

Evaluation of the report by Tokyo Electric Power Company regarding an alarm set off from a side ditch effluent radiation monitor at the Fukushima Daiichi Nuclear Power Station

Nuclear Regulation Authority
September 2, 2015

1. Overview

At around 10:00 on February 22, 2015, a “high” alarm indicating an increase in the radioactive concentrations of total β nuclides*¹ (alarm set at 1,500 Bq/L) was set off from a side ditch effluent radiation monitor downstream of drainage channel C (hereinafter referred to as “the monitor”). Subsequently at 10:10, a “high-high” alarm (set at 3,000 Bq/L) was set off.

In response to the alarm, BC-1 gate, which was located at the lowermost stream of the drainage channel C, was closed at 11:35. By 12:47, other five gates installed at drainage channels B and C were closed. After peaking at around 10:40, the readings of the monitor began to decrease. By 12:20, the “high-high” alarm was cancelled. At around 22:00, the radioactive concentrations of total β nuclides decreased to normal fluctuation range. After water in drainage channels was collected using vacuum trucks, BC-1 gate was opened at 3:50 on February 23 and other five gates were opened in series by 5:23.

On February 22, 2015, the Nuclear Regulation Authority (NRA) received an accident and failure report from Tokyo Electric Power Company (TEPCO) pursuant to Article 62-3 of the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors.

On July 3, 2015, the NRA received the final report by TEPCO which describes the causes of the event and TEPCO’s countermeasures (partially corrected as of August 10, 2015). After closely examining the final report, the NRA has compiled assessment results as follows.

Final report by TEPCO:

<http://www.nsr.go.jp/activity/bousai/trouble/houkoku/00000023.html>

2. Outline of the report submitted by TEPCO

(1) Assessment of released radiation and impact on the environment

The radiation level of total β nuclides that outflowed between around 9:30 on February 22, 2015, when an increase in the reading of the monitor was observed, and 11:35, when BC-1 gate was closed, was estimated at about 4×10^8 Bq (see Table 1) on the basis of the readings of the monitor and the data indicating the flow rates in drainage channels. From February 23, the frequency of measuring radioactive concentrations in seawater at 12 locations inside the NPS port was modified from once a week to once every day to monitor radiation expansion, but no significant variation was found as a result of analyses performed by late June (see Figure 4).

(2) Results of cause investigations

On the assumption that the readings of the monitor increased due to inflow of liquid whose total β nuclide concentrations was high into the drainage channel (an assumption made from the results of investigating the event situation and assessing the amount of radioactivity), investigations were carried out regarding the conditions of the monitor, a possibility of leakage from contaminated water treatment

*1 β ray-emitting radionuclides whose radioactivity is obtained through the all beta radioactivity measuring method, not including ³H

system, a temporarily-installed tank, piping, etc. and work situation on the day the event occurred. However, the cause of the inflow of the contaminated water whose concentration was high enough to set off the “high-high” alarm from the monitor could not be identified.

(3) Countermeasures

Although the cause investigations could not identify the route of the contaminated water inflow into the drainage channel, in order to prevent the recurrence of a similar event, measures necessary to improve the handling of and enhance the management (such as storage) of high-radioactive contaminated water shall be carried out. Moreover, measures shall be taken to ensure speedier responses upon the generation of a “high-high” alarm from a radiation monitor, early detection of leakage point and the prevention of outflow into the port (see Table 4).

3. NRA's assessment of the report submitted by TEPCO and future actions

(1) Assessment of the released radiation and impact on the environment

With regard to the TEPCO's estimate of the radiation level of the radioactive materials that outflowed into the port, namely 4×10^8 Bq for total β nuclides (about 1.7×10^8 Bq for $^{90}\text{Sr}^{*2}$), TEPCO has calculated the radiation level using the readings of the monitor and flow rates measured at drainage channel C while taking into account 30-minute delay caused by a sedimentation tank, etc. (see Figure 5). Therefore the NRA has concluded that this estimate is valid.

Because the results of monitoring the inside of the intake channels for Unit 1 to 4 and port showed that the radioactive concentrations of the total β nuclides inside them were within normal variation range and did not show significant fluctuation (see Figure 4), the NRA thinks that the contribution of the outflow of the high radioactive concentration effluent to the radioactive material concentration in the port was small (it was reported that the radiation level of the radioactive materials having flowed out into the port this time was estimated at about 1.7×10^8 Bq for ^{90}Sr , while the radiation level of ^{90}Sr that has been daily flowing into the port from the bank protection of the unclosed section of the seaside impermeable wall, estimated by the 33th Committee on Supervision and Evaluation of the Specified Nuclear Facilities on March 25, 2015, is 2.7×10^9 Bq/day).

Effective doses due to γ ray and skin equivalent doses due to β ray were checked for workers who were engaged in work in response to the generation of the monitor alarm from February 22 to 23, 2015. As a result, as Table 5 shows, they were well lower than annual exposure limits, namely effective dose of 50 mSv and skin equivalent dose of 500 mSv. Therefore the NRA has concluded that no radiation exposure occurred due to the event in question.

(2) Countermeasures

Although TEPCO has failed to identify the cause of the event, it has proposed the following measures intended to enhance the management of work handling a small amount of high-concentration contaminated-water using containers, etc. – work which may have been one cause of the event:

- To raise awareness on labeling of temporary storage items containing contaminated water and thoroughly disposing unnecessary items; and to aim to conduct patrols by plant executives four times a month.
- To prevent a container containing contaminated water from being left unattended without being recognized, its type or radioactive concentration, quantity, method, and storage location will be

*² The amount of ^{90}Sr outflow was calculated based on total β nuclides outflow (4×10^8 Bq), and the ratios of total β nuclides concentration in effluent in the vicinity of the monitor (3,800 Bq/L in effluent sampled at 11:00) and ^{90}Sr concentration 1,600 Bq/L.

clearly recorded in a work schedule, which will be checked by relevant staff of TEPCO.

- To prevent the taking out of contaminated water and its mixing into a drainage channel, the control of access to and from facilities containing contaminated water will be enhanced by locking, monitoring cameras, etc. and manhole covers that can be easily opened will be locked.
- To prevent high-concentration contaminated water from flowing into a drainage channel, the scheduled removal of or water removal from piping that will not be used any more will be carried out.

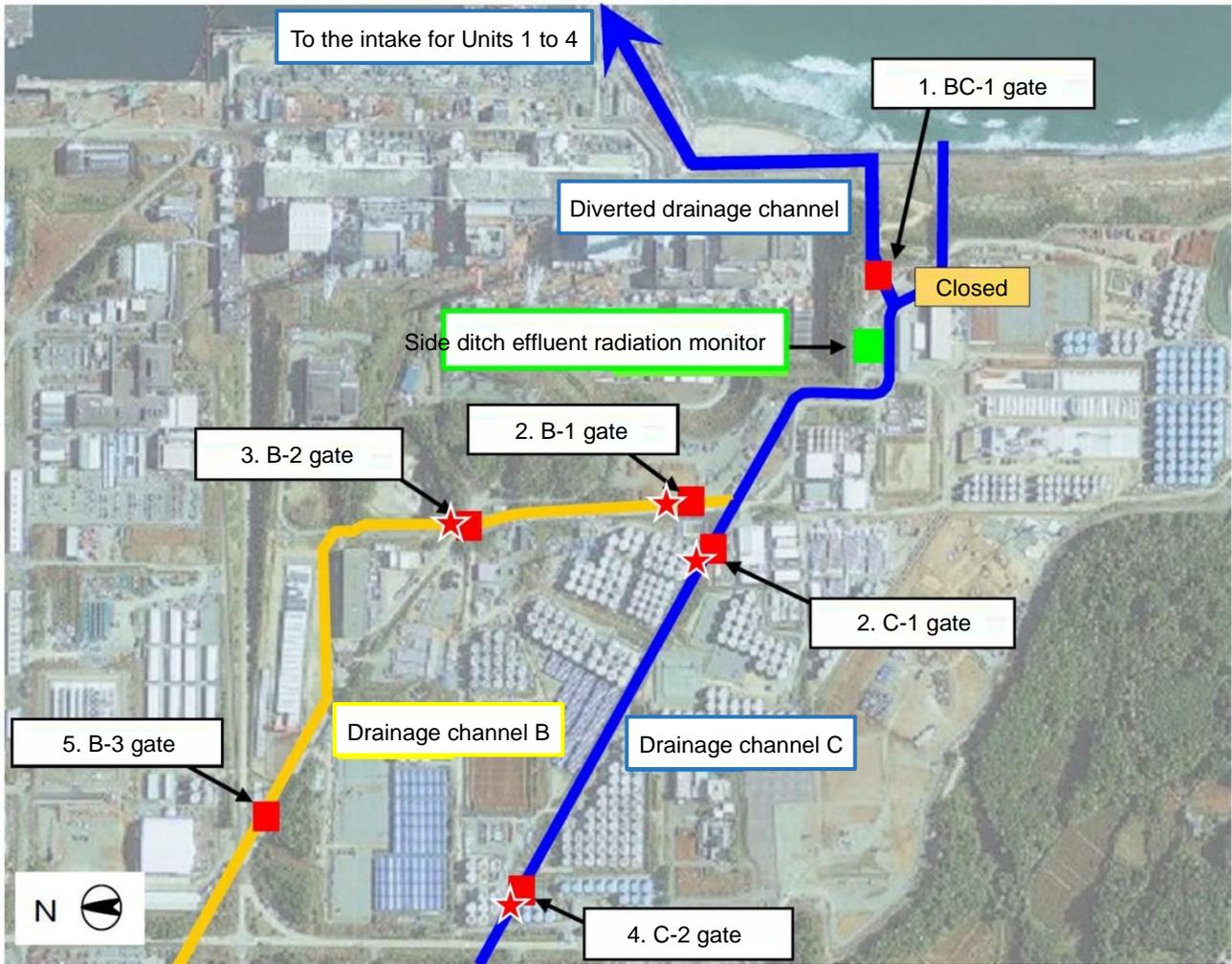
Thus, the NRA has concluded that appropriate measures for preventing the recurrence of a similar event have been taken based on the cause investigation results obtained so far.

In addition:

- With regard to BC-1 gate, which is located at the lowermost stream, its open and closure operations will be motorized and its remote control from the Main Anti-Earthquake Building will become possible, thereby significantly reducing time required for gate closure after the generation of an alarm from the monitor (as for the event in question, it took 1 hour and 30 minutes before gates were closed).
- Also regarding other gates located at drainage channels B and C, their open and closure operations will be motorized to shorten time from alarm generation to gate closure.
- Flow chart describing responses to a monitor alarm will be revised to enable prompt and appropriate responses – revisions such as adding procedures for gate closure upon high alarm generation and clarifying requirements for opening a closed gate, which shall be reflected in relevant manuals.
- Lighting equipment and pumps will be improved with gate closure and effluent collection work taken into account.
- To enable early detection of contamination, simplified radiation detectors are scheduled to be installed at four locations of drainage channels B and C (see Figure 1).

Thus the NRA has concluded that appropriate measures for suppressing the outflow of contaminated water from drainage channel C to the port upon the generation of a monitor alarm have been taken.

The NRA is going to check the implementation of these measures through operational safety inspections and other inspections.



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 (Fukushima Daiichi NPS as of March 12, 2013)

★ Locations where the installation of simple radiation detectors is scheduled (four locations)

【Clock times when the gates of drainage channels B and C closed after the event occurred】

- | |
|---|
| <ol style="list-style-type: none"> 1. BC-1 gate closed at 11:35 2. B-1 and C-1 gates closed at 11:55 3. B-2 gate closed at 12:07 4. C-2 gate closed at 12:24 5. B-3 gate closed at 12:47 |
|---|

Figure 1. Layout drawing of drainage channels B and C, side ditch effluent radiation monitor and gates (excerpt from TEPCO's final report)

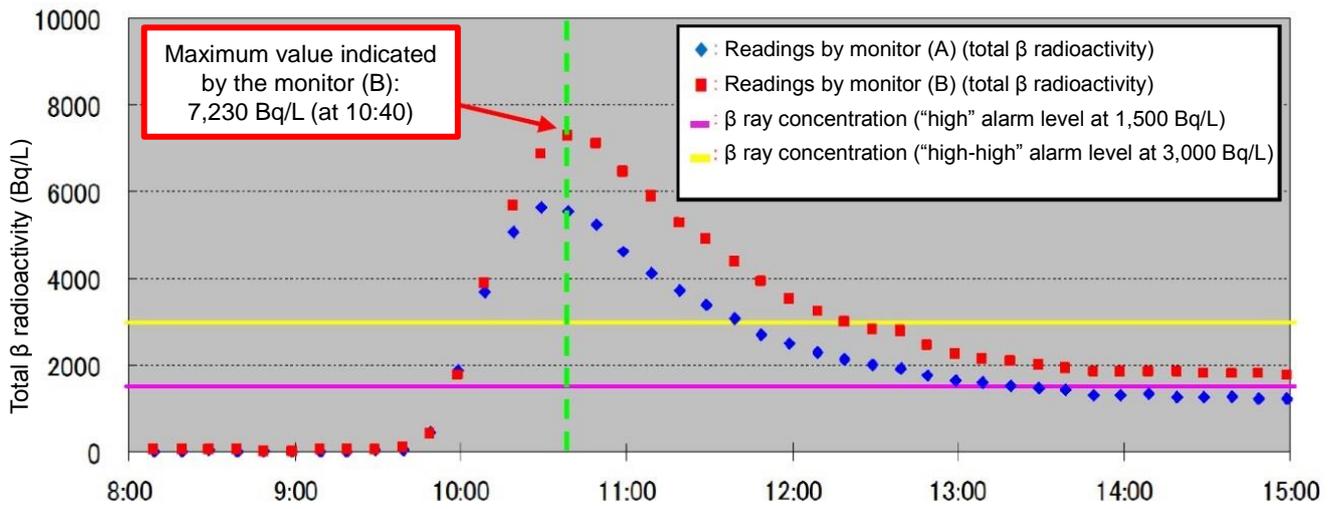


Figure 2. Total beta nuclide radioactivity concentrations measured by the side ditch effluent monitor before and after the alarm set off (excerpt from TEPCO's final report)

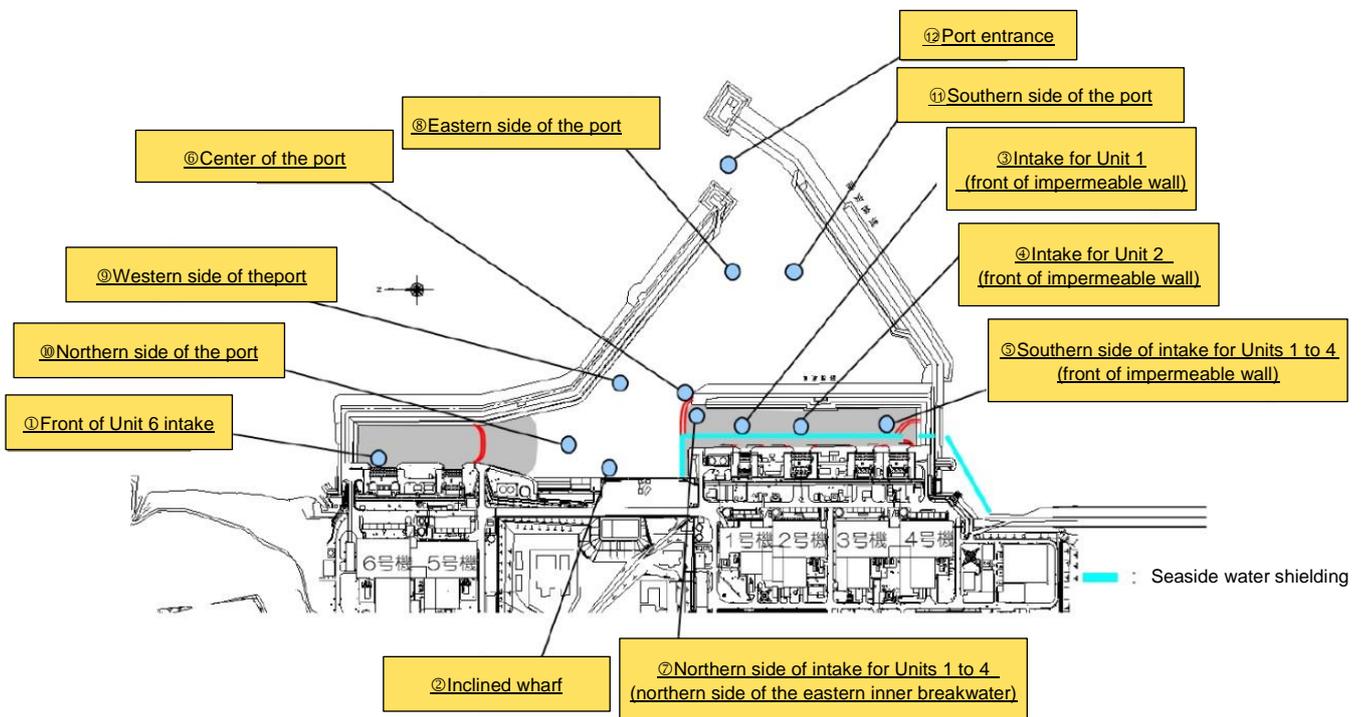


Figure 3. Monitoring locations inside the port (excerpt from TEPCO's final report)

February 22

February 22

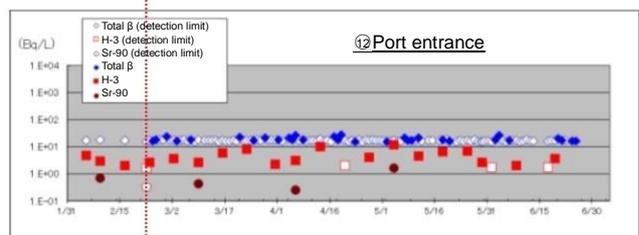
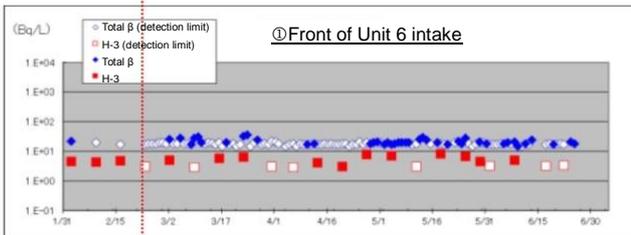
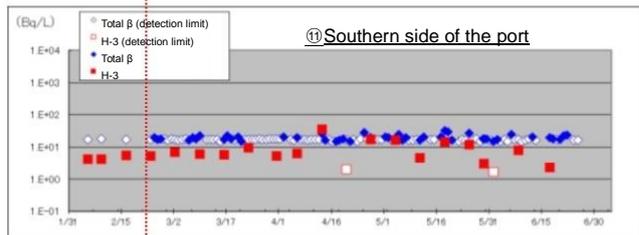
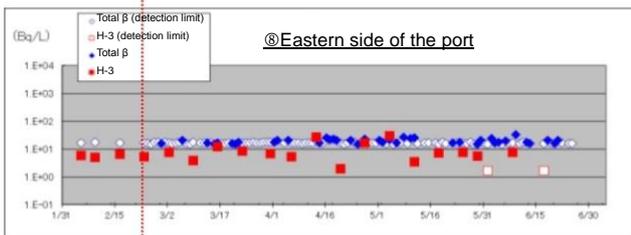
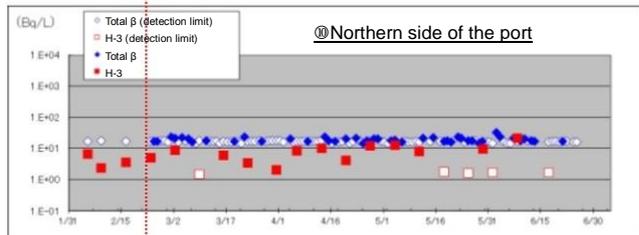
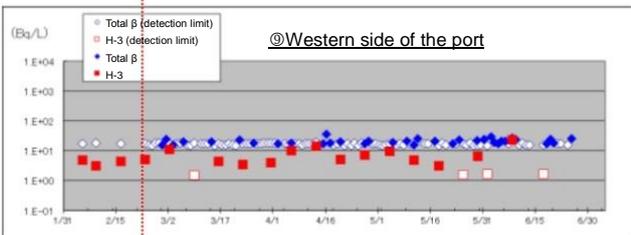
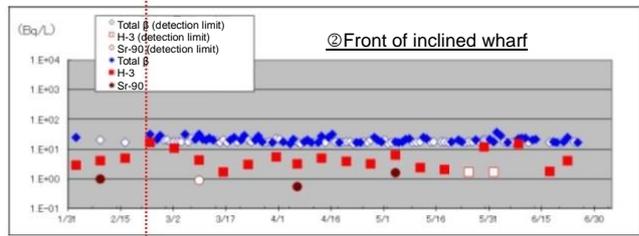
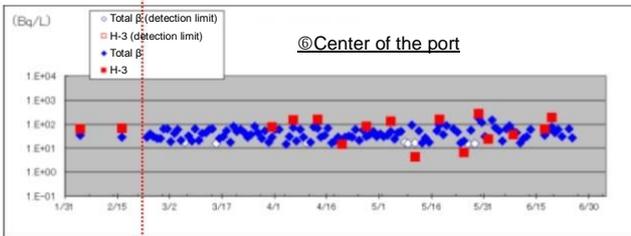
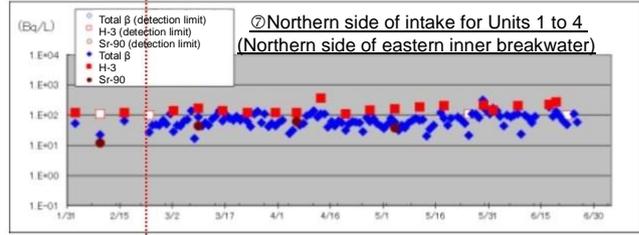
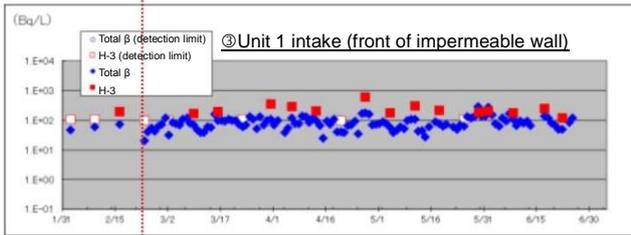
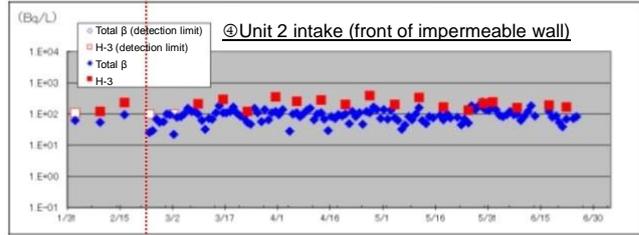
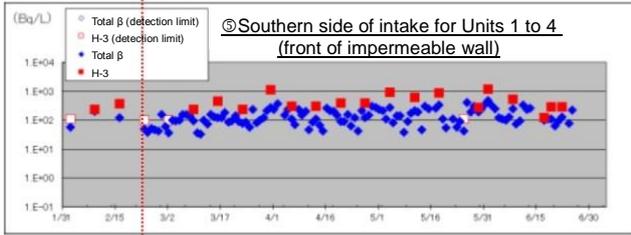
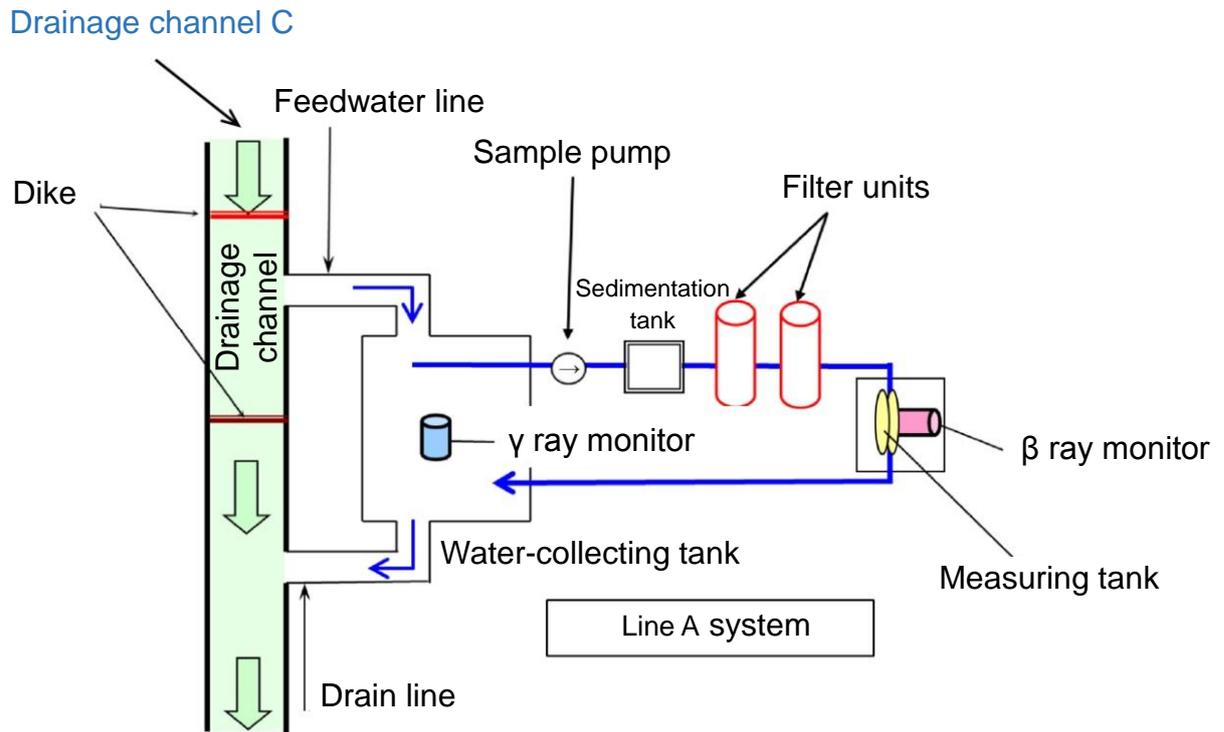


Figure 4. Results of analyzing radioactivity concentrations in the seawater in the port (excerpt from TEPCO's final report)



Monitor Line B is placed at the downstream of the drainage channel similarly to LineA system, thus redundant.

Figure 5. Outline of the side ditch effluent radiation monitor (excerpt from final report by TEPCO)

Table 1. Radioactivity of total β nuclide released after the side ditch effluent radiation monitor on the side of drainage channel C set off an alarm until the gates closed
(excerpt from final report by TEPCO)

Time	Average flow rate (L/10 min)	Time of monitoring	Line A monitor		Line B monitor		Remark
			Monitor reading	Amount of radioactivity	Monitor reading	Radiation level	
			【Bq/L】	【Bq】	【Bq/L】	【Bq】	
8:50		9:20	27		44		Monitor reading at 9:20 before radiation level increased is used as the background (BG).
9:00	8,800	9:30	35	7.0E+04	28	0	
9:10	8,300	9:40	34	5.7E+04	69	2.0E+05	
9:20	7,800	9:50	458	3.4E+06	405	2.8E+06	
9:30	7,500	10:00	1,880	1.4E+07	1,760	1.3E+07	
9:40	6,900	10:10	3,660	2.5E+07	3,870	2.6E+07	
9:50	6,300	10:20	5,050	3.2E+07	5,630	3.5E+07	
10:00	6,000	10:30	5,610	3.3E+07	6,810	4.1E+07	
10:10	5,900	10:40	5,560	3.3E+07	7,230	4.2E+07	
10:20	5,600	10:50	5,210	2.9E+07	7,060	3.9E+07	
10:30	5,600	11:00	4,630	2.6E+07	6,420	3.6E+07	
10:40	5,900	11:10	4,120	2.4E+07	5,830	3.4E+07	
10:50	6,600	11:20	3,700	2.4E+07	5,240	3.4E+07	
11:00	6,300	11:30	3,400	2.1E+07	4,860	3.0E+07	
11:10	6,000	11:40	3,040	1.8E+07	4,330	2.6E+07	
11:20	5,900	11:50	2,680	1.6E+07	3,910	2.3E+07	
11:30	5,700	12:00	2,480	1.4E+07	3,480	2.0E+07	
11:40	5,700	12:10	2,270	1.3E+07	3,200	1.8E+07	
Total				3.3E+08		4.2E+08	Total amount of radioactivity shall be 4×10^8 Bq by rounding off the Line B monitor value, which is higher than the Line A monitor value.

Table 2. Investigation contents and results regarding the outflow of radioactive materials from drainage channel C into the port

Investigation contents	Investigation results
Situation of the operation of the side ditch effluent radiation monitors	Because the readings of the monitors (Line A monitor: 3,400 Bq/L; Line B monitor: 4,900 Bq/L) were approximate to the results of analyzing the water in the drainage channel (total β nuclide: 3,800 Bq/L), we have concluded that the monitors were operating normally.
A possibility of leakage from the contaminated water treatment system (including tanks and transfer piping)	We have concluded that no leakage occurred from the tanks, treatment system or transfer piping containing contaminated water, judging from the facts that no significant fluctuation was observed at the contaminated water tank water-level indicator, no abnormality such as leakage was found by checking the tank area, and no abnormality such as leakage was found through on-site check carried out after stopping any contaminated water treatment equipment and transfer equipment installed 35 m above sea level.
A possibility of leakage from other than contaminated water treatment system, such as leakage from temporarily-installed tank	As a result of investigating contaminated water management regarding buildings, structures, materials and equipment in the vicinity of the drainage channel B, drainage channel C and side ditches connected to them, no trace of handling contaminated water around the time of the event was observed. Therefore we have concluded that no leakage occurred from other than contaminated water treatment system, such as leakage from a temporarily-installed tank.
Situation of work on the day the event occurred	<ul style="list-style-type: none"> - During the time zone of the event, no cleanup work that might increase radioactive material concentration was carried out at the drainage channels. - As a result of interviewing any worker who entered the site during the period from 4:00am to 10:00am on the day the event occurred and investigating the work records of each division, no work that may have caused the inflow of contaminated water or contaminated material into the drainage channel B, drainage channel C or side ditches connected to them was identified. - As a result of investigating the β ray exposure dose of any worker who entered the site during the period from 4:00 to 10:00 on the day the event occurred, β ray exposure was observed for two workers but it was found they had not worked at a location 35 m or higher above sea level. - As a result of checking footage from monitoring cameras installed in the contaminated water tank area, no work that may have caused the inflow of contaminated water into the drainage channels was identified.
A possibility of leakage from piping bypassing a drainage channel or its opening	As a result of checking leakage from piping bypassing the opening of a drainage channel or bypassing side ditches connected to drainage channel (including currently unused piping), no leakage was found.
A possibility of the inflow of contaminated soil from the H4 tank area	Soil contamination of 70 μm (or 35 mSv/h in dose equivalent rate) due to contaminated water leak that had taken place in the past was found locally. However, because the surrounding drainage channels are in the form of culvert (closed conduit), we have judged that no contaminated soil can be carried by e.g. rainwater and flow into the drainage channels.
Results of simulating monitor responses	As a result of simulating increases in monitor reading, it was found that, if 1 L to 400 L high-concentration contaminated water (1×10^6 to 4×10^8 Bq/L) flows into drainage channels B and C, monitor response behavior similar to that at the time the alarm set off can be reproduced.
Comparison of radionuclide composition ratio in contaminated water* <small>note</small>	As a result of comparing radionuclide composition in water sampled from drainage channel C and that of contaminated water stored or treated on site, ^{90}Sr and ^{137}Cs composition ratio in the said water was most similar to ^{90}Sr and ^{137}Cs composition ratio in water at the contaminated water treatment system's seawater desalination device inlet or ^{90}Sr and ^{137}Cs composition ratio in RO concentrated water. However, when ^3H composition ratio was taken into account, contaminated water similar to the contaminated water that flowed into the port was not identified.

Note: See Table 3 for the comparison of radionuclide composition ratio in contaminated water.

Table 3. Radionuclide composition in drainage channels and contaminated water treatment system (excerpt from TEPCO's document provided at the interview)

Type of water	^{137}Cs concentration (Bq/L)	^{90}Sr concentration (Bq/L)	^3H concentration (Bq/L)	Composition ratio ($^{90}\text{Sr}/^{137}\text{Cs}$)	Composition ratio ($^{90}\text{Sr}/^3\text{H}$)
Effluent in the vicinity of the side ditch effluent radiation monitor (sampled at 11:00 on February 22, 2015)	1.1×10^1	1.6×10^3	5.0×10^0	145	320
Water at the inlet of seawater desalination device (sampled in January 2015)	3.3×10^3	6.5×10^5	5.0×10^5	197	1
Concentrated water at the outlet of seawater desalination device (sampled in January 2015)	8.5×10^3	1.7×10^6	4.8×10^5	200	4

Table 4. Progress of measures against radioactive material outflow from drainage channel C into the port (excerpt from TEPCO's document provided at the interview)

Countermeasure		Completion period
Measures related to the handling and enhanced management (such as storage) of high-concentration contaminated water		
a	Each related division of the site shall be strictly instructed to ensure the labeling of temporally-installed tanks and containers containing contaminated water and ensure the disposal of unnecessary items.	April 17, 2015
	Periodic patrols shall be carried out to make sure that tanks, containers, etc. containing high-concentration contaminated water are not temporarily placed in the vicinity of major drainage channels or branch side ditch basins.	Ongoing since March 2015
b	When storing or pooling contaminated water in a plastic container(whose contamination level exceeding several hundred Bq/L), its type (or concentration), quantity, treatment method and storage location shall be clearly recorded in work schedule and the TEPCO's employees in charge of managing contaminated water shall check the work schedule, thereby preventing the unaccounted-for container containing contaminated water from being placed in the site.	Ongoing since May 27, 2015
c	Control of access to and from facilities where equipment containing contaminated water is placed shall be strengthened with surveillance cameras and key management, thereby preventing the unauthorized taking out of contaminated water.	Completion scheduled for the end of October 2015
d	Drainage channels B and C have been already modified to closed conduits. However, items that can be easily opened such as manhole cover shall be locked (15 locations in total).	End of May 2015
e	With regard to pipes having been used for transferring contaminated water and will not be used in the future, they shall be removed or water shall be removed from them.	Site investigation in FY 2015 and planned water removal thereafter
Measures related to response to alarm from the side ditch effluent radiation monitor		
f	Opening and closing operations of six gates for drainage channels B and C shall be motorized. BC-1 gate, which is a sea boundary gate, shall be modified so that it can be remotely controlled from the central monitoring station of the Main Anti-Earthquake Building.	Work for motorizing and enabling the remote control of BC-1 gate is scheduled to be completed in mid-September. Motorization of other gates shall be carried out thereafter one by one.
	Trainings for opening and closing the gates	All relevant workers shall be provided with trainings by the end of March 2015 and periodic trainings shall be carried out thereafter.
g	Infrastructure improvement, namely the installation of lighting equipment for nighttime work for gate closure and the pumping up of contaminated water left in drainage channels after the gate closure, shall be carried out.	April 9, 2015
	Infrastructure improvement, namely the temporary installation of pumps and the permanent installation of recovery tanks in preparation for gate closure and the pumping up of contaminated water left in drainage channels after the gate closure, shall be carried out.	Completion scheduled for mid-September 2015
h	Simple radiation detectors shall be installed in the vicinity of the upstream of each gate (four locations, i.e. B-1, B-2, C-1 and C-2) of the drainage channels B and C.	Their installation is scheduled to complete in December 2015 and their operation is scheduled to start in January 2016.
i	Work flow chart based on which responses to a monitor alarm are made shall be revised. Requirements concerning operation for opening a once-closed drainage channel gate shall be clarified and reflected in the work flow chart.	Complete in May 2015
	A guide for the work flow chart based on which responses to a monitor alarm are made shall be prepared and reflected in relevant manuals.	August 1, 2015

Table 5. Radiation exposure assessment
(excerpt from TEPCO's document provided at the interview)

Differences in radiation exposure dose among workers	Effective dose (γ ray)		Equivalent dose (skin) (β ray)	
	Annual dose limit: 50 mSv		Annual dose limit: 500 mSv	
	Average dose (mSv) per access (entry)	Maximum dose (mSv) per access	Average dose (mSv) per access	Maximum dose (mSv) per access
Emergency measures				
① Operation for closing drainage channel gates				
② Shutdown of contaminated water treatment equipment and transfer equipment on the 35m board and the checking for abnormality such as leakage	0.02	0.15	0.0	0.0
③ Checking of leakage from contaminated water transfer equipment and contaminated water tanks on the 35m board				
④ Collection of water accumulating in drainage channels				

