The commission on supervision and evaluation of the specified nuclear facilities
(92nd session)
Document 1

Status of Review Regarding the Sea Discharge Facility Relevant for the Handling of ALPS Treated Water

July 12, 2021

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Tokyo Electric Power Company Holdings, Inc.

Design and Operation of Necessary Facilities

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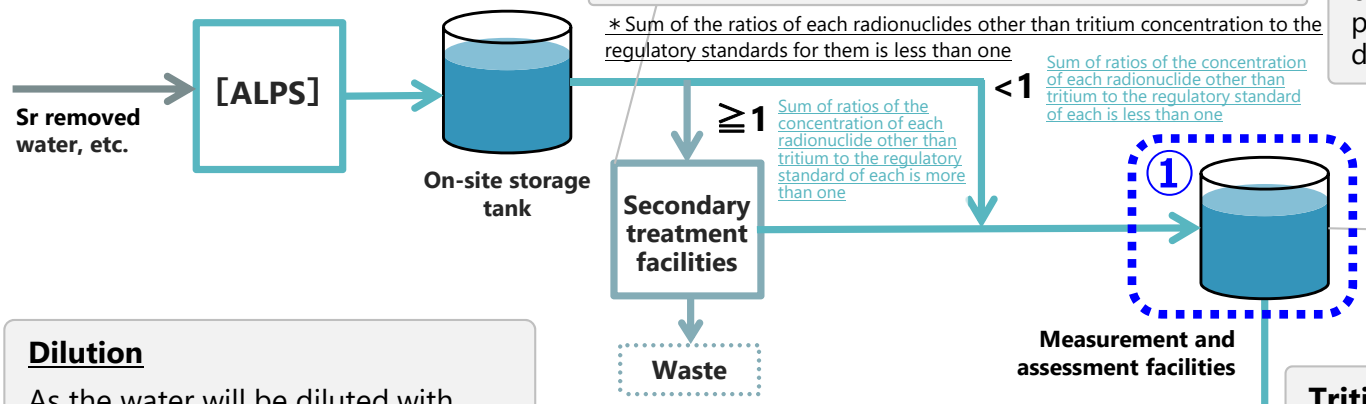
[Conceptual diagram of facilities for discharging ALPS treated water into the sea]

Red: area explained in current session, Blue: area previously explained, Green: area to be explained in the future

⑥ General items

Secondary treatment
Secondary treatment will be conducted as necessary to ensure that the level of radioactive materials excluding tritium is lower* than the regulatory standard value for safety

On-site work plan
Review measurement and assessment facilities, preparation of alternative tanks and the disassembly of storage tanks being emptied for the reliable discharge of ALPS treated water and for making continued progress in the construction of facilities required for decommissioning

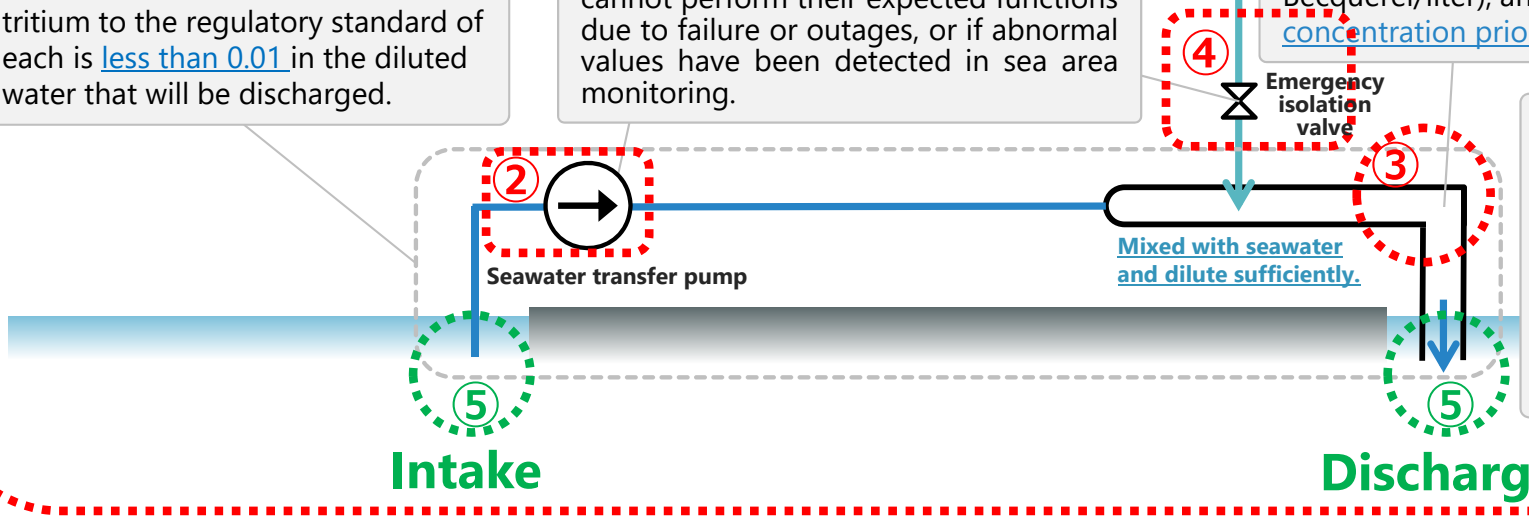


Analysis of ALPS treated water
TEPCO will publish the concentration of tritium, 62 nuclides (nuclides subject to removal by ALPS), and carbon-14 in ALPS treated water and the results of assessments as well as the 3rd parties' measurement and assessment results.

Dilution
As the water will be diluted with large amounts of seawater (diluted by more than hundred times), the sum of ratios of the concentration of each radionuclide other than tritium to the regulatory standard of each is less than 0.01 in the diluted water that will be discharged.

Emergency measures
Discharge will be stopped if the facilities cannot perform their expected functions due to failure or outages, or if abnormal values have been detected in sea area monitoring.

Tritium concentration in water discharged
The tritium concentration in water discharged shall be less than 1,500 Becquerel/liter which is 1/40th of the value stipulated in regulatory requirements (60,000 Becquerel/liter), and shall be evaluated based on the concentration prior to discharge and water for dilution.



Amount discharged
In the near term, discharge amounts will be within the threshold of 22 trillion Bq/year which is the target discharge management value for Fukushima Daiichi before the accident. This amount will be reviewed as needed based on progress made in decommissioning.

Topics Regarding the Application for the Authorization of Changes in Implementation Plan

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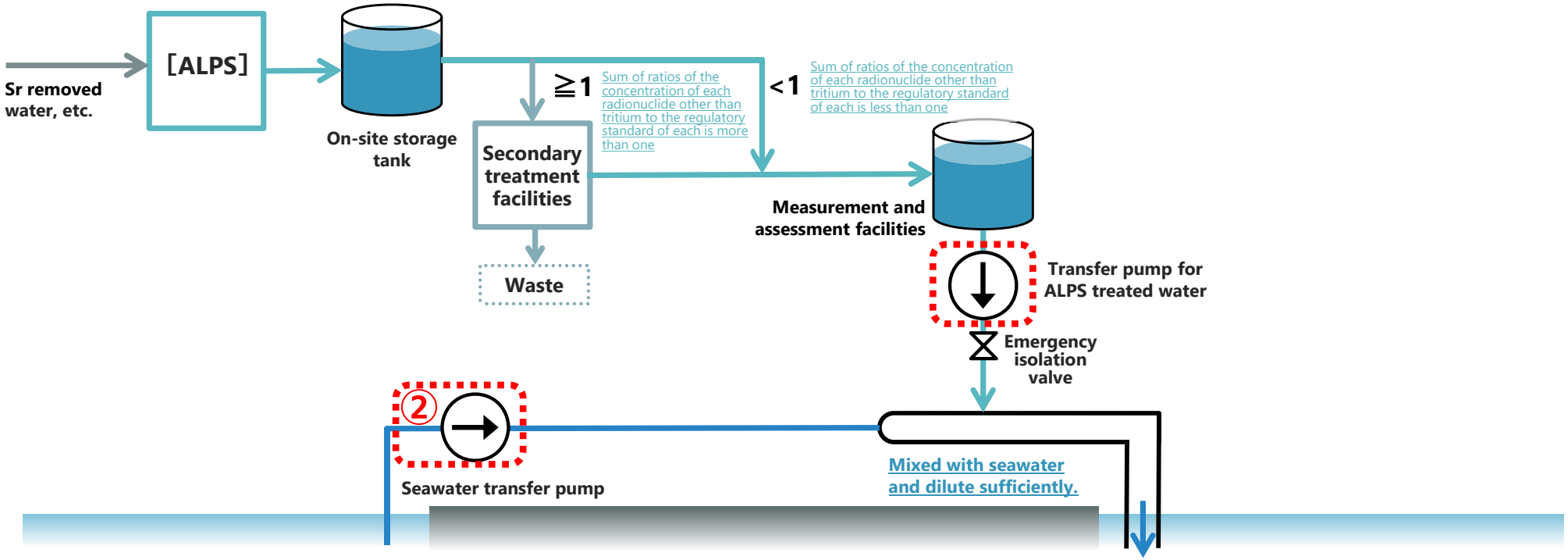
- Topics ②, ③, ④ and ⑥ shall be explained in this session.

Topic ① (Measurement/ assessment)	● Method of collecting samples for thoroughly measuring and assessing tritium, 62 isotopes (subject to removal by ALPS) and the radiation concentration of Carbon-14; facilities required for the sampling method and its management. ● Securing tanks required for thoroughly measuring and assessing radiation concentration. ● Quality assurance in the strict measurement and assessment of radiation concentration.
Topic ② (Specification of dilution facility)	● Specification of the seawater transfer pump (capacity) used for dilution and measurement method of seawater flow rate. ⇒p.3～9
Topic ③ (Assessment of dilution)	● Measurement of tritium concentration requires half a day to an entire day, so abnormality cannot be continuously detected through continuous measurement like those conducted for gamma emitting isotopes. The feasibility of confirming the tritium concentration of water discharged being less than 1,500 Becquerel/liter using measurement of tritium concentration prior to discharge and water for dilution (however, measure tritium concentration at the discharge end periodically) needs to be verified. ⇒p.10～15
Topic ④ (Measures in the event of abnormality)	● An interlock mechanism to stop the discharge in an emergency when the tritium concentration of the water discharged cannot be confirmed to be less than 1,500 Becquerel/liter. ● Redundancy of emergency isolation valve and location of its installation ● ALPS treated water is measured and assessed for its radiation concentration prior to dilution and discharge, and it is confirmed that the sum of ratios of the concentration of each radionuclide to the regulatory standard of each is less than one (excluding tritium). Radiation monitor (for gamma ray) and an emergency shutdown interlock in preparation for the unlikely discharge of particulate radioactive material. ⇒p.16～18
Topic ⑤ (Intake and discharge)	● Intake and discharge method (Preventing radioactive material near the sea floor of the harbor being blown upwards during intake and discharge, and promoting dispersion during discharge)
Topic ⑥ (General items)	● Design of necessary facilities, organization for the conduct of construction and implementation ● Preparations for the reliable management of facilities in general (securing auxiliary parts and measures for natural disasters, etc.) ⇒p.19,20

TOPIC ② Specification of dilution facility

- Specification of the seawater transfer pump used for dilution (capacity), and seawater flow rate measurement method

[Conceptual diagram of facilities for discharging ALPS treated water into the sea]



1. Design Principles of the Sea Water Transfer Pump for Transferring ALPS Treated Water

- **The tritium concentration of ALPS treated water** currently stored on the Fukushima Daiichi NPS site premises is **approx. 150,000-2,160,000 Becquerel/liter, with an average numbering at approx. 620,000 Becquerel/liter** (evaluated value on April 1, 2021)
- The amount of ALPS treated water transferred shall be set based on the standard for the amount of annual tritium discharged, and also considering the number of days discharged which accounts for facility maintenance and switching systems, and also the tritium concentration of ALPS treated water to be discharged.
- The flow rate of ALPS treated water is at its highest when its tritium concentration is at a low level of around 150,000 Becquerel/liter. The maximum flow rate would be **approx. 500m³/day**.

Tritium discharged annually 22 trillion Becquerel/year

Number of days discharged 292 days (availability factor 80%)

⇒ Amount of tritium discharged per day 75.3 billion Becquerel/day

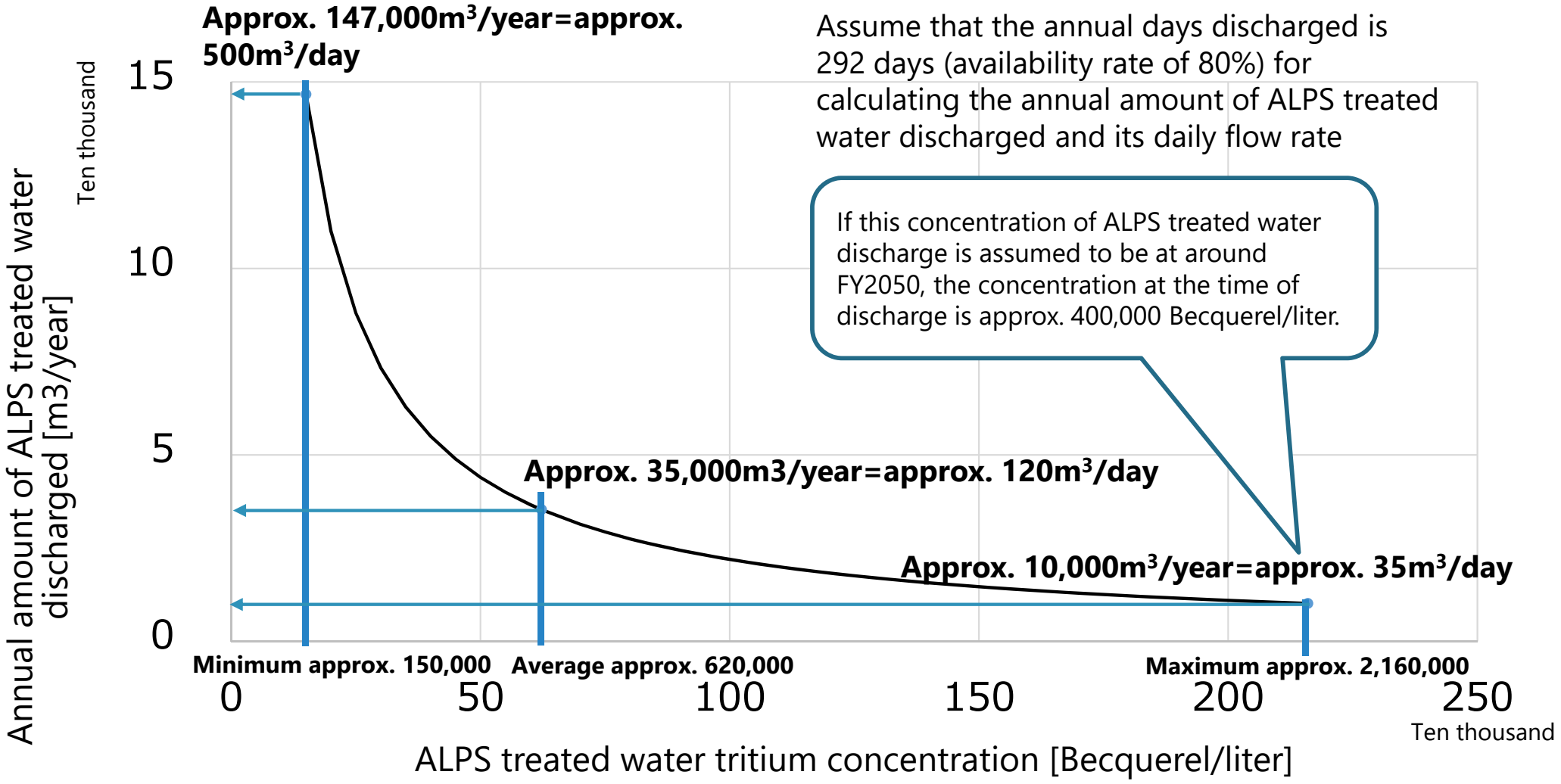
⇩

Tritium concentration in ALPS treated water, etc. Approx. 150,000-approx. 2,160,000 Becquerel/liter

⇒ 75.3 billion Becquerel/day ÷ 150,000 Becquerel/liter = approx. 500m³/day

【Reference】 Relationship Between Total Amount of Tritium Discharged and Amount of Water Discharged/Flow Rate of Treated Water

- If the standard for annual discharge of tritium is set below 22 trillion Becquerel, the amount of water that can be discharged fluctuates in accordance with the tritium concentration in the ALPS treated water (less concentration equates to more discharge being possible)



2-1. Design Principles Regarding the Seawater Transfer Pump (1/4)

- Consider the points below to secure the flexibility in pump management while keeping the tritium concentration after seawater dilution to less than 1,500 Becquerel/liter and keeping the annual tritium discharged to below 22 trillion Becquerel.

① Discharge of ALPS treated water can be responded to various tritium concentration ranging from approx. 150,000-2,160,000 Becquerel/liter in a flexible manner.

② The maximum amount of ALPS treated water that can be discharged shall be set up to approx. 500m^3/day, and action can be taken in a flexible manner to respond to the increase of treated water caused by heavy rain, and fluctuating work speed to disassemble tanks for the construction of facilities required for the decommissioning project.

③ A wide range of action is available in implementing the seawater transfer pump and conducting its maintenance and inspection.

2-2. Design Principles Regarding the Sea Water Transfer Pump (2/4)

- From the perspectives of ① and ②:
  - **<u>Risk case (Part 1: Discharge of ALPS treated water with high concentration)</u>**
    Assume a situation where ALPS treated water with approx. 2,160,000 Becquerel/liter needs to be temporarily discharged with contaminated water of 150m^3/day being generated (to prevent the total amount stored from increasing).

    The seawater flow rate necessary to bring the tritium concentration to less than 1,500 Becquerel/liter after seawater dilution is:
    2,160,000 Becquerel/liter ÷ 1,500 Becquerel/liter ×150m^3/day=approx. 220,000m^3/day

  - **<u>Risk case (Part 2: Discharge of a large amount of ALPS treated water)</u>**
    As approx. 400m^3/day of contaminated water is generated when there is heavy precipitation (maximum rainfall recorded in 2020), assume a situation where approx. 400m^3/day of ALPS treated water with an average of approx. 620,000 Becquerel/liter needs to be discharged.

    The seawater flow rate necessary to bring the tritium concentration to less than 1,500 Becquerel/liter after seawater dilution is:
    620,000 Becquerel/liter ÷1,500 Becquerel/liter ×400m^3/day=approx. 170,000m^3/day

2-3. Design Principles Regarding the Sea Water Transfer Pump (3/4)

- From the perspectives of ① and ②:
  - **Risk case (Part 3：Drop in the availability factor)**
    Assume a situation where long-term maintenance of facilities decrease the availability factor, and ALPS treated water with 22 trillion Becquerel (220billion Becquerel/day) with the annual days discharged being at 100 days.

    The seawater flow rate necessary to bring the tritium concentration to less than 1,500 Becquerel/liter after seawater dilution when discharging at 220billion Becquerel/day is:
    220billion Becquerel/day ÷ 1,500 Becquerel/liter ＝approx. 150,000m^3/day
  - Due to the points described, a minimum seawater flow rate of 220,000m^3/day is necessary when considering various risk cases. Further design margin of 50% margin shall be accounted for, **and a capacity for approx. 330,000m^3/day of seawater flow rate shall be prepared.**

2-4. Design Principles Regarding the Sea Water Transfer Pump (4/4)

- From the perspective of ③
  - Prepare three pumps to allow response when one pump fails and also considering maintenance and inspection. Reliable discharge can be achieved with two units operating and one unit on standby.
  - In other words, **reliable discharge can be achieved by securing three seawater transfer pumps.**

- To secure the necessary flow rate based on the information above, **Select a pump with the capacity of approx. 170,000m^3/day** based on approx. 330,000m^3/day ÷2 units
  - In the previously mentioned risk cases (2 and 3), the value of less than 1,500 Becquerel/liter can be secured with only one pump unit.
  - To verify that ALPS treated water has been diluted to less than 1,500 Becquerel/liter by seawater, it is important to precisely measure the ALPS treated water tritium concentration before dilution, ALPS treated water flow rate and the seawater flow rate. It has been confirmed that a pump with capacity of 170,000m^3/day for each unit is equipped with a flow meter (orifice type) which can measure the required values.
  - The design review assumes a two-unit operation to be normal, but three units can also be operated depending on the circumstances.

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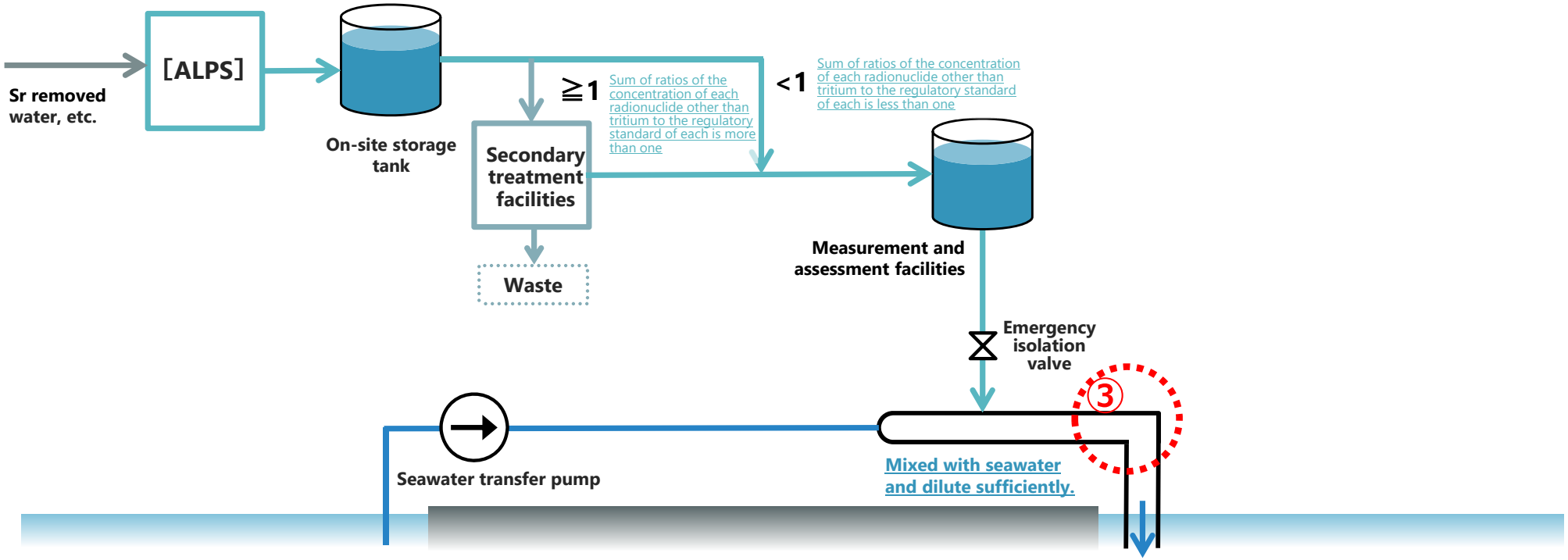
TOPIC ③ Method for assessing dilution

- Feasibility of assessing tritium concentration of discharged water using measurement of tritium concentration prior to discharge and water for dilution

[Conceptual diagram of facilities for discharging ALPS treated water into the sea]

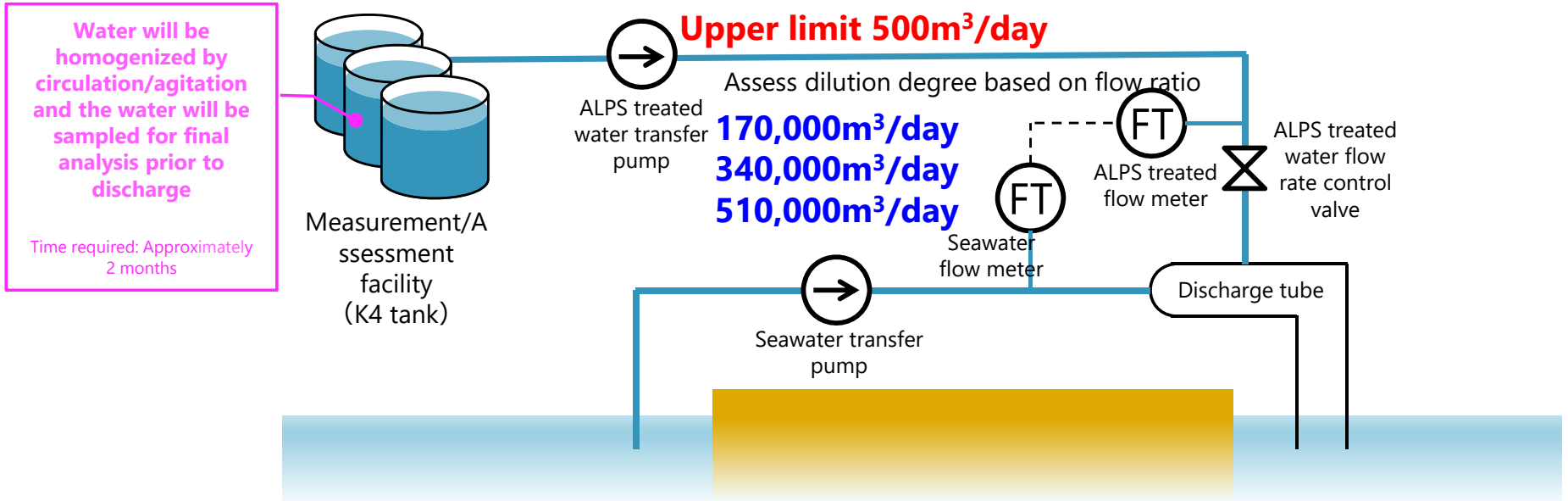


1. Tritium Concentration After Dilution with Seawater

- In general nuclear power stations, tritium concentration is measured prior to dilution, but due to the vast amount of seawater used for dilution, the amount of seawater is not constantly measured to assess tritium concentration.
- Due to ALPS treated water being designed to be discharged with an upper limit of 500m^3/day, and the seawater flow rate per day being either 170,000m^3, 340,000m^3 or 510,000m^3, **the design shall be to dilute at approx. 340 times or more, approx. 680 times or more, approx. 1020 times or more respectively**. Also, **analysis has confirmed that seawater and ALPS treated water are** mixed in the discharge pipe.

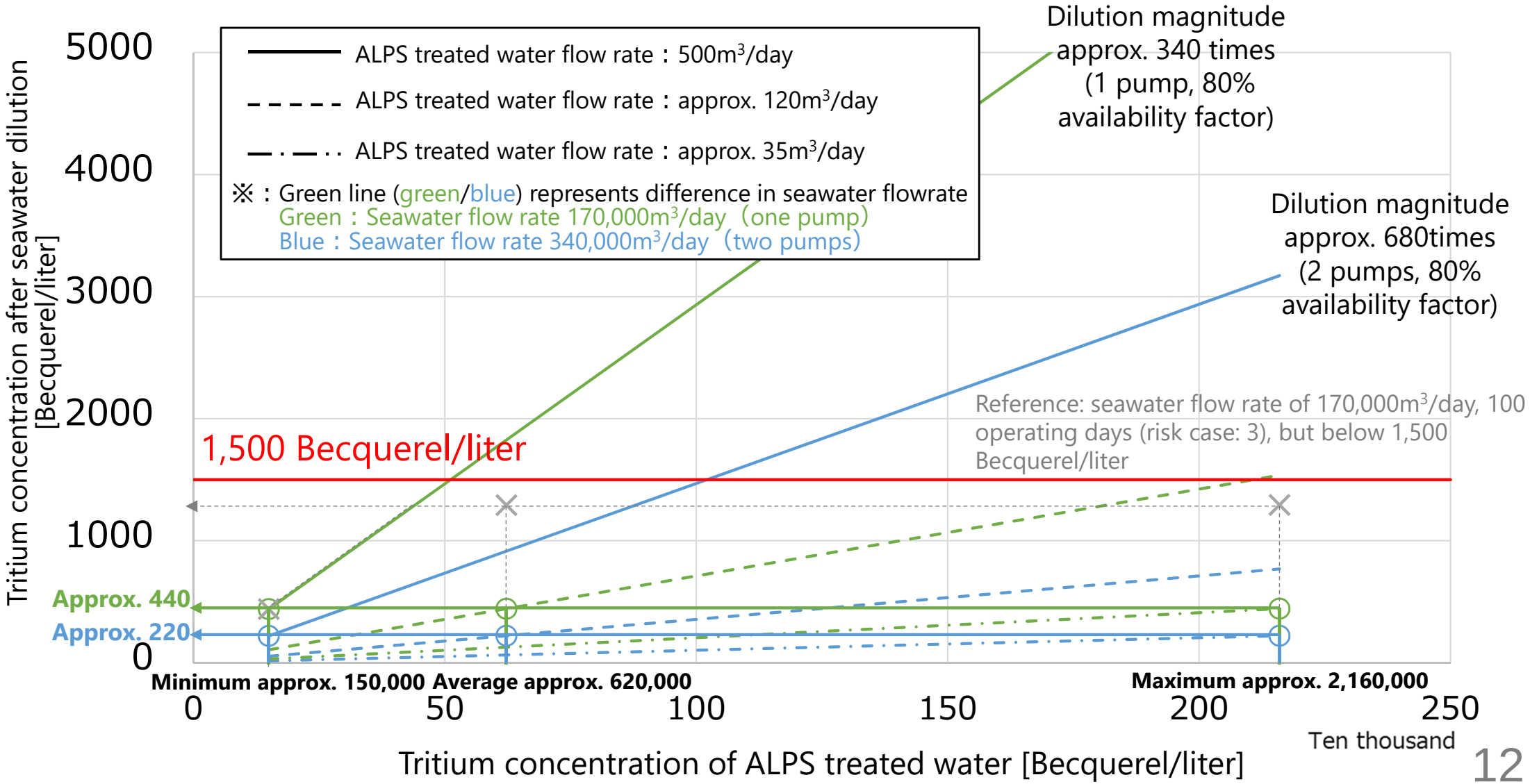
$$\text{Tritium concentration after seawater dilution} = \frac{\text{ALPS treated water tritium concentration} \times \text{ALPS treated water flow rate (controlled using flow rate control valve)}}{\text{ALPS treated water flow rate (controlled using flow rate control valve)} + \text{sea water flow rate}}$$

- During normal operation, it shall be assured that the tritium concentration after seawater dilution be kept below 1,500 Becquerel/liter after seawater dilution based on the tritium concentration derived from analysis results of measuring and assessment facilities and ALPS treated water and seawater flow ratio.
  Specific details on the implementation of pumps shall be reviewed based on the information above.
- Details on the method for confirming at the discharge end that water has been mixed, diluted as designed, and the tritium concentration being below 1,500 Becquerel/liter, shall be reviewed.

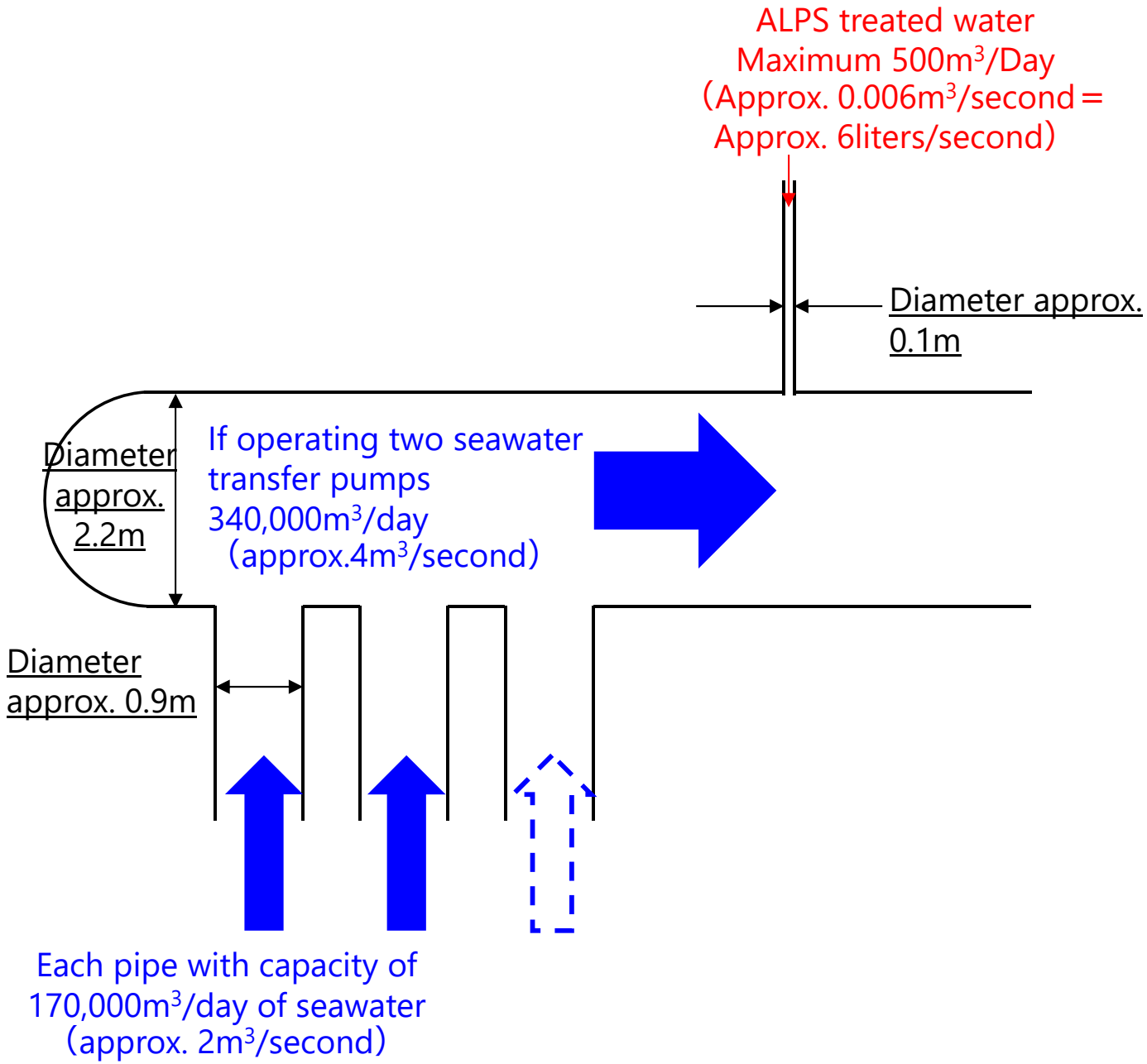


【Reference】Relationship Between Tritium Concentration and Flow Rate of ALPS Treated Water

- By combining ALPS treated water tritium concentration, ALPS treated water flow rate and seawater flow rate, keep tritium concentration after seawater dilution below 1,500 Becquerel/ liter, and realize a facility that can reliably continue discharge of ALPS treated water.



【Reference】Image of ALPS Treated Water and Seawater Joining

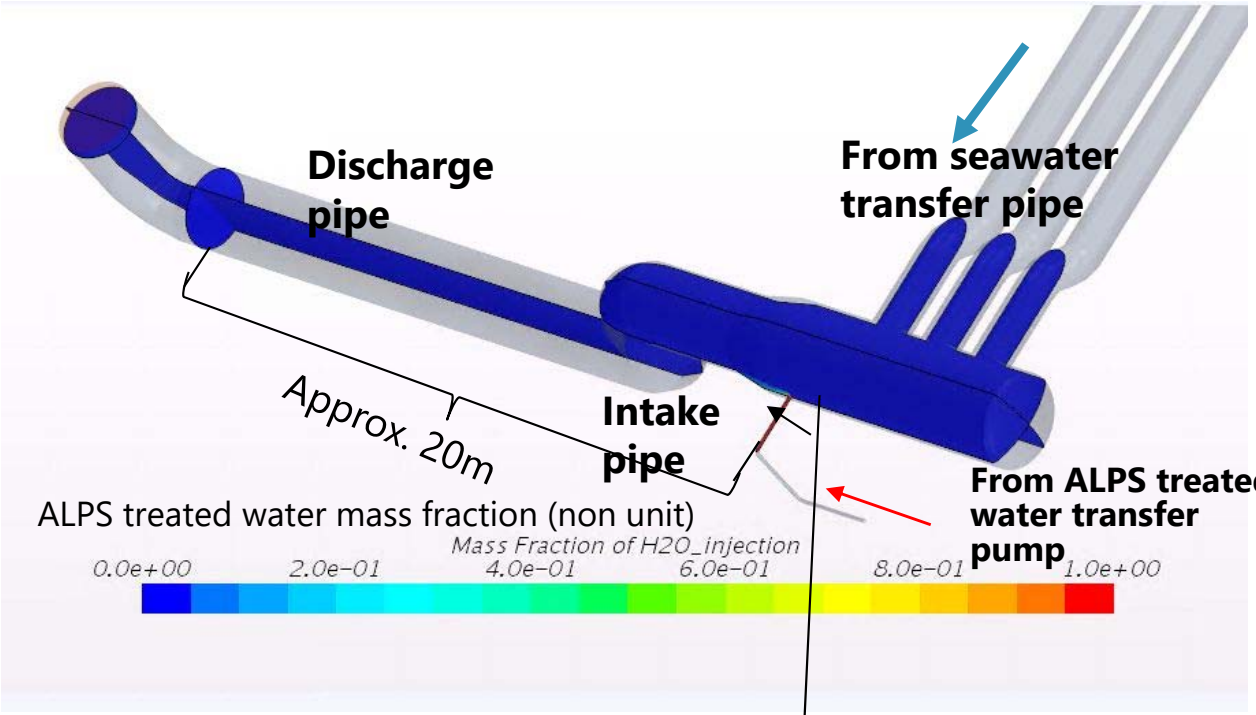


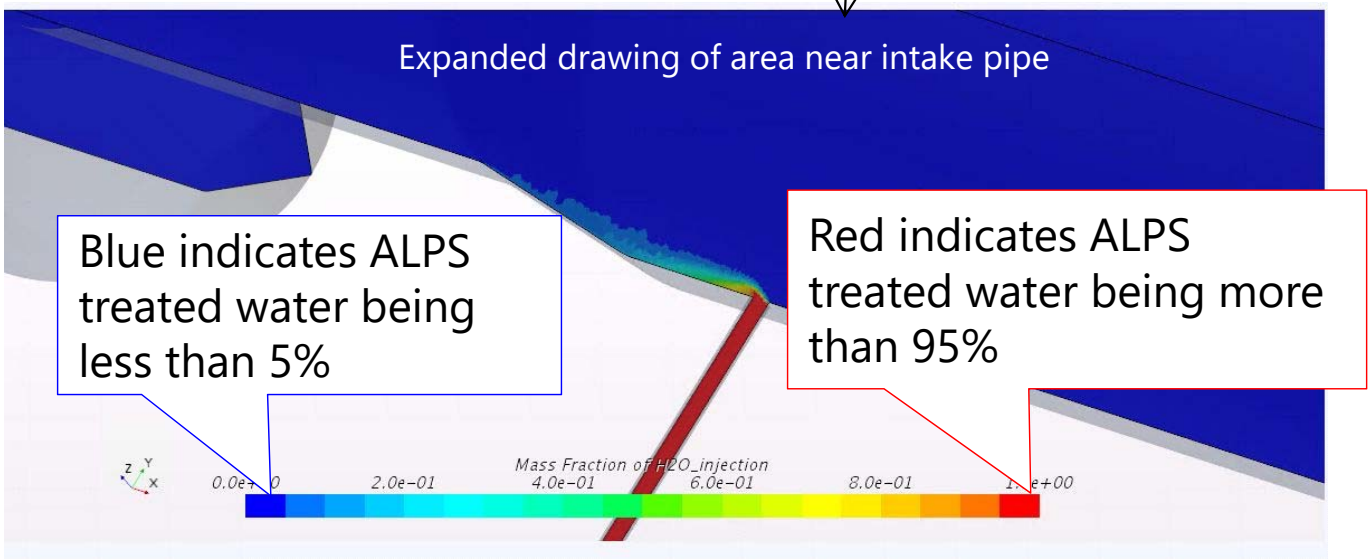
【Reference】 Result of Analyzing Diffusive Mixing Within Discharge Pipe Interior （1/2）

Result of analyzing diffusive mixing within discharge pipe if diluted at ALPS treated water flow rate 500m^3/day and seawater flow rate 340,000m^3/day

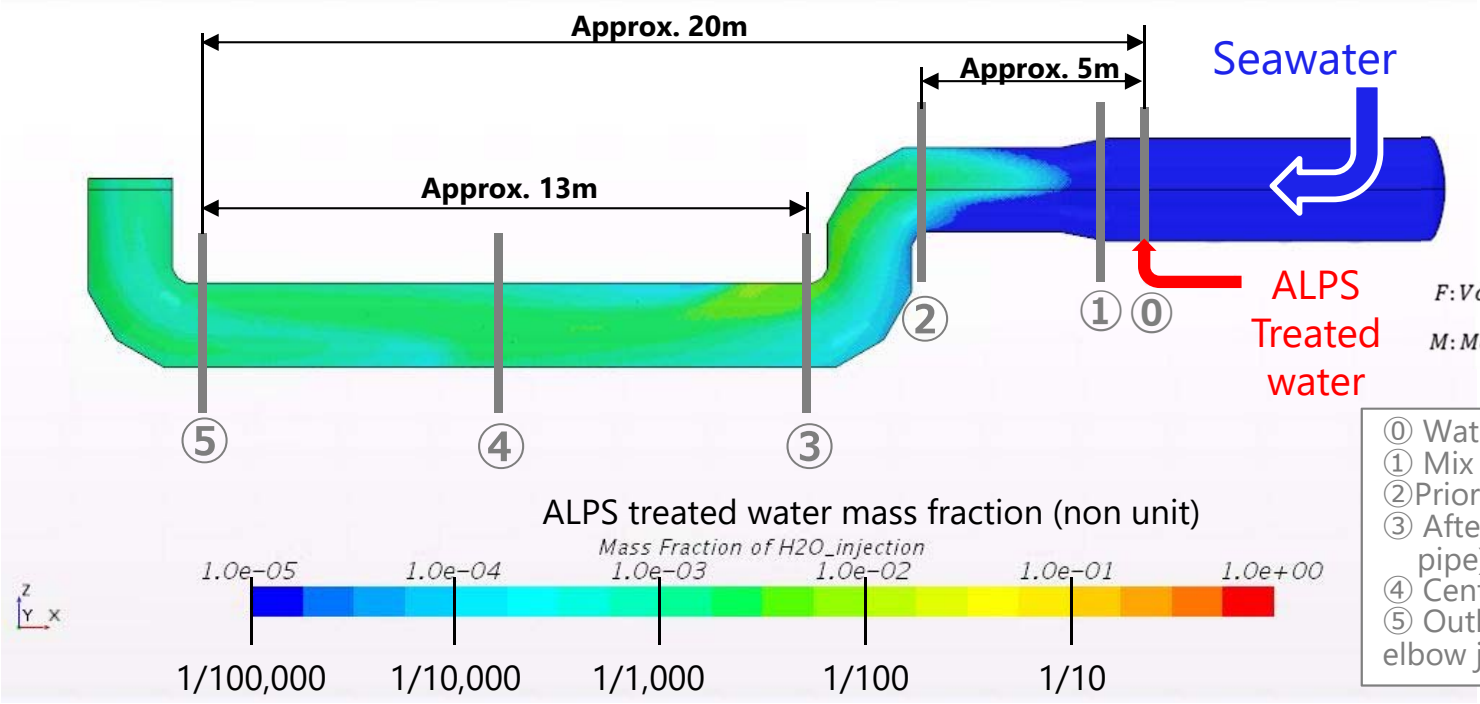
Confirmed that dilution is below 5% near the intake pipe (below 1/20)

The drawing to the right does not indicate a dilution of below 5%, so a logarithmic representation shall be presented in the next slide





【Reference】Result of Analyzing Diffusive Mixing Within Discharge Pipe Interior（2/2）



Reference：
Convert from mass fraction to volume fraction

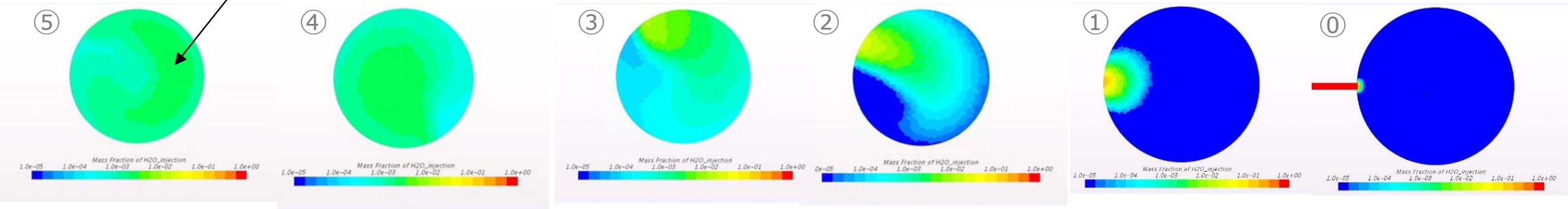
$$F = \frac{M}{(1-M)\frac{\rho_i}{\rho_R} + M}$$

F: Volume fraction(−)　ρ_i: ALPS treated water density(998.3 kg/m³)

M: Mass fraction(−)　ρ_R: seawater density(1025 kg/m³)

⓪ Water injection position
① Mix header outlet
②Prior to dropping elbow joint
③ After dropping elbow joint (entrance to straight pipe)
④ Center of straight pipe
⑤ Outlet of straight pipe (entrance to ascending elbow joint)

- The mass fraction of the ALPS treated water is 0.23% at maximum (approx. 1/430), and diluted to 0.14% on average (approx. 1/710)
- If ALPS treated water of 150,000 Becquerel/liter is discharged, the maximum is approx. 350 Becquerel/liter and the average is approx. 220 Becquerel/liter. (Average concentration is equivalent to tritium concentration after seawater dilution calculated (see slide 12))

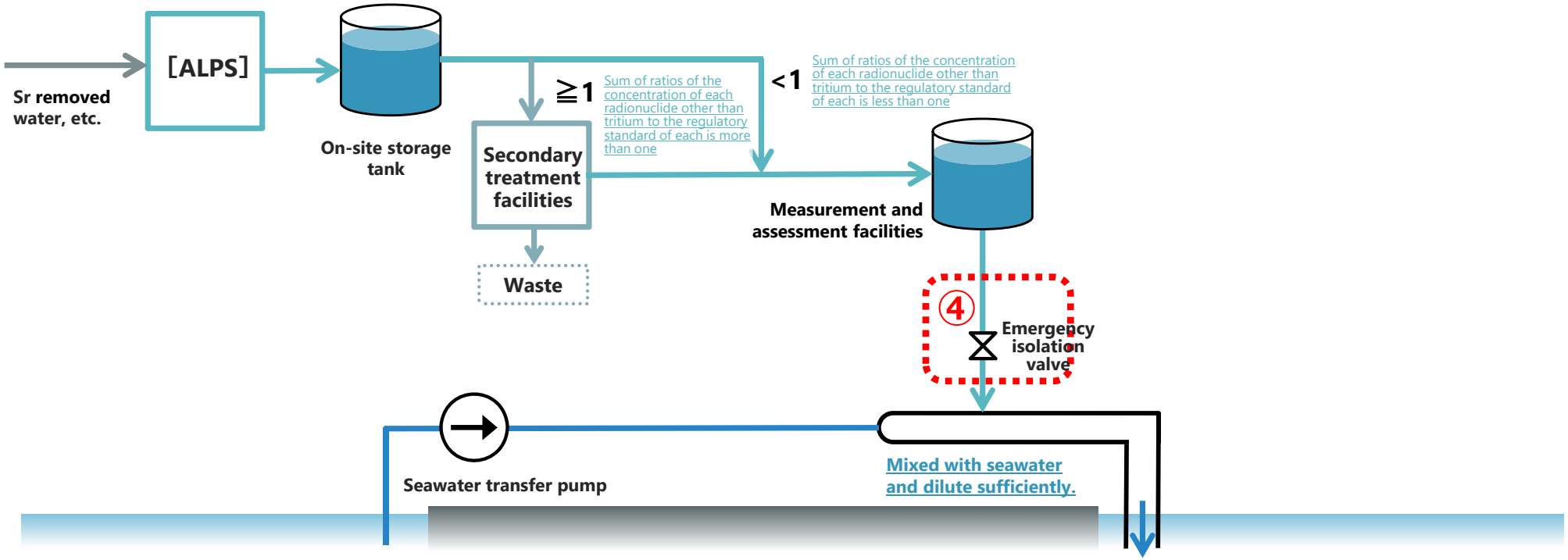


TOPIC ④ Measures in the event of abnormality

Interlock for emergency shutdown of discharge
(Abnormal concentration of discharge water, detection of gamma ray)

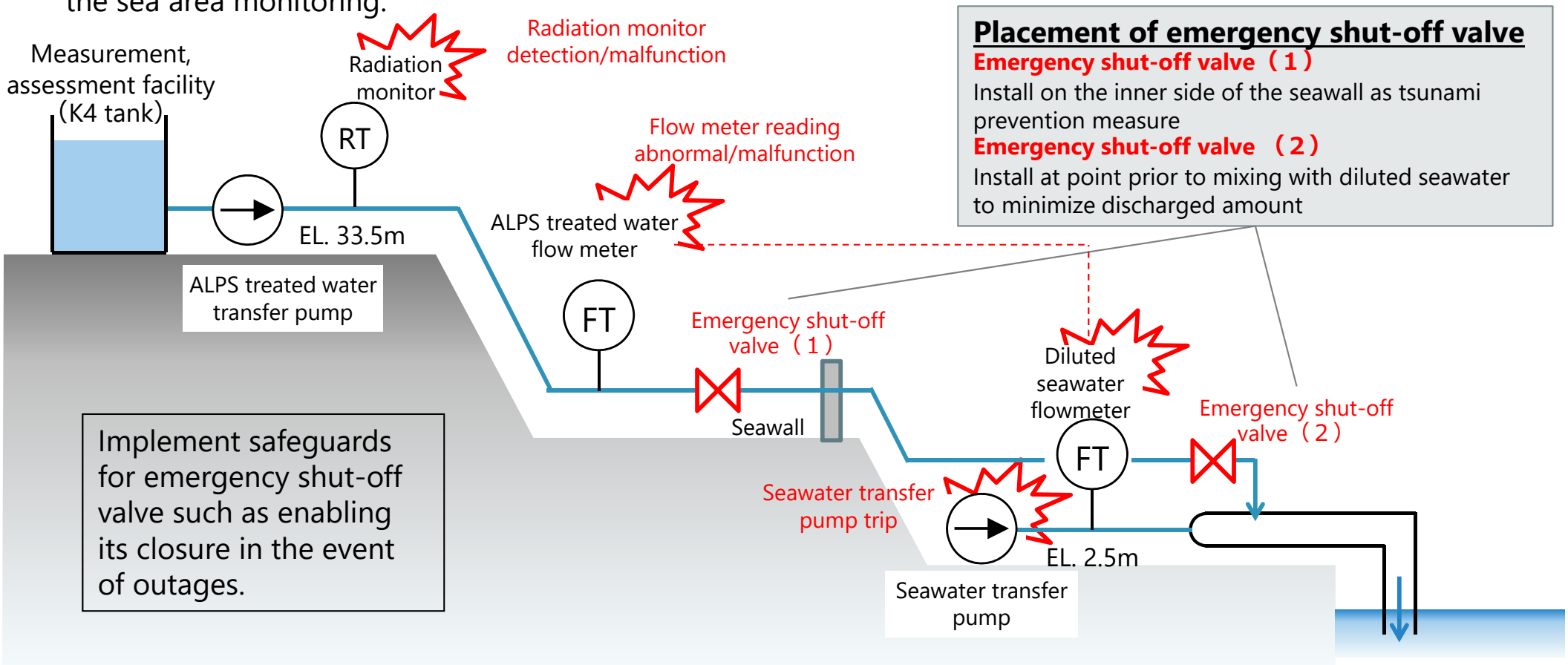
- redundancy of emergency shut-off valve, installation location

[Conceptual diagram of facilities for discharging ALPS treated water into the sea]



1．Response to Abnormality

- In the event of an abnormality in the dilution rate of ALPS treated water (shutdown of seawater pump, decrease in seawater flow rate, increase in ALPS treated water flow rate, malfunction of flowmeter) or when the properties of the ALPS treated water is abnormal (actuation/malfunction of radiation monitor), close the two emergency shut-off valves promptly, and shutdown the ALPS treated water transfer pump.
- One of the emergency shut-off valves shall be installed near the seawater transfer pipe to minimize the discharge of ALPS treated water in an abnormal event, and the other valve shall be installed on the inner side of the seawall to protect against flooding caused by tsunami.
- Although not an abnormality in facilities, discharge shall also be stopped if abnormal values are confirmed in the sea area monitoring.



2. Interlock

<Detected signal>

If ALPS treated water dilution rate is abnormal or cannot be confirmed.

- Seawater transfer system
  - Pump failure
  - Flow meter failure
  - Flow rate low
- ALPS treated water transfer system
  - Pump failure
  - Flow meter failure
  - Flow meter high

If ALPS treated water radiation is abnormal or cannot be confirmed.

- Radiation monitor
  - malfunction
  - Level high

Other facility abnormality and voluntary emergency shutdown

- Other
  - Emergency shutdown
  - Communication abnormal

Emergency shutdown valve Close※1

ALPS treated water transfer pump shutdown※2

Manual shutdown if sea area monitoring shows abnormal value

※1：Design shall allow ALPS treated water to shutoff discharge if abnormality such as outages occurs
※2：Continue operation of normal seawater transfer pump so that ALSP treated water can be diluted

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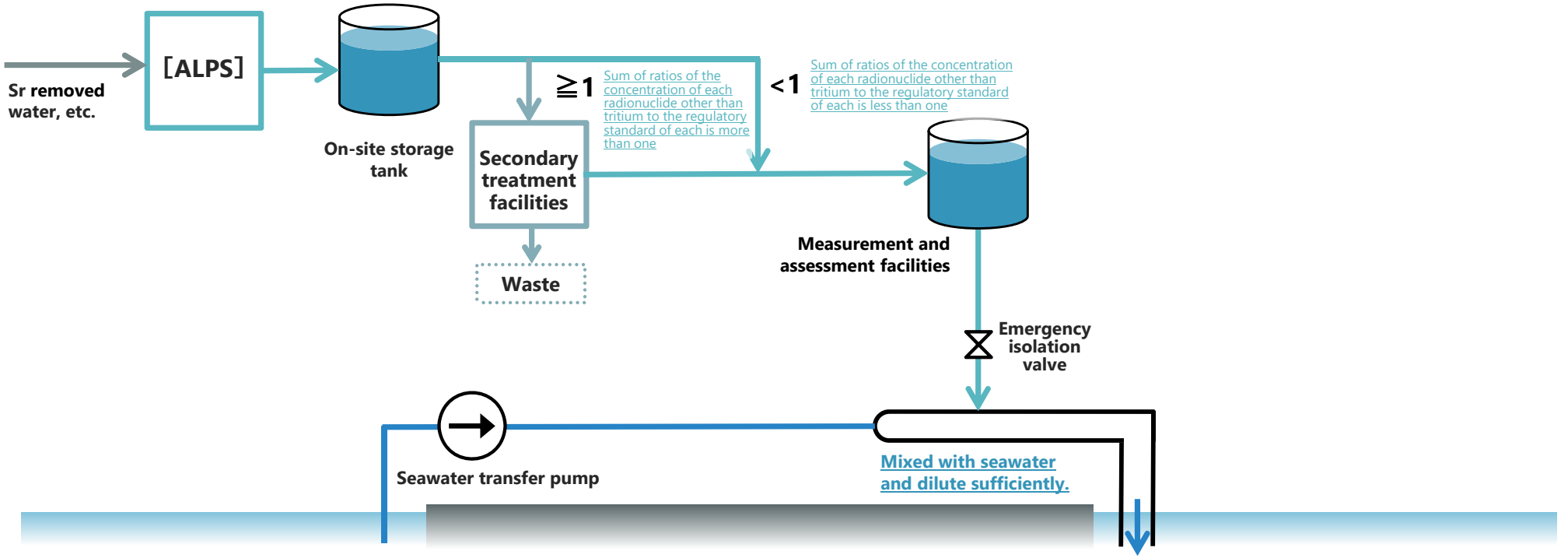
TOPIC⑥　GENERAL ITEMS

- Design of necessary facilities, organization for the conduct of construction and implementation

⑥ General items

[Conceptual diagram of facilities for discharging ALPS treated water into the sea]



1. Establishment of a Project Organization

- A plan to establish an organization specialized for ALPS treated water discharge work, which considers government policy, to execute the discharge of ALPS treated water into the sea.