

Background Information of the Contaminated Water Management at TEPCO's Fukushima Daiichi NPS

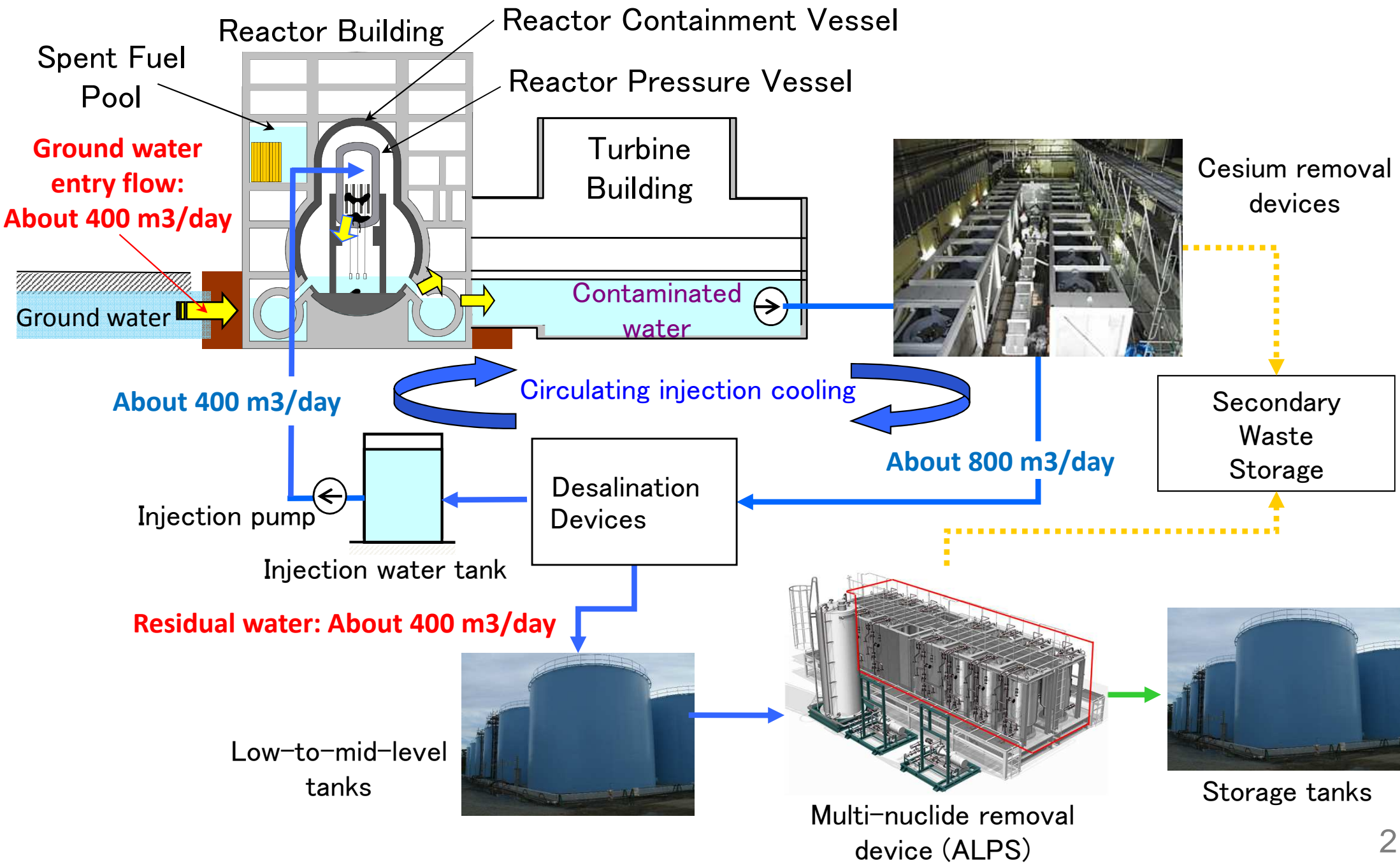
April 8, 2014

Secretariat of the Team for

Decommissioning and Contaminated Water Countermeasures

Cabinet Office

Contaminated Water Treatment System



1. Three Principles for Contaminated Water Issue

Fundamental countermeasures will be taken in several phases in addition to the immediate countermeasures, based on the following principles:

- (1) Removing the contamination source, (2) Isolating water from the contamination source,
- (3) Preventing leakage of contaminated water

2. Invitation of technical proposals (Request for Information, RFI)

On Sep. 20, 2013, a team of professionals was launched to gather domestic and overseas knowledge by receiving technical proposals, centering around the International Research Institute for Nuclear Decommissioning (IRID). (IRID was selected as the RFI secretariat)

1. Contaminated water storage (Storage tanks, micro-leakage detection techniques, etc.)
2. Contaminated water treatment (Tritium separation techniques, long-term stable tritium storage methods, etc.)
3. Purification of sea water in the harbor (Techniques to eliminate radioactive Cs and Sr in sea water, etc.)
4. Contaminated water control in the building (Building internal water leakage prevention techniques, ground improvement techniques, etc.)
5. Site management for inhibiting inflow of underground water (Water-shielding wall construction techniques, pavement techniques, etc.)
6. Understanding of underground water behavior, etc. (Geological condition and underground water data measuring systems, water quality analytical techniques, etc.)

Gathering domestic and overseas wisdom on solutions to contaminated water issues

■ Inviting technical proposals

- ◇ A team consisting of experts, such as members of the International Research Institute for Nuclear Decommissioning (IRID), was set up to collect wisdom from both home and abroad and accepted technical proposals (period: September 25 to October 23, 2013).
- ◇ The collected proposals were closely examined by the “Committee on countermeasures for contaminated water treatment,” to reflect the overall image of the preventive and multi-layered contaminated water measures.

■ Status 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 tanks, small leakage detection technology, etc.)	206
(2) Contaminated water treatment (Tritium separation technology, long-term, stable tritium storage methods, 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 pavement, etc.)	174
(6) Understanding behavior of groundwater (Geological/groundwater data measurement systems, water quality analysis technology, etc.)	115
Others (Those that do not fall under (1) to (6))	34

(Note 1) The fields are those identified in the proposer's application.
 (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 a complete picture of technologies for contaminated water treatment.
- ◇ Taking into consideration the maturity of technologies, the urgency 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 site:

- 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 (pavement, water shut-off, etc.)

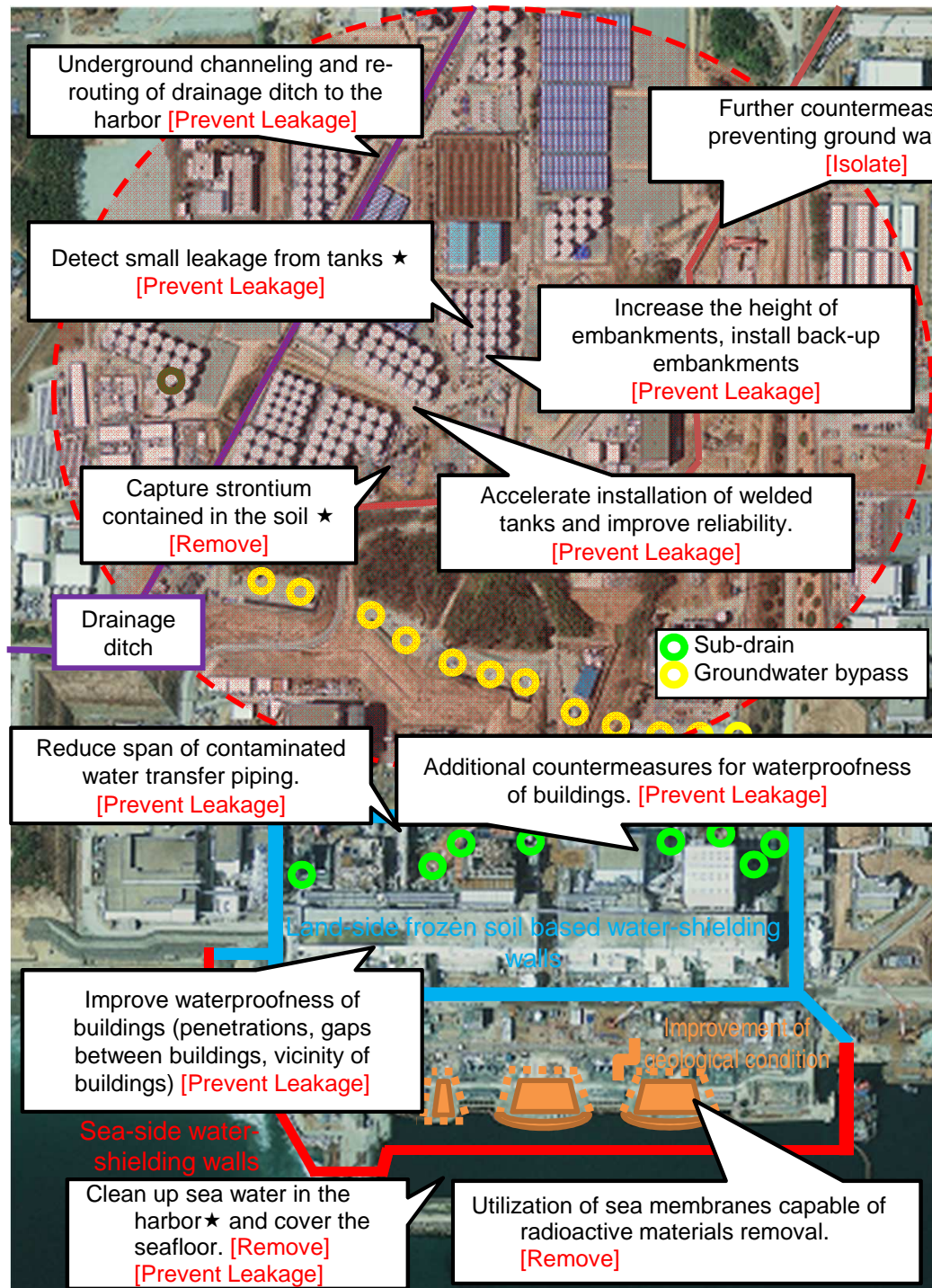
(3) Technologies that are expected to be effective but need to be checked and verified before being used

- 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 pushed forward 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 storage, etc.

Overview of preventive & multi-layered contaminated water treatment



Three principles

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

Immediate measures	Fundamental measures
1. Remove highly-contaminated water in the trenches [Remove]	1. Pump up groundwater from sub-drains near buildings [Isolate]
2. Soil improvement with sodium silicate (liquid glass), rainproof pavement, and pumping out [Isolate][Prevent leakage]	2. Install sea-side impermeable walls [Prevent leakage]
3. Pump up groundwater for bypassing [Isolate]	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 countermeasures for preventing ground water inflow **[Isolate]**
 2. Increase height of embankments, install back-up embankments **[Prevent leakage]**
 3. Accelerate installation of welded tanks and improve reliability **[Prevent leakage]**
 4. Underground channeling and re-routing of 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. Countermeasures for great tsunami (consideration of additional countermeasures for waterproofness of buildings, wave breakers, etc.) **[Prevent Leakage]**
 10. Clean up sea water in the harbor★ and cover the seafloor. **[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, 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 expense

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 expense
- 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 on 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 on 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 difficulty** 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**, which still has remaining risks, as soon as possible and consider appropriate measures.

2. Enhanced Communication as a Measure 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 Countermeasures.

Multi-Nuclide Removal Equipment

- ◇ It removes radioactive substances from contaminated water in tanks, and reduces risk.
- ◇ The goal of the existing Advanced Liquid Processing System (ALPS) is to reduce 62 nuclides in contaminated water to levels below the limits stipulated in the government announcement. (ALPS cannot remove tritium.)
- ◇ TEPCO is planning to install additional equipment similar to the existing ones.
- ◇ Moreover, TEPCO has already started the validation project for installation of high performance equipment, which can reduce wastes by more than eighty percent. (a project with national subsidies; the budget is 15.1 billion yen)
- ◇ With these measures, TEPCO seeks to complete purification of contaminated water in the tanks within this fiscal year.

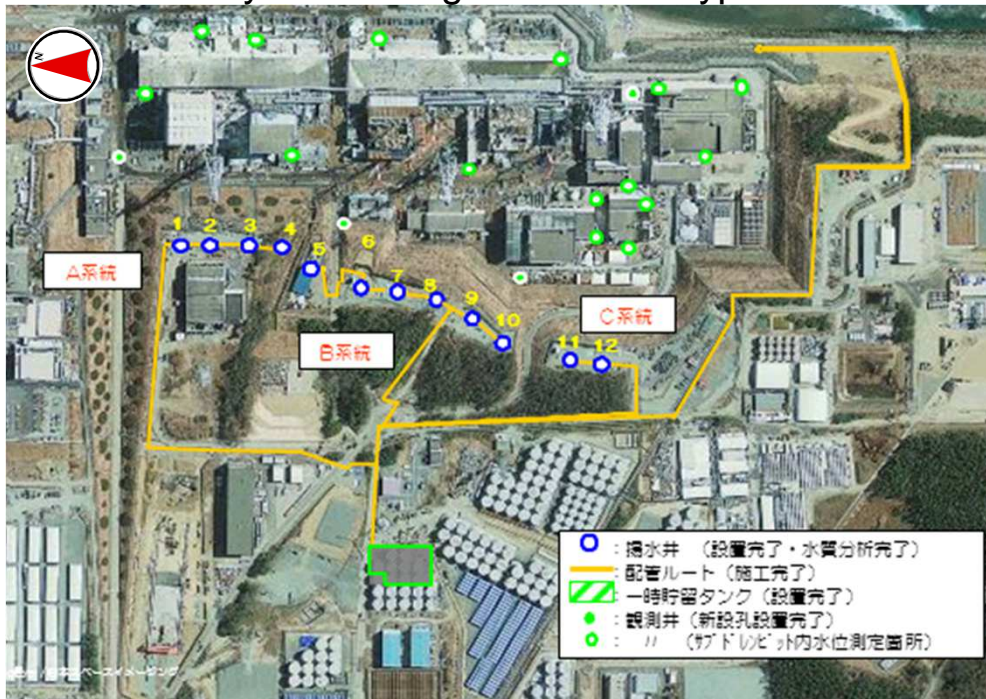
	Existing equipment	Additional equipment	High performance equipment※
Volume of treatment	750 m ³ /day	More than 750 m ³ /day	More than 500 m ³ /day
Number of systems	3 systems (250 m ³ /system)	3 systems (250 m ³ /system)	1 system
Volume of production of wastes	—	—	20 times less than existing equipment
Commission date	March 2013	In early period of FY2014	In early period of FY2014

※ The installation is conducted as a national subsidized project.

Groundwater Bypass

- ◇ In order to reduce groundwater flow into the buildings, hundreds of tons of groundwater will be pumped up on the mountain side of the buildings, and will be flown into the sea (bypass). It is expected that tens of tons, up to a maximum of 100 hundred tons, of groundwater inflow will be prevented.
- ◇ Explanations to concerned people such as Fisheries Cooperative were started at the end of January.

< Layout of the groundwater bypass >



< Results of analysis using simulation models of groundwater >

Case	Volume of pumped-up water	Volume of water inflow into buildings
Minimum case	460 ton/day	-20 ton/day
Maximum case where wells are additionally installed into the layer of medium-grained sandstone	790 ton/day	-110 ton/day

< Draft of performance target in drainage >

	Units : Bq/L			
	Cs 134	Cs 137	All β nuclides	tritium
Operational target	1	1	5	1,500
Density stipulated by Announcement※1	60	90	30	60,000
Drinking water quality guidelines by WHO※2	10	10	10	10,000

- If it is determined that the density exceeds the operational target, the bypass will be stopped temporarily, and countermeasures will be conducted to reach the target (for all β nuclides, 1 Bq / L).
- If the nuclide density in water stored in a tank exceeds the operational target, measures for purification will be conducted, and the water will be drained after assuring that the target has been reached (for all β nuclides, 1 Bq / L).

※1 Annual exposure dose is around 1 mSv even though people continue to drink approx. 2 liters of water per day whose nuclide density reaches the limits stipulated in the government announcement.

※2 Exposure dose through intake of water reaches around 0.1 mSv annually.

Land-side impermeable walls of frozen-soil type

- ◇ Install water shut-off walls of frozen-soil type surrounding buildings to restrict flow of groundwater into buildings.
- ◇ Techniques for countermeasures for the places where the flow velocity of groundwater is high, for controlling groundwater level, etc. have been validated since last August.
- ◇ The main construction phase will start soon, and the freezing is sought to start in FY 2014.

Budgets pertaining to the project of frozen soil walls

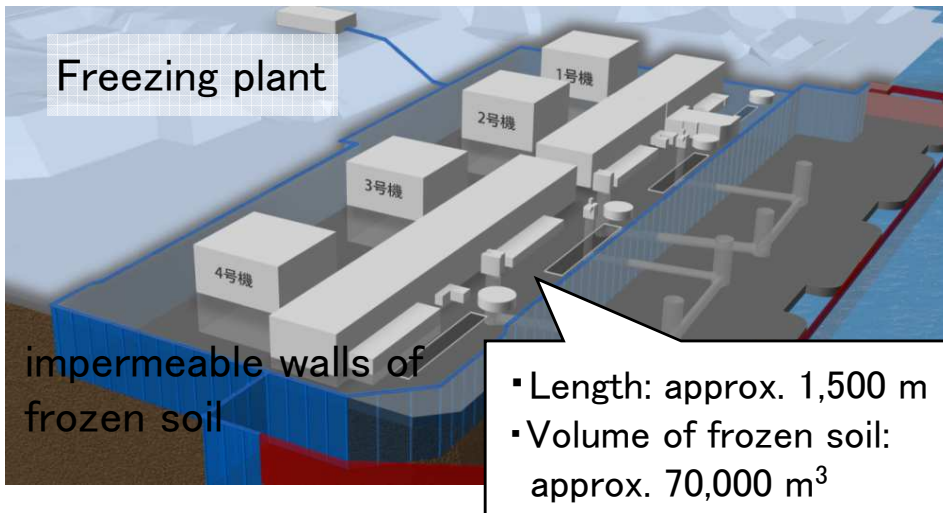
FY2013 reserve fund:

Approx. 13.6 billion yen

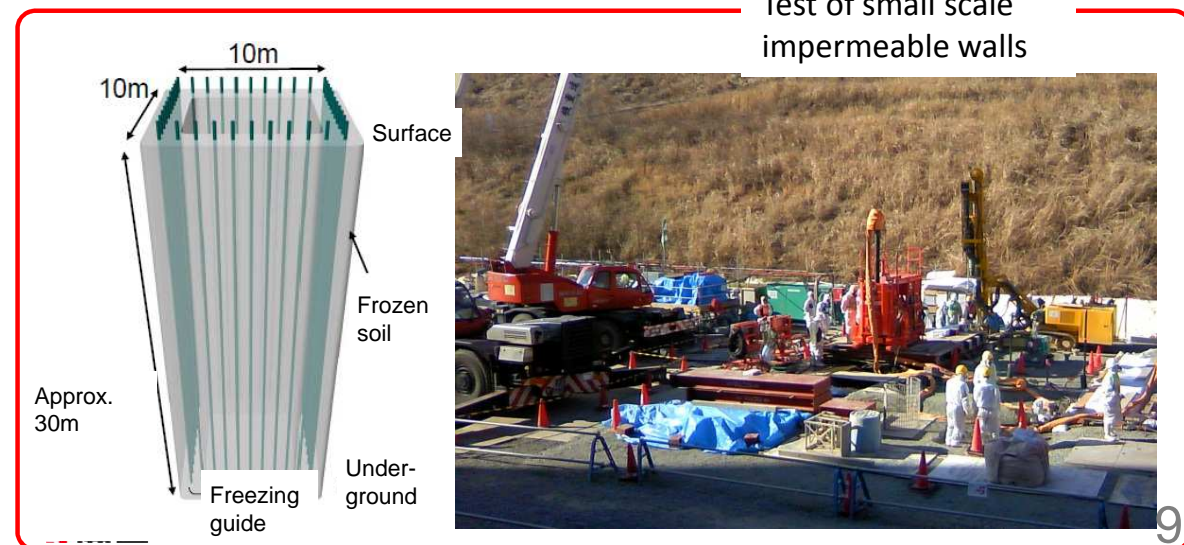
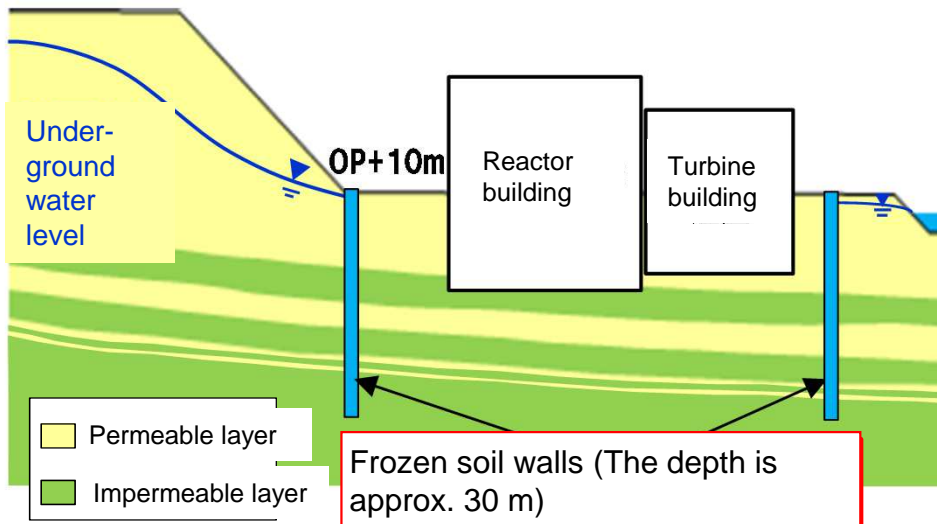
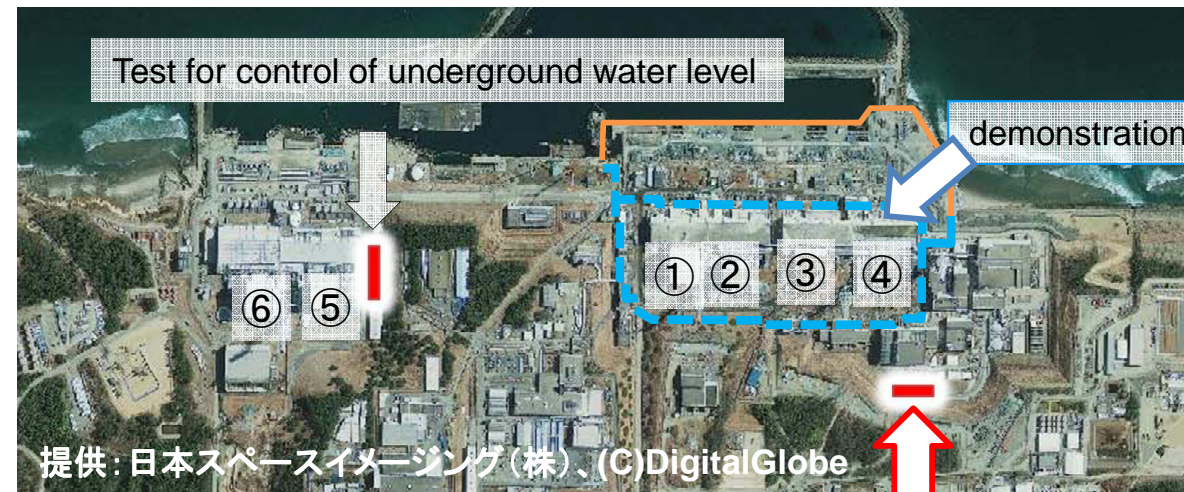
FY2013 Supplementary Budget :

Approx. 18.3 billion yen

Overall view and sectional view of the walls



Feasibility study

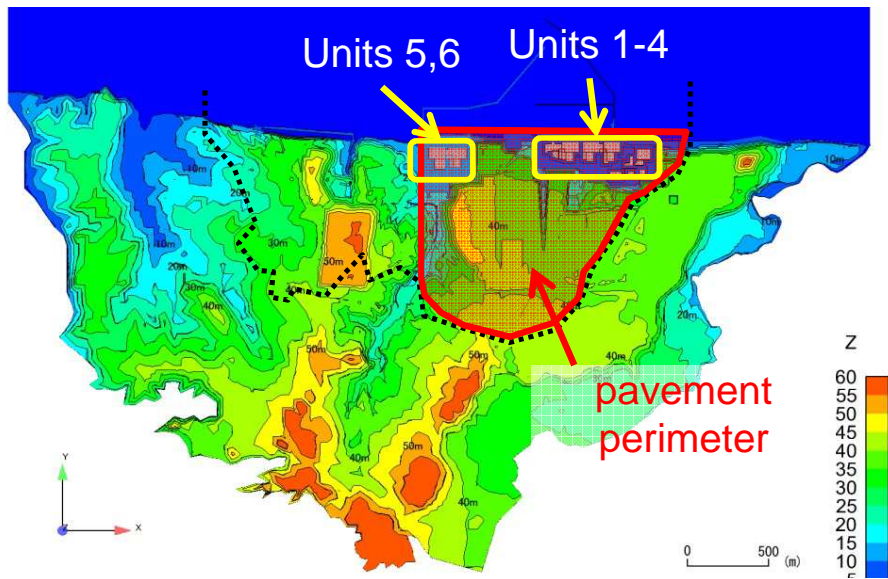


Paving the surface of ground to reduce rainwater penetration into the soil

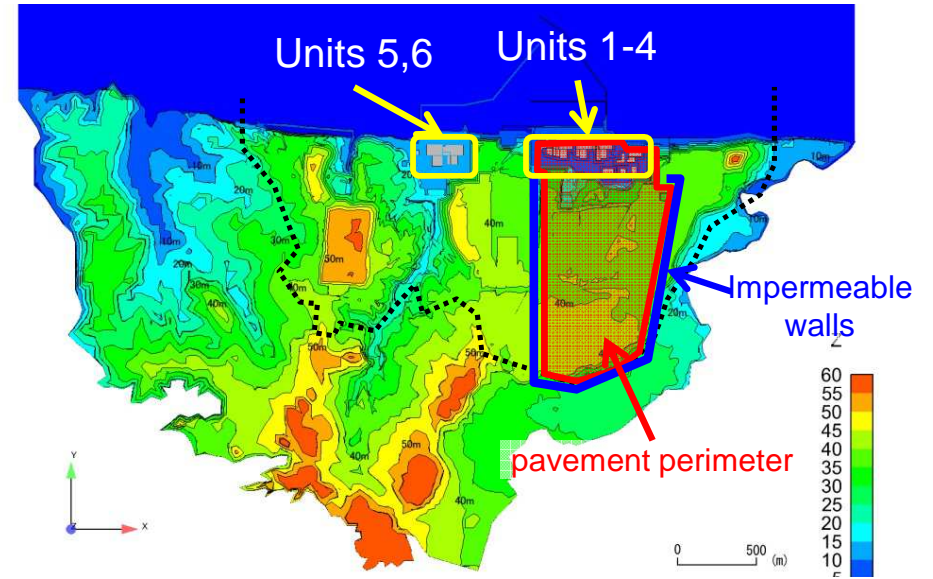
- ◇ After consideration by the Committee on Countermeasures for Contaminated Water Treatment (simulation of groundwater flow, etc.), it has been confirmed that most of the groundwater flowing into buildings originates in rainwater falling on or nearby the site.
- ◇ As multi-layered measures for prevention of groundwater affluence, “Wide-area pavement on surface (surface water shut-off)” or “Additional water shut-off and its inside pavement” will be conducted.
- ◇ Implementing methods, etc. will be decided as soon as possible. On implementation of the measures, measures for improvement of the working environment through dose reduction by surface decontamination, etc., or consideration of appropriate disposal method of wastes produced in the decontamination will be done.

【Examples of pavement perimeter】

• • • premises boundary line (outline)



Area of pavement perimeter : Approx. 1.7 km²



Area of pavement perimeter : Approx. 1.0 km²
Length of impermeable walls※ : Approx. 3 km

※To coarse-grained sandstone (The depth is approx. 25~50m from the surface.)

Sea-side water shut-off walls

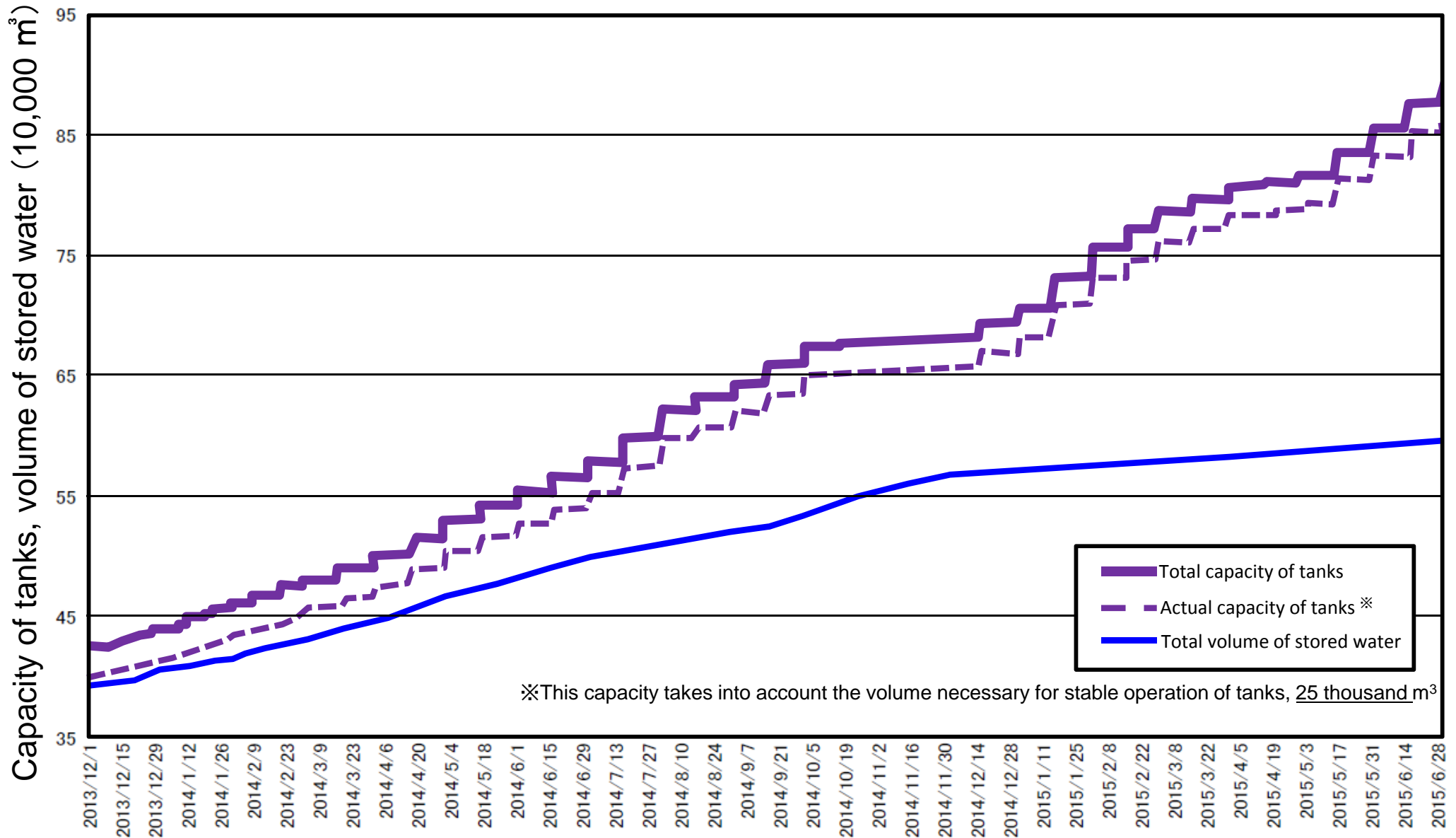
- ◇ Water shut-off walls will be installed outside of the shore protection in order to prevent contaminated groundwater flow into the sea.
- ◇ The construction work started in October 2011, and installation of steel sheet piles has almost been completed (approx. 94% completion). 【As of the end of March 2014】
- ◇ Commencement of the operation is planned this September, simultaneous with the pump-up from the sub-drains.

Recent situation of installation of the seaside water shut-off walls



Additional installation of water tanks

- ◇ The pace of installation will be accelerated, from 15,000 tons/month to 40,000 tons/month.
- ◇ Horizontal tanks installed in earlier periods, and bolted-joint tanks, where leaks occurred, will be replaced with welded-joint tanks, and the water level inside the tanks will be adjusted as a countermeasure for earthquakes (sloshing).



※This capacity takes into account the volume necessary for stable operation of tanks, 25 thousand m³

Concerning the status of considerations regarding tritiated water

- ◇ The radioactive energy (β -ray) emitted by Tritium (an isotope of hydrogen) is small and it can be shielded with a sheet of paper; however, tritium cannot be removed with ALPS, etc.; therefore the risk of a huge volume of tritiated water still remains. Accordingly, it is important to comprehensively evaluate various options for the treatment of tritium.
- ◇ Last December, the Task Force for Tritiated Water, consisted of experts of radiology, environmental influences of tritium, tritium removal from environment, etc. was set up under the Committee on Countermeasures for Contaminated Water Treatment. In order to prepare basic information which can contribute to the decision on handling of the tritiated water, the task force is proceeding with selection of various options such as separation, storage, release, etc. and considering items to be evaluated such as risks, environmental impacts, cost-benefit, etc. for each selected option, and a comprehensive evaluation.
- ◇ Additionally, interviews of foreign specialists(US, UK and France) to gather information on the overseas cases of tritium treatment, general evaluation, etc. are ongoing. The goal of this task force is not to decide which option is the right one, but rather the task force is proceeding with a general evaluation of each option that is necessary for the decision.

Valid options at this time and items to be evaluated

【Options】

- ✓ Separation
 - CECE method, others
 - Long-term storage
 - Storage in tanks, storage on the sea, underground storage
- ✓ On-site disposal
 - Injection into underground, burial of solidified waste
- ✓ Environmental Release
 - Natural evaporation, artificial evaporation, discharge into the sea

【Items to be evaluated】

- ✓ Environmental impact and risk
- ✓ Impacts and risk to marine products
- ✓ Impacts and risk to human
- ✓ Treatment term (period from commission to completion)
- ✓ Costs needed for the measure
- ✓ Technical feasibility (technical maturity, overseas experiences)
- ✓ Difficulties pertaining to regulations
- ✓ Others

Process from RFI to RFP

Time	Contents	Organization
Sep. 25, 2013 – Oct. 23, 2013	Implementation of the Request for Information (RFI) for addressing the Contaminated Water Issue	The Agency for Natural Resources and Energy (ANRE, METI) <International Research Institute for Nuclear Decommissioning (IRID) was selected as the RFI secretariat>
Nov. 15, 2013	IRID reported information which was submitted through the RFI process to the Committee on Countermeasures for Contaminated Water Treatment (CCCWT)	The same as above
Dec. 10, 2013	CCCWT released “Preventative and Multi-layered Measures for Contaminated Water Treatment at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company”	CCCWT
Dec. 20, 2013	Nuclear Emergency Response Headquarters released “Additional Measures for Decommissioning and Contaminated Water Issues at TEPCO’s Fukushima Daiichi NPS”	Government of Japan (Nuclear Emergency Response Headquarters)
Feb. 25, 2014	Selection of the project management office for the “Project of Decommissioning and Contaminated Water Management ” in the FY2013 Supplementary Budget	The Agency for Natural Resources and Energy (ANRE, METI) <Mitsubishi Research Institute was selected for the tasks of the project management office.>
Mar. 24, 2014	Start of the solicitation for Entities to Implement the Subsidy Program “Validation of technologies for contaminated water management project” in the FY2013 Supplementary Budget	The same as above
Apr. 8, 2014	Holding of the Information Session for RFP for Entities to Implement the Subsidy Program “Validation of Technologies for Contaminated Water Management Project” in the FY2013 Supplementary Budget	The same as above