



# U.S.NRC

United States Nuclear Regulatory Commission

*Protecting People and the Environment*

## IMPLEMENTING LESSONS LEARNED FROM FUKUSHIMA DAIICHI

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**June 1, 2016**

# Agenda

- The Earthquake and Tsunami
- Status of Fukushima Daiichi Today
- Status of U.S. Lessons Learned Activities
  - Overview
  - Seismic and Flooding Reevaluations
  - Tier 2/3 Items
    - Emergency Planning Zone
    - Other EP Items



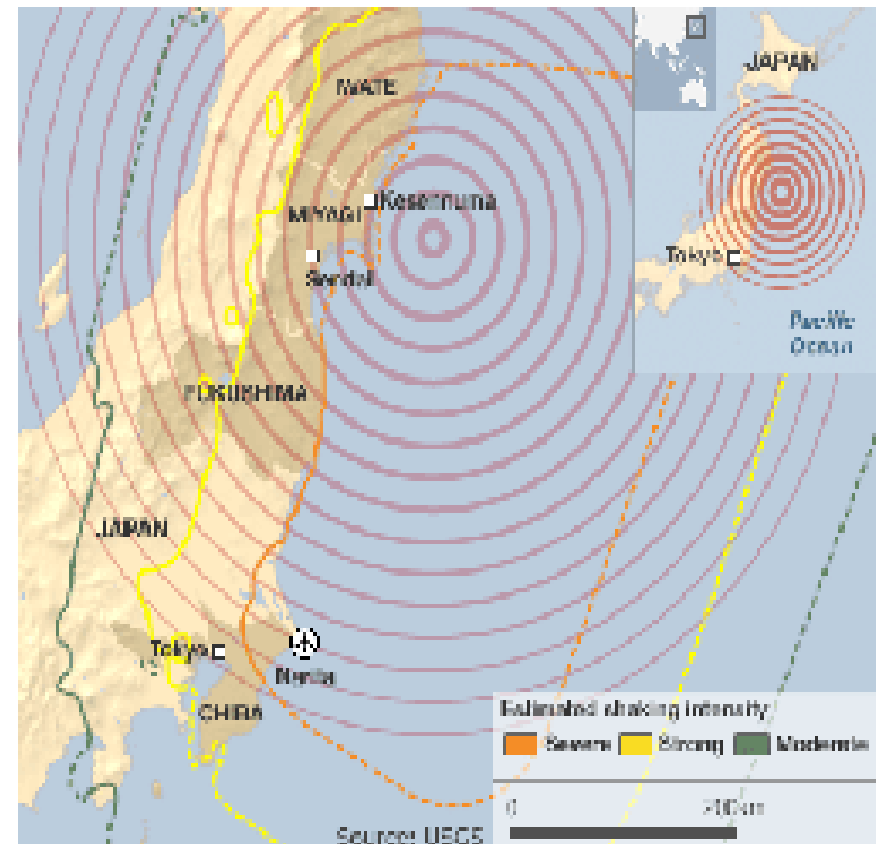
# Earthquake

## 9.0 Earthquake Strikes

- 5<sup>th</sup> strongest ever recorded
- Shaking lasted over 5 minutes
- Moved Japan 8 feet east
- Shifted Earth on its axis

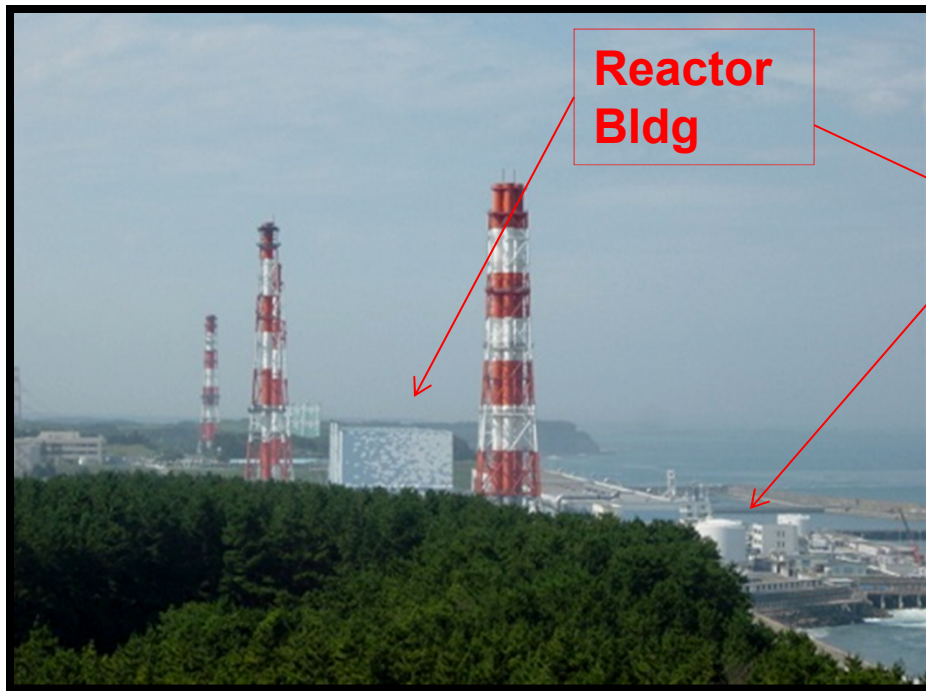
## Plant Response

- Reactors shut down as expected
- Emergency generators supplied power as expected
- Plant conditions stabilized and were controlled



# Tsunami

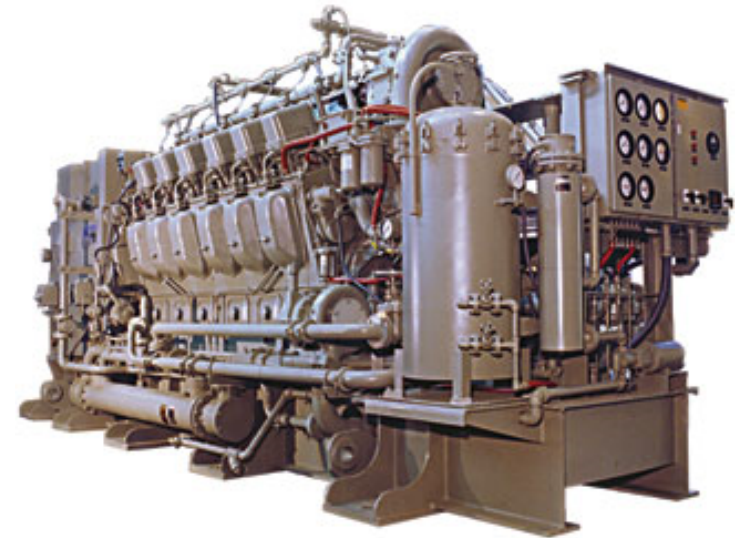
- Site designed to withstand ~6 meters (20 foot) tsunami
- Actual size estimated ~14 meters (46 feet)





# Sequence of Events at Fukushima

- Tsunami takes out all emergency power, which is needed to cool reactor cores
- Workers had very few alternatives to provide cooling
- Significant core melting occurs
- Hydrogen created from core melting accumulates and causes explosions



# **Fukushima Today**

Video created by the Japanese Government  
Ministry of Trade, Economics, and Industry  
Initially Presented September 15, 2015  
at the International Atomic Energy Agency  
Updated in March 2016 on the Fifth Anniversary  
of the Accident

<https://youtu.be/6CmvSBCstqA>

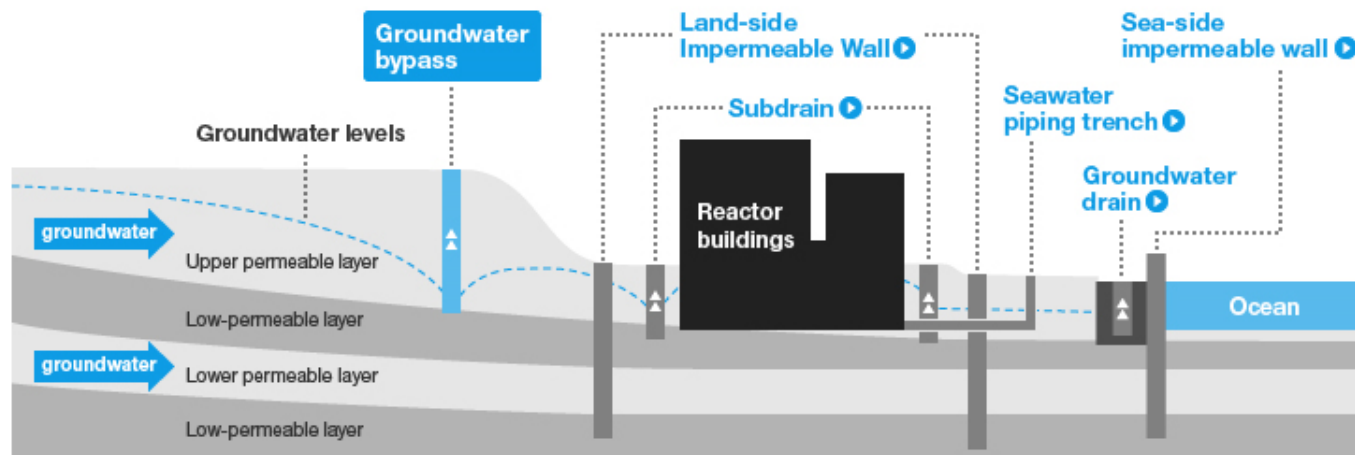
# Summary – Spent Fuel Removal

- Units 1-3 are being monitored and cooled
- Unit 4 - all spent fuel removed from spent fuel pool
- Unit 3 – large rubble removal in progress
  - spent fuel removal FY2017 (566 assemblies)
- Unit 2 – planning for spent fuel removal
  - spent fuel removal FY2020 (615 assemblies)
- Unit 1 – temporary building removal to support rubble removal
  - spent fuel removal FY2020 (392 assemblies)

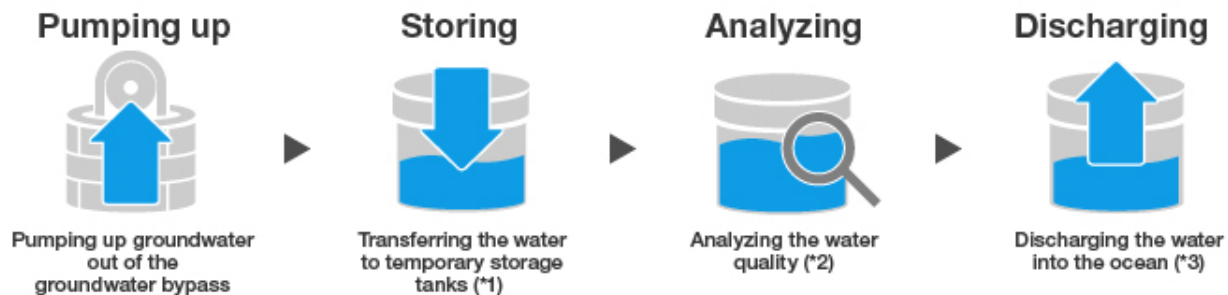
## Summary – Water Management

- Remove the source of contamination
  - water treatment
  - remove water from trench
- Keep water away from contamination sources
  - groundwater bypass and pumping
  - frozen soil walls
- Prevent leaks of contaminated water
  - welded tanks, seaside impermeable wall

# Summary – Water Management



## Procedures from Pumping up to Discharging

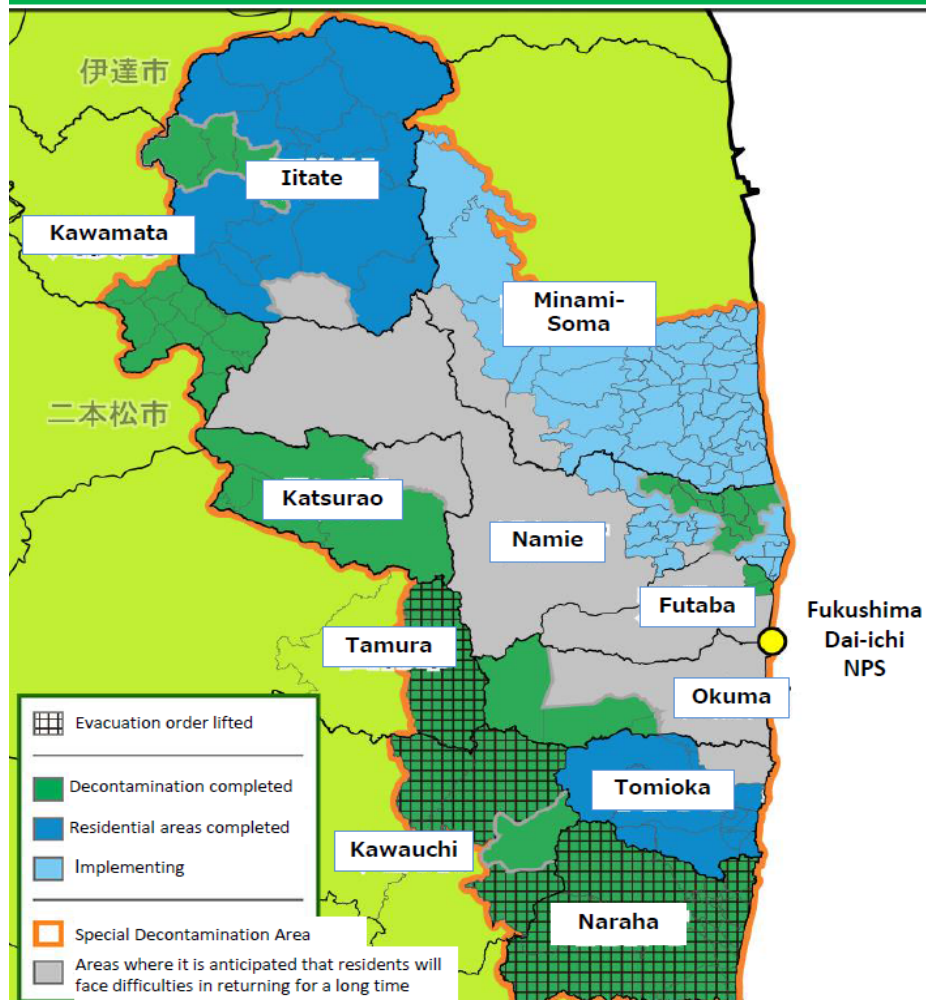


## Summary – Site Conditions

- All stored water on site has been treated
  - Over 70% fully treated with ALPS
  - Remainder treated for Sr and Cs removal – to be further treated with ALPS
- Site conditions have improved
  - Full face respirator not needed for >90%
  - Dose at boundary <1 mSv/yr at the end of FY2015 (March 2016)
  - Non-detectable airborne at site boundary

# Land Decontamination

## Progress in the Special Decontamination Area② (As of the end of March, 2016)



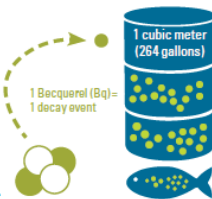
<Municipalities in which evacuation order were lifted>

Municipality	Evacuation order was lifted on
Tamura city	April 1, 2014
A part of Kawauchi village (former “areas to which evacuation orders are ready to be lifted”)	October 1, 2014
Naraha town	September 5, 2015

# How Radioactive is our ocean

## What is radiation?

Radiation is caused by unstable atoms breaking down and emitting high energy particles. The number of these events per second is called a Becquerel (Bq). The total number of Bq is often reported per cubic meter of (264 gallons) of seawater or kilogram (2.2 pounds) of fish.



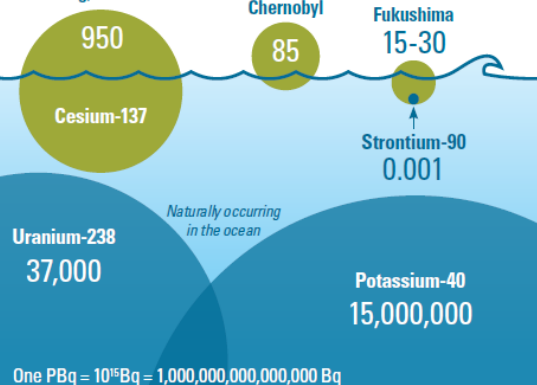
## Fukushima contaminants of concern



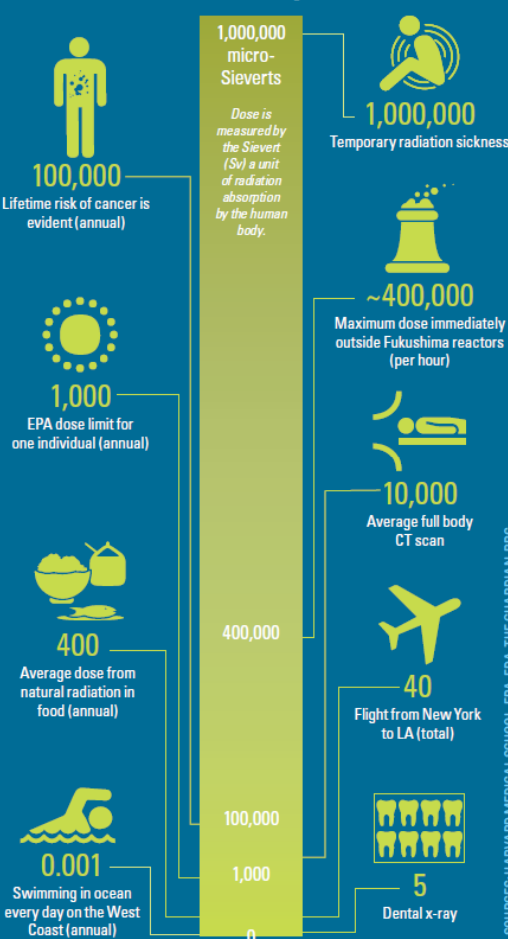
## Radioactivity in the ocean

Proportion of total radioactivity released (in PBq) that ended up in the ocean (area of each circle below the waterline).

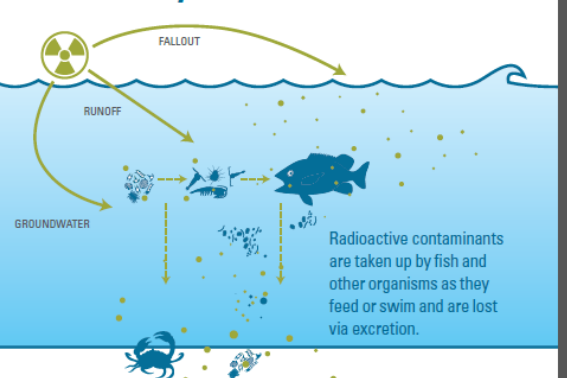
Global nuclear weapons testing, 1950s-60s



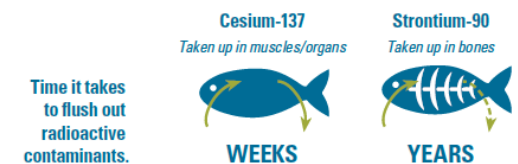
## Radiation dose and exposure



## Radioactivity in marine life

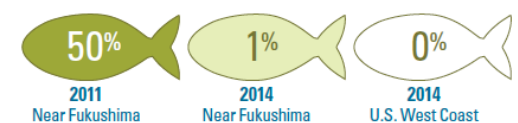


## Radioactivity in fish



## Seafood caught above radiation limits\*

\*Limits set by Japan (100 Bq/kg) and US (1000 Bq/kg) for fish sold in those countries.

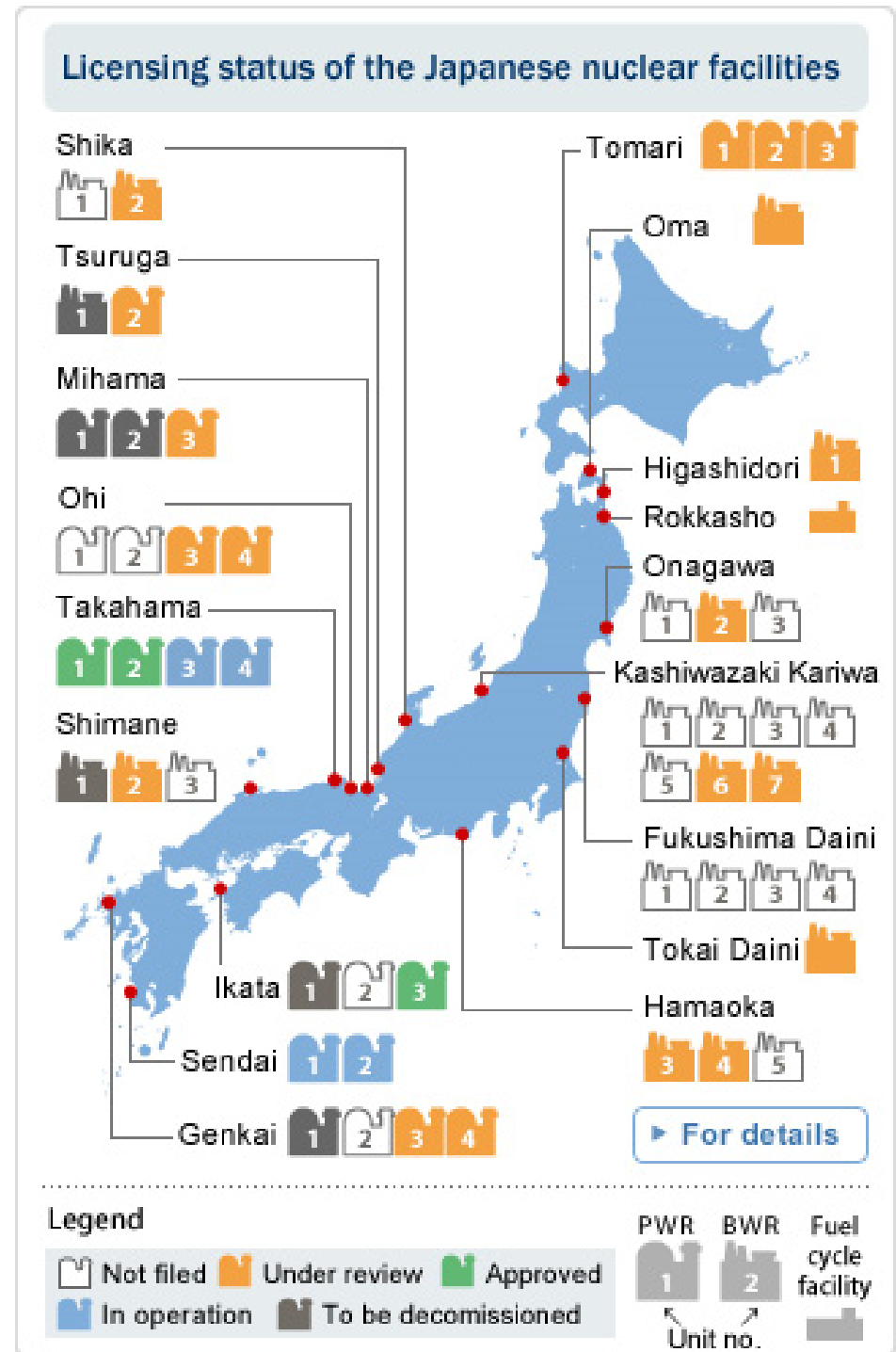


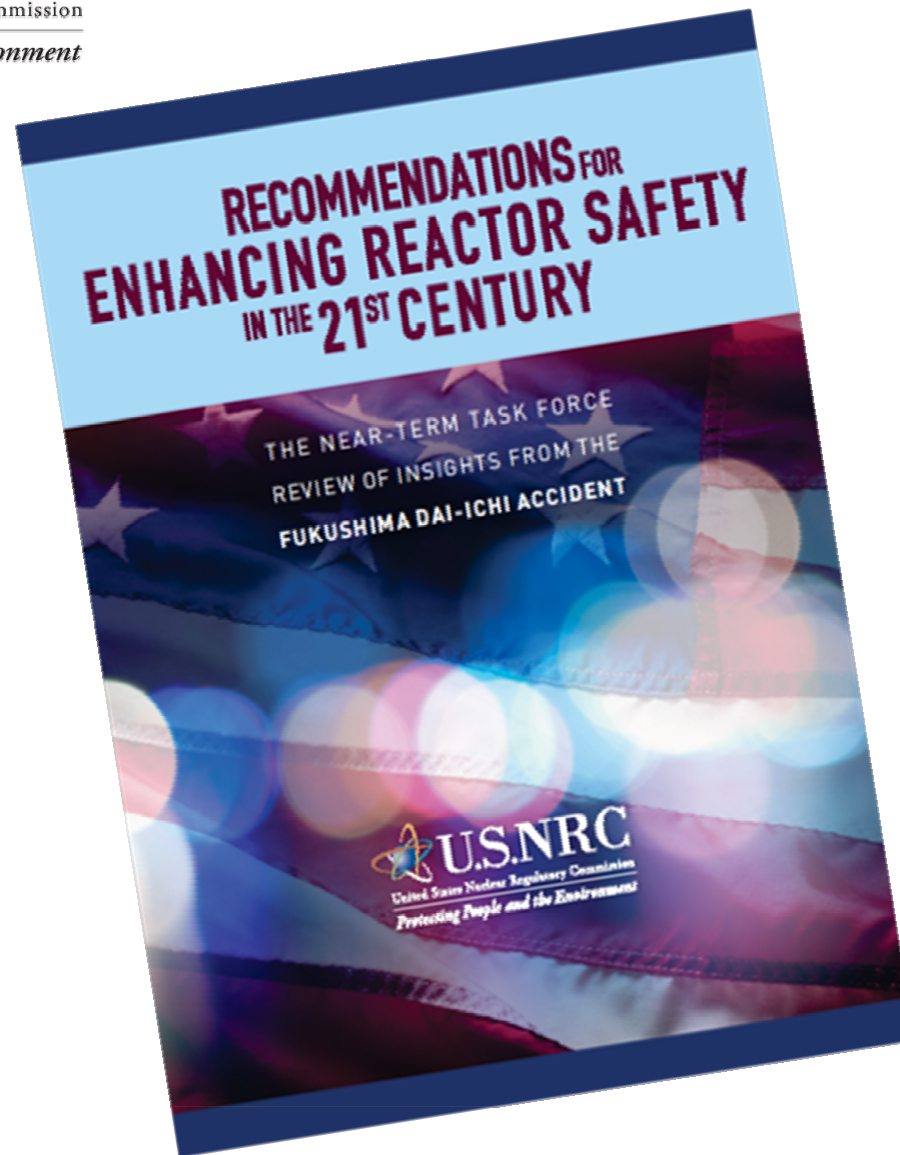
All fish contain trace levels of cesium-137 from nuclear weapons testing. Additional cesium from Fukushima closed fisheries in some areas of coastal Japan in 2011.

SOURCES: HARVARD MEDICAL SCHOOL, EPA, FDA, THE GUARDIAN, BBC



# Status of other Japanese Nuclear Power Plants

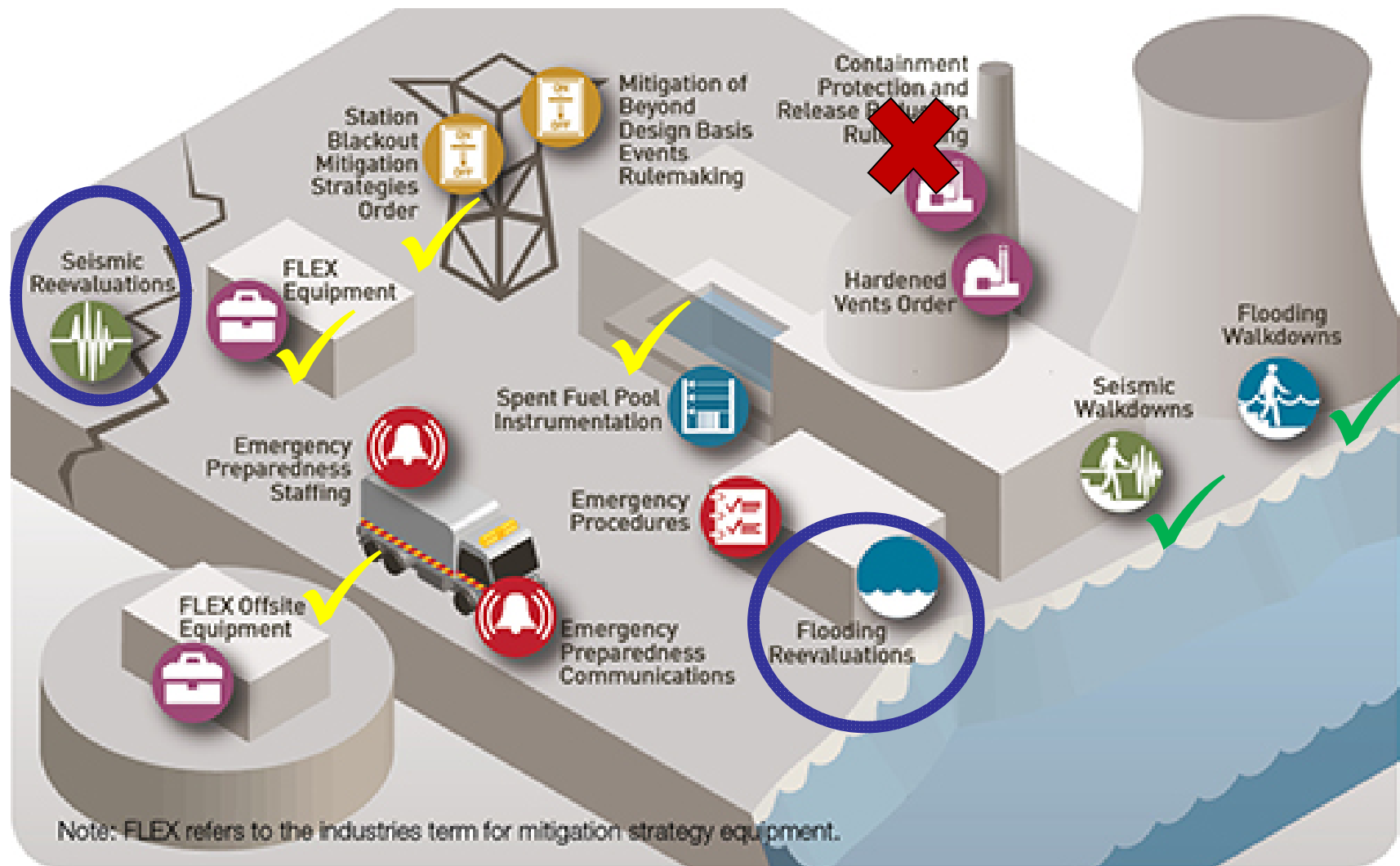






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Note: FLEX refers to the industries term for mitigation strategy equipment.

# Mitigating Strategies

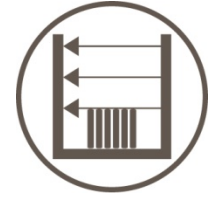


Requires a three-phase approach for maintaining or restoring core cooling, containment, and spent fuel cooling

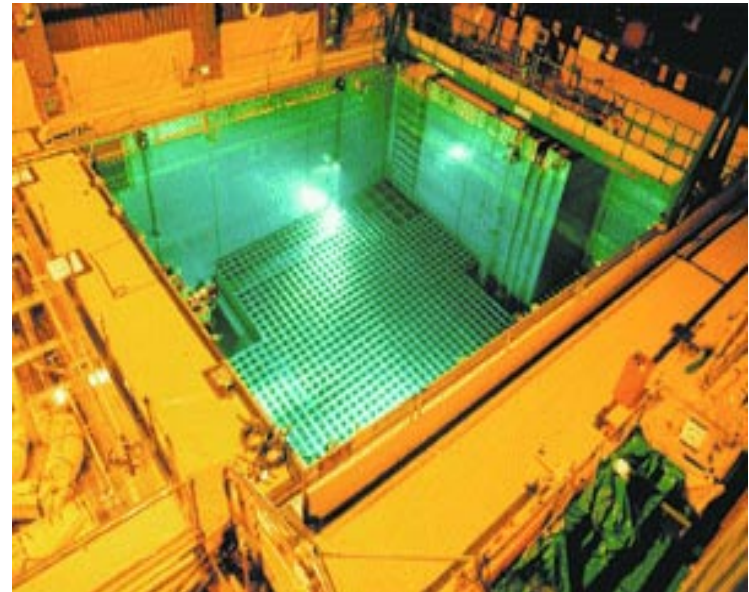
Phase	Licensee may use
Initial	Installed equipment
Transition	Portable, onsite equipment
Final	Resources obtained from offsite



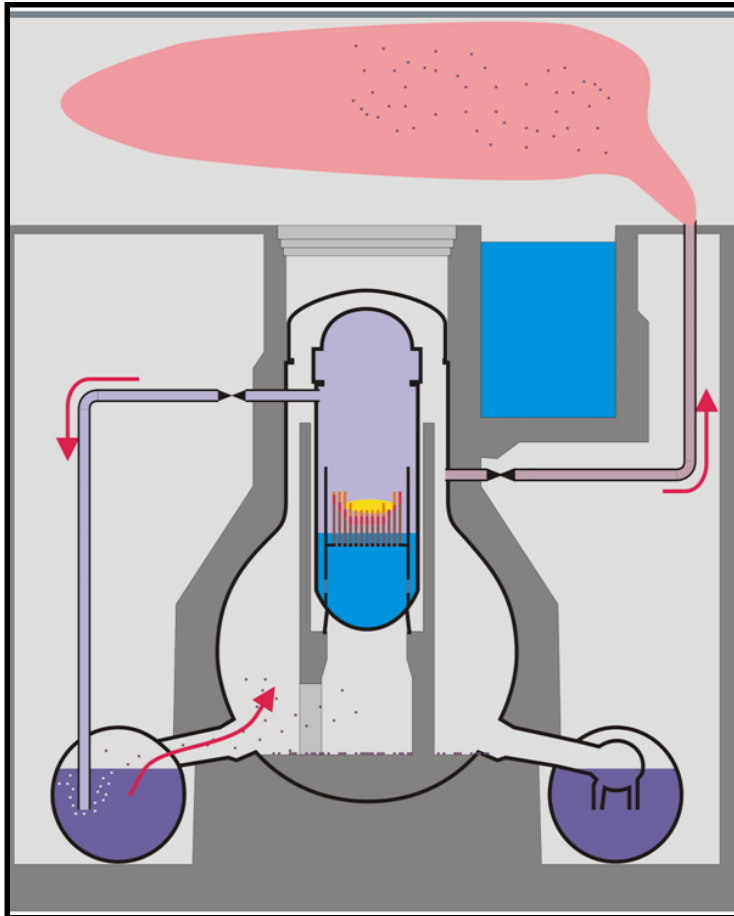
# Spent Fuel Pool Instrumentation



- Requires installation of water level instrumentation to indicate the following levels:
  - Normal fuel pool level
  - Below-normal level that still provides radiation shielding
  - Very low level, near top of fuel, where immediate action to add make-up water should be taken



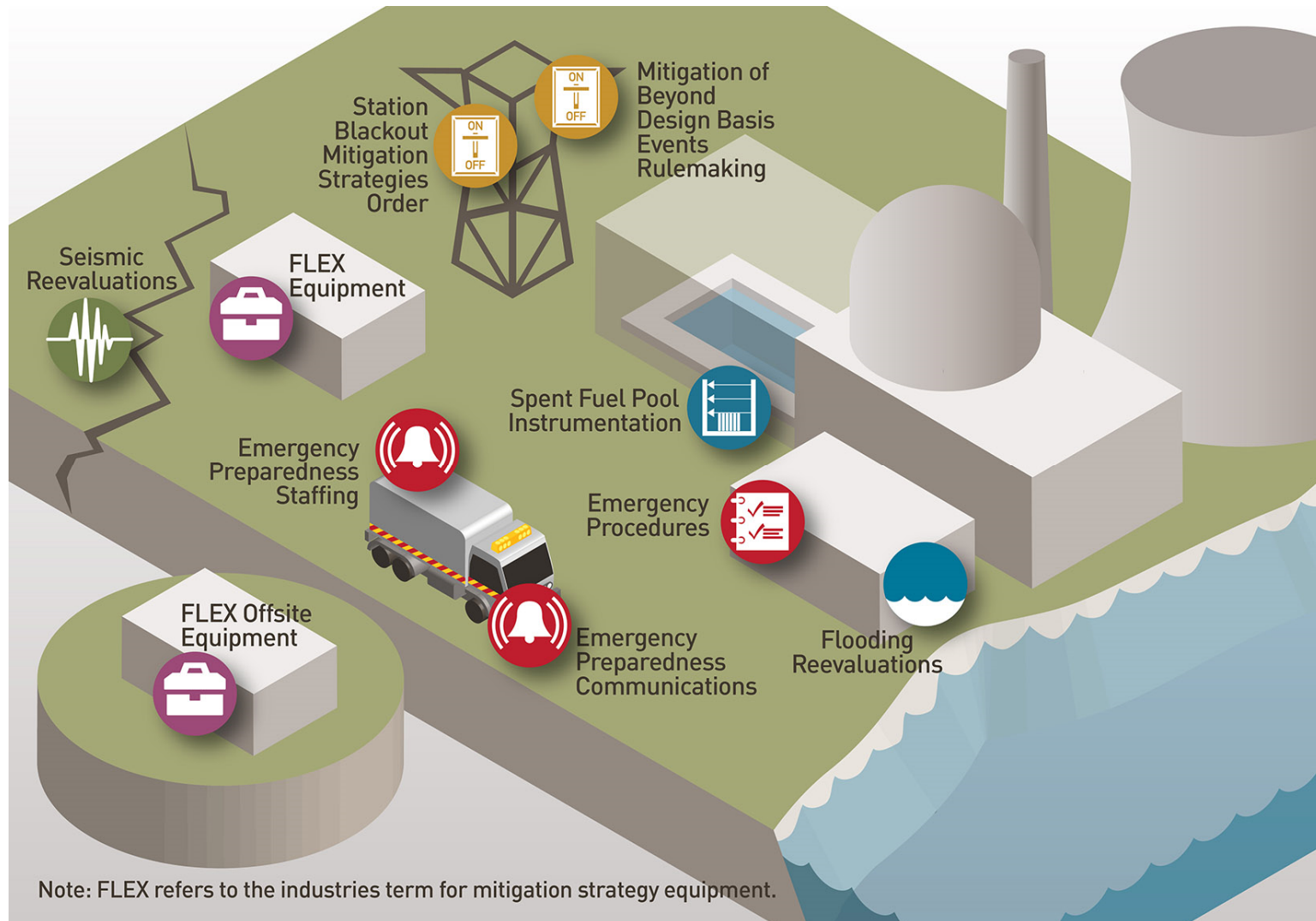
# Containment Vents



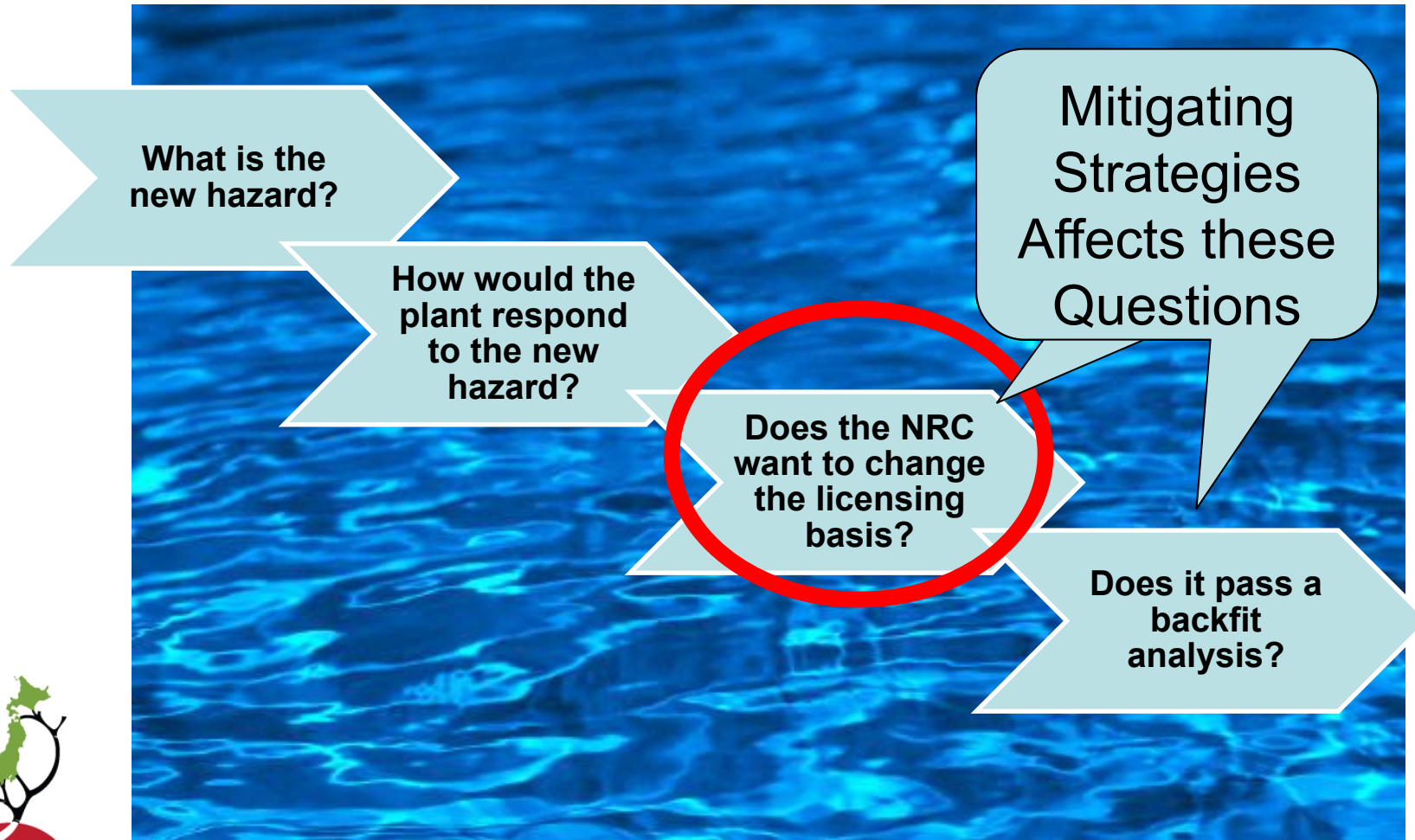
- Applies to boiling water reactors with certain designs (Mark I/II)
- Vents help control pressure by removing heat
- May help prevent core damage
- Must continue to function if core damage/melting occurs
- Required to work when normal power is lost
- Modified order has two phases



# Mitigation of Beyond-Design-Basis Events Rulemaking



# Seismic and Flooding Reevaluations





## **What does this mean?**

Licensees will already be required to  
plan how to preserve\*:

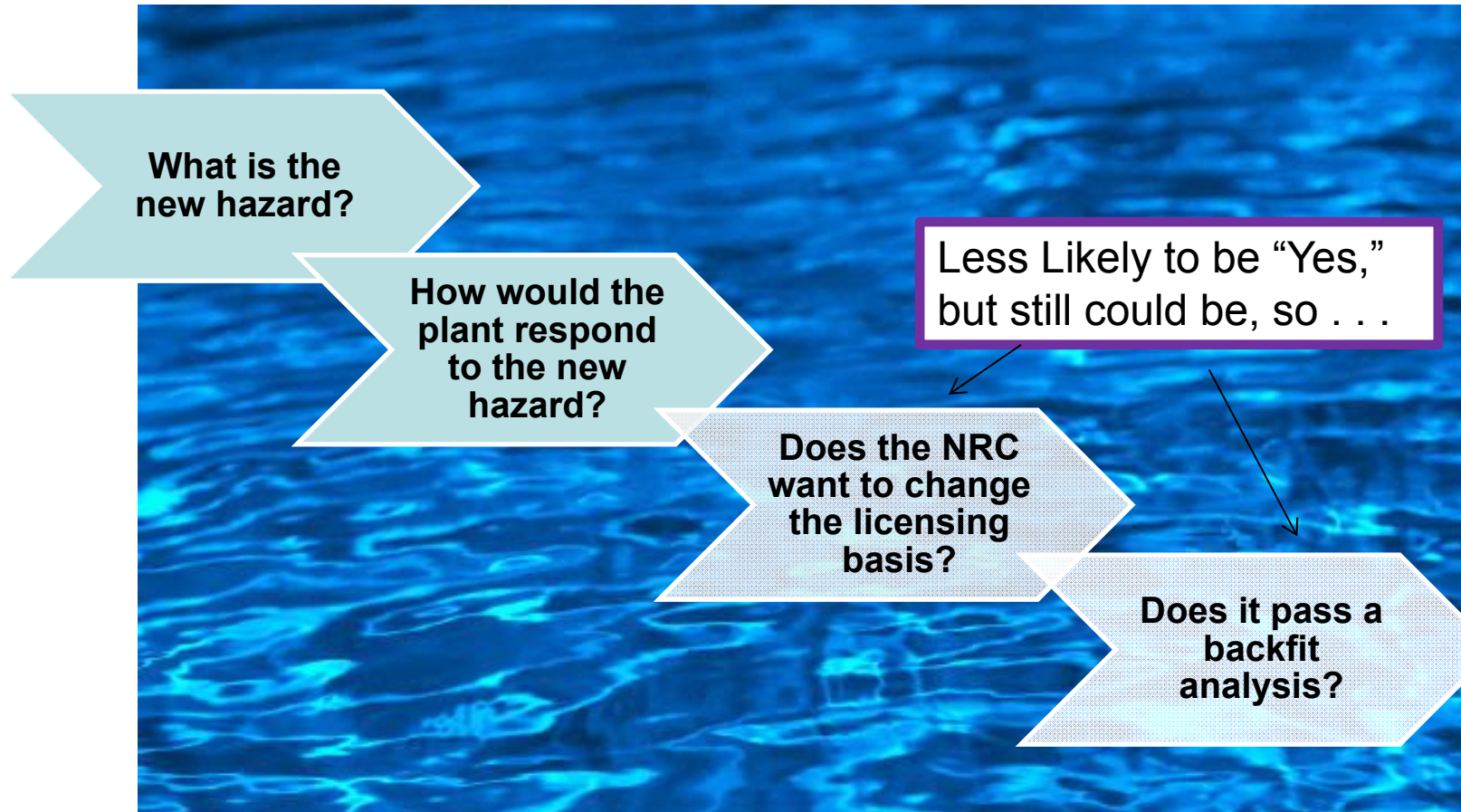
**Core Cooling  
Spent Fuel Pool Cooling  
and Containment**

under the conditions of the reevaluated  
flooding and seismic hazards

**Mitigating Strategies Assessment**

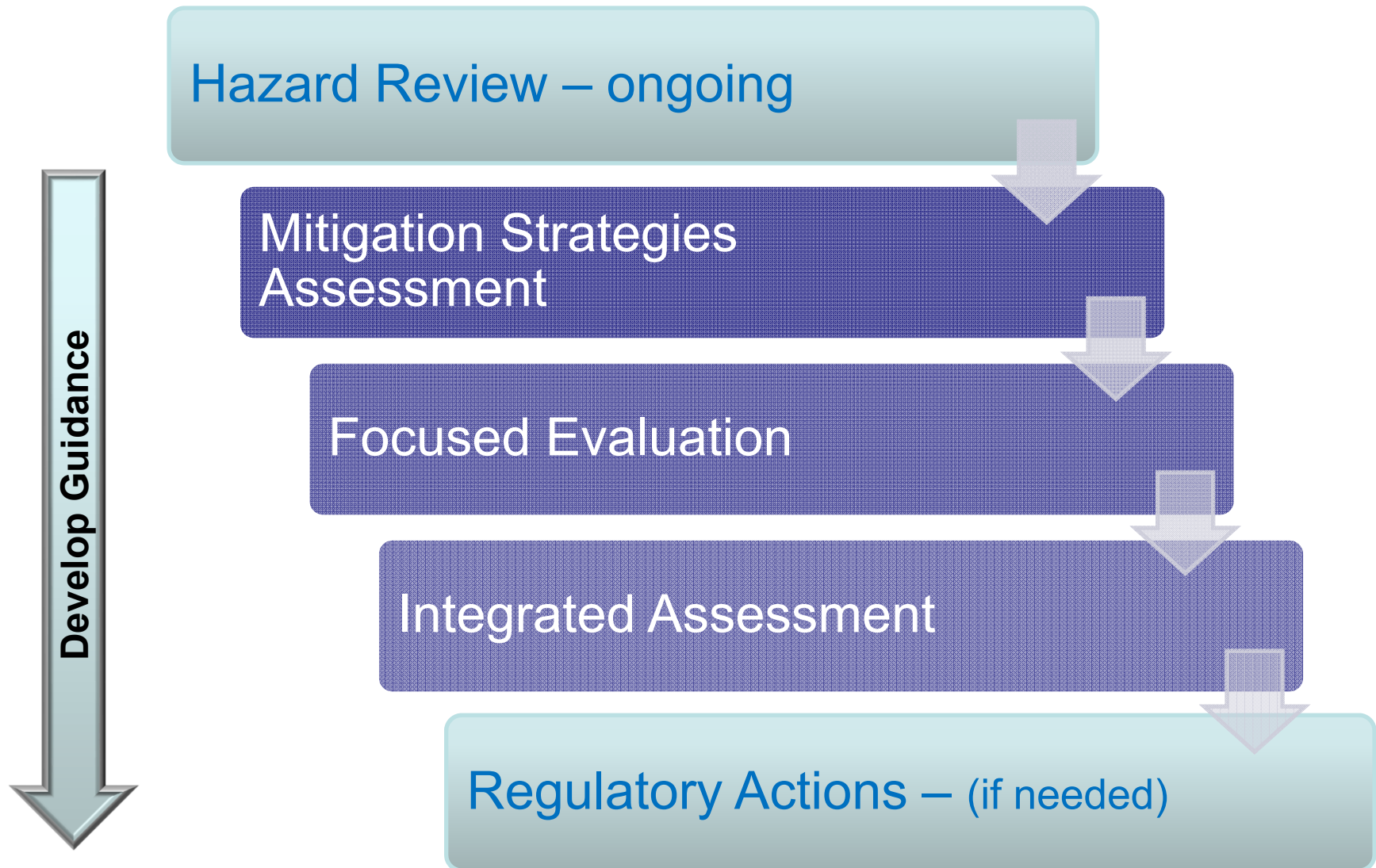
\*There may be limited exceptions which would have to be approved by the NRC.

# Seismic and Flooding Reevaluations

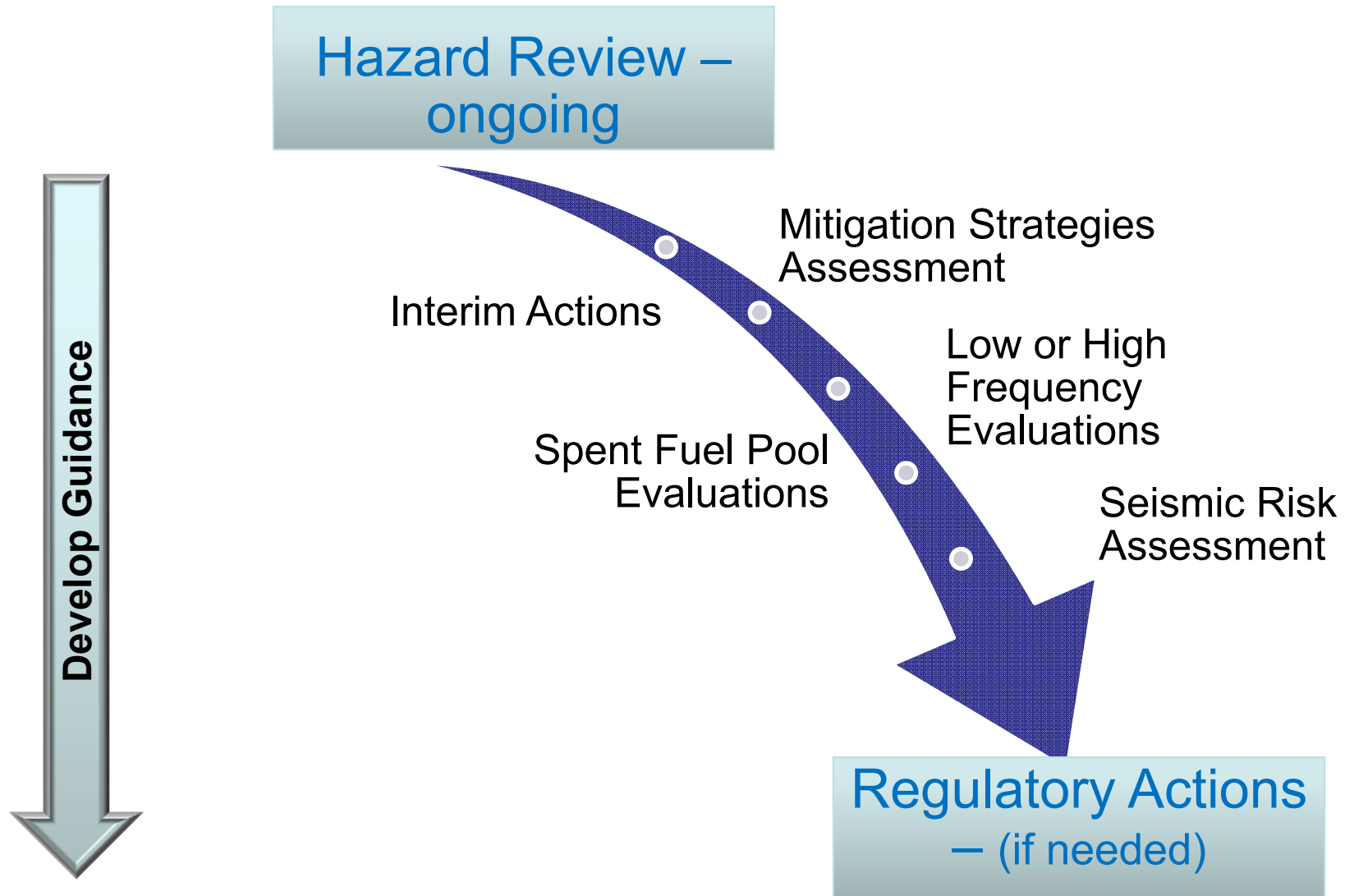


**. . . THE PROCESS CONTINUES.**

# Flooding Hazard Reevaluation Closure Plan



# Seismic Hazard Reevaluation Closure Plan



# Status Summary of Tier 2 and 3 Recommendations

**Resolved**

3	Enhanced capability to prevent/mitigate seismically-induced fires & floods
5.2	Reliable hardened vents for other containment designs
6	Hydrogen control and mitigation inside containment or in other buildings
9.3	ERDS capability throughout accident (partial)
10	Additional EP topics for prolonged SBO and multiunit events (partial)
11	EP topics for decision-making, radiation monitoring, and public education (partial)
12.1	Reactor Oversight Process modifications to reflect DID framework
12.2	Staff training on severe accidents and resident inspector training on SAMGs
-	Expedited transfer of spent fuel to dry cask storage
-	Revisit emergency planning zone size & pre-stage potassium iodide beyond 10 mi
-	Reactor and containment instrumentation
7.2 – 7.5	Spent fuel pool makeup capability
9.1/9.2	EP enhancements for prolonged SBO and multiunit events
9.3	Emergency preparedness (partial)
9.4	Improve ERDS capability
10	Additional EP topics for prolonged SBO and multiunit events (partial)
11	EP topics for decision-making, radiation monitoring, and public education (partial)
-	Reevaluation of external hazards other than seismic and flooding
2.2	Periodic confirmation of external hazards
11	EP topics for decision-making, radiation monitoring, and public education (partial)

**Reevaluation  
of external  
hazards other  
than seismic  
and flooding**

Closed

Subsumed in Tier 1

Further Assessment



# Tier 3 EP Recommendations

~~Ready to Close~~  
~~Now~~  
**CLOSED**

- Basis of EPZ Size and Pre-staging KI
- 9.3, ERDS Capability throughout an Accident
- 10.2, Protective Equipment Requirements
- 10.3c, ERDS Continuous Transmission
- 11.2, Recovery & Reentry Insights
- 11.4, Training in the Local Community

~~Additional~~  
~~Assessment or~~  
~~Documentation~~  
**CLOSED**

- 10.3a, Alternative Method for Transmitting ERDS
- 10.3, ERDS Data Set

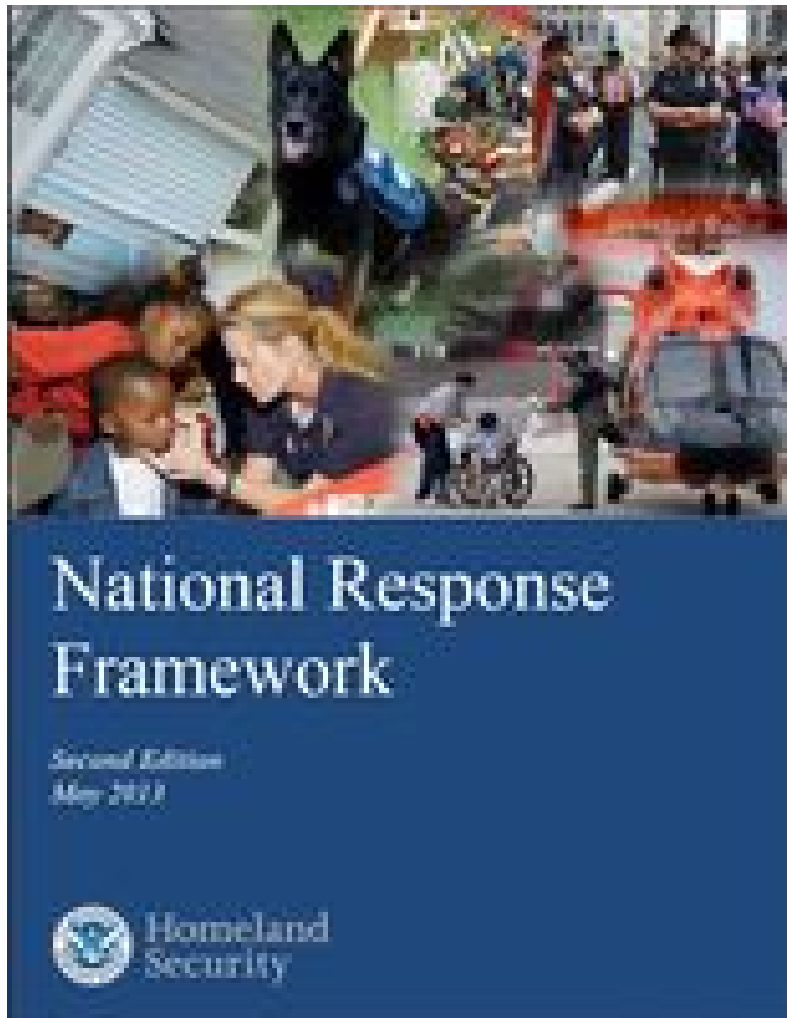
~~Additional~~  
~~Assessment or~~  
~~Documentation~~

- 11.3, Efficacy of Real Time Radiation Monitoring

# **Basis of Emergency Planning Zone Size and Pre-staging KI**

- Denied 2012 petition to expand EPZ, etc.
  - Response can be expanded as needed
  - The National Response Framework facilitates prompt and effective measures
- Information from Fukushima studies does not call those conclusions into question
  - UNSCEAR found that radiation doses were low, therefore health effects would be low
  - Average affected dose for adults ~ 5x background

# Recovery & Reentry Insights



- FEMA is leading an interagency effort to update the Nuclear/Radiological Incident Annex
- Southern Exposure Exercise, 2015

**Recommendation:**  
**Close**



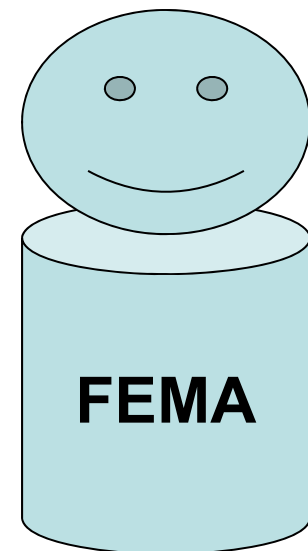
# Training in the Local Community

*Several states and local  
authorities have or are  
revising their public  
outreach materials  
subsequent to  
Fukushima.*

**Recommendation:  
Close**

+

FEMA's Radiological Emergency  
Preparedness Program outreach  
Integrated Process Team



# Summary

- Considerable progress has been made.
- Activities have already resulted in safety improvements.
- Expect further substantial safety enhancements in place by 2016.

## Public Website:

<http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard.html>