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# Potential Radiological Exposure Rates Resulting from Hypothetical Dome Failure at Tank W-10

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Energy Systems Environmental Restoration Program
ORNL Environmental Restoration Program

# Potential Radiological Exposure Rates Resulting from Hypothetical Dome Failure at Tank W-10

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Prepared by
Bechtel National, Inc./CH2M Hill/Ogden/Peer
Oak Ridge, Tennessee
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# EXECUTIVE SUMMARY

*Purpose*

The main plant area at Oak Ridge National Laboratory (ORNL) contains 12 buried Gunite tanks that were used for the storage and transfer of liquid radioactive waste. Although the tanks are no longer in use, they are known to contain some residual contaminated sludges and liquids. In the event of an accidental tank dome failure, however unlikely, the liquids, sludges, and radioactive contaminants within the tank walls themselves could create radiation fields and result in above-background exposures to workers nearby.

This Technical Memorandum documents a series of calculations to estimate potential radiological exposure rates and total exposures to workers in the event of a hypothetical collapse of a Gunite tank dome. Calculations were performed specifically for tank W-10 because it contains the largest radioactivity inventory (approximately half of the total activity) of all the Gunite tanks. These calculations focus only on external, direct gamma exposures for prescribed, hypothetical exposure scenarios and do not address other possible tank failure modes or routes of exposure. The calculations were performed with established, point-kernel gamma ray modeling codes.

*Approach and Assumptions*

The primary radiation sources in the tank are the bottom layer of sludge, the liquid layer on top of the sludge, and the contaminated tank wall. Each set of calculations provides results for two separate modeled source combinations, or "source terms," consisting of (1) the sludge plus the tank wall, and (2) the sludge plus the liquid plus the tank wall. The first source term (sludge plus tank wall) assumes that the hypothetical accident which causes the dome to collapse also creates cracks in the tank walls that allow the liquid to escape. The second source term (sludge plus liquid plus tank wall) assumes that all the primary radiation sources are present and contribute to the exposure.

Three other principal assumptions used for developing the code model are listed below.

- Although the failure of the dome would cause the concrete and dirt overburden to collapse into the tank, thereby forming an effective gamma-attenuating barrier to the tank contents, the calculations assume that the residual overburden materials provide no shielding of the tank's radioactive contents.

- A sensitivity analysis of the tank contaminants showed that most of the gamma exposure (>95%) was due to the cesium-137 (and barium-137m daughter) activity in tank W-10; therefore, the source term in the model only used cesium-137 activities. The cesium source strengths used for the calculations were 490 $\mu$Ci/cm$^3$ (or 11,000 Ci total) for the 4.8-in.-deep sludge and 6.7 $\mu$Ci/cm$^3$ (or 1700 Ci total) for the 55-in.-deep liquid.

- The source strength used in the modeling of the tank wall was assumed to be 20 $\mu$Ci/cm$^3$ (or 89 Ci total), per Energy Systems' recommendation. However, this value, which has not been verified with actual measurements, is larger by a factor of 3 than the modeled liquid source strength of 6.7 $\mu$Ci/cm$^3$. The cesium contamination was assumed to be uniform over the tank wall surface to a depth of 1 in.

To facilitate discussion of the modeling results, the calculations have been divided into the four sets discussed below.

*Calculation Set 1: Exposure Rates Radially Outward from the Tank Edge*

This calculation set estimates exposure rates as a function of distance from the tank edge out to a total distance of 150 ft, at heights of 4 ft and 6 ft above the ground surface. The results of this calculation set show that the exposure rates reach a maximum at the tank edge and then fall off rapidly as a function of distance from the tank, reaching area background between 25 and 50 ft from the tank edge. The maximum values at the tank edge are $2.5 \times 10^4$ to $2.7 \times 10^4$ mR/h for the first source term (sludge plus wall; no liquid layer present) and $1.2 \times 10^3$ to $1.3 \times 10^3$ mR/h for the second source term (sludge plus liquid plus wall; all primary sources present).

Comparison of the two source term results shows higher potential exposure rates from sludges that do not have a liquid cover (the first source term); these results indicate that although the liquids contain radioactive materials, they still provide a significant shielding effect for the sludges.

*Calculation Set 2: Exposure Rates Above the Tank*

This calculation set estimates exposure rates above the tank as a function of distance from the tank center out to a total radius of 25 ft (tank edge), at heights of 4 ft and 6 ft above a hypothetical platform that spans the tank and is situated 5 ft above the ground surface. The platform is assumed to be invisible to (i.e., does not shield) gamma rays emanating from the tank.

The exposure rate profiles as a function of radial position are relatively flat. The exposure rates range from $2.1 \times 10^4 \times$ to $3.2 \times 10^4$ mR/h for the first source term (sludge plus wall; no liquid layer present) and $9.6 \times 10^2$ to $1.7 \times 10^3$ mR/h for the second source term (sludge plus liquid plus wall).

*Calculation Set 3: Exposure Rate in Building 150 ft Away*

To model the potential exposure on the second floor of a hypothetical building 150 ft north of tank W-10, this set estimates the exposure rate at a location 150 ft from the tank edge, at a height of 20 ft above the ground. The exposure rates calculated in this set were insignificant (close to zero); therefore, no significant changes in local area background would be expected from direct exposure resulting from the hypothetical dome collapse modeled.

*Calculation Set 4: Total Exposures for Two Hypothetical Worker Response Scenarios*

Using the exposure rates from sets 1 and 2, this calculation set computes total gamma radiation exposures for two hypothetical worker exposure scenarios: (1) the "investigator" scenario, where a worker is attracted by the accident-generated noise of a dome collapse, but quickly leaves the area after noting the extent of the damage; and (2) the "fugitive" scenario, where a worker who is present on the platform above the tank when the postulated accident occurs flees the immediate area. The calculation parameters with regard to hypothetical worker response, evacuation routes, and exposure times are conservative. Ignored are the facts that the tank areas are roped off and restricted, and that ORNL's radiation workers are trained to minimize their exposure in the event of an accident or an

emergency situation. These (worst case) scenarios are provided as only two of many possible exposure situations that could be studied.

Estimated exposures for both investigator and fugitive scenarios were the same order of magnitude for a particular source term. For the first (sludge plus wall) source term, the exposures (which are in excess of background) are roughly equivalent to the average annual exposure to natural background (approximately 270 mrem/year). For the second (sludge plus liquid plus wall) source term, total exposures were an order of magnitude less than for the first source term because of the attenuating effect on the sludge by the liquid layer. In both worker response scenarios considered, the estimated total exposure values for the hypothetical worker are below the annual regulatory limits recommended by ORNL; ORNL's administrative goal is more than a factor of 2 greater than the maximum calculated exposure.

*Additional Observations*

The conservative nature of these calculations (e.g., lack of overburden, worker exposure parameters) has been stated. Although the results of this study indicate that direct external exposure levels are below annual regulatory limits, the calculations (and scenarios) could be modified, if desired, to simulate less conservative (more realistic) accident situations.

The results of this study should not be directly extrapolated to other Gunite tanks without appropriate analysis. As was shown by this study, the contaminated liquid covering the sludge provides a considerable amount of shielding for radiation fields generated by sludge radionuclides. Therefore, other Gunite tanks with minimal or no liquids covering the sludge could also be considered for a study such as this. As part of ORNL's planning activities for the Gunite tanks, additional modeling could also be performed to study various sludge/liquid remediation scenarios or other hypothetical accident scenarios. Additional tank characterization could also be performed to identify the extent of penetration and concentration of radioactive contaminants in the wall.

# 1. INTRODUCTION

## 1.1 BACKGROUND

The Oak Ridge National Laboratory (ORNL) main plant area contains 12 underground Gunite tanks (see Fig. 1) that were used for the storage and transfer of liquid radioactive and hazardous wastes before they were removed from service. These tanks were built in 1943 using a Gunite construction process in which a mixture of sand, cement, and water is applied in layers by spraying onto formed steel reinforcement bars and/or welded wire mesh. They have a circular shape in plan view, with vertical sidewalls and a domed top, and are buried under about 6 ft of compacted soil. The Gunite tanks with the largest capacity are tanks W-5 through W-10, located in the South Tank Farm.

The Gunite tanks contain more than 95% of the documented inventory of radionuclides within the inactive waste management units in ORNL's main plant area. Although there have been no documented releases from these tanks, their age and uncertain structural integrity suggest the potential for future release. Plans are being prepared to minimize or control the potential for and effects of leakage or failure of the containment structures. These effects may include contaminant migration into surrounding soil, with subsequent contamination of other environmental media and exposure of ORNL personnel through airborne contamination or direct radiation exposure.

This Technical Memorandum documents a series of calculations to estimate potential radiological exposure rates above and surrounding a Gunite tank in the event of a tank dome collapse. The exposure rates are then used to derive total exposures for assumed exposure situations. Specific calculations were performed for tank W-10 because it contains the largest inventory of radioactivity of all the Gunite tanks. These calculations focus only on external, direct gamma exposures for prescribed, hypothetical exposure scenarios and do not address other possible tank failure modes or routes of exposure. The calculations are provided to support ORNL's planning efforts for the Gunite tanks, but they are not intended as a complete assessment of all possible exposure pathways or risk scenarios.

This introduction provides a general description of Gunite tanks (Sect. 1.2), a delineation of specific calculation objectives and scope limitations (Sect. 1.3), and a brief discussion of the calculational approach or methodology (Sect. 1.4).

## 1.2 DESCRIPTION OF GUNITE TANKS

### 1.2.1 Tank Construction

Tanks W-5 through W-10 are large (170,000-gal capacity) Gunite tanks arranged in two rows of three tanks each, with a center-to-center distance of 60 ft between adjacent tanks. The tanks were constructed by excavating a large shallow basin, pouring individual concrete pads directly on bedrock, erecting the tanks, and backfilling the entire area.

The inside diameter of the tanks is 50 ft, and the 12-ft vertical sidewalls are 7.5 in. thick. The bottom Gunite liner is 3 in. thick on top of the concrete pad, and the domes are 10 in. thick, increasing in thickness at the point where the dome meets the tank walls. The dome curves upward approximately 6 ft from its outer edge to its center. Figure 2 shows a cross-sectional view of a

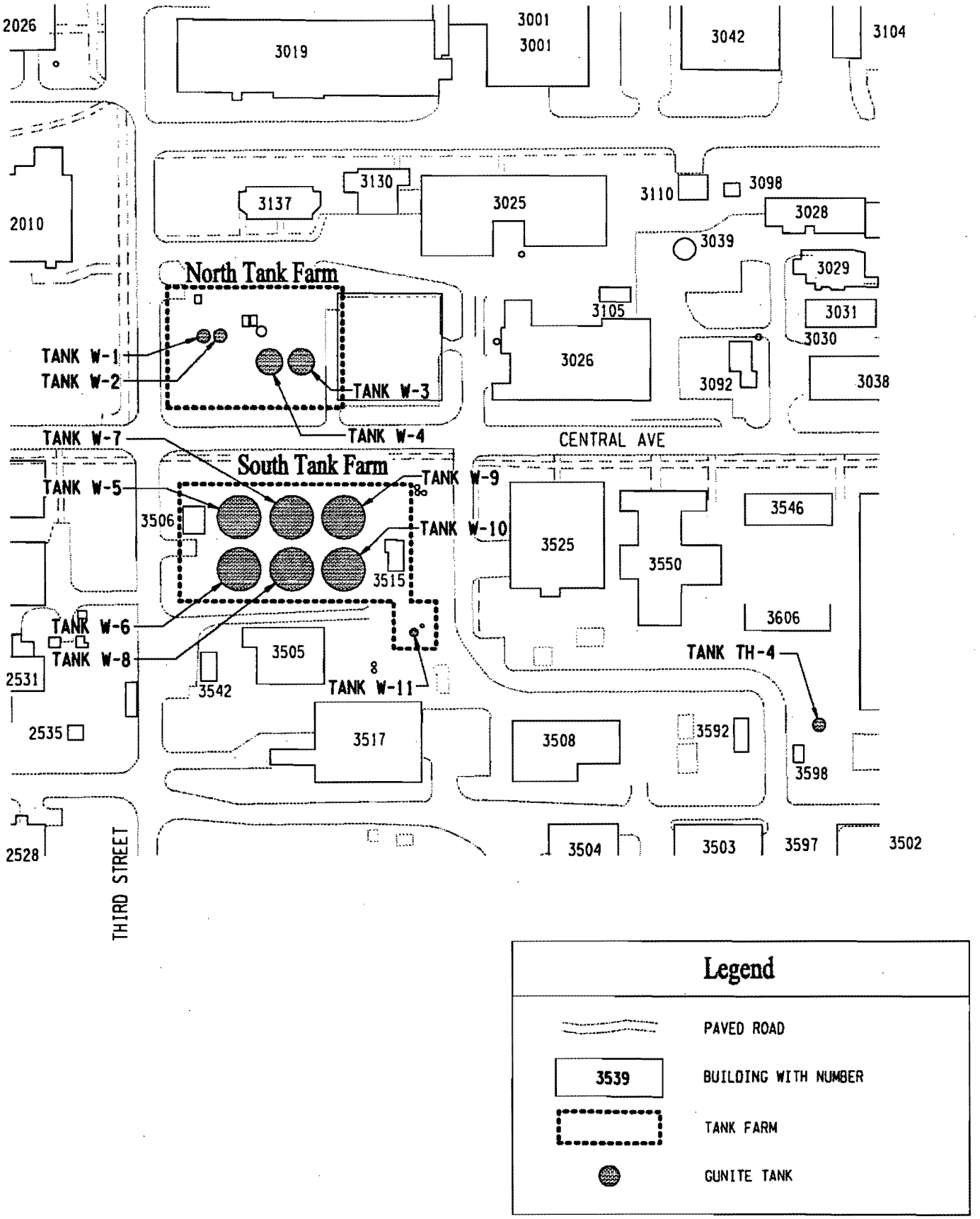


**Fig. 1. Location of Gunite tanks in ORNL's main plant area.**

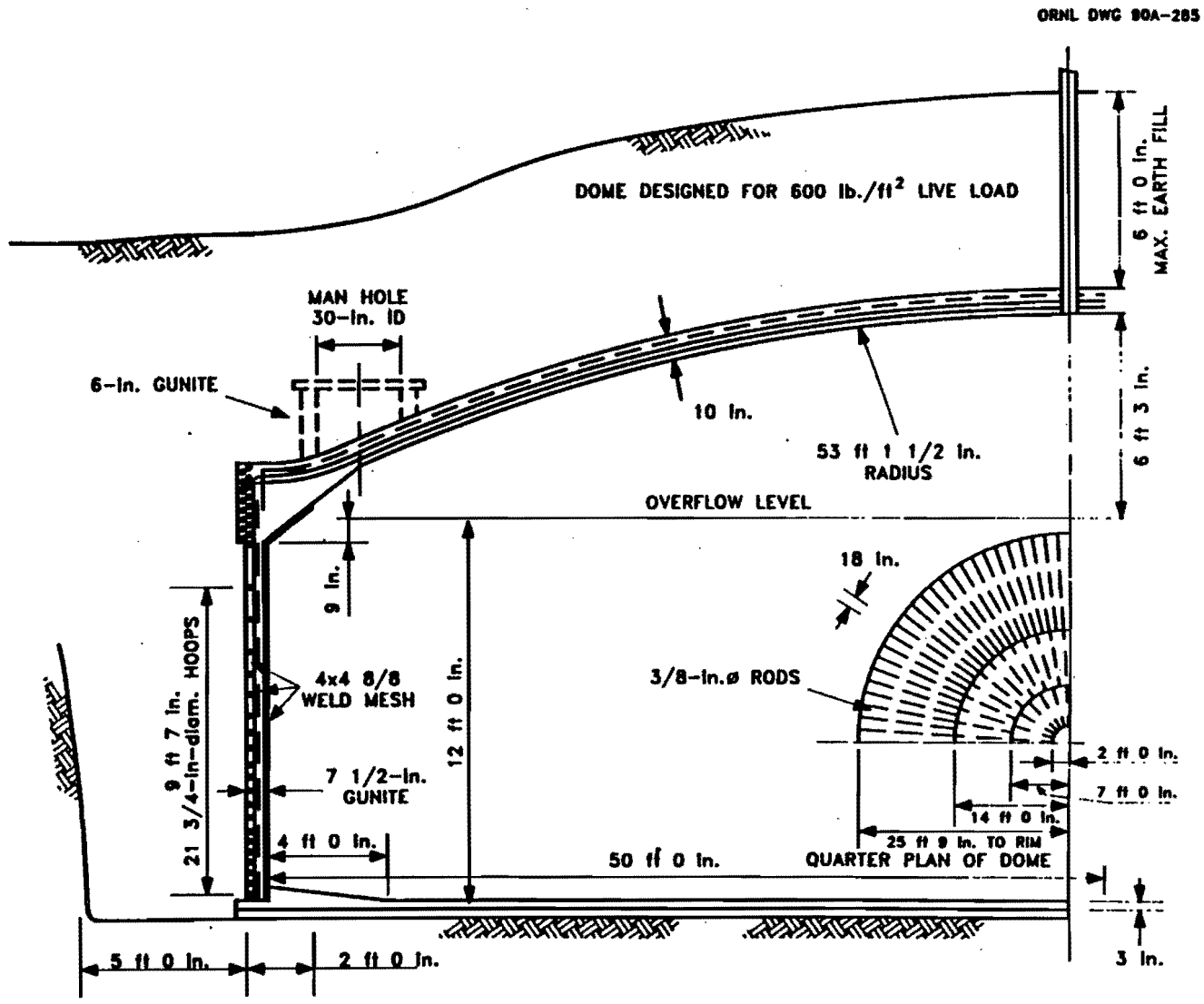


Fig. 2. Cross-sectional view of a tank.

Gunite tank, and Fig. 3 shows an enlarged sectional view of the area where the tank dome meets the vertical sidewalls.

An analysis of tanks W-5 through W-10 was performed in 1986 to assess their structural adequacy when subjected to seismic loads. The calculations performed in the structural analysis (Fricke 1986) revealed that the reinforcement steel in the part of the tank where the top dome meets the vertical sidewalls does not have sufficient strength to handle the size of the loads that were assumed in the original design specifications, without the support of the prestressed steel hoops in that part of the tank. This apparent weakness may be the result of overly conservative assumptions concerning the remaining strength in the steel used to form the hoops in the dome edge region or in the other reinforcing steel and the concrete in that area. These assumptions would theoretically allow creep and shrinkage in the concrete, losses in strength due to internal frictions, deformation at the dome ring, and excessive bending in that part of the tank. Given the absence of as-built drawings, it is also possible that design and/or material specifications were exceeded in the construction, resulting in greater strength than specified in the design. Because of uncertainties in estimating the variables used for the analysis, the actual structural behavior of these tanks is difficult to predict.

The backfill material around each tank is a 3-ft layer of 2-in. crushed stone surrounding the tank from the base to the top. The concrete pads under the tanks have larger diameters than the tanks and curb and gutter systems that drain via a 6-in. terra cotta drain tile system to six individual dry wells, all of which connect to a common drain for pumping to the equalization basin. In the event of a leak, the liquid was intended to flow down through the crushed stone, collect in the saucer-like concrete pad, and be captured in the dry wells, where routine monitoring would detect the leak.

### 1.2.2 Operating History of Tanks W-5 Through W-10

The six main Gunite tanks were originally built for permanent storage of radioactive liquid waste produced by the plutonium pilot plant and were intended to be operated in pairs. They were to receive waste from the building drains uphill to the north and to overflow from one tank to the next toward the south. W-5 initially received radioactive liquid chemical waste and overflowed into W-6, W-7 initially received liquid uranium waste and overflowed into W-8, and W-9 initially received liquid uranium waste and overflowed into W-10 (Mynatt and Webster 1963). As the laboratory grew, the storage tanks became inadequate to handle the volume of liquid waste that was being generated. The wastes were precipitated in the tanks by raising the pH with sodium hydroxide, and the supernatant was decanted to waste holding basin 3513 and subsequently discharged to White Oak Creek. This practice changed in 1949 when a new process was begun to concentrate the effluent from these tanks using a pot-type evaporator. The concentrate from the evaporator was returned to one of the storage tanks, and the condensate was discharged to White Oak Creek.

The use of each tank changed according to the growing needs of the laboratory over the years. As much as 130 tons of uranium were reclaimed from W-7, W-8, W-9, and W-10 between 1952 and 1957, making more room for waste in the tanks (Mynatt and Webster 1963). By the early 1960s, W-7, W-9, and W-10 were not being used, but they contained a solution of water, NaOH, and radioactive sludges. Most of the tanks were removed from service in 1978, and most of the liquid and sludge they contained was removed by sluicing; however, some liquid and sludge remain.

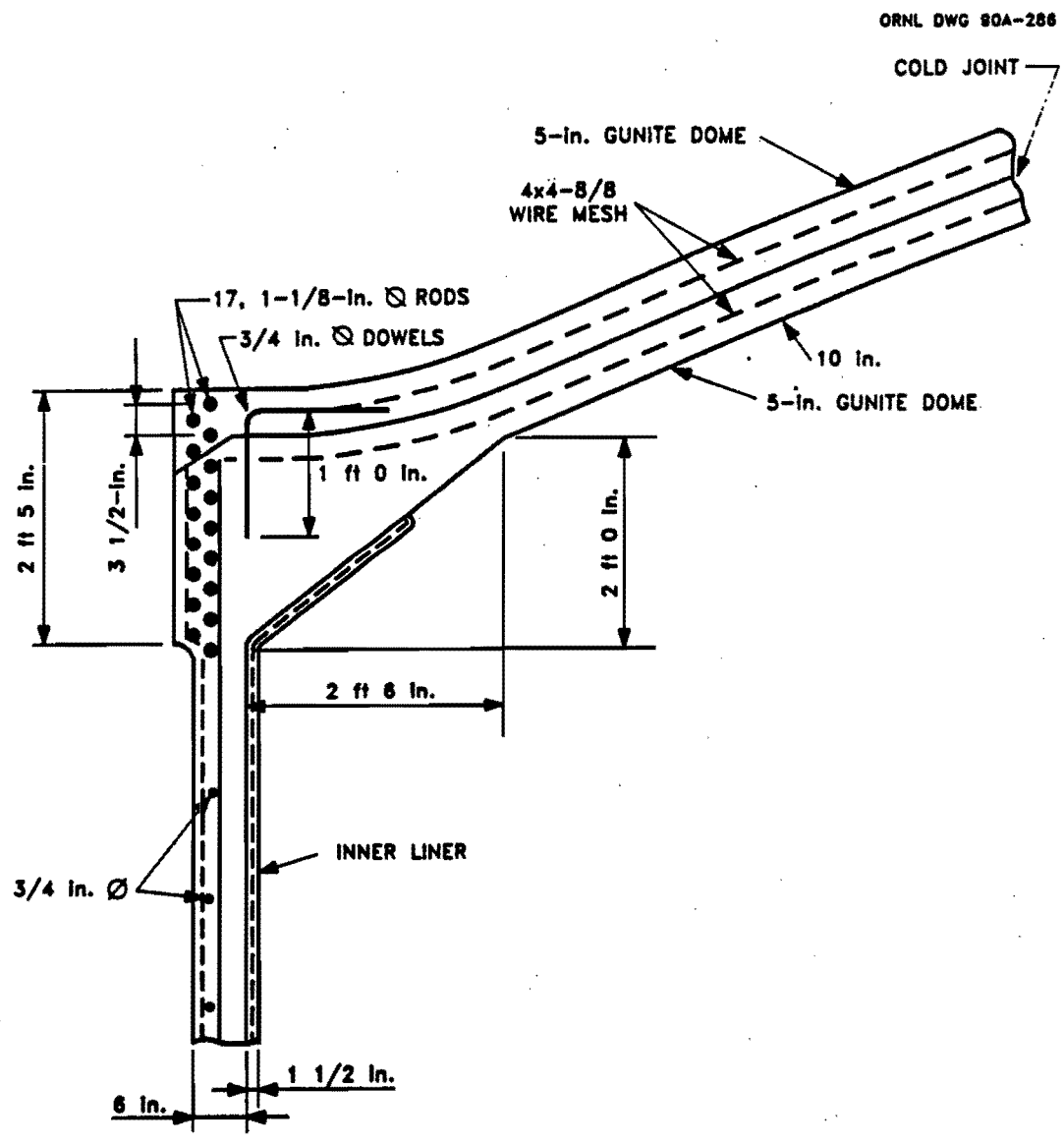


Fig. 3. Section through dome.

### 1.2.3 Contents of Tank W-10

Tank W-10 contains almost 5 in. of contaminated sludge covered by slightly more than 4.5 ft of contaminated liquid. The liquid and sludge contained within the Gunite tanks, including W-10, have been sampled and analyzed by ORNL (Autrey et al. 1990; ORNL 1992a). Approximately 50% of the total activity in the Gunite tanks is contained in tank W-10 (Bechtel 1991). Table 1 presents the total activity of radionuclides in the sludge and liquid of W-10, as reported by Bechtel (1991): activities in sludge range from 0.14 Ci tritium to 11,000 Ci cesium-137; activities in liquids range from 0.01 Ci plutonium-239 to 1700 Ci cesium-137. These estimates were generated by using published maximum radionuclide concentrations for the tank contents and tank volumes and are likely to provide a conservative estimate of the liquid inventories. However, the sludge results are not necessarily conservative: the sludge is likely to be heterogeneous, but the samples were collected from only one penetration in the tank (Fig. 4). In addition, sample quantities were limited to minimize radiation exposure to field personnel.

The principal gamma emitters in Table 1, and the radionuclides expected to have the most impact on direct gamma exposure, are cesium-137 (the radionuclide with the largest activity in the tank sludge and liquid), cesium-134, cobalt-60, europium-152, and europium-154. Some of the daughters in the uranium and plutonium decay chains are also gamma emitters.

## 1.3 OBJECTIVES AND SCOPE LIMITATIONS

This document presents a radiological exposure model for a hypothetical complete dome collapse of tank W-10 and estimates gamma exposure rates and total gamma exposures for workers under postulated worst-case conditions. To facilitate discussion of the modeling and associated results, the calculations are divided into four sets.

- *Calculation Set 1: Exposure Rates Radically Outward from the Tank Edge (see Sect. 2).* This calculation set estimates exposure rates as a function of distance from the tank edge out to a total distance of 150 ft, at heights of 4 ft and 6 ft above the ground surface. The 4-ft and 6-ft heights represent approximate waist and head heights for a worker.

- *Calculation Set 2: Exposure Rates Above the Tank (see Sect. 3).* This calculation set estimates exposure rates above the tank as a function of distance from the tank center out to a total radius of 25 ft (tank edge), at heights of 4 ft and 6 ft above an imaginary working platform situated above the tank.

- *Calculation Set 3: Exposure Rate in Building 150 ft Away (see Sect. 4).* This calculation set estimates the exposure rate at a hypothetical building 150 ft from the tank edge, at a height of 20 ft above the ground.

**Table 1. Gunite tank W-10 estimated radionuclide inventory**

| | Tank W-10 | |
|---|---|---|
| Radionuclide | Sludge (Ci) | Liquid (Ci) |
| $^{241}Am$ | 4.4E+00 | * |
| $^{244}Cm$ | 4.6E+01 | * |
| $^{60}Co$ | 1.3E+01 | 1.0E+00 |
| $^{134}Cs$ | 1.4E+00 | * |
| $^{137}Cs$ | 1.1E+04 | 1.7E+03 |
| $^{152}Eu$ | 4.5E+00 | * |
| $^{154}Eu$ | 7.9E+00 | * |
| $^{3}H$ | 1.4E-01 | 1.0E+00 |
| $^{238}Pu$ | 2.9E+01 | * |
| $^{239}Pu$ | 1.1E+01 | 1.4E-02 |
| $^{90}Sr$ | 8.5E+03 | 8.7E+00 |
| $^{23}3U$ | 2.1E+00 | 5.1E-02 |
| $^{234}U$ | 1.3E+00 | 2.2E-02 |

*Source:* Bechtel, "Radionuclide Inventory in the WAG 1 Inactive Tanks," 01-TB-18, Rev. 0, Oak Ridge, Tennessee.

*Asterisk indicates that data are not available.

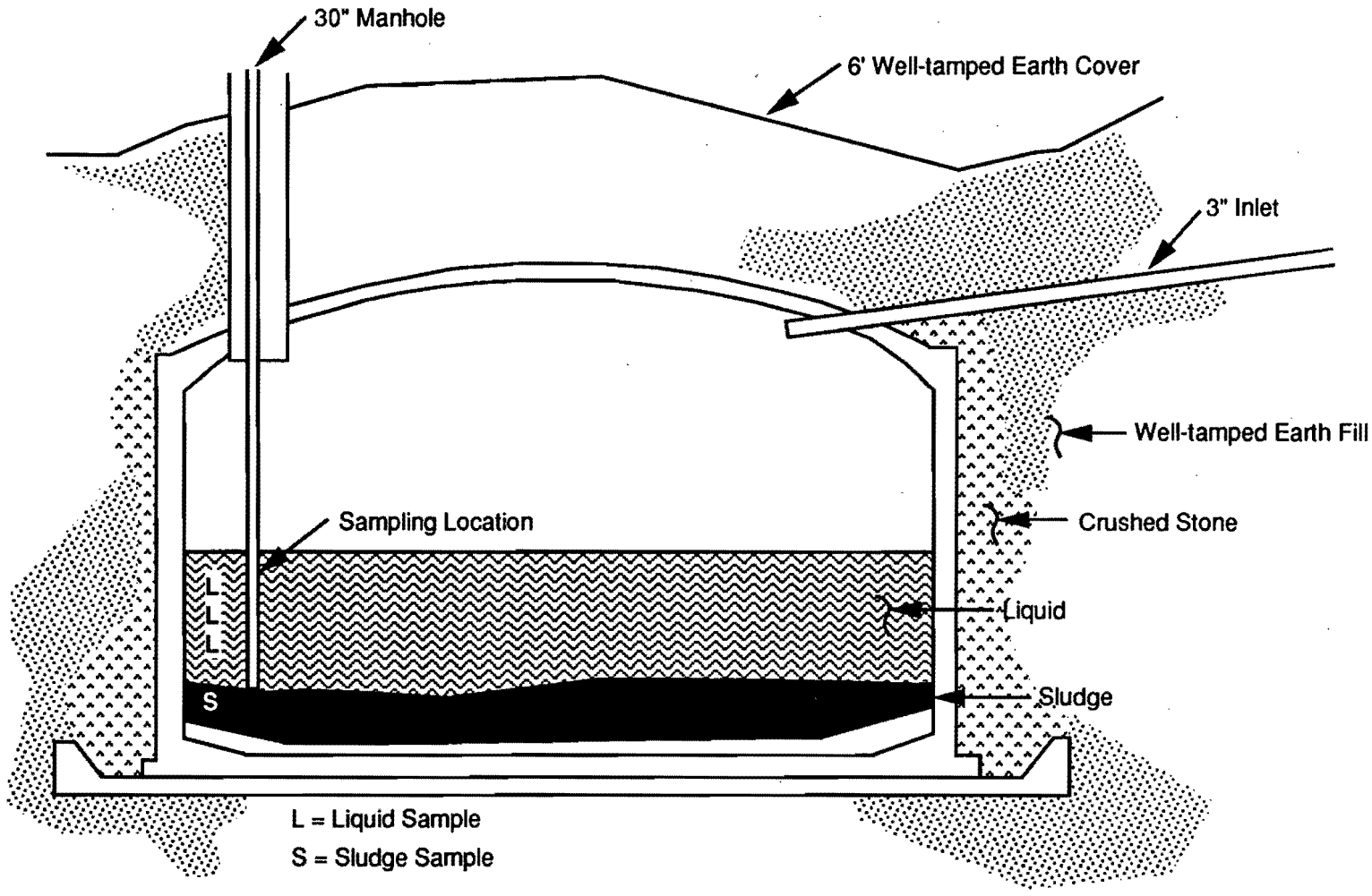


**Fig. 4. Typical tank configuration showing sampling location.**



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- *Calculation Set 4: Total Exposures for Two Hypothetical Worker Response Scenarios (see Sect. 5).* Using the exposure rates from sets 1 and 2, this calculation set computes total gamma radiation exposures for two hypothetical worker exposure scenarios: (1) the "investigator"scenario, where a worker is attracted by the accident-generated noise of a dome collapse but quickly leaves the area after noting the extent of the damage; and (2) the "fugitive" scenario, where a worker who is present on the platform above the tank when the accident occurs flees the immediate area.

The primary radiation sources in the tank are the layer of sludge at the bottom, the liquid layer on top of the sludge, and the contaminated tank wall. Each calculation set provides results for two separate modeled source combinations, or "source terms," consisting of (1) the sludge plus the tank wall, and (2) the sludge plus the liquid plus the tank wall. The first source term (sludge plus tank wall) assumes that the hypothetical accident which causes the dome to collapse also creates cracks in the tank walls or floor that allow liquid to escape. In this instance, only contamination in the sludge and tank walls contributes to the potential exposures above or around the tank. The second source term (sludge plus liquid plus tank wall) assumes that all the primary radiation sources contribute to the exposure. It is important to note, however, that the sludge emanations in this second source term are partially shielded by the liquid layer above the sludge.

The model assumptions are generally conservative and may in some cases be considered conservative to the point of being unrealistic; however, this lack of realism is deemed acceptable for this series of calculations so as to meet the stated objective of estimating upper limit or worst-case direct gamma exposures. A good example of a conservative assumption used in the calculations is that although the failure of the dome would cause the concrete and soil overburden to collapse into the tank, thereby forming an effective gamma-attenuating barrier to the tank contents, the calculations assume that the residual overburden materials provide no shielding of the tank's radioactive contents (i.e., the overburden in essence becomes "nonexistent" after the collapse and is not included in the model). If the overburden had been included in the calculations as a shielding material for the sludge and liquid, the calculated exposure rates would have been lower.

The calculations provide direct gamma exposures under prescribed conditions, and the calculational approach (as shown in Sect. 2) provides insight into the shielding protection offered by the contaminated liquids for the underlying sludge, as well as the contribution of the cesium-137 activity to the total gamma exposure. However, this document is not sufficient for, nor intended for, safety analyses of other possible exposure scenarios such as sludge/liquid remediation, dome removal, tank leaks and contaminant recovery, criticality, or airborne releases.

As stated, the modeling results are specifically for tank W-10. Although tank W-10 has the highest reported activity of any of the Gunite tanks, extrapolation of tank W-10 exposure results to other Gunite tanks should only be done after careful comparative analysis of the other tanks and their contents, and in consultation with qualified technical personnel. Alternatively, for the purposes of comparison, the same type of study conducted for tank W-10 could be conducted directly for other Gunite tanks in the South Tank Farm area.

## 1.4 METHODOLOGY

The exposure rates determined in calculation sets 1, 2, and 3 were computed using the gamma ray shielding codes QAD-CGGP (Cain 1977) and, to a much lesser extent, MicroShield, Version 4 (Grove Engineering 1987). Both codes are generally well known and receive widespread use in the nuclear engineering community, and verified and validated versions of these codes exist on Bechtel's computer network.

QAD-CGGP is a point-kernel (ray-tracing technique) code for calculating gamma ray penetration through various shield configurations defined by combinatorial geometry specifications. QAD-CGGP was used to perform exposure calculations because of its versatility in geometry combinations and exposure point locations. MicroShield is also a point-kernel code but with menu-driven features that allow for simpler and quicker, though less flexible, code input than QAD-CGGP. MicroShield was used to perform sensitivity analyses on source composition (loading) because it is relatively simple to use and modify for different radionuclides. These codes are discussed in more detail in Appendix A. Input files for QAD-CGGP and MicroShield used in this study are given in Appendices B and C for those readers familiar with the codes or who have access to code documentation.

Calculation sets 1 through 4 are discussed in Sects. 2 through 5, respectively. Each section lists the approach and assumptions used to make the calculations in a set, presents the results of the calculation set, and offers analysis of the results, as appropriate. Details regarding input parameters for QAD-CGGP and MicroShield, as well as copies of input and output files, are presented and explained in Bechtel Calculation No. 01-CA-09 (W-10 Tank Exposure Due to Hypothetical Tank Accident), Bechtel Calculation No. 01-CA-10 (W-10 Tank Exposure Map Extended to 24 ft from the Edge of the Tank), and Bechtel Calculation No. 01-CA-28 (Exposure Rate Estimates Due to Tank W-10 Wall).

# 2. CALCULATION SET 1: EXPOSURE RATES OUTWARD FROM THE TANK EDGE

This calculation set estimates the exposure rates as a function of distance from the tank edge out to a total distance of 150 ft, at heights of 4 ft and 6 ft above the ground surface.

## 2.1 SOURCE MODELING APPROACH

The three primary sources of gamma radiation consisted of the contaminated sludge, liquid, and tank wall. Exposure rates were to be provided for

- a situation where the liquid had escaped from the tank and only the sludge and tank wall were gamma ray contributors, and
- a situation where all three primary sources were contributors.

Since the codes only model one source region at a time (i.e., each primary source is composed of a different material, and only one of the materials input to the code can be designated as a source

in a code run), individual contributions to the exposure rate must be determined for each source and then added together to obtain the total exposure rates.

Individual calculations were performed for (1) the sludge as the source without an overlying layer of liquid, (2) the tank walls as the source with a sludge layer acting as a shield for the sludge-covered portion of the wall (no liquid layer present), (3) the liquid as the source, (4) the sludge as the source with an overlying layer of liquid acting as a shield or attenuator for the sludge contaminants (i.e., the liquid was not a source), and (5) the tank walls as a source with the sludge and liquid layers acting as a shield for that portion of the wall below the liquid surface. The results of these calculations were summed together in specific ways to give total contributions; specifically,

- exposure rate results from individual calculations (1) and (2) above were added together to give the exposure rates for a sludge-plus-tank-wall combined source, and
- exposure rate results from individual calculations (3), (4), and (5) above were added together to give the exposure rates for a sludge-plus-liquid-plus-tank-wall combined source.

## 2.2 ASSUMPTIONS AND CODE INPUT

### 2.2.1 Source Input

The depths of the sludge and liquid (see Sect. 2.2.2) were measured during the inactive waste tank sampling project in August 1988. Given the measured depths and known tank dimensions, the volumes of sludge and liquid used for the code model were 5930 gal (22,440 L) and 67,330 gal (254,830 L), respectively.

No information was reported on the density of sludge material collected during the sampling effort. For this study, the density of the sludge was assumed to be 1.5 g/cm$^3$, and the density of the liquid was assumed to be 1 g/cm$^3$.

A sensitivity analysis using MicroShield showed that most of the gamma exposure (>95%) was due to the cesium-137 activity; therefore, the source term in the QAD-CGGP model only uses cesium-137 radionuclide activities. (Note: cesium-137 actually decays by beta emission to barium-137m, which in turn decays by gamma emission to the ground state of barium.)

The source strengths used by the model for the sludge and liquid waste were assumed to be those reported in Table 1: 11,000 Ci (or 490 $\mu$Ci/cm$^3$) cesium-137 in the sludge and 1700 Ci (or 6.7 $\mu$Ci/cm$^3$) cesium-137 in the liquid. The source strength used in the modeling of the tank wall was assumed to be 20 $\mu$Ci/cm$^3$, per Energy Systems' recommendation. However, this value, which has not been verified with actual measurements, is larger by a factor of 3 than the assumed average cesium-137 concentration of 6.7 $\mu$Ci/cm$^3$ in the tank liquid.

### 2.2.2 Geometry Input

Figure 5 shows the model geometry used by the shielding codes to estimate the gamma exposure rates created by the liquid and sludge within the tank and in the tank wall. A cylindrical geometry

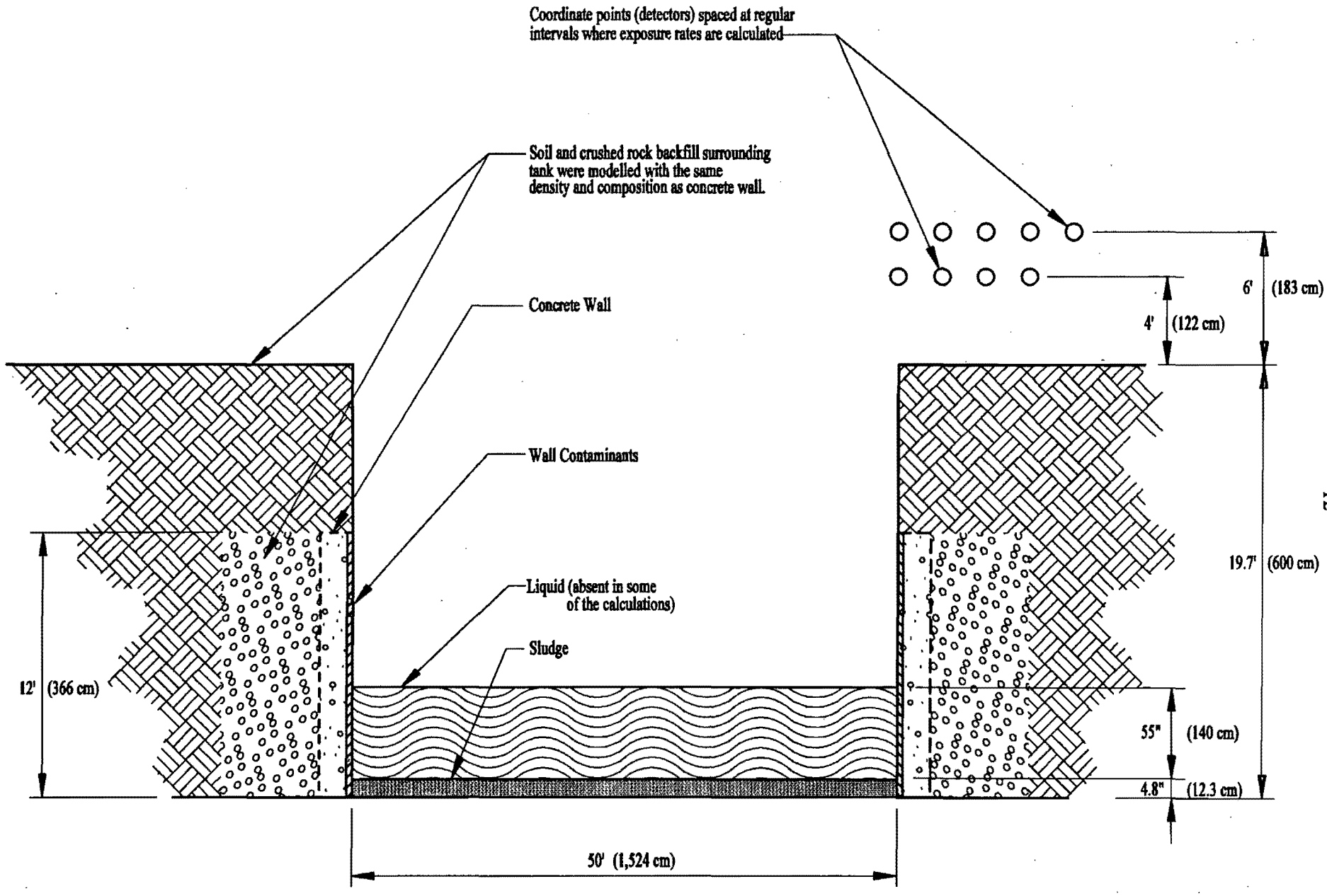


**Fig. 5. Tank cross-section geometry used for the QAD-CGGP shielding code model, calculation set 1. (Drawing is not to scale.)**

was used to model the tanks and tank contents. The sludge and liquid "solid cylinders" had depths of 4.8 in. (12.3 cm) and 55 in. (139.7 cm), respectively, and each had a radius of 25 ft.

There are no field measurement data that identify the nature and extent of contaminant penetration in the tank walls. For the purpose of this calculation set, it is assumed that only the interior surface of the tank wall is radioactive, and that significant contamination has not been adsorbed deeper than 1 in. (2.54 cm) into the wall. It is further assumed that the contamination is uniform over the surface of the wall. Thus, the contamination in the tank wall was modeled as a cylindrical shell 1 in. thick and 12 ft (365.76 cm) high; multiplying the shell volume times the specific activity of 20 $\mu$Ci/cm$^3$ gives a total loading for this shallow surface source of 89 Ci cesium-137.

The soil and crushed rock backfill surrounding the tank was assumed to be the same density and composition as the Gunite tank walls.

To calculate exposure rates outside of tank W-10, the collapsed residual dome material was assumed to provide no shielding of the gamma fields generated from the sources in the tank. Other tanks, buildings, or terrain were also assumed not to attenuate or shield exposures. It is assumed that the collapsed overburden does not increase the overall volume or height of the tank contents.

### 2.2.3 Detector Input

As defined for code input, detectors are the locations or coordinates of the points in space for which the code output (exposure rate) is calculated (see Fig. 5).

To estimate radiation exposure levels at waist and head height for a worker, exposure rates were calculated at code "detectors" at 4-ft and 6-ft elevations above the ground surface. The exposure rates were also calculated laterally out from the interior rim of the tank walls at approximately 1-ft intervals to a distance of 25 ft, and thereafter at distances of 50, 75, 100, and 150 ft from the tank rim.

The "water dose" buildup factor was selected for the code input to take into account the scattered component of the flux. The semiempirical buildup factor accounts for the increase (i.e., buildup) in the flux density at some detector positions due to scattered gamma rays; the buildup factor is multiplied by the uncollided flux in the code to obtain the total flux (additional discussion on is buildup provided in Appendix A).

## 2.3 RESULTS AND ANALYSES

Tables 2a and 2b show exposure rates at 4- and 6-ft elevations, respectively, calculated at 1-ft intervals from the tank's interior edge out to a distance of 25 ft. Not all of the exposure rates calculated are listed in the tables, however; calculated exposure rates that are significantly below background exposure rates are not included. [Since nominal background for nonradiological areas is on the order of 50 $\mu$R/h (background for the South Tank Farm is higher), values below about 10 $\mu$R/h are not included in Tables 2a and 2b. For example, exposure rates for distances of 50 ft and greater are not included because the calculated values are significantly below background.]

Table 2a. Calculation set 1: exposure rates as a function of distance from tank edge to 25 ft (4-ft elevation)

| Distance (ft) | Exposure Rate (mR/h) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sludge without liquid shield[a] | Wall with sludge shield[b] | Sludge plus wall (columns 2 + 3) | Liquid only[c] | Sludge with liquid shield[d] | Wall with sludge and liquid shield[e] | Liquid plus sludge plus wall (columns 5 + 6 + 7) |
| 0 | 2.7E+04 | 3.8E+02 | 2.7E+04 | 9.6E+02 | 1.2E+00 | 3.0E+02 | 1.3E+03 |
| 1 | 2.4E+04 | 3.1E+02 | 2.4E+04 | 8.0E+02 | 5.5E-01 | 2.4E+02 | 1.0E+03 |
| 2 | 1.9E+04 | 2.4E+02 | 1.9E+04 | 6.2E+02 | 1.5E-01 | 1.8E+02 | 8.0E+02 |
| 3 | 1.4E+04 | 2.0E+02 | 1.4E+04 | 4.6E+02 | 2.7E-02 | 1.5E+02 | 6.1E+02 |
| 4 | 1.0E+04 | 1.6E+02 | 1.0E+04 | 3.3E+02 | | 1.2E+02 | 4.5E+02 |
| 5 | 7.0E+03 | 1.4E+02 | 7.1E+03 | 2.4E+02 | | 1.1E+02 | 3.5E+02 |
| 6 | 4.6E+03 | 1.2E+02 | 4.7E+03 | 1.6E+02 | | 9.0E+01 | 2.5E+02 |
| 7 | 2.8E+03 | 1.0E+02 | 2.9E+03 | 1.2E+02 | | 7.8E+01 | 1.9E+02 |
| 8 | 2.1E+03 | 9.1E+01 | 2.2E+03 | 8.9E+01 | | 7.1E+01 | 1.6E+02 |
| 9 | 9.6E+02 | 8.1E+01 | 1.0E+03 | 5.8E+01 | | 6.4E+01 | 1.2E+02 |
| 10 | 3.2E+02 | 6.4E+01 | 3.8E+02 | 3.6E+01 | | 5.2E+01 | 8.9E+01 |
| 11 | 2.8E+01 | 5.7E+01 | 8.5E+01 | 2.0E+01 | | 4.8E+01 | 6.8E+01 |
| 12 | 7.5E-01 | 4.0E+01 | 4.1E+01 | 1.0E+01 | | 3.8E+01 | 4.8E+01 |
| 13 | 1.4E-02 | 3.4E+01 | 3.4E+01 | 3.6E+00 | | 3.3E+01 | 3.7E+01 |
| 14 | | 2.7E+01 | 2.7E+01 | 4.1E-01 | | 2.6E+01 | 2.6E+01 |
| 15 | | 2.0E+01 | 2.0E+01 | 1.5E-02 | | 2.0E+01 | 2.0E+01 |
| 16 | | 1.6E+01 | 1.6E+01 | | | 1.6E+01 | 1.6E+01 |
| 17 | | 1.4E+01 | 1.4E+01 | | | 1.4E+01 | 1.4E+01 |
| 18 | | 8.9E+00 | 8.9E+00 | | | 8.9E+00 | 8.9E+00 |
| 19 | | 5.9E+00 | 5.9E+00 | | | 5.9E+00 | 5.9E+00 |
| 20 | | 5.6E+00 | 5.6E+00 | | | 5.6E+00 | 5.6E+00 |
| 21 | | 3.9E+00 | 3.9E+00 | | | 3.9E+00 | 3.9E+00 |
| 22 | | 3.5E+00 | 3.5E+00 | | | 3.5E+00 | 3.5E+00 |
| 23 | | 1.9E+00 | 1.9E+00 | | | 1.9E+00 | 1.9E+00 |
| 24 | | 2.4E-01 | 2.4E-01 | | | 2.4E-01 | 2.4E-01 |
| 25 | | 1.3E-02 | 1.3E-02 | | | 1.3E-02 | 1.3E-02 |

[a]Sludge without liquid shield = Exposure rates in the absence of liquid to shield the radiation exposure fields generated by sludge alone.
[b]Wall with sludge shield = Exposure rates due to tank wall when liquid is not present in the tank; only the effect of sludge shielding part of the tank wall is considered. Sludge does not contribute to the source term, but acts only as a shield.
[c]Liquid only = Exposure rates due to liquid only.
[d]Sludge w/liquid shield = Exposure rates in the presence of a liquid layer that attenuates the radiation fields generated by the sludge. Liquid only acts as a shield and does not contribute to the source term.
[e]Wall with sludge and liquid shield = Exposure rates due to tank wall when both liquid and sludge are present and act as shield to cover portions of the tank wall; no contribution to the source term.

**Table 2b. Calculation set 1: exposure rates as a function of distance from tank edge to 25 ft (6-ft elevation)**

| Distance (ft) | Exposure Rate (mR/h) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sludge without liquid shield[a] | Wall with sludge shield[b] | Sludge plus wall (columns 2 + 3) | Liquid only[c] | Sludge with liquid shield[d] | Wall with sludge and liquid shield[e] | Liquid plus sludge plus wall (columns 5 + 6 + 7) |
| 0 | 2.5E+04 | 3.5E+02 | 2.5E+04 | 8.9E+02 | 1.2E+00 | 2.7E+02 | 1.2E+03 |
| 1 | 2.3E+04 | 3.0E+02 | 2.3E+04 | 7.5E+02 | 7.5E-01 | 2.2E+02 | 1.0E+03 |
| 2 | 2.0E+04 | 2.5E+02 | 2.0E+04 | 6.7E+02 | 3.6E-01 | 1.9E+02 | 8.6E+02 |
| 3 | 1.7E+04 | 2.1E+02 | 1.7E+04 | 5.6E+02 | 1.4E-01 | 1.7E+02 | 7.3E+02 |
| 4 | 1.4E+04 | 1.8E+02 | 1.4E+04 | 4.5E+02 | 4.7E-02 | 1.4E+02 | 5.9E+02 |
| 5 | 1.1E+04 | 1.6E+02 | 1.1E+04 | 3.7E+02 | 1.2E-02 | 1.2E+02 | 4.9E+02 |
| 6 | 8.9E+03 | 1.5E+02 | 9.0E+03 | 2.8E+02 | | 1.1E+02 | 3.9E+02 |
| 7 | 6.8E+03 | 1.3E+02 | 6.9E+03 | 2.3E+02 | | 9.7E+01 | 3.2E+02 |
| 8 | 5.9E+03 | 1.2E+02 | 6.0E+03 | 2.0E+02 | | 9.0E+01 | 2.9E+02 |
| 9 | 4.2E+03 | 1.0E+02 | 4.3E+03 | 1.5E+02 | | 8.0E+01 | 2.3E+02 |
| 10 | 3.2E+03 | 9.2E+01 | 3.3E+03 | 1.2E+02 | | 7.1E+01 | 1.9E+02 |
| 11 | 2.2E+03 | 8.4E+01 | 2.3E+03 | 8.8E+01 | | 6.4E+01 | 1.5E+02 |
| 12 | 1.5E+03 | 7.4E+01 | 1.6E+03 | 6.9E+01 | | 5.9E+01 | 1.3E+02 |
| 13 | 8.8E+02 | 6.9E+01 | 9.5E+02 | 5.1E+01 | | 5.4E+01 | 1.1E+02 |
| 14 | 4.6E+02 | 5.6E+01 | 5.2E+02 | 3.7E+01 | | 4.5E+01 | 8.2E+01 |
| 15 | 1.8E+02 | 5.4E+01 | 2.3E+02 | 2.8E+01 | | 4.4E+01 | 7.2E+01 |
| 16 | 2.4E+01 | 4.9E+01 | 7.1E+01 | 1.8E+01 | | 4.1E+01 | 5.9E+01 |
| 17 | 9.8E-01 | 3.6E+01 | 3.7E+01 | 1.2E+01 | | 3.2E+01 | 4.4E+01 |
| 18 | 2.6E-02 | 3.2E+01 | 3.2E+01 | 6.9E+00 | | 3.0E+01 | 3.7E+01 |
| 19 | | 2.8E+01 | 2.8E+01 | 3.4E+00 | | 2.7E+01 | 3.0E+01 |
| 20 | | 2.6E+01 | 2.6E+01 | 1.0E+00 | | 2.5E+01 | 2.6E+01 |
| 21 | | 1.9E+01 | 1.9E+01 | 1.0E-01 | | 1.9E+01 | 1.9E+01 |
| 22 | | 1.5E+01 | 1.5E+01 | | | 1.5E+01 | 1.5E+01 |
| 23 | | 1.5E+01 | 1.5E+01 | | | 1.5E+01 | 1.5E+01 |
| 24 | | 1.2E+01 | 1.2E+01 | | | 1.2E+01 | 1.2E+01 |
| 25 | | 1.1E+01 | 1.1E+01 | | | 1.1E+01 | 1.1E+01 |

[a]Sludge without liquid shield = Exposure rates in the absence of liquid to shield the radiation exposure fields generated by sludge alone.
[b]Wall with sludge shield = Exposure rates due to tank wall when liquid is not present in the tank; only the effect of sludge shielding part of the tank wall is considered. Sludge does not contribute to the source term, but acts only as a shield.
[c]Liquid only = Exposure rates due to liquid only.
[d]Sludge with liquid shield = Exposure rates in presence of a liquid layer that attenuates the radiation fields generated by the sludge. Liquid only acts as a shield and does not contribute to the source term.
[e]Wall with sludge and liquid shield = Exposure rates due to tank wall when both liquid and sludge are present and act as shield to cover portions of the tank wall; no contribution to the source term.

The tables each contain eight columns of data:

Column 1: Lateral distance (ft) out from the edge of the tank.
Column 2: Exposure rates for a sludge source with no overlying layer of liquid present.
Column 3: Exposure rates for a 1-in.-deep tank wall source, the bottom ~5 in. of which is covered by a sludge shield.
Column 4: Total exposure rates for a combined source of sludge and tank wall (Column 2 results plus Column 3 results).
Column 5: Exposure rates for a liquid-only source.
Column 6: Exposure rates for a sludge source with an overlying liquid (non-source) layer that absorbs some of the gamma energy emitted from the sludge.
Column 7: Exposure rates for a 1-in.-deep tank wall source, the bottom ~60 in. of which is covered by liquid and sludge layers.
Column 8: Total exposure rate for a combined source of sludge, liquid, and tank wall (Column 5 results plus Column 6 results plus Column 7 results).

The information in Tables 2a and 2b is presented graphically in Fig. 6. Relevant observations are summarized below.

For the combined sludge-plus-wall source (Figs. 6a and 6c):

- The total exposure rates calculated at the tank edge are 27,000 mR/h at a 4-ft height, and 25,000 mR/h at a 6-ft height.

- At 25 ft from the tank edge, the total exposures drop approximately 6 orders of magnitude to 0.013 mR/h at a 4-ft height, and approximately 3 orders of magnitude to 11 mR/h at a 6-ft height. Exposure rates at the 4-ft elevation decrease more rapidly as a function of distance from the tank edge than those at the 6-ft elevation because gamma rays must pass through slightly more attenuating material to reach the 4-ft-high detector than the 6-ft-high detector due to the geometry.

- Because of its relatively high activity, the sludge is the principal contributor to the exposure rates out to approximately 10 ft from the tank edge for the 4-ft elevation, or out to approximately 16 ft from the tank edge for the 6-ft elevation. Beyond 10 or 16 ft, respectively, the tank wall exposure rate contribution dominates. The reason for this is that as the detector moves away from the tank edge, the gammas must pass through more and more of the surrounding soil to reach the detector. The average path length (or line-of-sight distance) of the gammas through the surrounding soil is greater for the sludge than for the tank wall because the sludge layer is farther below the ground surface. Since gamma attenuation increases exponentially with path length, a tradeoff is eventually reached where the greater path length and more severe attenuation of the sludge gammas offset the larger sludge source strength, and the tank wall becomes the principal exposure rate contributor.

For the combined sludge-plus-liquid-plus-wall source (Figs. 6b and 6d):

- The total exposure rates calculated at the tank edge are 1300 mR/h at a 4-ft height, and 1200 mR/h at a 6-ft height.

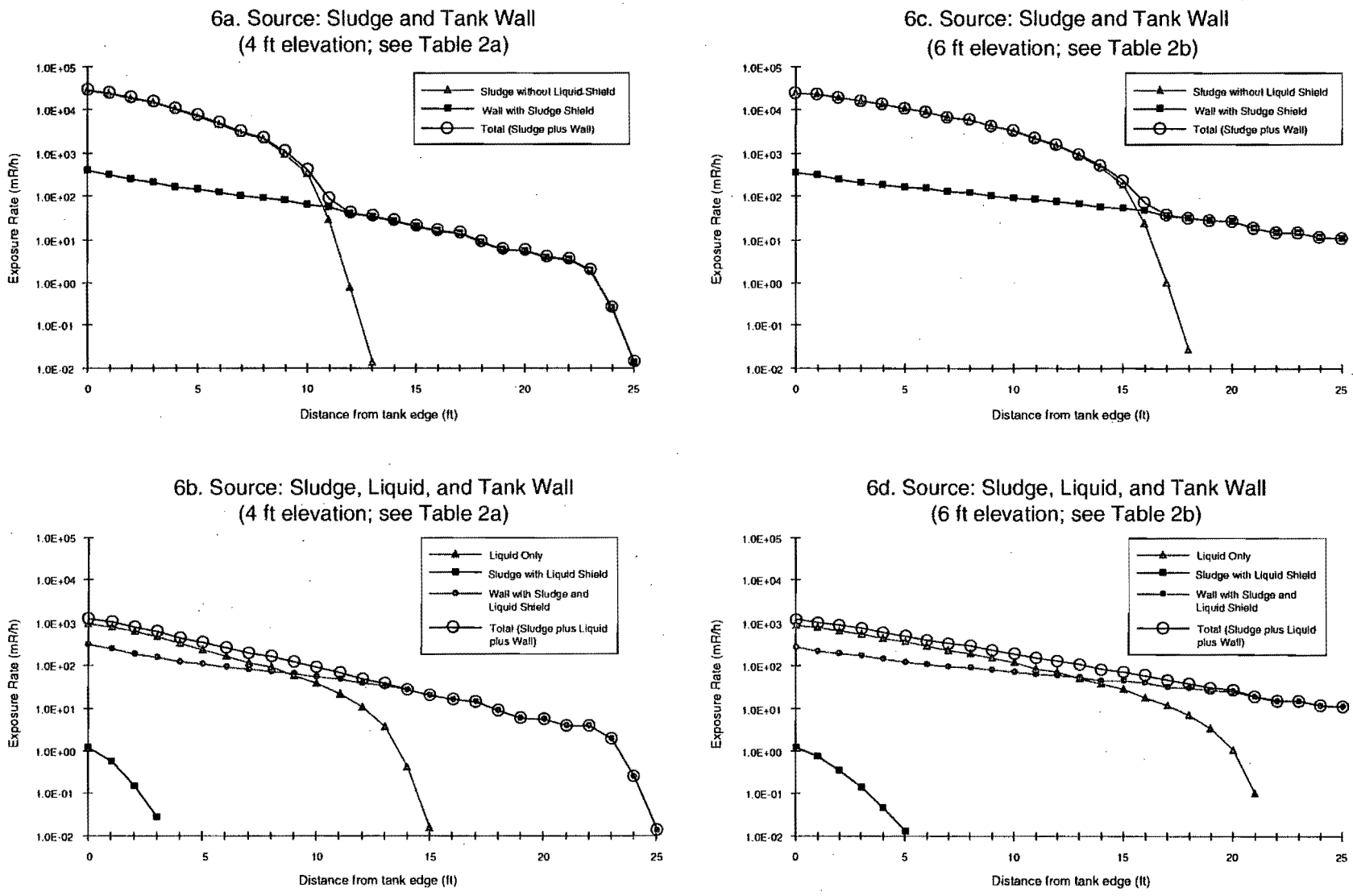


**Fig. 6. Exposure rates near edge of tank W-10, calculation set 1.**



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- At 25 ft from the tank edge, the total exposures drop approximately 5 orders of magnitude to 0.013 mR/h at a 4-ft height, and approximately 2 orders of magnitude to 11 mR/h at a 6-ft height.

- The liquid makes a slightly greater contribution to the total exposure rate than the tank wall out to a distance of 8 ft for the 4-ft elevation, or out to a distance of 12 ft for the 6-ft elevation. Beyond 8 or 12 ft, respectively, the tank wall contribution dominates. The unattenuated radiation exposure fields generated by the tank wall are not as high as those from the sludge or liquid, but the wall-generated fields do not diminish as fast with increasing distance as the sludge or liquid fields because of the comparatively shorter path lengths traveled by the wall-generated gammas through the surrounding soil.

- Comparison of individual exposure rates due to sludge (uncovered) and sludge covered with a liquid shield shows that although the liquid is contaminated and produces an exposure field of its own, it provides valuable shielding for the fields created by the radionuclide constituents in the sludge. Exposure rates at the tank edge for the uncovered sludge source are approximately 20 times greater than those for the sludge source covered with a liquid shield.

Figure 7 shows total exposure rates at specific distance contours for 4-ft and 6-ft elevations due to the following combined sources: (1) radioactive sludge (with no liquid shield cover) plus radioactive contaminants in the tank wall, and (2) radioactive sludge plus radioactive liquid plus radioactive contaminants in the tank wall. Distance contours are shown in 5-ft intervals out to 25 ft, then in 25-ft intervals out to 100 ft, and then at 150 ft.

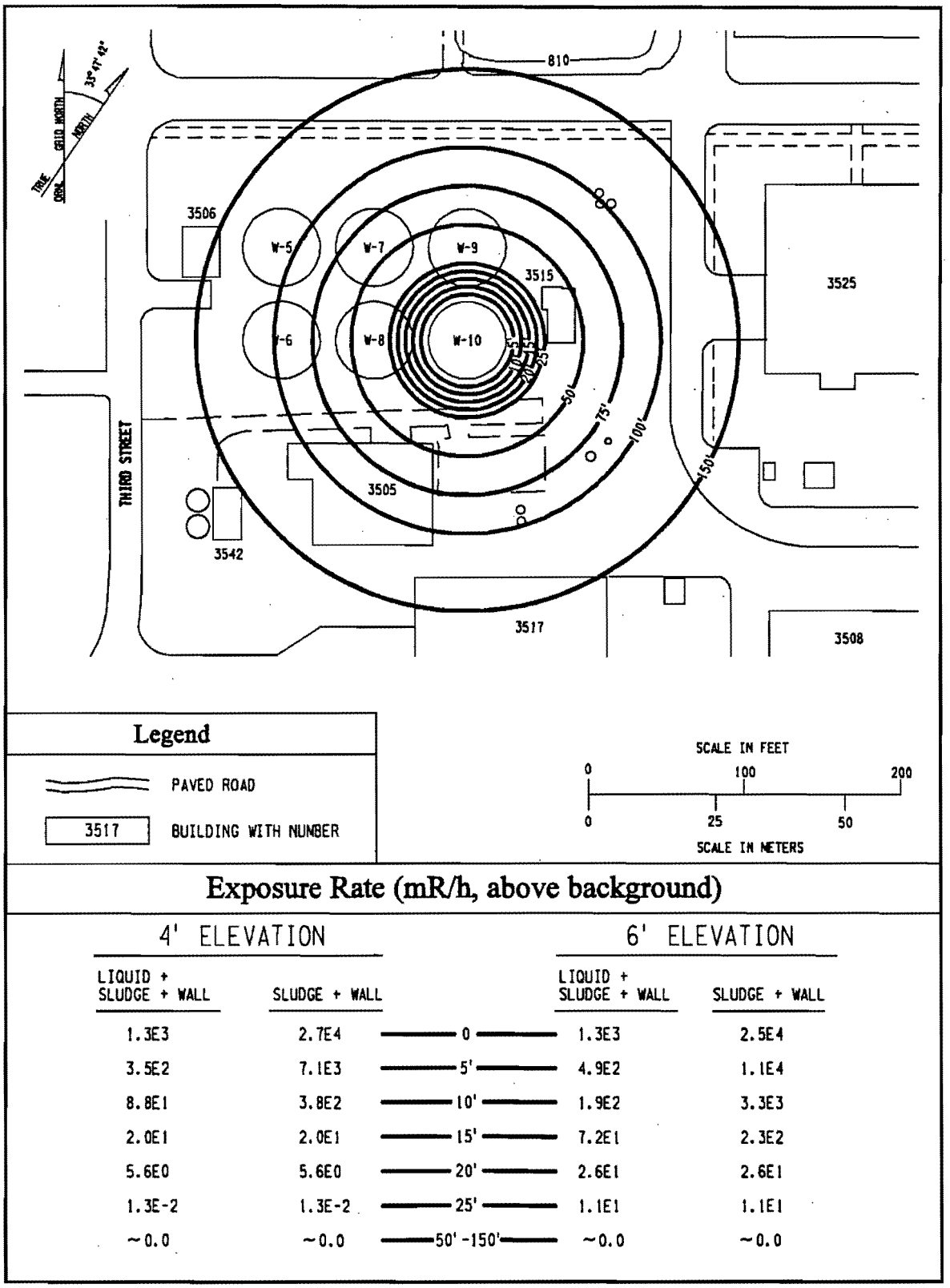
# 3. CALCULATION SET 2: EXPOSURE RATES ABOVE THE TANK

This calculation set estimates exposure rates above the tank as a function of distance from the tank center out to a total radius of 25 ft (tank edge), at heights of 4 ft and 6 ft above a hypothetical working platform situated above the tank.

## 3.1 ASSUMPTIONS AND CODE INPUT

Figure 8 shows the geometry used for the QAD-CGGP shielding code model. The geometry is similar to that used for calculation set 1 but with the addition of a work platform with a walking surface approximately 5 ft above ground surface. The work platform is assumed to be invisible to (i.e., does not attenuate) gamma rays emanating from the tank during the hypothetical accident.

To estimate radiation exposure levels at waist and head height for a worker on the platform, exposure rates were calculated at 4-ft and 6-ft elevations from the top of the platform's walking surface. Exposure rates were estimated at approximately 3.3-ft (1-m) intervals from the platform center to the edge. The platform was assumed to be staged such that the tank and platform centerlines were coincident; therefore, exposure rate profiles are symmetric about the platform centerline.




## Exposure Rate (mR/h, above background)

| 4' ELEVATION | | | 6' ELEVATION | |
|---|---|---|---|---|
| LIQUID + SLUDGE + WALL | SLUDGE + WALL | | LIQUID + SLUDGE + WALL | SLUDGE + WALL |
| 1.3E3 | 2.7E4 | 0 | 1.3E3 | 2.5E4 |
| 3.5E2 | 7.1E3 | 5' | 4.9E2 | 1.1E4 |
| 8.8E1 | 3.8E2 | 10' | 1.9E2 | 3.3E3 |
| 2.0E1 | 2.0E1 | 15' | 7.2E1 | 2.3E2 |
| 5.6E0 | 5.6E0 | 20' | 2.6E1 | 2.6E1 |
| 1.3E-2 | 1.3E-2 | 25' | 1.1E1 | 1.1E1 |
| ~0.0 | ~0.0 | 50'-150' | ~0.0 | ~0.0 |

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**Fig. 7. Exposure rates around tank W-10 at various distances from tank edge, calculation set 1.**

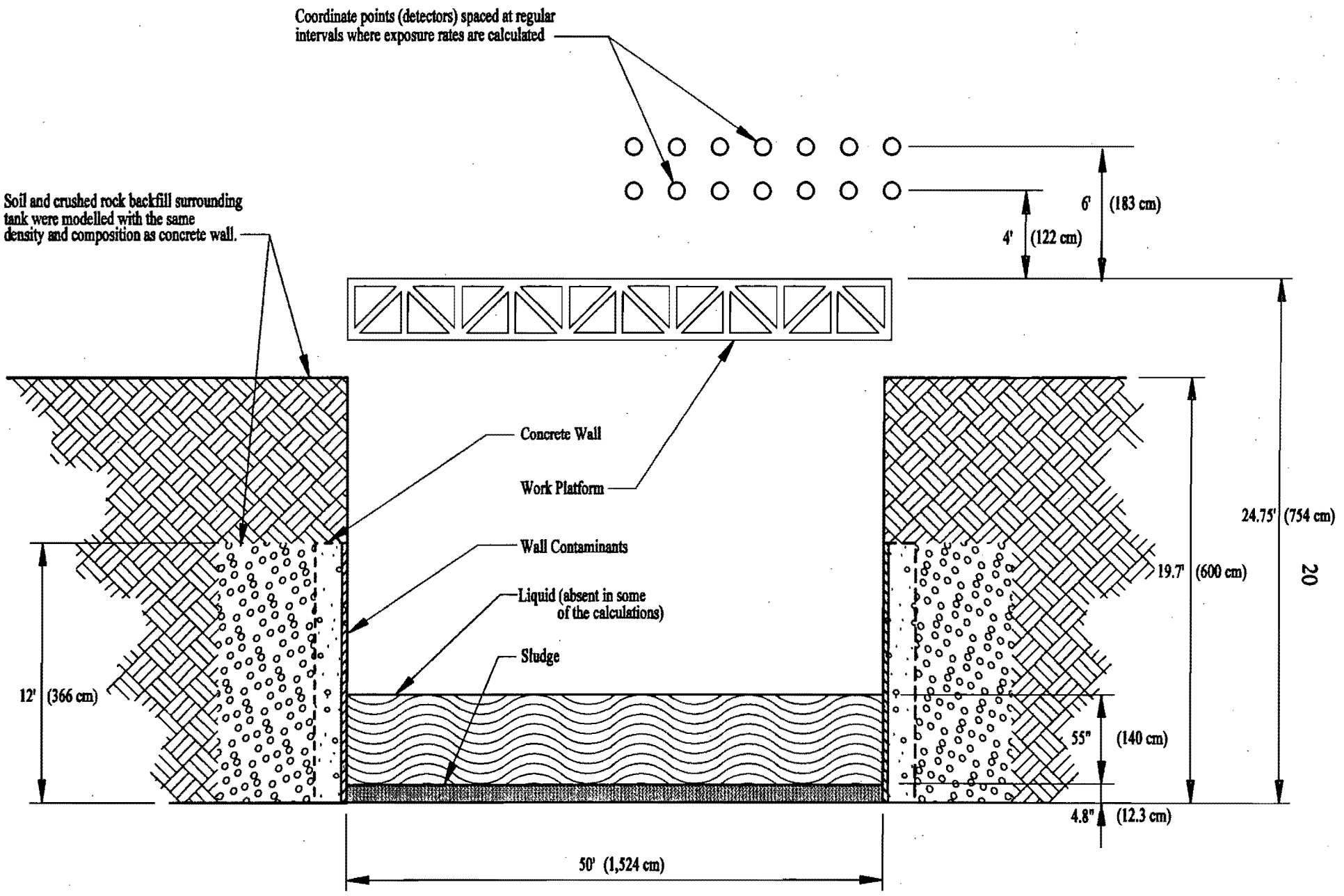



**Fig. 8. Tank cross-section geometry used for the QAD-CGGP shielding code model, calculation set 2. (Drawing is not to scale.)**

### 3.2 RESULTS AND ANALYSES

Tables 3a and 3b show exposure rates at 4- and 6-ft elevations above the working platform, respectively, calculated at 3.3-ft (1-m) intervals from the platform's centerline to the tank's interior rim (a radial distance of 25 ft). As in calculation set 1, each table contains columns of exposure rate data for individual and combined sources.

The information in Tables 3a and 3b is presented graphically in Fig. 9; as shown, little variation in exposure rates is manifest from the center to the edge of the tank platform and even less between data for the 4-ft and 6-ft elevations. Other relevant observations are summarized below.

For the combined sludge-plus-wall source (Figs. 9a and 9c):

- The total exposure rates calculated at the platform center are 32,000 mR/h at a 4-ft height, and 29,000 mR/h at a 6-ft height.

- At a radial distance of 25 ft from the platform center, which vertically coincides with the tank edge, the total exposure rates drop only slightly to 22,000 mR/h at a 4-ft height, and to 21,000 mR/h, at a 6-ft height.

- Because of its relatively high specific activity, sludge is the principal contributor to exposure rates at all detector positions. The sludge contribution is greater by a factor of 58 to 76 than the tank wall contribution.

For the combined sludge-plus-liquid-plus-wall source (Figs. 9b and 9d):

- The total exposure rates calculated at the tank edge are 1700 mR/h at a 4-ft height, and 1600 mR/h at a 6-ft height.

- At a radial distance of 25 ft from the platform center, the total exposure rates drop only slightly to 1000 mR/h at a 4-ft height, and to 960 mR/h at a 6-ft height.

- The liquid provides a greater share (75 to 80%) of the total exposure rates than either the tank wall or the sludge at all detector positions. The liquid contribution is greater by a factor of 3.2 to 3.6 than the tank wall contribution, and more than 2 orders of magnitude greater than the sludge contribution. As in calculation set 1, these results demonstrate the significant shielding effect of the liquid layer on the gamma fields created by the sludge contaminants.

## 4. CALCULATION SET 3: EXPOSURE RATE IN BUILDING 150 FT AWAY

This calculation set estimates the exposure rate at a location 150 ft from the tank edge, at a height of 20 ft above the ground, in an attempt to model the possible direct gamma exposure rate to a person on the second floor of a hypothetical building 150 ft north of tank W-10. With the exception of detector placement, code input for this calculation set was identical to that for calculation set 1.

**Table 3a. Calculation set 2: exposure rates as a function of distance from tank platform center to tank edge (4-ft elevation)**

| | Exposure Rate (mR/h) | | | | | | |
|---|---|---|---|---|---|---|---|
| Distance (ft) | Sludge without liquid shield[a] | Wall with sludge shield[b] | Sludge plus wall (columns 2 + 3) | Liquid only[c] | Sludge with liquid shield[d] | Wall with sludge and liquid shield[e] | Liquid plus sludge plus wall (columns 5 + 6 + 7) |
| 0.00 | 3.2E+04 | 5.3E+02 | 3.2E+04 | 1.3E+03 | 2.7E+00 | 4.0E+02 | 1.7E+03 |
| 3.28 | 3.1E+04 | 5.3E+02 | 3.2E+04 | 1.3E+03 | 2.7E+00 | 4.1E+02 | 1.7E+03 |
| 6.56 | 3.1E+04 | 5.3E+02 | 3.1E+04 | 1.3E+03 | 2.6E+00 | 4.1E+02 | 1.7E+03 |
| 9.84 | 3.0E+04 | 5.3E+02 | 3.0E+04 | 1.2E+03 | 2.5E+00 | 4.1E+02 | 1.6E+03 |
| 13.12 | 2.9E+04 | 5.2E+02 | 2.9E+04 | 1.2E+03 | 2.4E+00 | 4.1E+02 | 1.6E+03 |
| 16.40 | 2.7E+04 | 5.1E+02 | 2.8E+04 | 1.1E+03 | 2.2E+00 | 4.0E+02 | 1.5E+03 |
| 19.68 | 2.5E+04 | 4.8E+02 | 2.6E+04 | 9.7E+02 | 1.8E+00 | 3.8E+02 | 1.4E+03 |
| 22.96 | 2.3E+04 | 4.0E+02 | 2.4E+04 | 8.7E+02 | 1.4E+00 | 3.1E+02 | 1.2E+03 |
| 25.00 | 2.2E+04 | 2.9E+02 | 2.2E+04 | 8.0E+02 | 1.2E+00 | 2.3E+02 | 1.0E+03 |

[a]Sludge without liquid shield = Exposure rates in the absence of liquid to shield the radiation exposure fields generated by sludge alone.
[b]Wall with sludge shield = Exposure rates due to tank wall when liquid is not present in the tank; only the effect of sludge shielding part of the tank wall is considered. Sludge does not contribute to the source term, but acts only as a shield.
[c]Liquid only = Exposure rates due to liquid only.
[d]Sludge with liquid shield = Exposure rates in the presence of a liquid layer that attenuates the radiation fields generated by the sludge. Liquid only acts as a shield and does not contribute to the source term.
[e]Wall with sludge and liquid shield = Exposure rates due to tank wall when both liquid and sludge are present and act as shield to cover portions of the tank wall; no contribution to the source term.

**Table 3b. Calculation set 2: exposure rates as a function of distance from tank platform center to tank edge (6-ft elevation)**

| | Exposure Rate (mR/h) | | | | | | |
|---|---|---|---|---|---|---|---|
| Distance (ft) | Sludge without liquid shield[a] | Wall with sludge shield[b] | Sludge plus wall (columns 2 + 3) | Liquid only[c] | Sludge with liquid shield[d] | Wall with sludge and liquid shield[e] | Liquid plus sludge plus wall (columns 5 + 6 + 7) |
| 0.00 | 2.9E+04 | 4.9E+02 | 2.9E+04 | 1.2E+03 | 2.7E+00 | 3.7E+02 | 1.6E+03 |
| 3.28 | 2.8E+04 | 4.9E+02 | 2.9E+04 | 1.2E+03 | 2.6E+00 | 3.7E+02 | 1.6E+03 |
| 6.56 | 2.8E+04 | 4.8E+02 | 2.8E+04 | 1.2E+03 | 2.6E+00 | 3.7E+02 | 1.5E+03 |
| 9.84 | 2.7E+04 | 4.8E+02 | 2.8E+04 | 1.1E+03 | 2.5E+00 | 3.7E+02 | 1.5E+03 |
| 13.12 | 2.6E+04 | 4.8E+02 | 2.6E+04 | 1.1E+03 | 2.3E+00 | 3.7E+02 | 1.4E+03 |
| 16.40 | 2.5E+04 | 4.6E+02 | 2.5E+04 | 9.8E+02 | 2.1E+00 | 3.6E+02 | 1.3E+03 |
| 19.68 | 2.3E+04 | 4.3E+02 | 2.4E+04 | 9.0E+02 | 1.8E+00 | 3.4E+02 | 1.2E+03 |
| 22.96 | 2.1E+04 | 3.5E+02 | 2.2E+04 | 8.0E+02 | 1.4E+00 | 2.8E+02 | 1.1E+03 |
| 25.00 | 2.0E+04 | 2.7E+02 | 2.1E+04 | 7.4E+02 | 1.2E+00 | 2.1E+02 | 9.6E+02 |

[a]Sludge without liquid shield = Exposure rates in the absence of liquid to shield the radiation exposure fields generated by sludge alone.
[b]Wall with sludge shield = Exposure rates due to tank wall when liquid is not present in the tank; only the effect of sludge shielding part of the tank wall is considered. Sludge does not contribute to the source term, but acts only as a shield.
[c]Liquid only = Exposure rates due to liquid only.
[d]Sludge with liquid shield = Exposure rates in the presence of a liquid layer that attenuates the radiation fields generated by the sludge. Liquid only acts as a shield and does not contribute to the source term.
[e]Wall with sludge and liquid shield = Exposure rates due to tank wall when both liquid and sludge are present and act as shield to cover portions of the tank wall; no contribution to the source term.

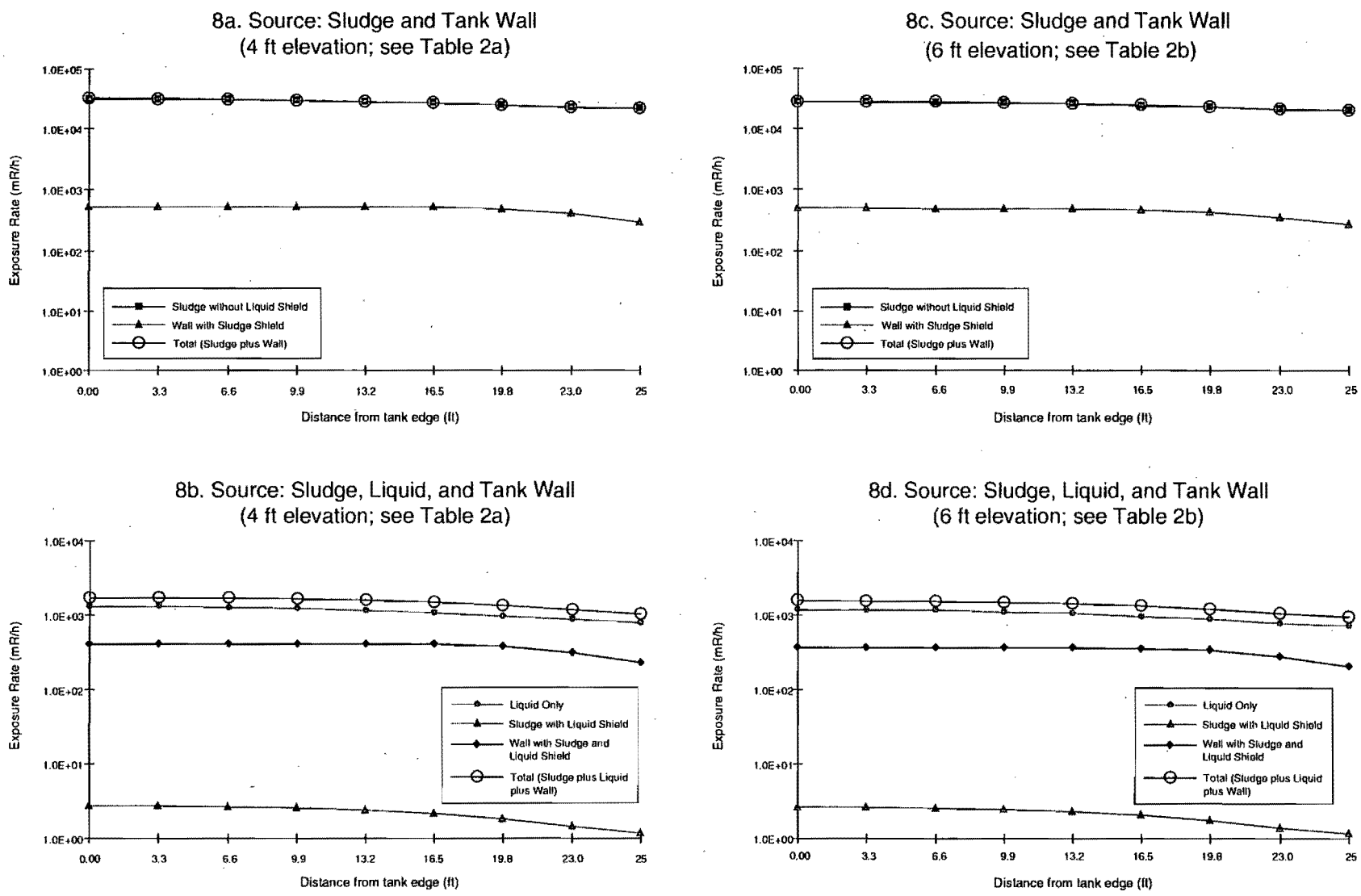



**Fig. 9. Exposure rates from platform center to edge of tank W-10, calculation set 2.**



5.48 1685A.5

The exposure rates calculated in this set were insignificant (close to zero); no significant changes in local area background would be expected from direct exposure resulting from the hypothetical dome collapse modeled in this document.

# 5. CALCULATION SET 4: TOTAL EXPOSURES FOR TWO WORKER RESPONSE SCENARIOS

Using the exposure rates from calculation sets 1 and 2, this calculation set computes total gamma radiation exposures for two hypothetical worker exposure scenarios: (1) the "investigator" scenario, where a worker is attracted by the accident-generated noise of a dome collapse but quickly leaves the area after noting the extent of the damage; and (2) the "fugitive" scenario, where a worker who is on the platform above the tank when the accident occurs flees the immediate area.

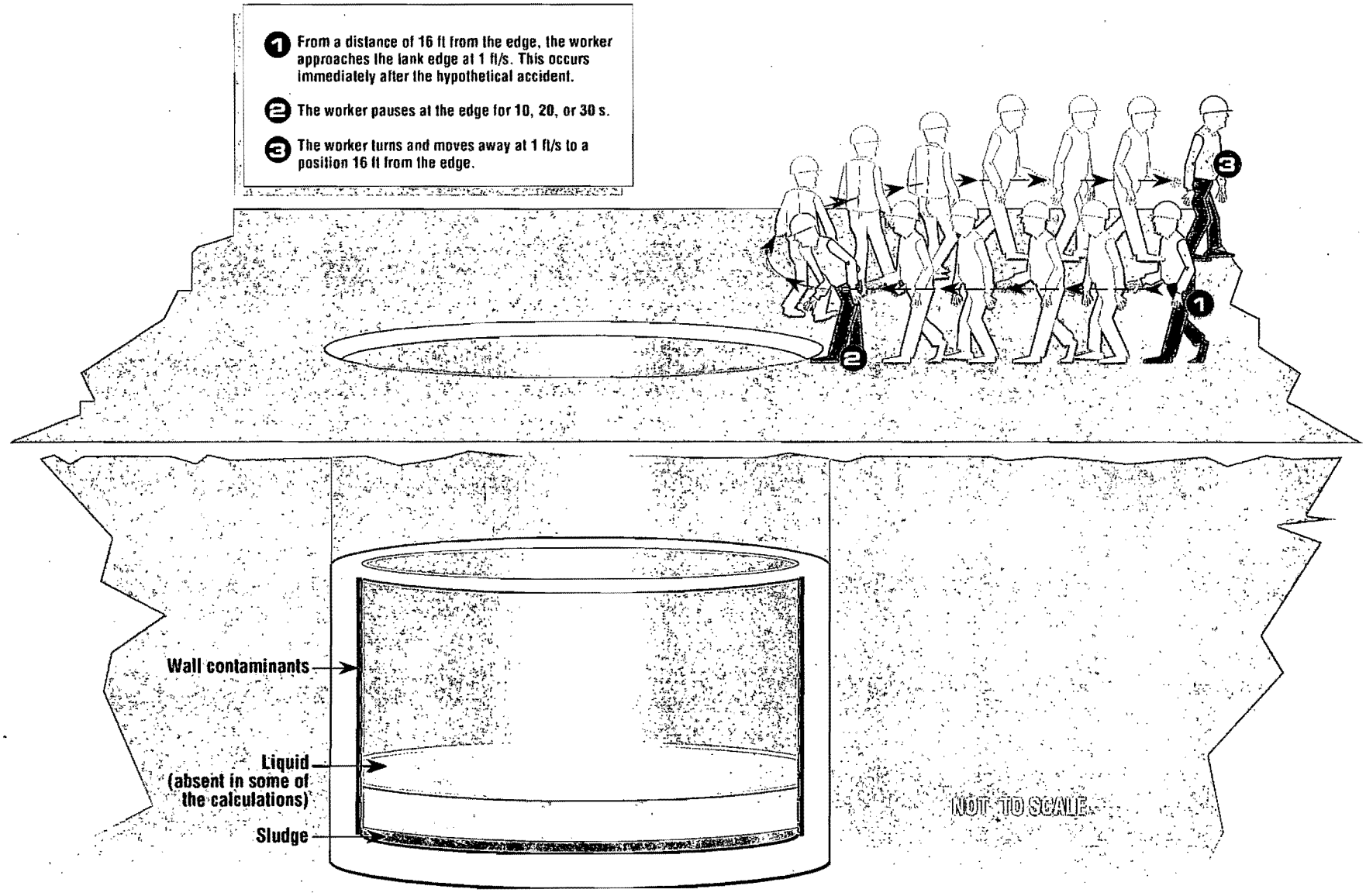
## 5.1 ASSUMPTIONS

As mentioned, two different exposure scenarios (i.e., unplanned occurrences) were considered for this study:

- *The investigator scenario* (see Fig. 10). A person working 16 ft from the tank edge investigates the accident-generated noise by (a) approaching the tank edge, (b) viewing the damage for a set period of time while standing at the tank edge, and then (c) quickly returning to the original location 16 ft from the tank edge. Exposure estimates performed for this scenario were divided into three cases. In each case, a worker travels (at 1 ft/s) from a location 16 ft away to the edge of the tank and back; the difference among the cases is the length of the investigation period (10, 20, and 30 seconds).
- *The fugitive scenario* (see Fig. 11). A person is on the tank work platform when the hypothetical accident occurs. The person is assumed to leave the platform using the longest path (from one side to the other) and subsequently travel to a point 16 ft from the tank edge. The person moves to this location at an assumed travel rate of 3.28 ft/s (1 m/s) on the platform and 1 ft/s on the ground.

These worst-case scenarios are provided as only two of many possible exposure situations that could be studied. It is important to note at the outset that any discussion of the investigator and fugitive scenarios as outlined above is not meant to imply that the scenarios are considered either likely to occur or reasonably realistic. The South Tank Farm area is considered a radiation area and is roped off and restricted. The closest distance from the rope to the edge of tank W-10 is approximately 50 ft, and results of the modeling indicate that exposure rates drop to area background between 25 ft and 50 ft. Personnel entering the area are trained radiation workers being monitored under Department of Energy (DOE) regulations, and radiation workers are trained to minimize their exposure in the event of an accident or an emergency situation.

With regard to the investigator scenario, it is considered unlikely that a trained radiation worker would move in the direction of the dome-collapse noise knowing that significant radioactive fields




1 105 4498

Fig. 10. Investigator exposure scenarios, calculation set 4.

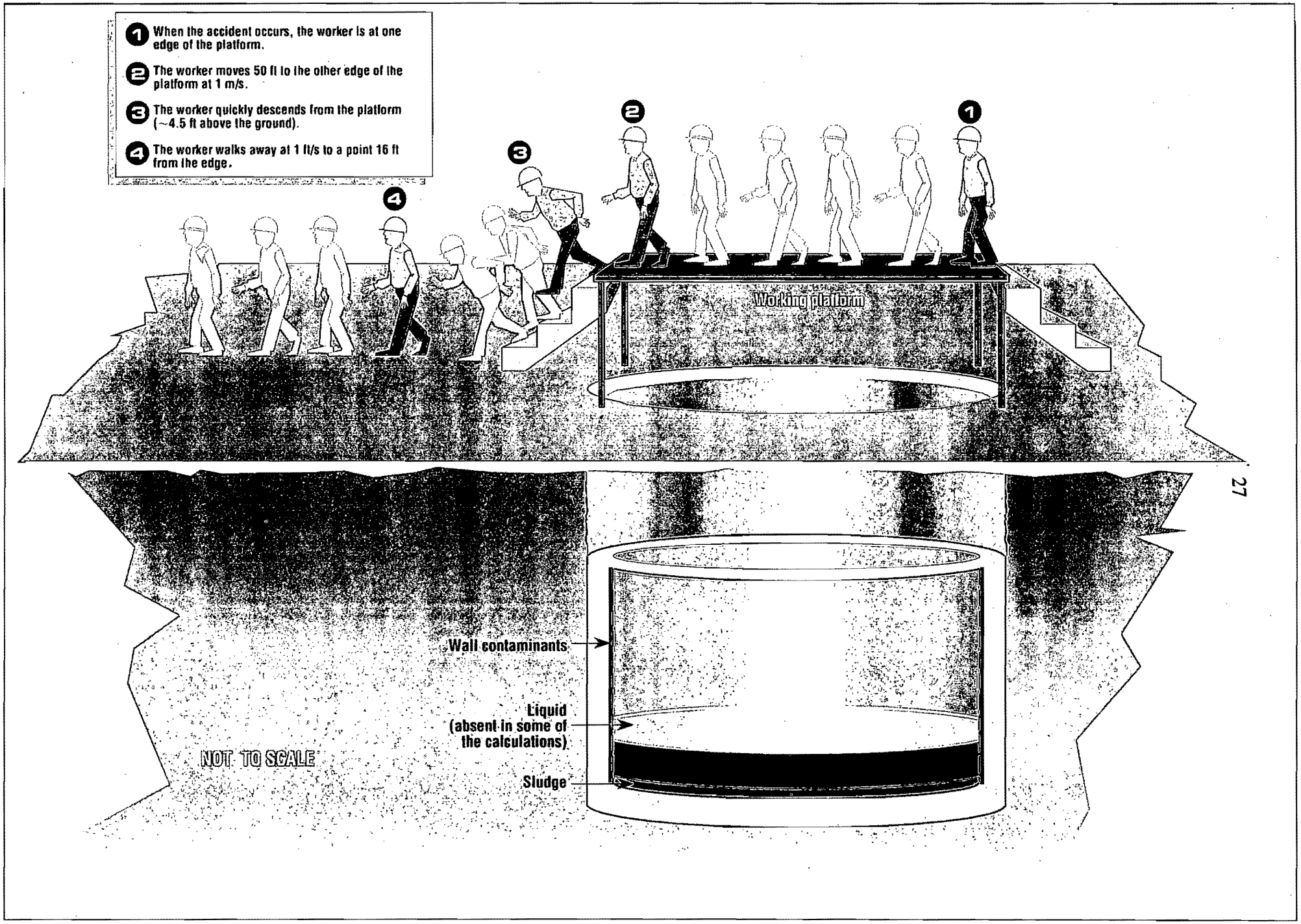



Fig. 11. Fugitive exposure scenario, calculation set 4.

1 105 4498.1

might exist near the tank. Radiation worker training would include disciplined responses to upset conditions, such as evacuation, with planned and controlled reentry to the area within prescribed limits. With regard to the fugitive scenario, it is acknowledged that a trained radiation worker on the platform when the postulated accident occurred would probably flee by the shortest and most direct route available. Assuming that a worker would cross from one edge of the tank to the other may be unrealistic, but again, the purpose of this calculation set is to provide exposure estimates based on ultraconservative evacuation routes and conditions.

The selection of a 16-ft-long evacuation or investigation distance on the ground is somewhat arbitrary, but a study of Tables 2a and 2b, which give exposure rates out to a distance of 25 ft from the tank's inner rim, indicates that use of the 16-ft distance accounts for over 97% of the cumulative exposure possible compared to using the full 25-ft distance.

The total exposures were calculated by

- determining the exposure rates at regular intervals along the path of exposure (this was done in calculation set 1 at 1-ft intervals out from the tank edge, and in calculation set 2 at 1-m intervals along the tank radius);
- multiplying the exposure rates by the time required to traverse the distance from one detector location to another (assumed to be 1 second in the investigator and fugitive scenarios); and
- summing the individual detector exposures over the exposure path of interest.

## 5.2 RESULTS AND ANALYSES

Table 4 gives the total exposures for the investigator and fugitive scenarios outlined above. Note that although the exposure rates in calculation sets 1 and 2 were determined for two separate elevations (4 ft and 6 ft), separate total exposures for different elevations are not given in Table 4. This is because the total exposures were determined using the average of the elevation-specific exposure rates.

**Table 4. Total exposures (above background) for worker response scenarios (mR)**

| Source Term | Worker Response Scenarios | | | |
|---|---|---|---|---|
| | Investigator[a] | | | Fugitive[b] |
| | Case 1 (10 s) | Case 2 (20 s) | Case 3 (30 s) | |
| Sludge (no liquid layer) and tank walls | 151 | 231 | 311 | 170 |
| Sludge, liquid, and tank walls | 6.8 | 10.4 | 13.9 | 8.8 |

[a] A person working 16 ft from the tank investigates the accident-generated noise by (a) approaching the tank edge at 1 ft/s, (b) viewing the damage for either 10, 20 or 30 seconds while standing at the tank edge, and then (c) returning to the starting position at 1 ft/s.
[b] A person (a) traverses the length of the working platform at 3.3 ft/s (1 m/s), (b) descends to the ground, and then (c) moves to a location 16 ft from the tank edge at the rate of 1 ft/s.

The exposures for the investigator and fugitive scenarios were the same order of magnitude for a particular combined source. For the sludge-plus-walls source, total exposures for the investigator scenario ranged from 151 to 311 mR, depending on the time spent at the tank edge viewing the damage, and the total exposure for the fugitive scenario was 170 mR. These calculated exposures (in excess of background) are roughly equivalent to the average exposure to natural background, which is approximately 270 mrem/year. For the sludge-plus-liquid-plus-walls source, total exposures were an order of magnitude less than for the sludge-plus-walls source because of the attenuating effect on the sludge by the liquid layer; total exposures ranged from 6.8 to 13.9 mR for the investigator scenario, and the total exposure was 8.8 mR for the fugitive scenario.

In both worker response scenarios considered, the estimated total exposure values for the hypothetical worker are below the annual regulatory limits recommended by DOE and ORNL. The DOE radiation dose limit for an individual during routine conditions is 5000 mrem/year and the DOE administrative control level during routine conditions is 2000 mrem/year. The ORNL absolute goal during routine conditions is 1000 mrem/year; however, its ALARA (as low as reasonably achievable) administrative goal is 750 mrem/year. This ORNL ALARA goal is more than a factor of 2 greater than the maximum (and conservative) exposure of 311 mR shown in Table 4. [Note: the *dose unit of mrem* mentioned in the regulatory limits is roughly equivalent (within 5% of) to the *exposure unit of mR* for cesium-137 gamma rays in an external exposure pathway.]

# 6. CONCLUSIONS

The purpose of this report was to model the unplanned external gamma exposure rates and total exposures potentially occurring after a hypothetical collapse of the tank W-10 dome. Even though the conservative model assumed no shielding contribution from the overburden, and even though the exposure scenarios assumed worker responses contrary to what might be expected based on worker training and site precautions, computed exposure rates were found to decrease relatively quickly with distance from the tank edge (i.e., at background within 25 to 50 ft of the tank edge), and the total exposures were found to be less than the regulatory and administrative annual limits for workers.

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# APPENDIX A:

# COMPUTER CODE DESCRIPTIONS

# A.1 INTRODUCTION

QAD-CG/GP is a 3-dimensional, combinational geometry, point kernel gamma radiation shielding code that is usually used to aid in technical evaluation of exposure or flux from shielded or unshielded radioactive sources.

- The model handles many different volume source and shield geometries in a combinatorial fashion. The geometries are rectangular parallelepiped, box, sphere, right circular cylinder, right elliptical cylinder, truncated right angle cone, ellipsoid, right angle wedge, and arbitrary convex polyhedron of 4, 5, or 6 sides.

- For the input file, the user defines the radionuclides for source loading in terms of their gamma energy and flux. The user also defines the decay correction of the radionuclides for the input file. The number of radionuclides that can be selected is limited because the code allows a limited number of gamma energy groups.

- Shield materials are custom-built by the user from the built-in table of elements and their shielding properties. The shielding material can be formed from a combination of elements with a user's specified density; the user provides the partial density of the elements in the shielding material.

- Handles many shield material regions and combinations.

- The code will calculate build-up in one of the shield or source materials; allowed build-up materials are aluminum, concrete, iron, lead, and water.

- The program is executed in batch mode. Case files are created via use of an editor with 80-character fixed record length (i.e., FORTRAN type).

MICROSHIELD is a gamma radiation shielding code that is usually used to aid in technical evaluation of exposure from shielded or unshielded radioactive sources and uses point kernel integration for volumetric geometries. The code has the following features.

- Handles 14 different source-shield geometries. The shield geometries are slab, cylindrical, and spherical. The source geometries are point, line, sphere, truncated cone, disk, cylinder (from side and end), rectangular area, infinite plane, and infinite slab. The user can define the dimensions of the source and the distance from the detector to the source, but not the shield dimensions except for thickness.

- Has a built-in radionuclide library for source loadings. It also has a built-in decay correction element called RADDECAY that can be executed separately (outside of the main program), which allows the user to decay-correct the selected radionuclides selected for source loading.

- Has 16 built-in shield materials and their shielding properties, but the user can choose to create custom shield material from the built-in element table. In both cases the user can determine both density and thickness for the shielding materials.

- Handles five material regions and an air gap. Regions are numbered one through five—one source material and four shield material regions. The air gap is automatically selected by the program from user-specified dimensions for a user-specified geometry.

- The code will calculate build-up in one of the shield or source materials; the user specifies source/shield number for build-up calculation.

- The program can be executed in both batch and interactive modes; case file creation is interactive and is very user-friendly. The program can also perform one parameter sensitivity analysis.

### A.1.1 QAD CALCULATIONAL TECHNIQUES

For gamma ray calculations, the QAD codes use the point-kernel ray-tracing technique. In this method, the point kernel representing the transfer of energy by the uncollided flux along a line-of-sight path is combined with an appropriate buildup factor to account for the contribution from the scattered photons. With a distributed source, the point kernel is integrated over the source volume for each source energy considered. Expressed as an equation, the gamma ray dose rate at any point due to an isotropic source emitting S photons of energy E per second per unit volume is

$$D(\vec{r}') = K_V \int \frac{S(\vec{r}')B(\mu|\vec{r} - \vec{r}'|,E)\exp(-\mu|\vec{r} - \vec{r}'|)}{4\pi|\vec{r} - \vec{r}'|^2}\, dV \qquad (1)$$

where

$\vec{r}$ = point at which gamma dose rate is to be calculated,

$|\vec{r}'|$ = location of source in volume V

V = volume of source region

$\mu$ = total attenuation coefficient at energy E,

$\vec{r} - \vec{r}$ = distance between source point and point at which gamma intensity is to be calculated,

$B(\mu\ \vec{r} - \vec{r}\ ,E$ = dose buildup factor,

K = conversion factor (flux-to-dose rate).

The buildup factors used in the QAD-P5A code are based on the Goldstein and Wilkins moments method calculations for gamma-ray transport in infinite homogeneous media. The code uses Capo's fit to the Goldstein-Wilkins data with bivariant polynomial expressions to calculate the appropriate buildup factors as a function of the gamma ray energy and the number of mean free paths from the source to the detector. For high-atomic-number materials, the polynomial fit has the form

$$B(\mu|\vec{r} - \vec{r}'|, E) \sum_{j=0}^{j=4} \sum_{i=0}^{i=3} C_{ij}(\mu|\vec{r} - \vec{r}')^i (E)^j \tag{2}$$

and for low-atomic-number materials it has the form

$$B(\mu|\vec{r} - \vec{r}'|,E) = \sum_{j=0}^{j=4} \sum_{i=0}^{i=3} C_{ij}(\mu|\vec{r} - \vec{r}'|)^i \left[\frac{1}{E}\right]^j \tag{3}$$

where the $C_{ij}$'s are the coefficients of the expansion.

Using these infinite-medium buildup factors should result in an overestimate of the dose rate at a surface external to the source region since it implies that reflecting material is located beyond the surface. However, because of the strong preferential forward scattering of photons, the error will usually not be more than a few percent and only in rather unusual cases will it reach 20 or 30%.

Using single-material buildup factors for multilayered shields or for shields made up mixtures of materials can be another source of error. For multilayered structures having an outer layer that is thicker than 2 or 3 mean free paths, the buildup factor used should be the one representing the outer layer, but the total number of mean free paths should be the number along the line of sight through all materials in the structure. This is a reasonable procedure since the gamma ray spectrum would readjust to the new medium and tend to approach the spectrum that would exist if the whole structure consisted of the outer layer, particularly when a low-atomic-number material is followed by a high-atomic-number material. For homogeneous mixtures or compounds, the so-called equivalent Z (atomic number) method can be used.

For multilayered structures in which each layer is less than 2 mean free paths thick, no clear-cut procedure is available. It has been shown that if one assumes that the structure is made entirely of the material having the largest buildup factor, then the dose is overestimated. Conversely, if one assumes that the material having the lowest buildup factor is representative of the structure, then the dose is underestimated.

The QAD code calculates the dose at a detector for each source energy group j with the following equation, which is a finite difference form of Eq. (1):

$$D_j = \sum_i K_j \frac{S_{ij}}{4\pi R_i^2} \exp\left[-\sum_k [\mu_j t)_k\right] B_{jk} \tag{4}$$

where

j = energy group index,

i = source point index,

k = region index,

K = flux-to-dose conversion factor (rad/unit flux),

S = volume-weighted gamma ray point source strength (photons/s),

R = distance from source point to detector (cm),

B = dose buildup factor,

$\mu$ = total attenuation coefficient ($cm^{-1}$),

t = zone penetration distance (cm).

The total dose is obtained by summing the contribution from each of the source energies.

### A.1.2 MICROSHIELD CALCULATIONAL TECHNIQUES

MICROSHIELD uses point kernel integration to calculate exposure rates at the receiver point from volumetric sources. The following sections describe the calculation method.

**Point Kernel Integration Parameters**—Point-kernel numeric integration is performed for cylindrical and rectangular solid sources. The geometric integration parameters represent the number of divisions in each direction which determine the number of kernels into which the source is divided. Each kernel is calculated as a point source solution and the overall result is the sum of the results for all the kernels. Simpsons's Rule formulation is used, the difference relative to the discussion above is that the user specifies the segmentation for integration.

It is important to understand the meaning of integration parameters. For the point kernel method, as viewed from the dose point, integration is performed incrementally along a horizontal angle, a vertical angle, and by steps that increase radially. Of the three integration parameters, called $N_{theta}$, $N_{psi}$, and $N_{radius}$, the first two represent the number of intervals into which the angular ranges are divided. For example, if the range of theta is 100°, $N_{theta}$ = 11 means that each sector is 10°, that is, 100 ÷ (11 - 1).

$N_{radius}$ represents the number of intervals into which a line projected from the dose point through the source is divided where the length is from the nearest to the furthest point within the source. The radial increment is only a starting point based on the perpendicular distance through the source. During the course of calculation, the actual number of radial intervals will depend on the distance through the source for the line being integrated for each kernel. Also note that if in the course of the radial march away from the dose point, a kernel's contribution to dose rate is less than one-ten-thousandth of the nearest kernel, then convergence for that radial line is assumed. This may reduce the calculation time for thick sources that are very dense.

The values chosen for the integration parameters determine how finely the source volume is divided for the numerical integration.

**Buildup Factor**—The effects of photon scattering contributions at the dose point are calculated by use of buildup factors which are based on empirical models derived from measurements. For thick, dense shields, the buildup will be a larger fraction of the total dose than for weak shielding of the same source; however, the total results will be less.

The no buildup option is provided because it is sometimes useful to know to what degree the buildup factor calculation affects the results. This can be observed by comparing cases with and without buildup. If such a comparison shows buildup to be a significant contribution to the total, and if the results are of significance relative to a design or operational decision, then it is important to investigate the range of results with different buildup methods and material bases.

**Buildup Factor Formulations**—The various expressions for buildup factor that follow are all based on the number of shielding mean free paths, $\mu r$, at a source energy, E. The number of coefficients for Taylor, GP, and Berger methods are 3, 5, and 2, respectively. These coefficients are a function of the material atomic number and incident photon energy. In MICROSHIELD, the coefficients for the Taylor and Berger methods are compiled with the source code, whereas the coefficients for the GP method are read from the disk file. The three methods are expressed by:

**Taylor**

$$BF(E,\mu r) = A(E) * e^{-\alpha 1(E) * \mu r} + [1 - A(E)] * e^{-\alpha 2(E) * \mu r} \qquad (5)$$

where the tabulated coefficients are A, $\alpha_1$, and $\alpha_2$.

**GP**

$$BF(E,\mu r) = 1 + (b - 1)\frac{(K^{\mu r} - 1)}{(K - 1)} \text{ for } K \neq 1 \tag{6}$$

$$BF(E,\mu r) = 1 + (b - 1)*\mu r \text{ for } K = 1 \tag{7}$$

and

$$K(\mu r) = c * (\mu r)^a + d\,\frac{\tanh(\frac{(\mu r)}{X_k} - 2) - \tanh(-2)}{1 - \tanh(-2)} \tag{8}$$

**Berger**

$$BF(E,\mu r)\ 1 + a(E)*\mu r\ *e^{+b(E)*\mu r} \tag{9}$$

where the tabulated coefficients are a and b.

**Material Basis for Buildup Calculation**—If a method other than "No Buildup" is chosen, then the material upon which the buildup is based must be specified. In the case of the Taylor and GP methods, the material is chosen by selecting one of the shields. In the case of the Berger method, the material is chosen from one of air, water, concrete, iron, or lead.

After all material and source entries have been processed, the user is requested to verify the shield or material to be used to calculate buildup. Examples for each are shown on the screen. The general rule is to use either the last material between the source and dose point or the most dominant shield. The latter will produce the greatest buildup factor.

As an example, if a shield arrangement of steel, water, and steel is used for a tank of water between the dose point and source, unless otherwise specified, the buildup factor associated with iron, the last shield region, will generally be the greatest. If the water-filled dimension of the tank

is large compared to the other dimensions, the analyst may consider it to be more appropriate to evaluate the buildup factor using water rather than iron.

In MICROSHIELD, the Berger buildup coefficients are based on the pure material designated. Thus, even though shields may be represented by mixed material, the buildup is based on only the selected one.

**Method of Calculating Buildup**—During the process of kernel integration, the buildup factor for each differential source volume is calculated for all of the materials between the source point and dose point. Values of the line-of-sight distance between the source kernel through the shields between it and the dose point are calculated for each new source point by trigonometric relationships. The attenuation mean free paths are determined and used in the buildup factor calculation.

The so-called infinite medium buildup factor method is used. The shielding mean free paths for <u>all</u> material between the source and dose point are used, with the buildup characteristics of one of the materials selected by the user. This approach is believed to be the most general and gives a good approximation for most shield configurations.

In the most general case, the material and incident photon energy will not necessarily be one of those for the tabulated sets of coefficients provided with the program. Therefore, interpolation for both parameters may be required.

Interpolation for energy is done for the coefficients before the buildup factor formula is calculated. Linear interpolation is used for the Taylor and Berger correlations and logarithmic interpolation is used for the GP method.

Interpolation for materials is done after the buildup factor formula is calculated. The radiation buildup factor for the mixture of materials is determined by first calculating the effective atomic number (EAN) of the material in the shield region. The effective atomic number is used as an index to interpolate in a built-in table of coefficients for calculating buildup factors. The buildup factor is calculated using coefficients tabulated at material atomic numbers that bracket the effective atomic number of the reference case material. Linear interpolation of the two bracketing buildup factors is then done with the EAN as the interpolating parameter. That is:

$$BF_{case} = BF_{lowerEAN} + \frac{[EAN_{case} - EAN_{lower}]}{[EAN_{upper} - EAN_{lower}]} * [BF_{upper} - BF_{lowerEAN}] \qquad (10)$$

where the coefficients for determination of buildup factor are energy specific.

# APPENDIX B:

# MICROSHIELD INPUT FILES

Page : 1
File : W10SA.MSH
Run date: December 11, 1991
Run time: 11:42 a.m.

File Ref: _____
Date: ___/___/___
By: _____
Checked: _____

CASE: W10S EXPOS. CASE SLUGE FOR ALL NUCL. WAG1

GEOMETRY 10: Cylindrical source from end - slab shields

| | | | |
|---|---|---|---|
| Distance to detector..... | X | 160. | cm. |
| Source cylinder radius..... | R | 762. | " |
| Source cylinder length..... | T1 | 12.3 | " |
| Thickness of second shield..... | T2 | 139.7 | " |
| Microshield inserted air gap..... | air | 8. | " |

Source Volume: 2.2437e+7 cubic centimeters

MATERIAL DENSITIES (g/cc):

| Material | Source | Shield 2 | Air gap |
|---|---|---|---|
| Air | | | .001220 |
| Aluminum | | | |
| Carbon | | | |
| Concrete | 1.50 | | |
| Hydrogen | | | |
| Iron | | | |
| Lead | | | |
| Lithium | | | |
| Nickel | | | |
| Tin | | | |
| Titanium | | | |
| Tungsten | | | |
| Urania | | | |
| Uranium | | | |
| Water | | 1.0 | |
| Zirconium | | | |



BUILDUP FACTOR: based on GP method.
Using the characteristics of the materials in shield 2.

INTEGRATION PARAMETERS:

| | |
|---|---|
| Number of angle segments (Npsi)..... | 11 |
| Number of radial segments (Nradius)..... | 11 |

SOURCE NUCLIDES:

| Nuclide | Curies | Nuclide | Curies | Nuclide | Curies |
|---|---|---|---|---|---|
| Am-241 | 4.4000e+00 | Ba-137m | 1.1000e+04 | Cm-244 | 4.6000e+01 |
| Co-60 | 1.3000e+01 | Cs-134 | 1.4000e+00 | Cs-137 | 1.1000e+04 |
| Eu-152 | 4.5000e+00 | Eu-154 | 7.9000e+00 | H-3 | 1.4000e-01 |
| Pu-238 | 2.9000e+01 | Pu-239 | 1.1000e+01 | Sr-90 | 8.5000e+03 |
| U-233 | 2.1000e+00 | U-234 | 1.3000e+00 | Y-90 | 8.5000e+03 |

Page : 1
File : W10S.MSH
Run date: November 19, 1991
Run time: 9:01 a.m.

File Ref: _____
Date: ___/___/___
By: _____
Checked: _____

CASE: W10S CASE SLUGE WAG1

GEOMETRY 10: Cylindrical source from end - slab shields

| | | | |
|---|---|---|---|
| Distance to detector..... | X | 160. | cm. |
| Source cylinder radius..... | R | 762. | " |
| Source cylinder length..... | T1 | 12.3 | " |
| Thickness of second shield..... | T2 | 139.7 | " |
| Microshield inserted air gap..... | air | 8. | " |

Source Volume: 2.2437e+7 cubic centimeters

MATERIAL DENSITIES (g/cc):

| Material | Source | Shield 2 | Air gap |
|---|---|---|---|
| Air | | | .001220 |
| Aluminum | | | |
| Carbon | | | |
| Concrete | 1.50 | | |
| Hydrogen | | | |
| Iron | | | |
| Lead | | | |
| Lithium | | | |
| Nickel | | | |
| Tin | | | |
| Titanium | | | |
| Tungsten | | | |
| Urania | | | |
| Uranium | | | |
| Water | | 1.0 | |
| Zirconium | | | |

Page 2 File: W10S.MSH

CASE: W10S CASE SLUGE WAG1

BUILDUP FACTOR: based on GP method.
Using the characteristics of the materials in shield 2.

INTEGRATION PARAMETERS:

| | |
|---|---|
| Number of angle segments (Npsi)..... | 11 |
| Number of radial segments (Nradius)..... | 11 |

SOURCE NUCLIDES:

| Nuclide | Curies | Nuclide | Curies | Nuclide | Curies |
|---|---|---|---|---|---|
| Ba-137m | 1.1000e+04 | Co-60 | 0.0000e+00 | Cs-137 | 1.1000e+04 |
| N-16 | 0.0000e+00 | | | | |

Page : 1
File : W10LA.MSH
Run date: December 11, 1991
Run time: 8:19 a.m.

File Ref: _____
Date: ___/___/___
By: _____
Checked: _____

CASE: W10L EXPOS., LIQUID PART ,ALL NUCL., WAG1

GEOMETRY 10: Cylindrical source from end - slab shields

| | | | |
|---|---|---|---|
| Distance to detector..... | X | 148. | cm. |
| Source cylinder radius..... | R | 762. | " |
| Source cylinder length..... | T1 | 139.7 | " |
| Microshield inserted air gap..... | air | 8.3 | " |

Source Volume: 2.54833e+8 cubic centimeters

MATERIAL DENSITIES (g/cc):

| Material | Source | Air gap |
|---|---|---|
| Air | | .001220 |
| Aluminum | | |
| Carbon | | |
| Concrete | | |
| Hydrogen | | |
| Iron | | |
| Lead | | |
| Lithium | | |
| Nickel | | |
| Tin | | |
| Titanium | | |
| Tungsten | | |
| Urania | | |
| Uranium | | |
| Water | 1.0 | |
| Zirconium | | |

Page 2 File: W10LA.MSH
CASE: W10L EXPOS., LIQUID PART ,ALL NUCL., WAG1

BUILDUP FACTOR: based on GP method.
Using the characteristics of the materials in shield 1.

INTEGRATION PARAMETERS:

| | |
|---|---|
| Number of angle segments (Npsi)..... | 11 |
| Number of radial segments (Nradius)..... | 11 |

SOURCE NUCLIDES:

| Nuclide | Curies | Nuclide | Curies | Nuclide | Curies |
|---|---|---|---|---|---|
| Am-241 | 0.0000e+00 | Ba-137m | 1.7000e+03 | Cm-244 | 0.0000e+00 |
| Co-60 | 1.0000e+00 | Cs-134 | 0.0000e+00 | Cs-137 | 1.7000e+03 |
| Eu-152 | 0.0000e+00 | Eu-154 | 0.0000e+00 | H-3 | 0.0000e+00 |
| Pu-238 | 0.0000e+00 | Pu-239 | 1.4000e-02 | Sr-90 | 8.7000e+00 |
| U-233 | 5.1000e-02 | U-234 | 2.2000e-02 | Y-90 | 8.7000e+00 |

Page : 1
File : W10L.MSH
Run date: November 19, 1991
Run time: 4:20 p.m.

File Ref: _____
Date: ___/___/___
By: _____
Checked: _____

CASE: W10L CASE ~~SLUGE~~ LQ WAG1

GEOMETRY 10: Cylindrical source from end - slab shields

| | | | |
|---|---|---|---|
| Distance to detector..... | X | 148. | cm. |
| Source cylinder radius..... | R | 762. | " |
| Source cylinder length..... | T1 | 139.7 | " |
| Microshield inserted air gap..... | air | 8.3 | " |

Source Volume: 2.54833e+8 cubic centimeters

MATERIAL DENSITIES (g/cc):

| Material | Source | Air gap |
|---|---|---|
| Air | | .001220 |
| Aluminum | | |
| Carbon | | |
| Concrete | | |
| Hydrogen | | |
| Iron | | |
| Lead | | |
| Lithium | | |
| Nickel | | |
| Tin | | |
| Titanium | | |
| Tungsten | | |
| Urania | | |
| Uranium | | |
| Water | 1.0 | |
| Zirconium | | |

Page 2 File: W10L.MSH

CASE: W10L CASE SLUGE WAG1

BUILDUP FACTOR: based on GP method.
Using the characteristics of the materials in shield 1.

INTEGRATION PARAMETERS:

| | |
|---|---|
| Number of angle segments (Npsi)..... | 11 |
| Number of radial segments (Nradius)..... | 11 |

SOURCE NUCLIDES:

| Nuclide | Curies | Nuclide | Curies | Nuclide | Curies |
|---|---|---|---|---|---|
| Ba-137m | 1.7000e+03 | Co-60 | 0.0000e+00 | Cs-137 | 1.7000e+03 |
| N-16 | 0.0000e+00 | | | | |

Page : 1
File : W10SA.MSH
Run date: December 11, 1991
Run time: 2:22 p.m.

File Ref: _____
Date: ___/___/___
By: _____
Checked: _____

CASE: W10S EXPOS. CASE SLUGE FOR ALL NUCL. WAG1 NO LIQUID

GEOMETRY 10: Cylindrical source from end - slab shields

| | | | |
|---|---|---|---|
| Distance to detector..... | X | 160. | cm. |
| Source cylinder radius..... | R | 762. | " |
| Source cylinder length..... | T1 | 12.3 | " |
| Microshield inserted air gap..... | air | 147.7 | " |

Source Volume: 2.2437e+7 cubic centimeters

MATERIAL DENSITIES (g/cc):

| material | Source | Air gap |
|---|---|---|
| | | .001220 |
| Aluminum | | |
| Carbon | | |
| Concrete | 1.50 | |
| Hydrogen | | |
| Iron | | |
| Lead | | |
| Lithium | | |
| Nickel | | |
| Tin | | |
| Titanium | | |
| Tungsten | | |
| Urania | | |
| Uranium | | |
| Water | | |
| Zirconium | | |

Page 2 File: W10SA.MSH
CASE: W10S EXPOS. CASE SLUGE FOR ALL NUCL. WAG1 NO LIQUID

BUILDUP FACTOR: based on GP method.
Using the characteristics of the materials in shield 2.

INTEGRATION PARAMETERS:

| | |
|---|---|
| Number of angle segments (Npsi)..... | 11 |
| Number of radial segments (Nradius)..... | 11 |

SOURCE NUCLIDES:

| Nuclide | Curies | Nuclide | Curies | Nuclide | Curies |
|---|---|---|---|---|---|
| Am-241 | 4.4000e+00 | Ba-137m | 1.1000e+04 | Cm-244 | 4.6000e+01 |
| Co-60 | 1.3000e+01 | Cs-134 | 1.4000e+00 | Cs-137 | 1.1000e+04 |
| Eu-152 | 4.5000e+00 | Eu-154 | 7.9000e+00 | H-3 | 1.4000e-01 |
| Pu-238 | 2.9000e+01 | Pu-239 | 1.1000e+01 | Sr-90 | 8.5000e+03 |
| U-233 | 2.1000e+00 | U-234 | 1.3000e+00 | Y-90 | 8.5000e+03 |

Page : 1
File : W10S.MSH
Run date: December 11, 1991
Run time: 2:27 p.m.

File Ref: _____
Date: ___/___/___
By: _____
Checked: _____

CASE: W10S CASE SLUGE WAG1 CS-137 ONLY NO LIQ

GEOMETRY 10: Cylindrical source from end - slab shields

| | | | |
|---|---|---|---|
| Distance to detector..... | X | 160. | cm. |
| Source cylinder radius..... | R | 762. | " |
| Source cylinder length..... | T1 | 12.3 | " |
| Microshield inserted air gap..... | air | 147.7 | " |

Source Volume: 2.2437e+7 cubic centimeters

MATERIAL DENSITIES (g/cc):

| Material | Source | Air gap |
|---|---|---|
| Air | | .001220 |
| Aluminum | | |
| Carbon | | |
| Concrete | 1.50 | |
| Hydrogen | | |
| Iron | | |
| Lead | | |
| Lithium | | |
| Nickel | | |
| Tin | | |
| Titanium | | |
| Tungsten | | |
| Urania | | |
| Uranium | | |
| Water | | |
| Zirconium | | |

Page 2 File: W10S.MSH
CASE: W10S CASE SLUGE WAG1 CS-137 ONLY NO LIQ

BUILDUP FACTOR: based on GP method.
Using the characteristics of the materials in shield 2.

INTEGRATION PARAMETERS:

Number of angle segments (Npsi)..... 11
Number of radial segments (Nradius)..... 11

SOURCE NUCLIDES:

| Nuclide | Curies | Nuclide | Curies | Nuclide | Curies |
|---|---|---|---|---|---|
| Ba-137m | 1.1000e+04 | Co-60 | 0.0000e+00 | Cs-137 | 1.1000e+04 |
| N-16 | 0.0000e+00 | | | | |

# APPENDIX C:

# QAD-CGGP INPUT FILES

INPUT DATA LIST

```
 1   WAG1 W10 TANK EXPOSURE MODLE, QAD-CG
 2   38 2 24 11 4 2 1 6 0 1 1 0 0 0 0 0
 3   3.664E+14  0  0  0  0  0  0
 4   0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
 5   160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
 6   320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
 7   480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
 8   640.0    660.0    680.0    700.0    720.0    740.0    762.0
 9   0.0      6.1      12.3
10   0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
11   2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
12   4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
13   6.283
14     0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10S2.INP
15     RCC    10.0       0.0       0.0       0.0       0.0       12.3
16              762.0
17     RCC    20.0       0.0       0.0       0.0       0.0       152.0
18              762.0
19     RCC    30.0       0.0       0.0       0.0       0.0       599.44
20              762.0
21     RCC    40.0       0.0       0.0       0.0       0.0       599.44
22              781.05
23     RPP    5-1000.0   1000.0    -1000.0   1000.0    0.0       1000.0
24     END
25     100    2      1
26     110    2      2     -1
27     120    2      3     -1     -2
28     130    2      4     -3
29     130    2      5     -1     -2     -3     -4
30     END
31       1    1    1    1    1
32       1    2    3    4 1000
33       1   1    7   8   11  12   13  14   16  19   20  26
34   .008     .000     0.678    .026     .004     .068     .470     .040
35   .029     .124     .018
36   .111     .0       .889     .0       .0       .0       .0       .0
37   .0       .0       .0
38   .0       .00104   .00025   .0       .0       .0       .0       .0
39   .0       .0       .0
40   .0103    .0       1.062    .040     .006     .107     .737     .063
41   .045     .194     .029
42   0.6641
43   0.6641
44   .0019231
45   1.0
46   .660-.670
47   .660-.670
48   mev/cm*2-sec            mrem/hr                  w/g
49   0.0      599.44   762.0        1   0   0   0
50   0.0      629.44   762.0        1   0   0   0
51   0.0      659.44   762.0        1   0   0   0
52   0.0      689.44   762.0        1   0   0   0
53   0.0      719.44   762.0        1   0   0   0
54   0.0      749.44   762.0        1   0   0   0
55   0.0      779.44   762.0        1   0   0   0
56   0.0      0.0      0.0         -1   0   0   0
```

INPUT DATA LIST

```
WAG1 W10 TANK EXPOSURE MODLE, QAD-CG
38 14 24 11 3 2 1 6 0 1 1 0 0 0 0 0
5.664E+13  0  0  0  0  0  0
0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
640.0    660.0    680.0    700.0    720.0    740.0    762.0
0.0      10.0     20.0     30.0     40.0     50.0     60.0     70.0
80.0     90.0     100.0    110.0    120.0    130.0    139.7
0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
6.283
  0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE LIQ. FN=W10L2.INP
  RCC    10.0       0.0       0.0       0.0       0.0       139.7
           762.0
  RCC    20.0       0.0       0.0       0.0       0.0       587.44
           762.0
  RCC    30.0       0.0       0.0       0.0       0.0       587.44
           781.05
  RPP    4-1000.0   1000.0    -1000.0   1000.0    0.0       1000.0
  END
  100    2      1
  110    2      2     -1
  120    2      3     -2     -1
  130    2      4     -1     -2     -3
  END
    1    1    1    1
    1    2    3 1000
    1    1    7    8   11  12  13  14  16  19  20  26
.111     .0       .889     .0       .0       .0       .0       .0
.0       .0       .0
.0       .00104   .00025   .0       .0       .0       .0       .0
.0       .0       .0
.0103    .0       1.062    .040     .006     .107     .737     .063
.045     .194     .029
0.6641
0.6641
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec          mrem/hr                    W/g
0.0      587.14   762.0        1   0   0   0
0.0      617.14   762.0        1   0   0   0
0.0      647.14   762.0        1   0   0   0
0.0      677.14   762.0        1   0   0   0
0.0      707.14   762.0        1   0   0   0
0.0      737.14   762.0        1   0   0   0
0.0      767.14   762.0        1   0   0   0
0.0      0.0      0.0         -1   0   0   0
```

INPUT DATA LIST

```
 1   WAG1 W10 TANK EXPOSURE MODLE, QAD-CG
 2   38 2 24 11 3 2 1 6 0 1 1 0 0 0 0 0
 3   3.664E+14  0  0  0  0  0  0
 4   0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
 5   160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
 6   320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
 7   480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
 8   640.0    660.0    680.0    700.0    720.0    740.0    762.0
 9   0.0      6.1      12.3
10   0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
11   2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
12   4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
13   6.283
14     0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10NW.INP
15     RCC    10.0       0.0       0.0       0.0       0.0       12.3
16              762.0
17     RCC    20.0       0.0       0.0       0.0       0.0       152.0
18              762.0
19     RCC    30.0       0.0       0.0       0.0       0.0       599.44
20              762.0
21     RCC    40.0       0.0       0.0       0.0       0.0       599.44
22              781.05
23     RPP    5-1000.0   1000.0    -1000.0   1000.0    0.0       1000.0
24     END
25     100    2      1
26     110    2      2     -1
27     120    2      3     -1     -2
28     130    2      4     -3
29     130    2      5     -1     -2     -3     -4
30     END
31       1    1    1    1    1
32       1    2    2    3 1000
33       1    1    7    8   11   12   13   14   16   19   20   26
34   .008     .000     0.678    .026     .004     .068     .470     .040
35   .029     .124     .018
36   .0       .00104   .00025   .0       .0       .0       .0       .0
37   .0       .0       .0
38   .0103    .0       1.062    .040     .006     .107     .737     .063
39   .045     .194     .029
40   0.6641
41   0.6641
42   .0019231
43   1.0
44   .660-.670
45   .660-.670
46   mev/cm*2-sec          mrem/hr                    W/g
47   0.0      599.44   762.0        1   0   0   0
48   0.0      629.44   762.0        1   0   0   0
49   0.0      659.44   762.0        1   0   0   0
50   0.0      689.44   762.0        1   0   0   0
51   0.0      719.44   762.0        1   0   0   0
52   0.0      749.44   762.0        1   0   0   0
53   0.0      779.44   762.0        1   0   0   0
54   0.0      0.0      0.0         -1   0   0   0
```

INPUT DATA LIST

```
WAG1 W10 TANK EXPOSURE MODLE, EXPOS. LIM. DUE TO SLUDGE WITH LIQ.,QAD-CG
38 2 24 11 4 2 1 6 0 1 1 0 0 0 0 0
3.664E+14  0  0  0  0  0  0
0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
640.0    660.0    680.0    700.0    720.0    740.0    762.0
0.0      6.1      12.3
0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
6.283
  0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10S2LIM.INP
  RCC    10.0       0.0       0.0       0.0       0.0       12.3
           762.0
  RCC    20.0       0.0       0.0       0.0       0.0       152.0
           762.0
  RCC    30.0       0.0       0.0       0.0       0.0       599.44
           762.0
  RCC    40.0       0.0       0.0       0.0       0.0       599.44
           900.0
  RPP    5-1000.0   1000.0    -1000.0   1000.0    0.0       1000.0
  END
  100    2      1
  110    2      2     -1
  120    2      3     -1     -2
  130    2      4     -3
  130    2      5     -1     -2     -3     -4
  END
    1    1    1    1    1
    1    2    3    4 1000
    1    1    7    8   11   12   13   14   16   19   20   26
.008     .000     0.678    .026     .004     .068     .470     .040
.029     .124     .018
.111     .0       .889     .0       .0       .0       .0       .0
.0       .0       .0
.0       .00104   .00025   .0       .0       .0       .0       .0
.0       .0       .0
.0103    .0       1.062    .040     .006     .107     .737     .063
.045     .194     .029
0.6641
0.6641
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec          mrem/hr                    w/g
0.0      719.44   762.0      1   0   0   0
0.0      719.44   792.0      1   0   0   0
0.0      719.44   822.0      1   0   0   0
0.0      719.44   852.0      1   0   0   0
0.0      719.44   882.0      1   0   0   0
0.0      719.44   912.0      1   0   0   0
0.0      719.44   942.0      1   0   0   0
0.0      719.44   972.0      1   0   0   0
0.0      719.44   990.0      1   0   0   0
0.0      0.0      0.0       -1   0   0   0
```

INPUT DATA LIST

```
 1   WAG1 W10 TANK EXPOSURE MODLE, EXPOS LIM DUE TO LIQ, QAD-CG
 2   38 14 24 11 3 2 1 6 0 1 1 0 0 0 0 0
 3   5.664E+13  0  0  0  0  0  0
 4   0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
 5   160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
 6   320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
 7   480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
 8   640.0    660.0    680.0    700.0    720.0    740.0    762.0
 9   0.0      10.0     20.0     30.0     40.0     50.0     60.0     70.0
10   80.0     90.0     100.0    110.0    120.0    130.0    139.7
11   0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
12   2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
13   4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
14   6.283
15     0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE LIQ. FN=W10L2LIM.INP
16     RCC    10.0       0.0       0.0       0.0       0.0       139.7
17              762.0
18     RCC    20.0       0.0       0.0       0.0       0.0       587.44
19              762.0
20     RCC    30.0       0.0       0.0       0.0       0.0       587.44
21              990.0
22     RPP    4-1000.0   1000.0    -1000.0   1000.0    0.0       1000.0
23     END
24     100    2      1
25     110    2      2     -1
26     120    2      3     -2     -1
27     130    2      4     -1     -2     -3
28     END
29       1    1    1    1
30       1    2    3 1000
31       1    1    7    8   11   12   13   14   16   19   20   26
32   .111     .0       .889     .0       .0       .0       .0       .0
33   .0       .0       .0
34   .0       .00104   .00025   .0       .0       .0       .0       .0
35   .0       .0       .0
36   .0103    .0       1.062    .040     .006     .107     .737     .063
37   .045     .194     .029
38   0.6641
39   0.6641
40   .0019231
41   1.0
42   .660-.670
43   .660-.670
44   mev/cm*2-sec            mrem/hr                  W/g
45   0.0      707.14   762.0        1   0   0   0
46   0.0      707.14   792.0        1   0   0   0
47   0.0      707.14   822.0        1   0   0   0
48   0.0      707.14   852.0        1   0   0   0
49   0.0      707.14   882.0        1   0   0   0
50   0.0      707.14   912.0        1   0   0   0
51   0.0      707.14   942.0        1   0   0   0
52   0.0      707.14   972.0        1   0   0   0
53   0.0      707.14   990.0        1   0   0   0
54   0.0      0.0      0.0         -1   0   0   0
```

INPUT DATA LIST

```
 1   WAG1 W10 TANK EXPOSURE MODLE, EXPOS LIMIT DUE TO LIQ., QAD-CG
 2   38 14 24 11 3 2 1 6 0 1 1 0 0 0 0 0
 3   5.664E+13  0  0  0  0  0  0
 4   0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
 5   160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
 6   320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
 7   480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
 8   640.0    660.0    680.0    700.0    720.0    740.0    762.0
 9   0.0      10.0     20.0     30.0     40.0     50.0     60.0     70.0
10   80.0     90.0     100.0    110.0    120.0    130.0    139.7
11   0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
12   2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
13   4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
14   6.283
15     0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE LIQ. FN=W10L2LIM.IN1
16     RCC    10.0       0.0       0.0       0.0       0.0       139.7
17              762.0
18     RCC    20.0       0.0       0.0       0.0       0.0       587.44
19              762.0
20     RCC    30.0       0.0       0.0       0.0       0.0       587.44
21              1500.0
22     RPP    4-2000.0   2000.0    -2000.0   2000.0    0.0       2000.0
23     END
24     100    2      1
25     110    2      2     -1
26     120    2      3     -2     -1
27     130    2      4     -1     -2     -3
28     END
29       1    1    1    1
30       1    2    3 1000
31       1    1    7    8   11   12   13   14   16   19   20   26
32   .111     .0       .889     .0       .0       .0       .0       .0
33   .0       .0       .0
34   .0       .00104   .00025   .0       .0       .0       .0       .0
35   .0       .0       .0
36   .0103    .0       1.062    .040     .006     .107     .737     .063
37   .045     .194     .029
38   0.6641
39   0.6641
40   .0019231
41   1.0
42   .660-.670
43   .660-.670
44   mev/cm*2-sec            mrem/hr                  w/g
45   0.0      707.14   990.0       1   0   0   0
46   0.0      707.14   1022.0      1   0   0   0
47   0.0      707.14   1052.0      1   0   0   0
48   0.0      707.14   1082.0      1   0   0   0
49   0.0      707.14   1112.0      1   0   0   0
50   0.0      707.14   1142.0      1   0   0   0
51   0.0      707.14   1172.0      1   0   0   0
52   0.0      707.14   1202.0      1   0   0   0
53   0.0      707.14   1232.0      1   0   0   0
54   0.0      0.0      0.0        -1   0   0   0
```

INPUT DATA LIST

```
 1   WAG1 W10 TANK EXPOSURE MODLE, EXPOS. LIM. DUE TO SLUDGE NO LIQ., QAD-CG
 2   38 2 24 11 3 2 1 6 0 1 1 0 0 0 0 0
 3   3.664E+14  0  0  0  0  0  0
 4   0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
 5   160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
 6   320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
 7   480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
 8   640.0    660.0    680.0    700.0    720.0    740.0    762.0
 9   0.0      6.1      12.3
10   0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
11   2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
12   4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
13   6.283
14     0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10NWLH.INP
15     RCC    10.0       0.0       0.0       0.0       0.0       12.3
16              762.0
17     RCC    20.0       0.0       0.0       0.0       0.0       152.0
18              762.0
19     RCC    30.0       0.0       0.0       0.0       0.0       599.44
20              762.0
21     RCC    40.0       0.0       0.0       0.0       0.0       599.44
22              990.0
23     RPP    5-1000.0   1000.0    -1000.0   1000.0    0.0       1000.0
24     END
25     100    2      1
26     110    2      2     -1
27     120    2      3     -1     -2
28     130    2      4     -3
29     130    2      5     -1     -2     -3     -4
30     END
31       1    1    1    1    1
32       1    2    2    3 1000
33       1    1    7    8   11   12   13   14   16   19   20   26
34   .008     .000     0.678    .026     .004     .068     .470     .040
35   .029     .124     .018
36   .0       .00104   .00025   .0       .0       .0       .0       .0
37   .0       .0       .0
38   .0103    .0       1.062    .040     .006     .107     .737     .063
39   .045     .194     .029
40   0.6641
41   0.6641
42   .0019231
43   1.0
44   .660-.670
45   .660-.670
46   mev/cm*2-sec          mrem/hr                    w/g
47   0.0      719.44   762.0        1   0   0   0
48   0.0      719.44   792.0        1   0   0   0
49   0.0      719.44   822.0        1   0   0   0
50   0.0      719.44   852.0        1   0   0   0
51   0.0      719.44   882.0        1   0   0   0
52   0.0      719.44   912.0        1   0   0   0
53   0.0      719.44   942.0        1   0   0   0
54   0.0      719.44   972.0        1   0   0   0
55   0.0      719.44   990.0        1   0   0   0
56   0.0      0.0      0.0         -1   0   0   0
```

INPUT DATA LIST

```
 1   WAG1 W10 TANK EXPOSURE MODLESLG/LIQ 8' ELV, QAD-CG
 2   38 2 24 11 4 2 1 6 0 1 1 0 0 0 0 0
 3   3.664E+14  0  0  0  0  0  0
 4   0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
 5   160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
 6   320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
 7   480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
 8   640.0    660.0    680.0    700.0    720.0    740.0    762.0
 9   0.0      6.1      12.3
10   0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
11   2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
12   4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
13   6.283
14     0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10S2LM8.INP
15     RCC    10.0       0.0       0.0       0.0       0.0       12.3
16              762.0
17     RCC    20.0       0.0       0.0       0.0       0.0       152.0
18              762.0
19     RCC    30.0       0.0       0.0       0.0       0.0       599.44
20              762.0
21     RCC    40.0       0.0       0.0       0.0       0.0       599.44
22              900.0
23     RPP    5-1000.0   1000.0    -1000.0   1000.0    0.0       1000.0
24     END
25     100    2      1
26     110    2      2     -1
27     120    2      3     -1     -2
28     130    2      4     -3
29     130    2      5     -1     -2     -3     -4
30     END
31       1    1    1    1    1
32       1    2    3    4 1000
33       1    1    7    8   11   12   13   14   16   19   20   26
34   .008     .000     0.678    .026     .004     .068     .470     .040
35   .029     .124     .018
36   .111     .0       .889     .0       .0       .0       .0       .0
37   .0       .0       .0
38   .0       .00104   .00025   .0       .0       .0       .0       .0
39   .0       .0       .0
40   .0103    .0       1.062    .040     .006     .107     .737     .063
41   .045     .194     .029
42   0.6641
43   0.6641
44   .0019231
45   1.0
46   .660-.670
47   .660-.670
48   mev/cm*2-sec          mrem/hr                    w/g
49   0.0      779.44   762.0       1   0   0   0
50   0.0      779.44   792.0       1   0   0   0
51   0.0      779.44   822.0       1   0   0   0
52   0.0      779.44   852.0       1   0   0   0
     0.0      779.44   882.0       1   0   0   0
     0.0      779.44   912.0       1   0   0   0
55   0.0      779.44   942.0       1   0   0   0
56   0.0      779.44   972.0       1   0   0   0
57   0.0      779.44   990.0       1   0   0   0
58   0.0      0.0      0.0        -1   0   0   0
```

INPUT DATA LIST

```
WAG1 W10 TANK EXPOSURE MODLE, EXPOS LIMIT DUE TO LIQ 8' ELV., QAD-CG
38 14 24 11 3 2 1 6 0 1 1 0 0 0 0 0
5.664E+13  0  0  0  0  0  0
0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
640.0    660.0    680.0    700.0    720.0    740.0    762.0
0.0      10.0     20.0     30.0     40.0     50.0     60.0     70.0
80.0     90.0     100.0    110.0    120.0    130.0    139.7
0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
6.283
  0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE LIQ. FN=W10L2LM8.INP
  RCC    10.0       0.0       0.0       0.0       0.0       139.7
           762.0
  RCC    20.0       0.0       0.0       0.0       0.0       587.44
           762.0
  RCC    30.0       0.0       0.0       0.0       0.0       587.44
           1500.0
  RPP    4-2000.0   2000.0    -2000.0   2000.0    0.0       2000.0
  END
  100    2      1
  110    2      2      -1
  120    2      3      -2     -1
  130    2      4      -1     -2     -3
  END
    1    1    1    1
    1    2    3 1000
    1   1    7   8   11  12   13  14   16  19   20  26
.111     .0       .889     .0       .0       .0       .0       .0
.0       .0       .0
.0       .00104   .00025   .0       .0       .0       .0       .0
.0       .0       .0
.0103    .0       1.062    .040     .006     .107     .737     .063
.045     .194     .029
0.6641
0.6641
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec          mrem/hr                    W/g
0.0      767.14   762.0        1   0   0   0
0.0      767.14   792.0        1   0   0   0
0.0      767.14   822.0        1   0   0   0
0.0      767.14   852.0        1   0   0   0
0.0      767.14   882.0        1   0   0   0
0.0      767.14   912.0        1   0   0   0
0.0      767.14   942.0        1   0   0   0
0.0      767.14   972.0        1   0   0   0
0.0      767.14   990.0        1   0   0   0
0.0      767.14   1022.0       1   0   0   0
0.0      767.14   1052.0       1   0   0   0
0.0      767.14   1082.0       1   0   0   0
0.0      767.14   1112.0       1   0   0   0
0.0      767.14   1142.0       1   0   0   0
0.0      767.14   1172.0       1   0   0   0
0.0      767.14   1202.0       1   0   0   0
0.0      767.14   1232.0       1   0   0   0
0.0      0.0      0.0         -1   0   0   0
```

INPUT DATA LIST

```
 1   WAG1 W10 TANK EXPOSURE MODLE, EXPOS DUE SLG NO LIQ 8'ELV, QAD-CG
 2   38 2 24 11 3 2 1 6 0 1 1 0 0 0 0 0
 3   3.664E+14  0  0  0  0  0  0
 4   0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
 5   160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
 6   320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
 7   480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
 8   640.0    660.0    680.0    700.0    720.0    740.0    762.0
 9   0.0      6.1      12.3
10   0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
11   2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
12   4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
13   6.283
14     0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10NWL8.INP
15     RCC    10.0       0.0       0.0       0.0       0.0       12.3
16              762.0
17     RCC    20.0       0.0       0.0       0.0       0.0       152.0
18              762.0
19     RCC    30.0       0.0       0.0       0.0       0.0       599.44
20              762.0
21     RCC    40.0       0.0       0.0       0.0       0.0       599.44
22              1500.0
23     RPP    5-2000.0   2000.0    -2000.0   2000.0    0.0       2000.0
24     END
25     100    2      1
26     110    2      2      -1
27     120    2      3      -1      -2
28     130    2      4      -3
29     130    2      5      -1      -2      -3      -4
30     END
31       1    1    1    1    1
32       1    2    2    3 1000
33       1    1    7    8   11   12   13   14   16   19   20   26
34   .008     .000     0.678    .026     .004     .068     .470     .040
35   .029     .124     .018
36   .0       .00104   .00025   .0       .0       .0       .0       .0
37   .0       .0       .0
38   .0103    .0       1.062    .040     .006     .107     .737     .063
39   .045     .194     .029
40   0.6641
41   0.6641
42   .0019231
43   1.0
44   .660-.670
45   .660-.670
46   mev/cm*2-sec          mrem/hr                    w/g
47   0.0      779.44   762.0       1   0   0   0
48   0.0      779.44   792.0       1   0   0   0
49   0.0      779.44   822.0       1   0   0   0
50   0.0      779.44   852.0       1   0   0   0
51   0.0      779.44   882.0       1   0   0   0
52   0.0      779.44   912.0       1   0   0   0
53   0.0      779.44   942.0       1   0   0   0
54   0.0      779.44   972.0       1   0   0   0
55   0.0      779.44   990.0       1   0   0   0
56   0.0      779.44   1022.0      1   0   0   0
57   0.0      779.44   1052.0      1   0   0   0
58   0.0      779.44   1082.0      1   0   0   0
59   0.0      779.44   1112.0      1   0   0   0
60   0.0      779.44   1142.0      1   0   0   0
61   0.0      779.44   1172.0      1   0   0   0
62   0.0      779.44   1202.0      1   0   0   0
63   0.0      779.44   1232.0      1   0   0   0
64   0.0      0.0      0.0        -1   0   0   0
```

INPUT DATA LIST

```
WAG1 W10 TANK EXPOSURE MODLE SLG/LIQ PLATFORM 4',8' ELV, QAD-CG
38 2 24 11 4 2 1 6 0 1 1 0 0 0 0 0
3.664E+14  0  0  0  0  0  0
0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
640.0    660.0    680.0    700.0    720.0    740.0    762.0
0.0      6.1      12.3
0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
6.283
  0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10SPL.INP
  RCC    10.0       0.0       0.0       0.0       0.0       12.3
           762.0
  RCC    20.0       0.0       0.0       0.0       0.0       152.0
           762.0
  RCC    30.0       0.0       0.0       0.0       0.0       599.44
           762.0
  RCC    40.0       0.0       0.0       0.0       0.0       599.44
           900.0
  RPP    5-1000.0   1000.0    -1000.0   1000.0    0.0       1000.0
  END
  100    2      1
  110    2      2      -1
  120    2      3      -1     -2
  130    2      4      -3
  130    2      5      -1     -2     -3     -4
  END
    1    1    1    1    1
    1    2    3    4 1000
    1    1    7    8   11   12   13   14   16   19   20   26
.008     .000     0.678    .026     .004     .068     .470     .040
.029     .124     .018
.111     .0       .889     .0       .0       .0       .0       .0
.0       .0       .0
.0       .00104   .00025   .0       .0       .0       .0       .0
.0       .0       .0
.0103    .0       1.062    .040     .006     .107     .737     .063
.045     .194     .029
0.6641
0.6641
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec          mrem/hr                    w/g
0.0      876.3    000.0        1   0   0   0
0.0      876.3    100.0        1   0   0   0
0.0      876.3    200.0        1   0   0   0
0.0      876.3    300.0        1   0   0   0
0.0      876.3    400.0        1   0   0   0
0.0      876.3    500.0        1   0   0   0
0.0      876.3    600.0        1   0   0   0
0.0      876.3    700.0        1   0   0   0
0.0      876.3    762.0        1   0   0   0
0.0      937.26   0.000        1   0   0   0
0.0      937.26   0.000        1   0   0   0
0.0      937.26   100.0        1   0   0   0
0.0      937.26   200.0        1   0   0   0
0.0      937.26   300.0        1   0   0   0
0.0      937.26   400.0        1   0   0   0
0.0      937.26   500.0        1   0   0   0
0.0      937.26   600.0        1   0   0   0
0.0      937.26   700.0        1   0   0   0
0.0      937.26   762.0        1   0   0   0
0.0      0.0      0.0         -1   0   0   0
```

INPUT DATA LIST

```
WAG1 W10 TANK EXPOSURE MODLE, EXPOS LIMIT PLTFORM 4,8 FT ELV., QAD-CG
38 14 24 11 3 2 1 6 0 1 1 0 0 0 0 0
5.664E+13  0  0  0  0  0  0
0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
640.0    660.0    680.0    700.0    720.0    740.0    762.0
0.0      10.0     20.0     30.0     40.0     50.0     60.0     70.0
80.0     90.0     100.0    110.0    120.0    130.0    139.7
0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
6.283
  0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE LIQ. FN=W10LPL.INP
  RCC    10.0       0.0       0.0       0.0       0.0       139.7
           762.0
  RCC    20.0       0.0       0.0       0.0       0.0       587.44
           762.0
  RCC    30.0       0.0       0.0       0.0       0.0       587.44
           1500.0
  RPP    4-2000.0   2000.0    -2000.0   2000.0    0.0       2000.0
  END
  100    2      1
  110    2      2      -1
  120    2      3      -2     -1
  130    2      4      -1     -2     -3
  END
    1    1    1    1
    1    2    3 1000
    1    1    7    8   11   12   13   14   16   19   20   26
.111     .0       .889     .0       .0       .0       .0       .0
.0       .0       .0
.0       .00104   .00025   .0       .0       .0       .0       .0
.0       .0       .0
.0103    .0       1.062    .040     .006     .107     .737     .063
.045     .194     .029
0.6641
0.6641
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec          mrem/hr                    w/g
0.0      864.0    0.0          1   0   0   0
0.0      864.0    100.0        1   0   0   0
0.0      864.0    200.0        1   0   0   0
0.0      864.0    300.0        1   0   0   0
0.0      864.0    400.0        1   0   0   0
0.0      864.0    500.0        1   0   0   0
0.0      864.0    600.0        1   0   0   0
0.0      864.0    700.0        1   0   0   0
0.0      864.0    762.0        1   0   0   0
0.0      [illegible]
```

INPUT DATA LIST

```
WAG1 W10 TANK EXPOSURE MODLE SLG NO LIQ PLATFORM 4',8' ELV, QAD-CG
38 2 24 11 3 2 1 6 0 1 1 0 0 0 0 0
3.664E+14  0  0  0  0  0  0
0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
640.0    660.0    680.0    700.0    720.0    740.0    762.0
0.0      6.1      12.3
0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
6.283
  0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10SNWPL.INP
  RCC    10.0       0.0       0.0       0.0       0.0       12.3
           762.0
  RCC    20.0       0.0       0.0       0.0       0.0       152.0
           762.0
  RCC    30.0       0.0       0.0       0.0       0.0       599.44
           762.0
  RCC    40.0       0.0       0.0       0.0       0.0       599.44
           990.0
  RPP    5-1000.0   1000.0    -1000.0   1000.0    0.0       1000.0
  END
  100    2      1
  110    2      2     -1
  120    2      3     -1     -2
  130    2      4     -3
  130    2      5     -1     -2     -3     -4
  END
    1    1    1    1    1
    1    2    2    3 1000
    1    1    7    8   11   12   13   14   16   19   20   26
.008     .000     0.678    .026     .004     .068     .470     .040
.029     .124     .018
.0       .00104   .00025   .0       .0       .0       .0       .0
.0       .0       .0
.0103    .0       1.062    .040     .006     .107     .737     .063
.045     .194     .029
0.6641
0.6641
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec          mrem/hr                    w/g
0.0      876.30   000.0        1   0   0   0
0.0      876.30   100.0        1   0   0   0
0.0      876.30   200.0        1   0   0   0
0.0      876.30   300.0        1   0   0   0
0.0      876.30   400.0        1   0   0   0
0.0      876.30   500.0        1   0   0   0
0.0      876.30   600.0        1   0   0   0
0.0      876.30   700.0        1   0   0   0
```

INPUT DATA LIST

```
 1   WAG1 W10 TANK EXPOSURE MODLE, EXPOS DUE SLG NO LIQ 8'ELV. QAD-CG
 2   38 2 24 11 3 2 1 6 0 1 1 0 0 0 0 0
 3   3.664E+14  0  0  0  0  0  0
 4   0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
 5   160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
 6   320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
 7   480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
 8   640.0    660.0    680.0    700.0    720.0    740.0    762.0
 9   0.0      6.1      12.3
10   0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
11   2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
12   4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
13   6.283
14     0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10sdmp8.INP
15     RCC    10.0       0.0       0.0       0.0       0.0       12.3
16              762.0
17     RCC    20.0       0.0       0.0       0.0       0.0       152.0
18              762.0
19     RCC    30.0       0.0       0.0       0.0       0.0       599.44
20              762.0
21     RCC    40.0       0.0       0.0       0.0       0.0       599.44
22              2000.0
23     RPP    5-2001.0   2001.0    -2001.0   2001.0    0.0       2000.0
24     END
25     100    2      1
26     110    2      2      -1
27     120    2      3      -1      -2
28     130    2      4      -3
29     130    2      5      -1      -2      -3      -4
30     END
31       1    1    1    1    1
32       1    2    2    3 1000
33       1    1    7    8   11   12   13   14   16   19   20   26
34   .008     .000     0.678    .026     .004     .068     .470     .040
35   .029     .124     .018
36   .0       .00104   .00025   .0       .0       .0       .0       .0
37   .0       .0       .0
38   .0103    .0       1.062    .040     .006     .107     .737     .063
39   .045     .194     .029
40   0.6641
41   0.6641
42   .0019231
43   1.0
44   .660-.670
45   .660-.670
46   mev/cm*2-sec          mrem/hr                    W/g
47   0.0      779.44   1232.0      1   0   0   0
48   0.0      779.44   1262.0      1   0   0   0
49   0.0      779.44   1292.0      1   0   0   0
50   0.0      779.44   1322.0      1   0   0   0
51   0.0      779.44   1352.0      1   0   0   0
52   0.0      779.44   1382.0      1   0   0   0
53   0.0      779.44   1412.0      1   0   0   0
54   0.0      779.44   1442.0      1   0   0   0
55   0.0      779.44   1472.0      1   0   0   0
56   0.0      779.44   1502.0      1   0   0   0
57   0.0      0.0      0.0        -1   0   0   0
```

INPUT DATA LIST

```
WAG1 W10 TANK EXPOSURE MODLE, EXPOS LIMIT DUE TO LIQ 8' ELV., QAD-CG
38 14 24 11 3 2 1 6 0 1 1 0 0 0 0 0
5.664E+13  0  0  0  0  0  0
0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
640.0    660.0    680.0    700.0    720.0    740.0    762.0
0.0      10.0     20.0     30.0     40.0     50.0     60.0     70.0
80.0     90.0     100.0    110.0    120.0    130.0    139.7
0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
6.283
  0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE LIQ. FN=W10LDMP8.INP
  RCC    10.0       0.0       0.0       0.0       0.0       139.7
           762.0
  RCC    20.0       0.0       0.0       0.0       0.0       587.44
           762.0
  RCC    30.0       0.0       0.0       0.0       0.0       587.44
           2000.0
  RPP    4-2001.0   2001.0    -2001.0   2001.0    0.0       2000.0
  END
  100    2      1
  110    2      2      -1
  120    2      3      -2      -1
  130    2      4      -1      -2      -3
  END
    1    1    1    1
    1    2    3 1000
    1    1    7    8   11   12   13   14   16   19   20   26
.111     .0       .889     .0       .0       .0       .0       .0
.0       .0       .0
.0       .00104   .00025   .0       .0       .0       .0       .0
.0       .0       .0
.0103    .0       1.062    .040     .006     .107     .737     .063
.045     .194     .029
0.6641
0.6641
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec          mrem/hr                    w/g
0.0      767.14   1232.0      1   0   0   0
0.0      767.14   1262.0      1   0   0   0
0.0      767.14   1292.0      1   0   0   0
0.0      767.14   1322.0      1   0   0   0
0.0      767.14   1352.0      1   0   0   0
0.0      767.14   1382.0      1   0   0   0
0.0      767.14   1412.0      1   0   0   0
0.0      767.14   1442.0      1   0   0   0
0.0      767.14   1472.0      1   0   0   0
0.0      767.14   1502.0      1   0   0   0
0.0      0.0      0.0        -1   0   0   0
```

```
WAG1 W10 TANK EXPOSURE MODLE, QAD-CG
1 4 24 11 4 2 1 6 0 4 1 0 0 0 0 0
3.13E+12  0  0  0  0  0  0
762.0     764.54
0.0       100.0     200.0     300.0     365.76
0.        .2618     .5236     .785      1.05      1.31      1.57      1.83
2.09      2.36      2.62      2.88      3.14      3.40      3.67      3.93
4.19      4.45      4.71      4.97      5.24      5.50      5.76      6.02
6.283
  0    0            WAG1 W10 TANK EXPOS. MODLE SLG/LIQ. FN=W10WAL.INP
  RCC     10.0      0.0       0.0       0.0       0.0       12.3
           762.0
  RCC     20.0      0.0       0.0       0.0       0.0       152.0
           762.0
  RCC     30.0      0.0       0.0       0.0       0.0       599.44
           762.0
  RCC     40.0      0.0       0.0       0.0       0.0       365.76
           764.54
  RCC     50.0      0.0       0.0       0.0       0.0       599.44
           5000.0
  RPP     5-10000.0 10000.0   -10000.0  10000.0   0.0       10000.0
  END
  100     2      1
  110     2      2     -1
  120     2      3     -1     -2
  130     2      4     -1     -2     -3
  140     2      5     -1     -2     -3     -4
  150     2      6     -1     -2     -3     -4     -5
  END
    1     1     1     1     1     1
    1     2     3     4     4 1000
    6   1     7   8    11   12    13   14    16   19    20   26
.008      .000      0.678     .026      .004      .068      .470      .040
.029      .124      .018
.111      .0        .889      .0        .0        .0        .0        .0
.0        .0        .0
.0        .00104    .00025    .0        .0        .0        .0        .0
.0        .0        .0
.0103     .0        1.062     .040      .006      .107      .737      .063
.045      .194      .029
0.6620
0.6620
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec            mrem/hr                   w/g
0.0       719.44    762.0        1   0   0   0
0.0       719.44    792.0        1   0   0   0
0.0       719.44    822.0        1   0   0   0
0.0       719.44    852.0        1   0   0   0
0.0       719.44    882.0        1   0   0   0
0.0       719.44    912.0        1   0   0   0
0.0       719.44    942.0        1   0   0   0
0.0       719.44    972.0        1   0   0   0
0.0       719.44    990.0        1   0   0   0
0.0       719.44    1022.0       1   0   0   0
0.0       719.44    1052.0       1   0   0   0
0.0       719.44    1082.0       1   0   0   0
0.0       719.44    1112.0       1   0   0   0
```

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.0 | 719.44 | 1142.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1172.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1202.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1232.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1262.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1292.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1322.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1352.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1382.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1412.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1442.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1472.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1502.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 762.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 792.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 822.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 852.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 882.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 912.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 942.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 972.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 990.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1022.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1052.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1082.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1112.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1142.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1172.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1202.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1232.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1262.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1292.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1322.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1352.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1382.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1412.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1442.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1472.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1502.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 000.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 100.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 200.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 300.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 400.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 500.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 600.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 700.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 762.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 0.000 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 100.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 200.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 300.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 400.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 500.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 600.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 700.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 762.0 | 1 | 0 | 0 | 0 |
| 0.0 | 1209.04 | 5334.0 | 1 | 0 | 0 | 0 |
| 0.0 | 0.0 | 0.0 | -1 | 0 | 0 | 0 |

```
WAG1 W10 TANK EXPOSURE MODLE, QAD-CG
1 4 24 11 4 2 1 6 0 4 1 0 0 0 0 0
3.13E+12  0  0  0  0  0  0
762.0     764.54
0.0       100.0     200.0     300.0     365.76
0.        .2618     .5236     .785      1.05      1.31      1.57      1.83
2.09      2.36      2.62      2.88      3.14      3.40      3.67      3.93
4.19      4.45      4.71      4.97      5.24      5.50      5.76      6.02
6.283
  0    0            WAG1 W10 TANK EXPOS. MODLE WALL NW FN=W10WAL.IN1
  RCC     10.0        0.0        0.0        0.0        0.0        12.3
           762.0
  RCC     20.0        0.0        0.0        0.0        0.0        152.0
           762.0
  RCC     30.0        0.0        0.0        0.0        0.0        599.44
           762.0
  RCC     40.0        0.0        0.0        0.0        0.0        365.76
           764.54
  RCC     50.0        0.0        0.0        0.0        0.0        599.44
           5000.0
  RPP     5-10000.0  10000.0   -10000.0  10000.0    0.0        10000.0
  END
  100     2      1
  110     2      2      -1
  120     2      3      -1      -2
  130     2      4      -1      -2      -3
  140     2      5      -1      -2      -3      -4
  150     2      6      -1      -2      -3      -4      -5
  END
    1     1     1     1     1     1
    1     3     3     4     4  1000
    6    1     7    8    11   12    13   14    16   19    20   26
.008      .000      0.678     .026      .004      .068      .470      .040
.029      .124      .018
.111      .0        .889      .0        .0        .0        .0        .0
.0        .0        .0
.0        .00104    .00025    .0        .0        .0        .0        .0
.0        .0        .0
.0103     .0        1.062     .040      .006      .107      .737      .063
.045      .194      .029
0.6620
0.6620
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec            mrem/hr                  w/g
0.0       719.44    762.0        1   0   0   0
0.0       719.44    792.0        1   0   0   0
0.0       719.44    822.0        1   0   0   0
0.0       719.44    852.0        1   0   0   0
0.0       719.44    882.0        1   0   0   0
0.0       719.44    912.0        1   0   0   0
0.0       719.44    942.0        1   0   0   0
0.0       719.44    972.0        1   0   0   0
0.0       719.44    990.0        1   0   0   0
0.0       719.44    1022.0       1   0   0   0
0.0       719.44    1052.0       1   0   0   0
0.0       719.44    1082.0       1   0   0   0
0.0       719.44    1112.0       1   0   0   0
```

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.0 | 719.44 | 1142.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1172.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1202.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1232.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1262.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1292.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1322.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1352.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1382.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1412.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1442.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1472.0 | 1 | 0 | 0 | 0 |
| 0.0 | 719.44 | 1502.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 762.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 792.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 822.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 852.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 882.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 912.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 942.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 972.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 990.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1022.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1052.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1082.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1112.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1142.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1172.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1202.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1232.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1262.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1292.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1322.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1352.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1382.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1412.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1442.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1472.0 | 1 | 0 | 0 | 0 |
| 0.0 | 779.44 | 1502.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 000.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 100.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 200.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 300.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 400.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 500.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 600.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 700.0 | 1 | 0 | 0 | 0 |
| 0.0 | 876.3 | 762.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 0.000 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 100.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 200.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 300.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 400.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 500.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 600.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 700.0 | 1 | 0 | 0 | 0 |
| 0.0 | 937.26 | 762.0 | 1 | 0 | 0 | 0 |
| 0.0 | 1209.04 | 5334.0 | 1 | 0 | 0 | 0 |
| 0.0 | 0.0 | 0.0 | -1 | 0 | 0 | 0 |

```
WAG1 W10 TANK EXPOSURE MODLE, QAD-CG
1 4 24 11 4 2 1 6 0 4 1 0 0 0 0 0
3.13E+12  0  0  0  0  0  0
762.0     764.54
0.0       100.0     200.0     300.0     365.76    500.0     599.44
0.        .2618     .5236     .785      1.05      1.31      1.57      1.83
2.09      2.36      2.62      2.88      3.14      3.40      3.67      3.93
4.19      4.45      4.71      4.97      5.24      5.50      5.76      6.02
6.283
  0    0            QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10WAL.INP
  RCC     10.0        0.0       0.0       0.0       0.0       12.3
           762.0
  RCC     20.0        0.0       0.0       0.0       0.0       152.0
           762.0
  RCC     30.0        0.0       0.0       0.0       0.0       599.44
           762.0
  RCC     40.0        0.0       0.0       0.0       0.0       365.76
           764.54
  RCC     50.0        0.0       0.0       0.0       0.0       599.44
           5000.0
  RPP     5-10000.0  10000.0   -10000.0  10000.0   0.0       10000.0
  END
  100     2      1
  110     2      2     -1
  120     2      3     -1     -2
  130     2      4     -1     -2     -3
  140     2      5     -1     -2     -3     -4
  150     2      6     -1     -2     -3     -4     -5
  END
    1     1    1    1    1    1
    1     2    3    4    4 1000
    6   1    7   8   11   12   13   14   16   19   20   26
.008      .000      0.678     .026      .004      .068      .470      .040
.029      .124      .018
.111      .0        .889      .0        .0        .0        .0        .0
.0        .0        .0
.0        .00104    .00025    .0        .0        .0        .0        .0
.0        .0        .0
.0103     .0        1.062     .040      .006      .107      .737      .063
.045      .194      .029
0.6620
0.6620
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec            mrem/hr                   w/g
0.0       719.44    1502.0       1   0   0   0
0.0       719.44    2074.0       1   0   0   0
0.0       719.44    3788.0       1   0   0   0
0.0       719.44    4550.0       1   0   0   0
0.0       719.44    5312.0       1   0   0   0
0.0       719.44    6074.0       1   0   0   0
0.0       779.44    1502.0       1   0   0   0
0.0       779.44    2074.0       1   0   0   0
0.0       779.44    3788.0       1   0   0   0
0.0       779.44    4550.0       1   0   0   0
0.0       779.44    5312.0       1   0   0   0
0.0       779.44    6074.0       1   0   0   0
0.0       0.0       0.0         -1   0   0   0
```

```
WAG1 W10 TANK EXPOSURE MODLE, QAD-CG
1 4 24 11 4 2 1 6 0 4 1 0 0 0 0 0
3.13E+12  0  0  0  0  0  0
762.0     764.54
0.0       100.0     200.0     300.0     365.76
0.        .2618     .5236     .785      1.05      1.31      1.57      1.83
2.09      2.36      2.62      2.88      3.14      3.40      3.67      3.93
4.19      4.45      4.71      4.97      5.24      5.50      5.76      6.02
6.283
  0    0            WAG1 W10 TANK EXPOS. MODLE WALL NW FN=W10WAL1.IN1
  RCC     10.0        0.0       0.0       0.0       0.0       12.3
           762.0
  RCC     20.0        0.0       0.0       0.0       0.0       152.0
           762.0
  RCC     30.0        0.0       0.0       0.0       0.0       599.44
           762.0
  RCC     40.0        0.0       0.0       0.0       0.0       365.76
           764.54
  RCC     50.0        0.0       0.0       0.0       0.0       599.44
           5000.0
  RPP     5-10000.0  10000.0   -10000.0  10000.0   0.0       10000.0
  END
  100     2      1
  110     2      2     -1
  120     2      3     -1     -2
  130     2      4     -1     -2     -3
  140     2      5     -1     -2     -3     -4
  150     2      6     -1     -2     -3     -4     -5
  END
    1     1     1     1     1     1
    1     3     3     4     4 1000
    6    1     7    8    11   12   13   14   16   19   20   26
.008      .000      0.678     .026      .004      .068      .470      .040
.029      .124      .018
.111      .0        .889      .0        .0        .0        .0        .0
.0        .0        .0
.0        .00104    .00025    .0        .0        .0        .0        .0
.0        .0        .0
.0103     .0        1.062     .040      .006      .107      .737      .063
.045      .194      .029
0.6620
0.6620
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec            mrem/hr                   w/g
0.0       779.44    1502.0       1   0   0   0
0.0       779.44    1532.0       1   0   0   0
0.0       779.44    1562.0       1   0   0   0
0.0       779.44    1592.0       1   0   0   0
0.0       779.44    1622.0       1   0   0   0
0.0       779.44    1652.0       1   0   0   0
0.0       779.44    1682.0       1   0   0   0
0.0       779.44    1712.0       1   0   0   0
0.0       779.44    1742.0       1   0   0   0
0.0       779.44    1772.0       1   0   0   0
0.0       779.44    1802.0       1   0   0   0
0.0       779.44    1832.0       1   0   0   0
0.0       779.44    1862.0       1   0   0   0
0.0       779.44    1892.0       1   0   0   0
0.0       0.0       0.0         -1   0   0   0
```

```
WAG1 W10 TANK EXPOSURE MODLE, QAD-CG
1 4 24 11 4 2 1 6 0 4 1 0 0 0 0 0
3.13E+12  0  0  0  0  0  0
762.0     764.54
0.0       100.0     200.0     300.0     365.76
0.        .2618     .5236     .785      1.05      1.31      1.57      1.83
2.09      2.36      2.62      2.88      3.14      3.40      3.67      3.93
4.19      4.45      4.71      4.97      5.24      5.50      5.76      6.02
6.283
  0    0            WAG1 W10 TANK EXPOS. MODLE WALL NW FN=W10WAL1.IN1
  RCC     10.0        0.0        0.0        0.0        0.0        12.3
           762.0
  RCC     20.0        0.0        0.0        0.0        0.0        152.0
           762.0
  RCC     30.0        0.0        0.0        0.0        0.0        599.44
           762.0
  RCC     40.0        0.0        0.0        0.0        0.0        365.76
           764.54
  RCC     50.0        0.0        0.0        0.0        0.0        599.44
           5000.0
  RPP     5-10000.0  10000.0   -10000.0  10000.0   0.0        10000.0
  END
  100     2       1
  110     2       2      -1
  120     2       3      -1      -2
  130     2       4      -1      -2      -3
  140     2       5      -1      -2      -3      -4
  150     2       6      -1      -2      -3      -4      -5
  END
    1     1     1     1     1     1
    1     3     3     4     4 1000
    6   1     7   8    11   12    13   14    16   19    20   26
.008      .000      0.678     .026      .004      .068      .470      .040
.029      .124      .018
.111      .0        .889      .0        .0        .0        .0        .0
.0        .0        .0
.0        .00104    .00025    .0        .0        .0        .0        .0
.0        .0        .0
.0103     .0        1.062     .040      .006      .107      .737      .063
.045      .194      .029
0.6620
0.6620
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec            mrem/hr                 w/g
0.0       719.44    1502.0        1   0   0   0
0.0       719.44    2074.0        1   0   0   0
0.0       719.44    3788.0        1   0   0   0
0.0       719.44    4550.0        1   0   0   0
0.0       719.44    5312.0        1   0   0   0
0.0       719.44    6074.0        1   0   0   0
0.0       779.44    1502.0        1   0   0   0
0.0       779.44    2074.0        1   0   0   0
0.0       779.44    3788.0        1   0   0   0
0.0       779.44    4550.0        1   0   0   0
0.0       779.44    5312.0        1   0   0   0
0.0       779.44    6074.0        1   0   0   0
0.0       0.0       0.0          -1   0   0   0
```

```
WAG1 W10 TANK EXPOSURE MODLE, EXPOS DUE SLG NO LIQ BLDG, QAD-CG
38 2 24 11 3 2 1 6 0 1 1 0 0 0 0 0
3.664E+14  0  0  0  0  0  0
0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
640.0    660.0    680.0    700.0    720.0    740.0    762.0
0.0      6.1      12.3
0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
6.283
  0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10SNWBL.INP
  RCC    10.0       0.0       0.0       0.0       0.0       12.3
          762.0
  RCC    20.0       0.0       0.0       0.0       0.0       152.0
          762.0
  RCC    30.0       0.0       0.0       0.0       0.0       599.44
          762.0
  RCC    40.0       0.0       0.0       0.0       0.0       599.44
          5000.0
  RPP    5-10000.0  10000.0   -10000.0  10000.0   0.0       10000.0
  END
  100    2      1
  110    2      2     -1
  120    2      3     -1     -2
  130    2      4     -3
  130    2      5     -1     -2     -3     -4
  END
    1    1    1    1    1
    1    2    2    3 1000
    1    1    7    8   11  12   13  14   16  19   20  26
.008     .000     0.678    .026     .004     .068     .470     .040
.029     .124     .018
.0       .00104   .00025   .0       .0       .0       .0       .0
.0       .0       .0
.0103    .0       1.062    .040     .006     .107     .737     .063
.045     .194     .029
0.6641
0.6641
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec            mrem/hr                  w/g
0.0      1209.0   5334.0       1   0   0   0
0.0      0.0      0.0         -1   0   0   0
```

```
WAG1 W10 TANK EXPOSURE MODLE, EXPPOS DUE TO SL WLS BLDG, QAD-CG
38 2 24 11 4 2 1 6 0 1 1 0 0 0 0 0
3.664E+14  0  0  0  0  0  0
0.0      20.0     40.0     60.0     80.0     100.0    120.0    140.0
160.0    180.0    200.0    220.0    240.0    260.0    280.0    300.0
320.0    340.0    460.0    380.0    400.0    420.0    440.0    460.0
480.0    500.0    520.0    540.0    560.0    580.0    600.0    620.0
640.0    660.0    680.0    700.0    720.0    740.0    762.0
0.0      6.1      12.3
0.       .2618    .5236    .785     1.05     1.31     1.57     1.83
2.09     2.36     2.62     2.88     3.14     3.40     3.67     3.93
4.19     4.45     4.71     4.97     5.24     5.50     5.76     6.02
6.283
  0    0          QAD-CG WAG1 W10 TANK EXPOS. MODLE SLUD. FN=W10SWLBL.INP
  RCC    10.0       0.0       0.0       0.0       0.0       12.3
          762.0
  RCC    20.0       0.0       0.0       0.0       0.0       152.0
          762.0
  RCC    30.0       0.0       0.0       0.0       0.0       599.44
          762.0
  RCC    40.0       0.0       0.0       0.0       0.0       599.44
          5000.0
  RPP    5-10000.0  10000.0   -10000.0  10000.0   0.0       10000.0
  END
  100    2      1
  110    2      2      -1
  120    2      3      -1      -2
  130    2      4      -3
  130    2      5      -1      -2      -3      -4
  END
    1    1    1    1    1
    1    2    3    4 1000
    1   1    7   8   11  12   13  14   16  19   20  26
.008     .000     0.678    .026     .004     .068     .470     .040
.029     .124     .018
.111     .0       .889     .0       .0       .0       .0       .0
.0       .0       .0
.0       .00104   .00025   .0       .0       .0       .0       .0
.0       .0       .0
.0103    .0       1.062    .040     .006     .107     .737     .063
.045     .194     .029
0.6641
0.6641
.0019231
1.0
.660-.670
.660-.670
mev/cm*2-sec            mrem/hr                  w/g
0.0      1209.04  5334.0       1   0   0   0
0.0      0.0      0.0         -1   0   0   0
```

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