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

RAMP
Radiation Protection Computer Code Analysis and Maintenance Program

WELCOME TO RASCAL TRAINING

Before we get started:

- *Ensure you have a working copy of RASCAL 4.3.3*
- *There's no requirement for an internet connection*
- *Let us know if you have any setup questions or issues*

INSTRUCTORS

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Athey Consulting

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US Nuclear Regulatory Commission
Office of Nuclear Security and Incident Response

WELCOME!

Show of hands:

- **Do you have RASCAL installed on your computer?**
- **Have you taken the online RASCAL courses?**
- **Do you have previous RASCAL experience?**
- **Do you have dose assessment experience?**

Let's go around the room:

- **Name and organization**

What this class "is" and "is not"

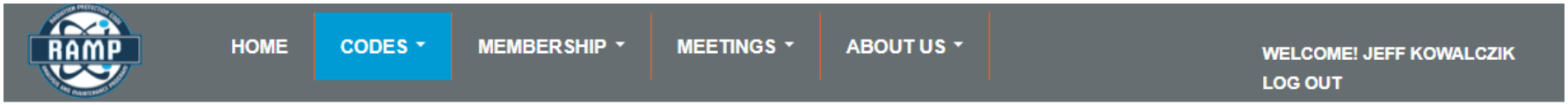
- It is an introduction to using the latest version of the RASCAL software
- You will get hands-on experience, primarily with the Source Term to Dose model running nuclear power plant scenarios
- It is not a class in the technical details of the RASCAL methods (although we do touch on some)
- It is not an introductory class in health physics or emergency response

Overview of Available RASCAL Training

Module 1	Introduction • Overview, what it is and does
Module 2	Fundamentals • How to Use RASCAL; basic navigation • Overview of models and methods
Module 3	Tutorials • Topical problems for scenarios & source terms • Reading / using results
Module 4	Advanced • Selecting source terms / outputs • Real world scenarios • Comparing with other codes

THE FIRST 3 TRAINING MODULES ARE AVAILABLE ONLINE

WWW.USNRC-RAMP.COM



RASCAL NAVIGATION

- DOWNLOAD THE RASCAL CODE
- RASCAL DOCUMENTATION
- RASCAL TRAINING
- RASCAL SUPPORT

RASCAL Training

Self-Study Training

This content provides introductory and refresher material for new and existing users.

Course (Click to access)	Description	Audience
Module 1 Introduction to RASCAL	15 min video Brief overview providing general information on RASCAL.	New users, managers, and decision-makers.
Module 2 RASCAL Fundamentals	1 hour interactive video In-depth course covering how to use RASCAL and the models and methods within.	New users.
Module 3 RASCAL Tutorials	Instructional PDFs. Self-paced walkthroughs for a variety of topical areas practicing RASCAL.	New users and refresh for existing users.

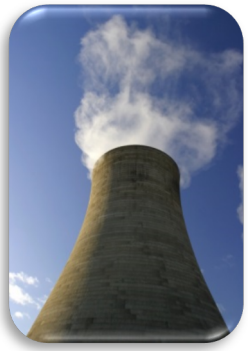
ALL OTHER SUPPORT ALSO AT WWW.USNRC-RAMP.COM

- Need Account to Access
  - Non-Disclosure Agreement (NDA)
  - Fed/State/Local/International/Private
- Code Distribution
- Technical Support
  - Technical documentation
  - Training
  - FAQs & Forums

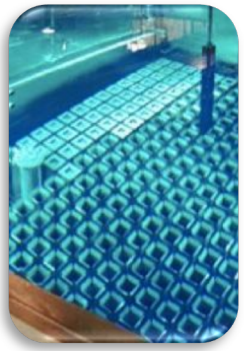
Course Scenario Disclaimer

This RASCAL presentation was developed by the U.S. Nuclear Regulatory Commission to support training for its Incident Response Program and the Radiation Protection Computer Code Analysis and Maintenance Program (RAMP). The situations presented may not be realistic or likely and are for training purposes only.

Before We Start, Do We Need to Review Any Basics on technology?



Nuclear Power Plant



Spent Fuel

Fuel Cycle

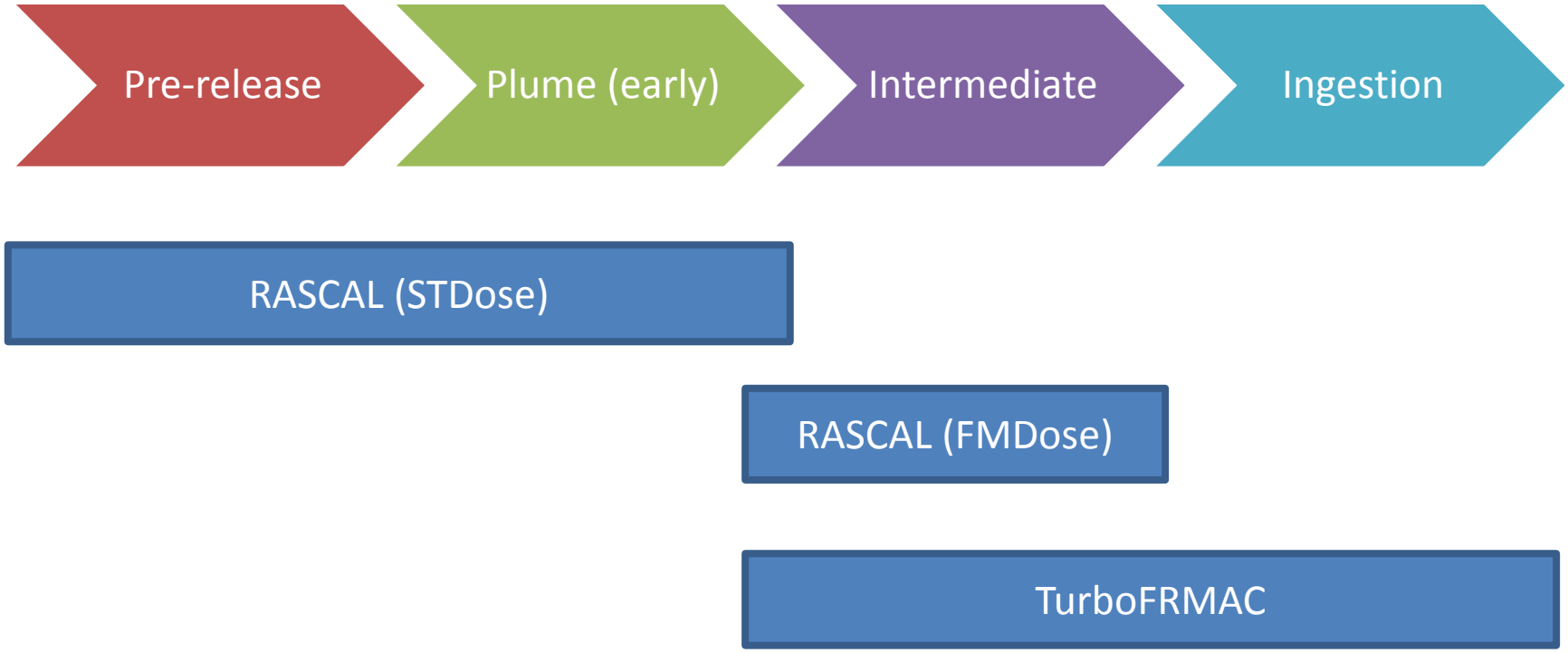
Other Material

MODULE 1

INTRODUCTION TO RASCAL

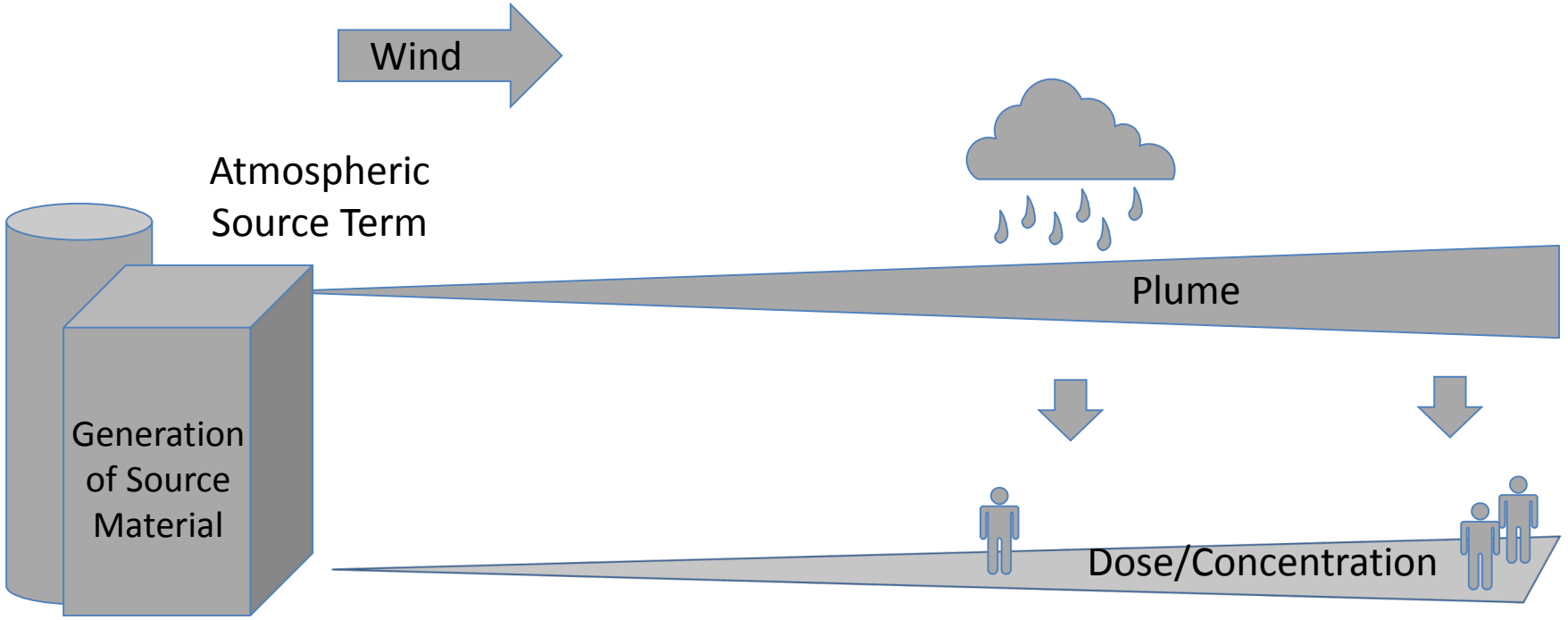
This module is a brief overview of RASCAL and its tools

Where does RASCAL fit in the phases of a radiological emergency?

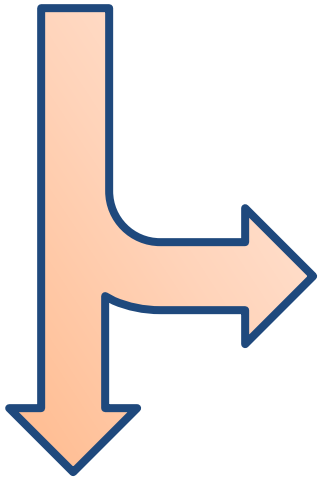


This Training Will Focus on STDose

- **Source Term to Dose Module Creates Source Term, Processes Met Conditions, & Calculates Doses**



Where to next?



More Module 1 review

Continue to Module 2

MODULE 2

RASCAL FUNDAMENTALS

This module describes the STDose process, including an overview of the models and methods

WHY ARE YOU USING STDOSE?

1. Determine possible PARs/PADs in pre-release?
   - No release yet, limited information available
2. Determine bounds of starting release?
   - Release just started. Have clearer understanding of how accident may progress.
3. Determine more detailed dose information?
   - Release ongoing or stopped. Most information available, including some field readings.
4. Compare or verify results.
   - Mostly used for event re-creation or research

DO YOU EVEN NEED RASCAL?

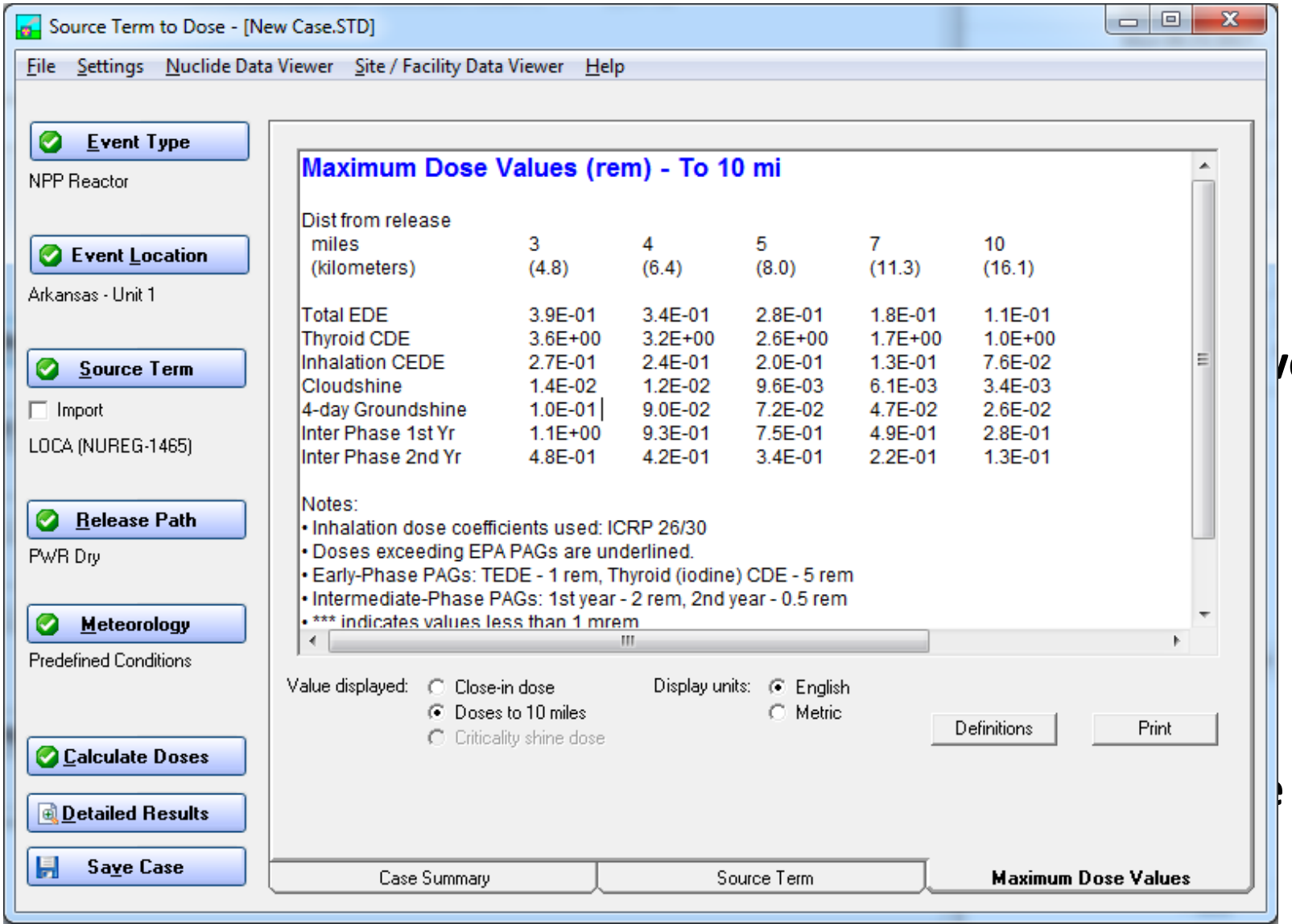
What is the most recent problem you've had with a power plant? Did you need RASCAL then?

For all examples in this training:

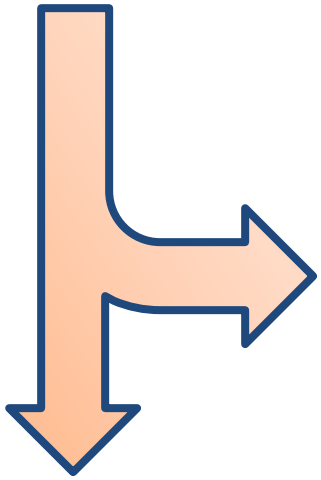
- Scenarios justify the use of RASCAL (so you can see how to use the models)
- We have ability to know all the parameters of the incident

But this might not be true in reality

Review of Inputs



Where to next?



More Module 2 review

Continue to Module 3

MODULE 3

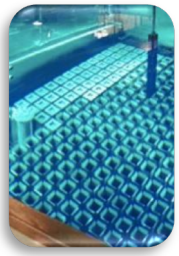
RASCAL TUTORIALS

This module contains topical problems
that focus on different scenarios and source terms

LET'S DISCUSS AVAILABLE MODELS WITHIN RASCAL

Nuclear Power Plant

LTSBO
LOCA
Coolant Release
Containment Rad Monitor
Coolant Sample
Containment Air
Monitored Release
Manual Releases



Spent Fuel

Pool - Uncovered Fuel
Pool - Damaged Rod
Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release
UO_2 Fire/Explosion
Criticality
Manual Releases

Other Materials

Manual Releases
Material in a Fire

Available Problems

- Loss of Coolant Accident (Module 2 Review)
- Long-Term Station Blackout
- Multi-Unit Assessment
- Monitored Mixtures
- Comparing with Field Measurements
- Download Met from Internet (MetFetch)
- Spent Fuel Pool
- Containment Rad Monitor
- Steam Generator Tube Rupture
- Transportation Accident

Additional Topics

Are there any specific topics we haven't covered or that you would like us to review?

Module 4

Advanced Problems

This module contains more advanced and realistic scenarios, focusing on how RASCAL would likely be used during an event

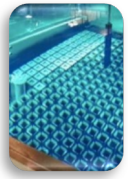
Overview

- Source Term Selection
- Comparing Models
- Problem 1 - ANO
- Problem 2 - WB
- Three Mile Island / Fukushima

Let's review our source term options. For each scenario, select the best source term option from all the models given

Nuclear Power Plant

LTSBO
LOCA
Coolant Release
Containment Rad Monitor
Coolant Sample
Containment Air
Monitored Release
Manual Releases



Spent Fuel

Pool - Uncovered Fuel
Pool - Damaged Rod
Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release
UO_2 Fire/Explosion
Criticality
Manual Releases

Other Materials

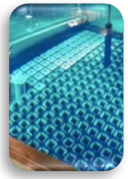
Manual Releases
Material in a Fire

Scenario 1

NPP utility reports routine release and provides stack monitor data; provide initial assessment of offsite impact, then determine if projections match field teams.

Nuclear Power Plant

LTSBO
LOCA
Coolant Release
Containment Rad Monitor
Coolant Sample
Containment Air
Monitored Release
Manual Releases



Spent Fuel

Pool - Uncovered Fuel
Pool - Damaged Rod
Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release
UO_2 Fire/Explosion
Criticality
Manual Releases

Other Materials

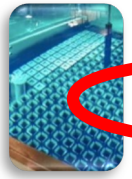
Manual Releases
Material in a Fire

Scenario 2

An earthquake struck near NPP, potentially affecting both units and a spent fuel pool.

Nuclear Power Plant

LTSBO
LOCA
Coolant Release
Containment Rad Monitor
Coolant Sample
Containment Air
Monitored Release
Manual Releases



Spent Fuel

Pool - Uncovered Fuel
Pool - Damaged Rod
Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release
UO_2 Fire/Explosion
Criticality
Manual Releases

Other Materials

Manual Releases
Material in a Fire

Scenario 3

A rad materials truck overturns near residential neighborhood; activity is measured by a field team; determine if residents must relocate.

Nuclear Power Plant

LTSBO

LOCA

Coolant Relea

C

Spe

Other Materials

Manual Releases

Material in a Fire

lease

O_2 Fire/Explosion

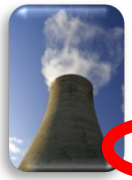
Criticality

Manual Releases

NOT RASCAL STDose!

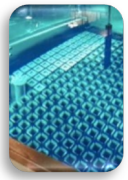
Scenario 4

NPP utility reports loss of coolant and provides containment monitor reading.



Nuclear Power Plant

LTSBO
LOCA
Coolant Release
Containment Rad Monitor
Coolant Sample
Containment Air
Monitored Release
Manual Releases



Spent Fuel

Pool - Uncovered Fuel
Pool - Damaged Rod
Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release
UO_2 Fire/Explosion
Criticality
Manual Releases

Other Materials

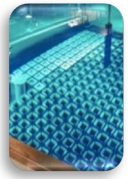
Manual Releases
Material in a Fire

Scenario 5

NPP utility reports abnormal conditions and provide list of nuclides in coolant sample.

Nuclear Power Plant

LTSBO
LOCA
Coolant Release
Containment Rad Monitor
Coolant Sample
Containment Air
Monitored Release
Manual Releases



Spent Fuel

Pool - Uncovered Fuel
Pool - Damaged Rod
Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release
UO_2 Fire/Explosion
Criticality
Manual Releases

Other Materials

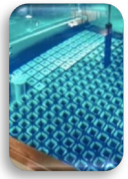
Manual Releases
Material in a Fire

Scenario 6

Diesel fuel spills into dry cask yard and catches fire.

Nuclear Power Plant

LTSBO
LOCA
Coolant Release
Containment Rad Monitor
Coolant Sample
Containment Air
Monitored Release
Manual Releases



Spent Fuel

Pool - Uncovered Fuel
Pool - Damaged Rod
Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release
UO_2 Fire/Explosion
Criticality
Manual Releases

Other Materials

Manual Releases
Material in a Fire

Scenario 7

Loss of offsite power at NPP.

Nuclear Power Plant

LTSBO

LOCA

Coolant Release

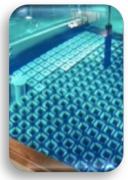
Containment Rad Monitor

Coolant Sample

Containment Air

Monitored Release

Manual Releases



Spent Fuel

Pool - Uncovered Fuel

Pool - Damaged Rod

Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release

UO_2 Fire/Explosion

Criticality

Manual Releases

Other Materials

Manual Releases

Material in a Fire

Scenario 8

NPP utility reports major loss of coolant due to earthquake, which also causes loss of offsite power.

Nuclear Power Plant

LTSBO

LOCA

Coolant Release

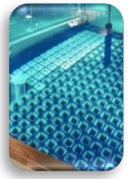
Containment Rad Monitor

Coolant Sample

Containment Air

Monitored Release

Manual Releases



Spent Fuel

Pool - Uncovered Fuel

Pool - Damaged Rod

Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release

UO_2 Fire/Explosion

Criticality

Manual Releases

Other Materials

Manual Releases

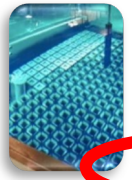
Material in a Fire

Scenario 9

While moving fuel elements in SFP, operators report that an assembly collided with the wall.

Nuclear Power Plant

LTSBO
LOCA
Coolant Release
Containment Rad Monitor
Coolant Sample
Containment Air
Monitored Release
Manual Releases



Spent Fuel

Pool - Uncovered Fuel
Pool - Damaged Rod
Dry Cask Release

Fuel Cycle

UF_6 Cylinder Release
UO_2 Fire/Explosion
Criticality
Manual Releases

Other Materials

Manual Releases
Material in a Fire

Comparing Models

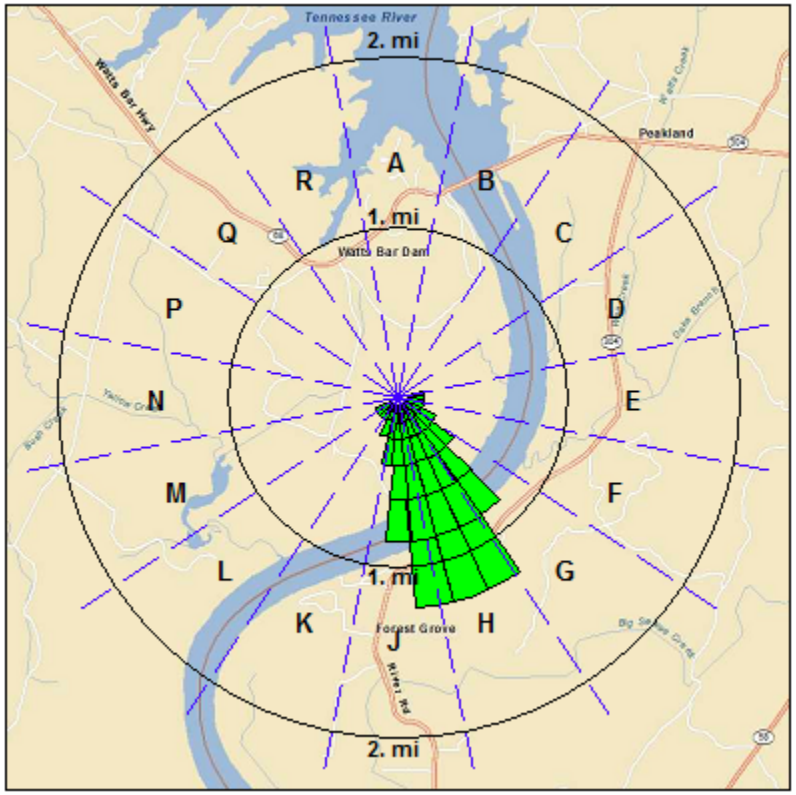
- It is almost certain that dose projections from other software will provide different results.
- Even within RASCAL there may be multiple ways to model a scenario resulting in differences.
- The challenge is to understand where these differences are and when they matter.

- Before we start, let's make sure we're comparing similar outputs:

CAN WE COMPARE THESE RESULTS?

Total Effective Dose Equivalent

Watts Bar - Unit 1



Maximum Dose Values (rem)

Dist from release miles (kilometers)	0.1 (0.16)	0.2 (0.32)
Total EDE	8.6E-01	3.0E-01
Thyroid CDE	2.0E+01	6.4E+00

Early Phase Guidance (Radioiodine)
(KI Administration based on Thyroid Radioiodine CDE)

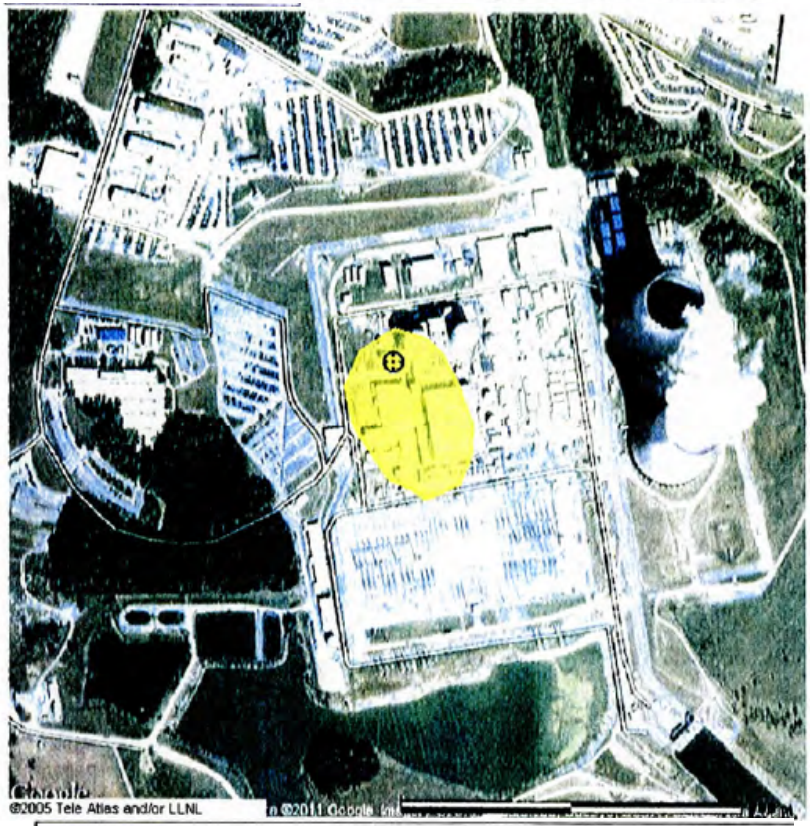
Effects and Actions

	Description	(rem) Extent Area
	EPA Early Phase PAG for considering evacuation. Shelter in place if no evacuation.	>5 162 m 20,004 m2

Note: Areas and counts in the table are cumulative. Population Source = V1.0.

How about comparing these?

Early Phase Dose (0-96 Hrs)
(Total Effective Dose Including Plume Passage)

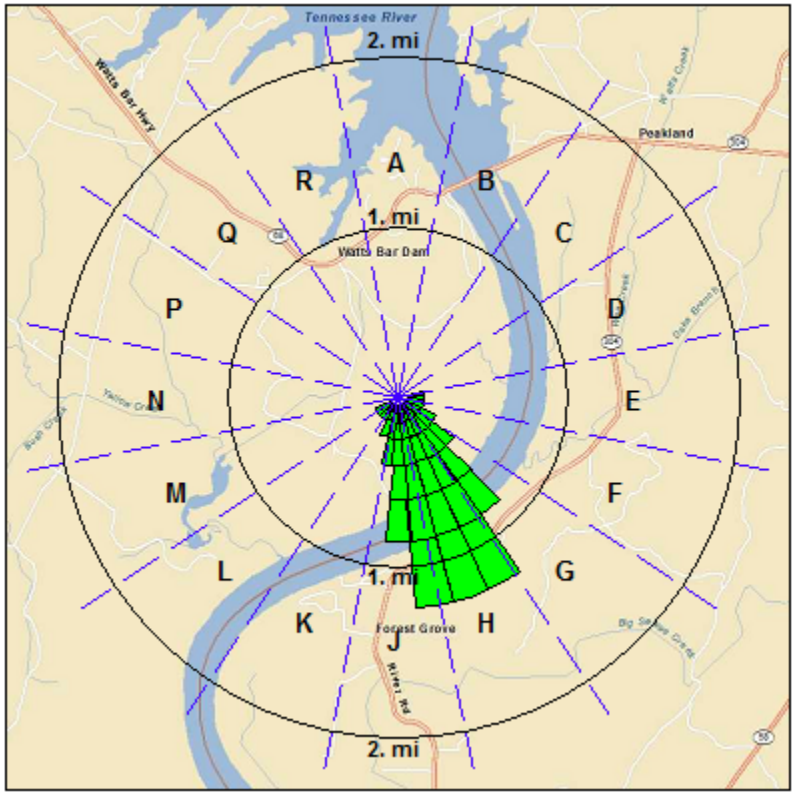


Actions and Long-Term Effects

	Description	(rem) Extent Area
	Exceeds 1 rem total effective dose.	>1 203 m 32,506 m2

Total Effective Dose Equivalent

Watts Bar - Unit 1



Maximum Dose Values (Sv)

Dist from release miles (kilometers)	0.1 (0.16)	0.2 (0.32)
Total EDE	8.6E-03	3.0E-03
Thyroid CDE	2.0E-01	6.4E-02

Comparing Models

Assuming we can now compare different outputs, modeling differences may exist for each of these categories:

- **Source Term**
- **Weather**
- **Dose Calculations**

Let's discuss each in a bit more detail.

Comparing Models – Source Term

Name some aspects of the source term models that might result in modeling differences:

- **Sprays on / off**
- **Leak rate**
- **Timing sequence**
- **Magnitude**
- **Radionuclide Composition**

For each one, how would differences show in outputs and where could you go in RASCAL to verify if there were differences? Remember sometimes there are inherent differences in methods that aren't as verifiable.

Comparing Models – Weather

Name some aspects of the weather or ATD models that might result in modeling differences:

- **Wind direction**
- **Stability**
- **Topography / roughness**
- **Time / spatial variance in wind fields**
- **Precipitation**
- **Observations vs forecasts**
- **Dispersion coefficients**

For each one, how would differences show in outputs and where could you go in RASCAL to verify if there were differences? Remember sometimes there are inherent differences in methods that aren't as verifiable.

Comparing Models – Dose Calculations

Name some aspects of the dose calculations that might result in modeling differences:

- **Dose coefficients (ICRP version)**
- **Other dose parameters (breathing rate, shielding)**
- **Decay**
- **Dose calculation time**
- **Pathways (internal/external)**

For each one, how would differences show in outputs and where could you go in RASCAL to verify if there were differences? Remember sometimes there are inherent differences in methods that aren't as verifiable.

Comparing Models – Closing thoughts

- There are lots of uncertainties in all parts of the modeling process
- Sometimes it may be okay to lie to RASCAL
- Don’t drive yourself crazy trying to understand all differences
- If the models match exactly something is probably wrong
- There is no “RIGHT” answer

Problem 1
Arkansas Nuclear One – Confirmatory Calculations

- **In response to an event report at Arkansas Nuclear One, you are called in to provide an initial assessment of potential offsite consequences.**

- **You are provided the initial notification message and asked if the PARs are appropriate. DO NOT USE THE FOLLOWUP NOTIFICATION SHEET YET.**

Problem 1
Arkansas Nuclear One – Confirmatory Calculations

- **30 minutes later, you receive a follow-up notification from ANO.**

- **Again, you are asked if the PARs are appropriate, as well as being asked to confirm if ANO's offsite dose projection is reasonable.**

Problem 2
Watts Bar - Best Method & Field Team Comparison

- **In response to an event report at Watts Bar, you are called in to provide an initial assessment of potential offsite consequences.**

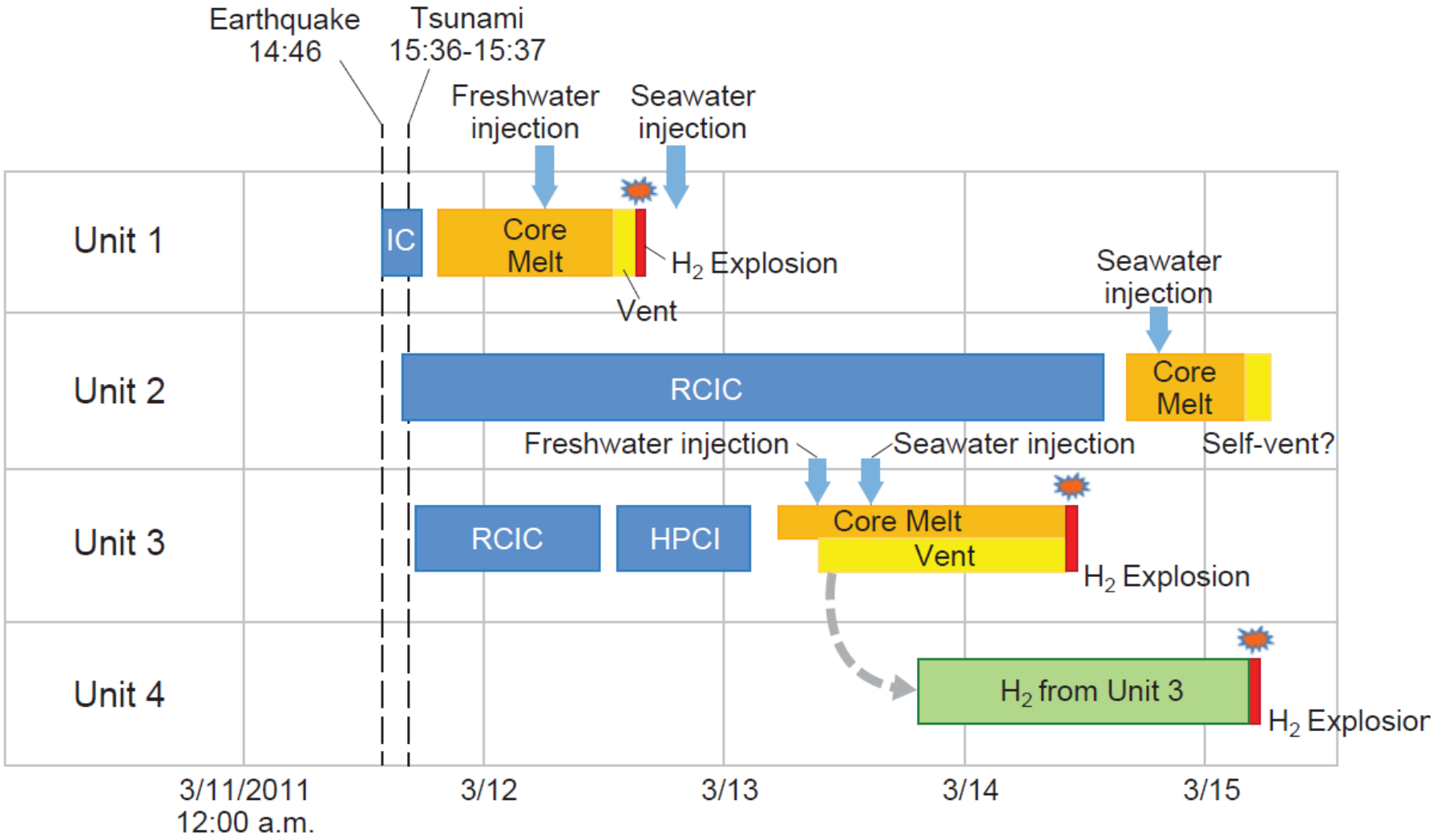
- **After reporting to duty, you have compiled some data from several sources. Run RASCAL to determine an initial assessment based on the data you have.**

Problem 2
Watts Bar - Best Method & Field Team Comparing

- **After completing your assessment, determine how your results compare with the field team readings that are being reported.**

- **Additionally, other organizations are providing independent model runs. How do your results compare?**

THREE MILE ISLAND & FUKUSHIMA



Three Mile Island & Fukushima

March 11

- **14:46 A 9.0 Magnitude earthquake strikes off the coast. Units 1, 2, and 3 are automatically shut down. Units 4, 5, and 6 had been shut down earlier for maintenance. Site loses power, but diesels start up.**
- **15:30 Unit 1 emergency condenser fails.**
- **15:46 A 46 ft (14 m) tsunami overtops the site seawall and disabled all diesels except one and washes away fuel tanks.**
- **18:00 Unit 1 water level reaches top of fuel.**
- **19:30 Unit 1 water level reaches bottom of fuel.**
- **21:00 Unit 1 containment pressure twice normal levels.**

March 12

- **02:44 Battery power for Unit 3 runs out**
- **04:15 Unit 3 water level below fuel**
- **05:30 Operators decide to vent steam to reduce pressure in Unit 1 (low amount of rad material). Freshwater injection into Unit 1.**
- **10:58 Operators decide to vent high pressure in Unit 2**
- **14:50 Freshwater injection in Unit 1 halted.**
- **15:36 Explosion in secondary containment of Unit 1**
- **19:00 Seawater injection started for Unit 1**

March 14

- **11:00 Unit 3 reactor building explodes**
- **13:15 Cooling system for Unit 2 stops.**
- **18:00 Unit 2 water level reaches top of fuel**
- **20:00 Unit 2 core damage occurs**

March 15

- **11:00 Second explosion of Unit 3**

Three Mile Island & Fukushima

March 11

- **14:46 A 9.0 Magnitude earthquake strikes off the coast. Units 1, 2, and 3 are automatically shut down. Units 4, 5, and 6 had been shut down earlier for maintenance. Site loses power, but diesels start up.**
- **15:46 A 46 ft (14 m) tsunami overtops the site seawall and disabled all diesels except one and washes away fuel tanks.**

March 12

- **15:36 Explosion in secondary containment of Unit 1**

March 14

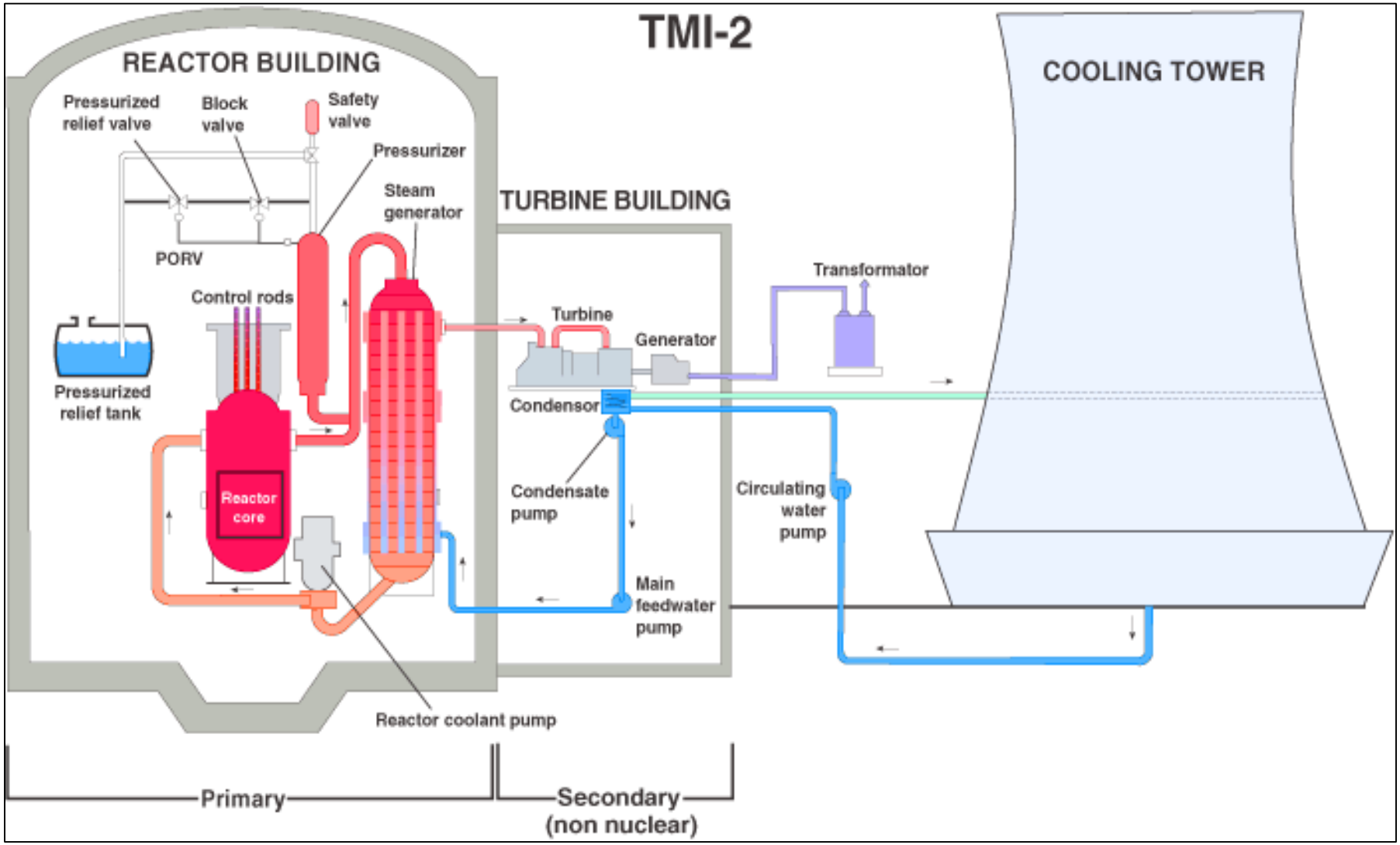
- **11:00 Unit 3 reactor building explodes**

March 15

- **11:00 Second explosion of Unit 3**

Also consider Spent Fuel Pools!

THREE MILE ISLAND & FUKUSHIMA



End of Class

- **Please let us know if you have any feedback on the course.**

- **For technical support with RASCAL, use the RAMP website forums and FAQs.**