Current status of Fukushima Daiichi NPS

- Efforts for Contaminated Water Issue and Decommissioning -

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METI
Ministry of Economy, Trade and Industry

Topics

1. Current status of Fukushima Daiichi NPPs
2. Decommissioning
3. Contaminated water and countermeasures
4. Efforts to work with global expertise
5. Summary

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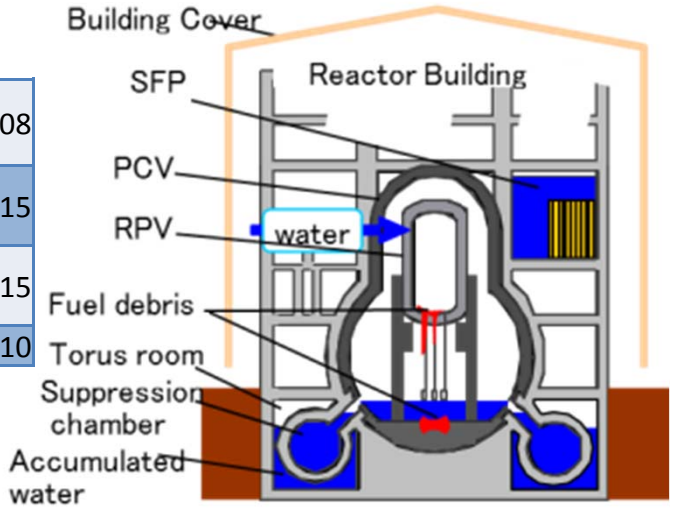
Ministry of Economy, Trade and Industry

Current Status of Fukushima Daiichi NPP

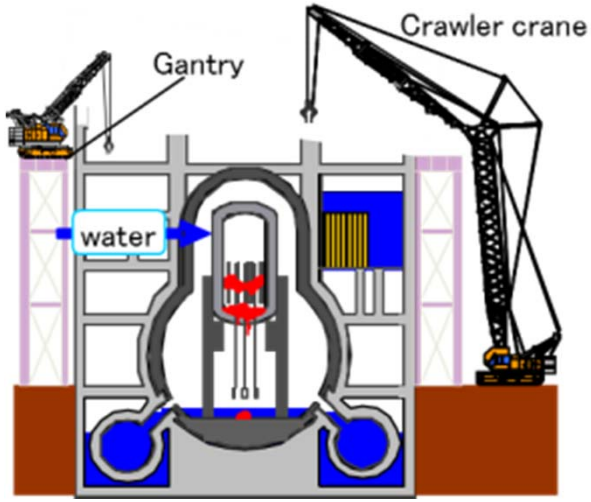
Unit 1

Water Injection to RPV[m^3/d]	108
RPV Bottom Temperature[℃]	15
PCV Temperature[℃]	15
SFP Temperature[℃]	10



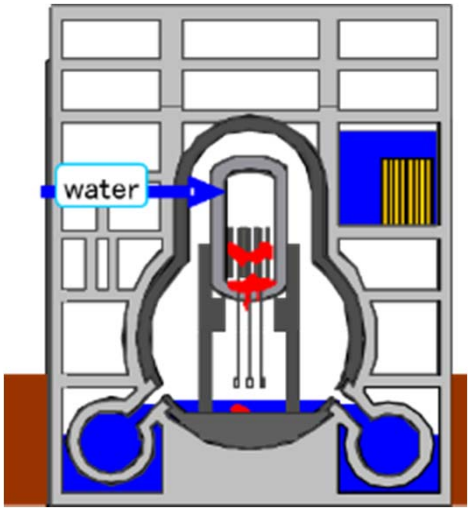
Unit 3

Water Injection to RPV[m^3/d]	106
RPV Bottom Temperature[℃]	22
PCV Temperature[℃]	21
SFP Temperature[℃]	8



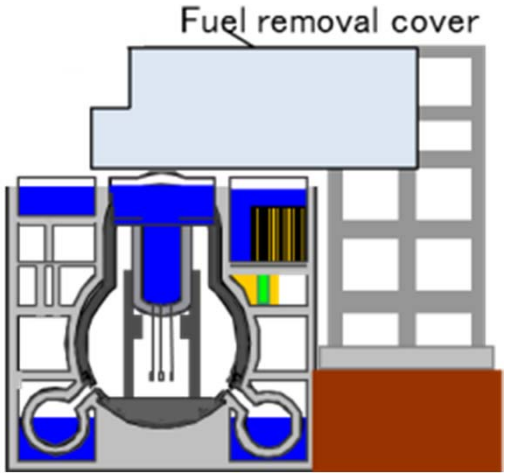
Unit 2

Water Injection to RPV[m^3/d]	106
RPV Bottom Temperature[℃]	25
PCV Temperature[℃]	24
SFP Temperature[℃]	10



Unit 4

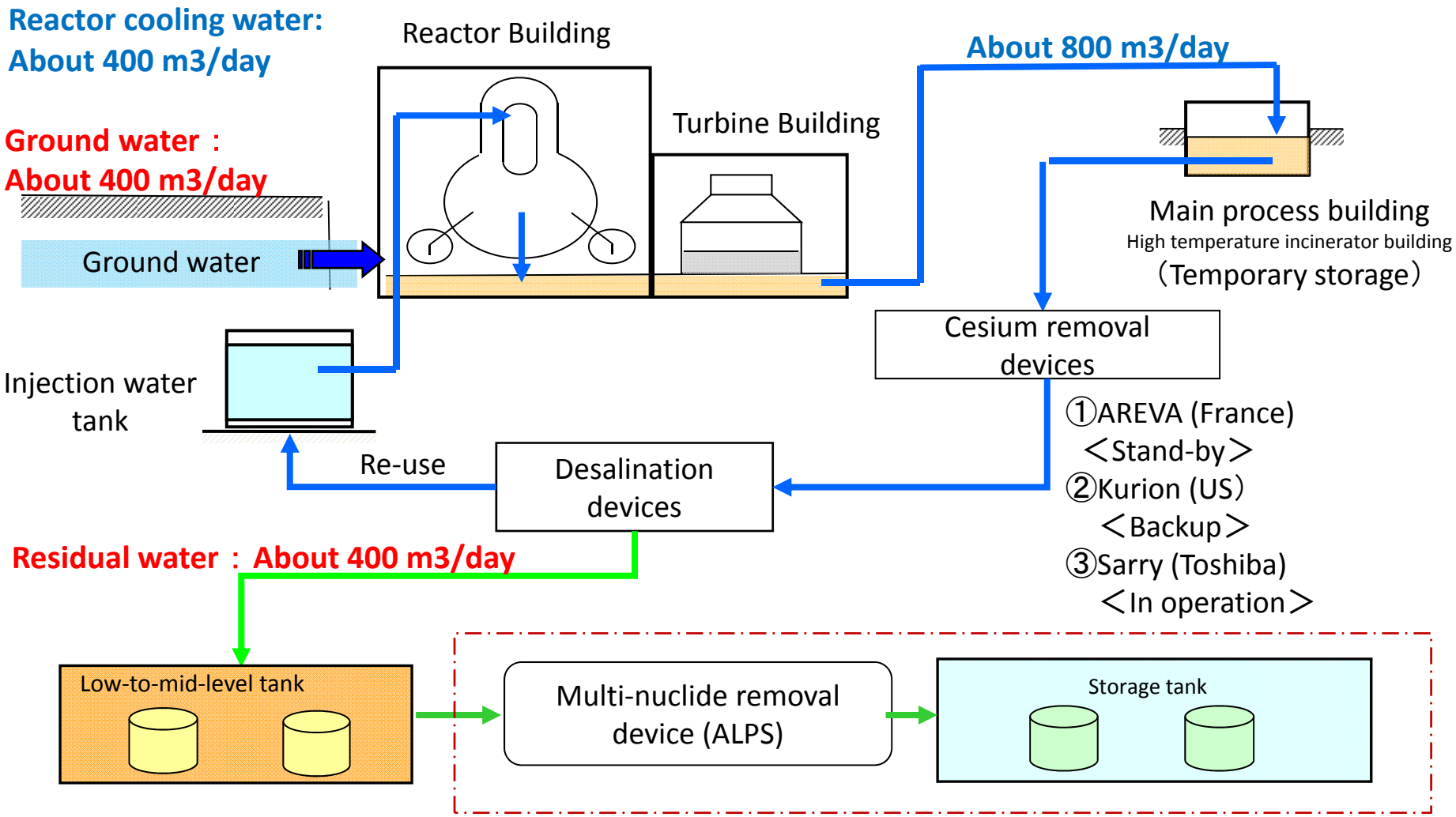
Water Injection to RPV[m^3/d]	No fuel in RPV
RPV Bottom Temperature[℃]	
PCV Temperature[℃]	
SFP Temperature[℃]	13



(Source: TEPCO, data are as of 11:00am on 14 Feb, 2014)

Contaminated Water Treatment System

＜Overview of the System＞



Fuel Rods Removal from Unit 4 SFP

Inside of Unit 4 cover

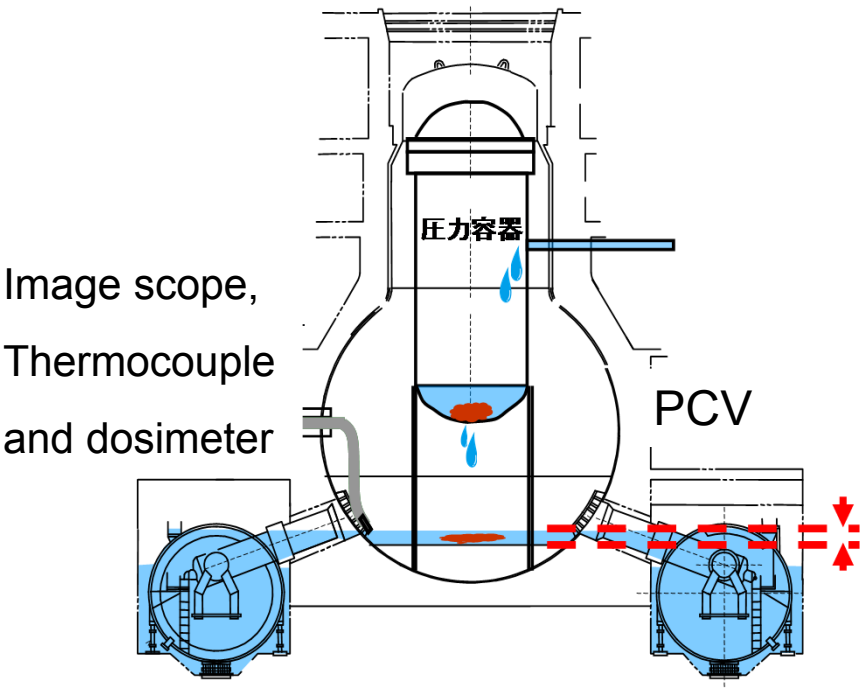
Inside of SFP in the Unit 4

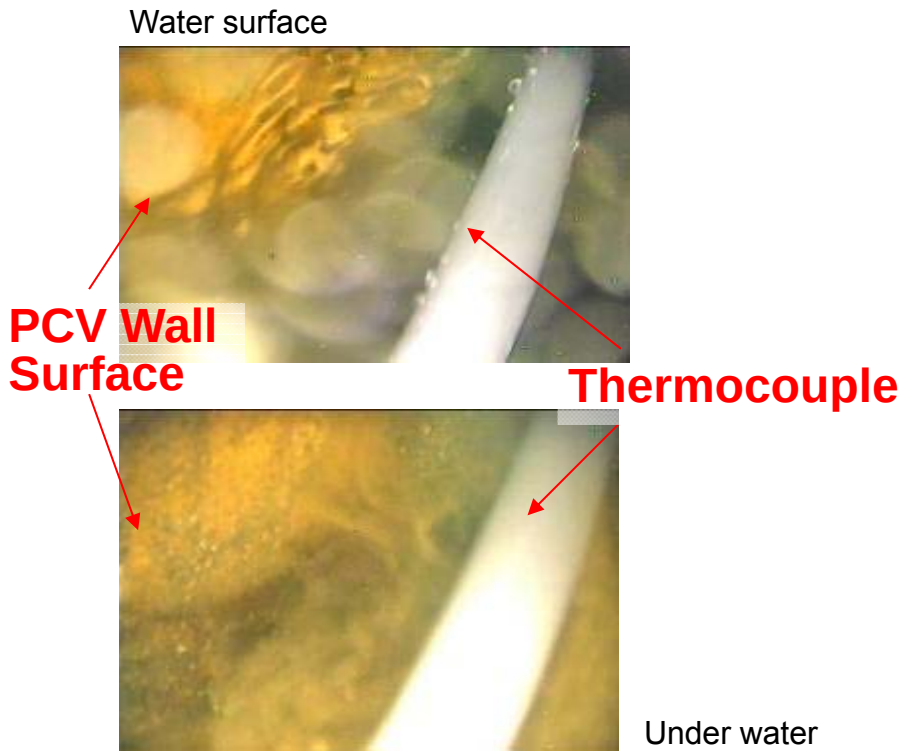
(Source: TEPCO's website)

→ <u>Removal of spent fuel from Unit 4 has started since 18 November 2013.</u>

Investigation of PCV internal of #2

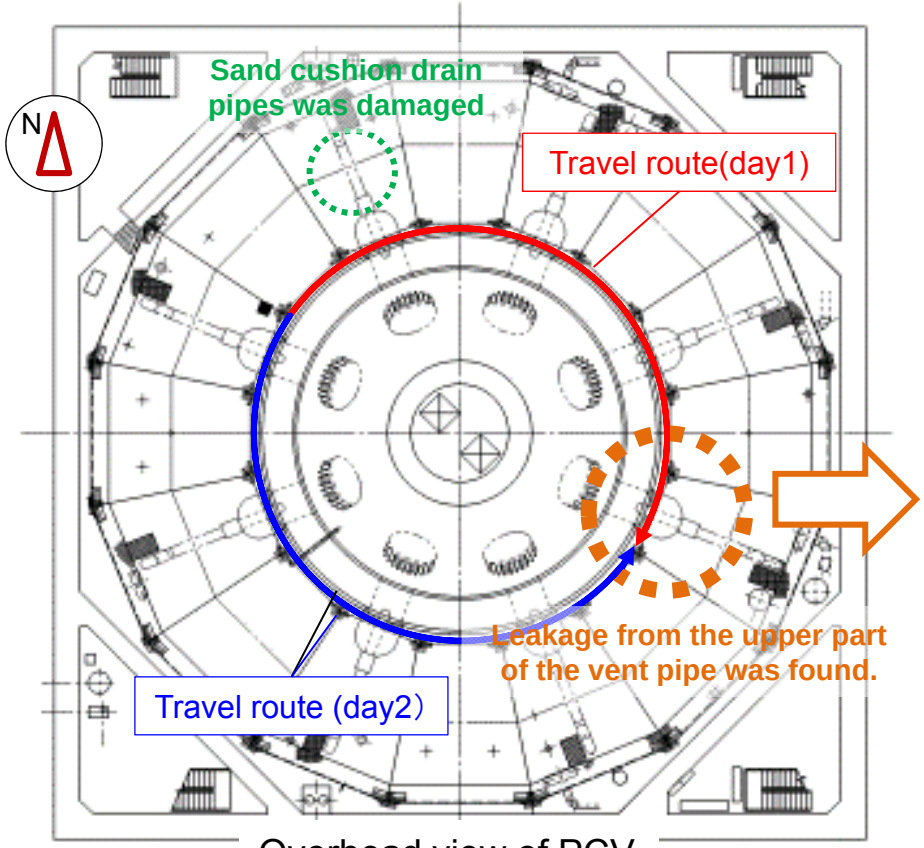
- Inside of PCV was investigated with a camera, and the radiation dose and water level were measured.
- Maximum radiation dose was 73 Sv/h, the water level was approx. +60 cm from the bottom of PCV.



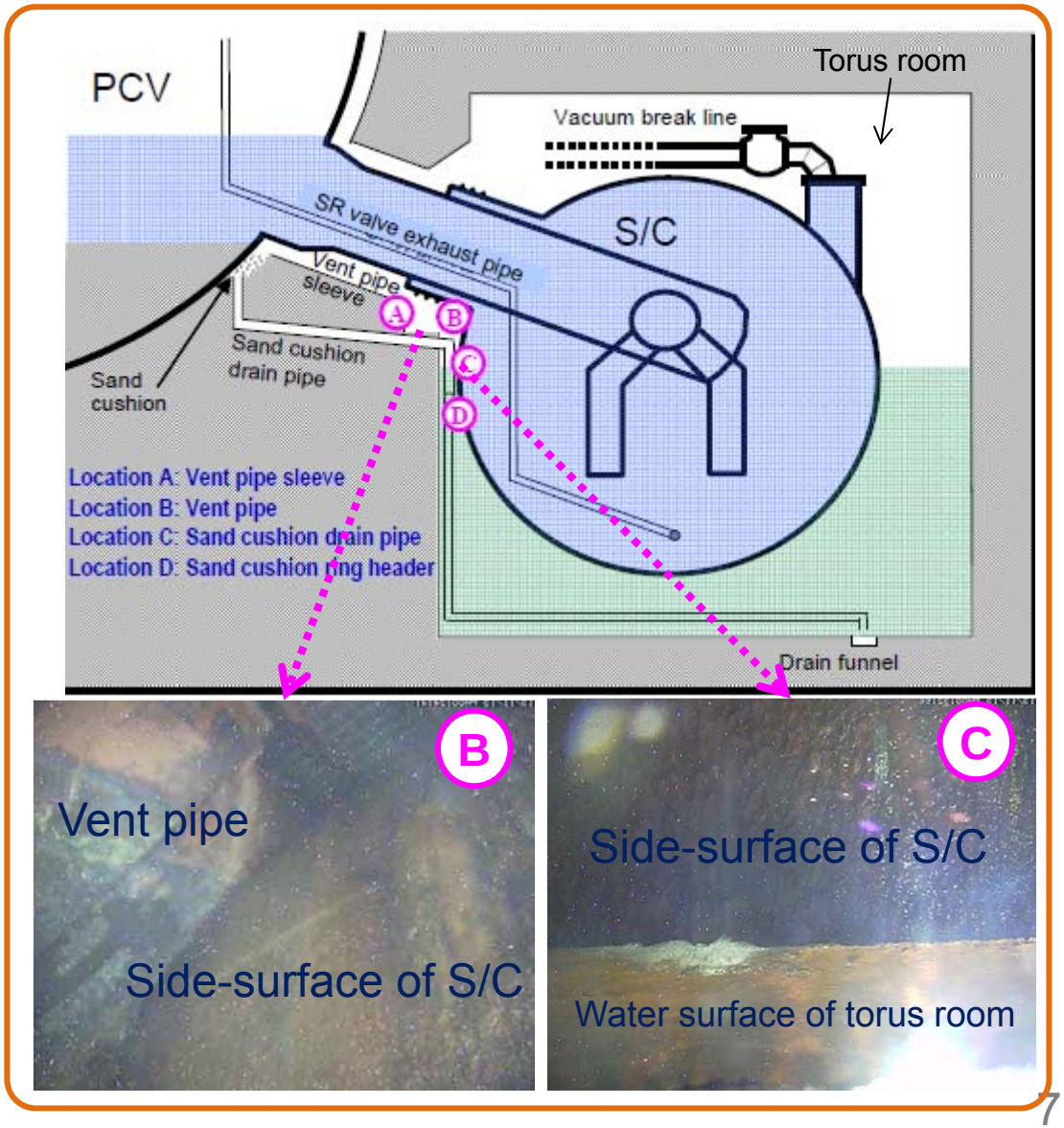


Identified some of Water Leakage Pathways from PCV

- It had been assumed that the water has been leaking from the PCV to the reactor buildings, but the specific place of the leakage had not been identified.



Overhead view of PCV



Surface boat
length : 90cm
width : 33cm
height : 29.3cm
weight : 27kg

Groundwater contamination and leakage from tanks

Decommissioning

Overview of the Mid-and-Long-Term Roadmap

Roadmap describes the main steps and activities towards the decommissioning of Fukushima Daiichi NPS

March 11, 2011	**The Great East Japan Earthquake**
December 21, 2011	The Government and TEPCO Council adopted "the Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi NPP Units 1-4 (Mid-and-Long-Term Roadmap ver. 1.0)"
June 27, 2013	**Mid-and-Long-Term Roadmap was revised (ver. 2.0).**

Principle 1: Systematically tackle the issues while placing top priority on the safety of local citizens and workers.

Principle 2: Move forward while maintaining transparent communications with local and national citizens to gain their understanding and respect.

Principle 3: Continuously update the roadmap in consideration of the on-site situation and the latest R&D result.

Principle 4: Harmonize the efforts of TEPCO and Government of Japan to achieve the goals indicated in this Roadmap. The Government of Japan should take the initiative in promoting the efforts to implement decommissioning measures safely and steadily.

Targets of Roadmap

December 2011 (Step 2 Achieved) | **December 2013** | **December 2021** | **30 to 40 years in the future**

Efforts to stabilize the NPP

＜Cold shutdown achieved＞
- Achieve cold shutdown
- Significantly reduce radiation releases

Phase 1	Phase 2	Phase 3
Period up to the commencement of the removal of the fuel from the spent fuel pool (within 2 years)	**Period up to the commencement of the removal of the fuel debris (within 10 years)**	**Period up to the completion of decommissioning measures (30 to 40 years in the future)**

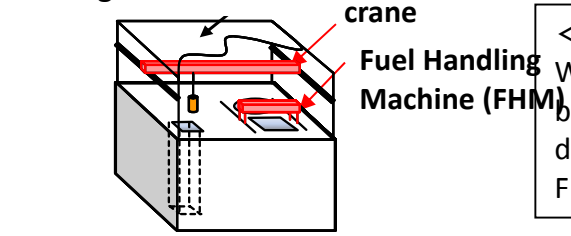
Since 18 Nov, TEPCO has started fuel rods removal from Unit 4 SFP as target of Phase 1

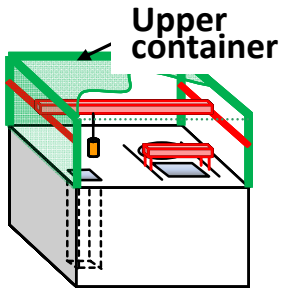
Major areas of the Roadmap

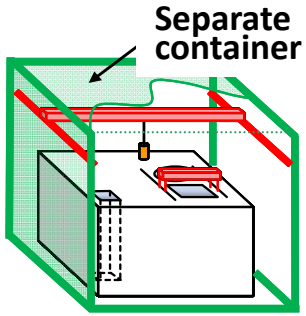
. The major areas of the roadmap are followings;

- Circulating Water Injection Cooling
- Accumulated Water Treatment
- Reducing of Environmental Radiation Dose
- Improvement of Work Environment
- Fuel Retrieval from Spent Fuel Pool
- Preparation for Fuel Debris Removal
- Radioactive Waste Treatment and Disposal

Plan under the Revised Roadmap (example: Unit 2)







December 2021

＜Plan 1＞
When the existing reactor building can be decontaminated and the FHM can be restored

First half of FY2020
(one-and-a-half years earlier than the initial plan)

Commencement of the removal of the fuel debris

＜Plan 2＞
When the reactor building has sufficient seismic resistance for a container to be constructed on its upper level

First half of FY2021
(6 months earlier than the initial plan)

Commencement of the removal of the fuel debris

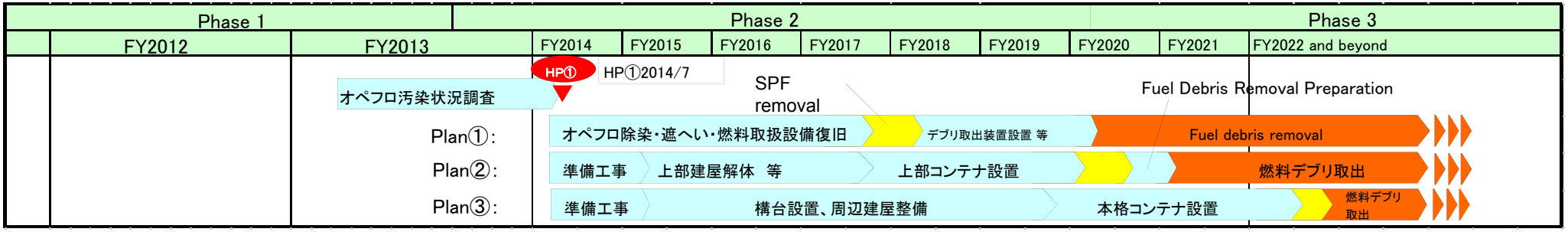
＜Plan 3＞
When the reactor building lacks sufficient seismic resistance, necessitating the construction of a separate container

First half of FY2024

Commencement of the removal of the fuel debris

Future plans will be narrowed down in the first half of FY2014 based on the results of analysis of 1)the possibility of the existing reactor building's decontamination, 2)restoration of the FHM and 3) the results of the assessment of the seismic resistance of the existing reactor building.

Plan for removing spent fuel and fuel debris; Unit 2



Hold points (HP①): Decision-making process in July 2014

*1: Safety concerning upper containment unit load
: Determination of containment unit design conditions is a precondition

Commencement of deliberation

Feasibility of operating floor decontamination (Below 1mSv/h) Fuel handling equipment restoration

Not feasible

Reactor building soundness *1

Not feasible

Feasible

Feasible

Fuel removal

Existing reactor building

Existing reactor building
既存原子炉建屋

Ceiling crane

Fuel handling equipment

Fuel handling machine

Fuel removal | Debris removal

Plan①

Upper containment unit

上部コンテナ
Upper containment unit

Fuel removal | Debris removal

Plan②

Full-scale containment unit

Full-scale containment unit
本格コンテナ

Fuel removal | Debris removal

Plan③

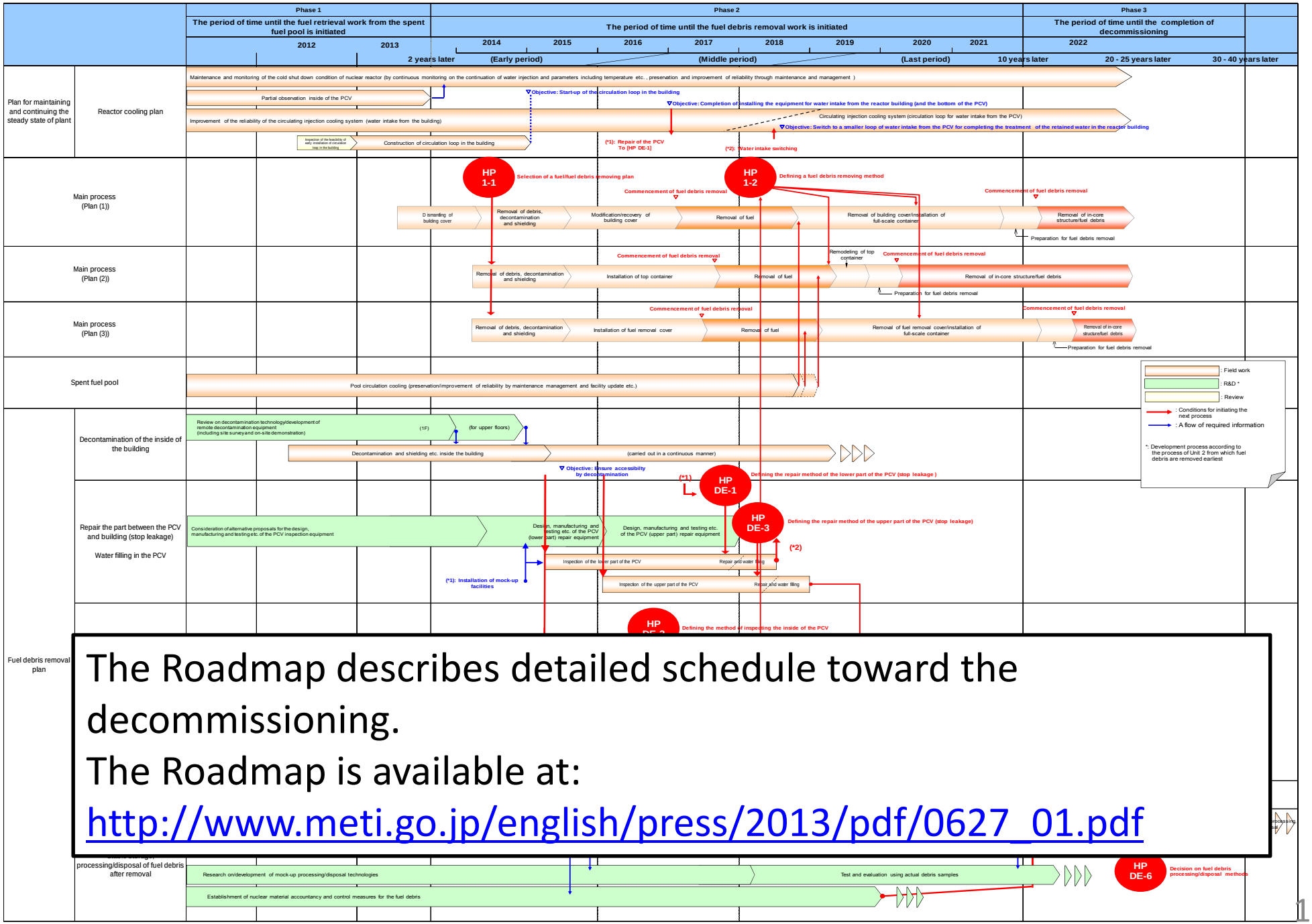
Planned Schedule for Each Unit (Summary)

	Fuel rods removal from SFPs (Target schedule)	Fuel debris removal (Target schedule)
Initial Target	December 2013 (the earliest unit)	December 2021 (the earliest unit)
Unit 1	First half of FY2017 (the earliest case) ~ Second half of FY2017	**First half of FY2020 (one-and-a-half years earlier than the initial plan)** ~ **Second half of FY2022**
Unit 2	Second half of FY2017 (the earliest case) ~ First half of FY2023	**First half of FY2020 (one-and-a-half years earlier than the initial plan)** ~ **First half of FY2024**
Unit 3	First half of FY2015	Second half of FY2021 (the earliest case) ~ Second half of FY2023
Unit 4	**November 2013 (one month earlier than the initial plan)**	–

Main schedule of the Mid-and-Long-Term Roadmap toward the decommissioning of TEPCO's Fukushima Daiichi NPS Units 1 to 4 (Unit 1)

June 27, 2013
Council for the Decommissioning of TEPCO's Fukushima Daiichi NPS

Attachment 1



The Roadmap describes detailed schedule toward the decommissioning.

The Roadmap is available at:

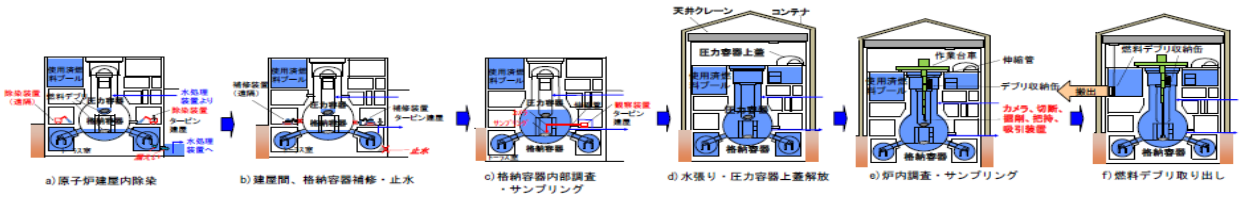
http://www.meti.go.jp/english/press/2013/pdf/0627_01.pdf

Key Areas of R&D Projects

- Preparation of fuel debris removal
  - ✓ Equipment/device development
  - ✓ Core status assessment and analysis
  - ✓ Fuel debris characterization and management
- Radioactive waste treatment and disposal
  - ✓ Processing and Disposal of Secondary Waste
  - ✓ Processing and Disposal of Radioactive Waste
- Remote-controlled technologies as a common tool

R&D Schedule and On-site Needs

- Debris characterization and treatment study -



Item/Year	Phase 1			Phase 2						
	2011	2012	2013	2014	2015	2016	2017~2020		2021	2022
				(beginning)			(mid)			(end)

Needs

1. Estimation of fuel debris character

(1) Estimation of the condition in which debris generated

(2) Characterization using simulated debris

(3) Comparison with TMI-2 debris

2. Analysis of actual 1F debris

3. Development of debris treatment technology

(1) Scenarios study

(2) Feasibility study of various technologies

To contribute estimation of the present status in PCV

To contribute sampling and defueling

To contribute handling and storage

To contribute assessment of debris treatment scenarios

To contribute technology development on debris treatment

Preparation of sampling tools

Sampling operation

Debris sample

Defueling operation

Preparation of defueling tools

Discussion start to decide debris treatment after defueling operation

Scenarios study

Study on long-term storage and disposal of debris

Comparative evaluation

Feasibility study

Assessment of technological establishment

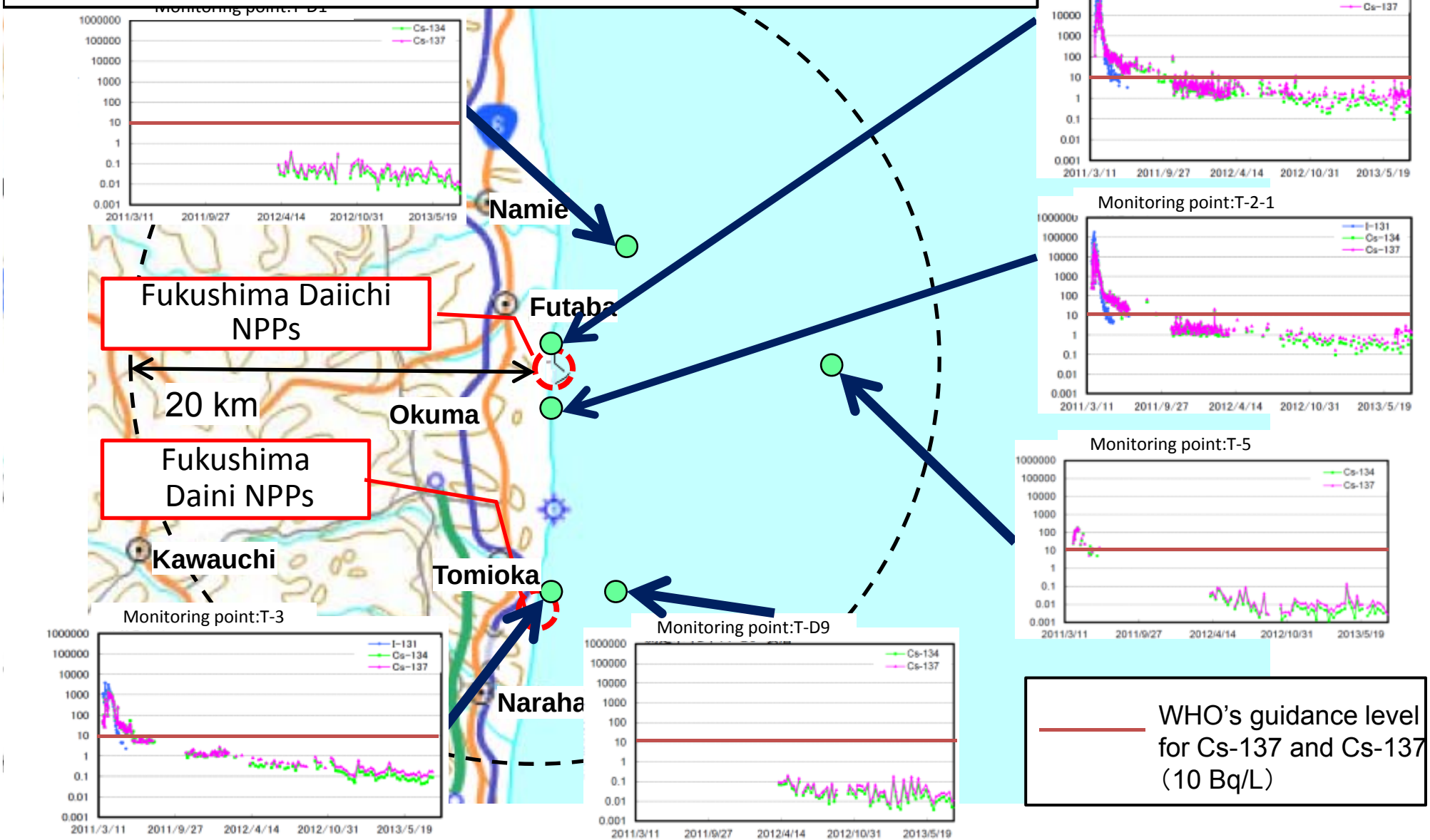
Evaluation of applicability

Contaminated water and countermeasures

Radioactive concentration of the sea (2011.3.11 – 2013.8)

○ Radioactive influence is observed in the limited area (smaller than 0.3 km^2)

(Data source: TEPCO)



Basic Policy and Action Plan for Contaminated Water Mgt.

(Sep. 3,2013)

1. The GoJ has determined to play a proactive role.
   ⇒ public relations to communities, fiscal support, reinforced environment monitoring etc.

2. Besides the measures responding to troubles, the preventive and multi-layered measures will be taken according to potential risks.
   ⇒ Identify potential risks by the expert group
   ⇒ Collect expertise from all over the world through IRID※
   ※IRID : International Research Institute for nuclear Decommissioning
   ⇒ Provide the package of preventive and multi-layered measures by the end of 2013

3. Intensive on-site examination in order not to miss any new events and to minimize their negative influence.

Preventive and Multi-layered Measures for Decommissioning and Contaminated Water Management

Decided by Nuclear Emergency Response Headquarters on 20 Dec., 2013

1. Preventive and Multi-layered Measures against Contaminated Water Issue

1) Remove sources of contamination

key measures already being implemented or decided :

- Remove contaminated water in the trenches and isolate the trenches
- Treat contaminated water with multi-nuclide removal equipment (ALPS)
- Install high performance multi-nuclide removal equipment at government expenditure

Key additional measures :

- **Install more multi-nuclide removal equipment**
- **Take measures to prevent water leakage from tanks (capturing strontium contained in the soil)**
- **Clean up sea water in the harbor**

2) Isolate water from contamination

key measures already being implemented or decided :

- Pump up groundwater for by-passing
- Pump up ground water from sub-drains near buildings
- Install land-side frozen soil impermeable walls at government expenditure
- Pave the area between building and sea

Key additional measures :

- **Implement "broader area pavement (surface waterproofing) in the site" or "limited area pavement with an impermeable enclosure", also consider dose-reduction measures (e.g. decontamination of land surface)**
- **Install gutters at top of tanks**

3) Prevent leakage of contaminated water

key measures already being implemented or decided :

- Improve soil with sodium silicate
- Install sea-side impermeable walls
- Install further tanks (replace bolted-joint tanks with welded-joint tanks)

Key additional measures:

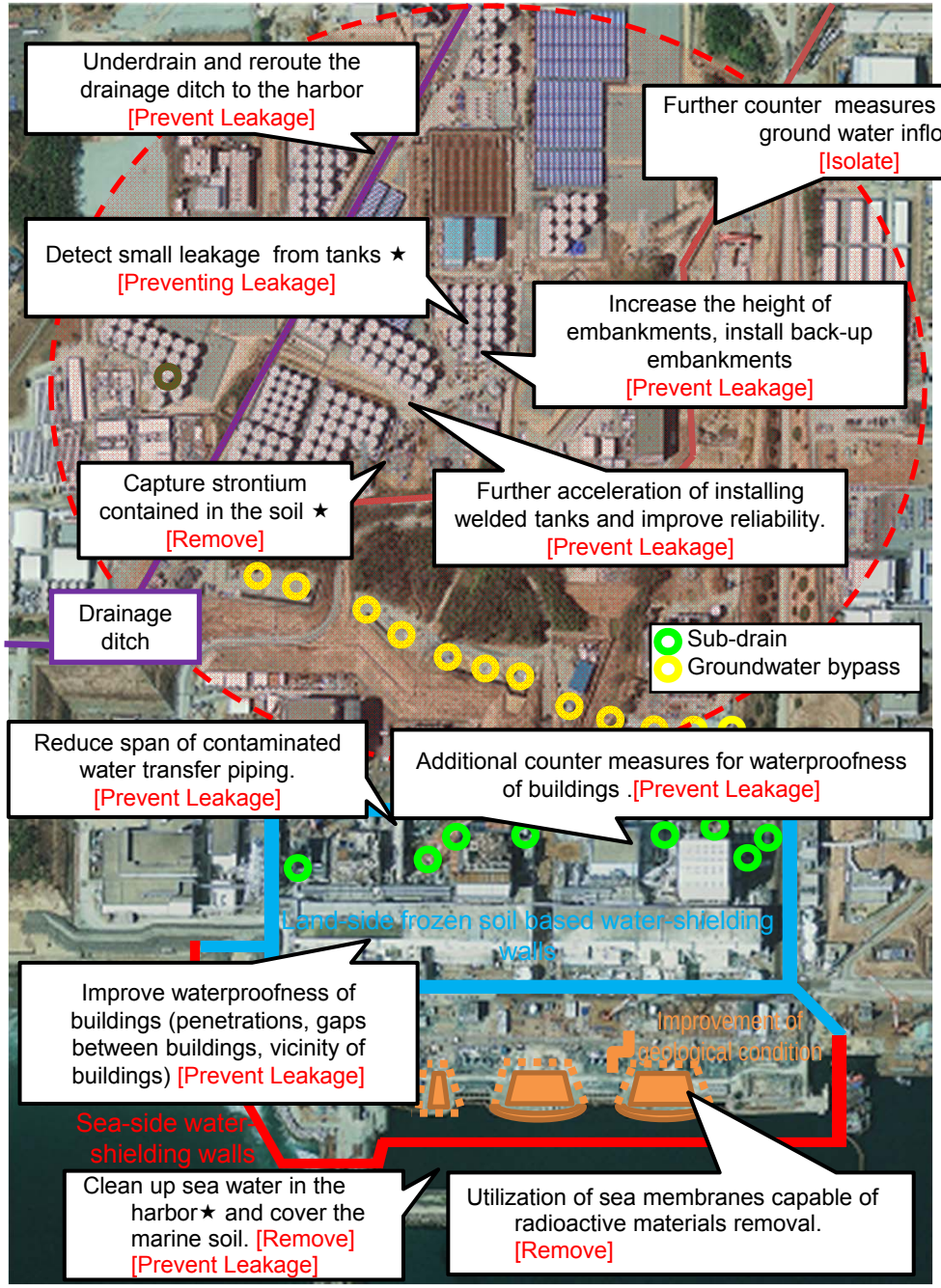
- **Accelerate installation of welded-joint tanks**
- **Prepare countermeasures against large tsunami (e.g. install watertight doors into buildings)**
- **Prevent contaminated water leakage from buildings**
- **Reduce length of contaminated water transfer piping**

- **Need to accelerate installation of further tanks to the extent possible with combined efforts of public- and private-sectors**, such as encouraging cooperation of relevant business operators, together with acceleration of installing welded-joint tanks, in order to secure enough storage capacity of tanks in preparation for waves on the surface of the liquid caused by earthquake.
- Press forward the **efforts such as verification of technology with Fiscal Year 2013 Supplementary Budget** for the additional **measures with high technical difficulties** such as the measures to clean up the sea water in the harbor and to remove radioactive materials in the soil.
- Make **a comprehensive evaluation of all options** for **tritiated water** containing residual risks as soon as possible and consider appropriate measures.

2. Enhanced Communication as Measures to Prevent Damage to Reputation

- Provide evidence-based information in an internationally open manner. Under the cooperation of relevant ministries, enhance the integrated communication of the Team for Decommissioning and Contaminated Water Countermeasure.

Overview of Preventive and Multi-layered Measures



Three principles

1. Remove source of contamination
2. Isolate water from contamination
3. Prevent leakage of contaminated water

Immediate measures

1. Remove highly-contaminated water in the trenches【Remove】
2. Soil improvement with sodium silicate (liquid glass) , rainproof pavement, and pumping out【Isolate】【Prevent leakage】
3. Pump up groundwater for by-passing【Isolate】

Fundamental measures

1. Pump up groundwater from sub-drains near buildings【Isolate】
2. Install sea-side impermeable walls【Prevent leakage】
3. Install land-side frozen soil impermeable walls【Isolate】
4. Install more efficient water treatment equipment【Remove】

etc.

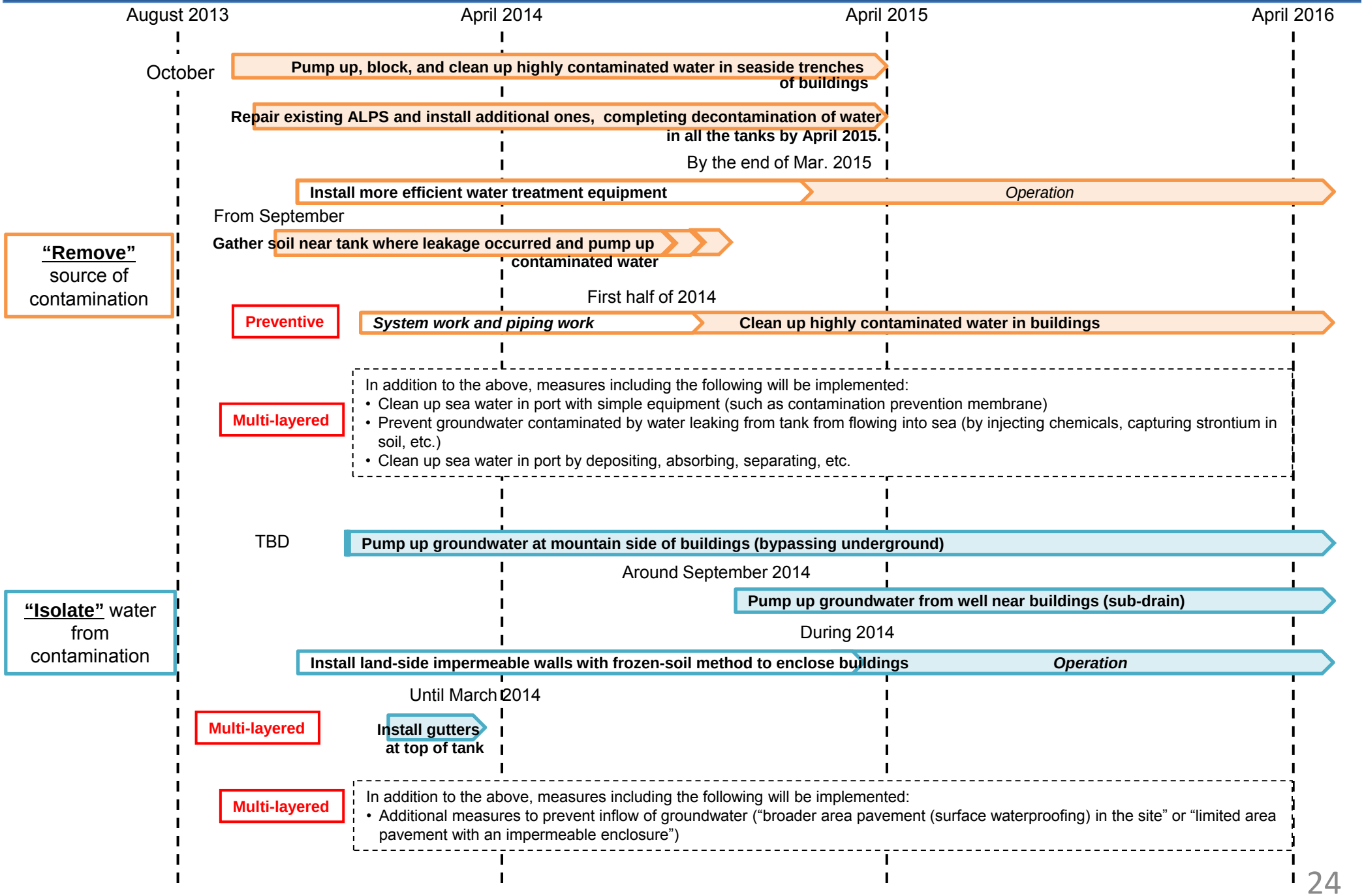
Preventive and Multi-layered Measures

(★:measure to be studied on its feasibility)

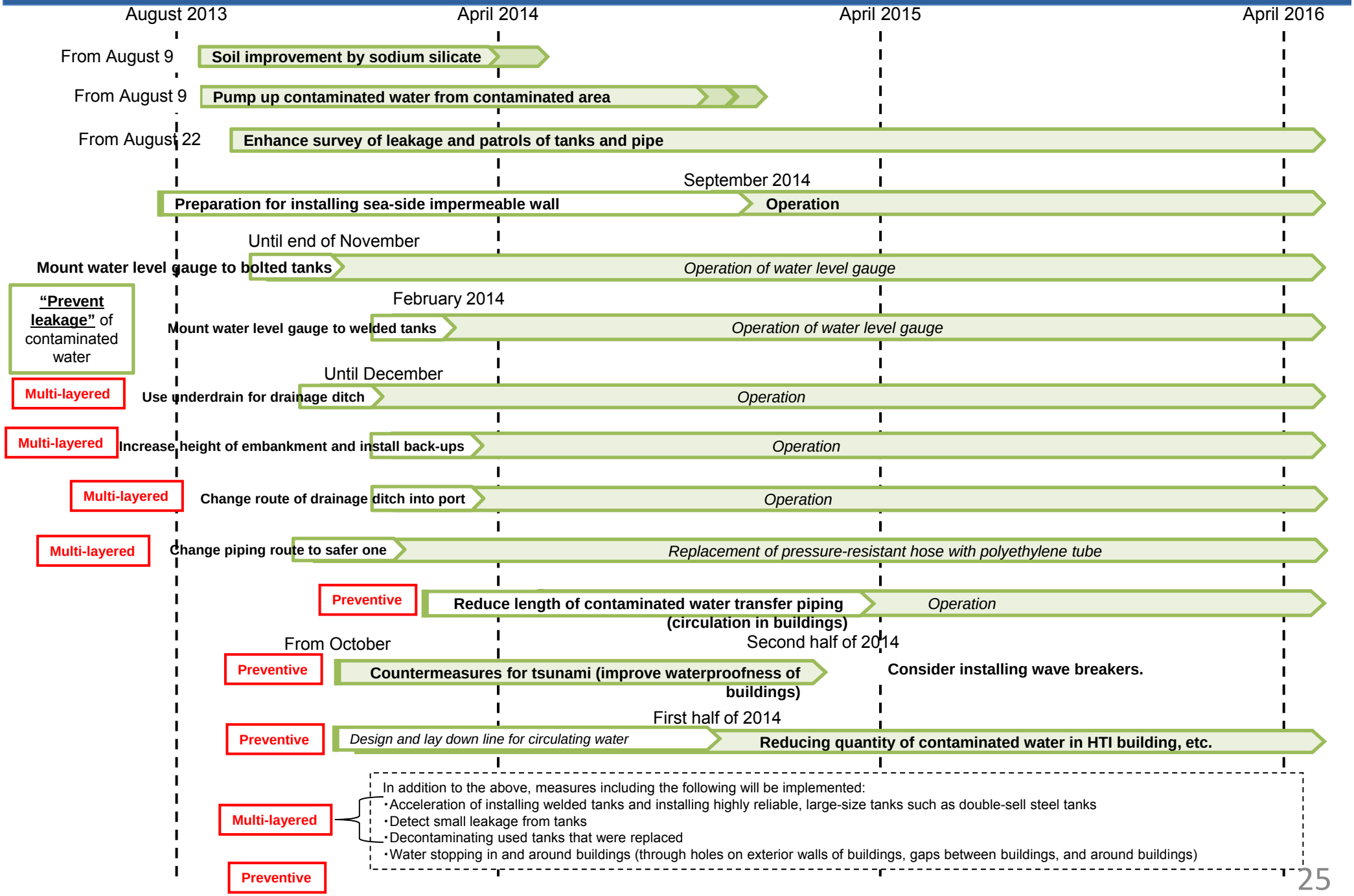
1. Further counter measures for Prevent ground water inflow【Isolate】
2. Increase height of embankments, install back-up embankments【Prevent leakage】
3. Further acceleration of installing welded tanks and improve reliability【Prevent leakage】
4. Underdrain and reroute the drainage ditch to the plant port【Prevent leakage】
5. Detect small leakage from tanks.★【Prevent leakage】
6. Capture strontium in contained water in soil.★[Remove]
7. Reduce span of contaminated water transfer piping. [Prevent Leakage]
8. Improve waterproofness of buildings(penetrations, gaps between buildings, vicinity of buildings), etc. [Prevent Leakage]
9. Counter measures for great tsunami (consideration on additional counter measures for waterproofness of buildings, wave breakers, etc.)[Prevent Leakage]
10. Clean up sea water in the harbor★ and cover the marine soil. [Remove] [Prevent Leakage]
11. Utilization of sea membranes capable of radioactive materials removal. [Remove]

Main measures taken or to be taken after decision of basic policy on Sep. 3

Key schedules (1)



Key schedules (2)



Efforts to work with global expertise

Establishment of IRID

〈Establishment〉

- 2013.8.1　Approved by Minister of Economic, Trade and Industry, Mr.Motegi, upon Research & Development Consortium Act of Japan.
- 2013.8.8　1st　General meeting was held to start the consortium. Organizational scheme was agreed, and actual activities kicked off.

〈Basic Role〉

- With perspective of enhancing technological basis for nuclear decommissioning for the future, fully commit to technology R&D that helps decommissioning project of Fukushima Daiichi NPS.

Efforts of IRID to Collect World-wide Expertise

International Advisors and International Expert Group (IEG)

1 International Advisors

- ✓ Providing advices on the overall management at IRID
- ✓ The first meeting on this January provided some advices such as enhanced participation of foreign firms and clarification of the roles of relevant organizations.

2 International Expert Group (IEG)

- ✓ Providing advices based on the expertise and experience of each expert to the IRID for safety and efficient decommissioning of Fukushima Daiichi.
- ✓ The first meeting on last September provided advices on the decommissioning process.

RFIs for decommissioning and contaminated water issue

1 Contaminated water issue: invitation period Sep 25 to Oct 23, 2013

- ✓ A total of 780 proposals were submitted from all over the world (proposals from oversea accounts for 30%). IRID classified and screened them.
- ✓ Preventive and multi-layered measures was decided by Nuclear Emergency Response Headquarters on last December considering the proposals.
- ✓ The Government of Japan provided additional budget to enhance technology development of this issue.

2 Alternate method for fuel debris removal: invitation period Dec 13 to Jan 31, 2014

- ✓ About 200 proposals were submitted.
- ✓ IRID will classify and screen them. Move to next step after that.

Gathering domestic and overseas wisdom on solution to contaminated water issues

■ Inviting technical proposals

◇ A team consisting experts, such as members of the International Research Institute for Nuclear Decommissioning (IRID), was set up to collect wisdom from both at home and abroad and accepted technical proposals (period: September 25 to October 23).

◇ The gathered proposals were closely examined by the "Committee on countermeasures for contaminated water treatment" to reflect on the overall image of the preventive and multi-layered contaminated water measures.

■ State of collection

◇ A total of 780 proposals were submitted. The details are as follows:

Field of information gathered	Number of proposals submitted
(1) Contaminated water storage (Storage tank, small leakage detection technology, etc.)	206
(2) Contaminated water treatment (Tritium separation technology, long-term, stable tritium storage method, etc.)	182
(3) Clean-up of seawater in port (Technology to eliminate radioactive Cs and Sr in seawater, etc.)	151
(4) Controlling contaminated water in buildings (Technologies to stop water in buildings and for soil improvement work, etc.)	107
(5) Management of premises to suppress groundwater inflow (Technologies to construct impermeable walls and conduct facing, etc.)	174
(6) Understanding behavior of groundwater (Geological/groundwater data measurement system, water quality analysis technology, etc.)	115
Others (Those that do not fall under (1) to (6))	34

(Note 1) A field was filed by the proposer.
(Note 2) Some proposals were related to two or more fields.

◇ Technical proposals presented from both inside and outside of Japan are precious data that provide the complete picture of technologies for contaminated water treatment.

◇ Taking into consideration the maturity of technologies, emergency of response, and adaptability of technologies to the site, the following technologies were selected:

(1) Technologies that should be adopted after confirming their adaptability to the side:
- High-reliability, large-size tanks such as double-shell steel tanks
- Lightweight shielding sheet that does not use lead
- Contamination prevention membrane (silt fence, etc.)
- Water stopping technology (stopping water in and around buildings)
- Geological/groundwater survey, preparing observation network etc.

(2) Technologies to be used by selecting an execution method based on workability and cost effectiveness
- Water shut-off technologies (facing, water shut-off, etc.)

(3) Technologies that are expected to be effective but need to be checked and verified before being used
- Small leakage detection technology (including dyes)
- Tank decontaminating technology without using water
- Tritiated water storage and separation technologies
- Technology for cleaning up seawater in port
- Technology for capturing strontium in soil
- Automated boring technology etc.

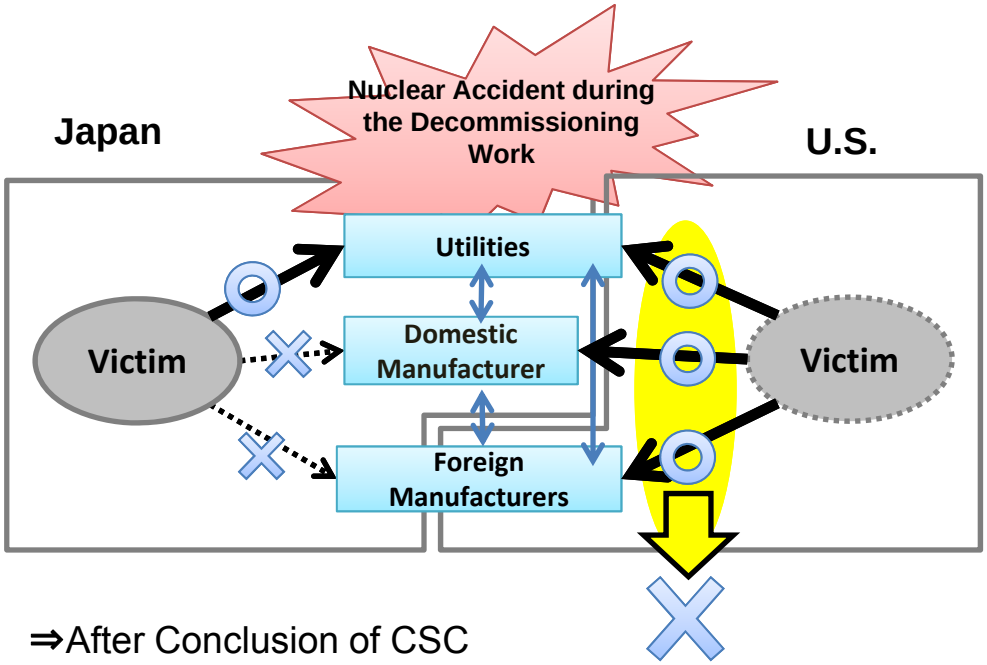
(4) Technologies to be moved ahead based on study by the Committee on countermeasures for contaminated water treatment
- General assessment of handling of tritiated water
- Study on issues related to tankers and underground storages, etc.

Conclusion of the CSC

(1) Japan announced the intention to conclude the Convention on Supplementary Compensation on Nuclear Damage (CSC) on Oct 31st , 2013.

(2) Conclusion of the CSC not only contributes to establish a global nuclear liability regime, but also improves the environment for foreign companies with expertise on decommissioning and countermeasures against contaminated water of the accident at the Fukushima Daiichi Nuclear Power Station to participate in related projects.

＜The jurisdiction is concentrated by CSC＞



⇒After Conclusion of CSC

Since the jurisdiction is concentrated only in Japan, the lawsuit in the U.S. cannot be permitted.

【Jurisdiction Concentration upon CSC Conclusion】

➢ In the current situation (non-conclusion of CSC), if a victim of an accident occurred during the nuclear reactor decommissioning work files a suit in the U.S., the lawsuit can be treated as under U.S. jurisdiction, and the U.S. manufacturers participating in the decommissioning might be liable for the huge amount of compensation.

➢ If Japan concludes the CSC, the jurisdiction over such a lawsuit is concentrated only in Japan. The foreign manufacturers are immune from the lawsuit risk in the U.S., which provides a favorable condition to the US manufacturers for participating in the decommissioning work.

※The application of jurisdiction concentration is subject to the judgment of the court in the country where such a lawsuit is filed.

US Technologies at Fukushima Daiichi NPS

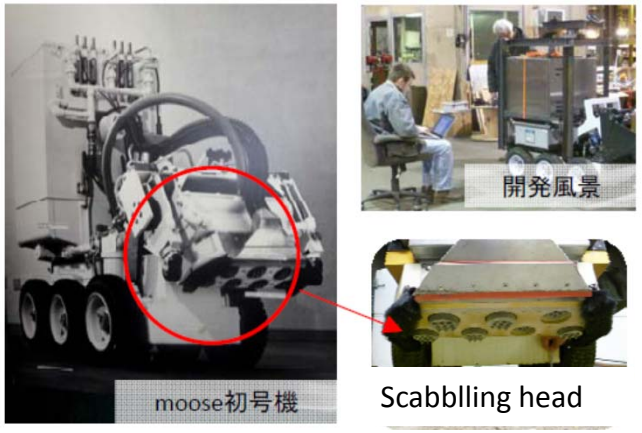
iRobot (PackBot for monitoring)

Kurion (for Kurion: cesium removal equipment)

Shaw Group (for SARRY: cesium removal equipment)

EnergySolutions (for ALPS: multi-nuclide removal equipment)

PENTEK (Moose for floor decontamination)



US companies joined METI supported project of Integrated Dose Reduction Planning in FY 2012:

- ✓ CH2M HILL
- ✓ Perma-Fix Environmental Services

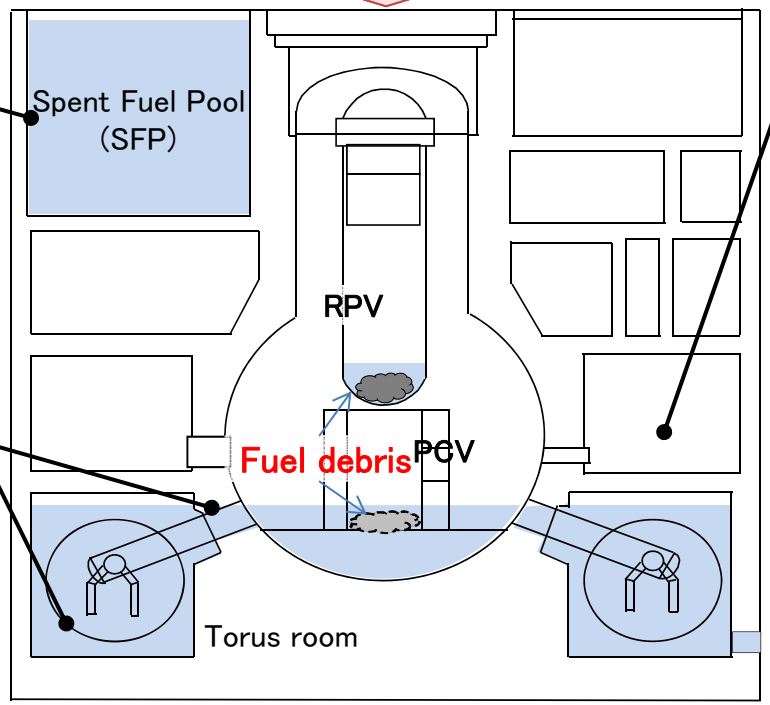
Summary

Technical challenges

Severe Environment
High-dose, underwater, limited space, high temperature, humidity, rubbles, sea water

Fuel Removal from SFP
✓ Assessment on long-term integrity of fuel assemblies removed from SFP, etc.

Fuel Debris Removal 1
✓ Remote decontamination in contaminated environment



R&D centers
✓ Mock-up facility for remote technologies and hot lab for radioactive materials analysis

Fuel Debris Removal 2
✓ Remote technology to identify leaking points in the PCV etc.

Radioactive Waste Management
✓ Management of rubbles, felled trees, and secondary wastes from water treatment

Contaminated water countermeasures
✓ Demonstration of frozen impermeable walls and more efficient multi-nuclide removal equipment

Fuel debris removal
✓ Alternative method for fuel debris removal etc.

F/S for technologies for contaminated water
✓ To clean up sea water in the harbor and to capture radioactive materials in the soil etc.

Questions

1. What technologies are needed for the decommissioning and contaminated water issue of Fukushima Daiichi?
2. What technologies are needed in short term(within 2 years)/middle term (2 to 5 years)/long term (5years and more)?
3. Can foreign firms contribute to the Fukushima Daiichi decommissioning works?

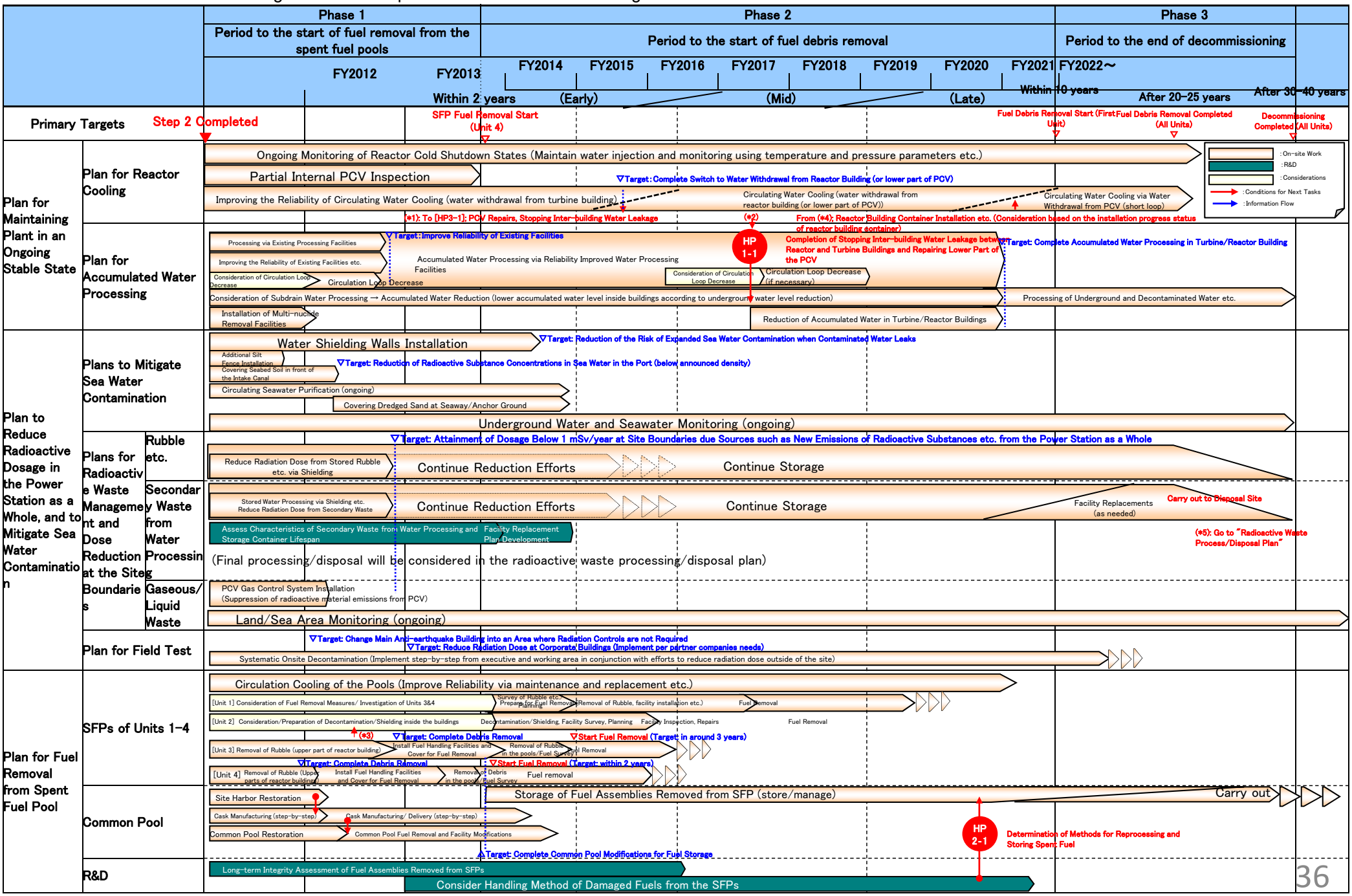
Thank you for your attention!

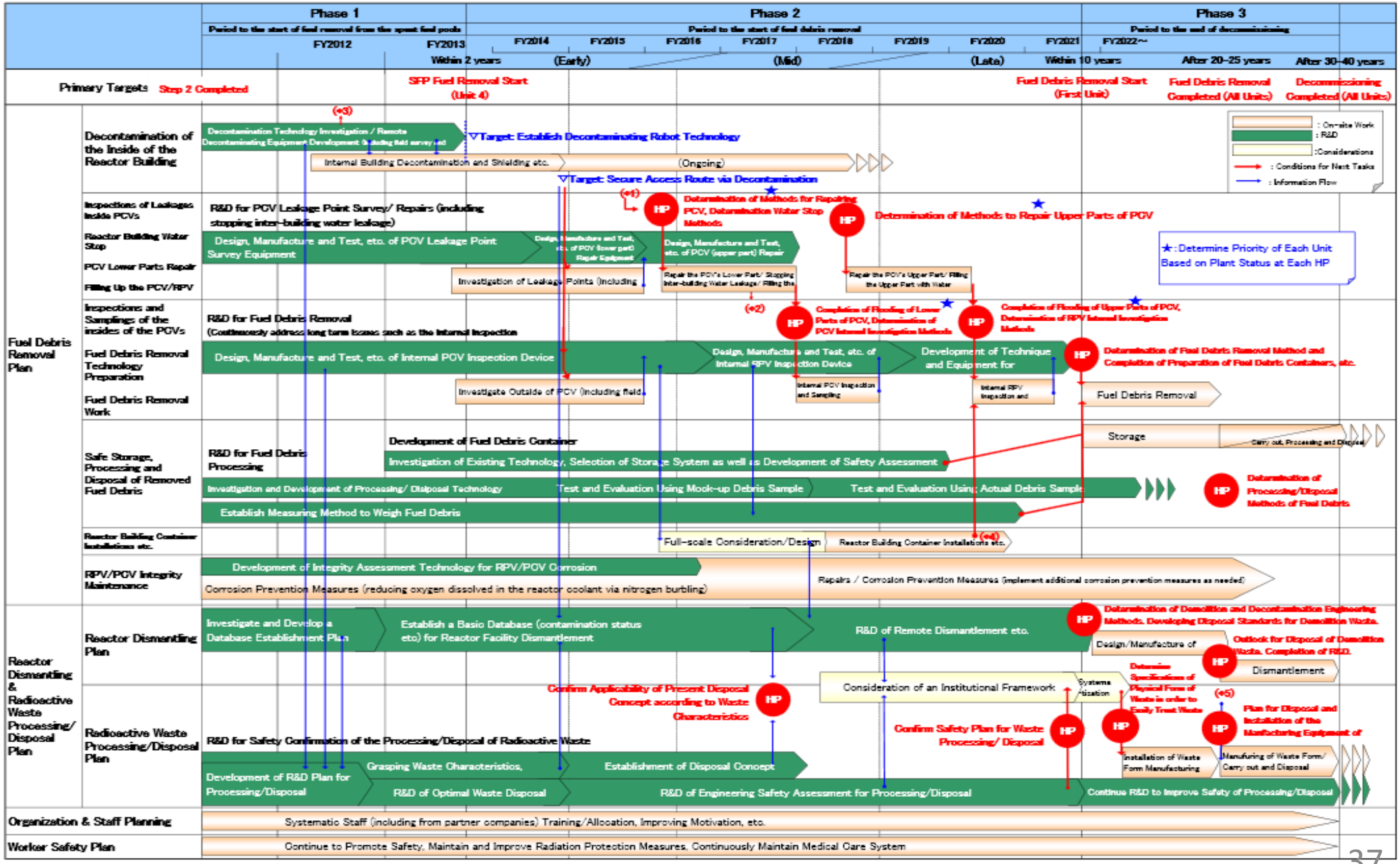
Agency for Natural Resources and Energy, METI

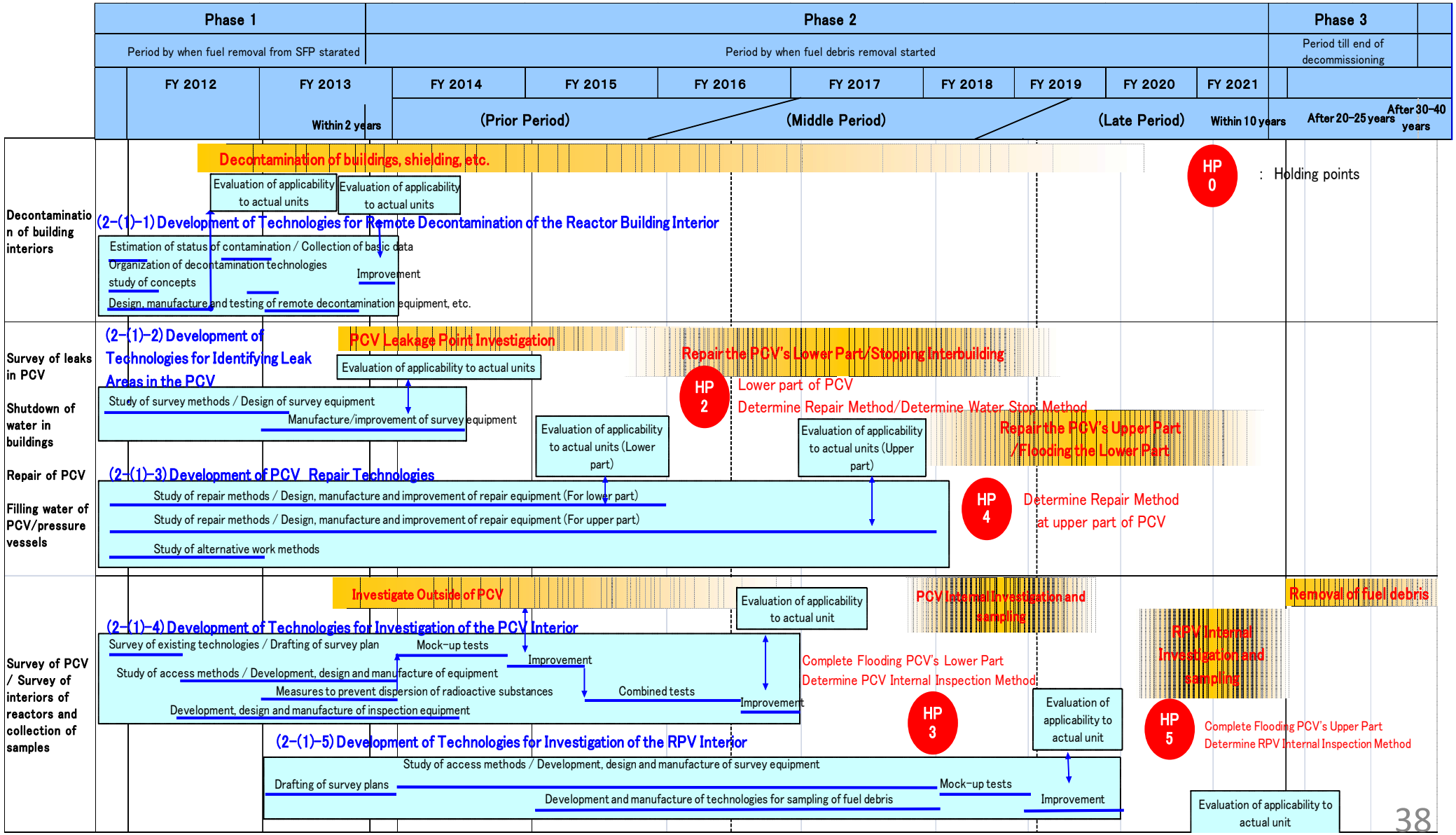
Please visit the following website for further information.
http://www.meti.go.jp/english/earthquake/nuclear/decommissioning/

METI
Ministry of Economy, Trade and Industry

Mid-and-long Term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Station Units 1-4





This roadmap will be updated in consideration of the on-site situation and the latest research and development results.

R&D Roadmap (Extract: Fuel Debris Removal)