Evaluation of the report of Tokyo Electric Power Company regarding the leakage from the RO-concentrated water storage tank (H6 area C1 tank) at the Fukushima Daiichi Nuclear Power Station

15 April 2015
Nuclear Regulation Authority, Japan

1. Overview

Around 23:25 on 19 February 2014, water was found to be dripping from the top ceiling plate of the RO-concentrated water[1] storage tank (C1 tank[2]) in the H6 tank area. When the water surface inside the tank was checked from the top of the C1 tank, it was found that the water level had reached the ceiling plate, and water was leaking from the top ceiling plate of the C1 tank (refer to Figure 1).

The water that had leaked from the ceiling plate of the C1 tank dripped into the dike,[3] whereupon it flowed outside the dike through the rain gutter for draining rainwater that had accumulated on the ceiling plate (refer to Figure 2).

On 20 February 2014, the Nuclear Regulation Authority (hereinafter, referred to as "NRA") received the report regarding accidents and failures based on the Article 62-3 of the Act on Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors from Tokyo Electric Power Company (hereinafter, referred to as "TEPCO").

Subsequently, the NRA received the report regarding causes and countermeasures of the aforementioned event (the final report) from TEPCO as of 23 January 2015 (partially corrected on 13 April 2015) and the NRA reviewed the contents and summarized the evaluation result.

Report from TEPCO
http://www.nsr.go.jp/activity/bousai/trouble/houkoku/00000010.html

1 Wastewater from the reverse osmosis wastewater treatment system
2 The name given to each tank
3 A concrete foundation and dike designed to prevent the water in the tank from leaking out into the site even if water leaks outside the tank.

2. Overview of the report submitted by TEPCO

(1) Environmental impact assessment (expansion of contaminated water)

Based on the amount of water transferred by the RO-concentrated water supply pump and available capacity of the C1 tank, the amount of leakage from the C1 tank was

estimated to be approximately 110 m^3. The amount that leaked outside the dike was estimated to be approximately 100 m^3 based on the results of an analysis of the radioactive concentration of water inside the dike. In addition, based on these analysis results, the radioactive concentration was estimated to be 2.4×10^8 Bq/L for total beta.

Although some of the leaked water permeated the soil, TEPCO concluded that there had been no contamination of the ocean based on the fact that there is no drainage ditch that discharges water into the ocean near the dike in the H6 tank area and other facts. In addition, the leaked water and contaminated soil have already been collected.

(2) Causes

The contaminated water was supposed to be transferred to the tank in the E area. However, at the time the leakage occurred, the line was configured to transfer contaminated water not to the E area but rather to the C1 tank in the H6 area. Incidentally, at the time the leakage was found, the line had been restored to its original configuration, in which contaminated water is transferred to the E area (refer to Figures 3 and 4).

The causes of leakage were as follows.

(i) Leakage of contaminated water was not prevented because the following two signs of equipment abnormalities were overlooked.

- Even though contaminated water was being transferred to the tank in the E area, the water level of the relevant tank was not increasing.
- Even though a high-high alarm for the water level of the tank in the H6 area was issued, it was not investigated sufficiently.

(ii) Opening/closing management of valves was not carried out.

- The environment made it easy for valves to be opened and closed.
- Instructions regarding opening/closing operation and management for valves were insufficient.

(3) Countermeasures

(3)-1 Countermeasures related to monitoring RO-concentrated water transfers

(i) In monitoring by an operator during RO-concentrated water transfer, on an hourly basis the operator confirms that the supply pump's activation state and the transfer destination tank's water level are in sync with each other. In addition, if an abnormality is found with respect to the trend in water level, the operator is to

stop the supply pump and check the line configuration and whether water leakage has occurred on-site.

(ii) Besides the operator, the person on duty in the seismic isolation tower also monitors the tank water level, thus serving as a double-check function.

(iii) Two water level monitoring screens for the transfer destination and branch area are placed adjacent to one another so as to visually facilitate simultaneous monitoring of the water levels of both the transfer destination and branch area.

(3)-2 Countermeasures related to the response to the issuance of the high-high alarm

(i) Although the receiving and discharging tank is only equipped with a high-high alarm, high and medium-high alarms will be added in order to enhance monitoring functionality. In addition, high-high alarms will be added to all connected tanks.

(ii) In the case in which high-high or medium-high alarms are issued by not only the tank currently receiving water but also tanks that are not receiving water, the pump will be stopped immediately (automatically shut off by interlock) and on-site checks to determine the occurrence of leakage, the open/close status of valves, and the actual tank water level will be performed.

(3)-3 Countermeasures related to opening/closing management of valves

(i) Enhancement of locking management

- Valves will be locked and their keys will be managed only by personnel involved in operation.
- The open/close status of valves on the transfer line will be checked daily.
- The open/close status of valves will be recorded.

(ii) Enhancement of patrols

- The frequency of patrols by the person on night duty will be increased from once to twice per night.
- Patrols by the maintenance management department will be performed twice per day.

(iii) Enhancement of monitoring cameras

- Additional monitoring cameras will be installed, and video recording functionality will also be added.
- Lighting will be enhanced.

3. NRA's evaluation with regard to the report submitted by TEPCO and the future response

(1) Environmental impact (expansion of contaminated water)

There is no obvious fluctuation in the results of monitoring before and after the leakage occurred in the vicinity of the south discharging outlet (T-2) of the C south drainage ditch. The NRA therefore concludes that this event did not cause ocean contamination that raises any concerns about effects on health or the environment (refer to Figure 5).

(2) Exposure radiation dose

The effective dose due to gamma rays and the equivalent dose to the skin caused by beta rays were evaluated for workers who patrolled the H6 tank area (refer to Table 1).

The effective dose showed no significant differences before and after discovery of the leakage. As for the equivalent dose to the skin, the maximum dose per single patrol increased significantly; however, it was well below the annual exposure dose limit of 500 mSv. The NRA therefore concludes that there was no exposure leading to concern.

(3) Countermeasures

TEPCO has already completed implementation of countermeasures based on the causes of this event (refer to Table 2).

Concerning these countermeasures, the NRA has confirmed that those for appropriately catching signs of abnormalities (such as setting alarms for all water level gauges) as well as those for management of opening and closing valves (such as implementation of valve locking management, recording of valves' open/close status, and enhancement of the monitoring system) have been implemented. The NRA thus concludes that these countermeasures have been prepared based on the event causes and will be effective in reducing the risk of leakage occurrence and countermeasures summarized by TEPCO shall be checked about its implementation situation at an appropriate timing by safety inspection, etc.

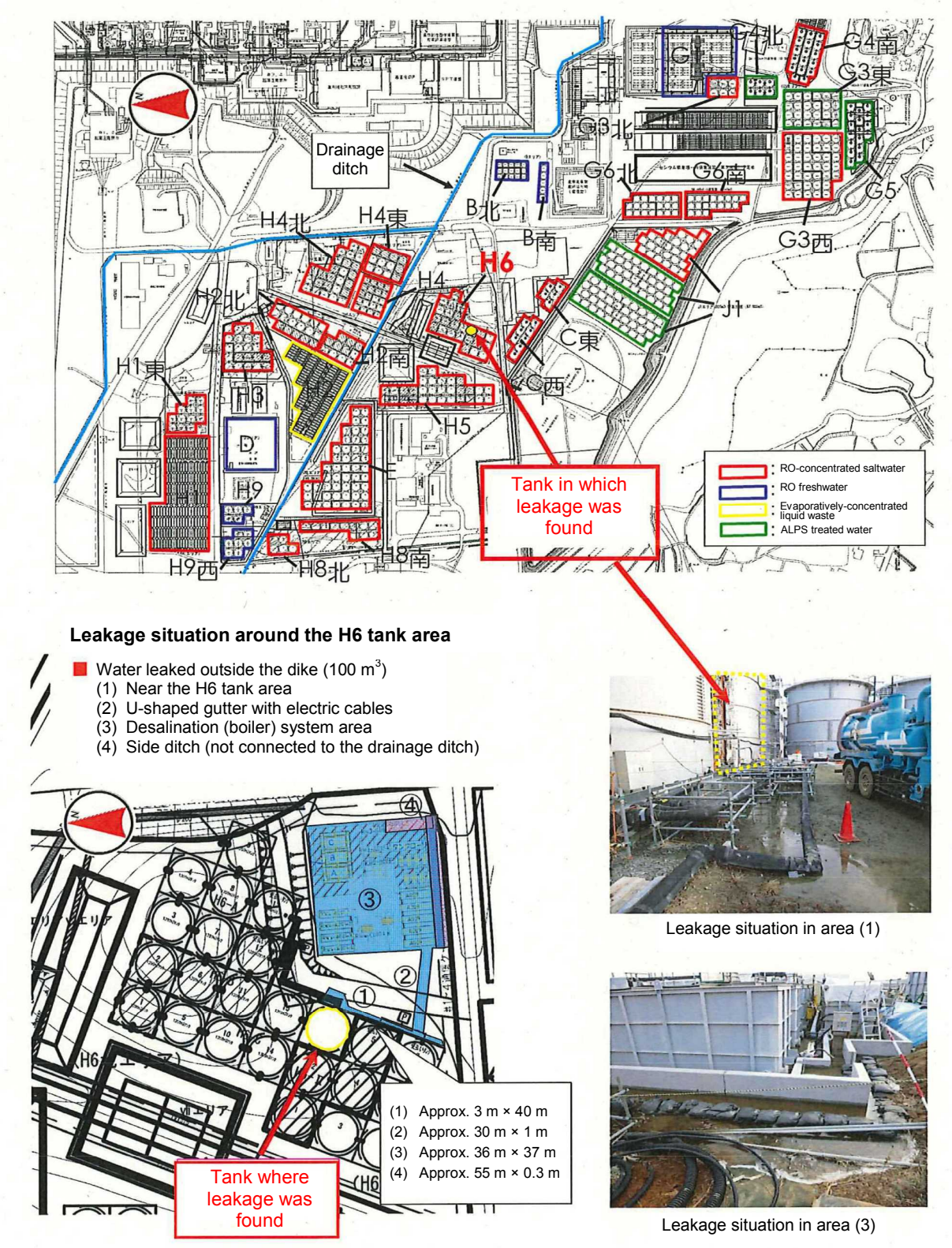


Figure 1 H6 tank and leakage location (extracted from the TEPCO report)

- RO-concentrated water leaked out of the dike through the rain gutter.
- The rain gutter was installed to discharge rainwater from the dike as a dike rainwater control countermeasure.

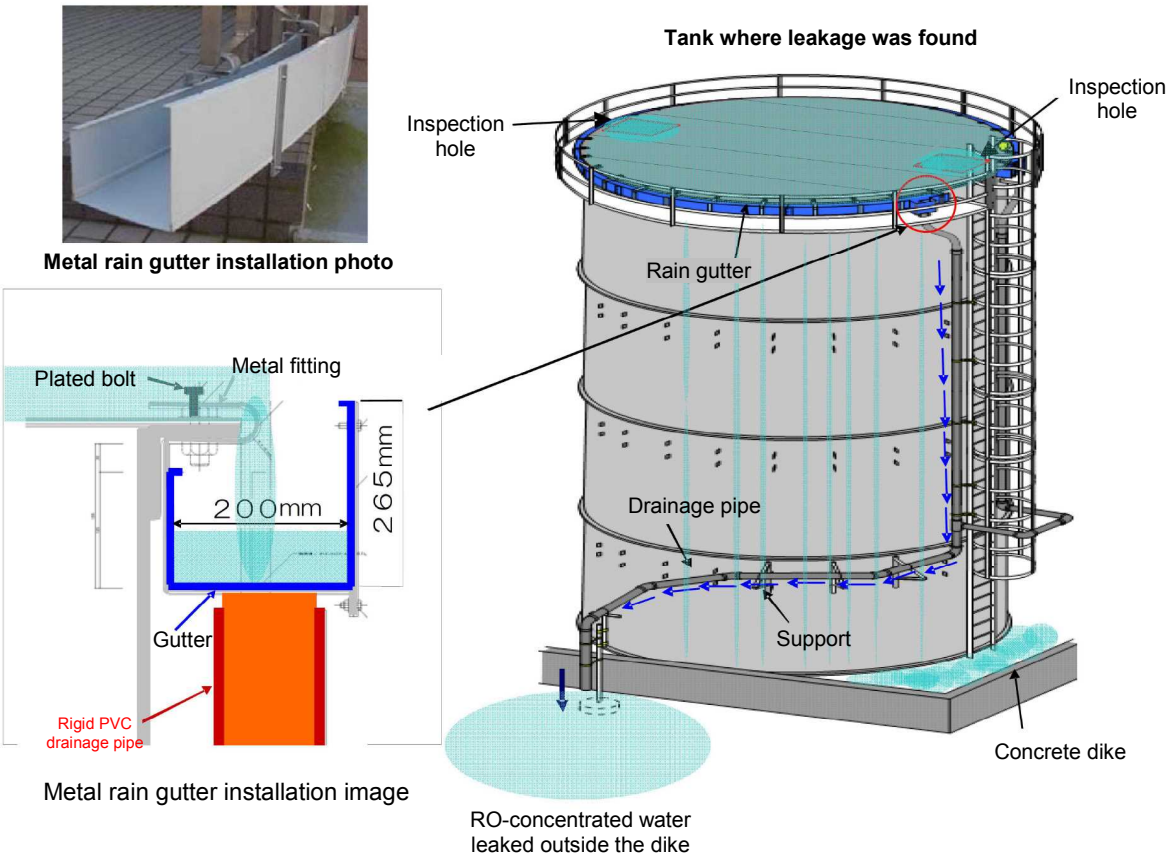
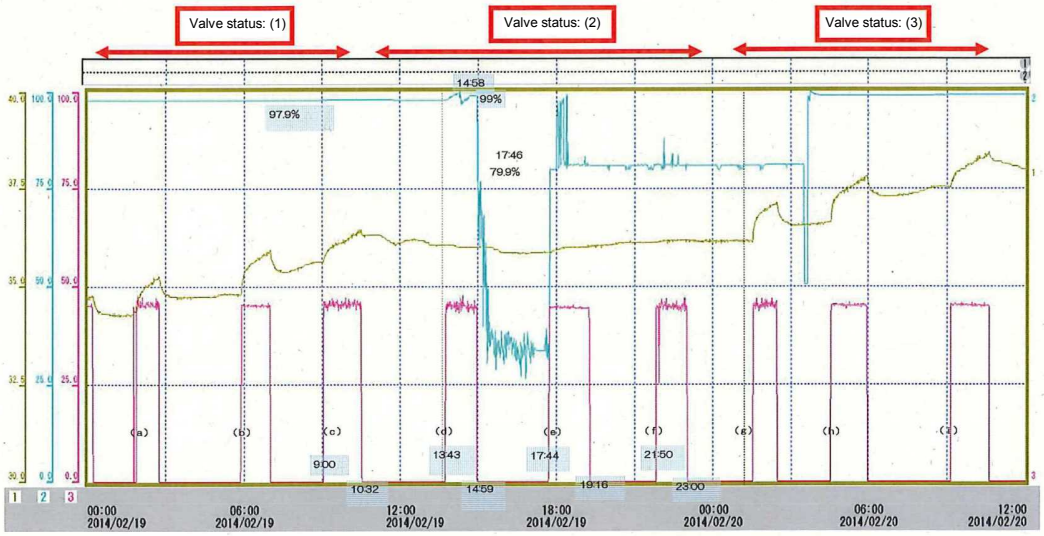


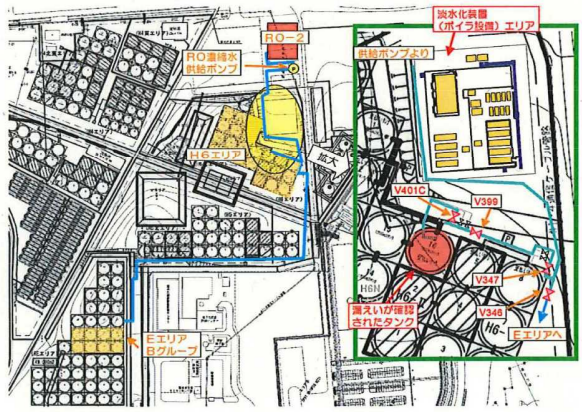
Figure 2 Leaked water flow-out route (extracted from the TEPCO report)

Results of the survey on tank water levels and valve open/close status management



Supply pump operation status and tank water level trend

Equipment arrangement around the transfer line



System schematic diagram (condition upon starting transfer on 17 Feb.)

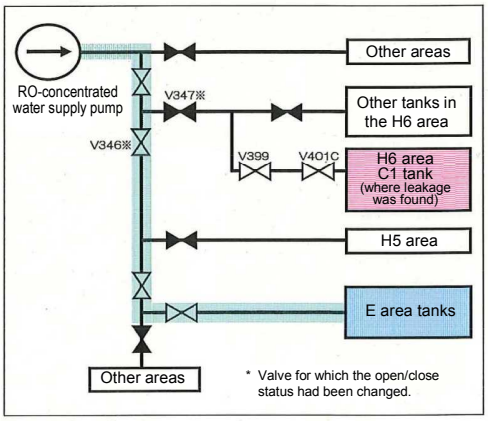
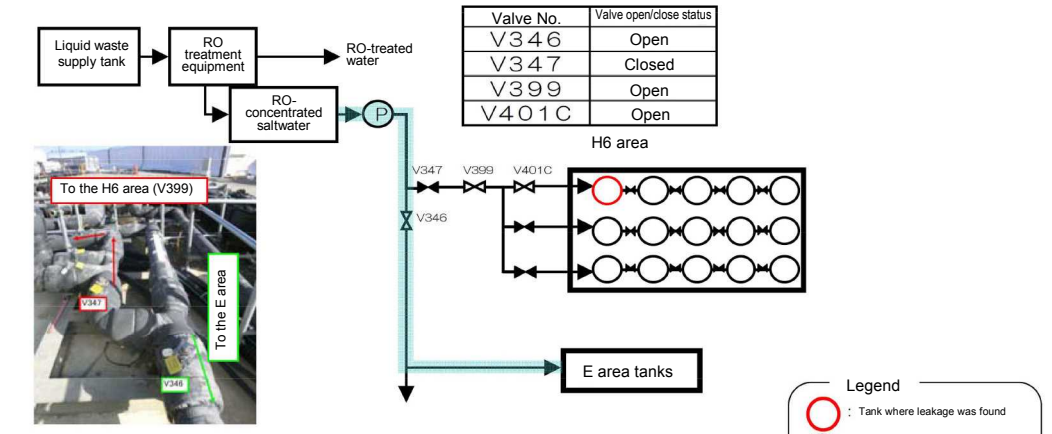


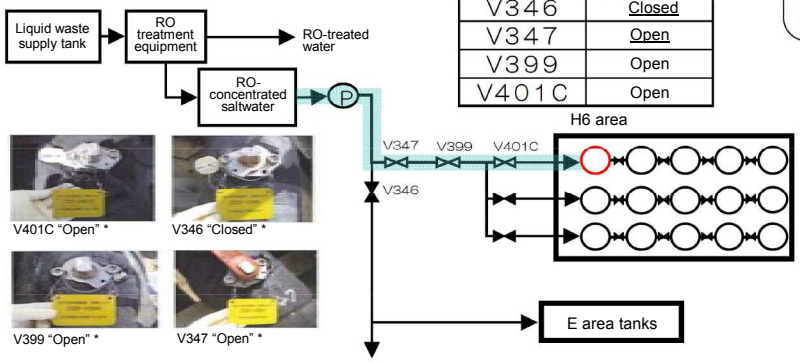
Figure 3 Tank water level, etc. (extracted from the TEPCO report)

Valve status (1)



Valve No.	Valve open/close status
V346	Open
V347	Closed
V399	Open
V401C	Open

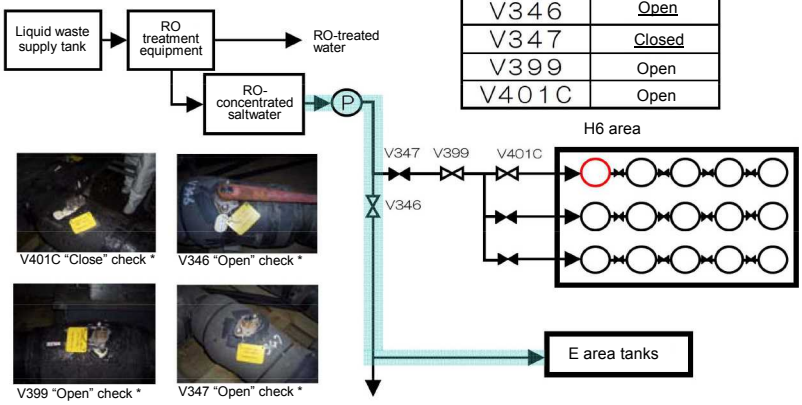
Valve status (2)



Valve No.	Valve open/close status
V346	Closed
V347	Open
V399	Open
V401C	Open

* Photos taken by Company B after attaching nameplates (19 Feb.)
Time taken: V401 (10:44), V399 (10:45), V346 (10:55), V347 (10:57)

Valve status (3)



Valve No.	Valve open/close status
V346	Open
V347	Closed
V399	Open
V401C	Open

* Photos taken by the employee in charge of operation management when checking the valve open/close status (20 Feb.)
Time taken: V401C (00:26), V399 (00:27), V347 (00:29), V346 (00:30)

Figure 4 Valve open/close status (extracted from the TEPCO report)

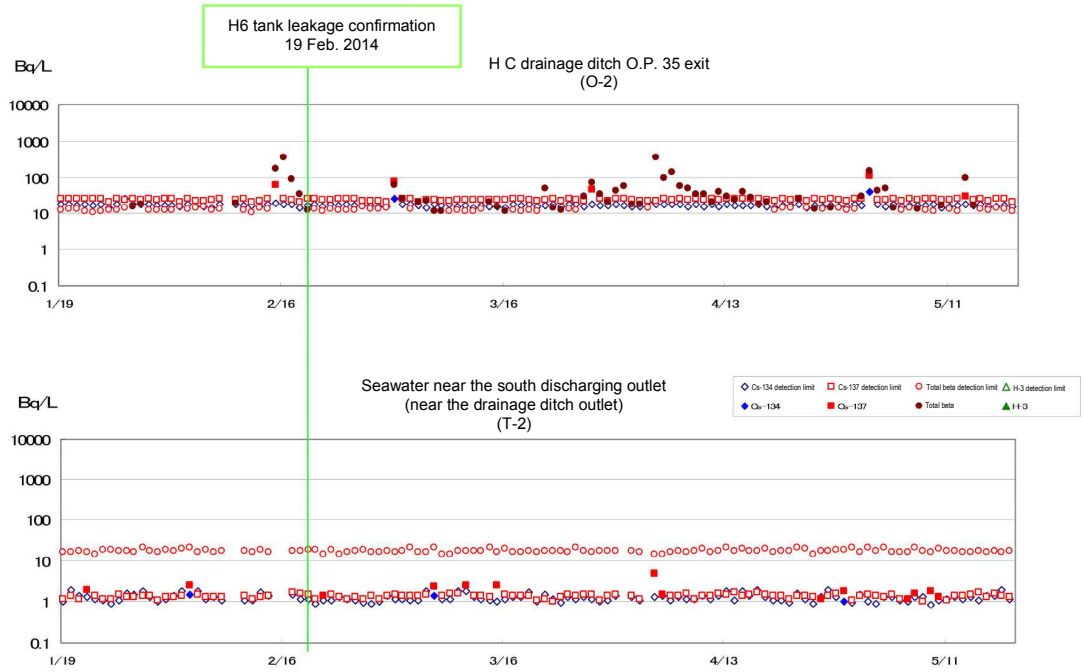


Figure 5 Results of monitoring the drainage ditch and seawater monitoring (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)

Table 1 Radiation exposure dose evaluation results (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)

Differences in workers' exposure doses	Effective dose (gamma rays)		Equivalent radiation dose (skin, beta rays)	
	Annual dose limit :50 mSv		Annual dose limit: 500 mSv	
	Avg. dose per a single entry [mSv]	Max. dose per a single entry [mSv]	Avg. dose per a single entry [mSv]	Max. dose per a single entry [mSv]
Tank patrol				
Before finding leakage (12–18 Feb.)	0.02	0.13	0.00	0.0
On the day the leakage was found (19 Feb.)	0.02	0.11	0.19	6.0
After finding leakage (20–26 Feb.)	0.02	0.05	0.00	0.1

Table 2 Progress in implementation of countermeasures related to tank leakage (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)

	Countermeasure	Data completed
Countermeasures related to operation	The method for monitoring tank water levels has been clarified and put into practice.	24 February 2014
	Tank water level monitoring by double-checking has begun.	3 March 2014
	The tank water level monitoring screen has been modified.	2 June 2014
	How to respond upon alarm issuance has been clarified and put into practice.	24 February 2014
	Enhancement of monitoring functionality (addition of warning points)	27 March 2014
	Addition of an interlock function	27 March 2014
Countermeasures related to valve opening/closing operation	Valve locking management	July 2014
	Implementation of the countermeasure of locking the valve open/close status every day has begun.	2 March 2014
	Recording of valve open/close status has begun.	1 June 2014
	Enhancement of patrols	21 February 2014
	Enhancement of monitoring cameras	26 February 2014