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PROJECT GASBUGGY
RADIATION CONTAMINATION CLEARANCE REPORT

by
Eberline Instrument Corporation
Santa Fe, New Mexico 87501

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ABSTRACT

Project Gasbuggy was the first U.S. underground nuclear experiment for the stimulation of low-productivity natural gas reservoirs.

This report describes the radiological health and safety operations required for site cleanup and restoration to return the site to approximately its original condition. These operations were conducted from August through September of 1978. All equipment on site which was radiologically contaminated during previous gas production test activities was steam decontaminated to well below applicable release criteria and was released for unrestricted use.

The radiological site restoration operations were successful. The radiological area survey indicates that no radiation levels above ambient background remain on-site. Only tritium (^{3}H) in quantities well below criteria remains in the on-site soil as determined by soil sampling.

The quality of the natural environment was improved by the removal of numerous man-made objects, the removal and controlled disposal of the site contaminants, and the sealing from possible release to the environment of a deep underground radiological source.

1. INTRODUCTION

Project Gasbuggy was a cooperative research effort undertaken between El Paso Natural Gas Company (EPNG) and the U.S. Atomic Energy Commission (AEC), now part of the Department of Energy (DOE), and the Department of the Interior's Bureau of Mines with technical assistance from the Lawrence Radiation Laboratory (LRL), now Lawrence Livermore Laboratory (LLL).

Early in 1967 exploration wells GB-1 and GB-2 were completed, and the San Juan Basin site in northwest New Mexico was accepted. (See Figure 1) The nuclear emplacement hole GB-E was started in June of 1967. On December 10, 1967 a 29-kiloton nuclear explosive was detonated at a depth of 4,240 feet in the low-permeability Pictured Cliffs sandstone formation.

After reentry drilling six major production tests were conducted. Two took place in 1968, three in 1969, and the last one 1973. The reentry well, GB-ER, has been shut in since the 1973 productivity test, with only pressure monitoring being conducted and small gas samples periodically taken since that time.

2. PURPOSE

The purpose of this report is to identify the extent of radioactive contamination of site property pursuant to the requirements of ERDA Manual Appendix 5301, to summarize all radiological activities during site restoration and to describe final site radiological conditions.

3. DISPOSAL OF RADIOACTIVE MATERIAL

No burial of radioactive material was made at the Gasbuggy site during the cleanup operation.

Approximately 60.5 barrels of tritium contaminated water and sludge at an average of 1439 pCi/ml and 7.3 barrels of tritium contaminated water and sludge at an average of 350 pCi/ml were pumped from the produced water storage tank which is referred to throughout this document as the "Red Tank" and decon sump, respectively, and injected into the GB-ER cavity before the reentry well was plugged. The tubing and annulus were then flushed with 3 annulus volumes of H_2O. The total tritium content of the injected fluid was 18.7 mCi. The water did not contain other radioactive isotopes above detection limits except naturally occurring radioactive elements. (See Tables 4 and 5.)

Some 400 objects were steam decontaminated, measured for radioactive contamination and found to be within the release limit criteria for unrestricted use. After steam cleaning no material exceeded the release limit for unrestricted use (see Table 8 for release limits).

Items of equipment having inaccessible interiors were flushed with steam until the exiting flush water and accessible area swipes of the item were below release limits. As an additional check, specified in NVO 195, (reference page 30), water was poured through various tubular goods and the exiting water sample was analyzed for tritium. None of these samples approached the 5,000 dpm/ml (2250 pCi/ml) arbitrary limit set as a double check. The 5,000 dpm/ml limit was not selected as a release limit criterion but on the basis that if the item were used as unrestricted radiologically, "clean" water contacting the surfaces of the item would be unlikely to ever exceed the 10 CFR 20 or State of New Mexico Concentration Guides for water in unrestricted areas (3000 pCi/ml). Experience at other sites similar to Gasbuggy had shown that while an item may be cleared radiologically immediately after cleaning, in some cases tritium would be detected after a watering delay of 12-24 hours. In addition these items could not be

cleared under the ANSI Standard because of the inaccessible surfaces and the above discussed test was devised to meet the "case by case basis" requirement as specified in the Standard.

One hundred seventy-five barrels of low level tritium contaminated water from the steam decontamination operation accumulated in the "Red Tank" after the GB-ER wellbore was sealed. The water was subsequently disposed of by vaporization to the atmosphere using the steam generator. The tritium level in this water ranged from 14.7 pCi/ml to 43.7 pCi/ml, and a total of 1.31 mCi was released to the atmosphere over a period of 25 days in September 1978. During the water vaporization and steam decontamination activities, air moisture samples were collected by molecular sieve units around the site (see Figure 4 for location). All of the moisture samples thus collected were less than the lower limit of detection (LLD) for tritium air moisture.

All unused portions of contaminated water and soil samples were placed in a single radioactive waste barrel to be shipped to the Nevada Test Site (NTS) for disposal.

A total of 10 barrels of materials, either known to be slightly radioactive or difficult to make a determination of radioactive content, were sealed, externally steam cleaned, and labeled for shipment as low level radioactive waste. Dry materials were barreled intact and all fluids were mixed with diatomaceous earth and cement before packaging. See Table 7 for a list of barrels and their contents. Nuclides other than tritium and naturally occurring isotopes were not found to be present. The total tritium content of all 10 barrels was less than 1 mCi.

4. PERSONNEL MONITORING AND BIOASSAY

All personnel participating in Gasbuggy cleanup were required to wear thermo-luminescent dosimeter (TLD) badges and to provide baseline and final day urine samples. The exceptions to this were persons who would be on site less than 3 days such as casual visitors and delivery people. TLD's were sent to the Eberline Instrument Corporation (EIC) facility in Santa Fe, New Mexico for readout. No radiation exposure was detected above normal background on the TLD's. The urine samples were analyzed on site. None exceeded the lower limit of detectablility (LLD).

5. RADIATION MONITORING EQUIPMENT

On-site radioactivity measuring equipment during site cleanup consisted of:

a. A Packard Model 2003 liquid scintillation spectrometer was used for tritium analysis. Channel 1 was gated for maximum sensitivity in the tritium beta energy region while channels 2 and 3 were both gated for the full range of beta energies. For this system the LLD was approximately 2 pCi/ml for tritium at 3 σ above background.

b. Portable survey equipment included sensitive gamma detectors (EIC PRM-5 with SPA-2 1x1 Na1 probe), general beta gamma detectors (EIC E-520 with HP-177 GM probe), thin window beta detectors <7 mg/cm^2 (EIC MS-2 and PRM 5-3 with HP-210 probes) and gas proportional alpha detector (EIC PAC-4G with 50 cm^2 AC-21 probe). The thin window beta probe (HP-210) has a sensitivity of 1800 cpm/mrad/hr.

6. PLUGGING AND ABANDOMENT ACTIVITIES

Wells GB-1, GB-2, GB-3 and GB-D were plugged and abandoned without incident.

Since these wells have no history of radioactive contaminations, the operations during abandonment received only minimal radiological support. Swipe samples were taken of equipment used at this time and samples of drilling mud and water used were checked for tritium contamination. Tools and wellhead components were routinely steam cleaned for cosmetic reasons, even though no contamination was encountered.

One sample of mud from the GB-3 abandonment operations indicated 6 pCi/ml of tritium. The activity was suspected to be the result of natural thorium daughters from drilling mud chemicals, and a second analysis by distillation showed <LLD for tritium. The mud contained a large amount of paraffin (a four inch layer in the mud tank). The entire mix of water, mud and paraffin was buried on site. See Figure 11 for location of this burial, labeled C.

The abandonment of GB-1, GB-2, GB-3 and GB-D wells was completed and the rig was moved to GB-ER.

Prior to the removal of the wellhead, a moisture sample was collected by passing gas from the GB-ER production tubing through a molecular sieve for several hours. This sample read 11,508 pCi/ml of tritium in gas borne moisture. Gas samples were not taken and evaluated for tritium content of the gas itself due to insufficient pressure for the small gas sample bottles available.

From the time work began on GB-ER, all personnel involved wore necessary protective clothing and continual radiological surveillance was established.

No personnel contamination occurred during the abandonment work on GB-ER and only minimal contamination of equipment and tools was encountered.

The McCullough wire line used for inserting the GB-ER casing plus was bundled for shipment as low level waste because decontamination was impractical due to the braided construction of the cable.

All pipe and tubing used during the abandonment of GB-ER were steam decontaminated and sent to DOE for use at NTS. The rig and tools were steam decontaminated and returned to their owners. All trucks were monitored and the wire line truck and rig were steam decontaminated. All swipes of steam cleaned equipment, trucks and tools were found to be below the release criteria.

7. DECONTAMINATION ACTIVITIES

The only decontamination method employed was steam cleaning. A decontamination pan was installed on a graded 3° slope adjacent to the steam generator and a controlled area was established around the pan using yellow rope and appropriate radiation warning signs. All decontamination work occurred within this controlled area. (See Figure 4)

A second controlled area was established to receive the released items. Within this area items were segregated as to ownership, i.e., DOE or EPNG. A third segment of this area was established for the storage of contaminated material barrels slated for shipment to NTS for burial as low level radioactive waste.

A log of all material released and stored in this area was maintained. A total of 425 items ranging from boxes of nuts and bolts to gas/liquid separators were checked (see Section V Procedures Supplement for the Radiological Field Operations Plan, NVO 195, for analytical methods employed) and found to be below the release criteria and were released for unrestricted use. Although all items subjected to the initial steam decontamination were below the release criteria, a few selected items were steam

decontaminated a second time and indeed showed somewhat lower levels of activity. It was felt that the added time and effort to do this for all items was not worth the cost at these initial low levels of activity.

8. SITE SAMPLING AND SURVEY ACTIVITIES

To delineate the extent of radioactive contamination of the Gasbuggy site numerous environmental samples were collected and analyzed.

No radionuclides other than tritium or those naturally occurring were encountered during the Gasbuggy cleanup operation.

The tritium levels encountered were found to be well below all applicable release criteria as specified in NVO-195 (see Table 8). The highest level of tritium found was in a soil sample which contained a tritium concentration of 1,303 pCi/ml of soil moisture. This represents less than 5% of the release criteria (see Table 8).

a. Surface Soil Samples

In the first 3 weeks of October 1973 EPNG carried out a soil sampling survey of the Gasbuggy site. They sampled at a dpth of 24 inches on a 50 foot grid over the entire fenced area. This grid used the GB-ER as the 0 point with true North-South as the vertical and true East-West the horizontal. Their findings were made available and appreciation is hereby acknowledged as it greatly assisted the final cleanup effort.

Site soil sampling points were set up similarly on a 50 foot grid with a sampling depth of 12 inches and was offset from EPNG sampling locations by shifting the 0 point 25 feet North and 25 feet East or 35.36 feet NE of GB-ER Vertical is true North-South and horizontal true East-West. The sampling grid was accurately surveyed using the GB-ER as a permanent reference.

One-hundred sixty-five (165) soil samples were taken and only 9 exceeded the lower limit of detectability (LLD). The LLD for tritium in soil was 2 pCi/ml at 3σ above background. See Table 1 for results and Figure 4 for locations.

b. Profile Soil Samples

The surface soil sample results guided selections of sampling points for the profile sets. The highest readings were selected first, 12 locations on site and 9 locations off site for an initial total of 21 locations (see Figure 5 for sample locations). The results from these determined the selections of 8 more locations and the need to go deeper than the original 6 feet at a few of the first 21 locations. From the results of these last 8 it was determined that 5 more locations would need to be sampled to completely define the extent and quantity of subsurface contamination. During the cleanup, advantage was taken of 3 operational holes which were dug to obtain three random profile sets.

Of the total of 32 profile sets 15 had readings of > 10 pCi/ml at all depths. Two had only one reading > 10 pCi/ml but < 50 pCi/ml while 15 had positive readings ranging from 10 to 1303 pCi/ml at all levels. See Figure 5 for locations, Table 2 and Figures 6, 7, 8 and 9 for results.

Profile #1 located at Grid W1, 0 near where the separators were located, and #22 at E1N1 + N 10' and W 18' and #23 at E1N1 + N 16' and 33' where the pump shack and red tank were located, were the only two locations of potential contamination not directly associated with the flare stack and steamer shack. The other 12 positive profiles were all in the flare stack and steam shed area and were

used to define the extent of the the soil contamination there. Profiles #11, 15, 16, 17, 25, 26 & 27 were located North of the flare stack, and Profiles #13, 14, 18 & 24, West and South of the flare stack. Profile #24 at E3, N2 + 45' N 17' W contained the highest concentrations found on site at a depth of 4 feet and was felt to be the center of the major contributions to the subsurface contamination in this area. The total size of this area is about 5000 ft^2. The depth varied in part because of an old solid mud barrier at 5 feet in a portion of this area. Penetration of this barrier in two locations yielded soil samples that contained no detectable tritium. An average depth for this 5000 ft^2 area was then felt to be about 5 feet. Using weighted averages and conservative assumptions the total activity in this mass is estimated to be less than 8 mCi tritium.

The two areas represented in Profile #1 and #'s 22 and 23 were much smaller being about 50 ft^2 and 150 ft^2, respectively, and contribute only a maximum of 0.36 mCi to the total tritium activity left in the Gasbuggy soil.

The highest level of activity found during the 1973 EPNG survey of the Gasbuggy site was 11,200 pCi/ml of soil moisture at a depth of 4 feet from a profile set near the Flare Stack. This sample was taken October 10, 1973.

The highest level soil sample was taken very close to this spot on September 19, 1978, also from profile set (#24) and at a depth of 4 feet. It read 1,303 pCi/ml of soil moisture.

c. Operational Soil Samples

A number of soil samples were taken in support of the cleanup whenever a hole needed to be dug or the soil disturbed. These samples indicated that no hazard to personnel from tritium existed during these operations.

A final surface soil survey was conducted to determine that the cleanup operation itself made no contribution to the surface contamination of the site. Forty-five (45) samples were taken in locations selected because there were cleanup related activities in these areas.

The sampling method employed was to remove man made and vegetative material from the surface and then take 100 cm^2 of soil to a sufficient depth to assure enough moisture for a soil moisture by distillation analysis. Twenty-seven (27) of the samples were $<$LLD, 15 were between 2 and 10 pCi/ml and only 3 were $>$ 10 pCi/ml. All three of these fell in areas of known previous contamination.

a. Under the Steamer Shack 60.7 pCi/ml;

b. Around the Steamer Shack 63.1 pCi/ml;

c. Six feet East of GB-ER 17.3 pCi/ml;

d. Operational Water Samples

Water samples were collected in support of the cleanup operation. The source of site water was a spring located about 5 miles from the site. Samples of this water indicated $<$LLD of tritium. Water used to circulate mud and gel in GB-ER was periodically sampled and typically falsely indicated about 6 pCi/ml tritium after mixing with mud most probably due to natural isotopes in the mud itself. This was verified when samples were distilled.

Sludge samples were treated as water samples. Samples from the red tank sludge, separators, flare line, water line and numerous pour through samples were processed. Samples were taken both before and after decontamination

efforts. The highest tritium water sample reading was 38,000 pCi/ml associated with sludge from the bottom of the red tank which became a part of barrel #1 to be shipped to NTS for burial.

e. Beta Gamma Survey

The site was beta-gamma surveyed after all the site activity was complete with the exception of the reseeding. A portable thin window <7 mg/cm^2 pancake geiger counter PRM-5-3 (EIC HP-210 probe), SN 1987, calibrated 8/10/78 was used. A 30 second count was made at each of the soil sampling locations, as shown in Figure 4, by holding the counter just a few centimeters above the ground. All readings were $<.05$ mrad/hr for beta/gamma. Average probe background was approximately .036 mrad/hr. away from site.

f. Additional Analysis

Additional analysis was provided by off-site EIC laboratories. Strontium-90 quantification on 8 samples and one sample for plutonium were performed by the EIC Albuquerque facility. Other isotopic identification was made on 8 samples by GeLi detector at the midwest facility. Results are in Tables 4 and 5.

g. Vegetation Samples

Six (6) vegetation samples were collected and submitted to the U.S. Environmental Protection Agency, Las Vegas, Nevada 89114 for analysis. Results appear in Table 6. The results were consistent with soil samples taken in the various areas. The vegetation samples represented quite a large area compared with soil samples due to the sparsity of available vegetation to obtain a required sample weight.

h. Quality Control

Quality control was maintained by using NBS standards and following standard laboratory practices of using blanks and duplicate samples.

9. DISPOSITION OF OTHER SITE MATERIALS

The site contained an unused concrete decontamination pad at the end of which was a plastic lined sump. This pad and several concrete trailer parking pads were broken up and buried in the enlarged unused decontamination sump. The sump was back filled and the area brought to natural grade. Swipe samples of the concrete pieces read $<$LLD in β activity and $<$LLD in tritium activity. Soil samples taken in the sump also read $<$LLD for tritium. These samples confirm that it was an unused decontamination pad and sump. No radioactive material was disposed of in this burial. See Figure 11 Area B for this location.

Mud and gel loaded water used during the various milling and plugging operations was buried at 3 separate locations. Samples of this material falsely read about 6 pCi/ml tritium. Samples after distillation were $<$LLD indicating the 6 pCi/ml was due to naturally occurring thorium daughters associated with drilling mud. See Figure 11 areas A, C & D for locations of these burials.

The past history of the samples taken from the Gasbuggy ground zero site, the numerous samples analyzed for beta and gamma emitters during this operation, the beta-gamma survey of the site itself and samples sent to other laboratories for detailed analyses confirms that tritium is the only radioactive isotope, other than naturally occurring radioactive istopes and worldwide fallout to be found in the Gasbuggy soil at this time.

10. CONCLUSIONS

No beta-gamma radionuclides other than tritium or naturally occurring radioisotopes were found during the Gasbuggy cleanup. No plutonium was found in "Red Tank" residue.

Only low levels of tritium were detected in soils and none in air or urine.

No exposure above natural background amounts resulted to personnel during the cleanup operations.

All equipment contaminated during gas production testing in the past and equipment used during the cleanup operations was decontaminated to well below release criteria and was released for unrestricted use.

It should be noted that the average concentrations of tritium remaining after this cleanup operation are small fractions of the RCG levels of 10 CFR 20 and DOE manual chapters. This cleanup therefore reflects the best effort of all parties to reduce contaminants to the lowest practicable level.

TABLE 1
Surface Soil Samples (12" to 14")

No.	Grid Location	Depth	Soil Moisture ^{3}H pCi/ml
1	W3 N9	1 ft.	5.2
2	W1 0	1 ft.	965
3	W1 0 + 25'	1 ft.	5.3
4	0 N2	1 ft.	20
5	E1 N3	1 ft.	16
6	E1 N4	1 ft.	23.5
7	E2 S3	1 ft.	8
8	E2 N3	1 ft.	20.4
9	E3 N3	1 ft.	8.6

All other, 12" to 14" soil samples were < LLD (2pCi/ml @ 3σ counting error for Tritium)

165 total, 12" to 14" soil samples were taken.

TABLE 2

Profile Soil Sample Sets

Hole No.	Grid Location	Depth	Soil Moisture ^3H pCi/ml
1	W1 N0	1 ft.	154
"	"	2 ft.	180
"	"	3 ft.	234
"	"	4 ft.	232
"	"	5 ft.	249
"	"	6 ft.	558
2	W6 S3	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD
3	W3 N4	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD
4	W2 N9	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD
5	E4 N9	1 ft.	< LLD
"	"	2 ft.	*(RC < LLD) 2.3
"	"	3 ft.	(RC < LLD) 1.9
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD

*RC means Recount (LLD 2pCi/ml @ 3σ counting error for Tritium).

TABLE 2 (Continued)
Profile Soil Sample Sets

Hole No.	Grid Location	Depth	Soil Moisture ^3H pCi/ml
6	E1 N9	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD
7	E3 N7	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD
8	E6 N4	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD
9	223 yds S of GB-ER on Grid E2	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD
10	E3 N5	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD

(LLD 2pCi/ml @ 3σ counting error for Tritium)

TABLE 2 (Continued)
Profile Soil Sample Sets

Hole No.	Grid Location	Depth	Soil Moisture ^3H pCi/ml
11	E1 N5	1 ft.	13.3
"	"	2 ft.	< LLD
"	"	3 ft.	2.0
"	"	4 ft.	< LLD
"	"	5 ft.	1.8
"	"	6 ft.	1.6
12	E4 N2	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	2.6
"	"	6 ft.	13.4
13	E2 N3	1 ft.	52.0
"	"	2 ft.	31.7
"	"	3 ft.	331
"	"	4 ft.	131
"	"	5 ft.	919
"	"	6 ft.	980
"	"	6 ft.	6.8
"	"	7 ft.	< LLD
"	"	8 ft.	< LLD
14	E3 N3	1 ft.	39.9
"	"	2 ft.	135
"	"	3 ft.	311
"	"	4 ft.	422
"	"	5 ft.	282
"	"	6 ft.	83
15	E2 N4	1 ft.	3.2
"	"	2 ft.	10.2
"	"	3 ft.	23.1
"	"	4 ft.	39.1
"	"	5 ft.	34.3
"	"	6 ft.	18.8

(LLD 2pCi/ml @ 3σ counting error for Tritium)

TABLE 2 (Continued)
Profile Soil Sample Sets

Hole No.	Grid Location	Depth	Soil Moisture ^{3}H pCi/ml
16	E3 N4	1 ft.	9.8
"	"	2 ft.	8.6
"	"	3 ft.	12.2
"	"	4 ft.	10.1
"	"	5 ft.	16.2
"	"	6 ft.	18.8
"	"	9 ft.	71.5
"	"	10 ft.	72.2
"	"	11 ft.	71.2
"	"	12 ft.	73.3
17	E1 N4	1 ft.	22.3
"	"	2 ft.	74.3
"	"	3 ft.	117.2
"	"	4 ft.	79.4
"	"	5 ft.	24.0
"	"	6 ft.	6.1
18	E1 N3	1 ft.	6.7
"	"	2 ft.	20.4
"	"	3 ft.	23.5
"	"	4 ft.	30.7
"	"	5 ft.	24.1
"	"	6 ft.	14.3
19	0 N2	1 ft.	4.7
"	"	2 ft.	7.1
"	"	3 ft.	6.6
"	"	4 ft.	5.2
"	"	5 ft.	3.0
"	"	6 ft.	< LLD
20	E6 S1	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD

(LLD 2pCi/ml @ 3σ counting error for Tritium)

TABLE 2 (Continued)
Profile Soil Sample Sets

Hole No.	Grid Location	Depth	Soil Moisture ^{3}H pCi/ml
21	W1 N1	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD
22	E1 N1 + 10' N 18' W	1 ft.	9.3
"	"	2 ft.	7.4
"	"	3 ft.	6.9
"	"	4 ft.	7.3
"	"	5 ft.	23.7
"	"	6 ft.	99
"	"	7 ft.	298
"	"	8 ft.	218
23	E1 N1 + 16' N 33' W	1 ft.	2.7
"	"	2 ft.	6.8
"	"	3 ft.	10.2
"	"	4 ft.	10.8
"	"	5 ft.	34.9
"	"	6 ft.	49.9
"	"	7 ft.	69.2
"	"	8 ft.	59.6
24	E3 N2 + 45' N 17' W	1 ft.	49.3
"	"	2 ft.	135
"	"	3 ft.	434
"	"	4 ft.	1303
"	"	5 ft.	578
"	"	6 ft.	385
"	"	7 ft.	186
"	"	8 ft.	86.9

(LLD 2pCi/ml @ 3σ counting error for Tritium)

TABLE 2 (Continued)
Profile Soil Sample Sets

Hole No.	Grid Location	Depth	Soil Moisture ^{3}H pCi/ml
25	E3 N3 + 27' N 14' W	1 ft.	16.2
"	"	2 ft.	6.6
"	"	3 ft.	25.3
"	"	4 ft.	61.5
"	"	5 ft.	158
26	E2 N3 + 19' N 7' W	1 ft.	3.2
"	"	2 ft.	3.4
"	"	3 ft.	6.4
"	"	4 ft.	15.5
"	"	5 ft.	35.1
27	E2 N3 + 32' N 9' E	1 ft.	4.9
"	"	2 ft.	13.0
"	"	3 ft.	10.6
"	"	4 ft.	31.5
"	"	5 ft.	52.5
28	E3 N2 + 21' N 11' W	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	2.5
"	"	7 ft.	< LLD
"	"	8 ft.	< LLD
29	E2 N2 + 21' E	1 ft.	< LLD
"	"	2 ft.	2.2
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	< LLD
"	"	6 ft.	31.5
"	"	7 ft.	< LLD
"	"	8 ft.	< LLD

(LLD 2 pCi/ml @ 3σ counting error for Tritium)

TABLE 2 (Continued)
Profile Soil Sample Sets

Hole No.	Grid Location	Depth	Soil Moisture ^{3}H pCi/ml
30	E2 N2	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	3.2
"	"	5 ft.	< LLD
"	"	6 ft.	< LLD
"	"	7 ft.	< LLD
"	"	8 ft.	4.9
33	E4 N3 + 38' N 19' W	1 ft.	< LLD
"	"	2 ft.	< LLD
"	"	3 ft.	< LLD
"	"	4 ft.	< LLD
"	"	5 ft.	3.7
"	"	6 ft.	6.9
"	"	7 ft.	5.1
"	"	8 ft.	3.2
Rerun 1	W1 NO	1 ft.	74.5
"	"	2 ft.	69.3
"	"	3 ft.	60.7
"	"	4 ft.	126
"	"	5 ft.	164
"	"	6 ft.	121
"	"	7 ft.	112
"	"	8 ft.	63.9
"	"	9 ft.	40.4
"	"	10 ft.	24.7
Rerun 12	E4 N2	1 ft.	3.8
"	"	2 ft.	9.2
"	"	3 ft.	4.2
"	"	4 ft.	7.8
"	"	5 ft.	33.1
"	"	6 ft.	42.3
"	"	7 ft.	44.9
"	"	8 ft.	31.3

(LLD 2 pCi/ml @ 3σ counting error for Tritium)

TABLE 2 (Continued)
Profile Soil Sample Sets

Hole No.	Grid Location	Depth	Soil Moisture ^{3}H pCi/ml
Rerun 13	E2 N3	1 ft.	15.7
"	"	2 ft.	38.1
"	"	3 ft.	83.2
"	"	4 ft.	34.6
"	"	5 ft.	181
Rerun 16	E3 N4	1 ft.	9.7
"	"	2 ft.	4.6
"	"	3 ft.	8.3
"	"	4 ft.	10.5
"	"	5 ft.	12.0
"	"	6 ft.	31.2
"	"	7 ft.	53.4
"	"	8 ft.	54.1

TABLE 3
POST OPERATIONAL SURFACE SOIL SAMPLES

Sample Number	Collection Date	Site Location	Soil Moisture ^{3}H pCi/ml
1	9/23/78	Near Red Tank and Pump Shack	< LLD
2	"	"	3.3
3	"	"	< LLD
4	"	"	< LLD
5	"	"	< LLD
6	"	"	< LLD
7	"	Along waterline from Red Tank	< LLD
8	"	"	< LLD
9	"	Along gas lines	< LLD
10	"	"	< LLD
11	"	"	< LLD
12	"	"	< LLD
23	"	Along old flare line	< LLD
24	"	"	< LLD
25	"	"	< LLD
26	"	"	< LLD
27	"	"	< LLD
28	"	"	< LLD
29	"	Around new operational	< LLD
30	"	location of Red Tank	3.0
31	"	and Decon Pan	< LLD
32	"	"	< LLD
33	"	"	1.7
34	"	"	10.5
35	"	"	4.0
36	"	"	3.9
37	"	"	2.6
38	"	"	2.4
39	"	"	1.8

See Figure 10 for location

(LLD 2 pCi/ml @ 3σ counting error for Tritium)

TABLE 3 (Continued)
POST OPERATIONAL SURFACE SOIL SAMPLES

Sample Number	Collection Date	Site Location	Soil Moisture ^{3}H pCi/ml
40	9/23/78	Around Steamer Shack	5.9
41	"	"	6.6
42	"	"	2.9
43	9/25/78	Around Steamer Shack	63.1
44	"	Under Steamer Sump	60.7
13	"	Where the separators sat	< LLD
14	"	"	< LLD
15	"	"	< LLD
16	"	"	2.5
17	"	"	< LLD
18	"	"	< LLD
19	"	6'N from GBER	< LLD
20	"	6'E from GBER	17.3
21	"	6'S from GBER	2.1
22	"	6'W from GBER	< LLD
46	"	At GBER	7.8
45	"	2.5' Under Steamer Sump	280

(LLD 2pCi/ml @ 3σ counting error for Tritium)

TABLE 4
DETERMINATION of STRONTIUM-90 and Plutonium-238 & 239 in SOIL SAMPLES

Sample Identification	Date Collected	Total Weight (g) Wet	Dry	pCi/g (dry) Pu-238	Pu-239	Sr-90
Red Tank sludge GB-428-23-1145 851 #95	8/23/78	307.5	278.5	0.00 ± 0.02	0.00 ± 0.02	< 0.07
Separator H^20 + Sludge	8/31/78		.300	N/A	N/A	< 14.3
Forestry Rd #357 Distance from site - 4.4 miles Distance from Highway 64 - 4.4 miles - 1 ft. depth soil at windmill		1150.4	1086.0	N/A	N/A	< 0.06
Forestry Rd #357 Distance from site - 4.4 miles Distance from Highway 64 - 4.4 miles - 2 ft. depth soil at windmill		1057.4	982.5	N/A	N/A	< 0.05

TABLE 4 (*Continued*)
DETERMINATION OF STRONTIUM-90 AND
Plutonium-238 & 239 in Soil Samples

Sample Identification	Date Collected	Total Weight (g) Wet	Dry	pCi/g (dry) Pu-238	Pu-239	Sr-90
1 ft. depth grid West 1 - North 0 Hole #1	9/11/78	178.4	152.0	N/A	N/A	< 0.03
4 ft. depth Hole #24	9/19/78	209.1	191.0	N/A	N/A	< 0.12
5 ft. depth Hole #1 grid West 1-North 0	9/19/78	388.3	331.0	N/A	N/A	< 0.04
Sludge from Decon Sump & Red Tank to be pumped down GB-ER	8/30/78	Liquid total Vol. 148 ml		N/A	N/A	< 12.3 pCi/l

N/A - Not Analyzed

TABLE 5
Gamma Emitting Isotopes in Site Samples

Sample Identification	Nuclide	pCi/l ± 2σ	pCi/g ± 2σ
Separator, water & sludge	Pb-212	200 ± 30	
	Pb-214	300 ± 40	
	Tl-208	< 50	
	Bi-214	< 50	
	Bi-212	< 300	
	Ac-228	< 100	
	K-40	750 ± 300	
	Cs-137	< 80	
Sludge from decon sample red tank to be pumped down GB-ER	Pb-212	400 ± 50	
	Pb-214	300 ± 50	
	Tl-208	200 ± 20	
	Bi-214	300 ± 50	
	Bi-212	< 400	
	Ac-228	100 ± 20	
	K-40	2000 ± 500	
	Cs-137	< 50	
Red Tank Sludge GB-428-23-1145 851 #95	Pb-212		0.6 ± 0.1
	Pb-214		0.4 ± 0.1
	Tl-208		< 0.3
	Bi-214		< 0.3
	Bi-212		< 2.0
	Ac-228		< 0.3
	K-40		< 2.0
	Cs-137		< 0.2
Forestry Road #357 Distance from site - 4.4 miles Distance from Hwy 64 - 4.4 miles 1 ft. depth soil at windmill	Pb-212		2.0 ± 1.0
	Pb-214		2.0 ± 1.0
	Tl-208		0.5 ± 0.1
	Bi-214		0.8 ± 0.2
	Bi-212		< 1.0
	Ac-228		< 0.2
	K-40		32 ± 5
	Cs-137		< 0.1

TABLE 5 (Continued)
Gamma Emitting Isotopes in Site Samples

Sample Identification	Nuclide	pCi/1 ± 2σ	pCi/g ± 2σ
Forestry Road #357	Pb-212		0.7 ± 0.2
Distance from site - 4.4 miles	Pb-214		0.4 ± 0.2
Distance from Hwy 64 -	Tl-208		< 0.3
4.4 miles	Bi-214		0.6 ± 0.2
2 ft. depth soil at windmill	Bi-212		< 2.0
	Ac-228		< 0.3
	K-40		20 ± 4
	Cs-137		< 0.2
1 ft. depth grid	Pb-212		0.7 ± 0.2
West 1 North 0, Hole #1	Pb-214		0.7 ± 0.2
	Tl-208		< 0.4
	Bi-214		0.6 ± 0.2
	Bi-212		< 1.0
	Ac-228		< 0.3
	K-40		41 ± 6
	Cs-137		< 0.2
4 ft. depth, Hole #24	Pb-212		3.0 ± 1.0
	Pb-214		2.0 ± 1.0
	Tl-208		1.2 ± 0.4
	Bi-214		0.4 ± 0.2
	Bi-212		< 2.0
	Ac-228		< 0.3
	K-40		41 ± 10
	Cs-137		< 0.2
5 ft. depth, Hole #1	Pb-212		0.9 ± 0.2
grid West 1 - North 0	Pb-214		< 0.2
	Tl-208		< 0.2
	Bi-214		0.2 ± 0.1
	Bi-212		< 1.0
	Ac-228		< 0.2
	K-40		10 ± 2
	Cs-137		< 0.1

TABLE 6
Environmental Vegetation Sample Results

Vegetation Samples

Collection Date	Location	Total Tritium* pCi/ml Water
9/20/78	S. Side of Road	2.8 ± 0.5
9/20/78	N. Side of Road	<3.2 ± 0.5
9/21/78	Red Tank Area	10.4 ± 0.3
9/21/78	Separator Area	7.7 ± 0.3
9/21/78	Stack Area	470 ± 2.6
9/21/78	Profile Hole #16	7.2 ± 0.6

*Free water and Organically bound

TABLE 8
Gasbuggy Site Clearance Criteria

Surface Water	
Tritium	300 pCi/ml
Buildings, Equipment & Materials	
Tritium (Non-removable)	5,000 pCi/100 cm^2
Tritium (Removable)	1,000 pCi/100 cm^2
Soil	
Tritium only	30,000 pCi/ml Soil Moisture
Beta-Gamma (Including worldwide fallout)	0.05 mrad/hr Beta-Gamma (Measured at 1 cm)

Reference:
DOE Appendix 0524 Annex A Table 2 and ANSI 328-1976 (Table 1 of 2) and NVO-195 Project Gasbuggy Well Plugging and Site Restoration Plan Section V.

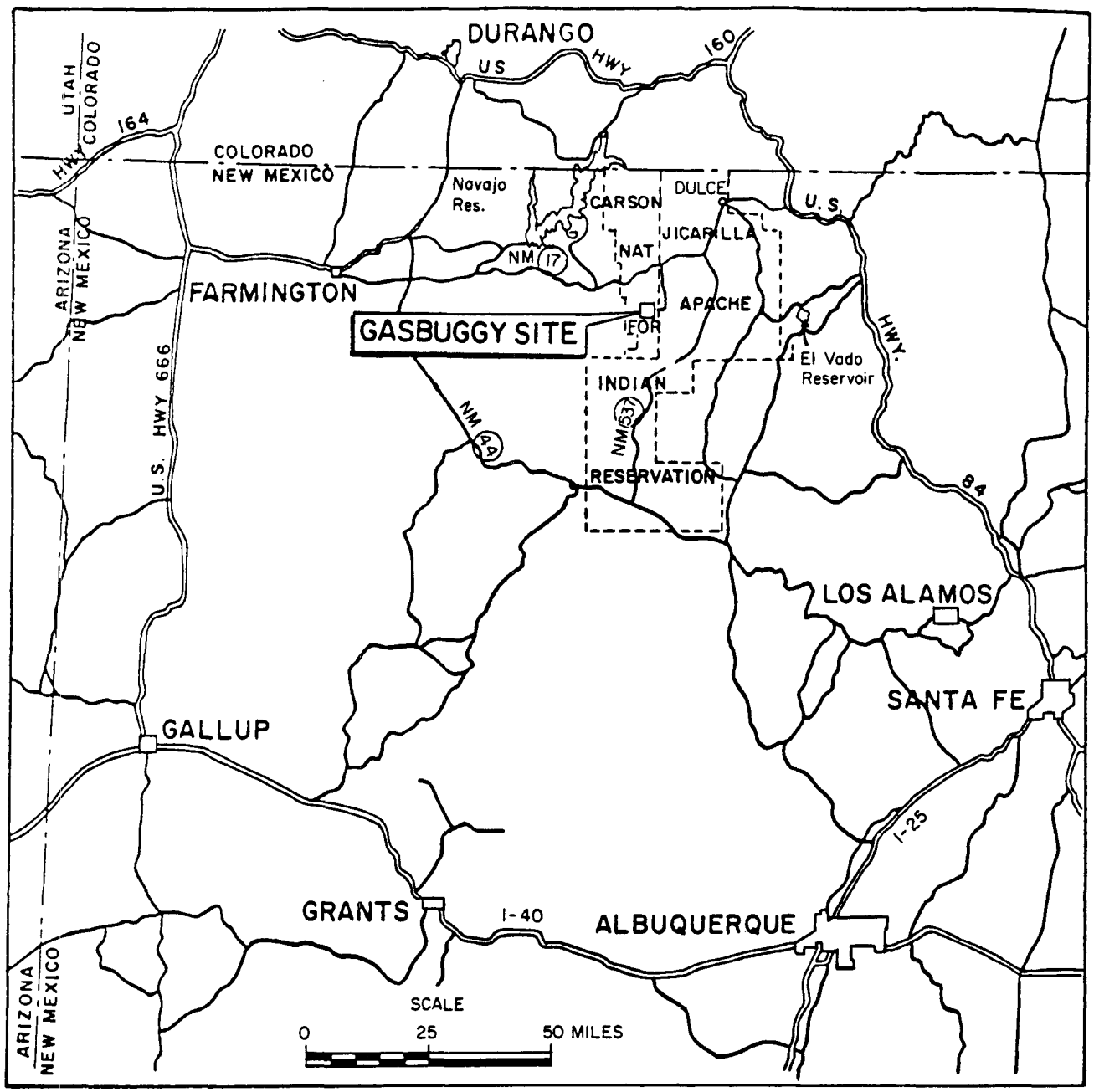


Figure 1 Project Gasbuggy Site Location Map

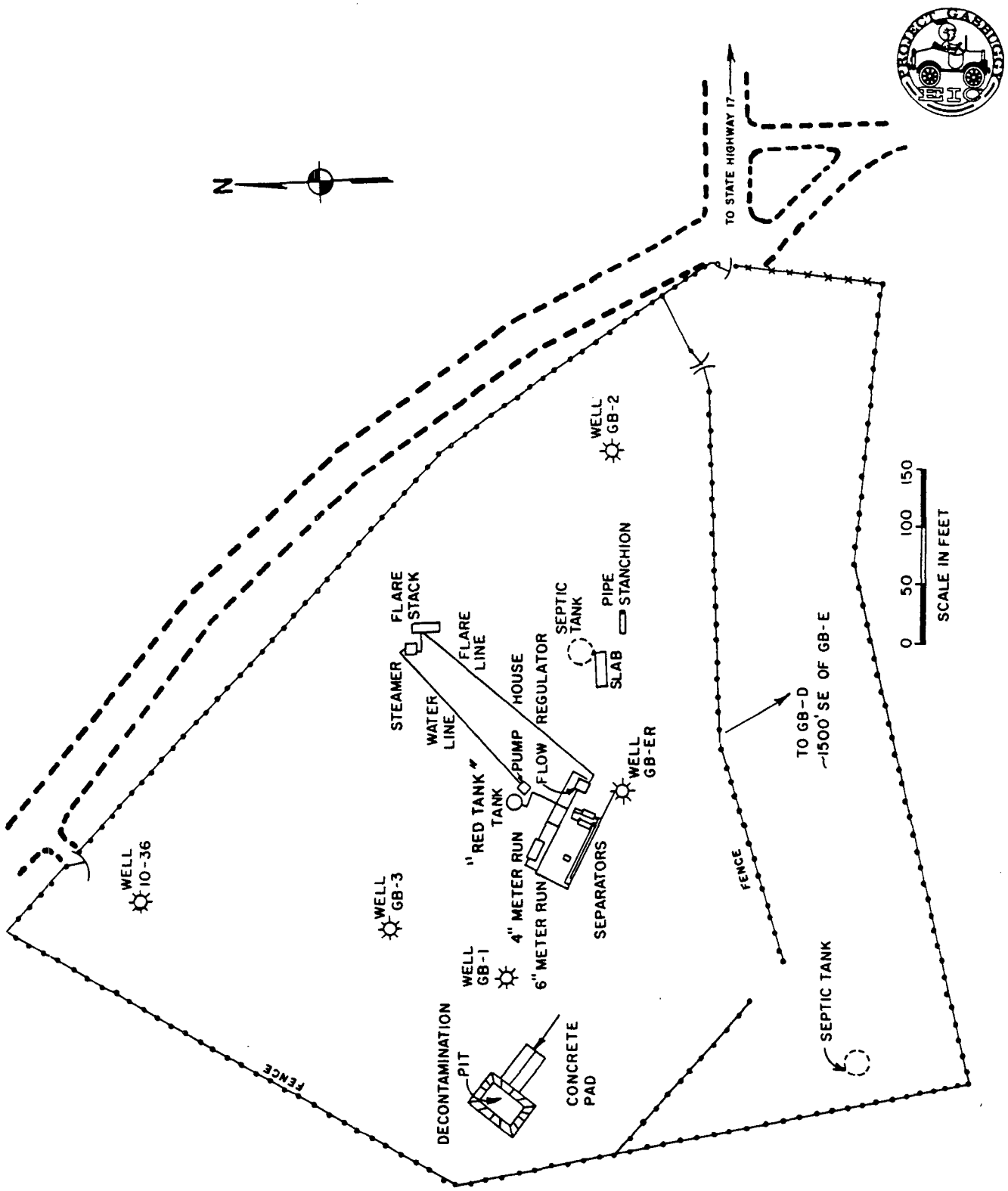


Fig. 2 PROJECT GAS BUGGY GROUND ZERO (GZ) AREA
STATUS AS OF DECEMBER 1976 PRE-CLEAN UP

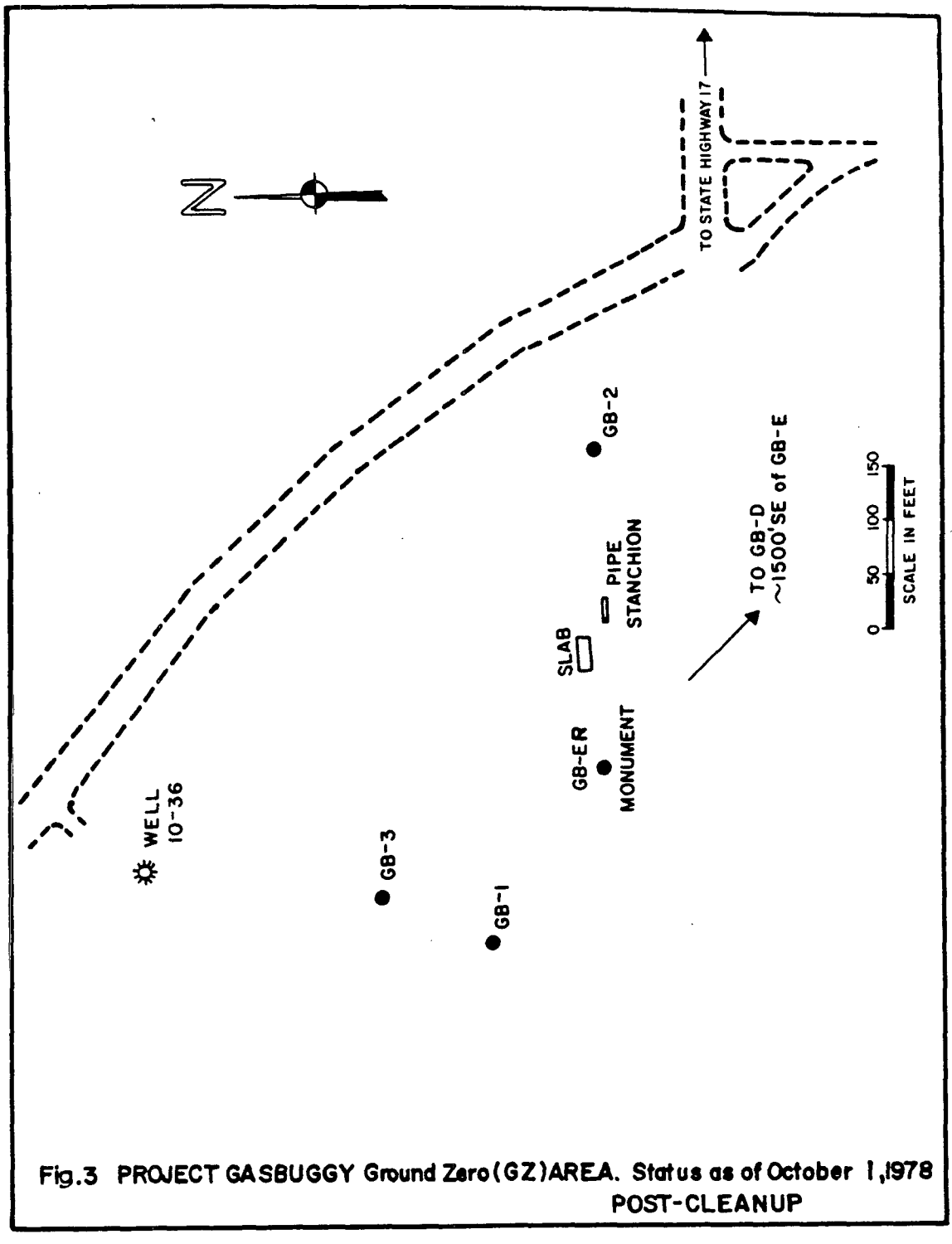


Fig.3 PROJECT GASBUGGY Ground Zero (GZ) AREA. Status as of October 1, 1978
POST-CLEANUP

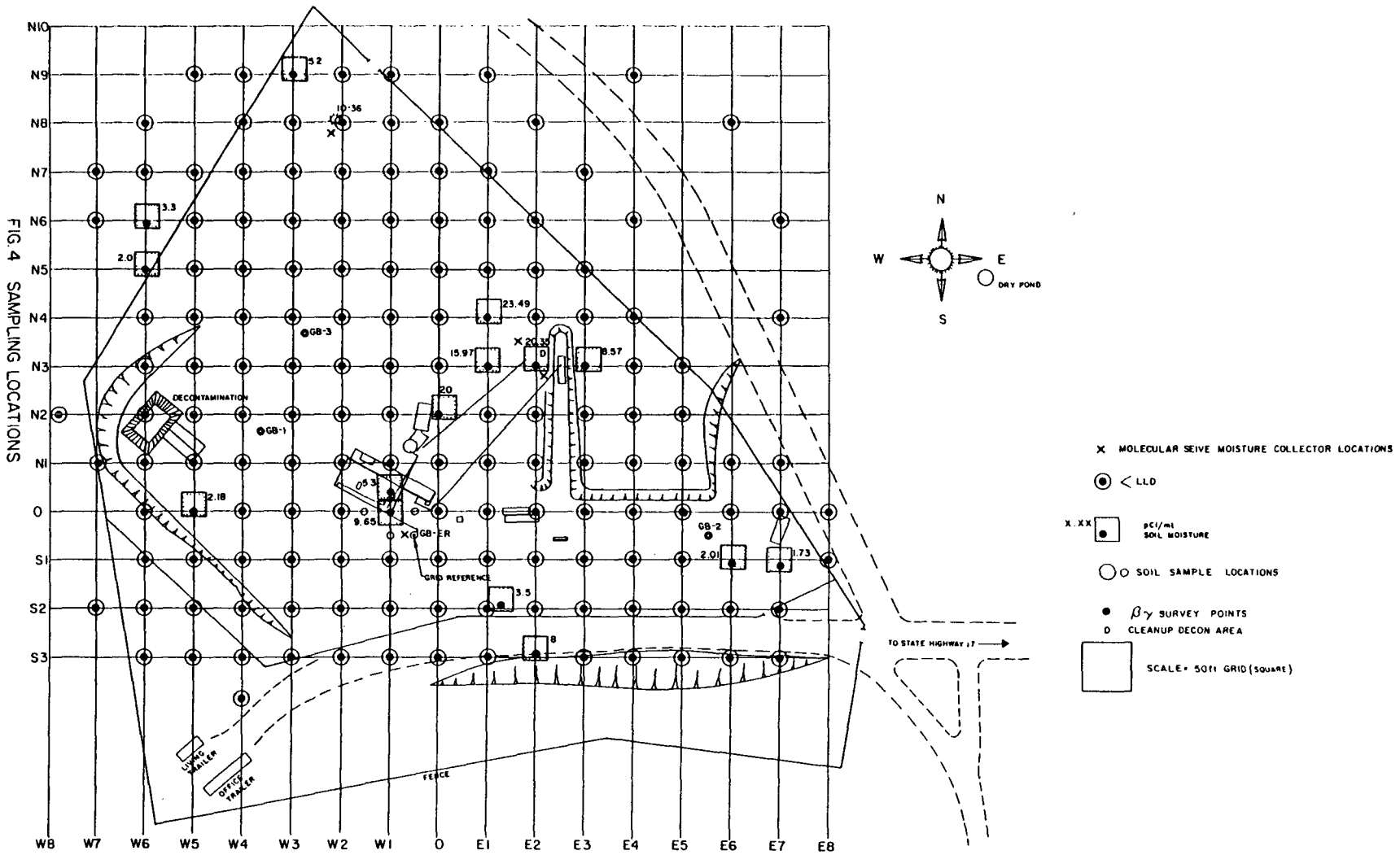


FIG. 4 SAMPLING LOCATIONS

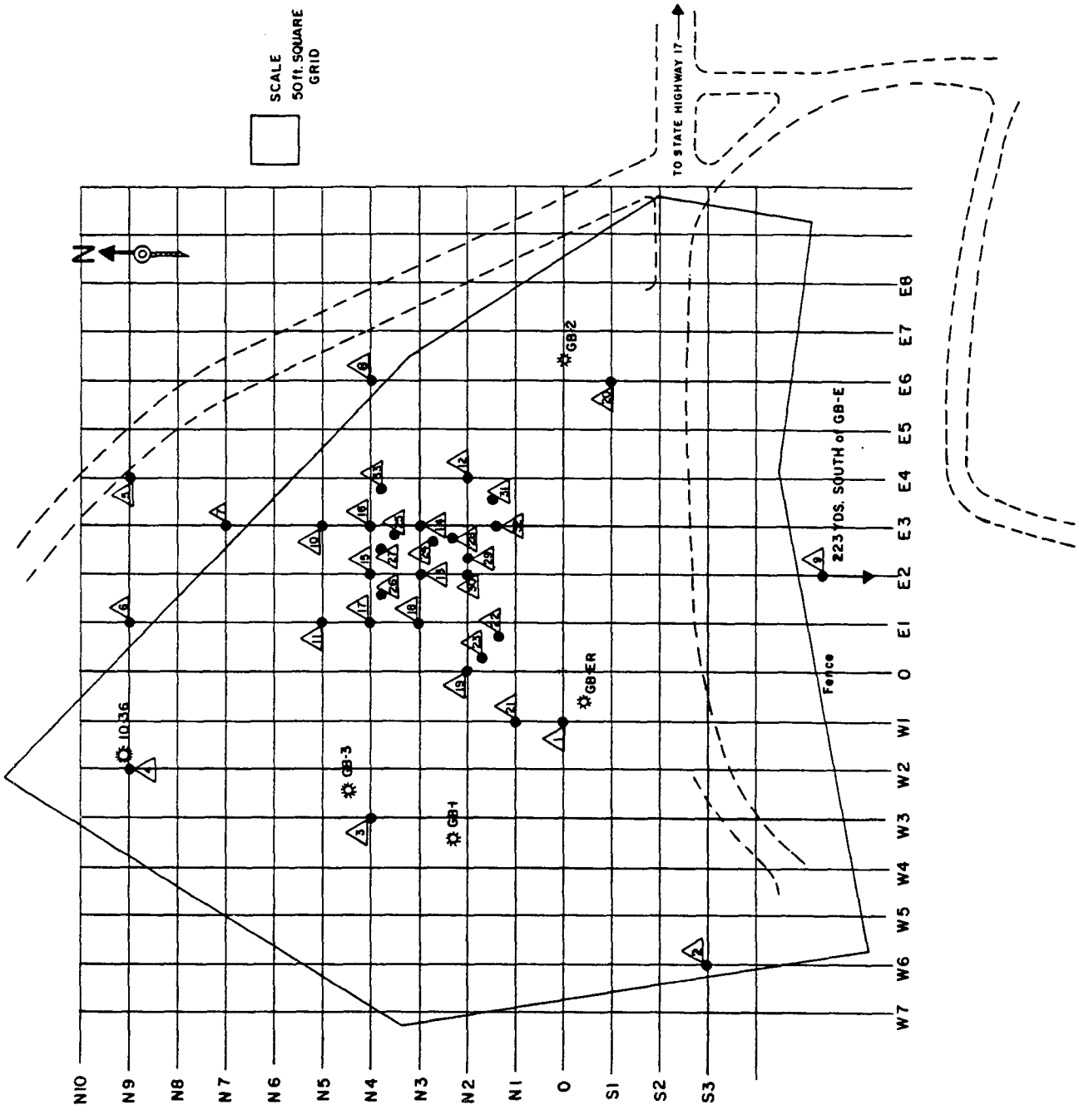


Fig. 5 PROFILE SOIL SAMPLE LOCATIONS

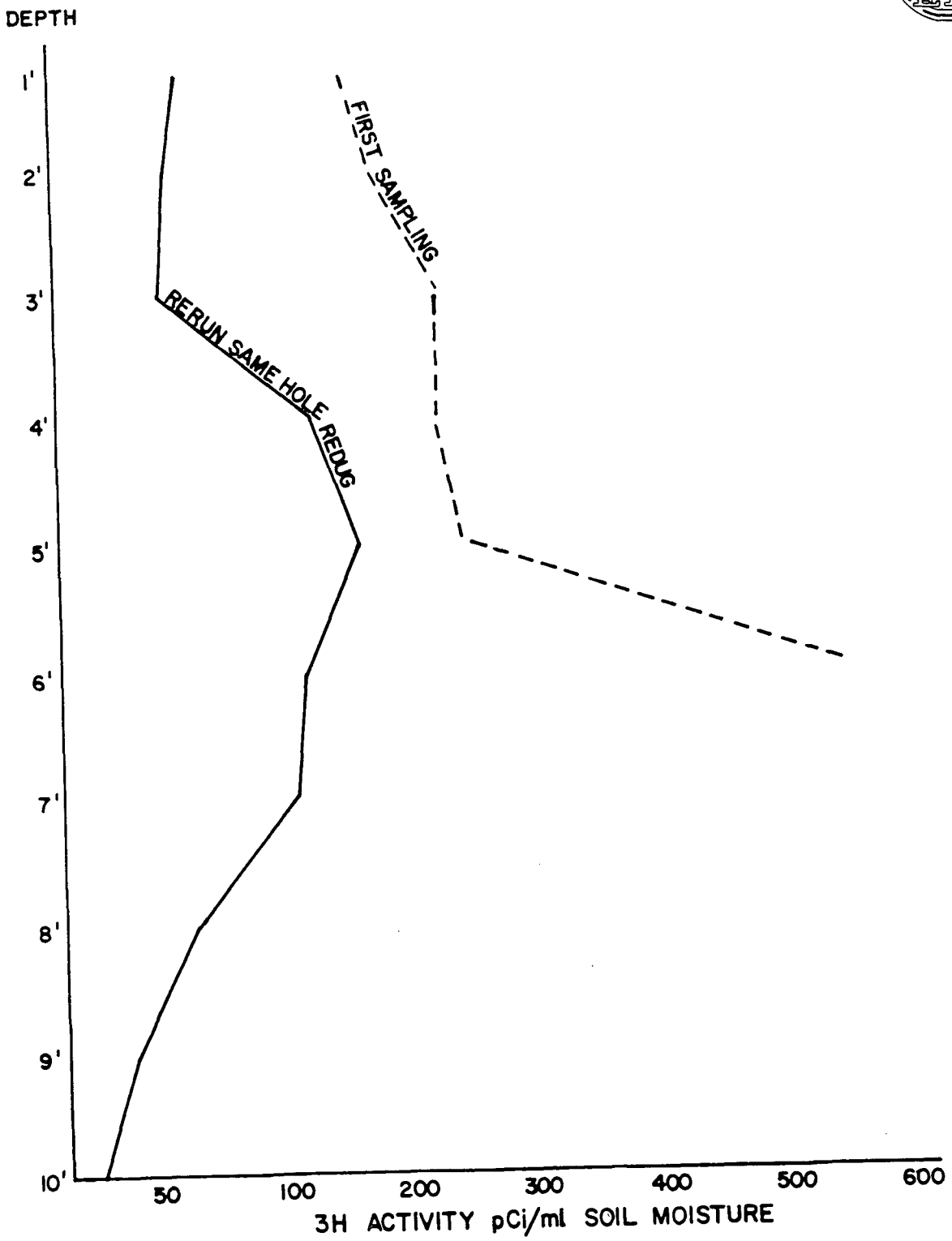


FIG. 6 TRITIUM ACTIVITY VS DEPTH FOR PROFILE HOLE 1 W1,Ø

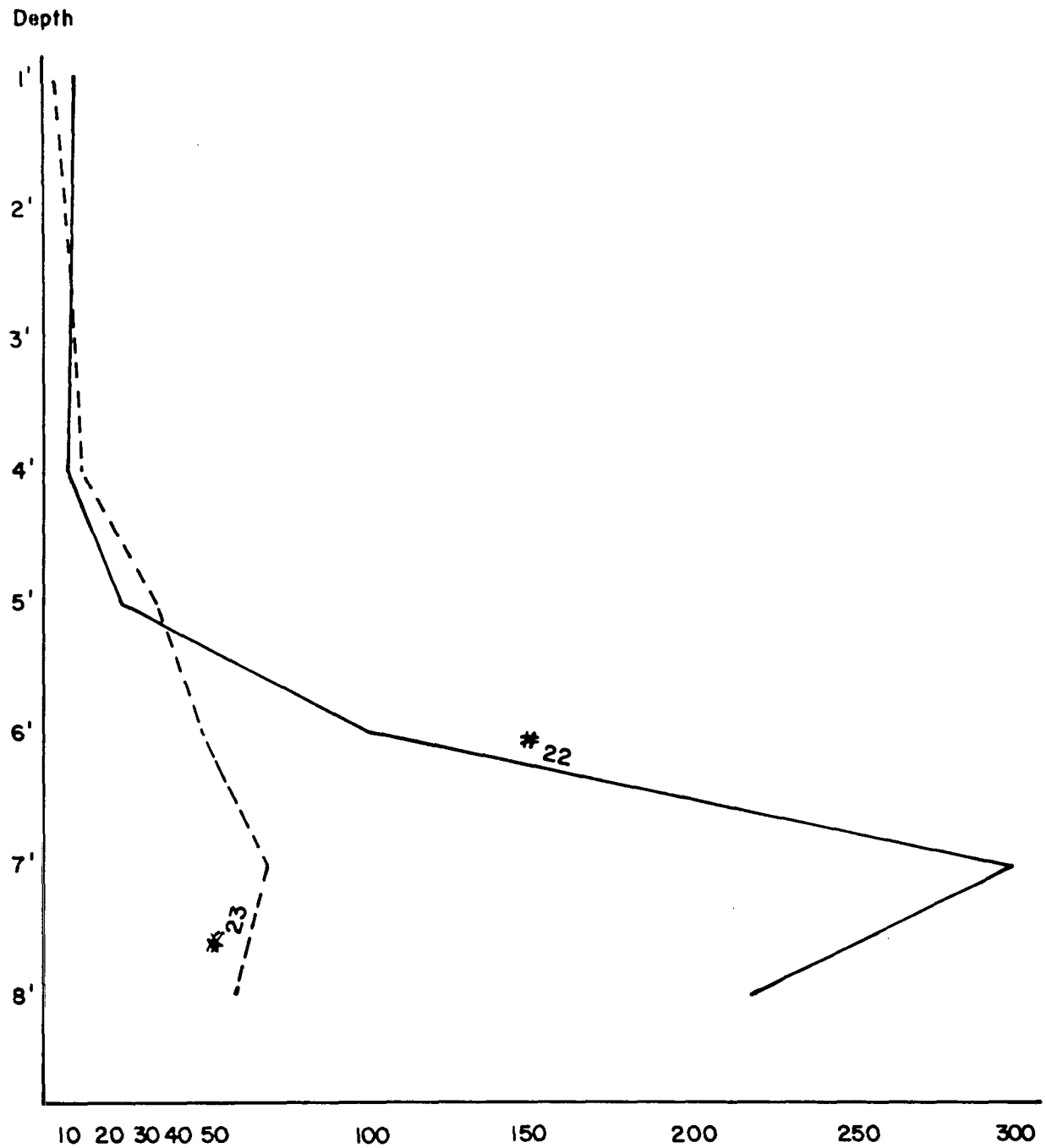


FIG.7 TRITIUM ACTIVITY VS DEPTH FOR PROFILE HOLES 22 EINI 10'N 18'W
23 EINI 16'N 33'W

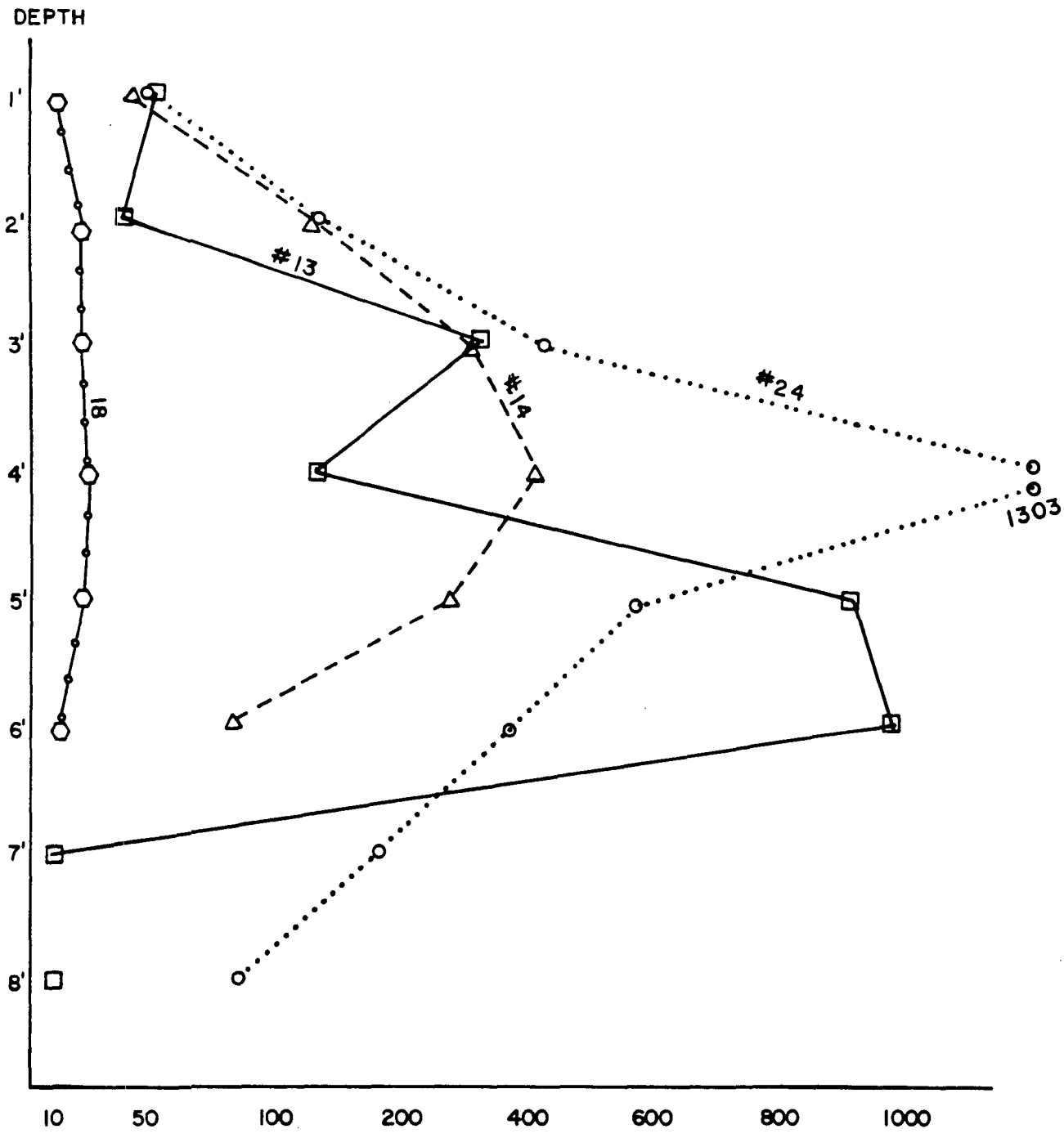


FIG.8 TRITIUM ACTIVITY VS DEPTH FOR PROFILE HOLES SOUTH OF FLARE STACK

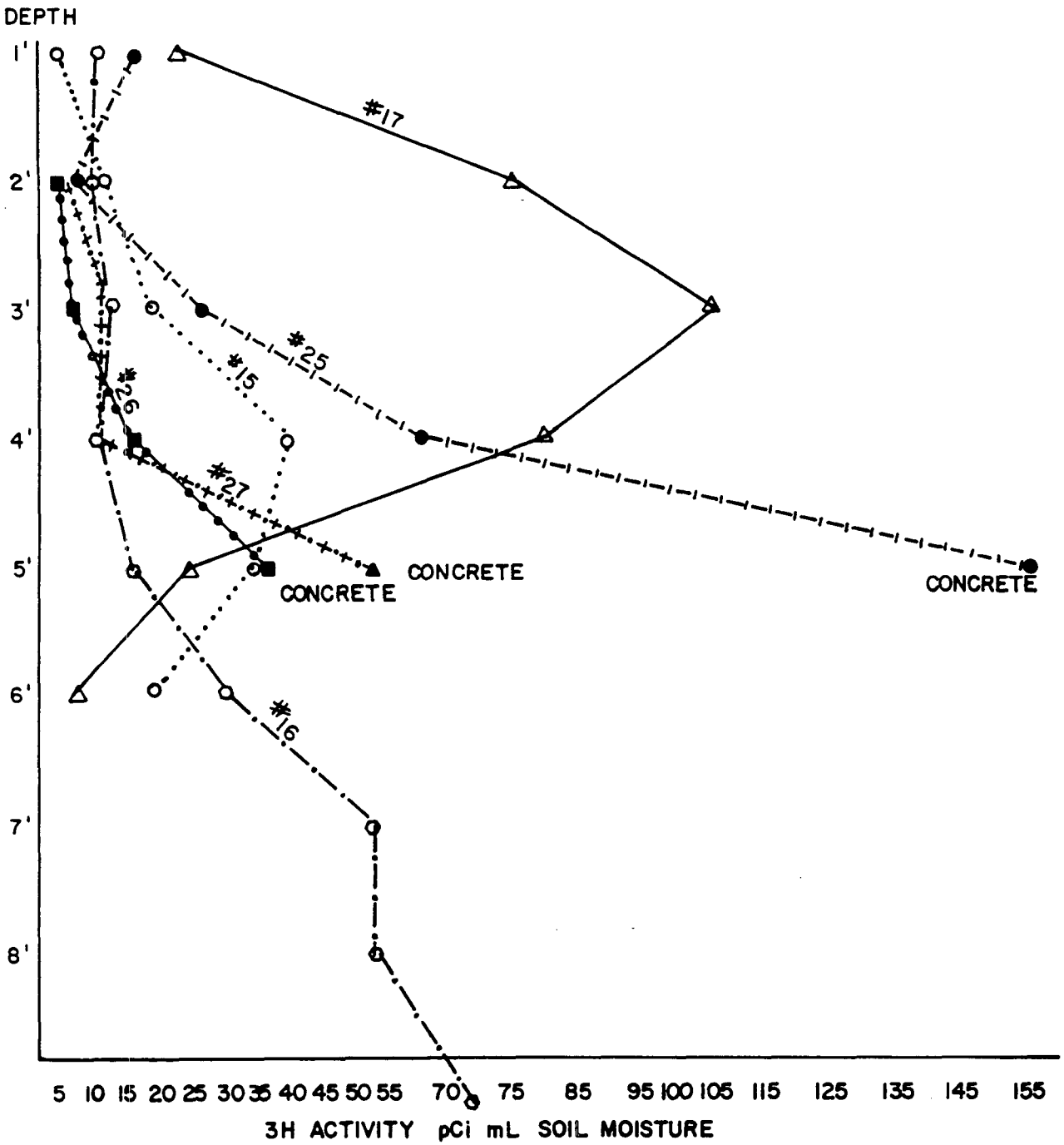
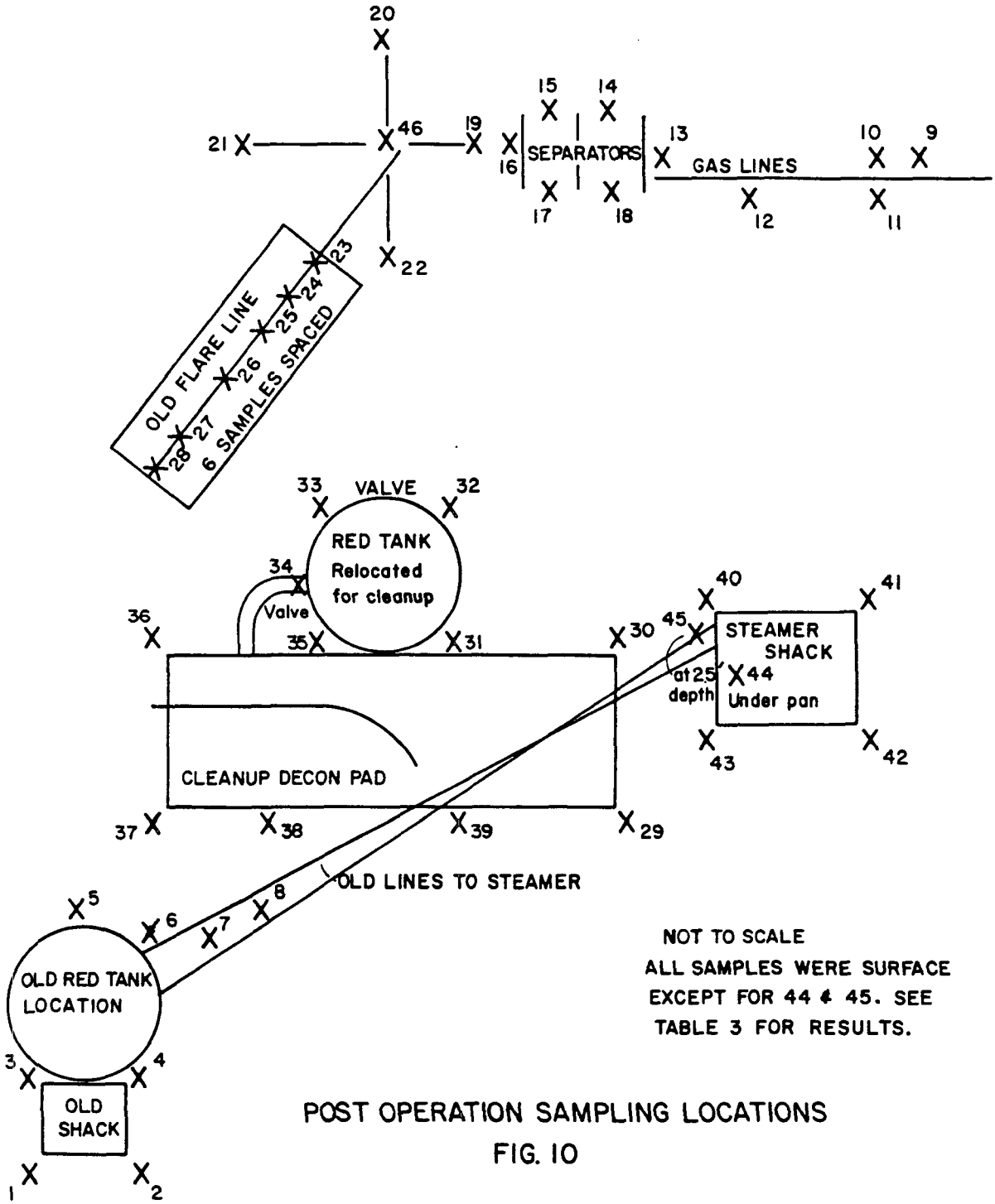


FIG.9 TRITIUM ACTIVITY VS DEPTH FOR PROFILE HOLES NORTH OF FLARE STACK



NOT TO SCALE
ALL SAMPLES WERE SURFACE EXCEPT FOR 44 & 45. SEE TABLE 3 FOR RESULTS.

POST OPERATION SAMPLING LOCATIONS
FIG. 10

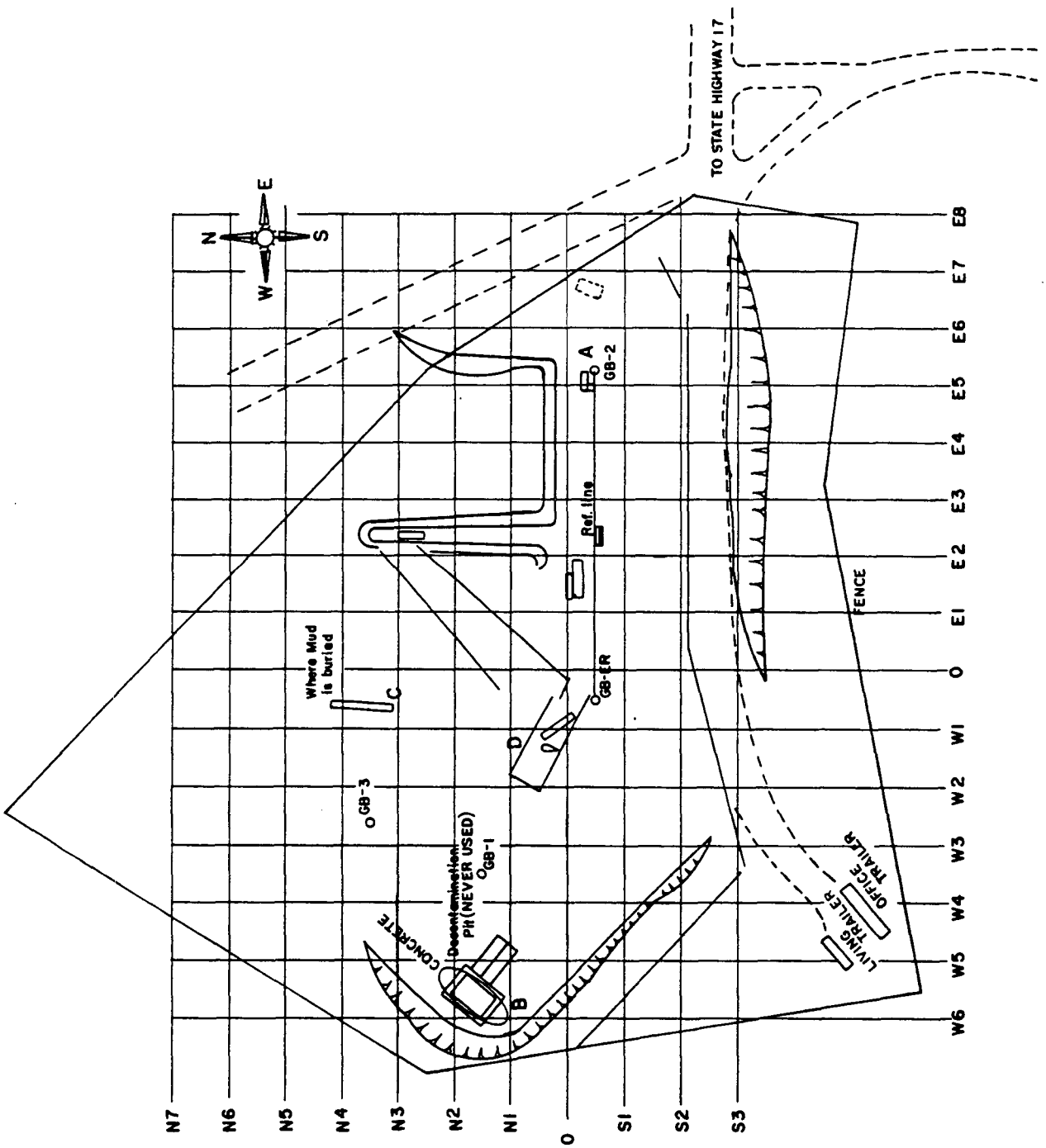


Fig. II LOCATION OF NON-RADIOACTIVE ON SITE BURIALS

DISTRIBUTION LIST

R.H. Hertzberg, Division of Fossil Fuel Extraction
J.K. Bratton, MA, HQ (2)
D.C. Ward, Division of Fossil Fuel Extraction
A. Crawley, Division of Fossil Fuel Extraction
M.E. Gates, Manager, NV
L. Silverstrom, Chief Cousel, NV
R.W. Taft, AMPE&B, NV
R.D. Duncan, AMA, NV
R.W. Newman, AMO, NV
D. Jackson, OPA, NV (2)
E.M. Douthett, Dir., P&LSD, NV (2)
P.J. Mudra, Dir., OSD, NV
J.B. Cotter, Dir., E&EAD, NV (5)
B.W. Church, Rad. Br., NV (3)
R.R. Loux, OPA, NV (20)
D.N. Canfield, El Paso Natural Gas Co., El Paso, TX
C.E. Matthews, El Paso Natural Gas Co., Farmington, NM (2)
J. Crellin, Forest Supervisor, Carson National Forest, USFS, Taos, NM (2)
J. Long, USGS, Durango, CO
A.E. Doles, Eberline, Santa Fe, NM (2)
R.H. Ashlock, F&S, Las Vegas, NV (3)
W.R. Woodruff, LLL, Livermore, CA (5)
L.B. Ballou, LLL, Livermore, CA
F. Holzer, LLL, Livermore, CA
J. Cramer, LLL, Livermore, CA
C. Costa, EPA-EMSL, Las Vegas, NV
TIC, Oak Ridge, TN (2)
T. Wolff, State of New Mexico (5)
S. Elliott, OS&H, NV
E. Campbell, NSD, NV
W.J. McCool, OES, Hq (2)
A.J. Whitman, ECT, Hq (2)
P.K. Fitzsimmons, OSD, NV (2)
A.E. Bicker REECO, Mercury, NV
E. Chew, INEL, ID