Characteristics of water recently treated with multi-nuclide removal equipment (ALPS) etc.

January 31, 2020

Tokyo Electric Power Company Holdings, Inc.

Basic information about multi-nuclide removal equipment

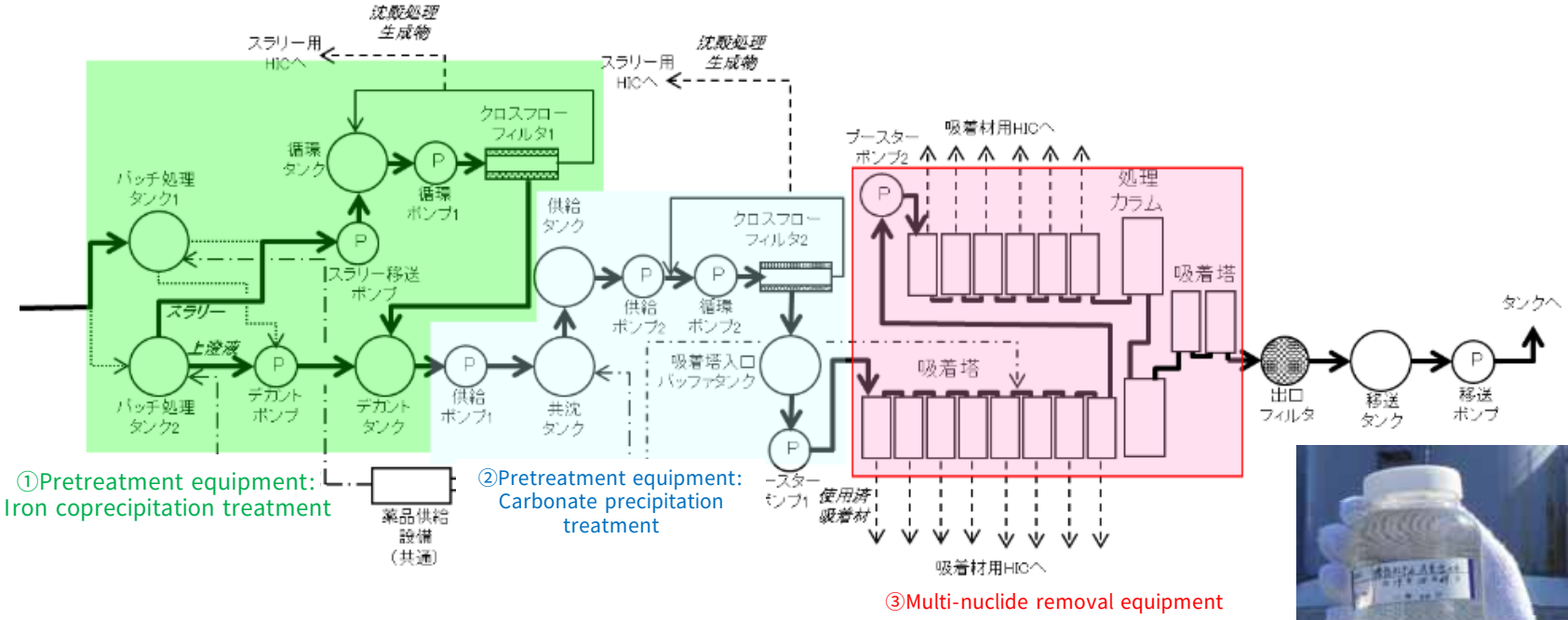
- Multi-nuclide removal equipment (ALPS) consists of existing ALPS, additionally installed ALPS and high-performance ALPS.
- ALPS has been designed with the ability to remove 62 radionuclides present in accumulated water, with the exception of tritium, thereby reducing the concentrations of these radionuclide to less than the concentration limits required by law.
- ALPS was used to treat RO concentrated brine (concentrated water from desalination equipment from which Strontium-90 has not been removed) until the end of May, 2015, and was then used to treat Strontium-treated water (concentrated water from desalination equipment for which the concentration levels of Strontium-90 has been reduced).
- Existing ALPS, additionally installed ALPS and high-performance ALPS have similar removal performance (DF; Decontamination Factor). Recently, existing ALPS and additionally installed ALPS have been used because the treatment amount can be easily adjusted.

○Treatment amount, etc. for each type of ALPS

Equipment type	Put into use	Treatment amount
Existing ALPS	Mar., 2013	250m^3/day/system ×3 systems
Additionally installed ALPS	Sept., 2014	250m^3/day/system ×3 systems
High-performance ALPS	Oct., 2014	500m^3/day

Overview of ALPS nuclide removal system

■Existing ALPS and additionally installed ALPS remove radionuclides through treatment methods and employ **both physical and chemical properties,** such as adsorption by chemicals, activated carbon and functional materials (adsorbents).



Existing ALPS system diagram (Systems A,B and C have the same configuration)

Role of main equipment in existing ALPS and additionally installed ALPS systems

I. Pretreatment equipment

①Iron coprecipitation equipment (existing ALPS only) : Removing alpha nuclides, heavy metals, etc. with iron coprecipitation

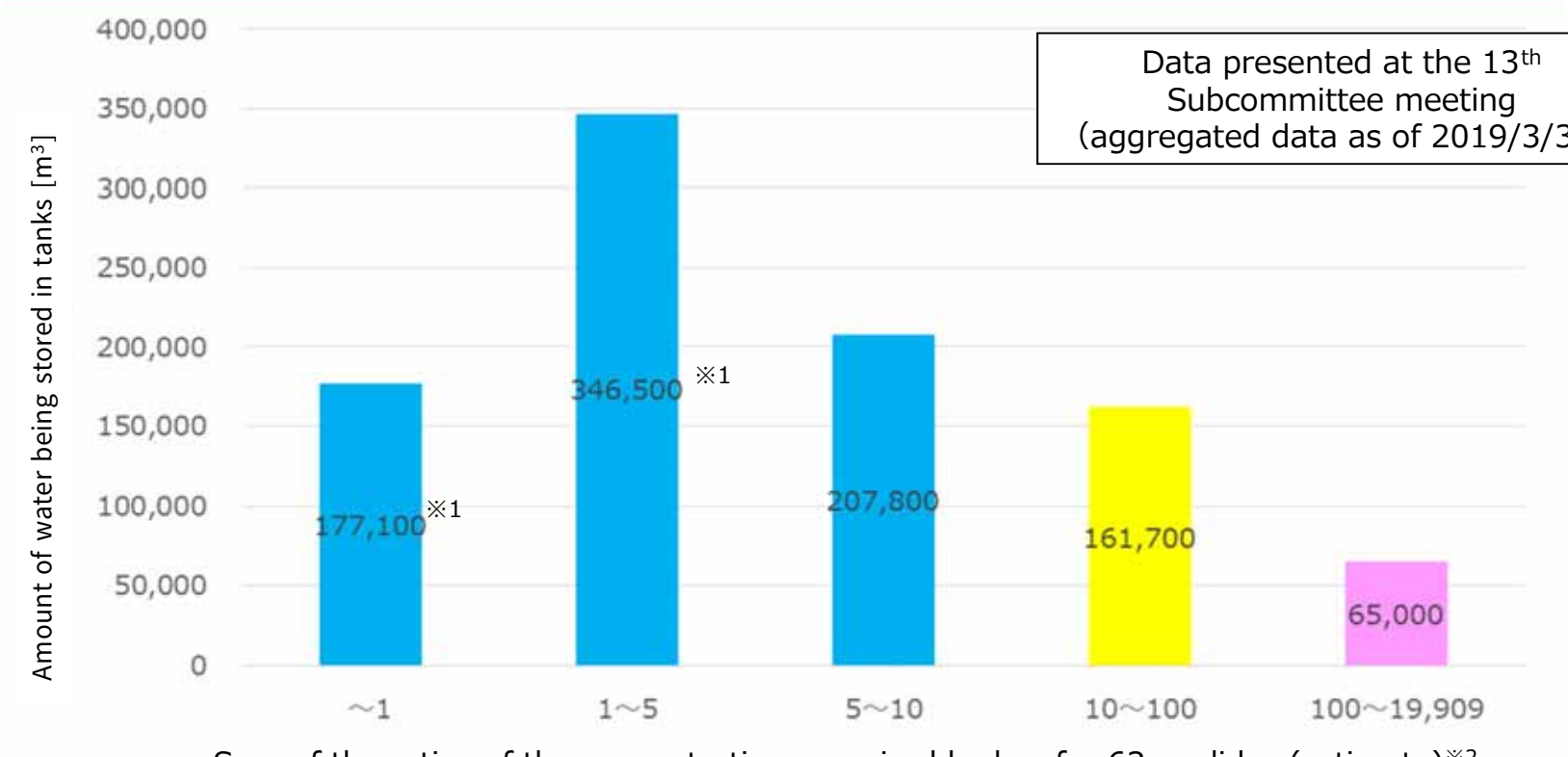
②Carbonate precipitation treatment equipment : Removing Mg ions, Ca ions, etc. which block Sr-adsorption in order to enhance the Sr removal performance of adsorption towers.

※Crossflow filters (pore diameter:20nm) in the pretreatment equipment remove fine particles from water to be treated.

II. Multi-nuclide removal equipment

③Adsorption towers, etc. : Removes ionic and colloidal nuclides (Cs, Sr, I, Sb, etc.) using multiple types of adsorbents.

Amount of ALPS-treated water being stored broken down by the sum (estimate) of the ratios of the concentrations required by law for 62 nuclides (as of the 13th Subcommittee meeting)

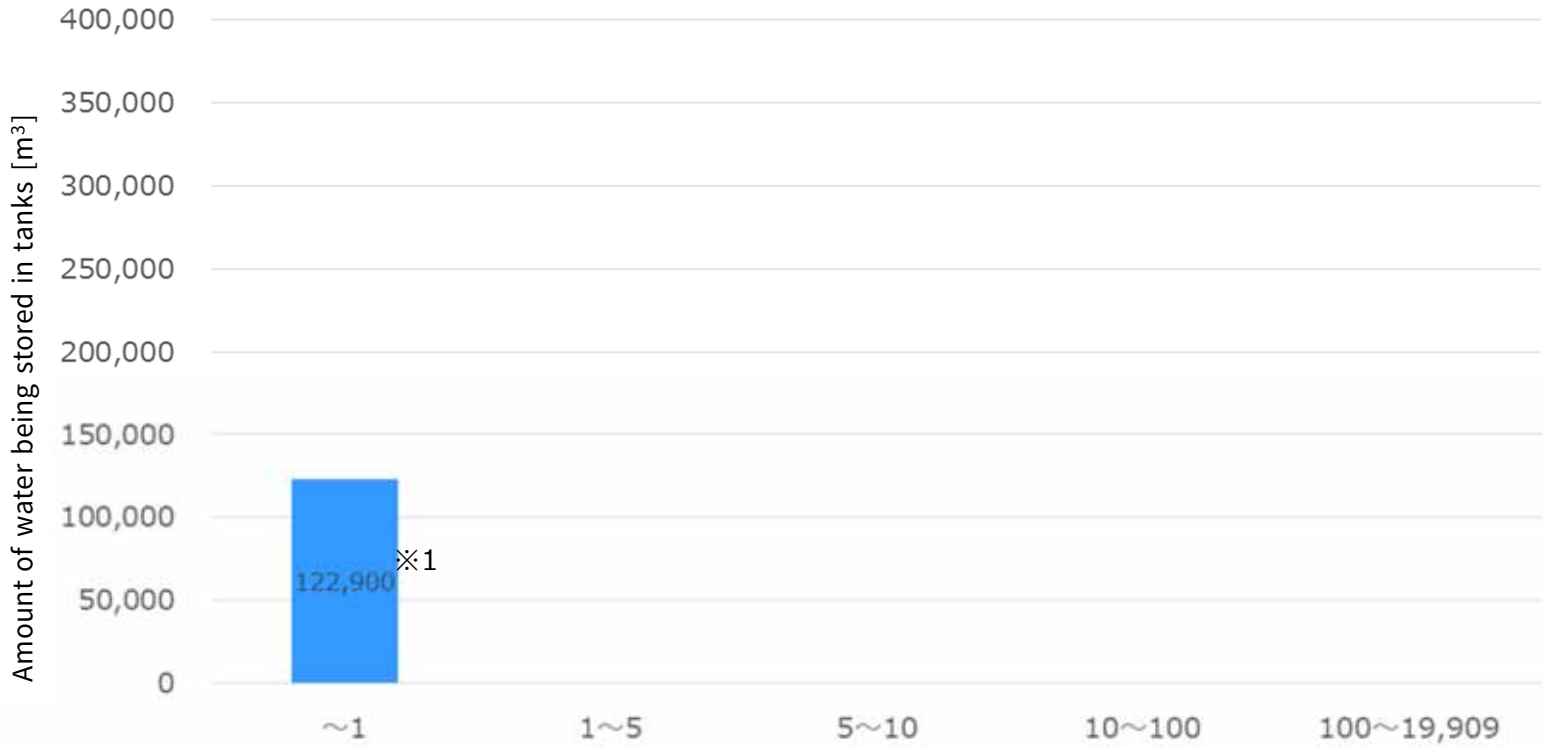


※1 Includes increased amount from the additional transfer of ALPS-treated water in conjunction with change in equipment operation water level (from Oct. 2018). The sum of the ratios of the concentrations required by law (estimate) for the tank group in question is the same as before the additional transfer of ALPS-treated water because the additional amount is small.

※2 Sum of the ratios of the concentrations required by law for seven primary radionuclides (Cs-134,Cs-137,Sr-90,I-129,Ru-106,Co-60,Sb-125) at the ALPS outlet plus 0.3, which is the estimated ratio of the concentrations required by law for the other nuclides.

※3 An event occurred in FY2013 in which slurry from carbonate precipitation treatment escaped through the equipment outlet due to existing ALPS crossflow filter trouble.

Amount of ALPS-treated water being stored broken down by the sum (estimate) of the ratios of the concentrations required by law for 62 nuclides (after the 13th Subcommittee meeting)



※1 Amount of water stored in tank areas which have become full during the period from the data collection date for the 13th Subcommittee meeting (March 31, 2019) to 2019/12/31.

※2 Sum of the ratios of the concentrations required by law for seven primary radionuclides (Cs-134,Cs-137,Sr-90,I-129,Ru-106,Co-60,Sb-125) at the ALPS outlet plus 0.3, which is the estimated ratio of the concentrations required by law for the other nuclides

Radiation concentration estimates for each tank area that has become full during the period from the data collection date for the 13th Subcommittee meeting (March 31, 2019) to 2019/12/31

Figures that exceed the concentrations required by law for each nuclide

Groups for which the sum of the ratios of the concentrations required by law (estimated for 62 nuclides) is less than 1.

B Area

Group	Radiation concentration for each nuclide (estimate)									Sum of the ratios of the concentrations required by law※1 estimated for 62 nuclides
	Cesium-137 Concentration required by law **9.00E+01** [Bq/L]	Cesium-134 Concentration required by law **6.00E+01** [Bq/L]	Cobalt-60 Concentration required by law **2.00E+02** [Bq/L]	Antimony-125 Concentration required by law **8.00E+02** [Bq/L]	Ruthenium-106 Concentration required by law **1.00E+02** [Bq/L]	Strontium-90 Concentration required by law **3.00E+01** [Bq/L]	Iodine-129 Concentration required by law **9.00E+00** [Bq/L]	Tritium-3 Concentration required by law **6.00E+04** [Bq/L]	Gross beta(β) [Bq/L]	
D	1.55E-01	2.08E-01	2.61E-01	5.63E-01	1.38E+00	8.97E-02	4.67E-01	5.49E+05	5.50E+00	0.38

G6 Area

A	6.21E-01	1.76E-01	1.73E+00	4.66E-01	1.52E+00	3.12E-01	4.43E-01	1.11E+06	2.12E+01	0.39
B	1.39E-01	1.73E-01	1.43E+00	4.55E-01	1.19E+00	8.34E-02	1.41E+00	1.11E+06	1.76E+01	0.48
C	1.29E-01	1.90E-01	4.30E-01	4.64E-01	1.21E+00	9.11E-02	1.72E+00	7.46E+05	1.40E+01	0.51

H3 Area

A	2.85E-01	1.59E-01	8.22E-01	4.43E-01	1.45E+00	5.75E-01	7.16E-01	8.48E+05	1.76E+01	0.42
B	2.88E-01	1.59E-01	8.34E-01	4.44E-01	1.60E+00	5.69E-01	7.23E-01	8.55E+05	1.82E+01	0.43

※1 The sum of the estimated ratios of the concentrations required by law for primary radionuclides (Cesium-137, Cesium-134, Cobalt-60, Antimony-125, Ruthenium-106, Strontium-90 and Iodine-129) and 0.3, which is the estimated ratio of the concentrations required by law for the other nuclides included in the 62 nuclides.

【Reference】Value notation for radioactive concentrations, etc.
(e.g.) 4.16E+01 = 4.16×10^{1} = 41.6
4.16E−01 = 4.16×10^{-1} = 0.416

Radiation concentration estimates for each tank area that has become full during the period from the data collection date for the 13th Subcommittee meeting (March 31, 2019) to 2019/12/31

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Figures that exceed the concentrations required by law for each nuclide

Groups for which the sum of the ratios of the concentrations required by law (estimated for 62 nuclides) is less than 1.

H5 Area

Group	Radiation concentration for each nuclide (estimate)									Sum of the ratios of the concentrations required by law※1 estimated for 62 nuclides
	Cesium-137 Concentration required by law **9.00E+01** [Bq/L]	Cesium-134 Concentration required by law **6.00E+01** [Bq/L]	Cobalt-60 Concentration required by law **2.00E+02** [Bq/L]	Antimony-125 Concentration required by law **8.00E+02** [Bq/L]	Ruthenium-106 Concentration required by law **1.00E+02** [Bq/L]	Strontium-90 Concentration required by law **3.00E+01** [Bq/L]	Iodine-129 Concentration required by law **9.00E+00** [Bq/L]	Tritium-3 Concentration required by law **6.00E+04** [Bq/L]	Gross beta(β) [Bq/L]	
A	1.52E-01	1.96E-01	1.44E+00	4.94E-01	1.52E+00	8.96E-02	2.05E+00	1.03E+06	1.94E+01	0.56
B	1.52E-01	1.98E-01	1.44E+00	5.99E-01	1.51E+00	9.01E-02	2.07E+00	1.03E+06	1.94E+01	0.56
C	1.51E-01	2.02E-01	1.47E+00	6.00E-01	1.51E+00	8.84E-02	2.00E+00	1.05E+06	1.96E+01	0.55

H6(Ⅱ) Area

A	1.53E-01	1.98E-01	1.80E+00	5.09E-01	1.24E+00	8.53E-02	2.23E+00	1.18E+06	1.96E+01	0.58
B	1.45E-01	2.00E-01	1.12E+00	9.58E-01	1.79E+00	8.63E-02	2.72E+00	7.81E+05	1.44E+01	0.63
C	2.62E-01	2.22E-01	1.06E+00	5.58E-01	1.29E+00	2.40E-01	4.04E-01	1.19E+06	1.97E+01	0.38

※1 The sum of the estimated ratios of the concentrations required by law for primary radionuclides (Cesium-137, Cesium-134, Cobalt-60, Antimony-125, Ruthenium-106, Strontium-90 and Iodine-129) and 0.3, which is the estimated ratio of the concentrations required by law for the other nuclides included in the 62 nuclides.

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(e.g.) 4.16E+01 = 4.16×10^{1} = 41.6
4.16E−01 = 4.16×10^{-1} = 0.416

ALPS-treated water stored in the future

- The latest concentrations of ALPS-treated water at the ALPS outlet are less than the concentration limit required by law. We intend to continuously keep the sum of the ratios of concentrations required by law less than 1 by remaining aware of the concentration limits required by law when engaging in treatment.
- At the same time, a plan to reuse tanks that were used for Sr-treated water (water before treatment by ALPS) as tanks for ALPS-treated water is underway. We will look into the impacts on the ratio of concentrations required by law of such reuse.

- Plan for repurposing tanks for Sr-treated water as tanks for ALPS-treated water
  - We plan to repurpose tanks for Sr-treated water (water before treatment by ALPS) for ALPS-treated water in order to secure 1.37million m^3 of tank storage capacity by the end of December, 2020.
  - When tanks were repurposed (changed from Sr-treated water tanks to ALPS-treated water tanks) in FY2015, ALPS-treated water was injected into tanks in which Sr-treated water and sludge remained at the bottom because securing storage capacity was the priority in light of the large amount of contaminated water being generated in those days. (Ratios of the concentrations required by law are more than 100. Refer to the figure on page 3.)
  - When these tanks (93 tanks; approx. 97,000m^3) will be repurposed for ALPS-treated water (transfer planned to start around March 2020), sludge will be removed and the bottoms of the tanks will be cleaned before injecting ALPS-treated water. The sum of the ratios of the concentrations required by law are expected to be lower than when the tanks were repurposed previously. However, it is expected to be higher than concentrations at the ALPS outlet due to radioactive materials that remain in the tanks. The impact on the ratios of the concentrations required by law will be checked after ALPS-treated water is injected.
  - When discharging ALPS-treated water into the environment, water for which the sum of the ratios of the concentrations required by law is confirmed by actual measurement to exceed 1 will be subject to secondary treatment.

Repurposing of tanks for Strontium-treated water

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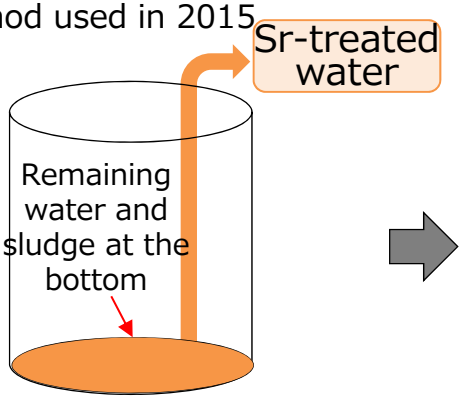
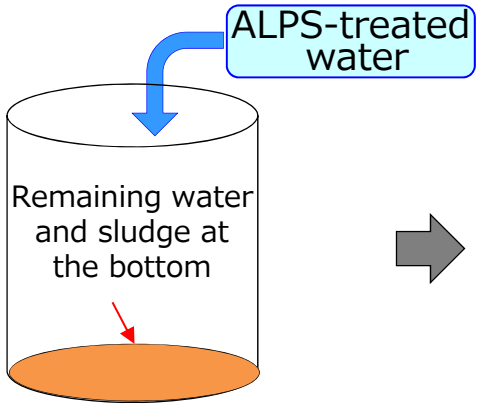
■ Method used in 2015



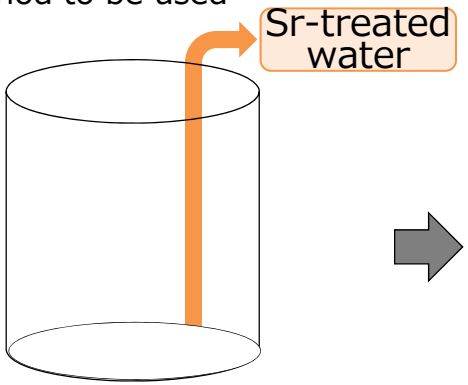
Draining Sr-treated water



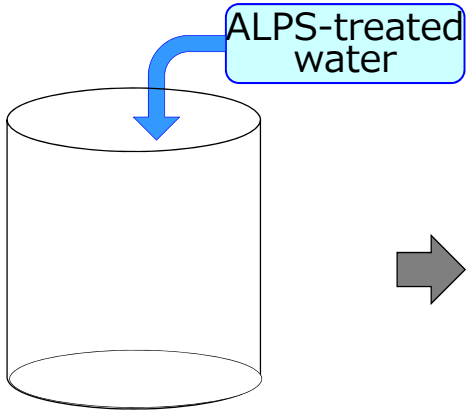
ALPS-treated water was injected into the tanks where Sr-treated water and sludge remained.

ALPS-treated water was mixed with remaining Sr-treated water and sludge.
Sum of the ratios of the concentrations required by law exceeded100.

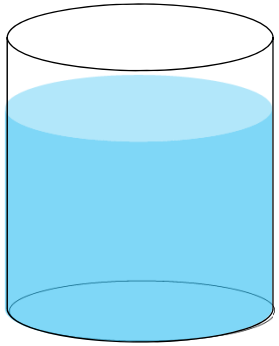
■ Method to be used



Draining Sr-treated water, removing sludge and cleaning bottom

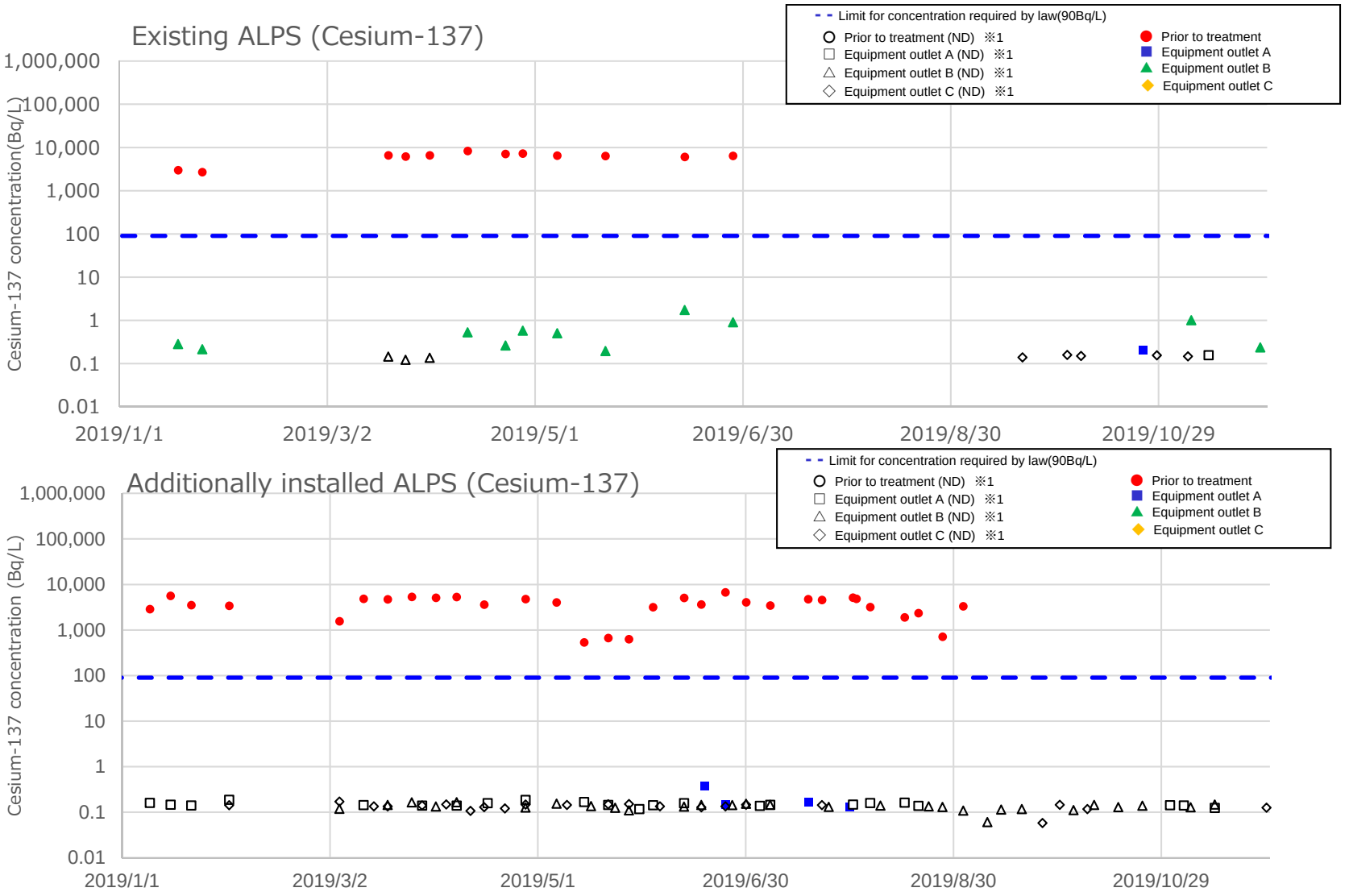


ALPS-treated water is injected.



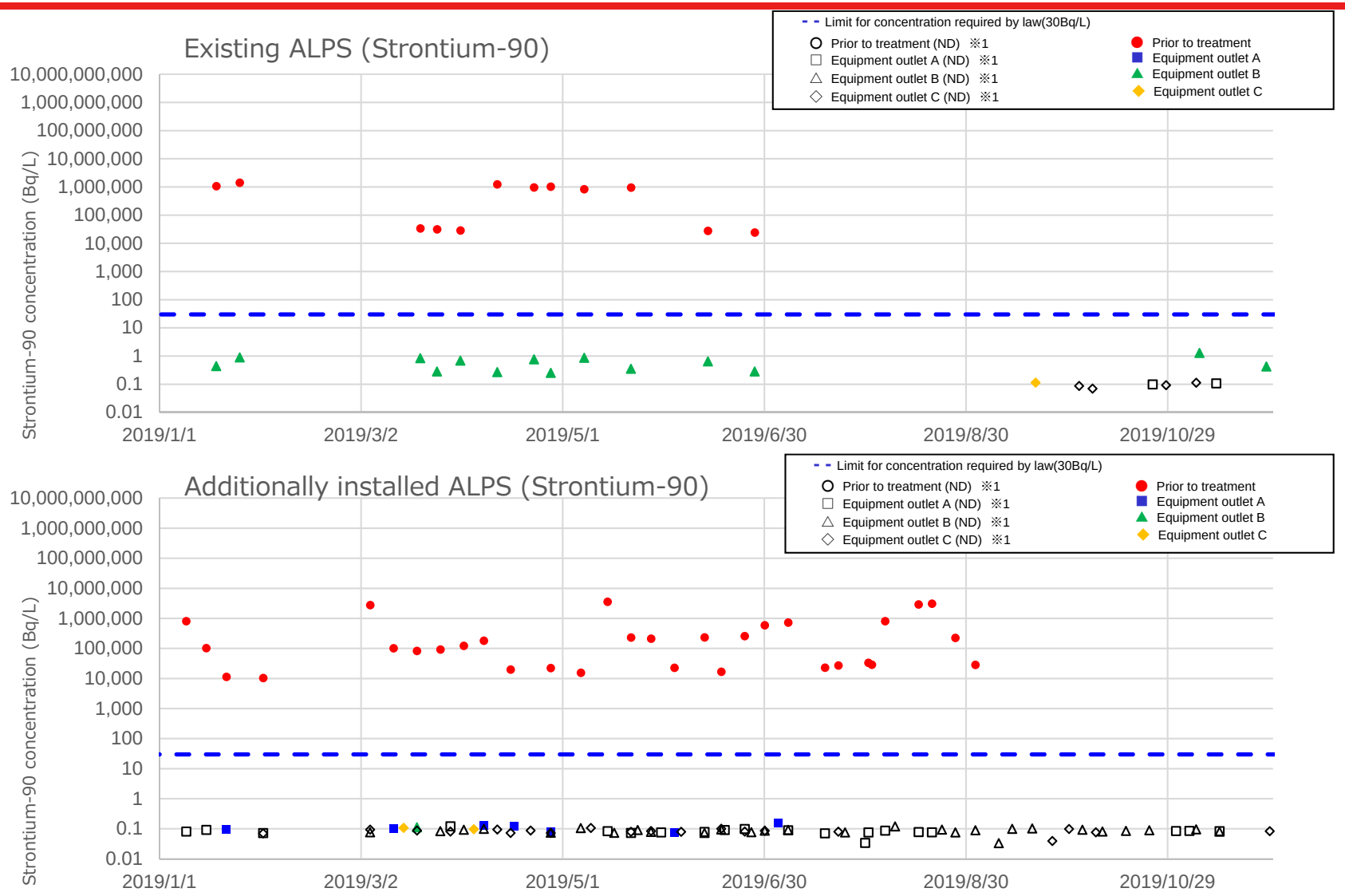
Sum of the ratios of the concentrations required by law can be kept lower compared to the former method.

Latest radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Cesium-137 concentration)



※1 “ND” means that concentrations were below detectable limits.
※2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Latest radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Strontium-90 concentration)



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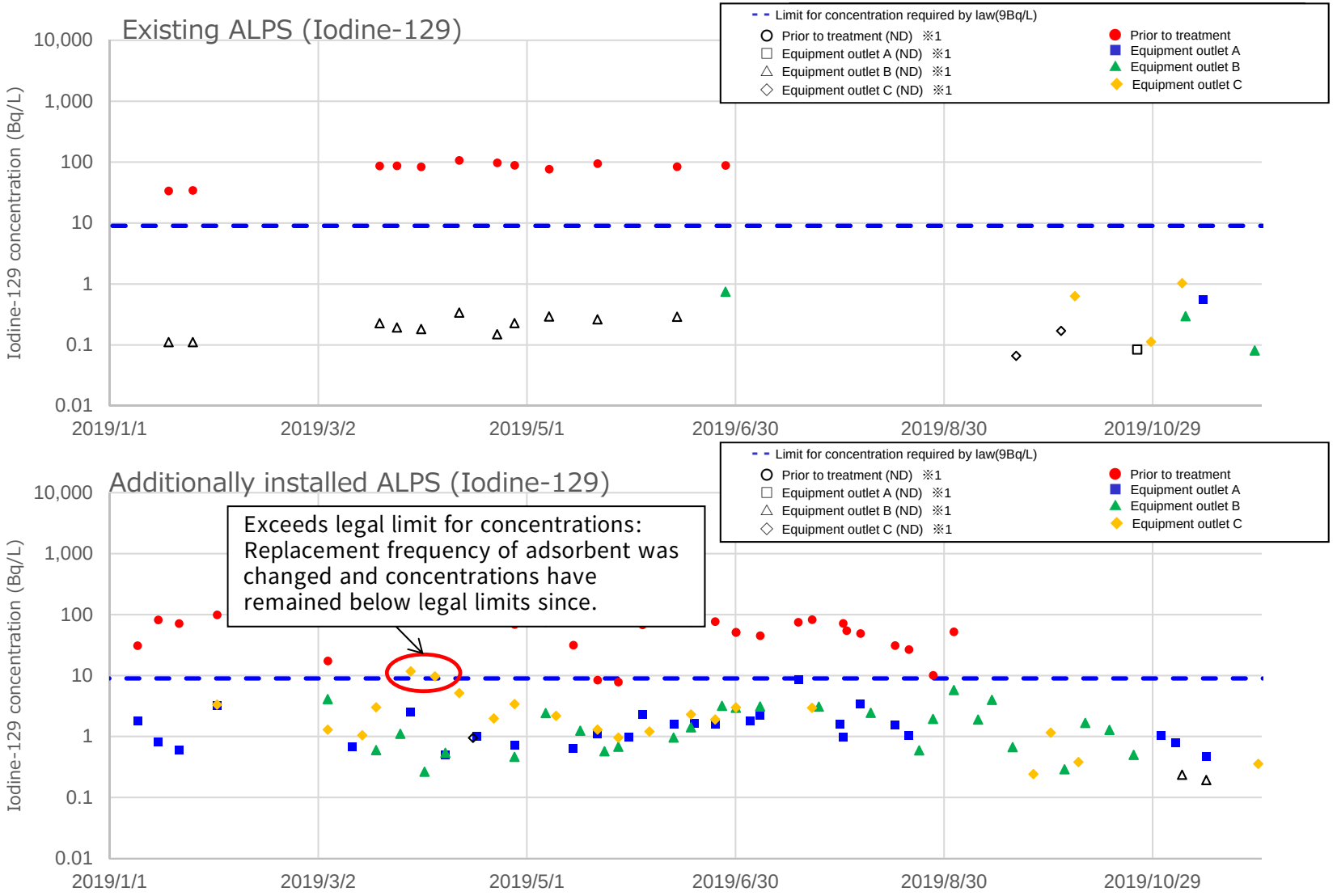
※2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Latest radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Iodine-129 concentration)



※1 "ND" means that concentrations were below detectable limits.
※2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Update of Treated Water Portal Site data

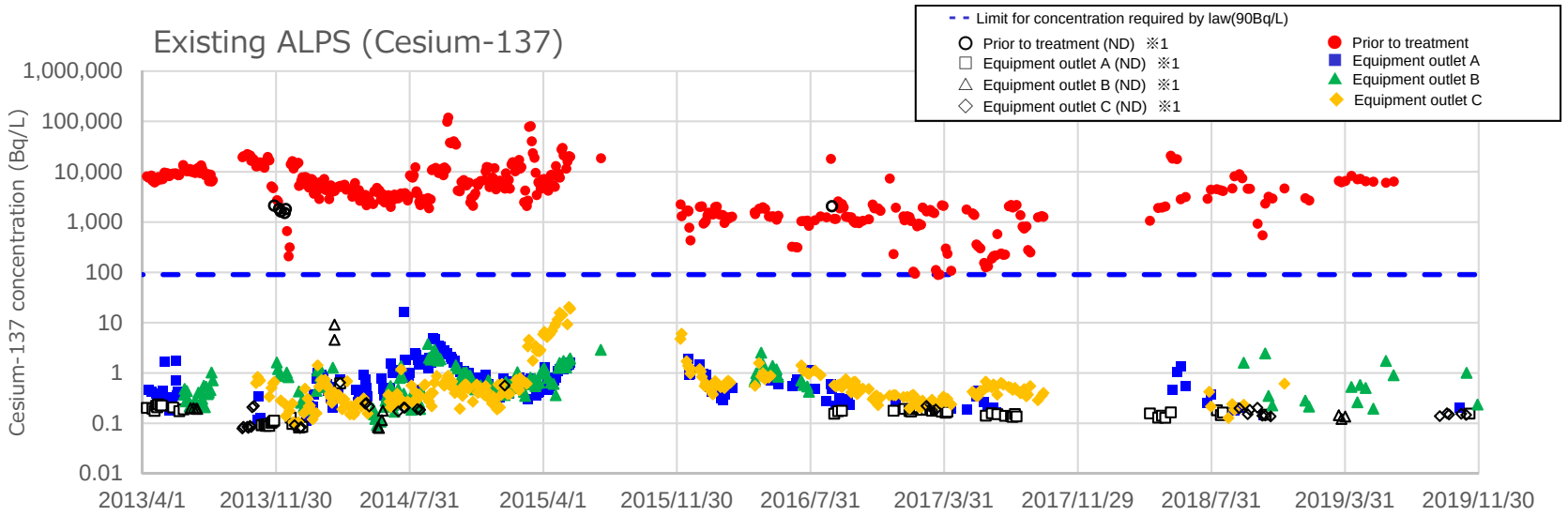
- As reported at the 11th Subcommittee on the Handling of ALPS Treated Water on November 30, 2018, we have created a “Treated Water Portal Site” to disclose information about treated water, which is of considerable public interest, in an easy-to-understand manner.
  - Japanese PC version launched on December 10, 2018
  - Japanese smartphone version launched on February 15, 2019
  - English PC version launched on January 21, 2019
  - English smartphone version launched on February 28, 2019

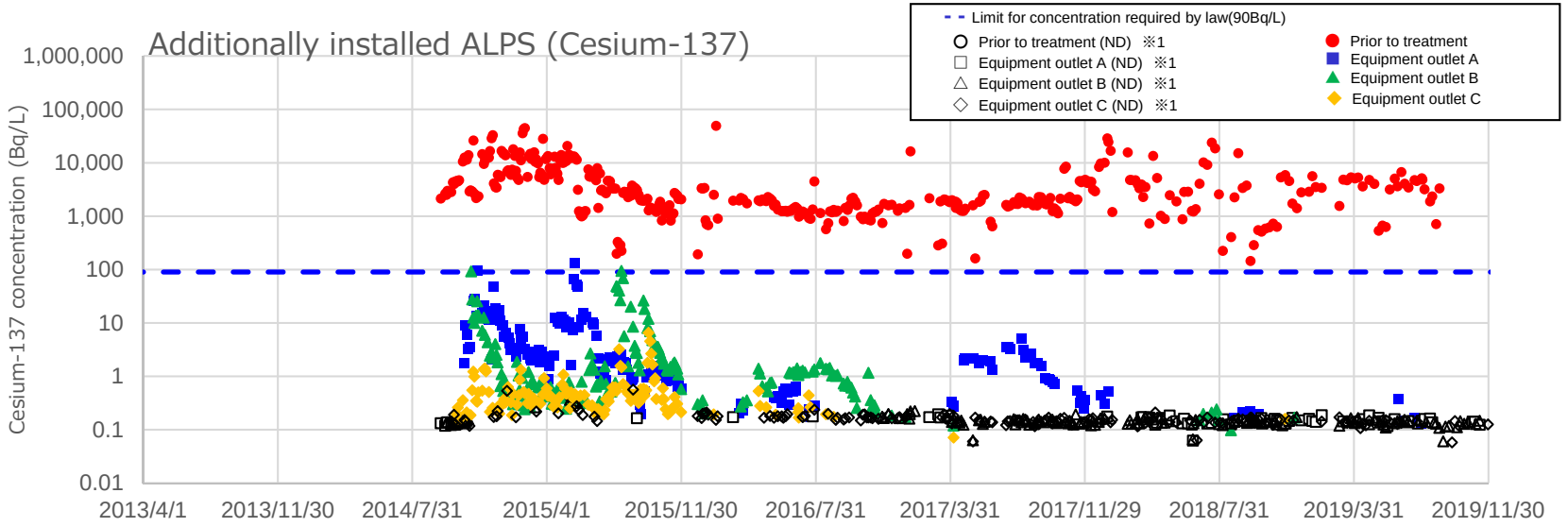
- We plan to update data on the amount of water treated with multi-nuclide removal equipment etc. every quarter. Data as of September 30, 2019 has already been uploaded to the portal site. (updated on November 26, 2019)

- Data as of December 31, 2019 will be posted by the end of February, 2020.

【Reference】
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (as of November 30, 2019)

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Cesium-137 concentration)





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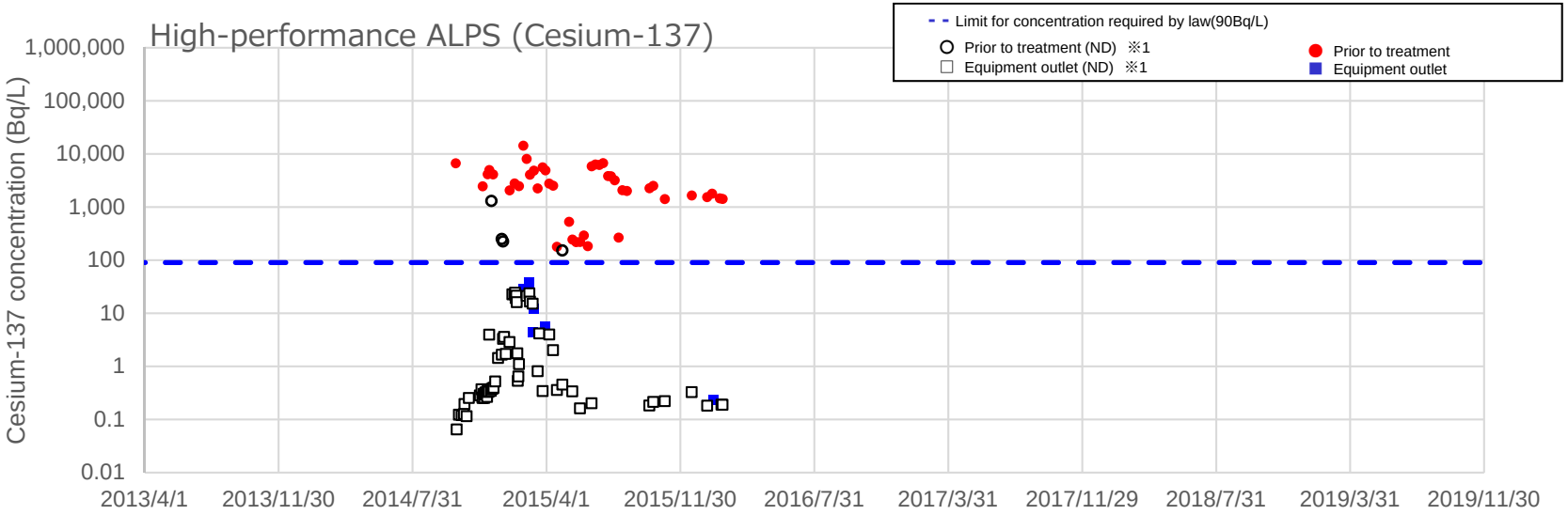
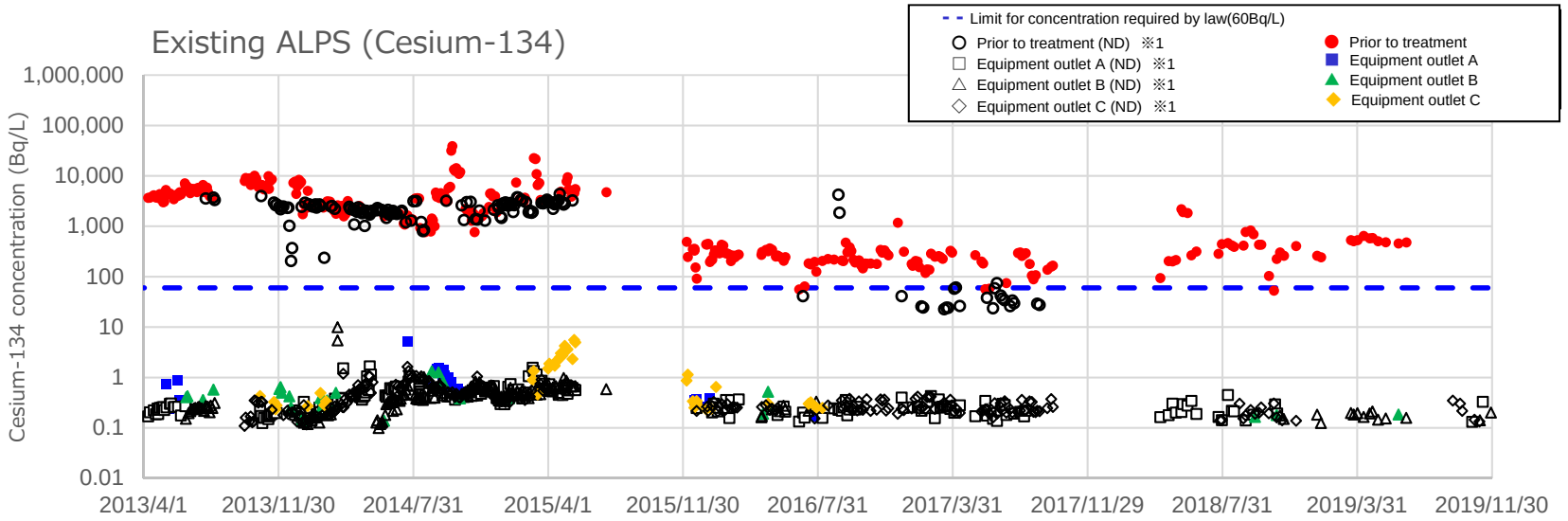
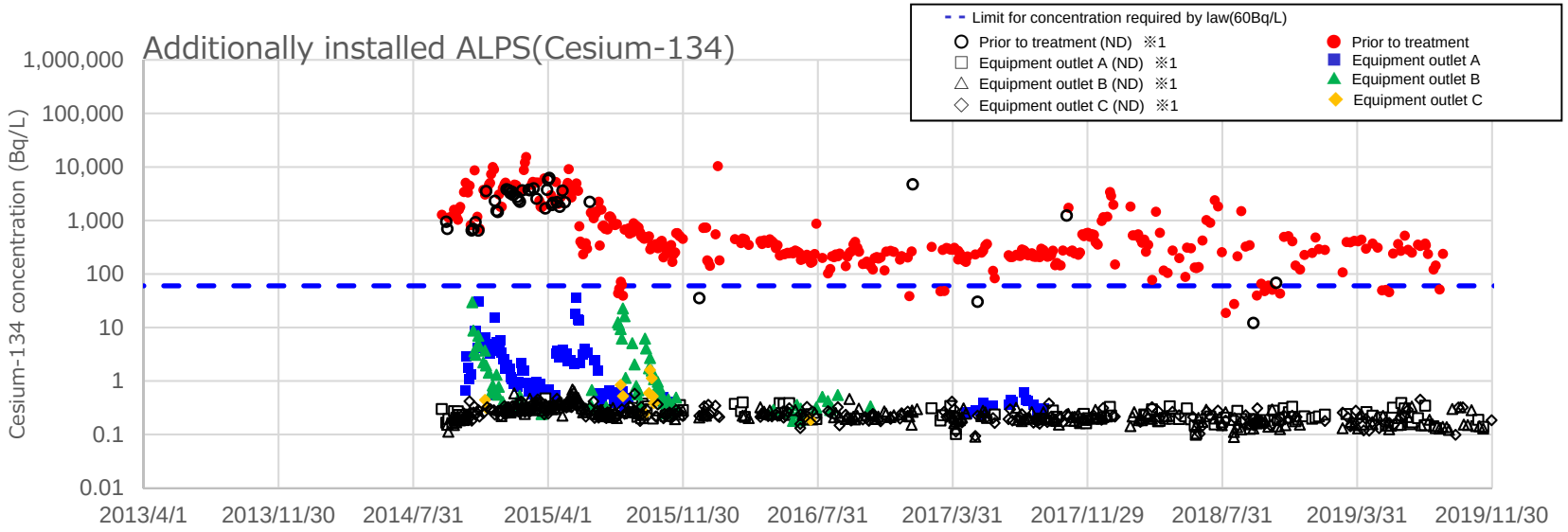
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Cesium-137 concentration)



※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Cesium-134 concentration)





※ 1 “ND” means that concentrations were below detectable limits.
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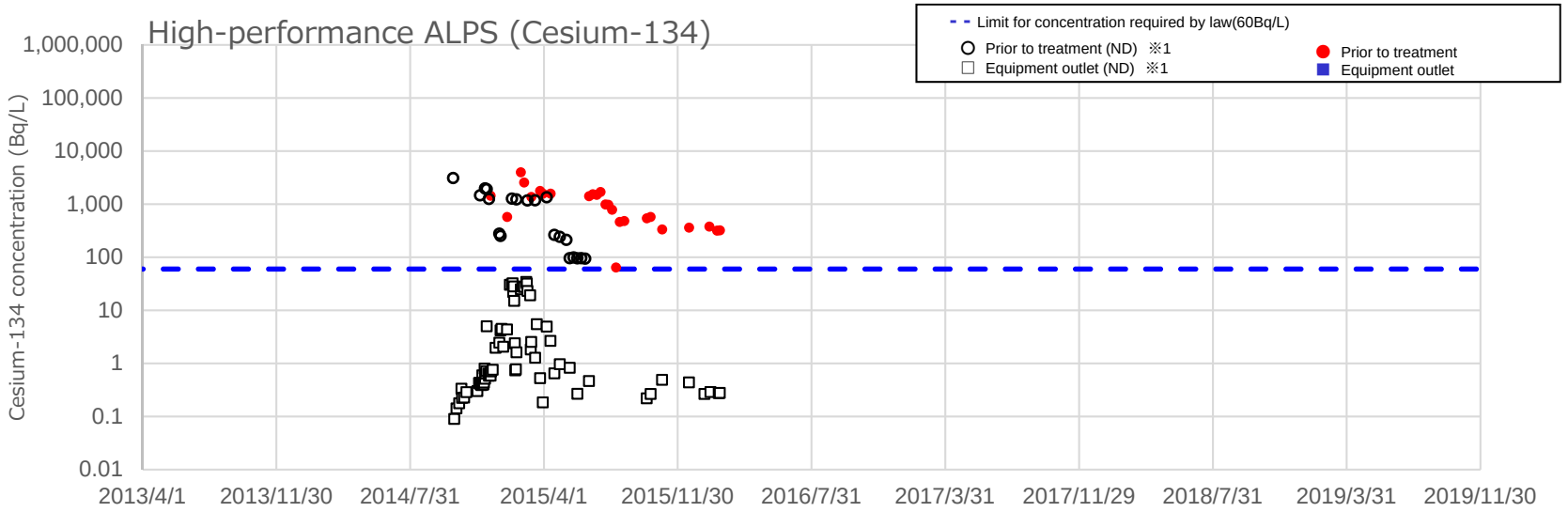
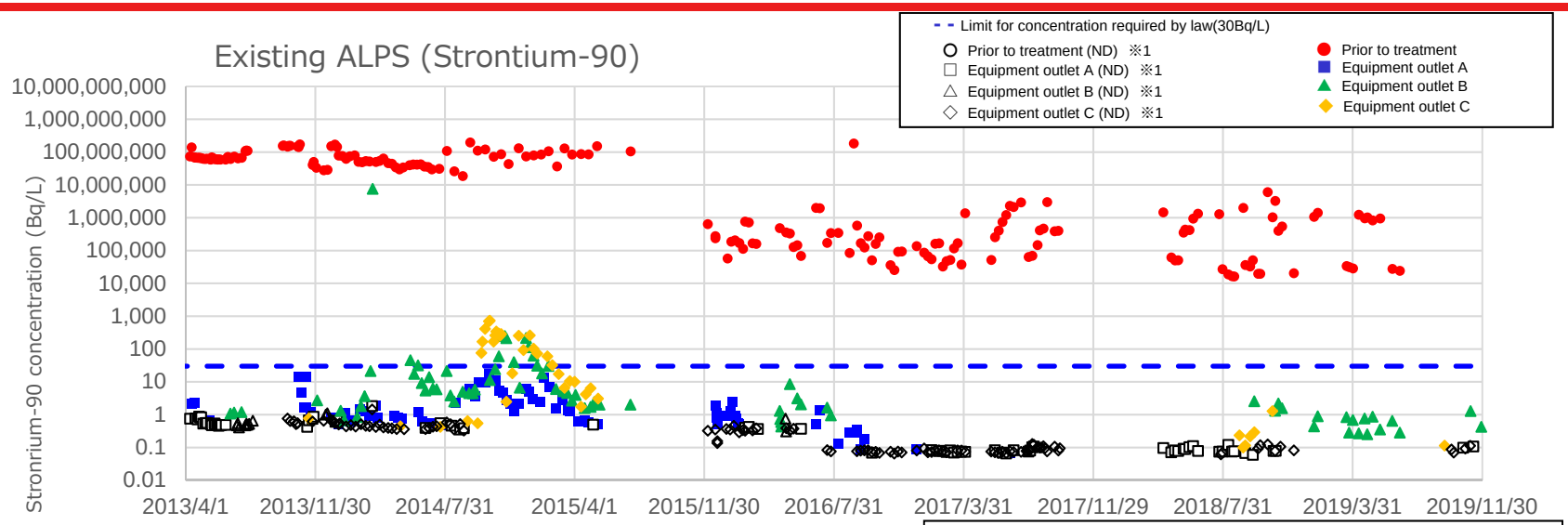
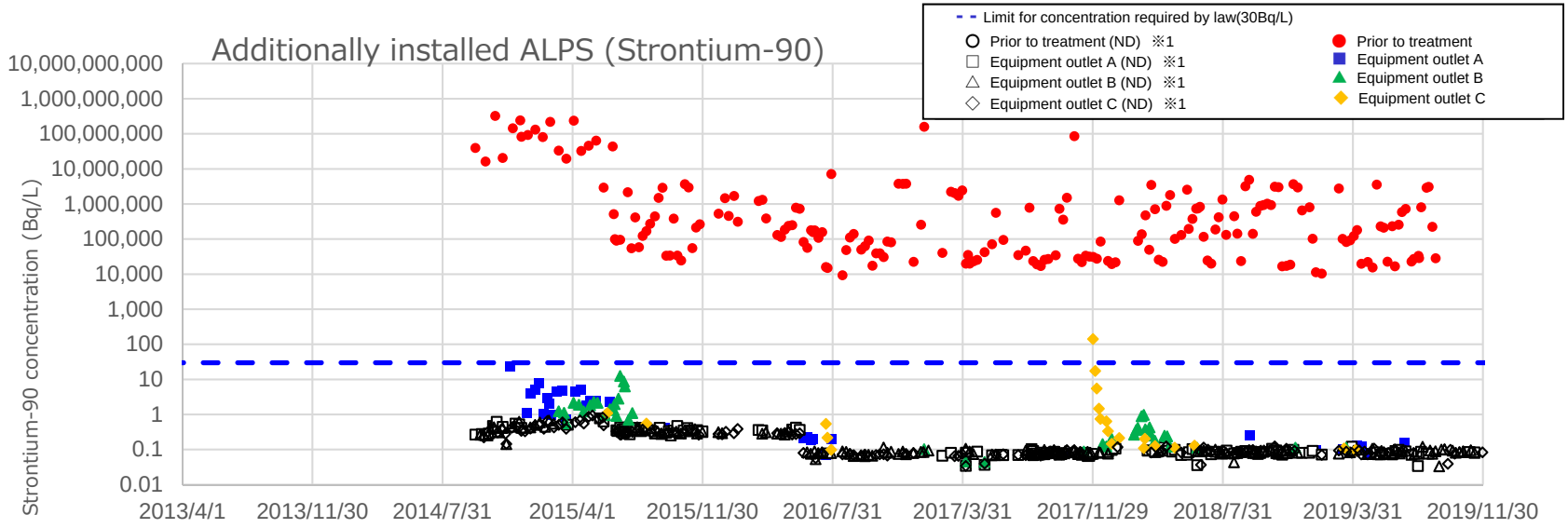
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Cesium-134 concentration)



※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Strontium-90 concentration)





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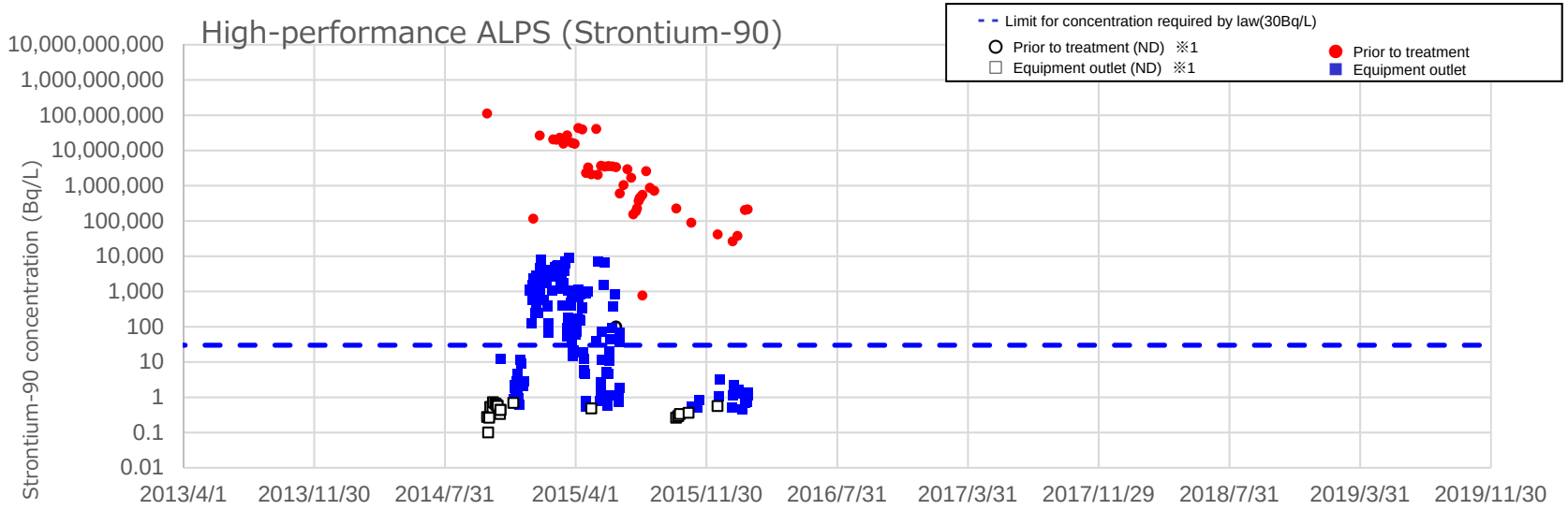
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Strontium-90 concentration)



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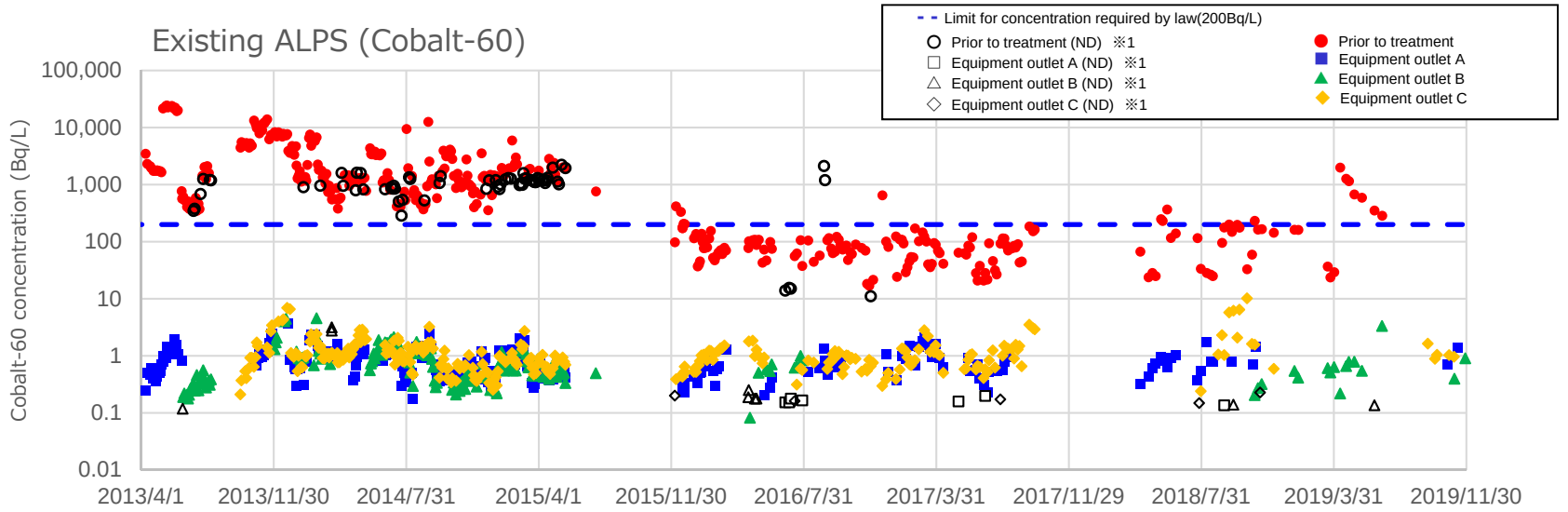
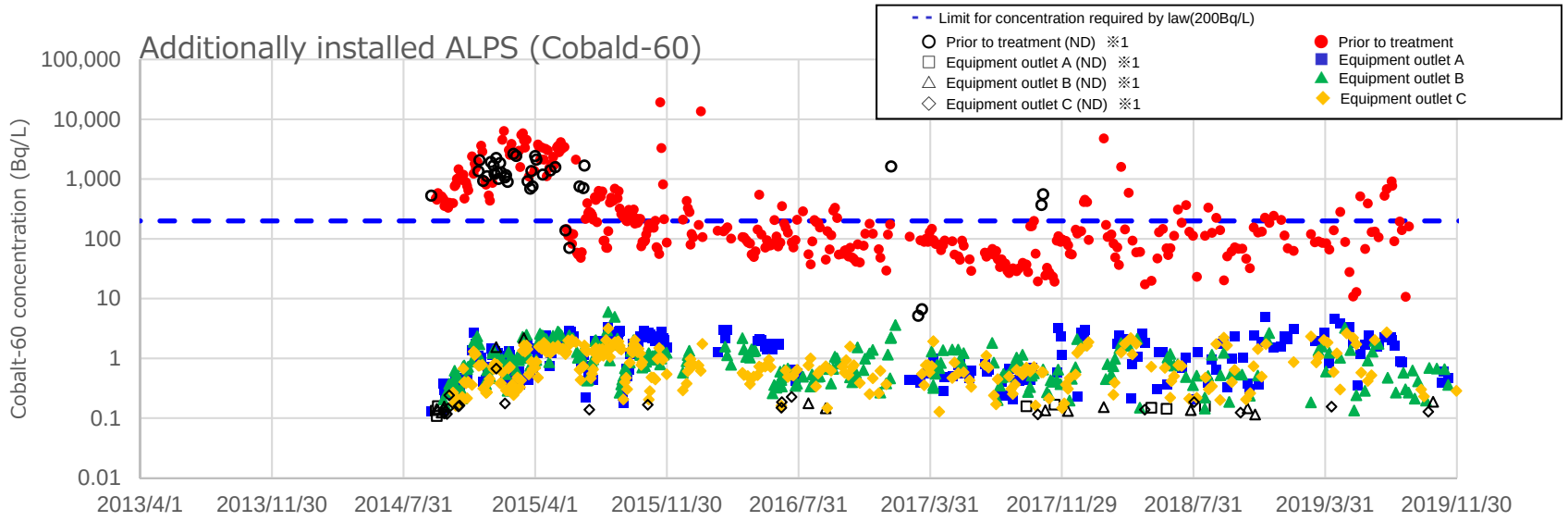
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Cobalt-60 concentration)





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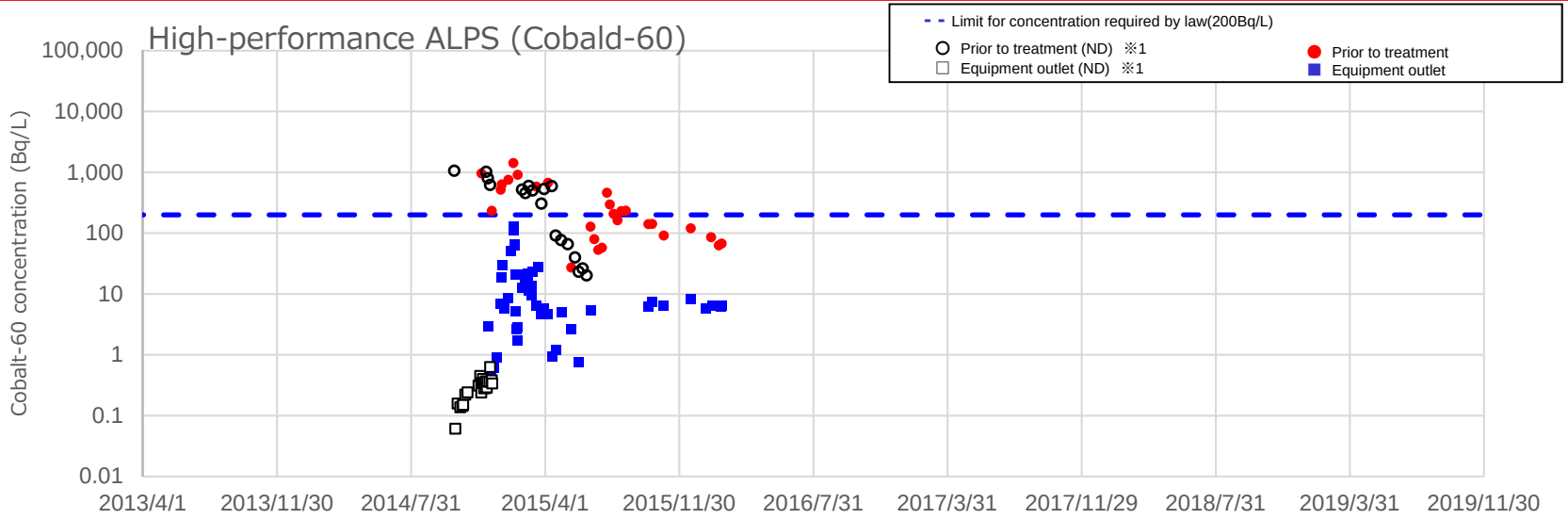
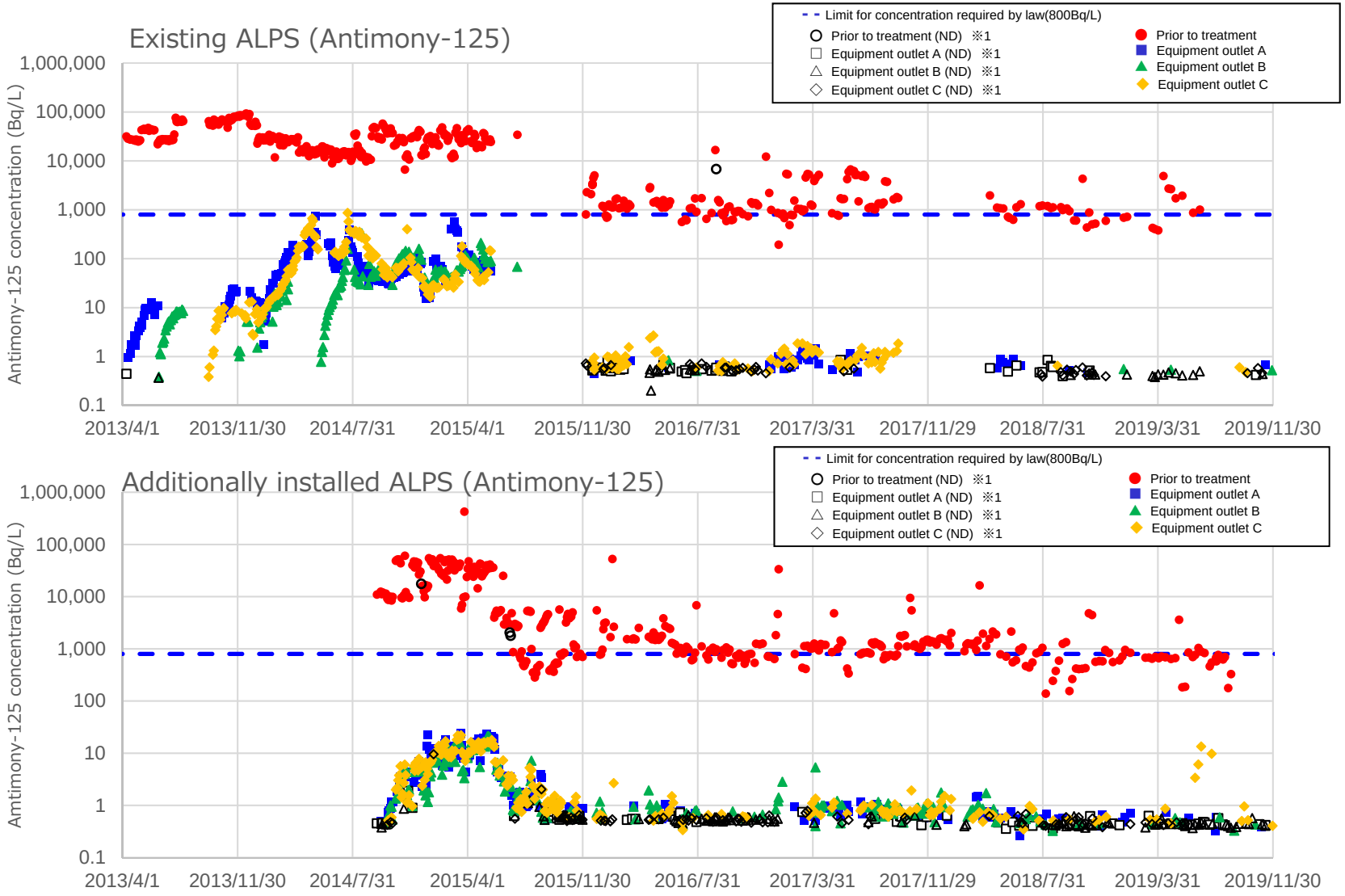
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Cobalt-60 concentration)



※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Antimony-125 concentration)



※ 1 “ND” means that concentrations were below detectable limits.
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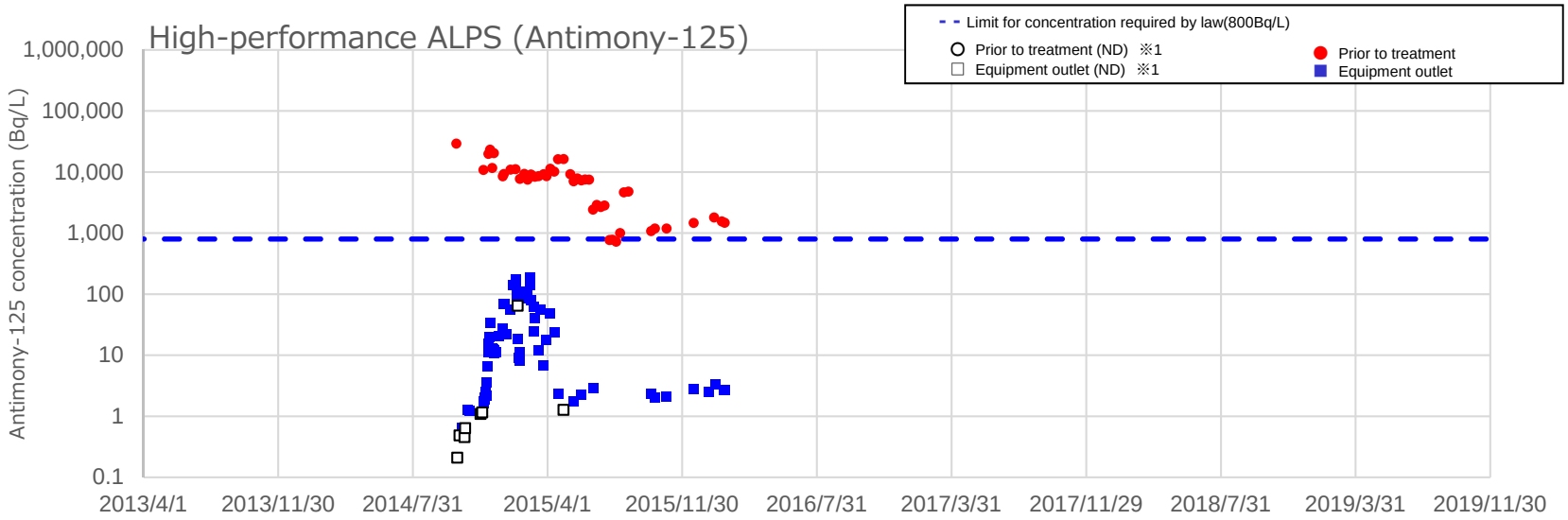
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Antimony-125 concentration)



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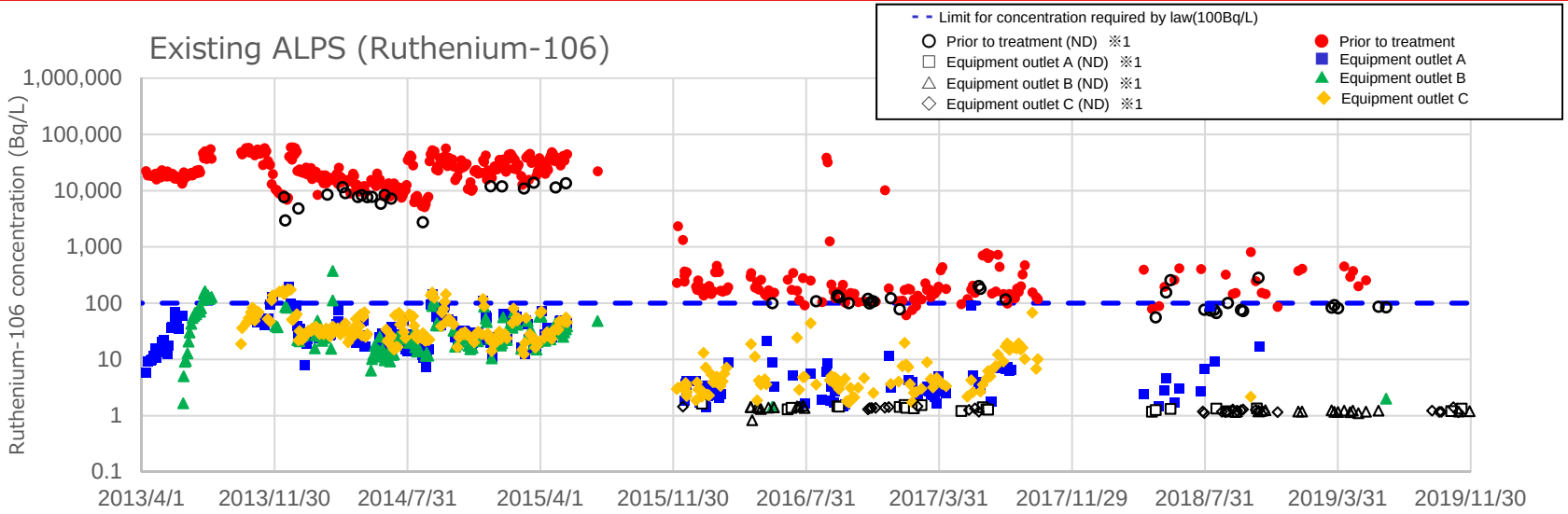
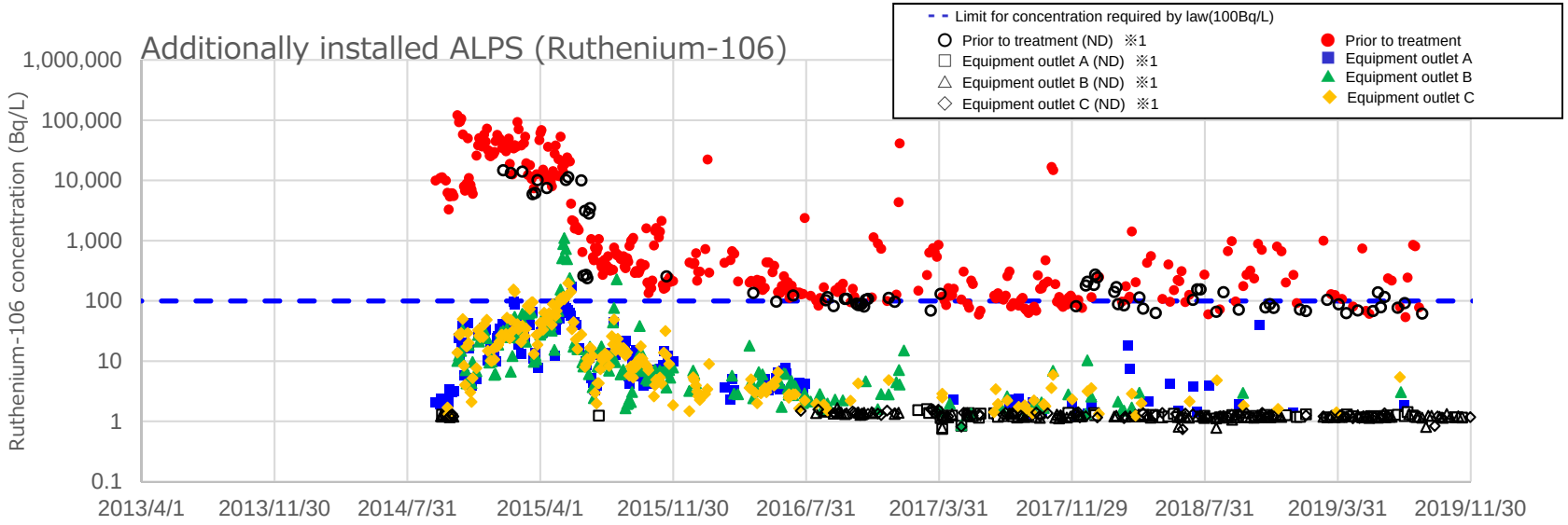
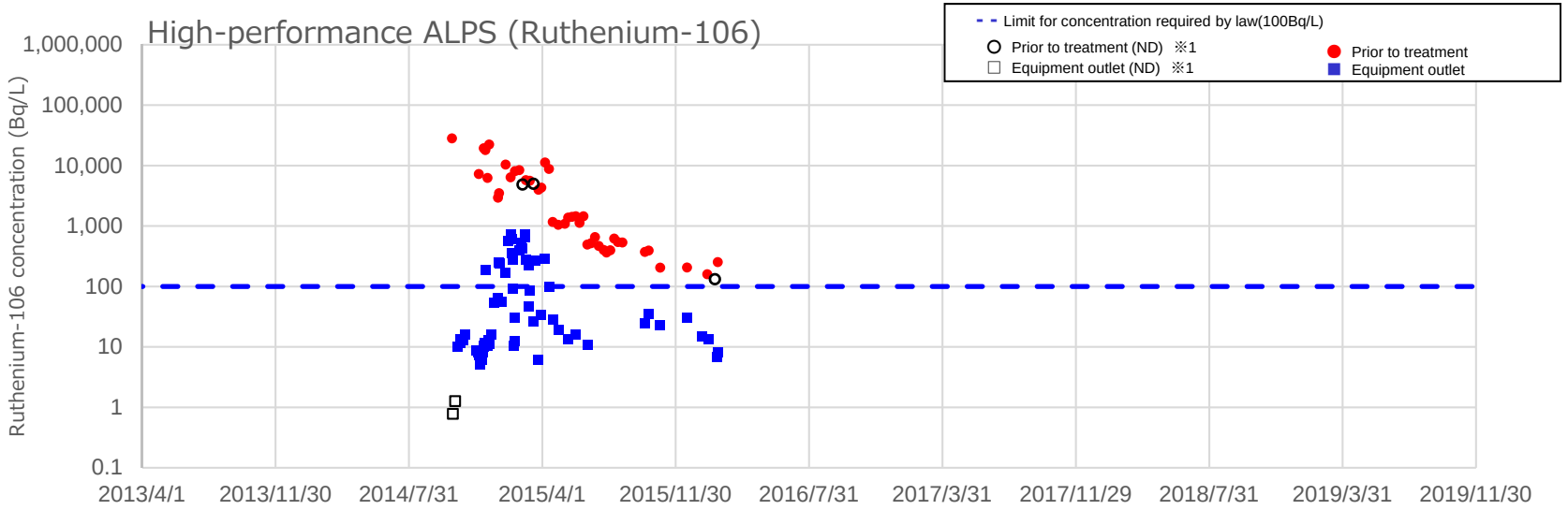
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Ruthenium-106 concentration)





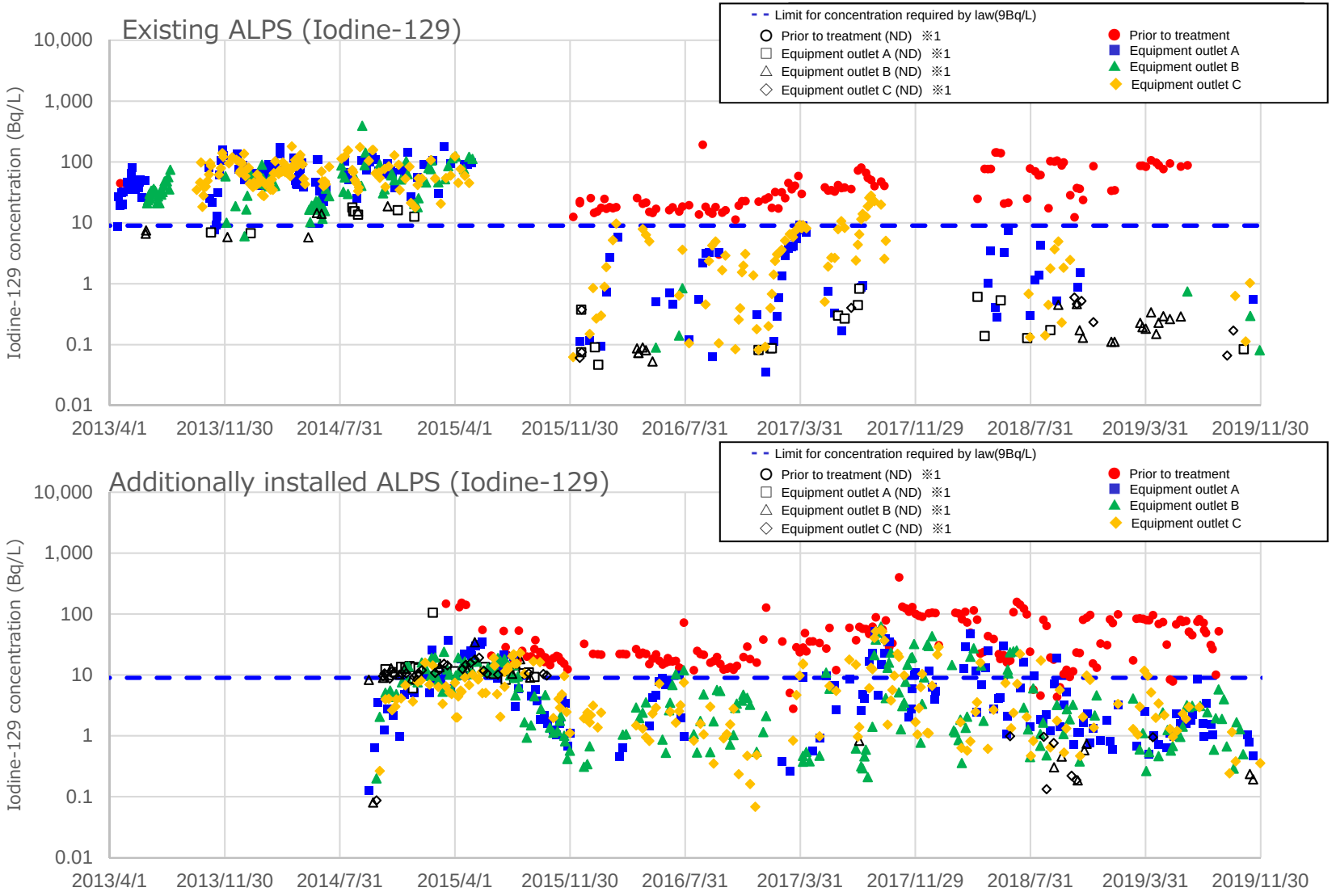
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Ruthenium-106 concentration)



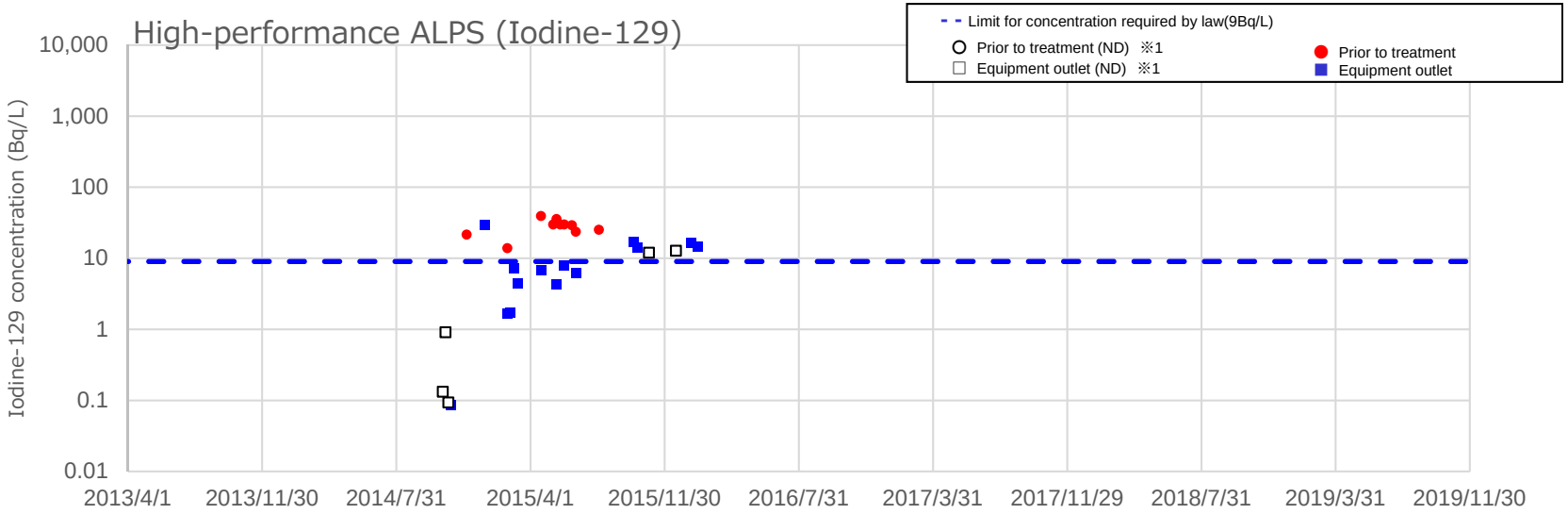
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Iodine-129 concentration)



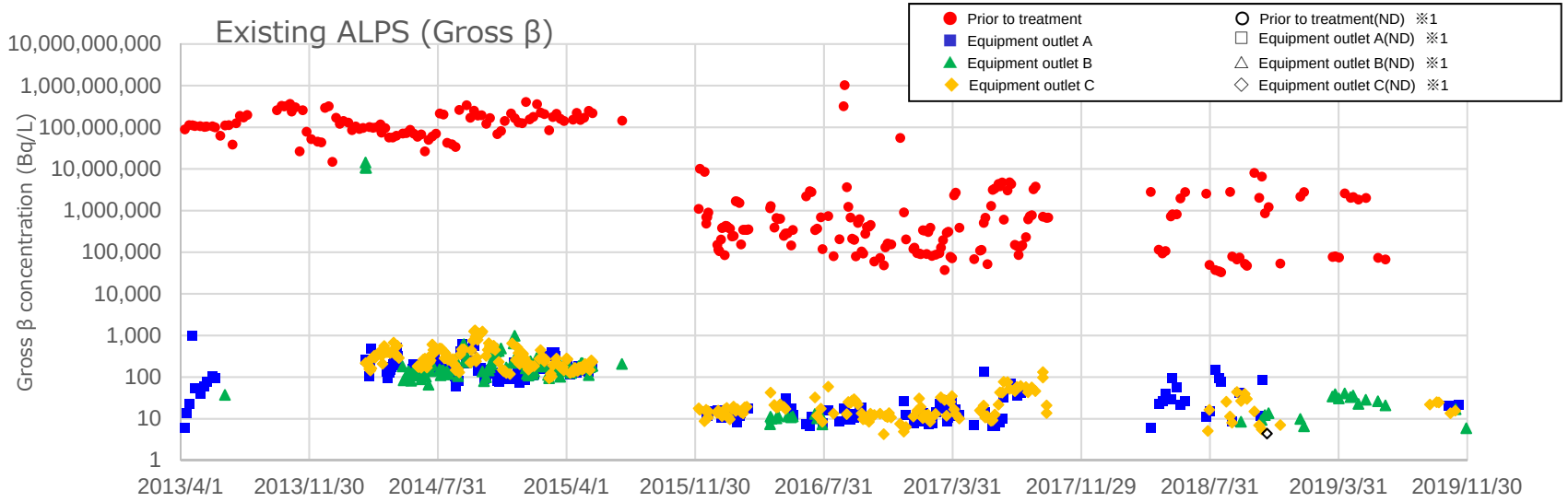
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

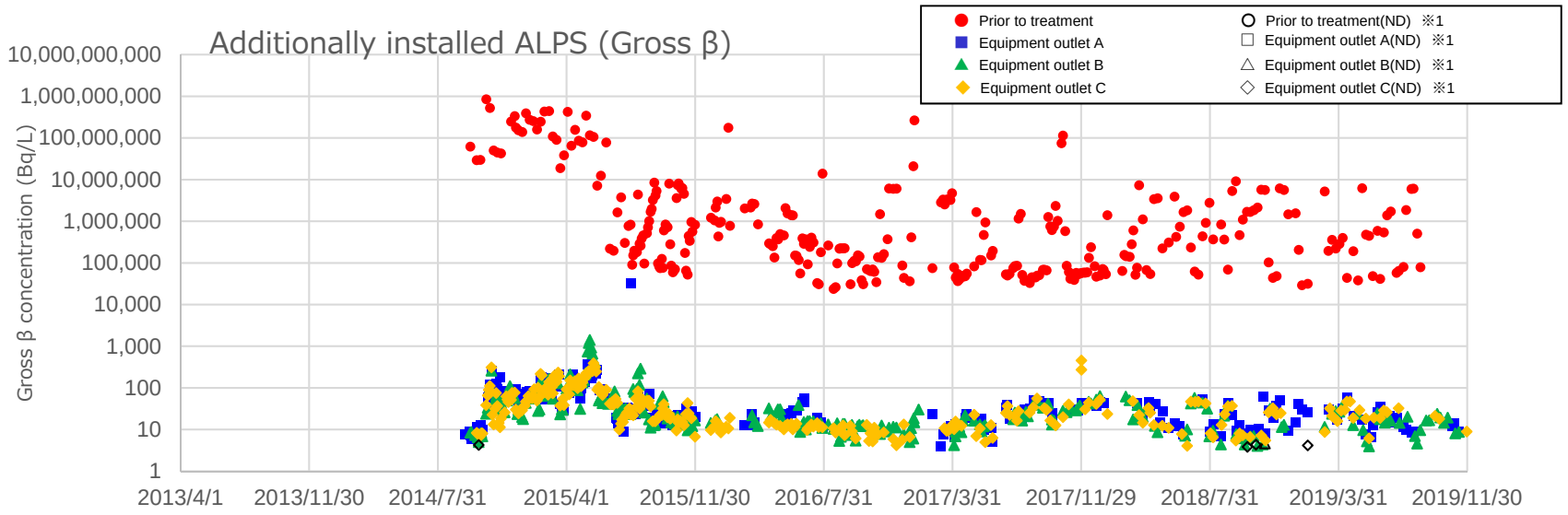
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Iodine-129 concentration)



※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

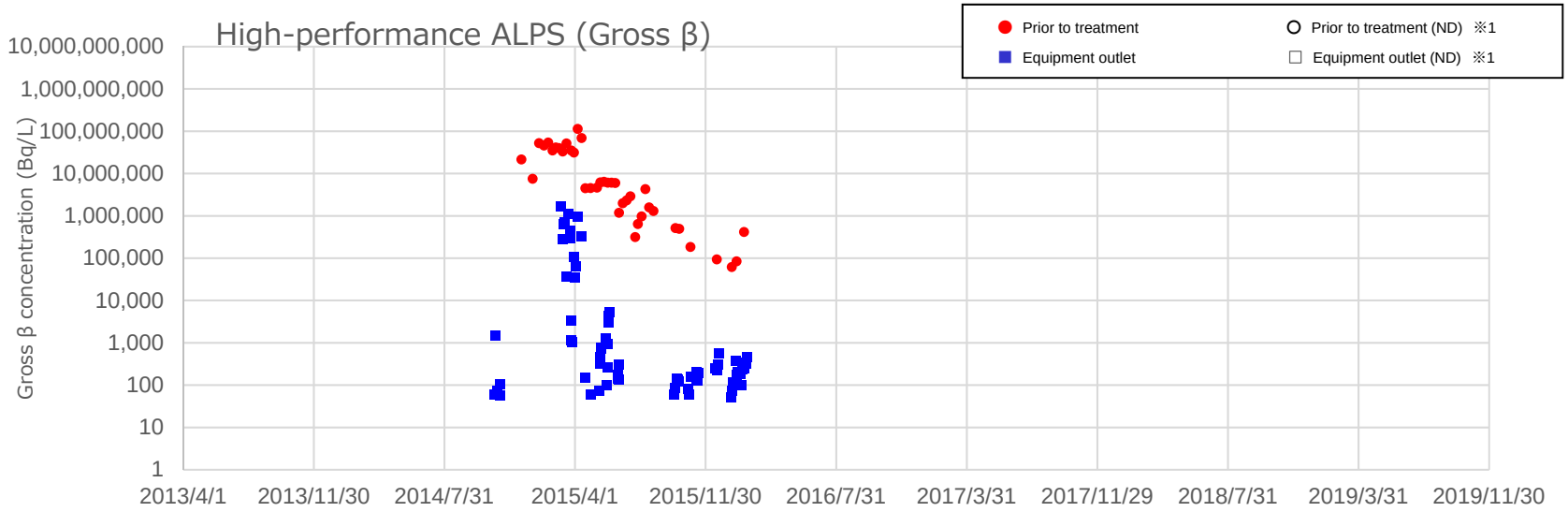
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Gross β concentration)





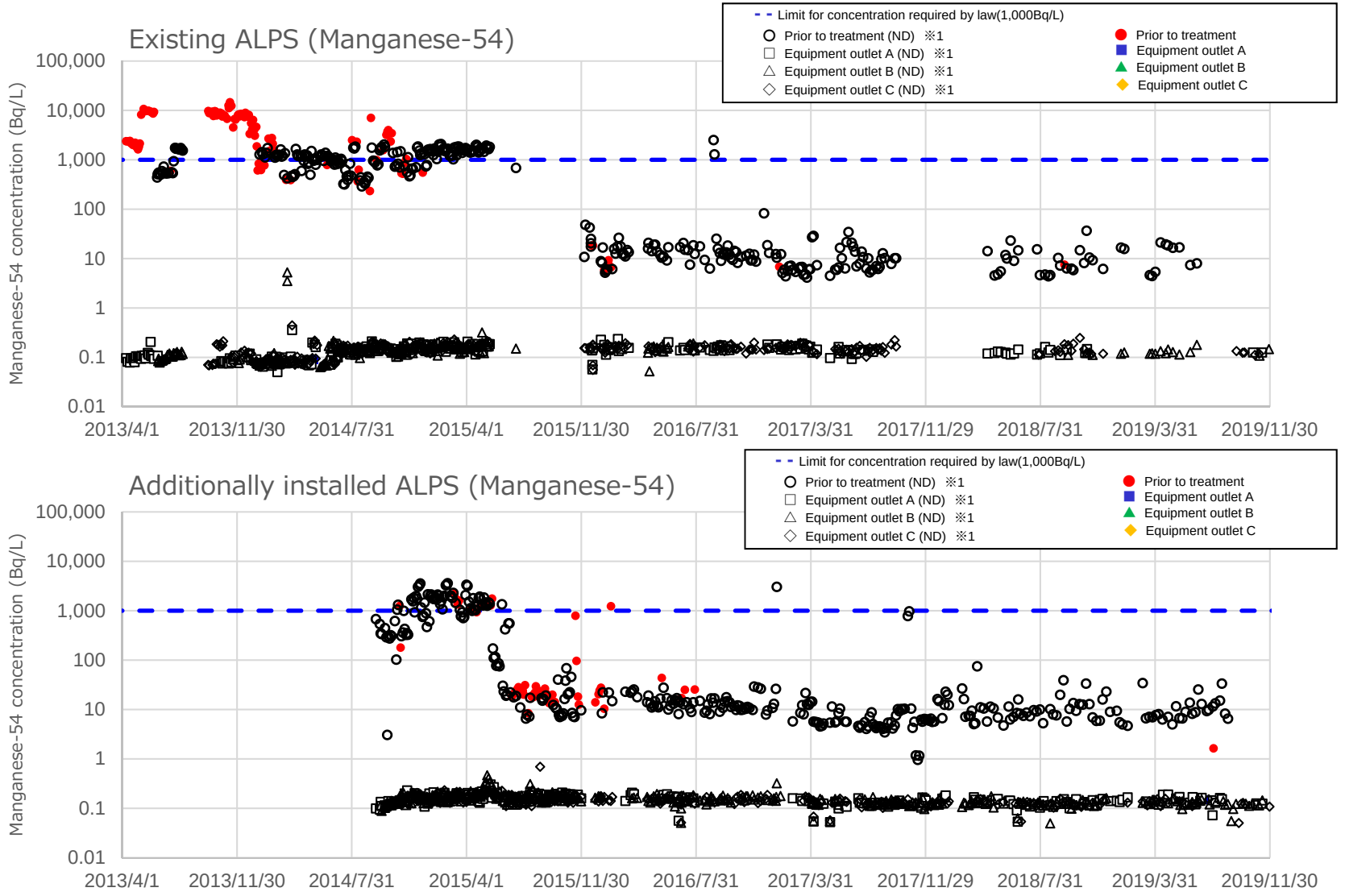
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Gross β concentration)



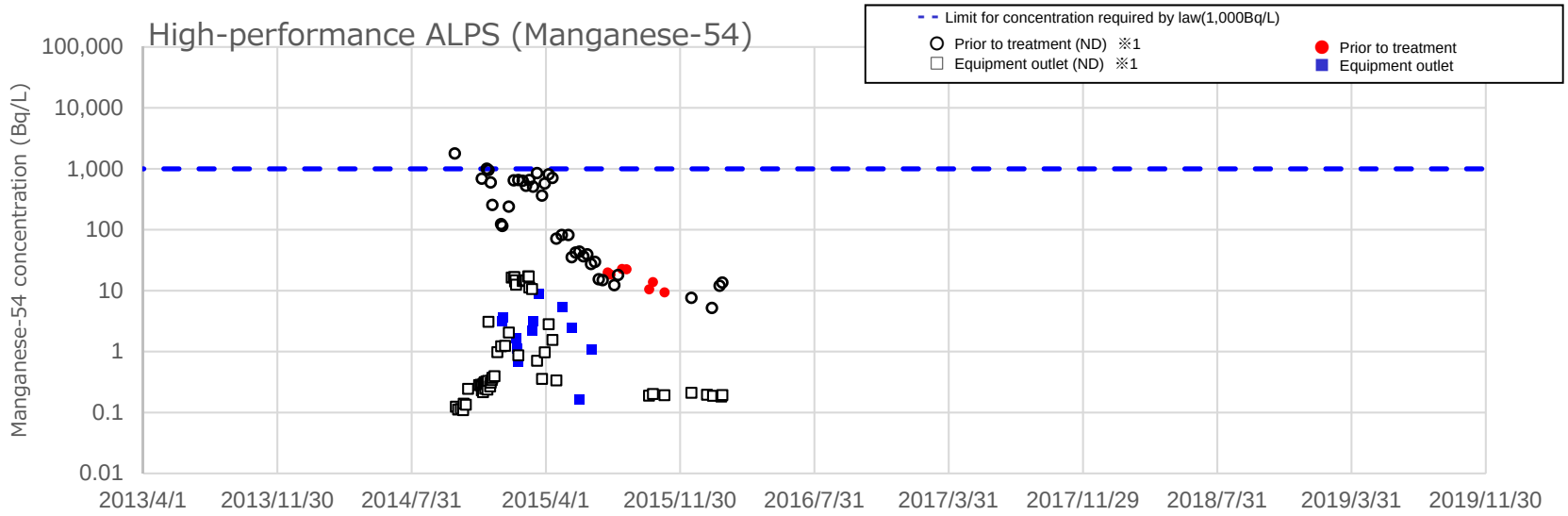
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Manganese-54 concentration)



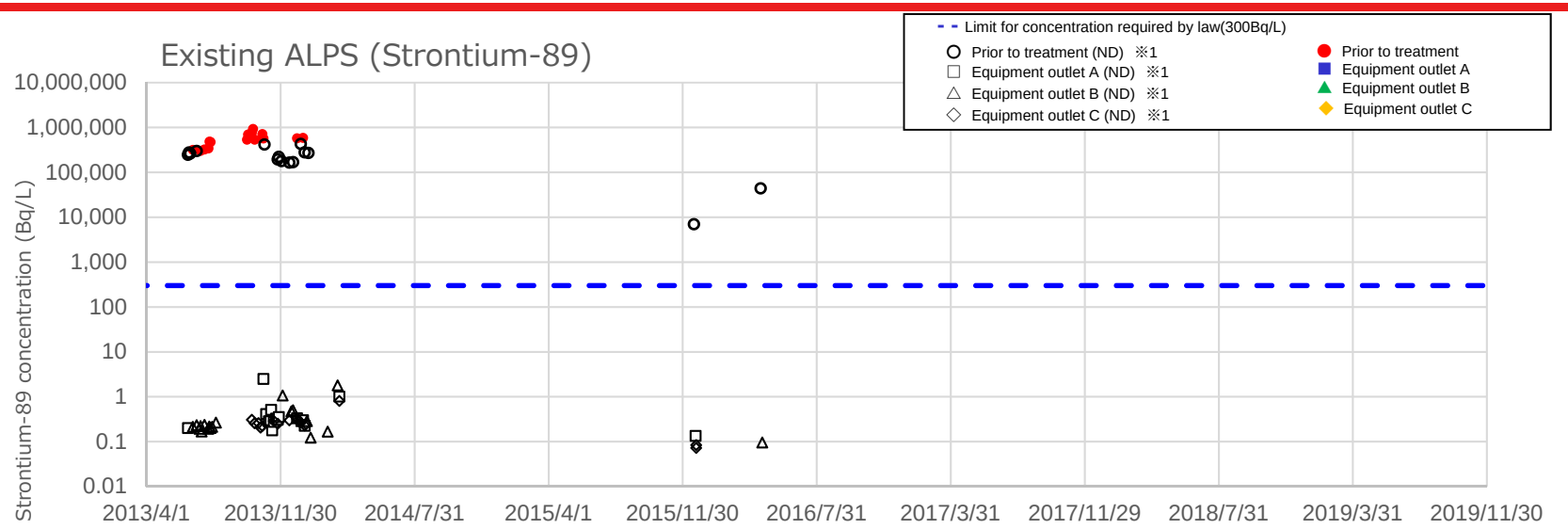
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

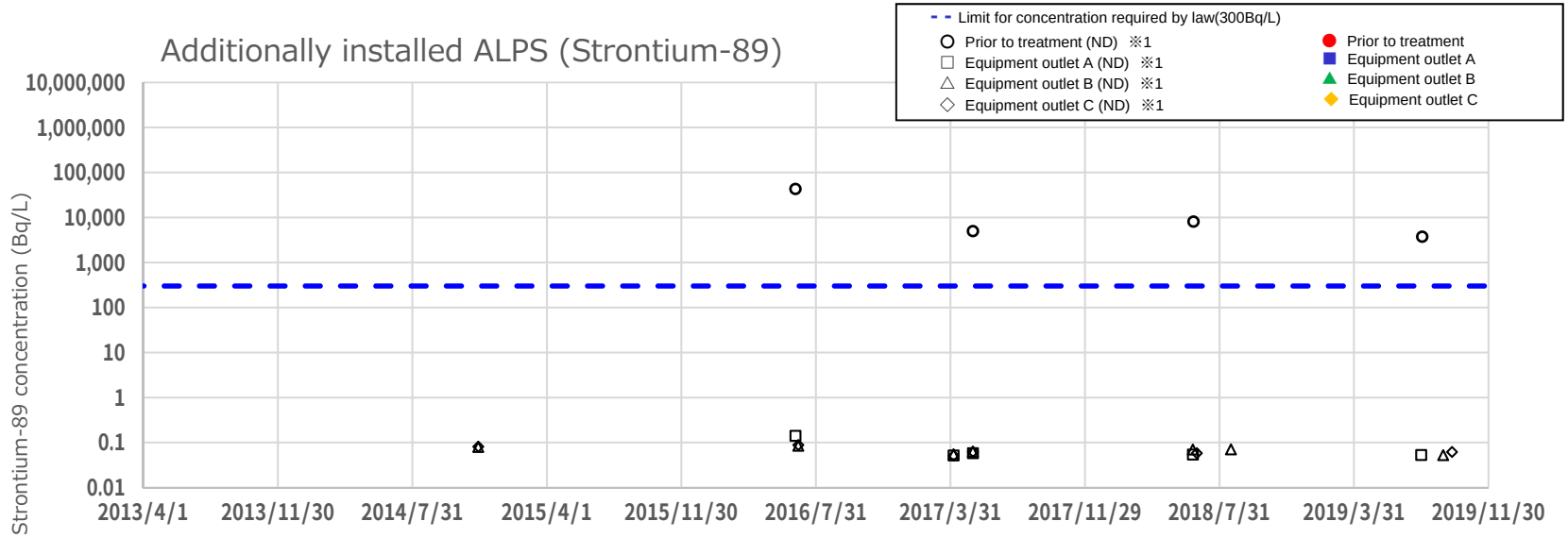
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Manganese-54 concentration)



※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

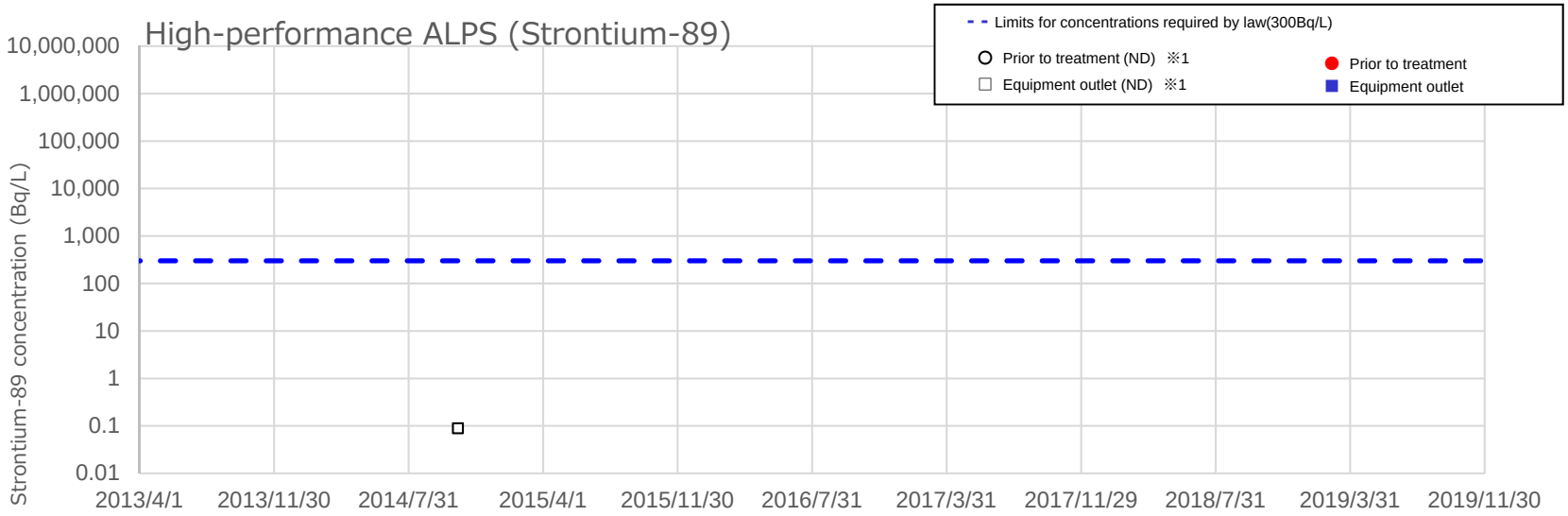
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Strontium-89 concentration)





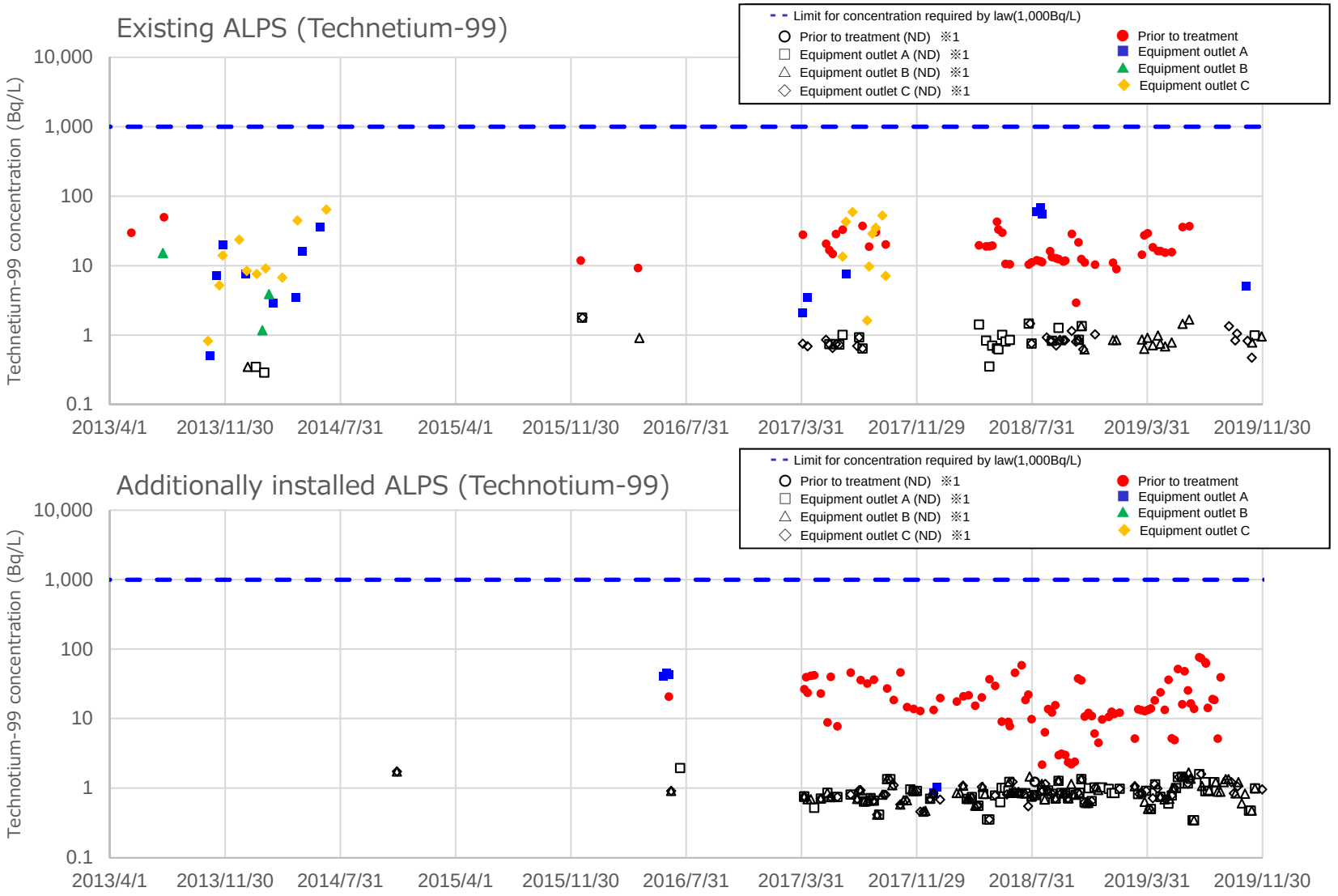
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Strontium-89 concentration)



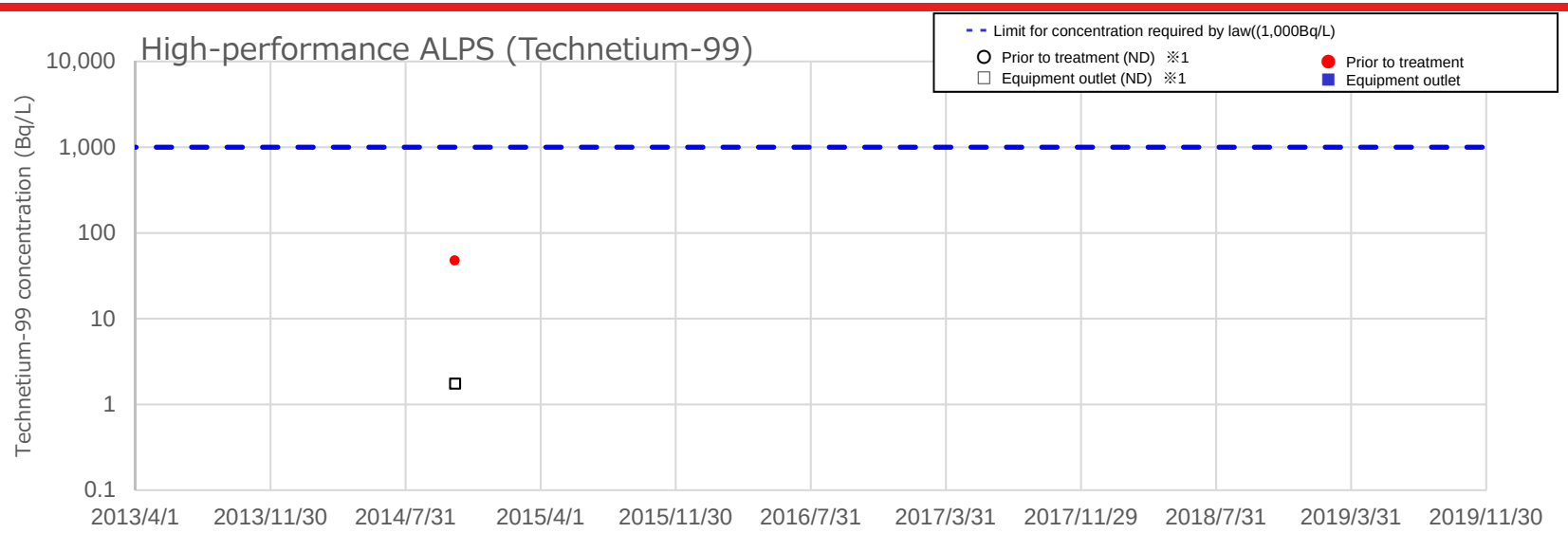
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Technetium-99 concentration)



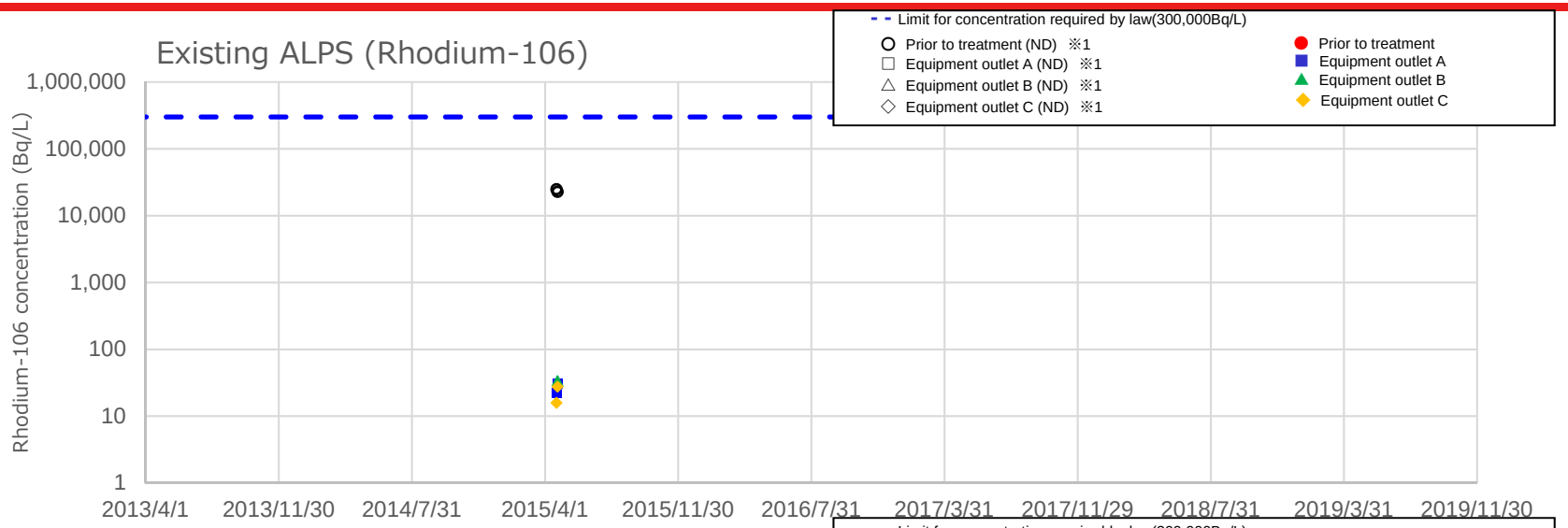
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

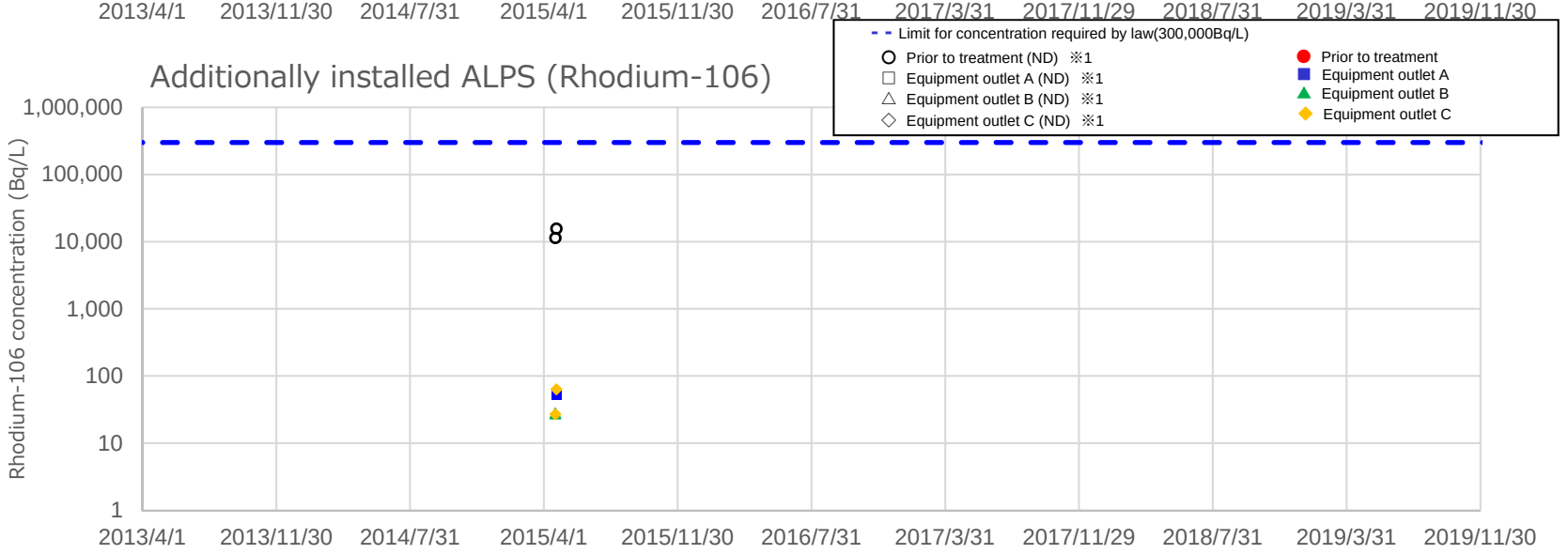
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Technetium-99 concentration)



※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

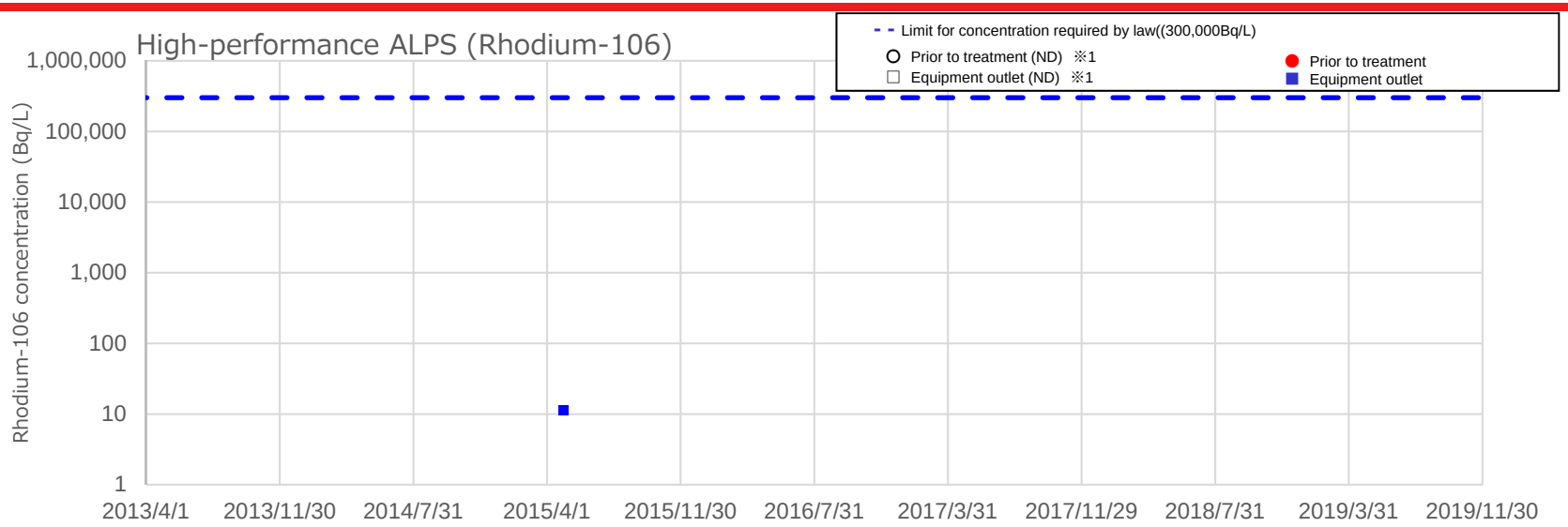
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Rhodium-106 concentration)





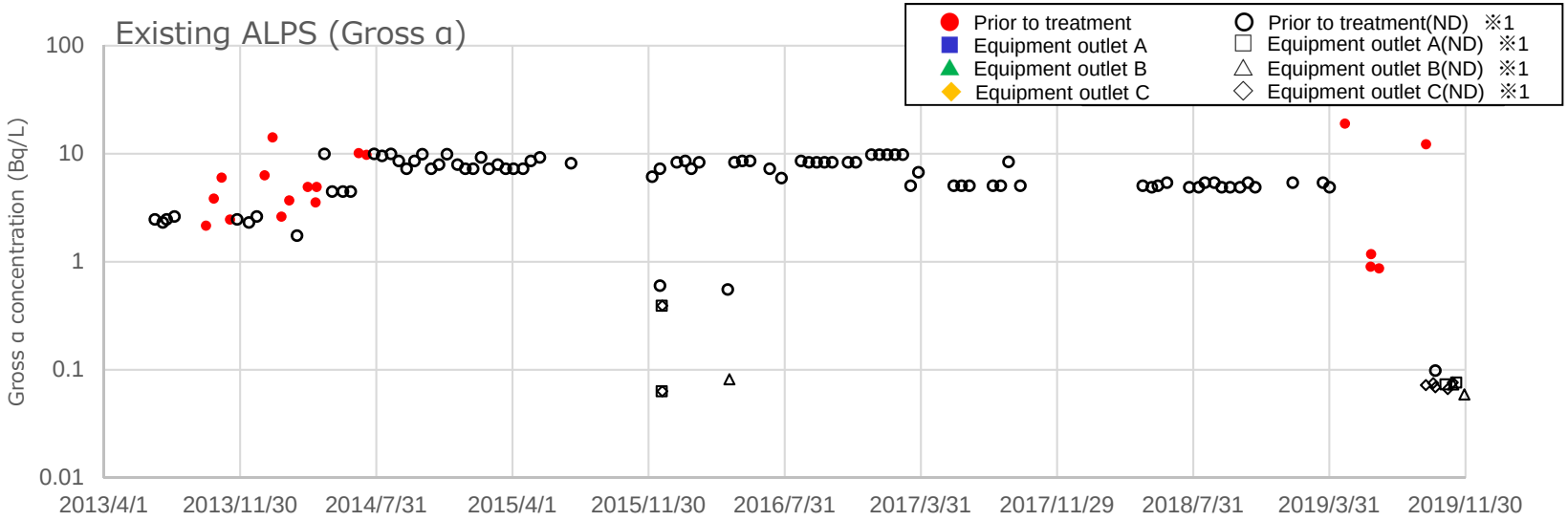
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

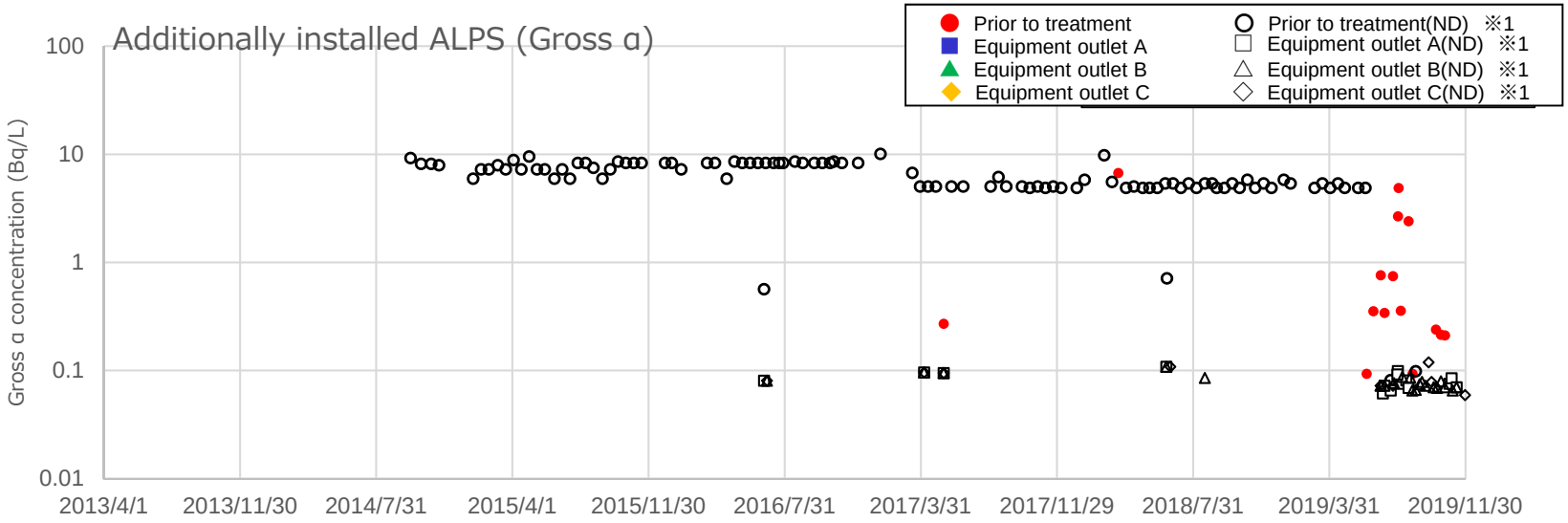
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Rhodium-106 concentration)



※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

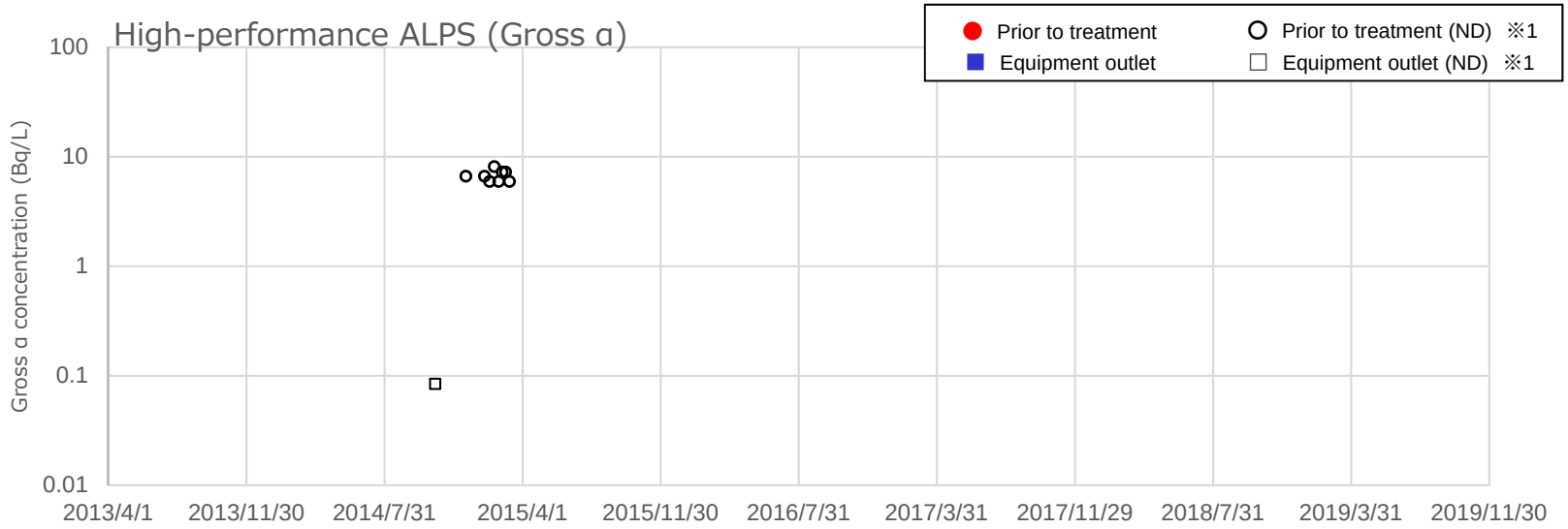
Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Gross α concentration)





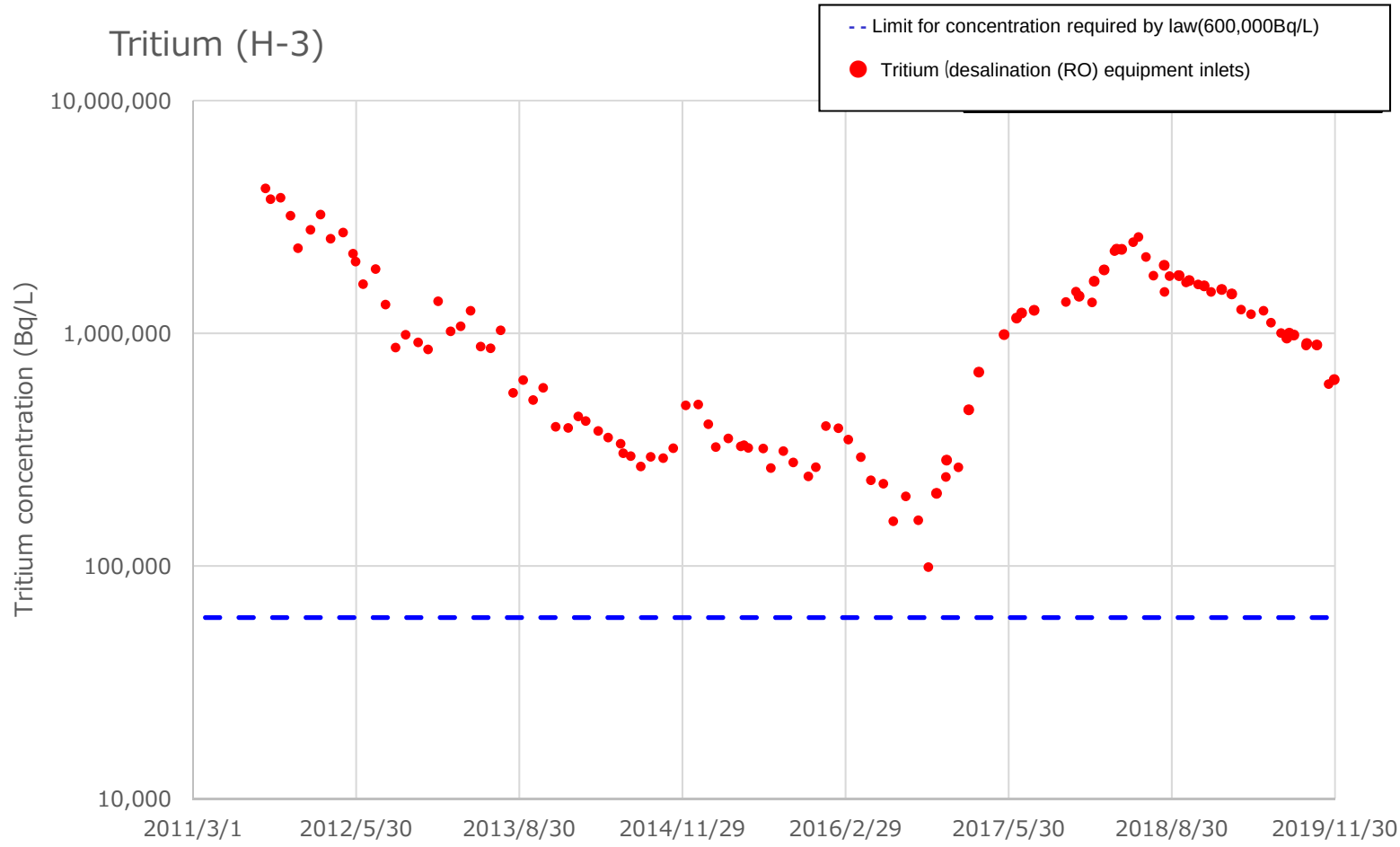
※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

Radiation concentrations measured at the multi-nuclide removal equipment (ALPS) outlet (Gross α concentration)



※ 1 “ND” means that concentrations were below detectable limits.
※ 2 Vertical scale is logarithmic, and one line indicates a ten-fold increase

[Reference]
Tritium (H-3) concentration trends at desalination (RO) equipment inlets



※1 Vertical scale is logarithmic, and one line indicates a ten-fold increase