Attachment 3

Results of the Re-evaluation of the Radiological Environmental Impact Assessment (Construction stage*) Based on a Revision of the Nuclides to be Measured and Assessed

TEPCO

February 14, 2023

* The assessment in this report will be revised as appropriate based on progress in discussions around design and operation of plans regarding discharged into the sea, opinions from relevant parties, reviews by IAEA experts, and cross check assessments by third parties.

Overview

- After the Radiological Impact Assessment Regarding the Discharge of ALPS Treated Water into the Sea (Design stage / Revised version) was published in April 2022, the assessment results were partially reviewed in November 2022 based on our consideration and progress in construction, as well as the results of the IAEA review and discussions with the Nuclear Regulation Authority (NRA).

- In the November 2022 assessment, the source terms were revised based on the selection of 30 nuclides to be measured and assessed at the time of the discharge of the ALPS treated water into the sea.

- Following discussions in a Technical Meeting with the Nuclear Regulation Agency, the approach to selecting the nuclides to be measured and assessed was partially revised. The Radiological Environmental Impact Assessment was conducted again, because we reselected 29 nuclides as the nuclides to be measured and assessed. The change to 29 nuclides has also been reviewed by the IAEA.

  (For details of the concept of selection of nuclides to be measured and evaluated, refer "Partial Revisions of the Application Documents for Approval to Amend the Implementation Plan Regarding the Handling of ALPS Treated Water [Overview]").

- In this assessment, the nuclide composition in the source terms was also amended to reflect decay as of March 2023 to match the use of inventory as of March 2023, that is 12 years after the Accident, in selecting the nuclides to be measured and assessed.

- Findings from IAEA review mission in November 2022 were also reflected in this assessment.

- With regard to the radiological environmental impact assessment, the conclusion remains the same as before that assessment doses are significantly less than the dose limits for the general public, dose constraint, and the values specified by international organizations for each species.

  - Dose assessment value for the humans has dropped by 1/40th to 1/2 compared to the values at the design stage.

  - Dose assessment value for the environment has dropped by 1/30th to 1/100th compared to the values at the design stage.

About the assessment

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- Following the Japanese Government's Basic Policy on the Handling of ALPS Treated Water, TEPCO developed a methodology to assess the radiological impact on humans and the environment, in accordance with internationally recognized methods (as found in the International Atomic Energy Agency (IAEA) Safety Standard documents and International Commission on Radiological Protection (ICRP) recommendations), for the discharge of ALPS treated water into the sea with the designs and operations of the facilities being considered by TEPCO.
- Exposure dose assessment conducted in accordance with this methodology indicated that effects of the discharge of ALPS treated water into the sea on the public and the environment are minimal as calculated doses were significantly less than the dose limits, dose targets, and the values specified by international organizations for each species.
- Going forward, TEPCO will go through the necessary procedures to gain the NRA's approval on the implementation plan, and will revise the assessment as necessary based on the IAEA experts' reviews and input/review by relevant parties, even after the discharge of ALPS treated water into the sea is initiated.
- TEPCO will continue to disseminate, in a transparent manner, scientific information regarding the radiological impact on the public and the marine environment to foster understanding and expel concerns for people at home and abroad.

TEPCO will strictly comply with various laws and regulations and the Government of Japan regulatory standards that conform to international recognized technical documents (IAEA safety standards and ICRP recommendations) on the concentrations of tritium and other radioactive materials in the water to be discharged to secure the safety of the public and the environment.

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Discharge method as preconditions for assessment

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- Before the discharge of the ALPS treated water, 29 nuclides to be measured and assessed toward the discharge of the ALPS treated water into the sea and tritium will be measured and assessed (including measurement and assessment by third-party laboratories) to verify that the water has been purified until the sum of ratios of the concentration of each radionuclide other than tritium to the regulatory concentration is less than one.
- The annual amount of tritium to be discharged will be less than 22 TBq as the discharge management target for the Fukushima Daiichi Nuclear Power Station (FDNPS) before the Accident at the FDNPS.
- Upon discharge, the ALPS treated water will be diluted by seawater by 100 times or more so that the tritium concentration at the discharge outlet will be less than 1,500 Bq/L. Through this process, the sum of ratios of the concentration of each radionuclide other than tritium to the regulatory concentration will be also diluted to less than 1/100.
- The diluted ALPS treated water will be discharged at the bottom of the sea approx. 1 km off the coast of FDNPS so that the discharged water is less likely to be re-taken in as seawater to dilute the ALPS treated water to be discharged.
- If there is an abnormality during the discharge of ALPS treated water, the emergency shut-off valves will be actuated immediately and the ALPS treated water transfer pumps will be shutdown to stop discharging.

* The sum of the ratios: When multiple types of radionuclides are contained in the discharge of ALPS treated water, the ratios of the concentration of each radionuclide to the regulatory concentration limit of each are calculated and then summed. The applicable law and regulations stipulate that at Fukushima Daiichi Power Station, the sum of the ratios of radionuclides must be less than 1 at the drain. In discharging ALPS treated water into the sea as planned this time, the water will be treated with ALPS and other equipment for the sum of the ratios of radionuclides other than tritium to be less than one and then diluted by 100 times or more with seawater before discharge until the tritium concentration is 1/40th (1,500 Bq/L) of the regulatory concentration limit of tritium (less than 60,000Bq/L). As a result, the concentrations of radionuclides other than tritium will be far below the regulatory concentration limit of each.

Remain the original

Procedures for the radiological environmental impact assessment

The radiological impact was assessed according to the following procedures based on the IAEA safety standards documents*1.

Impact on the public

Procedure	Description
Selection of the source terms	Define the type and amount of radioactive materials discharged into the sea of treated water
Modelling of direct irradiation, dispersion and transfer in the environment	Study how the various radioactive materials discharged into the sea diffuse, transfer, and accumulate
Identification of exposure pathways	Study the pathways by which people are exposed to the dispersed and transferred radioactive materials
Identification of the representative person for normal operation	Define the person most exposed in the population being assessed from the exposure pathways identified above
Assessment of the dose to the representative person	Assess the dose for the representative person
Comparison of estimated dose with dose constraint*2 and dose limits	Evaluate after comparing the estimated dose against the dose constraint (0.05 mSv/year) and the dose limit for the general public (1mSv/year)

Impact on environmental protection (organisms other than humans)

Procedure	Description
Select the source terms	Define the type and amount of radioactive materials discharged in treated water sea discharge
Model dispersion and transfer in the environment	Study how the various radioactive materials discharged into the sea disperse, transfer and accumulate
Identify exposure pathways	Study the pathways by which marine animals and plants exposed to the dispersed and transferred radioactive materials
Select reference animals and plants	Select species to be assessed (Flatfish, crabs, brown seaweed were selected based on ICRP documents)
Assess the dose rate for reference animals and plants	Assess dose rates for reference animals and plants
Compare estimated dose rates to with derived consideration reference levels	Evaluate after comparing the derived consideration reference level set out for each species

*1 IAEA GSG-9 "Regulatory Control of Radioactive Discharges to the Environment"
IAEA GSG-10 "Prospective Radiological Environmental Impact Assessment for Facilities and Activities"

*2 Dose constraint: A value lower than the dose limit, stipulated by the person responsible for radiation work or the radiation facility to optimize safety in physical protection. In regards to Fukushima Daiichi Nuclear Power Station , the NRA issued the opinion on February 16, 2022 that the station dose target (0.05 mSv/year) was equivalent to the dose constraint in the IAEA Safety Standards

Selection of source terms (type and amount of radioactive materials to be discharged)

Underlined parts: Major areas of updated

Updated

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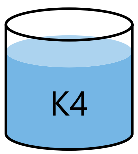
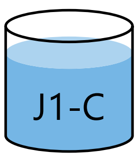
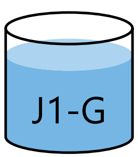
- From the standpoint of more realistic assumptions, this assessment assumes that the ALPS treated water from the three tank groups for which we have almost all the measured values of nuclides to be measured and assessed will be diluted with seawater, then discharged continuously during the discharge period.
- 30 nuclides including tritium were selected as the source term based on the nuclides to be measured and assessed (29 nuclides), which are selected based on the discussions at the Technical Meeting with the Nuclear Regulation Agency held in December 2022.
- Data from other tanks etc. were used in assessment for nuclides that have not been measured for each tank group.
- Radioactive materials that have not been detected before are assumed to be included at their detection limit.
- The nuclide concentration in each tank group was adjusted based on their half-life to March 2023, 12 years after the Accident.



i. K4 tank group
Tritium concentration: approx. 140,000 Bq/L
Sum of ratios of the activity concentration of 29 nuclides other than tritium to the regulatory concentration* ：0.26



ii. J1-C tank group
Tritium concentration: approx. 720,000 Bq/L
Sum of ratios of the activity concentration of 29 nuclides other than tritium to the regulatory concentration* ：0.21



iii. J1-G tank group
Tritium concentration: approx. 240,000 Bq/L
Sum of ratios of the activity concentration of 29 nuclides other than tritium to the regulatory concentration* ：0.10

All scenarios assume that

- The amount of tritium in discharged treated water is less than 22 TBq per year
- The tritium concentration of the treated water after dilution is less than 1,500 Bq/L

* The sum of the ratios : When multiple types of radionuclides are contained in discharge water, the ratios of the concentration of each radionuclide to the regulatory concentration limit of each are calculated and then summed. The law stipulates that at Fukushima Daiichi, the sum of the ratios of radionuclides must be less than 1 at the outlet. In discharging ALPS treated water into the sea as planned this time, the water will be treated with ALPS and other equipment for the sum of the ratios of radionuclides other than tritium to be less than one and then diluted by 100 times or more with seawater before discharge until the tritium concentration is 1/40th (1,500 Bq/L) of the regulatory concentration limit of tritium (less than 60,000Bq/L). As a result, the concentrations of radionuclides other than tritium will be far below the regulatory concentration limit of each.

[Reference] Comparison with nuclides to be removed with ALPS (62 nuclides) and carbon-14

Underlined parts: Major areas of updated

Updated

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- Since the NRA's approval in July 2022, the nuclides that have been changed by the time of this revised application are as follows.
- TEPCO will continuously and voluntarily measure nuclides subject to ALPS removal that were not selected as nuclides to be measured and assessed to verify ALPS performance.

Nuclides to be measured and assessed : 29 Nuclides (=24+5)

※ In addition to the nuclides in the table below, tritium will be also measured.

C-14 Carbon	**Y-90** Yttrium	**Cs-137** Cesium	**U-238** Uranium	**Cm-244** Curium
Mn-54 Manganese	**Tc-99** Technetium	**Ce-144** Cerium	**Np-237** Neptunium	
Fe-55 Iron	**Ru-106** Ruthenium	**Pm-147** Promethium	**Pu-238** Plutonium	
Co-60 Cobalt	**Sb-125** Antimony	**Sm-151** Samarium	**Pu-239** Plutonium	
Ni-63 Nickel	**Te-125m** Tellurium	**Eu-154** Europium	**Pu-240** Plutonium	
Se-79 Selenium	**I-129** Iodine	**Eu-155** Europium	**Pu-241** Plutonium	
Sr-90 Strontium	**Cs-134** Cesium	**U-234** Uranium	**Am-241** Americium	

(Shaded): Nuclides added to be on the conservative side based on the selection flow (5 nuclides)

Nuclides excluded from those to be measured and assessed among the nuclides to be removed with ALPS : 39 nuclides (=13+10+16)

Step 1 (13 nuclides)		Step 3 (10 nuclides)		Step 4 and 5 (16 nuclides)		
Fe-59 Iron	Te-129m Tellurium	Co-58 Cobalt	Te-123m Tellurium	Zn-65 Zinc	Ba-137m Barium	Cm-242 Curium
Rb-86 Rubidium	Cs-136 Cesium	Y-91 Yttrium	Te-127 Tellurium	Rh-106 Rhodium	Pr-144 Praseodymium	Cm-243 Curium
Sr-89 Strontium	Ba-140 Barium	Nb-95 Niobium	Te-127m Tellurium	Ag-110m Silver	Pr-144m Praseodymium	
Ru-103 Ruthenium	Ce-141 Cerium	Sn-123 Tin	Gd-153 Gadolinium	Cd-113m Cadmium	Pm-146 Promethium	
Rh-103m Rhodium	Pm-148 Promethium	Sb-124 Antimony	Tb-160 Terbium	Sn-119m Tin	Eu-152 Europium	
Cd-115m Cadmium	Pm-148m Promethium			Sn-126 Tin	Am-242m Americium	
Te-129 Tellurium				Cs-135 Cesium	Am-243 Americium	

- : Nuclides whose inventory volume decreased and excluded from selection in step 1 (13 nuclides)
- : Nuclides whose inventory volume decreased and excluded from selection in step 3 (10 nuclides)

(above two) All nuclides Half-life less than 1 year

- : Nuclides excluded from selection in step 4 and 5 as a result of reviewing the state of transition to contaminated water from nuclear reactors, etc. according to the actual situation. (16 nuclides)

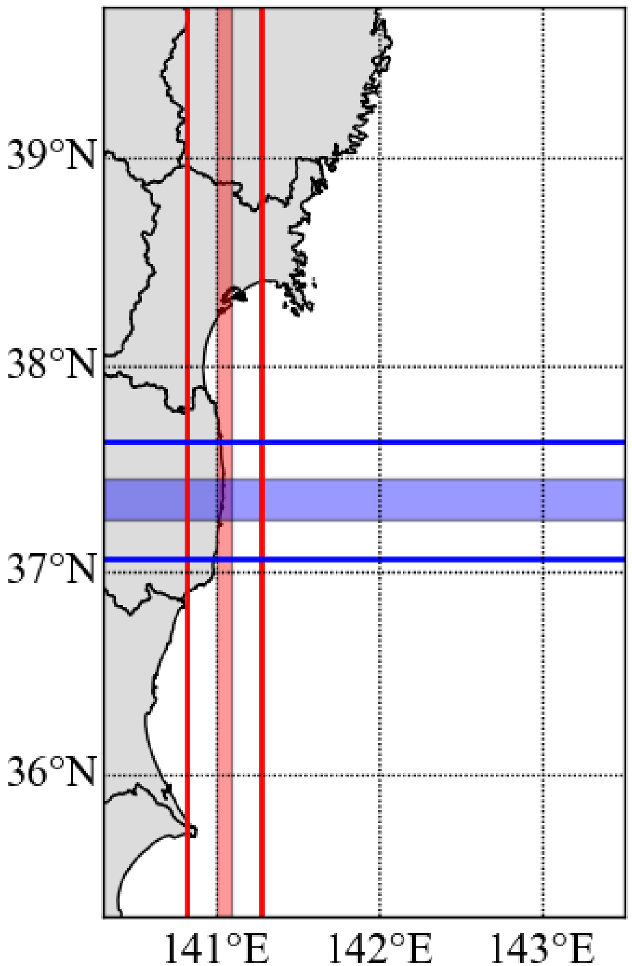
[Reference] Nuclides to be measured and assessed for tank groups used in the assessment and their concentrations

- The concentration of all the nuclides was adjusted based on their half-life to March 2023, 12 years after the Accident.

			Source term based on K4 tank water		Source term based on J1-C tank water		Source term based on J1-G tank water	
	Nuclides	Regulatory concentration limit (Bq/L)	Treated water concentration (Bq/L)	The ratios to regulatory concentrations	Treated water concentration (Bq/L)	The ratios to regulatory concentrations	Treated water concentration (Bq/L)	The ratios to regulatory concentrations
1	H-3	6.0E+04	1.4E+05		7.2E+05		2.4E+05	
2	C-14	2.0E+03	1.5E+01	7.5E-03	1.8E+01	9.0E-03	1.6E+01	8.0E-03
3	Mn-54	1.0E+03	8.5E-05	8.5E-08	5.3E-03	5.3E-06	5.4E-03	5.4E-06
4	Fe-55	2.0E+03	2.1E+00	1.1E-03	2.4E+00	1.2E-03	2.4E+00	1.2E-03
5	Co-60	2.0E+02	2.2E-01	1.1E-03	2.4E-01	1.2E-03	1.7E-01	8.5E-04
6	Ni-63	6.0E+03	2.1E+00	3.5E-04	8.3E+00	1.4E-03	8.7E+00	1.5E-03
7	Se-79	2.0E+02	1.5E+00	7.5E-03	1.5E+00	7.5E-03	1.5E+00	7.5E-03
8	Sr-90	3.0E+01	1.9E-01	6.3E-03	3.4E-02	1.1E-03	3.0E-02	1.0E-03
9	Y-90	3.0E+02	1.9E-01	6.3E-04	3.4E-02	1.1E-04	3.0E-02	1.0E-04
10	Tc-99	1.0E+03	7.0E-01	7.0E-04	1.2E+00	1.2E-03	1.3E+00	1.3E-03
11	Ru-106	1.0E+02	4.2E-02	4.2E-04	2.7E-01	2.7E-03	9.4E-02	9.4E-04
12	Sb-125	8.0E+02	8.6E-02	1.1E-04	1.2E-01	1.5E-04	7.5E-02	9.4E-05
13	Te-125m	9.0E+02	8.6E-02	9.6E-05	1.2E-01	1.3E-04	7.5E-02	8.3E-05
14	I-129	9.0E+00	2.1E+00	2.3E-01	1.2E+00	1.3E-01	3.3E-01	3.7E-02
15	Cs-134	6.0E+01	7.4E-03	1.2E-04	3.3E-02	5.5E-04	3.0E-02	5.0E-04
16	Cs-137	9.0E+01	3.7E-01	4.1E-03	1.7E-01	1.9E-03	3.1E-01	3.4E-03
17	Ce-144	2.0E+02	5.3E-04	2.7E-06	6.4E-02	3.2E-04	6.5E-02	3.3E-04
18	Pm-147	3.0E+03	4.5E-02	1.5E-05	4.2E-01	1.4E-04	3.8E-01	1.3E-04
19	Sm-151	8.0E+03	8.6E-04	1.1E-07	1.1E-02	1.4E-06	9.8E-03	1.2E-06
20	Eu-154	4.0E+02	7.8E-03	2.0E-05	9.4E-02	2.4E-04	8.4E-02	2.1E-04
21	Eu-155	3.0E+03	1.5E-02	5.0E-06	2.4E-01	8.0E-05	1.2E-01	4.0E-05
22	U-234	2.0E+01	6.3E-04	3.2E-05	3.2E-02	1.6E-03	2.8E-02	1.4E-03
23	U-238	2.0E+01	6.3E-04	3.2E-05	3.2E-02	1.6E-03	2.8E-02	1.4E-03
24	Np-237	9.0E+00	6.3E-04	7.0E-05	3.2E-02	3.6E-03	2.8E-02	3.1E-03
25	Pu-238	4.0E+00	6.0E-04	1.5E-04	3.2E-02	8.0E-03	2.7E-02	6.8E-03
26	Pu-239	4.0E+00	6.3E-04	1.6E-04	3.2E-02	8.0E-03	2.8E-02	7.0E-03
27	Pu-240	4.0E+00	6.3E-04	1.6E-04	3.2E-02	8.0E-03	2.8E-02	7.0E-03
28	Pu-241	2.0E+02	2.2E-02	1.1E-04	1.1E+00	5.5E-03	8.9E-01	4.5E-03
29	Am-241	5.0E+00	6.2E-04	1.2E-04	3.2E-02	6.4E-03	2.8E-02	5.6E-03
30	Cm-244	7.0E+00	5.1E-04	7.3E-05	3.0E-02	4.3E-03	2.6E-02	3.7E-03
			Sum of the ratios to regulatory concentrations		Sum of the ratios to regulatory concentrations	2.1E-01	Sum of the ratios to regulatory concentrations	1.0E-01

Dispersion and transfer in the environment (dispersion calculations in the sea area)

The assessment used a model that was found to be reproducible based on the repeatability calculations for the cesium concentration in seawater after the accident at the Fukushima Daiichi Nuclear Power Station. In addition, the calculations with higher resolutions was conducted so as to simulate the sea area near the power station in detail.



- Applied the Regional Ocean Modeling System (ROMS) to the sea area off the Fukushima coast
- Sea area flow data
  - Data interpolated from JMA short-term meteorological forecast data[1] was used in the sea surface driving force
  - Ocean reanalysis data (JCOPE2[2]) was used as the source for boundary conditions for the open sea and data assimilation*
- Scope of modeling: The resolution of the sea area 35.30-39.71°N, 140.30-143.50°E （490km×270km); 22.5 km north to south and 8.4 km east to west of the Station was increased gradually
  - Resolution (overall): NS approx.925m x EW approx.735m （approx.1km); 30 layers vertically
  - Resolution (immediate vicinity of the station): NS approx.185m x EW approx.147m （approx.200m); 30 layers vertically (sea area with red and blue hatching in the diagram on the left)
- Meteorological and sea condition data
  - Data from 2014 and 2019

*Data assimilation: a method for incorporating actual measurements in numerical simulations. Also known as nudging.

[1] A. Hashimoto, H. Hirakuchi, Y. Toyoda, and K. Nakaya, "Prediction of regional climate change over Japan due to global warming (Part 1) – Evaluation of Numerical Weather Forecasting and Analysis System (NuWFAS) applied to a long-term climate simulation-" CRIEPI Report, 2010.
[2] Y.Miyazawa, R.Zhang, X.Guo, H.Tamura, D.Ambe, J.-S.Lee, A.Okuno, H.Yoshinari, T.Setou, and K.Komatsu,, "Water mass variability in the western North Pacific detected in a 15-year eddy resolving ocean reanalysis," 2009.

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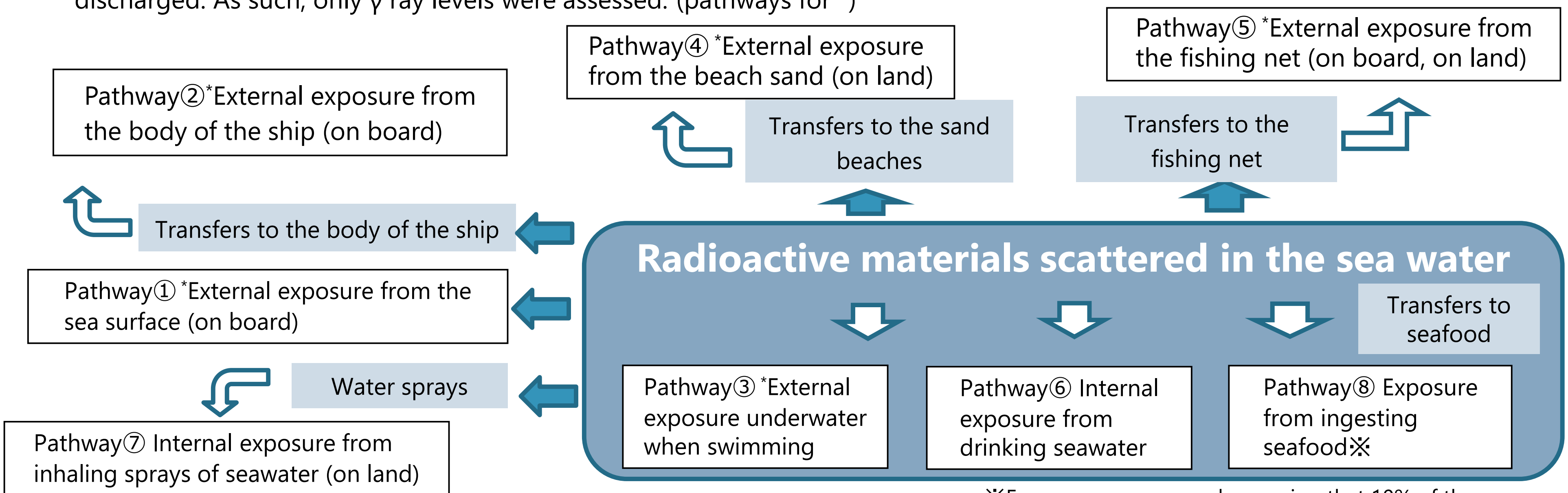
Identifying the exposure pathways (assessment model)

（1） Transfer and exposure pathways (human exposure)

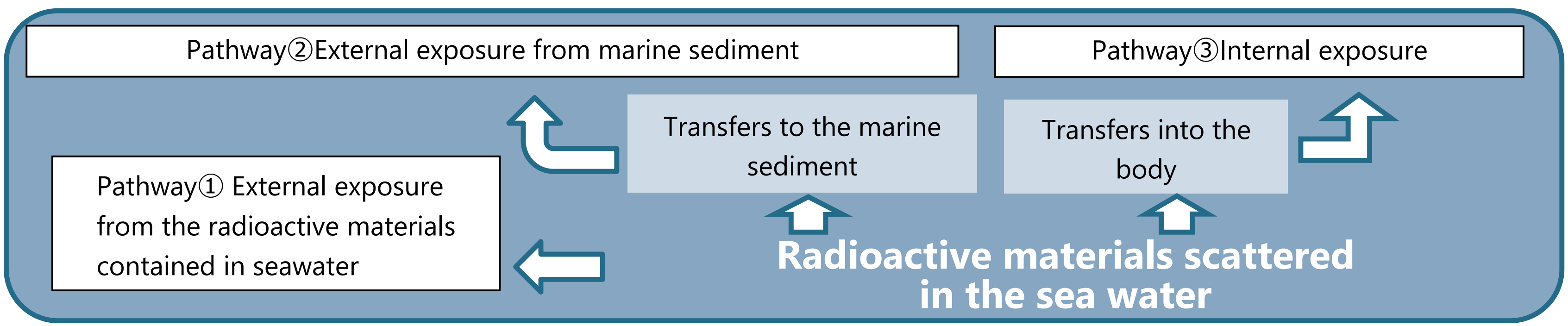
- Pathways were set based on IAEA Safety Standards and domestic examples (See Attachment VI "Transfer and exposure pathways not subject to assessment" for how the pathways were selected)

  ※ The impact of external exposure is expected to be minimal as the concentration of radioactive materials will be diluted and then discharged. As such, only γ ray levels were assessed. (pathways for *)



※Exposure was assessed assuming that 10% of the tritium ingested via seafood is organically bound tritium (OBT).

（2） Transfer and exposure pathways (plants and animals)



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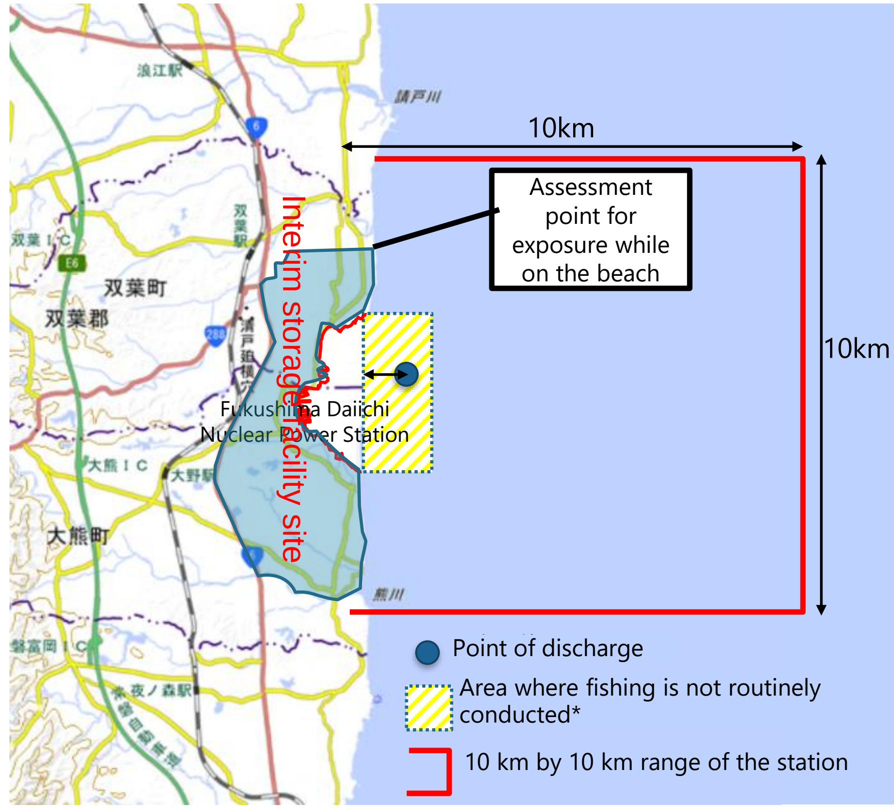
Dispersion and transfer in the environment (calculating concentrations of radioactive materials for the assessment)

- The tritium concentration in the sea area was calculated using the actual annual meteorological/sea conditions data assuming that tritium is discharged evenly throughout the year
- The annual average concentration of tritium was calculated for the 10km by 10km area around the station
- External exposure underwater when swimming, external exposure from the beach sand, internal exposure when drinking seawater, and internal exposure from inhaling seawater sprays were assessed using the assessment point for exposure while on the beach
- Other exposure pathways were assessed in the 10km by 10km area around the station
  - Doses were calculated for the upper layers (external exposure from the sea surface and ships), all layers (external exposure from fishing nets and internal exposure from ingesting seafood), and lower layers (exposure of animals and plants)
  - The concentrations of the other 63 nuclides were calculated using the calculated tritium concentration and the proportions of each nuclide in the discharged treated water
- In order to evaluate the uncertainty of the results depending on the size of sea area subject to assessment, exposure assessments were also conducted for the 5 km x 5 km area and the 20 km x 10 km area. (See Attachment XII “Effects of the area subject to seawater concentration assessment used in exposure assessment” for details.)



*Area where common fishery rights are not set

Assessment points for seawater concentrations used in dose assessment

Source: This map was created by Tokyo Electric Power Company Holdings, Inc. based on a map published by the Geographical Survey Institute (Electronic Map Web)
https://maps.gsi.go.jp/#13/37.422730/141.044970/&base=std&ls=std&disp=1&vs=c1j0h0k0l0u0t0z0r0s0m0f1

※Nuclides other than tritium are also evaluated as dispersing and transferring in a dissolved state in seawater.

Setting of the representative person and reference animals/plants

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(1) Representative person (human exposure)

- The lifestyle of the representative person (external exposure) was taken from the "public dose assessment in safety screening for commercial light-water reactor facilities"
  - Works 120 days (2,880 hours) per year in the fishery, of which 80 days (1,920 hours) are spent working near nets
  - Resides by the seashore 500 hours a year and swims 96 hours a year
- The amount of seafood ingested annually (internal exposure) was taken from the latest data on diet. Two scenarios, one for a person who ingests seafood at the national average and the other for a person who ingests a lot of seafood (mean + 2σ *) were considered

Table 6-1-13
Amount of seafood ingested by a person who ingests seafood at the national average (g/day)
(Set according to the 2019 National Health and Nutrition Examination Survey [6] published by the Ministry of Health, Labour and Welfare)

	Fish	Invertebrate	Seaweed
Adult	58	10	11
Toddler	29	5.1	5.3
Infant	12	2.0	2.1

Table 6-1-14
Amount of seafood ingested by a person who ingests a lot of seafood (g/day)
(Set according to the 2019 National Health and Nutrition Examination Survey [6] published by the Ministry of Health, Labour and Welfare)

	Fish	Invertebrate	Seaweed
Adult	190	62	52
Toddler	97	31	26
Infant	39	12	10

(2) Reference animals and plants (environmental protection)

Reference flatfish, reference crab, reference brown seaweed were selected from the marine environment reference organisms indicated in ICRP Pub.136**.

- Flatfish: Flounders widely inhabit in the surrounding sea area, and are important fish for the local fishery industry
- Crab：Many types of crabs (e.g., portunus trituberculatus, ovalipes punctatus) widely inhabit the surrounding sea area
- Brown seaweed：Many types of seaweed including gulfweed and sea oak widely inhabit the surrounding sea area

* σ : Standard deviation
** ICRP Pub.136 "Dose Coefficients for Non-human Biota Environmentally Exposed to Radiation"

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Dose assessment for representative individuals

External exposure (Pathway ①～⑤)

- Exposure due to radiation from the sea when moving by boat or working at sea （Pathway ① and ③）

Amount of exposure ＝Effective dose equivalent coefficient × Concentration of radioactive materials in the seawater

- Exposure due to radiation from the radioactive materials that have moved to the body of the ship or sand beaches from seawater （pathways②, ④ and ⑤）

Amount of exposure ＝ Effective dose equivalent coefficient ×Transfer coefficient× Concentration of radioactive materials in the seawater

- The effective dose equivalent coefficient that indicates the amount of radiation a person is exposed to from a 1 Bq/L concentration of radioactive material specified in the Handbook on Environmental Impact Assessment for Decommissioning Work*1 was used here
- The transfer coefficient that describes how much radioactive material transfers from the 1Bq/L concentration of radioactive material in the seawater to the body of the ship or sand beaches was mostly taken from the designated application for reprocessing businesses (Japan Nuclear Fuel Limited,1989)*2. The sand beach transfer coefficient specified in the old Nuclear Safety Commission guidelines*3 was used here.

*1 “Survey on Environmental Impact Assessment Technology for Decommissioning of Commercial Reactors - Survey on Environmental Impact Assessment Parameters (FY2006 Survey Commissioned by Ministry of Economy, Trade and Industry) Appendix: Handbook on Environmental Impact Assessment for Decommissioning Work, Central Research Institute of Electric Power Industry

*2 “Application for designation of the Rokkasho Reprocessing Plant as a reprocessing business”, Japan Nuclear Fuel Limited

*3 “Dose assessment for the general public in the safety assessment of light water reactor facilities for power generation”， Nuclear Safety Commission

Dose assessment for representative individuals

TEPCO

Internal exposure (Pathway⑥⑦⑧)

Amount of exposure = Effective dose coefficient × ingestion rate

- The rate at which a person ingests water when they accidentally drink seawater while swimming was set at 0.2 L/hour (Pathway⑥)
- The rate at which water sprays due to waves are inhaled at the beach was calculated using the formula below (Pathway ⑦)

Ingestion rate = Concentration of radioactive materials in the seawater × breathing rate × concentration of water sprays in the air ÷ seawater density

  - The coefficient set out in the guidelines of the former Nuclear Safety Commission (NSC) is used for the breathing rate
  - The coefficient set out in TECDOC-1759[*2] is used for the concentration of water sprays in the air

- Ingestion rate regarding ingestion of seafood (Pathway⑧)

Ingestion rate = Concentration of radioactive materials in seawater × concentration coefficient × amount of seafood ingested annually

  - The effective dose coefficient set out in IAEA GSR Part 3[*3] is used in calculations
  - The concentration coefficient set out for fish, invertebrates (excluding squid and octopi), and seaweed in IAEA TRS No.422[*4] is used in calculations
  - Dilution at the seafood market and attenuation of various radioactive materials from collection to ingestion is not considered
  - Seafood is classified into the categories of fish, invertebrates (including shrimp, crab, squid and octopi), and seafood in calculating the ingestion rate of seafood

*1 Nuclear Safety Commission, "Dose Assessment for the General Public in Commercial Light-water Reactor Facilities Safety Review"
*2 IAEA-TECDOC-1759, "Determining the Suitability of Materials for Disposal at Sea under the London Convention 1972 and London Protocol 1996: A Radiological Assessment Procedure"
*3 IAEA Safety Standards Series No. GSR Part 3, "Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards"
*4 IAEA Technical Report Series No.422, "Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment"

Remain the original

Dose assessment for representative individuals

TEPCO

Assessment standard (sum of external and internal exposure)

- The result was compared with 1mSv/year, the dose limit for the general public
- February 2022, the NRA issued opinions regarding its approach to and criteria for confirming the results of radiological impact assessments. In it they stated that the value of 0.05 mSv per year (50 µSv per year) can be considered equivalent to the dose constraint in the IAEA Safety Standards. In light of this, the value of 0.05 mSv per year as the dose constraint will be used in this assessment

Expanding on descriptions: Assessment of the transfer and accumulation of nuclides other than tritium (Chapter 4)

- Evaluated with the upper limit of the amount of tritium discharged annually (22 trillion Bq).
- It was confirmed in dispersion simulation over a 7-year period that fluctuations in advection and dispersion at sea across the years are small.
- Transfer and concentration of radioactive materials that in reality would take time are assumed to immediately reach their equilibrium.
  - This assessment, despite it being a one-year exposure assessment, assumes that the radioactive materials have already accumulated in the environment from discharge over a long period of time. Therefore, it is unlikely that actual dose exposure will exceed the results of this assessment at any point during the discharge period.

Remain the original

Dose assessment for reference animals and plants

TEPCO

Animals and plants

- Animals and plants are evaluated using the dose rate in their habitat
- The reference animals and plants and dose conversion coefficient from the ICRP will be used in the formula below to calculate the dose
- Exposure from the seawater and from the seabed are considered in external exposure.

Amount of internal exposure ＝*Internal dose conversion coefficient* × *Radiation material concentration in seawater* × *concentration ratio* （*Pathway*③）
Amount of external exposure ＝*0.5×external dose conversion coefficient* × *Radiation material 0concentration in seawater* （*Pathway*①） ＋*0.5*× *external dose conversion coefficient* × *Radiation material concentration in seawater* ×*partition coefficient* （*Pathway*②）

- Internal and external dose conversion coefficients specified in ICRP Pub 136[*1] and BiotaDC[*2] were used here
- The concentration ratio used here is the concentration coefficient specified in ICRP Pub 114[*3], IAEA TRS-479[*4], and TRS-422[*5]
- The partition coefficient specified in IAEA TRS-422（2.3.OCEAN MARGIN *Kd*s）was used here

Assessment standard

- The results are compared with the Derived Consideration Reference Levels (DCRLs)[*7] published by the ICRP in Pub.124[*6]

*1 ICRP Pub.136, "Dose Coefficients for Non-human Biota Environmentally Exposed to Radiation"
*2 ICRP BiotaDC Program v.1.5.1 (http://biotadc.icrp.org/)
*3 ICRP Pub.114, "Environmental Protection: Transfer Parameters for Reference Animals and Plants"
*4 IAEA Technical Report Series No.479, "Handbook of Parameter Values for the Prediction of Radionuclide Transfer to Wildlife"
*5 IAEA Technical Report Series No.422, "Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment"
*6 ICRP Pub.124 "Protection of the Environment under Different Exposure Situations"
*7 DCRL (Derived Consideration Reference Level): a band of dose rates with a single-digit range for each species of organisms, defined by the ICRP. In cases where this dose rate level is exceeded, the effect on the organism should be considered.

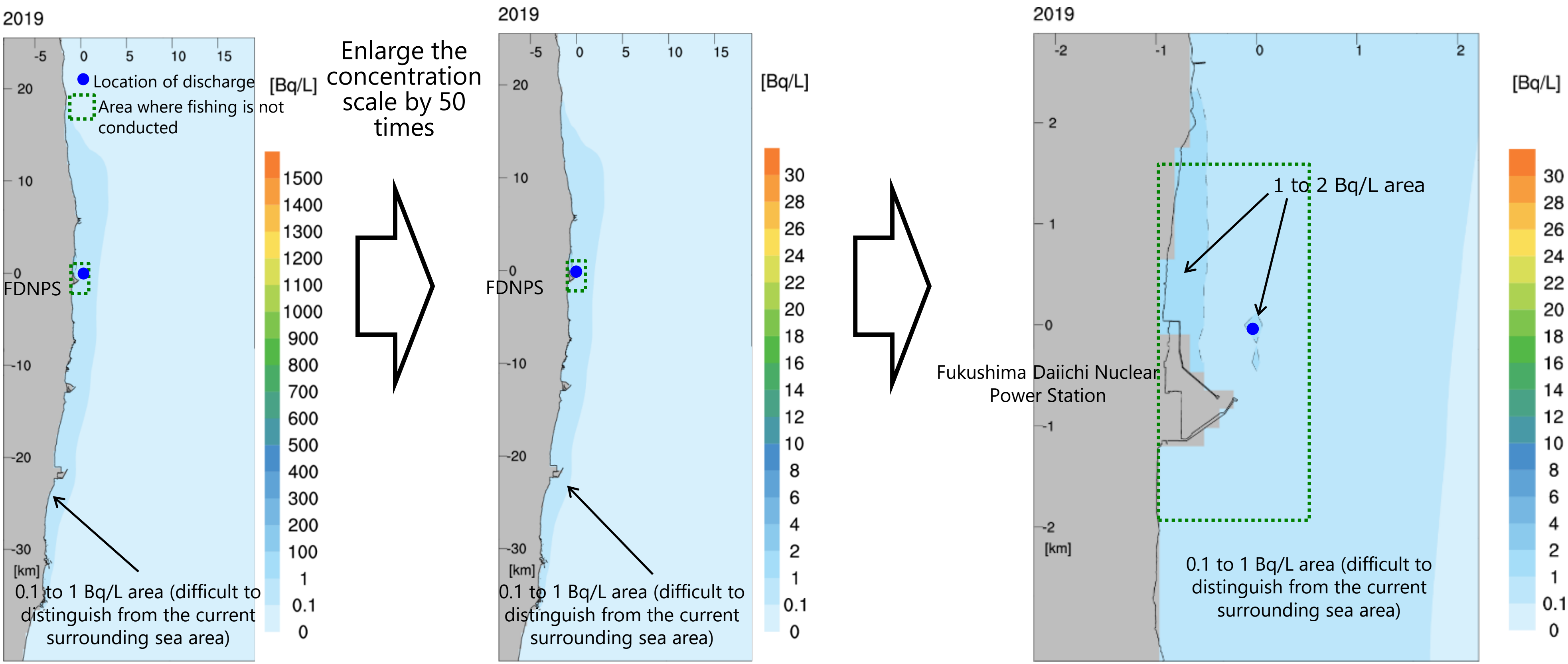
Remain the original (corrected typos)

Results of dispersion simulation at sea

TEPCO

Assessment using the meteorological and sea conditions data from 2019 found that the area with higher tritium concentrations than the current surrounding area (0.1-1 Bq/L*) (the area inside the dotted line) will be limited to the area 2 to 3 km from the station.

*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)



Enlarged view of the area off the coast of Fukushima (Largest value in scale at 30 Bq/L)

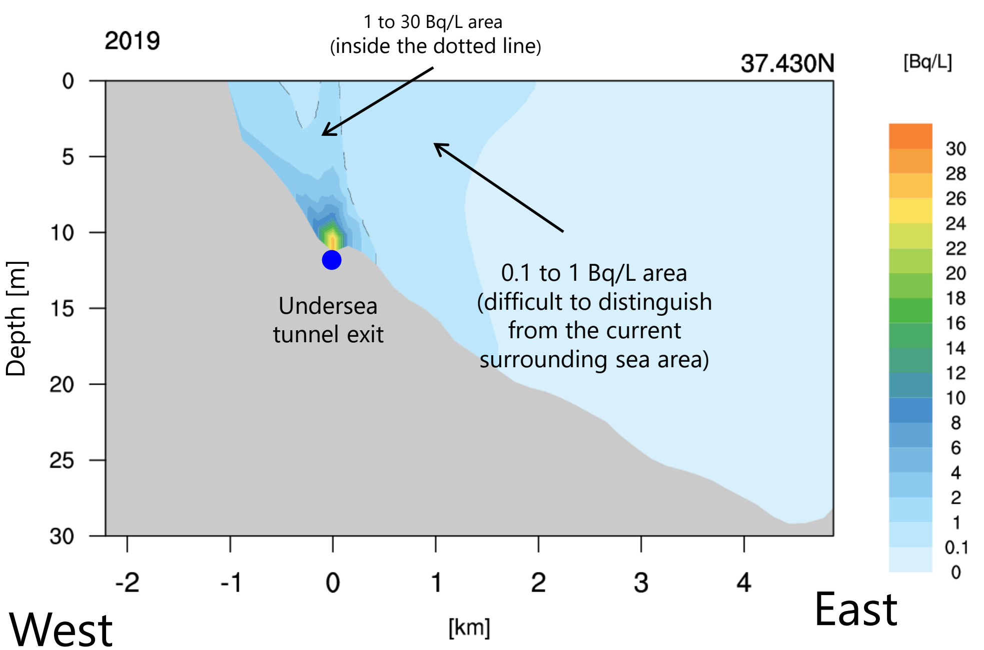
Enlarged view of the area around the station （Largest value in scale at 30 Bq/L）

Results of dispersion simulation at sea
(area around the tunnel exit)

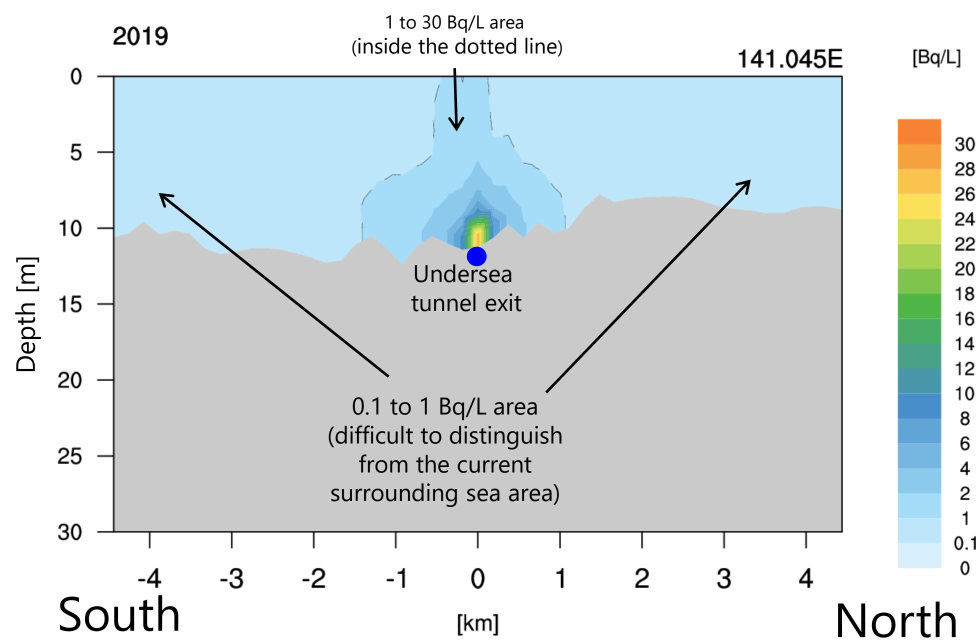
Remain the original

TEPCO

The concentration swiftly falls in the are surrounding the tunnel exit before dispersion.
Furthermore, simulated values are still **significantly below** the national regulatory standard (60,000 Bq/L) and the **WHO Guidelines for drinking-water quality (10,000 Bq/L).**



Cross-section view of the tunnel exit (East to west)
(Largest value in scale at 30Bq/L)



Cross-section view of the tunnel exit (North to south)
(Largest value in scale at 30Bq/L)

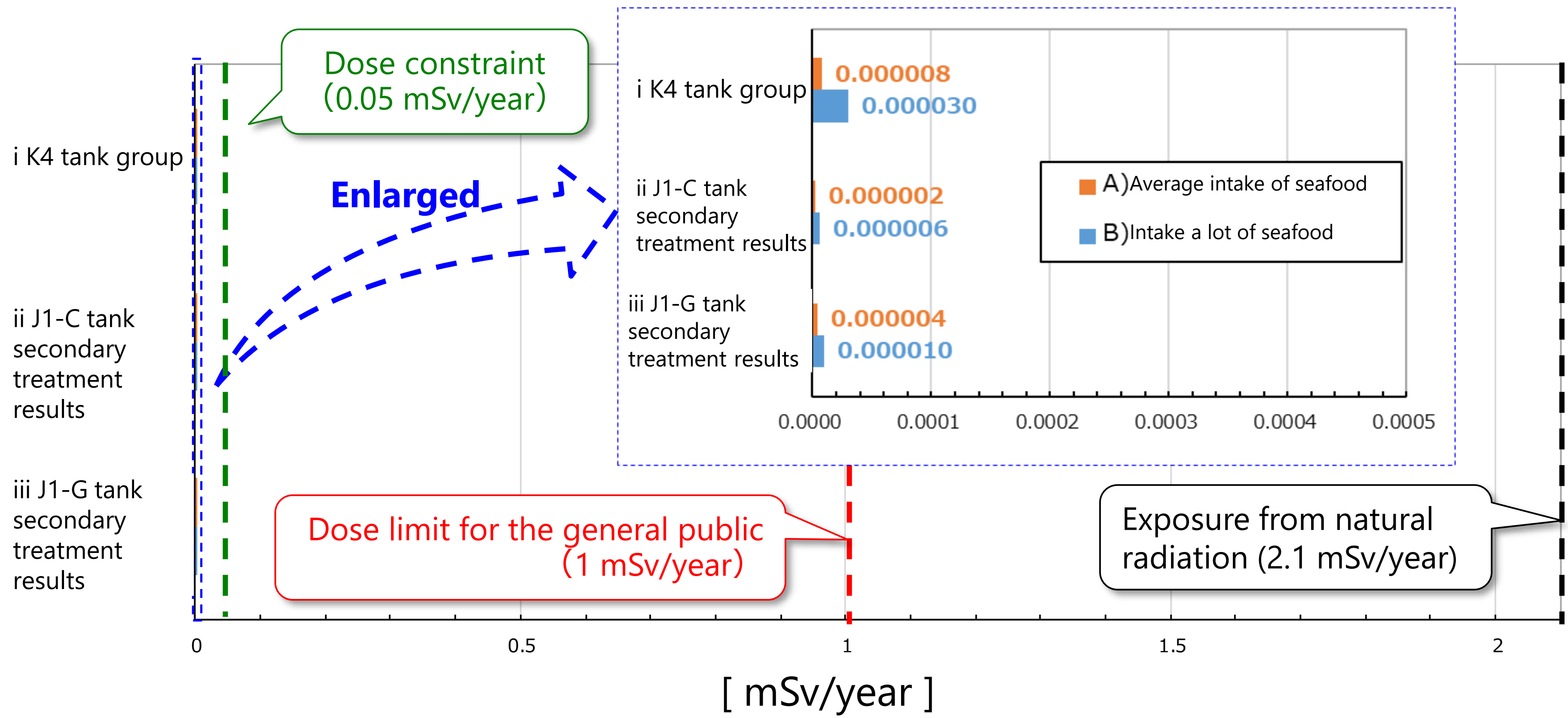
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

Updated

Human exposure assessment results (construction stage)

TEPCO

- **1/500,000 to 1/30,000 of the dose limit for the general public (1 mSv/year) and 1/25,000 to approx.1/1,700 of the dose target for Japanese nuclear power plants which is equivalent to the dose constraint (0.05 mSv/year)**



(Note) This figure shows results for adults only. This assessment assumed that nuclides that had never been detected before existed at the lower limit of detection. These are present results and may be updated according to future discussions and internal and external reviews.

Updated

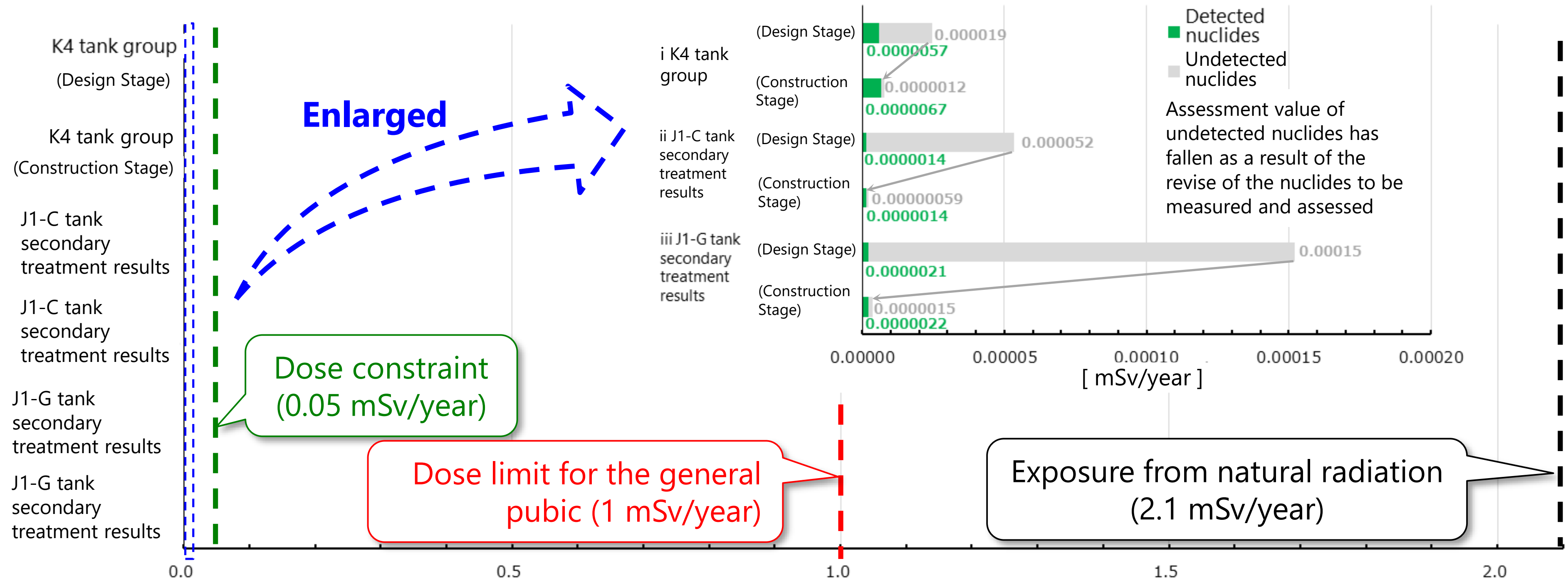
Impact to the assessment results by revising source term

TEPCO

- In the assessment at the design stage, **undetected nuclides accounted for the majority**. However, changing the source term to 30 nuclides by revising the nuclides to be measured and assessed reduced the contributions of undetected nuclides, and thus **the results of the assessment further decline**.
  - ✓ Going forward, water samples will be measured once a year using a lower detection limit than normal to assess the impact of the undetected nuclides.

ⅰ.K4: Detailed analysis with lowered detection limits
ⅱ.J1-C, ⅲ.J1-G:Detection limit set at a value that can be continuously used

Contributions of undetected nuclides to exposure (when ingesting an average amount of seafood)



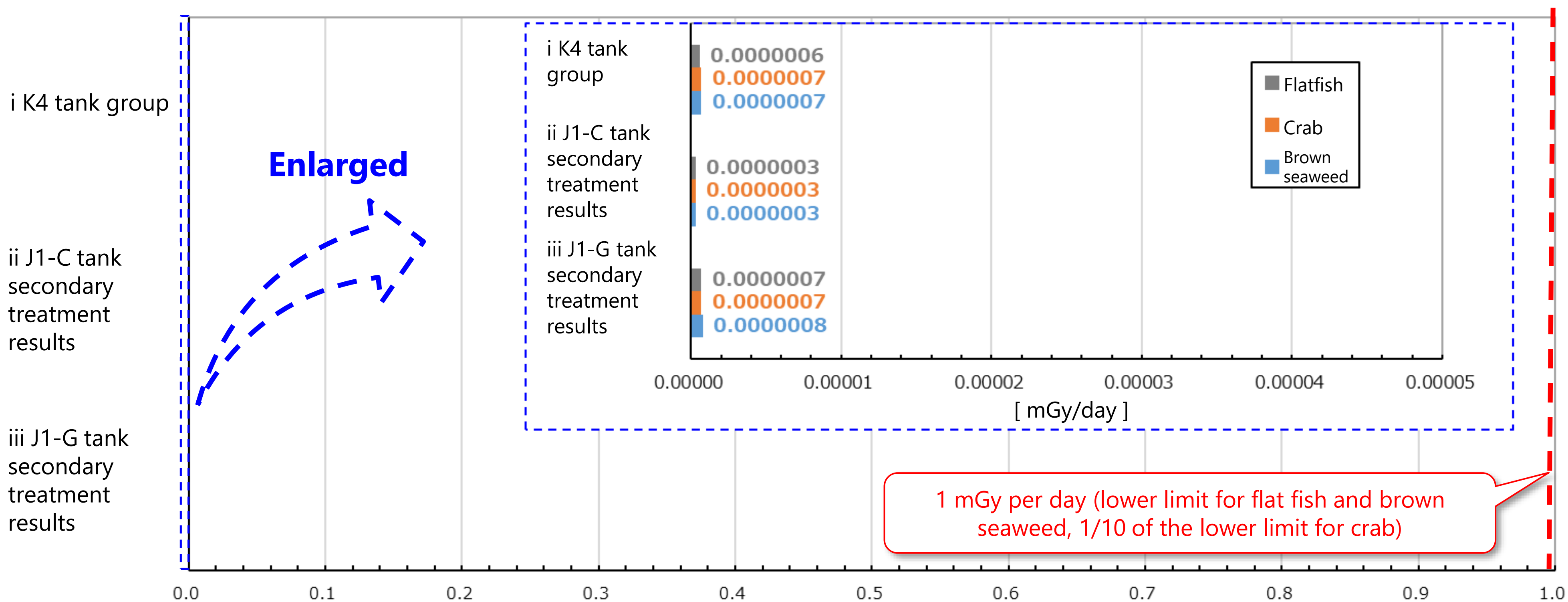
(Note) This figure shows results for adults only. These are present results and may be updated according to future discussions and internal and external reviews.

Animal and plant exposure assessment results (construction stage)

Updated

TEPCO

- Approx. 1/3.3 million to 1/1.25 million (approx. 1/33 million to approx. 1/12.5 million of crab) of the lower limit of the derived consideration reference level* (1 to 10 mGy**/day for flatfish, 10-100 mGy/day for crab, 1 to 10 mGy/day for brown algae) which is considered the standard in assessment.



(Note) This assessment assumes that "undetected nuclides" that have never been detected before exist at detection limit amounts. These are present results and may be updated according to future discussions and internal and external reviews.

*DCRL (Derived Consideration Reference Level): a band of dose rates with a single-digit range for each species of organisms, defined by the ICRP. In cases where this dose rate level is exceeded, the effect on the organism should be considered.
**Gy (gray) is a unit of energy absorbed by matter. Sv (sievert) is a unit expressing the impact of radiation on the human body. To be accurate, Sv = corrective coefficient × Gy but for gamma rays and beta rays, Sv and Gy are mostly equivalent.

Assessment conditions for potential exposure

- As shown in the table below, leaks from pipes (Case 1) and tank damage (Case 2) were selected as events that could lead to potential exposure*. Exposure assessments were conducted for each discharge scenario.
- The migration pathways, exposure pathways, and the characteristics of the representative persons were kept the same as normal times.

Evaluation Procedure	Assessment for the construction stage	Assessment for the design stage
Scenario selection	Case 1 : A pipe leak causes spillage of 500m^3 per day for 20 days Case 2 : Tank damage causes spillage of 30,000m^3 in one day	See left
Source term	Source term based on actual measurements (30 nuclides including tritium)	Source term based on actual measurements (64 nuclides including tritium)
Migration, exposure pathways	Same as normal exposure	See left
Representative Person	Exposure at sandy beach assessment point during normal life, internal exposure also considered	See left

*Potential exposure is defined as exposure that is "not expected to occur with certainty but could result from an accident or from an event or a sequence of events that may occur but is not certain to occur." (IAEA GSR Part3 para.1.20(a))

Newly added

Results of assessment for potential exposure

TEPCO

- **Assessment of the two scenarios that could lead to potential exposure found that the potential exposure was significantly less than 5mSv, which is the reference exposure value for an accident* in both scenarios.**

*mSv： millisievert

Values for Design stage in parentheses

Conditions	Nuclide composition in source term	Source terms based on actual values					
		i .K4 tanks		ii. J1-C tank After secondary treatment		iii. J1-G tank After secondary treatment	
	Case	Case1	Case 2	Case1	Case 2	Case1	Case 2
External exposure (mSv*)	Sea surface	1.8E-09 (3.5E-08)	8.8E-08 (1.7E-06)	3.5E-09 (4.0E-07)	1.7E-07 (1.9E-05)	2.5E-09 (3.6E-07)	1.2E-07 (1.7E-05)
	Body of the ship	1.9E-09 (2.5E-08)	9.4E-08 (1.2E-06)	3.6E-09 (2.8E-07)	1.7E-07 (1.4E-05)	2.5E-09 (2.5E-07)	1.2E-07 (1.2E-05)
	When swimming	1.7E-10 (3.3E-09)	8.3E-09 (1.6E-07)	3.3E-10 (3.8E-08)	1.6E-08 (1.8E-06)	2.3E-10 (3.4E-10)	1.1E-08 (1.6E-06)
	Beach sand	2.9E-07 (5.8E-06)	1.4E-05 (2.8E-04)	5.6E-07 (6.7E-05)	2.7E-05 (3.2E-03)	4.0E-07 (5.9E-05)	1.9E-05 (2.8E-03)
	Fishing nets	8.9E-07 (1.5E-05)	4.3E-05 (8.9E-04)	1.7E-06 (2.1E-04)	8.3E-05 (1.0E-02)	1.2E-06 (1.9E-04)	5.8E-05 (9.1E-03)
Internal exposure (mSv)	Drinking water	1.8E-07 (2.4E-07)	8.7E-06 (1.2E-05)	8.7E-07 (9.9E-07)	4.1E-05 (4.7E-05)	2.9E-07 (3.3E-07)	1.4E-05 (1.6E-05)
	Inhaling water sprays	5.0E-08 (6.9E-08)	2.4E-06 (3.3E-06)	5.4E-07 (6.4E-07)	2.6E-05 (3.1E-05)	3.5E-07 (4.2E-07)	1.7E-05 (2.0E-05)
	Ingesting seafood (when the amount is more than the average)	2.6E-04 (7.1E-04)	1.3E-02 (3.4E-02)	2.4E-04 (5.4E-03)	1.2E-02 (2.6E-01)	1.6E-04 (4.9E-03)	7.8E-03 (2.4E-01)
Total（mSv*）		**3E-04 (7E-04)**	**1E-02 (4E-02)**	**2E-04 (6E-03)**	**1E-02 (3E-01)**	**2E-04 (5E-03)**	**8E-03 (2E-01)**
Reference exposure value for an accident: 5mSv*							

Updated

[Reference] Detailed results of the radiological environmental impact assessment on the public

TEPCO

*mSv： millisievert

Conditions	Nuclide composition in source term	Source terms based on actual values (Values for Design stage in parentheses)					
		i .K4 tanks		ii. J1-C tank After secondary treatment		iii. J1-G tank After secondary treatment	
	Amount of seafood ingested	A:Average	B:More than the average	A:Average	B:More than the average	A:Average	B:More than the average
External exposure (mSv*/year)	Sea surface	4.6E-10（6.5E-09）		1.7E-10（1.7E-08）		3.7E-10（4.7E-08）	
	Body of the ship	4.9E-10（4.8E-09）		1.8E-10（1.2E-08）		3.7E-10（3.3E-08）	
	When swimming	3.2E-10（4.5E-09）		1.2E-10（1.2E-08）		2.5E-10（3.2E-08）	
	Beach sand	5.4E-07（7.8E-06）		2.0E-07（2.1E-05）		4.3E-07（5.6E-05）	
	Fishing nets	1.1E-07（1.6E-06）		3.9E-08（4.3E-06）		8.3E-08（1.2E-05）	
Internal exposure (mSv*/year)	Drinking water	3.4E-07（3.3E-07）		3.1E-07（3.1E-07）		3.1E-07（3.2E-07）	
	Inhaling water sprays	9.2E-08（9.3E-08）		1.9E-07（2.0E-07）		3.8E-07（4.0E-07）	
	Ingesting seafood	6.9E-06（1.5E-05）	3.1E-05（6.1E-05）	1.2E-06（2.8E-05）	5.5E-06（1.1E-04）	2.6E-06（7.9E-05）	1.1E-05（3.0E-04）
Total（mSv*/year）		**8E-06（3E-05）**	**3E-05（7E-05）**	**2E-06（5E-05）**	**6E-06（1E-04）**	**4E-06（1E-04）**	**1E-05（4E-04）**

Dose limit for the general public：1mSv*/year
Dose target for domestic nuclear power stations equivalent to the dose constraint: 0.05mSv/year

Updated

TEPCO

[Reference] Detailed results of the radiological environmental impact assessment on plants and animals

*mGy：milligray

Scenario		Source terms based on actual values (Values for Design stage in parentheses)		
		i. K4 tanks	ii. J1-C tanks	iii. J1-G tanks
Exposure (mGy*/day)	Flatfish	6E-07 (2E-05)	3E-07 (2E-05)	7E-07 (6E-05)
	Crab	7E-07 (2E-05)	3E-07 (2E-05)	7E-07 (6E-05)
	Brown seaweed	7E-07 (2E-05)	3E-07 (2E-05)	8E-07 (6E-05)
DCRL (Derived Consideration Reference Level Flatfish：1-10 mGy*/day　Crab：10-100mGy*/day　Brown seaweed：1-10mGy*/day				

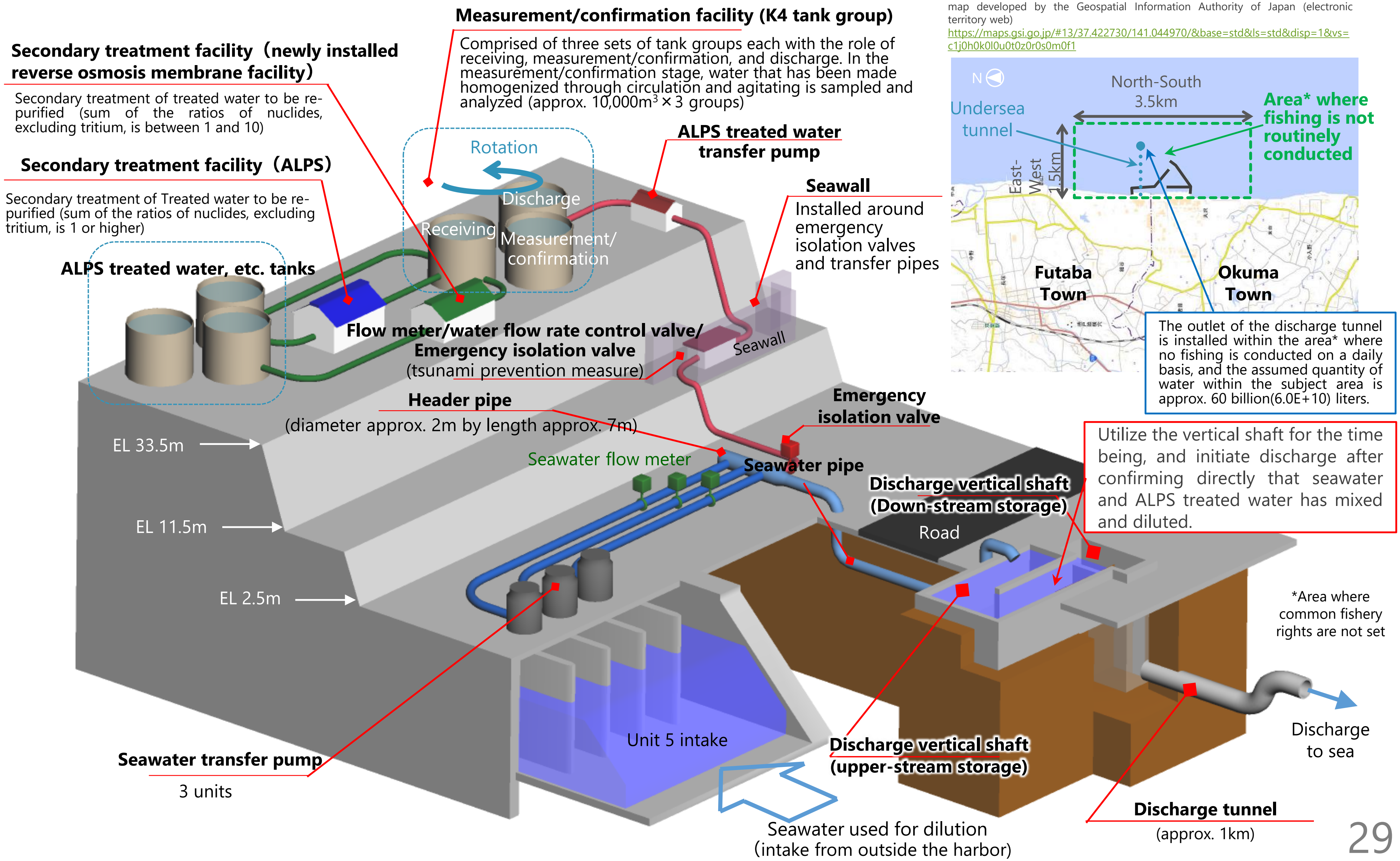
1. DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT
2. ASSESSMENT METHODS
3. ASSESSMENT RESULTS
4. REFFERENCES

Remain the original

[Reference]Overview of facilities for securing safety

TEPCO

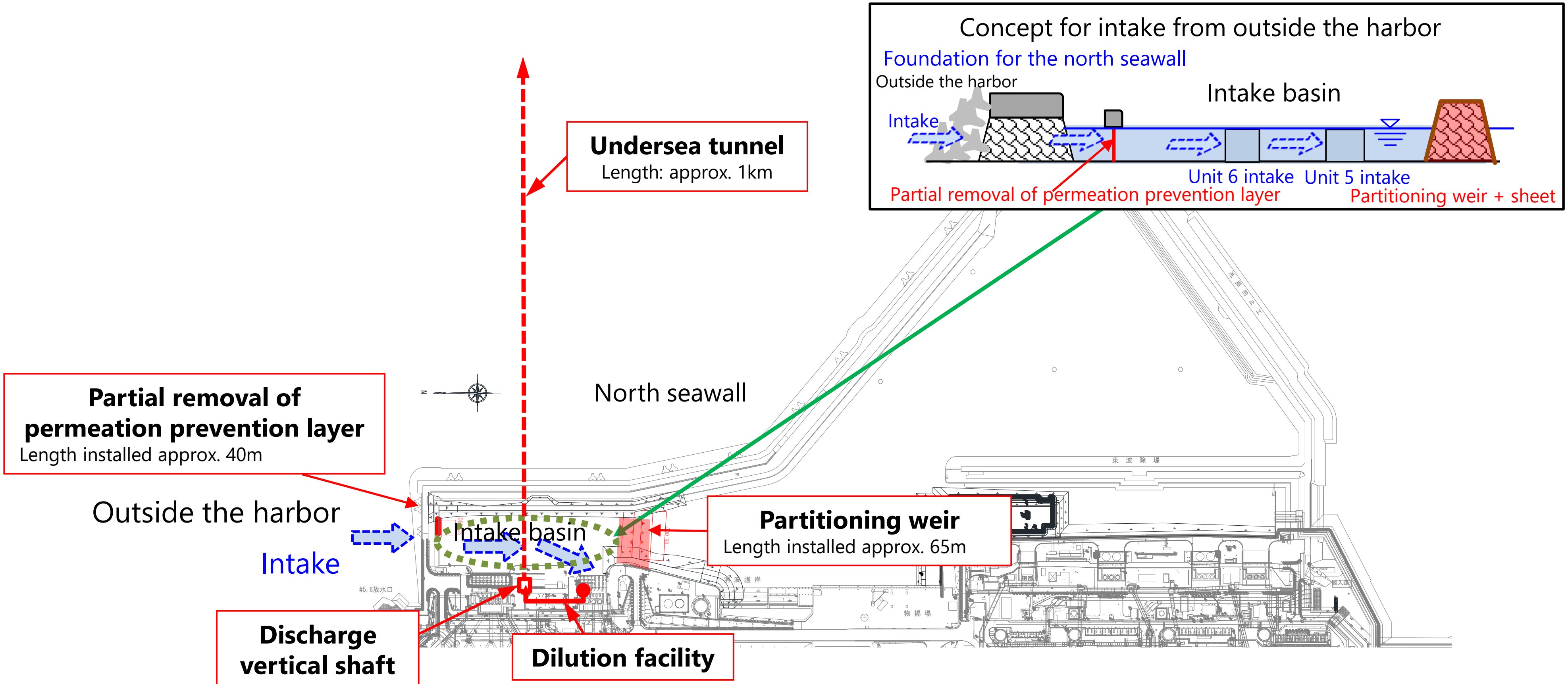
Source: Developed by Tokyo Electric Power Company Holdings, Inc. based on the map developed by the Geospatial Information Authority of Japan (electronic territory web)
https://maps.gsi.go.jp/#13/37.422730/141.044970/&base=std&ls=std&disp=1&vs=c1j0h0k0l0u0t0z0r0s0m0f1



[Reference] Harbor design

TEPCO

- Modify the north seawall to allow the intake of seawater outside the harbor for use in dilution, and **prevent seawater inside the harbor from mixing directly with the seawater for dilution** by separating from inside the harbor using a partitioning weir.
- The harbor shall be designed to discharge from approx. 1km from the coast to make it **difficult for seawater to recirculate** (unlikely for discharge to go through intake again as seawater for dilution).



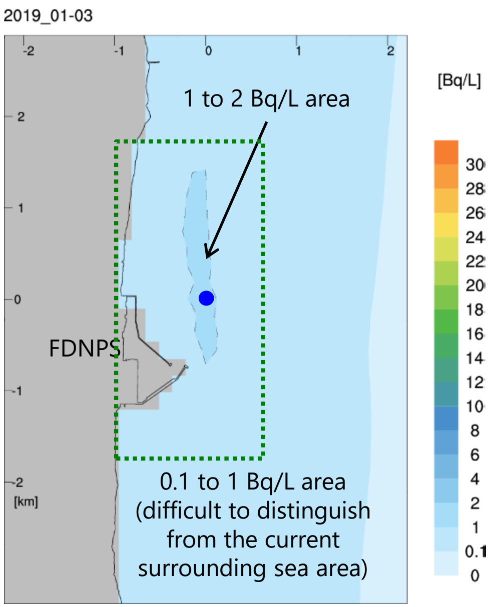
[Reference] Results of dispersion simulation at sea
(average for each season)

Remain the original

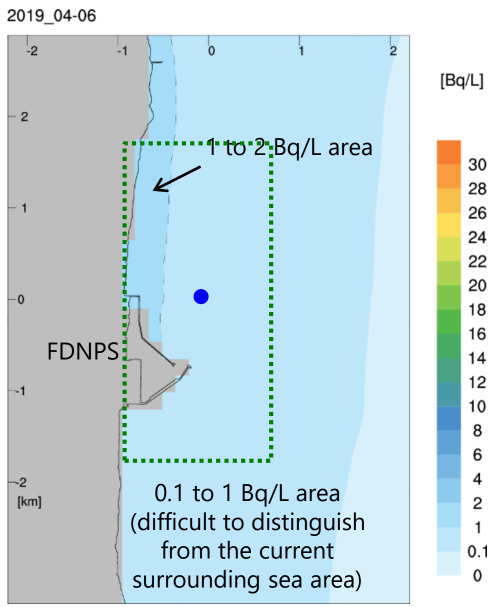
TEPCO

Assessments suggest that the area with higher tritium concentrations than current levels in the surrounding area (0.1-1 Bq/L*) (area in the dotted line) **will be limited to the area around the station** when looking at the average of any season.

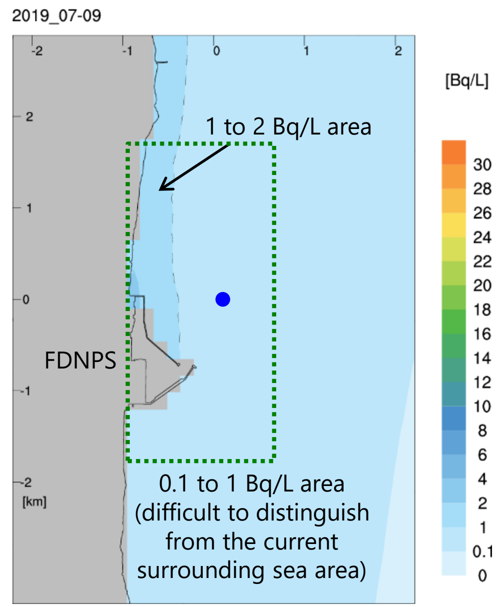
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10, 000 Bq/L)



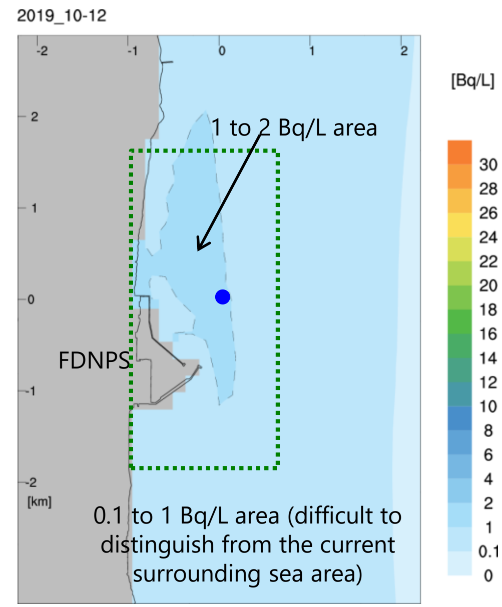
Average of
January to March



Average of
April to June



Average of July
to September



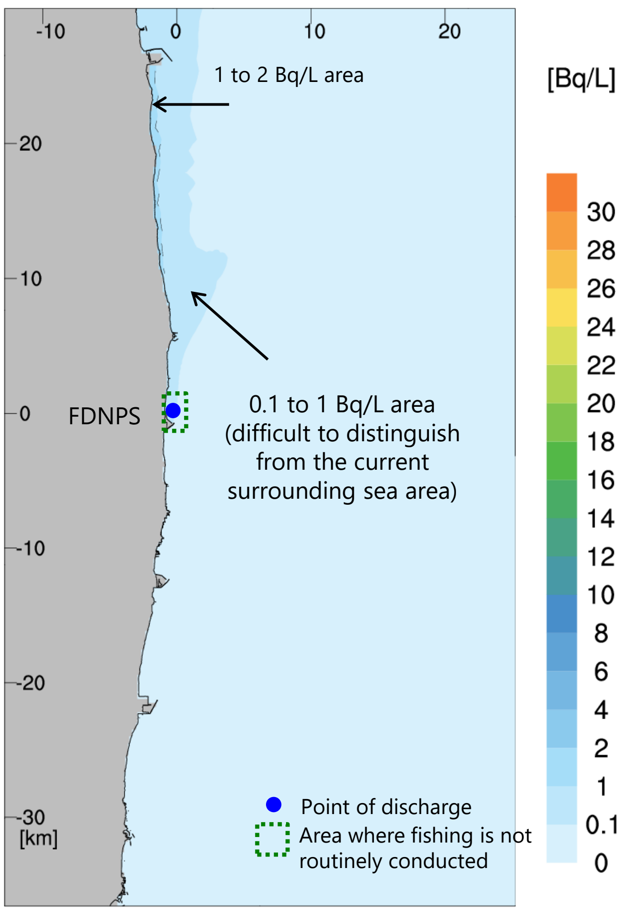
Average of October
to December

[Reference] Results of dispersion simulation at sea
(Trends in dispersion)

Simulations show that the area with higher tritium concentrations (area that exceeds 1Bq/L) than current levels in the surrounding area (0.1-1 Bq/L*) will be in a 30km range (North-South) of the discharge point even on days when the area spreads out most.

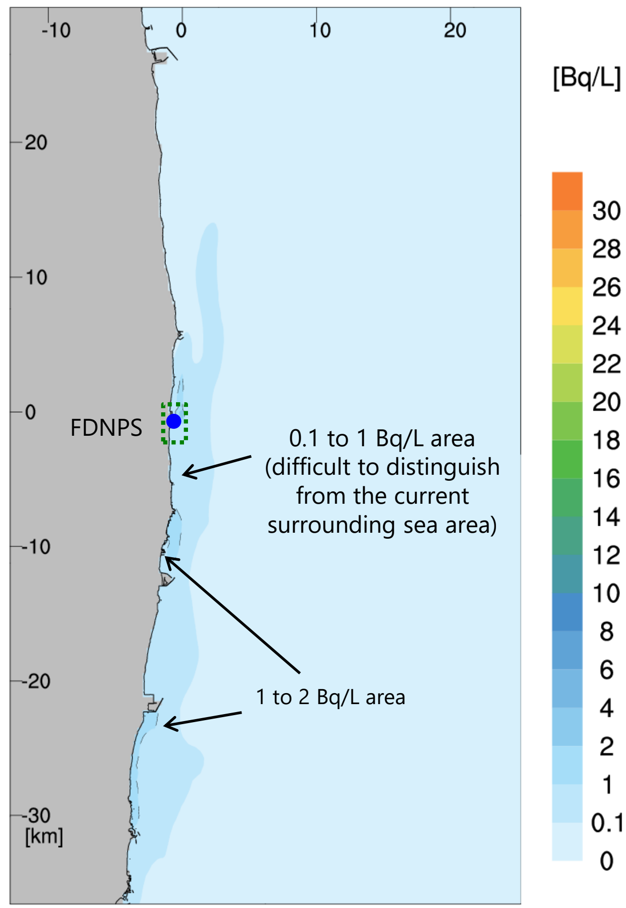
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

20190521



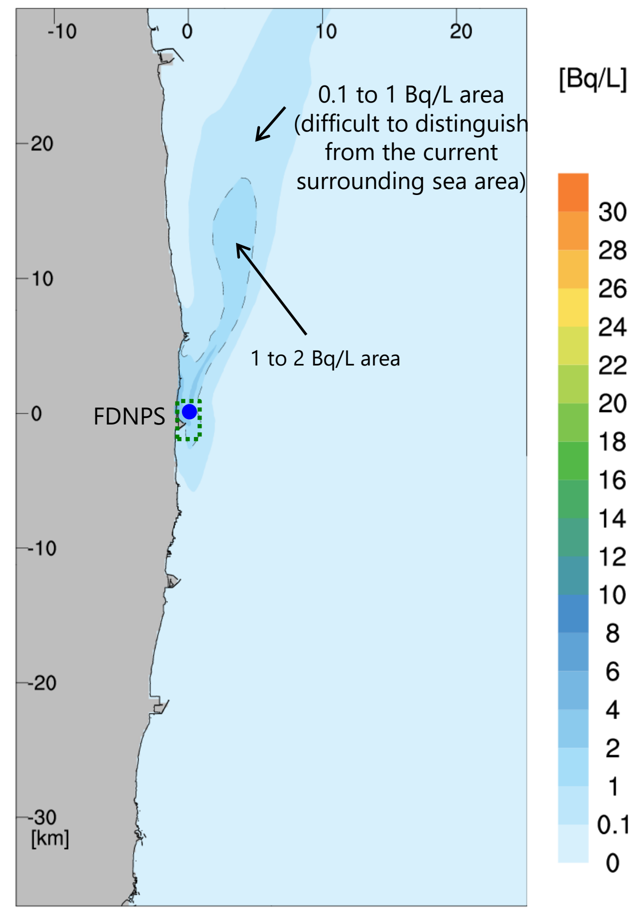
Area at its northernmost configuration
(Largest value in scale at 30Bq/L)

20190211



Area at its southernmost configuration
(Largest value in scale at 30Bq/L)

20190829



Area at its easternmost configuration
(Largest value in scale at 30Bq/L)

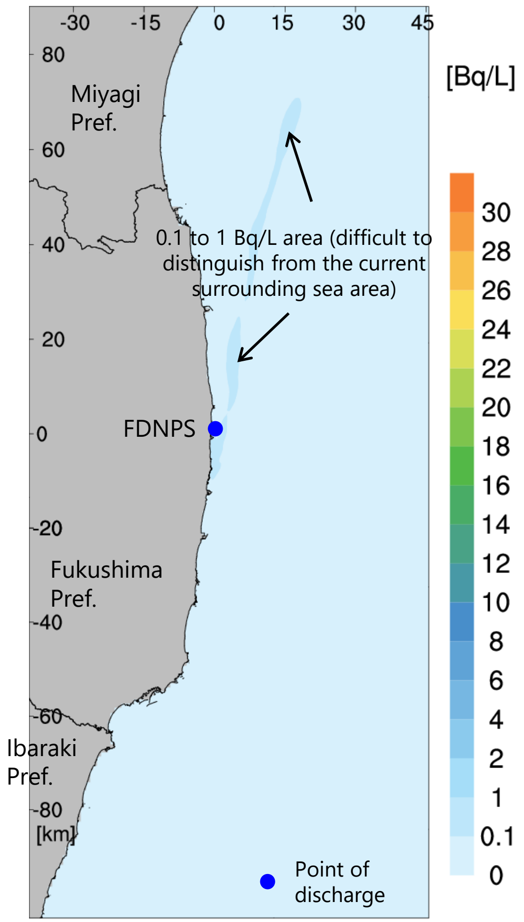
[Reference] Results of dispersion simulation at sea

(Trends in dispersion)

Simulations show that the area with low tritium concentrations (area that exceeds 0.1 Bq/L), where is indistinguishable from that of the surrounding sea area (0.1 to 1 Bq/L*) by actual measurements, will be as below even on days when the area spreads out most.

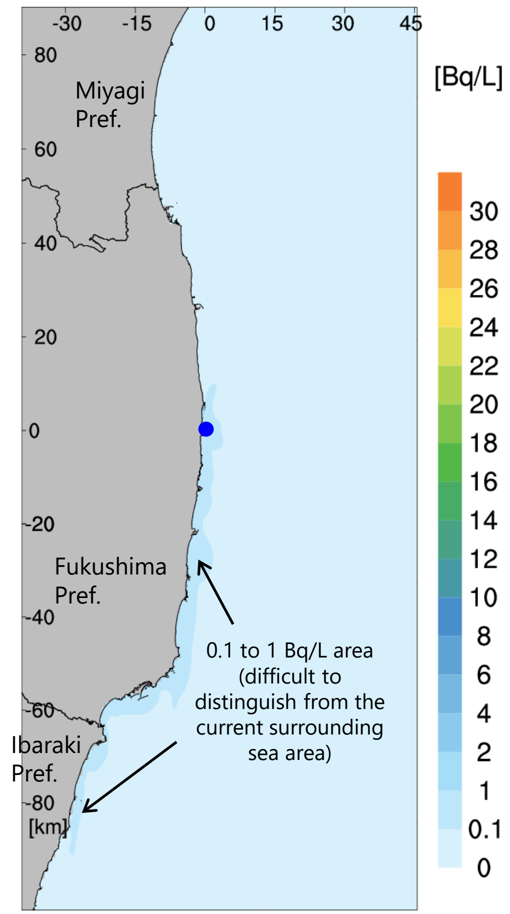
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

20190827



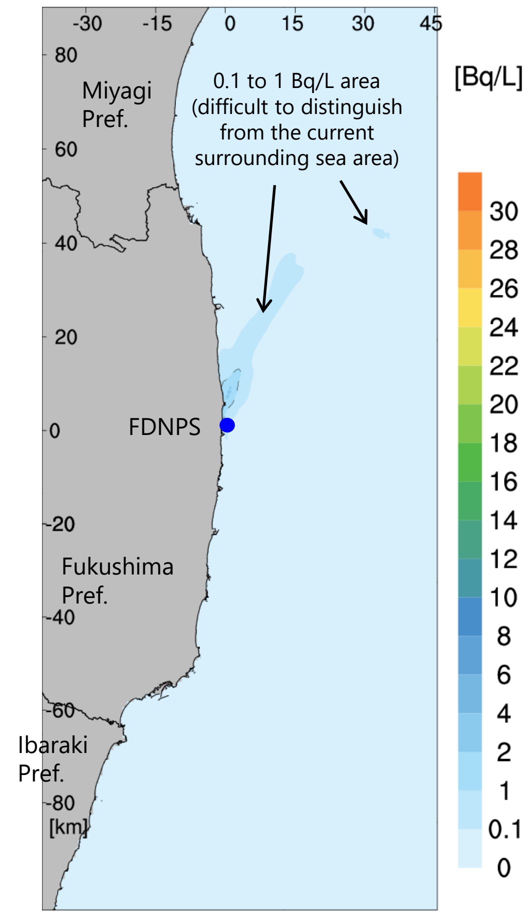
Area at its northernmost configuration (Largest value in scale at 30Bq/L)

20191027



Area at its southernmost configuration (Largest value in scale at 30Bq/L)

20190806



Area at its easternmost configuration (Largest value in scale at 30Bq/L)

[Reference] Insights of the impact on dispersion according to the discharge point

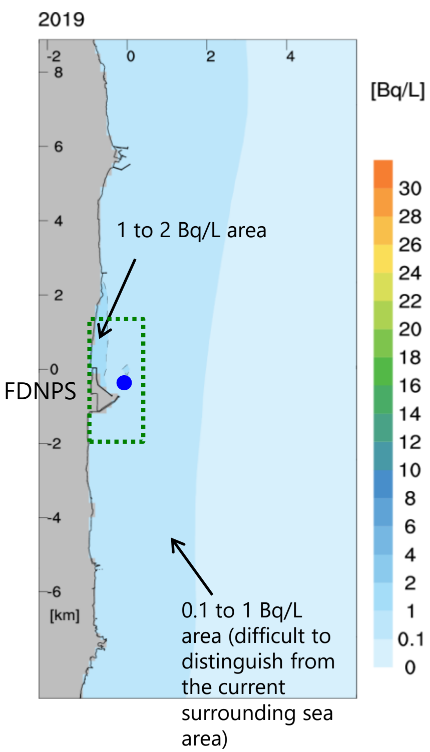
Remain the original

In addition to the scenario assuming that the ALPS treated water will be discharged according to the plan created by TEPCO, another scenario assuming that the ALPS treated water will be discharged from the Units 5 and 6 discharge port along the coast line was also simulated to see how the radioactive materials would diffuse (potential recirculation due to the proximity of the water intake cannel was not take into account).
The area assessed to have higher tritium concentrations than current levels in the surrounding sea area (0.1-1Bq/L*) (the area inside the dotted line) will be in a 6 to 7 km radius of the station in the scenario where ALPS treated water is discharged along the coast line while the area will be in a **2 to 3 km radius under the current plan that uses an undersea tunnel.**

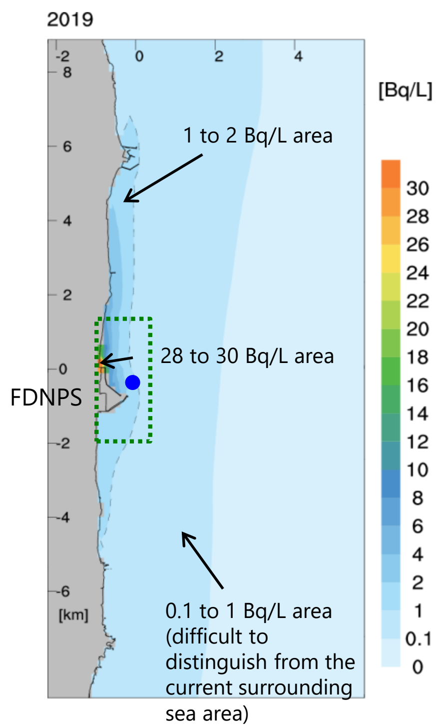
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

Expanded view of the area off the coast of Fukushima prefecture

Current plan

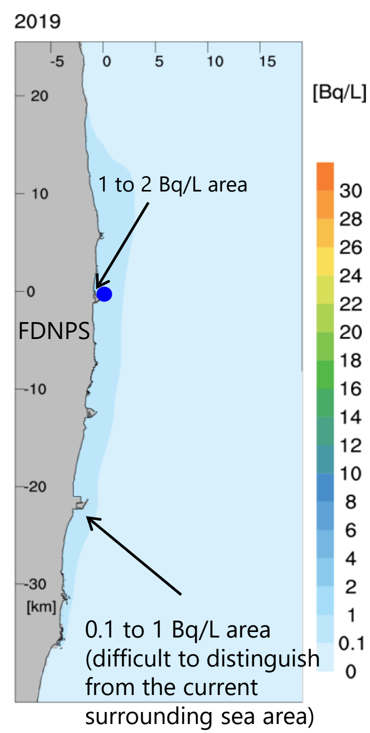


Coast line plan

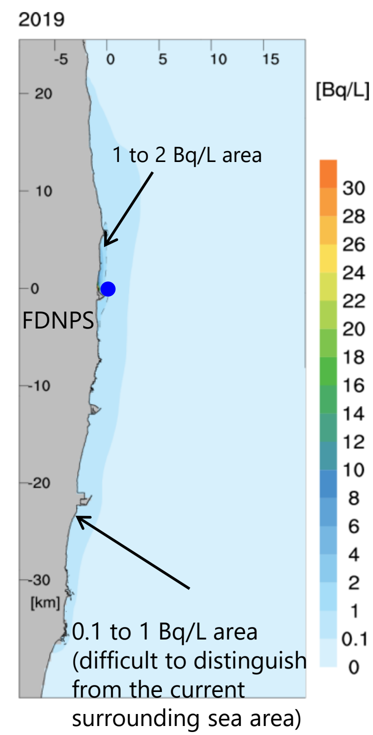


Wide area map

Current plan



Coast line plan



● Point of discharge ⬚ Area where fishing is not routinely conducted

Remain the original

[Reference] Effects outside the simulation's computational domain

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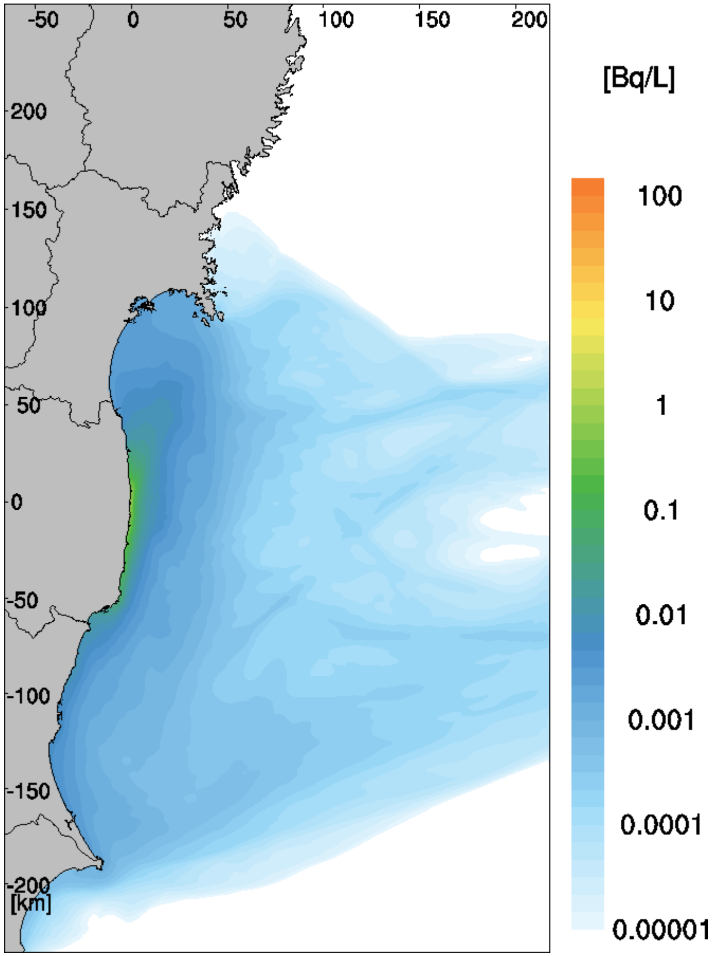
Annual Average Concentrations Diagram of the Whole Computational Domain (2019, Illustrated to 1E-05Bq/L)



Axes are distance from the station [km]

- The results are illustrated on the left for the annual average concentrations for the entire region, calculated with meteorological and oceanographic data for 2019, down to 1E-05 Bq/L.
- The maximum annual average concentrations from 2014 to 2020 at the boundaries of the calculation range, all in the east as shown in the table below, range from 1.1E-04 to 2.6E-04 Bq/L, which is sufficiently low compared to the tritium concentration in seawater in the sea area around Japan (about 1.0E-01Bq/L).
- Given that the result of the exposure assessment calculated from the annual average concentration in the area of 10 km x 10 km around the power plant is much lower than the dose limit for the general public of 1 mSv/year as well as the dose constraint value of 0.05 mSv/year, we consider that there is no need to assess radiation effects outside the calculation area as the concentration is lower than that.

Maximum annual mean concentration and location at model boundaries (north-south, and east-west) for each year

Year	Concentration (Bq/L)	Location (distance from the station)		
		East-West	North-South	Depth
2014	1.1E-04	218 km to the east	162 km to the south	approx. 9.0 m
2015	2.6E-04	218 km to the east	102 km to the south	approx. 0.6 m
2016	1.4E-04	218 km to the east	6 km to the south	approx. 5.5 m
2017	2.4E-04	218 km to the east	30 km to the south	approx. 9.0 m
2018	1.9E-04	218 km to the east	97 km to the south	approx. 0.6 m
2019	1.6E-04	218 km to the east	68 km to the south	approx. 1.7 m
2020	1.9E-04	218 km to the east	25 km to the south	approx. 1.7 m

[Reference] Preconditions of radiological environmental impact assessment on the public and the environment

Underlined parts: Major areas of updated

Updated

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- Amount of tritium discharged: 22 TBq/year

Scenario	i. K4 tanks	ii. J1-C tanks (after secondary treatment)	iii. J1-G tanks (after secondary treatment)
Tritium concentration [Bq/L]	140,000	720,000	240,000
Amount of ALPS treated water discharged annually [m^3/year]	160,000	31,000	92,000

- The average concentration in a 10 km X 10 km area around the Fukushima Daiichi Nuclear Power Station was assessed considering advection and dispersion in the seawater.
  - ✓ The Regional Ocean Modeling System (ROMS), an area ocean model, that CRIEPI (Central Research Institute of Electric Power Industry) applied to the sea off the coast of Fukushima, was used in the assessment

- The following exposure pathways were evaluated.

Radiological impact assessment on the public	Radiological impact assessment on the environment
✓External exposure from the sea surface ✓External exposure from the body of the ship ✓External exposure while swimming ✓External exposure from the beach sand ✓External exposure from the fishing nets ✓Internal exposure from drinking seawater ✓Internal exposure from inhaling seawater sprays ✓Internal exposure from ingesting seafood	✓External exposure from the seawater ✓External exposure from the sediment at the bottom of the sea ✓Internal exposure from ingested radioactive materials

Newly added

[Reference] Response to major IAEA review results

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Comments issued in the IAEA review	TEPCO response
Explain what kind of exposure assessment is necessary for Carbon-14 and Iodine-129 which have a long half-life and have comparatively high impacts on exposure in the Radiological Environmental Impact Assessment Report.	Since the amounts to be discharged will be smaller in comparison to the amounts of carbon 14 and iodine 129 that have already been discharged into the environment, we have additionally noted that the global impact from these amounts can be ignored and only representative individual assessments will be performed. (Chapter 4 (4) and (5))
Regarding the accumulation of radionuclides in the environment, clearly state that TEPCO has made dose estimates equivalent to the highest dose condition in decades by assuming equilibrium conditions between seawater and seabed soil.	We have clarified that our assessment takes long-term accumulation into account by assuming a state of equilibrium between seawater and seabed soil. (Chapter 4 (3))
Clearly state the reason why the scenario where a person only ingests seafood caught on the beaches 3 km from the station does not need to be considered.	We have noted that such an assessment is unnecessary even though we envisage that fishing will occur along beaches 3km from the power station, because the fish caught through fishing will represent only a small portion of the fish ingested during the year, and because this area is also included in the 10km X 10km region for which exposure from the ingestion of marine products has been assessed. Furthermore, we have conservatively assumed that the ingested fish only come from this 10km X 10km region. (Chapter 6 6-1-2 (4))
There is some uncertainty in the migration pathways of organically bound tritium (OBT) in the environment and its dose assessment. Describe the impact of OBT taking into account the uncertainty, and the results of an assessment of the uncertainty.	We have added that even though there may be uncertainty about the behavior of OBT in the environment, the amount of exposure from tritium would only represent a small amount of the total exposure assessment, and would have a minuscule impact on the total dose assessment even if there is uncertainty. (Chapter 8 space 8-2-5 and attachment III)
Describe the concentrations of nuclides that have a large impact on dose (e.g., Carbon-14 and Iodine-129) at the model boundary in addition to tritium to assess the impact of the nuclides outside of the modelled area.	We have added the maximum concentration values for carbon-14 and iodine 129 at the model boundary and stated that either concentration is relatively small compared to background radiation in the ocean area concerned, and that a simulation that includes areas further beyond this area is unnecessary. (Attachment VII)
Flesh out the descriptions on the optimization of radiation protection.	We have provided more details on how we have optimized protection in accordance with IAEA SF-1, GSR part 3 and GSG-9. (Reference G)