Tritium Extraction Facility Stack Height Determination

by

A. A. Simpkins

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Savannah River Site

Aiken, South Carolina 29808

DOE Contract No. DE-AC09-96SR18500

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Tritium Extraction Facility Stack Height Determination(U)

A. A. Simpkins

Technical Reviewer

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January 1998

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Key Words

Atmospheric Dispersion Dose Determination Atmospheric Release

Retention: Lifetime

Tritium Extraction Facility Stack Height Determination

A. A. Simpkins

Issued: January 1998

SRTC

SAVANNAH RIVER TECHNOLOGY CENTER

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PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

ABSTRACT

A good engineering practice (GEP) stack height has been determined for the Tritium Extraction Facility. Stack heights between 50 and 120 ft were analyzed to determine if there were any increased concentrations downwind due to building wake effects. Using EPAs "2 ½ times rule," a stack height of 100 ft was determined to be in accordance with GEP. Further detailed analysis of concentrations in the wake of a building demonstrate that a stack height of 90 ft is acceptable.

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By A. A. Simpkins

**Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808**

1. INTRODUCTION

The Tritium Extraction Facility (TEF) is a proposed facility at the Savannah River Site that will be used to extract tritium from either Commercial Light Water Reactor (CLWR) tritium producing rods or from Accelerator Production of Tritium (APT) rods. The TEF will be built adjacent to the current Replacement Tritium Facility (RTF) which is located somewhat near the center of the site in H Area.

In accordance with the Clean Air Act Amendments of 1977, Good Engineering Practices (GEP) must be used in determining the height of the stack that will be used to disperse routine emissions from TEF (EPA 1981a & EPA 1981b). With respect to stack heights, the GEP height is "the height necessary to insure that emissions from the stack do not result in excessive concentrations of any air pollutant in the immediate vicinity of the source as a result of atmospheric downwash, eddies and wakes which may be created by the source itself, nearby structures or nearby terrain obstacles." (EPA 1981a) The Environmental Protection Agency (EPA) has set specific criteria to determine if a stack is of the acceptable height. These criteria are used to determine a GEP stack height for TEF.

This work was requested by the Design Development group and the initial request and data provided is shown in Appendix A.

2. ANALYSIS

Wind passing over and around buildings creates a complicated dispersion pattern (See Figure 1 taken from EPA (1981b)). A recirculation cavity and zones of high turbulence are created on the building roof with a roof cavity region produced downwind of the structure. These regions may trap effluent material and produce high ground- or roof-level concentrations. Models that

neglect turbulence effects near structures will usually underestimate pollutant concentrations on building roofs or near buildings. Air-intake vents may be located downwind on building roofs or near the ground; therefore, an estimation of pollutant concentrations on or near a structure is important in determining expected pollutant levels. For this reason, EPA recommends considering all adjacent building structures when determining the GEP stack height.

EPA guidance is very clear on which nearby structures should be analyzed to determine if any increased concentrations could result because of the building's presence. Any building that is within a distance of $5L$ of the stack (where L is the lesser dimension of height or width of the building) needs to be considered. For the TEF, the only building that falls under this criteria is the remote handling building, which is east of the stack approximately 32m (See Figure 2.) The dimensions of the remote handling building are 15 m wide, 60 m long and 16.3 m tall. The height of the building is actually 14.8 m but it has been proposed that the building height will be increased 1.5m (5 ft) to account for modifications to some of the handling equipment. Therefore, for conservatism, this taller height is being considered in this analysis. There is a shield door housing on top of the building which adds to height for a small portion of the building. This increase in height is not being considered for the whole building.

To determine downwind concentrations, a detailed meteorological dataset is needed. Figure 3 shows the wind rose for H area based on a five-year meteorological database (Weber 1993). The percentages show the fraction of the time the wind blows toward a specified direction. Southwest is the predominant direction with all sectors in the Northeast quadrant having consistently high frequencies. Since the remote handling building is East of the stack, and the wind blows this direction about 8% of the time, this building cannot be discounted due to low wind frequency.

As shown in Figure 2, the face of the remote handling building is at about a 45 degree in relation to the stack. The effective face of the building when the plume is traveling toward the East is therefore 21 m wide. Using the $5L$ rule for the remote handling building,

$$5L = 5 * \text{minimum (H or W)}$$

$$5L = 5 * \text{minimum (16.3 or 21 m)}$$

$$5L = 81.5 \text{ m}$$

Since the stack is only 32 m away, this building must be considered. To minimize the adverse impact of this nearby building, EPA developed the following formulation for GEP stack height (EPA 1981):

$$H_g = H + 1.5L$$

where

H_g = Good Engineering Practice stack height

H = Height of the structure or nearby structure

L = Lesser dimension (height or projected width) of the structure or nearby structure

Using this equation

$$H_g = 16.3 \text{ m} + 1.5 * 16.3 \text{ m} = 40.8 \text{ m} (134 \text{ ft})$$

Often referred to as the "2 ½ times rule," this calculation is strongly supported by scientific literature. A taller or lower stack may be needed depending on "one's interpretation of what is significant influence and on the effect of plume rise." (EPA 1981a)

Under certain atmospheric conditions, downwash can serve to bring the plume to the ground and therefore result in higher ground-level concentrations near the stack. Downwash only occurs when the velocity of the effluent is sufficiently less than the wind speed. The velocity of the effluent is expected to be about 7 m/s and the average wind speed at the H Area is less than 4 m/s. Hourly average wind speed was greater than 7 m/s less than 5% of the time over the five-year period from 1987-1991. Since the velocity of the effluent is high compared to the windspeed, downwash is not expected to be a significant contributor.

Plume rise may be considered to justify decreasing the stack height. An annual average plume rise value was calculated for downwind distances which correspond to the front and back of the remote handling facility. A frequency weighted average plume rise of 11-12 m was calculated over the vicinity of the remote handling facility. See Appendix B for a detailed discussion of this analysis. Taking credit for plume rise would result in a recommended stack height of

$$H = 40.8 \text{ m} - 11 \text{ m} = 29.8 \text{ m} (98 \text{ ft})$$

Based on the "2 ½ times rule" a stack height of 100 ft is recommended which would fully support the GEP requirement (not allow adverse impacts due to nearby buildings).

Another way to justify a lower stack height is by using ground-level measurements to determine the increase in maximum concentration in the wake of the building. According to EPA rules, "Concentrations in the wake of the structure or terrain obstacle are considered excessive if the maximum ground-level concentrations are at least 40 percent greater than the maximum in the absence of their influences." Combining this with the definition of GEP stack height results in the following criteria for acceptable stack height:

$$\frac{\left(\frac{\chi}{Q_{\max}}\right)_{\text{building}}}{\left(\frac{\chi}{Q_{\max}}\right)_{\text{no building}}} < 1.4$$

where

$$\left(\frac{\chi}{Q_{\max}}\right)_{\text{building}} = \text{maximum ground level concentration with building present}$$

$$\left(\frac{\chi}{Q_{\max}}\right)_{\text{no building}} = \text{maximum ground level concentration with no building present}$$

χ = air concentration (Ci / m^3)

Q = amount released (Ci / s)

Modeling can be used to determine if concentrations will exceed desired amount. The VENTSAR XL code (Simpkins 1997) was designed to handle plume rise and building wake effects for vent or stack releases. VENTSAR XL utilizes site specific meteorology to determine relative air concentrations downwind of the release point. Analysis can be performed with or without plume rise or building structures. The effects of the remote handling facility on air concentration were analyzed using the VENTSAR XL code for stack heights ranging from 50 to 120 ft. Appendix C shows a complete listing of VENTSAR XL Output for a Stack height of 60 ft with plume rise included. The resulting annual average air concentrations as a function of distance are shown in Figures 4-11 for stack heights of 50 to 120 ft, respectively. Since the concentration in the wake of the structure can only exceed the maximum concentration in the absence of the building by a factor of 1.4, a plot was made to determine the stack height associated with such an increase. This plot is shown in Figure 12. According to this figure, the stack height would need to be between 80 and 90 feet. For conservatism, a stack height of 90 ft is assumed to be the minimum allowed that will not exceed desired concentrations.

Figures 13 and 14 show the dose as a function of distance for winds blowing to the NW where the Central Training Facility (766-H) and Saltstone (221-S) are located. Doses were calculated using annual average air concentrations and assuming the individual was present in the training facility 250 days per year for 8 hours per day. The source term used for this analysis is shown in Table 1. The maximum Committed Effective Dose Equivalent (CEDE) at the training facility was determined to be 0.05 mrem and the maximum CEDE at DWPF was determined to be 0.06 mrem. Radiation workers at SRS received an average dose of 12 mrem through the third quarter of 1997 (WSRC 1997). The DOE limit for members of the public is 100 mrem/yr of exposure (DOE 1990). The average person in the US receives about 1 mrem/day from natural background radiation, so an additional fraction of a mrem per year is negligible.

Table 1. Expected Atmospheric Annual Release Source Term
as a Result of TEF Operations (Narrows 1997)

Radionuclide	Quantity (Ci)
H-3	1.0E+04
C-14	4.2E-05
Co-60	4.2E-01

3. CONCLUSIONS

Using the simple EPA "2 ½ times rule" and accounting for plume rise, the height of the stack for the Tritium Extraction Facility should be approximately 100 ft. Further analysis demonstrates that lowering the stack to 90 ft would still be within the EPA limit of increased concentrations as a result of the structure. Dose calculations demonstrate no adverse effects to workers in downwind buildings.

Figure 1. Diagrammatic outline of the envelope and cavity regions in the wake of a building (vertical section).

Figure 2. Tritium Extraction Facility Layout.

Figure 3. H Area Wind Rose

Figure 4. Annual Average Concentration vs Distance
(Stack Height=50 ft)

Figure 5. Annual Average Concentration vs Distance
(Stack Height=60 ft)

Figure 6. Annual Average Concentration vs Distance
(Stack Height=70 ft)

Figure 7. Annual Average Concentration vs Distance
(Stack Height=80 ft)

Figure 8. Annual Average Concentration vs Distance
(Stack Height=90 ft)

Figure 9. Annual Average Concentration vs Distance
(Stack Height=100 ft)

Figure 10. Annual Average Concentration vs Distance
(Stack Height =110 ft)

Figure 11. Annual Average Concentration vs Distance
(Stack Height=120 ft)

Figure 12. Ratio of X/Q vs Stack Height

Figure 13. CEDE vs Distance for 766-H

Figure 14. CEDE vs Distance for DWPF

4.0 REFERENCES

DOE 1990, *Radiation Protection of the Public and the Environment*, Department of Energy Order 5400.5, US DOE, Washington DC, June 5, 1990.

EPA 1981a, *Guideline for Use of Fluid Modeling to Determine Good Engineering Practice Stack Height*, Environmental Protection Agency, EPA-450/4-81-003, July 1981.

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Narrows, William. *Tritium Extraction Facility Radioactive Airborne Release Determination*, M-CLC-H-01519, Rev. A, Westinghouse Savannah River Company, Aiken, SC, 12/10/97.

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Weber, A. 1993, *Comparison of Savannah River Site's Meteorological Databases(U)*, WSRC-RP-93-269, Westinghouse Savannah River, Aiken, SC 29808.

WSRC 1997, *Savannah River Site Radiological Performance- 3rd Quarter 1997*, ESH-SHP-97-0131, Westinghouse Savannah River Company, Aiken, SC 29808.

Appendix A. Work Request and Additional Data Provided

Author: John Purucker at SRCCH03

Date: 12/18/97 3:53 PM

Priority: Normal

TO: Brent Blunt at SRCCA02, Ali Simpkins at SRCCA08

CC: George Vozniak at SRCCA03, Suresh02 Patel at SRCCH04, William Narrows at SRCCH01,
Michael Cercy at SRCCB04, Clifton Rice, Henry King at SRCCB13, Dale Parrott at SRCCB09

TO: Tom Seeley at SRCCB01

Subject: CLWR-TEF STACK HEIGHT DETERMINATION

Based on a meeting conducted today with Messrs. Blunt, Narrows, Patel and Purucker the following work is authorized:

TASK DESCRIPTION- CLWR-TEF STACK HEIGHT DETERMINATION

OBJECTIVE- The objective is to define the height and basis for the CLWR-TEF stack.

CALCULATION RESULTS- For a range of stack heights calculate X/Q values, resultant dose values and evaluation of doses resulting in a recommended stack height. Key dose locations will be in the immediate vicinity of TEF, 233-H Area, Training Center and DWPF.

This should be in the format of a Technical Report

CALCULATION PARAMETERS-

Stack Heights- Parametric evaluation of stack heights from 50' to 120'.

Stack Flow Rate- The desire is to keep the stack no higher than 100'. Increased exit velocity can be used in the design to assist in plume rise. Bill Narrows or Suresh Patel have the details of the HVAC flow rates and stack diameter.

Building Information- Bill Narrows can supply the appropriate drawings.

SCHEDULE- Start January 1998. Complete by January 30, 1998.

AUTHORIZATION- 100 mh is authorized for this task.

ACTIVITY CODE- Please charge E6091ENGs, TWC DZ81.

CONTACT PERSON- Bill Narrows, 2-9461, 730-1B, fax 2-8666.

Author: William Narrows at SRCCH01

Date: 1/9/98 12:37 PM

Priority: Normal

TO: Ali Simpkins at SRCCA08

CC: Suresh02 Patel at SRCCH04

Subject: Site Plan, Stack Diameter, Maxium Flowrate, Aux Power Flowra

Ali-

The answers are as follows:

1. The site plan is being sent PJS this morning (1/9/98). Building heights are below:

Building	Building Height
TEF/Support Building	< 30 ft
Diesel Generator Building	< 15 ft
Chiller Building	< 15 ft
RHA	58 ft. (344-291) + 5 = 58 ft (C-SOW-H-00009-215, 216)
Cooling Towers	<15 ft
Substation	< 12 ft
Liquid Nitrogen Tanks	< 20 ft
233-22H	<20 ft (est. from walk down)
234-H	<25 ft (est. from walk down)
Fire protection Valve House	< 15 ft
H&V Supply Units	< 20 ft

2. The stack diameter basis is 6 ft. The basis is from the project estimate which assumes the DWPF stack.

3. The maximum flowrate is 50,000 SCFM.

4. The flowrate when the facility is on Aux power is 50,000 SCFM.

If you have any questions with regard to this information please call me at 2-9461.

-Bill

Author: William Narrows at SRCCH01
Date: 1/16/98 7:25 AM
Priority: Normal
TO: Ali Simpkins at SRCCA08
CC: Suresh02 Patel at SRCCH04
Subject: Re[2]: Site Plan, Stack Diameter, Maxium Flowrate, Aux Power

Ali-

The 50,000 SCFM is a maximum not a normal flow. I did not understand that when I have previously sent you the data. For the purposes of the calculation use 40,000 SFCM as the minimum flowrate. Also, how much would the stack have to move? a few feet might be possible but if it is more then a few feet then taller stack may be preferable. Please include both options in the calculation per our discussion.

Thank you,
Bill

Forward Header

Bill,

Is it a possibility to position the stack elsewhere? How was the location determined? I don't think the 100 ft stack is going to fly in its current location. I am still analyzing, but I am running out of options.

Thanks,
Ali

Forward Header

Subject: Re[2]: Site Plan, Stack Diameter, Maxium Flowrate, Aux Power
Author: William Narrows at SRCCH01
Date: 1/14/98 4:40 PM

Ali-

The stack flow will be 50,000 SCFM on both normal and backup power.

-Bill

MR LANG, Please confirm that this is correct by responding to this message (to all addresses please). Thank you, Bill

---

Reply Separator

Subject: Re: Site Plan, Stack Diameter, Maxium Flowrate, Aux Power Fl
Author: Ali Simpkins at SRCCA08
Date: 1/14/98 11:01 AM

Bill,

Are you sure that the back up generator provides the same CFM as the max flow rate? This seems a little odd to me. Does this mean that any time the stack is running (period) that it is 50,000 CFM. Please let me know.

Appendix B. Plume Rise Calculations

Appendix B. Plume Rise Calculations

Plume rise may occur because the initial vertical velocity of the effluent is great enough to elevate the plume. Plume rise due to momentum effects near the source for unstable to neutral weather conditions (Stability Classes A-D) is determined by the following equation (Briggs 1976):

$$\Delta h_M = \left[\frac{3\pi}{4\beta^2} \right]^{1/3} \left[\frac{DV_e M_o}{U} \right]^{2/3} X^{1/3} \quad (1)$$

where:

$\beta = 0.4 + 1.2U/V_e$, (unitless),

U wind speed (m/s)

V_e effluent velocity (m/s)

D diameter of the stack (m)

X downwind distance (m)

M_o measure of relative density of effluent plume to that of air (1 for this calc)

For ease in calculation within the spreadsheet the equation is rewritten as

$$\Delta h_M = [B1 * X * DHMOM^2]^{1/3} \quad (2)$$

where

$$B1 = \frac{0.75 * \pi}{(0.4 + 1.2U / V_e)^2} \quad (3)$$

$$DHMOM = D * \frac{V_e}{U} * M_o \quad (4)$$

with all terms previously defined.

The above equation is applicable for all distances less than XTEST where

$$XTEST = \frac{27.0 DHMOM}{B1} \quad (5)$$

For distances where $X > X_{TEST}$ the increase in plume height due to momentum effects is given by the following equation (Briggs 1969):

$$\Delta h_M = 3DHMOM \quad (6)$$

For stable weather conditions (Stability Classes E, F, and G) the change in plume height due to momentum effects is equal to the minimum of the following two equations (Briggs 1969):

$$\Delta h_M = 4.0 \sqrt{\frac{DHMOM * U}{2S^{1/2}}} \quad (7)$$

$$\Delta h_M = 1.5 \left(\frac{DHMOM^2 * U}{4S^{1/2}} \right)^{1/3} \quad (8)$$

where S is the stability parameter which is discussed in Hanna (1982).

The following page shows the calculation of plume rise for the east sector for a distance of 33 m which would be directly on top of the remote handling facility. For a downwind distance of 91 m (near the end of the remote handling facility), the plume rise only slightly increases to 12 m.

References

- Briggs, G.A. , 1969 *Plume Rise*, Air Resources Atmospheric Turbulence and Diffusion Laboratory, TID-25075, USAEC, Division of Technical Information.
- Briggs, G.A., 1976 "Plume Rise Predictions", *Lectures on Air Pollution and Environmental Impact Analyses*, American Meteorological Society, Boston, Mass.
- Hanna, S. R., 1982 and G. A. Briggs, and R. P. Hosker, Jr., *Handbook on Atmospheric Diffusion*. DOE/TIC-11223 (DE82002045) Technical Information Center, USDOE.

[illegible]

Freq. Wt	Total	11.28
	HM(m)	

[illegible]

Appendix C. VENTSAR XL OUTPUT

Appendix C. VENTSAR XL Output

The following page shows the input template used for the VENTSAR XL analysis. The pages that follow show the annual average air concentrations as a function of distance. The doses shown in this table are NOT appropriate for use with this stack height determination because they are based on worst case methodology with conditions that are only exceeded five percent of the time.

VENTSAR XL					
TEF 50 ft, PR,Building Ali Simpkins, 5-9643					
		Units	VAL	RANGE	
Meteorological File Name	SRS				
OR enter "SRS" and coordin					
SRS Grid Coordinates Eastin	61470	ft	0	120000	
Northin	73410	ft	0	120000	
Building Dimensions					
Building Height	16.3	m	0	1000	
Building Width	21	m	0	1000	
Building Length	60	m	0	1000	
Penthouse Height	0	m	0	1000	
Penthouse Width	0	m	0	1000	
Penthouse Length	0	m	0	1000	
Distance to Penthouse on R	0	m	0	1000	
Minimum Distance of Interest	10	m	10	99999	
Maximum Distance of Interest	1000	m	10	100000	
Number of Increments	200		1	200	
Compass Sector of Building (1-N, 2-NNE, 3-NE ...)	5		1	16	
Distance of Vent from Roof (negative is upwind)	-32		-1000	1000	
Vent Height	18.3	m	0	500	
Radioactive Calculations(Y or N)	y				
If No Mole Fraction of Vent Gas	0.00E+00				
Vent Gas Flow Rate	18.9	m3/s	0	1000	
Averaging Option (Y or N)	y				
If YES Specify Probability Level	0.005		0.001	0.5	
If NO Windspeed at Vent Height		m/s	0.1	15	
Stability Class(1-7 to A-G)			1	7	
Plume Rise(Y or N)	y				
Vent Diameter	1.83	m	0.001	100	
Gas Molecular Weight	29		0	400	
Vent Gas Temperature	30	C			
Ambient Air Temperature	30	C			
Calculate Dose?(Y or N)	y				
Inhalation Rate	10500	m^3/y	8000	20000	
Radionuclide	Curies				
H-3	1.00E+04				
C-14	4.20E-06				
Co-60	4.20E-01				

	99.50%		Annual	Inhalation	Plume Shine	Total
Distance	x/Q		Average	Dose	Dose	Dose
(m)	s/m^3		s/m^3	(mrem)	(mrem)	(mrem)
10.0	3.76E-33	10.0	5.08E-24	1.27E-27	6.51E-31	1.27E-27
15.0	1.17E-17	15.0	1.18E-15	3.93E-12	2.02E-15	3.93E-12
19.9	4.98E-12	19.9	1.19E-12	1.68E-06	8.62E-10	1.68E-06
24.9	2.24E-09	24.9	4.65E-11	7.54E-04	3.87E-07	7.54E-04
29.8	6.25E-08	29.8	5.27E-10	2.11E-02	1.08E-05	2.11E-02
34.8	5.76E-04	34.8	7.79E-06	1.94E+02	9.96E-02	1.94E+02
39.7	5.78E-04	39.7	9.47E-06	1.95E+02	9.99E-02	1.95E+02
44.7	4.47E-04	44.7	8.17E-06	1.51E+02	7.73E-02	1.51E+02
49.6	3.42E-04	49.6	7.03E-06	1.15E+02	5.92E-02	1.15E+02
54.6	2.73E-04	54.6	6.19E-06	9.20E+01	4.72E-02	9.20E+01
59.5	2.24E-04	59.5	5.54E-06	7.55E+01	3.87E-02	7.55E+01
64.5	1.87E-04	64.5	5.00E-06	6.31E+01	3.24E-02	6.31E+01
69.4	1.59E-04	69.4	4.54E-06	5.35E+01	2.74E-02	5.35E+01
74.4	1.36E-04	74.4	4.16E-06	4.59E+01	2.35E-02	4.59E+01
79.3	1.18E-04	79.3	3.83E-06	3.97E+01	2.04E-02	3.98E+01
84.3	1.09E-04	84.3	3.81E-06	3.68E+01	1.89E-02	3.68E+01
89.2	1.02E-04	89.2	3.82E-06	3.45E+01	1.77E-02	3.45E+01
94.2	3.94E-05	94.2	8.21E-07	1.33E+01	6.82E-03	1.33E+01
99.1	4.69E-05	99.1	9.00E-07	1.58E+01	8.11E-03	1.58E+01
104.1	5.32E-05	104.1	9.73E-07	1.79E+01	9.20E-03	1.79E+01
109.0	5.83E-05	109.0	1.04E-06	1.97E+01	1.01E-02	1.97E+01
114.0	6.24E-05	114.0	1.09E-06	2.10E+01	1.08E-02	2.11E+01
118.9	6.56E-05	118.9	1.13E-06	2.21E+01	1.13E-02	2.21E+01
123.9	3.15E-05	123.9	1.03E-06	1.06E+01	5.45E-03	1.06E+01
128.8	3.54E-05	128.8	1.13E-06	1.19E+01	6.13E-03	1.19E+01
133.8	4.93E-05	133.8	1.21E-06	1.66E+01	8.53E-03	1.66E+01
138.7	4.86E-05	138.7	1.29E-06	1.64E+01	8.40E-03	1.64E+01
143.7	4.95E-05	143.7	1.35E-06	1.67E+01	8.56E-03	1.67E+01
148.6	4.47E-05	148.6	1.38E-06	1.51E+01	7.73E-03	1.51E+01
153.6	4.00E-05	153.6	1.40E-06	1.35E+01	6.92E-03	1.35E+01
158.5	3.88E-05	158.5	1.42E-06	1.31E+01	6.72E-03	1.31E+01
163.5	3.97E-05	163.5	1.44E-06	1.34E+01	6.86E-03	1.34E+01
168.4	4.03E-05	168.4	1.46E-06	1.36E+01	6.98E-03	1.36E+01
173.4	4.09E-05	173.4	1.47E-06	1.38E+01	7.07E-03	1.38E+01
178.3	4.12E-05	178.3	1.48E-06	1.39E+01	7.14E-03	1.39E+01
183.3	4.15E-05	183.3	1.49E-06	1.40E+01	7.18E-03	1.40E+01
188.2	4.11E-05	188.2	1.49E-06	1.38E+01	7.11E-03	1.39E+01
193.2	4.09E-05	193.2	1.50E-06	1.38E+01	7.08E-03	1.38E+01
198.1	4.07E-05	198.1	1.50E-06	1.37E+01	7.04E-03	1.37E+01
203.1	4.04E-05	203.1	1.50E-06	1.36E+01	6.98E-03	1.36E+01
208.0	4.00E-05	208.0	1.50E-06	1.35E+01	6.92E-03	1.35E+01
213.0	3.96E-05	213.0	1.50E-06	1.33E+01	6.85E-03	1.34E+01
217.9	3.18E-05	217.9	1.50E-06	1.07E+01	5.50E-03	1.07E+01
222.9	3.23E-05	222.9	1.50E-06	1.09E+01	5.59E-03	1.09E+01
227.8	3.27E-05	227.8	1.49E-06	1.10E+01	5.66E-03	1.10E+01
232.8	3.31E-05	232.8	1.49E-06	1.12E+01	5.73E-03	1.12E+01

237.7	3.34E-05	237.7	1.48E-06	1.13E+01	5.78E-03	1.13E+01
242.7	3.36E-05	242.7	1.48E-06	1.13E+01	5.81E-03	1.13E+01
247.6	3.38E-05	247.6	1.47E-06	1.14E+01	5.84E-03	1.14E+01
252.6	3.39E-05	252.6	1.47E-06	1.14E+01	5.86E-03	1.14E+01
257.5	3.39E-05	257.5	1.46E-06	1.14E+01	5.87E-03	1.14E+01
262.5	3.39E-05	262.5	1.45E-06	1.14E+01	5.87E-03	1.14E+01
267.4	3.39E-05	267.4	1.44E-06	1.14E+01	5.86E-03	1.14E+01
272.4	3.33E-05	272.4	1.43E-06	1.12E+01	5.75E-03	1.12E+01
277.3	3.26E-05	277.3	1.42E-06	1.10E+01	5.65E-03	1.10E+01
282.3	3.20E-05	282.3	1.42E-06	1.08E+01	5.54E-03	1.08E+01
287.2	3.14E-05	287.2	1.41E-06	1.06E+01	5.44E-03	1.06E+01
292.2	3.08E-05	292.2	1.40E-06	1.04E+01	5.34E-03	1.04E+01
297.1	3.03E-05	297.1	1.39E-06	1.02E+01	5.24E-03	1.02E+01
302.1	2.97E-05	302.1	1.38E-06	1.00E+01	5.14E-03	1.00E+01
307.0	2.91E-05	307.0	1.37E-06	9.82E+00	5.04E-03	9.82E+00
312.0	2.86E-05	312.0	1.36E-06	9.63E+00	4.94E-03	9.63E+00
316.9	2.86E-05	316.9	1.35E-06	9.66E+00	4.96E-03	9.66E+00
321.9	2.85E-05	321.9	1.34E-06	9.61E+00	4.93E-03	9.61E+00
326.8	2.83E-05	326.8	1.33E-06	9.55E+00	4.90E-03	9.56E+00
331.8	2.78E-05	331.8	1.32E-06	9.36E+00	4.81E-03	9.37E+00
336.7	2.77E-05	336.7	1.31E-06	9.35E+00	4.80E-03	9.36E+00
341.7	2.77E-05	341.7	1.30E-06	9.33E+00	4.79E-03	9.34E+00
346.6	2.76E-05	346.6	1.29E-06	9.31E+00	4.78E-03	9.31E+00
351.6	2.75E-05	351.6	1.28E-06	9.28E+00	4.76E-03	9.29E+00
356.5	2.74E-05	356.5	1.27E-06	9.25E+00	4.75E-03	9.25E+00
361.5	2.72E-05	361.5	1.26E-06	9.17E+00	4.70E-03	9.17E+00
366.4	2.69E-05	366.4	1.25E-06	9.08E+00	4.66E-03	9.08E+00
371.4	2.67E-05	371.4	1.24E-06	8.99E+00	4.61E-03	8.99E+00
376.3	2.64E-05	376.3	1.23E-06	8.90E+00	4.57E-03	8.90E+00
381.3	2.61E-05	381.3	1.22E-06	8.81E+00	4.52E-03	8.81E+00
386.2	2.58E-05	386.2	1.21E-06	8.71E+00	4.47E-03	8.72E+00
391.2	2.56E-05	391.2	1.20E-06	8.62E+00	4.42E-03	8.63E+00
396.1	2.53E-05	396.1	1.19E-06	8.53E+00	4.38E-03	8.53E+00
401.1	2.50E-05	401.1	1.19E-06	8.44E+00	4.33E-03	8.44E+00
406.0	2.50E-05	406.0	1.18E-06	8.44E+00	4.33E-03	8.45E+00
411.0	2.49E-05	411.0	1.17E-06	8.41E+00	4.32E-03	8.41E+00
415.9	2.48E-05	415.9	1.16E-06	8.37E+00	4.30E-03	8.38E+00
420.9	2.68E-05	420.9	1.15E-06	9.03E+00	4.63E-03	9.03E+00
425.8	2.68E-05	425.8	1.14E-06	9.04E+00	4.64E-03	9.04E+00
430.8	2.68E-05	430.8	1.14E-06	9.04E+00	4.64E-03	9.04E+00
435.7	2.68E-05	435.7	1.13E-06	9.04E+00	4.64E-03	9.04E+00
440.7	2.68E-05	440.7	1.12E-06	9.03E+00	4.64E-03	9.04E+00
445.6	2.68E-05	445.6	1.11E-06	9.03E+00	4.63E-03	9.03E+00
450.6	2.67E-05	450.6	1.11E-06	9.02E+00	4.63E-03	9.02E+00
455.5	2.67E-05	455.5	1.10E-06	9.00E+00	4.62E-03	9.01E+00
460.5	2.67E-05	460.5	1.09E-06	8.99E+00	4.61E-03	8.99E+00
465.4	2.66E-05	465.4	1.09E-06	8.97E+00	4.60E-03	8.97E+00
470.4	2.65E-05	470.4	1.08E-06	8.95E+00	4.59E-03	8.95E+00
475.3	2.65E-05	475.3	1.07E-06	8.93E+00	4.58E-03	8.93E+00

480.3	2.64E-05	480.3	1.06E-06	8.90E+00	4.57E-03	8.91E+00
485.2	2.63E-05	485.2	1.06E-06	8.87E+00	4.55E-03	8.88E+00
490.2	2.62E-05	490.2	1.05E-06	8.85E+00	4.54E-03	8.85E+00
495.1	2.61E-05	495.1	1.05E-06	8.82E+00	4.52E-03	8.82E+00
500.1	2.60E-05	500.1	1.04E-06	8.78E+00	4.51E-03	8.79E+00
505.0	2.60E-05	505.0	1.03E-06	8.75E+00	4.49E-03	8.75E+00
510.0	2.58E-05	510.0	1.03E-06	8.72E+00	4.47E-03	8.72E+00
514.9	2.57E-05	514.9	1.02E-06	8.68E+00	4.45E-03	8.68E+00
519.9	2.56E-05	519.9	1.01E-06	8.64E+00	4.44E-03	8.65E+00
524.8	2.55E-05	524.8	1.01E-06	8.60E+00	4.42E-03	8.61E+00
529.8	2.54E-05	529.8	1.00E-06	8.56E+00	4.40E-03	8.57E+00
534.7	2.53E-05	534.7	9.96E-07	8.52E+00	4.37E-03	8.53E+00
539.7	2.52E-05	539.7	9.91E-07	8.48E+00	4.35E-03	8.49E+00
544.6	2.50E-05	544.6	9.85E-07	8.44E+00	4.33E-03	8.45E+00
549.6	2.49E-05	549.6	9.79E-07	8.40E+00	4.31E-03	8.40E+00
554.5	2.48E-05	554.5	9.74E-07	8.36E+00	4.29E-03	8.36E+00
559.5	2.47E-05	559.5	9.68E-07	8.31E+00	4.27E-03	8.32E+00
564.4	2.45E-05	564.4	9.63E-07	8.27E+00	4.24E-03	8.27E+00
569.4	2.44E-05	569.4	9.58E-07	8.22E+00	4.22E-03	8.23E+00
574.3	2.43E-05	574.3	9.52E-07	8.18E+00	4.20E-03	8.18E+00
579.3	2.41E-05	579.3	9.47E-07	8.13E+00	4.17E-03	8.14E+00
584.2	2.40E-05	584.2	9.42E-07	8.09E+00	4.15E-03	8.09E+00
589.2	2.38E-05	589.2	9.37E-07	8.04E+00	4.13E-03	8.05E+00
594.1	2.37E-05	594.1	9.32E-07	8.00E+00	4.10E-03	8.00E+00
599.1	2.36E-05	599.1	9.27E-07	7.95E+00	4.08E-03	7.95E+00
604.0	2.34E-05	604.0	9.22E-07	7.91E+00	4.06E-03	7.91E+00
609.0	2.33E-05	609.0	9.17E-07	7.86E+00	4.03E-03	7.86E+00
613.9	2.32E-05	613.9	9.12E-07	7.81E+00	4.01E-03	7.81E+00
618.9	2.30E-05	618.9	9.07E-07	7.77E+00	3.99E-03	7.77E+00
623.8	2.29E-05	623.8	9.02E-07	7.72E+00	3.96E-03	7.72E+00
628.8	2.27E-05	628.8	8.97E-07	7.67E+00	3.93E-03	7.67E+00
633.7	2.29E-05	633.7	8.93E-07	7.73E+00	3.97E-03	7.74E+00
638.7	2.29E-05	638.7	8.88E-07	7.72E+00	3.96E-03	7.73E+00
643.6	2.29E-05	643.6	8.83E-07	7.71E+00	3.96E-03	7.71E+00
648.6	2.28E-05	648.6	8.79E-07	7.70E+00	3.95E-03	7.70E+00
653.5	2.28E-05	653.5	8.74E-07	7.68E+00	3.94E-03	7.69E+00
658.5	2.27E-05	658.5	8.70E-07	7.67E+00	3.94E-03	7.67E+00
663.4	2.27E-05	663.4	8.65E-07	7.65E+00	3.93E-03	7.66E+00
668.4	2.27E-05	668.4	8.61E-07	7.64E+00	3.92E-03	7.64E+00
673.3	2.26E-05	673.3	8.56E-07	7.62E+00	3.91E-03	7.63E+00
678.3	2.26E-05	678.3	8.52E-07	7.61E+00	3.90E-03	7.61E+00
683.2	2.25E-05	683.2	8.48E-07	7.59E+00	3.90E-03	7.59E+00
688.2	2.25E-05	688.2	8.43E-07	7.57E+00	3.89E-03	7.58E+00
693.1	2.14E-05	693.1	8.39E-07	7.21E+00	3.70E-03	7.21E+00
698.1	2.15E-05	698.1	8.35E-07	7.25E+00	3.72E-03	7.26E+00
703.0	2.16E-05	703.0	8.31E-07	7.30E+00	3.74E-03	7.30E+00
708.0	2.18E-05	708.0	8.26E-07	7.34E+00	3.77E-03	7.34E+00
712.9	2.19E-05	712.9	8.22E-07	7.38E+00	3.79E-03	7.38E+00
717.9	2.20E-05	717.9	8.18E-07	7.42E+00	3.81E-03	7.42E+00

722.8	2.21E-05	722.8	8.14E-07	7.46E+00	3.83E-03	7.46E+00
727.8	2.22E-05	727.8	8.10E-07	7.49E+00	3.84E-03	7.50E+00
732.7	2.23E-05	732.7	8.06E-07	7.53E+00	3.86E-03	7.53E+00
737.7	2.24E-05	737.7	8.02E-07	7.56E+00	3.88E-03	7.56E+00
742.6	2.25E-05	742.6	7.98E-07	7.59E+00	3.90E-03	7.59E+00
747.6	2.26E-05	747.6	7.94E-07	7.62E+00	3.91E-03	7.63E+00
752.5	2.27E-05	752.5	7.90E-07	7.65E+00	3.93E-03	7.65E+00
757.5	2.28E-05	757.5	7.86E-07	7.68E+00	3.94E-03	7.68E+00
762.4	2.28E-05	762.4	7.82E-07	7.70E+00	3.95E-03	7.71E+00
767.4	2.29E-05	767.4	7.79E-07	7.73E+00	3.97E-03	7.73E+00
772.3	2.30E-05	772.3	7.75E-07	7.75E+00	3.98E-03	7.76E+00
777.3	2.31E-05	777.3	7.71E-07	7.78E+00	3.99E-03	7.78E+00
782.2	2.31E-05	782.2	7.67E-07	7.80E+00	4.00E-03	7.80E+00
787.2	2.32E-05	787.2	7.64E-07	7.82E+00	4.01E-03	7.82E+00
792.1	1.91E-05	792.1	7.60E-07	6.45E+00	3.31E-03	6.45E+00
797.1	1.96E-05	797.1	7.56E-07	6.62E+00	3.40E-03	6.63E+00
802.0	2.02E-05	802.0	7.53E-07	6.79E+00	3.49E-03	6.80E+00
807.0	2.07E-05	807.0	7.49E-07	6.97E+00	3.58E-03	6.97E+00
811.9	2.08E-05	811.9	7.45E-07	7.02E+00	3.60E-03	7.02E+00
816.9	2.13E-05	816.9	7.42E-07	7.18E+00	3.69E-03	7.19E+00
821.8	2.18E-05	821.8	7.38E-07	7.35E+00	3.77E-03	7.35E+00
826.8	2.23E-05	826.8	7.35E-07	7.51E+00	3.85E-03	7.52E+00
831.7	2.28E-05	831.7	7.31E-07	7.68E+00	3.94E-03	7.68E+00
836.7	2.32E-05	836.7	7.28E-07	7.81E+00	4.01E-03	7.81E+00
841.6	2.32E-05	841.6	7.24E-07	7.83E+00	4.02E-03	7.83E+00
846.6	2.33E-05	846.6	7.21E-07	7.85E+00	4.03E-03	7.86E+00
851.5	2.34E-05	851.5	7.17E-07	7.88E+00	4.04E-03	7.88E+00
856.5	2.34E-05	856.5	7.14E-07	7.90E+00	4.05E-03	7.90E+00
861.4	2.35E-05	861.4	7.11E-07	7.92E+00	4.06E-03	7.92E+00
866.4	2.35E-05	866.4	7.07E-07	7.94E+00	4.07E-03	7.94E+00
871.3	2.35E-05	871.3	7.04E-07	7.94E+00	4.07E-03	7.94E+00
876.3	2.36E-05	876.3	7.01E-07	7.94E+00	4.08E-03	7.95E+00
881.2	2.36E-05	881.2	6.97E-07	7.95E+00	4.08E-03	7.95E+00
886.2	2.36E-05	886.2	6.94E-07	7.95E+00	4.08E-03	7.95E+00
891.1	2.36E-05	891.1	6.91E-07	7.95E+00	4.08E-03	7.95E+00
896.1	2.36E-05	896.1	6.88E-07	7.97E+00	4.09E-03	7.97E+00
901.0	2.38E-05	901.0	6.84E-07	8.02E+00	4.11E-03	8.02E+00
906.0	2.38E-05	906.0	6.81E-07	8.01E+00	4.11E-03	8.01E+00
910.9	2.37E-05	910.9	6.78E-07	8.00E+00	4.11E-03	8.01E+00
915.9	2.37E-05	915.9	6.75E-07	8.00E+00	4.10E-03	8.00E+00
920.8	2.37E-05	920.8	6.72E-07	7.99E+00	4.10E-03	8.00E+00
925.8	2.37E-05	925.8	6.69E-07	7.98E+00	4.10E-03	7.99E+00
930.7	2.37E-05	930.7	6.66E-07	7.98E+00	4.09E-03	7.98E+00
935.7	2.36E-05	935.7	6.63E-07	7.97E+00	4.09E-03	7.97E+00
940.6	2.36E-05	940.6	6.60E-07	7.96E+00	4.09E-03	7.96E+00
945.6	2.36E-05	945.6	6.57E-07	7.95E+00	4.08E-03	7.96E+00
950.5	2.36E-05	950.5	6.54E-07	7.94E+00	4.08E-03	7.95E+00
955.5	2.35E-05	955.5	6.51E-07	7.93E+00	4.07E-03	7.94E+00
960.4	2.35E-05	960.4	6.48E-07	7.92E+00	4.07E-03	7.93E+00

965.4	2.35E-05	965.4	6.45E-07	7.91E+00	4.06E-03	7.92E+00
970.3	2.34E-05	970.3	6.42E-07	7.90E+00	4.06E-03	7.91E+00
975.3	2.34E-05	975.3	6.39E-07	7.89E+00	4.05E-03	7.89E+00
980.2	2.34E-05	980.2	6.36E-07	7.88E+00	4.04E-03	7.88E+00
985.2	2.33E-05	985.2	6.33E-07	7.87E+00	4.04E-03	7.87E+00
990.1	2.33E-05	990.1	6.30E-07	7.86E+00	4.03E-03	7.86E+00
995.1	2.33E-05	995.1	6.28E-07	7.84E+00	4.03E-03	7.85E+00
1000.0	2.32E-05	1000.0	6.25E-07	7.83E+00	4.02E-03	7.83E+00

Tritium Extraction Facility Stack Height Determination

DISTRIBUTION (20)

S. Wood, 773-A
D. B. Moore-Shedrow, 773-A
J.B. Gladden, 773-42A
B. Blunt, 742-A
W. H. Carlton, 773-42A
M. Cercey, 730-1B
G.T. Jannik, 773-A
W. Narrows, 730-1B
S. Patel, 730-1B
J. Purucker, 730-1B
A. A. Simpkins, 773-A

SRTC Records(4), 773 - 52A
EDG Records(5), 773 - A