The March 2011 Earthquake and Tsunami in Japan: A Perspective

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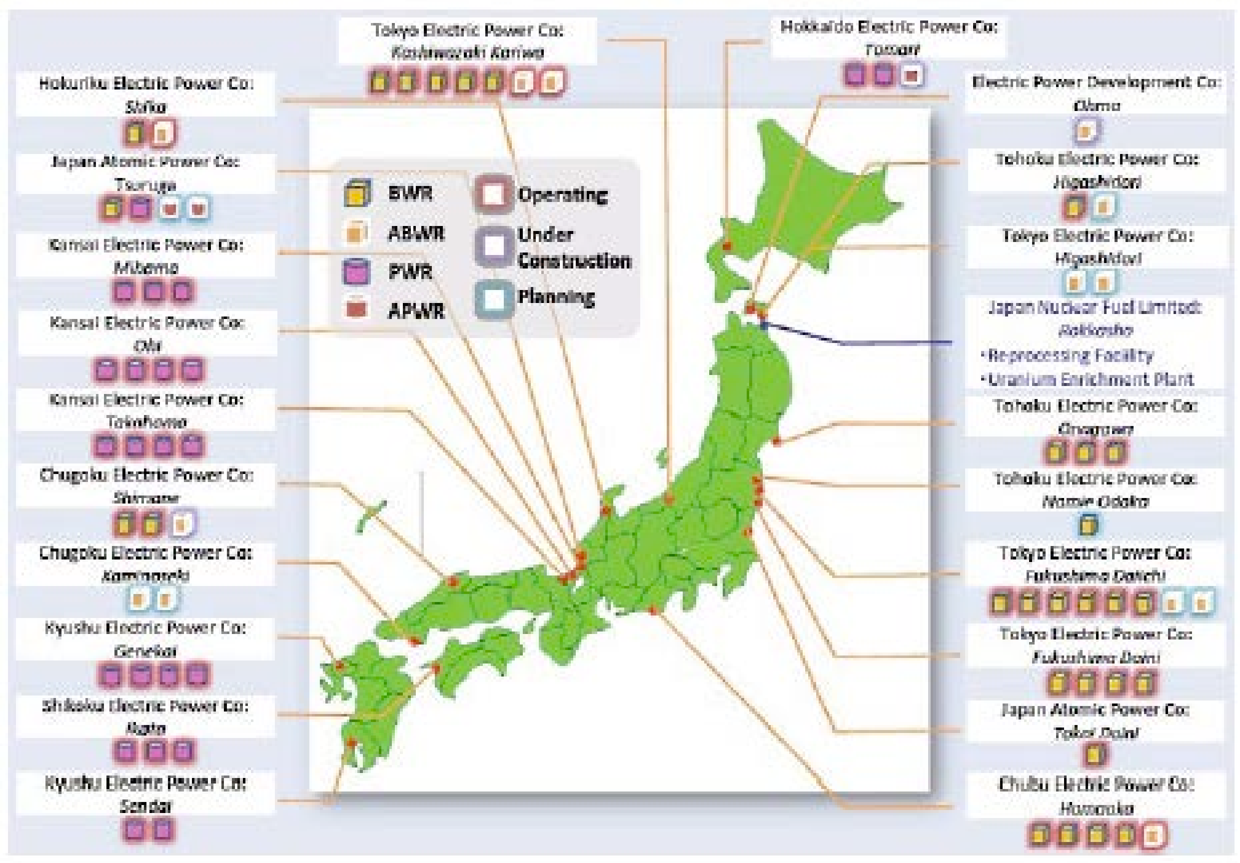
Content

1. Accident at Fukushima-1 in March 2011
2. Fukushima since the accident
3. Impact of accident and actions taken in U.S. and worldwide

1. Accident at Fukushima-1 in March 2011

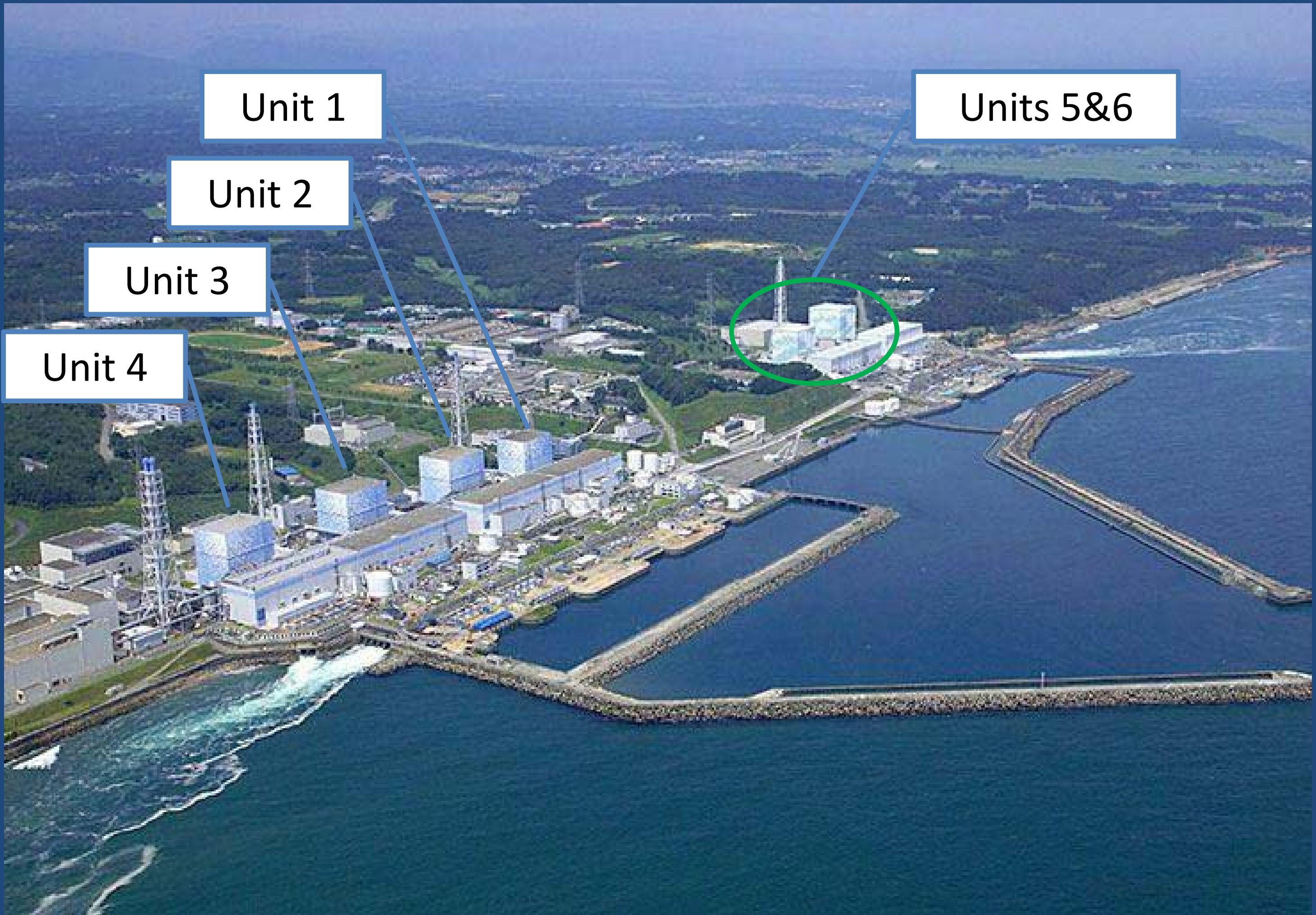
Japanese nuclear power industry

- Established in 1966 (with start of Tokai-1 NPP)
- ~ 30% of electrical power provided by nuclear power
- Plants built to withstand “design basis” accidents



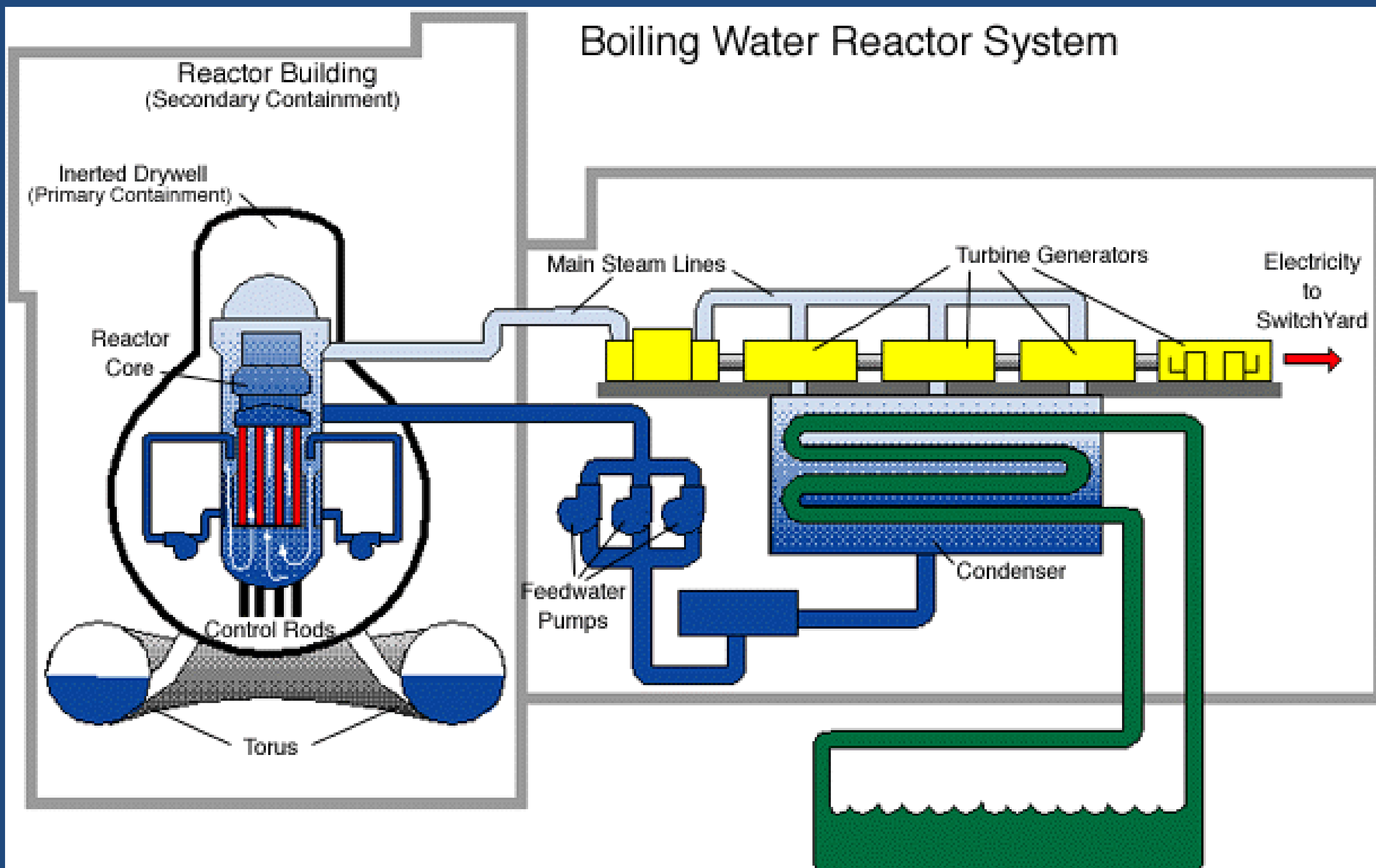
Fukushima-1 Plant – pre-earthquake status

- Units 1, 2 and 3 operating
- Unit 4 defueled, not operating (planned maintenance)
- Units 5 and 6 fueled, not operating (planned outage)



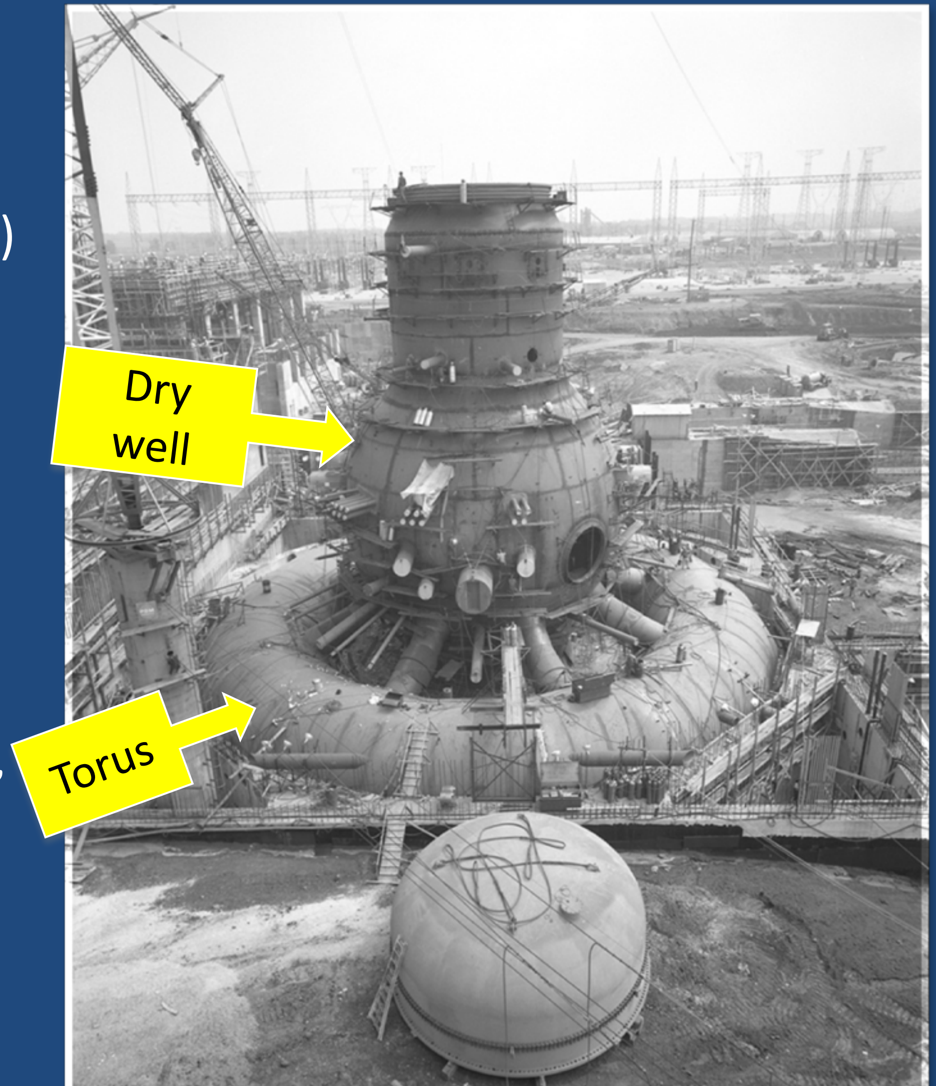
Fukushima-1 Plant

- Typical BWR-3 (Unit 1) and BWR-4 (Units 2 – 5) design
- Some similarities to Duane Arnold Plant in Iowa



Mark I Containment

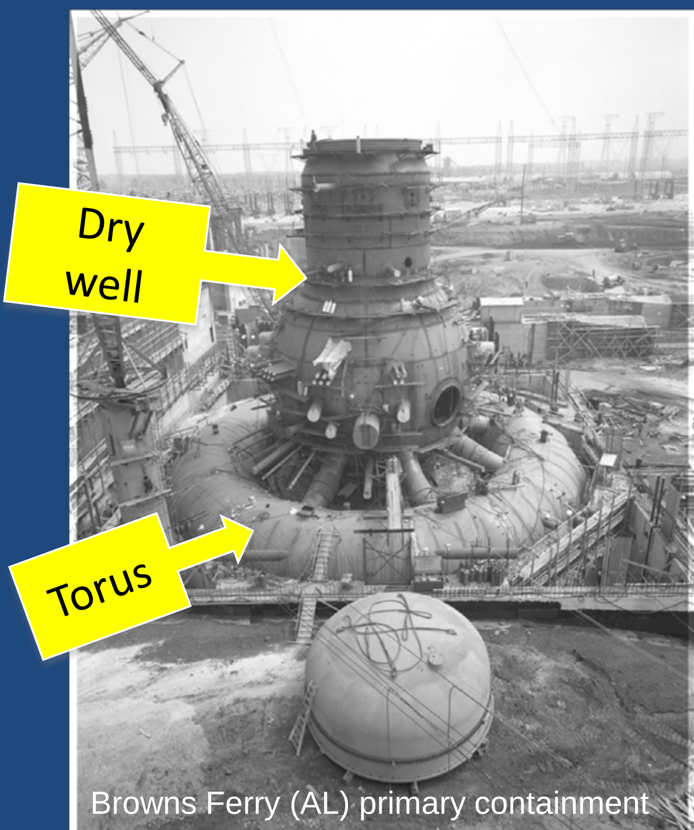
- Primary containment
  - Dry well (Pear)
  - Wet well/suppression pool (Torus)
- In U.S. 23 reactors use Mark I containments
- Some similarities exist in design and operation of Japanese and US Mark I containments
- Following 9/11 terrorist attacks, NRC required licensee's to develop beyond-design-basis mitigation strategies (i.e. procedures and staging of portable equipment)



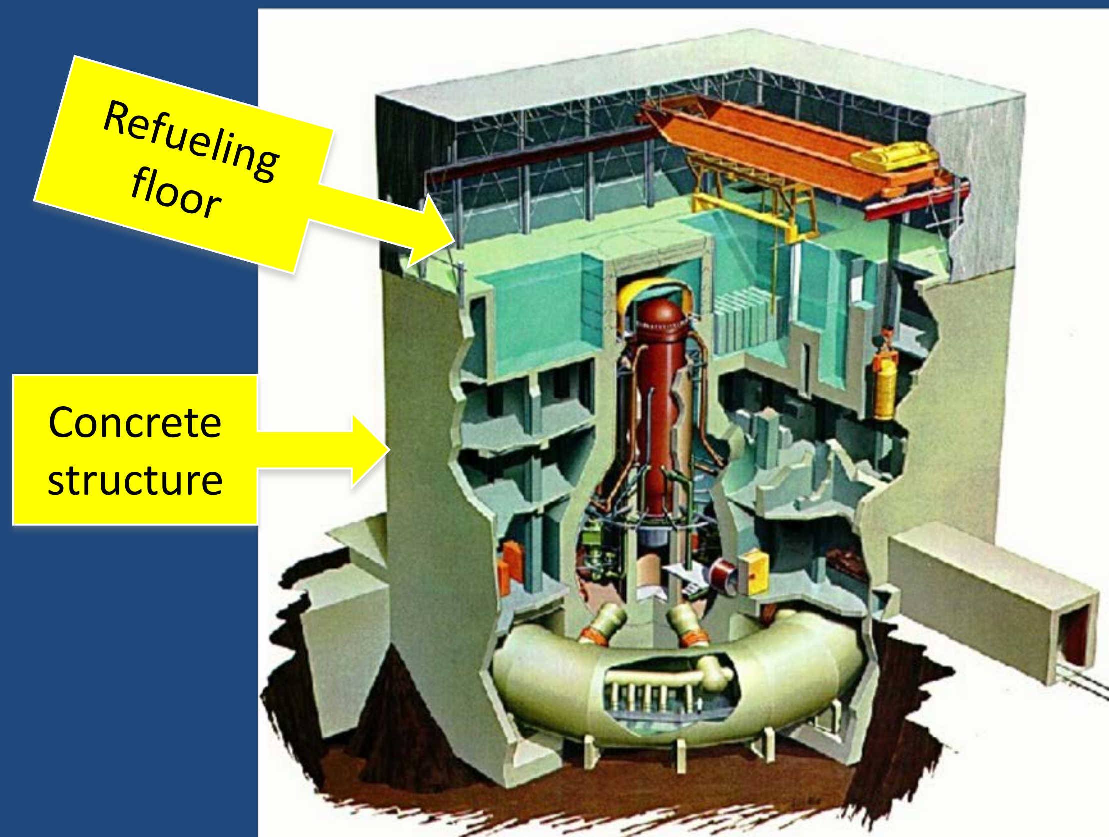
Browns Ferry (AL) primary containment

Mark I Containment

- Primary containment
  - Dry well (Pear)
  - Wet well/suppression pool (Torus)
- Secondary containment*
  - Concrete structure
  - Surrounds primary containment
  - Houses ECCS and spent fuel pool
- Metal-framed refueling floor (not part of containment)



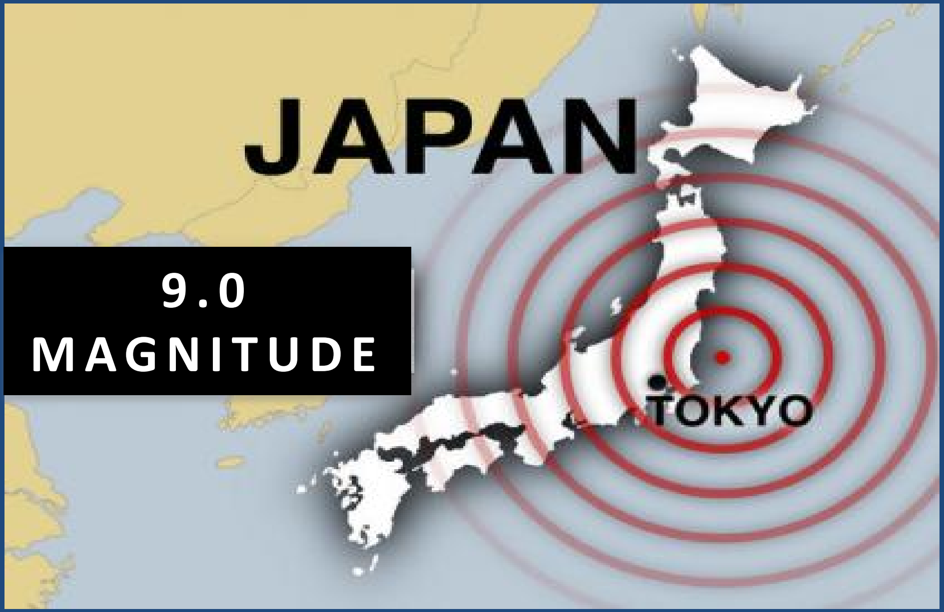
Browns Ferry (AL) primary containment



*Details of Mark I secondary containment design vary among reactor units.

The Tohoku Earthquake

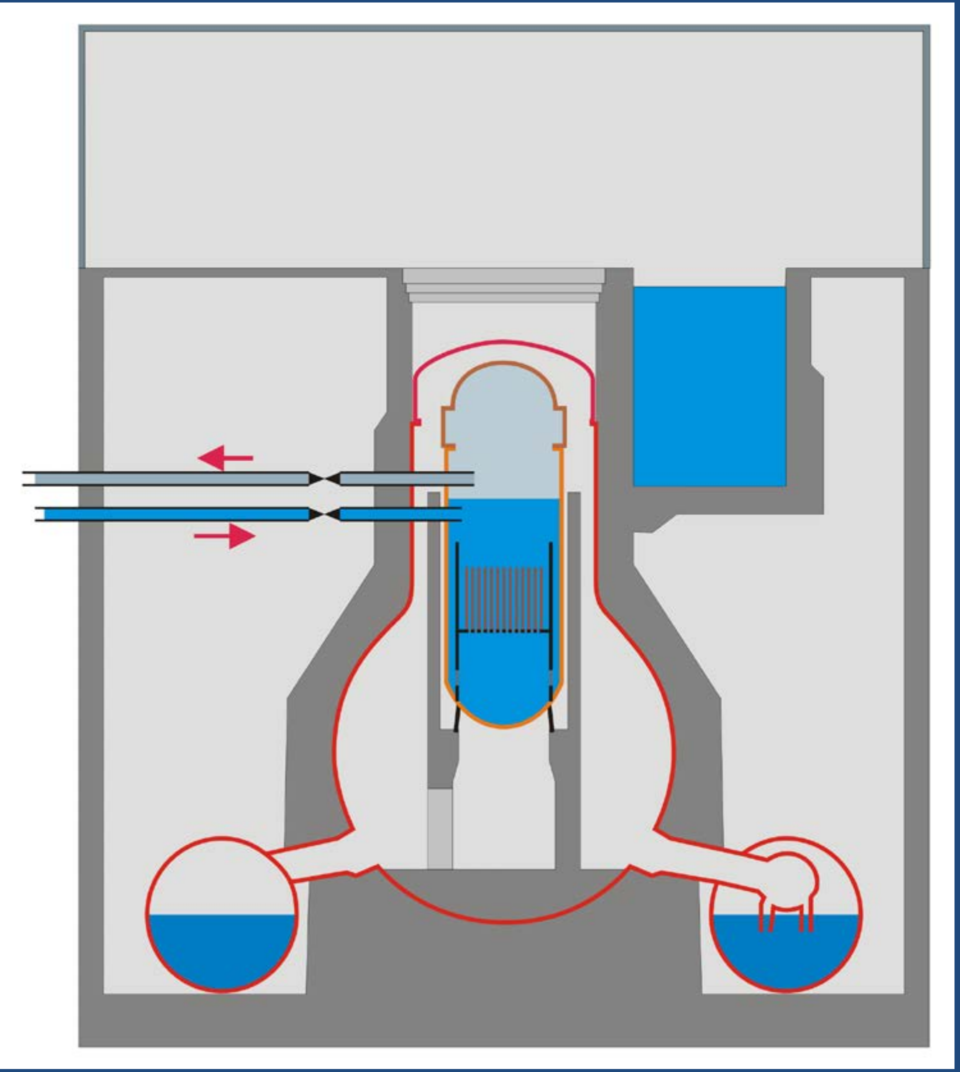
- 11 March 2011
- Largest in recorded history of Japan
  - 9.0 on Richter scale
- Among largest in world history
- Resulting Tsunami waves (series of 7) up to 15m (~ 50 ft)



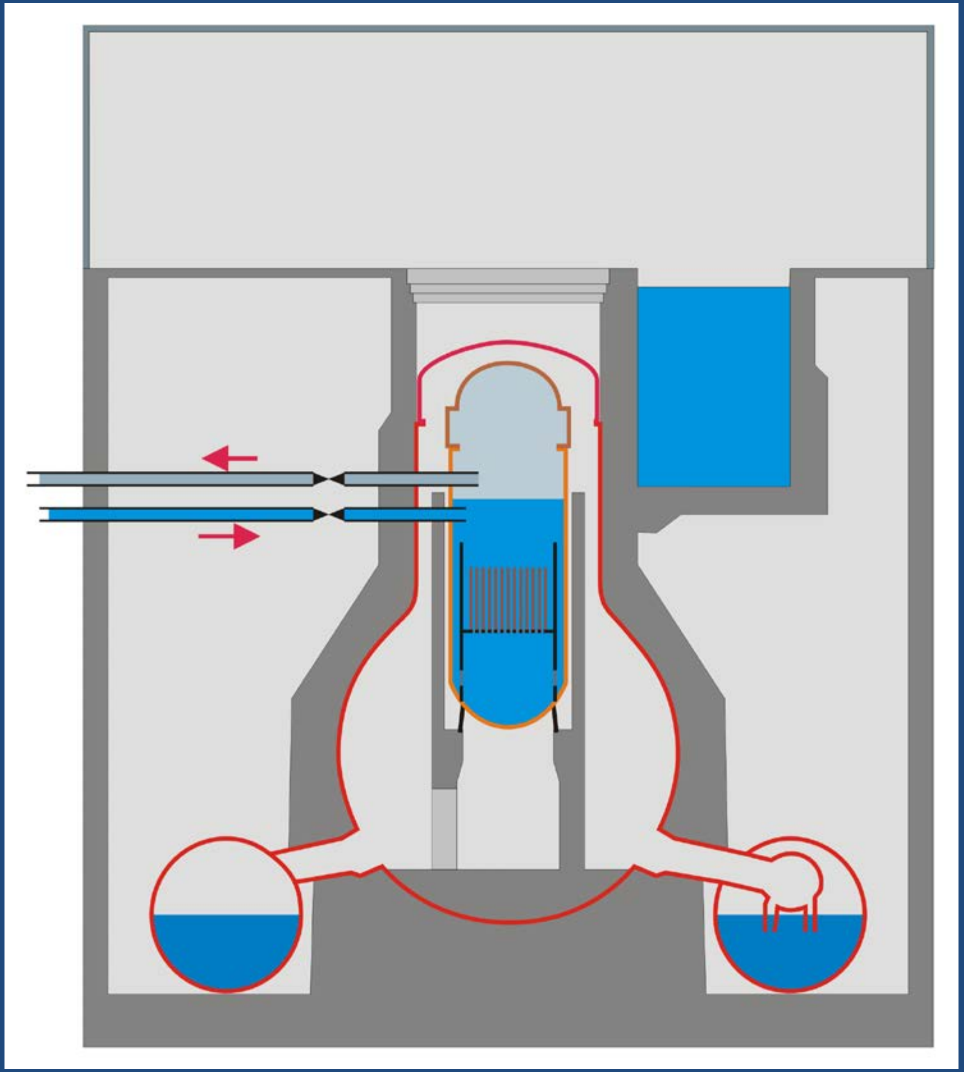
What happened at the Fukushima Daiichi Plant?

11 March 2011

- Tohoku Earthquake
  - Units 1 to 3 shutdown automatically (SCRAM), per design
  - Power generators “tripped”, per design
- Movement of plant foundation “exceeded design basis earthquake ground motion” (DBEGM) in Units 2,3,5
  - Disabled offsite power systems
  - No serious damage to onsite safety systems

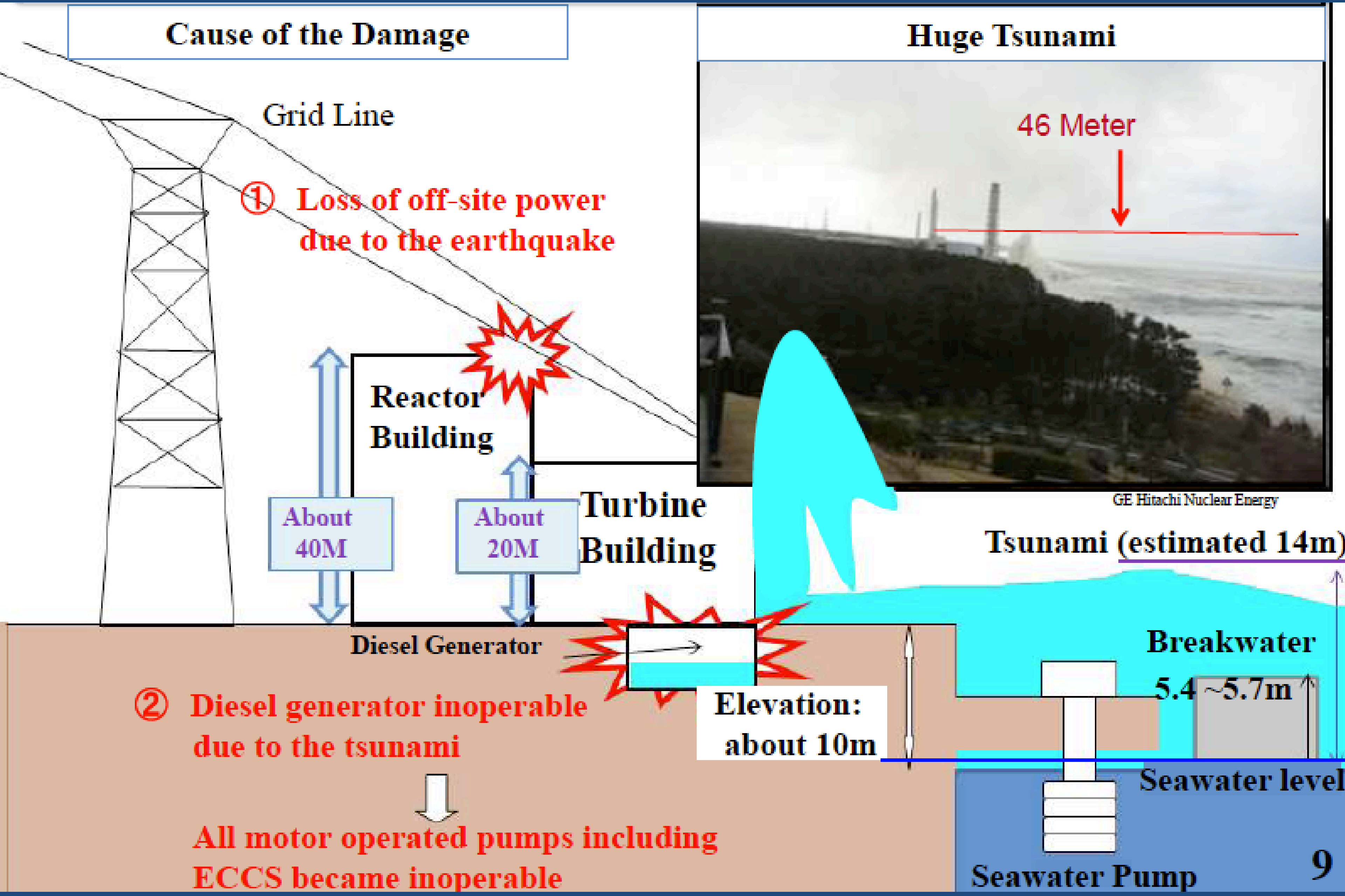


- Why is losing power a problem?
  - Heat generation due to fission of uranium stops with SCRAM
  - Heat generation due to radio-active decay of fission products continues*
  - Power needed to pump water, cool core
- Emergency diesel generators provide power to the core and fuel cooling systems



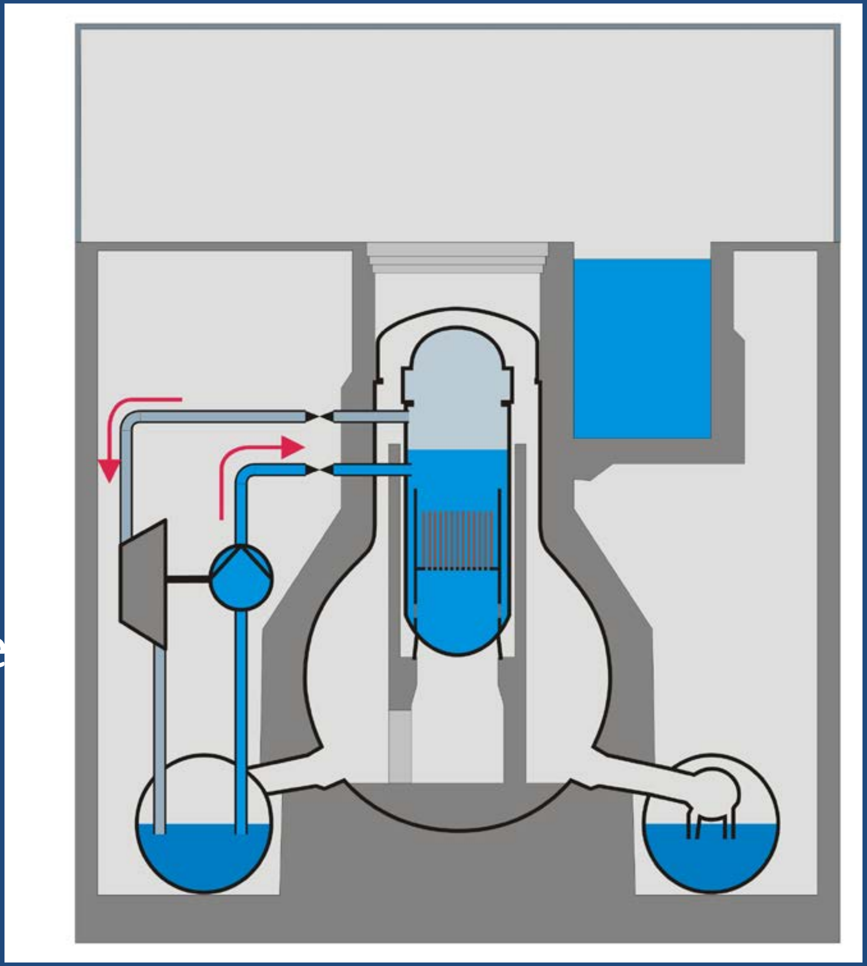
*About 1% of original thermal energy within a few hours

- Tsunami hit the plant (~55 minutes after quake)
  - Design basis Tsunami height 5.4 to 5.7 m (16.2 to 17.1 ft)
  - Actual maximum Tsunami height 14 to 15 m (42 to 45 ft)


Cause of the Damage
Huge Tsunami
Grid Line
① Loss of off-site power due to the earthquake
46 Meter
Reactor Building
Turbine Building
About 40M
About 20M
GE Hitachi Nuclear Energy
Tsunami (estimated 14m)
Breakwater
5.4 ~5.7m
Diesel Generator
Elevation: about 10m
② Diesel generator inoperable due to the tsunami
All motor operated pumps including ECCS became inoperable
Seawater level
Seawater Pump

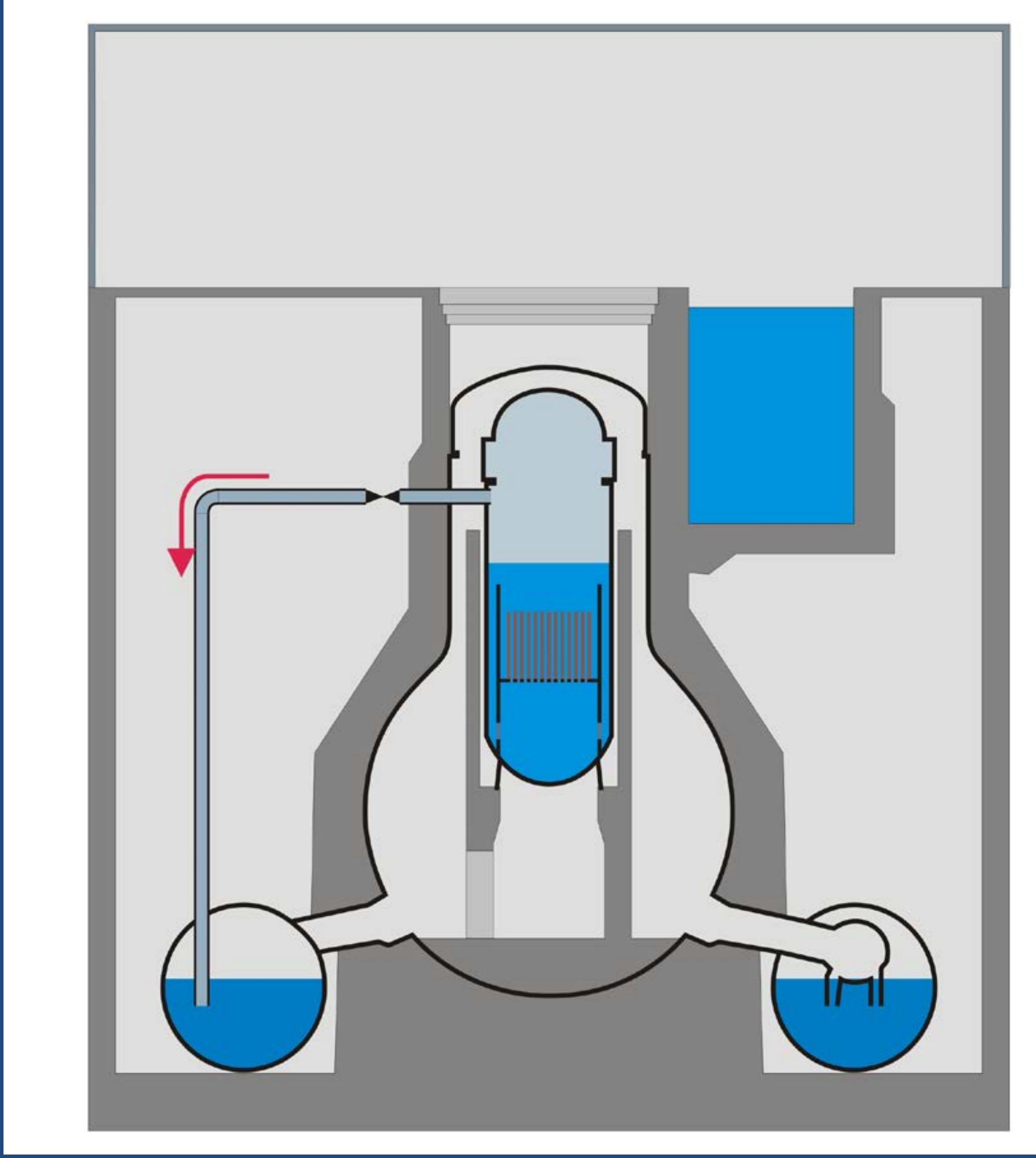
Results of Tsunami

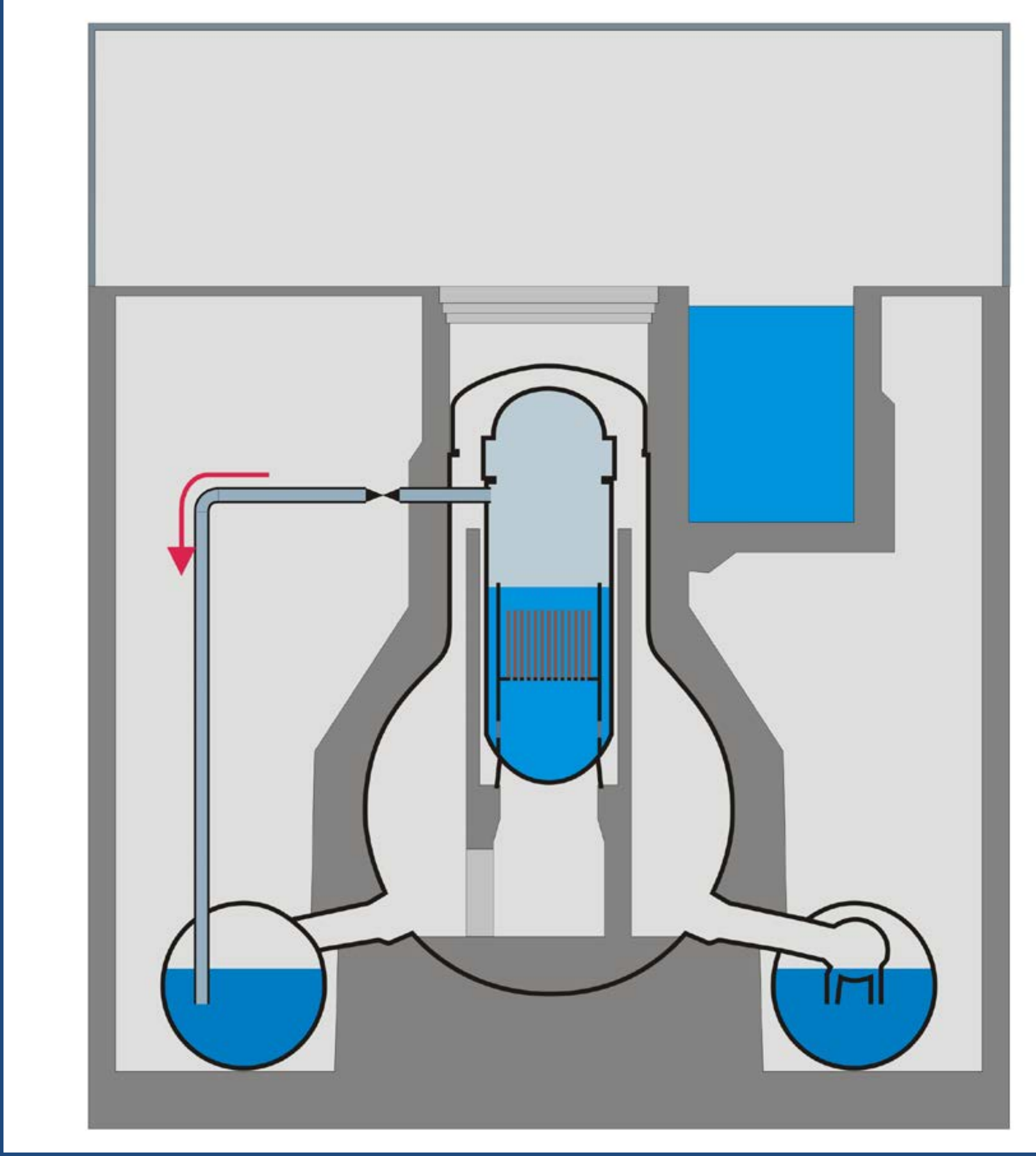
- AC power
  - Lost for Units 1 -5
  - Unit 6 retained one operating generator, which cooled Units 5 and 6
- Battery power (used if no AC)
  - Lost in Unit 1
  - Units 2 and 3 cooled with battery power for Reactor Core Isolation Cooling, followed by High Pressure Coolant Injection system in Unit 3

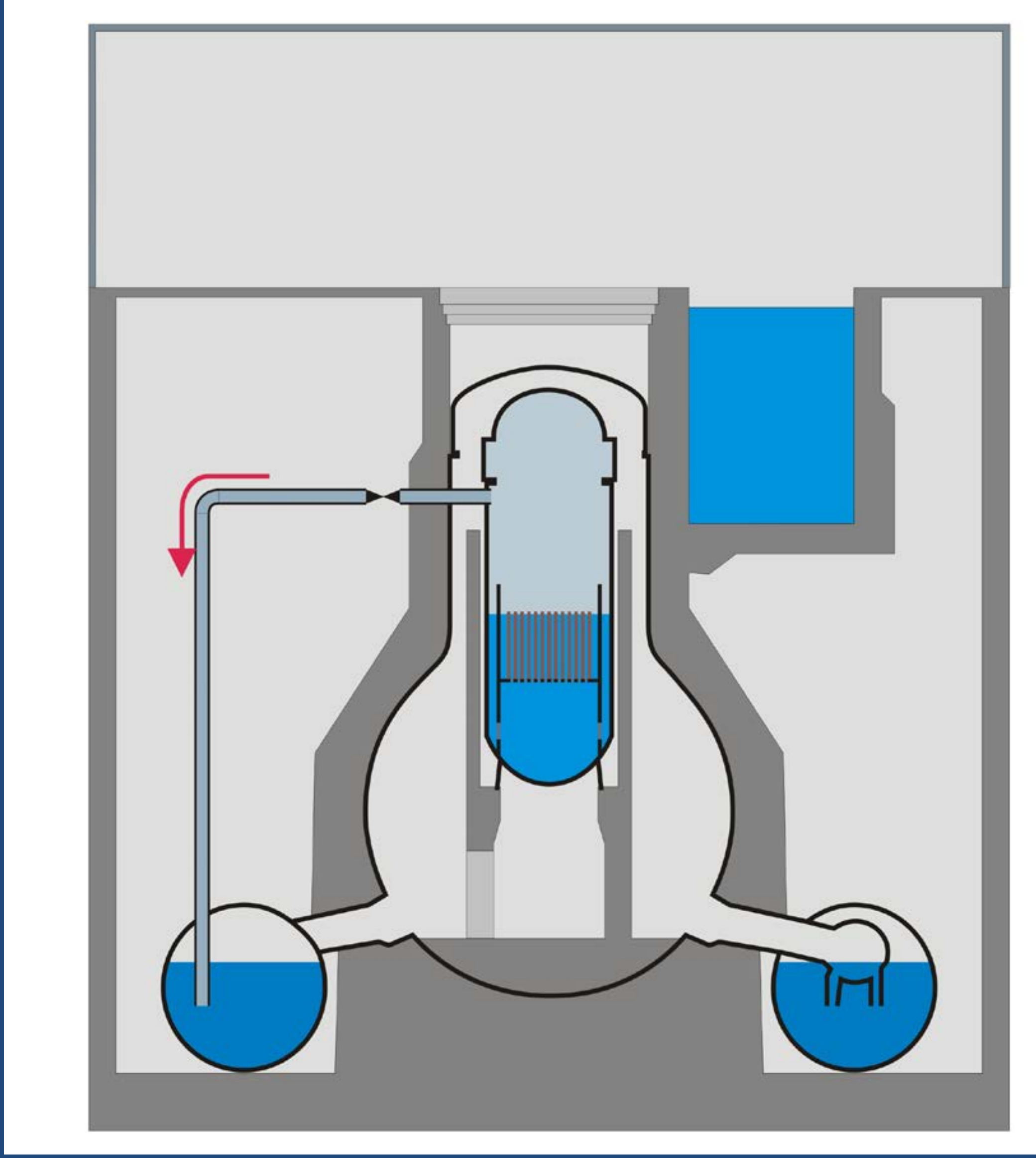


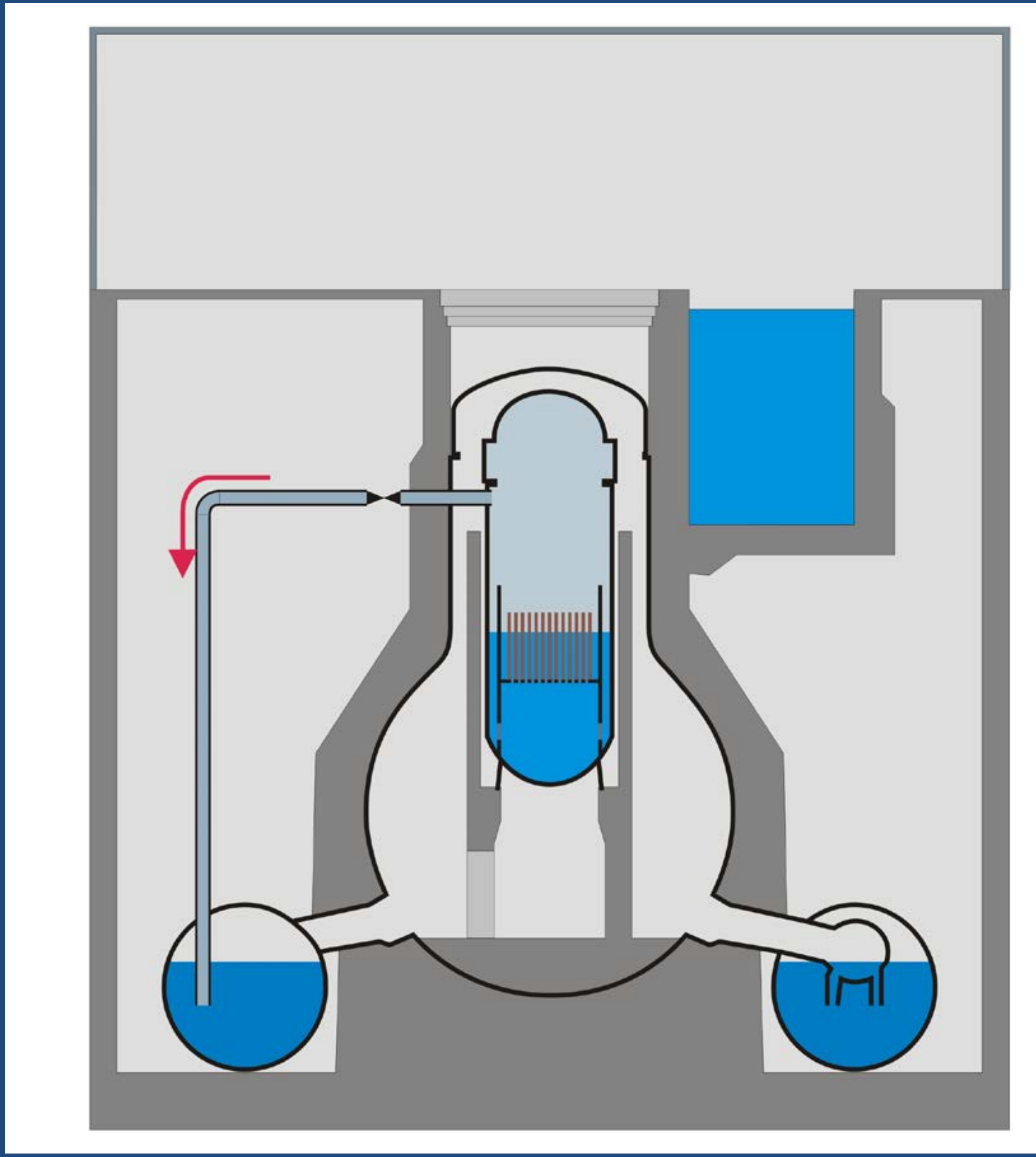
When power ran out and cooling stopped . . .

- Decay heat producing steam in reactor pressure vessel
  - Pressure rising
- Steam relief valves may have opened to relieve pressure
  - Steam discharged into wet well
- Some evidence of leak in vessel, attached pipes
- Decrease in coolant level in the reactor pressure vessel



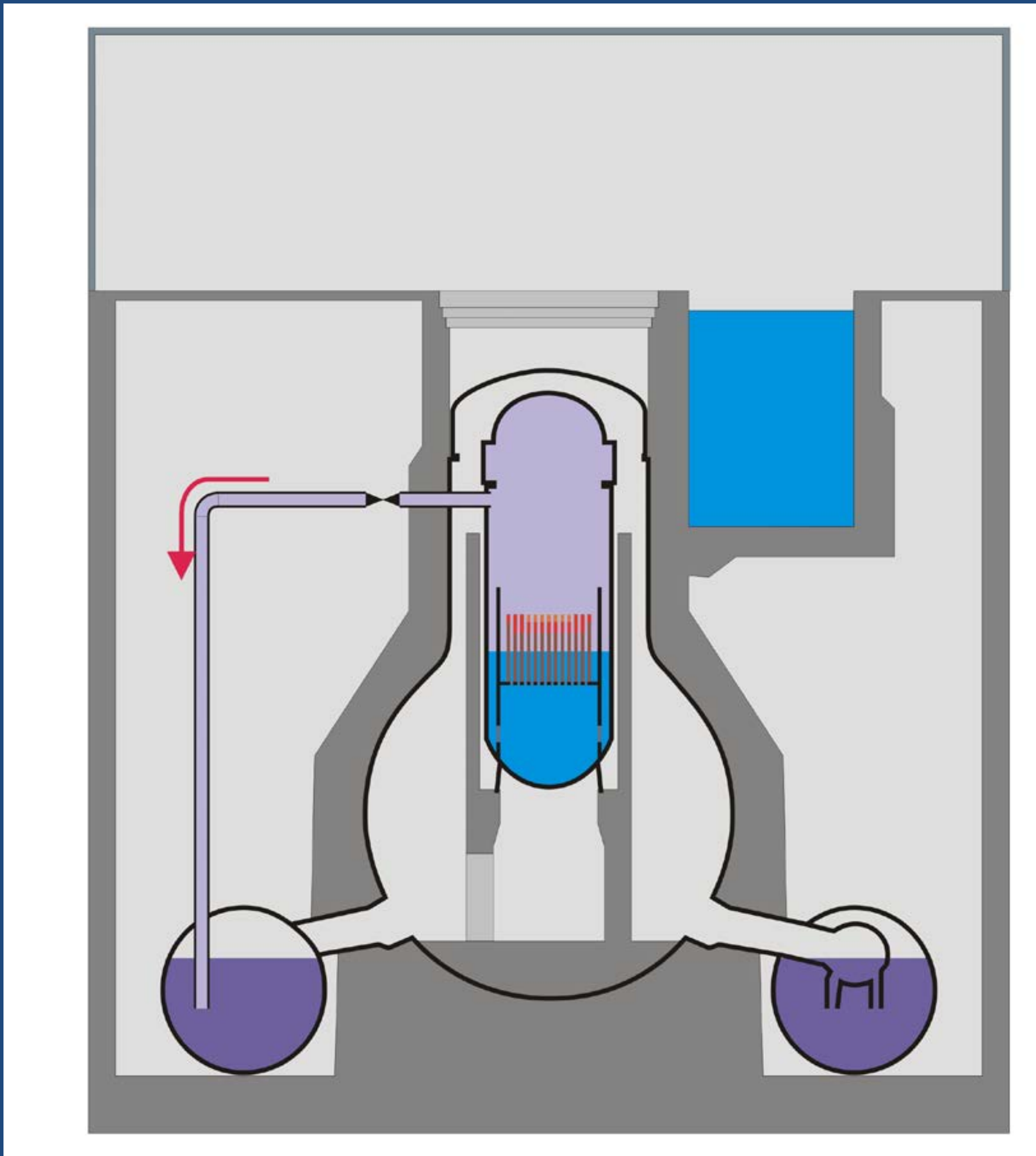




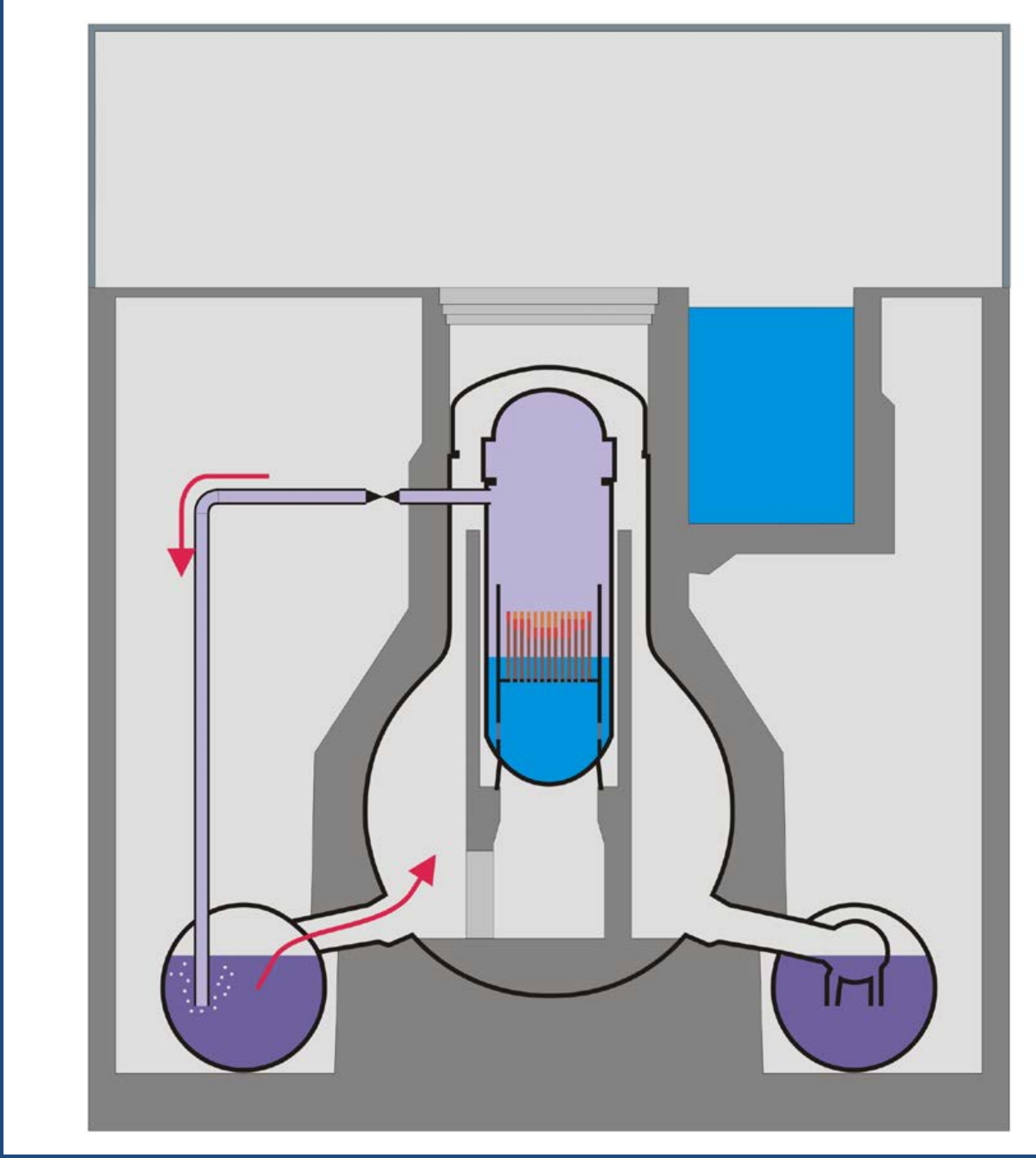


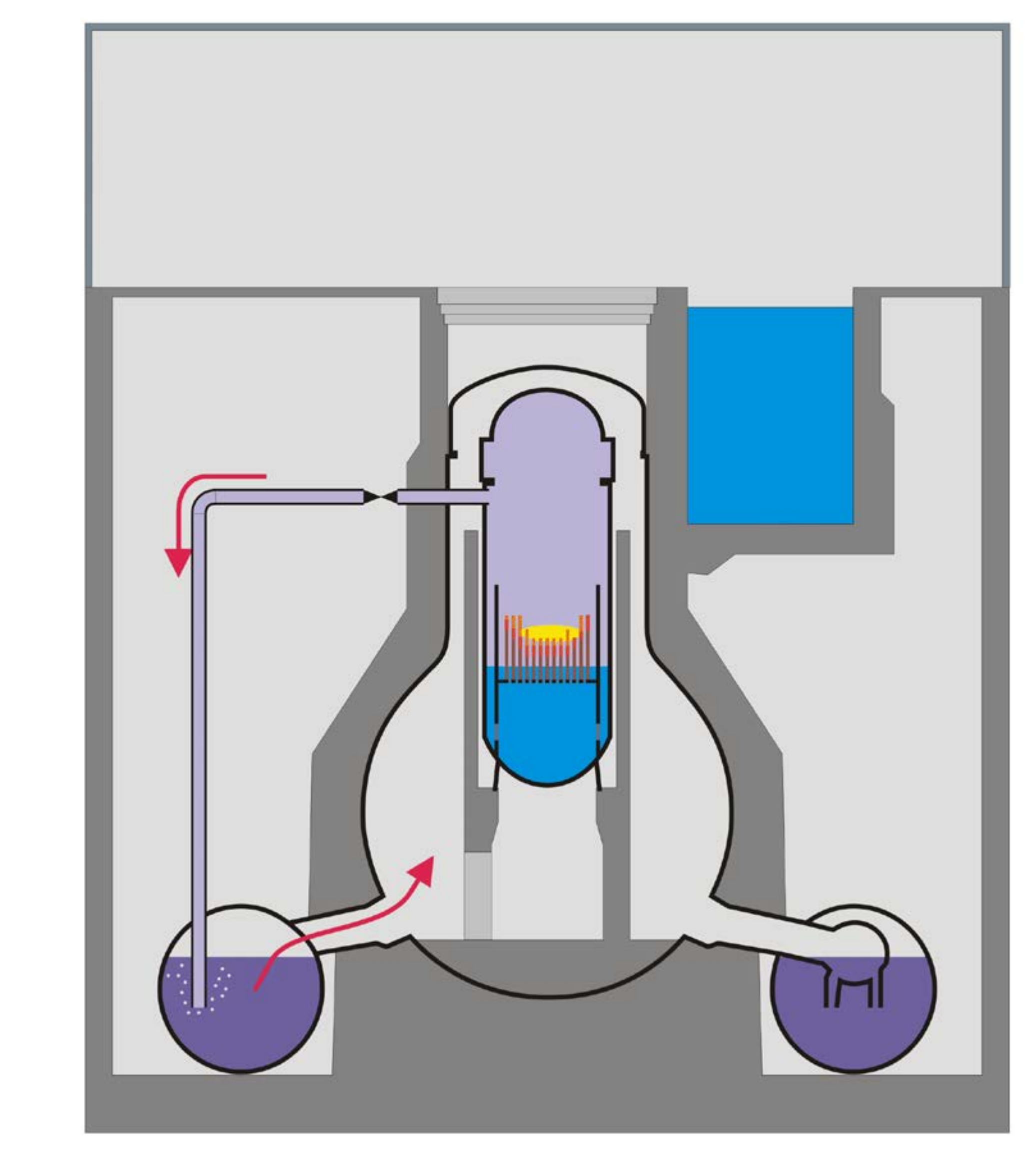
Core exposed and fuel heating

- At ~ 1200° C
  - Cladding cracks
  - Fission products released
- At ~1300° C
  - The zirconium cladding reacts with water (or steam)
  - $Zr + 2H_20 \rightarrow ZrO_2 + 2H_2$
  - Exothermic reaction further heats the core (This heat may be greater than decay heat!)
  - Hydrogen gas (H_2) enters wet well, continues to dry well and increases containment pressure
- At ~2800° C
  - UO_2 fuel melts

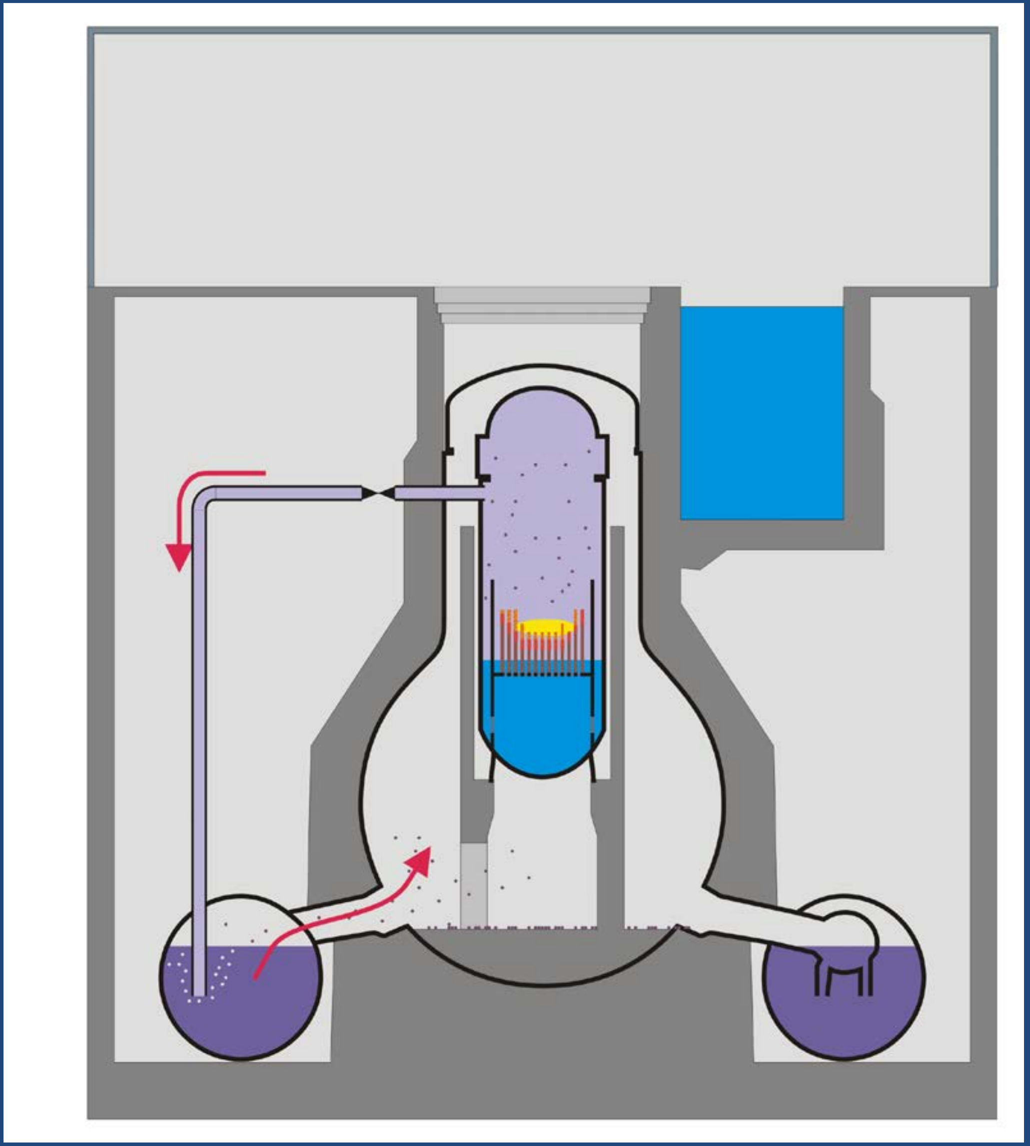


T (normal operations) ~ 300° C



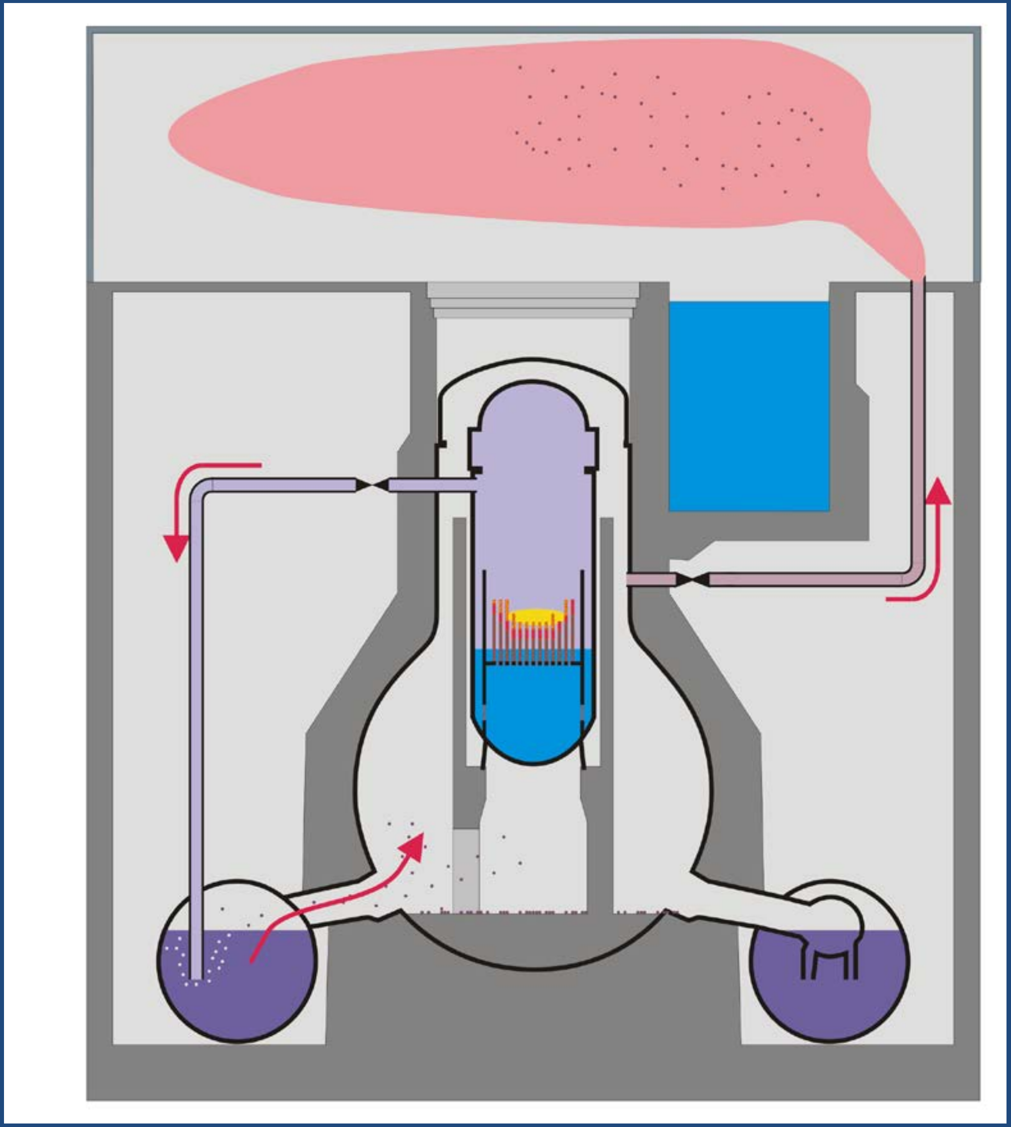


- Fission product release from damaged fuel
- Containment pressure
  - Build up of hydrogen, nitrogen and water vapor
  - Accident pressure 130 psi
  - Design pressure 73 psi



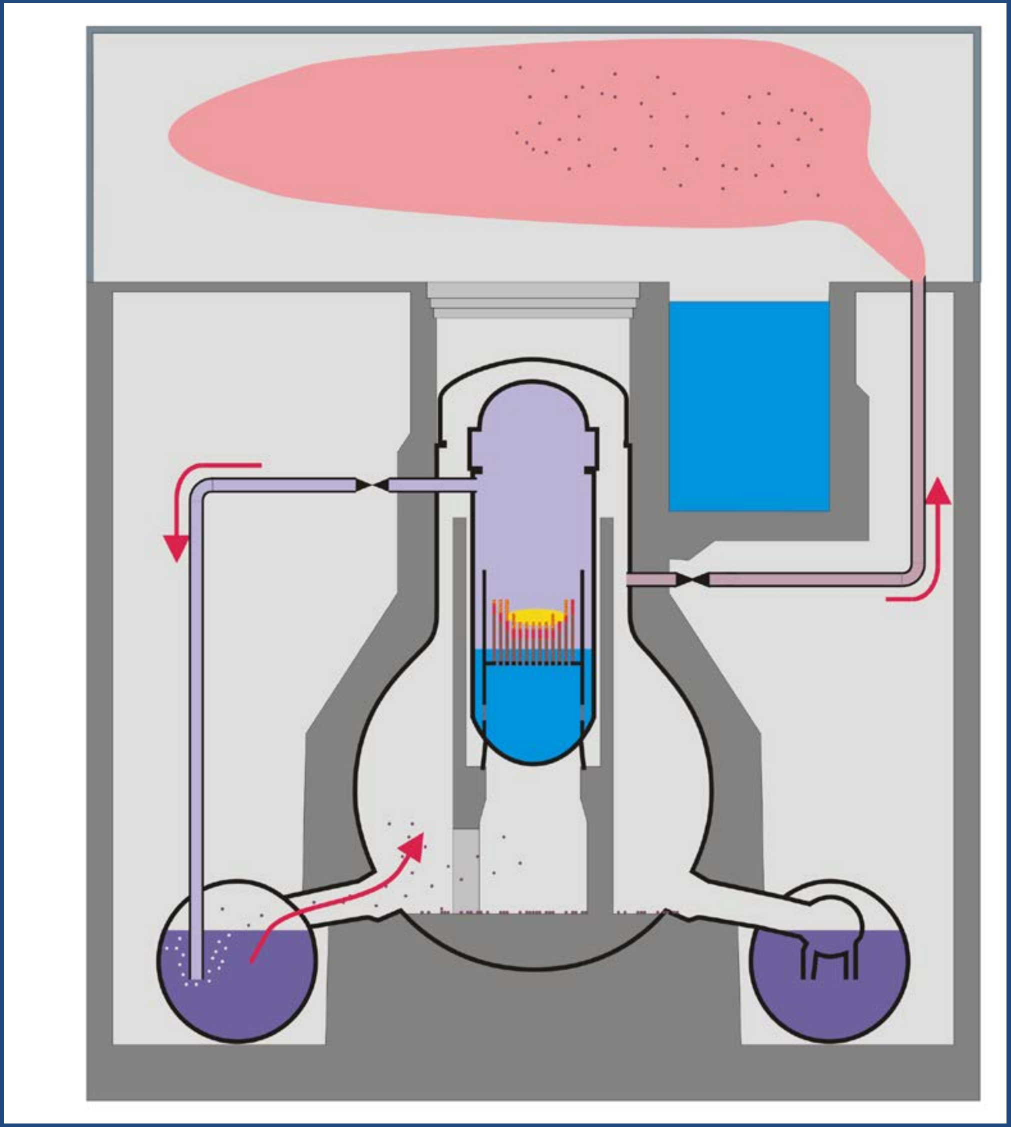
De-pressurization of containment

- Units 1, 2 and 3
- Attempts to vent gas from containment to outside, some flows into the reactor service floor



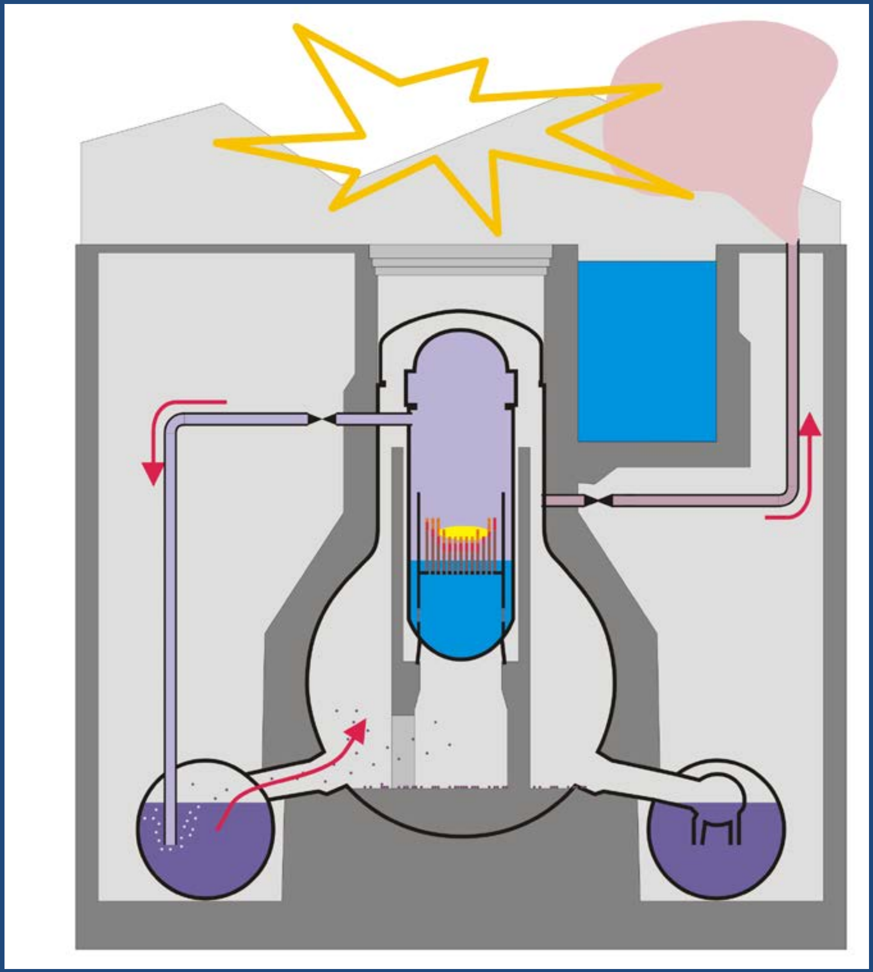
De-pressurization of containment

- Units 1, 2 and 3
- Attempts to vent gas from containment to outside, some flows into the reactor service floor (Units 2,3)
- Gas also may have leaked through containment
- Hydrogen and some fission products (iodine, cesium and noble gases)



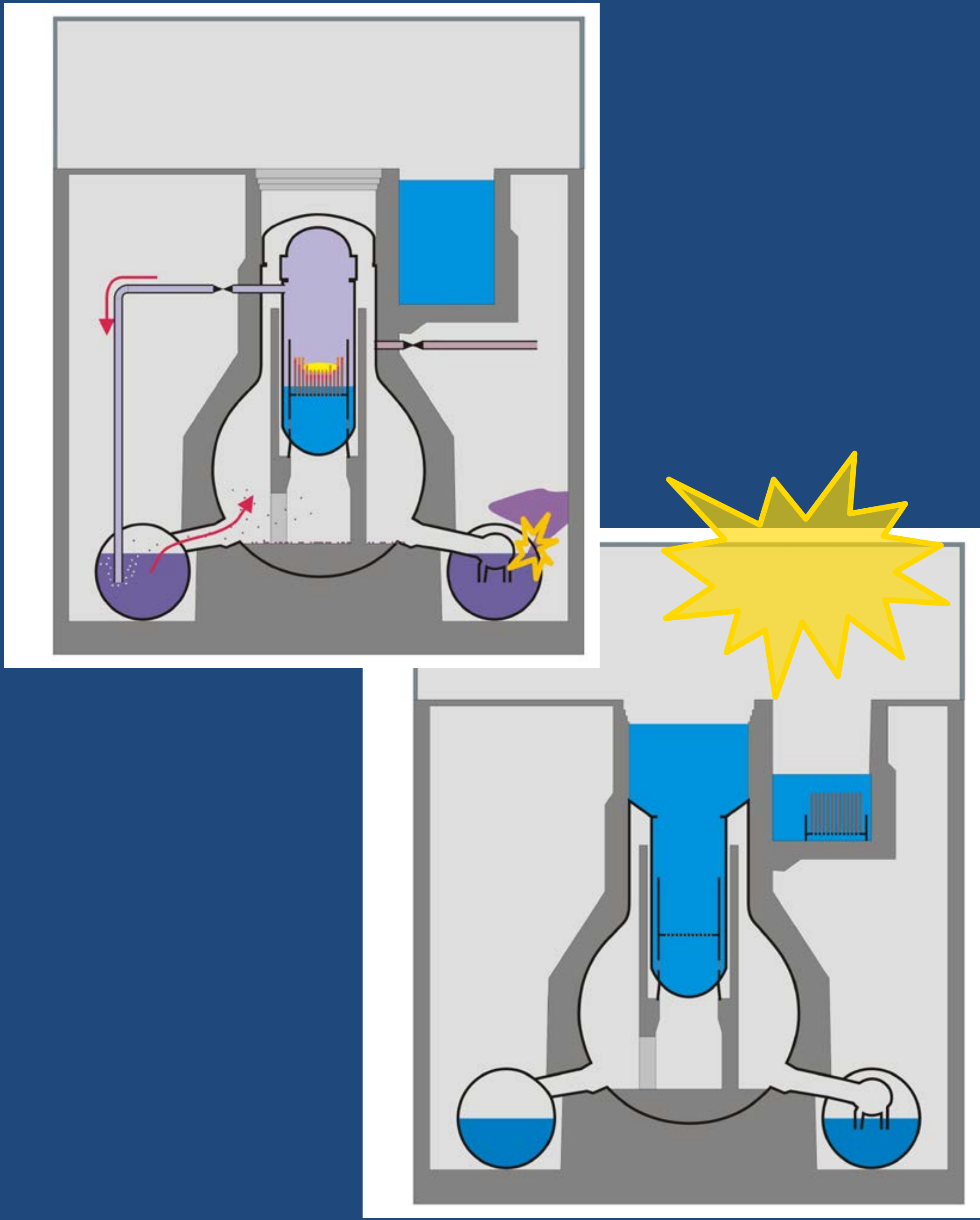
H_2 explosions

- Units 1 and 3 service areas
  - Steel frame roof destroyed
  - Concrete building intact
  - Seawater injected



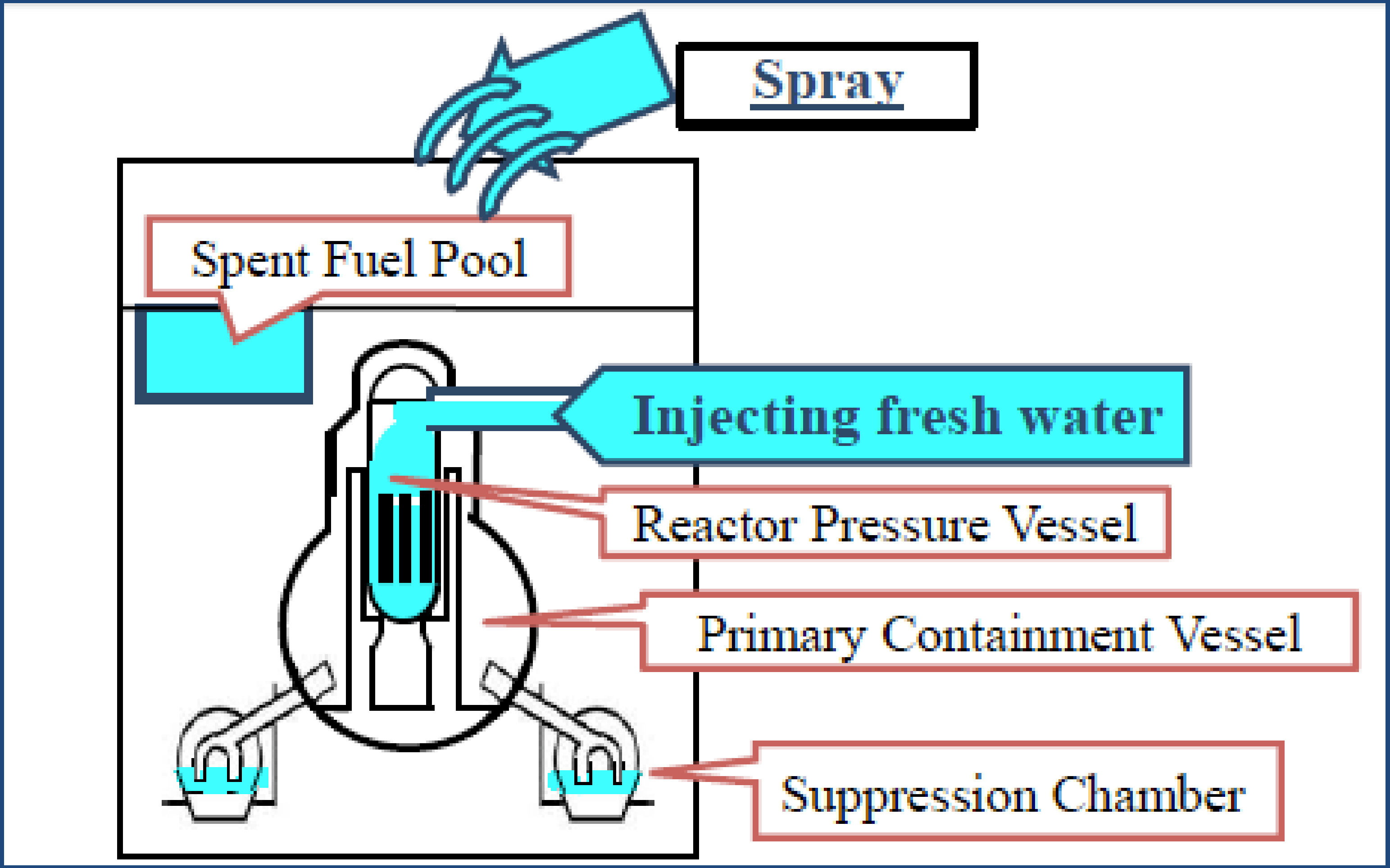
More H_2 explosions

- Unit 2
  - Possible H_2 explosion in secondary containment
  - Probable damage to wet well and pressure vessel leak
  - Release of fission products
  - Temporary evacuation of plant
- Unit 4
  - Explosion and fire in upper levels, apparently caused by leaking H_2 from Unit 3
  - Entire core stored in spent fuel pool



16 March 2011 (Day 6)

Cooling reactors and pools in early days . . .



Lessons learned immediately by Japan . . .

- Earthquake design basis adequate

- Tsunami design basis and emergency planning insufficient for NPP and other key infrastructure

- Must diversify, increase and secure onsite power supply to avoid core damage

Current Status of the Nuclear Power Plants in Japan

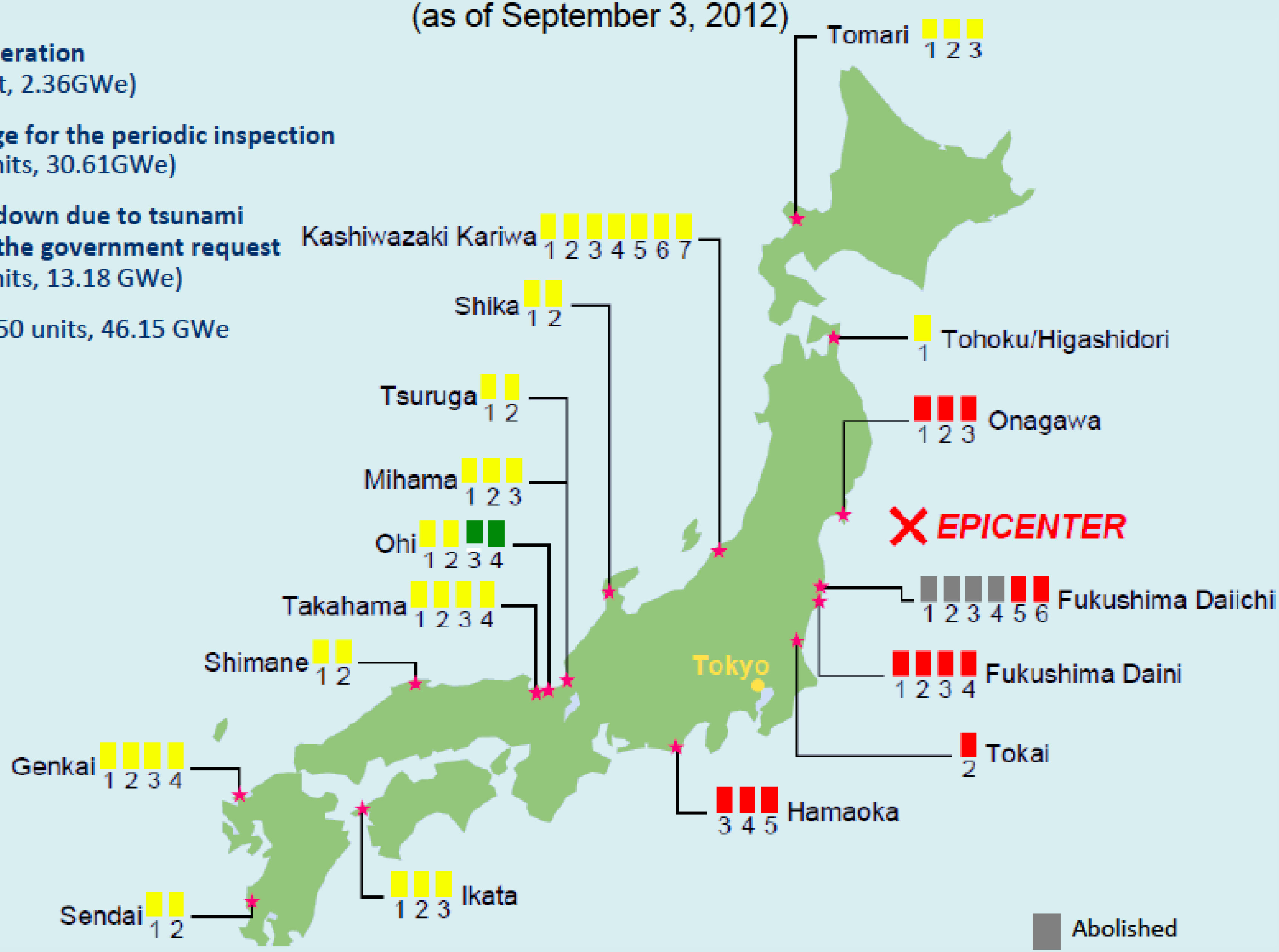
(as of September 3, 2012)

: **In operation**
(2 unit, 2.36GWe)

: **Outage for the periodic inspection**
(35 units, 30.61GWe)

: **Shutdown due to tsunami and the government request**
(13 units, 13.18 GWe)

TOTAL : 50 units, 46.15 GWe



2. Fukushima after the accident

TEPCO's Roadmap to Restoration

I. Cooling
   a) Reactors
   b) Used fuel pools
II. Mitigation
   a) Containment, storage, processing, and reuse of rad contaminated water
   b) Mitigate release of radioactive materials to air & soil
III. Monitoring and Decontamination
   a) Monitor radiation dose in & out of power station
   b) Enhance monitoring and quickly inform of results
   c) Reduce radiation dose in evacuated areas

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Cooling of reactors and fuel pools

- Cores of Units 1-3 at least partially melted within first 3 days of accident
- Reactors stable at 2 weeks with water addition, but no proper heat removal
- Reactors cooled with recycled, treated water by July, but continued to leak
- Temperatures below 80° C by end of October
- Official "cold shutdown" announced December 2011
  - Below 80° C and releases reduced to minimal levels
  - End of "accident"

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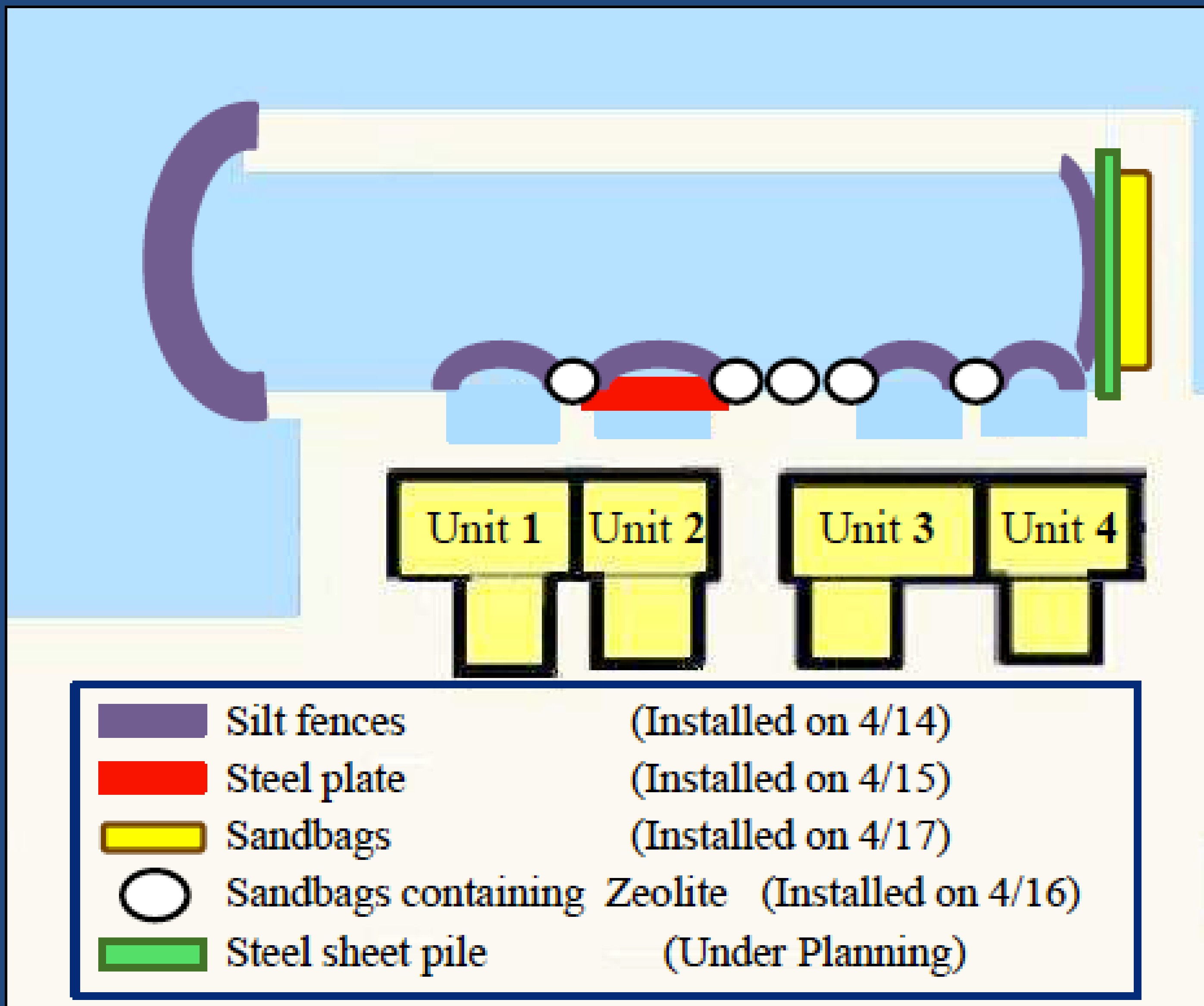
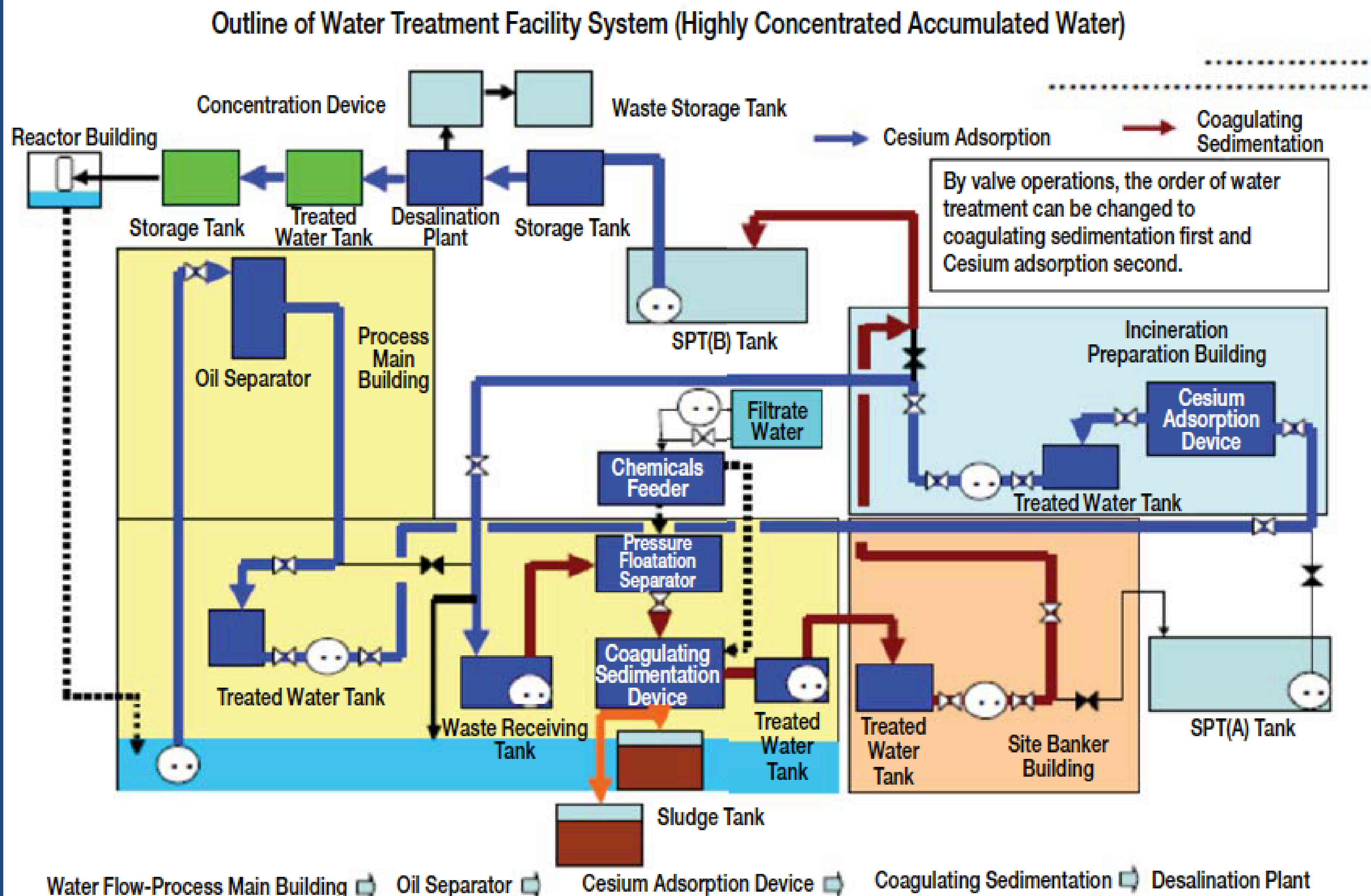
Mitigating further disasters

- 15-18 April – completed relocation of emergency power sources and fire trucks to upland and multiplexing injection lines
- 30 June – completed temporary tide barriers
- 28 May to 30 July – confirmed seismic stability and enhanced Unit 4 pool support

Early mitigation of water contamination



Water Treatment Facility at Fukushima-1



Mitigation of air and soil contamination

- Sprayed dispersion inhibitor outside and inside reactor and turbine buildings
- Removing debris with remote heavy machine
- Covering reactor buildings

Spraying of dispersion inhibitor

Debris removal

Steel frame for Unit 1 cover
(Cover completed Oct ‘11)

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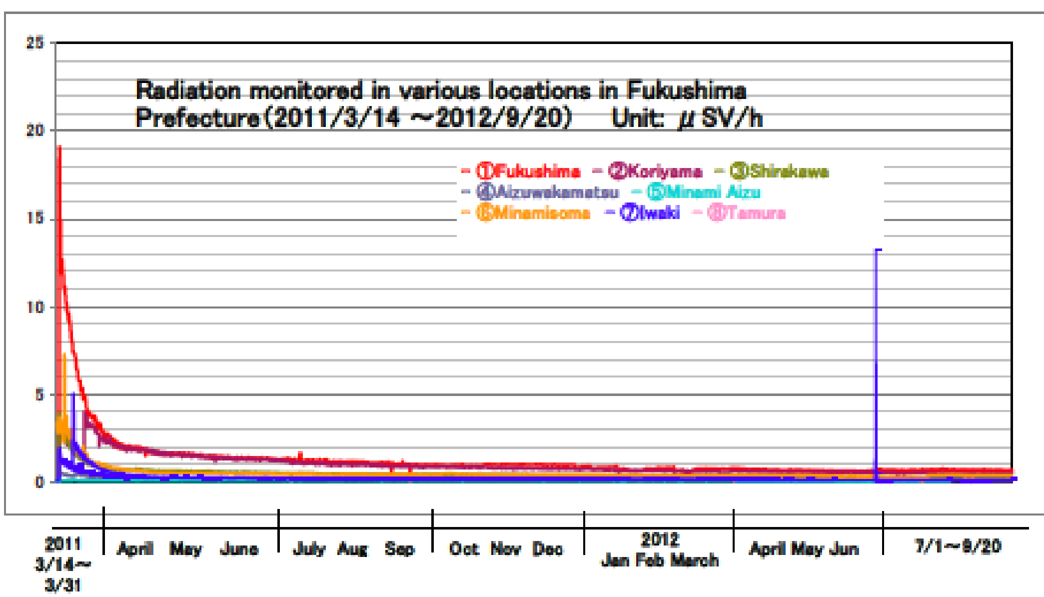
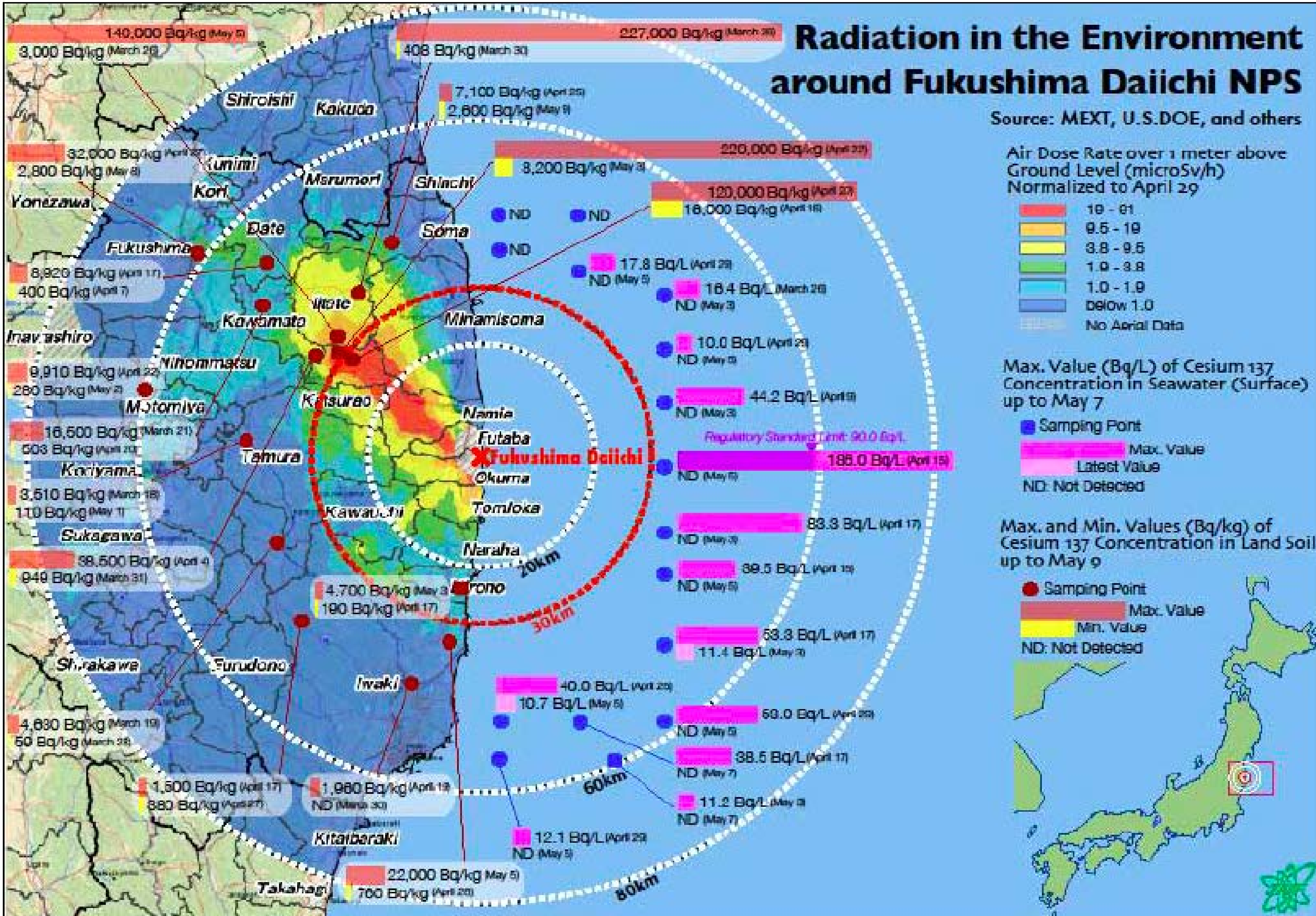
Monitoring and reporting

- Air
- Water (sea, rivers, drinking)
- Soil
- Food of any kind (plant or animal)

Trend of radiation in the environment at various locations

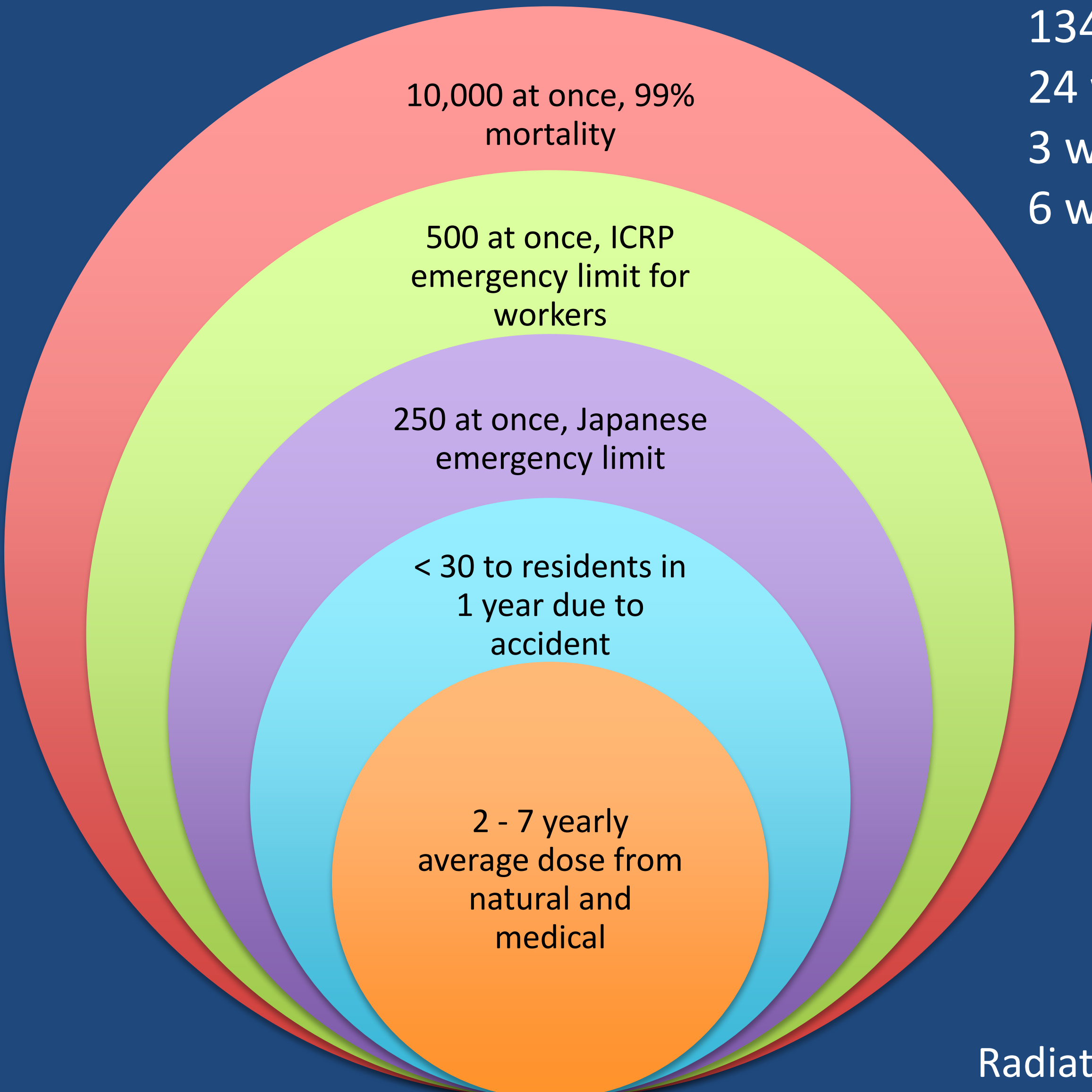


Locations for monitering



Radiation in the Environment around Fukushima Daiichi NPS
Source: MEXT, U.S.DOE, and others
Air Dose Rate over 1 meter above Ground Level (microSv/h) Normalized to April 29
19 - 91
9.5 - 19
3.8 - 9.5
1.9 - 3.8
1.0 - 1.9
below 1.0
No Aerial Data
Max. Value (Bq/L) of Cesium 137 Concentration in Seawater (Surface) up to May 7
Samping Point
Max. Value
Latest Value
ND: Not Detected
Max. and Min. Values (Bq/kg) of Cesium 137 Concentration in Land Soil up to May 9
Samping Point
Max. Value
Min. Value
ND: Not Detected
140,000 Bq/kg (May 5)
3,000 Bq/kg (March 26)
227,000 Bq/kg (March 26)
408 Bq/kg (March 30)
7,100 Bq/kg (April 25)
2,600 Bq/kg (May 9)
220,000 Bq/kg (April 29)
3,200 Bq/kg (May 3)
120,000 Bq/kg (April 22)
16,000 Bq/kg (April 16)
32,000 Bq/kg (April 27)
2,800 Bq/kg (May 8)
8,920 Bq/kg (April 17)
400 Bq/kg (April 7)
9,910 Bq/kg (April 22)
280 Bq/kg (May 2)
16,500 Bq/kg (March 21)
503 Bq/kg (April 29)
3,510 Bq/kg (March 18)
110 Bq/kg (May 1)
38,500 Bq/kg (April 4)
949 Bq/kg (March 31)
4,700 Bq/kg (May 3)
190 Bq/kg (April 17)
4,630 Bq/kg (March 19)
50 Bq/kg (March 28)
1,500 Bq/kg (April 17)
380 Bq/kg (April 27)
1,960 Bq/kg (April 19)
ND (March 30)
22,000 Bq/kg (May 5)
760 Bq/kg (April 28)
ND
ND
ND
17.8 Bq/L (April 29)
ND (May 5)
16.4 Bq/L (March 26)
ND (May 3)
10.0 Bq/L (April 29)
ND (May 5)
44.2 Bq/L (April 9)
ND (May 3)
Regulatory Standard Limit: 90.0 Bq/L
186.0 Bq/L (April 15)
ND (May 5)
83.3 Bq/L (April 17)
ND (May 3)
39.5 Bq/L (April 15)
ND (May 5)
53.3 Bq/L (April 17)
11.4 Bq/L (May 3)
40.0 Bq/L (April 29)
10.7 Bq/L (May 5)
60.0 Bq/L (April 29)
ND (May 5)
38.5 Bq/L (April 17)
ND (May 7)
11.2 Bq/L (May 3)
ND (May 7)
12.1 Bq/L (April 29)
ND (May 5)
Shiroishi
Kakuda
Kunimi
Marumori
Shinchi
Kori
Yonezawa
Date
Soma
Fukushima
Iitate
Kawamata
Minamisoma
Inawashiro
Nihonmatsu
Motomiya
Katsurao
Namie
Futaba
Fukushima Daiichi
Okuma
Tamura
Koriyama
Kawauchi
Tomioka
Sukagawa
Naraha
Hirono
Shirakawa
Furudono
Iwaki
Kitaibaraki
Takahagi
20km
30km
60km
80km

Radiation doses



TEPCO reports doses March ‘11 - September ‘12:

134 workers received 100-150 mSv

24 workers received 150-200 mSv

3 workers received 200-250 mSv

6 workers received 250-679 mSv

No observed effects

24118 workers monitored

Average dose 12 mSv

Radiation dose units millSieverts (mSv)

Radiation doses

TEPCO reports doses March ‘11 - March ‘12:

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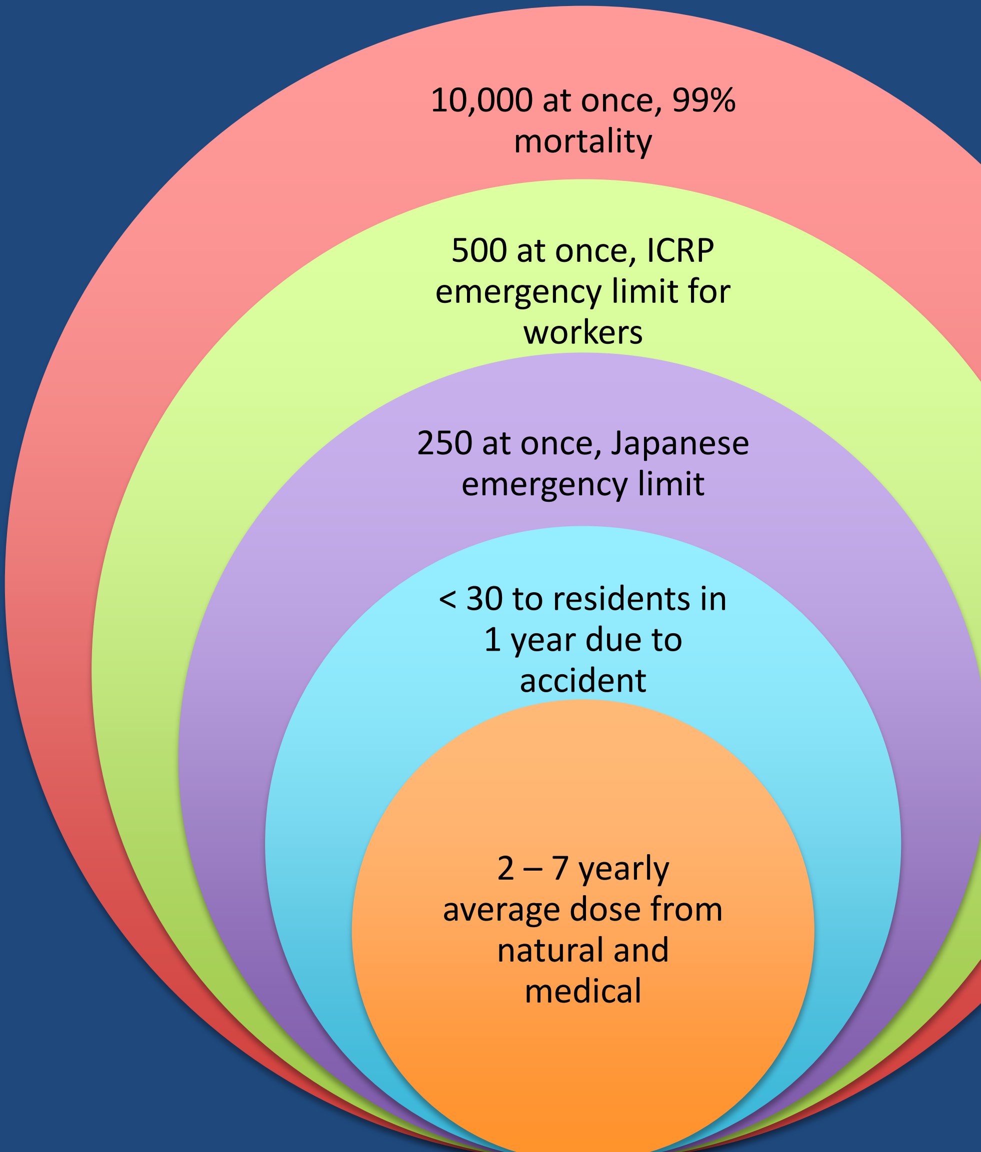


Radiation dose units millSieverts (mSv)

Event	Dose or releases	Deaths
Three Mile Island (1979)	Minor short term dose to public (within ICRP limits)	0
Chernobyl (1986)	Major radiation release across E. Europe and Scandinavia (1.52 E19 Bq I-131 equivalent)	47+
Fukushima (2011)	Significant local contamination (7.7 E17 Bq I-131 equivalent)	0

Relative risks of power production

Year	**Event**	**Dose/releases**	**Deaths**
1979	Hydro dam failure (India)	No rad	2500
	Three Mile Island Nuclear Reactor accident (USA)	Minor short term dose to public (within ICRP limits)	0
1984	Oil fire (Brazil)	No rad	508
1986	Chernobyl Nuclear Reactor accident (Ukraine)	Major radiation release across E. Europe and Scandinavia (15.2 EBq I-131 equivalent)	47+ (32 immediate)
2009	Coal mine explosions (China)	No rad ?	2631
2011	Fukushima nuclear reactors accident (Japan)	significant local contamination (770 PBq I-131 equivalent)	0

TEPCO's Midterm to Long-term Roadmap

Present (Completion of Step 2)	Within 2 Years	Within 10 Years	After 30-40 Years
Step 1, 2	**Phase 1**	**Phase 2**	**Phase 3**
-<Achieved Stable Conditions>-	Period to the start of fuel removal from the spent fuel pool (Within 2 years)	Period to the start of fuel debris removal (Within 10 years)	Period to the end of decommissioning (After 30-40 years)
-Condition equivalent to cold shutdown -Significant Suppression of Emissions	-Commence the removal of fuels from the spent fuel pools (Unit 4 in 2 years) -Reduce the radiation impact due to additional emissions from the whole site and radioactive waste generated after the accident (secondary waste materials via water processing and debris etc.) Thus maintain an effective radiation dose of less than 1 mSv/yr at the site boundaries caused by the aforementioned. -Maintain stable reactor cooling and accumulated water processing and improve their credibility. -Commence R&D and decontamination towards the removal of fuel debris -Commence R&D of radioactive waste processing and disposal	-Complete the fuel removal from the spent fuel pools at all Units -Complete preparations for the removal of fuel debris such as decontaminating the insides of the buildings, restoring the PCVs and filling the PCVs with water Then commence the removal of fuel debris (Target: within 10 years) -Continue stable reactor cooling -Complete the processing of accumulated water -Continue R&D on radioactive waste processing and disposal, and commence R&D on the reactor facilities decommission	-Complete the fuel debris removal (in 20-25 years) -Complete the decommission (in 30-40 years) -Implement radioactive waste processing and disposal

Actions towards systematic staff training and allocation, improving motivation, and securing worker safety will be continuously implemented.

Phase 1 Status as of October 2012 (I and II)

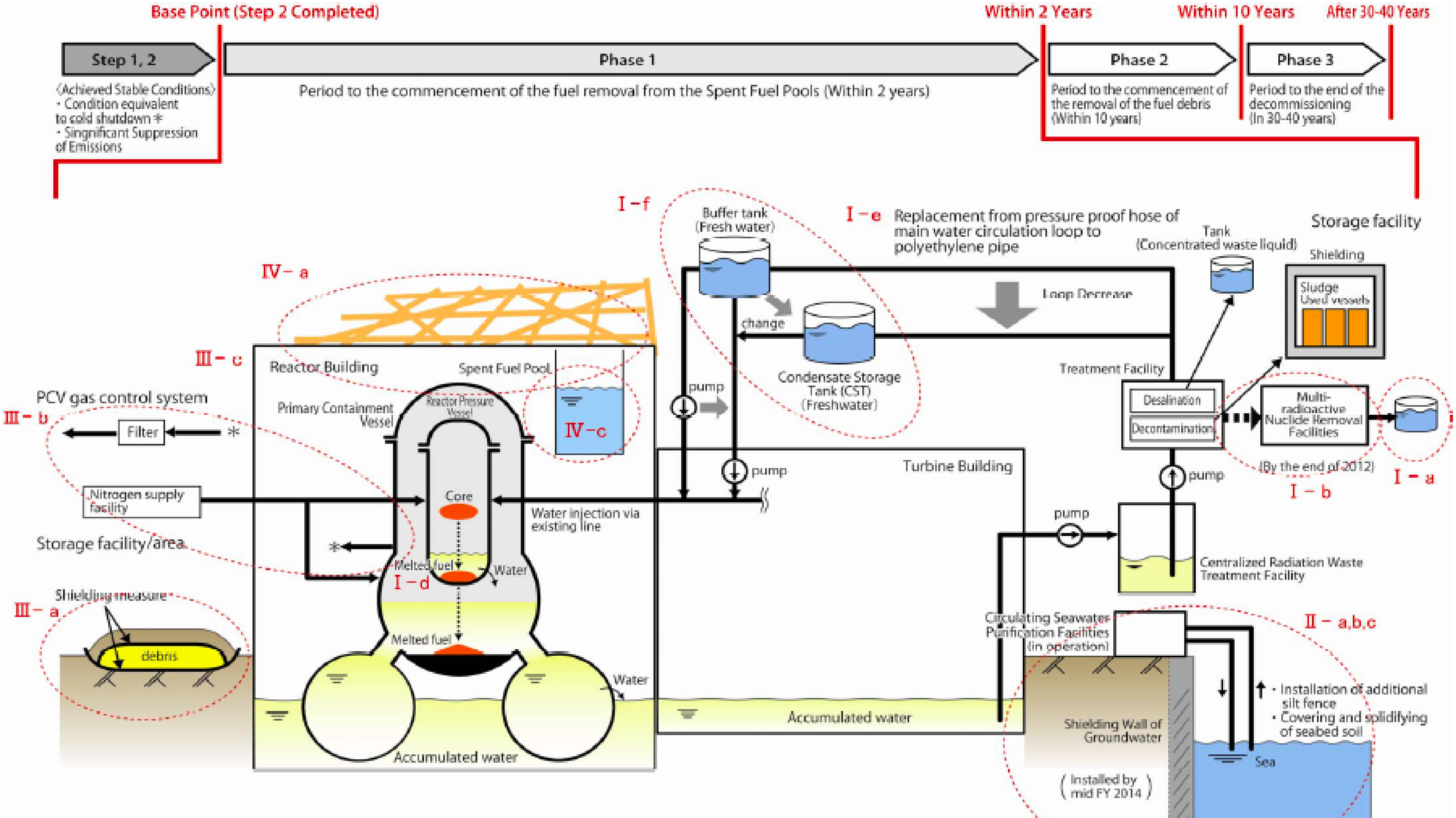
Status of the Efforts towards the Decommissioning of Fukushima Daiich NPS Units 1-4, as of October 31, 2012. (c

		Status of the Efforts towards the Decommissioning of Fukushima Daiich NPS Units 1-4
I. Reactor Cooling / Accumulated Water Processing	Plant Status	"Cold shutdown condition" is maintained at Units 1-3. By means of a circulating injection cooling system, huge amount of the highly radioactive waste water, which is accumulated in the basement of the R/Bs and T/Bs of Units 1-4, is being processed and injected into the reactor to cool down the damaged, melted core. ◇Temperatures of the bottom of RPVs and gas-phase parts of PCVs: nearly 30-50℃ (on October 21). ◇Reactor injection flow rate via feed water line / via core spray line (m3/h) : Unit 1: 2.7/2.0, Unit 2: 1.8/4.3, Unit 3: 2.0/4.5 (at 11:00, October 21)
	Timed Targets (TT)	Continually monitor stable "cold shutdown condition" by continuing water injection cooling till completion of the fuel debris removal. 1) Consider and implement methods to improve the reliability of the existing water processing and injection cooling facilities within FY2012, and continue improvements thereafter. 2) By mid-FY2012, install multi-nuclide removal facilities capable of removing radioactive materials other than Cesium, which are difficult to remove with the existing facilities. 3) Scale down the circulation loop in stages, according to improvement of the reliability of the existing water processing facilities and measures in Phase 2, such as stopping inter-building water leakage and repairing lower part of the PCV.
	Progress of measures towards TT	a. As expansion of processed water tanks, construction of 80,000m3 tanks will be completed in the first half of 2013, and construction of additional 300,000m3 tanks is planned, resulting in the total capacity of 700,000m3. b. As a result of verification test of the multi-nuclide removal facility, it was confirmed that 62 target radionuclides were decontaminated below measurable limits. Systematic test by real processed water is planned. c. A system to prevent groundwater from entering leaking into buildings by pumping the groundwater upstream (groundwater bypass) is under construction. Groundwater bypass will start in mid-December. d. Installation of alternative thermometers to substitute for the broken Unit 2 thermometers was completed on October 3. e. As regards RO processed water loop, replacement of pressure proof hose to polyethylene pipe were finished in August. f. Change of intake sources for circulating water cooling from Buffer tank to CST to increase the capacity and make earthquake more resistant will be finished in December. ◇The amounts of reactor injection water into Unit 1-3 were found to be lower than the required amounts stipulated in the Tech. Spec. on August 30. The flow rate of each unit was continuously adjusted. The cause is thought that foreign substance entered the system and narrowed the flow passage. The system was restored on September 13.
II. Mitigation of the Sea Water Contamination	Plant Status	Water including high concentration of radioactive materials flowed from the NPS into the front sea in April and May, 2011. A variety of measures have been taken to prevent radioactive materials from flowing into the underground water and the sea while decontaminating the seawater with circulating seawater purification facilities..
	Timed Targets (TT)	Reduce the risk of expanded seawater contamination while reducing radioactive material concentrations in seawater in the port. 1) Installation of water shielding walls in front of Units 1-4 by mid-FY 2014, to prevent contaminated underground water from flowing into the sea. 2) Rapidly reducing radioactive substance concentrations in seawater in the port below the legal density limit for out of supervised areas, by mid-FY 2012.
	Progress of measures towards TT	a. Installation works of the water shielding walls in front of the Units 1-4 have been in progress from October 2011. Advance rock boring for steel pipe forepole cast portions on June 29, as well as the installation of wave absorbing blocks to block seaside wave energy on July 20. b. Restart operation of circulating seawater purification facilities after shifting intake point to the Unit 3 side with relatively high radioactivity on July 30. c. As a result of covering seabed soil and operating circulating seawater purification facilities, Cs density was attained below legal limit in the areas of comparatively fast flow. In other areas, countermeasures will be carried out. ◇The maximum concentration of radioactive materials in the seawater within the Fukushima Daiichi NPS port (Bq/ℓ): 110(Cs134), 210(Cs137) [sampled on October 21 at Unit 3 screen (inside the silt fence)] ＊The legal density limit for out of supervised areas: 60(Cs134), 90(Cs137)

With completion of Steps 1 and 2 of the Roadmap to Restoration and the shift to Phase 1 of the mid-term plan, component III evolved and component IV was defined

III. Radioactive Waste Management and Dose Reduction at the Site Boundaries	Plant Status	Radioactive materials and radioactively contaminated debris scattered due to the hydrogen explosion. Splaying dispersion inhibitor and removing debris are in progress. Installation of Unit 1 R/B cover was completed in October 2011. Installation work of Unit 4 R/B cover for removal of fuels, including foundation improvement work began on April 17. PCV gas control systems in operation at Units 1, 2 and 3 to suppress the release of gaseous radioactive materials from PCVs.
	Timed Targets (TT)	Properly manage and control solid, gaseous, liquid radioactive waste 1) Reducing the effective radiation dose at the site boundaries to below 1 mSv/year within FY2012, including effective dose due to additional release of radioactive materials from the NPP as a whole, and radioactive waste produced after the accident and stored on the site (secondary waste from water processing, debris, etc.)
	Progress of measures towards TT	a. To decrease dose around the site, it is planned to cover logged trees with soil and to transfer rubbles in the solid waste storage facilities. b. PCV gas control systems in operation at Units 1, 2 and 3. c. Closure of opening of blowout panel of Unit 2 R/B is planned to reduce the risk of releasing radioactive materials. Construction work will begin in or after this autumn. ◇The release rate of radioactive materials from Units 1-3 PCVs is estimated to be totally about 10 million Bq/h (Cs-134 and 137) at maximum, leading to the exposure of 0.03mSv/y at the boundary of the site. [TEPCO report on October 22]
IV. Fuel Removal from the Spent Fuel Pool	Plant Status	Stably cooling SFP water of Units 1-4 with a circulation cooling system (Most spent fuels estimated to be undamaged) Purification of the SFP water with desalination equipment is implemented step by step at Units 2-4, at which seawater was injected in to the SFP, to prevent corrosion of components. Temperatures of SFP water of Units 1-4 are 19.6-28℃ (at 11:00, October 21)
	Timed Targets (TT)	Complete fuel removal from SFP of all Units during Phase 2 1) Unit 4: Start fuel removal within 2013, 2) Unit 3: Start fuel removal within 2014 3) Units 1 and 2: Develop a fuel removal plan based on the situation of decontamination, removal of debris, etc., and remove fuels during Phase 2
	Progress of measures towards TT	a. Removal of rubbles at the upper part of the R/Bs at Units 3 and 4 in progress, with Units 4 and 3 to be completed at mid FY 2012 and in the end of FY 2012 respectively. b. R/B cover for fuel removal of Unit 4 is being installed (to be completed in mid FY2013). c. Desalination of Unit 4 SFP was completed on October 12. The pool water will be sampled regularly to examine its water quality. Desalination is continuously being done in Unit 3 SFP. ◇ On September 22, during a rubble removal work of Unit 3, a worker tried to grab a steel beam (approx. 470kg) on the side of the SFP, and the steel beam slipped and fell into the SFP. There has been no significant change in the nuclide analysis results of Unit 3 SFP water and the monitoring post data. On October 3 and 19, a report including the cause of the incident and recurrence prevention measures was submitted to the Nuclear Regulation Authority. The rubbles near the SFP is currently being investigated to prepare for restarting rubbles removal.
Occupational Safety Assurance (Radiation Exposure of Workers)		◇On October 31, TEPCO released a monthly report of the occupational radiation exposure dose at the Fukushima Daiichi NPS. A total of 24,118 workers were there during the period from March 2011 to September 2012. The maximum cumulative dose was 678.80 mSv and the average dose was 11.86mSv. A total of 5,513 workers were there in September, 397 of which were new workers. The maximum and average doses in September were 18.57mSv and 0.94mSv. As usage of APD shielded with lead cover was unveiled, reevaluation of employees' radiation exposure levels was conducted and recurrence prevention measures was established. Workers engaged in works under high levels of radiation have worn protective clothings with a transparent chest part since October 15.

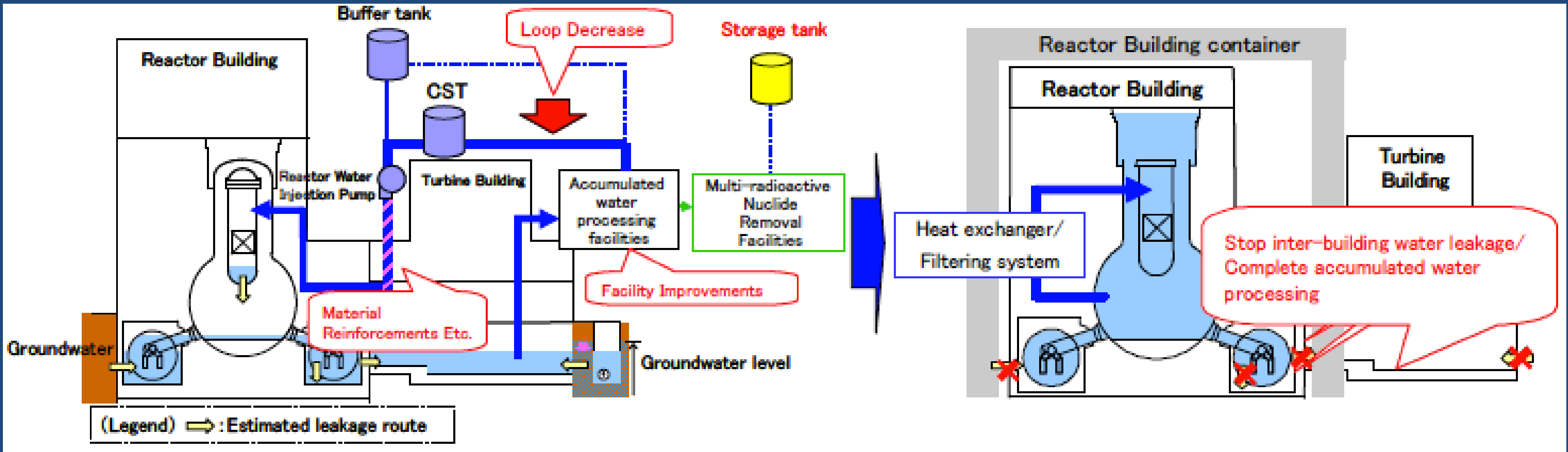
Graphic summary of Phase 1 activities



* Condition equivalent to cold shutdown: 1) Temperature of RPV bottom and containment is, in general, below 100℃,

2) Release of radioactive materials from PCV is under control and public radiation exposure by additional release is being significantly held down (Target: not exceeding 1 mSv/year at the site boundary.)

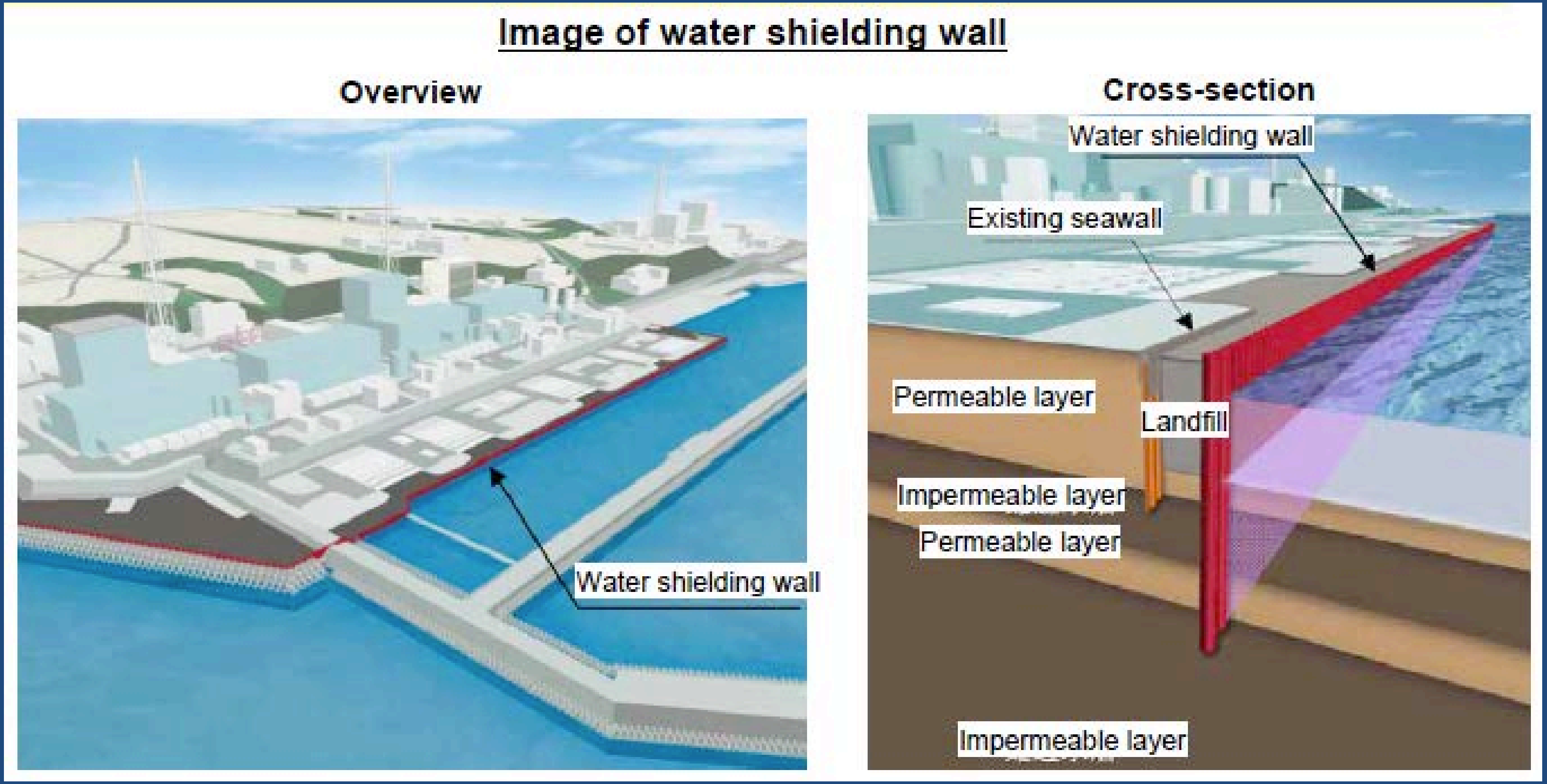
Reactor cooling & accumulated water processing (I)



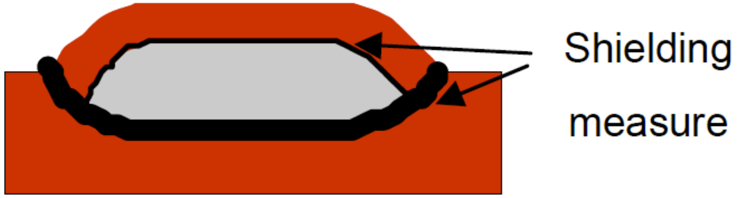
Actions during Phase 1

Actions during Phase 2 (loop decrease)

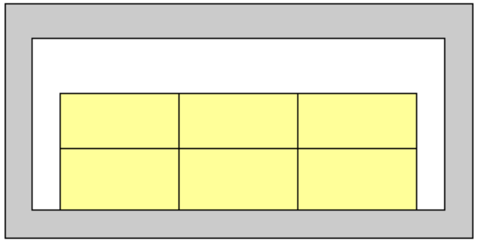
Mitigating seawater contamination (II)



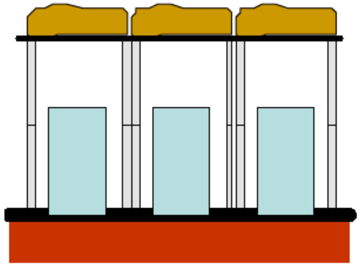
Waste management and dose reduction at site boundaries (III)



Shielding by soil (debris)



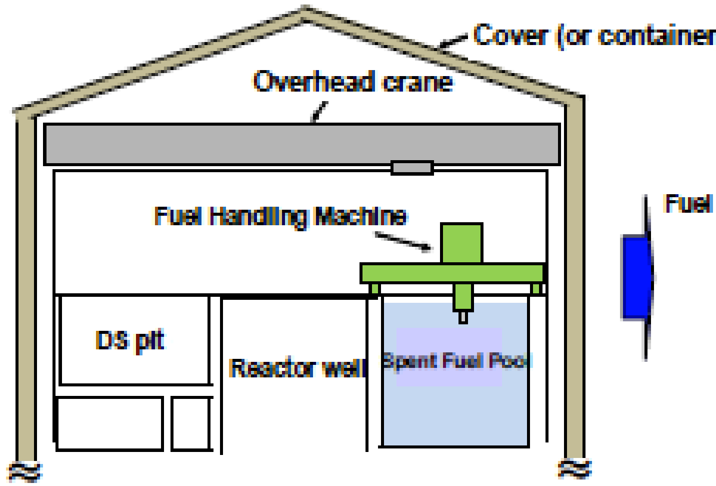
Shielding by building (debris)



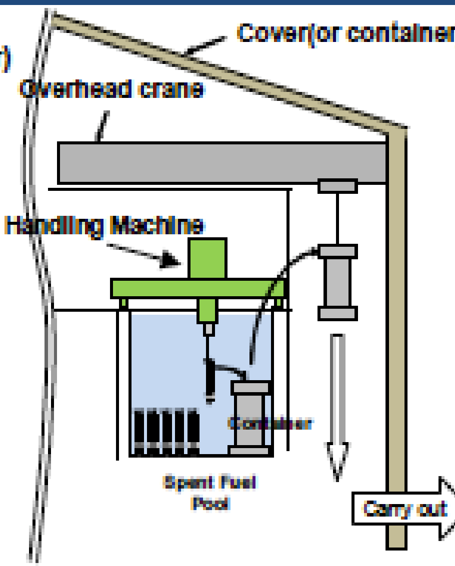
Shielding by sandbags etc.
(secondary waste materials via water processing)

Fuel removal from pool (IV)

Debris removal from the upper part of reactor building



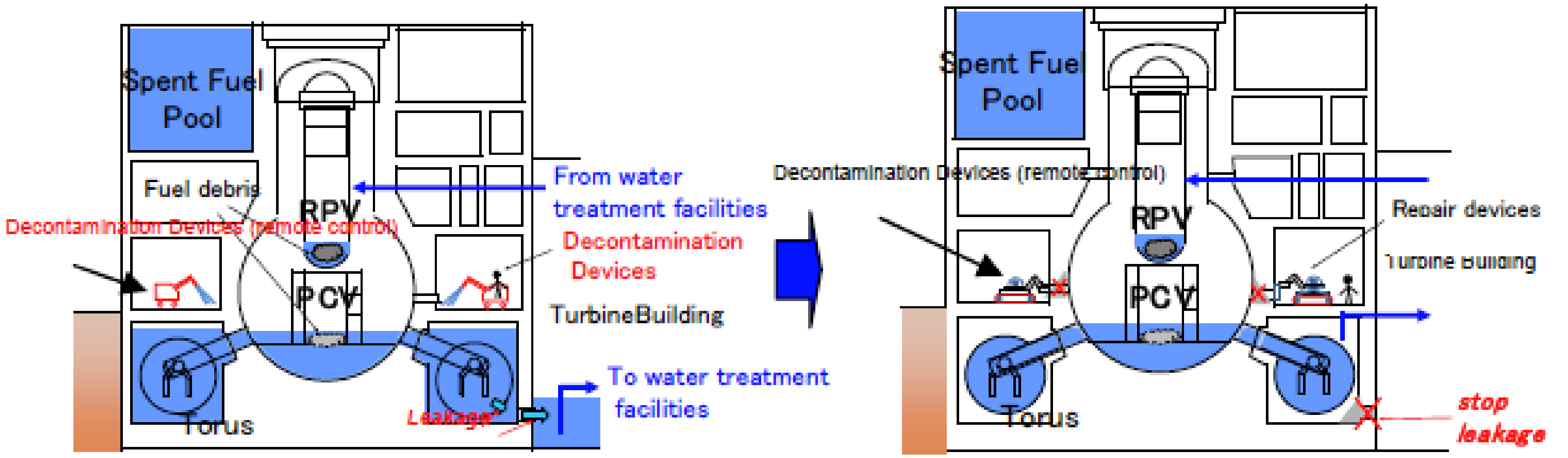
Installation of cover (or container) / crane



Fuel removal work

Overview of Phases 2 and 3

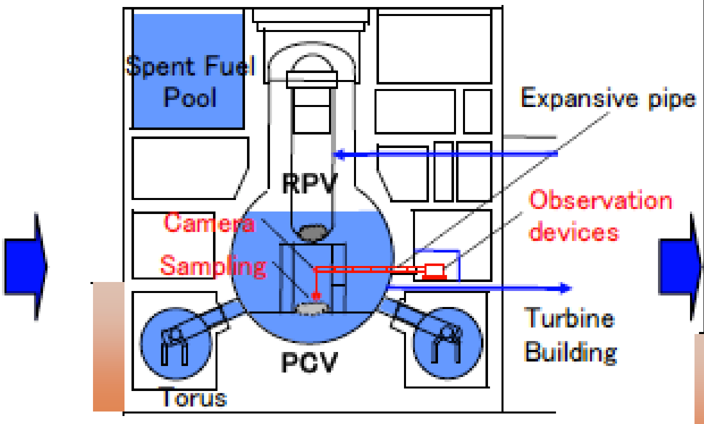
Removal of fuel debris from reactors



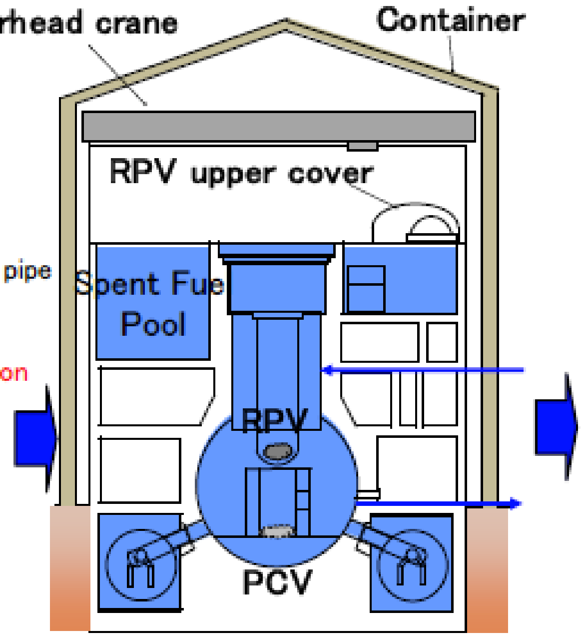
a) Reactor Building Decontamination

b) Repairs to stop inter-building and PCV leakage

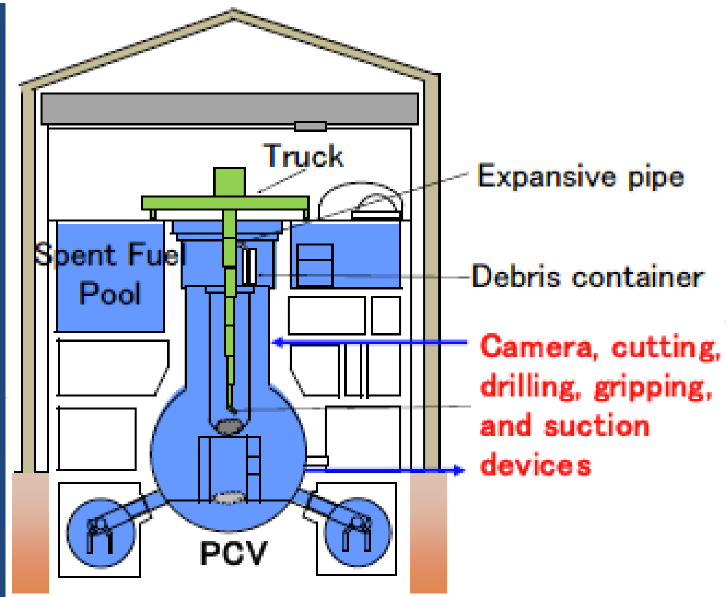
(continued)



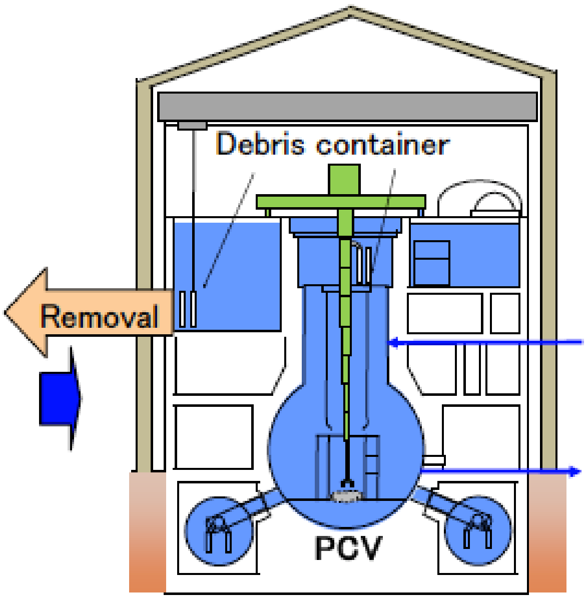
c) Investigation and Sampling of inside of PCV



d) Filling with water and removing RPV upper cover

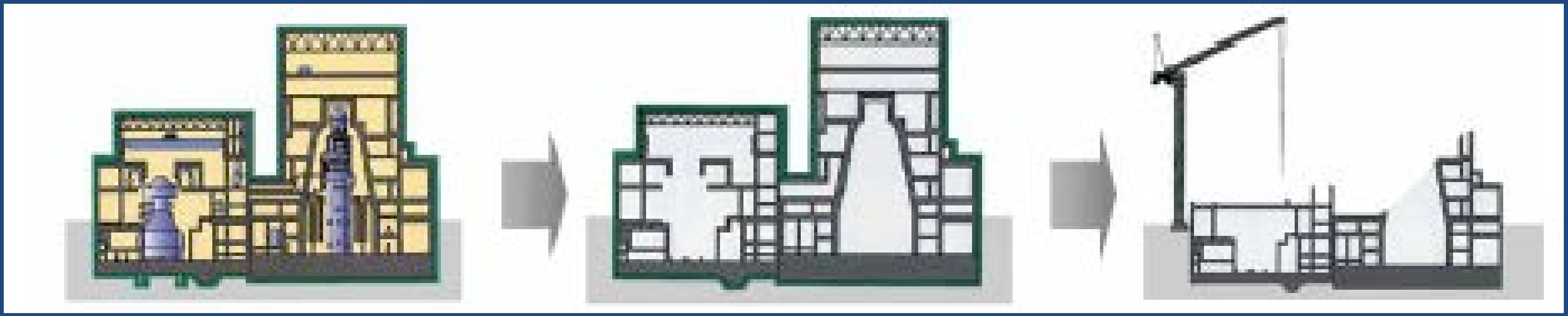


e) RPV inside investigation and sampling



f) Removal of fuel debris

Facilities disassembly



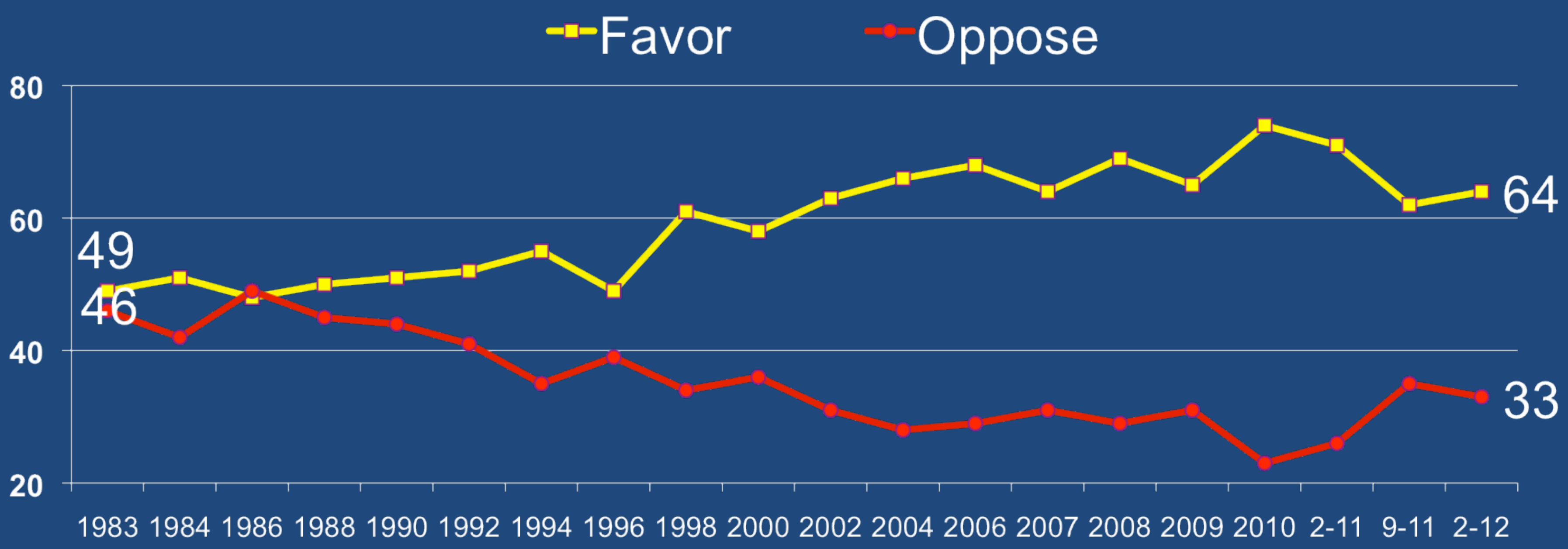
3. Impact of Fukushima-1 accident on the nuclear industry and actions taken

Effects of Fukushima on US Industry

- Nuclear Regulatory Commission (NRC) response
  - Fukushima Near-Term Task Force report
  - New regulations and requirements
- Effect on existing US nuclear plants
  - New/updated environmental hazard evaluations
  - Additional hardware & procedures
  - Older, BWR plants most affected
- Effect on new nuclear plant projects
  - Projects moving forward w/o significant delay
  - Projects will have to meet any new, Fukushima-related requirements
  - New plants less affected by Fukushima-related changes
    - Advanced, passive PWRs
    - Less susceptible to problems that occurred at Fukushima
    - Less design changes / upgrades will be required

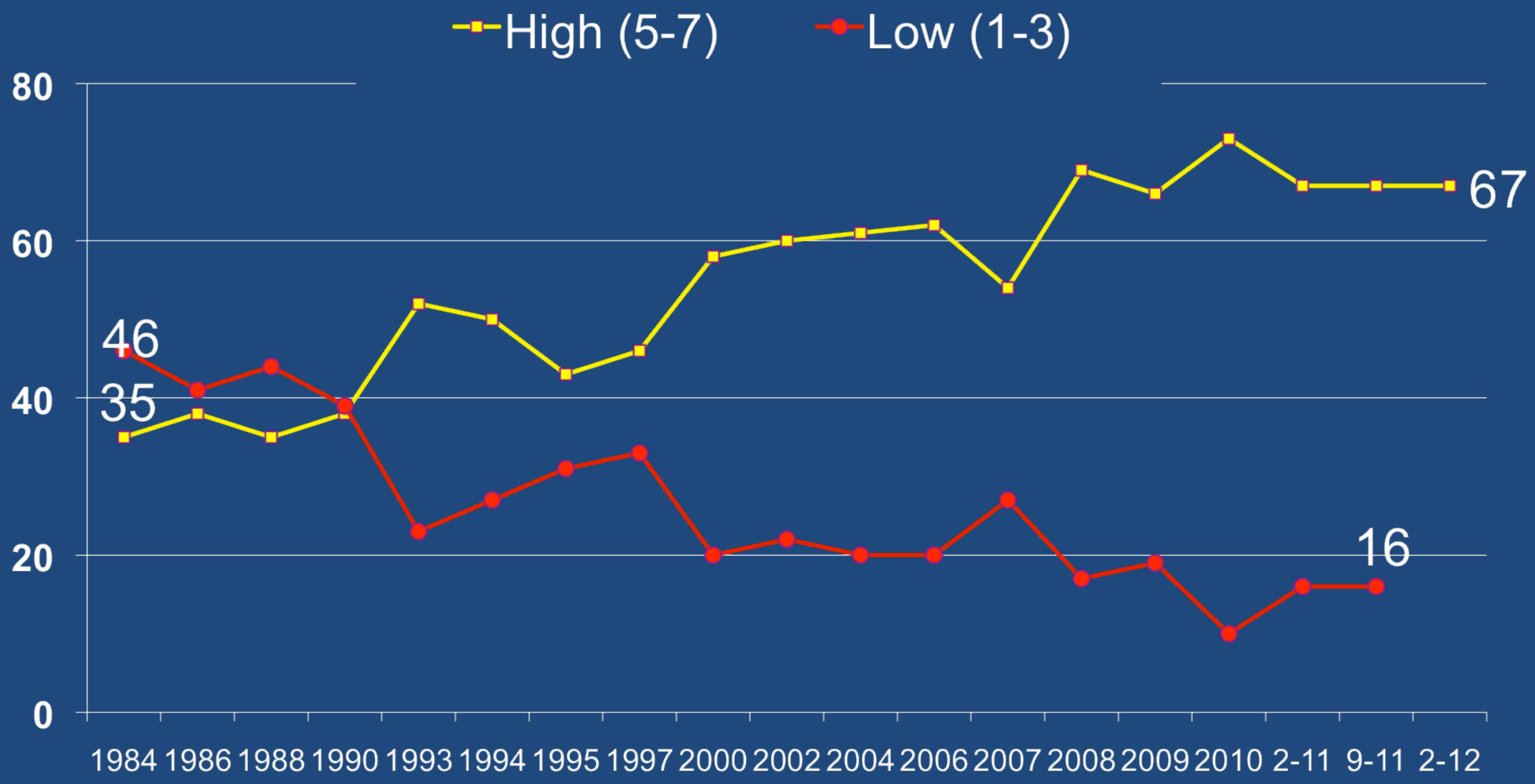
4. Perspective

Favorability to Nuclear Energy
(U.S. Public Opinion, Annual Averages until 2012, Percentages)



Bisconti Research, Inc.

67% Rate Nuclear Power Plant Safety High



Bisconti Research, Inc.

The BIGger post-tsunami picture along the northeast coast of Japan

- Number of buildings damaged/destroyed: >332,400
- Number of roads, bridges, railways: 2100, 56, 26
- Number of people displaced: 131,000
- **Number of people dead or missing: > 20,000**
- Number of deaths due to tsunami at NPP: 2
- Number of deaths due to radiation exposure: 0
- Number of cases of radiation sickness: 0

Perspective