TA-2 WATER BOILER REACTOR DECOMMISSIONING (PHASE I)

by

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ABSTRACT

Removal of external structures and underground piping associated with the gaseous effluent (stack) line from the TA-2 Water Boiler Reactor was performed as Phase I of reactor decommissioning. Six concrete structures were dismantled and 435 ft of contaminated underground piping was removed. Extensive soil contamination by ^{137}Cs was encountered around structure TA-2-48 and in a suspected leach field near the stream flowing through Los Alamos Canyon. Efforts to remove all contaminated soil were hampered by infiltrating ground water and heavy rains. Methods, cleanup guidelines, and ALARA decisions used to successfully restore the area are described. The cost of the project was approximately $320K; 970 m^3 of low-level solid radioactive waste resulted from the cleanup operations.

I. INTRODUCTION

A. Purpose of the Project.

The purpose of the TA-2 Water Boiler Reactor decommissioning project is to remove all remaining components of the reactor, thereby providing reusable space at the TA-2 site, reducing the hazard of accidental intrusion into contaminated structures, and eliminating the source of possible contamination of the stream bed in Los Alamos Canyon. The results of decommissioning activities performed in Phase I of the project are reported here. Phase I activities were to dismantle the exterior facilities associated with the gaseous effluent (stack) line. Phase II activities scheduled for FY 1989-90 will dismantle the reactor itself, its biological shield, and any remaining equipment or piping.

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The project was sponsored by the Department of Energy (DOE) under the direction of the Surplus Facilities Management Program (SFMP). Its cost was approximately $320K ($151K in FY 1985 and $169K in FY 1986).

B. History and Description of the Water Boiler Reactor.

The Water Boiler Reactor was operated from 1944 to 1974. The reactor was used primarily as a source of neutrons rather than as an experiment in reactor design. The Water Boiler was an 89% enriched uranium homogeneous reactor consisting of a 1-ft-diameter stainless steel sphere filled with a water solution of uranyl nitrate and surrounded by a graphite neutron reflector (Bunker 1963). Other major components included a concrete biological shield, two thermal columns, various access ports, and a gas recombination system. The latter system was added in 1951 to recombine hydrogen and oxygen radiolytically dissociated by reactor operation. The recombination system reduced the hydrogen explosion hazard as well as the quantity of radioactively contaminated gas requiring discharge to atmosphere via the gaseous effluent system. The gaseous effluent system made up most of the piping and structures to be removed in Phase I of the project. During 25 KW operation approximately 220 cm^3/min of excess gas flowed into the gaseous effluent line. This line ran underground (see Figure 1) to the top of an adjacent mesa where it terminated in a 150-ft stack. A centrifugal blower at the base of the stack provided adequate draft for gas flow in the long pipe. The constituents of the gaseous effluent were air and mixed fission products.

The Water Boiler Reactor was shut down, defueled, and placed in a safe shutdown condition in 1974. All systems outside the biological shield except for the gaseous effluent line were removed. The control room and reactor room were converted to other purposes. Decommissioning of the reactor, biological shield, other

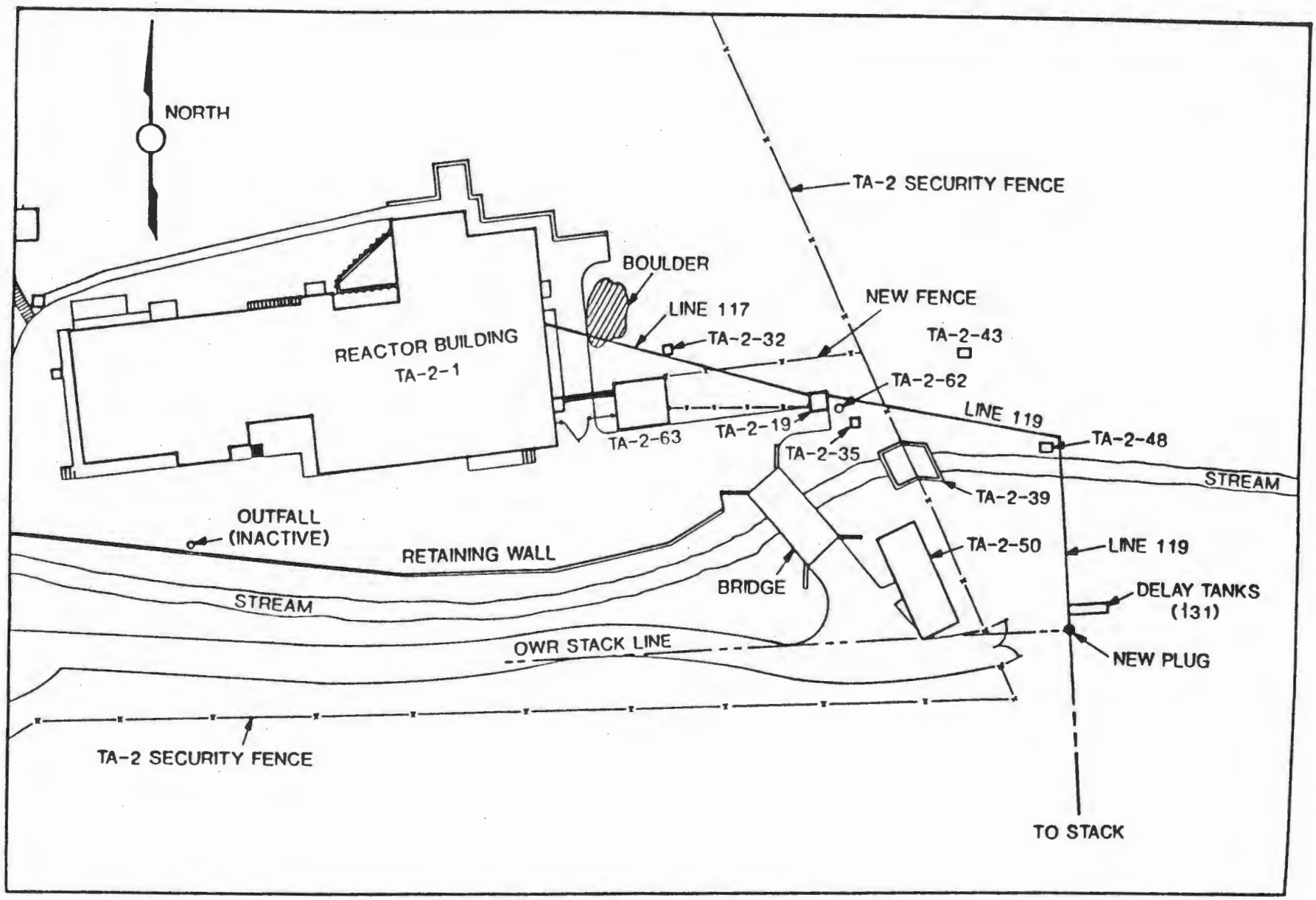

Fig. 1. TA-2 map showing major exterior structures and lines. Lines 117 and 119, structures TA-2-19, TA-2-32, TA-2-35, TA-2-43, TA-2-48, TA-2-62, and the delay tanks were removed by the project.

components within the biological shield, and a piping pit in the floor of the reactor building is scheduled to occur later. This future project will be Phase II of the Water Boiler Reactor decommissioning and is scheduled to begin in 1989.

C. Description of External Structures and Lines.

Phase I of the TA-2 Water Boiler Reactor decommissioning consisted primarily of the removal of structures TA-2-19, TA-2-32, TA-2-62, a set of delay tanks, TA-2-43, TA-2-48, and the gaseous effluent line. The layout of these components is shown schematically on Figure 1. The major components are described below.

TA-2-19, The Valve House. This heavy reinforced concrete structure was mostly above ground (see Figure 2). Its dimensions were 11 x 9 x 10 ft high; its walls were 18 in. thick. Its purpose was to provide valves, pumps, and a shielded tank where condensate from the gaseous effluent line could be collected and handled. Initial dose rate found in this structure was 70 mR/hr. Lead bricks had been placed to provide local shielding.

TA-2-62, A Holding Tank. This stainless steel tank (800 L capacity; see Figure 2) was placed adjacent to TA-2-19 to collect the reactor cooling water in case it became contaminated through a breach in one of the cooling coils inside the reactor sphere. The tank was housed inside a 6- x 4- x 3-ft wooden shed. Radiation levels from the tank and associated piping and valves were not above background.

TA-2-32, An Underground Chamber. This underground concrete chamber was located between Building Omega 1 (TA-2-1) and Structure TA-2-19 (see Figure 3). It provided a shielded collection point for any accidental leakage of the fuel solution from the reactor vessel. A tray below the reactor vessel was connected by pipe to a safe-geometry vessel in TA-2-32. A second vessel was

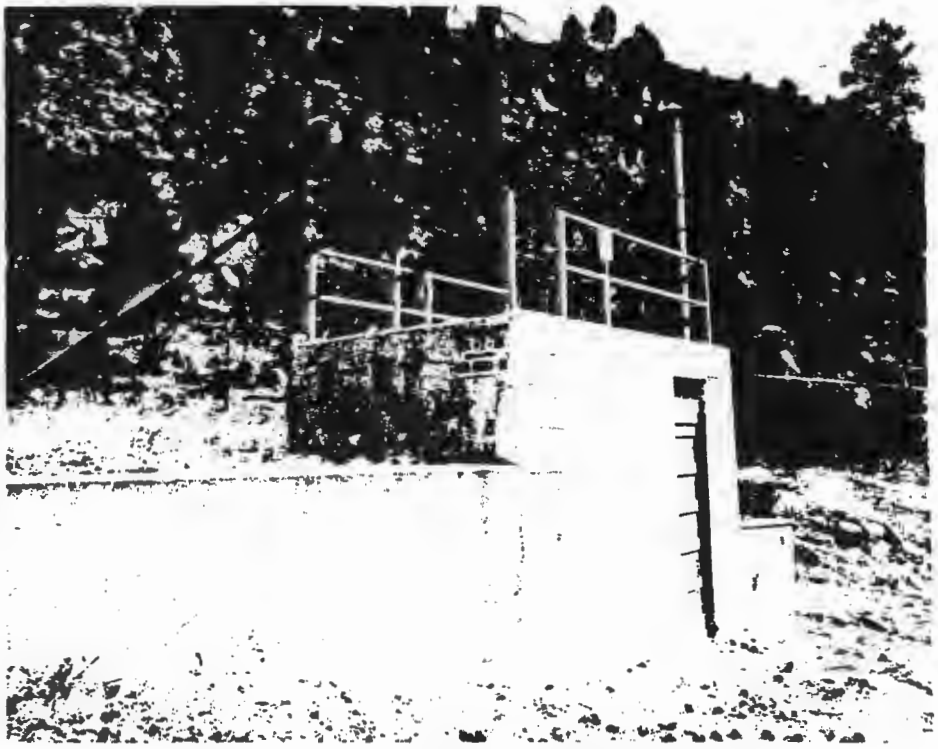

Fig. 2. TA-2-19, the Valve House, with TA-2-62, a holding tank, on the far side.

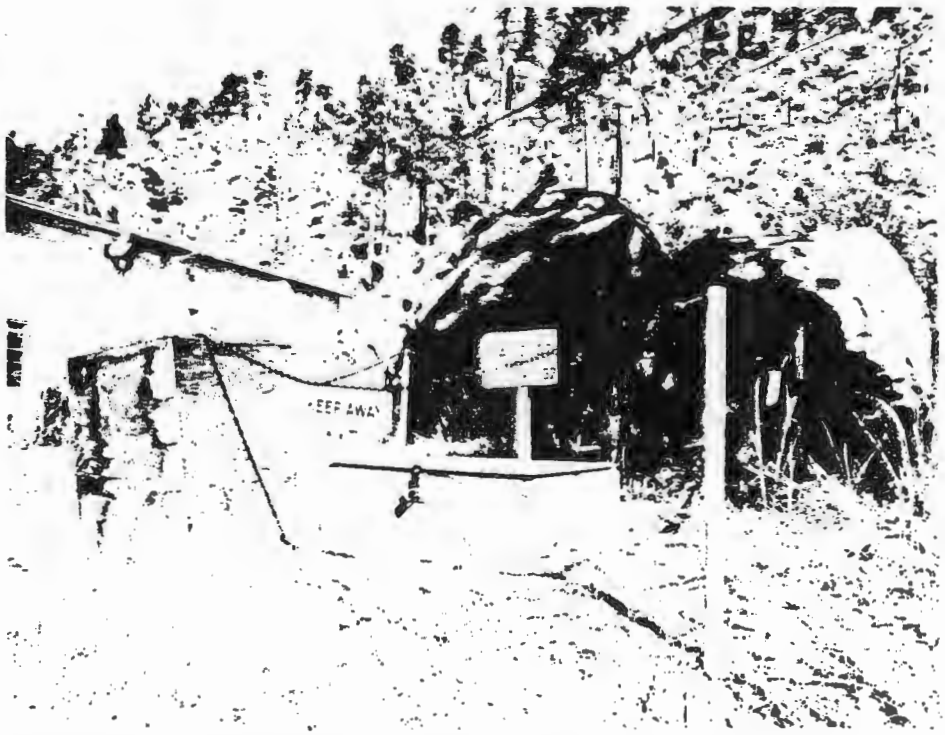

Fig. 3. Access hatch to TA-2-32, an underground chamber. TA-2-1, the reactor building, is in the background.

connected (prior to 1950) by valve and piping to the reactor sphere and could receive fuel solution dumped as an emergency measure. Neither vessel had been contaminated by any usage. Access to this 13- x 8-ft structure was by ladder to the floor, which was approximately 13 ft below ground level. The gaseous effluent line (Line 117 between TA-2-1 and TA-2-19) had no connection with TA-2-32.

TA-2-43, A Septic Tank. This concrete septic tank served the sanitary sewer needs of TA-2 in the early years but had been disconnected from the sanitary sewer in the 1950s. It was semiactive in recent years only because spring-fed water leakage into the basement of TA-2-1 was pumped to it routinely. It was believed that this tank had once been contaminated, although sampling during decommissioning did not detect any residual radioactivity.

TA-2-48, A Condensing Trap. This structure consisted of a concrete manhole superstructure (see Figure 4) and a small-diameter standpipe which intersected the gaseous effluent line (Line 119) at its low point between TA-2-19 and its junction with the Omega West Reactor vent line. Some confusion existed at the time of its removal because a large-diameter (24-in.) steel pipe 12 ft long was expected to be under the manhole. Removal operations showed that the 24-in. pipe had been partially removed earlier (probably in the late 1940s) and a new version (the standpipe) had been installed. As discussed in Section V.A., portions of the original device were also present and figured prominently in removal operations.

TA-2-35, A Drainage Basin (Manhole). This 3- x 4- x 4-ft concrete structure was located near TA-2-19; it was not contaminated.

Line 117. Line 117 was a 4-in. cast-iron pipe through which three smaller lines were passed from TA-2-1 to TA-2-19. The pipe read 20 mR/hr at contact in the pit inside TA-2-1; the 1/2-in. stainless steel gaseous effluent line inside it read 80 mR/hr at

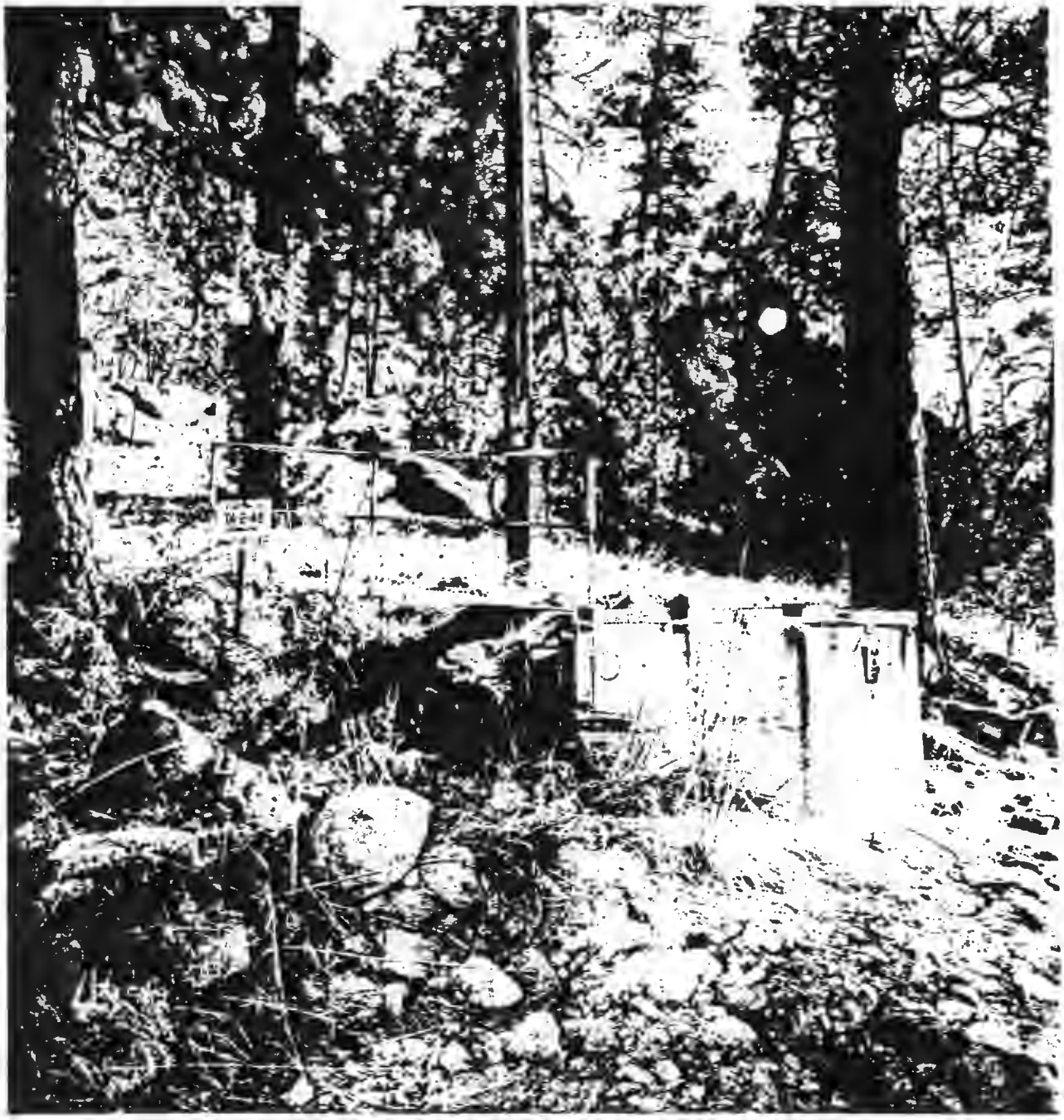

Fig. 4. The superstructure of TA-2-49, a condensing trap.

contact. Lead brick and melted paraffin were found surrounding Line 117 in a pit inside TA-2-1 where the line originated. Radiation level in the pit was 20 mR/hr.

Line 118. Line 118 was a small-diameter stainless steel line laid in a shallow trench from TA-2-19 to a location near the delay beds (item 131). It was probably a temporary gas vent or sampling line.

Line 119. Line 119 was a 3-in. stainless steel pipe which carried gaseous effluent from TA-2-19 to the intersection with the Omega West Reactor vent line (behind warehouse TA-2-50).

Unnumbered Lines. An unnumbered vitrified clay pipe (VCP) line extended from TA-2-43, the septic tank, to the stream. Its purpose had been to carry overflow from the septic tank but it apparently became plugged some years ago. Another clay line in the same area was discovered during soil cleanup operations east of TA-2-48 (see Section V.B).

Item 131, Delay Tanks. The delay tanks were two 12-in.-diameter stainless steel tanks 20 ft long lying parallel to each other. The extra volume they added to the effluent line allowed greater decay time for short-lived radionuclides.

D. Project Planning.

A project plan for Phase I of the TA-2 Water Boiler decommissioning was prepared in 1985 by the Laboratory's Radiation Protection Group (HSE-1) and approved by representatives of the following:

HSE-1, the Radiation Protection Group
ENG-1, the Construction Group
The Zia Company (later Pan Am)

INC-5, Research Reactor, the Operating Group
HSE-3, the Safety Group
HSE-5, the Industrial Hygiene Group
HSE-8, the Environmental Surveillance Group.

The project plan provided safety requirements, description of the work, expected hazards, and assignments of responsibilities. Soil cleanup guidelines adopted for the project were stated and justified in the project plan.

II. OPERATIONAL METHODS

A. Radiological Survey Methods.

The project involved primarily the total removal of small external structures, underground pipes, and contaminated soil, rather than the decontamination of walls or other surfaces. The survey methods and soil cleanup guidelines discussed in this section therefore deal primarily with residual activity in soil.

1. Soil Cleanup Guidelines. Guidelines for residual radioactivity concentrations in soil after removal of lines and structures were based on the general principle of as low as reasonably achievable (ALARA). Under this principle, the primary guidance was to keep any future exposure of employees or the general public to remaining radioactivity to as low a level as technically and economically reasonable. To expedite decision making concerning this principle, de minimus levels of soil contamination and upper-limit concentration guides were used. De minimus levels are those below which no environmental or physical effect is expected. These levels were recommended by the Laboratory's Environmental Surveillance Group (HSE-8). Establishing de minimus levels addressed the use of unreasonably long sample counting times in quest of continually lower detection limits. The upper limit concentration guides, also recommended by HSE-8, were selected to ensure conformance to the secondary requirement that no member of the public receive a dose, as a result of

exposure to residual contamination, exceeding 500 mrem/yr to any organ of the body. These latter limits were derived by calculations of potential dose equivalents associated with important radionuclides transported by various possible pathways. The derivation of these limits is presented in Appendix B of LA-10821-MS (Elder 1986).

The initial step in the application of these guidelines was removal of structures and excavation of soil until no above-background readings were obtained using beta/gamma survey meters or until it was impractical to proceed further (i.e., depth greater than backhoe reach, interference from obstacles, interference by ground water, and the like).

Soil samples were obtained at appropriate representative locations along the bottom and walls of the excavation or from the location where the excavated soil was placed. The number of soil sampling locations was dependent on relative radionuclide levels.

Soil samples were analyzed for various constituents such as gross alpha, gross beta, or gamma spectrum. Previous sample results were also observed. Sample analysis results were compared to the de minimus guidelines shown in Table I.

If the soil sample results were below the levels given in Table I, the area was considered acceptably free of contamination. If soil sample results exceeded the guidelines, additional cleanup was requested and the monitoring and sampling procedures were repeated until the guidelines were met or it was determined that further cleanup to the guidelines was impractical due to safety, economics, or other reasons. Administrative procedures by which ALARA decisions were made are provided in the Appendix.

TABLE I

SOIL CONCENTRATION GUIDELINES (ABOVE BACKGROUND)
CONFORMING TO DE MINIMUS LEVELS

	Surface Soil[a]	Subsurface Soil[b]
Gross Alpha	Nondetectable[c]	75 pCi/g
Gross Beta	25 pCi/g	75 pCi/g
External Gamma[d]	5 μR/h	20 μR/h

[a]Surface soil is defined as soil located within 5 ft (1.5 m) from the surface.

[b]Subsurface soil is located at any depth greater than 5 ft (1.5 m).

[c]Detector background plus 3 sigma counting error.

[d]If ^{137}Cs is present.

If the de minimus guidelines could not be reasonably met, the measured levels would be compared to those in Table II, which gives the upper limit concentration guidelines based on the 500 mrem/yr dose limit. The concentrations in Table II are based on very conservative scenarios and as such would not be construed as absolute limits. Conservative assumptions made in the scenarios might be very different from the field situation encountered. Thus, flexibility was used in applying the guidelines and consideration was given on a case-by-case basis to factors such as the extent, depth, and location of the contamination zone, the radionuclides present and their concentrations, the nature of the contaminated soil, and the safety, economic, and operational impact of further decontamination. Taking these factors into account and using Table II guidelines as reference points, decisions were made as to whether the contamination would result in a 500 mrem/yr dose to any organ of any member of the public. Decontamination

continued until it was felt that the occurrence of the 500 mrem/yr dose was very improbable.

TABLE II

SOIL CONCENTRATION GUIDELINES (pCi/g ABOVE BACKGROUND)
BASED ON 500 mrem/yr ORGAN LIMIT

Radionuclide	Surface Soil[a]	Subsurface Soil[a]
^{241}Am	50	600
^{241}Pu[b]	1 670	20 400
$^{239-240}Pu$	200	1 900
^{238}Pu	350	3 200
^{238}U	80	960
^{235}U	80	960
^{234}U	80	960
^{137}Cs	80	960
^{90}Sr	100	1 200
^{3}H[c]	8 870	120 000

[a]See definition in notes a and b, Table I.

[b]^{241}Pu limit derived from the ^{241}Am concentration.

[c]In pCi/ml of soil moisture.

2. Surveying During Operations. A trained health physics technician provided continuous surveillance of excavation and waste removal work. For detection of ^{137}Cs radioactivity in soil, the technician was equipped with a portable Ludlum Model 3 counting rate meter with a shielded end-window Geiger-Mueller (GM) detector and a National Nuclear HM-3 NaI scintillation detector. The 0.662-MeV photon emitted by ^{137}Cs has adequate range both in air and in soil to be readily detected. The scintillation detector was sensitive enough to allow location of hotspots by walking surveys with the instrument at waist level.

Monitoring of equipment surfaces and personnel was accomplished by end-window GM detectors for beta/ gamma radiation and air proportional counters for alpha radiation. These instruments received normal servicing and calibration checks through the Laboratory's health physics instrumentation section.

3. Sampling for Record Purposes. The Environmental Surveillance Group obtained soil samples at intervals selected to provide representative samples from the bottom and walls of the excavation or from excavated soil. Soil samples were more numerous in locations where radionuclide activity had been found or was expected.

Quality control procedures for soil sampling included the following:

- radiochemical analysis of selected soil samples,
- duplicate and split samples consisting of approximately 10% of the total number of samples, and
- daily calibration checks of gross alpha and gross beta counting instruments with soil samples spiked with ^{239}Pu and ^{137}Cs, respectively.

The primary laboratory alpha and beta/gamma counting instruments were 10-cm-diameter ZnS scintillation detectors equipped with single-channel analyzers. Soil samples were placed in plastic bags and manually worked to break up soil chunks. Approximately 75 g of soil was placed in 88-mm-diameter x 13-mm-deep plastic petri dishes. The samples were dried in a microwave oven, allowed to cool, and counted for 5 minutes. This procedure allowed detection above background of approximately 25 pCi/g alpha activity and 8 pCi/g beta/ gamma activity. Background and calibration counts were performed daily.

B. Removal Methods.

1. Excavation. A drawing search and walkthrough by all involved parties preceded decommissioning. The construction engineer prepared a work order which described the scope of work, location, cost estimate, manpower and equipment needed, and special safety requirements of the job. Personnel safety methods are discussed in Section III.B. The work order received approval from representatives of the Laboratory, DOE, and the Zia Company (later Pan Am).

A policy was followed that known underground utility lines near the pipe or structure be exposed by hand digging before machine excavation started. Machine excavation was typically performed by one of two hydraulically operated excavators:

- Liebherr excavator - 1.3 yd^3 bucket with 25-ft reach;
- John Deere backhoe - 0.25 yd^3 bucket with 16-ft reach.

Excavated soil determined to be clean was stockpiled for reuse as backfill material. Contaminated soil was loaded directly onto plastic-lined, tarpaulin-covered dump trucks for transport to the Solid Radioactive Waste Management Site (TA-54).

Excavations were backfilled with their own excavated material when practicable. Compaction at depths below 5 ft was accomplished hydraulically, by tamping with the backhoe bucket, or by a combination of methods depending on backfill material. From the 5-ft depth to the surface, compaction was by hand tamper, trench roller, or front-end loader depending on the area. The flour-like consistency of crushed tuff* required liberal wetting as the backfilled area was being compacted.

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*Tuff is rock composed of compacted volcanic ash and dust.

Pipe removal procedures were dictated somewhat by the type of pipe being removed. Vitrified clay pipe between TA-2-43 and the stream was broken by the backhoe bucket and removed directly with soil. Steel pipe was removed by hoisting a length out of the trench, cutting the pipe into appropriate lengths, taping both ends, and loading each section onto a truck. This operation did not require entry of personnel into the trench. Pipe cutting was accomplished by portable (saber) saw.

Pipe pulling, a technique which can be used with either steel or plastic pipe, was used on a few occasions. Pipe pulling permits removal of sections of pipe (up to 300 ft long) without trenching down to the pipe except at each end of the section. A cable is fed through the pipe, connected to the cable pulling device at one end, and is connected to the backhoe boom at the other end. Repeated short pulls with the boom and cutting of the pipe at appropriate intervals permits removal of the pipe at lower cost due to reduced excavation.

Structure removal was made in sections where possible. Several structures were removed whole, but in one case (TA-2-19) it was necessary to jackhammer all but the floor of the structure into rubble. Specific removal procedures are discussed further in Section V.A.

2. Contamination Control. Occasions with highest potential for spread of contamination occurred when pipes were cut, when pipes and soil were lifted from the excavation, or when soil and other material were transported by truck. Contamination control during removal operations involved wrapping and sealing contaminated materials, controlling airborne contamination by water spray, draining or soaking up contaminated liquids, and the like. Previous experience at Los Alamos and elsewhere provided useful methods by which contamination was retained in the desired location. Plastic bags or trays were

used to contain any liquid from a pipe as it was being cut. Both ends of cut sections of pipe were bagged and taped before transport. This was not the case with clay pipe, which was broken by the backhoe and removed with the soil and base coarse under it.

Water spray was used to suppress dust generation during excavation, depending on soil conditions and the level of contamination. At TA-2, the soil moisture was generally high throughout the project (either by rainfall or ground water), making spray seldom necessary.

Decontamination of equipment such as the backhoes or dump trucks was seldom necessary. Backhoes were monitored before moving away from the work site to avoid tracking or spreading. Dump trucks were routinely monitored before departing the worksite and TA-54.

Detailed description of decontamination of specific areas is provided in Section V.

3. Waste Disposal. The contaminated material removed by the project was transported to the Solid Radioactive Waste Management Site (TA-54) by dump trucks with plastic-lined and covered beds. The loads were routinely 5 m^3 volume. Load data were summarized from Radioactive Solid Waste Disposal records (RSWD load tickets) which accompanied every load and described the waste in the load. An estimate of activity in loads of soil, pipe, and debris was made. Activity within a length of pipe was estimated by taking several readings with a detector probe, converting average count rate to activity under the probe and multiplying by appropriate probe-to-pipe surface area ratios for the length and diameter of the pipe. The method assumed uniform deposition along the length of the pipe.

The waste from TA-2 was deposited in trenches at TA-54 Area G. Waste management operations at Area G are described in HSE-7 Standard Operating Procedures and Operating Instructions. Retrievable waste (> 100 nCi/g, TRU waste), had the project encountered any, would have been packaged for storage in sealed shafts.

4. Left Items or Contamination. Occasionally, a contaminated item or soil contamination was left in place because of interferences such as excessive depth or ground water. These items or contamination would be left only after ALARA decisions were made and suitable documentation was prepared. Locations where contamination was left are discussed individually in Section V. The basic procedure for arriving at an ALARA decision is discussed in the Appendix.

A monument, sign, or other marker was not installed at the site of left contamination. The contamination was generally left in a location not likely to be disturbed or in a condition not likely to cause a detectable hazard if disturbed.

III. SAFETY AND HEALTH PROVISIONS

A. Radiation Protection.

The Laboratory's Radiation Protection Group (HSE-1) provided continuous surveillance of excavating and waste removal operations by a trained health protection technician. Special requirements for radiation protection of workers were specified under the Laboratory practice of issuing Special Work Permit for Radiation Work (see RWP, Health and Safety Manual, Administrative Requirements 1-3 and 3-1). The RWP was initiated by the project technical manager and completed by HSE-1 personnel, once expected conditions had been reviewed. Anticontamination clothing, respiratory protection, and air sampling were provided as necessary. Experience with typical excavation and removal work showed very little measurable contamination was made airborne nor was it likely that significant soil contamination would be encountered without early detection by field instrumentation.

Personnel monitoring included normal monthly radiation badge dosimetry and bioassay analysis of urine specimens and in vivo counting on an annual basis. Continuous air sampling in the work area was not considered necessary due to previous experience. Occasional air sampling was performed in areas where contamination was significantly above background. Air samples were sent to the Health Physics Analysis Lab (HSE-1) for analysis of gross alpha and gross beta/gamma activity. Respiratory protection would be required (full-face respirators) whenever high soil activity was encountered; this condition was not encountered on the project. Respirators were fitted to each worker by the Industrial Hygiene Group (HSE-5).

Nasal smears were taken following dusty operations and checked for beta/gamma activity. None of the smears approached the action level of 5000 dpm beta/gamma at which an occurrence report would be required.

B. Safety Methods.

No lost time accidents occurred in the project. Special safety features of the project are discussed below.

1. Excavating Safety. Most of the excavating in the project could be accomplished with adequate slope on the excavation to preclude cave-in. The possibility of cave-in in deeper excavations would require issue of special work permits and the following safety practices to allow personnel entry:

- shoring rules were followed in accordance with OSHA regulations (OSHA 1979);
- approved shoring or trench wall sloping methods were applied whenever personnel access to trenches deeper than 5 ft was needed.

2. Industrial Hygiene. One occasion required personnel entry into a confined space (TA-2-32). The Zia Safety Office provided monitoring for safely breathable atmosphere.

Hazardous materials were encountered once in the removal operation. The unexplained presence of a small amount of mercury required cleanup under controlled conditions.

3. Traffic Control and Public Access. TA-2 is a controlled area on DOE-owned land. Access control to the work site was provided by normal security procedures.

C. Administrative Procedures.

Prior to excavation and removal, a series of steps was followed to insure that all involved parties had provided needed input. Administrative procedures were followed to:

- prepare a project plan and obtain concurrence within the DOE LAAO - Laboratory - Zia (later Pan Am) organizations;
- obtain authorization from DOE through DOE-AL to remove the lines and structures included in the project;
- initiate work orders as needed to inform and obtain approvals from operating groups affected by the project and coordinate efforts of the participating groups (HSE-1, HSE-7, HSE-8, ENG-1, INC-5, and the Zia Company [later Pan Am]);
- schedule personnel and equipment;
- provide preliminary surveys and research to avoid interference with existing utilities or operations to the greatest extent possible;

- provide complete documentation of operations such as manpower use, items removed, location of left items, waste volumes, and the like;

- reach informed, supportable ALARA decisions;

- provide complete documentation at the end of project, particularly as-left conditions and updating data in the DOE Real Property Inventory System.

The key administrative procedural items are summarized as follows:

- Safety policies, guidelines, and instructions in the Los Alamos Health and Safety Manual were applied to all the activities. These govern health physics monitoring, industrial safety, and environmental monitoring matters.

- Authorization to perform removal operations was obtained in advance through DOE, Laboratory, and Zia Company (later Pan Am) channels.

- The removal operations were conducted in a manner consistent with the ALARA principle viewed from the aspect of the worker and the environment (left items or soil contamination).

- Preliminary work was expended to avoid disruption of normal Laboratory operations or possible hazard to workers.

IV. ENVIRONMENTAL PROVISIONS

A. Preliminary Survey.

The long history of operation of the Water Boiler Reactor left the possibility of contamination spread at TA-2. Its proximity to a stream that eventually runs offsite approximately 6.4 km

away makes any environmental contamination at TA-2 of particular interest. A preliminary survey was conducted by the Laboratory's Environmental Surveillance Group (HSE-8) in an area from TA-2-1, the reactor building, along the path of the gaseous effluent line to TA-2-48, then southward across the stream, and upslope toward the exhaust stack on the mesa top. The preliminary survey was made by soil sampling at 20-ft intervals (grid) on June 28, 1985. Beta/gamma activity no higher than 66 pCi/g was detected east of TA-2-1. As discussed in Section V.B., this preliminary survey did not include the area east of TA-2-48 found later to be more highly contaminated.

B. Operational Survey.

Operational surveys were provided by HSE-8 on an as-needed basis to allow decontaminated areas to be backfilled at intermediate points in the operation. HSE-8 also provided extensive instrumental field surveys in areas near the stream where the possibility of contamination spread was particularly acute. These surveys were conducted using an HM-3 scintillation detector to locate hotspots. Cleanup of the hotspots was verified by soil sampling as discussed in Section II.A.3.

C. Final Survey.

A final survey of the TA-2 area was conducted by instrumental surveying and soil sampling. The results of the final survey are included in Section V.B.

D. Long-Term Surveillance.

HSE-8 will continue to provide long-term environmental surveillance in the form of water sampling (both surface water samples from the stream and well samples from Well No. LA-0-2) and soil and sediment sampling (Station LA-0-1, 100 m downstream of TA-2). These sampling locations are shown in Los Alamos Environmental Surveillance Report for 1985, LA-10721-ENV pages 160 and 170. The 1985 report shows ^{137}Cs levels in water at LA-0-1 to be $47 \pm 48 \times 10^{-9}$ μCi/mℓ on 4/9/85 and $-12 \pm 36 \times 10^{-9}$ μCi/mℓ on 9/19/85

and ^{137}Cs levels to be 0.16 $\pm$ 0.08 pCi/g in soil and sediment at LA-0-1. Any significant increase in these quantities will prompt a review of conditions at TA-2.

V. RESULTS OF OPERATIONS

A. Structure and Line Removal.

Brief descriptions of each structure and line removed are contained in Section I. The following sections provide a brief description of the removal operation and its results.

1. TA-2-19, The Valve House. TA-2-19 was removed by jackhammering and cutting rebar with a gas torch as it was exposed. Personnel wore dust respirators, ear plugs, and pocket dosimeters for this operation. The structure was wetted to reduce dust. Figure 5 A, B, and C show TA-2-19 at several stages of removal. Line 119 was removed from under the floor; it showed a contact reading of 35 mR/hr. No soil contamination was detected under the floor.

2. TA-2-62, A Holding Tank. Water found in this tank was sampled and found to be uncontaminated. It was drained and removed as a unit. Soil samples taken under the tank were low but positive (63 pCi/g). This soil was removed to establish de minimus surface levels (less than 25 pCi/g).

3. TA-2-32, An Underground Chamber. TA-2-32 was treated as a confined space where atmosphere testing and additional ventilation were provided. Decommissioning operations included jackhammering, cutting rebar, and wall removal in large sections by machine as shown in Figure 6 A, B, C, and D. Removal required a large excavation and backfilling. No radioactivity was detected in the soil under the structure. Soil wetting aided the compaction of the backfill.

4. TA-2-35, A Drainage Basin. Removal of this drainage basin (manhole) was accomplished as one piece. Soil sampling showed no activity under the structure.

Fig. 5 A.

Fig. 5 B.

Fig. 5 C.

Fig. 5. Three views of TA-2-19, the Valve House being demolished.

Fig. 6 A. Ventilation supplied during equipment removal.

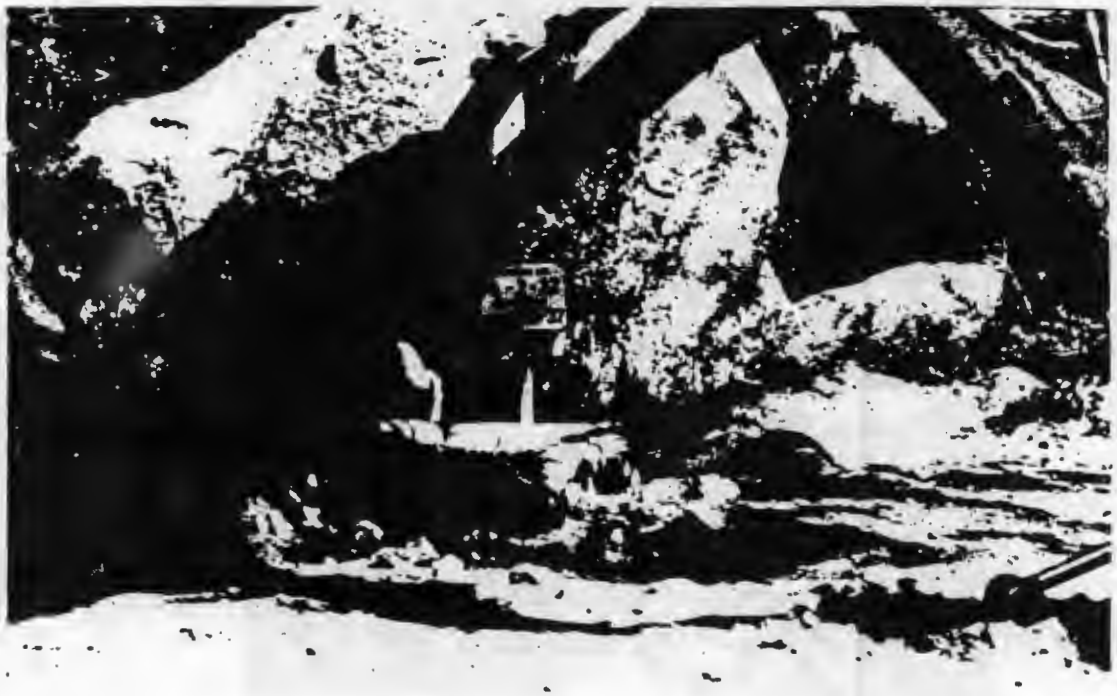

Fig. 6 B. Excavation by backhoe to expose the structure.

Fig. 6. Decommissioning operations at TA-2-32, an underground chamber.

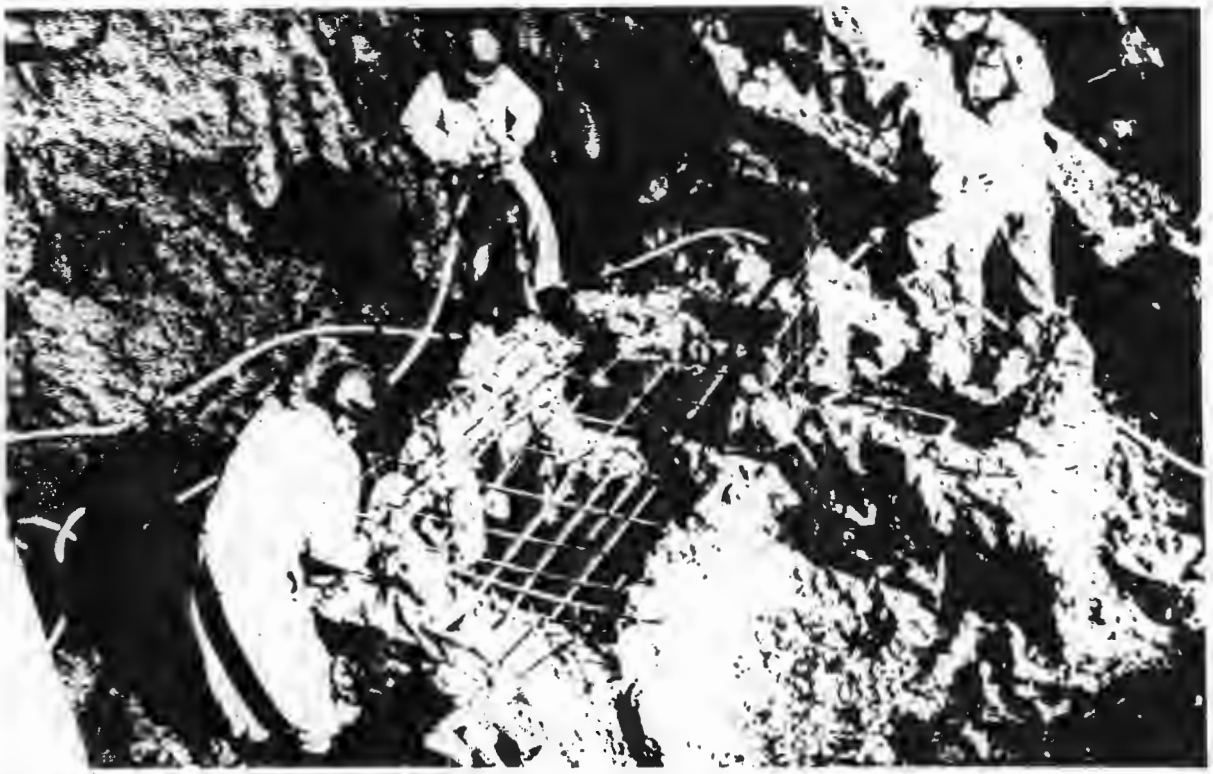

Fig. 6 C. Reducing the structure by jackhammering.

Fig. 6 D. Removing floor sections by backhoe.

5. TA-2-43, A Septic Tank. Samples of the water overflowing this septic tank and a sludge sample from its bottom showed no detectable activity (alpha or beta/gamma). The source of the water was verified by dye tracer to be infiltrating spring water being pumped from the basement of TA-2-1. Dye tracer in an unmarked sink in the reactor room did not come to TA-2-43. A 6-in. clay pipe from the TA-2-1 basement was rerouted by teeing off a 6-in. white PVC pipe from a location near TA-2-43 directly to the stream a few feet downstream of the concrete debris catcher (TA-2-39) (see Figure 7). HSE-8 reviewed the environmental implications of this previously unknown discharge and issued an NPDES* permit to document its existence.

Removal of TA-2-43 is shown in Figure 8 A and B. Its dimensions were 13 x 8 x 6 ft with walls 6 in. thick. This structure was also jackhammered into smaller pieces to permit removal.

An unnumbered 6-in. clay line drained the septic tank overflow to the stream. This line was removed from depths of 3-8 ft where it angled across the area east of the septic tank. This same area was worked extensively later to remove spots of contamination detected on the surface. This activity was not detected at the time the clay line was removed.

6. Effluent Line and Delay Tanks.

Line 117. Approximately 230 ft of Line 117 was removed between TA-2-1 and TA-2-19 at a depth of 6-7 ft. None of the soil samples from the trench showed activity concentrations above de minimus levels. Concrete shield blocks and lead plates had been used to shield Line 117 over its length to 30 ft east of TA-2-1. A large rock above the line required that a 20-ft section be removed using a pipe pulling device.

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*NPDES is National Pollutant Discharge Elimination System.

Fig. 7. Relocation of plastic pipe carrying infiltrating water from the TA-2-1 basement.

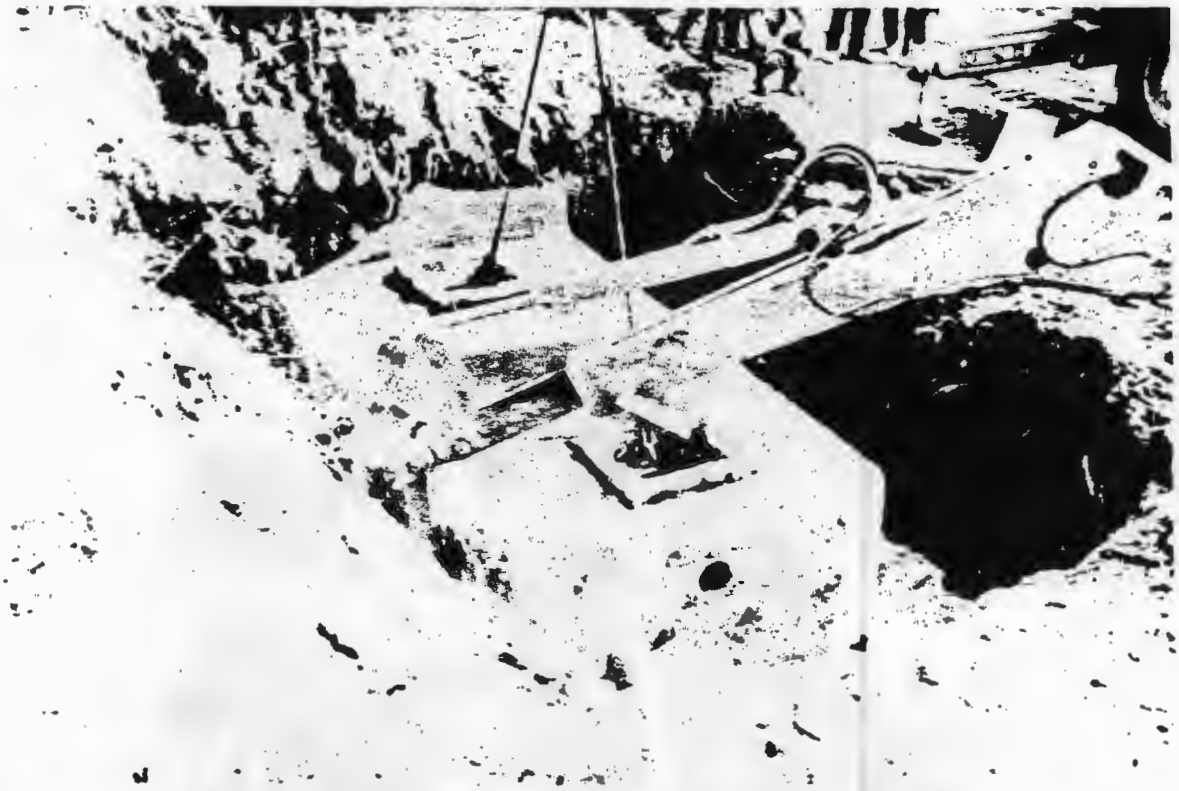

Fig. 8 A.

Fig. 8 B.

Fig. 8. Removal of TA-2-43, a septic tank.

Approximately 40 ft of Line 117 will remain inside TA-2-1 from the east entrance to the pit near the reactor.

Line 118. Removal of this small-diameter line required no excavation. It was pulled from shallow burial without difficulty and sent to TA-54.

Line 119. Approximately 205 ft of the 3-in. stainless steel gaseous effluent line was removed from depths ranging from 2 to 9 ft. Near TA-2-48, its depth was approximately 9 ft, which was deep enough to be in ground water. The excavation was pumped by a small trash pump to allow cutting and pulling the line. Contact readings along this portion of the pipe ranged from 4 to 35 mR/hr. A soil sample showed no activity at that location. This was the same general area near TA-2-48 where sampling later showed ^{137}Cs activity up to 1.2 nCi/g, indicating that extensive contamination existed at the time of this work. It may have been either preexisting or spread by the pipe-pulling operation. Removal of this contaminated soil is discussed further under TA-2-48 removal.

Item 131, Delay Tanks. The delay tanks were found approximately 4 ft underground. They were not a large radiation source (8 mR/h at contact, maximum). Their connection to the Omega West vent line was plugged by threaded cap. Soil sampling under the tanks showed no radioactivity.

7. TA-2-48, A Condensing Trap. This condensing trap/manhole structure was worked on in two periods. The first, in October 1985, accomplished removal of the manhole which was believed at the time to be the superstructure of a rather large (24-in.-diam x 12-ft-long) condensing trap (see Los Alamos drawing ENG-C-1718). The manhole was a concrete structure 5 x 5 x 7 ft with 8-in. walls and steel cover doors (see Figure 9 A and B). No activity was detected inside the

Fig. 9 A.

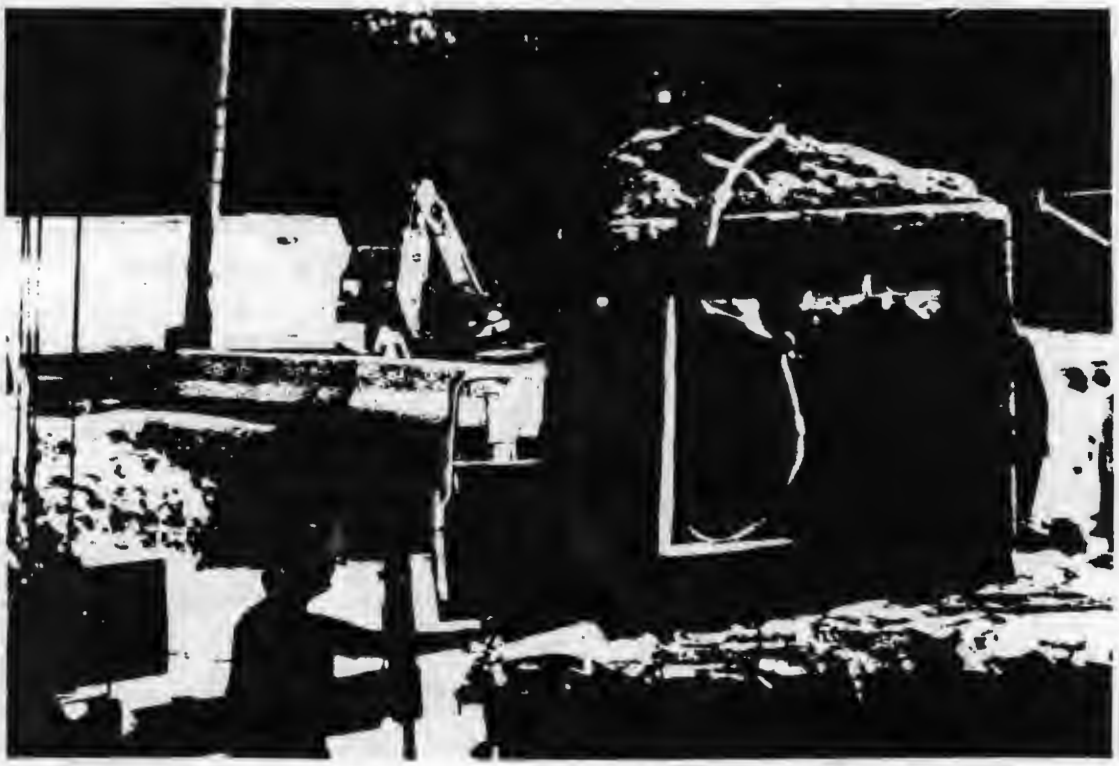

Fig. 9 B.

Fig. 9. Removal of TA-2-48, a condensing trap.

manhole. Approximately 5 ft of 3/4-in. stainless steel pipe was protruding a few feet from the bottom of the manhole. At the time, this was not considered the working portion of the trap. It was learned later that this small diameter pipe was the standpipe by which liquid had been removed from the low point in Line 119. This procedure had been used throughout the latter years of Water Boiler operation.

Components of the condensing trap (TA-2-48) believed to be under the manhole could not be removed due to infiltrating ground water. The stream was approximately 10 ft away. Water from the stream and spring water from the north side rapidly filled any excavation when it reached a level 2-3 ft below stream level. Because the components could not be observed nor grappled for adequately, further operations were postponed until drier conditions. May and June are typically dry months, falling between spring runoff of snow melt and the high frequency of thundershowers in July and August.

Operations resumed June 16, 1986, after no improvement in underground water level was observed at an observation well nearby. Stream flow was also higher than normal for June. A removal plan was devised by which the upper end of the suspected condensing trap would be exposed and infiltrating water would be pumped away by a large-capacity (10,000 gal./min rated) trash pump. This would allow examination of the trap and a determination could be made of its ability to retain any radioactivity left in it. However, unexpected cesium contamination up to 1200 pCi/g was detected in spots of contamination on the surface before operations started. This prompted an alternative plan by which a secondary pit was dug on the south side of the stream to receive potentially contaminated water pumped from the primary pit at the TA-2-48 location. Cesium-137 was identified as the only significant radionuclide present. HSE-1 and HSE-8 representatives agreed that water from the primary pit would not be

discharged directly to the creek. Water would not be discharged from the secondary pit unless sampling showed it to be under 40 nCi/L, which would not exceed the 3 nCi/L limit for offsite discharge once stream dilution was taken into account. (Discharge from the secondary pit was not needed.) Water activity in the primary pit, which showed rapid water infiltration from all sides once its depth was 2-3 ft below stream level, ranged from 10-30 nCi/L during digging but decreased to 1-2 nCi/L after time was allowed for sedimentation. This confirmed earlier environmental reports that ^{137}Cs activity would be associated with sediment in the alkaline soils of Los Alamos Canyon. The sediment was readily filtered out by percolation to soil from the secondary pit. The secondary pit was then decontaminated later by removing a few inches of soil from its sides and floor.

June 17 to June 26, 1986, was a period of unusually heavy rainfall (June total was a record 5.67 in.). The first heavy rain following resumption of operations prompted rerouting the stream approximately 6 ft further away from the TA-2-48 location. This involved constructing a temporary dike (see Figure 10 A) to prevent erosion by the stream into the contaminated area. Several heavier rains followed. Stream erosion into the TA-2-48 area was controlled through the period.

Excavation of the primary pit was approached very carefully to avoid breaking into the suspected condensing trap until its containment capability and its activity content were better known. Not until the primary pit had been pumped down by the large trash pump was it learned that only the base plate connected to a 2-ft section of the 24-in.-diameter condensing trap remained (see Figure 10 B). The top 10 ft of its length had been cut away by cutting torch and the base left in place for unexplained reasons. The base contained activity, as indicated by a 50 mR/hr contact reading. Also

found in the primary pit was a length of 3-in. stainless steel tubing attached to a large piece of concrete (see Figure 10 C). This tubing was approximately 10 ft long with a reducer (3-in. to 1-in. diameter) on one end and an elbow near the other end. These features resemble the connecting line between the gaseous effluent line and the condensing trap shown on a 1948 drawing (see ENG-C-1718). The large area excavated and the pieces removed give reasonable assurance that all components of the two condensing traps have now been removed.

The source of the ^{137}Cs contamination was considered. It was found in unexpected places where it should have been discovered in earlier operations. The only explanation presently available is that the contamination was in spots spread over a large area. Soil sampling locations on a 20-ft grid for the initial survey obviously missed the more active spots. Although the 0.663 MeV photon of ^{137}Cs is easy to detect with portable GM instruments, the spotty activity might be detected only by diligent surveying.

The gaseous effluent line and the base of the original condensing trap were obvious sources of contamination. Contamination from any pipe below ground water level could have been spread in the one or two locations where the pipe snapped as it was physically pulled from the ground. Contamination from the base was relatively free to be washed out, although a sediment sample taken from the pit after its removal was not excessive (420 pCi/g). No spots in the TA-2-48 area were found measuring above 1200 pCi/g. A possible source of surface contamination which is suspected but not verified is that excess condensate was disposed of on the ground (improperly by today's standards but perhaps not considered so in the late 1940s). This would explain the rather high, spotty nature of the contamination which over the years

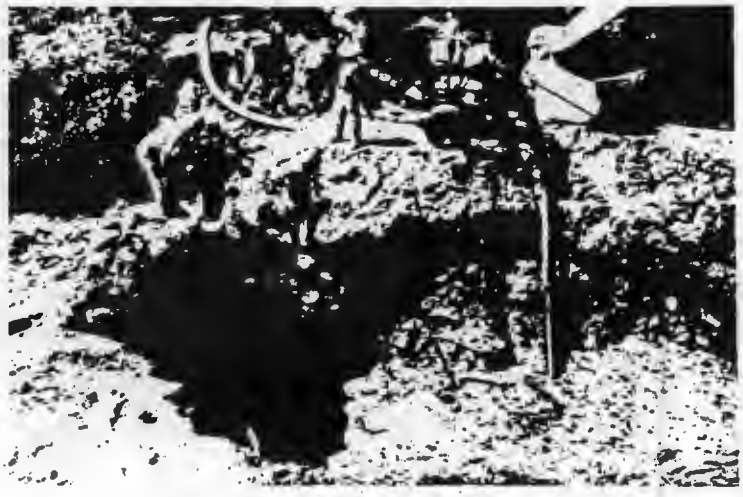

Fig. 10 A.

Fig. 10 B.

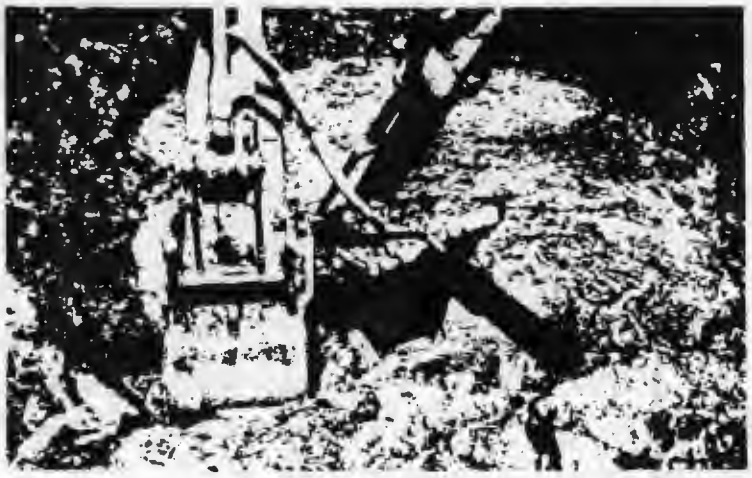

Fig. 10 C.

Fig. 10. Views of operations during component removal at TA-2-48, the condensing trap. Top view shows the trash pump resting on the dike separating the primary pit and the stream; other views show components removed from the primary pit.

has not moved very much, considering low sediment concentrations (< 10 pCi/g) in the stream bed 100-200 feet downstream.

Final radioactivity concentration in the soil at the TA-2-48 location was 1000 pCi/g left at a depth greater than 5 ft (much of the area was left under 7 ft of clean fill). Figure 11 shows the general location of the highest concentration left subsurface at the TA-2-48 location. A few locations in the surface layer (within 5 ft of the surface) were known to be slightly above the de minimus level but were within the concentration guide of 75 pCi/g. Stabilization of the stream bank by a line of riprap (boulders and smaller rock) and reseeding with western wheat grass was accomplished to prevent erosion into the area.

ALARA Decision. Economic reasons made it unlikely that all contaminated soil could be removed to de minimus level in the TA-2-48 area. Additional funding of $40-50K would be needed to finish the TA-2-48 location alone. Representatives of HSE-1, HSE-8, ENG-1, and Zia (now Pan Am) participated in a closure decision which was considered to meet ALARA policy, thereby providing reasonable assurance that the health and safety of employees and the public would be protected over the long term. As recorded by ALARA memorandum (Elder to Distribution, HSE-1-JE-20, June 5, 1985), the following steps were taken to reach closure of the area and prevent erosion into subsurface soil which contains radioactivity (1000 pCi/g is considered representative of maximum subsurface concentration in this area).

a. The TA-2-48 area (then at about stream level) was worked with soil removal equipment until no hotspots were found or until the ground water level was reached. Soil in the area immediately above the primary pit was removed down to water level.

b. The stream channel was straightened opposite the primary pit and its north bank was stabilized with riprap (large boulders and smaller rock).

c. HSE-8 performed a radiological survey of the area before backfilling.

d. The TA-2-48 area north of the stream was covered with at least 5 ft of clean crushed tuff, which has superior erosion resistance to ordinary soil. Contouring and reseeding were carried out as HSE-8 recommended.

e. HSE-8 would continue long-term monitoring of Los Alamos Canyon water and sediments to assure the adequacy of the project, as described in Section IV.D. above.

B. Other Contaminated Areas at TA-2.

Figure 11 shows locations where surface activity was detected and a cleanup effort was initiated. Additional funding ($36K from SFMP and $4K of local funding) was applied to these areas. Major contamination was found in the North-East area. The period July 10 to September 26, 1986, was spent resolving the contamination problems in these areas.

1. North-East Area. The North-East area was initially known to contain numerous spots of beta/gamma emitting surface contamination which ranged from 100 pCi/g to 5 nCi/g. One spot almost in the stream was measured by Ludlum Model 3 end-window GM detector at 15000 cpm (approximately 4 mR/hr) with the source being an undetermined distance below the surface. This spot was (perhaps coincidentally) very near the outfall for the TA-2-43 septic tank overflow pipe. The decontamination operations were conducted in a manner that would avoid spreading contaminated soil into the stream. In general, this approach was to draw soil away from the stream; where activity was below ground water level, the stream would be

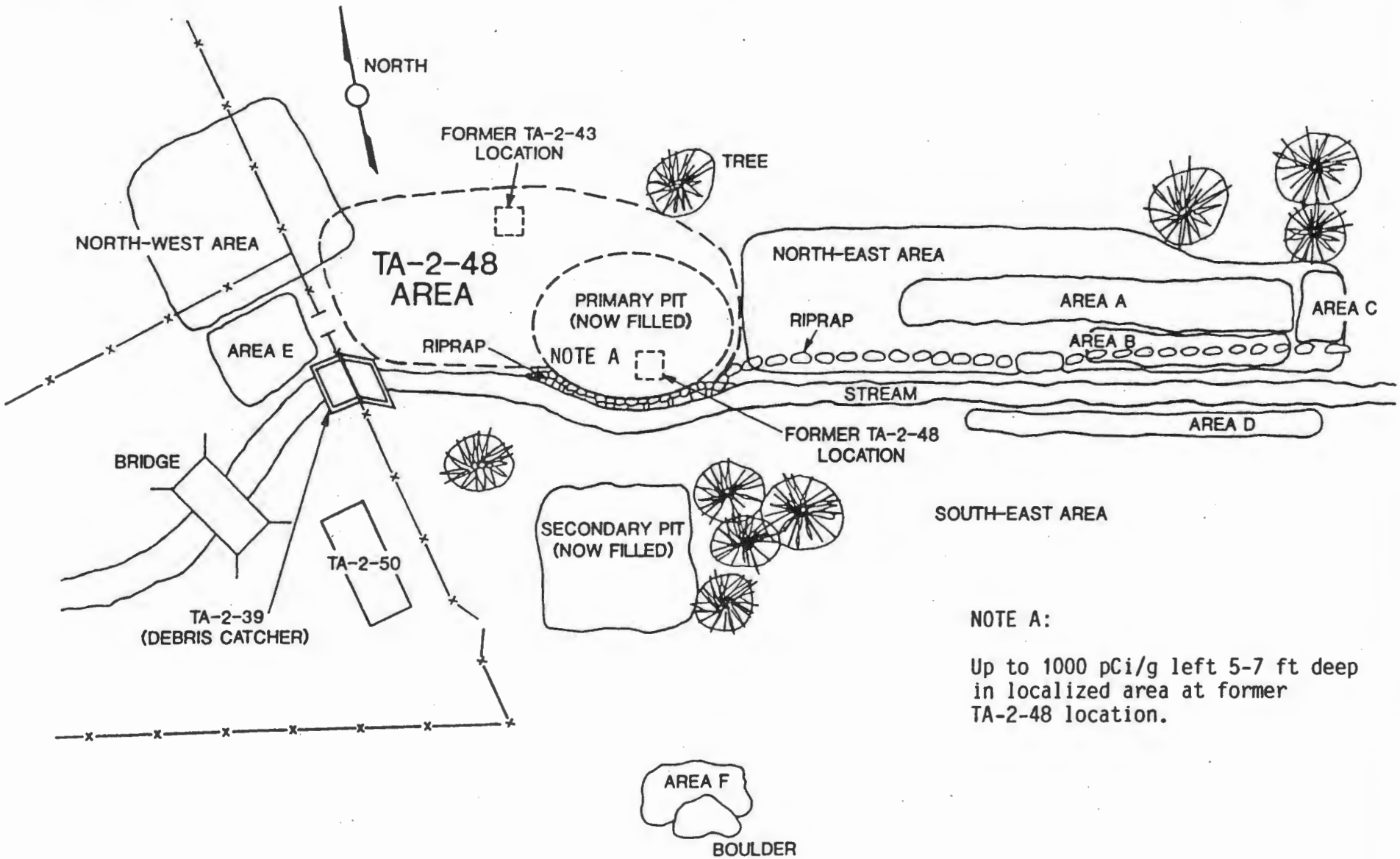

Fig. 11. Areas where surface radioactive contamination was removed.

diked with clean soil and contaminated wet soil would be placed in a secondary location to dry or to be mixed with dry soil as necessary to allow transport without dripping to TA-54.

The John Deere backhoe and the Liebherr excavator were used to remove a large pine tree and several smaller trees and undergrowth. Several large boulders were removed due to contamination which could not be removed without scabbling.

Three major areas of interest were encountered in the North-East area which required leaving some contamination near or slightly above de minimus levels (25 pCi/g surface and 75 pCi/g subsurface). These areas, designated A, B, and C, are shown in Figure 11 and discussed below.

AREA A. Two contaminated lengths of 6-in.-diameter VCP (34-ft and 20-ft sections separated by a gap) were uncovered approximately 24 in. below the route of the TA-2-43 septic tank drain pipe removed in October 1985. The arrangement of rock and sand around these pipes and uniform soil contamination in the area suggests that a leach field existed at some time in Water Boiler Reactor operation. A chemical waste treatment shack east of the reactor building was recalled by a veteran operator as a possible source of material disposed of in the leach field. The contamination found in the pipe sections and adjacent soil was a mixture of alpha and beta/gamma emitters, the alpha emitter primarily being ^{235}U fuel. Cross trenching along the probable path indicated that the sections found were probably the only sections left after earlier removal operations. Initial activity at this location was 2-4 nCi/g detected in a spotty array over an area 83 ft x 22 ft. At its nearest point, the stream was about 10 ft away from this area. After removal of soil down to ground water level, the remaining concentration of beta/gamma emitters was measured to be 53-67 pCi/g with no alpha emitter

remaining. These samples were taken 6-8 ft below the original grade. The area was backfilled with clean tuff after consultation with HSE-8. The activity left in Area A is discussed below under ALARA Decisions.

AREA B. This area was nearest the stream and contained the 4 mR/hr hotspot described earlier. Soil samples of 3 nCi/g beta/gamma were taken from this area after excavation to ground water level. Greater effort was expended by excavating 2-3 ft deeper and collecting the mud and water in a secondary pit at Area C. This soil was allowed to dry 24 hr, then was mixed with dry soil as needed to allow transport to TA-54 without dripping. The highest soil samples after this operation were taken at the location of the 4 mR/hr hotspot; these showed improvement to 74 pCi/g beta/gamma and 68 pCi/g alpha. The area was backfilled after consultation with HSE-8. The activity left in Area B is discussed below under ALARA Decisions.

AREA C. This area at the far east end of the contaminated area was cleaned up last after it had served as a secondary pit for wet soil from Area B. Soil removal to ground water reduced final soil samples to 40 and 87 pCi/g beta/gamma. The area was backfilled with clean tuff after consultation with HSE-8. The activity left in Area C is discussed below under ALARA Decisions.

2. South-East Area. This area was across the stream from Area B. Activity near the stream was positive but generally low. A portion of the stream bank on that side was taken out as part of a stream-widening operation. Final soil samples in Area D were less than 50 pCi/g beta/gamma, which will remain as a surface concentration.

Two local hotspots further from the stream were removed in September 1986 to complete the project. The first spot (designated Area F on Figure 11) was approximately 15 m east and 10 m south of the fence corner behind TA-2-50; the second, 130 m east of the fence corner. This latter location was decontaminated by removal of a length of tubing. Area F was excavated to 6 ft deep across the downhill face of a large boulder; this reduced soil concentration to below 25 pCi/g. During this operation, surveying uphill from the boulder detected other surface contamination, the highest being 273 pCi/g. Removal of this soil could not be undertaken at that time due to lack of funds. The location was logged for possible future decontamination.

3. North-West Area. The North-West area included a fenced area north of the original TA-2-19 location and an area used for truck staging near the bridge. The area along Lines 117 and 119 was cleaned to de minimus levels as described earlier. The area north of the TA-2-19 location was rechecked during June-August 1986 operations and found to have several contaminated items, the most notable being 30 ft of 1-in. stainless steel pipe routed along the north-south fence. Its source and destination are unknown. Local minor contamination remains in this area but was not addressed further because it was inside the TA-2 security fence.

The area which served as a truck staging area during decontamination operations showed minor positive activity (30 pCi/g average) before a final 6-in. layer of topsoil was applied.

ALARA Decisions. Closure operations in the North-East, South-East, and North-West areas provide reasonable assurance that radioactivity left in the soil is minimal and will not be a further hazard to employees, the public, or the environment. A decision regarding left contamination was recorded in an ALARA

memorandum (Elder to Distribution, HSE-1-JE-37, September 11, 1986). These operations are believed to meet Los Alamos ALARA policy for the following reasons:

- The cost of continuing removal of detectable radioactivity in the area was believed to exceed any additional benefit.

- Radioactivity in the North-East area was reduced to below (or only slightly above in Area C) subsurface de minimus levels (75 pCi/g alpha or beta). This area was backfilled to at least 5-ft depth.

- Radioactivity on the surface in the South-East area was near de minimus level and not deserving of extensive removal of vegetation.

- Radioactivity in the North-West area was near the de minimus level and inside the security fence.

- The stream bank was stabilized by a combination of logs and riprap along the full length of the North-East area. The stream bed was widened and straightened along the full length of this area to reduce the likelihood of washout.

- The closure of the area surface with topsoil and vegetation is expected to stabilize the 5-7 ft of backfill.

- Control over the area will be maintained. The area is outside the TA-2 fence but is approximately 6.4 km inside the boundary of DOE-owned land.

- Long-term environmental monitoring of the stream bed downstream of TA-2 will continue, as described in Section IV.D. above.

Figures 12 A and B show the area east of the reactor building, TA-2-1, at the close of Phase I operations.

Fig. 12. A.

Fig. 12. B.

Fig. 12. Views of the decontaminated area, looking eastward along the stream.

VI. SUMMARY

External structures and underground piping associated with the gaseous effluent (stack) line from the TA-2 Water Boiler Reactor were removed from the area east of the reactor building. The low-level waste volume transported to TA-54 Area G for disposal was 970 m^3 or 162 truck loads. Most of this waste (approximately 120 loads) was contaminated soil. Total cost of the project was $320K.

Three concrete structures were removed by jackhammering into manageable pieces. Three others were removed as units. One structure (TA-2-48) presented a difficult removal problem because several of its components were below ground water. Pumping ground water from the TA-2-48 excavation to a secondary pit with a large trash pump permitted removal of all components. Radioactivity above the de minimus level for subsurface soil (75 pCi/g if deeper than 5 ft) was left at the TA-2-48 location. An ALARA decision memorandum was prepared to document this soil and to describe the efforts taken to stabilize the area. These efforts included removal of soil to the ground water level, placing boulders and rock (riprap) along the stream bank, backfilling with clean soil to at least 5-ft depth, and revegetating the area.

Another area east of the TA-2-48 location was found to be contaminated up to 5 nCi/g with beta/gamma emitters. An alpha emitter was also present in the area, which is suspected of once containing a leach field. Its proximity to the stream required extensive removal of contaminated soil. After decontamination, soil activity exceeded the de minimus level in a few locations, as documented by an ALARA decision memorandum. Efforts to stabilize this area were similar to those for the TA-2-48 location. The stream bed was widened and straightened as a final measure to reduce erosion into areas where soil contamination was left. These measures plus continued long-term environmental surveillance in Los Alamos Canyon are expected to fully control the minor contamination remaining at TA-2.

ACKNOWLEDGEMENTS

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APPENDIX

PROCEDURES FOR ALARA DECISIONS

ALARA policy is applied to decontamination and decommissioning (D & D) activities at the Laboratory by way of

- normal efforts to keep exposure of each D & D worker or any other worker ALARA while performing his job,

- limitations on potential exposure of workers from any radiation source left after D & D activities, and

- limitations on potential exposure of any member of the public from any radiation source left after D & D activities.

Implementation of ALARA activities is directed by HSE-1 (Radiation Protection Group). Oversight or enforcement is provided by HSE-8 (Environmental Surveillance Group) when the project or activity could have a potential impact on the environment or has a human/environment interface.

ALARA activities are not directed by committee at Los Alamos. HSE-1 personnel responsible for monitoring operations involving radiation or radioactive material of a particular site advise the operating group on how best to perform the work in a manner that keeps doses ALARA.

ALARA applications have been common in D & D work at Los Alamos. D & D workers have had very low dose acquisition compared to radiation workers. Our experience shows that routine radiation protection practices (radiation monitoring, dosimetry, and airborne contamination sampling) and the relatively low dose rates encountered in D & D operations to date combine to keep dose levels low. An HSE-1 health physics technician is assigned full time to D & D projects.

ALARA decisions related to D & D work at Los Alamos have dealt primarily with left contaminated items or soil. The general procedure followed to arrive at ALARA decisions for left items is as follows:

1. The HSE-1 representative is informed by the construction engineering representative that an item should be left in place for substantive reasons: it is beneath or encased with major utility lines, it is beneath structures or streets, it is at depths too great to reach by normal means. Extra effort to remove the item would exceed cost/benefit guidance.

2. The HSE-1 representative verifies that the quantity of remaining radioactivity is either low enough or its depth is great enough that the item will not pose a hazard to workers or the public anytime in the future. Entombment or placarding or placement of a monument is considered in cases where intrusion by digging into the area could be hazardous.

3. The HSE-8 representative is informed of the need to leave the item in place. He investigates and concurs or asks for further effort.

4. When concurrence is reached, the HSE-1 representative prepares an ALARA memorandum and includes descriptive material as needed to document the location and activity level of the item.