

*OVER VIEW OF ACCIDENT OF FUKUSHIMA DAI-ICHI  
NPSs AND FUTURE PLANNING TOWARD D&D*

16 NOVEMBER, 2011

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**JAPAN ATOMIC ENERGY AGENCY**

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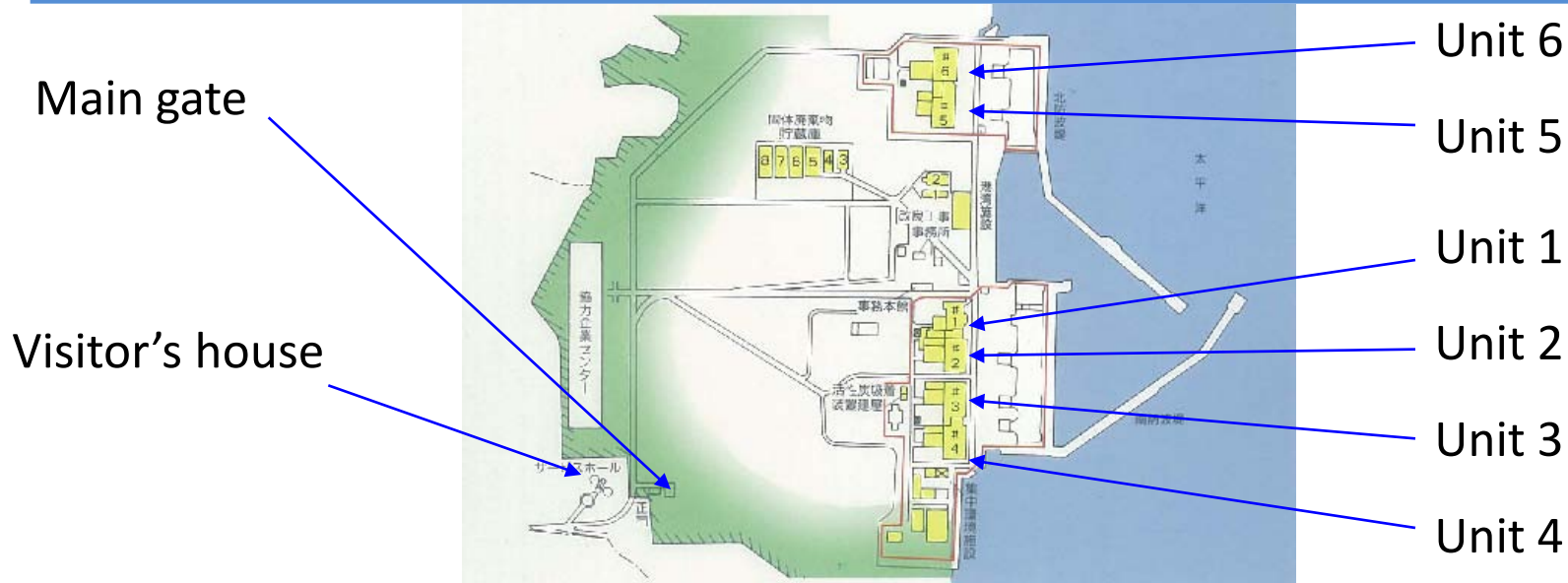
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# *1. What's happened at Fukushima Dai-Ichi NPSs after the Earthquake and the Tsunami*

# Overview of Fukushima Dai-Ichi NPSs



Location	Unit	In operation since	Plant type	Power Output (MW)	Main Contractor	Pre-earthquake status
Ohkuma	1	1971.3	BWR-3	460	GE	Operating
	2	1974.7	BWR-4	784	GE/Toshiba	Operating
	3	1976.3	BWR-4	784	Toshiba	Operating
	4	1978.10	BWR-4	784	Hitachi	Shutdown for maintenance Full core offloaded to spent fuel pool
Futaba	5	1978.4	BWR-4	784	Toshiba	Shutdown for maintenance
	6	1979.10	BWR-5	1,100	GE/Toshiba	Shutdown for maintenance



## 2011 off Tohoku Pacific Earthquake

Fukushima Dai-ichi NPP



Fukushima Dai-ni NPP

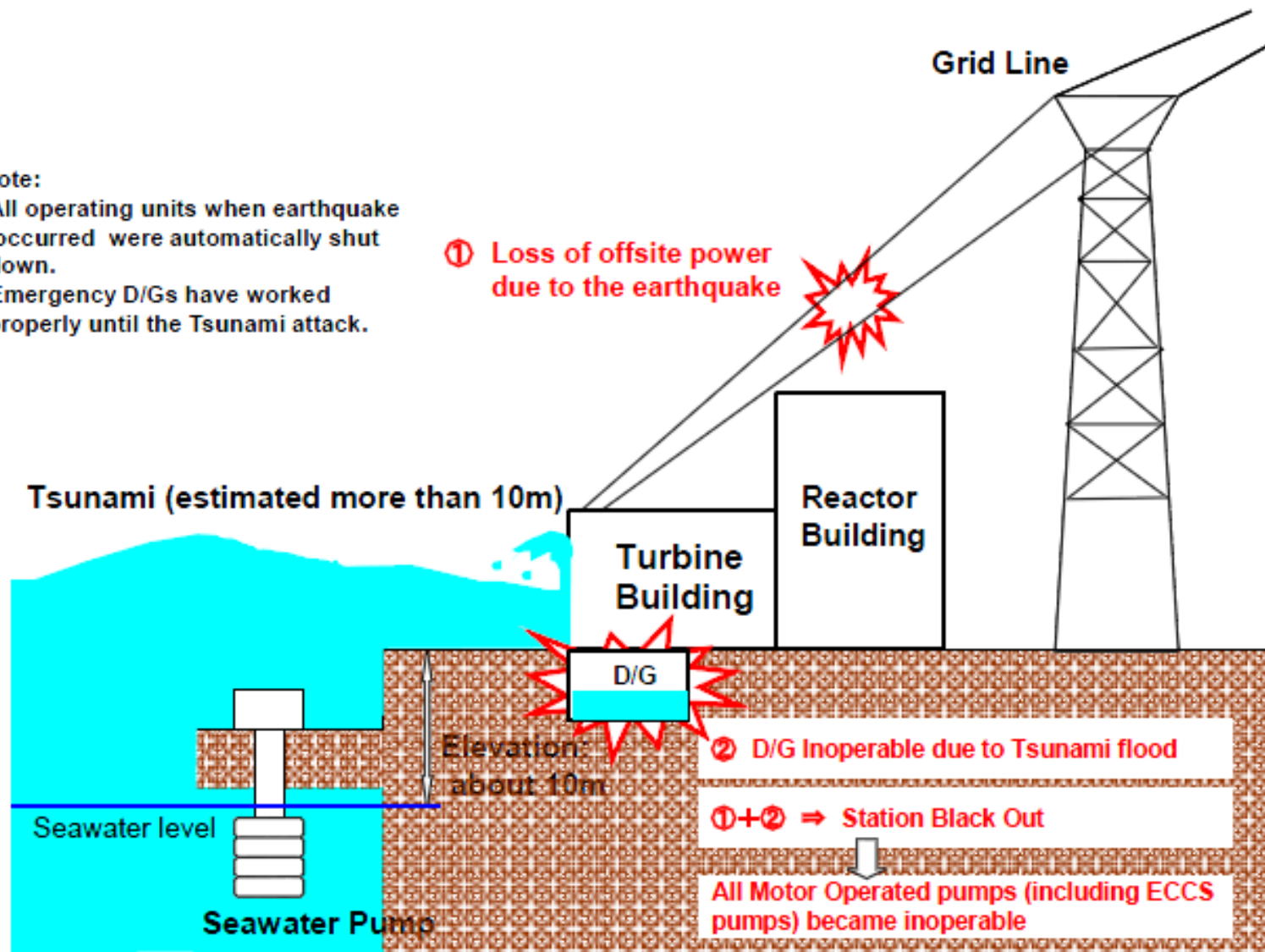


- Occurred 14:46 March 11, 2011
- Magnitude: 9.0 Mw
- Epicenter location: 38° 6" N and 142° 51" E, and 24 km in depth
- It is said that the height of tsunami attacked Fukushima NPP was more than 14 m

# Major root of cause of the damage

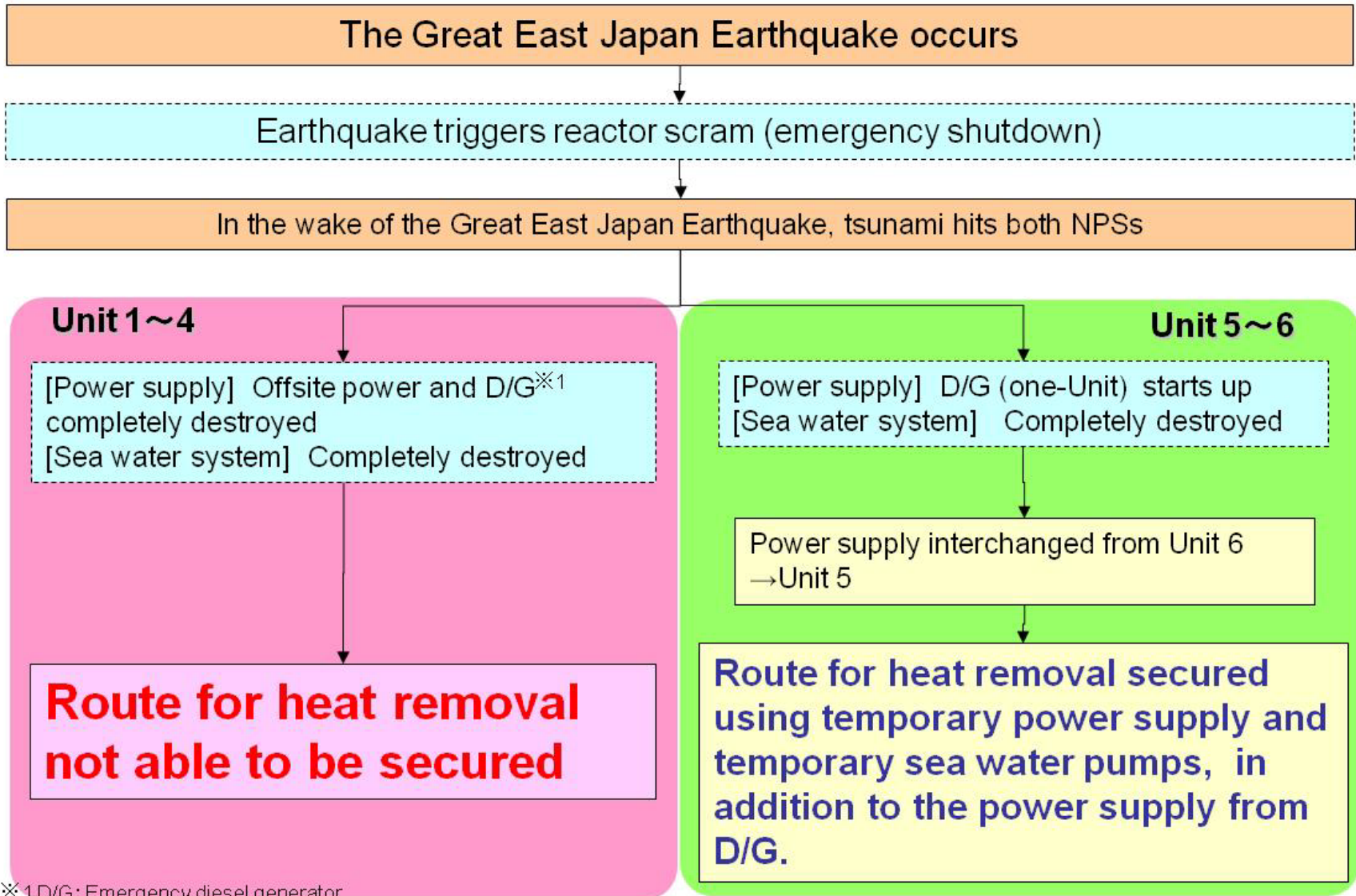
**Note:**

- All operating units when earthquake occurred were automatically shut down.
- Emergency D/Gs have worked properly until the Tsunami attack.



# *Influence by the earthquake and tsunami In Fukushima Dai-Ichi*

15-17 November, 2011  
OECD/NEA, 12<sup>th</sup> WPDD Meeting  
Issy-les-Moulineaux, France

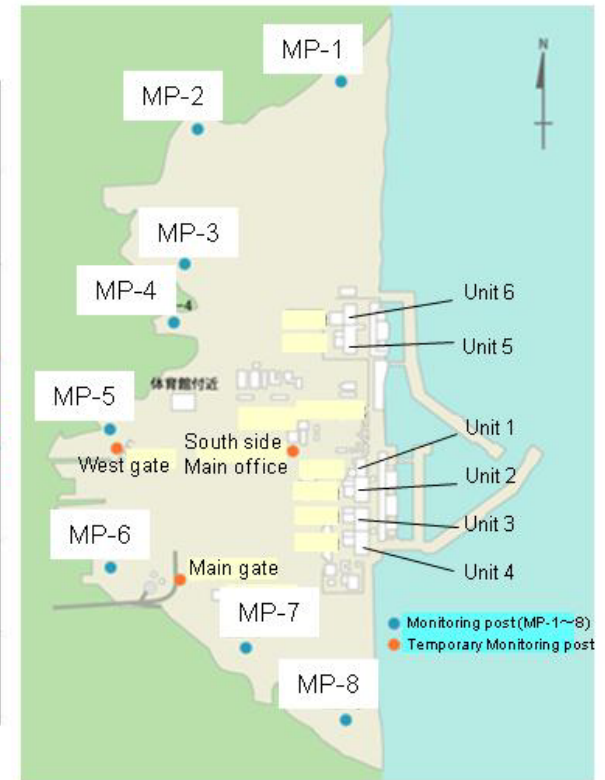
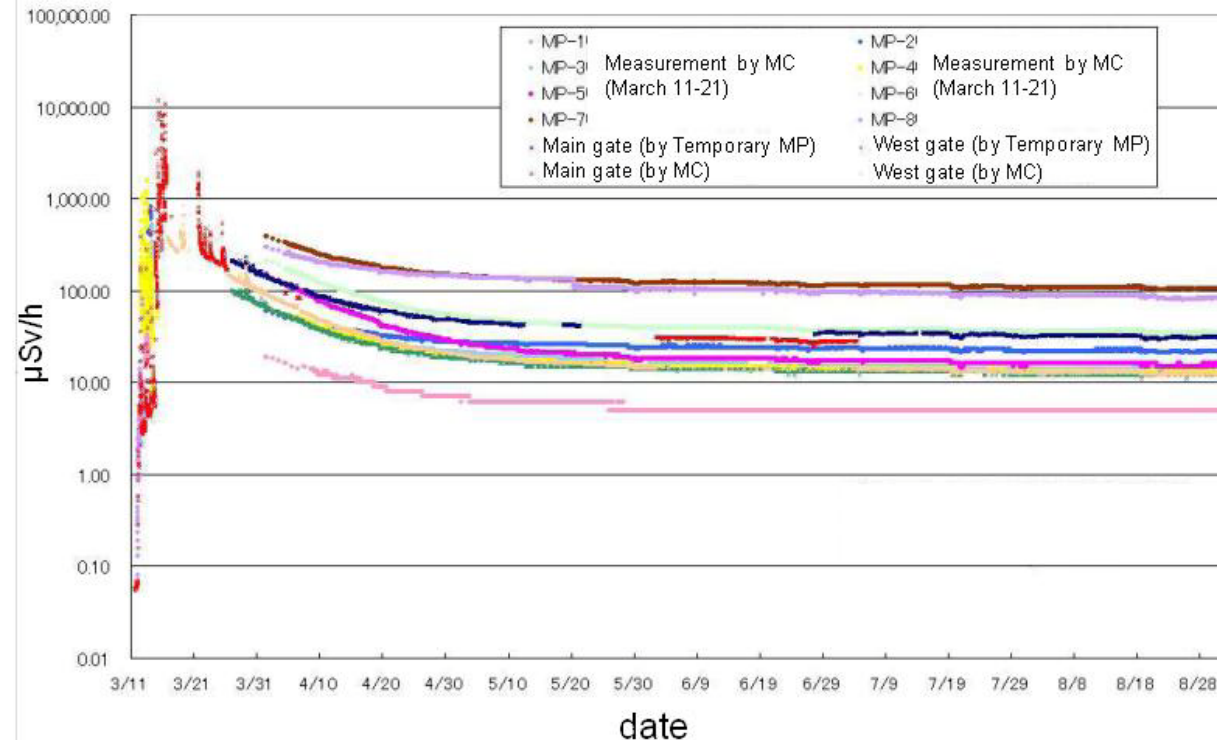


※1 D/G: Emergency diesel generator

## *2. Progression after the accident of Fukushima Dai-Ichi NPSs*

➤ Using the Monitoring post and Monitoring car (MC), the site boundary measure.

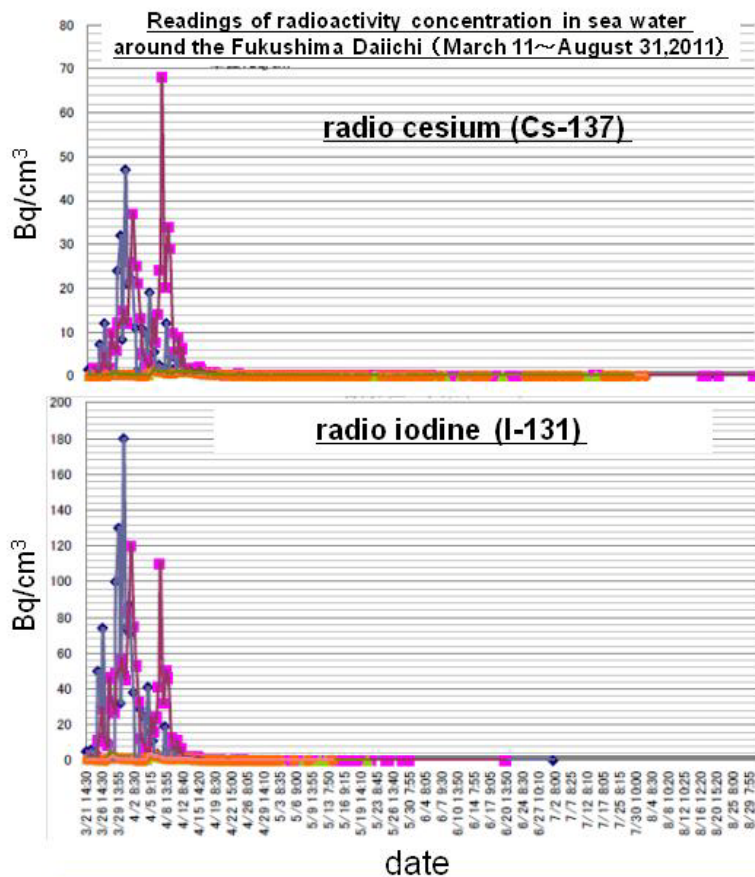
Readings of Air Dose Rate in Fukushima Daiichi (March 11~August 31, 2011)



- The main gate about 1km away from Unit 2, temporary measure a value greater than  $10,000\mu\text{Sv} / \text{h}$ .
- Current Trends in the value of about  $10 \sim 100\mu\text{Sv} / \text{h}$ .



# Radioactivity concentration in seawater

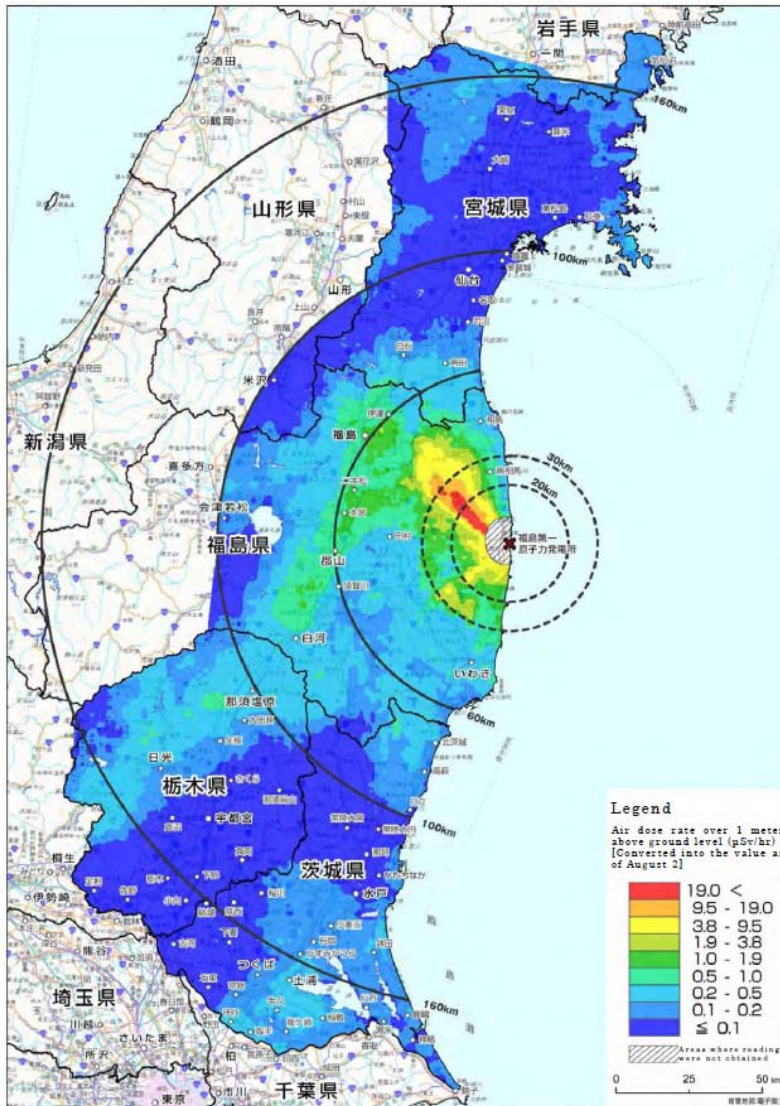


- ① Point about 330m South side of Unit 1-4's outlet.
- ② Point about 30m North side of Unit 5-6's outlet.
- ③ Point about 10km South side of Fukushima Daiichi.
- ④ Point about 7km South side of Fukushima Daiichi.

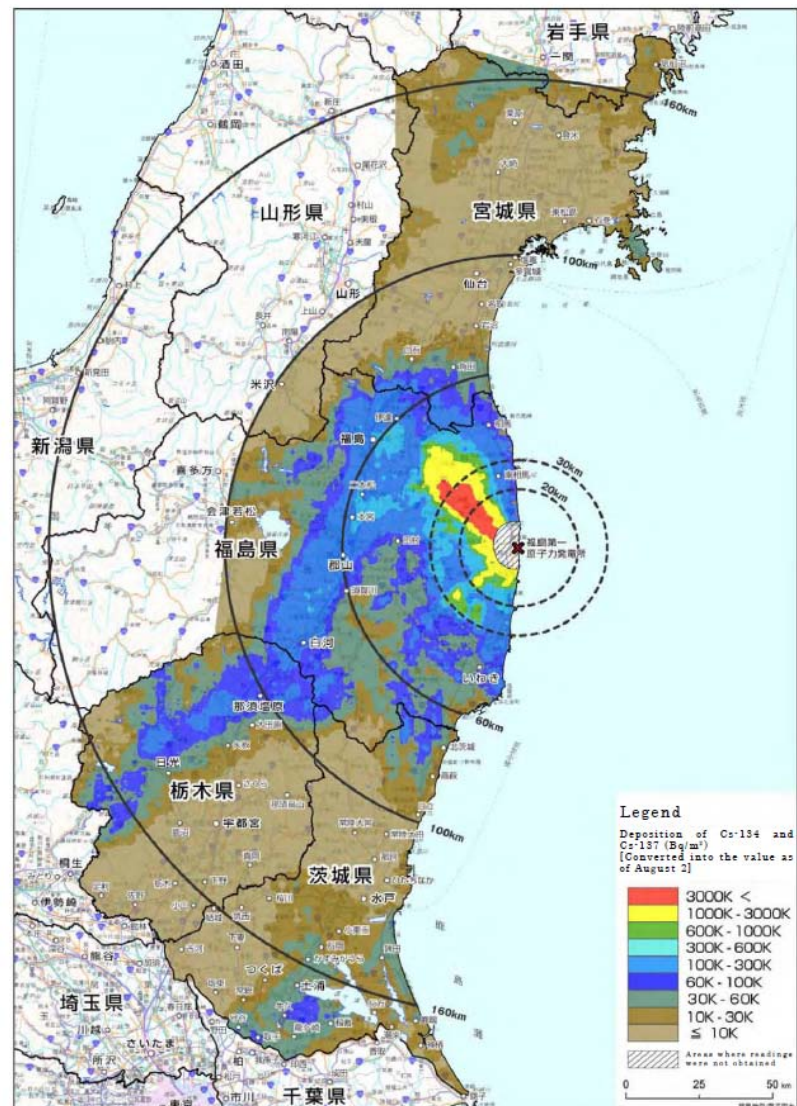


- (Cs-137) Point about 30m North side of Unit 5-6' s outlet, the maximum (about 70Bq/cm3) observed.
- (I-131) Point about 330m South side of Unit 1-4' s outlet, the maximum (about 180Bq/cm3) observed.

# Results of aircraft monitoring



Results of aircraft monitoring



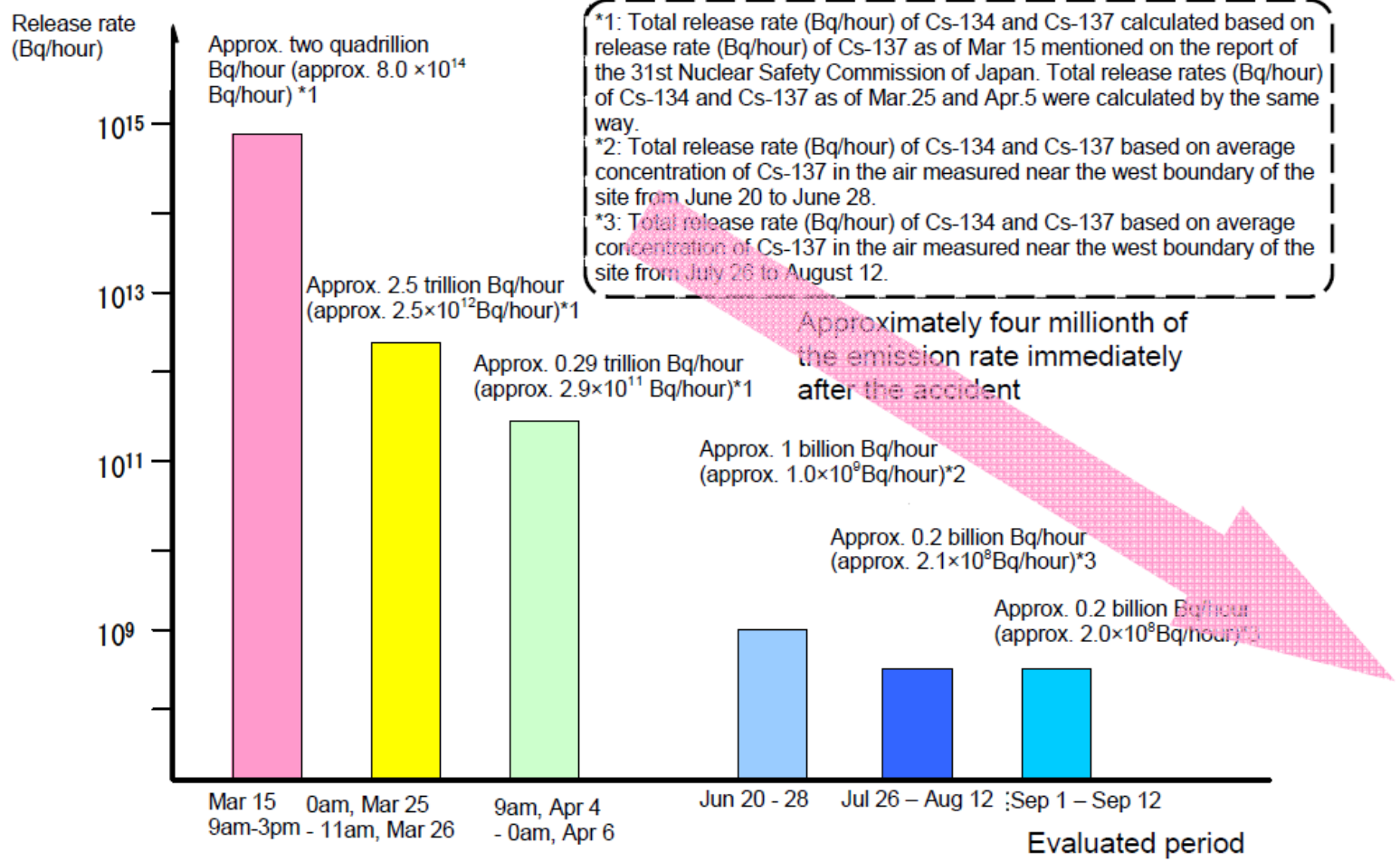
Results of aircraft monitoring

(Air dose rate over 1 meter above ground level; 2 Aug. '11) (Total of accumulative amount of Cs-134 and Cs-137; 2 Aug. '11)



# Release rates of radioactive materials from Unit 1 to 3

Release rates of radioactive materials from Units 1 to 3 at the Fukushima Daiichi



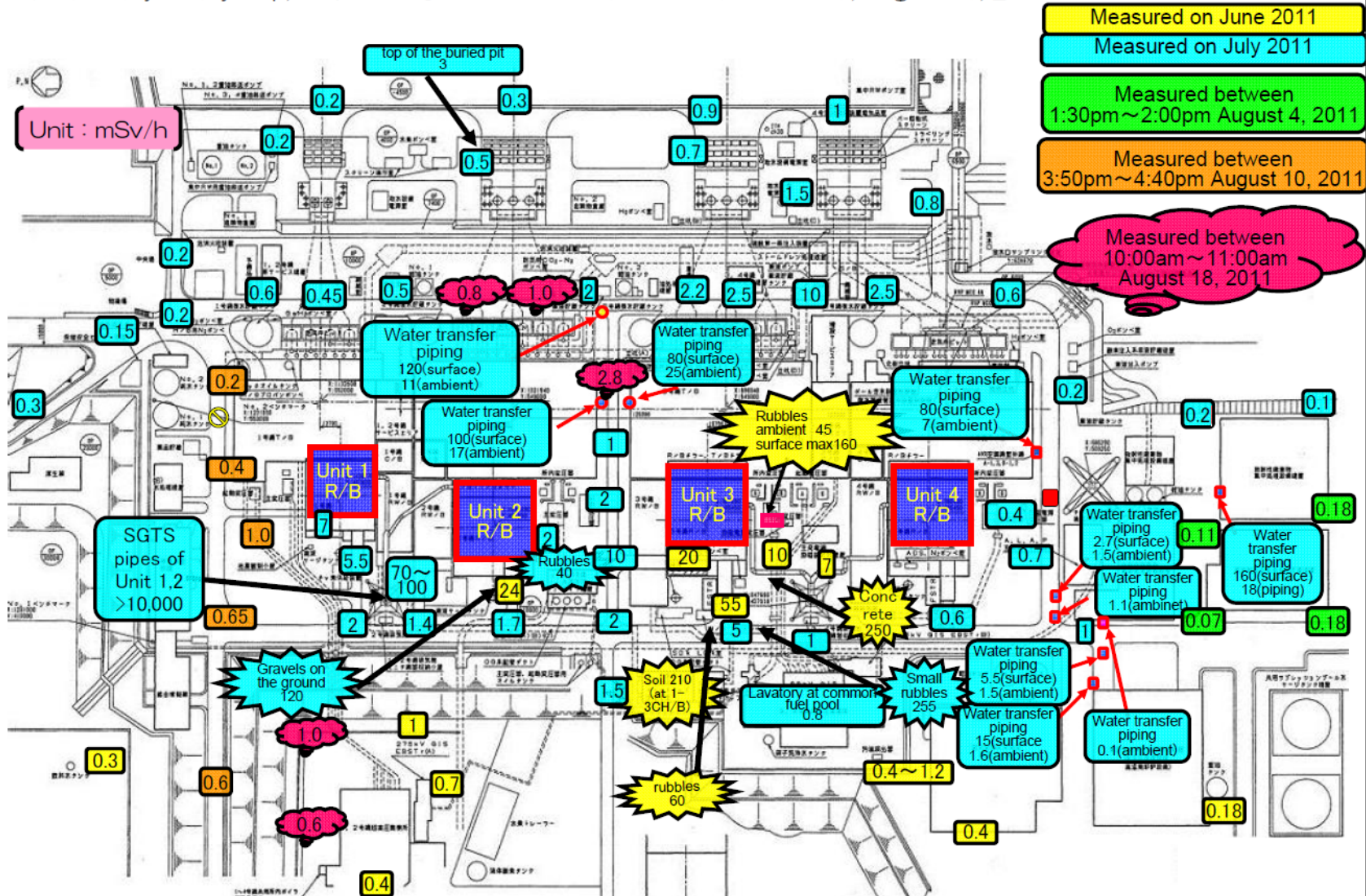


### ***3. Current On-site Status of Fukushima Dai-Ichi***

# Survey map

15-17 November, 2011  
 OECD/NEA, 12<sup>th</sup> WPDD Meting  
 Issy-les-Moulineaux, France

Radioactivity survey map, Fukushima Daiichi Nuclear Power Station (5:00 PM, August 18, 2011)



# Near the Main Exhaust Stack of Units 1 and 2

15-17 November, 2011  
OECD/NEA, 12<sup>th</sup> WPDD Meeting  
Issy-les-Moulineaux, France

August 5, 2011  
TEPCO

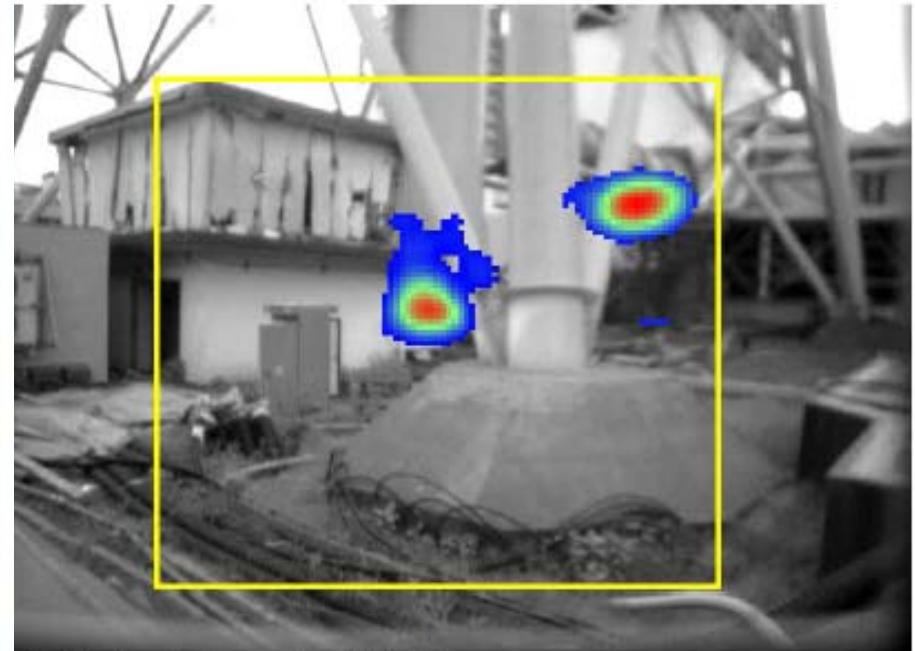


Location: Stack drain pipe at the main exhaust stack of Units 1 and 2 (view from the east side)

Time: August 4, 2011, around 15:30

Photographed by: TEPCO

August 2, 2011  
TEPCO



Location: Near the main exhaust stack of Units 1 and 2

Time: July 31, 2011, around 16:00

Photographed by: TEPCO

# High-dose detected area on the 2nd floor of Unit 1 turbine building

August 3, 2011  
TEPCO

High-dose detected area on the 2nd floor of Unit 1 turbine building in Fukushima  
Dai-ichi NPS

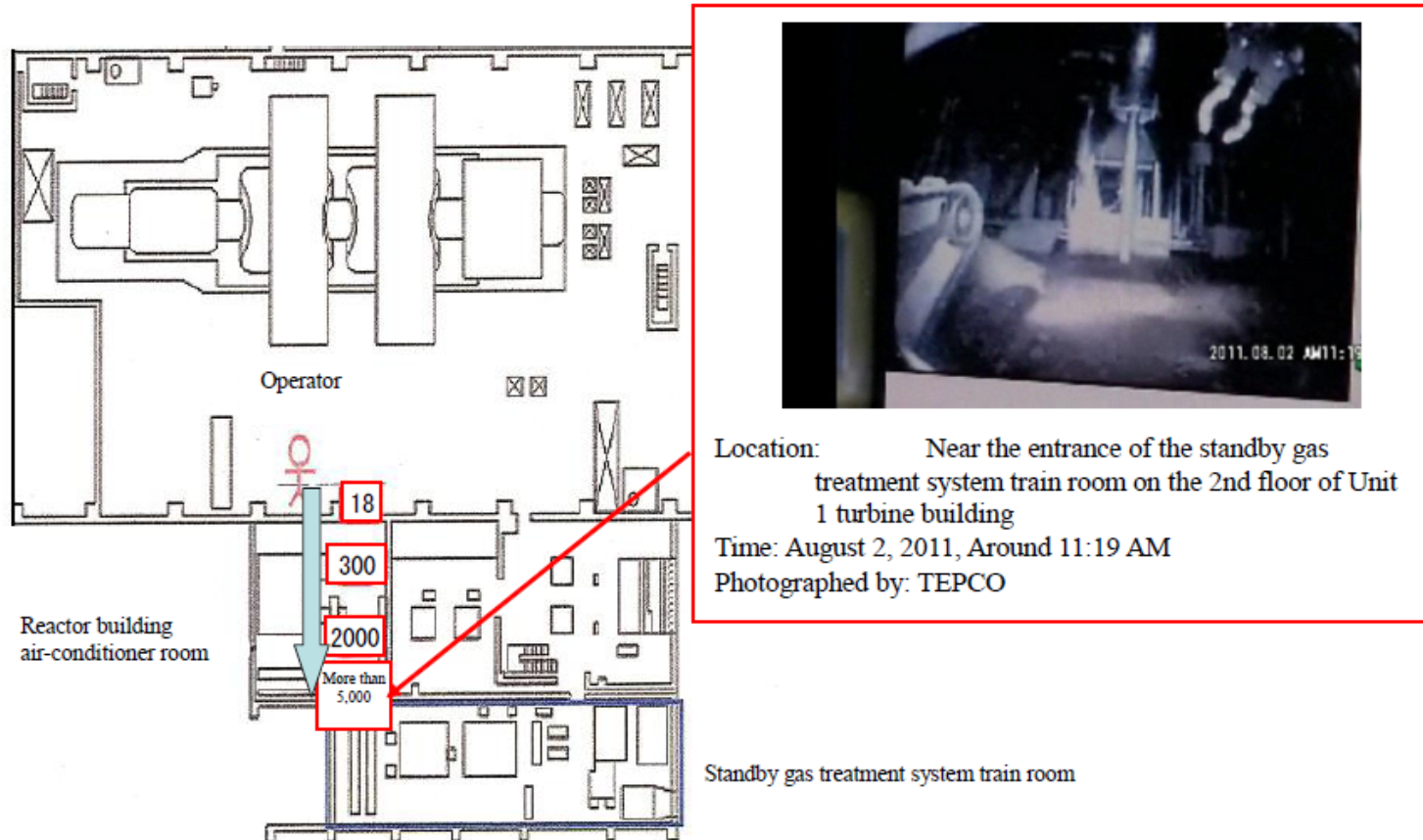
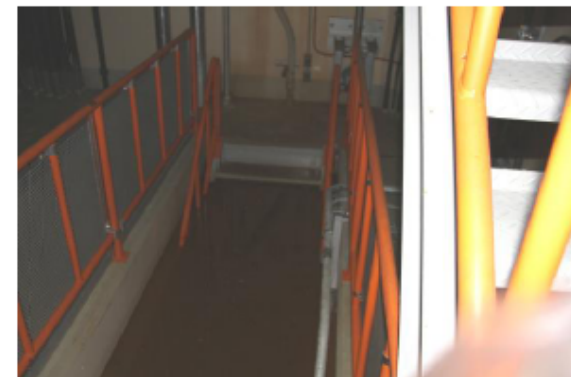
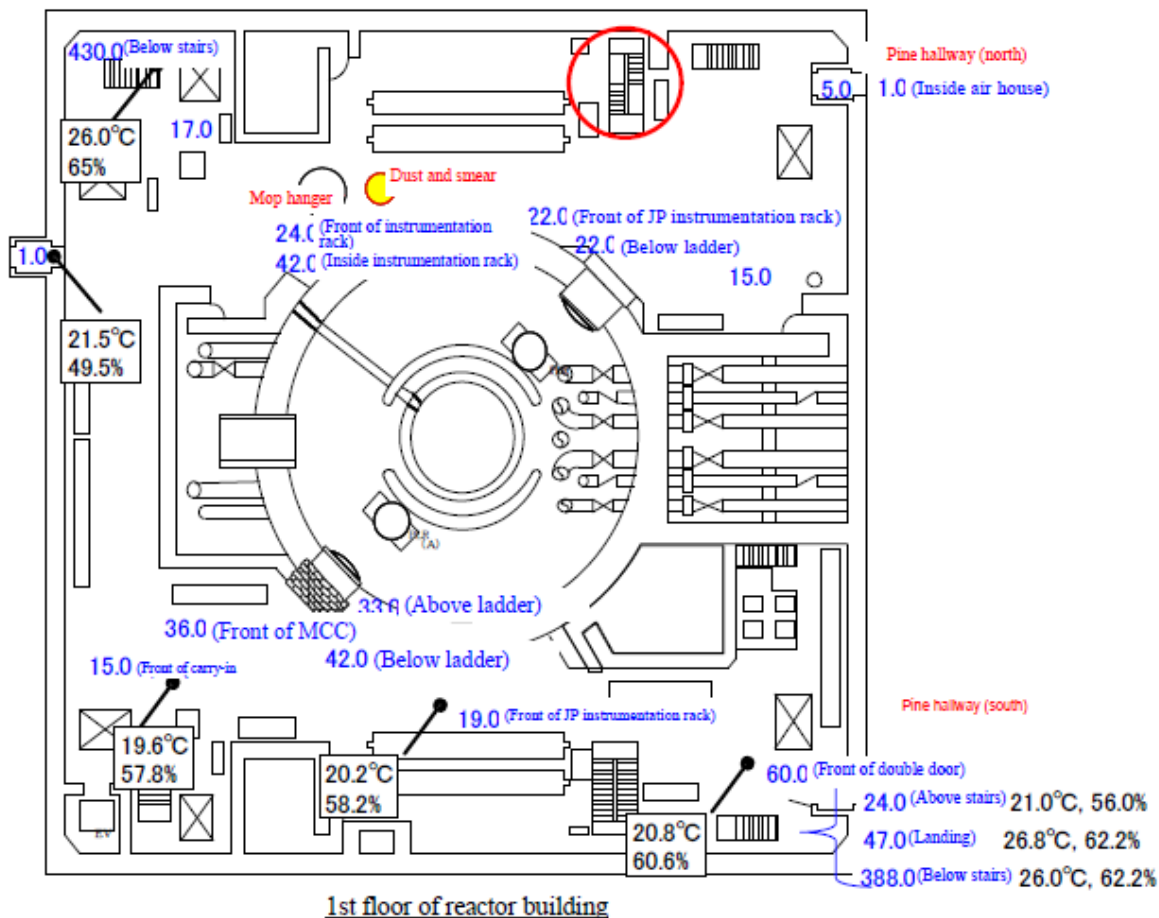


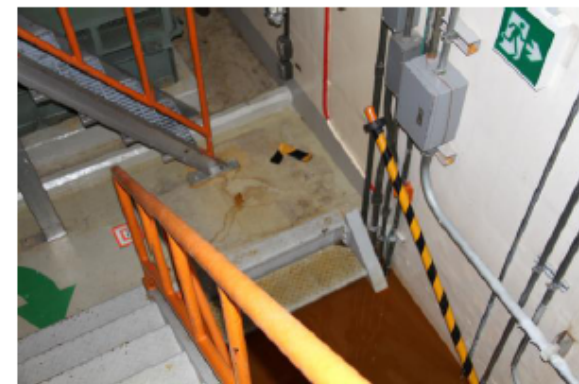
Figure II-2-61 High-dose Detected Area on the 2nd Floor of Unit 1 Turbine Building in Fukushima Dai-ichi NPS



# Dose rate of 1<sup>st</sup> floor of Unit 2 Reactor Building



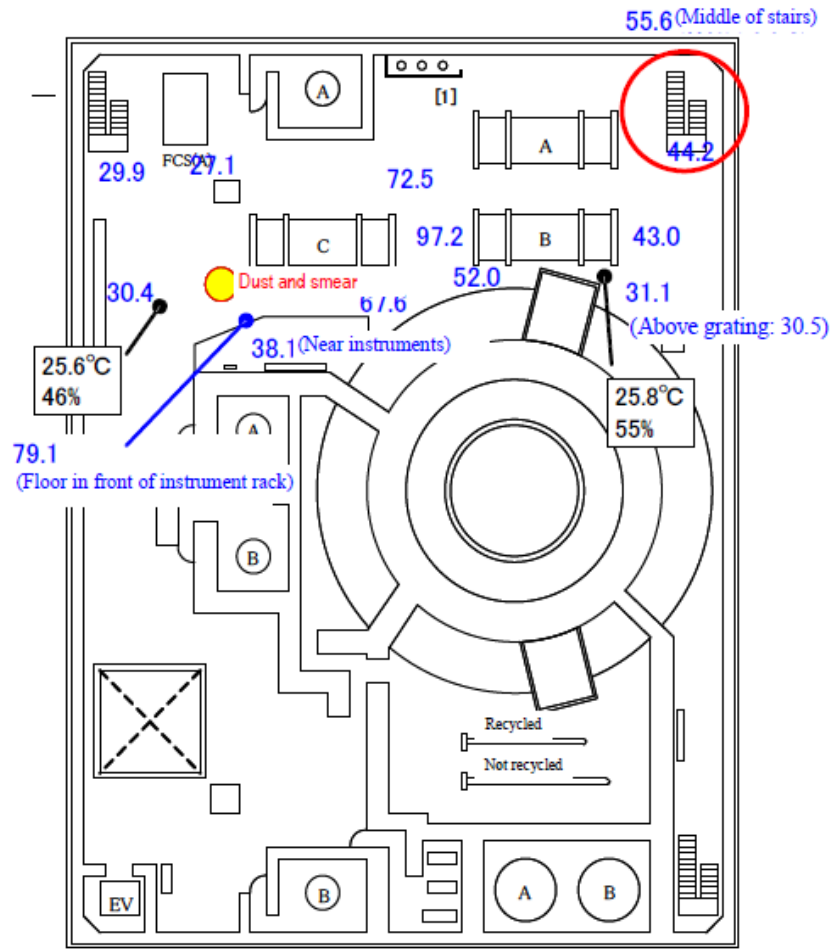
Northwest stairs (half basement)



Southeast stairs (half basement)

# Does rate of 2<sup>nd</sup> floor of unit 2 Reactor Building

15-17 November, 2011  
OECD/NEA, 12<sup>th</sup> WPDD Meeting  
Issy-les-Moulineaux, France



Reactor instrumentation rack



# Results of Investigation inside the Roof of Unite 2 Reactor Building

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Issy-les-Moulineaux, France

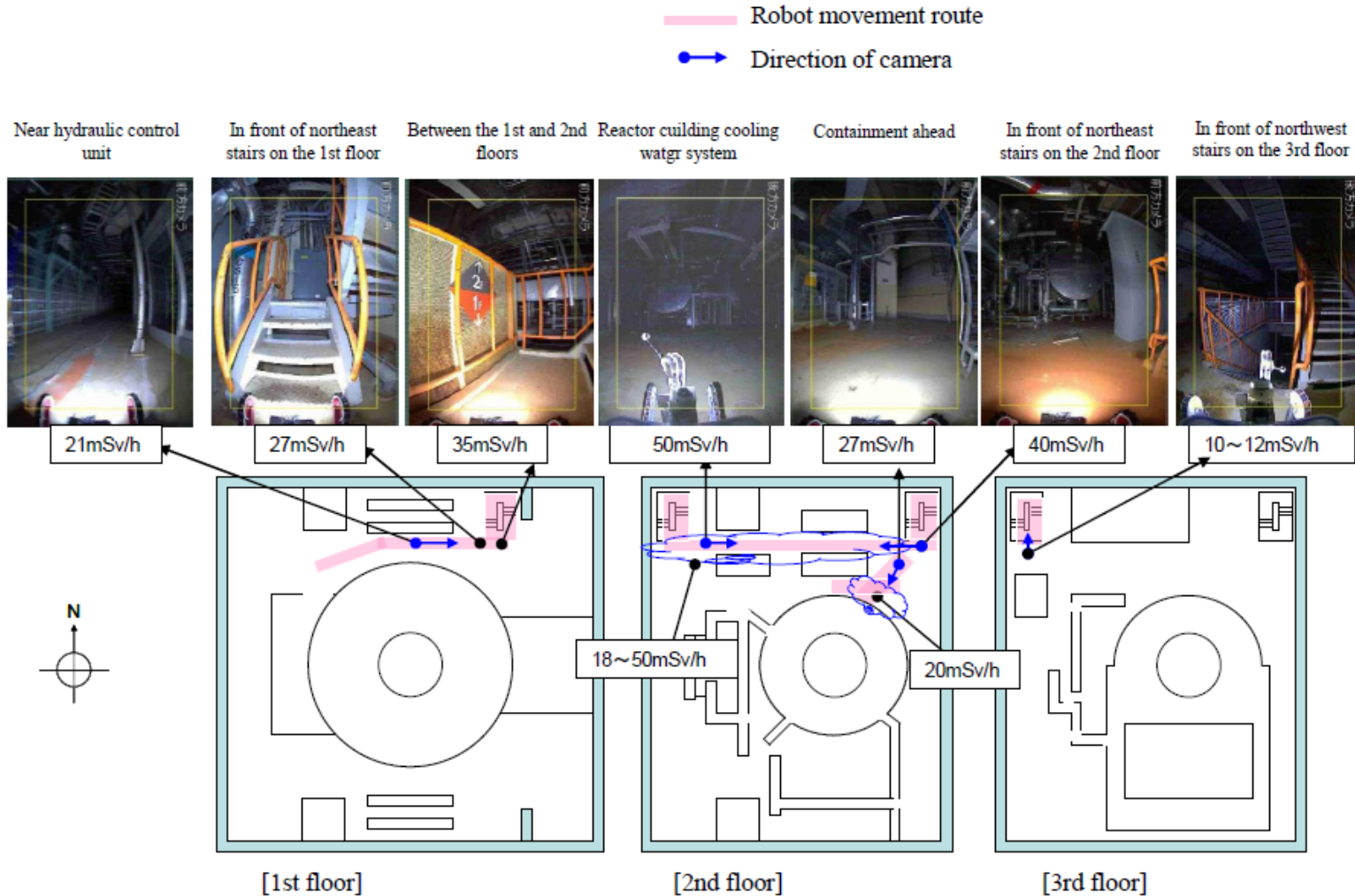
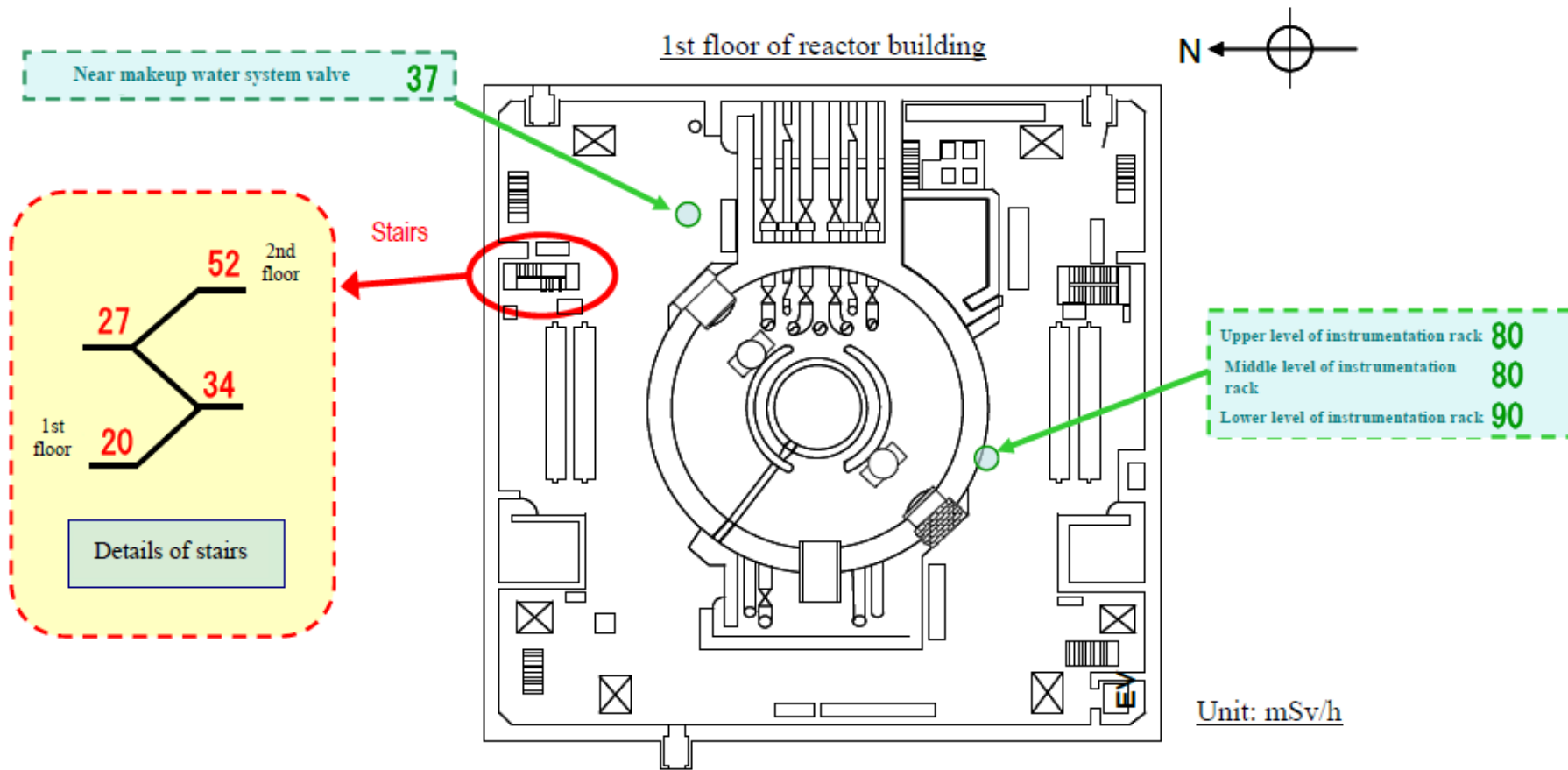


Figure II-2-65 Result of Investigation inside the Roof of Unit 2 Reactor Building in Fukushima

# Results of Investigation inside Unite 3 Reactor Building

15-17 November, 2011  
OECD/NEA, 12<sup>th</sup> WPDD Meeting  
Issy-les-Moulineaux, France



Red: On-the-spot investigation conducted by Quince on July 26  
Green: On-the-spot investigation conducted by workers on July 27

\* Building layout is image (scale and layout are not accurate)



## ***4. Future Planning toward Decommissioning and Dismantling of Fukushima Dai-Ichi NPSs***

# Current Status of "Roadmap towards Restoration from the Accident at Fukushima Dai-Ichi Nuclear Power Station, TEPCO" (Revised on 20 Sep. '11)

Issues	As of Apr. 17	Step 1 (around 3 months)	Step 2 (around 3 to 6 months after achieving Step 1) current status (as of Aug. 17)	Mid-term issues (around 3 years)		
I. Cooling	(一) Reactor	Fresh water Injection	Cooling by minimum injection rate (injection cooling)	Stable cooling	Cold shutdown condition	
			Consideration and preparation of reuse of accumulated water			Circulating water cooling (start) ☆
	Fresh water Injection	Nitrogen gas injection ☆	Improvement of work environment ☆	Nitrogen gas injection (continued)	Protection against corrosion cracking of structural materials* *partially ahead of schedule	
		Reliability improvement in injection operation / remote-control operation *ahead of schedule			Remote-controlled injection operation	Start of removal work of fuels
II. Mitigation	(二) Spent Fuel Pool	Fresh water Injection	Circulation cooling system ☆ (installation of heat exchanger) *partially ahead of schedule	Stable cooling	More stable cooling	
			Installation of storage / processing facilities ☆			Expansion ☆ / consideration of full-fledged processing facilities
	(三) Accumulated Water	Transferring water with high radiation level	Installation of storage facilities / decontamination processing	Secure storage place	Reduction of total amount of contaminated water	Continuous processing of accumulated water
						Storing water with low radiation level
(四) Ground water	Mitigation of contamination of groundwater	Consideration of method of impermeable wall against groundwater	Mitigate ocean contamination	Mitigate ocean contamination (continued)	Mitigation of contamination in the ocean	
					Sub-drainage management with expansion of storage / processing facilities	Mitigation of contamination of groundwater
(五) Atmosphere / Soil	Dispersion of inhibitor	Removal of debris	Mitigate scattering	Mitigate scattering (continued)	Dispersion of inhibitor (continued)	
					Removal of debris (continued)	Design / implementation of impermeable wall against groundwater
					Installation of reactor building cover (Unit 1) ☆	
					Removal of debris (top of Unit 3&4 R/B)	
					Consideration of reactor building container	
					Removal of debris / installation of reactor building cover (Unit 3&4)	
					Start of installation work of reactor building container	

# *Technical subjects of medium to long-term about the accident of Fukushima Daiichi NPSs*

*By Japan Atomic Energy Commission (14 September, '11)*

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15-17 November, 2011  
OECD/NEA, 12<sup>th</sup> WPDD Meeting  
Issy-les-Moulineaux, France

Technical subjects about the accident of Fukushima Daiichi NPS are extracted,  
which used the period until removal of the fuel debris in a reactor is started

## **1. Removal work of fuels from Spent Fuel Pool (SFP).**

- Handling technology of fuel in which was damaged and contained salt.  
(Handling, Washing, Inspection, Judgment of reprocessing possibility, etc)

## **2. The continuous measure towards Stabilization and Decommissioning.**

- Remote decontamination technology of the high dose place in a building.
- Corrosion control technology of PCV and RPV.
- Processing technology of a high dose waste which occurred by operation of a water processing facilities.

## **3. Preparation of removal work of debris / Removal.**

- Technology which specific and repair, water stops in a leakage part of PCV, and Implement technology of filling water. (Removal work of debris is most rational to carry out underwater.)
- Remote investigative technology of PCV and RPV.
- Development of debris extraction technology and a construction method
- Development of the technology of storing stably the debris fuel containing salt (storage can).
- Examination about suitable processing / disposal policy

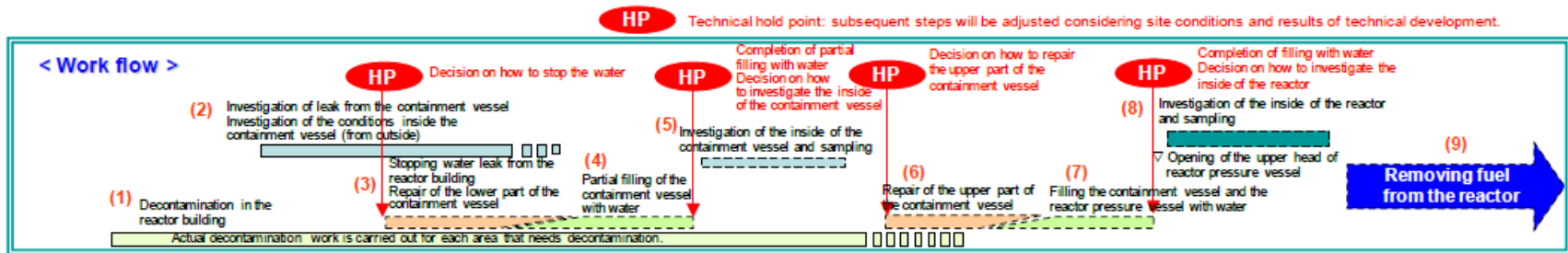
## **4. Processing and disposal of radioactive waste**

- Processing / disposal technology for every occurring radioactive waste.

## **5. The elucidation of progress of an accident**

- Development of the presumed technology of the inside situation of PCV after a severe accident.
- The advancement of the progress analysis technology of a severe accident phenomenon.

# Conceptual Diagram of Work flow for Removal of Fuel from Reactor core (1/3)



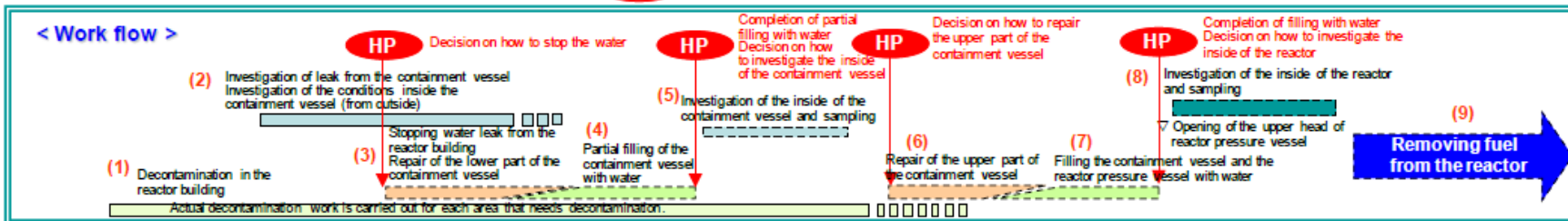
※ For the technical development purpose, underwater fuel removal work was assumed in planning the work, as was in TMI case. The plan will be modified considering the actual situations and technical development.

Work	(1) Decontamination in reactor building (Successive decontamination as required for next steps)	(2) Investigation of leak from the containment vessel Investigation of the conditions inside the containment vessel (from outside)	(3) Stopping water leak from the reactor building Repair of the lower part of the containment
Conceptual diagram			
Details	<p>The work area will be decontaminated using high-pressure water, coating, surface chipping, and so forth in order to provide greater access to the containment vessel.</p>	<p>Investigations will be conducted of leak in the containment vessel and the reactor building manually or using remote-controlled radiation dose measuring instruments, cameras, and other devices. The condition of the interior of the containment vessel will be investigated and estimated from outside through <math>\gamma</math> rays measurements, acoustic investigations, etc.</p>	<p>Since underwater work for removing damaged fuel is preferable in terms of radiation shielding, leaking points of containment vessel will be repaired to stop leakage. For that purpose, priority will be given to repairing the lower parts of containment vessel to facilitate inspection within containment vessel.</p>
Points & issues to be considered in technological development	<ul style="list-style-type: none"> <li>◆ High dose areas (some hundreds to 1000 mSv)</li> <li>◆ Limited accessibility due to rubble in buildings</li> <li>• It is necessary to consider remote decontamination methods and other measures for locations with high-level radioactivity.</li> </ul>	<ul style="list-style-type: none"> <li>◆ Objects of investigation are in high dose area, in contaminated water, or in narrow space</li> <li>• Development of methods and equipment to investigate leak</li> <li>• Development of methods and equipment to investigate the condition of the inside of the containment vessel from outside</li> </ul>	<ul style="list-style-type: none"> <li>◆ Stop water leak under high dose and water-flowing conditions in parallel with core cooling by circulating water injection</li> <li>• Development of technology and methods to repair leak in containment vessel and reactor building and stop water leak</li> <li>• Examination and development of alternative measures</li> </ul>



# Conceptual Diagram of Work flow for Removal of Fuel from Reactor core (2/3)

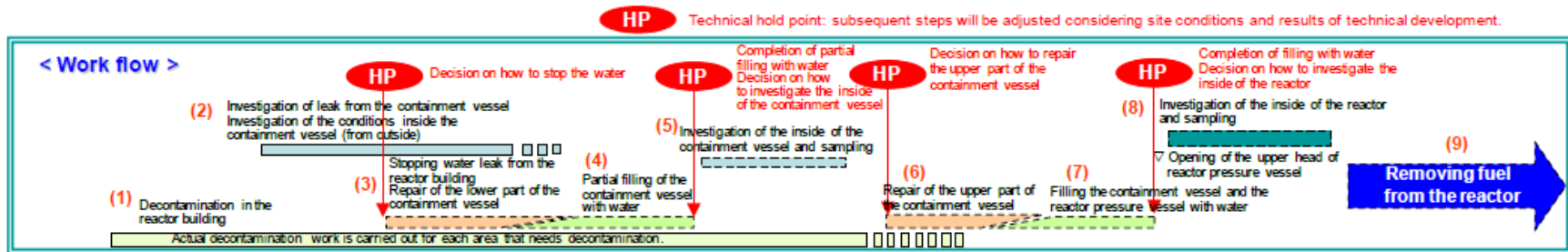
**HP** Technical hold point: subsequent steps will be adjusted considering site conditions and results of technical development.



\*For the technical development purpose, underwater fuel removal work was assumed in planning the work, as was in TMI case. The plan will be modified considering the actual situations and technical development.

Work	(4) Partial filling of the containment vessel with water	(5) Investigation of the inside of the containment vessel and sampling	(6) Repair of the upper part of the containment vessel
Conceptual diagram	<p>Once boundaries are established in the lower part of containment vessel, the source of water for circulating injection cooling will be changed from torus room to containment vessel.</p>		
Details	The lower part of the containment vessel will partially be filled with water before investigations of the inside of the containment vessel begin.	The inside of the containment vessel will be investigated to identify the distribution of damaged fuel, which is presumed to have leaked out of the reactor pressure vessel, and to carry out sampling and other types of work.	In order to fill the containment vessel with water to its top, leak in the upper part of the containment vessel will be repaired manually or through remote control.
Points & issues to be considered in technological development	<p>♦ <b>Same note as that for (3)</b></p> <p>•The major premise is to build boundaries in the lower part of the containment vessel (including the plan of filling the torus room with grout materials).</p>	<p>♦ <b>Limited accessibility due to high dose, difficult environment inside containment vessel (accumulated water, dropped damaged fuel, etc.)</b></p> <p>•Development of methods for remote investigations and sampling in the containment vessel where there is high-level radioactivity.</p>	<p>♦ <b>Same note as that for (2)</b></p> <p>•Development of technology and methods for repairing leak in the containment vessel and stop the water leak (same as in Process (3))</p>

# Conceptual Diagram of Work flow for Removal of Fuel from Reactor core (3/3)



※ For the technical development purpose, underwater fuel removal work was assumed in planning the work, as was in TMI case. The plan will be modified considering the actual situations and technical development.

Flow	(7) Filling the containment vessel and the reactor pressure vessel with water ⇒ Opening of the upper head of reactor pressure vessel	(8) Investigation of the inside of the reactor and sampling	(9) Removing fuel from the reactor
Conceptual diagram			
Details	After containment vessel and reactor pressure vessel are sufficiently filled with water for shielding purpose, the upper head of reactor pressure vessel will be removed.	The inside of the reactor will be investigated to ascertain the condition of the damaged fuel, structures in the reactor, etc., and sampling and other sorts of work will be performed.	Damaged fuel will be removed from the reactor pressure vessel and the containment vessel.
Points & issues to be considered in technological development	(The major premise is to build containment vessel boundaries in Process (6).)	<ul style="list-style-type: none"> <li>♦ Limited accessibility due to high dose, difficult environment inside containment vessel (accumulated water, damaged fuel, etc.)</li> <li>♦ Development of methods for remote investigations and sampling in the reactor where there is high-level radioactivity</li> </ul>	<ul style="list-style-type: none"> <li>♦ Further technological development might be needed depending on the situation (distribution) of damaged fuel</li> <li>♦ Development of more advanced techniques and methods than used at TMI for removing fuel.</li> </ul>

# Technical Issues for Medium-and long term Actions - 1)

## by JAEC (Japan Atomic Energy Commission)

15-17 November, 2011  
 OECD/NEA, 12<sup>th</sup> WPDD Meeting  
 Issy-les-Moulineaux, France

Item	Necessary of Implementation	Major Technical Issues
Removal of fuel assemblies from spent fuel pools(SFP)	1) About 3,100 (about 2,700 are SF) 2) All of them need to be removed from the reactor bldgs (RB).	1) Most of the fuel rods in the SFPs are assumed to be undamaged. 2) Some of them might be damaged or deformed by debris and other contaminant in the pools. 3) Seawater has been injected into the SFPs. <i>- How to handle the fuel rods damaged or exposed to seawater (handling, cleaning, inspection, possibility of reprocessing etc.</i>
Toward stabilization / decommissioning	1) Period to be required to remove the fuel in the reactor vessel 2) Core cooling, stable water treatment, ensuring of long-term integrity of RB and structures 3) Proper decontamination to improve work environment	1) Stable continuation of water-injection/circulation into the reactor vessel and treatment of cooling water <i>- How to process and dispose highly-radioactive secondary wastes generated from water treatment operation.</i> <i>- The method for remote decontamination to improve personnel accessibility for high-radiation area in the RB.</i> <i>- Assessment of the corrosion resistance of the reactor pressure vessel (RPV) and the primary containment vessel (PCV) and implementation of corrosion control measures as appropriate.</i>
Removal/preparation for removal of debris in the reactors	1) Part of debris might have leaked into PCV for Unit 1 to 3. 2) The properties, shape and location of the debris are unclear at present, investigation and study should be conducted.	1) Cooling water injected into the reactors are leaking into to the turbine bldgs through RPV and PCV and are being re-circulated after treatment. <i>- Removing the debris would be carried out under the water.</i> <i>- Leaking points have to be located and repaired before water-filling.</i> 2) The distribution of debris should confirmed and debris sampling should be carried out. <i>- Development of remote RPV/PCV interior inspection methods operable under high-radiation environment.</i> 3) Part of damaged fuel might have leaked into PCV (Unit 1 to 3) <i>- Development of more advanced techniques and methods than those used at TMI.</i>

Item	Necessary of Implementation	Major Technical Issues
Removal/preparation for removal of debris in the reactors	Advancing the development of storage methods and treatment/disposal methods for removed debris	1) TMI debris is still in stable storage. This will be applied. - <i>Development of technology for stable storage of debris containing salt (storage drum)</i> - <i>Consideration on proper treatment and disposal measures.</i>
Treatment/disposal of radioactive wastes	Radioactive wastes from restoration and decommissioning should be treated and disposal.	1) Some of radioactive wastes being generated in the power plant are temporarily stored at site. - <i>Consideration on proper treatment and disposal measures based on the estimated amount and property evaluation of the expected wastes.</i>
Understanding of progress of accident	1) Understanding of the detailed sequence is helpful for better consideration the fuel removal procedures.	1) Development and analysis etc. - <i>Development of techniques to estimate the conditions in PCV (analysis and inspection from outside PCV)</i> - <i>Improvement of event progression analysis methods based on the results of the inspection in PCV and RPV and the results of sampling and analysis of debris.</i>



# *Source of information*

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- (1) Japanese Government Website  
<http://www.kantei.go.jp/foreign/incident/index.html>
- (2) JAEC(Japan Atomic Energy Commission) Website  
<http://www.aec.go.jp/jicst/NC/eng/index.htm>
- (3) NISA (Nuclear and Industrial Safety Agency) Website  
<http://www.nisa.meti.go.jp/english/index.html>
- (4) TEPCO (Tokyo Electric Power Company) Website,  
<http://www.tepco.co.jp/en/index-e.html>
- (5) Report of the Japanese Government to the IAEA Ministerial Conference  
on Nuclear Safety  
- The Accident at TEPCO's Fukushima Nuclear Power Plants –  
June 2011
- (6) Additional Report of the Japanese Government to the IAEA  
- The Accident at TEPCO's Fukushima Nuclear Power Plants –  
(Second Report) , September 2011

# Conclusion

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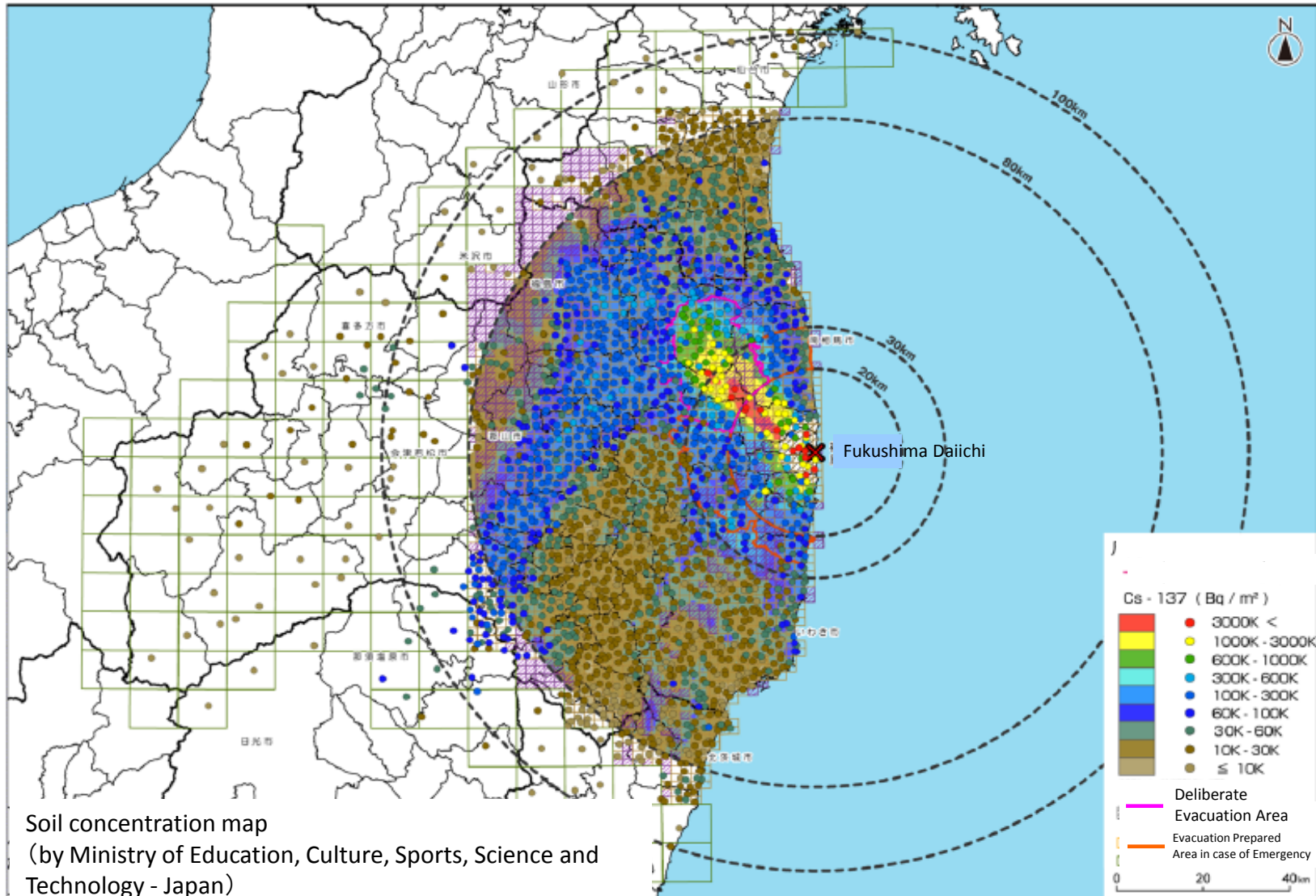
1. *Many people in Japan are engaged in on- and off-site remediation of Fukushima Dai-Ichi*
  - *Government (METI, MEXT, MOE, JAEC, NSC, and NISA etc.)*
  - *Local Government*
  - *Utilities, plant fabricators, general contractors*
  - *National organizations (JAEA, Universities, etc)*
2. *D&D of Fukushima Dai-Ichi NPSs will start after finishing Mid-term Issues (around 3 years)*
3. *International Cooperation is very important toward D&D of Fukushima Dai-Ichi NPSs.*

***Thank you for your attention!***

***Thank you for your useful information !***

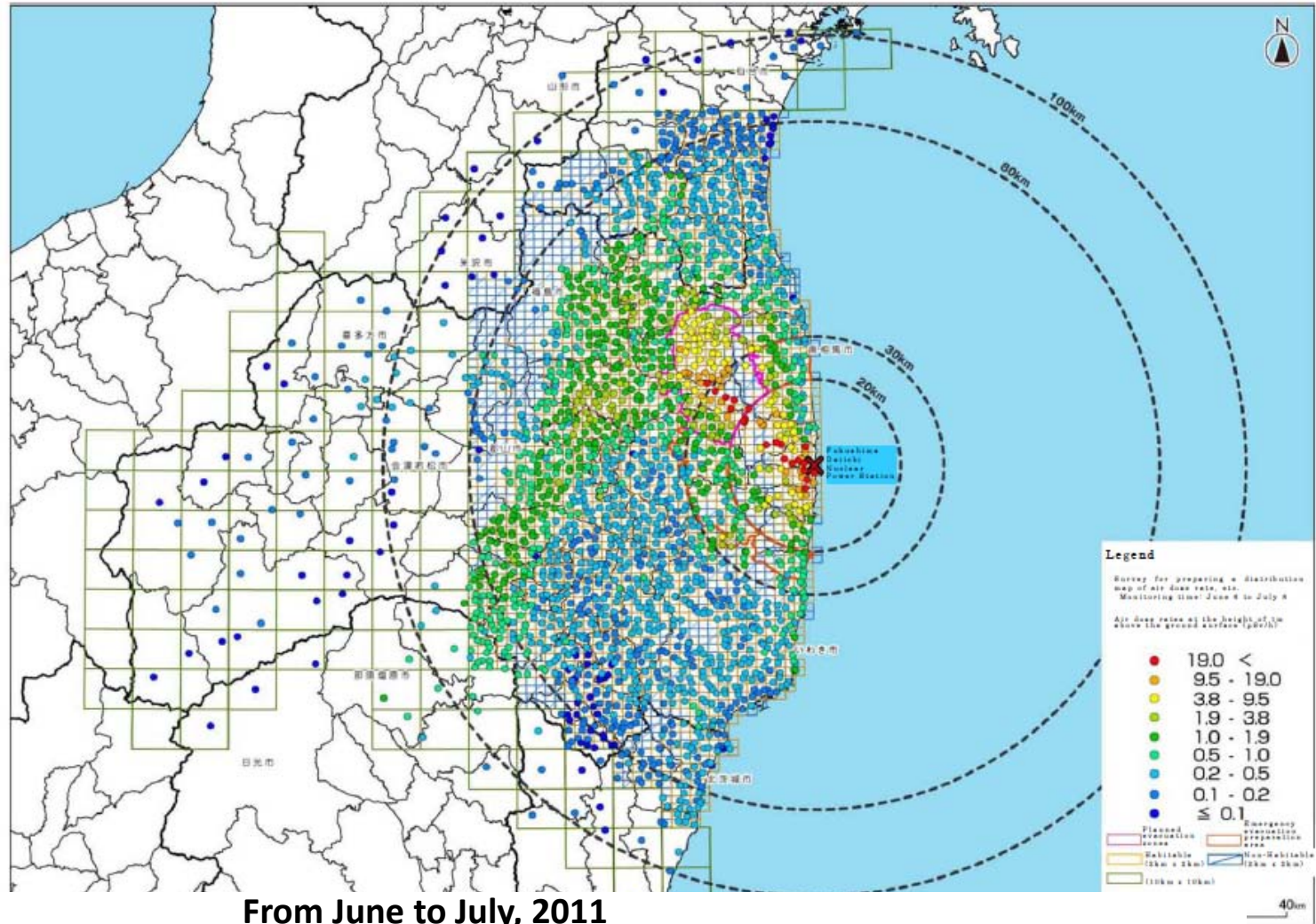
# *Appendix*

# Radioactivity concentration in soil (as of August 14<sup>th</sup>)



# Map of air dose rates at points where soil samples were collected

15-17 November, 2011  
OECD/NEA, 12<sup>th</sup> WPDD Meeting  
Issy-les-Moulineaux, France

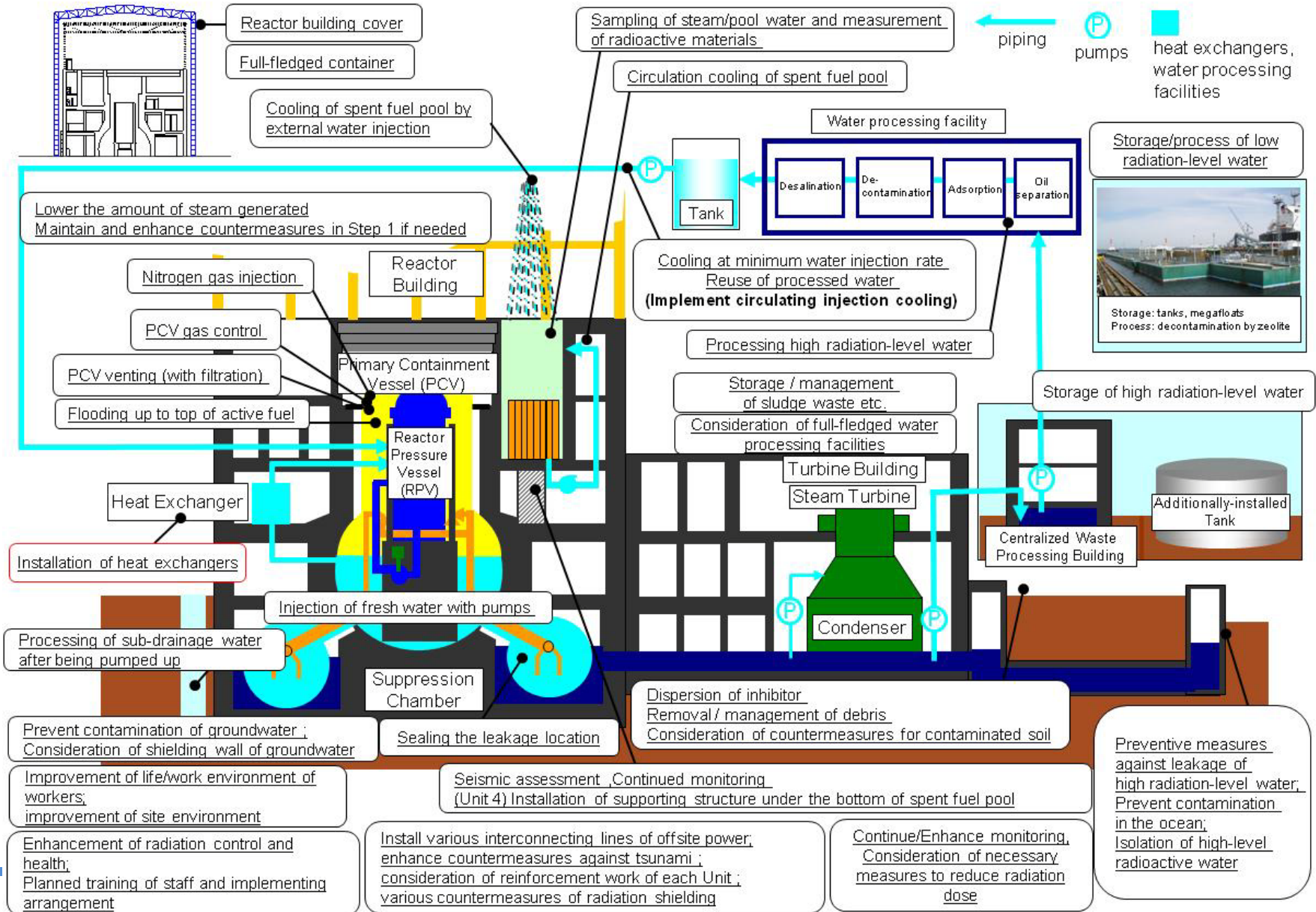




# Current Status of "Roadmap towards Restoration from the Accident at Fukushima Daiichi Nuclear Power Station, TEPCO" (Revised on 20 Sep. '11)

Issues		As of Apr. 17	Step 1 (around 3 months)	Step 2 (around 3 to 6 months after achieving Step1) ▼ current status (as of Sep. 20)	Mid-term issues (around 3 years)	
III. Monitoring/Decontamination	⑨ Measurement, Reduction and Disclosure	Expansion, enhancement and disclosure of radiation dose monitoring in and out of the power station			Decontamination	Continuous environmental monitoring
		Consideration / start of full-fledged decontamination				Continuous decontamination
IV. Countermeasures for aftershocks, etc	⑦ Tsunami, Reinforcement, etc	Enhancement of countermeasures against aftershocks and tsunamis, preparation for various countermeasures for radiation shielding			Mitigate disasters	Continue various countermeasures for radiation shielding
		(Unit 4 spent fuel pool) Installation of supporting structure ☆				Consideration / implementation of reinforcement work of each Unit ☆
V. Environment improvement	⑧ Living/working environment	Improvement of workers' living / working environment			Enhancement of environment improvement	Improvement of workers' living / working environment
	⑤ Radiation control / Medical care	Improvement of radiation control / medical system			Enhancement of Healthcare	Improvement of radiation control / medical system
	⑩ Staff Training, personnel allocation	Systematic implementation of staff training / personnel allocation			Exhaustive radiation dose control	Systematic implementation of staff training / personnel allocation
Measures for Mid-term issues				Government's concept of securing safety	Response based on the plant operation plan	
				Establishing plant operation plan based on the safety concept		

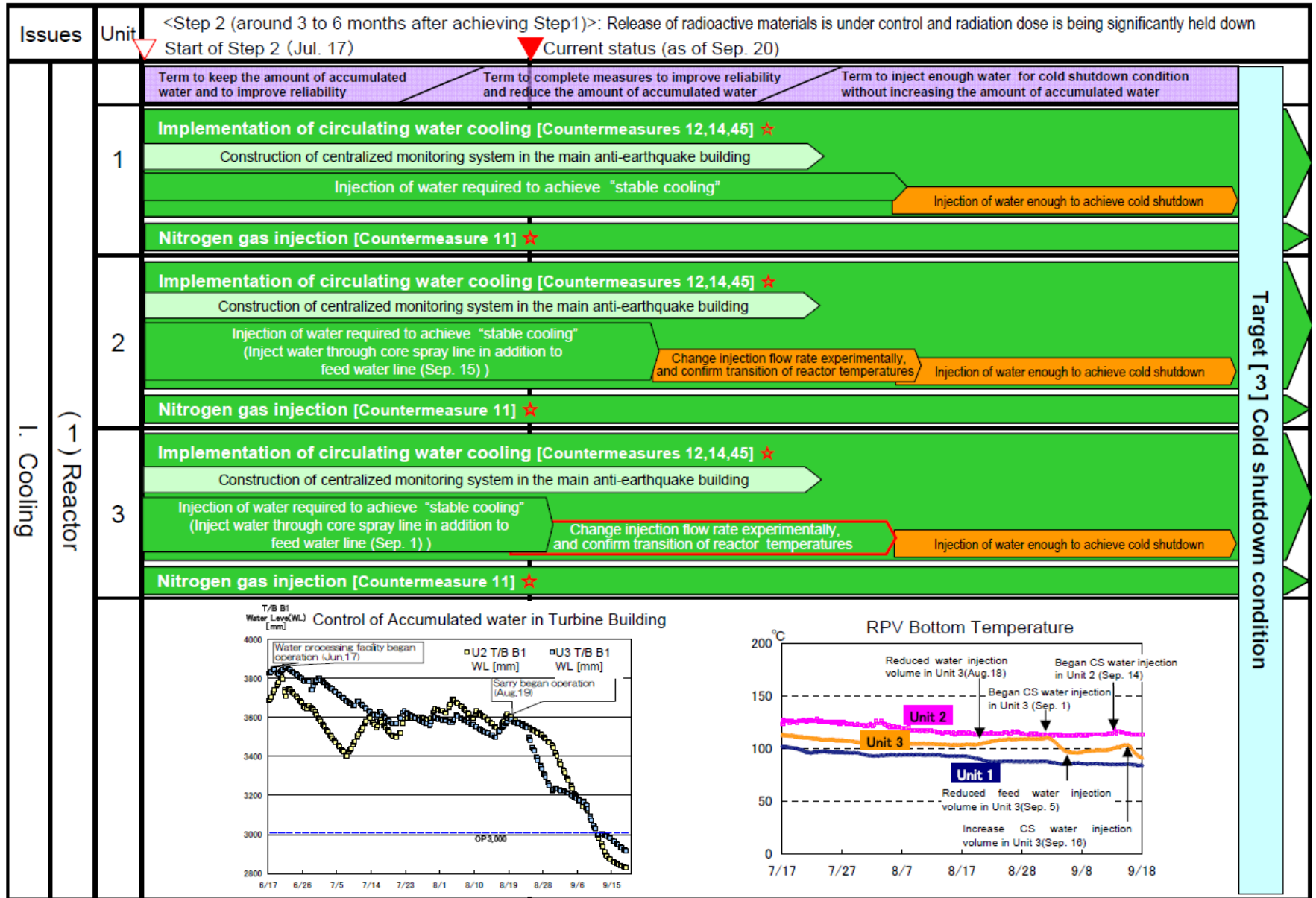
# Overview of Major Countermeasures in the Power Station





# Current Status of Countermeasure (1)

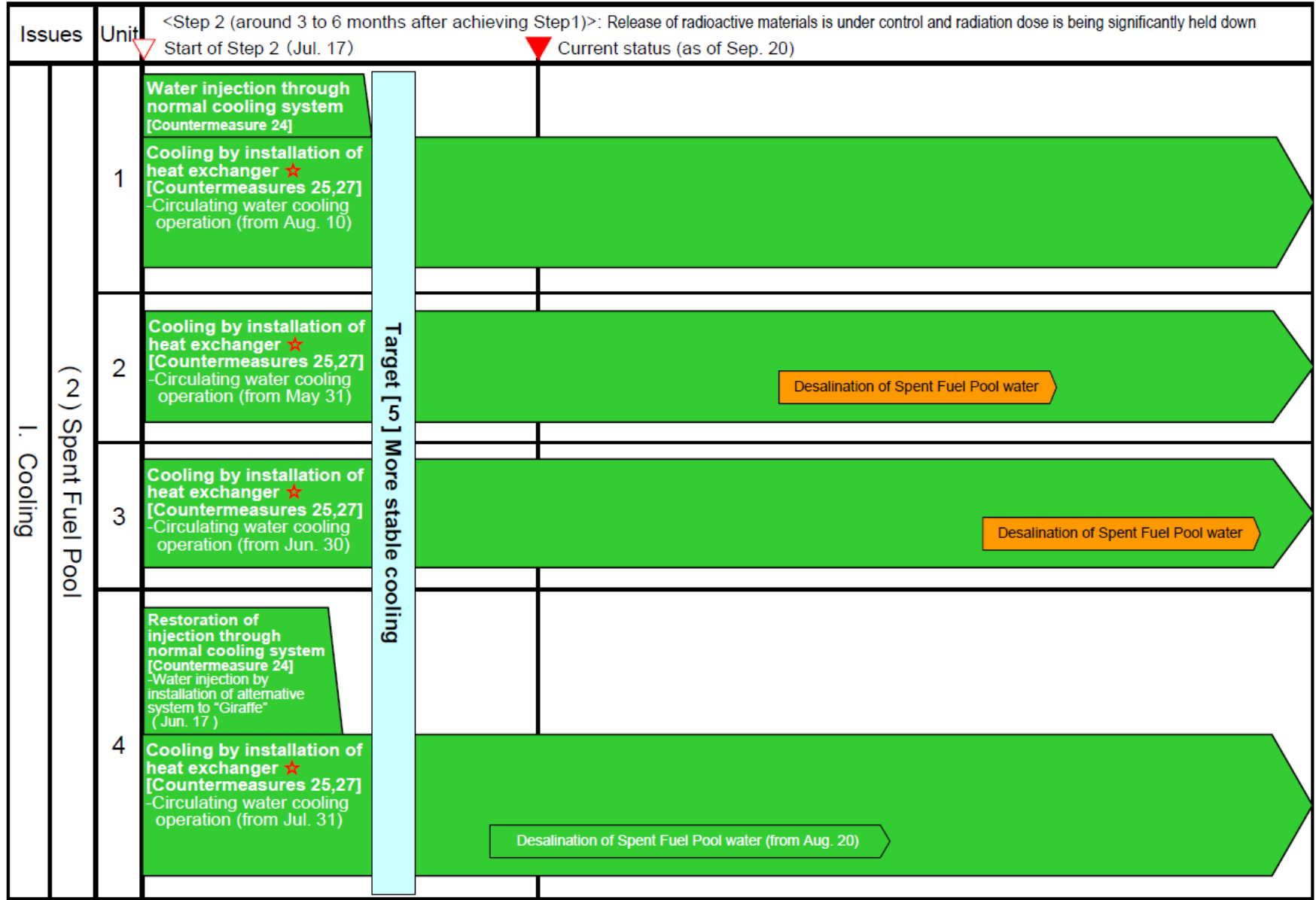
Red frame: progressed countermeasures from the previous version, ☆: already reported to the government



Legend:  : Implemented (monitored by government as necessary) ☆: Safety check by government (report)  : Under construction  : Field work started  : Field work not started yet

# Current Status of Countermeasure (2)

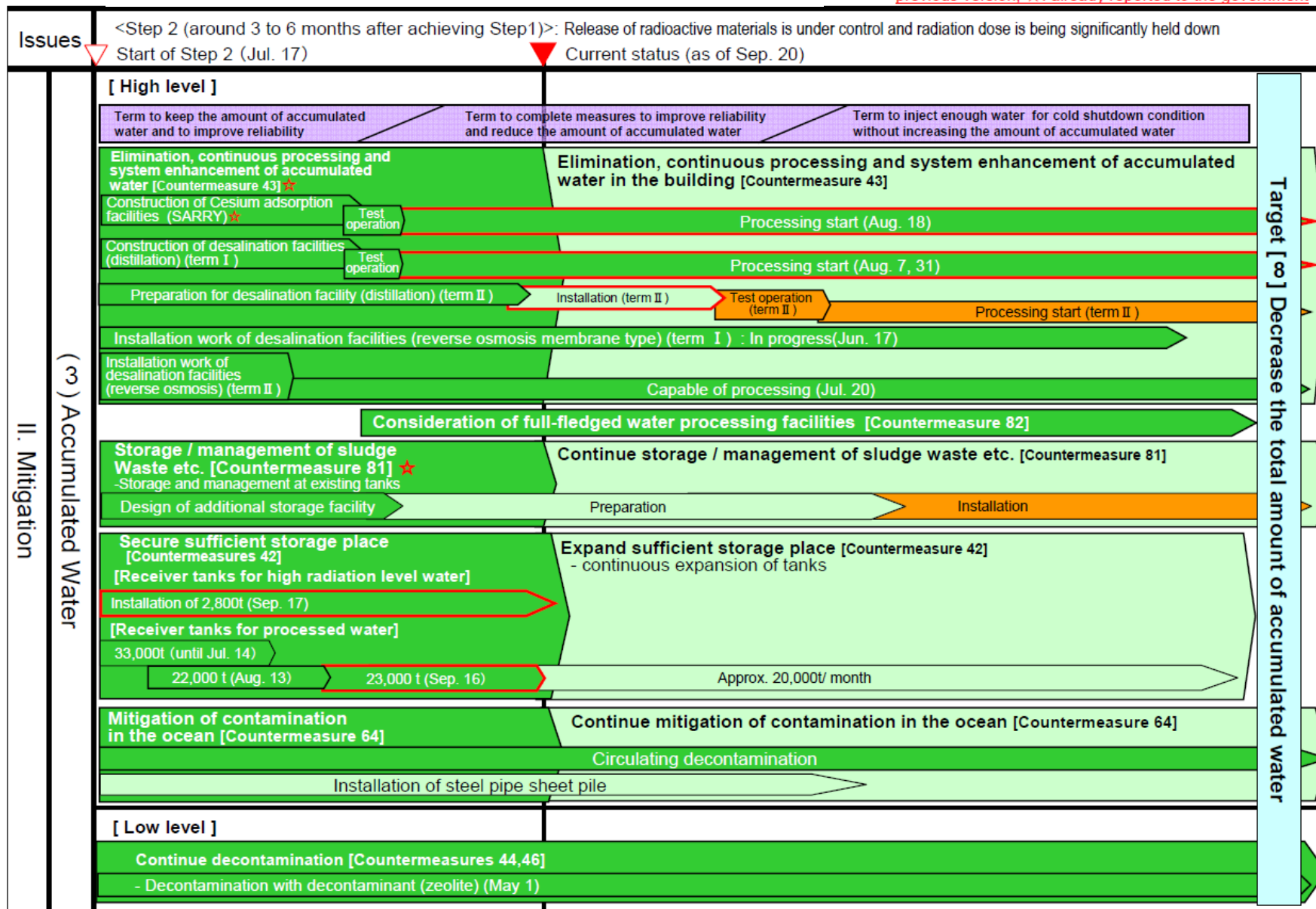
Red frame: progressed countermeasures from the previous version, ☆: already reported to the government



Legend:  : Implemented (monitored by government as necessary) ☆: Safety check by government (report)  : Under construction  : Field work started  : Field work not started yet

# Current Status of Countermeasure (3)

Red frame: progressed countermeasures from the previous version, ☆: already reported to the government



# Current Status of Countermeasure (4)

Red colored letter: newly added countermeasures. Red frame: progressed countermeasures from the previous version. ☆: already reported to the government

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Issues		<Step 2 (about 3 to 6 months after achieving Step1)>: Release of radioactive materials is under control and radiation dose is being significantly held down		
		Start of Step 2 (Jul. 17)	Current status (as of Sep. 20)	
II. Mitigation	(4) Groundwater	Implementation of preventions against expansion of groundwater contamination [Countermeasure 67] - Restoration of sub-drainage pumps with expansion of storage / processing facilities	Target [1] Mitigation of ocean contamination	
		Design of impermeable wall against groundwater [Countermeasure 68]	Begin establishment of impermeable wall against groundwater [Countermeasure 83]	
	(4) Atmosphere / Soil	Confirmation of solidification of inhibitor [Countermeasure 52]	Target [10] Prevent scattering of radioactive materials	
		Removal / management of debris [Countermeasure 53, 87] - Collected debris (Volume of approx. 800 containers (as of Sep. 20)) - Management of collected debris etc. in storage areas		
		Installation of reactor building cover (Unit 1) [Countermeasures 54,55] ☆ - Under construction		
		Removal of debris on top of reactor buildings (Unit 3&4) [Countermeasures 84] - Under preparatory construction (Unit3: Jun. 20, Unit4: Jun. 24)		
		Preparation for Unit 3 (Removal of debris on the ground, maintenance of road for crane etc.)		Removal of debris on top of reactor buildings (Sep. 10)
		Preparation for Unit 4 (Removal of debris on the ground, maintenance of road for crane etc.)		Removal of debris on top of reactor buildings
	Consideration of reactor building container [Countermeasure 50]	Target [2] Sufficiently reduce radiation dose		
	Installation of PCV gas control system [Countermeasure 86]			
III. Monitoring / Decontamination	(8) Measurement, Reduction and Disclosure	Continue to assess current release of radioactive materials [Countermeasures 60,61] • TEPCO has assessed the current release rate from Unit 1 to Unit 3 utilizing the airborne radioactivity concentration at the upper part of the reactor buildings.  - The total current release rate is estimated to be approx. 0.2 billion Bq/h from Unit 1 to Unit 3 (compared to the aftermath of the accident, the present measurement is approx. 1/4,000,000.)  - The maximum value of radiation exposure per year at the site boundaries is assessed at approx. 0.4 mSv/year provisionally. (excluding the effect of the radioactive materials already released up until now.)  • Continuously implement the measurements of airborne radioactivity concentration at the upper part of the reactor buildings, thus grasping the reduction tendency of the reduced amount from mitigation countermeasures. More accurate assessment is planned to be implemented in the future.	Target [2] Sufficiently reduce radiation dose	
		Implementation of monitoring in cooperation with the government, prefectures, municipalities and operators [Countermeasures 62]		
		Consideration / start of full-fledged decontamination [Countermeasures 63] "Basic Concept for Pushing Ahead with Decontamination Works" and "Basic Policy for Emergency Response on Decontamination Work", etc. have been established (Aug. 26.) From the end of August, the implementation of decontamination operations has begun.		

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# Current Status of Countermeasure (5)

Red colored letter: newly added countermeasures. Red frame: progressed countermeasures from the previous version. ☆: already reported to the government

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Issues		<Step 2 (around 3 to 6 months after achieving Step1)>: Release of radioactive materials is under control and radiation dose is being significantly held down	Start of Step 2 (Jul. 17)	Current status (as of Sep. 20)
IV. Countermeasures against aftershocks, etc	reinforcement, etc (㊦) Tsunami	(Unit 4) Installation of supporting structure under the bottom of the fuel pool [Countermeasure 26] ☆ (Jul. 30)	Consideration and implementation of reinforcement work of each Unit [Countermeasure 71] - Evaluation of seismic resistance has been completed (Aug.26) ☆ - Investigation inside the building is planned after countermeasures to reduce radiation dose achieved	Target [㉑] Mitigation of disasters
		Continue various countermeasures for radiation shielding [Countermeasure 73]		
V. Environment improvement	Living / working Environment (∞)	Continuation and enhancement of improvement of workers' living / working environment [Countermeasure 75] - Accommodations for approx. 1,600 people have been prepared. Approx. 1,100 people have already moved in (as of Sep. 11) - Seventeen on-site rest station have been established (approx. 3,400m <sup>2</sup> in size with a capacity to accommodate approx. 1,200 people) (as of Sep. 9)		Target [㉒] Enhancement of environment improvement
	Radiation control / Medical care (☉)	Continuous improvement of radiation control [Countermeasure 78] - Reinforcement of radiation control by NISA - Expansion of whole-body counters, implementation of monthly internal exposure measurement ☆ - Automated recording of personal radiation dose, written notification of exposure dose ☆, introduction of workers' certificates with photos ☆ - Consideration of long-term healthcare such as enhancement of safety training for workers and establishing database etc.		Target [㉓] Enhancement of healthcare
		Continuous reinforcement of medical system [Countermeasure 80] - Install new emergency medical facility, establish organization with resident specialists (on call 24 hours a day), speedy transportation of patients - Intensive preventive measures against heat stroke ☆ (trainings for new workers), countermeasures for mental health and conducting medical examination - Establish industrial hygiene system such as preventive healthcare		
	Staff Training / personnel allocation (㉔)	Systematic staff training and personnel allocation [Countermeasure 85] - Promote human resources training in cooperation with the government and operators		Target [㉔] Exhaustive radiation dose control

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## R &D Items for Medium- and Long-term Actions for Fukushima Daiichi NPSs (by JAEC)- (1)

Subject	Action	Breakthrough Technology
Retrieval of Fuel from Spent Fuel Pool (SFP)	(Technical Challenge) <i>Research on methods to deal with damaged saline fuel(handling, cleaning, inspection, availability for reprocessing, etc.</i>	
	1. Evaluation of the long-term integrity of fuel assemblies etc., in the SFP and the Common Pool.	1) <i>Evaluation of the long-term integrity of fuel assembly during storage</i> 2) <i>Establishment of cleaning criteria for fuel assembly</i>
	2. Establishment of Indicators on Possible Reprocessing	<i>Categorizing indicators will be identified in terms of their impact on the handling failed fuel, etc., and on chemical treatment processes, etc., and criteria will be developed to determine possible reprocessing.</i>
	3. Establishment of Method for Handling Failed Fuel	1) <i>Case research on failed fuel</i> 2) <i>Examination of the impact of failed fuel, etc., on chemical treatment process, etc.</i> 3) <i>Examination regarding the handling of failed fuel, etc.</i>



## R & D Items for Medium- and Long-term Actions for Fukushima Daiichi NPSs (by JAEC)- (2)

Subject	Action	Breakthrough Technology	
On going Efforts for Stabilization and Decommissioning	(Technical Challenge) 1) <i>Study of remote decontamination methods to improve human accessibility o high radioactive areas in a building.</i> 2) <i>Evaluation of corrosion resistance of the pressure vessel and the containment and implementation of corrosion control measures if necessary</i> 3) <i>Study of treatment and disposal methods of high dose secondary waste generated from operation of the water treatment system</i>		
	4. Examination of Method for Decontamination to Access Buildings Interiors	1) <i>Establishment of decontamination plan according to estimates and surveys on the contamination status.</i> 2) <i>Identification of decontamination techniques and decontamination planning.</i> 3) <i>Decontamination testing using simulated contamination.</i> 4) <i>Development of remotely operated devices to develop devices and systems that allow the possible measuring and decontamination techniques to be mounted on the existing traveling carriages.</i>	<i>Remote decontamination devices appropriate for different areas including high dose or narrow areas requiring decontamination</i>
	5. Assessment on the integrity of the Pressure Vessel and Containment Vessel against Corrosion	1) <i>Corrosion test of structural materials of RPVs and PCVs</i> 2) <i>Corrosion test of RPV pedestal reinforcement</i> 3) <i>Confirmation test of corrosion inhibitors for RPVs, and RPV pedestals</i> 4) <i>Residual life evaluation and life extension evaluation of RPVs, PCVs, and RPV pedestal structure.</i> 5) <i>Trial use of corrosion inhibitors in the actual plant (eligible material for effectiveness confirmation; PCV structural materials)</i>	
	6. R&D for Stable Disposal of Secondary Wastes Generated by Treatment of Contaminated Water	1) <i>Behavioral Assessment of waste zeolite, sludge, and concentrated liquid wastes.</i> 2) <i>Safety evaluation regarding generation of hydrogen gas and heat generation.</i> 3) <i>Establishment of a method for long-term storage taking into account the impact of seawater, heat generation, and high-level radioactivity, etc.</i> 4) <i>Consideration of disposal of waste zeolite, sludge, and concentrated liquid wastes in the form waste packages.</i> 5) <i>Characteristics evaluation of waste packages.</i> 6) <i>Study if optimizing waste disposal method</i>	

## R & D Items for Medium- and Long-term Actions for Fukushima Daiichi NPSs (by JAEC)- (3)

Subject	Action	Breakthrough Technology
<p>(Technical Challenge)</p> <p><i>Development of technologies and techniques to identify and repair a leaking portion such as the containment and then create the boundary in order to fill the affected portion with water, since it is considered that failed fuel can be most reasonably discharged underwater for the purpose of shielding radiation.</i></p>		
<p>7. Development of Measures and Equipment for Investigation of Locations of Leaks in Containment Vessel</p>	<p><i>1) Identification of all possible locations of leaks</i>  <i>2) Study of existing techniques</i>  <i>3) Development of techniques for identifying locations do leaks on PCVs.</i>  <i>4) Development of remote inspection devices around PCVs.</i></p>	<p><i>Inspection devices to remotely identify leaking portions on PCVs in a narrow or high dose area.</i></p>
<p>8. Establishment of Measures to prepare for Water Filling ( Repair, Sealing,etc.) and Development of Methods and Equipment</p>	<p><i>1) Surveying catalogs of existing techniques</i>  <i>2) Examination and development of materials and equipment for repair (seal materials, grout materials, etc.)</i>  <i>3) Development of methods and techniques for repair (stopping of water) of supposed leaking locations.</i>  <i>4) Development of robots for PCV remote repair.</i></p>	<p><i>Techniques to remotely repair (to stop water) leaking portions on PCVs under the situation of high dose and flowing water and repair devices</i></p>
<p>9. Development of Measures and Equipment for Investigation of the PCV Interior</p>	<p>1) Planning for Investigation based on the estimated states                  2) Development of an access method and remote equipment                  3) Measures to prevent dispersion of radioactive materials from inside PCVs.                  4) Development of remote inspection equipment and techniques</p>	<p>1) Remote inspection technologies by entering PCVs with poor accessibility under the conditions of under interior situation and high dose.                  2) Remote sampling technologies for fuel debris in PCVs.</p>

# R &D Items for Medium- and Long-term Actions for Fukushima Daiichi NPSs (by JAEC)- (4)

	Subject	Action	Breakthrough Technology
Preparation for Retrieval and Retrieval of Debris	10. Development of Measures and Equipment for Preliminary Survey of Reactor Interior	1) Study of existing techniques 2) Planning for investigation based on the estimation from fact findings and analyses conducted for the interior and exterior of PCVs. 3) Establishment of a method for get access to and investigate the inside of PCVs. 4) Development of remote investigation techniques under a high dose environment. 5) Development and Implementation of techniques to sample debris fuel	
	(Technical Challenge) <i>Development of advanced removal technologies compared with the TMI accident that the core damage was limited within the pressure vessel.</i>		
	11. Development of Method and Equipment for Retrieving Fuel and Reactor Internals	<i>1) Surveying catalogs of existing techniques (including the verification of equipment whose performance was proven in TMI)                      2) Planning of a method for retrieval based on the results of preliminary surveys                      3) Development of techniques for remotely discharging in-vessel fuel debris                      4) Development of techniques for remotely discharging fuel debris in PCVs</i>	<i>Remote technology to discharge in-vessel fuel depending on the distribution of fuel debris                      Remote technology to discharge fuel debris in PCVs</i>
12. Development of Techniques for Management of Criticality	<i>1) Evaluation of criticality                      2) Technologies for detecting re-criticality in the reactors                      3) Techniques for criticality prevention</i>	<i>Evaluation of criticality of in-vessel fuel depending on the distribution of fuel debris.                      Technology for preventing criticality</i>	

# R &D Items for Medium- and Long-term Actions for Fukushima Daiichi NPSs (by JAEC)- (5)

	Subject	Action	Breakthrough Technology	
Preparation for Retrieval and Retrieval of Debris	13. Characteristic Tests Using Simulated Debris	1) Preparation of simulated debris 2) Evaluation of Characteristics of simulated debris 3) Comparison with debris from TMI	<i>Development of simulated in-vessel fuel debris taking into consideration the duration of melting, sweater injection, etc.</i>	
	14. Property Analysis of Debris in Actual Reactors	<i>The property analysis of actual debris in the core will be carried out to establish techniques for collecting in-vessel fuel debris, review of treatment and disposal discharger duel and accident analysis.</i>		
	(Technical Challenge) 1) Development of technology (storage dram) to store stably 2) Review of appropriate measures for treatment and disposal			
	15. Development of Storage Drums for Debris	1) Study of existing techniques 2) Examination of storage systems for debris	<i>Technology to store in-vessel fuel debris taking into consideration the treatment and disposal</i>	