Document 1 for the 5th Review Meeting on the Implementation Plan Regarding the Handling of ALPS Treated Water

Installation of New ALPS Treated Water Dilution/Discharge Facilities and the Related Facility

20th January, 2022

TEPCO

Tokyo Electric Power Company Holdings, Inc.

The Japanese version shall prevail.

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Responses to major issues(*) concerning the content of the application for the Discharge Facilities of the ALPS treated water into the Sea

*Document 1-2 for (The 3rd) Review Meeting on the Implementation Plan Regarding the Handling of ALPS Treated Water

The Japanese version shall prevail.

Responses to major issues(*) concerning the content of the application for the Discharge Facilities of the ALPS treated water into the Sea

*Document 1-2 for (The 3rd) Review Meeting on the Implementation Plan Regarding the Handling of ALPS Treated Water

(2-1 Major issues to be reviewed based on the Nuclear Reactor Regulation Act)

(1) Discharge Facilities of the ALPS treated water into the Sea

(i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

To ensure that ALPS Treated Water will be discharged in a way that satisfies the requirement of the annual effective dose of 1 mSv or less at site boundaries, which has been designated as an item against which measures should be taken, explanations regarding the following points shall be provided: the mixing/dilution ratio with seawater that meets the tritium concentration limit, mixing/dilution method and monitoring, and their validity.

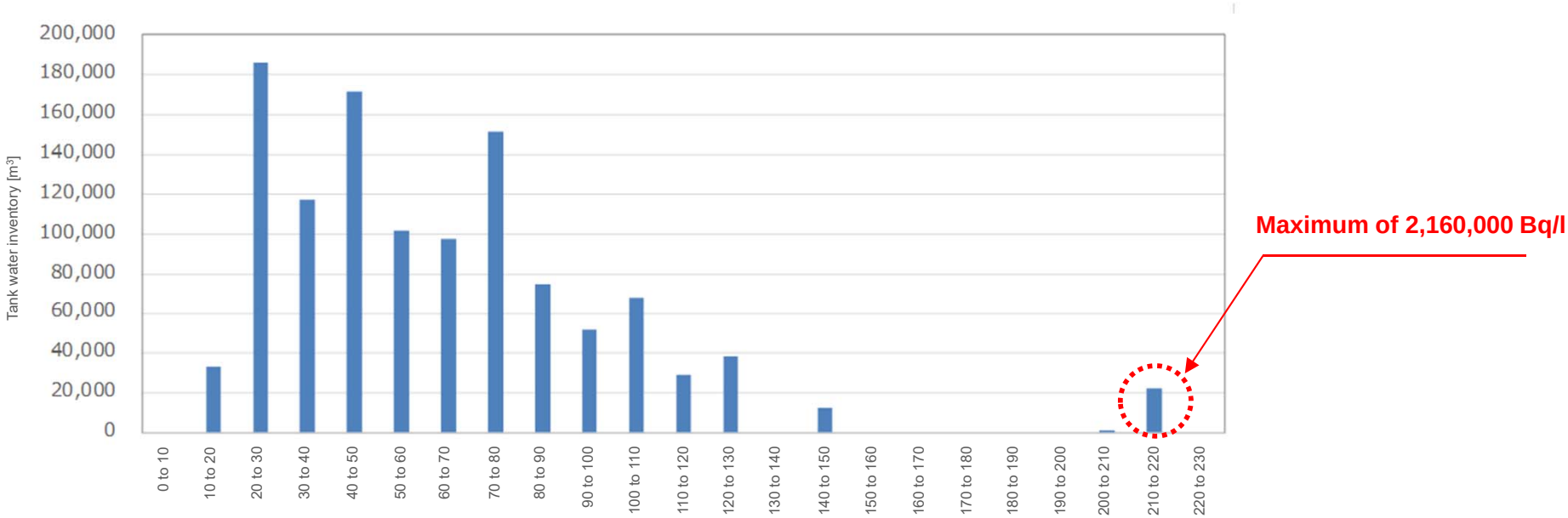
The Japanese version shall prevail.

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

(1) Mixing/dilution of the ALPS treated water with seawater

- At present, the tritium concentration in ALPS Treated Water stored on the premises of the Fukushima Daiichi NPS varies depending on the period stored in tanks (see the figure below). Since ALPS Treated Water in any tank contains tritium higher than the regulatory concentration limit of 60,000 Bq/l, the ALPS Treated Water requires the dilution with seawater before discharging into the sea.
- For this purpose, toward the ocean discharge of ALPS Treated Water, the capacities of each pump was set under the principle for designing each type of pumps, and summarized in the table below.

	Set value	Rationale
Flow rate of ALPS treated water	Up to 500 m^3/day	Set based on the maximum flow rate when 22 trillion Bq/l of tritium contained in ALPS Treated Water with low H-3 concentration (150,000 Bq/l) is released at a facility operating rate of 80%.
Flow rate of seawater transfer	170,000 m^3/day/unit	Assuming a risk case where highly concentrated ALPS treated water (2,160,000 Bq/l) is discharged at 150 m^3/day, a value equivalent to the amount of contaminated water generated per day and a seawater flow rate of approximately 220,000 m^3/day must be secured in order to dilute the contaminated water until the H-3 concentration drops to 1,500 Bq/l. Providing an allowance of 50% to the value, seawater of 330,000 m^3/day is needed. The capacity of each pump was set while assuming that three seawater transfer pumps will be installed to secure the required flow.



*Attenuation correction up to April 1, 2021, has been applied.

The Japanese version

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

[Supplement] Principle for designing ALPS Treated Water transfer pumps

- The tritium concentration in the ALPS treated water, etc., stored on the premises of the Fukushima Daiichi NPS ranges from about 150,000 to 2,160,000 Bq/l, averaging about 620,000 Bq/l (estimated value as of April 1, 2021).
- The amount of the ALPS treated water to be transferred is set based on the amount of Annual discharge of tritium, while taking into account the number of days of deischarge in consideration of facility maintenance and system switching, and the tritium concentration in ALPS Treated Water to be discharged.
- When the tritium concentration in ALPS Treated Water to be discharged is low, approximately 150,000 Bq/l, the flow rate of the ALPS treated water will be the maximum **approximately 500 m^3/day.**

Annual discharge of tritium
22 trillion Bq/year

Number of discharge days: 292 days
(Operating rate: 80%)

→ Daily amount of tritium discharged
75.3 billion Bq/day

↓

Tritium concentration in ALPS treated water, etc.
Approx. 150,000 to 2,160,000 Bq/l

→ 75.3 billion Bq/day ÷ 150,000 Bq/l
= approx. 500 m^3/day

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

[Supplement] Principle for designing seawater transfer pumps (1/4)

- In order to ensure flexibility in pump operation, while ensuring that the tritium concentration after dilution with seawater is less than 1,500 Bq/l and that the Annual discharge of tritium is below 22 trillion Bq, the following points must be considered:

(i) Pumps must be capable of flexibly responding to the discharge of the ALPS treated water with various tritium concentrations ranging from approximately 150,000 to 2,160,000 Bq/l.

(ii) The amount of the ALPS treated water to be discharged is up to approximately 500 m^3/day, but pumps must be capable of flexibly responding to increases in ALPS Treated Water due to heavy rains, etc., and to the progress of tank dismantling for the construction of facilities necessary for decommissioning.

(iii) Seawater transfer pumps must be capable of flexibly responding to operation and maintenance inspections.

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

[Supplement] Principle for designing seawater transfer pumps (2/4)

- From the view of described above (i) and (ii), assumed risd cases are as follows :
  - **Risk case 1: Discharge of highly concentrated ALPS treated water**
    This case assumes an inevitable and temporal discharge of the ALPS treated water with a tritium concentration of about 2,160,000 Bq/l at a rate of 150 m^3/day, a value equivalent to the amount of contaminated water generated per day (in order not to increase the total inventory).

    Seawater required to lower the tritium concentration after dilution to less than 1,500 Bq/l is: 2,160,000 Bq/l ÷ 1,500 Bq/l × 150 m^3/day = approx. 220,000 m^3/day.

  - **Risk case 2: Discharge of a large quantity of the ALPS treated water**
    Considering the fact that approximately 400 m^3 of contaminated water is generated per day during the rainy season (maximum data for 2020 actual), this case assumes an inevitable and temporal discharge of the ALPS treated water at an average of about 620,000 Bq/l at a rate of 400 m^3/day.

    Seawater, which needs to dilute the tritium concentration limit less than 1,500 Bq/l is approx. 170,000 m^3/day : 620,000 Bq/l ÷ 1,500 Bq/l × 400 m^3/day = approx. 170,000 m^3/day.

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

[Supplement] Principle for designing seawater transfer pumps (3/4)

- For the purpose of (i) and (ii):
  - **Risk case 3: Decline in operation rate**
    This case assumes a discharge of the ALPS treated water with an annual tritium discharge of 22 trillion Bq (220 billion Bq/day) when the number of discharge days is 100 days per year because the operation rate dropped due to a prolonged facility maintenance period and other reasons.

    When discharging treated water of 220 billion Bq/day, needed seawater to dilute by the tritium concentration less than 1,500 Bq/l is approx. 150,000 m^3/day : 220 billion Bq/day ÷ 1,500 Bq/l = approx. 150,000 m^3/day.

  - In consideration of various risk cases as described above, a seawater flow rate at least 220,000 m^3/day must be secured. Providing an allowance of 50%, **the design flow rate of seawater is set to approximately 330,000 m^3/day.**

The Japanese version shall prevail.

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

[Supplement] Principle for designing seawater transfer pumps (4/4)

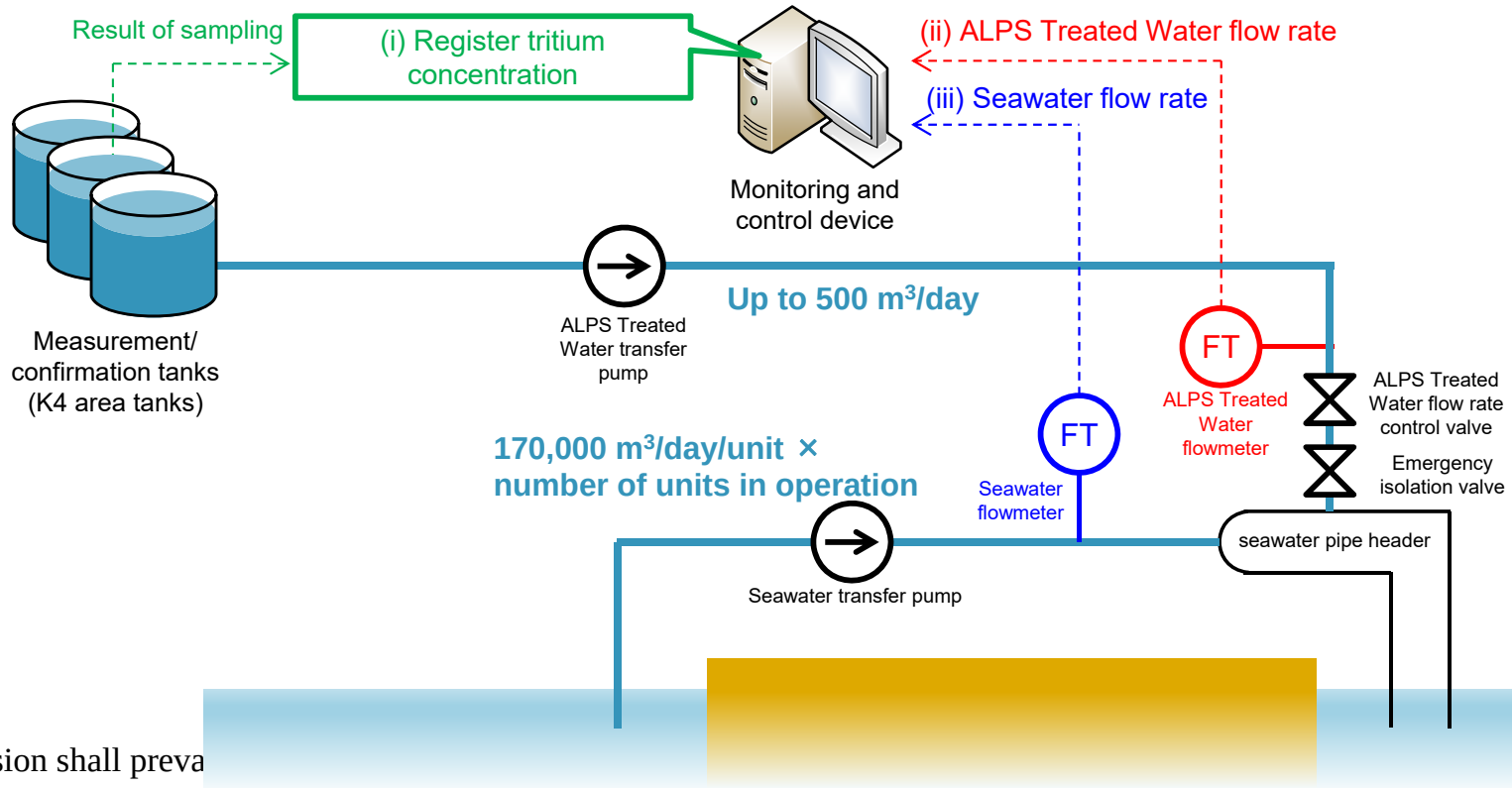
- For the purpose of (iii):
  - In view of maintenance such as inspections and cases when one of the pumps sops working, three pumps will be installed to ensure stable discharge; one is kept on standby while the other two pumps are in operation.
  - In short, to set **three seawater transfer pumps ensure stable discharge.**
- For the above reasons, pumps with a capacity of 170,000 m3/day each (approx. 330,000 m3/day ÷ 2 pumps) are required to secure the required flow rate.
  - In the case of the aforementioned risk cases (Cases 1 and 2), the requirement of less than 1,500 Bq/l can be secured even when only one pump is in operation.
  - In order to confirm that ALPS Treated Water has been diluted with seawater to less than 1,500 Bq/l, it is important to precisely measure the tritium concentration in the ALPS Treated Water before dilution, and the flow rates of the ALPS treated water and seawater. It has already been confirmed that there are flowmeters (orifice type) available for the measurement even when pumps of a capacity of 170,000 m^3/day/unit are selected.
  - Although two pumps are assumed to be operated under normal conditions when considering the design, all three can be put into operation when necessary.
- Even with an annual operation rate of 80%, annual tritium discharge of 22 trillion Bq, and operation of one pump, the tritium concentration after dilution with seawater is estimated to be about 440 Bq/l, which is well below 1,500 Bq/l.

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater
(2) Monitoring the mixing/dilution rate of the ALPS treated water with seawater

- Before discharging the ALPS Treated Water into the sea, the Treated Water is diluted with a large volume of seawater, therefore it is therefore impossible to measure the tritium concentration in a temporarily stored pool. As such, the tritium concentration after dilution with seawater evaluates based on the tritium concentration measured and confirmed by the measurement/confirmation facilities beforehand by determining the flow rate of ALPS Treated Water.
- The flow rates of the ALPS treated water and seawater are monitored to evaluate the tritium concentration after dilution with seawater.

Formula for the assessment of tritium concentration

$$\text{Tritium concentration after dilution with seawater} = \frac{\text{(i) Tritium concentration in ALPS Treated Water} \times \text{(ii) ALPS Treated Water flow rate}}{\text{(ii) ALPS Treated Water flow rate} + \text{(iii) seawater flow rate}}$$

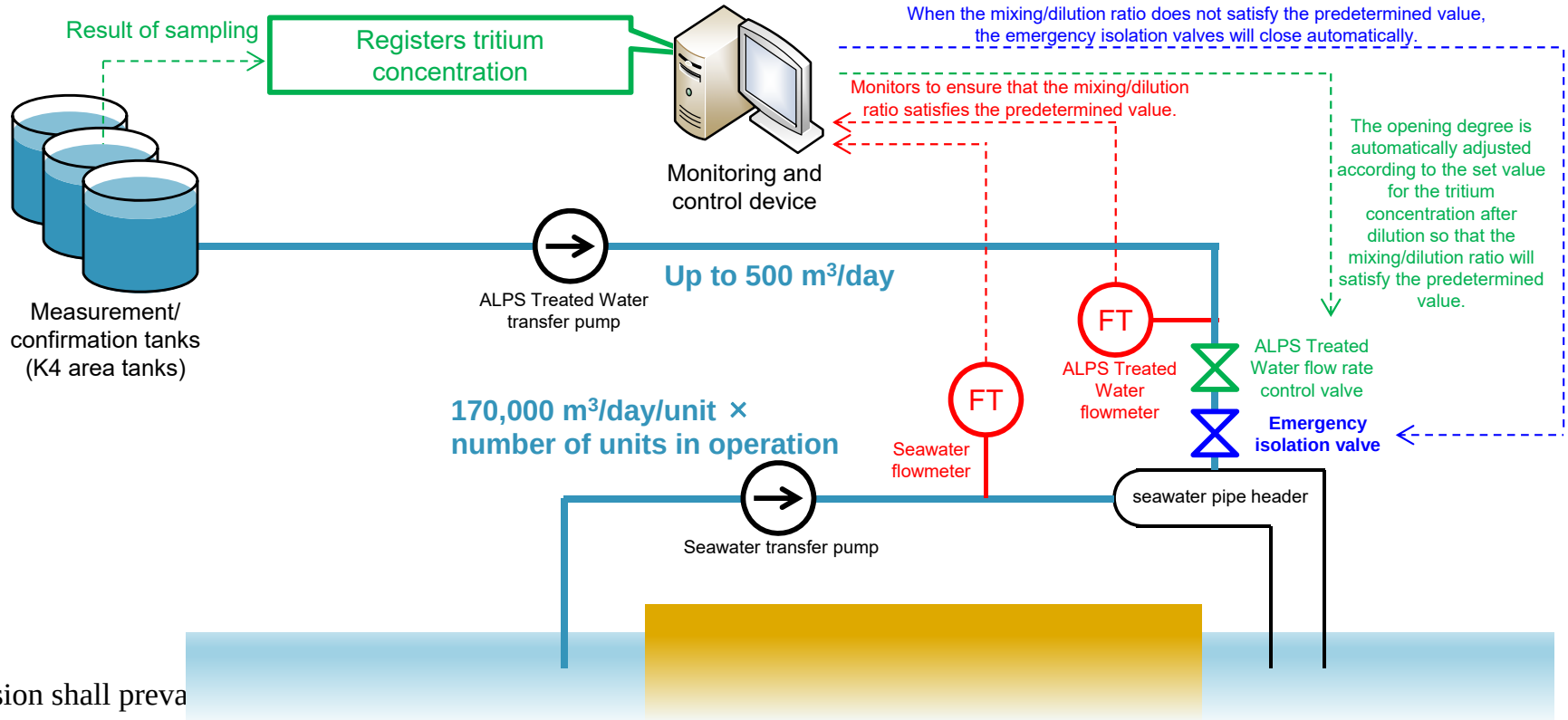


The Japanese version shall preva

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater
(3) Controlling the mixing/dilution rate of the ALPS treated water with seawater

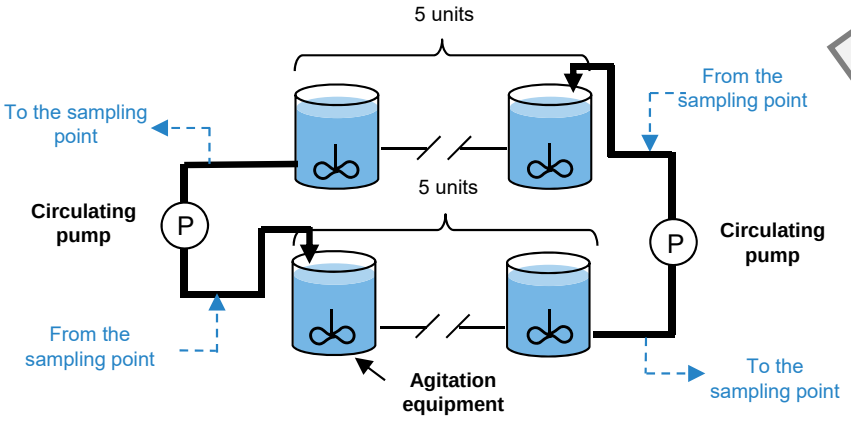
- Since the seawater transfer pumps are in rated operation, the flow rate of the ALPS treated water regulate the mixing/dilution ratio of the ALPS treated water with seawater.
- Specifically, in the process of the discharge operation, the tritium concentration in ALPS treated water, which was confirmed beforehand, is registered to the monitoring and control device, based on which and the set value for tritium concentration after dilution (less than 1,500 Bq/l[*1]), and the opening degree of the ALPS Treated Water flow rate control valve is adjusted so that the predetermined mixing/dilution ratio (100 times or more[*2]) may be achieved. When setting the tritium concentration after dilution, the accuracy of the instrument is taken into account.
- The flow rates of the ALPS treated water and seawater are constantly monitored by the monitoring and control device during the discharge operation, and when the mixing/dilution ratio does not satisfy the predetermined limit, the emergency isolation valves provided in the ALPS Treated Water transfer line are designed to be automatically closed by an interlock.

*1: The ratio to regulatory concentration limit for tritium is less than 0.025.
*2: The sum of ratio to regulatory concentration limits of nuclides, with the exception of tritium, is less than 0.01 (Although it is possible to achieve a dilution of 100 times or more with only one seawater transfer pump, two pumps are planned to be put into operation).



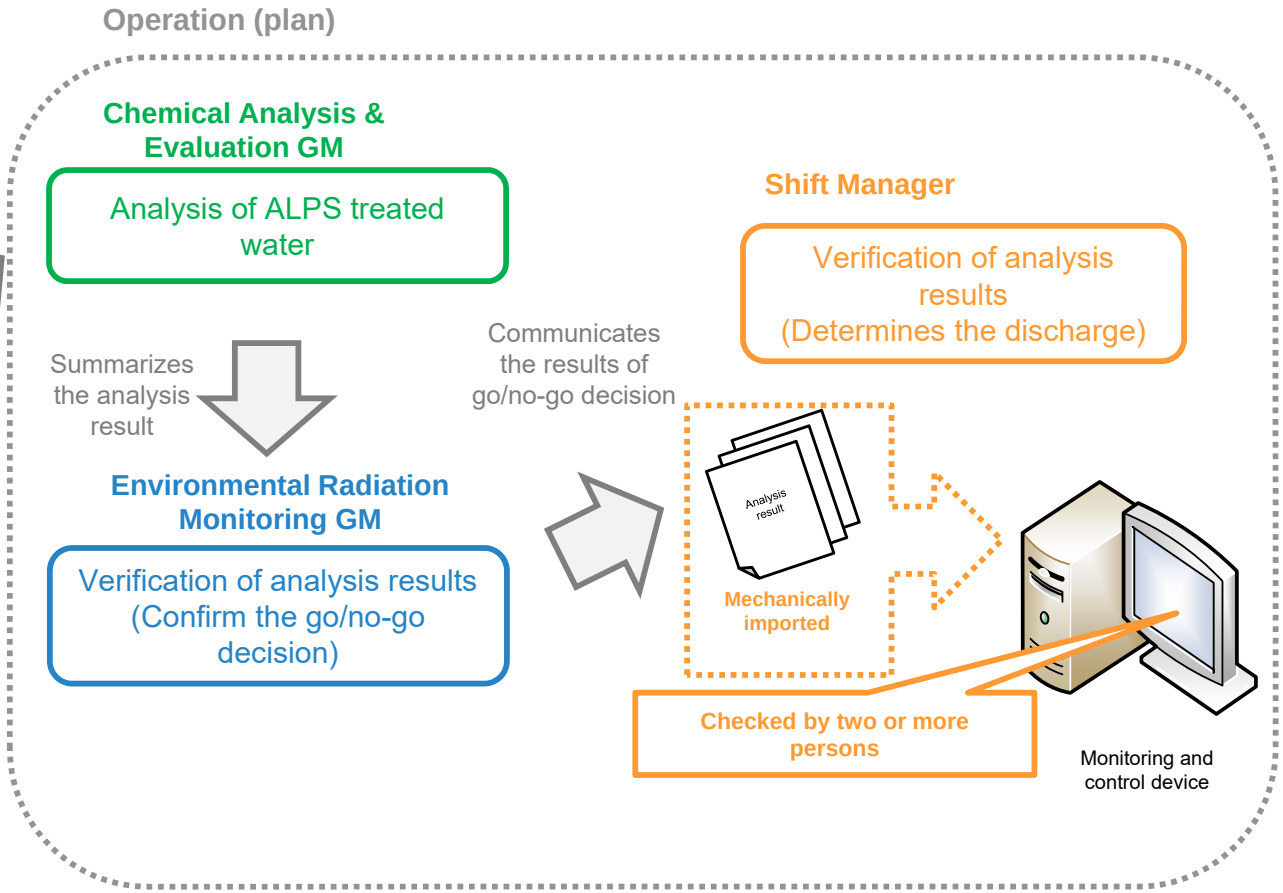
2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater
[Supplement] Registration of tritium concentration to the monitoring and control device

- In the process of the discharge operation, the results (tritium concentration) obtained through analyzing the ALPS Treated Water sampled by the measurement/confirmation facilities are registered to the monitoring and control device. In order to prevent human errors throughout this operation, a method of mechanically importing the tritium concentration into the monitoring and control device is planned to be adopted (See the figure below). The specific method will be examined.
- Since the above tritium concentration registration system uses an input support function, two or more persons will check if the values registered to the monitoring and control device are correct or not before discharging the water in the same way as they do when handling the subdrains and underground bypass.



After the quality of water in the tank group is homogenized by Agitation equipments and circulating pumps, sampling is performed.

Measurement/confirmation facilities



The Japanese version shall prevail.

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

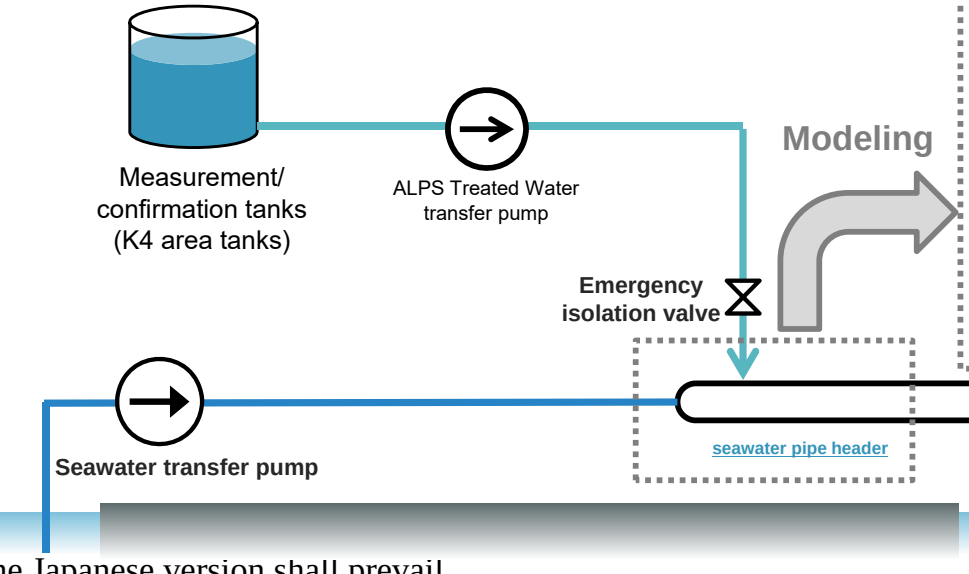
(4) How to mix and dilute ALPS Treated Water with seawater (1/4)

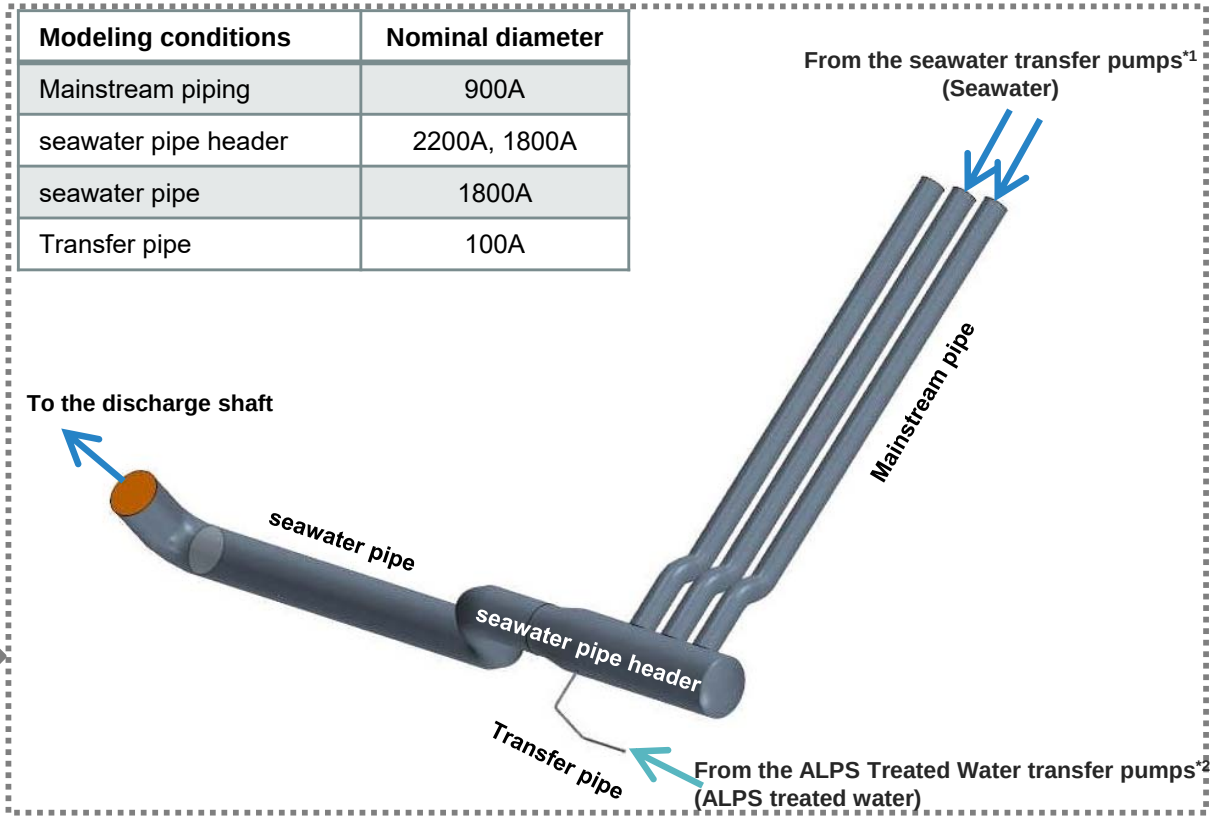
- To mix and dilute ALPS Treated Water with seawater, the treated water is injected into the seawater pipe header through which diluted seawater is running. The ALPS Treated Water injected into the seawater pipe header flows down through the seawater pipe and is mixed with surrounding seawater to reduce the concentration of radioactive materials.
- In order to check the dilution and mixing condition of the ALPS treated water in the seawater pipe, the effect of dilution was estimated by performing a simulation with the numerical values shown below.
- Upon completion of the facility installation, a verification test using a tracer for filtered water will be conducted.

Analysis code :STAR-CCM+(ver.11)

→ This tool is widely used in energy, automobile, and other industrial fields. TEPCO has also used it for thermal analysis and sloshing evaluation for the PCV pressure relief device of unit 7 at the Kashiwazaki-Kariwa NPS.

Modeling conditions	Nominal diameter
Mainstream piping	900A
seawater pipe header	2200A, 1800A
seawater pipe	1800A
Transfer pipe	100A





*1: Operated with two seawater pumps (170,000 m³/day/unit)
(The pipes marked with arrows are operated)
*2: Operated at the maximum flow rate of 500 m³/day

The Japanese version shall prevail.

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

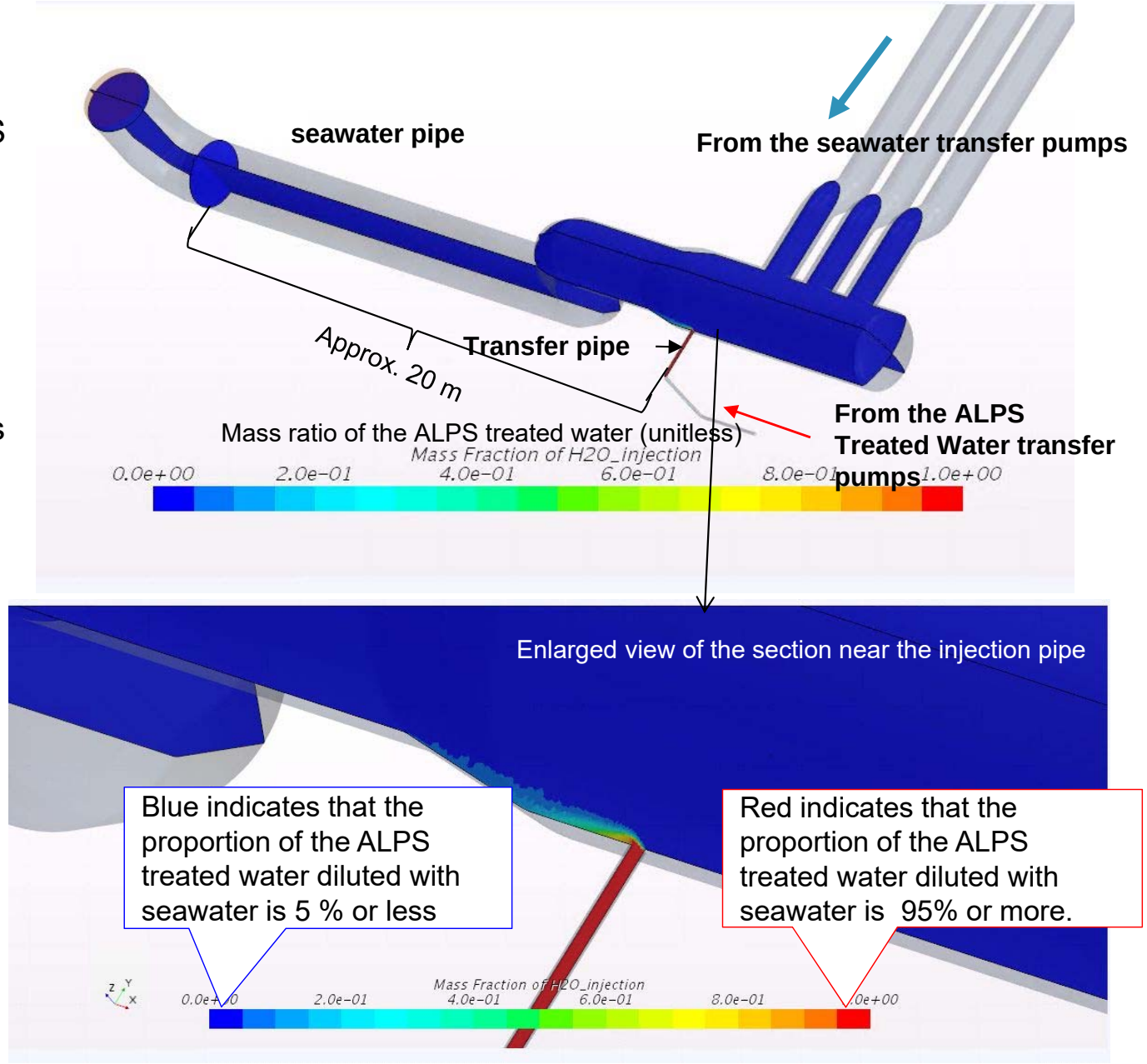
(4) How to mix and dilute the ALPS Treated Water with seawater (2/4)

Excerpt from document 1-1 for the 93rd Review Meeting on Monitoring and Evaluation of the Specified Nuclear Facility (the Title Changed + Some Sentences Revised)

Result of the dispersion and mixing analysis of the ALPS treated water in the seawater pipe when dilution is simulated with an ALPS Treated Water flow rate of 500 m^3/day and seawater flow rate of 340,000 m^3/day

Confirmed that the ALPS Treated Water was diluted to 5% or less (1/20 or less) in the vicinity of the Transfer pipe.

The figure on the right cannot show detailed dispersion behavior of the dilution rate of 5% or less. Therefore, the result expressed using the logarithmic scale is posted on the next slide.



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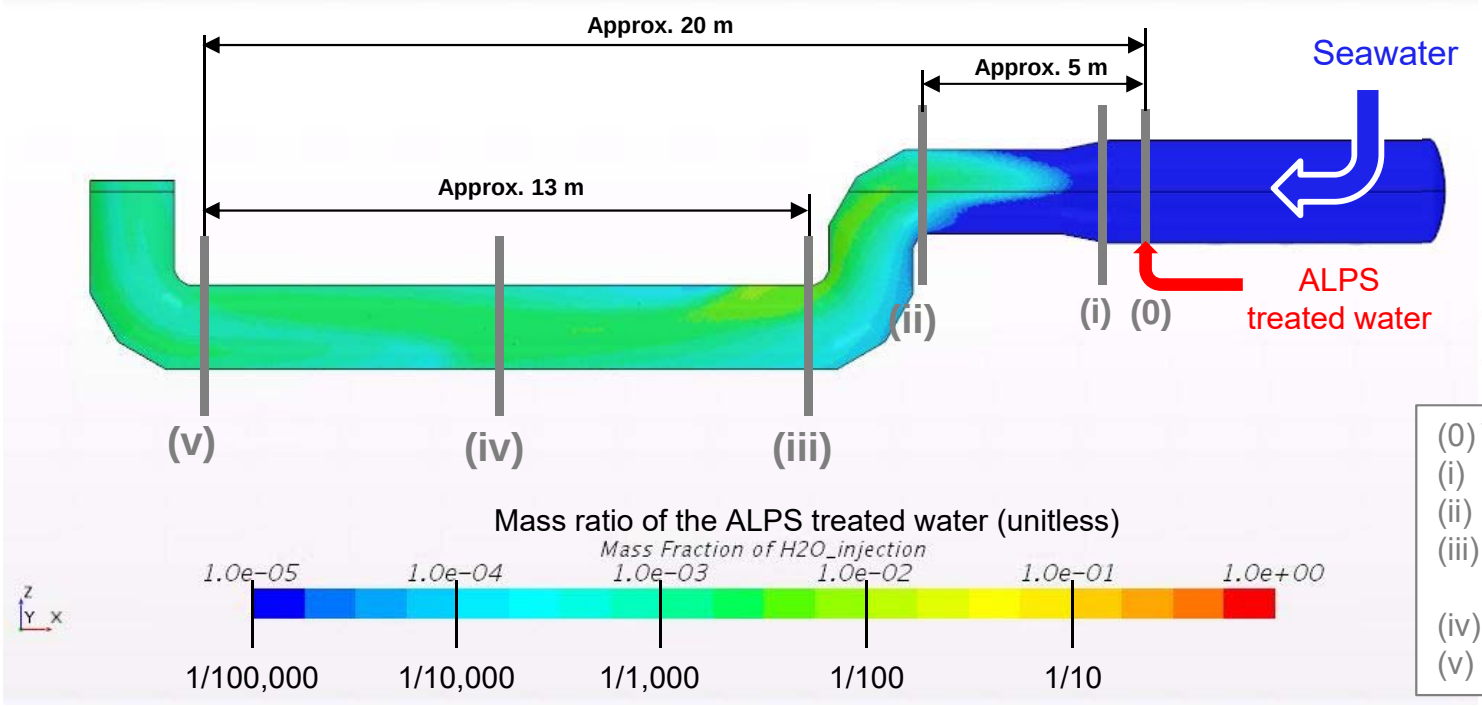
2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater

(4) How to mix and dilute ALPS Treated Water with seawater (3/4)

Excerpt from document 1-1 for the 93rd Review Meeting on Monitoring and Evaluation of the Specified Nuclear Facility (the Title Changed + Some Sentences Revised)



Reference:
Converting mass ratio to volume ratio

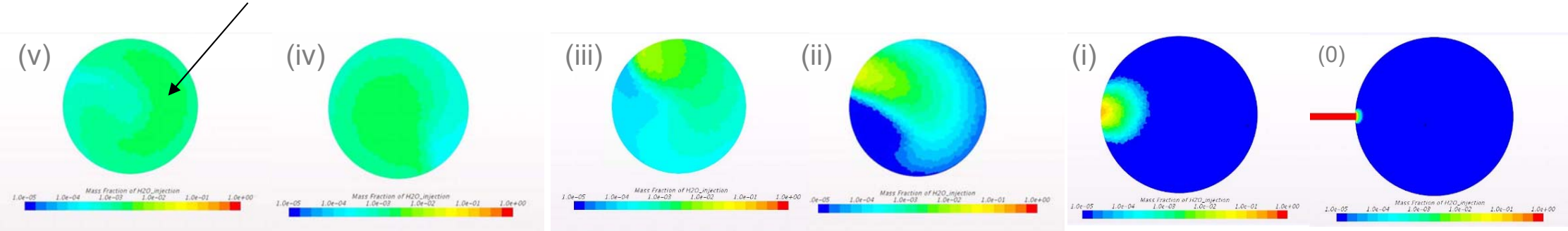
$$F = \frac{M}{(1-M)\frac{\rho_i}{\rho_R} + M}$$

F: *Volume ratio* $(-)$ ρ_i: *Density of ALPS treated water* $(998.3\ kg\ m/^3)$

F: *Mass ratio* $(-)$ ρ_R: *Density of seawater* $(1025 g/m^3)$

(0) Water injection point
(i) Mixing header outlet
(ii) Immediately before the down elbow
(iii) Immediately after the down elbow (inlet of straight piping)
(iv) Center of the straight pipe
(v) Outlet of the straight pipe (inlet of riser elbow)

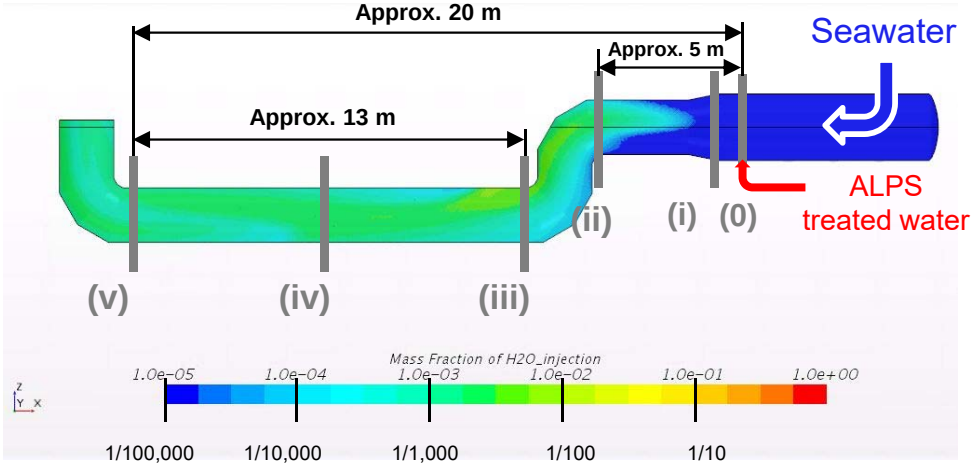
The mass ratio of the ALPS treated water is **up to 0.23% (approx. 1/430),** and diluted to an average of 0.14% (approx. 1/710).
When ALPS Treated Water of 150,000 Bq/l is discharged, the concentration becomes approximately 350 Bq/l at the maximum and approximately 220 Bq/l on average.
(The average concentration is almost equal to the calculated tritium concentration after dilution with seawater)



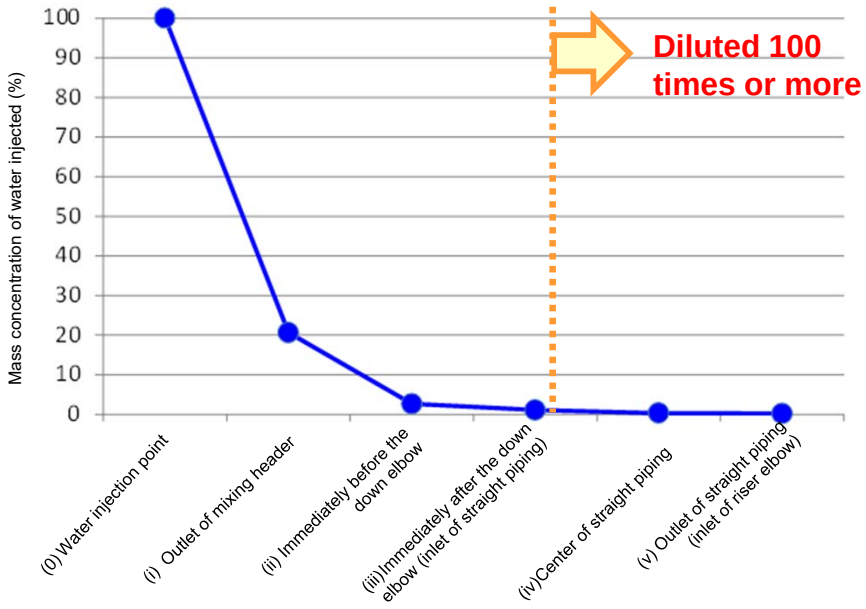
The Japanese version shall prevail.

2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater
(4) How to mix and dilute ALPS Treated Water with seawater (4/4)

- The figures below show the detailed result of the dilution and mixing condition of the ALPS treated water with seawater in seawater pipe.
- This result shows that a dilution effect of 100 times or more is achieved “(3) immediately after the down elbow (inlet of straight piping)”.

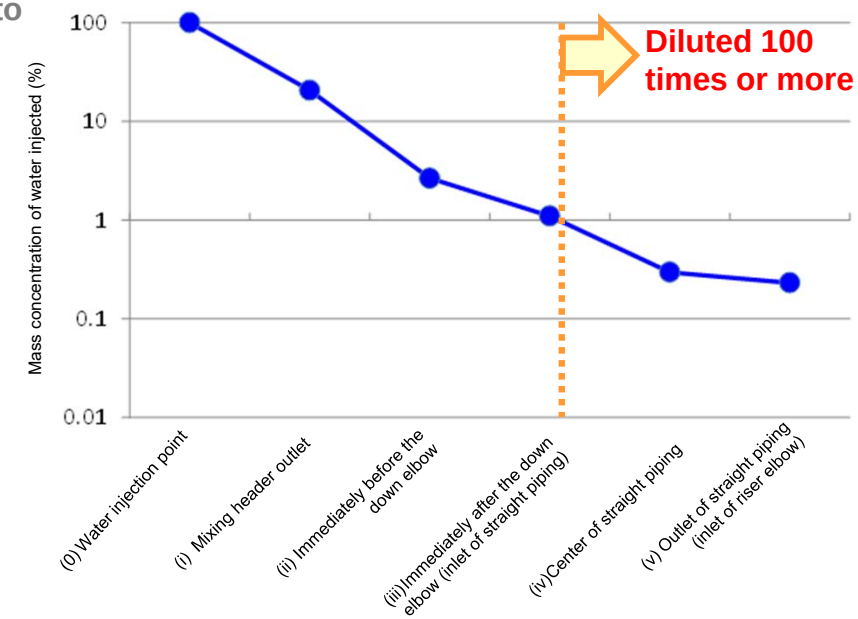


Mass ratio of the ALPS treated water (unitless)



Maximum mass concentration of the ALPS treated water at each section (Graph: Linear scale)

Converted to logarithmic expression



Maximum mass concentration of the ALPS treated water at each section (Graph: Logarithmic scale)

The Japanese version shall prevail.

Responses to major issues(*) concerning the content of the application for the Discharge Facilities of the ALPS treated water into the Sea

*Document 1-2 for (The 3rd) Review Meeting on the Implementation Plan Regarding the Handling of ALPS Treated Water

(2-1 Major issues to be reviewed based on the Nuclear Reactor Regulation Act)

(1) Discharge Facilities of the ALPS treated water into the Sea

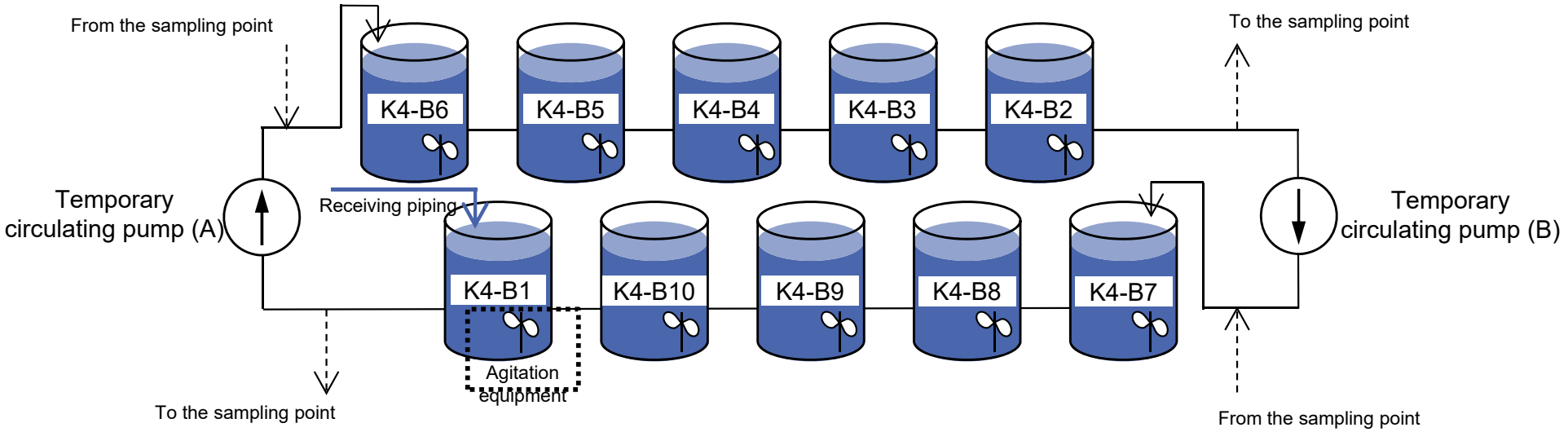
(ii) Homogenization of radioactive concentration in ALPS Treated Water in tanks before discharging into the sea

Explanations must be provided regarding the method for homogenizing the radioactive concentration in ALPS Treated Water in the K4 area tanks before discharging into the sea and the validity of the method.

2-1 (1) (ii) Homogenization of radioactive concentration in ALPS Treated Water in tanks before discharging into the sea

(1) Homogenization of radioactive concentration in ALPS Treated Water in tanks

- The ALPS Treated Water dilution/discharge facilities handles 10 tanks as one group in the discharge operation, and performs sampling to ensure that the ALPS Treated Water in the tanks satisfies the discharge standard before discharge.
- To homogenize radioactivity concentration in tanks in line with the Guidelines for the Measurement of Radioactive Materials to be Released from Light Water Nuclear Reactor Facilities, the measurement/confirmation facilities stir water in each tank with Agitation equipments and circulate water in all the tanks in a group with circulating pumps in order to collect representative samples.
- Circulation and agitation demonstration test will be performed in February 2022 (See the figure below), and the capability of these facilities, which can homogenize the concentration, at the review meetings to come.



Agitation demonstration test: Performed in November 2021
Circulation and agitation demonstration test: Scheduled in February 2022

The Japanese version shall prevail.

2-1 (1) (ii) Homogenization of radioactive concentration in ALPS Treated Water in tanks before discharge into the sea
(2) Circulation and agitation demonstration test plan

- As the agitating effect of a tank has been verified through the agitation demonstration test performed with one tank in November 2021, in the next place circulation and agitation demonstration test on connected 10 tanks is scheduled.
- According to the current plan, it takes two months to analyze the ALPS Treated Water before discharge. Therefore, the distribution of reagent concentration after stopping the circulation and agitation will also be checked to utilize the data in actual operation.

Date	February 7, 2022 - February 13, 2022		
Testing time	About 144 hours		
Tanks subject to the test	K4-Group B (10 units)		
Reagent*1	Tribasic sodium phosphate*2 (Injected through the manhole on the top plate of K4-B6 tank)		
Sampling	Before the test	During the test*3	After the test
Sampling point	Tanks from K4-B1 to B10 Middle (5 m)	2 points in the circulating line	Tanks from K4-B1 to B10 Upper (10 m)/Middle (5 m)/Lower (1.5 m)
Sampling volume	10 units of 1 liter samples	28 units of 1 liter samples	30 units of 6 liter samples
Subjects to be analyzed	Phosphate	Phosphate	Phosphate + tritium*4

*1: Since there is no difference in the density of tritium concentration in the measurement/confirmation tanks, a reagent that does not exist in the tanks is charged to check the concentration distribution.
*2: The volume of tribasic sodium phosphate to be charged is set to about one-hundredth of the drainage standard prescribed by the Fukushima prefectural ordinance (phosphorus content: “8 ppm/day on average”), having no environmental impact.
*3: Sampling is performed every six hours for 24 hours starting from the beginning of the testing, and then every 12 hours during the period from 24 to 144 hours after the start.
*4: The major 7 nuclides (Cs-134, Cs-137, Sr-90, I-129, Ru-106, Co-60, Sb-125) will also be measured for confirmation.

<Objectives to verify each analysis item>
Phosphate: Phosphate is checked as an evaluation parameter of the circulation and agitation demonstration test to see how long it takes for the system to make the water homogenized and to ensure that the homogenization can be achieved.
Tritium: Although it is not an evaluation parameter of the circulation and agitation demonstration test, tritium is checked to ensure that the homogenization can be achieved because the concentration of tritium differs from tank to tank.

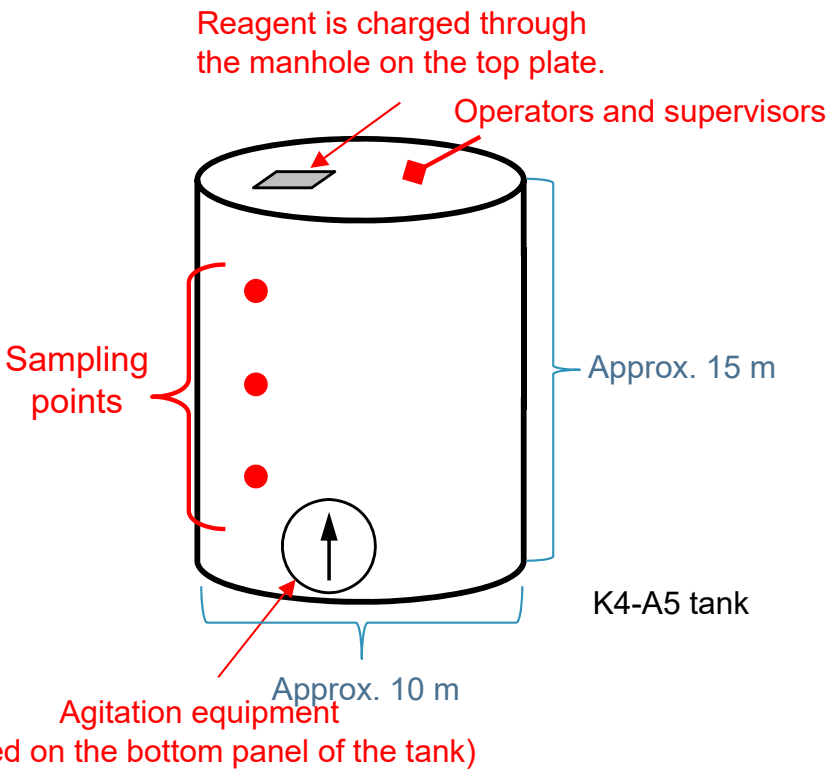
2-1 (1) (ii) Homogenization of radioactive concentration in ALPS Treated Water in tanks before discharging into the sea
[Supplement] Agitation demonstration test plan (1/2)

- In the agitation demonstration test to be conducted this time, agitators will be installed at the bottom of the tanks, and the operation of the agitators will be checked. In addition, the agitation effect will be evaluated by charging a reagent into the tanks.
- Circulation demonstration test to analyze 8 nuclides*1 and the same reagent is scheduled to be performed with K4-Group B tanks in February 2022.

*1: The major 7 nuclides (Cs-134, Cs-137, Sr-90, I-129, Ru-106, Co-60, Sb-125) and tritium

Date	23rd November, 2021
Test time	About 8 hours
Sampling	Every approx. 30 min/9 times including pre-test sampling
Sampling volume	1 liter from each of the three sampling points (upper (11.6 m), middle (7.6 m), and lower (2.6 m) parts of the tank)
Subjects to be analyzed	Reagent*2
Tanks subject to the test	K4-A5

*2: Since there is no difference in the density of tritium concentration in the measurement/ confirmation tanks, a reagent that does not exist in the tanks (tribasic sodium phosphate *3) is charged to check the concentration distribution.
*3: The volume of tribasic sodium phosphate to be charged is set to about one-hundredth of the drainage standard prescribed by the Fukushima prefectural ordinance (phosphorus content: “8 ppm/day on average”), having no environmental impact.



The Japanese version shall prevail.

2-1 (1) (ii) Homogenization of radioactive concentration in ALPS Treated Water in tanks before discharging into the sea
[Supplement] Agitation demonstration test plan (2/2)

[Agitation demonstration test]
Date of demonstration test: 23rd November, 2021
Test duration: 5 hours 25 minutes (agitation time: 4 hours)
Sampling: Every approx. 30 minutes
Sampling volume: 1 liter from each of the three sampling points (upper (11.6 m), middle (7.6 m), and lower (2.6 m) parts of the tank)
Subjects to be analyzed: phosphate* (Difference from theoretical average of 80 ppb was confirmed)
Tank to be analyzed: K4-A5

[Testing method]
8:00 Perform sampling (1st) before agitation testing
8:30 Charge tribasic sodium phosphate solution (about 2.6 L)
9:00 Activate an agitator
9:30 Deactivate the agitator (agitation time: 30 min)
9:30~ Perform sampling (2nd) after confirming that the water surface in the tank is stable

After that, sampling will be performed 9 times in total while activating and deactivating the agitator repeatedly (scheduled to finish at around 16:30).
After completion, the sample bottles (27 bottles in total) will be submitted to the units 5/6 hot laboratory.

* • Put the tracer (tribasic sodium phosphate*2) into the tank and check the concentration distribution.
• The volume of tribasic sodium phosphate to be charged is set to about one-hundredth of the drainage standard prescribed by the Fukushima prefectural ordinance, having no environmental impact.
• The concentration is measured by absorption photometry.

Agitation equipment

Water surface in the tank while the Agitation equipment is in operation (Picture shot at T/R)

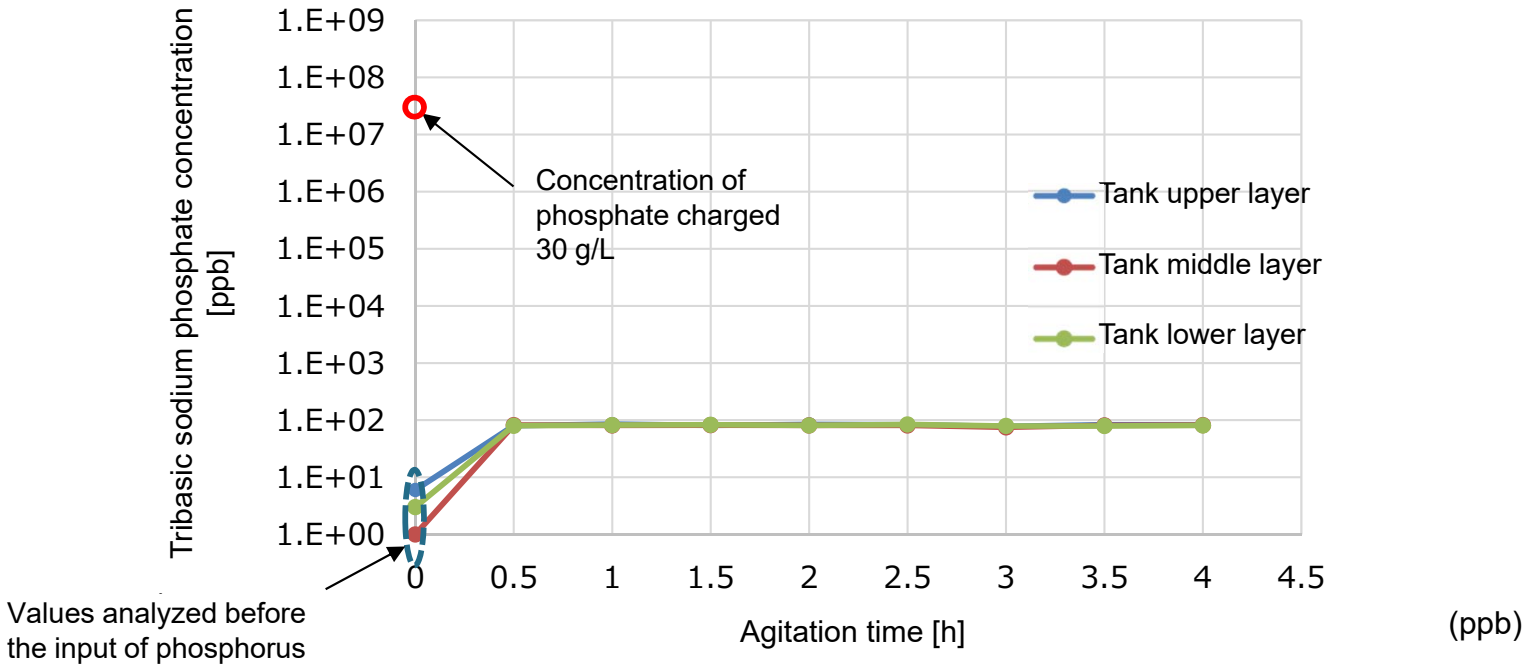
Water sampling on the day of the agitation demonstration test

The Japanese version shall prevail.

2-1 (1) (ii) Homogenization of radioactive concentration in ALPS Treated Water in tanks before discharging into the sea
[Supplement] Result of the agitation demonstration test

- The concentration of about 2.6 liters of tribasic sodium phosphate that was charged in the tank was about 30 g/l, and the theoretical concentration when diluted with about 970 m^3 of water contained in the tank is about 80 ppb.
- After agitation with the Agitation equipment for 30 minutes, the tribasic sodium phosphate concentration in the sample was stable at aro und 80 ppb, which shows that **the Agitation equipment has an agitation effect** (The standard deviation σ from the standard sample of 80 ppb is 3.0 ppb).

Analysis results of the agitation demonstration test
(23rd November)



(ppb)

	1st (0 h)	2nd (0.5 h)	3rd (1.0 h)	4th (1.5 h)	5th (2.0 h)	6th (2.5 h)	7th (3.0 h)	8th (3.5 h)	9th (4.0 h)
Upper layer	6	80	85	81	84	83	78	83	83
Middle layer	1	82	81	82	81	81	75	81	82
Lower layer	3	80	82	83	81	84	79	79	81

The Japanese version shall prevail.

Responses to major issues(*) concerning the content of the application for the Discharge Facilities of the ALPS treated water into the Sea

*Document 1-2 for (The 3rd) Review Meeting on the Implementation Plan Regarding the Handling of ALPS Treated Water

(2-1 Major issues to be reviewed based on the Nuclear Reactor Regulation Act)

(2) Safety measures at the time of discharge into the sea

(ii) Effective dose assessment at site boundaries due to the discharge of the ALPS treated water into the sea

2-1 (2) (ii) Effective dose assessment at site boundaries due to the discharge of the ALPS treated water into the sea

"11. Radiation protection around the site through suppressing discharge of radio active materials"

- Appropriate measures shall be taken to control radioactive materials released into the environment, such as the air and sea, from specified nuclear facilities in order to reduce doses around the site to as low as reasonably achievable.
- In particular, the effective dose at site boundaries due to rubble and contaminated water, etc., which were generated after the accident and have been stored in the specified nuclear facilities (including additional release of radioactive materials from the entire plant), shall be less than 1 mSv/year by March 2013.

■ Evaluation of doses due to radioactive liquid waste, etc. (Implementation Plan: III-3-2-2-3)

➢ Evaluation of doses at individual systems

- A measurement is performed before discharging ALPS treated water to ensure that the sum of ratios to regulatory concentration limit of radionuclides, with the exception of H-3, is less than 1. In addition, the treated water is diluted with seawater (100 times or more) before being discharged to reduce the H-3 concentration in it to less than 1,500 Bq/l, therefore the effective dose is calculated to be 0.035 mSv/year.

<Calculation method>

ALPS treated water will be diluted so that the H-3 concentration in it will be reduced to less than 1,500 Bq/l, and the ALPS treated water, which has been treated until the sum of ratios to regulatory concentration limit of radionuclides, with the exception of H-3, becomes less than 1, will be diluted with seawater 100 times or more.* Given these points, the effective dose is conservatively estimated as follows.

*: This system can dilute the treated water 430 times or more.
(From 2-1 (1) (i) Control and monitoring of mixing/dilution ratio of the ALPS treated water with seawater)

$$\frac{Concentration\ of\ H-3}{Legally\ required\ concentration\ for\ H-3} + \left(sum\ of\ ratios\ to\ regulatory\ concentration\ limit\ \right)_{,with\ the\ exception\ of\ H-3} \times \frac{1}{Dilution\ ratio\ with\ seawater}$$

$$= \frac{1500}{60000} + 1 \times \frac{1}{100} = 0.035$$

The Japanese version shall prevail.

2-1 (2) (ii) Effective dose assessment at site boundaries due to the discharge of the ALPS treated water into the sea

- As described above, the effective dose at the site boundaries due to the discharge of the ALPS treated water is calculated to be 0.035 mSv/year. Therefore, there is no change to the estimated effective dose due to the discharge of radioactive liquid waste, etc. (0.22 mSv/year[*1]).

*1: Maximum evaluated dose of the discharge of ALPS treated water, the groundwater bypass water, the rainwater in weirs, and the water treated by water treatment facilities including subdrain, etc.
→ The value adopted as the estimated dose due to the discharge of radioactive liquid waste was evaluated while assuming as follows: when drainage water is being discharged at the same concentration as the drainage standard, drainage water in which the sum of ratios to regulatory concentration limit is the largest being taken in for a year. Thus, it is assumed that this value can cover the estimated doses associated with other drainage water.

- With the current operation of facilities, the effective dose at site boundaries of the Fukushima Daiichi NPS is approximately 0.91 mSv/year, which is below 1 mSv/year.

Item	Effective dose at site boundaries
Release of gaseous waste	Approx. 0.03 mSv/month
Doses due to direct and skyshine rays from facilities on the premises	Approx. 0.58 mSv/year
Discharge of radioactive liquid waste, etc.	Approx. 0.22 mSv/year
Effective dose at site boundaries due to inhalation/intake of H-3 in the in-weir rainwater that has been treated and sprinkled on site	Approx. 3.3×10^{-2} mSv/year
Effective dose caused by γ-rays from radioactive materials deposited on the surface of the stagnant water at units 5 and 6 that has been treated and sprinkled on site	Approx. 4.2×10^{-2} mSv/year
Total	Approx. 0.91 mSv/year[*2]

*2: As the values herein are rounded, the total may differ from the sum of the values.

(Implementation Plan III-3-2-2-4-1)

The Japanese version shall prevail.

Responses to the major issues(*) concerning the content of the application for the facilities for the discharge of the ALPS treated water into the sea

*Document 1-2 for (The 3rd) Review Meeting on the Implementation Plan Regarding the Handling of ALPS Treated Water

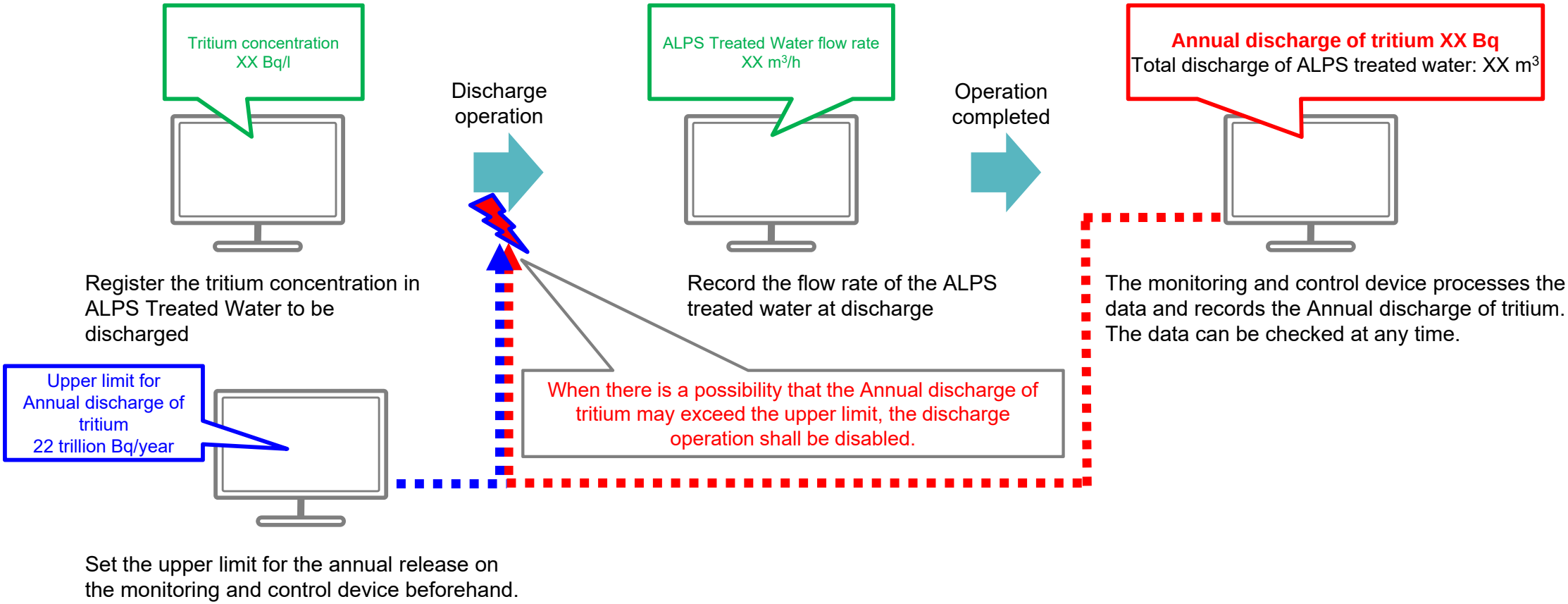
(2-2 Major items to be confirmed regarding activities in line with government policy)

(1) Annual discharge of tritium

Explanations shall be provided regarding how to control and ensure that the Annual discharge of tritium in ALPS Treated Water does not exceed the operational limit for discharge of 22 trillion Bq.

2-2(1) Annual discharge of tritium

- In the ALPS Treated Water dilution/discharge facilities, the tritium concentration in ALPS Treated Water to be discharged is registered to the monitoring and control device each time before discharge, and the monitoring and control device monitors the flow rate of the ALPS treated water at discharge, counting and recording the total flow rate.
- As for annual tritium discharge, the monitoring and control device sums up the results obtained by multiplying the tritium concentration registered each time of discharge and the integrated flow rate, and the data can be checked at any time.
- This device can also set the upper limit of the Annual discharge of tritium, and is equipped with an interlock system that does not allow the system to shift to the discharge operation when there is a possibility of exceeding the limit. In this way, the system is controlled so as not to exceed the operational limit for discharge per year (22 trillion Bq).



The Japanese version shall prevail.

The following slides are for reference.

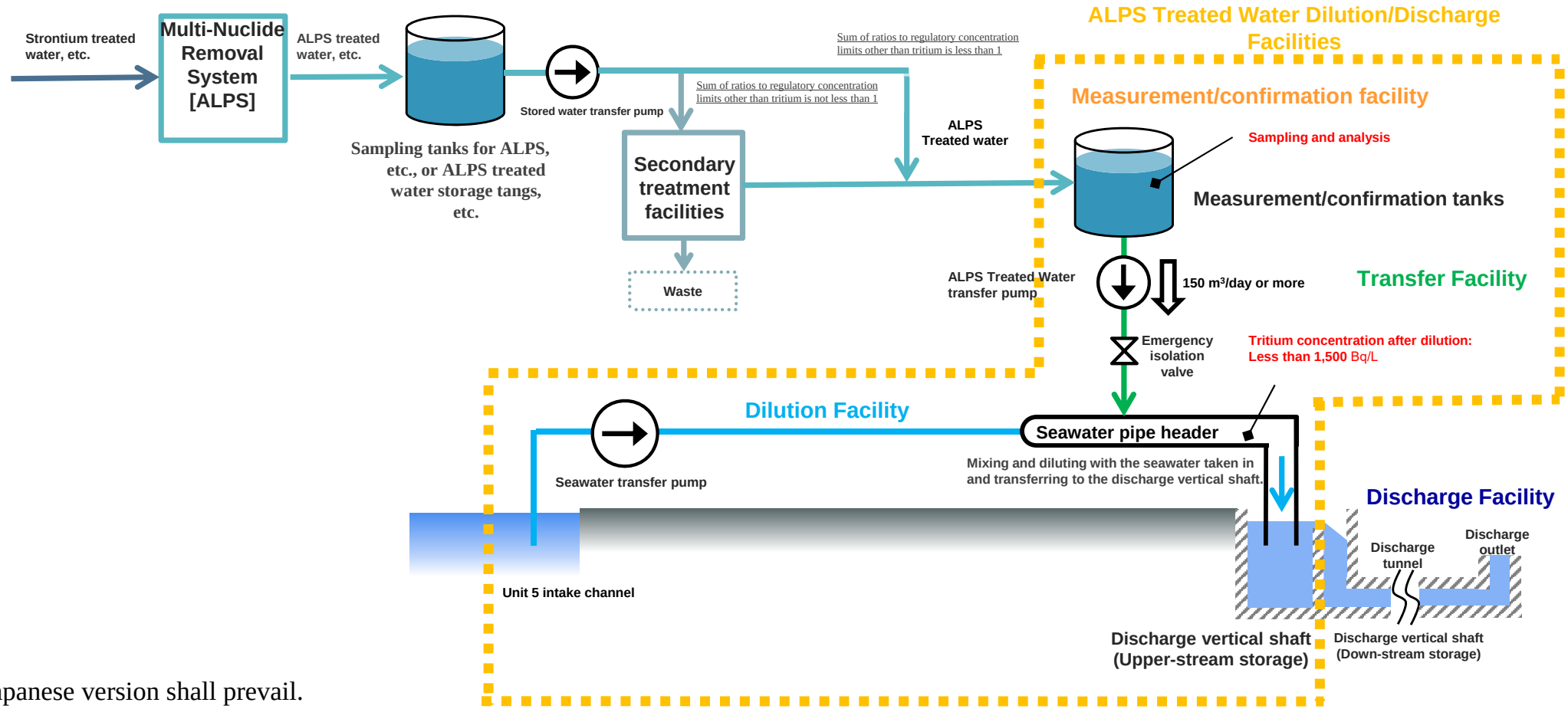
[Reference] Overview of the ALPS Treated Water Dilution/Discharge Facilities

Objective

The facilities ensure that the water treated by Multi-Nuclide Removal System (ALPS) until the radionuclide concentration becomes sufficiently low is the ALPS Treated Water (that is the water in which sum of the ratios to regulatory concentration limits other than tritium is less than 1), and dilute the treated water with seawater, then discharge it into the sea.

Facilities Overview

The Measurement/Confirmation Facility homogenizes the concentration of radionuclides all tanks of the tank group in the status of measurement/ confirmation, and then collects and analyzes samples to ensure that the water is ALPS treated water. Thereafter, the Transfer Facility sends the ALPS Treated Water to the seawater pipe header, and then the Dilution Facility dilutes the water with seawater taken in by the seawater transfer pump at the unit 5 intake channel until tritium concentration in it becomes less than 1,500 Bq/L, and discharge the water to the Discharge Facility.



The Japanese version shall prevail.

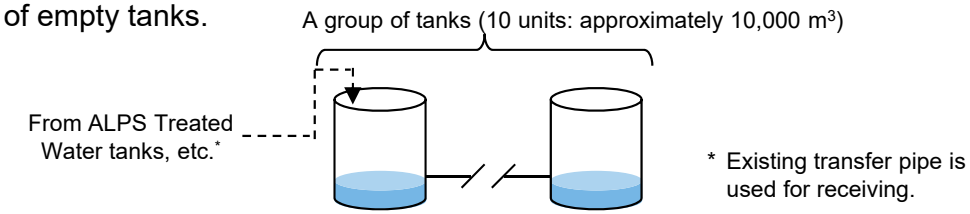
[Reference] Overview of the ALPS Treated Water Dilution/Discharge Facilities (Measurement/confirmation facility)

Measurement/confirmation facility

- K4 area tanks (approx. 30 000 m^3 in total) are reused for the measurement/confirmation tanks, and each group from A to C consists of 10 tanks (approximately 1,000 m^3 per unit).
- Each tank group takes the following steps (1) to (3) in rotation, and in the (2) measurement/confirmation process, water is circulated and stirred to become homogenized, and then sampled for analysis.

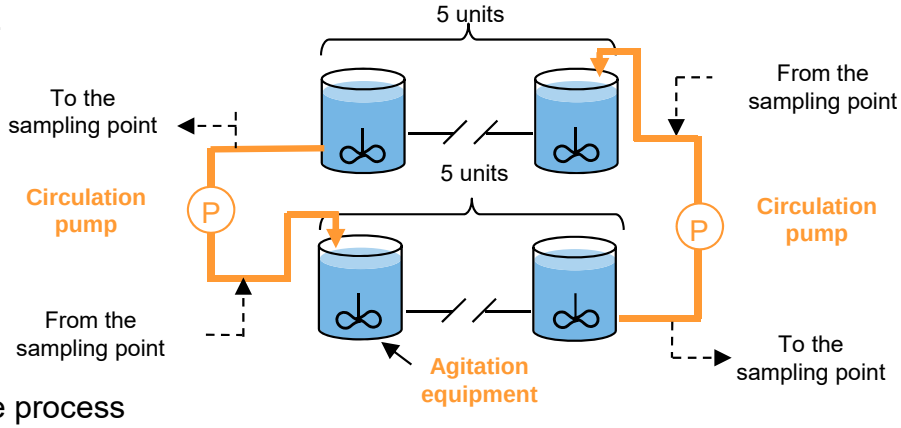
(1) Receiving process

ALPS Treated Water from ALPS Treated Water storage tanks, etc., is transferred into a group of empty tanks.



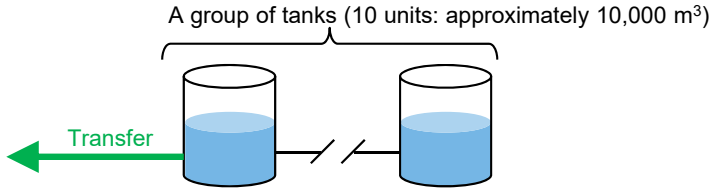
(2) Measurement/confirmation process

After the quality of water in the tank group is homogenized by the agitation equipment and circulation pumps, the water is sampled to check if it meets the discharge standard.

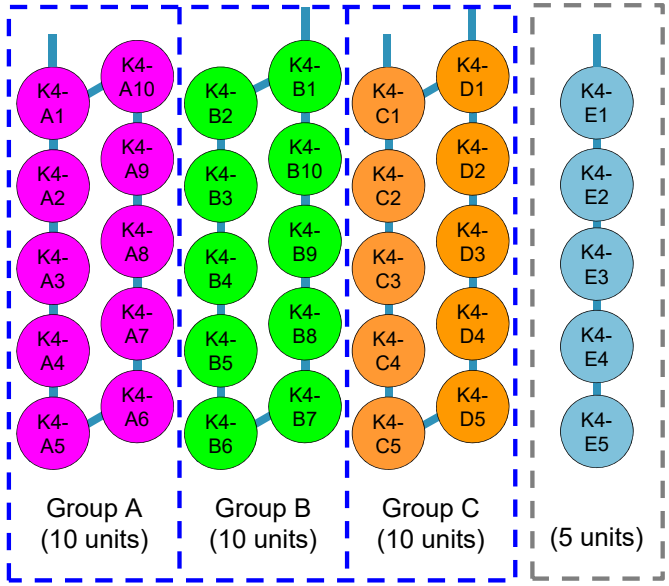


(3) Discharge process

After confirming that the ALPS Treated Water satisfies the discharge standard, the water is transferred to the Dilution Facility by the Transfer Facility.



K4 area tank groups: (35 units)



Chapter 2.50 ALPS Treated Water Dilution/Discharge Facilities

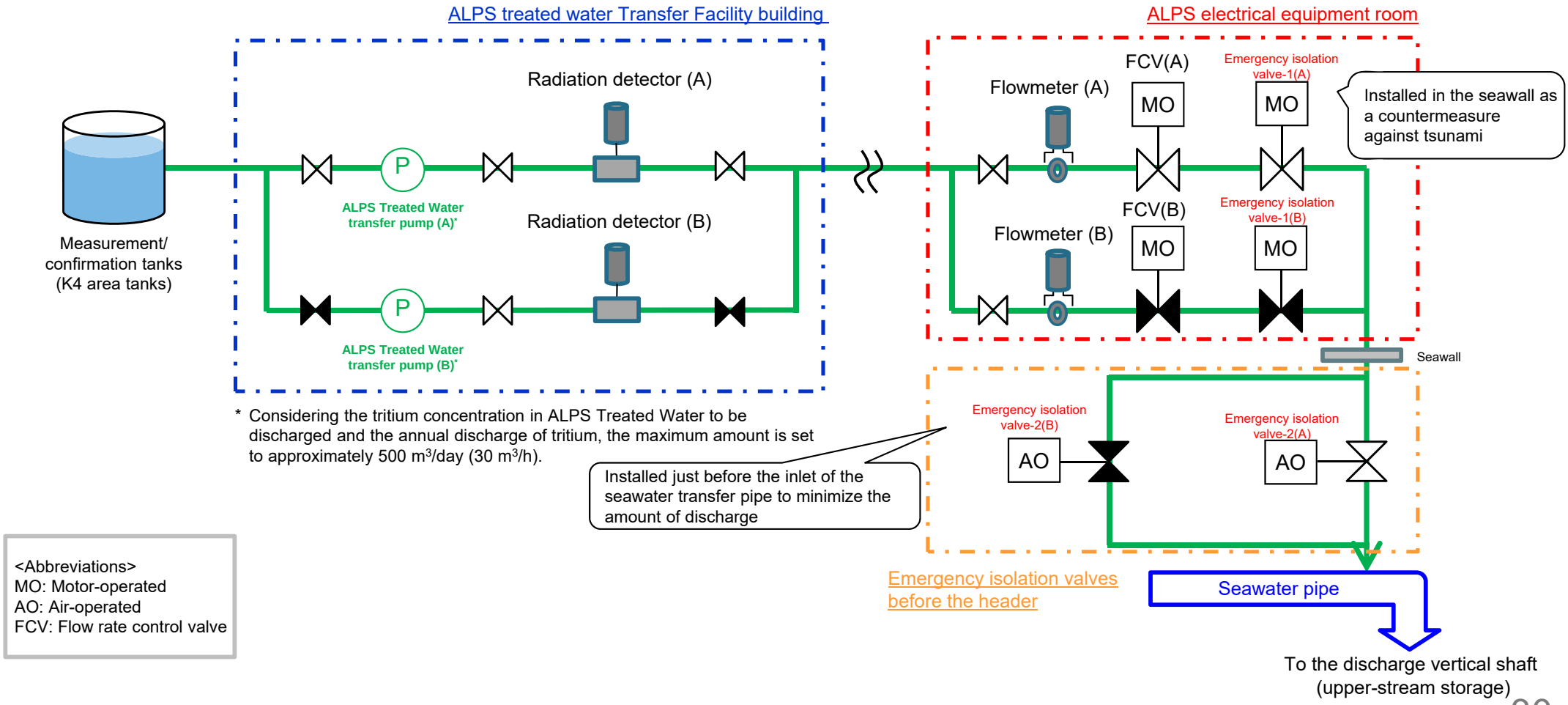
Chapter 2.5 ALPS Treated Water tanks

	Group A	Group B	Group C
1st cycle	Receiving	-	-
2nd cycle	Measurement/ confirmation	Receiving	-
3rd cycle	Discharge	Measurement/ confirmation	Receiving
4th cycle	Receiving	Discharge	Measurement/ confirmation
...	Measurement/ confirmation	Receiving	Discharge

[Reference] Overview of the ALPS Treated Water Dilution/Discharge Facilities (Transfer Facility)

Transfer Facility

- The Transfer Facility consists of the ALPS treated water transfer pumps and transfer pipes.
- Two ALPS Treated Water transfer pumps are prepared, a unit in operation and the other backup unit, to transfer ALPS Treated Water from measurement/confirmation tanks to the Dilution Facility.
- Emergency isolation valves are provided both before the seawater piping header and in the seawall as a countermeasure against tsunami so that the transfer can be stopped immediately when an abnormality occurs.



* Considering the tritium concentration in ALPS Treated Water to be discharged and the annual discharge of tritium, the maximum amount is set to approximately 500 m^3/day (30 m^3/h).

<Abbreviations>
MO: Motor-operated
AO: Air-operated
FCV: Flow rate control valve

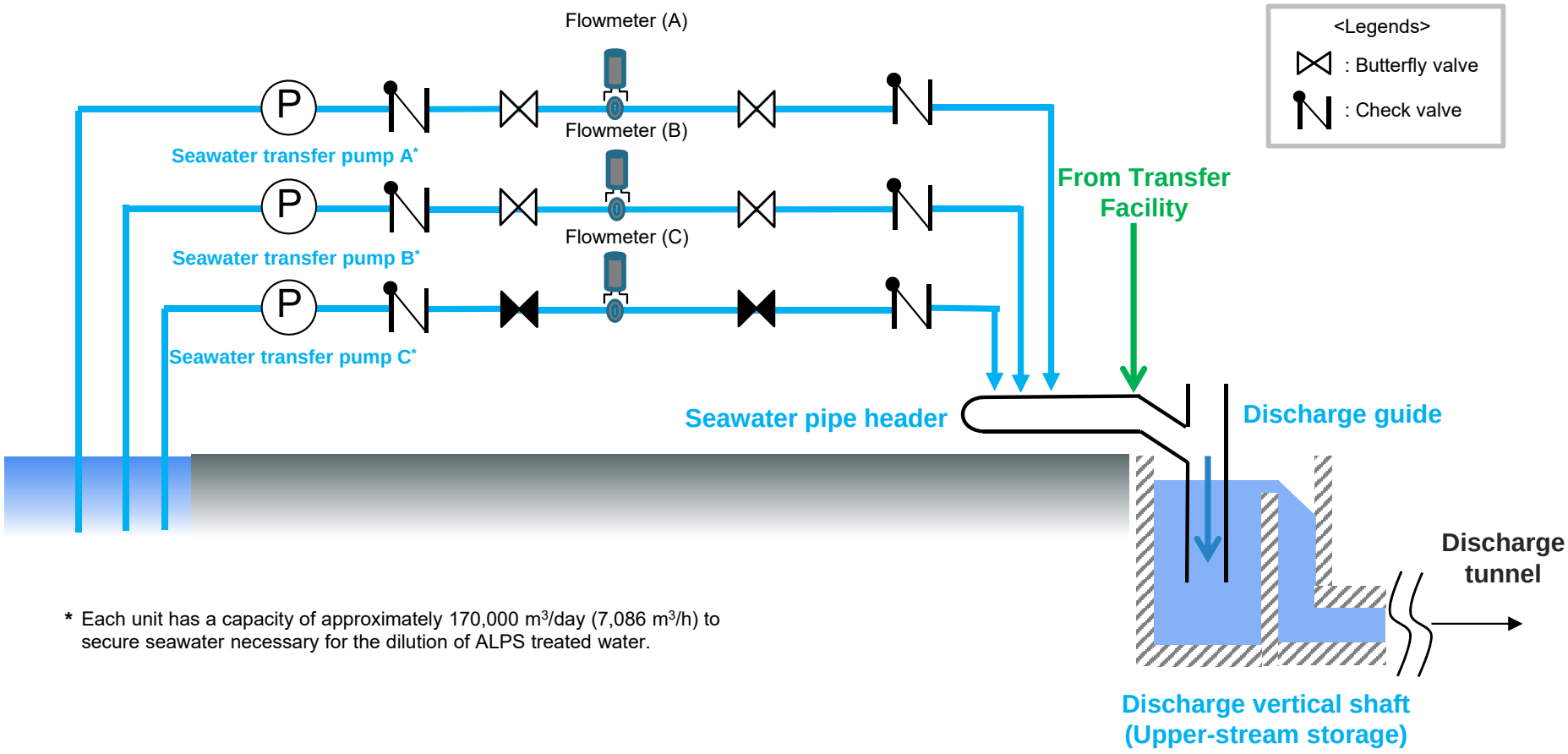
The Japanese version shall prevail.

[Reference] Overview of the ALPS Treated Water Dilution/Discharge Facilities (Dilution Facility)

TEPCO

Dilution Facility

- Consisting of seawater transfer pumps, seawater pipe (including a header pipes), a discharge guide, and a discharge vertical shaft (upper-stream storage), the Dilution Facility diluted ALPS Treated Water with seawater, transfers it to the discharge vertical shaft (upper-stream storage), and discharge it to the Discharge Facility.
- The seawater transfer pumps have a capacity that can dilute ALPS Treated Water transferred by the Transfer Facility 100 times or more.



* Each unit has a capacity of approximately 170,000 m³/day (7,086 m³/h) to secure seawater necessary for the dilution of ALPS treated water.

The Japanese version shall prevail.

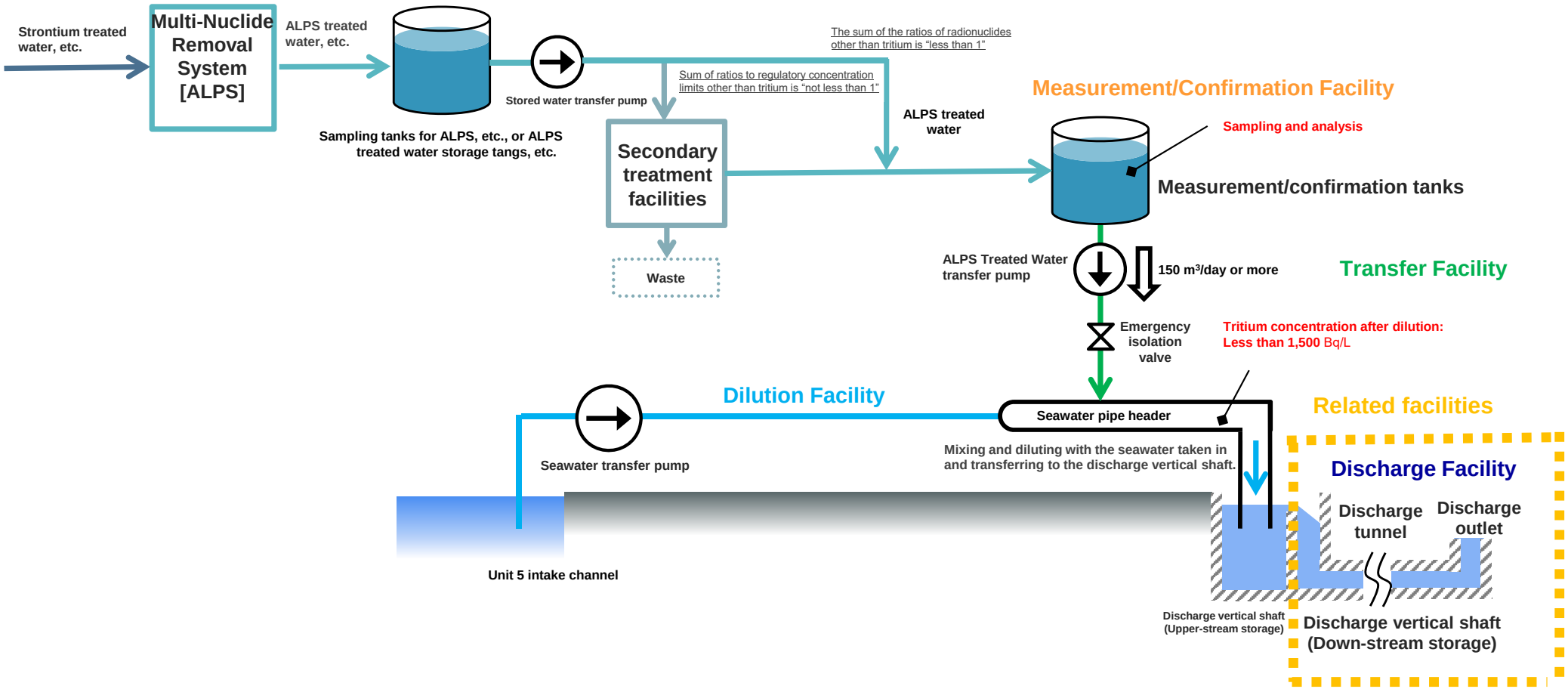
[Reference] Overview of the related facility (Discharge Facility)

Objective

Drainage water is discharged from the ALPS Treated Water Dilution/Discharge Facilities (water diluted with seawater so that the sum of which ratios to regulatory concentration limit including all nuclides together with tritium is less than 1) into the sea from a location approximately 1 km away from the coast.

Outline of the facilities

The Discharge Facility consist of a discharge vertical shaft (down-stream storage), a discharge tunnel, and a discharge outlet to achieve the above objective.

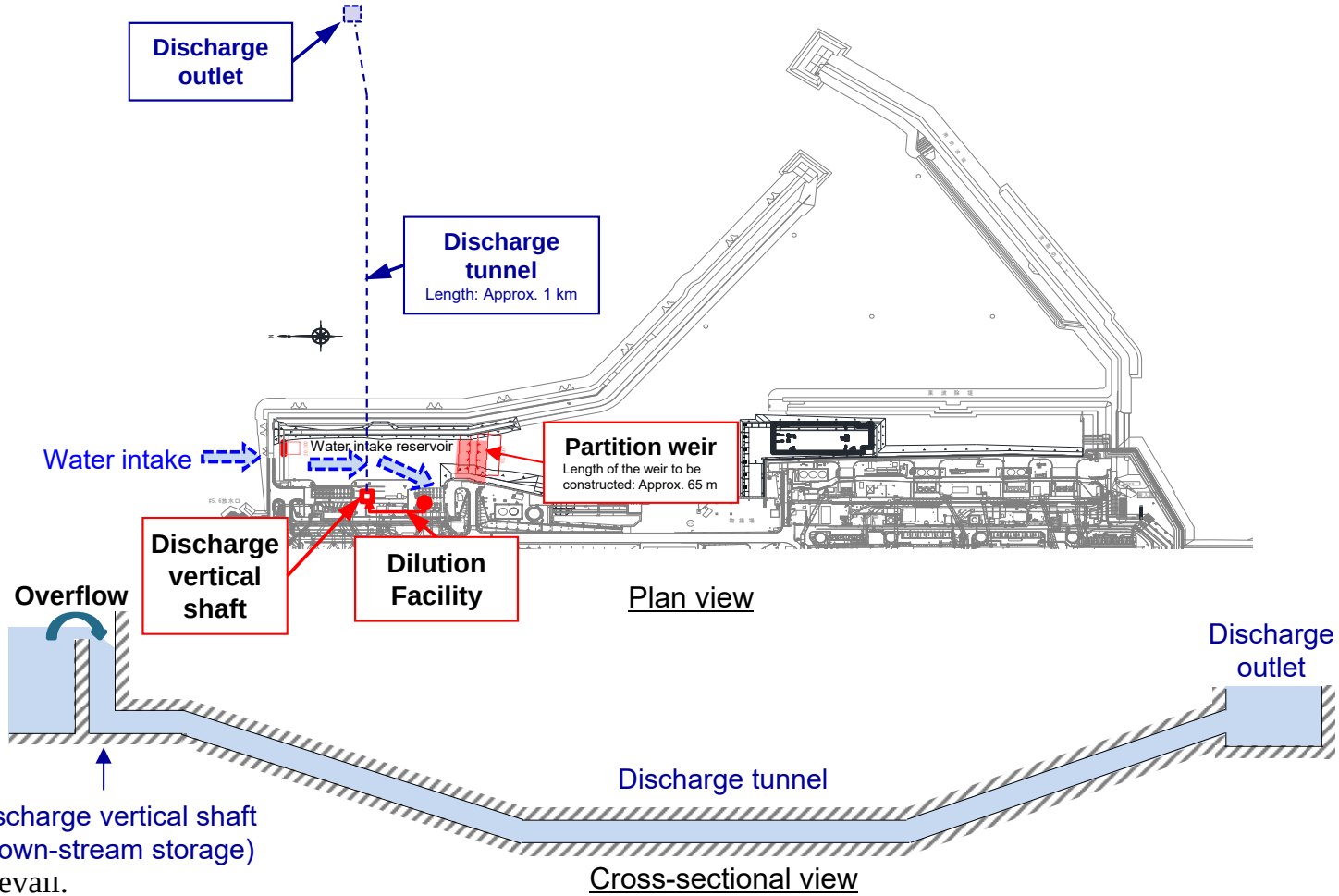


The Japanese version shall prevail.

[Reference] Overview of the related facility (Discharge Facility) (1/2)

TEPCO

- Discharge Facility
  - Discharge Facility has a design so that they can transfer water flowing out over the partition wall in the discharge vertical shaft to the outlet, which is approximately 1 km away from the shore, by using the water head difference between water in the discharge vertical shaft (down-stream storage) and the sea surface. In addition, the design concept includes friction losses in the Discharge Facility and elevation of water surface.



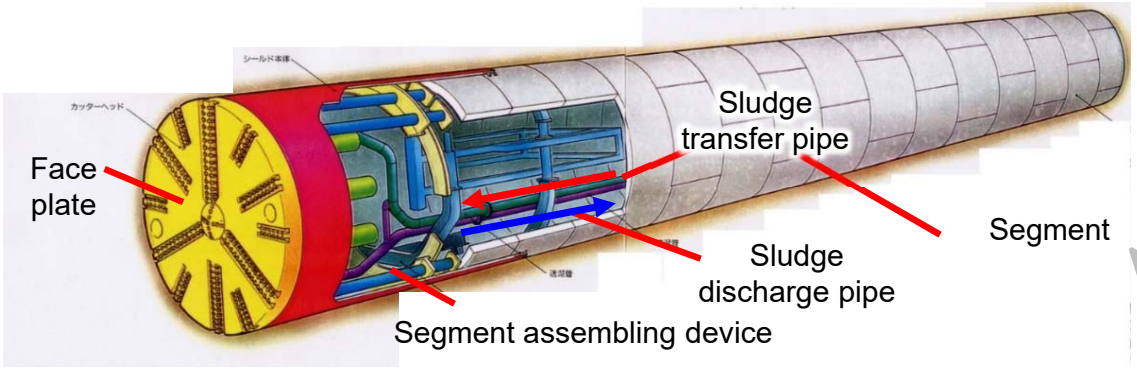
[Reference] Overview of related facilities (Discharge Facility) (2/2)

Overview of the structural design

- Water flows through the bedrock layer to minimize the leakage risk and to ensure a highly earthquake-resistant structure.
- A shield method is adopted and double-layer seals are installed in the reinforced concrete segment to ensure water cut-off performance.
- The tunnel body (segment) is designed considering the impacts of typhoons (high waves) and storm surges (sea level rise).

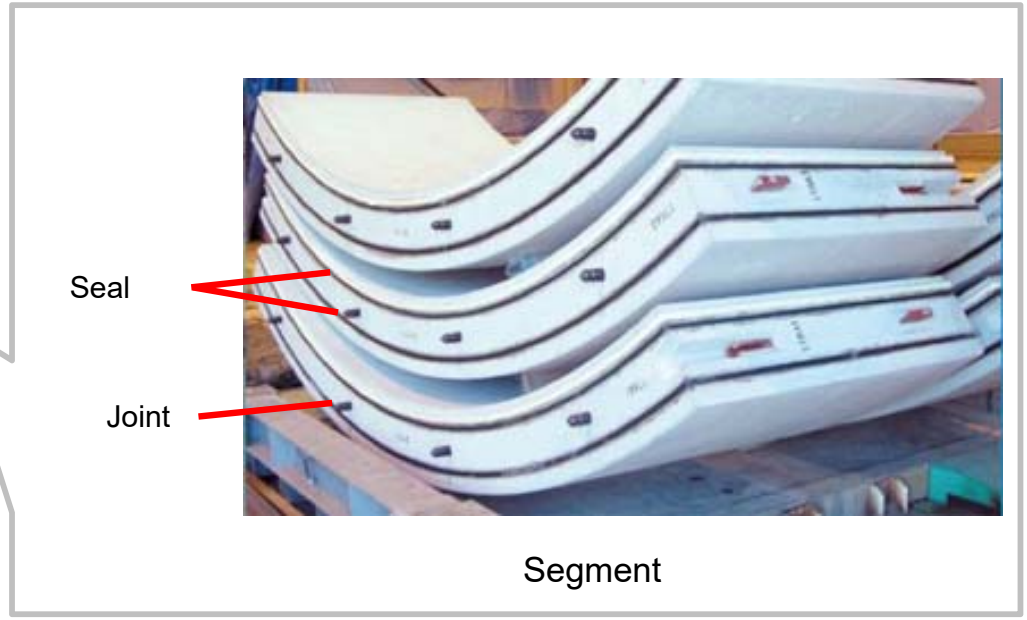
Construction of tunnel (shield method)

- As there are many discharge tunnels constructed by the shield method, this secure construction will minimize the possibility of trouble.



*Slurry shield method was adopted this time.

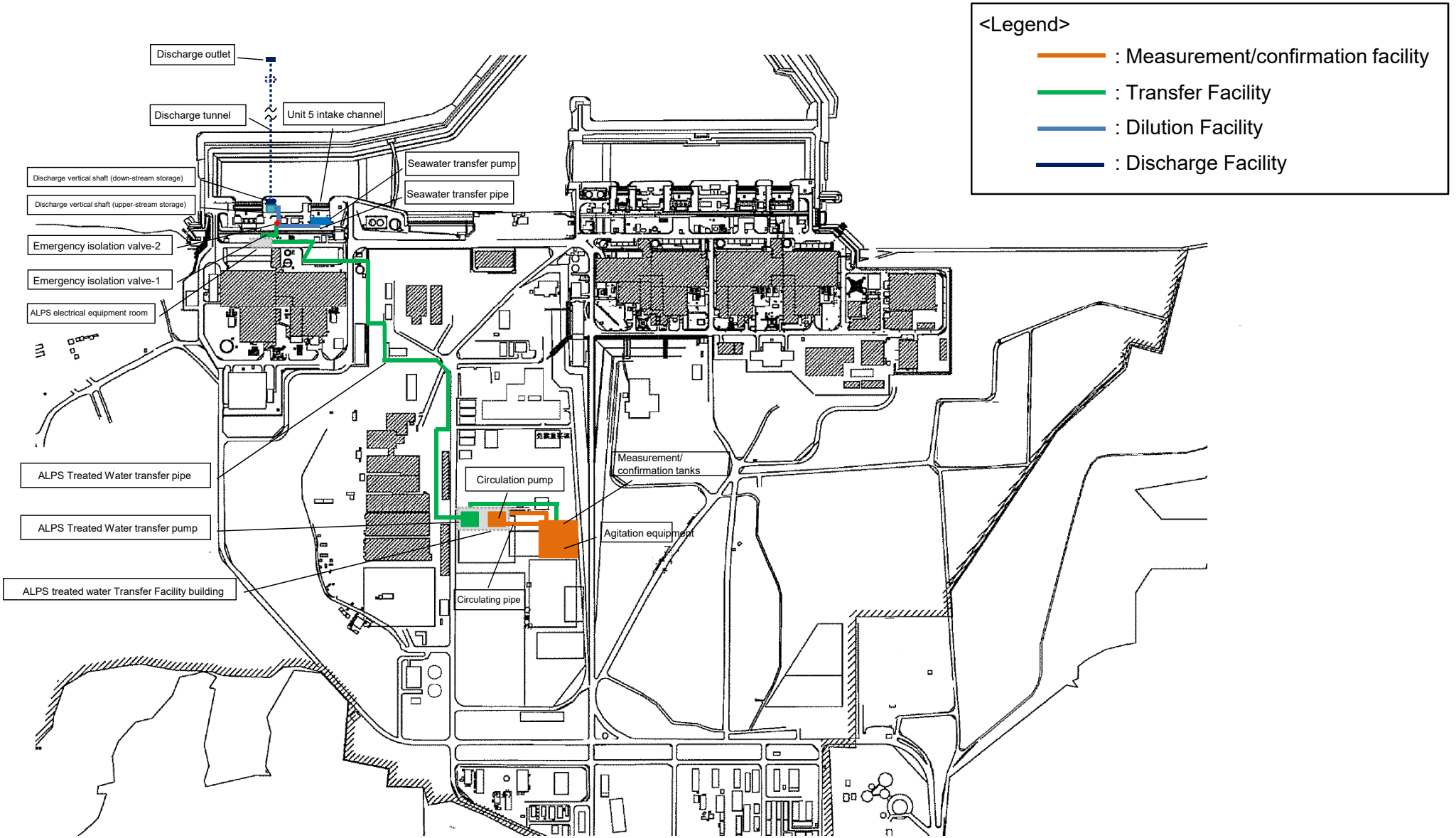
Schematic diagram of a shield machine



Segment

[Reference] Layout plan of the ALPS treated water Dilution/Discharge Facilities and the Related Facility

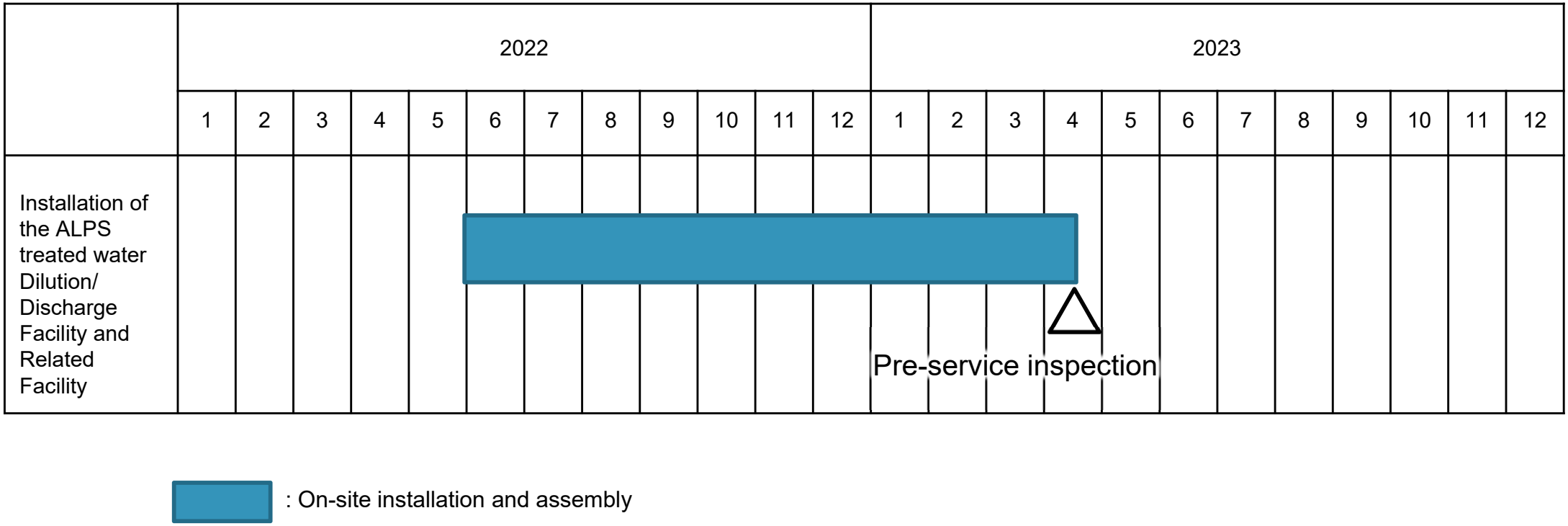
- The layout of the ALPS treated water Dilution/Discharge Facilities and the Related Facility is as follows. (Implementation Plan: II-2-50-Attachment 1-2)



The Japanese version shall prevail.

[Reference] Installation schedule for ALPS Treated Water Dilution/Discharge Facilities and the Related Facility

- Once the approval is granted after review by the Nuclear Regulatory Authority, the on-site installation and assembly of the facilities will commence, with completion scheduled for around mid-April 2023. (Implementation Plan: II-2-50-Attachment 6-1)



[Reference] Facility overview for ensuring safety

Secondary treatment facility (new reverse osmosis membrane equipment)

Secondarily treats treated water to be purified in which the sum of ratios to regulatory concentration limits other than tritium is “1 to 10”.

Secondary treatment facility (ALPS)

Secondarily treats treated water to be purified in which the sum of ratios to regulatory concentration limits other than tritium is “not less than 1”.

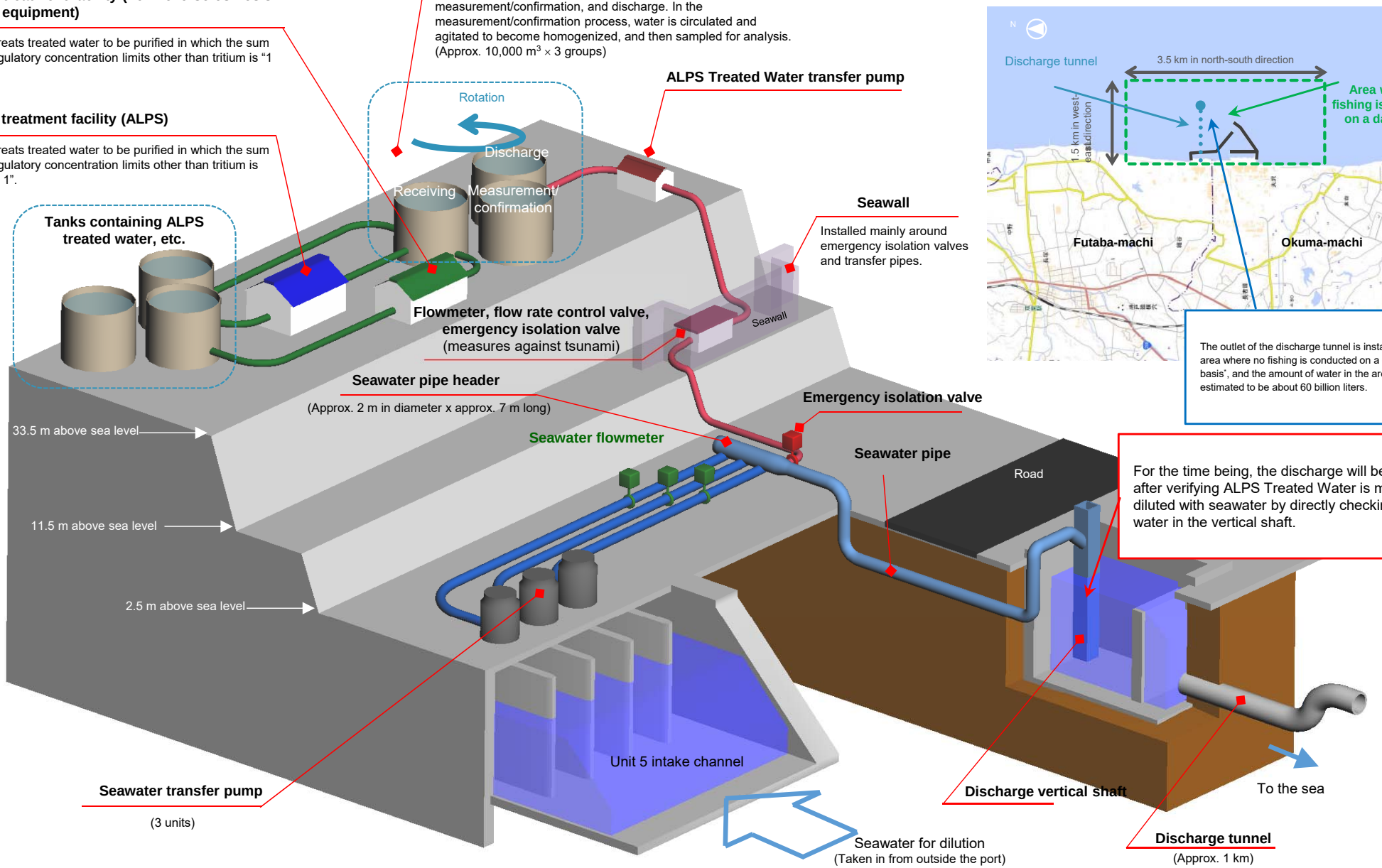
Measurement/confirmation facility (K4 tank groups)

Consists of 3 groups, each of which is responsible for receiving, measurement/confirmation, and discharge. In the measurement/confirmation process, water is circulated and agitated to become homogenized, and then sampled for analysis. (Approx. 10,000 m^3 × 3 groups)

ALPS Treated Water transfer pump

Seawall

Installed mainly around emergency isolation valves and transfer pipes.



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

The outlet of the discharge tunnel is installed in an area where no fishing is conducted on a daily basis*, and the amount of water in the area is estimated to be about 60 billion liters.

For the time being, the discharge will be started after verifying ALPS Treated Water is mixed and diluted with seawater by directly checking the water in the vertical shaft.

*Area where common fishery rights are not set.

The Japanese version shall prevail.