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ABSTRACT

A report on a comprehensive radiological survey of Building T029, performed in 1988, concluded that no residual radioactive contamination existed on the T029 floor or surrounding area, but recommended decontamination of a contaminated, below-floor-level Ra-226 source well. Accordingly, the source well and other equipment were removed from the facility and follow-up surveys were performed. Results of the two surveys show that all inspection tests were satisfactorily passed and that Building T029 is acceptably free of radioactive contamination.

The surveys demonstrate that the facility meets the requirements of "U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites (February 1985)," and is acceptable for release without radiological restrictions.

ETEC DISPOSITION

DTR. NO. 24909 — DATE 8-28-90

LEVEL OF APPROVAL	APPROVAL AS SUBMITTED	APPROVED W/COMMENT	REVIEW (REPLY TO SUBMITTER)	DISAPPROVED W/COMMENT	RESUBMITTAL REQUIRED	RECORD ON CONFIG. SUMY	RECORD INFORMATION	ACCEPTED AS SUBMITTED
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SUMMARY

PURPOSE. This report documents work performed to remove residual radioactive contamination in certain relatively inaccessible areas of Building T029, located in Rockwell International's Santa Susana Field Laboratories (SSFL), and to demonstrate that the facility is acceptably free of radioactive contamination.

BACKGROUND. Between the late-50's and April 1974, several radioisotope sources (Ra-226, Cs-137, Co-60, PoBe, and PuBe) were stored and utilized in T029 for calibration of radiation detection instruments. In 1964, release of radioactivity from a Ra-226 sealed source caused localized contamination of the below-grade source storage well. Outside of this inaccessible area, radiation surveys performed in 1974 and 1988 showed that radiation levels in T029 correspond to normal background levels at SSFL. All sources had been removed by 1974, and the facility is now being used to store reactive metals (sodium and NaK) prior to disposal.

WORK PERFORMED. To further reduce contamination to levels that are as low as reasonably achievable, the Ra-226 source storage well was excavated along with the Ra-226 source holder and both were disposed of as low-level radioactive waste. At the same time, the housing used for the Co-60 source was also demolished and the resulting uncontaminated debris was disposed of as nonradioactive waste. In addition, the exhaust system outside the building was removed, surveyed and determined to be clean for reuse. Soil samples collected during these operations were analyzed for radioactivity and showed no activity above background. The excavated area was then refilled.

STATUS. Building T029 currently stores nonradioactive hazardous materials (principally metallic sodium and NaK) prior to their planned disposal.

CONCLUSION. Based on results of the comprehensive 1988 radiation survey and the subsequent work described here, radiation and contamination levels in Building T029 do not exceed acceptable limits and hence the facility may be released for unrestricted use.

1. INTRODUCTION

Decontamination and decommissioning (D&D) of a number of formerly used radioactive material facilities is underway at Rockwell International's Santa Susana Field Laboratories (SSFL). During D&D of these facilities, efforts are taken to eliminate or reduce residual radioactive contamination to levels that are as low as reasonably achievable (ALARA). Upon completion of D&D, radiological surveys are performed to demonstrate that no residual radioactivity exceeds applicable limits.

This report documents the radiological D&D of Building T029 at SSFL in 1989 and supplements data obtained from a comprehensive radiation survey of this facility performed in 1988. Together, the 1988 survey data, and information and data presented in this report, demonstrate the current radiological cleanliness of this facility and its status for unrestricted release.

This report is organized as follows: A background discussion of the facility, including its location and operational history, is provided in Section 2. A detailed summary of the formal radiation survey performed in 1988 is provided in Section 3. The D&D efforts and the follow–up radiation survey data are described in Section 4. Conclusions are presented in Section 5. A list of items of record obtained during the D&D and the surveys, which are archived at Rockwell, are appended to this report.

2. BACKGROUND

2.1 FACILITY LOCATION

Building T029 is located within Rockwell International's Santa Susana Field Laboratories (SSFL) in the Simi Hills of southeastern Ventura County, California, adjacent to the Los Angeles County Line and approximately 29 miles northwest of downtown Los Angeles. Location of SSFL relative to Los Angeles and vicinities is shown in Figure 1. An enlarged map of neighboring SSFL communities is shown in Figure 2. Figure 3 shows relevant portions of a 1967 edition of the U.S. Geological Survey's (USGS) topographic map of the Calabasas Quadrangle where SSFL is located, with the author's markup of the location of Building T029. Using USGS terminology, the current USGS location description for Building T029 is: Township T2N; Range R17W; and, Section 30, Calabasas Quadrangle.

Figure 4 is a plot plan of the western portion of SSFL (known as "Area IV") where Building T029 is located. As shown in this figure, access to T029 is by way of 10th Street, which intersects "G" Street just southwest of building T064. An asphalt concrete roadway (10th Street) runs right up to the facility. A portion of the roadway is fenced in as part of the facility. Figure 5 is an old photograph of T029 and the surrounding area, looking south–southwest. Figure 6 shows the entrance gate on 10th Street and the west wall of T029, and Figure 7 shows a close–up view from the south.

2.2 BUILDING CHARACTERISTICS

Constructed in 1959, as an open bay facility, T029 is a Butler–type building with a steel frame, and corrugated metal siding and roofing. The building is 20 ft x 40 ft with a 12–ft eave height. It is a single room with no office, support laboratory, rest room areas or installed air conditioners. The ceilings and walls are insulated with 1–in. thick fiberglass mat. The floors were originally tiled with asphalt tile. The floor is now a bare concrete slab. Ventilation is provided by an exhaust blower, with the facility air exhausting through two HEPA filters. Figure 8 is a plot plan of T029.

2.3 FACILITY OPERATING HISTORY

From 1959 to 1974, Building T029 was used as a facility for calibrating radiation detection instruments. In 1959 and in subsequent years it was called the Radiation Measurements Facility and the Old Calibration Facility, respectively. The plot plan shows

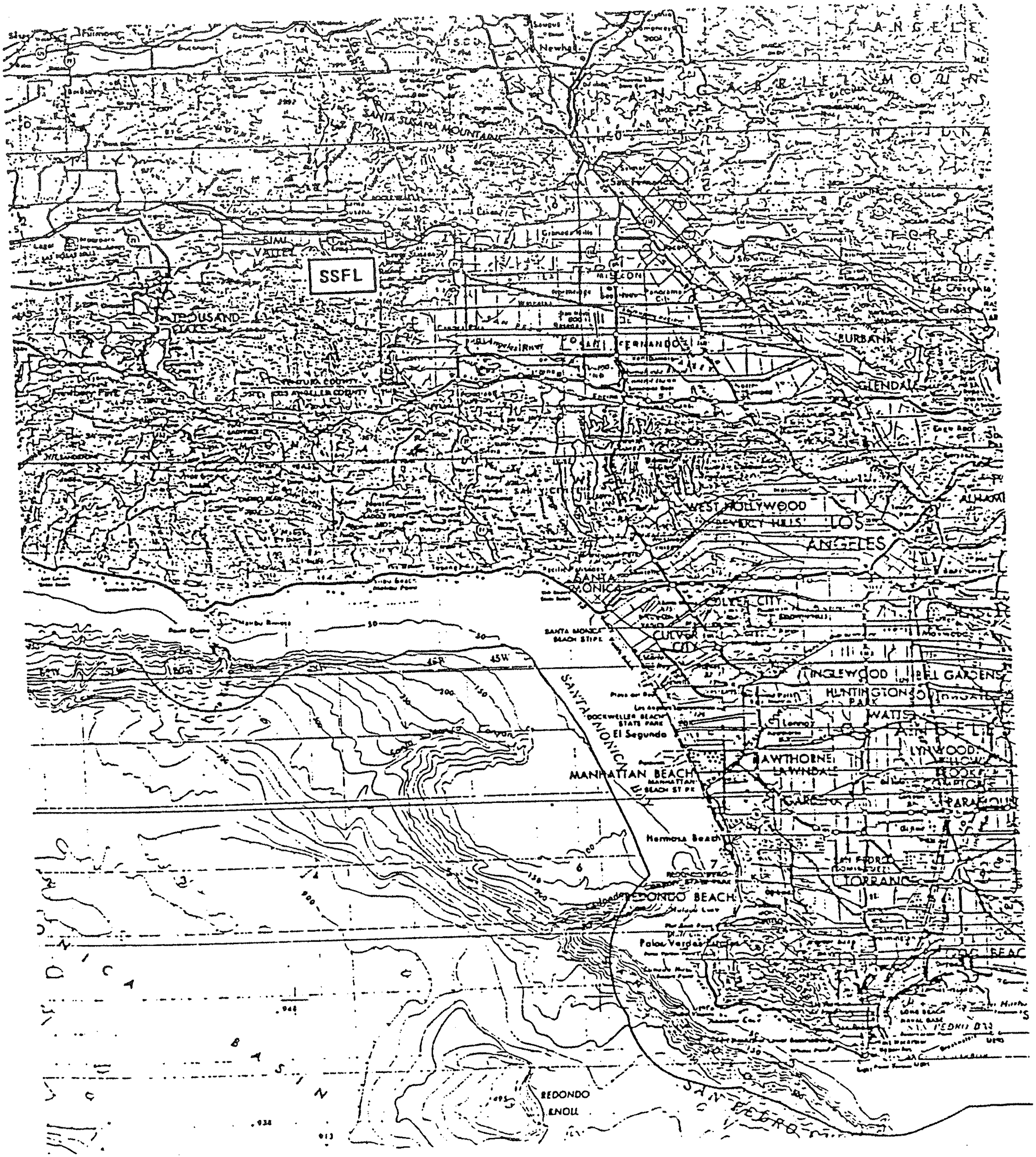

Figure 1. Map of Los Angeles Area

Figure 2. Map of Neighboring SSFL Communities

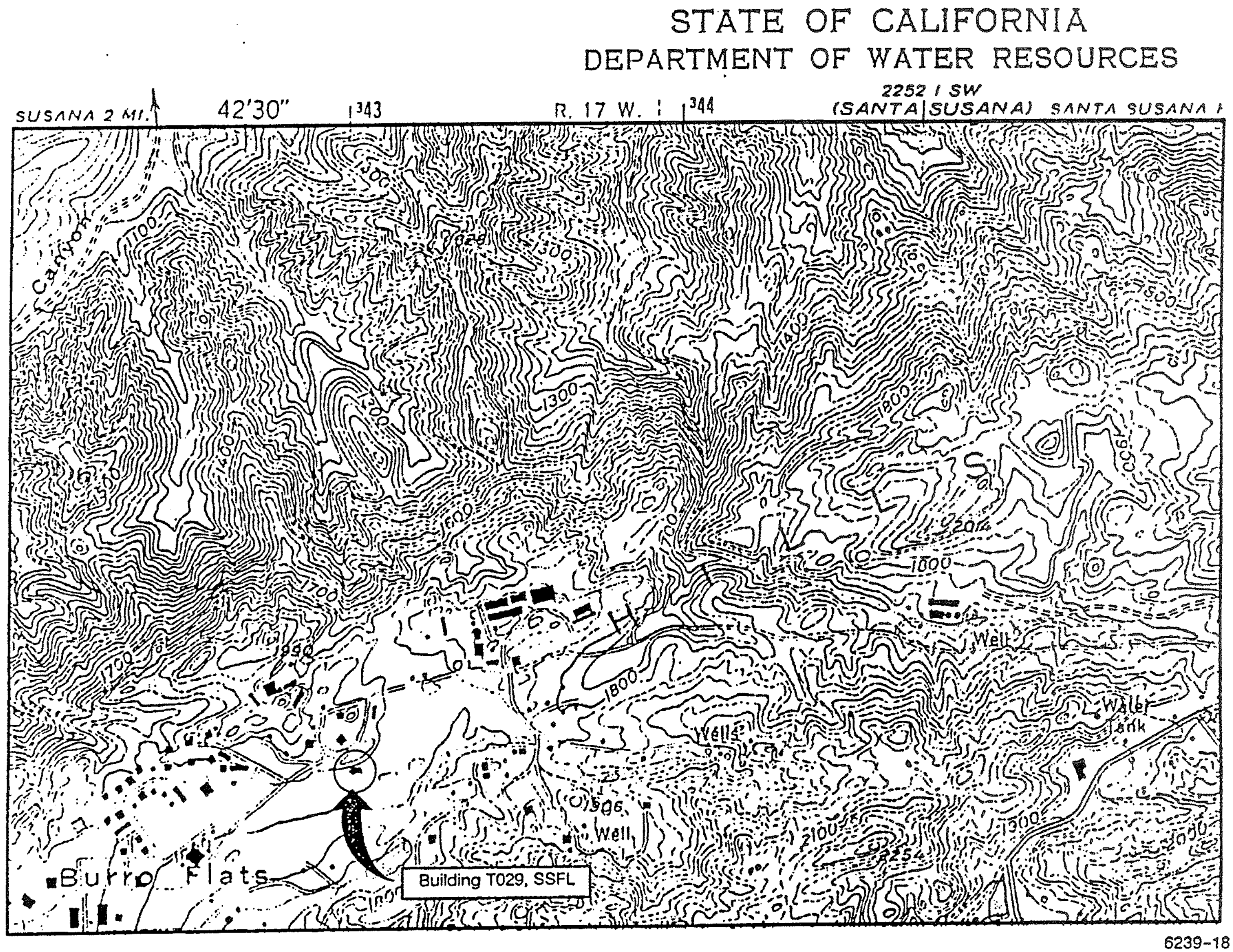

Figure 3. USGS Topographic Map of Portions of Calabasas Quadrangle; Bottom Left Area Corresponds to SSFL

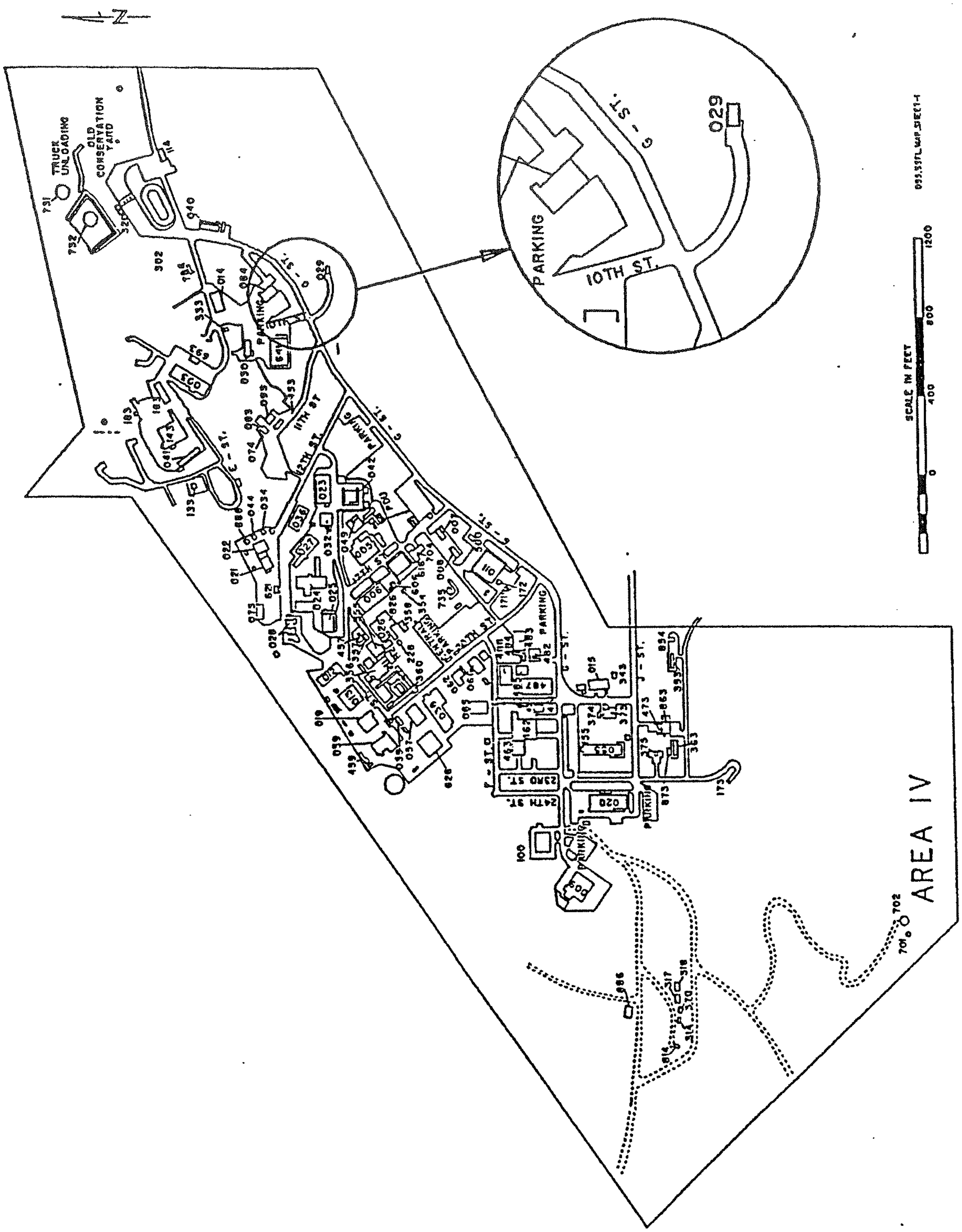

Figure 4. SSFL Layout, Showing the Location of Building T029

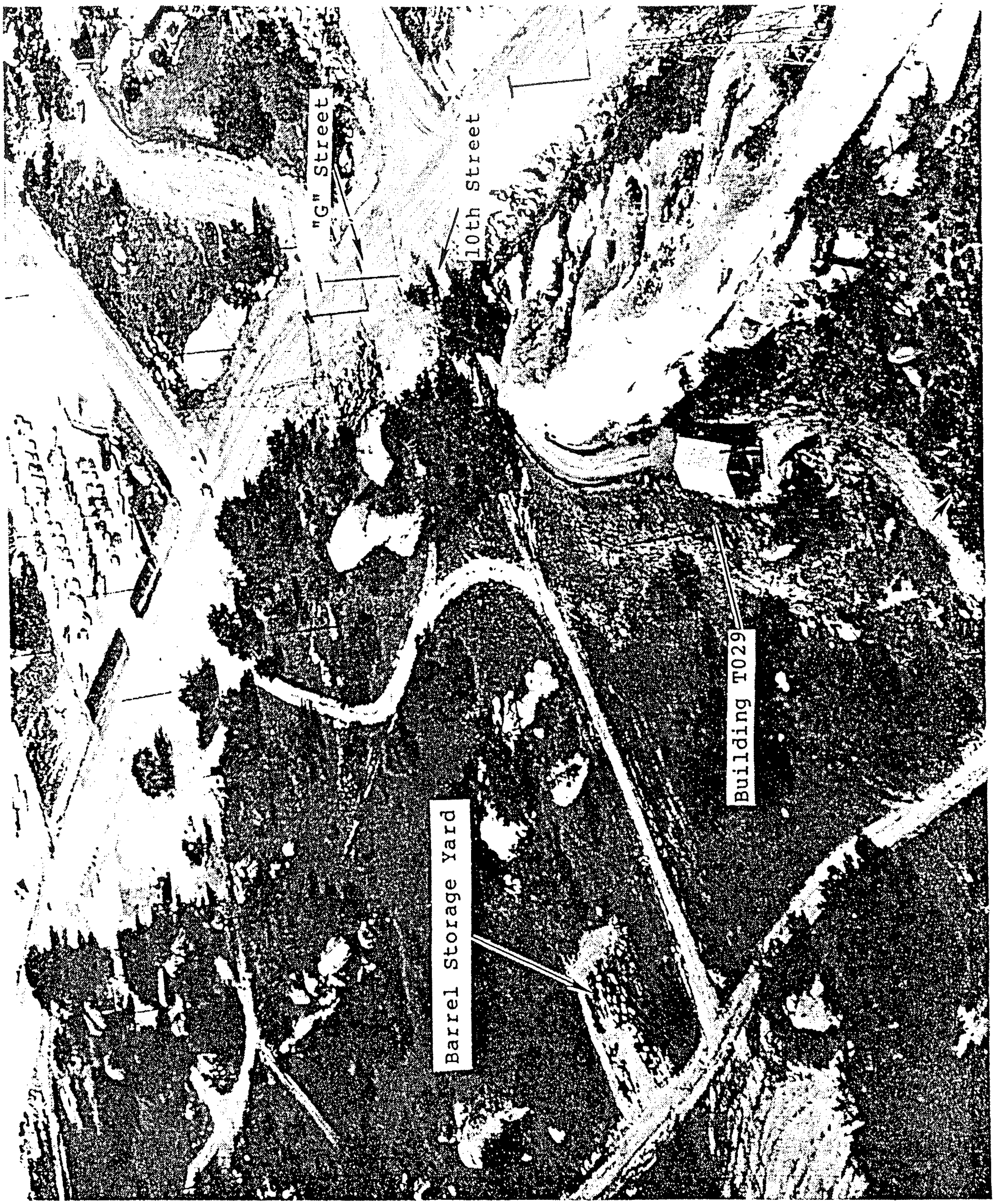

Figure 5. Photograph of T029 Looking South Southwest

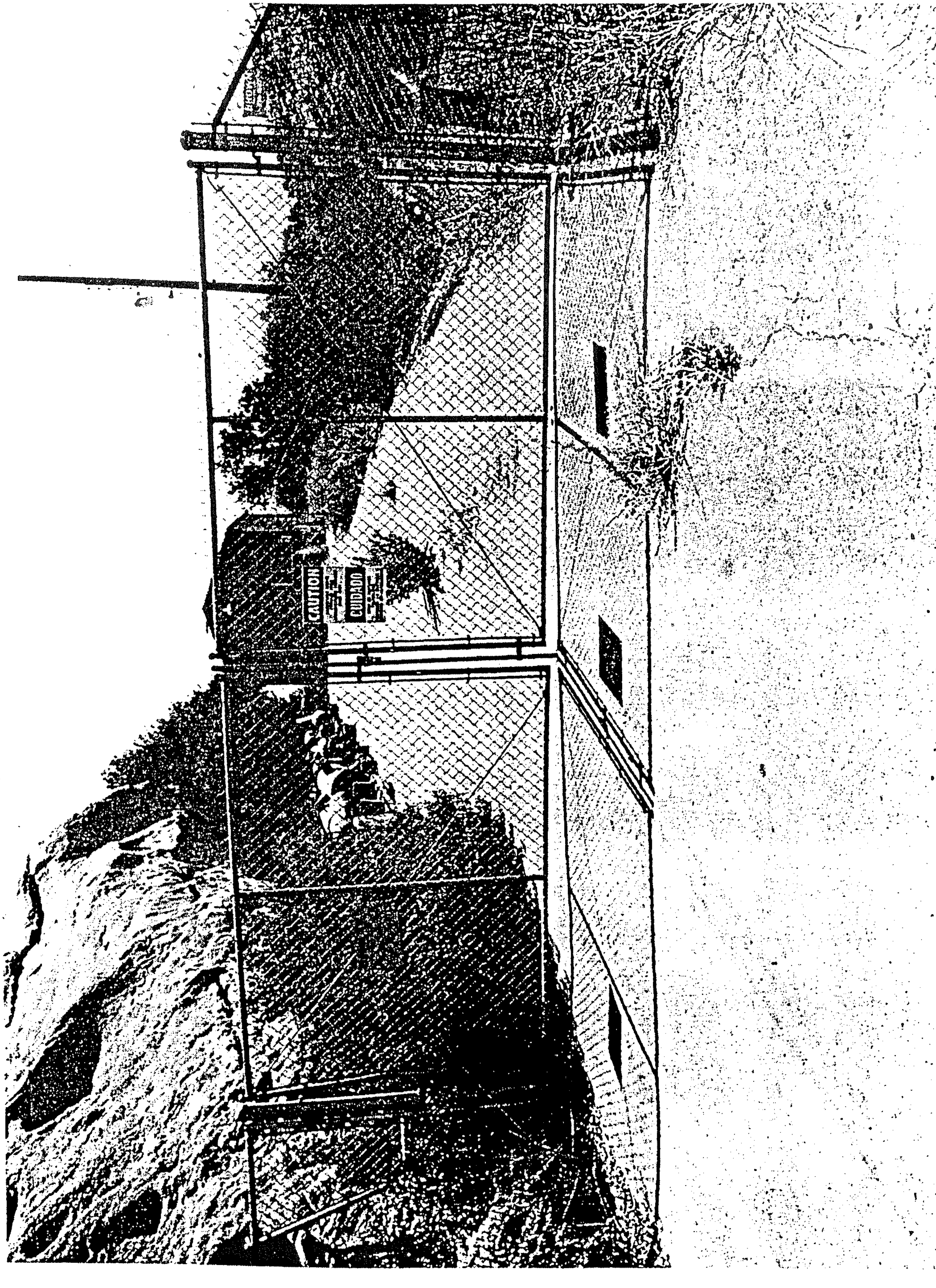

Figure 6. Entrance Gate to Building T029, From the West

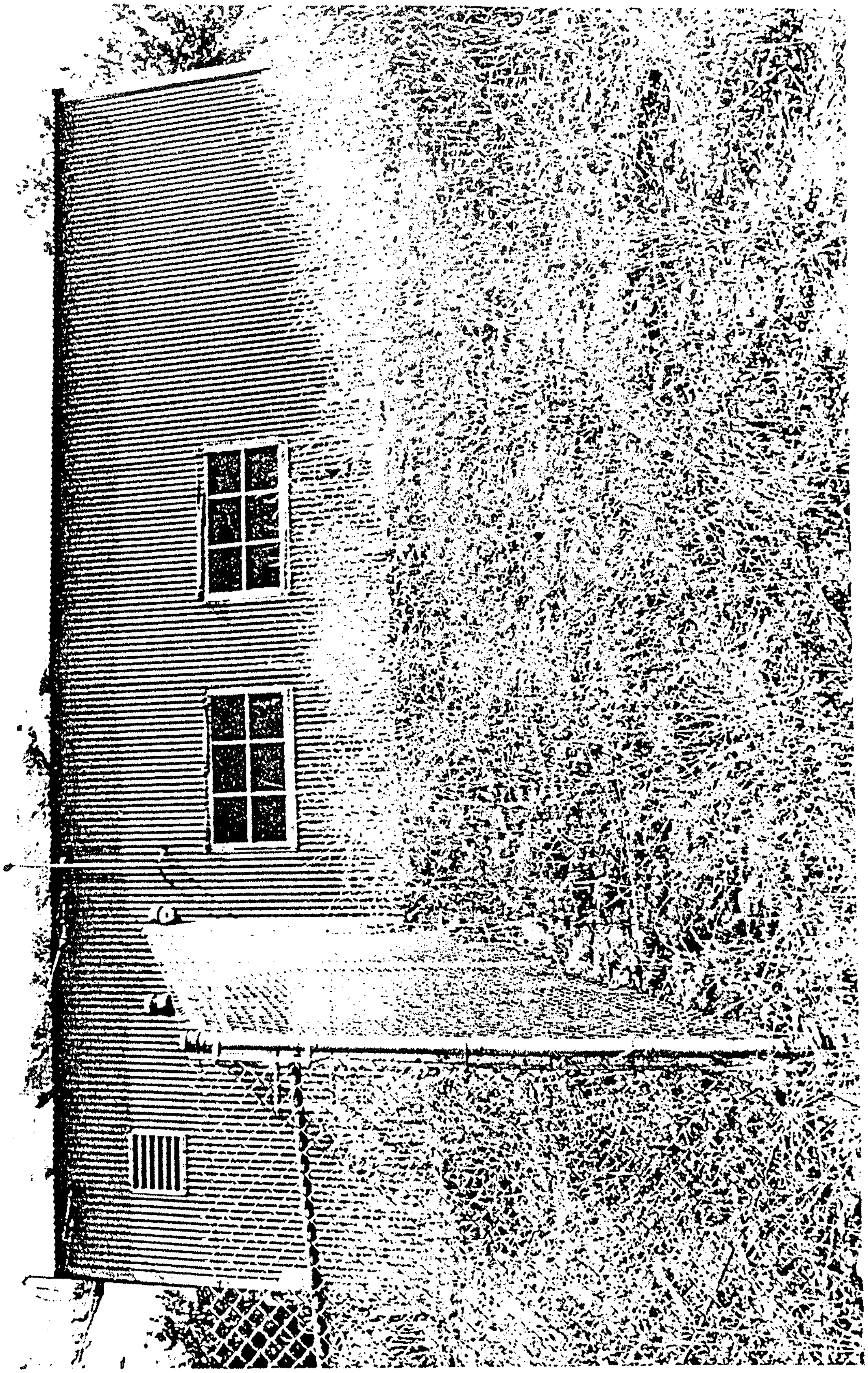

Figure 7. Building T029 View From the South (close-up)

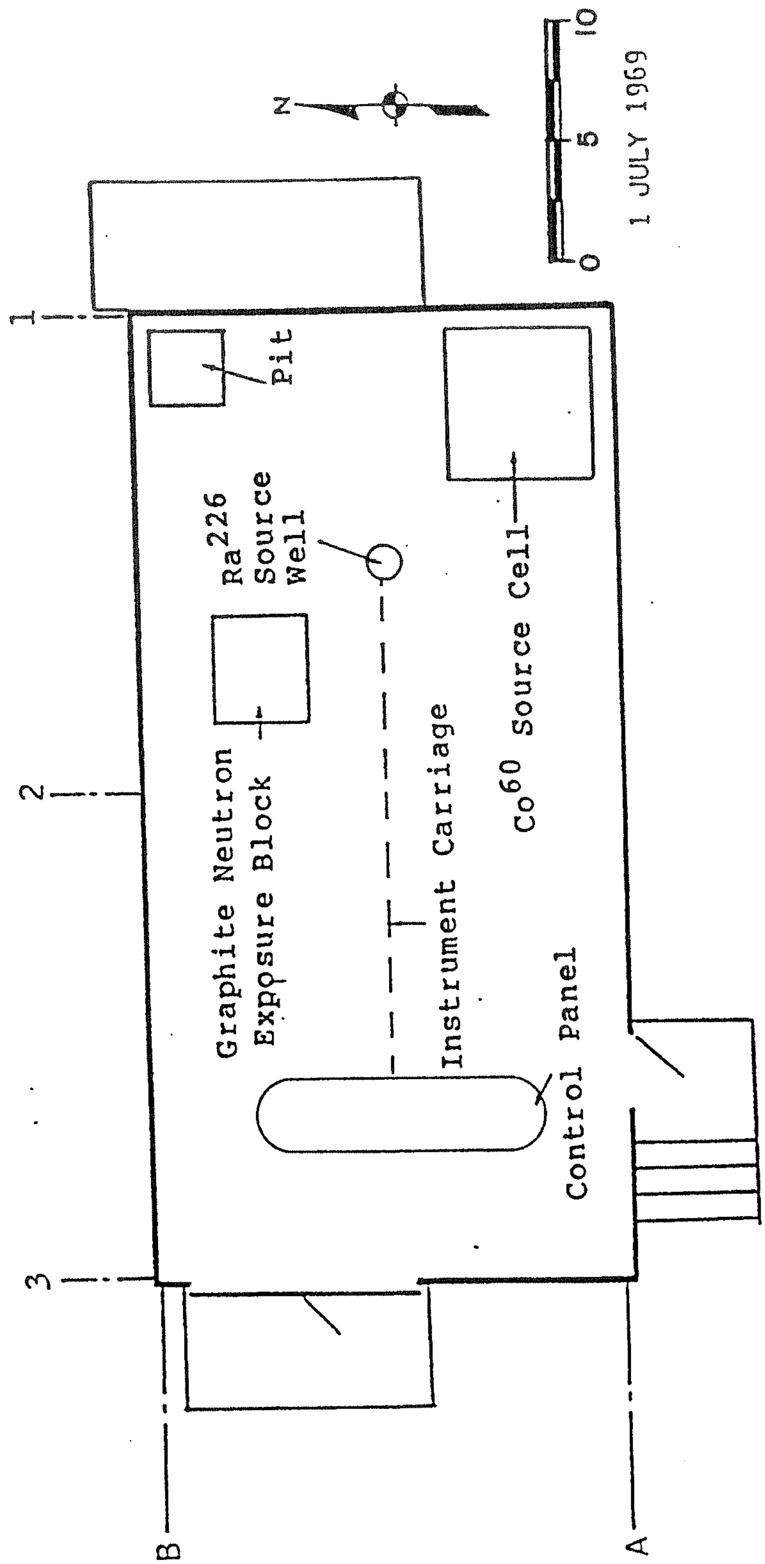

Figure 8. Plot Plan of the Radiation Measurements Facility, Building T029

locations within the building where the calibration sources were housed. Table 1 lists the calibration sources used in the facility, their source strengths and the measurement dates of their strengths. Of these, the three Ra-226, and subsequently the Cs-137 sources were housed inside a source storage well made from a 12-in. diameter, 10 ft long, Schedule-20 galvanized pipe casing which was installed below grade. Figure 9 shows details of the Ra-226 source storage well. The sources were attached to nylon strings and were guided through three 1-in. diameter pyrex tube thimbles within coaxial, Schedule-40 galvanized pipes which were embedded evenly within the casing, with concrete as embedment. The encapsulated Co-60 sources were housed separately in a 12-in. diameter pipe which extended 10 ft below grade and 4 ft above grade. Above grade, the pipe was enclosed with lead shielding, and covered by a 77-in. square concrete rolling door. The PoBe and PuBe neutron sources were housed in a 3 ft x 3 ft x 2 ft-deep pit, with a graphite neutron exposure block, shown in Figure 8.

All of the sources were fully encapsulated, were leak-tested at least every six months in compliance with State of California Radiation Control Regulations, and subsequently removed from T029. Thus, apart from one incident involving the dropping of a Ra-226 capsule (described below), there is no known cause for radioactive contamination in the facility.

Radioactivity was released from one of the Ra-226 source capsules (Source No. 1) on March 23, 1964 when this source became detached from the nylon string and fell into the bottom of the source thimble. The 13-ft fall cracked the outer plastic encapsulation

Table 1. Calibration Sources Used at T029

Source	Source Strength (mCi)	Date*
(1) Ra-226	24.8	1960
(2) Ra-226	132	1960
(3) Ra-226	930	1960
(4) Co-60	Unknown	
(5) PoBe	Unknown	
(6) PuBe	Unknown	
(7) Cs-137	5310	September 1963
(8) Cs-137	5260	September 1963

*Date Source Strength was measured

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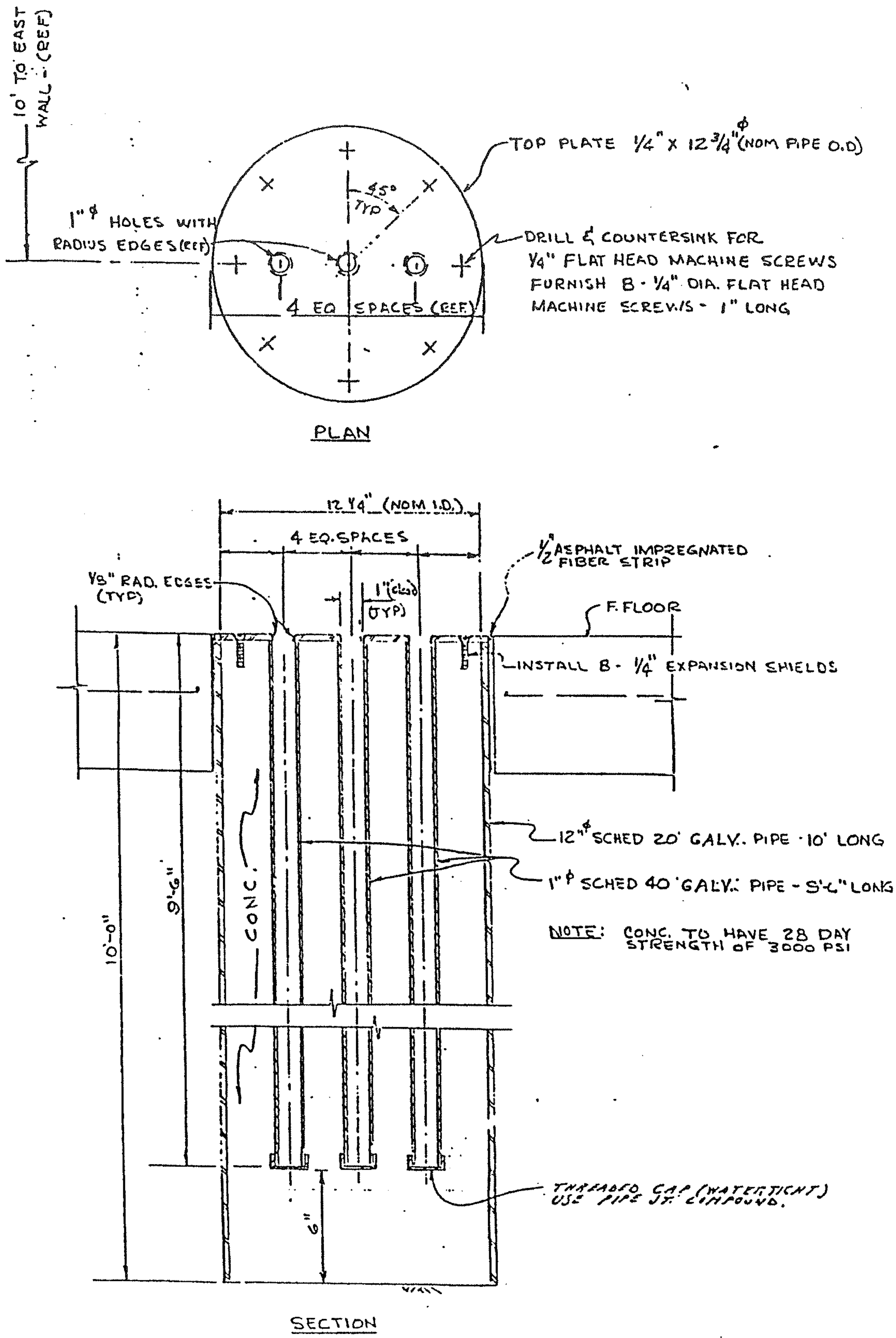

Figure 9. Ra-226 Source Storage Well Detail

surrounding the inner capsule and released some loose Ra-226. Release of radioactivity was primarily confined to the well and the source thimble. An April 10, 1964 report describing the incident, the subsequent recovery of the source, and the decontamination of the area outside the well is attached as Appendix A to this report.

Operation of the facility continued by replacing all the Ra-226 sources with two Cs-137 sources. Although two other operational incidents were experienced (the first involving dropping another Ra-226 source into the well in 1961, and the second involving dropping one of the Cs-137 sources into the well in 1970), neither of these incidents caused release of radioactivity, and hence were of no radiological consequence.

All operations in Building T029 with radioactive materials had been in support of DOE's predecessor agency programs. The facility was transferred to the DOE's Energy Technology Engineering Center (ETEC) operating contract in September 1989.

2.4 DECOMMISSIONING OPERATIONS AND RADIATION SURVEYS

Partial decommissioning of T029 was accomplished in April 1974 when all radioactive sealed sources were removed and transferred to another facility. Subsequently, T029 was redesignated as a nonradioactive hazardous waste storage facility for the storage of excess alkali metals and components containing alkali metals.

In 1985, building T029 was included in an overall survey plan for SSFL facilities (Ref. 1). A purpose of the survey plan is to inspect the facilities for residual radioactive contamination and recommend remedial actions.

In accordance with the plan described in Ref. 1, the interior of building T029, its surrounding areas, and the entrance roadway were surveyed in 1988 for gamma-emitting contamination. The Ra-226 source storage well was also surveyed for alpha contamination, with the source thimble in a raised position. The survey methods, results, and analyses are described in Ref. 2. A summary of this 1988 survey follows in Section 3.

The 1988 survey (Ref. 2) concluded that no residual contamination existed on the T029 floor surface or the surrounding area. The survey report also concluded that some alpha contamination existed on the source thimble and recommended further investigation, decontamination, and disposition of the well.

Accordingly, in the present effort, the source storage well was excavated and other equipment was removed using controlled procedures. The Ra-226 source storage well was disposed of as low-level radioactive waste. Follow-up smear surveys and soil activity measurements in the affected areas showed no residual radioactivity. The affected areas were then refilled and the floor was resurfaced. The remainder of this report, commencing in Section 4, provides details of this effort.

3. SUMMARY OF 1988 RADIATION SURVEY

3.1 OVERVIEW

Upon decontamination and decommissioning (D&D) of its radioactive constituents, releasing a facility for other unrestricted uses requires a radiation survey to demonstrate that the applicable regulatory limits for such a release are met. The survey is performed in accordance with an established plan, and a statistical interpretation of the data is performed to demonstrate that the numerical regulatory release criteria have been met. Together, the 1988 radiation survey of Building T029 (Ref. 2) and the follow-up work reported in this document fulfill the requirements for such a survey. For the sake of completeness, and for ease of future reference, a summary of the 1988 survey is provided in this section.

3.2 SCOPE OF SURVEY

The interior of Building T029, the surrounding area, and entrance roadway were surveyed for gamma-emitting contamination. The Ra-226 source well was surveyed for alpha contamination by raising the source thimble from the bottom of the well. An area south of T029 which was used in the early 1960s for storing barrels was also surveyed for indications of residual radioactive material. For purposes of comparison, natural background radiation data were also taken at about the same time at the three following SSFL locations where no radioactive materials were ever used, handled, or stored: Building 309 area, Well No. 13 Road (Dirt), and Incinerator Road (Dirt).

3.3 SURVEY METHOD

3.3.1 Criteria and Their Implementation

Acceptable contamination limits and gamma exposure rates for unrestricted use of a decommissioned facility are prescribed in Department of Energy (DOE) guidelines (Ref. 3), the Nuclear Regulatory Commission's (NRC) Regulatory Guide 1.86, NRC license SNM-21, and other references. Table 2 shows the composite of conservative limits derived from these references and adopted by Rocketdyne. Of these, the ambient gamma exposure rate criterion (5 μR/h above background) was first applied at SSFL during the decommissioning of the NRC-licensed L-85 reactor. Three specific "action levels" were

Table 2. Maximum Acceptable Contamination and Gamma Exposure Rate Limits (1988 Survey)

No.	Parameter	Limit, in Unit Specified	Reference
1	Total surface contamination (averaged over 1 m^2)	a) Alpha: 100 dpm/100 cm^2 b) Beta: 5,000 dpm/100 cm^2	3
2	Maximum surface contamination (in 1 m^2)	a) Alpha: 300 dpm/100 cm^2 b) Beta: 15,000 dpm/100 cm^2	3
3	Removable surface contamination (averaged over 100 cm^2)	a) Alpha: 20 dpm/100 cm^2 b) Beta: 1,000 dpm/100 cm^2	3
4	Gamma exposure rate* (at 1 m from surface)	5 μR/h above background	4
5	Soil activity concentration**	a) Alpha: 21 pCi/g (for depth $\leq$ 15 cm below surface) b) Alpha: 31 pCi/g (for depth > 15 cm below surface) c) Beta: 100 pCi/g	3, 5 & 6

* Although DOE Guide (Ref. 3) recommends a value of 20 μR/h above background for gamma exposure rate, the NRC Dismantling Order for the L-85 reactor decommissioning (Ref. 4) required 5 μR/h above background. For conservatism, 5 μR/h above background is used at Rocketdyne to compare survey results.

** Alpha activity concentration limits for Ra-226 are 5 pCi/g (Ref. 3) plus that contribution from naturally occurring radioactivity (about 16 pCi/g from Ref. 5, p. 93) averaged over the first 15 cm of soil below the surface. At a depth greater than 15 cm below the surface, 15 pCi/g averaged over 15-cm-thick layers of soil plus "background" is the limit. The total beta activity concentration limit is 100 pCi/g (Ref. 6), including background which is about 24 pCi/g.

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established and initiated if the surveyor detected radiation according to the following criteria:

1. Characterization Level – That level of exposure rate which is below 50% of the maximum acceptable limit. This level is typical of natural background levels, or slightly above, and requires no further action.
2. Reinspection Level – That level of exposure rate which is above 50% of the maximum acceptable limit. A further survey of the area and additional samples are required in this case.
3. Investigation Level – That level of exposure rate which exceeds 90% of the maximum acceptable limit. Specific investigation of the occurrence is required in this case.

Results of the Building T029 survey showed no exposure rates requiring reinspection or investigation (see Section 3.4). Thus, none of the additional criteria listed in Table 2 (e.g., surface soil activity or alpha and beta contamination measurements of the general area) warrant further consideration.

3.3.2 Survey Procedures

For purposes of the T029 radiation survey, the building and surrounding area were treated as a single sample lot for characterization and data interpretation. Figure 10 shows the survey sampling lot plan, made of 6–m by 6–m grids superimposed on the building plot. As shown, points within the grids (marked with "."), corresponding to the interior areas of T029, the roadway (10th street), and the fenceline (marked with "X") were surveyed for gamma exposure rates. In all, a total of 40 gamma exposure rate measurements were made. Direct alpha contamination measurements were made for "indication only" on an as needed basis, such as the case of the raised source thimble.

Measurements of gamma exposure rates were obtained from a 1 in. by 1 in. NaI scintillation crystal coupled to a Ludlum Model 2220–ESG portable scaler. The scaler was mounted on a tripod so that the sensitive NaI crystal was 1 m above the ground. The detector is equally sensitive in all directions (i.e., 4π geometry), and can detect variations in exposure rates down to 0.5 μR/h, on the basis of counts obtained during 1 minute. The count rate (cpm) obtained from the NaI crystal is readily converted to exposure rate (μR/h) by means of an efficiency factor for the device. The detector is calibrated quarterly using Cs–137 as the calibration source, in the mR/h range and cross–calibrated against a Reuter Stokes High–Pressure Ion Chamber in the μR/h range. Count rates were converted to exposure rates using the relationship that 215 cpm = 1 μR/h at background

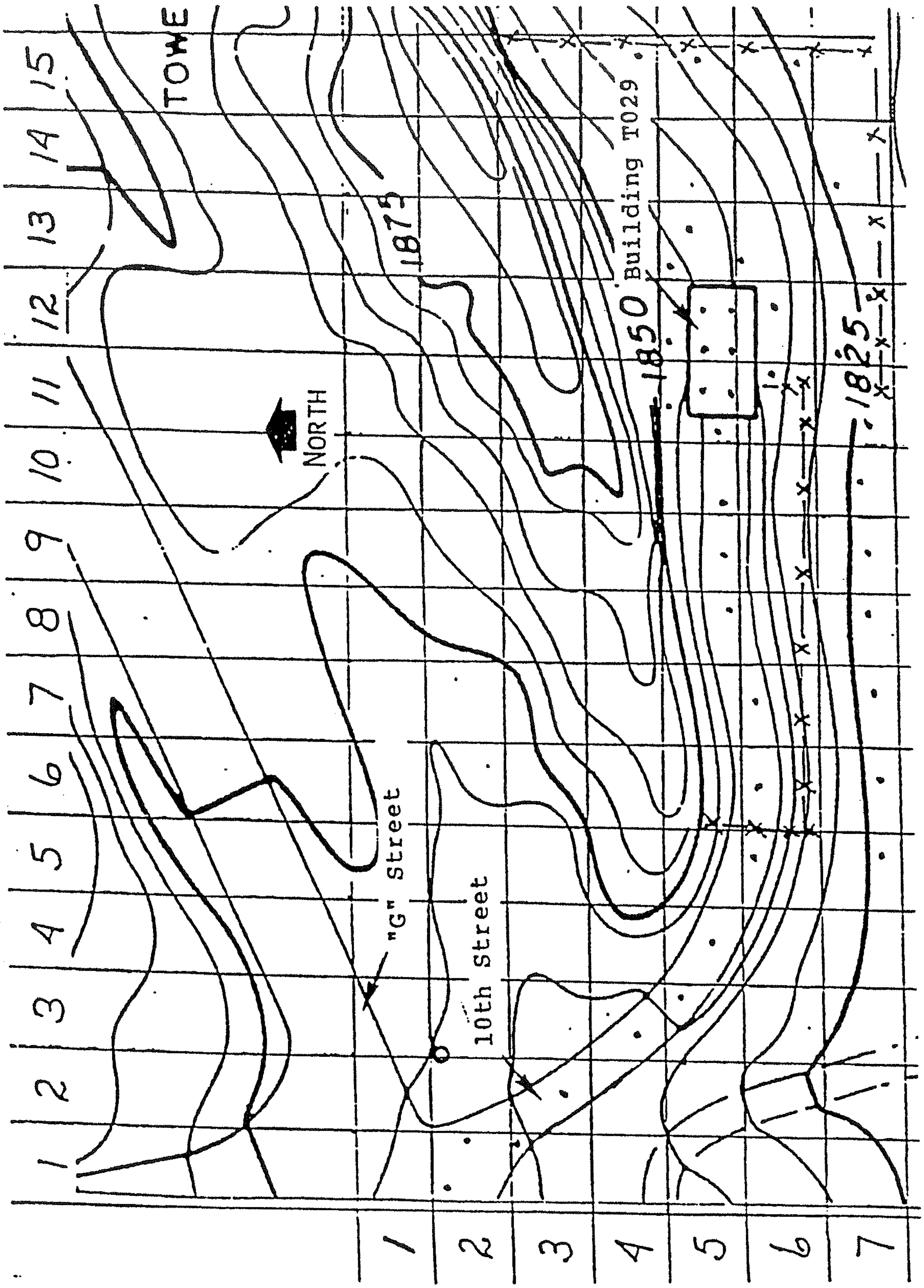

Figure 10. Building T029 Sampling Lot Plan (1988 Survey)

exposure rates. The instrument response was also checked three times daily using a Ra-226 calibration source.

Direct alpha contamination measurements were made using a Ludlum Model 43-5 alpha probe connected to a Ludlum Model 12 countratemeter.

3.3.3 Data Analyses

A statistical procedure is required to interpret the applicability of the exposure rate data collected at the 40 selected random locations to the entire facility. A statistical method known as "sampling inspection by variables" was used to analyze data from the Building T029 radiation survey (Ref. 2). The method has been widely applied in industry and the military, and is essential where destructive tests must be performed (e.g., in quality control) or where the lot size is impracticably large.

In sampling inspections by variables, the number of data points on which measurements are obtained is first chosen to be large so that the distribution of the data is normal (i.e., gaussian). The mean of the distribution, $\overline{X}$, and its standard deviation, s, are then related to a "test statistic," TS, as follows:

$$TS = \overline{X} + ks.$$

TS and $\overline{X}$ are then compared with the applicable limit (5 μR/h above background, in this case), to determine acceptance or other plans of actions, including rejection of the area. The value of k is determined from the sample size and two other statistical sampling coefficients which are related to a consumer's risk of accepting a lot, given that a fraction of the lot has rejectable items in it. These sampling coefficients, and use of the resulting calculated value of TS for comparison against the applicable limit and establishing action plans are further discussed in Ref. 2. It suffices to say here that the values chosen for the coefficients correspond to assuring, with 90% confidence, that 90% of the facility has residual contamination below 100% of the applicable limit (a 90/90/100 test). Also, the choice of values for the coefficients is consistent with industrial sampling practices and the State of California regulations (Ref. 7).

Data obtained from the T029 radiation survey were treated using this statistical approach. The reduced data were plotted against the cumulative probability for the gaussian with the cumulative values shown on a probability grade scale. Display of data in this manner permits clear identification of values with significantly greater exposure rates (and thus contamination) than expected for the lot.

3.4 RESULTS

Ambient gamma exposure rates obtained from the 40 measurements at the Building T029 grid locations shown in Figure 10 are provided in Table 3. The ambient exposure rates range from 10.45 μR/h to 16.50 μR/h, the lowest being at a point within the building. Figure 11 shows the data plotted against a probability-grade scale for the cumulative probability (x-axis). The average for the 40 measurements (14.4 μR/h) is at the 50% cumulative probability.

Six of the 40 survey locations were inside of the building and the remainder were outdoors. Table 4 provides averages, standard deviations and ranges (i.e., maximum – minimum) for the the entire set, the indoor set and the outdoor set. Also included for comparison are corresponding data from measurements taken at the three other SSFL locations where no radioactive materials were ever handled, stored or used.

Alpha measurements at the source storage well, with the source thimble in the raised position, showed 200 cpm, which corresponds to about 2800 α-dpm per 100 cm^2. The thimble was lowered back in position after this "indication only" measurement was made.

The area south of T029 where barrels of unknown materials were stored in the '60s showed no detectable activity.

3.5 DISCUSSION

Data shown in Table 4 clearly demonstrate that the ambient gamma exposure rates measured in Building T029 are similar to the background exposure rates measured in the general vicinity and are a result of natural radioactivity present at SSFL.

The mean of the three background average exposure rates shown in Table 4 is 15.3 μR/h which is slightly higher than the 14.4 μR/h average for the entire set of Building T029 measurements. To compare against the 5 μR/h-above-background limit (Table 2), the 15.3 μR/h background average is subtracted from the individual ambient exposure rates shown in Table 3. Application of the statistical criteria, discussed in Section 3.3.3, for the background-subtracted data for Building T029 is shown in Figure 12 which is plotted in the same manner as Figure 11. Figure 12 also shows the horizontal

Table 3. Ambient Gamma Exposure Rates in Building T029

Number	Grid Name	Exposure Rate (μR/h)
1	2–1	14.48
2	2–1	13.85
3	3–1	14.30
4	3–2	14.14
5	4–3	14.54
6	5–3	13.89
7	5–4	14.20
8	6–5	14.78
9	6–6	14.83
10	6–7	14.79
11	5–8	14.50
12	5–9	14.70
13	5–10	14.37
14	5–11	13.39
15	5–11	15.21
16	5–12	14.19
17	5–13	15.23
Highest ➧ 18	5–13	16.50
19	4–15	16.00
20	5–15	15.71
21	6–15	15.50
22	7–14	15.60
23	7–12	15.61
24	7–12	15.59
25	7–11	15.50
26	7–10	15.85
27	7–9	15.60
28	7–8	15.84
29	7–7	16.32
30	7–6	15.80
31	7–5	16.02
32	6–11	13.15
33	6–12	13.68
34	6–13	14.81
35	5–11*	12.17
36	5–12*	10.51
37	5–12*	10.95
38	5–12*	12.77
Lowest ➧ 39	5–12*	10.45
40	5–11*	11.52

Average = 14.4 μR/h

*Locations inside Building T029

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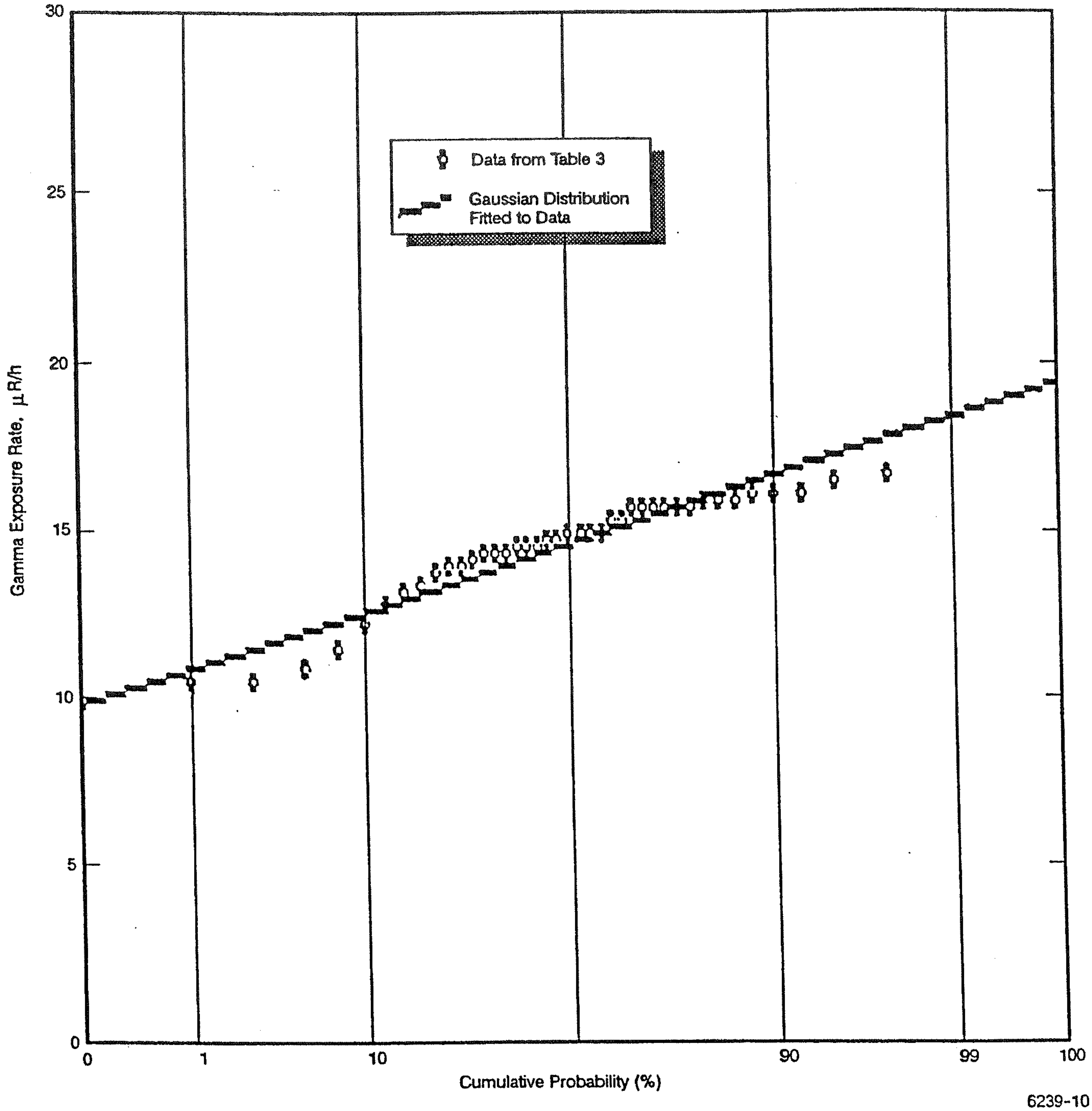

Figure 11. Ambient Gamma Radiation at Building T029 and Surrounding Areas

Table 4. Ambient Gamma Radiation at SSFL Compared to T029 Measurements

Location	Number of Measurements	Average Exposure Rate (μR/h)	Standard Deviation (μR/h)	Range (μR/h)
T029 Entire Data Set	40	14.4	1.55	6.05
T029 Indoor Data Set	6	11.4	0.94	1.32
T029 Outdoor Data Set	34	14.9	0.87	3.35
Bldg 309 Area (1/19/88)	36	15.6	0.82	3.4
Well No. 13 Road (Dirt) (4/29/88)	43	16.2	0.49	2.2
Incinerator Road (Dirt) (4/29/88)	35	14.0	0.36	1.4

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line corresponding to the background–subtracted Test Statistic at a value of 1.628 μR/h; the cumulative probability corresponding to this test statistic is 93%. As shown, the entire population of the 40 background–subtracted Building T029 exposure rate measurements lies below the test statistic and the maximum acceptance limit (5 μR/h). In fact, all of the data, and the test statistic, are below the 50% characterization level (2.5 μR/h). Thus, the area was found acceptably free of radioactivity by this inspection technique.

The single "indication only" data obtained on the raised source thimble confirmed that additional alpha contamination was likely to exist below the T029 floor level where the dropped Ra–226 source was originally located.

3.6 CONCLUSIONS

Based on the results obtained, the 1988 radiation survey concluded that the gamma exposure measurements showed that no residual contamination existed on the inspected areas of Building T029 facility floor or its surroundings. Accounting for the variations in the natural background, and subtracting a value best representing the natural background, the survey further concluded, through the sampling inspection by variables method, that the the area is generally clean of any residual radioactive contamination. The same conclusion applies to the barrel storage yard.

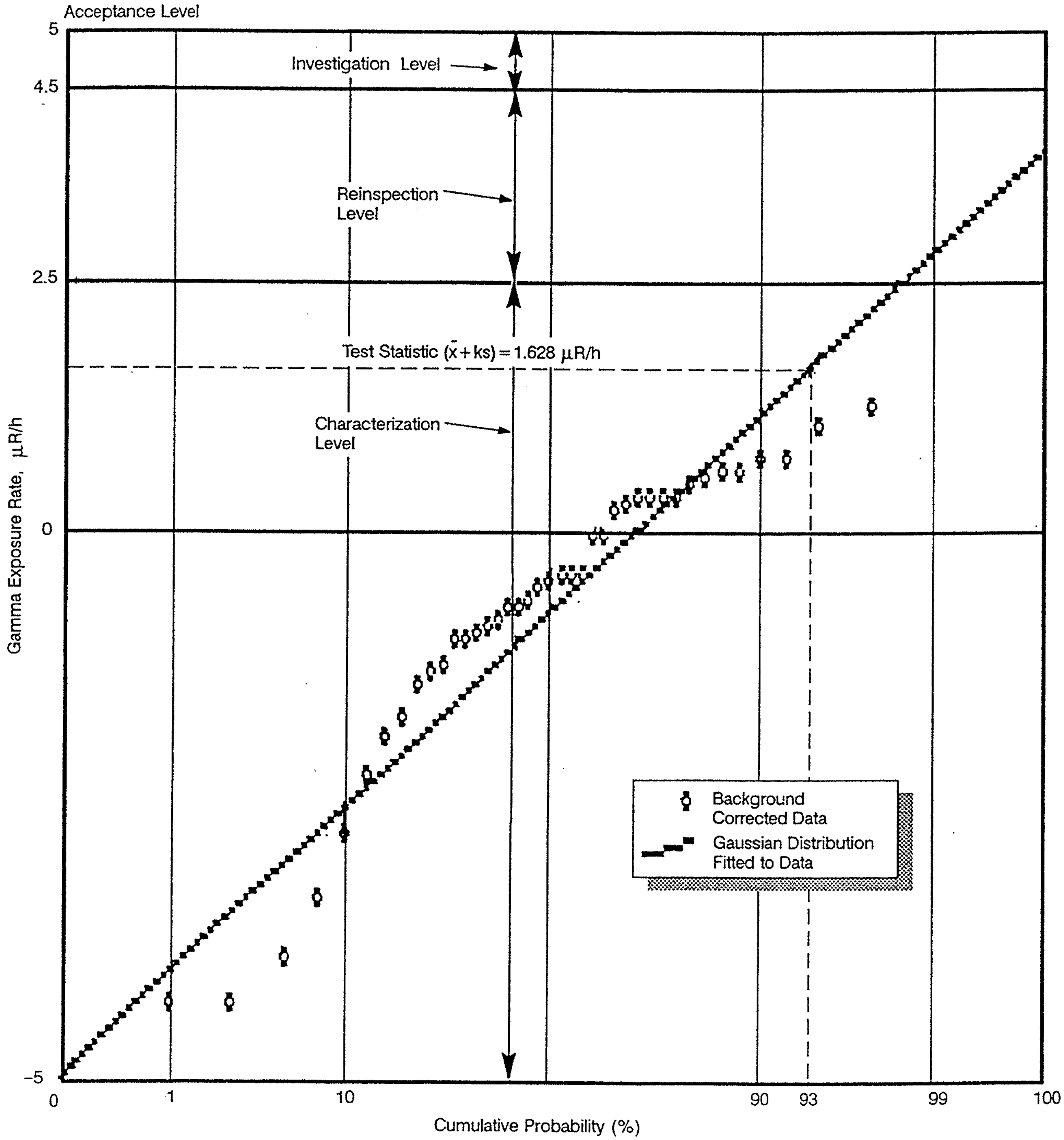

Figure 12. Ambient Gamma Radiation at Building T029 (Corrected for Background)

The 1988 radiation survey, at the same time, concluded that the Ra–226 storage well inside T029 was still contaminated.

3.7 RECOMMENDATION

The 1988 radiation survey recommended further investigation, decontamination, and disposition of the Ra–226 storage well.

3.8 IMPLEMENTATION OF THE RECOMMENDATION

The recommendation of the 1988 radiation survey was carried out in 1989. The source storage well and additional equipment were removed and appropriately disposed of, and follow–up analyses were performed. Details of this effort are discussed in the following sections of this report.

4. WORK PERFORMED

Based on the recommendation of the 1988 radiation survey, the Ra-226 source storage well was excavated and removed from Building T029. In addition, the structure that formerly stored the Co-60 sealed sources, and the building exhaust system located outside of T029 were also removed. Soil samples were collected and analyzed. The excavated areas were then refilled. These activities are described in this section.

4.1 PROCEDURE

Excavation and removal of the Ra-226 source storage well and other activities in T029 were performed under a documented procedure (Ref. 8). As specified in the procedure, a Controlled Work Permit was issued for monitoring and controlling radioactivity in the work area and exposures to personnel. Routine contamination surveys were performed to determine contamination levels and for segregation of contaminated material for subsequent disposal.

4.2 Ra-226 SOURCE STORAGE WELL REMOVAL

Following temporary removal of the material stored inside the building, a rectangular area of the floor surrounding the Ra-226 source storage well was marked up for excavation (see Figure 13) using concrete saws and jack-hammers. A back-hoe was used to dredge the soil from the cut-up area. A vacuum cleaner was then used to remove soil in the immediate vicinity of the 12-in.-diameter casing. Removal of the soil in this manner loosened the casing from the soil, with its inner contents of contaminated source thimble tubes (shown previously in Figure 9) still intact. A sling was attached to the casing and a fork-lift was used to move it to the floor where it was covered with plastic bags, tagged as radioactive material and transported to the Radioactive Material Disposal Facility (RMDF) at the SSFL. Figure 14 shows a photograph of the casing upon its arrival at the RMDF. A photograph of the excavated area of the well after removing the casing is shown in Figure 15. The Co-60 source cell and the pit where the PuBe and PoBe sources were formerly located are seen to the right and left side of the excavation respectively.

4.3 REMOVAL OF OTHER ITEMS

The Co-60 source cell was demolished, and its storage well was excavated partially to a depth of approximately 2 ft below grade in the same manner as the Ra-226 source storage well. Although, as noted previously, there was no contamination present in this

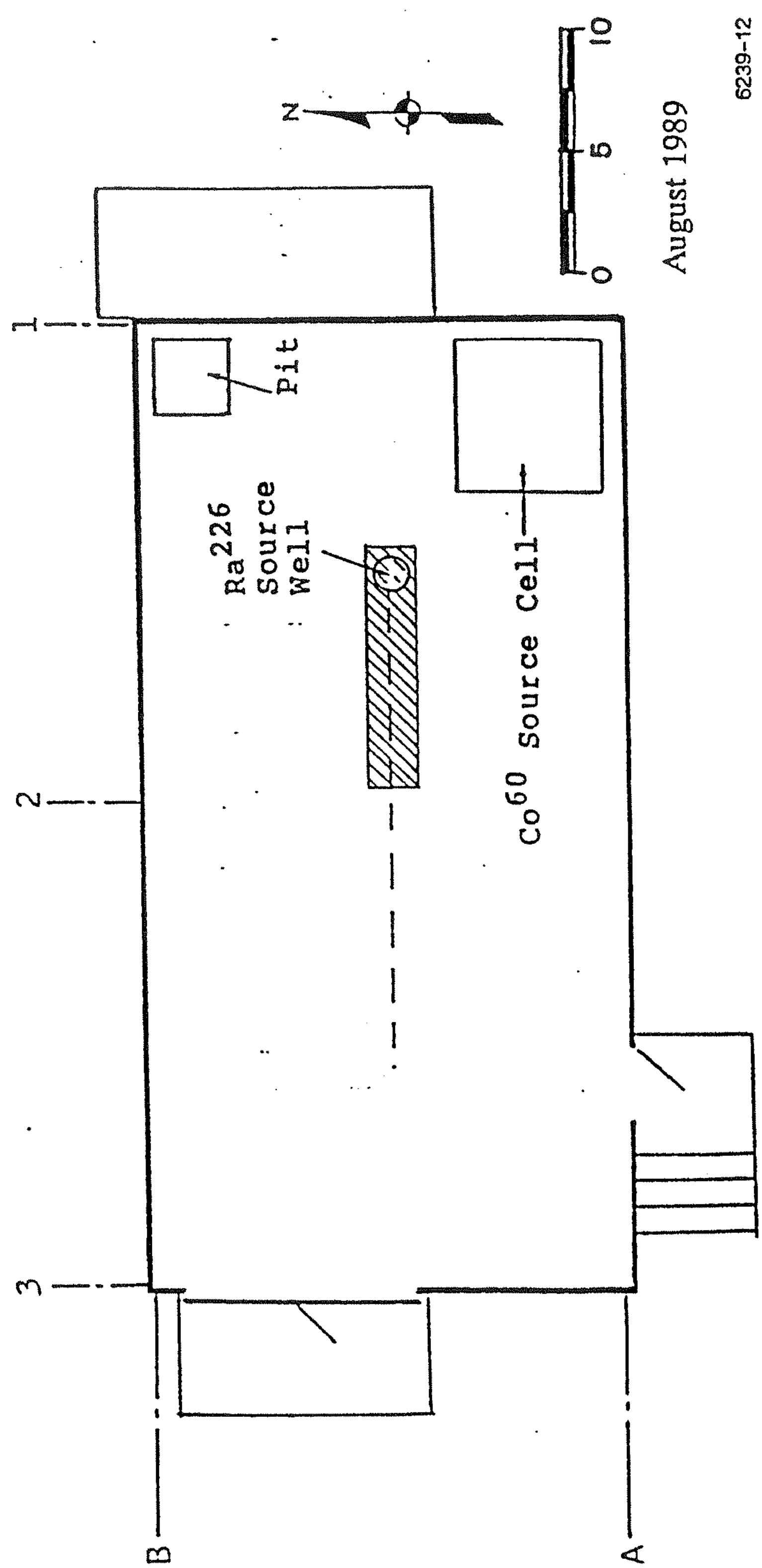

Figure 13. Ra-226 Source Well Floor Area (Shaded) Marked Up for Excavation

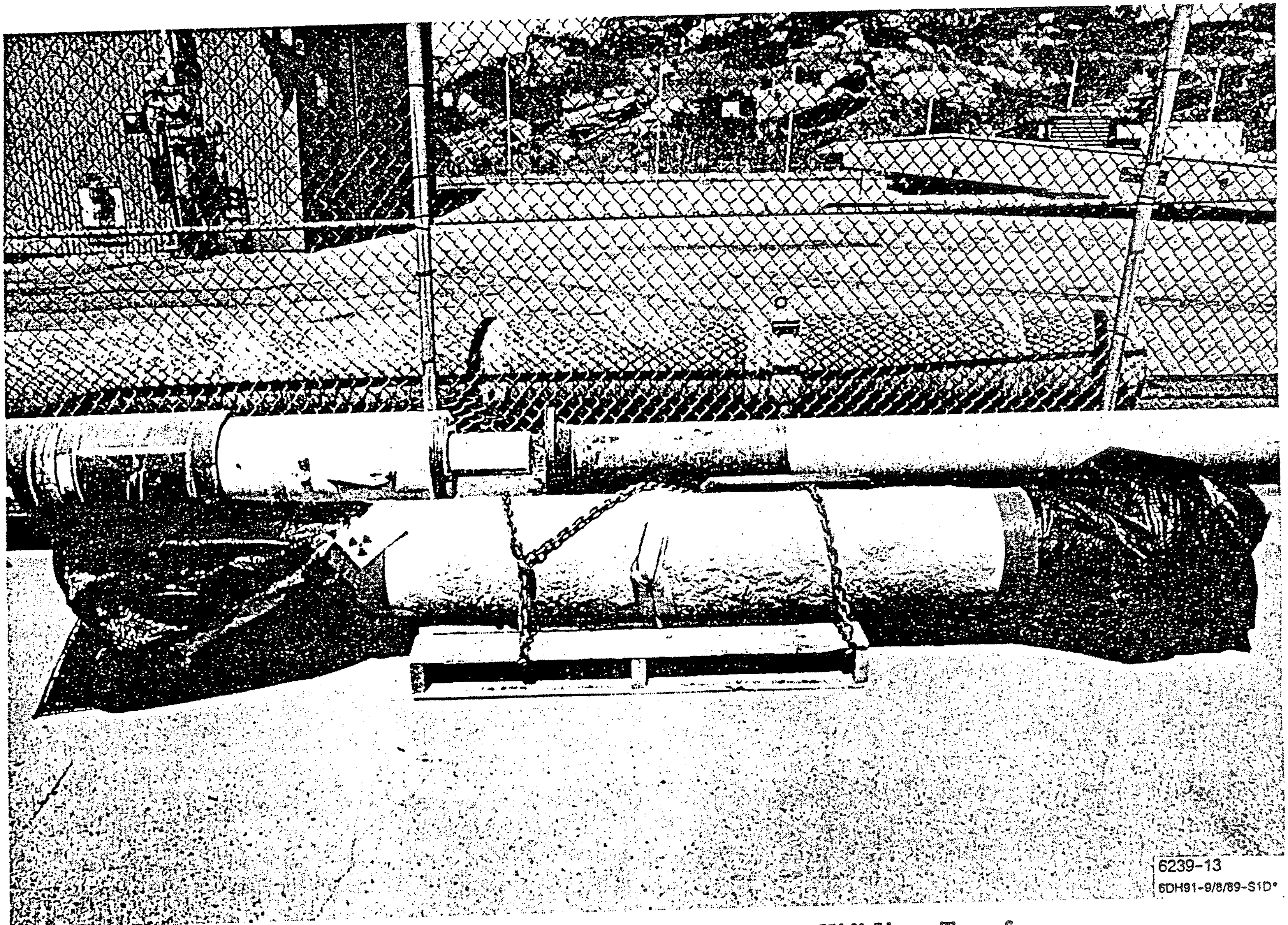

Figure 14. Photograph of Ra-226 Source Storage Well Upon Transfer to RMDF from T029 (front-most from fence)

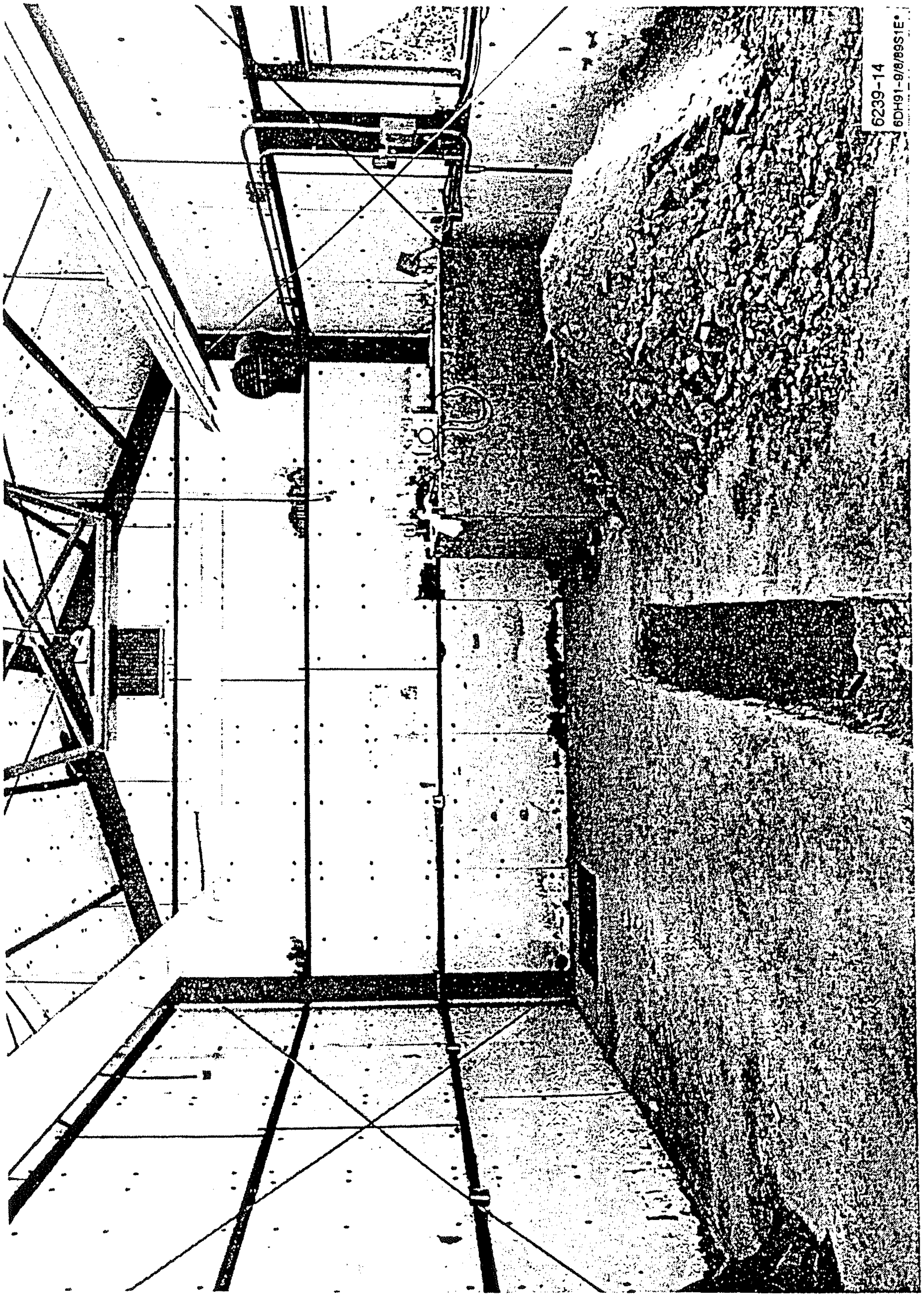

Figure 15. Photograph of Excavated Area of Ra-226 Source Storage Well in T029; Square Pit on Far Left at Floor Level is Former Location of PuBe, PoBe Sources. Former Co-60 Source Cell Block is to the Far Right

location, the Co–60 structure was eliminated to an extent that provides an obstruction–free floor–space there for future storage of nonradioactive materials. Routine smear surveys were performed at this location and the pit area to assure absence of contamination. Figures 16 and 17 show photographs taken during demolition of the Co–60 source cell and its storage well.

The facility's exhaust blower was also removed.

4.4 DISPOSITION OF REMOVED ITEMS

4.4.1 Ra–226 Source Storage Well

Routine smear surveys were performed on the surfaces of the thimbles. Swabs were taken from within the interiors of the thimble tubes after the casing was excavated. Results of the smear survey showed normal background activity, while the swabs showed, as expected, alpha–contaminated interiors. Therefore, it was determined that the source storage well must be disposed of as low–level radioactive waste. Accordingly, to facilitate its packaging, the casing was cut longitudinally into two pieces and the concrete embedment was separated from the casing and the three inner tubes. Figure 18 shows a photograph of the disassembled casing. All of the components shown were then packaged for disposal as low–level radioactive waste at an authorized site.

4.4.2 Other Items

Routine smear survey data on the Co–60 source well components such as the concrete, the removed and retained portions of the source well showed no activity above background and hence these items were disposed of as normal industrial waste; the lead shielding surrounding the source well was sold as scrap.

Routine smear survey of the exhaust blowers also showed no activity above background. These items were deemed reusable and hence were sent for refurbishment.

The survey data for all of the above items are maintained in the facility decommissioning file (see list shown in Appendix B).

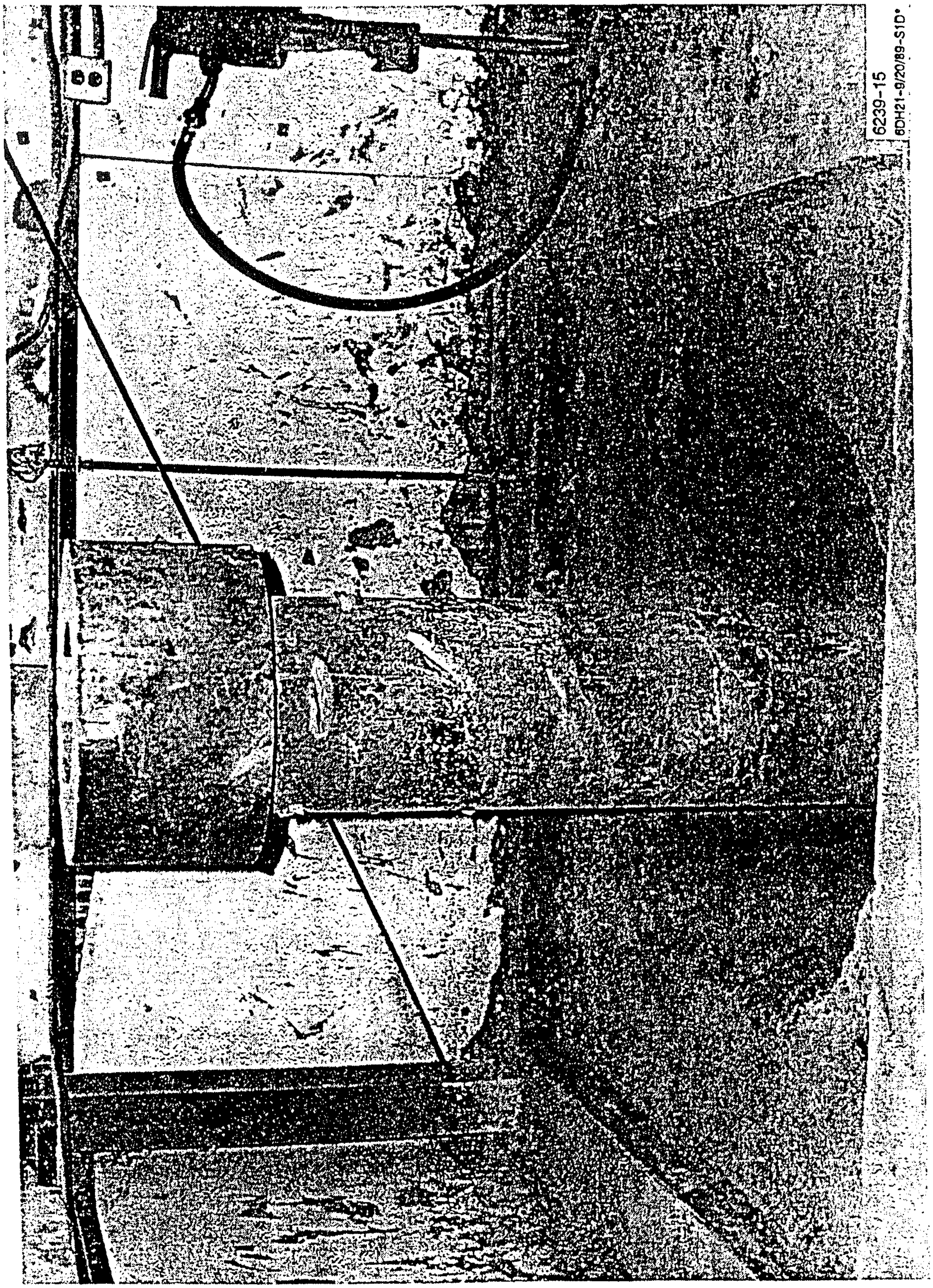

Figure 16. Co–60 Source Cell After Demolition of Surrounding Concrete

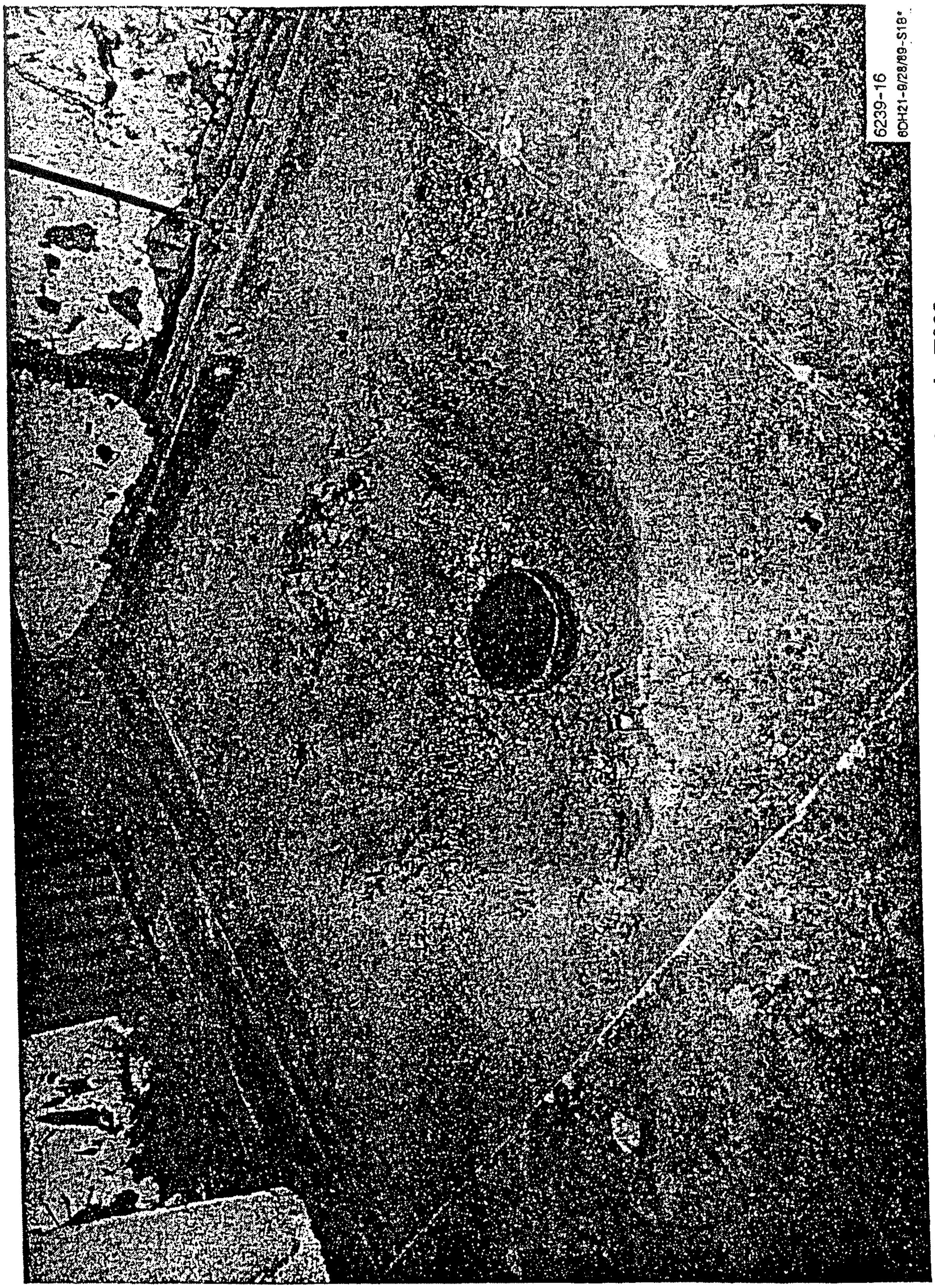

Figure 17. Photograph of Co–60 Source Cell Area in T029 After Partial Removal of Source Cell

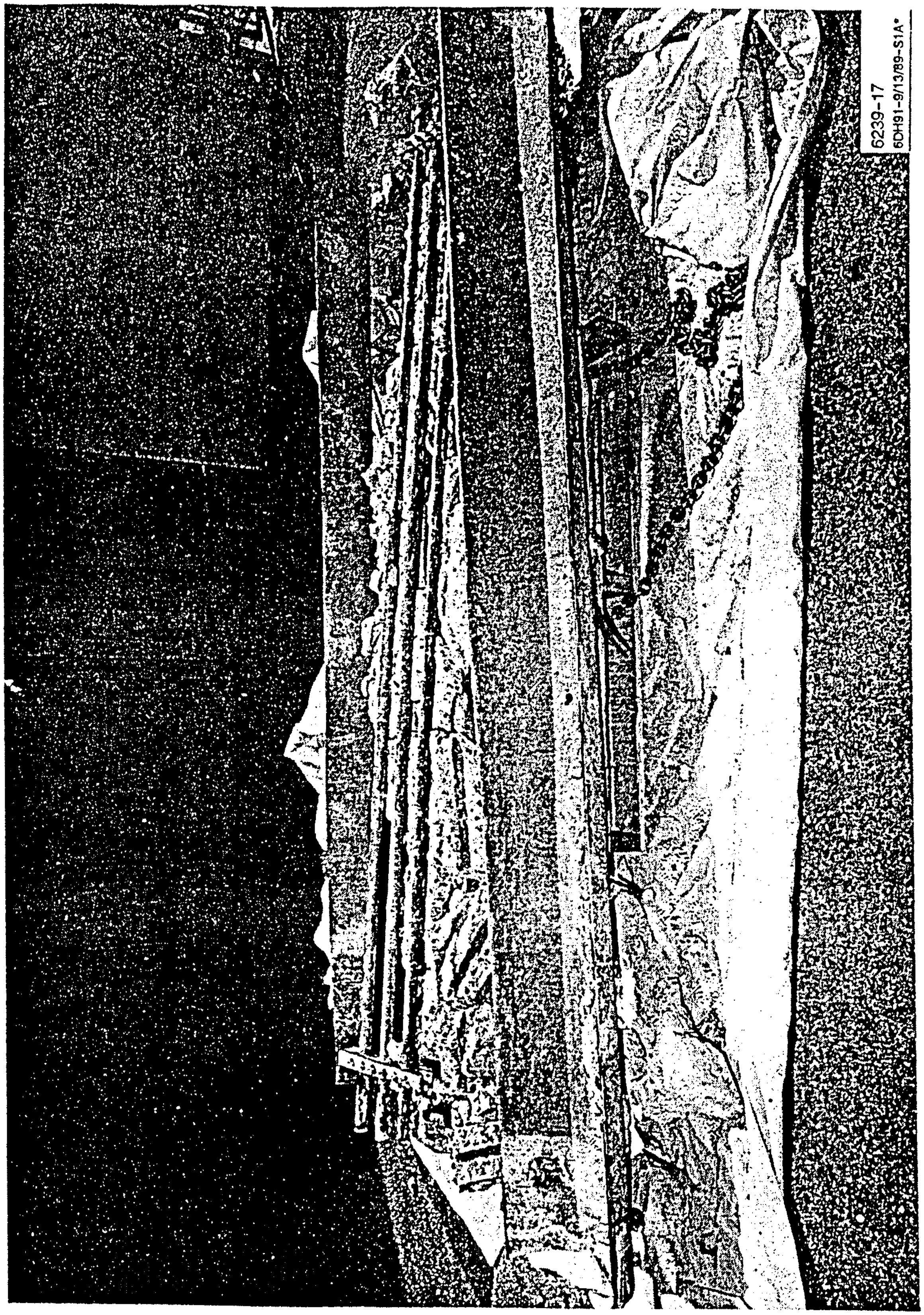

Figure 18. Photograph of Disassembled Ra-226 Source Well Casing in Preparation for Disposal

4.5 SOIL ANALYSES

4.5.1 Soil Samples for Analysis

Soil samples were collected to determine if any Ra–226 or Cs–137 isotopes had migrated from the source storage well casing into the adjacent soil and the extent of any such contamination. Four samples were collected in masses ranging from 227 g to 948 g for spectrometric analyses. The samples were collected from dirt adhering to the excavated source well casing (sample No. 1 and No. 3), the excavated pit (sample No. 2) and the excavated dirt pile (sample No. 4). As shown in Figure 19, sample No. 1 was from the side of the source well casing, while samples No. 2 and No. 3 were from its bottom. Sample No. 4, not shown in Figure 18, was a random sample taken from the excavated dirt pile.

Soil samples in the mass range of about 500 to 900 g are required for gamma spectrometric analysis using the standard Marinelli beaker (see Section 4.5.2 below) and three of the four samples had this desirable mass. However, one sample (sample No. 2 soil adhering to the bottom of the casing) weighed only 227 g which corresponded to all the dirt that was adhering to this area. Sample No. 2 was nevertheless analyzed along with the other samples, and results are presented in Section 4.5.3.

4.5.2 Analysis Procedure

Gamma spectrometry of the soil samples was performed with a Canberra Industries, Inc. Series 80 Multichannel Analyzer (MCA). The MCA is coupled to a planar high purity germanium (HPGe) radiation detector having about a 10% relative sensitivity (relative to the sensitivity of 3 in. x 3 in. NaI detector for cesium–137 gamma radiation), and a photopeak resolution capability of about 2.5 keV for the higher energy line of cobalt–60. The instrument was calibrated for gamma energy and for radionuclide quantification with a Marinelli Beaker Standard Source (MBSS) as specified in the Standard, ANSI/IEEE Std 680–1978, "IEEE Standard Techniques for Determination of Germanium Semiconductor Gamma–Ray Efficiency Using a Standard Marinelli (re–entrant) Beaker Geometry."

The soil samples collected were dried in an oven and large chunks and rock were removed. A Marinelli beaker (450–ml volume) was then filled with the soil sample, weighed and counted for 30 min.

The MCA is programmable; for any unknown sample, it will calculate the activity in μCi of any isotope it identifies corresponding to the associated library. Typically, the

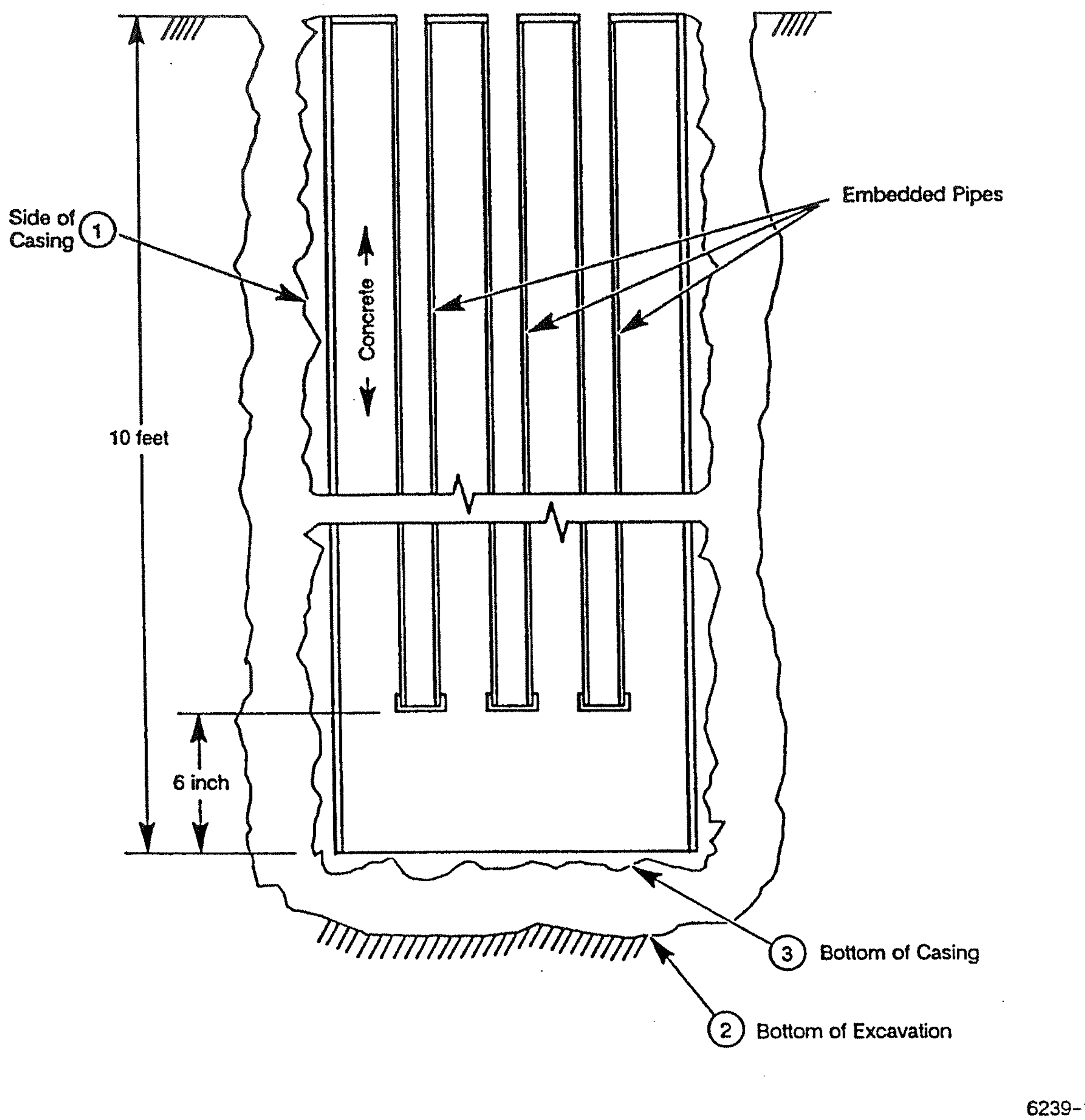

Figure 19. Schematic of Ra-22b Source Storage Well Showing Locations from where Soil Samples were taken for Analysis

instrument is used to measure U–238, U–235, Th–232, and their daughter products, K–40, Cs–137, Co–60, and Eu–152. Ra–226 (U–238 daughter) activity as well as the activities of its daughters (e.g., Pb–214 and Bi–214) are also measured. The MCA–calculated Ra–226 activity (and its daughters) includes the Ra–226 daughter from naturally occurring U–238 and any postulated Ra–226 that may have migrated from the source well.

A correction to the MCA–calculated activity is required because of the peak overlap at 185–186 keV from Ra–226 and U–235. Assuming that Ra–226 is in equilibrium with U–238 and that U–235 is 0.7% by weight of U–238, it can be shown that the true Ra–226 activity is equal to the MCA–calculated activity multipled by 0.5525. The stated assumption and the correction factor are valid because no enriched uranium was ever used at the facility.

Results from analysis of the soil samples in the above manner are presented in the next section. A statistical treatment of the type provided in the 1988 survey was not performed because of the narrow scope of this effort (namely removal of a relatively small contaminated item from an inaccessible area) and because of the limited number of samples.

4.5.3 Results and Discussion

MCA–calculated activities of selected radionuclides obtained from the gamma spectrometry of the soil samples are presented in Table 5. All values reported are concentrations in units of picocuries per gram (pCi/g). Concentration of Ra–226 and Cs–137 are reported because these are the suspect isotopes that could have migrated from the sources housed in the Ra–226 source storage well to the adjoining soil. Data on K–40 (naturally–occurring) and the two Ra–226 daughters, Pb–214, and Bi–214 are also shown; of these, the K–40 and Pb–214 data can also be compared with recently obtained background data for surface soils in SSFL (Ref. 9). In addition, background for Ra–226 activity reported in Ref. 9 is also included for comparison.

Referring to Table 5, no detectable activity is observed in regard to the suspect isotopes Ra–226 and Cs–137 for samples 1, 3, and 4. Also, for these samples, the values for K–40 are in a narrow range and are nearly the same as the background value elsewhere in SSFL for this naturally–occurring radionuclide.

The values for the Ra–226 daughters Pb–214 and Bi–214, are also in a narrow range for these three samples. However, the Pb–214 concentrations are a factor of about

Table 5. Results of Soil Sample Analysis

Sample No.	Soil Sample Location	Sample Weight (g)	Radioactivity Concentration (pCi/g)					Comment
			Ra-226	Cs-137	K-40	Pb-214*	Bi-214*	
Disposed								
1	Side of casing	938	ND	ND	24.2	0.33	0.36	Soil stuck to casing. Disposed of as radioactive waste
3	Bottom of casing	227	4.1	ND	35.7	1.69	1.60	Soil stuck to casing. Removed for analysis
4	Excavated dirt	920	ND	ND	23.1	0.28	0.40	Disposed of as ordinary dirt
Remainder								
2	Bottom of excavation	948	ND	ND	23.6	0.27	0.40	Soil in excavated area
Background								
	SSFL soil average	(average of three samples)	0.82	NM	22.2	0.84	NM	For comparison. Analyzed by U.S. Testing Company (Richland) for Groundwater Resources Consultants, Inc. (Ref. 9)
Acceptance Limit (DOE)	>15 cm below surface	--	15	--	--	--	--	Criterion from Table 2 (footnote **) of this report

ND: Not detected
NM: Not measured
*Daughter products of Ra-226

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three lower than SSFL background data. Duplicate MCA analyses of the same samples confirm these values. The background value for Bi–214 is not available for a similar comparison, but its activity, as a daughter of Pb–214, should be equal to that of Pb–214. The presence of below detectable concentrations of the parent Ra–226 could be the reason for the relatively low concentrations of these two daughters. It is conceivable that a material with lower activity of Ra–226 (from U–238, its parent) than normal soil (e.g., construction sand) was mixed with the soil during installation of the source storage well resulting in Ra–226 concentrations which are lower than the background for SSFL. The results, nevertheless, do not show any contribution to the activities of Ra–226, its daughters, or Cs–137, that could have migrated from the source storage well.

The data shown in Table 5 with respect to sample No. 3 warrant some discussion. This sample shows a value of 4.1 pCi/g of Ra–226. Data from this sample for the other radionuclides are also not consistent with corresponding data for the other samples or with respect to the background data. However, as mentioned earlier, this sample is of a lower mass value than that required for performing MCA analysis, and spurious data of this nature have been found in soil samples of low mass analyzed in other facility decontamination projects. However, for the present purpose, even if this value of 4.1 pCi/g is considered valid, it is still well below the 15 pCi/g DOE limit for Ra–226 for release of the facility "without radiological restrictions" (Ref. 3). The 15 pCi/g limit is also the remedial action standard used by regulatory agencies (for example, the U. S. Environmental Protection Agency and the Nuclear Regulatory Commission) for release with respect to "unrestricted use" (Ref. 10).

As shown in Figure 19, samples 2 and 3 were taken from locations that are immediately adjacent to each other. Thus, barring a highly localized spot (location of sample No. 3) to which the Ra–226 migrated, it would be reasonable to assume that Ra–226 activities would be the same for the two samples. If the migration of the Ra–226 was indeed localized, then it was contained in the 227 g of soil already removed from the facility, and hence, is of no future consequence. Given the consistency of the data from sample No. 2 with respect to samples No. 1 and No. 4, however, it is appropriate to conclude that the Ra–226 data for sample No. 3 is spurious, and that there is no actual Ra–226 in that location.

4.6 FACILITY STATUS

Upon completion of the removal operations associated with the source storage wells and other equipment, the excavated area was refilled and re-surfaced. Figure 20 shows a photograph of the interior of the facility after completion of these restorations. Nonradioactive materials (principally metallic sodium in 55-gallon drums), which were temporarily stored outside during the removal operations, were returned to the reinstalled racks shown in the photograph. Building T029 thus currently remains as a nonradioactive hazardous materials storage facility.

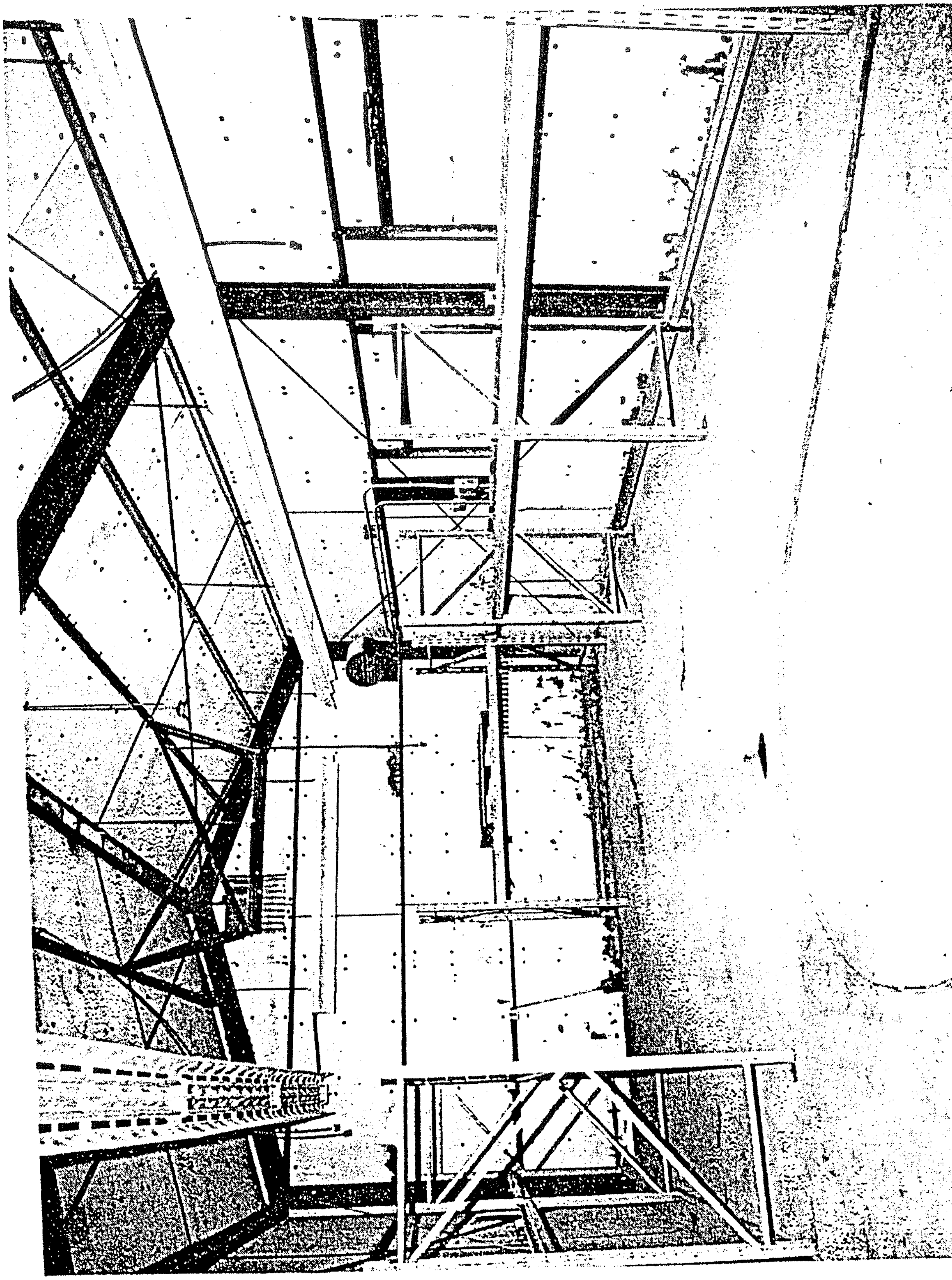

Figure 20. Interior of Building T029 Following Restoration

5. CONCLUSIONS

1. Based on a review of the 1988 radiological survey, all of the surface and above-surface areas of Building T029 and areas in its immediate vicinity are acceptably free of radioactive contamination.

2. As recommended by the 1988 survey, the Ra-226 source storage well was excavated and disposed of. Based on the analysis of soil samples collected during the removal operation, it is concluded that the subsurface soil surrounding the source storage well area is also free of radioactive contamination.

3. Results from the 1988 survey and the work reported here demonstrate that the current radiological cleanliness of Building T029 meets the DOE requirements for release without radiological restrictions and equivalent regulatory requirements with respect to release for unrestricted use.

6. REFERENCES

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6. Swanson, V.A. and Conners, C.C., "Action Description Memorandum for Decontamination and Decommissioning of the Surplus Facilities at the ESG Santa Susana Field Laboratory," Rockwell International Report ESG–DOE–13421, Rev. 2, June 30, 1984.

7. "State of California Guidelines for Decontaminating Facilities and Equipment Prior to Release for Unrestricted Use," DECON–1, Revised, March 24, 1983.

8. Frazier, R. S. "Radiological Decontamination of Building 029," Rockwell International Detailed Working Procedure N001DWP000024, August 24, 1989.

9. "Investigation of Naturally Occurring Radionuclides in Rock, Soils and Groundwater Santa Susana Field Laboratory, Ventura County, California," Groundwater Resources Consultants, Inc., report 8640M–77, June 1, 1990.

10. "Health and Environmental Protection Standards for Uranium Mill Tailings," U.S. Environmental Protection Agency Regulations 40 CFR 192, March 7, 1983.

APPENDIX A

COPY OF INTERNAL LETTER
"Report of Radioactive Contamination Incident of the Radiation Measurements Facility Building 029 - March 24, 1964"

INTERNAL LETTER

NORTH AMERICAN AVIATION, INC.

DATE April 10, 1964

TO R. M. Hill
ADDRESS 779-21
Building 040,
Santa Susana

FROM D. D. Busick and W. D. Hanson
ADDRESS 779-21
Building 040,
Santa Susana
PHONE 6301

SUBJECT Report of Radioactive Contamination Incident of the Radiation Measurements Facility - Building 029 - March 24, 1964

Summary

At 1045 hours, March 24, 1964, a call was received at Building 040, (Health and Safety) from personnel in Building 029, reporting a probable rupture of one of the Ra^{226} calibration sources. This source is one of three containing 24.78 mgm of Ra^{226} as a bromide salt. The other sources contain 132 and 930 mgm of Ra^{226} also in the bromide chemical form. All three sources are incapsulated in platinum iridium alloy of 1.0 mm wall thickness except for the 930 mgm source which has a wall thickness of 1.5 mm of platinum alloy.

Follow-up investigation revealed that three Instrumentation Applications unit personnel were contaminated with alpha activity, primarily on their hands - 1000 c/m (2500 d/m) maximum as determined by a portable alpha survey meter. The personnel were evacuated to Building 020 hot change room for decontamination. Cleaning was easily accomplished after the first soap and water treatment.

Bioassay specimens were collected, submitted and proved negative for radium content.

The facility was surveyed thoroughly for removable and fixed radioactive contamination. What was found, was largely confined to a small area surrounding the source storage wells, along with some low level removable alpha contamination elsewhere in the building. Decontamination of the facility reduced fixed and removable contamination below detectable levels with one exception, the source storage well at the floor level was (6 d/m/100cm² [illegible]).

The offending source was believed to be at the bottom of the storage well. Efforts to locate it elsewhere in the facility were negative. The γ activity at the top of the storage well was approximately 1.5 r/hr, indicating that the source was in fact, at the bottom (North well). A high volume air sample showed normal background alpha activity, 2.5 x $10^{[illegible]}$ uc/cm³.

Building 359, the instrument shop, was also surveyed and found to be free of removable and fixed alpha and beta-gamma contamination.

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From: D. D. Busick and W. D. Hanson
Subject: Report of Radioactive Contamination Incident of the Radiation Measurements Facility - Building 029 - March 24, 1964

On March 25, 1964, the offending source was recovered from its source well, apparently intact, by Health and Safety personnel. The source was placed in its lead shipping container to await disposition after first being placed in a sealed stainless steel tube to contain Rn^{222} generated by the decay of Ra^{226}.

The source evidently is not leaking badly since smears are reasonably free of removable alpha contamination of Rn^{222} and other short lived daughters of Ra^{226}. For this reason, the magnitude of the incident was limited. Surface and personnel contamination (internal and external) would have been several orders of magnitude greater had the source ruptured to the extent that the $RaBr_2$ had been released.

Sequence of Events

Monday afternoon, March 23, 1964, D. E. Van Dyke, Department 744-42, Clock #53 and J. W. Dodd, Jr., Department 744-42, Clock #9, were in the process of calibrating radiation survey instruments. This work was being accomplished at the Radiation Measurements Facility (RMF), Building 029, Santa Susana. At the present time, the facility is equipped with three radium sources, 24.78, 132, and 930 mgms, which are stored inside individual "wells". Each well is approximately 9.5 feet deep by 1 inch diameter. The sources are raised and lowered using nylon string. Over each well is pyrex tube 10 feet long, which is used to prevent lateral motion of the individual source during calibration. The two smaller sources are inside plastic capsules which are attached to the nylon string. The larger source is in a metal source holder.

At approximately 1500, March 23, 1964, the plastic capsule which contained the 24.78 mgs source, became lodged and fractured allowing the source to fall an estimated 13 feet to the bottom of the well. Since the primary container for the source is made of platinum, Van Dyke and Dodd did not feel a hazard existed, and did not notify either Health and Safety nor the Control Center. No attempt was made at that time to recover the source.

The next day, March 24, 1964, E. W. Slocumb, Department 744-42, Clock #47 and D. J. Dunlavy, Department 744-42, Clock #10, accompanied Van Dyke to the facility to assist in the recovery of the source. A 12 foot long piece of copper tubing, with a piece of tuck tape on the end, was inserted inside the well in an attempt to retrieve the source. After several futile attempts one of the employees discovered that the tape on the end of the tubing indicated 1.5 mrad/hr according to a Nuclear Chicago 2586 survey meter which they were using to monitor the operation. At that time they became concerned that the source had ruptured and notified Health and Safety at Building 020 at 1045.

W. D. Hanson from Health and Safety was instructed to evaluate the problem and monitor the personnel involved. Another Nuclear Chicago 2586 survey instrument was used to monitor the employees indicating only

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background radiation. Smears were taken inside to determine the magnitude and extent of the R/A contamination. The smear nearest the well in question showed 600 d/m $\beta\gamma$ and 200 d/m α. An Eberline portable monitor PAC-3G was borrowed from EDF to determine if additional alpha contamination was present. All three employees showed up to 1000 c/m (2500 d/m α) on their hands. Shoes were contaminated up to 100 c/m (250 d/m α). D. D. Busick of Health and Safety was notified of the personnel contamination and was requested to send protective clothing for the three employees, sufficient to allow transportation to another area for decontamination and more extensive monitoring. Due to the implications of a ruptured radium source, Mr. Busick classed this condition as an emergency and requested assistance from Traffic and Industrial Security. The personnel in question were taken to the CDHC for decontamination. Nasal smears were taken on the suspects indicating $<$.2d/m alpha and $<$30d/m $\beta\gamma$. The personnel were thoroughly monitored, and successfully decontaminated including all personal effects. They were then requested to submit a 24 hour bioassay with one sample to be submitted for immediate analysis. J. W. Dodd was also included in the bioassay since he was present when the source was dropped. He was also monitored for clothing, skin, and nasal contamination. Nothing above background was detected.

While the decontamination of personnel was progressing, other members of the Health and Safety Emergency Team were making a more extensive survey of Building 029. An air sample taken showed 2.5×10^{-11} uc/cc alpha which is normal for this site. Smear results of Building 029 showed almost all of the contamination to be concentrated around the well with a maximum of 90 d/m/100cm^2 $\beta\gamma$ and 120 d/m/100cm^2 α. A smear survey of Building 383 and also the pickup truck used by Department 744 showed nothing above background.

A portion of the broken plastic capsule and a piece of tuck tape that had been used in attempt to retrieve the source were taken to Building 028 for analysis on the multi-channel analyzer. The gamma scan demonstrated the presence of the daughters of Ra^{226}.

Decontamination of the floor of Building 029 was accomplished by Maintenance, and restrictions for entry were lifted at 1545, March 24, 1964. The well was plugged with a rubber stopper. A 2500 cc ion chamber was used to withdraw a sample of atmosphere from the well after a period of 24 hours. The sample was taken inside the well 5 feet from the top. Analysis showed 6.7×10^{-4} uc/cc of Rn^{222} as determined by Health and Safety Laboratory Unit. Rn^{222} has an eight hour MPC of 1×10^{-8} uc/cm^3, a half-life of 3.8 days and is the first radioactive daughter of Ra^{226}. The total volume of Building 029 is $\sim 3 \times 10^{8}$ cm^3. The concentration of radon in the building from the accumulated radon in the source well will raise the airborn alpha activity from $\sim 2 \times 10^{-11}$ uc/cm^3 to 1.7×10^{-9} uc/cm^3.

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The exhaust system for Building 029 is rated at 1540 ft^3/min producing 8.5 air-changes-per hour in the building. The atmosphere is exhausted from the building through two absolute filters and dumped immediately outside. This many air-changes-per hour will clear the building of radon in the above stated concentration in approximately 40 minutes.

The recovery of the source was accomplished at 1600 on March 26, 1964. This was done after a light was lowered into the well and a visual observation thru a telescope proved the source to be in one piece. The source removal was accomplished by dropping a small weight with a piece of tuck tape attached to one end.

The source was placed inside a lead shielded container. The equipment used was assumed to be contaminated, and after decontamination, ~50 smears taken showed no removable contamination above background. The offending source has been sealed in a 3 inch length of stainless steel pipe 1/2" in diameter to prevent the continuous release of Rn^{222} from contaminating the immediate environment.

Discussion and Recommendations

On or about September 2, 1961, the intermediate range radium source (132 mgm) plastic source holder was dropped in a similar manner from the top of its source well. This incident did not result in a release of radioactive material. However, like the incident of March 25, 1964, an immediate report was not made to Health and Safety, Industrial Security or to facility supervision. The situation was discovered 10 days following the 1961 incident. While the most recent incident was reported within eighteen hours after the source was dropped, an immediate report would have limited the emergency response. Also, we do not know if the source was leaking before or as the result of the initial recovery attempts.

The total body burden for Ra^{226} is 0.1 ug. The 24.78 mg source represents ~250,000 body burdens. The ingestion and subsequent tissue fixation of 4×10^{-4}% of the radium content of this capsule could result in an employee sustaining a single body burden of radium. Bone tumors have been reported to develop with 0.5 ug of radium fixed in bony tissue.

Radium has chemical properties very similar to barium. Halogen salts of barium and radium are extremely soluble in body fluids. The solubilities of $BaBr_2$ and $BaSO_4$ are 104 and 2.4×10^{-4} gm/100 gm of H_2O. Radium salts having similar chemical properties also will exhibit similar solubility properties. The halogen salts of radium then are more hazardous by many orders of magnitude than the sulphate radium compounds. Therefore, a very large portion of $RaBr_2$ ingested by personnel would be fixed in body tissue.

The personnel involved treated this incident with a great deal of casualness. Also, since a similar type of incident occurred on at least one other occassion by different personnel of the same unit, a greater supervisory effort by Department 744 seems in order. Although similar radium sources are handled safely every day in many places by many different people, unusual or atypical situations must be reported to operations supervision and Health and Safety immediately. The consequences of a single mistake resulting in the release of radium to uncontrolled environments are both costly and extremely hazardous to personnel.

The need for additional and continuing training of both supervisory and non-supervisory personnel is clear. These people are well indoctrinated in the control of external radiation problems. However, an understanding of the more serious problem of ingestion seems to be lacking.

Written procedures for use of this facility has been submitted to Health and Safety for approval. No recommendations pending the review of these procedures will be made at this time.

Finally we would recommend that the radium sources be replaced with Co-60 or Cs-137. The maximum permissible body burdens are 100 and 300 times that of Ra-226. Encapsulation problems are also minimal and have a long history of use under severe conditions with a correspondingly low incident of failure.

D. D. Busick
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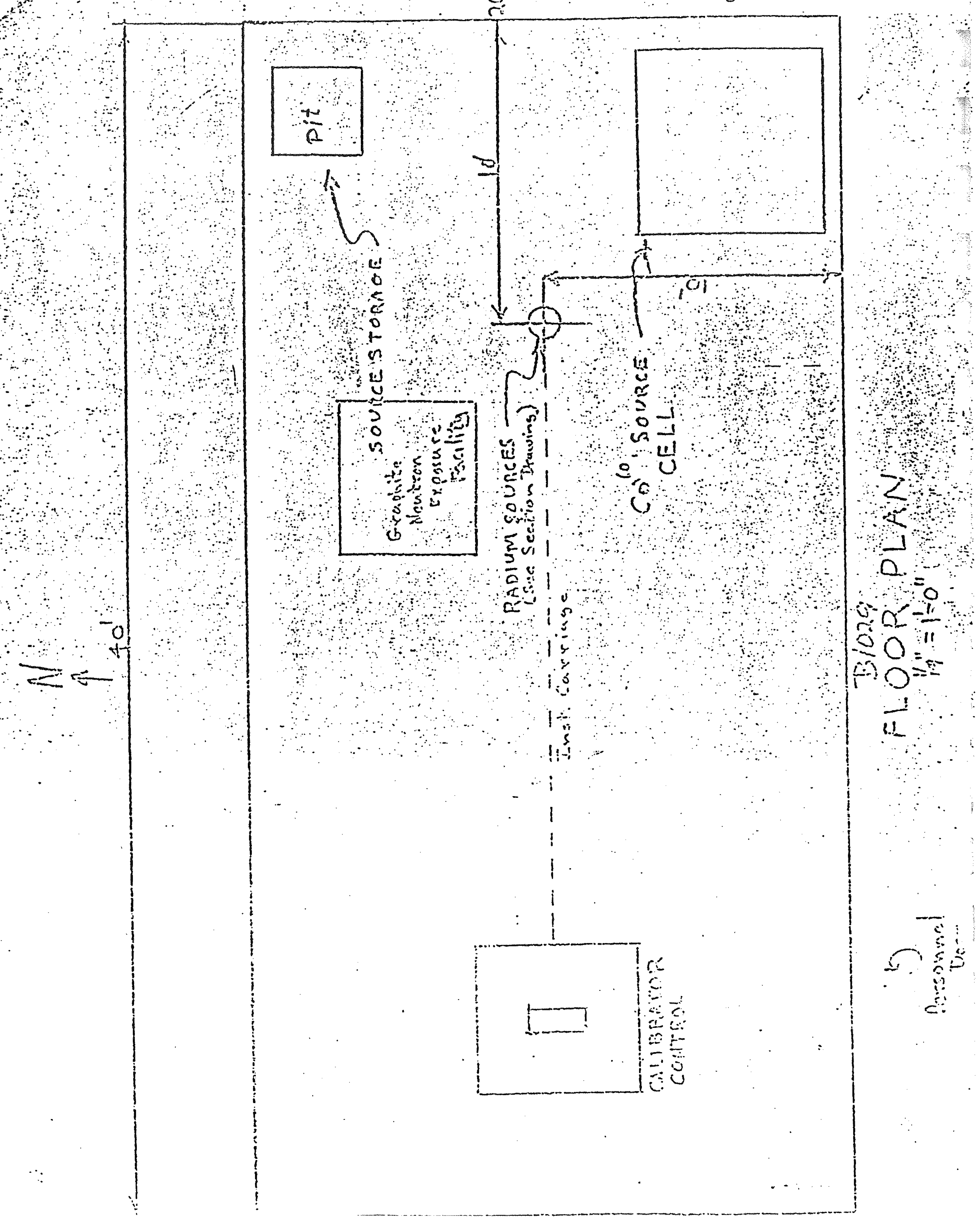
DDB:WDH:ap

cc: J. C. Lang
M. E. Healey
D. R. Shoemaker
E. O. Andersen
S. L. Jones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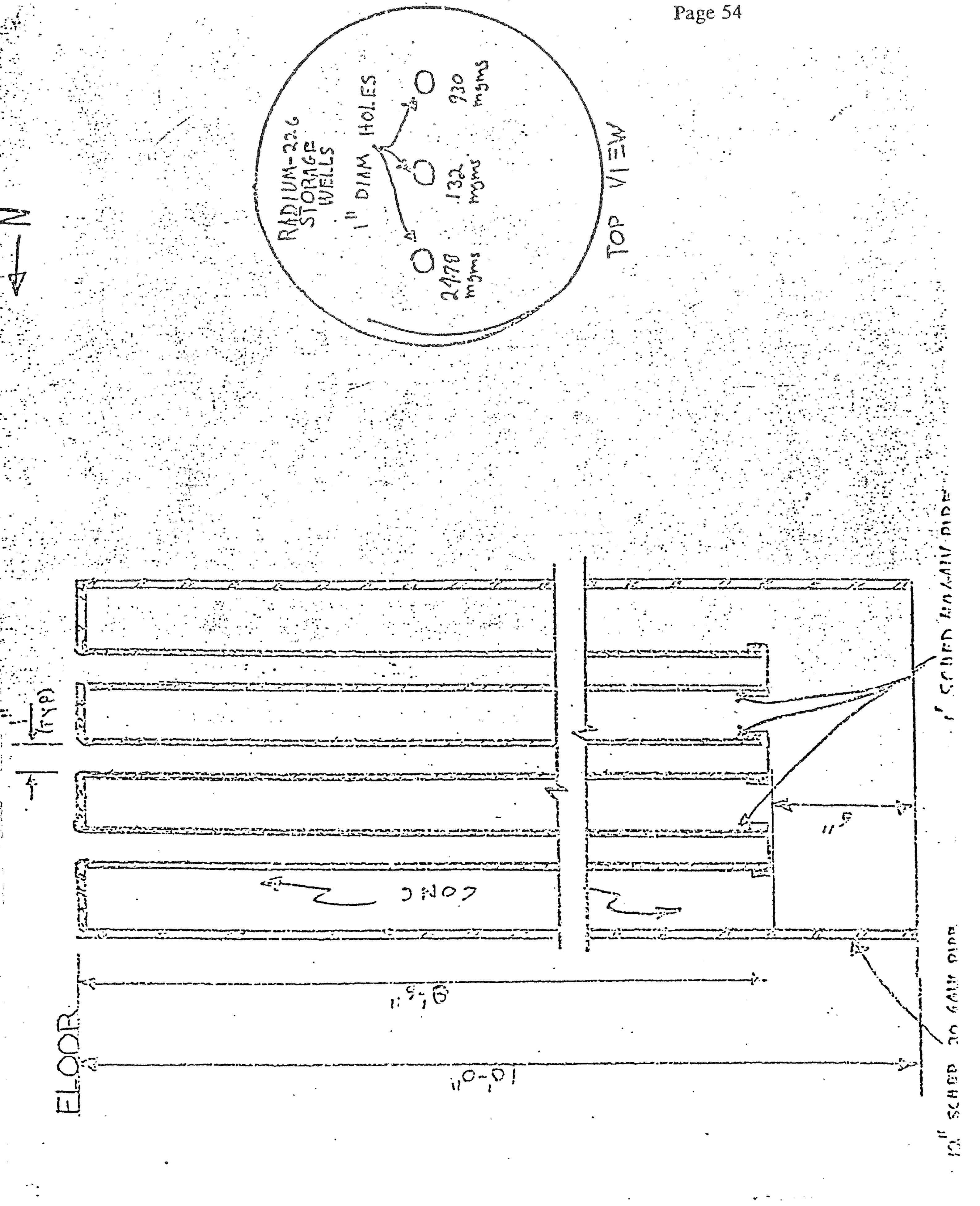
RADIUM-226 STORAGE WELLS
1" DIAM HOLES
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132 mgms
930 mgms
TOP VIEW
N
FLOOR
1" (TYP)
CONC
8'-6"
10'-0"
6"

APPENDIX B

CONTENTS OF BUILDING T029 DECOMMISSIONING FILE

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JUNE 1990

The following is an annotated list of documents in the Building T029 Decommissioning file.

1. Chapman, J. A., "Radiological Survey of the Old Calibration Facility – Building T029," Energy Technology Engineering Center Report, GEN-ZR-0006, August 19, 1988.

    - is the primary document reporting the comprehensive radiological survey of the facility and the surroundings; concludes that the facility is acceptably clean of radioactive materials and recommends further investigation of a below-grade Ra-226 source storage well.

2. Frazier, R. S., "Radiological Decontamination of Building 029," Rockwell International Detailed Working Procedure N001DWP000024, August 23, 1989.

    - sets forth the operational procedures to decontaminate and/or remove the Ra-226 and Co-60 source storage wells in Building T029.

3. Two drawings showing details of the Ra-226 and Co-60 source storage wells in Building T029.

4. Twenty one photographs taken during the decommissioning operations in Building T029.

5. Four "Health and Safety Analysis Report" forms of routing radiation and smear surveys performed as part of the Building T029 decommissioning operations.

6. Nine gamma spectrometry print-outs from the Multichannel Analyzer (MCA) on the four soil samples collected during Building T029 decommissioning operations; of these, four are initial MCA analysis print-outs, and four are duplicate analysis print-outs of the same four samples. The ninth is a third analysis performed on the sample with the lowest weight.

7. Subbaraman, G., "Final Decontamination and Radiological Survey of Building T029," Rockwell International Safety Review Report N704SRR99029, June 1990.

    - A released copy of the report containing this list.