Y-12 Site Experience with Deposition Velocity Issues

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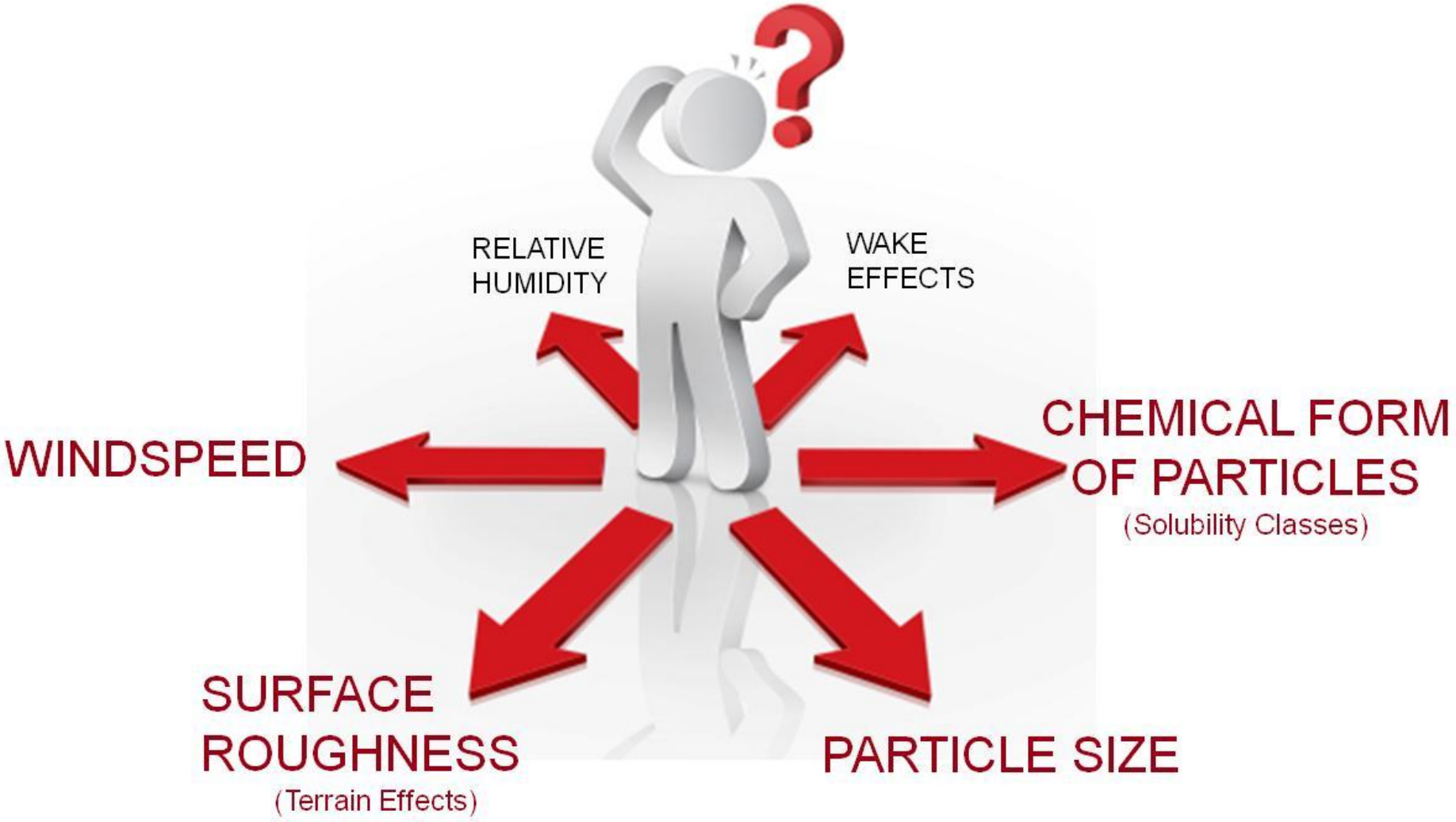
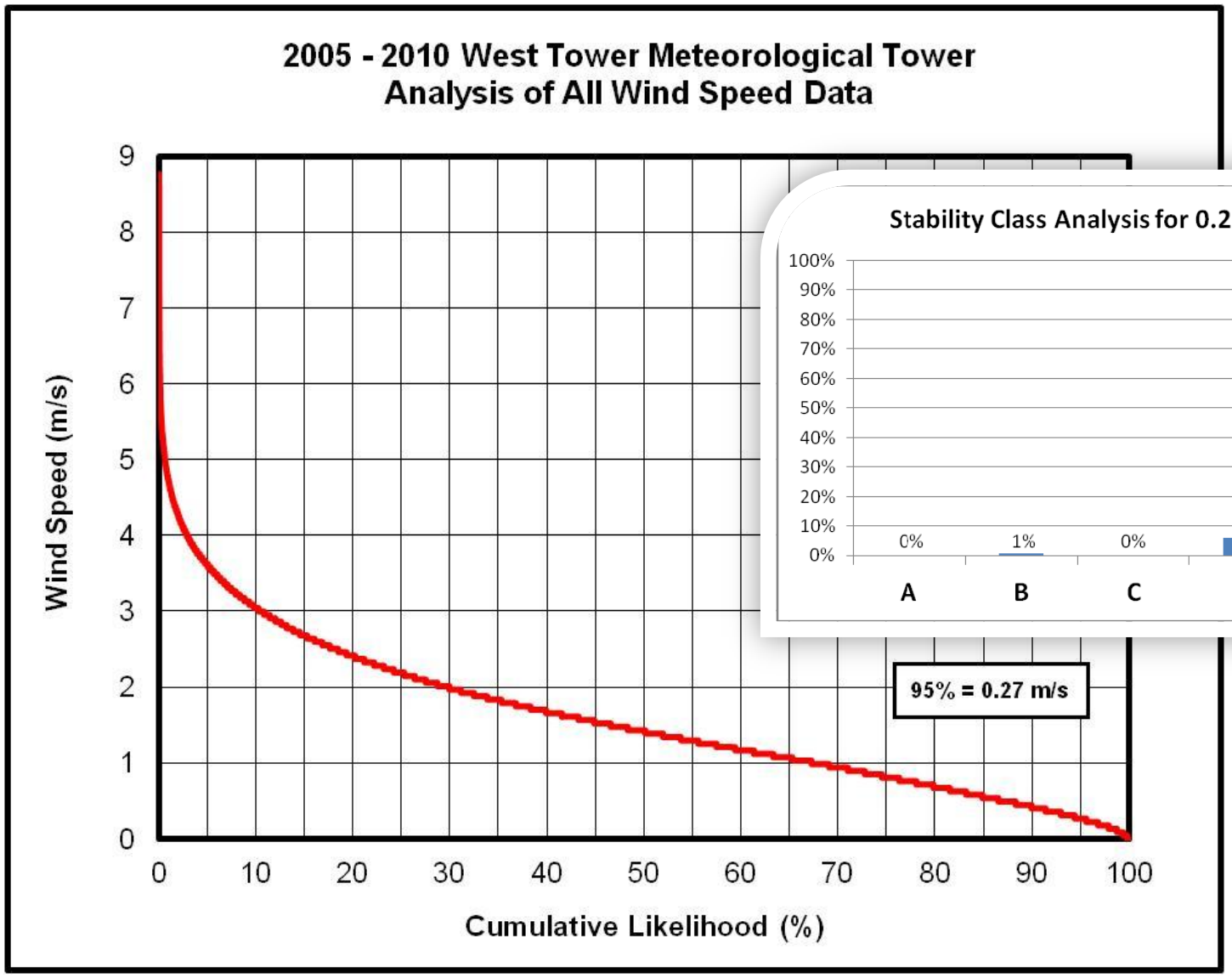
National Nuclear Security Administration

Y-12 National Security Complex

Y-12 Specific Issues



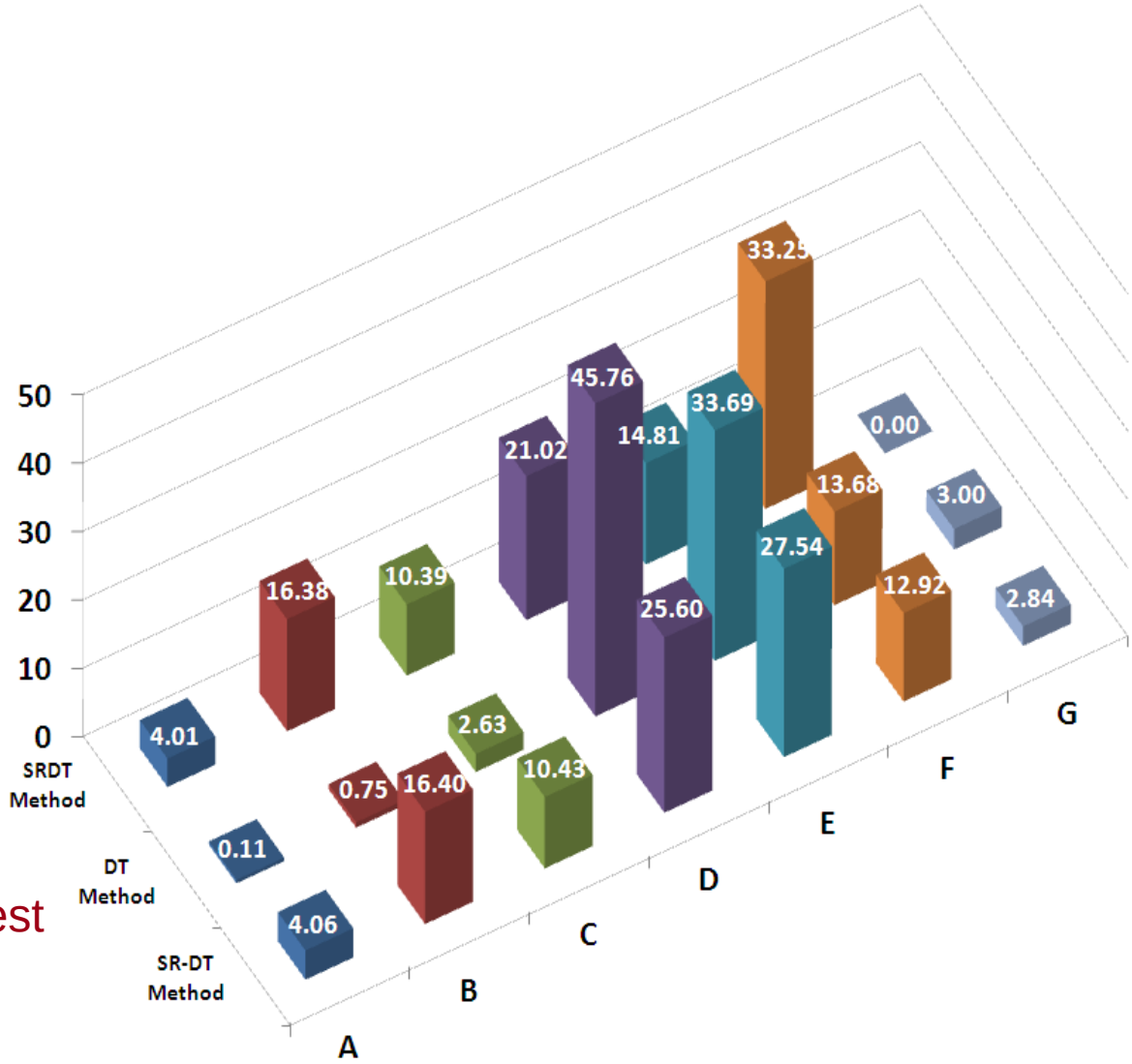
Windspeed – Calm Wind Conditions at Y-12 Site



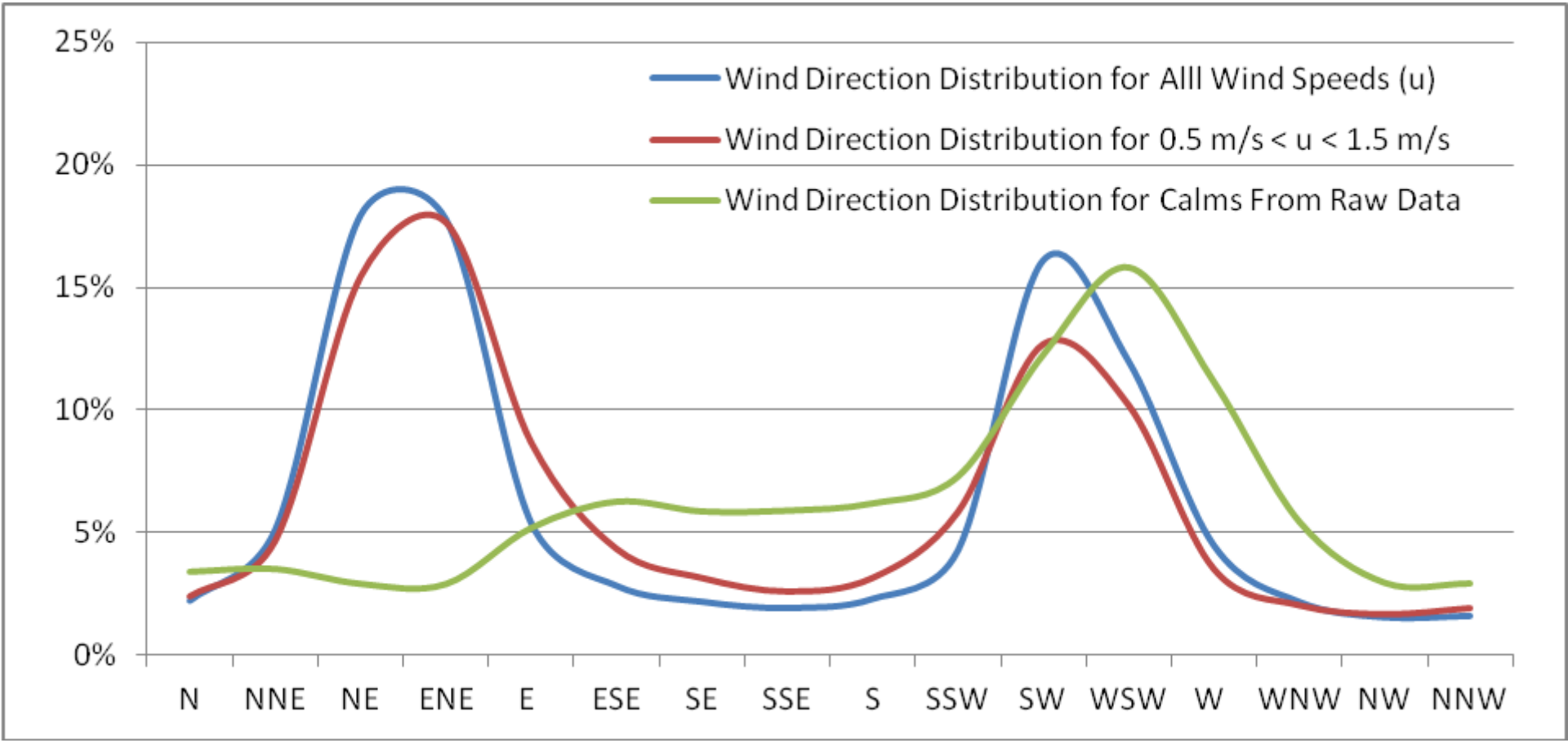
Windspeed – Stability Class Determinations

- NRC RG 1.23 ΔT-only method
- EPA-454/R-99-005 solar-radiation-delta-temperature (SRDT) method
- Hybrid SR – DT method
- wind direction standard deviation [sigma-theta (σ_θ)]
- elevation angle standard deviation [sigma-phi (σ_φ)]
- vertical wind speed standard deviation [sigma-omega (σ_ω)],
- wind-speed ratio method (u_R)

- All evaluated using data from west tower at Y-12 site
- DT-only method produces discrepancies other methods do not.



Windspeed – Wind Directions for Calms

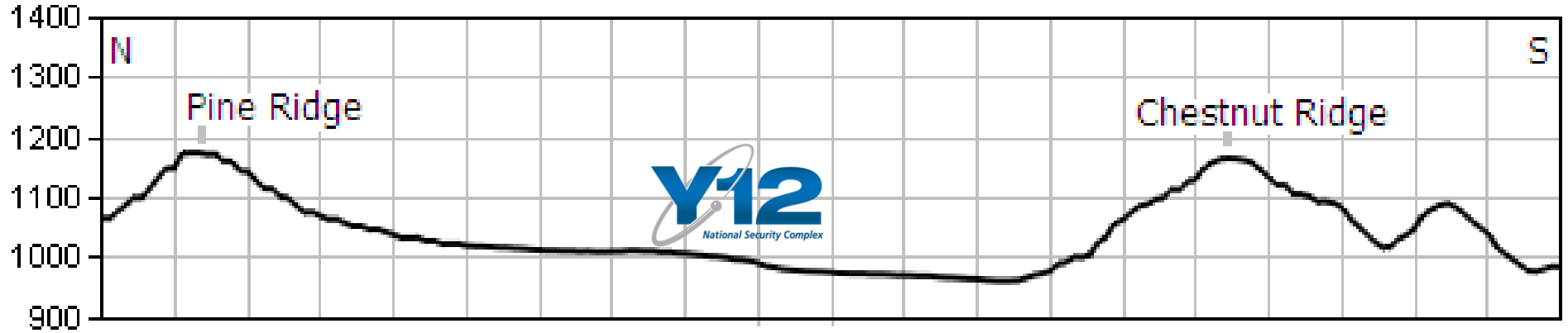


Y-12 Wind Direction Distribution (2005 – 2010)

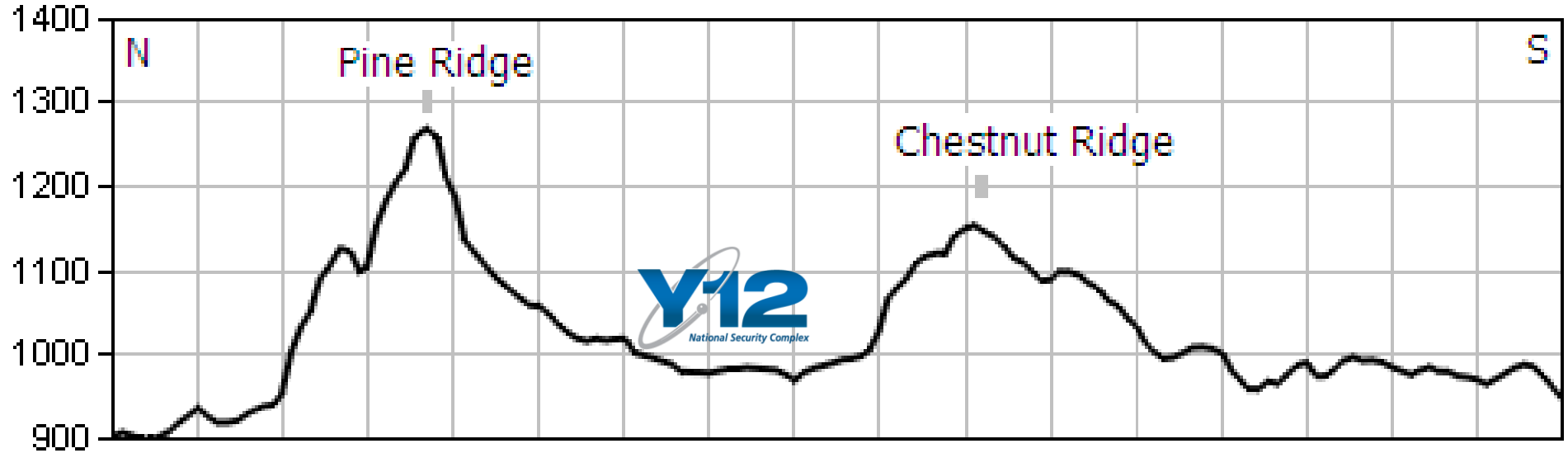
Significant Influence from the Orientation of the Y-12 Valley

Surface Roughness – Y-12 Site Topography

Surface Roughness – Y-12 Topography (cont.)



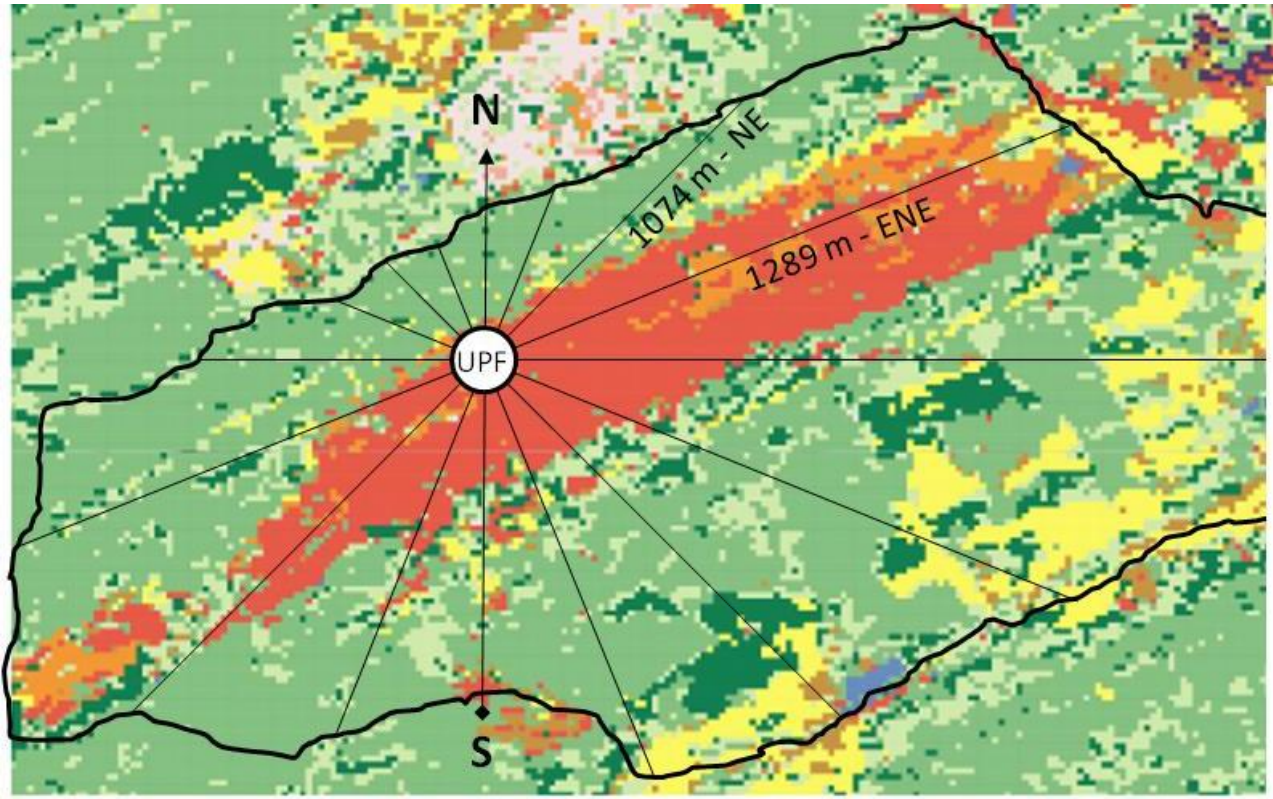
Cross Valley Elevation Profile on East Side of Y-12 Site



Cross Valley Elevation Profile on West Side of Y-12 Site

Surface Roughness – Y-12 Land Cover

- Used AERSURFACE program
- Neglected topographical roughness
  - Monthly Bounding Surface Roughness of 0.476 m
  - Annual Average Surface Roughness of 0.672 m

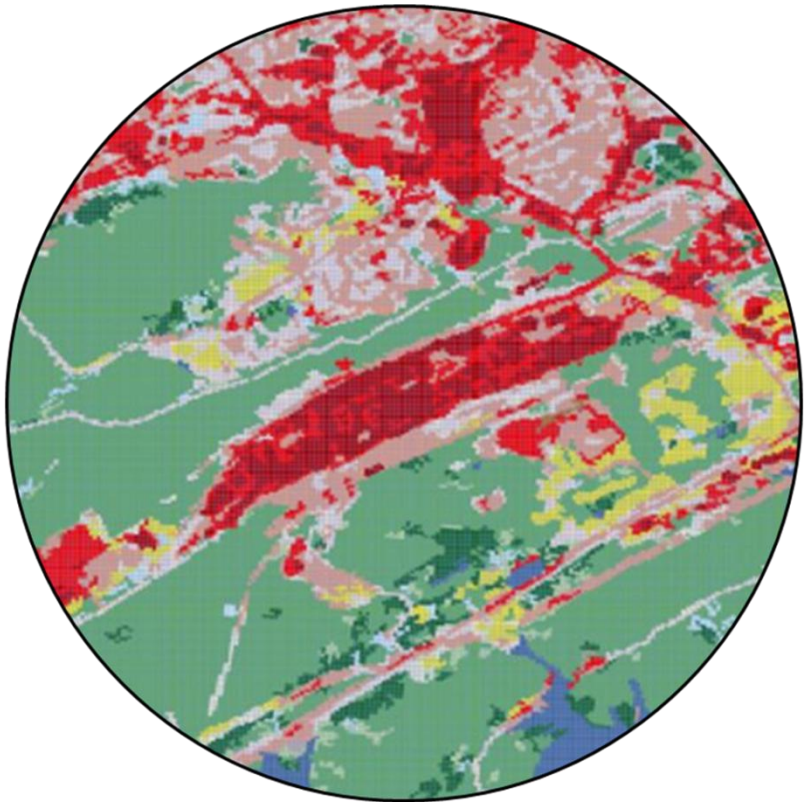


Legend	Class Number	Class Name
11	11	Open Water
21	12	Perennial Ice/Snow
22	21	Low Intensity Residential
23	22	High Intensity Residential
31	23	Commercial/Industrial/Transp (Site at Airport)
32		Commercial/Industrial/Transp (Not at Airport)
33	31	Bare Rock/Sand/Clay (Arid Region)
41		Bare Rock/Sand/Clay (Non-arid Region)
42	32	Quarries/Strip Mines/Gravel
43	33	Transitional
81	41	Deciduous Forest
82	42	Evergreen Forest
85	43	Mixed Forest
91	51	Shrubland (Arid Region)
92		Shrubland (Non-arid Region)
	61	Orchards/Vineyards/Other
	71	Grasslands/Herbaceous
	81	Pasture/Hay
	82	Row Crops
	83	Small Grains
	84	Fallow
	85	Urban/Recreational Grasses
	91	Woody Wetlands
	92	Emergent Herbaceous Wetlands

U.S. Department of the Interior ‖ Not accurate for measurement purposes. ‖ Visit us at http://gisdata.usgs.net

Surface Roughness – EPA methods

- A 3 km circle is drawn around the source and the land-use categories are assigned to portions of the circle.
- If more than 50% of the circle consists of land-use categories in the “urban” group, then the dispersion model is run using the Briggs-urban curves
  - Rural = Green/Blue
  - Urban = Red/Pink/Gray/Yellow



NLCD2006 data for 3 km around Y-12 site

Surface Roughness – Estimates from Wind Data

Y-12 is “Mountain Sheltered” based on normalized wind speed distribution

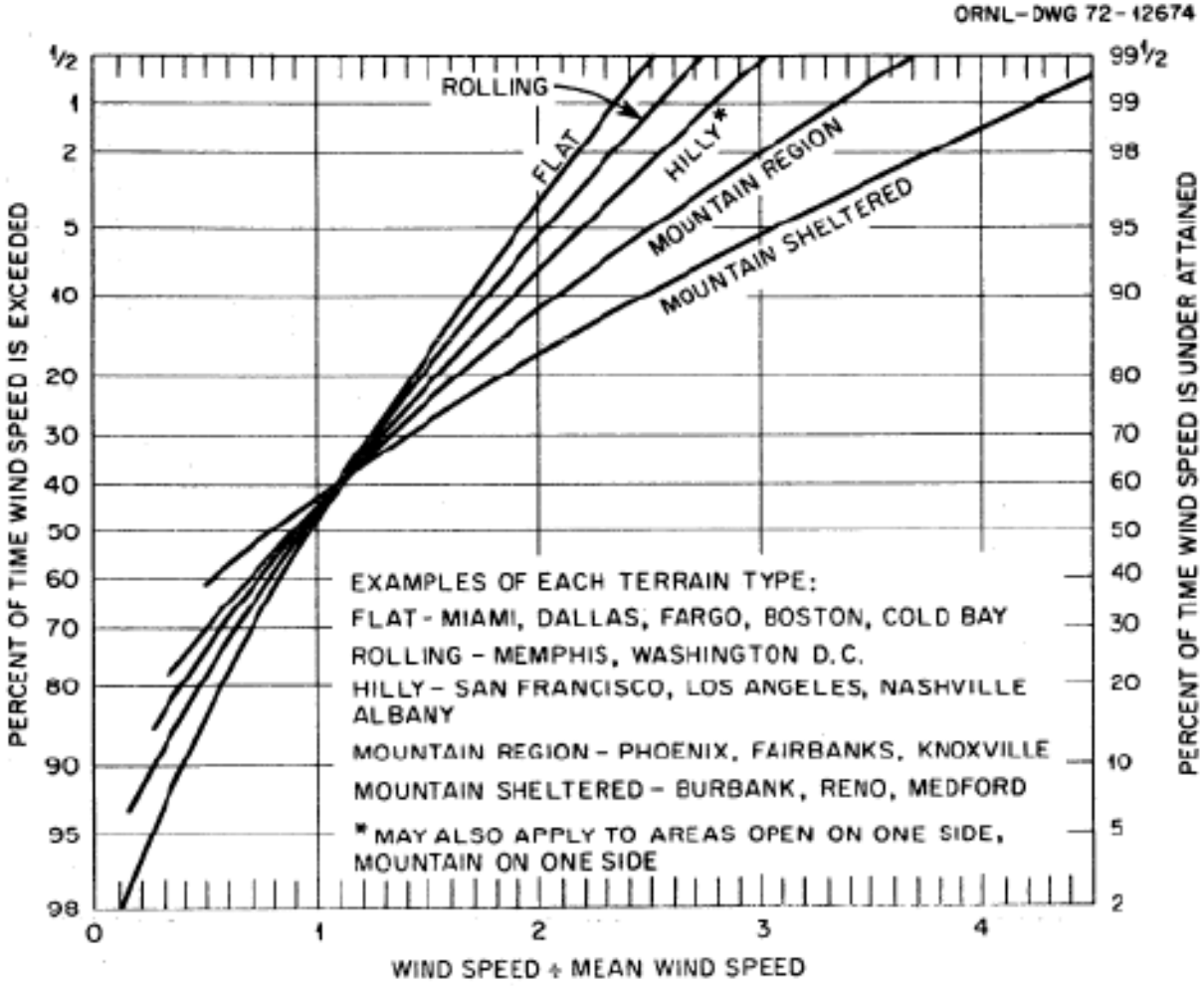


Figure 7 – Frequency of wind speeds [Briggs (1973)]

Table 7 – Frequency of Winds < 1 m/s for various terrain types [Briggs (1973)]

	Frequency of u < 1 m/s
Flat	2 to 5%
Rolling	5 to 10%
Hilly	10 to 20%
Mountain Region	20 to 30%
Mountain Sheltered	30 to 40%

Particle Size – Literature Review and Test Data

Releases of Uranium Oxides[1]

Activity Mean Aerodynamic Diameter	Fraction of Oxide Particulate	Fraction of Total Mass
d > 50 μm	64.4%	5E-2
20 μm < d < 50 μm	22.3%	2E-2
10 μm < d < 20 μm	12.1%	1E-2
5 μm < d < 10 μm	1.0%	8E-4
5 μm < d	0.2%	2E-4

ARF×RF = 1E-3

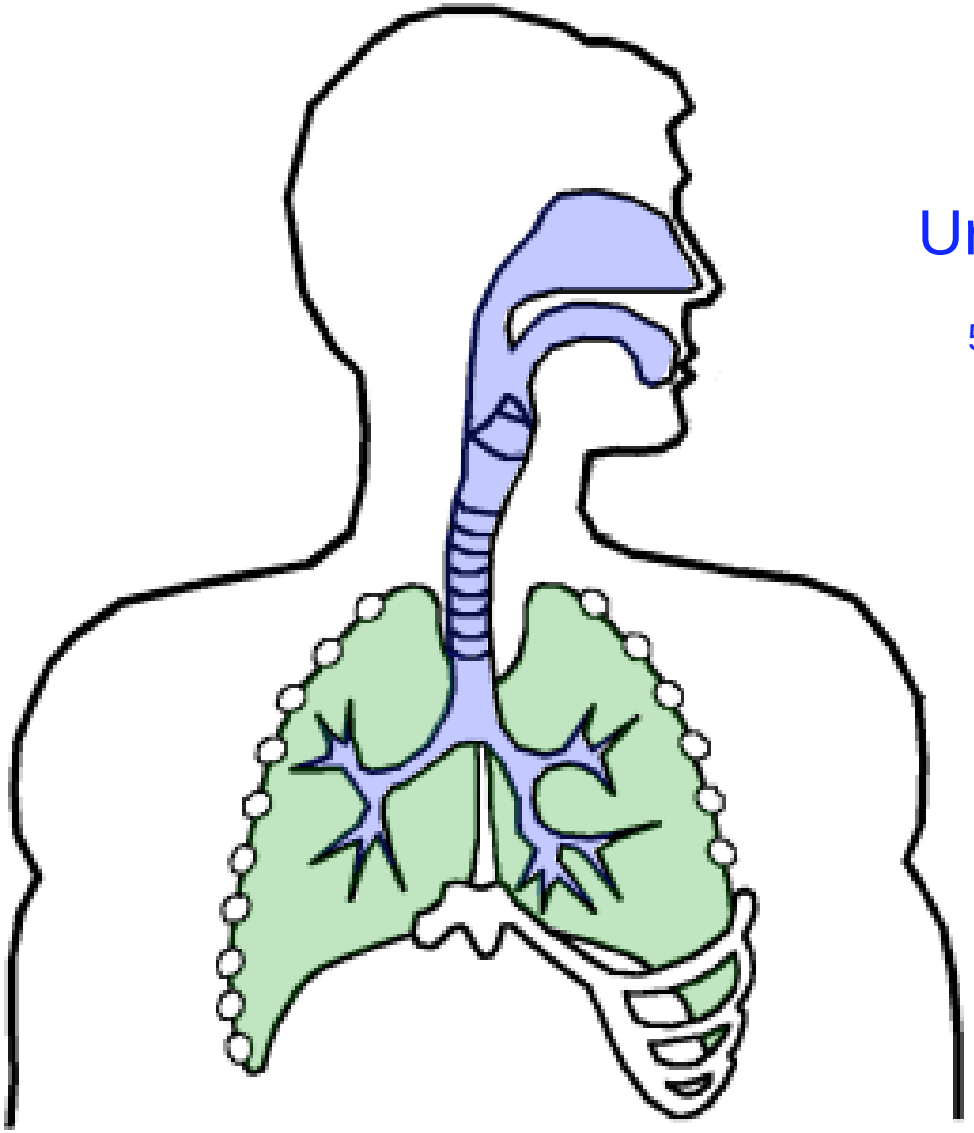
Respirable Fraction is 1.2% of total particulate

VS.

Respirable Fraction (AMMD of 1 μm, $\sigma_g = 2$) for Plutonium Oxide Particulates[2]

1. Hoover, M.D. *et al*, "Characterisation of Enriched Uranium Dioxide Particles From a Uranium Handling Facility," *Radiation Protection Dosimetry,* Vol. 79, Nos 1–4, pp. 57–62 (1998)
2. Mishima J. and L. C. Schwendiman. August 1973. *Some Experimental Measurements of Airborne Uranium (Representing Plutonium) In Transportation Accidents*, BNWL-1732, Pacific Northwest Laboratory, Richland, WA.

Particle Size – Lung Deposition Locations



Uranium Oxides

1.2% Respirable

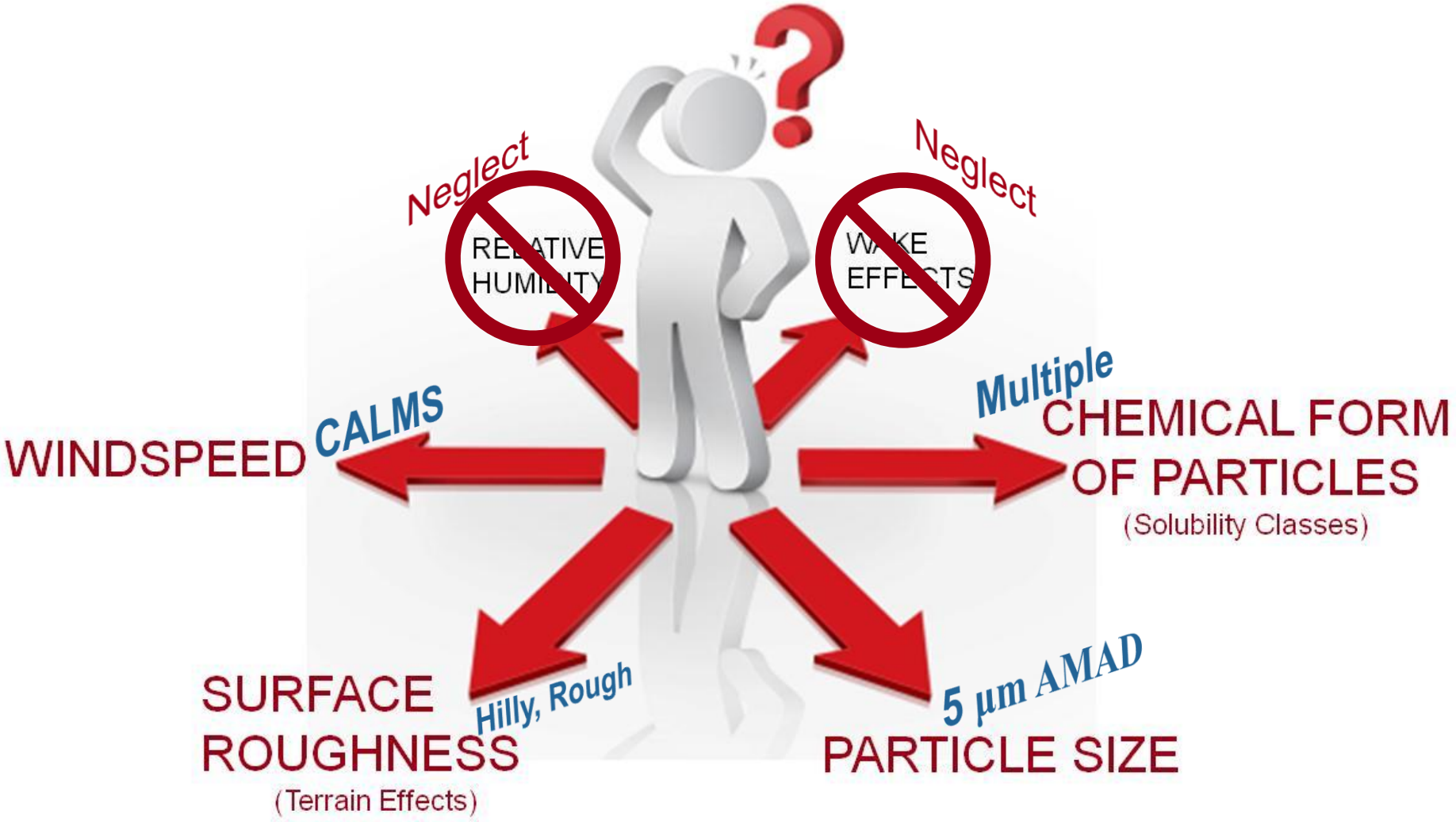
5 μm AMMD - σ_g = 2.1

Plutonium Oxides

99% Respirable

0.6 μm AMMD – σ_g = 3.1

Y-12 Specific Issues – Summary



Then HSS Safety Bulletin 2011-02 comes out…

HSS
Office of Health, Safety and Security

Safety Bulletin

Accident Analysis Parameter Update

May 2011

No. 2011-02

PURPOSE

To inform U.S. Department of Energy (DOE) and contractor personnel of an update in guidance for the default value for the dry deposition velocity (DV) parameter used in accident dose consequence calculations.

DV is the speed at which radioactive material settles out of a radioactive plume. The DV is one of several inputs to the DOE *Methods for Estimation of Leakages and Consequences of Releases Accident Consequences Code System Version 2* (MACCS2) computer code used to calculate hypothetical radiation doses to the public from potential accidents at DOE nuclear facilities. This calculated dose is used to identify controls to prevent or mitigate the potential accidents.

BACKGROUND

On February 1, 2010, the DOE Office of Environmental Management (EM) informed the DOE Office of Health, Safety and Security (HSS) about concerns raised by the Defense Nuclear Facilities Safety Board (DNFSB) regarding the default DV values used in the MACCS2 computer code. EM requested guidance from HSS on whether the accident dose calculations using the DOE-specified DV values were reasonably conservative, consistent with DOE Standard (STD) 3009-94, *Preparation Guide for DOE Nonreactor Nuclear Facility Documented Safety Analyses*.

On May 21, 2010, the DNFSB requested that DOE provide a better technical basis for default DV values in the *MACCS2 Computer Code Application Guidance for Documented Safety Analysis Final Report*. On November 5, 2010, DOE provided a response to the DNFSB that included a technical analysis of the assumptions behind the DV values used in DOE consequence modeling.

ANALYSIS

The DOE Chief of Nuclear Safety and HSS, with the support of industry experts in atmospheric sciences and accident dose consequences analysis, performed detailed analyses of the basis for the DV values used in the MACCS2 computer code. As a result of these analyses, DOE concluded that the MACCS2 default DV values of 1 centimeter/second (cm/s) for unfiltered/unmitigated releases and 0.1 cm/s for filtered/mitigated releases may not be reasonably conservative for all DOE sites and accident scenarios.

ACTIONS TO BE TAKEN

Until DOE formally revises the *MACCS2* guidance to address this issue, HSS recommends the following actions to calculate conservative results for accident dose consequence estimates when using MACCS2. For new projects that have not reached Critical Decision-2 (CD-2), use one of the three options below:

1) Use default DV values of 0.1 cm/s for unmitigated/unfiltered particulate releases and 0.01 cm/s for mitigated/filtered particulate release; or
2) Calculate site-specific DV values for unmitigated/unfiltered and mitigated/filtered particulate releases (refer to Attachment 1 for additional information); or
3) Use a more sophisticated computer code than MACCS2 to determine the 95th percentile dose at the site boundary.

For new projects beyond CD-2 and existing facilities, in which the Documented Safety Analysis (DSA) accident analysis utilized the MACCS2 code with a DV of 1 cm/s:

1) Use one of the three options stated above, or
2) Provide a technical justification that demonstrates the existing DSA accident dose calculation is reasonably conservative and meets the methodology by which the DSA was developed.

The results of any revised accident analyses should be evaluated to determine whether they indicate that additional safety controls (or changes to classification of existing controls) are warranted consistent with the DSA development methodology utilized for the facility.

Attachment 2 provides additional information regarding the technical basis for these recommended actions.

ADDITIONAL SOURCES OF INFORMATION

Contact your Program Secretarial Office representative or Mark Blackburn, Office of Nuclear Safety, at 301-903-8396 or mark.blackburn@hq.doe.gov.

Glenn S. Podonsky
Chief Health, Safety and Security Officer
Office of Health, Safety and Security

The technical data in the bulletin ties to AERSURFACE and includes additional data

Resistance Model of Deposition Velocity

$$S_{CF} = 1 + \frac{2x_2\left(a_1 + a_2 \exp\left(-\frac{a_3 d_p}{x_2}\right)\right)}{10^{-4} d_p}$$

$$v_{dd} = (r_a + r_s + r_t + r_a\, r_s\, v_g)^{-1} + v_g$$

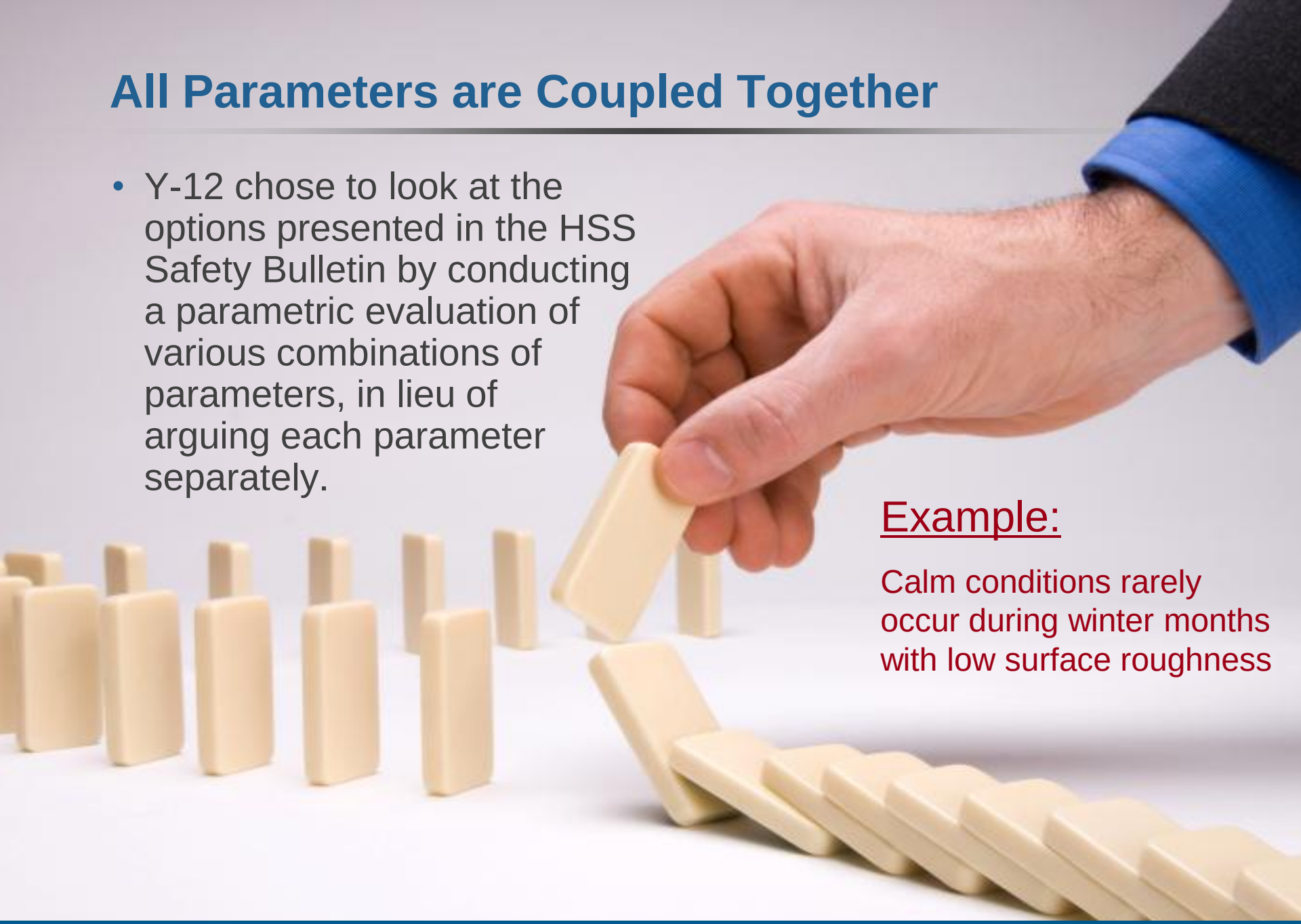
$r_s = 2.6 / (0.4u^*)$

$r_a = U(z) / (u_*)^2$

$$v_g = \frac{\rho - \rho_{air}\, g d_p^2 c_2}{18\mu} S_{CF}$$

All Parameters are Coupled Together

- Y-12 chose to look at the options presented in the HSS Safety Bulletin by conducting a parametric evaluation of various combinations of parameters, in lieu of arguing each parameter separately.

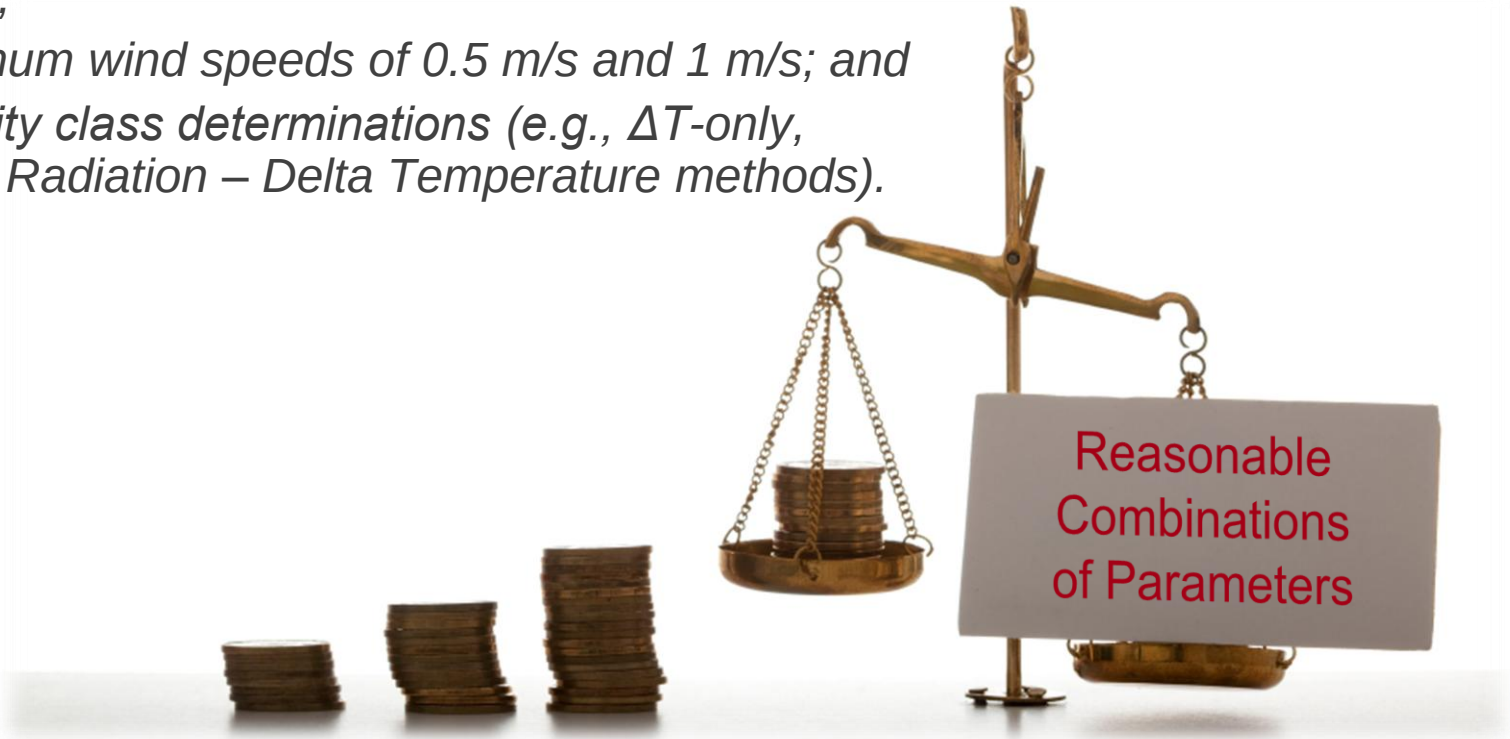


Example:

Calm conditions rarely occur during winter months with low surface roughness

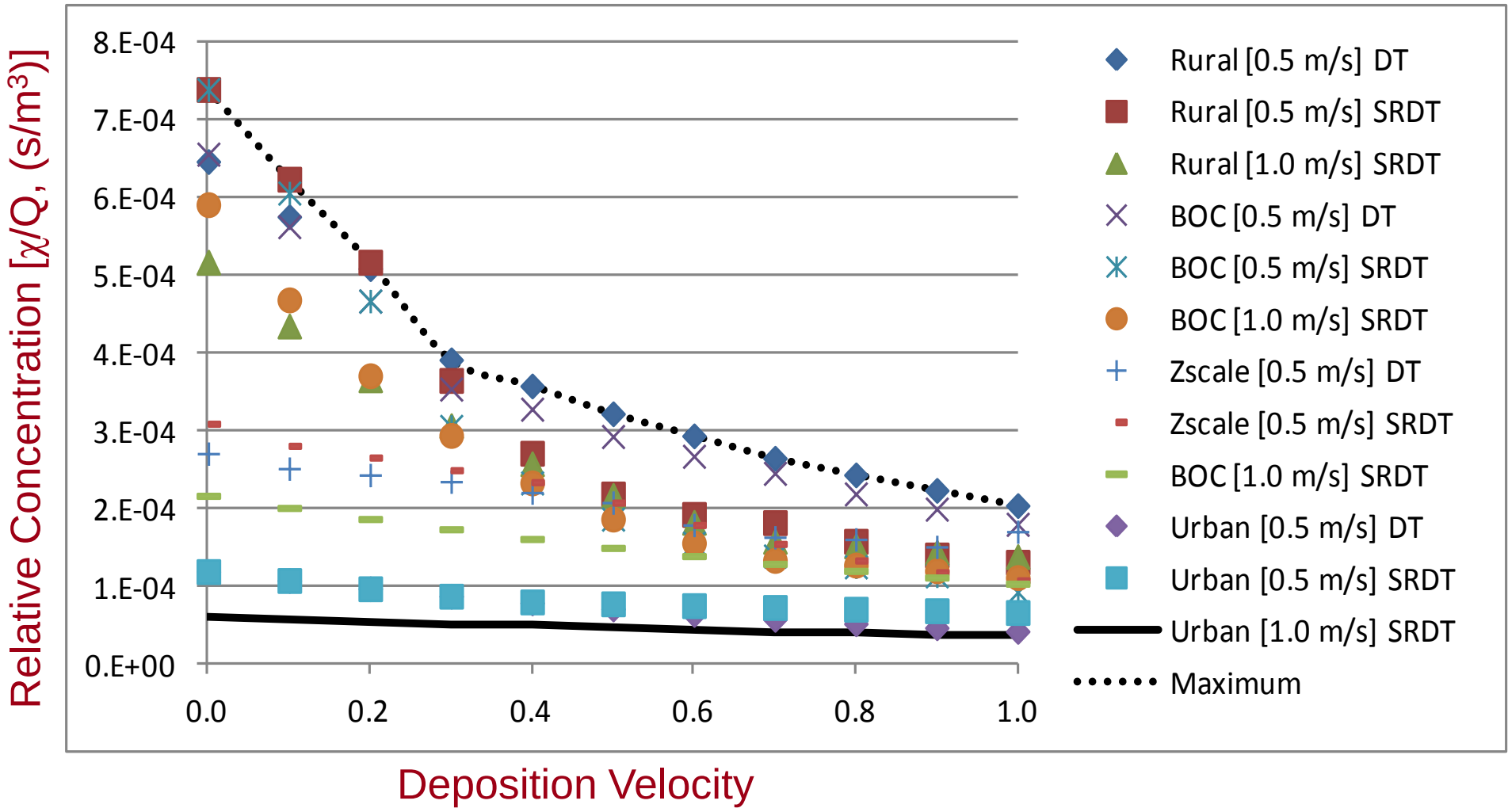
Parametric Evaluation

- *The project team conducted a parametric evaluation (DAC-F000Y12-F-0005) to determine the 95th percentile χ/Q values for combinations of the following:*
  - *dispersion coefficients (e.g., rural, open country, and urban) covering a range of surface roughness values from 3 cm to 100 cm;*
  - *deposition velocities ranging from 1 cm/s to no deposition (i.e., 0 cm/s);*
  - *minimum wind speeds of 0.5 m/s and 1 m/s; and*
  - *stability class determinations (e.g., ΔT-only, Solar Radiation – Delta Temperature methods).*



Documented Technical Basis for Each Parameter

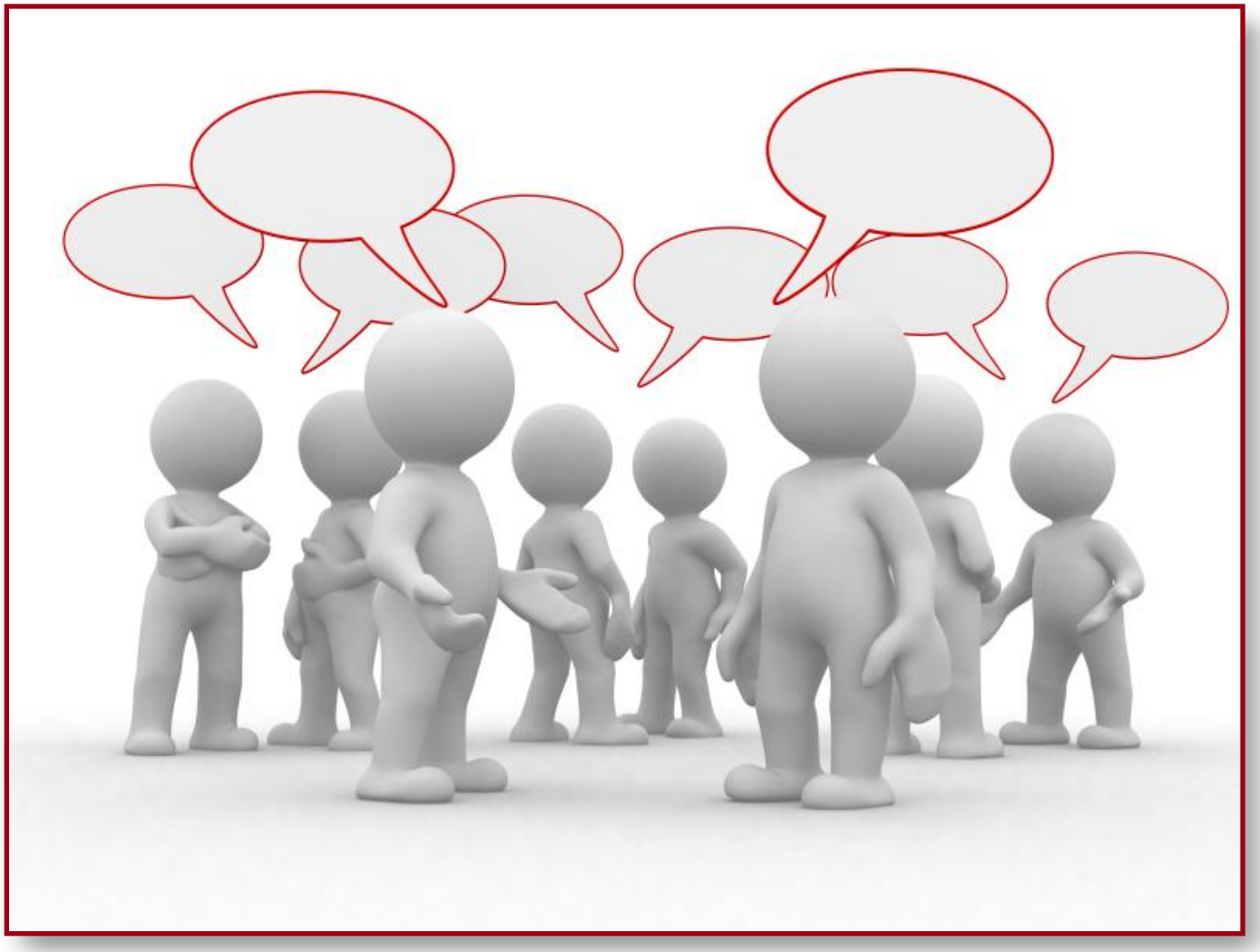
Parametric Evaluation Range



Summary

- *The project team conducted a parametric evaluation (DAC-F000Y12-F-0005) to determine the 95th percentile χ/Q values for combinations of the following:*
  - *dispersion coefficients (e.g., rural, open country, and urban) covering a range of surface roughness values from 3 cm to 100 cm;*
  - *deposition velocities ranging from 1 cm/s to no deposition (i.e., 0 cm/s);*
  - *minimum wind speeds of 0.5 m/s and 1 m/s; and*
  - *stability class determinations (e.g., ΔT-only, Solar Radiation – Delta Temperature methods).*
- *Based on the various approaches analyzed in the parametric analysis, the recommended χ/Q values range from 1.4E-4 s/m^3 to 4.3E-5 s/m^3.*
- *Looking at the various combinations of parameters that would reflect conditions at the Y-12 site, a χ/Q value of 1.4E-4 s/m^3 is appropriately conservative in the early design stages of new nuclear facilities.*

Questions



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