Attachment 3

Revision of the Radiological Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea (Design stage*)

TEPCO

April 28, 2022

* 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.

Newly added

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Overview of changes in the revised report

- After publishing the Radiological Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea (Design stage) in November 2021, TEPCO has conducted further studies, sought comments from the public domestic and abroad, has had processes reviewed by IAEA personnel and international experts, and engaged in discussions with the Nuclear Regulation Authority (NRA). In light of these developments, the assessment was updated and the report has been revised as follows
- This update does not change Changes between versions have not affected the conclusion of the radiological impact assessment that calculated doses are significantly less than the dose limits for the general public, dose constraint*, and the values specified by international organizations for each

Chapter	Changes
Executive summary	Added anew
Overview of the assessment	Reflected changes in Chapters 1 through 10
1.Background	Added background information including how ALPS treated water is generated
2.Discussions regarding the handling of ALPS treated water	Added history of discussions on the handling of ALPS treated water
3. Purpose of evaluation	No changes
4. Principle for assessment	See next slide "Major changes in assessment"
5. Water quality and discharge method for ALPS treated water	Reflected progress made in discussions (Implementation Plan, review meetings, etc.)
6. Assessment regarding public protection	See next slide "Major changes in assessment"
7. Assessment regarding environmental protection	Moved the section up from the reference materials to the main text
8. Insights regarding uncertainties in assessment	See next slide "Major changes in assessment"
9. Monitoring conducted for the discharge of ALPS treated water into the sea	Reflected progress made in discussions (review meetings, comprehensive monitoring plan, etc.)
10. Summary	Reflected changes in assessment

＊ See next page

Newly added

Major changes in assessment

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- In this revision, there was a slight increase in the calculated dose exposure for the general public due to the addition of exposure pathways and other factors. However, the conclusion that the effect of the discharge of ALPS treated water into the sea is minimal in comparison to the dose constraint remains unchanged.
- In February 2022, the Nuclear Regulation Authority (NRA) issued opinions regarding its approach to and criteria for confirming the results of radiological impact assessments. NRA stated that the dose targets adopted by domestic nuclear power stations (0.05 mSv 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 is used in this assessment.
- In the assessment of internal exposure from ingested seafood , 10% of ingested tritium is assumed to be organically bound tritium (OBT)
- The assumptions made in this assessment regarding accumulation of radioactive materials (equilibrium) is explained in further detail.
- In assessment regarding public protection, some of the source terms (type and amount of radioactive materials discharged), the exposure pathways and the concentration of the radioactive materials in seawater used in the assessment were revised and assessment results updated accordingly.
- Clarified the outcomes of dispersion simulation which found that the tritium concentrations at the boundary of the calculated regions was sufficiently lower than seawater tritium concentrations.
- Recalculated potential exposure for following two scenarios: (i)leaks from pipes; and (ii)leaks from tanks. The results confirmed that potential exposure was less than the safety standard at the time of the accident (5mSv) for both scenarios.
- Explored in detail the uncertainties in the results of the assessments in this report, and found that there were significant uncertainties in the nuclide composition in source term and in the transfer coefficients such as the concentration coefficient for fish and shellfish.

Remain the original (partly updated)

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.
- 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. OTHER CHANGES
5. REFFERENCES

Remain the original

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Discharge Method as Preconditions for Assessment

- The ALPS treated water to be discharged is purified until the sum of the ratios to regulatory concentration limits* (hereinafter "the sum of the ratios") of 62 radionuclides and Carbon-14, other than tritium, is less than one.
- The concentration of all 64 nuclides are measured and assessed (including measurement and assessment by third parties) before discharge to confirm the water meets the regulatory standard.
- The annual amount of tritium discharged will be less than 22 TBq, the discharge management target for the Fukushima Daiichi Nuclear Power Station (FDNPS) before the Accident.
- 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 the ratios" of 62 radionuclides and Carbon 14 other than tritium, 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 with the dilution rate or characteristics of the ALPS treated water, the emergency shut-off valves will be actuated swiftly 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 discharge 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, 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.

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1. DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT

2. ASSESSMENT METHODS

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Updated

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Procedures for the radiological impact assessment

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

Impact on the public

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)

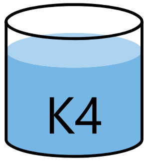
Select the source terms	Define the type and amount of radioactive materials discharged in treated water sea discharge
Model dispersion and transfer in the environment	Study how the various radioactive materials discharged into the sea disperse, transfer and accumulate
Identify exposure pathways	Study 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"

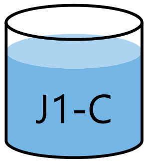
*2 Dose constraint: A value lower than the dose limit, stipulated by the person responsible for radiation work or the radiation facility to optimize safety in physical protection. In regards to Fukushima Daiichi Nuclear Power Station , the NRA issued the opinion on February 16, 2022 that the station 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 discharged)

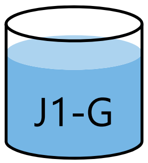
- From the standpoint of more realistic assumptions, the assessment assumes that the ALPS treated water from the three particular tank groups from which the actual measurements for the 64 nuclides have been gathered is diluted by seawater and then continuously discharged during the discharge period.
- Radionuclides that have not been detected before are assumed to be included at their detection limit.
- See Reference C "Exposure assessment results using operational management values and hypothetical ALPS treated water" for the results of the assessment based on source terms using hypothetical ALPS treated water found in the version of this report published in November 2021. This is listed separately from other assessment results as this assessment is overestimates exposure, assuming that the treated water only includes nuclides that have a relatively large impact on exposure dose.



i. K4 tank group
Tritium concentration: approx. 190,000 Bq/L
"The sum of the ratios" of radionuclides other than tritium* : 0.29



ii. J1-C tank group
Tritium concentration: approx. 820, 000 Bq/L
"The sum of the ratios" of radionuclides other than tritium : 0.35



iii. J1-G tank group
Tritium concentration: approx. 270,000 Bq/L
"The sum of the ratios" of radionuclides other than tritium : 0.22

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.

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

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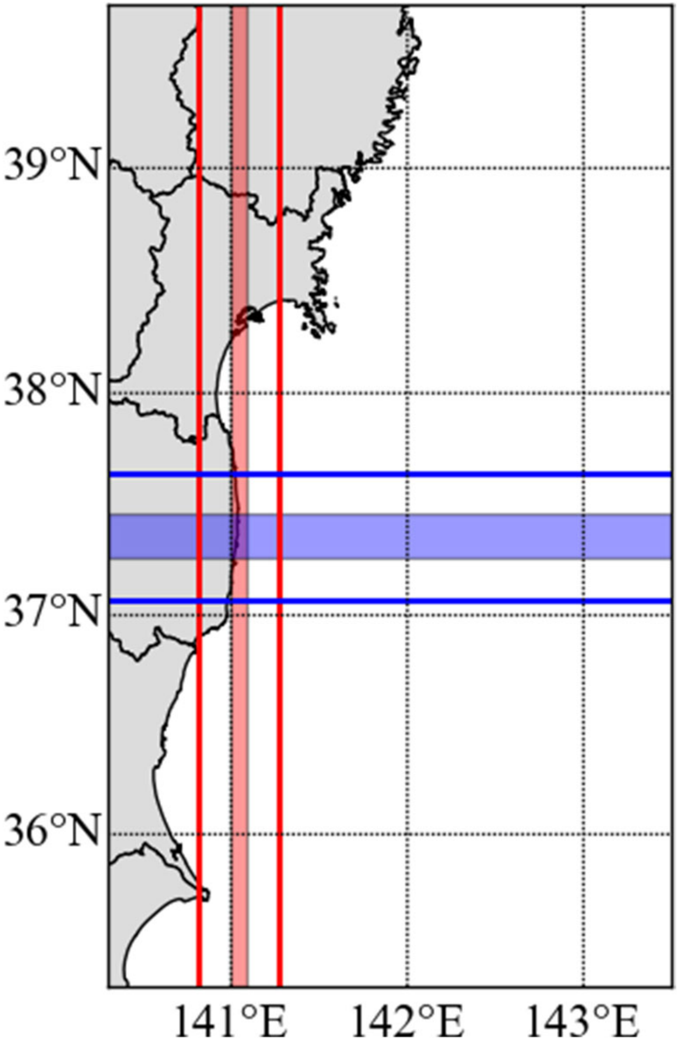
The assessment used a model that was found to be reproducible based on the repeatability calculations for the cesium concentration in seawater after the accident at the Fukushima Daiichi Nuclear Power Station. In addition, the calculations with higher resolutions was conducted so as to simulate the sea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

Identifying the exposure pathways (assessment model)

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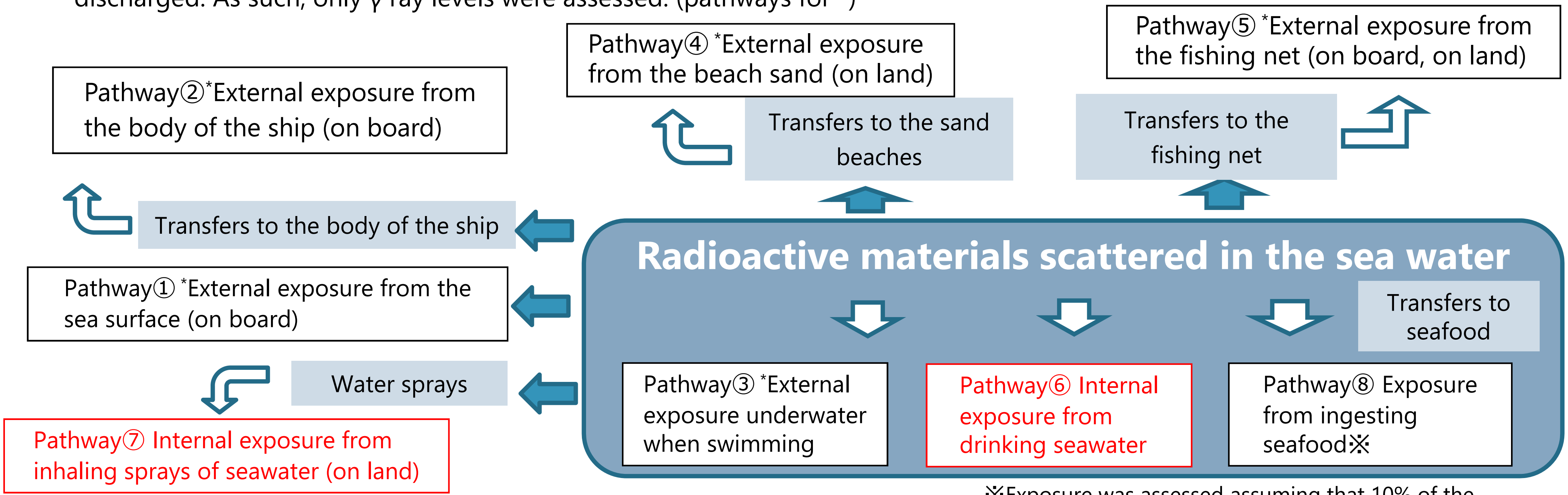
(1) Transfer and exposure pathways (human exposure)

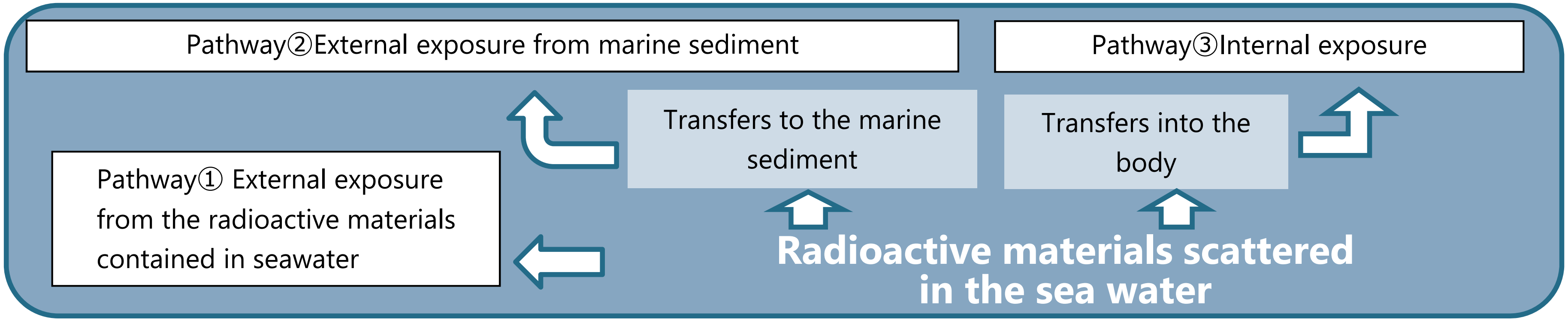
- Pathways were set based on IAEA Safety Standards and domestic examples (See Attachment VI “Transfer and exposure pathways not subject to assessment” for how the pathways were selected)

  ※ 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)



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

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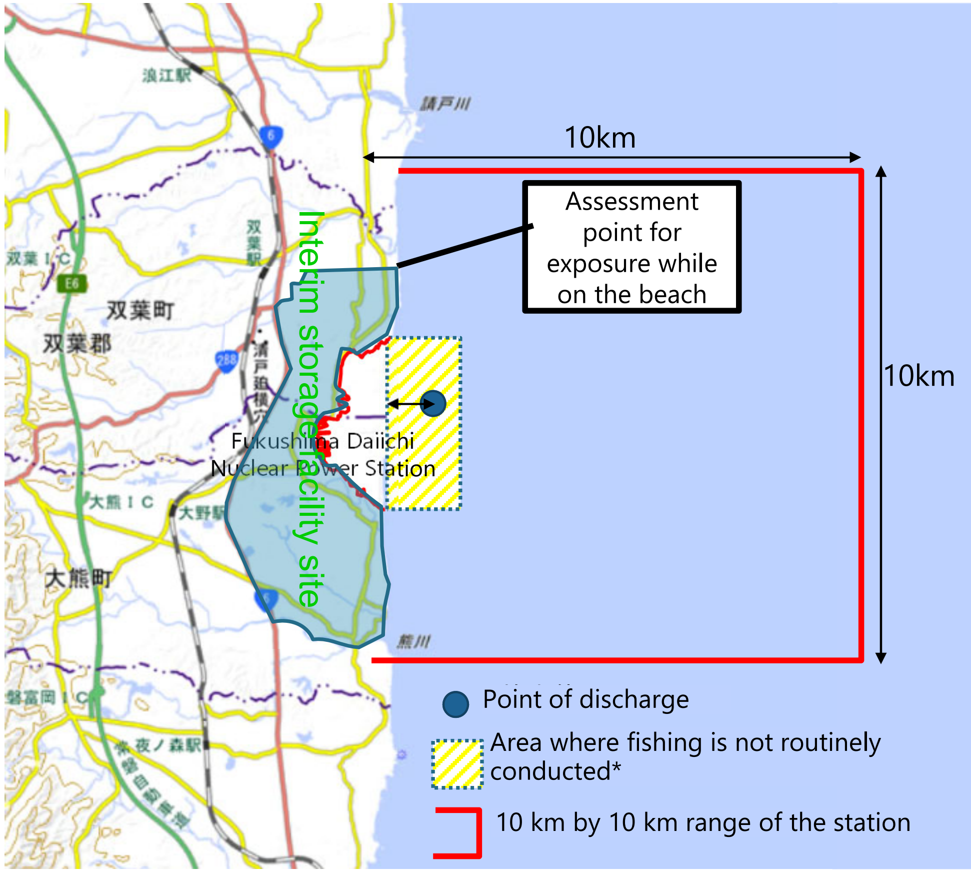
- The tritium concentration in the sea area was calculated using the actual annual meteorological/sea conditions data assuming that tritium is discharged evenly throughout the year
- The annual average concentration of tritium was calculated for the 10km by 10km area around the station
- External exposure 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"

Dose assessment for representative person

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

Updated

Dose assessment for representative individuals

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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"

Updated

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.

Updated

Dose assessment for reference animals and plants

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 *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
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4. OTHER CHANGES
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Remain the original (partly updated)

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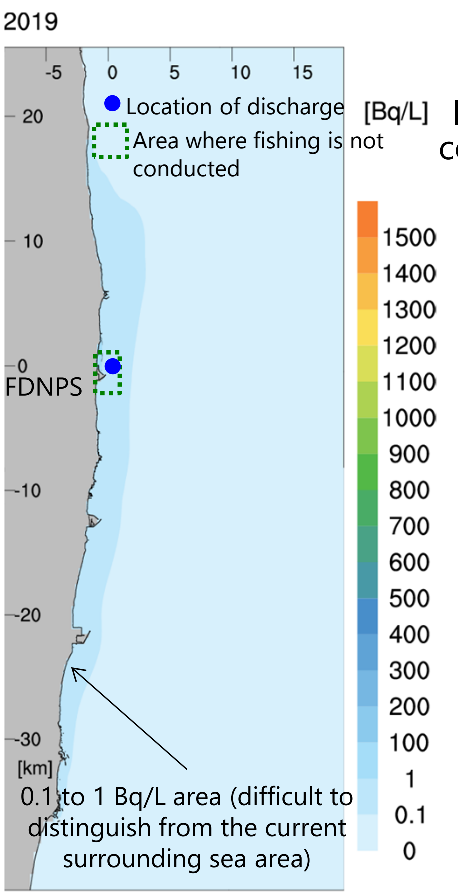
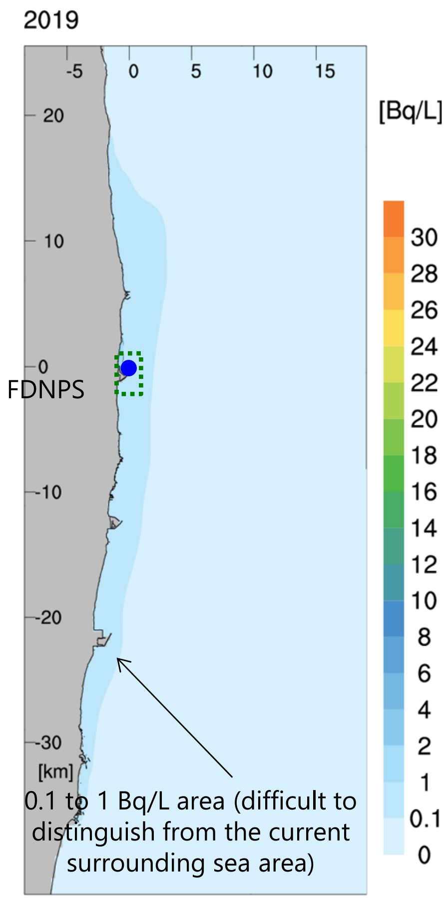
Results of dispersion simulation at sea

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)

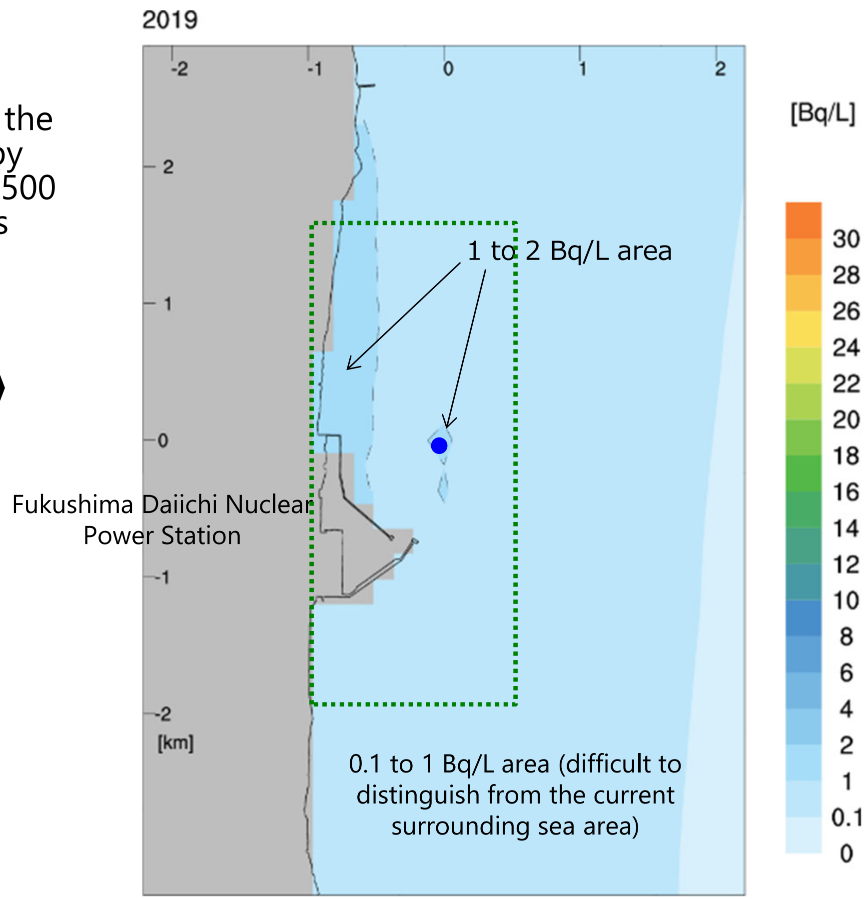


Increase the concentration by 50 times



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

Enlarge the area by approx. 500 times



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 (partly updated)

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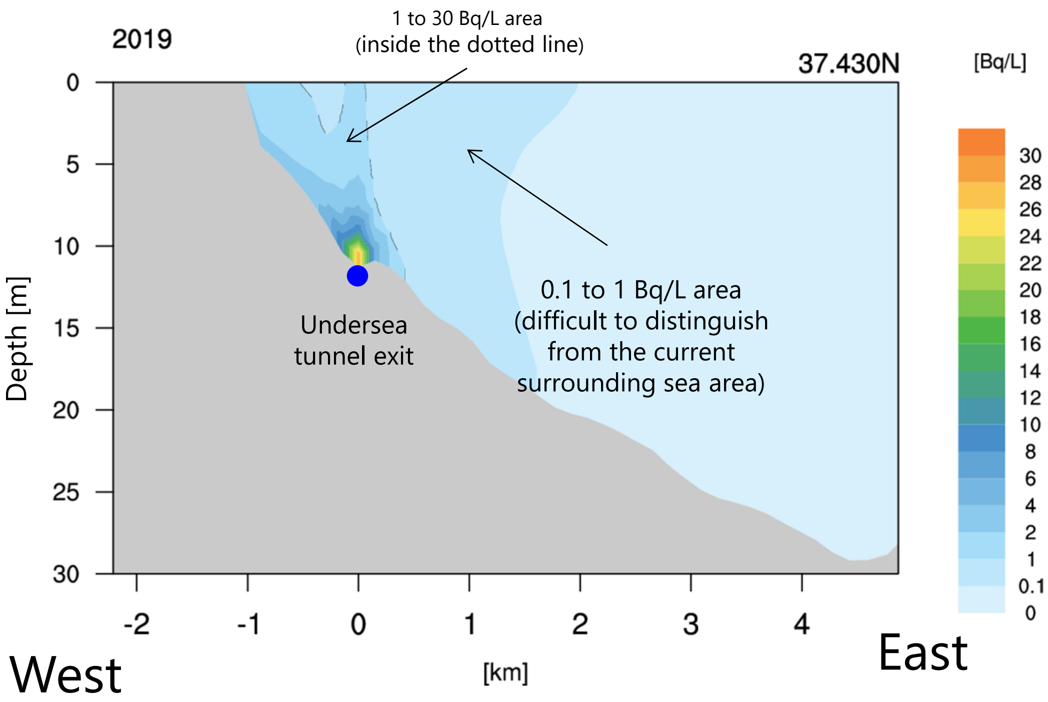
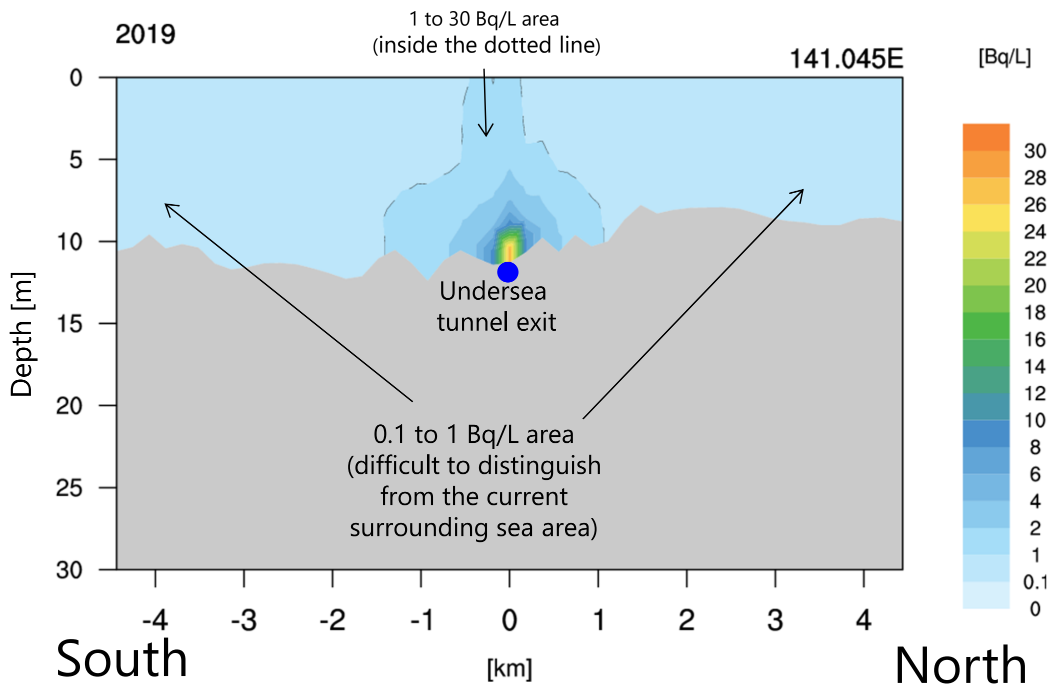
The concentration swiftly falls in the are surrounding the tunnel exit before dispersion. Furthermore, simulated values are still **significantly below** the national regulatory standard (60,000 Bq/L) and the **WHO Guidelines for drinking-water quality (10,000 Bq/L).**



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)

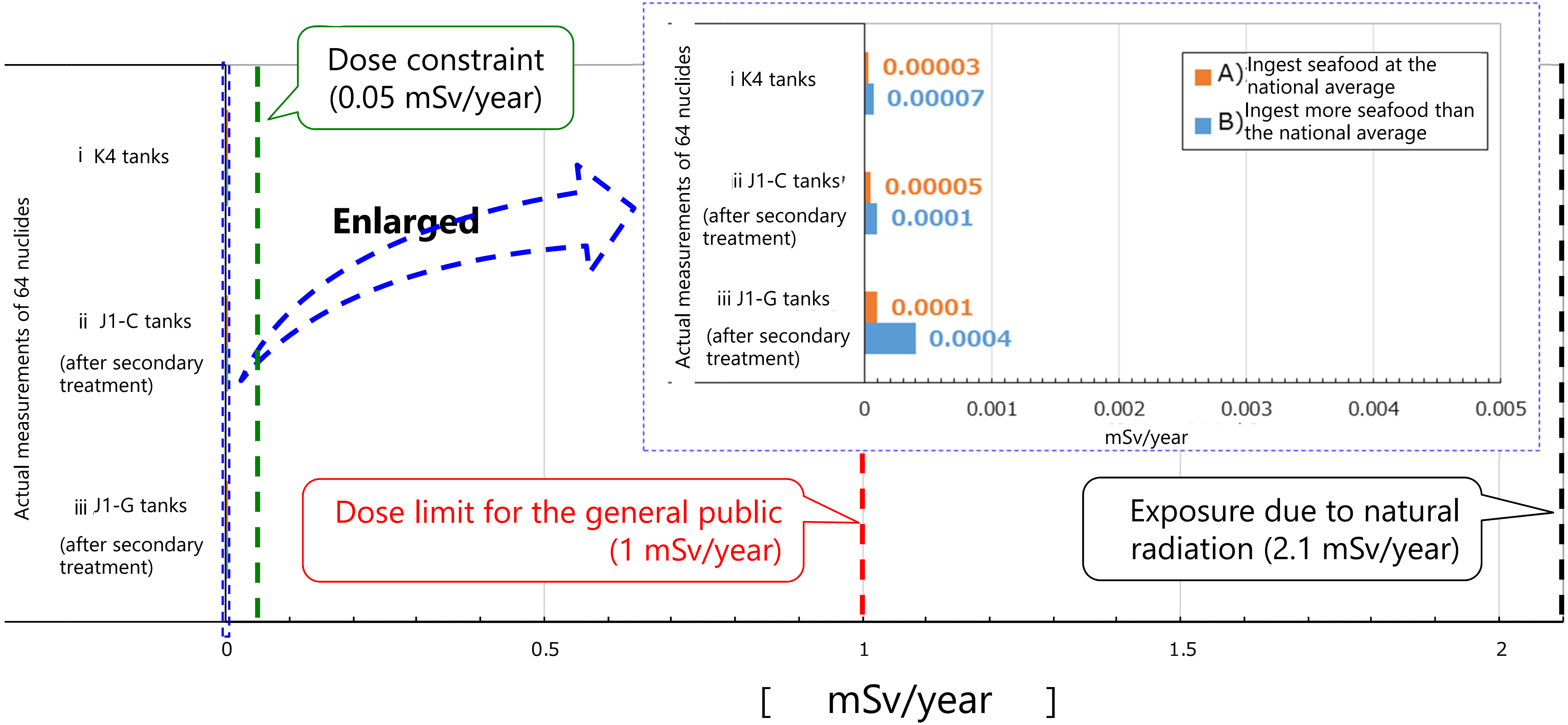
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

Human exposure assessment results
(design stage, assessment using actual measurements of 64 nuclides)

Updated

TEPCO

- Results of an assessment using actual measurements from 64 nuclides found that the **exposure dose was approx. 1/30,000 to 1/3,000 of the dose limit for the general public (1 mSv/year) and approx. 1/2000 to 1/100 of the dose target rate for domestic power plants (0.05 mSv/year) which is equivalent to the dose constraint**



(Note) These are figures 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.

Insights into undetected nuclides in the assessment results (design stage, assessment using actual measurements)

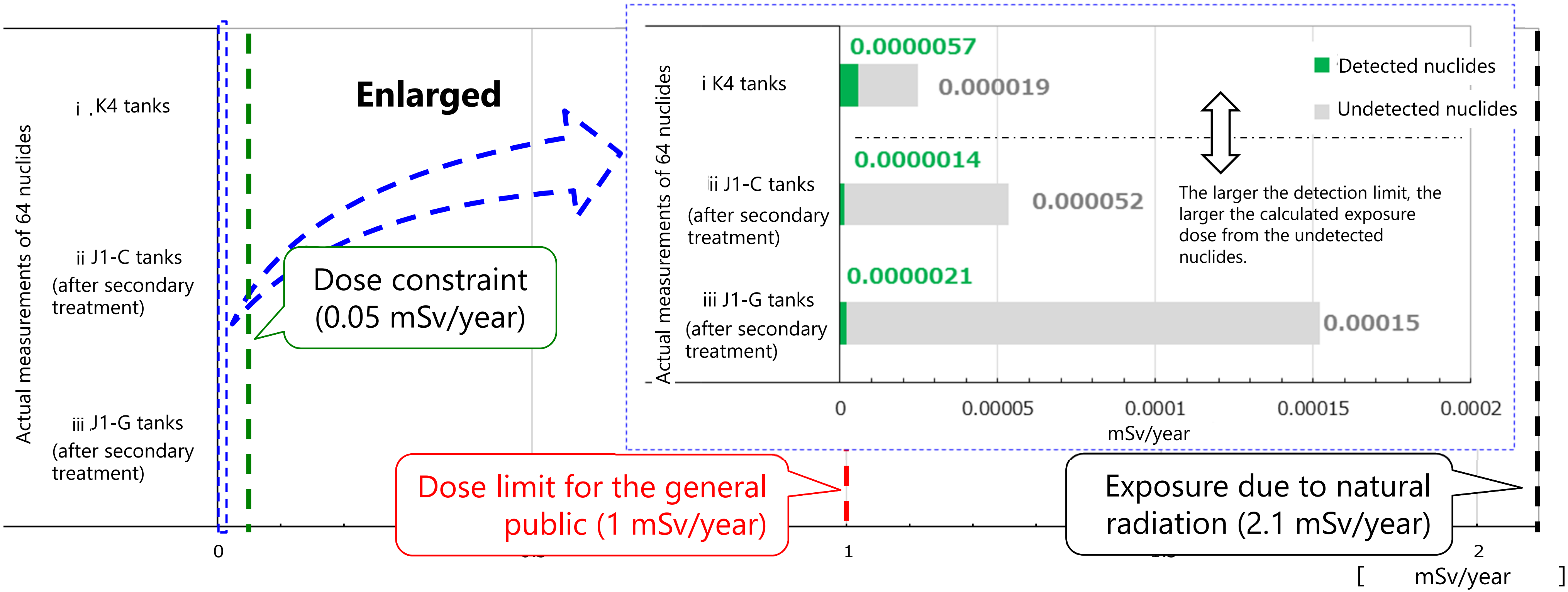
Updated

TEPCO

- Assessment based on actual measurements of 64 nuclides assumed that **"undetected nuclides" that had never been detected in analysis before existed in detection limit amounts. Exposure from these undetected nuclides are assumed to comprise the majority of the calculated exposure dose, and the dose from actual measurements is likely to be much lower.**
  - ✓ 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 limits that can be continuously used

Contribution of undetected nuclides in exposure
(when seafood is ingested in amounts at the national average)



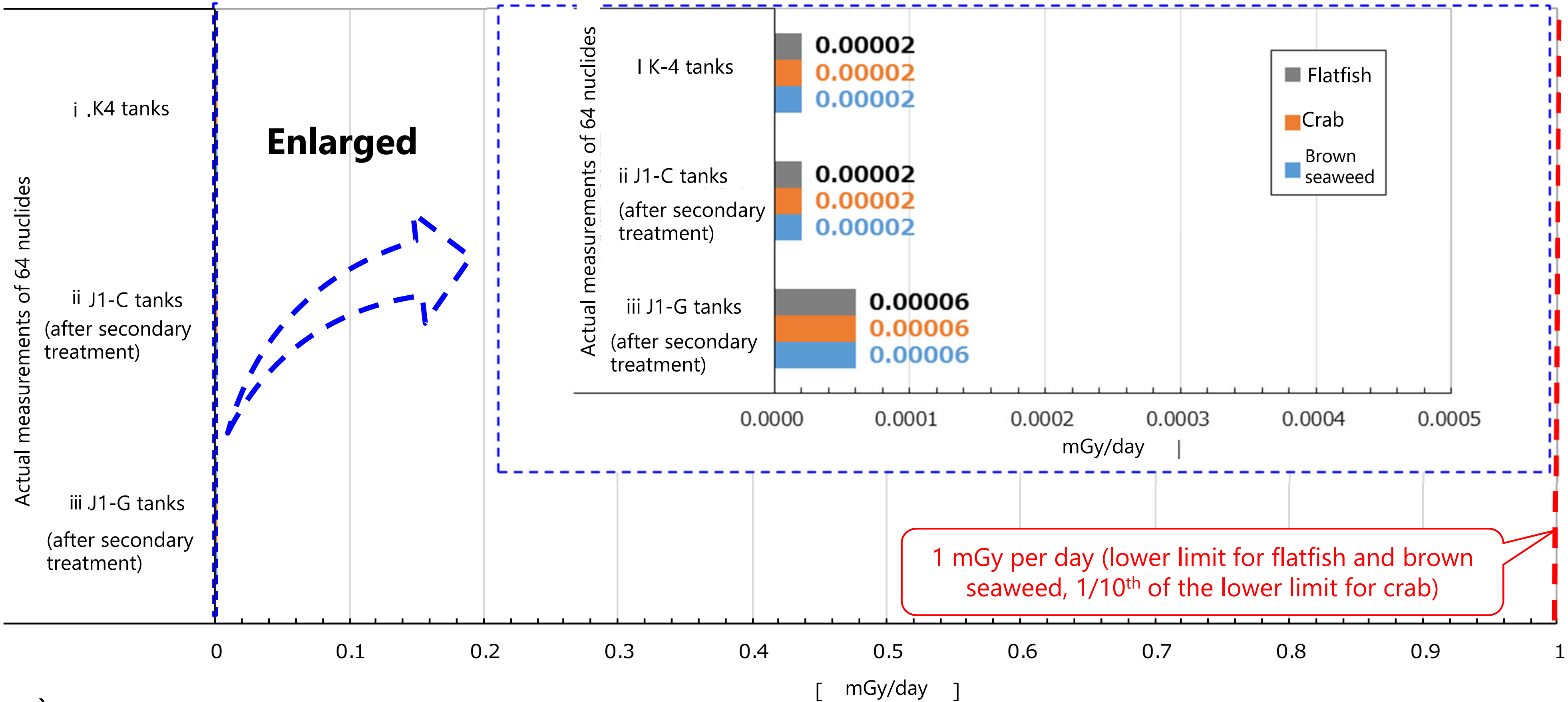
(Note) These are figures for adults only. These are present results and may be updated according to future discussions and internal and external reviews.

Results of animal and plant exposure assessment (design stage, assessment using actual measurements of 64 nuclides)

Remain the original (partly updated)

TEPCO

- Assessment using actual measurements of 64 nuclides found exposure doses to be approximately 1/50,000 to 1/20,000 (1/500,000 to 1/200,000 for crab) of the lower limit of the derived consideration reference level* (DCRL; 1 to 10 mGy /day for flatfish, 10 to 100 mGy/ day for crab, 1 to 10 mGy/day for brown seaweed) 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.

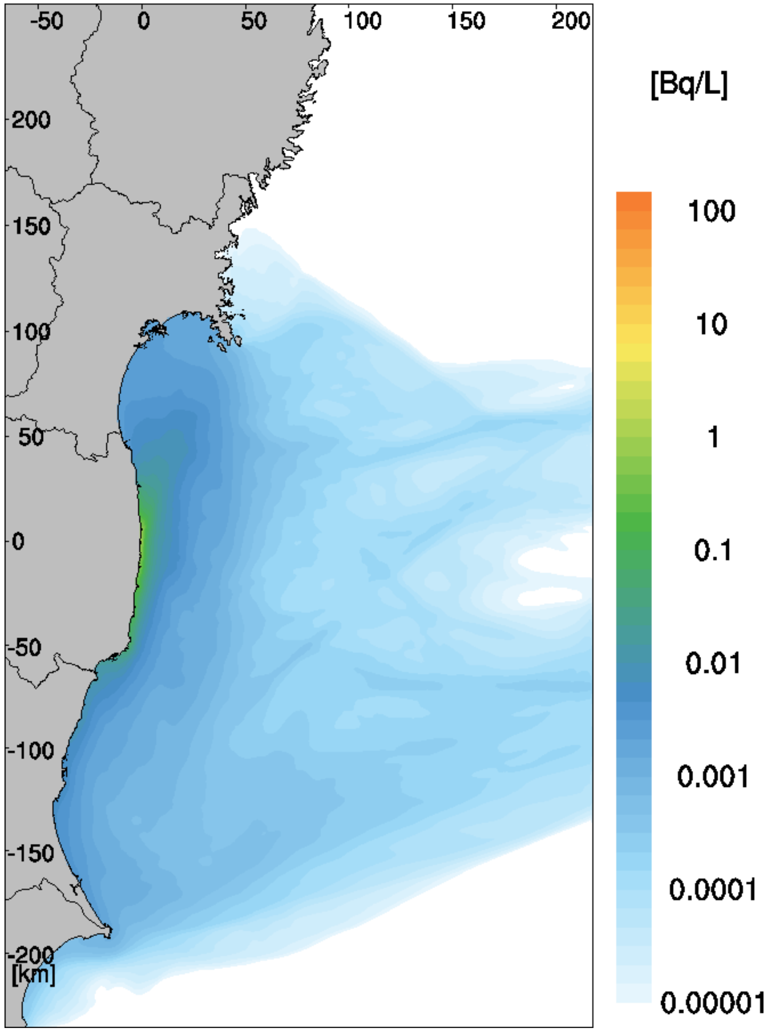
These are present results and may be updated according to future discussions and internal and external reviews.

- 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.

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

Other changes (effects outside the simulation's computational domain)

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

Updated

Other changes (review of evaluation of potential exposure)

- The evaluation regarding potential exposure was evaluated as reference before the revision, but in the discussions at the Review Meeting on the Implementation Plan Regarding the Handling of ALPS Treated Water of the Nuclear Regulatory Commission, we received opinions on the selection of scenarios considering facilities, use of realistic source terms, migration pathways, and comprehensiveness of exposure pathways, and revised the evaluation method as shown in the table below and included in the main text.
- Although the assessed value has increased because revising the selection of scenarios resulted in changes of the amount of outflow and exposure pathways, the result is still small compared to the 5 mSv standard at the time of the accident.

Evaluation Procedure	Report Before Revision	Current Report
Scenario selection	Pipe rupture causes 5,000 m3 of ALPS treated water to flow out in one day.	Case 1 : Spilled 500m^3 per day for 20 days due to pipe rupture Case 2 : Tank damage spills 3,000m^3 in one day
Source term	Te-127 only	Source term based on actual measurements
Migration, exposure pathways	External exposure from sea surface only	Same as normal exposure
Representative Person	Work in progress at 1 km from the outlet	Exposure at sandy beach assessment point during normal life, internal exposure also considered
Assessment Results	7.3E-05mSv	Case 1 7E-04 to 5E-03mSv Case 2 4E-02 to 2E-01mSv

Updated

Other changes (uncertainty considerations)

- The IAEA's GSG-10 requires that data variability and uncertainty be considered in the assessment of radiological effects.
- The pre-revision report discussed uncertainty as a reference at the end of the report.
- In this report, we attempted a detailed evaluation of more parameters and conditions based on the discussions in the Review Meeting on the Implementation Plan Regarding the Handling of ALPS Treated Water of the Nuclear Regulatory Commission, also using a parameter survey approach.
- The large uncertainties are likely to be from the radionuclide composition of the source term and the transfer coefficients such as enrichment factors for fish and shellfish, but the results of the exposure assessment are sufficiently small compared to the dose limit of 1 mSv/year and the dose constraint value of 0.05 mSv/year and therefore we do not believe that the conservatism of the assessment will be compromised.

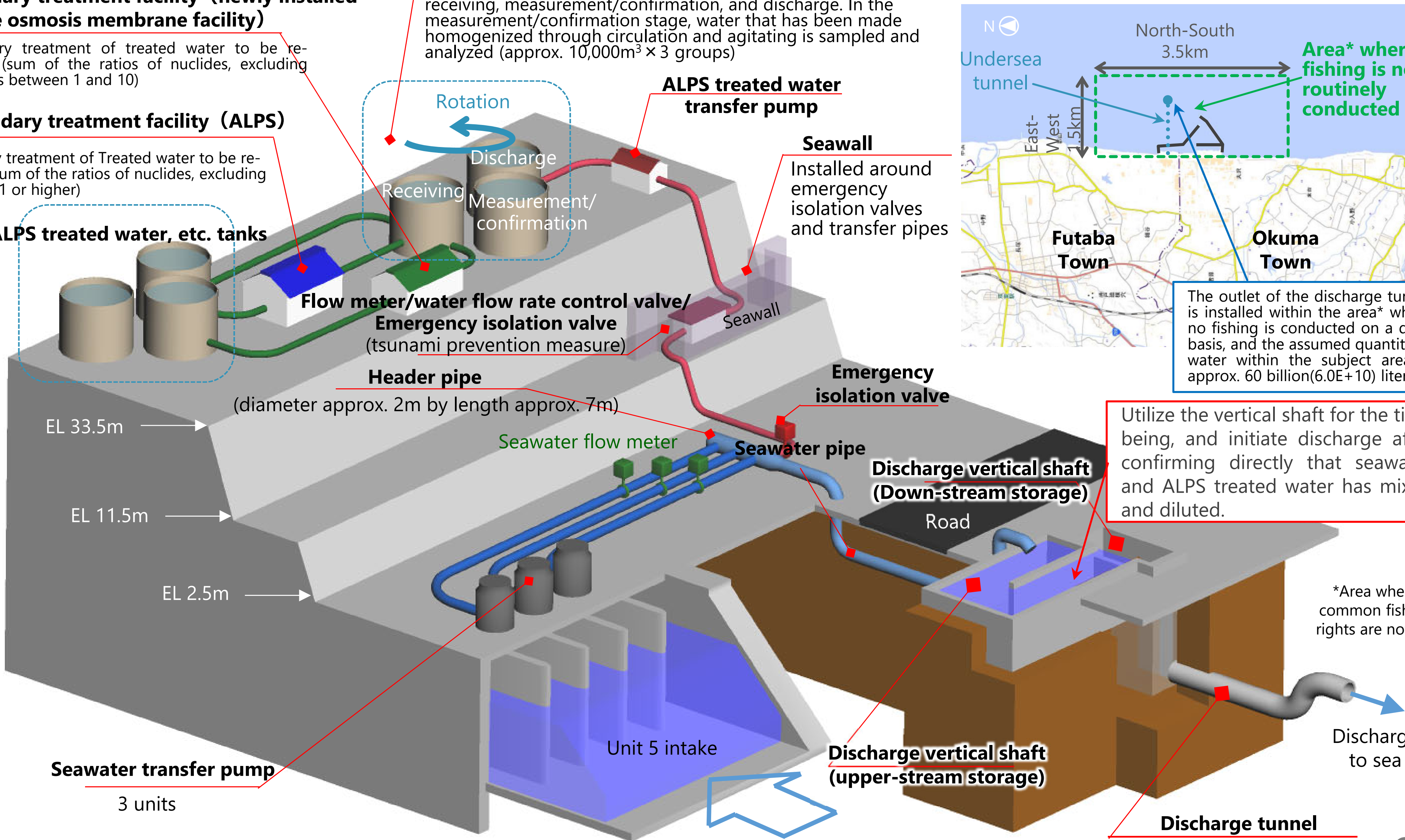
TEPCO

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

Updated

【Reference】Overview of facilities for securing safety

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.

*Area where common fishery rights are not set

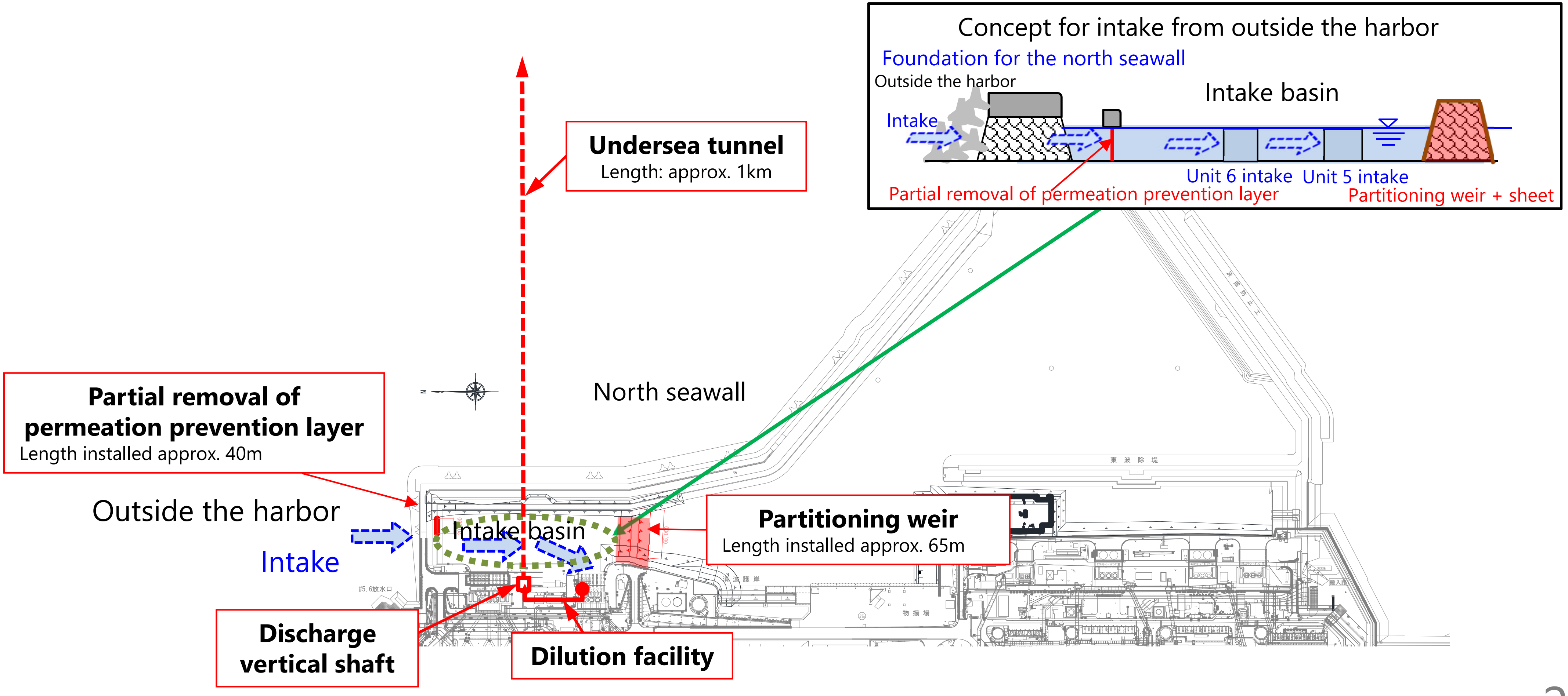
Utilize the vertical shaft for the time being, and initiate discharge after confirming directly that seawater and ALPS treated water has mixed and diluted.

Remain the original

TEPCO

【Reference】Harbor design

- 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).
- Details for the undersea tunnel shall be reviewed after conducting sea boring survey

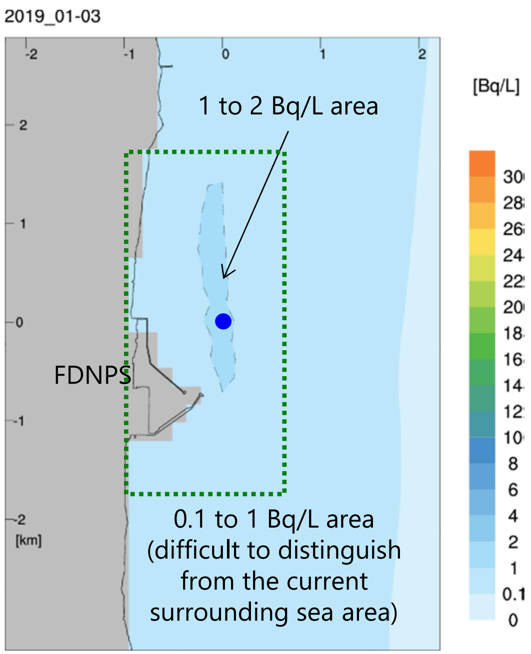


【Reference】Results of dispersion simulation at sea (average for each season)

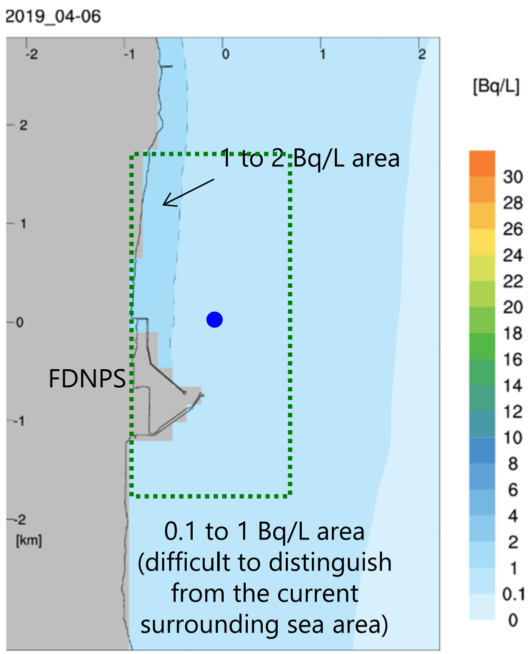
Remain the original (partly updated)

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.

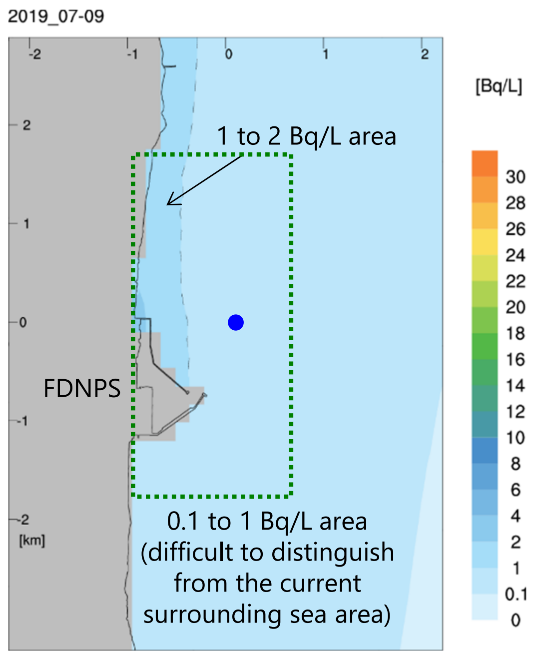
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10, 000 Bq/L)



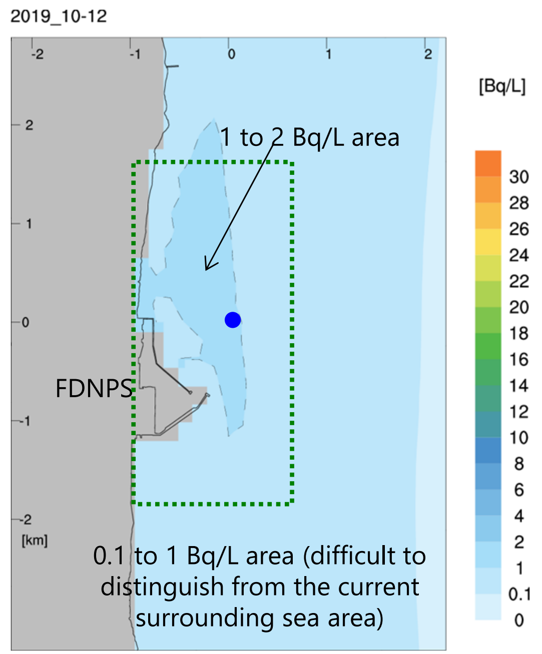
Average of January to March



Average of April to June



Average of July to September



Average of October to December

【Reference】Results of dispersion simulation at sea

Remain the original (partly updated)

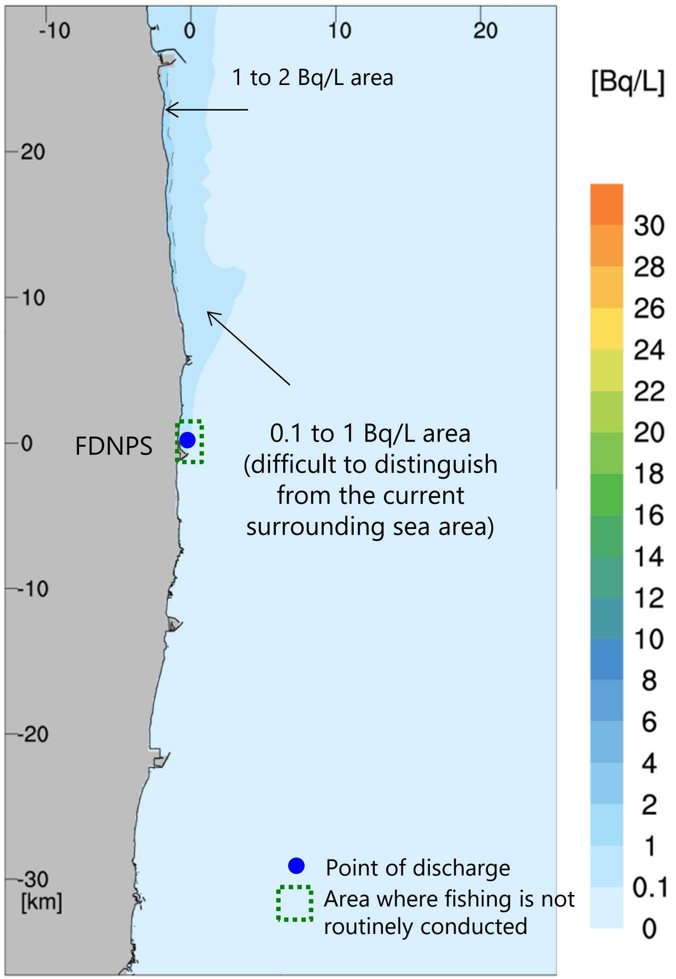
TEPCO

(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.

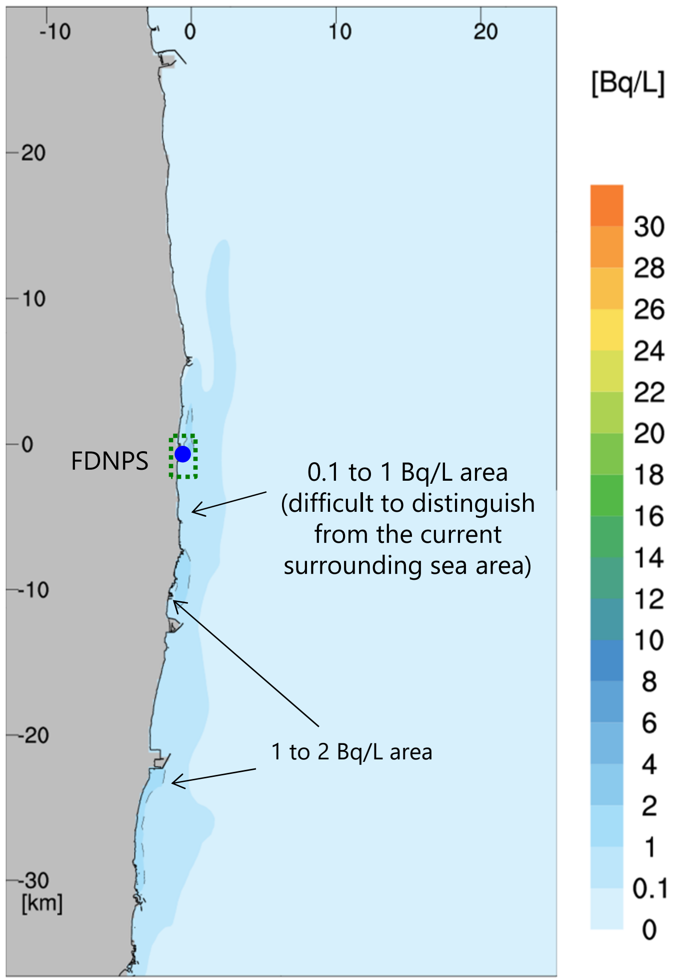
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

20190521



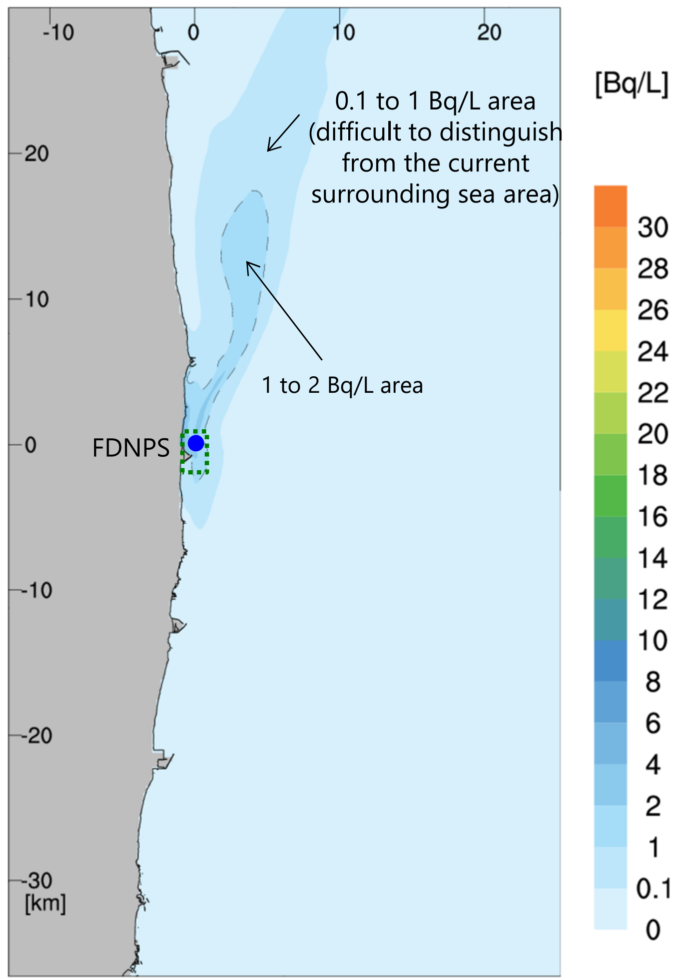
Area at its northernmost configuration
(Largest value in scale at 30Bq/L)

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

Remain the original (partly updated)

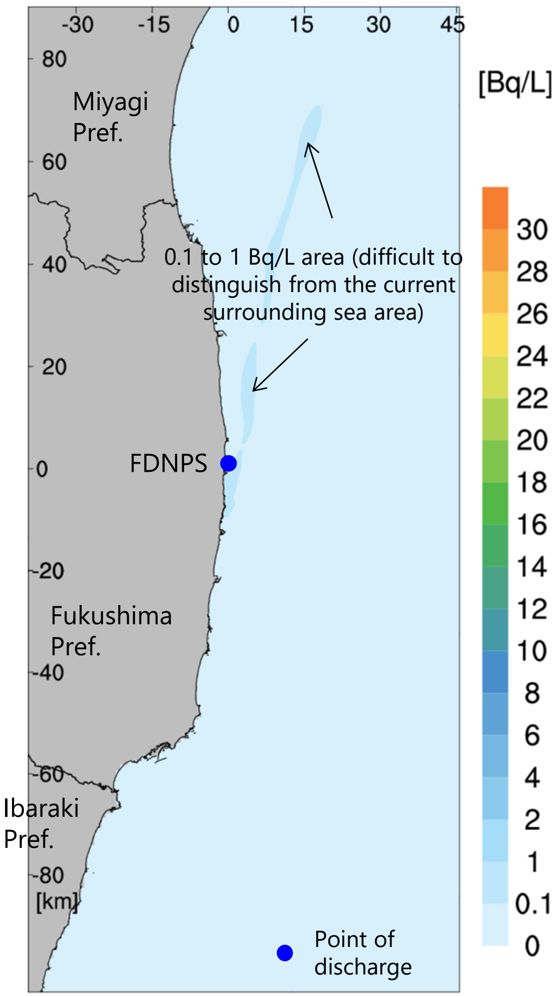
TEPCO

(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.

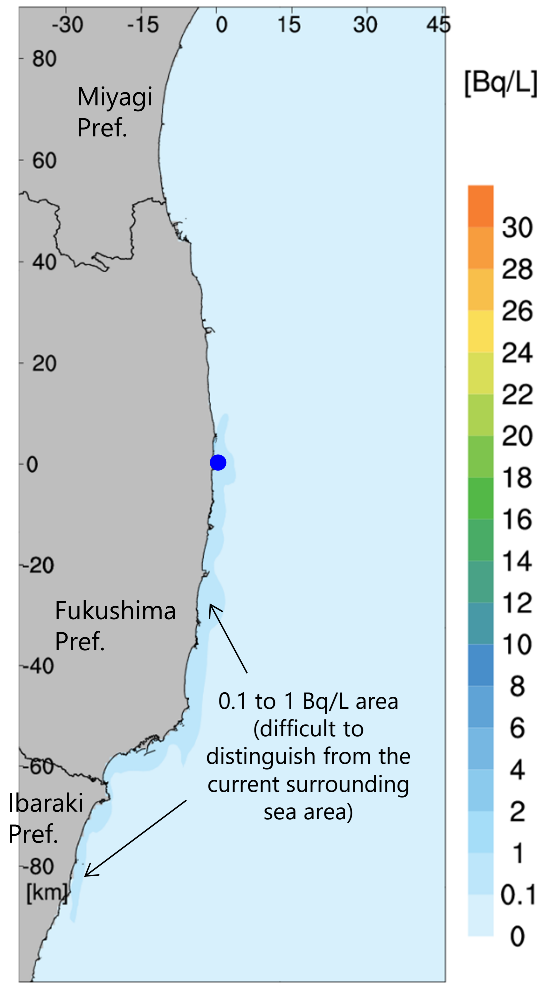
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

20190827



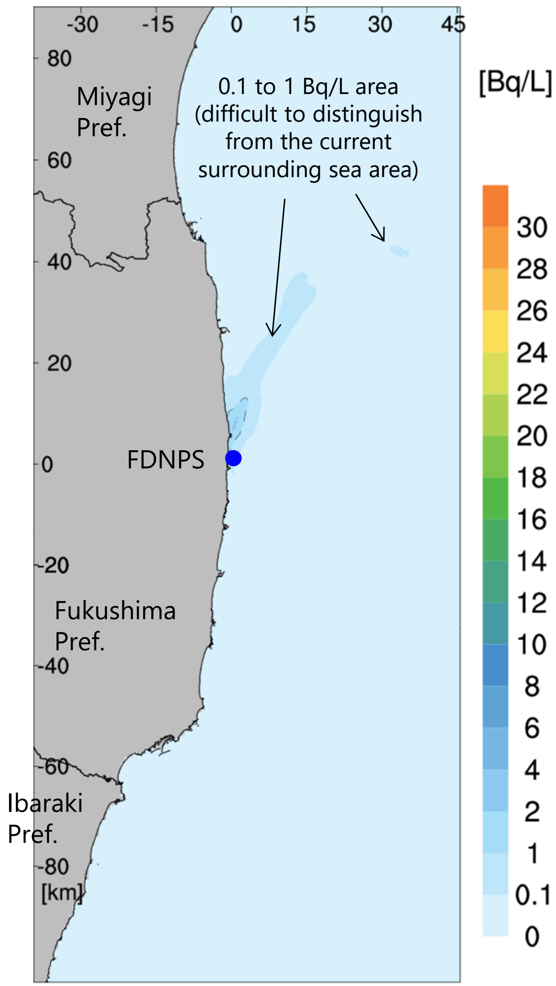
Area at its northernmost configuration (Largest value in scale at 30Bq/L)

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 (partly updated)

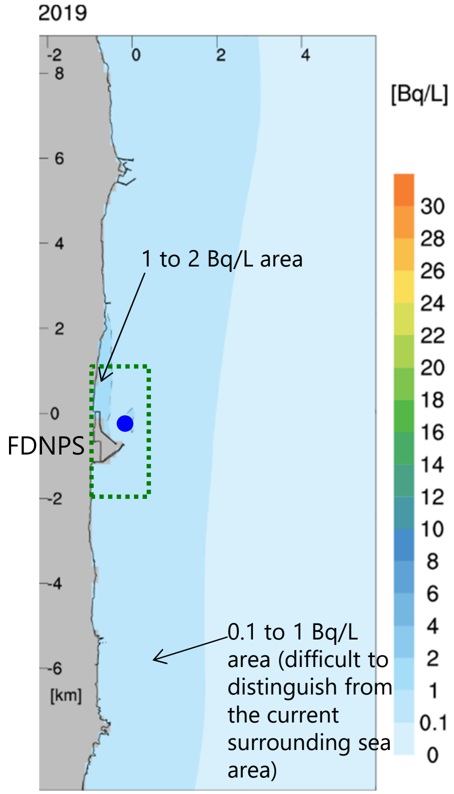
TEPCO

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.**

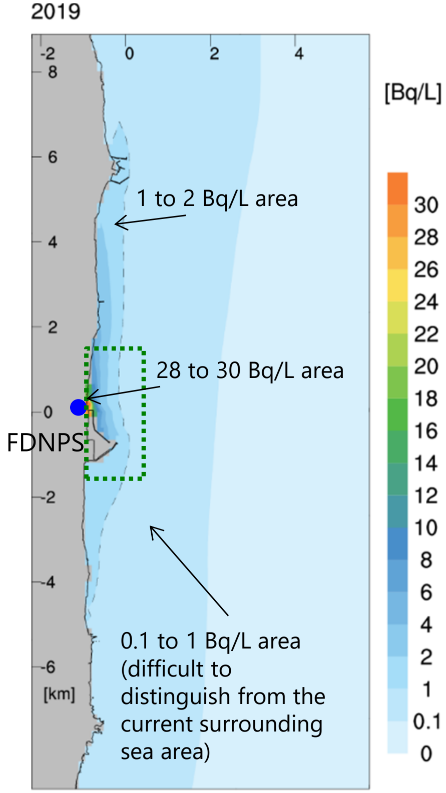
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

Expanded view of the area off the coast of Fukushima prefecture

Current plan



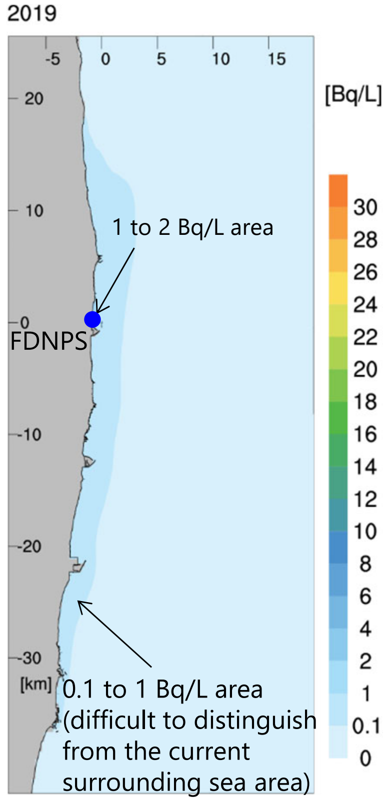
Coast line plan



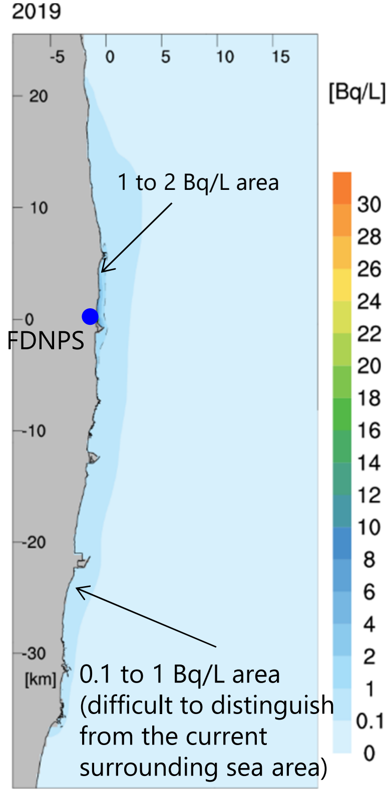
● Point of discharge Area where fishing is not routinely conducted

Wide area map

Current plan



Coast line plan



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

Updated

TEPCO

- 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]	190,000	820,000	270,000
Amount of ALPS treated water discharged annually [m^3/year]	120,000	27,000	81,000

- 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

【Reference】Detailed results of the radiological impact assessment on the public

Updated

TEPCO

Conditions	Nuclide composition in source term	Source terms based on actual values (Values for original report (pre-revision) in parentheses)					
		i .K4 tanks		ii. J1-C tank After secondary treatment		iii. J1-G tank After secondary treatment	
	Amount of seafood ingested	A: At the national average	B:More than the average	A: At the national average	B:More than the average	A: At the national average	B:More than the average
External exposure (mSv*/year)	Sea surface	6.5E-09 (6.5E-09)		1.7E-08 (1.7E-08)		4.7E-08 (4.7E-08)	
	Body of the ship	4.8E-09 (5.2E-09)		1.2E-08 (1.3E-08)		3.3E-08(3.4E-08)	
	When swimming	4.5E-09 (2.8E-10)		1.2E-08 (7.6E-10)		3.2E-08 (2.0E-09)	
	Beach sand	7.8E-06 (5.0E-07)		2.1E-05(1.3E-06)		5.6E-05(3.6E-06)	
	Fishing nets	1.6E-06 (1.6E-06)		4.3E-06 (4.3E-06)		1.2E-05 (1.2E-05)	
Internal exposure (mSv/year)	Drinking water	3.3E-07 (-)		3.1E-07 (-)		3.2E-07 (-)	
	Inhaling water sprays	9.3E-08 (-)		2.0E-07 (-)		4.0E-07 (-)	
	Ingesting seafood	1.5E-05 (1.5E-05)	6.1E-05 (6.1E-05)	2.8E-05 (2.8E-05)	1.1E-04 (1.1E-04)	7.9E-05 (7.9E-05)	3.0E-04 (3.0E-04)
Total（mSv/year)		**3E-05 (1.7E-05)**	**7E-05 (6.3E-05)**	**5E-05 (3.4E-05)**	**1E-04 (1.1E-04)**	**1E-04 (9.4E-05)**	**4E-04 (3.1E-04)**
Dose limit for the general public：1mSv/year Dose target for domestic nuclear power stations equivalent to the dose constraint: 0.05mSv/year							

*mSv： millisievert

【Reference】 Detailed results of the radiological impact assessment on plants and animals

Remain the original (partly updated)

TEPCO

Values for original report (pre-revision) in parentheses

Scenario		Source terms based on actual values		
		i. K4 tanks	ii. J1-C tanks	iii. J1-G tanks
Exposure (mGy*/day)	Flatfish	2E-05 (1.7E-05)	2E-05 (2.2E-05)	6E-05 (5.6E-05)
	Crab	2E-05 (1.7E-05)	2E-05 (2.2E-05)	6E-05 (5.5E-05)
	Brown seaweed	2E-05 (1.9E-05)	2E-05 (2.3E-05)	6E-05 (5.9E-05)
DCRL* Flatfish：1-10 mGy/day　Crab：10-100mGy/day　Brown seaweed：1-10mGy/day				

*mGy：milligray

*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.

Newly added

TEPCO

【Reference】Response to comments regarding the radiological impact assessment report

- At the time of the publication of this report in November 2021, TEPCO also sought the public's comments on the report to further enhance the report.
  - Public comment period: 30 days from November 18, 2021 0 AM JST to December 18, 2021 0 AM JST
  - Method: Comments to be submitted via a dedicated form on the TEPCO website
  - Languages: Japanese and English

- Total number of comments gathered: 414 (Including 14 duplicate posts from what seems to be a system malfunction)
  - 395 comments in Japanese and 19 comments in English

- Number of changes made in response to the comments gathered
  - Addition to the assessment/review of assessment (e.g., adding assessment conditions) : 9
  - Expanding on descriptions (e.g., adding details to the assessment conditions) : 32
  - Improvements in descriptions (e.g., correcting errors) : 5

➡ See the next slide for TEPCO's response to some representative comments

【Reference】 Major Reflections made to the radiological impact assessment report

Newly added

	Examples of changes
Adding and reviewing the assessment	■ Added exposure pathways (drinking water during swimming, inhalation of seawater sprays) ■ Revised potential exposure assessment methods ■ Considered the effects of organically bound tritium (OBT) ■ Considered the effects of radioactive materials already discharged into the environment ■ Considered the effects outside the model by the specific concentrations at model boundaries ■ Included a case study regarding seawater concentrations used in the assessment
Expanding on descriptions	■ Added chapters and reference materials on how the discharge method was selected ■ Added description of how nuclides accumulate in the environment ■ Added models and assessment conditions used in the simulation ■ Reflected progress made in NRA reviews and discussions after the report was published in November 2021 ■ Added information disclosed in other documents (insights into the discharge period, etc.) ■ Added the results of assessment of the impact of discharge on the environment other than radiation ■ Added information regarding monitoring
Improving descriptions	■ Rewrote difficult-to-understand passages ■ Improved the quality of the translation of the English version (to be disclosed at a later date) ■ Corrected errors