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ARCL CALCULATION FOR DECOMMISSIONING THE 115-F GAS RECIRCULATION BUILDING

Author

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ARCL CALCULATION FOR DECOMMISSIONING THE 115-F GAS RECIRCULATION BUILDING

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Environmental Control Subsection, (E&OSS)

Approved By _____ Date 8/2/84
R. A. Winship, Manager
Decommissioning Services

FOREWARD

The calculations in this document were prepared in accordance with UNI-2522 "Allowable Residual Contamination Levels for Decommissioning Facilities in the 100 Areas of the Hanford Site", and as authorized by DOE letter dated July 3, 1984, to Contractors, Richland, Washington, from Manager DOE-RL. Since this is the first effort in decommissioning a Hanford facility using the Allowable Residual Contamination Level (ARCL) methodology, the most conservative approach was taken. Some of these conservatisms are; volume calculations limited to contaminated concrete, sample with highest activity used to calculate to curie activity and the 1 to 4 meters of clean fill over the rubble was not used to calculate final activity.

The conservative approach was followed in order to understand procedural implementation methods of the ARCL more clearly. It is significant to note that the intent of this document was to illustrate and demonstrate the decommission of the 115-F Building by demolition and in-situ burial will not cause a dose to a maximum exposed individual greater than 25 mrem/year, to the whole body or, to any organ.

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ARCL CALCULATION FOR DECOMMISSIONING THE 115-F GAS RECIRCULATION BUILDING

I. DETERMINATION OF RESIDUAL CONTAMINATION LEVELS AND ALLOWABLE RESIDUAL CONTAMINATION LEVELS (ARCL) FOR THE 115-F GAS RECIRCULATION BUILDING

A. Introduction

The purpose of these calculations are to demonstrate the Allowable Residual Contamination Level (ARCL) methodology and to show that the remaining or residual contamination in the 115-F Gas Recirculation Building is less than the allowable levels specified by the ARCL. The ARCL establishes the amount of radioactive contamination that may remain within a structure when it is demolished and buried in-situ. ARCL calculations for the 115-F Building are based upon an unrestricted use mode when the structure is rubblized and buried in-situ 1-4 meters deep. The ARCL limit provides that the residual radioactive contamination does not result in a dose to a maximum exposed individual greater than 25 mrem/yr, to the whole body or, to any organ.

The data and information that were collected and utilized in preparing the ARCL work sheets are based on the following sources:

1. Field radiological sampling and analysis.

2. UNI-946, "Radiological Characterization of the Retired 100 Areas," dated 1977.

For the purpose of this report, Cooler/Blower Room #1 is used to demonstrate how the ARCL methodology was applied to the 115-F Building. Each additional contaminated room and space in the 115-F Building was similarly treated.

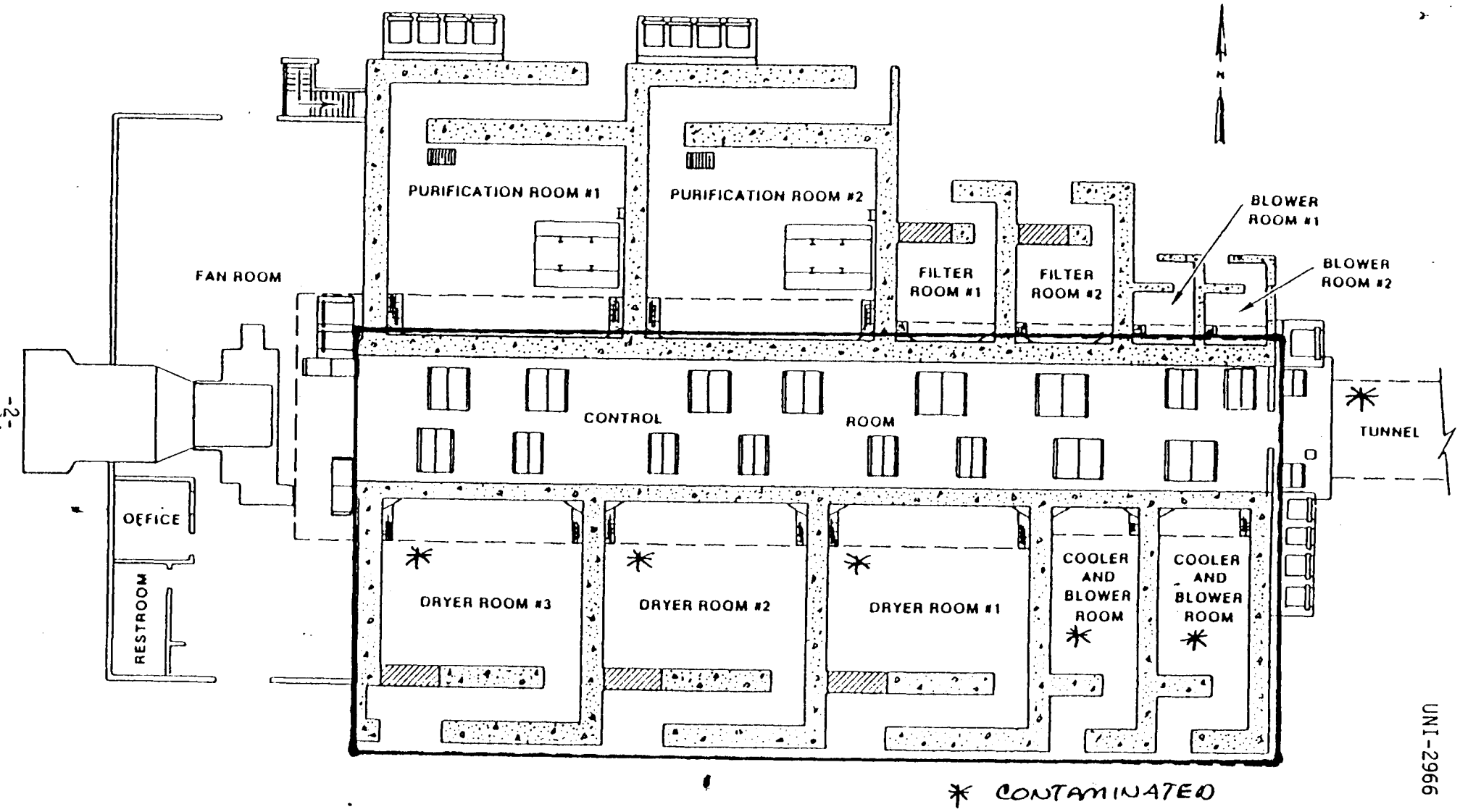
Upon completion of all 115-F Building radiological surveys, it became apparant that less than one half of the building was contaminated. Of the contaminated rooms and spaces, only a fraction of the surface area was found to be contaminated. In all cases the contamination was confined to the floor of each room. The contaminated rooms and spaces are identified below:

1. Cooler/Blower Rooms 1 and 2

2. Dryer Rooms 1, 2 and 3

3. Portion of the piping tunnel floor.

(See Figure A-1, 115-F Gas Recirculation Building)



115-F BUILDING
REACTOR GAS RECIRCULATION
100-F AREA

FIGURE A-1

UNI-2966

B. ARCL Calculations for 115-F Building Using Cooler/Blowers Room #1 as Example

Approximately one-third of the floor surface in Cooler/Blower Room #1 remained contaminated after decontamination efforts. The contamination is entirely fixed. Concrete samples were collected and analyzed on a multi-channel analyzer with a germanium detector. The only isotope identified was Cesium-137. In addition, a portable multichannel analyzer was used to scan the contaminated surface areas and Cs-137 was again the only isotope identified. (See Work Sheets for Cooler/Blower Room #1). Since the survey results reported in UNI-946 "Radiological Characterization of the Retired 100 Areas" listed activity levels of Carbon-14 and Tritium (H-3), it is assumed for the ARCL calculations that these isotopes are present in the same ratios as those found in UNI-946. Strontium-90 activities were also listed in UNI-946. However, because Sr-90 is the limiting radionuclide for determining the ARCL values, a representative concrete sample was analyzed by a strontium separation analytical technique to determine the concentration of Sr-90 actually present (UNI-946 data was based on smearable contamination). C-14 and H-3 contamination are not limiting by at least an order of magnitude compared to Sr-90 therefore the ratios obtained from the UNI-946 data are considered sufficient for the ARCL calculations.

C. Basic Assumptions

For ARCL work sheet preparation, the following assumptions were made in addition to those already present within the ARCL methodology:

1. Penetration of contamination into concrete extends to 1 cm. This is a conservative estimate.

2. The ratios between Cs-137 concentration and H-3 and C-14 have remained the same as the 1977 data reported in UNI-946.

3. The amount of radiologically clean concrete rubble assumed for dilution of the contaminated concrete was only taken to be the volume of concrete below the 1 cm deep layer of contaminated concrete surface.

4. Density of concrete was assumed to be 150 lbs/ft, based on standard industrial mixes for concrete.

D. Basic Approach

1. Determination of Residual Contamination Levels

a. Step 1 - Calculate total volume of concrete below contaminated floor surface for each room or space.

b. Step 2 - From volume calculate total mass of concrete.

c. Step 3 - Calculate volume of contaminated concrete based on an assumed radionuclide penetration of one centimeter.

d. Step 4 - From volume calculate mass of contaminated concrete to 1 cm depth.

e. Step 5 - From activity concentrations and mass of contaminated concrete, calculate toal curies content. (pCi/gm x Step 4)

f. Step 6 - Determine activity pCi/gm of rubblized concrete by using entire mass (includes clean concrete below contaminated surface) of sections of contaminated concrete floors. (Step 4 Step 2)

2. Using the following guidelines when calculating ARCL limits for each room or space.

a. When sample radioactive concentrations are fairly consistent for given room or space, use sample with highest activity to calculate ARCL.

b. When sample concentrations vary considerably (one sample result is not consistent with others) for given room or space use average activity to calculate ARCL only if the area of highest activity is small in relation to the total contaminated area. If this is not the case, use the highest activity.

E. Method of Sample Collection and Radiation Surveys

A diagram for each room was drafted and each surface (floors, walls, etc.) was divided into quadrants. Each quadrant was surveyed with portable alpha and beta-gamma instruments and micro-R-meter. Technical smears and gross masslinn smears were also collected and recorded in each quadrant. Based on the above radiological surveys, contamination on all concrete surfaces was identified, mapped and recorded.

E. Method of Sample Collection and Radiation Surveys (Cont'd)

The only surfaces which contained contamination levels above the unrestricted release levels specified in Table 5-1, UNI-M-30, REV1, "Radiation Control Manual" were floor surfaces. Therefore, concrete samples were only collected from the floor quadrants. See Section B for further information on sampling and sample analysis.

Both the cooler/blower rooms contained low level contamination. When fairly consistent activity levels were encountered for any given room or surface, the highest activity sample was taken as worst case, and the entire contaminated surface was assumed to contain this amount of activity. When sample analysis indicated a significant range of activities within a contaminated surface, the results were averaged to determine an overall activity level for the surface. Contingemt upon meeting the requirements of Section D, 2.b. This situation was encountered on the dryer rooms.

F. Determination of Residual Contamination Levels

Based on radiological surveys, the extent of contamination is determined and the dimensions of the contaminated area are established. From the contaminated surface area, the volume of contaminated concrete can be calculated. Reference Work Sheets, Cooler/Blower Room #1. The volume of the two contaminated areas are computed below:

1. Volume A = 9 cubic feet = 2.5 x 10 cm

   Volume B = 75 cubic feet = 2.1 x 10 cm

   Total - 84 cubic feet = 2.4 x 10 cm

2. The mass of concrete can then be determined using the calculated volume above.

Mass in Grams of Concrete below the Contaminated Floor Surfaces - Cooler/ Blower Room #1 =	$2.4 \times 10^6\ cm^3$	ft^3	150 lbs	450gm
		$2.8 \times 10^6\ cm^3$	ft^3	lb

$= 5.8 \times 10^6$ gm

Determination of Residual Contamination Levels (Cont'd)

3. Total Curie Inventory

Concrete samples were collected to a depth of one centimeter in the contaminated concrete surface. It is assumed that the contamination is confined within the top one cm of concrete. Total curie inventory is calculated by first determining the volume of the top one cm of the contaminated surface. From the volume the mass is calculated.

Volume of top 1 cm of contaminated surface = $7.2 \times 10^4 \, cm^3$

Mass = 1.8×10^5 gm

From isotopic analysis, the concentration of Cs-137 in cooler/blower room #1 was 1.4 pCi/gm. Based on this concentration of Cs-137, the concentrations of C-14 and H-3 can be determined by ratio from data listed in UNI-946 (reference page 7-16). The Sr-90 concentration was determined by a strontium separation analytical technique. The isotopic inventory in the cooler/blower room #1 was determined to be as follows:

Cs-137	1.4 pCi/gm	Isotopic Analysis
Sr-90	2.1 pCi/gm	Separation Technique
C-14	98 pCi/gm	UNI-946 Ratio to Cs-137
H-3	7 pCi/gm	UNI-946 Ratio to Cs-137
Total	108.5 pCi/gm	

Total curie inventory is determined from the product of the contaminated concrete mass and total activity.

Total Curie Inventory Cooler/Blower Room #1 $= \frac{109 \text{ pCi}}{\text{gm}} \cdot 1.8 \times 10^5 \text{gm}$

$= 2.0 \times 10^7 \text{pCi}$

B. Cont'd

of radionuclides does not exceed 25 mrem. A comparison of the ARCL, post decontamination survey (total of Item 6, ARCL Work Sheet) and the specific activity of the rubblized concrete, that will be buried in-situ, can be made to determine if additional decontamination is required.

C. Alpha Activity

Alpha activity was not a contributing factor in determining radioactive concentrations. Detailed radiological surveys and isotopic analyses of concrete samples did not detect any alpha activity or identify any alpha emitting isotopes.

D. Data Comparison

With respect to the Cooler/Blower Room #1, the following comparison can be made (reference Cooler/Blower Work Sheets, Appendix)

Post Decon Sample Activity	-	109 pCi/gm
Specific Activity of Rubble	-	3.4 pCi/gm
ARCL	-	59 pCi/gm

The specific activity of the rubble that will be buried 1-4 meters in soil is less than the ARCL value by a factor of 15. Based on the above data, the Cooler/Blower Room #1 could be rubblized and buried in-situ and the yearly occupational dose from the site would be considerably less than 25 mrem.

III. CONCLUSIONS

A. Summary data of all calculations are presented in Table III-1. As can be seen by comparing Item 7 (specific activity of rubblized concrete) with Item 8. (ARCL Limit)

B. Based on radiological surveys, sample analysis, UNI-946 and the ARCL methodology the 115-F Gas Recirculation Building can be demolished and buried in-situ and not produce a yearly dose greater than 25 mrem/year to a maximum exposed individual

COMPARISON OF RESIDUAL RADIOACTIVITY LEVELS AND
ARCL VALUES FOR THE 115-F GAS RECIRCULATION BUILDING

CALCULATION STEP	COOLER BLOWER #1	COOLER BLOWER #2	DRYER ROOM #1	DRYER ROOM #2	DYRER ROOM #3	TUNNEL AREA A	
1. VOLUME OF TOTAL FLOOR SECTION Units: cm^3	2.4E+6	1.3E+6	3.0E+7	2.5E+7	3.3E+7	6.3E+6	
2. MASS OF CONT. FLOOR SECTION Units: gm	5.8E+6	3.2E+6	7.2E+7	5.9E+7	7.9E+7	1.5E+7	
3. VOLUME OF CONT.FLOOR SURFACE 1 cm DEEP Units: cm^3	7.2E+4	4.4E+4	6.3E+5	4.4E+5	7.1E+5	2.1E+5	
4. MASS OF CONT. FLOOR SURFACE 1 cm DEEP Units: gm	1.8E+5	1.1E+5	1.5E+6	1.1E+6	1.7E+6	5.0E+5	
5. TOTAL CURIE INVENTORY Units: pCi (6x4)	2.0E+7	2.9E+6	1.0E+10	5.0E+6	5.2E+8	4.6E+9	
6. POST DECON SURVEY SPECIFIC ACTIVITY PRIOR TO DEMOLITION Units: pCi/gm	109	26	6940	4550	308	9111	
7. SPECIFIC ACTIVITY OF RUBBLIZED CONCRETE Units: pCi/gm (5/2)	3.4	0.91	145	84	7	306	
8. ARCL Units: pCi/gm	59	12	424	1087	82	912	

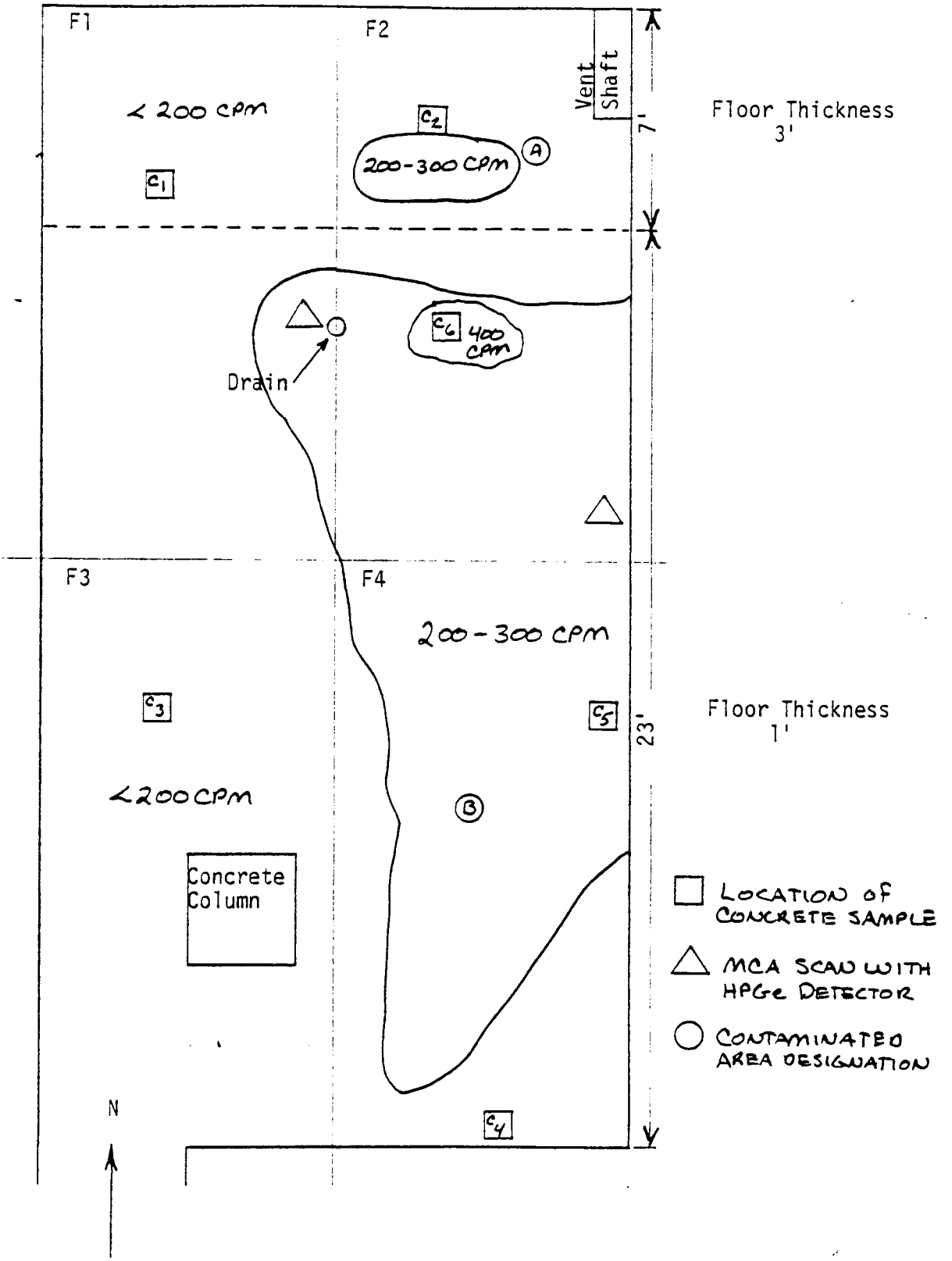
TABLE III-1

UNI-2966

APPENDIX

COOLER/BLOWER ROOM 1 UNI-2966

SAMPLE DATA LOCATIONS AND CONTAMINATION BOUNDARIES



ARCL DATA
CALCULATION WORK SHEET

BLDG./FACILITY 115F GAS RECIRC. BLDG.

DETERMINATION OF RESIDUAL CONTAMINATION LEVELS

Room/Area COOLER/BLOWER Room #1

1. Determine total surface area of contamination from survey program.

   AREA A = $3 ft^2$
   AREA B = $75 ft^2$

   TOTAL = $78 ft^2$

2. Determine total volume of contaminated concrete based on thickness of concrete.

   AREA A = $3 ft^2 \times 3 ft$
   AREA B = $75 ft^2 \times 1 ft$

   TOTAL = $8 ft^3$

   CONVERSION TO cm^3 — $2.4E+6\ cm^3$

3. Determine total mass of contaminated concrete section/area, based on volume above.

   CONCRETE DENSITY = $150 \frac{lbs}{ft^3}$

   $5.8E+6$ gm

ARCL DATA
CALCULATION WORK SHEET

4. Determine total curie inventory in contaminated concrete section/area.

   a. Assume 1 cm surface penetration. Calculate volume of contaminated concrete 1 cm thick.

   7.2 E+4 cm^3

   b. Calculate mass of contaminated concrete based on volume in 4a.

   1.8 E+5 gm

   c. Determine total curie inventory based on sample activity and mass from 4b.
   HIGHEST ACTIVITY SAMPLE WAS 1.4 pCi/gm Cs-137. NO OTHER γ ISOTOPES IDENTIFIED.
   TOTAL SPECIFIC ACTIVITY OF SAMPLE (H-3, C-14, Sr-90) WAS 109 pCi/gm

   109 pCi/gm X 4.b. above = 2.0 E+7 pCi

5. Determine specific activity for contaminated concrete when rubblized.

   STEPS 4c ÷ 3

   THIS ACTIVITY IS FOR THE PORTION OF CONCRETE IN COOLER BLOWER ROOM #1 THAT WAS CONTAMINATED. AFTER DECOMMISSIONING AND DEMOLITION, THE RUBBLE FROM CB ROOM #, WHEN BURIED 1-4 METERS IN SOIL, WILL HAVE A SPECIFIC ACTIVITY OF... 3.4 pCi/gm

CB/1

ARCL DATA
CALCULATION WORK SHEET

6. Calculate the ARCL value for the contaminated sections of concrete. For isotopic concentrations, use results from past decon concrete samples.
THE CALCULATED ARCL VALUE FOR THE CB ROOM #1 IS THE UPPER LEVEL OF ACTIVITY THAT THE RUBBLE CAN REACH BEFORE THE 25 mrem/year DOSE RATE IS REACHED.

56 pCi/gm

Compare the following:

Post Decon Analysis (AS THE 115F STANDS PRIOR TO DEMOLITION)	109	pCi/gm
Specific Activity of Rubble	3.4	
ARCL	59	

If specific activity of rubble is greater than the ARCL value, then additional decontamination should be attempted prior to demolition.

If specific activity of rubble is less than the ARCL value, then demolition can take place when appropriate approvals have been obtained.

ALLOWABLE RESIDUAL CONTAMINATION LEVEL WORKSHEET
FOR FACILITIES AT THE HANFORD SITE

1. Facility Name: 115F GAS RECIRCULATION BLDG, COOLER/BLOWER RM #1 - FOR UNRESTRICTED RELEASE IN SOIL 1-4 METERS DEEP
2. Preparer's Name: JOHN BECKSTROM
3. Date Prepared: 7/27/84
4. Determination of ARCL Dose Factors to Enter From Table 5.2.2. Check one Use Mode and one Contamination Condition.

Use Mode/Contamination Condition		Contaminated Surfaces Ci/m² or dpm/100 cm²		Surface Soil (pCi/g)		Soil 1-4 m Deep (pCi/g)		Soil ≥5 m Deep (pCi/g)	
Restricted Use @ 0.5 rem/yr		Column 1		Column 4		Column 5		Column 6	
Controlled Use @ 0.5 rem/yr		Column 2		Column 4		Column 5		Column 6	
Unrestricted Use @0.025 rem/yr	✓	Column 3		Column 4		Column 5	✓	Column 6	

5. Radionuclides Considered (List)	6. Radionuclide Concentrations (Available Units) pCi/gm	6a. Radionuclide* Concentrations ~~(Ci/m² or~~ pCi/g) RATIO	7. Scenario-Specific ARCL Dose Factors (Step 4; rem/yr per: [Ci/m² or pCi/g])	8. Product of Columns 6a & 7 (rem/yr)	9. ARCL - Product of Column 6a & Item 8b (Ci/m² or pCi/g)	10. Conversion to dpm/100 cm² Multiply Column 9 by 2.2 x 10¹⁰
Cs-137	1.4	0.013	5.3×10^{-4}	6.9×10^{-6}	0.77	
Sr-90	2.1	0.019	2.2×10^{-2}	4.2×10^{-4}	1.1	
C-14	98	0.903	1.7×10^{-8}	1.5×10^{-8}	53	
H-3	7	0.065	3.4×10^{-11}	2.2×10^{-12}	3.8	

6b. Total: 1.0
*May be taken from Decay Correction Worksheet

8a. Total: 4.2×10^{-4}
8b. Annual Dose Limit Divided by 8a.
(0.025 or 0.01/4.2×10^{-4})
= 59 = 8b

9a. Total: 59
9b. Check:
9a. Divided by 6b.
(59 ÷ 1)
= 59 = 8b? ✓ Yes

10a. Total:

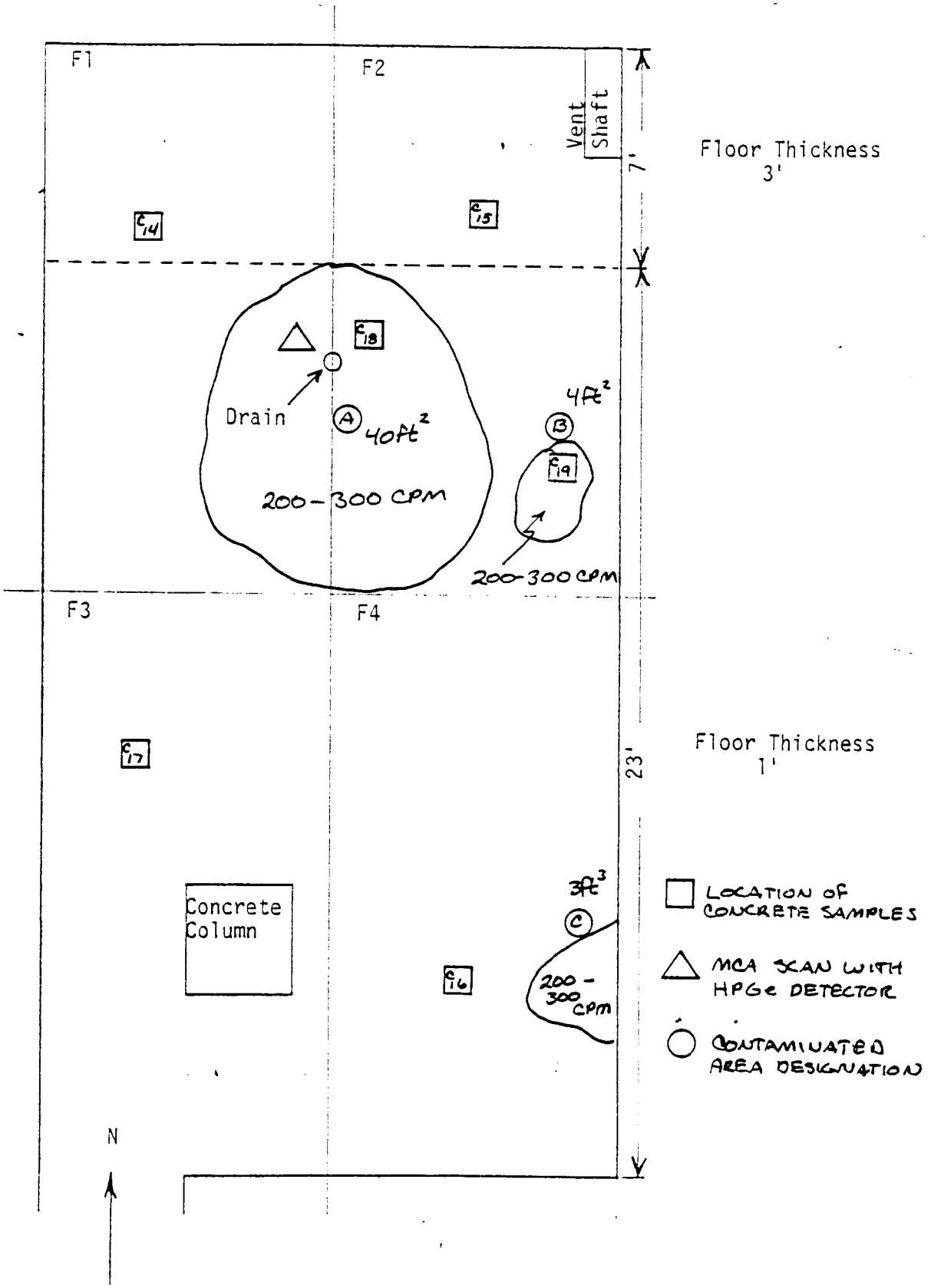
11. Present Gross Contamination Level Yielding Future ARCL of Item 9a: (Used only with Decay Correction Worksheet)
Product of Item 9a (or 10a) and Item 9 of Decay Correction Worksheet.
(9a or 10a) N/A x (9 of Figure B.4) N/A = N/A (Ci/m², pCi/g, or dpm/100 cm²)

12. Additional Notes.

UNI-2966

COOLER/BLOWER ROOM 2 UNI-2966

SAMPLE DATA LOCATIONS AND CONTAMINATION BOUNDARIES



ARCL DATA
CALCULATION WORK SHEET

BLDG./FACILITY 115 F GAS RECIRC. BLDG.

DETERMINATION OF RESIDUAL CONTAMINATION LEVELS

Room/Area COOLER/BLOWER Room # 2

1. Determine total surface area of contamination from survey program.

   Area A = 40 ft^2
   Area B = 4 ft^2
   Area C = 3 ft^2

   Total 47 ft^2

2. Determine total volume of contaminated concrete based on thickness of concrete.

   Volume = 47 ft^2 x 1 ft

   47 ft^3

   Conversion to cm^3

   1.3 E+6 cm^3

3. Determine total mass of contaminated concrete section/area, based on volume above.

   3.2 E+6 gm

ARCL DATA
CALCULATION WORK SHEET

4. Determine total curie inventory in contaminated concrete section/area.

   a. Assume 1 cm surface penetration. Calculate volume of contaminated concrete 1 cm thick.

   4.4 E+4 cm^3

   b. Calculate mass of contaminated concrete based on volume in 4a.

   1.1 E+5 gm

   c. Determine total curie inventory based on sample activity and mass from 4b.

   Total Activity

   Cs-137, Sr-90, C-14, H-3 } 26 pCi/gm

   2.9 E+6 pCi

5. Determine specific activity for contaminated concrete when rubblized.

   0.91 pCi/gm

ARCL DATA
CALCULATION WORK SHEET

6. Calculate the ARCL value for the contaminated sections of concrete. For isotopic concentrations, use results from past decon concrete samples.

12 pCi/gm

Compare the following:

Post Decon Analysis	26	pCi/gm
Specific Activity of Rubble	0.91	
ARCL	12	

If specific activity of rubble is greater than the ARCL value, then additional decontamination should be attempted prior to demolition.

If specific activity of rubble is less than the ARCL value, then demolition can take place when appropriate approvals have been obtained.

ALLOWABLE RESIDUAL CONTAMINATION LEVEL WORKSHEET
FOR FACILITIES AT THE HANFORD SITE

1. Facility Name: 115 F GAS RECIRC BLDG.; COOLER/BLOWER ROOM #2 — FOR UNRESTRICTED RELEASE IN SOIL 1-4 METERS DEEP.
2. Preparer's Name: JOHN BECKSTROM
3. Date Prepared: 7/27/84
4. Determination of ARCL Dose Factors to Enter From Table 5.2.2. Check one Use Mode and one Contamination Condition.

Use Mode/Contamination Condition		Contaminated Surfaces Ci/m² or dpm/100 cm²		Surface Soil (pCi/g)		Soil 1-4 m Deep (pCi/g)		Soil ≥5 m Deep (pCi/g)	
Restricted Use @ 0.5 rem/yr		Column 1		Column 4		Column 5		Column 6	
Controlled Use @ 0.5 rem/yr		Column 2		Column 4		Column 5		Column 6	
Unrestricted Use @ 0.025 rem/yr	✓	Column 3		Column 4		Column 5	✓	Column 6	

5. Radionuclides Considered (List)	6. Radionuclide Concentrations (Available Units) pCi/gm	6a. Radionuclide* Concentrations ~~(Ci/m² or~~ pCi/g) RATIO	7. Scenario-Specific ARCL Dose Factors (Step 4; rem/yr per: [Ci/m² or pCi/g])	8. Product of Columns 6a & 7 (rem/yr)	9. ARCL - Product of Column 6a & Item 8b (Ci/m² or pCi/g)	10. Conversion to dpm/100 cm² Multiply Column 9 by 2.2 x 10¹⁰
Cs-137	0.32	0.012	5.3×10^{-4}	6.4×10^{-6}	0.14	
Sr-90	2.5	0.095	2.2×10^{-2}	2.1×10^{-3}	1.1	
C-14	22	0.836	1.7×10^{-8}	1.4×10^{-8}	9.9	
H-3	1.5	0.057	3.4×10^{-11}	1.9×10^{-12}	0.7	

6b. Total: 1.0
*May be taken from Decay Correction Worksheet

8a. Total: 0.0021
8b. Annual Dose Limit Divided by 8a.
(0.025 or 0.05/0.0021)
= 11.8 / 12 = 8b

9a. Total: 11.8
9b. Check:
9a. Divided by 6b.
(11.8 ÷ 1)
= 11.8 = 8b? ✓ Yes

10a. Total:

11. Present Gross Contamination Level Yielding Future ARCL of Item 9a: (Used only with Decay Correction Worksheet)
Product of Item 9a (or 10a) and Item 9 of Decay Correction Worksheet.
(9a or 10a) N/A x (9 of Figure 8.4) N/A = N/A (Ci/m², PCi/g, or dpm/100 cm²)

12. Additional Notes.

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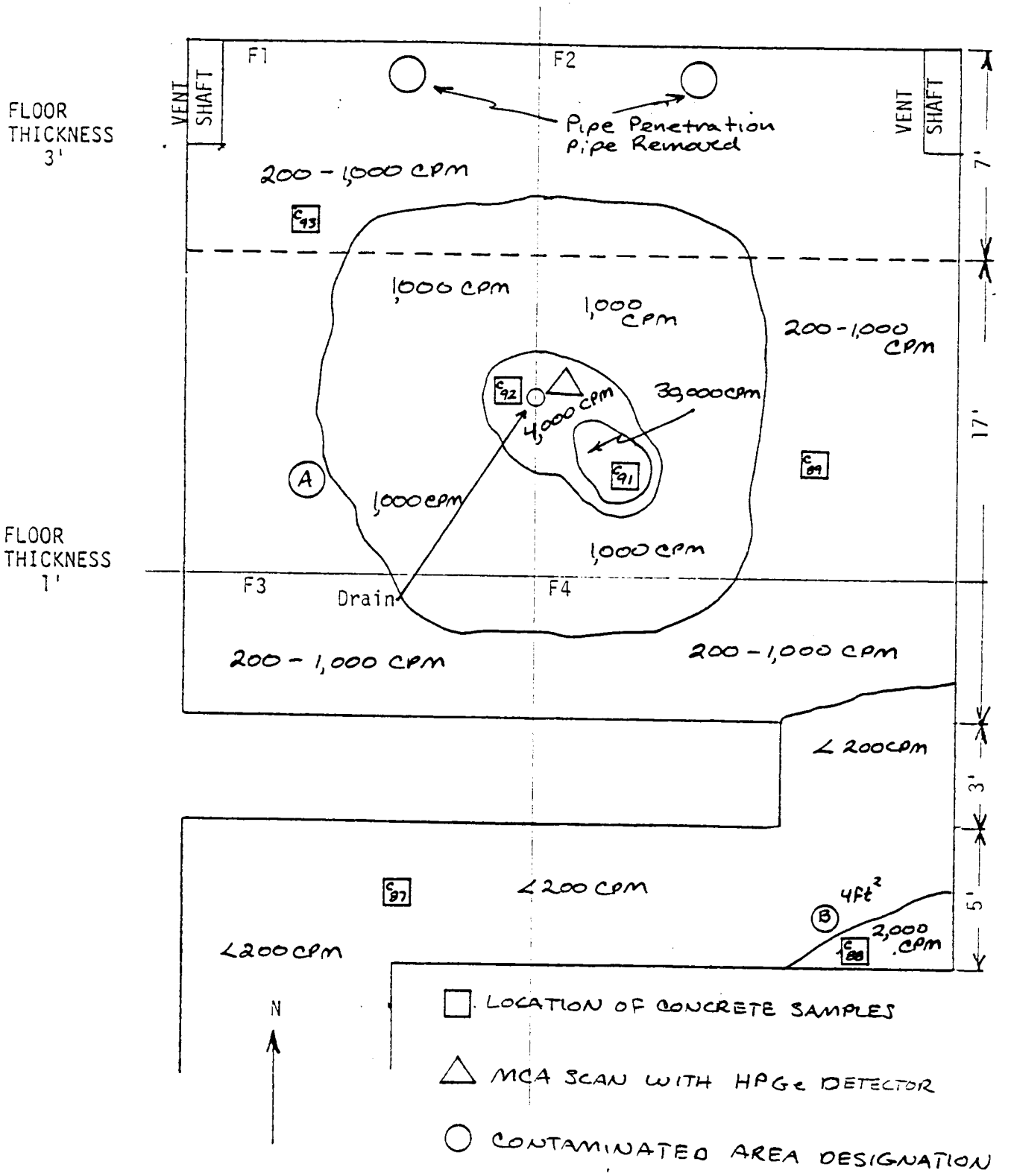
DRYER ROOM 1

SAMPLE DATA LOCATION AND CONTAMINATION BOUNDARIES



ARCL DATA
CALCULATION WORK SHEET

BLDG./FACILITY 115F GAS RECIRC. BLDG.

DETERMINATION OF RESIDUAL CONTAMINATION LEVELS

Room/Area DRYER ROOM # 1

1. Determine total surface area of contamination from survey program.

   Area A = 670 ft^2
   Area B = 4 ft^2

   Total = 674 ft^2

2. Determine total volume of contaminated concrete based on thickness of concrete.

   200 ft^2 at 3 ft
   474 ft^2 at 1 ft

   Total = 1,062 ft^2

   conversion to cm^3

   3.0E+7 cm^3

3. Determine total mass of contaminated concrete section/area, based on volume above.

   7.2E+7 gm

ARCL DATA
CALCULATION WORK SHEET

4. Determine total curie inventory in contaminated concrete section/area.

   a. Assume 1 cm surface penetration. Calculate volume of contaminated concrete 1 cm thick.

   6.3 E+5 cm^3

   b. Calculate mass of contaminated concrete based on volume in 4a.

   1.5 E+6 gm

   c. Determine total curie inventory based on sample activity and mass from 4b.

   1.0 E+10 pCi

5. Determine specific activity for contaminated concrete when rubblized.

   145 pCi/gm

ARCL DATA
CALCULATION WORK SHEET

6. Calculate the ARCL value for the contaminated sections of concrete. For isotopic concentrations, use results from past decon concrete samples.

424 pCi/gm

Compare the following:

Post Decon Analysis	6940	pCi/gm
Specific Activity of Rubble	145	
ARCL	424	

If specific activity of rubble is greater than the ARCL value, then additional decontamination should be attempted prior to demolition.

If specific activity of rubble is less than the ARCL value, then demolition can take place when appropriate approvals have been obtained.

ALLOWABLE RESIDUAL CONTAMINATION LEVEL WORKSHEET
FOR FACILITIES AT THE HANFORD SITE

1. **Facility Name:** 115 F GAS RECIRCULATION BLDG, DRYER RM #1 - FOR UNRESTRICTED RELEASE IN SOIL 1-4 METERS DEEP.
2. **Preparer's Name:** JOHN BECKSTROM
3. **Date Prepared:** 7/27/84
4. **Determination of ARCL Dose Factors to Enter From Table 5.2.2.** Check one Use Mode and one Contamination Condition.

Use Mode/Contamination Condition		Contaminated Surfaces Ci/m² or dpm/100 cm²		Surface Soil (pCi/g)		Soil 1-4 m Deep (pCi/g)		Soil ≥5 m Deep (pCi/g)	
Restricted Use @ 0.5 rem/yr		Column 1		Column 4		Column 5		Column 6	
Controlled Use @ 0.5 rem/yr		Column 2		Column 4		Column 5		Column 6	
Unrestricted Use @ 0.025 rem/yr	✓	Column 3		Column 4		Column 5	✓	Column 6	

5. Radionuclides Considered (List)	6. Radionuclide Concentrations (Available Units) pCi/gm	6a. Radionuclide* Concentrations ~~(Ci/m² or~~ pCi/g) RATIO	7. Scenario-Specific ARCL Dose Factors (Step 4; rem/yr per: [Ci/m² or pCi/g])	8. Product of Columns 6a & 7 (rem/yr)	9. ARCL - Product of Column 6a & Item 8b (Ci/m² or pCi/g)	10. Conversion to dpm/100 cm² Multiply Column 9 by 2.2 x 10¹⁰
Cs-137	92	0.0133	5.3×10^{-4}	7.0×10^{-6}	5.6	
Sr-90	16	0.0023	2.2×10^{-2}	5.1×10^{-5}	1.0	
Co-60	3	0.0004	2.2×10^{-3}	8.8×10^{-7}	0.2	
C-14	6400	0.9220	1.7×10^{-8}	1.6×10^{-8}	391	
H-3	430	0.062	3.4×10^{-11}	2.1×10^{-12}	26	
Total	69,411					

6b. Total: 1.0
*May be taken from Decay Correction Worksheet

8a. Total: 5.9×10^{-5}
8b. Annual Dose Limit Divided by 8a. (0.025 or $0.001/5.9 \times 10^{-5}$) = 424 = 8b

9a. Total: 424
9b. Check: 9a. Divided by 6b. (424 : 1) = 424 = 8b? ✓ yes

10a. Total:

11. Present Gross Contamination Level Yielding Future ARCL of Item 9a: (Used only with Decay Correction Worksheet) Product of Item 9a (or 10a) and Item 9 of Decay Correction Worksheet.
(9a or 10a) N/A x (9 of Figure B.4) N/A = N/A (Ci/m², PCi/g, or dpm/100 cm²)

12. Additional Notes.

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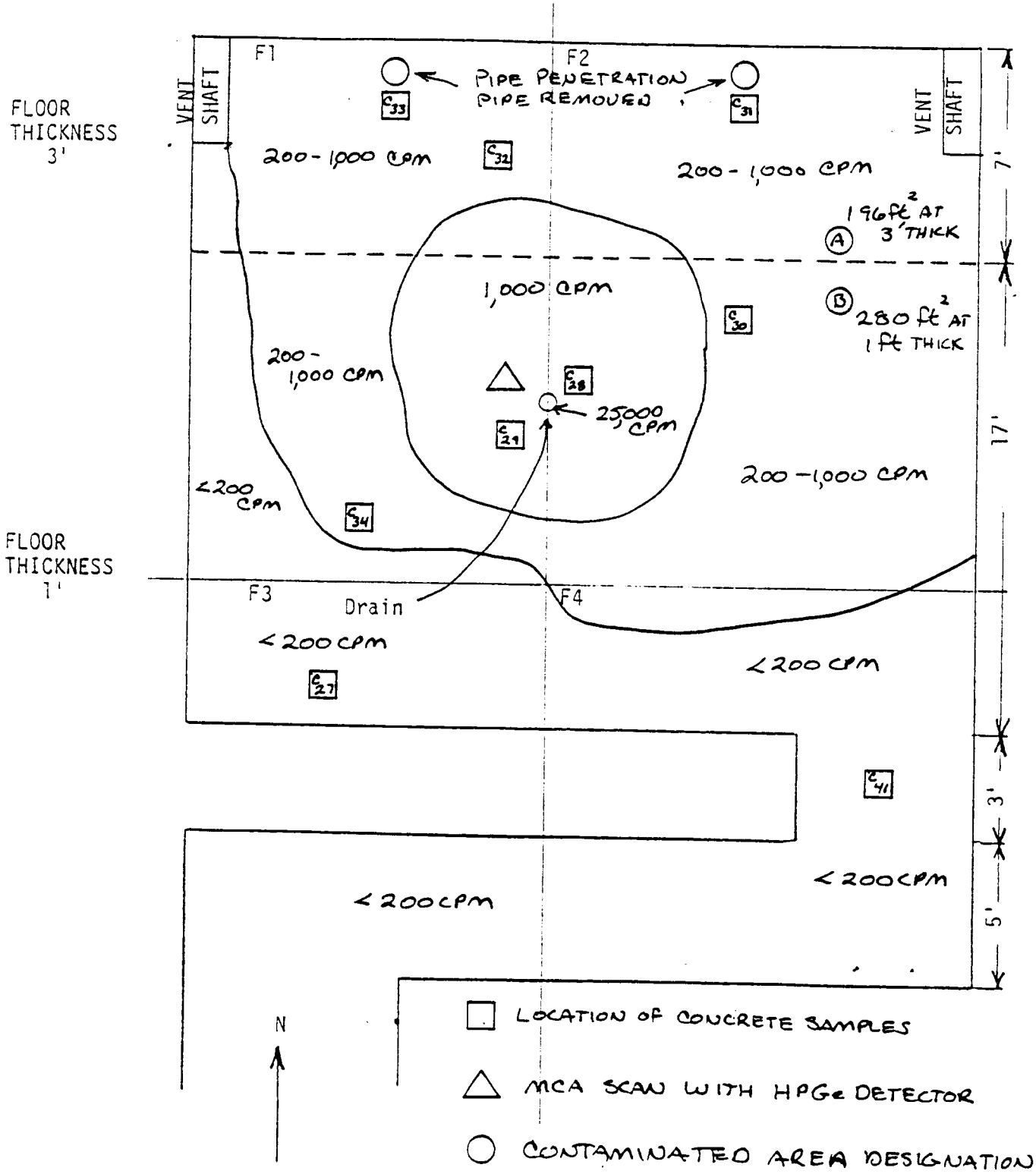
DRYER ROOM 2

SAMPLE DATA LOCATION AND CONTAMINATION BOUNDARIES



ARCL DATA
CALCULATION WORK SHEET

BLDG./FACILITY 115 F GAS RECIRC. BLDG.

DETERMINATION OF RESIDUAL CONTAMINATION LEVELS

Room/Area DRYER ROOM # 2

1. Determine total surface area of contamination from survey program.

   Area A = 196 ft^2
   Area B = 280 ft^2

   Total = 476 ft^2

2. Determine total volume of contaminated concrete based on thickness of concrete.

   Area A = 196 ft^2 x 3 ft
   Area B = 280 ft^2 x 1 ft

   Total = 868 ft^3

   Conversion to cm^3

   2.5 E+7 cm^3

3. Determine total mass of contaminated concrete section/area, based on volume above.

   5.9 E+7 gm

ARCL DATA
CALCULATION WORK SHEET

4. Determine total curie inventory in contaminated concrete section/area.

   a. Assume 1 cm surface penetration. Calculate volume of contaminated concrete 1 cm thick.

   4.4 E+5 cm^3

   b. Calculate mass of contaminated concrete based on volume in 4a.

   1.1 E+6 gm

   c. Determine total curie inventory based on sample activity and mass from 4b.

   5.0 E+6 pCi

5. Determine specific activity for contaminated concrete when rubblized.

   85 pCi/gm

ARCL DATA
CALCULATION WORK SHEET

6. Calculate the ARCL value for the contaminated sections of concrete. For isotopic concentrations, use results from past decon concrete samples.

1087 pCi/gm

Compare the following:

Post Decon Analysis	4550 pCi/gm
Specific Activity of Rubble	84 "
ARCL	1087 "

If specific activity of rubble is greater than the ARCL value, then additional decontamination should be attempted prior to demolition.

If specific activity of rubble is less than the ARCL value, then demolition can take place when appropriate approvals have been obtained.

ALLOWABLE RESIDUAL CONTAMINATION LEVEL WORKSHEET
FOR FACILITIES AT THE HANFORD SITE

1. Facility Name: 115F GAS RECIRC. BLDG, DRYER ROOM #2 – FOR UNRESTRICTED RELEASE IN SOIL 1-4 METERS DEEP
2. Preparer's Name: JOHN BECKSTROM
3. Date Prepared: 7/27/84
4. Determination of ARCL Dose Factors to Enter From Table 5.2.2. Check one Use Mode and one Contamination Condition.

Use Mode/Contamination Condition		Contaminated Surfaces Ci/m² or dpm/100 cm²		Surface Soil (pCi/g)		Soil 1-4 m Deep (pCi/g)		Soil ≥5 m Deep (pCi/g)	
Restricted Use @ 0.5 rem/yr		Column 1		Column 4		Column 5		Column 6	
Controlled Use @ 0.5 rem/yr		Column 2		Column 4		Column 5		Column 6	
Unrestricted Use @ 0.025 rem/yr	✓	Column 3		Column 4		Column 5	✓	Column 6	

5. Radionuclides Considered (List)	6. Radionuclide Concentrations (Available Units) pCi/gm	6a. Radionuclide* Concentrations ~~Ci/m² or~~ pCi/g) Ratio	7. Scenario-Specific ARCL Dose Factors (Step 4; rem/yr per: [Ci/m² or pCi/g])	8. Product of Columns 6a & 7 (rem/yr)	9. ARCL - Product of Column 6a & Item 8b (Ci/m² or pCi/g)	10. Conversion to dpm/100 cm² Multiply Column 9 by 2.2 x 10¹⁰
Cs-137	60	0.0132	5.3×10^{-4}	7.0×10^{-6}	14	
Sr-90	1.1	0.0002	2.2×10^{-2}	4.4×10^{-6}	0.2	
Co-60	20	0.0044	2.2×10^{-3}	9.7×10^{-6}	5	
Eu-152	2	0.0004	1.0×10^{-3}	4.0×10^{-7}	0.4	
Eu-154	4	0.0009	1.1×10^{-3}	9.9×10^{-7}	1.0	
C-14	4200	0.9233	1.7×10^{-9}	1.6×10^{-8}	1,000	
H-3"	280	0.0616	3.4×10^{-11}	2.1×10^{-12}	67	
Total	4,549					

6b. Total: _____
*May be taken from Decay Correction Worksheet

8a. Total: 2.3×10^{-5}
8b. Annual Dose Limit Divided by 8a. (0.025 or 0.01/2.3×10^{-5}) = 1087 = 8b

9a. Total: 1087
9b. Check: 9a. Divided by 6b. (1087 ÷ 1) = 1087 = 8b? ✓ Yes

10a. Total: _____

11. Present Gross Contamination Level Yielding Future ARCL of Item 9a: (Used only with Decay Correction Worksheet)
Product of Item 9a (or 10a) and Item 9 of Decay Correction Worksheet.
(9a or 10a) N/A x (9 of Figure B.4) N/A = N/A (Ci/m², PCi/g, or dpm/100 cm²)

12. Additional Notes.

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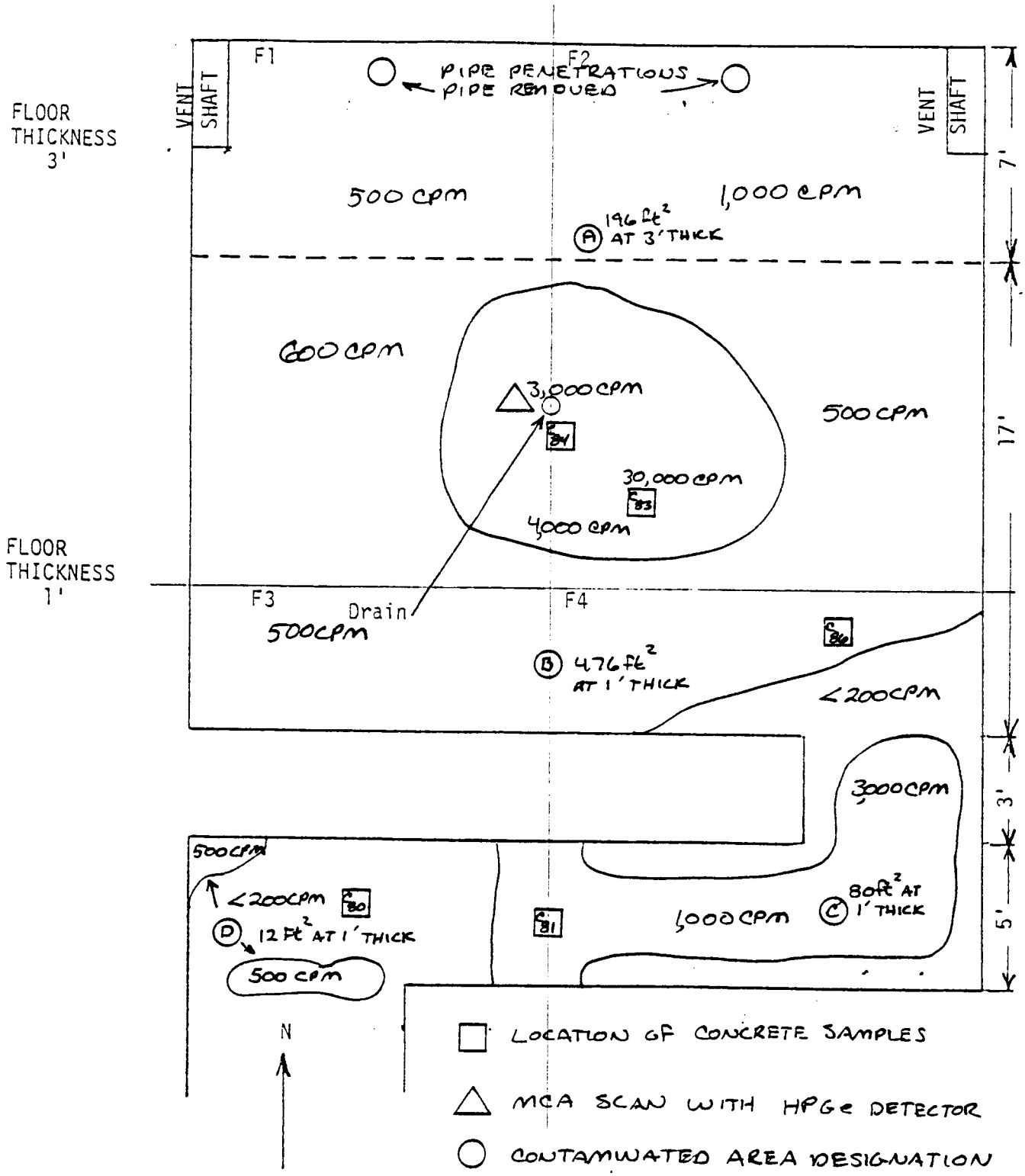
DRYER ROOM 3

SAMPLE DATA LOCATION AND CONTAMINATION BOUNDARIES



ARCL DATA
CALCULATION WORK SHEET

BLDG./FACILITY 115F GAS RECIRC. BLDG.

DETERMINATION OF RESIDUAL CONTAMINATION LEVELS

Room/Area DRYER ROOM #3

1. Determine total surface area of contamination from survey program.

Area A = 196 ft^2
B = 476 ft^2
C = 80 ft^2
D = 12 ft^2

Total = 764 ft^2

2. Determine total volume of contaminated concrete based on thickness of concrete.

Area A 3ft thick = 588 ft^3
Remainder 1ft thick = 568 ft^3

Total = 1,156 ft^3

conversion to cm^3

3.3 E+7 cm^3

3. Determine total mass of contaminated concrete section/area, based on volume above.

7.9 E+7 gm

ARCL DATA
CALCULATION WORK SHEET

4. Determine total curie inventory in contaminated concrete section/area.

   a. Assume 1 cm surface penetration. Calculate volume of contaminated concrete 1 cm thick.

   7.1 E+5 cm^3

   b. Calculate mass of contaminated concrete based on volume in 4a.

   1.7 E+6 gm

   c. Determine total curie inventory based on sample activity and mass from 4b.

   5.2 E+8 pCi

5. Determine specific activity for contaminated concrete when rubblized.

   7 pCi/gm

ARCL DATA
CALCULATION WORK SHEET

6. Calculate the ARCL value for the contaminated sections of concrete. For isotopic concentrations, use results from past decon concrete samples.

82 pCi/gm

Compare the following:

Post Decon Analysis	308	pCi/gm
Specific Activity of Rubble	?	
ARCL	82	

If specific activity of rubble is greater than the ARCL value, then additional decontamination should be attempted prior to demolition.

If specific activity of rubble is less than the ARCL value, then demolition can take place when appropriate approvals have been obtained.

ALLOWABLE RESIDUAL CONTAMINATION LEVEL WORKSHEET
FOR FACILITIES AT THE HANFORD SITE

1. Facility Name: 115F GAS RECIRCULATION BLDG, DRYER ROOM #3 — FOR UNRESTRICTED RELEASE IN SOIL 1-4 METERS DEEP.
2. Preparer's Name: JOHN BECKSTROM
3. Date Prepared: 7/27/84
4. Determination of ARCL Dose Factors to Enter From Table 5.2.2. Check one Use Mode and one Contamination Condition.

Use Mode/Contamination Condition		Contaminated Surfaces Ci/m² or dpm/100 cm²		Surface Soil (pCi/g)		Soil 1-4 m Deep (pCi/g)		Soil ≥5 m Deep (pCi/g)	
Restricted Use @ 0.5 rem/yr		Column 1		Column 4		Column 5		Column 6	
Controlled Use @ 0.5 rem/yr		Column 2		Column 4		Column 5		Column 6	
Unrestricted Use @ 0.025 rem/yr	✓	Column 3		Column 4		Column 5	✓	Column 6	

5. Radionuclides Considered (List)	6. Radionuclide Concentrations (Available Units) pCi/gm	6a. Radionuclide* Concentrations ~~(Ci/m² or~~ pCi/g) RATIO	7. Scenario-Specific ARCL Dose Factors (Step 4; rem/yr per: [Ci/m² or pCi/g])	8. Product of Columns 6a & 7 (rem/yr)	9. ARCL - Product of Column 6a & Item 8b (Ci/m² or pCi/g)	10. Conversion to dpm/100 cm² Multiply Column 9 by 2.2 x 10¹⁰
Cs-137	4	0.013	5.3×10^{-4}	6.9×10^{-6}	1.1	
Sr-90	4	0.013	2.2×10^{-2}	2.9×10^{-4}	1.1	
Co-60	1	0.0032	2.2×10^{-3}	7.0×10^{-6}	0.3	
C-14	280	0.909	1.7×10^{-8}	1.5×10^{-8}	75	
H-3	19	0.0617	3.4×10^{-11}	2.1×10^{-12}	5	
Total	308					

6b. Total: 1.0
*May be taken from Decay Correction Worksheet

8a. Total: 3.0×10^{-4}
8b. Annual Dose Limit Divided by 8a.
(0.025 or $0.01/3.0 \times 10^{-4}$)
= 82 = 8b

9a. Total: 82
9b. Check:
9a. Divided by 6b.
(82 ÷ 1)
= 82 = 8b? ✓ 4<5

10a. Total:

11. Present Gross Contamination Level Yielding Future ARCL of Item 9a: (Used only with Decay Correction Worksheet)
Product of Item 9a (or 10a) and Item 9 of Decay Correction Worksheet.
(9a or 10a) N/A x (9 of Figure B.4) N/A = N/A (Ci/m², PCi/g, or dpm/100 cm²)

12. Additional Notes.

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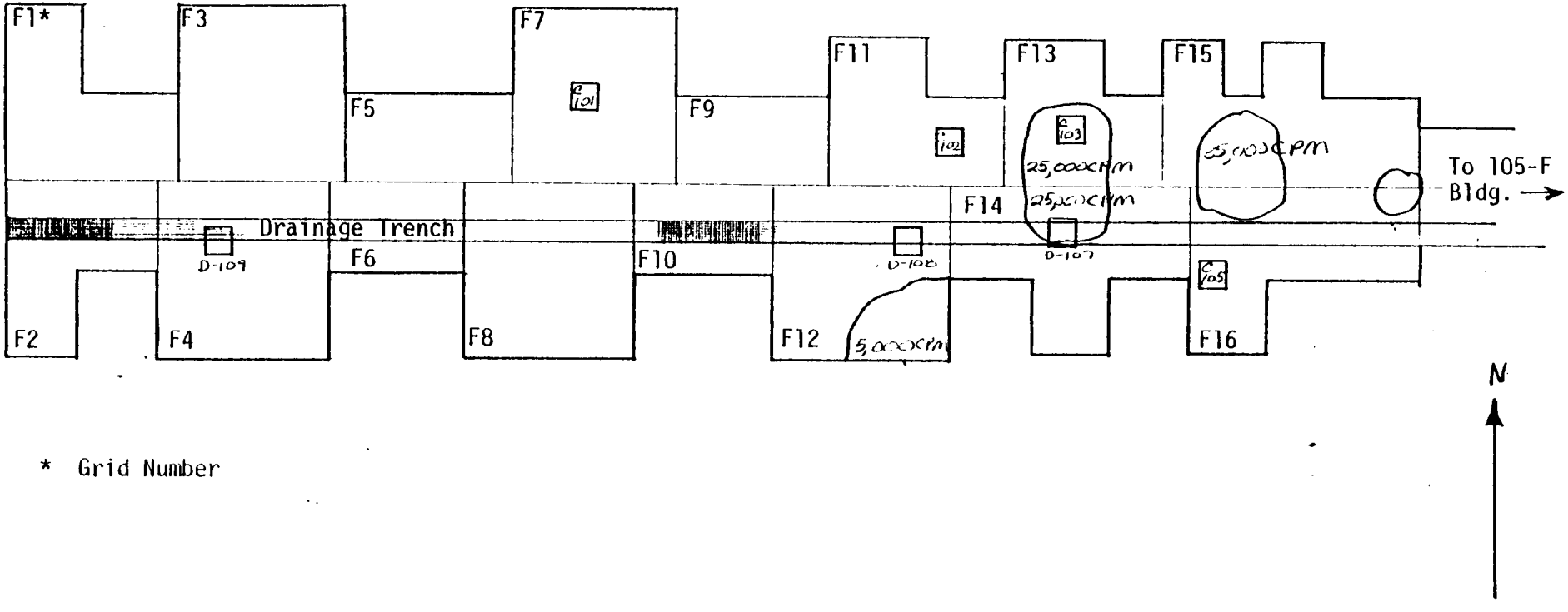

* Grid Number

GAS PIPING TUNNEL BENEATH 115-F BLDG.

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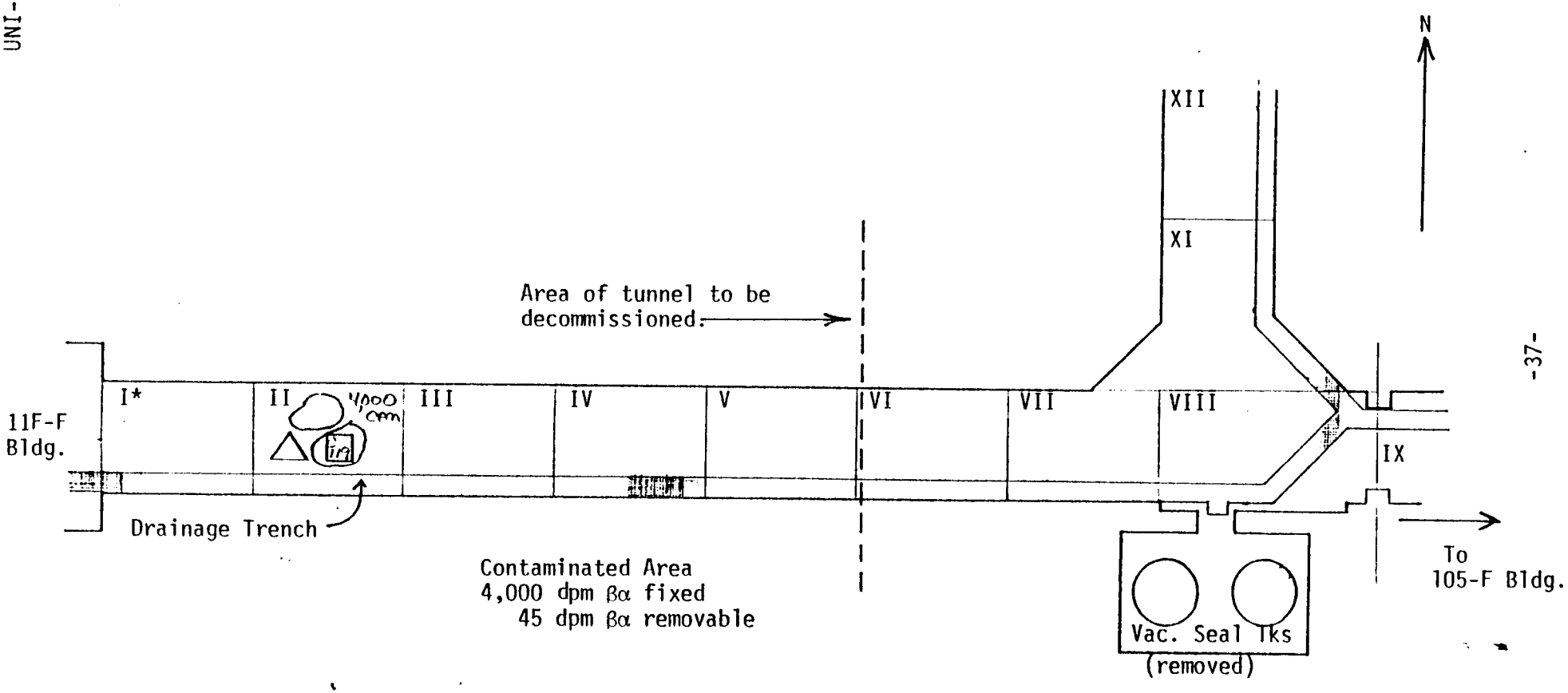
115-F GAS PIPING TUNNEL BETWEEN THE 115-F BLDG. AND 105-F BLDG.



* Grid Number

ARCL DATA
CALCULATION WORK SHEET

BLDG./FACILITY 115 F GAS RECIRC BLDG

DETERMINATION OF RESIDUAL CONTAMINATION LEVELS

Room/Area TUNNEL AREA "A".

1. Determine total surface area of contamination from survey program.

222 ft^2

2. Determine total volume of contaminated concrete based on thickness of concrete.

Concrete floor of Tunnel 1 ft thick

222 ft^3

Conversion to cm^3

6.3 E +6 cm^3

3. Determine total mass of contaminated concrete section/area, based on volume above.

1.5 E+7

Tun. "A"

ARCL DATA
CALCULATION WORK SHEET

4. Determine total curie inventory in contaminated concrete section/area.

   a. Assume 1 cm surface penetration. Calculate volume of contaminated concrete 1 cm thick.

   2.1 E+5

   b. Calculate mass of contaminated concrete based on volume in 4a.

   5.0 E+5

   c. Determine total curie inventory based on sample activity and mass from 4b.

   4.6 E+9

5. Determine specific activity for contaminated concrete when rubblized.

   306 pCi/gm

 Tun. "A"

ARCL DATA
CALCULATION WORK SHEET

6. Calculate the ARCL value for the contaminated sections of concrete. For isotopic concentrations, use results from past decon concrete samples.

912 pCi/gm

Compare the following:

Post Decon Analysis 9110 pCi/gm

Specific Activity of Rubble 306 pCi/gm

ARCL 912 pCi/gm

If specific activity of rubble is greater than the ARCL value, then additional decontamination should be attempted prior to demolition.

If specific activity of rubble is less than the ARCL value, then demolition can take place when appropriate approvals have been obtained.

ALLOWABLE RESIDUAL CONTAMINATION LEVEL WORKSHEET
FOR FACILITIES AT THE HANFORD SITE

1. Facility Name: 115F GAS RECIRC. BLDG, TUNNEL FLOOR AREA – FOR UNRESTRICTED RELEASE IN SOIL 1-4 METERS DEEP.
2. Preparer's Name: JOHN BECKSTROM
3. Date Prepared: 7/27/84
4. Determination of ARCL Dose Factors to Enter From Table 5.2.2. Check one Use Mode and one Contamination Condition.

Use Mode/Contamination Condition		Contaminated Surfaces Ci/m² or dpm/100 cm²		Surface Soil (pCi/g)		Soil 1-4 m Deep (pCi/g)		Soil ≥5 m Deep (pCi/g)	
Restricted Use @ 0.5 rem/yr		Column 1		Column 4		Column 5		Column 6	
Controlled Use @ 0.5 rem/yr		Column 2		Column 4		Column 5		Column 6	
Unrestricted Use @ 0.025 rem/yr	✓	Column 3		Column 4		Column 5	✓	Column 6	

5. Radionuclides Considered (List)	6. Radionuclide Concentrations (Available Units) pCi/g	6a. Radionuclide* Concentrations ~~(Ci/m² or~~ pCi/g) RATIO	7. Scenario-Specific ARCL Dose Factors (Step 4; rem/yr per: [Ci/m² or pCi/g])	8. Product of Columns 6a & 7 (rem/yr)	9. ARCL - Product of Column 6a & Item 8b (Ci/m² or pCi/g)	10. Conversion to dpm/100 cm² Multiply Column 9 by 2.2 x 10¹⁰
Cs-137	120	0.0132	5.3×10^{-4}	7.0×10^{-6}	12	
Sr-90	7.3	0.0008	2.2×10^{-2}	1.8×10^{-5}	6.7	
Co-60	6	0.0007	2.2×10^{-3}	1.5×10^{-6}	0.6	
Eu-152	7	0.0008	1.0×10^{-3}	8.0×10^{-7}	0.8	
Eu-154	1	0.0001	1.1×10^{-3}	1.1×10^{-7}	0.1	
C-14	8400	0.9219	1.7×10^{-8}	1.6×10^{-8}	840	
H-3*	570	0.0626	3.4×10^{-11}	2.1×10^{-12}	57	
Total	9,111					

6b. Total: 1.0
*May be taken from Decay Correction Worksheet

8a. Total: 2.7×10^{-5}
8b. Annual Dose Limit Divided by 8a. (0.025 or $0.01/2.7 \times 10^{-5}$) = 912 = 8b

9a. Total: 912
9b. Check: 9a. Divided by 6b. (912 ÷ ( )) = 912 = 8b? ✓ yes

10a. Total:

11. Present Gross Contamination Level Yielding Future ARCL of Item 9a: (Used only with Decay Correction Worksheet)
Product of Item 9a (or 10a) and Item 9 of Decay Correction Worksheet.
(9a or 10a) N/A x (9 of Figure B.4) N/A = N/A (Ci/m², pCi/g, or dpm/100 cm²)

12. Additional Notes.
Sample activities for each isotope is average of 6 samples (except Sr-90) Sr-90 UST analysis.

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