The Japanese Radiological Event at Fukushima Plant 1 (Daiichi)

Fukushima Daiichi Unit 4 (032411)

Joint Meeting of the SFBAC AAPM & NCC HPS, H's Lordships, Berkeley Marina, Berkeley, CA

April 14, 2011

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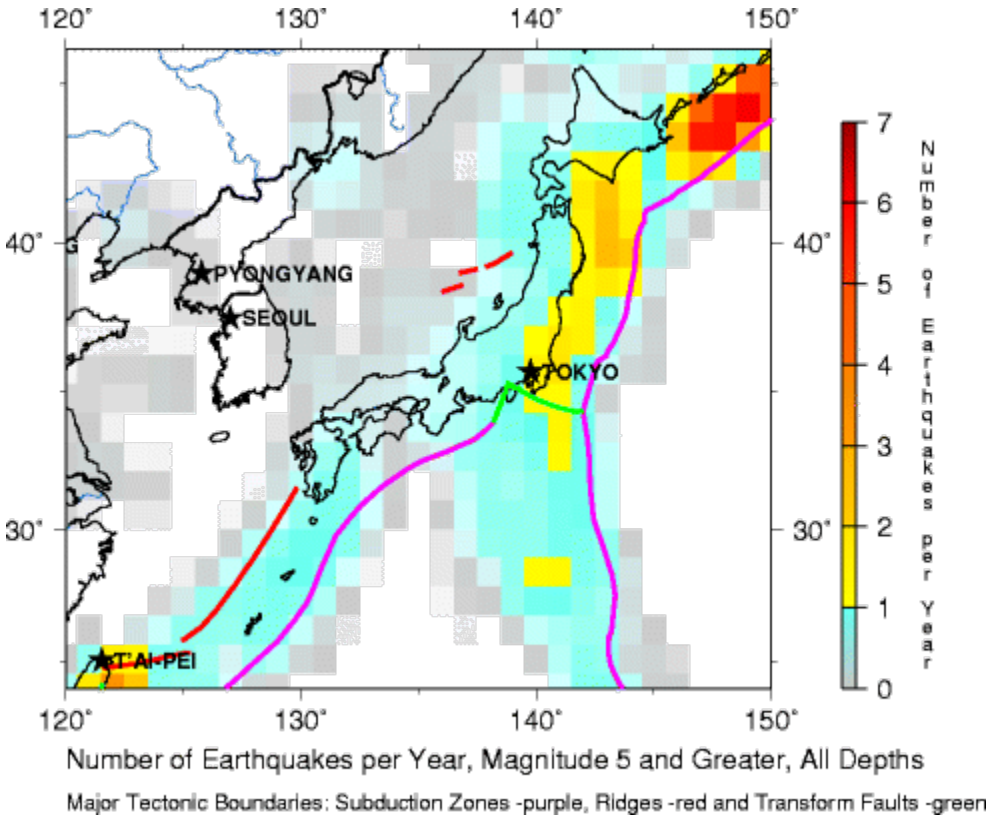
MPG HP Inc.

Objectives

- Set the stage regarding the two-prong natural disasters: earthquake and tsunami
- Sequence the events at Units 1-6 at Daiichi and place in perspective with the other significant reactor events in the last 60 years
- Discuss the known radiological levels encountered on site, throughout the Japanese home islands, and in Hawaii and North America
- A bit on the public health consequences based on events as close to the meeting date as practicable

Setting the Stage

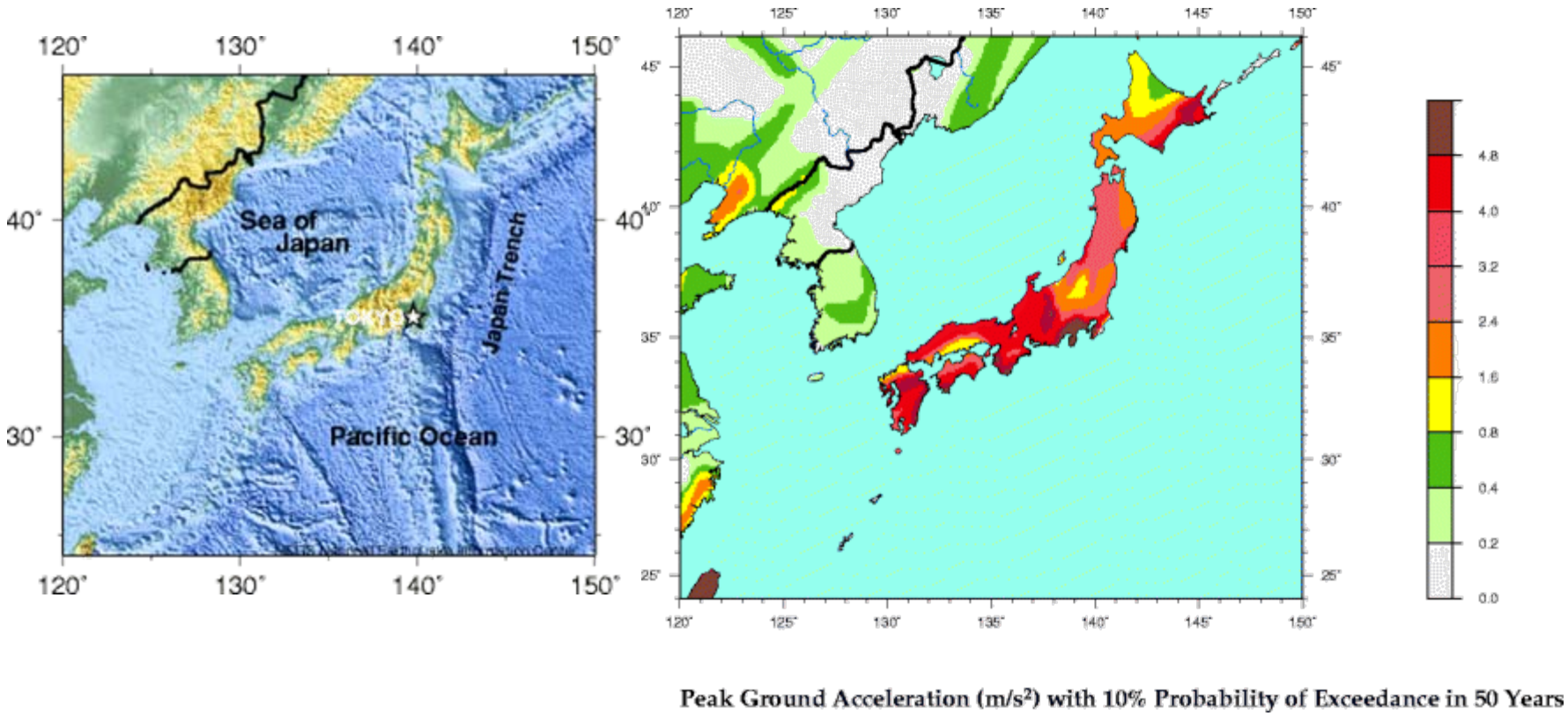


Number of Earthquakes per Year, Magnitude 5 and Greater, All Depths

Major Tectonic Boundaries: Subduction Zones -purple, Ridges -red and Transform Faults -green

There have been 100s of earthquakes since the force magnitude 9 great quake on 3/11/11.

Pacific Plate & Asian Plate Subduction Zone



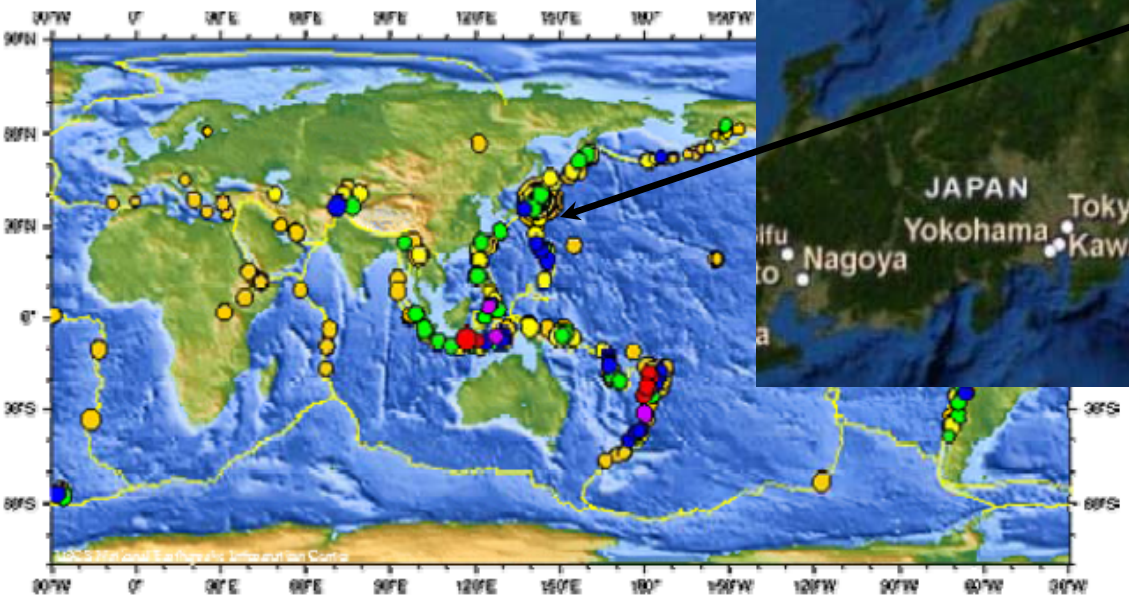
Peak Ground Acceleration (m/s²) with 10% Probability of Exceedance in 50 Years

The Great 9 Quake and Aftershocks to 4/12/11

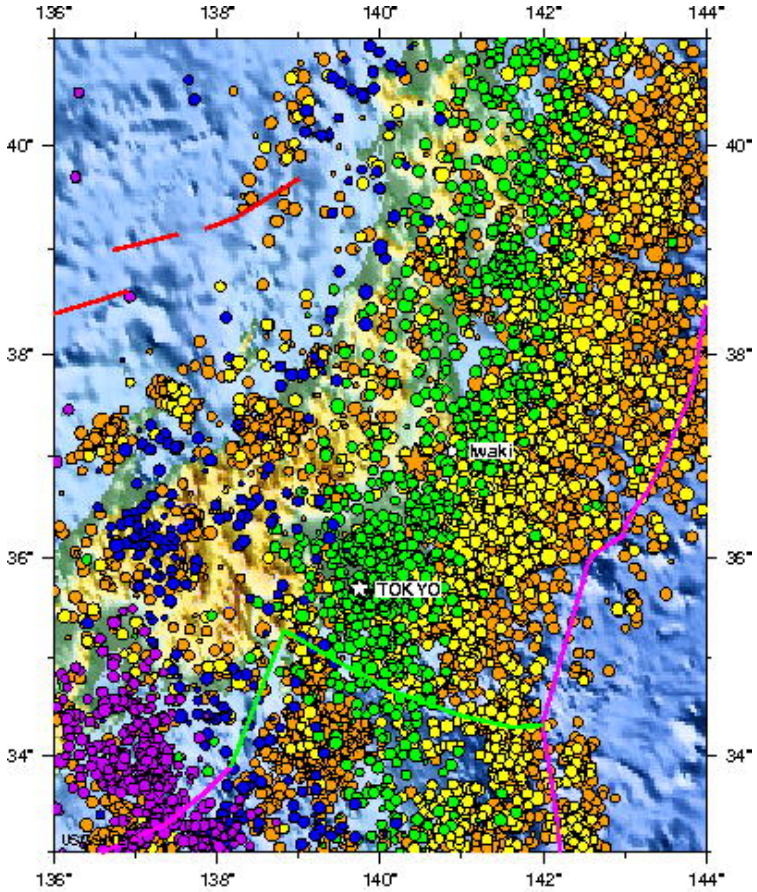
USGS
science for a changing world

Earthquake Hazards Program

Recent Earthquakes - Last 8-30 Days



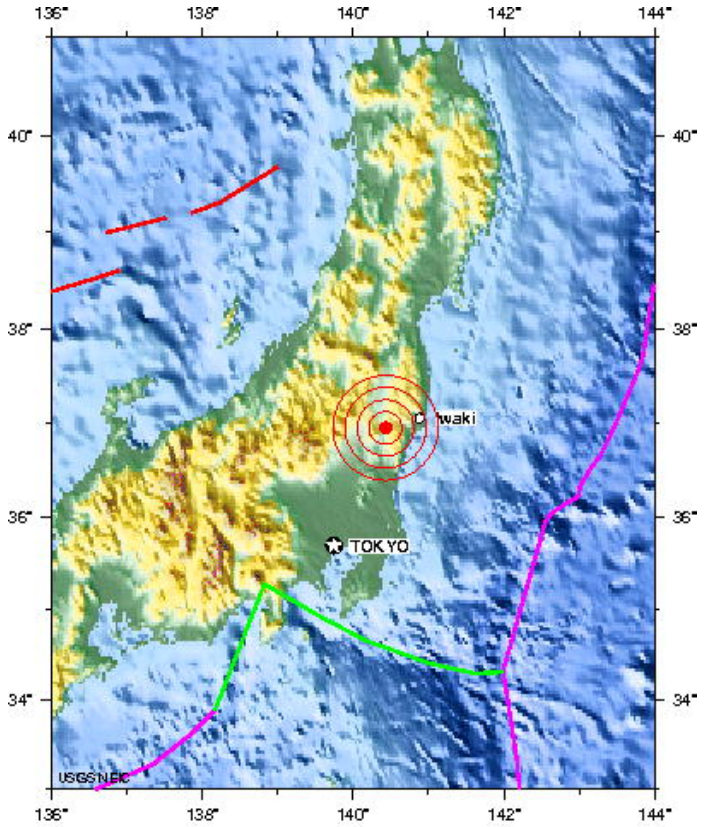
Earthquakes Not New for Japan Latest >5 on 4/13/11



NEAR EAST COAST OF HONSHU, JAPAN

2011 04 13 01:08:01 UTC 36.95N 140.43E Depth: 24.7 km

Seismicity 1990 to Present



NEAR EAST COAST OF HONSHU, JAPAN

2011 04 13 01:08:01 UTC 36.95N 140.43E Depth: 24.7 km

Earthquake Location

More Than 140,000 Still Displaced 4/13/11

It's cold and wet

camping outdoors

aftershocks multiplying

the misery

(Yasuharu You, Buddis Monk of Shin sect after Niigata earthquake October 2004)

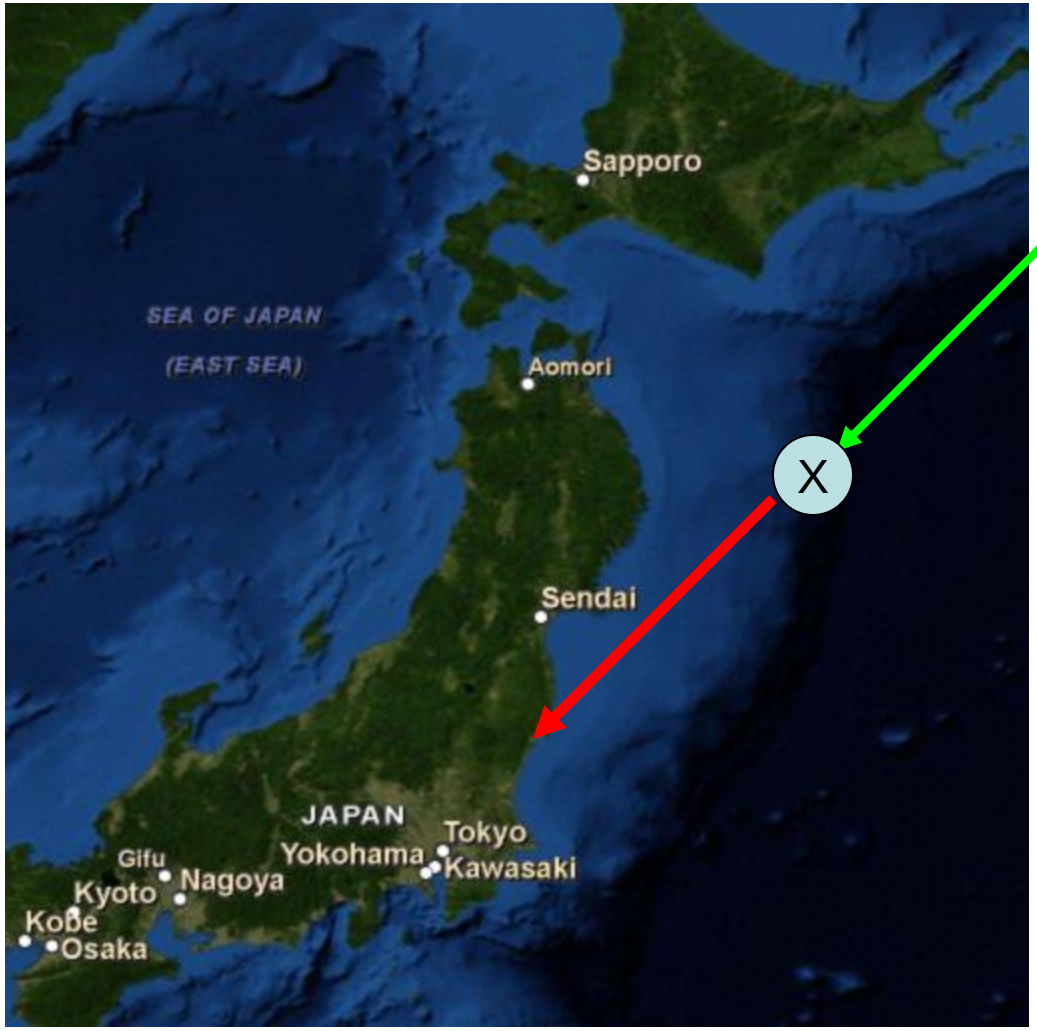
Day of disaster

I can never forget

the cold and wet

(Yasuharu You, Buddist Monk of Shin sect this disaster)

Minutes Later
Tsunami



The Asian Plate rebounded about 3 feet causing a wave of that size to cross the Pacific eastward to Hawaii and beyond. However, pressure gauges on the sea floor West of the 9 epicenter measured more than 5 feet of sea floor displacement. Waves reflecting off the coastline of Honshu or funneled into inlets resulted in tsunamis coming ashore that were much higher: A 46-foot wave was seen coming over the Fukushima Daiichi anti-tsunami seawall (16 feet).

Principal Cause of Loss of Life: The Tsunamis

Combining the latter numbers places the probable combined death toll for this date at nearly 27,000. But as we have seen, that number is changeable within a range of overlap of a couple of thousand persons between [illegible] and possibly by several thousand more at a later date as the unknown/unnamed missing get included.

As confusing as the death toll and these various numbers are, they reflect personal, societal and national tragedies for the people of Japan, and they must be dealt with on many levels... emotional, spiritual, physical and financial. So far, it has not been demonstrated that anyone is doing any of those things effectively.

The big tsunami

scattering as far as here

a cloud of seabirds

Boats cars

houses and people in the flow

western wind

tsunami at Natori Miyagi prefecture 031111

(Kazuo Oike - seismologist and former President Kyoto University)

Situation Muddled Due to Road, Rail and Shipping Disruptions

Mother's pain

Into the spring sea

her last sleep

(Murasaki Sagano whose mother died 5 days post tsunami)

mother's body remains buried in Onagawacho, Miyagi Prefecture 031711

Nearly entire villages were swept back out to sea by the receding tsunami waters. The Pacific Ocean East of Honshu became a great mass of floating debris: homes, animals, trees, bodies, cars, boats, trains, and more that created significant shipping hazards and impeded recovery efforts to save survivors (the Japanese Coast Guard saved one man on the roof of his house 3 days later and 10 miles out to sea – but his wife perished).

Debris at Sea

Wood, boats, roofs and other debris from Japan are floating in the Pacific Ocean following the March tsunami that devastated parts of the Japanese coastline, dragging items large and small back to sea.

Tsunami-generated debris from Japan to reach Hawaii, California coasts

Source: (AHN) Reporter: Windsor Genova
Location: Honolulu, HI, United States Published: April 13, 2011 02:41 pm EDT
Topics: Environmental Issue, Environmental Pollution, Water Pollution, Disaster And Accident, Earthquake, Human Interest, Curiosity

Cars, trees, roof tops and household items swept into the sea by the March 11 tsunami in Japan will move across the Pacific Ocean and reach the coasts of Hawaii and California in two to three years, researchers predict.

Ocean currents have already moved the island-size debris a few hundred kilometers away from Japan's shore, reported the lead researcher, Jan Hafner, from the University of Hawaii's International Pacific Research Center.

The garbage will hit Hawaii's coast in batches for five more years, Hafner said. The prediction is based on data from previous studies on objects drifting in the ocean.

The moving garbage patch poses environmental hazard to coastal communities and maritime hazard to ships sailing across the Pacific.

Basho's road

throughout Tohoku

hope remains

(Stephen DeGuire trek in post-disaster region)

Fires, Flooding and Aftershocks Added to the Misery

About the nuclear power

plant

too much detail I hear

such unhappiness

(Yoshikatsu Kurota in Asahi 3/24/11)

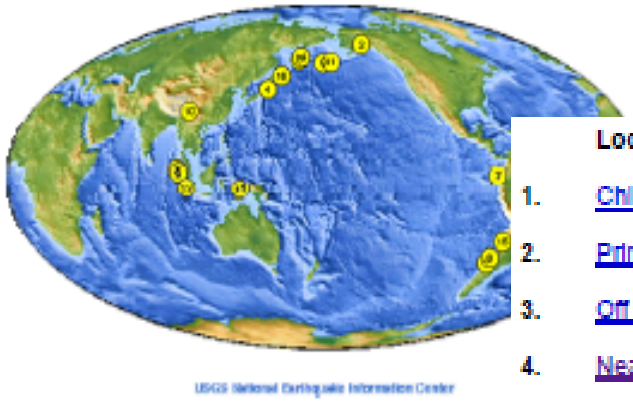
In the confusion and disarray during the first few hours after the great quake and tsunami, many reporting errors surfaced in the media. This famous image was shown with the caption "Fukushima Workers Evacuated From Nuclear Plant." In fact, it was a petroleum fire at an oil refinery but many in the world press thought it looked like a nuclear plant. The Japanese had no need for erroneous or misleading reporting, and it contributed to the shock of the moment.

Great Earthquakes Comparison

USGS science for a changing world

Earthquake Hazards Program

Largest Earthquakes in the World Since 1900

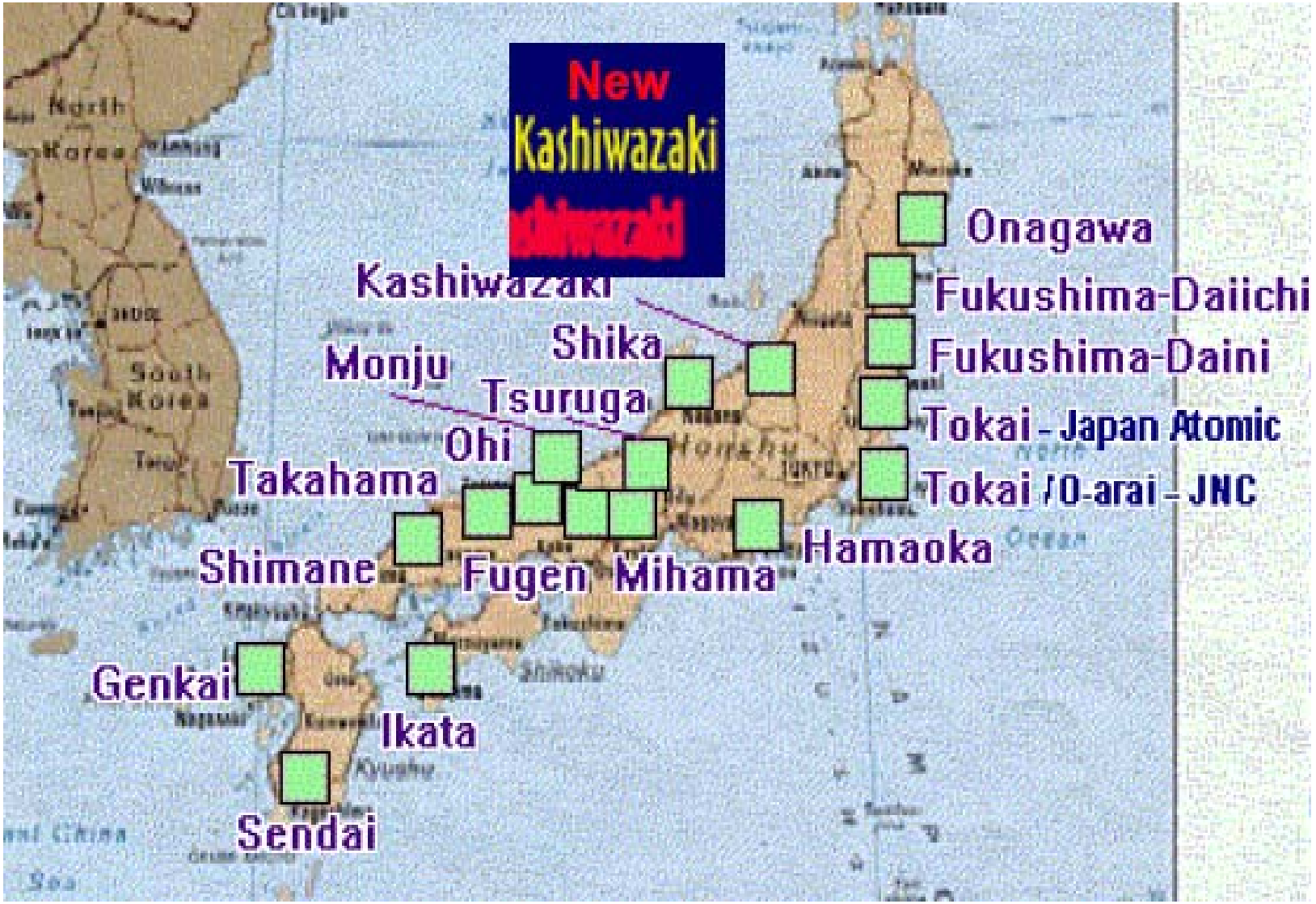


USGS National Earthquake Information Center

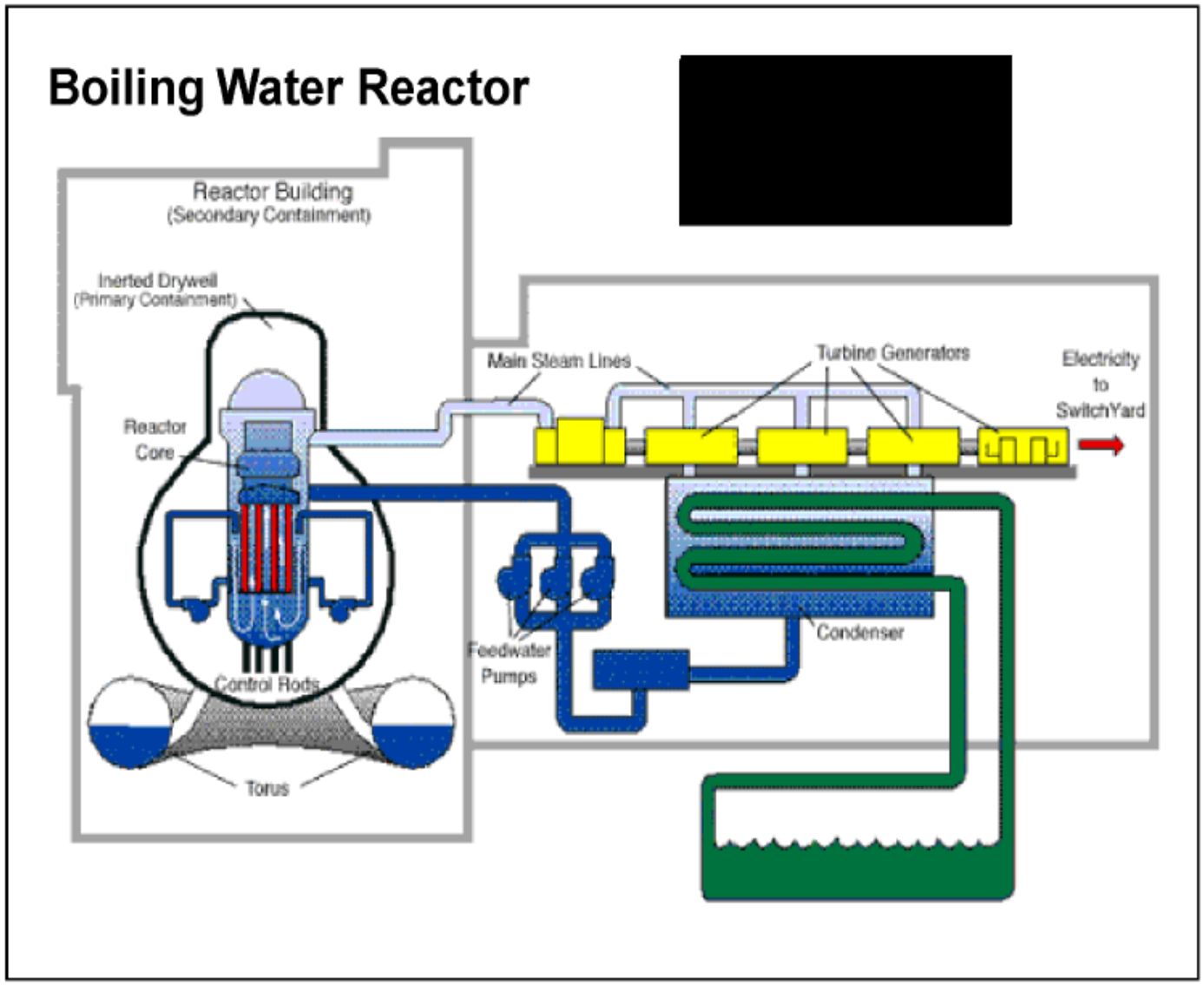
Google Earth KML
(requires Google Earth)

	Location	Date UTC	Magnitude	Lat.	Long.	Reference
1.	Chile	1960 05 22	9.5	-38.29	-73.05	Kanamori, 1977
2.	Prince William Sound, Alaska	1964 03 28	9.2	61.02	-147.65	Kanamori, 1977
3.	Off the West Coast of Northern Sumatra	2004 12 26	9.1	3.30	95.78	Park et al., 2005
4.	Near the East Coast of Honshu, Japan	2011 03 11	9.0	38.322	142.369	PDE
5.	Kamchatka	1952 11 04	9.0	52.76	160.06	Kanamori, 1977
6.	Offshore Maule, Chile	2010 02 27	8.8	-35.846	-72.719	PDE
7.	Off the Coast of Ecuador	1906 01 31	8.8	1.0	-81.5	Kanamori, 1977
8.	Rat Islands, Alaska	1965 02 04	8.7	51.21	178.50	Kanamori, 1977
9.	Northern Sumatra, Indonesia	2005 03 28	8.6	2.08	97.01	PDE
10.	Assam - Tibet	1950 08 15	8.6	28.5	96.5	Kanamori, 1977
11.	Andreanof Islands, Alaska	1957 03 09	8.6	51.56	-175.39	Johnson et al., 1994

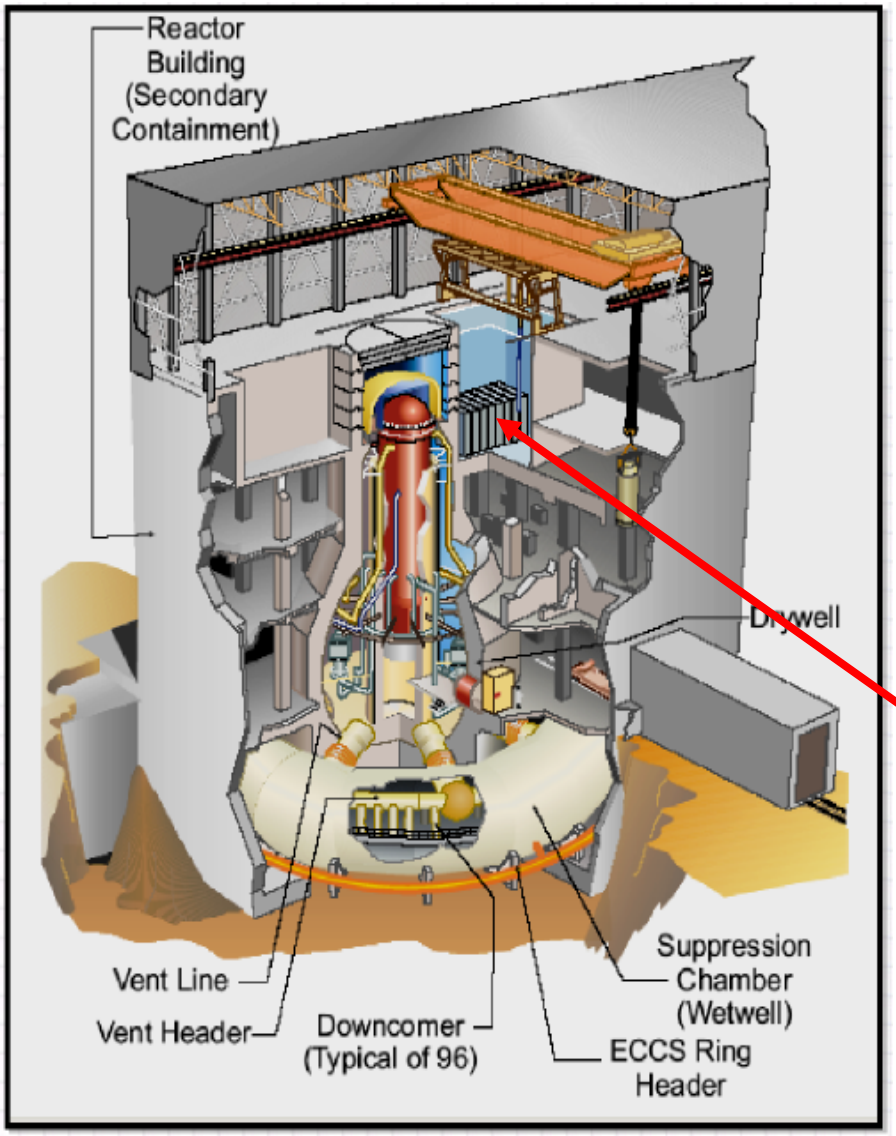
Japanese Nuclear Plants



Daiichi's Nuclear Facilities
GE Hitachi BWRs



Primary Containment Vessel Inside Containment Building



In the event of an explosion, such as from a hydrogen gas blast due to a loss of coolant accident (LOCA), the Containment Building was designed to come apart without significant damage to the much stronger built Primary Containment Vessel (PCV).

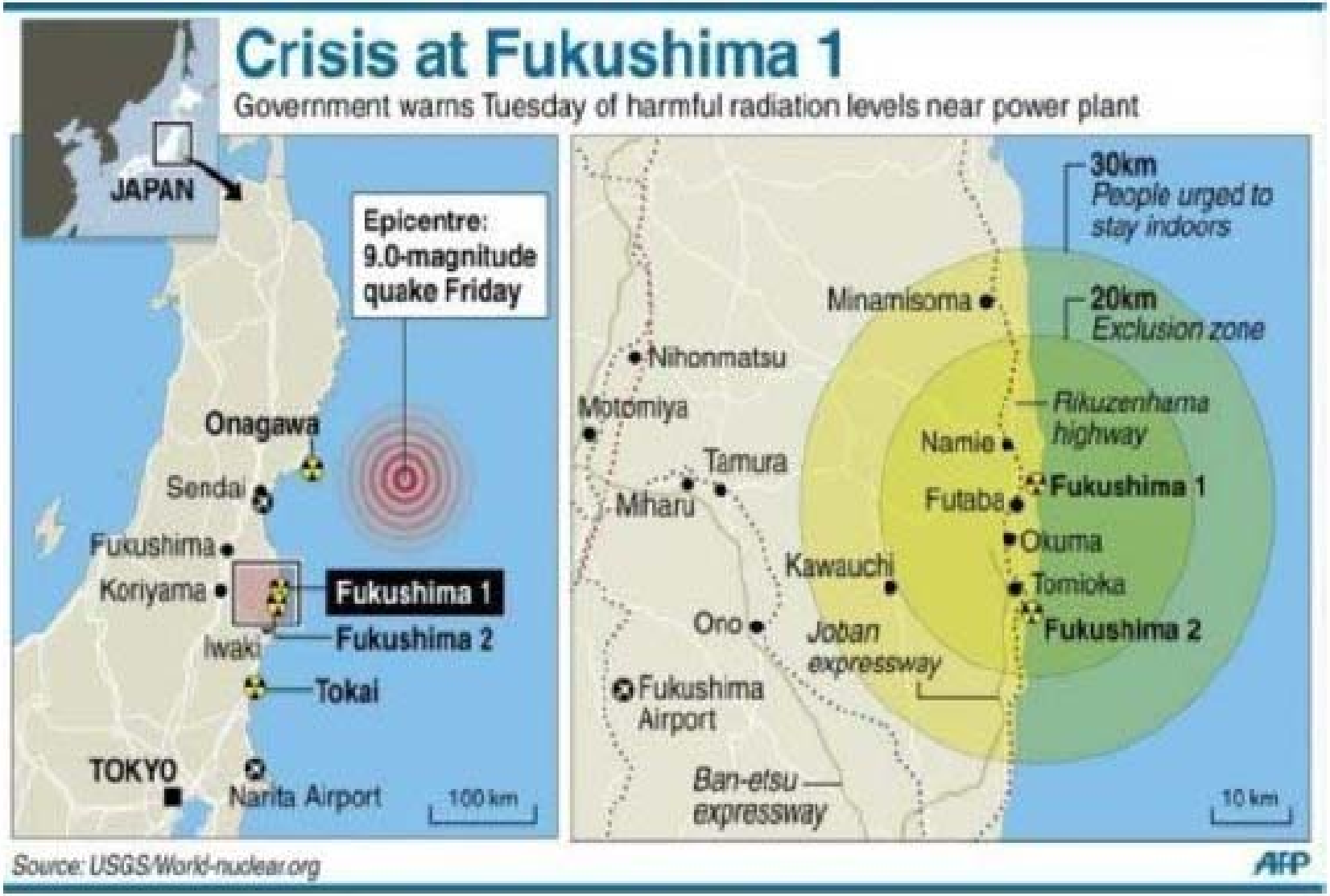
A bad practice for the very old GE BWR IIs at Daiichi (essentially 1960s technology commissioned in the early 1970s) was the 'perching' of the spent fuel pools on top of the PCV.

Fukushima Daiichi
Before the Quake/Tsunami

Fukushima Daiichi
After the Quake/Tsunami

The Site Before Disaster

Daiichi Relation to the Earthquake/Tsunami



Situation Near Plant

body onto truck Ishinomaki Japan 031811

prefectural road in Satte, Saitama Prefecture 031111

IAEA Daiichi Status 4/12/11

1. Current Situation

Overall, the situation at the Fukushima Daiichi plant remains very serious, but there are early signs of recovery in some functions such as electrical power and instrumentation.

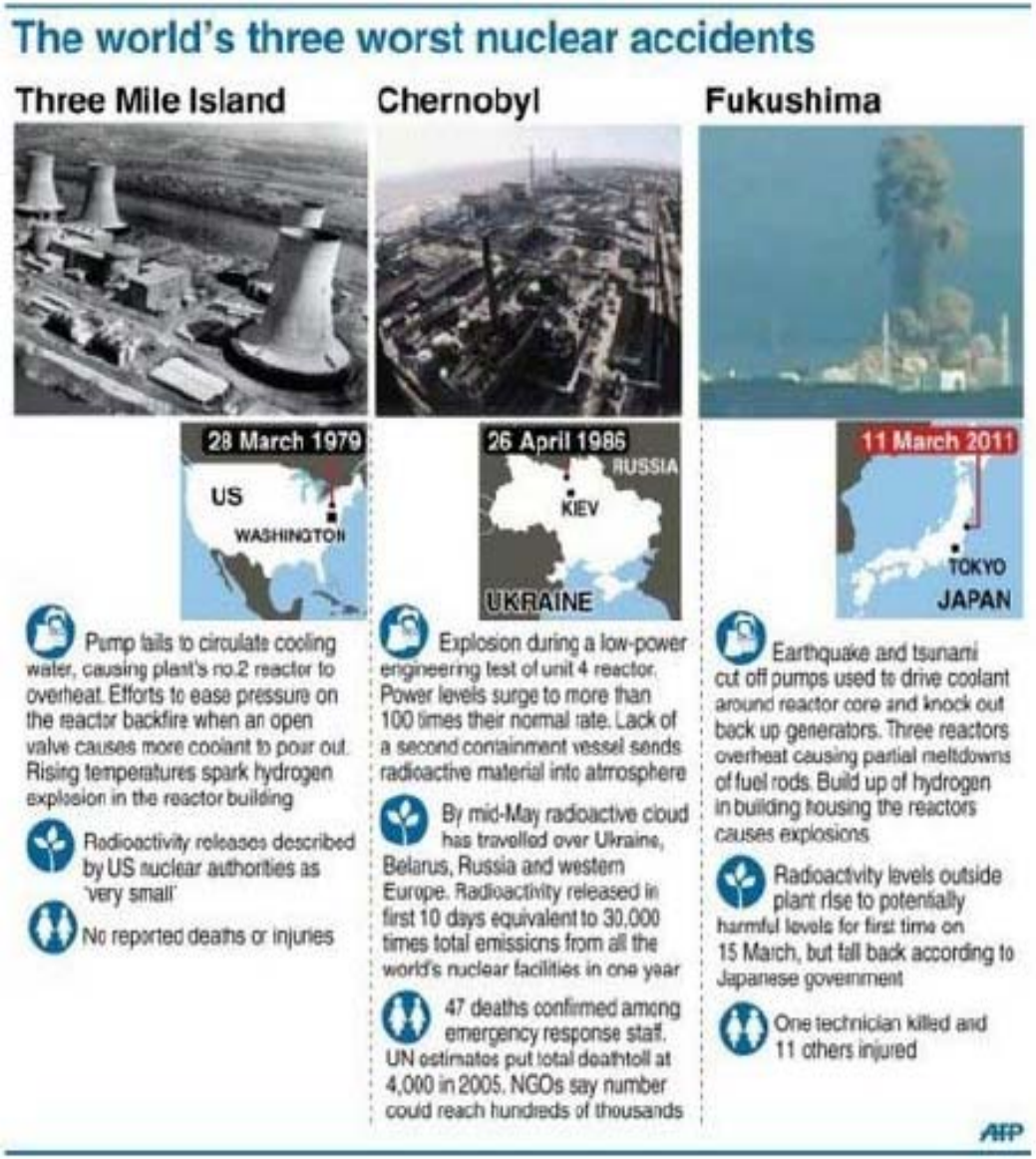
Provisional INES Level 7 Rating

The International Atomic Energy Agency (IAEA) can confirm that the Nuclear and Industrial Safety Agency (NISA) has submitted a provisional International Nuclear and Radiological Event Scale (INES) Level 7 rating for the accident at the Fukushima Daiichi nuclear power plant. This new provisional rating considers the accidents that occurred at **Units 1, 2 and 3** as a single event on INES and uses estimated total release to the atmosphere as a justification. Previously, separate provisional INES Level 5 ratings had been applied for **Units 1, 2 and 3**.

Japanese authorities notified the IAEA in advance of the public announcement and the formal submission of the new provisional rating.

The provisional rating was determined by NISA after it received the results of the analysis conducted by the Japan Nuclear Energy Safety Organization (JNES). NISA then applied the INES assessment methodology to calculate the total estimated release in terms of radiological equivalence to I-131. Based on this provisional assessment, NISA concluded that the accident would be provisionally rated INES Level 7 as per the definition below, taken from the *INES User's Manual, 2008 Edition (http://www-pub.iaea.org/MTCD/publications/PDF/INES-2009_web.pdf)* [pdf]:

Reactor Accidents Comparison



INES Ratings

TMI = 5

Chernobyl = 7

Fukushima = 7

Sequence of Events at Units 1-6 at Daiichi

It's safe, but

they say over and over

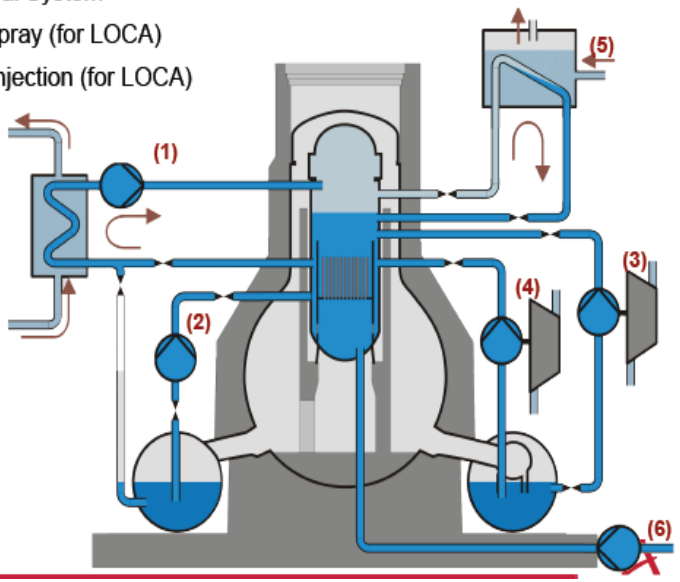
that's worrisome

(Tadashi Nishimura's lament from the Asahi)

Day 1 Earthquake (14:46 JST)

- Emergency Core Cooling Systems

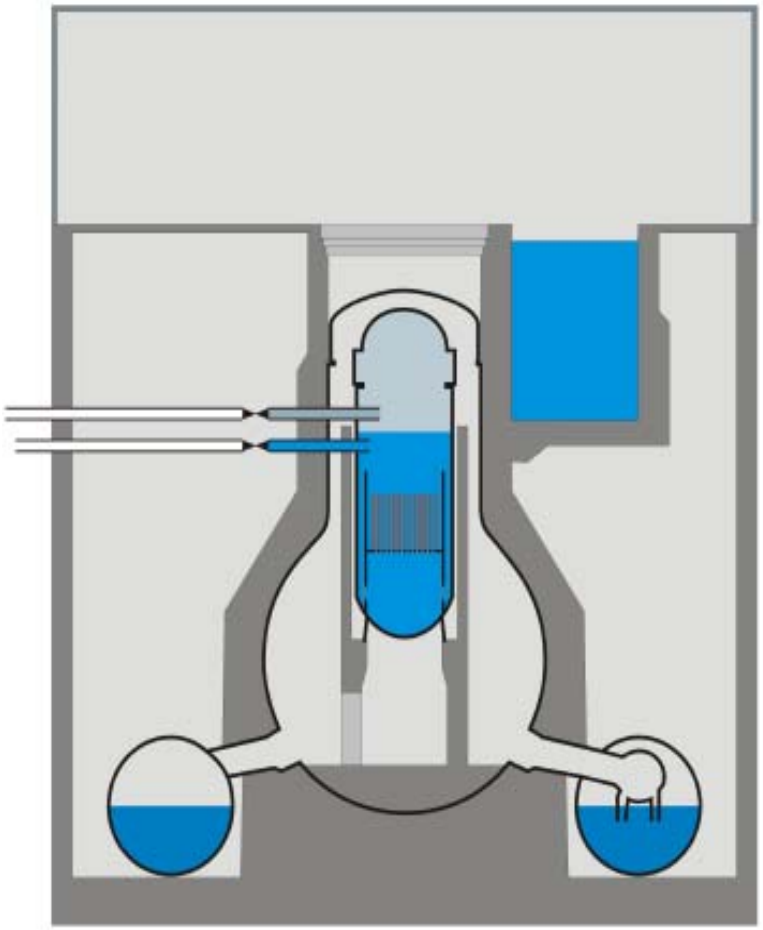
1) Residual Heat Removal System
2) Low-Pressure Core Spray (for LOCA)
3) High-Pressure Core Injection (for LOCA)
4) Reactor Core isolation cooling (Unit 2,3 [BWR4])
5) Isolation Condenser (Unit 1 [BWR3])
6) Borating System



- 11.3.2011 14:46 - Earthquake
  - Magnitude 9
  - Power grid in northern Japan fails
  - Reactors itself are mainly undamaged
- SCRAM
  - Power generation due to Fission of Uranium stops
  - Heat generation due to radioactive Decay of Fission Products
    - After Scram ~6%
    - After 1 Day ~1%
    - After 5 Days ~0.5%

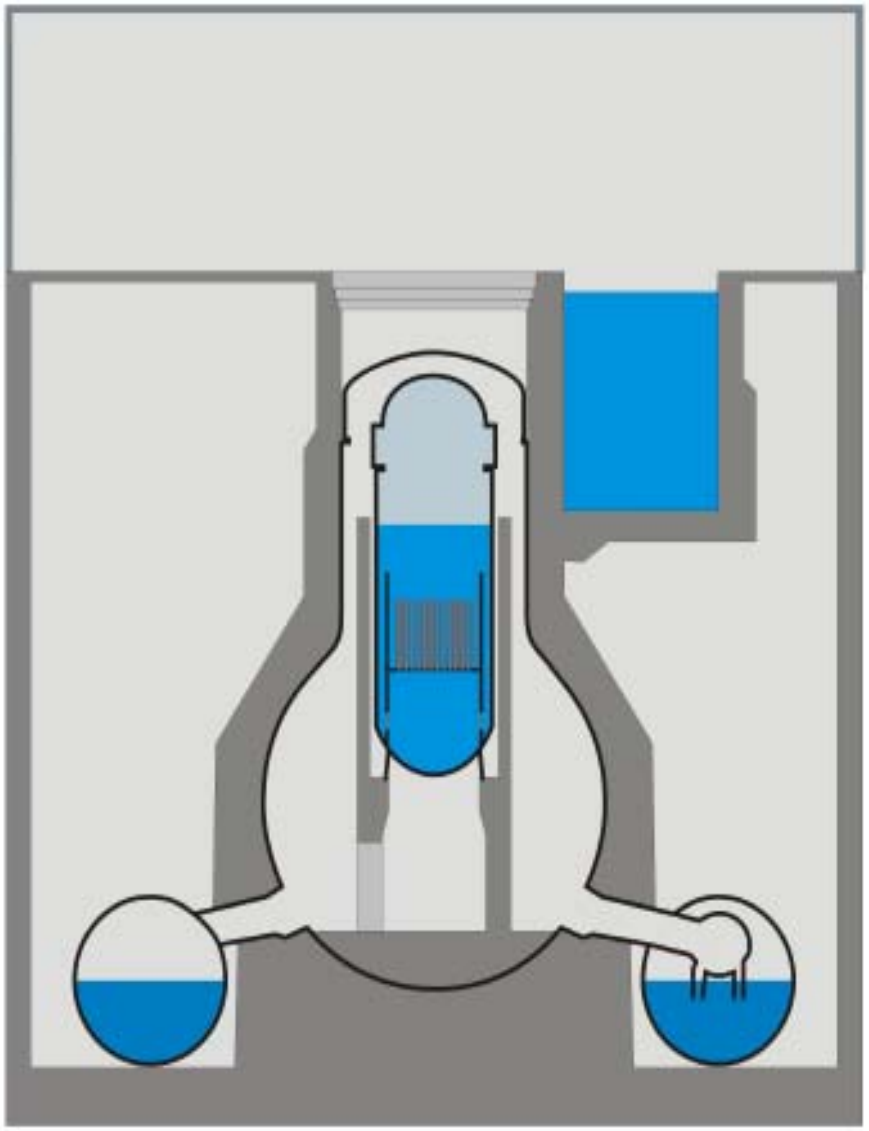
areva_japan_accident_20110324

Day 1 Earthquake (Emergency Diesels Running)



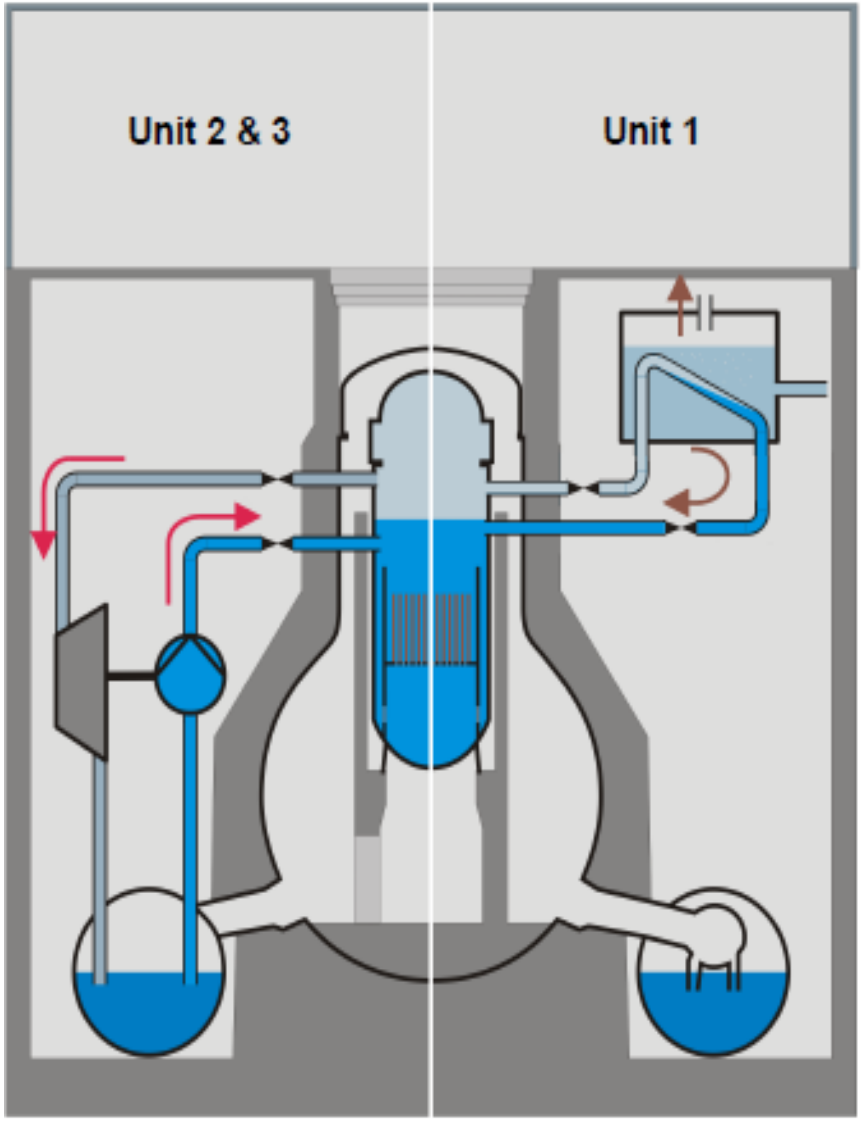
- Containment Isolation
  - Closing of all non-safety related Penetrations of the containment
  - Cuts off Machine hall
  - Due to successful containment isolation, a large early release of fission products is highly unlikely
- Diesel generators start
  - Emergency Core cooling systems are supplied
- Plant is in a stable save state

Day 1 Tsunami (15:01 JST)



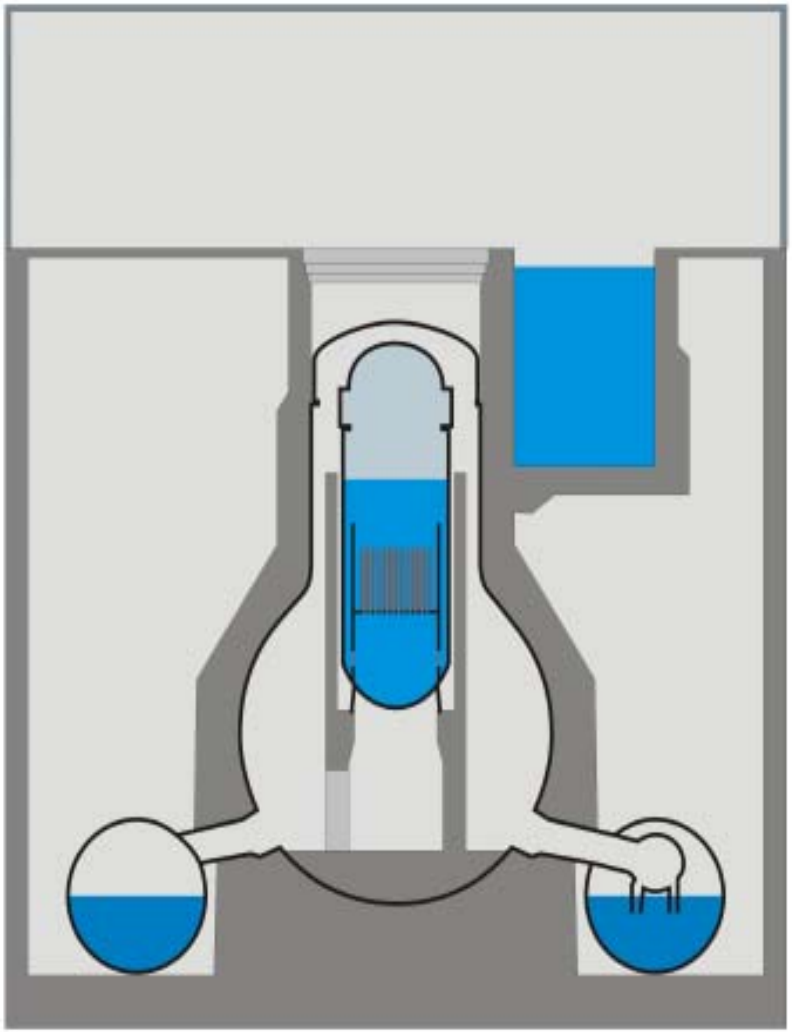
- 11.3. 15:01(?) Tsunami hits plant
  - Plant Design for Tsunami height of up to 5.7-6.5m
  - Actual Tsunami height 7-11m
  - Flooding of
    - Diesel and/or
    - Switchgear building and/or
    - Fuel Tanks and/or
    - Essential service water buildings
- 11.3. 15:41 Station Blackout
  - Common cause failure of the power supply
  - Only Batteries are still available
  - Failure of all but one Emergency core cooling system

Day 1 Tsunami (LOCA Begins)



- Fukushima I -Unit 1
  - Isolation Condenser
    - Steam enters heat exchanger
    - Condensate drains back to RPV
    - Secondary steam released from plant
  - Need Pumps for Water supply
  - Can't replace water in Reactor
- Fukushima I Unit 2 & 3
  - Reactor Core Isolation Pump
    - Steam from Reactor drives Turbine
    - Steam gets condensed in Wet-Well
    - Turbine drives a Pump, pumping Water from the Wet-Well in reactor
  - Necessary:
    - Battery power
    - Wet-Well Temperature < 100°C
  - No heat removal from the buildings

Day 1 LOCA (Heat Crisis Starts)

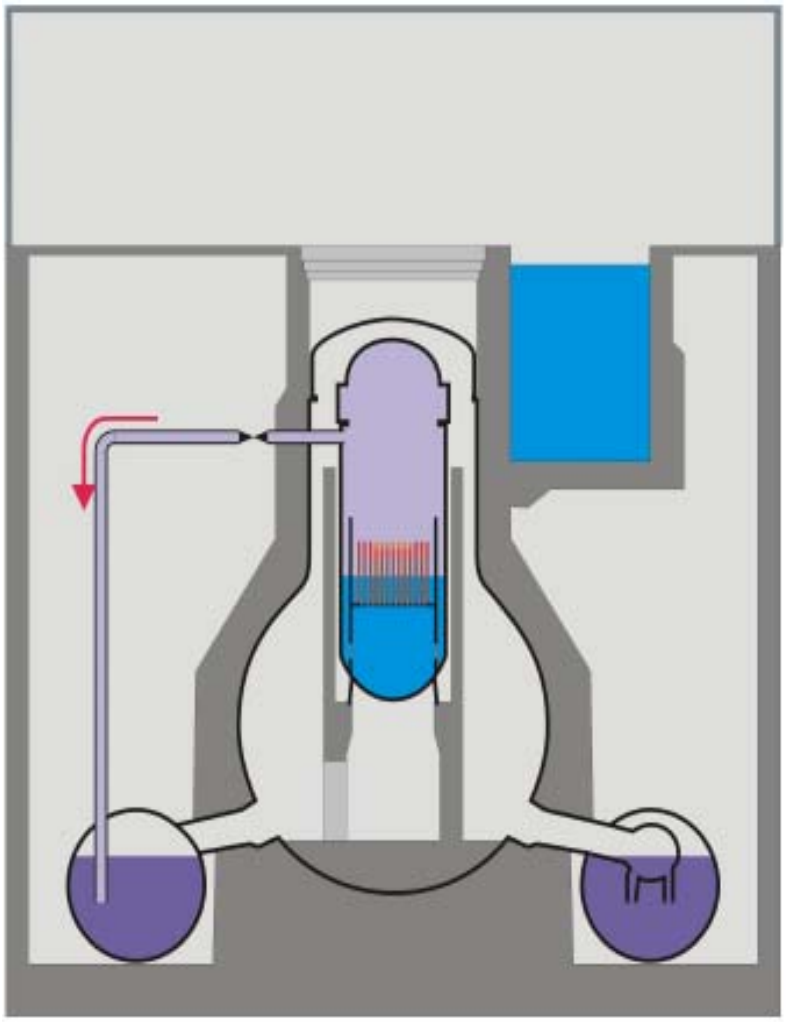


- 11.3. 16:36 in Unit 1
  - Isolation condenser stops
  - Tank empty(?)
- 13.3. 2:44 in Unit 3
  - Reactor Isolation pump stops
  - Batteries empty
- 14.3. 13:25 in Unit 2
  - Reactor Isolation pump stops
  - Pump failure
- Consecutively, all reactors are cut of from any kind of heat removal

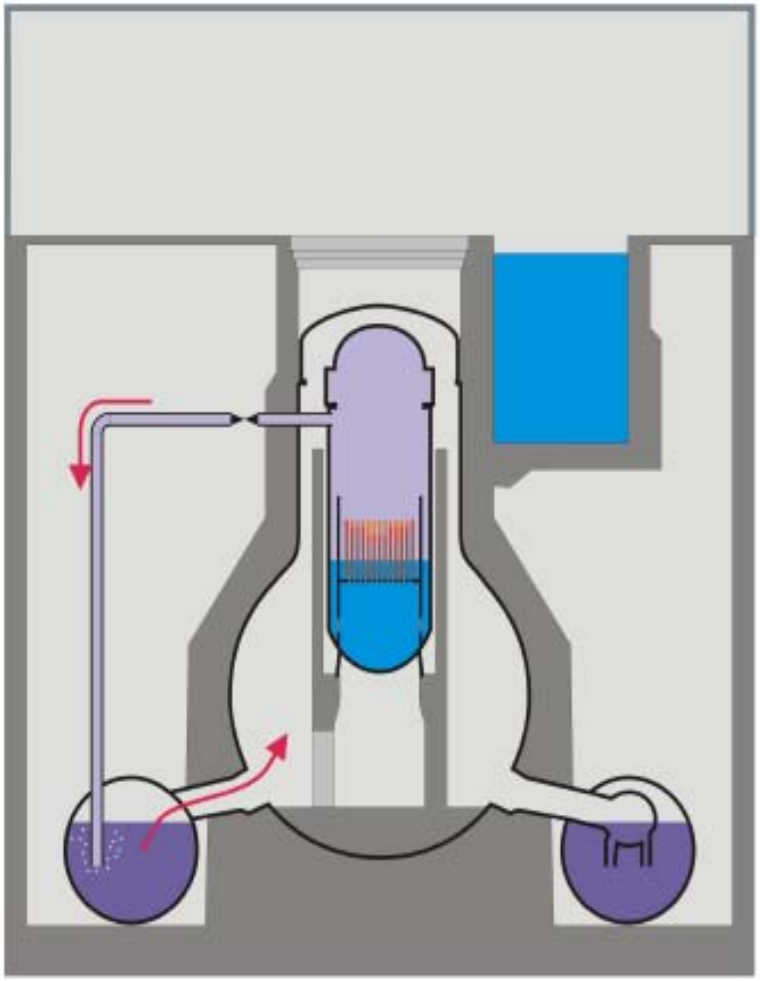
Day 1 LOCA (Steam Buildup Drives Down Water Levels)

- ~50% of the core exposed
  - Cladding temperatures rise, but still no significant core damage
- ~2/3 of the core exposed
  - Cladding temperature exceeds ~900°C
  - Balooning / Breaking of the cladding
  - Release of fission products from the fuel rod gaps

(Measured levels are collapsed level. The actual liquid level lies higher due to the steam bubbles in the liquid)

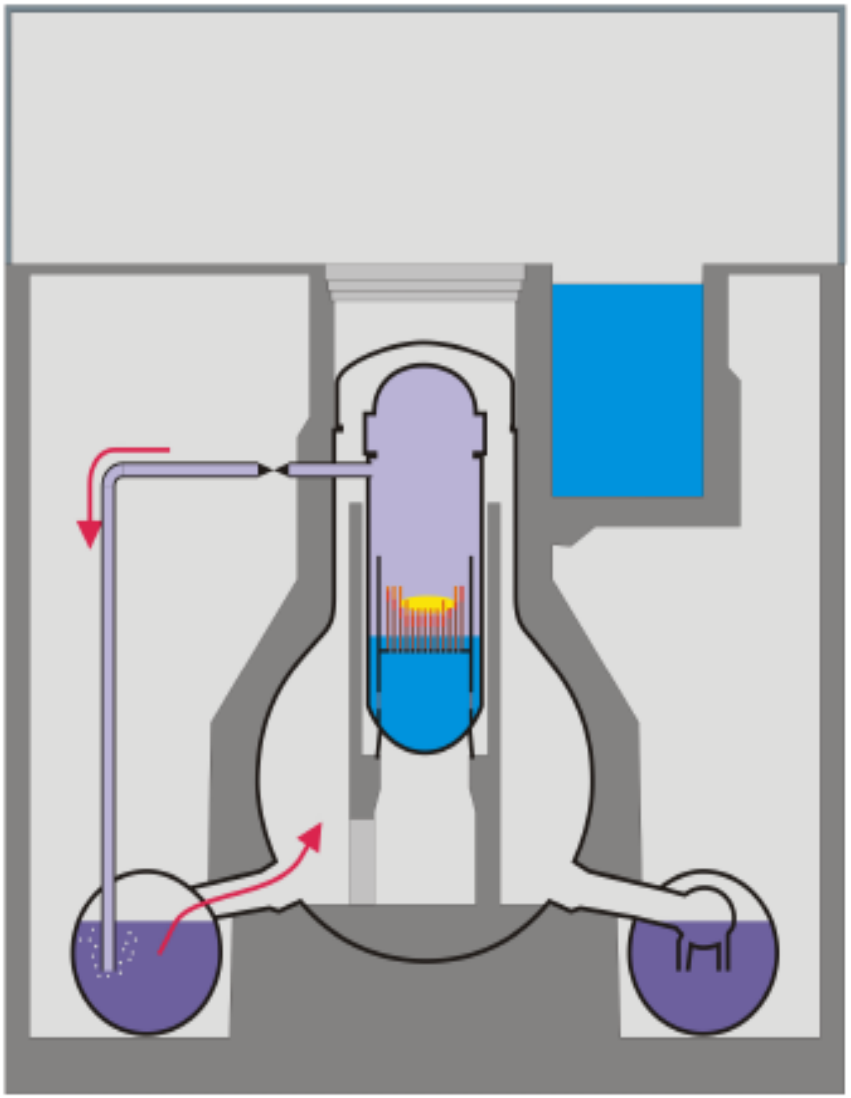


Day 1 LOCA (Zircalloy Burns)



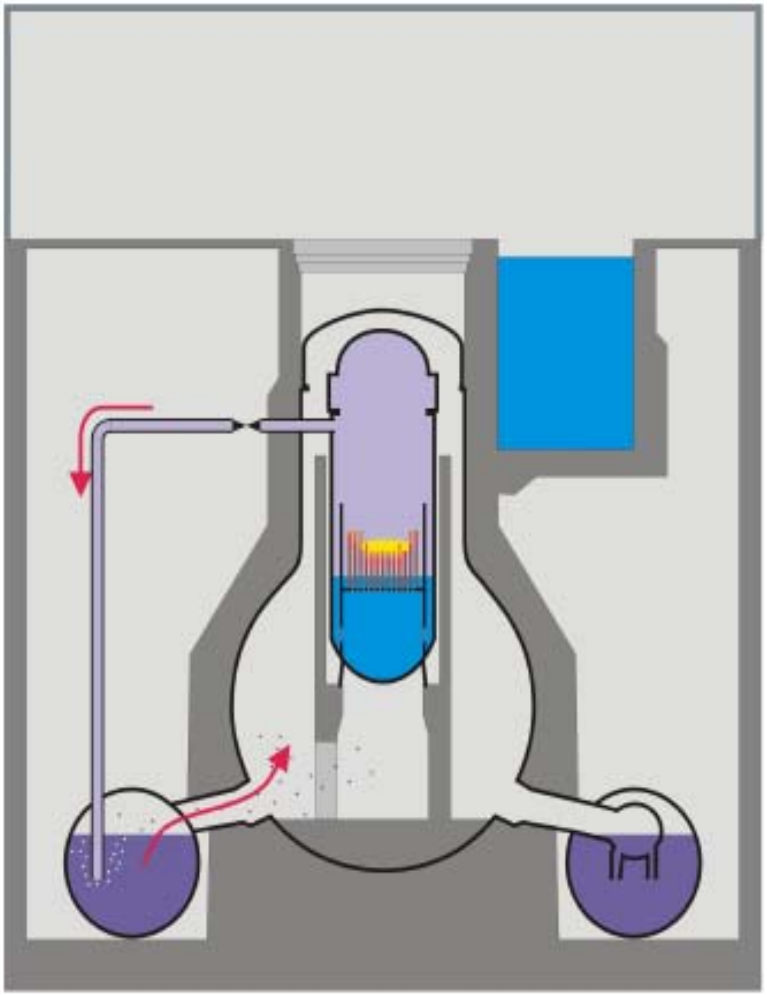
- ~3/4 of the core exposed
  - Cladding exceeds ~1200°C
  - Zirconium in the cladding starts to burn under steam atmosphere
  - $Zr + 2H_20 \rightarrow ZrO_2 + 2H_2$
  - Exothermal reaction further heats the core
  - Estimated masses hydrogen
    - Unit 1: 300-600kg
    - Unit 2/3: 300-1000kg
  - Hydrogen gets pushed via the wet-well and the wet-well vacuum breakers into the dry-well

Day 1 LOCA (Fuel Rods Rubblized)



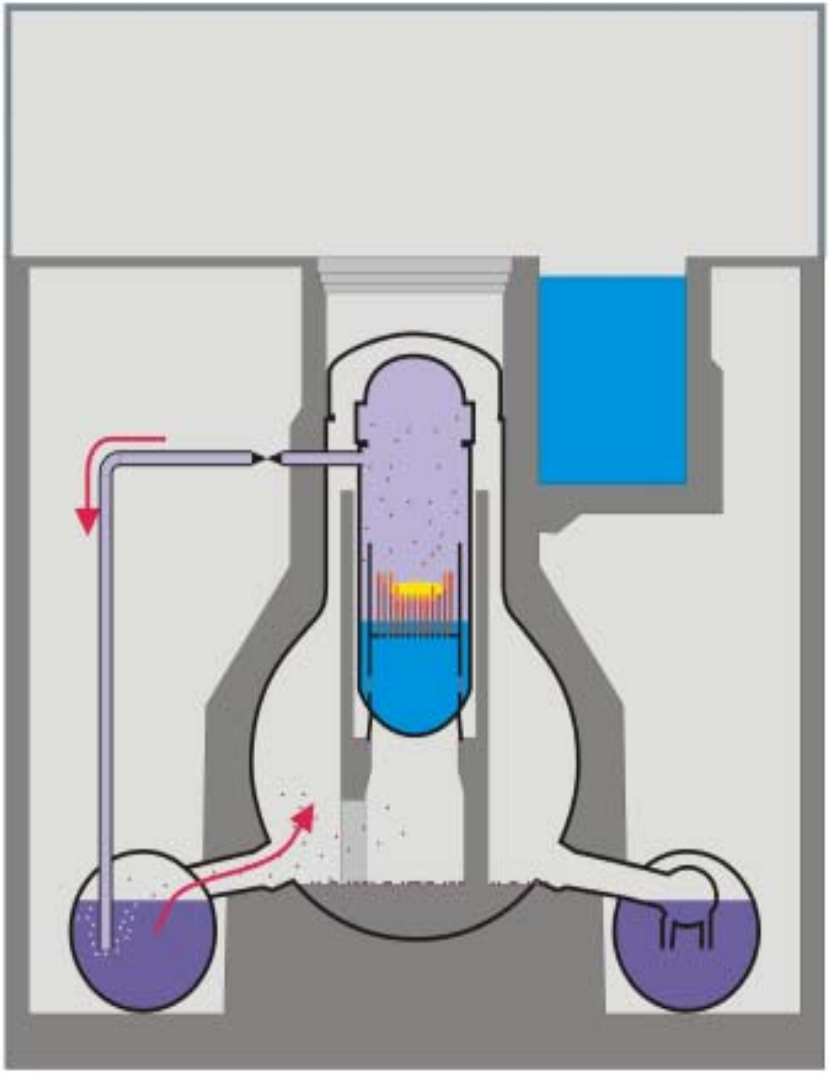
- at ~1800°C [expected Unit 1,2,3]
  - Melting of the Cladding
  - Melting of the steel structures
- at ~2500°C [expected Unit 1,2]
  - Breaking of the fuel rods
  - debris bed inside the core
- at ~2700°C [maybe Unit 1]
  - Significant melting of Uranium-Zirconium-oxides
- Restoration of the water supply stops accident in all 3 Units
  - Unit 1: 12.3. 20:20 (27h w.o. water)
  - Unit 2: 14.3. 20:33 (7h w.o. water)
  - Unit 3: 13.3. 9:38 (7h w.o. water)

Day 1 LOCA (Releases Escalate)



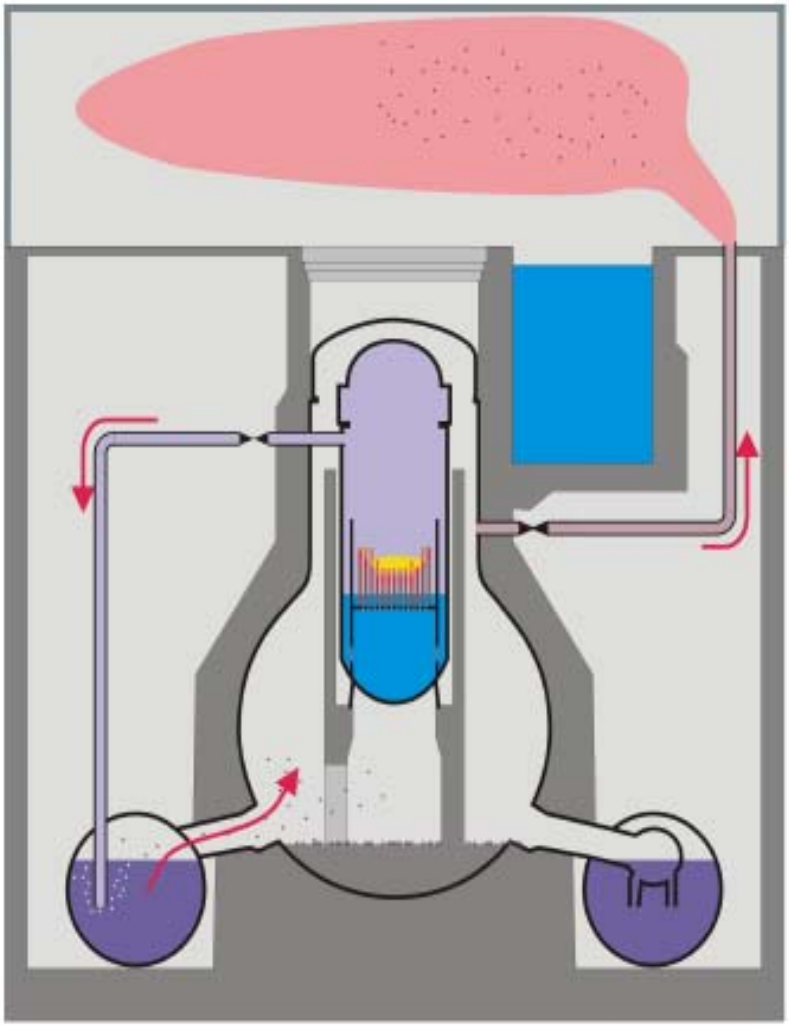
- Release of fission products during melt down
  - Xenon, Cesium, Iodine,…
  - Uranium/Plutonium remain in core
  - Fission products condensate to airborne Aerosols
- Discharge through valves into water of the condensation chamber
  - Pool scrubbing binds a fraction of Aerosols in the water
- Xenon and remaining aerosols enter the Dry-Well
  - Deposition of aerosols on surfaces further decontaminates air

Days 2-3 LOCA (Venting of Containment Buildings)



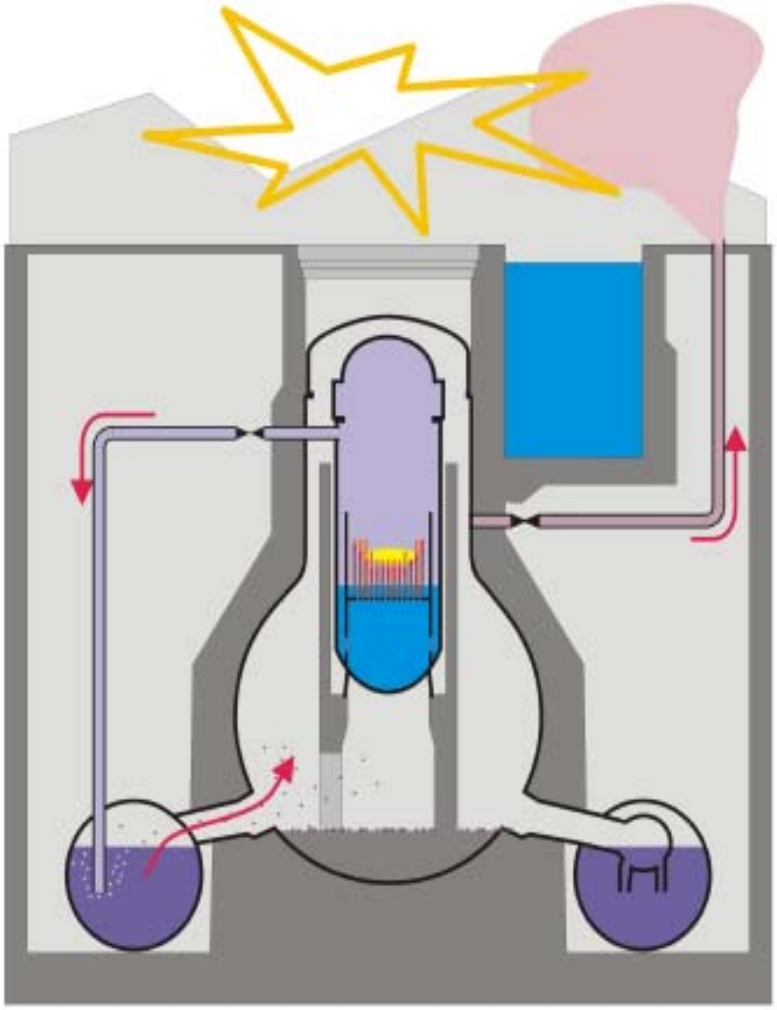
- Containment
  - Last barrier between Fission Products and Environment
  - Wall thickness ~3cm
  - Design Pressure 4-5bar
- Actual pressure up to 8 bars
  - Normal inert gas filling (Nitrogen)
  - Hydrogen from core oxidation
  - Boiling condensation chamber (like a pressure cooker)
- First depressurization of the containment
  - Unit 1: 12.3. 4:00
  - Unit 2: 13.3 00:00
  - Unit 3: 13.3. 8.41

Days 2-3 LOCA (Hydrogen Buildup Escalates)



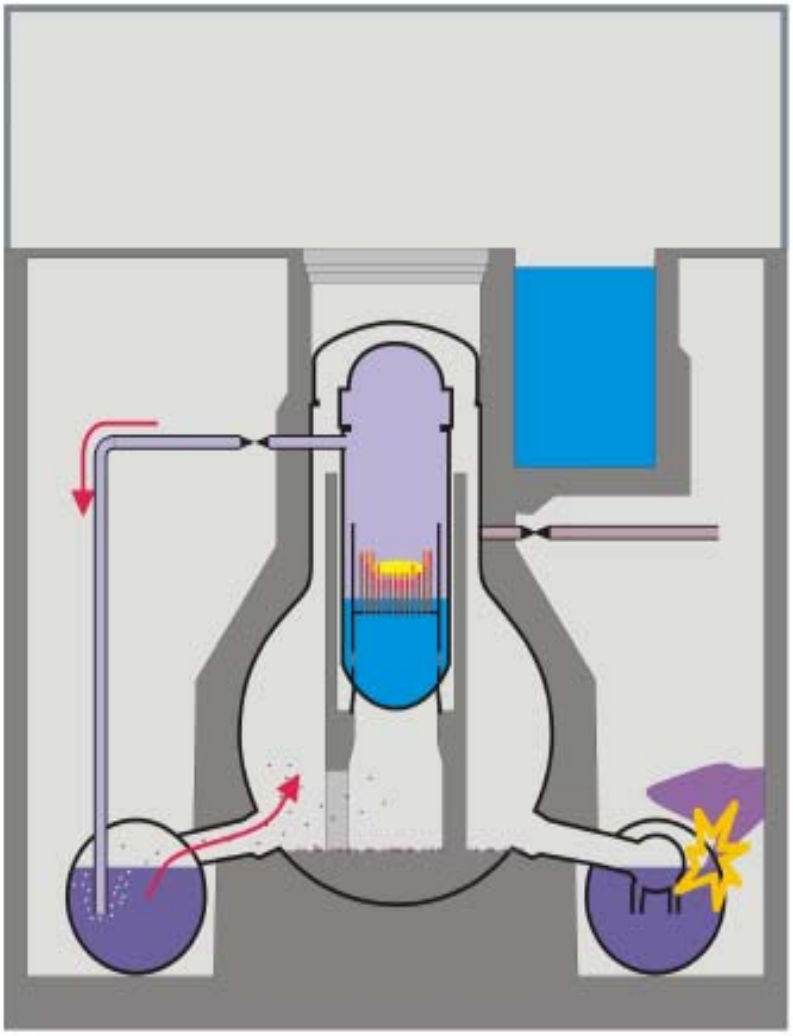
- Positive und negative Aspects of depressurizing the containment
  - Removes Energy from the Reactor building (only way left)
  - Reducing the pressure to ~4 bar
  - Release of small amounts of Aerosols (Iodine, Cesium…)
  - Release of all noble gases
  - Release of Hydrogen
- Release of unfiltered venting?
- Gas is released into the reactor service floor
  - Hydrogen is flammable

Days 2-3 LOCA (Units 1 and 3 Hydrogen Explosions)



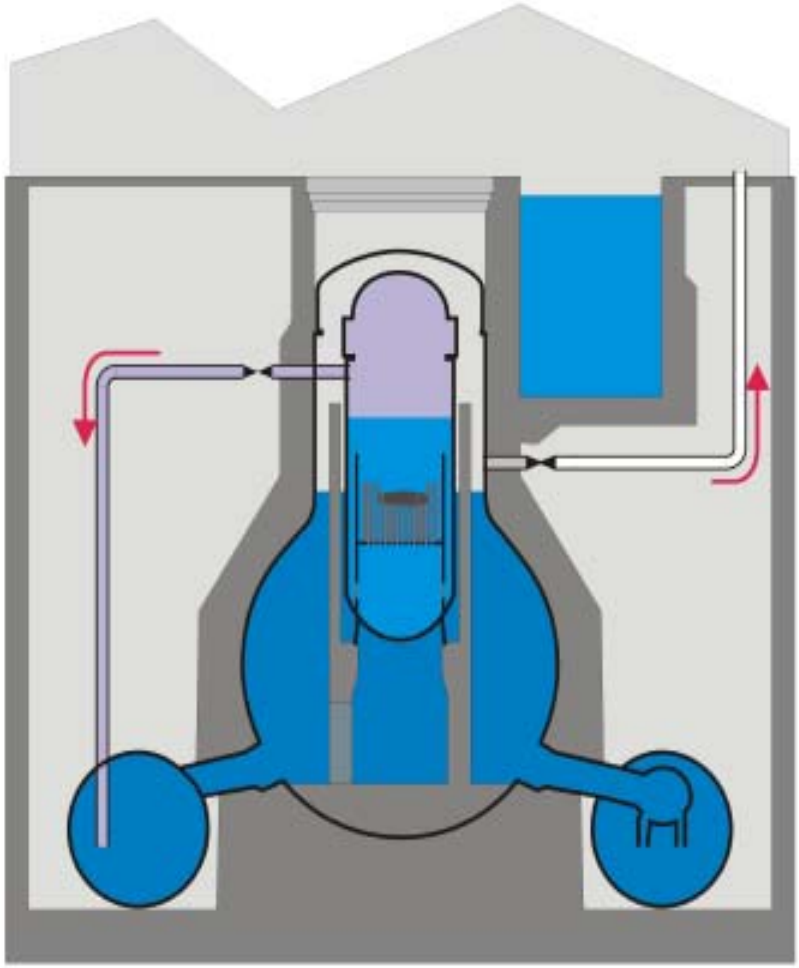
- Unit 1 and 3
  - Hydrogen burn inside the reactor service floor
  - Destruction of the steel-frame roof
  - Reinforced concrete reactor building seems undamaged
  - Spectacular but minor safety relevant

Days 3+ LOCA (Unit 2 “Muffled” Explosion)



- Unit 2
  - Probably Hydrogen leakage of the condensation chamber (actual pressure exceeds design pressure)
  - Burn inside the reactor building in proximity to the wet-well
  - Damage to the condensation chamber
  - Uncontrolled release of
    - Gas
    - highly contaminated water
    - Aerosols of fission products
  - Temporal evacuation of the plant
  - High local dose rates on the plant site due to wreckage hinder further recovery work

Reactors Status 3/31/11



- Current status of the Reactors
  - Core Damage in Unit 1,2, 3
  - Building damage due to various burns Unit 1-4
  - Reactor pressure vessels flooded in all Units with mobile pumps
  - At least containment in Unit 1 flooded
- Further cooling of the Reactors
  - Unit 1: by Isolation Condensers
  - Unit 2&3: by releasing steam
- Only small further releases of fission products can be expected from Unit 2 and 3

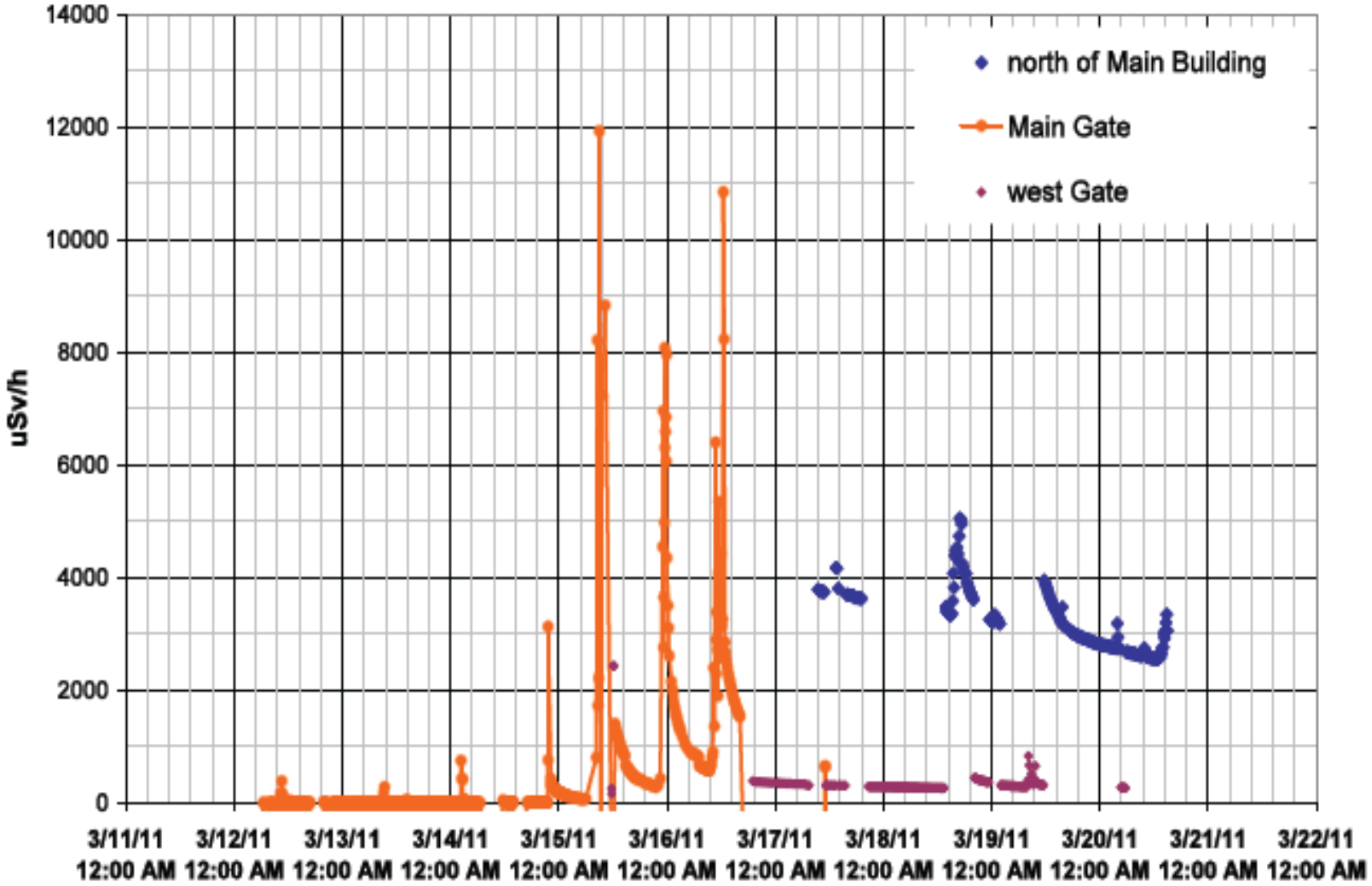
Radiological Levels
Dr. Braun's Assessment

- Its not Chernobyl-like
- Directly on the plant site
  - Before Explosion in Unit 2
    - Below 2mSv / h
    - Mainly due to released radioactive noble gases
    - Measuring posts on west side. Maybe too small values measured due to wind
  - After Explosion in Unit 2 (Damage of the Containment)
    - Temporal peak values 12mSv / h (Origins not entirely clear)
    - Local peak values on site up to 400mSv /h (wreckage / Wet-Well inventory)
    - Currently stable dose on site at 5mSv /h
    - Inside the buildings a lot more
  - Limiting time of exposure of the workers necessary

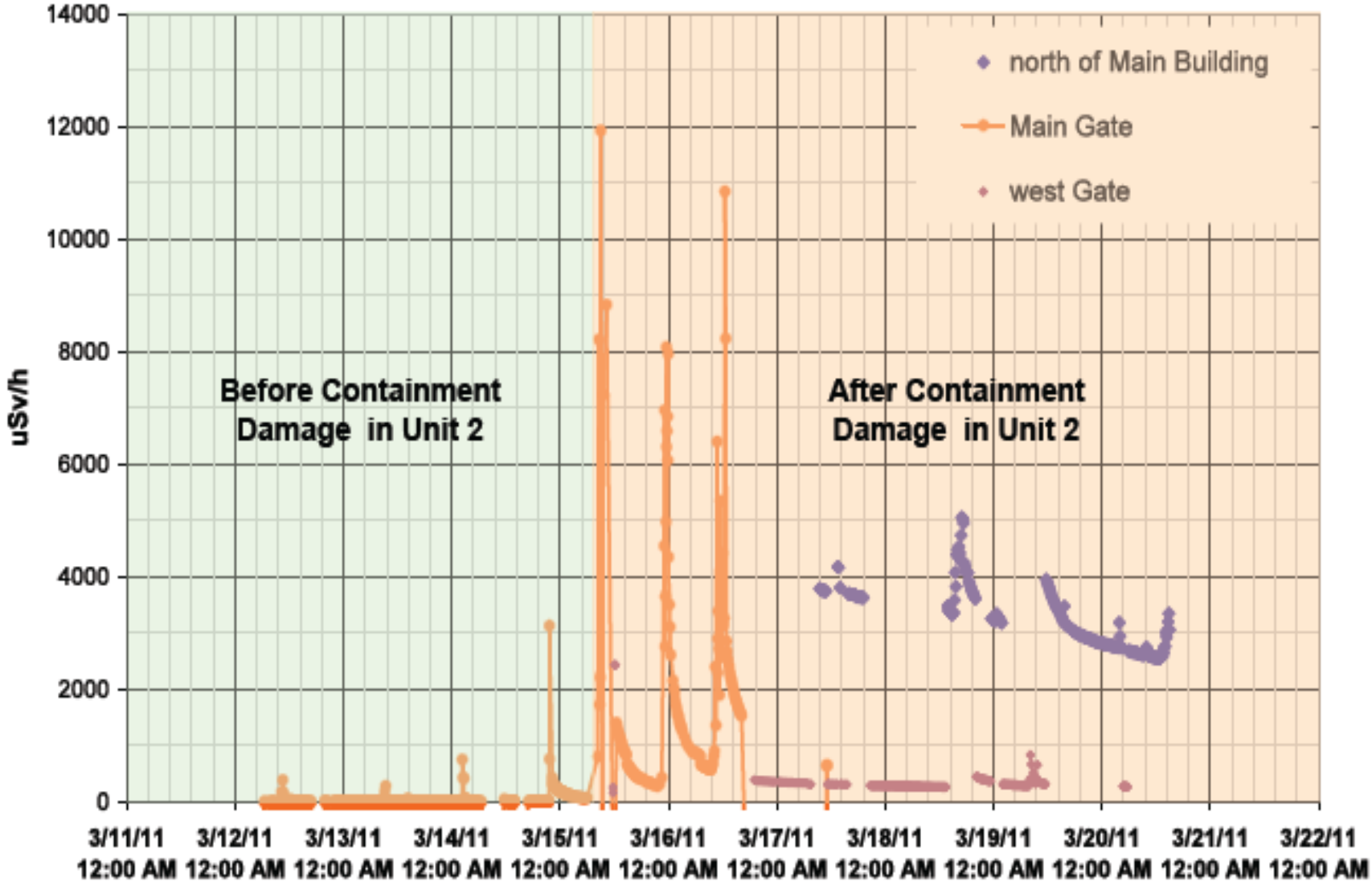
Reactors Status 4/13/11

- Dr. Braun's assessment of the Units 1-3 Reactors still applies
- Still difficulties keeping the remaining fuel under water
- The spent fuel pools eventually went through the same process at Units 1-4 ("going dry") but a much higher yield of radionuclides to the environmental
- TEPCO: "Very gradual improvement"
- Units 5 and 6 appear to be in steady cool down but they have had periodic temperature/pressure increases prior to off-site power being restored
- Status: Safe cool down has not been achieved to date – dispersal of radionuclides to the environment by air and water continues
- **Decay Time is our friend!**

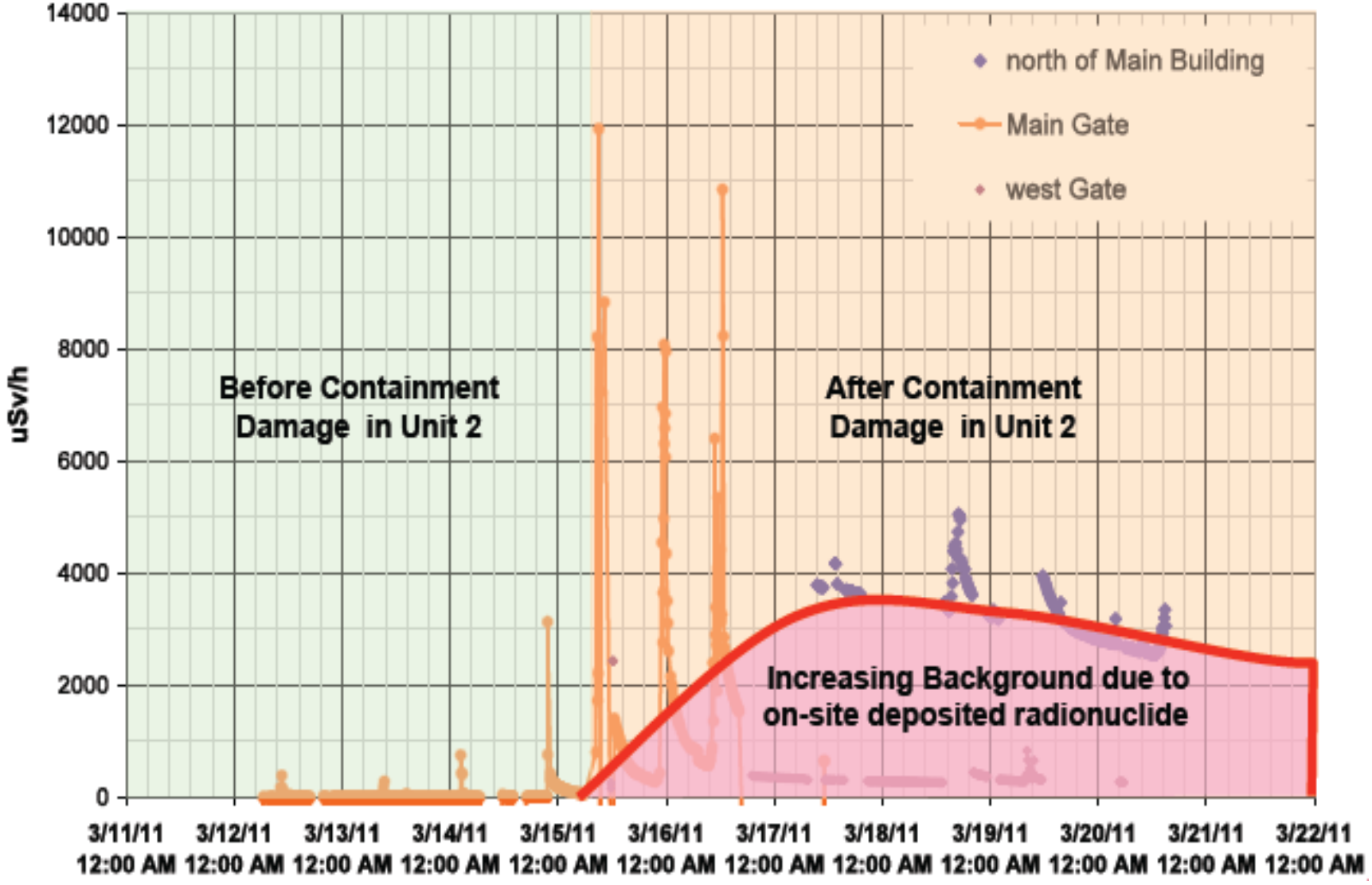
Radiological Releases Daiichi Site 3/11-22/11 3 Locations



Radiological Releases Daiichi Site 3/11-22/11 Unit 2



Radiological Releases Daiichi Site 3/11-22/11 Contaminated Debris



Fukushima Plant 1 032011 Units 1 thru 3 steam

Fukushima Plant 1 032011 Units 1 thru 4

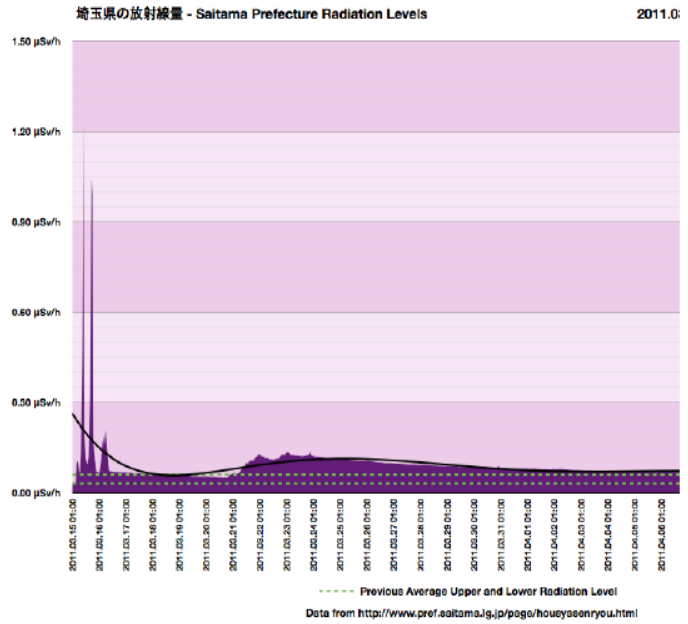
Earthquake Damage in Concrete

Fukushima Plant 1 032411 Unit 3 Fire Engines

Radiation Levels for Tokyo, Chiba, Saitama, Ibaraki

Tokyo Weather - □□□□□

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
□□□	□□□	□□□	□□□	□□□	□□□	□□□
2011.03.13	2011.03.14	2011.03.15	2011.03.16	2011.03.17	2011.03.18	2011.03.19
2011.03.20	2011.03.21	2011.03.22	2011.03.23	2011.03.24	2011.03.25	2011.03.26
2011.03.27	2011.03.28	2011.03.29	2011.03.30	2011.03.31	2011.04.01	2011.04.02



Fukushima Plant 1 032411 Debris

US EPA RadNet
The “Plume”

CORRECTION: UPDATED
Please note the addition of "hundreds of thousands" in the second and sixth paragraphs Radiation Monitors Continue to Confirm That No Radiation Levels of Concern Have Reached the United States

Release date: 03/22/2011
Contact Information: EPA Press Office press@epa.gov

WASHINGTON — During a detailed analysis of four west coast RadNet air monitor filters, the U.S. Environmental Protection Agency (EPA) identified trace amounts of radioactive iodine, cesium, and tellurium consistent with the Japanese nuclear incident. These levels are consistent with the levels found by a Department of Energy monitor last week and are to be expected in the coming days.

EPA's samples were captured by three monitors in California and one in Washington State on Friday, March 18 and sent to EPA scientists for detailed laboratory analysis. The data was reviewed over the weekend and the analysis was completed Monday night. The radiation levels detected on the filters from California and Washington monitors are hundreds of thousands to millions of times below levels of concern.

All units are in Picocuries per meter cubed.

- Filter results for Anaheim, Calif. found:
  - Cesium-137: 0.0017
  - Tellurium-132: 0.012
  - Iodine-132: 0.0095
  - Iodine-131: 0.046
- Filter results for Riverside, Calif. found:
  - Cesium-137: 0.00024
  - Tellurium-132: 0.0014
  - Iodine-132: 0.0015
  - Iodine-131: 0.011
- Filter results for Seattle, Wash. found:
  - Cesium-137: 0.00045
  - Tellurium-132: 0.0034
  - Iodine-132: 0.0029
  - Iodine-131: 0.013
- Filter results for San Francisco, Calif. found:
  - Cesium-137: 0.0013
  - Tellurium-132: 0.0075
  - Iodine-132: 0.0066
  - Iodine-131: 0.068

US EPA RadNet
March

March 30

- **As of 4:30pm (EDT)**
  EPA's RadNet radiation air monitors across the U.S. show typical fluctuations in background radiation levels. The levels detected are far below levels of concern.
- **As of 8:30am (EDT)**
  EPA's RadNet radiation air monitors across the U.S. show typical fluctuations in background radiation levels. The levels detected are far below levels of concern.
- **JOINT EPA/FDA STATEMENT: Update on Ongoing Monitoring**

  Release date: 03/30/2011
  Contact Information: EPA Press Office, press@epa.gov / FDA Press Office, fdaopa@fda.hhs.gov

  WASHINGTON — In response to the ongoing situation in Japan, the U.S. Environmental Protection Agency (EPA) has taken steps to increase the level of nationwide monitoring of milk, precipitation, drinking water, and other potential exposure routes.

  EPA conducts radiological monitoring of milk under its RADNET program, while the U.S. Food and Drug Administration has jurisdiction over the safety, labeling and identity of milk and milk products in interstate commerce. States have jurisdiction over those facilities located within their territory.

  Results from a screening sample taken March 25 from Spokane, Wash. detected 0.8 pCi/L of iodine-131, which is more than 5,000 times lower than the Derived Intervention Level set by the U.S. Food and Drug Administration. These types of findings are to be expected in the coming days and are far below levels of public health concern, including for infants and children. Iodine-131 has a very short half-life of approximately eight days, and the level detected in milk and milk products is therefore expected to drop relatively quickly.

  "Radiation is all around us in our daily lives, and these findings are a minuscule amount compared to what people experience every day. For example, a person would be exposed to low levels of radiation on a round trip cross country flight, watching television, and even from construction materials," said Patricia Hansen, an FDA senior scientist.

  EPA's recommendation to state and local governments is to continue to coordinate closely with EPA, FDA and CDC. EPA will continue to communicate our nationwide sampling results as they come in.

  EPA: http://www.epa.gov/japan2011

  FDA: http://www.fda.gov/NewsEvents/PublicHealthFocus/ucm247403.htm

US EPA RadNet
April

EPA United States Environmental Protection Agency

Japanese Nuclear Emergency: Radiation Monitoring

April Daily Data Summaries

Last updated on Tuesday, April 12, 2011 at 11:14:36 AM.

April 10 | April 9 | April 8 | April 7 | April 6 | April 5 | April 4 | April 3 | April 2 | April 1

Return to Main Daily Data Summary | View Daily Data Summaries for March

April 10

- **As of 8:00am (EDT)** EPA's RadNet radiation air monitors across the U.S. show typical fluctuations in background radiation levels. The levels detected are far below levels of concern.

  Today, EPA also released new data for milk, drinking water, precipitation and laboratory air analyses. Results have detected low levels of radioactive material consistent with estimated releases from the damaged nuclear reactors. These detections were expected and the levels detected are far below levels of public-health concern.

April 9

- **As of 8:00am (EDT)** EPA's RadNet radiation air monitors across the U.S. show typical fluctuations in background radiation levels. The levels detected are far below levels of concern.

  Today, EPA also released new data for milk, drinking water and laboratory air analyses. Results have detected low levels of radioactive material consistent with estimated releases from the damaged nuclear reactors. These detections were expected and the levels detected are far below levels of public-health concern.

  To view the most recent sampling and monitoring data, go to http://www.epa.gov/japan2011/rert/radnet-sampling-data.html.

Public Health Consequences

- **????**
- Way to early to call since we haven't:
  - Consolidated releases data for dose assessment
  - Validated the early measurements made
  - Determined the adequacy of the worker's dosimetry
  - Impact upon local Fukushima Prefecture foodstuffs
  - Impact on Japanese fishing industry in the home waters
  - Possible impact of recovery set-backs due to more large earthquakes at Fukushima Daiichi

Time Adjustments

UTC

Coordinated Universal Time

In the United States, Canada or Mexico, to convert to your local time, find your time zone and subtract the number of hours listed.

	Standard Time	Daylight Time
Newfoundland	UTC - 3½ hours	UTC - 2½ hours
Atlantic	UTC - 4 hours	UTC - 3 hours
Eastern	UTC - 5 hours	UTC - 4 hours
Central	UTC - 6 hours	UTC - 5 hours
Mountain	UTC - 7 hours	UTC - 6 hours
Pacific	UTC - 8 hours	UTC - 7 hours
Alaska	UTC - 9 hours	UTC - 8 hours
Hawaii	UTC - 10 hours	
Aleutian	UTC - 10 hours	UTC - 9 hours

March 29, 2011 | By Kenji Hall and Julie Makinen, Los Angeles Times

They sleep with just one blanket apiece anywhere there's space — in a conference room, in the hallway, near the bathroom. Because deliveries of supplies are limited, they get by on very little food: Breakfast is packages of high-calorie emergency crackers and a small carton of vegetable juice; dinner consists of a small bag of "magic rice" (just add bottled water) and a can of chicken, mackerel or curry. There is no lunch — handing out a noontime meal would be too complicated in the crowded two-story building.

USS RONALD REAGAN CVN-76

The Ronald Reagan aircraft carrier was redirected to help devastated Japan after earthquake and tsunami hit. (Los Angeles Times / March 12, 2011)

KTLA News

1:31 p.m. PDT, March 14, 2011

SAN DIEGO (KTLA) -- The aircraft carrier USS Ronald Reagan has repositioned itself away away from the Fukushima nuclear plant to avoid reactor fall-out.

Commanding officer, Capt. Thom Burke, wrote on the ship's Facebook page that very low levels of radioactivity were found on 17 sailors, all of whom were treated.

LTJG James Powell, MSC, USN has been the most intimately involved Radiation Health Officer (RHO) in the Fukushima Daiichi event since the very beginning aboard USS RONALD REAGAN (CVN-76). The video of the entire flight deck foamed for decontamination is worth seeing. The ship sailed to the East coast of Honshu Island to assist the Daiichi NPGS, but that was directly in the path of the wind driven airborne radioactivity at the time.

USS RONALD REAGAN
Decontamination

US Military Humanitarian Relief Action

An isolated Japanese hospital thank you photo from US helicopter delivering medical supplies from USS MUSTIN (LT Mannis, MSC, USN RHO, 3/23/11).

US Navy Radiation Health Officers at Atsugi

7 RHOs were held up in Atsugi awaiting assignment aboard conventional ships. They were transported aboard USS RONALD REAGAN today (3/18/11) via C-2 Greyhound. It appears that 5 of the 7 have been moved to destroyers.

Q & A

We earnestly make
donations
but the bank says
don't use our system

(Kunio Kataoka re Japanese ATM network failures post disaster)

"Daddy I'm fine"
time stopping and
restarting
email from Tokyo

(Raj Bose in Honolulu upon hearing from son in Japan)

Momoko Onodera evacuation ctr prays husband dead in tsunami 031811

San Francisco Bay Area Chapter of the American Association of Physicists in Medicine

HPS Health Physics Society
Specialists in Radiation Safety • Founded 1956 • http://hps.org

References 1

Drone aircraft photos: In these March 24, 2011 aerial photos taken by small unmanned drone and released by AIR PHOTO SERVICE, the crippled Fukushima Dai-ichi nuclear power plant is seen in Okumamachi, Fukushima prefecture, northern Japan. From top to bottom, Unit 1 through Unit 4.(Air Photo Service Co. Ltd., Japan)

http://cryptome.org/eyeball/daiichi-npp/daiichi-photos.htm

NOVA Japan's Killer Quake
An account and investigation of the epic earthquake, tsunami, and nuclear crisis

http://video.pbs.org/video/1863101157

CNN 48 foot tsunami wave hits Daiichi Plant after March 11, 2011 earthquake.

http://edition.cnn.com/video/#/video/world/2011/04/09/japan.nuclear.wave.hits.tepco

MIT NSE Nuclear Information Hub (http://web.mit.edu/nse/)

http://mitnse.com/author/mitnse/

The Fukushima Daiichi Incident – Dr. Matthias Braun - March 31, 2011

Areva presentation

Visual Radiation Exposure Chart by Reed Research Reactor staff

http://xkcd.com/radiation/

DOE Releases Monitoring Data – 3/22/11

http://energy.gov/news/10194.htm

USGS Earthquake Information (latest earthquakes in Japan)

http://earthquake.usgs.gov/earthquakes/eqarchives/last_event/world/world_japan.php

IAEA Updates

http://www.iaea.org/newscenter/news/tsunamiupdate01.html

Nuclear Energy Institute (NEI) – Latest NEI Update on Japan

http://nei.cachefly.net/newsandevents/information-on-the-japanese-earthquake-and-reactors-in-that-region/

NRC – NRC Actions on Japan's Emergency

http://www.nrc.gov/japan/japan-info.html

NIOSH Safety & Health Topic Webpage: Radiation Dispersal from Japan

http://www.cdc.gov/niosh/topics/radiation/

Wikipedia on Fukushima

http://en.wikipedia.org/wiki/2011_Fukushima_I_nuclear_accidents

TEPCO website (English version)

http://www.tepco.co.jp/en/index-e.html

And many more: LA Times, Denver Post, France24, NHK World Newsline, BBC World News, CNN World News, ABC/NBC/CBS National Network News Services and Local Affiliates

Fukushima Daiichi

Fukushima Daiichi Nuclear Power Station, in Fukushima Prefecture, began operation in 1971 and has six nuclear reactors, the capacity of which is 4,696 MW. The power station is located approximately 250 km (155 miles) north of Tokyo in the towns of Futaba and Ohkuma, facing the Pacific Ocean. The site of the station covers about 3.5 million square meters (865 acres) and the plants are built on solid bedrock.

References 2
Dr. Braun

- Good sources of Information
  - Gesellschaft für Reaktorsicherheit [GRS.de]
    - Up to date
    - Radiological measurements presented
    - German translation of Japanese / English web pages
  - Japan Atomic Industrial Forum [jaif.or.jp/english/]
    - Current Status of the plants
    - Measurement values of the reactors (pressure liquid level)
  - Tokyo Electric Power Company [Tepco.co.jp]
    - Radiological measurements published
    - Status of the recovery work
    - Casualties

Road Clearing Rikuzentakata Iwate Pref 031511