(The 4th) 1F Technical Meeting
Material 1-2

Reassessment results of Radiological Environmental Impact Assessment (Construction stage*) due to revising nuclides to be measured and assessed

December 27, 2022

Tokyo Electric Power Company Holdings, Inc.

* 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.

Updated

Overview

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- After the Revised Radiological Impact Assessment Regarding the Discharge of ALPS Treated Water into the Sea (Design stage) was published in April 2022, the assessment results were reviewed 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 this assessment, the source terms were revised based on the selection of nuclides to be measured and assessed toward the discharge of the ALPS treated water into the sea.
- At the third technical meeting held on December 21st, discussions about the revision of the nuclides to be measured and assessed converged in general, and re-assessment was carried out for the new nuclides to be measured and evaluated.
- In addition, based on the fact that the inventory 12 years after the accident was used in the selection of nuclides, the decay correction was made for the nuclide composition of the source term as of March 2023.
- With regard to the radiological environmental impact assessment, the conclusion remains 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 evaluation values for humans are about 1 to 1.5 times higher than before the nuclide revision.
    - Dose evaluation values for the environment are about 0.6 to 0.8 times compared with the evaluation before the nuclide revision.

About the Assessment

- 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.
- Assessment conducted in accordance with this methodology indicated that effects of the discharge of ALPS treated water into the sea on humans and the environment is 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 based on IAEA experts' reviews and input/review by relevant parties.
- 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.

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

Updated

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.

1. DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT

2. ASSESSMENT METHODS

3. ASSESSMENT RESULTS

4. REFFERENCES

Procedures for the radiological environmental impact assessment

Remain the original

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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

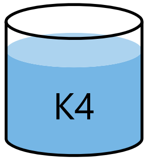
*1 IAEA GSG-9 "Regulatory Control of Radioactive Discharges to the Environment"
IAEA GSG-10 "Prospective Radiological Environmental Impact Assessment for Facilities and Activities"

*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

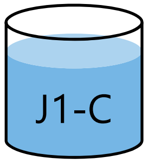
Selection of source terms(type and amount of radioactive material to be discharged)

Updated

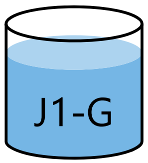
- From the standpoint of more realistic assumptions, this assessment assumes that the ALPS treated water from the three tank groups for which we have almost all the measured values of nuclides to be measured and assessed will be diluted with seawater, then discharged continuously during the discharge period.
- 30 nuclides including tritium were selected as the source term based on the nuclides to be measured and assessed as explained in the third technical meeting held on Dec. 21st.
- Data from other tanks 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 concentration of nuclides in each tank group are corrected for half-life as of 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.

Newly added

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

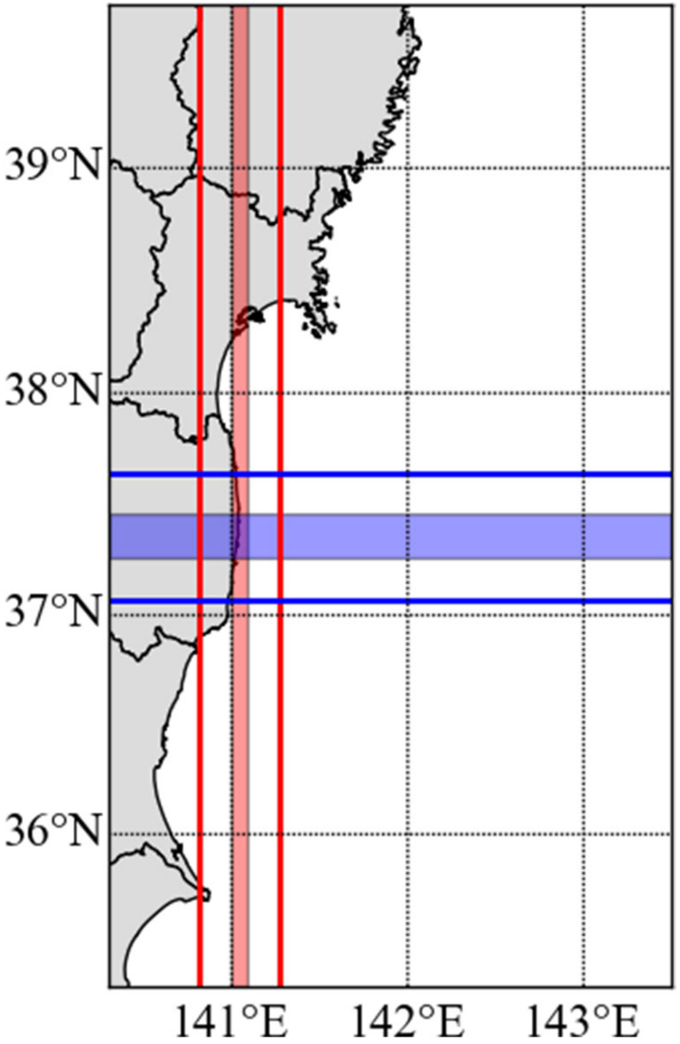
- The concentrations of all nuclides in each tank group were corrected for half-life as of March 2023, 12 years after the accident.

			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) ①	Concentration in treated water (Bq/L) ②	Sum of the ratios to regulatory concentration limit	Concentration of treated water (Bq/L) ②	Sum of the concentration ratios	Concentration of treated water (Bq/L) ②	Sum of the concentration ratios
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
			Total	2.6E-01	Total	2.1E-01	Total	1.0E-01

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

Remain the original

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.

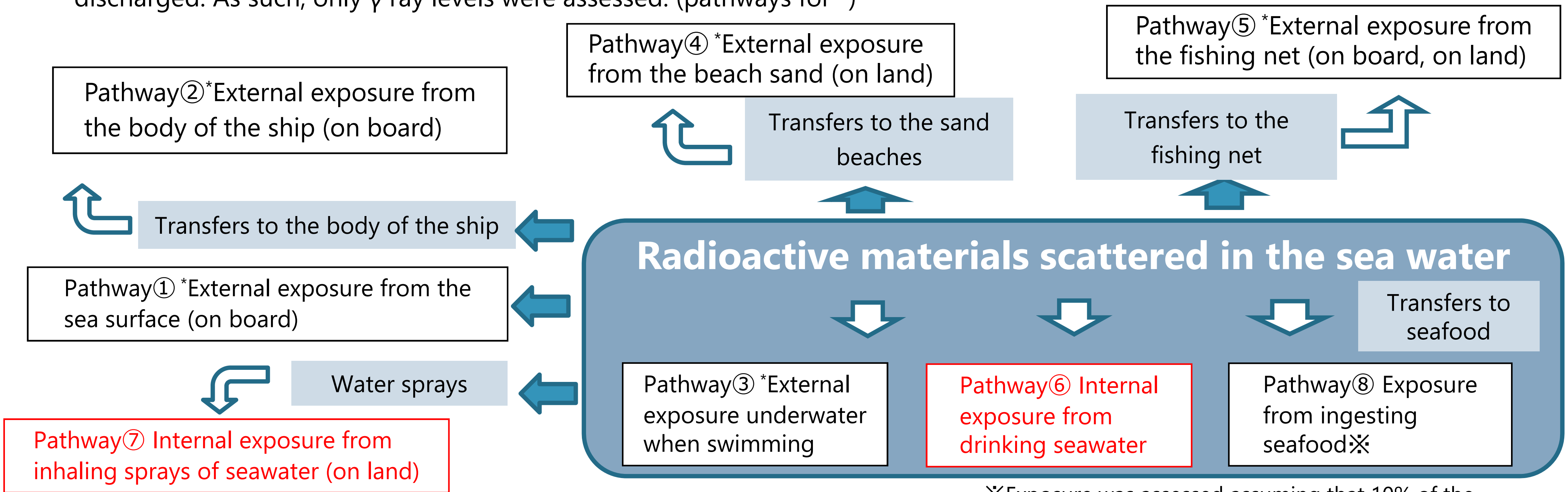
[1] A. Hashimoto, H. Hirakuchi, Y. Toyoda, and K. Nakaya, "Prediction of regional climate change over Japan due to global warming (Part 1) – Evaluation of Numerical Weather Forecasting and Analysis System (NuWFAS) applied to a long-term climate simulation-" CRIEPI Report, 2010.
[2] Y.Miyazawa, R.Zhang, 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.

Remain the original

Identifying the exposure pathways (assessment model)

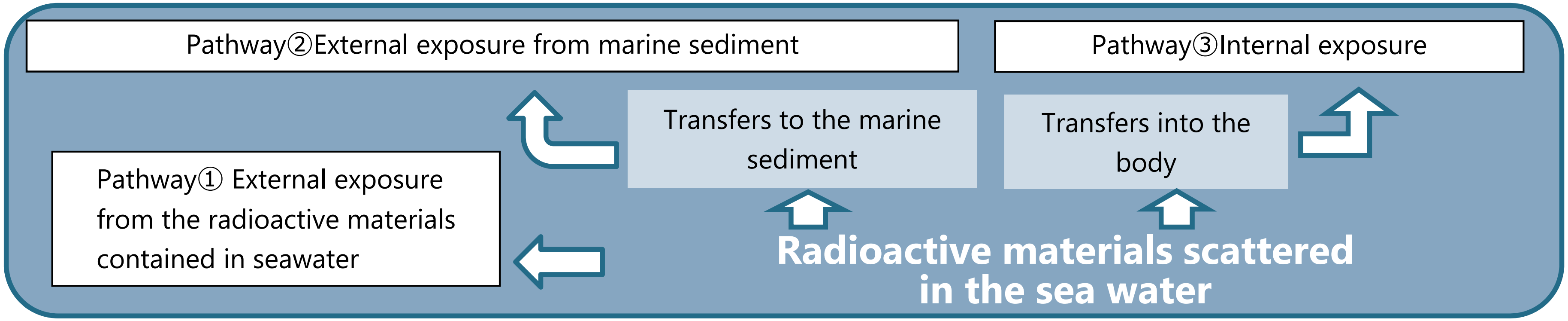
(1) Transfer and exposure pathways (human exposure)

- 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 *)



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

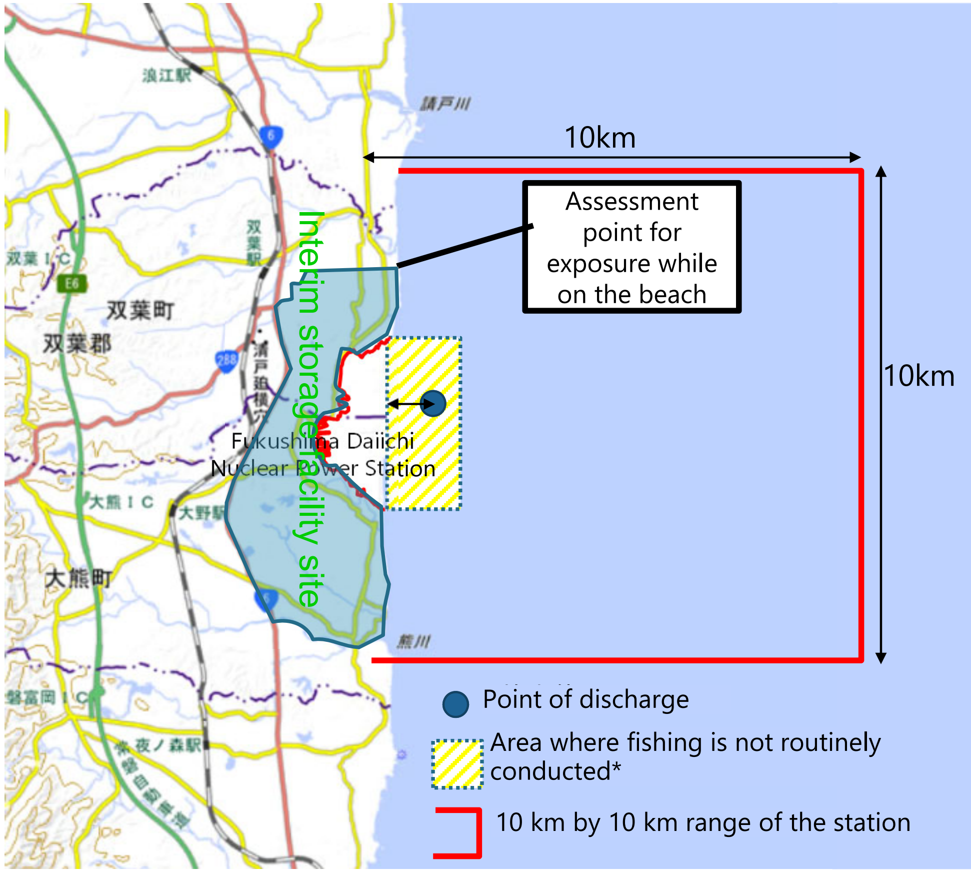
※Exposure was assessed assuming that 10% of the tritium ingested via seafood is organically bound tritium (OBT).



Remain the original

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

* 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

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Dose assessment for representative individuals

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"

Dose assessment for representative individuals

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

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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(Pathway③)

Amount of external exposure ＝0.5×external dose conversion coefficient × Radiation material 0concentration in seawater (Pathway①) ＋0.5× external dose conversion coefficient × Radiation material concentration in seawater ×partition coefficient (Pathway②)

- 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 *Kds*) 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]

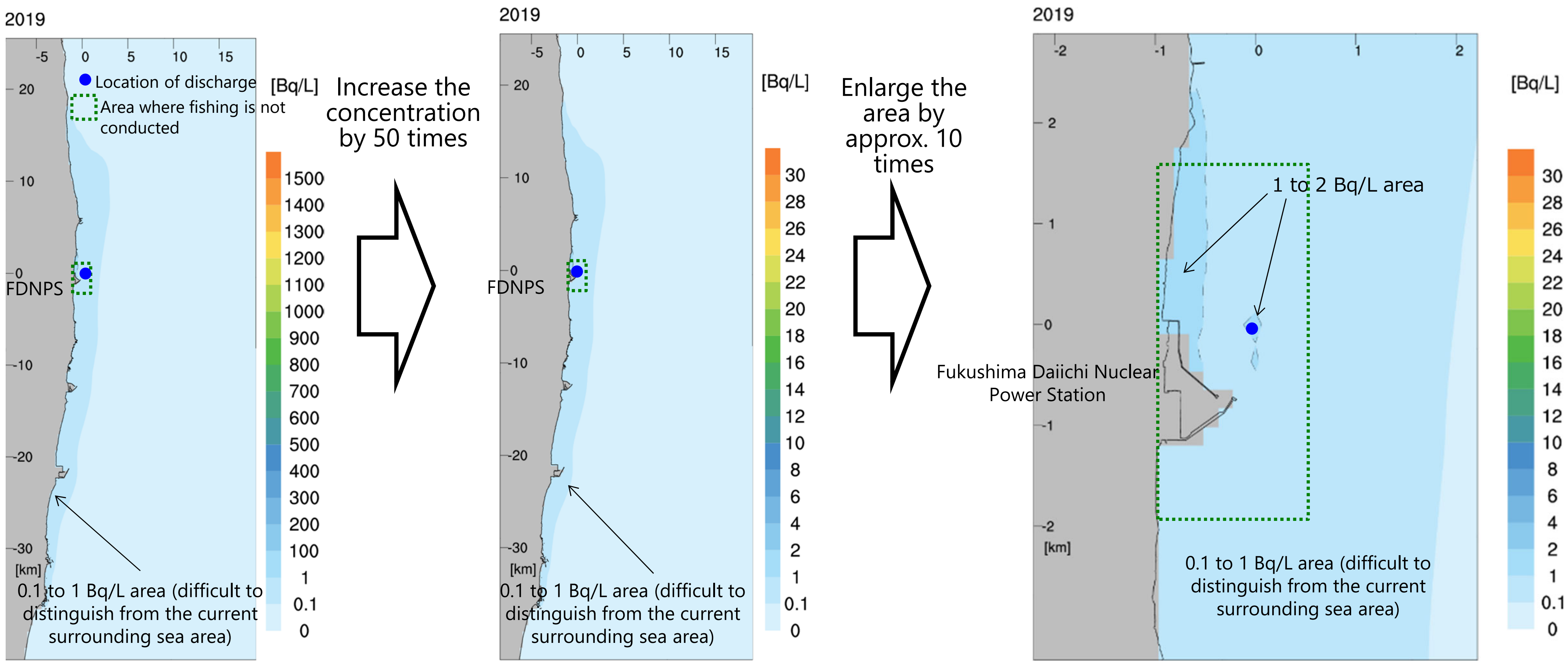
*1 ICRP Pub.136, "Dose Coefficients for Non-human Biota Environmentally Exposed to Radiation"
*2 ICRP BiotaDC Program v.1.5.1 (http://biotadc.icrp.org/)
*3 ICRP Pub.114, "Environmental Protection: Transfer Parameters for Reference Animals and Plants"
*4 IAEA Technical Report Series No.479, "Handbook 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.

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

Results of dispersion simulation at sea

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)

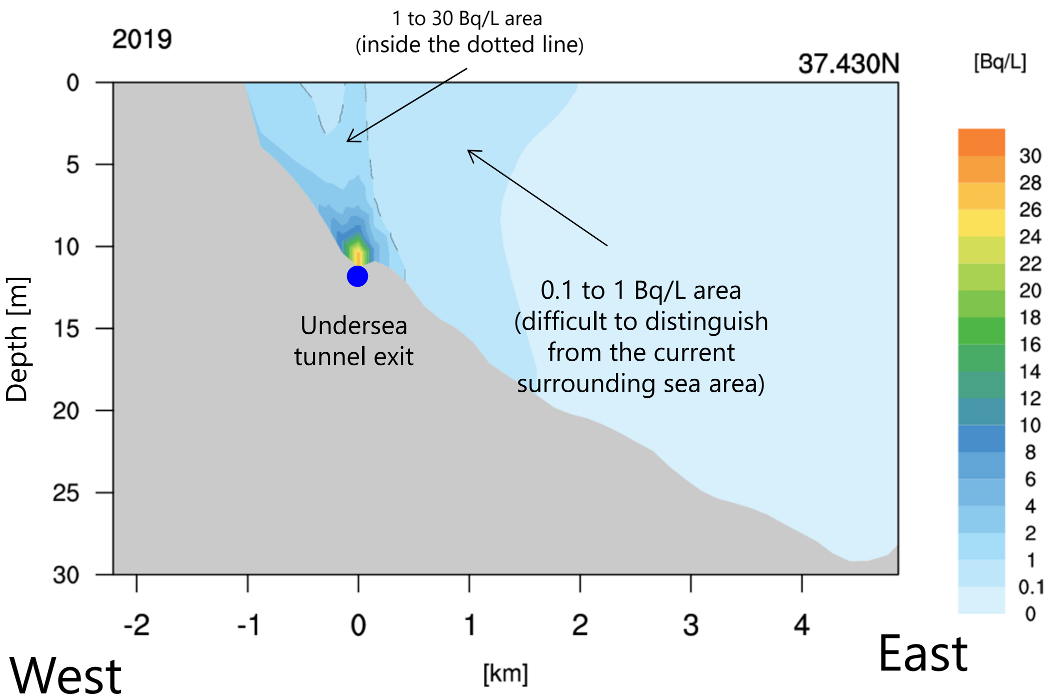


Enlarged view of the area off the coast of Fukushima (Largest value in scale at 30 Bq/L)

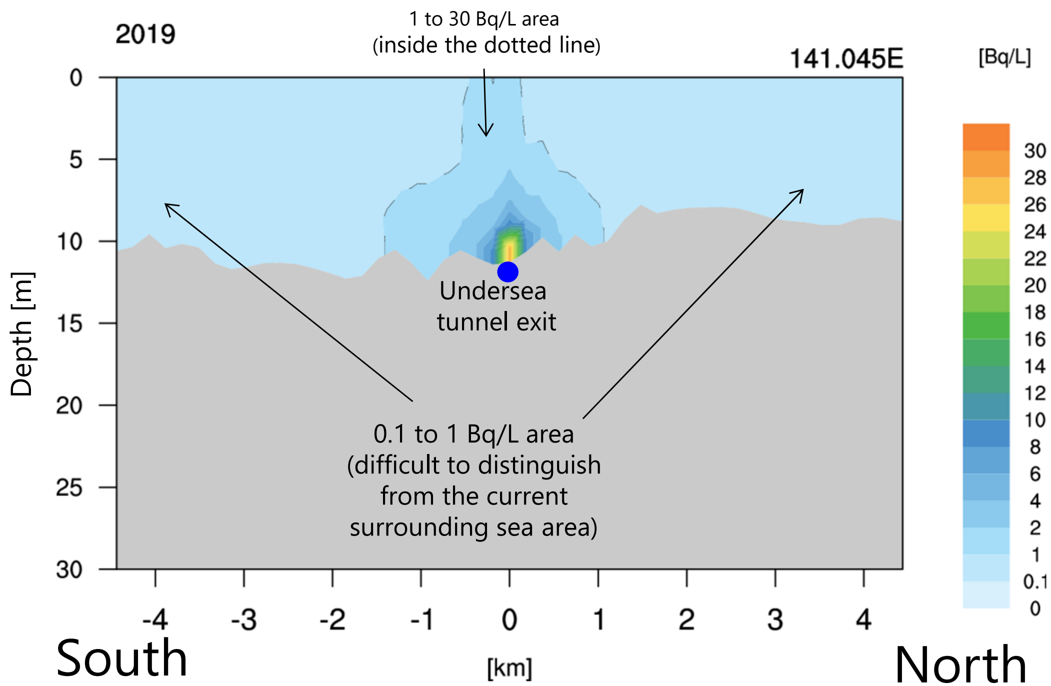
Enlarged view of the area around the station (Largest value in scale at 30 Bq/L)

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

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

TEPCO

Human exposure assessment results

- **External exposure decreases due to decay of short half-life nuclides, but internal exposure from ingestion of seafood because discharge amount of long half-life nuclides increase due to decay of tritium concentration.**
- **However, the dose limit 1mSv */year as well as 0.05mSv/ year corresponding to the dose constraint are still small.**

*mSv： millisievert

Conditions	Nuclide composition in source term	Source terms based on actual values (Values for before revising nuclides 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(7.6E-10)		1.7E-10(2.3E-10)		3.7E-10(4.8E-10)	
	Body of the ship	4.9E-10(7.2E-10)		1.8E-10(2.2E-10)		3.7E-10(4.6E-10)	
	When swimming	3.2E-10(5.2E-10)		1.2E-10(1.6E-10)		2.5E-10(3.2E-10)	
	Beach sand	5.4E-07(9.1E-07)		2.0E-07(2.7E-07)		4.3E-07(5.6E-07)	
	Fishing nets	1.1E-07(1.8E-07)		3.9E-08(5.3E-08)		8.3E-08(1.1E-07)	
Internal exposure (mSv/year)	Drinking water	3.4E-07(3.3E-07)		3.1E-07(3.1E-07)		3.1E-07(3.1E-07)	
	Inhaling water sprays	9.2E-08(9.1E-08)		1.9E-07(1.9E-07)		3.8E-07(3.8E-07)	
	Ingesting seafood	6.9E-06 (4.7E-06)	3.1E-05 (2.0E-05)	1.2E-06 (1.0E-06)	5.5E-06 (4.5E-06)	2.6E-06 (2.1E-06)	1.1E-05 (9.0E-06)
Total(mSv/year)		**8E-06 (6E-06)**	**3E-05 (2E-05)**	**2E-06 (2E-06)**	**6E-06 (5E-06)**	**4E-06 (3E-06)**	**1E-05 (1E-05)**

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

Updated

Assessment conditions for potential exposure

- As shown in the table, two cases were selected as events that could lead to potential exposure (Case 1: Leakage from piping and Case 2: Leakage from tank). Exposure assessments were carried out based on the given discharge scenarios.
- Transfer pathways, exposure pathways, and the characteristics of representative person were basically the same as in normal condition

Evaluation procedure	After revising nuclides to be measured and assessed	Before revising nuclides to be measured and assessed
Scenario selection	Case 1 : Pipe rupture causes spillage of 500m^3 per day for 20 days Case 2 : Tank damage causes spillage of 30,000m^3 in one day	Same as left
Source term	Source term based on actual measurements (30 nuclides including tritium)	Source term based on actual measurements (31 nuclides including tritium)
Migration, exposure pathways	Same as normal exposure	Same as left
Representative Person	Exposure at beach assessment point during normal life, internal exposure also considered	Same as left

Newly added

Potential exposure assessment results

- **As in normal times, external exposure decreases, while internal exposure due to the ingestion of seafood increases.**
- **However, it remains well below the accident reference value of 5 mSv*.**

*mSv: millisievert

Conditions	Nuclide composition in source term	Source terms based on actual values (Values for before revising nuclides in parentheses)					
		i .K4 tanks		ii. J1-C tank After secondary treatment		iii. J1-G tank After secondary treatment	
	Case	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
External exposure (mSv*)	Sea surface	1.8E-09 (4.1E-09)	8.8E-08 (2.0E-07)	3.5E-09 (5.4E-09)	1.7E-07 (2.6E-07)	2.5E-09 (3.6E-09)	1.2E-07 (1.7E-07)
	Body of the ship	1.9E-09 (3.8E-09)	9.4E-08 (1.9E-07)	3.6E-09 (5.2E-09)	1.7E-07 (2.5E-07)	2.5E-09 (3.5E-09)	1.2E-07 (1.7E-07)
	When swimming	1.7E-10 (3.9E-10)	8.3E-09 (1.8E-08)	3.3E-10 (5.0E-10)	1.6E-08 (2.4E-08)	2.3E-10 (3.4E-10)	1.1E-08 (1.6E-08)
	Beach sand	2.9E-07 (6.7E-07)	1.4E-05 (3.2E-05)	5.6E-07 (8.7E-07)	2.7E-05 (4.2E-05)	4.0E-07 (5.9E-07)	1.9E-05 (2.8E-05)
	Fishing nets	8.9E-07 (2.0E-06)	4.3E-05 (9.8E-05)	1.7E-06 (2.6E-06)	8.3E-05 (1.3E-04)	1.2E-06 (1.8E-06)	5.8E-05 (8.6E-05)
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 (6.8E-08)	2.4E-06 (3.2E-06)	5.4E-07 (6.2E-07)	2.6E-05 (3.0E-05)	3.5E-07 (4.0E-07)	1.7E-05 (1.9E-05)
	Ingesting seafood (In case of large numbers)	2.6E-04 (2.4E-04)	1.3E-02 (1.1E-02)	2.4E-04 (2.3E-04)	1.2E-02 (1.1E-02)	1.6E-04 (1.5E-04)	7.8E-03 (7.1E-03)
Total(mSv)		**3E-04 (2E-04)**	**1E-02 (1E-02)**	**2E-04 (2E-04)**	**1E-02 (1E-02)**	**2E-04 (2E-04)**	**8E-03 (7E-03)**
Reference values for exposure at the time of the accident: 5mSv							

Updated

Animal and plant exposure assessment Results

■Decreased exposure due to attenuation of short half-life nuclide

■Levels as low as one part per million compared to the induced consideration reference level remain the same.

Scenario		Source terms based on actual values Values for before revising nuclides in parentheses		
		i. K4 tanks	ii. J1-C tanks	iii. J1-G tanks
Exposure (mGy*/day)	Flatfish	6E-07 (9E-07)	3E-07 (5E-07)	7E-07 (1E-06)
	Crab	7E-07 (9E-07)	3E-07 (4E-07)	7E-07 (1E-06)
	Brown seaweed	7E-07 (1E-06)	3E-07 (5E-07)	8E-07 (1E-06)
DCRL Flatfish：1-10 mGy/day　Crab：10-100mGy/day　Brown seaweed：1-10mGy/day				

*mGy：milligray

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

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

The outlet of the discharge tunnel is installed within the area* where no fishing is conducted on a daily basis, and the assumed quantity of water within the subject area is approx. 60 billion(6.0E+10) liters.

Measurement/confirmation facility (K4 tank group)

Comprised of three sets of tank groups each with the role of receiving, measurement/confirmation, and discharge. In the measurement/confirmation stage, water that has been made homogenized through circulation and agitating is sampled and analyzed (approx. 10,000m³ × 3 groups)

Secondary treatment facility(newly installed reverse osmosis membrane facility)

Secondary treatment of treated water to be re-purified (sum of the ratios of nuclides, excluding tritium, is between 1 and 10)

Secondary treatment facility(ALPS)

Secondary treatment of Treated water to be re-purified (sum of the ratios of nuclides, excluding tritium, is 1 or higher)

ALPS treated water transfer pump

Seawall

Installed around emergency isolation valves and transfer pipes

ALPS treated water, etc. tanks

Flow meter/water flow rate control valve/ Emergency isolation valve

(tsunami prevention measure)

Header pipe

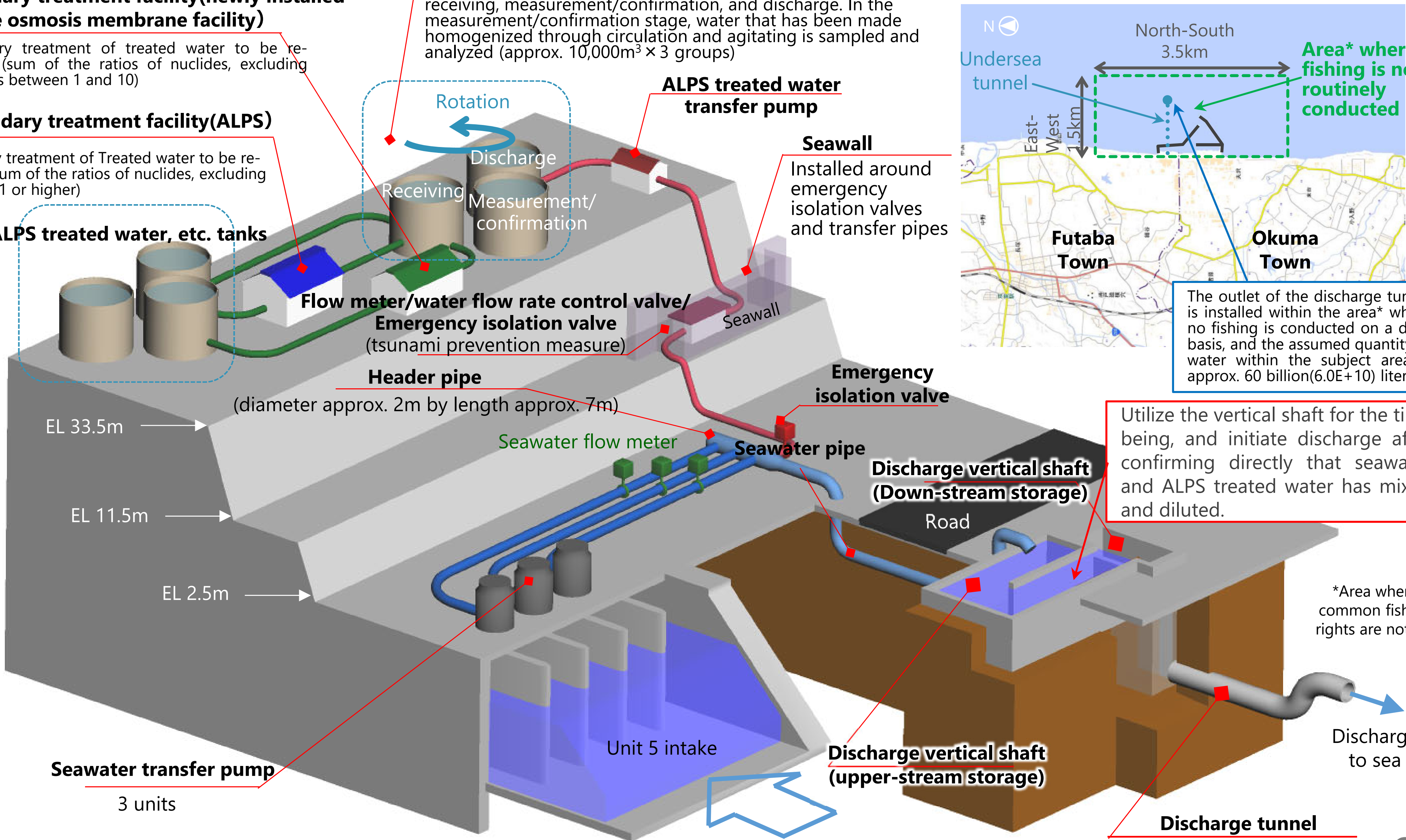
(diameter approx. 2m by length approx. 7m)

Emergency isolation valve

Seawater pipe

Discharge vertical shaft (Down-stream storage)

Utilize the vertical shaft for the time being, and initiate discharge after confirming directly that seawater and ALPS treated water has mixed and diluted.



*Area where common fishery rights are not set

Discharge to sea

Seawater transfer pump

3 units

Discharge vertical shaft (upper-stream storage)

Seawater used for dilution (intake from outside the harbor)

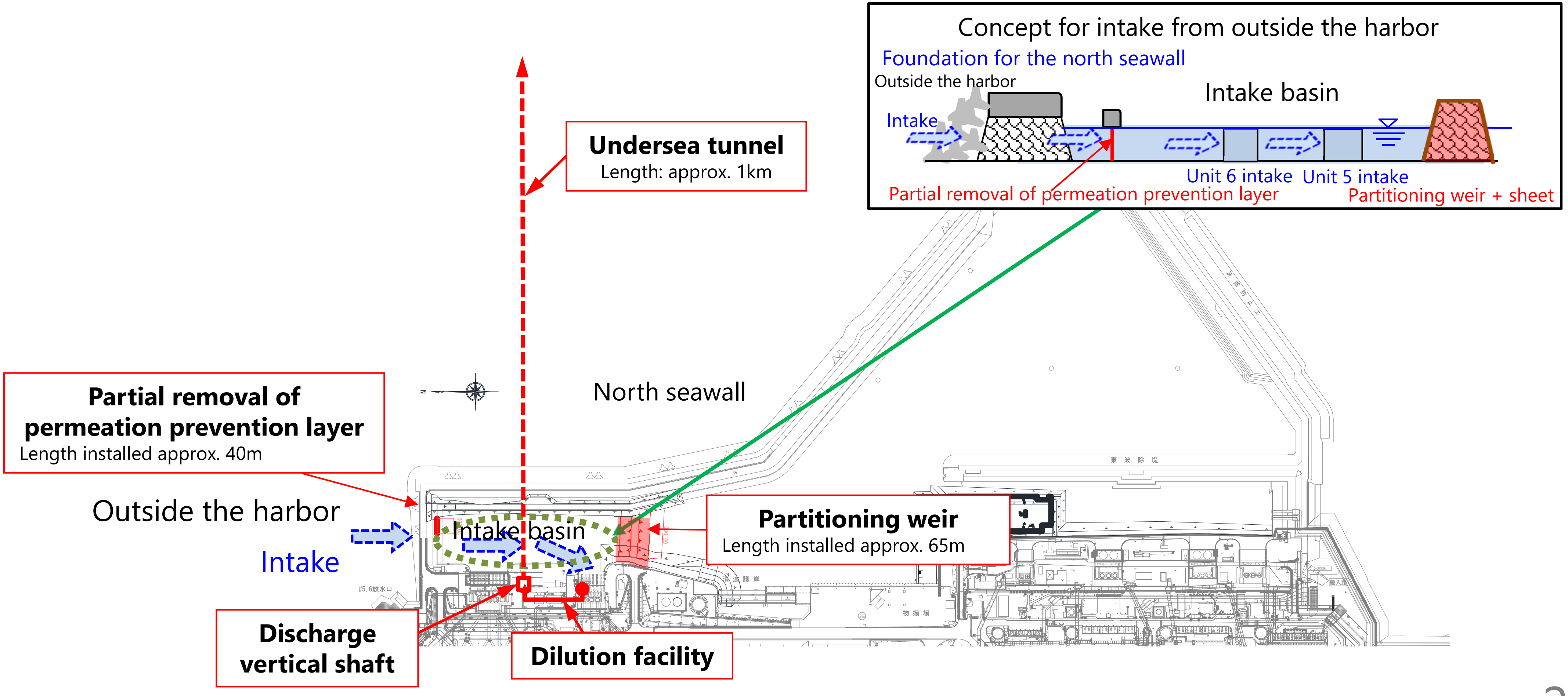
Discharge tunnel

(approx. 1km)

【Reference】Harbor design

Remain the original

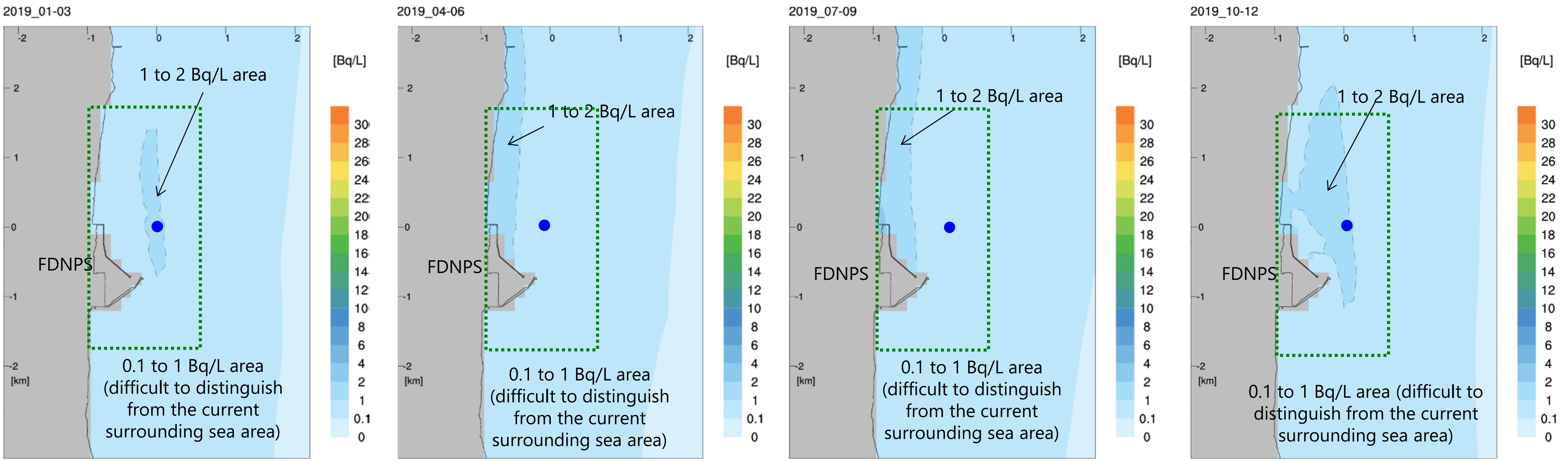
- Modify the north seawall to allow the intake of seawater outside the harbor for use in dilution, and **<u>prevent seawater inside the harbor from mixing directly with the seawater for dilution</u>** by separating from inside the harbor using a partitioning weir.
- The harbor shall be designed to discharge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



【Reference】Results of dispersion simulation at sea(average for each season)

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)

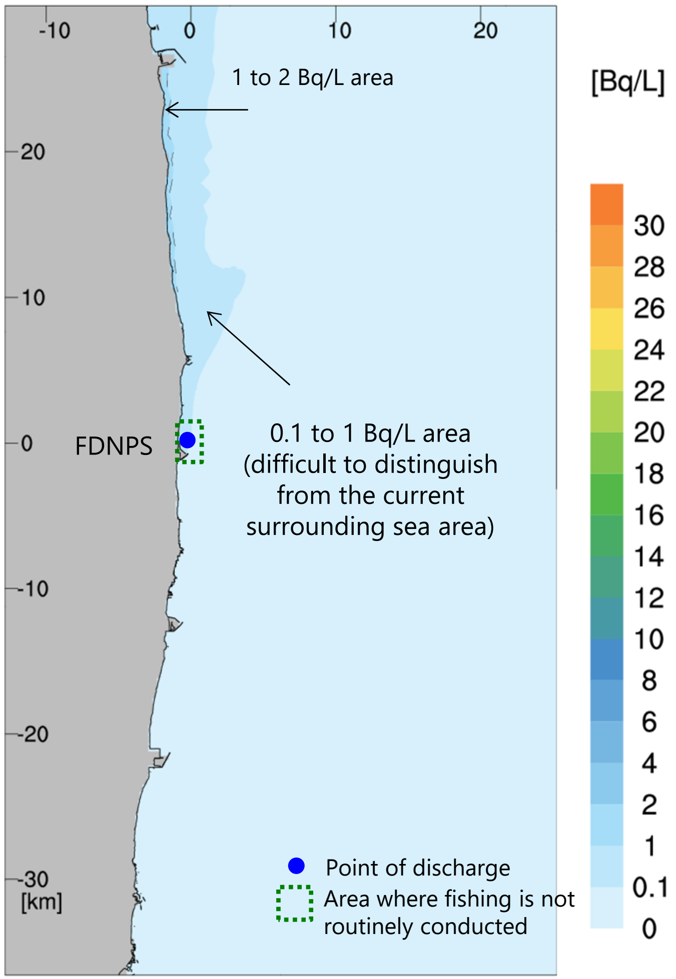
Remain the original

TEPCO

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.

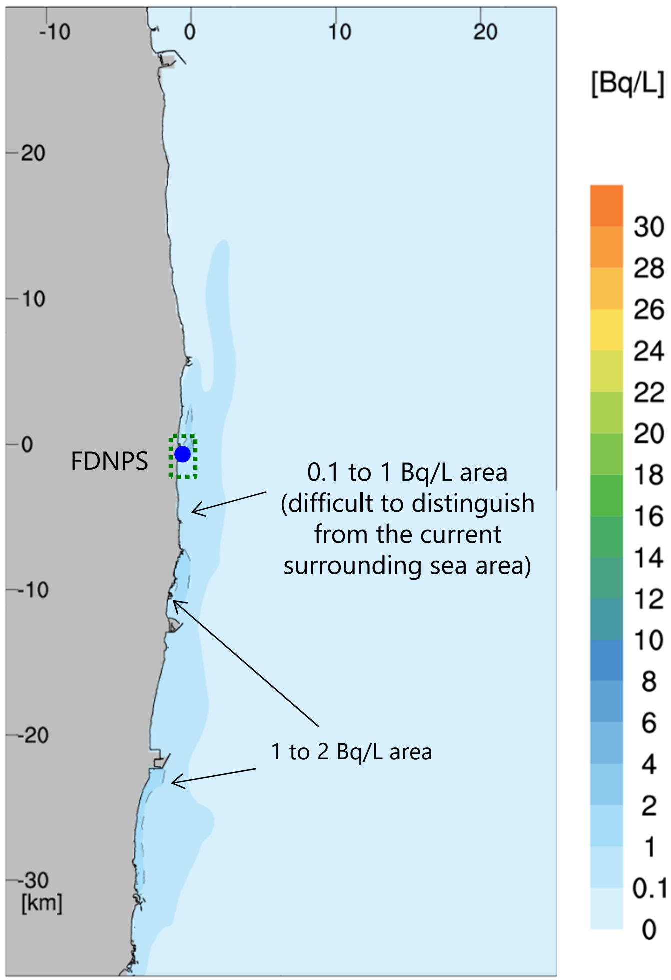
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

20190521



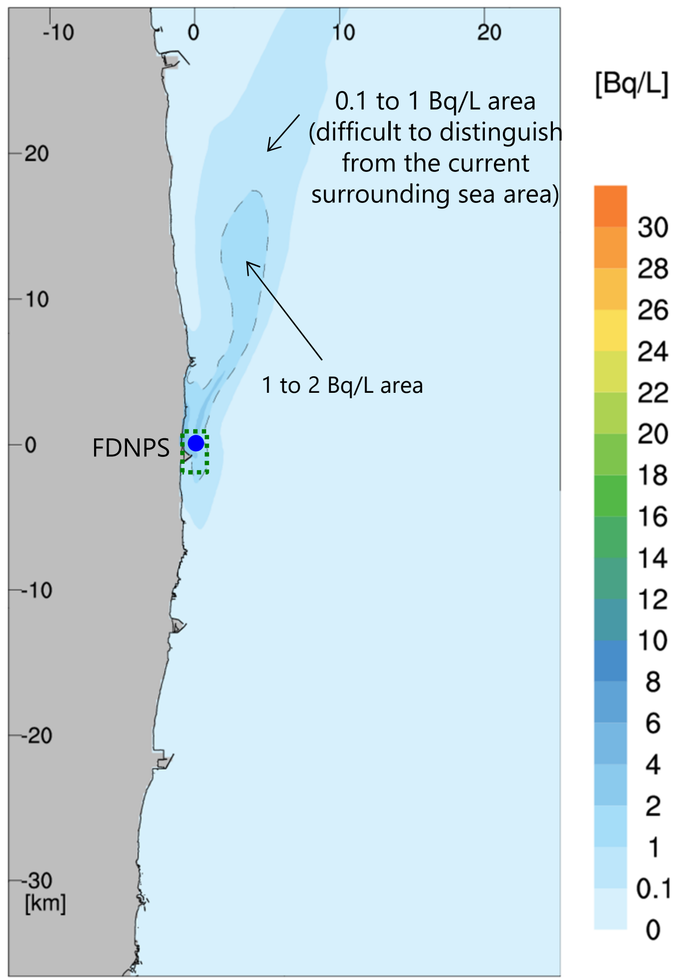
Area at its northernmost configuration
(Largest value in scale at 30Bq/L)

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)

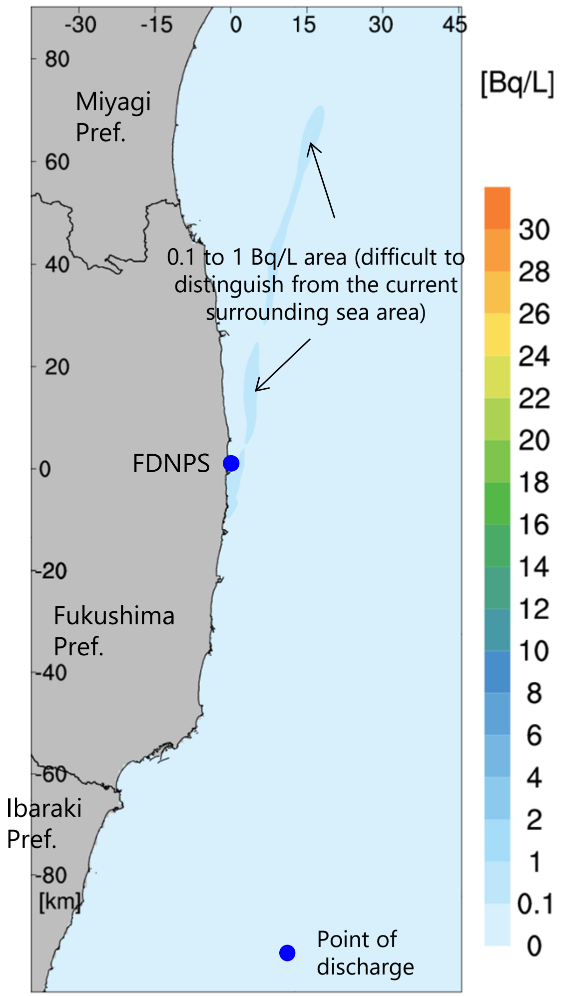
Remain the original

【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.

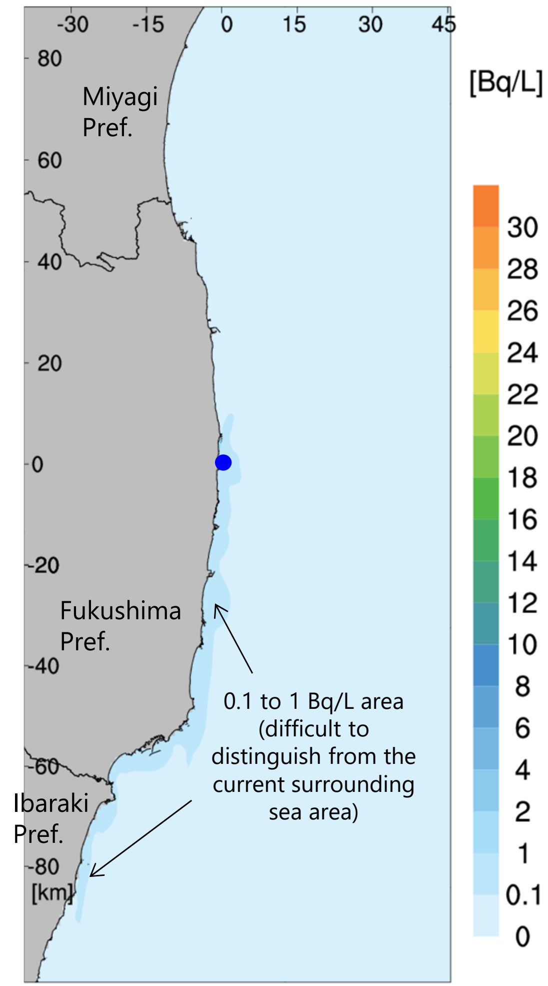
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

20190827



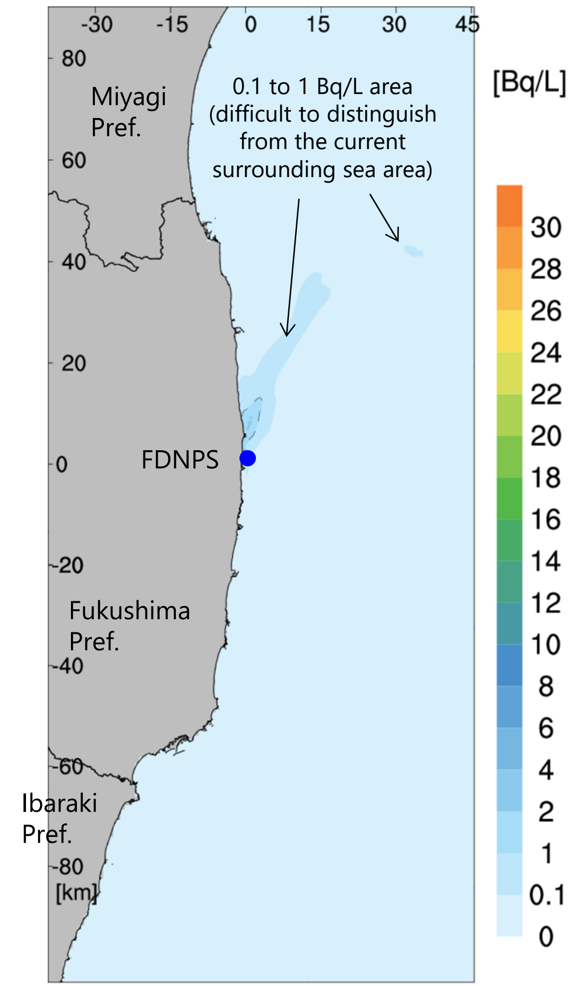
Area at its northernmost configuration (Largest value in scale at 30Bq/L)

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

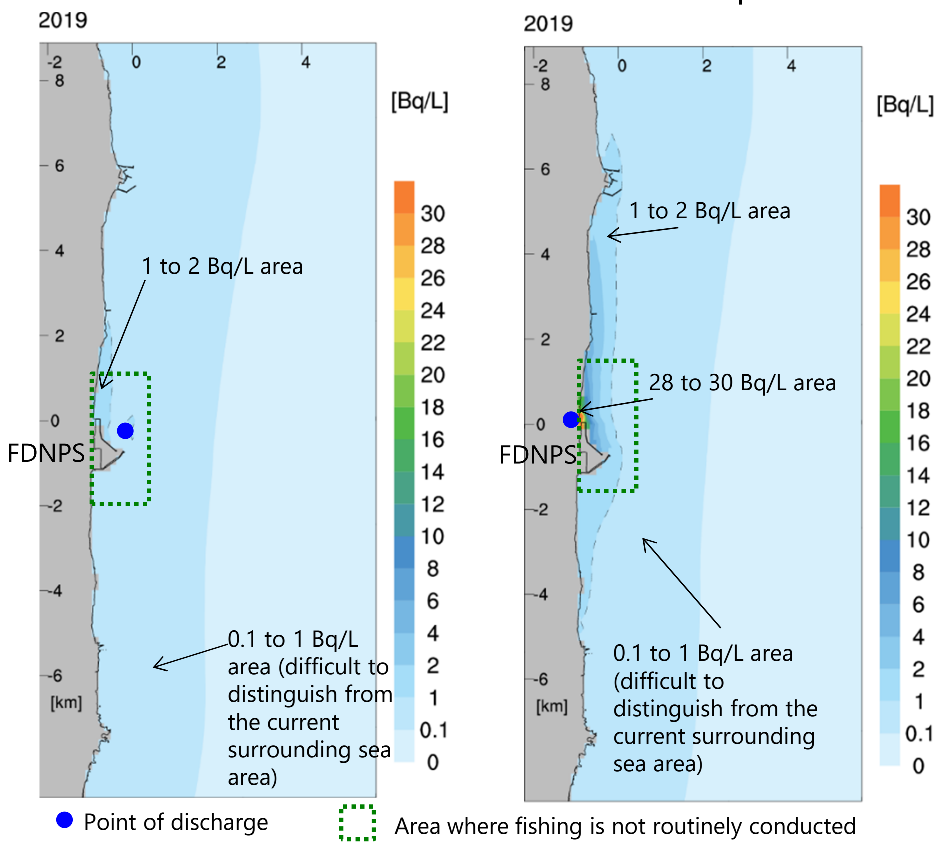
Remain the original

TEPCO

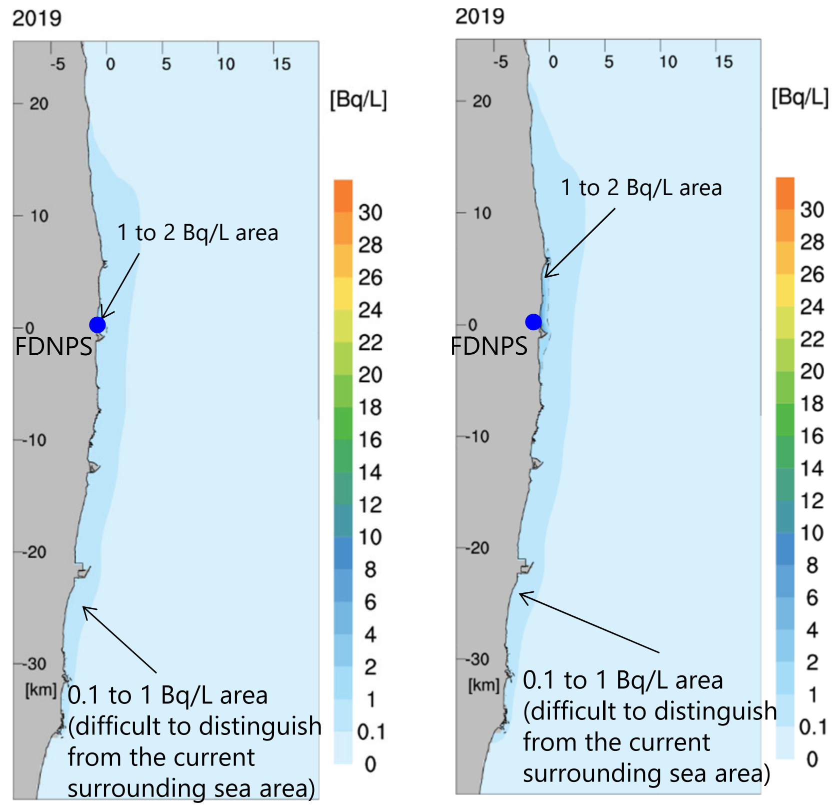
In addition to the scenario assuming that the ALPS treated water will be discharged according to the plan created by TEPCO, another scenario assuming that the ALPS treated water will be discharged from the Units 5 and 6 discharge port along the coast line was also simulated to see how the radioactive 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



Wide area map



【Reference】Assumptions in radiological impact assessment on the public and the environment

Updated

- 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
Volume 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