START

0008798

RHO-RE-EV-4 P

SUPPORTING INFORMATION FOR THE SCIENTIFIC BASIS FOR ESTABLISHING DRY WELL MONITORING FREQUENCIES

R. E. Isaacson
Research and Engineering

September 1982

9 2 1 2 4 9 9 1 5 5 2

Prepared for the United States
Department of Energy
Under Contract DE-AC06-77RL01030

Rockwell International

Rockwell Hanford Operations
Energy Systems Group
P.O. Box 800
Richland, Washington 99352

9212499 1553

THIS PAGE INTENTIONALLY
LEFT BLANK

ABSTRACT

A scientific basis has been developed for establishing the frequency of monitoring dry wells. Dry wells are used to detect radioactivity from a leaking underground high-level radioactive waste storage tank. The frequency of monitoring a dry well is dependent on the response characteristics of the radiation-detection system used periodically to monitor dry wells for encroaching radioactivity. The response characteristics of the detection system have been combined in the Dry Well Radioactivity Response Equation.

The Dry Well Radioactivity Response Equation is derived using the following information:

- Variation in dose rate (roentgen per hour) as a function of source strength
- Variations in dose attenuation by the soil as the radioactive waste front approaches the dry well
- Response of radiation detector, in counts per second, as dose rate changes (instrument calibration)
- Distance of dry well from tank leak source
- Leak rate
- Geometry of soil wetted by leaking waste
- Hydrologic properties of the soil.

These variables are used with the current status of tank contents and available liquid-level monitoring system information to generate a monitoring schedule for individual dry wells and horizontal laterals associated with single-shell, high-level waste storage tanks on the Hanford Site.

ACKNOWLEDGMENTS

The development of the Dry Well Radioactivity Response Equation required the integration of a number of diverse technologies. Many contributors provided specific portions of this study, and their participation in the many meetings and discussions during the development of this report is gratefully acknowledged.

W. M. Lindsay and C. M. Walker provided information on the current surveillance requirements and other aspects of the study report. R. C. Routson was a key member of the team providing the soil mechanics, soil moisture content, and other hydrologic inputs. In these activities, he was joined by W. H. Price, J. B. Sisson, V. W. Hall, and E. J. Rink. F. S. Stong provided the detailed description of the operation of the radiation-monitoring equipment. E. N. Dodd and H. J. Goldberg provided all of the ISOSHLD calculations for determining tenth-value thickness dependence upon ruthenium concentration. The spatial calculations, which are a part of the basic study, were performed by D. W. Duncan. Without these basic inputs, such a report could not be prepared.

The management support, patience, and guidance of J. H. Roecker, J. L. Deichman, W. F. Heine, G. W. Wilson, W. W. Schulz, E. J. Kosiancic, and D. D. Wodrich assured the successful completion of this endeavor.

Special acknowledgment and thanks are extended to J. W. Bailey, W. M. Lindsay, G. T. Dukelow, C. R. Carter, D. G. Wilkins, J. J. Kirk, and C. M. Walker for providing technical and operating expertise regarding the tank farm surveillance activities.

Finally, the support and assistance of numerous secretaries, technical publications specialists, and Battelle graphics made it possible to produce this report. Special thanks are extended to Dorothy Smith, Sharon Eckert, Rebecca Cardone, Susan Hoglen, Connie Poe, Martha Snodgress, Faye Stone, and Marilynne Smith of Rockwell and Ted Tanasse of Battelle Graphics for their untiring, good natured, and enthusiastic support.

CONTENTS

FIGURES (Contd.):

TABLES:

THIS PAGE INTENTIONALLY
LEFT BLANK

INTRODUCTION

The Hanford Site has served as a nuclear facility for the United States Government[1,2] since 1943. At this nuclear facility, high-level radioactive waste from chemical separation operations has been stored in 75-ft-diameter, underground, single-shell tanks. To evaluate the integrity of the waste tanks and to minimize environmental impact should a leak develop, the tanks are monitored for leakage by recording liquid levels within the tank.

A monitoring system of steel-encased dry wells surrounds the waste tanks. These dry wells are used to detect changes in gamma activity indicating a migration of radioactivity toward the wells.

Radioactivity sensors are lowered into the dry wells. As an advancing front of liquid waste reaches the dry well, the radioactivity count rate increases. When the count rate is adjudged to be consistently and/or significantly above the baseline level (background), action is initiated to determine the cause for the increase. A significant increase in count rate is generally defined as 20 counts per second (c/s) above baseline; this is the alert level. If there is a significant rise in count rate, the following steps are taken: the count rate data for nearby dry wells is examined; the available tank liquid level records for nearby tanks are examined; and the frequency of dry well monitoring is increased. When the count rate exceeds the action level of 160 c/s above background, the pumpable liquid wastes are moved to another tank. (See Appendix C for tanks which are scheduled to be salt-well pumped.)

The frequency of monitoring dry wells has been established on a somewhat subjective basis. Some proponents believe that dry wells should be monitored weekly, while others believe that biweekly monitoring is adequate to detect leaks on a timely basis.

This study was initiated to develop a scientific basis for establishing formal criteria and frequency of monitoring dry wells around single-shell tanks for radioactivity from leaking waste tanks. The calculations were completed for each dry well around each single-shell tank that contains liquid sufficient to require salt-well pumping in case a leak develops. Details on waste tanks requiring salt-well systems are included in Appendix C. The calculations were based on the status of the tanks as of September 30, 1981.

SUMMARY

A Dry Well Radioactivity Response Equation has been developed to assess the effectiveness of the dry well radioactivity monitoring system and to set formal criteria for establishing the frequency of monitoring dry wells.

The principal criteria recommended for establishing the frequency of monitoring dry wells are as follows:

1. The monitoring interval shall be established to assure that the incremental volume of waste that could be released between the time of first detecting a significant increase in count rate (20 c/s above background) and the time that the immediately preceeding radiation survey was made of that dry well, will not exceed 1,375 gal, i.e., equivalent to a liquid level decrease in the waste tank of 1/2 in.
2. When the count in a dry well exceeds the baseline level by 20 c/s, the monitoring frequency will be increased in that dry well and in adjacent dry wells.
3. The minimum monitoring interval for a dry well shall ensure that the count rate does not exceed an action level of 160 c/s above the baseline level within the period between successive readings for more than 10% of the leaks within the nearest range of any dry well. When the action level is reached, the drainable liquid is pumped to a nonleaking tank.

These criteria and the Dry Well Radioactivity Response Equation were applied on a dry-well-by-dry-well basis to generate a table of acceptable monitoring intervals, presented in Appendix N. The results are summarized in Table 1. For each dry well, a range of frequencies was developed that allows conformance to the criteria while permitting necessary flexibility to Operations' personnel for scheduling on a normal work-week basis. The resulting monitoring frequency will be every 2 wk or longer for the 200 East Area dry wells and weekly or longer for the 200 West Area dry wells.

TABLE 1. Summary of Dry Well Monitoring Intervals (10-21-81).

Monitoring period (wk)	Number of wells to be monitored*		
	200 East Area	200 West Area	Total
1	0	109	109
2	59	102	161
3	94	30	124
4	40	8	48
5	6	3	9
6	10	4	14
7	6	1	7
8	3	--	3
9	2	--	2
10	2	--	2
>10	2	--	2
Totals	224	257	481

*Only tanks that are scheduled for pumping are included in this listing.

A realistic monitoring frequency would be one that would assure that at least 90% of all possible leaks would be detected before the count rate reached the alert level. Then, only 10% of all possible leaks could be in the range of 20 c/s or above when first detected. Using this basis, the suggested frequency of monitoring dry wells would be every 2 to 4 wk in 200 East Area and every 1 to 3 wk in 200 West Area.

The proposed criteria are based on evaluating the effectiveness of the dry well monitoring system as it now exists. These criteria will assure the timely reporting of the arrival of a leak at a radiation monitoring dry well; however, the criteria cannot limit the maximum volume of the leak. An analysis of the maximum potential size of a leak indicated that as much as 117,000 gal of liquid could escape before the leak was detected if the leak occurred 36 ft from the closest dry well.

To limit the volume that could go undetected by the dry well system, more wells need to be installed at closer spacing to the tanks. To assure that the volume of a leak will not exceed 10,000 gal, 328 new dry wells would be needed. A limit of 20,000 gal would require 153 new dry wells.

An alternative to installing more dry wells would be to remove the supernatant solution and interstitial liquids from the single-shell tanks and proceed directly with the "Single-Shell Tank Stabilization and Isolation Plan." In lieu of installing additional dry wells around the perimeter of tanks, internal dry wells should be considered as a potentially cost-effective alternative to the present external dry well monitoring system.

THIS PAGE INTENTIONALLY LEFT BLANK

9 2 1 2 4 9 9 1 5 6 5

BACKGROUND

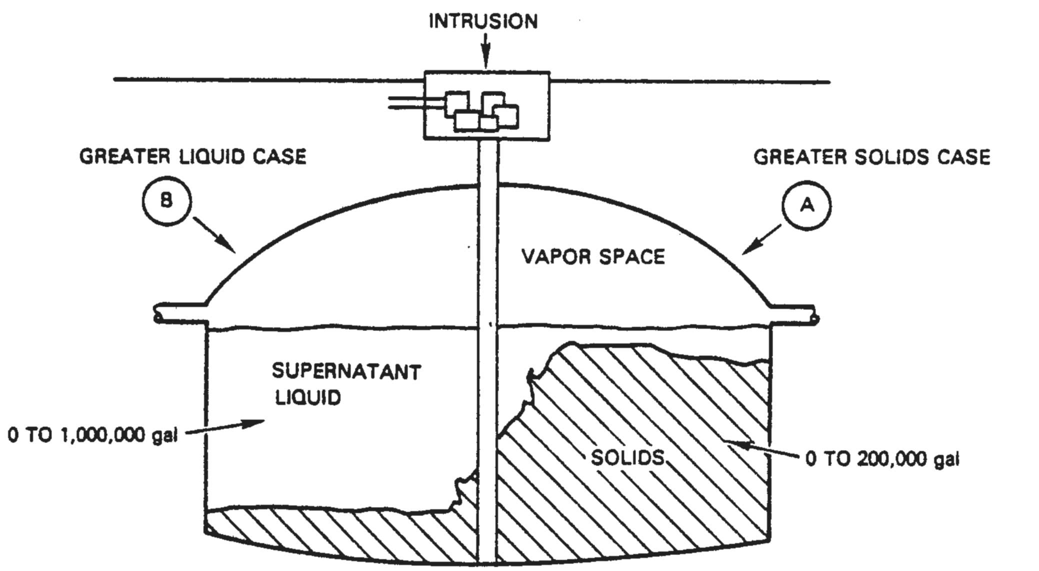
During July, August, and September 1978, the surveillance frequency of dry well monitoring was reviewed. Tank leak histories, investigations of tank leaks, tank parameters being monitored, monitoring methods, and monitoring redundancy were examined. At the start of the review, 740 dry wells were being monitored: 568 weekly, 154 monthly, and 35 quarterly. In addition, liquid levels and temperatures were being monitored in certain tanks. The need to monitor other tank parameters such as dome integrity and exhauster effluents was considered.

The review centered on the classification (categorization) of waste tanks as related to liquid content, amount of drainable liquid, and liquid-level measurement problems. In addition, radiation peak (count rate) growth rates for various tanks were reviewed. Four characteristic radioactivity count-rate changes as a function of time were studied in more detail for tanks 241-U-110, 241-TX-107, 241-AX-104, and 241-BY-105. The results of these studies revealed that the most rapid change in peak count rates occurred in the case of the 241-U-110 tank. The estimated leak rate for this tank was 0.023 gal/min.

Manual Chapters 0511, 0513, 0524, U.S. Department of Energy (DOE) Operations Directive for Contract Number EY-77-C-06-1030, and ERDA-1538, the Hanford Waste Management Operations Final Environmental Statement[1] were reviewed to determine if all DOE requirements were being met.

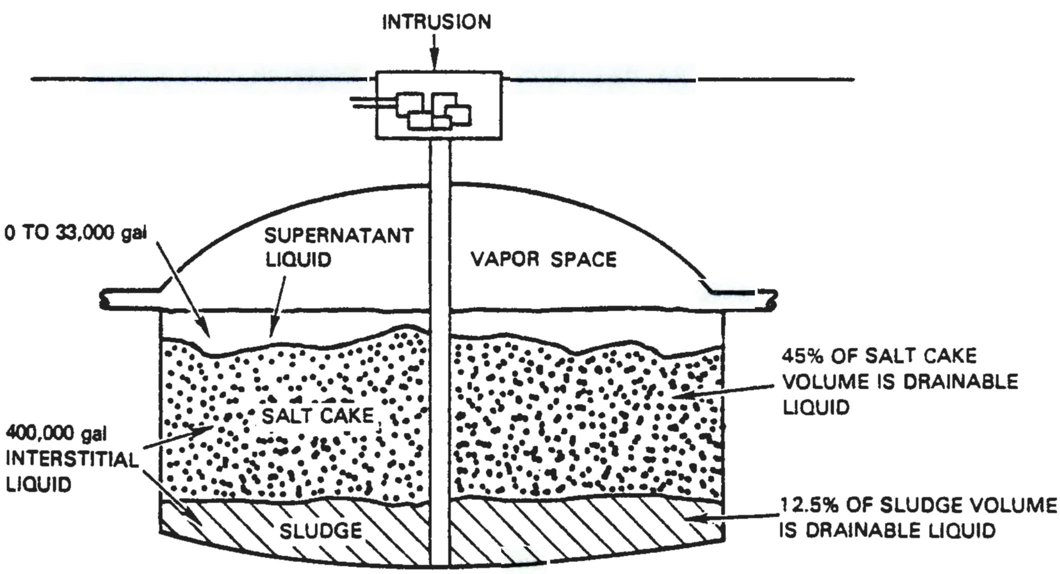
Findings, conclusions, and recommendations of the group were summarized and presented for management review on September 15, 1978.

The frequency of tank farm surveillance activities was then established according to tank classification and surveillance function. High-level waste tanks were classified as ACTIVE, INACTIVE AWAITING REVIEW AND ACTION, PRIMARY STABILIZED, INTERIM STABILIZED, and INTERIM ISOLATED. The conditions and bases for classification are provided in Figures 1 through 5. The schedule of the surveillance activities is provided in Table 2. Instrumentation used for high-level waste tank surveillance is shown in Figure 6, and the status of instrumentation is given in Table 3.



RCP8006-114A

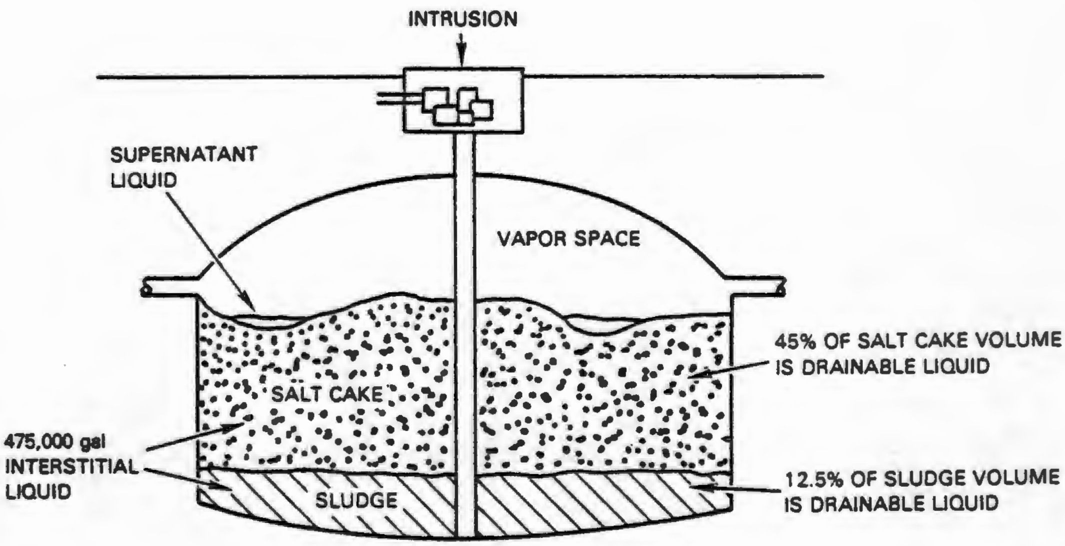
FIGURE 1. Active Tanks.



RCP8006-115B

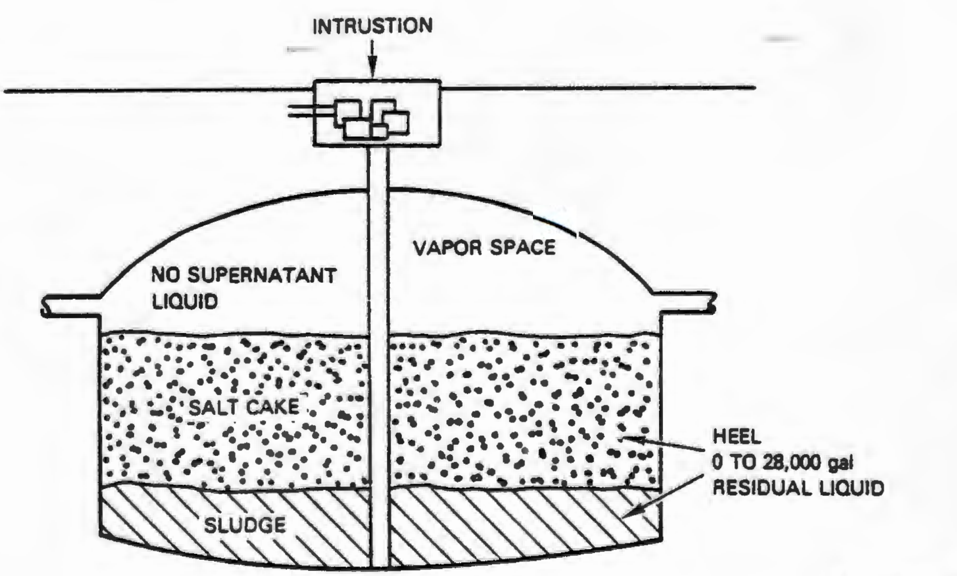
FIGURE 2. Inactive Tanks Awaiting Review and Action.

9212491567



RCP8006-116B

FIGURE 3. Primary Stabilized Tanks.



RCP8006-117A

FIGURE 4. Interim Stabilized Tanks.

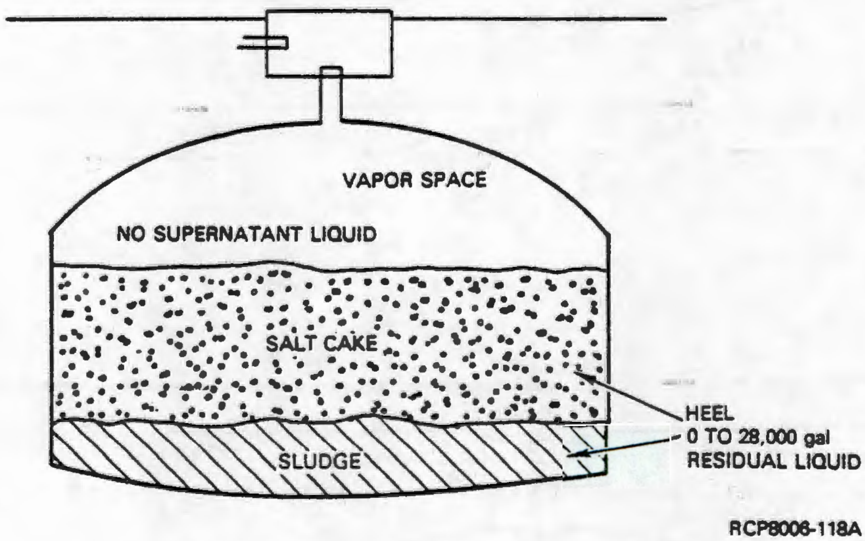


FIGURE 5. Interim Isolated Tanks.

TABLE 2. Surveillance Frequency by Tank Classification as of September 15, 1978.

Classification	Active	Inactive awaiting review and action	Primary stabilized	Interim stabilized	Interim isolated
		External Tank			
Vertical dry wells	2 wk	2 wk	2 wk	3 mo	12 mo
Horizontal laterals	2 wk	2 wk	2 wk	3 mo	12 mo
		Internal Tank			
Liquid level	Shift	Daily	Daily	Daily	Daily
Temperature	By procedure (CASS)	--	--	--	--
Other	By procedure	--	--	--	--
Photography	12 mo		As needed		1-5 yr
Dry well	--	--	Monthly	Monthly	6 mo
Gas sampling		Selected tanks			Variable
Tank pressure	--	--	--	--	Continuous
		Tank Integrity			
Dome					
Survey	6 mo	6 mo	6 mo	6 mo	6 mo
Electronic	Continuous	Continuous	Continuous	Continuous	Continuous
Photography	36 mo	36 mo	36 mo	36 mo	36 mo

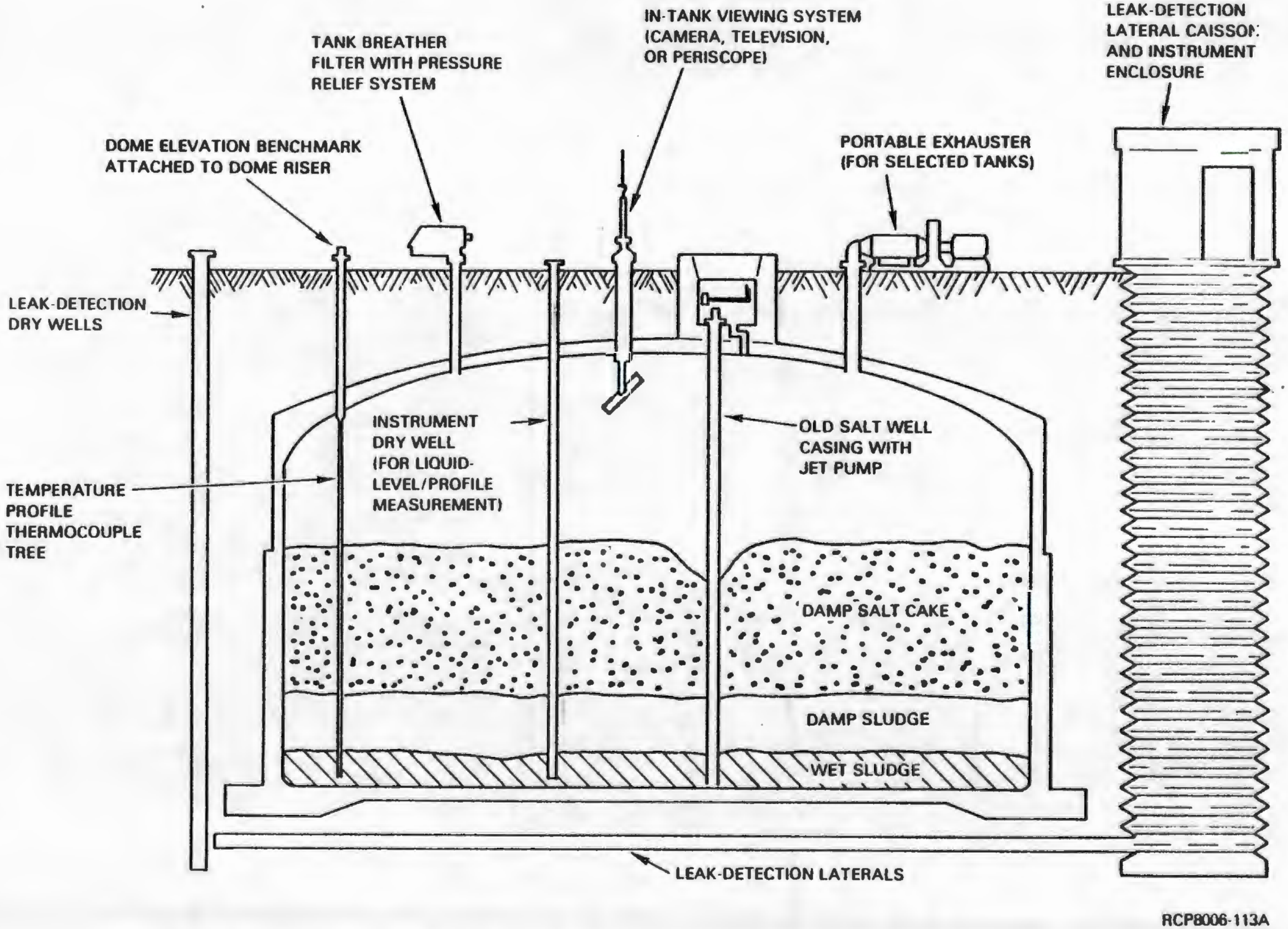


FIGURE 6. High-Level Waste Tank Surveillance Instrumentation.

TABLE 3. Instrumentation Installation Status.

Location	Status
<u>External Tank</u>	
Vertical dry wells	In-place
Horizontal laterals	In-place
<u>Internal Tank</u>	
Liquid level	In-place
Temperature	In-place
Other	In-place
Photography	In-place
In-tank dry well	B-221[a]
Gas sampling	B-221[a]
<u>Tank Integrity</u>	
Dome	
(Survey)	FY 1979, B-221[b]
Photography	In-place

[a]Scheduled to be available in 1982 with the completion of capital Project B-221.

[b]Partially completed in 1979; remainder scheduled to be available in 1982 with the completion of capital Project B-221.

The impact of tank leaks is provided in Table 4. Under worst case conditions, it is theoretically possible that traces of radioactivity might reach the Columbia River. However, in actual experience, radioactive contamination has been retained in the ground beneath the tanks and has not penetrated to the water table. The leak risk status for each class of tanks is shown schematically in Figure 7 for tanks that contain <2 ft of solids and in Figure 8 for tanks that contain >2 ft of solids. As can be noted from Figures 7 and 8, only active tanks and tanks containing more than 28,000 gal of residual liquids provide risks of leaks.

TABLE 4. Impact of Tank Leak.

Category	Condition	General population	Environment
Active	1,000,000 gal 0 to 1,000,000 gal of supernatant liquid 0 to 2,000 gal of drainable liquid from solids	Not assessed	Contamination of soil column beneath the tank. Not likely to reach groundwater.
Inactive-awaiting review and action	433,000 gal • 400,000 gal drainable liquid from salt cake and sludge • 33,000 gal of supernatant liquid	Not detectable	Contamination of >50% of the soil column beneath the tank.
Primary stabilized	400,000 gal - 400,000 gal from salt cake and sludge	Not detectable	Contamination of >50% of the soil column beneath the tank.
Interim stabilized	0 to 28,000 gal A maximum of 28,000 gal of drainable liquid from the wet solids	None	Contamination of <5% of the soil column beneath the tank.
Interim isolated	Same as above, but isolated	None	Contamination of <5% of the soil column beneath the tank.

9 2 1 2 4 9 9 1 5 7 4

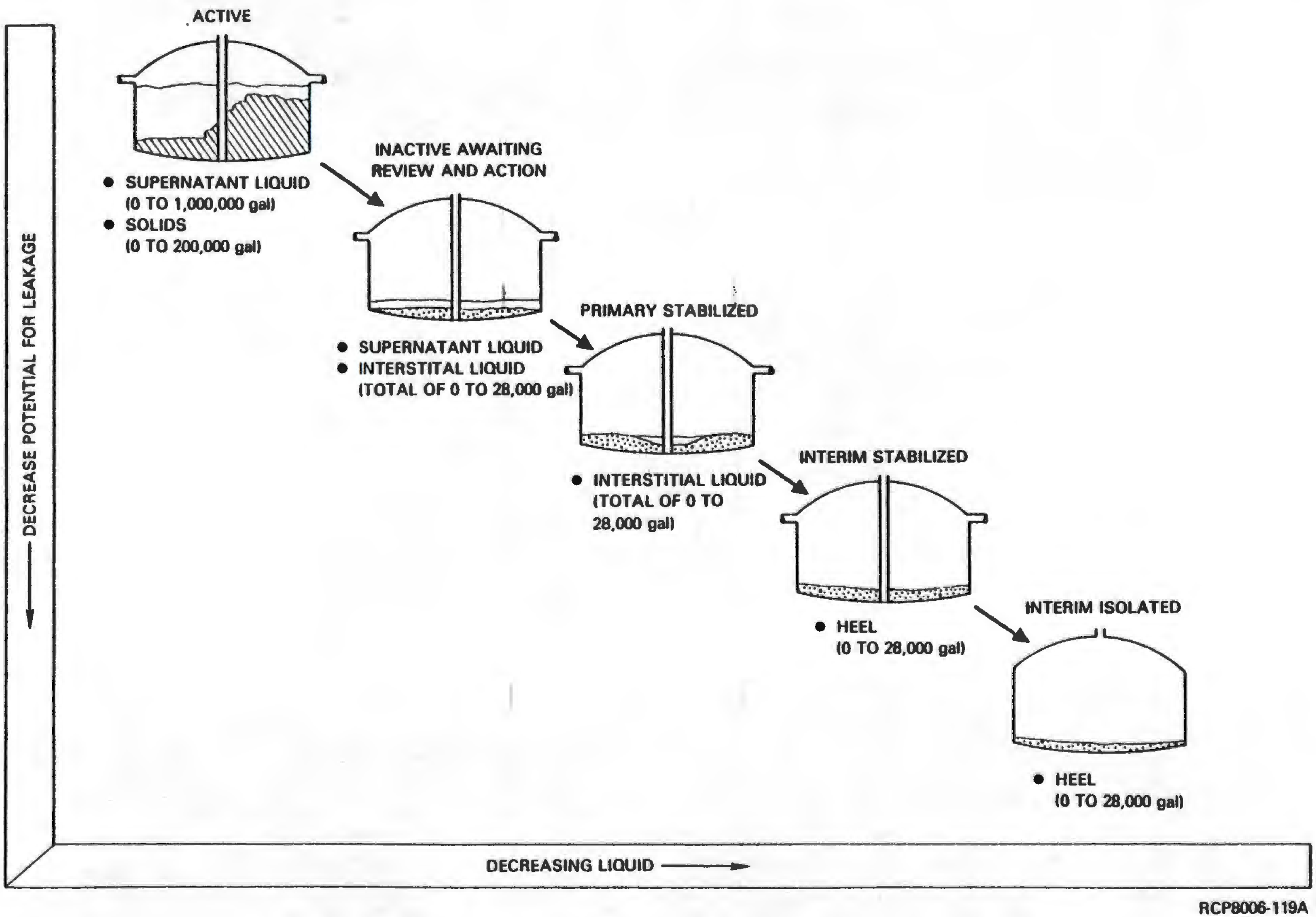
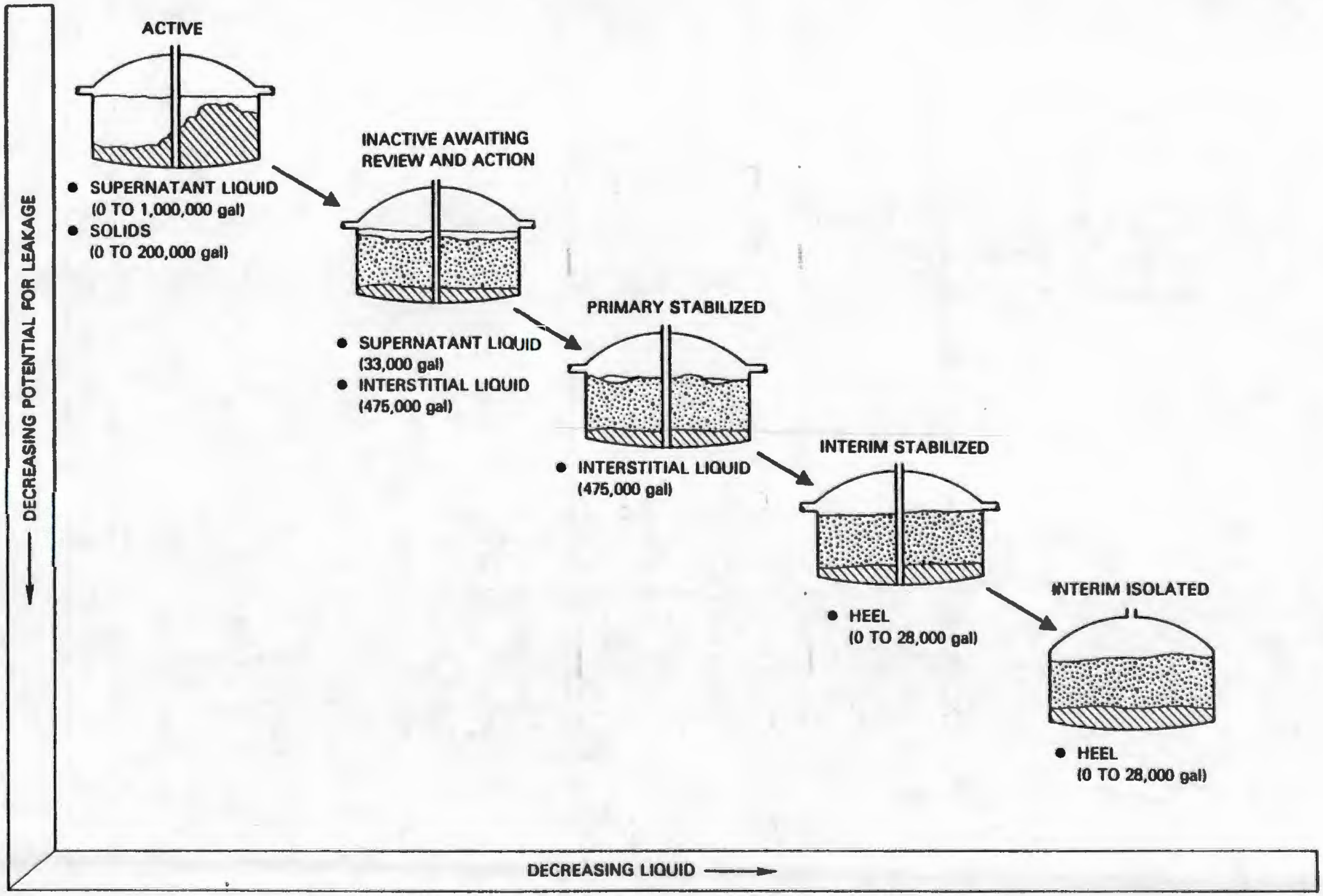


FIGURE 7. Leak Risk Status of Single-Shell Tanks (<2 ft of Solids).



RCP8006-120A

FIGURE 8. Leak Risk Status of Single-Shell Tanks (2 ft of Solids).

To assure timely detection and appraisal of tank leaks, redundant reviews of the surveillance data are made by different Rockwell Hanford Operations organizational components. The assigned responsibilities are given in Table 5. The computer-automated surveillance system (CASS) is a key component in detecting leaks based on liquid-level measurements.

TABLE 5. Responsibilities for Independent Evaluation/Analysis.

Classification (09-15-78)	Production operations			Research & Engineering	Health, Safety & Environment
	TFPO		TFS analysis	TFPE analysis	EP
	CASS	Operations			
External Tank					
Vertical dry wells	(F)		X	X →	(F)
Horizontal laterals	(F)		X	X →	(F)
Internal Tank					
Liquid level	X		X	X	(F)
Temperature	X		X	X	
Other	X	X	X	X	
Photography			X	X	
In-tank dry well	(F)		(F)	X	
Gas sampling			(F)	X	
Tank Integrity					
Dome					
Survey		(F)	(F)	(·)	
Photography			X	X	

NOTE: X = Activity by charter; (F) = Future activity; (·) = Future data reviewed for other purposes; TFPO = Tank farm process operations; TFS = Tank farm surveillance; TFPE = Tank farm process engineering; EP = Environmental protection.

The ability to detect and confirm leaks of high-level radioactive wastes from tanks depends on leak rates, sensitivity of instrumentation, and rates of fluid movement through soils. These data give rise to the question, "How frequently should dry wells be monitored to assure that leaks would be confirmed on a timely basis?"

Dry well monitoring data for leaking tanks were collected and evaluated. The peak radioactivity count rate in Dry Well 60-10-07 near Tank 241-U-110 increased more rapidly than that in any other case. Therefore, this example was used as a baseline for determining the frequency of monitoring dry wells. These data are plotted in Figure 9 with data for Dry Well 51-03-12 near Tank 241-TX-107. Detailed data for Dry Well 60-10-07 are plotted in Figure 10. The chronology of events associated with the 241-U-110 tank leak follows:

06-23-75 - Dry Well 60-10-07 monitoring frequency increased

06-26-75 - Battelle Northwest Laboratories soil resistivity surveillance started at selected wells about Tank 241-U-110

- In-tank photographs taken
- Neutron probe scan (probe considered to be malfunctioning)

06-30-75 - Dry Well 60-10-07 peak exceeded criterion

07-01-75 - Data logged and Occurrence Report 75-67 prepared

- Pump installed, route to Tank 241-U-111 established, and leak checked

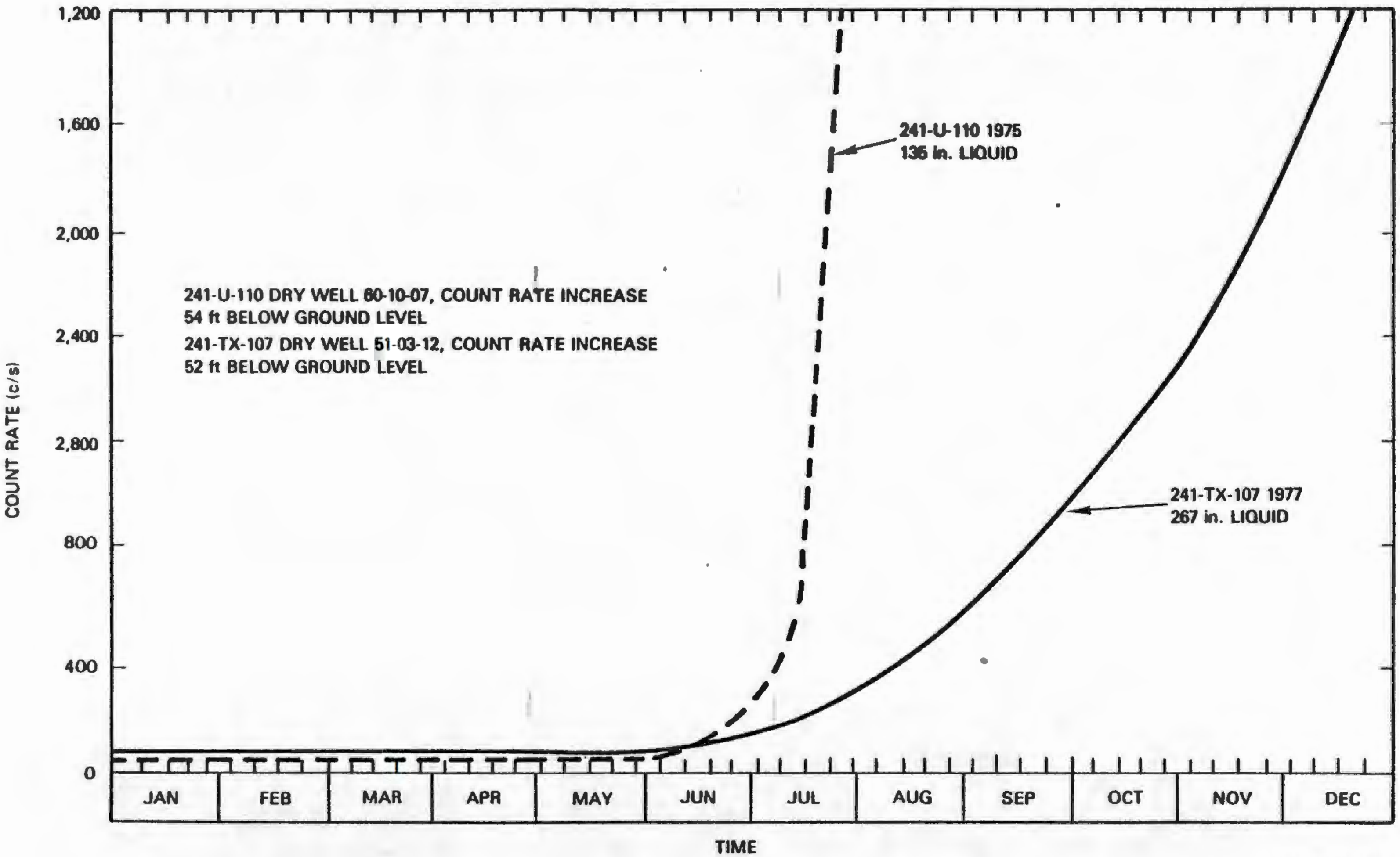
07-02-75 - Occurrence Report 75-67 issued

- Boeing soil conductivity surveillance system installed

07-07-75 - Tank 241-U-110 status changed to "Confirmed Leaker"

07-08-75 - Tank supernatant pumped to Tank 241-U-111

07-28-75 - Salt well pumping program commenced to remove as much residual liquid as possible.



RCP8006-121A

FIGURE 9. Dry Well Monitoring Data for Tanks 241-U-110 and 241-TX-107.

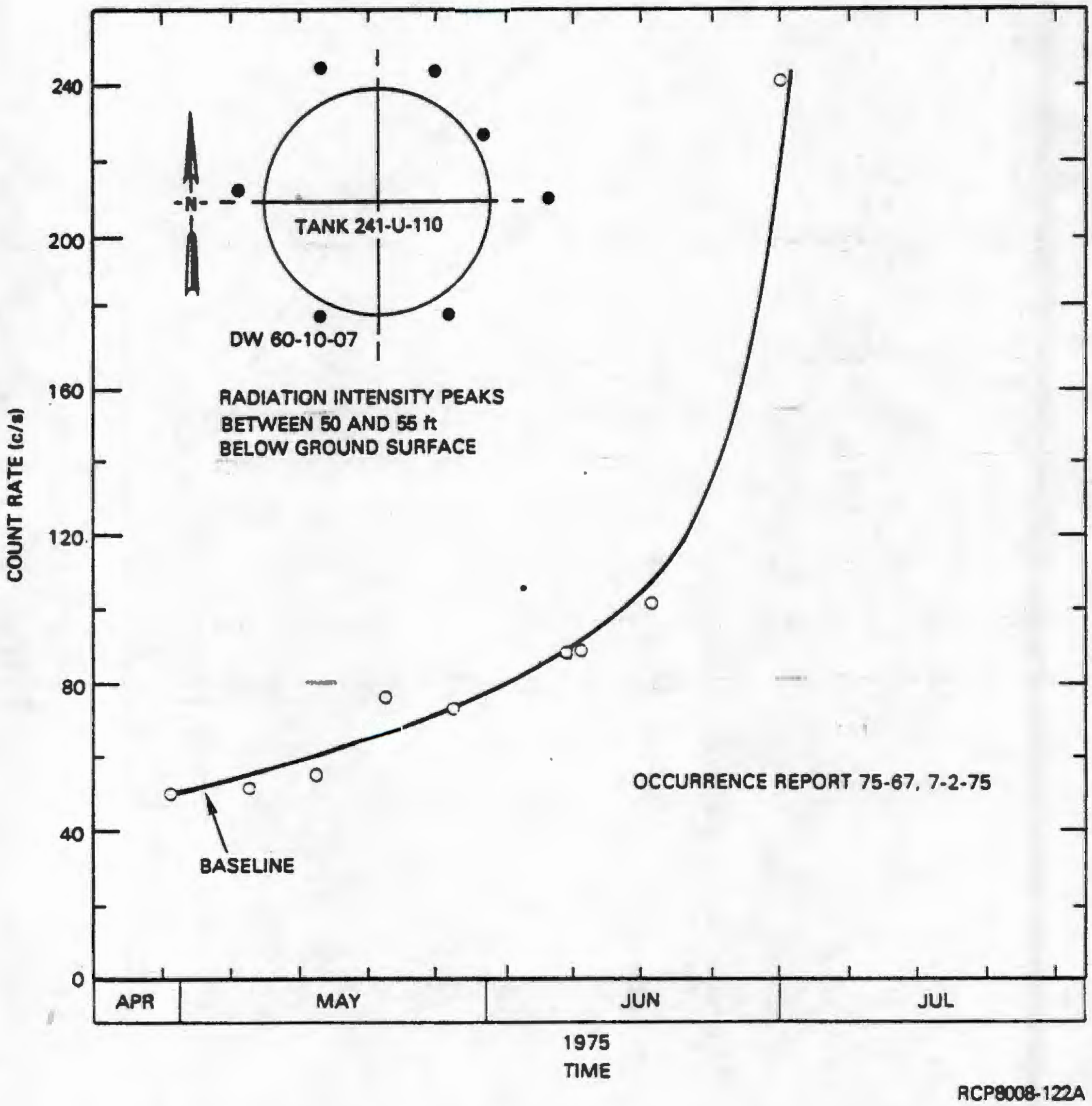


FIGURE 10. Dry Well Monitoring Data for tank 241-U-110.

An inspection of the data indicates that the radioactivity in Dry Well 60-10-07 increased slightly between June 3 and June 10 and continued to increase as noted on June 17 and June 23. Although the count rates were still within the range of normal variations in background, increased surveillance was initiated on June 23. On June 30 the count rate exceeded the action criterion of 200 c/s (see Figure 10) and an occurence report was filed.

A period of 20 days elapsed before the increase in count rate was sufficient to cause increased surveillance activity. Another 7 days elapsed before the action criterion of 200 c/s was reached. Based on this experience, it is obvious that if the dry wells had been monitored every 2 wk, the increase in count rate would have been recognized at any time between June 10 and June 24, and timely action would have been taken to increase surveillance activities. Thus, the study group concluded that biweekly monitoring of dry wells would be sufficient to assure that leaking tanks would be detected and action taken to minimize the volume of a leak based on sound action criteria.

Subsequent to these reviews the Catlin Report[2] was published. One of the recommendations in this report was that "dry well and horizontal lateral monitoring frequency should be determined on a tank by tank basis.... Formal criteria are needed to redetermine the surveillance frequency for each tank and the development of such criteria is recommended, taking into account pertinent technical factors such as available monitoring systems, tank contents and their relative mobility."

THIS PAGE INTENTIONALLY
LEFT BLANK

DISCUSSION

THE DRY WELL RADIOACTIVITY RESPONSE EQUATION

As a consequence of the Catlin recommendation,[2] the response of the dry well radioactivity monitoring system has been evaluated and characterized. The results of this evaluation and characterization have been summarized in the Dry Well Radioactivity Response Equation:

$$n_t = n_{t-\Delta t}\,\frac{10^x}{2^y} \qquad (1)$$

n_t = Count rate at time t from start of leak (generally 160 c/s)

$n_{t-\Delta t}$ = Count rate at time of alert (generally 20 c/s)

Δt = Time for count rate to increase from alert level (20 c/s) to action (160 c/s) when used to determine monitoring interval.

$$X = \frac{C\,\Delta d}{\frac{\ell'}{\bar{m}}} = \frac{0.918\left(B - \sqrt[3]{B^3 - \frac{s\Delta t}{q\,g'}}\right)}{0.8694\left(\frac{[^{106}Ru]}{2^{\Delta t/368}}\right)^{0.0698}} \qquad (2)$$

or

$$X = \left\{\left[1.0559\left(\frac{2^{\Delta t/368}}{[^{106}Ru]}\right)^{0.0698}\right]\left(B - \sqrt[3]{B^3 - \frac{s\Delta t}{q\,g'}}\right)\right\}$$

and

$$y = \frac{\Delta t}{368} \qquad (3)$$

The other terms are as follows:

C = Detector calibration factor = 0.918 for sensitive gross counting scintillator

B = Distance of detector from source of tank leak

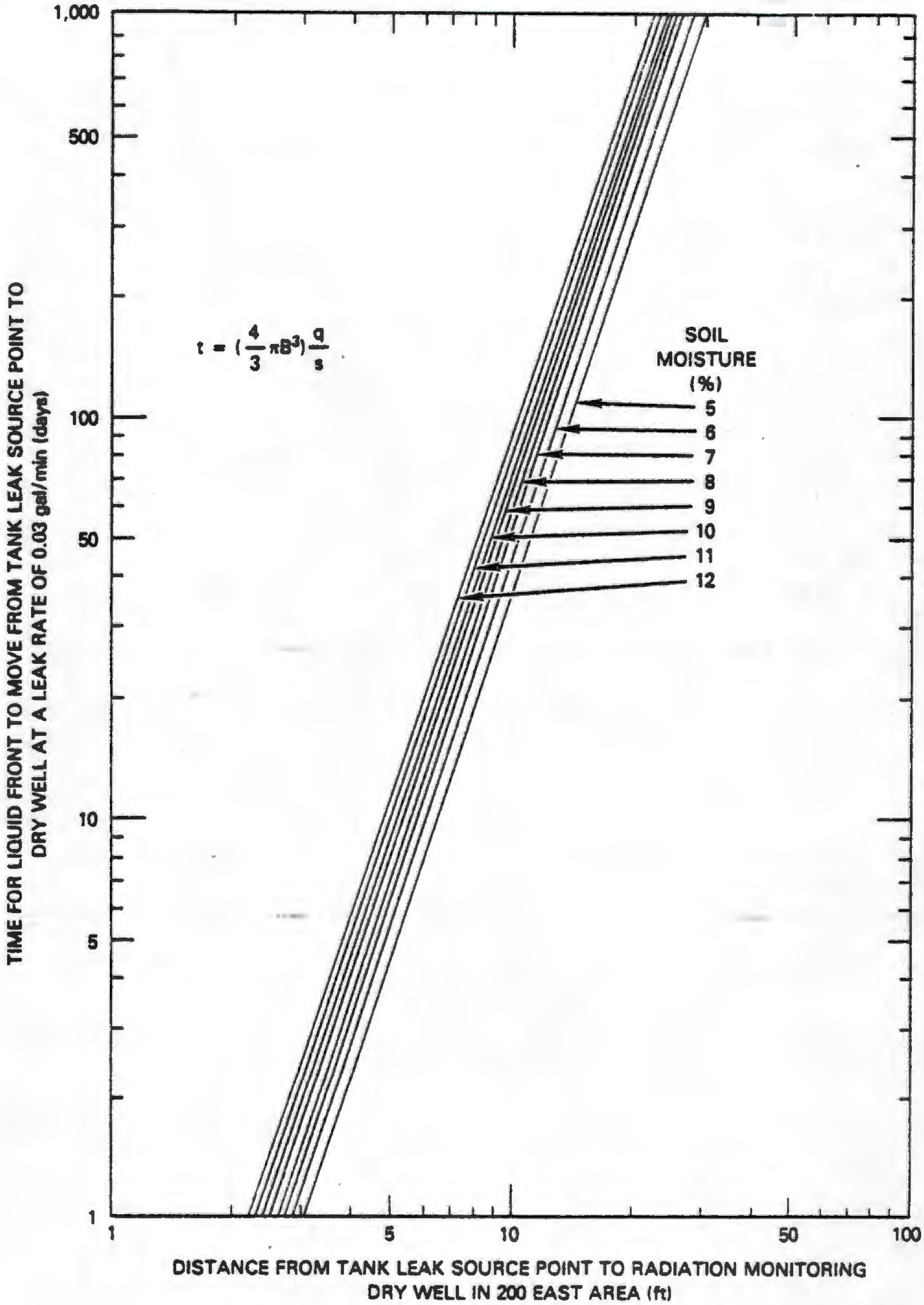
s	=	Leak rate in ft^3/day
Δt	=	Time for count rate to increase from 20 to 160 c/s (minus background count rate)
q	=	Soil moisture content (volume fraction)
g'	=	Geometric factors including hydrologic anisotropy
$\ell'_{\bar{m}}$	=	Effective mean tenth-value thickness of soil corrected for radioactive decay
[^{106}Ru]	=	Concentration of ruthenium-106 in Ci/L
368	=	Half life of ^{106}Ru (days)
0.8694	=	Coefficient to convert one-tenth value thickness to feet
0.0698	=	Exponent derived from ISOSHLD calculations of one-tenth value thickness of Hanford soils as a function of varying concentrations of ^{106}Ru-^{106}Rh.

The derivation of this equation is given in Appendix K. The equation includes the variation in dose rate (roentgen/hr) as a function of source strength, variations in attenuation of the dose by the soil as the liquid waste front approaches a dry well, response of the radiation detectors in c/s as the dose rate changes (instrument calibration), distance of the radiation monitoring dry well from the tank leak source, the leak rate, the geometry of the soil wetted by the leaking waste, and the hydrologic properties of the soil.

The total time (t) for the liquid waste to reach a radioactivity monitoring dry well is inversely proportional to the leak rate (s) and proportional to the volume of soil moisture displaced (q), the geometric factors (g) of the soil volume wetted, and the cube of the distance (B) between the tank leak source point and the dry well. Thus,

$$t = \frac{4/3\pi B^3 g\ q}{s} \tag{4}$$

The total elapsed time from the start of a leak to verification of the leak at a radiation monitoring dry well is provided in Figures 11 and 12 as a function of the distance of the dry well from the waste tank



RCP8011-245A

FIGURE 11. Total Time (Days) for Radioactive Liquid Front to Migrate as a Function of Distance (ft) from Waste-Tank Leak Source Point to Radiation Monitoring Dry Well (200 East Area).

9 2 1 2 4 9 9 1 5 8 4

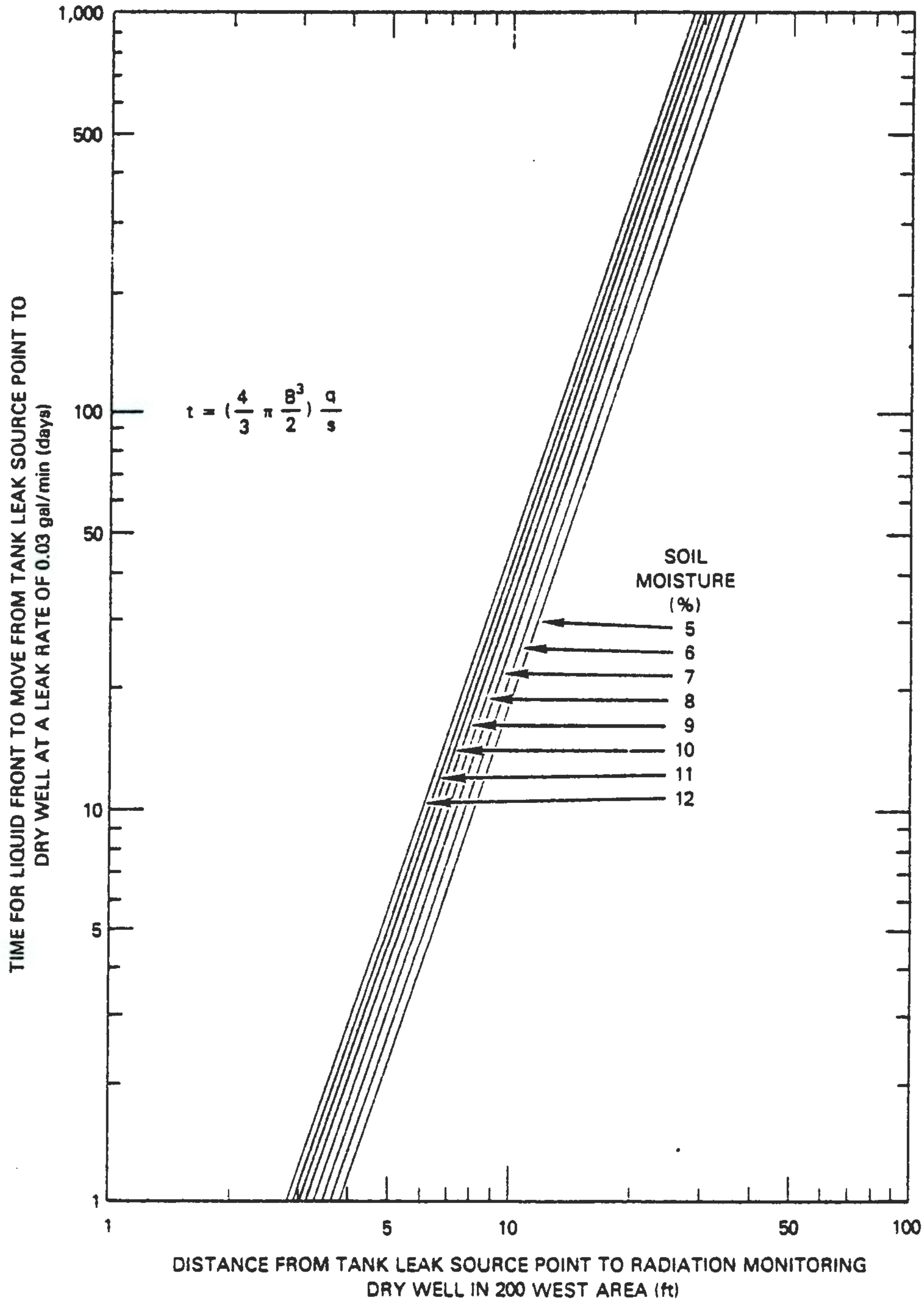


FIGURE 12. Total Time (Days) for Radioactive Liquid Front to Migrate as a Function of Distance (ft) from Waste-Tank Leak Source Point to Radiation Monitoring Dry Well (200 West Area).

9 2 1 2 4 9 9 1 5 3 5

leak source for 200 East and West Areas, respectively. The calculations were based upon a leak rate of 0.03 gal/min (5.77 ft^3/day), an incremental soil moisture increase of 8 vol% to cause capillary transport, spherical geometry of the leak plume in 200 East Area, and oblate spheroid geometry with a height to diameter ratio of 0.5 in 200 West Area. Once the liquid waste front has reached the vicinity of the well, the incremental time (Δt) required for the count rate to increase to the action level of 160 c/s above background can be determined from the following equation:

$$\Delta t_{\Delta d} = \left(B^3 - \left\{ B - \left[\frac{\ell'_{\overline{m}}}{C} \right] \left[\left(\log_{10} \frac{n_t}{n_{t-\Delta t}} \right) + \left(\frac{\Delta t}{368} \log_{10} 2 \right) \right] \right\}^3 \right) \frac{g'q}{s} \quad (5)$$

where

$$\ell'_{\overline{m}} = 0.8694 \left(\frac{[^{106}Ru]}{2^{\Delta t/368}} \right) 0.0698 \text{ ft}$$

where

C	=	0.918 count-rate instrument calibration factor
$[^{106}Ru]$	=	The ^{106}Ru-^{106}Rh concentration in the liquid high-level waste in Ci/L of waste
n_t	=	The action level count rate at time t
$n_{t-\Delta t}$	=	The count rate when an increase above background is noted
Δt	=	Time for the count rate to increase from $n_{t-\Delta t}$ to n_t. When $n_{t-\Delta t}$ = 20 and n_t = 160 c/s, Δt is the "Dry Well Response Time" used to establish the monitoring frequency for a given dry well.

See Appendix K for the derivation. It should be noted that Δt is negative with respect to t, since t is defined as the elapsed time required for the liquid waste front to migrate to the dry well. The elapsed time is that period from the time that the leak started to the time that the count rate reaches 160 c/s above background. Thus, the time to a lesser count rate must be less. The term Δt' can be approximated by deleting the correction for radioactive decay ($\frac{\Delta t'}{368} \log_{10} 2$) from the above equation. If $\Delta t'$ is significantly less than Δt, a more exact solution can be developed by iterating the above equation using successive values of Δt for $\Delta t'$.

Further, it should be noted that regardless of the frequency of monitoring, there is no assurance that a tank has not leaked based only on the fact that the radioactive front has not reached a radioactivity monitoring dry well. The front could be a matter of hours or less from being first detected or recognized at the time of the last dry well survey. The rate of rise in count rate is a function of the leak rate and the distance from the leak source to the dry well.

Relationships of time required for the count rate to increase from incremental levels above baseline to 160 c/s above baseline are plotted as a function of distance of dry wells from the tank leak source in Figures 13 and 14 for 200 East and 200 West Areas, respectively. In these cases, a constant leak rate of 0.03 gal/min (5.77 ft^3/day) and a ^{106}Ru-^{106}Rh concentration of 4 x 10^{-4} Ci/L were used to calculate the curves. These curves can be used to determine the period between successive dry well surveys (monitoring frequency) for a variety of applications.

For example, if all leaks are to be limited to 10,000 gal, based on plume geometry and moisture content, the maximum distance a radiation monitoring dry well could be located from a tank leak source would be 15.9 ft in 200 East Area and 20.0 ft in 200 West Area. For the above conditions, the time required for the count rate to increase from baseline to the action level would be as follows. Assuming that at the time of the last monitoring the count rate was 2 c/s above background (not a recognizable increase in count rate above baseline) about 44 days would elapse in 200 East Area and about 35 days would elapse in 200 West Area before the count rate would increase to the "Action Level." After the count rate increased to the "Alert Level," about 21.5 days would elapse in 200 East Area and 17.1 days would elapse in 200 West Area before the count would increase to the "Action Level." Thus, the time for the count rate to increase from the "Alert Level" to the "Action Level" is

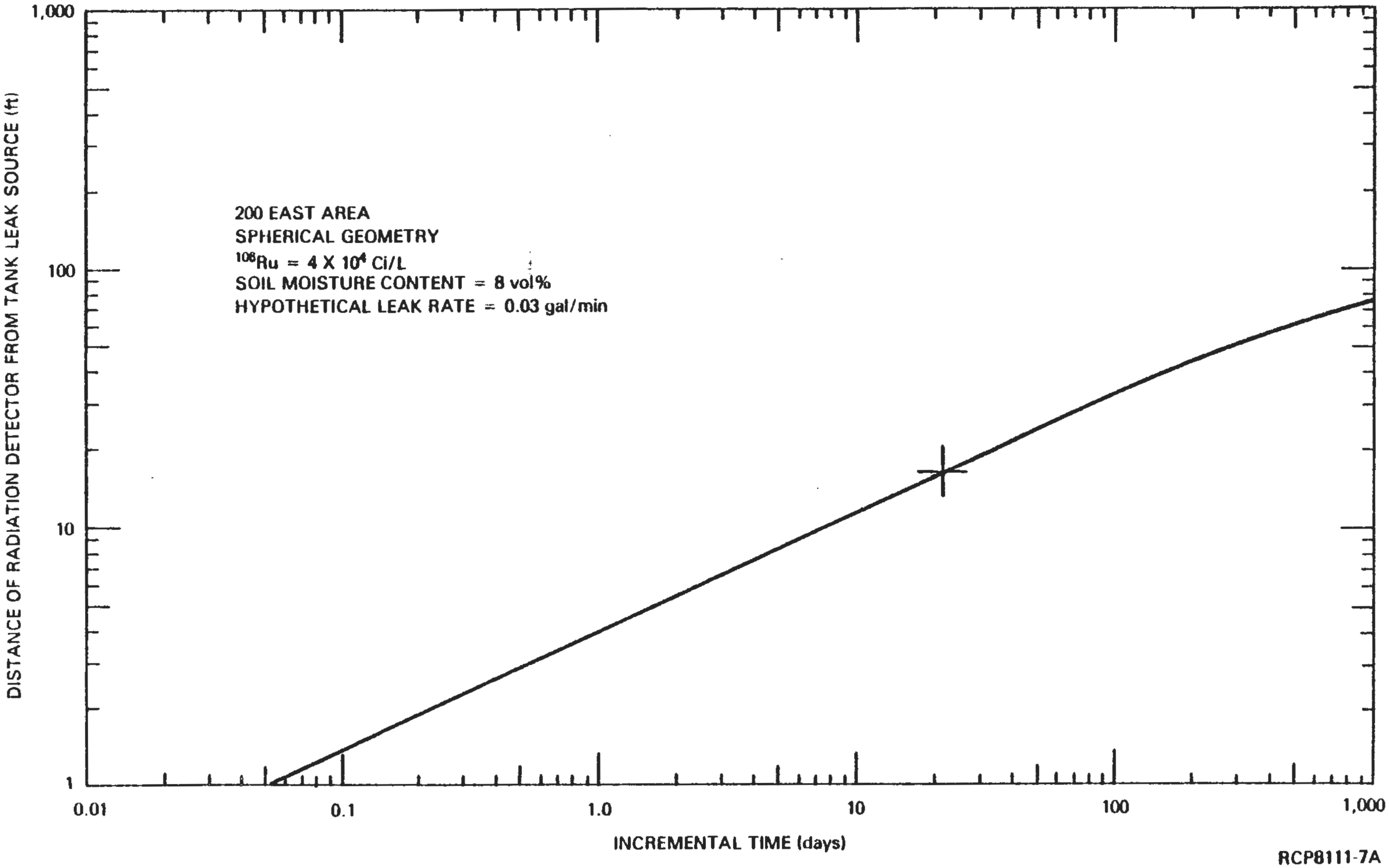


FIGURE 13. Incremental Time (Days) for Count Rate to Increase from 20 c/s Above Baseline to 160 c/s Above Baseline (200 East Area).

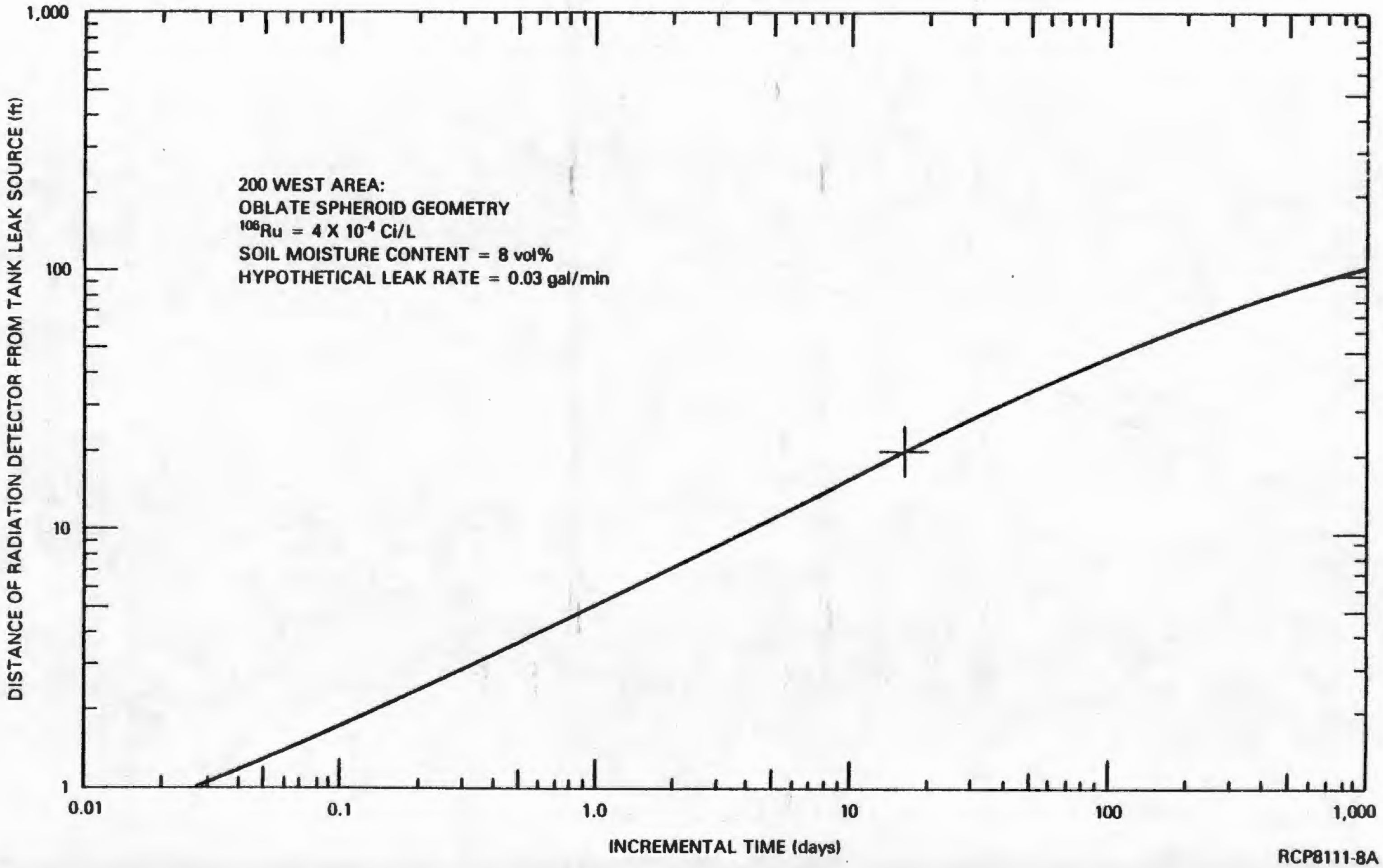


FIGURE 14. Incremental Time (Days) for Count Rate to Increase from 20 c/s Above Baseline to 160 c/s Above Baseline (200 West Area).

about the same as the time it takes for the count rate to increase from the baseline to the "Alert Level."

These data have been plotted in different format in Figures 15 and 16 to illustrate how count rate changes as a function of time for dry wells located at various distances from tank leak sources.

APPLICATION OF DRY WELL RADIOACTIVITY RESPONSE EQUATION TO TANK LEAK ANALYSIS

Leak rates can be estimated from historic data if the soil moisture content adjacent to the dry well is known and the time that elapsed from the start of the leak to the time that the count rate reached 160 c/s above background is also known. These data can be used to estimate the distance, B, from the dry well to the leak source. The leak source could be anywhere on a circle of radius B from the dry well. When a number of dry wells are involved, then the probable source of the leak would be within an area intersected by, or common to, all such circles as illustrated in Figures 17 and 18 for a suspected leak between tanks 241-TK-103 and 241-TX-107.

Another useful tool in this type of analysis is the apparent "equilibrium" count rate in the various dry wells near the leak. Since various minerals in the soil are effective ion exchange materials,[1,3,4] the further a dry well is from a leak, the lower the "equilibrium" count rate will be in that dry well. Accordingly, the count rate gradient will increase toward the leak source and thus, will "point" toward the source.

Increased count rates in radioactivity monitoring dry wells situated between Tanks 241-TX-103 and 241-TX-107 have raised questions as to the integrity of Tank 241-TX-107.

The chronology of count rate data by dry well is given in Table 6 and tank liquid level data are plotted in Figure 19. Count rate data for these tanks are plotted in Figures D-20 through D-23, Appendix D.

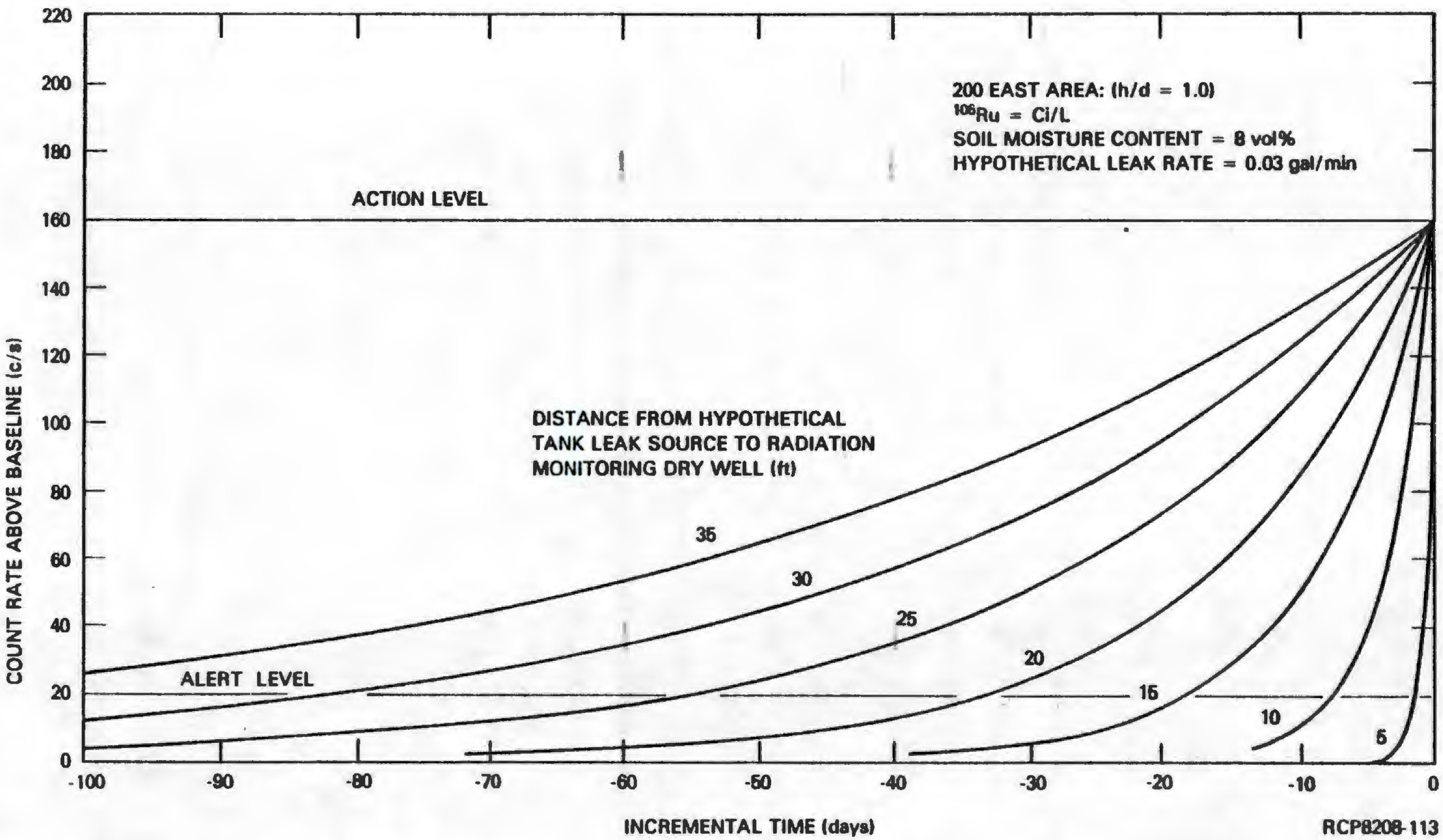


FIGURE 15. Incremental Time from Radiation Monitoring Dry Well for Count Rate to Increase to 200 c/s at the Dry Well as Radioactive Waste Reaches Dry Well (Days). (200 East Area.)

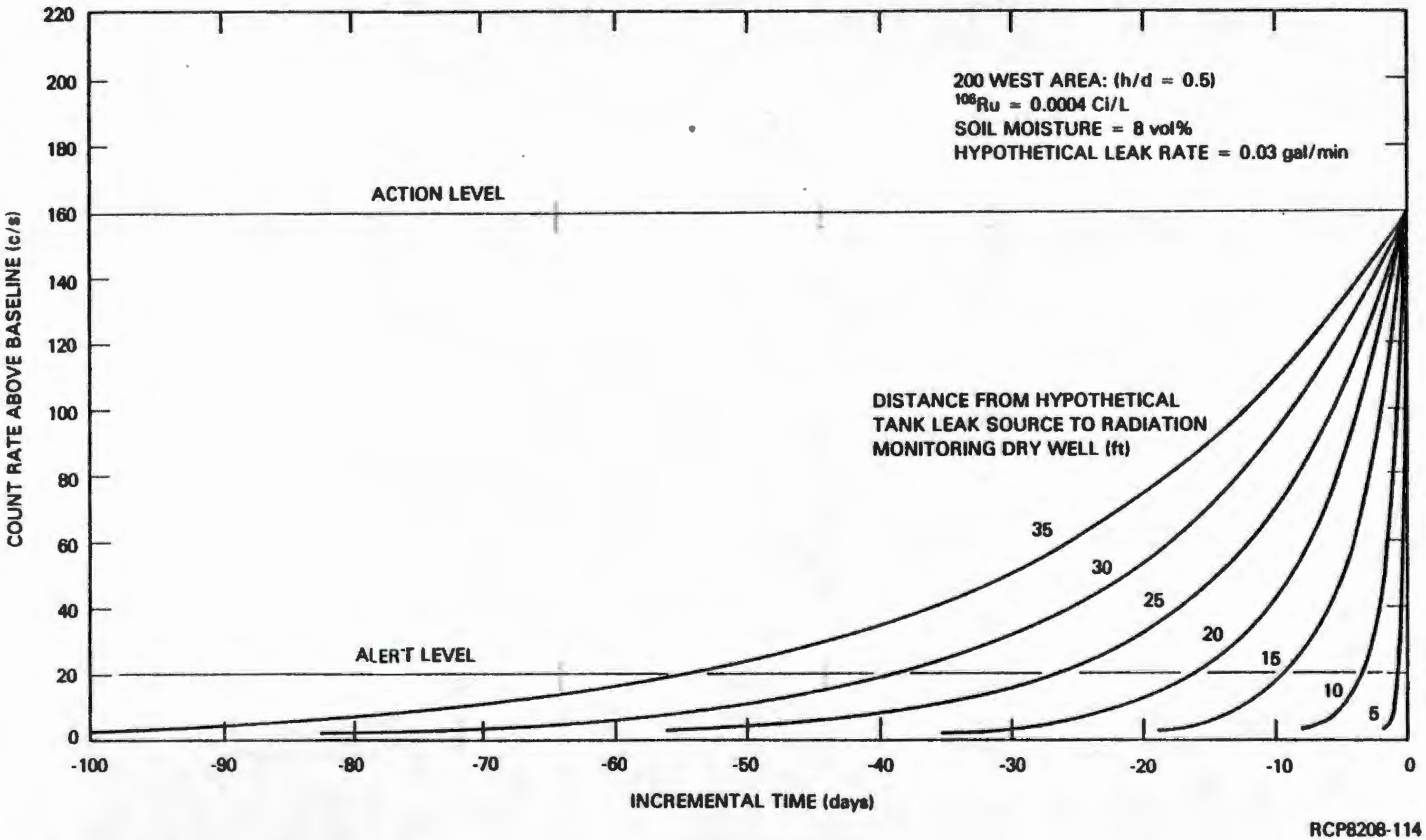
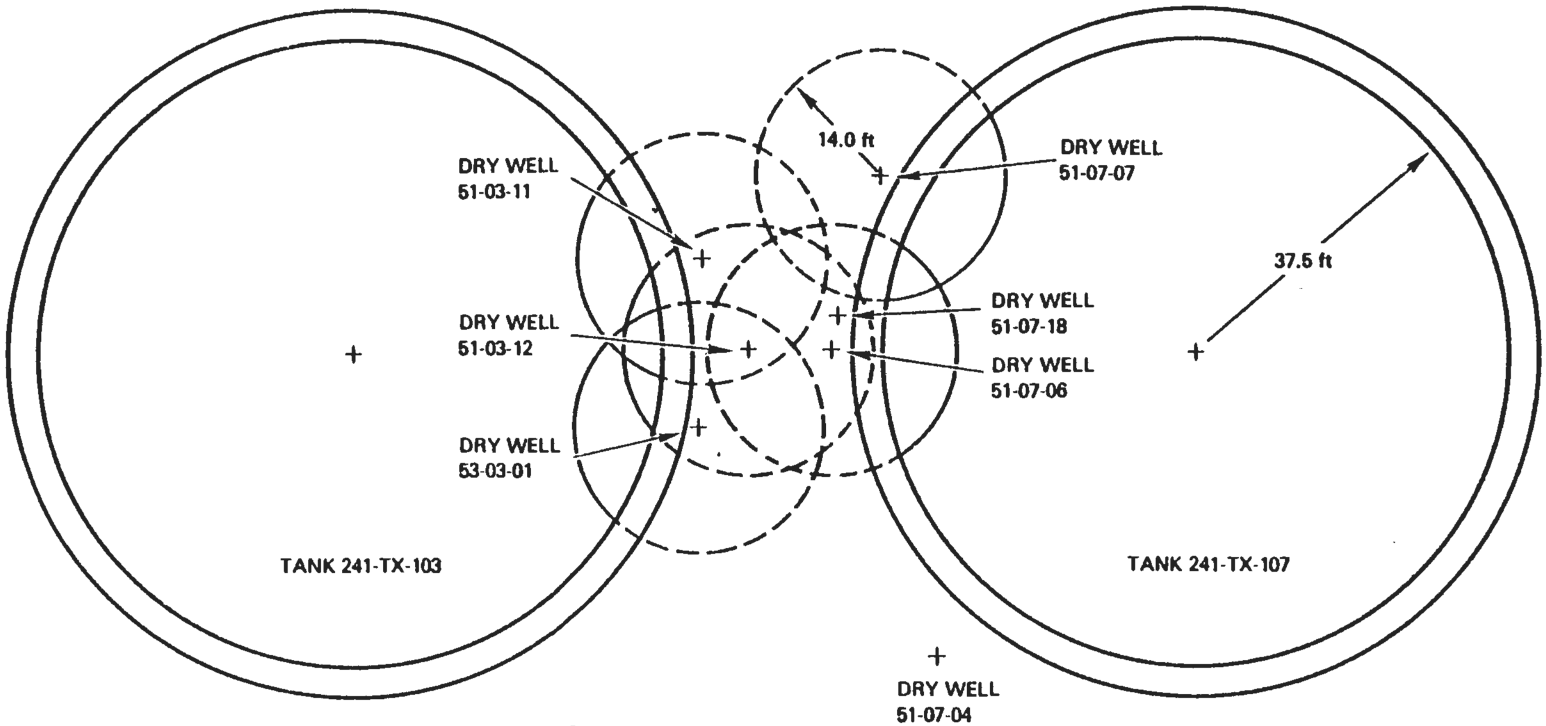


FIGURE 16. Incremental Time from Radiation Monitoring Dry Well for Count Rate to Increase to 200 c/s at the Dry Well as Radioactive Waste Reaches Dry Well (Days). (200 West Area).

9 2 1 2 4 9 9 1 5 9 3



NOTE: + DENOTES CENTERS OF TANKS AND DRY WELLS

RCP8012-148A

FIGURE 17. Probable Sources of Tank Leak Based Upon a Maximum Leak Size of 1,375 Gal (1/2 in. Liquid-Level Decrement in Tank 241-TX-107) and Soil Moisture Content of 6.8% (Average).

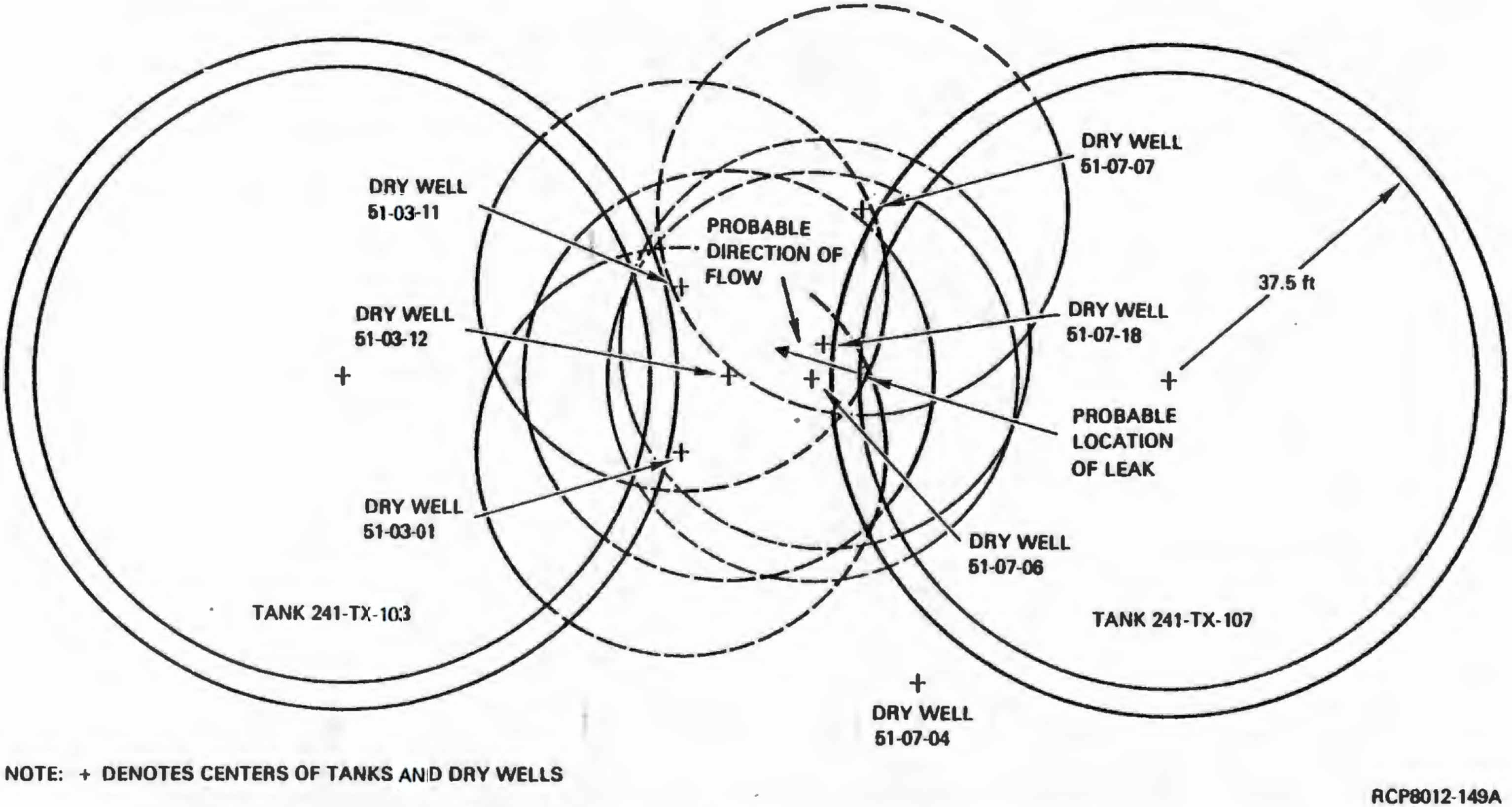


FIGURE 18. Distance from Radioactivity Monitoring Dry Wells to Potential Tank Leak Sources Based on Incremental Times for the Radioactivity Count Rate to Increase from 20 c/s to 160 c/s Above Baseline.

TABLE 6. Data Compilation for the Radiation Peak Observed at the 51-ft Depth in Leak Detection Dry Wells Associated with Tanks 241-TX-103 and 241-TX-107.

Date	DW 51-03-12		DW 51-07-07[a]		DW 51-03-11[b]		DW 51-03-01[c]		DW 51-07-06[d]		DW 51-07-18[e]	
	Peak c/s	Peak depth (ft)	Peak c/s	Peak depth (ft)	Peak c/s	Peak depth (ft)	Peak c/s	Peak depth (ft)	Peak c/s	Peak depth (ft)	Peak c/s	Peak depth (ft)
12-29-76	38	66										
02-03-77	40	52										
03-03-77	37	64										
03-31-77	53	52										
04-29-77	70	52	48	50	52	50						
05-31-77	118	51	39	50	49	50	42	71	30,978	51		
06-29-77	245	51	41	93	83	50	37	49			31,515[f]	51
07-29-77	289	51	38	56	189	50	40	51	[g]		4,831[h]	50
08-31-77	633	51	36	84	259	50	68	50			4,865	50
09-30-77	965	52	35	56	472	50	87	51			5,050	50
10-31-77	1,520	51	35	63	732	50	112	51			6,181	50
11-30-77	2,301	51	35	76	992	50	153	51			5,463	50
12-30-77	3,535	50	40	50	1,204	50	273	51			7,382	50
01-30-78	4,885	50	38	50	2,425	49	330	50			8,454	50
02-27-78	7,211	50	41	49	2,121	50	359	50			7,059	50
03-29-78	10,180	50	44	50	3,166	49	523	50			6,956	50
04-28-78	11,078	51	44	50	3,300	50	659	50			7,502	50
05-30-78	12,922	50	105?	89	3,372	50	831	50			7,247	50
06-30-78	12,871	51	73	52	3,829	50	935	51			8,586	50
07-31-78	18,711	51	79	49	6,064	50	1,180	50			8,233	50
08-30-78	15,626	51	85	50	6,522	50	1,133	51			7,476	50
09-29-78	15,827	51	100	51	5,001	50	1,360	50			7,901	50
10-30-78	18,899	51	124	50	6,731	51	1,766	50			9,746	50
11-29-78	16,350	51	127	50	7,953	51	1,907	50			9,652	50
12-29-78	15,322	51	156	51	7,340	51	2,173	51			10,867	51
01-31-79	16,836	51	193	50	7,584	51	2,057	51			10,177	50
06-19-80	21,000	51	608	50	6,650	51	3,163	51			9,527	50

[a]New 05-13-77
[b]New 05-25-77
[c]New 06-08-77
[d]New 06-24-77
[e]New 07-14-77
[f]S Probe
[g]Well abandoned
[h]SS Probe

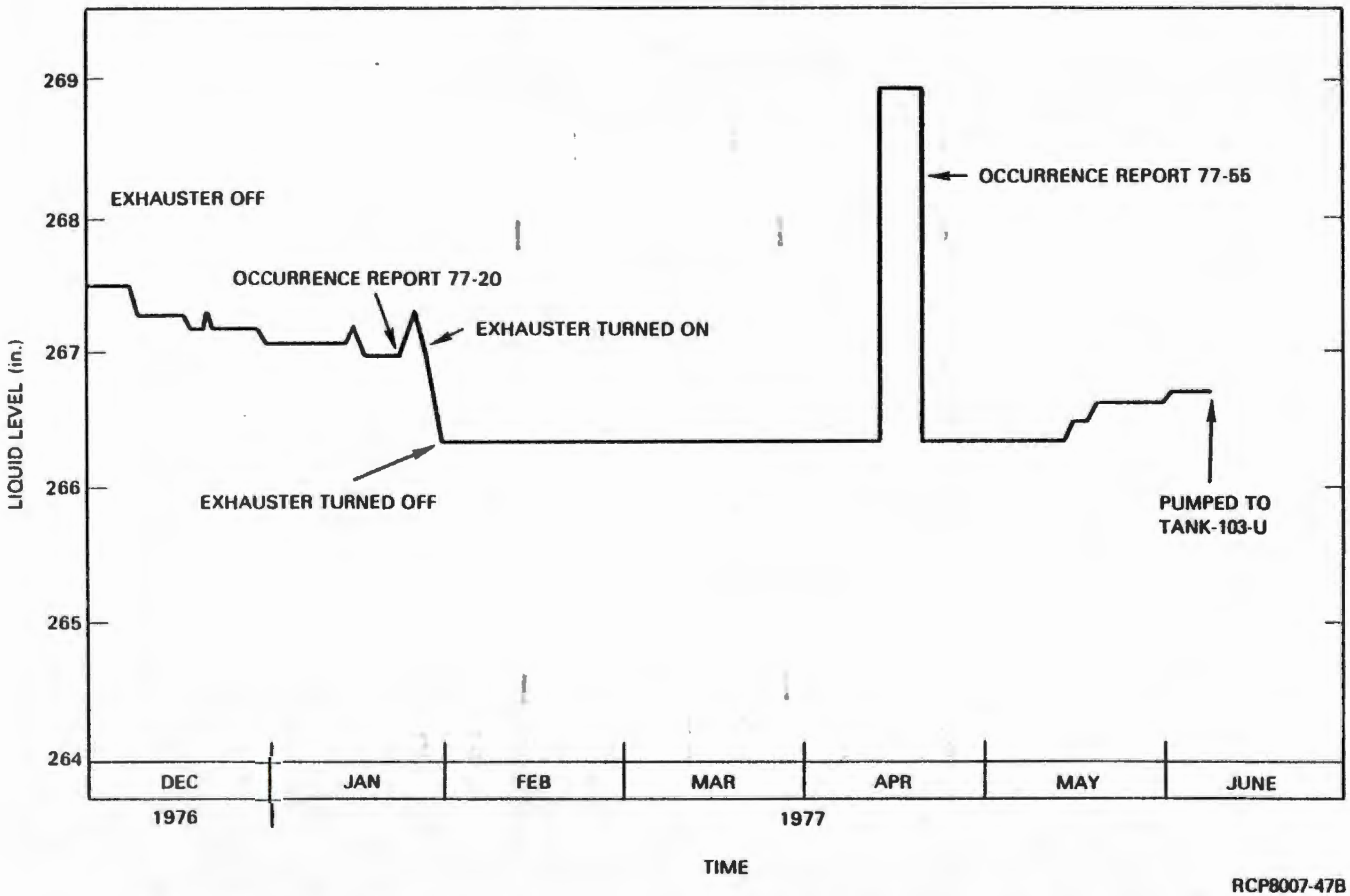


FIGURE 19. Tank 241-TX-107 Liquid-Level Data Plot, December 1976 to June 1977.

9 2 1 2 4 9 9 1 5 9 7

The liquid level in the tank decreased from 267.5 in. on December 9, 1976 to 267.0 in. on January 18, 1977, a period of 40 days. Subsequently, the liquid level decreased to 266.4 in. during the time period when the exhauster was turned on. The liquid level appeared to stabilize at 266.4 in. after the exhauster was turned off (see Figure 19).

The zone of contamination appears to be confined to a thin lens (8- to 10-ft thick) relative to the probable diameter of the wetted zone (50 to 60 ft) based on the count rate data charts and the distances to the dry wells. Thus, the geometric factor of the leak is in the range of 8/60 to 10/50 (0.13 to 0.20). For purposes of this analysis, 0.2 was used. The soil moisture factor (q) was assumed to be 8% based upon the average of the available data (see Table 7).

TABLE 7. Soil Moisture in Tank Farm 241-TX Wells.

Well number	Percent moisture by volume	
	31 ft depth	65 ft depth
51-04-05	7.8	6.9
51-01-08	9.0	6.5
51-06-12	9.6	7.2
Average (each horizon)	8.8	6.87
Average	8	

If Tank 241-TX-107 was the source of the leak, the maximum volume of the leak is estimated to be 1,375 gal, consistent with the loss of 1/2 in. of liquid. The maximum probable distance the leak would travel, based upon uniformly layered soils, would be as follows:

$$B = \sqrt[3]{\frac{\frac{1,375}{7.481}}{(\frac{4}{3}\pi)(0.2)(0.08)}} = 14.0 \text{ ft}$$

The probable source of the leak would be within a distance of the tank intercepted by an arc of radius B (i.e., 14.0 ft) centered on each of the dry wells (see Figure 17).

It is apparent from these estimates that if the leak was limited to 1,375 gal it was not sufficient to reach all of the dry wells at a soil saturation of 8% by volume. The leak may have been larger and continued longer than that indicated from the liquid-level readings associated with Tank 241-TX-107 in December 1976 and January 1977. In order to intercept all dry wells of concern, the effective radius of such a leak must be at least 25 ft, as illustrated in Figure 18. Based on a soil moisture content of 8%, the minimum volume of the leak would be as follows:

$$Q = st = (4/3)(\pi)(25^3)(0.08)(0.2) = 1{,}047 \text{ ft}^3$$
$$= 7{,}830 \text{ gal, or } 2.85 \text{ in. of waste.}$$

(This volume is not consistent with the measured liquid-level decrement of 1/2 in. viz., 184 ft^3, in Tank 241-TX-107).

The total time to reach the various dry wells and the apparent leak rates are given in Table 8.

TABLE 8. Time Required for Waste to Migrate from Tank 241-TX-107 to Various Dry Wells and Apparent Leak Rates.

Well number	Total time to reach dry well (at time count rate = 160 c/s) (days)	Apparent leak rate (Q/t) (ft^3/days)
51-03-11	232	4.513
51-03-12	197	5.316
51-03-01	373	2.808
51-07-07	852	1.229

It can be seen from the results in Table 8 that the migration of moisture was anisotropic (see Figure 18) and possibly continued to spread by a slower diffusion process and "equilibration." The anisotropy, while not fully explored, could be caused by variations in soil properties and/or moisture content. Considerably more geological information is needed to assess anisotropy caused by the presence of geologic anomalies such as clastic dikes (vertical layers of fine-grained silts and clays, common to the Hanford Site) or the presence of a unique lens of fine-grained silts.

Variations in moisture content could be caused by infiltration of uncontaminated water from various activities in the tank farm such as using water for soil compaction during construction, water used for clean-up of equipment, or from leaking water lines and/or steam lines. Such water sources could act as a "barrier" if they result in an opposing soil moisture gradient that is greater than that due to leaking waste.

Variations in soil moisture in the region of concern are given in Table 9. These data were obtained in March 1979. The moisture content at the 51-ft depth is significant since this is the horizon, or soil layer, within which the radioactivity has preferentially migrated outward from the leak source as can be deduced from the higher radioactivity count rate at this depth. Retention of the leaking waste in this soil horizon is indicative of a layer of relatively finer textured materials which has a higher matric or capillary potential than the surrounding soil.

TABLE 9. Soil Moisture Measurements in Dry Wells Associated with Tank 241-TX-107 Investigations (vol%).

Depth (ft)	Dry well number					
	51-03-11	51-03-12	51-03-01	51-07-07	51-07-18	51-07-04
45	15.1	11.5	8.5	13.5	12.9	11.8
49	9.3	10.0	11.6	8.5	10.2	10.5
50	10.3	11.8	11.3	7.3	9.4	14.8
51	11.3	8.8	10.2	14.8	14.9	10.3
55	6.6	6.4	5.7	6.0	5.3	5.4

NOTE: Estimated error is in the range of ±1% moisture.

Additional insight as to the probable source of the leak can be gained from reviewing the gross count rates in the various wells to establish concentration gradients. This approach can be refined by using gamma energy analyses to identify specific isotopes since some isotopes are readily sorbed by the sediments (cesium, strontium), while some are not (ruthenium-rhodium, cobalt).[1,3,4] Gamma energy analyses were completed in March 1979 and are given in Table 10 for the horizon 51 ft below ground level.

An examination of the data in Table 10 clearly shows that the source of the leak is closest to Wells 51-07-06 and 51-07-18 (both are at the 6 o'clock position near Tank 241-TX-107). Also, based on ^{106}Rh concentrations in Table 10, it appears that Dry Well 51-03-12 may be slightly closer to the leak source than 51-03-11. The total time required to reach 160 c/s in Dry Wells 51-03-11 and 51-03-12 (Table 8) also indicates that the leak source is closer to 51-03-12. The incremental time that the count rate increased from 20 to 160 c/s was less for Dry Well 51-03-11 than for Dry Well 51-03-12. This apparent disparity may be related to hydraulic anisotropy.

TABLE 10. Isotope Concentrations at 51 ft Below Ground Level Between Tanks 241-TX-103 and 241-TX-107.

Well number	Isotope concentration (μCi/L soil)			
	^{106}Rh	^{60}Co	^{154}Eu	^{134}Cs
51-07-06[a]	27.7	1.46	0.19	ND
51-07-18	7.257 ± 21%	2.724 ± 5.4%	1.385 ± 15%	<0.21
51-07-07	<0.33	<0.006	<0.019[b]	<0.005
51-03-11	1.116 ± 34%	0.1580 ± 22%	<0.097	<0.056
51-03-01	<0.21	<0.031	<0.097	<0.020
51-03-12	<0.20	0.087 ± 14%	<0.025[b]	<0.019
51-03-12 @55 ft	1.244 ± 25%	0.084 ± 30%	<0.097	<0.035
51-07-04	<0.16	<0.031	<0.097	<0.020

[a]Based on auger samples at time of drilling.

[b]Extended count rate period.

All of the data taken together lead to the conclusion that the source of the leak is closest to Dry Well 51-07-06 followed by Dry Well 51-07-18 and is furthest from Dry Wells 51-03-01 and 51-07-04. The locus of points consistent with all available data appears to be near the edge of Tank 241-TX-107 at about 6 o'clock (Figures 17 and 18). While this analysis addresses the data related to whether or not Tank 241-TX-107 leaked, the status of this tank is the subject of a separate study.

Similar analyses can be made for other tank leaks using the historical data that are included in Appendix D.

EFFECT OF FREQUENCY ON DRY WELL MONITORING EFFECTIVENESS

The Dry Well Radioactivity Response Equation was used to calculate and/or predict changes in count rate data at dry wells as a function of time, distance of dry well from a hypothetical tank leak source, ruthenium concentrations, and soil moisture content. These calculations were made to evaluate the effectiveness of monitoring each dry well based on its proximity to a tank and the rate of migration of potential leaking wastes from tanks to the dry wells.

For example, in the case of Tank 241-SX-106, the closest distance from a hypothetical tank leak source to a dry well is 6.3 ft (Appendix N) and the farthest distance is 30.7 ft. At an average (equilibrium) soil moisture content of 8.5% (Appendix F), a ruthenium concentration of about 4×10^{-4} Ci/L, and a leak rate of 5.77 ft^3/day (0.03 gal/min), using equation 4 the total time required to reach the closest and the farthest dry well would be 7.9 days and 892 days, respectively. Once the waste front reaches a point sufficiently close to the dry well to cause a minimal response (2 c/s) of the radioactivity detector, using equation 5 it would take 3.3 days (of the 7.9 day total) for the count rate to reach the action criteria of 160 c/s above the background for the dry well located 6.3 ft from the leak source and 94.5 days (of the 892 day total) for the dry well located 30.7 ft from the leak source. The times required for the count rate to increase from the alert level

(20 c/s above background) to the action level (160 c/s above background) would be about 1.7 days for the well located 6.3 ft from the tanks and 45.4 days for the well located 30.7 ft away. Thus, for those cases where a leak is close to a radiation monitoring dry well, the time for a leak to reach a dry well and the time for the count rate to rise to the action level is short. As a consequence, the volume of leaking solution will be small, i.e., a few hundred gallons. On the other hand, where long distances are involved, the time to reach the dry well can exceed a year. In the latter case, the volume that will have leaked will be large, exceeding 100,000 gal, especially when liquid-level measurement capability is also inadequate for any reason. Another point that must be considered is the probability of a leak occurring at a specific point closest to a dry well. For the purposes of establishing a realistic monitoring schedule, a probability equivalent to 10% of the tank perimeter per well was assumed to be appropriate; this assumption will assure that 99.5% of the leaks will be detected before the count rate would exceed the action level of 165 c/s above the baseline.

Calculations for various monitoring periods were made for Tank 241-SX-106. The results are shown in Table 11.

The maximum potential volume a tank leak exceeding a given size is provided in Table 12. The probability of detection as used here assumes that a leak will be detected if it is located within a certain distance of a dry well. The probability of detection is the sum of the percentage of the tank perimeter within detection range of all existing dry wells around that tank for a specified monitoring interval.

The effectiveness of monitoring Tank 241-B-105 was calculated as a limiting case. There are four wells around this tank at distances from 9.6 to 18.64 ft from the tank and the spacing between wells is 85°, 94°, 79°, and 101° in a sequentially clockwise direction. The results are summarized in Tables 13 and 14. (Under certain conditions a leak could reach Dry Well 20-08-02 before reaching 20-08-03 or 20-06-06.)

TABLE 11. Effectiveness of Monitoring Tank 241-SX-106 at Various Intervals.

Monitoring interval (wk)	Distance from tank leak source to dry well (ft)	Percentage of time that count rate will fall within given range[a]			Probability of detection for each monitoring interval (%)
		2-20 c/s[b]	20-160 c/s	>160 c/s	
<1	9.3[c]	77.04	22.96	--	22.96
1	12.9	34.77	19.31	22.96	42.27
2	18.1	27.40	30.33	42.27	72.60
3	22.1	13.28	14.12	72.60	86.72
4	25.4	5.78	7.50	86.72	94.22
5	28.2	2.10	3.68	94.22	97.90
6	30.8	0	2.10	97.90	100.0
7	33.1	--	--	100.0	--

[a]First count could be slightly over background but not discernible. Next count would be in 20 to 160 c/s range. Subsequent count would exceed 160 c/s.

[b]Count rates are net c/s above background.

[c]Distance at 2 c/s = 9.3 ft or greater.

As will be noted by comparing Tables 11 and 13, a monitoring interval for Tank 241-B-105 of 6 wk would result in about the same probability of detecting a leak as an interval of 1 wk for Tank 241-SX-106. Based on the probability of detecting a leak, an interval of 16 wk for 241-B-105 would be comparable to an interval of 3 wk for 241-SX-106.

The probability of a tank leak exceeding a given size for Tank 241-B-105 before being detected by surveillance of the radiation monitoring dry wells is provided in Table 14.

The incremental volume is the additional volume of waste that will seep out of a tank during the "Dry Well Response Time," assuming a leak rate of 0.03 gal/min. Dry Well Response Time is the time required for the count rate to increase from the alert level of 20 c/s above background to the action level of 160 c/s above background. The "Total Elapsed Time for the Waste Front to Migrate to a Dry Well" is the time from the start of a leak to the time that the count rate reaches the action level of 160 c/s above background at the dry well.

9 2 1 2 4 9 9 1 6 0 4

TABLE 12. Leak Volumes, Elapsed Time, and Probability of Detection for Each Monitoring Interval for Tank 241-SX-106.

Monitoring interval (wk)	Distance from tank leak source to a dry well (ft)	Total elapsed time for waste front to migrate to a dry well (d)	Maximum potential volume of leak (gal)	Incremental leak volume (gal)	Probability of detection for each monitoring interval (%)
<1	9.3	23	1,000	--	23
1	12.9	62	2,700	300	42
2	18.1	172	7,400	600	73
3	22.1	313	13,500	900	87
4	25.4	475	20,500	1,200	94
5	28.2	650	28,000	1,500	98
6	30.8	848	36,600	1,800	100
7	33.1	1,052	45,500	2,100	--

TABLE 13. Effectiveness of Monitoring Tank 241-B-105 at Various Intervals.

Monitoring interval (wk)	Distance from tank leak source to dry well at 20 c/s (ft)	Percentage of time that count rate will fall within given range[a]			Probability of detection for each monitoring interval (%)
		2-20 c/s[b]	20-160 c/s	160 c/s	
1	9.2[c]	100	0	0	0
2	12.9	93.4	6.54	0	6.54
3	15.7	90.6	2.90	6.54	9.44
4	18.0	84.26	6.30	9.44	15.74
5	20.0	68.35	15.91	15.94	31.65
6	21.9	59.10	9.25	31.65	40.90
7	23.5	51.88	7.22	40.90	48.12
8	25.0	45.73	6.15	48.12	54.27
9	26.4	40.29	5.44	54.27	59.71
10	27.8	35.35	4.94	59.71	64.65
11	29.0	30.82	4.53	64.65	69.18
12	30.2	26.60	4.22	69.18	73.40
13	31.3	22.65	3.95	73.40	77.35
14	32.4	18.92	3.73	77.35	81.08
15	33.4	15.83	3.09	81.08	84.17
16	34.4	13.29	2.54	84.17	86.71
17	35.3	10.88	2.41	86.71	89.12
18	36.2	8.21	2.67	89.12	91.79
19	37.1	4.68	3.53	91.79	95.32
20	37.9	2.27	2.41	95.32	97.73
21	38.7	1.19	1.08	97.73	98.81
22	39.5	0.24	0.95	98.81	99.76
23	40.2	0	0.24	99.76	100.0
24	--	--	--	100.0	--

[a]First count could be slightly over background but not discernible. Next count would be in 20 to 160 c/s range. Subsequent count would exceed 160 c/s.

[b]Count rates are net c/s above background.

[c]Distance at 2 c/s = 9.2 ft or greater.

TABLE 14. Leak Volumes, Elapsed Time, and Probability of Detection for Various Monitoring Intervals for Tank 241-B-105.

Monitoring interval (wk)	Distance from tank leak source to a dry well at 20 c/s (ft)	Total elapsed time for waste front to migrate to a dry well (d)	Maximum potential volume of leak (gal)	Incremental leak volume (gal)	Probability of detection for each monitoring interval (%)
1	9.2	45	1,950	300	0
2	12.9	125	5,380	600	6.5
3	15.7	225	9,700	900	9.4
4	18.0	338	14,600	1,200	15.7
5	20.0	464	20,000	1,500	31.7
6	21.9	610	26,300	1,800	40.9
7	23.5	753	32,500	2,100	48.1
8	25.0	907	39,200	2,400	54.3
9	26.4	1,068	46,100	2,700	59.7
10	27.8	1,247	53,900	3,000	64.7
11	29.0	1,415	61,100	3,300	69.2
12	30.2	1,598	69,000	3,600	73.4
13	31.3	1,779	76,900	3,900	77.4
14	32.4	1,974	85,300	4,200	81.1
15	33.4	2,162	93.400	4,500	84.2
16	34.4	2,362	102,000	4,800	86.7
17	35.3	2,553	110,300	5,100	89.1
18	36.2	2,753	119,000	5,400	91.8
19	37.1	2,963	128,000	5,700	95.3
20	37.9	3,159	136,000	6,000	97.7
21	38.7	3,363	145,000	6,350	98.8
22	39.5	3,576	154,500	6,650	99.8
23	40.2	3,770	162,900	7,000	100.0

In the case of Tank 241-B-105, it is conceivable that a leak could go undetected (based on dry well surveillance) for a period of 23 wk. In such a case the incremental leak volume would be about 7,000 gal and the total leak volume would be 157,000 gal; the probability of such an occurrence is less than 1%. A leak of this magnitude would be located about 39.7 ft from a dry well and it would take about 9.9 years to reach the dry well. At least 23 wk would elapse between the time that the count rate started to rise above background and reached 20 c/s and another 23 wk to increase to 160 c/s above background.

The method of calculating the probability of detection utilized the methods described in Appendix M.

DRY WELL MONITORING FREQUENCY BASED ON THE DRY WELL RESPONSE TIME

A well-by-well analysis was completed to determine an effective monitoring frequency for each radioactivity monitoring dry well. The monitoring intervals are those required when the tank leak rate is 0.03 gal/min. These results are given in Appendix N and are summarized in Table 1 and Figure 20. These calculations were not completed to the same degree as the foregoing examples in that the percentages of the tank periphery within the range of a dry well for each monitoring period have not been summed for all dry wells. Calculations were completed for each dry well around each single-shell tank containing sufficient liquid to require salt well pumping if a leak develops. Details on waste tanks requiring salt well systems are included in Appendix C.

The data in Appendix N were used to prepare the dry well radioactivity monitoring intervals for individual dry wells, as appropriate. Because of the inherent soil properties in the 200 East Area tank farms, the monitoring intervals should be every 2 to 3 wk; in 200 West Area the monitoring interval should be about once per week, except for those cases where dry wells are located about 15 ft or more from a tank. The schedules developed in these tables are conservative in at least two aspects: (1) the maximum typical leak (95% confidence Table III Appendix D) is about one-half the value used as the maximum expected

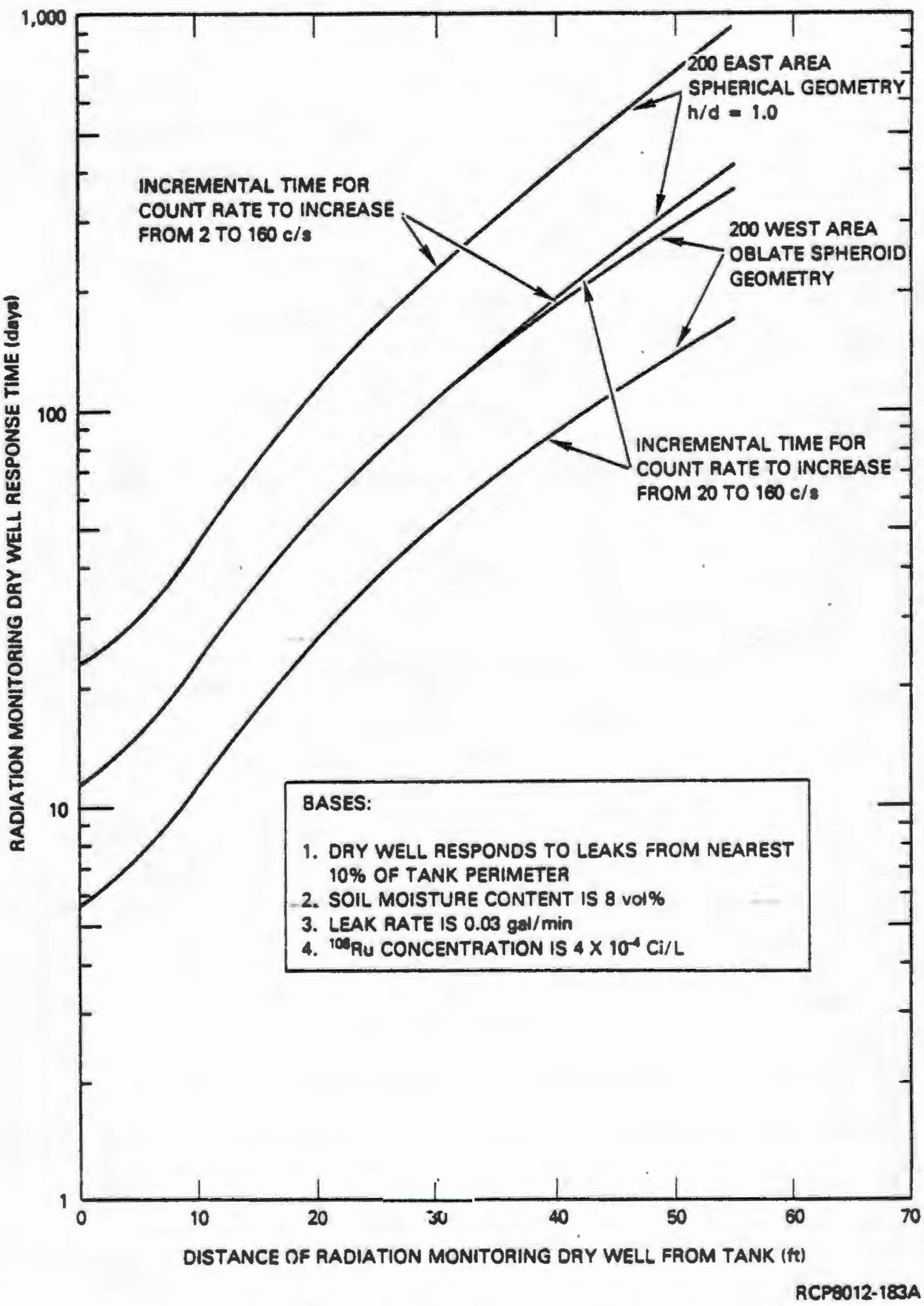


FIGURE 20. Radiation Monitoring Dry Well Response Time as a Function of Distance from Waste tanks for Cases Where Dry Wells Respond to Leaks from the Nearest 10% of the Tank Perimeter Within the Response Period.

9 2 1 2 4 9 9 1 6 0 8

leak, thus the response time would be about twice as long as the values derived; (2) the alert level of 20 c/s provides a period equal to the dry-well-response time for the count rate to increase from background to 20 c/s. However, it is quite likely that an increase in count rate will be recognized before the alert level is reached. Assuming that 2 c/s above background is just discernible and that a leak is within an arc of 10% of the tank perimeter, at a leak rate of 0.0158 gal/min the time for the count rate to increase from 2 c/s to 160 c/s in a dry well located 6.5 ft from a tank in 200 West Area would be 33 days (instead of 17 days); for the same leak rates and distances in 200 East Area the response time for a count rate change from 2 to 160 c/s would be 67.6 days (instead of 35 days), based on 8% soil moisture and a ^{106}Ru concentration of 4×10^{-4} Ci/L. Thus, the tabulated monitoring intervals provide for a "safety factor" about equal to the monitoring interval for recognizing an initial increase in count rate.

CONCLUSIONS AND RECOMMENDATIONS

The Dry Well Radioactivity Response Equation was developed and was used to establish a dry-well-by-well monitoring interval based upon the "Dry Well Response Time" (Appendix N). The results are summarized in Table 1.

A realistic monitoring frequency would be one that would assure that at least 90% of all possible tank leaks would be detected before the count rate reached the alert level; then, only 10% of all possible leaks could be in the range of 20 c/s or above. Using this basis, the recommended frequency of monitoring dry wells in 200 East Area would be every 2 to 4 wk and in 200 West Area every 1 to 3 wk.

The recommended schedules are based upon typical and/or generalized conditions and assumptions. When more specific data are available for any of the variables, more precise "Dry Well Response Times" and monitoring intervals can be determined.

The criteria and the equations can be applied to horizontal laterals as well as to dry wells. The critera should only be applied to single-shell tanks that contain pumpable waste solutions. When all pumpable liquid has been removed from a tank, monitoring frequency should be reduced to that necessary to evaluate environmental impact and effects.

THIS PAGE INTENTIONALLY LEFT BLANK

9 2 1 2 4 9 9 1 6 1 1

REFERENCES

1. U. S. Energy Research and Development Administration, Final Environmental Statement Waste Management Operations, ERDA 1538, Richland, Washington (December 1975).

2. Catlin, R. J., Assessment of the Surveillance Program of the High-Level Waste Storage Tanks at Hanford, Office of Environmental Compliance and Overview, for the U. S. Department of Energy, Washington, D.C. (March 1980).

3. Ames, L. L., Jr., and B. F. Hajek, Statistical Analysis of Cesium and Strontium Sorption on Soil, BNWL-CC-539, Battelle, Pacific Northwest Laboratories, Richland, Washington (March 8, 1966).

4. Routson, R. C., A Review of Studies on Soil-Waste Relationships on the Hanford Reservation, BNWL-1464, Battelle, Pacific Northwest Laboratories, Richland, Washington (1973).

THIS PAGE INTENTIONALLY
LEFT BLANK

APPENDIX A

STATUS OF HANFORD TANK FARM FACILITIES AND EXISTING RADIATION MONITORING DRY WELL LOCATION MAPS

Compiled by W. H. Price

The inventory and status of all Hanford waste tanks as of September 30, 1980 are given in Figure A-1. This figure is prepared by Rockwell and updated quarterly.

The locations of the dry wells used for surveillance of radioactivity that would be indicative of leaking tanks are provided in Figures A-2 through A-13. The details for the horizontal laterals, which are located in the 241-A and 241-SX Tank Farms, are provided in Figures A-14 and A-15.

Tank classification records and detailed inventories of each tank are updated on a monthly basis.

NUMBERING SYSTEM

The dry wells are numbered using three pairs of hyphenated numbers. The first pair of numbers designates the tank farm, the second pair of numbers designates the tank, and the third pair of numbers designates the approximate position to the closest "hour" in a clockwise direction starting with 12 o'clock at the northernmost position on the tank (Tables A-1 and A-2).

THIS PAGE INTENTIONALLY LEFT BLANK

9 2 1 2 4 9 9 1 6 1 6

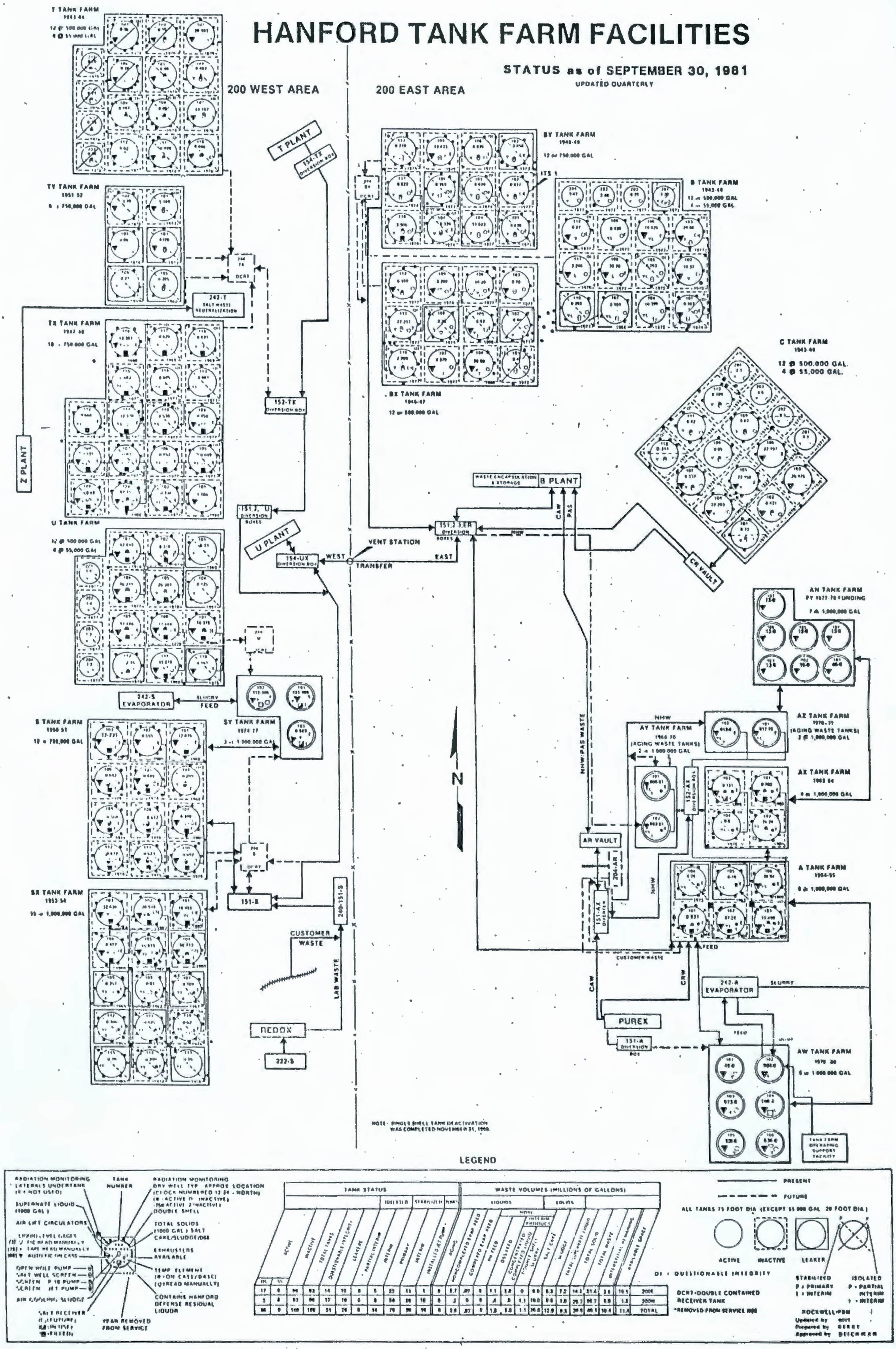
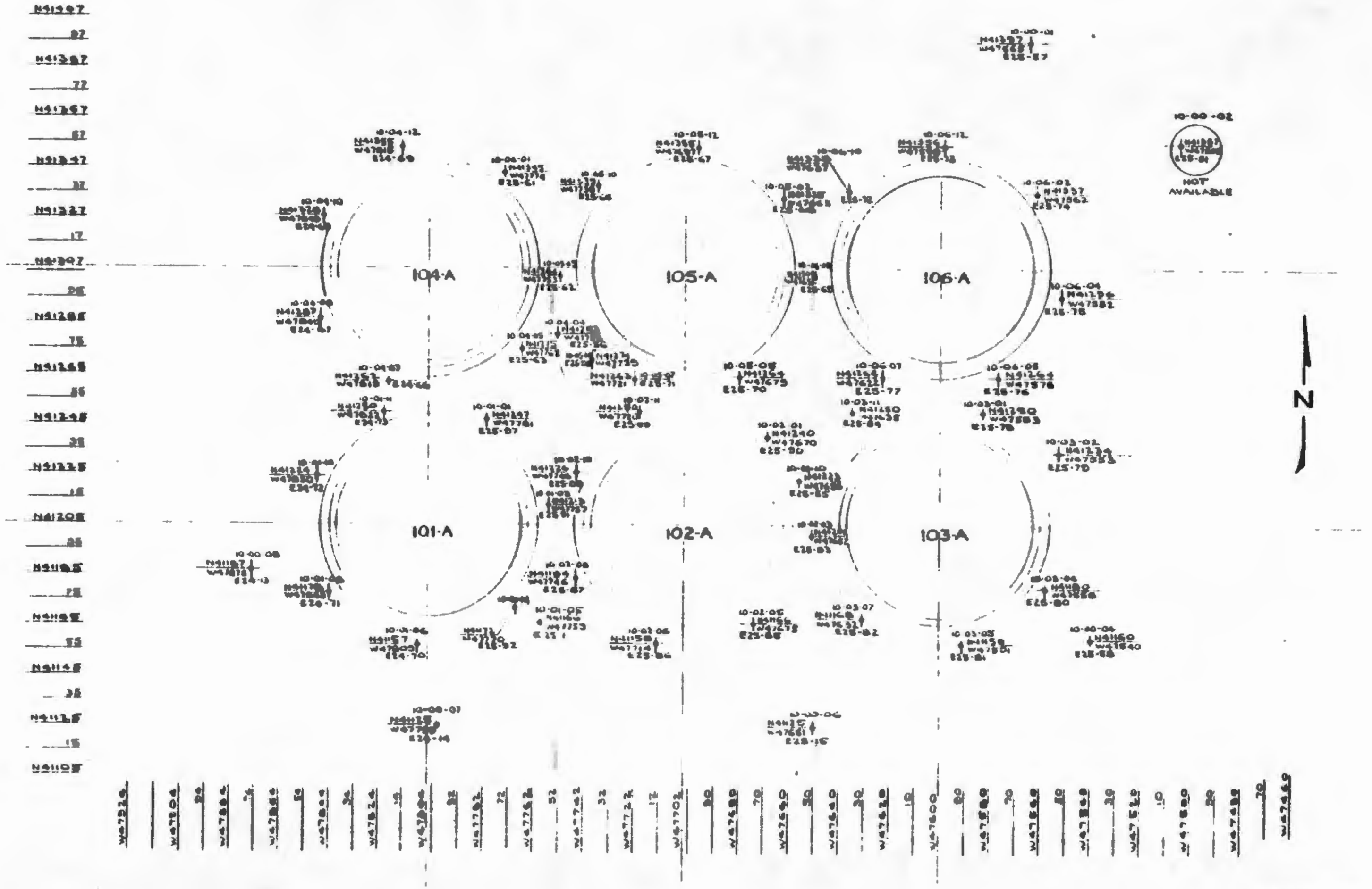


FIGURE A-1. Status of Hanford Tank Farm Facilities as of September 30, 1981.

A-3/A-4 blank

THIS PAGE INTENTIONALLY
LEFT BLANK



H-2-36934 (REF)

FIGURE A-2. Well Locations for Radioactivity Monitoring Dry Wells in the 241-A Tank Farm.

9 2 1 2 4 9 9 1 6 1 8

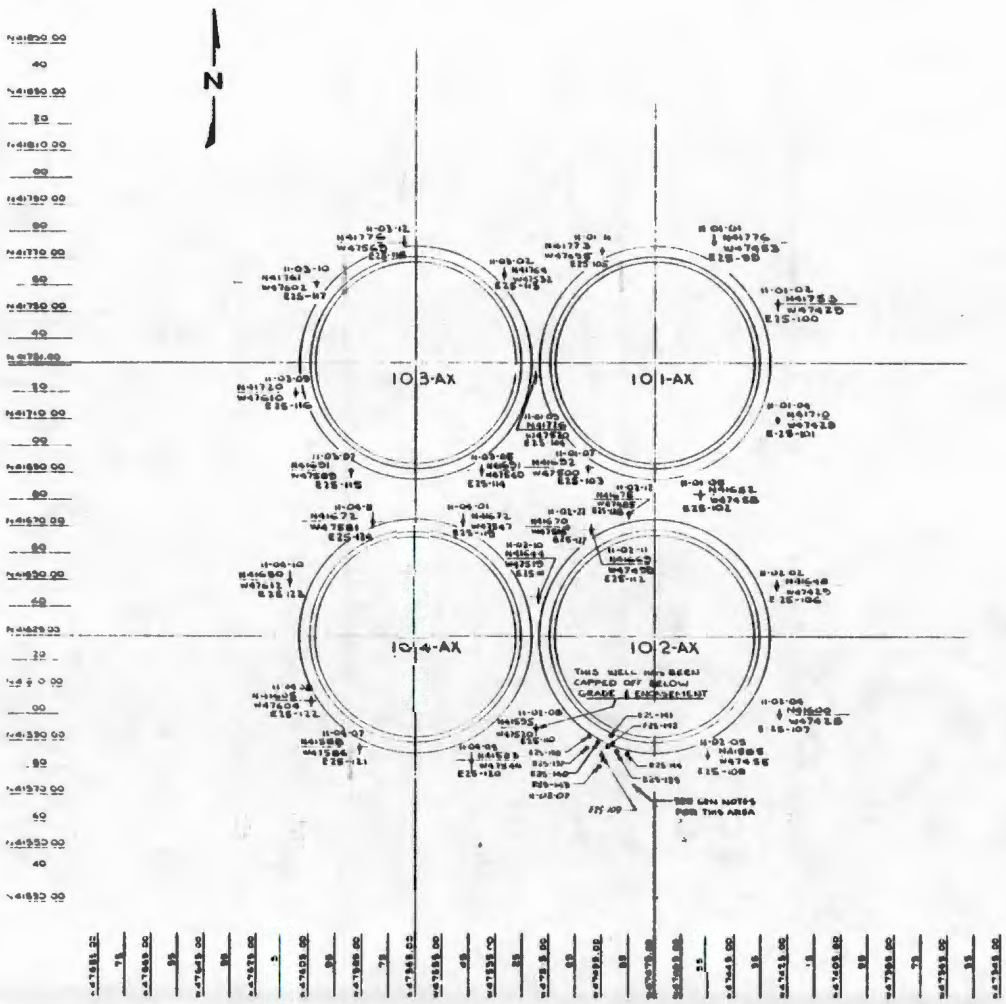


FIGURE A-3. Well Locations for Radioactivity Monitoring Dry Wells in the 241-AX Tank Farm.

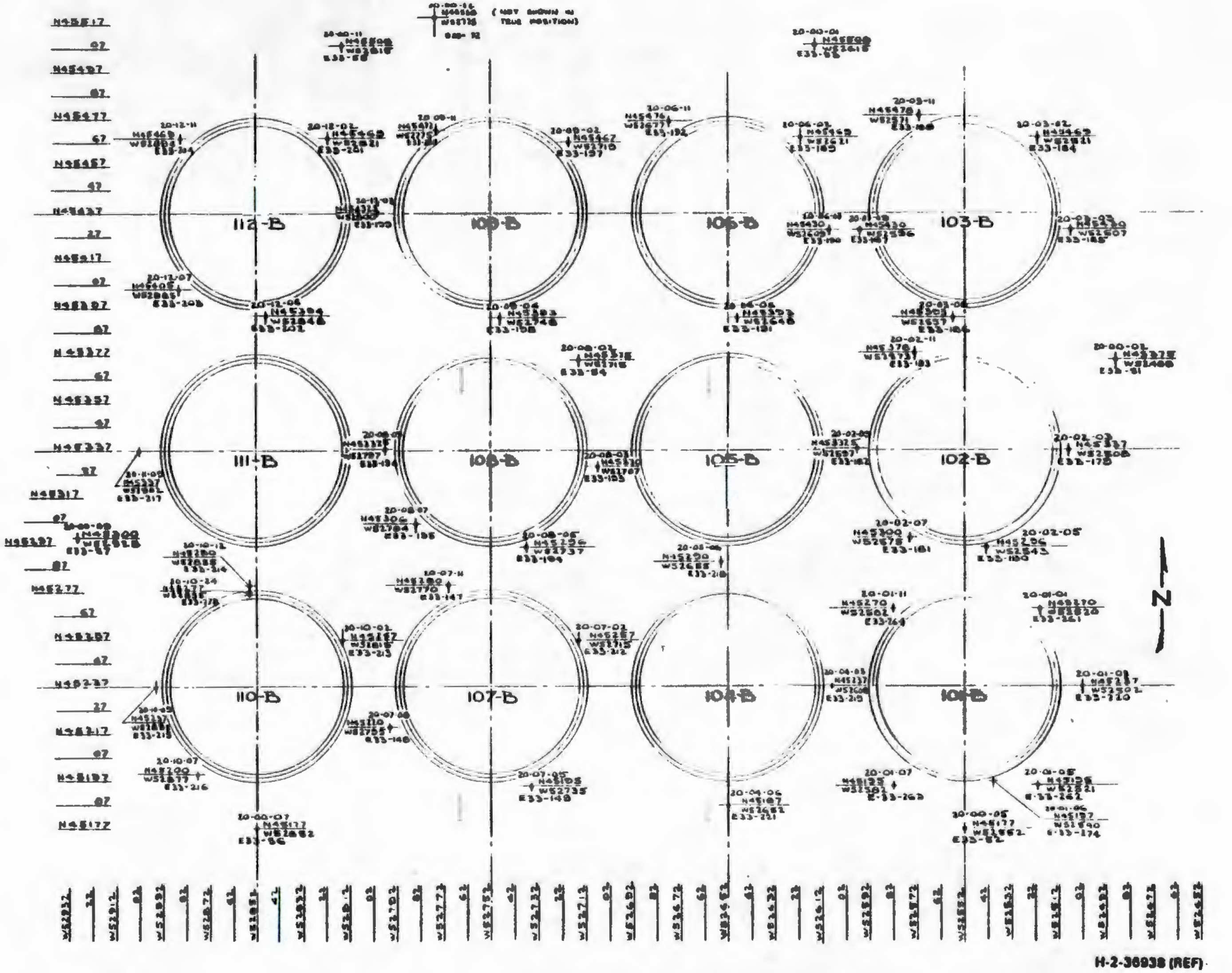


FIGURE A-4. Well Locations for Radioactivity Monitoring Dry Wells in the 241-B Tank Farm.

9 2 1 2 4 9 9 1 6 2 0

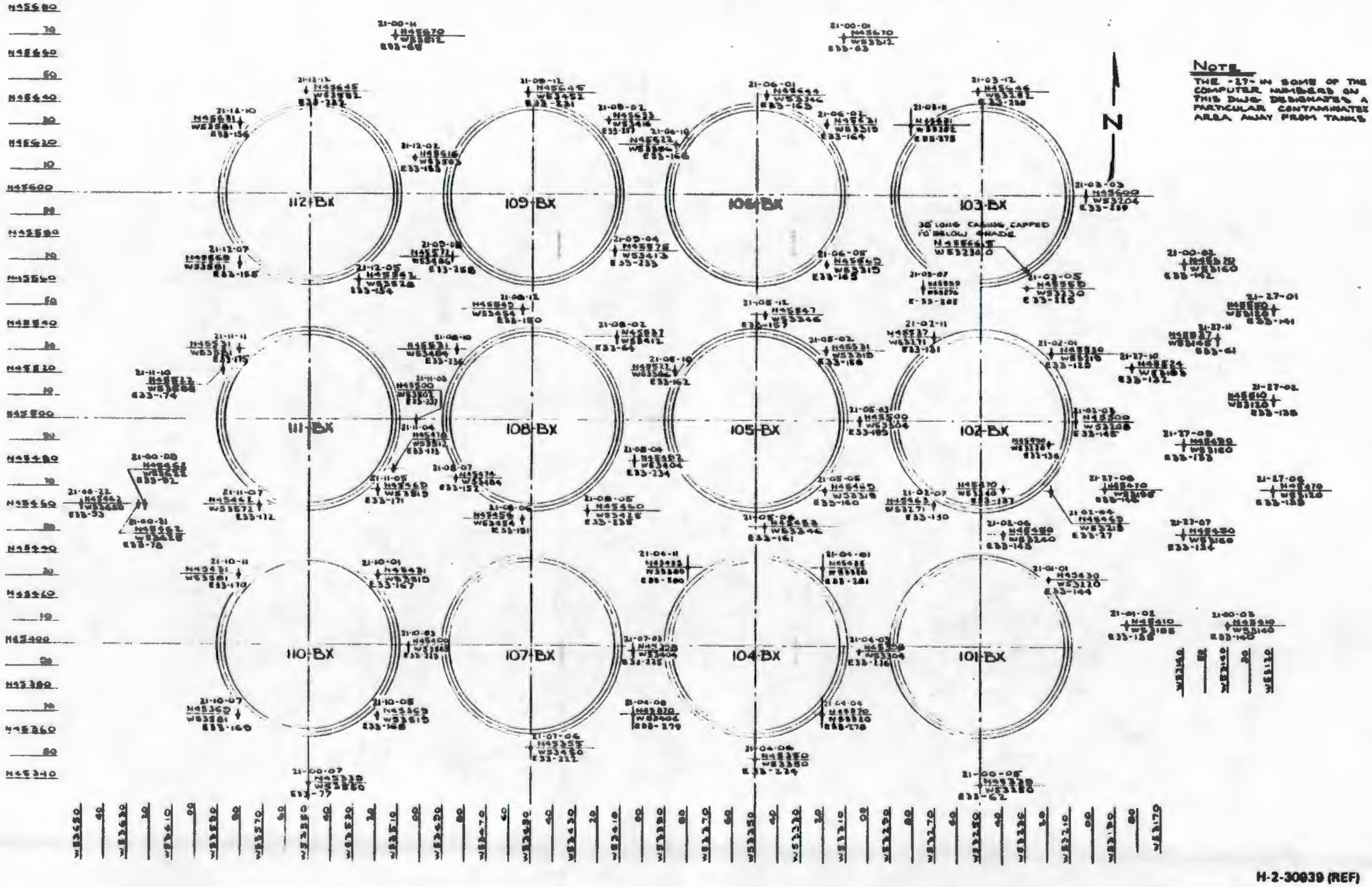


FIGURE A-5. Well Locations for Radioactivity Monitoring Dry Wells in the 241-BX Tank Farm.

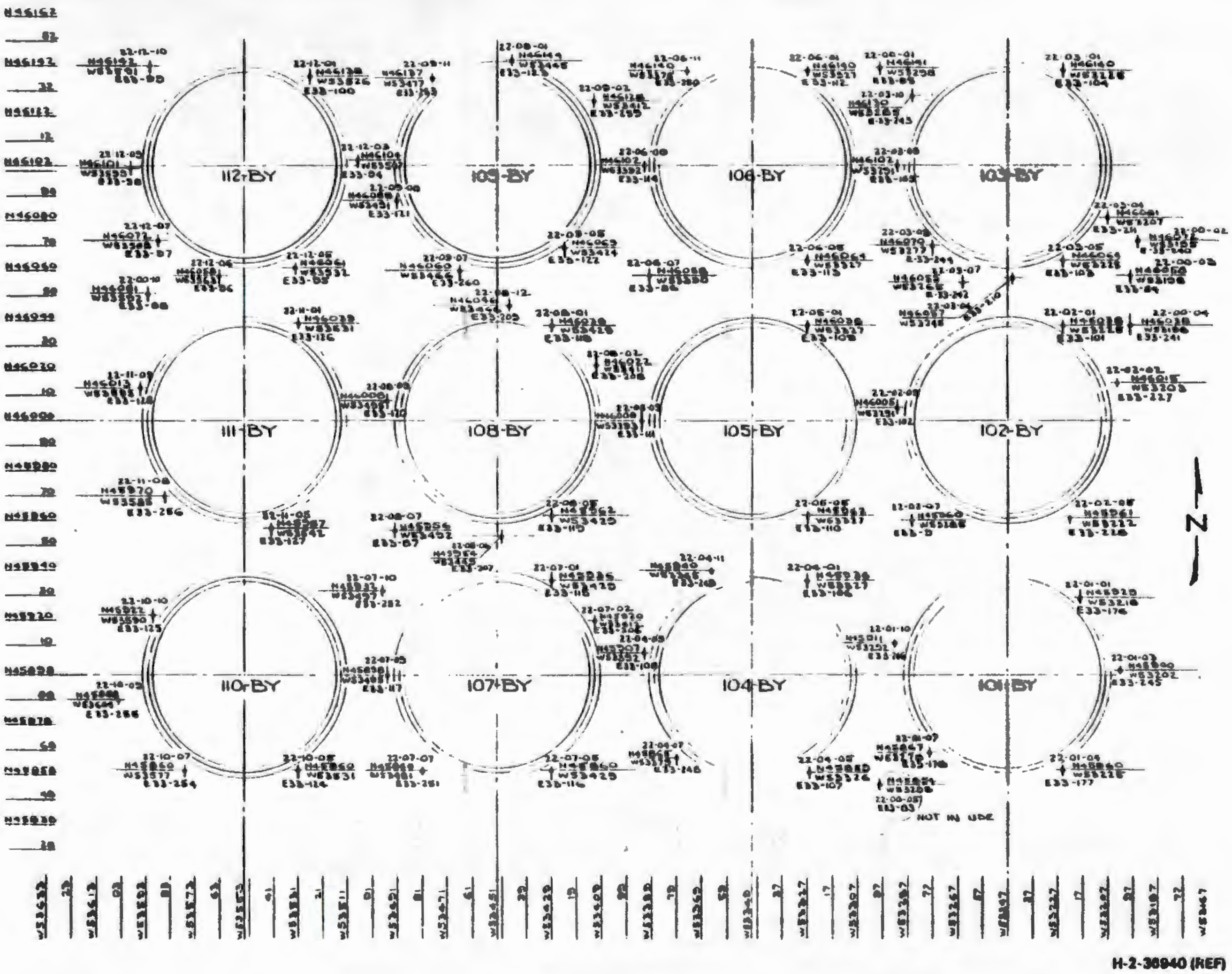
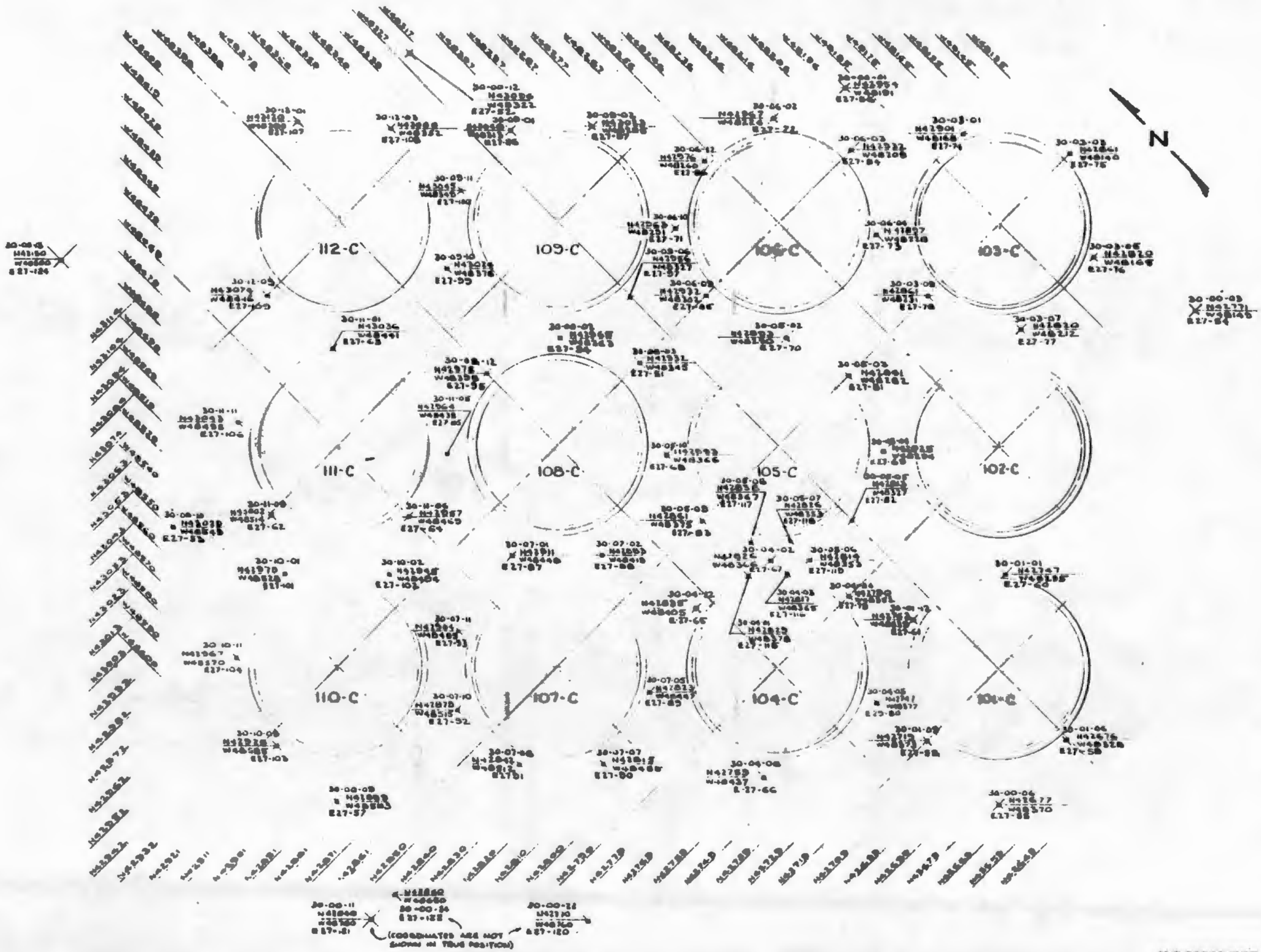


FIGURE A-6. Well Locations for Radioactivity Monitoring Dry Wells in the 241-BY Tank Farm.



H-2 36941 (REF)

FIGURE A-7. Well Locations for Radioactivity Monitoring Dry Wells in the 241-C Tank Farm.

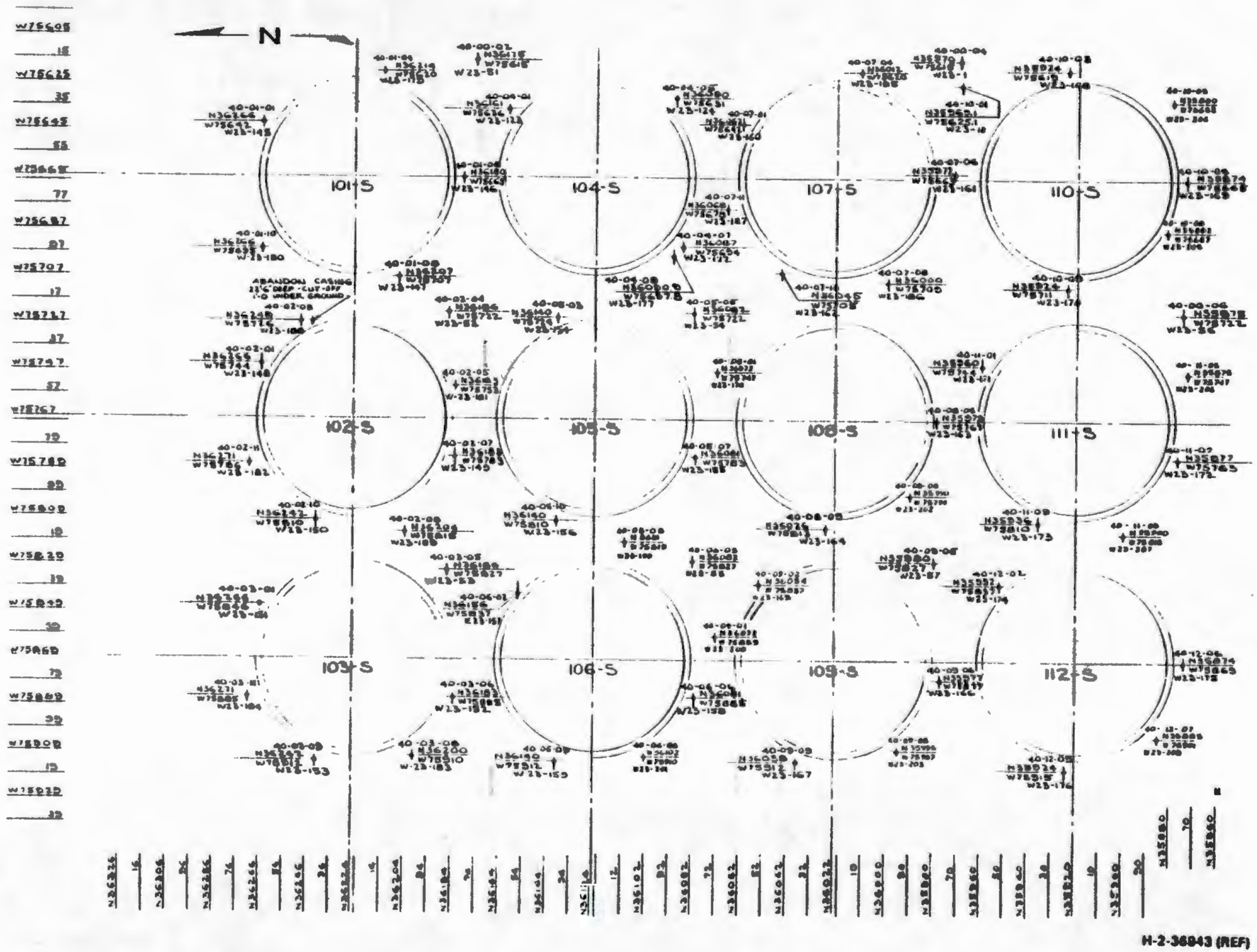


FIGURE A-8. Well Locations for Radioactivity Monitoring Dry Wells in the 241-S Tank Farm.

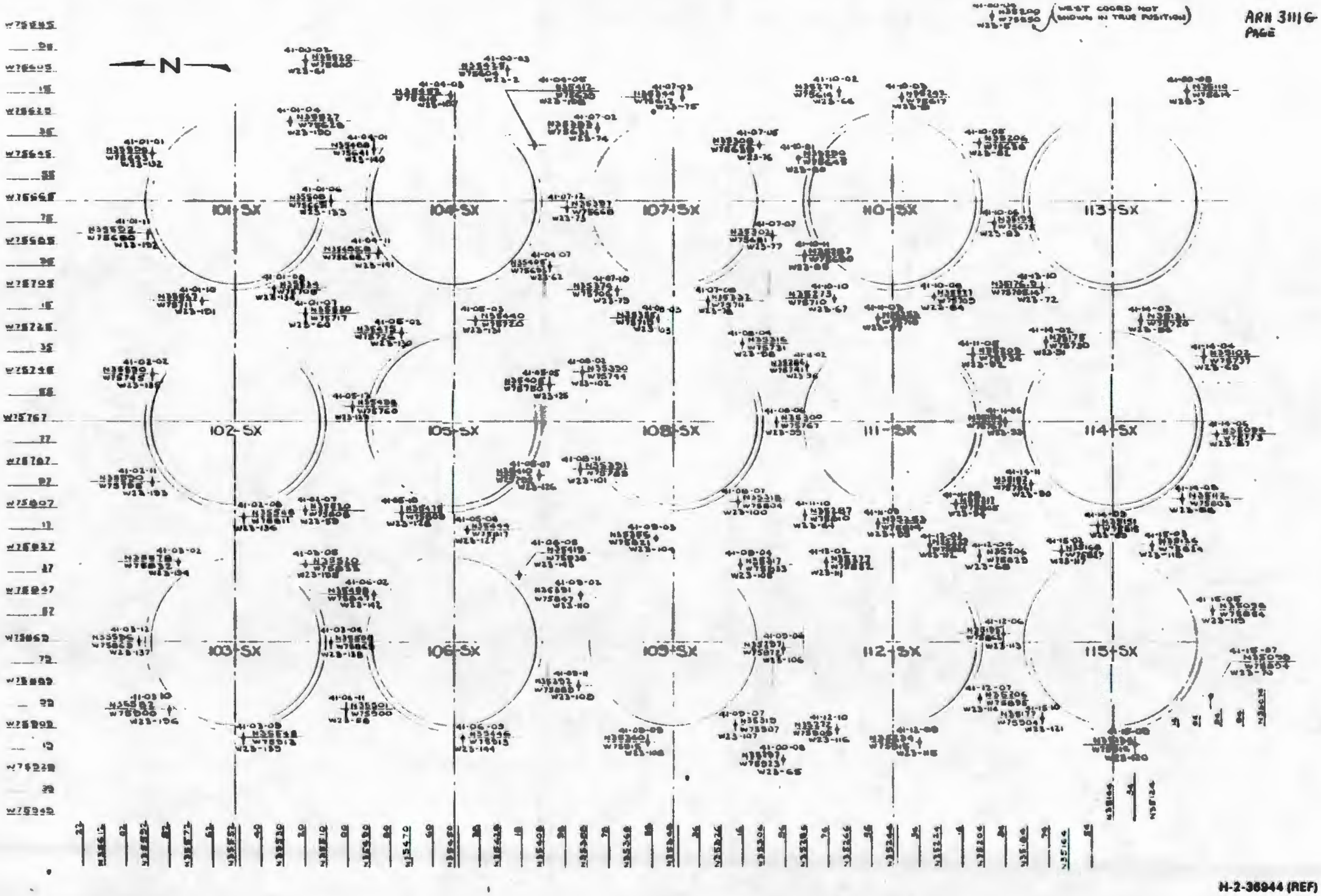


FIGURE A-9. Well Locations for Radioactivity Monitoring Dry Wells in the 241-SX Tank Farm.

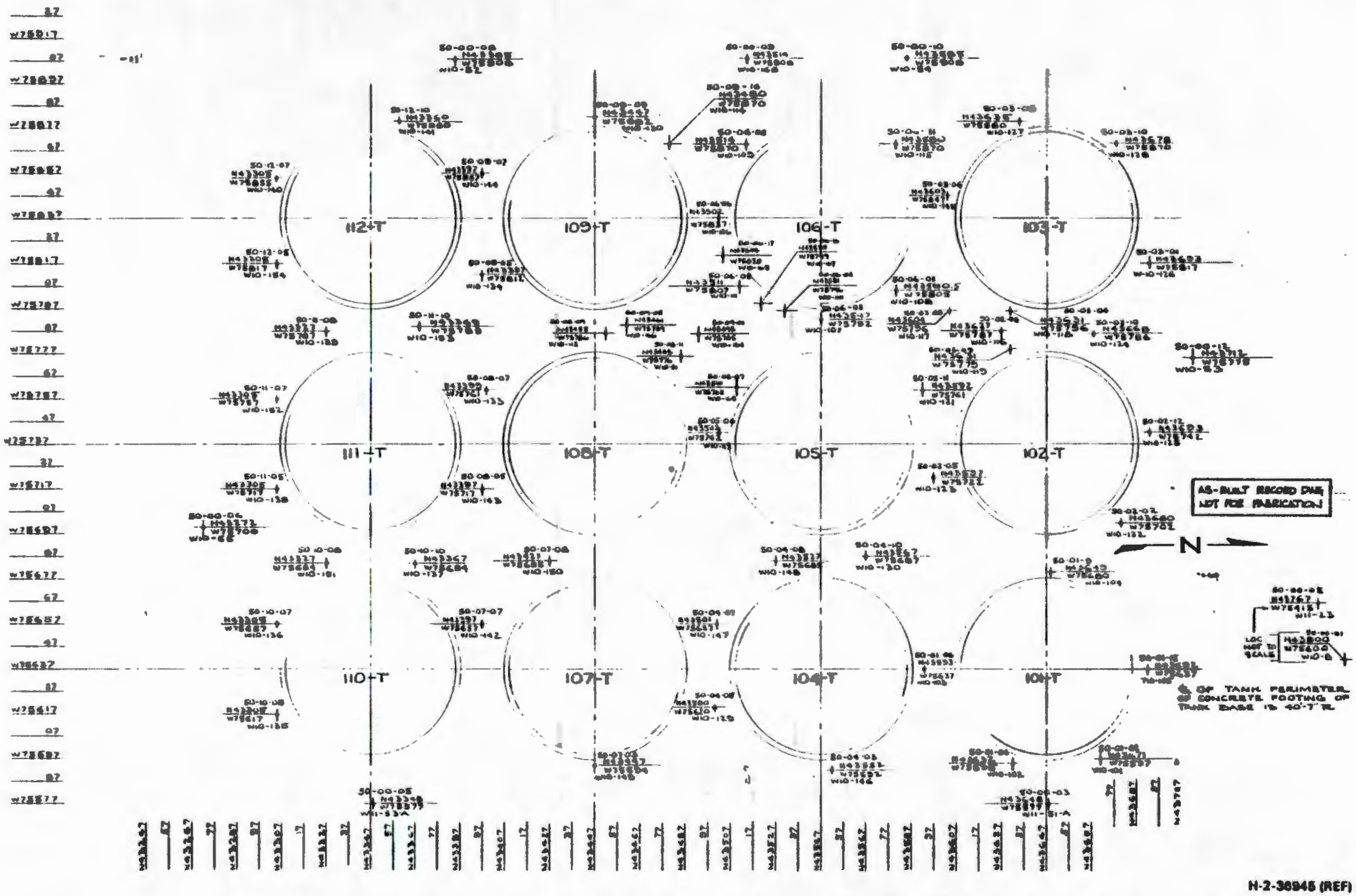


FIGURE A-10. Well Locations for Radioactivity Monitoring Dry Wells in the 241-T Tank Farm.

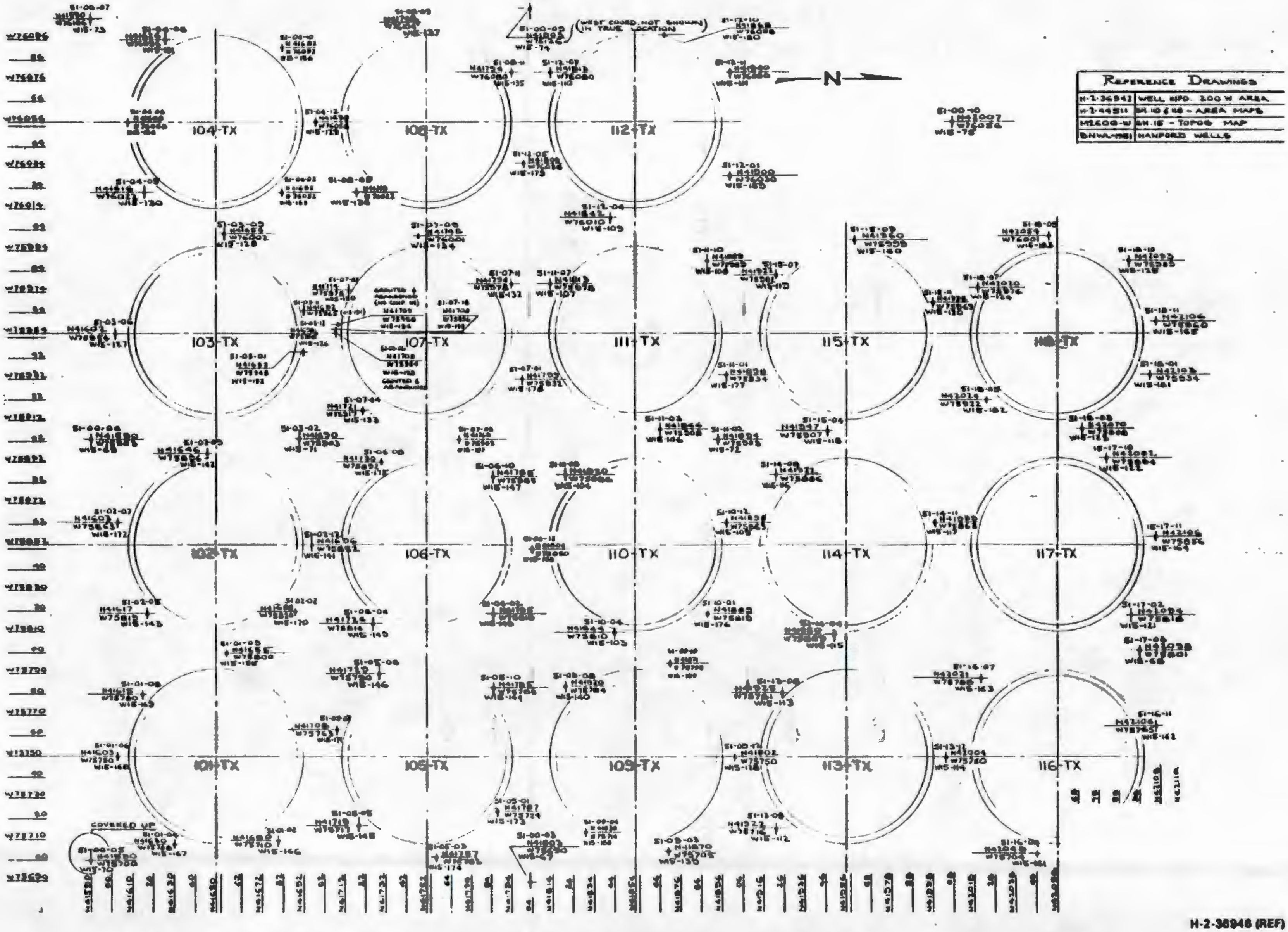


FIGURE A-11. Well Locations for Radioactivity Monitoring Dry Wells in the 241-TX Tank Farm.

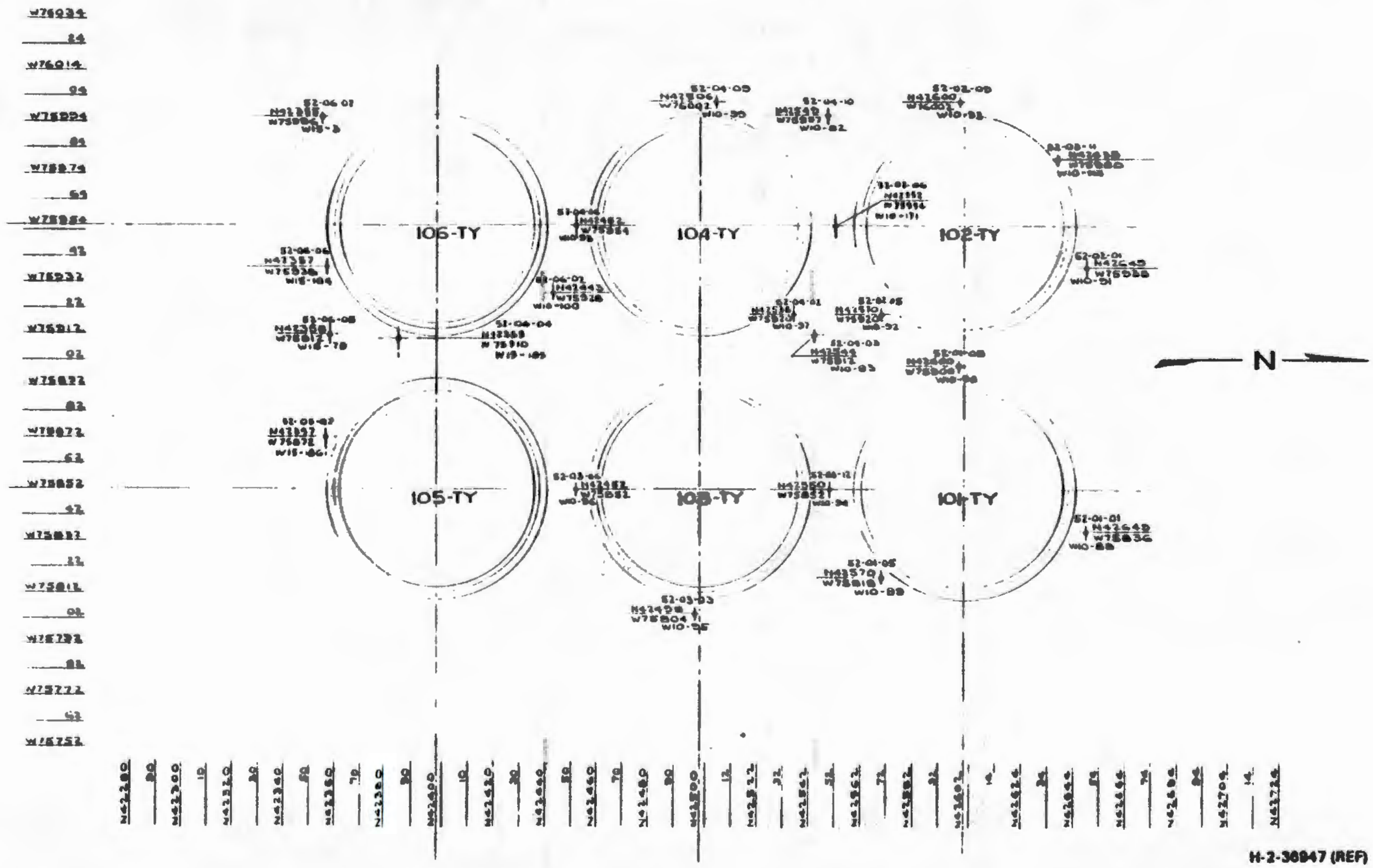


FIGURE A-12. Well Locations for Radioactivity Monitoring Dry Wells in the 241-TY Tank Farm.

9 2 1 2 4 9 9 1 6 2 8

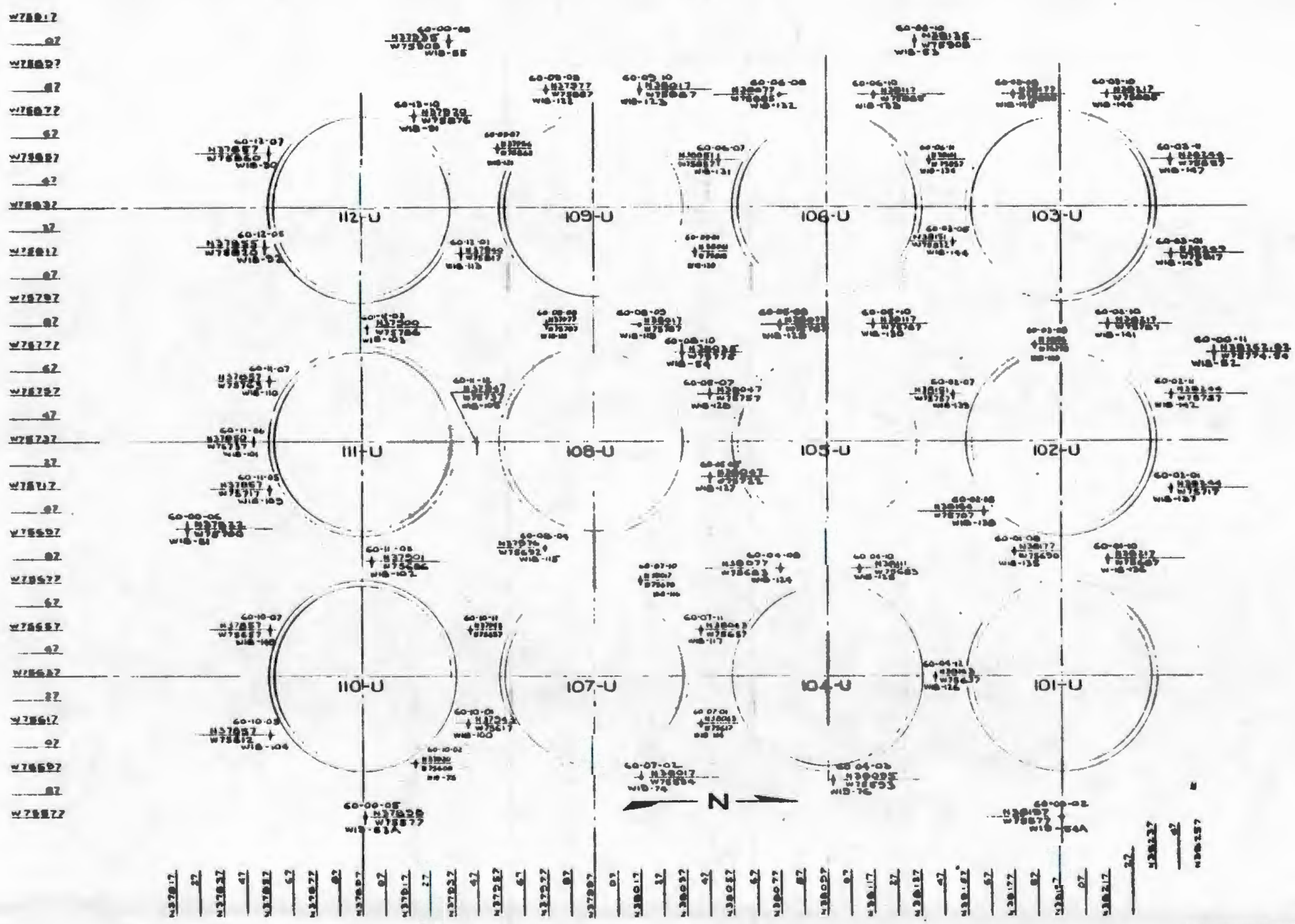


FIGURE A-13. Well Locations for Radioactivity Monitoring Dry Wells in the 241-U Tank Farm.

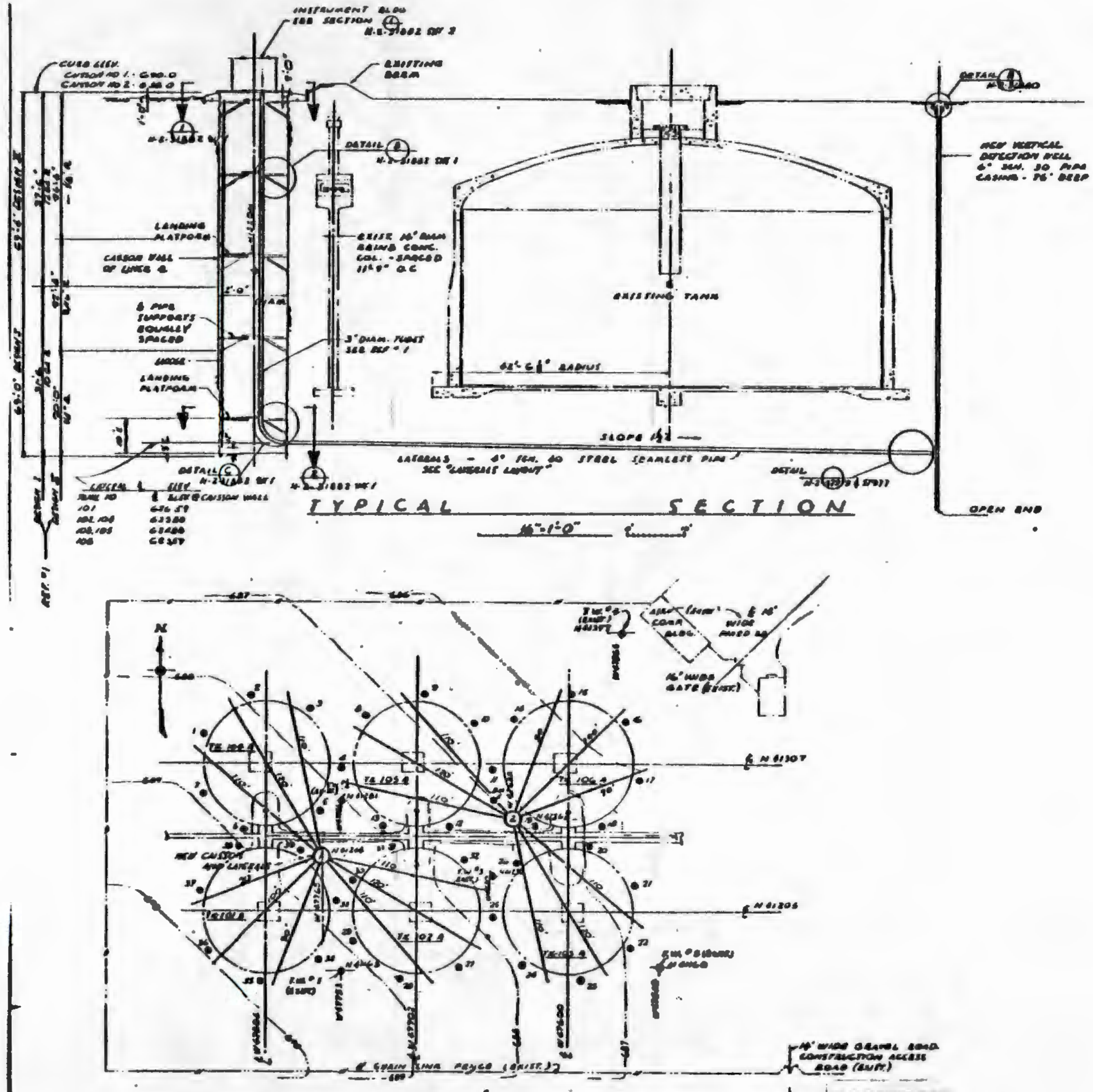


FIGURE A-14. 241-A Tank Farm Leak Detection System.

9212499 1630

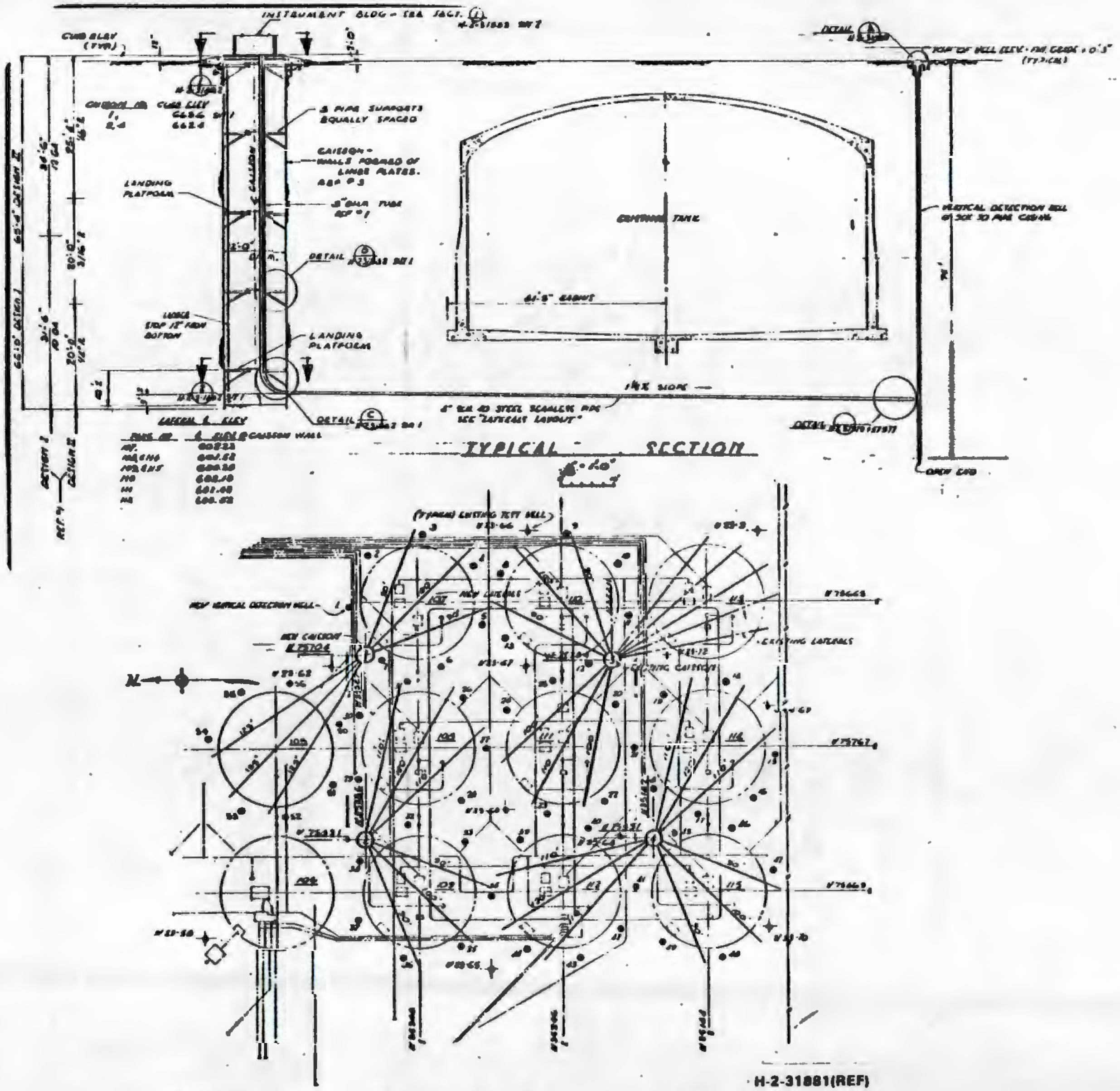


FIGURE A-15. 241-SX Tank Farm Leak Detection System.

TABLE A-1. Tank farm numerical designation.

Tank farm	Number
A	10
AX	11
AY	12
B	20
BX	21
BY	22
C	30
S	40
SX	41
T	50
TX	51
TY	52
U	60

TABLE A-2. Dry well numerical designation according to tank number.

Tank number	Well number
101	01
102	02
103	03
104	04
105	05
106	06
107	07
108	08
109	09
110	10
111	11
etc.	etc.

As an example, a dry well numbered 41-08-07 would be a well in the 7 o'clock position on Tank Number 108 in the SX Tank Farm.

THIS PAGE INTENTIONALLY
LEFT BLANK

APPENDIX B

ACTION CRITERIA BY TANK FARM

W. M. Lindsay and C. M. Walker

Liquid high-level wastes are removed from waste tanks when one of the surveillance systems action criteria are exceeded. The surveillance action criteria are summarized in this appendix by tank farm.

Action criteria include count rate limits for scintillation probes and for Geiger-Müller probes (GMP) in radiation monitoring dry wells, count rates in horizontal leak detection laterals, and liquid level (LL) measurements. The frequency of monitoring dry wells is included and is given by well location number.

Where applicable, action criteria for leak detection pits and for the annulus of double-shell tanks are provided.

The radioactivity monitoring dry-well frequency given in this appendix was in force at the time of this study. Monitoring intervals given in Appendix N will serve as the basis for updating the monitoring schedules for this appendix.

INDEX

241-A TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-1.

1. Scintillation Probe--unshielded (SP) and shielded (SSP)
   a. Less than 200 counts per second (c/s)--radiation level must triple and exceed 200 c/s.
   b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller (GMP)
   a. 16 to 1,000 c/s--tripling of radiation.
   b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe action criteria, Tank Farm Surveillance Analysis (TFSA), performed by Health, Safety and Environment (HS&E), and Tank Farm Evaporator and Process Control (TFEPC) personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LEAK DETECTION LATERALS

1. Activity <12 c/s must increase 10 c/s from an established base line and also exceed 12 c/s.
2. Activity >12 c/s must increase 50% from an established base line.
3. Contaminated laterals associated with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and lateral criteria limits will not apply.

TABLE B-1. A Farm Dry Well Monitoring Log. (Sheet 1 of 2)

A - FARM DRY WELL MONITORING LOG

10-00-07

Monitoring Day ~~Monday~~ 1st and 3rd week
Frequency Fortnightly,
Unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
10-00-01 (57)	10^4	150	S		
04 (58)	10^4	151	S		
06 (15)	10^4	340	S		
07 (14)	10^4	340	S		
08 (13)	10^4	340	S		
01-01 (97)	10^4	125	S		
03 (91)	10^4	75	S		
04 (92)	10^4	125	S		
05 (1)	10^4	322	S		
06 (70)	10^4	125	S		
08 (71)	10^4	125	S		
09 (75)	10^4	75	S		
10 (72)	10^4	125	S		
11 (73)	10^4	125	S		
02-01 (90)	10^4	125	S		
03 (83)	10^4	125	S		
05 (85)	10^4	125	S		
06 (86)	10^4	86	S		
08 (87)	10^4	125	S		
10 (88)	10^4	125	S		
11 (89)	10^4	125	S		
03-01 (78)	10^4	125	S		
02 (79)	10^4	125	S		
04 (80)	10^4	125	S		
05 (81)	10^4	125	S		
07 (82)	10^4	125	S		
10 (55)	10^4	151	S		
11 (84)	10^4	85	S		
04-01 (61)	10^4	125	S		Quarterly
04 (56)	10^4	151	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

TABLE B-1. A Farm Dry Well Monitoring Log. (Sheet 2 of 2)

A - FARM DRY WELL MONITORING LOG

10-00-08

Monitoring Day Monday
1st and 3rd week

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
10-04-05 (63)	10^4	125	S		Quarterly
07 (66)	10^4	120	S		Quarterly
08 (67)	10^4	125	S		Quarterly
10 (68)	10^4	120	S		Quarterly
12 (69)	10^4	69	S		Quarterly
05-02 (68)	10^4	125	S		
05 (70)	10^4	75	S		
07 (71)	10^4	75	S		
08 (98)	10^4	56	S		
09 (62)	10^4	75	S		
10 (66)	10^4	125	S		
12 (67)	10^4	75	S		
06-02 (74)	10^4	125	S		
04 (75)	10^4	125	S		
05 (76)	10^4	75	S		
07 (77)	10^4	125	S		
09 (69)	10^4	125	S		
10 (72)	10^4	125	S		
12 (73)	10^4	100	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

C. LIQUID LEVEL READINGS

All LL data are evaluated for conformance to the limits stated in Table B-2. In the event that a limit is exceeded, Tank Farm Surveillance and Operations (TFS&O) and Environmental Analysis and Monitoring (EA&M) management are to be notified immediately.

TABLE B-2. Limits for Liquid Level Readings, 241-A Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease[c]	Increase	Minimum	Maximum	
241-A-101	1.0	3.0	12	360	D
241-A-102	0.50	2.0	6	38	D
241-A-103	1.0	3.0	12	194	D
241-A-104	no criterion	1.0	[d]	12	D
241-A-105	no criterion	1.0		16	D
241-A-106	1.0	2.0	30[e]	50	D

[a]The listed limits denote the maximum permissible change from a baseline value established by TFSA (HS&E).

[b]D = once per day.

[c]Long-term decreases may be expected if the tank contains surface liquid since A-Farm tanks are connected to an operating exhauster system.

[d]Declared leaker. No water additions may be made to 241-A-104 unless flushing during removal of equipment is approved.

[e]The tank contains high strontium bearing sludge which requires liquid cover for evaporative cooling.

241-AX TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-3.

1. Scintillation Probe--SP and SSP
   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.
   b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller Probe
   a. 16 to 1,000 c/s--tripling of radiation.
   b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe action criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LEAK DETECTION PITS

1. A weight factor increase in excess of 4 in. or two whole dial divisions (8 in.) from an established baseline value and accompanied by an increase of >3 times background radiation from an established baseline.
2. A criteria exceeded in only one of the above may warrant issuance of a deviation report.
3. Failure of both pit leak detection systems (weight factor and radiation sensor) will require repair of at least one within 16 hr, otherwise a nonconformance report will be issued.

TABLE B-3. AX Farm Dry Well Monitoring Log.

11-00-06

AX- FARM DRY WELL MONITORING LOG

Monitoring Day Monday 2nd and 4th week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
11-01-01 (99)	10^4	100	S		Weekly
02 (100)	10^4	100	S		Weekly
04 (101)	10^4	100	S		Weekly
05 (102)	10^4	100	S		Weekly
07 (103)	10^4	102	S		Weekly
09 (104)	10^4	103	S		Weekly
11 (105)	10^4	100	S		Weekly
02-01 (132)	10^4	125	S		
02 (106)	10^4	100	S		
04 (107)	10^4	100	S		
05 (108)	10^4	104	S		
07 (109)	10^4	99	S		
10 (111)	10^4	100	S		
11 (112)	10^4	101	S		
12 (128)	10^5	52	S		Weekly
22 (127)	10^4	125	S		
03-02 (113)	10^4	102	S		
05 (114)	10^4	100	S		
07 (115)	10^4	100	S		
09 (116)	10^4	121	S		
10 (117)	10^4	99	S		
12 (118)	10^4	100	S		
04-01 (119)	10^4	100	S		
05 (120)	10^4	100	S		
07 (121)	10^4	95	S		
08 (122)	10^4	98	S		
10 (123)	10^4	101	S		
11 (124)	10^4	125	S		
19 (147)	10^4	125	S		

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

4. Failure of one leak detection system (with the other remaining functional) will require repair within 7 working days, otherwise a nonconformance report will be issued.

C. LIQUID LEVEL

All LL data are evaluated for conformance to the limits stated in Table B-4. In the event that any of the limits are exceeded, TFS&O and EA&M management shall be notified immediately.

TABLE B-4. Limits for Liquid Level Readings, 241-AX Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease[c]	Increase	Minimum	Maximum	
241-AX-101	1.0	3.0	12	285	D
241-AX-102	1.0	2.00	12	25	D
241-AX-103	1.0	3.0	12	49	D
241-AX-104	no criterion	2.00	--	7[d]	D

[a]The listed limits denote the maximum permissible change from a baseline value established by TFSA (HS&E).

[b]D = once per day.

[c]Long-term decreases may be expected if the tank contains surface liquid since AX tanks are connected to an operating exhauster system.

[d]Removed from service; not to be reused.

241-B TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-5.

1. Scintillation Probe--SP and SSP

   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.

   b. Greater than 200 c/s--radiation level must double.

2. Geiger-Müller Probe

   a. 16 to 1,000 c/s--tripling of radiation.

   b. Greater than 1,000 c/s--doubling of radiation.

3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.

4. For increasing peak and total count activity trends which have not violated the appropriate probe criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LIQUID LEVEL

All LL data are evaluated for conformance to the limits stated in Table B-6. In the event that a limit is exceeded, TFS&O and EA&M (HS&E) management are to be notified immediately.

TABLE B-5. B Farm Dry Well Monitoring Log. (Sheet 1 of 2)

B - FARM DRY WELL MONITORING LOG

20-00-06

Monitoring Day Monday
1st and ~~3rd week~~

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
20-00-01	(53)	10^4	101	S		
02	(51)	10^4	135	S		
05	(52)	10^4	140	S		
07	(56)	10^4	77	S		
09	(57)	10^4	135	S		
11	(55)	10^4	159	S		
23	(72)	10^4	60	S		
01-01	(261)	10^4	100	S		
03	(220)	10^4	135	S		
05	(262)	10^4	100	S		
06	(274)	10^4	61	S		
07	(263)	10^4	100	S		
11	(264)	10^4	100	S		
02-03	(179)	10^4	100	S		
05	(180)	10^4	140	S		
07	(181)	10^4	100	S		
09	(182)	10^4	100	S		Weekly
11	(183)	10^4	100	S		
03-02	(184)	10^4	112	S		
03	(185)	10^4	100	S		
06	(186)	10^4	135	S		
09	(187)	10^4	100	S		
11	(188)	10^4	100	S		
04-03	(219)	10^4	100	S		
06	(221)	10^4	135	S		
05-06	(218)	10^5	120	SS		Weekly
06-02	(189)	10^4	100	S		
03	(190)	10^4	140	S		
06	(191)	10^5	100	S		Weekly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

9 2 1 2 4 9 9 1 6 4 3

TABLE B-5. B Farm Dry Well Monitoring Log. (Sheet 2 of 2)

B - FARM DRY WELL MONITORING LOG 20-00-07

Monitoring Day Tuesday 1st and 3rd week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
20-06-11	(192)	10^4	125	S		
07-02	(212)	10^4	100	S		
05	(149)	10^4	100	S		
08	(148)	10^4	135	S		
11	(147)	10^4	100	S		
08-02	(54)	10^4	110	S		
03	(193)	10^4	135	S		Weekly
05	(194)	10^4	100	S		
07	(195)	10^4	100	S		
09	(196)	10^4	130	S		
09-02	(197)	10^4	100	S		
06	(198)	10^4	100	S		
11	(200)	10^4	100	S		
10-02	(213)	10^4	100	S		
07	(216)	10^4	100	S		
09	(215)	10^4	135	S		
12	(214)	10^4	120	2-GM	XXX	
11-09	(217)	10^4	120	S		
12-02	(201)	10^4	125	S		
03	(199)	10^4	100	S		
06	(202)	10^4	100	S		
07	(203)	10^4	100	S		
11	(204)	10^4	100	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

92124991644

TABLE B-6. Limits for Liquid Level Readings, 241-B Tank Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)[a]		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
241-B-101[c,d,e]	no criterion	0.50	--	40	D
241-B-102	0.05	2.00	--	16	D
241-B-103[e]	0.05	2.00	--	32	D
241-B-104[d]	1.00	2.00	--	147	D
241-B-105[c,d,e]	no criterion	2.00	--	47	D
241-B-106	0.05	2.00	--	50	D
241-B-107[c,d,f]	no criterion	1.00	--	60	D
241-B-108	0.50	2.00	--	37	D
241-B-109	0.50	2.00	--	47	D
241-B-110[c,d,e]	no criterion	1.00	--	90	D
241-B-111	0.50	2.00	--	89	D
241-B-112[e]	0.50	2.00	--	15	D
241-B-201[d,f]	1.00	1.00	--	153	D
241-B-202	1.00	2.00	--	145	D
241-B-203	1.00	2.00	--	265	D
241-B-204	1.00	2.00	--	260	D

[a]The listed limits denote the maximum permissible change from a base line value established by TFSA (HS&E).

[b]D = once per day.

[c]Tank contains surface sludge.

[d]Salt well pumped.

[e]Questionable integrity.

[f]Confirmed leaker (January 1980).

241-BX TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-7.

1. Scintillation Probe--SP and SSP

   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.

   b. Greater than 200 c/s--radiation level must double.

2. Geiger-Müller Probe

   a. 16 to 1,000 c/s--tripling of radiation.

   b. Greater than 1,000 c/s--doubling of radiation.

3. Contaminated dry wells that are only associated with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.

4. For increasing peak and total count activity trends which have not violated the appropriate probe criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LIQUID LEVEL

All LL data are evaluated for conformance to the limits stated in Table B-8. In the event that any of the limits are exceeded, TFS&O and EA&M (HS&E) management shall be notified immediately.

TABLE B-7. BX Farm Dry Well Monitoring Log. (Sheet 1 of 3)

BX - FARM DRY WELL MONITORING LOG

21-00-06

Monitoring Day Mon. & Tues. 2nd and 4th week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
21-00-01	(63)	10^4	143	S		
02	(142)	10^4	100	S		Quarterly
05	(62)	10^4	135	S		Quarterly
07	(77)	10^4	87	S		Weekly
09	(92)	10^4	75	S		
11	(65)	10^4	138	S		
21	(78)	10^4	145	S		
22	(93)	10^4	75	S		
01-01	(144)	10^5	100	S		Quarterly
02	(135)	10^4	100	S		Quarterly
02-01	(129)	10^4	100	S		Quarterly
03	(145)	10^4	100	S		Quarterly
04	(27)	10^5	255	2-GM	XX	Quarterly
06	(143)	10^4	100	S		Quarterly
07	(130)	10^4	100	S		Quarterly
11	(131)	10^4	100	S		Quarterly
03-03	(239)	10^4	100	S		
05	(229)	10^4	100	S		
07	(282)	10^4	100	S		
11	(277)	10^4	100	S		
12	(238)	10^5	100	S		
04-01	(281)	10^4	100	S		
03	(226)	10^4	100	S		
04	(278)	10^4	100	S		
06	(224)	10^4	100	S		
08	(267)	10^4	100	S		Weekly
11	(265)	10^4	100	S		
05-02	(158)	10^4	100	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

9212491647

TABLE B-7. BX Farm Dry Well Monitoring Log. (Sheet 2 of 3)

21-00-07

BX- FARM DRY WELL MONITORING LOG

Monitoring Day Mon. & Tues. 2nd and 4th week

Frequency Fortnightly unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
21-05-03 (159)	10^4	100	S		
05 (160)	10^4	100	S		
06 (161)	10^4	100	S		
10 (162)	10^4	100	S		
12 (157)	10^4	100	S		
06-01 (163)	10^4	100	S		
02 (164)	10^4	100	S		
05 (165)	10^4	100	S		
10 (166)	10^4	100	S		
07-03 (225)	10^4	100	S		Weekly
06 (222)	10^5	100	1-GM	XXX	Weekly
06 (222)	10^4	100	2-GM	XXX	Weekly
08-02 (64)	10^4	133	S		
04 (234)	10^4	100	S		
05 (235)	10^4	100	S		Weekly
06 (151)	10^4	100	S		Weekly
07 (152)	10^4	100	S		Quarterly
10 (236)	10^4	100	S		
12 (150)	10^4	100	S		Weekly
09-02 (257)	10^4	100	S		Weekly
04 (233)	10^4	100	S		Weekly
08 (258)	10^4	100	S		Weekly
12 (231)	10^4	100	S		Weekly
10-01 (167)	10^4	100	S		Weekly
03 (223)	10^5	100	1-GM	XXX	Weekly
03 (223)	10^4	100	2-GM	XXX	Weekly
05 (168)	10^5	100	SS		Weekly
07 (169)	10^4	100	S		Weekly
11 (170)	10^4	100	S		Weekly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

9212499 1648

TABLE B-7. BX Farm Dry Well Monitoring Log. (Sheet 3 of 3)

21-00-08

BX- FARM DRY WELL MONITORING LOG

Monitoring Day Mon. & Tues.
2nd and 4th week

Frequency Fortnightly.
unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
21-11-03	(237)	10^5	100	S		
04	(173)	10^5	100	S		
05	(171)	10^4	100	S		
07	(172)	10^4	100	S		
10	(174)	10^4	100	S		
11	(175)	10^4	100	S		
12-02	(153)	10^4	100	S		Weekly
05	(154)	10^4	100	S		
07	(155)	10^4	100	S		
10	(156)	10^4	100	S		
12	(232)	10^4	100	S		
27-01	(141)	10^4	100	S		Quarterly
02	(138)	10^4	100	S		Quarterly
06	(139)	10^4	100	S		Quarterly
07	(134)	10^4	136	S		Quarterly
08	(146)	10^4	150	S		Quarterly
09	(133)	10^4	146	S		Quarterly
10	(132)	10^4_4	146	S		Quarterly
11	(61)	10	145	S		Quarterly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

TABLE B-8. Limits for Liquid Level Readings, 241-BX Tank Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)[b]		Monitoring frequency[c]
	Decrease[b]	Increase[b]	Minimum	Maximum	
241-BX-101[d]	no criterion[e]	1.0	--	16	D
241-BX-102[d,f]	no criterion	1.0	--	35	D
241-BX-103	0.5	2.0	--	20	D
241-BX-104	0.5	2.0	--	183	S
241-BX-105	0.5	2.0	--	183	S
241-BX-106	0.5	2.0		14[g]	D
241-BX-107	0.5	2.0	--	131	D
241-BX-108[d,f]	no criterion	0.5	--	9	D
241-BX-109[d]	no criterion	2.0	--	75	D
241-BX-110	0.75	1.0	--	78	S
241-BX-111	0.75	1.0	--	82	D
241-BX-112	0.5	2.0	--	63	D

[a]Limits listed denote the maximum permissible change from a baseline value established by TFSA (HS&E).

[b]Corrected for cooling or heating trends based on a 1 vol% change per 20°C increase or decrease.

[c]S = once per shift; D = once per day.

[d]Tank contains surface sludge.

[e]Questionable integrity.

[f]Leaker.

[g]241-BX-106 is the designated alternate if either 241-BX-104 or 241-BX-105 is removed from service. The tank will then be activated and the maximum level will be changed to 183 in.

241-BY TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-9.

1. Scintillation Probe--SP and SSP
   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.
   b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller Probe
   a. 16 to 1,000 c/s--tripling of radiation.
   b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LIQUID LEVEL

All LL data are evaluated for conformance with the limits stated in Table B-10. In the event that a limit is exceeded, TFS&O and EA&M (HS&E) management are to be notified immediately.

TABLE B-9. BY Farm Dry Well Monitoring Log. (Sheet 1 of 3)

BY- FARM DRY WELL MONITORING LOG

22-00-06

Monitoring Day Tues. & Wed. 2nd and 4th week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
22-00-01	(85)	10^4	140	S		
02	(240)	10^4	100	S		
03	(84)	10^4	150	S		
04	(241)	10^4	100	S		
10	(88)	10^4	119	S		Weekly
01-01	(176)	10^4	100	S		
03	(245)	10^4	100	S		
04	(177)	10^4	100	S		
07	(178)	10^4	100	S		
10	(246)	10^4	100	S		Weekly
02-01	(101)	10^4	100	S		Weekly
02	(227)	10^4	100	S		Weekly
05	(228)	10^4	100	S		Weekly
07	(9)	10^4	150	S		Weekly
09	(102)	10^4	100	S		Weekly
03-01	(104)	10^4	100	S		Weekly
04	(211)	10^4	100	S		Weekly
05	(103)	10^5	100	1-GM	XXX	Weekly
05	(103)	10^5	100	2-GM	XXX	Weekly
06	(210)	10^4	100	S		Weekly
07	(242)	10^4	100	S		Weekly
08	(244)	10^4	100	S		Weekly
09	(105)	10^4	100	S		Weekly
10	(243)	10^4	87	S		Weekly
04-01	(106)	10^4	100	S		Weekly
05	(107)	10^4	100	S		Weekly
07	(248)	10^4	100	S		Weekly
09	(108)	10^4	100	S		Weekly
11	(249)	10^4	100	S		Weekly
05-01	(109)	10^4	100	S		Weekly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

92124991652

TABLE B-9. BY Farm Dry Well Monitoring Log. (Sheet 2 of 3)

BY - FARM DRY WELL MONITORING LOG

22-00-07

Monitoring Day Tues. & Wed. 2nd and 4th week

Frequency Fortnightly. unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
22-05-05	(110)	10^4	100	S		Weekly
09	(111)	10^4	100	S		Weekly
06-01	(112)	10^4	100	S		Weekly
05	(113)	10^4	100	S		Weekly
07	(86)	10^4	136	S		Weekly
09	(114)	10^4	100	S		Weekly
11	(250)	10^4	100	S		Weekly
07-01	(115)	10^4	100	S		Weekly
02	(206)	10^4	100	S		Weekly
05	(116)	10^4	100	S		Weekly
07	(251)	10^4	100	S		Weekly
09	(117)	10^6	100	S		Weekly
10	(252)	10^4	100	S		Weekly
08-01	(118)	10^4	100	S		Weekly
02	(208)	10^4	100	S		Weekly
05	(119)	10^4	100	S		Weekly
06	(207)	10^4	100	S		Weekly
07	(87)	10^4	135	S		Weekly
09	(120)	10^4	100	S		Weekly
12	(209)	10^4	100	S		Weekly
09-01	(123)	10^4	100	S		
02	(259)	10^4	100	S		
05	(122)	10^4	100	S		
07	(260)	10^4	100	S		
08	(121)	10^5	100	S		Weekly
11	(253)	10^4	100	S		
10-05	(124)	10^4	100	S		
07	(254)	10^4	100	S		
09	(255)	10^4	100	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

9212491653

TABLE B-9. BY Farm Dry Well Monitoring Log. (Sheet 3 of 3)

BY - FARM DRY WELL MONITORING LOG

22-00-08

Monitoring Day Tues. & Wed. 2nd and 4th week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
22-10-10	(125)	10^4	100	S		
11-01	(126)	10^4	100	S		Weekly
05	(127)	10^4	100	S		Weekly
08	(256)	10^4	100	S		Weekly
09	(128)	10^4	100	S		Weekly
12-01	(100)	10^4	100	S		Weekly
03	(94)	10^4	100	S		Weekly
05	(95)	10^4	100	S		Weekly
06	(96)	10^4	100	S		Weekly
07	(97)	10^4	100	S		Weekly
09	(98)	10^4	100	S		Weekly
10	(99)	10^4	100	S		Weekly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

9212499654

TABLE B-10. Limits for Liquid Level Readings, 241-BY Tank Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
241-BY-101	1.00	3.00	--	175	D
241-BY-102	1.00	2.00	--	165	D
241-BY-103[c,d]	no criterion	2.00	--	178	S
241-BY-104[c]	no criterion	2.00	--	245	D
241-BY-105[c,e]	no criterion	2.00	--	205	D
241-BY-106[c,e]	no criterion	2.00	--	240.50	D
241-BY-107[c,e]	no criterion	2.00	--	116	D
241-BY-108[c,d]	no criterion	2.00	--	103	S
241-BY-109	1.00	3.00	--	185	D
241-BY-110[c,f]	no criterion	3.00	--	195	D
241-BY-111[f]	1.00	3.00	--	250	D
241-BY-112	no criterion	3.00	--	120	D

[a]Values listed denote the maximum permissible change from a baseline value established by TFSA (HS&E).

[b]S = once per shift; D = once per day.

[c]Tank has no measurable surface liquid.

[d]Confirmed leaker.

[e]Questionable integrity.

[f]Corrected for evaporation to an operating exhauster.

241-C TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-11.

1. Scintillation Probe-- SP and SSP
   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.
   b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller Probe
   a. 16 to 1,000 c/s--tripling of radiation.
   b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LIQUID LEVEL

All LL data are evaluated for conformance to the limits stated in Table B-12. In the event that any of the limits are exceeded, TFS&O and EA&M (HS&E) management shall be notified immediately.

TABLE B-11. C Farm Dry Well Monitoring Log. (Sheet 1 of 3)

C. FARM DRY WELL MONITORING LOG 30-00-06

Monitoring Day Wednesday
1st and 3rd week
Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
30-00-01	(56)	10^4	100	S		
03	(54)	10^4	120	S		
06	(55)	10^4	114	S		
09	(57)	10^4	56	S		
10	(53)	10^4	54	S		
11	(121)	10^4	60	S		
12	(52)	10^4	140	S		
13	(123)	10^4	60	S		
22	(120)	10^4	60	S		
24	(122)	10^4	60	S		
01-01	(60)	10	100	S		Weekly
06	(59)	10^4	100	S		
09	(58)	10^5	100	S		
12	(61)	10^4	100	S		
03-01	(74)	10^4	100	S		
03	(75)	10^4	100	S		
05	(76)	10^4	100	S		
07	(77)	10^4	100	S		Weekly
09	(78)	10^4	100	S		Weekly
04-01	(115)	10^4	50	S		
02	(67)	10^4	130	S		
03	(116)	10^5	50	S		
04	(79)	10^4	100	S		
05	(80)	10^4	100	S		
08	(66)	10^4	145	S		
12	(65)	10^4	135	S		
05-02	(70)	10^4	126	S		Weekly
03	(81)	10^4	100	S		Weekly
04	(69)	10^4	120	S		Weekly
05	(82)	10^4	100	S		

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

9212491658

TABLE B-11. C Farm Dry Well Monitoring Log. (Sheet 2 of 3)

30-00-07

C - FARM DRY WELL MONITORING LOG

Monitoring Day Wednesday 1st and 3rd week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
30-05-06	(119)	10^4	60	S		
07	(118)	10^5	70	2-GM	XXX	
08	(117)	10^4	52	S		
09	(83)	10^4	100	S		
10	(68)	10^4	135	S		
06-02	(72)	10^4	125	S		Weekly
03	(84)	10^4	100	S		Weekly
04	(73)	10^4	130	S		Weekly
09	(85)	10^4	100	S		Weekly
10	(71)	10^4	130	S		Weekly
12	(86)	10^4	100	S		Weekly
07-01	(87)	10^4	100	S		
02	(88)	10^4	100	S		
05	(89)	10^4	100	S		
07	(90)	10^4	99	S		
08	(91)	10^4	99	S		
10	(92)	10^4	100	S		
11	(93)	10^4	100	S		
08-02	(94)	10^5	100	S		
03	(51)	10^4	59	S		
12	(95)	10^4	100	S		
09-01	(96)	10^4	100	S		
02	(97)	10^4	100	S		
06	(98)	10^4	100	S		
10	(99)	10^4	100	S		
11	(100)	10^4	100	S		
10-01	(101)	10^4	100	S		
02	(102)	10^4	100	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Mulier Probe (GM) (Green 1)

7/30/80

TABLE B-11. C Farm Dry Well Monitoring Log. (Sheet 3 of 3)

30-00-08

C - FARM DRY WELL MONITORING LOG

Monitoring Day Wednesday
1st and 3rd week

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
30-10-09 (103)	10^4	100	S		
11 (104)	10^4	100	S		
11-01 (63)	10^4	100	S		
05 (105)	10^4	100	S		
06 (64)	10^4	100	S		
09 (62)	10^4	100	S		
11 (106)	10^4	100	S		
12-01 (107)	10^4	100	S		
03 (108)	10^4	100	S		
09 (109)	10^4	100	S		
13 (125)	10^4	125	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

92124991659

TABLE B-12. Limits for Liquid Level Readings, 241-C Tank Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
241-C-101[c,d]	no criterion	2.00	--	30	D
241-C-102[c]	no criterion	2.00	--	154	D
241-C-103	0.50	2.00	--	71	D
241-C-104	0.50	2.00	--	115	S
241-C-105[e,f]	0.50	2.00	57.0	63	S
241-C-106[e,f]	2.0 in 2 wk	2.00	74.5	79	S
241-C-107[c]	no criterion	2.00	--	107	D
241-C-108[c]	no criterion	2.00	--	23	D
241-C-109[c]	no criterion	2.00	--	22	D
241-C-110[c,g]	no criterion	2.00	--	75	D
241-C-111[c,g]	no criterion	2.00	--	21	D
241-C-112[c]	no criterion	2.00	--	37	D
241-C-201	0.75	2.00	--	28	D
241-C-202	0.75	2.00	--	22	D
241-C-203	0.75	2.00	--	50	D
241-C-204	0.75	2.00	--	23	D

[a]The listed limits denote the maximum permissible change from a baseline LL established by TFSA (HS&E).

[b]S = once per shift; D = once per day.

[c]The tank is equipped with a salt well system.

[d]Confirmed leaker (January 1980).

[e]The tank is connected to an operating exhauster.

[f]Baseline changes for LL decreases must not exceed decreases based on current psychrometric data and new baselines must be within 0.5 in. of current LL.

[g]Questionable integrity.

200 EAST AREA DIVERSION BOX CATCH TANKS AND DIVERTER STATION CATCH TANKS ACTION CRITERIA

A. LIQUID LEVEL LIMITS

Tables B-13 and B-14 list diversion box and diverter station catch tanks within the 200 East Area. Two LL limits are stated for the diversion box catch tanks. The first, at 45 vol% capacity, is the point at which TFS&O must commence its preparation of arrangement for transfer of the contained solution. The second limit, at 50 vol% capacity, is the maximum stated limit if transfer through its associated diversion box is to be permitted.

TABLE B-13. Liquid Level Limits for Diversion Box Catch Tank, 200 East Area.

Diversion box	Tank	Size	Capacity (gal)	~45 vol%		~50 vol%	
				LL	Gal	LL	Gal
A-151	241-A-302 A	9 ft x 16 ft 6 in.	7,852	4 ft 2 in.	3,557	4 ft 6 in.	3,927
A-152	241-A-302 B	8 ft x 30 ft	11,700	3 ft 8 in.	4,800	4 ft 0 in.	5,846
B-151	241-B-301 B	20 ft x 15 ft 6 in.	36,400	6 ft 11 in.	16,300	7 ft 9 in.	18,200
B-154	241-B-302 B	9 ft x 36 in.	17,684	4 ft 2 in.	8,000	4 ft 6 in.	8,840
BX-153	241-BX-302 A	9 ft x 36 in.	17,684	4 ft 2 in.	8,000	4 ft 6 in.	8,840
BX-154	241-BX-302 B	10 ft x 18 ft	11,389	4 ft 6 in.	4,900	5 ft 0 in.	5,694
BX-155	241-BX-302 C	10 ft x 18 ft	11,389	4 ft 6 in.	4,900	5 ft 0 in.	5,694
ER-151	241-ER-311	9 ft x 36 in.	17,684	4 ft 2 in.	8,000	4 ft 6 in.	8,840
C-151	241-C-301 C	20 ft x 15 ft 6 in.	36,400	6 ft 11 in.	16,300	7 ft 9 in.	18,200
Vent station		4 ft x 6 ft x 8 in.	800	3 ft 0 in.	360	3 ft 4 in.	400
	241-AZ-154	2 ft x 2 ft x 1 ft (sump) plus 5 ft x 5 ft x 4 ft 6 in. (to overflow)	872	2 ft 6 in.	392	2 ft 9 in.	435
	241-AZ-151	11 ft x 6 ft x 24 ft (overflow to pump pit)	11,900	4 ft 11 in.	5,300	5 ft 6 in.	5,900

TABLE B-14. Volume Limits for Diverter and Lift Station Catch Tanks, 200 East Area.

Station	Capacity (gal)	Weight factor limit diversion	Maximum volume (gal)
<u>Diverter</u>			
151-AX (Tank 241-AX-151)	11,000	60	5,500
152-AX (Tank 241-AX-152)	11,000	60	5,500
<u>Drainage Lift</u>[a]			
A-350	776 (82 in.)	66 in.	624
<u>244-A Lift</u>[b]			
Tank 241-A-244	16,280	44.5[c]	13,024
Sump 244-A	--	6	~8

[a]The A-350 drainage lift station tank is an exception to the above action requirements because an instrument weight factor reading at the 70% capacity level provides for automatic pump out. A second interlock at the 80% capacity level (LL in.) actuates a high-level alarm at the 242-A vacuum crystallizer building.

[b]The 244-A lift station receives drainage from the 241-ER-153 diversion box, the 244-A pump pit, and the two lines leading to the 241-A and -B valve pits. Also, facilities are provided for the draining, to Tank 241-A-244, of pipelines associated with the transfer route between the 241-ER-151 diversion box and the 241-A-A valve pit, and subsequent pump out to a designated waste receiver tank. In addition to the limit stated above for the maximum 241-A-244 weight factor (at 80% of the overflow volume), a second operational limit of 8,000 gal (corrected weight factor + 27.2) applies to waste transfers through the associated piping. The purpose of the limit is to permit sufficient freeboard to receive the transfer line drain back without exceeding the upper limit. The volume of tank contents must be reduced to below this limit before a transfer can be authorized.

[c]Weight factor readings must be corrected for specific gravity.

B. LIQUID LEVEL DECREASE

The limits stated in Table B-15 denote the maximum permissible decrease from baseline values established by the TFSA Section. In the event that a limit is exceeded, TFS&O and EA&M (HS&E) managers must be notified immediately.

TABLE B-15. Maximum Permissible Decrease from Baseline Values.

Catch tank	Receives waste from	Monitoring frequency[a]	LL decrease limit (in.)
241-A-302 A	151-A diversion box	D	2.0
241-A-302 B	152-A diversion box	D	1.5
241-B-301 B	151-B, 152-B, 153-B, 252-B diversion boxes	D	2.0
241-B-302 B	154-B diversion box	D	2.0
241-BX-302 A	153-BX, 152-BXR, 152-BR, 152-BYR diversion boxes	D	2.0
241-BX-302 B	154-BX diversion box	D	2.0
241-BX-302 C	155-BX diversion box	D	2.0
241-ER-311	151-ER, 152-ER diversion boxes	D	1.5
241-C-301 C	151-C, 152-C, 153-C, 252-C diversion boxes	D	2.0
Vent station	Vent station	D	2.0
241-AZ-151	152-AZ transfer pit, loop seal	S	2.0
241-AZ-154	101, 102-AZ heating coil cond.	S	2.0
241-AX-151	151-AX diverter station	S	4.0 weight factor divisions
241-AX-152	152-AX diverter station	S	4.0 weight factor divisions
241-A-350	A Farm valve, flush and service pit drains clean out boxes (COB) 242-A condensate retention basin	S	2.0
241-A-244	153-ER, 241-A-A valve pit	S	
Sump 244-A	241-A process pit	S[b]	2.0 weight factor divisions

[a]S = once per shift; D = once per day.

[b]Any increase in 244-A sump weight factor in excess of 2 divisions must be reported.

200 EAST AREA SPECIAL SURVEILLANCE TANKS

Table B-16 contains a listing of special surveillance tanks and process cell sumps within the 200 East Area. All of these sites have been removed from active service and are awaiting final removal of residual liquid. All LL data are evaluated for conformance to the limits stated. In the event that a limit is exceeded, EA&M (HS&E) and TFS&O managers are to be notified immediately.

TABLE B-16. Monitoring and Operating Limits for Special Surveillance Tanks and Process Cell Sumps, 200 East Area.

Location	Monitoring liquid level criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
011 BXR tank	1.00	2.00	--	55.00	D
011 BXR sump	2.00	2.00	--	36.00	D
001 BXR tank	1.00	2.00	--	50.00	D
001 BXR sump	2.00	2.00	--	47.00	D
002 BXR tank	1.00	2.00	--	82.00	D
002 BXR sump	2.00	2.00	--	41.00	D
003 BXR tank	1.00	2.00	--	55.00	D
003 BXR sump	2.00	2.00	--	80.00	D
241-CX-70	1.00	2.00	--	60.00	D
361-B	2.00	2.00	--	125.00	D

[a]The listed criteria denote the maximum permissible change from a baseline value established by TFSA (HS&E).

[b]D = once per day.

9 2 1 2 4 9 9 1 6 6 4

241-S TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-17.

1. Scintillation Probe--SP and SSP
   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.
   b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller Probe
   a. 16 to 1,000 c/s--tripling of radiation.
   b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe action criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LIQUID LEVEL

All LL data are compared against the limits stated in Table B-18. In the event that a limit is exceeded, TFS&O and EA&M (HS&E) managers are to be notified immediately.

TABLE B-17. S Farm Dry Well Monitoring Log. (Sheet 1 of 3)

S - FARM DRY WELL MONITORING LOG 40-00-07

Monitoring Day Monday 2nd and 4th week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
40-00-02	(51)	10^4	142	S		
04	(1)	10^4	262	S		
06	(56)	10^4	150	S		Weekly
01-01	(145)	10^4	130	S		
04	(179)	10^4	100	S		
06	(146)	10^4	100	S		
08	(147)	10^4	100	S		
10	(180)	10^4	100	S		
02-01	(148)	10^4	130	S		
03	(188)	10^5	100	1-GM	XXX	
03	(188)	10^4	100	2-GM	XXX	
04	(52)	10^4	150	S		
05	(181)	10^4	100	S		Weekly
07	(149)	10^4	100	S		Weekly
08	(189)	10^4	100	S		
10	(150)	10^4	100	S		
11	(182)	10^4	100	S		
03-01	(151)	10^4	100	S		
03	(212)	10^4	125	S		
05	(53)	10^4	150	S		
06	(152)	10^4	100	S		Weekly
08	(183)	10^4	100	S		
09	(153)	10^4	130	S		
11	(184)	10^4	100	S		
04-01	(123)	10^4	100	S		
05	(124)	10^5	134	1-GM	XXX	
05	(124)	10^4	134	2-GM	XXX	
07	(122)	10^4	100	S		
08	(177)	10	50	S		
05-03	(154)	10^4	100	S		Weekly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

92124991666

TABLE B-17. S Farm Dry Well Monitoring Log. (Sheet 2 of 3)

S - FARM DRY WELL MONITORING LOG 40-00-08

Monitoring Day Monday
2nd and 4th week

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
40-05-05	(54)	10^4	150	S		Weekly
07	(155)	10^4	100	S		Weekly
08	(199)	10^4	100	S		Weekly
10	(156)	10^4	86	S		Weekly
06-02	(157)	10^4	100	S		Weekly
04	(213)	10^4	125	S		Weekly
05	(55)	10^4	137	S		Weekly
06	(158)	10^4	94	S		Weekly
08	(201)	10^4	100	S		Weekly
09	(159)	10^4	100	S		Weekly
07-01	(160)	10^4	100	S		
04	(185)	10^4	100	S		
06	(161)	10^4	100	S		Weekly
08	(186)	10^4	100	S		Weekly
10	(162)	10^4	100	S		Weekly
11	(187)	10^4	100	S		
08-01	(178)	10^4	100	S		Weekly
06	(163)	10^4	100	S		Weekly
08	(202)	10^4	100	S		Weekly
09	(164)	10^4	100	S		Weekly
12	(216)	10^4	125	S		Weekly
09-01	(200)	10^4	100	S		Weekly
02	(165)	10^4	100	S		Weekly
05	(57)	10^4	140	S		Weekly
06	(166)	10^4	94	S		Weekly
08	(203)	10^4	100	S		Weekly
09	(167)	10^4	130	S		Weekly
10-01	(72)	10^4	250	S		Weekly
03	(168)	10^4	100	S		Weekly
05	(204)	10^4	100	S		Weekly

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

TABLE B-17. S Farm Dry Well Monitoring Log. (Sheet 3 of 3)

S - FARM DRY WELL MONITORING LOG 40-00-09

Monitoring Day Monday
2nd and 4th week

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
40-10-06	(169)	10^4	148	S		Weekly
08	(205)	10^4	100	S		Weekly
09	(170)	10^4	100	S		Weekly
13	(218)	10^4	125	S		Weekly
11-01	(171)	10^4	146	S		Weekly
05	(206)	10^4	100	S		Weekly
07	(172)	10^4	100	S		Weekly
08	(207)	10^4	100	S		Weekly
09	(173)	10^4	100	S		Weekly
12-02	(174)	10^4	100	S		Weekly
04	(220)	10^4	125	S		Weekly
06	(175)	10	140	S		Weekly
07	(208)	10^4	100	S		Weekly
09	(176)	10^4	100	S		Weekly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

TABLE B-18. Limits for Liquid Level Readings, 241-S Tank Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
241-S-101	2.0	3.0	--	275.0	S
241-S-102	1.0	3.0	--	233.0[c]	S
241-S-103[d,e]	0.5	2.0	--	249.0	S
241-S-104[f,g]	no criterion	1.0	--	120.0	D
241-S-105[g]	no criterion	3.0	--	170.0	D
241-S-106[g]	no criterion	3.0	--	195.0	D
241-S-107[h]	1.0	2.0	--	275.0	S
241-S-108[g]	no criterion	3.0	--	205.0	S
241-S-109[g]	no criterion	3.0	--	209.0	S
241-S-110[g]	no criterion	3.0	--	170.0	S
241-S-111[g]	no criterion	3.0	--	214.0	D
241-S-112[g]	no criterion	3.0	--	226.0	D

[a]The listed limits denote the maximum permissible change from a baseline value established by TFSA (HS&E).

[b]S = once per shift; D = once per day.

[c]In-tank photographs taken July 19, 1975 show tank liner anomalies of unidentified origin at the 240-in. level. Limit was imposed to ensure an operating level below these marks.

[d]Limit established to provide adequate freeboard for two volume equivalents of the 242-S vacuum crystallizer when the evaporator is in operation. The actual LL limit is 275 in., which includes two evaporator "dumps."

[e]241-S-103 is designated, per SOP TO-001-050, as an alternate contingency receiver for complexant waste.

[f]Denotes questionable integrity.

[g]Salt well systems installed.

[h]241-S-107 is designated, per SOP TO-001-050, as an alternate contingency receiver for noncomplexant waste only.

A number of tanks have "no criteria" designations for LL decrease, or in the case of evaporator bottoms tanks, a criteria statement applies to static periods only. The following discussion clarifies these designations.

a. Tanks in active bottoms service or containing surface crusting may display significant LL variations from shift to shift. Liquid inventories in the active bottoms system are monitored by calculating overall material balances on a daily basis in addition to the routine transfer material balances. For tanks in the 242-S bottoms system, daily overall material balance discrepancies indicating a loss of >3.3 in. (9,000 gal) shall be reported immediately. Ten day moving average discrepancies of >±2,000 gal must be reported immediately to the managers of TFEPC, TFS&O, TFSA (HS&E), and EA&M (HS&E). Additional reporting and action requirements are stated in the material balance operating procedure, TO-700-090. Following a transfer or shutdown, a 24-hr period will be allowed for stabilization of the LL in an active bottoms tank.

b. Tanks that contain sludge with very little solution will show decrease in "liquid (surface) level" measurement, particularly if a salt well system is in operation. Such losses are due to sludge at the point of probe contact. Therefore, LL generally is not a means for leak detection and there are no criteria listed for these tanks. Such tanks shall require special evaluation by TFSA and TFEPC prior to any definition of status based upon liquid (surface) level data.

241-SX TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-19.

1. Scintillation Probe--SP and SSP
   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.
   b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller Probe
   a. 16 to 1,000 c/s--tripling of radiation.
   b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe action criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LEAK DETECTION LATERALS

1. Linear Plots--Tanks 241-SX-108, 109, 112, 114, and 115
   a. Activity must increase 50% from an established baseline and also exceed 150 counts per minute (c/min).
2. Logarithmic Plots--Tanks 241-SX-105, 107, 110, and 111
   a. Activity <12 c/s must increase 10 c/s from an established baseline and also exceed 12 c/s.
   b. Activity $\geq$12 c/s must increase 50% from an established baseline.

TABLE B-19. SX Farm Dry Well Monitoring Log. (Sheet 1 of 4)

SX - FARM DRY WELL MONITORING LOG 41-00-08

Monitoring Day Mon., Tues. 1st and 3rd week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
41-00-02	(61)	10^4	102	S		
03	(2)	10^4	236	S		
04	(5)	10^4	250	S		Quarterly
05	(3)	10^4	232	S		Quarterly
08	(65)	10^4	125	S		Quarterly
01-01	(132)	10^4	135	S		
04	(190)	10^4	100	S		
06	(133)	10^4	100	S		
07	(60)	10^4	100	S		
08	(134)	10^4	100	S		
10	(191)	10^4	100	S		
11	(192)	10^4	100	S		
02-02	(135)	10^4	135	S		
05	(223)	10^4	125	S		
07	(59)	10^4	101	S		
08	(136)	10^4	100	S		
11	(193)	10^4	100	S		
03-02	(194)	10^4	100	S		
05	(195)	10^4	100	S		
06	(138)	10^4	100	S		
09	(139)	10^4	100	S		
10	(196)	10^4	100	S		
12	(137)	10^4	135	S		
04-01	(140)	10^4	100	S		
03	(197)	10^4	100	S		
05	(198)	10^4	100	S		
07	(62)	10^4	100	S		
08	(225)	10^4	125	S		
11	(141)	10^4	100	S		
05-02	(130)	10^4	125	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

TABLE B-19. SX Farm Dry Well Monitoring Log. (Sheet 2 of 4)

SX- FARM DRY WELL MONITORING LOG

41-00-09

Monitoring Day Mon., Tues. 1st and 3rd week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
41-05-03	(131)	10^4	125	S		
05	(125)	10^4	130	S		
07	(126)	10^4	125	S		
08	(127)	10^4	125	S		
10	(128)	10^4	125	S		
12	(129)	10^4	125	S		
06-02	(142)	10^4	100	S		
05	(143)	10^4	135	S		
06	(226)	10^4	125	S		Weekly
09	(144)	10^4	100	S		
11	(58)	10^4	101	S		
23	(227)	10^4	125	S		
07-02	(74)	10^4	75	S		Quarterly
03	(75)	10^4	75	S		Quarterly
05	(76)	10^4	75	2-GM	XXX	Quarterly
07	(77)	10^4	75	2-GM	XXX	Quarterly
08	(78)	10^4	75	S		
10	(79)	10^4	75	S		Quarterly
12	(73)	10^4	85	S		
08-02	(102)	10^5	75	SS		Quarterly
03	(103)	10^4	75	S		Quarterly
04	(98)	10^4	75	S		Quarterly
06	(99)	10^4	125	S		Quarterly
07	(100)	10^4	75	2-GM	XXX	Quarterly
11	(101)	10^4	75	2-GM	XXX	
09-02	(110)	10^4	75	S		
03	(104)	10^4	75	2-GM	XXX	
04	(105)	10^4	100	2-GM	XXX	Quarterly
06	(106)	10^4	75	S		
07	(107)	10^5	75	1-GM	XXX	
07	(107)	10^5	75	2-GM	XXX	

Scintillation probe (S) (4)
Shielded Scintillation probe (SS)(5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

TABLE B-19. SX Farm Dry Well Monitoring Log. (Sheet 3 of 4)

41-00-10

SX - FARM DRY WELL MONITORING LOG

Monitoring Day Mon., Tues.
1st and 3rd week
Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
41-09-09	(108)	10^4	125	S		
11	(109)	10^4	75	S		
10-01	(80)	10^4	137	S		Quarterly
02	(66)	10^4	126	S		Quarterly
03	(81)	10^4	75	S		Quarterly
05	(82)	10^4	75	S		Quarterly
06	(83)	10^4	75	S		Quarterly
08	(84)	10^4	75	S		Quarterly
10	(67)	10^4	126	S		Quarterly
11	(85)	10^4	75	S		Quarterly
11-02	(96)	10^4	75	S		Quarterly
03	(97)	10^4	75	S		Quarterly
05	(92)	10^4	137	S		Quarterly
06	(93)	10^4	75	S		Weekly
08	(94)	10^4	130	S		Quarterly
09	(95)	10^4	75	S		Quarterly
10	(64)	10^5	125	1-GM	XXX	Quarterly
10	(64)	10^4	125	2-GM	XXX	Quarterly
12-02	(111)	10^4	120	2-GM	XXX	Quarterly
03	(112)	10^5	75	SS		Quarterly
04	(68)	10^4	125	S		Quarterly
06	(113)	10^4	75	S		Quarterly
07	(114)	10^4	75	S		Quarterly
09	(115)	10^4	75	S		Quarterly
10	(116)	10^4	75	S		Quarterly
13-10	(72)	10^4	100	S		Quarterly
14-02	(91)	10^4	75	S		Weekly
03	(86)	10^4	75	S		Weekly
04	(69)	10^4	120	S		Weekly
06	(87)	10^4	75	S		Weekly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

92124991674

TABLE B-19. SX Farm Dry Well Monitoring Log. (Sheet 4 of 4)

SX - FARM DRY WELL MONITORING LOG

41-00-11

Monitoring Day Mon., Tues., 1st and 3rd week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
41-14-08 (88)	10^4	75	S		Weekly
09 (89)	10^4	75	S		Weekly
11 (90)	10^4	75	S		Weekly
15-02 (117)	10^4	75	S		Quarterly
03 (118)	10^4	75	S		Quarterly
05 (119)	10^4	75	S		Quarterly
07 (70)	10^4	125	S		Quarterly
09 (120)	10^4	75	S		Quarterly
10 (121)	10^4	130	S		Quarterly

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

3. Contaminated laterals associated with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and lateral criterion limits will not apply.

C. LIQUID LEVEL

All LL data are compared against the limits stated in Table B-20. In the event that a limit is exceeded, TFS&O and EA&M management are to be notified immediately.

A number of tanks have "no criteria" designations for LL decrease, or in the case of evaporator bottoms tanks, a criteria statement applies to static periods only. The following discussion clarifies these designations.

a. Tanks in active bottoms service or containing surface crusting may display significant LL variations from shift to shift. Liquid inventories in the active bottoms system are monitored by calculating overall material balances on a daily basis, in addition to the routine transfer material balances. For 241-S-242, a daily overall material balance discrepancy indicating a loss of >3.3 in. (9,000 gal) shall be immediately reported. Ten day 241-S-242 moving average discrepancies of >±2,000 gal, respectively, must be reported immediately to the TFEPC, TFS&O, and TFSA managers. Additional reporting and action requirements are stated in the material balance operating procedures. Following a transfer or shutdown, a 24-hr period will be allowed for the LL in an active bottoms tank to stabilize.

b. Tanks that contain sludge with very little solution will show decreases in "liquid (surface) level" measurements, particularly if a salt well system is in operation. Such losses are due to sludge slumping, tape flushes, and perforation of the exposed sludge at the point of probe contact. Therefore, liquid (surface) level is generally not a means for leak detection and there are no criteria listed for these tanks. Such tanks shall require special evaluation by TFSA (HS&E) and TFEPC prior to any definition of status based upon liquid (surface) level data.

TABLE B-20. Limits for Liquid Level Readings, 241-SX Tank Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
241-SX-104	1.0	3.00[c]	--	286	S
241-SX-105	1.0	3.00[c]	--	258	D
241-SX-106	0.50	3.00[c]	--	362	S
241-SX-107[d]	no criterion	1.00	--	46	D
241-SX-108[d]	no criterion	1.00	--	50	D
241-SX-109[d]	no criterion	1.00	--	99	D
241-SX-110[e]	no criterion	1.00	--	32	D
241-SX-111[d]	no criterion	1.00	--	52	D
241-SX-112[d]	no criterion	1.00	--	42	D
241-SX-113[d]	no criterion	1.00	--	19	D
241-SX-114[e]	no criterion	1.00	--	75	D
241-SX-115[d]	no criterion	1.00	--	10	D

[a]Denotes changes from a baseline value established by TFS (HS&E).

[b]S = once per shift; D = once per day.

[c]Contents of tanks in active or completed evaporator bottoms service experience a growth mechanism upon entering an inactive status. An engineering review will be undertaken for such tanks within 3 mo following the last receipt of slurry or when the LL increase has reached 3 in. The results of this review will allow revising the LL baseline value without the issuance of an Occurrence Report. The baseline change will be authorized by the TFSA (HS&E) and TFEPC managers.

[d]Denotes confirmed leaker.

[e]Denotes removed from service; questionable integrity.

241-SY TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

No dry well installed.

B. LEAK DETECTION PITS

1. A weight factor increase on one whole dial division (4 in.) from the established baseline and accompanied by an increase in radiation level in excess of 0.1 roentgen per hour (R/hr).
2. A criterion exceeded in only one of the above may warrant issuance of a deviation report.

C. ANNULUS LEAK DETECTION

1. Any indication by conductivity probe sensor.
2. A confirmed increase in the tank annulus vent radiation monitor.

D. LIQUID LEVEL

All LL data are evaluated for conformance to the limits stated in Table B-21. In the event that any of the limits are exceeded, the Manager, Tank Farm Surveillance shall be notified immediately.

TABLE B-21. Limits for Liquid Level Readings, 241-SY Tank Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)[a]		Monitoring frequency[b]
	Decrease[c]	Increase	Minimum	Maximum	
241-SY-101	0.50	3.00	18	360	S
241-SY-102	0.50	3.00	18[d]	360	S
241-SY-103	0.50	2.00	18	360	S

[a]The listed limits denote a maximum permissible change from a baseline value established by TFSA (HS&E).

[b]S = once per shift.

[c]The tank is connected to an operating exhauster and routine psychrometric surveys are performed.

[d]TFEPC limit of 70 in., except when the evaporator is shut down, or if the feed has been analyzed and found not to contain organics.

241-T TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-22.

1. Scintillation Probe--SS and SSP
   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.
   b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller Probe
   a. 16 to 1,000 c/s--tripling of radiation.
   b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe criteria, TFSA and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LIQUID LEVEL

All LL data are compared against the limits stated in Table B-23. In the event that a limit is exceeded, TFS&O and EA&M (HS&E) management are to be notified immediately.

TABLE B-22. T Farm Dry Well Monitoring Log. (Sheet 1 of 3)

50-00-07

T- FARM DRY WELL MONITORING LOG

Monitoring Day Tuesday
2nd and 4th week

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
50-00-03	(51A)	10^4	150	S		
05	(53A)	10^4	150	S		Weekly
08	(52)	10^4	150	S		
09	(168)	10^5	120	S		
10	(54)	10^4	140	S		
12	(53)	10^4	140	S		
01-02	(101)	10^4	94	S		
04	(102)	10^4	87	2-GM	XXX	
06	(103)	10^4	94	S		
09	(104)	10^4	96	S		
12	(105)	10^4	92	S		
02-02	(122)	10^4	91	S		
05	(123)	10^5	91	S		
08	(116)	10^4	87	S		
09	(119)	10^4	91	S		
10	(124)	10^4	91	S		
12	(125)	10^4	92	S		
03-01	(126)	10^4	92	S		
04	(118)	10^5	87	S		
05	(117)	10^4	90	S		
06	(145)	10^4	122	S		
08	(127)	10^4	86	S		
10	(128)	10^4	93	S		
04-03	(146)	10^4	92	S		
05	(129)	10^4	94	S		Weekly
07	(147)	10^4	100	S		Weekly
08	(148)	10^4	100	S		
10	(130)	10^4	93	S		
05-06	(113)	10^4	120	S		

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

9 2 1 2 4 9 9 1 6 3 1

TABLE B-22. T Farm Dry Well Monitoring Log. (Sheet 2 of 3)

T - FARM DRY WELL MONITORING LOG 50-00-08

Monitoring Day Tuesday
2nd and 4th week

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
50-05-07 (165)	10^5	88	S		
11 (121)	10^4	92	S		
06-02 (108)	10^5	120	S		
03 (107)	10^5	120	SS		
04 (110)	10^4	93	2-GM	XXX	
05 (111)	10^4	120	2-GM	XXX	
06 (106)	10^5	120	SS		
08 (109)	10^5	120	1-GM	XXX	
08 (109)	10^4	120	2-GM	XXX	
11 (115)	10^4	87	S		
16 (167)	10^5	88	S		
17 (162)	10^4	88	2-GM	XXX	
07-03 (149)	10^4	92	S		Weekly
07 (142)	10^4	94	S		Weekly
08 (150)	10^4	94	S		Weekly
08-05 (143)	10^4	93	S		Weekly
07 (133)	10^4	90	S		
08 (176)	10^4	103	S		
09 (112)	10^5	120	S		
11 (51)	10^5	138	SS		
19 (178)	10^4	88	S		
09-01 (164)	10^5	88	SS		
02 (166)	10^5	88	S		
05 (134)	10^4	94	S		
07 (144)	10^4	94	S		
09 (120)	10^4	120	S		
10 (114)	10^5	120	S		

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

9 2 1 2 4 9 9 1 6 8 2

TABLE B-22. T Farm Dry Well Monitoring Log. (Sheet 3 of 3)

T- FARM DRY WELL MONITORING LOG

50-00-09

Monitoring Day Tuesday
2nd and 4th week
Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
50-10-05 (135)	10^4	95	S		Weekly
07 (136)	10^4	94	S		Weekly
08 (151)	10^4	93	S		Weekly
10 (137)	10^4	94	S		Weekly
11-05 (138)	10^4	93	S		Weekly
07 (152)	10^4	94	S		Weekly
08 (139)	10^4	94	S		Weekly
10 (153)	10^4	100	S		Weekly
11 (177)	10^4	84	S		Weekly
12-05 (154)	10^4	100	S		
07 (140)	10^4	94	S		
10 (141)	10^4	120	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

92124991683

TABLE B-23. Limits for Liquid Level Readings, 241-T Tank Farm.

Tank number	Monitoring leak detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
241-T-101	0.50	2.00	--	46	D
241-T-102[c]	no criterion	2.00	--	9	D
241-T-103[d]	no criterion	1.00	--	7	D
241-T-104[c]	no criterion	2.00	--	162	D
241-T-105[c]	no criterion	2.00	--	34	D
241-T-106[e]	no criterion	0.50	--	5	D
241-T-107[d,f]	no criterion	1.00	--	65	D
241-T-108[d,f]	no criterion	1.00	--	14	D
241-T-109[d,f]	no criterion	1.00	--	22	D
241-T-110[c]	no criterion	2.00	--	150	D
241-T-111[d,f]	no criterion	1.00	--	165	D
241-T-112	0.50	2.00	--	25	D
241-T-201[f]	no criterion	2.00	--	150	D
241-T-202[f]	no criterion	2.00	--	103	D
241-T-203[f]	no criterion	2.00	--	186	D
241-T-204[f]	1.00	2.00	--	191	D

[a]Denotes changes from a baseline value established by TFSA (HS&E).
[b]D = once per day.
[c]Denotes not intended for reuse; administrative control.
[d]Denotes removed from service; questionable integrity.
[e]Denotes confirmed leaker.
[f]Salt well system installed.

241-TX TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-24.

1. Scintillation Probe--SP and SSP
   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.
   b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller Probe
   a. 16 to 1,000 c/s--tripling of radiation.
   b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LIQUID LEVEL

All LL data are evaluated for conformance to the limits stated in Table B-25. In the event that any of the limits are exceeded, TFS&O and EA&M (HS&E) management shall be notified immediately.

TABLE B-24. TX Farm Dry Well Monitoring Log. (Sheet 1 of 4)

TX - FARM DRY WELL MONITORING LOG 51-00-07

Monitoring Day Wed. & Thurs.
1st and 3rd week

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
51-00-03 (67)	10^4	150	S		
06 (69)	10^4	150	S		
07 (73)	10^4	150	S		
09 (74)	10^4	150	S		
10 (75)	10^4	150	S		
01-02 (166)	10^4	112	S		
04 (167)	10^4	115	S		
06 (168)	10^4	100	S		
08 (169)	10^4	100	S		
09 (155)	10^4	115	S		Weekly
02-02 (170)	10^4	100	S		Weekly
05 (143)	10^4	100	S		Weekly
07 (172)	10^4	100	S		Weekly
09 (142)	10^4	100	S		Weekly
12 (141)	10^4	100	S		Weekly
03-01 (192)	10^4	100	S		
02 (71)	10^4	150	S		Weekly
06 (127)	10^4	100	S		
09 (128)	10^4	100	S		
11 (191)	10^4	100	S		
12 (126)	10^5	100	S		
04-02 (153)	10^4	100	S		Quarterly
05 (130)	10^4	100	S		Quarterly
06 (154)	10^4	100	S		Quarterly
08 (131)	10^4	100	S		Quarterly
10 (156)	10^4	100	S		
12 (129)	10^4	100	S		Weekly
05-01 (173)	10^4	100	S		Weekly
03 (174)	10^4	115	S		Weekly
05 (145)	10^4	100	S		Weekly

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

TABLE B-24. TX Farm Dry Well Monitoring Log. (Sheet 2 of 4)

TX - FARM DRY WELL MONITORING LOG 51-00-08

Monitoring Day 1st and 3rd week: Wed. & Thurs.

Frequency unless otherwise stated in comments: Fortnightly,

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
51-05-07 (171)	10^4	111	S		Weekly
08 (146)	10^4	100	S		Weekly
10 (144)	10^4	100	S		Weekly
06-02 (148)	10^4	100	S		Weekly
04 (149)	10^4	100	S		Weekly
08 (175)	10^4	100	S		Weekly
10 (147)	10^4	100	S		Weekly
12 (158)	10^4	100	S		Weekly
07-01 (178)	10^4	110	S		
03 (187)	10^4	100	S		Weekly
04 (133)	10^4	100	S		Quarterly
07 (190)	10^4	100	S		
09 (134)	10^4	100	S		Weekly
11 (132)	10^4	100	S		Quarterly
18 (195)	10^4	100	SS		
08-05 (136)	10^4	100	S		Weekly
09 (137)	10^4	100	S		Weekly
11 (135)	10^4	100	S		Weekly
09-03 (139)	10^4	100	S		Weekly
04 (188)	10^4	100	S		Weekly
08 (140)	10^4	100	S		Weekly
10 (189)	10^4	100	S		Weekly
12 (138)	10^4	100	S		Weekly
10-01 (176)	10^4	100	S		Weekly
04 (103)	10^4	100	S		Weekly
08 (104)	10^4	100	S		Weekly
12 (105)	10^4	100	S		Weekly
13 (196)	10^4	100	S		Weekly
25 (197)	10^4	125	S		Weekly

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

TABLE B-24. TX Farm Dry Well Monitoring Log. (Sheet 3 of 4)

TX - FARM DRY WELL MONITORING LOG 51-00-09

Monitoring Day Wed. & Thurs. 1st and 3rd Week

Frequency Fortnightly, unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
51-11-01	(177)	10^4	110	S		Weekly
02	(72)	10^4	150	S		Weekly
03	(106)	10^4	100	S		Weekly
07	(107)	10^4	100	S		
10	(108)	10^4	100	S		
12-01	(159)	10^4	100	S		
04	(109)	10^4	100	S		
05	(179)	10^4	100	S		Weekly
07	(110)	10^4	100	S		
10	(180)	10^4	100	S		
11	(111)	10^4	100	S		
13-05	(112)	10^4	100	S		Weekly
08	(113)	10^4	100	S		Weekly
12	(114)	10^4	100	S		Weekly
14-04	(115)	10^5	100	SS		Weekly
08	(116)	10^4	100	S		Weekly
11	(117)	10^4	100	S		Weekly
15-04	(118)	10^4	100	S		Weekly
07	(119)	10^4	100	S		Weekly
09	(160)	10^4	100	S		Weekly
11	(120)	10^4	100	S		Weekly
16-04	(161)	10^4	100	S		Weekly
07	(163)	10^4	100	S		Weekly
11	(162)	10^4	100	S		Weekly
17-02	(121)	10^4	100	S		Weekly
03	(68)	10^4	150	S		Weekly
10	(122)	10^4	100	S		Weekly
11	(164)	10^4	100	S		Weekly
18-01	(181)	10^4	100	S		
03	(123)	10^4	78	S		

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

9 2 1 2 4 9 9 1 6 3 8

TABLE B-24. TX Farm Dry Well Monitoring Log. (Sheet 4 of 4)

TX - FARM DRY WELL MONITORING LOG 51-00-10

Monitoring Day Wed. & Thurs.
1st and 3rd week
Frequency Fortnightly.
unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
51-18-05 (182)	10^4	100	S		Weekly
07 (124)	10^4	100	S		
09 (183)	10^4	100	S		
10 (125)	10^4	100	S		
11 (165)	10^4	100	S		

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

92124991689

TABLE B-25. Limits for Liquid Level Readings, 241-TX Tank Farm.

Tank number	Monitoring liquid detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
241-TX-101	1.0[c]	2.00	--	51.00	D
241-TX-102	2.00[d]	3.00	--	135.00	D
241-TX-103	1.0[d]	2.00	--	86.00	S
241-TX-104	1.0[d]	2.00	--	36.00	D
241-TX-105	no criterion[c,e]	3.00	--	235.00	D
241-TX-106	2.00[d]	3.00	--	175.00	D
241-TX-107	1.00[d,e]	2.00	--	25.00	D
241-TX-108	no criterion[c]	2.00	--	62.00	D
241-TX-109	2.00[c,d]	3.00	--	176.00	D
241-TX-110	2.00[c,e]	2.00	--	195.00	D
241-TX-111	2.00[c]	3.00	--	165.00	D
241-TX-112	2.00[c]	3.00	--	252.00	D
241-TX-113	no criterion[c,e]	2.00	--	240.00	D
241-TX-114	no criterion[c,e]	2.00	--	215.00	D
241-TX-115	no criterion[c,e]	3.00	--	235.00	D
241-TX-116	no criterion[c,e]	2.00	--	225.00	D
241-TX-117	no criterion[c,e]	2.00	--	165.00	D
241-TX-118	1.00	3.00	--	145.00	S

[a]The listed limits denote the maximum permissible change from a baseline value established by TFSA (HS&E).

[b]S = once per shift; D = once per day.

[c]Salt well systems are, or have been, installed for the removal of interstitial liquid.

[d]Corrected for evaporation using psychrometric data when the exhauster is in operation. A psychrometric survey, including flow measurement, shall be routinely scheduled on a bimonthly frequency during periods that the exhauster is in operation.

[e]Removed from service; questionable integrity.

241-TY TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-26.

1. Scintillation Probe--SP and SSP
   a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.
   b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller Probe
   a. 16 to 1,000 c/s--tripling of radiation.
   b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LIQUID LEVEL

All LL data are evaluated for conformance to the limits stated in Table B-27. In the event that any of the limits are exceeded, TFS&O and EA&M (HS&E) management shall be notified immediately.

TABLE B-26. TY Farm Dry Well Monitoring Log.

TY- FARM DRY WELL MONITORING LOG — 52-00-07

Monitoring Day Wednesday
2nd and 4th week

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
52-01-01	(88)	10^4	100	S		
05	(89)	10^4	100	S		
09	(90)	10^4	100	S		
02-01	(91)	10^4	100	S		Quarterly
05	(92)	10^4	100	S		Quarterly
06	(171)	10^4	100	S		
09	(93)	10^4	100	S		Quarterly
11	(161)	10^4	100	S		Quarterly
03-03	(95)	10^5	100	1-GM	XXX	
03	(95)	10^4	100	2-GM	XXX	
06	(96)	10^4	100	S		Weekly
12	(94)	10^4	100	S		
04-02	(97)	10^4	100	S		
03	(83)	10^4	150	S		
06	(98)	10^4	100	S		
09	(99)	10^4	100	S		
10	(82)	10^4	150	S		
05-07	(186)	10^4	100	S		Weekly
06-02	(100)	10^4	66	S		
04	(185)	10^4	100	S		Weekly
05	(79)	10^4	150	S		Quarterly
06	(184)	10^4	100	S		Quarterly
07	(3)	10^4	245	S		Quarterly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

TABLE B-27. Limits for Liquid Level Readings, 241-TY Tank Farm.

Tank number	Monitoring liquid detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
241-TY-101[c,d]	no criterion	1.00	--	55.00	D
241-TY-102	no criterion	2.00	--	38.00	D
241-TY-103[d,e]	no criterion	1.00	--	74.00	D
241-TY-104[d,e]	no criterion	1.00	--	26.00	D
241-TY-105[d,e]	no criterion	1.00	--	100.00	D
241-TY-106[e]	no criterion	1.00	--	16.00	D

[a]The listed limits denote the maximum permissible change from a baseline value established by TFSA (HS&E).

[b]D = once per day.

[c]Questionable integrity.

[d]Salt well pumped.

[e]Confirmed leaker.

241-U TANK FARM ACTION CRITERIA

A. LEAK DETECTION DRY WELLS

The dry well numbers, the instrument range settings, well depths and probe types required are provided on the Dry Well Monitoring Logs, Table B-28.

1. Scintillation Probe--SP and SSP
    a. Less than 200 c/s--radiation level must triple and exceed 200 c/s.
    b. Greater than 200 c/s--radiation level must double.
2. Geiger-Müller Probe
    a. 16 to 1,000 c/s--tripling of radiation.
    b. Greater than 1,000 c/s--doubling of radiation.
3. Contaminated dry wells that are associated only with tanks classified as of questionable integrity or as confirmed leakers will be monitored for migration of activity, and dry well criteria limits will not apply.
4. For increasing peak and total count activity trends which have not violated the appropriate probe criteria, TFSA (HS&E) and TFEPC personnel will confer to determine if increased monitoring for the subject dry well(s) is necessary.

B. LIQUID LEVEL

All LL data are evaluated for conformance to the limits stated in Table B-29. In the event that any of the limits are exceeded, TFS&O and EA&M (HS&E) management shall be notified immediately.

92124991695

TABLE B-28. U Farm Dry Well Monitoring Log. (Sheet 1 of 3)

U - FARM DRY WELL MONITORING LOG — 60-00-08

Monitoring Day Thurs. 2nd and 4th week

Frequency Fortnightly. unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
60-00-02	(54-A)	10^4	153	S		
05	(53-A)	10^4	148	S		
06	(51)	10^4	123	S		
08	(55)	10^4	73	S		
10	(53)	10^4	150	S		
11	(52)	10^4	128	S		
01-08	(135)	10^4	121	S		Weekly
10	(136)	10^4	100	S		Weekly
02-01	(137)	10^4	124	S		Weekly
05	(138)	10^4	100	S		Weekly
07	(139)	10^4	120	S		Weekly
08	(140)	10^4	100	S		Weekly
10	(141)	10^4	125	S		Weekly
11	(142)	10^4	100	S		Weekly
03-01	(143)	10^4	100	S		
05	(144)	10^4	115	S		
08	(145)	10^4	125	S		
10	(146)	10^4	100	S		
11	(147)	10^4	125	S		
04-03	(76)	10^4	125	S		Quarterly
08	(124)	10^4	120	S		
10	(125)	10^4	120	S		
12	(126)	10^4	125	S		Quarterly
05-04	(176)	10^4	70	S		
05	(127)	10^4	125	S		
07	(128)	10^4	125	S		
08	(129)	10^4	125	S		
10	(130)	10^4	100	S		
06-07	(131)	10^4	125	S		
08	(132)	10^4	100	S		

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

TABLE B-28. U Farm Dry Well Monitoring Log. (Sheet 2 of 3)

U - FARM DRY WELL MONITORING LOG

60-00-09

Monitoring Day Thursday
2nd and 4th week

Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.		RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
60-06-10	(133)	10^4	124	S		
11	(134)	10^4	98	S		
07-01	(114)	10^4	100	S		
02	(74)	10^4	125	S		
10	(116)	10^4	100	S		
11	(117)	10^4	120	S		
08-04	(115)	10^4	124	S		
08	(118)	10^4	100	S		
09	(119)	10^4	124	S		
10	(54)	10^4	150	S		
09-01	(120)	10^4	100	S		
07	(121)	10^4	100	S		
08	(122)	10^4	120	S		
10	(123)	10^4	120	S		
10-01	(100)	10^4	125	S		
02	(75)	10^4	100	S		
05	(104)	10^4	125	S		
07	(148)	10^5	120	1-GM	XXX	
07	(148)	10^4	120	2-GM	XXX	
11	(107)	10^4	100	S		
11-03	(102)	10^4	125	S		
05	(109)	10^4	122	S		
06	(101)	10^4	125	S		
07	(110)	10^4	125	S		
12	(105)	10^4	125	S		
12-01	(113)	10^5	125	1-GM	XXX	
01	(113)	10^5	125	2-GM	XXX	
03	(103)	10^4	125	S		
05	(92)	10^4	100	S		Quarterly
07	(90)	10^4	100	S		Quarterly

7/30/80

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

TABLE B-28. U Farm Dry Well Monitoring Log. (Sheet 3 of 3)

U - FARM DRY WELL MONITORING LOG

60-00-10

Monitoring Day Thursday
2nd and 4th week
Frequency Fortnightly,
unless otherwise stated in comments

DRY WELL NO.	RANGE SETTING	WELL DEPTH	PROBE TYPE REQUIRED	DATE MONITORED	COMMENTS
60-12-10 (91)	10^4	100	S		Quarterly

Scintillation probe (S) (4)
Shielded Scintillation probe (SS) (5)
Geiger Muller Probe (GM) (Red 2)
Geiger Muller Probe (GM) (Green 1)

7/30/80

92124991697

TABLE B-29. Limits for Liquid Level Readings, 241-U Tank Farm.

Tank number	Monitoring liquid detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease[c,d]	Increase[d]	Minimum	Maximum	
241-U-101[e]	1.00	0.50	--	18.00	D
241-U-102	1.00	3.00[f]	--	139.00	D
241-U-103	0.50	3.00[f]	--	165.00	D
241-U-104[g]	no criterion	1.00	--	42.00	D
241-U-105	0.50	3.00[f]	--	148.00	D
241-U-106[h]	0.50	3.00[f]	--	80.00	D
241-U-107	0.50	3.00[f]	--	183.00	S
241-U-108	0.50	3.00[f]	--	168.00	D
241-U-109	0.50	3.00[f]	--	165.00	D
241-U-110[g]	no criterion	0.50	--	65.00	D
241-U-111	0.50	3.00[f]	--	183.00	S
241-U-112[i]	no criterion	0.50	--	15.00	D
241-U-201	1.00	2.00	--	30.00	D
241-U-202	1.00	2.00	--	29.00	D
241-U-203	1.00	2.00	--	22.00	D
241-U-204	1.00	2.00	--	20.00	D

[a]Values listed in the "Decrease" and "Increase" columns for LL criteria are maximum permissible changes from a baseline value established by TFSA (HS&E).

[b]S = once per shift; D = once per day.

[c]Corrected for evaporation using psychrometric data when the exhauster is in operation. A psychrometric survey, including flow measurement, shall be routinely scheduled on a monthly frequency during periods that the exhauster is in operation.

[d]Corrected for cooling or heating trends based on a volume change of 1% per 20°C increase or decrease.

[e]241-U-101 is a declared leaker, but has a liquid heel which necessitates maintaining a decrease criteria. Readings have been erratic and, with a manual tape readout, a 1.0 in. criteria was established instead of the normal 0.5 in.

[f]Contents of tanks in active or completed evaporator bottoms service experience a growth mechanism upon entering an inactive status. An engineering review will be undertaken for such tanks within 3 mo following the last receipt of slurry, or when the LL increase has reached 3 in. The results of this review will allow revising the LL baseline value without the issuance of an Occurrence Report. The baseline change will be authorized by the TFSA (HS&E) and TFEPC managers.

[g]Confirmed leakers with no decrease criteria since they contain no surface liquid.

[h]Questionable integrity.

[i]Confirmed leaker (January 1980).

A number of tanks have a "no criteria" designation for LL decrease, or in the case of 241-S-242 evaporator bottoms tanks, the criteria statement applies to static periods only. The following discussion is designed to clarify these designations.

a. Tanks in active bottoms service or continuing surface crusting display significant LL variations from shift to shift. Liquid inventories in the active bottoms system are monitored by calculating overall material balances on a daily basis, in addition to routine transfer material balances. For 241-S-242 bottoms tanks, daily overall material balance discrepancies indicating a loss of >3.3 in. (9,000 gal) or a 10-d moving average discrepancy of >±2,000 gal, must be reported to the TFEPC, TFS&O, and TFSA managers. Additional reporting and action requirements are stated in the material balance operating Procedure TO-700-090. Following a transfer or shutdown, a 24-hr period will be allowed for the LL in an active bottoms tank to stabilize, with the requirement that any decrease in excess of 2 in. must be reported immediately to the TFEPC, TFS&O, and TFSA managers. After this period, a further decrease in excess of the limits stated in Table B-29 shall require the initiation of special investigation. If the readings are confirmed during the next 24 hr and cannot be explained by evaporation or other effect, the change shall be reported to the TFEPC and TFS&O managers for a decision on further reporting and action.

b. Tanks that contain sludge with very little solution will show decreases in liquid surface level measurements, particularly if a salt well system is in operation. Such losses are due to sludge slumping, tape flushes, and perforation of the exposed sludge at the point of probe contact. Therefore, liquid surface criteria is generally not a means for leak detection, and there are no criteria listed for these tanks. Such tanks shall require special evaluation by TFSA and TFEPC prior to any definition of status based upon liquid surface level data.

200 WEST AREA DIVERSION BOX CATCH TANKS AND 241-S-141 AND 241-S-142 ACTION CRITERIA

LIQUID LEVEL LIMITS

Table B-30 lists diversion box catch tanks within the 200 West Area. Also included are the two REDOX Hexone Organic Waste Storage Tanks. Catch tanks receiving drainage from their associated diversion boxes have two limits stated. The first, at 45 vol% capacity, is the point at which TFS&O must commence the preparation of arrangements for transfer of the contained solution. The second, 50 vol capacity, is the maximum stated limit if transfer through the associated diversion box is to be permitted.

TABLE B-30. Volume Limits for Diversion Box Catch Tanks, 200 West Area.

Diversion box	Catch tank	Tank size	Capacity	Limit at 45 vol%		Limit at 50 vol%	
				LL	Volume	LL	Volume
240-S-151	240-S-302	9 ft x 36 in.	17,684	4 ft 2 in.	8,000	4 ft 6 in.	8,840
241-S-151	240-S-302 A	9 ft x 36 in.	17,684	4 ft 2 in.	8,000	4 ft 6 in.	8,840
S-ENC	241-S-302 B	9 ft x 33 in.	14,306	4 ft 1 in.	5,140	4 ft 6 in.	7,159
SX-151	241-SX-304	9 ft x 31 ft 9 in.	17,618	4 ft 1 in.	7,560	4 ft 6 in.	8,815
T-151	241-T-301 B	20 ft x 15 ft 6 in.	36,400	6 ft 11 in.	16,300	7 ft 9 in.	18,200
TX-153	241-TX-302 A[a]	9 ft x 36 ft				32.5 in.	
TX-153	241-TX-302 X(B)	9 ft x 33 ft	14,306	4 ft 1 in.	6,140	4 ft 6 in.	7,159
TX-154	241-TX-302 C	9 ft x 36 ft	17,684	4 ft 2 in.	8,000	4 ft 6 in.	8,840
TX-155	241-TX-302 B	9 ft x 36 ft	17,684	4 ft 2 in.	8,000	4 ft 6 in.	8,840
TY-153	241-TY-302 A	9 ft x 36 in.	17,684	4 ft 2 in.	8,000	4 ft 6 in.	8,840
U-151	241-U-301 B	20 ft x 15 ft x 6 in.	36,400	6 ft 4 in.	16,300	7 ft 9 in.	18,200
UX-154	241-UX-302 R	9 ft x 36 ft	17,684	4 ft 2 in.	8,000	4 ft 6 in.	8,840
TY-ENC	241-TY-302 B	9 ft x 33 ft	14,306	4 ft 1 in.	6,140	4 ft 6 in.	7,159

Hexone storage tanks	Size	Capacity	Weight factor limit diversion	Maximum volume
241-S-141	11 ft 6 in. x 26 ft	21,500	0.510	18,000
241-S-142[b]	11 ft 6 in. x 26 ft	21,500	0.310	16,000

[a]Tank is classed as being active restricted, and transfers through the associated diversion box are permitted if the catch tank LL is equal to or less than the stated value. This value applies to the reading obtained from the manual tape (new) installed in the 4-in. riser that is nearest the 12-in. pumpout riser.

[b]The low (see Occurrence Report #78-129, 11/78) elevation manometer dip tube is referenced to a point 18 in. above the bottom of the tank.

For the REDOX Hexone Organic Waste Storage Tanks, 241-S-141 and 241-S-142, only the current weight factor reading is stated as a limit.

LIQUID LEVEL

The limits stated in Table B-31 denote the maximum permissible decrease from baseline values established by TFSA. In the event that a limit is exceeded, the EA&M (HS&E) and TFS&O managers must be notified immediately.

TABLE B-31. Maximum Permissible Decrease from Baseline Values.

Diversion box	Catch tank	LL decrease limit (in.)	Monitoring frequency*
240-S-151	240-S-302	2.00	D
241-S-151	240-S-302 A	2.00	D
S-ENC	241-S-302 B	2.00	D
SX-151	241-SX-302	1.50	D
T-151	241-T-301 B	1.50	D
TX-153	241-TX-302 A	2.00	D
TX-153	241-TX-302 X(B)	2.00	D
TX-154	241-TX-302 C	2.00	D
TX-155	241-TX-302 B	2.00	D
TY-153	241-TY-302 A	2.00	D
U-151	241-U-301 B	1.50	D
UX-154	241-UX-302 A	2.00	D
TY-ENC	241-TY-302 B	2.00	D

Hexone storage tanks	Weight factor decrease (in Hg)	Monitoring frequency*
241-S-141	0.03	D
241-S-142	0.03	D

*D = once per day.

200 WEST AREA SPECIAL SURVEILLANCE TANKS

Table B-32 contains a listing of special surveillance tanks and process cell sumps within the 200 West Area. All of these sites have been removed from active service and are awaiting final removal of residual liquid. All liquid level data are evaluated for conformance to the limits stated. In the event that a limit is exceeded, TFS&O and EA&M (HS&E) managers are to be notified immediately.

TABLE B-32. Monitoring and Operational Limits for Special Surveillance and Process Cell Sumps, 200 West Area.

Location	Monitoring LL detection criteria (in.)[a]		Operational LL limits (in.)		Monitoring frequency[b]
	Decrease	Increase	Minimum	Maximum	
011-UR sump	2.00	2.00	--	32.00	D
001-UR tank[c]	1.00	2.00	--	15.00	D
002-UR sump[c]	2.00	2.00	--	55.00	D
002-UR tank	1.00	2.00	--	8.00	D
003-UR sump[c]	2.00	2.00	--	35.00	D
003-UR tank[c]	1.00	2.00	--	15.00	D
001-TXR sump	2.00	2.00	--	25.00	D
001-TXR tank	1.00	2.00	--	30.00	D
002-TXR sump	2.00	2.00	--	24.00	D
002-TXR tank	1.00	2.00	--	35.00	D
003-TXR sump	2.00	2.00	--	20.00	D
003-TXR tank	1.00	2.00	--	71.00	D
241-T-361	1.00	2.00	--	153.00	D
241-U-361	1.00	2.00	--	177.00	D

[a]The listed criteria denote the maximum permissible change from a baseline value established by TFSA (HS&E).

[b]D = once per day.

[c]Maximum operating limits modified to accommodate replacement of zip cords with reel mounted LL tapes. Investigation indicates zip cords may have contributed lower readings due to poor installation or placement of these temporary devices.

9 2 1 2 4 9 9 1 7 0 2

APPENDIX C

INSTALLATION OF SALT WELL JET PUMPS ON SINGLE-SHELL TANKS

J. W. Bailey

INTRODUCTION

Tank Farm Evaporator Process Control developed criteria to identify waste storage tanks where the portable jet pump (PJP) could be employed should leaks develop. A list of the tanks identified to potentially receive a PJP is provided in Table C-1.

TABLE C-1. Single-Shell Tanks in Which Portable Jet Pump May be Installed.

Tank	Tank	Tank	Tank	Tank
241-A-101	241-BX-112	241-C-107	241-SX-104	241-TX-111
241-A-103	241-BY-101	241-C-110	241-SX-105	241-TX-112
241-AX-101	241-BY-102	241-S-101	241-SX-106	241-TX-113
241-AX-102	241-BY-103	241-S-102	241-SX-109	241-TX-114
241-B-103	241-BY-104	241-S-103	241-T-101	241-TX-115
241-B-104	241-BY-105	241-S-104	241-T-104	241-TX-116
241-B-105	241-BY-106	241-S-105	241-T-105	241-TX-117
241-B-106	241-BY-107	241-S-106	241-T-107	241-TX-118
241-B-107	241-BY-108	241-S-107	241-T-110	241-TY-105
241-B-108	241-BY-109	241-S-108	241-T-111	241-U-102
241-B-109	241-BY-110	241-S-109	241-TX-102	241-U-103
241-B-110	241-BY-111	241-S-110	241-TX-103	241-U-105
241-B-111	241-BY-112	241-S-111	241-TX-105	241-U-106
241-BX-104	241-C-102	241-S-112	241-TX-106	241-U-107
241-BX-107	241-C-103	241-SX-101	241-TX-108	241-U-108
241-BX-109	241-C-104	241-SX-102	241-TX-109	241-U-109
241-BX-110	241-C-105	241-SX-103	241-TX-110	241-U-111
241-BX-111	241-C-106			

This work was done in response to action items assigned during the 6/4/80 "Cartwright Recommendation Response" Committee Meeting.

BACKGROUND

The need for a pumping system capable of removing leaking interstitial liquid from a waste storage tank was identified early in Fiscal Year 1979 by Surveillance and Maintenance. A modification of the proven jet pump salt well system, the PJP, was selected to provide this capability due to economic and availability considerations. No available/developed pumping system other than the jet pump salt well system is capable of providing this type of service.

The PJP was to be capable of being assembled to fit in any tank, installed and operational within 10 days of the decision to install it.

As it exists today, the PJP system includes a partially assembled jet pump unit (borrowed from the 241-TX Farm salt well system, Project B-136b), and a salt well screen. Final assembly of these components will be made on an "Emergency" basis when the leaking tank is identified. The length of these components is determined by the tank and pit in which they are to be installed. Also included is a jet pump discharge jumper assembly.

These components are stored in a locked storage area and are tagged "for emergency portable jet pump use only." In the event a tank containing a significant volume of drainable/leakable interstitial liquid is identified as a confirmed leaker, and the PJP corrective action option is selected, the jet pump and screen will be immediately transported to the shops for final assembly. The completed unit will then be transported to the leaking tank and installed. During this same period, Tank Farm Maintenance personnel will assemble and/or fabricate (on an emergency basis) the necessary auxiliary services and equipment. These auxiliary services would include a motor control center with safety interlocks, an electrical supply, an air supply and a water supply.

As initially installed, the PJP will be capable of only manual (set flow rate) operation. If it is determined that the volume of liquid to be pumped and the timing of the project jet pump system warrant upgrading the PJP to the automatic flow control mode, the necessary instrumentation would be provided. An instrument enclosure providing the necessary instrumentation and controls could be borrowed from a jet pump project or assembled from spare parts for this purpose. Implementation of the automatic control system would require significant engineering, design and fabrication time.

DISCUSSION

The final decision of whether or not to install the PJP will be made at the time of the leak confirmation by Tank Farm Surveillance and Operations (TSF&O) and Tank Farm Evaporator and Process Control (TFEPC) management and will include considerations of the following factors:

- Tank leak rate and volume of pumpable liquid
- Availability of a project jet pump system - Installation of a project jet pump designed for the tank would be more cost-effective if it can be achieved in a reasonably short time.
- Proximity of tank to other leaking tanks or other sources of contamination
- Alternate leak reduction techniques
- Environmental impact of the leak.

Because of changes in the estimated porosity, capillarity and permeability of solids, six tanks presently identified as requiring project jet pumps are not included in Table C-1. These tanks (112-C, 109-T, 101-TX, 101-TY, 103-TY and 110-U) are now estimated to contain less than 10,000 gal of pumpable liquid. Some tanks containing less than 10,000 gal are retained in Table C-1 because there is a significant uncertainity in the accuracy of P-10 pumping volume estimates which, if excluded from the interstitial liquid remaining calculation, would leave about 10,000 gal or more of pumpable liquid.

Tanks which already contain a project or prototype jet pump and, therefore, would not receive a PJP, are retained in the table for comparison.

REEVALUATION OF CRITERIA FOR INSTALLING JET PUMPS

A previous evaluation performed by Tank Farm Process Engineering (TFPE), in which tanks containing between 2 and 4 ft of sludge received an engineering evaluation, had reduced the number of tanks to receive jet pumps to 98. The second evaluation further reduced this number to 90 with the removal of 8 tanks from the list; 102-A, 210-B, 202-B, 203-B, 204-B, 105-C, 106-C and 104-U. The second evaluation to reduce the number of tanks receiving salt wells included a review of 31 tanks in which the estimated jet pumpable liquid volume was less than 30,000 gal.

Because no clear cut eliminate/retain criteria could be developed during the evaluation, engineering judgment was applied to determine which tanks would be deleted as not technically and economically practi- able. The factors considered in making the judgment decisions are listed below and are tabulated for the 31 tanks in question in Table C-2:

- Estimated pumpable liquid
- Heat load (as measured by thermocouples or estimated from available sludge samples)
- P-10 pump production
- Photographic evaluation of the tank contents
- Existing piping routes and pump pits
- Total construction cost savings to be realized by the elimina- tion of the tank
- The area relationship of the tank to other tanks in the tank farm.

Several tanks which contain marginal pumpable liquid volumes were retained in the salt well projects because eliminating them would not produce an appreciable cost saving.

TABLE C-2. Factors Used to Reevaluate Tanks to Receive Salt Well Jet Pump Systems. (Sheet 1 of 4)

Tank/ status[a]	Interstitial liquor[b]				Super natant liquid[c]	Total pump- able liquid[d]	Pump in tank?	New pit re- quired?	New process piping required?	Max. temp. in tank (°F)	Additional cooling required?	Solids level data evaluation	Photographic evaluation and data	Remarks and plans
	P-10 pumped to date	Min. pump- able	Max. pump- able	Best guess pump- able										
241-A-102/ A-NCPLX	0	0	0	0	132.0	132.0	Prod pump	No	Yes/≈20 ft	96	No	Multiple solids levels taken.	No applicable photos available.	Delete--previously projected salt cake additions will not be required.
241-AX-102/ A-CC	0	See remarks			88.0	See remarks	P-10	No	No/elimination could affect B-180	149	No	Multiple solids levels taken.	No applicable photos available.	An undetermined volume of salt will be added to this tank before 1-1-81. A SW should be retained for this reason.
241-B-103/ I-NCPLX	0	0	13.2	6.6	24.0	30.6	No	No	Yes/≈120 ft	71	No	Solids level taken at tank edge.	100% liquid with some light floating solids 8-1-77.	Retain SW to remove supernatant liquid.[e]
241-B-106/ I-NCPLX	0	0	23.9	10.4	14.0	24.4	No	Yes/ tank has side pit	Yes/≈70 ft	82	No	Solids volume determined from photos and 2 solids level measurements.	85% liquid with scattered islands of solids 9-8-77.	Retain SW to remove supernate and pumpable interstitial liquid.
241-B-107/ I-INACT	17.0	0	44.6	2.3 to 19.3	0	2.3 to 19.3	No	No	Yes/≈50 ft	82	Possibly	Solids volume determined from photos and sludge level.	33% liquid, 2-in. deep pool, mounds of dried salt cake 7-18-74.	Retain SW to remove pumpable interstitial liquid.[e]
241-B-108/ I-NCPLX	0	0	14.9	7.4	33.0	40.4	No	Yes/ tank has side pit	Yes/≈50 ft	83	No	Solids volume determined from photos and 3 sludge levels.	75% liquid with solids around wall 9-7-77.	Same as 241-C-103.
241-B-109/ I-NCPLX	0	8.3	44.6	22.3	14.0	36.3	No	Yes/ tank has side pit	Yes/≈50 ft	83	No	Solids volume determined from FIC and sludge level data.	75% liquid, FIC on solids, manual tape near equipment 4-18-78.	Retain SW to remove supernate and due to volume of liquid potentially pumpable.
241-B-110/ I-PS	35.0	0	71.0	0 to 30.7	0	0 to 30.7	No	No	Yes/≈50 ft	91	No	Solids volume determined from 3 solids levels all at edge.	100% dry cracked solids, hazy photo 7-25-74.	Retain SW due to large volume of liquid potentially pumpable.[e]
241-B-111/ I-NCPLX	0	0	60.2	26.1	3.0	29.0	No	Yes	Yes/≈50 ft	96	No	Solids volume determined from 2 solids levels both at tank edge.	Never photographed.	Retain SW to remove supernate and pumpable interstitial liquid.[e]

TABLE C-2. Factors Used to Reevaluate Tanks to Receive Salt Well Jet Pump Systems. (Sheet 2 of 4)

Tank/status[a]	Interstitial liquor[b] P-10 pumped to date	Min. pumpable	Max. pumpable	Best guess pumpable	Supernatant liquid[c]	Total pumpable liquid[d]	Pump in tank?	New pit required?	New process piping required?	Max. temp. in tank (°F)	Additional cooling required?	Solids level data evaluation	Photographic evaluation and data	Remarks and plans
241-B-201/ I-PS	4.0	0	8.4	0 to 3.6	0	0 to 3.6	No	No	Yes/≈510 ft if all B200 series tanks dropped	68	No	Solids volume determined from solids level at tank edge.	60% liquid surf. 9-7-77.	Delete SW due to small volume of estimated pumpable liquid and due to construction cost savings.
241-B-202/ I-INACT	0	0	7.8	3.4	0	3.4	No	Yes	Yes/same as 241-B-201	69	No	Suspect high solids volume Estimate ≈1 to 3K Gal.	60% solids 9-6-77.	Same as 241-B-201.
241-B-203/ I-NCPLX	0	0	13.9	6.0	3.0	9.0	No	Yes	Yes/same as 241-B-201	69	No	--	60% liquid 7-11-77.	Same as 241-B-201. Air dry supernate.
241-B-204/ I-NCPLX	0	0	13.5	5.8	3.0	8.8	No	Yes	Yes/same as 241-B-201	74	No	Suspect high solids volume estimate.	95% liquid surf. shallow pool 7-11-77.	Same as 241-B-201. Air dry supernate.
241-BX-104/ A-W-RCR	0	0	26.4	11.4	137.0	148.4	Prod pump	No	Yes/≈50 ft	84	No	--	No applicable photo available.	Retain SW to remove supernate and pumpable interstitial liquid.[e]
241-BX-109/ I-INACT	0	0	48.7	21.1	0	21.1	P-10	No	Yes/≈50 ft	83	No	Solids volume determined from multiple solids levels.	75% liquid surf. 2-in. to 3-in. deep pool 11-4-75.	Retain SW to remove pumpable interstitial liquid.[e]
241-BX-112/ I-INACT	0	0	39.6	17.2	0	17.2	P-10	No	Yes/≈50 ft	75	No	Suspect slightly high solids volume estimate.	30° liquid surf. shallow pool 6-6-77.	Same as 241-BX-109.
241-C-103/ A-SWRCR	0	0	38.8	16.8	113.0	129.8	Prod pump	No	Yes/≈50 ft	156	Unknown	Solids volume determined from 2 solids levels at opposite sides of tank.	No photo available.	Retain SW to remove pumpable liquid and to allow draining SW systems lines to this tank.
241-C-105/ A-PSS	0	0	36.3	15.7	60.0	75.7	Prod pump	No	No	103	Yes	Solids volume determined from solids level taken at tank edge.	No photo available.	Delete SW pump supernate with product pump. Allow tank to self dry.
241-C-106/ A-W-RCR	0	0	33.0	14.3	288.0	302.3	Prod pump	No	No	139	Yes	Same as 241-C-105.	No photo available.	Same as 241-C-105.

TABLE C-2. Factors Used to Reevaluate Tanks to Receive Salt Well Jet Pump Systems. (Sheet 3 of 4)

Tank/ status[a]	Interstitial liquor[b]				Super natant liquid[c]	Total pump-able liquid[d]	Pump in tank?	New pit re-quired?	New process piping required?	Max. temp. in tank (°F)	Additional cooling required?	Solids level data evaluation	Photographic evaluation and data	Remarks and plans
	P-10 pumped to date	Min. pump-able	Max. pump-able	Best guess pump-able										
241-C-110/ I-INACT	6.0	0	49.5	15.5 to 21.5	0	15.5 to 21.5	P-10	No	No	89	No	Solids volume determined from solids level at opposite sides of tank.	90% solids surf. 10% shallow liquid pool 7-19-77.	Retain SW to remove pumpable liquid.[e]
241-C-112/ I-INACT	1.0	0	19.0	7.2 to 8.2	0	7.2 to 8.2	P-10	No	No	112	No	Solids volume determined from 2 solids levels at opposite tank edge.	Never photographed.	Same as 241-C-110.
241-T-101/ A-SWRCR	0	0	17.3	7.5	129.0	136.5	Prod pump	No	No	87	No	--	100% liquid surf. 8-17-73.	Same as 241-C-110.
241-T-105/ I-INACT	0	0	20.6	8.9	0	8.9	P-10	No	No	85	No	Suspect high solids volume estimate.	Never photographed.	Same as 241-C-110.
241-T-107/ I-NCPLX	0	0	31.4	13.6	27.0	40.6	P-10	No	No	84	No	Solids volume estimated. Used mult. solids level and photo evaluation.	50% liquid surf. 4-6-77.	Same as 241-C-110.
241-T-109/ I-PS	4.0	0	30.5	9.2 to 13.2	0	9.2 to 13.2	P-10	No	No	80	No	Solids volume estimate should be accurate.	99% solids surf. 2-in. diam. pool 8-19-77.	Retain SW to remove pumpable liquid.[e]
241-TX-103/ A-SWRCR	0	0	29.7	12.9	442.0	454.9	Prod pump	No	--	103	No	Solids volume determined from 3 solids levels readings.	No applicable photo available.	Retain SW construction virtually complete.[e]
241-TX-108/ I-PS	0	5.5	21.5	10.7	0	10.7	No	No	--	90	No	Suspect low solids volume estimate.	100% solids surf. walls encrusted with salt 4-4-77.	Same as 241-TX-103.
241-TY-101/ I-PS	6.0	0	37.1	10.1 to 16.1	0	10.1 to 16.1	P-10	No	No	76	No	Suspect high solids volume estimate.	100% solids surf. dry and cracked 6-9-75.	Same as 241-T-109.
241-TY-103/ L-PS	6.0	0	52.0	16.5 to 22.5	0	16.5 to 22.5	P-10	No	No	86	No	Suspect high solids volume estimate.	100% solids surf. 7-15-77.	Same as 241-T-109.

TABLE C-2. Factors Used to Reevaluate Tanks to Receive Salt Well Jet Pump Systems. (Sheet 4 of 4)

Tank/ status[a]	Interstitial liquor[b]				Super natant liquid[c]	Total pump- able liquid[d]	Pump in tank?	New pit re- quired?	New process piping required?	Max. temp. in tank (°F)	Additional cooling required?	Solids level data evaluation	Photographic evaluation and data	Remarks and plans
	P-10 pumped to date	Min. pump- able	Max. pump- able	Best guess pump- able										
241-U-104/[f] L-PS-LI	0	0	18.2	7.6	0.5	8.1	No	No	Yes/≈50 ft	73	No	Corrected solids volume used.	5 to 10% surf. liquid pool, 10% wet solids, 80% dry cracked solids 8-31-78.	Delete SW due to relatively low, pumpable liquid, construction savings and 60-ton diam. earth add.
241-U-110/ L-PS	0	0	34.7	15.0	0	15.0	P-10	No	No	97	No	Corrected solids volume used.	100% wet solution surf. with large mound of dry solids 9-12-75.	Same as 241-T-109.

[a]See Table C-3 for an explanation of status codes and Table C-4 for definition of terms.

[b]Interstitial Liquid Estimates

(1) P-10 pumped to date is based on an engineering evaluation of P-10 production data.

(2) Minimum pumpable is calculated assuming there is 0% drainable liquid in sludge, 20% in salt cake, and a 3-ft nonpumpable zone at the bottom of the tank.

(3) Maximum pumpable is calculated assuming there is a 30% drainable liquid in sludge, 60% in salt cake, and a 2-ft nonpumpable zone at the bottom of the tank.

(4) Best guess pumpable is calculated assuming there is 12.5% drainable liquid in sludge and 30% in salt cake. Where multiple figures are presented, the latter is calculated as above; the former is this number minus the estimated P-10 pumped to date.

[c]Supernatant liquid volumes are for September 1978.

[d]Total pumpable liquid is the sum of b(4) and c figures.

[e]Little cost savings can be realized by the elimination of this salt well.

[f]The volume equivalent of the 60 tons of diatomaceous earth was subtracted from the 241-U-104 sludge volume because the diatomaceous earth is assumed to contain no drainable liquid.

NOTE: SW = salt well
FIC = Food Industries Corporation gauge.
Tanks selected for elimination from salt well projects are underlined in Column 1.

TABLE C-3. Tank Status/Condition and Abbreviations Used by Tank Farm Process Engineering. (Sheet 1 of 2)

Abbreviated status	Complete status
A-DSS	Active - Double-shell slurry
A-SRCVR	Active - Slurry receiver tank
A-CPLX	Active - Contains complexed evaporator feed
A-NCPLX	Active - Contains noncomplexed evaporator feed
A-SP AG	Active - Spare aging waste storage space
A-AGING	Active - Contains aging waste
A-PNF	Active - Contains partial neutralization feed
A-DSSF	Active - Contains double-shell slurry feed
A-CC	Active - Contains complexant waste concentrate
A-PSS	Active - Contains PUREX sludge supernate
A-W-RCR	Active - Waste receiver
A-SLUIC	Active - Sluicing or sluicing evaluation
A-SWRCR	Active - Salt well receiver tank
A-DOSSF	Active - Dilute double-shell slurry feed
A-LNWVDW	Active - Active PNL defense waste vitrification demo waste
L-LEAKR	Leaker
L-PS	Leaker - Primary stabilized
L-PS-PI	Leaker - Primary stabilized and partially isolated
L-IS-PI	Leaker - Interim stabilized and partially isolated
L-IS-II	Leaker - Interim stabilized and interim isolated
L-IS	Leaker - Interim stabilized
L-PI	Leaker - Partially isolated
I-INACT	Inactive
I-CPLX	Inactive - Contains complexed evaporator feed
I-NCPLX	Inactive - Contains noncomplexed evaporator feed
I-PNF	Inactive - Contains partial neutralization feed
I-DSSF	Inactive - Contains double-shell slurry feed
I-PS	Inactive - Primary stabilized
I-PS-PI	Inactive - Primary stabilized and partially isolated
I-IS-PI	Inactive - Interim stabilized and partially isolated
I-IS-II	Inactive - Interim stabilized and interim isolated

TABLE C-3. Tank Status/Condition and Abbreviations Used by Tank Farm Process Engineering. (Sheet 2 of 2)

Abbreviated status	Complete status
I-IS	Inactive - Interim stabilized
I-PI	Inactive - Partially isolated
I-CC	Inactive - Contains complexant waste concentrate
R-PNF	Active Restricted - Contains partial neutralization feed
U-CNSTR	Under Construction (includes ATP OTP testing period)
QI	Questionable Integrity/Inactive
QI-CPLX	Questionable Intergrity/Inactive - Complexed evaporator feed
QI-NCPLX	Questionable Integrity/Inactive - Noncomplexed evaporator feed
QI-PNF	Questionable Integrity/Inactive - Partial neutralization feed
QI-DSSF	Questionable Integrity/Inactive - Double-shell slurry feed
QI-PS	Questionable Integrity/Inactive - Primary stabilized
QI-PS-PI	Questionable Integrity/Inactive - Primary stabilized and part isolated
QI-IS-PI	Questionable Integrity/Inactive - Interim stabilized and part isolated
QI-IS-II	Questionable Integrity/Inactive - Interim stabilized and interim isolated
QI-IS	Questionable Integrity/Inactive - Interim stabilized
QI-PI	Questionable Integrity/Inactive - Partially isolated
QI-CC	Questionable Integrity/Inactive - Complexant waste concentrate
A-Cw	Active - Customer waste
A-CCw	Active - Concentrated customer waste
I-Cw	Inactive - Customer waste
I-CCw	Inactive - Concentrated customer waste
QI-Cw	Questionable Integrity/Inactive - Customer waste
QI-CCw	Questionable Integrity/Inactive - Concentrated customer waste
QI-PS-II	Questionable Integrity/Inactive - Primary stabilized and interim isolated

TABLE C-4. Definition of Terms Used by Tank Farm Process Engineering. (Sheet 1 of 4)

Term	Definition
Active tank	A tank being used or planned for use for the storage of liquid in excess of a supernatant liquid heel in connection with production and/or waste processing.
Active, restricted	A tank that is awaiting pumping of supernatant liquid but is not scheduled to be reused in processing or for liquid storage. Includes tanks previously classified "removed from service, administrative control," "removed from service, operating convenience," "removed from service, questionable integrity," "removed from service, salt filled."
Aging waste	The high heat waste which is stored for the decay of short-lived fission products, after which time the material may be processed as evaporator feed.
Available evaporator feed	Evaporator feed in or available for transfer in an evaporator feed tank. Interstitial liquid not available for transfer is not included.
Available space	Tank space not now filled which is available and accessible for use.
Drainable interstitial liquid	Interstitial liquid that is not held in place by capillary forces, and will, therefore, migrate or move by gravity.
Inactive tank	A tank which has been removed from liquid processing service, pumped to minimum supernatant liquid heel, and is awaiting or is in the process of being stabilized and interim isolated, includes all tanks not in active or active restricted categories.
Isolation	Segregating a tank (or series of tanks) from active tanks or active tank farm processes to minimize the potential for any unplanned liquid addition. The objective of interim is to provide at least one positive physical barrier to any credible source of liquid addition, precluding any other intrusions except necessary air ventilation.

TABLE C-4. Definition of Terms Used by Tank Farm Process Engineering. (Sheet 2 of 4)

Term	Definition
Interim stabilized	The condition of an inactive waste storage tank after all liquid technically and economically practical has been removed by a salt well system using a jet pump. Tanks not requiring salt wells and jet pumps will be interim stabilized by other methods that are to be defined through technology development for each specific tank. Tank evaluations will be performed during the interim stabilization effort to determine when a tank will be considered "interim stabilized."
Pumpable interstitial liquid	The portion of interstitial liquid that can be removed from salt cake via a screened well point.
Interstitial liquor	The liquid which fills the voids in a solid. In the waste tanks this liquid may be evaporator feed or Hanford defense residual liquor.
Interstitial liquid heel	The amount of drainable interstitial liquid remaining in the solids after salt well pumping is complete.
Minimum heel	Supernatant liquid remaining in a tank after pumping as completely as practical using current equipment, excluding salt well pumping systems.
Report date	Data is current up to and including this date. No data taken after this report date will be entered for this report date.
HDRL	Hanford defense residual liquor (formerly terminal liquor). The liquid product from the concentration of Hanford defense waste by a solid crystallization process which forms a solid unacceptable for storage in single-shell tanks. Upon additional standard evaporation there are three forms of HDRL: 1. Partial neutralization feed: all noncomplexed HDRL in 200 West Area which has not been partially neutralized to maximum specified aluminum concentration. (See double-shell slurry feed definition).

TABLE C-4. Definition of Terms Used by Tank Farm Process Engineering. (Sheet 3 of 4)

Term	Definition
	2. Double-shell slurry feed: all noncomplexed HDRL produced in 200 East Area and all 200 West Area HDRL which has been partially neutralized to the maximum specified aluminum concentration. After 242-S Evaporator-Crystallizer shutdown all 200 West Area partial neutralization feed will be considered double-shell slurry feed. 3. Complexant concentrate: the product of concentrating complexed evaporator feed.
Sludge	Solids formed by precipitation or self concentration which may settle and accumulate in the bottom of a tank or sump.
Supernatant liquid (Sup. Liq.)	The liquid lying above solids in a vessel.
Total waste	The sum of liquid and solid wastes in tank.
Volume calculations	Tank volumes are calculated as follows: 1. For all tanks (exceptions noted below): Volume (gal) = (inches) x (2,750) 2. For B, BX, C, T, and D Farms (except 200 series tanks): Volume (gal) = (inches) x (2,750) + 12,500 3. For BY, S, TX, and TY Farms: Volume (gal) = (inches - 12) x (2,750) + 12,500 4. For SX Farm: Volume (gal) = (inches - 12) x (2,750) + 18,500 5. For all 200 series tanks: Volume (gal) = (inches - 6) x (196) + 590
The following definitions are according to TFEPC 9/23/80	
CW	Customer waste: waste received from 100N or FFTF having phosphate/sulfate concentrations which, after concentration, exhibit complexed liquid characteristics.
CCW	Concentrated customer waste: the product of concentrating customer waste.

TABLE C-4. Definition of Terms Used by Tank Farm Process Engineering. (Sheet 4 of 4)

Term	Definition
CPLX	Complexed evaporator feed: dilute waste material containing relatively high concentration of chelating agents such as ethylenediaminetriacetetate (EDTA).
NCPLX	Noncomplexed evaporator feed: a general waste term applied to all dilute Hanford liquors not identified as CPLX, Cw, or aging waste.
DSSF	Double-shell slurry feed: *a general waste term applied to HDRL coming primarily from three sources: 1. Noncomplexed HDRL from East Area. 2. Noncomplexed HDRL from West Area that has been partially neutralized in 242-S Evaporator-crystallizer. 3. After 242-S shutdown, all noncomplexed HDRL wastes from West Area.

*When diluted for a cross-site, there is no change in classification.

APPENDIX D

HIGH-LEVEL WASTE TANK LEAK RATES

R. E. Isaacson and C. M. Walker

Available data for high-level waste tank leaks are given in Table D-1. Liquid level histories are plotted in Figures D-1 through D-10. (Note that only data that were readily available were reviewed in this study.)

Count rates for radioactivity monitoring dry wells associated with tank leak investigations are plotted in Figures D-11 through D-28. A typical gamma ray profile is illustrated in Appendix I, Figure I-1.

Data from Figures D-1 through D-10 can be used to calculate dry-well-response times. The results from these calculations can be compared with Figures D-11 through D-28, as appropriate. (See text for discussion.)

The available data were statistically analyzed and reported by L. Jensen. The results of the analysis are included in this appendix for information.

TABLE D-1. Liquid Level Decrease Rates for Questionable Integrity and Confirmed Leaker Tanks.

Tank no.	In./time	In./d	Gal/min	Gal/d	Ft^3/d	Status[a]
241-B-107	3/18 mo	0.005	0.011	15.7	2.12	L
241-B-110	3/12 mo	0.004	0.020	30	3.85	QI
241-B-201	4.0/36 mo	0.003	0.0005	0.73	0.096	L
241-C-101	4.0/12 mo	0.010	0.019	28	3.66	L
241-SX-110	--[b]	--[b]	0.2	--	38.5	QI
241-T-103	0.3/92 d	0.003	0.006	9	1.15	QI
241-T-106	--[c]	0.89[c]	1.7[c]	2455[c]	328[c]	L
241-T-108	0.3/370 d	0.0008	0.0015	2	0.289	QI
241-T-111	0.3/273 d	0.001	0.002	3	0.385	QI
241-TX-107	0.4/121 d	0.003	0.006	9	1.15	QI
241-TY-101	0.35/50 d	0.007	0.013	19.25	2.50	QI
241-U-110	0.5/41 d	0.012	0.023	33.5	4.43	L
241-U-112	3/14 mo	0.009	0.02	25	3.85	L

[a]L = Confirmed leaker; QI = Questionable integrity.

[b]Loss due to evaporation is suspected because this tank was connected to an exhauster and waste was thermally hot.

[c]Leak rates were redetermined for this study using liquid level readings reported in the 241-T-106 leak chronology (see Appendix K).

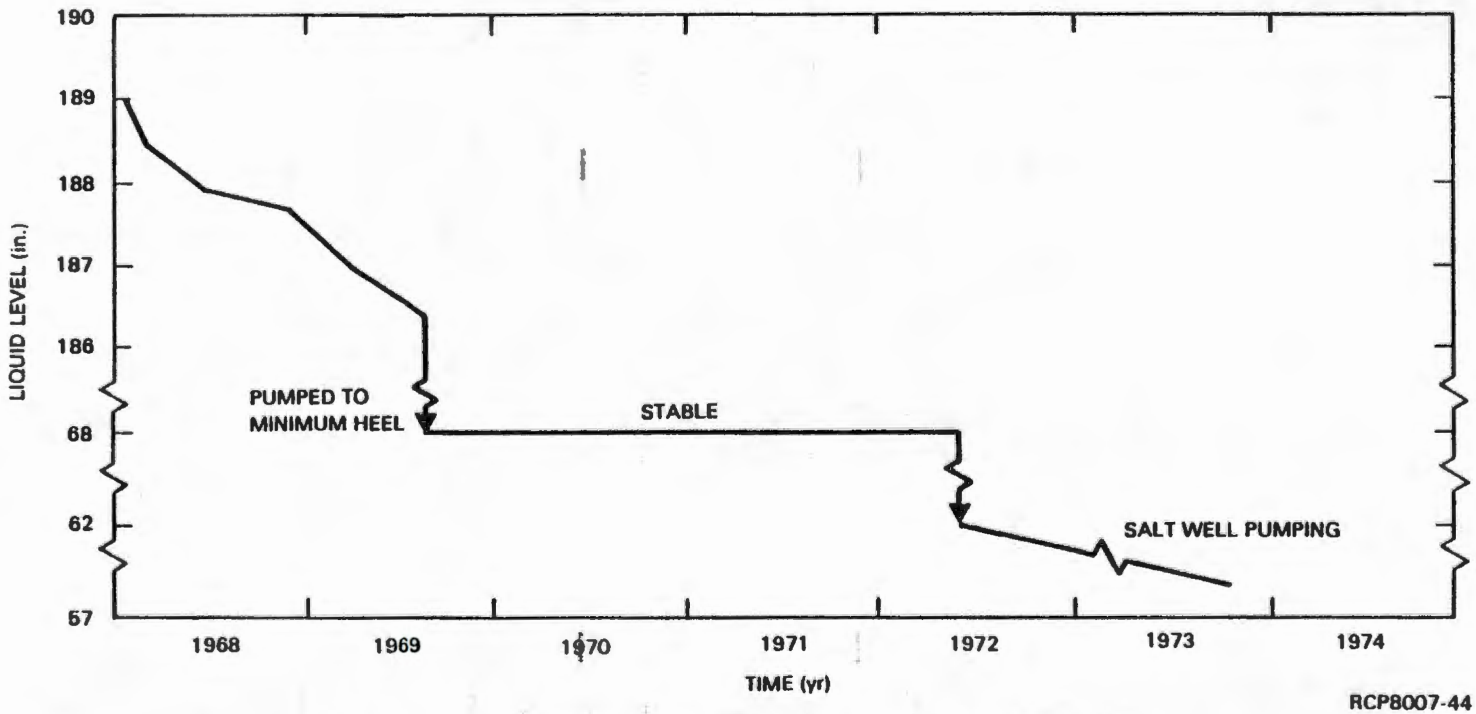


FIGURE D-1. Liquid Level History for Tank 241-B-107.

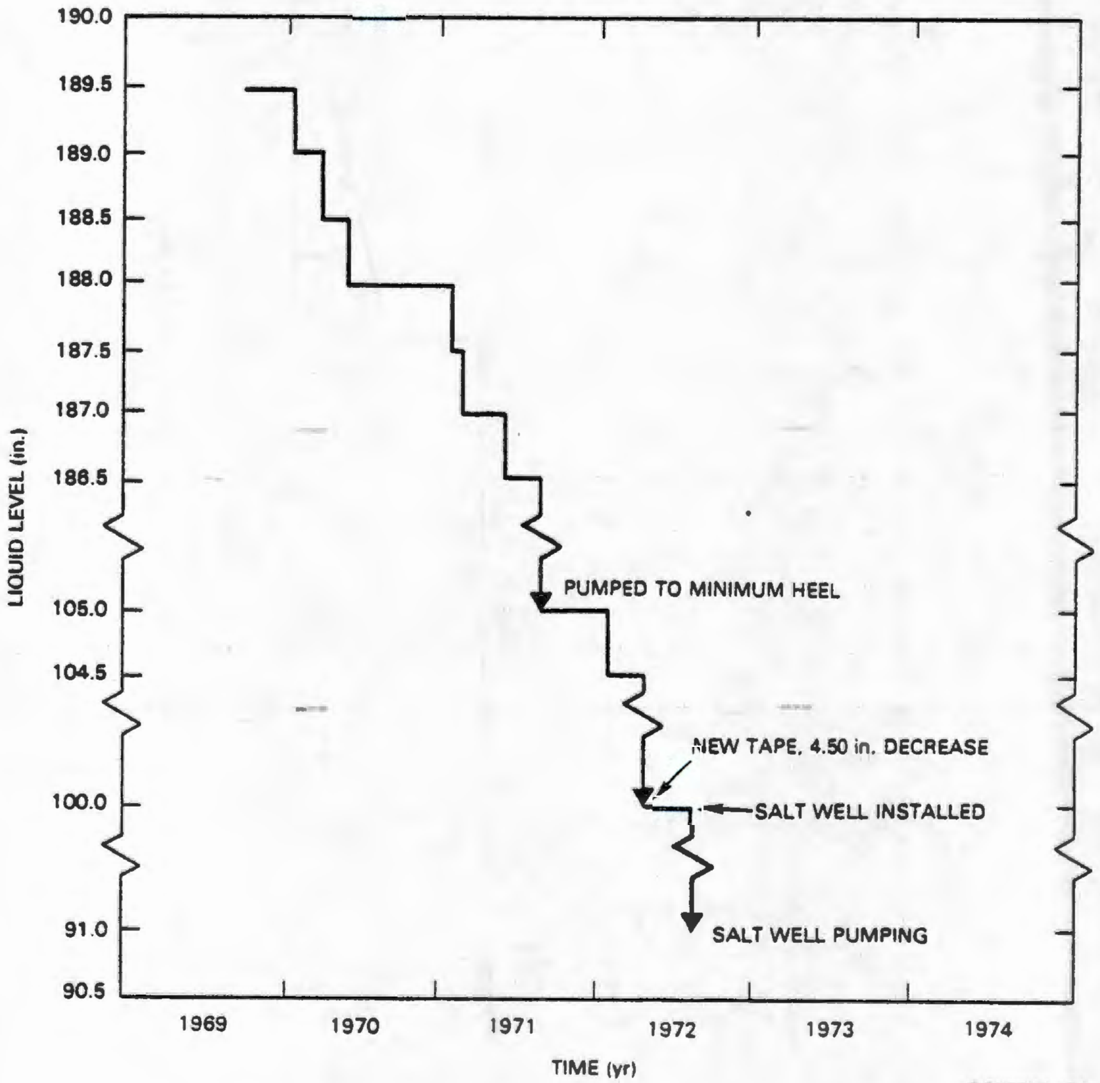


FIGURE D-2. Liquid Level History for Tank 241-B-110.

9 2 1 2 4 9 9 1 7 2 0

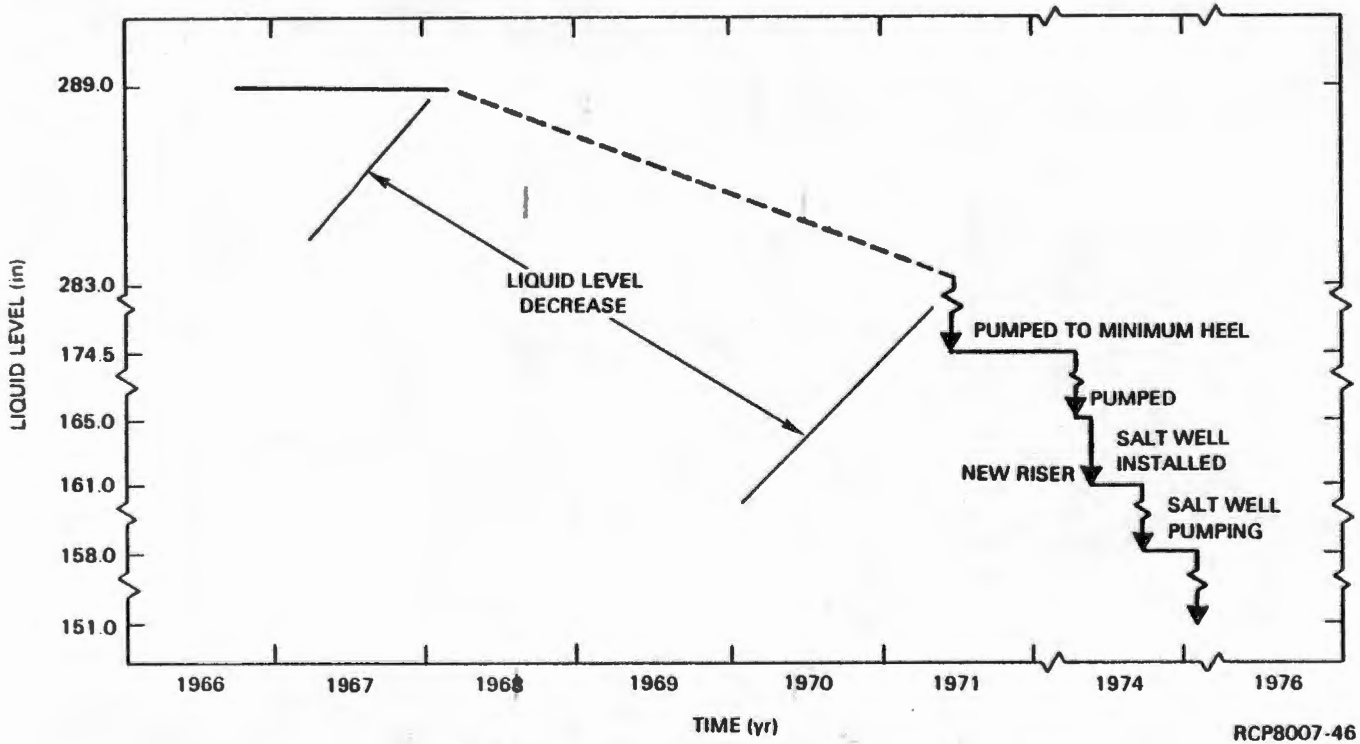


FIGURE D-3. Liquid Level History for Tank 241-B-201.

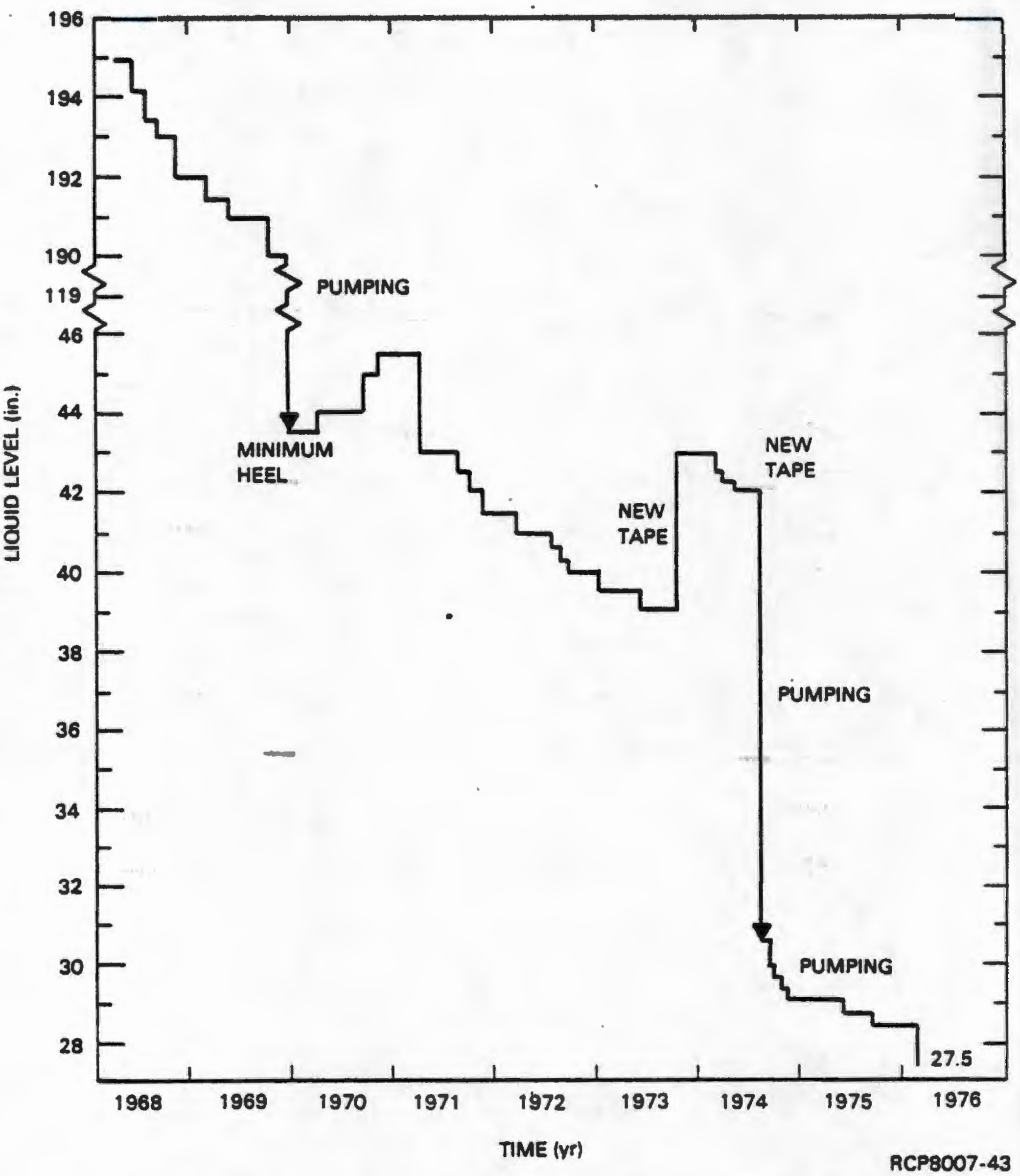


FIGURE D-4. Liquid Level History for Tank 241-C-101.

9 2 1 2 4 9 9 1 7 2 2

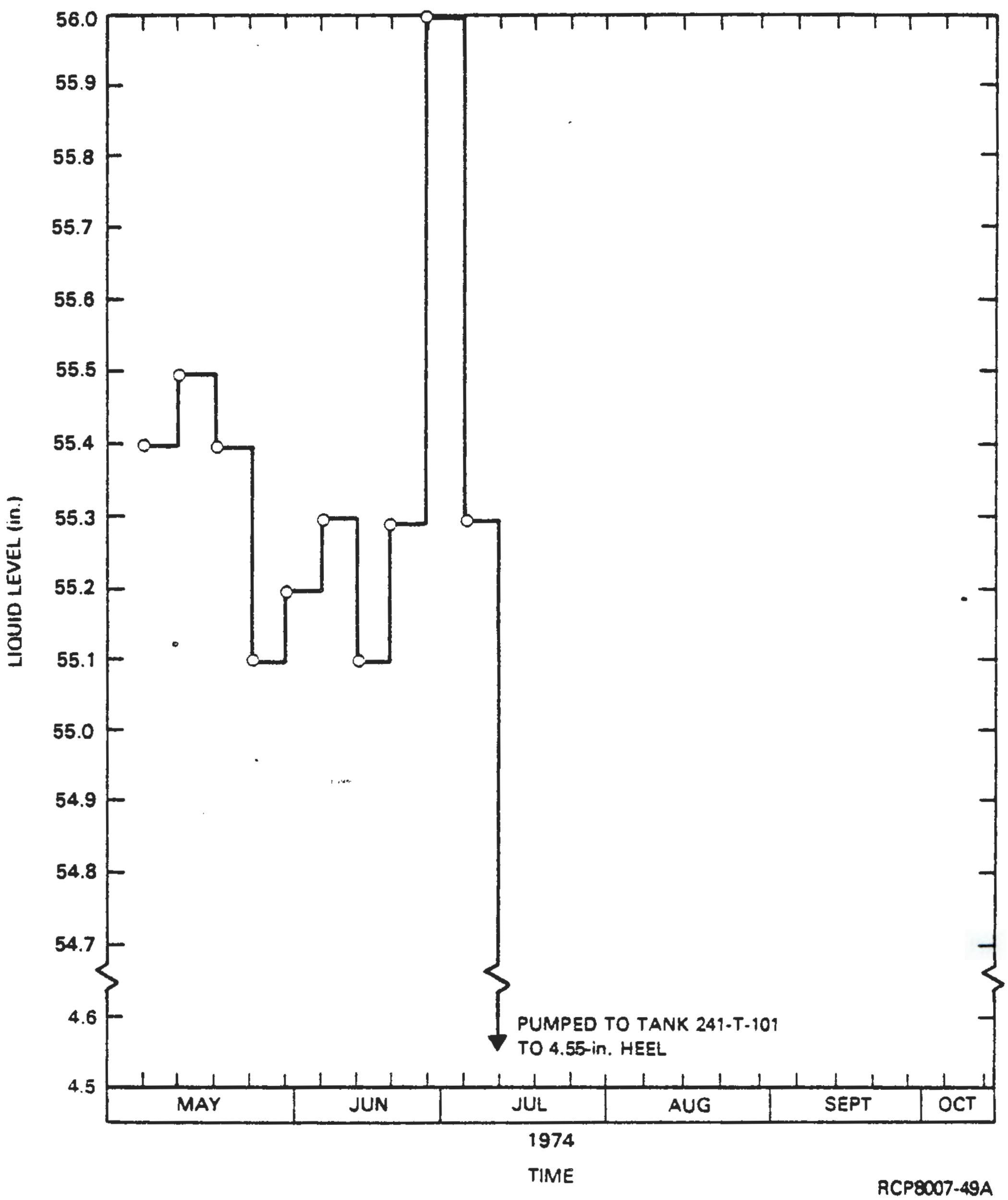


FIGURE D-5. Liquid Level History for Tank 241-T-101.

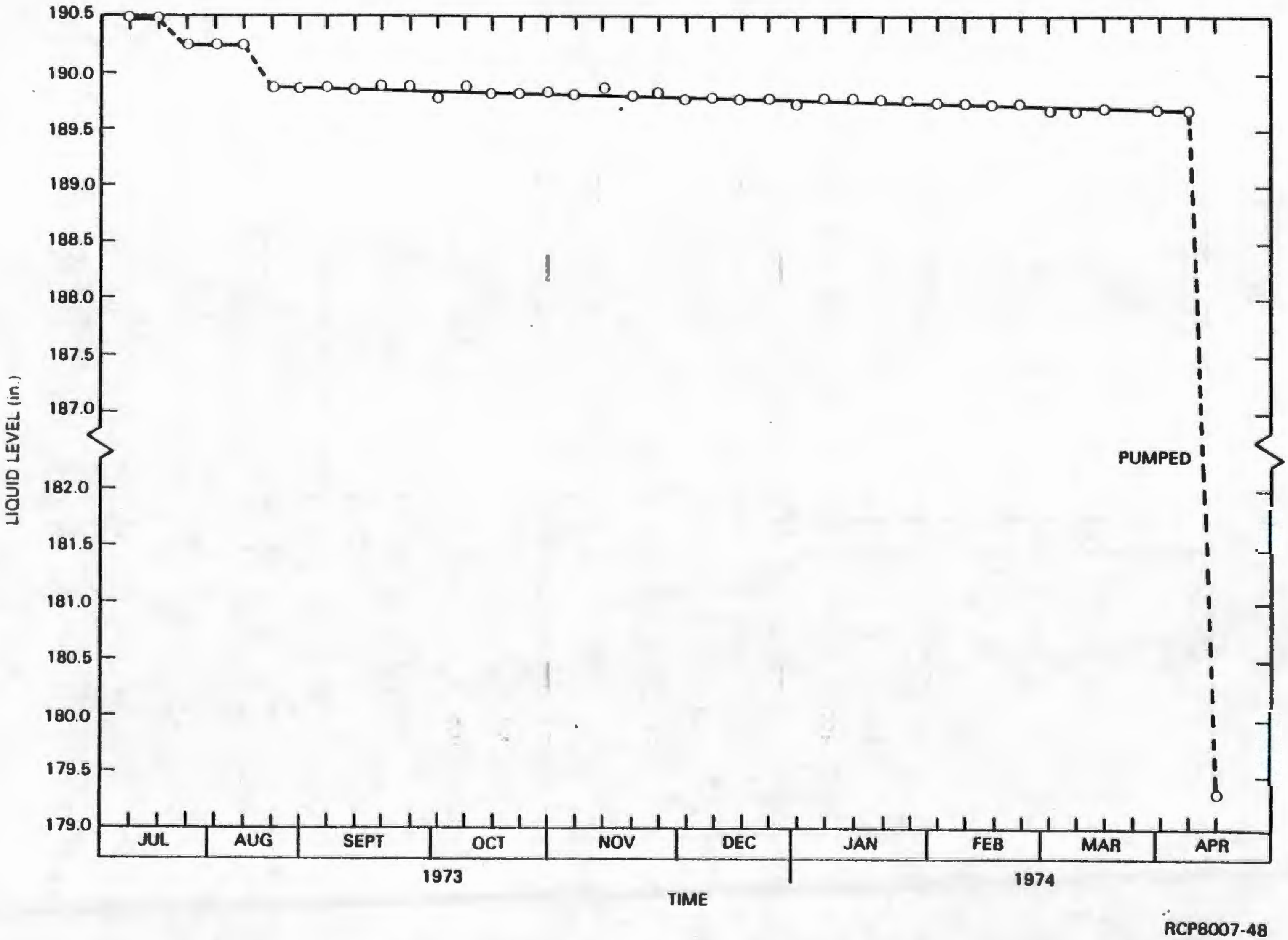


FIGURE D-6. Liquid Level History for Tank 241-T-111.

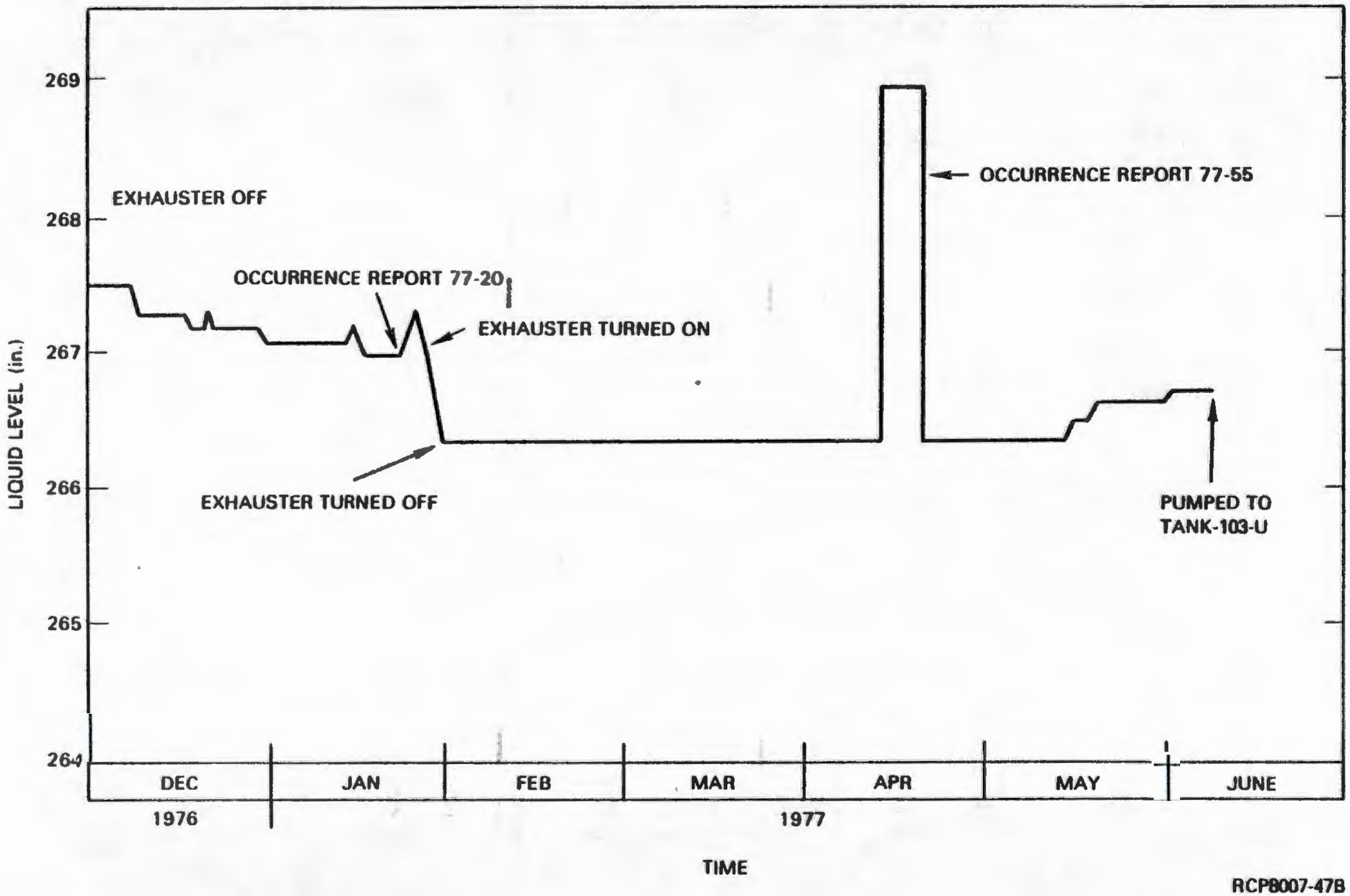


FIGURE D-7. Liquid Level History for Tank 241-TX-107.

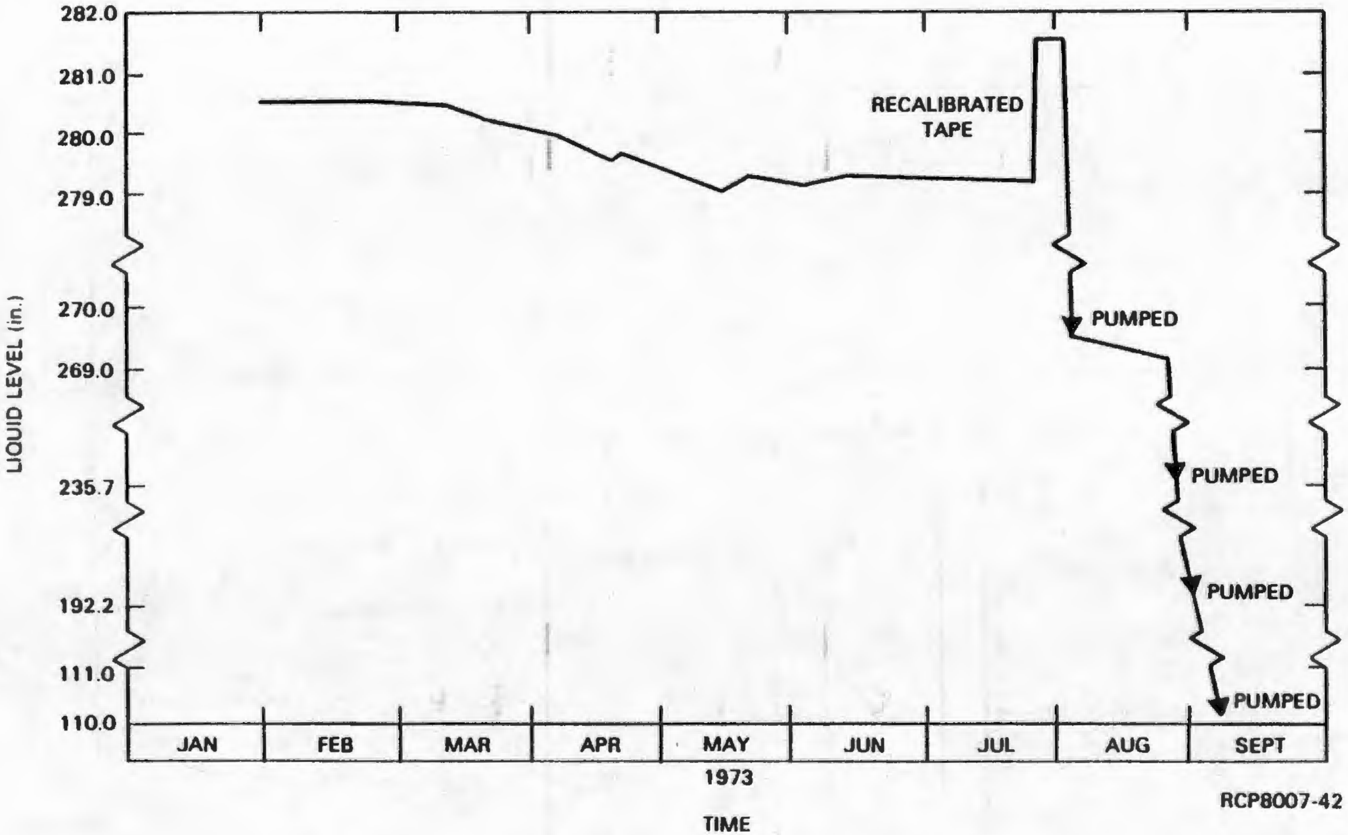


FIGURE D-8. Liquid Level History for Tank 241-TY-101.

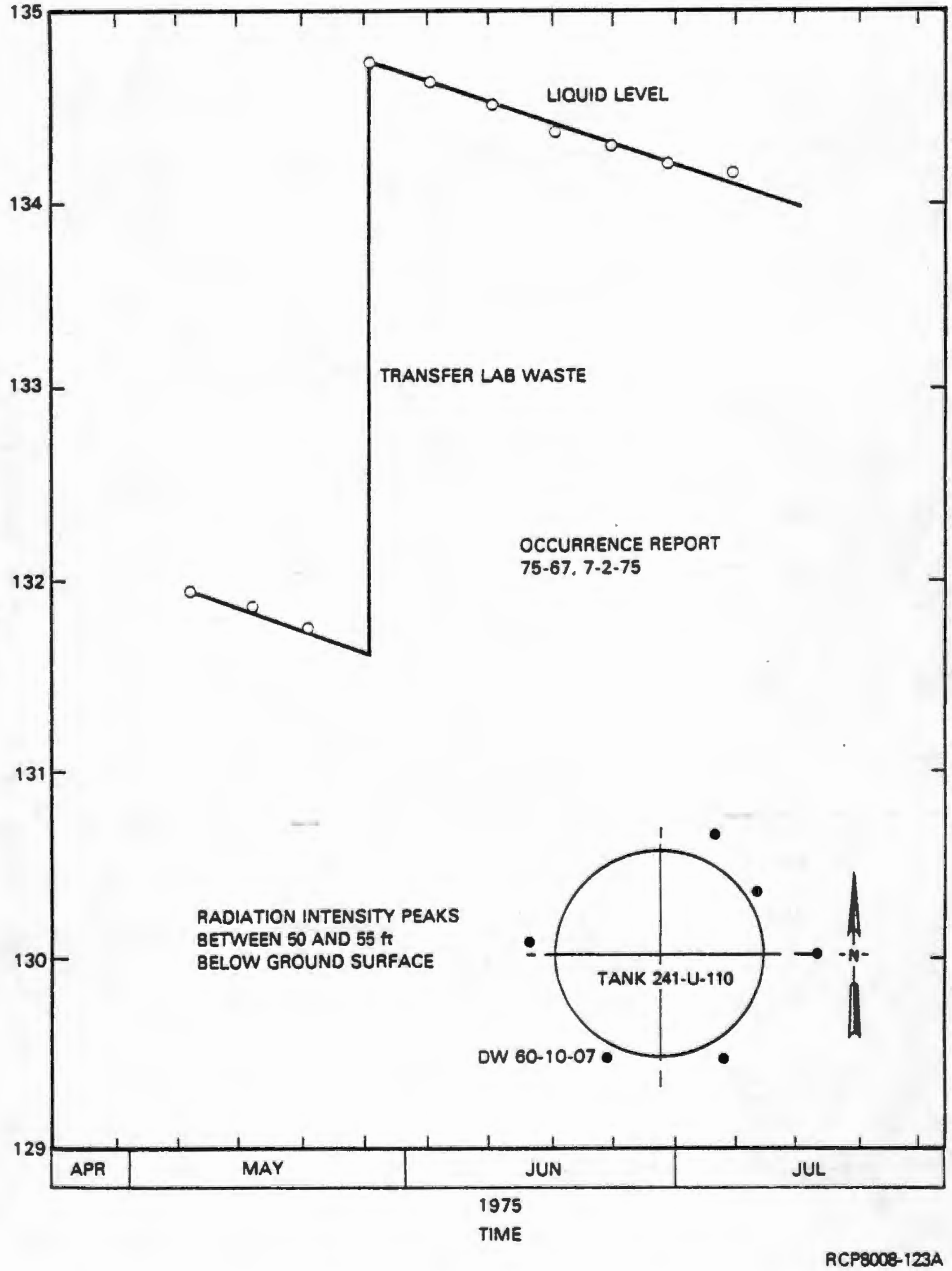


FIGURE D-9. Liquid Level History for Tank 241-U-110.

9 2 1 2 4 9 9 1 7 2 7

9 2 1 2 4 9 9 1 7 2 8

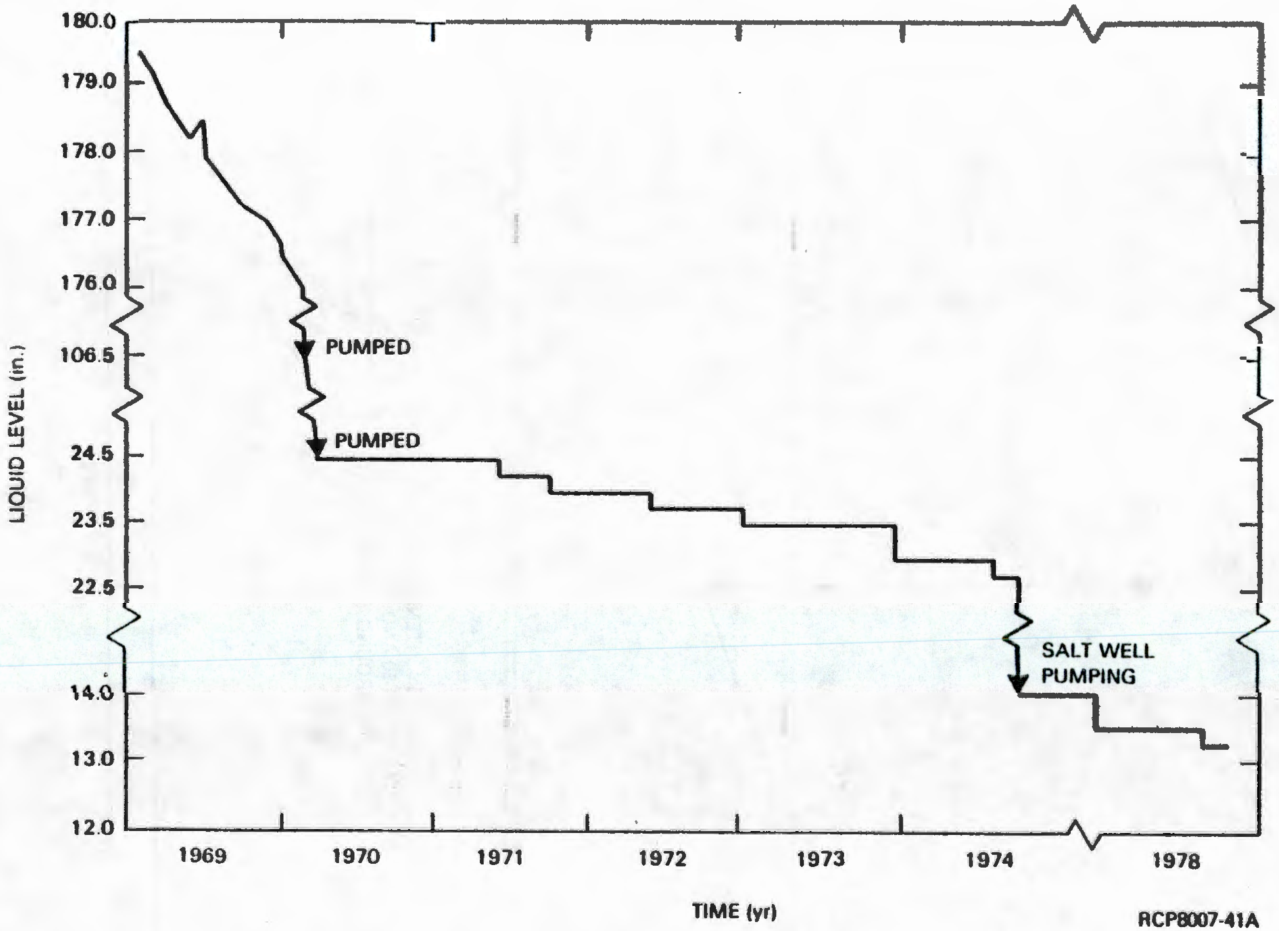


FIGURE D-10. Liquid Level History for Tank 241-U-112.

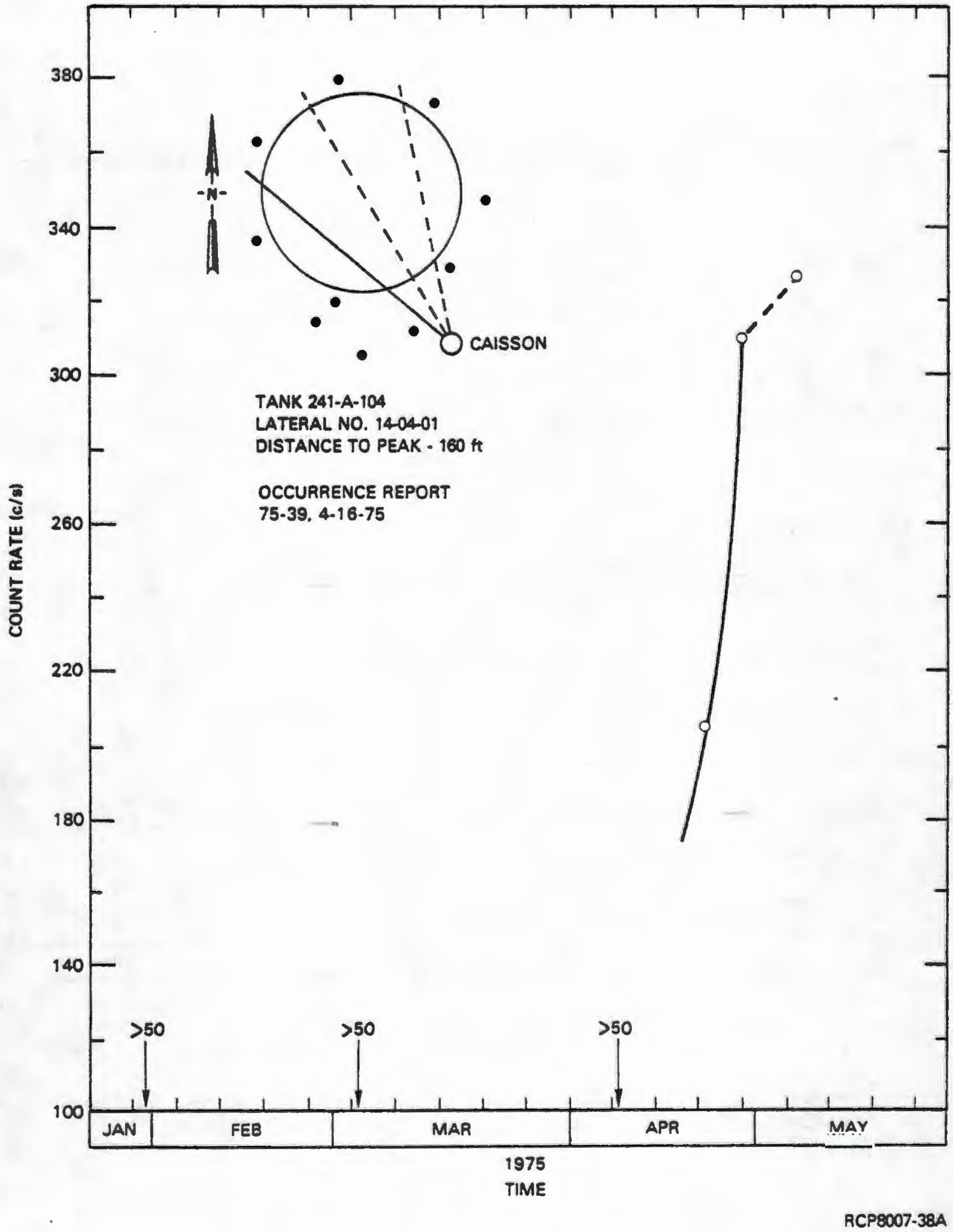


FIGURE D-11. Radioactivity Count Rate as a Function of Time for Radiation Surveillance Lateral No. 14-04-01 Beneath Tank 241-A-104.

9 2 1 2 4 9 9 1 7 2 9

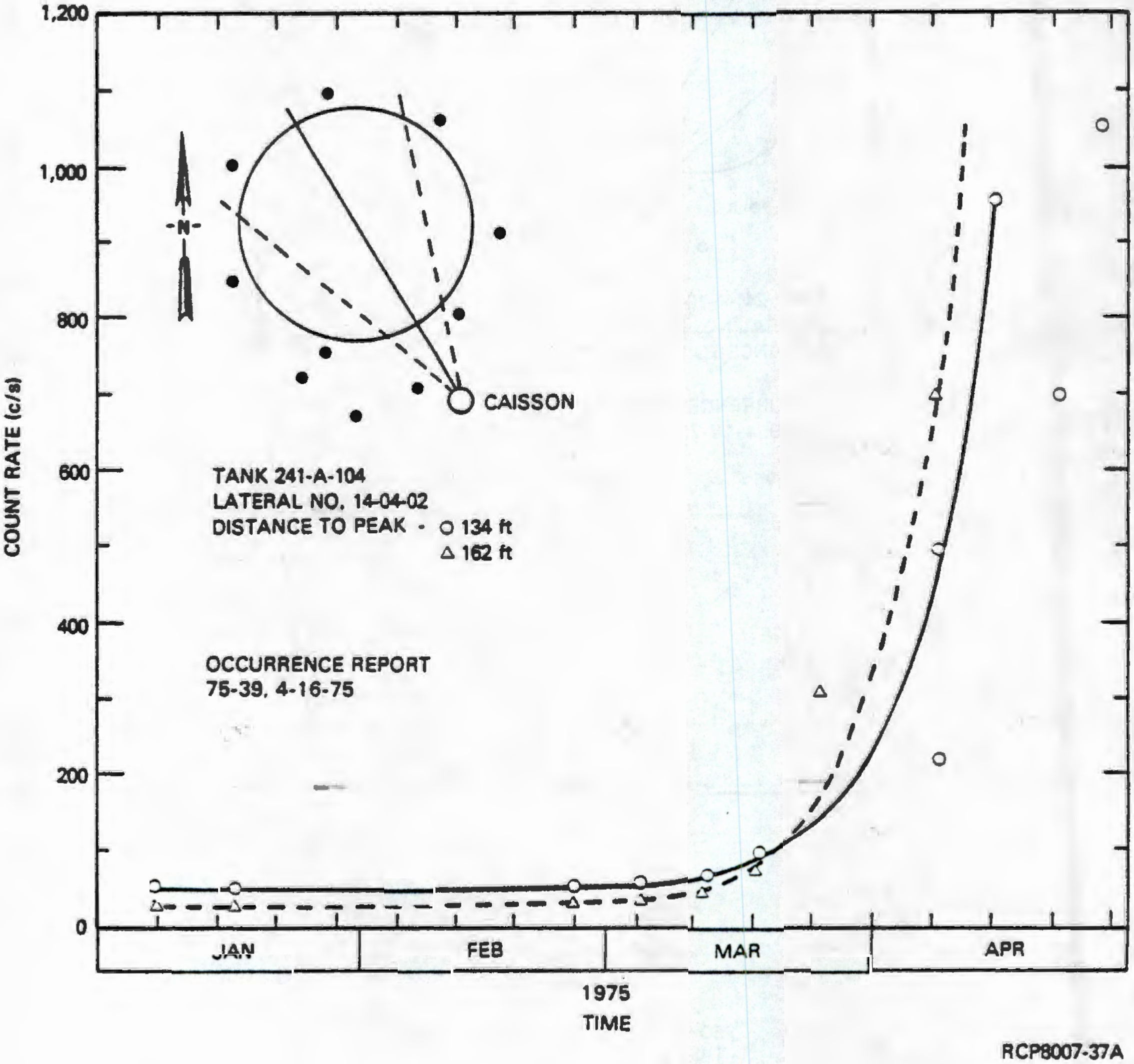


FIGURE D-12. Radioactivity Count Rate as a Function of Time for Radiation Surveillance Lateral No. 14-04-02 Beneath Tank 241-A-104.

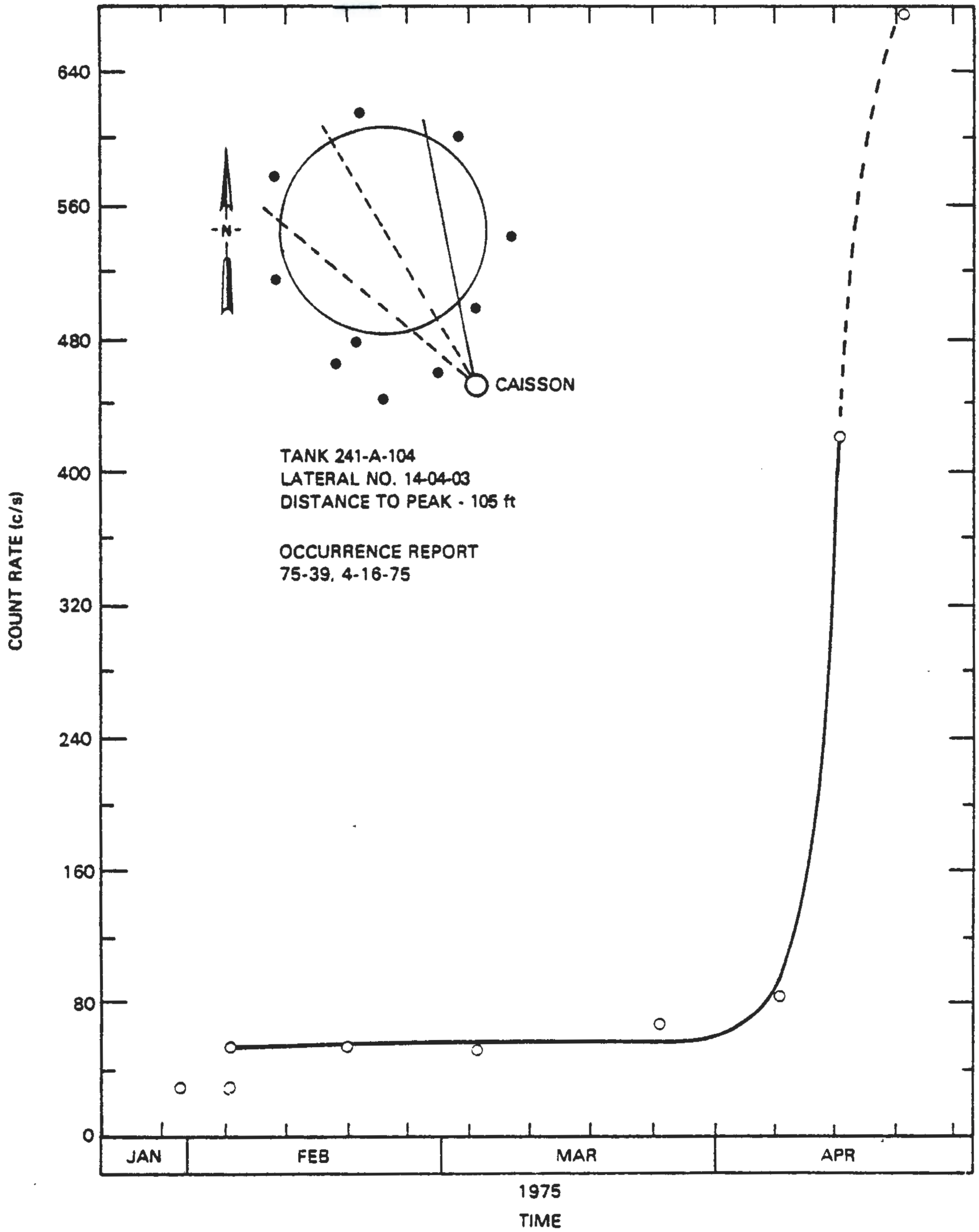


FIGURE D-13. Radioactivity Count Rate for Radiation Surveillance Lateral No. 14-04-03 Beneath Tank 241-A-104.

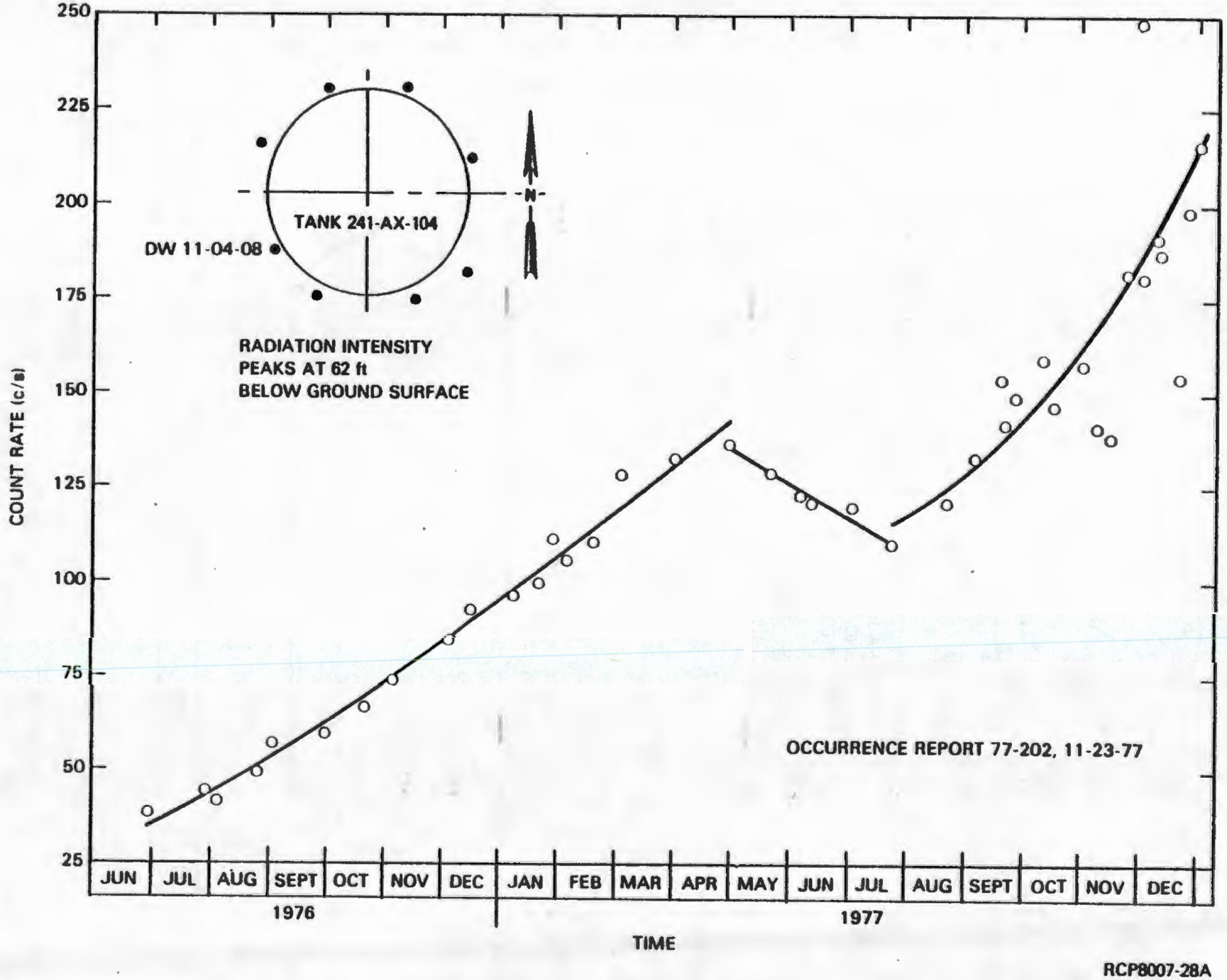


FIGURE D-14. Radioactivity Count Rate as a Function of Time for Dry Well DW-11-04-08 Near Tank 241-AX-104.

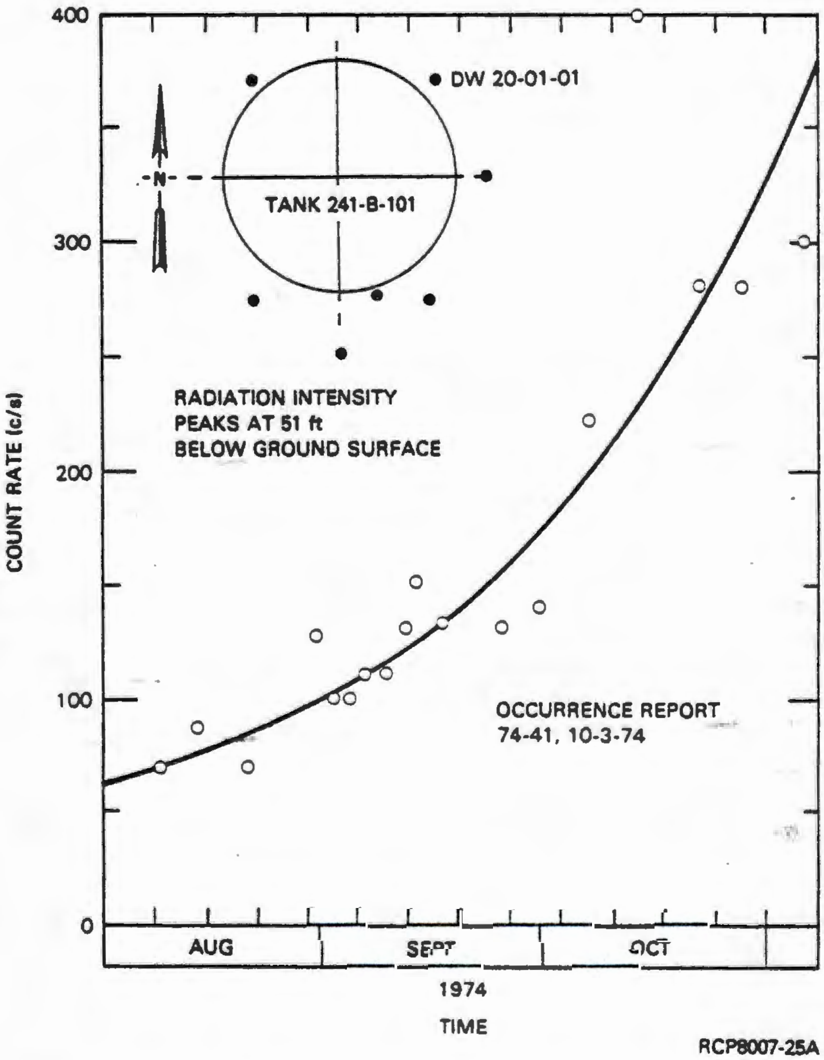


FIGURE D-15. Radioactivity Count Rate as a Function of Time for Dry Well DW-20-01-01 Near Tank 241-B-101.

9212499173

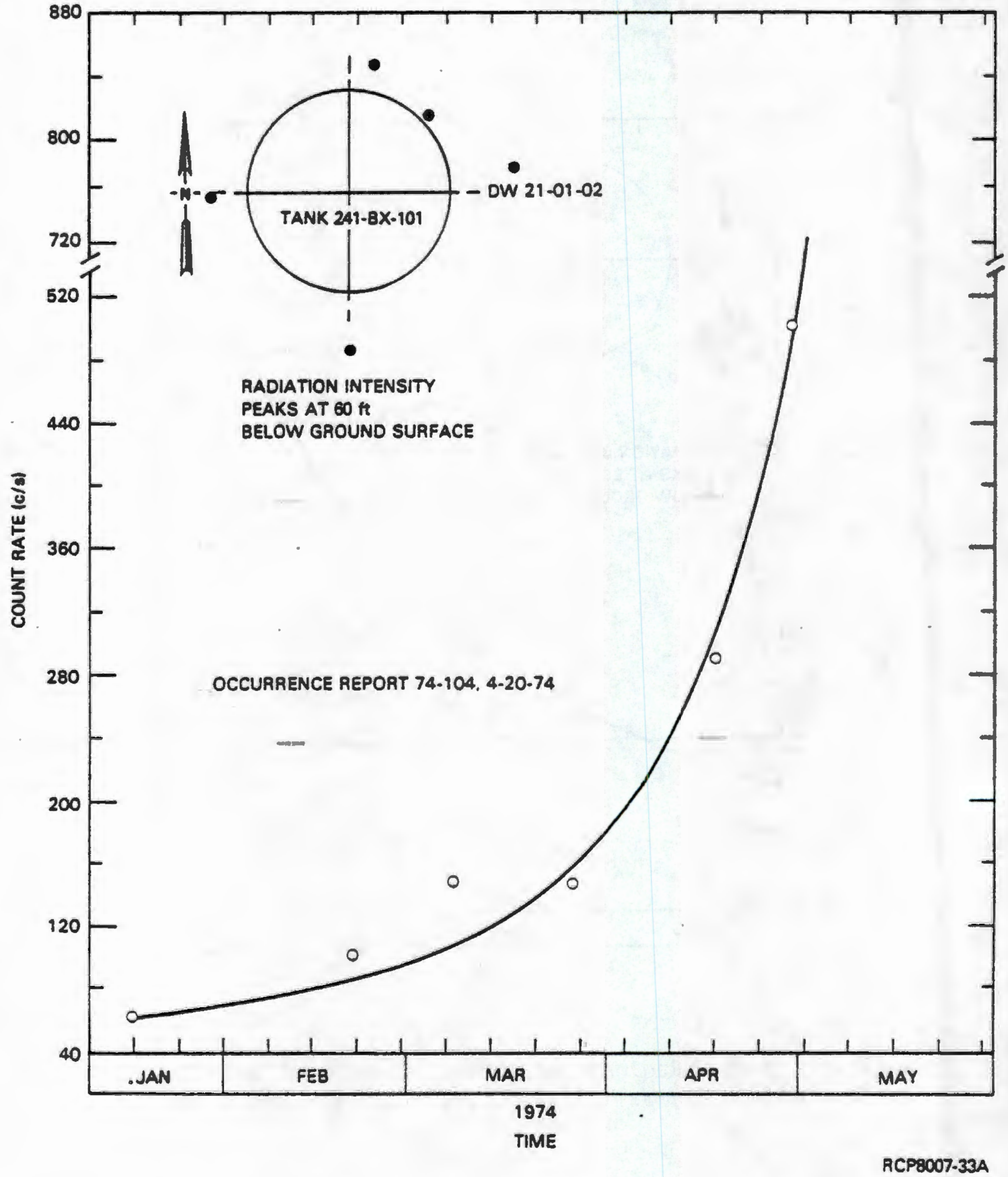


FIGURE D-16. Radioactivity Count Rate as a Function of Time for Dry Well DW-21-01-02 Near Tank 241-BX-101.

9 2 1 2 4 9 9 1 7 3 4

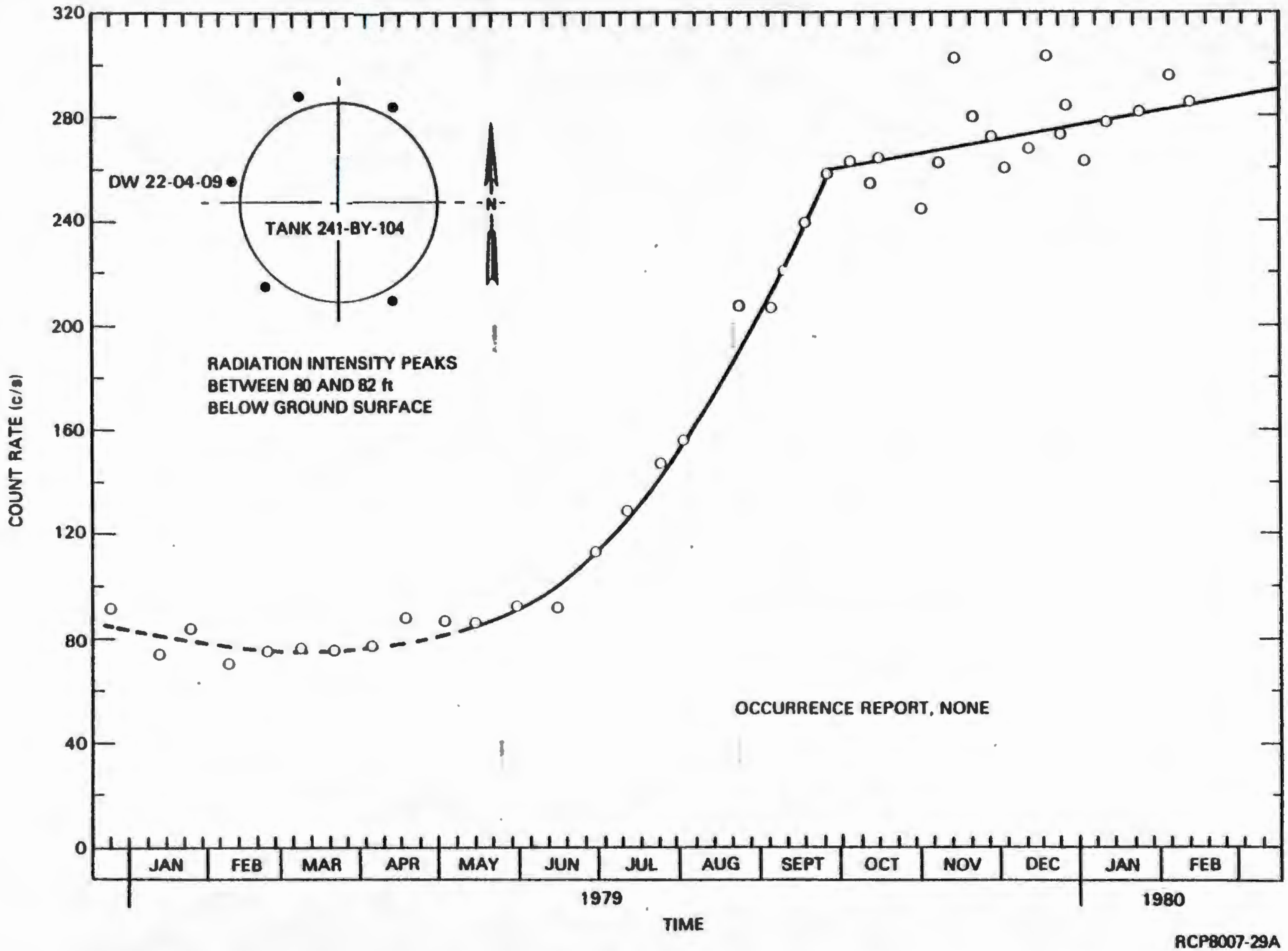


FIGURE D-17. Radioactivity Count Rate as a Function of Time for Dry Well DW-22-04-09 Near Tank 241-BY-104.

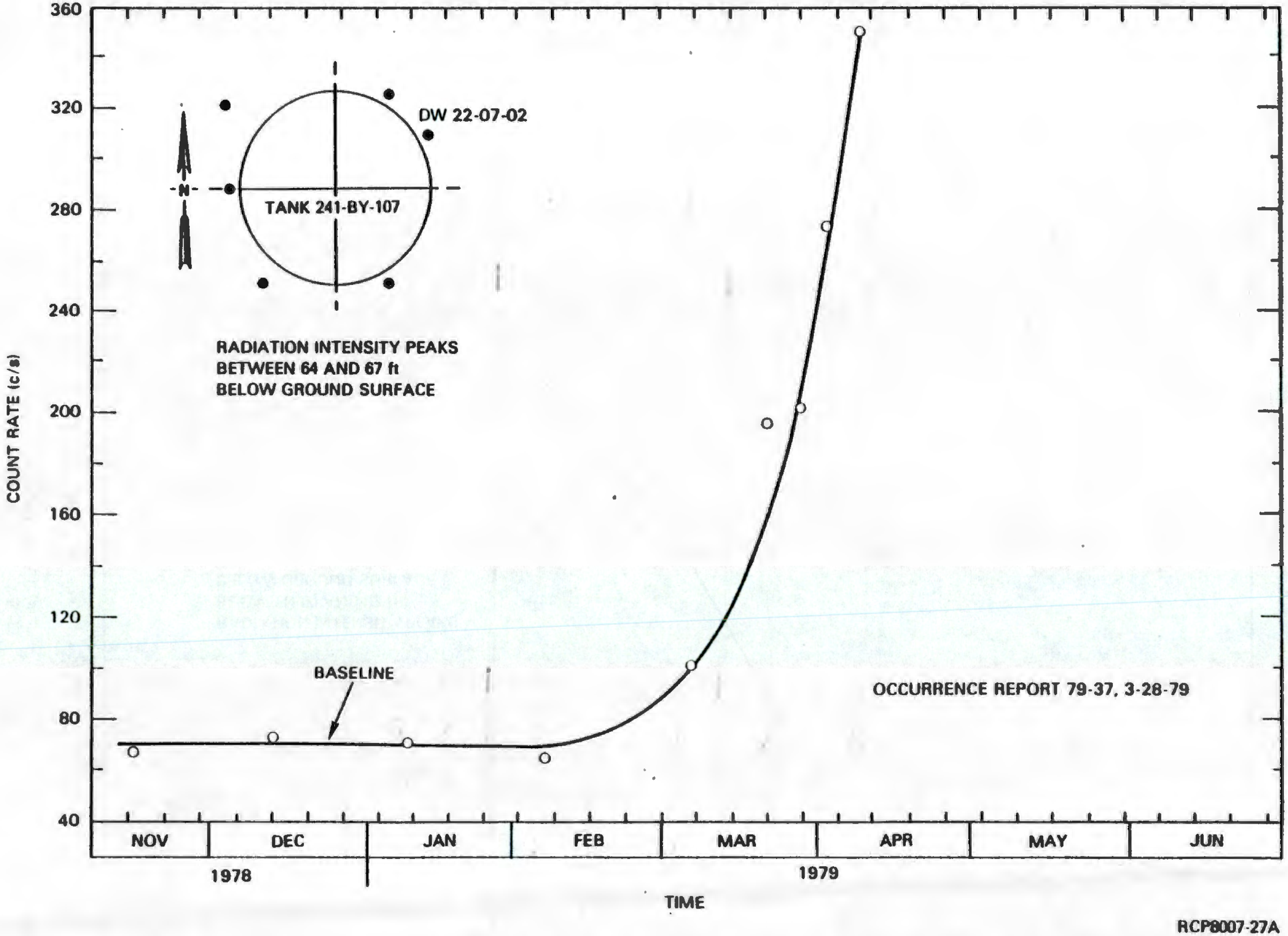


FIGURE D-18. Radioactivity Count Rate as a Function of Time for Dry Well DW-22-07-02 Near Tank 241-BY-107.

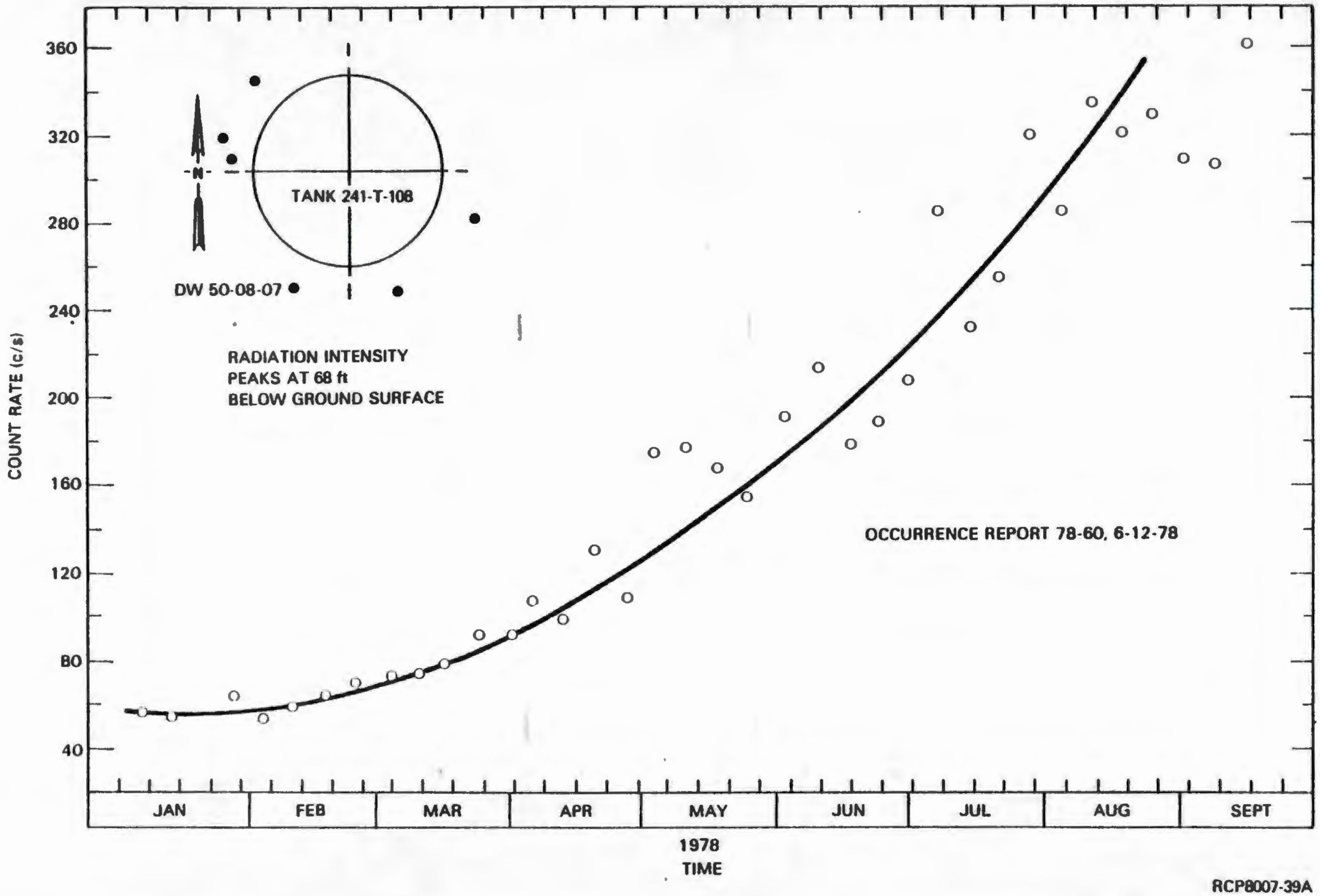


FIGURE D-19. Radioactivity Count Rate as a Function of Time for Dry Well DW-50-08-07 Near Tank 241-T-108.

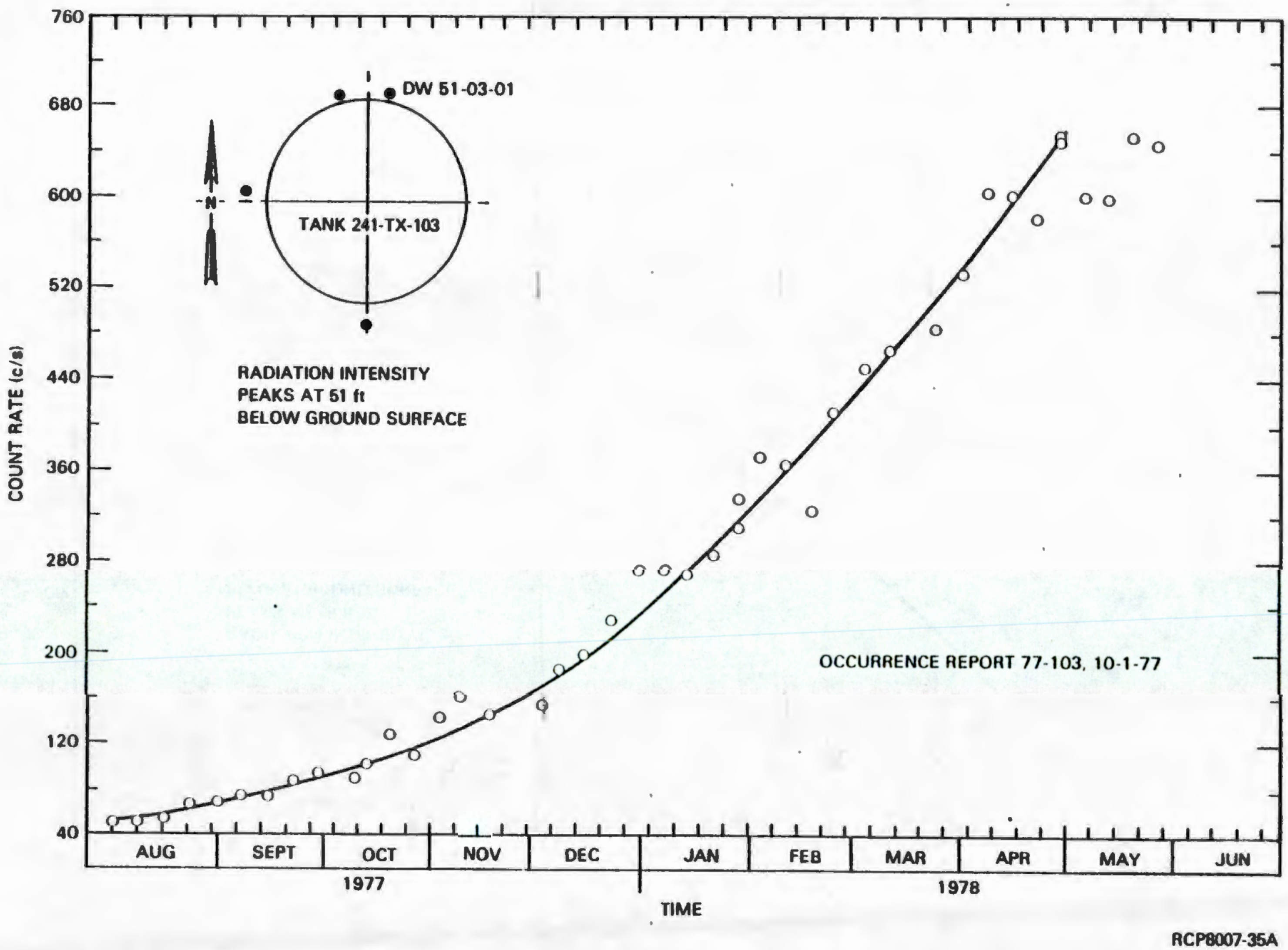


FIGURE D-20. Radioactivity Count Rate as a Function of Time for Dry Well DW-51-03-01 Near Tank 241-TX-103.

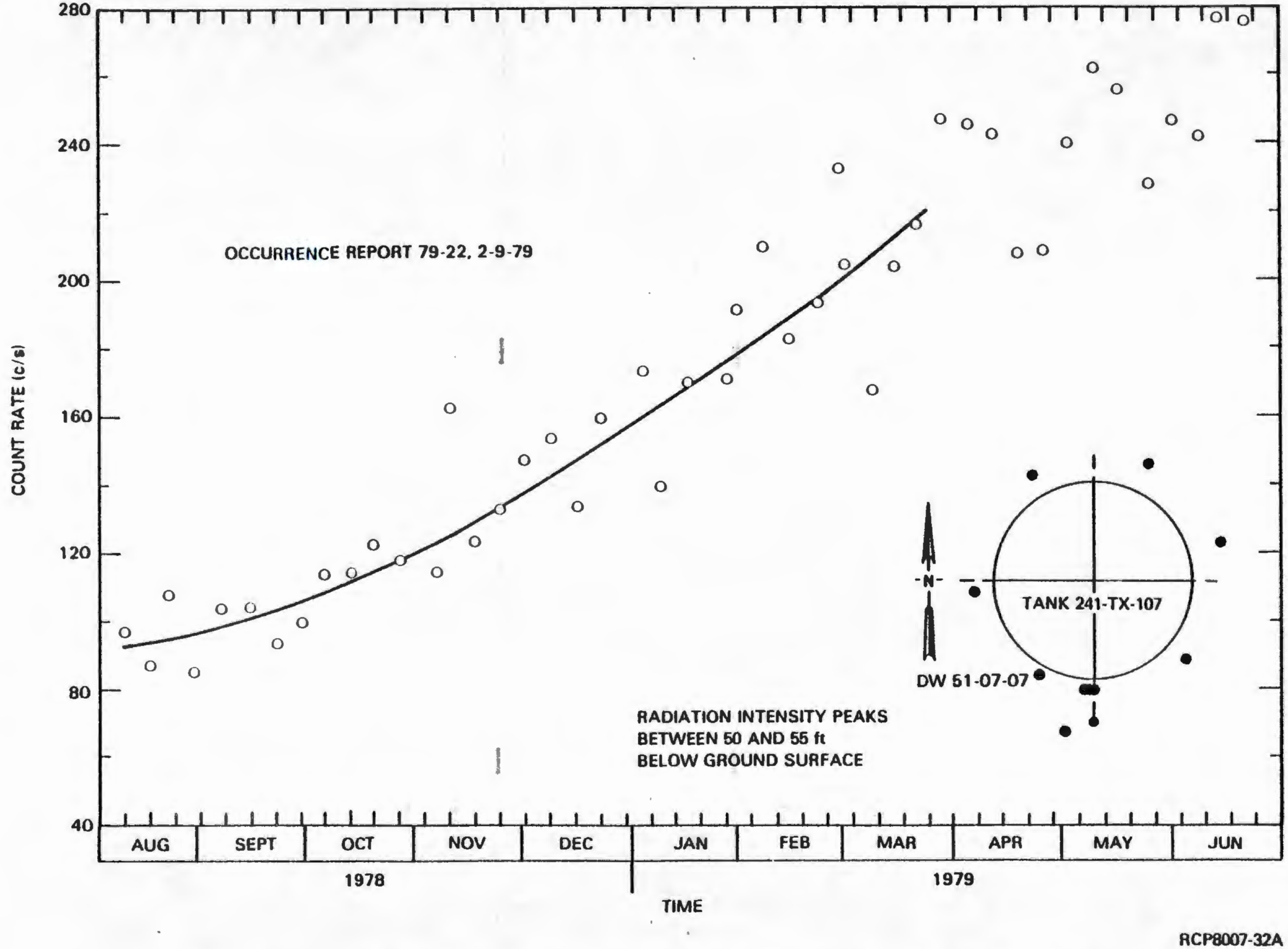
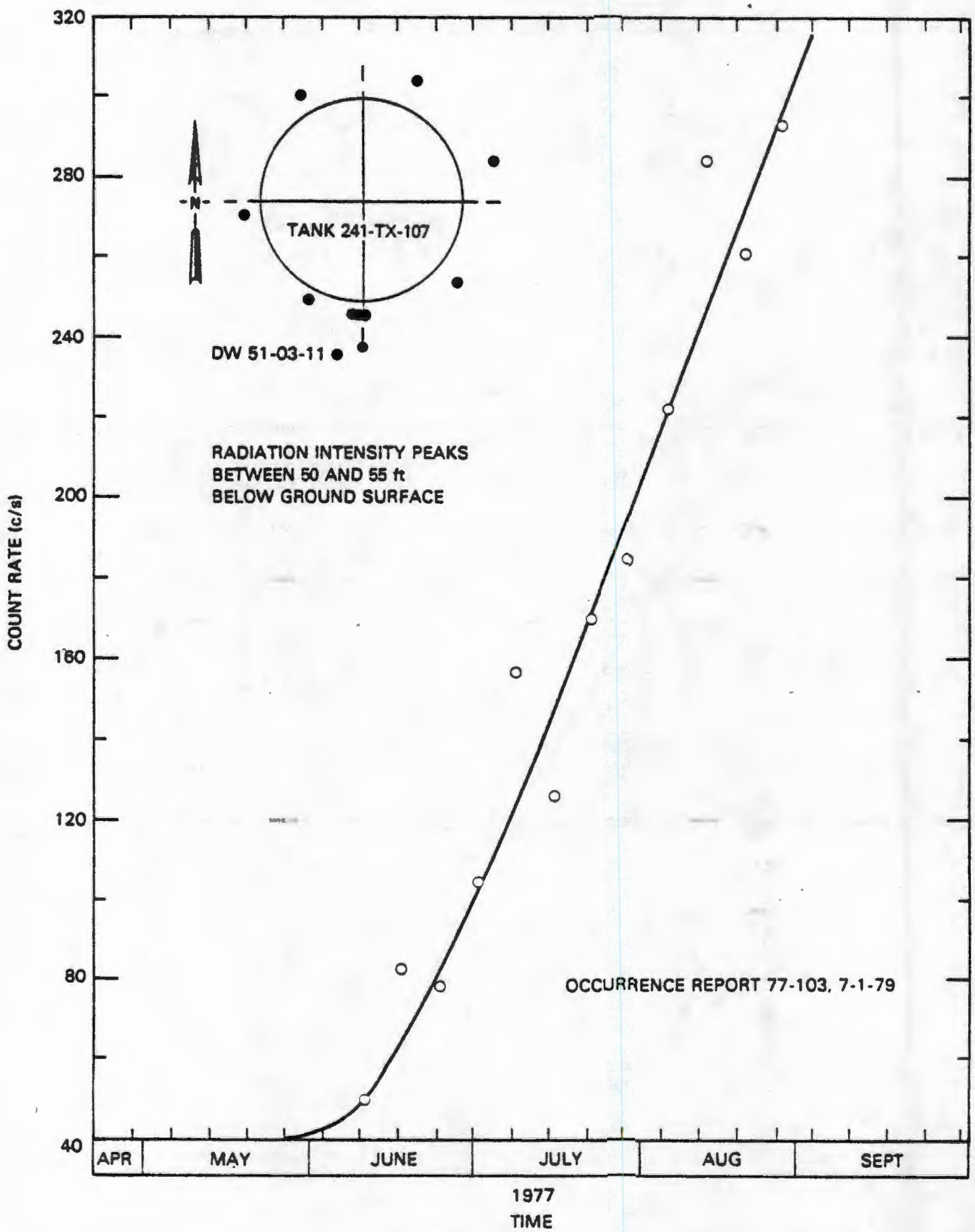


FIGURE D-21. Radioactivity Count Rate as a Function of Time for Dry Well DW-51-07-07 Near Tank 241-TX-107.



RCP8007-30A

FIGURE D-22. Radioactivity Count Rate as a Function of Time for Dry Well DW-51-03-11 Near Tank 241-TX-107.

9212491740

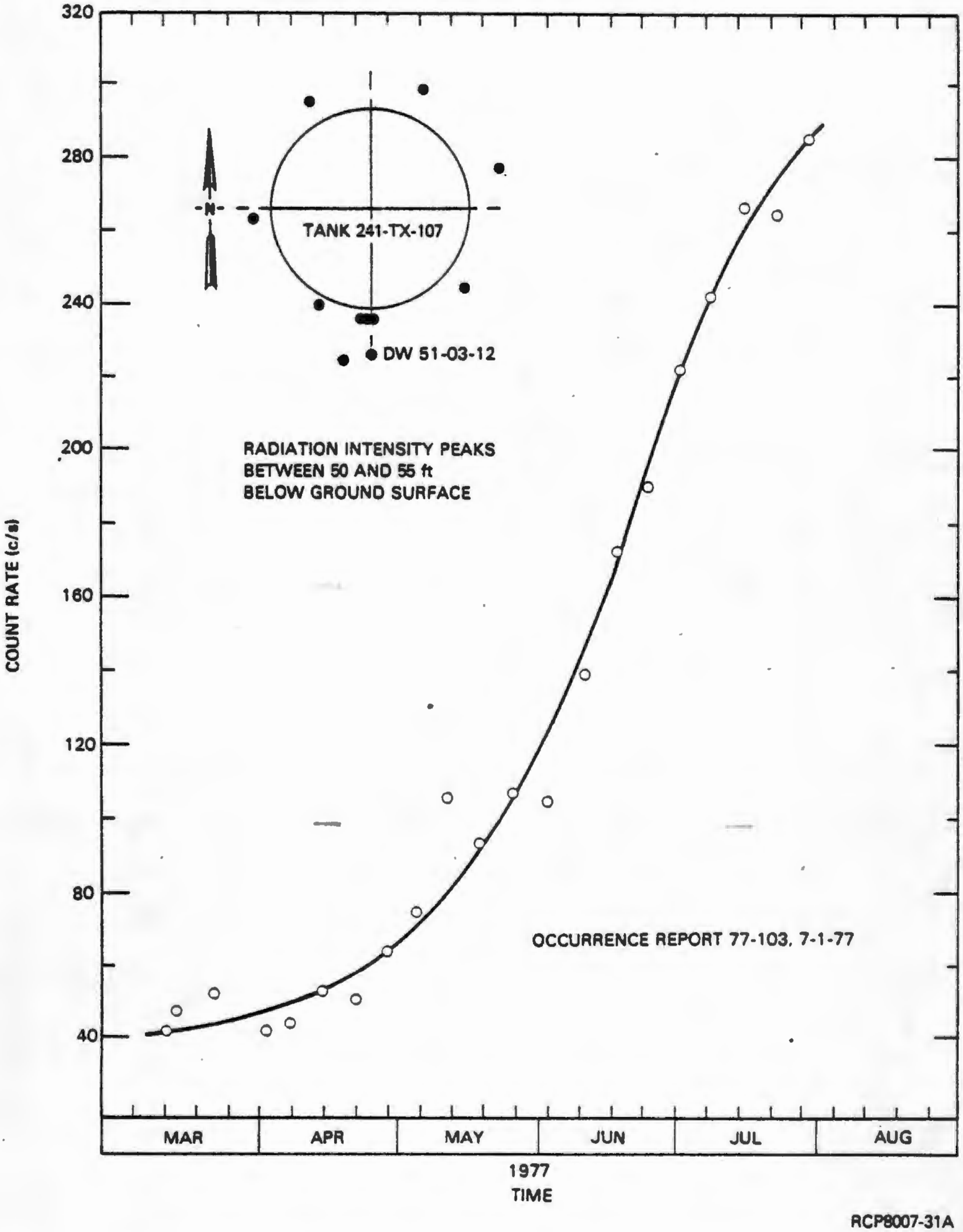


FIGURE D-23. Radioactivity Count Rate as a Function of Time for Dry Well DW-51-03-12 Near Tank 241-TX-107.

9212497741

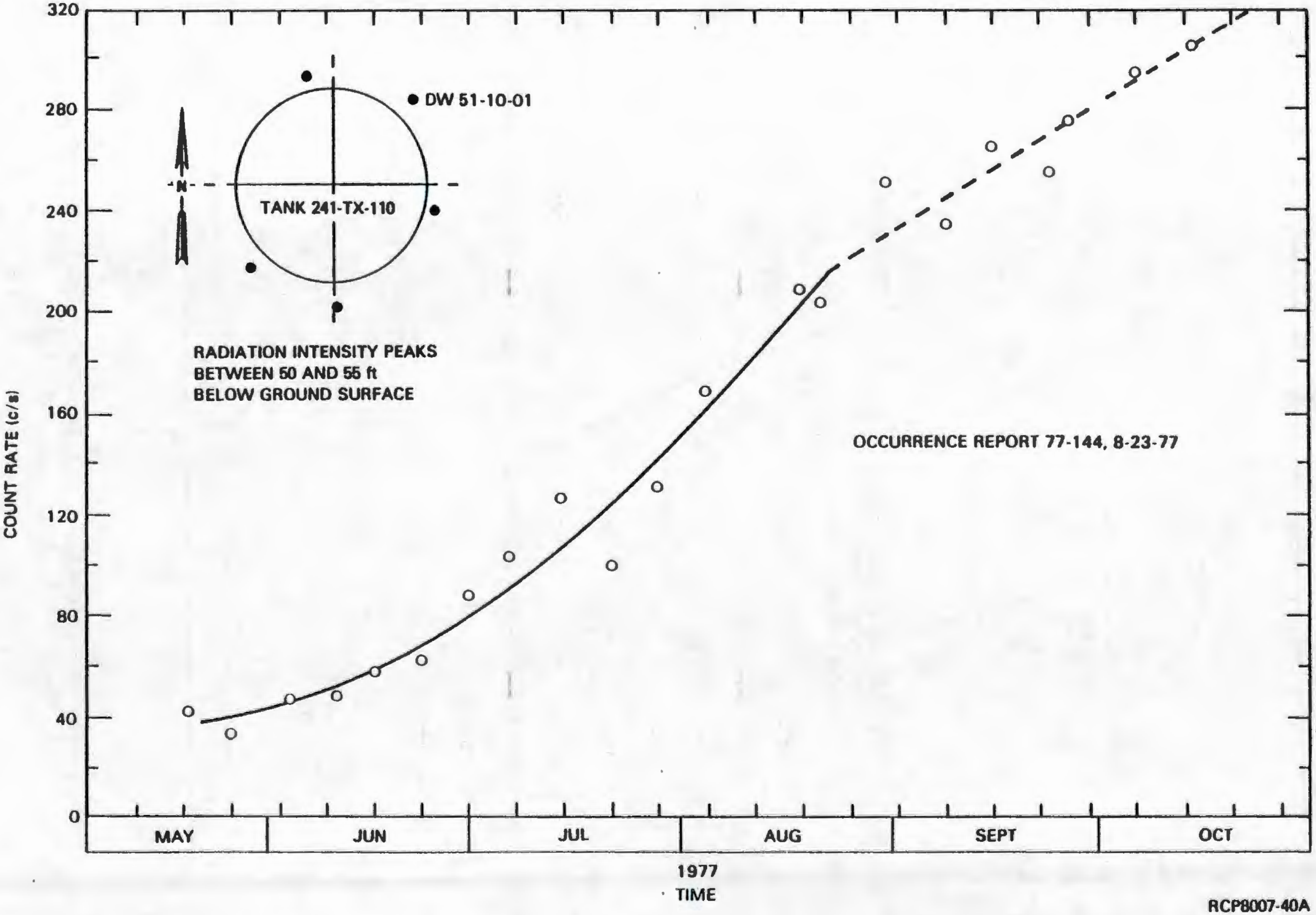


FIGURE D-24. Radioactivity Count Rate as a Function of Time for Dry Well DW-51-10-01 Near Tank 241-TX-110.

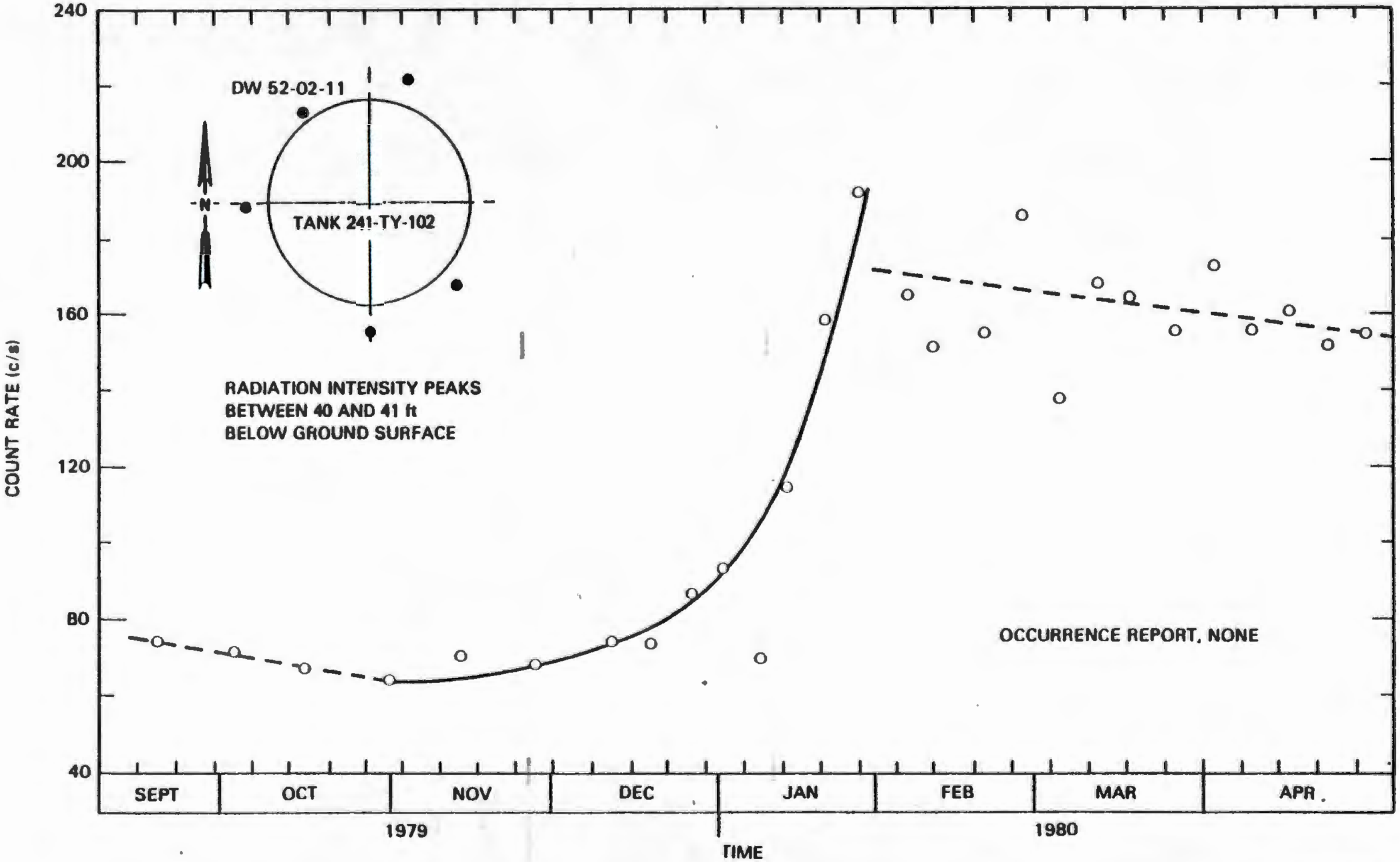


FIGURE D-25. Radioactivity Count Rate as a Function of Time for Dry Well DW-52-02-11 Near Tank 241-TY-102.

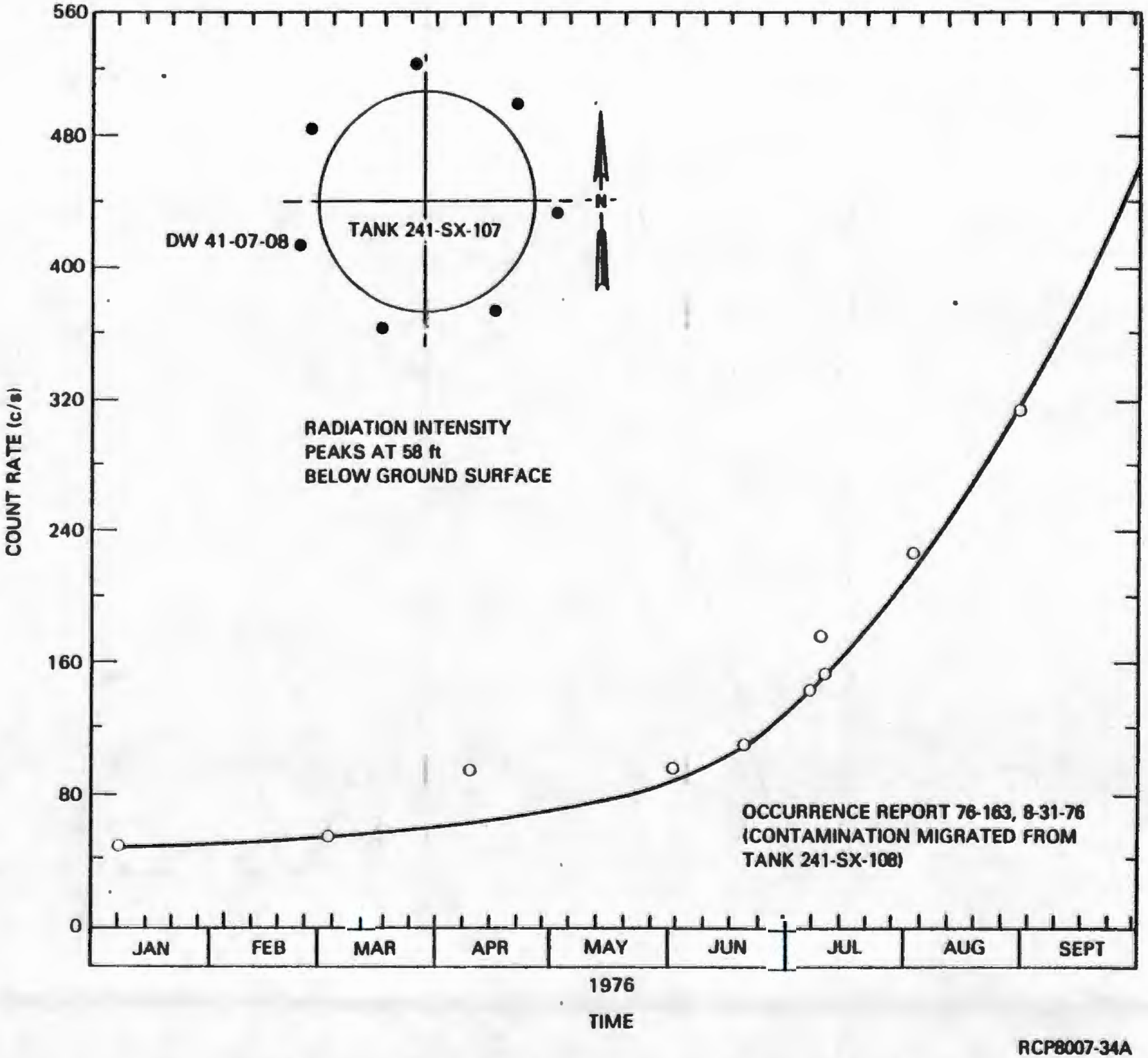


FIGURE D-26. Radioactivity Count Rate as a Function of Time for Dry Well DW-41-07-08 Near Tank 241-SX-107.

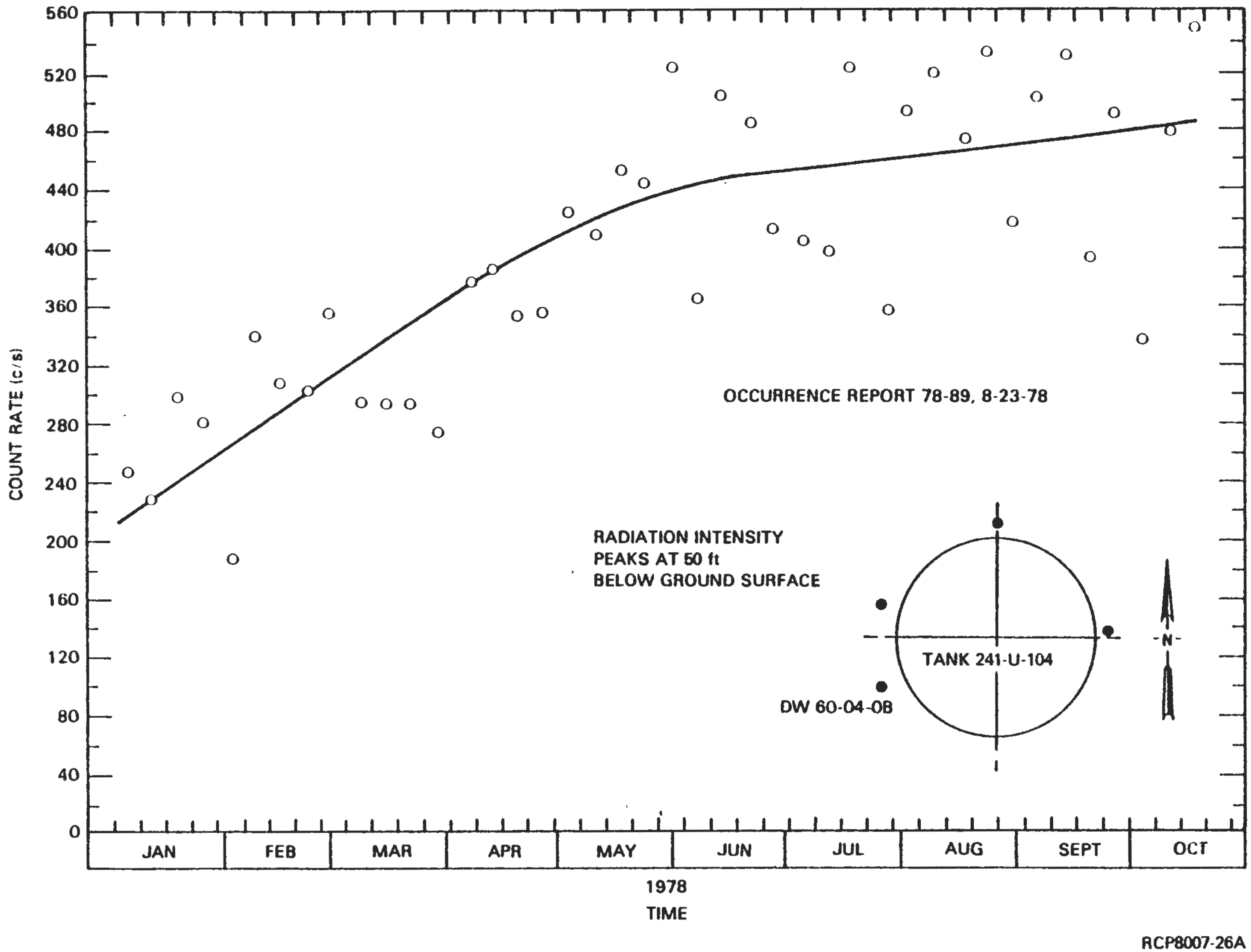


FIGURE D-27. Radioactivity Count Rate as a Function of Time for Dry Well DW-60-04-08 Near Tank 241-U-104.

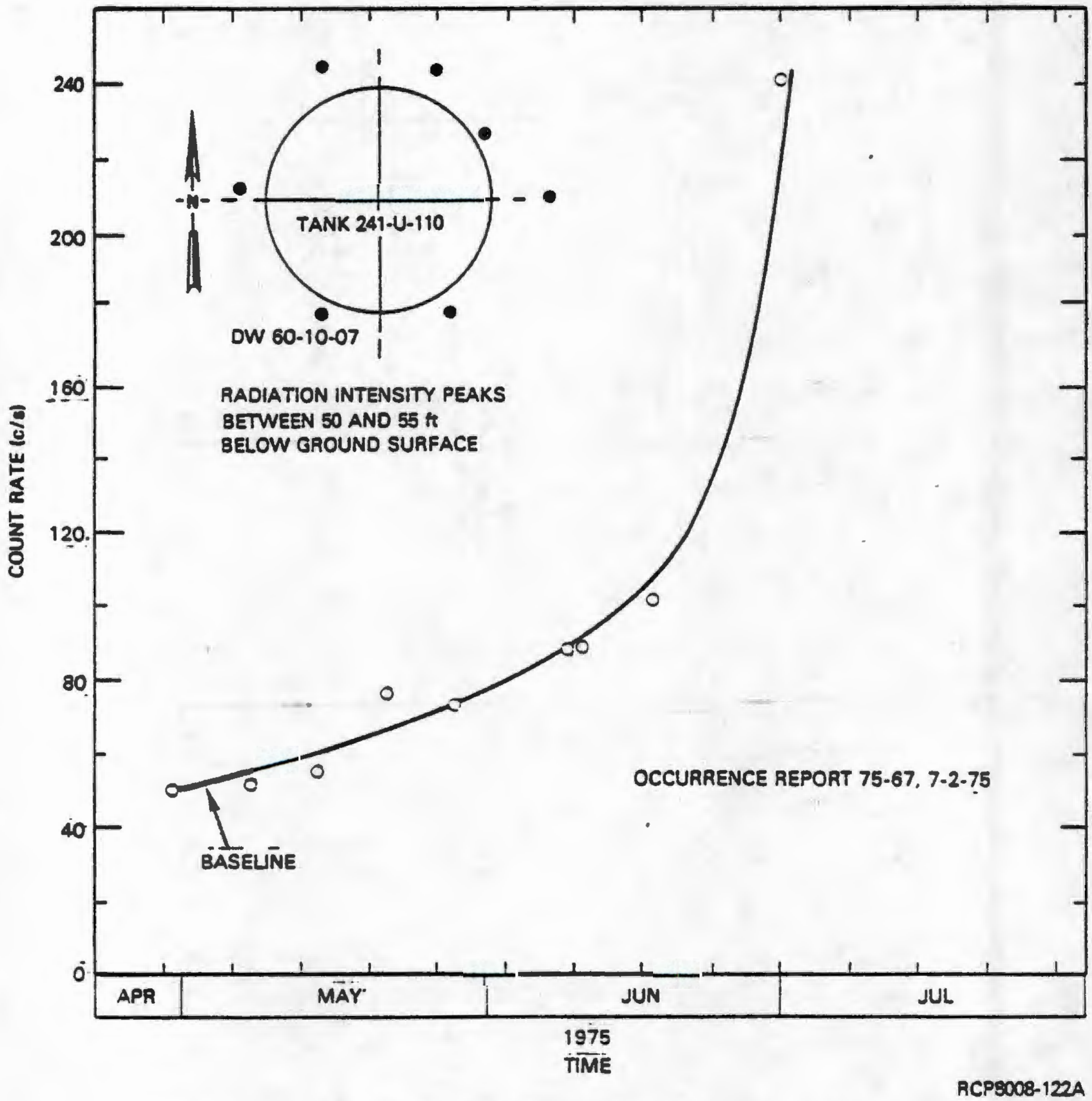


FIGURE D-28. Dry Well Monitoring Data for Tank 241-U-110.

May 19, 1981 65451-81-064

R. E. Isaacson
BWIP-Project Engineering
Peoples Bank Building/700 Area

L. Jensen
Statistics & Mathematics
2704S/200W
3-2475

Estimates of Leak Rates from Single Shell Tanks

Summary

We are 95% confident that at least 95% of the population of single shell tanks that will leak will have a leak rate less than 0.03 gallons/minute.

Table I of the Appendix lists the leak rates from six confirmed leaking tanks; Table II gives the postulated leak rates from seven tanks of a questionable integrity. Some summary statistics and confidence statements regarding the leak rate are listed in Table III. All of the data was not used to compute these summary statistics. The leak rates for Tanks 241-T-106 and 241-SX-110 were omitted.

Currently all of the single shell tanks are inactive, except for removal of supernatant and interstitial liquids. It is unlikely that these tanks will be subjected to sudden stress conditions. If this is true the most probable cause of a leak would be due to pitting corrosion or stress corrosion cracking. The confidence statements made in this letter are only applicable to inactive tanks not subjected to sudden stress conditions.

The leak rate data for tanks 241-T-106 and 241-SX-110 was not used in the summary statistics. These tanks were subjected to unusual conditions, e.g. sudden operational stresses, corrosion conditions, structural and construction inadequacies. The confidence statements are not applicable to tanks having undergone these type of severe conditions.

Table I has five usable pieces of data and Table II has six. Neither of these numbers of observations is adequate to make confidence statements regarding the leak rate. Consequently all usable data was combined. Table III gives two types of confidence statements, an upper confidence number and an upper tolerance number. The statements have the following interpretations (the data is rounded to two significant figures).

95% Confidence Interval: We are 95% confident that the true unknown leak rate in single shell tanks that will leak is less than 0.02 gallons per minute.

R. E. Isaacson
Page 2
May 19, 1981

95%/95% Tolerance Interval: We are 95% confident that at least 95% of the population of single shell tanks that will leak will have a leak rate less than 0.03 gallons per minute.

It is my belief that you should use 0.03, coming from the tolerance statements, as the best estimate of the leak rate.

The Appendix contains some statements regarding the computations and their limitations. If further interpretation is required, please contact me.

L. Jensen, Manager
Statistics & Mathematics Unit

LJ/pjm

cc: L. C. Brown

APPENDIX

Table I

Leak Rates from Confirmed Leaking Tanks

Tank Number	Leak Rate (gallons/minute)
241-B-201	0.005
241-B-107	0.011
241-C-101	0.019
241-U-112	0.020
241-U-110	0.023
*241-T-106	1.70

Table II

Postulated Leak Rates from Tanks of Questionable Integrity

Tank Number	Leak Rate (gallons/minute)
241-T-108	0.0015
241-T-111	0.002
241-TX-103	0.006
241-TX-107	0.006
241-TY-101	0.013
241-B-110	0.020
*241-SX-110	0.20

*Omitted from all computations

Table III

Summary Statistics from Table I and II

	$n^{(1)}$	$\overline{x}^{(2)}$	$s^{(3)}$	95% Confidence Statement	95%/95% Tolerance Statement
Table I	5	0.0156	0.0074	0.0227	0.0467
Table II	6	0.00808	0.0072	0.0140	0.0346
Table I & II	11	0.0115	0.0079	0.0158	0.0338

(1) n is the number of observations

(2) $\overline{x}$ is the sample mean

(3) s is the sample standard deviation

Computations

The upper confidence interval for the true unknown leak rate is $\overline{x} + ts/\sqrt{n}$, t is from a table of Student's-t distribution. It is a function of n and the desired confidence. The data is assumed to follow a normal distribution.

The upper tolerance statement is $\overline{x}$ + ks, k is tabulated. It is a function of n, the desired confidence, and the proportion of the population being predicted. The data is assumed to follow a normal distribution. The assumption of normality is more critical than for a confidence interval.

The data was tested for normality. The evidence against normality is not strong. I am comfortable believing the data is normally distributed.

The data in Table I and II was tested for equality of leak rates. There is no reason to believe that Table I and II are different. Statistically, it is justified to pool the data in the two tables.

THIS PAGE INTENTIONALLY
LEFT BLANK

APPENDIX E

ESTIMATED MAXIMUM AND MINIMUM TRAVEL TIMES FOR HYPOTHETICAL WASTE TANK LEAKS TO REACH RADIATION MONITORING DRY WELLS

R. C. Routson and J. B. Sisson

Estimated maximum and minimum travel times of waste solutions from waste tanks to their respective monitoring dry wells are listed in Table E-1. Maximum travel times for leaks from tanks with contents not generating large amounts of heat were estimated by measuring the longest distance from any point on the side of the tank to the nearest well. This measurement was determined from plan views of as-built drawings of Hanford Tank Farms (see Appendix A). High heat content tanks are listed in Reference 1. Minimum travel times for both high heat generation content tanks and non-high heat generation content tanks were estimated using a measurement of the shortest distance between tank and well from the Hanford Tank Farm plan view as-built drawings. The maximum travel times for high heat generation content tanks (Ref. 1, Table 13) were estimated using a measurement of the longest distance from any point on the side of the tank or the bottom center of the tank - whichever is longer. High heat generation content tanks include tanks 241-A-106 and 241-C-106 of this study (Ref. 1, Table 20). It is believed that leaks are more likely to be on the side of the tank rather than on the bottom of the tank due to the protection provided by the sludge over the tank bottom which restricts the movement of liquid to the tank bottom. In contrast, high heat generation content tanks may have been self boiling at some time in the past and may have ruptured or been weakened at the tank bottom.

The estimation of travel times was based on an unsaturated flow analysis of the Hanford Tank Farms soil system. This leak-flow system is essentially a displacement process where natural moisture is displaced by leaking fluid. Thus, inflow rate is controlled by the rate of leakage of the tank. The rate of migration (frontal movement of the leak), initially rapid near the tank, slows markedly with distance from

TABLE E-1. Estimated Maximum and Minimum Hanford High-Level Waste Liquid Travel Times Based on Selected Leak Rate Criteria and Associated High-Level Waste Tank Data. (Sheet 1 of 4)

Tank no.	Leak rate (gal/min)	Active or inactive	Distance		Distance		Supernate		Salt		Sludge	
			Maximum	Minimum	Maximum	Minimum						
			Ft	Days	Ft	Days	Gal x 10^3	In.	Gal x 10^3	In.	Gal x 10^3	In.
200 East												
101 A	0.03	Active	22	618	9.9	56	102	37	330	120	3	1
102 A	0.03	Active	22	618	9.9	56	453	165	8	3	8	3
103 A	0.03	Active	28	1,274	10	58	239	87	300	109	3	1
106 A	0.03	Active	25	907	11	77	613	224	0	0	50	18
101 AX	0.03	Active	23	706	8.0	30	13	5	3	1	597	217
103 AX	0.03	Active	25	907	7.7	26	882	322	6	2	0	0
103 B	0.03	Inactive	32	1,902	6.7	17	24	9	68	20	0	0
104 B	0.03	Inactive	47	6,025	6.5	16	14	5	94	34	301	105
105 B	0.03	Inactive	40	3,714	9.6	51	0	0	253	92	40	10
106 B	0.03	Inactive	51	7,698	6.1	13	14	5	0	0	125	41
107 B	0.0022	Inactive	34	31,000	4.5	72	0	0	0	0	194	65
108 B	0.03	Inactive	37	2,939	6.2	14	33	12	70	21	0	0
109 B	0.03	Inactive	44	4,943	4.4	5	14	5	120	39	0	0
110 B	0.0071	Inactive	29	6,000	8.0	125	0	0	0	0	282	98
111 B	0.0048	Inactive	41	25,000	13	800	3	1	0	0	246	85
104 BX	0.03	Active	31	1,729	5.0	7	36	13	3	1	133	44
105 BX	0.03	Active	33	2,084	4.7	6	99	36	8	3	65	19
109 BX	0.0032	Inactive	30	15,000	7.1	360	0	0	0	0	208	71
110 BX	0.0016	Inactive	32	36,000	6.3	272	2	1	12	4	188	64
111 BX	0.03	Inactive	35	2,488	6.3	15	22	8	143	52	67	20
112 BX	0.03	Inactive	30	1,567	6.3	15	0	0	0	0	169	57
101 BY	0.03	Inactive	41	3,400	5.0	7	8	3	330	120	109	47
102 BY	0.03	Inactive	32	1,902	6.4	15	0	0	0	0	417	159
103 BY	0.03	Inactive	31	1,729	6.4	15	3	2	459	172	2	2
104 BY	0.03	Inactive	31	1,729	6.4	15	11	4	580	211	43	23
105 BY	0.03	Inactive	41	4,000	6.4	15	0	0	539	196	86	39
106 BY	0.03	Inactive	32	1,902	5.5	10	0	0	532	193	94	--

9 2 1 2 4 9 9 1 7 5 5

TABLE E-1. Estimated Maximum and Minimum Hanford High-Level Waste Liquid Travel Times Based on Selected Leak Rate Criteria and Associated High-Level Waste Tank Data. (Sheet 2 of 4)

Tank no.	Leak rate (gal/min)	Active or inactive	Distance Maximum	Minimum	Distance Maximum	Minimum	Supernate		Salt		Sludge	
			Ft	Days	Ft	Days	Gal x 10^3	In.	Gal x 10^3	In.	Gal x 10^3	In.
200 East (Cont.)												
108 BY	0.03	Inactive	31	1,729	6.4	15	0	0	181	66	178	72
109 BY	0.03	Inactive	25	907	4.9	7	33	12	355	129	78	36
110 BY	0.03	Inactive	33	2,085	6.4	15	3	1	382	139	123	52
111 BY	0.03	Inactive	35	2,488	6.4	15	0	0	589	214	26	17
112 BY	0.03	Inactive	30	1,561	7.5	24	0	0	294	107	15	13
102 C	0.024	Inactive	63	18,000	14.2	200	0	0	0	0	431	152
103 C	0.03	Inactive	30	1,567	6.0	13	25	9	0	0	175	59
104 C	0.03	Inactive	33	2,085	5.1	8	22	8	0	0	293	102
105 C	0.03	Inactive	38	3,184	6.1	13	22	8	0	0	150	50
106 C	0.03	Inactive	31	1,729	6.7	17	22	8	0	0	197	67
107 C	0.0042	Inactive	33	15,000	6.4	108	0	0	0	0	337	118
110 C	0.0035	Inactive	36	23,000	7.9	250	0	0	0	0	211	72
112 C	0.01	Inactive	37	9,000	6.0	38	0	0	0	0	109	35
200 West												
101 S	0.03	Active	28	637	8.6	18	379	138	89	32	243	96
102 S	0.03	Active	32	951	7.7	13	99	36	11	4	499	189
103 S	0.03	Active	30	783	8.4	17	522	190	146	56	7	7
104 S	0.0041	Inactive	37	11,000	8.0	110	0	0	0	0	299	116
105 S	0.03	Inactive	30	783	8.4	17	0	0	485	182	3	3
106 S	0.03	Inactive	29	708	7.7	13	0	0	581	211	31	19
107 S	0.03	Active	29	708	8.6	18	107	39	314	114	29	18
108 S	0.03	Inactive	32	951	5.5	4.8	0	0	607	226	4	4
109 S	0.03	Inactive	28	637	7.7	13	0	0	555	202	13	12
110 S	0.03	Inactive	34	1,140	6.4	8	0	0	561	204	131	55
111 S	0.03	Inactive	31	864	8.4	17	0	0	484	176	139	58
112 S	0.03	Inactive	33	1,043	7.7	13	0	0	668	247	5	5
101 SX	0.03	Active	33	1,043	5.2	4	314	124	275	100	128	52

TABLE E-1. Estimated Maximum and Minimum Hanford High-Level Waste Liquid Travel Times Based on Selected Leak Rate Criteria and Associated High-Level Waste Tank Data. (Sheet 3 of 4)

Tank no.	Leak rate (gal/min)	Active or inactive	Distance Maximum Ft	Distance Minimum Days	Distance Maximum Ft	Distance Minimum Days	Supernate Gal x 10^3	Supernate In.	Salt Gal x 10^3	Salt In.	Sludge Gal x 10^3	Sludge In.
200 West (Cont.)												
102 SX	0.03	Active	29	708	6.4	8	349	127	380	138	117	48
103 SX	0.03	Active	26	510	5.6	5	22	8	602	219	112	46
104 SX	0.03	Active	29	708	5.4	5	195	71	586	213	170	67
105 SX	0.03	Active	27	571	9.7	26	143	52	668	243	73	32
106 SX	0.03	Active	31	864	6.4	8	173	63	76	30	11	7
101 T	0.03	Inactive	35	1,244	5.5	5	28	10	0	0	103	33
104 T	0.03	Inactive	31	864	7.8	14	0	0	0	0	483	171
105 T	0.03	Inactive	31	864	7.1	10	0	0	0	0	115	37
107 T	0.03	Inactive	41	2,000	5.5	5	11	4	0	0	167	56
110 T	0.03	Inactive	47	3,012	9.0	21	0	0	0	0	466	165
111 T	0.03	Inactive	26	510	8.1	15	0	0	0	0	488	173
102 TX	0.03	Inactive	29	708	6.7	9	0	0	334	129	0	0
103 TX	0.03	Active	36	1,354	5.5	5	484	177	0	0	145	60
105 TX	0.03	Inactive	30	783	6.1	7	0	0	609	229	0	0
106 TX	0.03	Inactive	30	783	8.2	16	0	0	453	172	0	0
108 TX	0.03	Inactive	35	1,244	10.6	35	0	0	131	55	0	0
109 TX	0.03	Inactive	36	1,354	5.8	6	0	0	450	171	0	0
110 TX	0.03	Inactive	28	637	5.7	5	0	0	530	200	0	0
111 TX	0.03	Inactive	36	1,354	10.0	29	33	12	370	142	0	0
112 TX	0.03	Inactive	31	864	6.8	9	9	3	664	249	0	0
113 TX	0.03	Inactive	48	3,209	6.3	7	0	0	681	225	0	0
114 TX	0.03	Inactive	39	1,721	5.9	6	0	0	645	242	0	0
115 TX	0.03	Inactive	41	2,000	6.5	8	0	0	640	240	0	0
116 TX	0.03	Inactive	44	2,472	9.6	26	0	0	631	237	0	0
117 TX	0.03	Inactive	42	2,150	10.7	36	0	0	626	235	0	0
118 TX	0.03	Active	27	571	6.4	8	275	100	340	131	0	0

TABLE E-1. Estimated Maximum and Minimum Hanford High-Level Waste Liquid Travel Times Based on Selected Leak Rate Criteria and Associated High-Level Waste Tank Data. (Sheet 4 of 4)

Tank no.	Leak rate (gal/min)	Active or inactive	Distance		Distance		Supernate		Salt		Sludge	
			Maximum	Minimum	Maximum	Minimum						
			Ft	Days	Ft	Days	Gal x 10^3	In.	Gal x 10^3	In.	Gal x 10^3	In.
200 West (Cont.)												
105 TY	0.0093	Inactive	44	8,000	10	95	0	0	0	0	285	110
102 U	0.03	Inactive	26	510	4.9	3	0	0	336	122	42	11
103 U	0.03	Inactive	30	783	10.9	38	42	15	380	138	32	7
105 U	0.03	Inactive	37	1,470	7.8	14	25	9	349	127	32	7
106 U	0.03	Inactive	28	637	10.8	37	16	6	185	67	26	5
107 U	0.03	Active	39	1,721	8.2	16	242	88	140	51	15	1
108 U	0.03	Inactive	30	783	12.2	53	17	6	415	151	29	6
109 U	0.03	Inactive	29	708	10.4	33	11	4	396	144	48	--
110 U	0.00069	Inactive	29	31,000	6.1	290	0	0	0	0	161	54
111 U	0.03	Active	34	1,140	7.2	11	116	42	355	129	26	5

the leak due to spreading of the leaking fluid and the rapidly decreasing capillary potential. Since this is a displacement process, flow will cease when the natural moisture content of the sediments equals that of the leak. At that time, there is no longer any driving force and frontal movement will cease. To estimate how much time is required to reach a specific distance, an estimate of how long it will take a leak to supply enough liquid to equal the natural moisture content of the sediments over the distance of interest is required.

To estimate travel times for given distances, the geometry of the plume and the natural soil moisture content must be approximated. Tank leaks in the 200 East Area tend to approach spheres although the depth of penetration often slightly exceeds the lateral extent. This is probably an effect of gravitational forces. The plume geometry in the 200 West Area was assumed to be represented by an oblate spheroid with the depth axis equal to 1/2 the lateral axis of an ellipse. The soils and sediments are markedly layered in the 200 West Area which results in about twice the lateral spreading as compared to depth penetration.[2,3] The natural moisture content of the sediments ranges from 5 to 10 vol%.[4,5] Moisture contents were measured for this study in each tank farm (see Appendix F). The data are summarized and listed in Table E-2. These values were used in the calculations. A sample calculation is presented below for Tank 241-A-101.

(Wetted Volume Maximum Case)

$$V = 4/3\pi(24)^3(7.48) = 4.33 \times 10^5 \text{ gal}$$

where

r = maximum distance from the steel liner of the tank to any well (24 ft)

7.48 converts cubic feet to gallons

Equilibrium moisture is 8 vol% = $(0.08)(4.330 \times 10^5)$ = 3.5×10^4 gal.

Time to reach the distance r is the same as the time it takes to leak that volume of moisture into the system, assuming a leak rate of 0.03 gal/min (see below):

$$T = \frac{3.5 \times 10^4}{(0.03\ \text{gal/min})(60\ \text{min/hr})(24\ \text{hr/day})} = 800\ \text{days}$$

To determine if the above method of estimating is reasonable, the estimate was compared with the 241-T-106 leak. This method gave a good estimate of the time required for the leak to reach the initial dry well.

TABLE E-2. Average Moisture Content of Hanford Tank Farms.[a]

Tank farm	Volumetric moisture content (rounded 0.05%)		Average
	Depth 1[b]	Depth 2[b]	
A	11.0	5.0	8.0
AX	12.5	7.0	9.5
B	10.0	7.0	8.5
BX	9.0	8.0	8.5
BY	10.0	6.0	8.0
C	9.5	5.0	7.0
S	12.5	11.0	12.0
SX	12.5	6.5	8.5
T	12.0	8.5	10.0
TX	9.0	7.0	8.0
TY	10	6.5	8.0
U	12	8.5	10.0
		Average	9.0

[a]Each value is the average of a reading from each of five wells within each tank farm.

[b]Depths represent the centers of two major sediment types within each well as determined from granulometric data.

To estimate the time required for the fluid from a tank leak to travel to a dry well, two leak rates were assumed: one for tanks that contained more than 2 ft of salt cake after January 1, 1981; and one for tanks that contained mostly sludge after January 1, 1981.

For tanks that contained more than 2 ft of salt cake on January 1, 1981, a maximum probable leak rate of 0.03 gal/min (43 gal/day) was used. A calculation was made to determine if the soil permeability would restrict the above flow rate.(6) The calculation for Tank 241-AX-101 is provided below:

$$q = 2.75\ K_m D H_c$$

$$q = 2.75(100)(0.500)(521) = 7.3 \times 10^4\ cm^3/hr = 0.32\ gal/min$$
$$= 460\ gal/day = 62\ ft^3/day$$

where

q = flow rate of solution (in cm^3/hr)

K_m = soil permeability in cm/hr estimated from field infiltration measurements

D = diameter of the rupture in cm--estimated for the 241-T-106 tank leak(7)

H_c = head in cm for Tank 241-AX-101.

This result indicates that the diameter of the hypothetical 241-AX-101 Tank rupture could be more than 5 times larger, based on the apparent size of the rupture estimated for the 241-T-106 Tank leak, before soil permeability would become a constraint on the waste leak flow rate.

For tanks that contained sludge as the principal constituent on January 1, 1981, D'Arcy's formula was used to determine if the low permeability sludge would support a flow rate as high as 0.03 gal/min. If not, the lower, calculated flow rate was used. The specific gravities of the tank solution were estimated by the Tank Farms Processing Operations Group (C. M. Walker and J. W. Bailey) and are listed in Table E-3.

TABLE E-3. Estimated Specific Gravity and Viscosity of Selected Hanford High-Level Waste Tanks. (Sheet 1 of 3)

Tank number	Specific gravity (γ)	Estimated viscosity (μ) centipose
101 A	1.5	10.4
102 A	1.5	10.6
103 A	1.5	9.1
106 A	1.4	9.3
101 AX	1.3	8.6
103 AX	1.4	10.2
104 B	1.2	3.3
105 B	1.2	3.3
106 B	1.15	3.3
107 B	1.15	3.3
108 B	1.15	3.3
109 B	1.15	3.3
111 B	1.15	3.3
104 BX	1.2	3.2
105 BX	1.2	3.2
109 BX	1.15	3.0
110 BX	1.3	6.8
111 BX	1.3	6.8
112 BX	1.3	6.8
101 BY	1.4	10.2
102 BY	1.4	10.2
103 BY	1.4	10.6
104 BY	1.4	6.1
105 BY	1.4	6.0
106 BY	1.4	6.0
108 BY	1.4	9.8
109 BY	1.15	3.0
110 BY	1.4	7.8
111 BY	1.4	10.2
112 BY	1.4	10.2

TABLE E-3. Estimated Specific Gravity and Viscosity of Selected Hanford High-Level Waste Tanks. (Sheet 2 of 3)

Tank number	Specific gravity (γ)	Estimated viscosity (μ) centipose
102 C	1.15	3.0
103 C	1.15	2.5
104 C	1.15	2.5
105 C	1.15	2.4
106 C	1.15	2.4
107 C	1.15	3.8
109 C	1.15	3.0
110 C	1.15	2.8
112 C	1.15	2.4
101 S	1.4	10.4
102 S	1.4	10.6
103 S	1.4	10.6
105 S	1.4	10.6
106 S	1.4	10.6
107 S	1.4	6.9
108 S	1.4	10.1
109 S	1.4	8.9
110 S	1.4	5.2
111 S	1.4	10.3
112 S	1.4	6.9
101 SX	1.0	1.0
102 SX	1.4	3.1
103 SX	1.4	3.0
104 SX	1.4	2.9
105 SX	1.4	2.9
106 SX	1.4	10.2
101 T	1.2	3.0
104 T	1.15	2.4
105 T	1.2	3.0
107 T	1.2	3.0

TABLE E-3. Estimated Specific Gravity and Viscosity of Selected Hanford High-Level Waste Tanks. (Sheet 3 of 3)

Tank number	Specific gravity (γ)	Estimated viscosity (μ) centipose
110 T	1.2	3.0
111 T	1.2	3.0
102 TX	1.3	5.6
103 TX	1.3	6.6
105 TX	1.3	3.8
106 TX	1.3	5.8
108 TX	1.15	3.1
109 TX	1.15	2.9
110 TX	1.3	4.8
111 TX	1.3	5.5
112 TX	1.3	6.6
113 TX	1.3	5.5
114 TX	1.3	5.5
115 TX	1.3	6.6
116 TX	1.3	6.1
117 TX	1.3	6.6
118 TX	1.2	5.2
105 TY	1.15	3.4
102 U	1.4	6.8
103 U	1.4	6.4
105 U	1.4	6.6
106 U	1.4	6.6
107 U	1.4	6.8
108 U	1.4	6.6
109 U	1.4	6.6
110 U	1.4	6.6
111 U	1.4	6.8

The sludge permeability (K) was assumed to be 0.1 Darcies (D). The value is approximately an order of magnitude below that of the salt cake.

D'Arcy's formula is as follows:

$$q = \frac{64.4\ K\gamma H_e^2}{\mu \ln\left(\frac{r_e}{r_r}\right) - 0.5}$$

where

q = leak rate in gal/day

K = permeability of solids (salt cake or sludge) in D

γ = specific gravity of interstitial liquid

μ = viscosity in centipoise

r_e = radius of tank (ft)

r_r = radius of rupture (ft)

H_e = height of interstitial liquid at tank wall calculated in ft.

A sample calculation for Tank 241-B-107 (Table E-1) is listed below:

$$q = \frac{(64.4)(0.1)(1.15)(3.4)^2}{(3.3)\ \ln\left(\frac{37.5}{0.0077}\right) - 0.5} = 3.1 \text{ gal/day} = 0.0022 \text{ gal/min}$$

where

$K = 0.1$ (7)

γ = 1.15 (from Table E-2)

μ = 3.3 (from Table E-2)

$r_e = \frac{75}{2} = 37.5$ ft

r_r = 0.0077 ft

H_e = 3.4 ft (from Table E-1)

Individual figures are provided for each of the tanks.

REFERENCES

1. Catlin, R. J., Assessment of the Surveillance Program of the High-Level Waste Storage Tank at Hanford, U.S. Department of Energy, Washington, D.C. (1980).

2. Routson, R. C., W. H. Price, D. J. Brown, and K. R. Fecht, High-Level Waste Leakage from the 241-T-106 Tank at Hanford, RHO-ST-14, Rockwell Hanford Operations, Richland, Washington (1979).

3. Brown, D. J., R. C. Routson, W. H. Price, and K. R. Fecht, Status of Liquid Waste Leaked from the 241-T-106 Tank, RHO-ST-1, Rockwell Hanford Operations, Richland, Washington (1979).

4. Routson, R. C. and K. R. Fecht, Soil (Sediment) Properties of Twelve Hanford Wells with Geologic Interpretation, RHO-LD-82, Rockwell Hanford Operations, Richland, Washington (1980).

5. Hsieh, J. J., A. E. Reisenauer, and L. E. Brownell, A Study of Soil Water Potential and Temperature in Hanford Soils, BNWL-1712, Pacific Northwest Laboratories, Richland, Washington (1973).

6. U.S. Army Corps of Engineers Staff, Time Lag and Soil Permeability in Ground-Water Observations, Bulletin 36, Waterway Experiment Station, Vicksbury, Mississippi (1951).

7. Kirk, J. J., Permeability, Porosity and Capillarity of Hanford Waste Material and Its Limits of Pumpability, RHO-CD-925, Rockwell Hanford Operations, Richland, Washington (1980).

THIS PAGE INTENTIONALLY
LEFT BLANK

APPENDIX F

SOIL MOISTURE CONTENT OF HANFORD TANK FARMS

V. W. Hall, E. J. Rink, and R. C. Routson

Soil moisture was measured in five selected radiation monitoring dry wells in each tank farm. The wells were selected near the four corners and near the center of each tank farm. Measurements were made with a Campbell Pacific Hydroprobe,* Model 503. The data are provided for various depths by well number for each tank farm in Tables F-1 through F-12.

Four wells in T Tank Farm, W-10-104, -128, -137, and -148, at depths of 100 ft (90 ft for Well 104) gave high readings indicating presence of water in the bottom of these wells.

The hydroprobes were calibrated in the 200 East Area calibration facility in containers of soil having fixed moisture contents of 0, 5, 10, and 15 vol%. The calibration containers of soil are 36 in. in diameter with a standard 6-in. well casing in the center. Construction details are provided in Drawing H-2-35011. Calibration data are given in Tables F-13 and F-14 and are plotted in Figures F-1 and F-2.

*Registered trade name.

TABLE F-1. Soil Moisture Data for 241-A Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(E 24-71) 10-01-08	30	8,030	0.218	12.5
	60	4,347	0.118	4.5
	105	5,166	0.140	6.2
Well depth >128 ft	128	11,488	0.312	21.2
(E 24-71) 10-01-08	30	7,044	0.191	10.2
	60	4,916	0.133	5.6
Well depth ∿124 ft	105	6,048	0.164	8.0
(E 25-70) 10-05-05	30	7,534	0.205	11.4
	60	5,466	0.148	6.7
Well depth 74 ft				
(E 25-74) 10-06-02	30	7,156	0.194	10.5
	60	4,094	0.111	4.0
	105	5,065	0.138	6.0
Well depth >128 ft	128	5,815	0.158	7.5
(E 25-80) 10-03-04	30	6,489	0.176	9.0
	60	5,114	0.139	6.0
Well depth 124.5 ft	105	5,523	0.150	6.8

NOTE: Date: 08-12-80

TABLE F-2. Soil Moisture Data for 241-AX Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(E 25-117) 11-03-10	35	8,364	0.227	13.4
	65	6,289	0.171	8.5
Well depth 100 ft	85	5,780	0.157	7.5
(E 25-122) 11-04-08	35	8,033	0.218	12.4
	65	4,235	0.123	4.8
Well depth 100 ft	85	5,448	0.148	6.7
(E 25-127) 11-02-22	35	7,957	0.216	12.3
	65	6,020	0.163	7.9
Well depth 100 ft	85	3,924	0.106	3.6
(E 25-100) 11-01-02	35	7,964	0.216	12.3
	65	5,399	0.147	6.6
Well depth 100 ft	85	5,598	0.152	7.1
(E 25-107) 11-02-04	35	8,100	0.220	12.7
	65	5,667	0.154	7.2
Well depth 100 ft	85	5,855	0.159	7.6

NOTE: Date: 08-12-80
Time: 1345

TABLE F-3. Soil Moisture Data for 241-B Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(E 33-203) 20-12-07	30	6,473	0.175	8.8
	45	5,311	0.143	6.3
	60	5,812	0.157	7.5
Well depth 100 ft	80	5,364	0.145	6.5
(E 33-215) 20-10-09	30	6,360	0.172	8.6
	45	4,830	0.130	5.3
	60	6,050	0.163	8.0
Well depth 135 ft	80	7,120	0.192	10.3
(E 33-193) 20-08-03	30	7,641	0.206	11.4
	45	6,064	0.164	8.1
	60	5,763	0.156	7.4
Well depth 135 ft	80	7,507	0.203	11.2
(E 33-185) 20-03-03	30	7,415	0.200	11.0
	45	6,406	0.173	8.8
	60	4,129	0.112	4.1
Well depth 100 ft	80	5,925	0.160	7.7
(E 33-220) 20-01-03	30	6,915	0.187	9.8
	45	5,687	0.154	7.2
	60	5,838	0.158	7.5
Well depth 135 ft	80	5,493	0.148	6.7

NOTE: Date: 08-14-80

TABLE F-4. Soil Moisture Data for 241-BX Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(E 33-155) 21-12-07	30	6,783	0.183	9.6
	50	6,616	0.179	9.2
Well depth 100 ft	75	5,034	0.136	6.0
(E 33-170) 21-10-11	30	6,566	0.177	9.0
	50	5,587	0.151	7.0
Well depth 100 ft	75	5,200	0.140	6.2
(E 33-234) 21-08-04	30	5,830	0.157	7.5
	50	6,913	0.187	9.9
Well depth 100 ft	75	4,461	0.120	4.6
(E 33-239) 21-08-03	30	6,795	0.183	9.6
	50	5,912	0.160	7.7
Well depth 100 ft	75	9,267	0.250	15.4
(E 33-144) 21-01-01	30	6,840	0.185	9.6
	50	5,944	0.160	7.7
Well depth 100 ft	75	5,339	0.144	6.4

NOTE: Standard count: 36727-36907-37475
Average: 37036
Date: 08-14-80
Time: 0940
Weather: Clear, 80°

TABLE F-5. Soil Moisture Data for 241-BY Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(E 33-97) 22-12-07	30	6,979	0.188	10.0
	60	5,195	0.140	6.2
	80	5,243	0.142	6.3
Well depth 100 ft	100	4,884	0.132	5.6
(E 33-125) 22-10-10	30	7,136	0.193	10.3
	60	7,721	0.208	11.5
	80	6,994	0.189	9.8
Well depth 100 ft	100	6,283	0.170	8.6
(E 33-111) 22-05-09	30	7,841	0.212	11.9
	60	5,276	0.142	6.3
	80	5,391	0.146	6.5
Well depth 98 ft				
(E 33-211) 22-03-04	30	6,654	0.180	9.3
	60	4,795	0.129	5.3
	80	4,621	0.125	4.9
Well depth 100 ft	100	6,326	0.171	8.6
(E 33-176) 22-01-01	30	6,685	0.181	9.5
	60	5,356	0.145	6.4
	80	5,110	0.138	5.9
Well depth 98 ft				

NOTE: Date: 08-14-80

TABLE F-6. Soil Moisture Data for 241-C Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(E 27-109) 30-12-04	30	6,695	0.181	9.3
	45	5,199	0.140	6.2
	65	5,335	0.144	6.4
Well depth 100 ft	80	5,619	0.152	7.0
(E 27-104) 30-10-11	30	7,193	0.194	10.5
	45	4,385	0.118	4.5
	65	5,136	0.139	6.1
Well depth 100 ft	80	5,366	0.145	6.5
(E 27-68) 30-05-10	30	6,552	0.177	9.1
	45	3,871	0.105	3.6
	65	5,113	0.138	6.0
Well depth 135 ft	80	5,736	0.155	7.3
(E 27-76) 30-03-05	30	7,044	0.190	10.1
	45	4,486	0.121	4.7
	65	5,023	0.136	5.7
Well depth 100 ft	80	5,503	0.149	6.8
(E 27-60) 30-01-01	30	6,665	0.180	9.3
	45	4,848	0.131	5.4
	65	4,758	0.128	5.2
Well depth 100 ft	80	6,674	0.180	9.3

NOTE: Standard count: 36712-37148-37298
Average: 37053
Date: 08-13-80
Time: 1005
Weather: Clear, 80°

TABLE F-7. Soil Moisture Data for 241-S Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(W 23-180) 40-01-10	30	7,255	0.197	10.6
	50	7,042	0.191	10.1
Well depth 98 ft	60	6,376	0.173	8.7
(W 23-151) 40-03-01	30	7,754	0.211	11.8
	50	9,041	0.245	15.0
Well depth 99 ft	60	5,112	0.139	6.1
(W 23-155) 40-05-07	30	8,295	0.225	13.3
	50	8,066	0.219	12.7
Well depth 97.5 ft	60	4,571	0.124	4.9
(W 23-169) 40-10-06	30	8,513	0.231	13.6
	50	5,527	0.150	6.9
	60	6,291	0.171	8.7
	130	10,979	0.298	19.9
Well depth >140 ft	140	8,712	0.237	14.2
(W 23-175) 40-12-06	30	8,151	0.221	12.7
	50	6,823	0.185	9.7
	60	8,136	0.220	12.6
	130	7,891	0.214	12.2
Well depth >140 ft	140	6,320	0.172	8.6

NOTE: Standard count: 36772-36819-36891
Average: 36827
Date: 08-12-80
Time: 0900
Weather: Clear, 80°

TABLE F-8. Soil Moisture Data for 241-SX Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(W 23-192) 41-01-11[a]	30	7,161	0.211	11.8
	60	4,544	0.134	5.7
Well depth 100 ft[a]	85	7,370	0.217	12.3
(W 23-137) 41-03-12[a]	30	7,325	0.216	12.3
	60	5,837	0.172	8.8
	85	5,510	0.162	8.0
Well depth >130 ft[a]	130	7,764	0.229	13.5
(W 23-99) 41-08-06[b]	30	8,669	0.238	14.3
	60	4,623	0.127	5.0
	85	6,195	0.170	8.5
Well depth >130 ft[b]	130	11,232	0.309	20.9
(W 23-86) 41-14-03[b]	30	8,212	0.226	13.4
	60	7,321	0.201	11.1
Well depth 75 ft[b]				
(W 23-119) 41-15-05[b]	30	7,940	0.218	12.4
	60	9,924	0.273	17.6
Well depth 75 ft[b]				

NOTE: Standard count: 36429-36355-36297
Average: 36360

[a]Data taken on 08-08-80.

[b]Data taken on 08-11-80. New probe used.

TABLE F-9. Soil Moisture Data for 241-T Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(W 10-153) 50-11-10	30	8,464	0.250	15.4
	60	8,754	0.258	16.2
	75	7,070	0.208	11.5
	85	6,506	0.192	10.2
Well depth 100 ft	95	9,493	0.280	18.2
(W 10-137) 50-10-10	30	7,205	0.212	11.9
	60	6,128	0.181	9.3
	75	6,545	0.193	10.4
	85	7,956	0.235	14.1
Well depth 100 ft	95	14,701	0.434	>25.0
(W 10-128) 50-03-10	30	5,175	0.153	7.1
	60	5,964	0.176	8.9
	75	6,103	0.180	9.3
	85	10,682	0.315	21.5
Well depth 100 ft in water	95	19,629	0.579	>25.0
(W 10-148) 50-04-08	30	7,290	0.215	12.3
	60	4,950	0.146	6.5
	75	7,105	0.210	11.8
	85	8,710	0.257	16.0
Well depth 100 ft	95	12,324	0.363	>25.0
(W 10-104) 50-01-12	30	5,420	0.160	7.7
	60	6,097	0.180	9.3
	75	5,308	0.157	7.5
	85	9,536	0.281	18.3
Well depth 90 ft in water ~3 in.				

NOTE: Standard count: 33729-34046-33952
1-1/2-in. depth probe
Average: 33909
Date: 08-07-80
Time: 1030
Weather: Clear, 80°
Depth is from ground level

TABLE F-10. Soil Moisture Data for 241-TX Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(W 15-130) 51-04-05	30	5,509	0.162	7.8
	60	5,063	0.149	6.9
	85	5,410	0.160	7.7
Well depth 100 ft	95	6,810	0.201	11.1
(W 15-169) 51-01-08	30	6,028	0.178	9.0
	65	4,914	0.145	6.5
	85	4,763	0.140	6.2
Well depth 100 ft	95	4,768	0.141	6.2
(W 15-158) 51-06-12	30	6,270	0.185	9.6
	65	5,235	0.154	7.2
	85	6,543	0.193	10.4
Well depth 100 ft	95	4,979	0.147	6.6
(W 15-181) 51-18-01	30	6,510	0.192	10.2
	65	5,490	0.162	7.8
	85	5,590	0.165	8.1
Well depth 100 ft	95	5,876	0.173	8.7
(W 15-162) 51-16-11	30	6,097	0.180	9.3
	65	5,448	0.161	7.7
	85	5,180	0.153	7.1
Well depth 100 ft	95	6,754	0.199	11.0

NOTE: Standard count: 34054-33888-33766
Average: 33903
Date: 08-08-80
Time: 0925
Weather: Cloudy, 75°

TABLE F-11. Soil Moisture Data for 241-TY Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(W 15-184) 52-06-06	30	5,981	0.176	8.9
	60	4,678	0.138	6.0
	90	5,541	0.163	7.9
Well depth 100 ft	95.5	8,750	0.258	16.2
(W 15-186) 52-05-07	30	5,860	0.173	8.7
	60	4,866	0.144	6.4
	90	5,238	0.154	7.2
Well depth 100 ft	95.5	6,231	0.184	9.6
(W 10-83) 52-04-03	30	5,368	0.158	7.5
	60	8,814	0.260	16.1
	90	6,088	0.180	9.3
Well depth 150 ft	95.5	9,082	0.268	17.0
(W 10-91) 52-02-01	30	7,909	0.233	13.9
	60	5,415	0.160	7.7
	90	4,781	0.141	6.2
Well depth 100 ft	95.5	10,280	0.303	20.4
(W 10-88) 52-01-01	30	6,602	0.195	10.5
	60	4,889	0.144	6.4
	90	5,774	0.170	8.5
Well depth 100 ft	95.5	10,967	0.323	22.2

NOTE: Date: 08-07-80

9212491778

TABLE F-12. Soil Moisture Data for 241-U Tank Farm.

Well number	Depth (ft)	Counts	Ratio	Moisture (vol%)
(W 18-92) 60-12-05	30	6,764	0.200	11.1
	45	6,323	0.187	9.9
	75	6,391	0.189	10.0
Well depth 98.5 ft	98	7,520	0.222	12.8
(W 18-148) 60-10-07	30	6,923	0.204	11.3
	45	6,225	0.184	9.5
	75	6,541	0.193	10.4
Well depth 121 ft	98	7,197	0.212	11.9
(W 18-127) 60-05-05	30	7,545	0.223	12.9
	45	5,540	0.163	7.9
	75	5,005	0.148	6.7
Well depth 123.6 ft	98	6,658	0.196	10.8
(W 18-143) 60-03-01	30	6,278	0.185	9.7
	45	5,391	0.158	7.3
	75	6,639	0.196	10.8
Well depth 100 ft	98	7,668	0.226	13.4
(W 18-136) 60-01-10	30	7,700	0.227	13.4
	45	5,826	0.172	8.6
	75	6,424	0.189	10.0
Well depth 100 ft	97	8,343	0.246	15.0

NOTE: Date: 08-08-80

TABLE F-13. 200 East Area Calibration Facility, August 13, 1980.

Hole	Standard (%)	Depth (ft)	Count	Average count	Ratio
00-04					
A	0	4.5	1) 1,713 2) 1,697 3) 1,677	1,696	0.046
B	5	9	1) 4,997 2) 4,970 3) 5,029	4,965	0.134
C	10	13.5	1) 6,793 2) 6,843 3) 6,808	6,815	0.184
D	15	18	1) 9,298 2) 9,246 3) 9,227	9,257	0.249
00-05					
B	5	3	1) 4,347 2) 4,483 3) 4,352	4,394	0.118
	5	5	1) 4,808 2) 4,846 3) 4,775	4,810	0.130
	5	7	1) 4,528 2) 4,670 3) 4,655	4,618	0.124
00-06					
	10	4	1) 7,159 2) 7,196 3) 7,110	7,155	0.193
00-07					
	15	4	1) 9,167 2) 9,186 3) 9,121	9,158	0.247

NOTE: 1-1/2-in. Hydroprobe H38092509 Model 503, Probe 2510
Standard count: 36712-37148-37298-37339-37190-37097
Average: 37131
Weather: Clear, 88°
Time: 1335

TABLE F-14. 200 East Area Calibration Facility, May 9, 1980.

Hole	Standard (%)	Depth (ft)	Count	Average count	Ratio
00-04					
A	0	4.5	1) 1,486 2) 1,482 3) 1,520	1,496	0.044
B	5	9	1) 4,578 2) 4,589 3) 4,565	4,577	0.135
C	10	13.5	1) 6,088 2) 6,015 3) 6,114	6,072	0.179
D	15	18	1) 8,204 2) 8,429 3) 8,137	8,257	0.243
00-05					
B	5	3	1) 4,067 2) 4,034 3) 4,117	4,073	0.120
	5	5	1) 4,212 2) 4,275 3) 4,219	4,235	0.125
	5	7	1) 4,214 2) 4,197 3) 4,115	4,175	0.123
00-06					
	10	4	1) 6,584 2) 6,482 3) 6,595	6,554	0.193
00-07					
	15	4	1) 8,347 2) 8,309 3) 8,210	8,289	0.244

NOTE: 1-1/2-in. Hydroprobe H38092509 Model 503
Standard count: 33951-33723-34223-33744
Average: 33910
Weather: Cloudy, 70°
Time: 1300

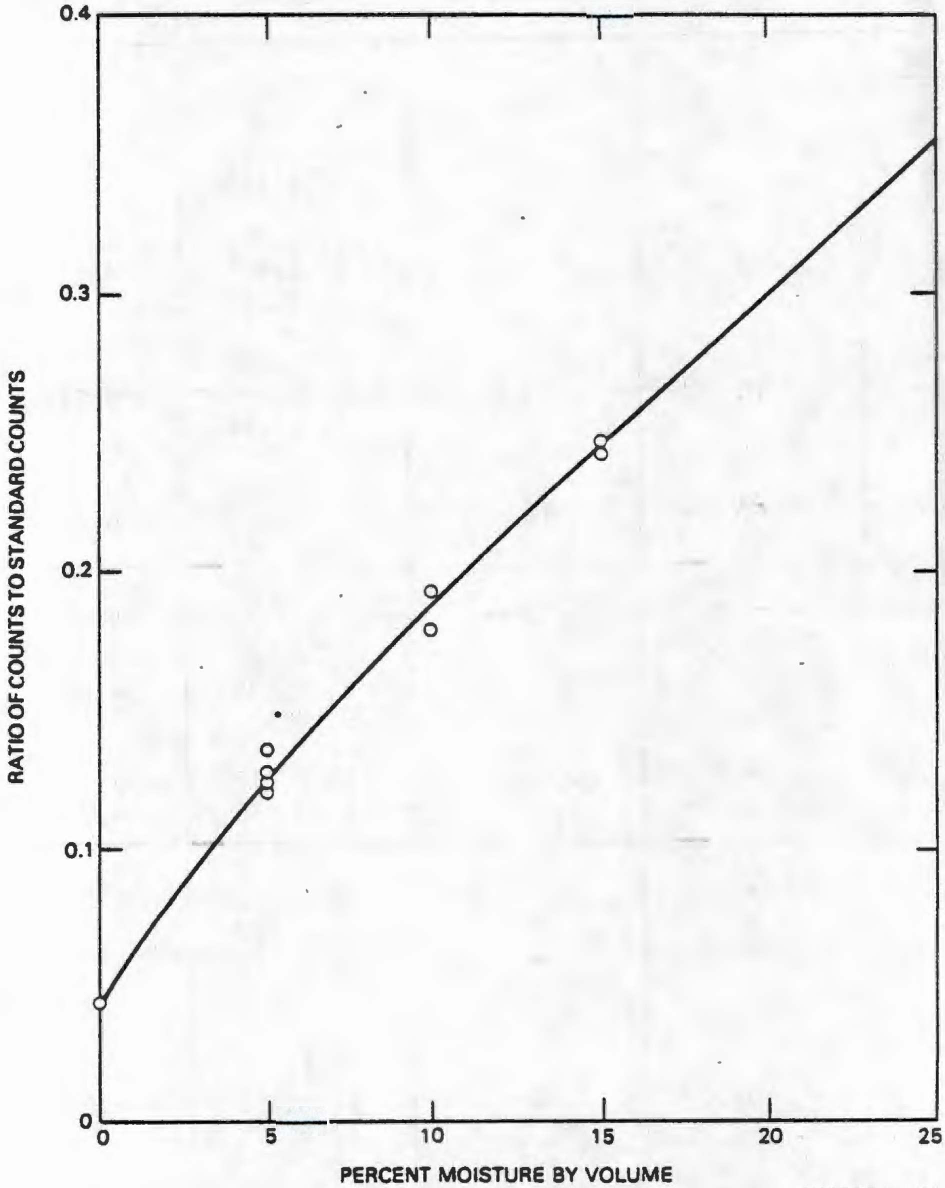


FIGURE F-1. Calibration Plot for 1-1/2-in. Neutron Probe #2509, in 6-in. Well, 200 East Area Calibration Facility, May 12, 1980.

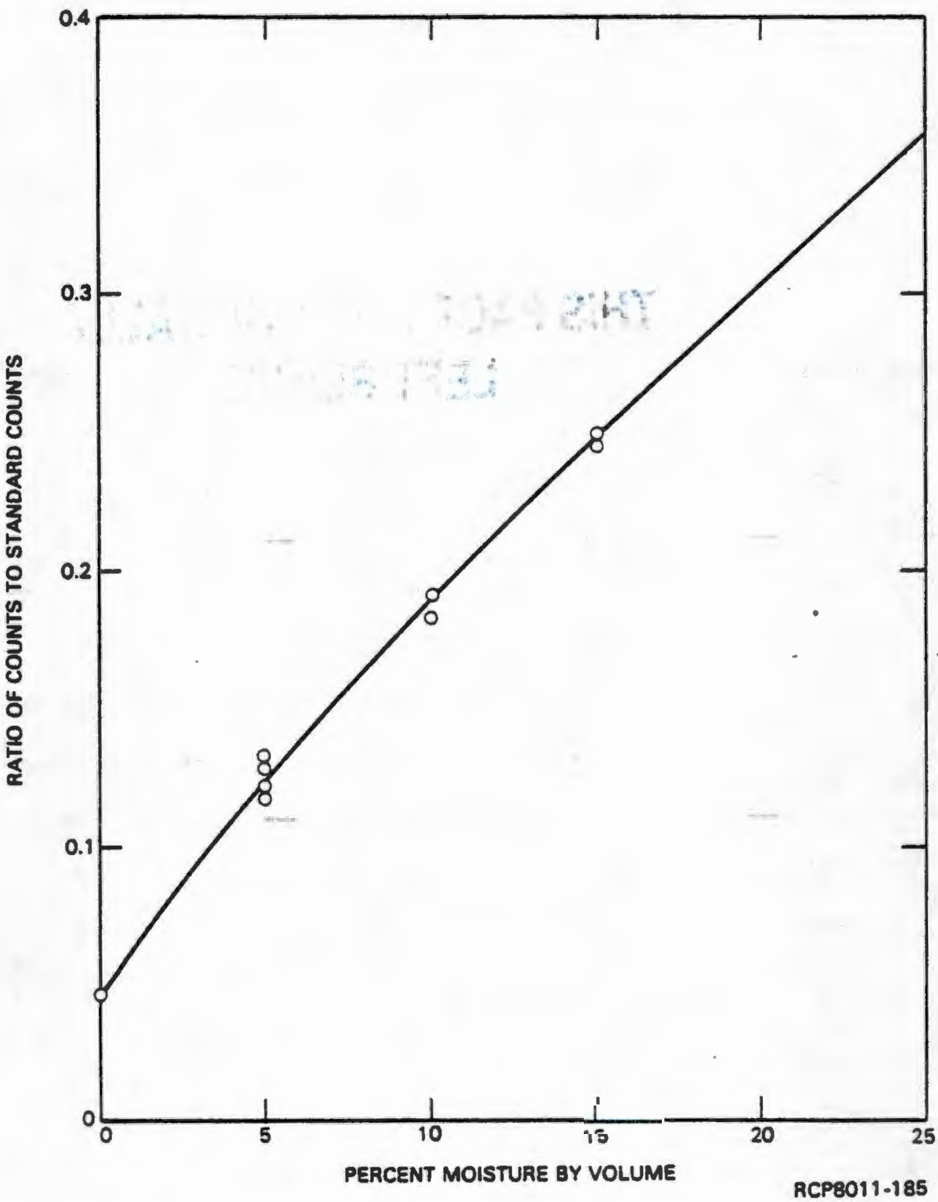


FIGURE F-2. Calibration Plot for 1-1/2-in. Neutron Moisture Probe, S.N. H38092509, Probe #2510, in 6-in. Well, 200 East Area Calibration Facility, May 12 and August 13, 1980.

THIS PAGE INTENTIONALLY
LEFT BLANK

APPENDIX G

HIGH-LEVEL WASTE TANK GEOLOGY

R. C. Routson

Schematic drawings of the high-level waste tanks subject to this evaluation (Figures G-1 through G-82) are provided in this appendix. The number and location of radiation monitoring dry wells are provided in the plan elevation. The description and layering of the sands and gravels (stratigraphy) as well as the tank contents is given in plan elevations for each tank. Inventories and properties of solutions in the tank are included. The tanks included in this evaluation are listed in Table G-1.

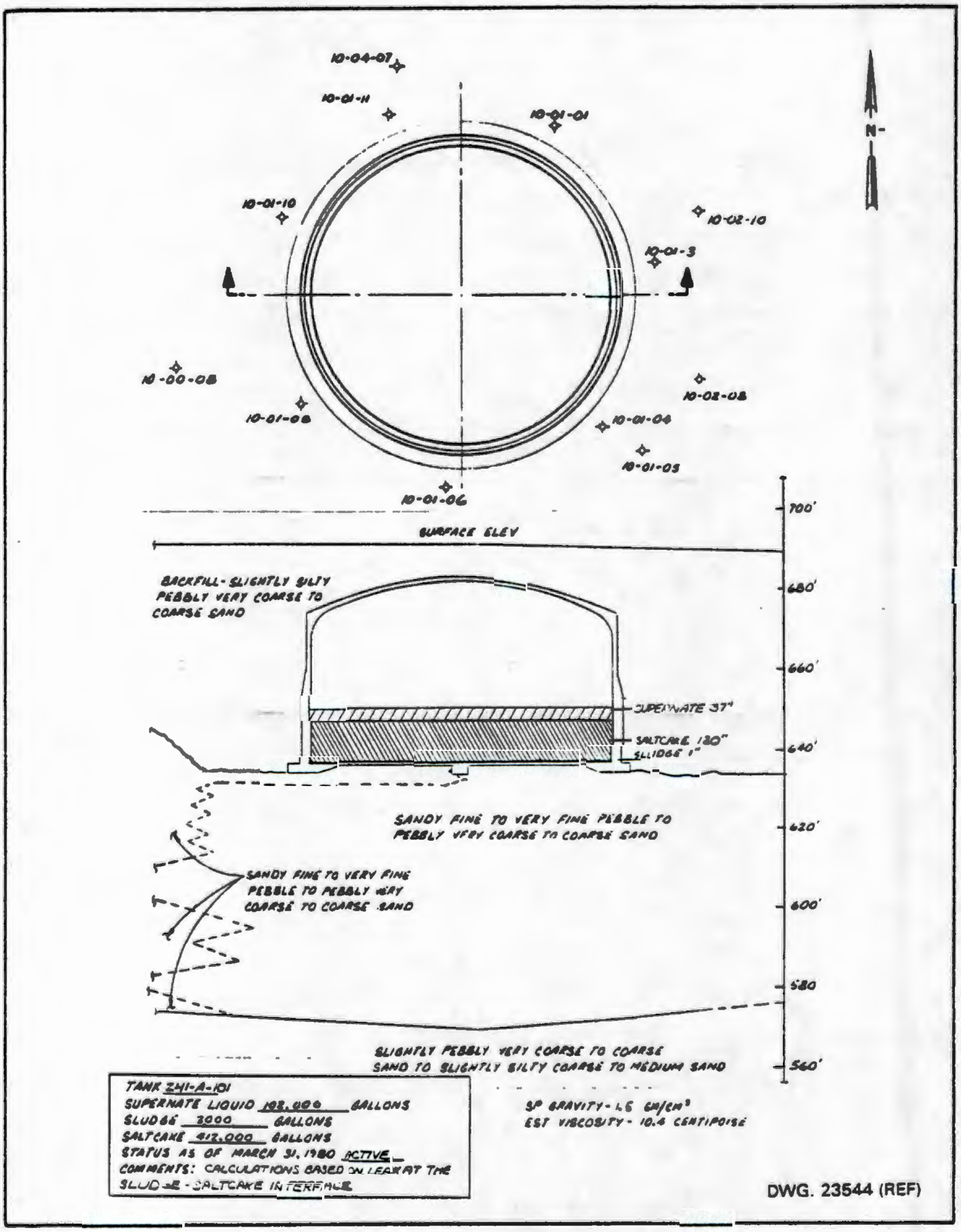


FIGURE G-1. Tank 241-A-101.

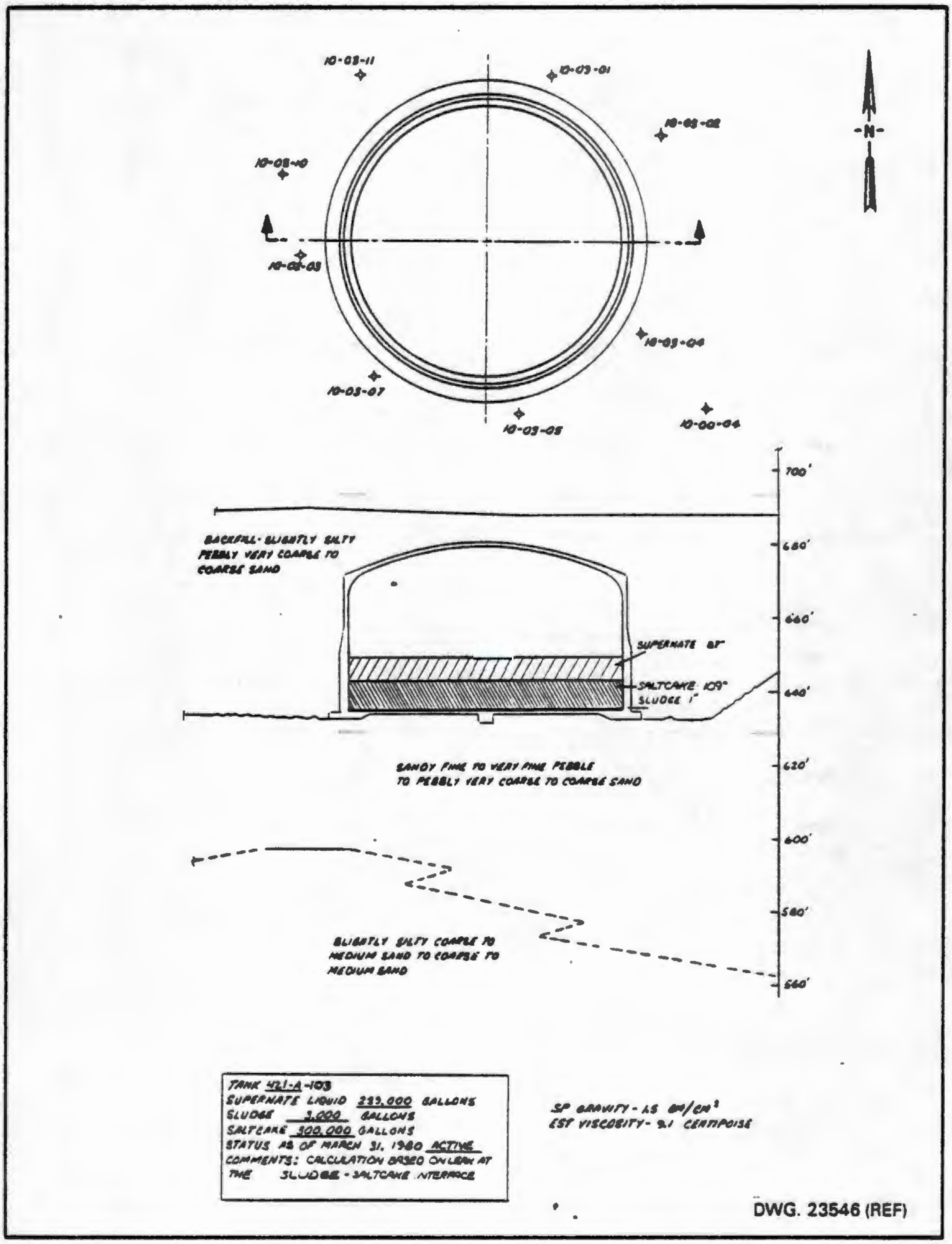


FIGURE G-2. Tank 241-A-103.

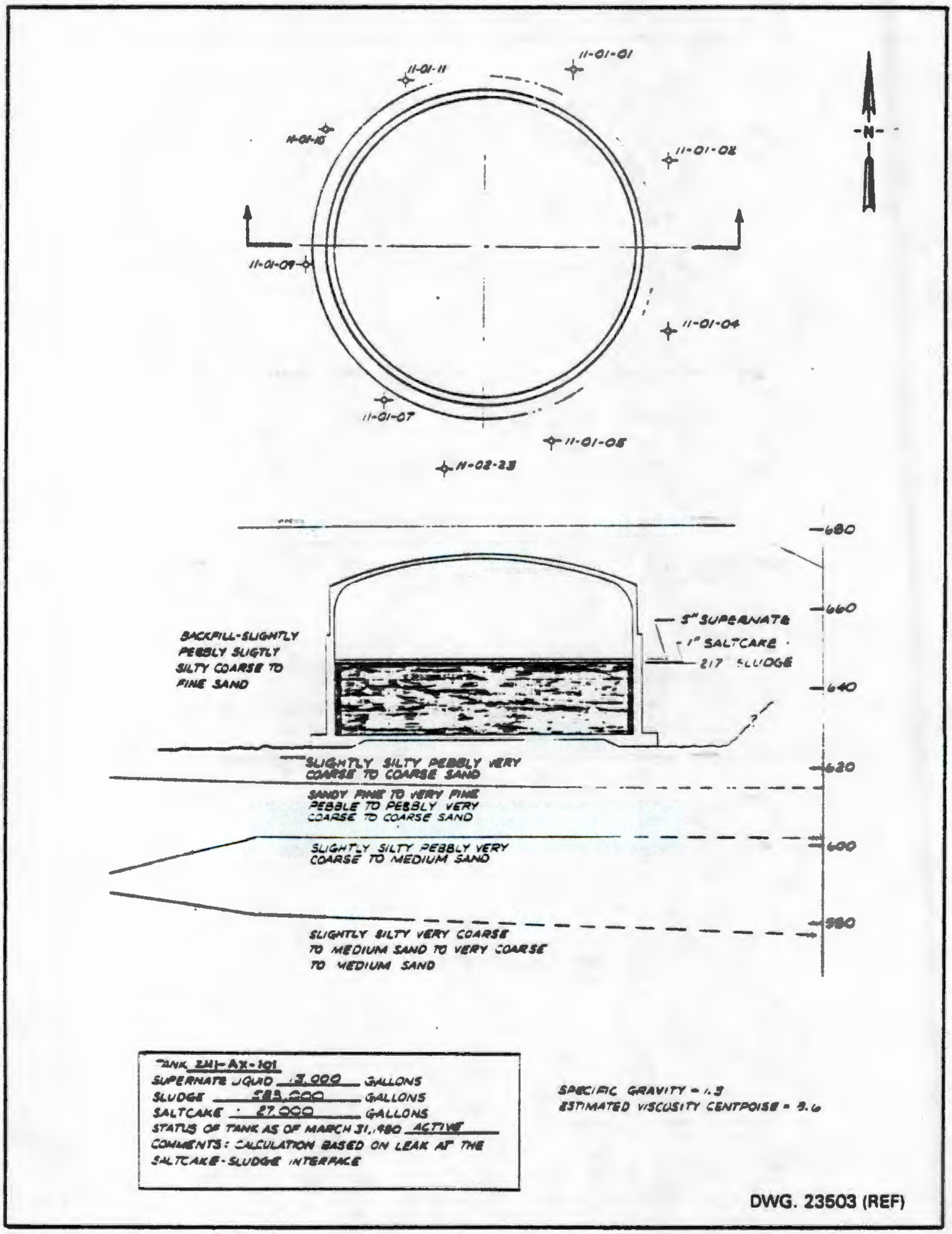


FIGURE G-3. Tank 241-AX-101.

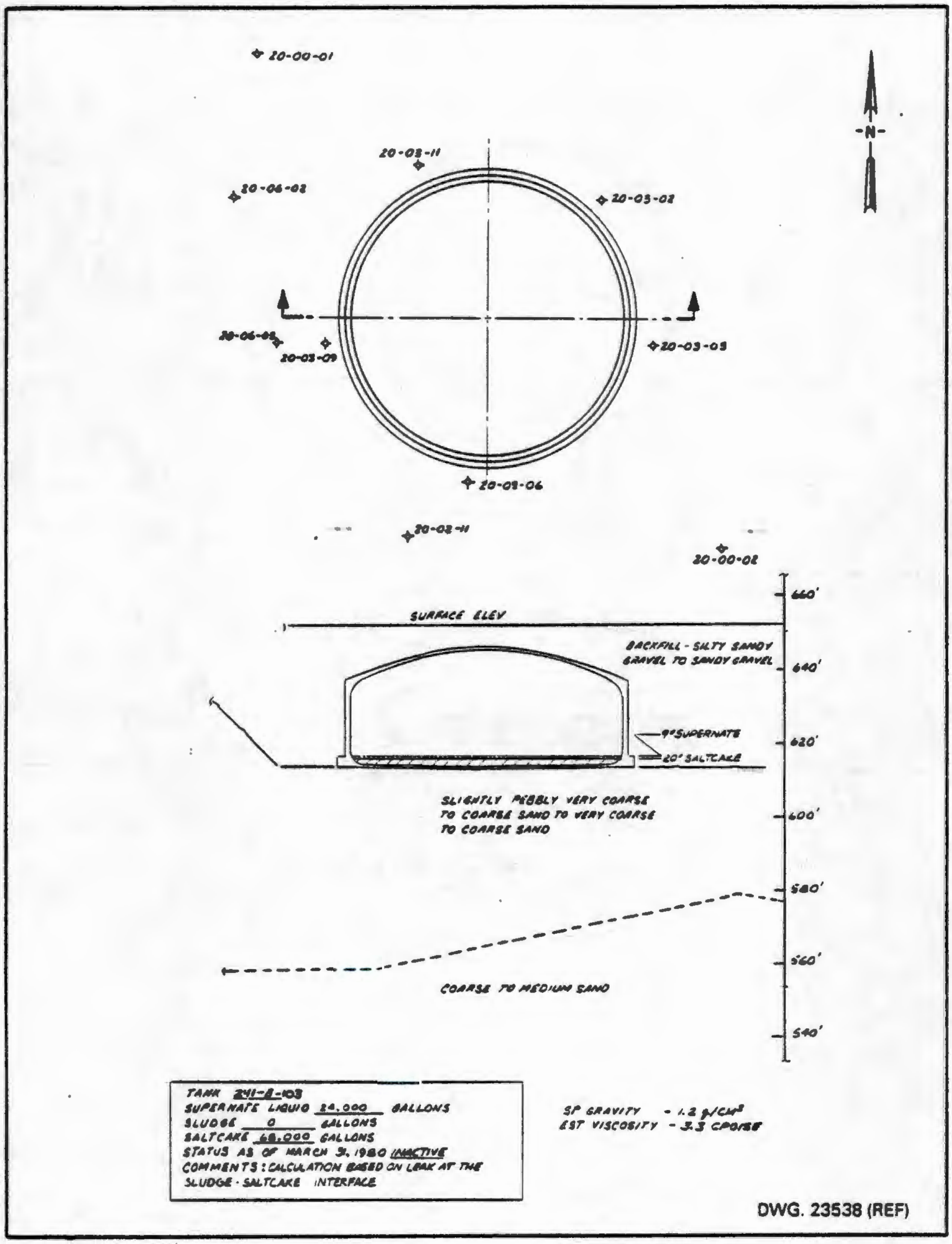


FIGURE G-4. Tank 241-B-103.

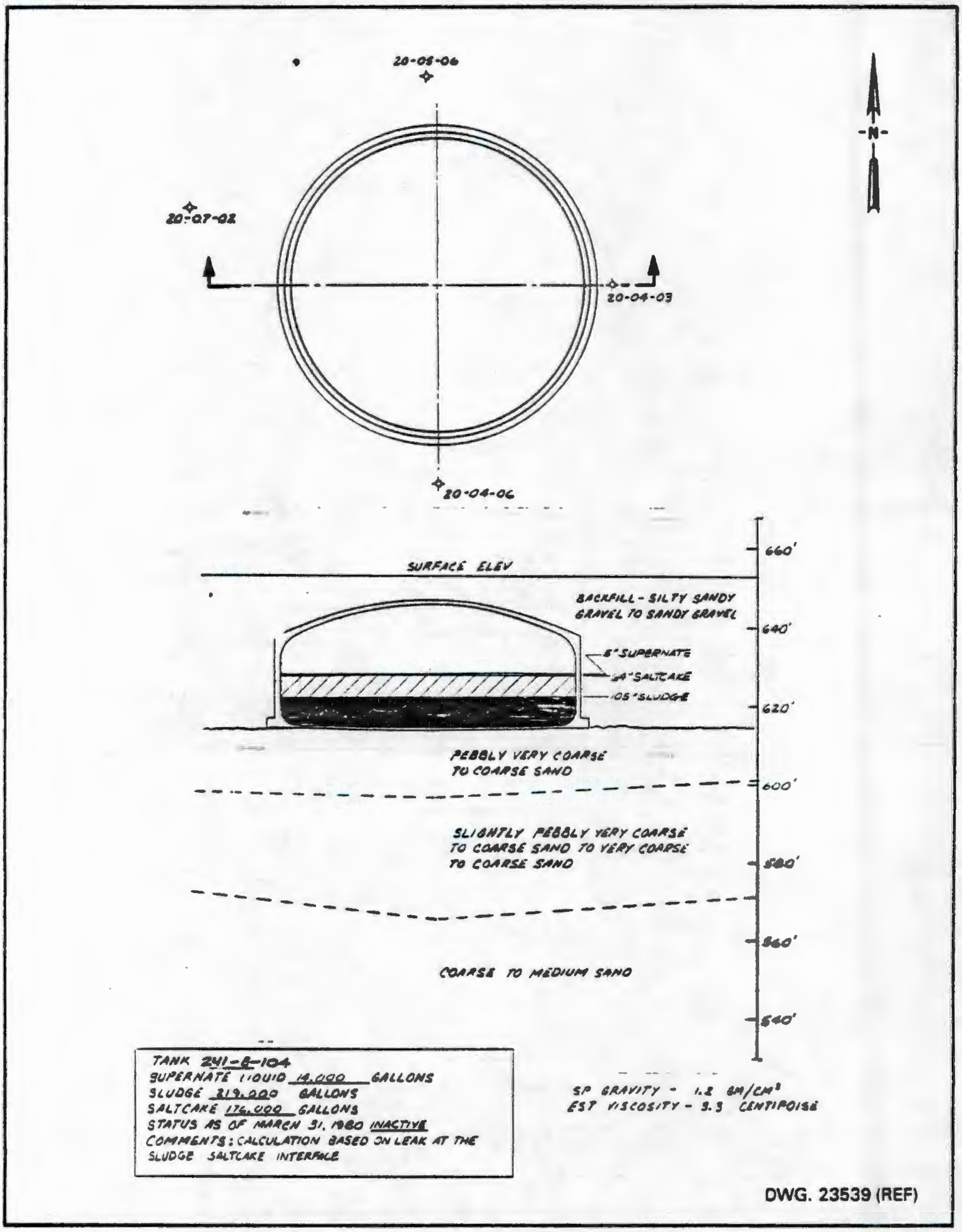


FIGURE G-5. Tank 241-B-104.

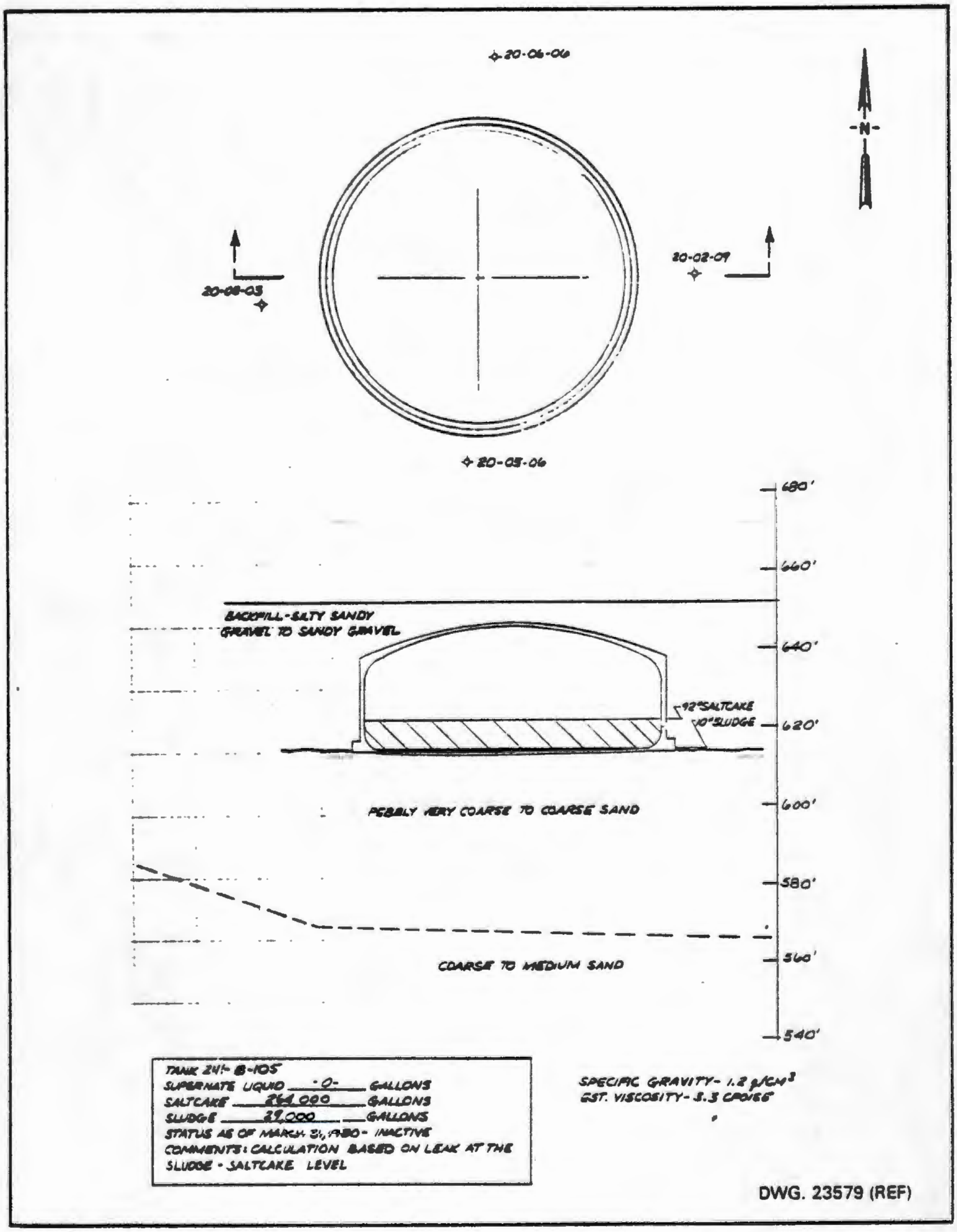


FIGURE G-6. Tank 241-B-105.

9 2 1 2 4 9 9 1 7 9 0

9212499179

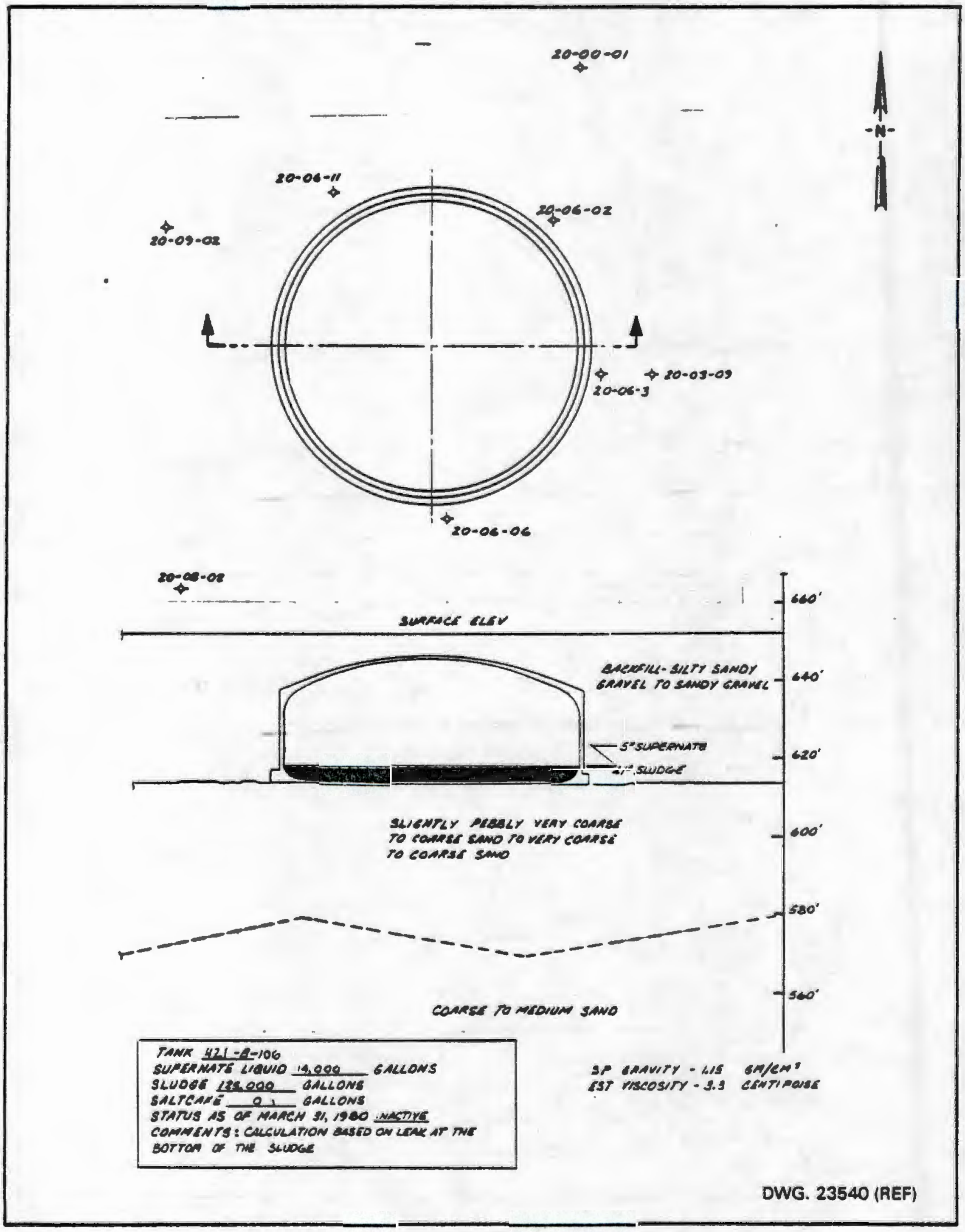


FIGURE G-7. Tank 241-B-106.

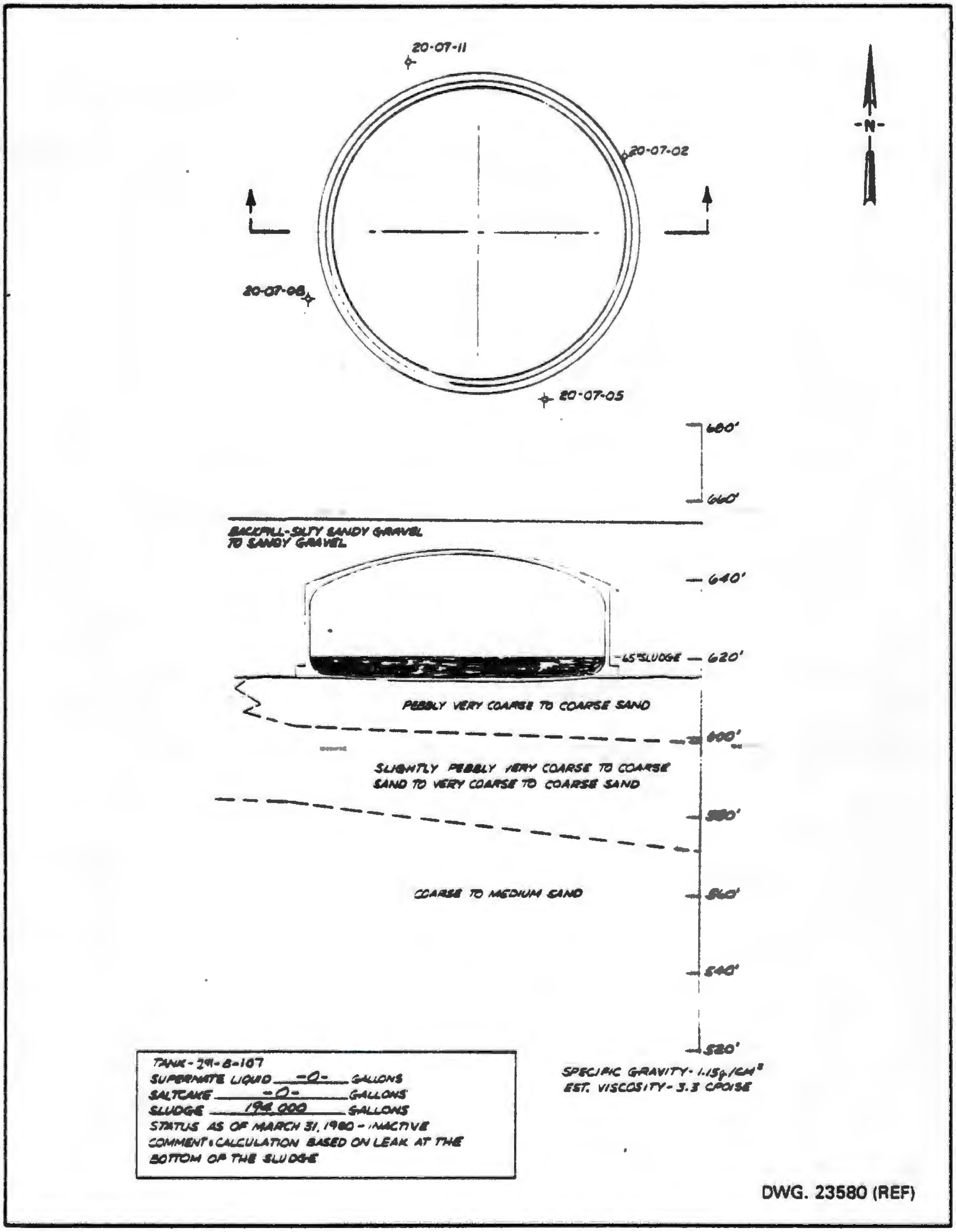


FIGURE G-8. Tank 241-B-107.

9 2 1 2 4 9 9 1 7 9 2

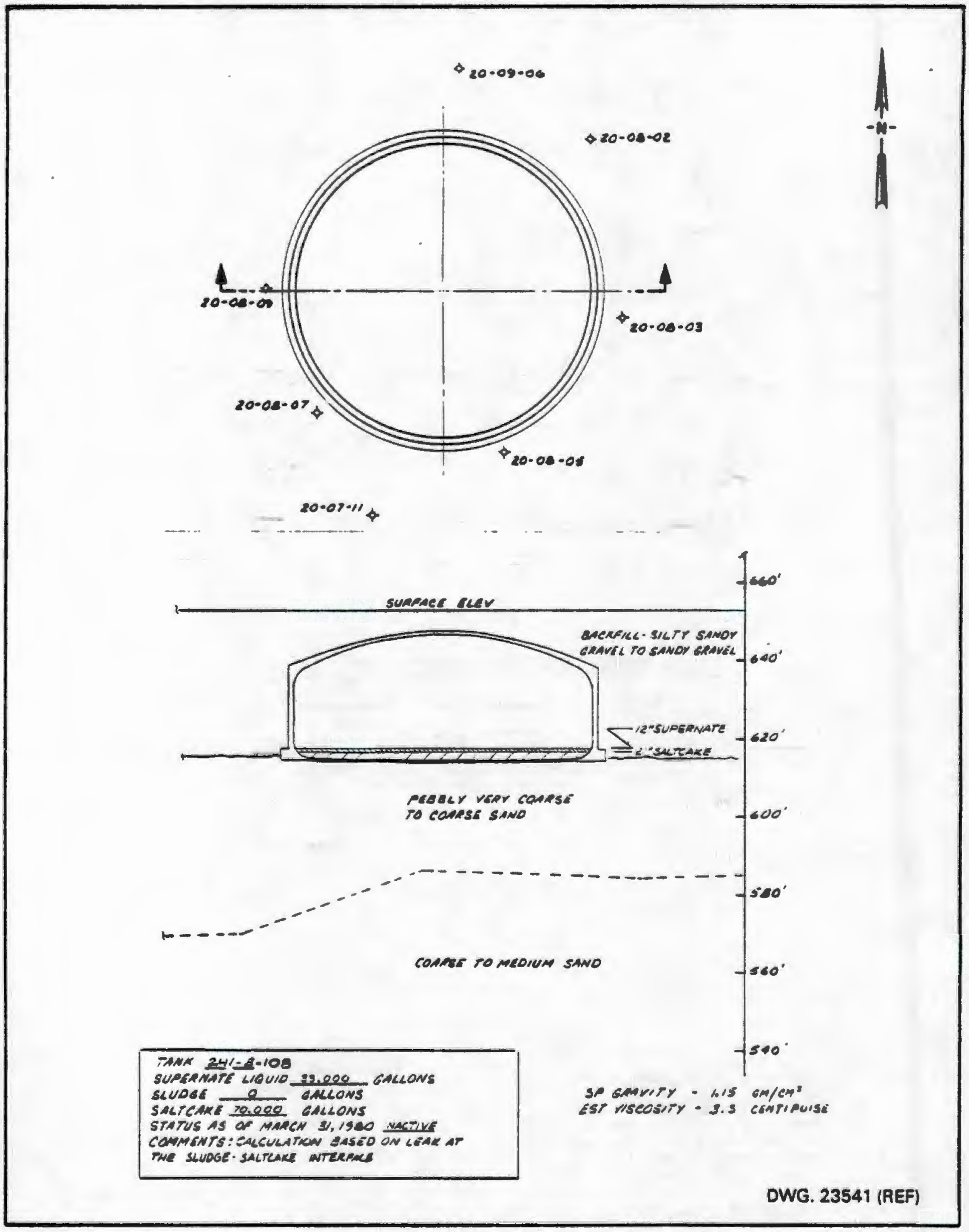


FIGURE G-9. Tank 241-B-108.

92124991793

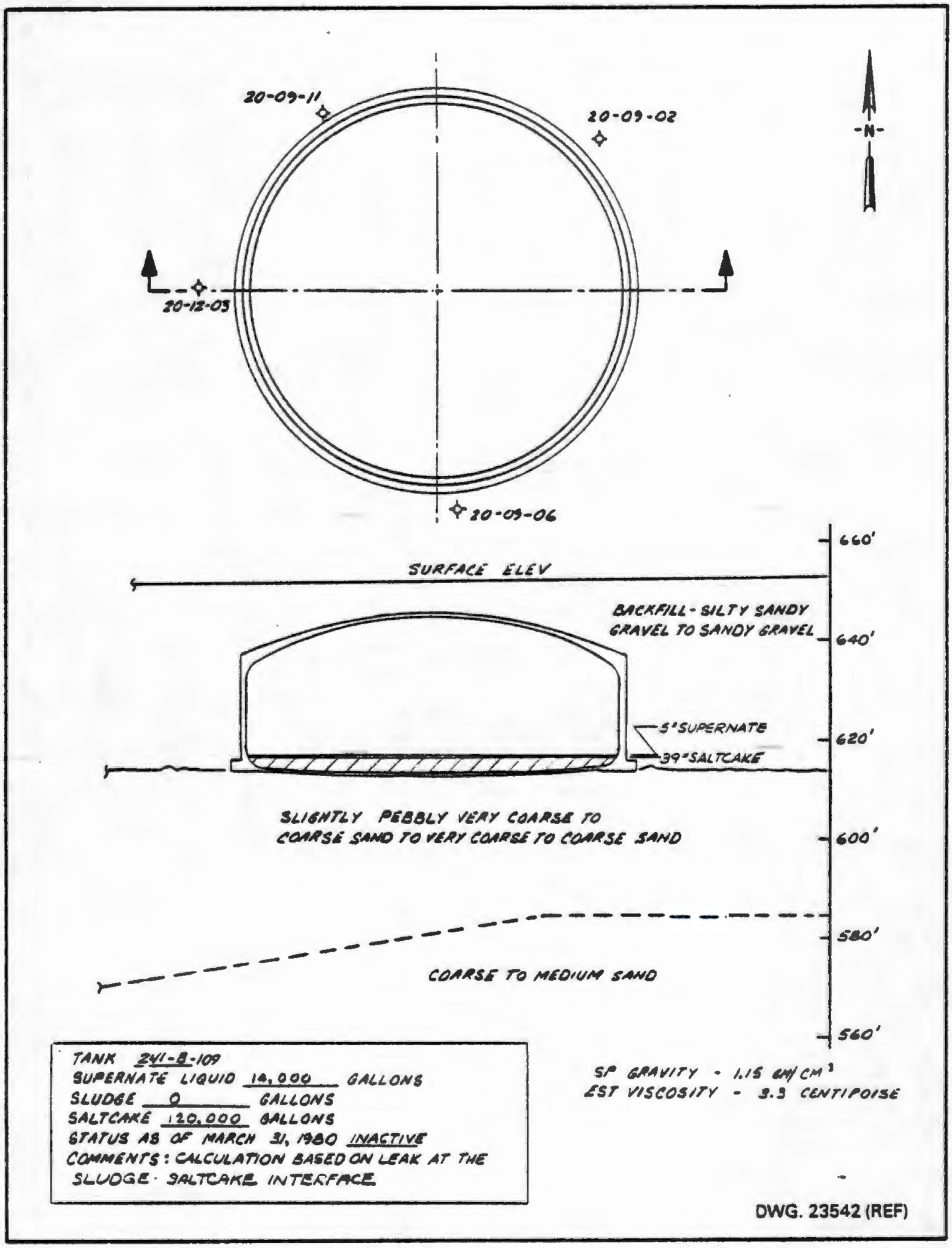


FIGURE G-10. Tank 241-B-109.

9 2 1 2 4 9 9 1 7 9 4

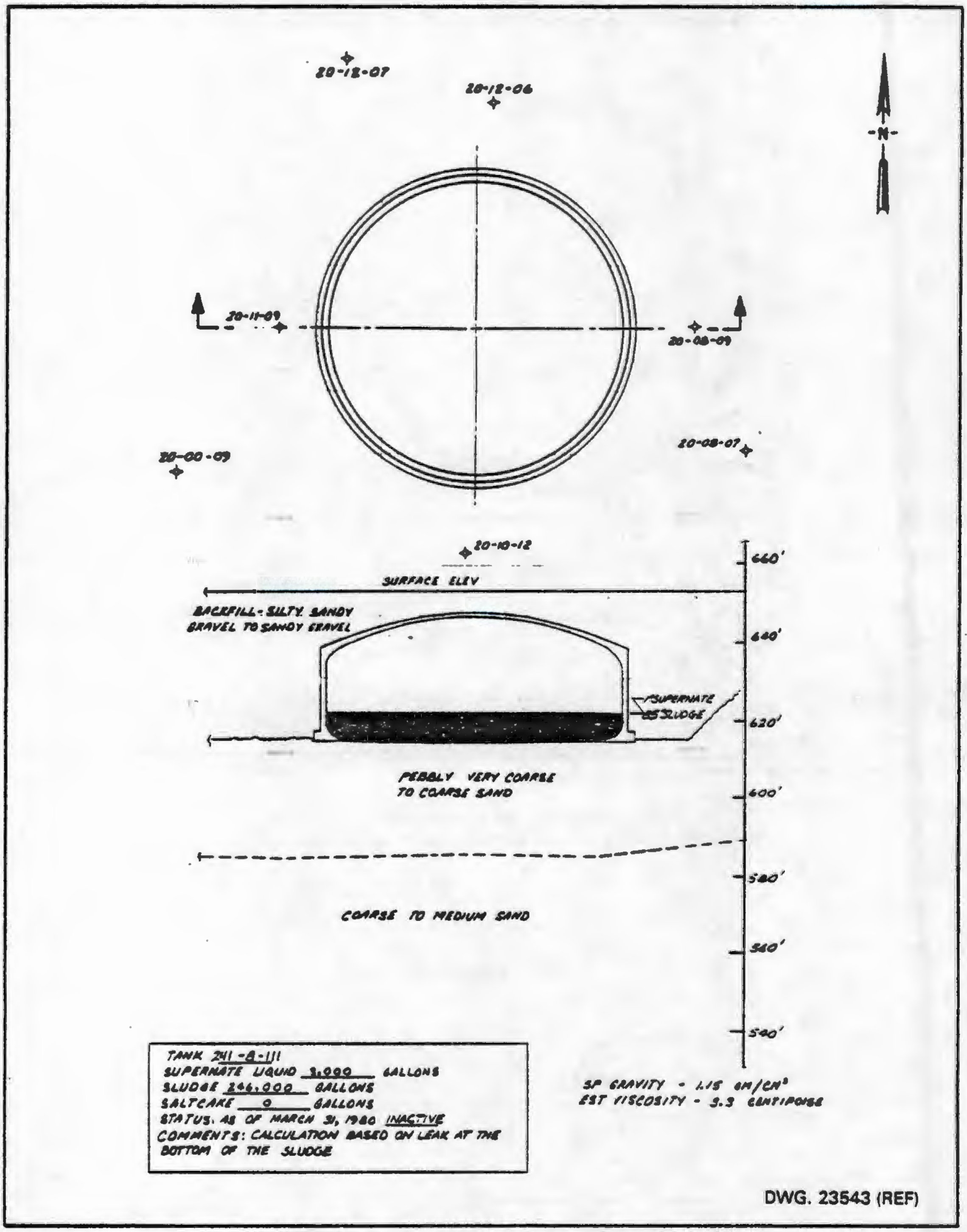


FIGURE G-11. Tank 241-B-111.

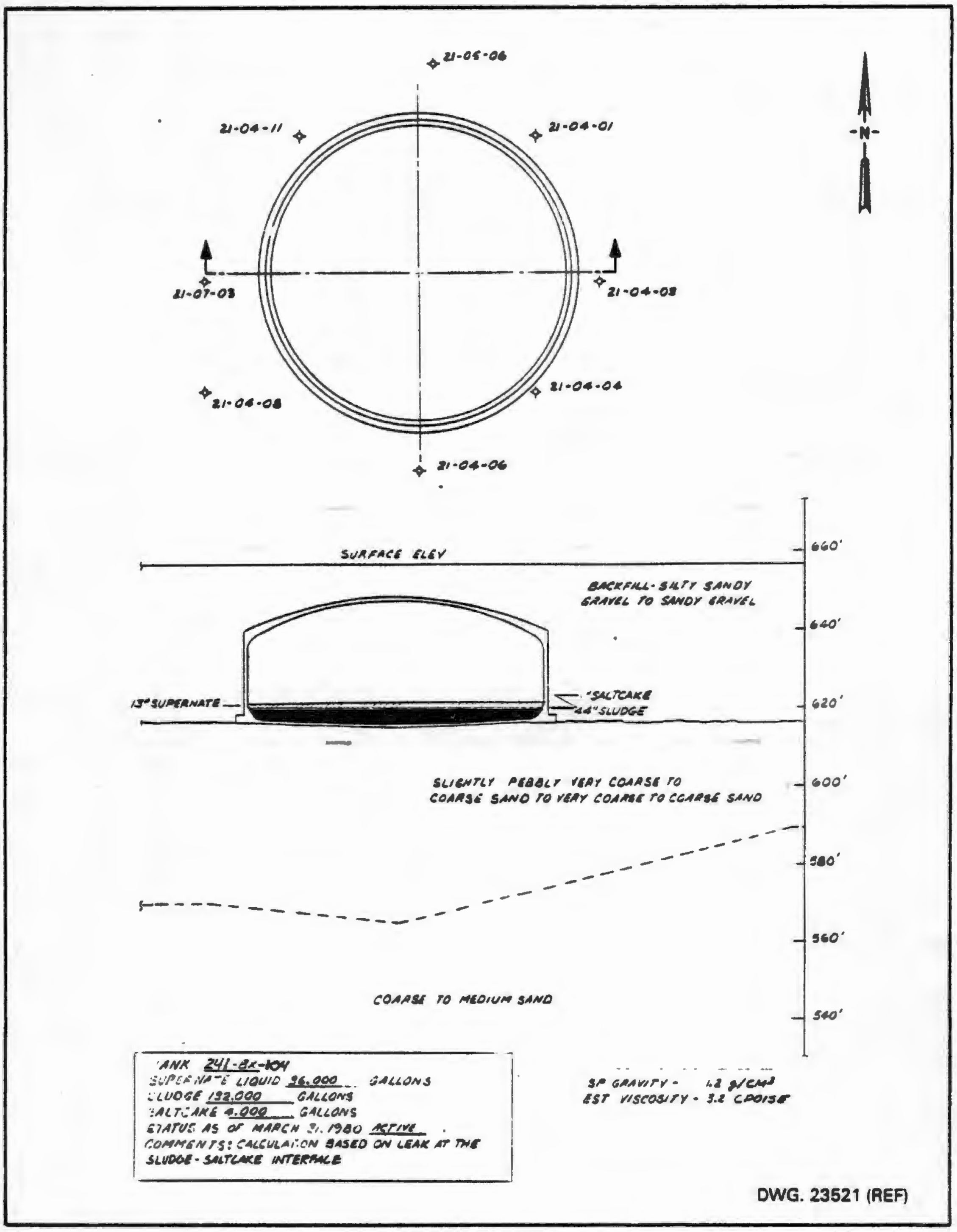


FIGURE G-12. Tank 241-BX-104.

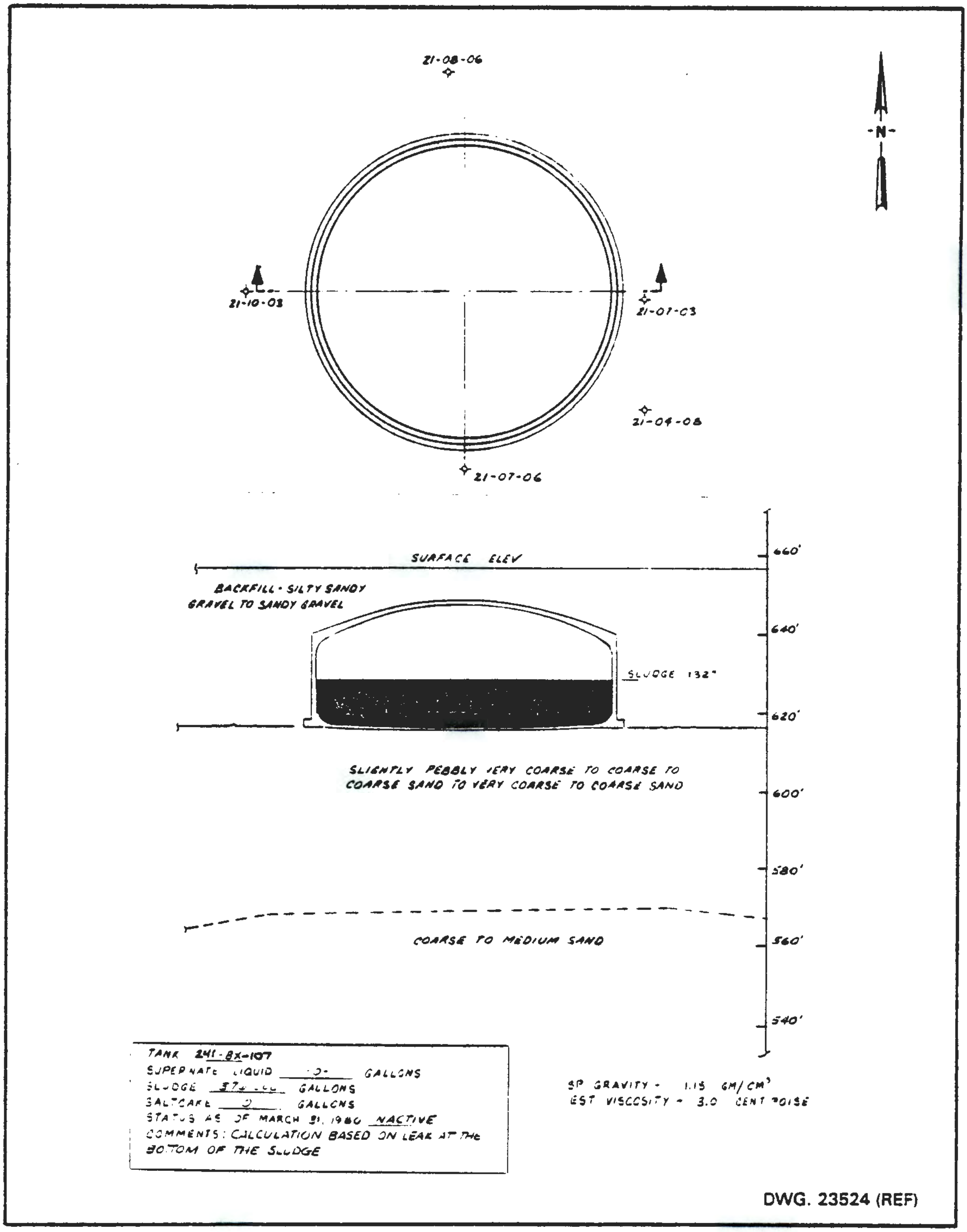


FIGURE G-13. Tank 241-BX-107.

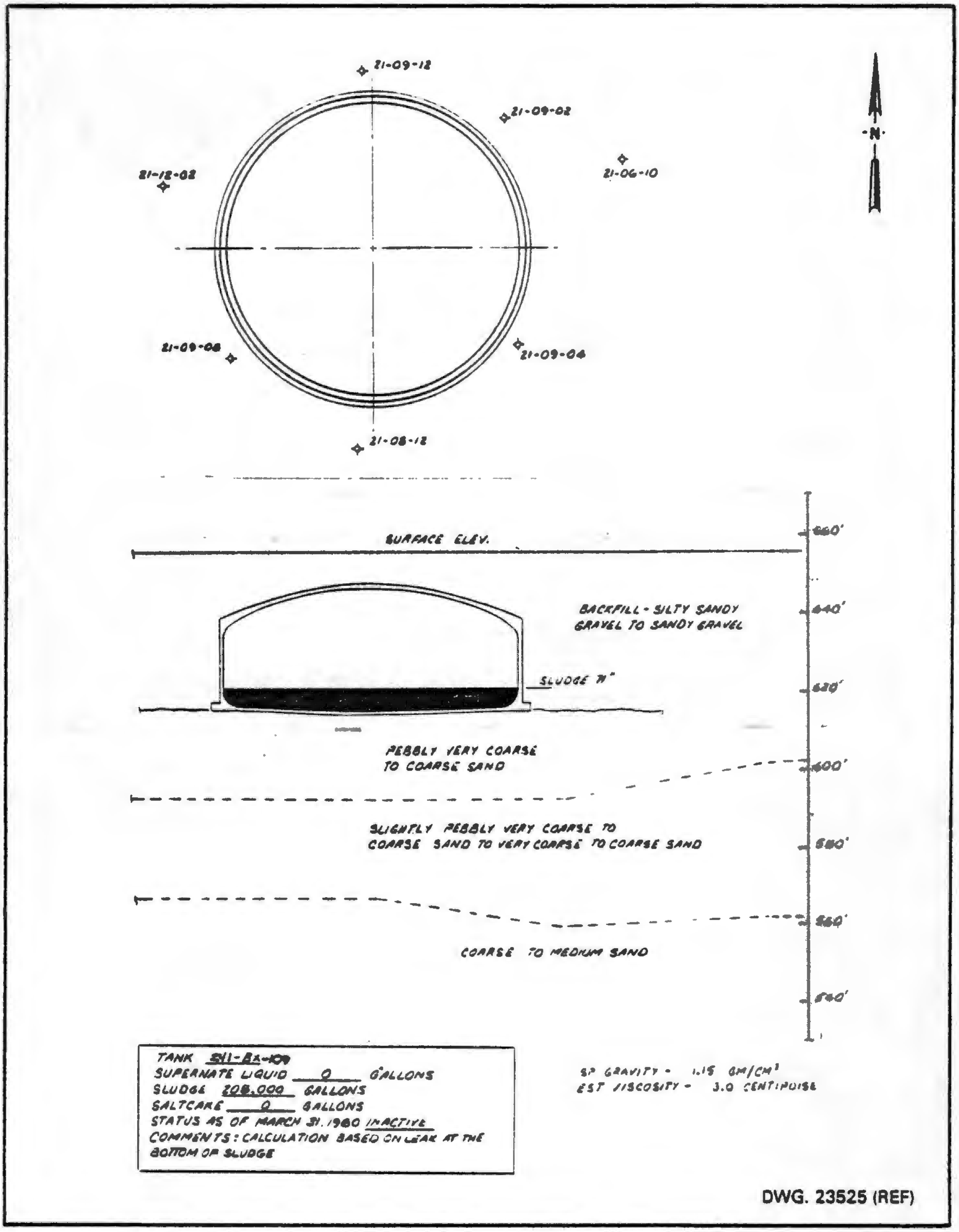


FIGURE G-14. Tank 241-BX-109.

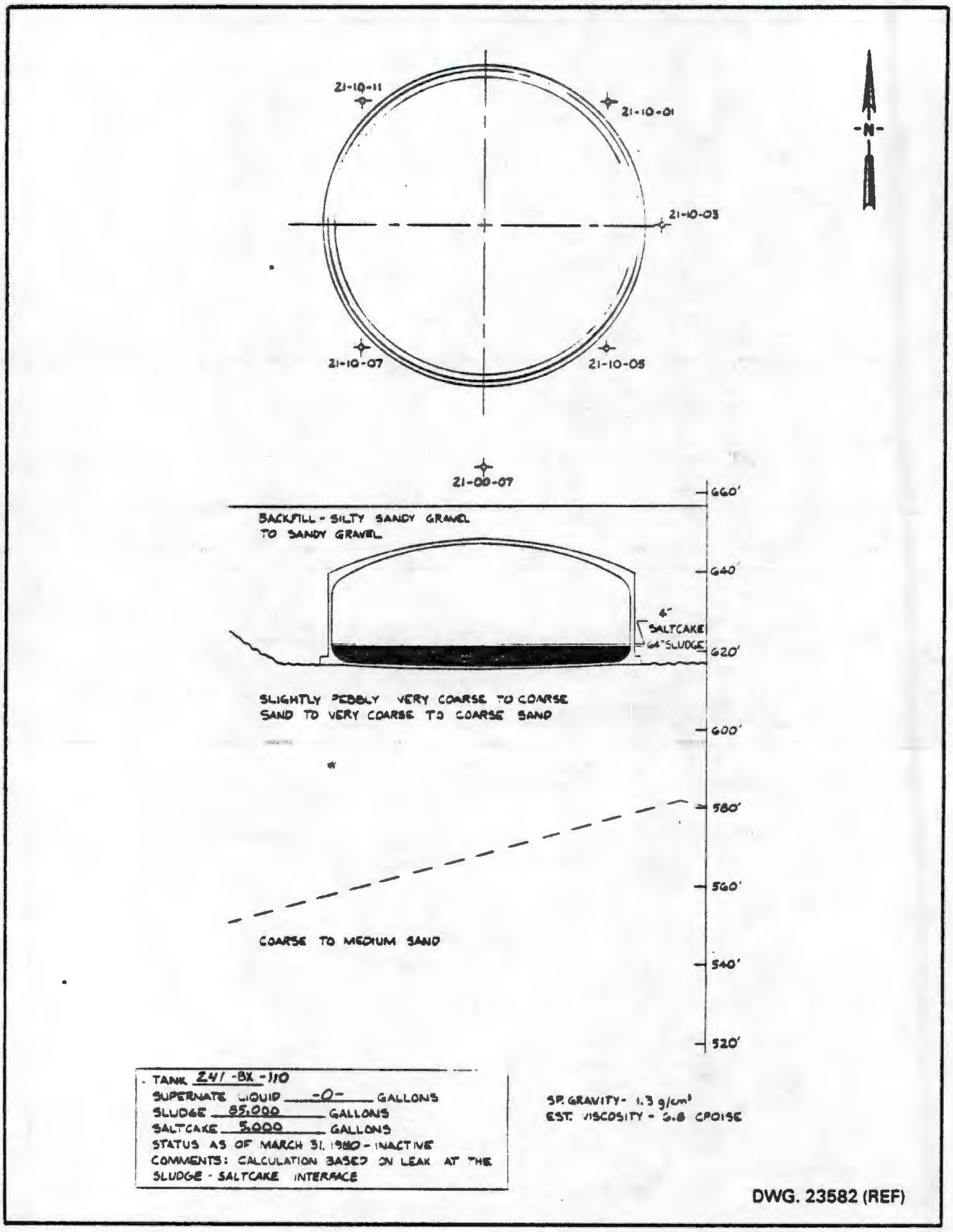


FIGURE G-15. Tank 241-BX-110.

9212491799

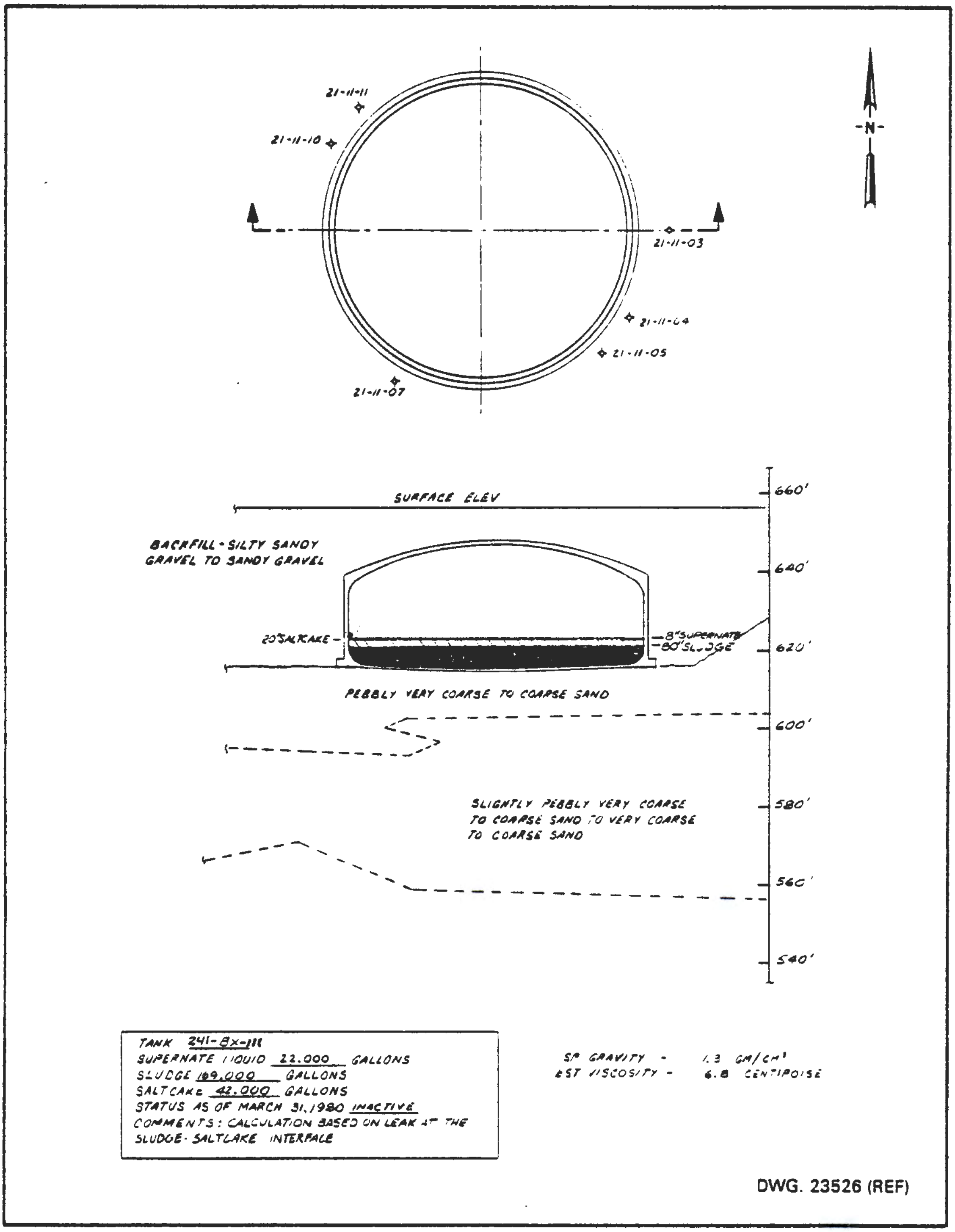


FIGURE G-16. Tank 241-BX-111.

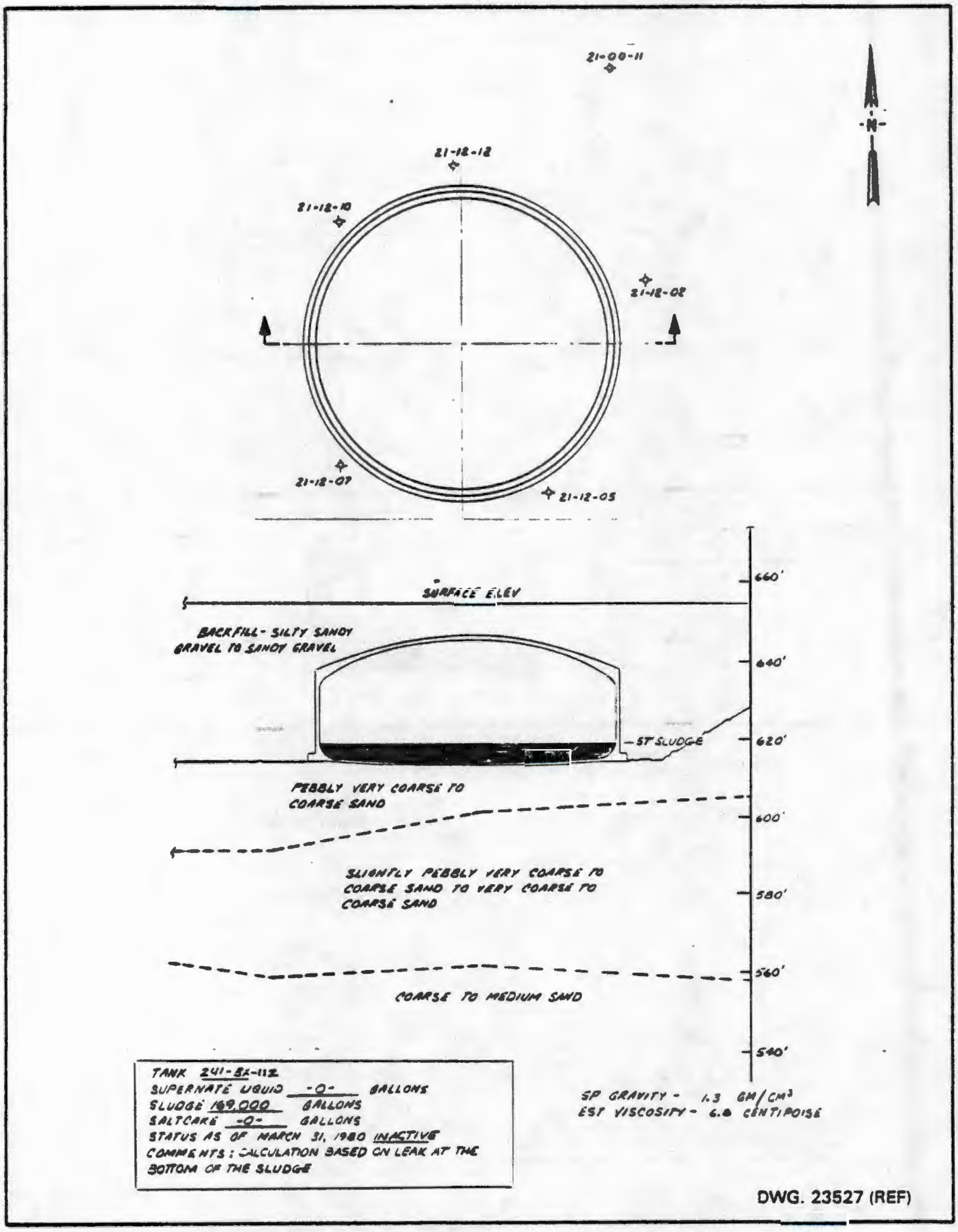


FIGURE G-17. Tank 241-BX-112.

9 2 1 2 4 9 9 1 8 0 1

92124991802

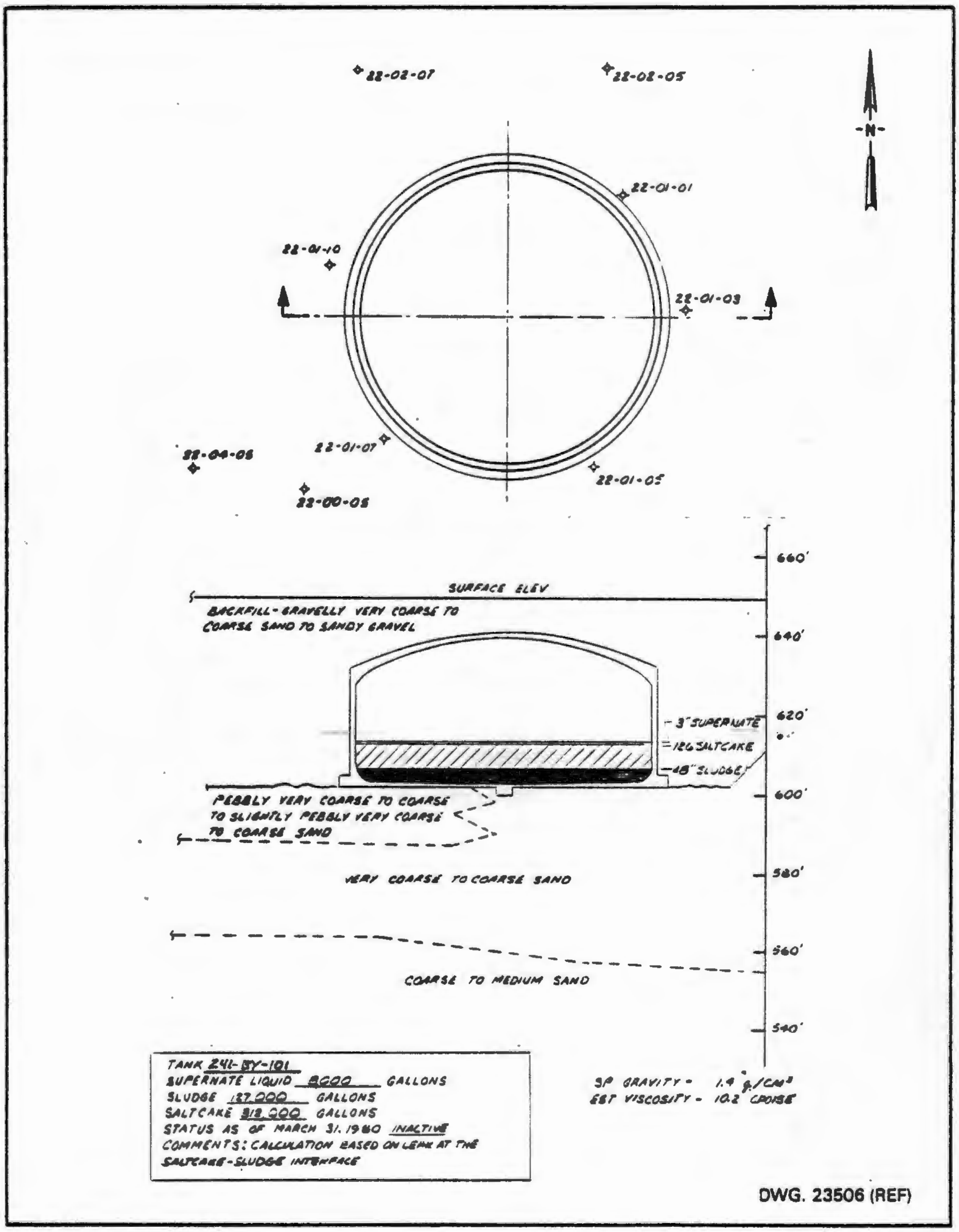


FIGURE G-18. Tank 241-BY-101.

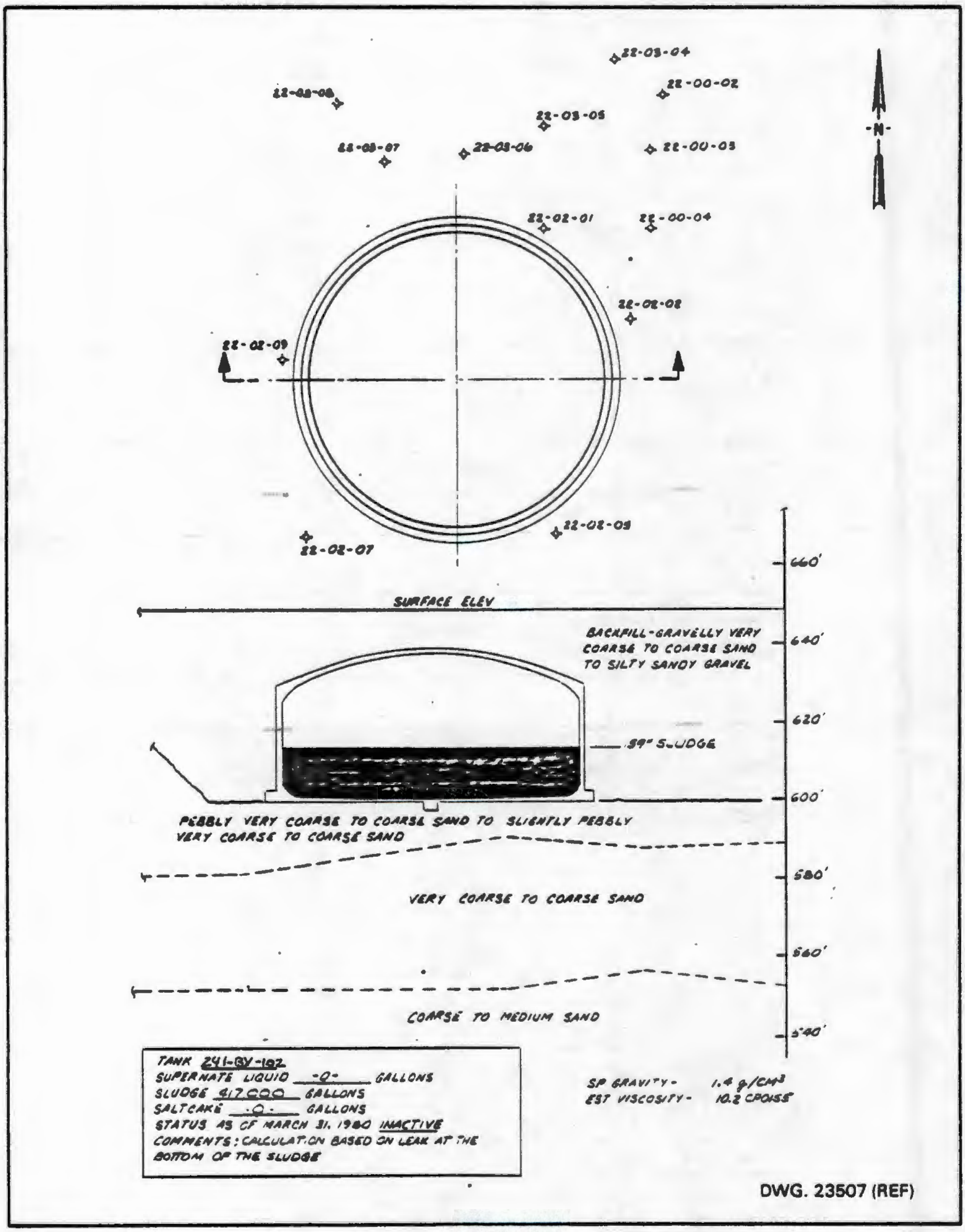


FIGURE G-19. Tank 241-BY-102.

9212499I803

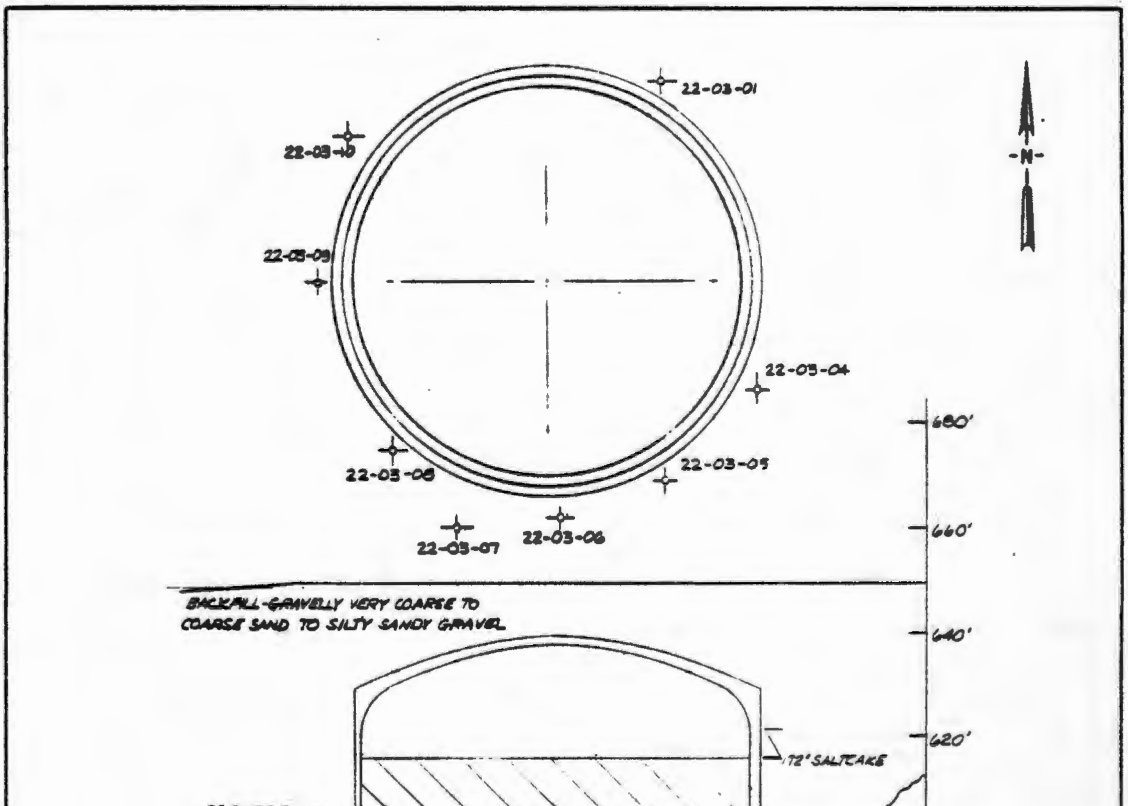


FIGURE G-20. Tank 241-BY-103.

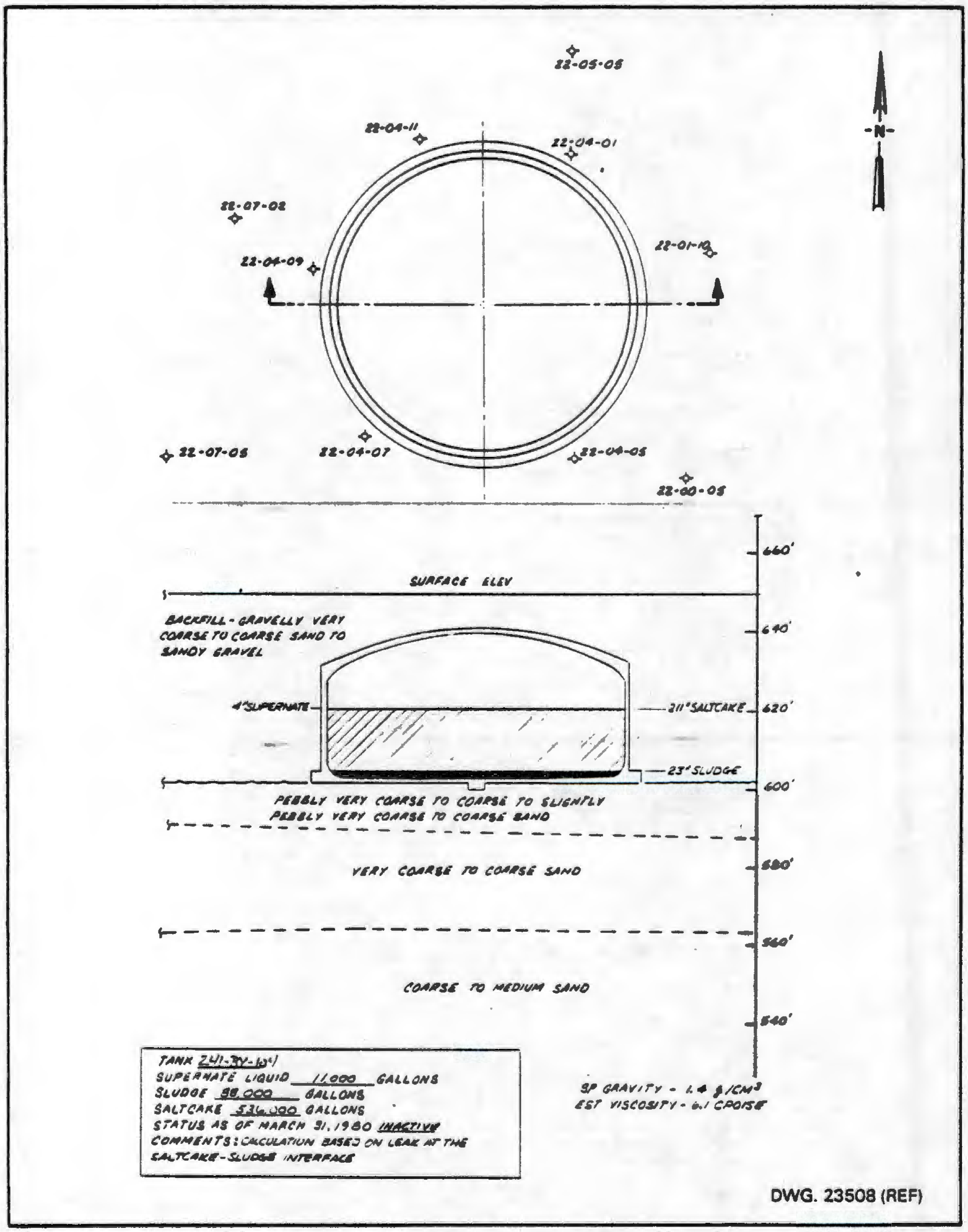


FIGURE G-21. Tank 241-BY-104.

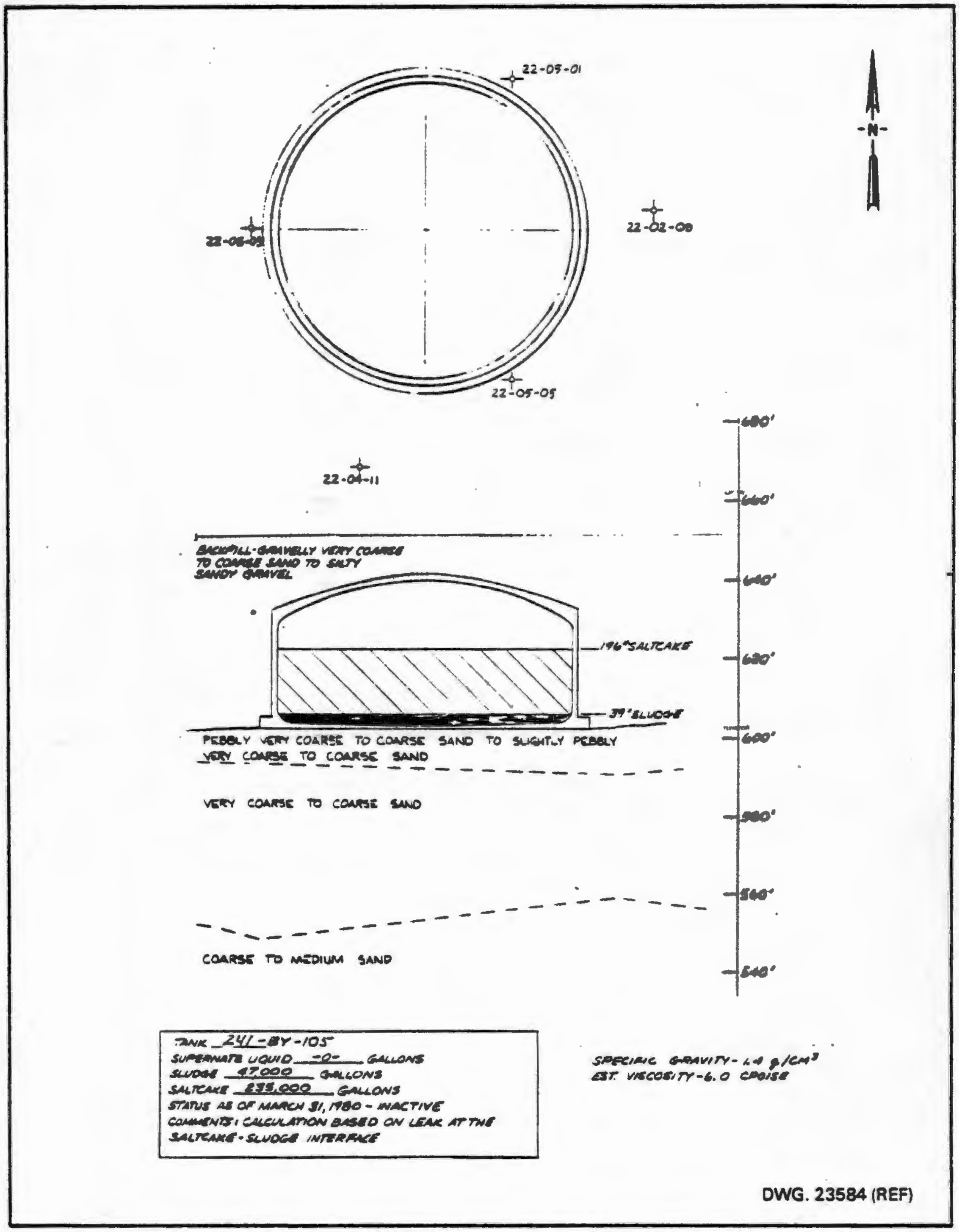


FIGURE G-22. Tank 241-BY-105.

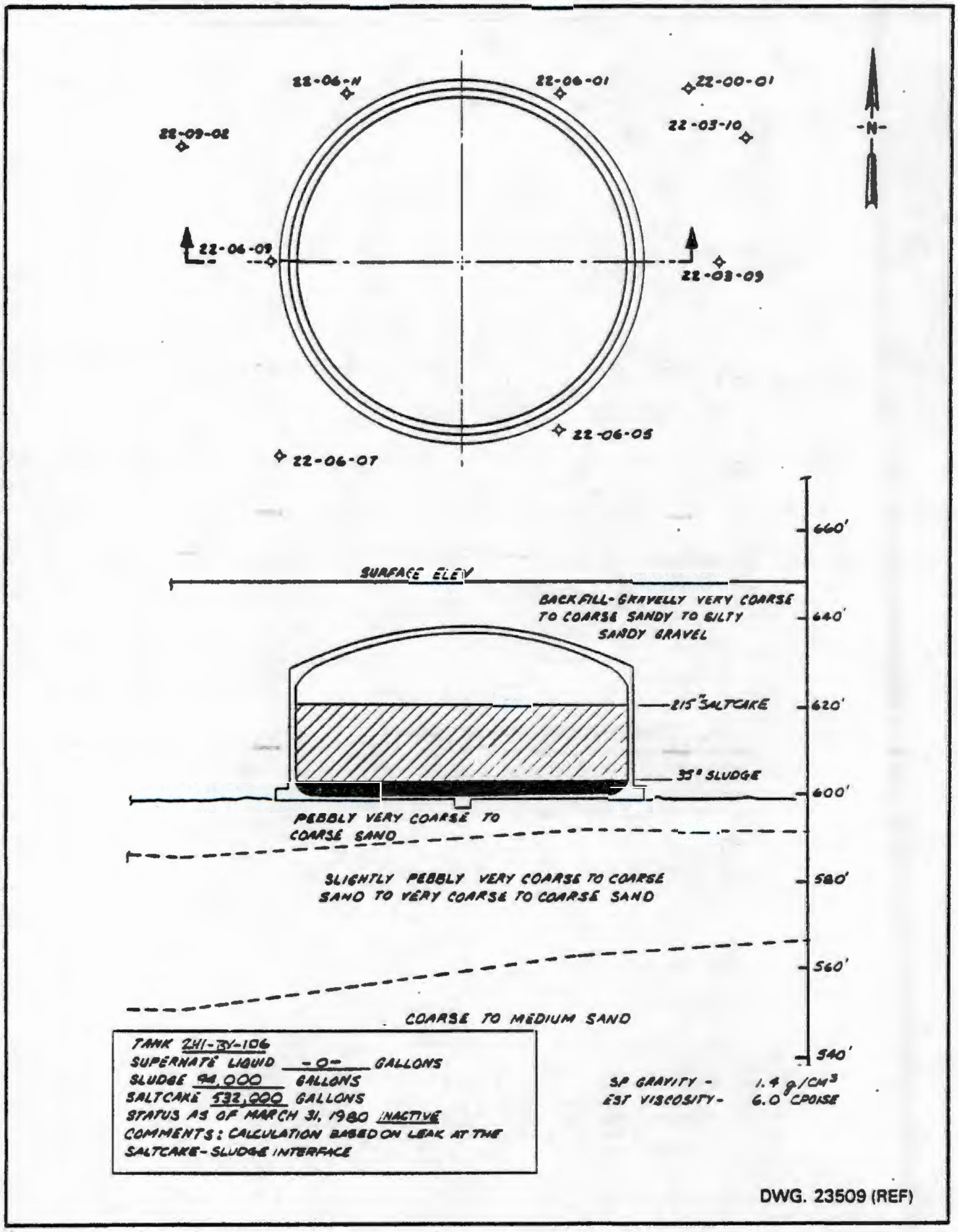


FIGURE G-23. Tank 241-BY-106.

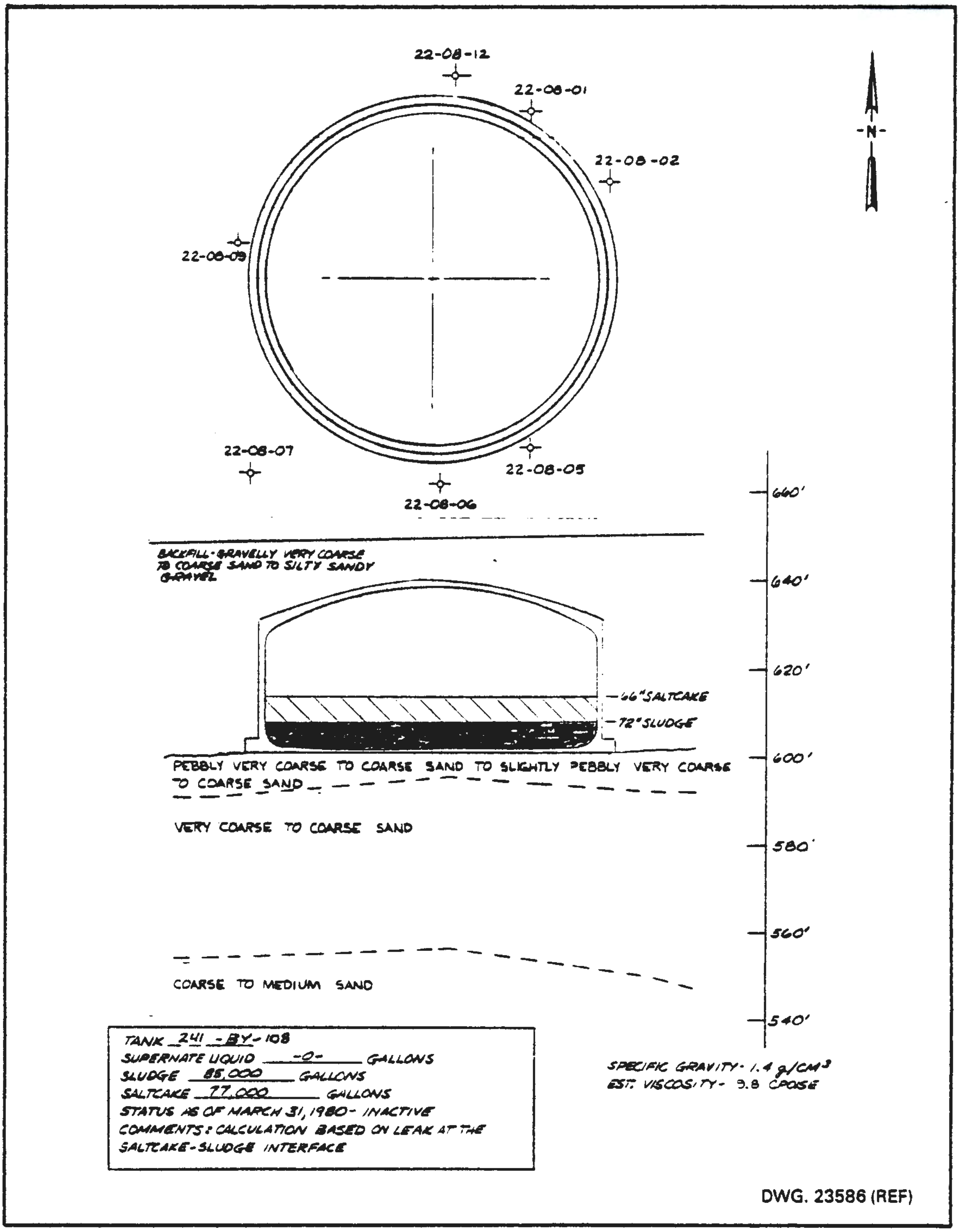


FIGURE G-24. Tank 241-BY-108.

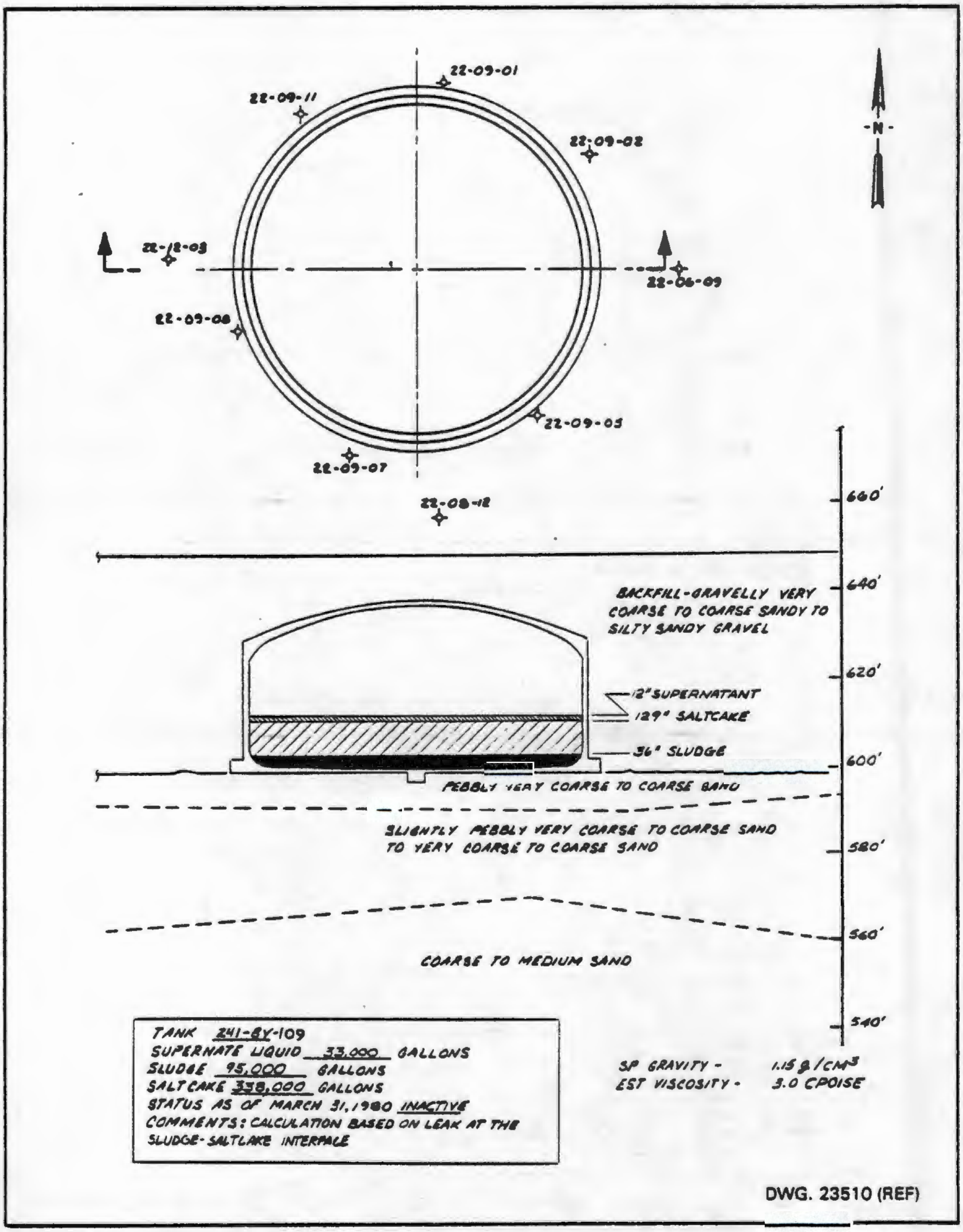


FIGURE G-25. Tank 241-BY-109.

9 2 1 2 4 9 9 1 8 0 9

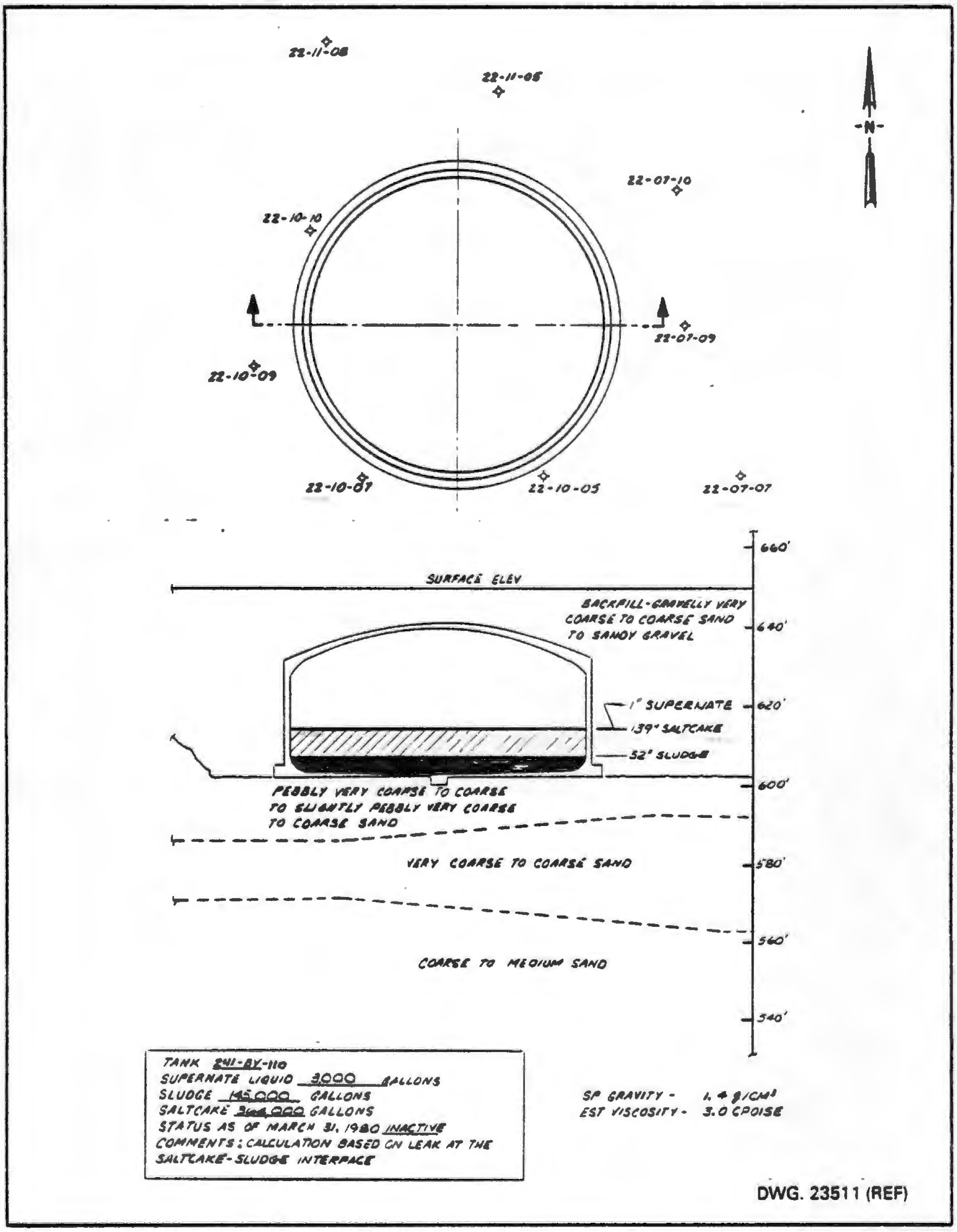


FIGURE G-26. Tank 241-BY-110.

9212499810

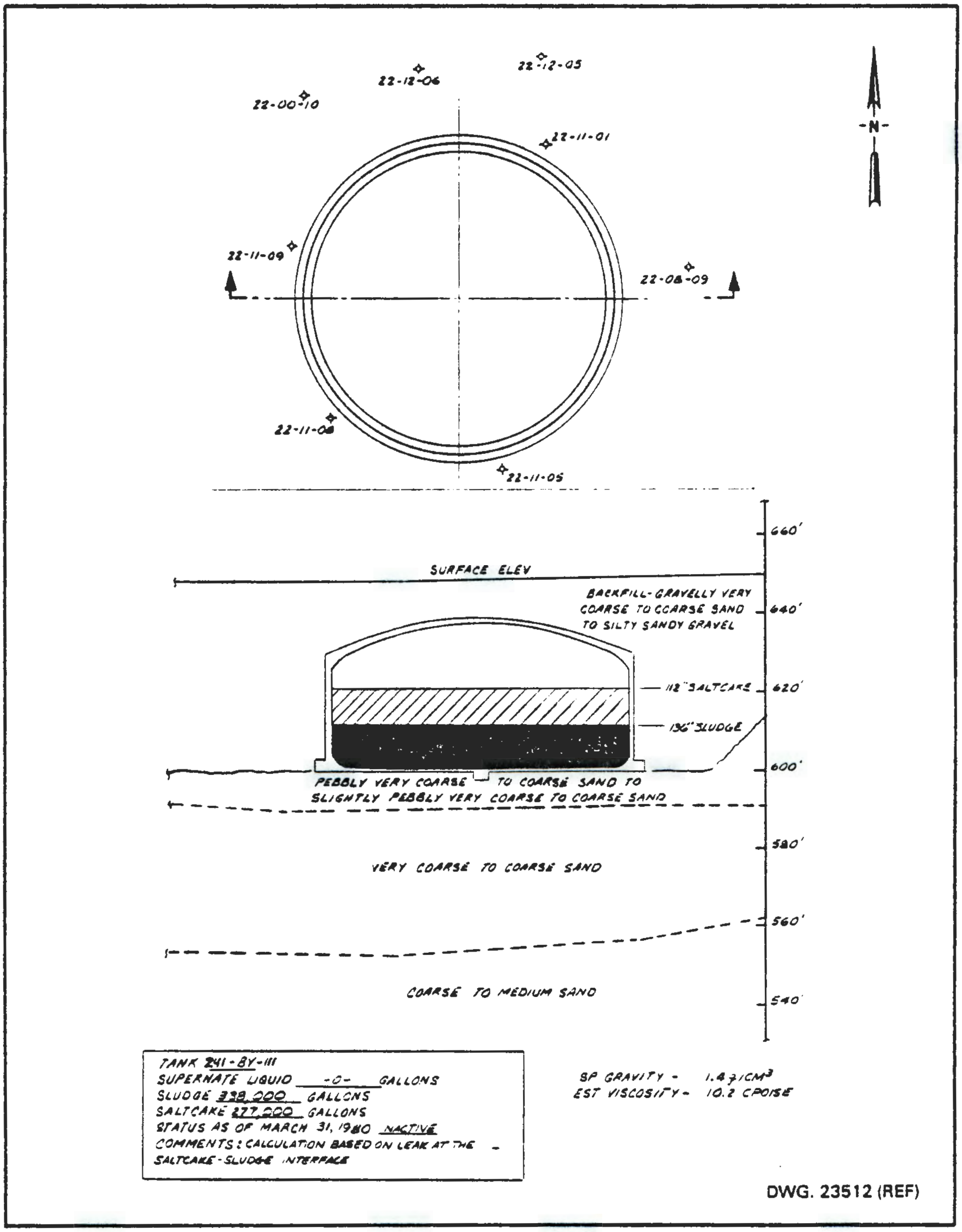


FIGURE G-27. Tank 241-BY-111.

9212991811

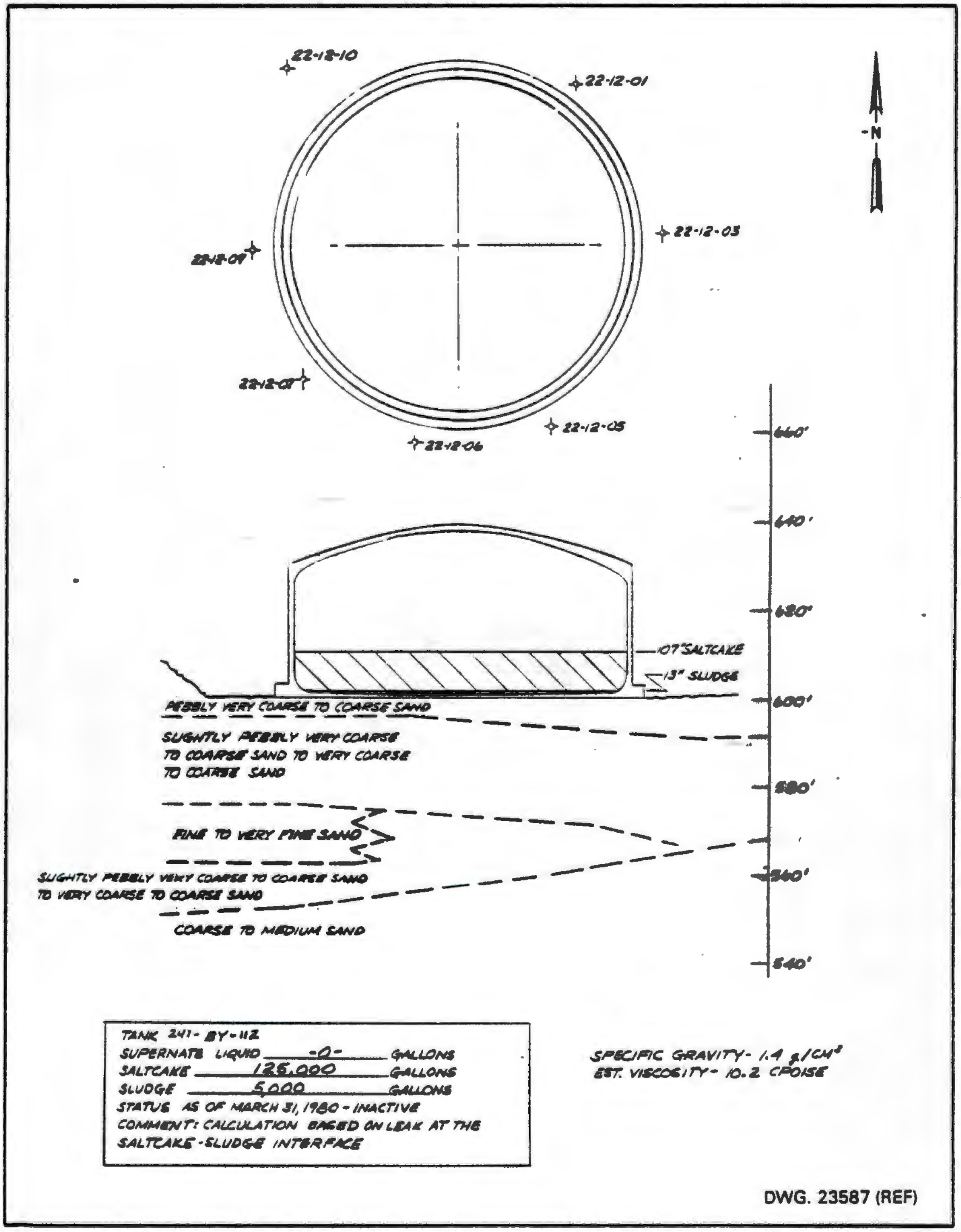


FIGURE G-28. Tank 241-BY-112.

92124991812

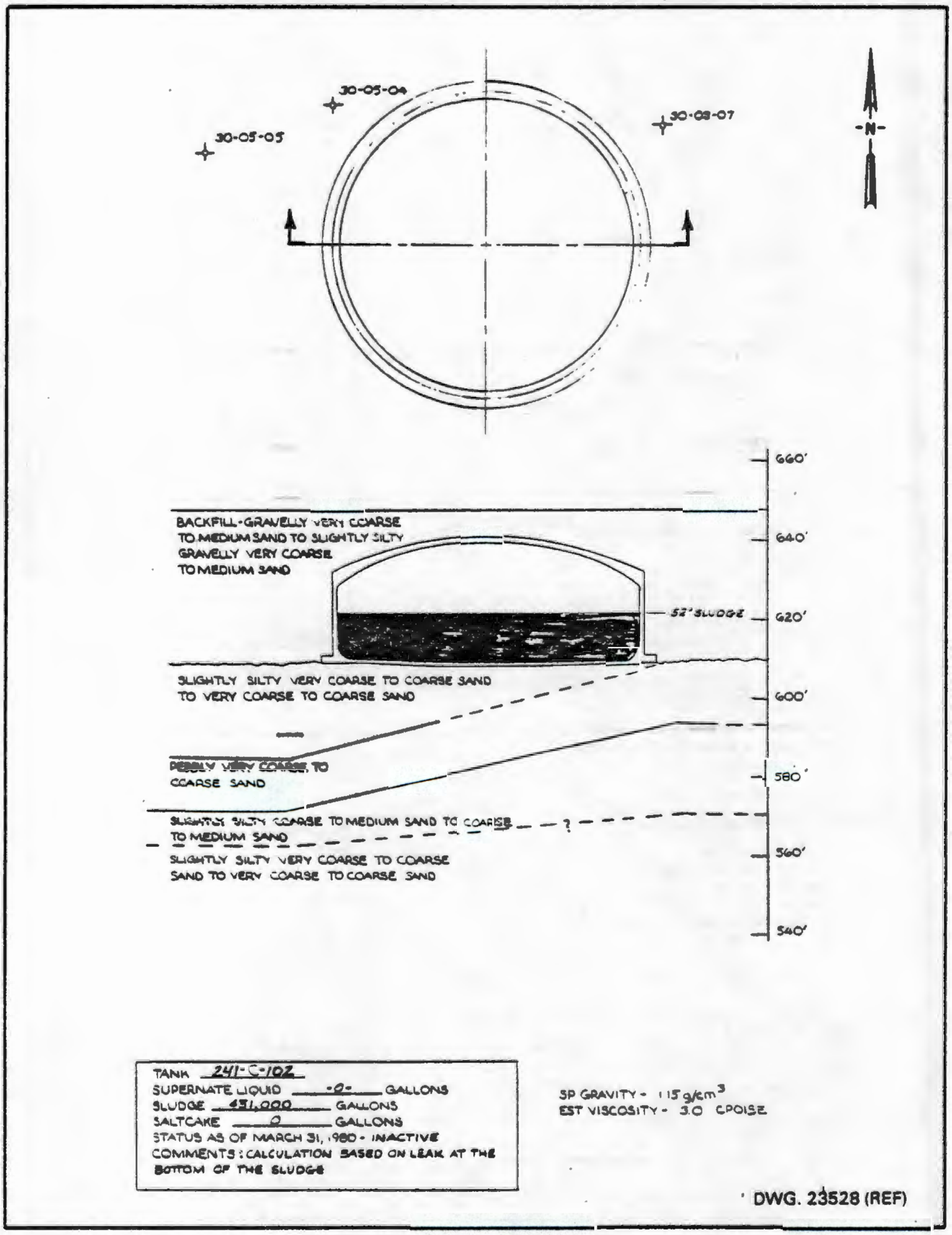


FIGURE G-29. Tank 241-C-102.

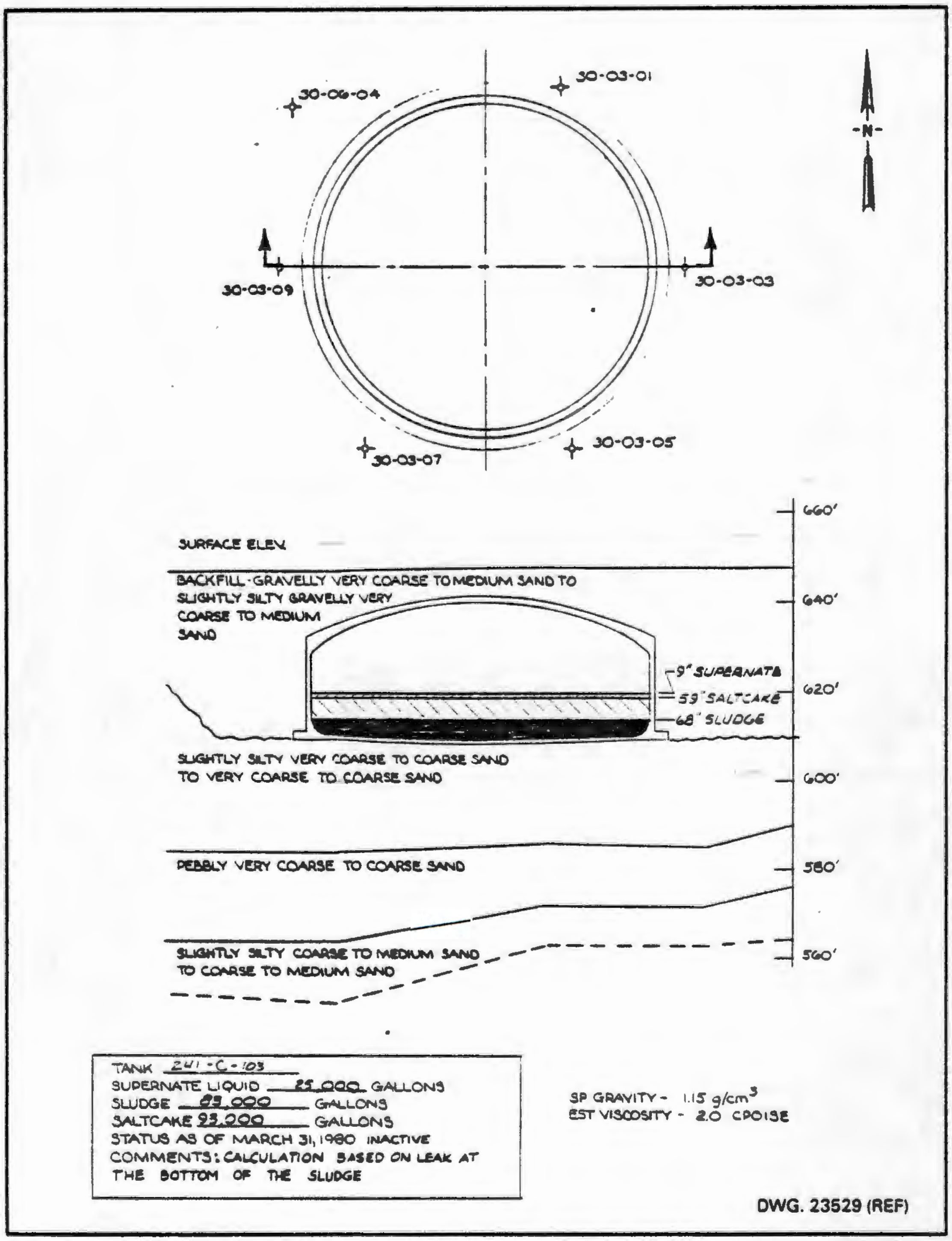


FIGURE G-30. Tank 241-C-103.

9 2 1 2 4 9 9 1 8 1 4

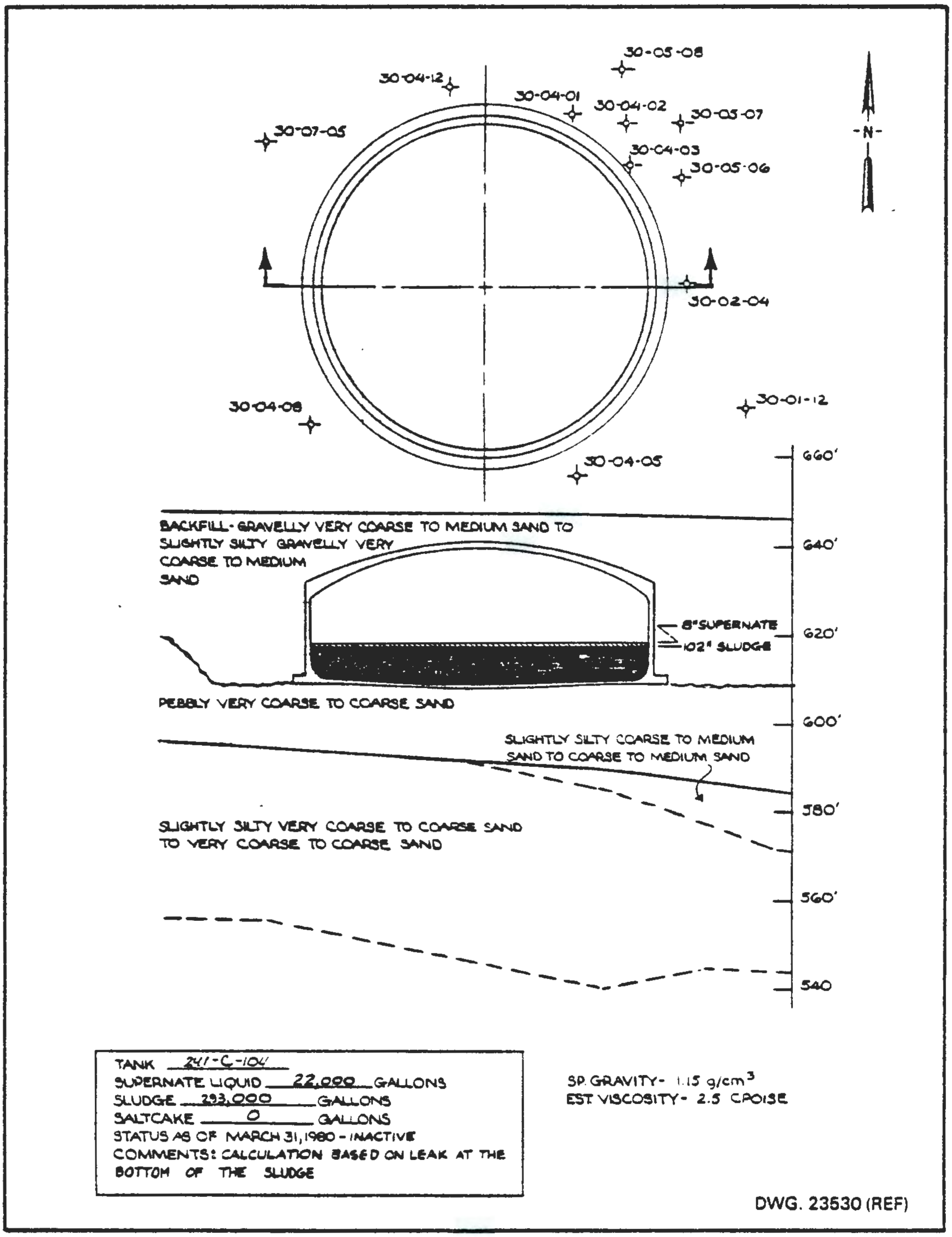


FIGURE G-31. Tank 241-C-104.

9 2 1 2 9 9 1 8 1 5

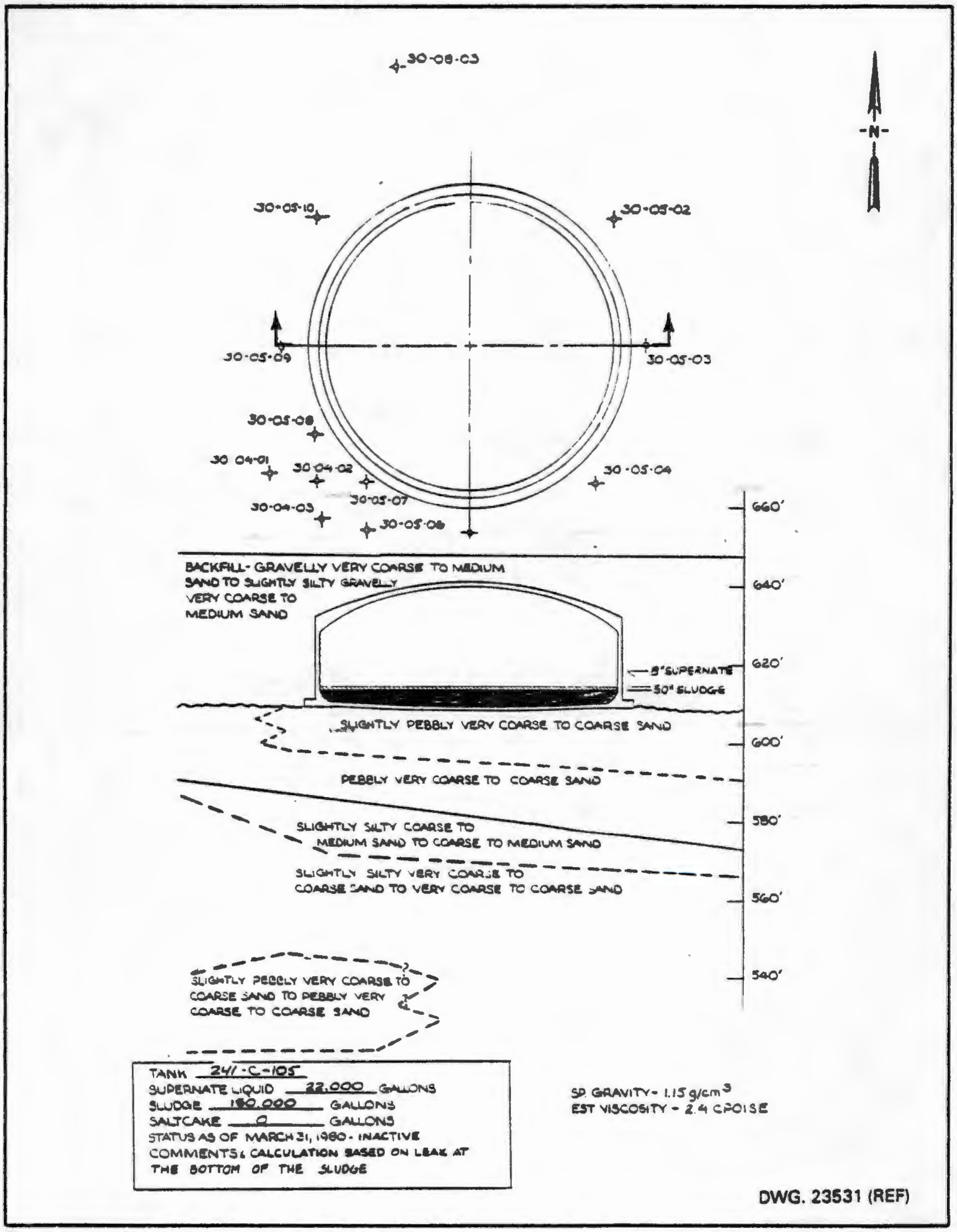


FIGURE G-32. Tank 241-C-105.

9 2 1 2 4 9 9 1 8 1 6

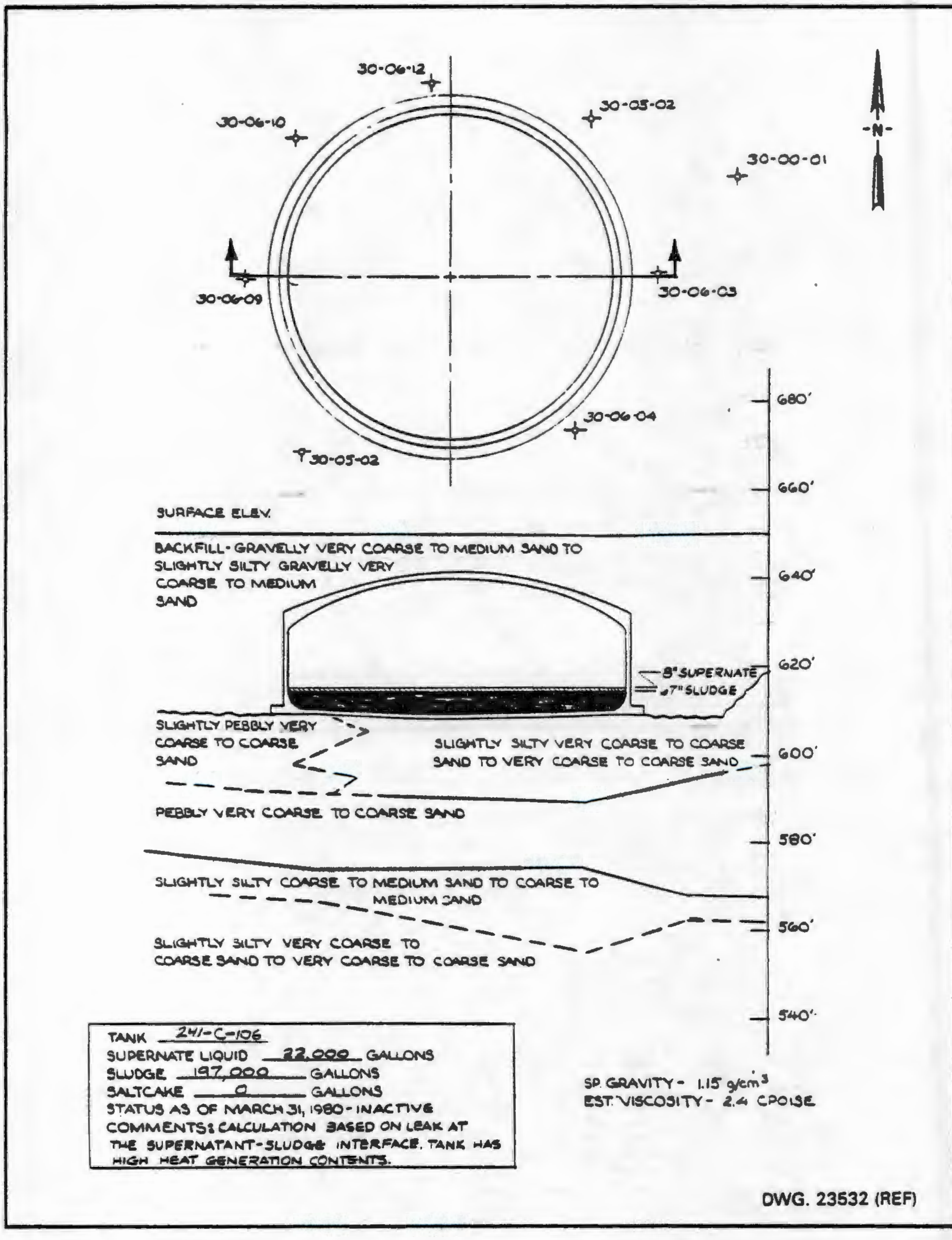


FIGURE G-33. Tank 241-C-106.

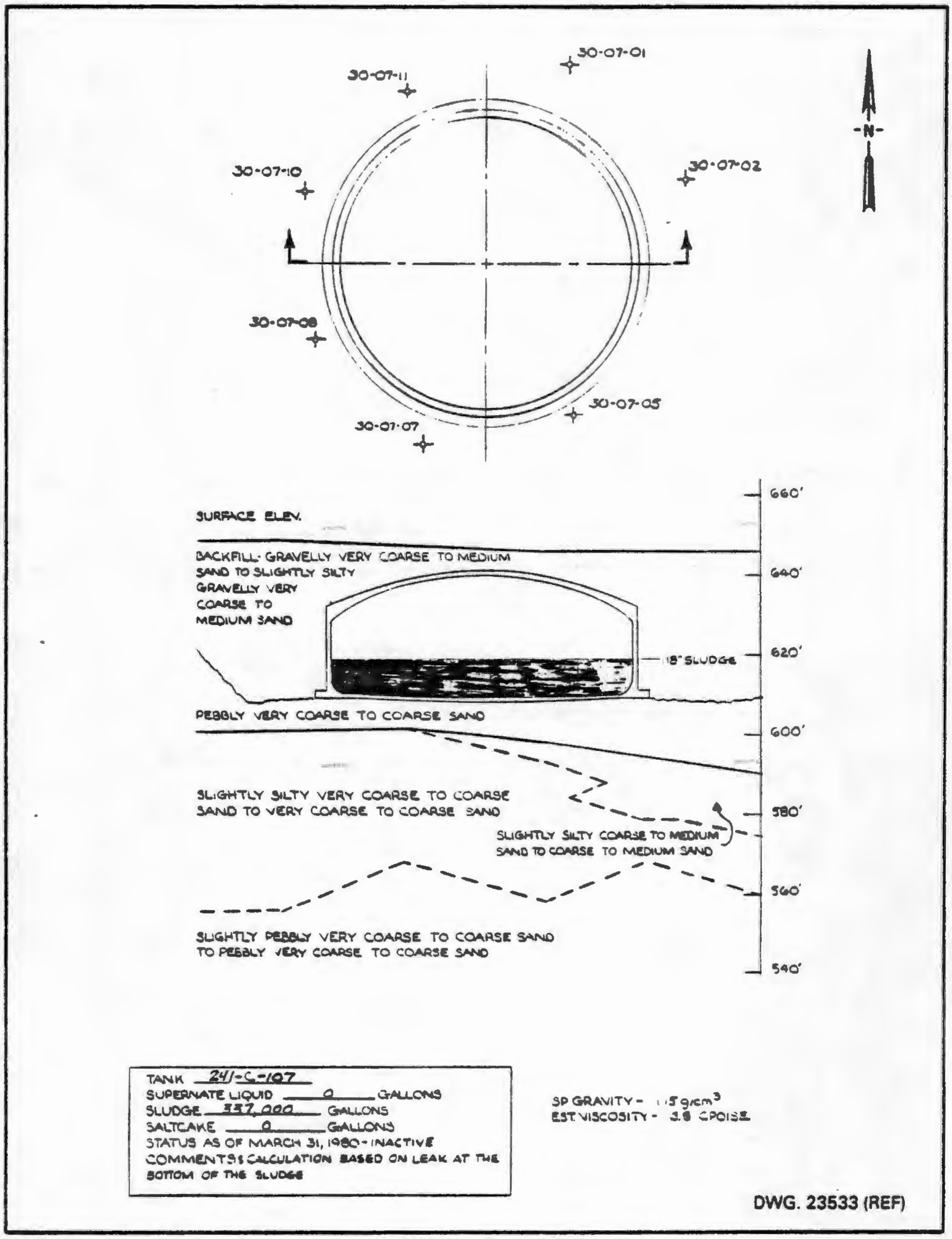


FIGURE G-34. Tank 241-C-107.

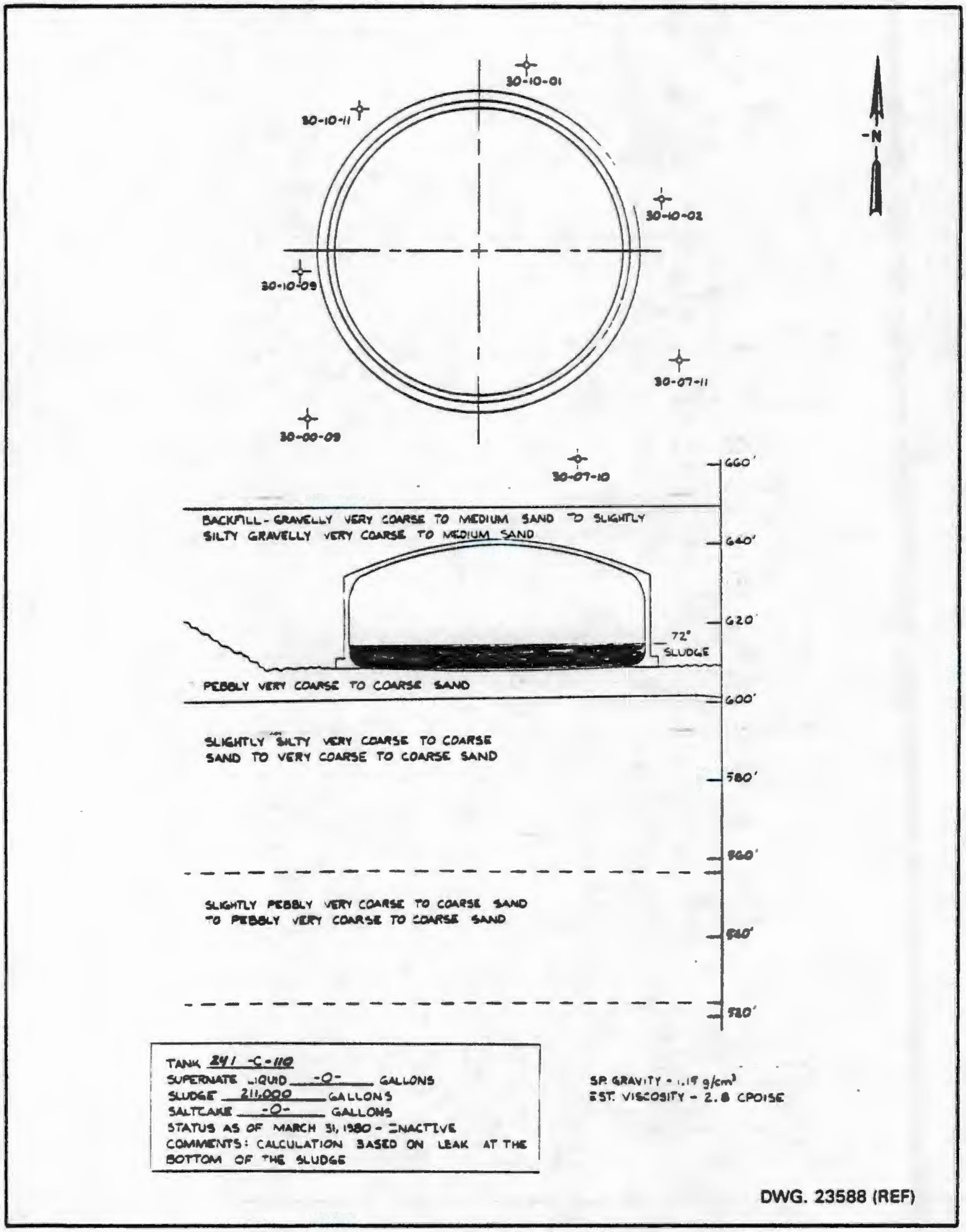


FIGURE G-35. Tank 241-C-110.

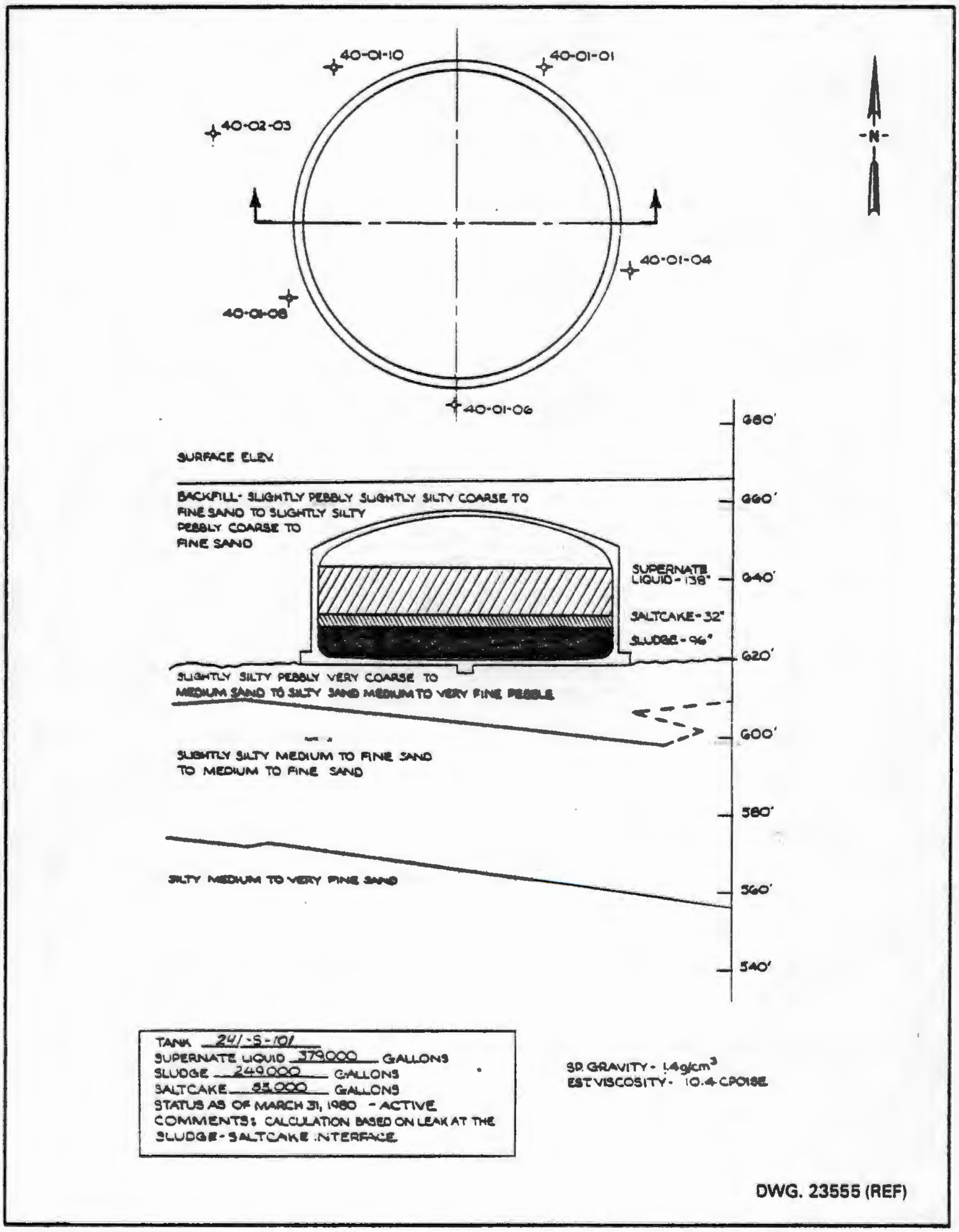


FIGURE G-36. Tank 241-S-101.

9212991821

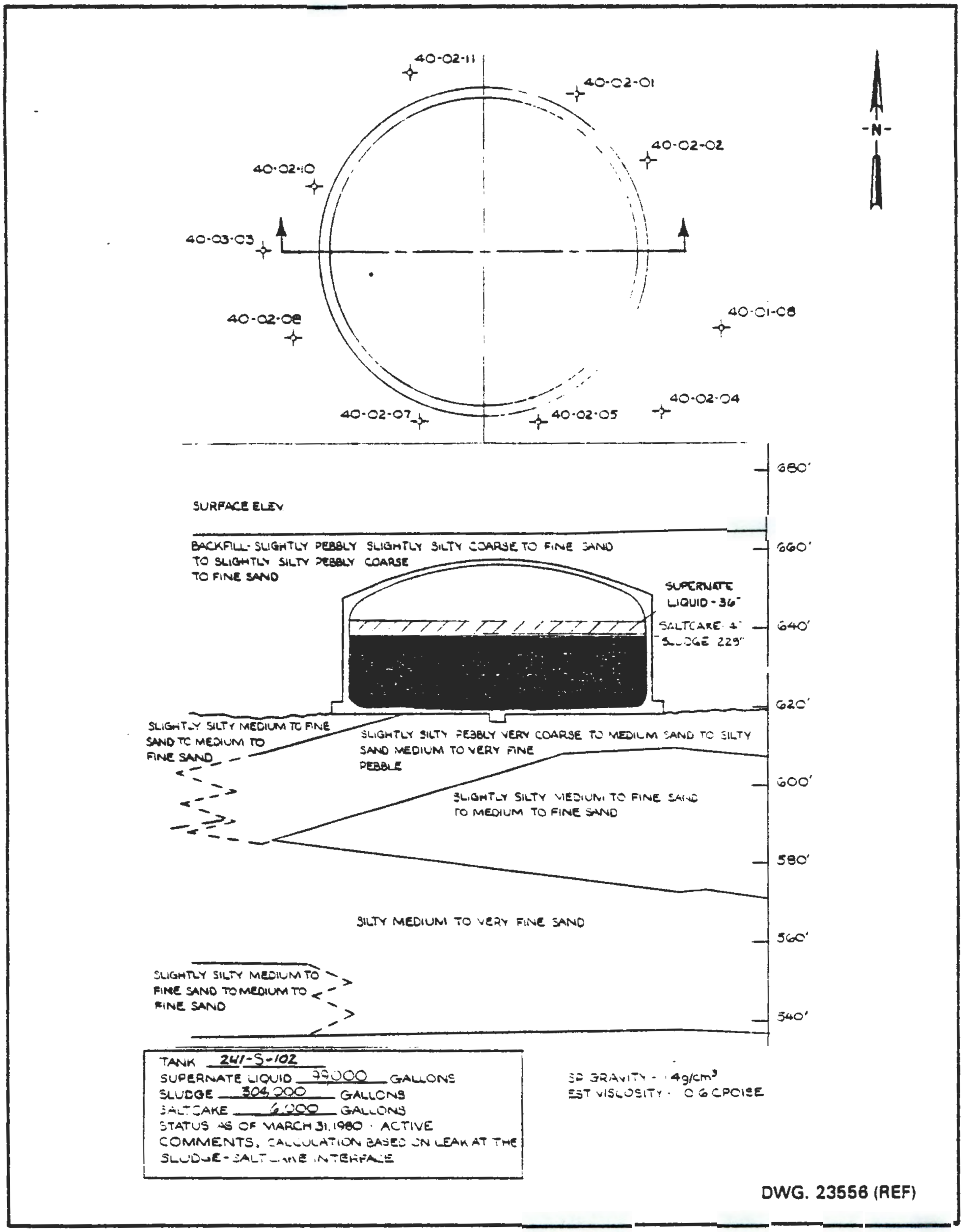


FIGURE G-37. Tank 241-S-102.

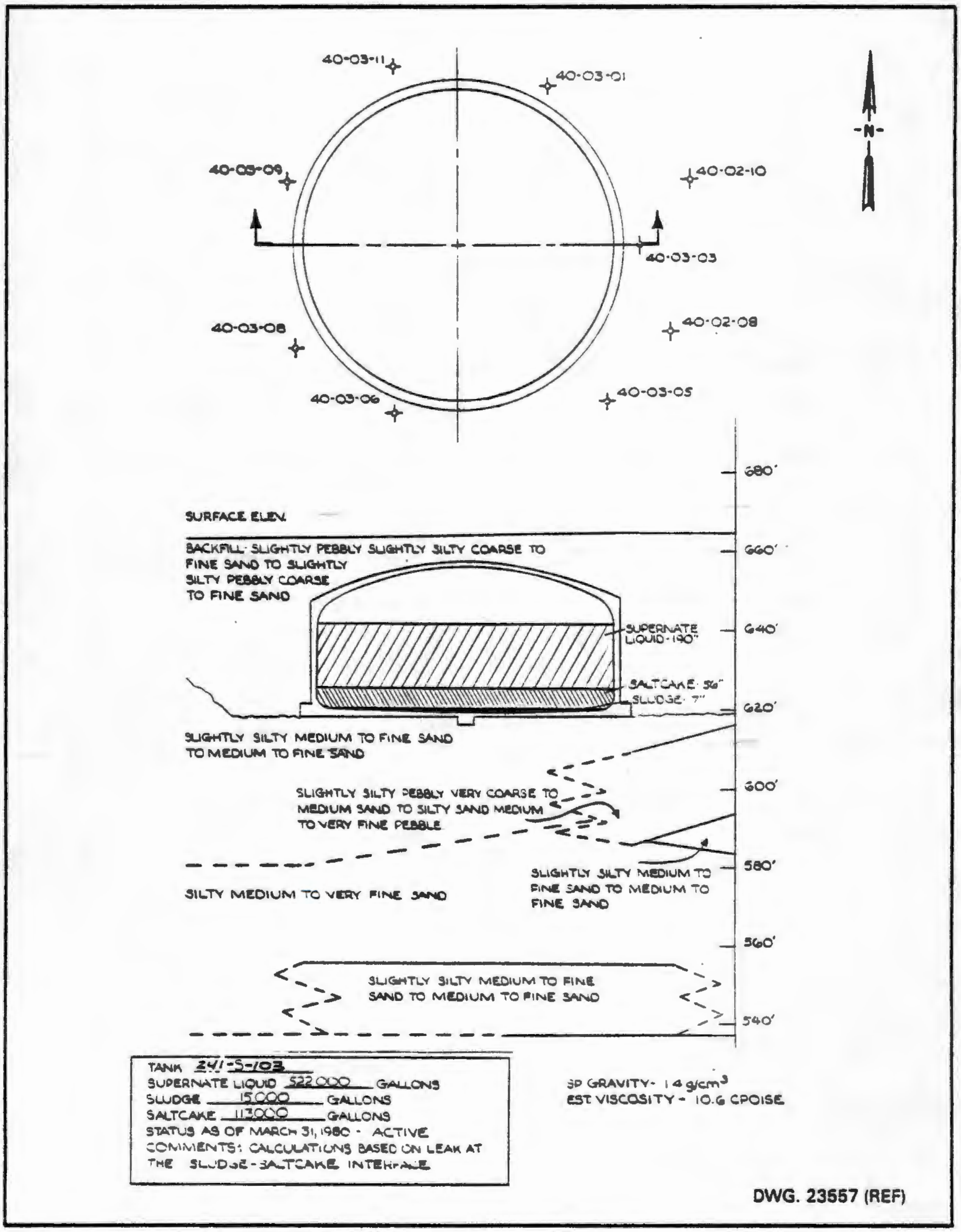


FIGURE G-38. Tank 241-S-103.

92124991822

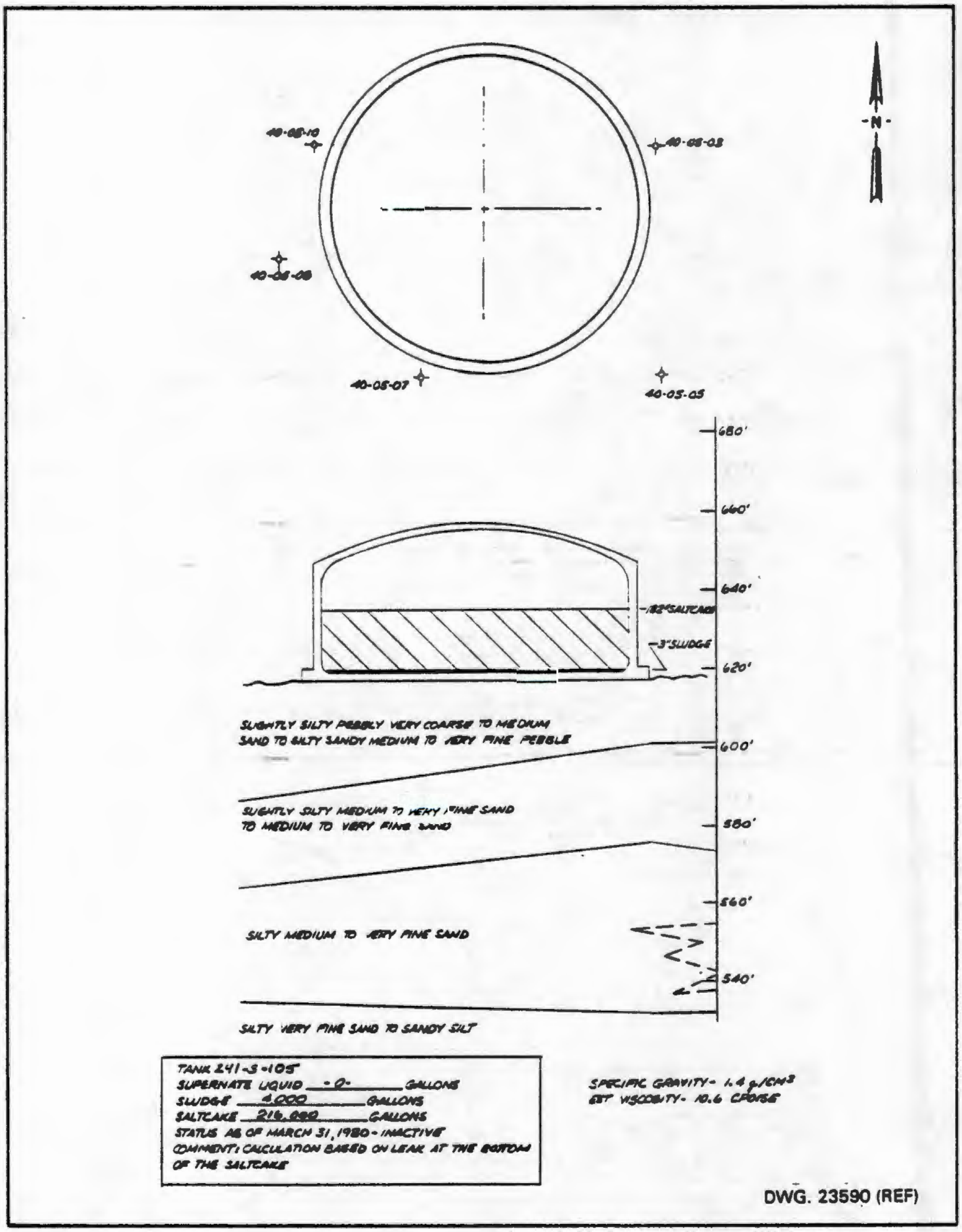


FIGURE G-39. Tank 241-S-105.

9212499823

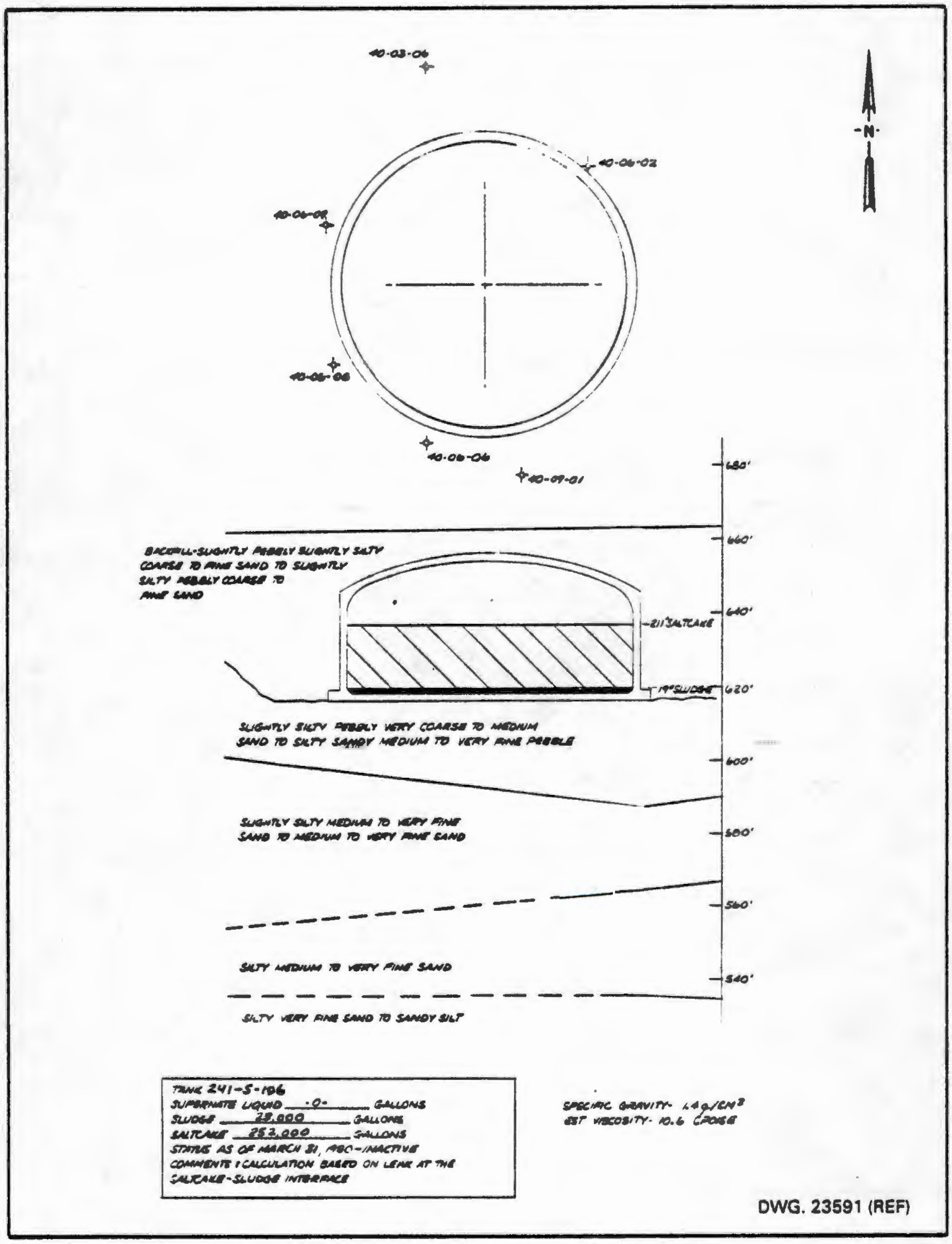


FIGURE G-40. Tank 241-S-106.

9 2 1 2 4 9 9 1 8 2 4

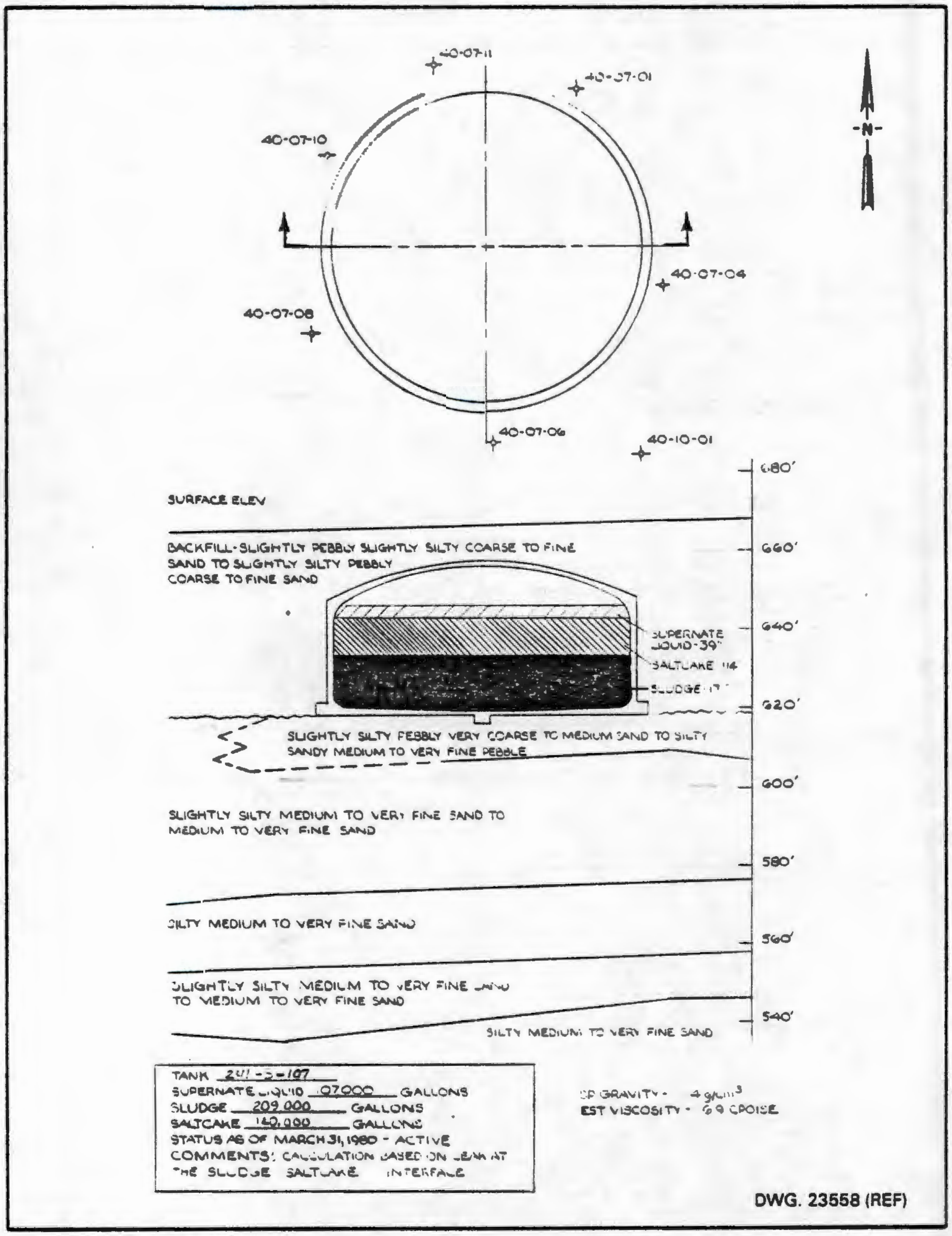


FIGURE G-41. Tank 241-S-107.

92124991825

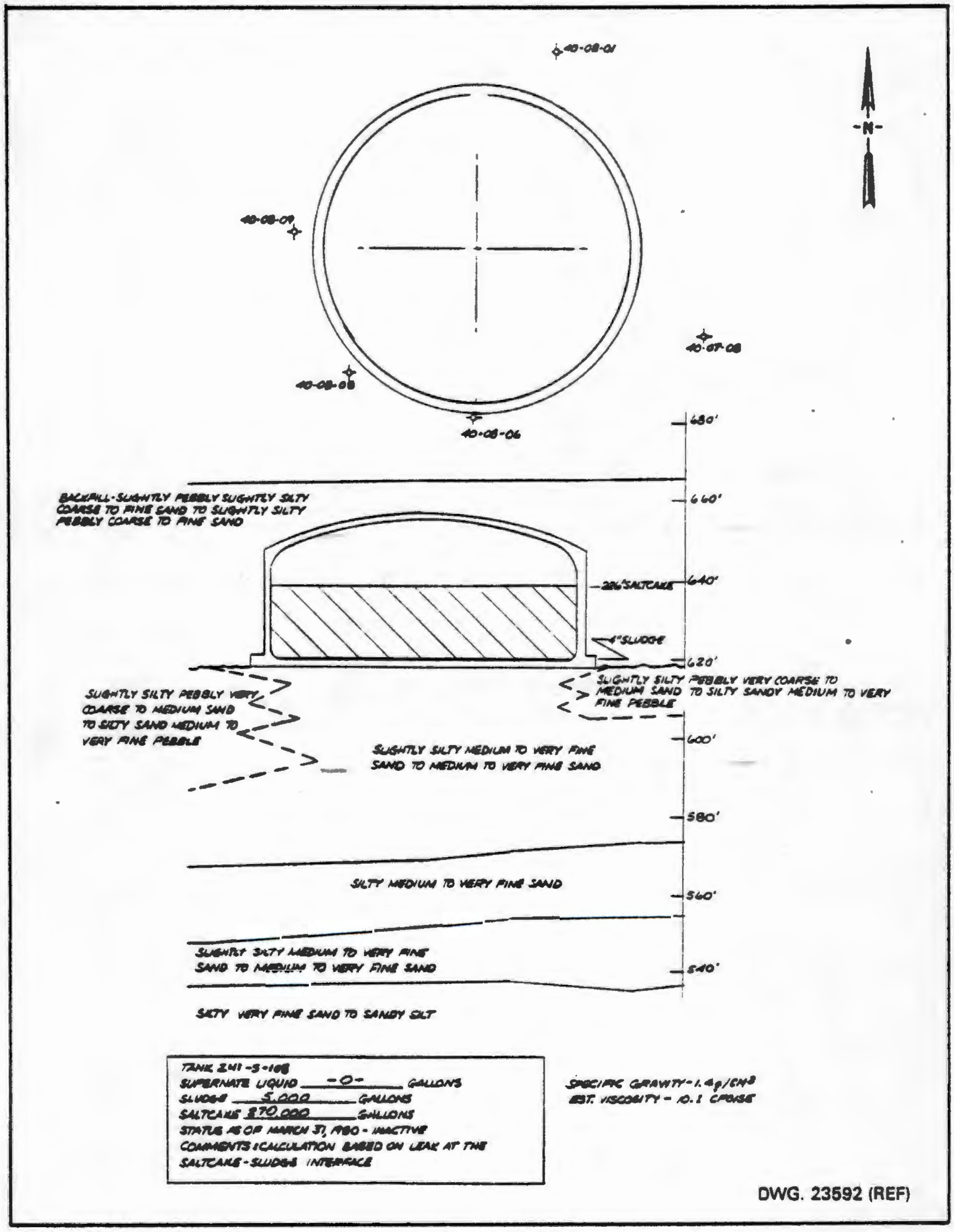


FIGURE G-42. Tank 241-S-108.

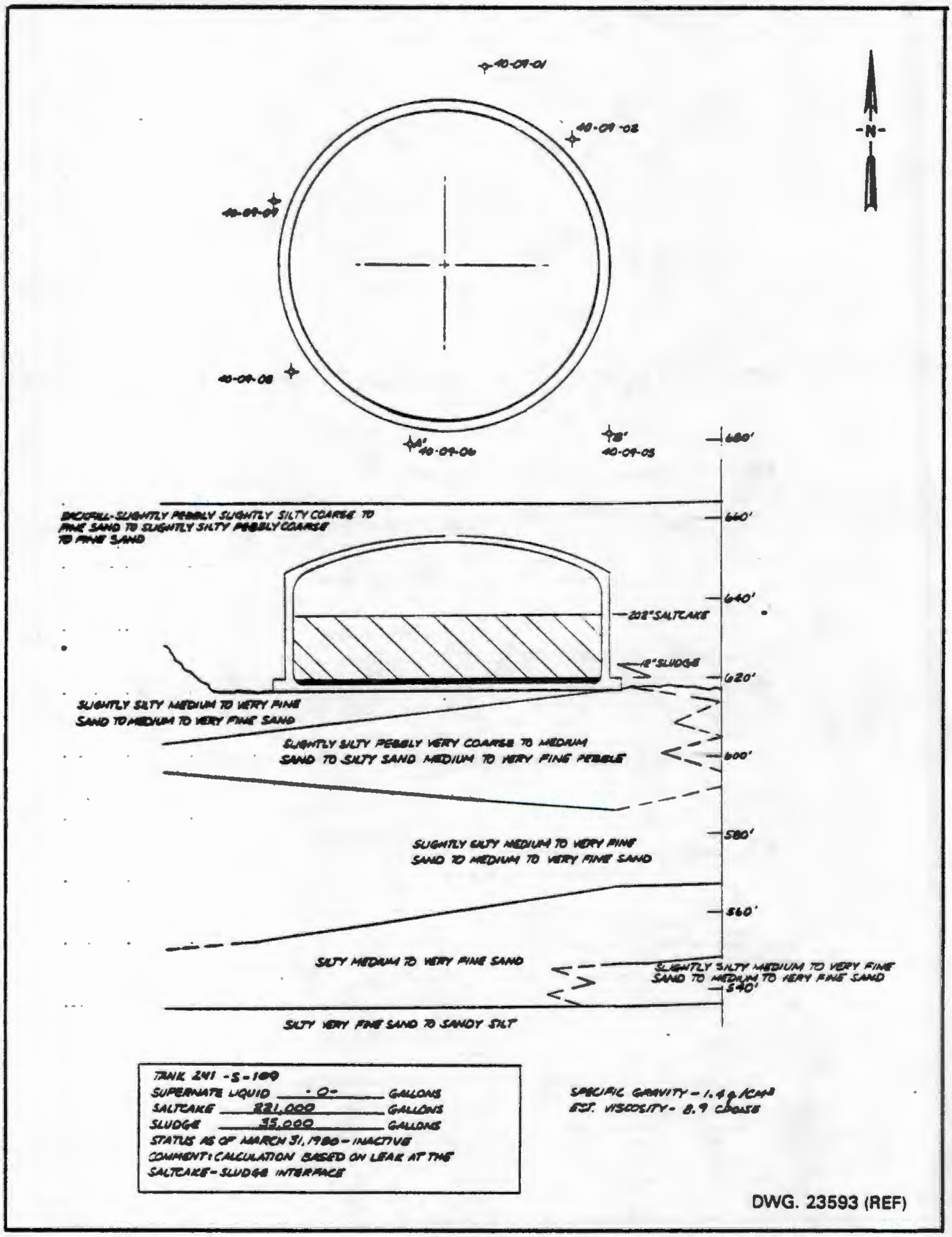


FIGURE G-43. Tank 241-S-109.

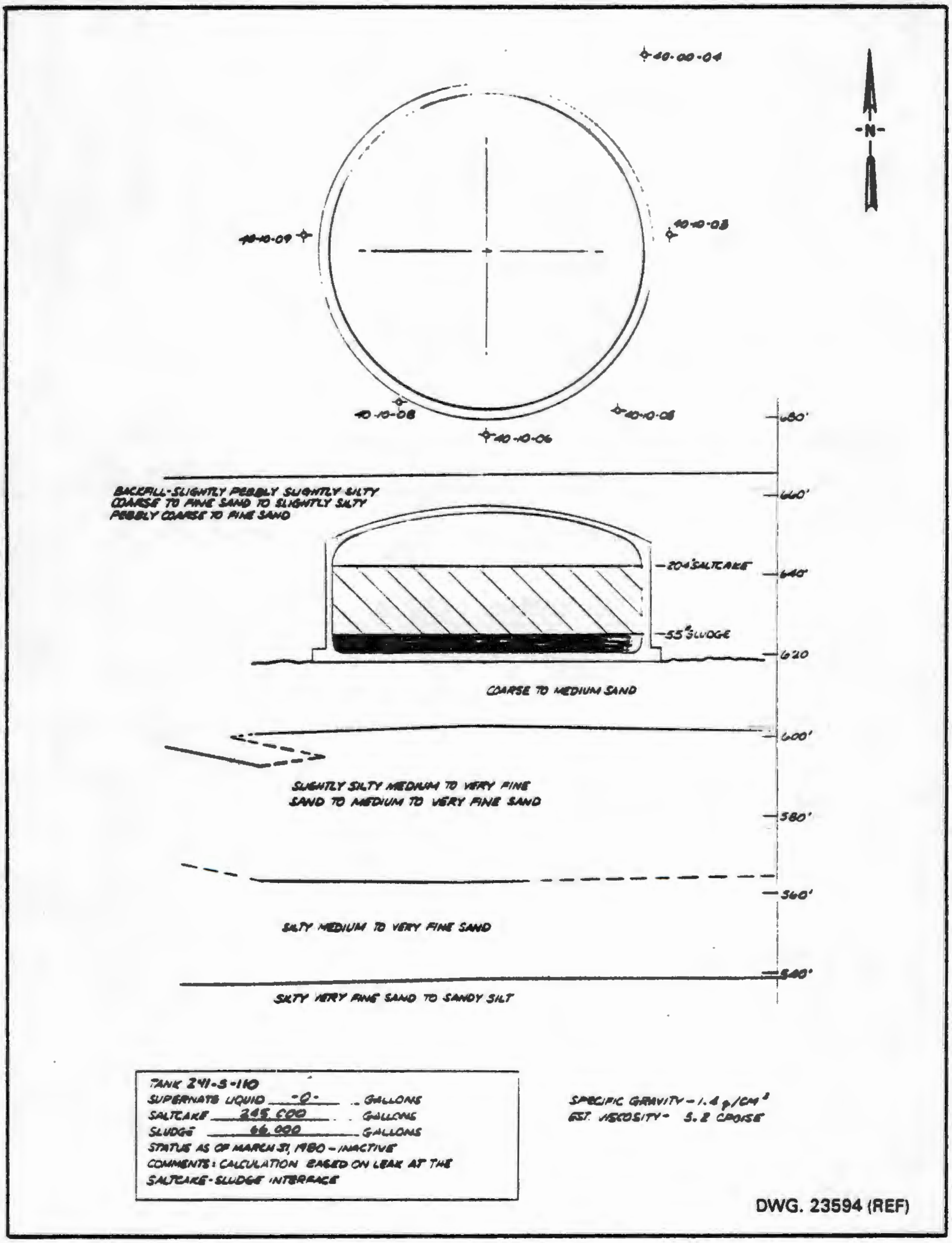


FIGURE G-44. Tank 241-S-110.

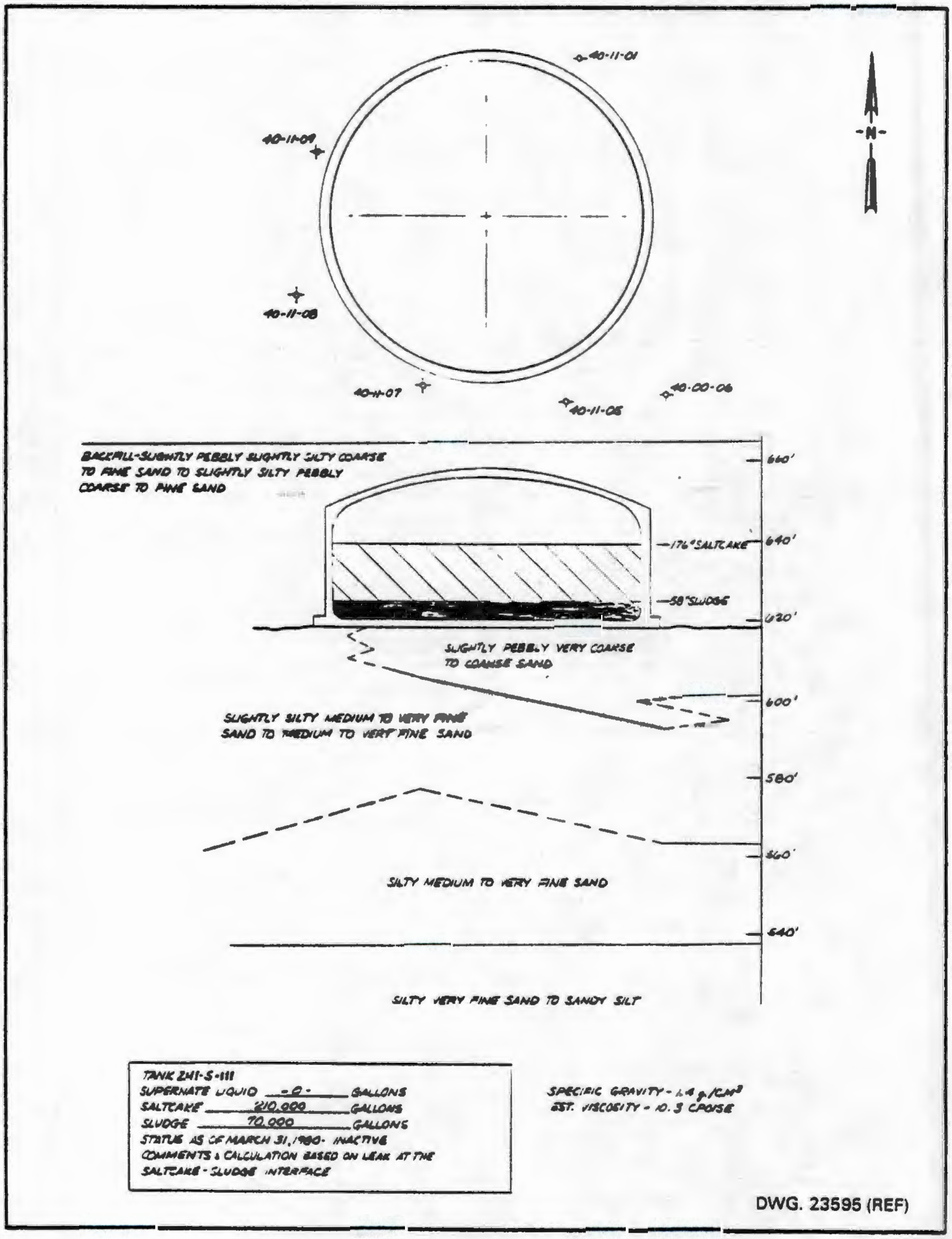


FIGURE G-45. Tank 241-S-111.

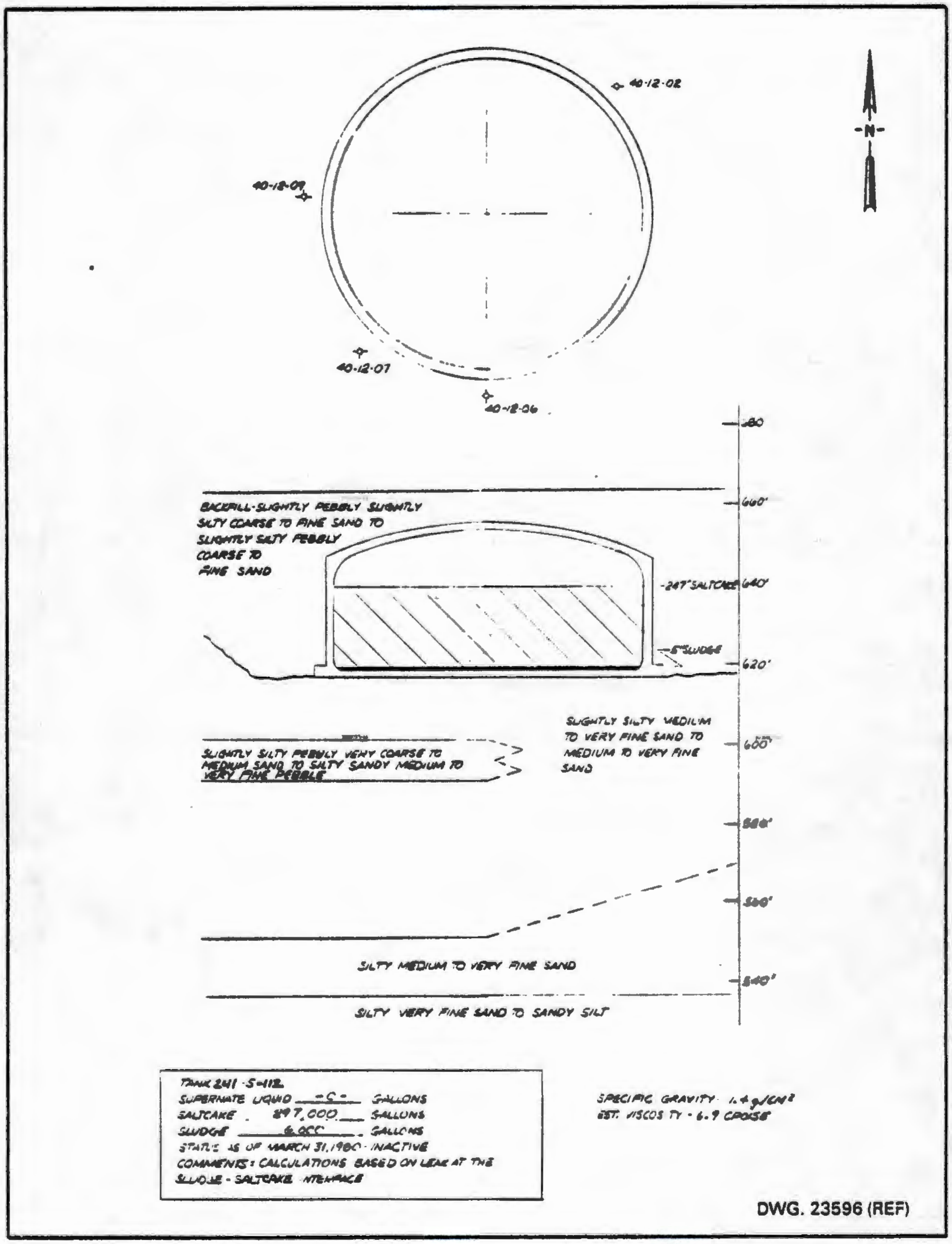


FIGURE G-46. Tank 241-S-112.

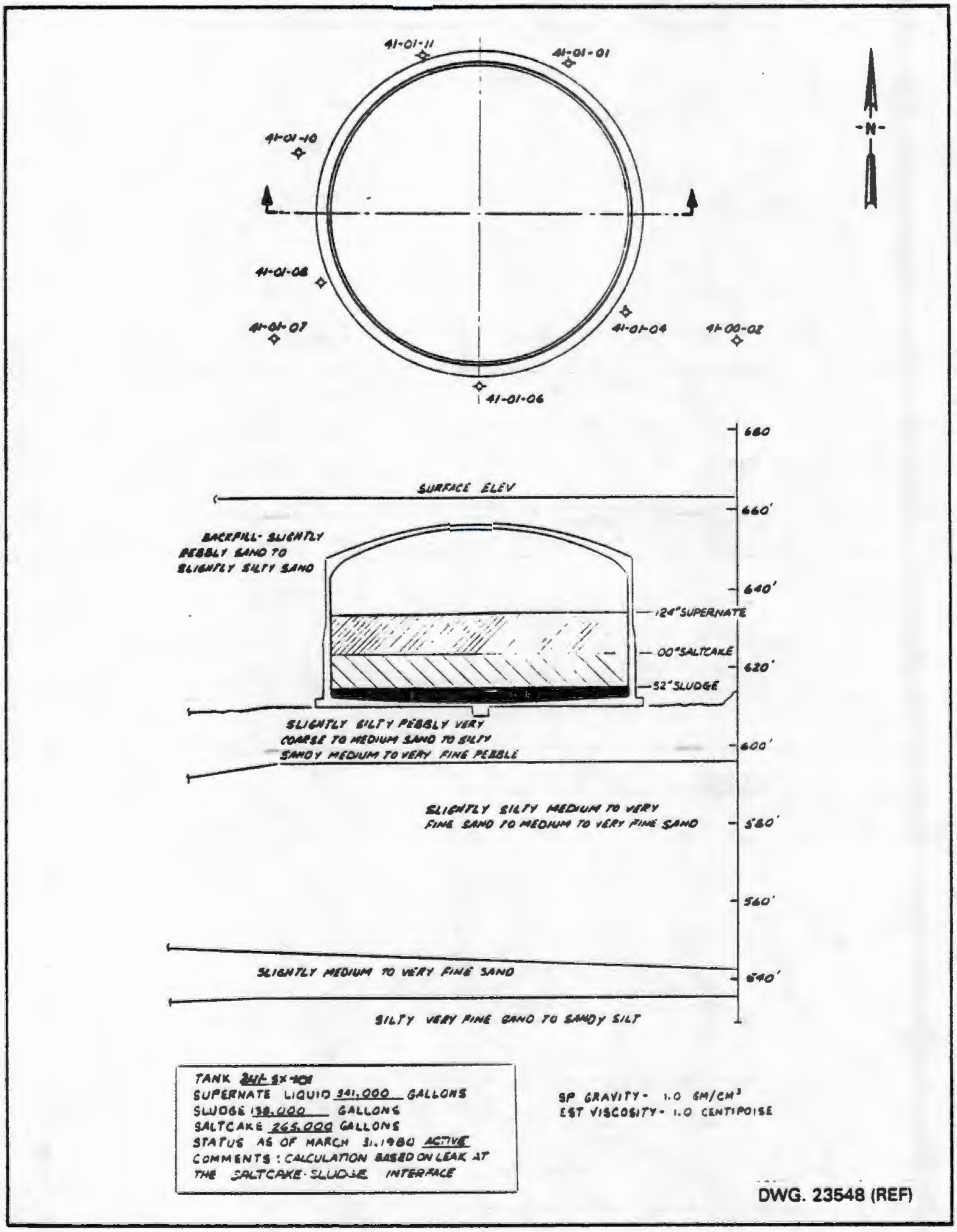


FIGURE G-47. Tank 241-SX-101.

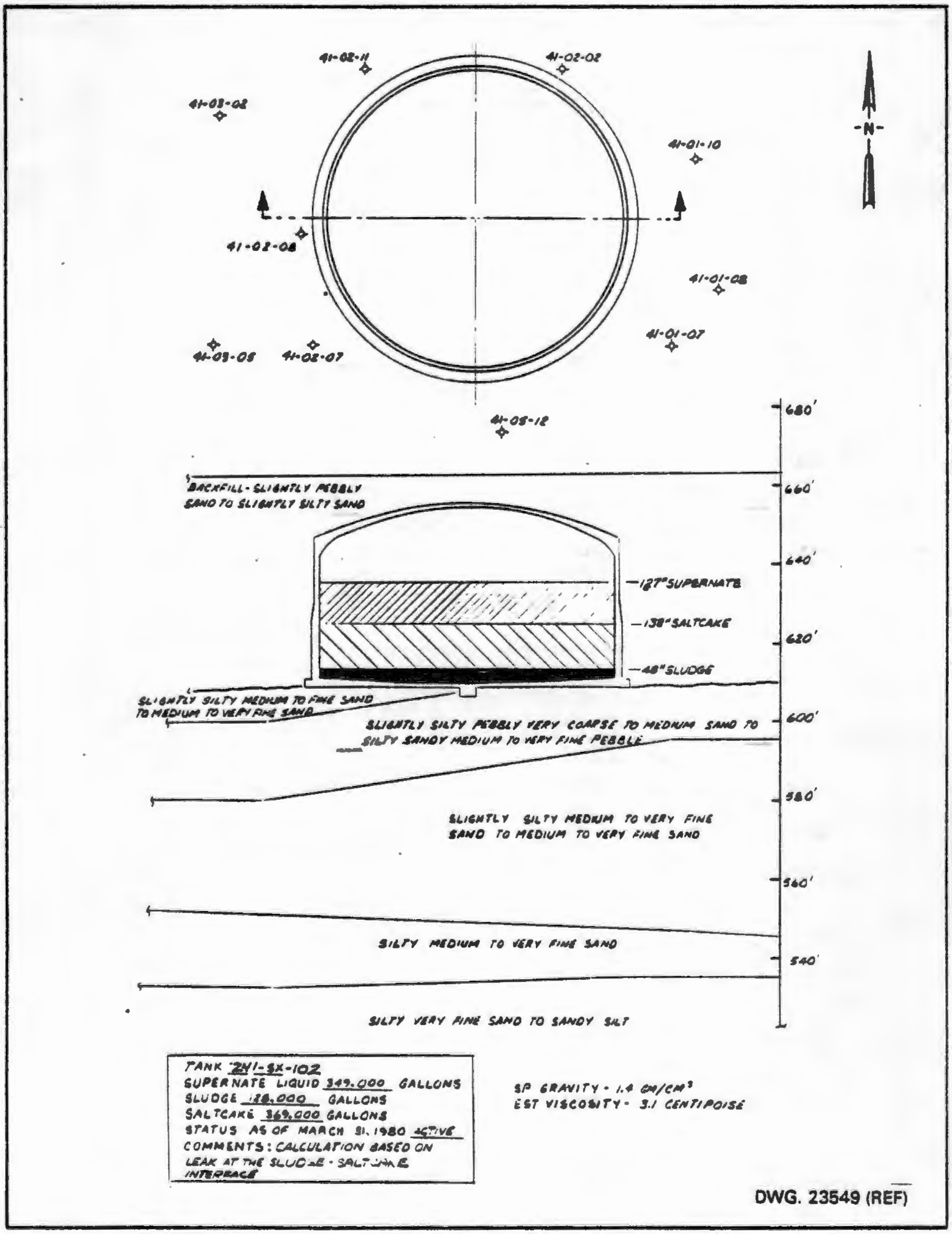


FIGURE G-48. Tank 241-SX-102

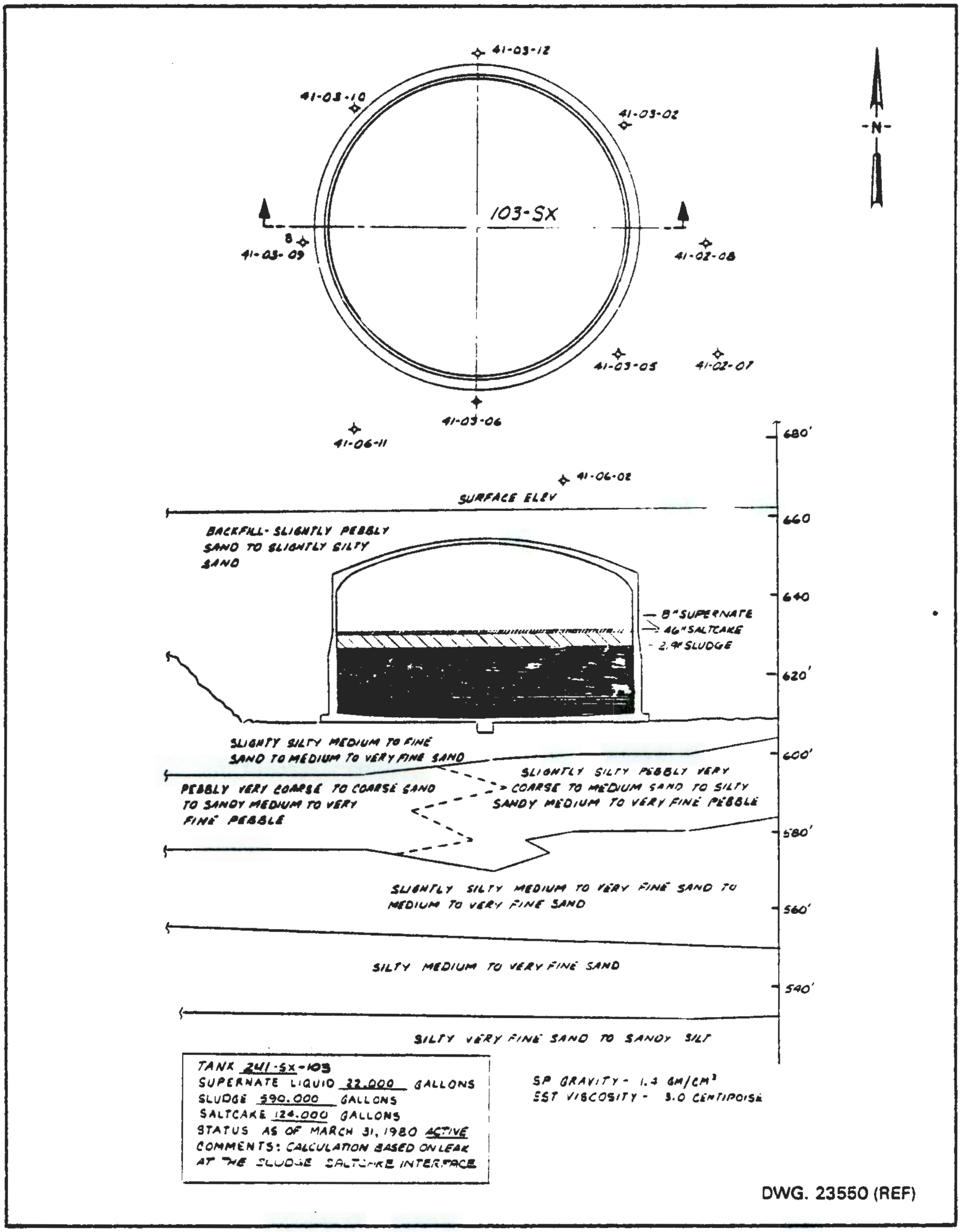


FIGURE G-49. Tank 241-SX-103.

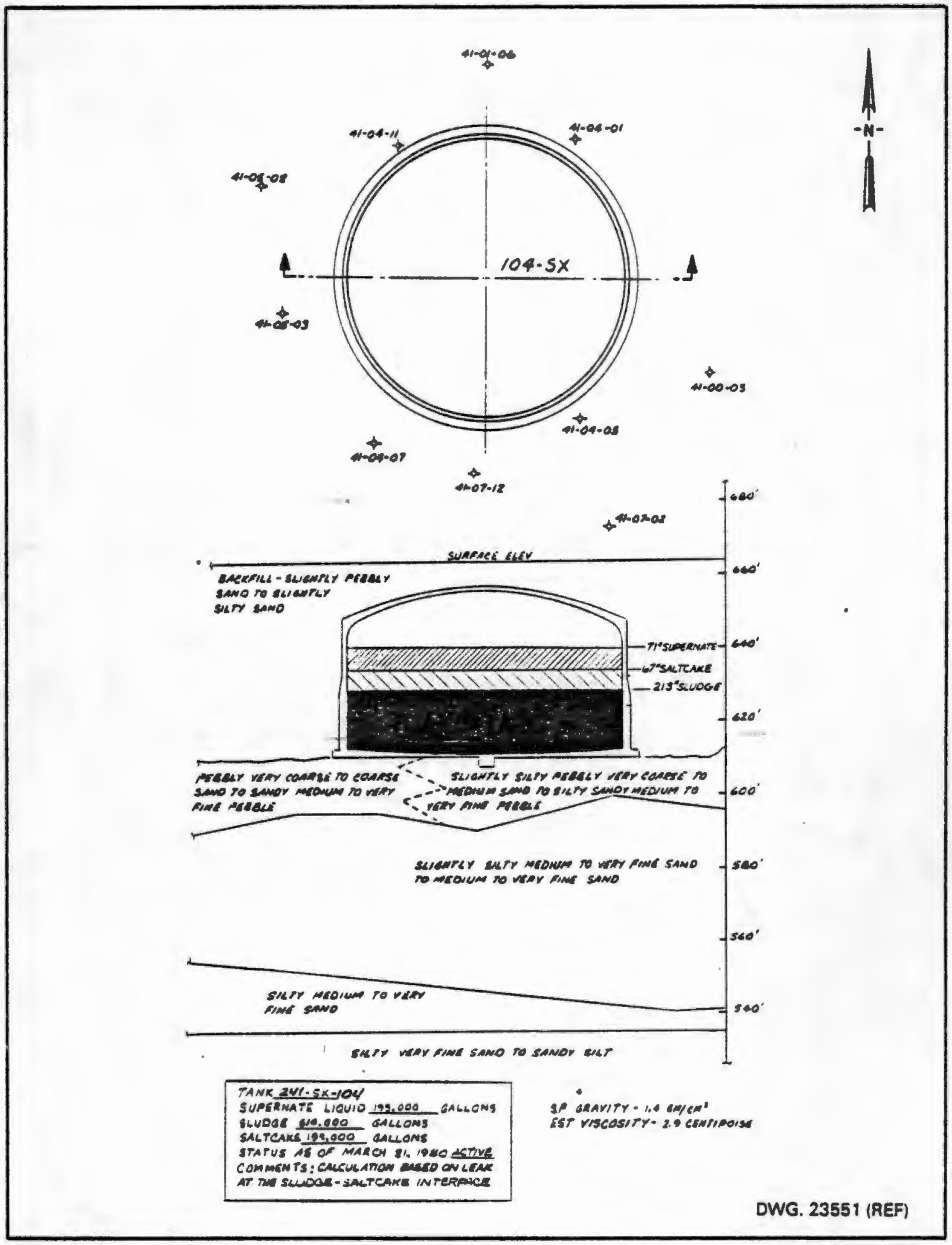


FIGURE G-50. Tank 241-SX-104.

9 2 1 2 4 9 9 1 8 3 4

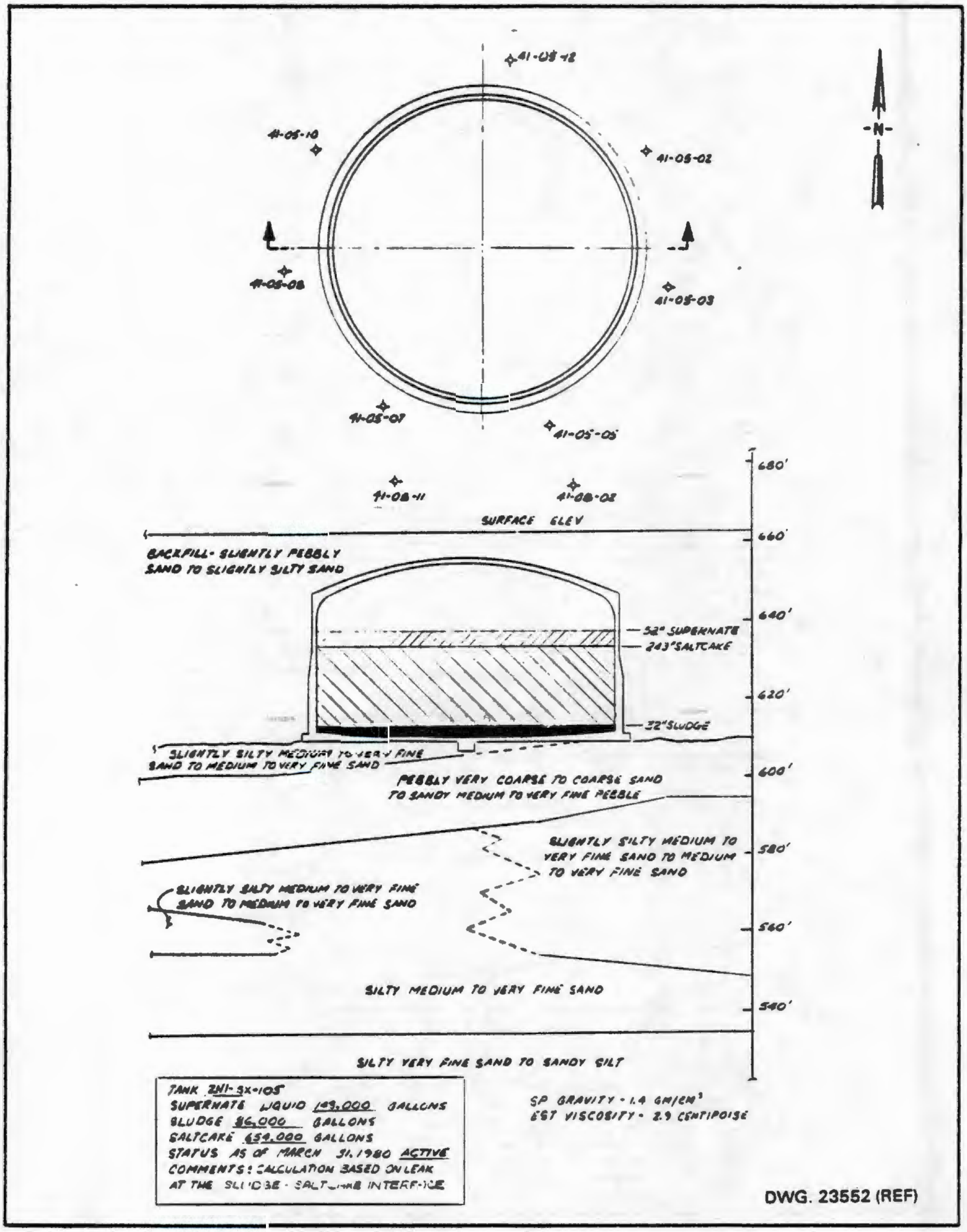


FIGURE G-51. Tank 241-SX-105.

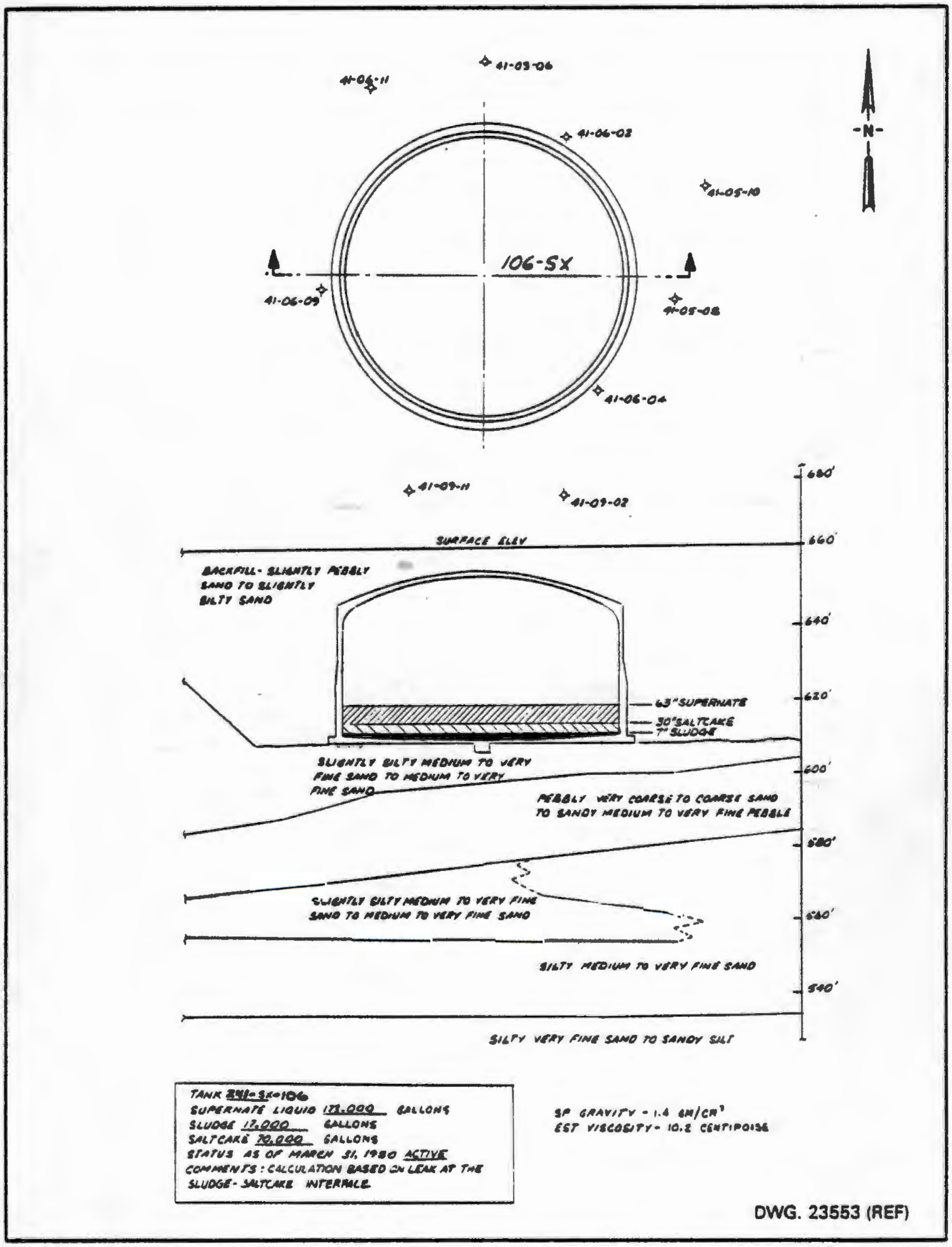


FIGURE G-52. Tank 241-SX-106.

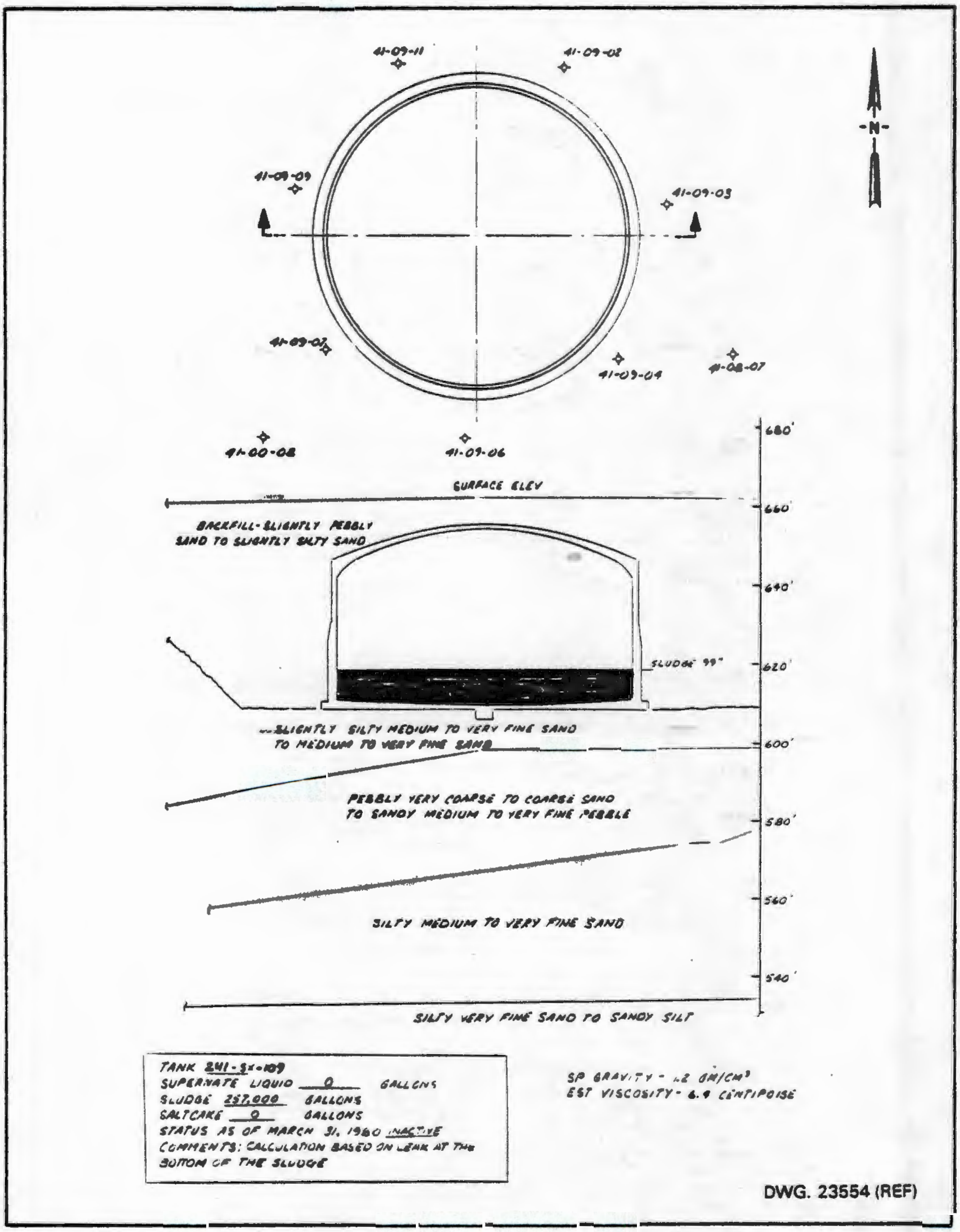


FIGURE G-53. Tank 241-T-101.

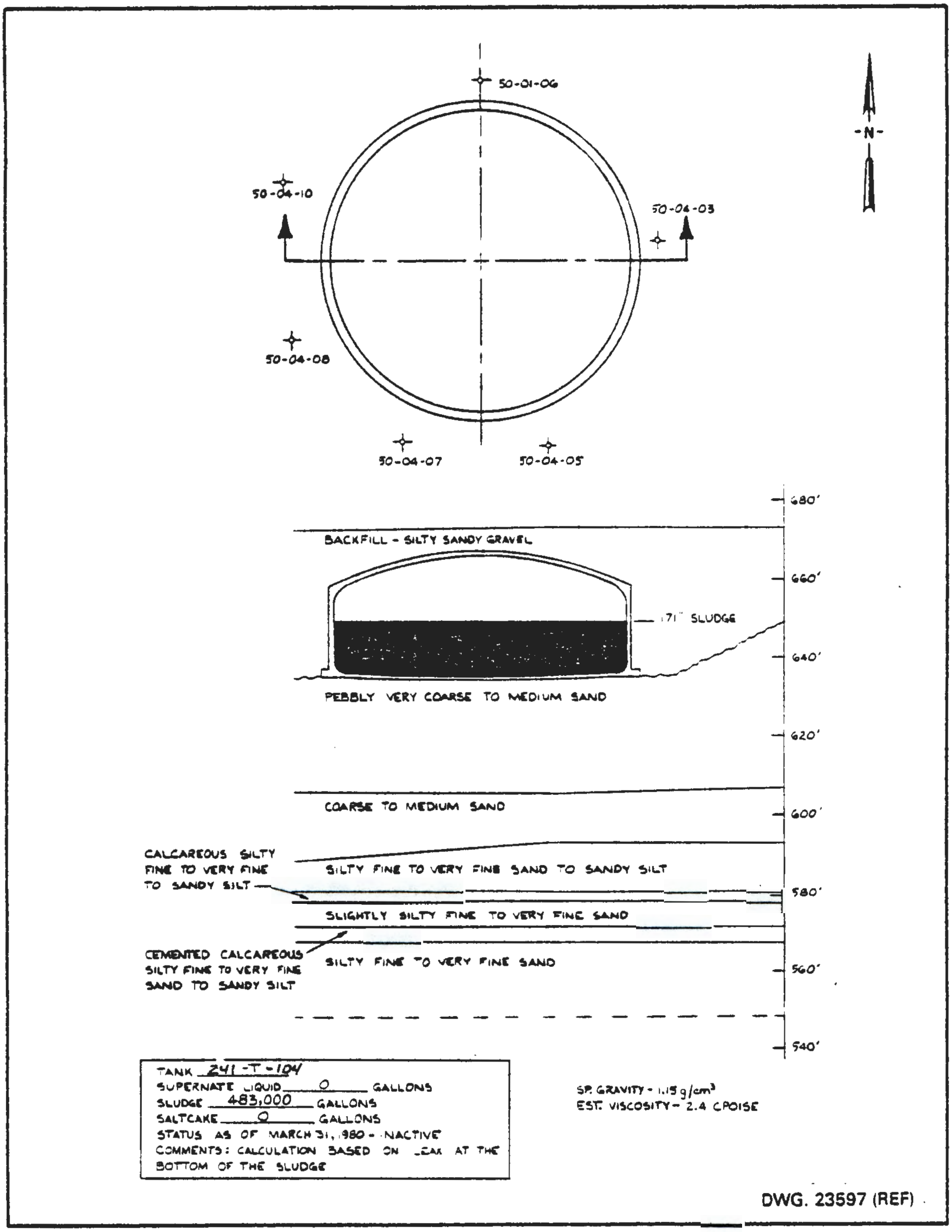


FIGURE G-54. Tank 241-T-104.

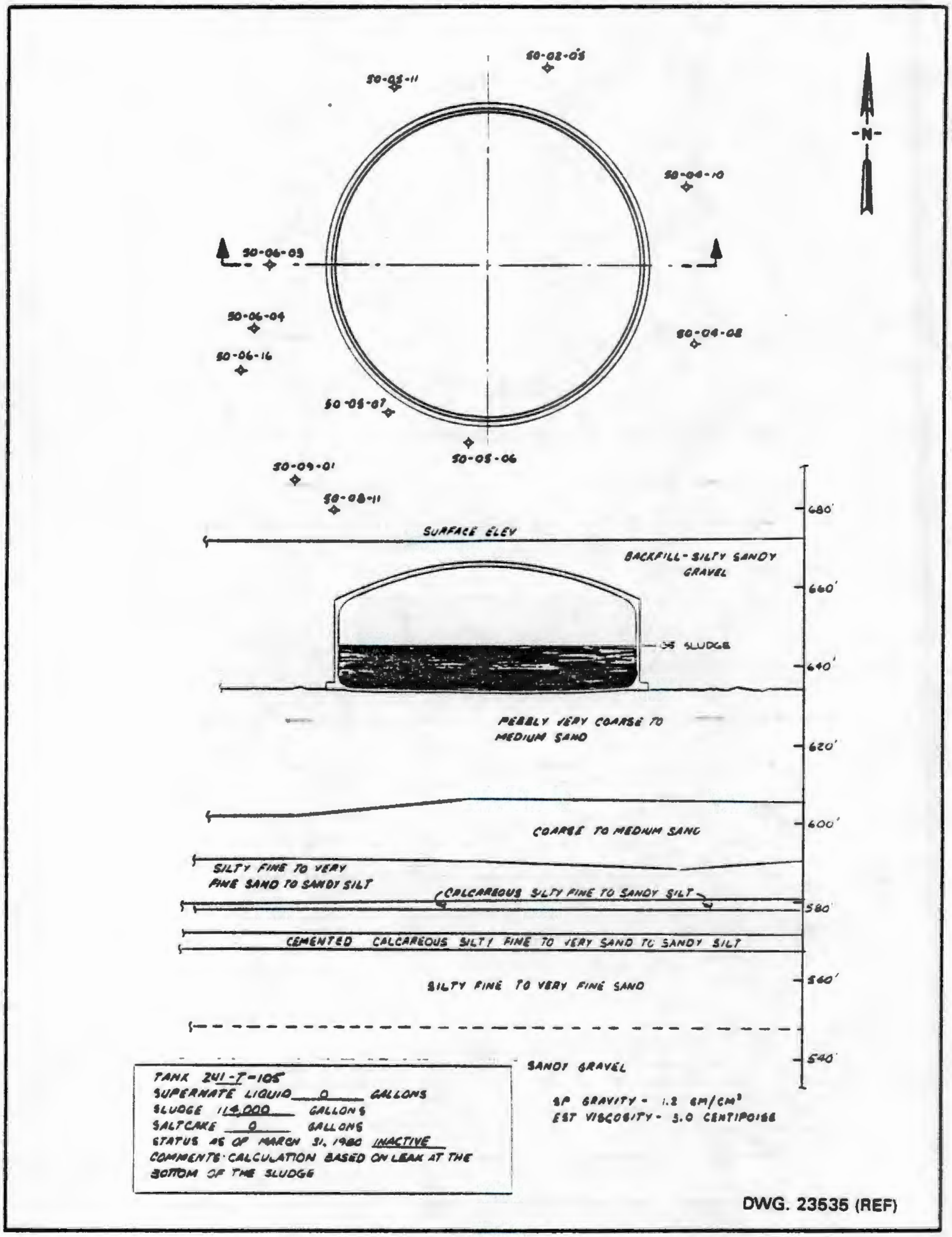


FIGURE G-55. Tank 241-T-105.

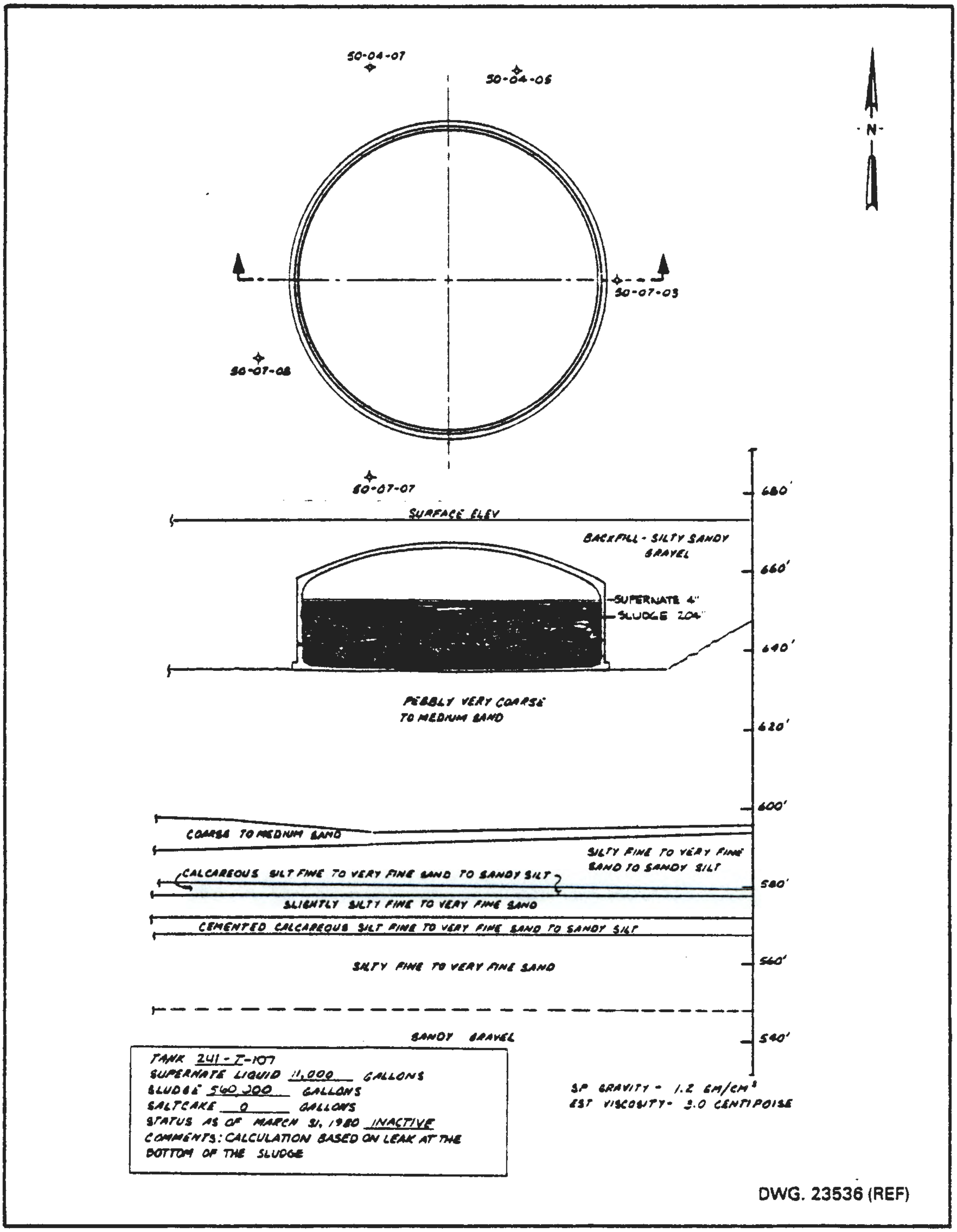


FIGURE G-56. Tank 241-T-107.

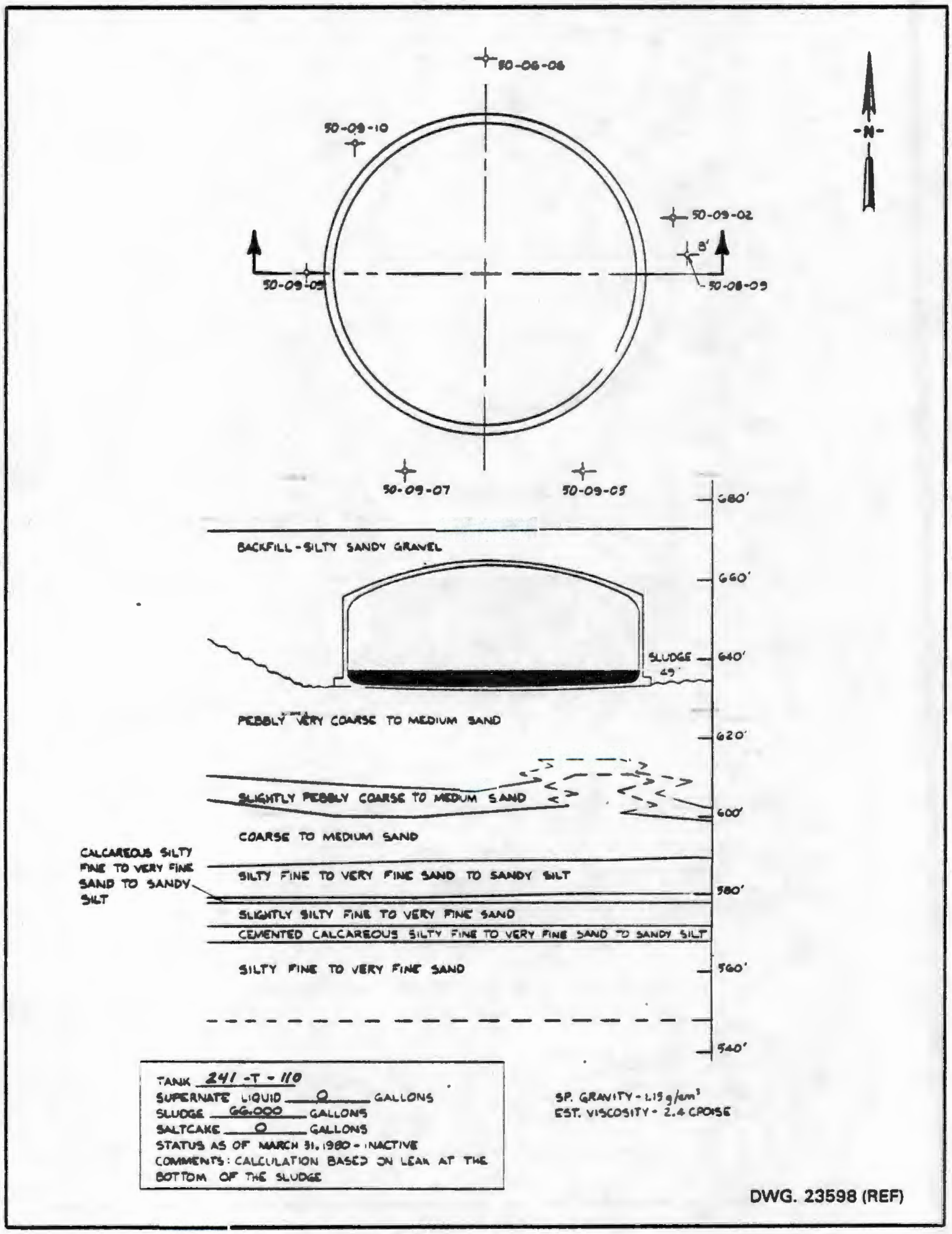


FIGURE G-57. Tank 241-T-110.

9 2 1 2 4 9 9 1 8 4 1

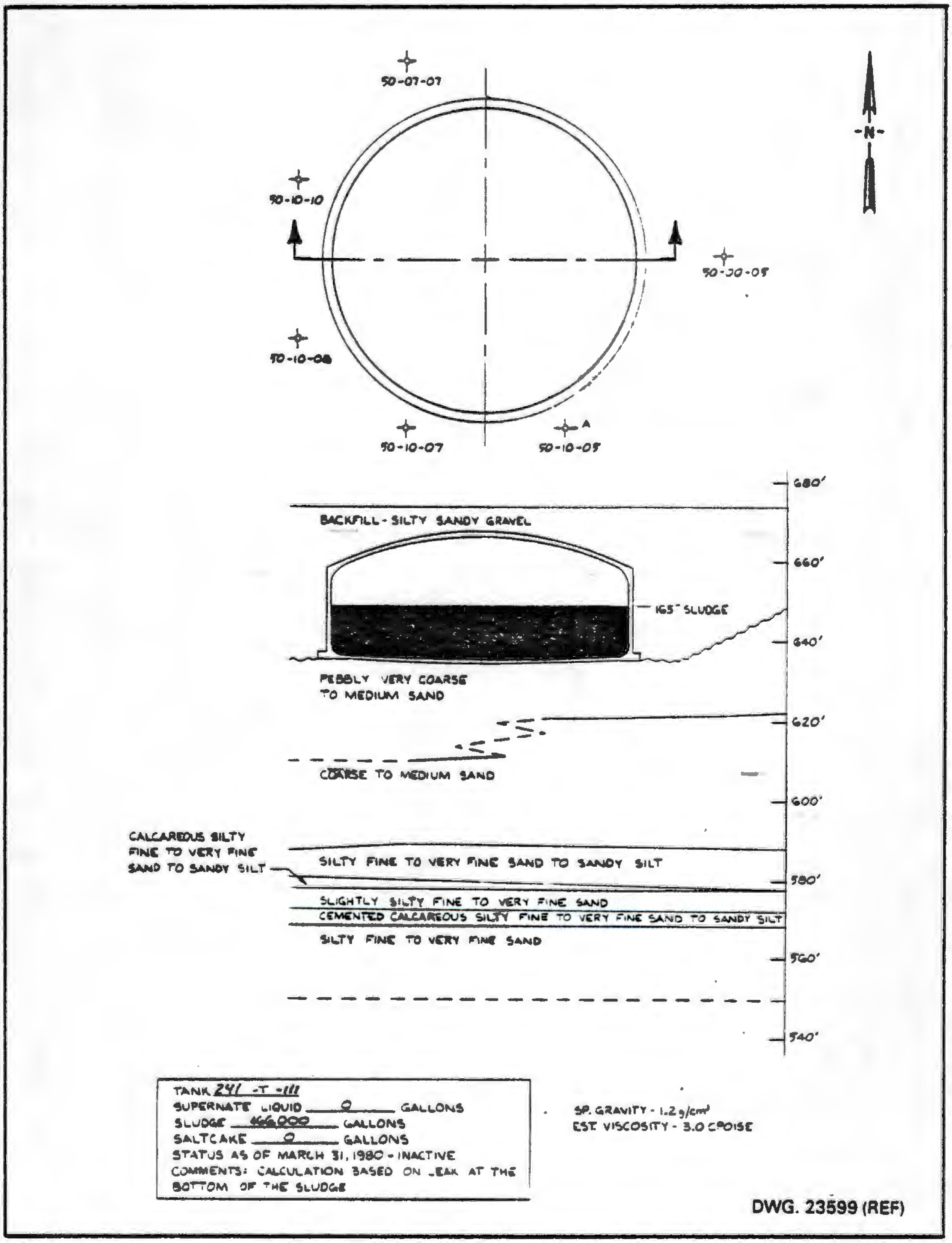


FIGURE G-58. Tank 241-T-111.

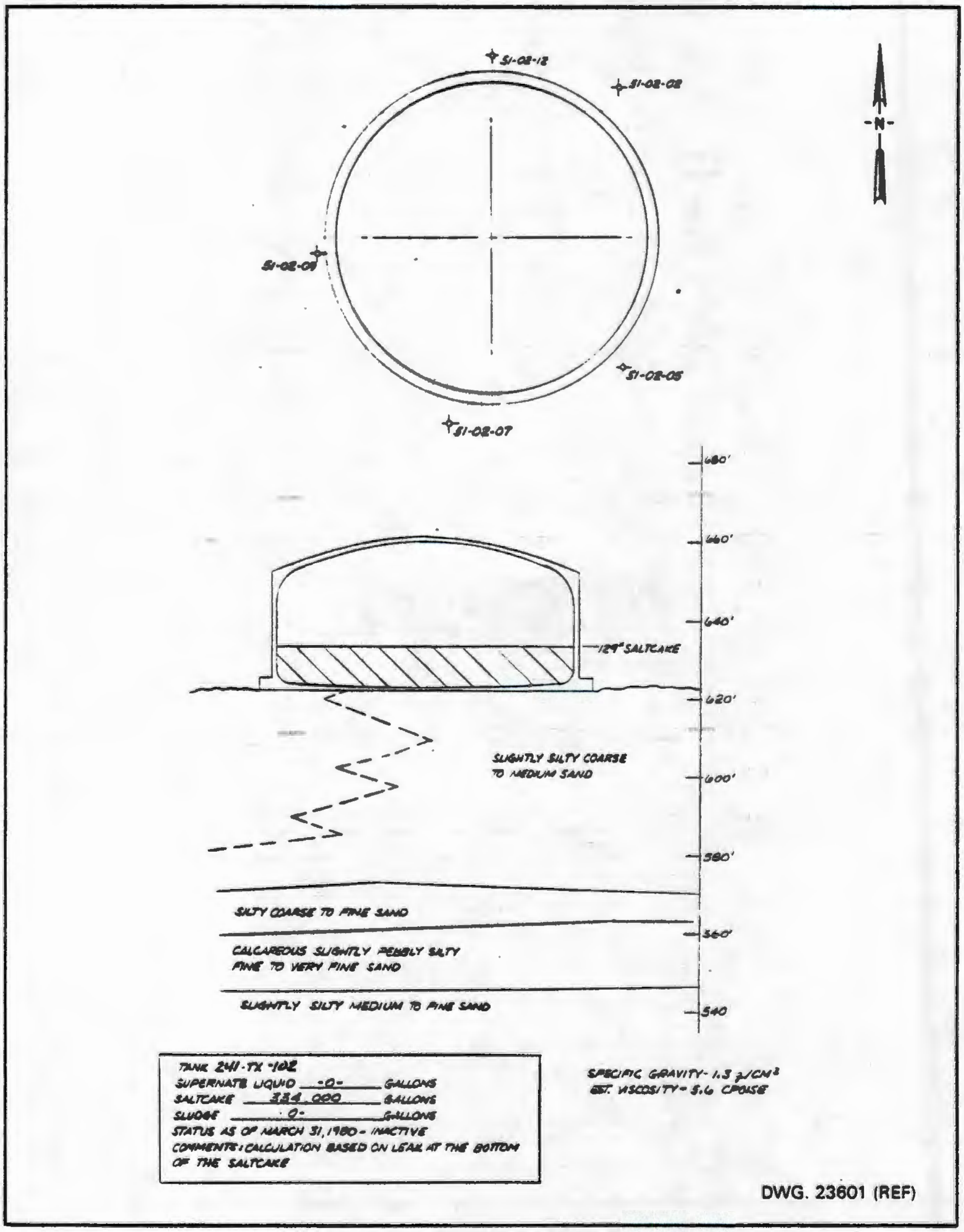


FIGURE G-59. Tank 241-TX-102.

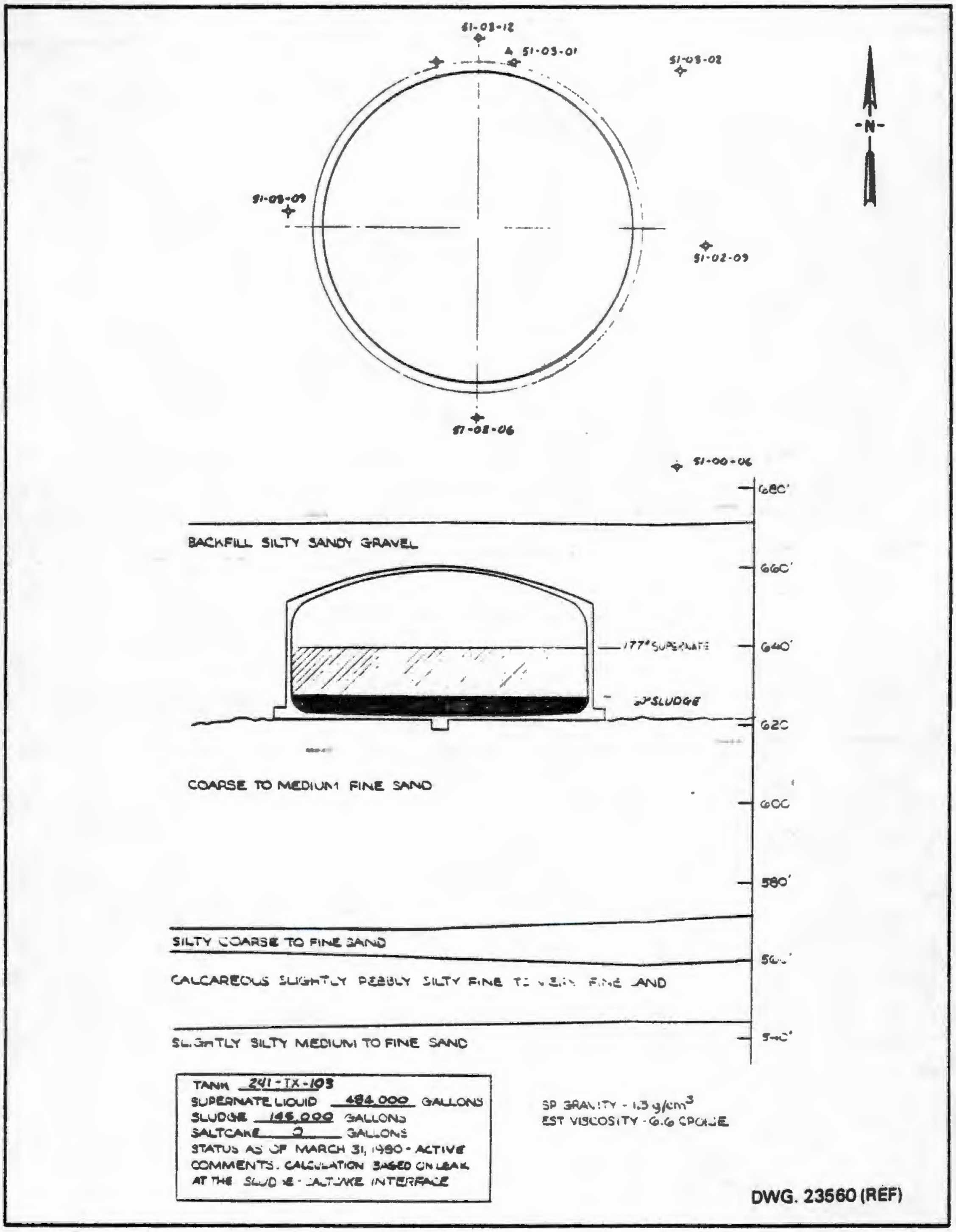


FIGURE G-60. Tank 241-TX-103.

9 2 1 2 4 9 9 1 8 4 4

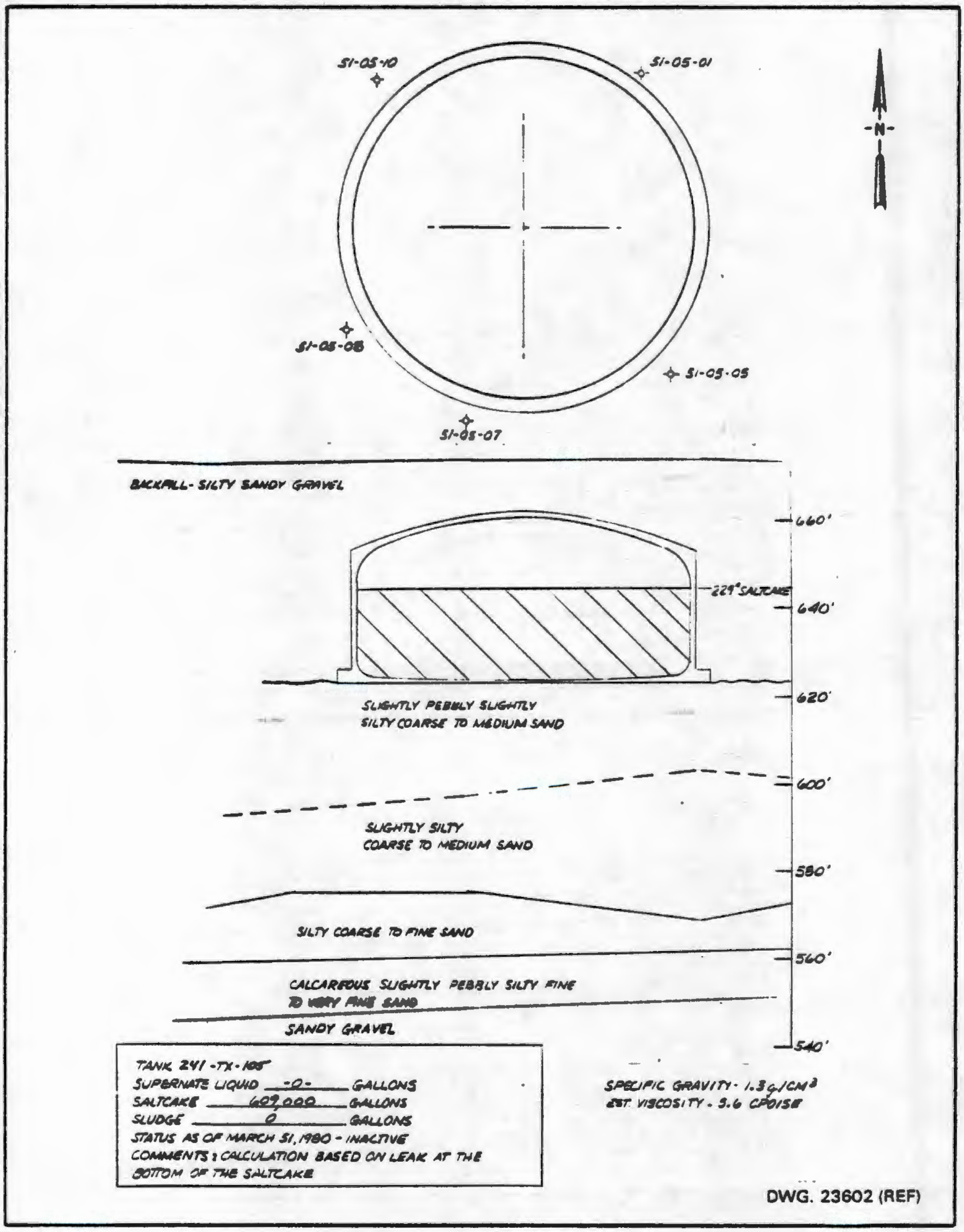


FIGURE G-61. Tank 241-TX-105.

9212499I845

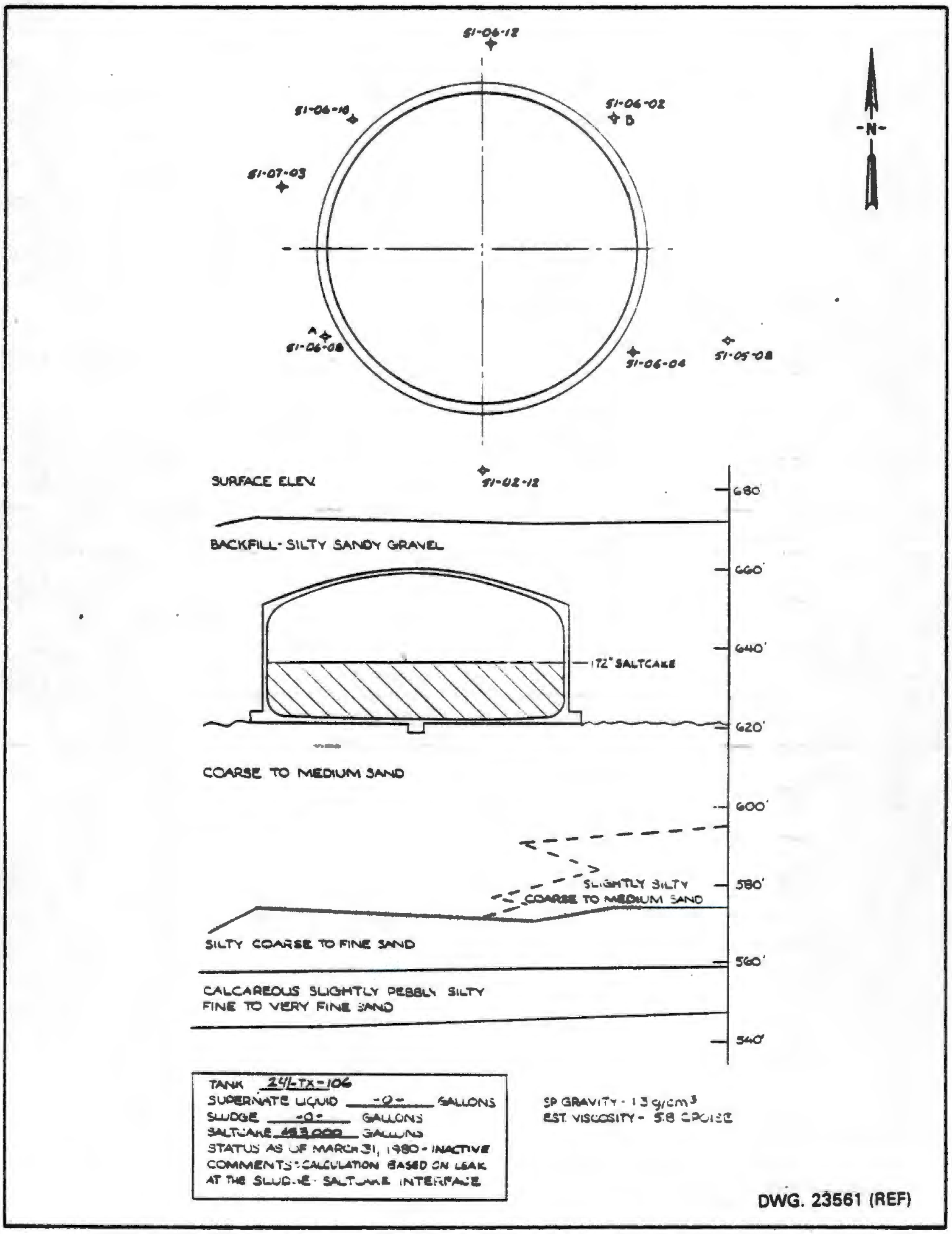


FIGURE G-62. Tank 241-TX-106.

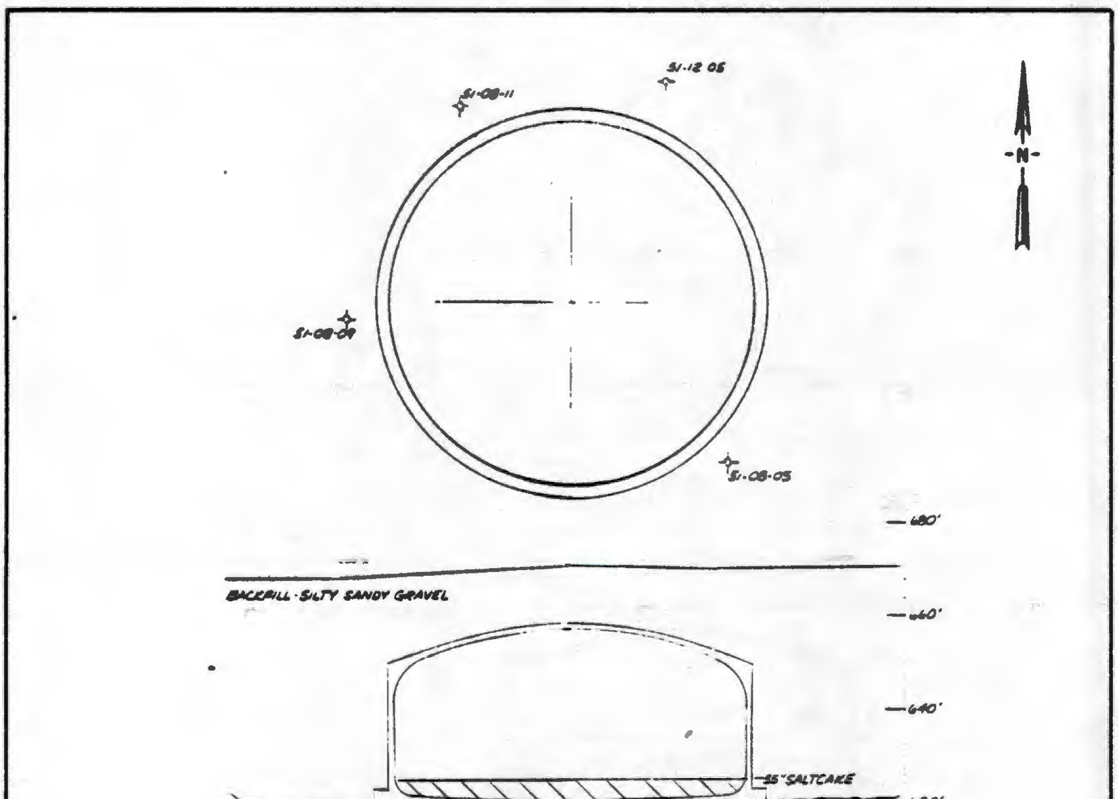


FIGURE G-63. Tank 241-TX-108.

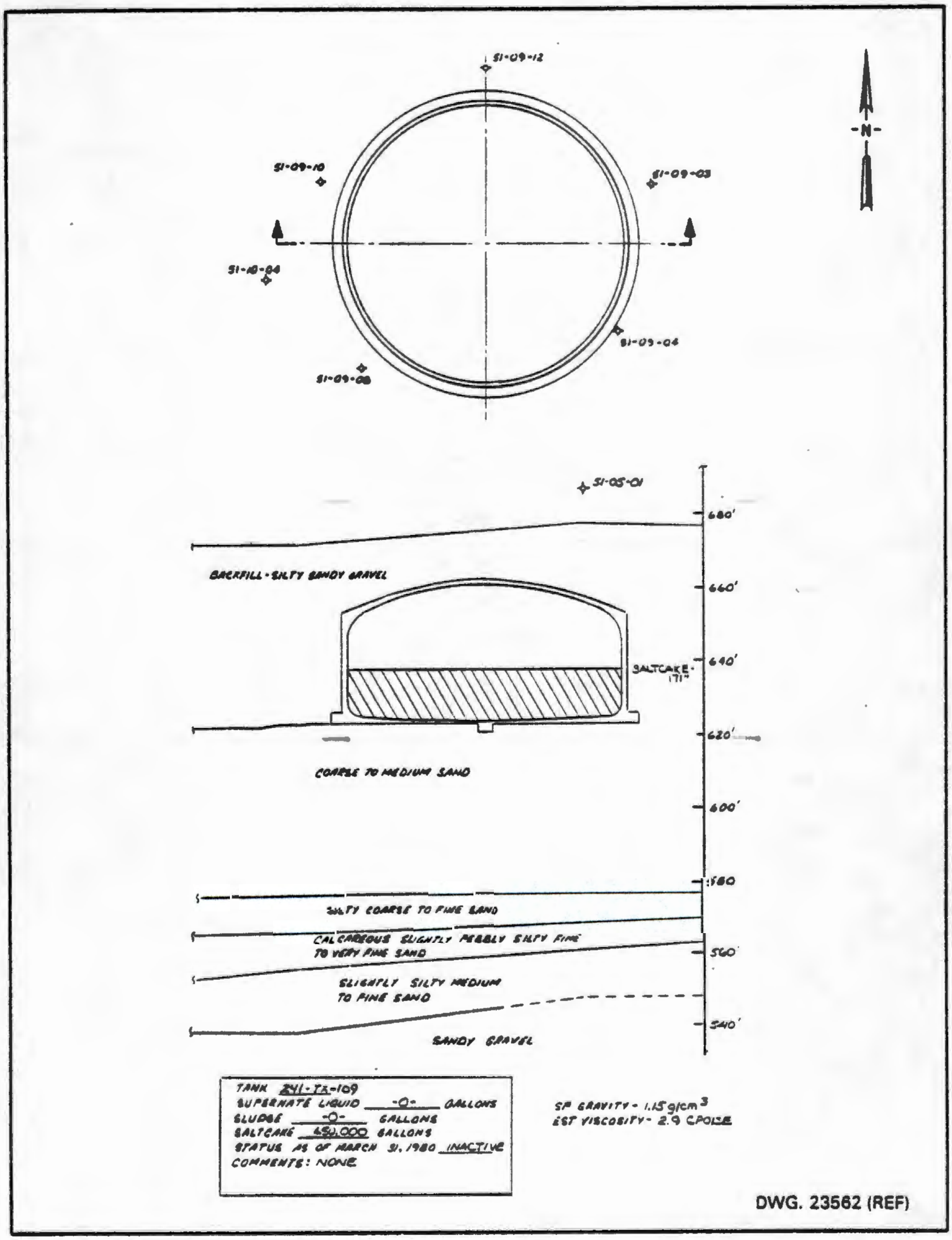


FIGURE G-64. Tank 241-TX-109.

9212499849

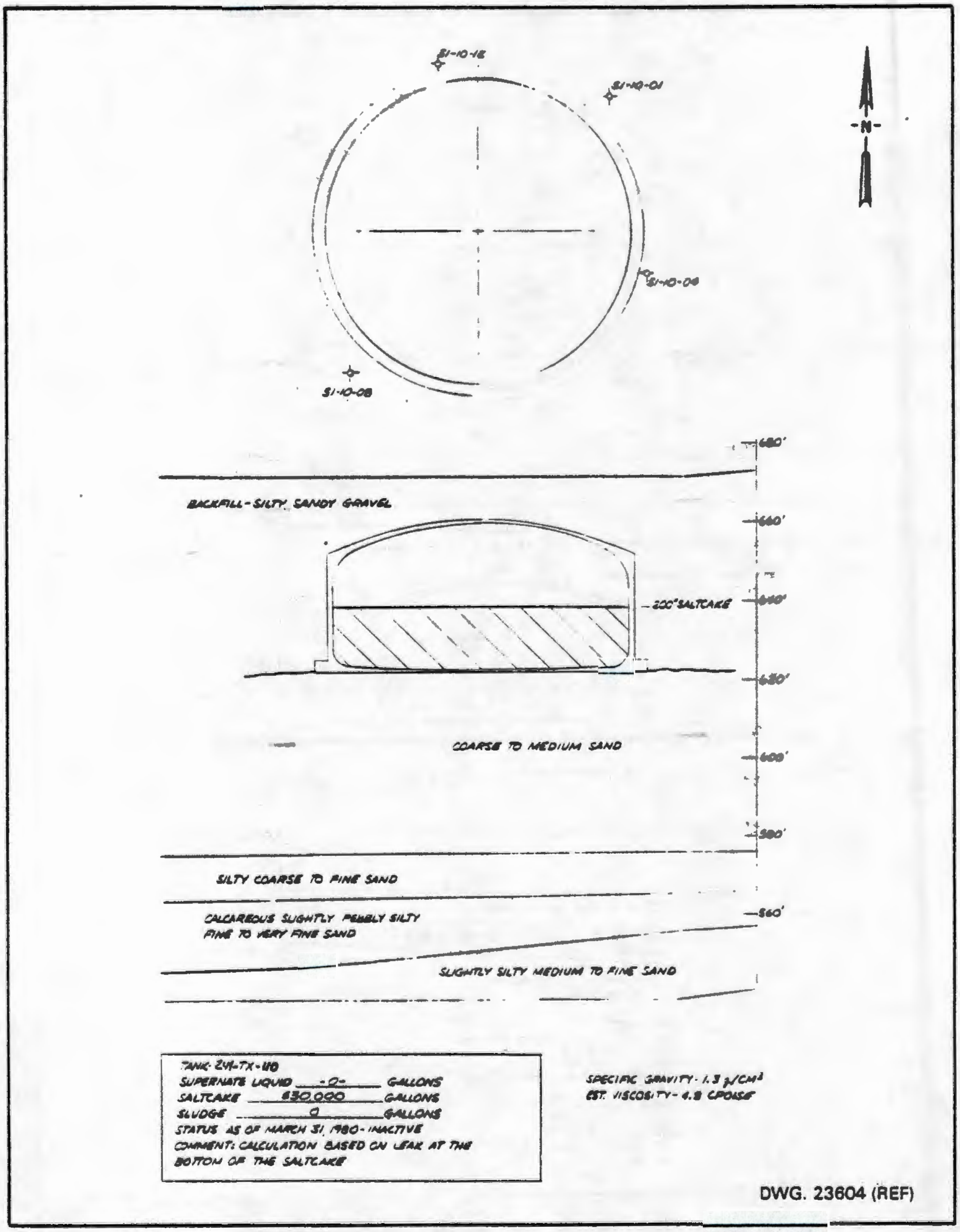


FIGURE G-65. Tank 241-TX-110.

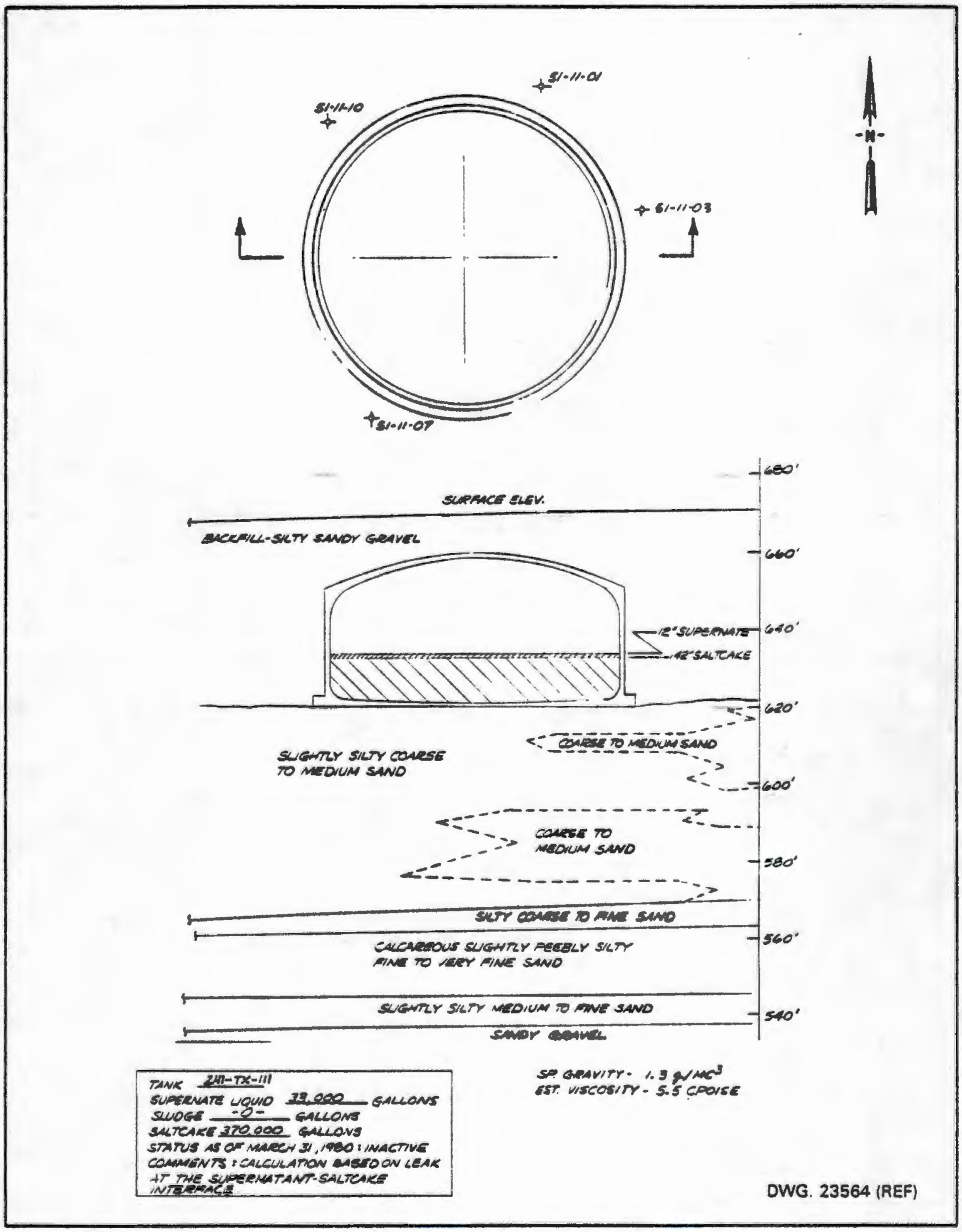


FIGURE G-66. Tank 241-TX-111.

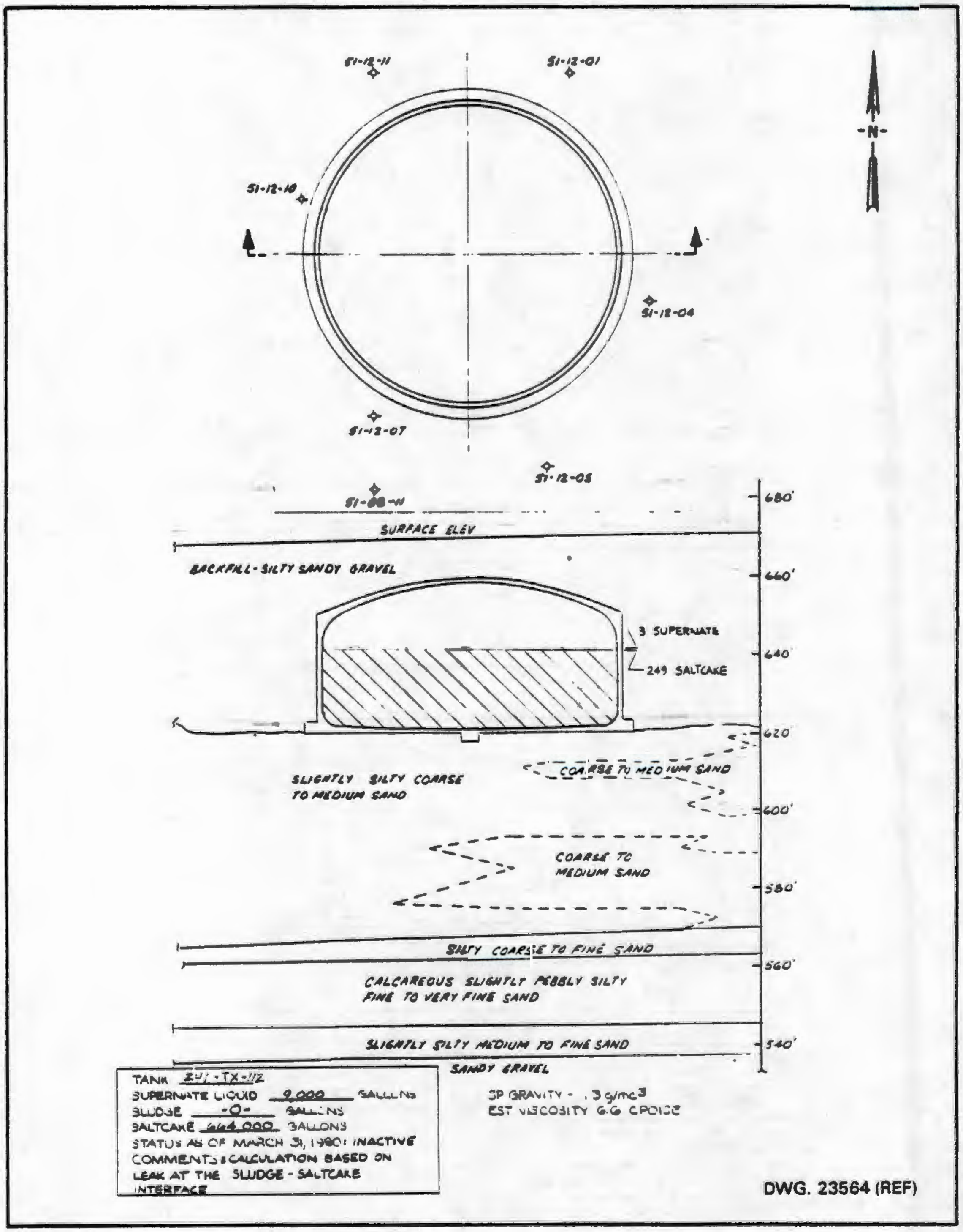


FIGURE G-67. Tank 241-TX-112.

9212499185l

92124991852

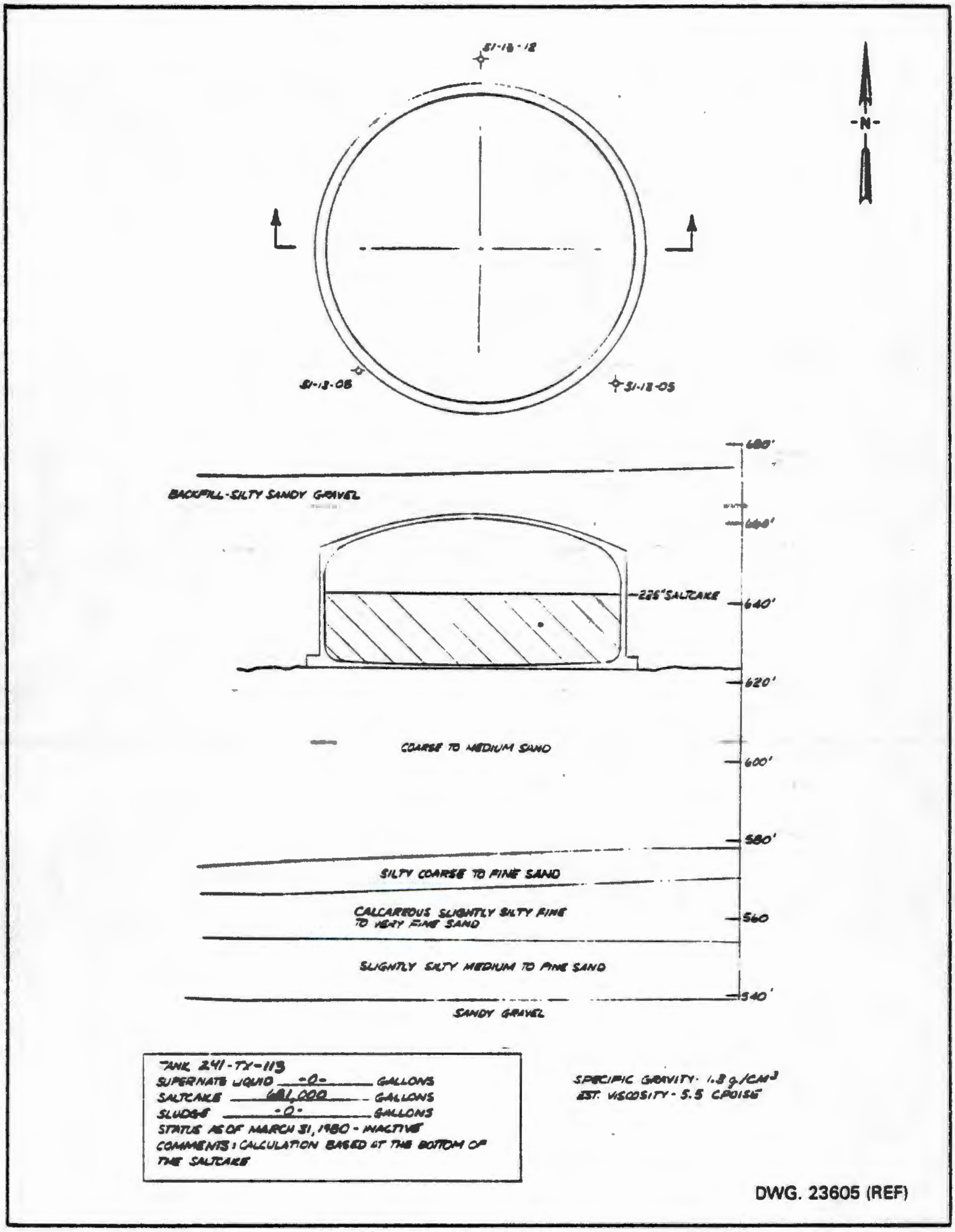


FIGURE G-68. Tank 241-TX-113.

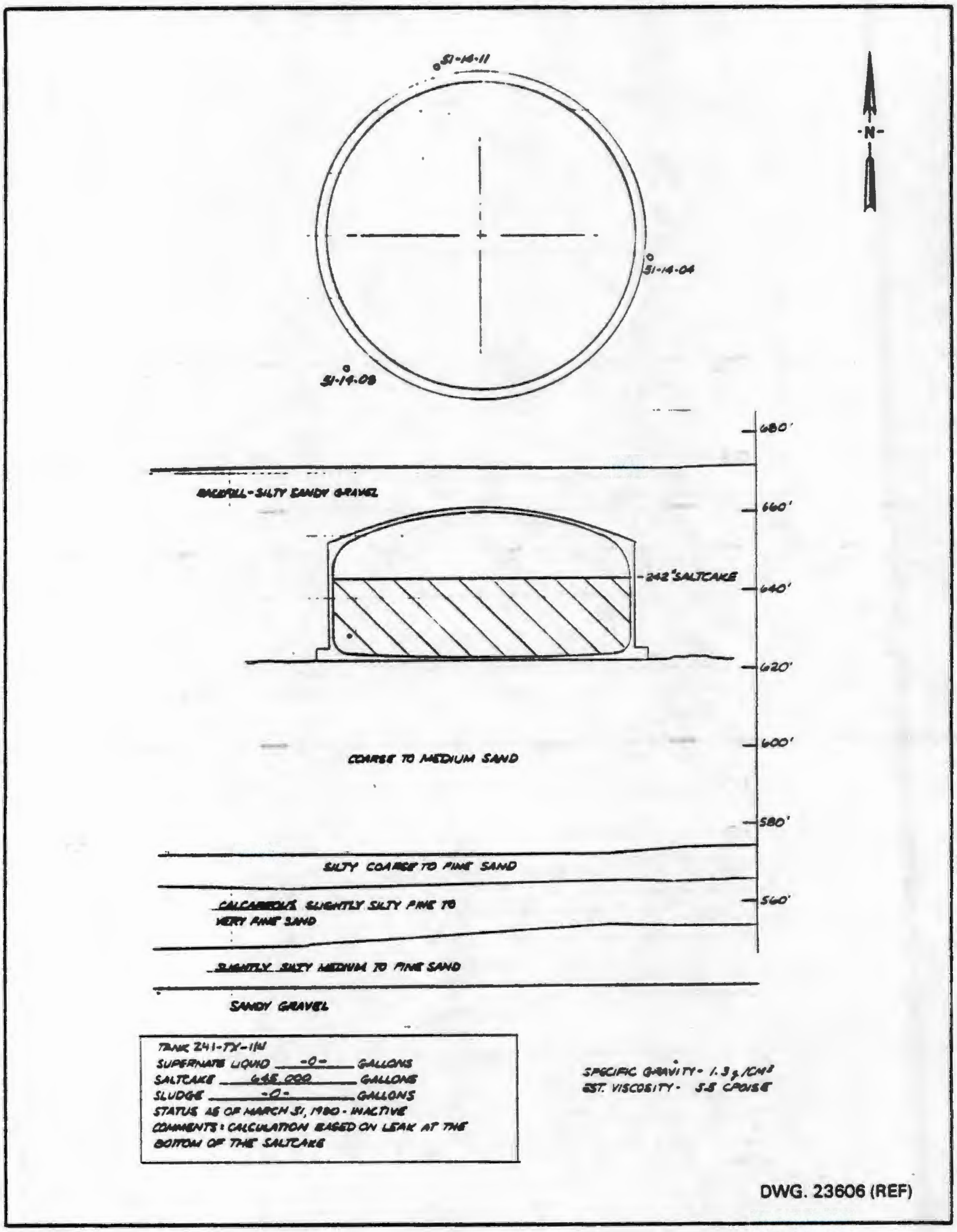


FIGURE G-69. Tank 241-TX-114.

9 2 1 2 4 9 9 1 8 5 4

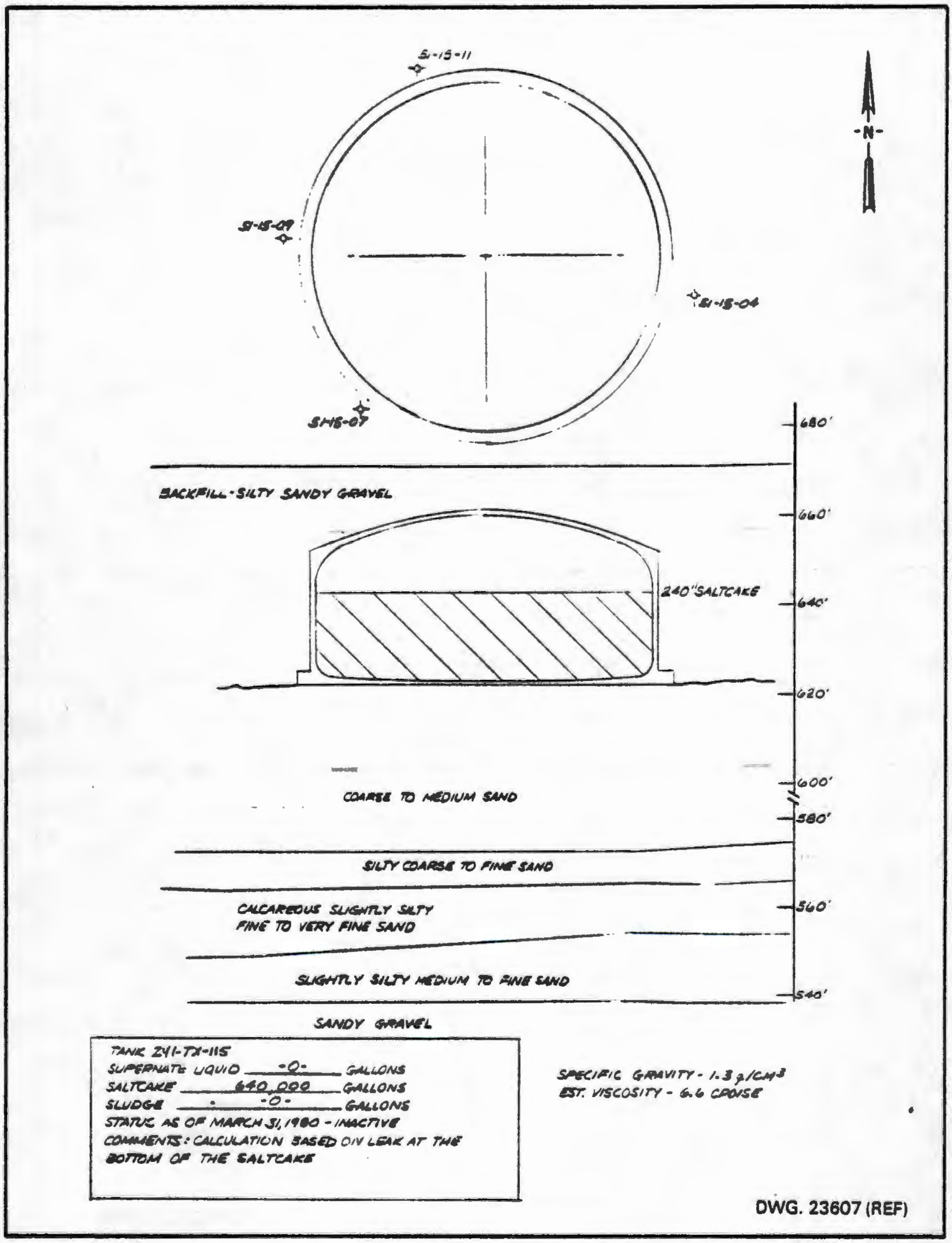


FIGURE G-70. Tank 241-TX-115.

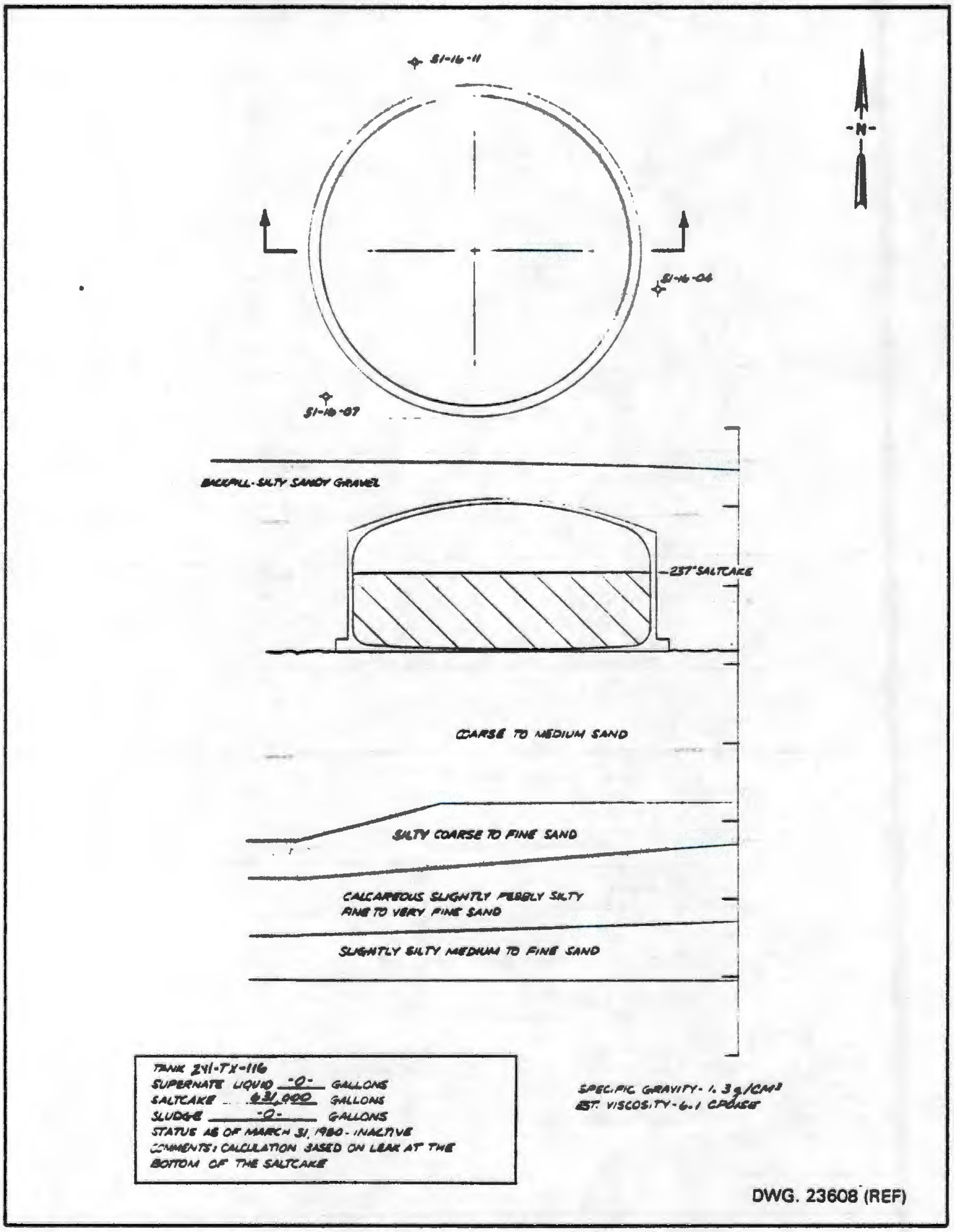


FIGURE G-71. Tank 241-TX-116.

92124991855

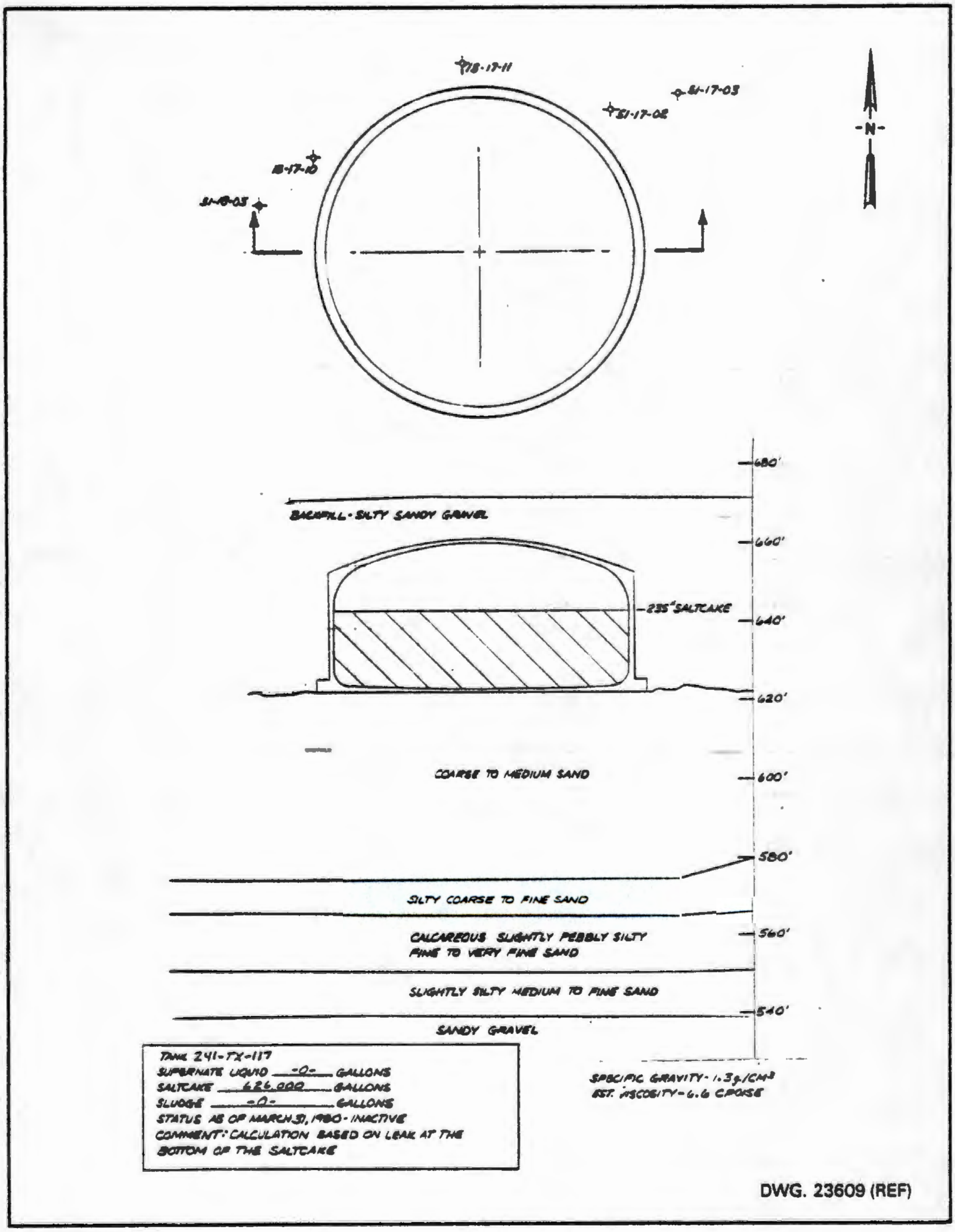


FIGURE G-72. Tank 241-TX-117.

9212499I856

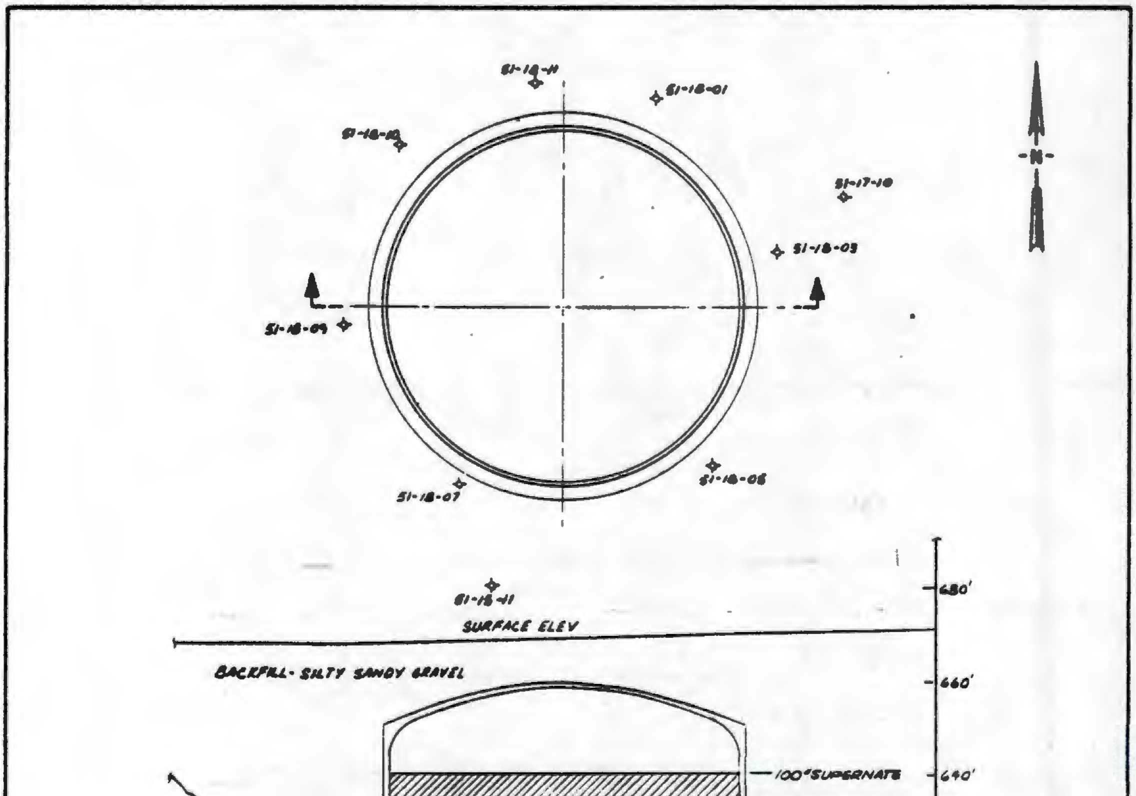


FIGURE G-73. Tank 241-TX-118.

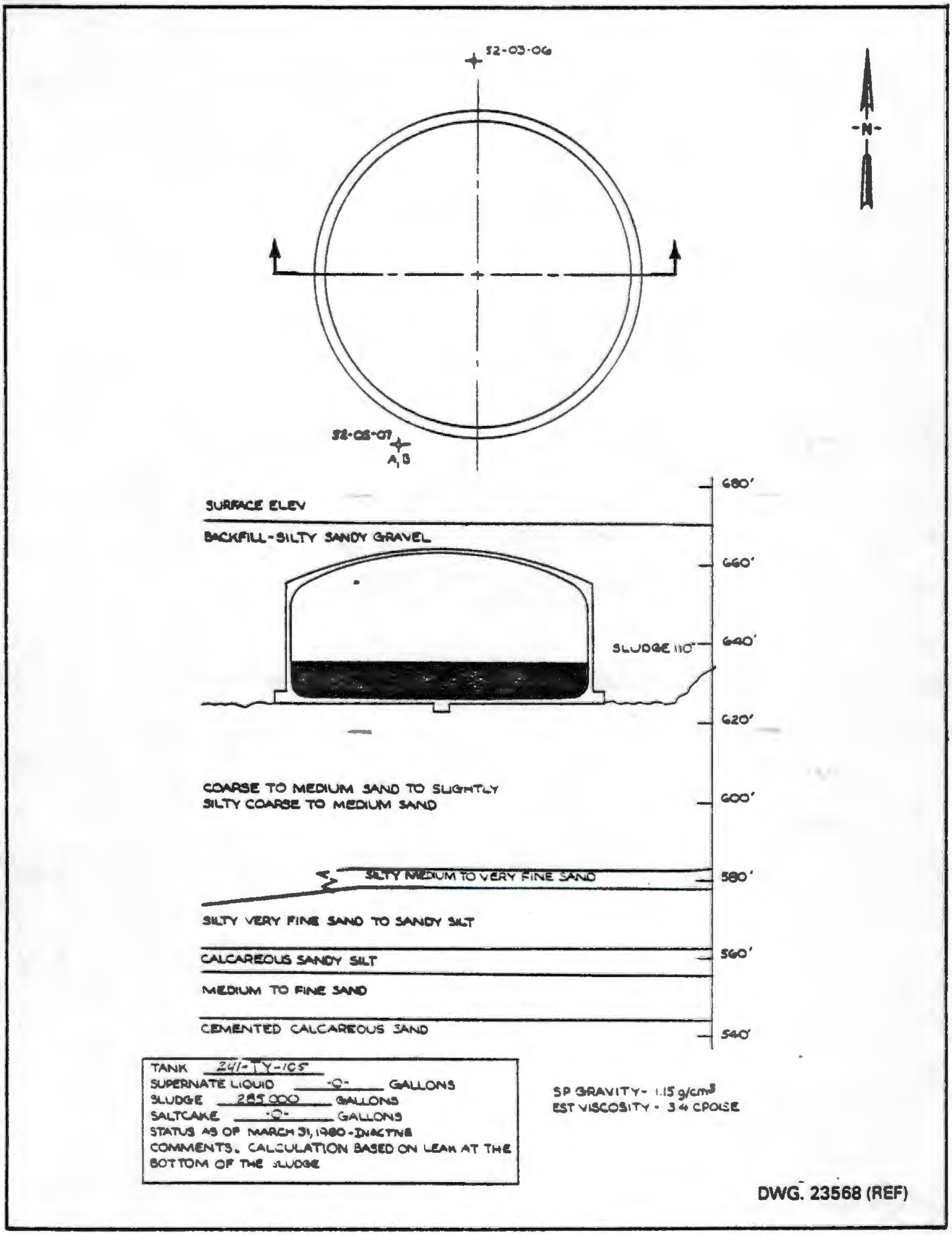


FIGURE G-74. Tank 241-TY-105.

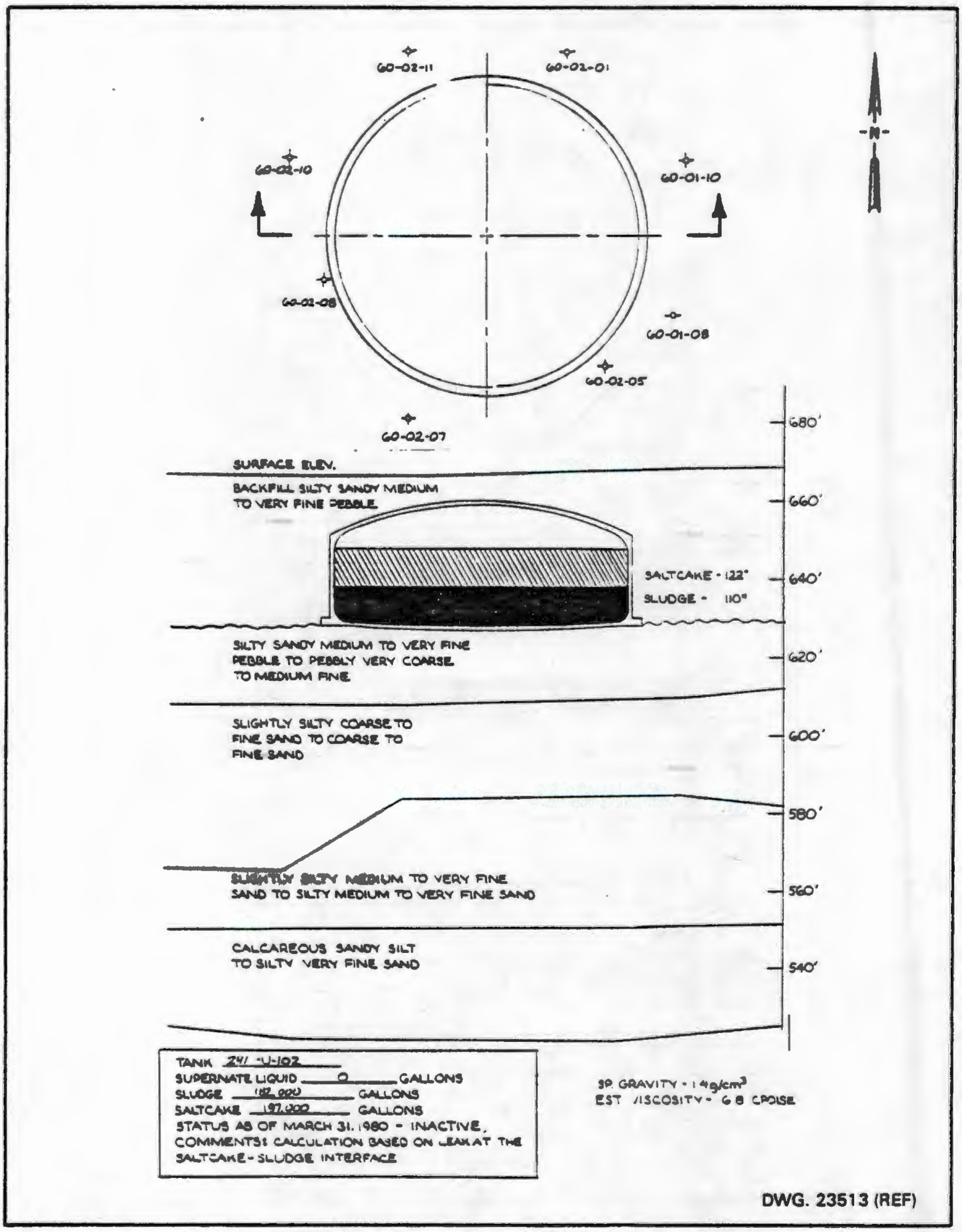


FIGURE G-75. Tank 241-U-102.

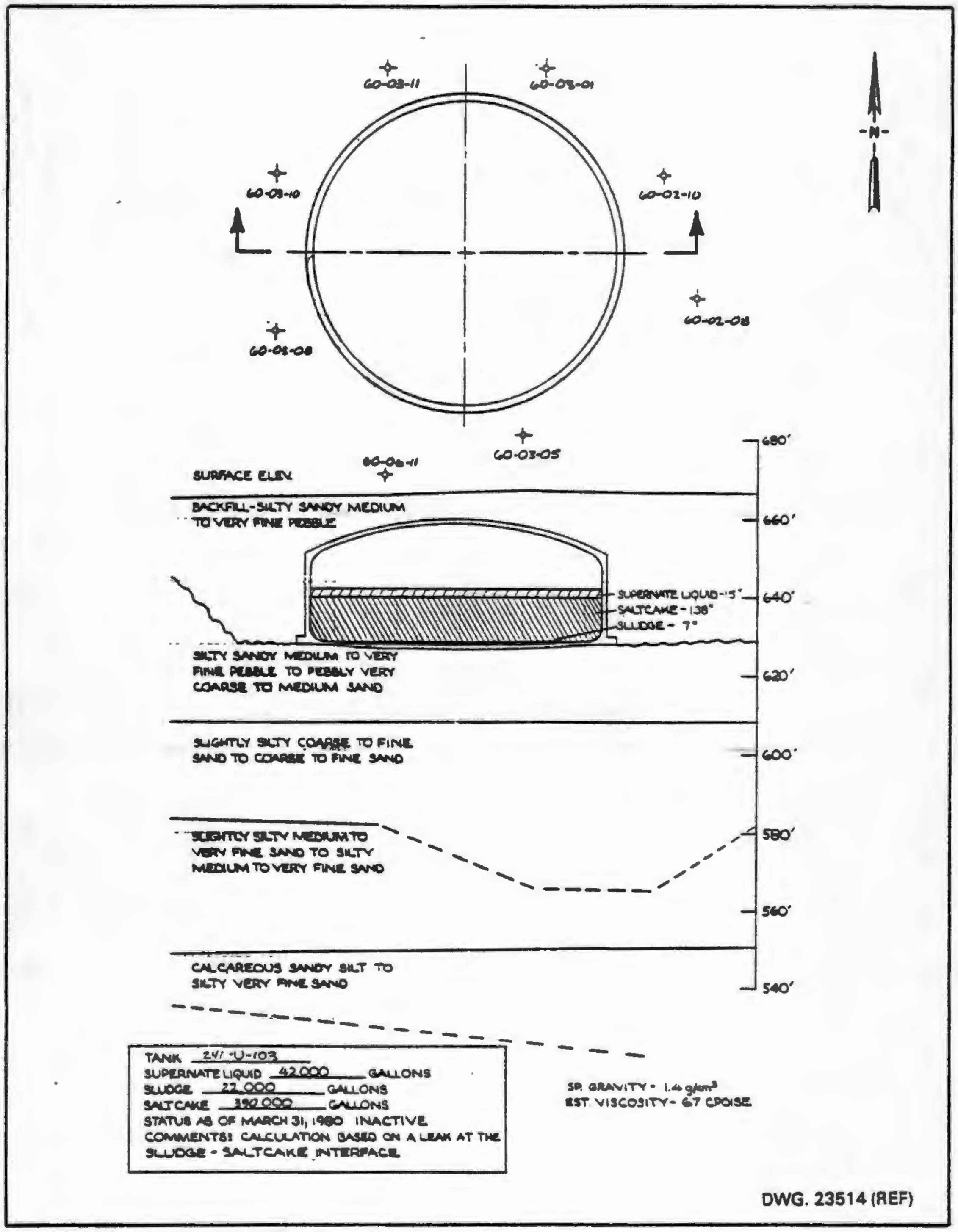


FIGURE G-76. Tank 241-U-103.

9212499 1860

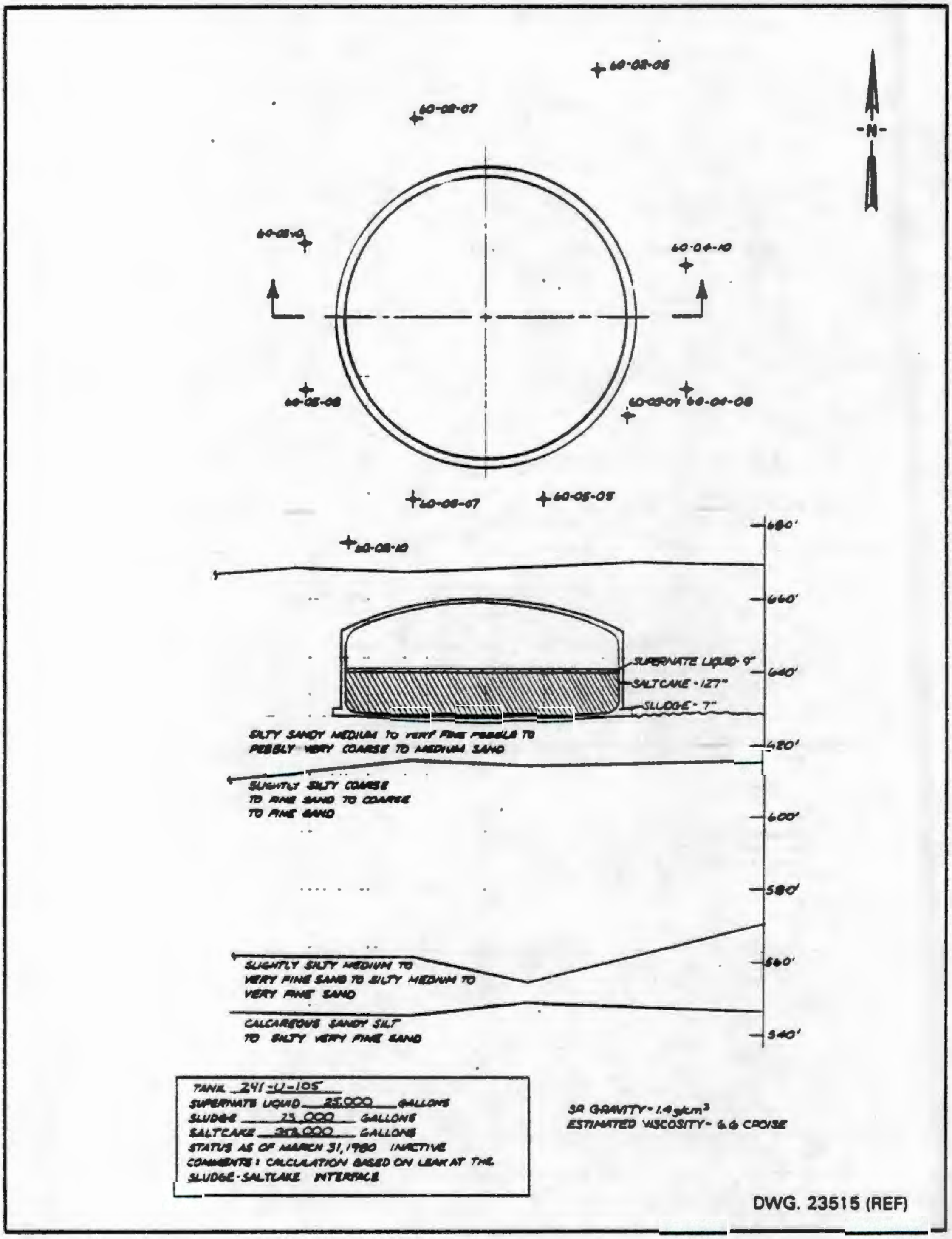


FIGURE G-77. Tank 241-U-105.

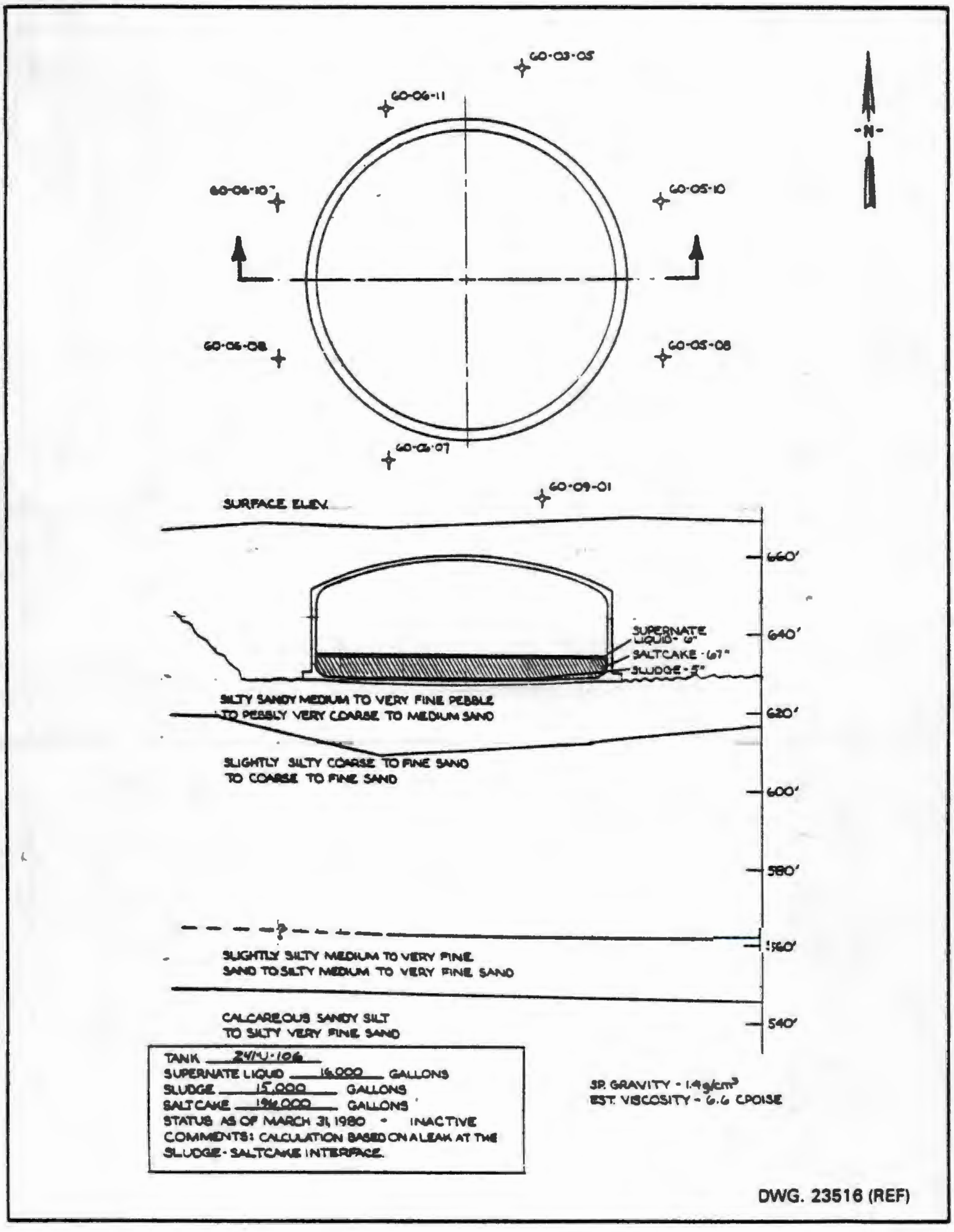


FIGURE G-78. Tank 241-U-106.

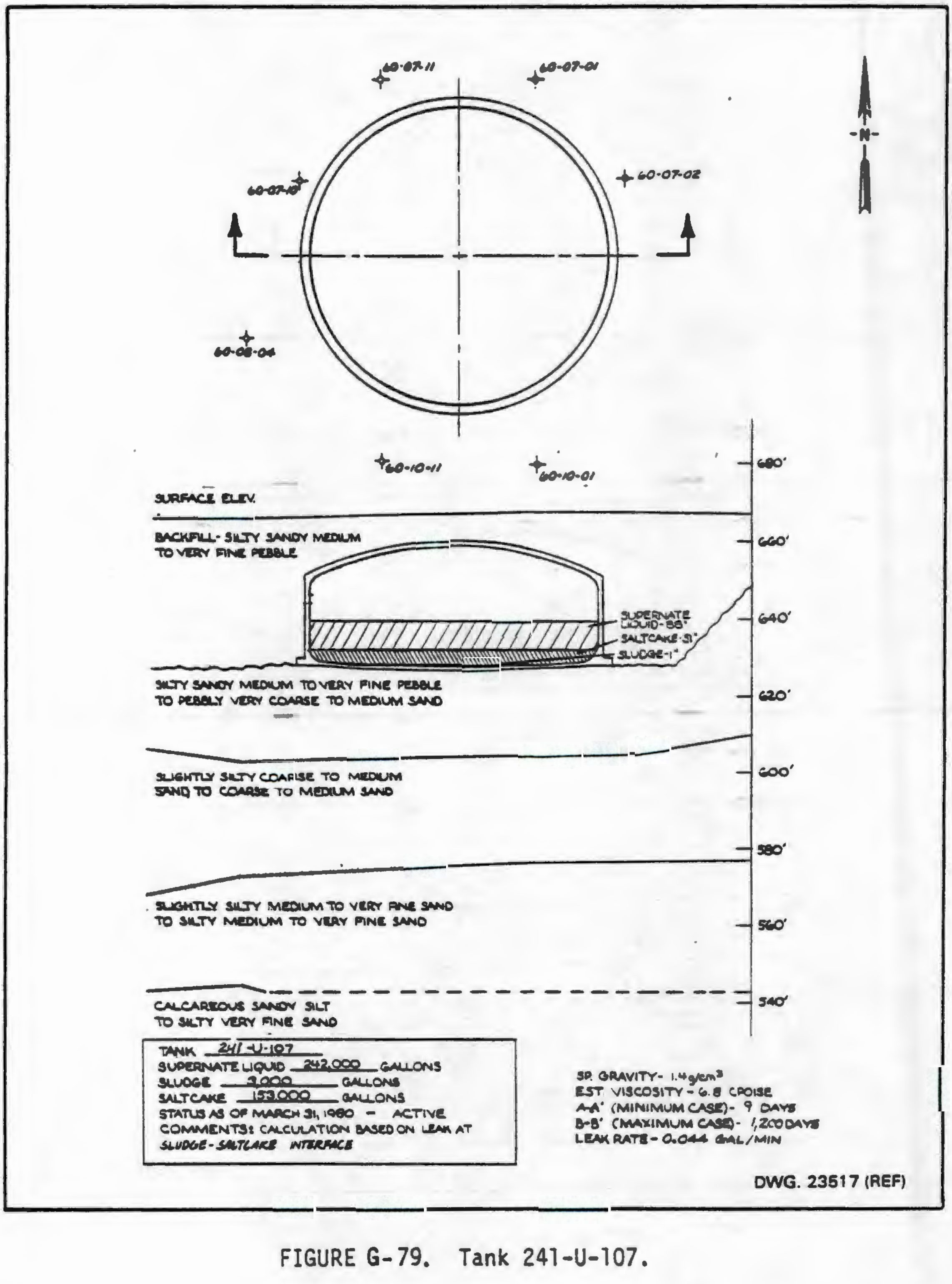


FIGURE G-79. Tank 241-U-107.

9 2 1 2 4 9 9 1 8 6 3

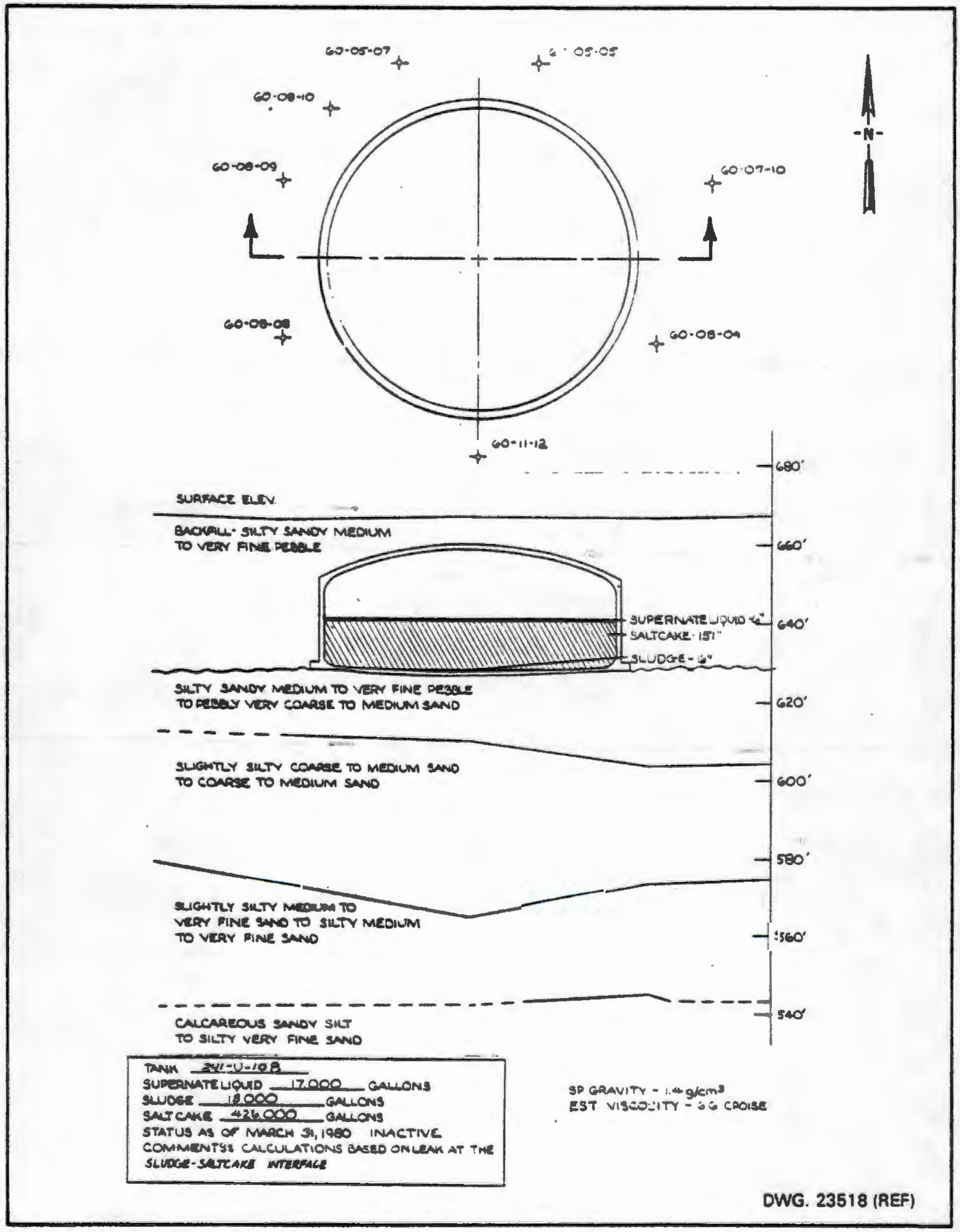


FIGURE G-80. Tank 241-U-108.

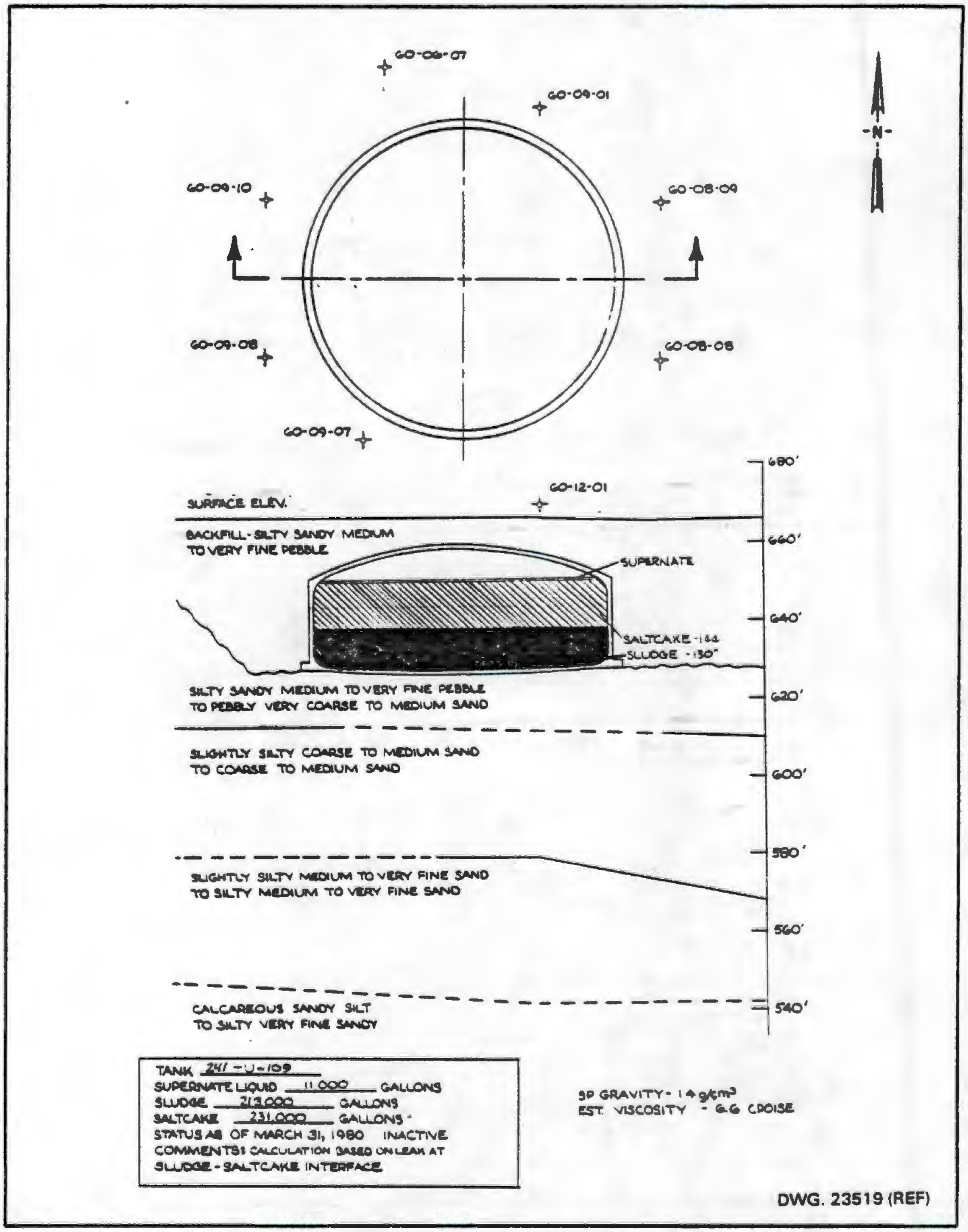


FIGURE G-81. Tank 241-U-109.

92124991865

92124991866

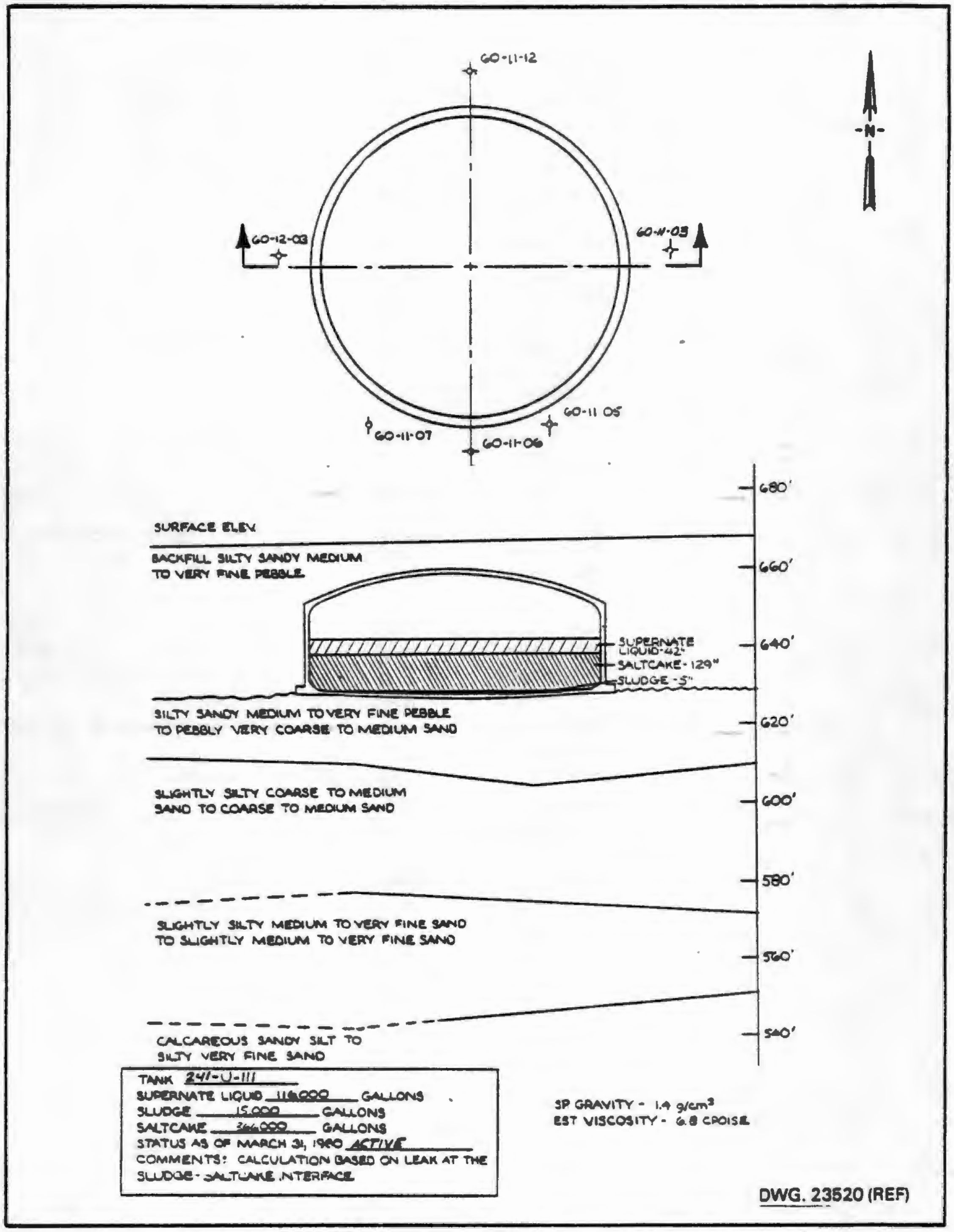


FIGURE G-82. Tank 241-U-111.

TABLE G-1. Schematic Drawings of Radiation Monitoring Dry Well Locations for Hanford High-Level Waste Tank Leak Detection, Geologic Cross Sections, and Travel Times to Wells for Minimum and Maximum Undetected Elapsed Time of Tank Leaks.

Figure number	Tank number	Referenced drawing number	Figure number	Tank number	Referenced drawing number
G-1	241-A-101	SK-2-23544	G-42	241-S-108	SK-2-23592
G-2	241-A-103	SK-2-23546	G-43	241-S-109	SK-2-23593
G-3	241-AX-101	SK-2-23503	G-44	241-S-110	SK-2-23594
G-4	241-B-103	SK-2-23538	G-45	241-S-111	SK-2-23595
G-5	241-B-104	SK-2-23539	G-46	241-S-112	SK-2-23596
G-6	241-B-105	SK-2-23579	G-47	241-SX-101	SK-2-23548
G-7	241-B-106	SK-2-23540	G-48	241-SX-102	SK-2-23549
G-8	241-B-107	SK-2-23580	G-49	241-SX-103	SK-2-23550
G-9	241-B-108	SK-2-23541	G-50	241-SX-104	SK-2-23551
G-10	241-B-109	SK-2-23542	G-51	241-SX-105	SK-2-23552
G-11	241-B-111	SK-2-23543	G-52	241-SX-106	SK-2-23553
G-12	241-BX-104	SK-2-23521	G-53	241-T-101	SK-2-23534
G-13	241-BX-107	SK-2-23524	G-54	241-T-104	SK-2-23597
G-14	241-BX-109	SK-2-23525	G-55	241-T-105	SK-2-23535
G-15	241-BX-110	SK-2-23582	G-56	241-T-107	SK-2-23536
G-16	241-BX-111	SK-2-23526	G-57	241-T-110	SK-2-23599
G-17	241-BX-112	SK-2-23527	G-58	241-T-111	SK-2-23600
G-18	241-BY-101	SK-2-23506	G-59	241-TX-102	SK-2-23601
G-19	241-BY-102	SK-2-23507	G-60	241-TX-103	SK-2-23560
G-20	241-BY-103	SK-2-23583	G-61	241-TX-105	SK-2-23602
G-21	241-BY-104	SK-2-23508	G-62	241-TX-106	SK-2-23561
G-22	241-BY-105	SK-2-23584	G-63	241-TX-108	SK-2-23603
G-23	241-BY-106	SK-2-23509	G-64	241-TX-109	SK-2-23562
G-24	241-BY-108	SK-2-23586	G-65	241-TX-110	SK-2-23604
G-25	241-BY-109	SK-2-23510	G-66	241-TX-111	SK-2-23564
G-26	241-BY-110	SK-2-23511	G-67	241-TX-112	SK-2-23564
G-27	241-BY-111	SK-2-23512	G-68	241-TX-113	SK-2-23605
G-28	241-BY-112	SK-2-23587	G-69	241-TX-114	SK-2-23606
G-29	241-C-102	SK-2-23528	G-70	241-TX-115	SK-2-23607
G-30	241-C-103	SK-2-23529	G-71	241-TX-116	SK-2-23608
G-31	241-C-104	SK-2-23530	G-72	241-TX-117	SK-2-23609
G-32	241-C-105	SK-2-23531	G-73	241-TX-118	SK-2-23565
G-33	241-C-106	SK-2-23532	G-74	241-TY-105	SK-2-23568
G-34	241-C-107	SK-2-23533	G-75	241-U-102	SK-2-23513
G-35	241-C-110	SK-2-23588	G-76	241-U-103	SK-2-23514
G-36	241-S-101	SK-2-23555	G-77	241-U-105	SK-2-23515
G-37	241-S-102	SK-2-23556	G-78	241-U-106	SK-2-23516
G-38	241-S-103	SK-2-23557	G-79	241-U-107	SK-2-23517
G-39	241-S-105	SK-2-23590	G-80	241-U-108	SK-2-23518
G-40	241-S-106	SK-2-23591	G-81	241-U-109	SK-2-23519
G-41	241-S-107	SK-2-23558	G-82	241-U-111	SK-2-23520

APPENDIX H

NUMBER OF NEW RADIATION MONITORING DRY WELLS NEEDED TO ASSURE MAXIMUM LEAK VOLUMES WILL NOT EXCEED 10,000 AND 20,000 GAL

D. W. Duncan

Several calculations were made related to waste tank leaks and radiation monitoring of dry wells. The first set provided minimum and maximum distances from the tanks to the surrounding dry wells. For example, in Figure H-1, the minimum distance between the tank and Well 2 was the distance W. The farthest distances from Well 2 that a leak could be without being detected first by another well were B and C in the clockwise and counterclockwise directions, respectively. For the maximum distances there is a point on the periphery of the tank where the distance to the nearest wells is equal in each direction. Thus, B and D are equal and C and E are equal, i.e., the distances and thus the travel time are equal. These three distances (minimum, maximum clockwise, and maximum counterclockwise) were determined from blue prints for each dry well around every tank with significant supernatant contents. These distances are given in Table H-2 for 77 tanks in 11 tank farms.*

The second set of calculations was concerned with the number of additional wells that would be needed to assure detection of 10,000-gal leaks and 20,000-gal leaks from any point on the inner steel liner of the tanks that contain supernatant solutions.

The following assumptions were used in the calculations: a 10,000-gal leak would extend 19 ft in the 200 East Area farms and 23 ft in the 200 West Area farms; and a 20,000-gal leak would extend 23 ft in the 200 East Area and 29 ft in the 200 West Area. These distances reflect the soil characteristics and geology of the 200 East and West Areas as described in Appendix E. Existing microfilm "as-built" drawings were searched to determine possible interferences that would prevent

*Editor's Note: Later these distances were calculated from tank and dry well coordinates (see Appendix N). While the later data differ slightly from the data in this appendix, the impact on the additional number of wells needed, as addressed in this appendix, is trivial. (REI)

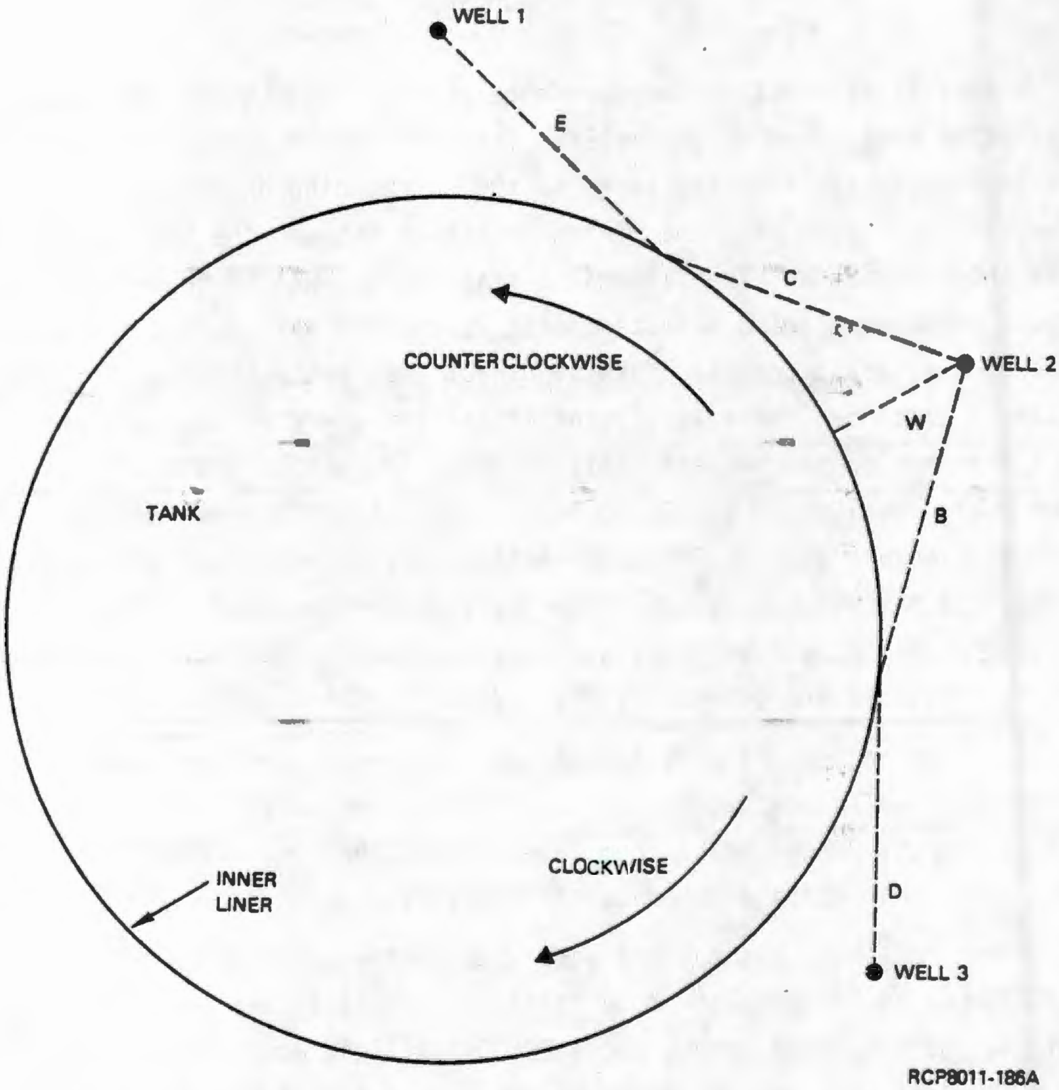


FIGURE H-1. Calculation of Minimum and Maximum Distances from Tanks to Dry Wells.

TABLE H-1. Minimum Distance and Maximum Clockwise and Counterclockwise Distances from Monitoring Dry Wells to Waste Tank Inner Liners. (Sheet 1 of 6)

Well number	Closest distance	Counter-clockwise distance	Clockwise distance
Tank 241-A-101			
10-01-01	11.2	21.6	22.4
10-01-03	11.6	22.4	22.4
10-01-04	10.8	22.4	21.6
10-01-06	10.8	21.6	21.6
10-01-08	11.2	21.6	24.0
10-01-10	11.2	24.0	20.0
10-01-11	11.2	20.0	21.6
Tank 241-A-102			
10-02-01	11.2	31.6	21.2
10-03-10	18.8	21.2	28.4
10-02-03	12.0	28.4	21.2
10-02-05	10.8	21.2	21.6
10-02-06	11.2	21.6	21.6
10-02-08	14.0	21.6	22.0
10-02-10	22.0	22.0	25.2
10-02-11	20.0	25.2	31.6
Tank 241-A-103			
10-03-01	11.2.	31.6	21.2
10-03-02	18.8	21.2	28.4
10-03-04	12.0	28.4	21.2
10-03-05	10.8	21.2	21.6
10-03-07	11.2	21.6	21.6
10-02-03	14.0	21.6	28.0
10-03-11	20.0	28.0	31.6
Tank 241-A-106			
10-06-12	12.4	22.4	22.0
10-06-02	12.0	22.0	22.4
10-06-04	12.4	22.4	21.6
10-06-05	12.0	21.6	24.0
10-06-07	11.2	24.0	24.8
10-06-09	13.2	24.8	20.4
10-06-10	15.2	20.4	22.4
Tank 241-AX-101			
11-01-01	12.4	22.4	19.6
11-01-02	13.2	19.6	22.8
11-01-04	12.8	22.8	22.4
11-01-05	14.0	22.4	20.0
11-02-23	18.8	20.0	18.8
11-01-07	8.0	18.8	20.0
11-01-09	7.2	20.0	18.4
11-01-10	12.0	18.4	15.2
11-01-11	8.8	15.2	22.4
Tank 241-AX-102			
11-02-01	10.8	17.6	18.8
11-02-02	12.0	18.8	14.8
11-02-03	8.0	14.8	18.0
11-02-04	17.6	18.0	19.6
11-02-05	11.2	19.6	21.2
11-02-07	10.4	21.2	23.2
11-02-08	18.4	23.2	25.6
11-02-10	8.0	25.6	17.2
11-02-22	9.2	17.2	11.2
11-02-23	9.2	11.2	17.6
Tank 241-AX-103			
11-03-02	9.2	20.0	20.0
11-03-09	7.6	20.0	20.4
11-03-05	9.6	20.4	24.8
11-03-07	9.6	24.8	19.2
11-03-09	8.8	19.2	21.6
11-03-10	9.2	21.6	18.0
11-03-12	7.6	18.0	20.0
Tank 241-B-102			
20-02-03	7.2	40.3	27.2
20-02-05	5.6	27.2	16.8
20-02-07	6.8	16.8	22.0
20-03-09	8.4	22.0	24.0
20-02-11	9.6	24.0	40.8
Tank 241-B-103			
20-03-02	7.6	25.6	21.2
20-03-03	8.4	21.2	31.6
20-03-06	7.6	31.6	26.8
20-03-09	6.8	26.8	26.8
20-03-11	8.8	26.8	25.6
Tank 241-B-104			
20-05-06	16.0	36.8	35.6
20-04-03	7.2	35.6	34.0
20-04-06	13.2	34.0	47.6
20-07-02	28.8	47.6	36.8
Tank 241-B-105			
20-06-06	19.2	43.6	37.6
20-02-09	17.6	37.6	38.0
20-05-06	10.0	38.0	33.2
20-08-03	18.4	43.6	33.2
Tank 241-B-106			
20-06-02	7.2	28.0	20.8
20-06-03	6.8	20.8	27.2
20-06-06	7.6	27.2	55.6
20-06-11	9.2	55.6	28.0
Tank 241-B-107--Sludge only			
Tank 241-B-108			
20-09-06	19.2	37.2	24.0
20-08-02	16.0	24.0	24.0
20-08-03	8.4	24.0	22.4
20-08-05	6.8	22.4	24.4
20-08-07	7.2	24.4	17.6
20-08-09	7.6	17.6	37.2
Tank 241-B-109			
20-09-02	7.2	28.4	43.6
20-09-06	6.8	43.6	35.2
20-12-03	10.4	35.2	19.6
20-09-11	4.8	19.6	28.4

TABLE H-1. Minimum Distance and Maximum Clockwise and Counterclockwise Distances from Monitoring Dry Wells to Waste Tank Inner Liners. (Sheet 2 of 6)

Well number	Closest distance	Counter-clockwise distance	Clockwise distance
Tank 241-B-110--Sludge only			
Tank 241-B-111--Sludge only			
Tank 241-BX-104			
21-05-06	12.4	21.2	18.8
21-04-01	8.4	18.8	20.8
21-04-03	8.8	20.8	16.8
21-04-04	4.8	16.8	19.2
21-04-06	12.8	19.2	30.8
21-04-08	24.8	30.8	25.2
21-07-03	17.2	25.2	23.6
21-04-11	8.8	23.6	21.2
Tank 241-BX-105			
21-05-02	6.4	16.8	17.6
21-05-03	9.2	17.6	18.4
21-05-04	6.8	18.4	16.8
21-05-06	10.4	16.8	32.8
21-05-10	4.8	23.6	23.6
21-05-12	9.6	23.6	16.8
21-08-04	19.6	32.8	23.6
Tank 241-BX-106			
21-06-01	7.6	22.8	15.6
21-06-02	6.8	15.6	31.6
21-06-05	6.4	31.6	19.6
21-05-12	16.0	19.6	38.4
21-09-04	26.8	38.4	31.6
21-06-10	7.2	31.6	22.8
Tank 241-BX-107--Sludge only			
Tank 241-BX-109--Sludge only			
Tank 241-BX-110			
21-10-01	6.8	32.0	17.6
21-10-03	7.2	17.6	17.6
21-10-05	6.0	17.6	32.0
21-10-07	6.0	32.0	32.0
Tank 241-BX-111			
21-12-05	28.4	32.8	35.6
21-11-03	10.8	35.6	14.0
21-11-04	6.8	14.0	8.4
21-11-05	6.4	8.4	26.8
21-11-07	6.8	26.8	31.6
21-11-10	6.8	31.6	8.3
21-11-11	6.8	8.8	32.8
Tank 241-BX-112--Sludge only			
Tank 241-BY-101			
22-01-01	7.2	39.6	16.8
22-01-03	7.6	16.8	22.8
22-01-04	6.8	22.8	26.8
22-01-07	7.2	26.8	22.8
22-01-10	9.6	22.8	36.0
22-02-07	35.6	36.0	39.6
Tank 241-BY-102--Sludge only			
Tank 241-BY-103			
22-03-01	8.8	30.8	31.2
22-03-04	10.4	31.2	14.0
22-03-05	9.2	14.0	12.8
22-03-06	10.0	12.8	14.4
22-03-07	16.4	14.4	14.0
22-03-08	8.8	14.0	18.0
22-03-09	8.8	18.0	15.6
22-03-10	12.0	15.6	30.8
Tank 241-BY-104			
22-04-01	7.2	19.6	24.4
22-01-10	21.6	24.4	31.6
22-04-05	8.4	31.6	26.8
22-04-07	8.0	26.3	22.0
22-04-07	7.2	22.0	21.6
22-04-11	8.0	21.6	19.6
Tank 241-BY-105			
22-05-01	7.2	51.6	32.0
22-02-09	26.0	32.0	35.6
22-05-05	6.4	35.6	32.8
22-04-11	31.2	32.8	42.0
22-05-09	8.8	42.0	51.6
Tank 241-BY-106			
22-06-01	6.8	24.0	27.2
22-03-09	20.8	27.2	27.6
22-06-05	6.8	27.6	32.0
22-06-07	23.2	32.0	25.2
22-06-09	6.0	25.2	20.8
22-06-11	8.8	20.8	24.0
Tank 241-BY-107			
22-08-06	18.8	29.2	18.4
22-07-01	6.8	18.4	13.2
22-07-02	8.0	13.2	31.6
22-07-05	6.0	31.6	26.0
22-07-07	10.8	26.0	20.8
22-07-09	6.0	20.8	20.8
22-07-10	19.2	20.8	29.2
Tank 241-BY-108			
22-08-12	8.8	31.2	11.6
22-08-01	6.4	11.6	13.6
22-08-02	8.0	13.6	20.4
22-05-09	19.6	20.4	26.8
22-08-05	6.8	26.8	12.8
22-08-06	8.8	12.8	24.8
22-08-07	22.4	24.3	27.6
22-08-09	7.2	27.6	31.2
Tank 241-BY-109			
22-09-01	5.6	16.8	18.8
22-09-02	9.6	18.8	22.8
22-06-09	22.0	22.8	24.8
22-09-05	5.6	24.8	20.0
22-08-12	18.8	20.0	18.8
22-09-07	7.6	18.8	19.2
22-09-08	5.6	19.2	25.6
22-09-11	6.4	25.6	16.8

TABLE H-1. Minimum Distance and Maximum Clockwise and Counterclockwise Distances from Monitoring Dry Wells to Waste Tank Inner Liners. (Sheet 3 of 6)

Well number	Closest distance	Counter-clockwise distance	Clockwise distance
Tank 241-BY-110			
22-11-05	28.8	38.0	41.6
22-07-10	35.6	41.6	36.8
22-07-09	25.6	36.8	33.6
22-10-05	8.8	33.6	26.0
22-10-07	10.0	26.0	26.8
22-10-09	18.8	26.8	25.6
22-10-10	8.8	25.6	38.0
Tank 241-BY-111			
22-11-01	8.0	23.2	26.0
22-08-09	21.6	26.0	34.8
22-11-05	7.6	34.8	22.4
22-11-08	7.2	22.4	22.4
22-11-09	7.2	22.4	28.0
22-12-06	22.0	28.0	23.2
Tank 241-BY-112			
22-12-01	7.2	32.8	20.0
22-12-03	8.8	20.0	25.2
22-12-05	8.8	25.2	16.4
22-12-06	8.0	16.4	15.6
22-12-07	8.8	15.6	16.4
22-12-09	8.8	16.4	22.8
22-12-10	18.0	22.8	32.8
Tank 241-C-102--Sludge only			
Tank 241-C-103			
30-03-01	7.2	30.4	24.4
30-03-03	8.0	24.4	24.0
30-03-05	8.8	24.0	23.6
30-03-07	12.4	23.6	23.2
30-03-09	9.6	23.2	22.0
30-06-04	19.6	22.0	30.4
Tank 241-C-104			
30-04-01	6.8	15.2	10.0
30-04-03	6.0	10.0	15.6
30-02-04	8.8	15.6	25.2
30-04-05	10.8	25.2	30.4
30-04-08	13.2	30.4	33.2
30-07-05	22.4	33.2	25.2
30-04-12	9.2	25.2	15.2
Tank 241-C-105			
30-05-02	12.0	38.0	18.0
30-05-03	8.4	18.0	19.6
30-05-04	10.8	19.6	18.8
30-05-06	10.8	18.8	16.0
30-05-07	6.8	16.0	11.2
30-05-08	8.8	11.2	14.8
30-05-09	11.2	14.8	20.0
30-05-10	14.4	20.0	38.0
Tank 241-C-106			
30-05-02	11.2	19.2	20.0
30-06-03	10.0	20.0	20.4
30-06-04	8.0	20.4	30.8
30-05-02	15.2	30.8	22.0
30-06-09	9.6	22.0	18.4
30-06-10	10.4	18.4	17.2
30-06-12	7.2	17.2	19.2
Tank 241-C-107--Sludge only			
Tank 241-C-110--Sludge only			
Tank 241-C-112--Sludge only			
Tank 241-S-101			
40-01-01	6.8	26.8	28.4
40-01-04	6.4	28.4	28.0
40-01-06	6.8	28.0	25.2
40-01-08	7.6	25.2	27.6
40-02-03	27.6	27.6	27.2
40-01-10	12.0	27.2	26.8
Tank 241-S-102			
40-02-01	7.6	21.6	14.0
40-02-02	8.4	14.0	26.8
40-01-08	24.0	26.8	25.6
40-02-04	21.6	25.6	22.0
40-02-05	6.4	22.0	15.6
40-02-07	6.8	15.6	20.4
40-02-08	14.0	20.4	20.4
40-02-10	6.8	20.4	19.6
40-02-11	10.0	19.6	21.6
Tank 241-S-103			
40-03-01	6.8	20.0	23.2
40-03-03	6.4	23.2	18.0
40-02-08	18.0	18.0	20.0
40-03-05	11.2	20.0	26.8
40-03-06	6.4	26.8	16.0
40-03-08	9.6	16.0	21.2
40-03-09	6.8	21.2	20.0
40-03-11	9.2	20.0	20.0
Tank 241-S-104--Sludge only			
Tank 241-S-105			
40-02-05	22.0	25.6	27.6
40-05-03	7.2	27.6	30.0
40-05-05	22.8	30.0	23.2
40-08-01	16.8	23.2	20.4
40-05-07	6.8	20.4	24.0
40-05-08	14.8	24.0	18.0
40-05-10	7.2	18.0	27.2
40-02-07	22.8	27.2	25.6
Tank 241-S-106			
40-06-02	4.4	34.4	28.0
40-05-10	27.6	28.0	28.0
40-05-00	16.4	28.0	27.2
40-06-05	25.6	27.2	28.0
40-09-01	17.2	28.0	20.8
40-06-06	8.4	20.8	21.2
40-06-08	9.6	21.2	17.6
40-09-01	17.2	17.6	20.0
40-06-09	8.8	20.0	27.2
40-03-06	22.8	27.2	34.4

TABLE H-1. Minimum Distance and Maximum Clockwise and Counterclockwise Distances from Monitoring Dry Wells to Waste Tank Inner Liners. (Sheet 4 of 6)

Well number	Closest distance	Counter-clockwise distance	Clockwise distance
Tank 241-S-107			
40-07-01	7.2	18.8	26.8
40-07-04	6.4	26.8	27.2
40-10-01	26.4	27.2	26.8
40-07-06	10.4	26.8	27.2
40-07-08	10.4	27.2	22.4
40-07-10	7.2	22.4	18.0
40-07-11	8.8	18.0	18.8
Tank 241-S-108			
40-08-01	14.8	24.8	30.0
40-07-10	26.8	30.0	30.8
40-07-08	22.8	30.8	31.2
40-08-06	4.8	31.2	16.8
40-08-08	7.6	16.8	20.0
40-08-09	7.6	20.0	31.6
40-05-07	22.0	31.6	24.8
Tank 241-S-109			
40-09-01	12.0	22.0	16.0
40-09-02	6.4	16.0	20.0
40-08-09	16.4	20.0	31.6
40-09-05	20.4	31.6	26.8
40-09-06	7.2	26.8	18.0
40-09-08	8.0	18.0	21.6
40-09-09	6.4	21.6	27.2
40-06-06	21.6	27.2	22.0
Tank 241-S-110			
40-07-06	12.4	34.0	24.8
40-00-04	24.0	24.8	25.6
40-10-03	6.8	25.6	23.6
40-10-05	12.0	23.6	18.0
40-10-06	6.8	18.0	12.0
40-10-08	4.0	12.0	24.4
40-10-09	6.8	24.4	34.0
Tank 241-S-111			
40-08-06	19.6	30.8	20.4
40-11-01	7.2	20.4	25.2
40-10-09	16.8	25.2	31.6
40-11-05	11.2	31.6	18.8
40-11-07	6.4	18.8	20.4
40-11-08	12.8	20.4	19.6
40-11-09	6.4	19.6	30.8
Tank 241-S-112			
40-09-06	18.8	32.4	25.2
40-12-02	6.8	25.2	28.8
40-11-08	18.4	28.8	30.4
40-12-06	6.8	30.4	17.6
40-12-07	8.4	17.6	20.8
40-12-09	7.2	20.8	32.4
Tank 241-SX-101			
41-01-01	6.8	18.8	33.2
41-01-04	7.2	33.2	21.2
41-01-06	6.0	21.2	24.0
41-01-08	6.4	24.0	17.6
41-01-10	25.6	17.6	20.4
41-01-11	5.2	20.4	18.8
Tank 241-SX-102			
41-02-02	6.4	25.2	23.2
41-01-10	20.8	23.2	28.8
41-01-07	21.6	28.8	28.0
41-05-12	17.6	28.0	28.0
41-02-07	14.8	28.0	17.2
41-02-08	6.8	17.2	23.2
41-02-11	9.6	23.2	25.2
Tank 241-SX-103			
41-03-12	6.8	17.6	20.8
41-03-02	7.6	20.8	22.0
41-02-08	20.8	22.0	22.4
41-03-05	10.4	22.4	19.6
41-03-06	7.2	19.6	21.6
41-06-11	21.6	21.6	26.4
41-03-09	6.8	26.4	17.6
Tank 241-SX-104			
41-01-06	20.4	20.8	20.8
41-04-01	7.2	20.8	22.0
41-04-03	11.2	22.0	24.0
41-04-05	8.0	24.0	18.8
41-07-12	15.2	18.8	20.0
41-04-07	16.8	20.0	25.2
41-05-03	18.4	25.2	28.0
41-04-11	5.2	28.0	20.8
Tank 241-SX-105			
41-05-12	10.8	26.8	21.6
41-05-02	10.4	21.6	19.2
41-05-03	10.4	19.2	23.6
41-05-05	10.4	23.6	21.6
41-05-07	9.6	21.6	22.0
41-05-08	12.8	22.0	18.4
41-05-10	11.2	18.4	26.8
Tank 241-SX-106			
41-03-06	20.0	24.8	20.4
41-06-02	6.0	20.4	26.4
41-05-08	14.8	26.4	18.0
41-06-05	6.0	18.0	30.0
41-09-11	24.0	30.0	30.4
41-06-09	6.4	30.4	29.2
41-06-11	22.0	29.2	24.8
Tank 241-SX-109--Sludge only			
Tank 241-T-101			
50-01-12	6.8	30.8	22.8
50-01-02	8.8	22.8	20.0
50-01-04	6.8	20.0	29.2
50-01-06	16.0	29.2	36.0
50-01-09	5.6	36.0	30.8
Tank 241-T-104--Sludge only			
Tank 241-T-105--Sludge only			

TABLE H-1. Minimum Distance and Maximum Clockwise and Counterclockwise Distances from Monitoring Dry Wells to Waste Tank Inner Liners. (Sheet 5 of 6)

Well number	Closest distance	Counter-clockwise distance	Clockwise distance
Tank 241-T-107			
50-04-05	17.6	24.4	31.6
50-07-03	5.2	31.6	42.0
50-07-07	15.6	42.0	23.6
50-07-08	14.4	23.6	40.0
50-04-07	19.6	40.0	24.4
Tank 241-T-109--Sludge only			
Tank 241-T-110--Sludge only			
Tank 241-T-111--Sludge only			
Tank 241-TX-101			
51-05-07	21.2	32.8	31.2
51-01-02	15.2	31.2	25.2
51-01-04	8.0	25.2	25.2
51-01-06	8.8	25.2	16.8
51-01-08	7.6	16.8	22.8
51-01-09	11.2	22.8	32.8
Tank 241-TX-102			
51-02-12	6.8	28.4	17.6
51-02-02	10.4	17.6	20.8
51-01-09	12.8	20.8	22.0
51-02-05	7.6	22.0	23.2
51-02-07	8.8	23.2	27.2
51-02-09	6.8	27.2	26.4
51-03-02	25.6	26.4	28.4
Tank 241-TX-103			
51-03-12	8.8	9.2	8.8
51-03-01	3.6	8.8	26.0
51-03-02	25.6	26.0	29.2
51-02-09	18.8	29.2	36.0
51-03-06	8.8	36.0	36.0
51-03-09	9.2	36.0	26.8
	4.0	26.8	9.2
Tank 241-TX-105			
51-05-01	5.2	30.4	20.0
51-05-03	10.0	20.0	20.8
51-05-05	8.4	20.8	24.0
51-05-07	7.2	24.0	17.6
51-05-08	7.6	17.6	28.4
51-05-10	8.4	28.4	30.4
Tank 241-TX-106			
51-06-12	12.4	20.8	19.6
51-06-02	7.6	19.6	30.0
51-06-04	7.2	30.0	25.2
51-02-12	17.2	25.2	26.4
51-06-08	6.8	26.4	21.2
51-07-03	14.0	21.2	15.6
51-06-10	7.2	15.6	20.8
Tank 241-TX-108			
51-12-05	12.8	23.2	31.6
51-07-09	16.0	31.6	20.8
51-08-05	8.4	20.8	20.8
51-04-12	15.2	20.8	34.8
51-08-09	9.6	34.8	26.0
51-08-11	9.6	26.0	23.2

Well number	Closest distance	Counter-clockwise distance	Clockwise distance
Tank 241-TX-109			
51-09-12	10.4	27.6	27.6
51-09-03	10.4	27.6	20.8
51-09-04	5.6	20.8	37.2
51-09-08	10.4	37.2	23.6
51-10-04	22.4	23.6	23.2
51-09-10	10.4	23.2	27.6
Tank 241-TX-110			
51-10-12	5.2	24.8	22.0
51-10-01	9.2	22.0	20.8
50-09-10	20.4	20.8	21.2
51-10-04	5.2	21.2	28.0
51-06-12	12.8	28.0	21.2
51-10-08	9.6	21.2	26.8
51-11-03	17.6	26.8	24.4
51-11-02	24.0	24.4	24.8
Tank 241-TX-111			
51-11-10	10.6	26.7	28.0
51-11-01	9.5	28.0	21.1
51-11-03	9.2	21.1	35.5
51-07-01	20.4	35.5	25.8
51-11-07	9.3	25.8	23.3
51-12-04	18.3	23.3	26.7
Tank 241-TX-112			
51-12-01	15.2	26.4	30.8
51-12-04	14.4	30.8	26.8
51-12-05	20.0	26.8	25.2
51-12-07	10.0	25.2	29.6
51-12-10	7.2	29.6	20.0
51-12-11	14.4	20.0	26.4
Tank 241-TX-113			
51-13-12	8.8	48.0	48.8
51-13-05	9.2	48.8	33.6
51-13-08	4.8	33.6	48.0
Tank 241-TX-114			
51-14-11	4.8	34.4	39.2
51-14-04	4.4	39.2	39.6
51-10-01	39.2	39.6	39.2
51-10-12	19.2	39.2	21.2
51-14-08	9.2	21.2	19.6
51-15-04	16.4	19.6	34.4
Tank 241-TX-115			
51-15-11	6.0	24.0	43.6
51-15-04	8.4	43.6	29.2
51-11-01	19.6	29.2	28.8
51-15-07	5.6	28.8	20.8
51-15-09	6.4	20.8	24.0
Tank 241-TX-116			
51-16-11	10.8	25.6	44.8
51-16-04	8.0	44.8	32.0
51-13-12	14.8	32.0	22.8
51-16-07	13.6	22.8	39.2
51-17-03	25.2	39.2	25.6

TABLE H-1. Minimum Distance and Maximum Clockwise and Counterclockwise Distances from Monitoring Dry Wells to Waste Tank Inner Liners. (Sheet 6 of 6)

Well number	Closest distance	Counter-clockwise distance	Clockwise distance
Tank 241-TX-117			
51-17-11	9.2	22.8	20.4
51-17-02	10.0	20.4	40.8
51-16-07	34.4	40.8	42.0
51-14-11	20.4	42.0	42.4
51-18-03	18.4	42.4	18.4
51-17-10	9.6	18.4	22.8
Tank 241-TX-118			
51-18-11	10.8	18.4	16.4
51-18-01	11.2	16.4	21.6
51-18-03	9.6	21.6	24.4
51-18-05	9.2	24.4	27.2
51-18-07	6.4	27.2	21.6
51-18-09	9.6	21.6	21.6
51-18-10	11.6	21.6	18.4
Tank 241-TY-101--Sludge only			
Tank 241-TY-103--Sludge only			
Tank 241-TY-105--Sludge only			
Tank 241-U-102			
60-02-10	15.2	18.0	22.8
60-02-11	12.0	22.8	21.6
60-02-01	12.0	21.6	22.8
60-01-10	15.2	22.8	22.4
60-01-08	12.4	22.4	13.6
60-02-05	6.0	13.6	25.6
60-02-07	12.0	25.6	20.8
60-02-08	4.0	20.8	18.0
Tank 241-U-103			
60-03-10	9.6	27.6	26.8
60-03-11	8.8	26.8	22.0
60-03-01	10.8	22.0	22.8
60-02-10	14.0	22.8	23.2
60-02-08	17.2	23.2	29.2
60-03-05	14.0	29.2	23.2
60-06-11	17.2	23.2	26.0
60-03-08	9.6	26.0	27.6
Tank 241-U-105			
60-02-05	36.0	36.4	37.6
60-04-10	18.0	37.6	23.6
60-04-08	20.0	23.6	22.8
60-05-04	8.8	8.8	18.8
60-05-05	13.6	18.8	20.8
60-05-07	14.8	20.8	23.6
60-05-08	14.8	23.6	22.8
60-05-10	15.2	26.0	26.0
60-02-07	19.6	26.0	36.4

Well number	Closest distance	Counter-clockwise distance	Clockwise distance
Tank 241-U-106			
60-03-05	18.0	22.0	26.8
60-05-10	26.8	15.2	23.2
60-05-08	16.0	23.2	31.6
60-09-01	20.8	31.6	24.0
60-06-07	12.0	24.0	21.6
60-06-08	14.0	21.6	22.8
60-06-10	14.0	22.8	20.0
60-06-11	10.0	20.0	22.0
Tank 241-U-107			
60-07-01	11.2	21.2	18.4
60-07-02	9.2	18.4	38.8
60-10-01	19.2	38.8	24.8
60-10-11	18.4	24.8	28.0
60-08-04	20.8	28.0	24.0
60-07-10	7.2	24.0	18.0
60-07-11	11.6	18.0	21.2
Tank 241-U-108			
60-05-05	13.6	21.2	30.0
60-07-10	24.0	30.0	26.4
60-08-04	11.6	26.4	26.8
60-11-12	12.0	26.8	29.2
60-08-08	15.2	29.2	22.4
60-08-09	14.8	22.4	17.6
60-08-10	15.2	17.6	18.0
60-05-07	15.6	18.0	21.2
Tank 241-U-109			
60-09-01	9.6	22.8	21.6
60-08-09	15.2	21.6	24.0
60-08-08	15.6	24.0	31.6
60-12-01	22.0	31.6	26.8
60-09-07	10.0	26.8	23.2
60-09-08	15.6	23.2	22.8
60-09-10	15.6	22.8	26.0
60-06-07	18.8	26.0	22.8
Tank 241-U-110--Sludge only			
Tank 241-U-111			
60-11-12	11.6	34.0	34.0
60-11-03	13.2	34.0	26.8
60-11-05	7.2	26.8	12.4
60-11-06	8.8	12.4	15.6
60-11-07	12.0	15.6	24.8
60-12-03	10.8	24.8	34.0

construction of the wells. It was assumed that the center of the well must miss any obstruction by a minimum of 3 ft. Based on preliminary research, the number of wells that could not be installed because of interfering installed equipment and structures was also determined.

A summary of the second set of calculations is provided in Table H-2. The first entry in each category in Table H-2 is the number of new wells needed, and the second entry is the number that cannot be built due to obstructions.

In order to limit the maximum volume of a leak to 10,000 gal, 328 new dry wells would be needed. A limit of 20,000 gal would require 153 new dry wells.

Drawings of each tank farm are provided showing the location of existing dry wells and of the new dry wells needed to assure that the maximum leak will not exceed 10,000 and 20,000 gal (Figures H-2 through H-23).

TABLE H-2. Dry Wells for Monitoring Tank Leaks.

Tank farm	Number of new dry wells needed to monitor 10,000-gal tank leaks		Number of new dry wells needed to monitor 20,000-gal tank leaks	
	Total wells	Wells with probable obstructions	Total wells	Wells with probable obstructions
A	27	2	7	2
AX	15	5	4	2
B	41	4	28	1
BX	21	5	16	3
BY	53	8	28	4
C	20	2	10	2
S	36	2	15	1
SX	16	0	3	0
T	8	1	5	0
TX	63	2	29	2
U	28	4	8	1
Total	328	35	153	18

NOTE: Possible interferences have been determined solely on a search through existing microfilm files.

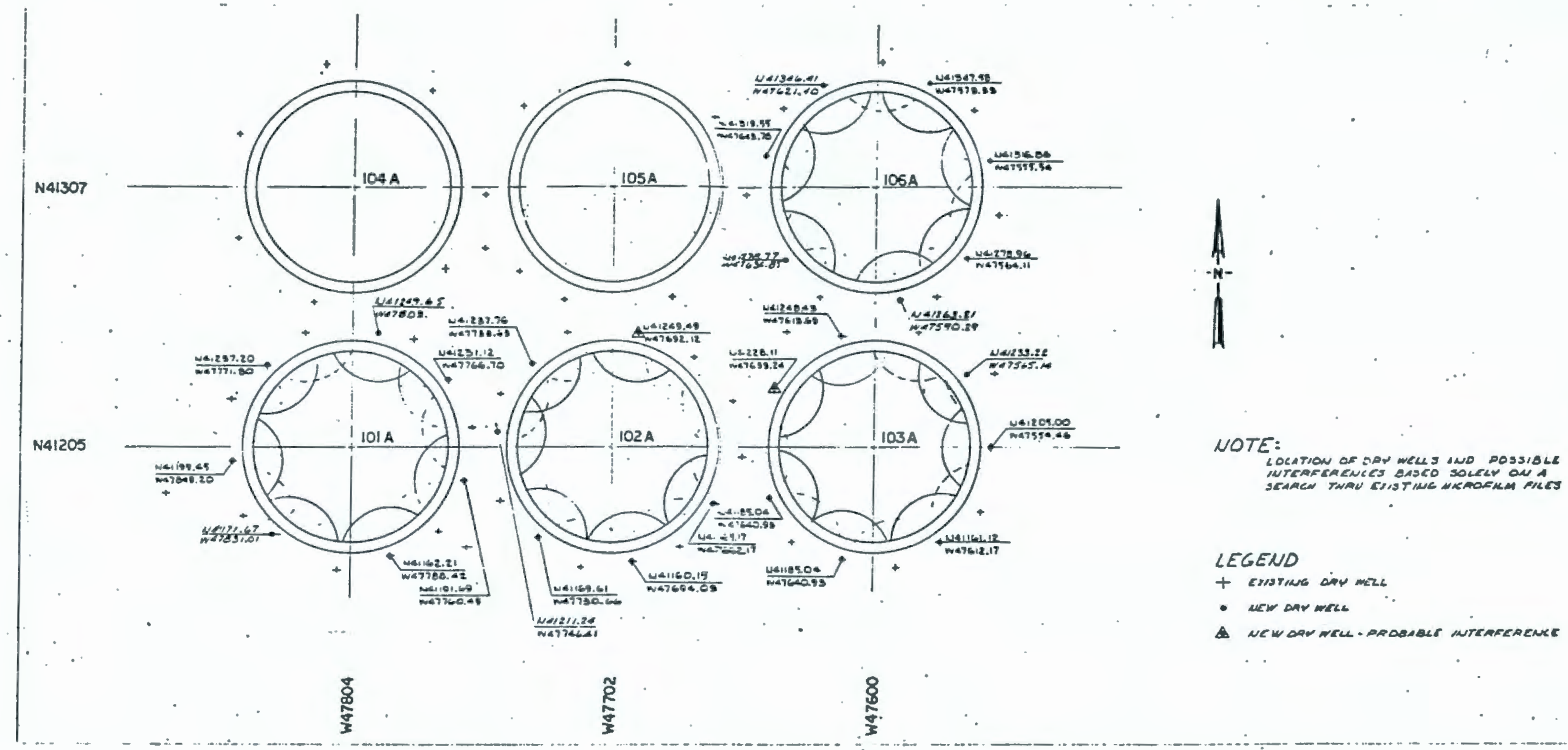


FIGURE H-2. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 10,000 Gal in Tank Farm 241-A.

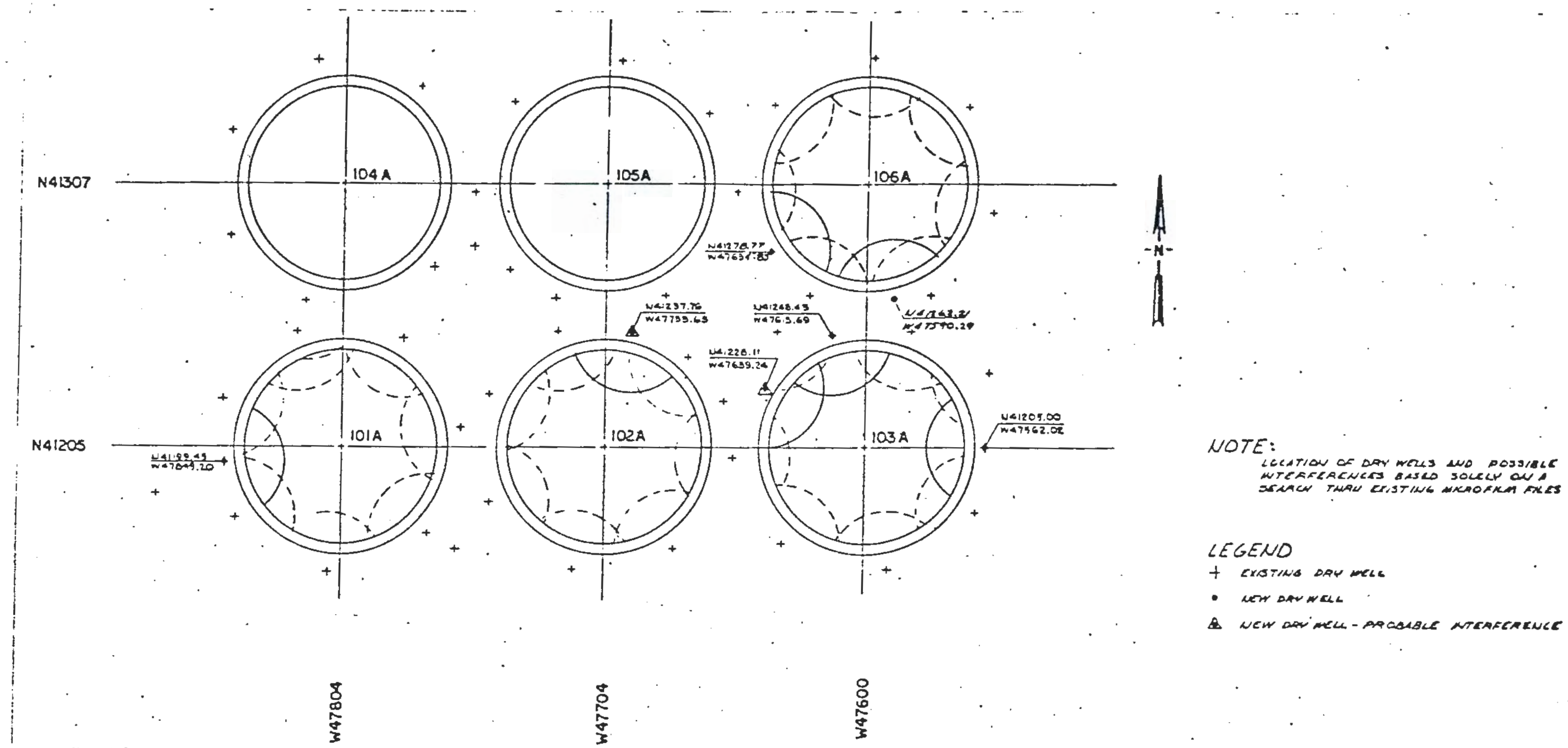


FIGURE H-3. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-A.

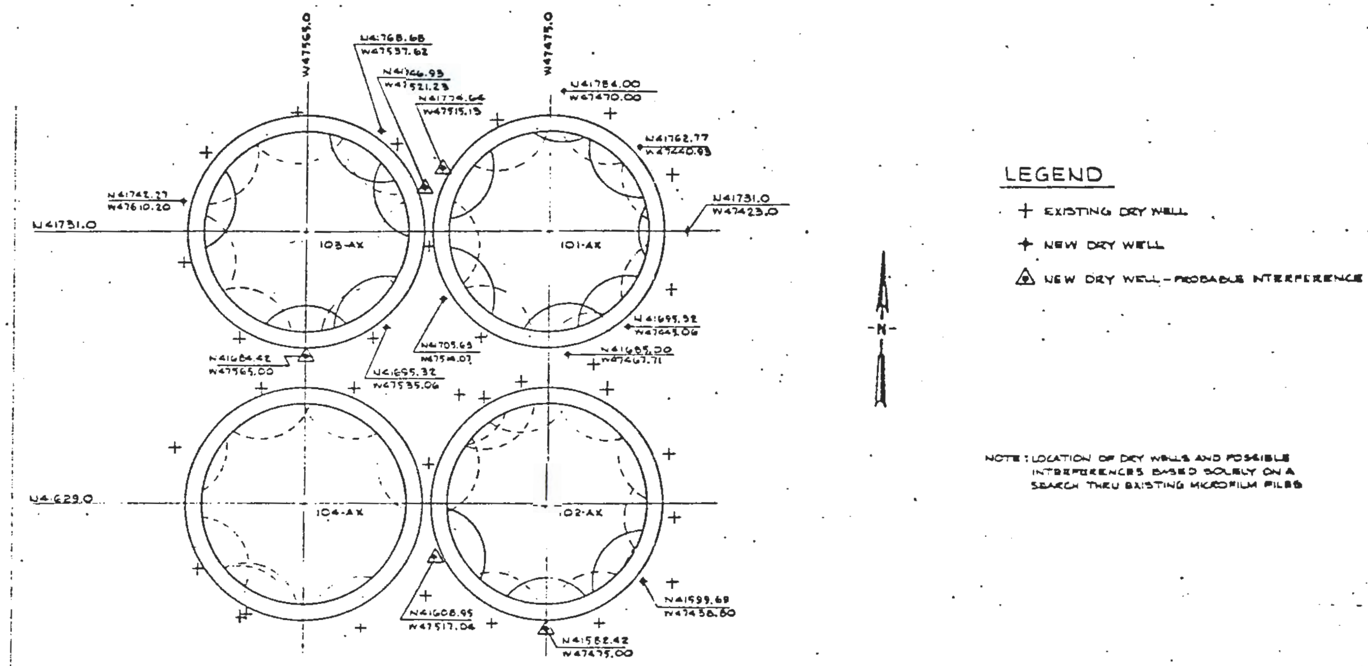


FIGURE H-4. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 10,000 Gal in Tank Farm 241-AX.

92124961831

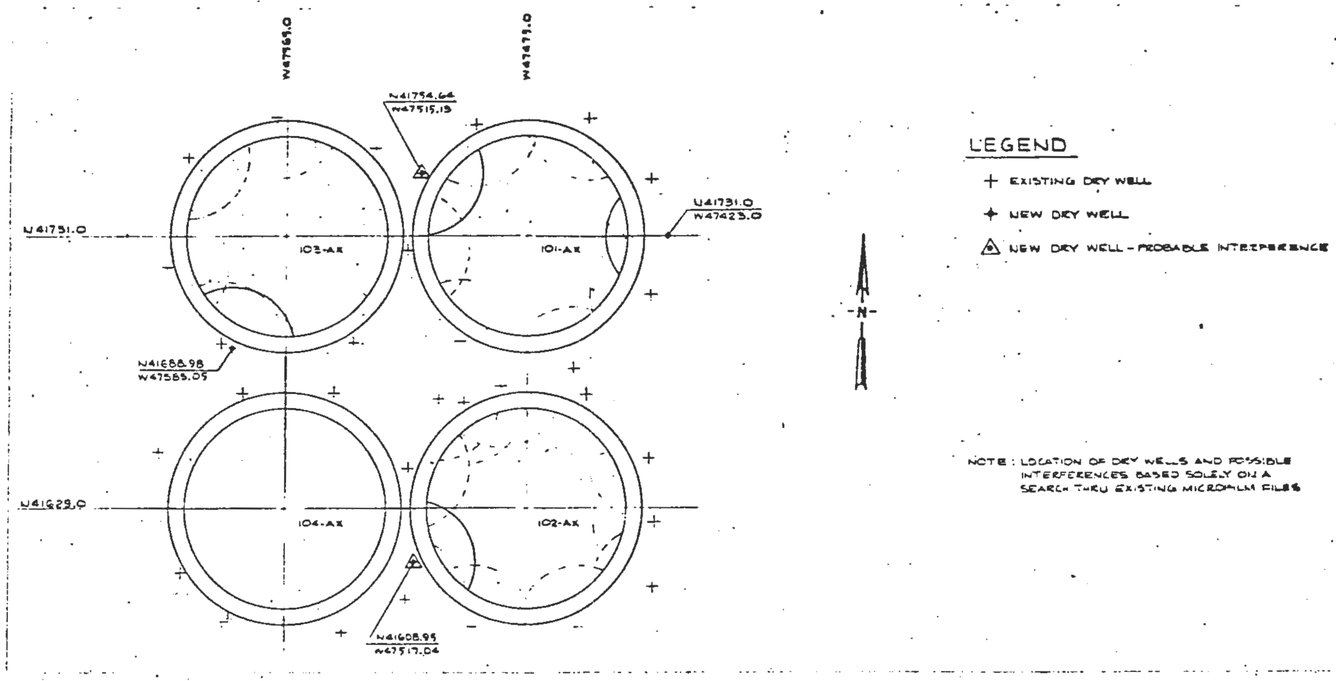


FIGURE H-5. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-AX.

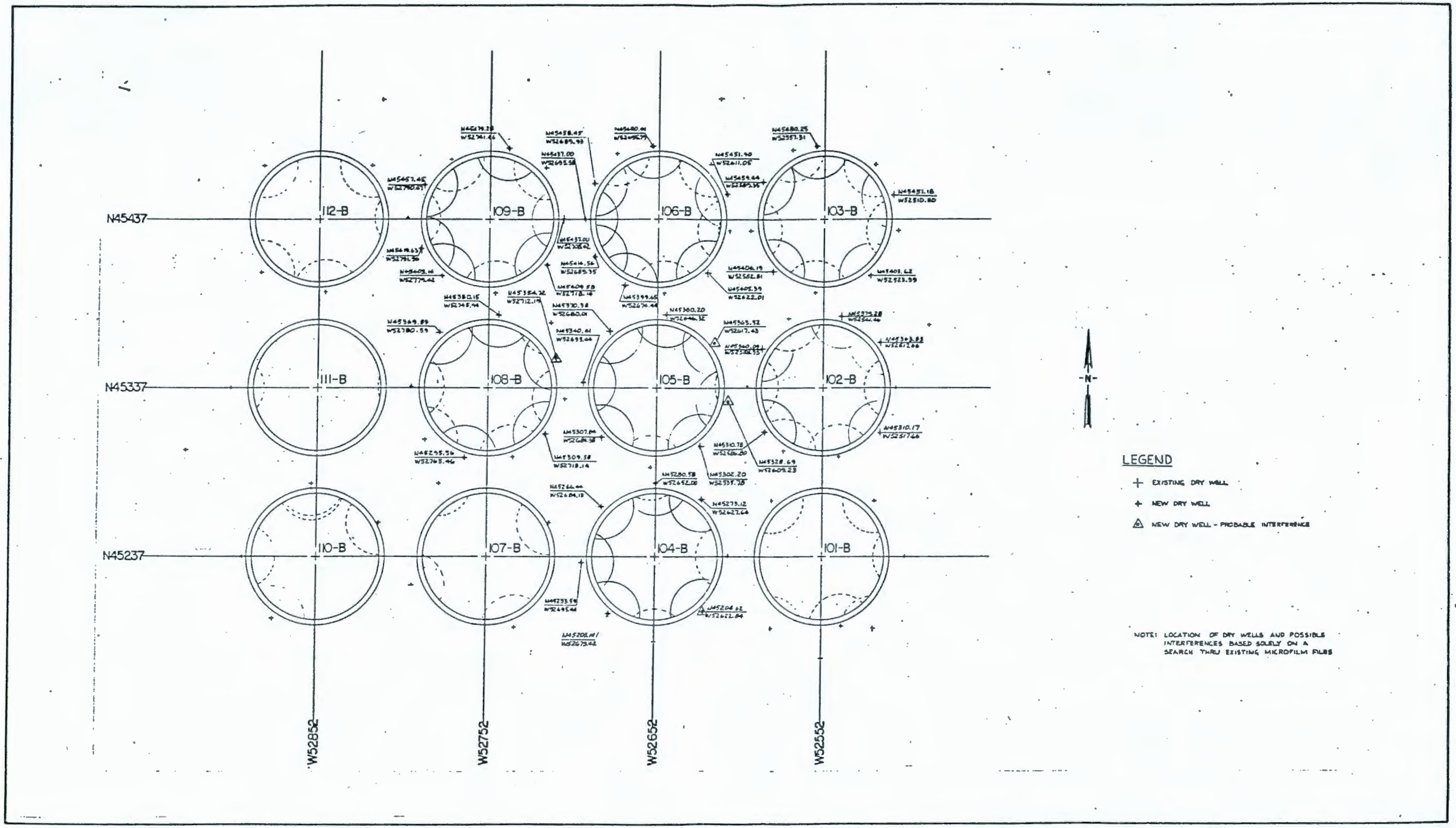


FIGURE H-6. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 10,000 Gal in Tank Farm 241-B.

9 2 1 2 4 9 9 1 8 8 3

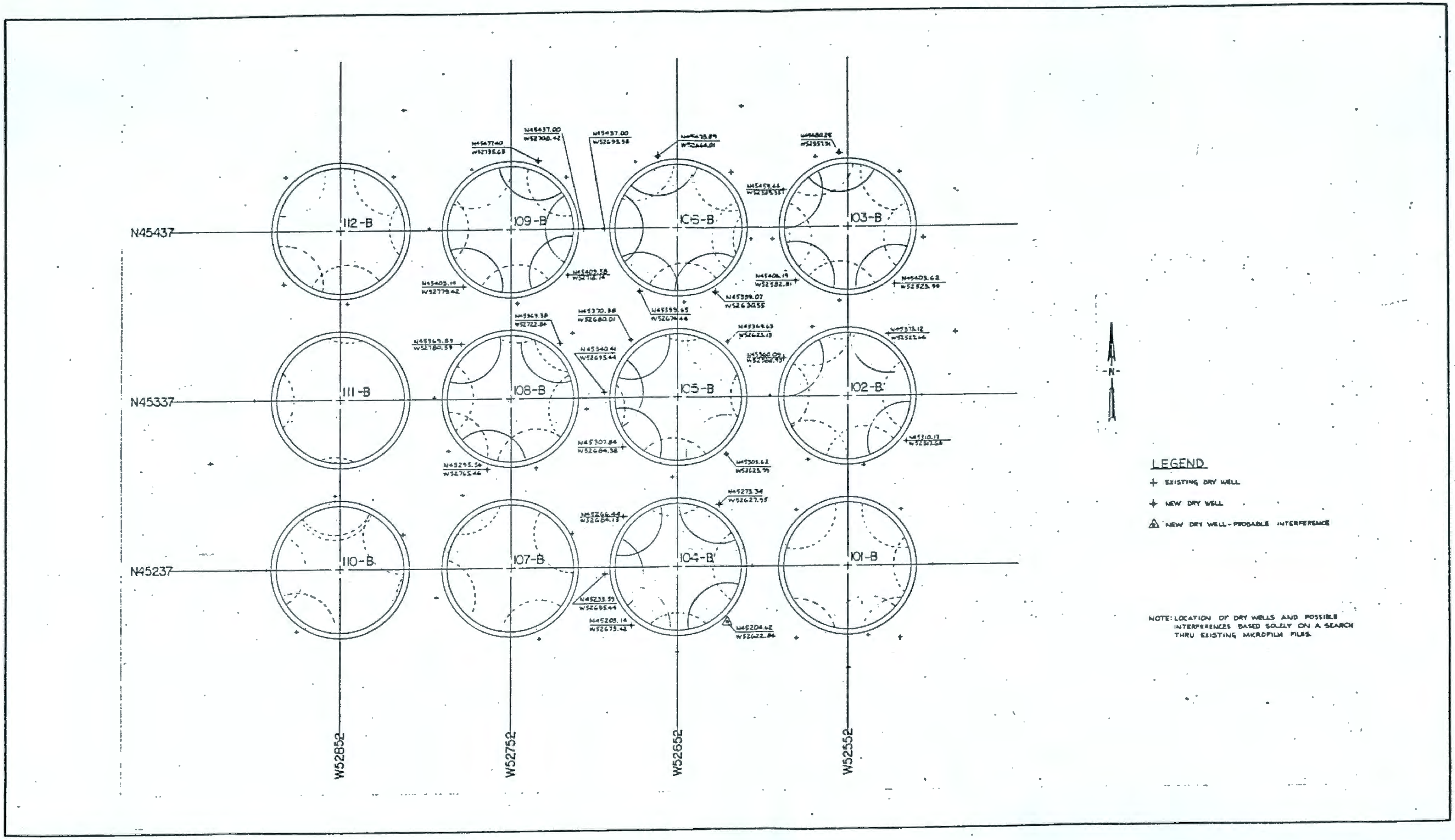


FIGURE H-7. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-B.

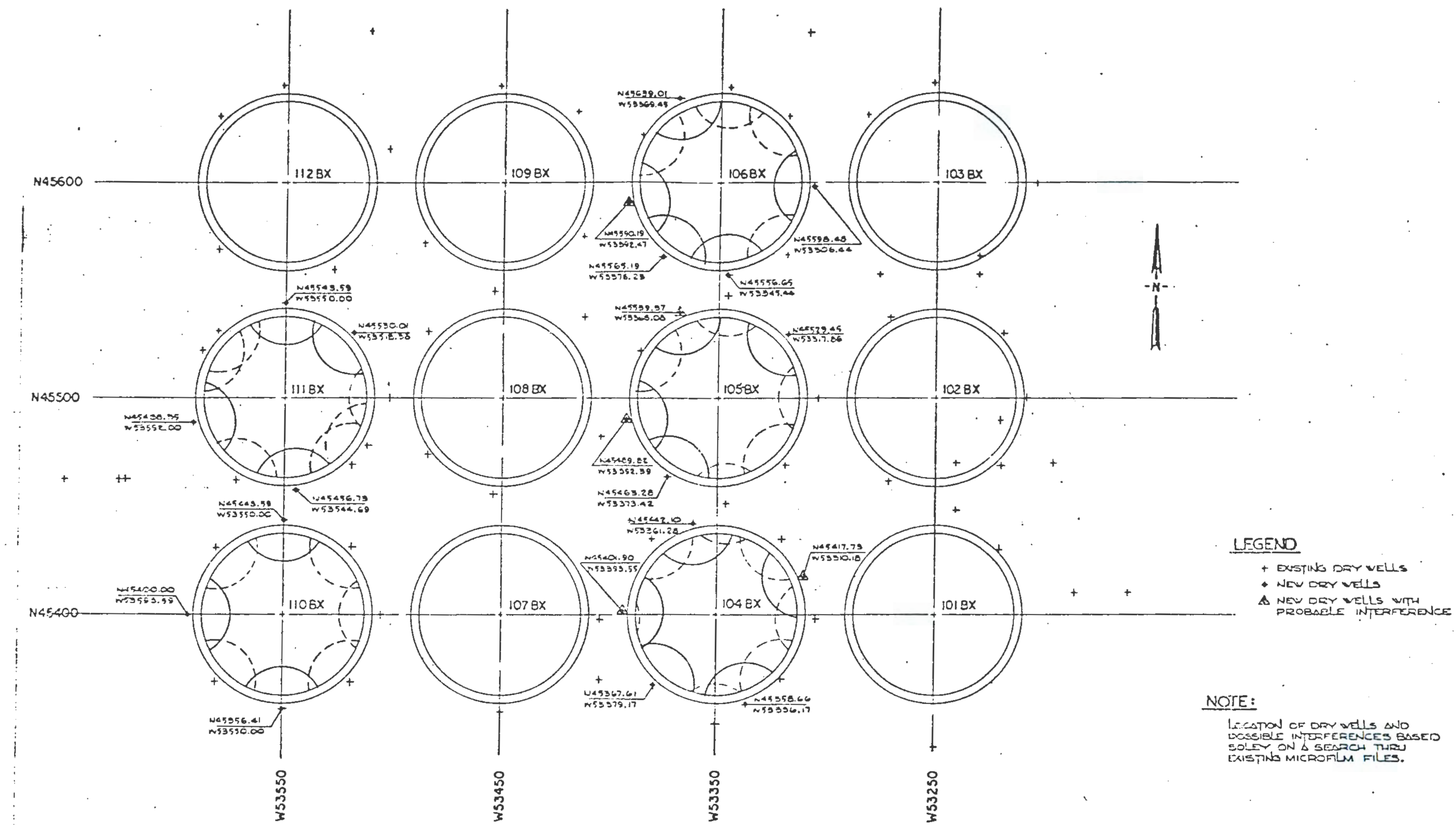


FIGURE H-8. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 10,000 Gal in Tank Farm 241-BX.

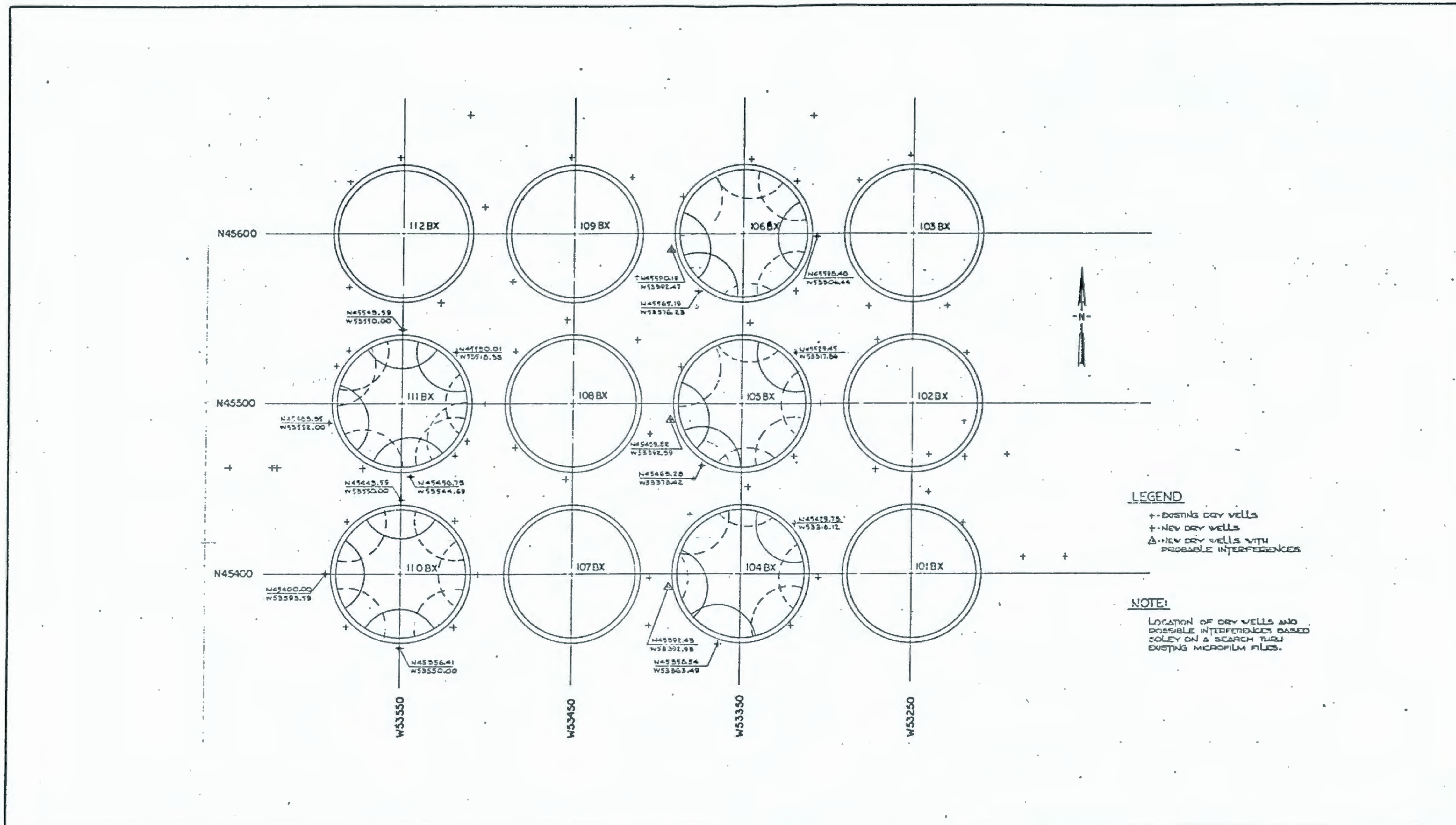


FIGURE H-9. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-BX.

9 2 1 2 4 9 9 1 8 B 5

92124991386

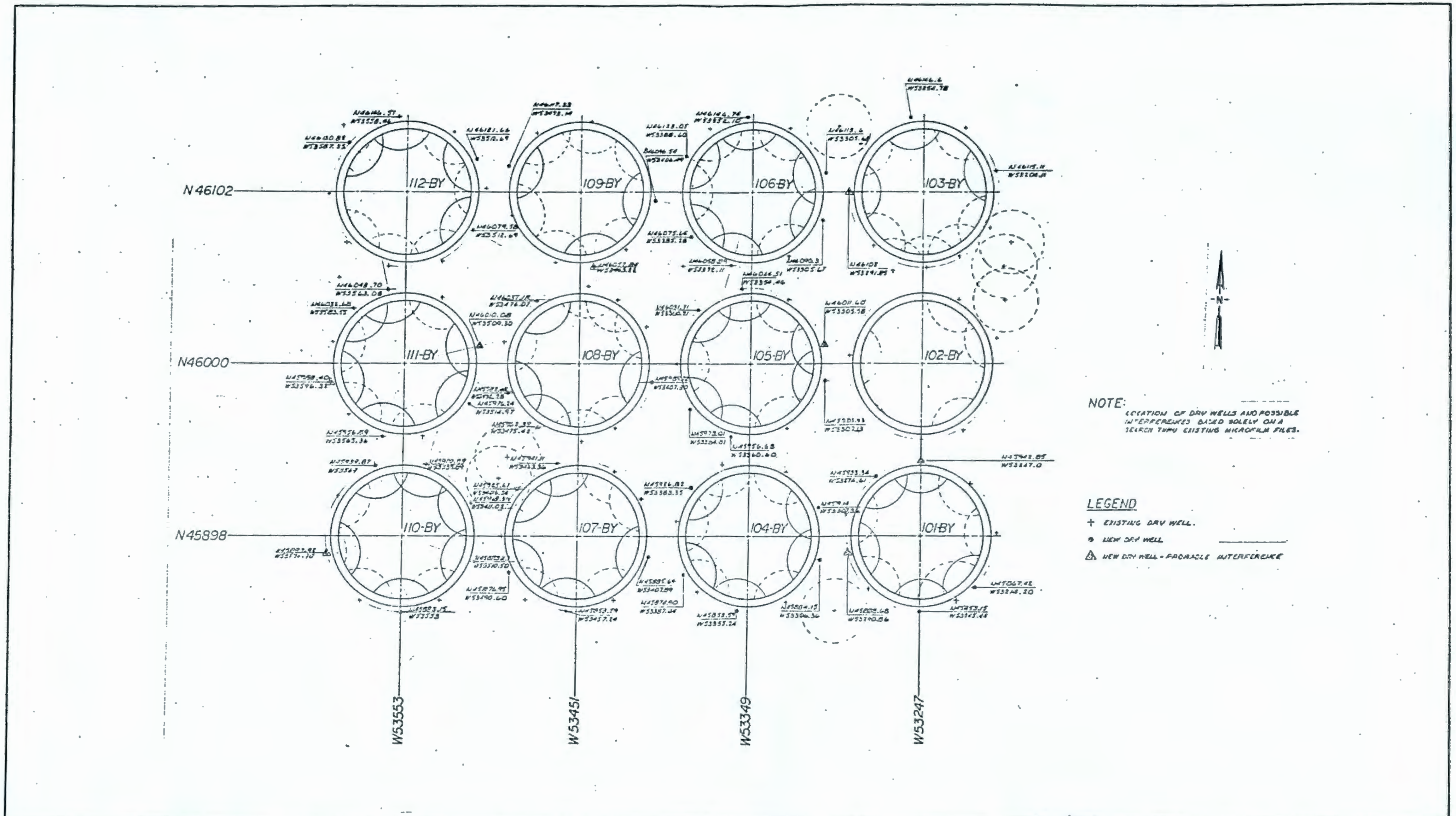


FIGURE H-10. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 10,000 Gal in Tank Farm 241-BY.

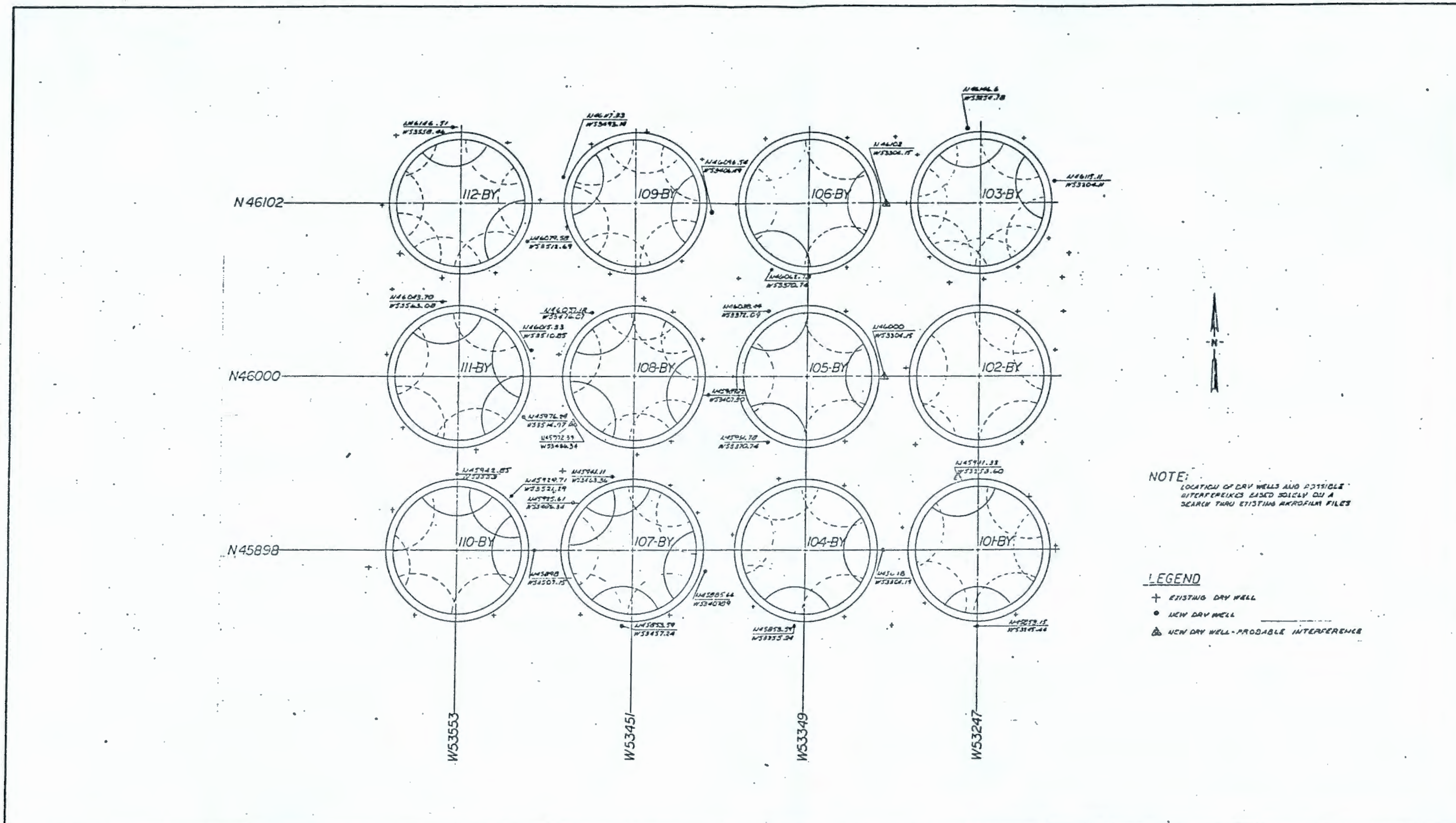


FIGURE H-11. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-BY.

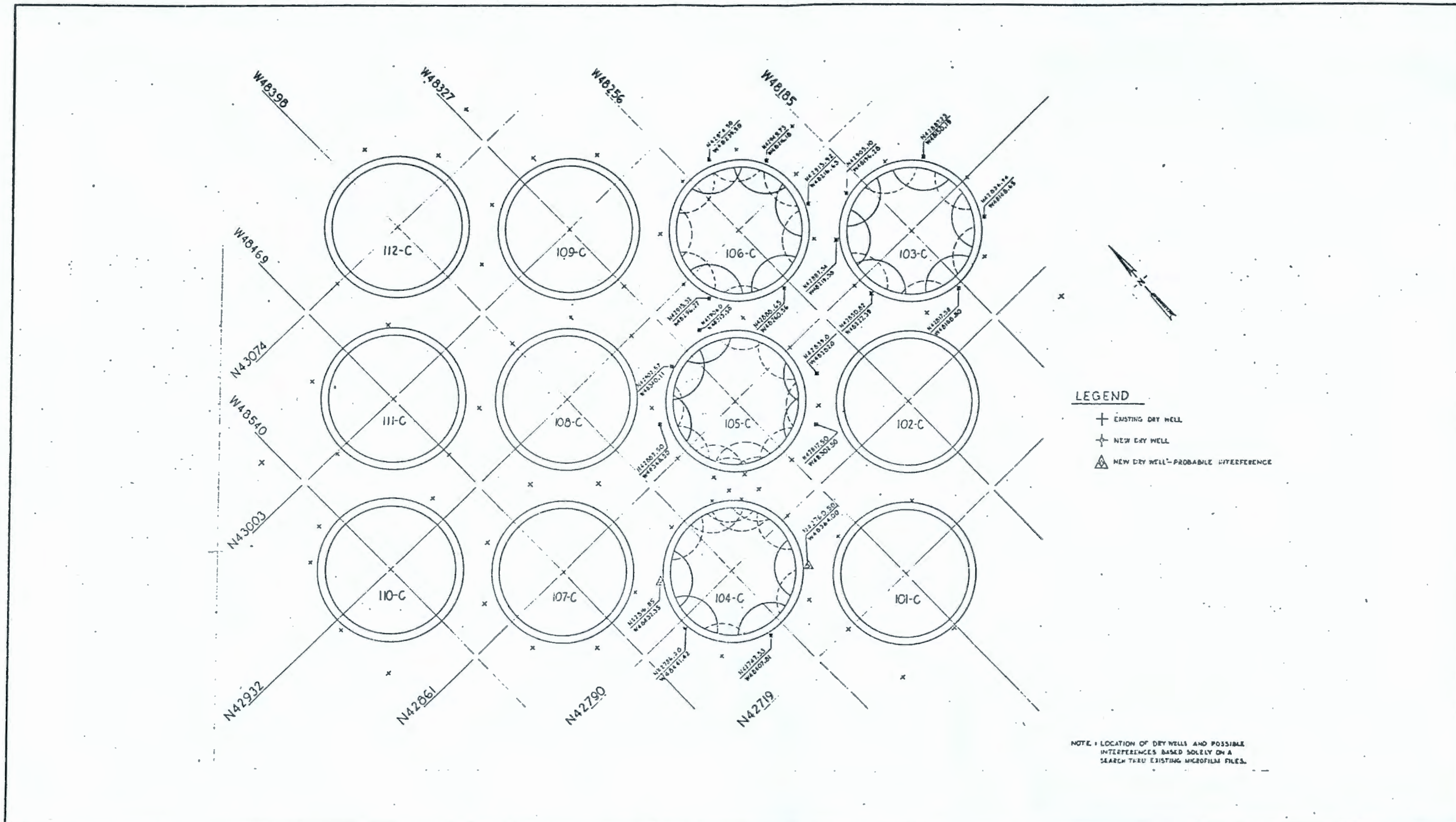


FIGURE H-12. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 10,000 Gal in Tank Farm 241-C.

92124991839

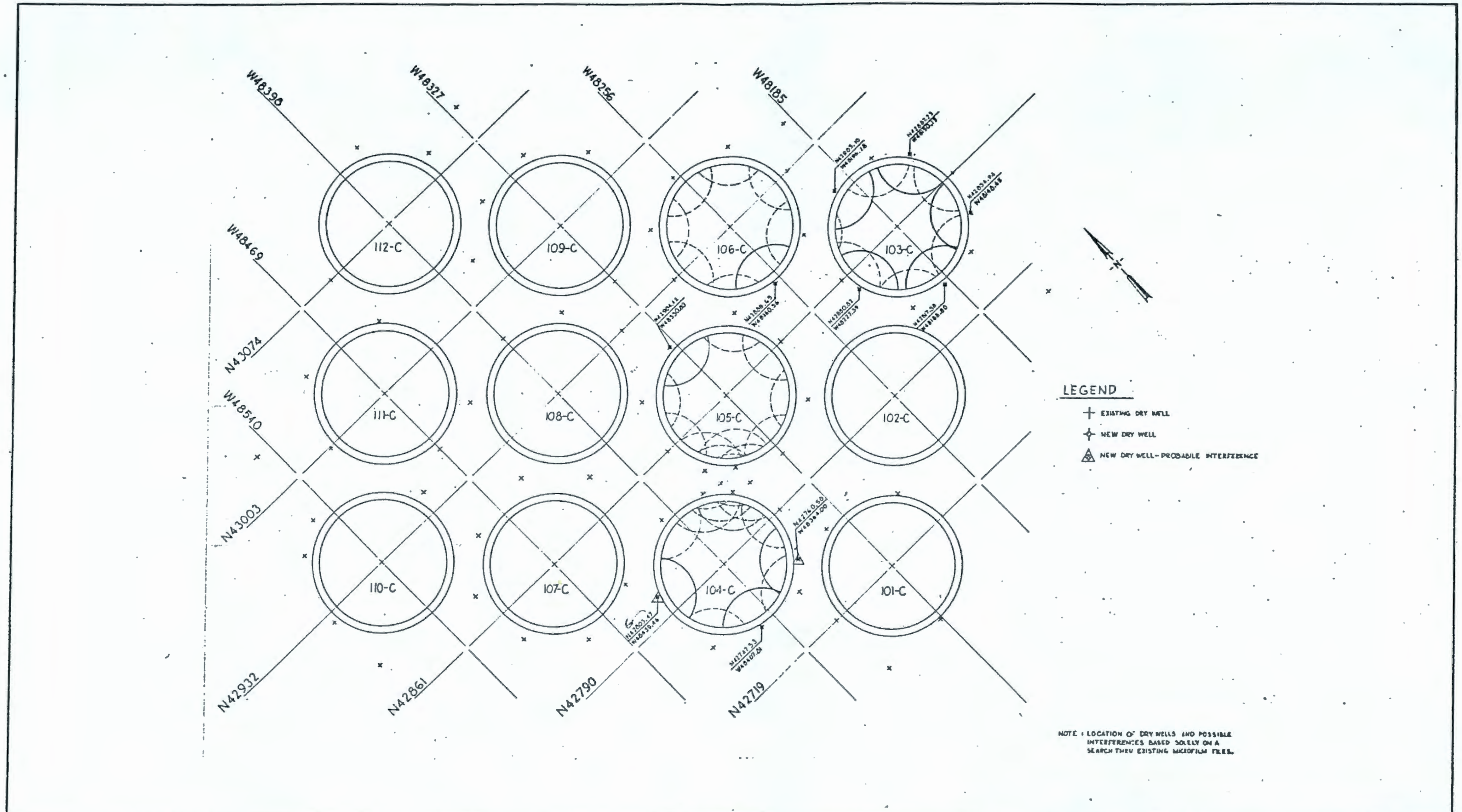


FIGURE H-13. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-C.

9212499189 0

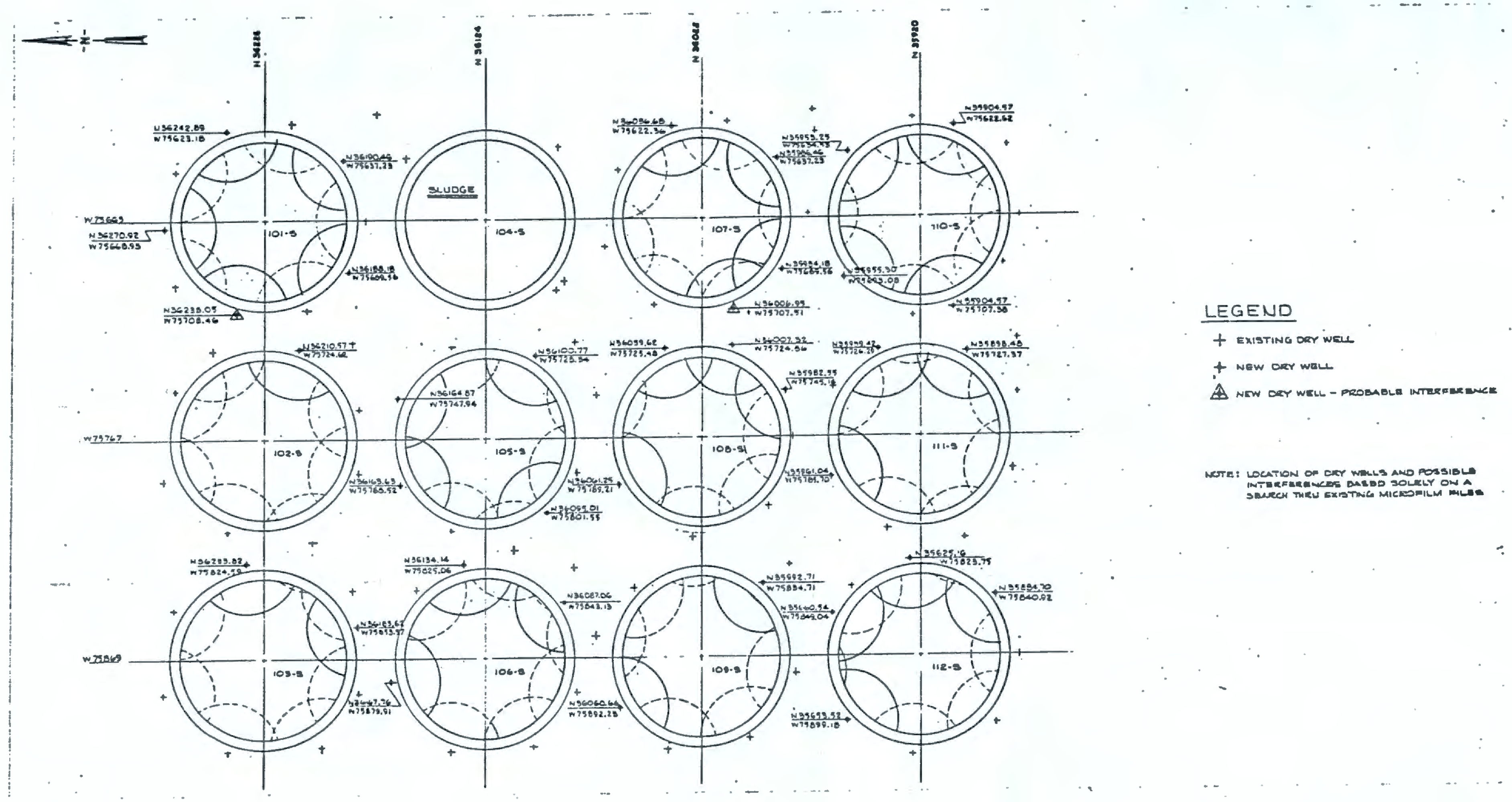


FIGURE H-14. Locations for New Radiation Mon toring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will No Exceed 10,000 Gal in Tank Farm 241-S.

92124991891

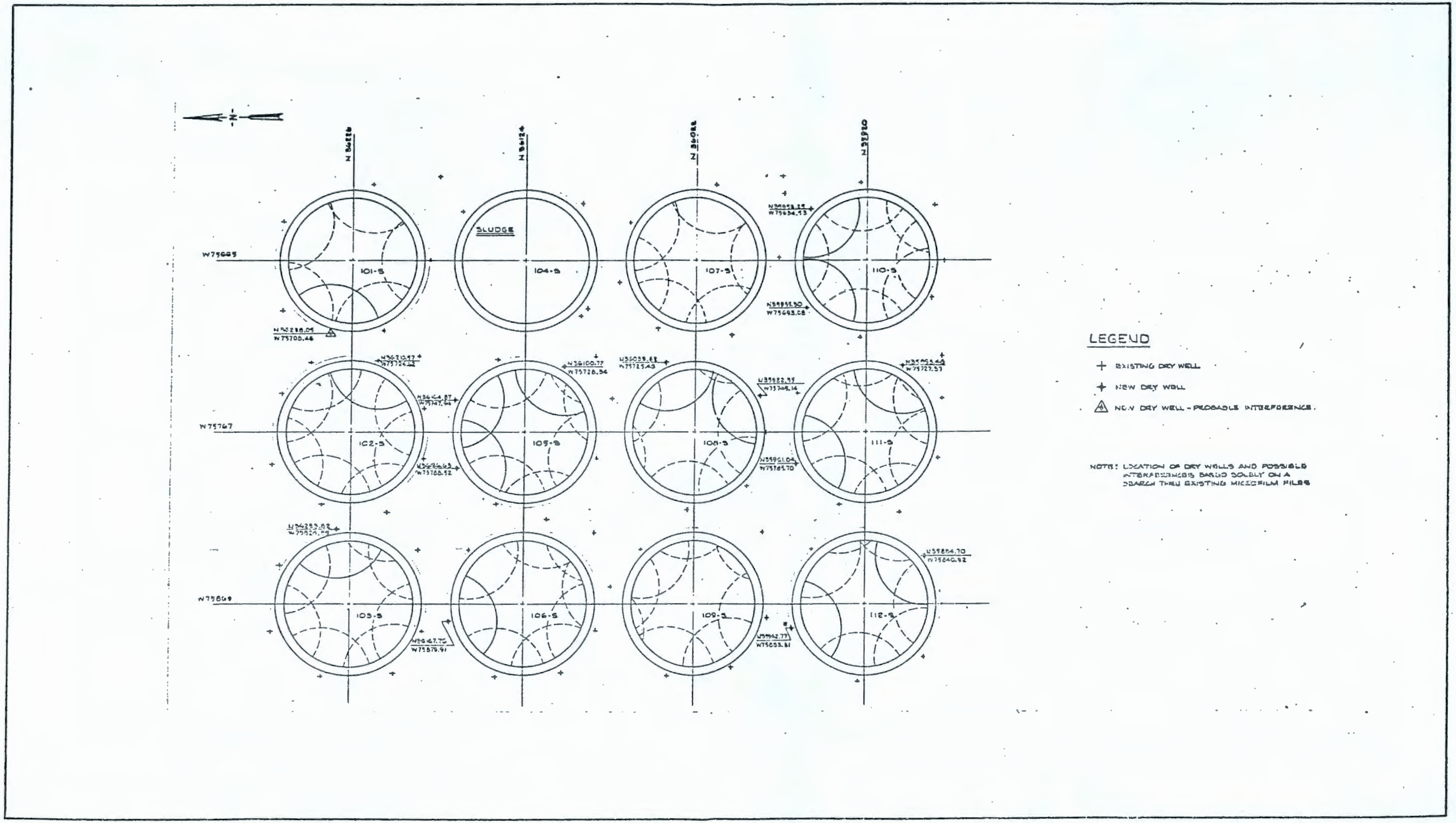


FIGURE H-15. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-S.

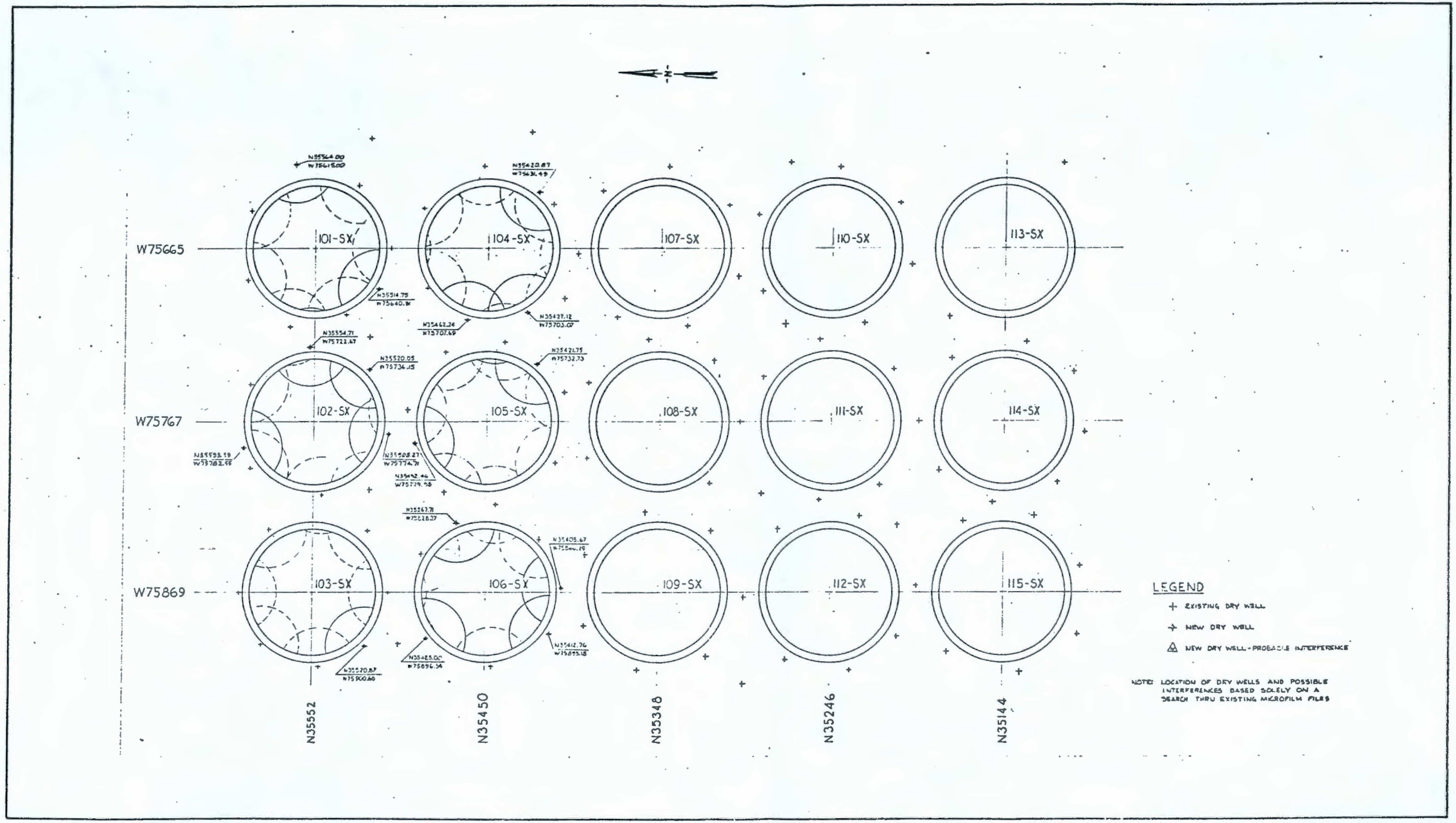


FIGURE H-16. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 10,000 Gal in Tank Farm 241-SX.

9212499893

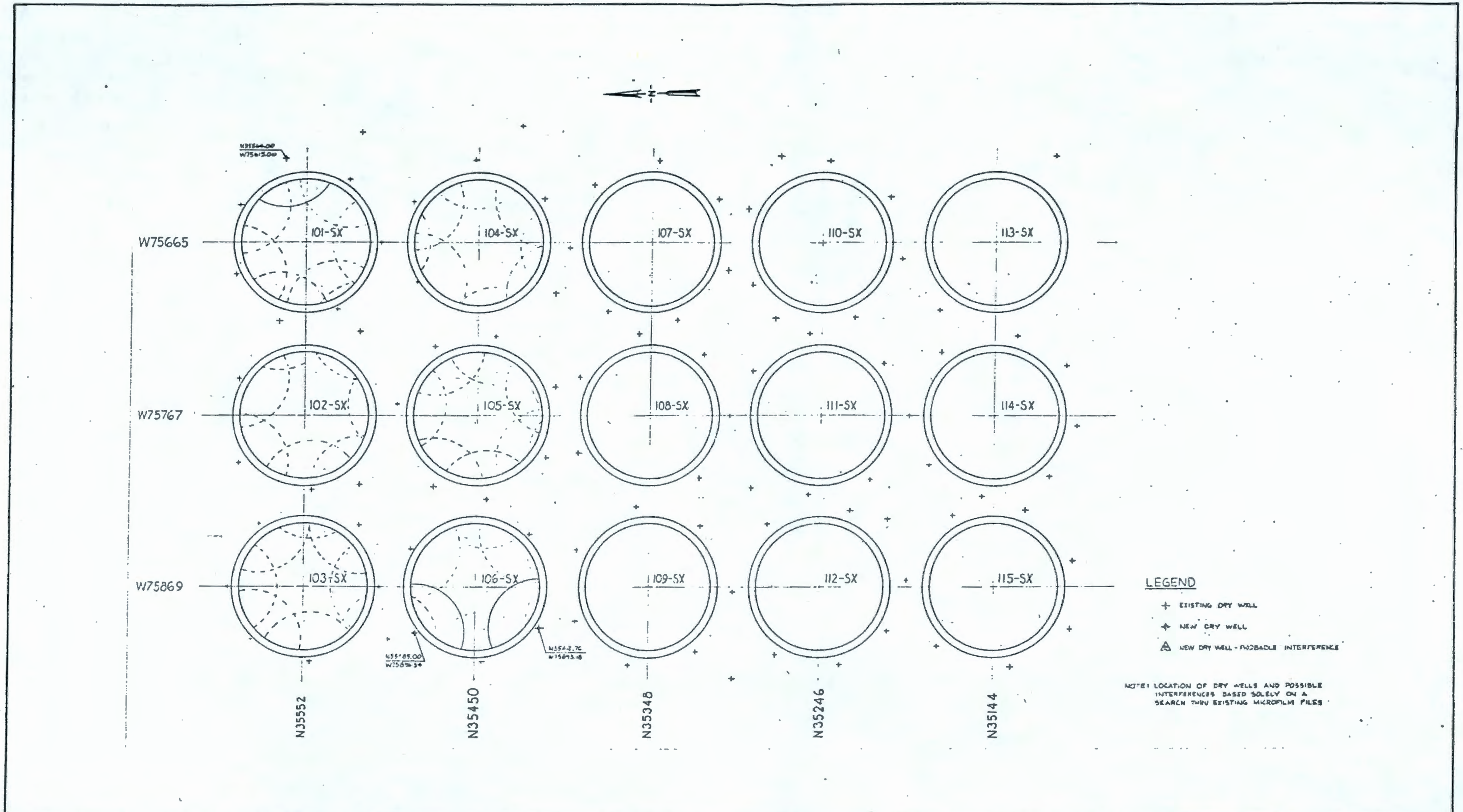


FIGURE H-17. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-SX.

9212491894

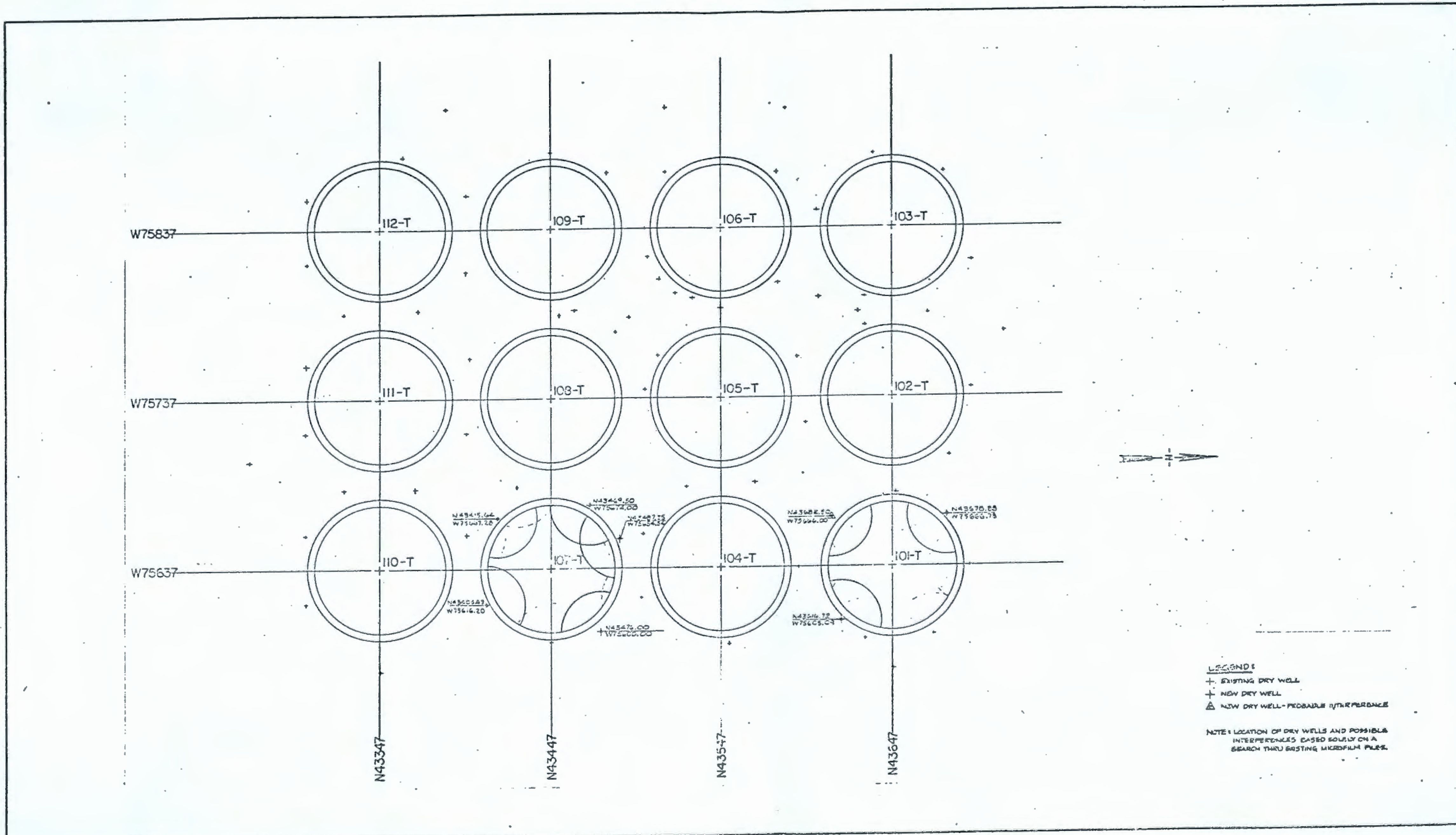


FIGURE H-18. Locations for New Radiation Mon toring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will No Exceed 10,000 Gal in Tank Farm 241-T.

92124991895

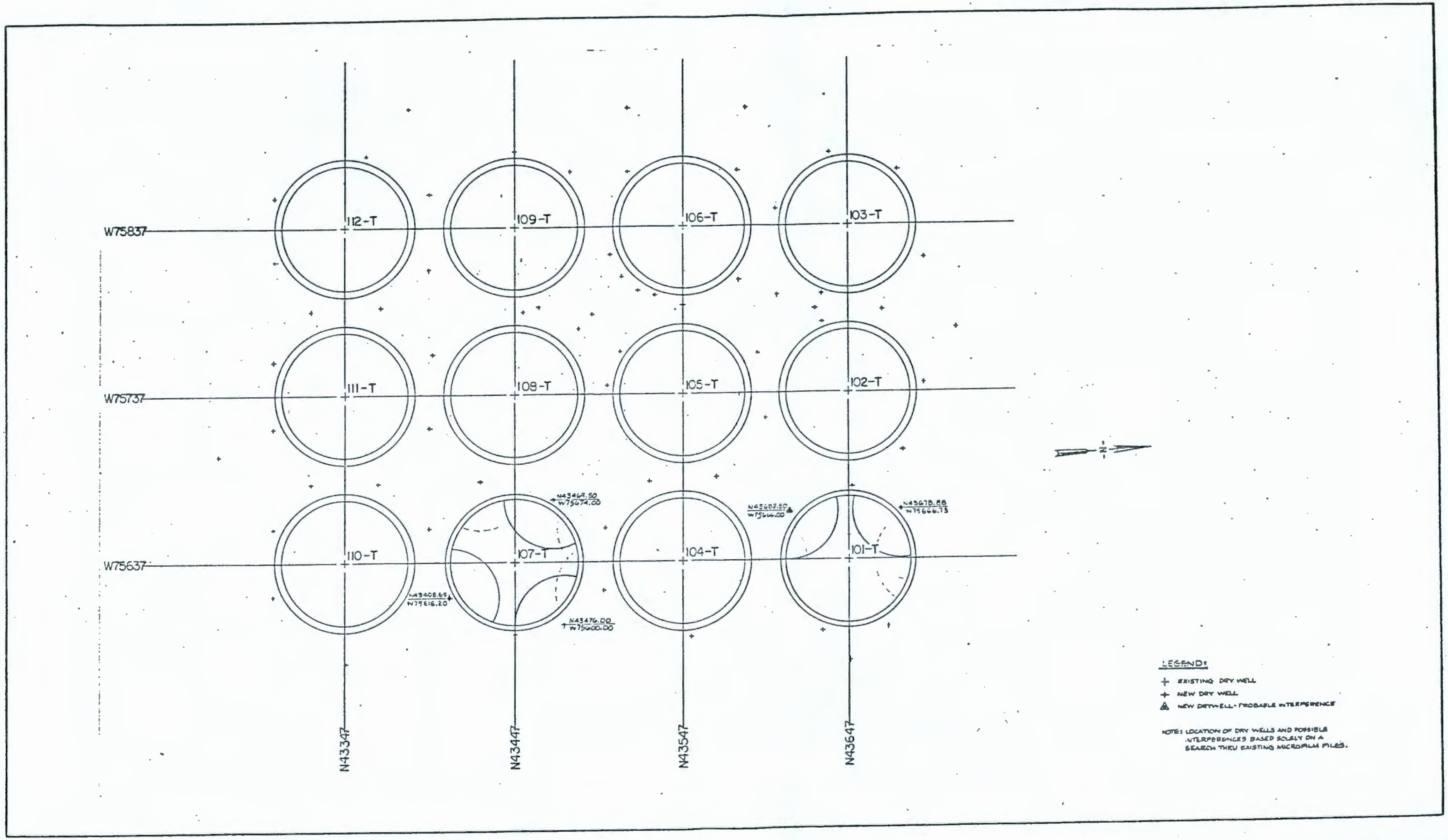


FIGURE H-19. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-T.

H-45/H-46 blank

9212499189 6

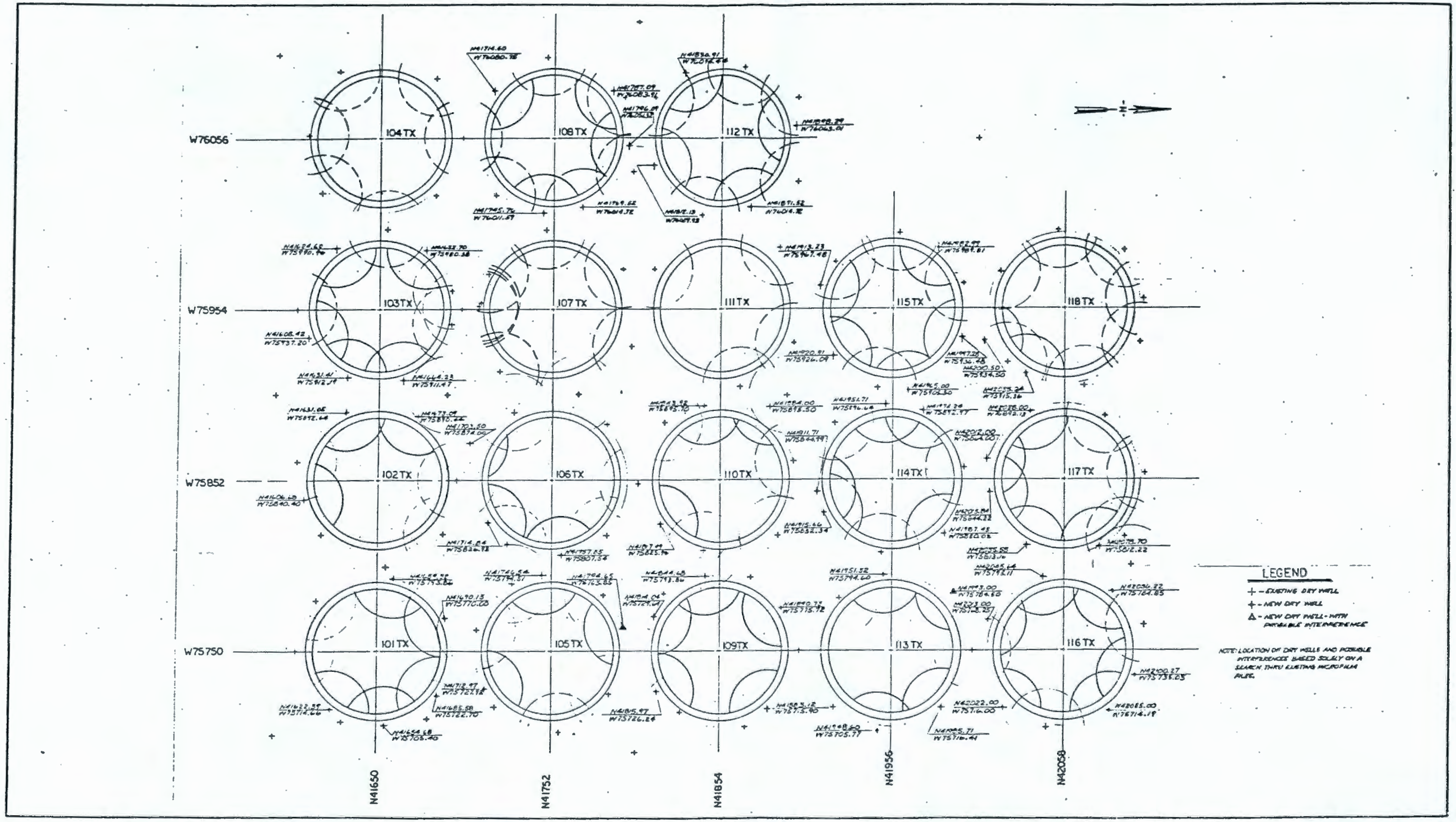


FIGURE H-20. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 10,000 Gal in Tank Farm 241-TX.

9212491.897

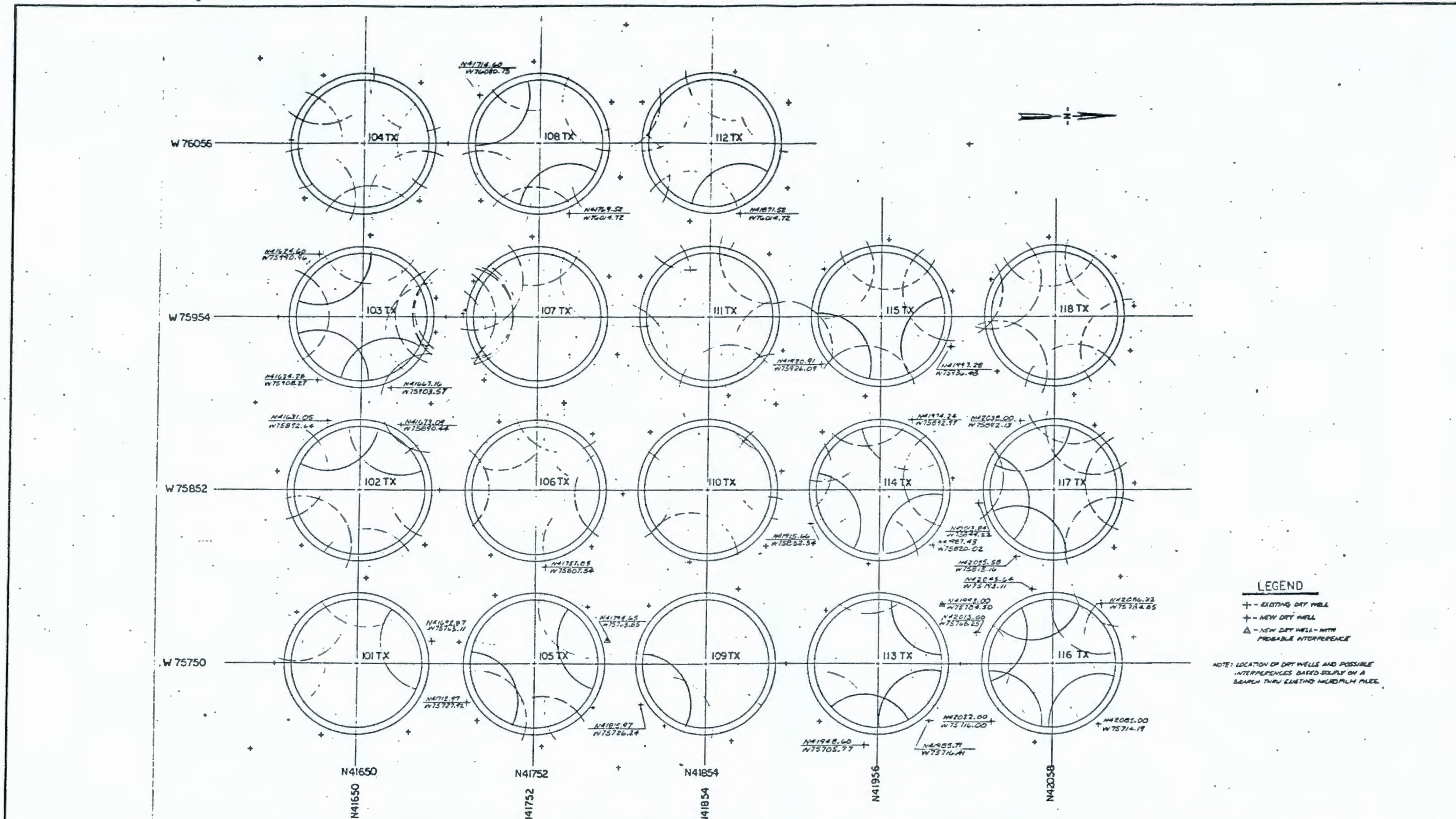


FIGURE H-21. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-TX.

92124991893

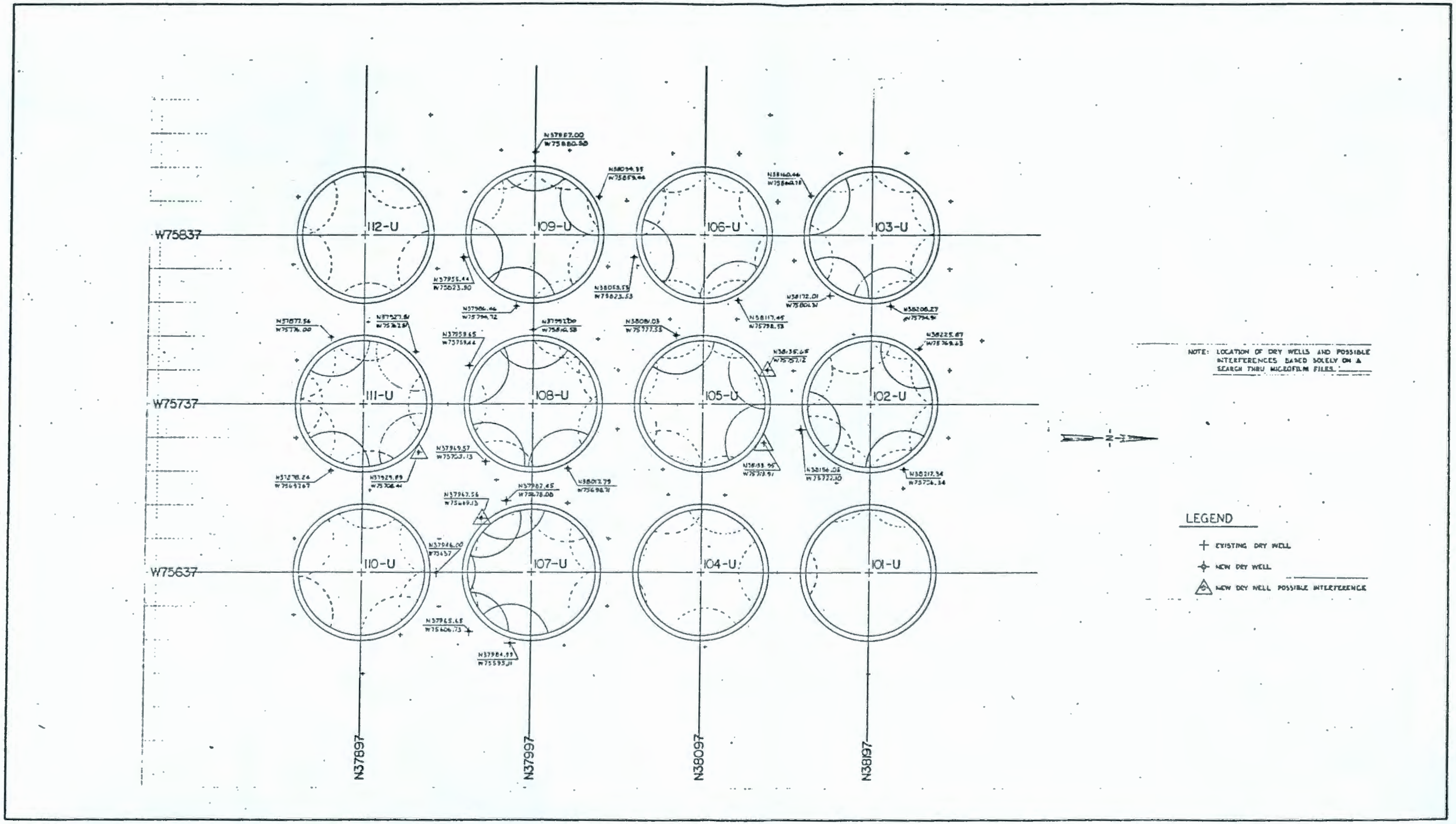


FIGURE H-22. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 10,000 Gal in Tank Farm 241-U.

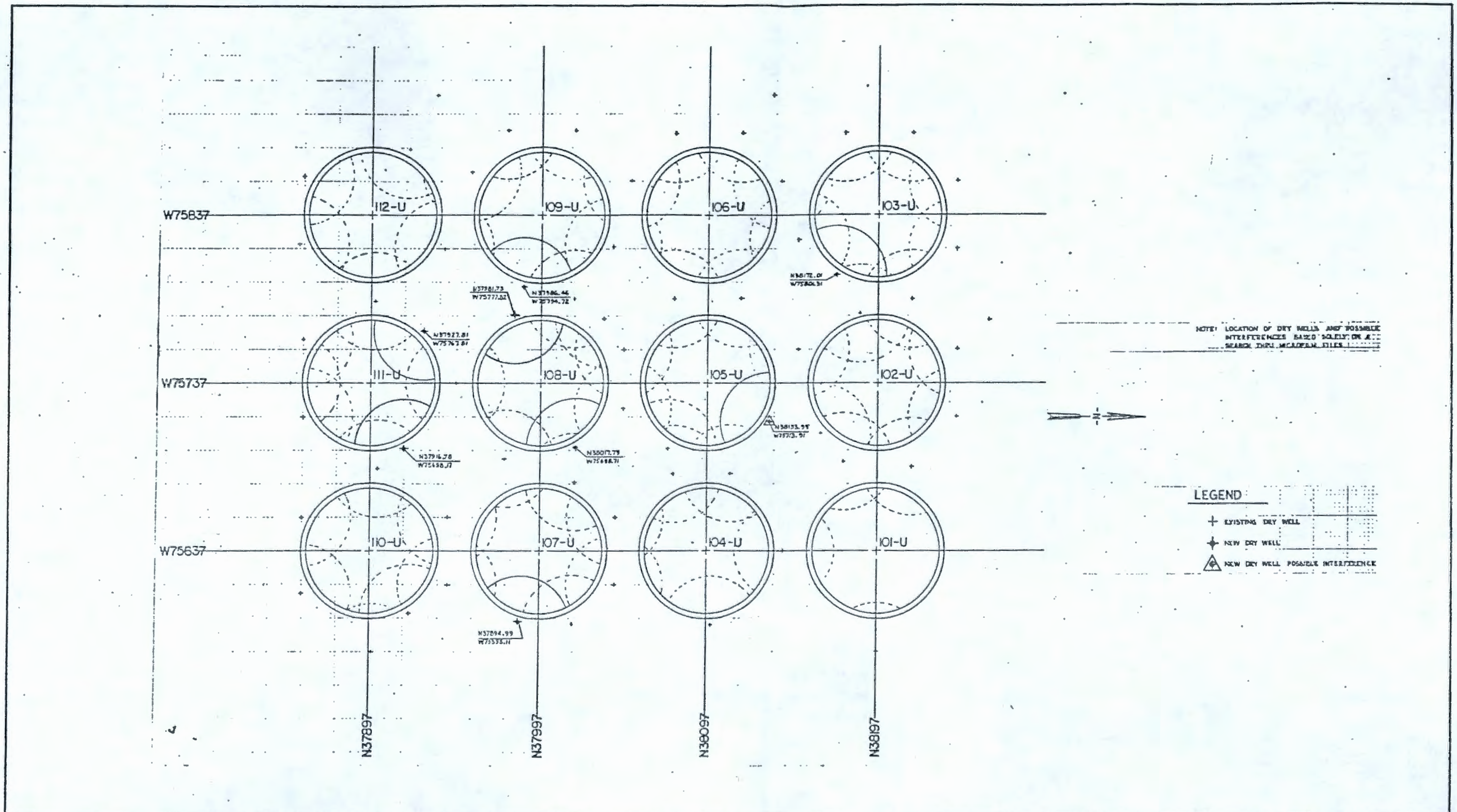


FIGURE H-23. Locations for New Radiation Monitoring Dry Wells Needed to Assure that the Maximum Hypothetical Tank Leak Volume Will Not Exceed 20,000 Gal in Tank Farm 241-U.

APPENDIX I

INSTRUMENTATION SYSTEMS

F. S. Stong

OVERVIEW

Dry well surveillance systems used for waste storage tank external leak detection utilize interchangeable detection probes to profile or scan the vertical dry wells surrounding waste tanks or to scan the horizontal laterals positioned below tanks in the 241-A and 241-SX Tank Farms. The type of probe used is coordinated with the status of the dry well. In general, the most sensitive probe suitable for the purpose is used.

The primary means of determing the presence of a leaking tank by this method is the detection of the presence of gamma radiation in the surrounding media that is different from the established baseline (background) reference for a specific vertical dry well or horizontal lateral. Secondary surveillance tools useful in enhancing data analysis include plotting soil moisture content as a function of depth (soil moisture profiling), gamma directional assessment, and gamma energy analysis.

VERTICAL WELL SURVEILLANCE

Equipment Description and Operation

Six dry well surveillance automotive van systems are currently used to monitor or profile vertical dry wells. Three vans are assigned to 200 East Area tank farms and three vans are assigned to 200 West Area tank farms. The dry well vans utilize the same radiation monitoring equipment and probe types and are, therefore, functionally interchangeable.

The dry well van system is comprised of a modified automobile van with the following equipment:

1. Electrical equipment power is 115 V, 60 Hz, single phase supplied by either of two independent generating systems of 3 and 4 kW capacity. The power to the electronics equipment has under and over voltage cut-outs for system protection. Additionally, continuous voltage and frequency readouts are provided for each power system.

2. The draw works and boom provide the mechanism to payout and retrieve the cable, which electronically connects the detection probe to the on-board electronics equipment.

   The draw works is a modified commercial assembly with a 120 VDC, 1/4 HP electric motor and motor speed control unit. The operator can control the payout speed to a maximum of ∿6 ft/sec. The retrieving scan speed is fixed at a rate not to exceed 0.75 ft/sec and is not operator controlled.

   The cable used is a double-armored, single-conductor type with a tensile rating of 2,000 lb. It is 1/8 in. in diameter and ∿1,000 ft long. The cable is terminated at the detector end by a cable head. The cable head provides a quick-disconnect coupling to the detection probe. The other end of the cable terminates in a special low-noise redundant slip ring assembly mounted on the draw works. The slip ring is used to transfer the electrical signals from the rotating cable reel drum to the nonmoving parts.

   The booms are used to direct the cable from the draw works within the van to a position directly above the vertical well to be monitored. In case the vertical well is not accessible in this manner, the booms are used to direct the cable to a secondary device positioned at the well entrance. This secondary device then directs the cable down the well.

3. The van electronics system consists of commercially available equipment except for the Hanford designed interchangeable probes and matching amplifier/discriminator. The following commercial equipment is used:

   NIMBIN* enclosure and power supply
   Interval timer
   Count scaler
   6 digit data input units (2)
   Count rate meter
   Paper tape punch interface unit
   Paper tape punch
   Strip chart recorder.

   To obtain a well scan, the van is positioned adjacent to a well and the probe rapidly lowered to the bottom by means of the draw works. A turns-counting dial indicates the detector probe depth as it descends. On reaching the bottom, the operator enters the date, well number, probe type, and van number by means of thumb-wheel switches. The information is encoded on paper tape by means of a pushbutton. The well data scan is obtained automatically on probe withdrawal. This is done at fixed reel speed by the draw works speed controller. The count data and time of traverse for each scanned foot are output automatically by the counting system electronics for encoding on paper tape. Simultaneously, the output of a count rate meter is graphically recorded on the strip chart recorder. After field data have been acquired, the strip charts and paper punched tape are submitted for analysis. The latter is computer processed to yield a graph of the radiation profile of the well (Figure I-1) and to prepare pertinent reports.

PROBE DESCRIPTION, SENSITIVITY, AND RESPONSE

General

There are five types of interchangeable probes that can be used by the dry well van instrument system. Each will be discussed in turn providing operational characteristics and some functional design detail.

*Trademark of ORTEC Inc., Specification TID-20893.

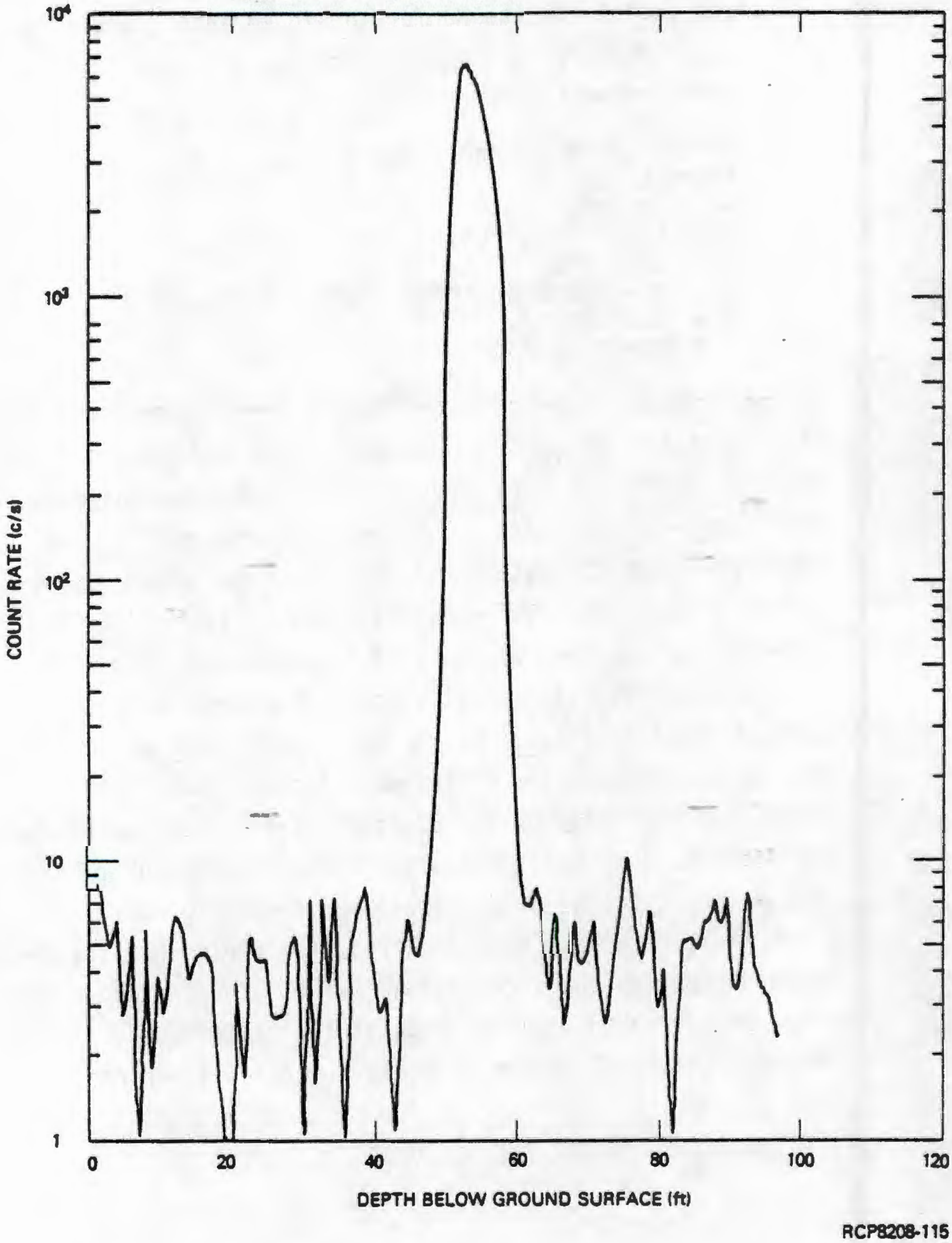


FIGURE I-1. Typical Radiation Count Rate Profile Showing Radiation Intensity Peak.

With three exceptions (which will be covered), the physical construction of the probe housing is the same for all probes. It is fabricated of stainless steel. The housing is 14 in. (35.6 cm) in length overall and 3.5 in. (8.9 cm) in diameter. The cable head is screwed to a threaded receptacle for the single-conductor armored cable. The detector is located in the opposite end of the assembly. Approximately 3.75 in. (9.5 cm) of this end is necked down to a diameter of 2 in. (5.8 cm) to accommodate a removable 0.5 in. (1.3 cm) lead shield. The shield can be used to extend the effective probe range in a gamma radiation field. If modified with a suitable hole, the shield can be used to provide gamma directional data when the probe is systematically rotated.

The electronics used in all probes are similar, with variations being made to accommodate the different detector requirements. There are two main printed circuit assemblies to provide detector high voltage and signal conditioning. These assemblies are 3 in. (7.6 cm) in diameter and are mounted on supports located within the housing at the connector end.

The housing assembly and cable head are provided with O-ring seals and packing to prevent water entry from severe condensation encountered in the dry wells.

The following probe descriptions use references to gamma radiation intensities in roentgens per hour (R/hr) in describing sensitivity and response. These references are intended in the practical sense and generally with respect to the sources used in calibration (Figure I-2).

Gross Count Scintillation Probe (Type Code 4)

This probe assembly (Figure I-3) is the most frequently used in vertical dry well surveillance for early leak detection. The scintillation detector is a 1-in.-diameter (2.54-cm) by 1-in.-long (2.54-cm) sodium iodide, thallium activated (NaI(Tl)) crystal of Polyscin* construction that is optically coupled to an RCA 2060 photomultiplier tube

*Tradename of the Harshaw Chemical Company.

9 2 1 2 4 9 9 1 9 0 5

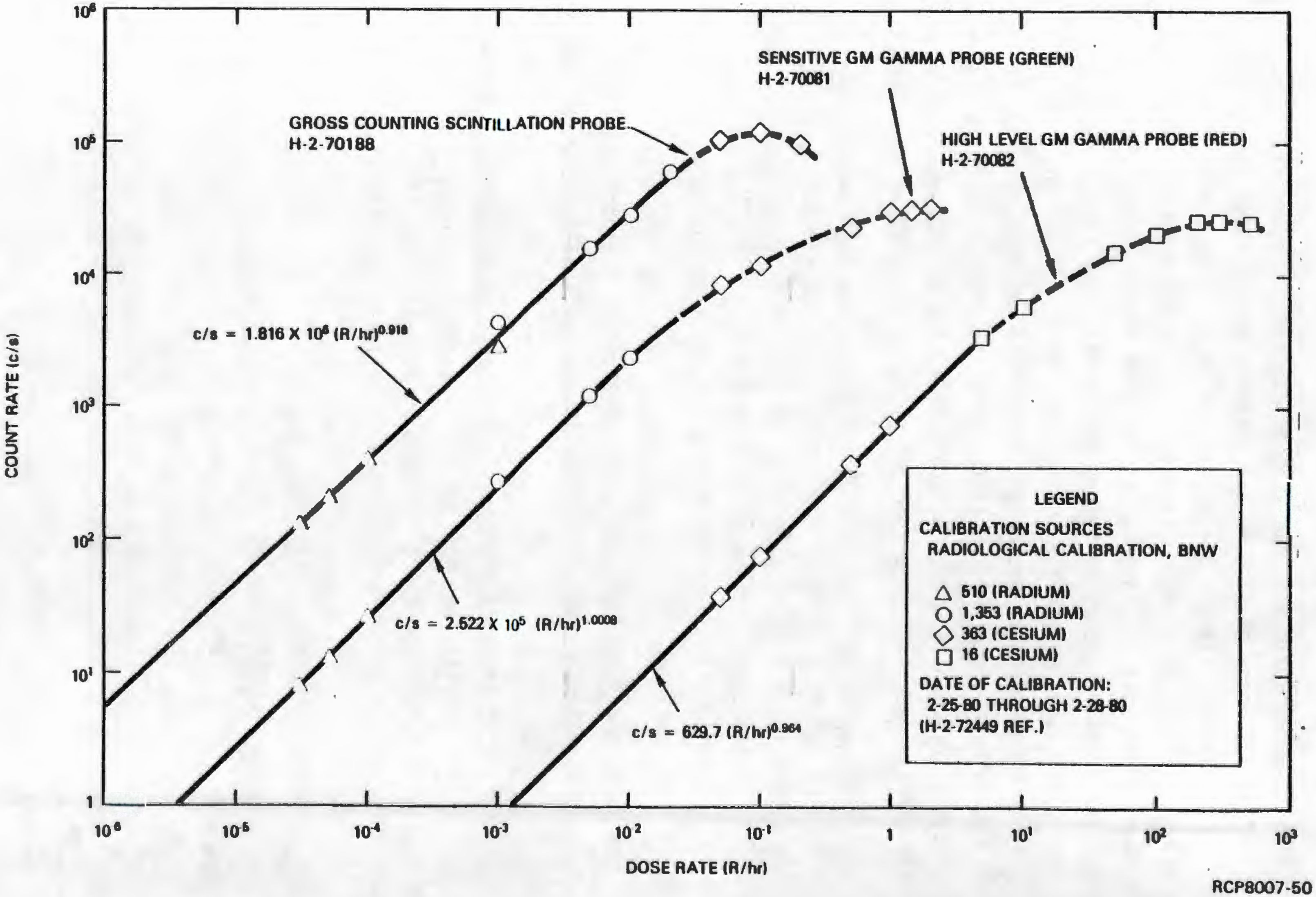
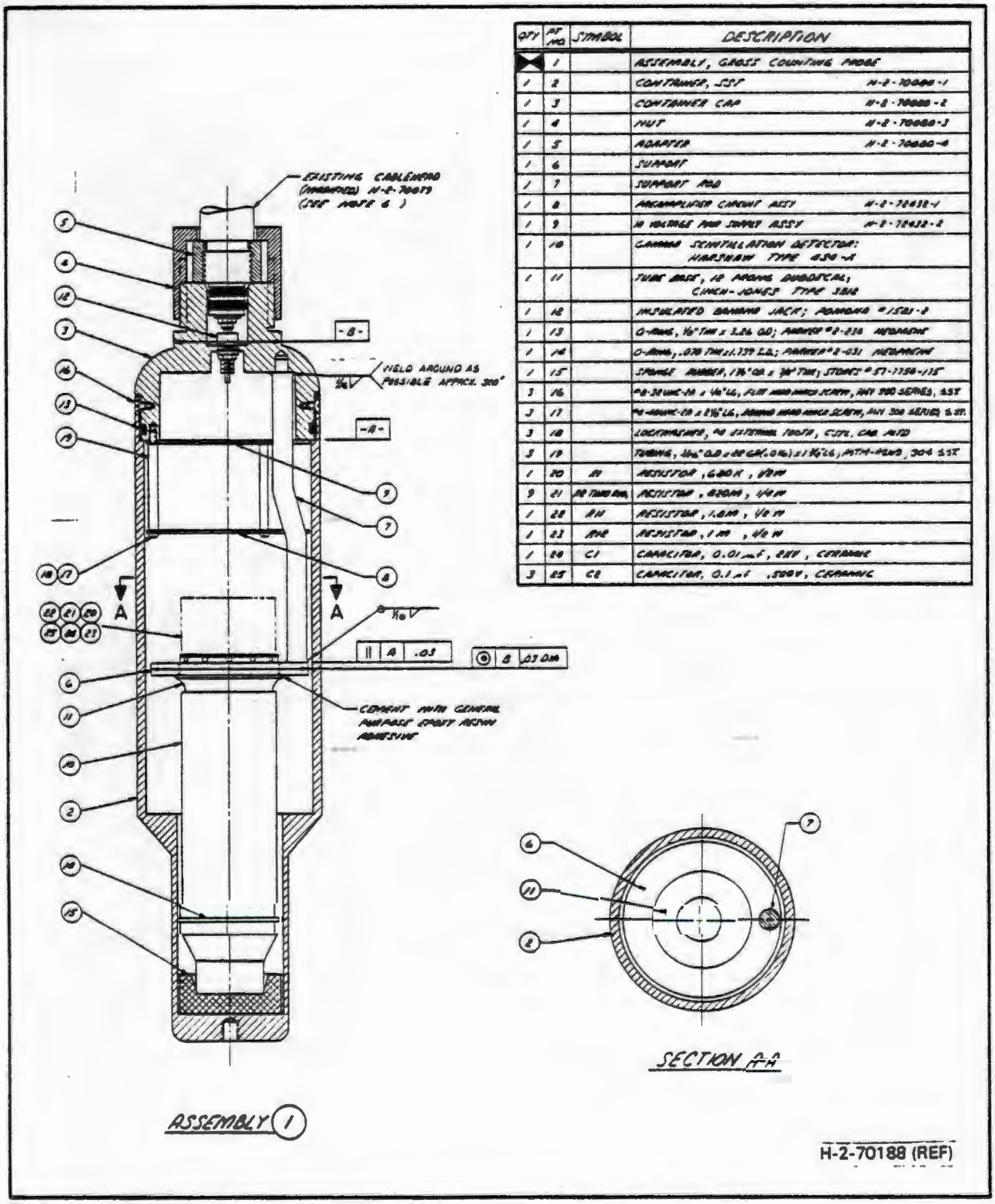


FIGURE I-2. Calibration Curves for Gamma-Ray Detectors Used for Radiation Monitoring in Dry Wells.

9 2 1 2 4 9 9 1 9 0 6



QTY	PT NO	SYMBOL	DESCRIPTION
	1		ASSEMBLY, GROSS COUNTING PROBE
1	2		CONTAINER, SST H-2-70080-1
1	3		CONTAINER CAP H-2-70080-2
1	4		NUT H-2-70080-3
1	5		ADAPTER H-2-70080-4
1	6		SUPPORT
1	7		SUPPORT ROD
1	8		PREAMPLIFIER CIRCUIT ASSY H-2-72432-1
1	9		HI VOLTAGE PWR SUPPLY ASSY H-2-72432-2
1	10		GAMMA SCINTILLATION DETECTOR: HARSHAW TYPE 4S4-A
1	11		TUBE BASE, 12 PRONG DUODECAL, CINCH-JONES TYPE 3B12
1	12		INSULATED BANANA JACK; POMONA #1581-2
1	13		O-RING, 1/8" THK x 3.26 OD; PARKER #2-234 NEOPRENE
1	14		O-RING, .070 THK x 1.739 I.D.; PARKER #2-031 NEOPRENE
1	15		SPONGE RUBBER, 1¾" OR x ¾" THK; STORES # 57-7750-115
3	16		#8-32UNC-2A x 1/2" LG, FLAT HEAD MACH SCREW, ANY 300 SERIES, SST
3	17		#8-40UNC-2A x 2½" LG, ROUND HEAD MACH SCREW, ANY 300 SERIES S.ST.
3	18		LOCKWASHER, #8 EXTERNAL TOOTH, CSTL, CAD PLTD
3	19		TUBING, 1/16" O.D x 22 GA(.016) x 1 5/8 LG; ASTM-A269, 304 SST
1	20	R1	RESISTOR, 680K, 1/2W
9	21	R2 THRU R10	RESISTOR, 820K, 1/2W
1	22	R11	RESISTOR, 1.8M, 1/2W
1	23	R12	RESISTOR, 1M, 1/2W
1	24	C1	CAPACITOR, 0.01 µF, 2KV, CERAMIC
3	25	C2	CAPACITOR, 0.1 µF, 500V, CERAMIC

FIGURE I-3. Gross Counting Scintillation Probe Assembly.

in an integral, magnetically shielded assembly. Although the phototube is an inexpensive general purpose type, this detector has demonstrated superior field performance at less cost than multi-alkali and ruggedized types.

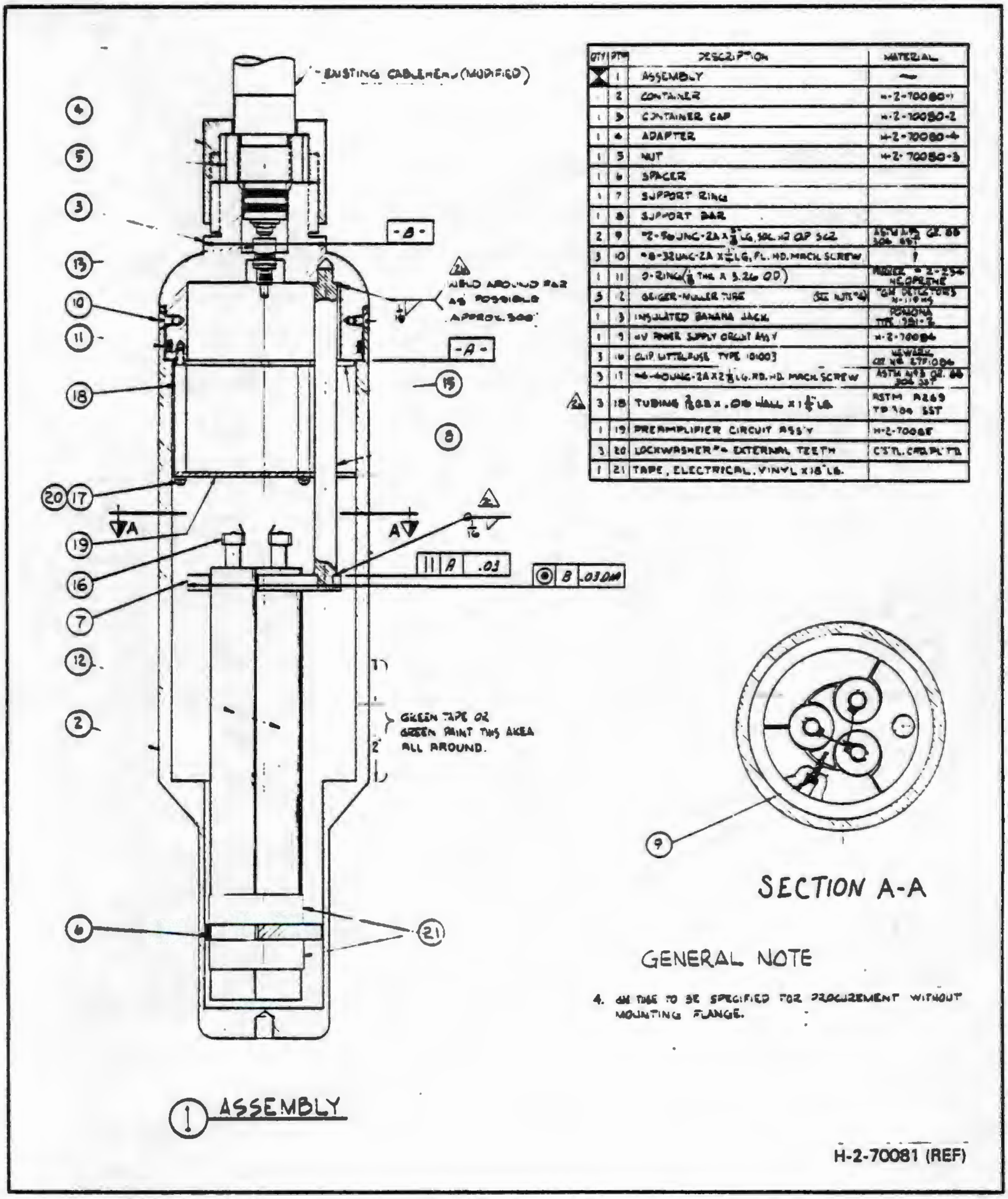
The probe preamplifier design incorporates circuitry to cause all output gamma pulses to be of the same amplitude, regardless of incident gamma energy. This is somewhat analogous to the operation of a Geiger-Müller (GM) detector. Since all pulses are larger than the threshold (discriminator) setting, a higher counting rate of low energy or degraded gamma results. Further, drift from temperature effects on the photomultiplier tube and electronics circuitry is effectively reduced. The result is a detector assembly of increased sensitivity to the degraded gammas experienced in the well environment and one that is highly stable and insensitive to electronic system drifts or adjustment.

At a scanning rate of 0.75 ft/sec, this probe will provide a gamma response of $\sim$42 counts in a nominal background of 7 x 10^6 R/hr when integrated over the normal scan interval of 1 ft (Figure I-2). The probe has a useful range of four decades above this background. The range may be extended by a factor of $\sim$3.5 by installing the optional shield assembly. The probe count rate is designed to peak at 10^5 counts per second (c/s) (at a radiation level of $\sim$100 milliroentgen per hour (mR/hr) unshielded). Thereafter, it decreases with increasing gamma dose rate limiting the photomultiplier tube anode current to an acceptable maximum.

High Sensitivity Geiger-Müller Probe (GMP) (Type Code 1 - Green GM)

This probe assembly (Figure I-4) is designed to provide high sensitivity coupled with long-term stability in the presence of moderate gamma fields. It is very useful in monitoring dry wells which have leak interceptions with radiation levels in some places exceeding the operating range of the gross counting scintillation probe. The probe will not be damaged by excessive radiation encountered in this way.

Three halogen-quenched GM tubes are operated in parallel in this probe. The tubes are 0.75 in. (1.9 cm) in diameter and have an active length of 5.5 in. (14.0 cm). The probe operates quite linearly at low count rates and has a significant count threshold in the normal scan



QTY	ITEM	DESCRIPTION	MATERIAL
X	1	ASSEMBLY	—
1	2	CONTAINER	H-2-70080-1
1	3	CONTAINER CAP	H-2-70080-2
1	4	ADAPTER	H-2-70080-4
1	5	NUT	H-2-70080-3
1	6	SPACER	
1	7	SUPPORT RING	
1	8	SUPPORT BAR	
2	9	#2-56UNC-2A X 3/8 LG. SOC. HD CAP SCR	ASTM A193 GR. B8 304 SST
3	10	#8-32UNC-2A X 1/2 LG. FL. HD. MACH. SCREW	↓
1	11	O-RING (1/8 THK X 3.26 OD)	PARKER # 2-234 NEOPRENE
3	12	GEIGER-MULLER TUBE (SEE NOTE 4)	GM DETECTORS N-119HG
1	13	INSULATED BANANA JACK	POMONA TYPE 1391-2
1	14	HV POWER SUPPLY CIRCUIT ASS'Y	H-2-70084
3	16	CLIP LITTELFUSE TYPE 101003	NEWARK CAT NO. 27F1004
3	17	#6-40UNC-2A X 2 1/8 LG. RD. HD. MACH. SCREW	ASTM A193 GR. B8 304 SST
3	18	TUBING 3/8 OD X .010 WALL X 1 1/8 LG.	ASTM A269 TP 304 SST
1	19	PREAMPLIFIER CIRCUIT ASS'Y	H-2-70085
3	20	LOCKWASHER #4 EXTERNAL TEETH	C STL. CAD. PLTD
1	21	TAPE, ELECTRICAL, VINYL X 18" LG.	

FIGURE I-4. High Sensitivity GMP.

9 2 1 2 4 9 9 1 9 0 8

mode (0.75 ft/sec and 1-ft interval) at ~5 x 10^5 R/hr. If necessary, low-level data can be enhanced by processing to improve this threshold. Though increasingly nonlinear above ~5 x 10^{-2} R/hr, the probe is still functional at radiation intensities >2 R/hr (Figure I-2, Calibration Curve 2).

High-Level GMP (Type Code 2 - Red GM)

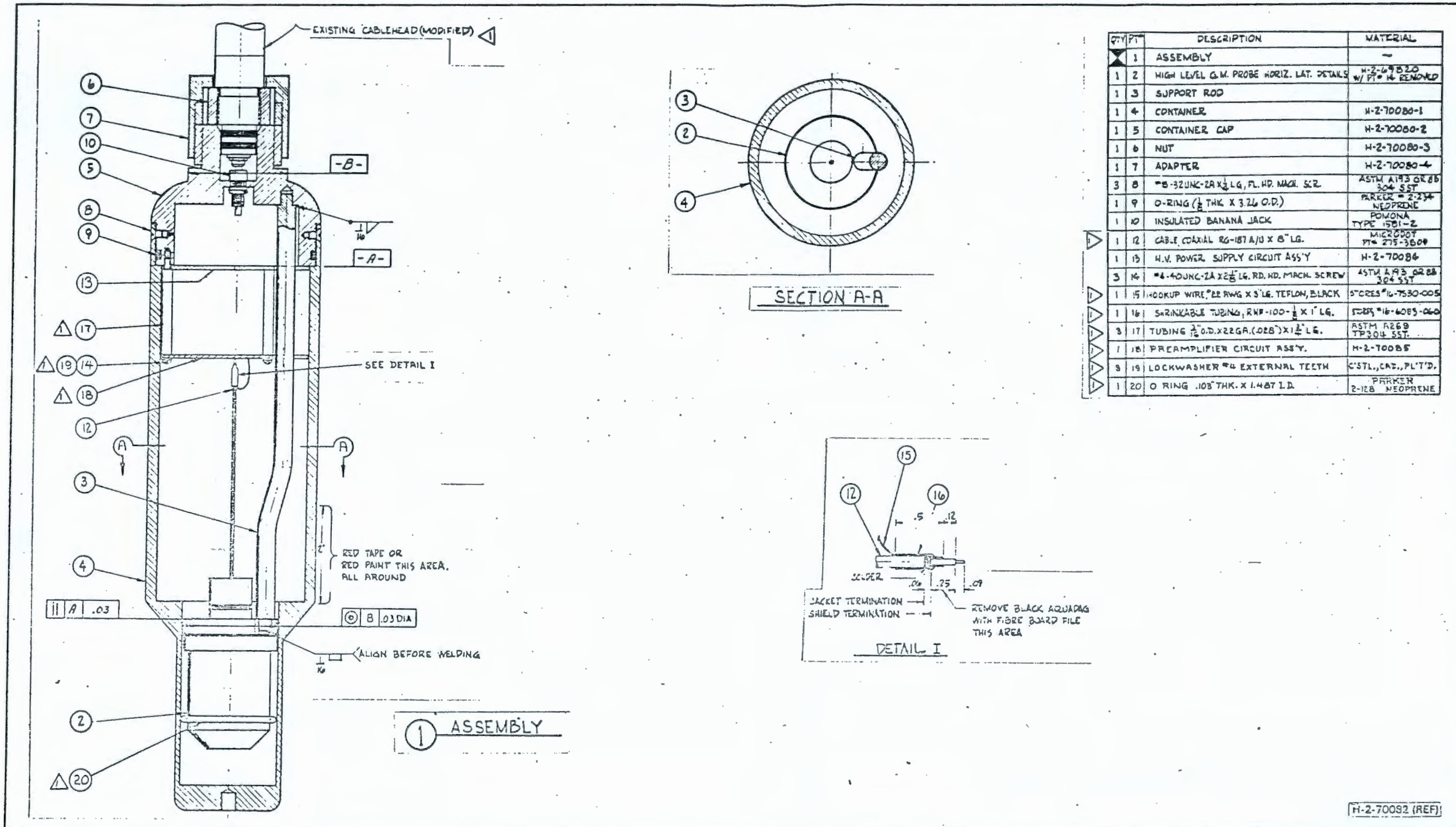
The detector for this probe (Figure I-5) is a small halogen-quenched GM tube inserted in a gamma shield consisting of lead with an aluminum core. The GM tube's active zone is 0.28 in. (0.71 cm) in diameter by 0.25 in. (0.64 cm) in length.

This probe assembly is intended to be operated in dry wells that have been intercepted by major parts of a leak plume. It is designed to operate with good linearity from 10 mR/hr to 10 R/hr. However, the probe provides an acceptable and useful response to 200 R/hr and is still operational at 500 R/hr (Figure I-2, Calibration Curve 3).

Soil Moisture or Neutron Probe (Type Code 3)

The housing for the soil moisture monitor (Figure I-6) is fabricated of stainless steel and generally is similar to the other housings except that the necked-down portion is considerably longer. The housing is 20.5 in. (52.1 cm) in length and 3.5 in. (8.9 cm) in diameter. Approximately 10 in. (25.4 cm) of the detector end is reduced to a diameter of 2 in. (5.1 cm) to accommodate a 0.63-in.-thick (1.6-cm) lead shield. The end of the probe is threaded to accept a 1.5 Ci ^{241}Am/Be neutron source. This source is contained in a double sealed, approved pellet which, in turn, is placed in a stainless steel holder 3.3 in. (8.4 cm) long by 1 in. (2.5 cm) in diameter. When the source holder is screwed to the probe, the assembly length is then 23 in. (58.4 cm) long.

The detector used in the soil moisture monitor is a boron-trifluoride (BF_3) type with an active length of 8.1 in. (20.6 cm) and a diameter of 1.5 in. (3.8 cm). The fill pressure is 25-cm Hg and the tube contains carbon to reduce gamma-induced neutron pulse degradation. The specific neutron sensitivity is ~5 c/s in a uniform neutron flux of 1 neutron/cm^2/sec.



QTY	PT	DESCRIPTION	MATERIAL
	1	ASSEMBLY	—
1	2	HIGH LEVEL G.M. PROBE HORIZ. LAT. DETAILS	H-2-69820 W/ PT# 14 REMOVED
1	3	SUPPORT ROD	
1	4	CONTAINER	H-2-70080-1
1	5	CONTAINER CAP	H-2-70080-2
1	6	NUT	H-2-70080-3
1	7	ADAPTER	H-2-70080-4
3	8	#8-32UNC-2A X $\frac{1}{2}$ LG, FL. HD. MACH. SCR.	ASTM A193 GR B8 304 SST
1	9	O-RING ($\frac{1}{8}$ THK X 3.26 O.D.)	PARKER # 2-234 NEOPRENE
1	10	INSULATED BANANA JACK	POMONA TYPE 1581-2
1	12	CABLE, COAXIAL RG-187 A/U X 8" LG.	MICRODOT PT# 275-3809
1	13	H.V. POWER SUPPLY CIRCUIT ASS'Y	H-2-70084
3	14	#4-40UNC-2A X 2$\frac{1}{8}$" LG. RD. HD. MACH. SCREW	ASTM A193 GR B8 304 SST
1	15	HOOKUP WIRE, #22 AWG X 3" LG. TEFLON, BLACK	STORES #16-7530-005
1	16	SHRINKABLE TUBING, RNF-100-$\frac{1}{8}$ X 1" LG.	STORES #16-6085-060
3	17	TUBING $\frac{3}{16}$" O.D. X 22GA. (.028") X 1$\frac{3}{4}$" LG.	ASTM A269 TP304 SST.
1	18	PREAMPLIFIER CIRCUIT ASS'Y.	H-2-70085
3	19	LOCKWASHER #4 EXTERNAL TEETH	C'STL., CAD., PL'T'D.
1	20	O RING .103" THK. X 1.487 I.D.	PARKER 2-128 NEOPRENE

FIGURE I-5. High-Level GMP.

9212499191.0

THIS PAGE INTENTIONALLY
LEFT BLANK

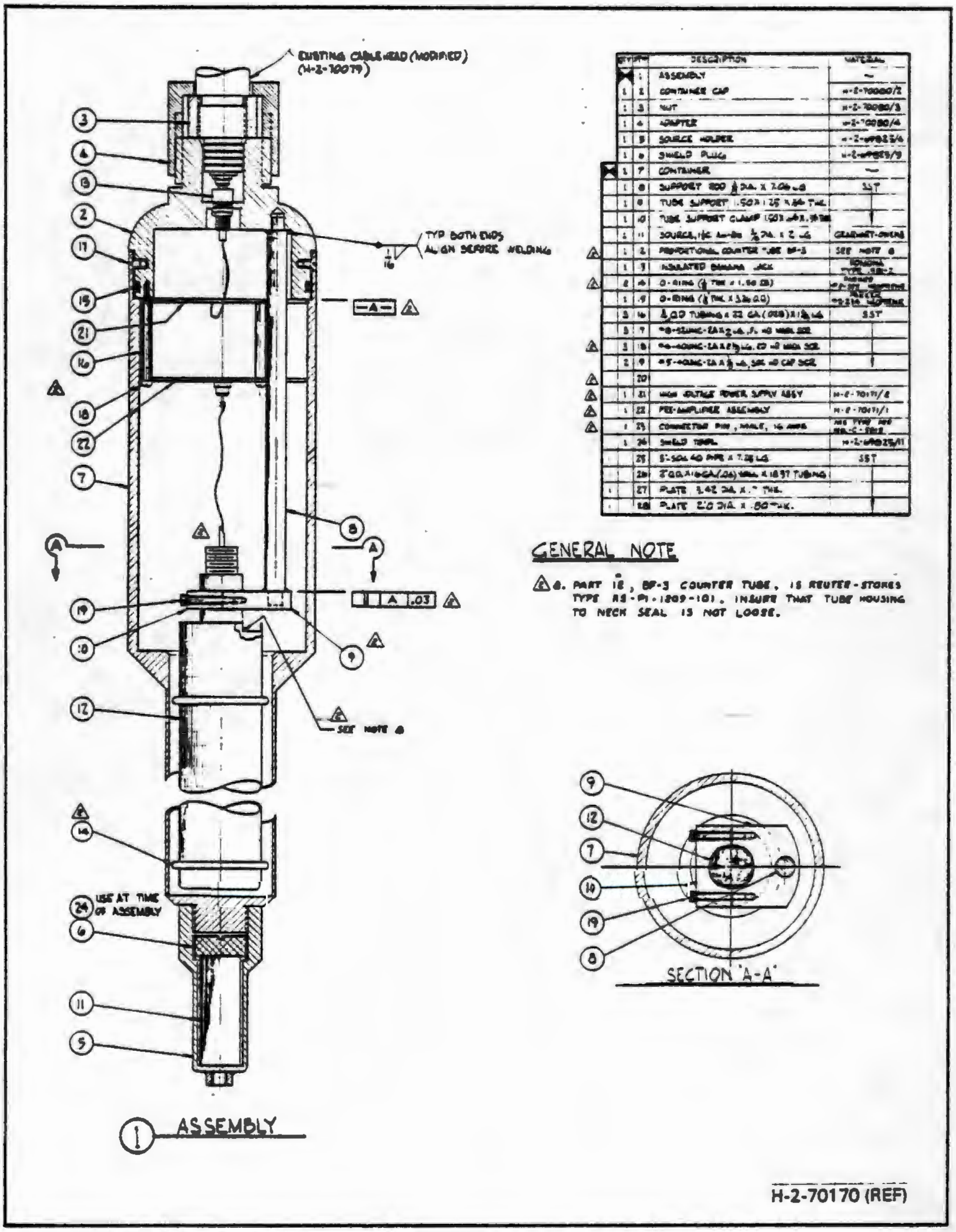


FIGURE I-6. Soil Moisture (Neutron) Probe.

The detector and preamplifier are designed to provide a good pulse height resolution in order to operate in high gamma fields. Thus, the probe can be operated with zero gamma interference counts in gamma radiation fields of up to 30 R/hr unshielded and 300 R/hr shielded.

A BF_3 detector is sensitive only to fully moderated or thermal neutrons and is insensitive to fast and epithermal neutrons. Moisture or water contains hydrogen which is efficient in moderating the fast neutrons emitted by the neutron source. Therefore, in the absence of other moderators, the observed count rate from this probe is a direct function of the moisture present in the surrounding media. The calibration curve and an example of a soil moisture profile are provided in Figures I-7 and I-8, respectively.

<u>Gamma Energy Analysis Scintillation Probe (Figure I-9)</u>

Two probes of different sensitivity are available for dry well gamma energy analysis. These probes differ only in detector size and probe housing configuration. They may be used with their portable auxiliary equipment on any of the six dry well vans.

The extra portable equipment used is commercially available and is as follows:

- Portable NIMBIN*
- Linear pulse stabilizer
- Single-channel analyzer
- Auto-ranging count rate meter
- 1,024 channel multi-channel analyzer.

The scintillation detectors contain a ^{241}Am pulser source that has a gamma equivalent peak of ∿1.8 megaelectron volts (MeV). This peak is detected and locked onto by the linear pulse stabilizer which controls the system gain at a constant value to compensate for drifting. The system normally is calibrated with ^{137}Cs (0.662 MeV) in Channel 400. This provides a gamma energy range of 0.03 MeV to 1.69 MeV for analysis without field recalibration.

*Trademark of ORTEC, Inc.

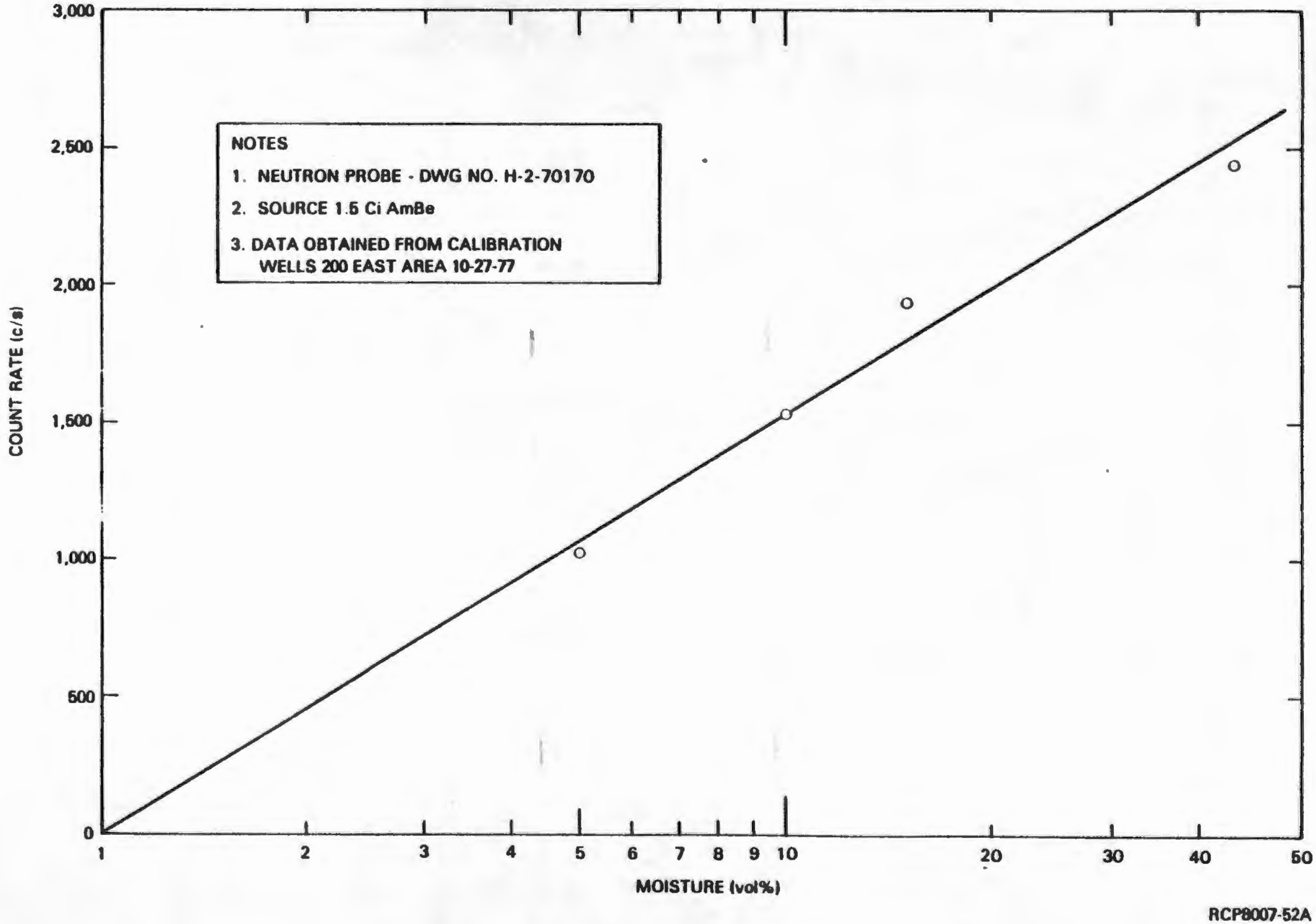


FIGURE I-7. Soil Moisture Calibration Curve.

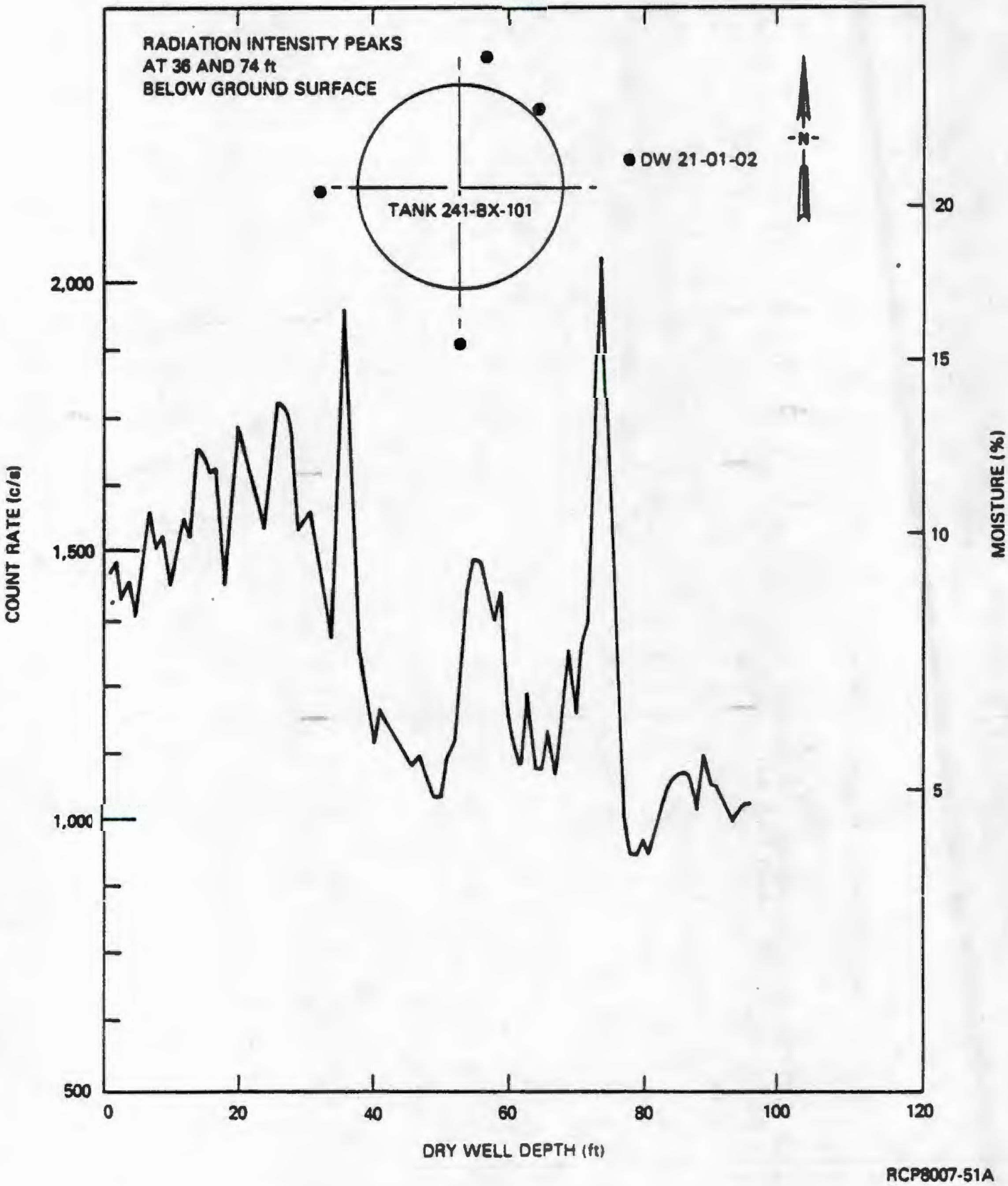
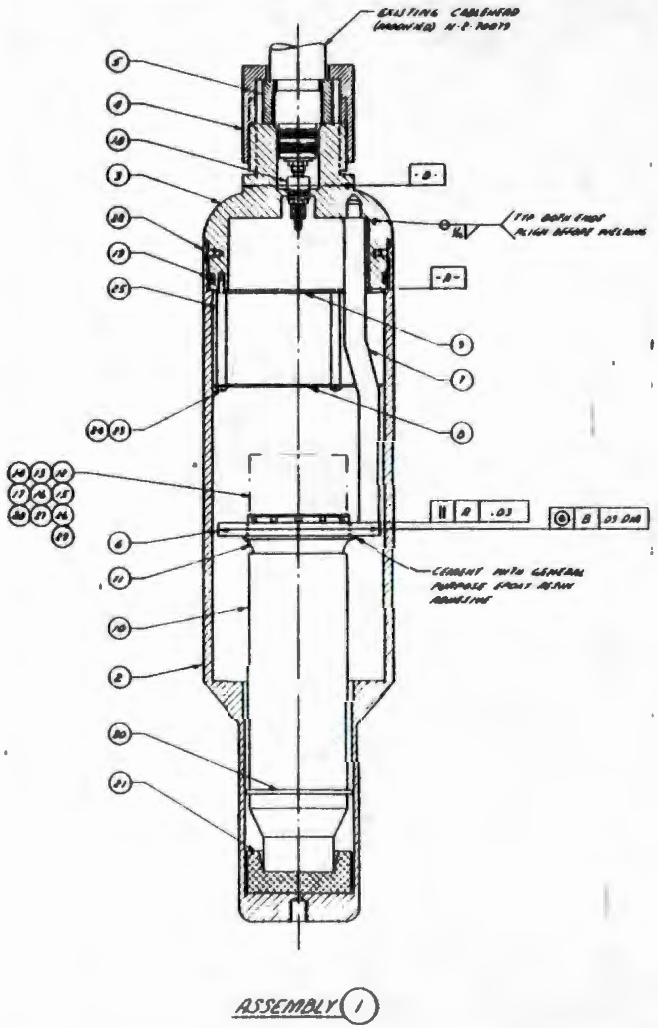


FIGURE I-8. Soil Moisture Profile.

9 2 1 2 4 9 9 1 9 1 4



QTY	IT NO	SYMBOL	DESCRIPTION
X	1		ASSEMBLY, GAMMA SPECTROMETRY PROBE
1	2		CONTAINER, ALUMINUM H-2-70080-1
1	3		CONTAINER CAP H-2-70080-2
1	4		NUT H-2-70080-3
1	5		ADAPTER H-2-70080-4
1	6		SUPPORT
1	7		SUPPORT ROD
1	8		PREAMPLIFIER CIRCUIT ASSY H-2-72481-1
1	9		HI VOLTAGE PWR SUPPLY ASSY H-2-72481-2
1	10		GAMMA SCINTILLATION DETECTOR; HARSHAW TYPE [illegible]
1	11		TUBE BASE, 12 PRONG DUODECAL; CINCH-JONES TYPE 3B12
1	12	C1	CAPACITOR, 0.01 μF, 2KV, CERAMIC
1	13	C2	CAPACITOR, 0.005 μF, 1KV, CERAMIC
1	14	C3	CAPACITOR, 0.001 μF, 1KV, CERAMIC
1	15	C4	CAPACITOR, 300 PF, 1KV, CERAMIC
1	16	C5	CAPACITOR, 0.0047 μF, 2KV, CERAMIC
1	17	C6	CAPACITOR, 100 PF, 100V, DIPPED SILVER MICA
1	18		INSULATED BANANA JACK; POMONA # 1581-2
1	19		O RING, 1/16" THK x 3.26 O.D.; PARKER #2-[illegible] NEOPRENE
1	20		O RING, [illegible] x 1.739 I.D.; PARKER #2-[illegible] NEOPRENE
1	21		SPONGE RUBBER, [illegible] O.D. x [illegible]; [illegible]
3	22		#8 [illegible] x [illegible], FLAT HEAD MACH SCREW, 300 SST
3	23		#4 [illegible] x [illegible], ROUND HEAD MACH SCREW, 300 SST
3	24		LOCKWASHER, #4, EXTERNAL TOOTH, [illegible]
1	25		TUBING, [illegible] O.D. x [illegible] x [illegible], 300 SST
1	26	R1	RESISTOR, 390K, 1/2 W
9	27	R2 [illegible]	RESISTOR, 510K, 1/2 W
2	28	R1, R12	RESISTOR, 1M, 1/2 W
1	29	R13	RESISTOR, 47K, 1/2 W

H-2-72438 (REF)

FIGURE I-9. Gamma Energy Analysis Scintillation Probe.

Precise downhole gamma peak acquisition is provided by the differentially operated single-channel analyzer and auto-ranging count rate meter. The latter is calibrated in counts per minute (c/min).

Both detectors use NaI(Tl) scintillators of Polyscin construction, optically coupled to an integrally contained and magnetically shielded photomultiplier tube. Either detector will yield a ^{137}Cs resolution exceeding 8.0% full-width-half maximum in the field environment.

The less sensitive probe is contained in a housing of standard dimensions and construction except for the detector cover which is fabricated of aluminum. The 1.5-in. (3.8-cm) photomultiplier tube is coupled to a 1.5-in.-diameter (3.8-cm) by 1.25-in.-long (3.2-cm) scintillation crystal.

The more sensitive probe is contained in a housing with a stainless steel base and aluminum detector cover. The overall diameter is 4 in. (10.2 cm) and the length is 16 in. (40.6 cm). The detector end is necked-down for ~9.5 in. (24.1 cm) to accommodate a 0.5-in.-thick (1.3-cm) lead shield.

The 2.0-in.-diameter (5.1-cm) photomultiplier tube is coupled to a 2-in.-diameter (5.1-cm) by 3-in.-long (7.6-cm) scintillation crystal.

HORIZONTAL LATERAL SURVEILLANCE

Equipment Description and Operation

This leak surveillance system utilizes three horizontal laterals located 10 ft below a waste tank, which converge to a 75-ft-deep vertical caisson positioned between waste tanks. The caisson is capped by an instrument enclosure. In this way, the bottoms of up to four waste tanks (12 laterals) can be monitored by the same equipment.

Two caissons are used to monitor the six tanks in 241-A Tank Farm and four caissons are used to monitor ten tanks in 241-SX Tank Farm.

The two caissons in 241-A Tank Farm and two of the caissons in 241-SX Tank Farm have the same electronic equipment. The equipment is similar to the dry well vans previously described. The remaining two caissons in 241-SX Tank Farm do not output data on paper punched tape. This more simplistic system is comprised of:

Detector
Count rate meter with integral amplifier/discriminator
"XY" recorder

The detector probes are inserted into the horizontal laterals from the caissons by low pressure air (1 psi). The operation is automatic and is terminated by a drop in air pressure as the probe opens bypass ports located ~3 ft from the lateral end. The laterals are 3 in. (7.6 cm) in diameter.

The cable reel, as in the dry well van, is speed controlled on pay out by the operator and on retrieval to 0.75 ft/sec.

The probe cable is a special RG187/AU coaxial cable that is 0.1 in. (0.25 cm) in diameter by 250 ft (76.2 m) long. It has a rated tensile strength of 120 lb.

Probe Description, Sensitivity, and Response

Two interchangeable basic probe types can be used by the horizontal lateral systems. Each will be covered, providing operational characteristics and some functional design detail.

The physical configuration for all probes is the same. The housing is essentially an aluminum tube 2.0 in. (5.1 cm) in diameter by 10.25 in. (26.0 cm) long with a 3-in.-diameter (7.6-cm) thin Teflon* air seal at each end. A special MHV type connector is used to attach the coaxial cable to the probe.

The probe electronics in the horizontal laterals are somewhat different than the dry well vans. The high voltage supply for the detector is located in the caisson, not in the probe. An additional difference is that a preamplifier is not used in those probes for the systems where the data are recorded on punched paper tapes (four caissons). In two caissons with older electronics, only passive impedance matching is used in those probes. The coaxial cable carries both high voltage to the detectors and the returning signal.

*Trademark of E. I. du Pont de Nemours & Co.

9 2 1 2 4 9 9 1 9 1 8

High Sensitivity GMP (Type Code 1)

There are functionally two different probes (Figures I-10 and I-11). One probe type is for the newer electronics (no preamplifier circuitry) and the second type (containing the passive network) for the older system used in two caissons.

The first probe type consists of three GM tubes identical to those used by the same type probe in the dry well van. These tubes are operated in parallel.

Except for the minor difference caused by the stainless steel housing used by the dry well van configuration, response characteristics of this probe are identical.

A smaller GM tube is used in the other probe to make room for the simple passive electronics in the probe. The GM tube is 0.75 in. (1.9 cm) in diameter and has an active length of 2.5 in. (6.4 cm). It is a standard "survey" type detector with a sensitivity of ~3,000 counts per minute per milliroentgen per hour (c/min/mR/hr).

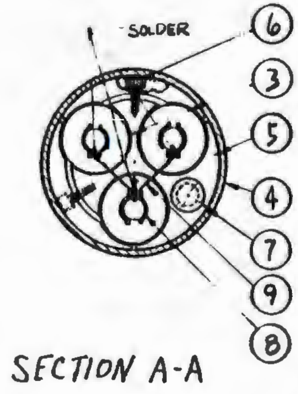
High-Level GMP (Type Code 2) (Figures I-12 and I-13)

Although the probe for the older lateral system electronics must contain the passive impedance matching network, there is sufficient space for the high-level GM detector. Therefore, either detector is functionally and responsively identical to that described for the dry well van.

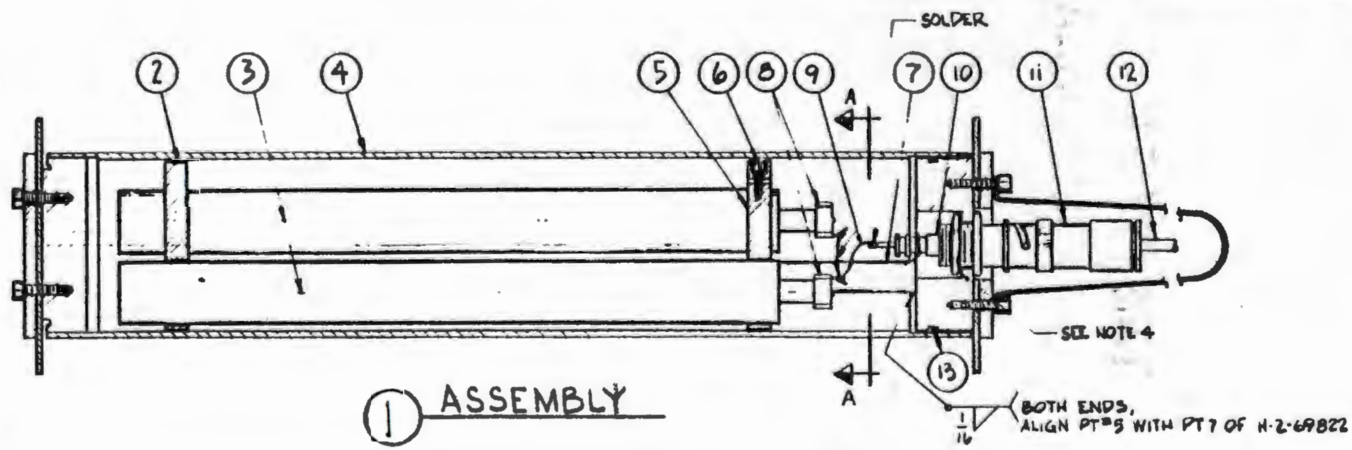
CALIBRATION PROCEDURES AND OPERATIONAL TESTS

Calibration of Probes

Surveillance probe types are calibrated at the facility operated by Pacific Northwest Laboratories (PNL). The procedure consists of positioning the probe in a known gamma radiation field and obtaining a timed count. The data thus obtained are plotted on log-log graph as c/s versus R/hr (see Figure I-2). Source references are provided.



QTY	PT#	DESCRIPTION	MATERIAL
X	1	ASSEMBLY	
1	2	SPACER	
3	3	GEIGER-MÜLLER TUBE, TGM TYPE,	N-119HS (SEE NOTE 3)
1	4	STR PROBE HOUSING ASSEMBLY	H-2-69822
1	5	SUPPORT RING	
2	6	#2-56UNC-2A x 1/4 LG, SOC. HD CAP SCR.	ASTM-A193-GR BB
1	7	SUPPORT BAR	
3	8	CLIP, LITTELFUSE, TYPE 101003	NEWARK CAT. N° 27F1084
AR	9	HOOKUP WIRE #20 AWG, SOLID	STORES # 16-7500-040
1	10	BNC HI-VOLTAGE JACK RECEPTACLE	SPECIALTY CONNECTOR Co. P/N 22JR113-1
1	11	BNC HI-VOLTAGE PLUG	SPECIALTY CONNECTOR Co. P/N 22P114-1
AR	12	CABLE, COAXIAL RG-187A/U	MICRODOT PT# 275-3809
1	13	O-RING STATIC SEAL, 1/16" WIDTH	PARKER O-RING N° 2-5-0 OR EQ., SILICONE RUBBER

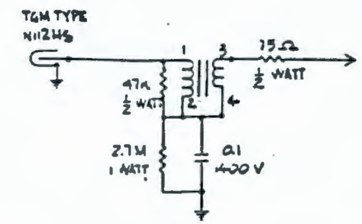


H-2-69823 (REF)

FIGURE I-10. High Sensitivity GMP.

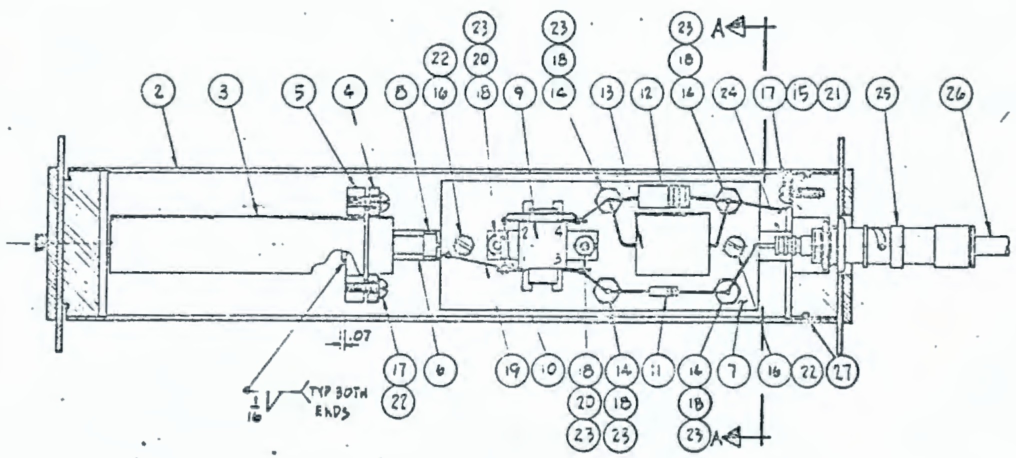
THIS PAGE INTENTIONALLY LEFT BLANK

9 2 1 2 4 9 9 1 9 2 0

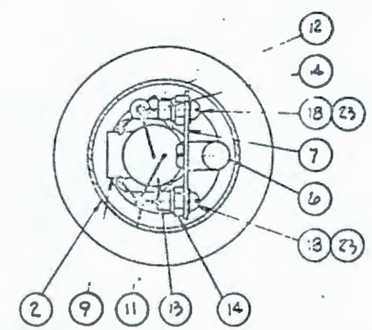


SCHEMATIC DIAGRAM

QTY	PT	DESCRIPTION	MATERIAL
	1	ASSEMBLY	
1	2	STANDARD PROBE HOUSING ASSEMBLY	H-2-69822
1	3	GEIGER-MULLER TUBE	TGM DETECTORS N-112HS
1	4	CLAMP RING	
1	5	SUPPORT RING	
1	6	SUPPORT ROD	
1	7	MOUNTING BOARD	
1	8	CLIP, LITTELFUSE TYPE 101005	NEWARK CAT# 27F1084
1	9	TRANSFORMER, PULSE	PULSE ENG. PE-5003
1	10	RESISTOR 47K, ½ WATT	
1	11	RESISTOR 75 Ω, ½ WATT	
1	12	RESISTOR 2.7M, 1 WATT	
1	13	CAPACITOR 0.1 MFD, 1400 V, MYLAR	TEXAS CAPACITOR CO PT# 1254
4	14	TERMINAL, INSULATED STANDOFF (CERAMIC)	STORES #16-4068-060
1	15	SOLDER LUG	STORES # 16-1690-20
2	16	6-32UNC-2AX½, PAN HD MACH. SCR.	ASTM A193 GRADE B8 (304)
3	17	6-32UNC-2AX5/16, RD HD MACH. SCR	↓
6	18	4-40UNC-2AX3/16, RD. HD MACH SCR	↓
2	19	WIRE, HOOKUP #20 AWG, SOLID	STORES #16-7300-030
2	20	4-40UNC-2B, HEX. NUT	ASTM A194 GRADE 8F (304)
1	21	#6 INTERNAL TOOTH LOCK WASHER	SST COMMERCIAL
4	22	#6 EXTERNAL TOOTH LOCK WASHER	↓
6	23	#4 EXTERNAL TOOTH LOCK WASHER	↓
1	24	BNC HI-VOLTAGE JACK RECEPTACLE	SPECIALITY CONN. CO. P/N 22JR13-1
1	25	BNC HI-VOLTAGE PLUG	SPECIALITY CONN CO P/N 22P114-1
AR	26	CABLE, COAXIAL RG-187 A/U	MICRODOT PT# 275-3809
1	27	O-RING STATIC SEAL, 1/16" WIDTH	PARKER O-RING No 2-5-0A [illegible]



(1) ASSEMBLY



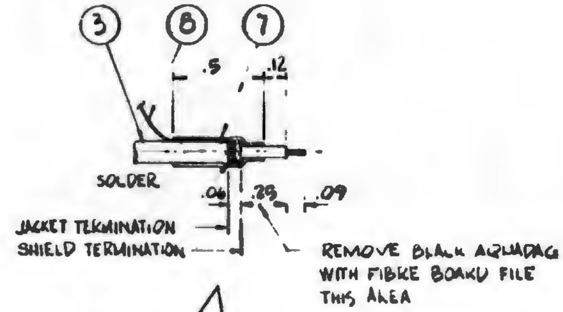
SECTION A-A

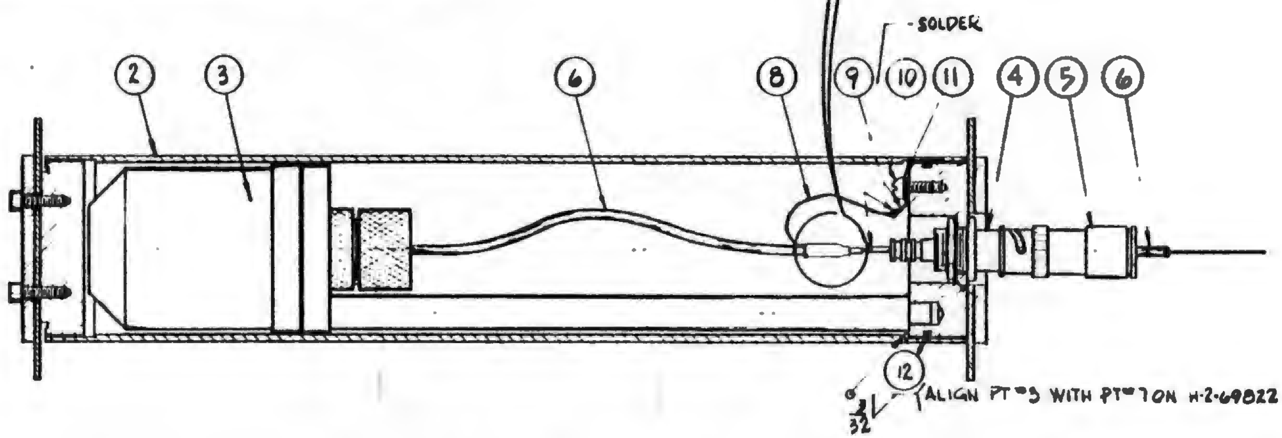
H-2-69828 (REF)

FIGURE I-11. High Sensitivity GMP.

THIS PAGE INTENTIONALLY
LEFT BLANK

QTY	PT#	DESCRIPTION	MATERIAL
	1	ASSEMBLY	—
1	2	STANDARD PROBE HOUSING ASSEMBLY	H-2-69822
1	3	HIGH LEVEL G.M. PROBE DETAILS	H-2-69820-1
1	4	BNC HI-VOLTAGE JACK RECEPTACLE	SPECIALTY CONNECTOR Co P/N 22JR113-1
1	5	BNC HI-VOLTAGE PLUG	SPECIALTY CONNECTOR Co P/N 22P114-1
AR	6	CABLE, COAXIAL RG-187A/U	MICRODOT PT# 279-3809
AR	7	SHRINKABLE TUBING, RNF-100-1/4	STORE #16-6083-060
AR	8	HOOKUP WIRE, #22 AWG TEFLON, BLACK	STORE # 16-7930-005
1	9	SOLDER LUG	STORE #16-1690-200
1	10	6-32UNC-2A×1/4 LG, RD HD MACH SCR.	C. STL. ASTM A307 GR 'A'
1	11	#6 INTERNAL TOOTH LOCK WASHER	STEEL COMMERCIAL
1	12	O-RING STATIC SEAL, 1/16 WIDTH	PARKER O-RING Nº 2-5-031 OR EQ, SILICONE RUBBER





1 ASSEMBLY

H-2-69821 (REF)

FIGURE I-12. High-Level GMP.

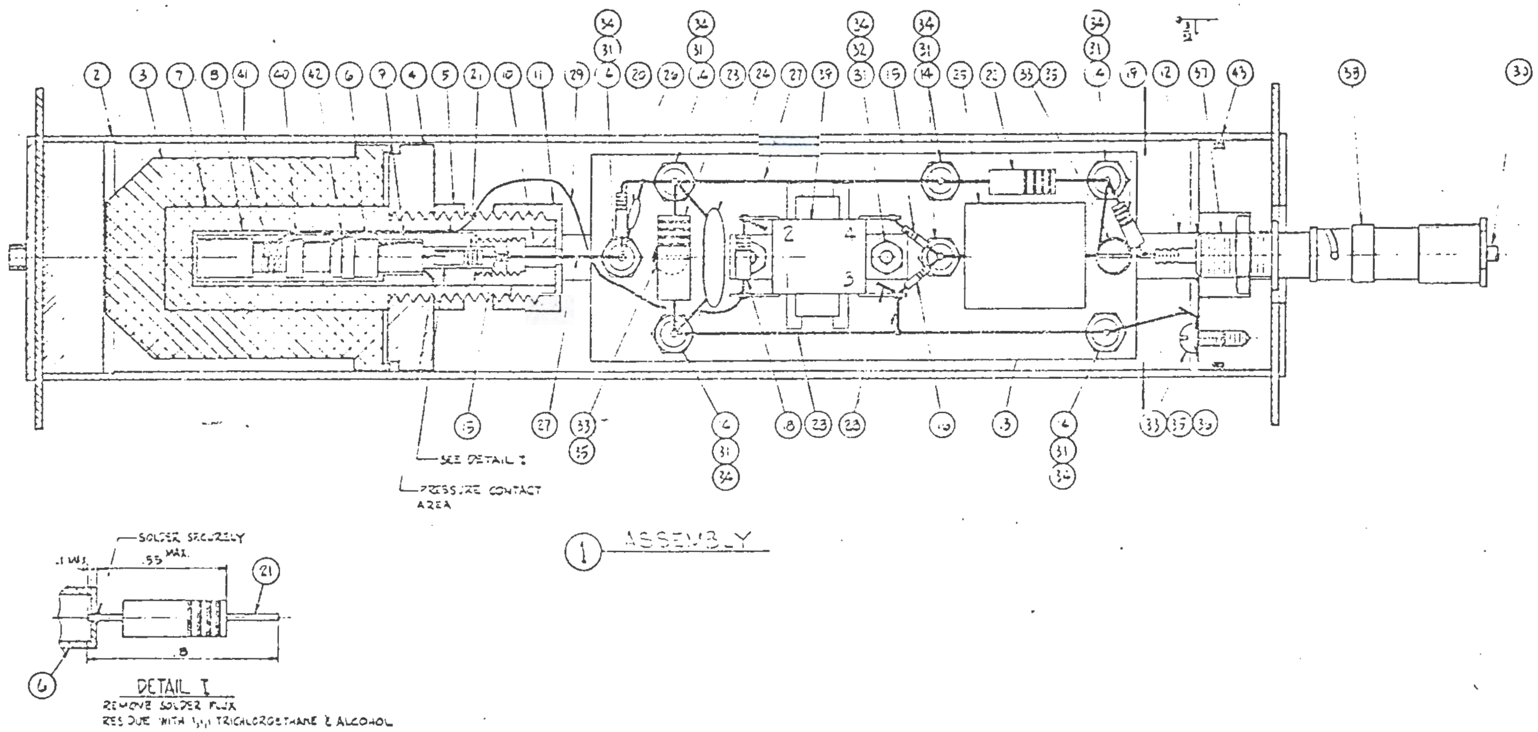
THIS PAGE
INTENTIONALLY
LEFT BLANK

92124991923

GENERAL NOTE

4 G.M. TUBE (PT-41) GENERAL OPERATING PARAMETERS: 900 V D.C., 30°C UPPER TEMPERATURE LIMIT, SENSITIVITY TO BE CONTROLLED BY MANUFACTURER IN ACCORDANCE WITH ORIGINAL PROCUREMENT AGREEMENT. THE CAP THREADS SHALL BE 2-20UNC-2B
MANUFACTURER: TGM DETECTORS, INC.
60 BEAR HILL ROAD
WALTHAM, MASS. 02154
NO SUBSTITUTION WITHOUT ENGINEERING & QA CONCURRENCE

QTY	ITEM	DESCRIPTION	MATERIAL
	1	ASSEMBLY	—
1	2	STANDARD PROBE HOUSING ASSEMBLY	H-2-69822-1
1	3	GAMMA SHIELD	H-2-69824-2
1	4	FLANGE	H-2-69820-6
1	5	LOCK NUT	H-2-69820-4
1	6	TUBE CAP	H-2-69820-5
1	7	INSERT	
1	8	INSULATOR	
1	9	SPACER #1	
1	10	SPACER #2	H-2-69820-12
1		CAP	H-2-69820-11
1	2	SUPPORT BAR	
1	3	MOUNTING BOARD	
7	4	TERMINAL, INSULATED STANDOFF (CERAMIC)	STORES 76-4048-060
1	5	EYELET	U.S.M.C. TYPE SE-26
1	6	RESISTOR 56 Ω, 1/2 WATT	
1	17	RESISTOR 22 Ω, 1/4 WATT	
1	18	RESISTOR 47 K, 1/2 WATT	
1	19	RESISTOR 75 K, 1/2 WATT	
1	20	RESISTOR 1.5 M, 1/2 WATT	
1	21	RESISTOR 4.7 M, 1/2 WATT	
1	22	RESISTOR 220 K, 1 WATT	
1	23	RESISTOR 1 M, 2 WATT	
1	24	CAPACITOR .01 MFD, 3 KV	
1	25	CAPACITOR 0.1 MFD, 1400 V, MYLAR	TEXAS CAPACITOR CO. P/N 1254
1	26	CAPACITOR 47 PF, 1 KV	
1	27	WIRE HOOKUP #22 AWG TEFLON, BLACK	STORES 16-7550-003
12	28	WIRE, HOOKUP #20 AWG, SOLID	STORES 16-7550-040
12	29	WIRE, HOOKUP #30 AWG, SOLID	STORES 16-7600-100
40	30	CABLE, COAXIAL RG-57 A/U	P/N 27-22099
8	31	4-40UNC-2A x 3/8 LG, RD HD MACH SCR	ASTM A193 GRADE B8 (304)
2	32	4-40UNC-2B, HEX HD NUT	ASTM A193 GRADE B8 (304)
3	33	6-32UNC-2A x 1/2 LG, PAN HD MACH SCR.	ASTM A193 GRADE B8 (304)
8	34	#4 EXTERNAL TOOTH LOCK WASHER	SST COMMERCIAL
3	35	#6 EXTERNAL TOOTH LOCK WASHER	↓
1	36	SOLDER LUG	STORES 76-1670-20
1	37	BNC HI-VOLTAGE JACK RECEPTACLE	SPECIALTY CONNECTOR CO. P/N 22R 19-1
1	38	BNC HI-VOLTAGE PLUG	SPECIALTY CONNECTOR CO. P/N 22P 4-1
1	39	TRANSFORMER	PULSE ENG. PE-5063
1	40	GEIGER-MUELLER PROBE, THE TUNGSTEN	SEE NOTE #4
	41	CONDUCTIVE EPOXY	SEE NOTE #5
AR	42	ADHESIVE SEALANT	SEE NOTE 8 & 9
1	43	O-RING STATIC SEAL, 1/16 WIDTH	PARKER O-RING NO. 5-013 SEAL, O-RING 2-128



H-2-69827 (REF)

FIGURE I-13. High-Level GMP.

THIS PAGE INTENTIONALLY
LEFT BLANK

Operational Validation Tests (Figures I-14, I-15, and I-16)

In accordance with procedure, each dry well surveillance van and horizontal lateral caisson system is tested prior to use by means of a cask operational check.

There are two casks provided for the dry well vans. One is in 200 East Area for the use on the three vans assigned there; and one is in 200 West Area for the three vans there (see Figure I-14).

There is also a similar test cask in each horizontal lateral caisson. These are located in the caisson at an approximate depth of 25 ft (see Figures I-15 and I-16).

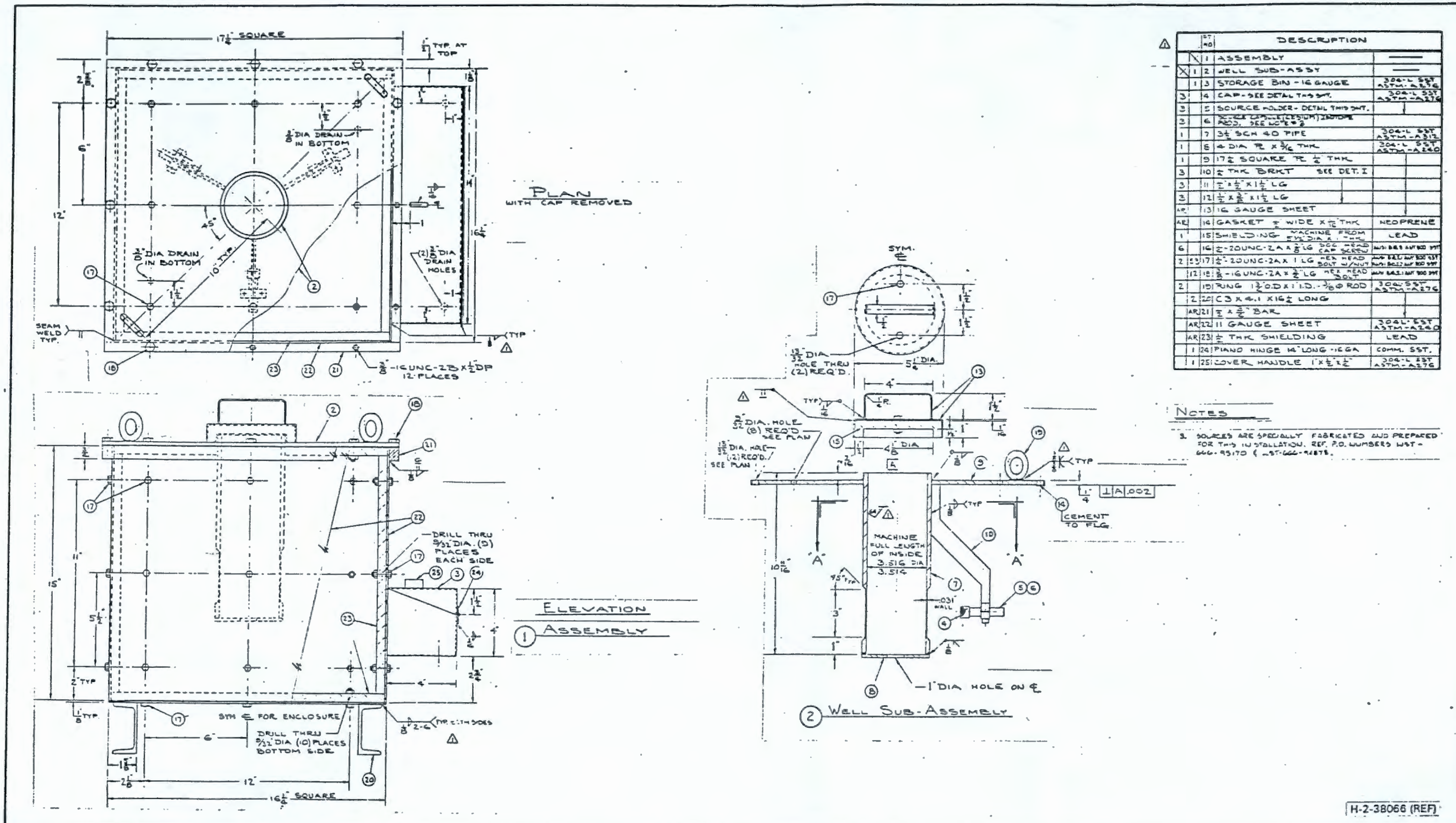
The basic configuration of all calibration casks is identical. Three sources are equally spaced around the center cask access tube at a distance of 10 cm from the vertical centerline of the tube. The casks are shielded to reduce background counts.

The sources were specially fabricated and calibrated to include scattering caused by the source holder. They are matched 100 μCi ^{137}Cs sources and, at time zero, produced a gamma field of 333 mR/hr at 1 cm (Table I-1).

The calibration curves for all detectors is essentially a line of fixed slope. The cask test for operational validation determines that the ordinate (count value) for a point on the line (whose abscissa is determined by the gamma dose rate) is within a predetermined count range. This is a valid functional test since no operational adjustment of the electronics can affect the slope.

The measured count must be correct or the system must be repaired. The predetermined count range for each probe provides a maximum count, a nominal count, and a minimum count value as a function of source age. The values are revised quarterly to account for decay.

THIS PAGE INTENTIONALLY LEFT BLANK

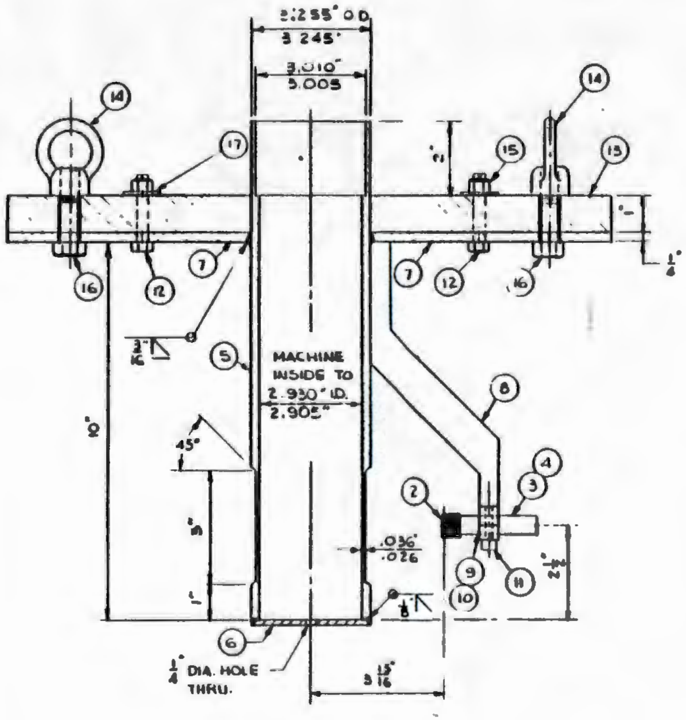


9 2 1 2 4 9 9 1 9 2 6

FIGURE I-14. Source Holds for Validating Operability of Dry Well Surveillance Van Systems.

THIS PAGE INTENTIONALLY
LEFT BLANK

I-33/I-34 blank



1. ASSEMBLY

QTY	PT NO	DESCRIPTION	MATERIAL
X	1	FIXTURE ASSEMBLY	SEE NOTE 2
3	2	CAP	ALUMINUM
3	3	SOURCE HOLDER	ALUMINUM
3	4	SOURCE CAPSULE	SEE NOTE 1
AR	5	3" PIPE SCH. 80	ASTM A-312 304-L SST
1	6	3 1/4" DIA PL x 3/16" THK.	ASTM A-240 304-L SST.
1	7	17 1/4" DIA PL 1/4" THK	↓
3	8	1/4" THK. BRKT. SEE DET. I	↓
3	9	1/2" x 1/2" x 1 1/2" LG. SEE DET I	↓
3	10	1/2" x 3/8" x 1 1/2" LG. SEE DET I	↓
3	11	1/4"-20UNC-2A x 7/8" LG. SOC HD CAP SCR.	ASTM A-193 304-L SST
3	12	1/4"-20UNC-2A x 2" LG. HEX. HD BOLT.	ASTM A-193 304-L SST.
A/R	13	1" THK. SHIELDING-O.D. TO MATCH #7	LEAD
2	14	1/2" DROP FORGED EYE NUT	ASTM A-193 304-L SST
3	15	1/4"-20 UNC-2B HEX NUT	ASTM A-193 304-L SST
3	16	1/2"-13UNC-2A x 1 3/4" HEX.HD. BOLT	ASTM A-193 304-L SST.
3	17	1/4" PLAIN WASHER	CARBON STL.
1	18	1/4" SOCKET WRENCH (3/16" ACROSS FLATS)	———
1	19	STD. LONG SCREW-DRIVER	———
1	20	1/2" THK. PLATE	ALUMINUM
1	21	1/2 Ø ROD x 15" LG.	ALUMINUM

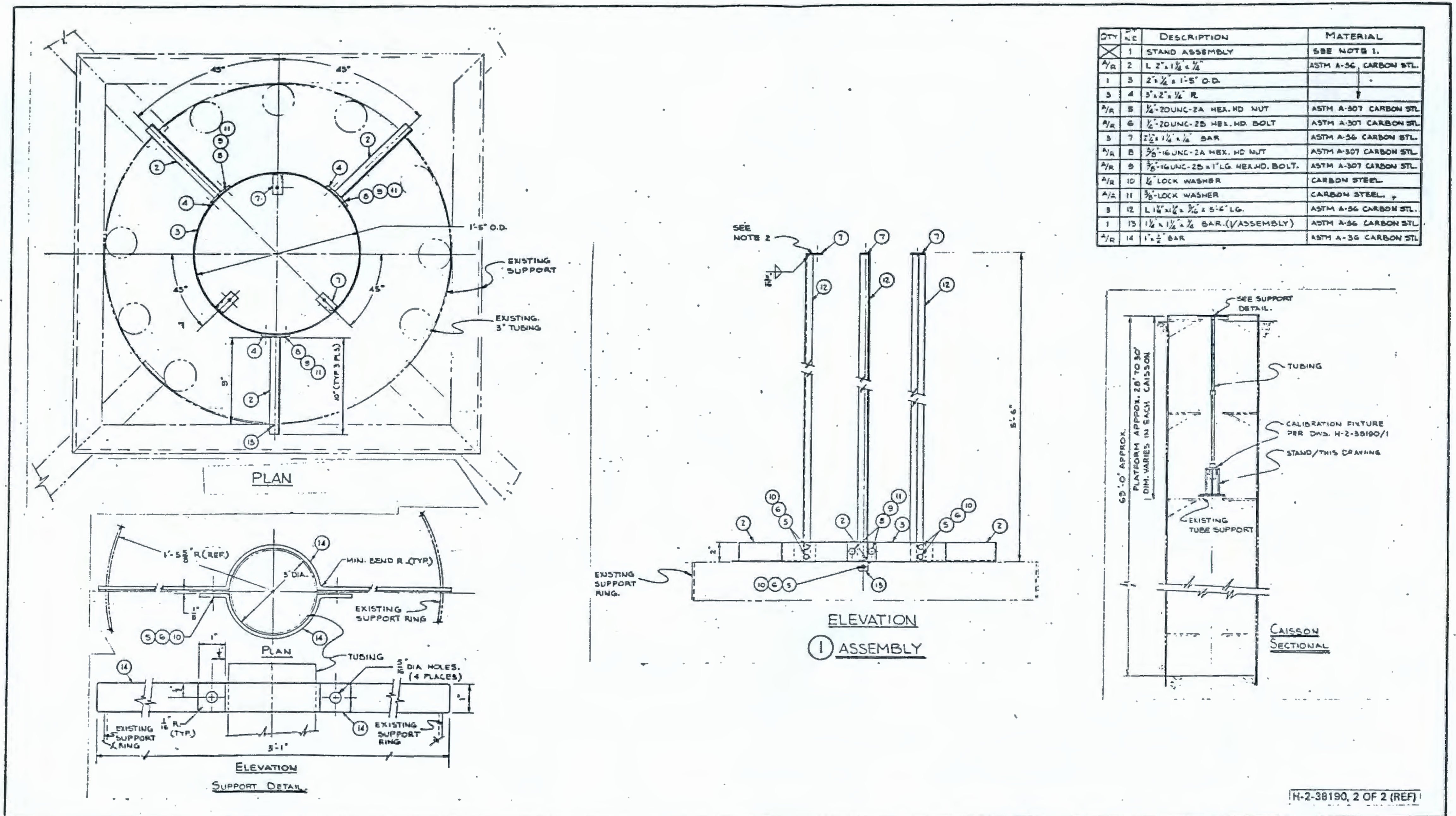
GENERAL NOTES:

1. NER 570, CESIUM 137, ONE-TENTH MILLICURIE, CAPSULE NO G 316A.
2. ONE ASSEMBLY PER THIS DRAWING WILL BE USED PER INSTALLATION IN EACH CAISSON. FOR MOUNTING ASS'Y, SEE H-2-38190 SHT-2
3. ONE ITEM PER ASSEMBLY.
4. ITEMS 12, 15, & 17 ARE ATTACHMENT HARDWARE (3 PLACES) FOR FIXTURE ASSEMBLY TO STAND ASSEMBLY.
5. Q A LEVEL III.

H-2-38190, 1 OF 2 (REF)

FIGURE I-15. Source Holder for Validating Operability of Dry Well Surveillance Van Systems.

THIS PAGE
INTENTIONALLY
LEFT BLANK



QTY	NO	DESCRIPTION	MATERIAL
X	1	STAND ASSEMBLY	SEE NOTE 1.
A/R	2	L 2" x 1 1/4" x 1/4"	ASTM A-36 CARBON STL.
1	3	2" x 1/4" x 1'-5" O.D.	↓
3	4	3" x 2" x 1/4" R	↓
A/R	5	1/4"-20UNC-2A HEX. HD NUT	ASTM A-307 CARBON STL
A/R	6	1/4"-20UNC-2B HEX. HD. BOLT	ASTM A-307 CARBON STL
3	7	2 1/2" x 1 1/4" x 1/4" BAR	ASTM A-36 CARBON STL.
A/R	8	3/8"-16UNC-2A HEX. HD NUT	ASTM A-307 CARBON STL.
A/R	9	3/8"-16UNC-2B x 1" LG. HEX.HD. BOLT.	ASTM A-307 CARBON STL.
A/R	10	1/4" LOCK WASHER	CARBON STEEL
A/R	11	3/8"-LOCK WASHER	CARBON STEEL.
3	12	L 1 1/4" x 1 1/4" x 3/16" x 5'-6" LG.	ASTM A-36 CARBON STL.
1	13	1 1/4" x 1 1/4" x 1/4" BAR. (1/ASSEMBLY)	ASTM A-36 CARBON STL
A/R	14	1" x 1/2" BAR	ASTM A-36 CARBON STL

FIGURE I-16. Test Cask for Validating Operability of Dry Well Surveillance Vans Systems.

THIS PAGE INTENTIONALLY
LEFT BLANK

TABLE I-1. Sources Used in Calibration.

Source no.	μCi	Average μCi/group	Source no.	μCi	Average μCi/group
1	98.3		7	98.9	
3	99.7	100.1/A	9	100.9	100.2/E
16	102.3		18	100.9	
2	100.3		12	98.2	
4	100.3	100.1/B	15	99.2	100.1/F
14	99.7		17	102.9	
5	101.6		10	99.0	
6	98.7	100.1/C	22	98.0	100.1/G
19	100.0		23	103.3	
8	103.0		11	98.0	
13	99.0	100.1/D	20	103.6	100.2/H
21	98.3		24	98.9	

Application of sources:

- Group A: Dry well fixture, 200 West Area
- Group B: Dry well fixture, 200 East Area
- Groups C, D, F, G: Lateral fixtures, 241-SX Tank Farm
- Groups E, H: Lateral fixtures, 241-A Tank Farm

Source calibration date: 11-01-74

Approval date: 11-19-74

Combined dose rate at 1 cm:

- Groups A, B, C, D, F, G: 1.039 R/hr/group
- Groups E, H: 1.040 R/hr/group

IN-PROCESS SYSTEM UPGRADES

Dry Well Van Instrument System

A demonstration prototype computer installation in one dry well van was successfully made during FY 1979. This development was an upgrade intended to replace troublesome paper tape data media. The random access memory of the computer was used for temporary data storage. The data were subsequently transferred via the Computer Automated Surveillance System (CASS) to the Central Surveillance Computer. The scope of the dry well van computer has been increased to include automated control of the dry well van systems to eliminate probe positional errors and enhance precision and repeatability. Full computer control of probe indexing, insertion, withdrawal, traverse speed, and data interval are being added. The computer is provided with a library of dry wells and probe data such that a proper solution to the well scan problem can be resolved automatically. Special scanning functions are also provided for those instances of unusual circumstances or those requiring unusual detail. Implementation of this control system is scheduled for all dry well vans during 1981.

Horizontal Lateral Instrument System

To accomplish a similar improvement in operation of the horizontal laterals, a microprocessor is being installed at each caisson. It will provide a means to automate the system and to transfer the scan data to a connected dry well van, master control system.

APPENDIX J

CALCULATION OF TENTH-VALUE THICKNESSES OF HANFORD SEDIMENTS (SOILS)

H. J. Goldberg and E. N. Dodd

The effective tenth-value thickness of Hanford sediments as a function of the concentration of ruthenium in an advancing front of leaking waste solution has been calculated in the following manner.

The dose rate at a point P from photons originating from a point source So is given by

$$DR = \frac{SoBe^{-b_1}}{K4\pi r^2}$$

$$b_1 = \sum_{i=1}^{N} \mu_i t_i$$

where

DR = dose rate

So = source emission rate

B = buildup factor

μ_i = linear absorption coefficient for the i^{th} shield

t_i = slant distance through the i^{th} shield

K = conversion factor of γ-ray flux to dose rate (Figures J-1 to J-3)

r = distance from So to P

N = number of shields.

These calculations were performed with the computer code ISOSHLD-III.

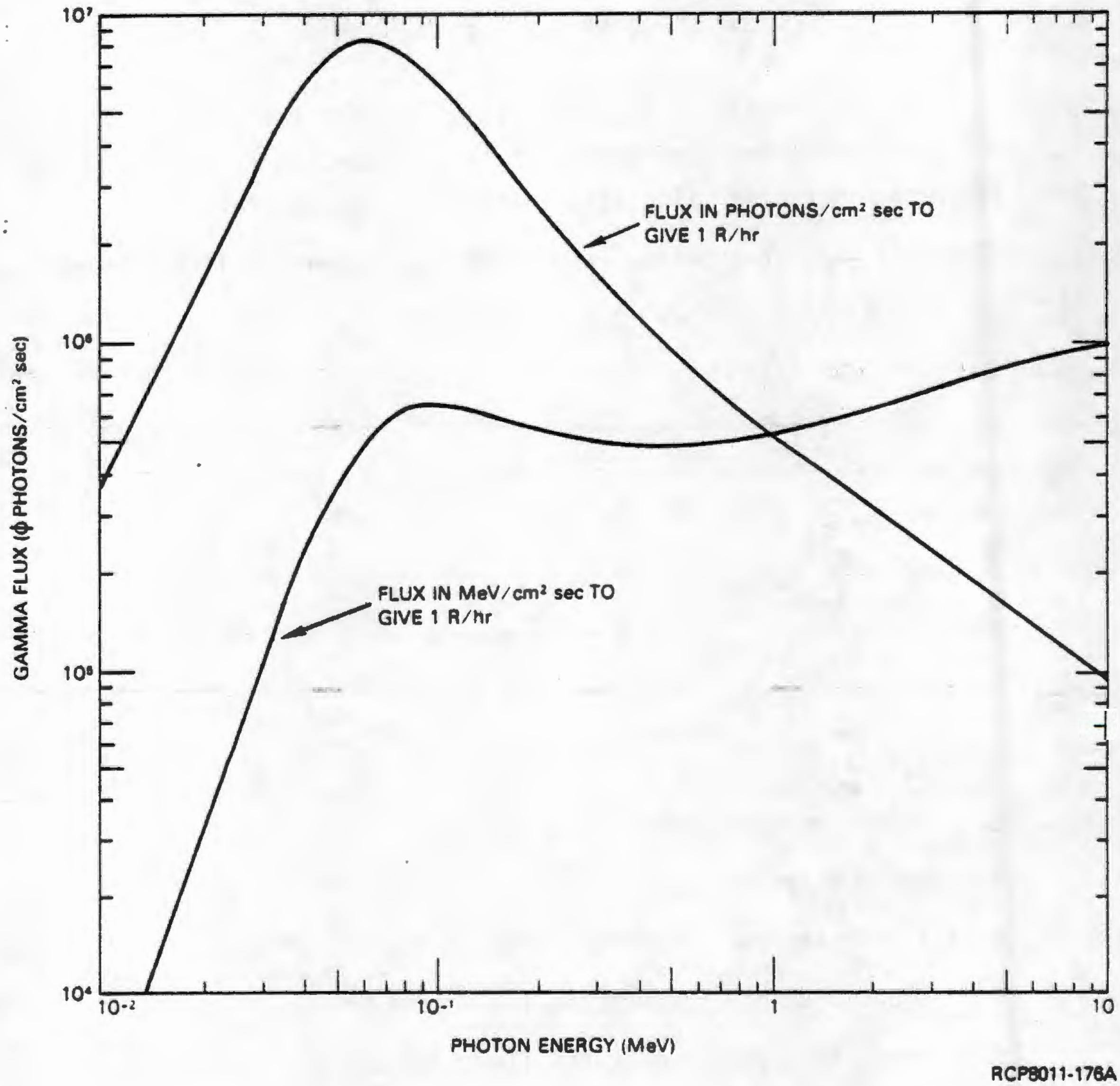


FIGURE J-1. Gamma Flux to Give 1 R/hr (from Ref. 4).

9 2 1 2 4 9 9 1 9 3 3

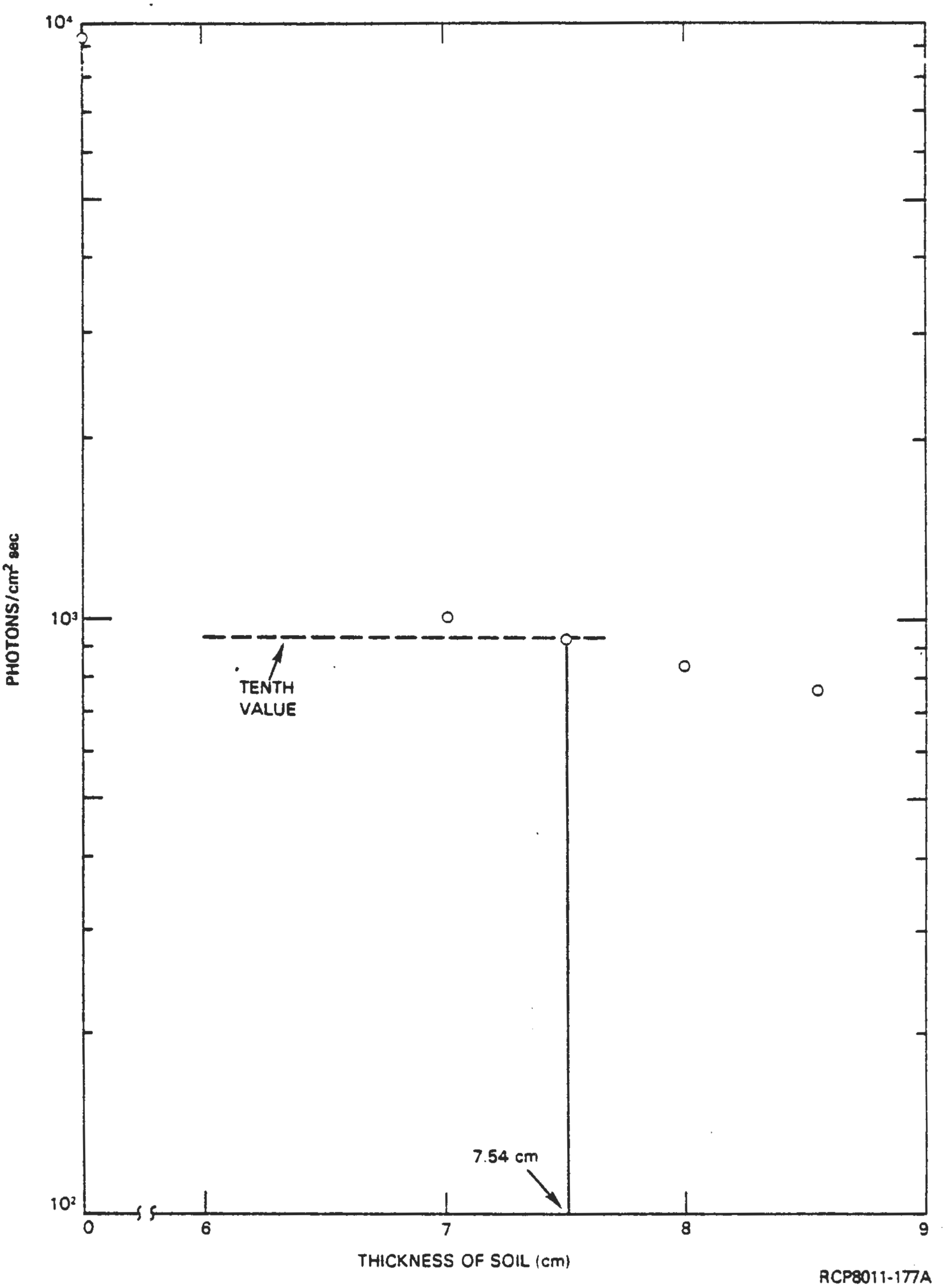


FIGURE J-2. Flux from a ^{106}Ru-^{106}Rh Source of 1 Ci in Soil as a Function of Distance from Source.

9 2 1 2 4 9 9 1 9 3 4

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

PAGE 3
JOB NO. 60D-RE-HXG-035
DATE
BY Harvey Goldberg
CHECKED BY [illegible]

FOR
LOCATION
SUBJECT

Group no.	Average group energy (MeV)	Conversion factor* $\left(\frac{\text{photons/cm}^2\text{ sec}}{\text{R/hr}}\right)$	Dose rate (R/hr)	Photon flux (photons/cm² sec)
1	1.500×10^{-2}	8.7×10^{5}	0	0
2	2.500×10^{-2}	2.3×10^{6}	5.870×10^{-5}	1.350×10^{2}
3	3.5×10^{-2}	4.7×10^{6}	4.258×10^{-5}	2.001×10^{2}
4	4.5×10^{-2}	7.0×10^{6}	2.343×10^{-5}	1.640×10^{2}
5	5.5×10^{-2}	8.1×10^{6}	1.985×10^{-5}	1.608×10^{2}
6	6.5×10^{-2}	8.3×10^{6}	1.721×10^{-5}	1.428×10^{2}
7	7.5×10^{-2}	7.9×10^{6}	1.524×10^{-5}	1.204×10^{2}
8	8.5×10^{-2}	7.4×10^{6}	1.440×10^{-5}	1.066×10^{2}
9	9.5×10^{-2}	6.7×10^{6}	1.497×10^{-5}	1.003×10^{2}
10	1.5×10^{-1}	3.9×10^{6}	2.548×10^{-4}	9.937×10^{2}
11	2.5×10^{-1}	2.05×10^{6}	1.844×10^{-4}	3.780×10^{2}
12	3.5×10^{-1}	1.4×10^{6}	1.499×10^{-4}	2.099×10^{2}
13	4.75×10^{-1}	1.0×10^{6}	3.910×10^{-3}	3.910×10^{3}
14	6.5×10^{-1}	7.4×10^{5}	2.729×10^{-3}	2.019×10^{3}
15	8.25×10^{-1}	6.0×10^{5}	1.991×10^{-4}	1.195×10^{2}
16	1.00	5.2×10^{5}	5.916×10^{-4}	3.076×10^{2}
17	1.225	4.45×10^{5}	2.598×10^{-4}	1.156×10^{2}
18	1.475	3.9×10^{5}	1.185×10^{-4}	4.622×10^{1}
19	1.7	3.5×10^{5}	3.855×10^{-5}	1.349×10^{1}
20	1.9	3.25×10^{5}	3.446×10^{-5}	1.120×10^{1}
21	2.1	3.00×10^{5}	3.145×10^{-5}	9.435
22	2.3	2.82×10^{5}	1.685×10^{-5}	4.721
23	2.5	2.6×10^{5}	2.981×10^{-5}	7.751
24	2.7	2.475×10^{5}	1.556×10^{-5}	3.851
25	3.0	2.25×10^{5}	4.696×10^{-7}	1.057×10^{-1}
Total			8.771×10^{-3}	9.281×10^{3}

*From Rockwell, see Figure J-1.

FIGURE J-3. Flux from a ^{106}Ru-^{106}Rh Source of 1 Ci in Soil as a Function of Distance from Source (for 0.01 cm of Hanford Soil). (Sheet 1 of 5)

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

PAGE 2
JOB NO. GA-RE-4136-035
DATE
BY Harvey Goldberg
CHECKED BY [signature]

FOR
LOCATION
SUBJECT

Group no.	Average group energy (MeV)	Conversion factor* (photons/cm² sec / R/hr)	Dose rate (R/hr)	Photon flux (photons/cm² sec)
1	1.500×10^{-2}	8.7×10^{5}	0	0
2	2.500×10^{-2}	2.3×10^{6}	0	0
3	3.5×10^{-2}	4.7×10^{6}	0	0
4	4.5×10^{-2}	7.0×10^{6}	6.482×10^{-10}	4.537×10^{-3}
5	5.5×10^{-2}	8.1×10^{6}	5.050×10^{-8}	4.091×10^{-1}
6	6.5×10^{-2}	8.3×10^{6}	1.386×10^{-7}	1.150
7	7.5×10^{-2}	7.9×10^{6}	2.473×10^{-7}	1.954
8	8.5×10^{-2}	7.4×10^{6}	4.138×10^{-7}	3.062
9	9.5×10^{-2}	6.7×10^{6}	5.830×10^{-7}	3.916
10	1.5×10^{-1}	3.9×10^{6}	1.267×10^{-5}	4.941×10^{1}
11	2.5×10^{-1}	2.05×10^{6}	1.631×10^{-5}	3.344×10^{1}
12	3.5×10^{-1}	1.4×10^{6}	1.857×10^{-5}	2.600×10^{1}
13	4.75×10^{-1}	1.0×10^{6}	5.448×10^{-4}	5.448×10^{2}
14	6.5×10^{-1}	7.4×10^{5}	3.571×10^{-4}	2.643×10^{2}
15	8.25×10^{-1}	6.0×10^{5}	2.625×10^{-5}	1.575×10^{1}
16	1.00	5.2×10^{5}	8.664×10^{-5}	4.505×10^{1}
17	1.225	4.45×10^{5}	3.734×10^{-5}	1.662×10^{1}
18	1.475	3.9×10^{5}	1.762×10^{-5}	6.872
19	1.7	3.5×10^{5}	5.936×10^{-6}	2.078
20	1.9	3.25×10^{5}	5.679×10^{-6}	1.846
21	2.1	3.00×10^{5}	5.221×10^{-6}	1.566
22	2.3	2.8×10^{5}	2.797×10^{-6}	7.832×10^{-1}
23	2.5	2.6×10^{5}	5.037×10^{-6}	1.310
24	2.7	2.475×10^{5}	2.657×10^{-6}	6.576×10^{-1}
25	3.0	2.25×10^{5}	8.708×10^{-8}	1.959×10^{-2}
Total			1.146×10^{-3}	1.021×10^{3}

*From Rockwell, see Figure J-1.

FIGURE J-3. Flux from a ^{106}Ru-^{106}Rh Source of 1 Ci in Soil as a Function of Distance from Source (for 7.0 cm of Hanford Soil). (Sheet 2 of 5)

9 2 1 2 4 9 9 1 9 3 6

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

FOR ______
LOCATION ______
SUBJECT ______

PAGE 5
JOB NO. GD-RE-HJG-035
DATE ______
BY Harvey Goldberg
CHECKED BY [signature]

Group no.	Average group energy (MeV)	Conversion factor* (photons/cm^2 sec / R/hr)	Dose rate (R/hr)	Photon flux (photons/cm^2 sec)
1	1.500×10^{-2}	8.7×10^{5}	0	0
2	2.500×10^{-2}	2.3×10^{6}	0	0
3	3.5×10^{-2}	4.7×10^{6}	0	0
4	4.5×10^{-2}	7.0×10^{6}	3.323×10^{-10}	2.326×10^{-3}
5	5.5×10^{-2}	8.1×10^{6}	3.474×10^{-8}	2.814×10^{-1}
6	6.5×10^{-2}	8.3×10^{6}	1.113×10^{-7}	9.238×10^{-1}
7	7.5×10^{-2}	7.9×10^{6}	1.964×10^{-7}	1.552
8	8.5×10^{-2}	7.4×10^{6}	3.443×10^{-7}	2.548
9	9.5×10^{-2}	6.7×10^{6}	4.903×10^{-7}	3.285
10	1.5×10^{-1}	3.9×10^{6}	1.082×10^{-5}	4.220×10^{1}
11	2.5×10^{-1}	2.05×10^{6}	1.451×10^{-5}	2.975×10^{1}
12	3.5×10^{-1}	1.4×10^{6}	1.692×10^{-5}	2.369×10^{1}
13	4.75×10^{-1}	1.0×10^{6}	5.004×10^{-4}	5.004×10^{2}
14	6.5×10^{-1}	7.4×10^{5}	3.281×10^{-4}	2.428×10^{2}
15	8.25×10^{-1}	6.0×10^{5}	2.425×10^{-5}	1.455×10^{1}
16	1.00	5.2×10^{5}	8.066×10^{-5}	4.194×10^{1}
17	1.225	4.45×10^{5}	3.478×10^{5}	1.548×10^{1}
18	1.475	3.9×10^{5}	1.647×10^{-5}	6.423
19	1.7	3.5×10^{5}	5.560×10^{-6}	1.946
20	1.9	3.25×10^{5}	5.343×10^{-6}	1.736
21	2.1	3.00×10^{5}	4.917×10^{-6}	1.475
22	2.3	2.8×10^{5}	2.635×10^{-6}	7.378×10^{-1}
23	2.5	2.6×10^{5}	4.752×10^{-6}	1.236
24	2.7	2.475×10^{5}	2.509×10^{-6}	6.210×10^{-1}
25	3.0	2.25×10^{5}	8.261×10^{-8}	1.859×10^{-2}
Total			1.054×10^{-3}	9.336×10^{2}

*From Rockwell, see Figure J-1.

FIGURE J-3. Flux from a ^{106}Ru-^{106}Rh Source of 1 Ci in Soil as a Function of Distance from Source (for 7.5 cm of Hanford Soil). (Sheet 3 of 5)

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

PAGE 4
JOB NO. GD-KE-HJG-035
DATE
BY Harvey Gilbert
CHECKED BY [signature]

FOR
LOCATION
SUBJECT

Group no.	Average group energy (MeV)	Conversion factor* $\left(\frac{\text{photons/cm}^2\text{ sec}}{\text{R/hr}}\right)$	Dose rate (R/hr)	Photon flux (photons/cm^2 sec)
1	1.500×10^{-2}	8.7×10^5	0	0
2	2.500×10^{-2}	2.3×10^6	0	0
3	3.5×10^{-2}	4.7×10^6	0	0
4	4.5×10^{-2}	7.0×10^6	1.339×10^{-10}	9.373×10^{-4}
5	5.5×10^{-2}	8.1×10^6	2.237×10^{-8}	1.812×10^{-1}
6	6.5×10^{-2}	8.3×10^6	8.702×10^{-8}	7.223×10^{-1}
7	7.5×10^{-2}	7.9×10^6	1.537×10^{-7}	1.214
8	8.5×10^{-2}	7.4×10^6	2.801×10^{-7}	2.073
9	9.5×10^{-2}	6.7×10^6	4.168×10^{-7}	2.793
10	1.5×10^{-1}	3.9×10^6	9.254×10^{-6}	3.609×10^1
11	2.5×10^{-1}	2.05×10^6	1.292×10^{-5}	2.649×10^1
12	3.5×10^{-1}	1.4×10^6	1.543×10^{-5}	2.160×10^1
13	4.75×10^{-1}	1.0×10^6	4.599×10^{-4}	4.599×10^2
14	6.5×10^{-1}	7.4×10^5	3.017×10^{-4}	2.233×10^2
15	8.25×10^{-1}	6.0×10^5	2.243×10^{-5}	1.346×10^1
16	1.00	5.2×10^5	7.518×10^{-5}	3.909×10^1
17	1.225	4.45×10^5	3.244×10^{-5}	1.444×10^1
18	1.475	3.9×10^5	1.541×10^{-5}	6.010
19	1.7	3.5×10^5	5.215×10^{-6}	1.825
20	1.9	3.25×10^5	5.034×10^{-6}	1.636
21	2.1	3.00×10^5	4.637×10^{-6}	1.391
22	2.3	2.8×10^5	2.486×10^{-6}	6.961×10^{-1}
23	2.5	2.6×10^5	4.490×10^{-6}	1.167
24	2.7	2.475×10^5	2.372×10^{-6}	5.871×10^{-1}
25	3.0	2.25×10^5	7.848×10^{-8}	1.766×10^{-2}
Total			9.700×10^{-4}	8.546×10^2

*From Rockwell, see Figure J-1.

FIGURE J-3. Flux from a ^{106}Ru-^{106}Rh Source of 1 Ci in Soil as a Function of Distance from Source (for 8 cm of Hanford Soil). (Sheet 4 of 5)

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

FOR
LOCATION
SUBJECT

PAGE 7
JOB NO. 60-RE-HJG-035
DATE
BY Harvey Goldberg
CHECKED BY [signature]

A straight line was fitted to the data:

$\ln(1.02 \times 10^3) = 6.93 = a + 7b$ (1)

$\ln(9.33 \times 10^2) = 6.84 = a + 7.5b$ (2)

(1) - (2) = (3)

$9 \times 10^{-2} = (-5 \times 10^{-1})b$ (3)

b = -0.18

Substitute into (1)

a = 8.19

$\ln(9 - 28 \times 10^2) = 8.19 = -0.18t$

t = 7.54 cm

ISOSHLD uses the following source terms: ^{106}Rh, No. γ, 0.0394 MeV, β - 1.0, and ^{106}Ru.

γ		β	
Probability	Energy (MeV)	Probability	Energy (MeV)
0.098	0.5116	0.79	3.54
0.0034	0.6166	0.08	3.03
0.0475	0.6228	0.11	2.41
0.0001	0.7176	0.01	1.98
0.0021	0.8734	0.004	1.54
0.0073	1.05	0.001	1.24
0.0001	1.062	0.001	1.10
0.0001	1.114	0.001	0.91
0.002	1.129	0.001	0.66
0.0001	1.18		
0.0003	1.193		
0.0001	1.496		
0.0008	1.562		
0.0001	1.765		
0.0001	1.796		
0.0001	1.925		
0.0001	1.986		
0.0002	2.111		
0.0001	2.367		
0.0001	2.407		
0.0001	2.571		
0.0001	2.65		

FIGURE J-3. Flux from a ^{106}Ru-^{106}Rh Source of 1 Ci in Soil as a Function of Distance from Source. (Sheet 5 of 5)

9 2 1 2 4 9 9 1 9 3 9

This version of ISOSHLD[1,2,3] includes bremsstrahlung photons obtained by using the Knipp-Uhlenbeck approximation to calculate internal bremsstrahlung spectral distribution. The external bremsstrahlung uses the Bethe-Heitler approximation.

The dose rate at point P from all points within a source of volume Sv is given by:

$$\text{DR total} = \int_{\text{energy}} \int_{\text{volume}} \frac{\text{So}(E,V)\ B\ (E,b_1)\ e^{-b_1}}{K(E)4\pi r^2(V)}\, dVdE$$

where

E = gamma energy in MeV

V = volume.

The actual numerical integration technique used in ISOSHLD (commonly known as point kernal integration) consists of dividing the source volume into a number of differential volumes. The source energy is divided into 25 energy groups. Each monoenergetic differential volume source is then treated as a point source, and the dose from each of these point sources is calculated. For each point source, new values of each of the constants are needed and are calculated using trigonometric relationships and the basic data in ISOSHLD libraries appropriate to the system geometry, source photon energies, maximum β-ray energies, and materials. Integration over the source volume and source energy is then obtained by summing the dose contributions from all the differential source volumes and source energies.

In the process of kernal integration, the buildup factor for each differential source volume is calculated for all of the materials between the point source and the dose point using Taylor's equation, i.e.,

$$B = Ae^{-a_1 b_1} + (1-A)e^{-a_2 b_1}$$

where the three constants a_1, a_2, and A are obtained from the buildup factor library for the specific materials and energy group involved (Figures J-4 and J-5).

This program was run to calculate dose rate for an essentially infinite thin slab of contamination for various contamination levels (Figures J-6 to J-11). The shield was packed soil with a density of 1.83 g/cm^3 which is typical of sediments beneath the Hanford high-level waste tanks. This shielding also extended into the source region. The source region included 13% water, while the soil outside of the source had a moisture content of 8%. The change in source concentration did not affect the moisture content of the soil in the source region. At this level of concentration, the self-shielding due to the two radionuclides is of negligible significance.

The dose rates per curie per liter of ^{106}Ru-^{106}Rh for various thicknesses of Hanford sediments (soils) are given in Table J-1 and plotted in Figures J-12 through J-15.

The dose rates are normalized with respect to various source densities and are plotted versus various thicknesses of Hanford sediments (soils) in Figures J-13 through J-15 and tabulated in Table J-1. This normalized dose rate, designated by the letter f, has units of $\frac{R/hr}{Ci/L}$. This normalization imparts a degree of universality to these curves in that the dose rate from any source can be obtained merely by multiplying f by the source density in Ci/L.

The dose rate is, of course, model specific. This analysis was performed using a very thin slab source and finding the dose at various distances from the thin edge.

Once the dose rate has been determined for a specific source, tenth-value layers, half-value layers, etc. can be obtained. Since the curve is not linear on the semi log paper, the values of these tenth-value layers will be dependent upon the minimum level of detection that is itself dependent on the sensitivity of the measuring apparatus and the background level; i.e., the slope of the curve varies over the range of the graph.

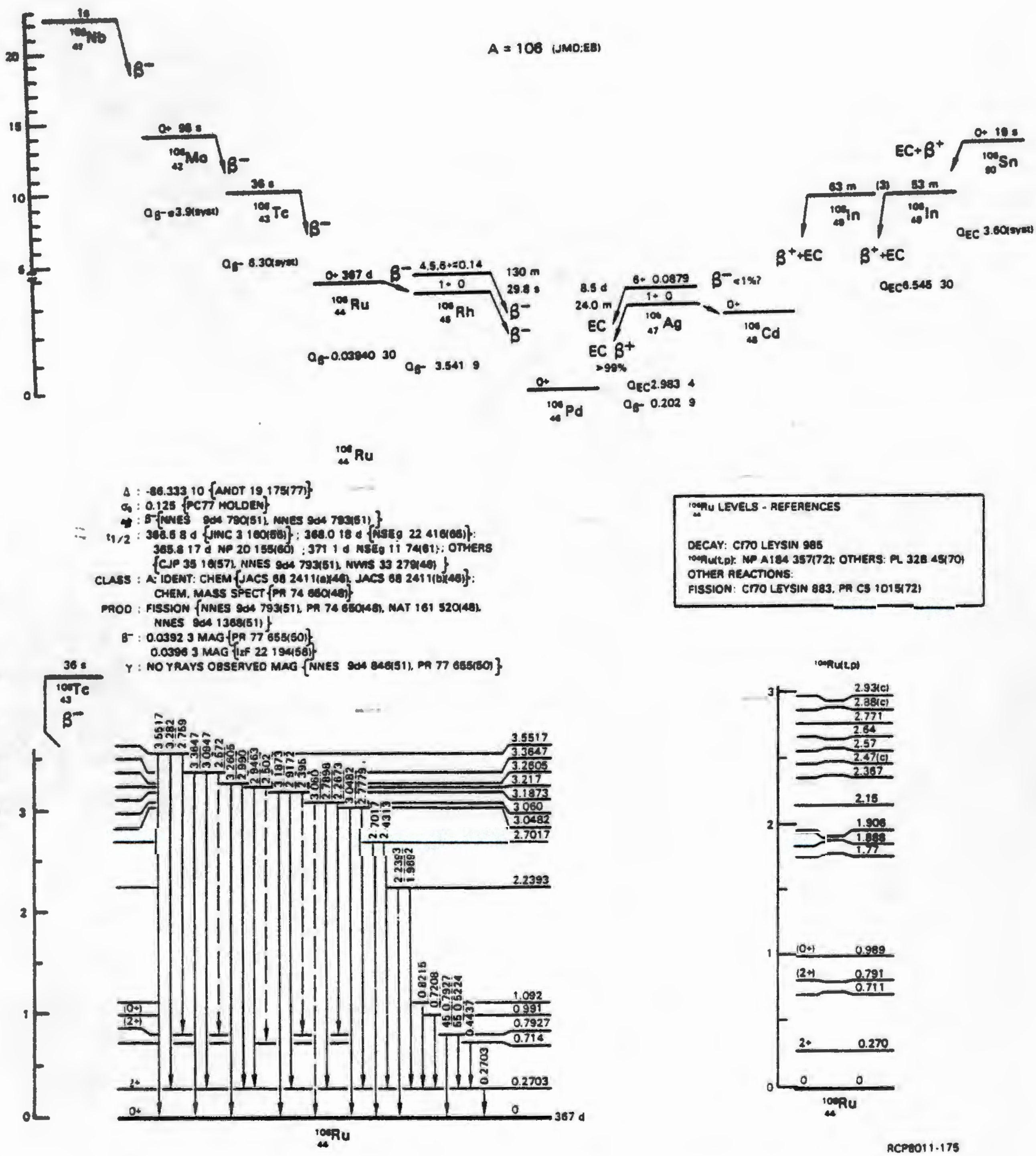


FIGURE J-4. Decay Scheme of ^{106}Ru.

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

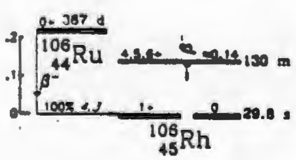
DESIGN ANALYSIS

FOR ______________________
LOCATION ______________________
SUBJECT ______________________

PAGE 6
JOB NO. (GN-RE-HJG-040)
DATE 25/8/80
BY Harvey Goldberg
CHECKED BY [signature]

$^{106}_{45}Rh$

Δ: -86.372 10 {ANDT 19 175(77)}
π: β⁻ {NNES 9d4 793(51)}
$t_{1/2}$: 29.80 8s {JAERI-1178 21(69)}; 30.35 15s {KDVM 35n8(66), Nat 211 283(66)}; **others:** {NNES 9d4 793(51), Nwis 33 279(46)}
Class: A; **Ident:** chem, genet {JACS 68 2411(b)(46), NNES 9d4 793(51)}
Prod: daughter ^{106}Ru {Nwis 33 279(46), Nat 156 163(46), NNES 9d4 793(51)}
β⁻: 3.53 1 (68 10%), 3.1 1 (11 3%), 2.44 7 (12 3%), 2.0 1 (3 1%), other β⁻ groups observed (total intensity 6%) *mag* {PR 88 339(52)}
3.55 (67.2%), 3.05 (12.5%), 2.39 (1.7%), 2.0 (2%) *mag* {NP 29 657(62)}
3.55 (79.2%), 3.04 (7.9%), 2.41 *mag* {BAPS 11 409(66), ND 13 397(74), PC67 Johnson}
others: {ZP A275 127(75), NIM 76 77(69), NIM 24 142(63), NIM 24 109(63), NP 16 138(60), IzF 22 194(56), PR 72 1049(47)}
γ: 0.5118605 31 *Ge(Li)* {NIM 137 599(76)}
(norm: $γ_{0.512}$ (γ 19 1%), RoAc 12 64(69), JMD) 0.3277 10 (†,0.023 6), 0.42839 22 (†,3.12 16), 0.4285 15 (†,0.25 6), 0.4343 5 (†,1.16 6), 0.51180 15 (†,1000 40), 0.5249 10 (†,<0.1), 0.5326 7 (†,<0.2), 0.5782 9 (†,0.4 3), 0.61633 17 (†,43 6), 0.6222 3 (†,515 20), 0.6477 8 (†,<0.3), 0.6607 5 (†,1.3 3), 0.6806 4 (†,0.44 8), 0.6848 6 (†,0.31 22), 0.7157 5 (†,0.34 15), 0.7173 5 (†,0.34 15), 0.7517 8 (†,0.06 4), 0.87373 9 (†,23.7 12), 0.9087 10 (†,<0.02), 0.9621 12 (†,0.23 22), 0.9774 13 (†,0.21 21), 1.0448 15 (†,0.59 16), 1.05047 7 (†,84 4), 1.06222 6 (†,1.67 11), 1.10866 19 (†,0.26 4), 1.11469 10 (†,0.55 4), 1.12821 6 (†,22.0 12), 1.18021 24 (†,0.17 3), 1.18086 9 (†,0.76 5), 1.19468 6 (†,3.11 17), 1.2102 7 (†,0.027 14), 1.2664 7 (†,0.06 3), 1.3052 8 (†,0.040 23), 1.31543 24 (†,0.16 3), 1.3604 4 (†,0.095 24), 1.3717 3 (†,0.137 21), 1.39766 15 (†,0.169 21), 1.4762 11 (†,0.097 23), 1.4795 15 (†,0.033 12), 1.48946 16 (†,0.090 12), 1.49622 8 (†,1.19 7), 1.49871 16 (†,0.37 4), 1.56220 6 (†,8.9 5), 1.5727 3 (†,0.086 23), 1.5771 5 (†,0.056 24), 1.7306 3 (†,0.100 17), 1.76625 7 (†,1.62 10), 1.7742 8 (†,0.042 22), 1.79677 7 (†,1.48 8), 1.8548 10 (†,0.043 23), 1.9093 5 (†,0.068 22), 1.92696 6 (†,0.80 5), 1.98609 7 (†,1.41 8), 2.0925 12 (†,0.022 16), 2.11213 9 (†,1.95 12), 2.19269 15 (†,0.26 3), 2.24204 17 (†,0.105 11), 2.2715 3 (†,0.051 11), 2.30647 12 (†,0.306 21), 2.31565 12 (†,0.348 21), 2.36555 10 (†,1.25 7), 2.39004 12 (†,0.337 21), 2.40549 11 (†,0.81 4), 2.43855 13 (†,0.253 21), 2.4840 3 (†,0.05 1), 2.5156 12 (†,0.012 7), 2.5254 10 (†,0.015 6), 2.54289 17 (†,0.158 11), 2.5707 3 (†,0.068 12), 2.6510 4 (†,0.030 7), 2.7051 3 (†,0.137 21), 2.70874 21 (†,0.211 21), 2.8084 5 (†,0.033 6), 2.8203 3 (†,0.074 11), 2.8770 11 (†,0.011 6), 2.9171 3 (†,0.046 7), 3.0365 3 (†,0.065 6), 3.0535 9 (†,0.019 9) *Ge(Li)*, *Ge(Li)-Ge(Li) γγ coinc* {PR C12 582(75)}
0.4985 15 (†,0.2 1), 0.5118 2 (†,1000, $e_K/γ$ assumed 0.00485), 0.5440 5 (†,0.15 5), 0.5529 15 (†,0.10 3), 0.5857 15 (†,0.07 2), 0.5692 15 (†,0.10 3), 0.5881 4 (†,0.05 1), 0.6025 15 (†,0.08 3), 0.6162 3 (†,33.7 27, $e_K/γ$ 0.0029 12), 0.6218 3 (†,476 15, $e_K/γ$ 0.00315 43), 0.6643 8 (†,0.12 3), 0.7746 15 (†,0.31 8), 0.8731 3 (†,20.2 8), 1.0501 3 (†,70.6 28), 1.1280 3 (†,18.7 6), 1.1338 (†,≤1.3, $e_K/γ$ ≥0.23), 1.1501 15 (†,<0.02), 1.1587 20 (†,0.02 1), 1.2204 20 (†,0.02 2), 1.2317 12 (†,0.036 16), 1.2570 20 (†,0.048 24), 1.2666 15 (†,0.033 16), 1.3056 10 (†,0.14 6), 1.3107 10 (†,0.17 5), 1.3550 6 (†,0.031 15), 1.3599 4 (†,0.058 10), 1.4578 5 (†,0.05 1), 1.5744 9 (†,0.045 15), 1.5927 10 (†,0.04 2), 1.6057 15 (†,0.04 2), 1.6098 10 (†,0.011 5), 1.6861 20 (†,0.05 2), 1.7331 6 (†,0.06 2), 1.7840 20, 1.7890 20 (†,($γ_{1.784}$+$γ_{1.789}$) 0.025 15), 1.9040 8 (†,0.016 5), 1.9094 8 (†,0.033 6), 1.9504 15 (†,0.030 15), 1.9568 20 (†,0.030 15), 2.0140 20 (†,0.02 2), 2.0339 10 (†,0.015 10), 2.0419 15 (†,0.015 15), 2.1932 6, 2.2107 12 (†,0.010 4), 2.2304 10 (†,0.014 4), 2.2424 6 (†,0.070 15), 2.5252 20 (†,0.004 4), 2.7405 6 (†,0.010 3), 2.7835 10 (†,0.004 3), 2.9041 15 (†,0.006 2), 3.0271 10 (†,0.004 2), 3.0859 20 (†,0.002 1), 3.1615 20 (†,0.002 2), 3.1690 20 (†,0.002 2), other γ rays observed *Ge(Li)*, *mag conv*, *Ge(Li)-scint γγ coinc* {ZP 221 231(69), YadF 17 1121(73)}
0.2795 8 (†,0.07 2), 0.3072 8 (†,0.10 3), 0.3170 8 (†,0.11 3), 0.3247 8 (†,0.17 3), 0.3283 8 (†,0.10 2), 0.3332 10 (†,0.15 2), 0.3825 10 (†,0.20 4), 0.3936 10 (†,0.17 6), 0.3971 10 (†,0.17 6), 0.4047 15 (†,0.13 4), 0.4194 10 (†,0.29 9), 0.4307 8 (†,0.50 15), 0.4375 8 (†,0.20 5), 0.4396 10 (†,0.30 6), 0.4635 8 (†,0.15 3), 0.5118 2 (†,1000), 0.5304 6 (†,0.12 5), 0.5358 8 (†,0.15 3), 0.5594 6 (†,0.09 3), 0.5965 8 (†,0.13 3), 0.6362 8 (†,0.11 2), 0.6661 8 (†,0.07 3), 0.7043 5 (†,0.12 4), 0.7087 5 (†,0.09 3), 0.7158 3 (†,0.46 5), 0.7173 5 (†,0.39 4), 0.7398 8 (†,0.11 5), 0.7718 10 (†,0.09 3), 0.7949 8 (†,0.07 2), 0.9427 10 (†,≈0.05), 0.9494 8 (†,0.11 2), 0.9619 8 (†,0.10 2), 0.9743 8 (†,0.09 2), 0.9836 8 (†,0.09 2), 1.1438 5 (†,0.06 1), 1.1504 5 (†,0.14 2), 1.1721 10 (†,0.030 3), 1.1805 3 (†,0.69 7), 1.2097 10 (†,0.020 4), 1.2124 10 (†,0.020 4), $γ_{1.220}$ (†,0.025 5), 1.2223 10 (†,0.030 6), 1.2524 15 (†,0.010 5), 1.2552 10 (†,0.060 12), 1.2895 15 (†,0.017 3), 1.3304 5 (†,0.040 6), 1.3720 4 (†,0.10 2), 1.4072 10 (†,0.04 2), 1.4795 10 (†,0.03 1), 1.4982 8 (†,0.25 6), 1.5770 7 (†,0.06 1), 1.5886 10 (†,0.09 2), 1.6211 10 (†,0.020 6), 1.6284 10 (†,0.017 6), 1.6305 10 (†,0.020 6), 1.6564 15 (†,0.022 6), 1.6602 10 (†,0.025 5), 1.6786 20 (†,0.020 6), 1.6935 8 (†,0.058 17), 1.7001 10 (†,0.020 6), 1.7182 10 (†,0.020 6), 1.7845 10 (†,0.02 1), 1.7906 10 (†,0.10 3), 1.8641 10 (†,0.007 2), 1.8698 10 (†,0.008 2), 1.9220 15 (†,0.03 1), 1.9270 3 (†,0.51 10), 1.9275 9 (†,0.20 4), 2.0173 10 (†,0.008 4), 2.0586 10 (†,0.010 3), 2.0625 20 (†,0.007 3), 2.1394 10 (†,0.007 3), 2.1930 3 (†,0.25 3), 2.3084 6 (†,0.15 2), 2.3093 6 (†,0.10 1), 2.4573 10 (†,0.006 3), 2.5353 10 (†,0.002 1), 2.5548 3 (†,0.14 1), 2.6247 15 (†,0.010 5), 2.7395 10 (†,0.009 2), 2.7409 10 (†,0.007 2), 2.7546 10 (†,0.002 1), 2.7628 10 (†,0.002 1), 2.7865 10 (†,0.004 1), 2.941 2 (†,≈0.001), 3.1531 25 (†,0.0010 5), 3.2518 15 (†,0.004 1), 3.2755 15 (†,0.003 1), 3.299 3 (†,≈5×10⁻⁶), other γ rays observed *Ge(Li)* {CR 275B 805(72), ND 13 397(74), PC73 Marsol, JMD}
$γ_{0.512}$ (K/L+M+... 6.15 62), other γ rays observed *scint*, *scint-scint γγ coinc*, *scint γγ sum coinc* {NP 16 138(60)}
$γ_{0.512}$ (K/L+M+... 7.1 10), $γ_{0.622}$ (K/L+M+... 5 2), other γ rays observed *mag*, *mag conv* {IzF 22 194(58)}
others: {IzF 39 555(75), ANCR-1088 392(72), AOsa 12 28(71), RoAc 12 64(69), AFen n274(68), CR 264B 1614(67), IzF 31 696(67), NP A103 385(67), YadF 4 683(66), NP 29 657(62), PR 122 1600(61), PR 119 1692(60), IzF 21 1633(57), PR 100 1357(55), PR 92 902(53), Phca 18 1110(52), PR 88 339(52), PR 86 575(52), PR 79 398(50), PR 72 1049(47)}
βγ(θ): {PR 174 1426(68)}
γγ(θ): {PR C12 562(75), IAoP 12 391(74), PR C7 1238(73), AmJP 40 1542(72), NIM 105 141(72), AOsa 12 28(71), JPJa 29 1111(70), ZP 221 231(69), AFen n274(68), ArkF 37 445(68), NIM 65 77(68), NP A122 577(68), NP A103 300(67), NP 16 138(60), PR 92 1469(53), PR 89 1061(53)}
$γγ_{lin\ p}$(θ): {NP A122 577(68), PR 89 1061(53), PR 78 622(50), PR 78 551(50)}



$^{106}_{45}Rh$ levels - References
Decay: PR 77 655(50), ZNat 10a 80(55)

FIGURE J-5. Decay Scheme of ^{106}Rh (from Ref. 5).

9212499943

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

FOR Fred Stong
LOCATION C
SUBJECT

PAGE 1
JOB NO. (GN-RE-HJG-039)
DATE 19 Aug 80
BY Warren Gibbons
CHECKED BY [illegible]

Group no.	Average energy in this group (MeV)	% of photons initially in this group (1 Ci/L)	% of energy in this flux group at 125 cm	% of photons in this flux group at 125 cm*
1	0.015	12.253	0	0
2	0.025	6.339	0	0
3	0.035	4.338	0	0
4	0.045	3.090	0	0
5	0.055	2.360	0	0
6	0.065	1.931	5.35×10^{-29}	7.882×10^{-28}
7	0.075	1.536	6.30×10^{-23}	1.718×10^{-21}
8	0.085	1.298	1.05×10^{-18}	2.526×10^{-17}
9	0.095	1.177	2.36×10^{-16}	5.080×10^{-15}
10	0.150	8.412	2.59×10^{-10}	3.532×10^{-9}
11	0.250	3.052	4.17×10^{-6}	3.411×10^{-5}
12	0.350	1.620	1.32×10^{-3}	7.712×10^{-3}
13	0.475	30.94	0.296	1.274
14	0.650	16.32	0.324	1.018
15	0.825	1.014	0.158	0.393
16	1.000	2.548	4.515	9.234
17	1.225	0.973	3.056	5.103
18	1.475	0.386	4.906	6.802
19	1.700	0.111	2.968	3.571
20	1.900	0.0908	10.32	11.107
21	2.100	7.792×10^{-2}	14.53	14.151
22	2.300	3.973×10^{-2}	9.739	8.659
23	2.500	6.53×10^{-2}	26.89	22.00
24	2.700	3.239×10^{-2}	19.84	15.03
25	3.000	8.937×10^{-4}	2.428	1.655

*This column was obtained by dividing Column 4 by Column 2 and normalizing.

FIGURE J-6. ISOSHLD Results of Shielding Effect of 125 cm of Hanford Soil on 25 Group Energy Spectrum for 1 Ci/L ^{106}Ru-^{106}Rh. (Sheet 1 of 2)

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

PAGE 2
JOB NO. (GN-RE-HJG-039)
DATE 19 Aug 80
BY Harvey Goldberg
CHECKED BY [signature]

FOR Fred Stong
LOCATION
SUBJECT

The results of the ISOSHLD runs for 1 Ci/L are as follows:

Thickness of earth (cm)	Dose rate (R/hr)
10	7.127×10^{0}
15	2.467×10^{0}
20	9.214×10^{-1}
25	3.704×10^{-1}
30	1.571×10^{-1}
35	6.961×10^{-2}
40	3.208×10^{-2}
45	1.535×10^{-2}
50	7.607×10^{-3}
55	3.902×10^{-3}
60	2.067×10^{-3}
65	1.129×10^{-3}
70	6.337×10^{-4}
75	3.647×10^{-4}
80	2.145×10^{-4}
85	1.286×10^{-4}
90	7.834×10^{-5}
95	4.840×10^{-5}
100	3.026×10^{-5}
105	1.911×10^{-5}
110	1.218×10^{-5}
115	7.817×10^{-6}
120	5.050×10^{-6}
125	3.281×10^{-6}
130	2.142×10^{-6}
135	1.405×10^{-6}

NOTE: The above numbers can be scaled linearly for the other concentrations. (These data are plotted in Figure J-3.)

FIGURE J-6. Dose Rate in Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source, Results of the ISOSHLD Runs for 1 Ci/L. (Sheet 2 of 2)

9 2 1 2 4 9 9 1 9 4 6

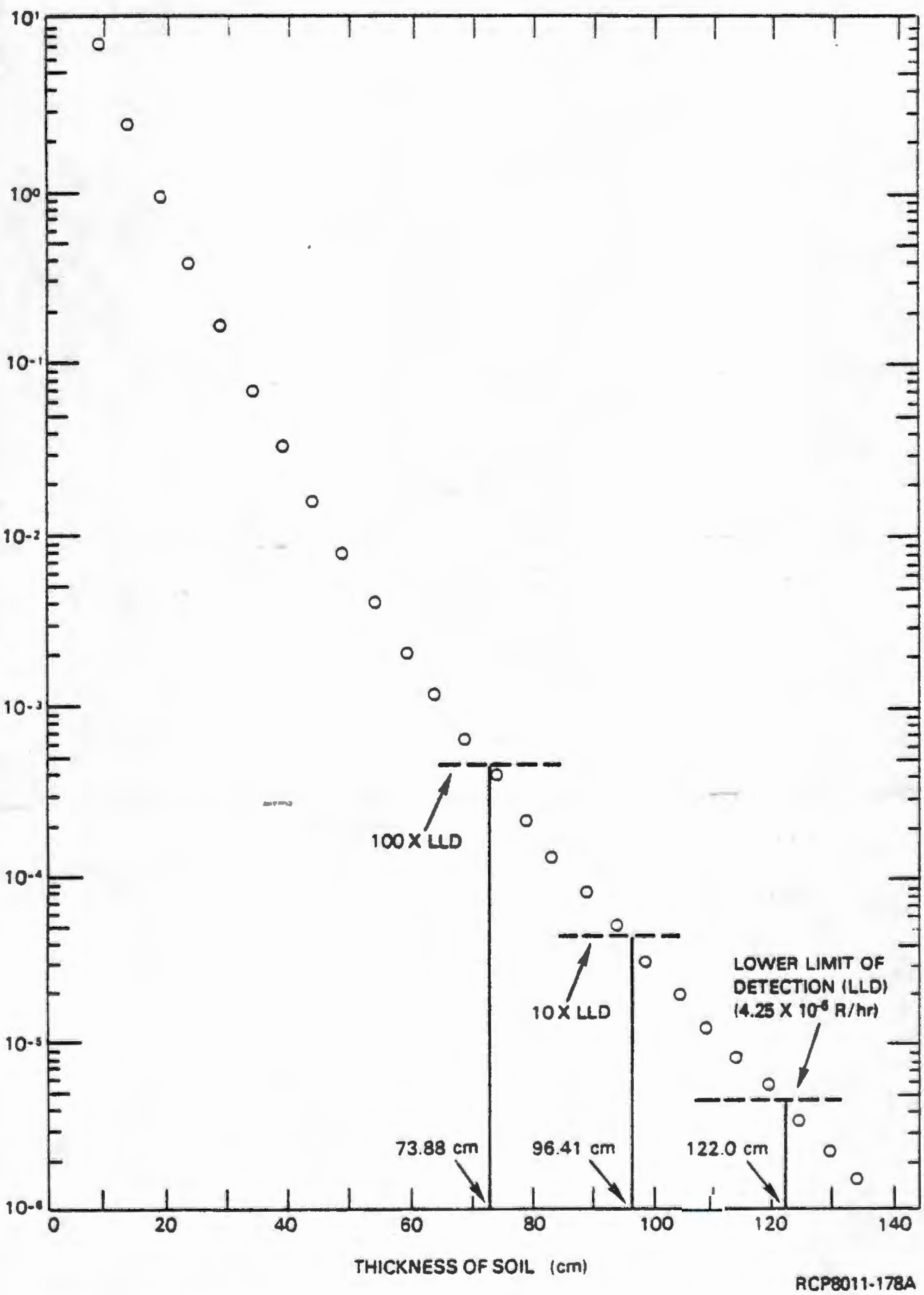


FIGURE J-7. Dose Rate in Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 1 Ci/L. (Sheet 1 of 2)

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

FOR Fred Stong
LOCATION
SUBJECT

PAGE 4
JOB NO. (GN-RE-HJG-039)
DATE 19 Aug 80
BY Harvey Goldberg
CHECKED BY [signature]

To find the distance of bare detection:

(1) $\ln(5.050 \times 10^{-6}) = -12.20 = 2 + 120b$

(2) $\ln(3.281 \times 10^{-6}) = -12.63 = a + 125b$

(3) = (2) - (1) $-0.430 = 5b$

(4) $b = -0.086$.

Substitute into (1)

(5) $-12.20 = a - 10.32$

(6) $a = -1.88$

(7) $\ln(4.25 \times 10^{-6}) = -12.37 = -1.88 - 0.086t$

(8) $t = 122.0$ cm = 48.02 in.

We now do the same for 10 x LLD:

(1) $\ln(3.026 \times 10^{-5}) = -10.41 = a + 100b$

(2) $\ln(4.840 \times 10^{-5}) = -9.936 = a + 95b$

(3) $0.474 = -5b$

(4) $b = -0.0948$

(5) $-10.41 = a - 9.48$

(6) $a = -0.930$

(7) $\ln(4.25 \times 10^{-5}) = -10.07 = -0.930 - 0.0948t$

(8) $t = 96.41$ cm = 37.96 in.

Finally the 100 x LLD.

(1) $\ln(6.337 \times 10^{-4}) = -7.364 = a + 70b$

(2) $\ln(3.647 \times 10^{-4}) = -7.916 = a + 75b$

(3) $-0.552 = 5b$

(4) $b = -0.110$

(5) $-7.364 = a - 7.728$

(6) $a = 0.364$

(7) $\ln(4.25 \times 10^{-4}) = -7.763 = +0.364 - 0.110t$

(8) $t = 73.88$ cm = 29.09 in.

Thus, the last tenth-value thickness before the detector cannot detect the radiation is 25.59 cm (10.07 in.), and the next to last tenth-value thickness is 22.53 cm (8.87 in.).

This is for 1 Ci/L.

FIGURE J-7. Dose Rate in Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 1 Ci/L. (Sheet 2 of 2)

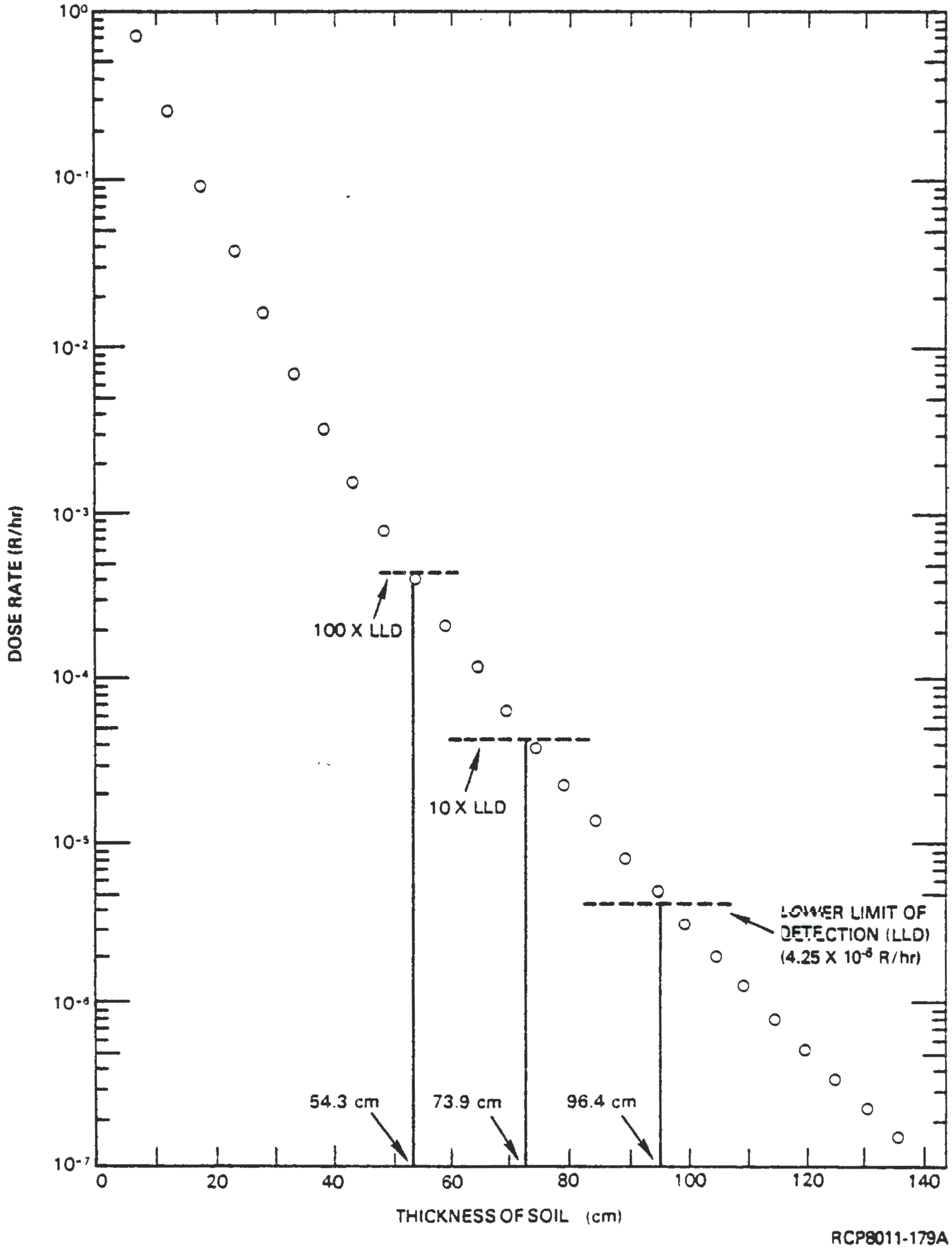


FIGURE J-8. Dose Rate of Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 0.1 Ci/L. (Sheet 1 of 2)

9 2 1 2 4 9 9 1 9 3

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

PAGE 6
JOB NO. (GN-RE-HJG-039)
DATE 19 Aug 80
BY Harvey Goldberg
CHECKED BY [signature]

FOR Fred Stong
LOCATION
SUBJECT

0.1 Ci/L

To find the lower limit of detection:

$\ln(3.026 \times 10^{-6}) = -12.71 = a + 100b$

$\ln(4.840 \times 10^{-6}) = -12.24 = a + 95b$

$b = -00.094$

$a = -03.31$

$\ln(4.25 \times 10^{-6}) = -12.37 = -03.31 - 00.094t$

$t = 96.38$ cm $= 37.95$ in.

10 x LLD

$\ln(3.647 \times 10^{-5}) = -10.219 = a + 75b$

$\ln(6.337 \times 10^{-5}) = -9.667 = a + 70b$

$b = -0.110$

$a = -1.94$

$\ln(4.25 \times 10^{-5}) = -10.066 = -1.94 - 0.110t$

$t = 73.87$ cm $= 29.08$ in.

100 x LLD

$\ln(7.607 \times 10^{-4}) = -7.181 = a + 50b$

$\ln(3.902 \times 10^{-4}) = -7.849 = a + 55b$

$b = -0.134$

$a = -0.481$

$\ln(4.25 \times 10^{-4}) = -7.763 = -0.481 - 0.134t$

$t = 54.34$ cm $= 21.39$ in.

Thus, the last tenth-value thickness before the detector cannot detect the radiation is 22.51 cm (8.86 in.), and the next to last tenth-value thickness is 19.53 cm (7.69 in.).

FIGURE J-8. Dose Rate of Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 0.1 Ci/L. (Sheet 2 of 2)

9 2 1 2 4 9 9 1 9 5 0

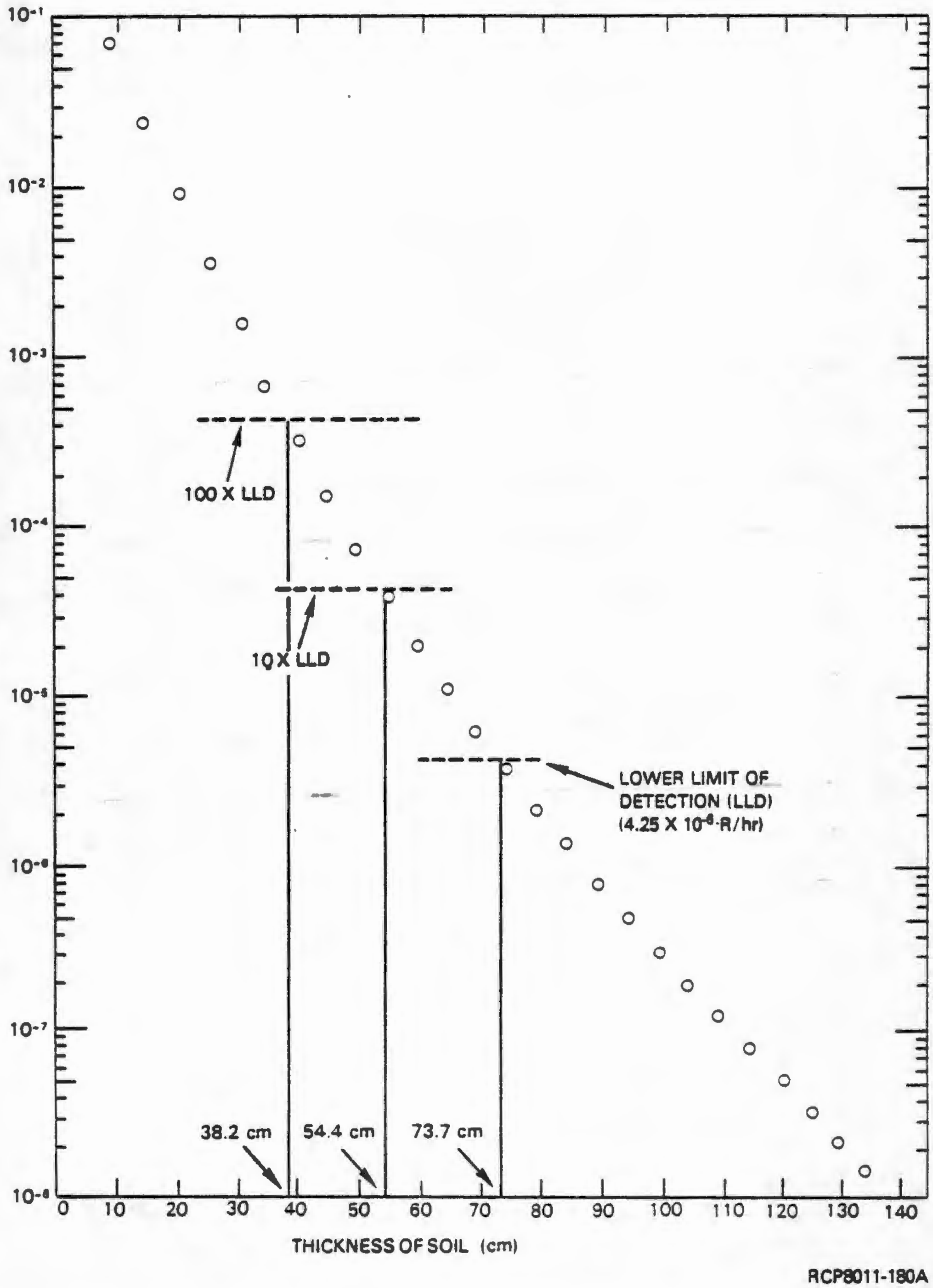


FIGURE J-9. Dose Rate of Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 0.01 Ci/L. (Sheet 1 of 2)

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

PAGE 8
JOB NO. (GN-RE-HJG-039)
DATE 19 August 80
BY Harvey Goldberg
CHECKED BY [signature]

FOR Fred Stong
LOCATION
SUBJECT

0.01 Ci/L

Lower limit of detection:

$$\ln(6.337 \times 10^{-6}) = -11.969 = a + 70b$$

$$\ln(3.647 \times 10^{-6}) = -12.52 = a + 75b$$

$$b = -0.110$$

$$a = -4.269$$

$$\ln(4.25 \times 10^{-6}) = -12.37 = -4.269 - 0.110t$$

$$t = 73.65 \text{ cm} = 28.99 \text{ in.}$$

10 x LLD

$$\ln(7.607 \times 10^{-5}) = -9.484 = a + 50b$$

$$\ln(3.902 \times 10^{-5}) = -10.151 = a + 55b$$

$$b = -0.133$$

$$a = -2.834$$

$$\ln(4.25 \times 10^{-5}) = -10.066 = -2.834 - 0.133t$$

$$t = 54.38 \text{ cm} = 21.41 \text{ in.}$$

100 x LLD

$$\ln(6.961 \times 10^{-4}) = -7.270 = a + 35b$$

$$\ln(3.208 \times 10^{-4}) = -8.045 = a + 40b$$

$$b = -0.155$$

$$a = -1.845$$

$$\ln(4.25 \times 10^{-4}) = -7.763 = -1.845 - 0.155t$$

$$t = 38.18 \text{ cm} = 15.03 \text{ in.}$$

Thus, the last tenth-value layer before the detector cannot detect the radiation is 19.27 cm (7.59 in.), and the next to last tenth-value layer is 16.20 cm (6.38 in.).

FIGURE J-9. Dose Rate of Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 0.01 Ci/L. (Sheet 2 of 2)

9 2 1 2 4 9 9 1 9 5 1

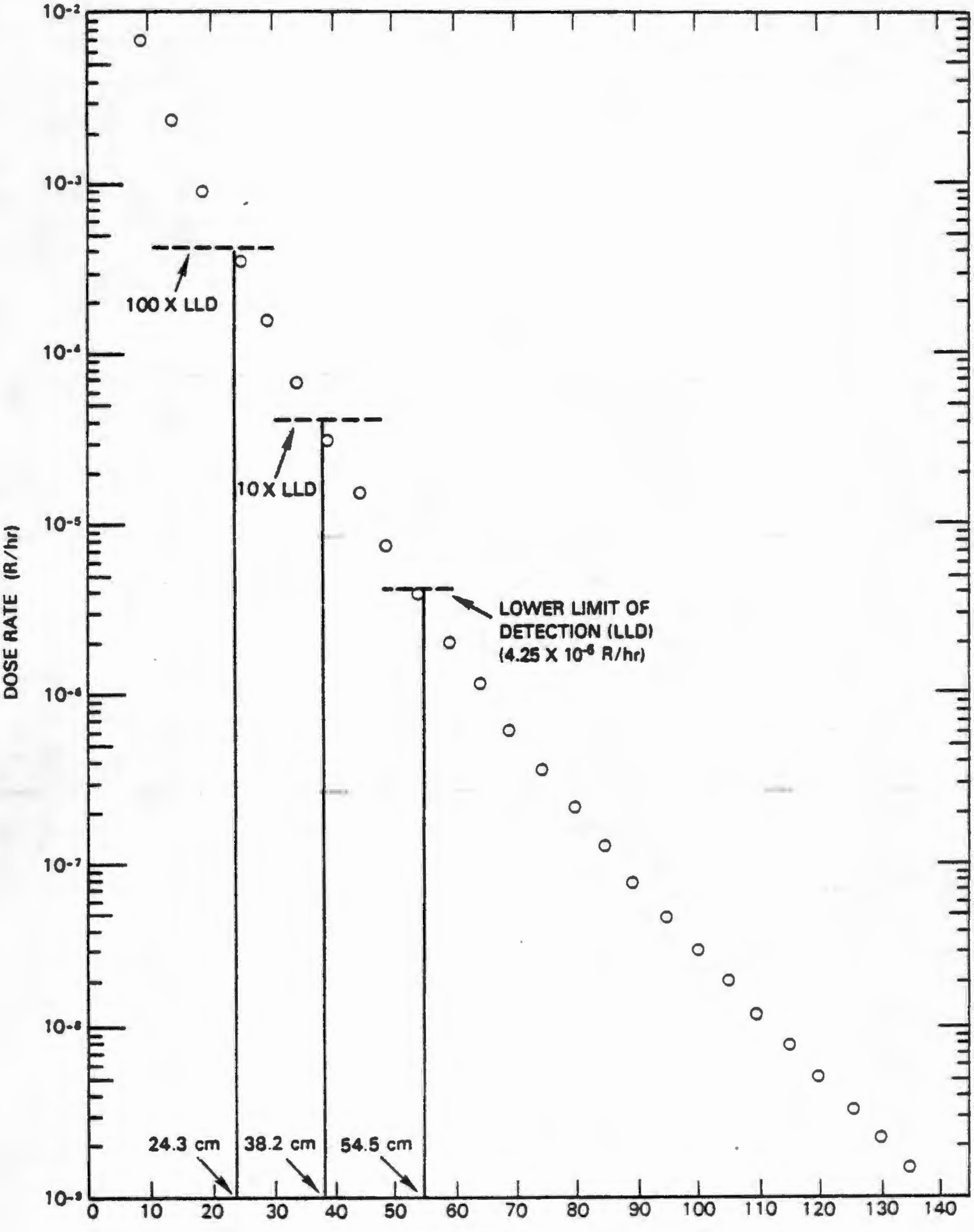


FIGURE J-10. Dose Rate of Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 0.001 Ci/L. (Sheet 1 of 2)

9 2 1 2 4 9 9 1 9 5 2

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

FOR Fred Stong
LOCATION 0
SUBJECT

PAGE 10
JOB NO. (GN-RE-HJG-039)
DATE 19 August 86
BY Harvey Goldberg
CHECKED BY [signature]

0.001 Ci/L

Lower limit of detection:

$\ln(7.607 \times 10^{-6}) = -11.79 = a + 50b$

$\ln(3.902 \times 10^{-6}) = -12.43 = a + 55b$

$b = -0.128$

$a = -5.39$

$\ln(4.25 \times 10^{-6}) = -12.37 = -5.39 - 0.128t$

$t = 54.53$ cm $= 21.47$ in.

10 x LLD

$\ln(6.961 \times 10^{-5}) = -9.573 = a + 35b$

$\ln(3.208 \times 10^{-5}) = -10.347 = a + 40b$

$b = -0.155$

$a = -4.148$

$\ln(4.25 \times 10^{-5}) = -10.066 = -4.148 - 0.155t$

$t = 38.18$ cm $= 15.03$ in.

100 x LLD

$\ln(9.214 \times 10^{-4}) = -6.990 = a + 20b$

$\ln(3.704 \times 10^{-4}) = -7.901 = a + 25b$

$b = -0.182$

$a = -3.350$

$\ln(4.25 \times 10^{-4}) = -7.763 = -3.350 - 0.182t$

$t = 24.25$ cm $= 9.55$ in.

Thus, the last tenth-value thickness before the detector cannot detect the radiation is 16.35 cm (6.44 in.), and the thickness of the next to last tenth-value thickness is 13.93 cm (5.48 in.).

FIGURE J-10. Dose Rate of Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 0.001 Ci/L. (Sheet 2 of 2)

9212499953

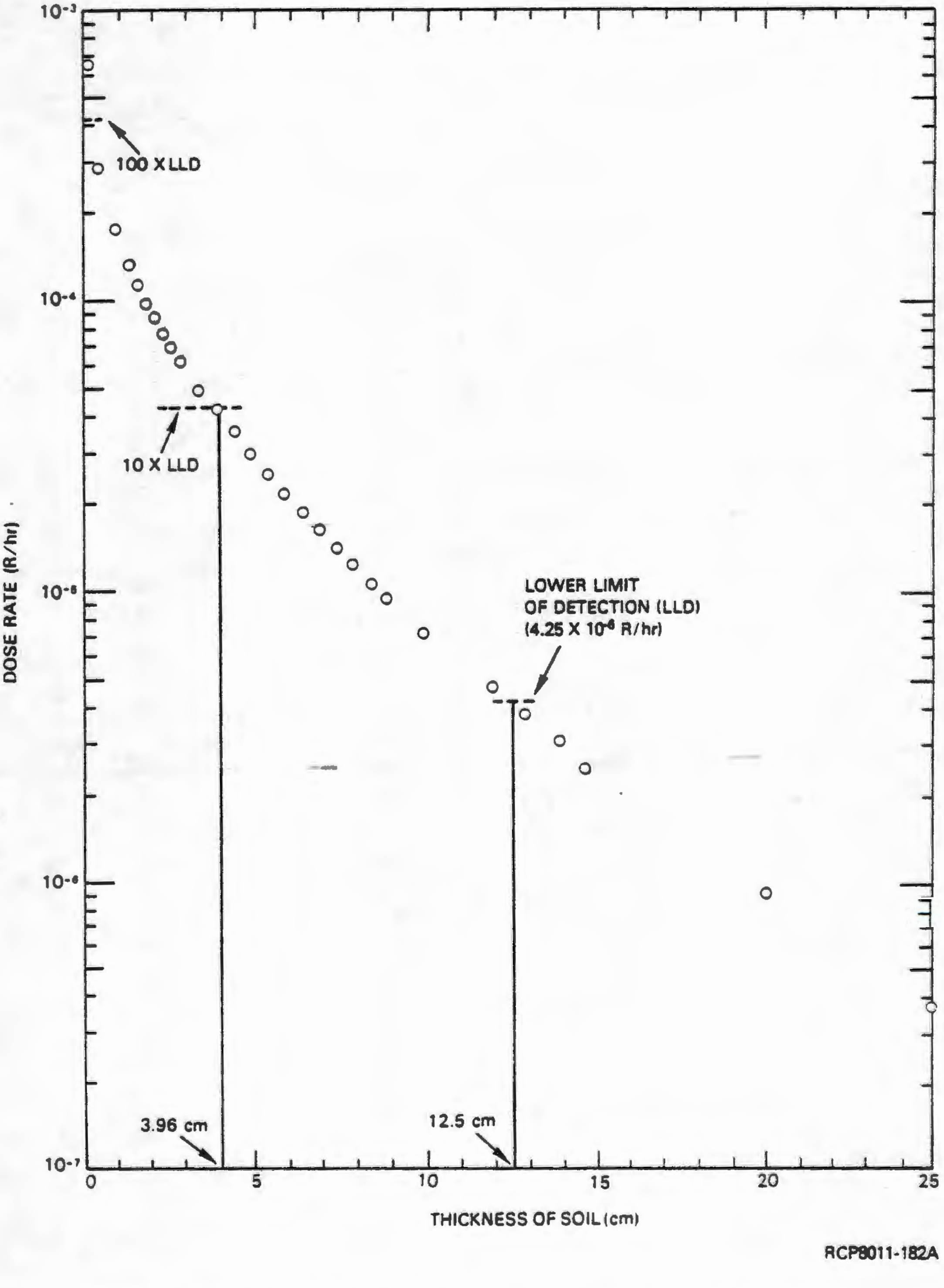


FIGURE J-11. Dose Rate of Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 1 μCi/L. (Sheet 1 of 3)

9 2 1 2 4 9 9 1 9 5 4

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

PAGE 12
JOB NO. (GN-RE-HJG-039)
DATE 19 August 1980
BY Harvey Goldberg
CHECKED BY [signature]

FOR Fred Stong
LOCATION
SUBJECT

Thickness of dirt (cm)	Dose rate (R/hr)	Thickness of dirt (cm)	Dose rate (R/hr)
0.01	6.68×10^{-4}	14.0	3.04×10^{-6}
0.5	2.87×10^{-4}	15.0	2.47×10^{-6}
1.0	1.85×10^{-4}	20.0	9.21×10^{-7}
1.5	1.32×10^{-4}	25.0	3.70×10^{-7}
1.75	1.14×10^{-4}	30.0	1.57×10^{-7}
2.0	9.97×10^{-5}	35.0	6.96×10^{-8}
2.25	8.78×10^{-5}	40.0	3.21×10^{-8}
2.5	7.783×10^{-5}	45.0	1.54×10^{-8}
2.75	6.94×10^{-5}	50.0	7.61×10^{-9}
3.0	6.13×10^{-5}	55.0	3.90×10^{-9}
3.5	5.068×10^{-5}	60.0	2.07×10^{-9}
4.0	4.19×10^{-5}	65.0	1.13×10^{-9}
4.5	3.50×10^{-5}	70.0	6.34×10^{-10}
5.0	2.96×10^{-5}	75.0	3.65×10^{-10}
5.5	2.52×10^{-5}	80.0	2.15×10^{-10}
6.0	2.16×10^{-5}	85.0	1.29×10^{-10}
6.5	1.86×10^{-5}	90.0	7.83×10^{-11}
7.0	1.62×10^{-5}	95.0	4.84×10^{-11}
7.5	1.41×10^{-5}	100.0	3.03×10^{-11}
8.0	1.23×10^{-5}	105.0	1.91×10^{-11}
8.5	1.08×10^{-5}	110.0	1.22×10^{-11}
9.0	9.52×10^{-6}	115.0	7.82×10^{-12}
9.5		120.0	5.05×10^{-12}
10.0	7.13×10^{-6}	125.0	3.28×10^{-12}
11.0		130.0	2.14×10^{-12}
12.0	4.69×10^{-6}	135.0	1.41×10^{-12}
13.0	3.77×10^{-6}		

FIGURE J-11. Dose Rate of Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 1 μCi/L. (Sheet 2 of 3)

Rockwell International
Rockwell Hanford Operations
Energy Systems Group

DESIGN ANALYSIS

PAGE 15
JOB NO. (GN-RE-HJG-039)
DATE 19 August 1980
BY Harvey Goldberg
CHECKED BY

FOR Fred Strong
LOCATION
SUBJECT

For the lower limit of detection:

$$\ln(3.77 \times 10^{-6}) = -12.49 = a + 13b$$

$$\ln(4.69 \times 10^{-6}) = -12.27 = a + 12b$$

$$b = -0.220$$

$$a = -9.63$$

$$\ln(4.25 \times 10^{-6}) = -12.37 = -9.63 - 0.220t$$

$$t = 12.45 \text{ cm} = 4.9 \text{ in.}$$

For 10 x LLD:

$$\ln(5.068 \times 10^{-5}) = -9.890 = a + 3.5b$$

$$\ln(4.19 \times 10^{-5}) = -10.080 = a + 4.0b$$

$$b = -0.380$$

$$a = -8.56$$

$$\ln(4.25 \times 10^{-5}) = -10.066 = -8.56 - 0.380t$$

$$t = 3.96 \text{ cm} = 1.56 \text{ in.}$$

For 100 x LLD:

$$\ln(6.68 \times 10^{-4}) = -7.311 = a + 0.01b$$

$$\ln(2.87 \times 10^{-4}) = -8.156 = a + 0.5b$$

$$b = -1.724$$

$$a = -7.294$$

$$\ln(4.25 \times 10^{-4}) = -7.763 = -7.294 - 1.724t$$

$$t = 0.27 \text{ cm} = 0.107 \text{ in.}$$

To get a level of 5.2×10^{-5} R/hr:

$$\ln(5.068 \times 10^{-5}) = -9.890 = a + 3.5b$$

$$\ln(6.13 \times 10^{-5}) = -9.700 = a + 3.0b$$

$$b = -0.38$$

$$a = -8.56$$

$$\ln(5.2 \times 10^{-5}) = -9.864 = -8.56 - 0.38t$$

$$t = 3.43 \text{ cm} = 1.35 \text{ in.}$$

The last tenth-value thickness is 8.49 cm (3.34 in.), and the next to last tenth-value thickness is 3.69 cm (1.45 in.). The distance from the point of the limit of detection to the point at which the level is 5.2×10^{-5} R/hr is 9.02 cm (3.55 in.).

FIGURE J-11. Dose Rate of Soil as a Function of Distance from a ^{106}Ru-^{106}Rh Source of 1 µCi/L. (Sheet 3 of 3)

TABLE J-1. Radiation Levels Per Source Density for Various Thicknesses of Hanford Sediments (at a bulk density of 1.83 g/cm^2 of sediments, i.e., Hanford sand).

Sediment thickness (cm)	$f = \frac{\text{Dose rate}}{\text{Source density}}$ (R/hr)/(Ci/L)	Sediment thickness (cm)	$f = \frac{\text{Dose rate}}{\text{Source density}}$ (R/hr)/(Ci/L)
0.01	6.68×10^2	10.0	7.13×10^0
0.1	4.80×10^2	12.0	4.69×10^0
0.2	4.12×10^2	13.0	3.77×10^0
0.3	3.60×10^2	14.0	3.04×10^0
0.4	3.20×10^2	15.0	2.47×10^0
0.5	2.87×10^2	20	9.21×10^{-1}
0.6	2.60×10^2	25	3.70×10^{-1}
0.7	2.37×10^2	30	1.57×10^{-1}
0.8	2.17×10^2	35	6.96×10^{-2}
0.9	2.00×10^2	40	3.21×10^{-2}
1.0	1.85×10^2	45	1.54×10^{-2}
1.5	1.32×10^2	50	7.61×10^{-3}
1.75	1.14×10^2	55	3.90×10^{-3}
2.0	9.97×10^1	60	2.07×10^{-3}
2.25	8.78×10^1	65	1.13×10^{-3}
2.5	7.78×10^1	70	6.34×10^{-4}
2.75	6.98×10^1	75	3.65×10^{-4}
3.0	6.13×10^1	80	2.15×10^{-4}
3.5	5.07×10^1	85	1.29×10^{-4}
4.0	4.19×10^1	90	7.83×10^{-5}
4.5	3.50×10^1	95	4.84×10^{-5}
5.0	2.96×10^1	100	3.03×10^{-5}
5.5	2.52×10^1	105	1.91×10^{-5}
6.0	2.16×10^1	110	1.22×10^{-5}
6.5	1.86×10^1	115	7.82×10^{-6}
7.0	1.62×10^1	120	5.05×10^{-6}
7.5	1.41×10^1	125	3.28×10^{-6}
8.0	1.23×10^1	130	2.14×10^{-6}
8.5	1.08×10^1	135	1.41×10^{-6}
9.0	9.52×10^0		

DESIGN ANALYSIS

FOR Fred Stong
LOCATION
SUBJECT

PAGE 11
JOB NO. (GN-RE-HJG-039)
DATE 19 August 80
BY Harvey Goldberg
CHECKED BY [signature]

Find the point at which the level reaches 5.2×10^{-5} R/hr

1 Ci/L

$\ln(7.834 \times 10^{-5}) = -9.454 = a + 90b$

$\ln(4.840 \times 10^{-5}) = -9.936 = a + 95b$

$b = -0.0964$

$a = -0.778$

$\ln(5.2 \times 10^{-5}) = -9.864 = -0.778 - 0.0964t$

$t = 94.25$

This point is 27.75 cm (10.93 in.) from the LLD point.

0.1 Ci/L

$\ln(6.337 \times 10^{-5}) = -9.667 = a + 70b$

$\ln(3.647 \times 10^{-5}) = -10.219 = a + 75b$

$b = -0.110$

$a = -1.961$

$\ln(5.2 \times 10^{-5}) = -9.864 = -1.961 - 0.110t$

$t = 71.85$ cm

This point is 24.53 cm (9.66 in.) from the LLD point.

0.01 Ci/L

$\ln(7.607 \times 10^{-5}) = -9.484 = a + 50b$

$\ln(3.902 \times 10^{-5}) = -10.151 = a + 55b$

$b = -0.133$

$a = -2.834$

$\ln(5.2 \times 10^{-5}) = -9.864 = -2.834 - 0.133t$

$t = 52.86$ cm

This point is 20.79 cm (8.18 in.) from the LLD point.

0.001 Ci/L

$\ln(6.961 \times 10^{-5}) = -9.624 = a + 135b$

$\ln(3.208 \times 10^{-5}) = -10.347 = a + 40b$

$b = -0.145$

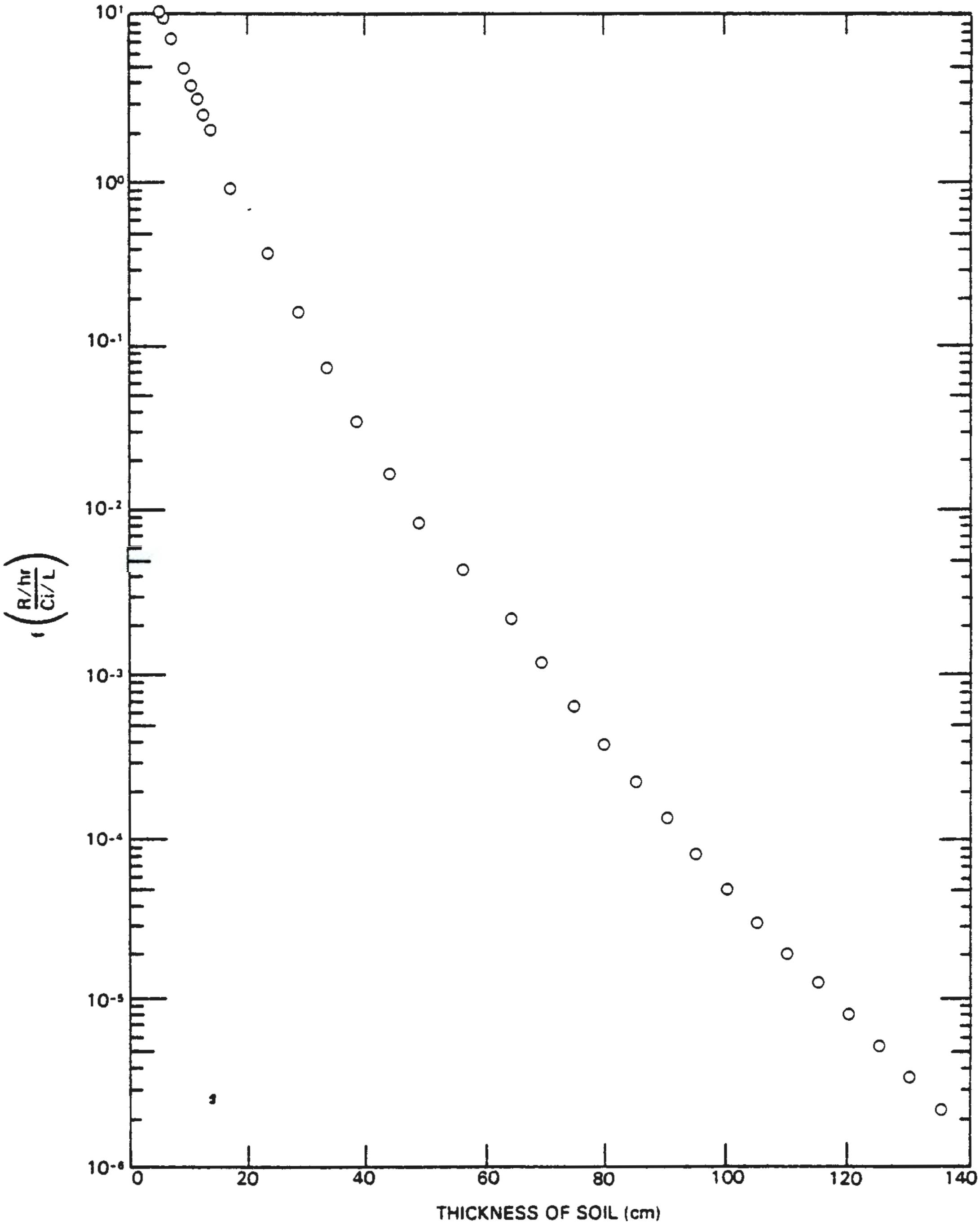
$a = -4.55$

$\ln(5.2 \times 10^{-5}) = -9.864 = -4.55 - 0.145t$

$t = 36.65$ cm

This point is 17.88 cm (7.04 in.) from the LLD point.

FIGURE J-12. Distances at Which the Dose Rate is 5.2×10^{-5} R/hr for ^{106}Ru-^{106}Rh Sources of 1, 0.1, 0.01, and 0.001 Ci/L.



RCP8011-172

FIGURE J-13. Radiation Levels Per Source Density for Various Thicknesses of Hanford Sediments (at a bulk density of 1.83 g/cm^2 of sediments, i.e., compacted Hanford sand) for the Range 0 to 140 cm.

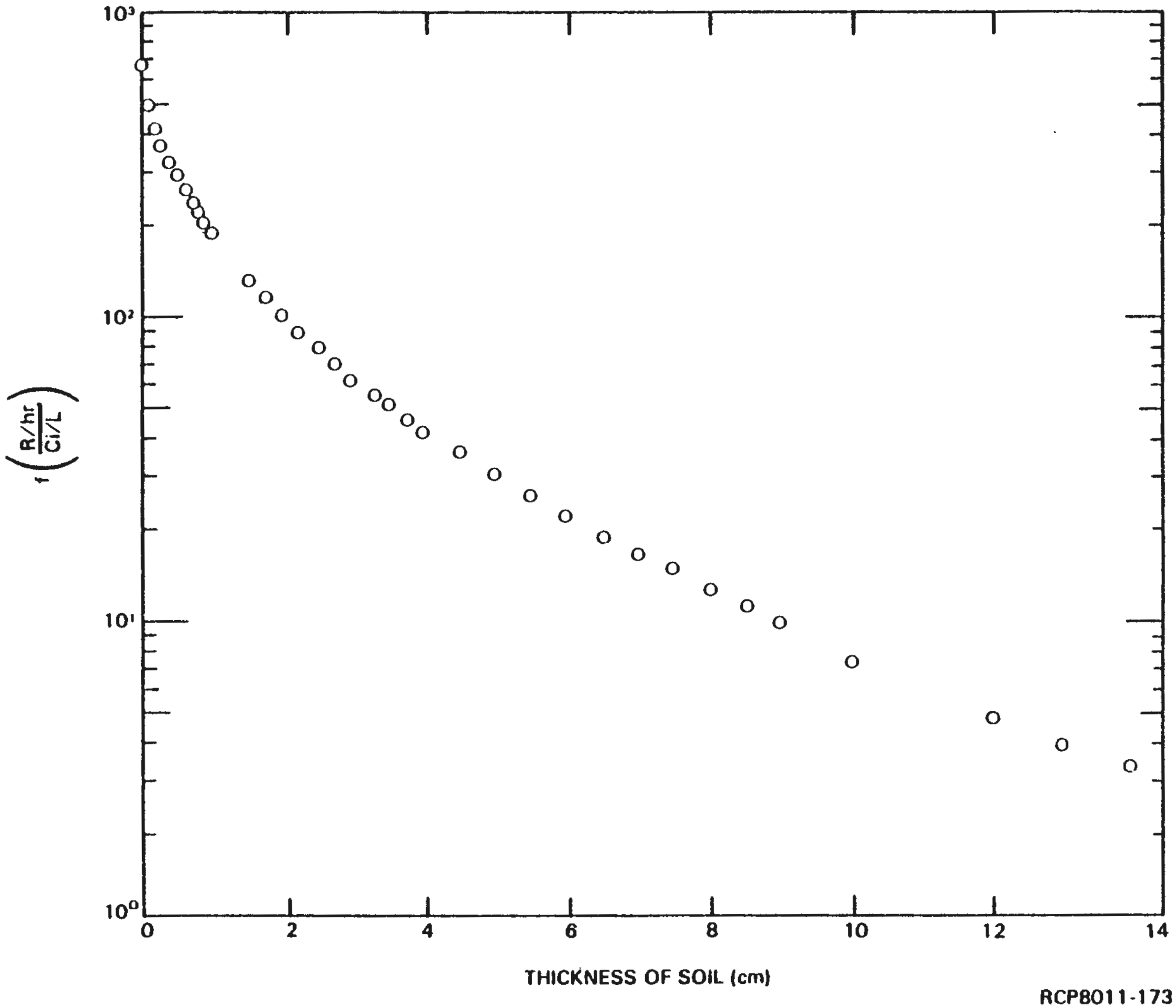


FIGURE J-14. Radiation Levels Per Source Density for Various Thicknesses of Hanford Sediments (at a bulk density of 1.83 g/cm^2 of sediments, i.e., completed Hanford sand) for the Range 0 to 14 cm.

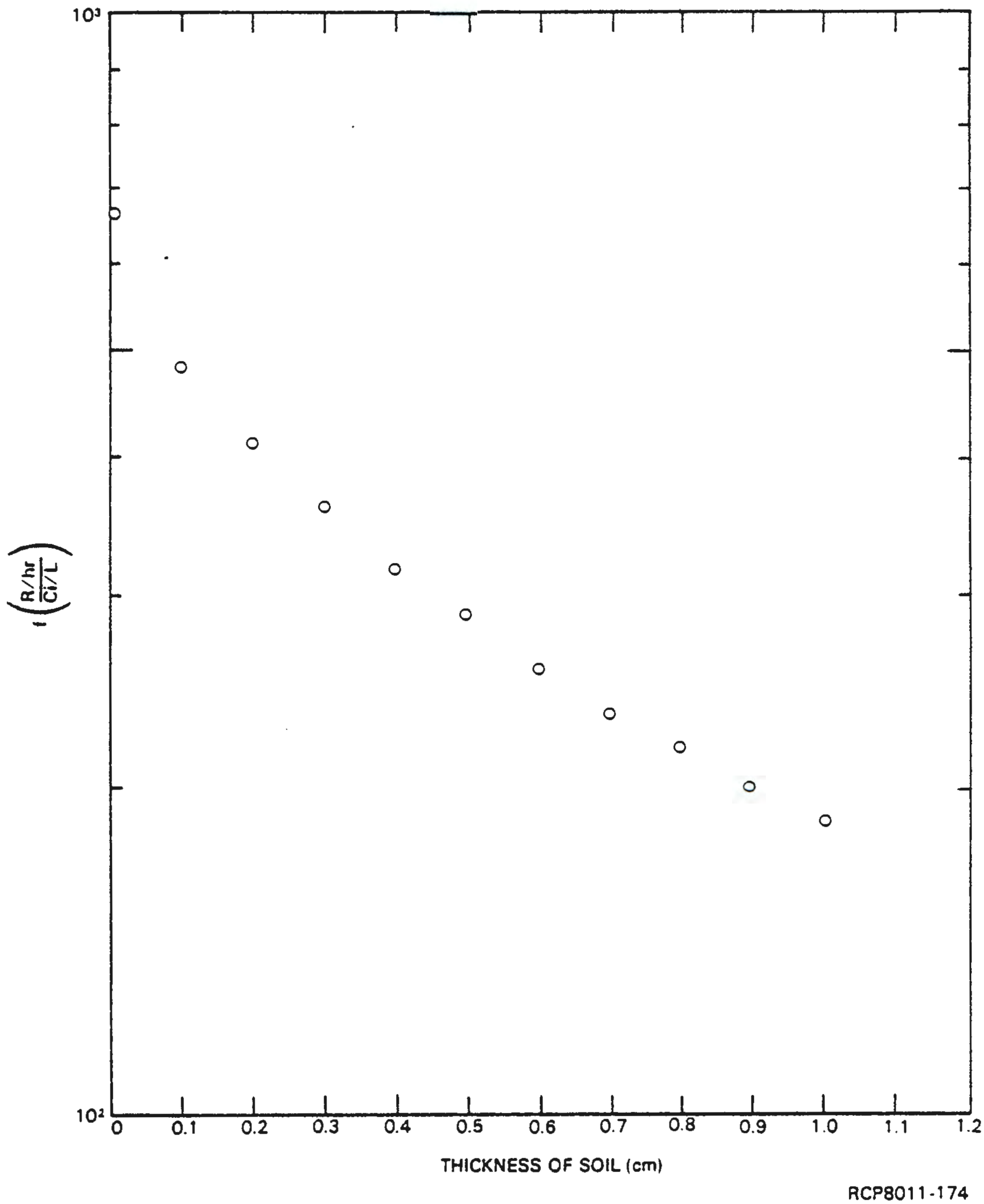


FIGURE J-15. Radiation Levels Per Source Density for Various Thicknesses of Hanford Sediments (at a bulk density of 1.83 g/cm^2 of sediments, i.e., completed Hanford sand) for the Range 0 to 1.2 cm.

9 2 1 2 4 9 9 1 9 5 1

Note that the computer program, ISOSHLD, has a few limitations. Errors can develop if there are source photons significantly <0.015 MeV or >3.0 MeV. Generally bremsstrahlung does not extend very high in energy, but with ^{106}Rh emitting electrons with energies up to 3.5 MeV a problem could result. Also, on the low energy end the photons are shielded out very quickly. However, as the thickness of the shield gets very thin these low energy photons become more significant.

Finally, the validity of the correspondence between the physical situation, whatever it is, and the calculational model is in question when the dose point is too near the source.

These data were evaluated to derive the effective tenth-value thickness of Hanford sediments as a function of the concentration of ruthenium in an advancing front of leaking waste solution. The logarithm of the tenth-value thickness appears to relate to the ruthenium concentration according to the equation $\ell_{\bar{m}} = 26.5[^{106}Ru]^{0.0698}$, where $\ell_{\bar{m}}$ is the effective mean tenth-value thickness in centimeters (averaged for all gamma energy groups) for ruthenium concentrations of 5×10^{-6} to 1 Ci/L. The data are summarized in Figure J-16.

REFERENCES

1. Engle, R. L., J. Greenborg, and M. W. Hendrickson, ISOSHLD - A Computer Code for General Purpose Isotope Shielding Analysis, BNWL-236, Battelle, Pacific Northwest Laboratories, Richland, Washington (June 1966).

2. Simmons, E. L., J. J. Regimbal, J. Greenborg, E. L. Kelly, Jr., and H. H. Van Tuyl, ISOSHLD - II: Code Revisions to Include Calculations of Dose Rate Bremsstrahlung Sources, BNWL-236, SUP 1, Battelle, Pacific Northwest Laboratories, Richland, Washington (March 1967).

3. Mansius, C. A., A Revised Photon Probability Library for Use with ISOSHLD - III, BNWL-236, Battelle, Pacific Northwest Laboratories, Richland, Washington (April 1969).

4. Rockwell, T. Ed., Reactor Shielding Design Manual, D Van Nostrand Publishing Company, Princeton, New Jersey (1956).

5. Lederer, C. M. and V. S. Shirley, Eds., Tables of Isotopes 7th Edition, John Wiley & Sons (1978).

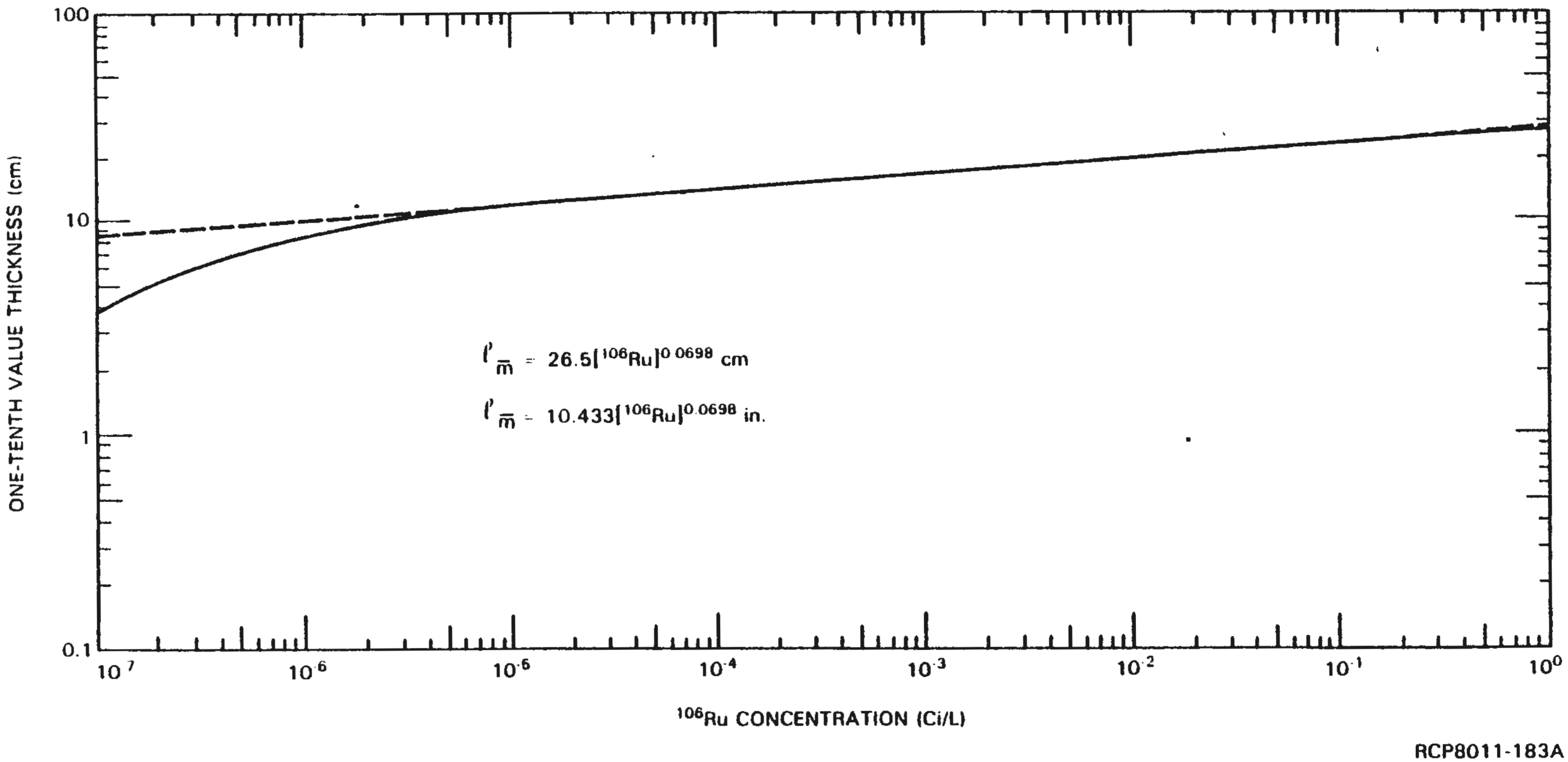


FIGURE J-16. Gamma Energy Attenuation in Hanford Soils as a Function of ^{106}Ru Concentration.

APPENDIX K

DERIVATION OF THE DRY WELL RESPONSE EQUATION AND THE DRY-WELL-RESPONSE TIME EQUATION

R. E. Isaacson

The total radioactivity count rate in a dry well is dependent upon the count rate response of the detectors used as described in Appendix I. During routine monitoring, the more sensitive "Gross Counting Scintillation Probe" is used. The calibration data for the "Gross Counting Scintillation Probe" has been plotted and analyzed. A graphical plot of the data appears to be linear using log-log coordinates over the range of about 3×10^{-5} R/hr to 2×10^{-2} R/hr (Figure K-1). Over this range, the count rate in counts per second (c/s) appears to fit the relationship

$$c/s = C_1 (R/hr)^{C_2} = n_t \qquad \text{(K-1)}$$

where

$$C_1 = 1.816 \times 10^6$$

and

$$C_2 = 0.918$$

with a correlation coefficient of 0.999.

ATTENUATION OF RADIOACTIVITY IN HANFORD SOILS

Using equation K-1, count rates at two different times (n_{t_1} and n_{t_2}) in a dry well as a liquid waste front approaches the well can be expressed as

$$\frac{n_{t_1}}{n_{t_2}} = \frac{C_1 (R/hr)_1^{C_2}}{C_1 (R/hr)_2^{C_2}} \qquad \text{(K-2)}$$

where C_1 and C_2 are the calibration constants given above.

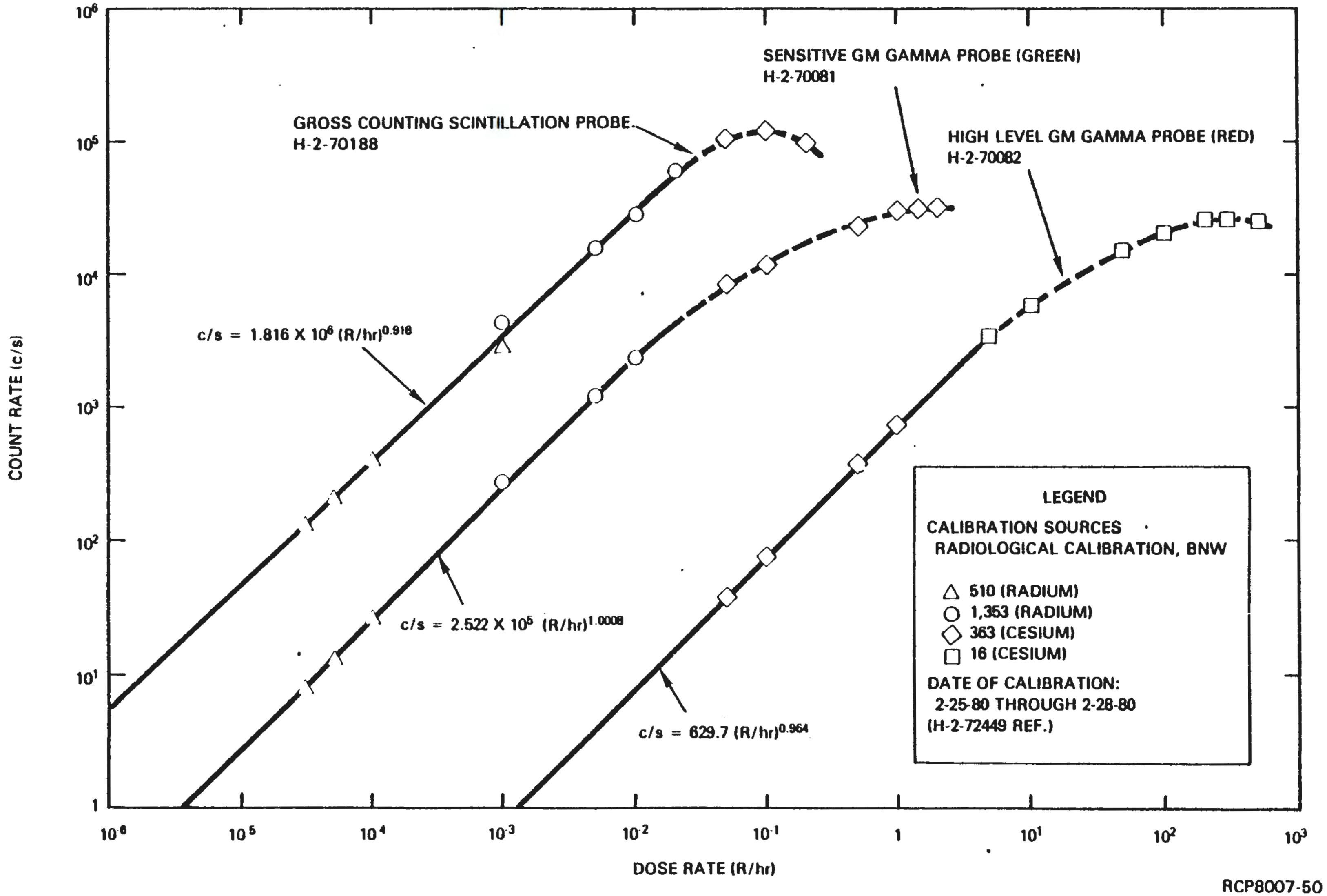


FIGURE K-1. Calibration Curves for Probes Used in Monitoring Dry Wells for Radioactivity.

Since the dose rate increase is due to the diminishing thickness of intervening soil for a constant source strength, in this case an advancing waste front in soil, the relationship of dose rates at different times over small distances can be expressed accordingly; that is to say,

$$\frac{(R/hr)_1}{(R/hr)_2} = \frac{1}{(10^{\Delta d/\ell_{\bar{m}}})} \qquad \text{(K-3)}$$

where Δd is the incremental change in the intervening thickness of soil and $\ell_{\bar{m}}$ is the effective mean tenth-value thickness of soil.

Combining equations K-2 and K-3 gives

$$n_{t_2} = [10^{(0.918\Delta d/\ell_{\bar{m}})}]n_{t_1} \qquad \text{(K-4)}$$

The effective mean tenth-value thickness of soil is that thickness of soil between the waste front and the radiation detector in the dry well that decreases (attenuates) the dose rate by a factor of 10. The attenuation of the gamma dose rate in the soil is a function of the gamma energy spectrum reaching the detector for a given count rate and, because ^{106}Ru is the predominant soluble isotope that advances with the waste front,[1] is a function of the ruthenium concentration. The ruthenium concentration at the waste front is a function of the volumetric dilution factor and liquid front kinetics. Preliminary estimates of tenth-value thicknesses for Hanford soils were made using interpolations from the work of Moteff[2] (see Figure K-2 and Table K-1).

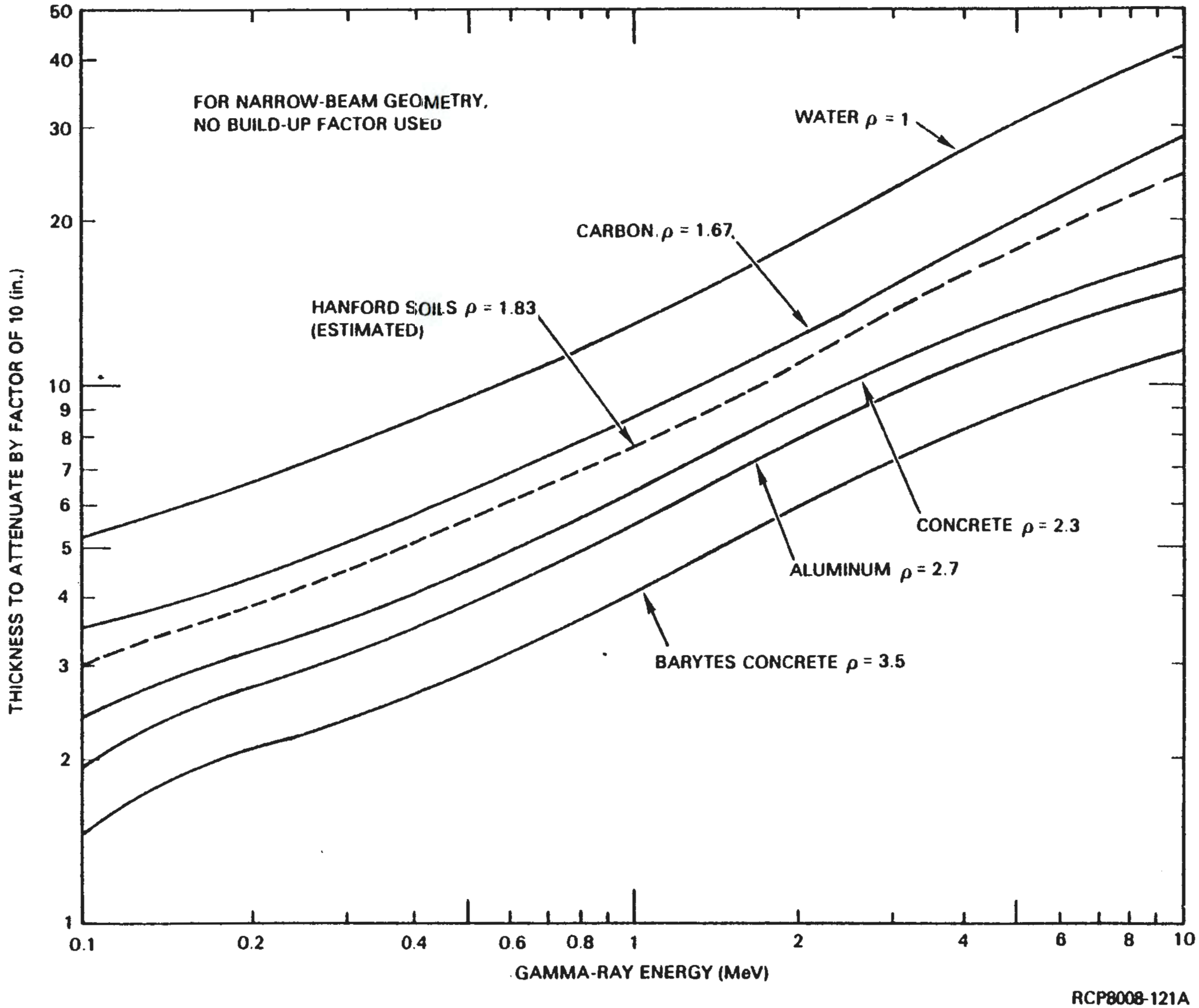


FIGURE K-2. Tenth-Value Thicknesses as a Function of Gamma Energy.

TABLE K-1. Tenth-Value Thickness of Hanford Soil for Various Gamma Ray Energies.

Gamma ray energy (MeV)	Tenth-value thickness	
	In.	Ft
0.160	3.6	0.3
0.250	4.2	0.35
0.512	5.7	0.475
0.622	6.2	0.517
1.05	7.9	0.658
1.13	8.1	0.675
2.1	11.14	0.928
2.5	11.25	0.9375

The dose rate contribution of the lower energy portion of the ^{106}Ru-^{106}Rh spectrum and the bremsstrahlung contribution increase as the liquid waste front advances toward the detector. Thus, for very dilute and very old waste solutions the following assumptions can be made: the low energy end of the ^{106}Ru-^{106}Rh spectrum will predominate; the thickness of soil required to reduce the count rate will be small; and the count rate will increase more rapidly once the waste front is detected. An example of the gamma energy spectrum in a dry well is shown in Figure K-3. As the source density (concentration in curies per liter (Ci/L)) decreases, the contribution of the low energy portion of the gamma spectrum must increase for a given dose rate. The tenth-value thickness, therefore, decreases as the concentration decreases since low energy gamma rays are attenuated more extensively by the sediments. This effect is demonstrated quantitatively in Appendix J (Figures J-3 through J-9).

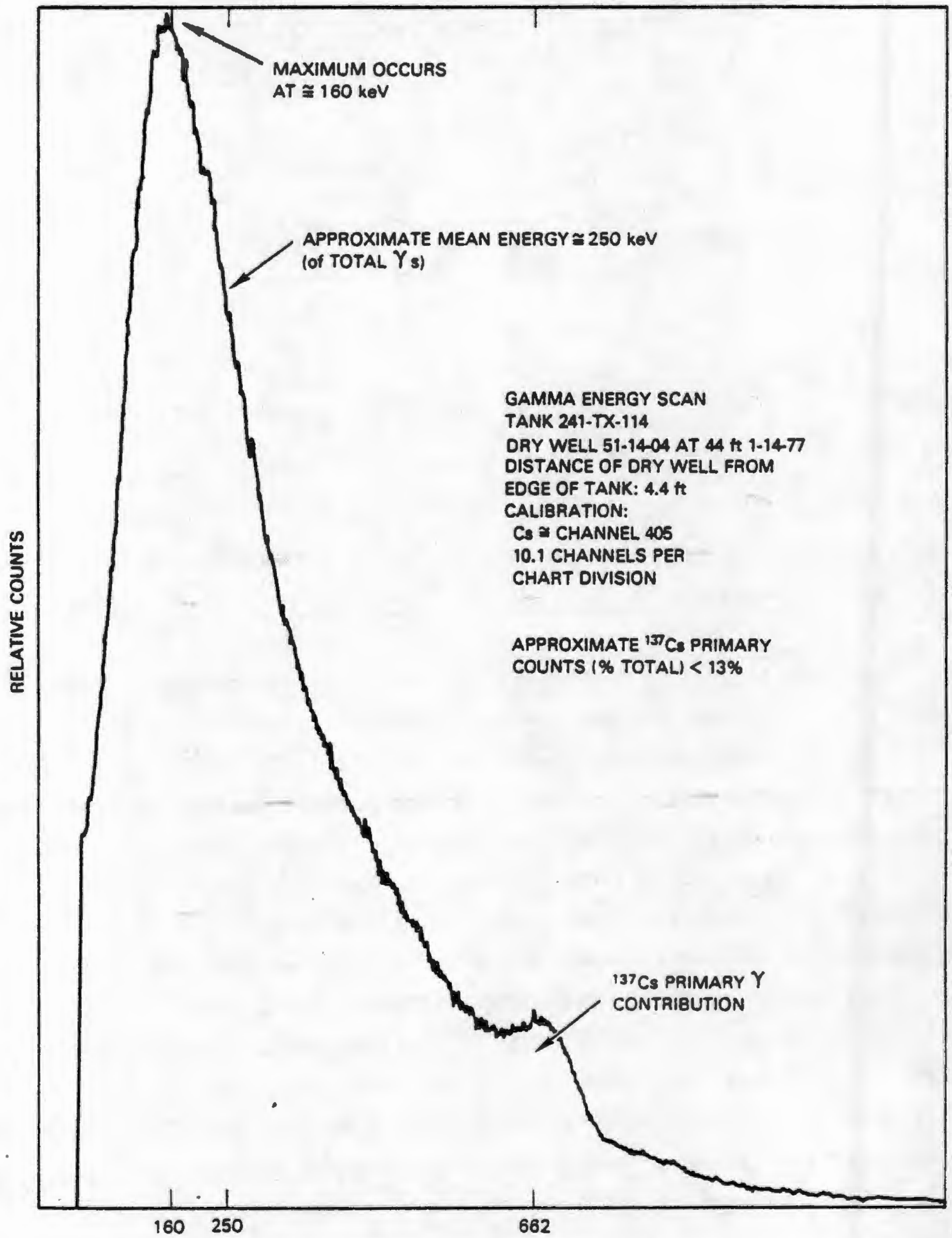


FIGURE K-3. An Example of the Gamma Energy Spectrum in a Dry Well from the Seepage of Underground High-Level Waste.

EFFECT OF RUTHENIUM-106 RHODIUM-106 CONCENTRATION

The relationship of the tenth-value thickness to the concentration of ^{106}Ru-^{106}Rh has been evaluated by using the ISOSHLD computer program (see Appendix J). These results have been summarized in the equation

$$\ell_{\bar{m}} = 0.8694[^{106}\mathrm{Ru}]^{0.0698} \text{ ft} \qquad \text{(K-5)}$$

where $\ell_{\bar{m}}$ is the mean tenth-value thickness of Hanford soils (bulk density = 1.83 g/cm^3); and [^{106}Ru] is the concentration of ^{106}Ru-^{106}Rh in Ci/L. The tenth-value thickness is plotted as a function of ^{106}Ru-^{106}Rh concentration in Figure K-4 based upon the analysis in Appendix J.

Records have been searched to obtain data on ruthenium concentrations in waste tanks of concern in this study. Data were available for only nine tanks and date back to 1975 (see Table K-2). These data were averaged when they appeared self-consistent, otherwise the latest analysis was used. These data were adjusted to January 1, 1981 using a half-life of 368 days.

It was hoped that it would be possible to describe a model of the ^{106}Ru-^{106}Rh concentration in the waste front for each tank based on knowledge of this concentration in the tank. From the concentration model, the function for the tenth-value thickness could be ascribed for each tank. Unfortunately, insufficient ruthenium analyses exist to develop the model for each tank and estimates have, of necessity, been used in the various tank-by-tank analyses.

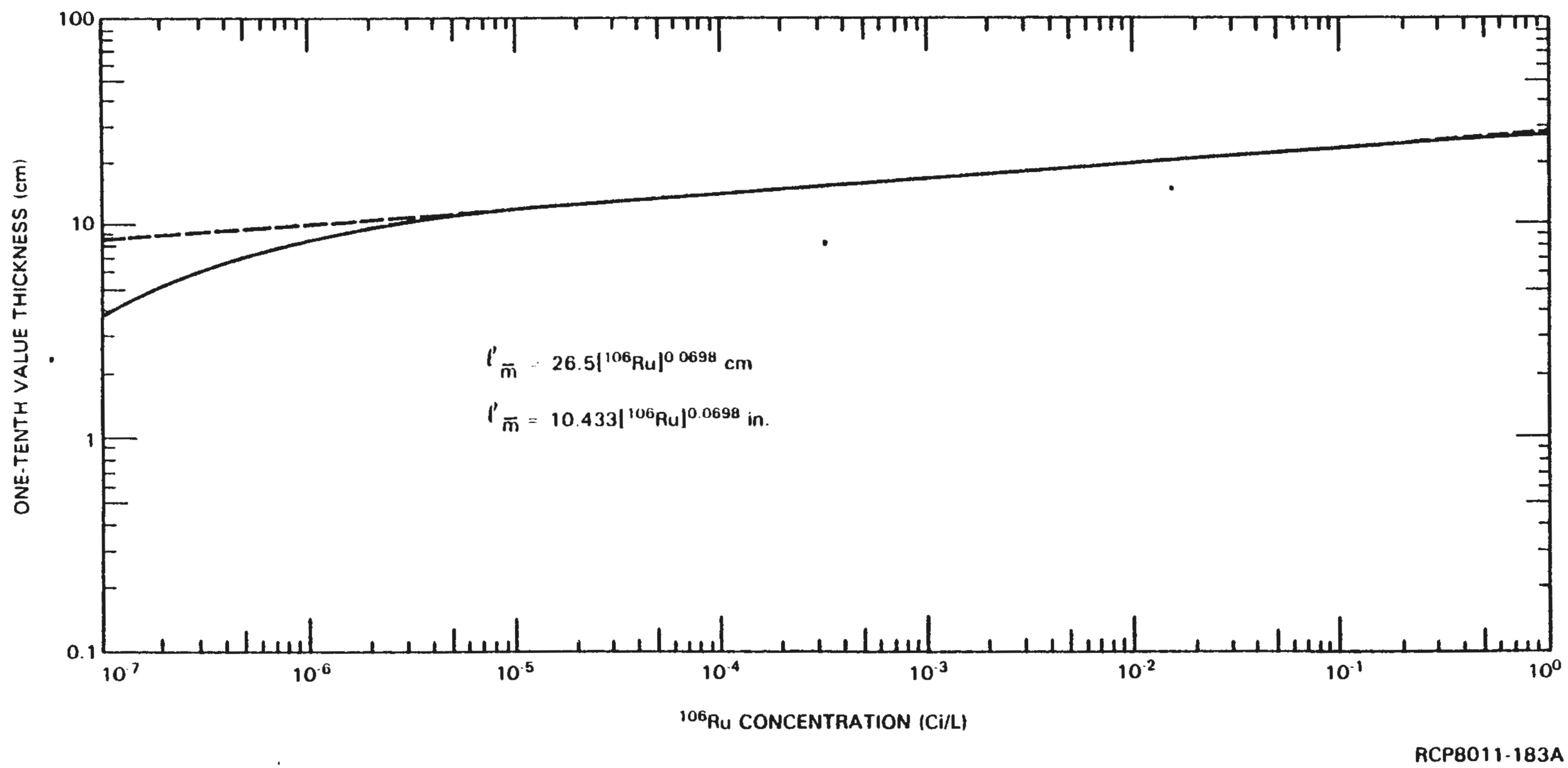


FIGURE K-4. Gamma Energy Attenuation in Hanford Soils as a Function of ^{106}Ru Concentration.

TABLE K-2. Ruthenium-106 Concentrations and Corresponding Tenth-Value Thickness of Hanford Tank Farm Sediments.

Tank no.	Date	^{106}Ru-Rh concentration (µCi/gal)	Extrapolated ^{106}Ru-Rh concentration, January 1, 1981 (Ci/L)	Average or most recent value (Ci/L)	Tenth-value thickness (ft)
241-A-101	04-09-78	6.13×10^5	2.473×10^{-2}		
241-A-101	05-24-78	5.24×10^5	2.300×10^{-2}	2.387×10^{-2}	0.6699
241-A-102	07-30-78	1.50×10^5	7.469×10^{-3}		
241-A-102	07-26-78	1.59×10^5	7.858×10^{-3}	7.664×10^{-3}	0.6188
241-A-103	02-19-76	1.50×10^4	1.392×10^{-4}		
241-A-103	11-23-77	3.32×10^5	2.057×10^{-2}	2.057×10^{-2}	0.6631
241-BX-104	08-03-78	4.16×10^5	2.089×10^{-2}		
241-BX-104	01-27-78	2.98×10^5	1.049×10^{-2}	1.569×10^{-2}	0.6506
241-BX-104	11-05-75	1.44×10^5	(1.094×10^{-3})		
241-C-104	03-17-79	3.06×10^2	2.348×10^{-5}		
241-C-104	02-20-76	2.12×10^4	1.971×10^{-4}		
241-C-104	02-19-76	1.90×10^4	1.763×10^{-4}		
241-C-104	12-05-75	2.57×10^4	2.067×10^{-4}	2.348×10^{-5}	0.4131
241-C-105	03-05-79	1.20×10^4	9.009×10^{-4}	9.009×10^{-4}	0.5328
241-C-107	01-17-78	1.87×10^3	1.683×10^{-4}	1.683×10^{-4}	0.4741
241-S-102	12-06-76	3.45×10^4	5.538×10^{-4}		
241-S-102	04-29-76	6.41×10^4	6.786×10^{-4}		
241-S-102	04-23-76	4.57×10^4	4.784×10^{-4}		
241-S-102	04-19-76	3.29×10^4	3.418×10^{-4}		
241-S-102	04-13-76	4.62×10^4	4.746×10^{-4}		
241-S-102	04-02-76	5.87×10^4	5.906×10^{-4}		
241-S-102	03-26-76	3.26×10^4	3.237×10^{-4}		
241-S-102	03-10-76	3.97×10^4	3.825×10^{-4}		
241-S-102	03-24-76	2.63×10^4	2.602×10^{-4}		
241-S-102	03-24-76	2.61×10^4	2.582×10^{-4}		
241-S-102	03-01-76	3.06×10^4	2.899×10^{-4}	4.211×10^{-4}	0.5052

The sensitivity of the dry-well-response time (Δt) to the ruthenium concentration [^{106}Ru] was determined for a hypothetical leak of 0.03 gal/min located 15 ft from the dry well (see Figure K-5). The results can be summarized in the empirical equations

$$\Delta t = 32.67[^{106}\mathrm{Ru}]^{0.0685} \text{ days} \qquad \text{(K-6)}$$

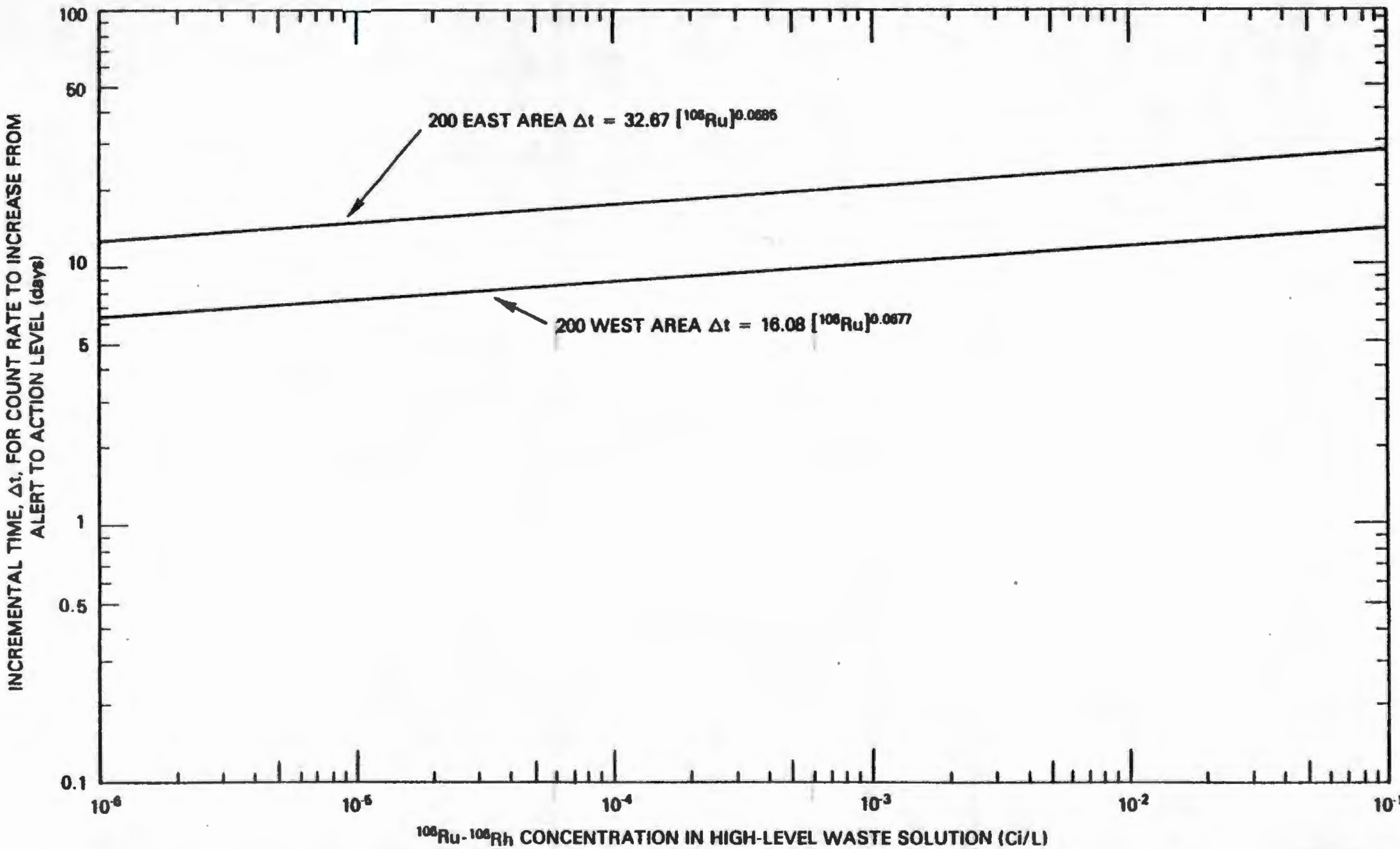
in 200 East Area and

$$\Delta t = 16.08[^{106}\mathrm{Ru}]^{0.0677} \text{ days} \qquad \text{(K-7)}$$

in 200 West Area, where 32.726 and 16.122 are the response times in days for a ^{106}Ru concentration of 1 Ci/L. While the results were calculated from the dry well response equation, the correlation coefficient for the empirical equation is essentially 1.0 (i.e., 0.99999+).

As time passes, the ruthenium concentration decreases by natural decay with a half-life of 368 days. At concentrations below 10^{-6} Ci/L, the tenth-value thickness falls rapidly. Thus it will become progressively more important to know the ruthenium concentration on a tank-by-tank basis. This rapid decrease will occur for some tanks within 5 yr. The tenth-value thickness can be compensated for radioactive decay using the decay factor $2^{\Delta t/368}$. Thus, $\ell'_{\bar{m}}$ ($\ell_{\bar{m}}$ corrected for decay) is given in equation K-8

$$\ell'_{\bar{m}} = 0.8694 \left(\frac{[^{106}\mathrm{Ru}]}{2^{\Delta t/368}}\right)^{0.0698} \text{ ft} \qquad \text{(K-8)}$$



RCP8208-116

FIGURE K-5. Effect of ^{106}Ru-^{106}Rh Concentration on Time Required for Count Rate to Increase from the Alert Level (20 c/s above background) to the Action Level (160/cs above background) for a Dry Well Located 15 ft from a Tank Leak Source at a Postulated Leak Rate of 0.03 gal/min.

GEOMETRIC RELATIONSHIP OF LEAK VOLUME BETWEEN TANK AND DRY WELL

The distance the waste front moves as the count rate increases from the alert level to the action level is shown schematically in Figures K-6 and K-7. The total volume of the leak, Q_t, at time t, can be expressed

$$Q_t = st \qquad \text{(K-9)}$$

where

s = average leak rate

t = elapsed time

This volume is also equal to the liquid-level decrement, Q_L, in inches times the volume per inch (2,750 gal/in.).

The volume of soil wetted, Qs, by the leak is

$$Q_s = \frac{4}{3}\pi ab^2 \qquad \text{(K-10)}$$

where

a = one-half vertical axis of wetted volume

b = one-half horizontal axis of wetted volume

As shown in Figure K-6, a and b are one-half of the vertical and horizontal axes of the oblate spheriod-shaped wetted volume. For a sphere of radius, r, a = b = r and $Q_s = 4/3\pi r^3$.

The volume of waste in the soil can be represented by the average soil-moisture content on a volume fraction basis, q, resulting from the leak. Thus, since the volumes must be equal

$$Q_L = q_t = qQ_s \qquad \text{(K-11)}$$

hence

$$st = q\frac{4}{3}\pi ab^2 \qquad \text{(K-12)}$$

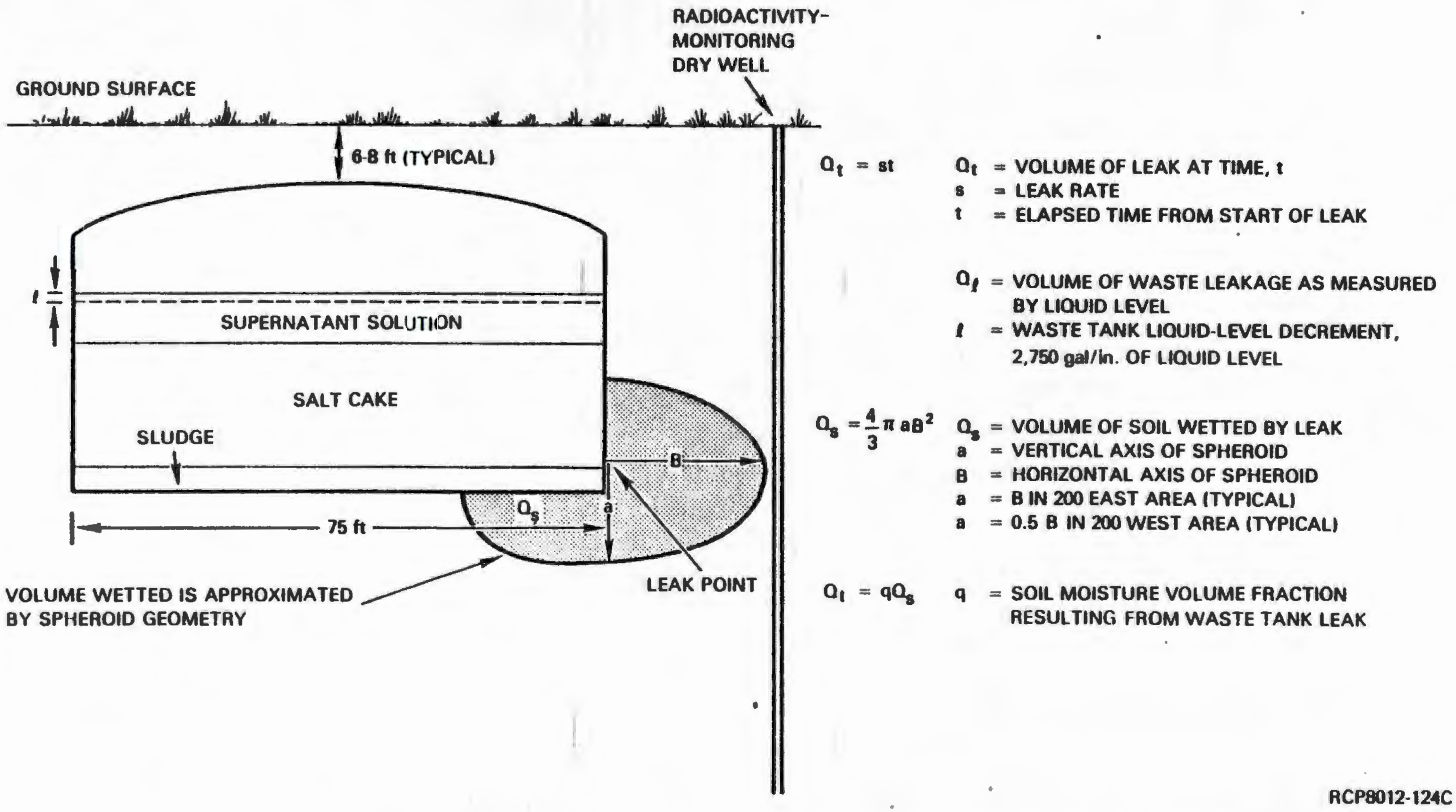
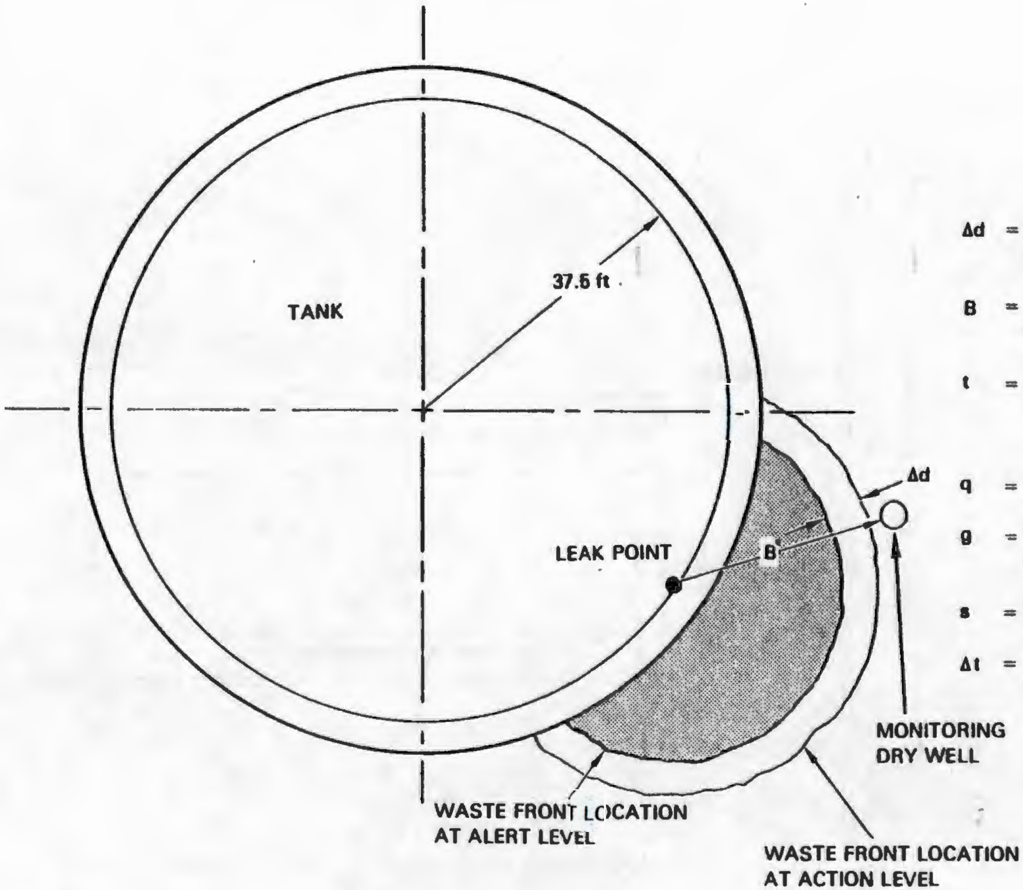


FIGURE K-6. Volumetric and Geometric Relationships of Waste Storage Tank Leaks.



Δd = DISTANCE WASTE FRONT MOVES AS COUNT RATE INCREASES FROM ALERT LEVEL TO ACTION LEVEL

B = DISTANCE FROM TANK LEAK SOURCE TO RADIATION-MONITORING DRY WELL. REPONSE DISTANCE

$t = (\frac{4}{3}\pi B^3)\ \frac{qg}{s}$ TOTAL TIME FOR WASTE FRONT TO MIGRATE FROM LEAK SOURCE TO DRY WELL

q = VOLUME FRACTION OF SOIL MOISTURE

g = GEOMETRIC FACTOR RELATED TO SOIL MOISTURE CONTROL

s = LEAK RATE SOURCE TERM

Δt = INCREMENTAL TIME FOR WASTE FRONT TO MOVE DISTANCE, Δd, RESPONSE TIME

RCP8012-1258

FIGURE K-7. Factors Affecting Response Time of Radiation Monitoring Dry Wells to High-Level Waste Storage Tank Leaks.

The vertical axis can be expressed in terms of the horizontal axis: $a = bg$. Then g is a geometric factor representing the "nonsphericity" (anisotropy in a vertical direction) of the volume of wetted soil

$$st = q\frac{4}{3}\pi b^3 g \qquad \text{(K-13)}$$

and

$$t = \frac{4}{3}\pi b^3 \frac{qg}{s} \qquad \text{(K-14)}$$

Typically, $g = 0.5$ for 200 West Area and about 1.0 for 200 East Area based on characterization studies of waste tank leaks.

When a well is located at a distance, b, from a waste tank leak, there is some distance, b_1, where the count rate will be just at the alert level, and a greater distance, b_2, where the count rate will be at the action level. For simplification, b_2 is taken to be equal to b. Therefore, $b - b_1 = \Delta d$ = action rate distance (distance between alert level and action level). It is assumed that the distance, b (taken from Figure K-7), the distance to the dry well, is the same distance that the waste front will have migrated when the count rate is at action level. Actually, the waste front will be a few inches away from the dry well.

The volume of the waste that must have leaked as the count rate increases from the alert level to the action level is that volume, ΔQ_s, that wets the envelope of thickness, Δd, between b and $b - \Delta d$ from the leak source; thus,

$$\Delta Q_s = \frac{4}{3}\pi b^3 qg - \frac{4}{3}\pi (b - \Delta d)^3 qg \qquad \text{(K-15)}$$

$$\Delta Q_s = \frac{4}{3}\pi \left[b^3 - (b - \Delta d)^3\right] qg \qquad \text{(K-16)}$$

Since this volume must be equal to the volume that leaked during this period, Δt, then,

$$(s)(\Delta t) = \frac{4}{3}\pi \left[b^3 - (b - \Delta d)^3\right] qg \qquad \text{(K-17)}$$

and

$$\Delta t = \frac{4}{3}\pi \left[b^3 - (b - \Delta d)^3\right] \frac{gq}{s} \qquad \text{(K-18)}$$

where

Δt = response time for radioactive front to move the distance, Δd.

Solving for Δd gives

$$\Delta d = b - \sqrt[3]{b^3 - \frac{3}{4\pi}\frac{s\Delta t}{qg}} \qquad \text{(K-19)}$$

or, defining a modified geometric factor, $g' = \frac{4\pi g}{3}$

$$\Delta d = b - \sqrt[3]{b^3 - \frac{s\Delta t}{qg'}} \qquad \text{(K-20)}$$

The distance Δd, in which the count rate is attenuated from 160 c/s at time, t, to 20 c/s at time, t-Δt, can be substituted in equation K-4 to give

$$n_t = 10^{\left[\frac{0.918\left(b - \sqrt[3]{b^3 - \frac{s\Delta t}{qg'}}\right)}{0.8694\left(\frac{[^{106}Ru]}{2^{\Delta t/386}}\right)^{0.0698}}\right]} n_{t-\Delta t} \qquad \text{(K-21)}$$

or to simplify,

$$n_t = 10^x n_{t-\Delta t} \qquad \text{(K-22)}$$

where

$$X = \left[\frac{0.918\left(b - \sqrt[3]{b^3 - \frac{s\Delta t}{qg'}}\right)}{0.8694\left(\frac{[^{106}Ru]}{2^{\Delta t/368}}\right)^{0.0698}}\right] \qquad (K\text{-}23)$$

EFFECT OF RADIOACTIVE DECAY

Corrections for radioactive decay should be made when the time, Δt, for the waste front to move through the distance, Δd, is large. In simplified form, the relationship of count rate to half-life can be expressed as

$$n_{t_2} = \frac{n_{t_1}}{2^y} \qquad (K\text{-}24)$$

That is, the count rate at time t_2 is equal to the count rate at some earlier time divided by 2 to the exponent y. In this case, y is the time increment Δt divided by the half-life of the radioisotope. Since ^{106}Ru is the predominant soluble isotope that advances with the waste front and has a half-life of 368 days,

$$y = \frac{\Delta t}{368} \qquad (K\text{-}25)$$

Combining equations K-24 and K-25 gives

$$n_t = n_{t-\Delta t}\left(\frac{10^x}{2^y}\right) \qquad (K\text{-}26)$$

THE "DRY-WELL-RESPONSE TIME"

When the action level and alert levels are fixed by definition, the incremental time (Δt) for the count rate to increase can be calculated for various distances (b) from tank leak sources to radiation monitoring dry wells.

The incremental time, Δt, Dry Well Response Time required for the count rate to increase from the alert level ($n_{t-\Delta t}$) to the action level (n_t) is the same as the time required for the waste front to advance the incremental distance Δd. In this case the incremental distance is that thickness of soil that attenuates the count rate from n_t to $n_{t-\Delta t}$. Thus, since

$$\Delta t_{\Delta d} = \left[b^3-(b-\Delta d)^3\right] \cdot \left(\frac{g'q}{s}\right) \tag{K-27}$$

and

$$\frac{n_t}{n_{t-\Delta t}} = [10^{\Delta d/\ell_{\bar{m}}}]^{0.918}; \quad \frac{n_t}{n_{t-\Delta t}} = 10^{(0.918\Delta d/\ell_{\bar{m}})} \tag{K-28}$$

Solving equation K-28 for Δd gives

$$\Delta d = \left[\left(\frac{\ell_{\bar{m}}}{0.918}\right) \log_{10}\left(\frac{n_t}{n_{t-\Delta t}}\right)\right] \tag{K-29}$$

and by combining equations K-27 and K-29

$$\Delta t'_{\Delta d} = \left\{b^3-\left[b-\left(\frac{\ell_{\bar{m}}}{0.918}\right)\left(\log_{10}\frac{n_t}{n_{-\Delta t}}\right)\right]^3\right\}\frac{g'q}{s} \tag{K-30}$$

where $\Delta t'_{\Delta d}$ is the estimated incremental time uncorrected for radioactive decay.

With corrections for radioactive decay, the distance Δd is increased to include the equivalent thickness of soil through which the waste front moves to compensate for the loss of counts due to radioactive decay.

$$\Delta t = \left(b^3-\left\{b - \left[\left(\frac{\ell_{\bar{m}}}{0.918}\right)\left(\log_{10}\frac{n_t}{n_{-\Delta t}}\right) + \left(\frac{\Delta t'}{368}\right)\left(\log_{10} 2\right)\right]\right\}^3\right)\left(\frac{g'q}{s}\right) \tag{K-31}$$

Since the solution of the equation requires an iteration, $\Delta t'$ can be estimated using equation K-30.

For relatively small Δt's the residual error will be small; for large Δt's an iterative solution should be used.

LEAK RATE AND SOURCE TERM, S

The source term, s, is the leak rate in ft^3/day. The leak rate is dependent upon the contents of the tank, the size of the hole in the tank, and the permeability of the soils, the salt cake, or the sludge according to the position of the leak with respect to the contents of the tank.

A review of leak sizes was made and the results indicate that the size of the hole in the tank controls the leak rate. Data on leak rates are provided in Table K-3. These data were reviewed to determine an appropriate maximum leak rate to use in these studies. Except for leaks for Tanks 241-SX-110 and 241-T-106, the maximum typical leak rate was from Tank 241-U-110 (0.5 in. in 41 days, or 0.023 gal/min). Leaks from Tanks 241-SX-110 and 241-T-106 are believed to have resulted from construction and operational deficiencies that resulted in unusually large leak rates. For the purposes of this study, such leaks are considered to be atypical and are unlikely to be repeated, hence, they were omitted from the statistical calculations of leak rates in Appendix D. Since there are no other tanks in service that would be expected to fail in a manner similar to those two tanks, the decision was made to assume that the worst case (maximum expected) leak rate would be 0.03 gal/min (i.e., $s = 5.77\ ft^3$/day).

The characteristic effect of leak rate on the dry-well-response time is illustrated in Figures K-9, K-10, K-11, and K-12. The data in Table K-3 can be used to estimate dry-well-response times for various leak rate conditions using Figures K-9, K-10, and K-11.

TABLE K-3. Liquid Level Decrease Rates for Questionable Integrity and Leaker Tanks.

Tank no.	In./time	In./d	Gal/min	Gal/d	Ft^3/d	Status[a]
241-B-107	3/18 mo	0.005	0.011	15.7	2.12	L
241-B-110	3/12 mo	0.004	0.020	30	3.85	QI
241-B-201	4.0/36 mo	0.003	0.0005	0.73	0.096	L
241-C-101	4.0/12 mo	0.010	0.019	28	3.66	L
241-SX-110	--[b]	--[b]	0.2	--	38.5	QI
241-T-103	0.3/	0.003	0.006	9	1.15	QI
241-T-106	--[c]	0.89[c]	1.7[c]	2,455[c]	328[c]	L
241-T-108	0.3/370 d	0.0008	0.0015	2	0.289	QI
241-T-111	0.3/273 d	0.001	0.002	3	0.385	QI
241-TX-107	0.4/121 d	0.003	0.006	9	1.15	QI
241-TY-101	0.35/50 d	0.007	0.013	19.25	2.50	QI
241-U-110	0.5/41 d	0.012	0.023	33.5	4.43	L
241-U-112	3/14 mo	0.009	0.02	25	3.85	L

[a]QI = Questionable integrity; L = Confirmed leaker.

[b]Loss due to evaporation is suspected because this tank was connected to an exhauster and waste was thermally hot.

[c]Leak rates were redetermined for this study using liquid level readings reported in the 241-T-106 leak chronology. (See Figure K-8.)

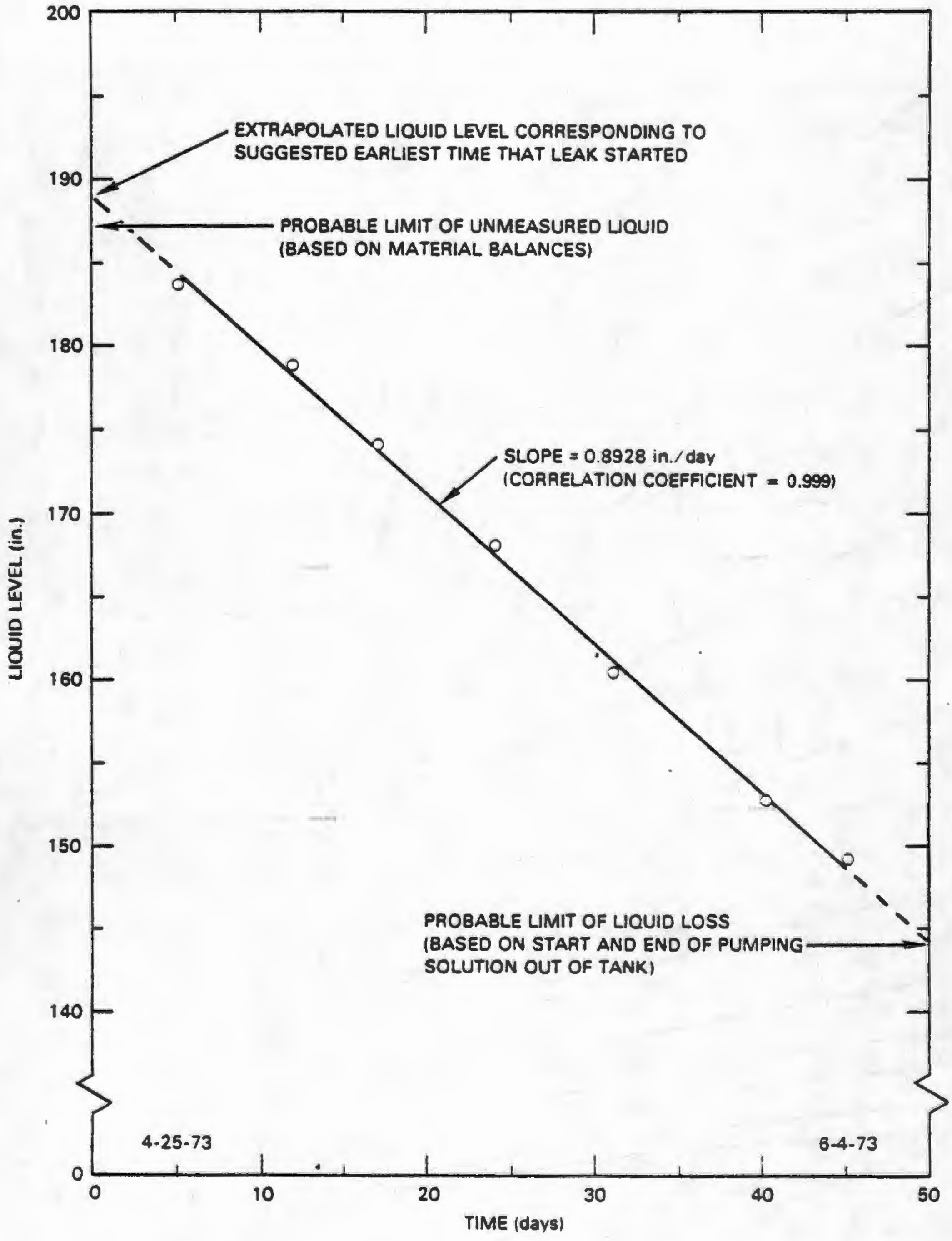


FIGURE K-8. 241-T-106 Tank Leak Data.

92124991984

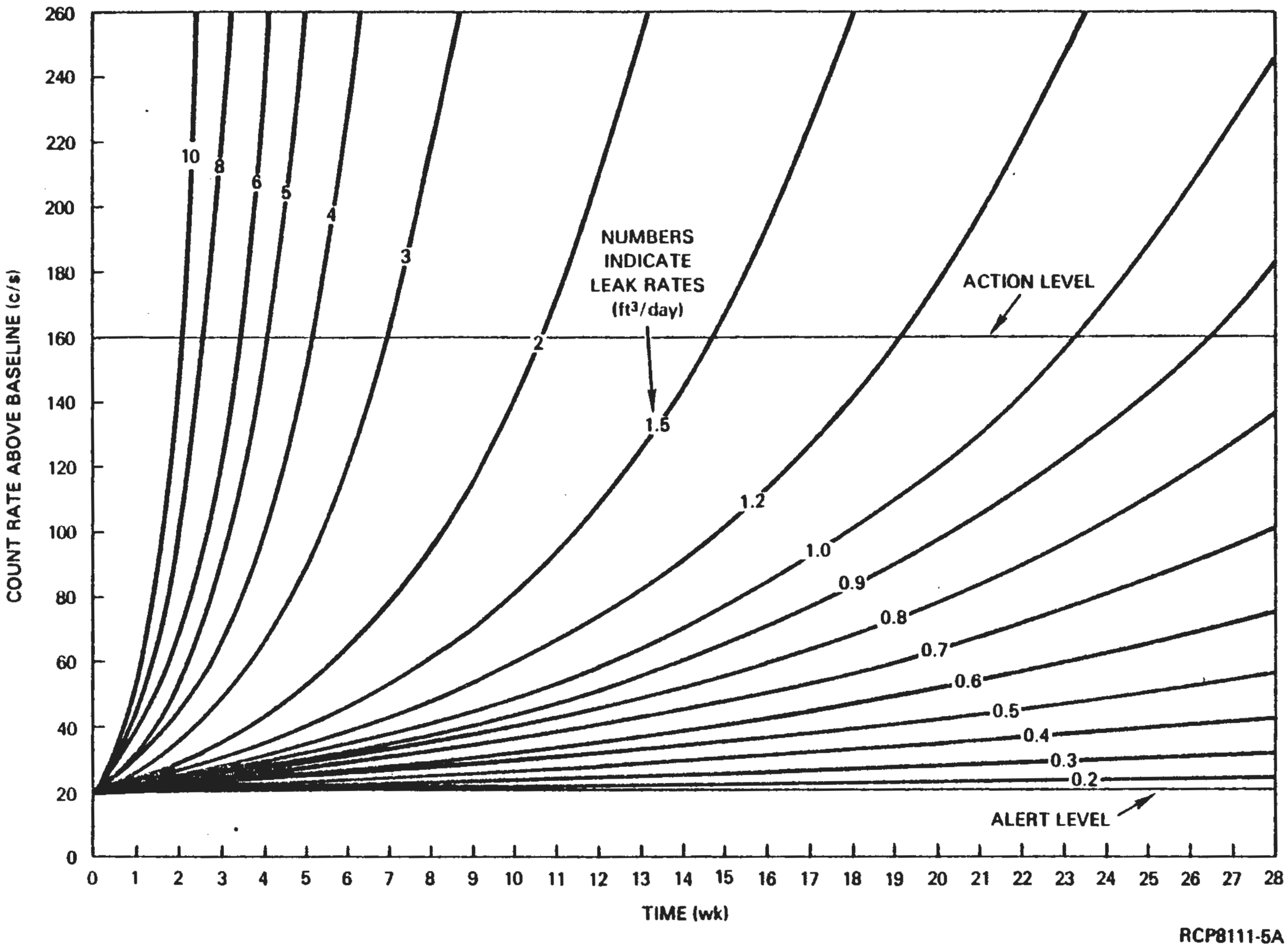


FIGURE K-9. Count Rate at Dry Well as a Function of Time for Various Leak Rates (ft^3/day) for 200 East Area.

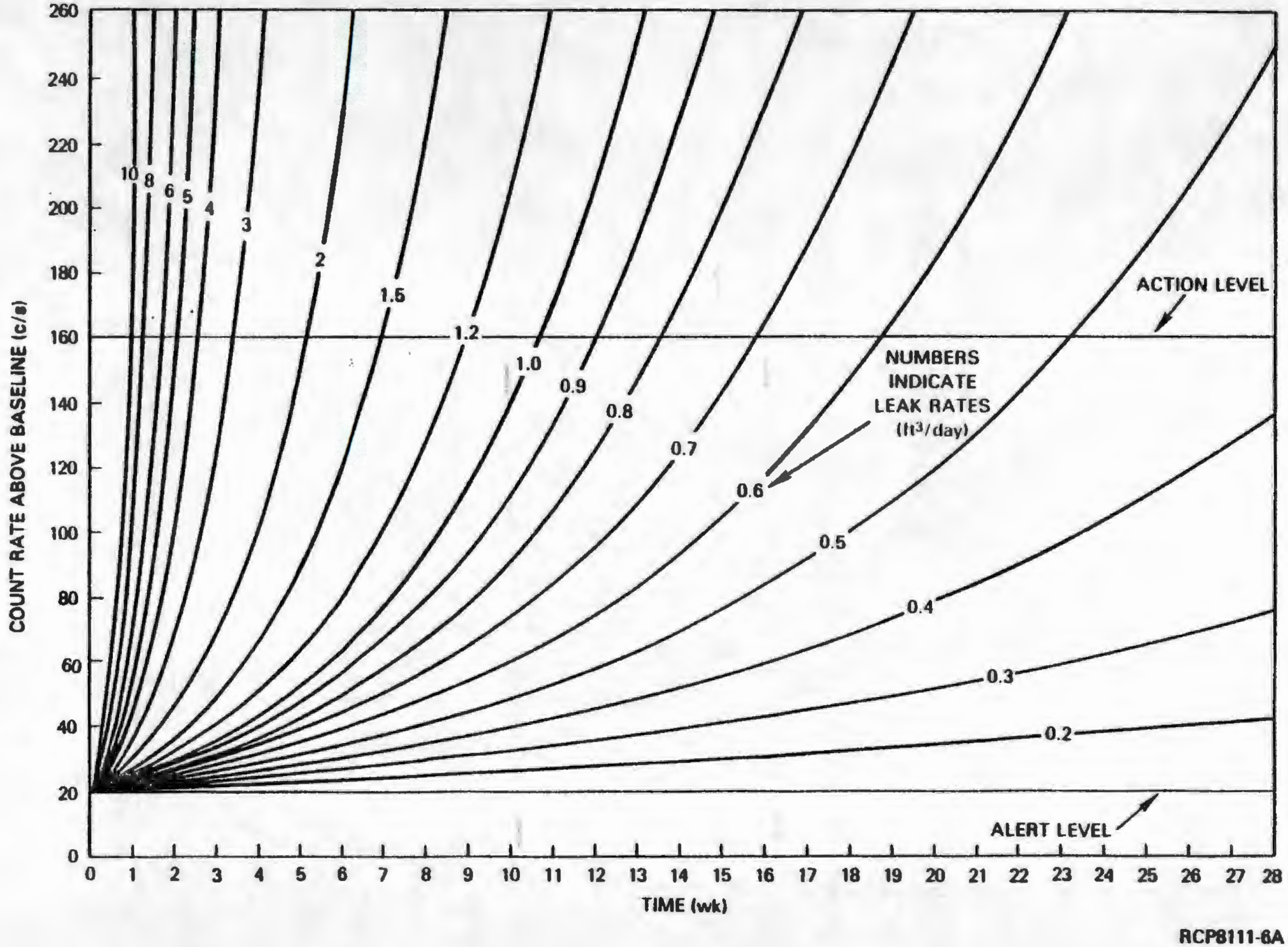


FIGURE K-10. Count Rate at Dry Well as a Function of Time for Various Leak Rates (ft^3/day) for 200 West Area. Assumptions: Incremental soil moisture of 8 vol%, oblate spheriod geometry 17 ft from tank leak source to dry well.

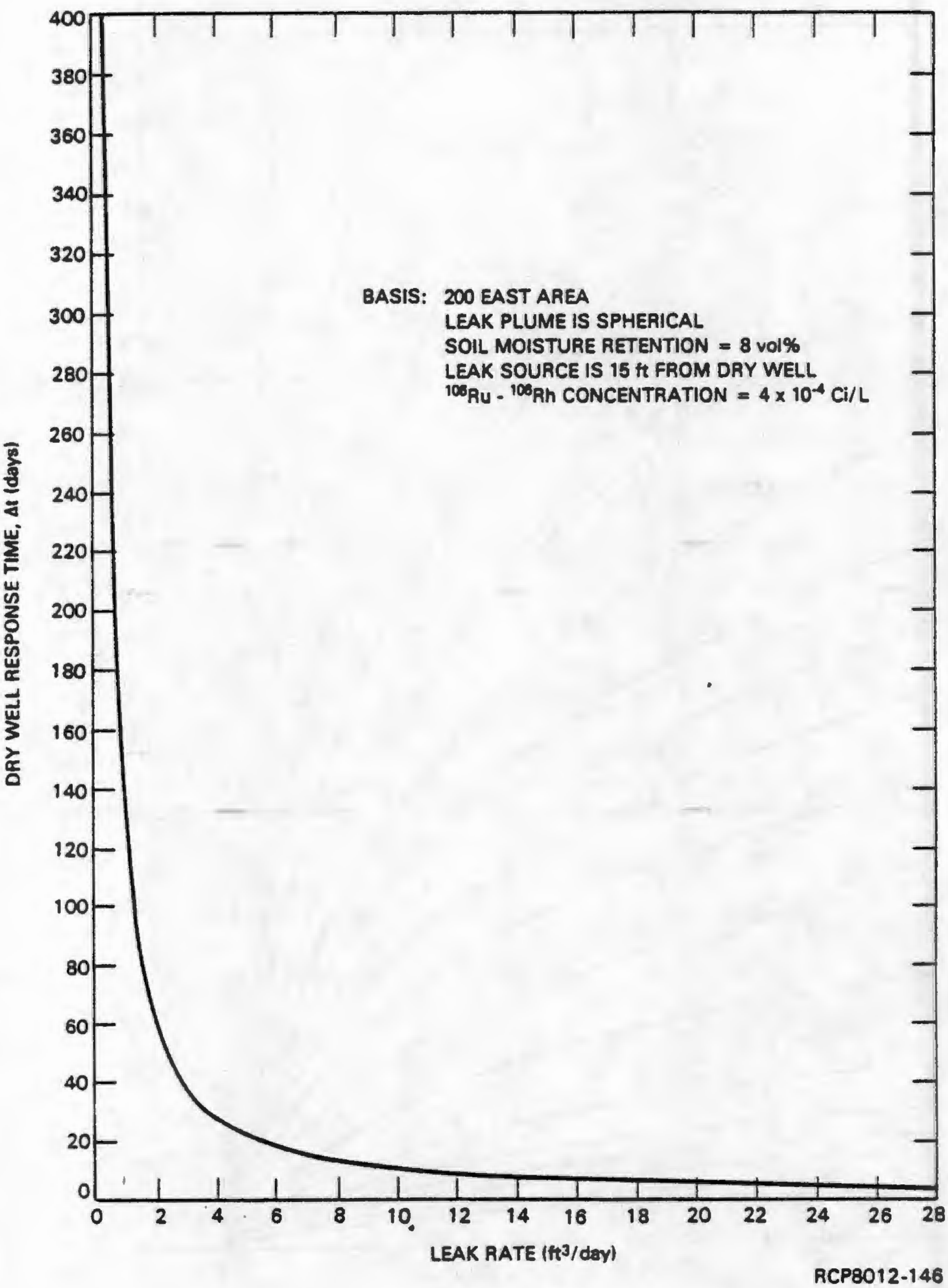


FIGURE K-11. Characteristic Effect of Leak Rate on the Dry-Well Response Time, Δt, for Radioactive Count Rate to Increase from 20 to 160 c/s Above Background.

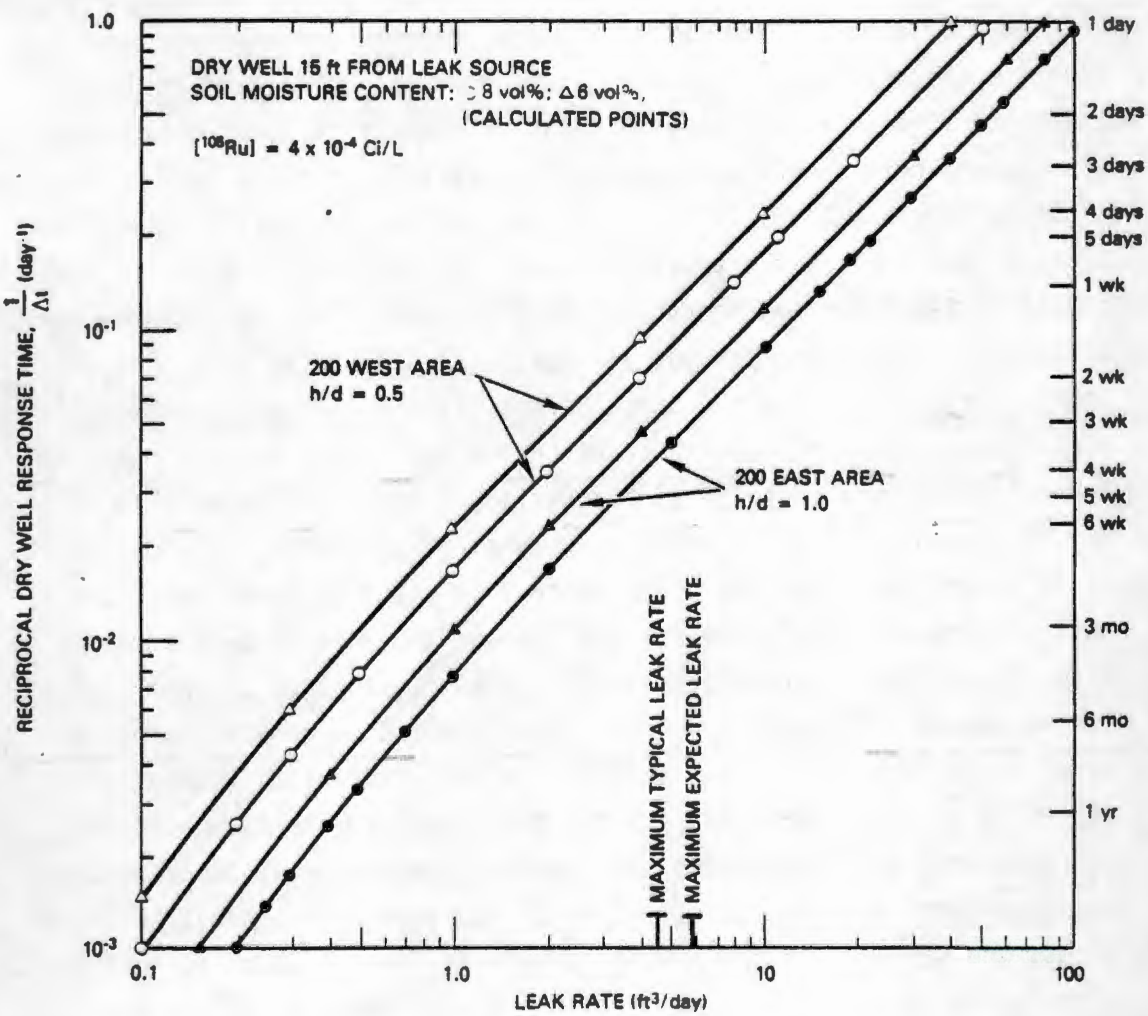


FIGURE K-12. Reciprocal Dry Well Response Time, $1/\Delta t$, as a Function of Leak Rate for the 200 East and West Areas and for 6 and 8 vol% Soil Moisture.

SOIL MOISTURE AND GEOMETRY OF SUBSURFACE LEAK PLUMES

The movement of water in Hanford sediments has been studied for a number of years.[1,6-13] These sediments are deficient in soil moisture and large volumes of water must be added in order to cause moisture to move significant distances. Based upon studies in the Hanford lysimeters, soil moisture due to precipitation appears to move downward by gravity and both upward and downward by capillary flow at soil saturations above about 6 vol%.[8, 10, 12] At soil saturations of about 10% or less, soil moisture transport appears to be primarily that due to capillary and vapor transport. Water from precipitation that enters the soil during the cooler periods penetrates to a depth of from 3 to 25 ft and is entirely lost to the atmosphere by evaporation during the following summer. Soil moisture in zones unaffected by the activities of man and below the zone of seasonal fluctuation ranges from about 4 to 6 vol%. About 6 to 8% of water by volume, or more, must be added to cause significant movement of moisture. In cases of tank leaks, the rate of movement then becomes a function of the rate of addition, the rate of capillary transport, and the total volume added through the "point source" of addition. In fine uniform sediments when water is added subsurface via a point source, the wetted front will tend to expand in spherical geometry and the time required for the moisture front to move will be proportional to the cube of the distance of the moisture front from the point source of addition.[14] In coarse sediments, the geometry of the wetted zone tends to be that of a prolate spheriod, a spheriod with the distance between poles being greater than the equatorial diameter. In layered or bedded sediments, the geometry tends to be that of an oblate spheriod, with the distance between poles being less than the equatorial diameter. In the case of coarse sediments when the moisture front reaches a soil layer having markedly different characteristics, the moisture front will spread laterally, especially when the interface is a layer of relatively fine sediments. Under these conditions, the geometry of the wetted sediments approaches that of a cone with a vertical axis. Variations from these generalized examples become infinite as the geological complexities of the sediments increase. Thus, for a given volume of waste and a constant leak rate, the distance that the front moves in a horizontally radial direction from the leak source will be a function of the soil parameters.

Although the generalized geology of the tank farms has been established, the exact geometry of a leak plume is not predictable. For this reason, the geometry of a leak plume in 200 West Area is assumed to be an oblate spheriod with the vertical dimension equal to one-half of the lateral dimension (i.e., $g_{2w} = 0.5$). In 200 East Area, the geometry is assumed to be spherical (i.e., $g_{2e} = 1.0$). These generalized geometries are based on past experience of characterizing the geometry of subsurface radioactivity from tank leaks and crib operations. The presence of finer sediment layers in 200 West Area tend to spread liquids horizontally due to capillary control. The general absence of the finer grained sediments in 200 East Area results in greater downward migration due to gravitational effects. Considerably more research is required to understand the interaction of gravity and capillary flow in the moisture deficient soils at Hanford.(8,13)

For tank-by-tank analyses, soil moisture was measured at each of five locations in the various tank farms. These data are provided in Appendix F. Soil moisture was measured at several depths ranging from 30 to 140 ft below ground surface. The soil moisture was found to vary from 3.6 vol% in the AX Tank Farm to >25% in the T Tank Farm. The moisture content at the 30 ft depth is significant for leaks at the sides of tanks and the moisture content below 45 ft depths is significant for bottom leaks. The average soil moisture content for the various depths are listed in Table K-4. The overall soil moisture content appears to be about 8 vol%; this value was used for most of the tank-by-tank analyses.

TABLE K-4. Average Soil Moisture Content by Tank Farm and Depth.

Tank farm	Average soil moisture content (vol%)					
	Depth (ft)					
	30-35	45-50	60-65	75	80-90	105
A	10.7	--	5.4	--	--	6.7
AX	12.6	--	7.0	--	6.5	--
B	9.9	7.1	6.9	--	8.5	--
BX	9.1	8.3	--	7.7	--	--
BY	10.2	--	7.1	--	6.7	--
C	9.7	4.9	5.9	--	7.4	--
S	12.4	10.9	8.2	--	--	--
SX	12.8	--	9.6	--	9.6	--
T	10.9	--	10.0	10.1	(16.0)?	--
TX	9.2	--	7.2	--	7.9	8.7
TY	9.9	--	8.5	--	7.8	--
U	11.7	8.6	--	9.6	--	--
Overall averages	10.8	8.0	7.6	9.1	(8.9)? 7.8	7.7

After a tank leak is stopped, the volume of liquid released will continue to spread or "equilibrate" by capillary transport and gravity drainage. When the matric (capillary) potential (also referred to as suction or tension) exceeds gravity, the soil moisture will move preferentially in a lateral direction and will equilibrate with the existing soil moisture. In such instances, the source term, s, becomes a function of unsaturated flow which is a function of the moisture content gradient which can be described as

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x}\left[D(\theta)\,\frac{\partial \theta}{\partial x}\right] \qquad \text{(K-32)}$$

for the general case[14] where Θ is the wetness of the soil. For a fixed volume leak, the moisture gradient decreases with time and distance from the leak source as shown in Figure K-13. As a consequence, the rate of increase in count rate is reduced with time as can be noted in Appendix D for Tanks 241-U-104 and 241-TX-110, for example. Eventually, the moisture gradient becomes so small that lateral migration stops and the radioactivity becomes "fixed." Subsequently, radioactive decay results in decreased count rates such as shown in Appendix D for Tank 241-TY-102.

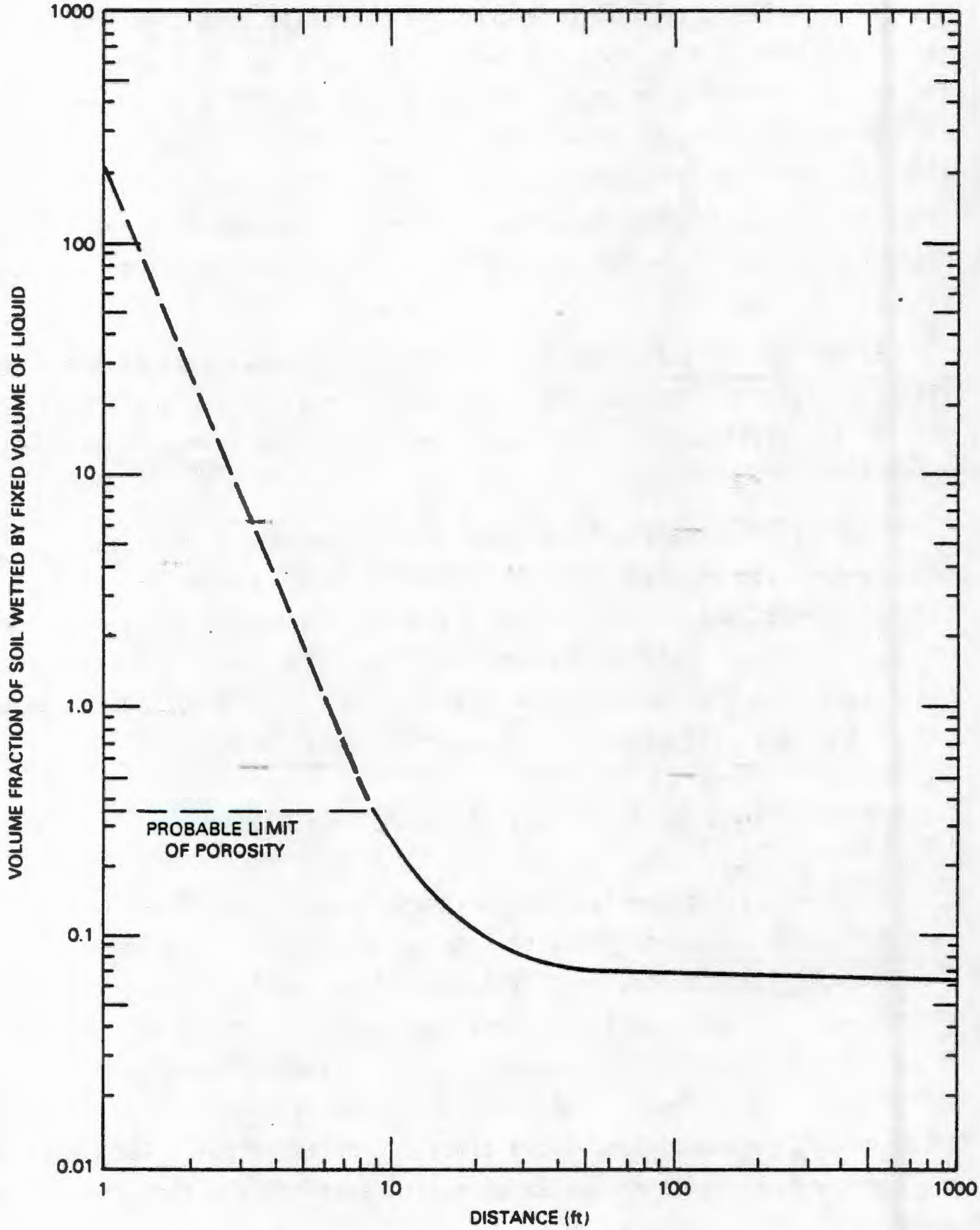
Extensive characterization studies of tank leaks such as the 241-T-106 leak has provided considerable information and insight regarding the distribution of radioactivity in the sediments beneath waste tanks.[15-17]

For the case where a leak stops after some period (t_1-t_0), s becomes the rate of capillary redistribution based on the relative saturation gradient. This becomes a special study case since the rate of change of count rate in dry wells will be very slow. Dry wells associated with the questionable integrity Tank 241-TX-107 appear to be examples of dry-well-response characteristics of this type.

INCREMENTAL SOIL MOISTURE CONTENT ASSOCIATED WITH KNOWN TANK LEAK, 241-T-106

The average incremental soil moisture content (q) of sediments that result from an advancing front of leaking wastes can be estimated from the characterization studies of the 241-T-106 tank leak.[15-17] The chronology of events and liquid level measurements are summarized in Table K-5. The generalized geometry of the distribution of the waste solutions in the sediments was found to be approximately oblate spheroidal having a diameter about two times the polar height. Assuming that the geometry can be described as an oblate spheroid and that the volume

92124991993



RCP8012-132

FIGURE K-13. Volume Fraction of Soil Wetted by Fixed Volume of Liquid (1,375 gal or 1/2 in. liquid level decrement in waste tank).

TABLE K-5. 241-T-106 Tank Leak Chronology.[a]

Date	Day	Liquid level (in.)	Radioactivity at Dry Well 299W-10-51	Distance, tank to dry well
04/20/73	0[b]	(188.8_8)[c]		
04/25/73	5	183.7		
05/02/73	12	178.9		
05/11/73	17	174.0		
05/14/73	24	167.9		
05/21/73	31	160.4		
05/30/73	40	152.7		
05/31/73	41		>167 c/s	47 ft
06/04/73	45	149.2		
06/09/73	50[d]	(144.2_4)[c]		

Slope = -0.8928 in./d; or -2,455 gal/d; or -328 ft^3/d

Correlation coefficient = 0.999

Intercept = 188.88 in. if day 0 was 04/20/73

Extrapolated liquid level at day 50 = 144.24 in. on 06/09/73

Volume of liquid lost = (2,750 gal)(188.88 - 144.24) = 122,760 gal

Estimated liquid lost from material balances = 115,000 gal

Equivalent liquid level decrement = 41.82 in.

Equivalent starting liquid level height $(145.1_3 + 41.82)$ = 186.95

Probable date of start of tank leak = 2.16 d or 04/22/73.

[a]Abstracted from TID 26431.(17)

[b]Estimated date that leak began based on material balances of supernatant solution transfers determined after the fact.

[c]Liquid level equivalent based on linear regression extrapolations (see Figure K-8).

[d]Probable day that liquid level was below the point at which leaking occurred (pumping started 10:00 p.m. 06/08/73 and ended about noon on 06/10/73).

of moisture added to the sediments must equal the volume of the leak, the incremental increase in moisture content of the sediments can be estimated as follows (see Table K-5)

Volume of leak = leak rate x time = st

Volume of sediments wetted = $(4/3\ \pi r^2) \times (\frac{r}{2}) = 2.0944r^3$

Let q = volume fraction of soils wetted,

then volume of added moisture in soils = $(q)(2.0944r^3)$

and $(q)(2.0944r^3) = st$

$s = 328\ ft^3/day$

t = 41 days for leak to reach dry well based on assumption that leak started on 04-20-73.

r = distance of dry well to tank = 47 ft

$$(q)(2.0944)(47^3) = (328)(41)$$

$$q = 0.0618 \text{ or } 6\%$$

if t' = 39 days, based on finding that the total leak volume was 115,000 gal

then q = 0.0588 or 6%

In either case q is the average incremental soil moisture content that caused the liquid waste front to advance from the tank leak source to the radiation monitoring dry well located about 47 ft away.

REFERENCES

1. "Final Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington," (II.1-45 and Fig. II.1-52), ERDA-1538, United States Energy Research and Development Administration, December 1975.

2. J. Moteff, "Tenth Value Thickness for Gamma Ray Absorption," Nucleonics Data Sheet No. 5, Nucleonics, McGraw Hill, 330 West 42nd St., New York, N.Y., 1959.

3. ARH-1888, L. E. Brownell, "Soil Moisture Studies Based on Wells at 32-49 Coordinates," Atlantic Richfield Hanford Company, January 1971.

4. BNWL-1712, J. J. Hsieh, A. E. Reisenauer, and L. E. Brownell, "A Study of Soil Water Potential and Temperature in Hanford Soils," Battelle, 1972b.

5. BNWL-1711, J. J. Hsieh, L. E. Brownell, and A. E. Reisenauer, "Lysimeter Experiment Description and Progress Report on Neutron Measurements," Battelle, 1972a.

6. BNWL-1710, A. E. Reisenauer, "Calculation of Soil Hydraulic Conductivity from Soil-Water Retention Relationships," Battelle, 1973.

7. ARH-2983, R. E. Isaacson, L. E. Brownell, and J. C. Hanson, "Soil Moisture Transport in Arid Site Vadose Zones," Atlantic Richfield Hanford Company, October 1974a.

8. ARH-SA-169, R. E. Isaacson, L. E. Brownell, R. W. Nelson, and E. L. Roetman, "Soil Moisture Transport in Arid Site Vadose Zones," Atlantic Richfield Hanford Company, January 1974b.

9. RHO-ST-15, T. L. Jones, "Sediment Moisture Relations: Lysimeter Project 1976-1977 Water Year," June 1978.

10. ARH-ST-123, L. E. Brownell, J. G. Backer, R. E. Isaacson, and D. J. Brown, "Soil Moisture Transport in Arid Site Vadose Zones," Atlantic Richfield Hanford Company, July 1975.

11. ARH-ST-146, G. V. Last, P. G. Easley, and D. J. Brown, "Soil Moisture Transport During the 1974-1975 and 1975-1976 Water Years."

12. ARH-ST-155, D. J. Brown and R. E. Isaacson, "The Hanford Environment as Related to Radioactive Waste Burial Grounds and Transuranium Waste Storage Facilities," Atlantic Richfield Hanford Company, June 1977.

13. RHO-LD-47, B. A. Finlayson, R. W. Nelson, and R. G. Baca, "A Preliminary Investigation Into the Theory and Techniques of Modeling the Natural Moisture Movement in Unsaturated Sediments," Rockwell Hanford Operations, February 1978.

14. D. Hillel, "Soil and Water Physical Principles and Processes," Academic Press, New York and London, 1971.

15. ARH-2874, "241-T-106 Tank Leak Investigation," Atlantic Richfield Hanford Company, November 1973.

16. TID 26431, "Report on the Investigation of the 106-T-Tank Leak at the Hanford Reservation, Richland, Washington," AEC-RL Staff, 1973.

17. RHO-ST-14, R. C. Routson, W. H. Price, D. J. Brown, and K. R. Fecht, "High-Level Waste Leakage from the 241-T-106 Tank at Hanford," Rockwell Hanford Operations, February 1979.

THIS PAGE
INTENTIONALLY
LEFT BLANK

APPENDIX L

EVALUATION OF DRY WELL RESPONSE EQUATION BASED ON DIFFUSION EQUATIONS

H. A. Forrester

An analytical model of the plume produced by a leak from a waste tank was derived by solving the partial differential equations governing motion of fluid in soil. Some simplifications are introduced, but the essential physics of the situation are covered. Since the differential equations are generally called diffusion equations, this analytical model is called the diffusion model.

The diffusion model was intended to replace the model developed by Ray Isaacson. Somewhat unexpectedly, the diffusion model turned out to be in essential agreement with the Isaacson model. It is, of course, of good value to be able to support the Isaacson model on theoretical grounds.

DERIVATION OF DIFFUSION MODEL NOTATION

The following notation is used:

U = volume concentration of fluid

U_0 = concentration of fluid in soil prior to the leak

U_1 = critical concentration of fluid

V = volume concentration of radioactive tracer element

A = V/U = ratio of tracer to fluid

A_0 = value of A in leaking fluid

K = permeability of soil (i.e., diffusion constant)

$$K = \begin{cases} K_1 \text{ if } U \geq U_2 \\ K_2 \text{ if } U < U_1 \end{cases}$$

r = distance from leak source

t = time, $t = 0$ is start of leak

$X_1, X_2, \ldots, X_n$ = coordinates centered at leak

n = "dimension" of leak, where

n = 2; leak confined between impermeable strata

n = 3; unconfined leak

R(t) = radius of leak front at time t

R_0 = limiting value of R(t) (for n = 3)

S = rate of leak

H = height of confined layer (for n = 2).

EQUATIONS GOVERNING LEAK

$$\frac{\partial U}{\partial t} = K \frac{\partial^2 U}{\partial r^2} + \frac{n-1}{r} \frac{\partial U}{\partial r} \quad \text{(L-1)}$$

$$U \frac{\partial A}{\partial t} = K \frac{\partial U}{\partial r} \frac{\partial A}{\partial r} \quad \text{(L-2)}$$

$$U = U_0 \text{ for } t \leq 0 \quad \text{(L-3)}$$

$$A = A_0 \text{ for } r = 0 \text{ and } t \geq 0 \quad \text{(L-4)}$$

$$\text{The rate of U at A = 0 for t = 0 is } \begin{cases} S \text{ if } n = 3 \\ S/H \text{ if } n = 2. \end{cases} \quad \text{(L-5)}$$

Here $A = A_0\ F(\beta)$ where $F(\beta) = 0$ if $\beta > 0$; 1 if $\beta < 0$ and $\beta = \int r^{n-1}\ U\ dr$.

SYNOPSIS OF RESULTS

As the leak fluid moves through the soil, it displaces fluid already in the soil. The displaced fluid undergoes surprisingly little mixing with the leak fluid. Thus, the forward part of the leak is formed by fluid with little or no tracer element present. In the region between the leak and the displaced fluid, both A and U are nearly constant, except for the immediate vicinity of the leak. This conclusion is essentially the same as that given by the Isaacson model.

There is an exceptional case (i.e., when $V_0 = 0$) when the Isaacson model does not apply. However, since the soils in the tank farms have U_0 in the range 0.04 to 0.12, U_0 is a substantial fraction of U_1 (which is about 0.10). Therefore, this case is not considered to be relevant.

Details of Analytical Model

Derivation. Two matters must be considered in derivation of equations governing the formation of the plume of a leak: (1) the motion of fluid through soil; and (2) the motion of a tracer element carried by the fluid. It is assumed that there is a radionuclide in the tank fluid which moves without being adsorbed by the soil. It is the detection of this radionuclide at a dry well which permits detection of the leak. If the soil were absolutely dry, the motion of the fluid and of the tracer radionuclide would coincide. However, the amount of groundwater in even relatively dry soils will be enough to have a substantial effect.

Let U denote the volume concentration of fluid and V denote the volume concentration of the radioactive tracer. U and V both are dimensionless, i.e., they have units of the form volume/volume. Let A = V/U denote the fraction of fluid volume formed by the tracer. Thus, A is also a dimensionless number.

Let $X_1, X_2, \ldots, X_n$ denote rectangular coordinates centered at the leak. The reason for choosing an arbitrary dimension n is economy, since two important cases occur. The case n = 3, corresponds to the leak being unconstrained; and n = 2, corresponds to the leak being confined to a layer of soil having the highest matric potential (capillary retention) in a layered soil system. (Typically water will be confined in a layer of fine grained sediments sandwiched between two layers of coarse grained sediments.)

Let $F_1, F_2, \ldots, F_n$ be the rate of diffusion of the fluid in the $X_1, X_2, \ldots, X_n$ direction. It is assumed that the rate of motion of the fluid is proportional to the rate of change of concentration, and that the fluid moves from higher to lower concentrations. Consequently,

$$F_i = -K \frac{\partial U}{\partial X_i} \qquad \text{(L-6)}$$

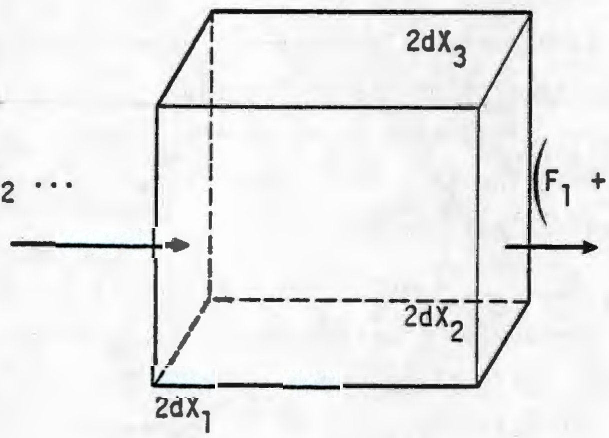
where K is the diffusion constant.

Let E_1, E_2, ... denote the rate of diffusion of the tracer elements. The assumption that the tracer element moves with the fluid is expressed by

$$E_i = AF_i = -K A\frac{\partial U}{\partial X_i} \qquad \text{(L-7)}$$

where A = V/U, the fraction of the tracer present in the fluid. Consider a rectangular box of sides $2dX_1$, $2dX_2$, ... centered at (X_1, X_2, ...).

$$\left(F_1 - \frac{F_1}{X_1} dX_1\right) \cdot 2dX_2 \ldots$$



$$\left(F_1 + \frac{F_1}{X_1} dX_1\right) \cdot 2dX_2 \ldots$$

(L-8)

The flow into the box across the face at $X_1 - dX_1$ is

$$\left(F_1 - \frac{\partial F_1}{\partial X_1} dX_1\right) \times \text{(area of face)} \qquad \text{(L-9)}$$

while the flow out of the box across the face at $X_1 + dX_1$ is

$$\left(F_1 + \frac{\partial F_1}{\partial X_1} dX_1\right) \times \text{(area of face)} \tag{L-10}$$

Thus the net accumulation in the box due to flow in the X_1 direction is

$$- \frac{\partial F_1}{\partial X_1} \times 2dX_1 \times \ldots \times 2dX_n \tag{L-11}$$

The total rate of accumulation per unit volume of soil is the sum of all such terms divided by the volume

$$2dX_1 \times \ldots \times 2dX_n \tag{L-12}$$

of the box. That is,

$$\frac{\partial U}{\partial t} = -\Sigma_{r=1}^{n} \frac{\partial F_r}{\partial X_r} = \Sigma_{r=1}^{n} \frac{\partial}{\partial X_r} \left(K \frac{\partial V}{\partial X_r}\right) \tag{L-13}$$

A similar argument yields

$$\frac{\partial V}{\partial t} = -\Sigma_{r=1}^{n} \frac{\partial F_i}{\partial X_r} = \Sigma_{r=1}^{n} \frac{\partial}{\partial X_r} \left(KA \frac{\partial U}{\partial X_r}\right) \tag{L-14}$$

or, since

$$\frac{\partial AU}{\partial t} = \Sigma_{r=1}^{n} K \frac{\partial}{\partial X_r} \left(KA \frac{\partial U}{\partial X_r}\right) \tag{L-15}$$

subtraction of (A times the equation for U) from the above equation gives

$$U \frac{\partial A}{\partial t} = \Sigma_{r=1}^{n} \quad K \frac{\partial U}{\partial X_r} \frac{\partial A}{\partial X_r} \qquad \text{(L-16)}$$

There is a criticism which can be made. One is that possible anisotropies of the soil have not been taken into account. The equations allowing for anisotropy are

$$\frac{\partial U}{\partial t} = \Sigma_{r=1}^{n} \quad \Sigma_{j=1}^{n} \quad \frac{\partial}{\partial X_i} \left(K_{ij} \frac{\partial U}{\partial X_j} \right)$$

$$U \frac{\partial A}{\partial t} = \Sigma_{r=1}^{n} \quad \Sigma_{j=1}^{n} \quad K_{ij} \frac{\partial U}{\partial X_j} \frac{\partial A}{\partial X_i} \qquad \text{(L-17)}$$

A change of coordinates will reduce these equations to the previous form, and the change of coordinates can be so chosen as not to change the scale in any particular direction of interest (i.e., along a line from the leak to the dry well).

The diffusion "constant" K will be taken as being a function of U and as having the form

$$K = \begin{cases} K_1 \text{ if } U < U_1 \\ K_2 \text{ if } U \geq U_1 \end{cases} \qquad \text{(L-18)}$$

This is an approximation to the physical situation. Fluid moves slowly in relatively dry soil and much faster at a certain level of ground moisture represented by U_1: approximately $U_1 = 0.10$. The corresponding values of K are denoted by K_1 and K_2; K_1 is $\sim 10^{-5}$ cm^2/s, and K_2 is $\sim 10^{-2}/s$. That is, K_2 is $\sim 1{,}000$ times K_1.

Let r denote $\sqrt{X_1^2 + X_2^2 + \ldots +, X_n^2}$, so that r is the distance from the leak. Hereafter, U and A will be taken as functions of r and of t = time. Now

$$\frac{\partial}{\partial X_i} = \frac{X_i}{r} \frac{\partial}{\partial r} \tag{L-19}$$

so the equations for U and A become

$$\frac{\partial U}{\partial t} = K\left(\frac{\partial^2 V}{\partial r^2} + \frac{n-1}{r} \frac{\partial U}{\partial r}\right)$$

$$\frac{U \partial A}{\partial t} = K \frac{\partial U}{\partial r} \frac{\partial A}{\partial r}$$

$$K = \begin{cases} K_1 & \text{for } U \geq U_2 \\ K_2 & \text{for } U < U_1 \end{cases} \tag{L-20}$$

It is assumed that a constant level of ground moisture is present with a value of U_0; that is, $U = U_0$ for t = 0. The leak is assumed to start at time t = 0, and have a constant flow rate. The expression for the leak rate takes two forms. For the case n = 3 (i.e., unconstrained plume), the leakage rate is simply S (with units volume/time). In the case n = 2, with the leak constrained by variation in matric potential at a distance H apart, the leak rate is S/H (with units area/time or volume/length/time).

METHOD FOR SOLVING THE DIFFUSION EQUATIONS

The method for solving the equations for U is first to obtain a solution U_{int} for

$$\frac{\partial U}{\partial t} = K_1 \left(\frac{\partial^2 U}{\partial r^2} + \frac{n-1}{r} \frac{\partial U}{\partial r}\right) \tag{L-21}$$

for $r \leq R(t)$, where $R(t)$ is the value of r for which

$$U_{int} = U_1$$

and then to obtain a solution U_{ext} of

$$\frac{\partial U}{\partial t} = K_2 \left(\frac{\partial^2 U}{\partial r^2} + \frac{n-1}{r} \frac{\partial U}{\partial r} \right) \qquad \text{(L-22)}$$

for $r \geq R(t)$, so as to satisfy the patching conditions when $r = R(t)$

$$U_{ext} = U_{int}$$

$$\frac{\partial U_{ext}}{\partial r} = \frac{\partial U_{int}}{\partial r} \qquad \text{(L-23)}$$

The solution U is then the result of patching these two equations together. The location of $r = R(t)$ will be called the leak front.

In the case $n = 2$ (i.e., the plume confined to a fine grained soil having highest matric (capillary) potential) there is a leak front only when the leak rate S is sufficiently large, i.e., when

$$S > 4\pi K_2 H \left(U_1 - U_0 \right) \qquad \text{(L-24)}$$

In this case, the plume will be well described by the Isaacson model. If the leak rate is small, so that no leak front forms, an explicit solution is given by $U = U_{ext}$ for all r and t. In the case $n = 3$, (i.e., an unconfined plume), a leak front always exists. Moreover, $R(t)$ will approach a limiting value R_0 which will be small. There will be substantial leakage across the leak front, so that $U = U_{ext}$ will be given later.

The solution of the equation for A is obtained by the method of characteristics. A first order equation $M\frac{\partial A}{\partial r} - N\frac{\partial A}{\partial t} = 0$ has the following features:

(1) If β is any non-trivial solution, then the general solution, A, is given by $A = F(\beta)$ for an arbitrary function F.

(2) The solution A is constant along the solution curves of $N\,dr + M\,dt = 0$. Since if

$$\frac{dr}{dt} = -\frac{M}{N}$$

then

$$\frac{dA}{dt} = \frac{\partial A}{\partial r}\frac{dr}{dt} + \frac{\partial A}{\partial t} = -\frac{M}{N}\frac{\partial A}{\partial r} + \frac{\partial A}{\partial t} = 0 \qquad \text{(L-25)}$$

(3) If $\beta(r,t) = 0$ is the solution of $N\,dr + M\,dt = 0$, then β is a solution of the partial differential equation.

(4) The equation $N\,dr + M\,dt = 0$ has a solution $\beta = \int N\,dr$ when the equation is exact, that is, when $\frac{\partial N}{\partial t} = \frac{\partial M}{\partial r}$.

Now

$$\frac{\partial}{\partial r}\left(r^{n-1}\frac{\partial U}{\partial r}\right) = r^{n-1}\frac{\partial^2 U}{\partial r} + (n-1)\,r^{n-2}\frac{\partial U}{\partial r}$$

$$= r^{n-1}\left(\frac{\partial^2 U}{\partial r} + \frac{n-1}{r}\,\frac{U}{r}\right) \qquad \text{(L-26)}$$

and so the differential equation for U can be written

$$\frac{\partial}{\partial t}\left(r^{n-1}U\right) = K\frac{\partial}{\partial r}\left(r^{n-1}\frac{\partial U}{\partial r}\right) = \frac{\partial}{\partial r}\left(Kr^{n-1}\frac{\partial U}{\partial r}\right) \qquad \text{(L-27)}$$

Thus, $\left(r^{n-1}U\right)dr + \left(Kr^{n-1}\frac{\partial U}{\partial r}\right)dt = 0$ is exact. Hence, its solution β is a solution of

$$U\frac{\partial A}{\partial t} = K\frac{\partial U}{\partial r}\ \frac{\partial A}{\partial r} \qquad \text{(L-28)}$$

(after multiplying by r^{n-1}) and hence $\beta = \int r^{n-1}U\,dr$. Thus, $A = F(\int r^{n-1}\,U\,dr)$ for some function F. The determination of F remains to be carried out.

COMPARISON OF DIFFUSION AND ISAACSON MODELS

The Isaacson model assumes that U (or perhaps V) is uniformly distributed inside a region $r = R(t)$, and that U (or V) is a constant value independent of time for $r \lesseqqgtr R(t)$. Thus for $n = 3$ (unconfined plume), $R(t) = \text{Const.}\ \sqrt[3]{t}$, and for $n = 2$ (confined plume), $R(t) = \text{Const.}\ \sqrt[2]{t}$.

Solution for the Confined Plume

The solution of

$$\frac{\partial^2 U_{int}}{\partial r^2} = K_1\left(\frac{\partial^2 U_{int}}{\partial r^2} + \frac{1}{r}\ \frac{\partial U_{int}}{\partial}\right) \qquad \text{(L-29)}$$

(in the case $n = 2$) is $U_{int} = U_0 + S/(4\pi K_1 H)\exp(-r^2/4K_2 t)$. The leak front $r = R(t)$ is the solution, for r as a function of t, of $U_1 = U_0 + S/\left(4\pi K_2 H\right)\exp\left(-r^2/4K_1 t\right)$ which is

$$R(t) = \sqrt{\log\frac{S}{4\pi K_1 H\left(U_1 - U_0\right)}}\cdot\sqrt{t} \qquad \text{(L-30)}$$

This is valid only for log

$$\frac{S}{4\pi K_2 H\left(U_1 - U_0\right)} > 0$$

that is, for $S > 4\pi K_2 H(U_1 - U_0)$. If $S < 4\pi K_2 H(U_1 - U_0)$, the solution is $U = U_{int} = U_0 + S/(4\pi K_1 H)\ \exp(-r^2/4K_1 t)$. If $S > 4\pi K_2 H(U_1 - U_0)$, the exterior solution, U_{est}, is determined as follows.

The first step is to determine the amount of leak fluid contained behind the leak front. The total amount of fluid leaked is St at time t, and the amount behind the front is the integral over $r \leq R(t)$ of $(U - U_0)$ times the element of volume $H \cdot rdr \cdot d\theta$(in polar coordinates). The amount is

$$\frac{S}{4K_1 H\pi} \cdot H \cdot 2\pi \int_0^{R(H)} r\, e^{-r^2/4K_1 t}\, dr$$

$$= St\left(1 - e^{-R^2(H)/4K_1 t}\right)$$

$$= St\left(1 - e^{-\log\left(\frac{S}{4\pi K_1 H\ \left(U_1 - U_0\right)}\right)}\right) \qquad \text{(L-31)}$$

Now

$$\frac{4\pi K_1 H\left(U_1 - U_0\right)}{S} \qquad \text{(L-32)}$$

is <1, so a constant fraction

$$St\left(1 - \frac{4\pi K_1 H\left(U_1 - U_0\right)}{S}\right) \qquad \text{(L-33)}$$

of the fluid moves outside the leak front $r = R(t)$. Taking U_{ext} in the form

$$U_{ext} = U_0 + \frac{\sigma}{4\pi K_1 H} e^{-r^2/4K_2 t} \qquad \text{(L-34)}$$

for some constant σ, and such that

$$U_{ext} = U_1 \text{ at } r = R(t) \qquad \text{(L-35)}$$

gives

$$U_1 - U_0 = \frac{\sigma}{4\pi K_1 H} e^{-\left(\frac{K_1}{K_2} \cdot \frac{(RH)^2}{4\pi K_1 t}\right)}$$

$$= \frac{\sigma}{4\pi K_1 H} \cdot \left(\frac{4\pi K_1 H\left(U_1 - U_0\right)}{S}\right)^{\frac{K_1}{K_2}} \qquad \text{(L-36)}$$

so that

$$\sigma = \left(\frac{S}{4\pi K_1 H (U_1 - U_0)}\right)^{\left(\frac{K_1}{K_2} - 1\right)} \cdot S \qquad \text{(L-37)}$$

Since

$$\frac{S}{4\pi K_1 H (U_1 - U_0)} < 1 \qquad \text{(L-38)}$$

and K_1/K_2 is about 1,000, σ is very small and U_{ext} is close to U_0 for r only slightly $>R(t)$.

Consequently, the solution is closely given by

$$U = U_0 + \frac{S}{4\pi K_1 H} e^{-r^2/4K_2 t} \quad \text{for } r \leq R(t)$$

$$= U_0 \quad \text{for } r > R(t) \qquad \text{(L-39)}$$

Moreover, the derivative of U with respect to r is small for all r and t except for r or t close to 0. Thus, U can be taken as substantially constant for $r \leq R(t)$ except close to the leak or during early stages of formation of the plume. This result is essentially the same as given by the Isaacson model.

For small leak rates, the confined plume departs from the Isaacson model since no leak front develops. However, the significant quantity is

$$\dot{V} = F(\beta)\, U \qquad \text{(L-40)}$$

where

$$\beta = \int r\, U\, dr \qquad \text{(L-41)}$$

This is due to the fact that detection of the leak depends on V rather than U.

Now F(β) at time t = 0 is 0 for r >0, and is 1 for r = 0. Integrating for β gives

$$\beta = \frac{U_0}{2} r^2 - \frac{St}{2\pi H} e^{-r^2/4K_1 t} \tag{L-42}$$

so that

$$\beta = 0 \text{ when } r = 0,\ t = 0$$

$$\beta > 0 \text{ when } r > 0,\ t = 0$$

consequently

$$F(\beta) = 1 \text{ when } \beta \leq 0$$

$$F(\beta) = 0 \text{ when } \beta > 0$$

that is

$$V = 0 \text{ for } \frac{U_0}{2} r^2 > \frac{St}{4\pi H} e^{-r^2/4K_1 t} \tag{L-43}$$

and

$$V = U_{int} \text{ for } \frac{U_0}{2} r^2 \leq \frac{St}{4\pi H} e^{-r^2/4K_1 t} \tag{L-44}$$

This means that V shows a leak front; the previous argument then applies to V to show that the Isaacson model is a good approximation.

Solution for the Unconfined Model

The interior solution for $n = 3$ is

$$U_{int} = U_0 + \frac{S}{2\pi^{3/2}K_1} \cdot \frac{1}{r} \int_{\frac{r}{\sqrt{4K_1 t}}}^{\infty} e^{-S^2} \, ds \qquad \text{(L-45)}$$

Using the notation

$$\text{erfc}\ (x) = \frac{2}{\sqrt{\pi}} \int_x^{\infty} e^{-S^2} \, ds$$

the solution is

$$U_{int} = U_0 + \frac{S}{4\pi K_1} \cdot \frac{1}{r} \, \text{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right) \qquad \text{(L-46)}$$

The function erfc (x) has the following behavior:

$$\text{erfc}\ (0) = 1$$

$$\text{erfc}\ (x) \simeq \frac{e^{-x^2}}{x_2} \text{ as } x \to \infty \qquad \text{(L-47)}$$

consequently for $U_1 > U_0$ (which is always the case) the equation

$$U_1 = U_0 + \frac{S}{4\pi K_1} \cdot \frac{1}{r} \cdot \text{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right) \qquad \text{(L-48)}$$

or

$$\frac{1}{r} \, \text{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right) = \frac{4\pi K_1 \left(U_1 - U_0\right)}{S} \qquad \text{(L-49)}$$

always has a unique solution $r = R(t)$. Moreover, as $t \to \infty$ so that $\frac{r}{\sqrt{4K_2 t}} \to 0$, the equation becomes

$$\frac{1}{r} = \frac{4\pi K_2 \left(U_1 - U_0\right)}{S} \qquad \text{(L-50)}$$

thus $R(t)$ tends to

$$R_0 = \frac{S}{4\pi K_1 \left(U_1 - U_0\right)} \qquad \text{(L-51)}$$

as a limit. A natural length R_0 is thus defined and a natural time t_0 is given by

$$\frac{R_0^{\,2}}{4K_1 t_0} = 1 \text{ or } t_0 = \frac{R_0^{\,2}}{4K_1} \qquad \text{(L-52)}$$

A lengthy computation which will not be given here shows that

(1) For $t < t_0$, almost all the leak fluid is confined behind leak front $t = t_0$

(2) Initially $R(t)$ expands at the rate

$$\text{const.}\sqrt{\left(\frac{t}{\log \left(t_0/t\right)}\right)}$$

which is very much faster than $\sqrt{t}$ (or $\sqrt[3]{t}$)

(3) For $t > t_0$, $R(t)$ is approximately $R(t) \approx R_0 \cdot \left(1-\sqrt{t_0/t}\right)$

(4) For $t > 3t_0$, $R(t)$ can be taken as approximately R_0; the fluid leaks through the leak front at the same rate at which it enters the leak.

An approximate value for R_0 and t_0 can be obtained with the typical values:

$S = 0.03$ gal/min $= 1.9$ cm^3/s

$U_1 = 0.10$

$U_0 = 0.05$

$K_2 = 10^{-2}$ cm^2/s

Then $R_0 = 30$ cm $= 1$ ft, and $t_0 = 22{,}500$ s $\simeq$ 6-1/4 hr. If $U_1 = 0.10$, and $U_0 = 0.09$, then $R_0 = 5$ ft and $t_0 = 153$ hr $\simeq$ 1 wk. Thus for dry wells outside a distance of 5 ft from the leak, only the exterior solution is significant.

The exterior solution for $t > t_0$ can be taken in the form (for some σ)

$$U_{ext} = U_0 + \frac{\sigma}{4K_1\pi} \cdot \frac{1}{r} \operatorname{erfc}\left(\frac{r}{\sqrt{4K_2 t}}\right) \tag{L-53}$$

where the rate of leakage at $r = R_0$ is that produced by the motion of leak fluid through the sphere $r = R_0$ at a constant rate

$$\frac{S}{4\pi R_0^{\,2}} \tag{L-54}$$

for $t > t_0$. That is

$$U_1 = U_0 + \frac{\sigma}{4\pi K_1} \cdot \frac{1}{R_0} \operatorname{erfc}\left(\frac{R_0}{\sqrt{4K_2 t}}\right) \tag{L-55}$$

and since

$$\operatorname{erfc}\left(\frac{R_0}{\sqrt{4K_1 t}}\right) \simeq 1 \text{ for } t > t_0$$

$$\sigma = 4\pi K_2 \left(U_1 - U_0\right) \cdot R_0$$

$$= 4\pi K_1 \left(U_1 - U_0\right) \cdot \frac{S}{4\sqrt{K_1}\left(U_1 - U_0\right)} = S \qquad \text{(L-56)}$$

thus

$$U_{ext} = U_0 + \frac{S}{4\pi K_1} \cdot \frac{1}{r} \operatorname{erfc}\left(\frac{r}{\sqrt{4K_2 t}}\right) \qquad \text{(L-57)}$$

consequently, the total solution for U is

(1) For $t \leq t_0$

$$U = U_0 + \frac{S}{4\pi K_1} \cdot \frac{1}{r} \operatorname{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right) \text{ for } r \leq R(t)$$

$$U = U_0 \text{ for } r > R(t) \qquad \text{(L-58)}$$

(2) For $t > t_0$

$$U = U_0 + \frac{S}{4\pi K_2} \cdot \frac{1}{r} \operatorname{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right) \text{ for } r \leq R_0$$

$$U = U_0 + \frac{S}{4\pi K_2} \cdot \frac{1}{r} \operatorname{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right) \text{ for } r > R_0 \qquad \text{(L-59)}$$

The special solution β of the differential equation for A is then, for $r > R_0$,

$$\beta = \int r^2\, U\, dr = \frac{U_0}{3}\; r^3 + \frac{S}{4\pi K_2}\; \int r \;\text{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right) dr$$

$$= \frac{U_0}{3}\; r^3 + \frac{S}{4\pi K_2} \cdot 4K_1 t \int \frac{r}{\sqrt{4K_1 t}}\; \text{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right) d\left(\frac{r}{\sqrt{4K_1 t}}\right)$$

$$= \frac{U_0}{3}\; r^3 + \frac{K_1 S}{K_2}\; t \int^{S\, =\left(\frac{r}{\sqrt{4K_1 t}}\right)} S\; \text{erfc}(S)\; ds \qquad \text{(L-60)}$$

Now

$$\int S\; \text{erfc}(S)\; ds = \frac{2}{\sqrt{\pi}}\; S\left(\int_S^\infty e^{-x^2}\, dx\right) ds \qquad \text{(L-61)}$$

and an integration by parts yields

$$\frac{2}{\sqrt{\pi}} \int S \left(\int_S^\infty e^{-x^2}\, dx\right) ds = \left(\frac{S^2}{2} - \frac{1}{4}\right) \text{erfc}(S) - \frac{S\, e^{-S^2}}{2\sqrt{\pi}} \qquad \text{(L-62)}$$

so

$$\beta = \frac{U_0}{3}\; r^3 + \frac{K_1 S}{K_2}\; t \cdot \left[\left(\frac{r^2}{8K_1 t} - \frac{1}{4}\right) \text{erfc}\left(\frac{r}{\sqrt{4U_1 t}}\right) - \frac{r e^{-r^2/4U_1 t}}{2\sqrt{4\pi U_1 t}}\right]$$

$$= \frac{U_0}{3}\; r^3 + \left(\frac{r^2 S}{8K_2} - \frac{K_1 S}{4K_2 t}\right) \text{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right)$$

$$- \frac{U_1}{\sqrt{\pi} K_2}\; \frac{r}{4U_2\sqrt{t}} \cdot e^{-r^2/U_1 X_1 t} \qquad \text{(L-63)}$$

then $A = F(\beta)$. Now for $t = 0$, $A = A_0$ at $r = 0$ and $A = 0$ for $r > 0$. Also

$$\beta = \frac{U_0}{3} r^3 \text{ for } t = 0 \tag{L-64}$$

Consequently, $F(\beta) = A_0$ for $\beta \leq 0$ and $F(\beta) = 0$ for $\beta > 0$. Now for t large, both

$$\operatorname{erfc}\left(\frac{r}{\sqrt{4K_1 t}}\right)$$

and

$$e^{-r^2/4K_1 t}$$

are close to 1, while $\frac{r}{\sqrt{4K_1 t}}$ is close to 0. Thus

$$\beta \approx \frac{U_0}{3} r^3 - \frac{K_2 S}{2K_1} t \tag{L-65}$$

and hence $\beta = 0$ for

$$r = \frac{\sqrt[3]{3K_1 S}}{2K_2 U_0} \cdot \sqrt[3]{t} \tag{L-66}$$

Again $\frac{\partial U}{\partial r}$ is small, so the result of V is that

$$V \approx \text{constant for } r \leq \text{constant} \cdot \sqrt[3]{t}$$
$$V \approx 0 \text{ for } r \geq \text{constant} \cdot \sqrt[3]{t}$$

when t is large and r is larger than a few feet. This is essentially the same result as obtained by the Isaacson model.

APPENDIX M

MONITORING INTERVALS AND EFFECTIVENESS

R. E. Isaacson

The spatial relationships used in the development of the dry well radioactivity response equation are shown in Figure M-1 and Appendix K, Figures K-6 and K-7.

The dry well response distance, B, is the distance of the dry well from a potential tank leak source. This distance is determined from the relationship shown in Figure M-1. It can be shown that

$$B = \sqrt{R^2 + (R + W)^2 - 2R(R + W)(\cos \frac{\Theta}{2})}$$

where

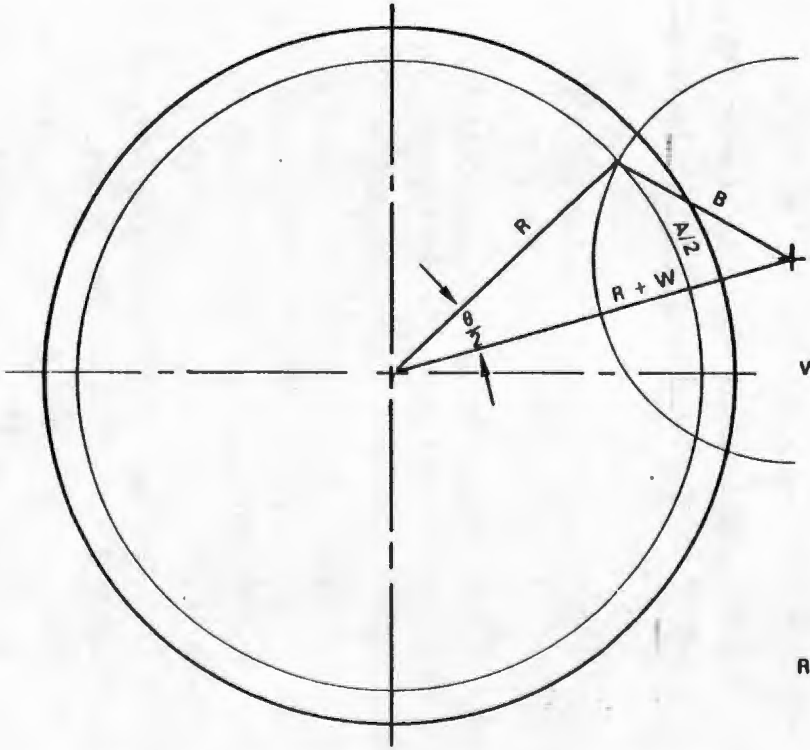
R = the radius of the tank

W = the distance of the dry well to the tank

$\frac{\Theta}{2}$ = the half-angle subtended by the percentage of the perimeter of the tank to be monitored by the dry well, as a limiting case.

These relationships were used to calculate the effectiveness of monitoring Tanks 241-SX-106 and 241-B-105, as examples.

In the case of 241-SX-106, the dry well response distance B was found for each of the monitoring wells for monitoring intervals of 1 to 7 wk based on an assumed maximum expected leak rate of 0.03 gal/min. The portion of the tank within the response time of each well for each monitoring interval is listed in Tables M-1 and M-2 and shown in Figure M-2. The percentage of the tank perimeter that is within the range of all dry wells for each monitoring interval is given in Table M-2 as the probability for each monitoring interval. This is graphically illustrated in Figure M-3. The significance is that if the monitoring frequency for Tank 241-SX-106 is set at 1 wk, then 58% of all leaks will have a response time >1 wk; i.e., the time required for the count rate



$$A = R\theta = (37.5)\left(\frac{2\pi}{180}\right)\left[\cos^{-1}\left\{\frac{R^2 + (R + W)^2 - B^2}{2R(R + W)}\right\}\right]$$

WHERE

A = ARC ALONG TANK CIRCUMFERENCE WITHIN THE DRY WELL RESPONSE DISTANCE FOR A GIVEN MONITORING TIME INTERVAL

θ = ANGLE SUBTENDED BY ARC "A"

B = DISTANCE OF HYPOTHETICAL TANK LEAK SOURCE FROM RADIATION MONITORING DRY WELL (DRY WELL RESPONSE DISTANCE)

R = RADIUS OF TANK (37.5 ft)

R + W = RADIAL DISTANCE FROM CENTER OF TANK TO DRY WELL

RCP8012-126C

FIGURE M-1. Method of Determining the Waste Tank Arc that is Within the Response Distance of a Radiation Monitoring Dry Well for that Time in Which the Count Rate Increases from Alert Level to Action Level.

TABLE M-1. Effectiveness of Monitoring Tank 241-SX-106 at Various Intervals.

Monitoring interval (wk)	Distance from tank leak source to dry well (ft)	Percentage of time that count rate will fall within given range[a]			Probability of detection for each monitoring interval (%)
		2-20 c/s[b]	20-160 c/s	>160 c/s	
<1	9.3[c]	77.04	22.96	--	22.96
1	12.9	34.77	19.31	22.96	42.27
2	18.1	27.40	30.33	42.27	72.60
3	22.1	13.28	14.12	72.60	86.72
4	25.4	5.78	7.50	86.72	94.22
5	28.2	2.10	3.68	94.22	97.90
6	30.8	0	2.10	97.90	100.0
7	33.1	--	--	--	--

[a]First count could be slightly over background but not discernible. Next count would be in the 20 to 160 c/s range. Subsequent count would exceed 160 c/s.

[b]Count rates are net c/s above background.

[c]Distance at 2 c/s = 9.3 ft or greater.

TABLE M-2. Leak Volumes, Elapsed Time, and Probability of Detection for Various Monitoring Intervals for Tank 241-SX-106.

Monitoring interval (wk)	Distance from tank leak source to dry well at 20 c/s (ft)	Total elapsed time for waste front to migrate to a dry well (d)	Maximum potential volume of leak (gal)	Incremental leak volume (gal)	Probability of detection for each monitoring interval (%)
<1	9.3*	23	1,000	--	23
1	12.9	62	2,700	300	42
2	18.1	172	7,400	600	73
3	22.1	313	13,500	900	87
4	25.4	475	20,500	1,200	94
5	28.2	650	28,000	1,500	98
6	30.8	848	36,600	1,800	100
7	33.1	1,052	45,500	2,100	--

*Distance at 2 c/s = 9.3 ft or greater

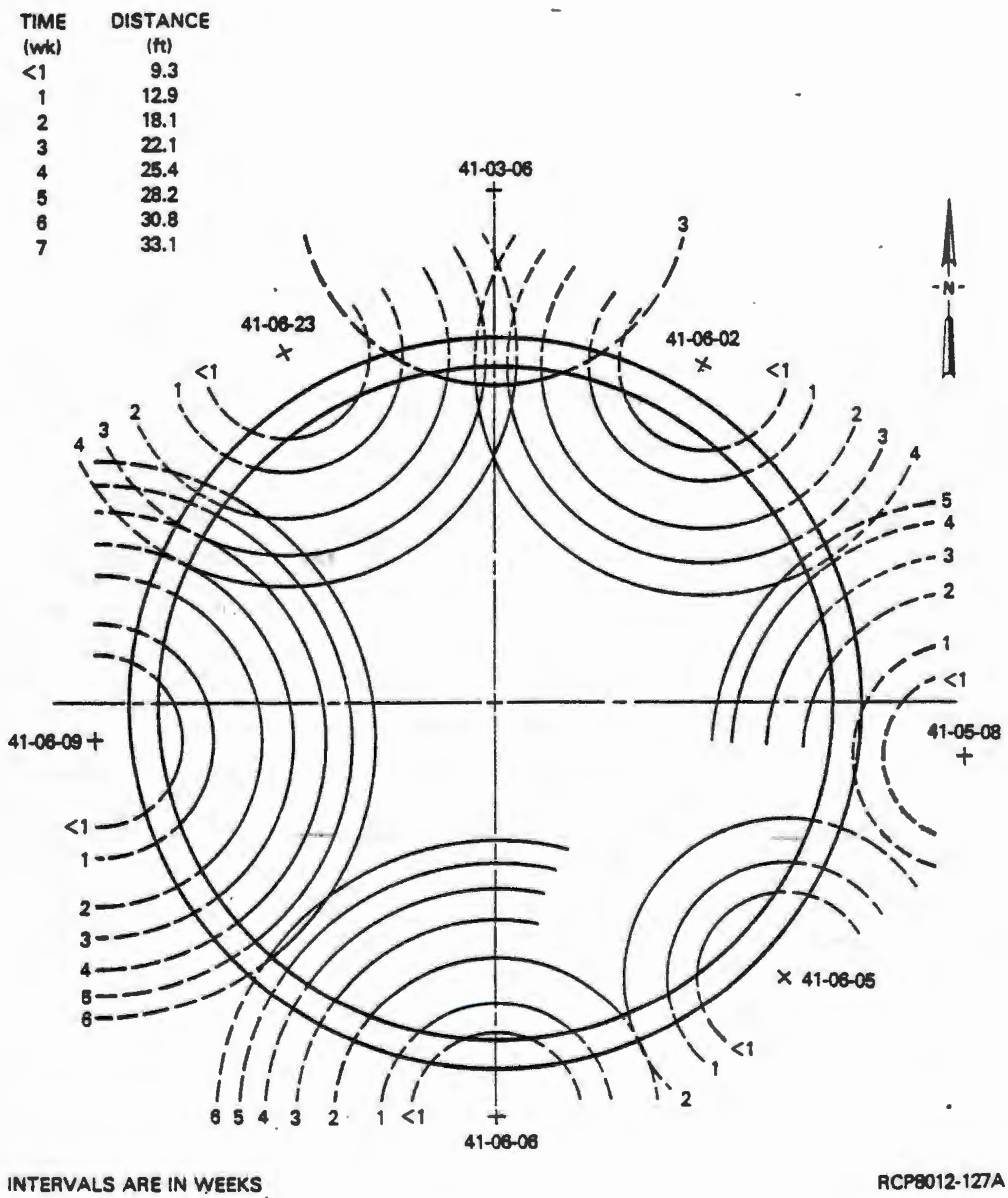
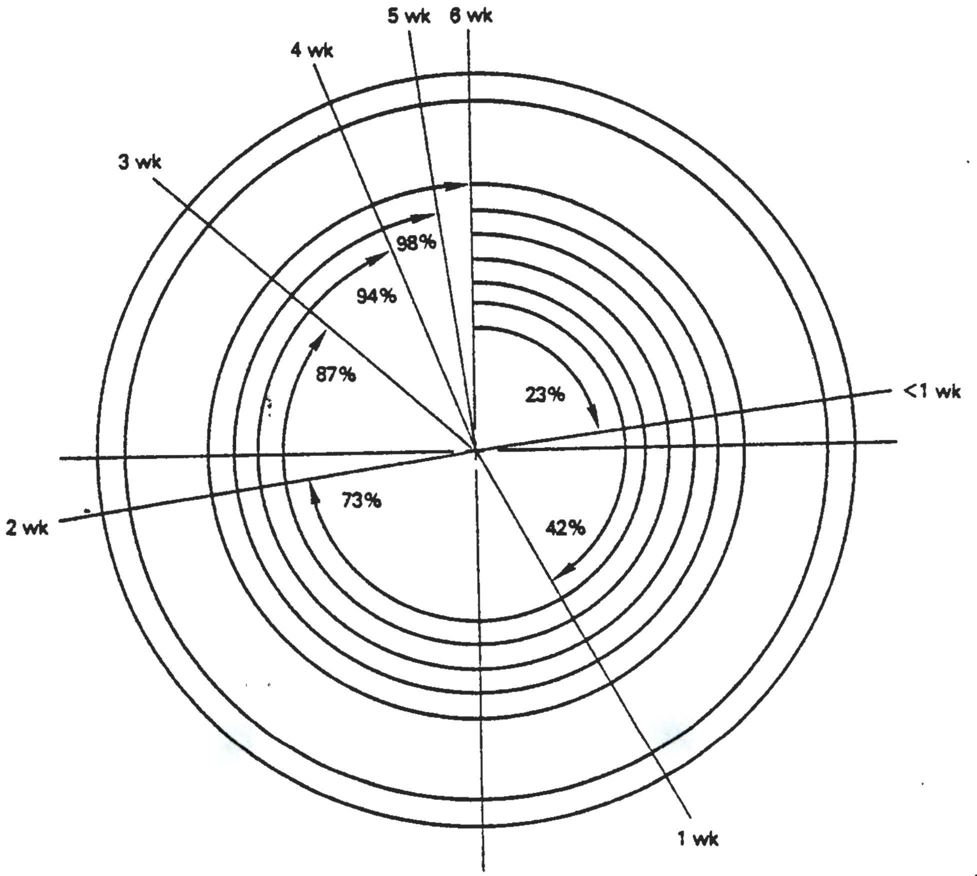


FIGURE M-2. Segments of Tank 241-SX-106 Within Range of Radiation Monitoring Dry Wells During Various Monitoring Intervals. The monitoring intervals shown are the incremental times for the count rate to increase from the alert level of 20 c/s to the action level of 160 c/s above background.



RCP8208-117

FIGURE M-3. Summations of Segments of Tank 241-SX-106 Having Potential Leak Sources that Would Result in Count Rate Increases from the Alert Level to the Action Level Within Monitoring Periods from Less than 1 wk to 6 wk. The count rate for 98% of all possible leaks will increase from background to 20 c/s within 5 wk and will also increase from 20 c/s to 160 c/s within 5 wk.

to increase from background to 160 c/s above baseline will be >1 wk for 77% of all possible leaks. If the monitoring schedule is set at 4 wk, 87% of the potential leaks could result in a count rate >160 c/s when first detected.

The relationships for monitoring intervals and the portion of the tank perimeter within the response time and response distance for Tank 241-B-105 are given in Table M-3 and are shown in Figure M-4. In this case, there are only four monitoring wells associated with this tank. However, it is possible that a leak could reach Dry Well 20-08-02 before reaching Dry Well 20-08-03 or 20-06-06 based on the distances from the leak to the dry wells. Should a leak occur at a maximum distance between adjacent wells, it would take at least 23 wk for the count rate to increase from 20 to 160 counts above background. This case is based on a maximum expected leak rate of 0.03 gal/min. The leak volume, elapsed time, and probability of detecting a leak is given in Table M-4. (Note: Subsequent studies have shown that 95% of the leaks will be <0.03 gal/min at the 95% confidence level, see Appendix D).

The response distance for all monitoring wells around tanks, which contain sufficient liquid wastes as to require pumping in case of a leak, were determined for monitoring intervals of 1 to 10 wk in 200 East Area and 1 to 7 wk in 200 West Area, Table M-5. Using these distances, the percent of a tank perimeter that is within the response time of each dry well for each monitoring period can be determined. Such data can be used to establish a tank-by-tank monitoring schedule. A realistic monitoring frequency would be one that would assure that at least 90% of the leaks would be detected before the count rate reached the alert level. Then, only 10% of all possible leaks could be in the range of 20 c/s or above. Using this basis, the suggested frequency of monitoring tanks would be every 2 to 4 wk in 200 East Area and every 1 to 3 wk in 200 West Area.

Estimated monitoring intervals based on fixed frequency monitoring on a dry-well-by-dry-well basis for each tank are given in Appendix N.

The foregoing calculations were modified by determining the response time for each dry well for the cases where 10% of the tank perimeter would be within range of the dry well during that monitoring interval (see Appendix N).

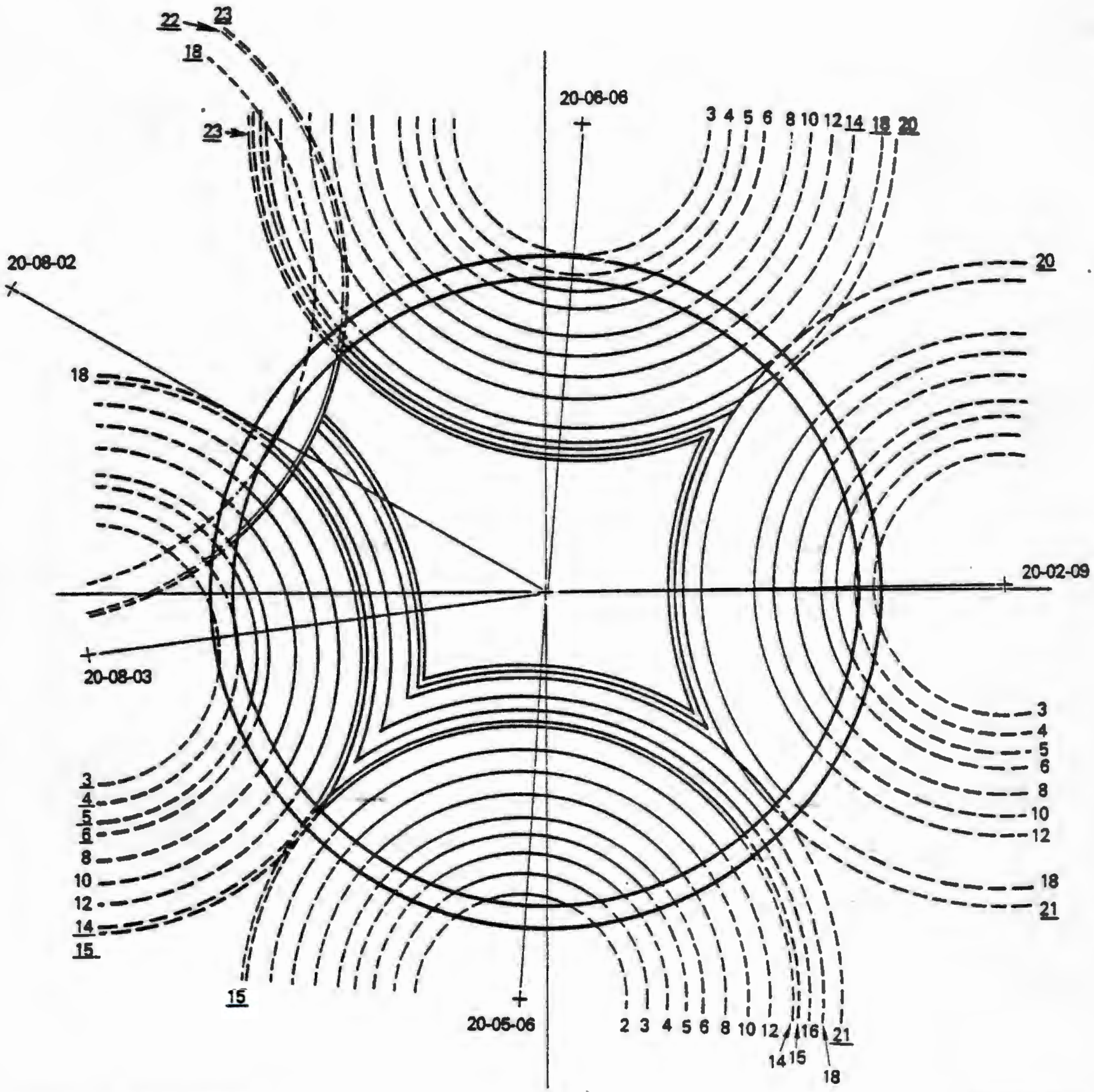
TABLE M-3. Effectiveness of Monitoring Tank 241-B-105 at Various Intervals.

Monitoring interval (wk)	Distance from tank leak source to dry well (ft)	Percentage of time that count rate will fall within given range[a]			Probability of detection for each monitoring interval (%)
		2-20 c/s[b]	20-160 c/s	>160 c/s	
1	9.2[c]	100	0	0	0
2	12.9	93.4	6.54	0	6.54
3	15.7	90.6	2.90	6.54	9.44
4	18.0	84.26	6.30	9.44	15.74
5	20.0	68.35	15.91	15.74	31.65
6	21.9	59.10	9.25	31.65	40.90
7	23.5	51.88	7.22	40.90	48.12
8	25.0	45.73	6.15	48.12	54.27
9	26.4	40.29	5.44	54.27	59.71
10	27.8	35.35	4.94	59.71	64.65
11	29.0	30.82	4.53	64.65	69.18
12	30.2	26.60	4.22	69.18	73.40
13	31.3	22.65	3.95	73.40	77.35
14	32.4	18.92	3.73	77.35	81.08
15	33.4	15.83	3.09	81.08	84.17
16	34.4	13.29	2.54	84.17	86.71
17	35.3	10.88	2.41	86.71	89.12
18	36.2	8.21	2.67	89.12	91.79
19	37.1	4.68	3.53	91.79	95.32
20	37.9	2.27	2.41	95.32	97.73
21	38.7	1.19	1.08	97.73	98.81
22	39.5	0.24	0.95	98.81	99.76
23	40.2	0	0.24	99.76	100.0
24	--	--	--	100.0	--

[a]First count could be slightly over background but not discernible. Next count would be in the 20 to 160 c/s range. Subsequent count would exceed 160 c/s.

[b]Count rates are net c/s above background.

[c]Distance at 2 c/s = 9.3 ft or greater.



INTERVALS ARE IN WEEKS

RCP8012-129A

FIGURE M-4. Segments of Tank 241-B-105 Within Range of Radiation Monitoring Dry Wells During Various Monitoring Intervals. The monitoring intervals shown are the incremental times for the count rate to increase from the alert level of 20 c/s to the action level of 160 c/s above background. The underlined weeks are the approximate monitoring intervals for the equidistant points between adjacent dry wells.

TABLE M-4. Leak Volumes, Elapsed Time, and Probability of Detection for Various Monitoring Intervals for Tank 241-B-105.

Monitoring interval (wk)	Distance from tank leak source to dry well at 20 c/s (ft)	Total elapsed time for waste front to migrate to a dry well (d)	Maximum potential volume of leak (gal)	Incremental leak volume (gal)	Probability of detection for each monitoring interval (%)
1	9.2	45	1,950	300	0
2	12.9	125	5,380	600	6.5
3	15.7	225	9,700	900	9.4
4	18.0	338	14,600	1,200	15.7
5	20.0	464	20,000	1,500	31.7
6	21.9	610	26,300	1,800	40.9
7	23.5	753	32,500	2,100	48.1
8	25.0	907	39,200	2,400	54.3
9	26.4	1,068	46,100	2,700	59.7
10	27.8	1,247	53,900	3,000	64.7
11	29.0	1,415	61,100	3,300	69.2
12	30.2	1,598	69,000	3,600	73.4
13	31.3	1,779	76,900	3,900	77.4
14	32.4	1,974	85,300	4,200	81.1
15	33.4	2,162	93,400	4,500	84.2
16	34.4	2,362	102,000	4,800	86.7
17	35.3	2,553	110,300	5,100	89.1
18	36.2	2,753	119,000	5,400	91.8
19	37.1	2,963	128,000	5,700	95.3
20	37.9	3,159	136,000	6,000	97.7
21	38.7	3,363	145,000	6,350	98.8
22	39.5	3,576	154,500	6,650	99.8
23	40.2	3,770	162,900	7,000	100.0

TABLE M-5. Monitoring Intervals for Dry Wells Located at Various Distances from Tank Leak Sources.

Dry well response time (wk)*	Distance between tank leak source and dry well (ft)		
	200 East Area		200 West Area
	[^{106}Ru]=1.7x10^{-2} Ci/L	[^{106}Ru]=4x10^{-4} Ci/L	[^{106}Ru]=4x10^{-4} Ci/L
1	8.20	9.23	12.94
2	11.42	12.90	18.14
3	13.87	15.69	22.08
4	15.91	18.02	25.37
5	17.69	20.04	28.24
6	19.29	21.86	30.81
7	20.74	23.51	33.14
8	22.07	25.03	--
9	23.31	26.44	--
10	24.47	27.77	--

*The Dry-Well-Response Time is the time required for the count rate to increase from 20 to 160 c/s above background in dry wells located at the listed distances from tank leak sources based upon a leak rate of 0.03 gal/min and a soil moisture content of 8 vol%. As noted elsewhere in the text, this leak rate is about two times the normal maximum expected, thus the Dry-Well-Response Time and the monitoring interval are probably two times the values given.

THIS PAGE
INTENTIONALLY
LEFT BLANK

9 2 1 2 4 9 9 2 0 2 9

APPENDIX N

TABLES FOR DRY WELL MONITORING FREQUENCIES FOR SINGLE-SHELL WASTE TANKS, 200 EAST AND WEST AREAS

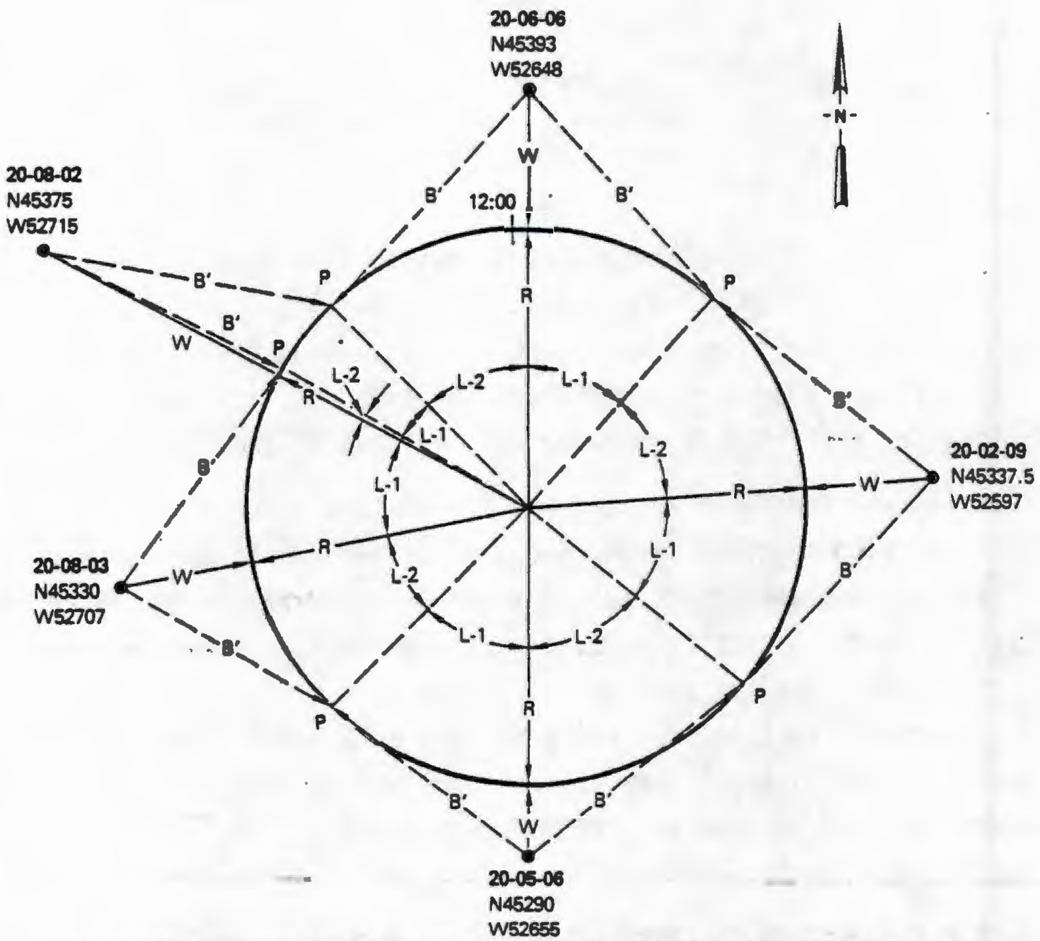
R. E. Isaacson

The tables in this appendix were developed from data and results collected for RHO-ST-34 REV 1, "A Scientific Basis for Establishing the Frequency of Monitoring Hanford High-Level Waste Tank Dry Wells." Calculations were made for each dry well by tank and tank farm. Only tanks that are scheduled for pumping are included in the listings.

Special programs were written and are available for calculating the monitoring frequency for individual dry wells based upon the surveyed coordinates of the center of each tank and each dry well. Survey coordinates were used to calculate the distance of each well from the tank of interest, the angle of each dry well from true north in a clockwise direction around the tank, the point on the periphery of the tank that is between and equidistant from adjacent dry wells, and the angle of the sector of the tank between each equidistant point and the corresponding dry wells (Figure N-1).

All distances are in feet and angles in degrees. The angle L-1 is the angle between a well and the equidistant point in a clockwise direction. The angle L-2 is the angle between the equidistant point and the next adjacent dry well. In some cases where one of the dry wells is relatively far from the tank, the distance from the adjacent dry well is less than the radial distance from the dry well to the tank. In such cases, the equidistant point is outside of the space or arc of the tank between the adjacent dry wells, thus the angle L- is negative.

The results of the survey calculations were used in the Dry Well Response Equation along with the basic data discussed in RHO-ST-34 REV 1 to calculate the minimum and maximum dry well response time and the recommended monitoring interval.



NOTE: THE EQUIDISTANT POINT FOR WELLS 20-08-03 AND 20-08-02 AS APPLIED TO TANK 241-B-105 IS OUTSIDE OF THE SPACE BETWEEN THESE WELLS.

WHERE

$$B' = \sqrt{R^2 + (R + W)^2 - 2R(R + W)(\cos L)}$$

W = MINIMUM DISTANCE BETWEEN TANK AND DRY WELL

B' = MAXIMUM DISTANCE BETWEEN TANK AND DRY WELL

P = EQUIDISTANT POINT BETWEEN ADJACENT DRY WELLS

L-1, L-2 = ANGLES BETWEEN ADJACENT WELLS AND EQUIDISTANT POINTS

RCP8111-1A

FIGURE N-1. Example of Dry Well Coordinates and Angles Using Tank 241-B-105.

To reiterate, the values for the basic data in the Dry Well Response Equation were

- Maximum probable tank leak rate, S, 0.03 gal/min
- Soil moisture increment, Q, to cause frontal movement 8 vol%
- Height to diameter ratio of wetted soil, g = 0.5 in 200 West Area; 1.0 in 200 East Area.

241-A-101 (N41205, W47804)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
10-01-01	41247	47781	28.706	10.385	47.885				9.0		24.3	3
						21.526	25.709	25.925		40.3		
10-01-03	41213	47757	80.340	10.176	47.676				8.6		23.9	3
						22.054	26.755	27.050		42.7		
10-01-04	41172	47770	134.145	9.881	47.381				8.1		23.2	3
						21.609	26.354	25.448		40.7		
10-01-06	41157	47809	185.947	10.760	48.260				9.7		25.2	4
						21.827	25.794	24.892		41.5		
10-01-08	41178	47845	236.634	11.592	49.092				11.2		27.0	4
						15.564	13.905	13.635		20.7		
10-01-09	41200	47853	264.174	11.754	49.254				11.6		27.5	4
						16.027	14.563	13.707		21.8		
10-01-10	41224	47850	292.443	12.269	49.769				12.7		28.7	4
						20.621	22.118	23.638		36.9		
10-01-11	41250	47822	338.199	10.966	48.466				10.1		25.6	4
						21.433	24.946	25.562		40.0		

241-A-102 (N41205, W47702)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
10-02-01	41240	47702	42.436	9.924	47.423				8.1		23.2	3
						14.676	14.732	11.462		18.3		
10-03-10	41223	47656	68.629	11.896	49.496				11.8		27.8	4
						15.696	13.665	12.281		21.0		
10-02-03	41201	47652	97.574	12.660	50.160				13.5		29.8	4
						21.961	23.879	26.852		42.3		
10-02-05	41166	47675	145.305	9.934	47.434				8.1		23.2	3
						20.834	25.080	23.938		37.6		
10-02-06	41158	47714	194.323	11.008	48.508				10.1		25.6	4
						21.630	25.216	24.948		40.7		
10-02-08	41184	47746	244.486	11.254	48.754				10.6		26.3	4
						20.164	22.565	11.225		35.4		
10-01-03	41213	47757	278.276	18.079	55.579				28.2			
						18.143	-1.921*	19.159		28.2		
10-02-10	41226	41746	295.514	11.254	48.754				10.6		26.3	4

241-A-102 (N41205, W47702) (Contd)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
10-02-11	41250	47720	388.199	10.966	48.466	19.325	21.173	21.513		32.2	25.6	4
									10.1			
						25.684	31.613	32.624		58.8		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-A-103 (N41205, W47600)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
10-03-01	41250	47583	20.695	10.604	48.104				9.3		24.7	3
						20.696	24.153	13.477		37.3		
10-03-02	41234	47553	58.325	17.727	55.227				26.9		45.3	6
						28.036	27.612	34.826		70.6		
10-03-04	41180	47558	120.763	11.377	48.877				10.8		26.5	4
						20.906	23.640	24.757		38.0		
10-03-05	41158	47591	169.160	10.354	47.854				9.0		24.3	3
						21.951	26.411	25.284		42.3		
10-02-07	41168	47632	220.855	11.418	48.918				10.8		26.5	4
						21.411	24.415	20.331		40.0		
10-02-03	41201	47652	265.601	14.654	52.154				18.3			
						21.381	20.277	1.941		40.0		
10-03-10	41223	47656	287.819	21.322	58.822				39.6			
						24.743	15.361	18.945		54.0		
10-03-11	41250	47635	322.125	19.509	57.009				32.9		52.1	7
						27.384	23.988	34.582		67.4		

241-A-106 (N4307, W47600)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
10-06-12	41356	47598	2.337	11.541	49.041				11.0		26.8	4
10-06-02	41337	47562	51.710	10.915	48.415	21.452	24.342	25.032	9.9	40.3	25.4	4
10-06-04	41296	47552	102.907	11.744	49.244	22.090	26.050	25.148	11.4	42.7	27.3	4
10-06-05	41264	47576	150.832	11.744	49.244	21.360	23.963	23.963	11.4	40.0	27.3	4
10-06-07	41264	47622	207.096	10.801	48.301	23.652	27.640	28.624	9.7	49.5	25.2	4
10-06-09	41304	47651	266.634	13.588	51.088	25.342	31.249	28.289	15.6	56.9	32.2	5
10-06-10	41338	47637	309.958	10.770	48.270	20.344	19.920	23.404	9.7	35.8	25.2	4
						22.343	26.601	25.778		43.6		

241-AX-101 (N41731, W47475)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
11-01-01	41776	47453	26.053	12.590	50.090				13.3		29.5	4
						19.520	19.820	18.568		32.9		
11-01-02	41753	47429	64.440	13.490	50.990				15.4		31.9	4
						23.121	24.797	25.301		46.9		
11-01-04	41710	47429	114.538	13.067	50.567				14.4		30.8	4
						22.323	23.988	22.340		43.6		
11-01-05	41682	47458	160.866	14.365	51.865				17.5		34.5	5
						20.849	19.730	9.530		37.6		
11-02-12	41675	47485	190.125	19.386	56.886				32.5		51.7	7
						19.420	-1.418*	23.954		32.5		
11-01-07	41692	47500	212.661	8.825	46.325				6.3		21.1	3
						20.104	25.029	26.000		35.0		
11-01-09	41726	47520	263.660	7.777	45.277				4.9		19.3	3
						19.221	24.631	23.211		31.8		
11-01-10	41762	47510	311.532	9.255	46.755				7.1		22.0	3
						12.399	11.311	11.693		12.9		
11-01-11	41773	47495	334.537	9.019	46.519				6.6		21.4	3
						21.903	27.649	23.867		41.9		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-AX-103 (N41731, W47565)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
11-03-02	41764	47532	45.000	9.169	46.669				7.0		21.7	3
						20.311	25.020	26.320		35.8		
11-01-09	41726	47520	96.340	7.777	45.277				4.9			
						20.571	26.723	24.932		36.9		
11-03-05	41691	47540	147.995	9.670	47.170				7.8		22.8	3
						24.628	31.342	31.728		53.6		
11-03-07	41691	47589	210.964	9.148	46.648				6.8		21.7	3
						18.700	22.486	22.814		30.1		
11-03-09	41720	47610	256.264	8.825	46.325				6.3		21.1	3
						21.385	27.027	25.745		40.0		
11-03-10	41761	47602	309.036	10.134	47.634				8.4		23.7	3
						18.871	21.709	24.175		30.8		
11-03-12	41776	47569	354.920	7.677	45.177				4.8		19.1	3
						19.879	25.740	24.340		34.3		

241-B-103 (N45437, W52552)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
20-03-02	45469	52521	44.091	7.053	44.553				4.1		18.1	3
20-03-03	45430	52507	98.842	8.041	45.541	20.869	27.804	26.948		38.0	19.6	3
									5.2			
20-03-06	45393	52557	186.483	6.783	44.283	31.515	43.269	44.373		91.1	17.7	2
									3.7			
20-03-09	45430	52596	260.961	7.053	44.553	26.964	37.351	37.127		65.3	18.1	3
									4.1			
20-03-11	45478	52571	335.136	7.688	45.188	27.113	37.356	36.820		65.8	19.0	3
									4.8			
						25.407	34.211	34.744		57.3		

241-B-104 (N45237, W52652)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
20-04-03	45238	52608	90.000	6.500	44.000				3.4		38.2	5
						33.569	47.831	42.169		104.9		
20-04-06	45187	52652	180.000	12.500	50.000				13.1		17.2	2
						47.166	63.357	44.256		192.0		
20-07-02	45257	52715	287.613	28.598	66.098				73.9			
						36.325	25.999	43.148		124.5		
20-05-06	45290	52655	356.760	15.585	53.085				20.7			
						35.651	42.117	51.123		120.0		

241-B-105 (N45337, W52652)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
20-06-06	45393	52648	4.086	18.643	56.143				29.8		48.6	
20-02-09	45337.5	52597	89.479	17.502	55.002	37.835	42.049	43.345		136.4	44.6	6
									26.3			
20-05-06	45290	52655	183.652	9.596	47.096	37.577	42.950	51.223		134.8	22.6	3
									7.6			
20-08-03	45330	52707	262.747	17.944	55.444	32.874	43.936	35.160		100.2		
									27.5			
20-08-02	45375	52715	301.097	36.073	73.573	36.113	40.199	-1.849*		123.0		
									123.0			
						39.682	18.110	44.880		152.5		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-B-106 (N45437, W52652)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
20-06-02	45469	52621	44.091	7.053	44.553				4.1		18.1	3
						20.462	27.178	27.977		36.5		
20-06-03	45430	52609	99.246	6.066	43.566				3.0		16.7	2
						27.027	38.029	37.531		65.3		
20-06-06	45393	52648	174.806	6.681	44.181				3.6		17.5	2
						51.458	77.621	74.911		272.5		
20-06-11	45476	52677	327.339	8.825	46.325				6.3		21.1	3
						28.280	37.606	39.146		72.2		

241-B-107 (N45237, W52752)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
20-07-02	45257	52715	61.607	4.559	42.059				1.6		14.8	2
20-07-05	45195	52735	157.964	7.810	45.310	33.629	49.604	46.753		104.9	19.3	3
									4.9			
20-07-08	45220	52795	248.429	8.739	46.239	32.924	45.656	44.810		100.2	20.9	3
									6.2			
20-10-02	45257	52815	287.613	28.598	66.098	28.611	38.189	0.995		73.9		
									73.9			
20-07-11	45280	52770	337.286	9.115	46.615	29.863	9.909	39.765		81.3	21.6	3
									6.8			
						30.163	40.224	44.098		83.1		

241-B-108 (N45337, W52752)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
20-09-06	45393	52748	4.086	18.643	56.143				29.8			
						23.346	17.618	22.532		47.8		
20-08-02	45375	52715	44.236	15.538	53.038				20.4		37.8	5
						23.750	23.234	31.373		50.0		
20-08-03	45330	52707	98.842	8.041	45.541				5.2		19.6	3
						22.691	29.750	31.313		45.2		
20-08-05	45296	52737	159.905	6.158	43.658				3.1		16.8	2
						22.835	31.535	6.087		45.6		
20-07-11	45280	52770	197.526	22.275	59.775				43.6			
						22.316	-1.638*	30.021		43.6		
20-08-07	45306	52784	225.910	7.053	44.553				4.1		18.1	3
						17.482	22.568	22.160		26.3		
20-08-09	45337.5	52797	270.637	7.503	45.003				4.6		18.8	3
						37.113	52.512	40.937		130.8		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-B-109 (N45437, W52752)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
20-09-02	45467	52719	47.726	7.098	44.598				4.1		18.1	3
20-09-06	45393	52748	174.806	6.681	44.181	43.512	63.318	63.762		188.5	17.5	2
									3.6			
20-12-03	45437	52800	270.597	10.503	48.003	34.848	49.686	46.106		113.4	24.5	3
									9.1			
20-09-11	45472	52775	326.689	4.381	41.881	21.418	25.415	30.677		40.0	14.6	2
									1.5			
						28.490	41.607	39.430		73.3		

241-B-111 (N45337, W52852)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
20-12-06	45394	52848	4.014	19.640	57.140				33.2		52.5	7
						38.235	41.509	43.957		139.7		
20-08-09	45337.5	52797	89.479	17.502	55.002				26.3			
						40.846	47.947	45.59		162.4		
20-10-12	45280	52855	183.013	19.579	57.079				33.2		52.5	7
						36.967	39.617	47.370		130.0		
20-11-09	45337	52902	270.000	12.500	50.000				13.1		29.3	4
						39.269	50.916	43.100		149.0		

241-BX-104 (N45400, W53350)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
21-05-06	45453	53346	4.316	15.651	53.151				21.0			
21-04-01	45435	53320	40.601	8.598	46.098	18.721	13.213	23.073	6.0	30.1	20.7	3
21-04-03	45398	53304	92.490	8.543	46.043	20.535	25.919	25.970	5.9	36.5	20.5	3
21-04-04	45370	53320	135.000	4.926	42.426	16.557	19.652	22.858	1.9	23.5	15.1	2
21-04-06	45350	53350	180.000	12.500	50.000	18.813	26.313	18.687	13.1	30.5	29.3	4
21-04-08	45370	53404	240.945	24.274	61.774	30.884	38.064	22.881	52.2	87.3	See 241-BX-107	
21-07-03	45398	53404	267.879	16.537	54.037	24.483	3.797	23.137	23.2	53.1		
21-04-11	45435	53380	319.399	8.598	46.098	23.395	21.184	30.336	6.0	48.2	20.7	3
						21.066	26.745	18.173		38.8		

241-BX-105 (N45500, W53350)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
21-05-12	45547	53346	4.865	9.670	47.170				7.8		22.8	3
						16.558	18.390	21.746		23.5		
21-05-02	45531	53319	45.000	6.341	43.841				3.2		16.9	2
						17.681	23.487	21.513		26.9		
21-05-03	45500	53304	90.000	8.500	46.000				5.9		20.5	3
						17.681	21.513	23.487		26.9		
21-05-05	45469	53319	135.000	6.341	43.841				3.2		16.9	2
						16.559	21.746	18.390		23.5		
21-05-06	45453	53346	175.135	9.670	47.170				7.8		22.8	3
						32.619	43.476	32.954		98.2		
21-08-04	45482	53404	251.565	19.421	56.921				32.5		51.7	7
						23.433	16.316	33.549		48.2		
21-05-10	45522	53386	301.430	4.690	42.190				1.7		14.9	2
						23.591	33.792	29.644		49.1		

241-BX-107 (N45400, W53450)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
21-08-05	45460	53425	22.620	27.500	65.000				67.9		91.3	13
						33.958	23.280	46.590		107.7		
21-07-03	45398	53404	92.490	8.5400	46.043				5.9		20.5	3
						18.494	22.767	7.855		29.5		
21-04-08	45370	53404	123.111	17.418	54.918				26.0		44.2	6
						25.105	22.980	33.910		55.9		
21-07-06	45355	53450	180.000	7.500	45.000				4.6		18.8	3
						35.588	50.104	39.896		119.2		
21-10-03	45400	53505	270.00	17.500	55.000				26.3			
						38.004	43.606	42.308		138.1		
21-08-06	45456	53454	355.914	18.643	56.143				29.8		48.6	7
						27.521	25.489	1.217		67.9		

241-BX-109 (N45600, W53450)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
21-09-02	45633	53416	45.855	9.881	47.381				8.1		23.2	3
						29.083	37.866	40.296		76.7		
21-09-04	45575	53413	124.046	7.154	44.654				4.2		18.3	3
						24.599	33.426	27.014		53.6		
21-08-12	45549	53454	184.485	13.657	51.157				15.8		32.5	5
						20.868	20.754	26.886		38.0		
21-09-08	45572	53486	232.125	8.107	45.607				5.3		19.8	3
						24.667	32.719	21.518		54.0		
21-12-02	45616	53503	286.798	17.862	55.362				27.5			
						29.699	30.185	40.909		80.1		
21-09-12	45645	53452	357.455	7.544	45.044				4.6		18.8	3
						19.548	25.347	23.083		32.9		

241-BX-110 (N45400, W53550)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
21-10-01	45431	53519	45.000	6.341	43.841				3.2		16.9	2
						17.373	23.009	21.991		26.0		
21-10-03	45400	53505	90.000	7.500	45.000				4.6		18.8	3
						17.373	21.991	23.009		26.0		
21-10-05	45369	53519	135.000	6.341	43.841				3.2		16.9	2
						25.014	34.721	10.279		55.4		
21-00-07	45339	53550	180.000	23.500	61.000				48.6		69.8	10
						25.014	10.279	34.721		55.4		
21-10-07	45369	53581	225.000	6.341	43.841				3.2		16.9	2
						31.674	45.000	45.000		92.3		
21-10-11	45431	53581	315.000	6.341	43.841				3.2		16.9	2
						31.674	45.000	45.000		92.3		

241-BX-111 (N45500, W53550)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
21-12-05	45562	53528	19.537	28.288	65.788				72.2			
21-11-03	45500	53502	90.000	10.500	48.000	35.048	24.046	46.417	9.1	114.8	24.5	3
21-11-04	45478	53512	120.069	6.409	43.909	13.972	12.471	17.597	3.3	16.5	17.1	2
21-11-05	45469	53519	135.000	6.341	43.841	8.279	7.404	7.528	3.2	5.6	16.9	2
21-11-07	45462	53572	210.069	6.409	43.909	26.867	37.562	37.507	3.3	64.8	17.1	2
21-11-10	45522	53588	300.069	6.409	43.909	31.711	45.000	45.000	3.3	92.3	17.1	2
21-11-11	45531	53581	315.000	6.341	43.841	8.279	7.404	7.528	3.2	5.6	16.9	2
						32.425	46.175	18.362		96.8		

241-BX-112 (N45600, W53550)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
21-12-02	45616	53503	71.200	12.149	49.649				12.2		28.2	4
						29.781	36.732	42.000		80.7		
21-12-05	45562	53528	149.931	6.409	43.909				3.3		17.1	2
						26.867	37.507	37.562		64.8		
21-12-07	45569	53581	225.000	6.341	43.841				3.2		16.9	2
						31.674	45.000	45.000		92.3		
21-12-10	45631	53581	315.000	6.341	43.841				3.2		16.9	2
						16.574	21.770	20.686		23.5		
21-12-12	45645	53552	357.456	7.544	45.044				4.6		18.8	3
						28.472	39.024	34.721		73.3		

241-BY-101 (N45898, W53247)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
22-01-01	45929	53218	43.091	4.950	42.450				2.0		15.2	2
						16.835	23.266	21.099		24.1		
22-01-03	45900	53202	87.455	7.544	45.044				4.6		18.8	3
						23.076	30.771	31.705		46.9		
22-01-04	45860	53225	149.931	6.409	43.909				3.3		17.1	2
						26.867	37.507	37.562		64.8		
22-01-07	45867	53278	225.000	6.341	43.841				3.2		16.9	2
						23.139	31.854	29.259		46.9		
22-01-10	45911	53292	286.113	9.340	46.840				7.1		22.0	3
						40.621	56.280	60.698		160.6		

241-BY-102 (N46000, W53247)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
22-03-06	46057	53245	2.010	19.535	57.035				32.9			
22-02-01	46038	53225	30.069	6.409	43.909	19.583	1.699	26.361		33.2	17.1	2
									3.3			
22-02-03	46015	53203	71.175	8.987	46.487	16.634	21.806	19.3		23.5	21.4	3
									6.6			
22-02-05	45961	53222	147.339	8.825	46.325	28.640	38.009	38.155		73.9	21.1	3
									6.3			
22-02-07	45960	53285	223.531	17.672	55.172	31.609	42.706	33.486		91.7	45.3	6
									26.9			
22-02-09	46005	53291	276.483	6.783	44.283	23.875	20.328	32.624		50.4	17.7	2
									3.7			
22-03-07	46055	53265	341.878	20.371	57.871	28.794	40.163	25.233		75.0		
									36.1			
						21.577	8.760	11.373		40.7		

241-BY-103 (N46102, W53247)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
22-03-01	46140	53225	30.069	6.409	43.909				3.3		17.1	2
						31.304	44.364	43.266		89.8		
22-03-04	46081	53207	117.700	7.677	45.177				4.8		19.1	3
						13.467	15.448	16.784		15.4		
22-03-05	46064	53225	149.931	6.409	43.909				3.3		17.1	2
						12.035	14.422	13.102		12.0		
22-03-06	46057	53245	177.455	7.544	45.044				4.7		18.8	3
						13.921	16.367	7.135		16.3		
22-03-07	46055	53265	200.956	12.829	50.329				13.8		30.0	4
						13.461	5.378	16.818		15.4		
22-03-08	46070	53277	223.152	6.363	43.863				3.3		17.1	2
						17.689	23.481	23.367		26.9		
22-03-09	46102	53291	270.000	6.500	44.000				3.4		17.2	2
						15.475	19.909	16.475		20.4		
22-03-10	46130	53285	306.384	9.702	47.202				7.8		22.8	3
						30.621	40.383	43.302		85.5		

241-BY-104 (N45898, W53349)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
22-04-01	45936	53327	30.069	6.409	43.909				3.3		17.1	2
22-01-10	45911	53292	77.152	20.964	58.464	23.910	32.979	14.105		50.4		
									38.4			
22-04-05	45859	53326	149.470	7.777	45.277	31.425	28.953	43.365		90.4	19.3	3
									4.9			
22-04-07	45865	53379	222.274	7.098	44.598	26.702	36.115	36.689		63.8	18.1	3
									4.1			
22-04-09	45907	53392	281.821	6.432	43.932	22.002	29.502	30.045		42.3	17.1	2
									3.3			
22-04-11	45940	53365	339.146	7.444	44.944	21.371	29.081	28.245		40.0	18.6	3
									4.4			
						19.283	25.024	25.900		32.2		

241-BY-105 (N46000, W53349)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
22-05-01	46038	53327	30.069	6.409	43.909				3.3		17.1	2
						25.852	35.950	19.054		59.8		
22-02-09	46005	53291	85.073	20.715	58.215				37.3			
						28.695	24.538	40.322		74.4		
22-05-05	45962	53327	149.931	6.409	43.909				3.3		17.1	2
						41.130	60.080	59.989		165.2		
22-05-09	46000	53393	270.000	6.500	44.000				3.4		17.2	2
						33.996	48.502	6.242		107.7		
22-06-07	46058	53390	324.744	33.528	71.028				104.2			
						35.782	13.911	51.415		120.7		

241-BY-106 (N46102, W53349)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
22-06-01	46140	53327	30.069	6.409	43.909				3.3		17.1	2
						27.146	37.935	21.997		65.8		
22-03-09	46102	53291	90.000	20.500	58.000				36.5			
						27.146	21.997	37.935		65.8		
22-06-05	46064	53327	149.931	6.409	43.909				3.3		17.1	2
						32.015	45.474	27.574		94.2		
22-06-07	46058	53390	222.979	22.641	60.141				44.8		65.5	9
						24.743	12.061	34.960		54.0		
22-06-09	46102	53392	270.000	5.500	43.000				2.4		15.9	2
						20.900	29.082	26.538		38.0		
22-06-11	46140	53375	325.620	8.543	46.043				5.9		20.5	3
						24.007	31.324	33.126		50.8		

241-BY-108 (N46000, W53451)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
22-08-12	46046	53446	6.203	8.771	46.271				6.3		21.1	3
22-08-01	46038	53429	30.069	6.409	43.909	11.529	10.303	13.563		11.0	17.1	2
									3.3			
22-08-02	46022	53411	61.189	8.151	45.651	13.304	16.519	14.601		14.9	20.0	3
									5.5			
22-05-09	46000	53393	90.000	20.500	58.000	20.592	26.420	2.392		36.9		
									36.5			
22-08-05	45962	53429	149.931	6.409	43.909	27.146	21.997	37.935		65.8	17.1	2
									3.3			
22-08-06	45954	53449	177.510	8.543	46.043	12.436	15.093	12.487		12.9	20.5	3
									5.9			
22-08-07	45956	53492	222.979	22.641	60.141	24.956	32.778	12.692		55.4	65.5	9
									44.8			
22-08-09	46008	53495	280.305	7.221	44.721	27.664	19.269	38.059		69.0	18.3	3
									4.2			
						31.286	43.639	42.259		89.8		

241-BY-109 (N46102, W53451)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
22-09-01	46144	53445	8.130	4.926	42.426				1.9		15.1	2
						18.632	26.035	22.145		29.8		
22-09-02	46128	53412	56.310	9.372	46.872				7.3		22.2	3
						22.077	27.583	6.108		42.7		
22-06-09	46102	53392	90.000	21.500	59.000				40.3			
						24.873	15.279	35.433		55.0		
22-09-05	46069	53424	140.711	5.138	42.638				2.0		15.4	2
						21.482	30.238	28.706		40.3		
22-09-07	46060	53466	199.654	7.098	44.598				4.1		18.1	3
						18.849	24.654	26.402		30.5		
22-09-08	46088	53491	250.710	4.879	42.379				1.9		15.1	2
						19.019	26.661	-5.326*		31.2		
22-12-03	46104	53507	272.045	18.536	56.036				29.5			
						23.674	18.487	32.861		49.5		
22-09-11	46137	53477	323.393	6.100	43.600				3.0		16.7	2
						16.536	21.912	22.826		23.2		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-BY-110 (N45898, W53553)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
22-11-05	45957	53542	10.561	22.517	60.017				44.4			
22-07-10	45932	53497	58.736	28.013	65.513	32.609	28.788	19.388		98.2	94.3	13
									70.6			
22-07-09	45898	53495	90.000	20.500	58.000	28.588	6.594	24.670		73.9	56.2	8
									36.5			
22-10-05	45860	53531	149.93	6.409	43.909	27.146	21.997	37.935		65.8	17.1	2
									3.3			
22-10-07	45860	53577	212.276	7.444	44.944	23.006	31.597	30.748		46.5	18.6	3
									4.4			
22-10-09	45888	53604	258.906	14.471	51.971	20.735	27.266	19.366		37.3	34.8	5
									17.8			
22-10-10	45922	53590	302.969	6.602	44.102	19.776	17.563	26.499		34.0	17.4	2
									3.5			
						30.381	42.766	24.826		84.3		

241-BY-111 (N46000, W53553)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
22-11-01	46039	53531	29.427	7.277	44.777				4.3		18.4	3
						25.594	34.844	17.876		58.3		
22-08-09	46008	53495	82.147	21.049	58.549				38.4			
						34.699	34.238	49.266		112.6		
22-11-05	45957	53542	165.651	6.885	44.385				3.8		17.8	2
						22.466	30.389	30.809		44.4		
22-11-08	45970	53585	226.848	6.363	43.863				3.3		17.1	2
						22.079	30.217	30.135		42.7		
22-11-09	46013	53595	287.199	6.466	43.966				3.4		17.2	2
						26.752	37.283	-1.887*		64.3		
22-00-10	46051	53592	322.595	26.703	64.203				63.8		86.7	12
						27.318	6.733	20.891		66.9		
22-12-06	46058	53563	350.218	21.356	58.856				40.0			
						22.584	8.967	30.243		44.8		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-BY-112 (N46102, W53553)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
22-12-01	46138	53526	36.870	7.500	45.000				4.6		18.8	3
						19.813	25.797	24.844		34.0		
22-12-03	46104	53507	87.510	8.543	46.043				5.9		20.5	3
						24.902	32.694	32.674		55.0		
22-12-05	46061	53532	152.879	8.565	46.065				6.0		20.6	3
						16.468	19.484	20.442		23.2		
22-12-06	46058	53563	192.804	7.622	45.122				4.7		18.9	3
						15.459	18.818	17.776		20.4		
22-12-07	46072	53588	229.399	8.598	46.098				6.0		20.7	3
						16.580	19.632	19.724		23.5		
22-12-09	46101	53599	268.755	8.511	46.011				5.9		20.5	3
						22.797	29.497	18.218		45.6		
22-12-10	46142	53599	316.469	17.672	55.172				26.9		45.2	6
						29.503	39.757	40.644		79.0		

241-C-102 (N42790, W48256)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
30-03-07	42820	48212	55.713	15.754	53.254				21.3			
30-01-01	42747	48295	222.207	20.552	58.052	63.314	86.648	79.846		494.8	56.6	8
									36.9			
30-05-04	42825	48294	312.647	14.162	51.662	39.022	41.646	48.794		146.4		
									17.0			
						41.363	52.396	50.670		168.0		

241-C-103 (N42861, W48185)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
30-03-01	42901	48168	23.025	5.963	43.463				2.9		16.5	2
30-03-03	42861	48140	90.000	7.500	45.000	24.421	34.111	32.864		52.7	18.8	3
									4.6			
30-03-05	42820	48165	153.997	8.118	45.618	24.028	32.264	31.733		50.8	19.8	3
									5.3			
30-03-07	42820	48212	213.366	11.592	49.092	23.783	31.358	28.011		50.0	27.0	4
									11.2			
30-03-09	42861	48231	270.000	8.500	46.000	23.015	26.794	29.840		46.5	20.5	3
									5.9			
30-06-04	42897	48228	309.936	18.580	56.080	21.227	27.084	12.852		39.2		
									29.8			
						30.193	30.080	43.010		83.1		

241-C-104 (N42790, W48398)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
30-04-01	42829	48378	27.150	6.329	43.829				3.2		17.0	2
30-04-03	42817	48365	50.711	5.138	42.638	10.082	11.106	12.454		8.4	15.4	2
									2.0			
30-05-06	42814	48353	61.928	13.500	51.000	15.386	20.897	-9.680*		20.2	31.9	4
									15.4			
30-04-04	42790	48352	90.000	8.500	46.000	15.529	10.069	18.003		20.4	20.5	3
									5.9			
30-04-05	42747	48377	153.970	10.354	47.854	24.980	32.847	31.124		55.4	24.3	3
									9.0			
30-04-08	42759	48437	231.520	12.320	49.820	30.600	39.738	37.812		85.5	28.7	4
									12.7			
30-07-05	42823	48447	303.960	21.576	59.076	33.061	41.574	30.865		101.5		
									40.7			
30-04-12	42835	48405	351.158	8.041	45.541	24.625	14.487	32.712		53.6	19.6	3
									5.2			
						14.710	17.141	18.851		18.3		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-C-105 (N42861, W48327)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
30-05-02	42893	48290	49.145	11.418	48.918				10.8		26.5	4
30-05-03	42861	48282	90.000	7.500	45.000	17.754	18.265	22.591		27.2	18.8	3
									4.6			
30-05-04	42825	48294	137.490	11.336	48.836	19.753	25.702	21.788		34.0	26.3	4
									10.6			
30-05-05	42813	48327	180.000	10.500	48.000	19.142	20.765	21.745		31.5	24.5	3
									9.1			
30-05-07	42826	48353	216.607	6.100	43.600	15.754	15.914	20.694		21.3	16.7	2
									3.0			
30-05-08	42838	48367	240.101	8.641	46.141	11.284	13.484	10.01		10.6	20.7	3
									6.0			
30-05-09	42861	48375	270.000	10.500	48.000	14.574	16.220	13.680		18.0	24.5	3
									9.1			
30-05-10	42893	48366	309.370	12.948	50.448	18.846	21.256	18.114		30.5	30.3	4
									14.0			
						38.394	49.103	50.673		141.4		

241-C-106 (N42932, W48256)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
30-06-02	42967	48224	42.436	9.924	47.424				8.1		23.2	3
30-06-03	42932	48209	90.000	9.500	47.000	19.876	23.563	24.002		34.7	22.4	3
									7.4			
30-06-04	42897	48228	141.340	7.322	44.822	20.289	24.656	26.684		35.8	18.4	3
									4.3			
30-05-02	42893	48290	221.082	14.240	51.740	31.067	43.211	36.531		88.6		
									17.0			
30-06-09	42932	48302	270.000	8.500	46.000	21.603	21.252	27.666		40.7	20.5	3
									5.9			
30-06-10	42963	48291	311.532	9.255	46.755	17.462	21.163	20.369		26.3	22.0	3
									7.1			
30-06-12	42976	48260	354.806	6.681	44.181	17.476	20.392	22.882		26.3	17.5	2
									3.6			
						19.075	25.357	22.273		31.5		

241-C-107 (N42861, W48469)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
30-07-01	42911	48448	22.782	16.731	54.231				23.8		41.8	6
						24.018	22.028	21.442		50.8		
30-07-02	42888	48419	66.251	17.126	54.626				25.0		43.1	6
						32.777	35.966	9.892		99.5		
30-04-12	42835	48405	112.109	31.580	69.080				91.7			
						32.427	-8.296*	46.118		96.8		
30-07-05	42823	48447	149.931	6.409	43.909				3.3		17.1	2
						19.967	26.949	22.300		34.7		
30-07-07	42815	48485	199.179	11.203	48.704				10.4		26.1	4
						20.136	22.578	24.404		35.0		
30-07-08	42842	48512	246.161	9.511	47.011				7.4		22.4	3
						19.845	23.942	21.268		34.0		
30-07-10	42879	48515	291.371	11.896	49.396				11.8		27.8	4
						19.513	20.705	22.981		32.9		
30-07-11	42904	48489	335.056	9.924	47.424				8.1		23.2	3
						22.735	28.071	19.655		45.2		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-C-109* (N43003, W48327)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
30-09-01	43048	48313	17.281	9.627	47.127				10.0		29.9	4
						19.530	23.319	23.937		43.7		
30-09-02	43023	48285	64.537	9.019	46.519				8.7		28.3	4
						30.279	40.488	32.988		113.3		
30-06-10	42963	48291	138.013	16.314	53.814				29.9			
						20.803	16.520	25.468		49.9		
30-09-06	42956	48327	180.000	9.500	47.000				9.7		29.5	4
						20.529	25.036	18.416		48.6		
30-08-02	42965	48363	223.452	14.845	52.343				24.6		47.5	7
						31.196	36.076	32.852		121.2		
30-09-10	43024	48378	292.380	17.654	55.154				35.3		See 241-C-112	
						21.063	14.513	25.462		51.3		
30-09-11	43045	48349	332.354	9.913	47.413				10.6		30.6	4
						19.091	22.311	22.617		41.6		

*Maximum probable leak rate is 0.023 gallon per minute as restricted by the tank sludge.

241-C-110 (N42932, W48540)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
30-10-01	42979	48528	14.323	11.008	48.508				10.1		25.6	4
						24.411	29.597	30.299		52.7		
30-10-02	42945	48494	74.219	10.302	47.801				8.8		24.1	3
						23.976	29.628	14.922		50.8		
30-07-11	42904	48489	118.768	20.681	58.181				37.3			
						25.507	18.392	17.586		29.1		
30-07-10	42879	48515	154.747	21.100	58.600				38.8			
						36.191	36.556	33.700		126.9		
30-00-09	42889	48583	225.000	23.311	60.811				47.8		68.9	10
						23.809	5.816	31.590		50.0		
30-10-09	42926	48585	262.405	7.898	45.398				5.1		19.4	3
						21.996	28.810	28.184		42.3		
30-10-11	42967	48570	319.399	8.598	46.098				6.0		20.7	3
						22.297	28.647	26.277		43.6		

241-C-112 (N43074, W48398)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
30-12-13	43116	48387	14.676	5.917	43.417				2.8		13.9	2
						16.622	22.196	-15.502*		23.5		
30-12-01	43120	48380	21.371	11.896	49.396				11.8		27.8	4
						22.193	25.143	26.559		43.1		
30-12-03	43088	48352	73.072	10.583	48.083				9.3		24.7	3
						24.173	29.656	17.891		51.7		
30-09-11	43045	48349	120.619	19.439	56.939				32.5			
						23.377	16.155	21.425		48.2		
30-09-10	43024	48378	158.199	16.352	53.851				23.0		40.6	6
						33.049	37.272	33.061		100.8		
30-11-01	43036	48441	228.532	19.885	57.385				34.7		53.7	8
						22.815	13.848	27.620		45.6		
30-12-09	43074	48446	270.000	10.500	48.000				9.1		24.5	3
						37.450	50.130	54.546		134.0		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-S-101 (N36226, W75665)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
40-01-01	36266	75642	29.899	8.641	46.141				3.0		10.2	1
40-01-04	36214	75620	104.931	9.073	46.573	28.241	37.710	37.322	3.4	34.7	10.7	1
40-01-06	36180	75665	180.000	8.500	46.000	28.212	37.278	37.792	2.9	34.7	10.2	1
40-01-08	36207	75707	245.659	8.598	46.098	24.994	32.874	32.786	3.0	27.1	10.2	1
40-02-03	36249	75720	290.659	27.692	65.192	28.356	37.925	7.073	33.5	35.2		
40-01-10	36266	75695	323.130	12.500	50.000	27.698	-0.693*	33.167	6.5	33.5	14.4	2
						26.633	31.515	35.255		30.8		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-S-102 (N36226, W75767)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
40-02-01	36266	75744	29.900	8.641	46.141				3.0		10.2	1
						14.427	15.965	14.845		8.7		
40-02-03	36249	75726	60.709	9.511	47.011				3.7		11.1	2
						32.244	43.048	27.877		45.8		
40-02-04	36186	75722	131.634	22.708	60.208				22.2		32.1	5
						22.709	0.275	30.057		22.1		
40-02-05	36183	75753	161.966	7.722	45.222				2.4		9.5	1
						15.981	19.562	18.882		10.8		
40-02-07	36183	75783	200.410	8.380	45.880				2.9		10.1	1
						20.863	26.629	18.337		18.7		
40-02-08	36204	75815	245.376	15.302	52.802				9.9		18.3	3
						20.882	18.375	26.659		18.7		
40-02-10	36242	75810	290.410	8.380	45.880				2.9		10.1	1
						19.759	24.913	21.786		16.7		
40-02-11	36271	75786	337.109	11.347	48.847				5.3		13.0	2
						21.746	25.033	27.757		20.2		

241-S-103 (N36226, W75869)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
40-03-01	36266	75846	29.899	8.641	46.141				3.0		10.2	1
						22.396	28.761	28.850		21.5		
40-03-03	36228	75823	87.510	8.543	46.043				3.0		10.2	1
						27.863	26.480	-1.824*		18.7		
40-02-08	36204	75815	112.166	20.810	58.310				18.5			
						22.424	10.252	11.185		21.6		
40-03-05	36186	75827	133.603	20.500	58.000				18.0		27.4	4
						29.696	26.636	40.172		38.7		
40-03-06	36183	75885	200.410	8.380	45.880				2.9		10.1	1
						16.781	20.188	17.022		11.9		
40-03-08	36200	75910	237.619	11.049	48.549				5.0		12.7	2
						21.567	25.071	27.720		20.0		
40-03-09	36242	75912	290.410	8.380	45.880				2.9		10.1	1
						20.418	25.941	24.077		17.8		
40-03-11	36271	75885	340.427	10.260	47.760				4.4		11.9	2
						20.323	23.924	25.548		17.6		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-S-105 (N36124, W75767)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
40-02-05	36183	75753	13.349	23.138	60.638				23.0			
40-05-03	36140	75724	69.590	8.380	45.880	27.901	18.819	37.423	2.9	34.0	10.1	1
40-05-05	36082	75722	133.025	24.055	61.555	30.365	41.197	22.238	25.1	40.6	35.3	5
40-08-01	36072	75747	158.962	18.214	55.714	24.469	5.345	20.593	14.1	25.9		
40-05-07	36081	75783	200.410	8.380	45.880	21.366	14.038	27.41	2.9	19.6	10.1	1
40-05-08	36111	75819	255.964	16.100	53.600	24.365	32.017	23.537	10.9	25.7	See 241-S-106	
40-05-10	36140	75810	290.410	8.380	45.880	18.463	11.569	22.877	2.9	14.6	10.1	1
40-02-07	36183	75783	344.827	23.631	61.131	27.685	37.092	17.326	24.0	33.5		
						26.226	13.645	14.877		29.8		

241-S-106 (N36124, W75869)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
40-06-02	36156	75837	45.000	7.750	45.255				2.5		9.6	1
						24.675	33.035	26.539		26.4		
40-05-08	36111	75819	104.574	14.162	51.662				8.5		16.7	2
						14.162	-0.178*	15.502		8.5		
40-06-04	36101	75829	119.899	8.641	46.141				3.0		10.2	1
						22.245	28.528	20.688		21.2		
40-09-01	36072	75859	169.114	15.453	52.953				10.1			
						17.358	10.179	21.117		12.8		
40-06-06	36081	75885	200.410	8.380	45.880				2.9		10.1	1
						17.300	21.024	20.348		12.7		
40-06-08	36102	75910	241.783	9.030	46.530				3.3		10.6	1
						19.576	24.000	24.628		16.4		
40-06-09	36140	75912	290.410	8.380	45.880				2.9		10.1	1
						27.685	37.092	17.326		33.5		
40-03-06	36183	75885	344.827	23.631	61.131				24.0			
						29.083	20.395	39.779		37.1		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-S-107 (N36022, W75665)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
40-07-01	36062	75642	20.899	8.641	46.141				3.0		10.2	1
40-07-04	36012	75620	102.529	8.598	46.098	27.315	36.296	36.335		32.5	10.2	1
									3.0			
40-10-01	35969.1	75625.1	142.974	28.760	66.260	28.804	38.611	1.835		36.3	47.5	7
									36.3			
40-07-06	35972	75663	177.709	12.540	50.040	28.76	-0.030*	34.765		36.3	14.4	2
									6.5			
40-07-08	36000	75709	243.435	11.693	49.193	27.248	32.428	33.298		32.5	13.5	2
									5.7			
40-07-10	36045	75705	299.900	8.641	46.141	23.036	26.718	29.746		22.8	10.2	1
									3.0			
40-07-11	36068	75678	344.219	10.302	47.802	18.726	23.037	21.283		14.9	11.9	2
									4.4			
						19.148	21.976	23.704		15.5		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-S-108 (N36022, W75767)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
40-08-12	36070	75767	0.000	10.500	48.000				4.6		12.1	2
						16.684	17.578	4.223		11.8		
40-08-01	36072	75747	21.801	16.352	53.852				11.4		20.0	3
						31.011	34.097	13.749		42.3		
40-07-10	36045	75705	69.647	28.629	66.129				35.8			
						32.005	16.520	24.606		45.2		
40-07-08	36000	75709	110.772	24.532	62.032				25.9			
						31.543	23.724	45.504		43.8		
40-08-06	35979	75767	180.000	5.500	43.000				1.2		7.9	1
						17.234	23.468	21.532		12.5		
40-08-08	35990	75799	225.00	7.755	45.255				2.5		9.6	1
						19.711	25.411	24.559		16.6		
40-08-09	36026	75813	274.970	8.674	46.174				3.1		10.3	1
						31.950	43.368	41.662		45.2		

241-S-109 (N36022, W75869)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
40-09-01	36072	75859	11.310	13.490	50.990				7.6		15.7	2
						16.723	12.974	20.716		11.8		
40-09-02	36054	75837	45.000	7.755	45.255				2.5		9.6	1
						21.338	27.924	12.990		19.4		
40-08-09	36026	75813	85.914	18.643	56.143				14.7			
						28.397	26.998	22.088		35.2		
40-09-05	35980	75827	135.000	21.897	59.397				20.6		30.3	4
						26.895	19.045	36.036		31.5		
40-09-06	35977	75877	190.081	8.206	45.706				2.7		9.9	1
						18.256	22.717	21.807		14.2		
40-09-08	35995	75907	234.605	9.115	46.615				3.4		10.7	1
						21.906	27.563	28.243		20.6		
40-09-09	36038	75912	290.410	8.380	45.880				2.9		10.1	1
						27.685	37.092	17.326		33.5		
40-06-06	36081	75885	344.827	23.631	61.131				24.0			
						23.642	0.830	25.653		24.0		

241-S-110 (N35920, W75665)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
40-07-06	35972	75663	2.203	14.538	52.038				8.8			
						16.025	8.750	19.578		10.8		
40-10-13	35959	75665	30.530	7.777	45.277				2.5		9.6	1
						21.177	27.656	26.845		19.3		
40-10-03	35924	75619	85.030	8.674	46.174				3.1		10.3	1
						23.706	30.746	24.702		24.2		
40-10-05	35880	75632	140.477	14.356	51.856				8.7		17.0	2
						18.913	16.051	23.472		15.2		
40-10-06	35874	75665	180.000	8.500	46.000				2.9		10.2	1
						13.129	13.836	16.233		7.2		
40-10-08	35882	75687	210.069	6.409	43.909				1.6		8.5	1
						24.192	33.410	31.491		25.3		
40-10-09	35924	75711	274.970	8.674	46.174				3.1		10.3	1
						33.995	46.526	40.707		51.4		

NOTE: 40-10-01 is redundant for Tank 241-S-110; see 241-S-107.

241-S-111 (N35920, W75767)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
40-08-06	35979	75767	0.000	21.500	59.000				19.8			
40-11-01	35960	75744	29.899	8.641	46.141	21.589	2.384	27.516	3.0	20.0	10.2	1
40-10-09	35924	75711	85.914	18.643	56.143	25.688	33.810	22.206	14.7	28.6		
40-00-06	35875	75722	135.000	26.140	63.640	30.519	30.532	18.554	29.6	40.9	40.2	6
40-11-05	35875	75747	156.038	11.744	49.244	29.113	-15.076*	36.114	5.7	37.1	13.5	2
40-11-07	35877	75783	200.410	8.380	45.880	19.192	20.346	24.026	2.9	15.7	10.1	1
40-11-08	35900	75815	247.380	14.500	52.000	21.095	26.989	19.981	8.8	19.1	17.1	2
40-11-09	35936	75810	290.410	8.380	45.880	19.941	17.833	25.197	2.9	16.9	10.1	1
						30.986	42.15	27.44		42.3		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-S-112 (N35920, W75869)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
40-12-02	35952	75837	45.000	7.755	45.255				2.5		9.6	1
40-11-09	35936	75810	74.827	23.631	61.131	23.673	31.504	-1.677*		24.2		
									24.0			
40-12-04	35897	75829	119.899	8.641	46.141	25.514	11.530	33.542		28.2	10.2	1
									3.0			
40-12-06	35874	75869	180.000	8.500	46.000	23.193	29.987	30.114		23.2	10.2	1
									2.9			
40-12-07	35885	75901	222.436	9.924	47.424	17.969	21.975	20.461		13.8	11.5	2
									4.0			
40-12-09	35924	75915	274.970	8.674	46.174	21.196	25.660	26.874		19.3	10.3	1
									3.1			
40-09-06	35977	75877	352.011	20.059	57.559	32.777	44.643	32.398		47.6		
									17.3			
						25.271	19.043	33.946		27.7		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-SX-101 (N35552, W75665)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
41-01-01	35590	75643	30.069	6.409	43.909				1.7		8.5	1
41-01-04	35527	75628	124.046	7.154	44.654	33.191	47.318	46.660		48.9	21.3	3
									2.2			
41-01-06	35508	75665	180.000	6.500	44.000	20.862	27.708	28.246		18.7	20.2	3
									1.7			
41-01-08	35534	75705	245.772	6.363	43.863	23.861	32.832	32.940		24.7	20.0	3
									1.6			
41-01-10	35567	75711	288.060	10.884	48.383	17.678	23.464	18.824		13.3	12.6	2
									4.9			
41-01-11	35592	75680	339.444	5.220	42.720	20.238	23.107	28.277		17.4	7.7	1
									1.1			
						18.601	25.774	24.851		14.7		

NOTE: 41-01-07 is redundant for Tank 241-SX-101; see 241-SX-102.

241-SX-102 (N35552, W75767)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
41-02-02	35590	75745	30.069	6.409	43.909				1.6		8.5	1
						23.105	31.748	13.188		23.0		
41-01-10	35567	75711	75.005	20.474	57.974				18.0			
						28.694	24.899	22.715		36.0		
41-01-07	35520	75717	122.619	21.863	59.363				20.6		30.3	4
						22.263	5.102	27.334		21.4		
41-02-05	35509	75747	155.056	9.924	44.424				40.0		11.5	2
						16.981	18.806	-1.248*		12.2		
41-05-12	35498	75760	172.614	16.952	54.452				12.2			
						27.814	28.245	31.169		33.7		
41-02-07	35520	75808	232.028	14.510	52.010				8.8		17.1	2
						16.787	10.969	21.809		11.9		
41-02-08	35548	75811	264.806	6.681	44.181				1.8		8.7	1
						22.592	30.746	28.064		22.0		
41-02-11	35590	75795	323.616	9.702	47.202				3.9		11.3	2
						25.008	31.796	34.658		27.1		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

9 2 1 2 4 9 9 2 0 8 8

241-SX-103 (N35552, W75869)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
41-03-12	35596	75864	0.000	6.500	44.000				1.7		8.5	1
41-03-02	35578	75832	54.904	7.722	45.222	20.679	27.966	26.938		18.3	15.0	2
									2.4			
41-02-08	35548	75811	93.945	20.638	58.138	22.141	29.187	9.855		21.0		
									18.1			
41-03-05	35520	75833	131.634	10.666	48.166	22.440	10.828	26.862		21.6	12.3	2
									4.7			
41-03-06	35508	75869	180.000	6.500	44.000	19.520	22.178	26.188		16.2	8.5	1
									1.7			
41-06-11	35501	75900	211.298	22.182	59.682	22.197	30.289	1.005		21.2	31.0	4
									21.2			
41-03-09	35548	75913	264.806	6.681	44.181	26.279	17.130	36.384		30.0	8.7	1
									1.8			
41-03-10	35582	75900	314.061	5.639	43.139	18.331	24.209	25.046		14.2	7.9	1
									1.2			
						17.208	23.320	22.620		12.5		

241-SX-104 (N35450, W75665)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
41-01-06	35508	75665	0.000	20.500	58.000				18.0			
						20.869	4.803	27.473		18.7		
41-04-01	35488	75641	32.276	7.444	44.944				2.2		9.2	1
						22.303	29.673	25.715		21.4		
41-04-03	35452	75616	87.663	11.541	49.041				5.5		13.2	2
						23.434	27.512	30.445		23.6		
41-04-05	35412	75639	145.620	8.543	46.043				2.9		10.2	1
						19.016	23.592	14.028		15.4		
41-07-12	35397	75668	183.240	15.585	53.085				10.3		18.8	3
						20.009	16.167	14.283		17.1		
41-04-07	35405	75695	213.690	16.583	54.083				11.6		20.3	3
						16.983	4.667	21.114		12.2		
41-04-08	35427	75704	239.470	7.777	45.277				2.5		9.6	1
						18.606	23.672	-3.448*		14.7		
41-05-03	35440	75720	259.695	18.402	55.902				14.4			
						28.718	27.865	4.727		36.0		
41-05-02	35475	75726	292.286	28.424	65.924				35.2			
						29.192	-7.674*	41.883		37.3		
41-04-11	35485	75689	326.495	5.434	42.934				1.1		7.8	1
						20.823	29.013	4.493	18.5			

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-SX-105 (N35450, W75767)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
41-05-12	35498	75760	8.297	11.008	48.508				5.0		12.7	2
41-05-02	35475	75726	58.627	10.521	48.021	21.436	24.905	25.425	4.6	19.6	12.1	2
41-05-03	35440	75720	102.011	10.552	48.052	19.135	21.710	21.674	4.6	15.5	12.2	2
41-05-05	35405	75750	159.305	10.604	48.104	23.522	28.673	28.621	4.6	23.8	12.2	2
41-05-07	35410	75792	212.005	9.670	47.170	21.775	25.876	26.824	3.9	20.4	11.3	2
41-05-08	35444	75817	263.157	12.859	50.359	22.085	27.307	23.845	6.9	21.0	15.0	2
41-05-10	35475	75809	300.763	11.377	48.877	18.607	17.803	19.803	5.4	14.7	13.1	2
						27.228	33.585	33.949		32.2		

241-SX-106 (N35450, W75869)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
41-03-06	35508	75869	0.000	20.500	58.000				18.0			
						20.577	2.184	27.884		18.1		
41-06-02	35488	75847	30.069	6.409	43.909				1.6		8.5	1
						26.781	37.375	29.139		31.2		
41-05-08	35444	75817	96.582	14.845	52.345				9.2			
						18.328	13.934	24.485		14.2		
41-06-05	35419	75838	135.000	6.341	43.841				1.6		8.4	1
						17.681	23.487	21.513		13.3		
41-06-06	35404	75869	180.000	8.500	46.000				2.9		10.2	1
						30.703	41.608	43.198		41.5		
41-06-09	35446	75913	264.806	6.681	44.181				1.8		8.7	1
						24.151	33.128	32.638		25.3		
41-06-23	35489	75891	330.573	7.277	44.777				2.1		9.2	1
						20.582	27.174	2.254		18.1		

NOTE: 41-06-11 is redundant for Tank 241-SX-106; see 241-SX-103.

241-T-101 (N43647, W75637)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
50-01-12	43692	75637	0.000	7.500	45.000				2.3		9.3	1
						22.714	30.254	28.783		22.2		
50-01-02	43671	75597	59.036	9.148	46.648				3.4		10.7	1
						19.883	24.367	26.251		16.9		
50-01-04	43632	75595	109.654	7.098	44.598				2.0		9.0	1
						28.809	39.921	30.425		36.3		
50-01-06	43593	75637	180.000	16.500	54.000				11.5		See 241-T-104	
						35.511	40.901	51.763		56.3		
50-01-09	43649	75680	272.663	5.546	43.046				1.2		7.9	1
						30.927	44.499	42.839		42.0		

241-T-104 (N43547, W75637)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
50-01-06	43593	75637	0.000	8.500	46.000				2.9		10.2	1
						30.638	41.509	42.151		41.2		
50-04-03	43552	75592	83.660	7.777	45.277				2.5		9.6	1
						29.530	40.446	36.010		28.2		
50-04-05	43500	75620	160.115	12.480	49.980				6.5		14.4	2
						20.590	21.805	21.579		18.1		
50-04-07	43501	75657	203.500	12.660	50.160				6.7		14.7	2
						21.517	23.142	20.740		19.8		
50-04-08	43527	75685	247.380	14.500	52.000				8.8		17.1	2
						23.101	23.499	20.922		23.0		
50-04-10	43567	75687	291.801	16.352	53.852				11.4		20.0	3
						28.456	30.035	38.165		35.5		

241-T-105 (N43547, W75737)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
50-02-05	43597	75722	16.699	14.702	52.202				9.1		17.4	3
50-04-10	43567	75687	68.199	16.352	53.852	25.235	26.804	24.696		27.5		
									11.4			
50-04-08	43527	75685	111.038	18.214	55.714	24.164	22.834	20.006		25.3		
									14.1			
50-05-06	43502	75742	186.340	7.777	45.277	31.235	32.23	43.072		42.9	9.6	1
									2.5			
50-05-07	43510	75762	214.046	7.154	44.654	12.408	13.475	14.231		6.4	9.1	1
									2.1			
50-06-03	43547	75792	270.000	17.500	55.000	24.773	33.692	22.262		26.6	21.8	3
									13.0			
50-05-11	43592	75761	331.928	13.500	51.000	28.468	28.625	33.303		35.5	15.7	2
									7.6			
						22.158	23.177	21.594		21.2		

241-T-107 (N43447, W75637)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
50-04-05	43500	75620	17.784	18.160	55.660				14.1			
50-07-03	43447	75594	90.000	5.500	43.000	29.634	29.699	42.517		38.4	7.9	1
									1.2			
50-07-07	43397	75657	201.801	16.352	53.852	41.487	61.600	50.205		78.5	20.0	3
									11.4			
50-07-08	43427	75685	247.380	14.500	52.000	23.431	21.523	24.057		23.6	17.1	2
									8.8			
50-04-07	43501	75657	339.677	20.085	57.585	39.563	49.265	43.032		71.0		
									17.3			
						24.501	17.368	20.740		29.5		

241-T-110 (N43347, W75637)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
50-00-05	43348	75577	89.045	22.508	60.008				21.8		31.6	4
50-10-05	43305	75617	154.537	9.019	46.519	30.382	24.844	40.648		40.6	10.6	1
									3.3			
50-10-07	43305	75657	205.463	9.019	46.519	20.500	25.463	25.463		18.0	10.6	1
									3.3			
50-10-08	43327	75684	246.949	13.578	51.078	19.266	23.519	17.967		15.9	15.9	2
									7.7			
50-10-10	43367	75684	293.051	13.578	51.078	22.141	23.051	23.051		21.0	15.9	2
									7.7			
50-07-07	43397	75657	338.199	16.352	53.852	22.978	24.454	20.694		22.8		
									11.4			
						47.185	59.006	51.840		103.9		

241-T-111 (N43347, W75737)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
50-08-05	43397	75717	21.801	16.352	53.852				11.2		20.0	3
50-10-10	43367	75684	69.326	19.148	56.648	25.868	25.773	21.751		29.1		
									15.5			
50-10-08	43327	75684	110.674	19.148	56.648	25.303	20.674	20.674		27.7		
									15.5			
50-11-05	43305	75717	154.537	9.019	46.519	22.643	15.068	28.749		22.0	10.6	1
50-11-07	43305	75757	205.463	9.019	46.519	20.500	25.463	25.463	3.3	18.0	10.6	1
50-11-08	43327	75787	248.199	16.352	53.852	20.898	26.086	16.650	3.3	18.7	21.5	3
50-11-10	43369	75789	292.932	18.963	56.462	25.012	24.315	20.149	11.2	27.0	24.5	3
50-11-11	43387	75759	331.189	8.151	45.651	20.990	11.224	27.034	15.4	18.9	9.9	1
						22.925	30.014	20.593	2.7	22.6		

9 2 1 2 4 9 9 2 0 9 8

Tank 241-TX-102 (N41650 W75852)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-02-12	41696	75852	0	8.500	46.000				2.9		10.2	1
51-02-02	41688	75820	40.101	12.179	49.679	18.121	22.218	17.884		13.9	14.1	2
									6.2			
51-01-09	41655	75800	84.508	14.740	52.240	21.602	23.855	20.552		20.0	17.4	2
									9.1			
51-02-05	41617	75819	135.000	9.169	46.669	22.475	22.100	28.392		21.8	10.8	1
									3.5			
51-02-07	41603	75863	193.173	10.770	48.270	23.428	29.866	28.308		23.6	12.4	2
									4.8			
51-02-09	41646	75896	264.806	6.681	44.181	27.101	33.988	37.645		32.0	8.7	1
									1.8			
51-03-02	41690	75903	308.108	27.315	64.815	27.631	38.458	4.844		33.2		
									32.5			
						29.319	12.406	39.486		37.6		

Tank 241-TX-103 (N41650 W75954)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-03-12	41698	75954	0	10.500	48.000				4.6		12.1	2
						10.515	-0.768*	12.863		4.6		
51-03-01	41692	75945	12.095	5.453	42.953				1.2		7.9	1
						27.324	38.971	0.827		32.5		
51-03-02	41690	75903	51.892	27.315	64.815				32.5		43.3	6
						30.139	14.847	27.207		39.8		
51-02-09	41646	75896	93.945	20.638	58.138				18.1			
						36.431	37.505	48.550		59.3		
51-03-06	41602	75954	180.000	10.500	48.000				4.6		12.1	2
						35.727	47.463	47.301		57.0		
51-03-09	41654	76002	274.764	10.666	48.166				4.7		12.3	2
						26.519	33.195	37.365		30.5		
51-03-11	41692	75965	345.324	5.917	43.147				1.4		8.1	1
						10.618	12.543	2.133		4.6		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

Tank 241-TX-105 (N41752 W75750)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-05-01	41787	75724	36.607	6.100	43.600				1.5		8.3	1
51-05-03	41757	75702	84.053	10.760	48.258	19.070	25.820	21.626		15.5	12.4	2
									4.8			
51-05-05	41719	75717	135.000	9.169	46.669	21.030	24.800	26.147		18.9	10.8	1
									3.5			
51-05-07	41708	75763	196.460	8.380	45.880	23.758	30.372	31.088		24.4	10.1	1
									2.9			
51-05-08	41729	75790	240.101	8.641	46.141	17.879	21.951	21.690		13.6	10.2	1
									3.0			
51-05-10	41785	75783	315.000	9.169	46.669	28.225	37.688	37.212		34.7	10.8	1
									3.5			
						29.704	39.472	42.136		38.7		

Tank 241-TX-106 (N41752 W75852)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-06-12	41804	75850	2.203	see TX-110	52.038				8.8			
						20.109	18.095	24.703		17.3		
51-06-02	41785	75819	45.000	9.169	46.669				3.5		10.8	1
						29.662	39.408	39.972		39.5		
51-06-04	41726	75814	124.380	8.543	46.043				2.9		10.2	1
						25.480	33.578	22.042		28.2		
51-02-12	41696	75852	180.000	18.500	56.000				14.6			
						27.049	24.868	36.322		31.7		
51-06-08	41730	75892	241.189	8.151	45.651				2.7		9.9	1
						21.465	27.769	18.461		19.8		
51-07-03	41768	75903	287.418	15.951	53.451				10.8		19.4	3
						17.066	7.770	19.812		12.4		
51-06-10	41785	75885	315.000	9.169	46.669				3.5		10.8	1
						21.400	26.725	20.478		19.6		

92124992102

Tank 241-TX-108 (N41650 W75852)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-12-05	41800	76036	22.620	14.500	52.000				8.8		17.1	2
						31.908	37.547	33.993		44.9		
51-07-09	41748	76001	94.160	17.645	55.145				13.1		22.0	3
						21.462	15.439	25.401		19.8		
51-08-05	41718	76022	135.000	10.583	48.083				4.6		12.2	2
						22.039	26.315	18.685		20.8		
51-04-12	41698	76056	180.000	16.500	54.000				11.5		20.2	3
						34.655	39.585	45.651		53.6		
51-08-09	41748	76104	265.236	10.666	48.166				4.7		12.3	2
						26.139	32.611	32.408		29.6		
51-08-11	41794	76080	330.255	10.874	48.374				4.9		12.6	3
						23.463	28.254	24.111		23.8		

Tank 241-TX-109 (N41854 W75750)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-09-12	41902	75750	0	10.500	48.000				4.6		12.1	2
						27.656	35.099	35.328		33.5		
51-09-03	41870	75705	70.427	10.260	47.760				4.4		11.9	2
						20.752	24.611	28.653		18.5		
51-09-04	41830	75714	123.690	5.767	43.267				1.3		8.1	1
						36.367	52.939	48.371		59.3		
51-09-08	41820	75784	225.000	10.583	48.083				4.6		12.2	2
						23.909	29.245	6.293		24.7		
51-10-04	41844	75810	260.538	23.328	60.828				23.4			
						23.341	0.908	30.125		23.4		
51-09-10	41871	75793	291.571	8.739	46.239				3.1		10.3	1
						26.546	35.033	33.396		30.5		

NOTE: 51-10-13 is redundant.

Tank 241-TX-110 (N41854 W75852)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-10-25	41895	75831	27.121	8.565	46.065				3.0		10.2	1
						11.428	10.446	5.748		5.4		
51-10-01	41889	75819	43.315	10.604	48.104				4.6		12.2	2
						23.037	27.862	32.215		22.8		
51-10-04	41844	75810	103.392	5.674	43.174				1.3		8.0	1
						28.286	40.284	34.340		35.0		
51-06-12	41804	75850	177.709	12.540	50.040				6.5		14.4	2
						21.062	22.528	24.763		19.1		
51-10-08	41820	75886	225.000	10.583	48.083				4.6		12.2	2
						27.058	34.103	22.993		32.0		
51-11-03	41866	75908	282.095	19.771	57.271				16.7			
						27.393	23.608	2.406		32.7		
51-11-02	41894	75903	308.108	27.315	64.815				32.5		43.3	6
						27.325	0.855	37.001		32.5		
51-10-12	41898	75863	345.964	7.854	45.354				2.5		9.6	1
						16.920	20.938	20.220		12.1		

NOTE: 51-10-13 is redundant.

Tank 241-TX-111 (N41854 W75954)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
51-11-01	41898	75934	24.444	10.832	48.332				4.8		12.4	2
						21.410	25.054	25.882		19.6		
51-11-03	41866	75908	75.379	10.039	47.539						11.6	2
									4.1			
						35.694	47.862	34.958		57.0		
51-07-01	41799	75932	158.199	21.737	59.237						29.9	4
									20.2			
						26.457	18.414	33.730		30.5		
51-11-07	41813	75978	210.343	10.008	47.508						11.6	2
									4.1			
						24.195	30.253	17.309		25.3		
51-12-04	41842	76010	257.905	19.771	57.271							
									16.7			
						27.474	23.757	33.339		33.0		
51-11-10	41889	75989	315.000	11.997	49.497						13.8	2
									6.0			
						27.997	34.144	35.300		34.2		

NOTE: 51-11-02 is redundant for Tank 241-TX-111; see 241-TK-110.

Tank 241-TX-112 (N41854 W76056)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-12-01	41900	76030	29.476	15.339	52.839				9.9		18.3	3
						30.763	34.860	40.286		41.7		
51-12-04	41842	76010	104.621	10.039	47.539				4.1		11.6	2
						26.457	33.700	21.356		30.5		
51-12-05	41800	76036	159.677	20.085	57.585				17.3		see 241-TX-108	
						25.204	18.859	31.807		27.5		
51-12-07	41813	76080	210.343	10.008	47.508				4.1		11.6	2
						28.994	37.611	40.480		36.8		
51-12-10	41868	76098	288.435	6.772	44.272				1.9		8.8	1
						19.763	26.339	17.673		16.7		
51-12-11	41900	76080	332.447	14.384	51.884				8.7		17.0	2
						26.410	29.081	27.948		30.3		

Tank 241-TX-113 (N41956 W75750)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-13-12	42004	75750	0	10.500	48.000				4.6		12.1	2
51-13-05	41922	75716	135.000	10.583	48.083	48.326	67.548	67.452		109.3	12.2	2
									4.6			
51-09-12	41902	75750	180.000	16.500	54.000	22.039	26.315	18.685		20.8		
									11.5			
51-13-08	41925	75781	225.000	6.341	43.841	20.949	16.492	28.508		18.7	8.4	1
									1.6			
51-14-04	41950	75809	264.193	21.804	59.304	22.756	31.271	7.923		22.4		
									20.4			
						40.012	41.674	54.132		72.6		

Tank 241-TX-114 (N41956 W75852)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-14-04	41950	75809	97.943	5.917	43.417				1.4		8.1	1
51-10-12	41898	75863	190.739	21.534	59.034	37.526	54.670	38.125		63.2	12.2	2
									19.8			
51-14-08	41922	75886	225.000	10.583	48.083	22.377	7.414	26.848		21.6		
									4.6			
51-15-04	41947	75907	260.707	18.231	55.731	20.517	23.890	11.817		18.0		
									14.1			
51-14-11	41999	75863	345.651	6.885	44.385	34.061	36.682	48.262		51.7	8.8	1
									1.9			
						38.722	55.679	56.613		67.6		

Tank 241-TX-115 (N41956 W75954)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-18-05	42024	75922	25.201	37.653	75.153				63.9			
51-15-04	41947	75907	100.840	10.354	47.854	41.521	18.974	56.666		78.5	12.0	2
									4.5			
51-11-01	41898	75934	160.974	23.851	61.351	29.843	38.581	21.553		39.0		
									24.7			
51-15-07	41922	75982	219.472	6.545	44.045	28.466	18.643	39.855		35.5	8.5	1
									1.7			
51-15-09	41960	75999	275.080	7.677	45.177	20.907	28.279	27.329		17.1	9.5	1
									2.4			
51-15-11	41998	75969	340.346	7.098	44.598	24.209	32.390	32.876		25.3	9.0	1
									2.0			
						39.033	55.974	-11.119*		68.7		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

Tank 241-TX-116 (N42058 W75750)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-16-04	42048	75704	102.265	9.574	47.074				3.8		11.2	2
						31.886	42.440	35.296		44.9		
51-13-12	42004	75750	180.000	16.500	54.000				11.5			
						23.933	22.211	23.552		24.7		
51-16-07	42021	75788	225.764	15.538	53.038				10.1		18.7	3
						39.703	48.362	33.982		71.4		
51-17-03	42098	75801	308.108	27.315	64.815				32.5		43.3	6
						27.379	2.169	32.369		32.7		
51-16-11	42106	75765	342.646	12.789	50.289				6.8		14.9	2
						44.050	58.068	61.550		89.6		

Tank 241-TX-117 (N42058 W75852)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-17-02	42094	75818	43.363	12.018	49.518				6.0		13.8	2
51-16-07	42021	75788	120.033	36.426	73.926	41.503	54.895	21.776		78.5		
									59.3			
51-14-11	41999	75863	190.561	22.517	60.017	43.011	25.088	45.440		84.8		
									21.8			
51-18-05	42024	75922	244.093	40.320	77.820	41.498	43.107	10.425		78.5		
									73.7			
51-18-03	42070	75908	282.095	19.771	57.271	40.934	-7.499*	45.501		76.1		
									16.7			
51-17-10	42082	75894	299.745	10.874	48.374	20.268	-5.516*	23.166		17.6	12.6	2
									4.9			
51-17-11	42106	75856	355.236	10.666	48.166	23.070	27.639	27.852		23.0	12.3	2
									4.7			
						21.154	24.821	23.306		19.3		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

Tank 241-TX-118 (N42058 W75954)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
51-18-01	42103	75934	23.962	11.744	49.244				5.7		13.5	2
						21.877	24.803	26.615		20.6		
51-18-03	42070	75908	75.379	10.039	47.539				4.1		11.6	2
						24.232	30.279	31.081		25.3		
51-18-05	42024	75922	136.736	9.190	46.690				3.5		10.8	1
						27.098	35.469	37.862		32.0		
51-18-07	42020	75976	210.069	6.409	43.909				1.6		8.5	1
						21.299	28.988	26.078		19.4		
51-18-09	42054	76001	265.135	9.670	47.170				3.9		11.3	2
						21.767	26.811	28.411		20.4		
51-18-10	42093	75983	320.356	7.953	45.453				2.6		9.7	1
						15.240	18.117	14.402		9.7		
51-18-11	42106	75960	352.875	10.874	48.373				4.9		12.6	2
						16.189	16.189	14.899		11.1		

Tank 241-TY-105 (N42400 W75852)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
52-03-06	42452	75852	0.000	14.500	52.000				8.8			
						68.364	98.306	106.638		236.3		
52-05-07	42357	75872	204.944	9.924	47.424				4.0		11.5	2
						26.373	33.682	16.874		30.3		
52-06-04	42385	75910	255.500	22.409	59.908				21.6		31.4	4
						44.419	47.730	56.771		90.9		

241-U-102 (N38197, W75737)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
60-02-01	38244	75717	23.051	13.578	51.078				7.7		15.9	2
						22.978	24.454	20.694		22.8		
60-01-10	38217	75687	68.199	16.352	53.852				11.4		20.0	3
						22.893	20.539	24.313		22.6		
60-01-08	38177	75690	113.051	13.578	51.078				7.7		15.9	2
						14.543	6.821	17.855		8.8		
60-02-05	38164	75707	137.726	7.098	44.598				2.0		9.0	1
						25.937	35.517	30.256		29.1		
60-02-07	38151	75757	203.499	12.660	50.160				6.7		14.7	2
						20.867	22.050	29.434		18.7		
60-02-08	38186	75778	254.982	4.950	42.450				1.0		7.6	1
						18.489	25.800	11.020		14.6		
60-02-10	38217	75787	291.801	16.352	53.852				11.4		20.0	3
						22.978	20.694	24.454		22.8		
60-02-11	38244	75757	336.949	13.578	51.078				7.7		15.9	2
						22.141	23.051	23.051		21.0		

241-U-103 (N38197, W75837)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
60-03-01	38244	75817	23.051	13.578	51.078				7.7		15.9	2
						22.978	24.454	20.694		22.8		
60-02-10	38217	75787	68.199	16.352	53.852				11.4			
						23.957	22.467	9.895		24.9		
60-02-08	38186	75778	100.561	22.517	60.017				21.8			
						29.690	23.538	37.841		38.7		
60-03-05	38151	75822	161.940	10.884	48.384				4.9		12.6	2
						23.354	28.073	9.641		23.6		
60-06-11	38141	75857	199.654	21.964	59.464				20.8			
						26.651	18.393	29.333		31.0		
60-03-08	38177	75885	247.380	14.500	52.000				8.8		17.1	2
						22.588	22.620	22.620		22.0		
60-03-10	38217	75885	292.620	14.500	52.000				8.8		17.1	2
						21.978	21.556	22.774		20.8		
60-03-11	38244	75857	336.949	13.578	51.078				7.7		15.9	2
						22.141	23.051	23.051		21.0		

241-U-105 (N38097, W75737)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
60-02-05	38164	75707	24.121	35.910	73.410				57.6			
60-04-10	38111	75683	75.466	18.285	55.785	37.070	10.062	41.283		61.8	23.2	3
									14.2			
60-05-04	38074	75698	120.530	7.777	45.277	22.204	15.289	29.235			9.6	1
									2.5			
60-05-05	38047	75722	163.301	14.702	52.202	19.800	25.531	17.241			17.4	2
									19.1			
60-05-07	38047	75757	201.801	16.352	53.852	21.555	20.521	17.979		20.0	19.9	3
									11.4			
60-05-08	38077	75787	248.199	16.352	53.852	24.372	23.199	23.199		25.7	19.9	3
									11.4			
60-05-10	38117	75787	291.801	16.352	53.852	23.585	21.801	21.801		24.0	19.9	3
									11.4			
60-02-07	38151	75757	339.677	20.085	57.585	26.390	26.649	21.227		30.3		
									17.3			
						36.378	38.094	6.35		59.3		

241-U-106 (N38097, W75837)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
60-03-05	38151	75822	15.524	18.545	56.045				14.6			
						27.088	24.871	27.805		32.0		
60-05-10	38117	75787	68.199	16.352	53.852				11.4			
						23.585	21.801	21.801		24.0		
60-05-08	38077	75787	111.801	16.352	53.852				11.4			
						27.557	28.576	20.882		33.2		
60-09-01	38041	75818	161.259	21.635	59.135				20.0			
						24.555	14.165	28.075		26.2		
60-06-07	38051	75857	203.499	12.660	50.160				6.7		14.7	2
						21.517	23.142	20.740		19.8		
60-06-08	38077	75885	247.380	14.500	52.000				8.8		17.1	?
						22.588	22.62	22.62		22.0		
60-06-10	38117	75885	292.620	14.500	52.000				8.8		17.1	?
						20.632	19.132	23.804		18.1		
60-06-11	38141	75857	335.556	10.832	48.332				4.8		12.4	2
						21.784	25.649	14.319		20.4		

241-U-107 (N37997, W75637)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
60-07-01	38043	75617	23.499	12.660	50.160				6.7		14.7	2
						19.178	19.119	22.439		15.7		
60-07-02	38017	75594	65.056	9.924	47.424				4.0		11.6	2
						38.785	52.789	41.833		68.0		
60-10-01	37943	75617	159.677	20.085	57.585				17.3			
						25.928	20.323	20.323		29.1		
60-10-11	37943	75657	200.323	20.085	57.585				17.3			
						28.637	25.375	23.404		35.8		
60-08-04	37976	75692	249.102	21.373	58.873				19.6			
						24.451	14.521	32.380		25.9		
60-07-10	38017	75678	296.003	8.118	45.618				2.7		9.8	1
						18.330	22.918	17.580		14.2		
60-07-11	38043	75657	336.501	12.660	50.160				6.7		14.7	2
						21.732	23.499	23.499		20.2		

241-U-108 (N37997, W75737)

Well No.	Coordinates North	Coordinates West	Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-) L-1	Equidistance angles (L-) L-2	Dry well response time (days) Min	Dry well response time (days) Max	Monitoring frequency day	Monitoring frequency wk
60-05-05	38047	75722	16.699	14.702	52.202				9.1			
60-07-10	38017	75678	71.274	24.798	62.298	30.022	34.412	20.164	26.6	39.5		
60-08-04	37976	75692	115.017	12.159	49.659	26.703	11.764	31.980	6.2	31.0	14.1	2
60-11-12	37947	75737	180.000	12.500	50.000	27.148	32.669	32.315	6.5	32.0		
60-08-08	37977	75787	248.199	16.352	53.852	29.675	36.212	31.987	11.4	38.7	20.0	3
60-08-09	38017	75787	291.801	16.352	53.852	23.585	21.801	21.801	11.4	24.0	20.0	3
60-08-10	38035	75775	315.000	16.240	53.740	18.654	11.464	11.736	11.2	14.9	19.7	3
60-05-07	38047	75757	338.199	16.352	53.852	18.654	11.736	11.464	11.4	14.9		
						21.555	17.979	20.521		20.0		

241-U-109 (N37997, W75837)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
60-09-01	38041	75818	23.356	10.427	47.927				4.5		12.0	2
60-08-09	38017	75787	68.199	16.352	53.852	21.880	26.226	18.618		20.6		
									11.4			
60-08-08	37977	75787	111.801	16.352	53.851	23.585	21.801	21.801		24.0		
									11.4			
60-12-01	37940	75817	160.665	22.907	60.407	28.024	29.336	19.528		34.2	32.5	5
									22.6			
60-09-07	37956	75862	211.373	10.521	48.021	26.835	16.888	33.82		31.2	12.1	2
									4.6			
60-09-08	37977	75887	248.199	16.352	53.852	19.738	22.696	14.130		16.6	20.0	3
									11.4			
60-09-10	38017	75887	291.801	16.352	53.852	28.585	21.801	21.801		24.0	20.0	3
									11.4			
60-06-07	38051	75857	399.677	20.085	57.585	26.390	26.649	21.227		30.3		
									17.3			
						23.456	14.982	28.697		23.8		

241-U-110 (N37897, W75637)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
60-10-01	37943	75617	23.499	12.660	50.160				6.6		14.6	2
						16.155	13.288	21.348		11.1		
60-10-02	37920	75600	58.134	6.067	43.566				1.5		8.3	1
						22.509	31.108	-0.197*		21.8		
60-00-05	37898	75577	89.045	22.508	60.088				21.8		31.6	4
						28.654	21.544	37.406		36.0		
60-10-05	37857	75612	147.995	9.670	47.170				3.9		11.3	2
						22.648	28.182	30.388		22.0		
60-10-07	37857	75657	206.565	7.221	44.721				2.1		9.1	1
						26.387	36.103	31.999		30.3		
60-11-03	37901	75686	274.667	11.663	49.163				5.7		13.5	2
						26.025	31.439	30.395		29.3		
60-10-11	37943	75657	336.501	12.660	50.160				6.7		14.7	2
						21.732	23.499	23.499		20.2		

*The distance from the adjacent dry well is less than the radial distance from the dry well to the tank. The equidistant point is outside of the space between the adjacent dry wells; thus, the angle is negative.

241-U-111 (N37897, W75737)

Well No.	Coordinates		Angle from 12:00 o'clock (N)	Distance to tank (W) (ft)	Radial distance (W+R) (ft)	Equidistance between wells (B) (ft)	Equidistance angles (L-)		Dry well response time (days)		Monitoring frequency	
	North	West					L-1	L-2	Min	Max	day	wk
60-11-12	37947	75737	0.000	12.500	50.000				6.5		14.4	2
60-11-03	37901	75686	85.515	13.657	51.157	34.342	43.351	42.164		52.3	see 241-U-110	
									7.9			
60-11-05	37857	75717	153.435	7.221	44.721	27.013	30.859	37.061		31.7	9.1	1
									2.1			
60-11-06	37850	75737	180.000	9.500	47.000	12.802	14.833	11.733		6.8	11.1	2
									3.7			
60-11-07	37857	75763	213.024	10.207	47.707	15.612	26.970	16.054		10.3	11.8	2
									4.3			
60-12-03	37900	75786	273.504	11.592	49.092	24.762	30.935	29.545		26.6	13.4	2
									5.6			
						33.978	43.702	42.794		51.4		

THIS PAGE
INTENTIONALLY
LEFT BLANK

92124992123

APPENDIX O

GLOSSARY OF TERMS APPLICABLE TO WASTE STORAGE TANK FARMS MANAGEMENT

active tank - a tank which contains greater than a minimum heel of liquid (>33,000 gal) and/or has material transfers in progress.

aging waste - the high heat waste which has been processed for cesium and strontium removal and is being stored for the decay of short-lived fission products. The current storage period is ∿5 yr from date of reactor discharge, after which time the material may be processed as evaporator feed.

annulus - a vessel space in the form of a ring; the space between the concentric walls of two tanks.

background - the amount of radiation that is present at a given location due to natural or induced radiation.

baseline - a reference point, specified liquid level or radiation level, against which new information is compared.

CASS - Computer Automated Surveillance System.

catch tanks - small capacity single-shell tanks, associated with diversion boxes and diverter stations. The tanks are designed to receive any transfer line leakage from these boxes or adjacent pipe encasements.

complexed liquid - chemically bound with an organic compound.

conductivity probe - a device which completes an electrical circuit when contacted by a conductive material.

confirmed or declared leaker - the official designation of an underground waste storage tank that has leaked into the ground as determined from reviews and analyses of accumulated data.

crust - a hard surface layer which has formed in many waste tanks that contain concentrated solutions.

deliquescent - a solid capable of absorbing moisture from the air and becoming a liquid.

desiccant - a drying agent.

diatomaceous earth - diatomite, a light friable siliceous material derived chiefly from diatom remains (siliceous exoskeletons of unicellular algae) which is added to selected underground waste storage tanks to absorb and thereby immobilize residual heels.

diversion box - a below-grade concrete enclosure containing the remotely maintained jumpers and spare nozzles for diversion of waste solution to storage tank farms.

double-shell slurry - waste solutions from which salts cannot be further crystallized without chemical additions.

double-shell tank - the newer 1,000,000-gal underground waste storage tanks consisting of a concrete shell and two concentric carbon steel liners with an annulus.

dry well - a steel casing, generally 6 in. in diameter, drilled into the ground to various depths above the water table and used for access of monitoring instruments to measure the presence of radioactivity or moisture content. Each dry well is numbered as follows: xx-yy-zz. The xx designates the tank farm by code, the yy designates the tank, and the zz designates the "clock" position with 12 being at the north, 0°, position.

environs - area immediately surrounding the facility of interest.

evaporator-crystallizers - 242-A and 242-S waste concentration facilities that operate at a reduced pressure (vacuum) and are capable of producing a slurry containing about 30 vol% solids at a specific gravity of >1.6.

evaporator feed - any liquid that forms acceptable salt cake with further concentration, e.g., low heat waste, dilute interstitial liquor, aged waste, and other radioactive waste solutions.

FIC - a Food Instrument Corporation automatic liquid level gauge based on a conductivity probe installed in $\sim$85 underground waste storage tanks and, in most cases, electrically connected to a computer for data transmission, analysis, and reporting. Local readings may also be obtained from a dial.

GM instrument - instrument for detecting low-level beta and gamma radiation using a Geiger-Müller tube.

heel - the amount left in a vessel or container after the bulk of the contents has been removed.

hexone - methyl isobutyl ketone solvent used in the Redox chemical separations process.

interstitial liquor - the liquid which fills the voids in the solids in the waste tank. This liquid is estimated to be about 50% of the solids volume. In salt cake, $\sim$60% of the liquor is drainable and $\sim$40% is held in place by capillary forces (nondrainable). In the sludge portion of the tank farm waste this liquor is not considered pumpable or drainable, but may contain pockets of pumpable liquid which cannot be estimated. Interstitial liquor may be evaporator feed or terminal liquor.

inactive tank - a tank which has been removed from liquid-processing service, pumped to minimum supernatant liquid heel (<33,000 gal) and is waiting to be or is in the process of being stabilized and interim-isolated; includes all tanks not in active or active-restricted categories. Otherwise inactive contingency spares which would be used in the event of the failure of an active tank are also included.

interim isolation - completion of the physical effort required to minimize the inadvertent addition of liquids into an inactive storage tank, auxiliary tank, process vault, sump, catch tank, or diversion box.

interim stabilized - the condition of an inactive waste storage tank after all liquid practical has been removed by a salt well system using a jet pump. Tanks not requiring salt wells and jet pumps will be interim stabilized by other methods. Tank evaluations will be performed during the interim stabilization effort to determine the status and eventually to determine when a tank will be considered "interim stabilized."

jet pump - a modified commercially available low capacity jet pump used as an effective salt well pump. A centrifugal pump in the pit recirculates a stream to serve as the motive fluid for the jet located at the bottom of the well which draws additional solution into the loop at a rate equal to the discharge rate that is controlled by a diaphragm operated valve (DOV).

lateral - horizontal pipe installed beneath high-level waste tanks for inserting radiation and moisture detectors to monitor for tank leaks.

leak detection pit - collection point for any leakage from AX Farm tanks. The pits are equipped with radiation and liquid detection instruments.

leaker - a tank which has been confirmed as leaking from the outer containment vessel (see confirmed leaker).

liquid level - the surface level of the liquid contents of a vessel.

monitoring interval - the elapsed time between successive radioactivity surveys in dry wells.

monitoring period - same as monitoring interval.

neutron probe - a soil moisture measuring device consisting of a fast neutron source and thermal neutron detector which is used as a means for detecting increased moisture in soils such as from leaks in underground waste storage tanks or pipelines.

open hole salt well - a pump inserted into a waste tank with the suction at or below the solids level, frequently used to remove the bulk of the liquid, particularly in tanks containing <2 ft of sludge.

probe - an instrument package designed to be inserted in dry wells, tank risers, or other access ports to measure conductivity, radiation, moisture, temperature, etc.

profile - a graphical illustration of physical measurements such as radiation count rates or soil moisture content as a function of depth.

primary stabilization - the condition of an inactive waste storage tank after all liquid above the solids, other than isolated surface pockets, has been removed. Isolated surface pockets of liquid are those not pumpable by conventional techniques.

psychrometry - determination of the humidity or dew point of a gas from wet or dry bulb temperatures that is used in conjunction with flow rate data to calculate evaporator rates.

questionable integrity - any tank which has a small decrease in liquid level or a radiation increase in an associated dry well, for which the data are insufficient to support a conclusion that the tank is sound (95% confidence that the tank is sound) and for which a leak has not been confirmed.

radiation zone - an area or item of equipment requiring access control.

removed from service - any tank which is a confirmed leaker or is not intended for reuse.

riser - a casing or pipe inserted into the top of the waste tank and usually covered with a flange; riser sizes vary from 6 to 48 in. in diameter.

salt cake - nondeliquescent crystals (at average Hanford air conditions) formed by evaporation, cooling, and/or settling.

salt well - a pipe casing with a water-well screen inserted into a waste tank containing solids. The pipe is inserted to within about 2 in. of the bottom of the tank. The larger solid particles are rejected by the screen while liquid is allowed to migrate into the well for pumping.

scintillation monitor - a radiation detection instrument based on the principle that light pulses are produced in some materials when they are exposed to radiation.

sludge - solids formed by precipitation without additional concentration.

slurry - watery mixture of insoluble material coming from an evaporator, before the salt crystals have grown.

stabilization - the removal or immobilization, as completely as possible, of the liquid contained in a radioactive waste storage tank by salt well pumping, open hole salt well pumping, diatomaceous earth addition, etc.

static tank - a tank with no significant change in liquid level or involvement in transfer operations during a stated period of time.

supernate (supernatant liquid) - the volume difference between the measured liquid level and the measured average solids level in any tank; that liquid which lies above the solid layer within the tank.

surveillance - the act of watching closely.

tank farm - area containing a number of storage tanks; i.e., chemical tank farm for storage of chemicals used in a plant, or underground tank storage of radioactive waste.

terminal liquor - the liquid product from the evaporation-crystallization process which upon further concentration forms an unacceptable solid for storage in single-shell tanks. Terminal liquor is characterized by a caustic concentration of ~5.5M (the caustic molarity will be lower if the aluminum salt saturation is reached first).

tank number - alpha-numeric identification of tanks within tank farms. All tank farms are designated by the number 241. Letters A, B, C, etc., associate the tank farm with an original reprocessing plant: A for Purex; B, C, T, U for B, C, T, and U Plants (C was never built); and, S for Redox. Individual tanks are numbered consecutively starting with 101 in each tank farm. Thus, 241-U-110 would be tank number 10 in U tank farm.

thermocouple - a probe for measuring temperature, consisting of two dissimilar metal wires joined at one end (hot junction) with the free ends joined to a measuring instrument.

thermocouple tree - a group of thermocouples assembled in a pipe and inserted into a waste tank for measuring temperatures at regular (normally 2 ft) vertical intervals.

waste code - abbreviations shown below used in the former quarterly "Production and Waste Management Division Waste Status Summary" reports to identify the source of various wastes currently stored.

B - B Plant high-level waste
BL - B Plant low-level waste
BNW - 300 Area waste
CW - Coating waste
DW - Decontamination waste
EB - Evaporator bottoms
IX - Ion exchange waste
OWW - Organic wash waste
P - Purex waste
PSS - Sludge wash waste
PL - Purex low-level waste
R - Redox waste
RIX - Ion exchange waste from supernatant
SIX - Ion exchange waste from sludge supernatant (PSS)

SSW - Semiworks waste
TBP - TBP waste
U - Unavailable
IC - First cycle waste
2C - Second cycle waste
224 - 224 Building waste
N - 100-N waste
LW - 222-S laboratory waste

weight factor - the weight of a column of liquid between two instrument dip tubes, one at the bottom of the vessel and one referenced to ambient pressures. The instrument transmitter readout is normally in inches of H_2O and must be corrected for specific gravity of the liquid being measured.

zip cord - a tape for measuring depth to a liquid surface using a conductivity probe.

DISTRIBUTION

Number of Copies	
2	U.S. Department of Energy Richland Operations Office Richland, Washington 99352
	J. J. Schreiber A. R. Schwankoff
40	Rockwell Hanford Operations Richland, Washington 99352
	B. W. Anderson D. C. Bartholomew D. A. Berg D. J. Brown D. J. Cockeram G. T. Dukelow K. A. Gasper H. J. Goldberg M. J. Graham V. W. Hall W. F. Heine G. A. Huff R. E. Isaacson (10) A. G. Law A. H. Lu K. M. LaRue S. J. Phillips W. H. Price J. K. Prince R. C. Routson W. W. Schulz F. S. Stong D. L. Uhl C. M. Walker D. G. Wilkins Technical Files Document Control (2) RCP No. 1 (3)

THIS PAGE INTENTIONALLY
LEFT BLANK