaminated areas had been located, isolated, and appropriate action was being taken. The site PAO, after consulting with the NRC team leader, returned home about 9:00 p.m., September 17. He was notified on Sunday, September 18, that additional contaminated sites had been found, and he returned to Hebron on Monday, September 19.

Because the National Guard Armory was too far from the Shelwell location, the site PAO sought a more suitable location closer to Shelwell. He conferred with Police Chief Clark, who obtained permission from the Hebron American Legion Post to use its facility less than one-half mile from Shelwell.

The site PAO made arrangements through the Regional Office in Glen Ellyn, Illinois, to have additional telephones installed in the American Legion Hall. Office equipment, including a copy machine and a telecopier, also was obtained.

News media interest peaked on September 21, the day the NRC announced that Shelwell's NRC license had been suspended. The senior PAO in Region III wrote a news release concerning the suspension which was dictated by telephone to the site PAO, who then contacted AP and UPI in Columbus and the two major Columbus newspapers.

The site PAO also arranged for another briefing of village officials. The NRC site team leader held the briefing on September 21 in the American Legion Hall with the chief of police, representing the mayor, and two village councilmen present. The site PAO also continued to brief the police chief on a daily basis and provided him with copies of Region III Preliminary Notifications (PNs) as they were issued.

The site PAO took more than 150 photographs of the NRC/ODSA response to the incident. He also obtained use of a Hebron Fire Department snorkel unit with a 75-foot boom to take aerial photos of the Shelwell site.

The site PAO maintained periodic communication with the senior PAO in Glen Ellyn, and with the public information officer (PIO) in the State of Ohio's Disaster Services Agency. The State PIO was kept fully informed of the NRC's activities and was provided NRC press releases, updates, and assessments. A good working relationship was established. Equally important, information provided to the media by the NRC and the ODSA was thus fully coordinated. The

State PIO also referred many questions and queries to the NRC's site PAO. The State PIO visited the Shelwell site on Thursday, September 22, and conferred at some length with the site PAO.

The site PAO departed Hebron at noon on Friday, September 23. Media interest at that time had dwindled and it was determined that all future inquiries into Shelwell could be easily handled from the Regional Office.

Appendix H reproduces several articles from local newspaper as well as NRC news releases.

8 REFERENCES

(1) R. Baker, A Primer of Oil-Well Drilling, Fourth Edition. Austin, Texas: Petroleum Extension Service, The University of Texas at Austin, in cooperation with International Association of Drilling Contractors, Houston, Texas, 1979.

(2) U.S. Department of Commerce, National Bureau of Standards, Handbook #69, Washington, D.C., June 5, 1959.

(3) Code of Federal Regulations, Title 10, "Energy," U.S. Government Printing Office, Washington, D.C.

(4) U.S. Nuclear Regulatory Commission, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," Washington, D.C., July 1982.

APPENDIX A

SUMMARY OF SURVEY RESULTS

Individual or facility	Home or facility	Auto	Clothing	Personal
#1	Clean	Clean	Clean	Clean
#2	N.A.	Clean	N.A.	N.A.
#3	Detectable activity highest 15 µR/hr vac bag, wipes = BKG, 20 µR/hr kitchen carpet	Highest 30 µR/hr floor	Highest 46 µR/hr shirt confiscated	N.D.
#4	N.A.	Detectable activity highest 50 µR/hr floor	Clean	N.D.
#5	Detectable activity 15 µR/hr gun barrel, bathroom = clean	N.A.	N.A.	N.A.
#6	Contaminated 300 µR/hr living room chair	800 µR/hr left floor mat	46 µR/hr confiscated	Clean
#7	Couch, tables, and blanket = clean	N.A.	N.A.	N.A.

Notes:
N.A. = not applicable,
N.D. = no data.

All results are highest readings on contact (hard gamma).

Individual or facility	Home or facility	Auto	Clothing	Personal
#8	Detectable activity 25 μR/hr, may be due to floor tile thorium, wipes = BKG	N.A.	N.A.	N.A.
#9	Clean	N.A.	N.A.	N.A.
#10	Clean	Clean	Confiscated shirt and shoes	N.D.
#11	Clean	11 μR/hr driver's seat	Clean	N.D.
#12	Contaminated 270 μR/hr kitchen floor	150 μR/hr floor	Numerous items confiscated 120 μR/hr	N.D.
#13	Activity detected 12 μR/hr hall carpet	N.A.	N.A.	N.A.
#14	Clean (A.H.P.)			
#15	Highly contaminated throw rug 23 mR/hr, rug confiscated. Other carpeted area 20 μR/hr, wipes <1,000 dpm	N.A.	N.A.	N.A.

Individual or facility	Home or facility	Auto	Clothing	Personal
#16	Contaminated 150 µR/hr throw rug	N.A.	3 µR/hr sweater, kept sweater	Clean
#17	N.A.	Activity detected, told to wash seat cover	N.A.	N.A.
#18	Clean	N.A.	N.A.	N.A.
#19	Clean	N.A.	N.A.	N.A.
#20	Clean	N.A.	N.A.	N.A.
#21	Contaminated 120 µR/hr family room floor	Contaminated	Numerous items confiscated	Clean
#22	Clean Wipes = BKG	N.A.	N.A.	N.A
#23	Clean	N.A.	N.A.	N.A.
#24	Contaminated ~300 µR/hr living room couch	N.A.	N.D.	N.D.

Individual or facility	Home or facility	Auto	Clothing	Personal
#25	Highly contaminated >1 mR/hr dryer from survey done by AHP	N.D.	Clothing confiscated	N.D.
#26	Clean	N.A.	N.A.	N.A.
#27	Clean	N.A.	N.A.	N.A.
#28	Contaminated 150 µR/hr hallway carpet	Highly contaminated 2 mR/hr gamma	Clothing confiscated 300 µR/hr shirt	500 cpm tips of thumb
#29	Clean	Confiscated two seat covers	Tennis shoes show detectable activity but less than criteria	Clean
#30	Clean	N.A.	N.A.	N.A.
#31	N.A.	Detectable activity <50 µR	N.A.	N.A.
#32	Clean	Clean	Clean	Clean
#33	Contaminated <20 µR/hr areas on carpet, vacuum bag confiscated 150 µR/hr wipes <1,000 dpm	N.A.	N.A.	N.A.

Individual or facility	Home or facility	Auto	Clothing	Personal
#34	Clean	90 µR/hr floor mat	40 µR skirt and pantyhose	15 µR/hr right calf
#35	Detectable activity confiscated rug 90 µR/hr	N.A.	N.A.	N.A.
#36	Clean	N.A.	N.A.	N.A.
#37	Clean	N.A.	N.A.	N.A.
#38	(Need AHP results)			
#39	Clean	N.A.	N.A.	N.A.
#40	Contaminated 150 µR/hr basement floor	80 µR/hr driver's seat	Numerous items confiscated	Clean
#41	Clean	N.A.	N.A.	N.A.
#42	Clean	Detectable activity 15 µR/hr passenger seat	Numerous items confiscated	Clean
#43	N.A.	Clean	Clean	Clean

Individual or facility	Home or facility	Auto	Clothing	Personal
#44	Detectable activity 60 µR/hr rocking chair	N.A.	N.A.	N.A.
#45	Contaminated ~200 µR/hr	N.A.	N.D.	N.D.
#46	Highly contaminated 1.5 mR/hr sofa and	Auto confiscated 40 µR/hr rear seat	Numerous items confiscated	Contaminated (awaiting results from (medical consultant)
#47	Contaminated 100 µR/hr mattress	N.A.	Confiscated one shirt and eyeglass	Clean
#48	Highly contaminated 20 mR/hr carport floor	Auto confiscated	Numerous items confiscated	Contaminated (awaiting results from medical consultant)
#49	Detectable activity <20 µR/hr afgan	N.A.	N.A.	N.A.
#50	Detectable activity 42 µR/hr vacuum bag	9 µR/hr floor	Numerous items confiscated	Clean

Individual or facility	Home or facility	Auto	Clothing	Personal
#51	Detectable activity 14 µR/hr living room floor	7 µR/hr floor mat	Items confiscated 160 µR/hr on boot, bagged boots	Clean
#52	Clean	Truck 15 µR/hr - deconned to BKG	Confiscated clothing of Shelwell employees 15 µ/R/hr	Driver clean
#53	N.A.	N.A.	Shoes clean	Clean
#54	Detectable activity 30 µR/hr chair	30 µR/hr	Clothing confiscated	Clean
#55	Clean	N.A.	N.A.	N.A.
#56	N.A.	Clean	N.A.	N.A.
#57	Highly contaminated 1.2 mR/hr	Confiscated	Numerous items confiscated	Contaminated (awaiting results from medical consultant)
#58	Highly contaminated 10 mR/hr	N.D.	Numerous items confiscated	N.D.

Individual or facility	Home or facility	Auto	Clothing	Personal
#59	Detectable activity confiscated bathroom rug 15 μR/hr	15 μR/hr rear seat	Confiscated boots	Clean
#60	N.A.	Clean	N.A.	N.A.
#61	Contaminated garage area 300 μR/hr	30 μR/hr floor mat	Items confiscated	Clean
#62	Detectable activity 16 μR/hr floor	10 μR/hr floor mat	Clothing confiscated 25 μR/hr shirt	Clean
#63	N.A.	Clean	Clean	Clean
#64	Detectable activity 20 μR/hr dust mop	N.A.	50 μR/hr sweat band	N.A.

APPENDIX B

ACCEPTABLE RADIATION LEVELS

Decontamination Criteria for Fixed and Loose Radioactivity as Determined by Field Measurements

During this incident, the licensee, state, and NRC used the "NRC Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material, July 1982." Specifically Table 1 of that guideline was used. The two major criteria were: (1) The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber; and (2) removable beta-gamma contamination should not exceed 1000 dpm/100 cm^2. The latter criterion was easily implemented by counting smears using a scaler/G-M shielded probe installed in the NRC operations area. Smears were taken by field teams and counted at a later date.

Field measurements for release of areas and items exhibiting fixed contamination were made by using a gamma-micro-Roentgen meter and a beta-gamma pancake G-M meter. The pancake probe was typically used to detect contamination, and a smear survey was performed to determine if contamination was fixed or removable. If the removable contamination was determined to be less than 1000 dpm/100cm^2, direct gamma (contact) measurements were made using the micro-Roentgen meter. A release rate of 100 micro-Roentgen per/hour was used. The following calculations were made to justify this criteria:

(1) Cs-137 electron (beta) dose rate conversion factor for exposure 1 meter above an infinite ground surface for 1 $\mu Ci/cm^2$ is 3.99×10^5.

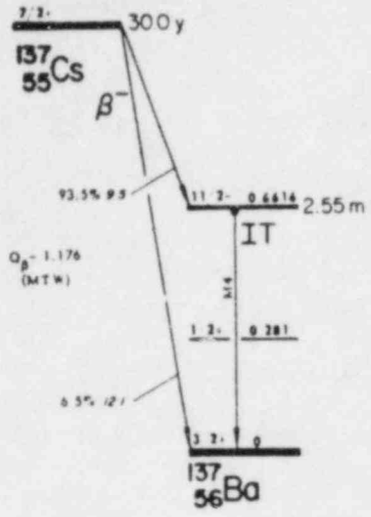
(2) Ba-137m photon (gamma) dose rate conversion factor for the same geometry is 1.04×10^6.

(3) The total dose rate ($\beta+\gamma$) conversion factor is 2.22×10^6.

(4) Therefore, $$\frac{1.04 \times 10^6\ (\gamma)}{(3.99 \times 10^5 \beta) + 2.22 \times 10^6\ (\beta+\gamma)} = 0.40$$

Accordingly, approximately half of the measured beta-gamma dose rate in mrad/hr can be equated to a gamma only measurement dose rate in mR/hr for cesium-137. Therefore, 100 μR/hr (gamma only) is approximately equivalent to 200 μrad/hr (beta-gamma), the NRC criterion. The dose rate conversion factors used for this calculation are published in The Health Physics Journal, Vol. 38 (April 1980), pp 543-621, Pergamon Press Ltd., 1980.

The measurement of only gamma surface contamination avoided the problem of considering the different self-absorption properties of the beta radiation from the various types of materials that were contaminated (i.e., rugs, clothes, cars, and furniture). Further, beta dose rate measurements under field conditions are difficult to reproduce (confirm with another survey team) because of high geometry dependency. Figure B.1 shows the decay scheme for cesium-137 and barium-137m.



137
Cs (30.0 y):

I: 7/2+ μ +2.8382 atomic beam; q: +0.050 opt double res (Linu g164)

β⁻: β_1 1.176 (6.5%), β_2 0.514 (93.5%) mag spect (DaniH62b)

β_1 1.176 (7.6%), β_2 0.514 (92.4%) mag spect (YosY58)

others (KatoT57, AgnH50, OlsJ54, LangeL51, AzuT54, WapA54a, BroyC53, PeaC49, OsoJ49, RiccR57, DrabG55, MacqP54, BosH63a, CharP65)

137m
Ba (2.55 m):

γ: γ_1 0.6616 (K/L_I/L_{II}/L_{III} 1000/151/22/19) mag spect conv (GeiJ62)

γ_1 (ϵ_K/γ 0.093, K/L+M+... 4.5) mag spect conv (DaniH62b)

γ_1 (ϵ_K/γ 0.095) mag spect, mag spect conv (HulS61)

γ_1 (K/L/M 56/10/2.2) mag spect conv (ChuY64a)

γ_1 (K/L/M 566/100/26.0) mag spect conv (YosY58)

γ_1 (γ 86%, ε/γ 0.1100) semicond spect (MerJ65)

γ_1 ($I_{\gamma\gamma}/I_\gamma$ 6 x 10^{-6}) (BeuW60)

others (MullD52, LindsG53a, GravG52, LangeL50b, DVriC60b, HulS59, SubbB61c, KurcT63, WapA54a, WagM51, MGowF57a, KatoT57, MaeR53, AzuT54, BrndW52, KruP52, MitA49, OsoJ49, TownJ48, RiccR57, VerhJ54, AntoI56a, AntoI56, DolV53, BhaS54, DrabG55, BosH63a, RaoMR63)

Source: U.S. Department of Health, Education and Welfare, Radiological Health Handbook, Rockville, Maryland, Public Health Service Publication No. 2016, January 1970, p. 399.

Figure B.1 Decay scheme for cesium-137 and barium-137m.

A radiation level of 20 μR/hr was selected as the criterion for identifying radiation contamination on personal items. The survey team members decided that the 20 μR/hr levels were sufficiently above the background levels of radiation to identify the presence of radioactivity.

APPENDIX C

WIPE TEST RESULTS FROM A HIGHLY CONTAMINATED HOME

Wipe test results from smears taken at the home illustrated in Figures 14 through 19 showed the following:

Wipes 1, 2, 3, 4, 5, 7, and 8 showed no removable contamination above 1,000 dpm beta. Wipe 6 was from a soda can in the main bedroom, and indicated 1,315 dpm beta.

Wipe tests were analyzed using the following instruments:

(1) Canberra Alpha/Beta Low Background Counter, Model 2201

(2) Nuclear Measurement Corporation Proportional Counter, Model PC-5

The Canberra printout showed alpha counts from the sample (the alpha counts were due to electronic interference from the beta). To verify that no alpha was present in the sample, the sample was counted again using the Nuclear Measurement Corp. Proportional Counter. No alpha was detected in the sample.

APPENDIX D

SOURCE/SOURCE HOLDER DIMENSIONS AND EXTREMITY EXPOSURE CALCULATIONS

Source Holder Dimensions

(1) Per licensee (sales representative), see Figure D.1.

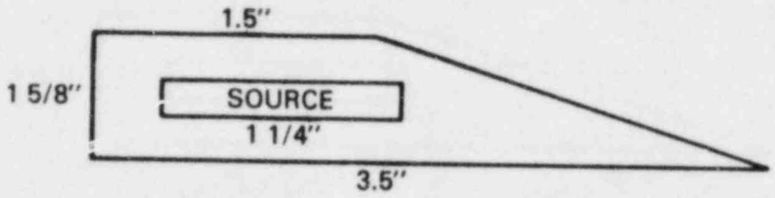


Figure D.1 Sketch of source/source holder as described by licensee.

(2) Per licensee (machinist), see Figure D.2.

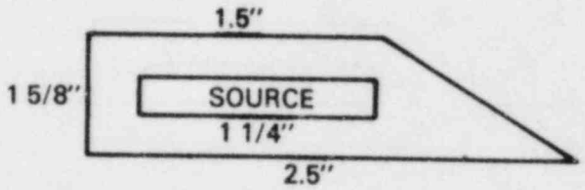


Figure D.2 Sketch of source/source holder as described by licensee.

A 3/6" drill bit was used to drill into the holder.

Source Capsule Identification

(1) Per licensee (ARSO and company president)

Manufacturer: Gulf Nuclear
Model: Not known
Serial No. INBCS-1000

Purchased by licensee in approximately 1964-1967. At that time, source was 2.0 curies.

(2) Gulf Nuclear. formerly known as General Nuclear, Inc.

Data given below taken from the Texas State Department of Health sealed source information sheet, December 5, 1968 (see pp. 5 and 6 of this appendix)

Manufacturer: General Nuclear, Inc.
Model: GNI-CS-1000
Doubly encapsulated in Type 304 stainless steel.
Inner capsule wall thickness is 19 mils (0.019").
Outer capsule wall thickness is 28 mils (0.028").
Overall outer capsule length is 1½".
Overall outer capsule diameter is 0.34".

Assumptions Used in NRC Calculations

(1) Measurements of Source/Source Holder (see Figure D.3)

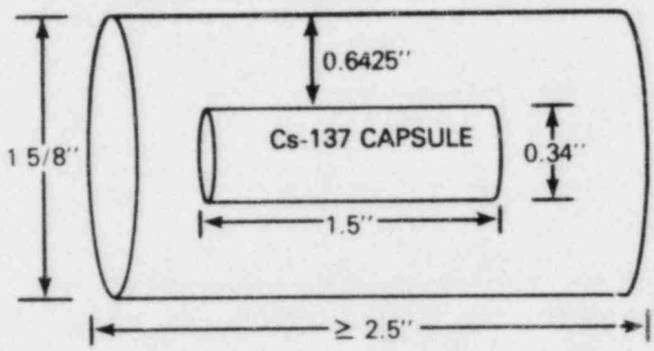


Figure D.3 Sketch of source/source holder model used for exposure calculations

1 5/8" - 0.34" = 1.625" - 0.34" = 1.285"
0.6425" = 1.63 cm stainless steel between outside diameter of source capsule and surface of holder

(2) 1.5 curie source (Cs-137)

$T_{\frac{1}{2}}$ = 30 years
β = 1.176 MeV max (7%)
γ = 0.662 MeV (85%)
Γ = $\Gamma^*/10$ = 3.3/10 R/hr @ meter/Ci = 0.33R/hr @ meter/Ci (Ref. 1)

Therefore, for 1.5 curie point source

Γ = 0.495 R/hr @ meter
Γ = 4,950 R/hr @ cm
Γ = 1,863 R/hr @ 1.63 cm

However, radiation level falloff from a point source is equivalent to a line source for about the first few centimeters distance.

It can then be assumed

Γ = 4,950 R/hr @ cm

Γ = 3,037 R/hr @ 1.63 cm

$X = BX_o \exp [-(\mu_t d)]$

where X = exposure rate, shielded, at point X

X_o = exposure rate, unshielded, at point X

B = dose buildup factor

μ_t = linear total attenuation coefficient (cm^{-1}) (includes both absorption and scatter)

d = shield thickness (cm)

or

$X = BX_o \exp [-(\mu_t d)] = BX_o \exp [-(\mu/\rho)(\rho)(d)]$

where μ/ρ = mass attenuation coefficient (cm^2/gm)

ρ = shield media density (gm/cm^3)

Mass attenuation coefficient for a 0.66 MeV gamma through iron equals 0.072 cm^2/gm (Ref. 2, p. 447).

Since density iron (ρ iron) = 7.86 gm/cm^3 (Ref. 1, p. 65), then

$\mu_t = (\mu/\rho)(\rho) = (0.072\ cm^2/gm)(7.86\ gm/cm^3) = 0.566$ cm (Ref. 1)

Computation for Dose Buildup

Dose buildup in iron, assuming a point isotropic source, is given by (Ref. 2, p. 417)

$$B(E, \mu d) = A_1 \exp [-(\alpha_1 \mu d)] + A_2 \exp [-(\alpha_2 \mu d)]$$
$$= A_1 \exp [-(\alpha_1 \mu d)] + (1 - A_1) \exp [-(\alpha_2 \mu d)]$$

For an ~ 0.65 MeV gamma

A_1 = 9.55

$-\alpha_1$ = 0.093

α_2 = 0.0170

then

$$B(E, \mu d) = 9.55 \exp [(0.093)(\mu d)] - 8.55 \exp [-(0.017)(\mu d)]$$
$$= 9.55 \exp [(0.093)(0.566\ cm^{-1})(1.63\ cm)] -$$
$$8.55 \exp [-(0.017)(0.566\ cm^{-1})(1.63\ cm)]$$
$$= 2.0$$

Therefore, at point X (i.e., surface of source holder perpendicular to center of source)

$X = BX_o \exp [-(\mu_t d)]$

$= (2)(1{,}863 \text{ R/hr}) \exp [-(0.566)(1.63)]$

= 1,481 R/hr (point source radiation level falloffs assumed at all distances)

= 123.4 R/5 min

or

$X = BX_o \exp [-(\mu_t d)]$

$= (2)(3{,}037 \text{ R/hr}) \exp [-(0.566)(1.63)]$

= 2,414 R/hr (point and line source radiation level falloffs assumed)

= 201 R/5 min

NRC calculations will assume a pure point isotropic source for all extremity exposures.

References

(1) U.S. Department of Health, Education, and Welfare, Radiological Health Handbook, Rockville, Maryland, Public Health Service Publication No. 2016, January 1970.

(2) T. Rockwell III, ed., Reactor Shielding Design Manual, First Edition, D. Van Nostrand Company, Inc., Princeton, New Jersey, 1956.

OFFICIAL USE ONLY

SEALED SOURCE

DISTRIBUTOR:

General Nuclear, Inc.

MANUFACTURER:

Same

USE:

Any use within the temperature and pressure ranges specified below.

ISOTOPE:

Any beta or gamma emitter up to 20 Ci (See Note #1 below)

MODEL NO:

GNI-CS-1000

DESCRIPTION:

These sources are almost identical to U. S. Nuclear Corp. types 375 and 376. The radioactive material is in the form of ceramic pellets, metal pellets or powder (up to 1 Ci) and is doubly capsulated in Type 304 stainless steel. The initial capsulation consists of a stainless steel cup containing the radioactive material and one or more spacer plugs with the final plug acting as a cap. This inner capsule is sealed by heliarc welding the cap to the housing. This capsule is then placed in a second stainless steel cup. The outer capsule is sealed by heliarc welding a plug in place. This plug has a 0.250 inch long by 0.138 inch in diameter extension which is threaded (6-32) for use with an adaptor. Overall outer dimensions are 1 1/2 inches in length by 0.34 inch in diameter (maximum). Inner capsule wall thickness is 19 mils and outer capsule wall thickness is 28 mils.

Each outer capsule will be engraved with at least the following information:

Danger R/A Material
Isotope
GNI
Serial No.

Sources are inspected visually and leak tested prior to distribution.

Note #1:

Only the isotopes and chemical forms listed below have actually been evaluated:

1. Barium 133 as Barium Chloride
2. Cadmium 109
3. Cerium 144/Praseodymium 144 as Ceirum Chloride
4. Cesium 137 as Pelletized CsCl or CsCl Powder
5. Cobalt 47 as Metal
6. Cobalt 60 as Metal
7. Iridium 192 as Metal Pellets
8. Iron 59
9. Radium 226 as Radium Bromide or Radium Sulfate

APPENDIX

SIEMENS FILM BADGE RESULTS

SIEMENS

September 26, 1983

Mr. William Axelson
U.S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Dear Mr. Axelson:

Enclosed is a copy of the radiation exposure report which we sent to Shelwell Services for the badges for [redacted]. [redacted] Also enclosed are Polaroid enlargements of the film from those three badges.

All three badges show evidence of contamination by radioactive material. In the case of [redacted], this is principally in evidence in the open window area of the badge and also in the upper portion where the film packet is exposed through the window in the badge holder that allows the name and date to be seen. In the case of [redacted] film, the contamination appears principally at the top and left of the film.

Normally in calculating the dose on a film badge it is necessary to obtain the optical density reading under each of the filters in the film badge holder. These densities are then processed through a mathematical protocol to calculate the dose. This technique was impossible in this case because on all of the badges some of the filter areas were darkened by contamination.

However, it was not necessary to obtain optical density readings under all of the filters in this situation in order to determine the type and energy of the exposing radiation. In this case we know that the badges were exposed to Cs-137 Therefore, to eliminate as much as possible the effects of the contamination, we selected the lightest of the filter

SEP 28 1983

SIEMENS GAMMASONICS, INC.
Health Physics Services
2000 Nuclear Drive • Des Plaines, IL 60018 • Telephone (800) 323-6015 • (312) 635-3387

areas in each film and measured the optical density at that point. The dose was then calculated in accordance with ANSI Standard N13.11.

Although I believe that the majority of the dose determined by this procedure was not caused by the contamination, we did assign Note 5 in Column 6 on the radiation exposure report to indicate that the films were unevenly exposed and that this may have caused some loss of accuracy in the calculation.

If you need any additional information, please contact me.

Sincerely,

William E. Todd
Manager
Health Physics Services

WET/k
enc.

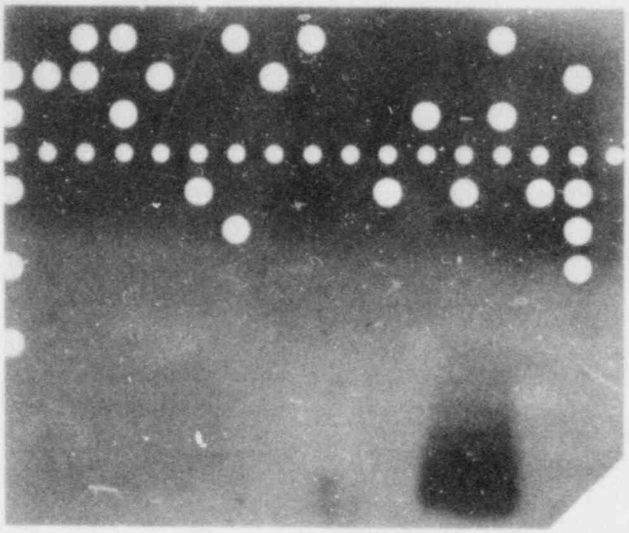


Figure E.1 Film badge, sales representative.

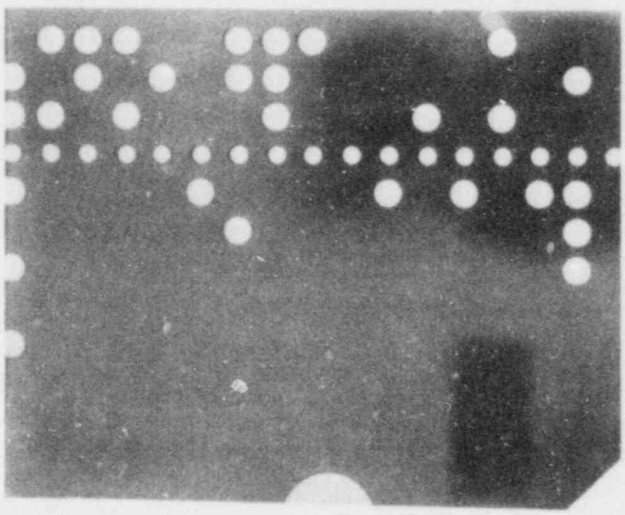


Figure E.2 Film badge, president.

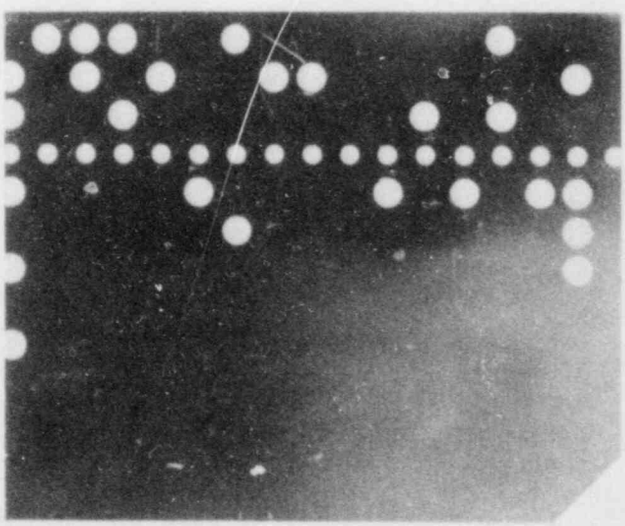


Figure E.3 Film badge, machinist.

Radiation Exposure Report

Seal of Approval

Shipped To:

SHELWELL SERVICES INC
447 LAKESHORE DR W
HEBRON OH
43025

Customer Number	Report Printed	Notification Level	Freq	Standard Exposure Period
85848	09/20/83		0	1 MONTH
Process Number	Film Received	**Important** See reverse side for complete explanation of report data		0244
850	09/12/83			

When making inquiries about this exposure report, refer to the customer and process number.

										Quarter to Date			Year to Date		Life Time Whole Body	Unused Permissible Dose	Birth Date and Sex	Service Start Date
							G rating	X B G Non Penetrating	Neutron	Whole Body	Skin	Whole Body	Skin		Whole Body	Skin				
								10	11	12	13	14	15	16	17	18	19	20	21	22
							710	0		2710	2710	2710	2710	2	2710	2710	3340	126700	010639	04/25/81
017	12		356204944	08/25/83	5		110	0		110	110	110	110	2	210	210	2995	167005	120630	04/25/81
022	12		294488508	08/25/83	5		13480	0		13480	13480	13480	13480	2	13480	13480	13850	61150	062850	04/25/81

Device Type
Exposure Type

You should keep this Report for your records

APPENDIX E

APPENDIX F

AERIAL RADIOACTIVE MONITORING SURVEY
OVERFLIGHT RESULTS

Department of Energy
Eastern Measurements Office
P.O. Box 330
Suitland, Maryland 20746

Larry Kohen
4340 East-West Highway
Bethesda, Maryland 20814

Dear Mr. Kohen:

An aerial radiological survey was conducted over the Hebron, Ohio area during the period of October 17 through October 26.

The survey was flown at an altitude of 46 m along lines spaced 76 m apart at a speed of 70 knots. The survey covered an area of approximately 64 square kilometers with Shelwell Services, Inc. at the center of the survey area.

The aerial data indicate that detectable quantities of Cs-137 were found only over the Shelwell Services Inc. plant area. Detectable quantities of Cs-137 for this survey would be approximately two to three times the anticipated Cs-137 concentrations due to worldwide fallout which is approximately 0.08 uCi/m^2. This assumes that the Cs-137 was uniformly spread over an area with dimensions of at least two to three times the survey altitude of 46 m. Localized source material (i.e. "point" sources) would be detectable if two to three mCi of Cs-137 were present. The minimum detectable concentrations do not apply if the source was shielded or was within the "shine" from the strong source signals detected over the plant itself.

Please advise us of your future needs for any further documentation concerning the aerial survey data.

Sincerely,

Herbert F. Hahn

HFH:kj

c.c.: Don Sreniawski

11-15-83
3.10

APPENDIX F

APPENDIX C

NRC LETTER DATED OCTOBER 25, 1983,
CONCERNING DECONTAMINATION OF DRAIN TILE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

October 25, 1983

Shelwell Services, Inc.
ATTN: Mr. Clyde Shelton
President
Route 1
Harbor Hills
Hebron, OH 43025

License No. 34-10445-01

Gentlemen:

We have completed our review of your proposed decontamination plan for remedial action at the Shelwell Services, Inc. (SSI) facility in Hebron, Ohio (Revision 1, dated October 17, 1983). My staff discussed this plan with your staff and Messrs. R. Gallaghar, AHP and John Holberg, Esq. on October 21, 1983, via a telephone conference call. We find that the plan has adequately addressed the four elements required in Section IV.D of the September 30, 1983, Order to Show Cause and Order Temporarily Suspending License

As discussed with your staff, two issues were clarified related to your plan. Section 4.0 of the plan indicates that an onsite NRC representative must approve release of decontaminated areas prior to unrestricted use. This is not necessary as the plan requires SSI to adhere to the approved NRC guidelines for decontamination of facilities and equipment prior to release for unrestricted use. Our role during the onsite decontamination will be one of pericdic inspections. We do not plan to have an onsite NRC representative stationed at the site at all times during decontamination activities. However, we do plan to conduct periodic confirmatory and independent measurements of decontaminated areas.

The second issue clarified related to the decontamination actions necessary to cope with apparent significant contamination of an underground sewer/drain line leading from the contaminated buildings. Currently, we understand that you do not have sufficient data to determine the extent of this contamination. As agreed, this area of decontamination will be delayed until further data is obtained and your proposed actions will be discussed with us prior to any removal of sewer or drain lines.

Based upon the NRC staff's review of your plan and the October 21, 1983, telephone conference call and pursuant to Section IV.D of the September 20, 1983, Order, I approve your October 17, 1983, Revision 1, Decontamination Plan of Shelwell Services, Inc. Facility in Hebron, Ohio, as clarified. You may therefore enter the facility to initiate decontamination activities. Please contact Mr. Donald Sreniawski of my staff when you begin these operations.

Your cooperation with us is appreciated.

Sincerely,

(Original signed by
R. L. Spessard for)

James G. Keppler
Regional Administrator

APPENDIX H

NEWSPAPER ARTICLES AND NRC PRESS RELEASES

COLUMBUS CITIZEN JOURNAL
September 16, 1983

3 in Hebron exposed to radiation leak

United Press International

Three workers in Hebron exposed to radiation when they drilled into a capsule containing cesium were being examined at the University of Cincinnati yesterday to determine how much radiation they absorbed.

Nuclear Regulatory Commission spokesman Jan Strasma said yesterday the three men are employees of Shelwell Service Inc., an oil and gas well drilling company.

University officials are using a device called a whole body radiation counter to determine the amount of radioactivity the workers absorbed during the accident late Wednesday in Licking County.

Strasma said the radiation contamination released from the capsule was not life threatening, but was potentially above NRC safety levels. The NRC is investigating the incident.

"At this point we don't know enough to say whether or not there is any long-term medical effect," he said.

Strasma added test results would not be complete "until we do additional surveys to see if any radioactive material was inhaled or absorbed in the body."

The workers drilled into the capsule while trying to remove it from its storage container, Strasma said.

The drilling resulted in the spread of the powder-like radioactive contamination to the trio and to the company's facility.

Radiation surveys were being performed at the three workers' homes to determine whether the contamination was spread beyond the Shelwell facility.

An NRC inspector and an Ohio Disaster Services Agency representative were sent to the site yesterday, after the incident was reported late Wednesday by the company.

The NRC said initial reports by the company did not indicate how the radioactive sources were damaged or report that there was any contamination of workers involved.

Following a preliminary inspection yesterday, the NRC dispatched an additional team of four inspectors from its regional office in Chicago, and requested further assistance from the ODSA and the U.S. Department of Energy and its radiation survey team.

NEWARK ADVOCATE
September 16, 1983

Radiation leaks at Hebron firm

By DAWN PETTIT
Advocate Reporter

Investigators were searching for possible radiation contamination at a Hebron firm this morning after an accidental spill Tuesday.

Three employees of Shelwell Services Inc., 447 Lakeshore Drive West, were attempting to move a capsule of radioactive cesium into another capsule Tuesday evening. When they couldn't remove a seal, the employees began drilling into it, causing the cesium to spill out, said Russ Marabito of the Nuclear Regulatory Commission.

The company reported the incident to the NRC Wednesday. A NRC investigator and a representative from the Ohio Disaster Services agency were at the site Thursday.

This morning, investigators from the NRC, U.S. Department of Energy, Ohio Disaster Services, Mound Laboratories of Miamisburg and Battelle Laboratories of Columbus were at the the scene checking radiation levels.

"It's not life-threatening and that must be underscored," Marabito said.

After the employees were finished with work for the day they returned home. "It (cesium) spread from themselves, to the floor of the building, to their cars and then to their homes," Marabito said.

Davida Matthews of Ohio Disaster Services said a representative from her agency and the NRC checked the worker's homes and cars and no unusual radiation levels were found. "It was well below the standard level," Ms. Matthews said.

The three have been taken to the University of Cincinnati where they will be checked for radiation in a special whole-body radiation counter. "They are decontaminated, but they could have inhaled some," Marabito said.

Investigators also will check on six other employees who may have come in indirect contact with the cesium. "They're not directly involved," Marabito said They may have picked up a little of the radioactivity on the bottom of a pair of shoes, for example, he said.

The area where the accident occurred has been sealed off, but the entire company grounds must be checked as a safety requirement of the NRC, Marabito said. He said he doesn't believe the radioactivity extended beyond the company grounds.

"We first have to define where the problem might be and then contain it," Marabito said. As soon as both of thosee things have been done, any possible high level of radioactivity must be cleaned up, he added.

How much, if any, possible cleanup was unknown at presstime. "When you're dealing with radiation, it's difficult to tell," Marabito said. "Something the size of the head of a pin might have to be cleaned up."

Shelwell Services Inc., is a gas/oil well logging business. It uses cesium as a way to tell the density and soil of a hole that will be drilled for a well. "It's a common tool used in well logging," Matthews said.

COLUMBUS DISPATCH
September 17, 1983

Workers undergo radiation tests

Dispatch State Service

HEBRON, Ohio — Three employees of an oil and gas well company underwent radiation tests Friday at the University of Cincinnati's medical center after an accident earlier this week.

The workers were contaminated Tuesday at Shellwell Services Inc. when they drilled into a sealed capsule of cesium while trying to free it from a storage container, said Jan Strasma, a spokesman for the Nuclear Regulatory Commission.

The radioactive cesium contaminated the workers' hands, clothing and the room they were working in at the company, he said.

The workers were identified as [redacted] both of Hebron, and [redacted] of Newark, said a spokesman for the Ohio Disaster Services Agency.

The cesium, which Strasma described as a powdery radioactive material, was later found in other parts of the facility, in the workers' cars and in their homes.

He said radiation from the cesium is used to survey the chemical content of oil and gas wells as they are drilled.

Preliminary results showed that the three workers inhaled some cesium but not enough to threaten their health.

The NRC sealed off the company, on E. Main St. here, so that 10 investigators from the NRC, U.S. Department of Energy and the state disaster services agency can continue radiation surveys today.

The team will continue to survey the homes of Shellwell employees, particularly those of the three contaminated workers.

Strasma said there was no health hazard to the workers' neighbors or people living near the company.

A preliminary survey found radiation levels at the company and homes too low to present any health hazard but high enough to require a cleanup, Strasma said.

He said Shellwell will hire a radiation services company to decontaminate the homes.

Shellwell employees performed some cleanup activities at the time of the accident Tuesday afternoon and reported the incident to the NRC on Wednesday.

COLUMBUS CITIZEN JOURNAL
September 17, 1983

Few ill effects expected from trio's radiation exposure

By PAUL SUSSMAN
Citizen-Journal Staff Writer

HEBRON — Three workers who were exposed to radioactive powder here Tuesday may develop some reddened finger tips, but probably will suffer no long-term health problems, a spokeswoman for the state Disaster Services Agency said yesterday.

Davida Matthews said final test results from the University of Cincinnati on [redacted] of Newark and [redacted], both of Hebron, probably will be available today.

In the meantime, radiation experts are surveying the houses of nine other workers who may have accidentally tracked some of the radioactive powder into their homes. All the workers were from Licking County.

The men were exposed to cesium while working at Shelwell Service Inc., on U.S. Route 40, which is owned by Shelton. The company helps oil and gas well drillers analyze potential well sites with a machine called a whole-body radiation counter.

The canister-like device, which is made of stainless steel and coated with lead, is lowered down well shafts.

Matthews said the workers were trying to remove the damaged lead cover from the machine and drilled into the compartment containing the radioactive cesium.

Russ Marabito, a spokesman for the Nuclear Regulatory Commission, said drilling is "not an authorized method of dealing with radioactive material." He said Shelwell might face NRC sanctions.

Marabito said the company has voluntarily stopped using radioactive material for the time being.

About 15 radiation experts from the Disaster Services Agency, the NRC, the U.S. Department of Energy and the Battelle Memorial Institute in Columbus are running tests at the workers' houses.

Officials said families are not being asked to leave their homes, since the radiation level is considered to be less than what would be received in a medical X-ray.

"We are certainly not talking about a life-threatening situation," said Marabito.

Shelwell has contacted a company from near Pittsburgh to scrub down the houses if necessary, he said.

The workers' homes were involved because Shelwell did not inform the NRC about the incident until Wednesday, about 23 hours after the accident, said Matthews.

"They tried to clean it up themselves," she said. "But it's a powder similar to talcum and they just stirred it up more."

COLUMBUS DISPATCH
September 21, 1983

Nuclear agency lifts Hebron plant's license

HEBRON, Ohio — The license of Shellwell Services Inc. to handle radioactive materials has been suspended by the Nuclear Regulatory Commission because of an accident involving radioactive cesium last week, NRC public affairs officer Russ Marabito said Tuesday.

Powdered cesium-137 contaminated 16 homes of Shellwell employees and some of their friends and relatives, as well as three business places.

Shellwell's facility here uses sealed cesium in surveys for natural gas and oil.

Three Shellwell employees were trying to free a capsule containing cesium from a storage tube Sept. 13, Marabito said. They put the tube on a lathe to cut away one end but cut into the container. Some cesium escaped.

The powder was carried on their clothing and shoes through the Shellwell plant and into homes and businesses.

Marabito said Shellwell has until Oct. 15 to show why its NRC license should not be revoked.

Although the levels of contamination do not represent an immediate health hazard, Marabito said, Shellwell has hired a radiation services contractor and cleanup of the houses has begun.

Minor spots of contamination in the business places already have been cleaned up by the NRC and a team from the Ohio Disaster Services Agency, Marabito said. But a plan for cleaning the Shellwell plant has to be approved by the NRC before decontamination can begin.

COLUMBUS CITIZEN JOURNAL
September 21, 1983

Shelwell loses OK to handle radiation

By PAUL SUSSMAN
Citizen-Journal Staff Writer

HEBRON — The Nuclear Regulatory Commission yesterday suspended Shelwell Services Inc.'s permit to use radioactive materials following an accident at the company last week.

NRC spokesman Russ Marabito said Shelwell has until Oct. 15 to file papers explaining why the permit shouldn't be permanently revoked.

The accident occurred last week when three workers put a canister of radioactive cesium powder on a lathe in an attempt to remove a damaged lead cover. The canister is used by Shelwell to analyze gas and oil well shafts.

Marabito said the company's handling of the radioactive material was a "very serious" violation. "It's not an authorized means of dealing with a source of radiation," he said.

He said the company would be permitted to remain open and perform any services that did not require the use of radioactive materials.

A Shelwell spokesman said the company would not comment on the sanctions until it was notified officially by the NRC.

Even though nine employees were exposed to the radioactive material, it appears none will suffer long-term health problems. Tests on company owner [redacted] and two other workers will continue as a precaution, however.

"Radiation contamination has been identified in a total of 16 homes occupied by either Shelwell employees, friends or relatives," said Marabito.

He also said "miniscule" amounts of the radioactive material were found at three area businesses. Marabito, who refused to name the businesses, said those sites were cleaned yesterday.

NEWARK ADVOCATE
September 21, 1983

Hebron firm faces loss of NRC license

By DAWN PETTIT
Advocate Reporter

The Nuclear Regulatory Commission has taken steps to permanently revoke the license of Shelwell Services Inc., because of a worker-caused radiation leak last week.

"The Nuclear Regulatory Commission has suspended Shelwell's license effective immediately," said Russ Marabito of the NRC.

The order, came from the NRC's Office of Inspection and Enforcement in Washington, D.C., Tuesday and was signed by Director Richard DeYoung.

"They have 25 days to show cause why (the license) should not be permanently revoked," Marabito said.

Shelwell, 447 Lakeshore Drive, was the site of a radiation spill on Sept. 13, when three employees drilled into a capsule of radioactive cesium, accidentally rupturing it. The workers reportedly were attempting to move the capsule into another storage unit.

The company is a gas/oil well logging operation which uses cesium to help determine the density and soil of a hole that will be drilled for a well.

Radioactive materials may be used in 50 to 75 percent of Shelwell's business, according to an informed source.

The latest incident was not the first time Shelwell has had problems with its radioactive materials. In 1978, a radioactive probe fell off a Shelwell truck en route to Ravenna, Ohio. After an intense week-long search, the probe was found by a worker at a construction site on I-77 in downtown Canton.

Meanwhile, Davida Matthews of Ohio Disaster Services said that the number of homes checked for cesium contamination by investigators has increased, but she doesn't expect that number to rise.

"Sixteen homes have been checked, including the home of a relative of one of the employees," Ms. Matthews said. "They've also checked four businesses, including a school."

Marabito said nine workers' homes and the relative's home will be decontaminated, but that the other six showed insignificant amounts of contamination and will not require any cleanup.

"Three of the four businesses showed some contamination, but all three were cleaned up very easily by the NRC and the state," Marabito said. "We found nothing at the school."

Marabito said Shelwell "is required to decontaminate all off-site locations." The company has hired Applied Health Physics of Bethel Park, Pa., for the cleanup operation. One home has already been decontaminated.

Shelwell also must seek the NRC's approval to clean up its own building and grounds. "They can't do any decontamination until a plan on how they will clean up is received by us," Marabito said. "We have to approve the plan." That plan must be submitted prior to Oct. 19.

Officials say Shelwell must pay for all cleanup operations.

Marabito said the NRC will remain at its Hebron American Legion Post headquarters until all the homes are decontaminated and will be monitoring the cleanup program on the Shelwell site once it gets under way.

NEWARK ADVOCATE
September 22, 1983

TEMPORARY HOME. A pool table covered with a plywood ping-pong court at Hebron's American Legion Post has become the center of operations for a four-member Nuclear Regulatory Commission team. From left here are radiation specialists Bill Reichhold and Jim Mullauer, left, and site team leader Don Sreniawski and public affairs officer Russ Marabito, right. The team has its own copy machine and a fascimile transmitting machine to send and receive paper copies from the NRC Chicago office. United Telephone Co. has installed a telephone line at the Legion post for the team's use. On the table here, background right, are a radiation detector and a speaker phone. — Gary Smith, Advocate

Leak turns Hebron into 'lab town'

By LARRY FUGATE
Advocate Reporter

HEBRON — Very few village mayors in Licking County expect to receive a 1 a.m. telephone call and be told by the Nuclear Regulatory Commission that they have a radiation leak in their community.

Mayor Henry Porter's home phone rang Friday morning. It was then that he found out the NRC was in town.

Porter was told the NRC team was staying at a Heath motel, and called them back minutes later to verify the whole thing was not a hoax. He then telephoned Police Chief Huck Clark.

The leak occurred Sept. 13, when three employees of Shelwell Services Inc. on East Main Street, about a half-mile east of the Hebron Municipal Building, attempted to move a capsule of radioactive cesium into another capsule. When they could not remove the seal, they tried drilling into it to remove the cesium, triggering the radioactive leak. Shelwell is a gas-and-oil well firm that uses cesium in its well-probing evaluations.

The somewhat bizzare event has brought the NRC, the Ohio Disaster Services Administration, the state Department of Engineers and Columbus' Battelle Memorial Institute to Hebron, according to village officials.

After learning of the incident, Clark said the first thing village officials wanted to know was how safe the village was and if there should be evacuations.

By Friday morning, Clark said the agency officials "were as busy as all-get-out." They had determined there was no real danger to the town.

The police department assisted the NRC team in tracing the paths of the Shelwell workers after they had been exposed to the radioactive material. "They (the NRC officials) knew every footstep those guys took after work," Clark said.

Some went to a local tavern. Hebron patrolman [redacted] routinely checks the tavern's doors at night and he, and the village police cruiser, had to be inspected for possible radioactive contamination. The NRC even learned a United Parcel Service deliveryman had been in the vicinity of the Shelwell operation, prompting yet another search. "They rounded him up and he was all clean," Clark said. "They haven't missed a trick."

The NRC team used a machine similar to a Geiger counter to trace the steps of the Shelwell workers and other people possibly exposed to the radiation. The employeees' homes were searched and anywhere their families went, including stores and restaurants as far away as Heath, were inspected.

The NRC workers also went out to local cornfields in their radiation search.

Village officials also were concerned that radiation may have seeped into the town's sewer system, since a lift station is on the Shelwell property. "Some (radioactive material) did get into the lift station," Clark said. But no radioactive material was found in the town's sewer system or sewer plant.

Hebron has been the subject of statewide and regional news coverage since last week. Sightseers have came to town to drive by the Shelwell plant, Councilman Harold Dugan said. But Hebronites basically have taken the episode in stride. Clark said there was no panic in town when news of the radiation leak broke.

The event has brought a gang of government officials to town. The NRC has set up shop in the Hebron American Legion Hall. "You wouldn't believe the paperwork coming out down there," Dugan said. The NRC brought in typewriters, telephones and copying machines to send reports to a Chicago regional office and to Washington. Today, NRC officials plan to do an aerial search over the Hebron area.

Clark said he was impressed with the thoroughness of the agencies. He said they met with local officials and village councilmen to update them on the situation. The agency officials plan to be in town for at least another week. "They intend to stay on top of it until it's all cleaned up," Clark said.

Clark said Hebron officials were concerned about the "lapse of time" between the Sept. 13 accident and the time action was taken, and the possibility a similar mishap could happen again. But Clark said the possibility of such a leak happening again is remote, Clark said.

"It's very unlikely there will be anything like that again," he said, "if for the simple reason they (Shelwell) lost their license." The NRC said Tuesday it pulled Shelwell's license to use radioactive materials.

While the Shelwell operation remains closed, nearby businesses have been allowed to open. However, workers at one of the businesses cannot park their cars in the area and the village is letting them park at the nearby Hebron Cemetery.

The whole experience has turned Hebron into something akin to an experimental laboratory for the state agencies. Apparently, a similar incident has not happened elsewhere in the state. "By the way they talk it is unique," one village official said. Hebron has offered the agencies a "good experience" in preparation for similar events, he added.

UNITED STATES
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NEWS ANNOUNCEMENT: 83-68
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FEDERAL AND STATE AGENCIES PERFORMING RADIATION SURVEYS
AFTER RADIOACTIVE CONTAMINATION INCIDENT IN HEBRON, OHIO

Radiation survey teams from the Nuclear Regulatory Commission Region III (Chicago) office, the Ohio Disaster Services Agency, and the Department of Energy Radiological Assistance Program have begun surveying the Shelwell Service, Inc., facility in Hebron, Ohio, and the homes of several Shelwell employees for radioactive contamination resulting from an incident September 13, 1983, in which a sealed radiation source was damaged.

Shelwell uses sealed radiation sources to survey gas and oil wells. The damaged source contained radioactive cesium 137 in a double-walled steel capsule.

An NRC inspector, dispatched to the site early September 15, and an Ohio Disaster Services representative determined that there was extensive contamination of one building at the Shelwell site with some additional contaminated areas elsewhere on the site. Based on these findings, four additional NRC inspectors were dispatched by charter aircraft and NRC requested assistance from the DOE Radiological Assistance Teams and the State of Ohio.

On September 15, preliminary surveys of the homes of the three individuals involved in handling the damaged source identified numerous small areas of low-level radioactive contamination. The contamination does not represent an immediate health and safety problem but should be cleaned up promptly.

The survey teams will be performing more extensive surveys of the three homes on September 16, as well as checking the homes of several other Shelwell employees who were in the contaminated building. Any areas of significant contamination in the homes will be covered or isolated to prevent further spread of the material. Shelwell is retaining a radiation service firm to clean up the contamination in the homes.

The three employees were to be checked for evidence of any internal deposition in a whole body counter at the University of Cincinnati on September 16, 1983. An NRC medical consultant has been retained to evaluate the exposures.

The NRC inspection on September 15 determined that three Shelwell employees drilled into the source while trying to remove it from its storage container. The workers handled the source with their hands after it was damaged, and there was significant personnel contamination and spread of contamination in the room.

Shelwell has agreed to halt all licensed activities pending a full assessment of the contamination problems. Appropriate enforcement action will be taken, based on the results of the inspection activities.

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NOTE TO EDITORS: Preliminary information on this incident was provided to Associated Press and United Press International on September 15, 1983.

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NEWS ANNOUNCEMENT: 83-70
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NRC STAFF SUSPENDS LICENSE OF OHIO FIRM WHERE
RADIATION SOURCE DAMAGE AND CONTAMINATION OCCURRED

The Nuclear Regulatory Commission staff has suspended the NRC license of Shelwell Service, Inc., of Hebron, Ohio, as a result of an incident September 13, 1983, in which a radioactive source was damaged. The damage to the source led to radioactive contamination of the Shelwell facility and to the homes of some Shelwell employees and other locations off the Shelwell site.

Cleanup activities are underway to remove the contamination from the homes and the off-site locations. The levels of contamination do not represent an immediate health hazard to Shelwell employees, occupants of the home, or the public. The contamination levels, however, do require cleanup.

The NRC Order, issued September 20, requires the company to stop all activities under its license, including field activities. Shelwell is a well logging company, using sealed radiation sources to survey gas and oil wells. The company is also required to decontaminate any employees' homes or other off-site locations where material from the damaged source has been carried. A plan for decontamination of the Shelwell facility itself is to be submitted to the NRC for approval before the site decontamination begins.

Shelwell also has until October 15 to show cause why its license should not be revoked.

Radiation survey and decontamination activities are continuing to be performed by survey teams from the Nuclear Regulatory Commission's Region II Office and the Ohio Disaster Services Agency. A radiation services contractor, retained by Shelwell, has completed decontamination of one home, and is completing a second.

Radioactive contamination has been identified in a total of 16 homes -- occupied either by Shelwell employees, friends, or relatives. The radioactive material was carried there on the shoes and clothing of the employees Minor spots of contamination have also been found in three area businesses visited by employees last week. These three locations were cleaned up by the NRC/Ohio teams.

The radiation exposures to the three principal employees involved in the source damage incident are being evaluated by an NRC medical consultant.

The contamination incident occurred September 13 when the three employees attempted to free a capsule containing radioactive cesium 137 from its storage tube. When other efforts failed, the workers placed the tube on a lathe to cut away one end. In doing so, the source was damaged, allowing the cesium powder to escape. The powder was then carried about the facility and off the site on the workers' clothing and shoes.

NOTE: The NRC has established a base of operations in the American Legion Hall in Hebron. A Public Affairs Officer is on duty there and can be reached at 614/928-7361.

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September 21 1983

UNITED STATES
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NEWS ANNOUNCEMENT: 83-76
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NRC REPORTS COMPLETION OF DECONTAMINATION OF LOW-LEVEL RADIOACTIVITY AT HOMES AND OTHER LOCATIONS IN HEBRON, OHIO, AREA

All off-site radioactive survey and decontamination activities have been completed for homes and other locations in the Hebron, Ohio, area, which were contaminated with low-level radioactivity as a result of a radiation source damage incident at a well logging company near there, according to the Nuclear Regulatory Commission.

The low-level radioactive contamination was caused by an incident September 13, 1983, at Shelwell Services, Inc., Hebron, in which a sealed radiation source was damaged while three employees were trying to remove it from a storage container. The damage resulted in the spread of radioactive cesium in a powder form. Radioactive contamination was subsequently spread throughout the Shelwell facility and carried off-site on the workers' clothing and shoes.

Twenty-six homes were surveyed by teams from NRC Region III (Chicago), the Ohio Disaster Services Agency, and (initially) the Department of Energy. Radiological Assistance Program. Fourteen of these homes required decontamination, which was performed by a contractor hired by the licensee. All of the homes have been decontaminated, and final surveys have been performed by NRC and State personnel. In some cases, furnishings were removed for later decontamination.

In addition to the homes, the survey teams checked 12 area businesses. Contamination was identified at three of them, and the facilities were readily decontaminated by the survey teams. Five individuals who had visited the Shelwell site and their vehicles were also surveyed. Minor contamination requiring cleanup was found on one vehicle.

The licensee's radiation services contractor has been authorized to begin on-site building surveys. The licensee and its contractor are preparing an on-site decontamination plan, which is to be submitted to Region III by October 19, 1983.

The NRC plans to maintain a staff of one or two inspectors at the Shelwell site during cleanup activities.

An NRC medical consultant has examined the three workers involved in the source damage incident and two additional Shelwell employees who helped with the company's initial attempts to clean up the contamination. Evidence of internal deposition of the radioactive materials was observed, but the levels are well within regulatory limits for workers in radiation-related fields.

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AERIAL RADIATION SURVEY PLANNED FOR HEBRON, OHIO, AREA

A small red, white, and blue helicopter, flying at low altitudes, will perform an aerial survey of environmental radiation in the vicinity of a Hebron, Ohio, site where a radioactive contamination incident occurred in September 1983.

The survey will begin about October 17 and continue for about 10 days. The exact schedule and duration of the survey will depend on weather conditions.

The aerial survey is being conducted for the Nuclear Regulatory Commission to assure that all areas of significant radioactive contamination have been identified. The low-level contamination occurred when a capsule containing radioactive cesium was damaged at Shelwell Services, Inc., Hebron. Shelwell workers subsequently spread the cesium contamination throughout the Shelwell facility and carried it to their homes and other off-site locations on their shoes and clothing.

All known off-site locations where the contamination was spread have been decontaminated. The decontamination was performed by a contractor retained by Shelwell Services, and followup surveys were performed by the NRC and the State of Ohio.

The helicopter, owned by the U.S. Department of Energy and operated by E G & G of Las Vegas, Nevada, will fly at an altitude of 150 feet over the Hebron area during daylight hours. A special waiver for federal air regulations has been obtained to permit the low altitude flights.

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October 13, 1983

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16. ABSTRACT (200 words or less)

This U.S. Nuclear Regulatory Commission report documents the circumstances surrounding the September 13, 1983, cesium-137 sealed source rupture incident at Shelwell Services, Inc., facility in Hebron, Ohio. It focuses on the period from approximately 4:00 p.m. (EDT) on September 13, 1983, when the source ruptured, to October 5, 1983, when the radiological emergency response aspects of the event were concluded. Information outside these periods is recounted as necessary. The incident resulted in radiation doses to two licensee employees that exceeded the regulatory limits for whole-body and extremity exposures, and contamination of the licensee's employees, families, and friends. The emergency response required the combined efforts of NRC, the U.S. Department of Energy, and state personnel. The report describes the factual information and significnat findings associated with the event and, thereby, provides a data base for subsequent detailed analyses and recommendations by various NRC offices.

17. KEY WORDS AND DOCUMENT ANALYSIS

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