ARH-2035

INVESTIGATION AND EVALUATION OF 102-BX TANK LEAK

J. C. Womack and D. J. Larkin
Waste Management Process Engineering Section
Operations Support Engineering Department

March 26, 1971

Work performed under Contract AT(45-1)-2130
between the Atomic Energy Commission and
Atlantic Richfield Hanford Company
Richland, Washington 99352

NOTICE

LEGAL NOTICE

54 6000-020 (1-69) AEC-RL RICHLAND. WASH

INVESTIGATION AND EVALUATION OF

102-BX TANK LEAK

J. C. Womack and D. J. Larkin

March 26, 1971

DISTRIBUTION

1 - 3 - AEC-RL, Attention:
O. J. Elgert

4 - G. E. Backman
5 - [illegible]. J. Beard
6 - D. J. Brown
7 - H. L. Caudill
8 - R. P. Corlew
9 - J. B. Fecht
10 - W. L. Godfrey
11 - R. B. Guenther
12 - G. L. Hanson
13 - R. E. Isaacson
14 - G. R. Kiel
15 - D. J. Larkin
16 - C. A. Lorenzen
17 - B. J. McMurray
18 - G. C. Oberg
19 - L. M. Richards
20 - L. W. Roddy
21 - W. C. Schmidt
22 - H. P. Shaw
23 - P. W. Smith
24 - R. E. Smith
25 - R. E. Tomlinson
26 - J. H. Warren
27 - J. C. Womack
28-29 - ARHCO Files
30-35 - Extra

INVESTIGATION AND EVALUATION OF 102-BX TANK LEAK

INTRODUCTION

A responsibility of the Atlantic Richfield Hanford Company Waste Management Program is to provide surveillance in the waste storage tank farms to confine the high-level boiling and non-boiling wastes. Since 1943, 151 waste tanks located in 13 tank farms have been constructed at Hanford. To date, leaks have been confirmed in eleven tanks located in four of the farms, and six other tanks are suspected leakers. Inventory data from the suspect tanks indicated relatively small losses of liquid waste, and in some cases radioactivity had been noted in adjacent monitoring wells. All suspect as well as leaking tanks have been removed from service.

One of these suspected leaking tanks is 241-BX-102 and the purpose of this document is to report the findings of a field investigation to determine if radioactive wastes had indeed leaked from this tank, and if so, estimate the volume lost and extent of waste liquid movement through the soil.

SUMMARY AND CONCLUSIONS

Based on analyses of liquid level history, test well radiation profiles and soil sampling and analyses, tank 102-BX has been confirmed as a leaker he most probable explanation of the tank 102-BX leak is as follows:

1) The concrete shell of tank 102-BX was breached on its southeast edge near the tank footing, approximately 40 feet below grade.

2) The carbon steel liner failed approximately two feet from the tank bottom. Pit corrosion caused by a static tank liquid level of more than five years is thought to be the cause of liner failure.

The tank leaked approximately 70,000 gallons of waste to the ground, amounting to a loss of no more than 51 KCi of ^{137}Cs. The contamination extends eastward in a 1 to 6-foot wide band approximately 100 feet from the tank. It is held for the most part in a sand and silt lens 75 feet below grade. However a relatively small amount of ^{137}Cs percolated to a distance of 120 feet below grade (135 feet above the regional water table).

Since a leak has been now confirmed in tank 102-BX, it will be isolated from the tank farm piping systems and the residual liquid immobilized in a manner similar to other declared leakers.

The groundwater directly below the tank and surrounding the tank farm has been analyzed and all radionuclides including ^{137}Cs were well below AEC limits as shown in Manual Chapter 0524.

DISCUSSION

Tank 102-BX was constructed in 1946 and was filled for the first time in 1948 with uranium processing waste. Since 1954 it has been utilized intermittently for the storage of high-level non-boiling liquid waste. During this period, dry well number 61, located approximately 100 feet east-northeast of the tank, has been one of the primary means of monitoring for sub-surface contamination originating from within the BX Tank Farm.

Figure 1 depicts the liquid level history of tank 102-BX since 1954 and the Geiger-Muller (GM) and scintillation probe readings from dry well number 61 since late 1959. It should be noted that the tank was held static from 1957 to mid-1962 at a minimum pump heel of approximately 22 inches and was subsequently static at maximum capacity between mid-1962 and 1968. During the 1959-1969 period, dry well radiation monitoring results indicated a high amount of radioactivity. These readings were believed to be the result of a 30,000 to 90,000-gallon spill of first cycle waste in 1951 between tanks 102-BX and 103-BX(3). Geiger-Muller probe readings of about 100,000 cpm in 1959 gradually decreased to approximately 10,000 cpm in 1963. When a change was made to the more sensitive scintillation probe, off-scale readings of greater than 1×10^6 cpm resulted through 1968. Starting in 1969, the probe readings began decreasing rapidly until October, when they again rose above the scintillation probe's maximum detection capability. This corresponds in time to when the tank was returned to active tank farm operations. In May 1970, the tank was pumped to the minimum pump heel (22 inches) and taken out of service.

Subsequently, nineteen new dry wells were drilled to determine the extent of suspected contamination. Figure 2 depicts the location of the new wells and the original monitoring well, number 51. Since the tank was pumped to minimum heel, scintillation probe readings in well number 51 have decreased to less than one-third of what they were during early 1970. A neutron probe was also utilized in May 1970 to determine the relative moisture content of the soil surrounding each well as a function of depth. Results showed that high relative moisture content peaks occurred generally at the same depth as peak scintillation probe readings in all wells.

When well number 27, near the southeast corner of the tank, was drilled to the water table in July 1970, soil samples were collected at one-foot intervals and analyzed for ^{137}Cs content. The soil underlying the BX Tank Farm is described below:

a)	Grade to 102-BX tank bottom (40 ft depth)	- sand and silt backfill
b)	102-BX tank bottom to 70 ft depth	- sand
c)	70 ft to 120 ft depth	- coarse sand and silt
d)	120 ft to 150 ft depth	- sand
e)	150 ft to 175 ft depth	- coarse sand and silt
f)	175 ft to 210 ft depth	- sand and gravel
g)	210 ft to 255 ft depth (water table)	- coarse sand and silt

The ^{137}Cs content in the soil was plotted as a function of depth on semi-log paper (Figure 4). Peak ^{137}Cs values occur approximately

40 feet below grade. This is consistent with the peak GM probe readings in that well (Figure 3) and leads to the conclusion that the concrete shell of the tank failed at this level. The sharp, narrow peaks at 58 and 65 feet are believed due to either sample contamination or soil with a higher ion exchange capacity. The small peaks at 105 to 120 feet correspond to the bottom of the coarse sand and silt lens beginning at the 70-foot level[2]. Liquid traveling downward through this lens can be expected to travel more rapidly and to a greater distance laterally when first entering the lens at the top and just before exiting the bottom. Liquid and ^{137}Cs can be expected to become adsorbed in this lens due to the sponge effect and the higher ion exchange capacity of the smaller soil particles, respectively.

In contrast to high-level self-boiling wastes which tend to self-seal upon leaking because of crystallization upon cooling, the non-boiling dilute waste from tank 102-BX continued to leak and percolate downward to a depth of 120 feet below grade (135 feet above the regional water table) before being absorbed. Indications are that the majority of the cesium-137 was contained in the vicinity of the tank; however, detectable concentrations were carried along with the waste to the 120-foot level.

Cesium-137 was also detected in the groundwater underneath tank 102-BX at this time, but at a concentration below AEC release limits[8]. Since the groundwater moves very slowly in a southerly direction, interpretation of ^{137}Cs in the groundwater is complicated by the many disposal sites surrounding the tank farms in the area. Initially the source of the ^{137}Cs in the groundwater beneath tank 102-BX was believed to be from the B-Cribs and/or other disposal sites in the area. Breakthroughs of ^{137}Cs into the groundwater from cribs occurred in 1957 and 1959. These cribs were subsequently removed from use. However, when the groundwater wells surrounding BX and BY Farms (Figure 5) were sampled and analyzed for ^{137}Cs in January 1971, the results (shown in Table II) indicated that the ^{137}Cs concentration in the groundwater, although within AEC release limits, was slightly higher under tank 102-BX than under cribs and tank farms surrounding the BX Farm (9×10^{-3} vs. 8×10^{-4} $\mu Ci/\ell$). These results led to the estimation that the ^{137}Cs in the groundwater under tank 102-BX is due to the spread of minor contamination during the drilling of well number 27 rather than from the B-Cribs.

An analysis of the scintillation and neutron probe results leads to the contamination pattern shown in Figure 3. Well number 27 has the highest probe readings of any of the wells immediately surrounding the tank, and is also the only with peak readings at the 40-foot level below grade. From this it is concluded that the tank's concrete shell failed near this well. An estimated 31,000 ft^3 of earth has been wetted by the waste from the leak. This volume was deduced by characterizing the leak as three geometric figures and summing their volumes. The area immediately surrounding the leak source is in the shape of a sphere having a radius of 10 feet and a volume of 4190 ft^3. The saturated area immediately below this sphere and extending into the sand and silt layer is a cylinder having a height of 30 ft, radius of 5 ft, and volume of 2355 ft^3. The saturated zone in the sand and silt layer is an inverted wedge having a maximum height of 6 ft, base of 8000 ft^2, and volume of 24,000 ft^3. This sub-surface contamination configuration is also depicted in Figure 2 and can be seen to extend in an easterly direction 100 feet from the leak source. It is contained generally in a 1 to 6-foot wide layer at the 75-foot level below grade.

Analyses of the waste contained in tank 102-BX were made in early 1970 (Table I). These analyses (using the highest ^{137}Cs concentration of 0.725 Ci/gal), plus an assumed soil porosity of 30 percent are the bases for the conclusion that the tank leaked 70,000 gallons of waste, for a loss of 51 KCi of ^{137}Cs. A material balance based on liquid level measurements provides inconclusive evidence of a leak.

It is interesting to note that well 61, which was drilled in 1947, has a higher peak reading at the 70-foot level than any of the wells drilled later between it and the leak source. This may be explained by the existence of a carbonate and/or silicate adsorbent deposit on the well casing which has entrapped radionuclides from the liquid waste, creating an area which is more radioactive than the surrounding soil contacting the well casing. To test this deposition hypothesis, the well casing was raised ten feet, a radiation profile taken, and then lowered to its original position and another radiation profile taken. It was concluded from the results that there is a radioactive deposit of some sort on the casing. Research and Development plans to further investigate the distribution of radionuclides in the ground at this site and the material apparently deposited on the well casing.

It has been observed that pit corrosion of carbon steel occurs at the liquid-air interface in cool, unagitated tanks when the liquid level is held constant for an extended period(5). From Figure 1 it can be seen that tank 102-BX had a 22-inch liquid heel for over five years. To date, photographs taken after the tank was pumped again to a 22-inch liquid level heel in 1970 are not of high enough resolution to pin-point any liner failure in this area. It is possible that the liner and concrete shell failed some time prior to October 1969 when the probe readings started to rise. Scintillation probe readings from 1964 to 1969 were off-scale and therefore inconclusive. If failure did occur during that period, the leak may have self-sealed, since probe readings began decreasing in mid-1969; however, normally, non-boiling wastes do not self-seal. In any event, when pumping activity was resumed within the tank in October 1969, possibly the concrete shell failed or the leak re-opened, as evidenced by the increase in probe readings. Initial pit corrosion, aggravated by stresses from the fluctuating hydrostatic head are believed to have caused the liner to fail somewhere near the tank bottom. The exact date and location of this failure are unknown. However, since the tank was pumped to a minimum heel the tank is no longer leaking, as evidenced by the decrease in probe readings within well 61.

REFERENCES

1. HW-37519, "Structural Evaluation - Underground Waste Storage Tanks", E. F. Smith, 1955

2. HW-67729, "Geology Underlying 200-Area Tank Farms", D. J. Brown, 1960.

3. Letter October 1960, R. A. Wonacott to J. C. Glover, "Dry Well Radiation Levels"

4. ISO-SA-32, "Migration Characteristics of Radionuclides through Sediments Underlying the Hanford Reservation", D. J. Brown, 1967

5. ARH-1495, "Review of Storage Tank Integrity", W. L. Godfrey, 1969

6. Letter, April 7, 1970, W. L. Godfrey to P. W. Smith, "Proposed Non-Boiling Waste Tank Policy"

7. Conversations with D. J. Brown, Research and Development, January 12-14, 1971

8. AEC Manual Chapter 0524, Table II

TABLE I

TANK 102-BX LIQUID SAMPLE ANALYSES

Sample T-83, January 27, 1970	Sample #527, March 1, 1970	Sample #3270, April 30, 1970
^{137}Cs = 2.75 x 10^5 μCi/gal	^{137}Cs = 1.17 x 10^5 μCi/gal	^{137}Cs = 7.26 x 10^5 μCi/gal
^{134}Cs = 6.45 x 10^3 μCi/gal	^{125}Sb = 2.07 x 10^3 μCi/gal	^{134}Cs = 2.33 x 10^4 μCi/gal
^{90}Sr = 1.54 μCi/gal	^{60}Co = 2.77 x 10^2 μCi/gal	-
^{10} Rh = 0.0462 Ci/gal	$^{106}RuRh$ = 4.35 x 10^4 μCi/gal	-
OH^- = 1.15 M	$^{95}ZrNb$ = 2.80 x 10^3 μCi/gal	-
Na^+ = 3.07 M	-	-
pH = 12.5	-	-
SpG = 1.03	-	-
NVR = 242 g/l	-	-

TABLE II

GROUND WATER SAMPLE ANALYSES JANUARY 15, 1971

Well No.	Dir. From TK-102-BX	Filtrates (nCi/l)*** Calc. as TB $^{106}RuRh$	Filtrates GEA ^{137}Cs	Filtrates GEA ^{106}Ru	Filtrates GEA ^{60}Co	Residue on Filters (nCi/g, wet) Calc. as TB $^{106}RuRh$	Residue GEA ^{137}Cs	Residue GEA ^{106}Ru	Residue GEA ^{60}Co
299E 33-1 **	N	10.4	<0.044	1.7 ±0.22	6.8	0.44 ±0.12	<0.010	<0.083	0.50
299E 33-5	NNW	11	<0.025	3.0	3.8	0.32 ±0.069	0.037 ±0.033	<0.34	0.16 ±0.058
299E 33-8	NW	0.56	<0.034	0.19 ±0.12	<0.031	0.20 ±0.19	0.11 ±0.04	<0.17	<0.035
299E 33-10	WSW	0.039 ±0.035	<0.017	<0.099	<0.019	0.046 ±0.040	<0.029	<0.11	<0.021
299E 33-13 **	NNE	8.8	<0.060	0.96 ±0.24	7.8	0.052 ±0.065	<0.037	<0.13	0.42 ±0.044
299E 33-18 *	E	<0.610	<0.770	-	0.850	-	-	-	-
299E 33-21	WSW	0.32	0.100 ±0.024	<0.12	<0.026	1.1 ±0.36	0.90	<0.15	<0.029
299E 33-27	-	-	9.2	<0.23	<0.030	-	39	0.42	0.03
299E 28-8	S	-	<0.021	<0.10	0.08 ±0.02	-	<0.007	<0.035	0.017 ±0.005

* Sample taken October 1970

** Values of residue on filters may be only one-half their actual value.

*** 1 μCi = 1000 nCi

AEC control limits(8): ^{137}Cs = 20 nCi/l ; ^{106}Ru = 10 nCi/l ; ^{60}Co = 50 nCi/l

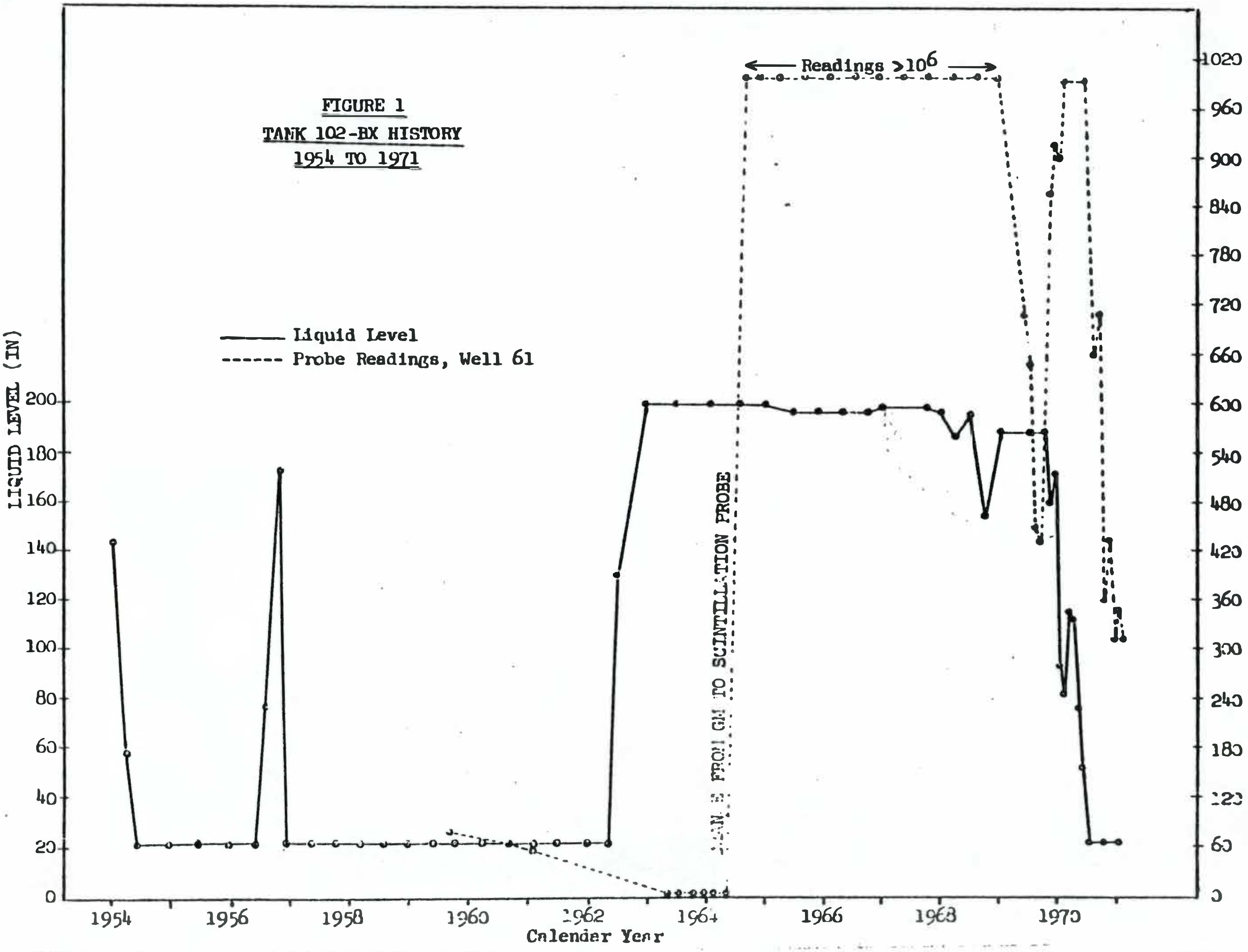


FIGURE 1
TANK 102-BX HISTORY
1954 TO 1971

FIGURE 2

PLAN VIEW OF WELL LAYOUT

AND ESTIMATED LEAK PATTERN

AT 75-FOOT LEVEL

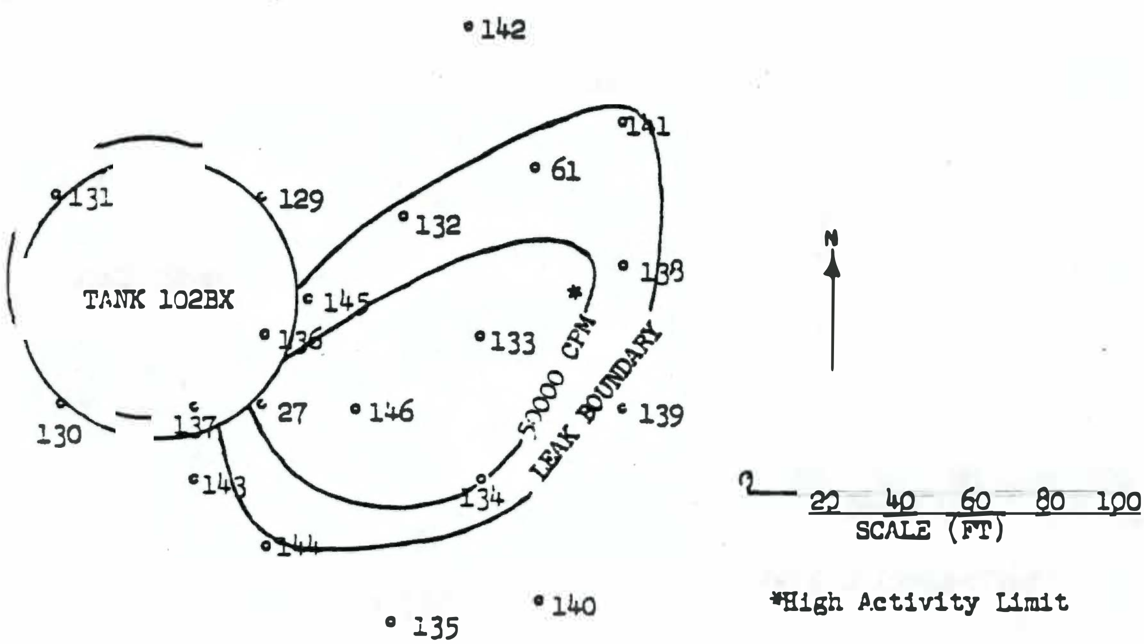
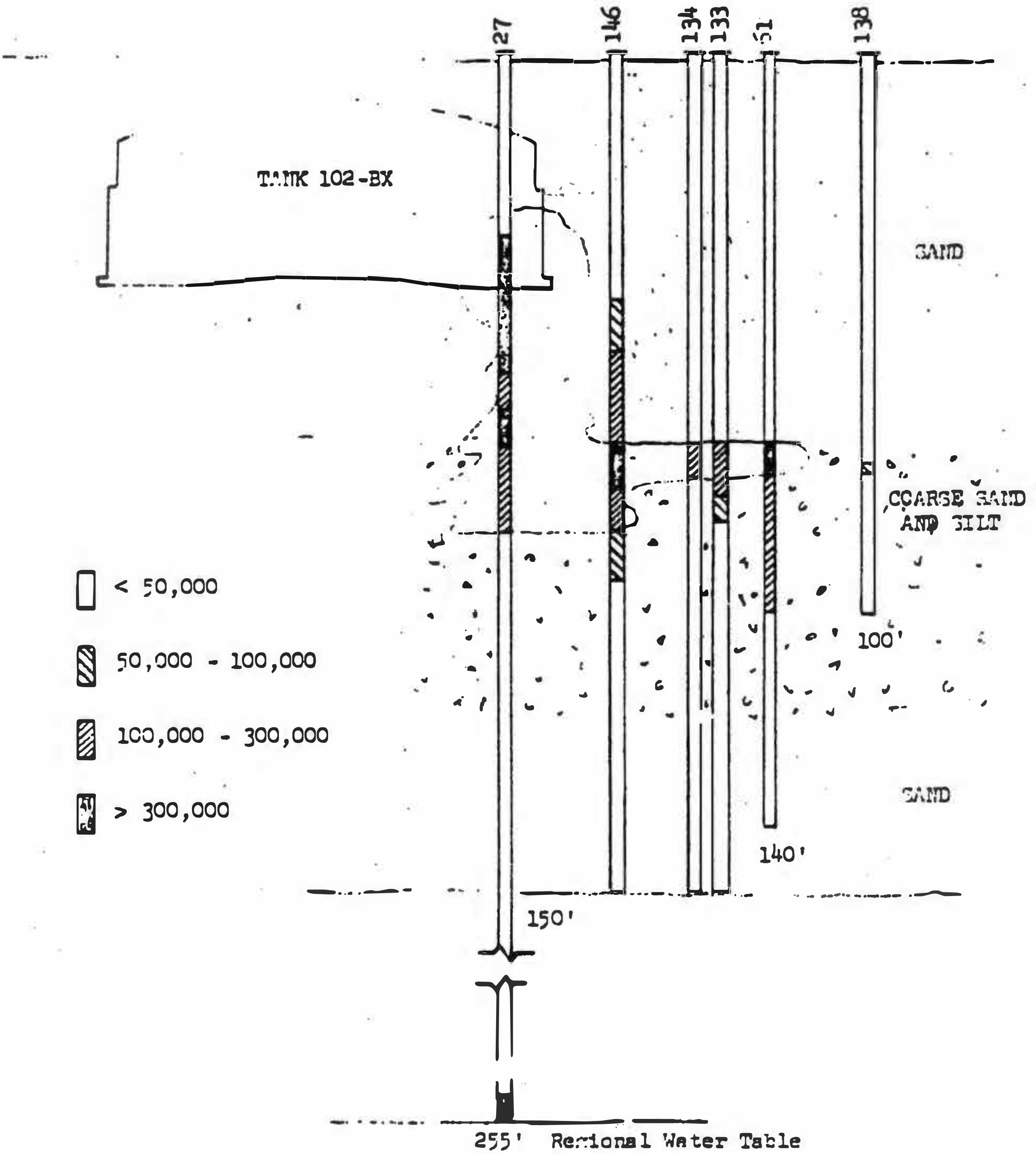


FIGURE 3

SUBSURFACE VIEW OF WELLS WITH READINGS >50,000 cpm AND ESTIMATED LEAK PATTERN AS OF JANUARY 1971



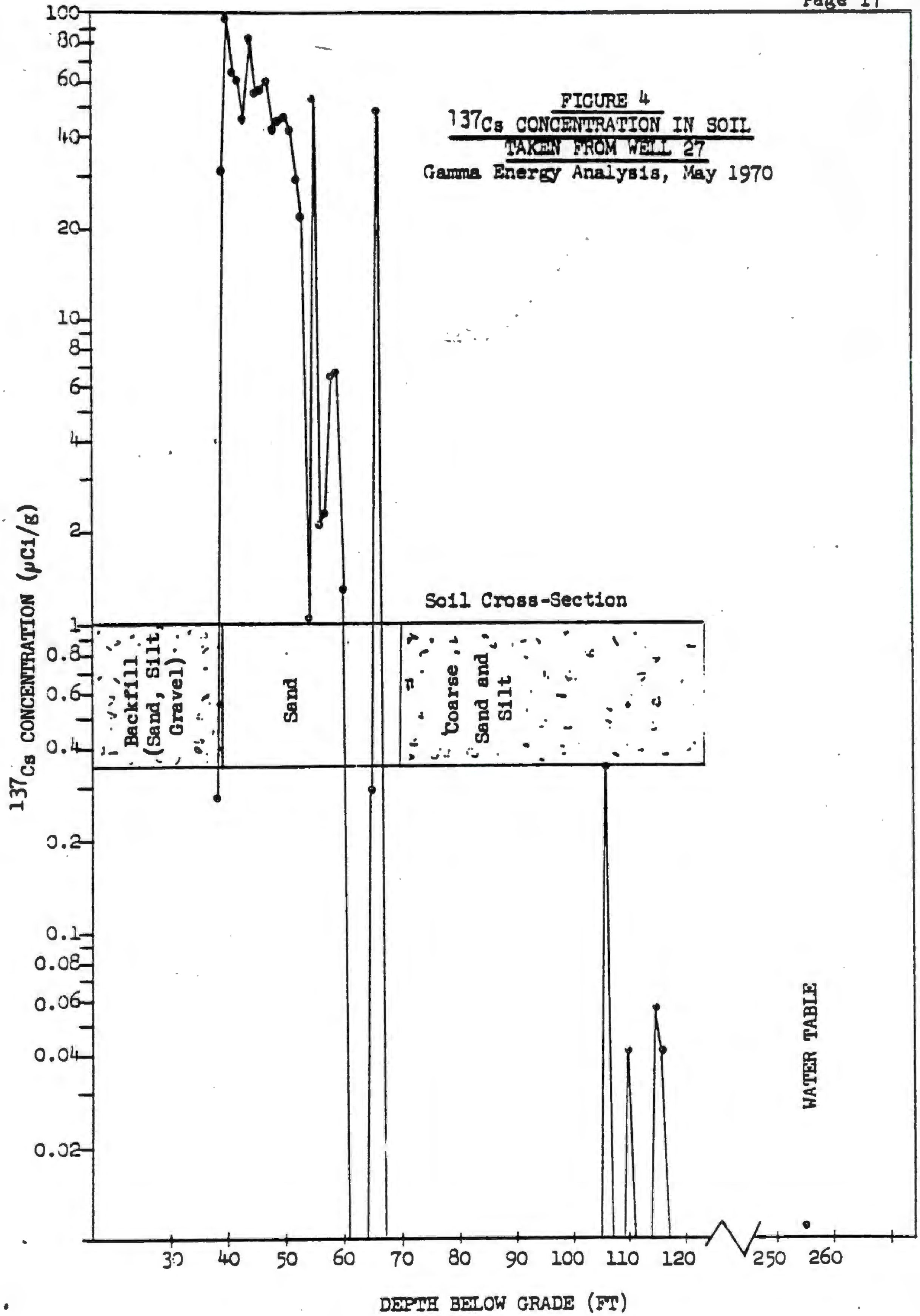


FIGURE 4
137Cs CONCENTRATION IN SOIL
TAKEN FROM WELL 27
Gamma Energy Analysis, May 1970
137Cs CONCENTRATION (μCi/g)
100
80
60
40
20
10
8
6
4
2
1
0.8
0.6
0.4
0.2
0.1
0.08
0.06
0.04
0.02
Soil Cross-Section
Backfill (Sand, Silt, Gravel)
Sand
Coarse Sand and Silt
WATER TABLE
30
40
50
60
70
80
90
100
110
120
250
260
DEPTH BELOW GRADE (FT)

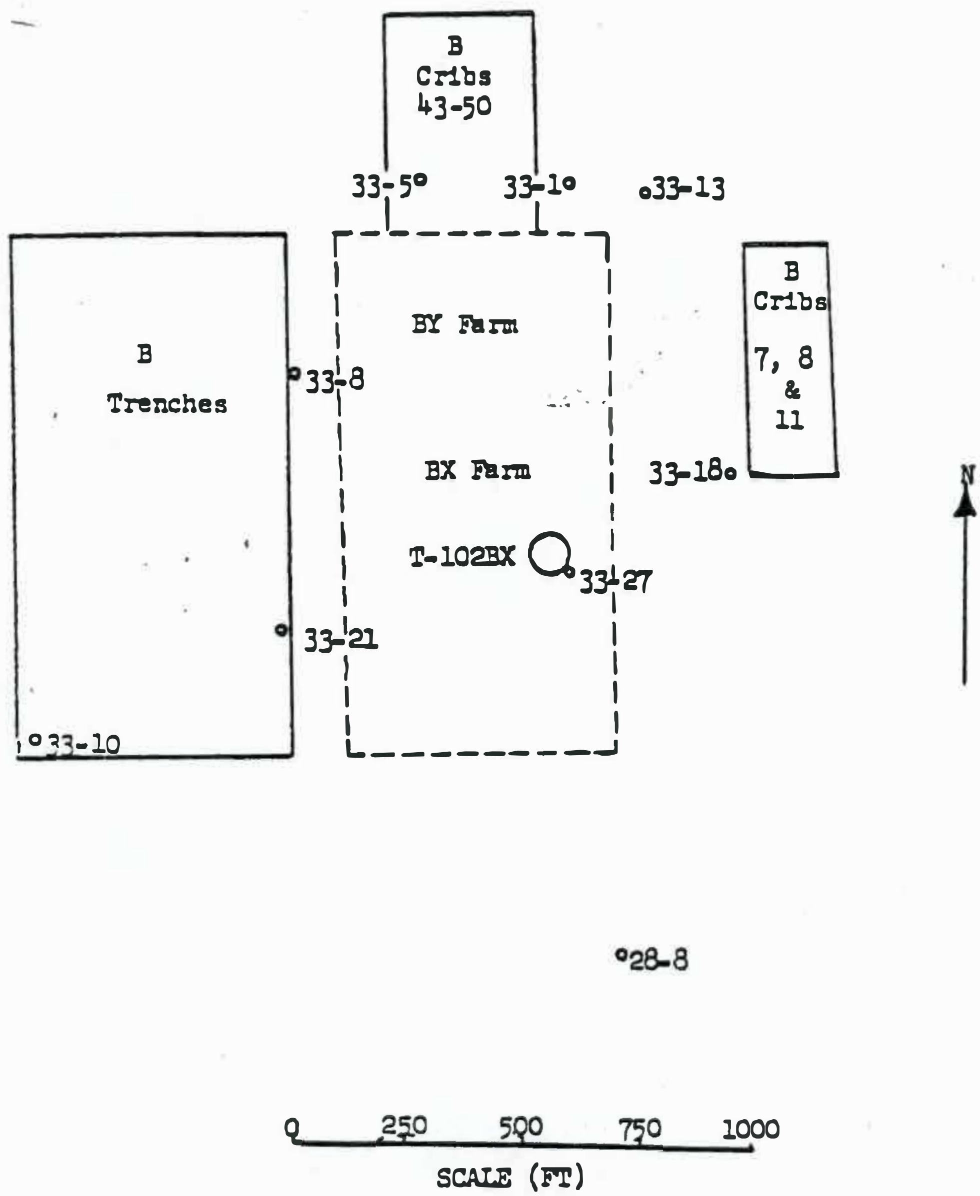


FIGURE 5

GROUND WATER WELLS SAMPLED AROUND T-102BX