U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

The Impact of Weather on Radiological Dose Projections

IMUG Meeting
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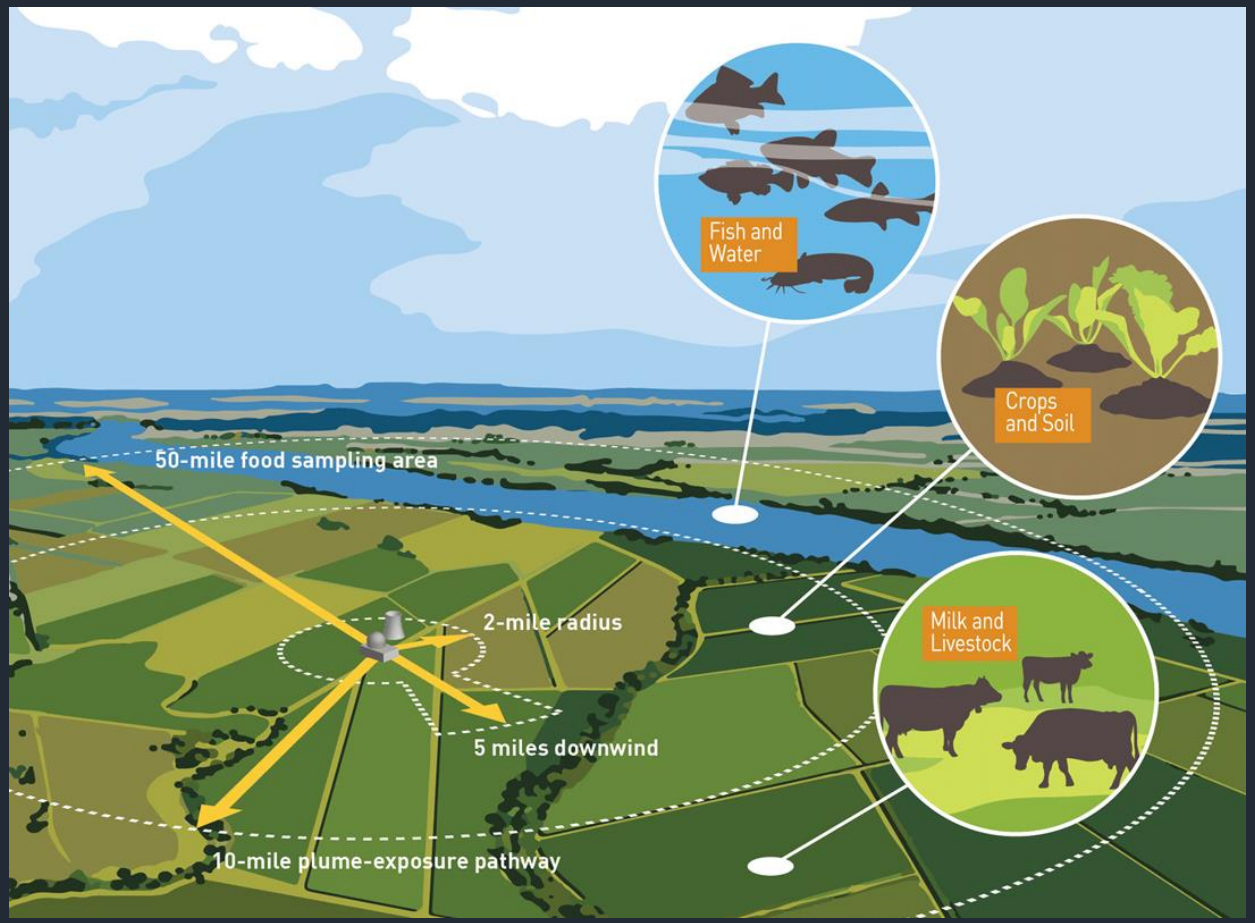
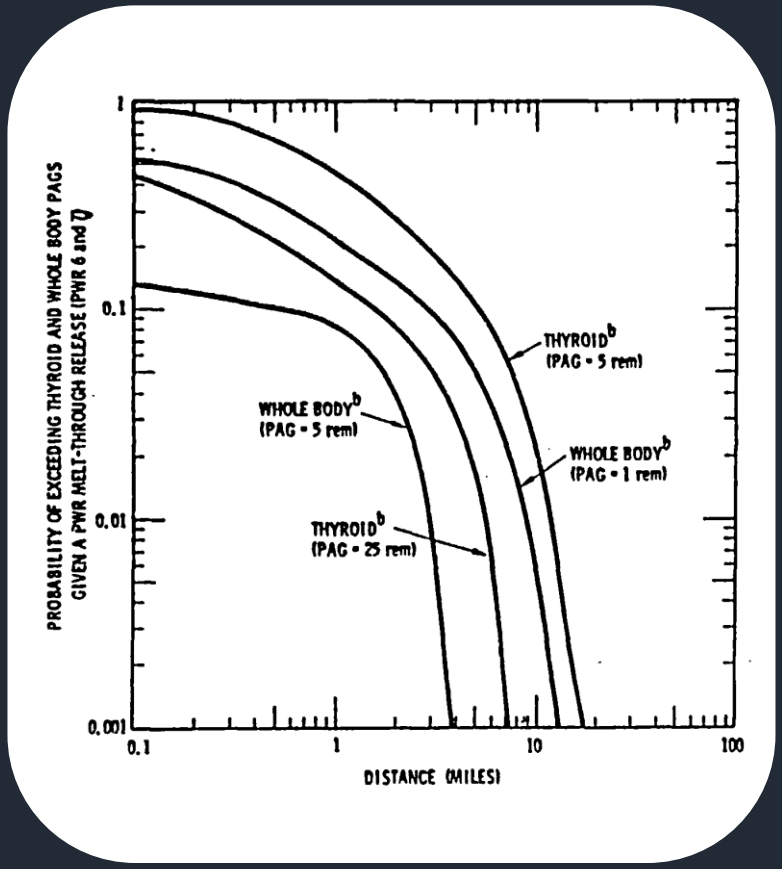
USNRC

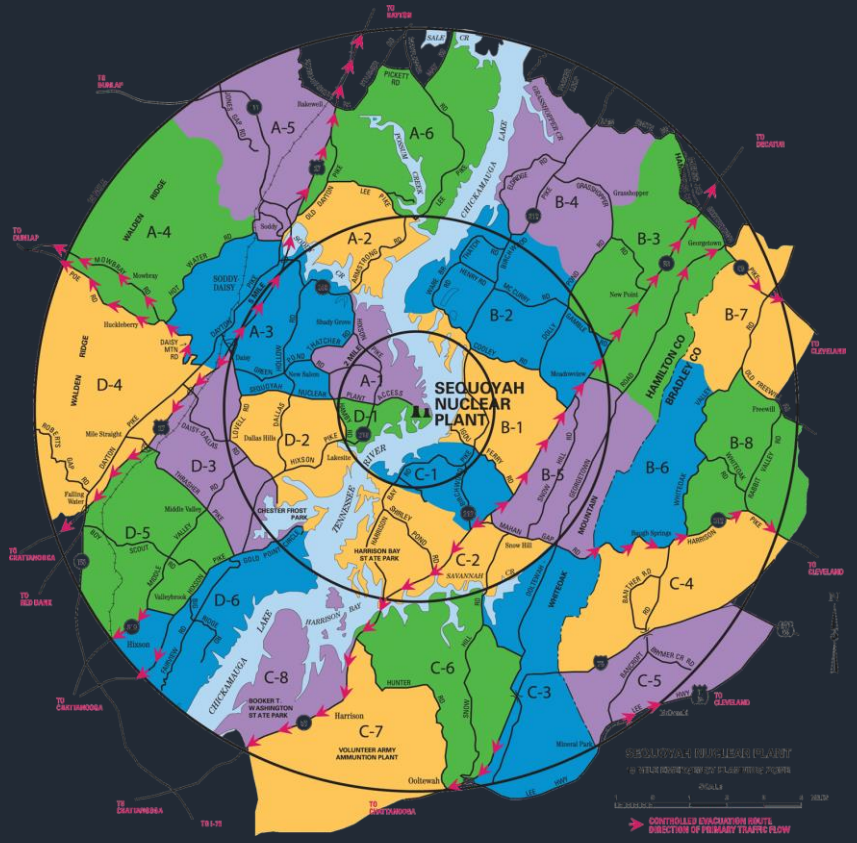
Emergency Preparedness	Incident Response
a state of readiness to respond to a hazard to protect the health and safety of the public.	integrates NRC capabilities for the response and recovery of radiological incidents.

Emergency Planning Zones



Basis for EPZs
NUREG-0396 Methodology





Emergency Preparedness

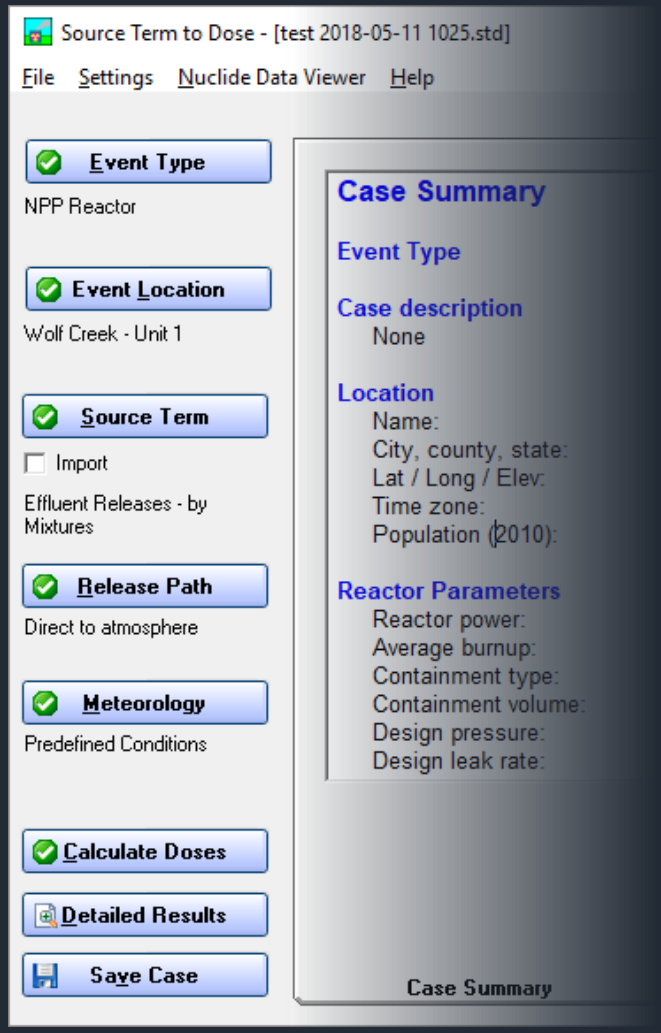
Incident Response

- Ensure utility actions protect public health and safety
- Support State/Local response efforts
- Support larger Federal response

Independent reactor and offsite dose assessment


RASCAL4
WIND

INCIDENT RESPONSE



RASCAL

- Source Term
  - Determines time-dependent isotopes and activities
- Atmospheric Transport and Dispersion
  - Transports material downwind

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} e^{-\frac{y^2}{2\sigma_y^2}} \left(e^{-\frac{(z+H)^2}{2\sigma_z^2}} + e^{-\frac{(z-H)^2}{2\sigma_z^2}} \right)$$

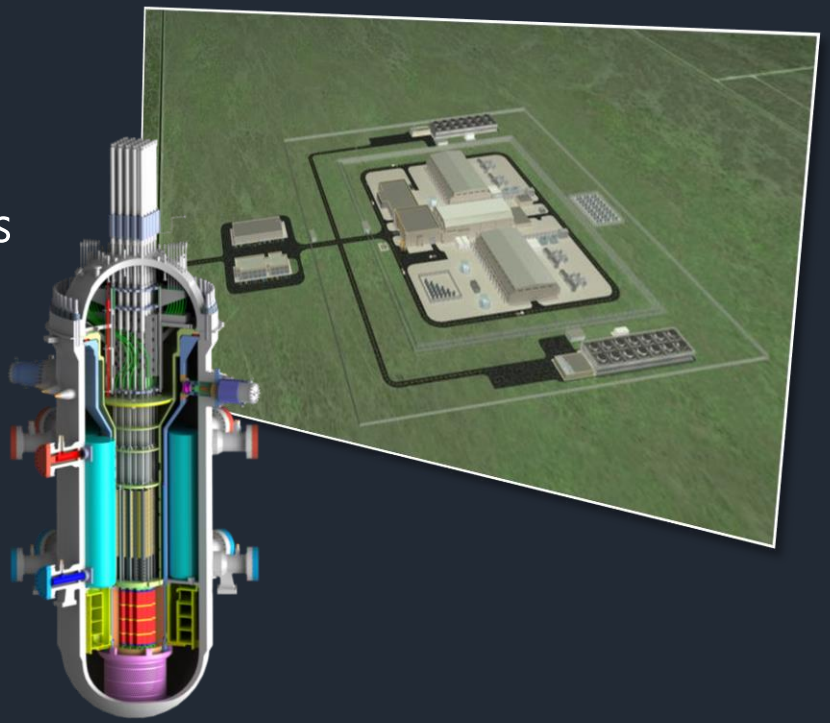
- Dose Calculations
  - Determines dose based on deposited material
  - Comparable to PAGs; helps inform protective actions

EMERGENCY PREPAREDNESS | **INCIDENT RESPONSE**

UPCOMING CHALLENGES FOR BOTH PROGRAMS

Small modular and advanced reactor designs will significantly reduce the risk of an offsite radiological release. These design enhancements have implications for:

- EPZ size determination
- Dose Assessment Capabilities
- Protective Action Strategies
- Physical and Cyber Security



Design Project Statement

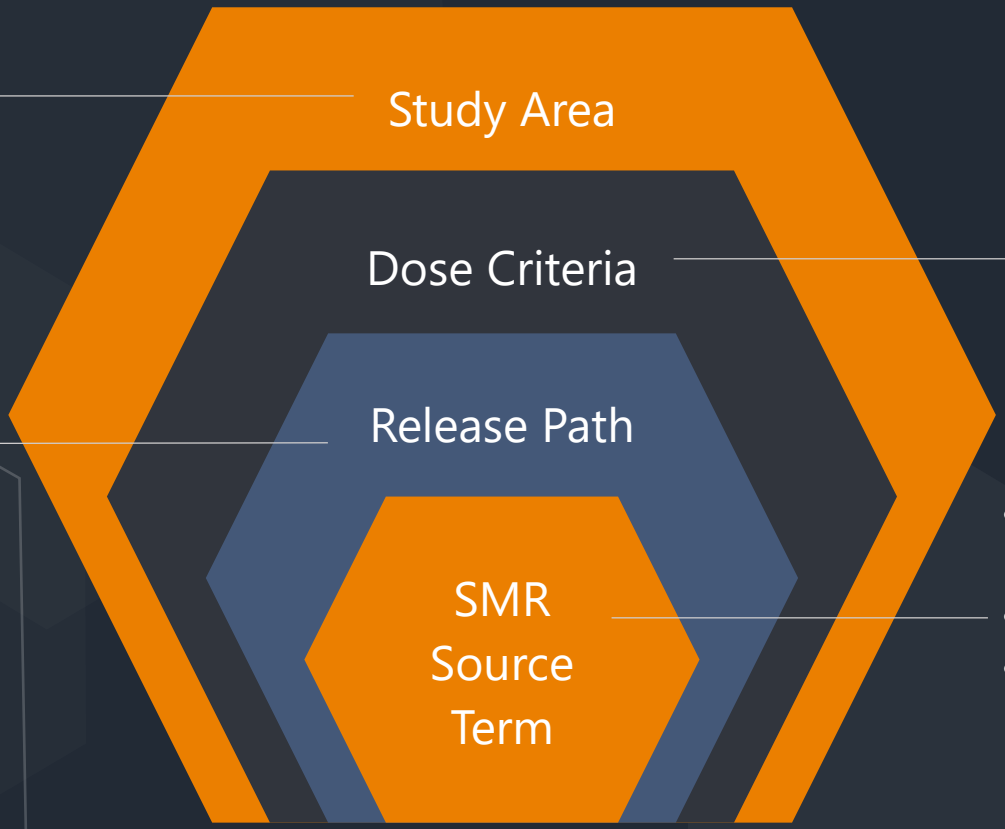
How will new reactor technologies affect current assumptions and methodologies for radiological dose projections?

Enhance Preparedness - Understand the sensitivity of weather related factors to inform emergency planning and EPZ size

Improve Response - Assess the adequacy of RASCAL modeling using SMR source terms and close-in projections

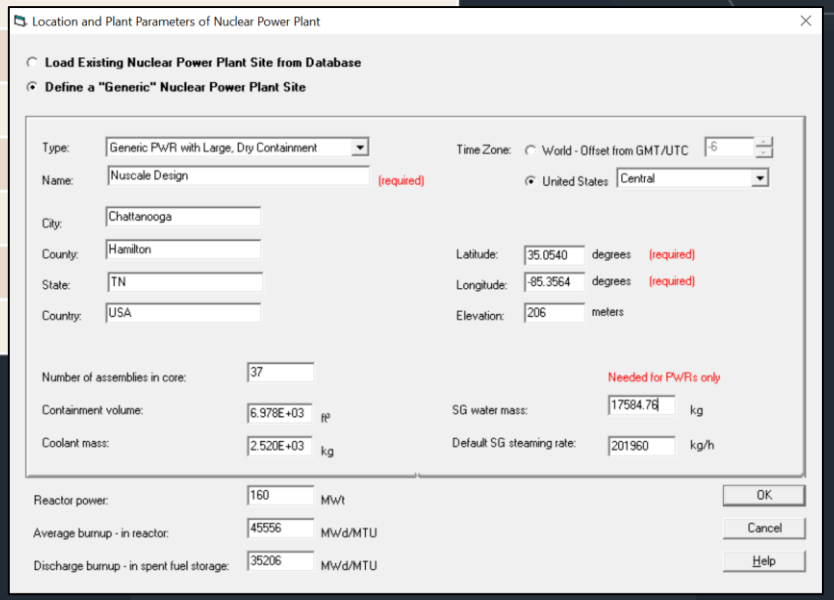
Sensitivity of Dose Projections

Constraints



Source Term
Representative SMR

RASCAL Field Entry to Produce Source Term	User Defined Parameter
Reactor Type	Generic PWR with Large, Dry Containment
Name	TVA-1
Location	Clinch River, Chattanooga, TN (Location of first NuScale plant)
Assemblies [#]	37
Containment Volume [ft^3]	6,978.43
Coolant Mass [kg]	2,520.28
Steam Generator Water Mass [kg]	17,584.76
Steaming Rate [kg/hr]	201,960
Reactor Power [MWt]	160
Average Burnup (in reactor) [MWd/MTU]	45,556
Discharge Burnup (spent storage) [MWd/MTU]	35,206
Release Height [m]	10



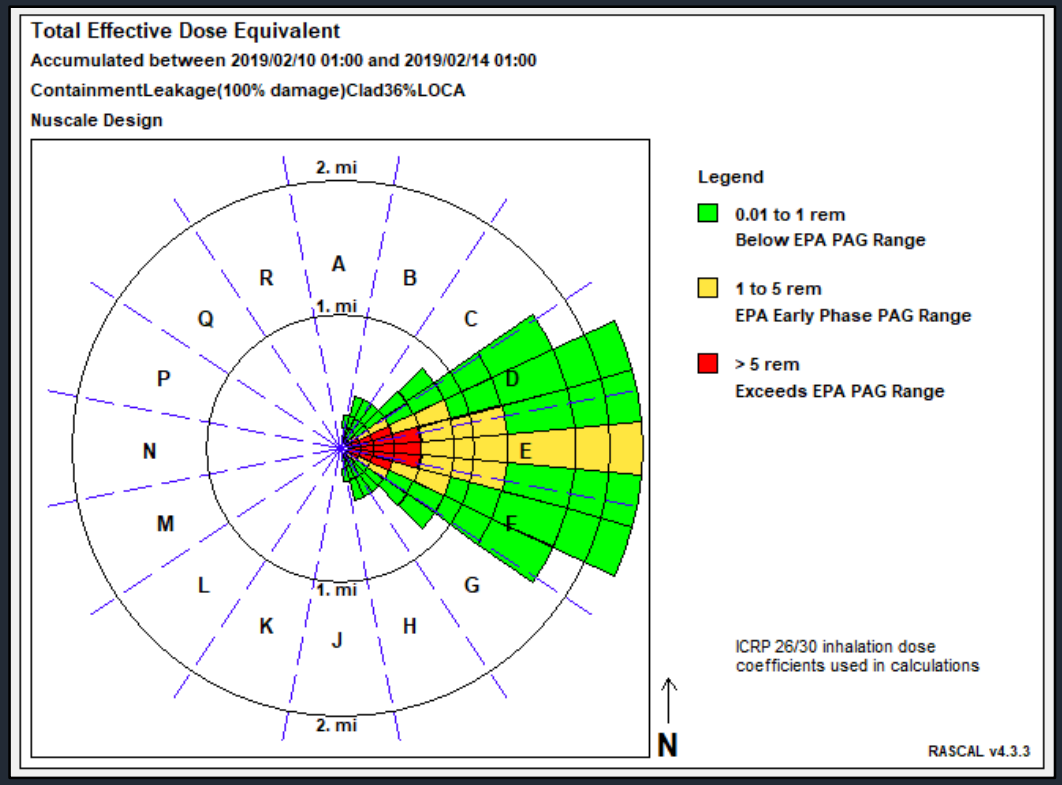
LOCA

LTSBO

36% cladding damage

100% per hour containment leakage (no containment)

Core uncovers and release begins in 1 hour



LOCA

LTSBO

1% core melt

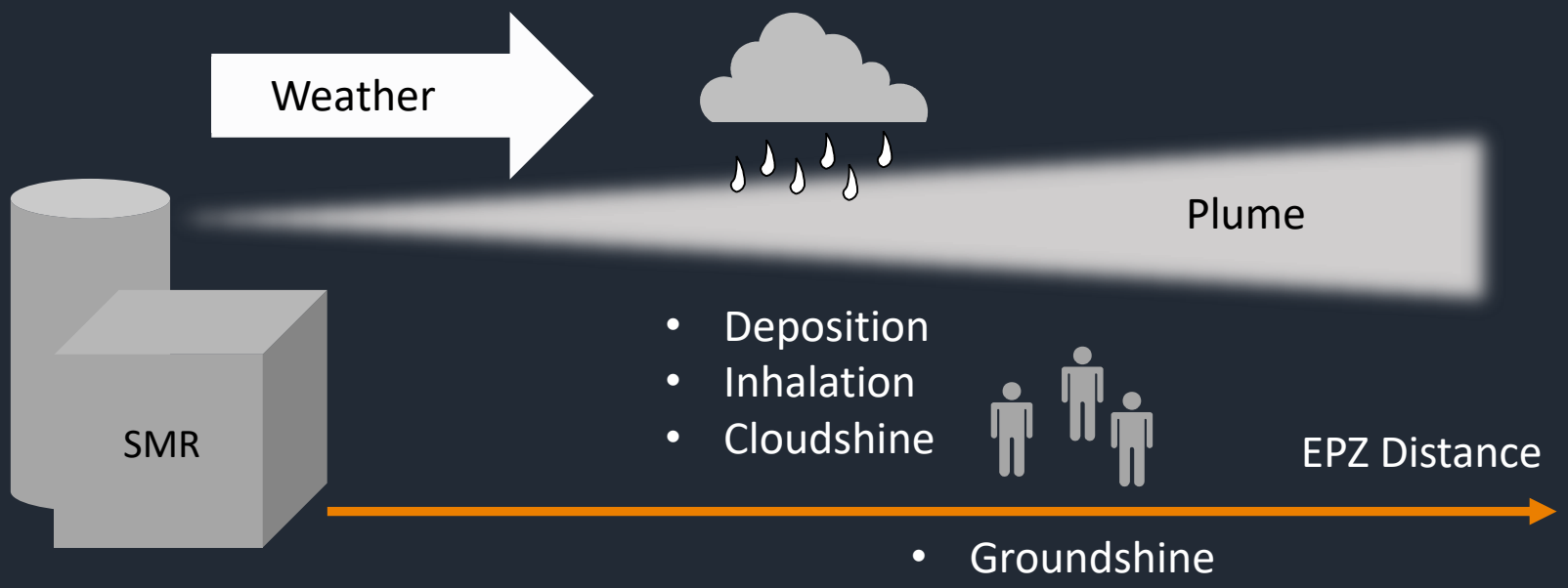
8% per hour containment leakage

Core uncovers and release begins in 8 hours

Maximum Dose Values (rem) - Close-In

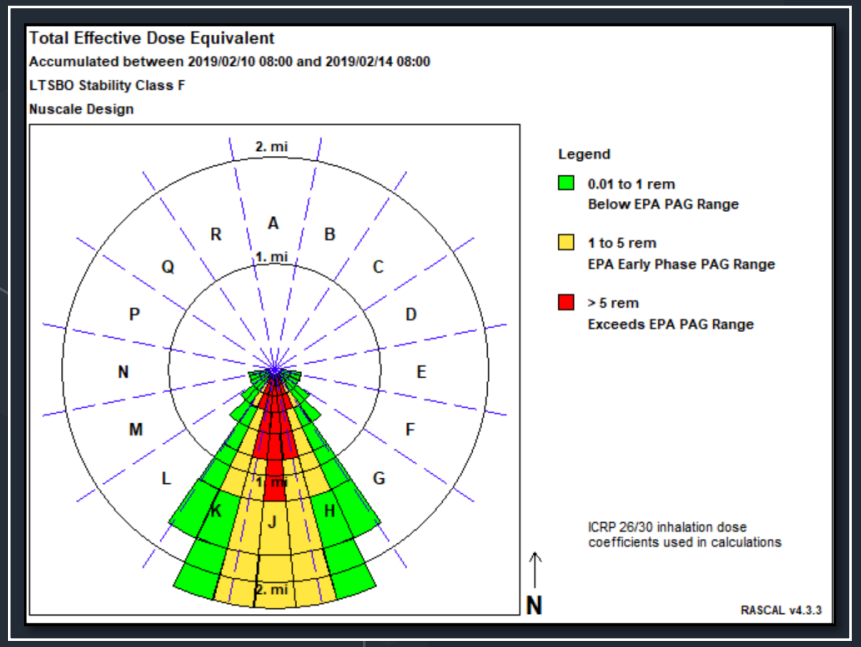
Dist from release miles (kilometers)	0.1 (0.16)	0.2 (0.32)	0.3 (0.48)	0.5 (0.8)	0.7 (1.13)	1. (1.61)	1.5 (2.41)	2. (3.22)
Total EDE	8.7E+01	2.8E+01	1.5E+01	6.7E+00	4.0E+00	2.3E+00	1.3E+00	1.0E+00
Thyroid CDE	1.1E+03	3.4E+02	1.8E+02	8.3E+01	4.9E+01	2.8E+01	1.6E+01	1.2E+01
Inhalation CEDE	5.1E+01	1.6E+01	8.6E+00	3.9E+00	2.3E+00	1.3E+00	7.6E-01	5.9E-01
Cloudshine	8.6E-01	4.2E-01	2.8E-01	1.5E-01	1.0E-01	6.0E-02	4.1E-02	3.5E-02
4-day Groundshine	3.5E+01	1.1E+01	5.9E+00	2.7E+00	1.6E+00	8.9E-01	5.2E-01	4.0E-01
Inter Phase 1st Yr	4.2E+02	1.3E+02	7.1E+01	3.2E+01	1.9E+01	1.1E+01	6.3E+00	4.9E+00
Inter Phase 2nd Yr	2.6E+02	8.2E+01	4.4E+01	2.0E+01	1.2E+01	6.6E+00	3.9E+00	3.0E+00

RASCAL Model for Dose Projection

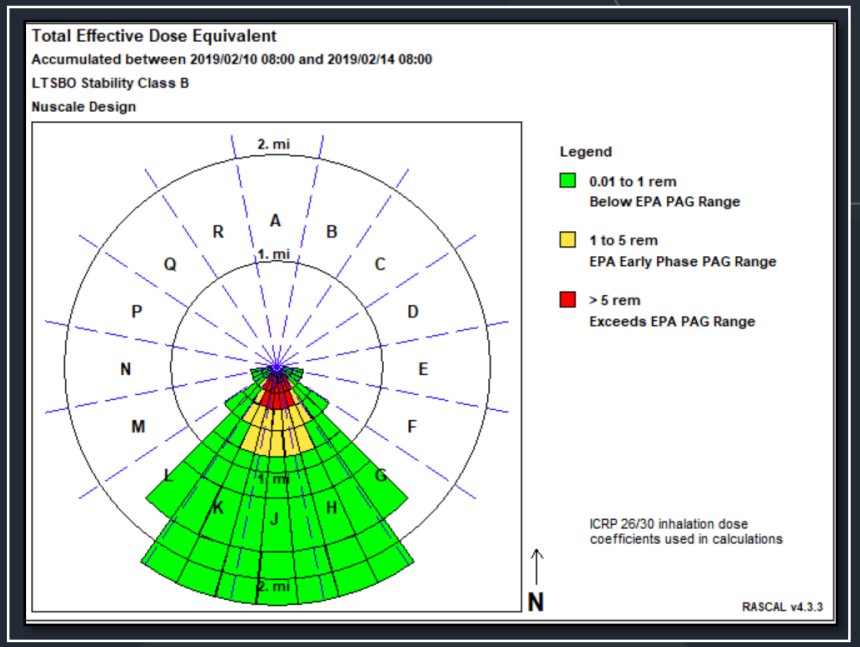


Stability Class
Sensitivity Analysis

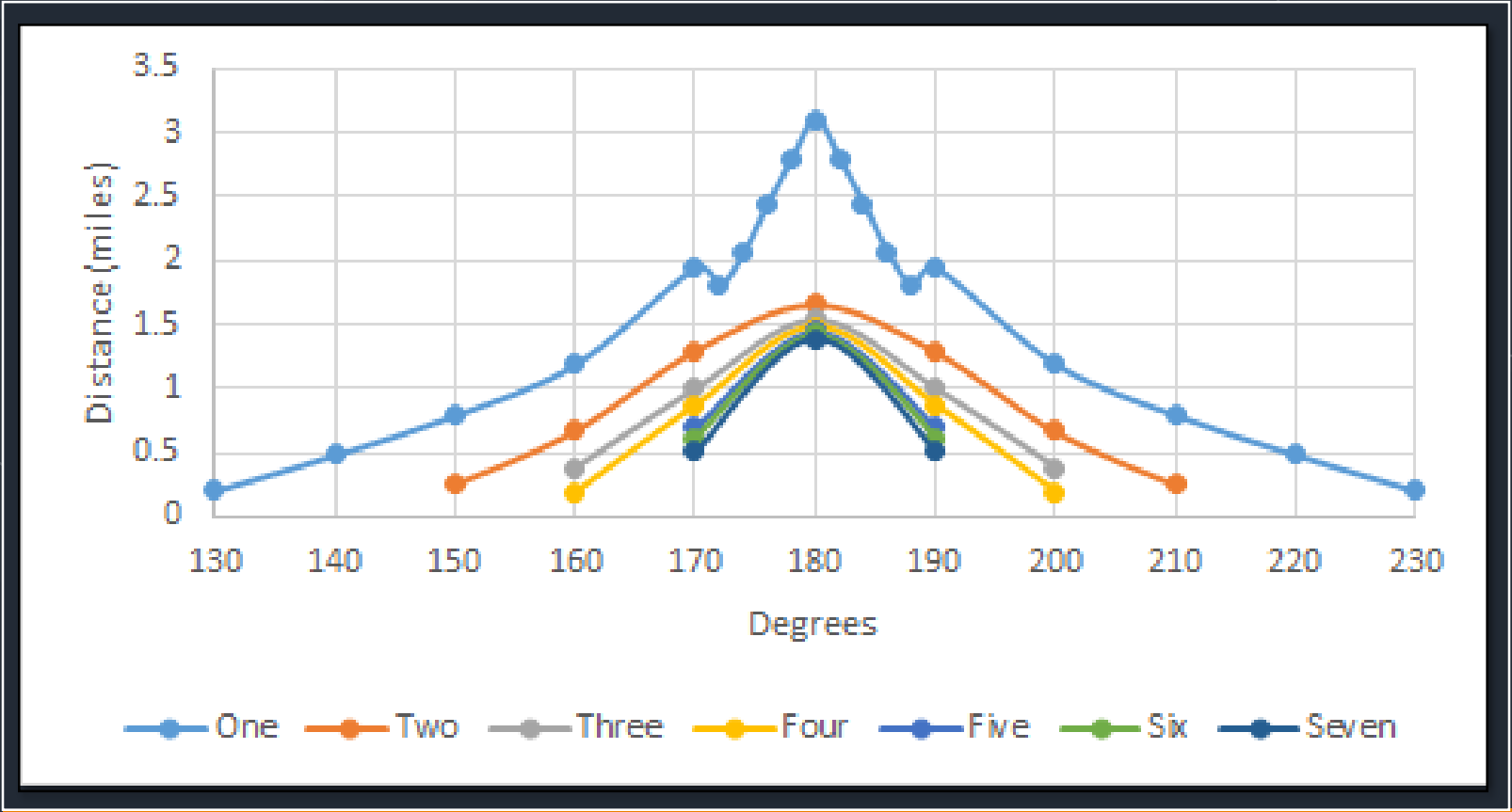
Stability Class F (Stable)



Stability Class B (Unstable)

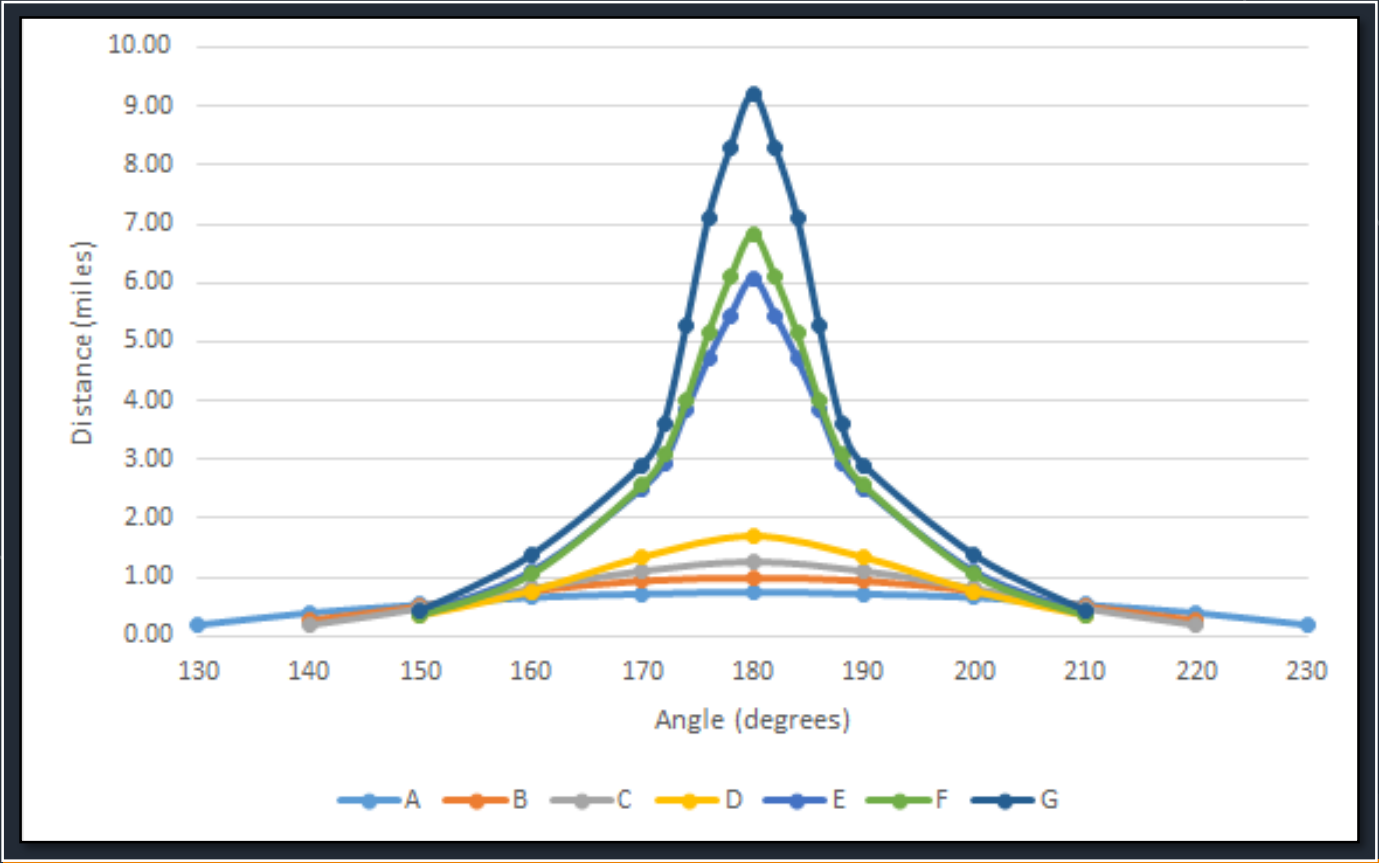


Wind Speed
Sensitivity Analysis



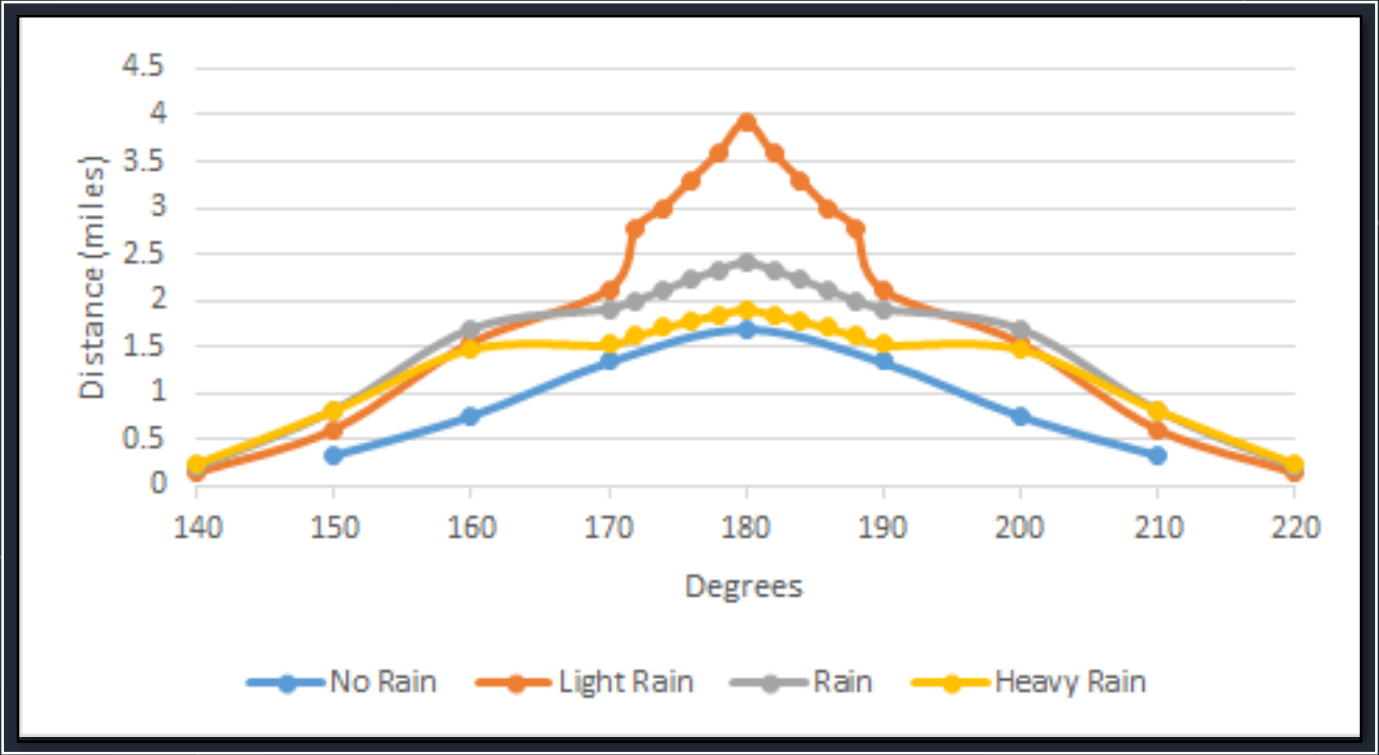
Variable Wind Speed **Stability Class D** **No Rain**

Stability Class
Sensitivity Analysis



4 MPH WIND **VARIABLE STABILITY CLASS** **NO RAIN**

Precipitation
Sensitivity Analysis



4 MPH WIND **STABILITY CLASS D** **VARIABLE RAIN**

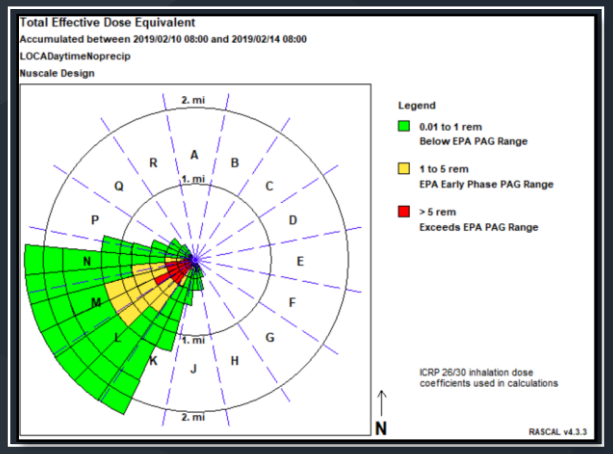
Realistic Weather
Scenario Development

- Real 2 day, hourly weather data from site compared to historical daily average
- Stability class for each one was estimated based on Stability Class Chart and compared to historical daily average
- Four weather cases tested:
  - Daytime Release (8 am) without Rain
  - Nighttime Release (7 pm) without Rain
  - Daytime Release with Rain (13 hours)
  - Nighttime Release with Rain

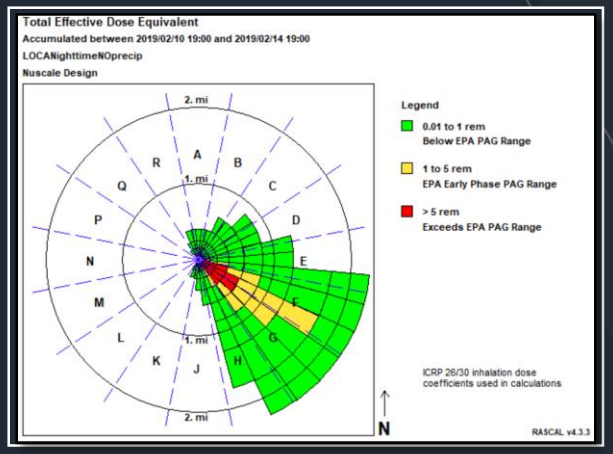
Realistic Weather

LOCA

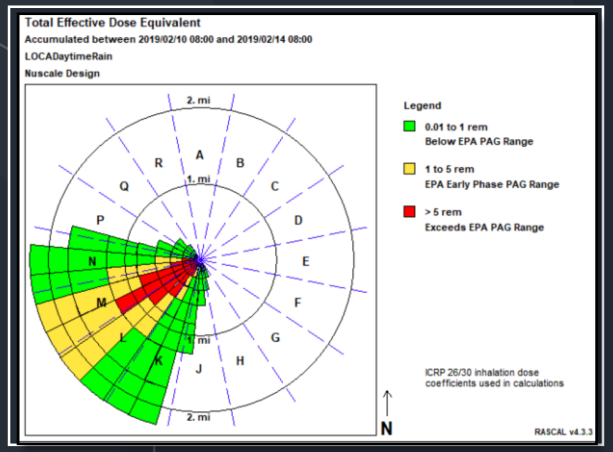
Daytime No Rain



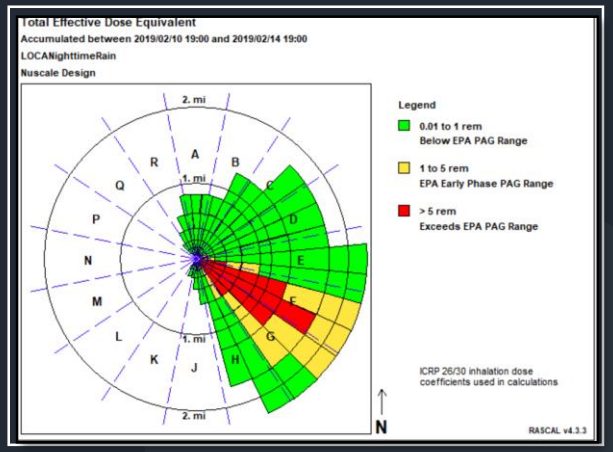
Nighttime No Rain



Daytime Rain



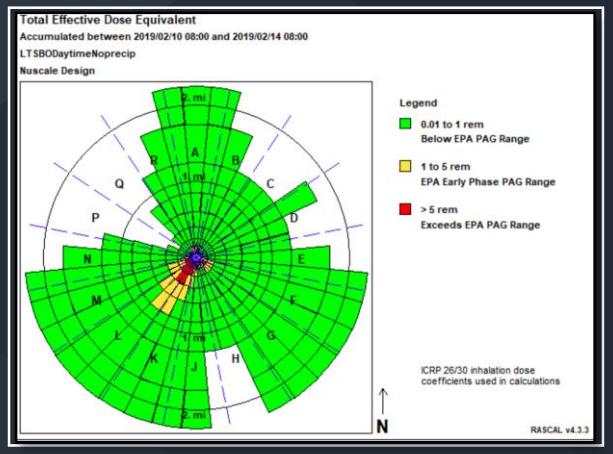
Nighttime Rain



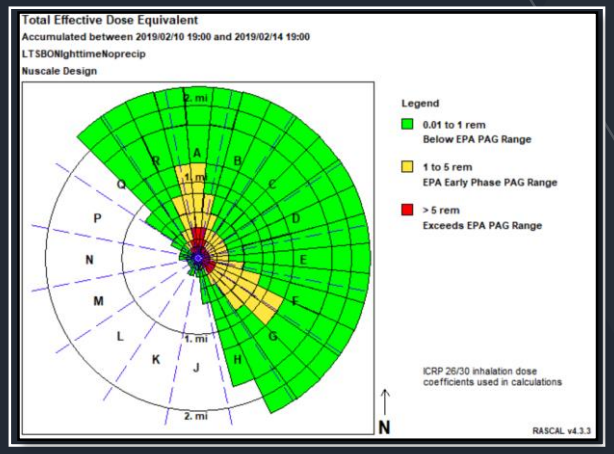
Realistic Weather

LTSBO

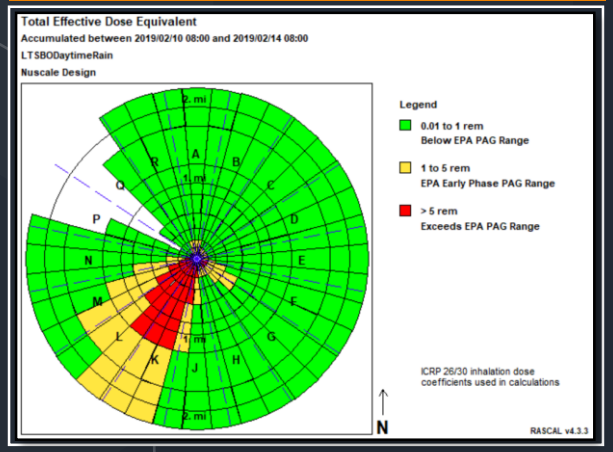
Daytime No Rain



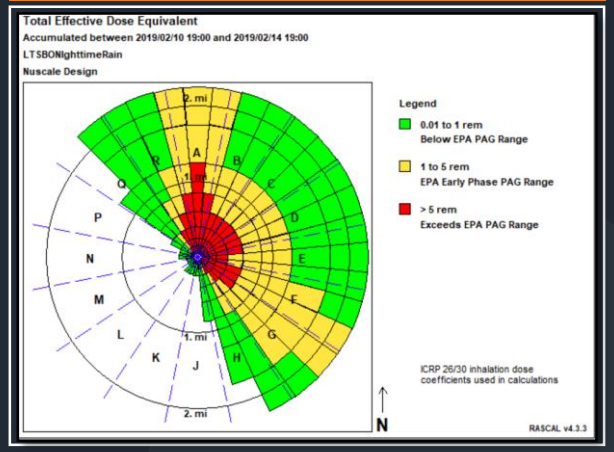
Nighttime No Rain



Daytime Rain



Nighttime Rain



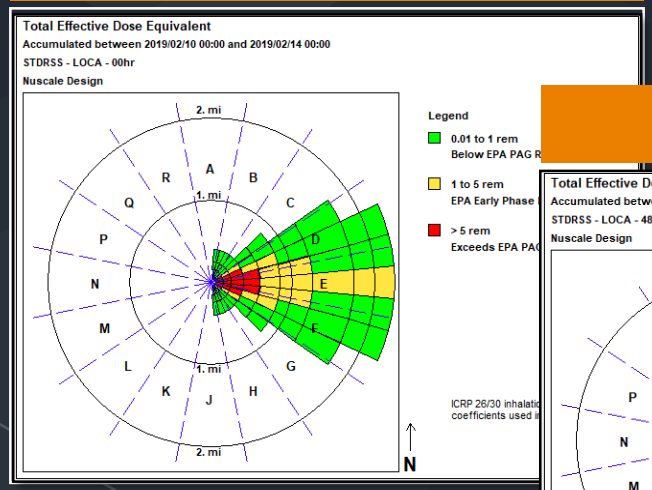
Delayed Release
Scenario Development

- SMRs and advanced reactors designed to delay or prevent release
- RASCAL model adjustments
  - LOCA - Set delay from time of reactor shutdown and when core uncovered
  - LTSBO - Set delay by increasing ECCS operation time (limit 48 hours)
- Base Case: Using standard meteorology for 96 hours after release
  - 4 mph wind speed, winds to East
  - Stability Class D

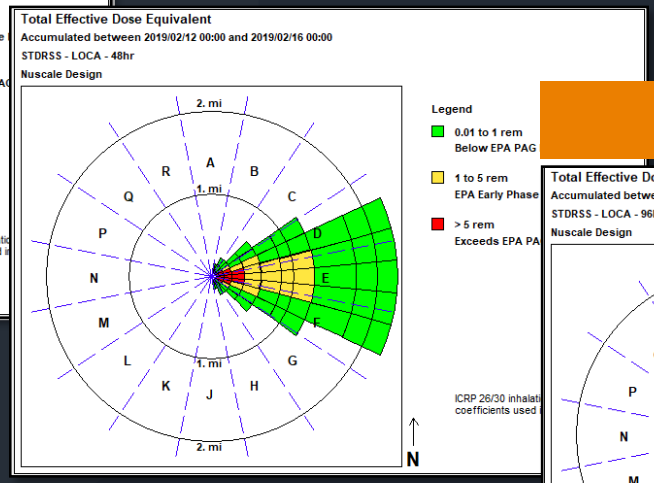
Delayed Release

LOCA

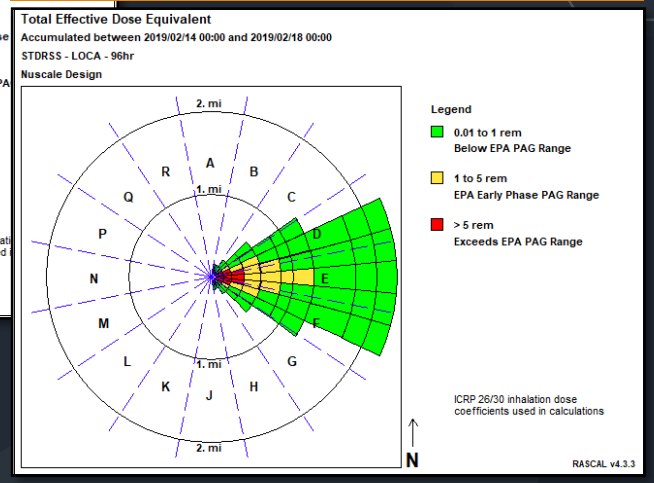
No Delay



48 Hour Delay

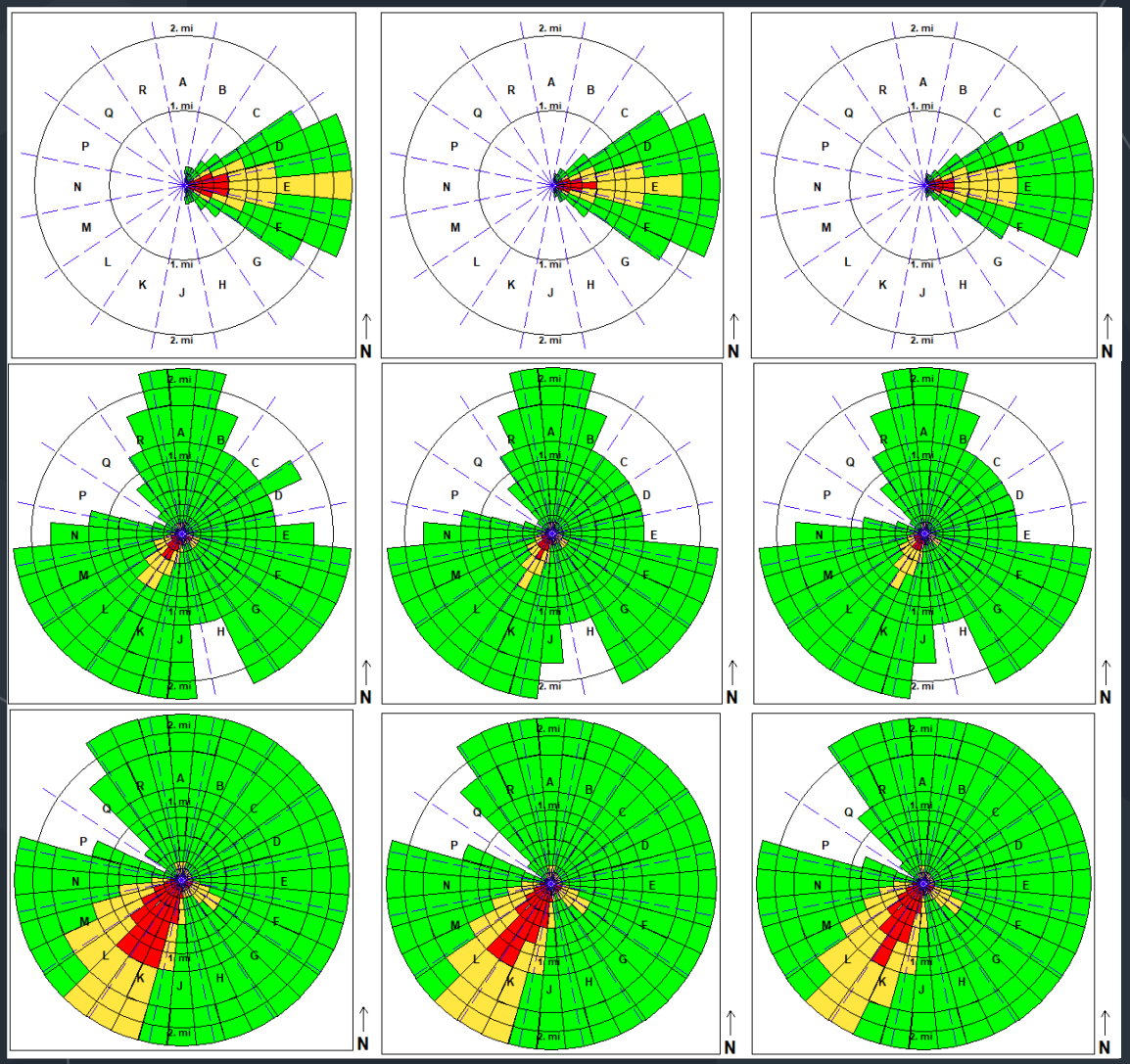


96 Hour Delay



Delayed Release

LTSBO



Conclusions

- EPZ size is sensitive to weather related phenomena. Wind speed and persistence, stability class, and precipitation are all important to some degree.
- Dispersion modeling is important: many factors vary significantly within a short distance, creating large variation in dose-at-distance.
- Release timing and release rate are important to the sensitivity analysis.

Insights and Recommendations

- Realistic, site-specific weather patterns should be used for EPZ size determination analyses as opposed to simple, conservative assumptions.
- Advanced reactors that minimize source term or delay potential releases can reduce emergency planning needs (commensurate to risk).
- The NRC may want to consider technology-neutral source term models for RASCAL to enhance emergency response capabilities.

Questions?

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